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Waste Isolation Pilot Plant Salado Hydrology Program Data Report #3

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ABSTRACT

WIPP Salado Hydrology Program Data Report #3 presents hydrologic data collected during permeability testing, coupled permeability and hydrofracture testing, and gas-threshold-pressure testing of the Salado Formation performed from November 1991 through October 1995. Fluid-pressure monitoring data representing August 1989 through May 1995 are also included. The report presents data from the drilling and testing of three boreholes associated with the permeability testing program, nine boreholes associated with the coupled permeability and hydrofracture testing program, and three boreholes associated with the gas-threshold-pressure testing program. The purpose of the permeability testing program was to provide data with which to interpret the disturbed and undisturbed permeability and pore pressure characteristics of the different Salado Formation lithologies. The purpose of the coupled permeability and hydrofracture testing program was to provide data with which to characterize the occurrence, propagation, and direction of pressure induced fractures in the Salado Formation lithologies, especially MB139. The purpose of the gas-threshold-pressure testing program was to provide data with which to characterize the conditions under which pressurized gas displaces fluid in the brine-saturated Salado Formation lithologies. All of the holes were drilled from the WIPP underground facility 655 m below ground surface in the Salado Formation. All testing was conducted using multipacker test tools with inflatable packers to allow formation pore-pressure buildup and subsequent test events to be carried out in isolated intervals. The testing sequences performed or monitored in boreholes C1H05, C1H06, C1H07, C1X05, C1X06, C1X10, C2H01, C2H02, DPD02, DPD03, L4P51, L4P52, SCP01, and S1P74 involved Marker Beds 138, 139, 140, a clean halite above Marker Bed 140, and an argillaceous halite approximately 10 m below Marker Bed 140. Test data include pressures and temperatures from the brine-filled, packer-isolated test intervals, fluid production during constant-pressure-flow tests, nitrogen-injection rates during gas-threshold-pressure tests, and borehole-closure and axial test-tool movement measurements. The boreholes associated with the permeability and gas-threshold-pressure testing programs were drilled and/or cored to a nominal 4-inch (10.2-cm) diameter using compressed air or brine circulation to remove drill cuttings. The two test boreholes associated with the coupled permeability and hydrofracture testing program were drilled and/or cored to a nominal 3-inch (7.62-cm) diameter using similar drilling techniques. The observation boreholes associated with the coupled permeability and hydrofracture testing program were similar to those associated with the permeability and gas-threshold-pressure testing programs. Compliance tests were conducted on the test tools in sections of stainless-steel casing to evaluate the mechanical performance and behavior of the tools. Compliance testing sequences include leak tests and zone compressibility tests (zone compressibility test were sometimes conducted within a test borehole. Following permeability and/or gas-threshold-pressure testing, fluid pressures were monitored in packer-isolated sections of test boreholes C2H01, C2H02, DPD01, DPD02, DPD03, L4P52, SCP01, S1P71, and S1P72. This was done in an effort to quantify the relationship between proximity to an excavation and change in formation pore pressure as a function of time.

EXECUTIVE SUMMARY

WIPP Salado Hydrology Program Data Report #3 contains data collected during the drilling and permeability testing of boreholes L4P51, L4P52, and S1P74, the drilling and coupled permeability and hydrofracture testing of boreholes C1H05, C1H06, C1H07, C1X05, C1X06, C1X10, C2H01, DPD02, and DPD03, and the drilling and gas-threshold-pressure testing of boreholes C2H02, L4P52, and SCP01. All of the test boreholes were drilled with 4.0-inch (10.2-cm) core and drill bits using compressed air or circulated brine to remove drill cuttings, except for the hydrofracture test boreholes C1X05 and C1X10, which were drilled with 3.0-inch (7.62-cm) core and drill bits using similar techniques. Descriptions of the recovered core samples are presented in Appendix A.

Permeability tests were designed to meet three objectives: 1) to provide technically defensible data with which to interpret the permeability characteristics of the different lithologies of the Salado Formation that could contribute to fluid flow to and/or from the WIPP underground facility; 2) to delineate, if possible, the extent of hydrogeologic disturbance in the Salado Formation around the WIPP underground facility; and 3) to provide estimates of the formation pore pressure of the Salado Formation near the WIPP underground facility, and where possible, establish a pore-pressure profile from the surface of the excavation to undisturbed far-field conditions in the formation. Permeability testing boreholes were drilled in Room L4 and Waste Panel 1, Room 7. Borehole L4P51 was deepened from 10.06 to 22.35 m vertically downward from the floor in Room L4 to test Marker Bed (MB) 140 during permeability-testing sequence L4P51-C1 and to test the halite above MB140 during permeability-testing sequence L4P51-C2. Borehole L4P51 was later deepened to a total depth of 30.45 m to allow testing of an argillaceous halite from 29.62 to 30.40 m below the room floor during permeability-testing sequences L4P51-D1 and L4P51-D2. Borehole L4P52 was deepened from 5.56 to 14.18 m at an upward angle of 40° from vertical from near the top of the west rib of Room L4 to test MB138 during permeability-testing sequence L4P52-B. Borehole S1P74 was drilled at an upward angle of 40° from vertical from near the top of the east rib of Waste Panel 1, Room 7 to a depth of 7.69 m to test anhydrite "a" during permeability-testing sequence S1P74-A. Borehole S1P74 was later deepened to a total depth of 16.88 m to test MB138 and the argillaceous halite below MB138 during permeability-testing sequence S1P74-B.

Permeability testing was performed using multipacker test tools to isolate brine-filled sections of the boreholes for pressure buildup/falloff, pulse-withdrawal, and constant-pressure-flow testing. The test tools utilized two or three 3.75-inch-(9.53-cm) diameter packers with 92-cm-(36.22-inch) long elements to isolate single or multiple test zones and guard zones of various lengths. Multiple isolated zones are useful for decreasing the pressure gradient across a packer, thereby decreasing the possibility for pressure bypass around a packer and also for detecting pressure bypass if it does occur. The principal test zones were the bottom-hole zones, although testing was also performed in selected middle zones that contained horizons of hydrologic interest.

The permeability test tools were equipped with pressure transducers to monitor fluid pressure in the zones and the inflation pressure of each of the packers. In some cases, thermocouple were used to monitor temperatures in the zones. Also, in some cases, the test tools were equipped with three radially oriented linear variable-differential transformers (LVDTs) to measure borehole closure, and an axially oriented LVDT to monitor test-tool movement in response to pressure changes in the isolated intervals as well as in the packers. A differential-pressure-transmitter (DPT) panel was used to measure brine production during zone compressibility tests and constant-pressure-flow tests. Calibration data for the pressure transducers, LVDTs, and DPT panel columns are stored in the Sandia WIPP Central Records File (SWCF) under WPO #42269.

In most permeability-testing sequences, pulse-withdrawal tests and constant-pressure-flow tests were performed after fluid pressures in the zones to be tested had built up to relatively stable levels. Pulse-withdrawal tests were used because of the low permeability of the Salado Formation as indicated by other testing at the WIPP site (Beauheim et al., 1991). Pulse-withdrawal tests were performed in preference to pulse-injection tests to avoid potential hydrofracturing of the formation, which could occur if a pulse-injection were to exceed the formation's lithostatic pressure. Pulse-withdrawal tests were typically repeated to provide an indication of the reproducibility of the test results. In some cases, pulse injections were performed in order to increase the fluid pressure in isolated intervals in which little or no fluid-pressure responses were observed after shut in. Constant-pressure-flow tests were performed in order to obtain brine-production information and data to allow for the evaluation of the formation's hydraulic properties. Permeability-testing results are presented in sequence plots of the parameters monitored versus time in Section 3.6.

Pulse-withdrawal and constant-pressure-flow tests were conducted in the isolated guard zone containing the halite above MB140 in borehole L4P51 during permeability testing sequence L4P51-C1. Several constant-pressure-withdrawal tests were conducted in the isolated test zone containing MB140 during the same testing sequence. Pulse-withdrawal tests, constant-pressure-injection tests, and constant-pressure-withdrawal tests were conducted in the isolated test zone containing the halite above MB140 in borehole L4P51 during permeability testing sequence L4P51-C2. In borehole L4P52, both constant-pressure-injection tests and constant-pressure-withdrawal tests were conducted in the isolated test zone containing MB138 during permeability-testing sequence L4P52-B.

A pulse-withdrawal test and a constant-pressure-withdrawal test were conducted in the isolated test zone containing anhydrite "a" in borehole S1P74 during permeability-testing sequence S1P74-A. Pulse-withdrawal tests were conducted in both the isolated test intervals containing MB138 and the argillaceous halite below MB138 (AH-1) in borehole S1P74 during permeability-testing sequence S1P74-B.

Unsuccessful attempts were made to perform permeability tests in the isolated test zone containing the argillaceous halite below MB140 in borehole L4P51 during permeability-testing sequence L4P51-D1. Testing was suspended for permeability-testing sequence L4P51-D1 when the test tool was determined to be unreliable. Pressure monitoring only was performed with tool configuration L4P51-D2. The following table notes the hydrologic units monitored in the test and guard zone intervals for the respective permeability-testing sequences.

Summary of Hydrologic Units Tested During the Permeability Testing Program

PERMEABILITY TESTING SEQUENCE	TEST ZONE 1	TEST ZONE 2	GUARD ZONE
L4P51-C1	Marker Bed 140	N/A	halite
L4P51-C2	Marker Bed 140	halite	halite
L4P51-D1	argillaceous halite		Marker Bed 140
L4P51-D2	argillaceous halite	N/A	N/A
L4P52-B	Marker Bed 138	N/A	halite, clay J, argillaceous halite
S1P74-A	anhydrite "a"	N/A	halite, anhydrite "b"
S1P74-B	Marker Bed 138	argillaceous halite	N/A

The hydraulic fracturing program was designed to meet six objectives: 1) to determine the fluid pressures at which fracturing will occur in anhydrite interbeds, especially MB139, both in a potentially disturbed state and in its undisturbed state; 2) to determine whether fracturing would take place by the opening and interconnection of preexisting, partially healed fractures of by the formation of new fractures; 3) to determine at what induced pressure (liquid or gas) fracturing might be sustained; 4) to determine if fracturing in MB139 involved the development of new fractures, would the fracturing be confined to the anhydrite interbed, or would newly created fractured extend across the MB139 contacts; 5) to determine if the total stress state (matrix stress plus pore pressure) in MB139 and MB140 is isotropic or not, and can near-field stress measurements around excavations be used to infer the undisturbed state of stress in the interbeds; and 6) to determine the magnitude of the smallest principal stress in anhydrite interbeds, if the stress state is anisotropic. Complementary pre- and post-fracture hydrological measurements were intended to meet three objective: 1) to provide reliable values of formation (pore) fluid pressure; 2) to provide permeability values of the interbeds before and after hydraulic fracturing; and 3) to provide a comparison of permeability measurements in MB139 relatively near existing excavations with equivalent data in MB140, which was expected to be essentially undisturbed. Coupled permeability and hydrofracture testing and observation boreholes were drilled in Room C1. Boreholes in Room C2 and in the North 1420 drift were also monitored. Borehole C1X10 was drilled vertically downward from the floor of Room C1 to a total depth of 10.16 m to test MB139 and clay E during testing sequence C1X10. Testing sequence C1X10 had five associated observation boreholes, all completed to allow monitoring of MB139 and clay E: C1H05, C1H06, C2H01, DPD02, and DPD03. Borehole C1H05 was drilled vertically downward from the floor of Room C1 to a total depth of 8.26 m. Borehole C1H06 was drilled downward, 30° from vertical, to a depth of 9.40 m at the intersection of the floor and the north rib of the North 1420 drift west of Room C1. Borehole C2H01 was drilled vertically downward into the floor of Room C2 to a total depth of 8.97 m. Boreholes DPD02, and DPD03 are located at the junction of the north rib and the floor of the North 1420 drift positioned between Room C1 and Room D. Borehole DPD02 was drilled downward, 46.8° from vertical to a total depth of 13.11 m. Borehole DPD03 was drilled downward, 45.8° from vertical to a total depth of 13.11 m.

Borehole C1X05 was drilled vertically downward from the floor of Room C1 to a depth of 9.14 m to test MB139 and clay E during coupled permeability and hydrofracture-testing sequence C1X05-A. Testing sequence C1X05-A had six associated observation boreholes: C1H05, C1H06, C1H07, C1X06, C1X10, and C2H01. The configurations of boreholes C1H05, C1H06, C1X10, and C2H01 have already been described. Boreholes C1H07 and C1X06 were drilled vertically downward from the floor of Room C1 to depths of 8.18 m and 7.63 m, respectively.

Borehole C1X05 was deepened vertically downward to a total depth of 30.20 m to test MB140 during coupled permeability and hydrofracture testing sequence C1X05-B. Testing sequence C1X05-B had two associated observation boreholes completed to MB140: C1H07 and C1X06. C1H07 and C1X06 were deepened vertically downward to total depths of 27.88 m and 27.99 m from the floor of Room C1 respectively.

Hydraulic fracturing of the Salado Formation was conducted at three locations within Room C1. Section 4.3 gives a detailed description of the actual hydrofracture process. Pre- and post-hydrofracture permeability testing were performed in each of the testing sequences using multipacker test tools to isolate the individual sections of the test boreholes for pressure-buildup/falloff, pulse-withdrawal, and constant-pressure-flow testing. The test tools utilized two or three 2-5/8-inch-(6.67-cm) diameter packers with 40-inch-(102-cm) long elements to isolate test and guard zones of various lengths. Pressure responses to hydrofracture events were also monitored in nearby boreholes during all three of the hydrofracture events. Single- and triple-packer test tools as described in Section 4.3 were used to monitor pressure, temperature, borehole closure, test-tool movement, and fluid production in the observation boreholes. The hydrofracture test and monitor tools were equipped similar to the permeability-testing tools.

In all of the coupled permeability and hydrofracture testing sequences, typical permeability tests (as described previously) were conducted both prior to and after hydraulic fracturing of the formation. By proceeding along these lines, the pre-fracture and post-fracture formation parameters could be characterized. Coupled permeability and hydrofracture testing results are presented in sequence plots of the parameters monitored versus time in Section 4.6.

In borehole C1X10, constant-pressure-injection tests and constant-pressure-withdrawal tests were conducted in the isolated test zone containing MB139 during testing sequence C1X10. Both pre- and post-fracture tests were conducted during this testing sequence. In borehole C1X05, constant-pressure-injection tests and constant-pressure-withdrawal tests were conducted in the isolated test zone containing MB139 during testing sequence C1X05-A. Both pre- and post-fracture tests were conducted during this testing sequence as well. In borehole C1X05, constant-pressure-injection tests, constant-pressure-withdrawal tests, and a pulse-withdrawal test were conducted in the test zone isolating a portion of MB140 during testing sequence C1X05-B. Both pre- and post-fracture constant-pressure flow tests were conducted during this testing sequence and a pulse-withdrawal test was conducted post-fracture. The following table notes the hydrologic units monitored and the test-zone intervals for the coupled permeability and hydrofracture-testing sequences.

Summary of Hydrologic Units Tested During the Hydrofracture Testing Program

HYDROFRACTURE TESTING SEQUENCE	TEST ZONE 1	TEST ZONE 2
C1X10	Marker Bed 139	N/A
C1X05-A	Marker Bed 139	N/A
C1X05-B	Marker Bed 140	Marker Bed 140

The gas-threshold-pressure testing (GTPT) program was designed to meet five objectives: 1) to provide information about the far-field gas-threshold pressure in the Salado Formation anhydrite interbeds, particularly MB139 and MB140; 2) to determine, if possible, the far-field gas-threshold pressure in both argillaceous and pure halite beds of the Salado Formation; 3) to determine if the gas-threshold pressure varies with distance from the excavation in the WIPP underground facility; 4) to determine if the gas-threshold pressure is related to formation permeability; and 5) to determine if there will be sustained gas flow into the formation after gas-threshold pressure is reached, and at what rate pressure will the gas flow. GTPT was performed in boreholes previously drilled in Room C2, Room L4, and in the Core Storage Library. Borehole C2H02 was drilled at the intersection of the west rib and floor of Room C2 downward, 45° from vertical to a total depth of 10.91 m and allowed testing of MB139 and clay E during testing sequence C2H02. Borehole SCP01 was drilled downward, 77° from vertical on the south rib of the Core Storage Library to a total depth of 15.39 m allowing testing of MB139 and clay E during testing sequences SCP01-1 and SCP01-2. The configuration of borehole L4P52-B has already been described.

GTPT was performed using three different types of multipacker test tools to isolate gas-filled sections of the boreholes. A detailed description of the three different types of multipacker test-tools used in the GTPT program is given in Section 5.3. All of the GTPTs were performed in the bottom-hole zones of the respective boreholes. The GTPT tools were equipped similar to the permeability-testing tools.

In GTPT sequences, the isolated test zone was allowed to reach stabilization pressure under typical permeability-testing conditions (brine-filled zones) at which point the brine was exchanged with gas (nitrogen) in preparation for the GTPT. Upon successful completion of the gas/brine exchange, additional gas was introduced into the isolated test zone at a constant rate, thereby increasing the test-zone pressure. When it was determined that the gas threshold pressure had been reached, gas injection was terminated and the test-zone pressure was allowed to decay continuously or by imposing step decreases by withdrawing a volume of the gas from the test zone. GTPT results are presented in sequence plots of the parameters monitored versus time in Section 5.6.

Constant-rate-injection, and pulse-withdrawal tests were conducted in the isolated test zone containing MB139 and clay E in borehole C2H02 during GTPT sequence C2H02. Also, a pulse-withdrawal test was conducted in the isolated test zone containing the halite above MB139 in borehole C2H02 during this same GTPT sequence. In borehole L4P52, constant-rate-injection and pulse-withdrawal tests were conducted in the isolated test zone containing MB138 during GTPT sequence L4P52-B. In borehole SCP01, only constant-rate-injection tests were conducted in the isolated test zone containing MB139 and clay E during GTPT sequence SCP01-2.

Unsuccessful attempts were made to perform GTPTs in the isolated test zone including MB139 and clay E in borehole SCP01 during GTPT sequence SCP01-1. Testing was suspended when it was determined that the test-zone packer was not properly sealed and the test-zone pressure was bypassing the test-zone packer. The following table notes the hydrologic units monitored and the test and guard zone intervals for the respective GTPT sequences:

Summary of Hydrologic Units Tested During the Gas Threshold-Pressure Testing Program

GTPT SEQUENCE	TEST ZONE	GUARD ZONE
SCP01-1	Marker Bed 139, clay E	polyhalitic halite 4
C2H02	Marker Bed 139, clay E	polyhalitic halite 4
L4P52-B	Marker Bed 138	halite, clay J, argillaceous halite
SCP01-2	Marker Bed 139, clay E	polyhalitic halite 4

In most cases, compliance testing of the multipacker test tools was performed before each testing sequence in order to achieve the following three objectives: 1) to characterize test-tool performance, 2) to identify the responses due to test-tool movement, and 3) to identify changes in the size and shape of the elastic packer elements caused by changes in packer and zone pressures. During a typical compliance testing sequence, the multipacker test tool was installed in a sealed chamber and pressure checked to ensure that the tool's components were not leaking. Constant-pressure injection and withdrawal tests were performed in the isolated intervals in the chamber in order to determine zone compressibility (in some cases zone compressibility tests were performed in test boreholes). The responses of the pressure transducers, thermocouple, LVDTs, and DPTs were monitored over the entire duration of the testing sequence in order to determine the test-tool behavior. Compliance testing results are presented in Section 6.

The fluid-pressure monitoring program was designed to meet two objectives: 1) to determine if pore pressures in the various Salado Formation interbeds change as a function of time due to the underground excavation; and 2) to determine the relationship between proximity to an excavation and change in formation pore pressure as a function of time. As part of the fluid-pressure monitoring program, fluid-pressure data obtained during the various testing programs were supplemented with data collected from packer-isolated intervals of test boreholes C2H01, C2H02, DPD01, DPD02, DPD03, L4P52, SCP01, S1P71, and S1P72. Borehole DPD01 is located at the junction of the north rib and the floor of the North 1420 drift positioned between Room C1 and Room D. Borehole DPD01 was drilled downward, 49.9° from vertical to a total depth of 12.34 m to test MB139 and clay E. Borehole S1P71 was drilled vertically downward to a depth of 4.55 m and deepened to a total depth of 10.15 m from the floor of Waste Panel 1, Room 7 to test anhydrite "c" and clay B. Borehole S1P72 was drilled downward, 58° from vertical to a total depth of 6.05 m to test MB139 and clay E. The configurations and locations of boreholes C2H01, C2H02, DPD02, DPD03, L4P52, and SCP01 have already been described. The following table notes the hydrologic units monitored during the fluid-pressure monitoring.

Summary of Hydrologic Units Monitored During the Fluid-Pressure Monitoring Program

FLUID-PRESSURE MONITORING BOREHOLE	TEST ZONE
C2H01	Marker Bed 139, clay E
C2H02	Marker Bed 139, clay E
DPD01	Marker Bed 139, clay E
DPD02	Marker Bed 139, clay E
DPD03	Marker Bed 139, clay E
L4P52	Marker Bed 138
SCP01	Marker Bed 139, clay E
S1P71	anhydrite "c"
S1P72	Marker Bed 139, clay E

Data from the fluid-pressure monitoring are shown graphically in Section 7.

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1. INTRODUCTION

WIPP Salado Hydrology Program Data Report #3 is the third and final in a series of reports that make available hydrologic data collected during drilling, permeability testing, coupled permeability and hydrofracture testing, gas-threshold-pressure testing (GTPT), and fluid-pressure monitoring in the Salado Formation at the Waste Isolation Pilot Plant (WIPP) site near Carlsbad, New Mexico. The data presented in this report were collected between November 1991 and October 1995. The purpose of this series of reports is to disseminate basic hydrologic data to interested parties in a timely manner, often before data interpretation. The underground testing described in this report was carried out by INTERA Inc. under the direction of the Geohydrology Department of Sandia National Laboratories, Albuquerque, New Mexico.

This report presents data from the drilling and testing of fourteen boreholes drilled from the WIPP underground facility in the Salado Formation 655 m below ground surface (Figure 1-1). The boreholes were in the experimental, operations, and waste-storage areas of the underground facility. The boreholes are oriented vertically downward, angled downward, and angled upward. The data presented include the pressures and temperatures in brine-filled, packer-isolated test intervals, fluid production during constant-pressure-flow tests, nitrogen-injection rates during gas-threshold-pressure testing, and borehole-closure and test-tool movement measurements collected during pressure-buildup/falloff periods and in response to pressure-pulse and constant-pressure-flow tests. The report also contains fluid-pressure monitoring data from packer-isolated intervals of selected boreholes encompassing the time period from August 1989 to May 1995.

This report is written using standard SI units and abbreviations with the following exceptions. For convenience, liter, abbreviated L, is used instead of 0.001 m^3. When certain equipment has been manufactured using materials specified in inch-pound units (such as standard tubular supplies), or the equipment is rated in inch-pound units (such as pressure equipment), the inch-pound units are used, followed by the SI equivalent in parentheses.

Information and data contained in this report is kept on file in electronic form in the Sandia WIPP Central File (SWCF) under WPO #42269. Persons interested in obtaining this information should make inquiries to the SWCF of Sandia National Laboratories.

NOTE: The use of brand names in this report is for identification purposes only and does not imply any endorsement of specific products by Sandia National Laboratories or INTERA Inc.

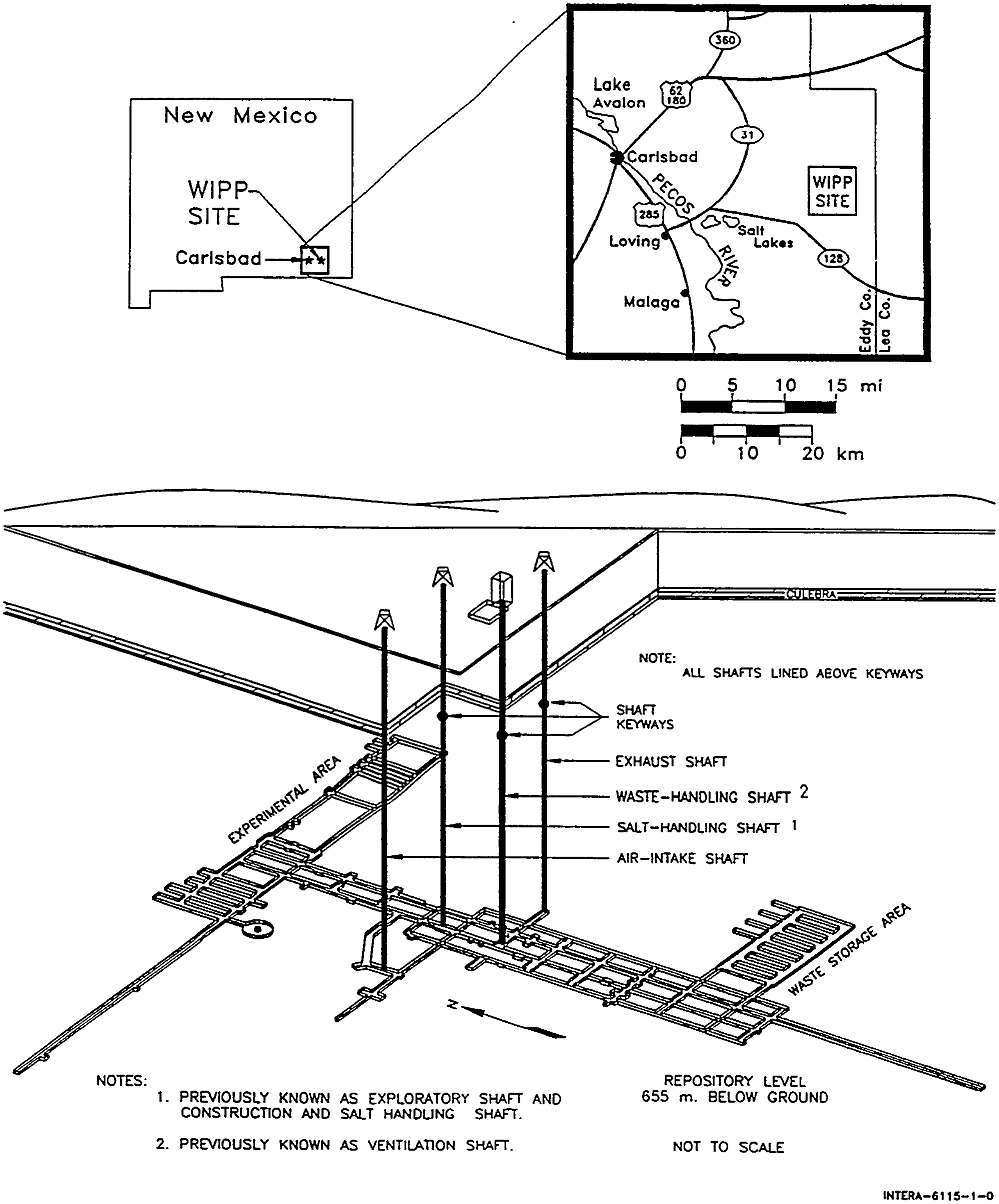

Figure 1.1 Location of WIPP Site and associated access shafts.

2. THE WIPP UNDERGROUND FACILITY

2.1 Construction

Figure 2-1 diagrammatically illustrates the WIPP underground facility as it exists at the time of this report. The facility is being constructed in the Salado Formation approximately 655 m below ground surface. The Salado Formation is a bedded-evaporite sequence consisting primarily of bedded halite with associated interbeds composed principally of anhydrite, polyhalite, clay, and siltstone. As shown in Figure 1-1, the underground facility is accessed by four vertical shafts.

The underground rooms and drifts of the WIPP facility were excavated by continuous-mining techniques. Blasting techniques were not employed in the WIPP underground facility. The drifts in the underground excavations are numbered according to their north-south or east-west distance in feet from the salt-handling (SH) shaft. These designations are used to identify locations such as the East 140 drift. Figures 2-2a and 2-2b show the geometry of typical rooms in the northern experimental area and in the southern waste-storage area, and the generalized local stratigraphy of the Salado Formation. The figure shows that the floors of the simulated waste experimental rooms are stratigraphically approximately 1.8 m above the backs of the rooms in the waste-storage area. Bechtel (1986) provides construction details for the WIPP underground facility and the locations of geomechanical instrumentation stations in both the experimental and waste-storage areas.

2.2 Stratigraphy

Figures 2-2a and 2-2b illustrate the typical stratigraphic sequence encountered in the Salado Formation near the WIPP underground facility and shows that the Salado contains evaporite-mineral and clay-rich interbeds above and below the repository level. Figures 2-2a and 2-2b also indicate the named clay units and anhydrite interbeds and shows map-unit designations according to terminology presented in Bechtel (1986) and Deal et al. (1989). Anhydrite marker beds and their associated clay seams, as well as other clay seams, are of particular interest to the testing programs. These stratigraphic interbeds are often the loci for stress-relief fractures and salt efflorescences noted in 10- to 90-cm-diameter boreholes drilled from the drifts and rooms in the underground facility (Bechtel, 1986).

During this reporting period, the anhydrite interbeds "a", "b", Marker Bed (MB) 138, MB139, MB140, the halite approximately 1 m above MB140, and an argillaceous halite approximately 10 m below MB140 were tested under the permeability-testing program, the anhydrite interbeds MB139 and MB140 were tested under the coupled permeability and hydrofracture testing program, and the anhydrite interbeds MB138 and MB139 were tested under the gas-threshold-pressure testing (GTPT) program. Also, the anhydrite interbeds "c", MB138, and MB139 were monitored under the long-term fluid-pressure monitoring program.

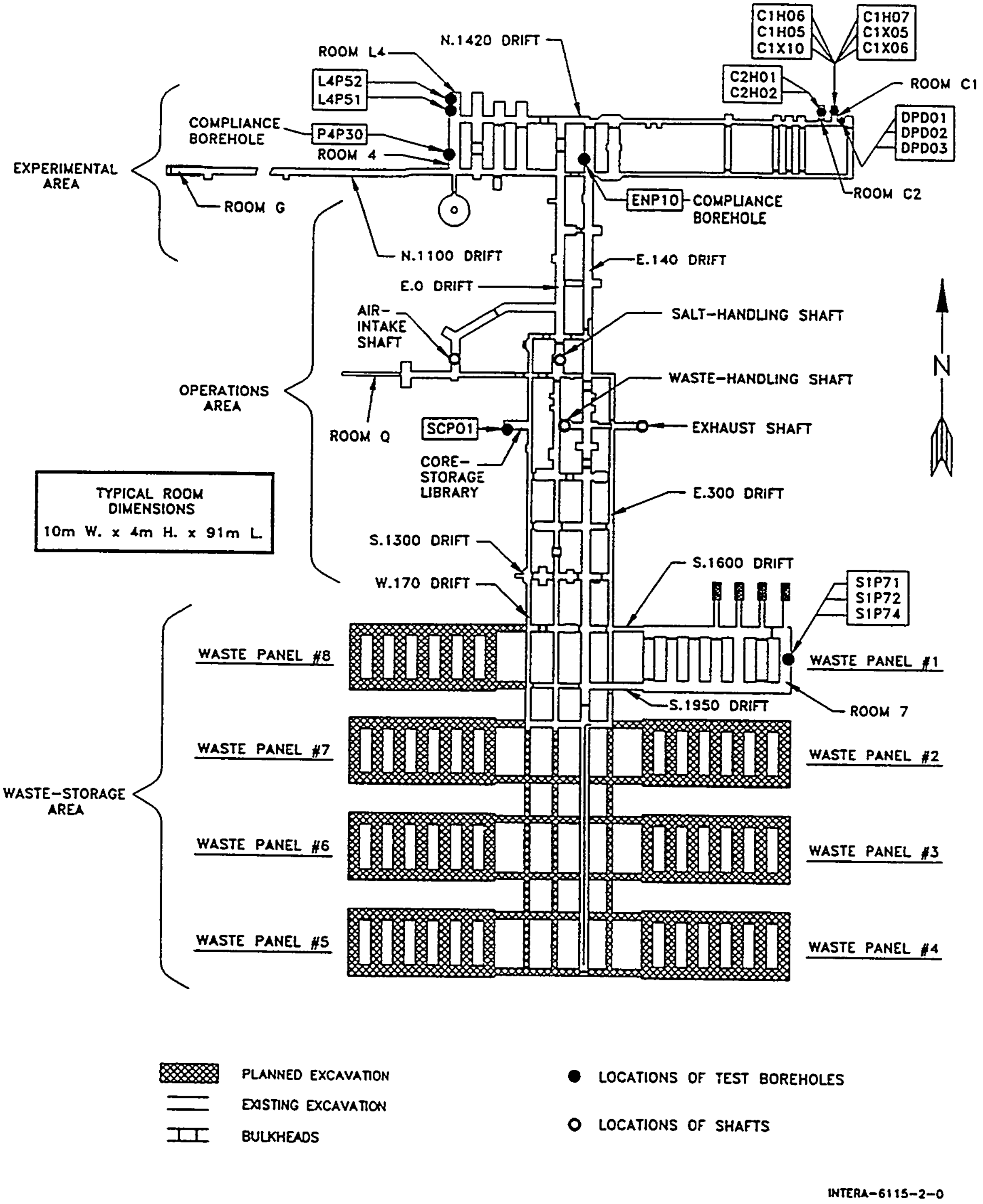

Figure 2-1. Map of the WIPP Site underground facility and test and observation borehole locations.

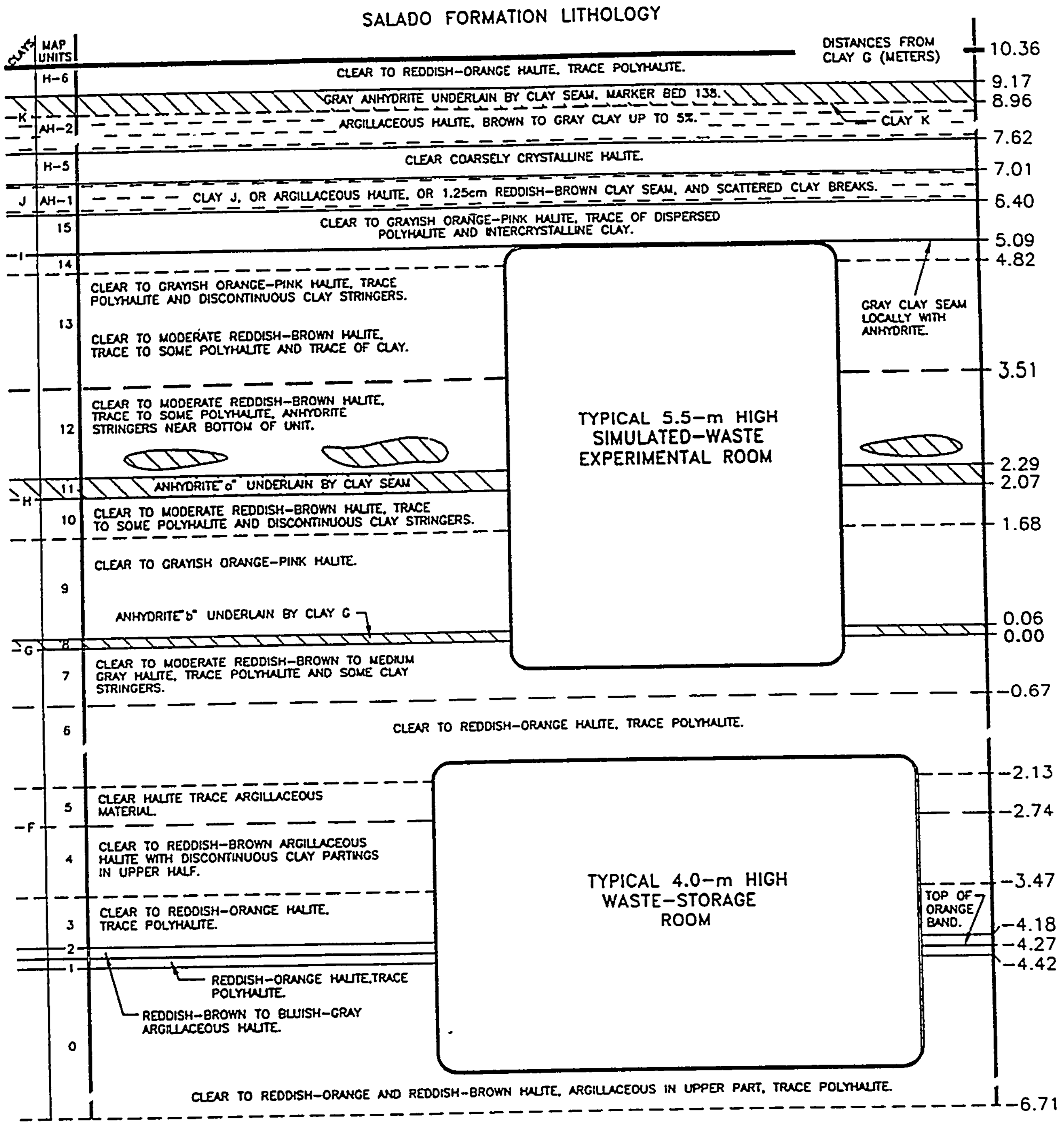

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Figure 2-2a. Detailed lithology of the Salado Formation and typical positions of WIPP underground rooms.

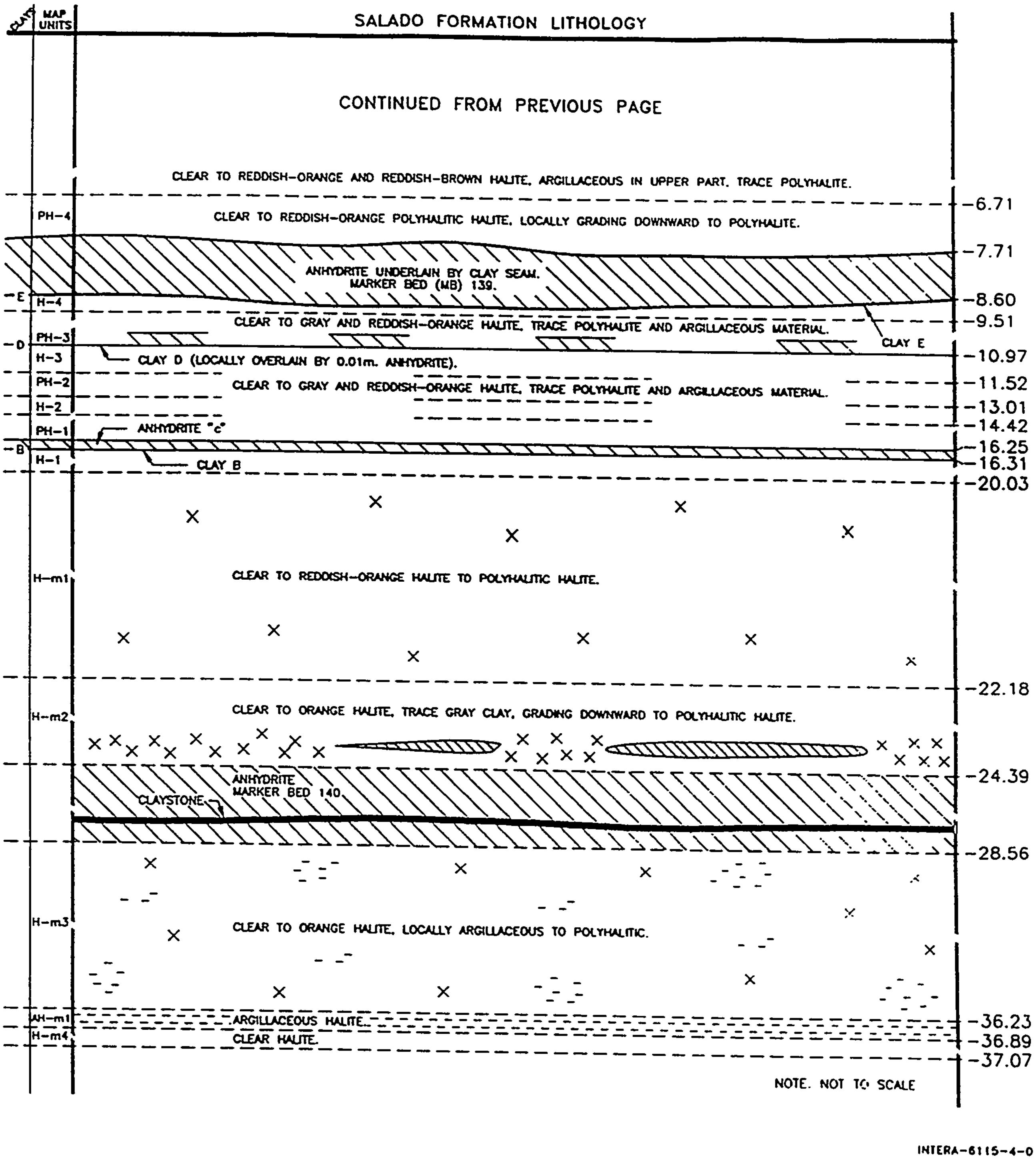


Figure 2-2b. Detailed lithology of the Salado Formation and typical positions of WIPP underground rooms (continued).

3. PERMEABILITY TESTING PROGRAM

The permeability-testing program for the WIPP underground facility was designed to provide data on the permeability and formation pore pressure of the Salado Formation. These data are required for estimating brine flow into and away from the repository, a factor that will affect the saturation state and pressurization of the sealed waste panels after closure of the repository. Analysis of the data provided by the Salado Hydrology Program reduces the level of uncertainty in permeability values used in performance-assessment calculations for the WIPP repository. The permeability-testing program was designed to provide hydraulic data both within the zone of influence of the WIPP excavations and in the undisturbed "far-field" parts of the Salado Formation. WIPP Procedure 483 describes the permeability testing procedure in detail.

3.1 Test Objectives

The design of effective plugs and seals for the repository's waste panels, proper evaluation of backfill, and performance-assessment calculations for the WIPP underground facility require knowledge of the distribution of permeability and formation pore pressure within the geologic media surrounding the facility. The far-field permeability may control the rate of brine flow into and away from the facility after closure. The amount of brine that enters the repository will affect the state of consolidation of the backfill and, therefore, the condition of the material in the sealed waste panels.

The specific objectives of the permeability-testing program are:

- to provide technically defensible data with which to interpret the permeability characteristics of the different lithologies of the Salado Formation that could contribute to fluid flow to and/or from the WIPP underground facility;
- to delineate, if possible, the extent of hydrogeologic disturbance in the Salado Formation around the WIPP underground facility; and
- to provide estimates of the formation pore pressure of the Salado Formation near the WIPP underground facility, and where possible, establish a pore-pressure profile from the surface of the excavation to undisturbed far-field conditions in the formation.

3.2 Test Design

The underground-permeability tests discussed in this data report were conducted in three boreholes drilled at two locations in the WIPP underground facility shown in Figure 2-1 and described in detail in Section 3.5. The boreholes were drilled vertically downward and angled upward. In the experimental area, boreholes L4P51 and L4P52 were drilled in Room L4. In the waste-storage area, borehole S1P74 was drilled in Waste Panel 1, Room

7. The test locations were chosen to provide an adequate representation of permeability in the Salado Formation and its interbeds at and near the repository horizon and to provide comparisons with previously tested areas. Borehole locations and orientations are discussed in Section 3.5.1.

After drilling, a multipacker test tool (see Section 3.3) was installed in each borehole. The packers were used to isolate a bottom-hole test zone and a guard zone between the two packers in the case of a double-packer test tool, and to isolate a bottom-hole test zone, a middle zone between the bottom two packers, and a guard zone between the top two packers in the case of a triple-packer test tool. In a triple-packer configuration, the bottom-hole zone is referred to as test-zone 1, the "middle zone" is referred to as test-zone 2, and the isolated zone closest to the repository is the guard zone. The zones were filled with 1.22 kg/L sodium-chloride brine. The middle and/or guard zones were used to detect pressure leakage from the bottom-hole test zone transmitted either through the test-tool or through the formation and to reduce the pressure gradient across any one of the packers. The middle and/or guard zones were also used as a testing zone in some instances. After packer inflation, the zones were shut in and the fluid-pressure buildup was monitored with pressure transducers and recorded on a computer-controlled data-acquisition system (DAS). As fluid pressures stabilized, over periods ranging from weeks to months, permeability tests were performed on the isolated, bottom-hole test zones, as well as on the middle and/or guard zones of selected boreholes.

Pulse-withdrawal testing and constant-pressure-injection/withdrawal testing procedures are described in Section 3.4. The permeability tests were conducted in a manner similar to that used to measure permeability and pore pressure in the WIPP waste-handling shaft (Stensrud et al., 1988; Saulnier and Avis, 1988) and to that used to measure permeability and pore pressure in the Salado Formation (Saulnier et al., 1991; Stensrud et al., 1992). For the Salado Hydrology Program, permeability tests were conducted in halite, argillaceous halite, and in anhydrite interbeds, similar to those described in Saulnier et al. (1991) and in Stensrud et al. (1992), at depths of approximately 7 to 30 m from the ribs, floor, or back of the WIPP underground facility.

Pulse-withdrawal tests were performed in order to provide data with which to estimate the compressibility of the zone being tested as well as formation hydraulic conductivity (K), formation pore pressure, and specific storage. Constant-pressure-injection/withdrawal tests were performed because this type of test allows a much larger radius of influence within the formation to be investigated than with pulse-withdrawal tests. Also, for testing sequences in which test-zone compressibility was not calculated, a constant-pressure-injection/withdrawal test is less sensitive to uncertainty in compressibility estimates.

Figure 3-1 illustrates the stratigraphic position of each of the permeability-testing boreholes and shows which strata were included in the test intervals.

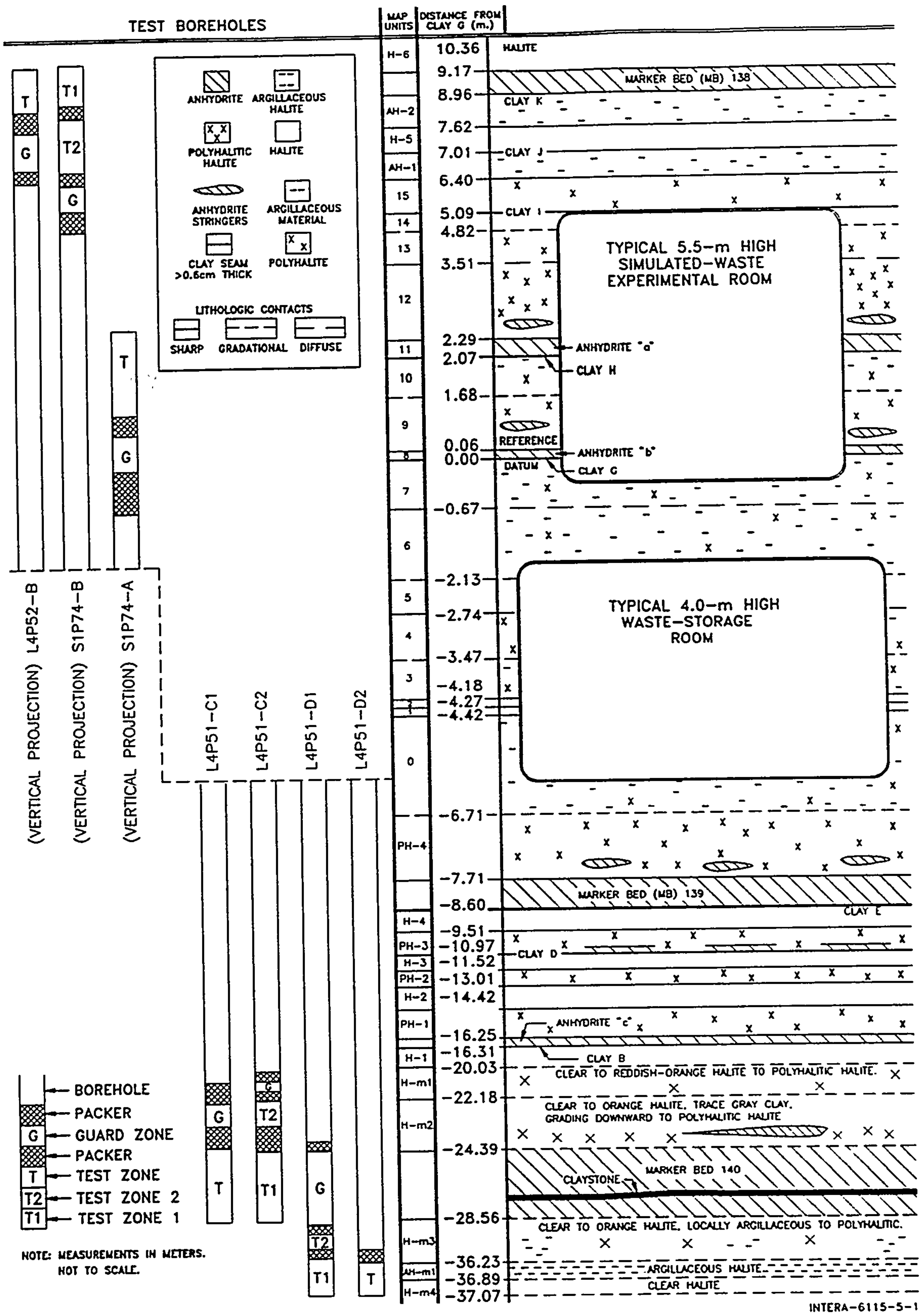


Figure 3-1. Stratigraphic positions of permeability-testing boreholes with test zones and guard zones indicated.

3.3 Test Equipment for Permeability Testing

The following section (3.3.1) briefly describe the equipment used in the permeability-testing program in the WIPP underground facility. The equipment includes multipacker test-tools, data-acquisition systems, pressure transducers, thermocouples, linear variable-differential transformers, a differential-pressure-transmitter panel, and a constant-rate injection system. Equipment specific to individual testing sequences is provided in Section 3.6. More detailed descriptions of the testing equipment and the procedures are presented in Stensrud et al. (1992). Equipment calibration is discussed in Section 3.3.2.

3.3.1 Description of Equipment

3.3.1.1 MULTIPACKER TEST TOOLS

The multipacker test tools, shown in Figures 3-2 and 3-3, were designed and built specifically for the permeability-testing program by Baski Inc. in conjunction with SNL and INTERA Inc. The test tool in Figure 3-2 has two sliding-end, 3.75-inch (9.53-cm) O.D. packers mounted on a 1.9-inch (4.83-cm) mandrel with the fixed ends oriented toward the bottom-hole end of the test tool. The test tool in Figure 3-3 has three sliding-end, 3.75-inch (9.53-cm) packers mounted on a 1.9-inch (4.83-cm) mandrel with the fixed ends oriented toward the bottom-hole end of the test tool. Figure 3-4 shows the nominal dimensions of the test tools' parts. Packers were inflated using a Teledyne Sprague Engineering Model S-216-J series air-driven hydraulic pump. When inflated, the packers provide isolation of a bottom-hole test zone, and one or two other zones between packers depending on the test-tool configuration. Pipe extensions of different lengths can be added to the test tool to accommodate boreholes and test zones of varying lengths. Packers had either a 0.92-m or 0.60-m long, inflatable, synthetic rubber element which had seal lengths of 0.84 m and 0.51 m, respectively, in a 4-inch- (10.2-cm) diameter borehole.

In some cases, a volume displacement device was used during testing in order to minimize the effective borehole volume. The volume displacement device was constructed of 3.75-inch (9.53-cm) O.D. stainless steel of various lengths. Two or more of the individual volume displacement devices could be connected if necessary to fill a long portion of a borehole.

During permeability and compliance testing, the test tool was anchored to the borehole collar or compliance chamber using a slip-type restraining device. The slip-type restraining device (Figure 3-5) consisted of a set of radially oriented, tapered slips that tightened onto the test-tool's extension tubing as the test tool attempted to move out of the borehole in response to fluid-pressure buildup.

The multipacker test tools were equipped with pressure transducers and thermocouples, in most cases, to monitor the pressures and temperatures in the zones and the inflation pressure in each of the packers (Figure 3-6). The test tools had vent and/or injection ports for all of the zones. The vent and/or injection ports allow for the dissipation of squeeze

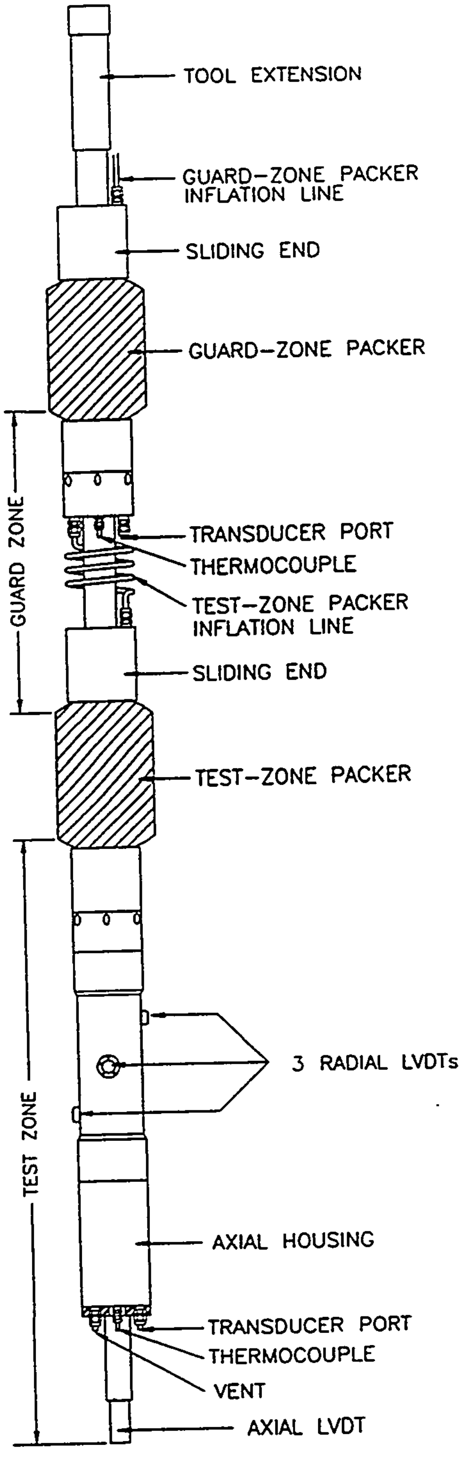
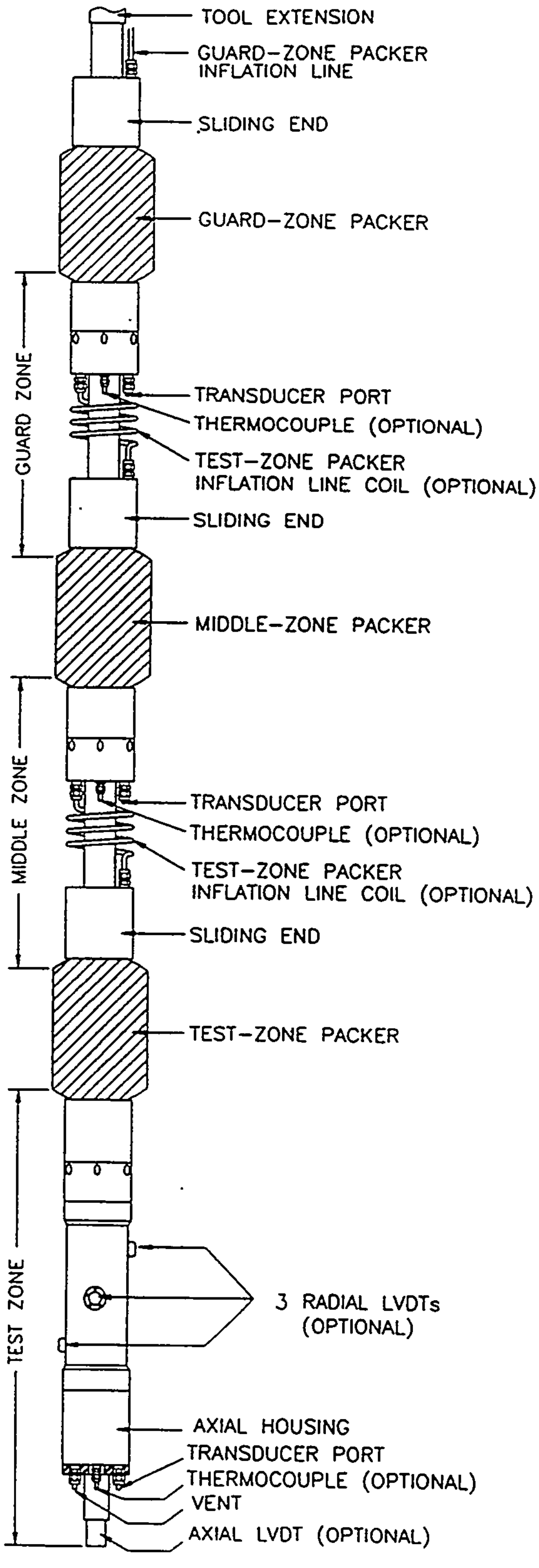


Figure 3-2. Generic double-packer test-tool configuration used for permeability testing.



NOTE: SOME INSTALLATIONS USED INTERNAL INFLATION LINES.

PACKER LENGTHS VARIED.

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Figure 3-3. Generic triple-packer test-tool configuration used for permeability testing.

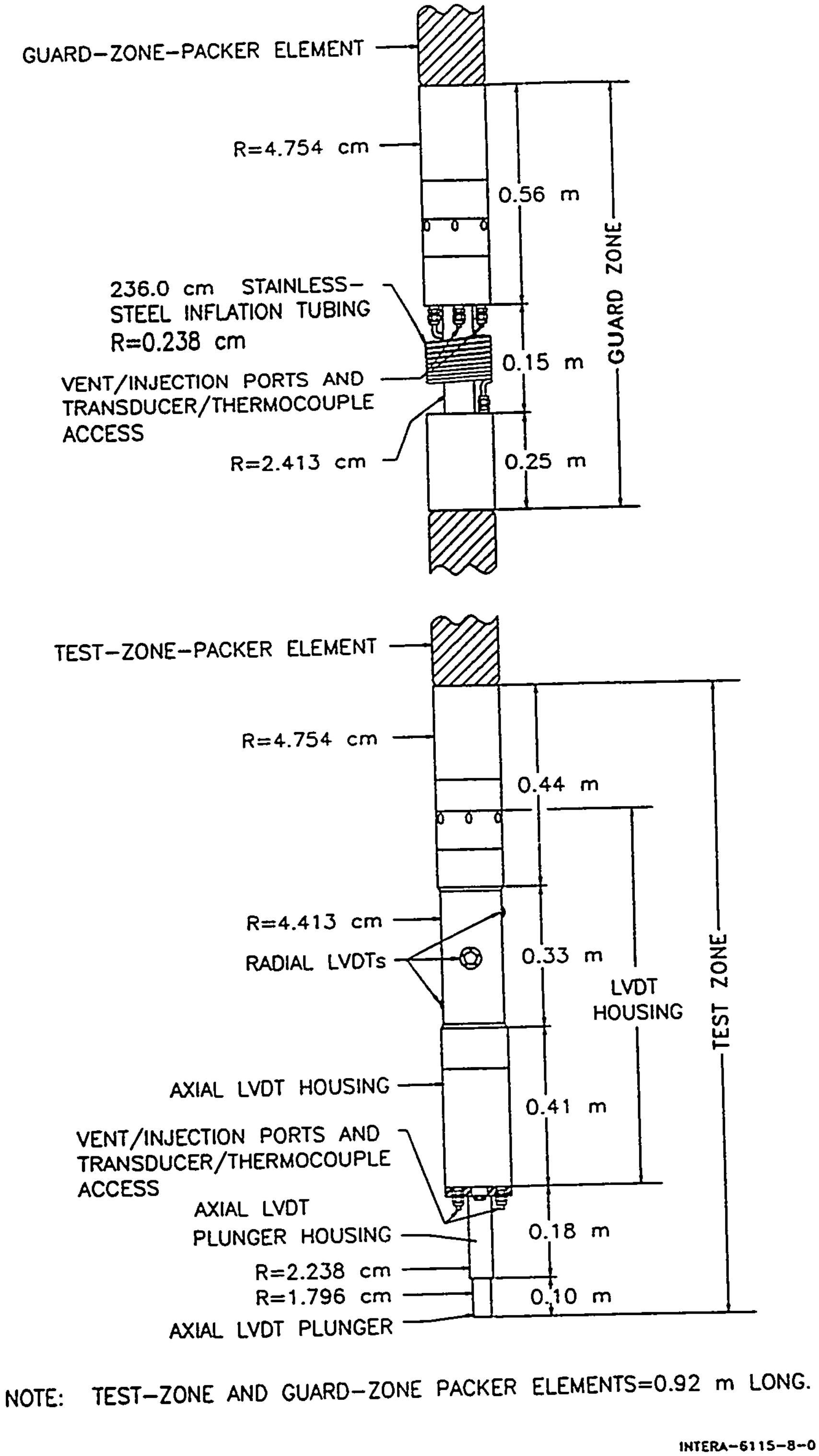
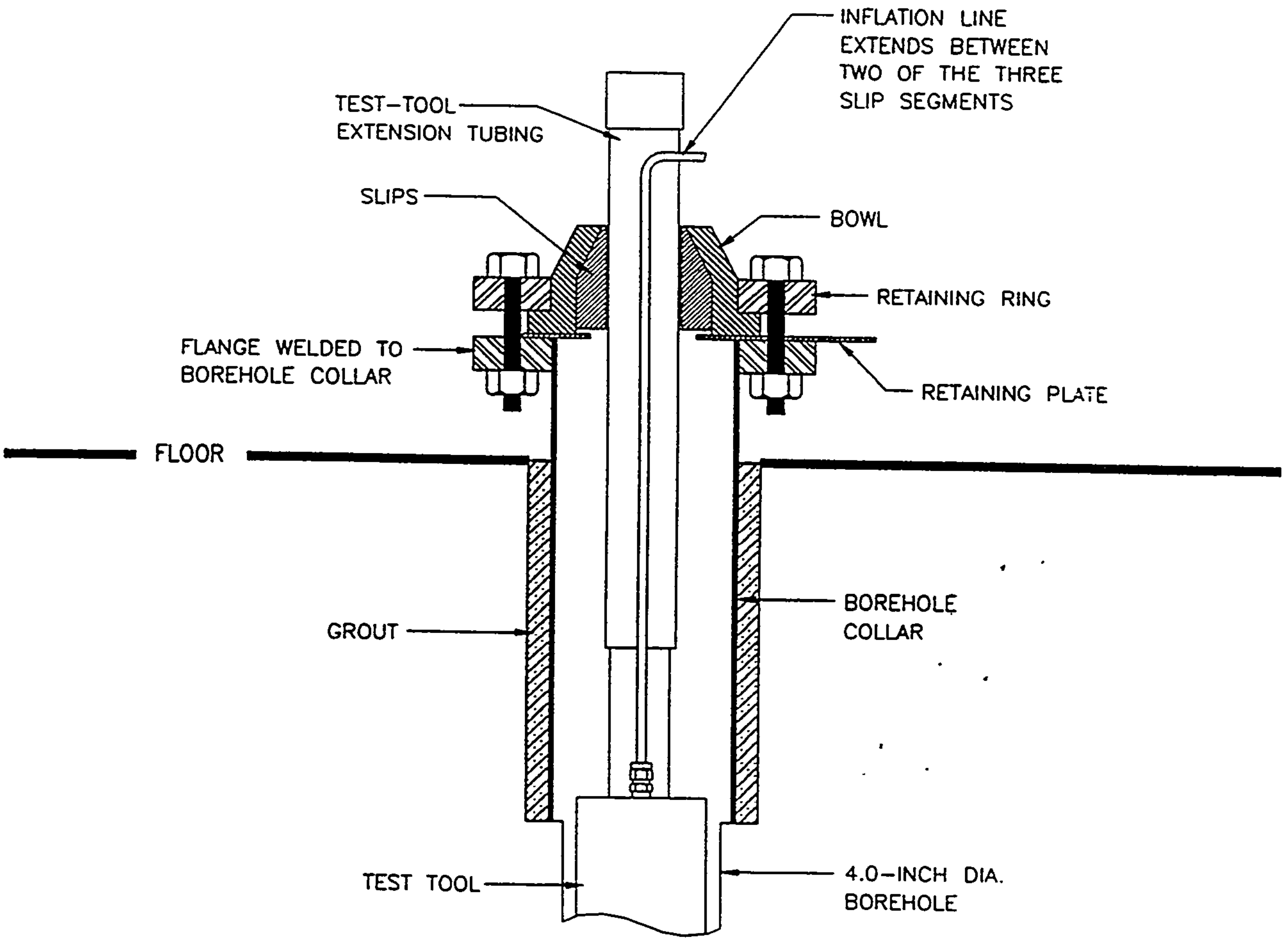


Figure 3-4. Detail of multipacker test tool.



NOTE:

SLIPS ARE DESIGNED TO TIGHTEN ON THE EXTENSION TUBING AS THE TEST TOOL MOVES OUT OF THE BOREHOLE DUE TO PRESSURE BUILDUP.

NOT TO SCALE.

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Figure 3-5. Slip-type test-tool restraint device.

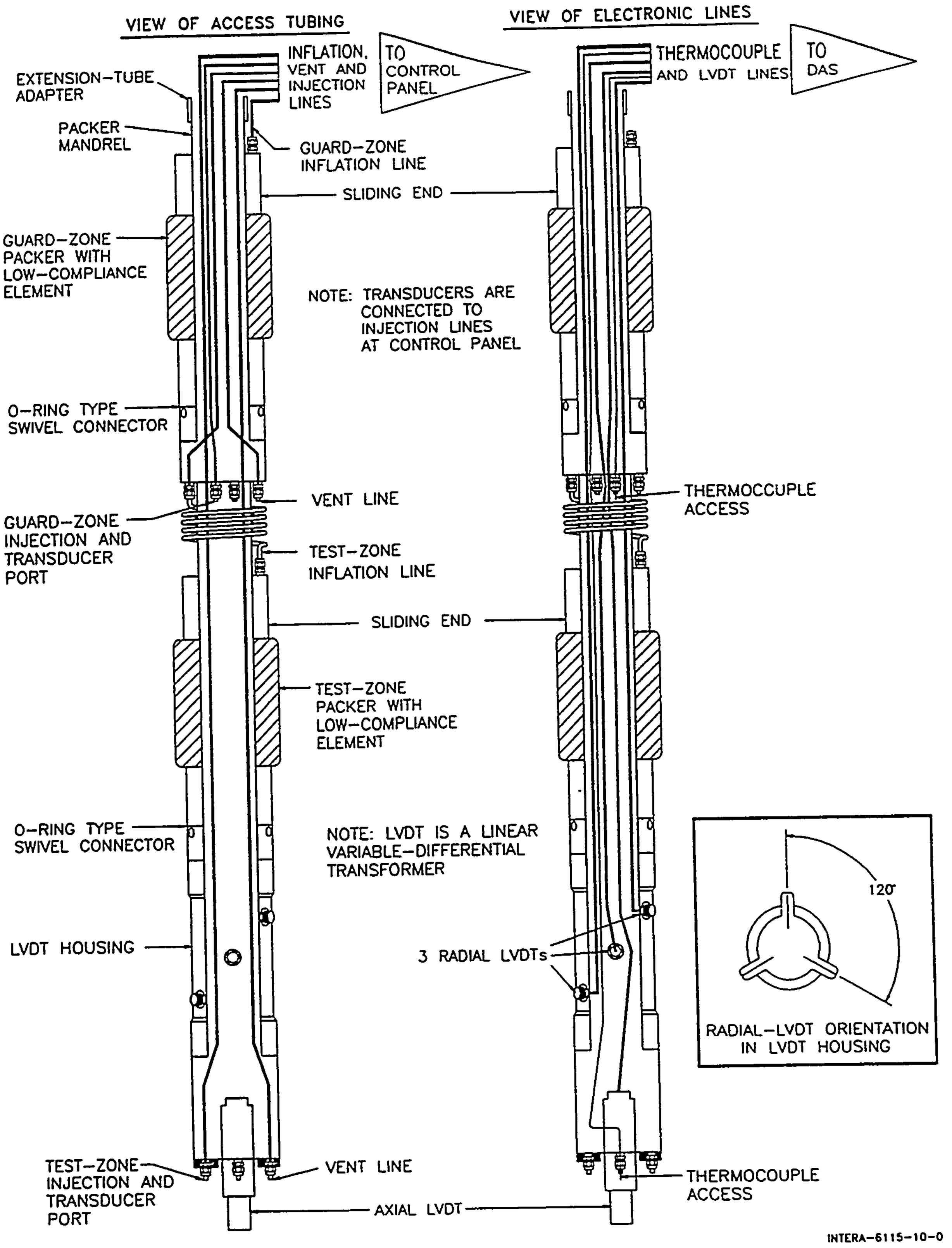

Figure 3-6. Generic split-view schematic illustration of a multipacker test tool used for permeability testing.

pressure during packer inflation and for venting of entrapped air or formation-derived gas from the zones. When the test tools were assembled, the vent tubes for angled and vertically upward installations were left as long as possible in order to minimize air entrapment. The injection ports could also be used to apply pressure to the isolated zones. Under-pressures and over-pressures could be applied as pressure pulses or as constant-pressure-brine injection/withdrawal tests.

In most instances, the test-zone section of the test tool was equipped with LVDTs to measure radial-borehole deformation and/or test-tool movement during the permeability test. Three LVDTs were radially oriented 120° apart, immediately below the test-zone packer (Figure 3-6) One axially oriented LVDT was mounted at the bottom end of the test tool and was used to measure axial borehole elongation and test-tool movement during permeability testing.

An control panel with pressure gages was sometimes used to monitor the progress of packer inflation and fluid injection/withdrawal directly (Figures 3-7a and 3-7b). Packer inflation and fluid injection were controlled by positive-displacement intensifier pumps which were activated using compressed air or pressurized nitrogen. The various intensifier pump configurations were designed to accommodate different needs during testing.

3.3.1.2 DATA-ACQUISITION SYSTEM (DAS)

A computer-controlled data-acquisition system (DAS) was used to monitor the progress of each test and recorded pressure, in some cases temperature, and in some cases radial borehole closure and axial tool movement (Figure 3-8). Each DAS consisted of an IBM compatible desktop computer for system control and data storage, a Hewlett Packard (HP) 3497A Data-Acquisition/Control Unit (DCU) containing power supplies to excite the instruments associated with a given test (transducers, thermocouples, differential-pressure transmitters (DPTs, and LVDTs), a signal scanner to switch and read channels, a 5-1/2 digit voltmeter to measure the output from the instruments associated with a given test (transducers, thermocouples, DPTs, and LVDTs), and an Elgar Model 6000B uninteruptable power supply. The HP-3497A was used with PERM data acquisition software (PERM4C and PERM4F). The data-acquisition software allowed sampling of the instrument output signals at user-specified time intervals ranging from approximately 10 seconds to several days. As data were acquired, they were stored both on the computer's hard disk and on a 3.5-inch diskette. Real-time listing of the data on an auxiliary printer and monitor and/or printer plots of the accumulated data were also possible.

3.3.1.3 PRESSURE TRANSDUCERS

During permeability testing, pressures in the test and guard zones and in the packers were monitored with various Druck strain-gage pressure transducers (models PDCR 10/D,

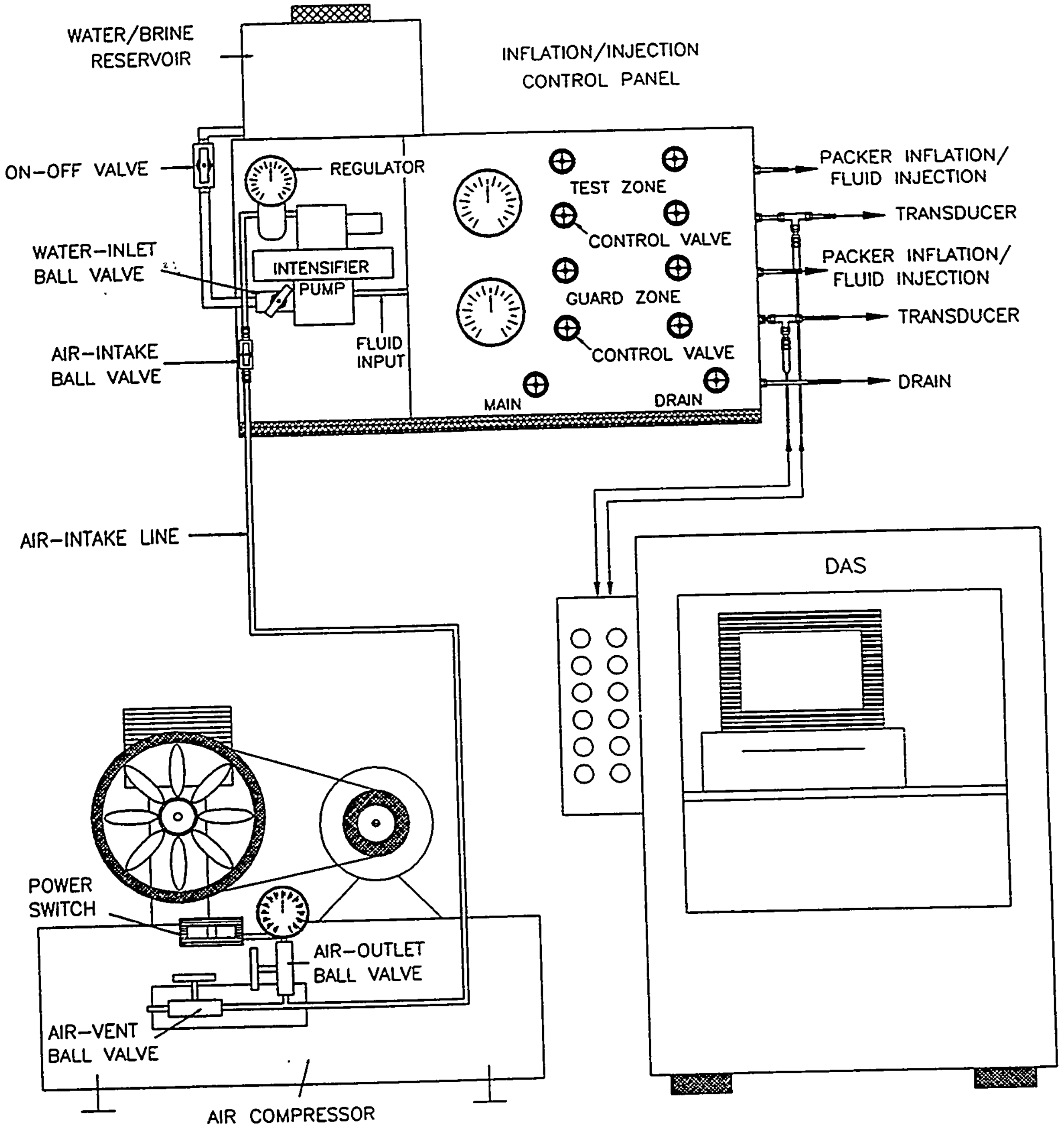

Figure 3-7a. Intensifier pump system for packer inflation and fluid injection (configuration #1).

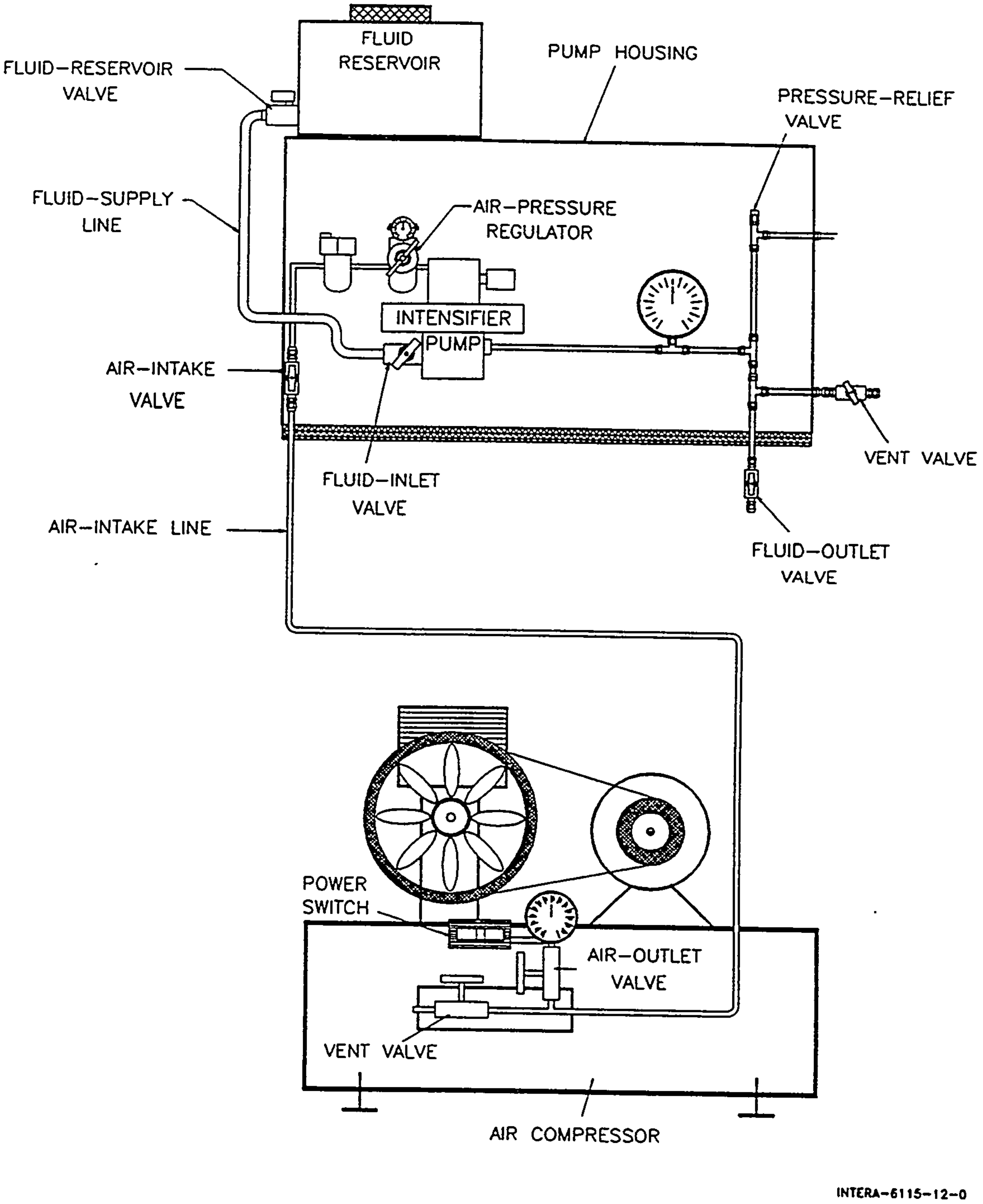

Figure 3-7b. Intensifier pump system for packer inflation and fluid injection (configuration #2).

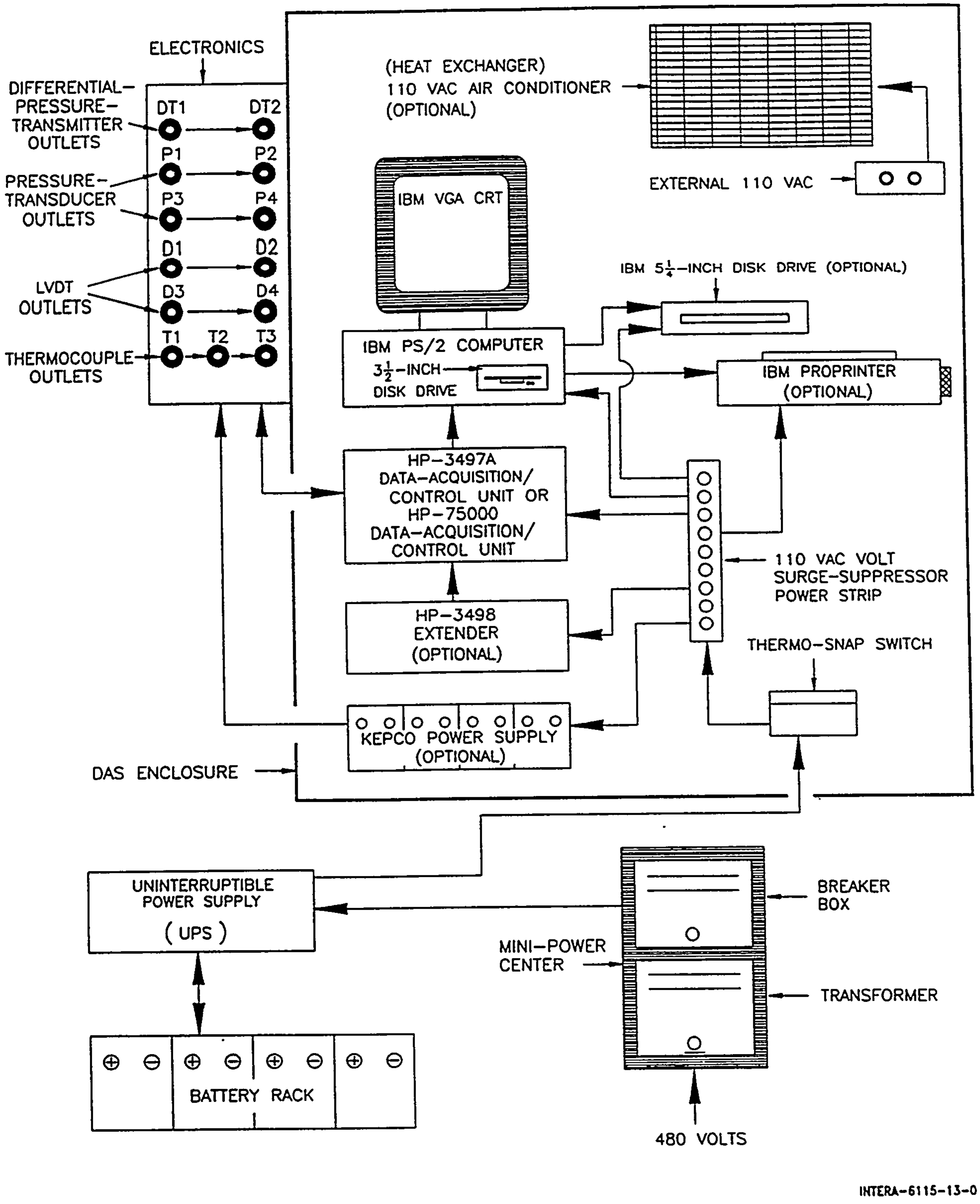

Figure 3-8. Schematic illustration of the data acquisition system.

PDCR 830, PDCR 910, and D930-18) rated to monitor pressures from 0 to 3000 psi (0 to 20.7 MPa). The transducers were mounted on instrument panels outside the boreholes and were connected to the isolated zones and the packers through 3/16-inch (0.48-cm) O.D. and/or 1/4-inch (0.64-cm) O.D. stainless-steel tubing which passed into and through the packer mandrels (Figure 3-6) to the respective termination points. The manufacturer's stated accuracy of the least accurate of these Druck transducers is ± 0.1% of full scale, or approximately ± 3 psi (0.021 MPa).

3.3.1.4 THERMOCOUPLES

Type E Chromel-Constantan thermocouples are used to monitor temperatures within the test and guard zones during permeability testing, in monitor boreholes during coupled permeability and hydrofracture testing, and in some test zones during GTPT's. The thermocouples are 1/8 inch (0.32 cm) in diameter and are sheathed in Inconel 600. The thermocouples are reported to be accurate to within ± 0.06 °C by the manufacturer, ARI Industries.

3.3.1.5 LINEAR VARIABLE-DIFFERENTIAL TRANSFORMERS (LVDTs)

Open boreholes, rooms, and drifts in the WIPP underground facility exhibit closure, deformation, and differential movement between halite and anhydrite beds (Bechtel, 1986). Measurable borehole closure (on the order of a few tenths-of-a-millimeter change in borehole diameter) in a shut-in, fluid-filled test interval could raise the pressure in the hole given the low compressibility of the fluid. Three Trans-Tek Model 241 LVDTs were radially mounted, with 120° separation, on the test-interval part of the multipacker test tool to measure radial borehole deformation (Figure 3-6). These LVDTs can each measure a range of motion of 0.5 cm. Axial movement of the multipacker test tool can occur due to changes in packer-inflation pressure, pressure buildup or withdrawal in the isolated intervals, and hole elongation resulting from creep closure of the excavations. The rate of rock creep decreases with increasing distance from an excavation (Westinghouse, 1990), causing boreholes drilled from an excavation to elongate. Axial movement of the test tool can change the test-zone volume, which, in low-permeability media, can affect the observed pressure response in an isolated borehole interval. An axially mounted Trans-Tek Model 245 LVDT on the bottom of the test tool measures tool movement relative to the bottom of the borehole along the borehole axis (Figure 3-6). This LVDT has a range of motion of 10 cm. The LVDT responses are reported by Trans-Tek to be linear within ± 0.5% over their working ranges. Two Trans-Tek Model 242 LVDTs were used during permeability-testing sequence S1P74-B to measure fracture dilation as a function of pressure, however, this testing sequence was terminated prior to obtaining information about fracture dilation. These LVDTs were similar in design and specification to the Trans-Tek Model 245 LVDTs. Jensen (1990) discusses in detail the design, calibration, and use of the LVDTs. LVDTs were used in order to account for any change in interval pressure caused by too movement and/or borehole closure.

3.3.1.6 DIFFERENTIAL PRESSURE-TRANSMITTER PANEL

Fluid volumes produced from or injected into test zones during test-zone-compressibility tests and constant-pressure-flow tests were measured using a differential-pressure-transmitter panel (Figures 3-9a, 3-9b, and 3-9c). The panel consists of a differential-pressure transmitter (DPT) and injection/withdrawal columns which act as fluid reservoirs. Rosemount Alphaline Model 1151DP4E44M3B2 DPTs were used in the WIPP permeability-testing program.

The DPT panel can be used with several different cylindrical columns: 8-inch (20.32-cm), 4-inch (10.16-cm), 1-inch (2.54-cm), 1/2-inch (1.27-cm), and 3/8-inch (0.95-cm) O.D. stainless-steel columns, and a 1/4-inch (0.64-cm) Lexan-column manometer (Figures 3-9a, 3-9b, and 3-9c) depending upon the volume of fluid that is withdrawn from or injected into the test zone. Ideally, the smaller the volume of fluid required, the smaller the diameter of the column to be used so that accuracy is not sacrificed when only small fluid volumes are required. Fluid level in a column increases as the fluid leaves the test zone and enters the column or decreases as the fluid leaves the column and enters the test zone. The DPT measures the difference in the pressure exerted on two sides of a sensing diaphragm. On one side of the diaphragm is the ambient test pressure. On the other side of the diaphragm is the pressure exerted by the fluid in the column, plus the ambient pressure. Therefore, the difference, or differential pressure, is equal to the pressure exerted by the fluid in the column. As the fluid level in the column changes (a change in fluid-column height corresponds to a linear change in the volume), the voltage output from the DPT changes proportionally. The DPT output voltage signal is recorded by the DAS.

During test-zone compressibility tests and constant-pressure-flow tests, it is necessary that the pressure inside the injection/withdrawal column remain under near constant-pressure conditions. In all testing sequences, a Victor SR4J-580 pressure regulator was used to regulate the pressure on the gas-side of the DPT panel. In some cases (testing sequences L4P51-C2 and L4P51-D1) an electronic pressure controller was used in conjunction with a Victor SR4J-580 pressure regulator, a TESCOM 54-2000 series pressure-reducing regulator, a TESCOM ER-2000 pressure controller, and a Druck D930-18 pressure transducer to maintain constant pressure conditions. To maintain constant pressure, the injection/withdrawal column is connected to a TESCOM ER-2000 pressure controller which is, in turn, connected to a pressurized nitrogen reservoir. As the fluid moves into or out of the injection/withdrawal column during testing, the pressure controller maintains a constant back-pressure on the fluid column. Pressure relief valves were incorporated into each of the differential pressure-transmitter panels (see Figures 3-9a, 3-9b, and 3-9c) in order to eliminate the possibility of over-pressurizing equipment.

The various differential pressure-transmitter panel configurations were designed to accommodate different needs during testing.

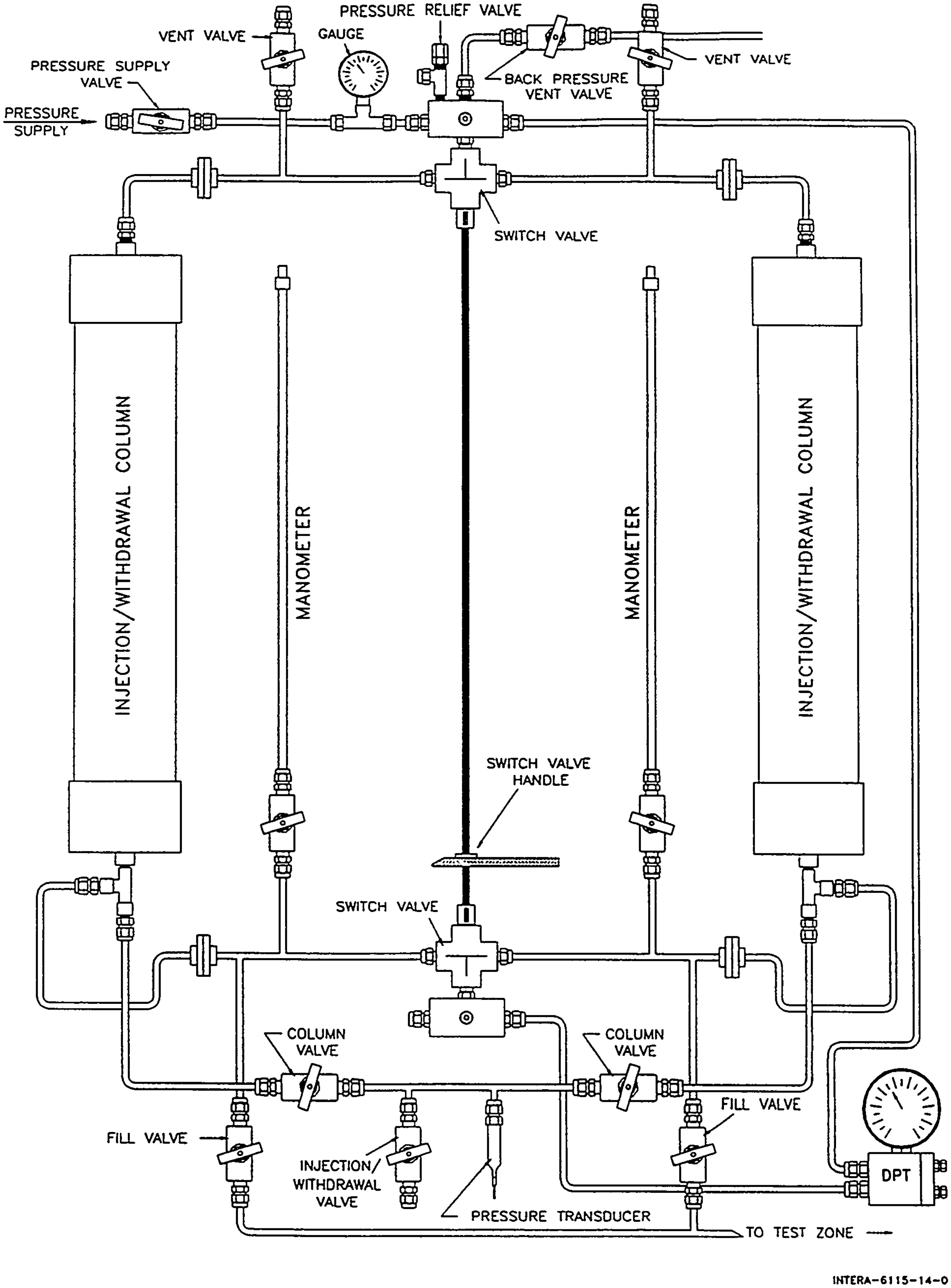

Figure 3-9a. Differential-pressure-transmitter panel (configuration #1).

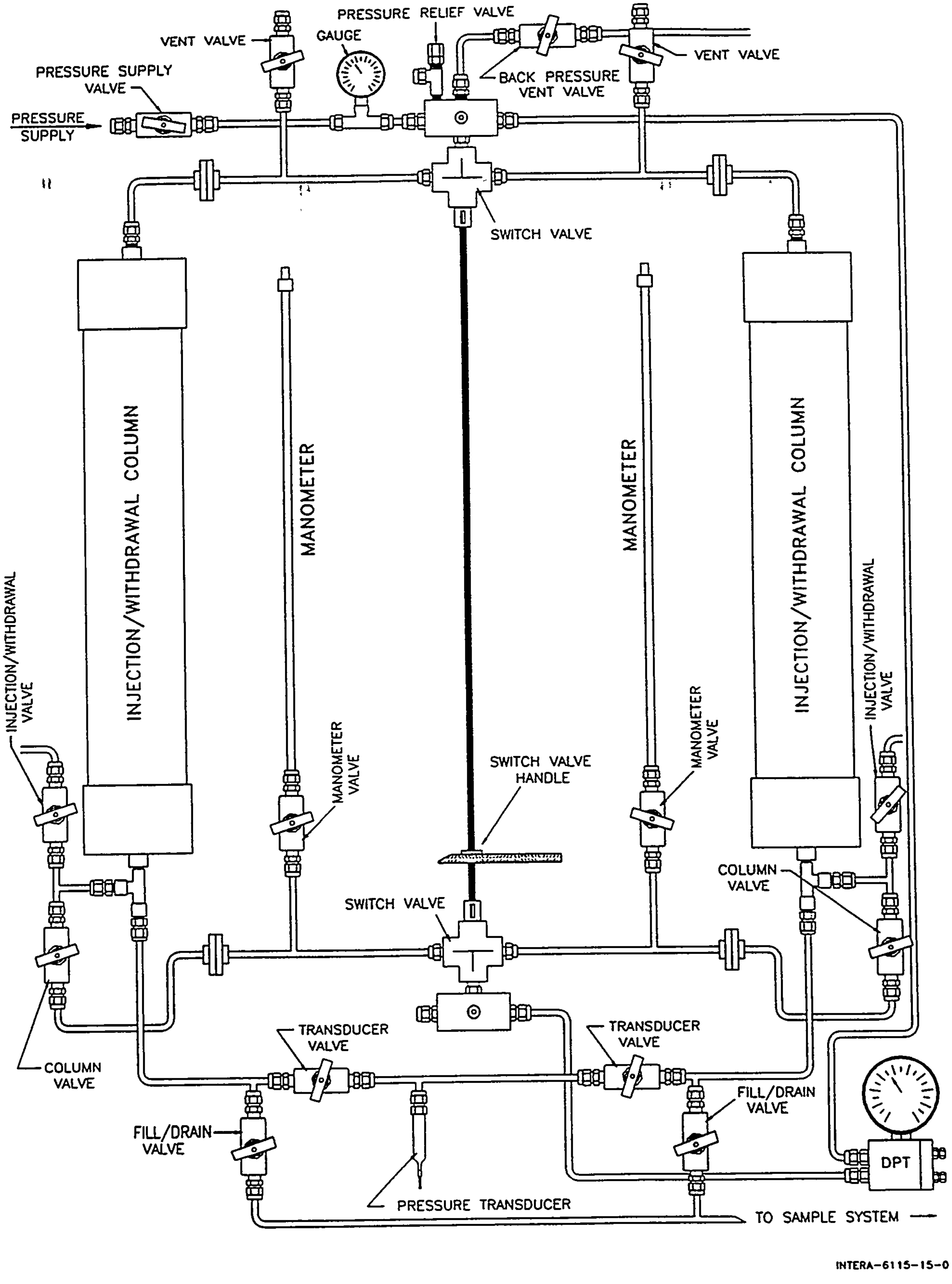

Figure 3-9b. Differential-pressure-transmitter panel (configuration #2).

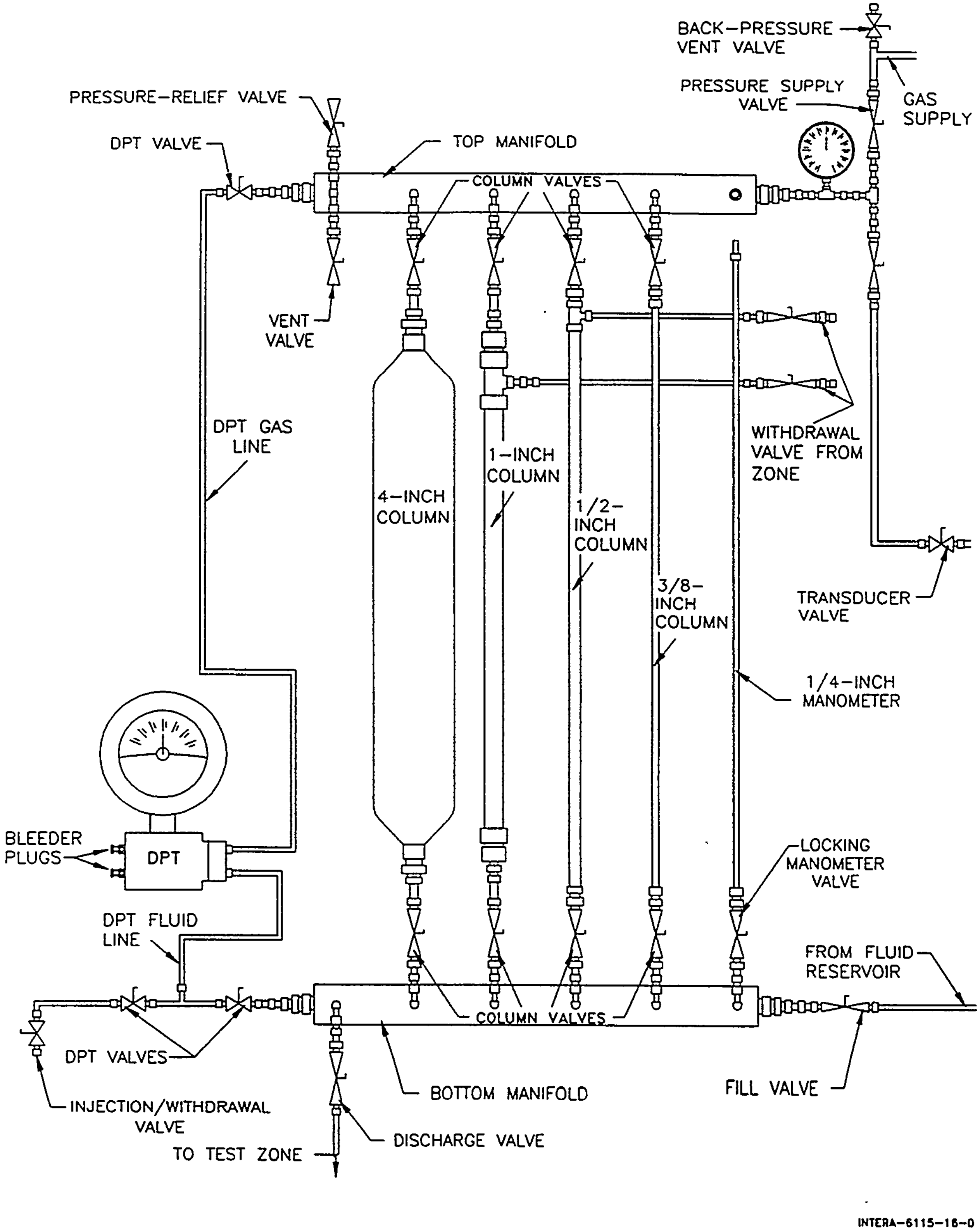

Figure 3-9c. Differential-pressure-transmitter panel (configuration #3).

3.3.1.7 PRESSURIZED-BRINE-SAMPLING APPARATUS

Brine/gas samples were collected during constant-pressure flow tests during permeability-testing sequence L4P51-C1 in order to help define the types, amounts, and origins of gas being produced by the tested strata. Figure 3-10 is a diagram of the pressurized-brine-sampling apparatus used in the permeability-testing program. The sampling apparatus was incorporated into the DPT panel and consisted of a Whitey sample cylinder, two Nupro non-rotating stem valves, and two Nupro rising-plug valves. The sampling apparatus was incorporated into the DPT panel in such a way that fluid and/or gas fills the sample cylinder on its way to the designated fluid reservoir. When the sample is to be removed, the four Nupro valves were closed allowing the fluid and/or gas to bypass the sample cylinder. When a new sample cylinder is installed, the valves are opened and the sample cylinder is again filled. A vacuum pump is attached to the sampling apparatus prior to installation to evacuate all gas from the sample cylinder. After drawing a vacuum on the sample cylinder, the cylinder is flushed with argon gas and the two Nupro non-rotating stem valves are closed. Finally, the sampling apparatus is installed in the DPT panel.

3.3.1.8 PRESSURE-MAINTENANCE SYSTEM

Packer pressures steadily declined during some testing sequences, potentially jeopardizing the isolation of test and/or guard zones. In most testing sequences, a pressure-maintenance system (Figures 3-11 and 3-12) was attached to the packers associated with the test to hold the packer pressure nearly constant during testing. In some cases, a pressure-maintenance system was attached to zones in order to minimize pressure perturbations in the test zone. A Whitey 1-gallon cylinder was filled, with water when attached to packers and brine when attached to zones, and then pressurized with nitrogen to the desired pressure. The control valve between the cylinder and the nitrogen tank was left open, creating a large buffer volume. When the desired pressure in the cylinder was achieved, the control valve between the cylinder and the packer/zone was opened, allowing the pressures in the packer/zone and in the cylinder to equilibrate. Subsequent losses of fluid from the packer/zone and/or changes in packer/zone volume thereafter resulted in smaller changes in pressure than would have otherwise occurred. The operation and use of the pressure-maintenance system is described, in detail, in WIPP Procedure 470.

3.3.2 Equipment Calibration

This section discusses calibrations performed on equipment described in Section 3.3.1. Calibrations performed by the SNL WIPP calibration laboratory or INTERA personnel were in accordance with SNL WIPP procedures. Calibrations performed by the SNL calibration laboratory in Albuquerque, NM were in accordance with that organization's policies and procedures. Calibration records associated with this equipment are provided in the SWCF under WPO #42269.

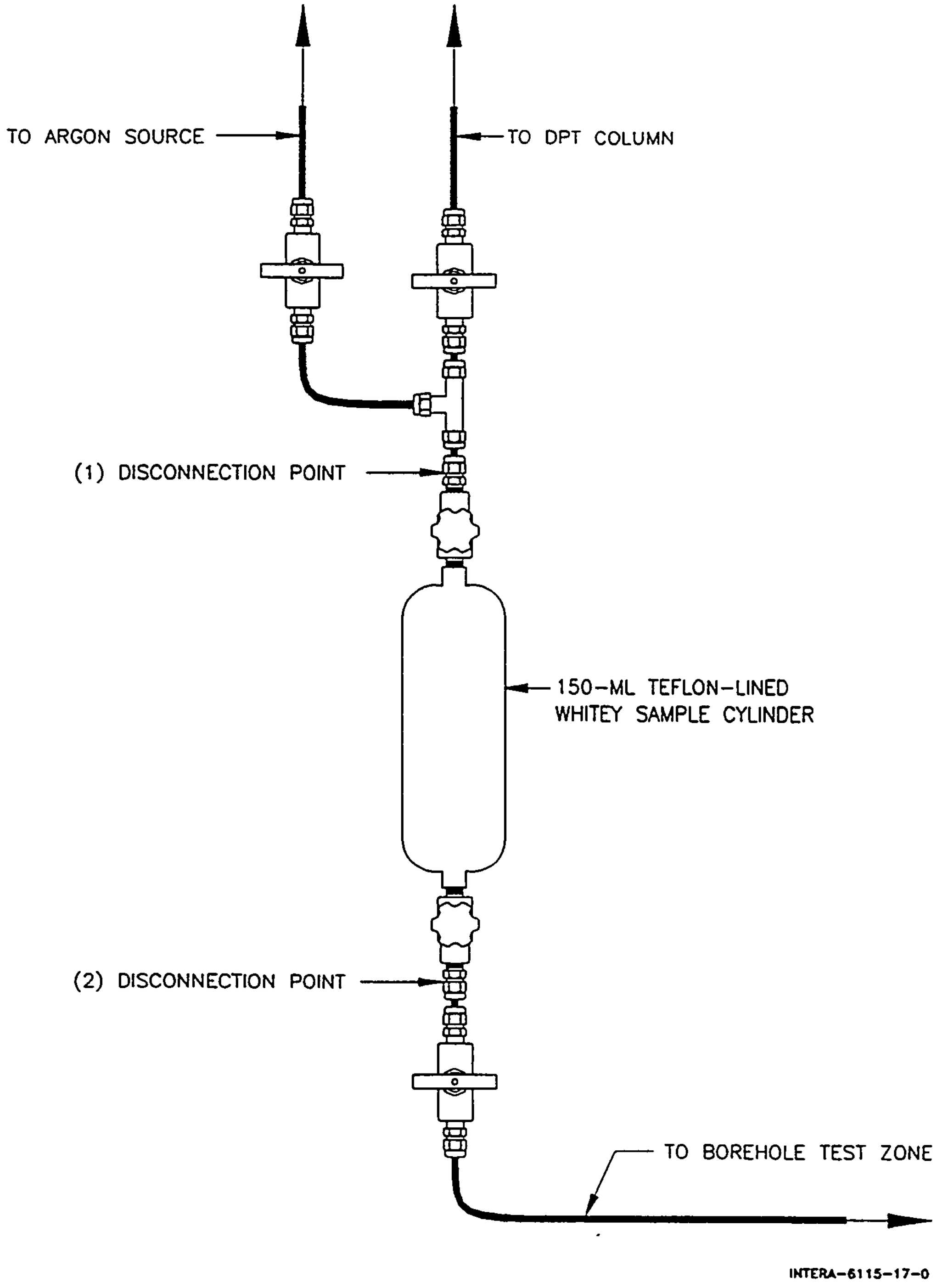

Figure 3-10. Pressurized-brine-sampling apparatus.

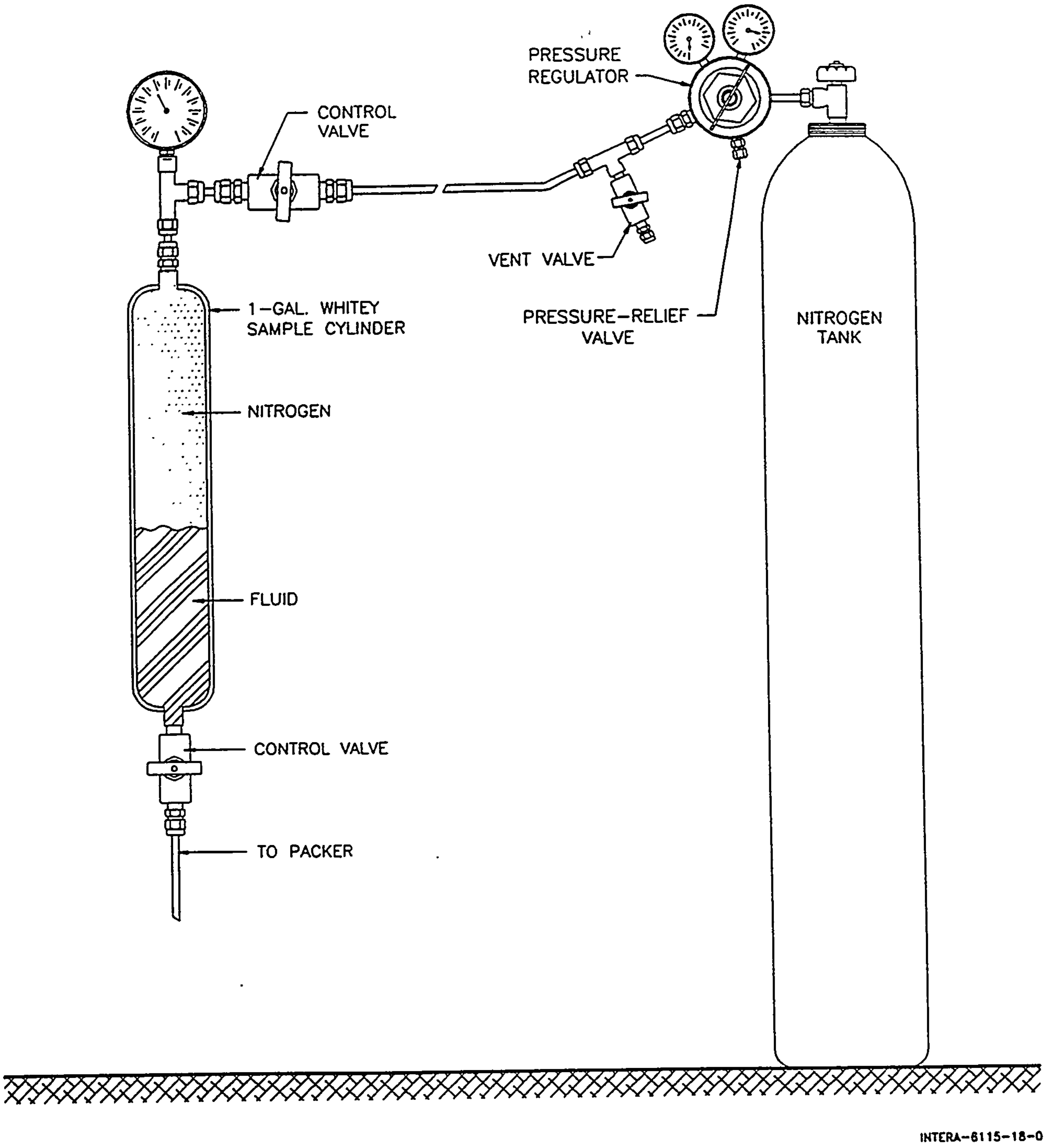

Figure 3-11. Typical stainless-steel vessel pressure-maintenance system.

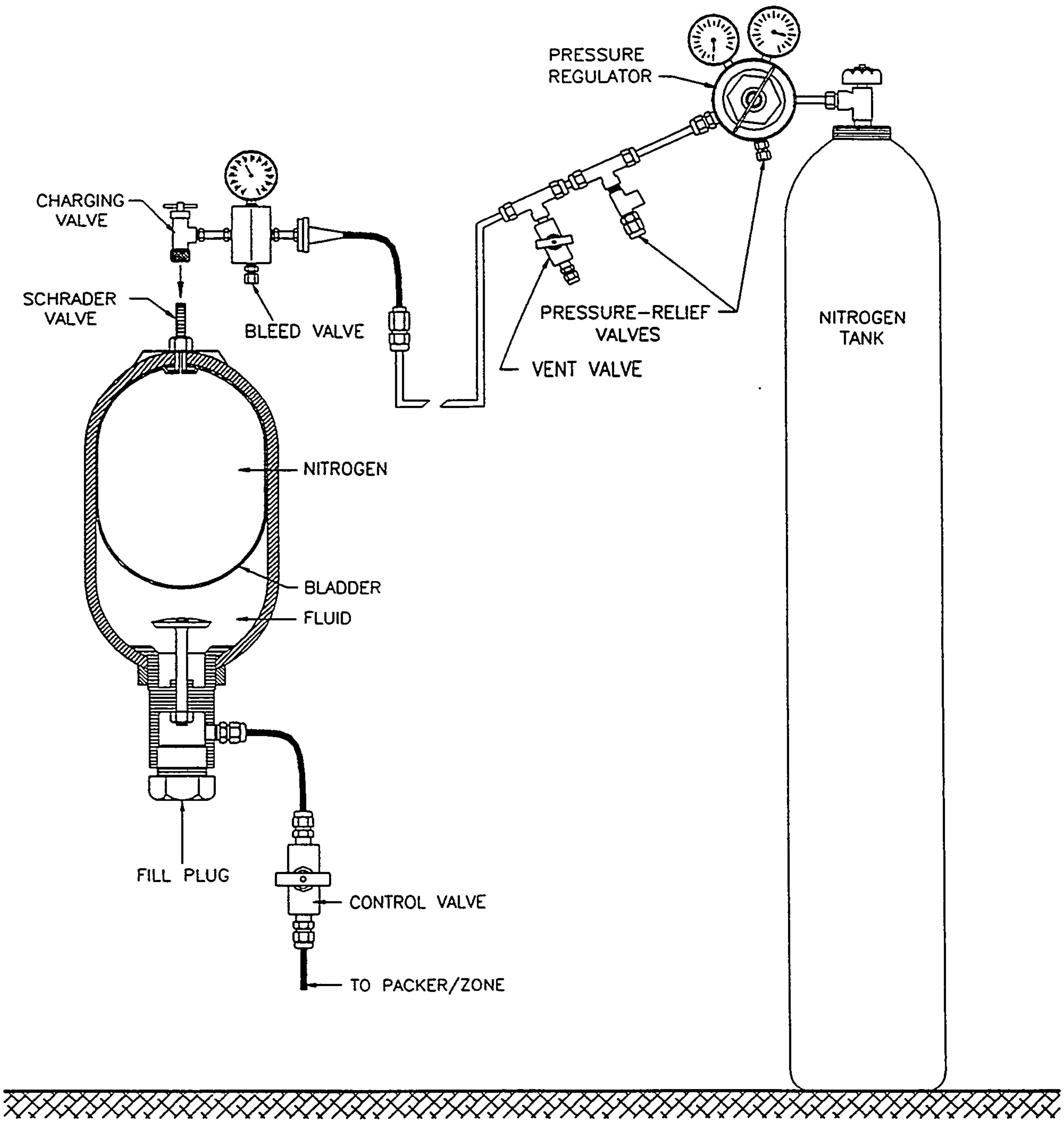

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Figure 3-12. Typical gas-bladder pressure-maintenance system.

3.3.2.1 DATA-ACQUISITION SYSTEM

The DAS equipment and associated software were tested prior to the start of the permeability-testing program to ensure proper operation. The procedure consisted of testing the response of the HP-3497A Data-Acquisition/Control Unit and the DAS software using known input signals to ensure proper signal conversion. The DAS software was designed and tested by SNL and INTERA Inc. The DAS software was baselined and controlled in accordance with the SNL approved INTERA WIPP Quality Assurance Manual. In addition, the HP-3497A DC voltmeter option was calibrated by SNL WIPP calibration laboratory using WIPP Procedure 182.

3.3.2.2 PRESSURE TRANSDUCERS

All pressure transducers associated with the permeability-testing program were calibrated before and after use for each permeability test. Two methods of calibration have been employed to calibrate pressure transducers for use in the permeability- testing program. In both methods, the pressure transducers were calibrated in a constant-temperature environment.

The first, as illustrated in Figure 3-13, was employed by INTERA personnel until November 11, 1993. In this method, the transducers were connected to a Heise pressure-measurement gage (Model CMM) and to an intensifier pump with an air compressor used as the source of pressure. Pressure was applied to the transducers in stepwise increments, measured with the Heise gage, over the transducers' rated pressure range, typically 0-2000 psig. The transducers' responses to the applied pressures were then analyzed by linear-regression techniques to determine their sensitivity coefficients, which consisted of the slopes, expressed as pressure/mV, and the y-intercepts, expressed as pressure. The sensitivity coefficients were used to convert the transducers' millivolt output signals to pressure values. The Druck pressure transducers used in the permeability-testing program were pressure rated by the manufacturer in pounds per square inch, gage pressure (psig). The Heise gage used to calibrate the transducers by this method used a psig scale and was itself calibrated by the manufacturer and by the SNL calibration laboratory in Albuquerque, NM. Because the transducers' ratings and the calibration gage's scale are in psig, the test-tool pressure transducers are calibrated in psig. The calibrations that were performed following the method described above were done so using the transducer calibration code RAMBO1D, RAMBO2, or PERM4F. The DAS software converts the transducers' psig/mV sensitivity coefficients to MegaPascals (MPa) using the conversion factor 0.006895 MPa/psig. More detailed descriptions of methods used to calibrate the equipment are presented in Stensrud et al. (1992).

The second method employed to calibrate pressure transducers used in the permeability-testing program was done so by the SNL WIPP calibration laboratory after November 11,1993 in accordance with WIPP Procedure 054. Here, a dead weight tester was used to apply pressures in stepwise increments, over the transducers' rated pressure range. This method also analyzed the transducers' responses to the applied pressures by linear-regression in order to establish sensitivity coefficients for the transducers with the psig to MPa conversion incorporated into the coefficients.

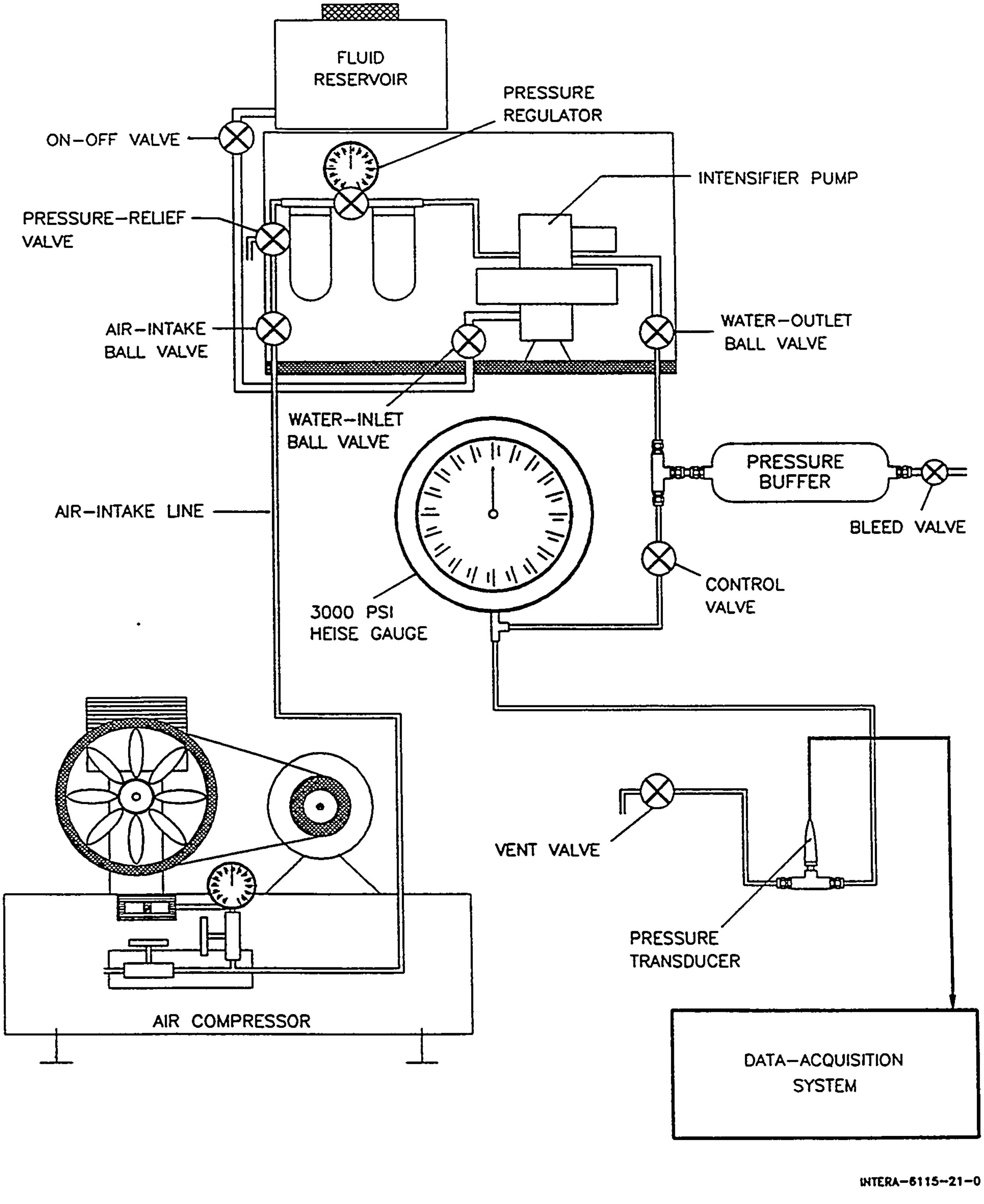

Figure 3-13. Schematic illustration of the pressure-transducer-calibration system.

3.3.2.3 THERMOCOUPLES

Type E Chromel-Constantan thermocouples were used to monitor temperatures within the test and guard zones during permeability testing. The thermocouples were 1/8-inch (0.32 cm) in diameter and were sheathed in Inconel 600. The thermocouples were reported to be accurate to within ± 0.06 °C by the manufacturer, ARI Industries. The thermocouples were calibrated by SNL calibration laboratory in Albuquerque, NM.

3.3.2.4 LINEAR VARIABLE-DIFFERENTIAL TRANSFORMERS

Each of the radially-oriented LVDT plunger assemblies used to measure radial deformation was calibrated by the SNL WIPP calibration laboratory in accordance with WIPP Procedure 204. Linear-regression analysis of the calibration data provides slope (sensitivity) and offset (y-intercept) values that are used by the DAS software to convert the DC voltage output to a linear dimension (cm), starting near zero (0) when the plungers are extended and increasing in magnitude as the plungers are depressed. The technique used to establish the LVDT response to a known radius is to use a Radial LVDT Measurement Device (Figure 3-14). Establishing a known reference radius for the radial LVDT assemblies was done in accordance with WIPP Procedure 473. The Radial LVDT Measurement Device provides an accurately machined radius of 4.9735±0.0005 cm, and is designed to center and align the LVDT assembly. The Radial LVDT Measurement Device is also used at the end of a permeability testing sequence when the test tool is retrieved from the borehole to recalibrate the plunger depressions and provide a measure of instrument drift with respect to time. The average plunger depression value along with the known calibration sleeve radius is used to establish the initial borehole radius after installing the multipacker test tool in a test borehole and inflating the packers. Combining the average change in plunger depressions with the previously calculated borehole radius, the change in borehole radius is measured during permeability testing.

The LVDT plunger assembly used to measure axial test-tool movement is calibrated prior to installation using WIPP Procedure 205. Linear-regression analysis of the calibration data provides slope (sensitivity) and offset (y-intercept) values that are used by the DAS software to convert the DC voltage output to linear dimensions (cm) starting near zero (0) when the plunger is extended and increasing in magnitude as the plunger is depressed. These measurements correspond directly to the axial movements of the test tool relative to the bottom of the test borehole. Axial LVDT values decrease in magnitude if the test-tool moves out of the borehole and increase in magnitude if the test tool moves into the borehole.

3.3.2.5 DIFFERENTIAL-PRESSURE-TRANSMITTER PANEL

The DPTs are calibrated from 0 to 100 cm of water (0-9.8 kPa) by the SNL WIPP calibration laboratory in accordance with WIPP Procewdure 353. The manufacturer's stated accuracy of the DPTs is ± 0.2% of the calibrated span, including the combined effects of hysteresis, repeatability, and independent linearity. The various injection/withdrawal columns associated with the DPT panels were verified in the field using

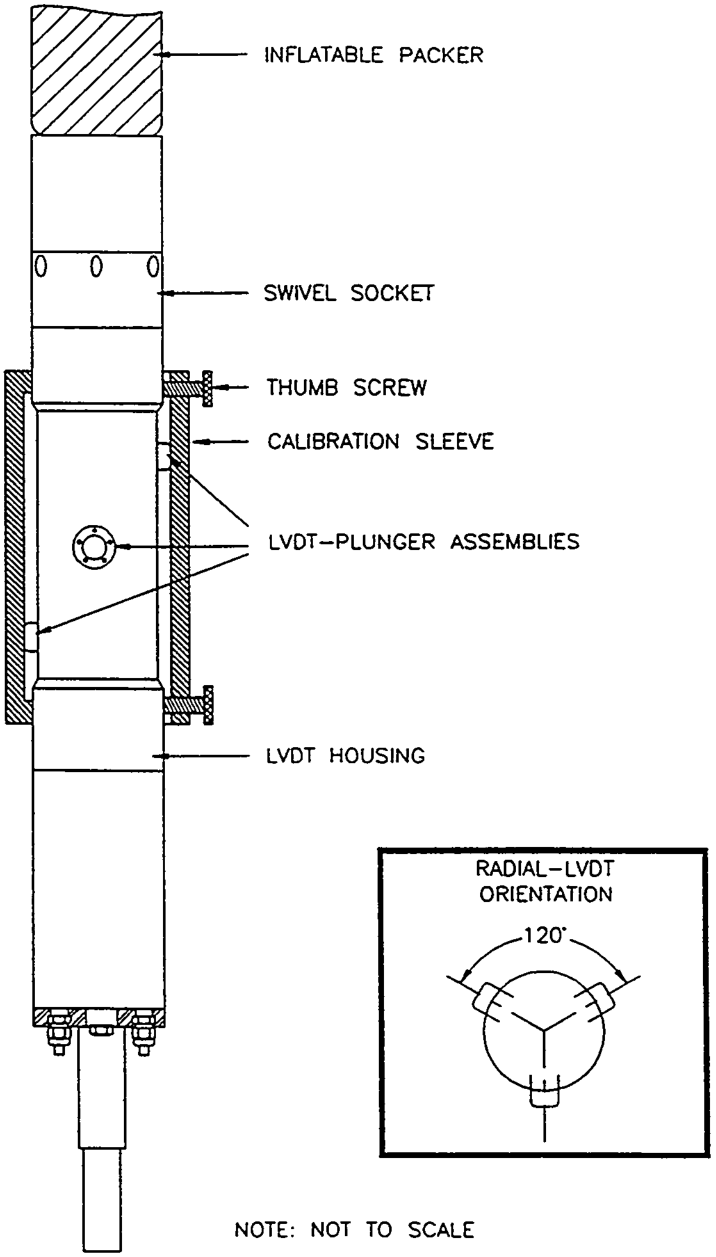

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Figure 3-14. Radial-LVDT Measurement Device.

the DPT. The verification procedure involves filling a column with the fluid to be used in a constant-pressure-injection/withdrawal test. The column is pressurized to the test pressure and a fixed volume of fluid is removed from the column, generating a voltage drop across the DPT. This process is repeated until the column has been emptied. Linear-regression analysis of the DPT voltage output versus the cumulative volume of fluid removed from the column provides sensitivity values, which consist of the slope expressed as volume/volt, and the y-intercept expressed as volume. Sensitivity coefficients are used to convert the DPT voltage signal to a volume measurement for a given test pressure. A step-by-step description of the verification procedure is presented in SOP INT-5 (INTERA, 1992) and in WIPP Procedure 476.

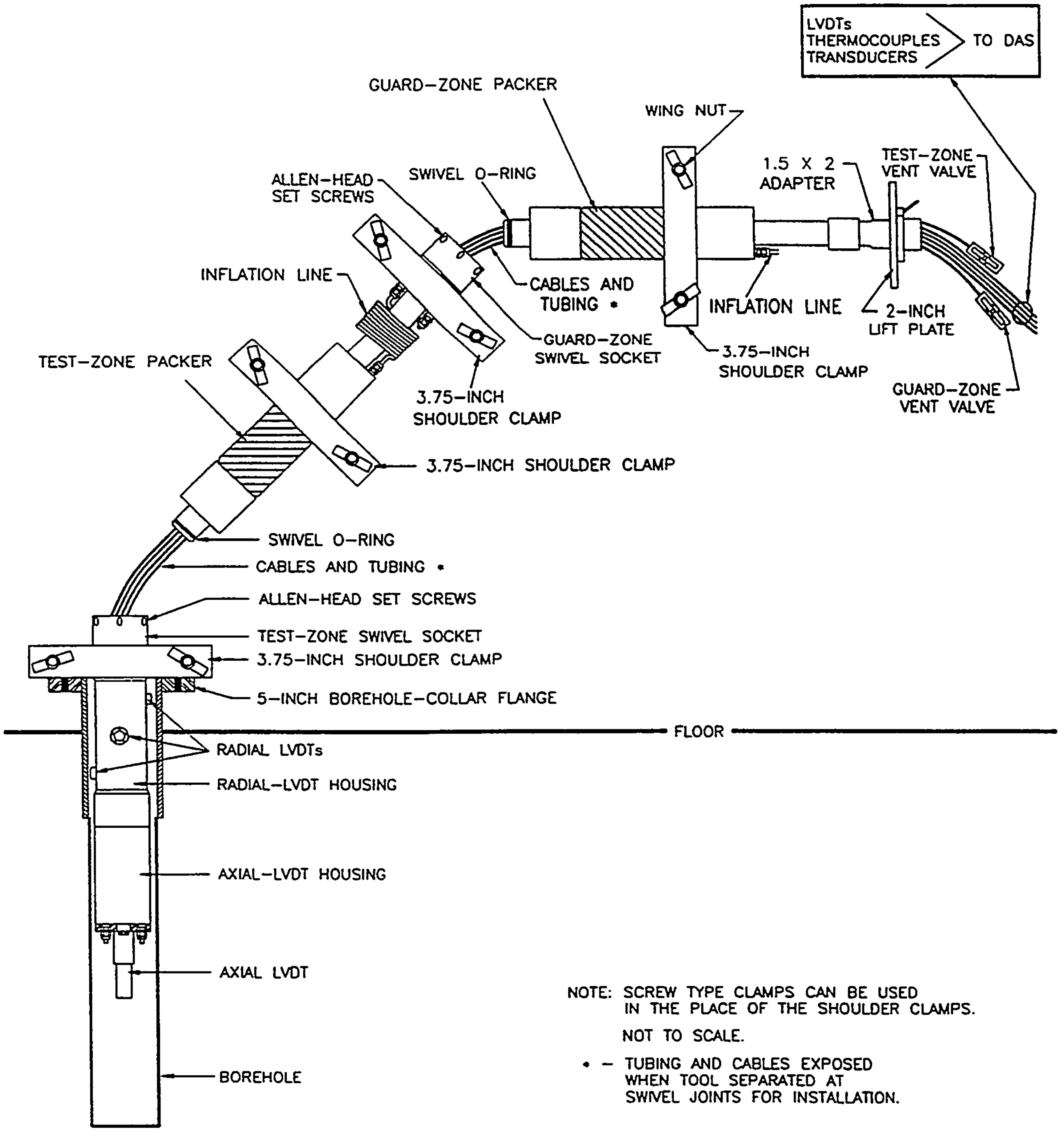
3.4 Procedures for Permeability Testing

3.4.1 Test-Tool Installation Procedures

The following paragraphs describe a typical test-tool-installation sequence. Multipacker test tools were installed in each of the test boreholes as soon after drilling as possible in order to minimize depressurization of the formation surrounding the borehole. All multipacker test-tools were installed following test tool installation procedures presented in SOP INT-5 (INTERA, 1992) and/or WIPP Procedures for multipacker-test-tool installation (479, 480, and 481) (see Figures 3-15 through 3-17). Before test-tool installation, in vertically down or angled downward borehole orientations enough brine was added to the borehole to fill all of the zones, helping to minimize air entrapment. After the multipacker test tool was installed and the DAS activated, the packers were sequentially inflated to approximately 14 MPa, beginning with the uppermost packer and continuing until the bottom-hole packer was inflated. Pressures and, in some cases, temperatures were monitored until the observed values stabilized or the packers were put on a pressure-maintenance system.

If the packers were not put on a pressure maintenance system, the packer inflation pressures were monitored for 24 to 48 hours after inflation. If compliance-related pressure decreases of greater than 3 MPa were observed, the packer inflation pressures were increased to approximately 14 MPa and observed for an additional 24 hours. After achieving satisfactory packer inflation pressure response, the zones were shut in by closing all associated valves. The pressure buildups in the isolated zones were monitored for the duration of the testing sequence.

For boreholes oriented vertically or angled upward, the multipacker test tools were installed and the guard-zone packer inflated to approximately 14 MPa. The isolated borehole was then filled with brine while a vacuum pump was attached to the bottom-hole zone vent line to removed entrapped air. In some cases, 10 psi (0.07 MPa) check valves were attached to the vent lines to prevent brine from draining from the isolated borehole interval, assuring that all zones were fluid filled (Figure 3-18). The next packer (going into the borehole) was then inflated to approximately 14 MPa. The in-line check valves prevented the zone



NOTE: SCREW TYPE CLAMPS CAN BE USED IN THE PLACE OF THE SHOULDER CLAMPS.

NOT TO SCALE.

* – TUBING AND CABLES EXPOSED WHEN TOOL SEPARATED AT SWIVEL JOINTS FOR INSTALLATION.

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Figure 3-15. Test-tool installation in a borehole oriented vertically downward.

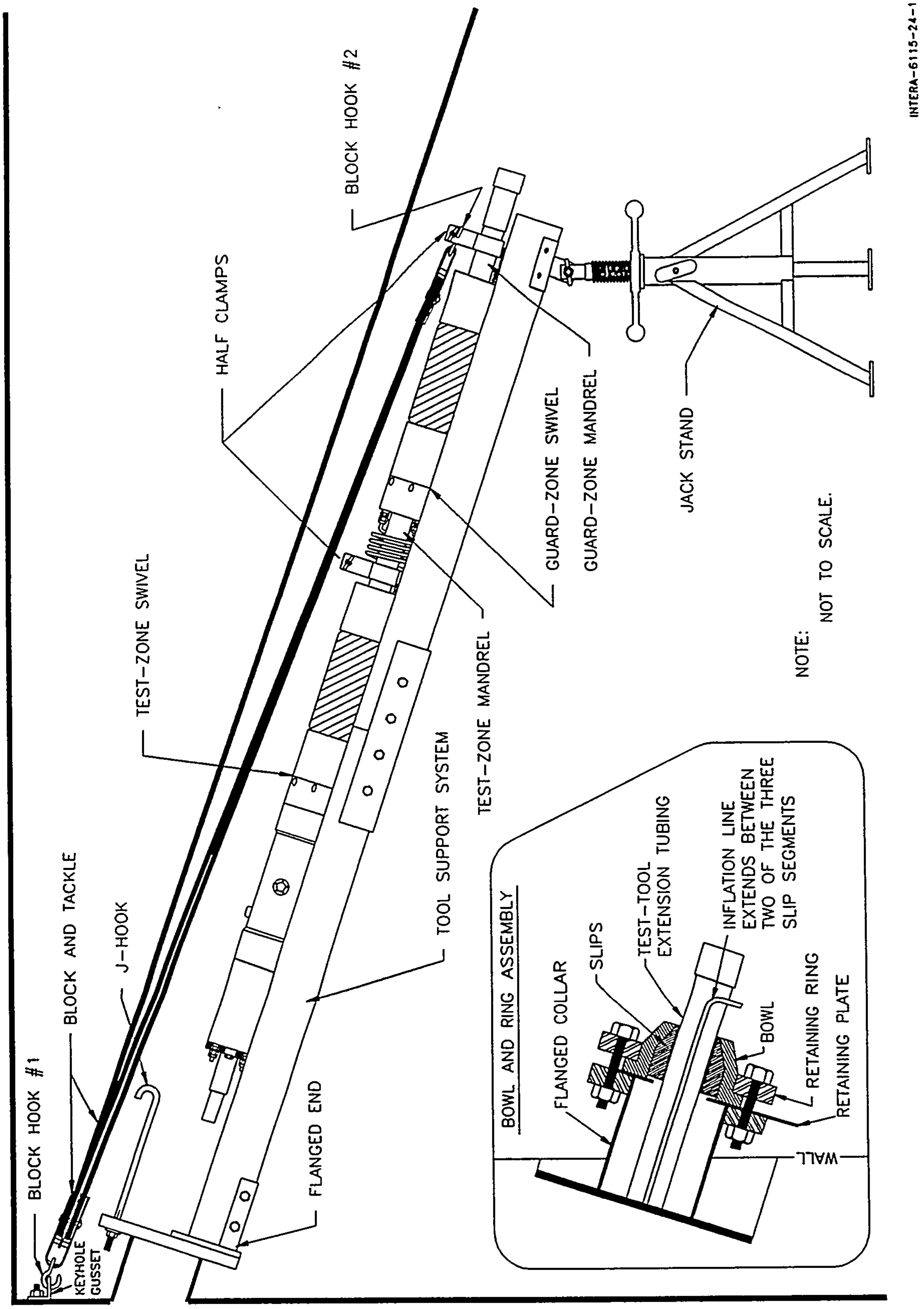

Figure 3-16. Test-tool installation in a borehole oriented upward at an angle.

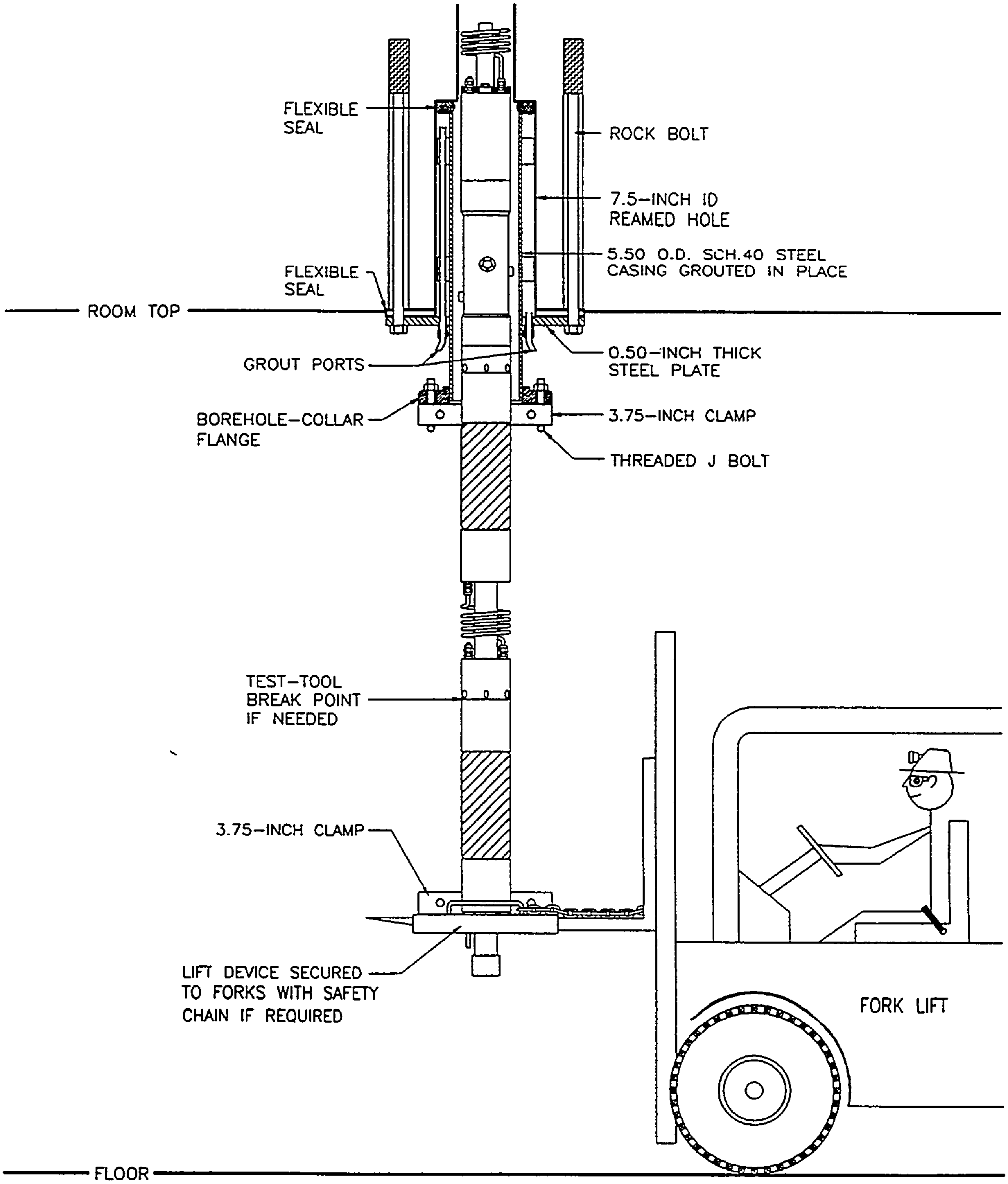

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Figure 3-17. Test-tool installation in a borehole oriented vertically upward.

pressures from exceeding 10 psi (0.07 MPa) during packer inflation. This process was repeated until all of the packers were inflated. In instances when the check valves were not incorporated into the vent lines, all associated valves were shut in during packer inflation and the zone pressures were closely monitored as the packers were inflated. If the zone pressures showed an increase, the associated vent valves were opened slightly to relieve the pressure buildup. This process was repeated until all of the packers were inflated to the desired pressure.

3.4.2 Pulse-Withdrawal Testing Procedures

Pulse-withdrawal tests performed as part of the permeability-testing sequences were conducted after monitoring fluid-pressure buildups in the test zones until the rate of pressure increase had decreased to a satisfactory level and the pressure-recovery curves appeared to be on asymptotic trends toward stable values. For the majority of permeability-testing sequences, pulse-withdrawal tests were conducted in one or more of the zones after the fluid-pressure buildups in the zones had achieved relative stability. Pulse withdrawals rather than pulse injections were chosen for permeability-testing sequences because, in some cases, the pressure buildups in the zones approached lithostatic pressure. With zone pressures of this magnitude, pulse-injection pressures of sufficient magnitude to generate interpretable fluid-pressure responses would have approached the hydrofracture pressure of the Salado Formation. In this case, the boreholes would have been artificially stimulated, resulting in an invalid representation of formation conditions. Figure 3-19 illustrates the elements of a typical permeability-testing sequence including a pulse-withdrawal test.

The following procedures were used to conduct most of the pulse-withdrawal tests that are reported here. The DAS was set to scan the instruments' return signals at frequencies sufficient to monitor test responses adequately. Then the test-zone vent valve was opened and a portion of the shut-in pressure was allowed to dissipate by allowing fluid to leave the test zone. When the desired pressure decrease was achieved, the test zone was shut in. The resulting test-zone fluid-pressure buildup, packer-inflation pressure, and guard-zone pressure were all monitored with the DAS according to prescribed frequencies. The volume of fluid removed from the test zone was measured and recorded for each pulse-withdrawal test performed. Pulse-withdrawal tests were sometimes repeated, after the formation showed full recovery, to ensure that the fluid-pressure responses were reproducible and that they were representative of the actual formation responses. Pulse-withdrawal tests allowed for the determination of the compressibility of the zone being tested by measuring the volume of fluid required to increase/decrease the zone pressure a measured amount.

3.4.3 Constant-Pressure-Injection/Withdrawal Testing Procedures

Constant-pressure-injection and/or withdrawal tests were performed as part of the permeability-testing sequences were conducted after monitoring fluid-pressure buildups

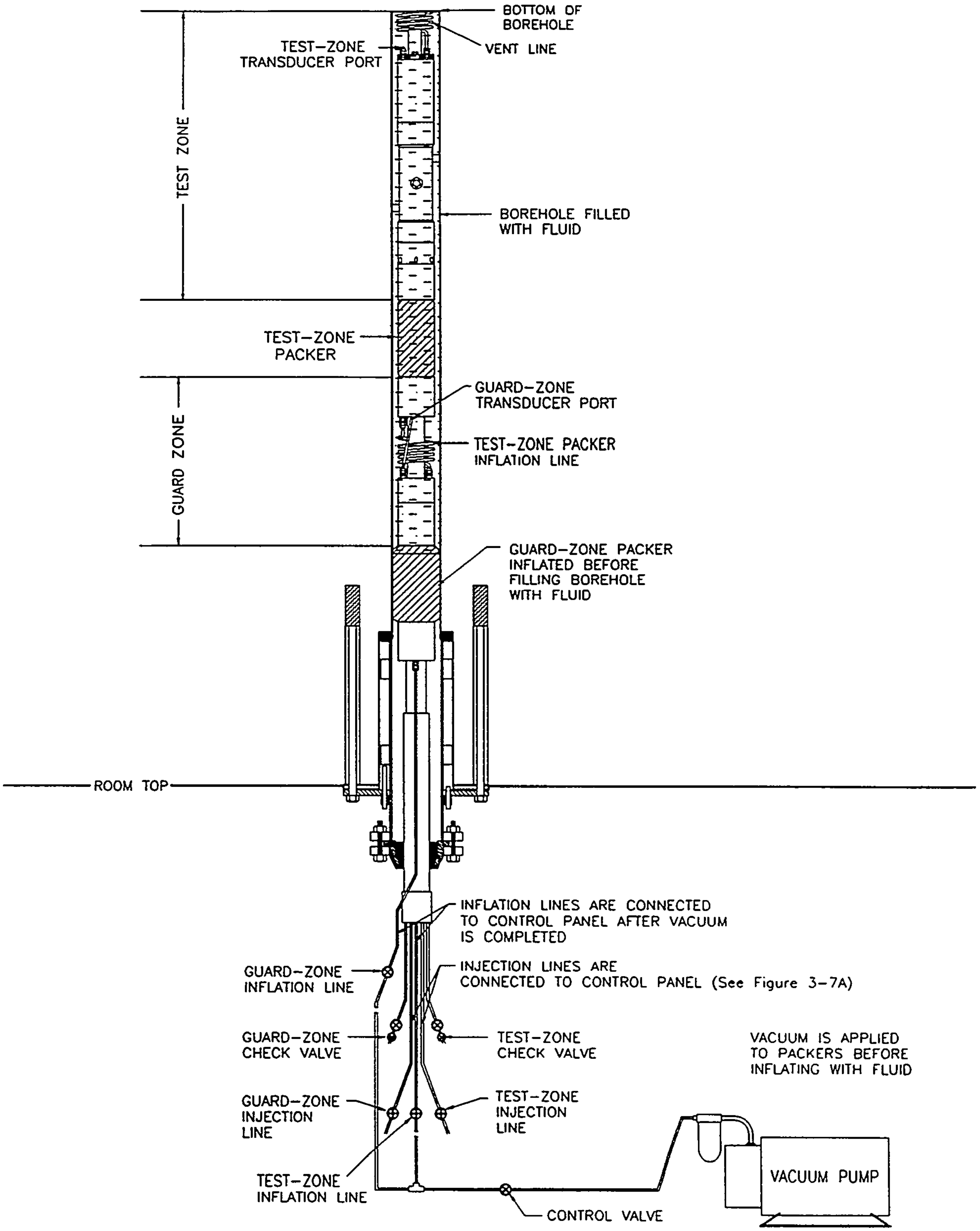

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Figure 3-18. Test-tool packer-inflation and fluid-injection configuration for vertically upward and angled upward boreholes.

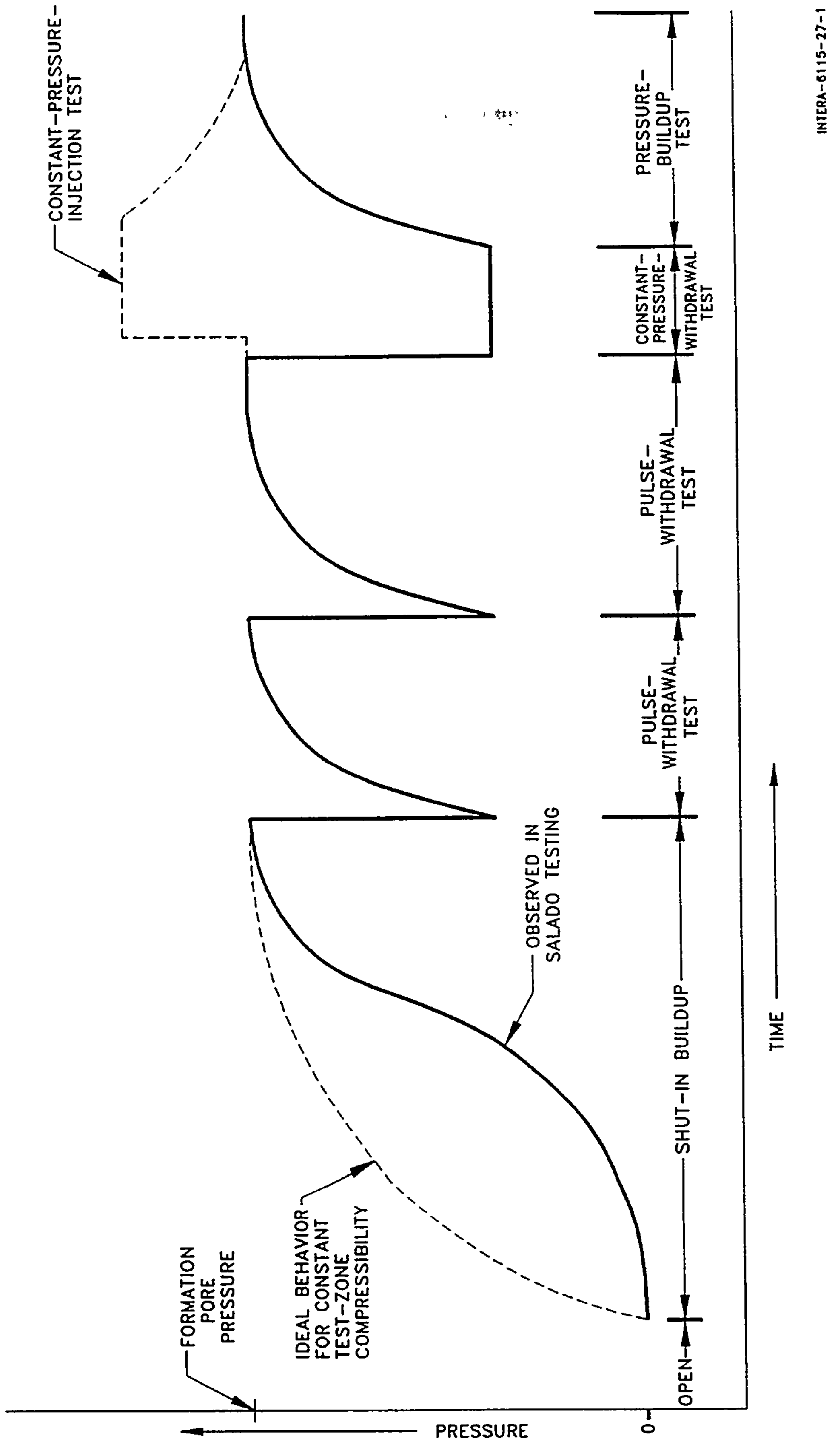

Figure 3-19. Typical permeability-testing sequence.

in the test zones until the rate of pressure increase had decreased to a satisfactory level and the pressure-recovery curves appeared to be on asymptotic trends toward stable values. The DPT panel, as described in Section 3.3.1.6 and illustrated in Figure 3-9, was used to perform the constant-pressure-injection/withdrawal tests. In some of the permeability-testing sequences, both constant-pressure injection and constant-pressure withdrawal tests were performed in order to evaluate the flow properties of the formation in the vicinity of the borehole as a function of pressure. Figure 3-19 illustrates the elements of a typical permeability-testing sequence. Due to the much longer period of time during a constant-pressure-injection/withdrawal test relative to the pulse tests when the formation is subjected to over- or under-pressure conditions, a much larger portion of the formation can be effectively tested. Another advantage of the constant-pressure-injection/withdrawal test is that it provides flow-rate data for the testing period which provide an additional constraint during analysis of the data. A detailed description of the steps that must be followed in order to conduct a constant-pressure-injection/withdrawal test successfully is given in SOP INT-5 (INTERA, 1992) and WIPP Procedure 476.

In some cases, a series of constant-pressure-injection or constant-pressure-withdrawal tests were performed at different pressures in succession. By conducting several tests at different pressures, the formation pressure and flow responses could be evaluated as a function of pressure without going through the intermediate step of pressure recovery after each individual flow period.

A variation of the constant-pressure injection/withdrawal test is a zone compressibility test. In a zone compressibility test the pressure within a given zone is increased from 0 to something approaching the maximum pressure that would be expected in that zone while the test tool is in the borehole. The pressure is increased slowly through the DPT panel in order to measure the fluid volume required to increase the zone pressure by a certain amount. A needle valve is used to regulate the rate at which the zone pressure is increases. When the maximum pressure is achieved, the procedure is repeated only the zone pressure is decreased back to 0. The zone compressibility tests are typically conducted in a compliance chamber during compliance testing, however, in some cases they were conducted in test boreholes. A more detailed description of zone compressibility tests is given in Section 6.

3.4.4 Pressurized Brine-Sampling Procedures

Pressurized brine samples were collected as part of the permeability-testing program from MB140 during permeability-testing sequence L4P51-C1. These pressurized brine samples were collected in order to determine the volume and composition of dissolved gas contained in the formation fluid within MB140 at this location as well as the chemical composition of the fluid. Because nitrogen was expected to be one of the principal gases in solution, the sampling apparatus was pressurized with argon gas.

The following procedures were used to collect all of the pressurized brine samples associated with permeability-testing sequence L4P51-C1. Following a pre-determined schedule, samples were collected at approximately 14-day intervals. A sampling apparatus as shown in Figure 3-10 was used in conjunction with the differential-pressure-transmitter (DPT) panel to collect the pressurized brine samples as part of a constant-pressure-withdrawal test. During a constant-pressure-withdrawal test formation fluid flows through the sampling apparatus prior to entering the designated column on the DPT panel. When a sample is to be retrieved, a series of valves are opened and/or closed in a prescribed sequence in order to allow the formation fluid to bypass the sampling apparatus. When the sampling apparatus is effectively isolated, the sample is retrieved. WIPP Procedure 467 describes the steps required to collect and submit for analysis a pressurized brine sample to assure that an uncontaminated sample was supplied to the laboratory conducting the analysis.

The gas analysis that was performed on each of the samples was conducted by the geochemistry department at New Mexico Institute of Mining and Technology under the supervision of Dave Norman. The brine analysis on each of the samples was conducted by Chem-Nuclear Geotech Analytical Laboratory. A portion of the results from the brine analysis is presented in Section 3.6.3.

3.5 Boreholes and Test-Tool Configurations for Permeability Testing

3.5.1 Borehole Locations and Orientations

Figure 2-1 presents the locations of the boreholes associated with the permeability-testing program. A testing sequence is referred to by the borehole designation in which it was conducted. Modifications to this reference system were required when a borehole was deepened and additional tests performed in new (deeper) intervals or when a new test-tool configuration was used to conduct tests in borehole intervals that had been previously tested. When a borehole was deepened to test a new interval a letter designation was added to the borehole designation with "A" referring to the initial testing sequence and all subsequent borehole deepenings proceeding alphabetically. An example of this is illustrated in the S1P74-A and S1P74-B testing sequences. The initial testing sequence was conducted in borehole S1P74 and was referred to by this designation. Then the borehole was deepened and the new interval was tested. Therefore, the initial testing sequence (S1P74) was redesignated S1P74-A and the new testing sequence (in the deeper borehole) was designated S1P74-B. In the case when a new test-tool configuration was used to conduct tests in a borehole that had been previously tested a number designation was added to the appropriate borehole and letter designation with "1" referring to the original test-tool configuration and all subsequent test-tool configurations proceeding numerically. An example of this is illustrated in the L4P51-C1 and L4P51-C2 testing sequences. The initial test-tool configuration used in testing sequence L4P51-C was a double-packer configuration and was referred to as L4P51-C and a testing sequence was conducted using this configuration. Later, it was decided that a triple-packer configuration was needed to better test a particular interval. Therefore, the original test tool was removed and the new one was installed and a second testing sequence was performed. Under these circumstances the first testing sequence was redesignated L4P51-C1 and the second testing sequence was designated L4P51-C2.

The locations for the WIPP underground permeability-testing boreholes were based on the ages of excavations and access to Salado Formation lithologies of interest. Therefore, permeability testing results from boreholes located in more recently excavated areas of the underground facility could be compared with those from areas that had been excavated earlier, thus providing an opportunity to investigate the permeability of geologic media least affected by the pressure relief imposed on the Salado Formation by excavations. Table 3-1 summarizes the location and orientation of each of the boreholes associated with the permeability testing program. Borehole orientations at an underground location attempt to accomplish three objectives:

- to characterize the interbeds in close areal proximity;
- to test the same interbed at varying distances from an excavation while maintaining close areal proximity; and
- to characterize the interbeds at a maximum distance from the excavation.

Table 3-1. Summary of Borehole Locations and Orientations

Test Sequence (Orientation)	**Drilling Method**	**Interval Drilled/Cored (m)**	**Date Drilled/ Cored**	**Location**	**Excavation Date of Room**
L4P51-C1 (vertical down)	Brine-rotary w/ coring bit	10.06 - 23.35	4-1-92 to 4-15-92	Room L4	February 1989
L4P51-C2 (vertical down)	Brine-rotary w/ coring bit	10.06 - 23.35	4-1-92 to 4-15-92	Room L4	February 1989
L4P51-D1 (vertical down)	Brine-rotary w/ coring bit	23.35 - 30.45	9-20-94 to 9-22-94	Room L4	February 1989
L4P51-D2 (vertical down)	Brine-rotary w/ coring bit	23.35 - 30.45	9-20-94 to 9-22-94	Room L4	February 1989
L4P52-B (angled upward 40°) (from vertical)	Air-rotary w/ coring bit	9.02 - 14.12	12-10-92 to 12-14-92	Room L4	February 1989
S1P74-A (angled upward 40°) (from vertical)	Air-rotary w/ coring bit	0.00 - 7.69	7-27-92 to 7-29-92	Waste Panel 1, Room 7	March 1988
S1P74-B (angled upward 40°) (from vertical)	Air-rotary w/ coring bit	7.69 - 16.88	1-26-95 to 1-31-95	Waste Panel 1, Room 7	March 1988

Tables 3-2 provides pertinent information on the boreholes and test zones associated with the permeability-testing program.

Table 3-2. Permeability-Testing Sequence Test-Zone Information

Test Sequence	Test Horizon	Test Horizon Penetrated	Borehole Diameter (cm)	Test Interval Depth (m)	Borehole Depth (m)	Sequence Started	Sequence Terminated
L4P51-C1	Halite	4-3-92 (09:00)	11.12	15.59 - 16.55	22.20	4-24-92	11-11-93
L4P51-C1	MB140	4-14-92 (14:20)	10.33	17.80 - 21.97	22.20	4-24-92	11-11-93
L4P51-C2	Halite	4-3-92 (09:00)	11.12	15.59 - 16.53	22.20	11-18-93	7-19-94
L4P51-D1	Argillaceous Halite	9-21-94 (14:30)	10.33	29.62 - 30.40	30.45	9-30-94	3-21-95
L4P51-D2	Argillaceous Halite	9-21-94 (14:30)	10.33	29.62 - 30.40	30.45	4-6-95	10-25-95
L4P52-B	MB138	12-14-92 (12:00)	10.15	13.89 - 14.02	14.18	12-17-92	12-29-93
S1P74-A	Anhydrite "a"	7-29-92 (09:15)	10.35	7.15 - 7.41	7.69	8-5-92	8-9-93
S1P74-B	MB138 (TZ1)	1-31-95 (12:45)	10.35	16.38 - 16.66	16.88	2-7-95	5-18-95
S1P74-B	Argillaceous Halite (TZ2)	1-27-95 (12:15)	10.35	12.58 - 13.49	16.88	2-7-95	5-18-95

Figure 3-20 schematically depicts Room L4 in plan view and in cross section, showing the locations and orientations of boreholes L4P51 and L4P52. Figure 3-21 schematically depicts Waste Panel 1, Room 7 in plan view and in cross section, showing the location and orientation of borehole S1P74.

3.5.2 Borehole Drilling

Requests for borehole drilling and coring were made in accordance with WIPP Procedure 140 and WIPP Procedure 125. Drilling and coring operations were performed by Westinghouse including installation and load-testing of borehole-flanged collars and borehole surveys. Records of borehole drilling and coring activities are maintained by Westinghouse.

The boreholes for the permeability-testing program were drilled using two different procedures. The first of the two procedures consisted of an air-rotary drilling technique in which the following steps were followed:

- A Longyear D-65 compressed-air drill was set in place at each borehole location and used to drill the test and observation boreholes into the floors and ribs of the test rooms. The boreholes were drilled primarily with a coring bit and core barrel for sample recovery. Compressed air was the principal means used to remove drilling cuttings from the boreholes as they were being drilled. The bottom of each borehole was faced off with a flat bit to insure a smooth surface for proper test-tool seating and test-zone-volume calculations.

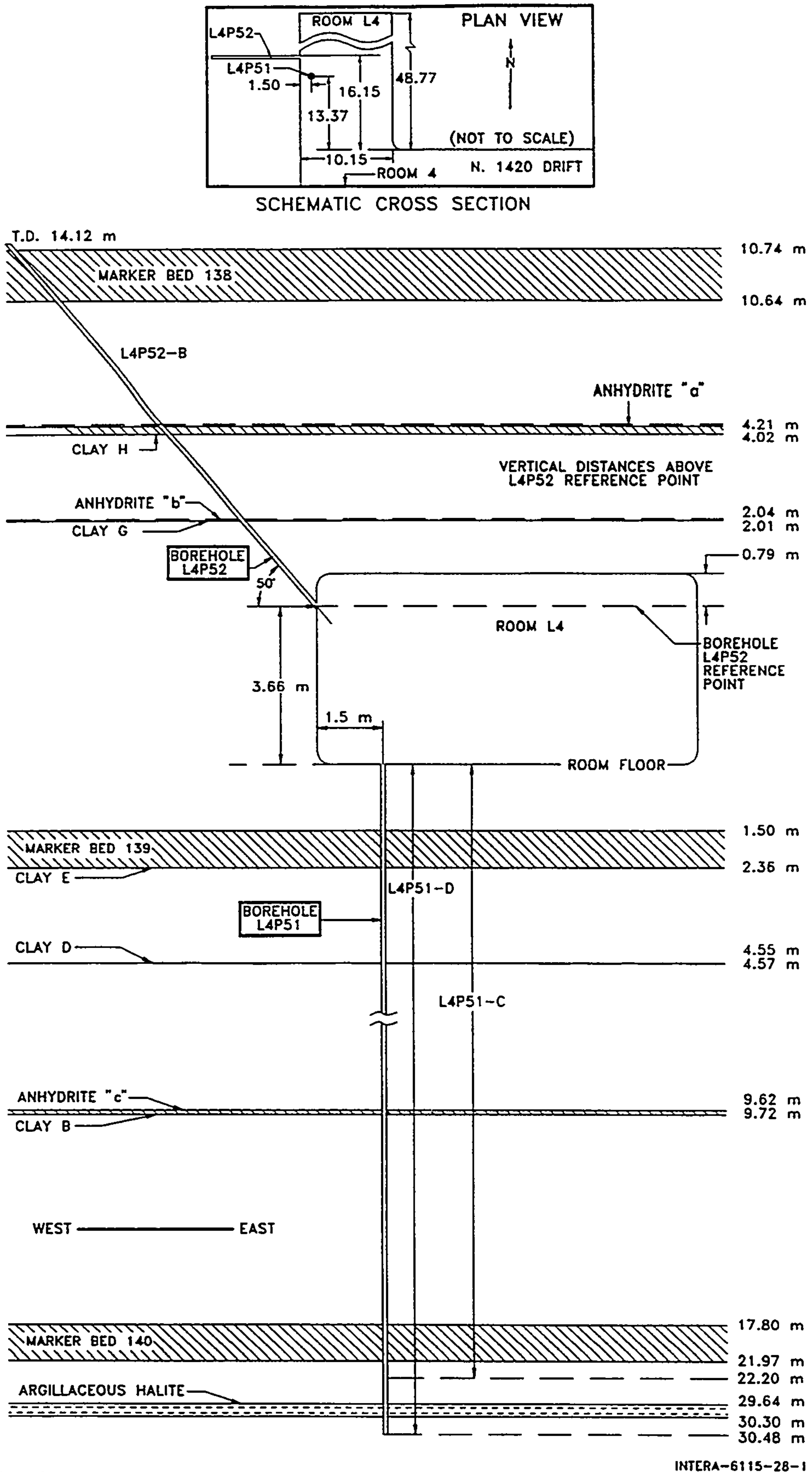

Figure 3-20. Spatial representation of Room L4 showing the locations and orientations of boreholes L4P51 and L4P52.

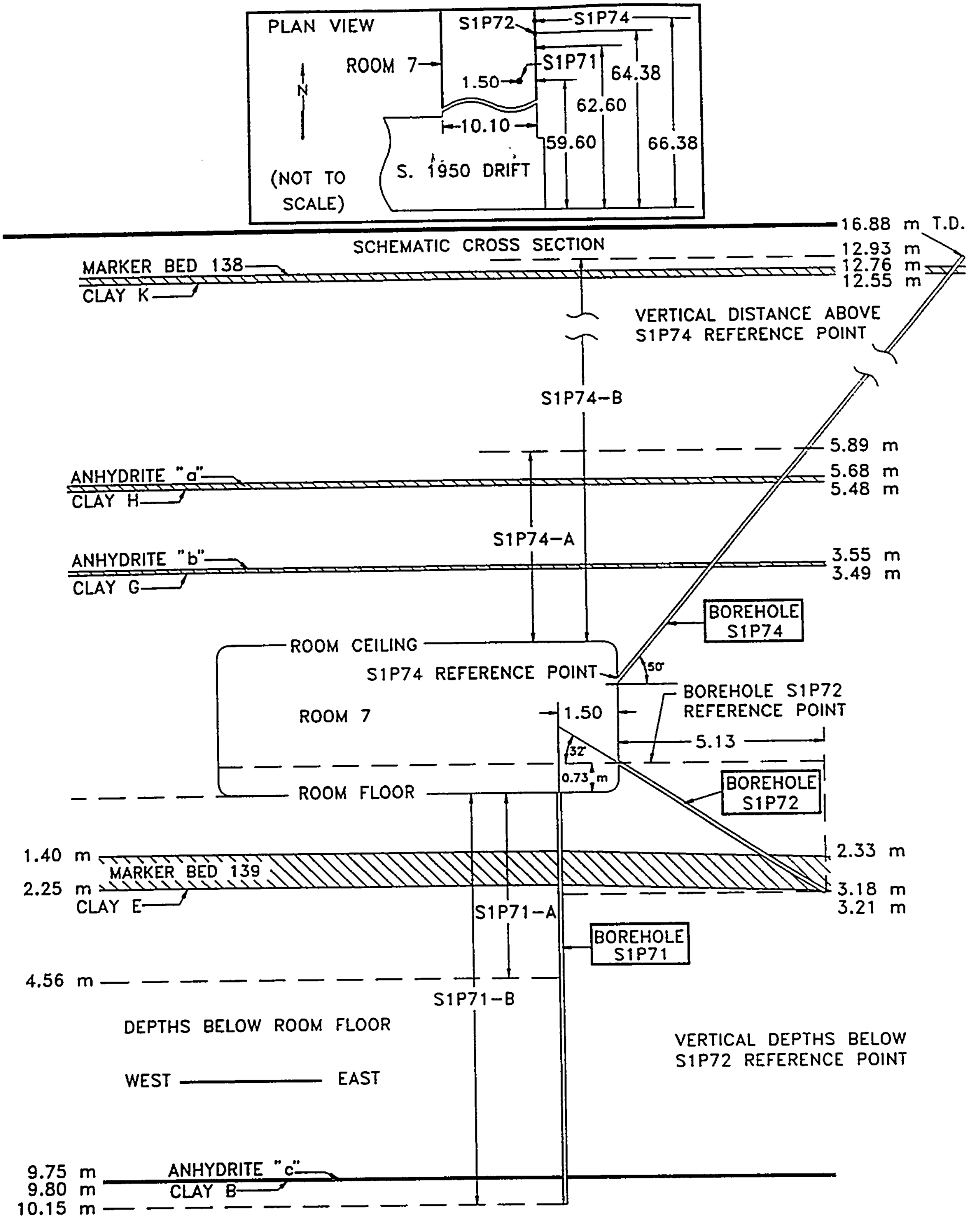

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Figure 3-21. Spatial representation of Waste Panel 1, Room 7 showing the locations and orientations of boreholes S1P71, S1P72, and S1P74.

- Using 4.0-inch (10.2-cm) drill and core bits, the test and observation boreholes were drilled and cored to depths of up to 10 m from the excavations. The following data and associated core logs and descriptions were recorded and are included in Appendix A of this report:

  1) the time of the start of drilling and interval times for every 1 m penetrated;
  2) the presence and depth of any brine produced by the formation;
  3) the presence and depth of any significant fracturing; and
  4) the time and depth at which the bottom of the borehole was reached.

- Core samples were recovered from over 95% of the cored sections and were marked, boxed, and described. The core samples were marked to indicate their proper orientation relative to the bottom of the boreholes and each 0.1-m increment was marked on each core sample. Core was transferred to the WIPP underground Core Storage Library upon completion of core logging. Core logs are included in Appendix A for boreholes S1P74, C1H05, C1H06, C1H07, C1X05, C1X06, C1X10, L4P51 (C and D series), and L4P52 (B series). Additional documentation for boreholes L4P51 (A and B series) and L4P52 (A series) are provided in Stensrud et al. (1992).

- The boreholes were reamed to 7-inch (17.8-cm) diameter to a depth of approximately 20 inches (50.8 cm). A 5-1/2-inch (14.0-cm) I.D., 20-inch- (50.8-cm) long, steel borehole collar was then installed and grouted to the surrounding formation material. The multipacker test tool was bolted to the borehole collar to help eliminate test-tool movement in response to packer inflation and fluid-pressure buildup.

The second of the two procedures consisted of a brine-rotary drilling technique in which a Longyear D-38 pressurized-fluid drill was set in place and used at the remaining borehole locations. In this drilling procedure, due to the depth of the boreholes, pressurized brine was the principal means used to remove drilling cuttings from the boreholes.

Boreholes L4P52 and S1P74-B were drilled using air drilling techniques. All other boreholes were drilled using brine as the circulation medium.

3.5.3 Test-Tool Configurations

Figures 3-20 and 3-21 schematically depict Room L4 and Waste Panel 1, Room 7 and show the positions of the boreholes associated with the testing program. Figures 3-22 through 3-33 show the test-tool configurations and associated installations that were used during the testing program. It should be noted that Figures 3-25, 3-26, 3-27, 3-28, and 3-29 each consist of two parts (ex. 3-25a and 3-25b). Specific test tools associated with each permeability-testing sequence are identified in the events tables (Tables 3-4, 3-6, 3-8, 3-10, 3-12, 3-14, and 3-16).

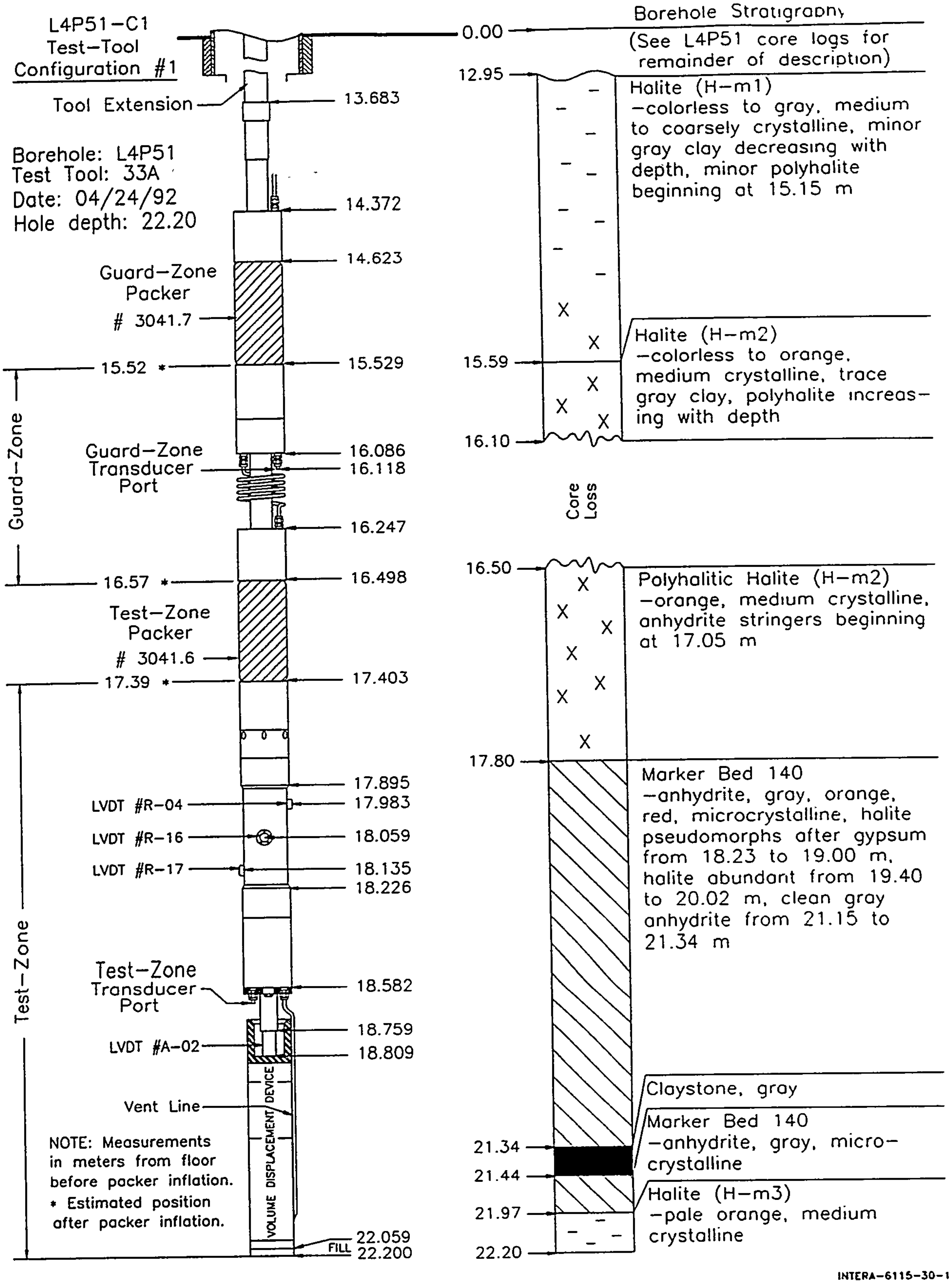


Figure 3-22. Configuration #1 of permeability test tool for sequence L4P51-C1.

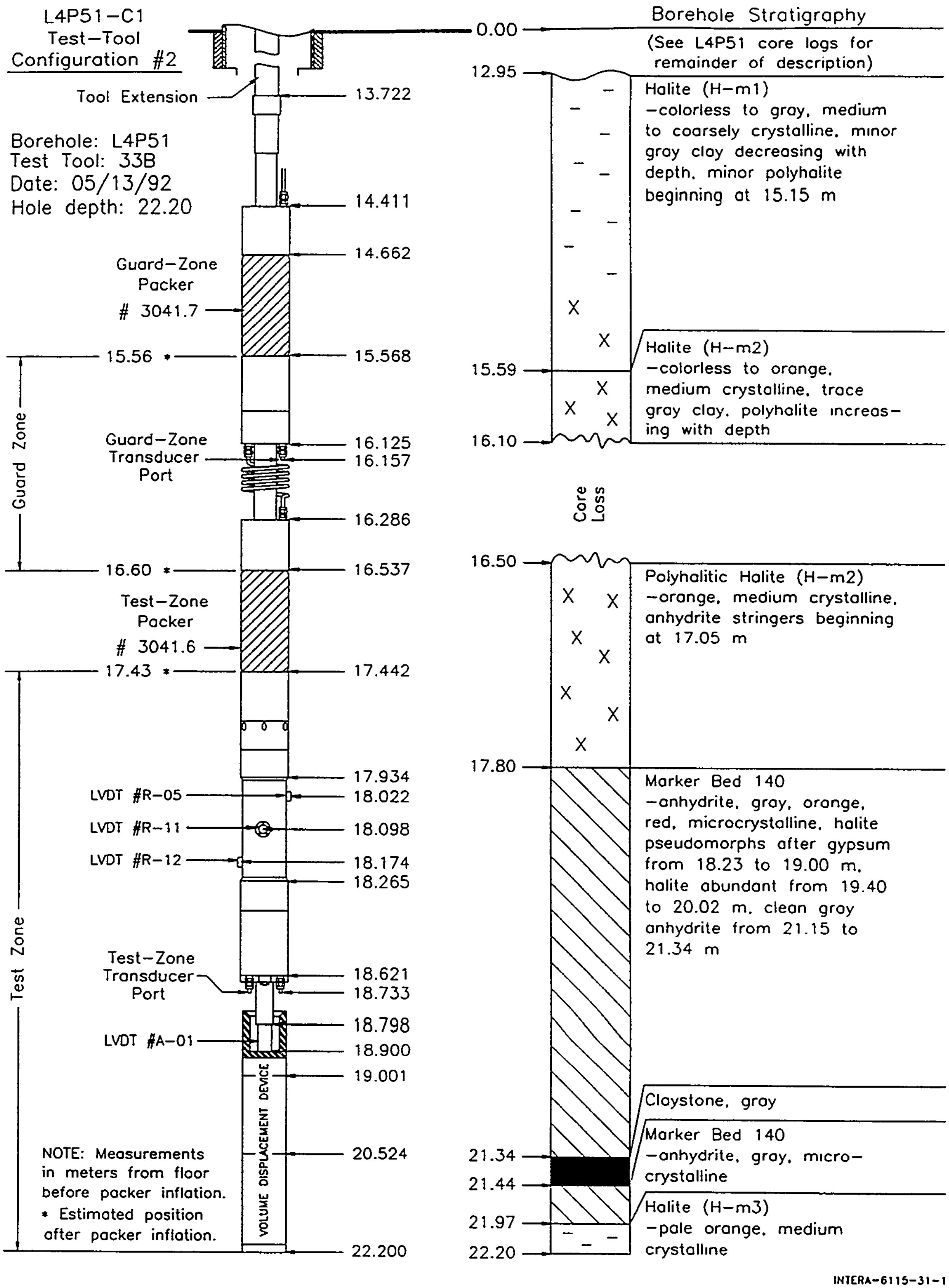


Figure 3-23. Configuration #2 of permeability test tool for sequence L4P51-C1.

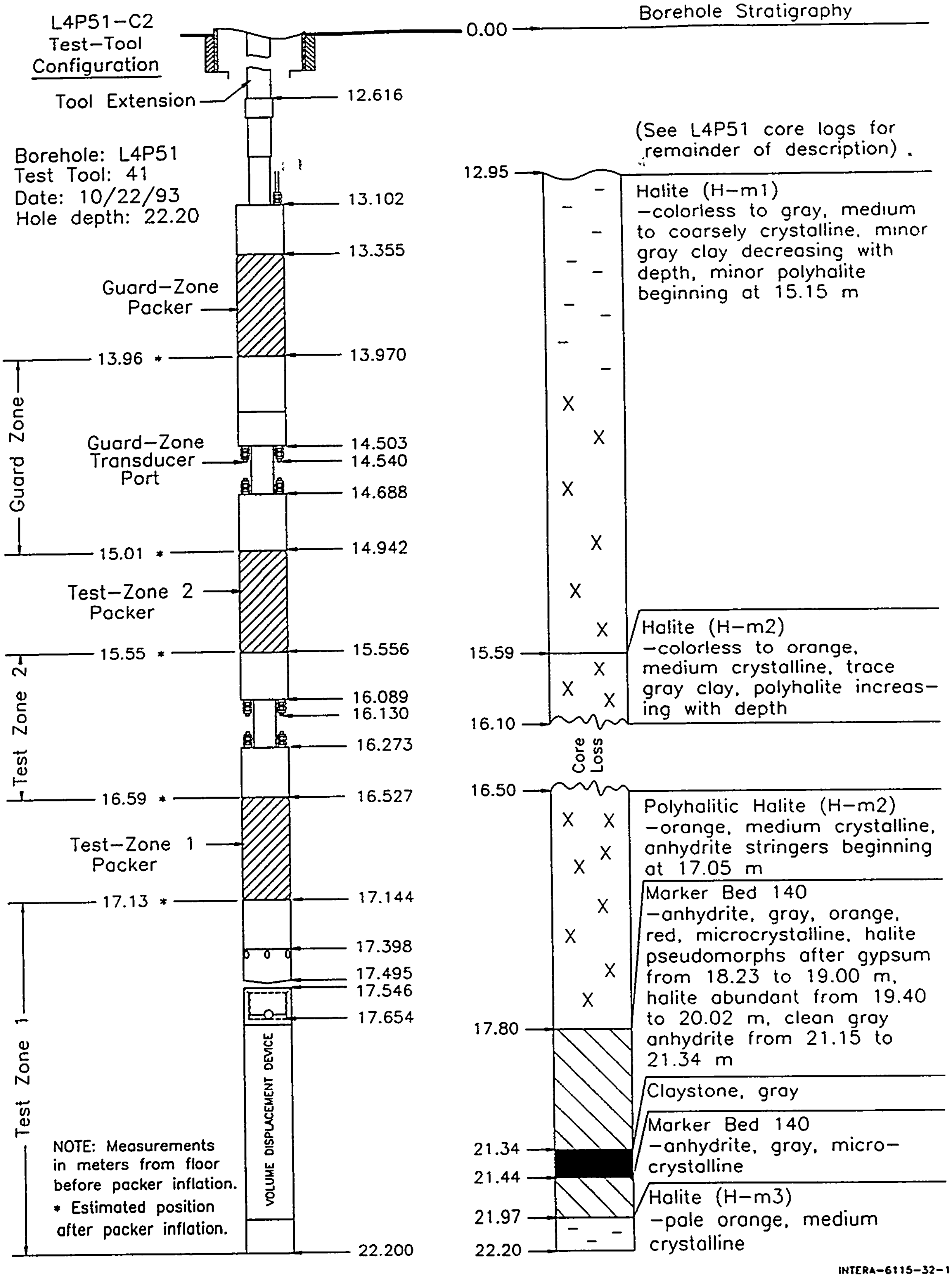
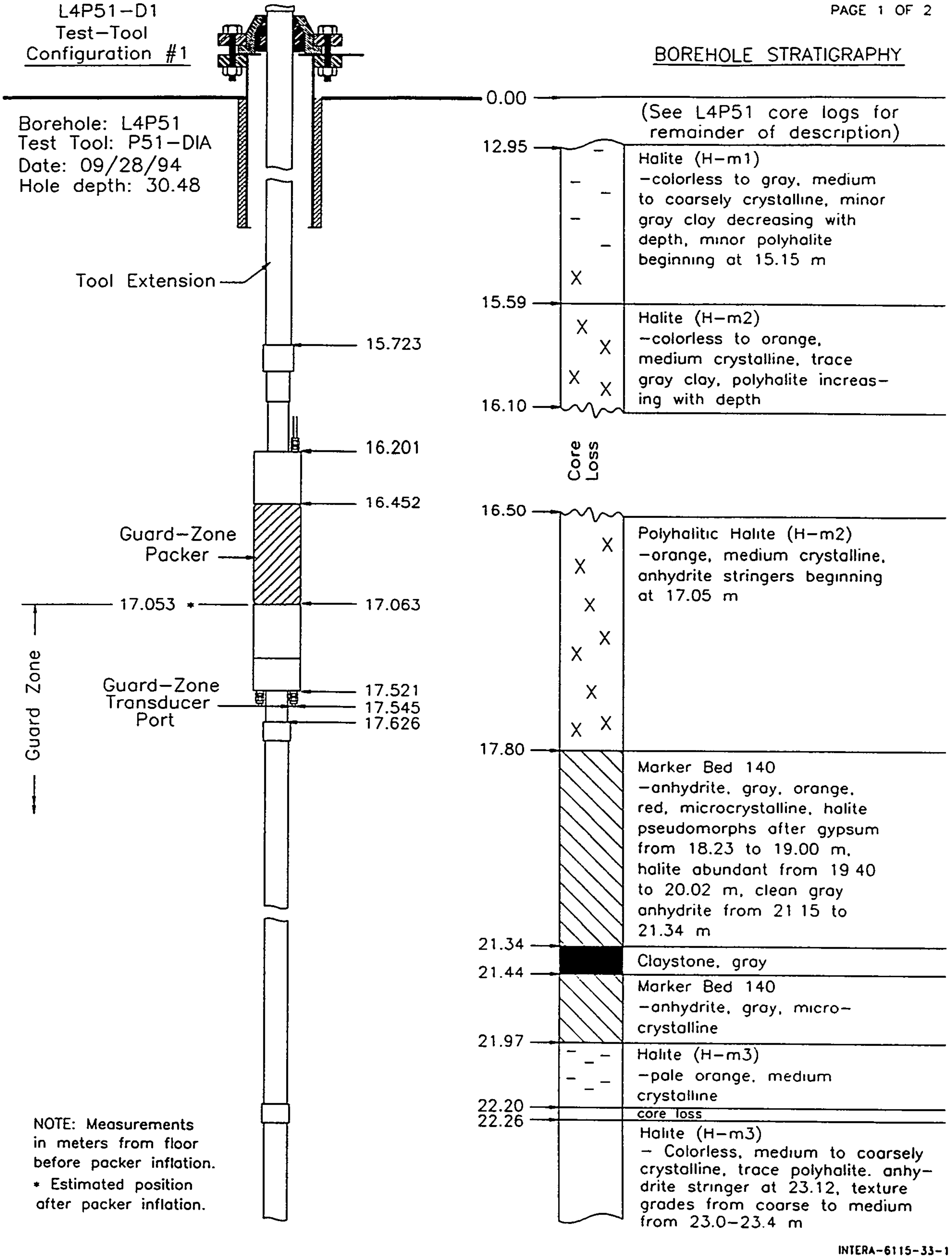


Figure 3-24. Configuration of permeability test tool for sequence L4P51-C2.



(See L4P51 core logs for remainder of description)

Halite (H-m1)
-colorless to gray, medium to coarsely crystalline, minor gray clay decreasing with depth, minor polyhalite beginning at 15.15 m

Halite (H-m2)
-colorless to orange, medium crystalline, trace gray clay, polyhalite increasing with depth

Polyhalitic Halite (H-m2)
-orange, medium crystalline, anhydrite stringers beginning at 17.05 m

Marker Bed 140
-anhydrite, gray, orange, red, microcrystalline, halite pseudomorphs after gypsum from 18.23 to 19.00 m, halite abundant from 19 40 to 20.02 m, clean gray anhydrite from 21 15 to 21.34 m

Claystone, gray

Marker Bed 140
-anhydrite, gray, microcrystalline

Halite (H-m3)
-pale orange, medium crystalline

core loss

Halite (H-m3)
- Colorless, medium to coarsely crystalline, trace polyhalite, anhydrite stringer at 23.12, texture grades from coarse to medium from 23.0-23.4 m

NOTE: Measurements in meters from floor before packer inflation.
* Estimated position after packer inflation.

Figure 3-25a. Configuration #1 of permeability test tool for sequence L4P51-D1.

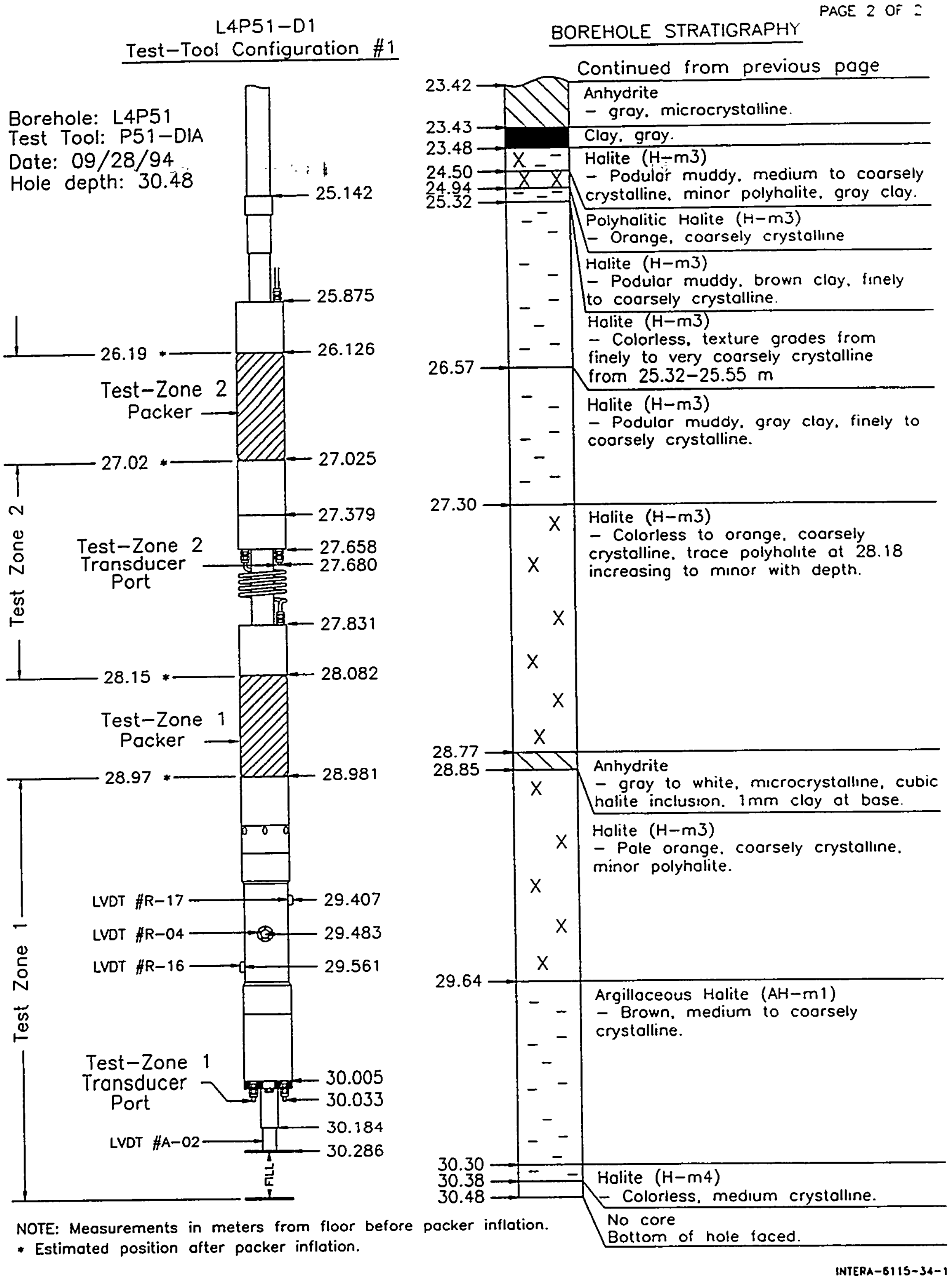


Figure 3-25b. Configuration #1 of permeability test tool for sequence L4P51-D1 (continued).

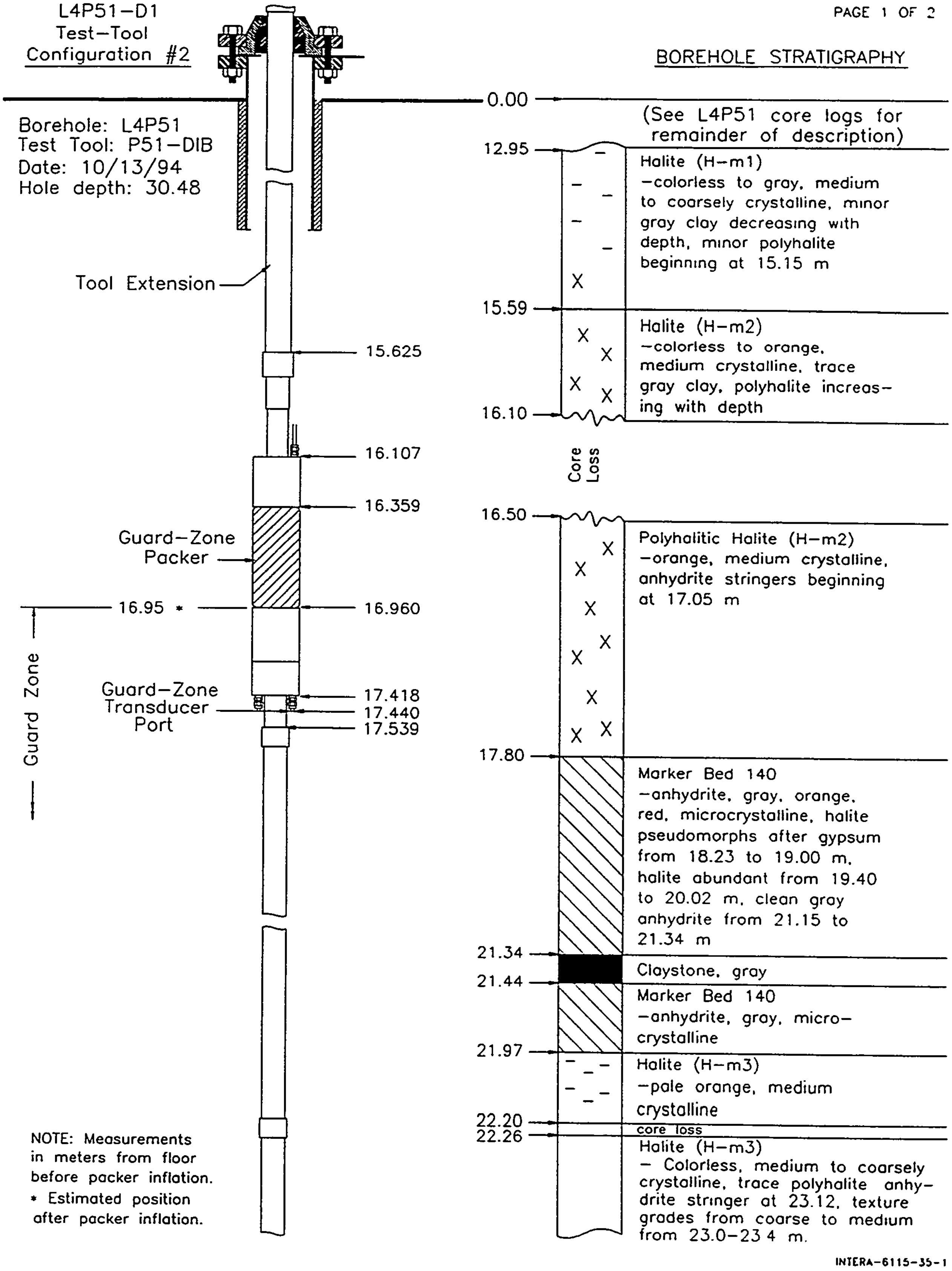


Figure 3-26a. Configuration #2 of permeability test tool for sequence L4P51-D1.

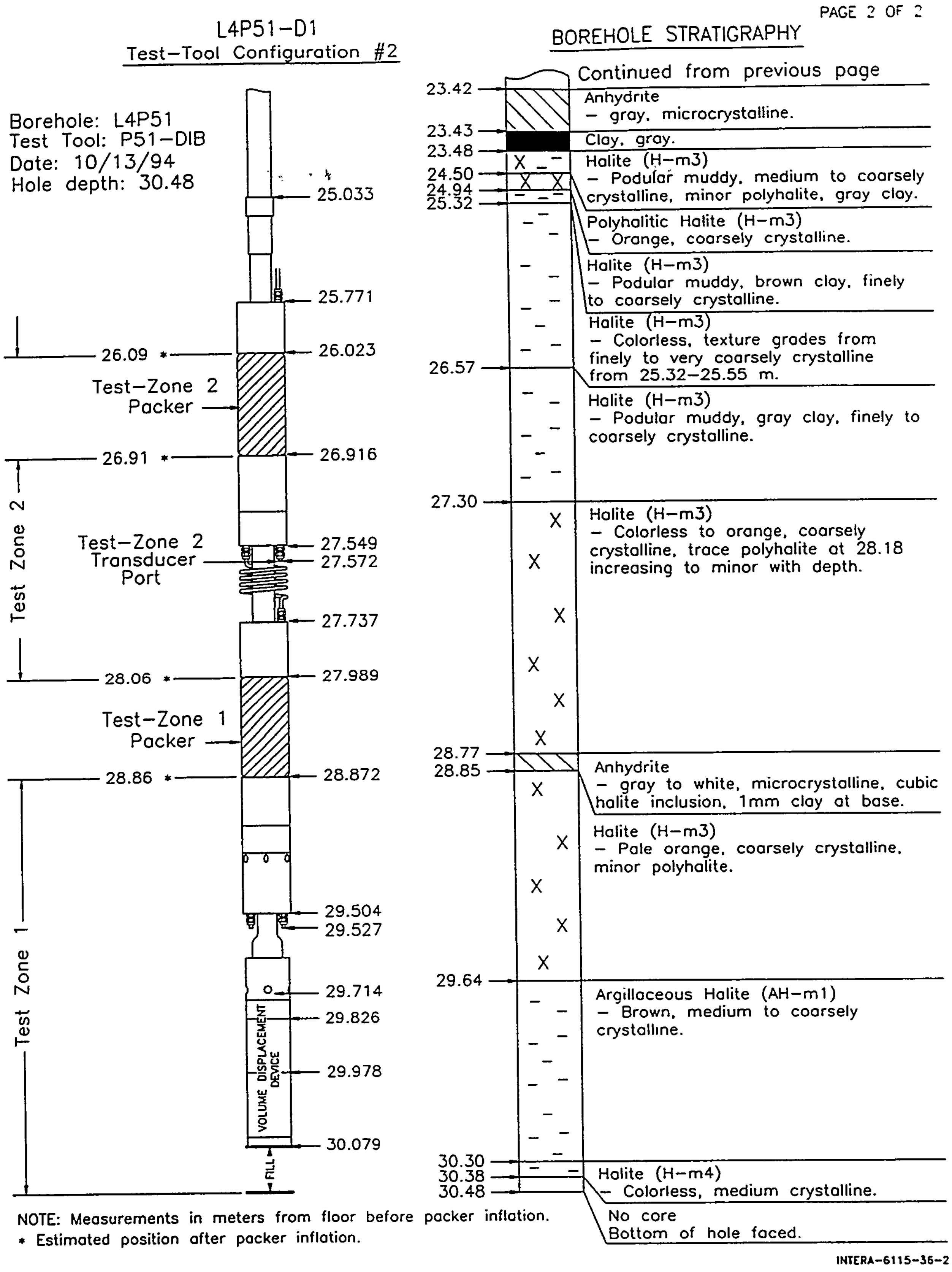


Figure 3-26b. Configuration #2 of permeability test tool for sequence L4P51-D1 (continued).

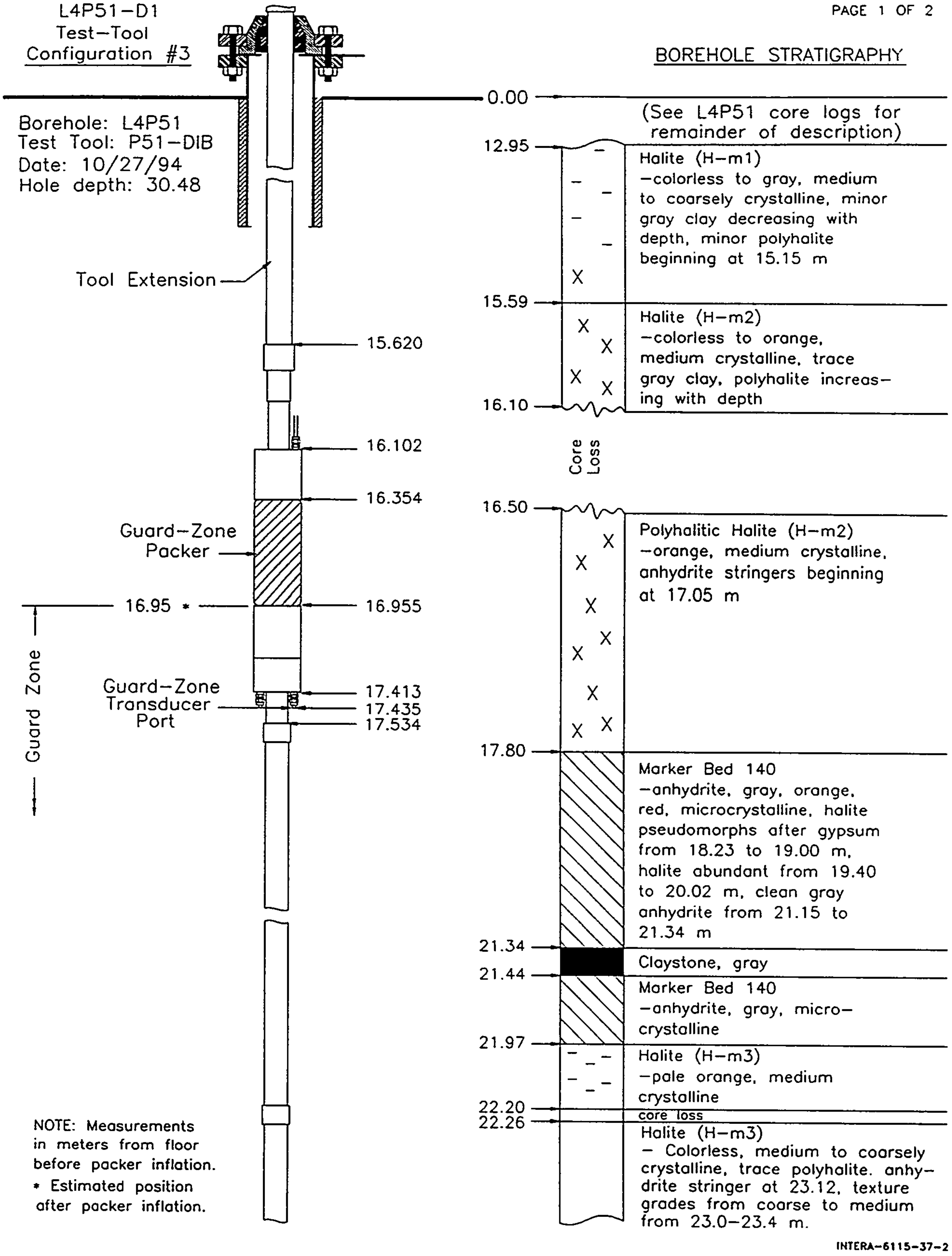


Figure 3-27a. Configuration #3 of permeability test tool for sequence L4P51-D1.

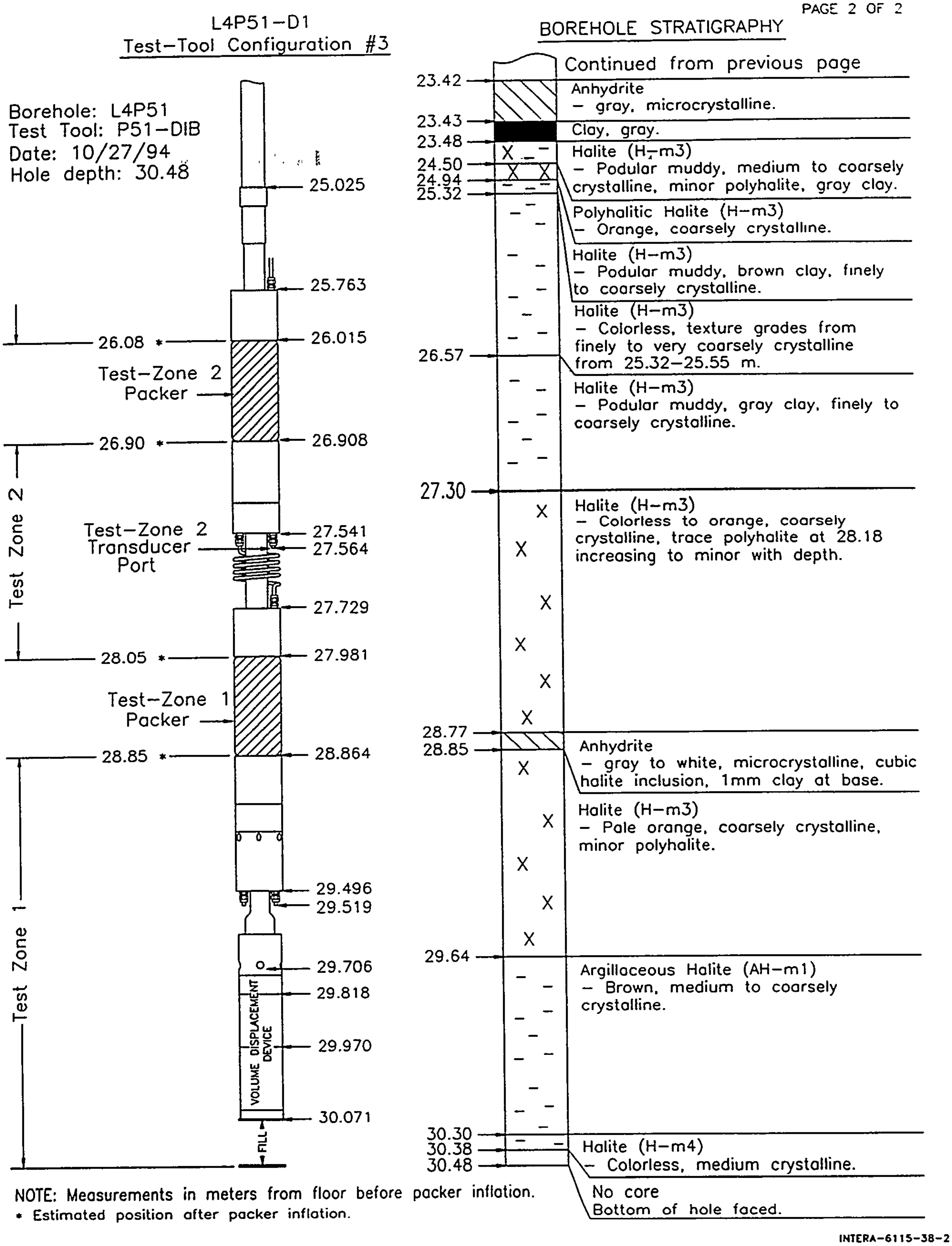


Figure 3-27b. Configuration #3 of permeability test tool for sequence L4P51-D1 (continued).

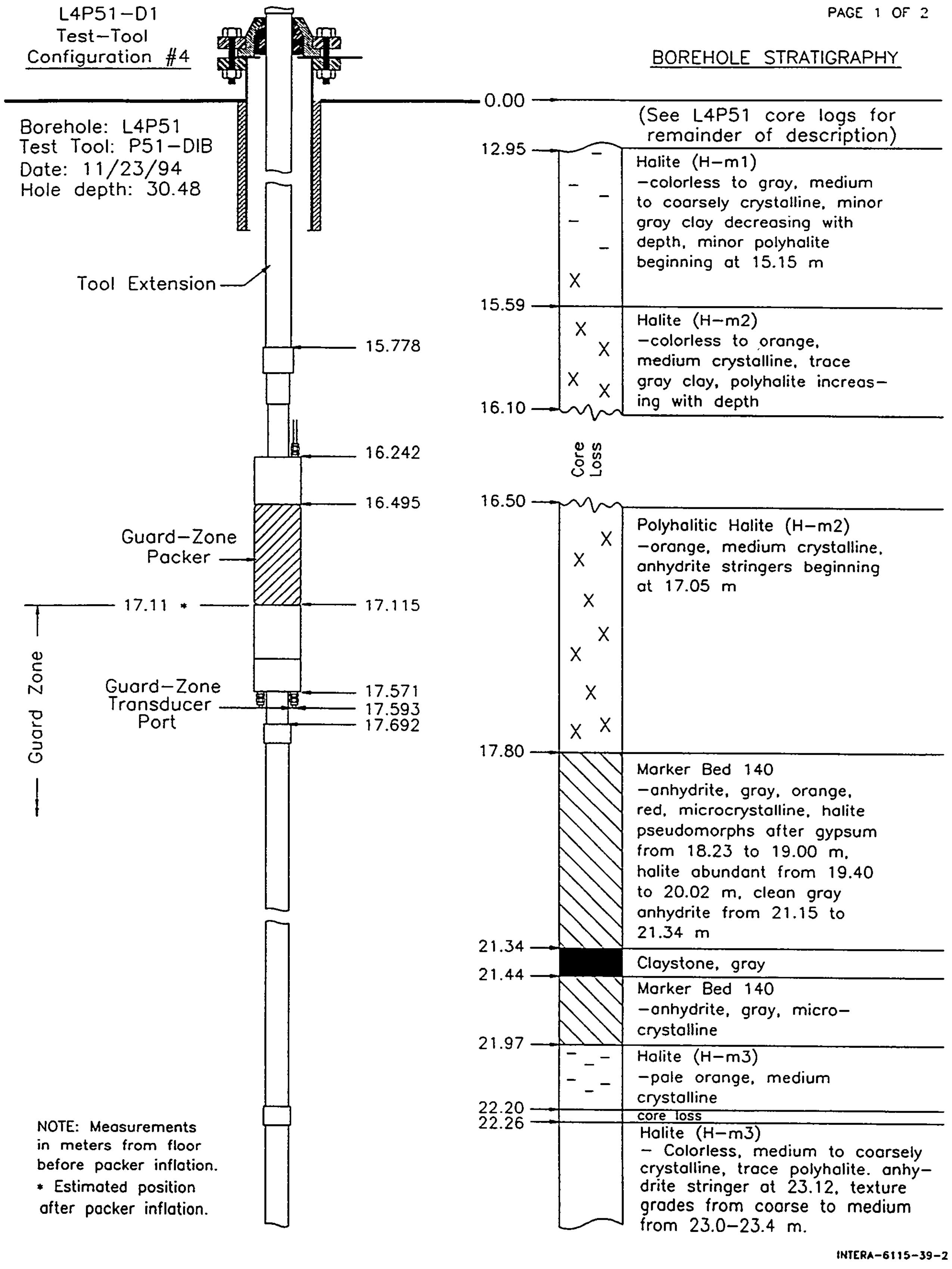


Figure 3-28a. Configuration #4 of permeability test tool for sequence L4P51-D1.

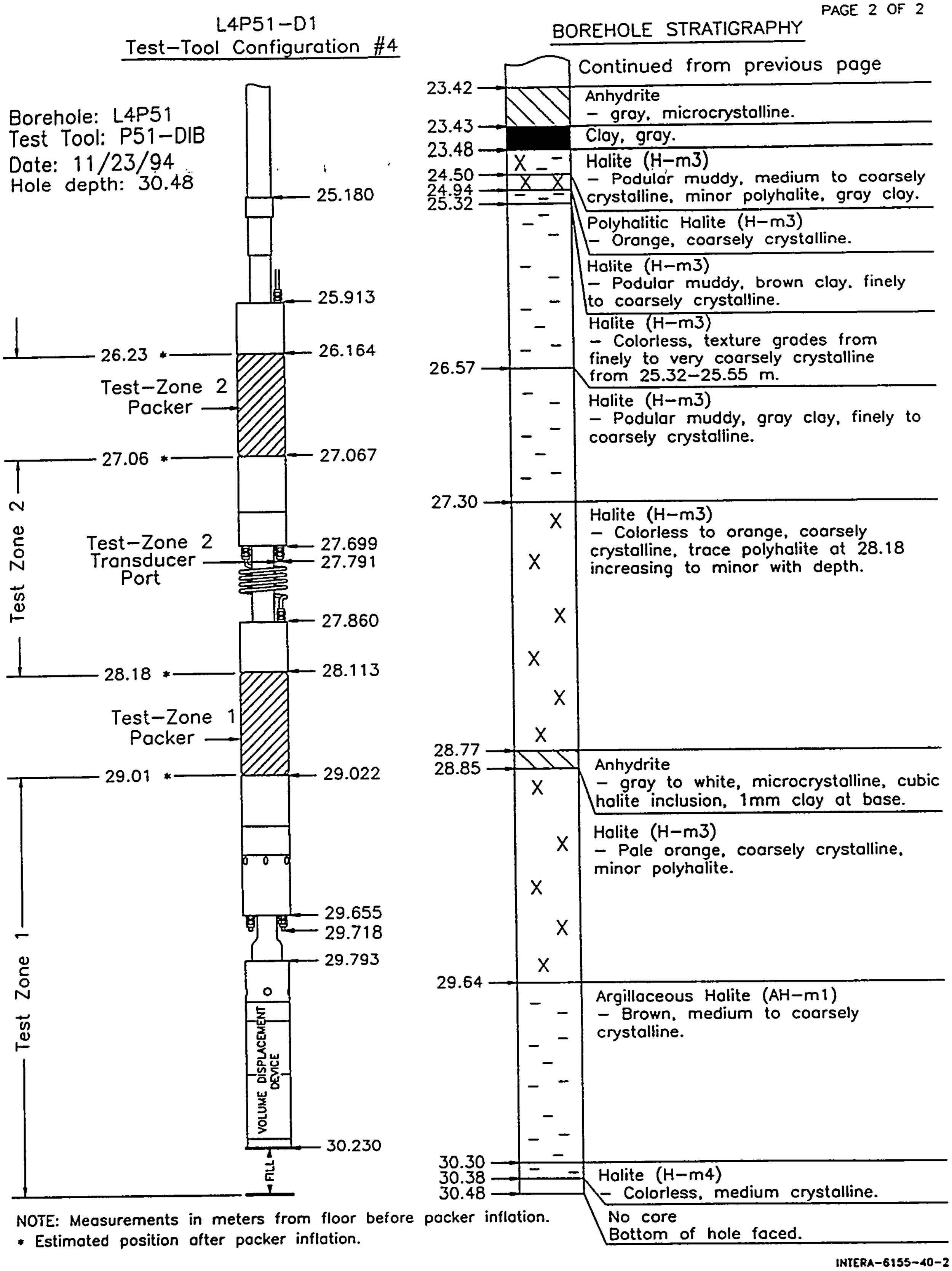


Figure 3-28b. Configuration #4 of permeability test tool for sequence L4P51-D1 (continued).

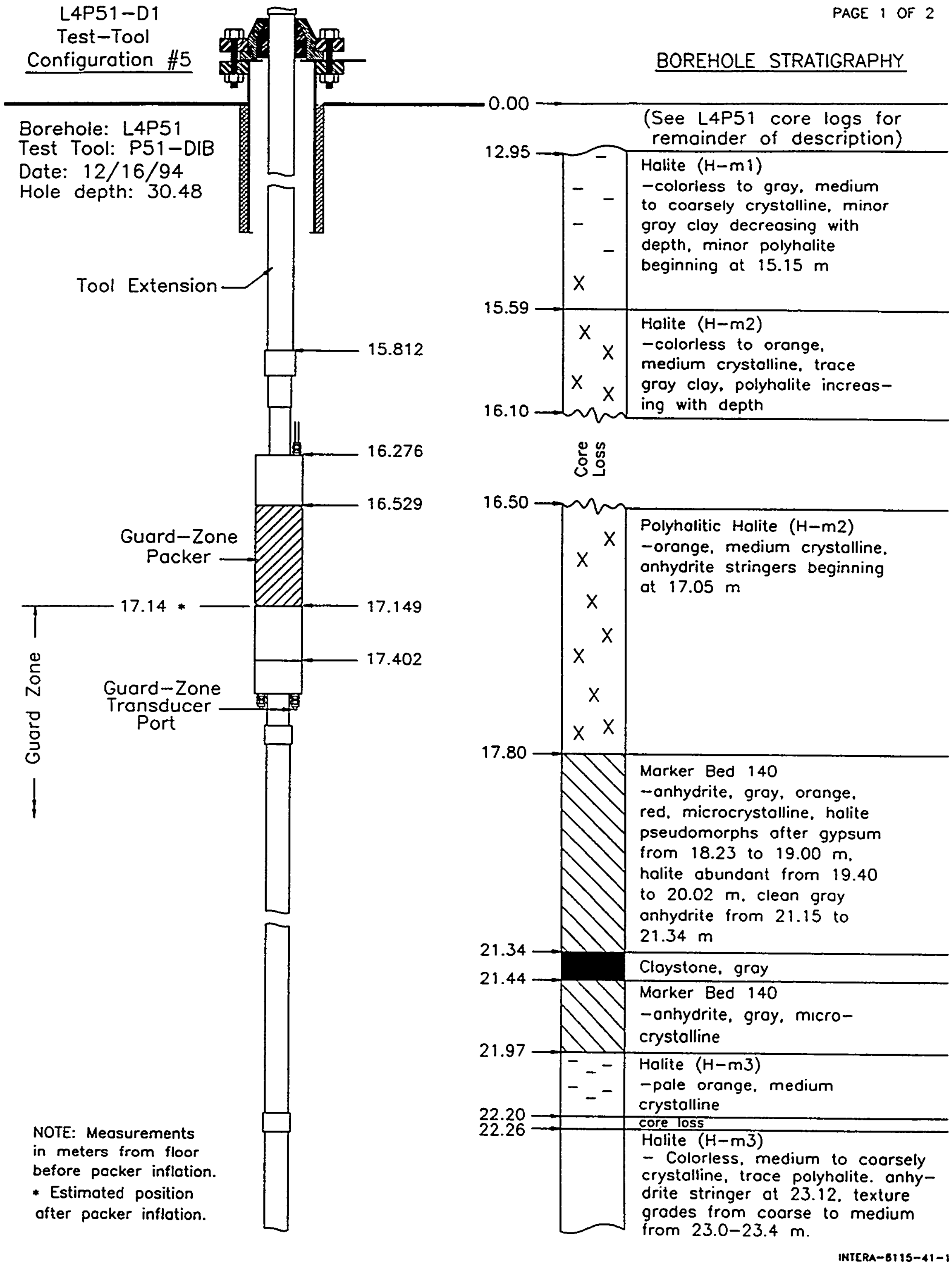
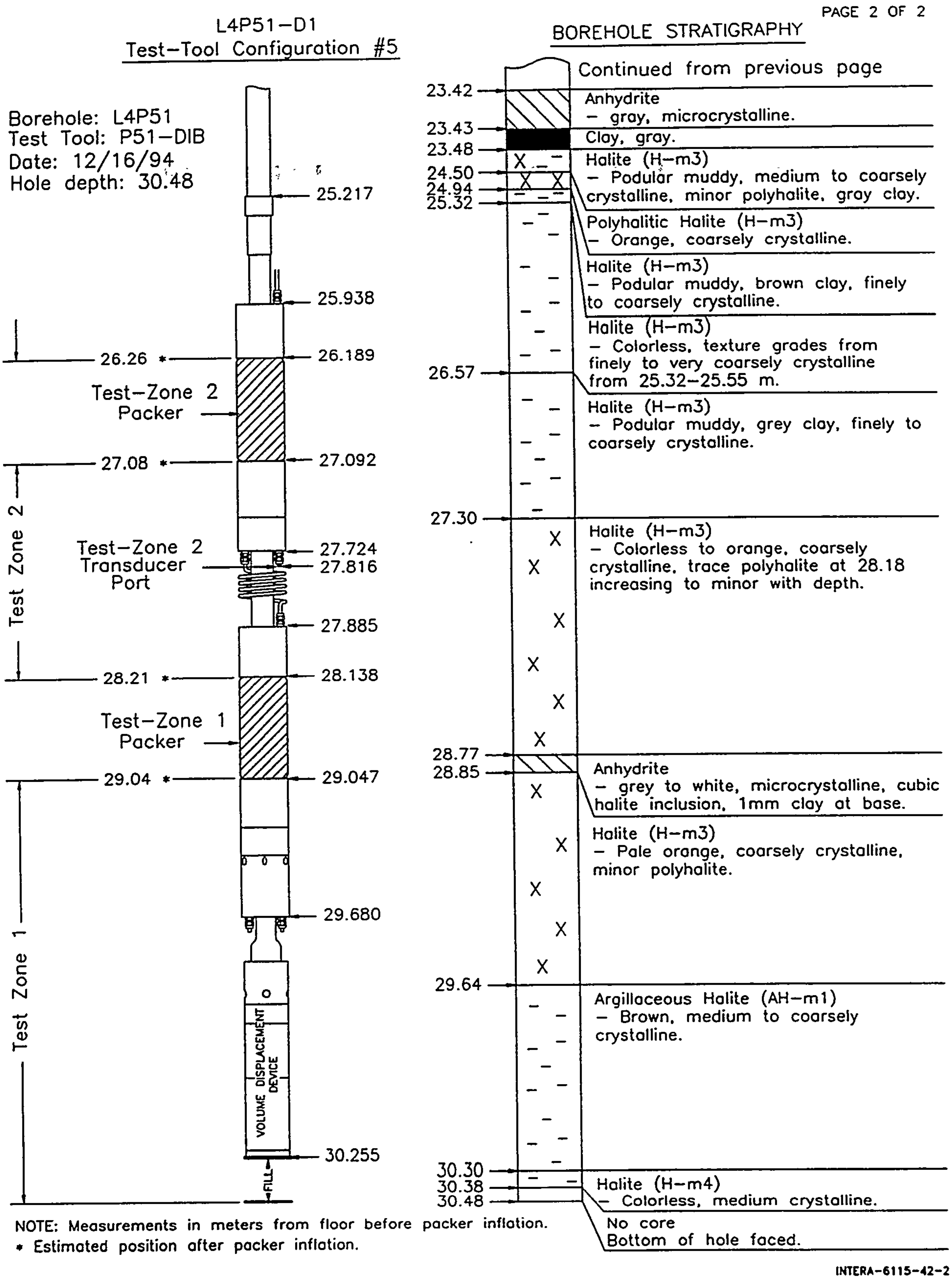


Figure 3-29a. Configuration #5 for permeability test tool for sequence L4P51-D1.



NOTE: Measurements in meters from floor before packer inflation.
* Estimated position after packer inflation.

Figure 3-29b. Configuration #5 for permeability test tool for sequence L4P51-D1 (continued).

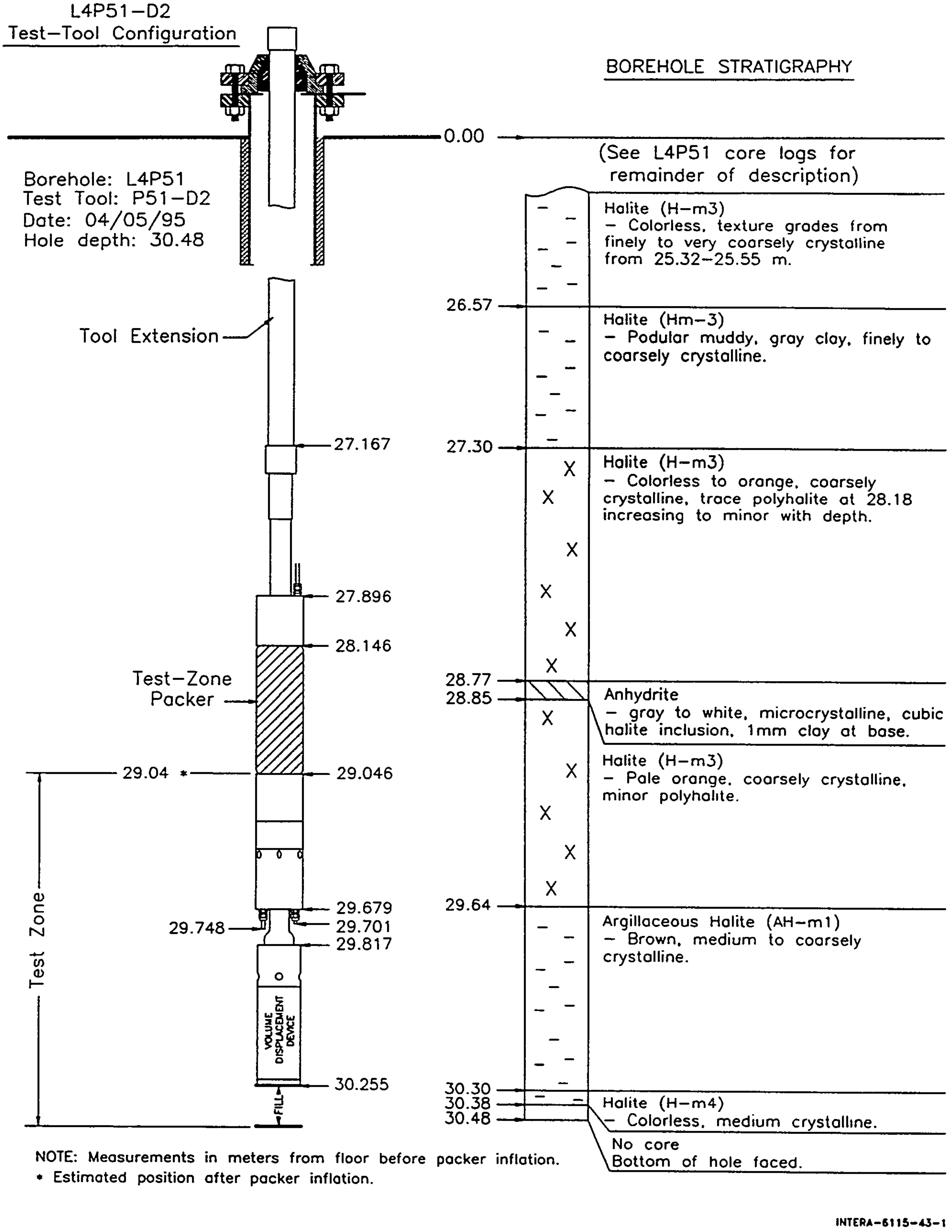


Figure 3-30. Configuration of permeability test tool for sequence L4P51-D2.

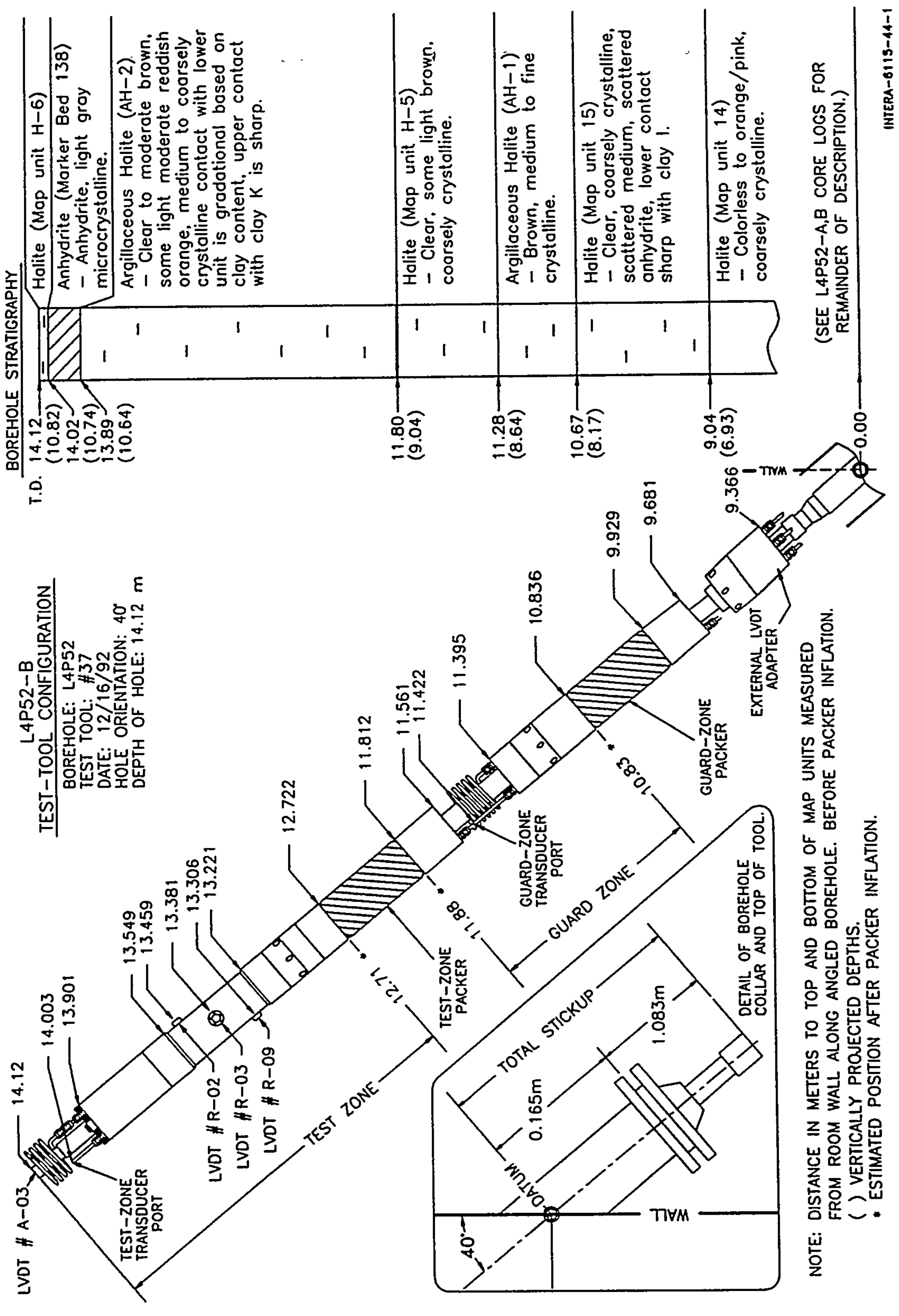
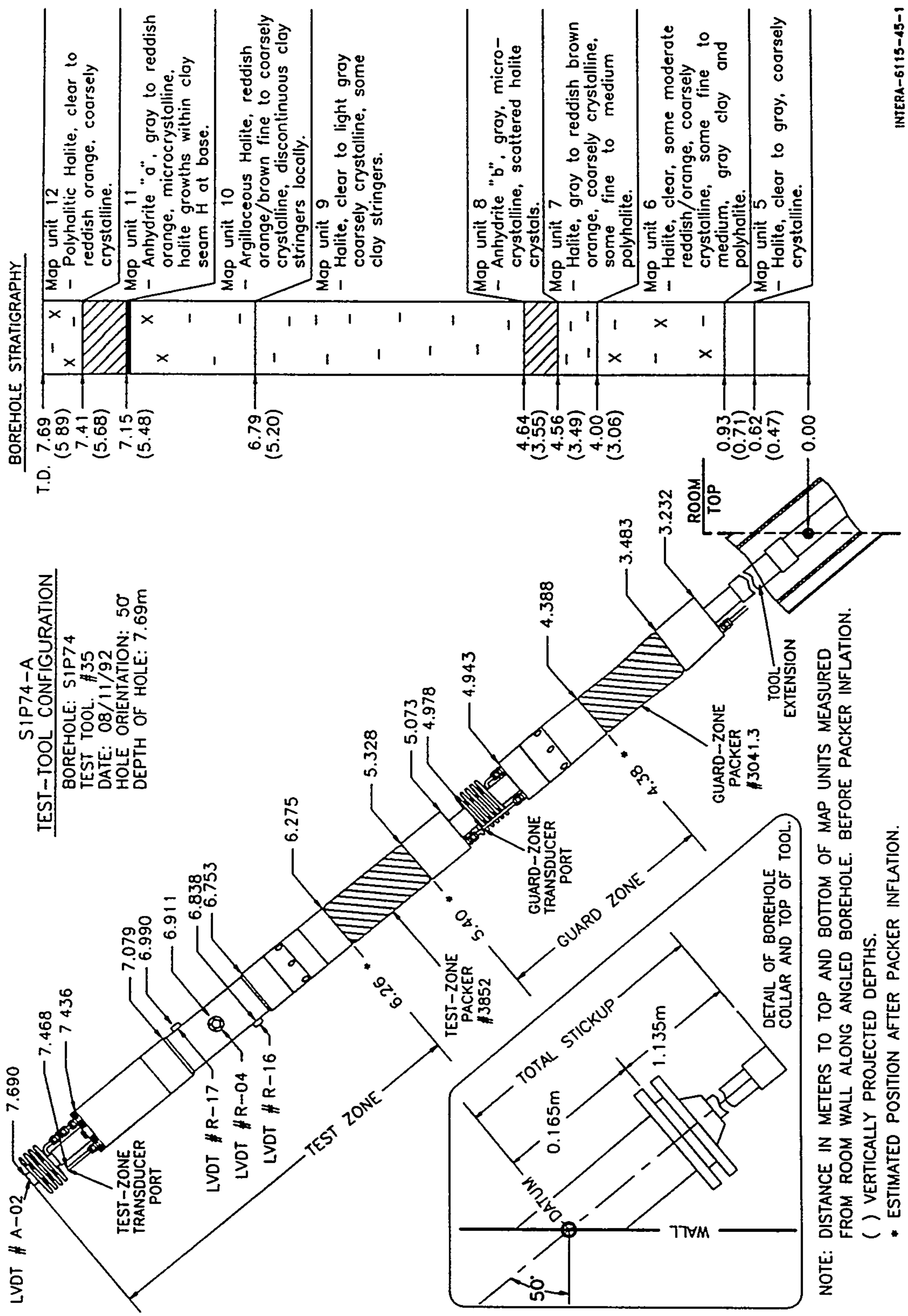
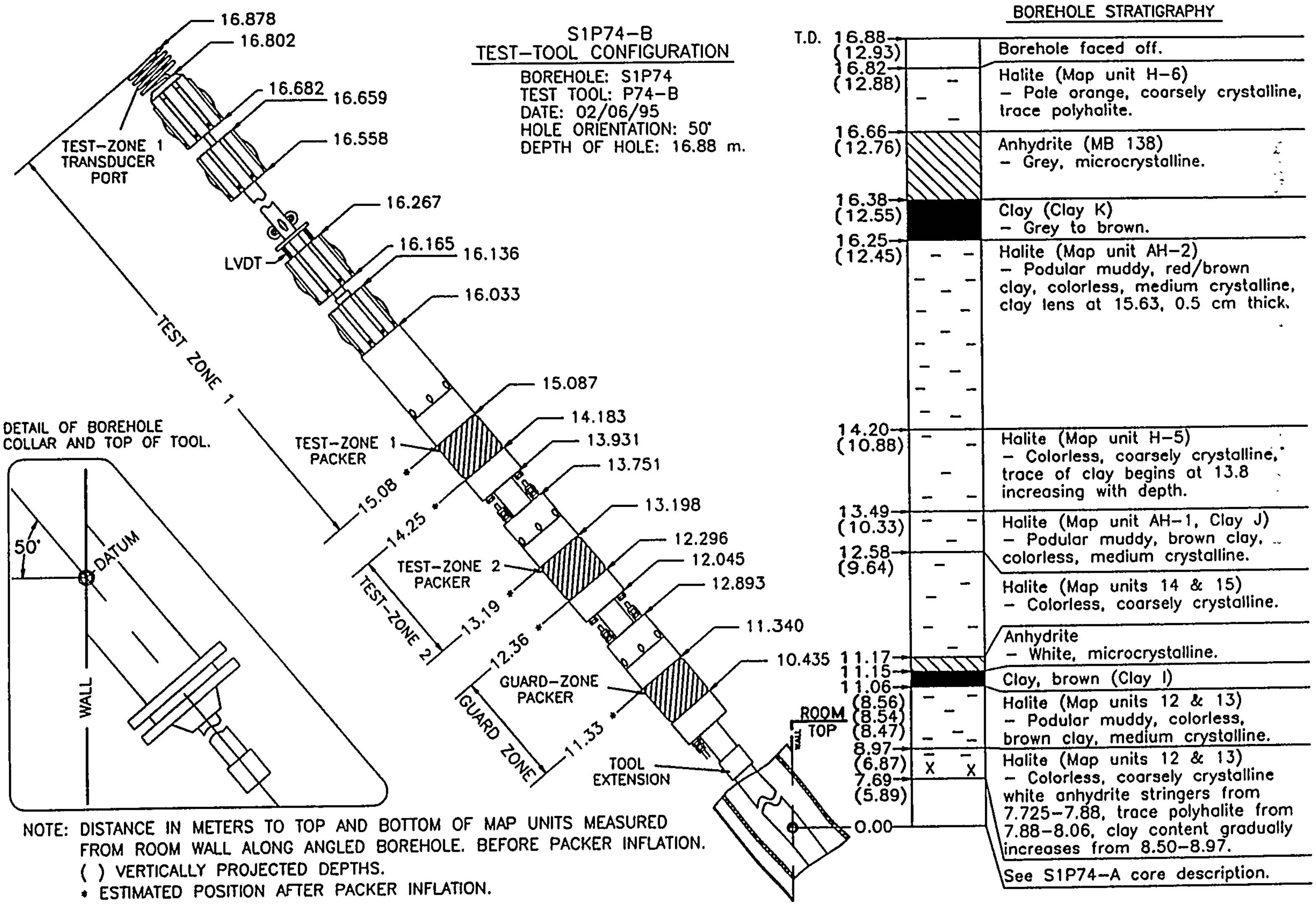


Figure 3-31. Configuration of permeability test tool for sequence L4P52-B.



NOTE: DISTANCE IN METERS TO TOP AND BOTTOM OF MAP UNITS MEASURED FROM ROOM WALL ALONG ANGLED BOREHOLE. BEFORE PACKER INFLATION.
( ) VERTICALLY PROJECTED DEPTHS.
* ESTIMATED POSITION AFTER PACKER INFLATION.

Figure 3-32. Configuration of permeability test tool for sequence S1P74-A.



NOTE: DISTANCE IN METERS TO TOP AND BOTTOM OF MAP UNITS MEASURED FROM ROOM WALL ALONG ANGLED BOREHOLE. BEFORE PACKER INFLATION.
( ) VERTICALLY PROJECTED DEPTHS.
* ESTIMATED POSITION AFTER PACKER INFLATION.

Figure 3-33. Configuration of permeability test tool for sequence S1P74-B.

3.6 Permeability Test Data

The following section presents the data from the permeability-testing sequences conducted. Four zone-compressibility tests (see Section 6.1), 7 pulse-withdrawal tests, 11 constant-pressure-injection tests, and 11 constant-pressure-withdrawal tests were performed.

Acronyms used in the tables presented in this section are as follows:

TZ = Test Zone
TZP = Test Zone Packer
TZ1P= Test Zone 1 Packer (Triple-Packer Configuration)
TZ2P = Test Zone 2 Packer (Triple-Packer Configuration)
GZ = Guard Zone
GZP = Guard Zone Packer
CMP = Compressibility Test
CPI = Constant-Pressure-Injection Test
CPW = Constant-Pressure-Withdrawal Test
PW = Pulse-Withdrawal Test
TZ1 = Bottom-Hole Zone (Triple-Packer Configuration)
TZ2 = Middle Zone (Triple-Packer Configuration)
Zone Fluid Volume = Isolated Zone Volume+Tubing Volume-Tool Volume
AH = Argillaceous Halite

Table 3-3 summarizes the information from these tests. Complete data files and abridged tabulations of the data are stored in the SWCF under WPO #42269.

Table 3-3. Test Summary Associated with Permeability Testing

Permeability Test Sequence	Zone	Date Started (mm-dd-yy)	Test Type	Unit	Initial Pressure (MPa)	Final Pressure (MPa)	Fluid Volume Injected (+) Withdrawn (-) (mL)	Zone Length (cm)	Zone Radius (cm)	Tool Volume (mL)	Zone Fluid Volume (mL)
L4P51-C1	GZ	5-7-92	PW #1	Halite	8.826	0.011	-225	105	5.56	6586	3773
L4P51-C1	GZ	5-26-92	CPW #1	Halite	8.246	6.106	-1750	104	5.56	6586	3773
L4P51-C1	TZ	6-23-92	CPW #1	MB140	8.584	8.060	-9834	477	5.165	32308	7999
L4P51-C1	GZ	7-29-92	PW #2	Halite	7.567	0.073	-96.5	104	5.56	6586	3773
L4P51-C1	TZ	8-26-92	CPW #2	MB140	8.833	8 407	-5056	477	5.165	32308	7999
L4P51-C1	TZ	10-13-92	CPW #3	MB140	8.952	8.462	-13853	477	5.165	32308	7999
L4P51-C1	TZ	10-26-92	CPW #4	MB140	8.650	7.943	-22326	477	5.165	32308	7999
L4P51-C1	TZ	2-11-93	CMP	MB140	7.578	0.344	N/A	477	5.165	32308	7999
L4P51-C1	TZ	4-15-93	CPW #5	MB140	8.621	7.728	-143869	477	5.165	32308	7999
L4P51-C2	TZ2	3-9-94	CPW #1	Halite	7.849	7.255	-1227	104	5.56	6466	3998
L4P51-C2	TZ2	4-4-94	CPI #1	Halite	7.963	8.136	+3025	104	5.56	6466	3998
L4P51-C2	TZ2	4-21-94	CPI #2	Halite	8.080	8.885	+4677	104	5.56	6466	3998

Table 3-3 (Continued). Test Summary Associated with Permeability Testing

Permeability Test Sequence	Zone	Date Started (mm-dd-yy)	Test Type	Unit	Initial Pressure (MPa)	Final Pressure (MPa)	Fluid Volume Injected (+) Withdrawn (-) (mL)	Zone Length (cm)	Zone Radius (cm)	Tool Volume (mL)	Zone Fluid Volume (mL)
L4P51-C2	TZ2	5-12-94	CPW #2	Halite	8.346	~7.8	-466	104	5.56	6466	3998
L4P51-C2	TZ2	5-17-94	PW	Halite	8.126	4.158	-38.2	104	5.56	6466	3998
L4P51-C2	TZ2	6-14-94	CPW #3	Halite	8.133	4.206	-3469	104	5.56	6466	3998
L4P51-D1	TZ1	12-8-94	CPI #1	AH	0.006	2.323	+3389	147	5.165	7466	3692
L4P51-D1	TZ1	12-21-94	CPI #2	AH	0.004	2.325	+2519	147	5.165	7466	3692
L4P51-D1	TZ1	12-28-94	CPI #3	AH	0.025	2.245	+374	147	5.165	7466	3692
L4P51-D1	TZ1	1-18-95	CPI #4	AH	0.361	2.069	+7	147	5.165	7466	3692
L4P51-D1	TZ1	1-19-95	CPI #5	AH	2.013	4.404	+279	147	5.165	7466	3692
L4P51-D1	TZ1	1-23-95	CPI #6	AH	4.438	6.962	+193	147	5.165	7466	3692
L4P51-D2					Only initial pressure build-up data recorded						
L4P52-B	TZ	2-11-93	CPW#1	MB138	9.084	7.971	-435	141	5.08	8525	3114
L4P52-B	TZ	6-7-93	CPI #1	MB138	9.155	9.598	+219	141	5.08	8525	3114
L4P52-B	TZ	6-22-93	CPI #2	MB138	9.592	10.086	+484	141	5.08	8525	3114
L4P52-B	TZ	7-7-93	CPI #3	MB138	10.068	11.090	+1241	141	5.08	8525	3114
S1P74-A	TZ	1-25-93	CPW	Anhydrite "a"	6.420	5.523	-66	143	5.174	8399	3735
S1P74-A	TZ	8-3-93	CMP #1	Anhydrite "a"	6.542	~0.030	N/A	143	5.174	8399	3735
S1P74-A	TZ	8-3-93	CMP #2	Anhydrite "a"	~0.030	~8.8	N/A	143	5.174	8399	3735
S1P74-A	TZ	8-3-93	PW	Anhydrite "a"	~8.8	0.319	-498	143	5.174	8399	3735
S1P74-A	GZ	8-4-93	CMP #1	Halite	4.045	0.024	N/A	102	5.174	6531	2079
S1P74-B	TZ1	4-10-95	PW	MB138	9.273	8.860	-8.9	180	5.174	5654	9284
S1P74-B	TZ2	4-24-95	PW #1	AH-1	8.801	7.083	-7.1	106	5.174	6587	2375
S1P74-B	TZ2	5-13-95	PW #2	AH-1	8.814	4-977	-20.5	106	5.174	6587	2375

3.6.1 Permeability Testing in Room L4

3.6.1.1 BOREHOLE L4P51, PERMEABILITY-TESTING SEQUENCE L4P51-C1

Permeability-testing sequence L4P51-C1 took place in Room L4 in borehole L4P51. This test sequence was designed to investigate the brine permeability of MB140. Table 3-4 gives a detailed description of the events that occurred during permeability-testing sequence L4P51-C1.

Table 3-4. Permeability-Testing Sequence L4P51-C1 Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Ream borehole L4P51 to a diameter of 7.5-inch (19.05-cm) to a depth of 10 feet.	3-30-92	90	90	12:00:00
Install and grout into place a 10-foot borehole flanged collar.	3-30-92	90	90	14:00:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 11.10 m.	4-1-92	92	92	14:30:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 12.62 m.	4-2-92	93	93	12:45:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 14.10 m.	4-2-92	93	93	13:20:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 15.68 m.	4-2-92	93	93	14:20:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 17.18 m.	4-3-92	94	94	09:22:00
Suspend drilling activities until a drilling fluid that is more fully saturated with respect to NaCl can be obtained.	4-6-92	97	97	08:00:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 18.10 m.	4-14-92	105	105	13:40:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 18.61 m.	4-14-92	105	105	14:22:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 20.17 m.	4-15-92	106	106	09:45:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 21.74 m.	4-15-92	106	106	13:50:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 22.20 m.	4-15-92	106	106	14:30:00
Perform video-log of borehole L4P51 (COLOG).	4-22-92	113	113	12:00:00
Install volume displacement device in borehole L4P51 as indicated in the test-tool configuration diagram #1 (Figure 3-22).	4-23-92	114	114	14:00:00
Install multipacker test tool #33A in borehole L4P51 for permeability testing sequence L4P51-C1 as indicated in the test-tool configuration diagram #1 (Figure 3-22).	4-24-92	115	115	09:27:00
Begin data file L4P51C01.	4-24-92	115	115	09:47:37
Inflate GZP to ~ 10.3 MPa.	4-24-92	115	115	09:50:00
Inflate TZP to ~ 10.3 MPa.	4-24-92	115	115	09:55:00
Increase GZP pressure.	4-24-92	115	115	09:58:00
Increase TZP pressure.	4-24-92	115	115	10:00:00
Shut in GZ and TZ.	4-24-92	115	115	10:07:00
Increase GZP pressure.	4-27-92	118	118	06:58:00
Increase TZP pressure.	4-27-92	118	118	07:00:00
Leaky fitting on GZ.	4-28-92	119	119	07:38:00
Leaky fittings on GZ and TZ.	4-30-92	121	121	09:00:00
LVDT #1 has been disconnected since day 125.	5-6-92	127	127	08:03:00
End data file L4P51C01.	5-7-92	128	128	11:33:11
Power outage in Room L4.	5-7-92	128	128	11:45:00
Begin data file L4P51C02.	5-7-92	128	128	12:43:40
Initiate pulse-withdrawal test #1 in GZ from 8.826 to 0.011 MPa removing 225 mL of fluid.	5-7-92	128	128	12:44:00
Shut in GZ.	5-7-92	128	128	12:46:10
Depressurize TZ.	5-11-92	132	132	08:32:56
Depressurize GZ ending pulse-withdrawal test #1 in GZ.	5-11-92	132	132	08:34:24
Deflate TZP and GZP.	5-11-92	132	132	08:38:00

Table 3-4 (Continued). Permeability-Testing Sequence L4P51-C1 Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
End data file L4P51C02.	5-11-92	132	132	08:40:47
Remove multipacker test tool #33A from borehole L4P51.	5-11-92	132	132	14:00:00
Install multipacker test tool #33B in borehole L4P51 as indicated in the test-tool configuration diagram #2 (Figure 3-23).	5-13-92	134	134	09:30:00
Begin data file L4P51C03.	5-13-92	134	134	11:41:00
Inflate GZP to ~10.3 MPa.	5-13-92	134	134	11:41:30
Inflate TZP to ~ 10.3 MPa.	5-13-92	134	134	11:43:00
Shut in TZ and GZ.	5-13-92	134	134	11:45:00
Increase TZP pressure to ~ 11 MPa.	5-21-92	142	142	10:15:43
End data file L4P51C03.	5-26-92	147	147	07:53:40
Begin data file L4P51C04.	5-26-92	147	147	07:59:40
Begin constant-pressure-withdrawal test in GZ at ~ 2 MPa below GZ pressure (~ 6.1 MPa).	5-26-92	147	147	08:17:40
Increase back pressure on the DPT panel.	5-28-92	149	149	11:00:04
Leaky fitting on DPT panel.	5-29-92	150	150	09:34:00
Increase back pressure on the DPT panel.	6-2-92	154	154	09:36:00
Increase back pressure on the DPT panel.	6-4-92	156	156	09:46:00
Increase back pressure on the DPT panel.	6-5-92	157	157	07:33:00
Shut in GZ from DPT panel, terminating the constant-pressure-withdrawal test.	6-8-92	160	160	08:17:00
End data file L4P51C04.	6-10-92	162	162	08:29:05
Begin data file L4P51C05.	6-10-92	162	162	08:46:24
Begin constant-pressure-withdrawal test #1 in TZ at ~ 0.5 MPa below TZ pressure (~ 8.0 MPa).	6-23-92	175	175	08:20:10
Shut in TZ from DPT panel terminating the constant-pressure-withdrawal test #1 in TZ.	6-26-92	178	178	12:36:30
End data file L4P51C05.	6-29-92	181	181	12:16:13
Begin data file L4P51C06.	6-29-92	181	181	12:20:00
Open GZP to accumulator.	7-8-92	190	190	12:03:03
DAS running on unconditioned power since day 191.	7-13-92	195	195	10:15:00
Increase TZP pressure.	7-16-92	198	198	12:15:37
Open TZP and GZP to same accumulator.	7-16-92	198	198	12:19:37
Initiate pulse-withdrawal test #2 in GZ from 7.567 to 0.073 MPa, removing 96.5 mL of fluid.	7-29-92	211	211	08:00:29
Deflate GZP.	7-29-92	211	211	08:02:44
Inflate GZP to 10.898 MPa.	7-29-92	211	211	08:08:29
Increase GZP pressure.	7-29-92	211	211	08:19:14
Open GZP to accumulator.	7-29-92	211	211	08:25:14
Shut in GZ.	7-29-92	211	211	09:00:00
End data file L4P51C06 terminating pulse-withdrawal test #2 in GZ.	8-14-92	227	227	07:57:06

Table 3-4 (Continued). Permeability-Testing Sequence L4P51-C1 Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Begin data file L4P51C07.	8-14-92	227	227	08:31:00
End data file L4P51C07.	8-24-92	237	237	05:42:52
Begin data file L4P51C08.	8-24-92	237	237	12:41:28
Begin constant-pressure-withdrawal test #2 in TZ at ~ 0.5 MPa below TZ pressure (~ 8.4 MPa).	8-26-92	239	239	08:41:37
Decrease back pressure on DPT panel.	8-28-92	341	241	10:04:00
Decrease back pressure on DPT panel.	8-31-92	244	244	08:43:00
Leaky fitting on DPT panel.	8-31-92	244	244	08:45:00
Shut in TZ from DPT panel terminating the constant-pressure withdrawal test #2 in TZ.	9-1-92	245	245	09:54:00
End data file L4P51C08.	9-8-92	252	252	07:52:01
Begin data file L4P51C09.	9-8-92	252	252	09:51:12
End data file L4P51C09.	9-21-92	265	265	07:42:34
Begin data file L4P51C10.	10-2-92	276	276	09:00:35
End data file L4P51C10.	10-8-92	282	282	11:21:32
Begin data file L4P51C11.	10-8-92	282	282	13:11:06
Begin constant-pressure-withdrawal test #3 in TZ at ~ 0.5 MPa below TZ pressure (~ 8.4 MPa.)	10-13-92	287	287	09:04:36
Increase back pressure on DPT panel.	10-21-92	295	295	12:30:00
Decrease the rate of gas coming from the column.	10-22-92	296	296	12:21:30
Increase back pressure on DPT panel.	10-23-92	297	297	11:50:00
Decrease back pressure on DPT panel to ~ 7.4 MPa terminating the constant-pressure-withdrawal test #3 in TZ and beginning the constant-pressure-withdrawal test #4 in TZ.	10-26-92	300	300	09:19:07
Shut in TZ from DPT panel terminating the constant-pressure-withdrawal test #4 in TZ.	11-6-92	311	311	09:52:38
End data file L4P51C11.	11-6-92	311	311	14:25:28
Begin data file L4P51C12.	11-6-92	311	311	14:29:45
End data file L4P51C12.	1-8-93	8	374	04:21:46
Begin data file L4P51C13.	1-8-93	8	374	09:44:47
Possible leaky fitting on DPT panel.	1-13-93	13	379	08:00:00
Perform compressibility test in TZ dropping the pressure in steps from 7.578 to 0.344 MPa.	2-11-93	42	408	12:12:00
Depressurize TZ terminating the TZ compressibility test.	2-11-93	42	408	12:12:18
Depressurize GZ.	2-11-93	42	408	12:16:48
Deflate TZP.	2-11-93	42	408	12:21:18
Deflate GZP.	2-11-93	42	408	12:23:18
Inflate TZP to ~ 10.3 MPa.	2-11-93	42	408	12:57:15
Inflate GZP to ~ 10.3 MPa and increase TZP pressure.	2-11-93	42	408	12:59:15
Increase GZP pressure.	2-11-93	42	408	13:03:30
Open TZP to accumulator.	2-11-93	42	408	13:04:30

Table 3-4 (Continued). Permeability-Testing Sequence L4P51-C1 Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Open GZP to accumulator.	2-11-93	42	408	13:04:45
Shut in TZ.	2-11-93	42	408	13:10:46
Shut in GZ.	2-11-93	42	408	13:13:31
End data file L4P51C13.	3-9-93	68	434	11:24:11
Begin data file L4P51C14.	3-9-93	68	434	11:32:04
End data file L4P51C14.	4-14-93	104	470	07:08:13
Begin data file L4P51C15.	4-14-93	104	470	10:16:33
Begin constant-pressure-withdrawal test #5 in TZ at ~ 1 MPa below TZ pressure (~ 7.7 MPa) and obtain pressurized brine sample #13105-1.	4-15-93	105	471	09:50:00
Shut in TZ from DPT panel due to overfull fluid reservoir.	4-19-93	109	475	10:02:22
Resume constant-pressure-withdrawal test #5 in TZ.	4-19-93	109	475	11:45:00
Shut in TZ from DPT panel due to plugged flow line.	4-21-93	111	477	12:52:14
Resume constant-pressure-withdrawal test #5 in TZ.	4-21-93	111	477	13:22:28
Shut in TZ from DPT panel due to plugged flow line.	4-27-93	117	483	12:10:00
Resume constant-pressure-withdrawal test #5 in TZ.	4-27-93	117	483	12:16:56
Shut in TZ from DPT panel due to plugged flow line.	5-7-93	127	493	12:00:00
End data file L4P51C15.	5-10-93	130	496	11:32:21
Begin data file L4P51C16.	5-10-93	130	496	11:35:40
Resume constant-pressure-withdrawal test #5 in TZ.	5-10-93	130	496	11:40:00
Decrease back pressure on DPT panel.	5-10-93	130	496	14:26:00
Decrease back pressure on DPT panel.	5-13-93	133	499	14:08:00
Decrease back pressure on DPT panel.	5-17-93	137	503	08:20:00
Obtain pressurized brine sample #13152-1 from TZ (cylinder flushed with argon).	6-1-93	152	518	08:58:00
Obtain pressurized brine sample #13167-1 from TZ (cylinder flushed with argon).	6-25-93	176	542	11:13:53
Obtain pressurized brine sample #13176-1 from TZ (cylinder flushed with argon).	7-2-93	183	549	10:53:41
Obtain pressurized brine sample #13183-1 from TZ (cylinder flushed with argon).	7-9-93	190	556	10:31:52
Obtain pressurized brine sample #13190-1 from TZ (cylinder flushed with argon).	7-15-93	196	562	13:22:44
End data file L4P51C16.	8-6-93	218	584	07:43:00
Begin data file L4P51C17.	8-6-93	218	584	07:47:24
Obtain pressurized brine sample #13258-1 from TZ (cylinder flushed with argon).	9-15-93	258	624	08:05:33
Decrease back pressure on DPT panel.	9-23-93	266	632	07:37:47
End data file L4P51C17.	9-23-93	266	632	07:46:18
Obtain pressurized brine sample #13274-1 from TZ (cylinder flushed with argon).	10-1-93	274	640	08:59:30
Decrease back pressure on DPT panel.	10-6-93	279	645	07:02:00
Obtain pressurized brine sample #13281-1 from TZ (cylinder flushed with argon).	10-8-93	281	647	09:17:00
Decrease back pressure on DPT panel.	10-11-93	284	650	08:45:00
Power outage in Room L4 since day 284.	10-12-93	285	651	13:52:00

Table 3-4 (Continued). Permeability-Testing Sequence L4P51-C1 Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Decrease back pressure on DPT panel.	10-15-93	288	654	09:53:00
Decrease back pressure on DPT panel.	10-18-93	291	657	08:08:00
Obtain pressurized brine sample #13294-1 from TZ (cylinder flushed with argon).	10-21-93	294	660	09:00:00
Begin data file L4P51C18.	10-22-93	295	661	08:38:02
Obtain pressurized brine sample #13302-1 from TZ (cylinder flushed with argon).	10-29-93	302	668	08:28:25
Increase back pressure on DPT panel.	10-29-93	302	668	08:38:07
Decrease back pressure on DPT panel.	11-3-93	307	673	10:15:32
Obtain pressurized brine sample #13308-1 from TZ (cylinder flushed with argon).	11-4-93	308	674	09:36:44
Decrease back pressure on DPT panel.	11-5-93	309	675	10:11:00
DAS powered by generator.	11-10-93	314	680	09:27:53
Shut in TZ from DPT panel terminating the constant-pressure-withdrawal test #5 in TZ.	11-11-93	315	681	08:58:00
Depressurize TZ.	11-11-93	315	681	09:04:00
Depressurize GZ (~ 100 mL of brine removed).	11-11-93	315	681	09:09:00
Deflate TZP.	11-11-93	315	681	09:15:00
Deflate GZP.	11-11-93	315	681	09:18:00
End data file L4P51C18.	11-11-93	315	681	09:26:00
Remove multipacker test tool #33B from borehole L4P51 and terminate permeability testing sequence L4P51-C1.	11-11-93	315	681	12:00:00

Figures 3-34 through 3-40 illustrate the zone pressures, packer pressures, zone temperature, axial-LVDT displacement, radial-LVDT displacement, fluid production during constant-pressure-flow tests, and test-zone compressibility, respectively, for permeability-testing sequence L4P51-C1. It should be noted that Figure 3-39 (Fluid production during constant-pressure -flow tests in permeability testing sequence L4P51-C1) consists of two parts (Figures 3-39a and 3-39b). Copies of the video-log associated with testing sequence L4P51-C1 identified in Table 3-4 are provided in the SWCF under WPO #45907.

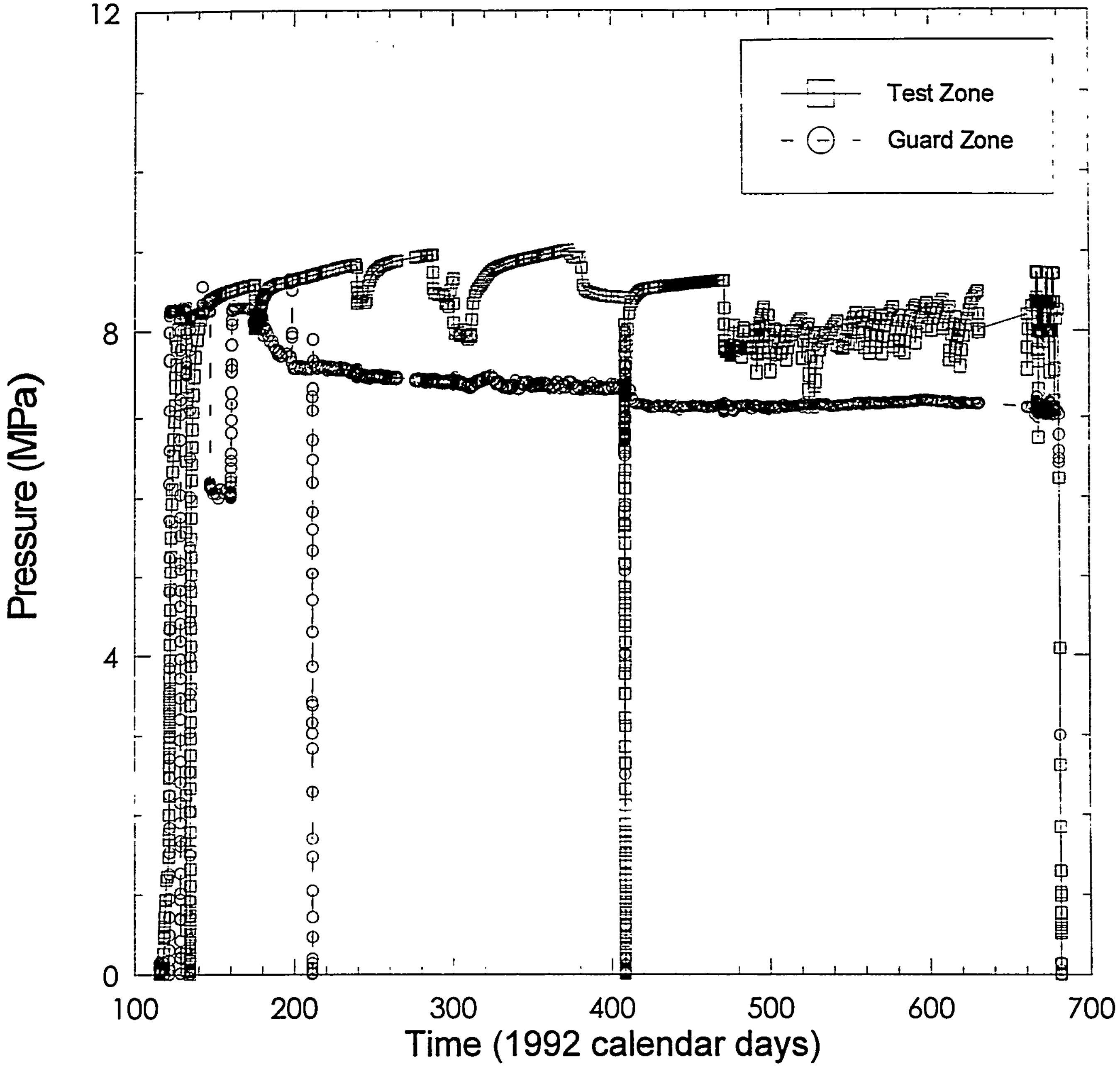


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Figure 3-34. Zone pressures during permeability-testing sequence L4P51-C1.

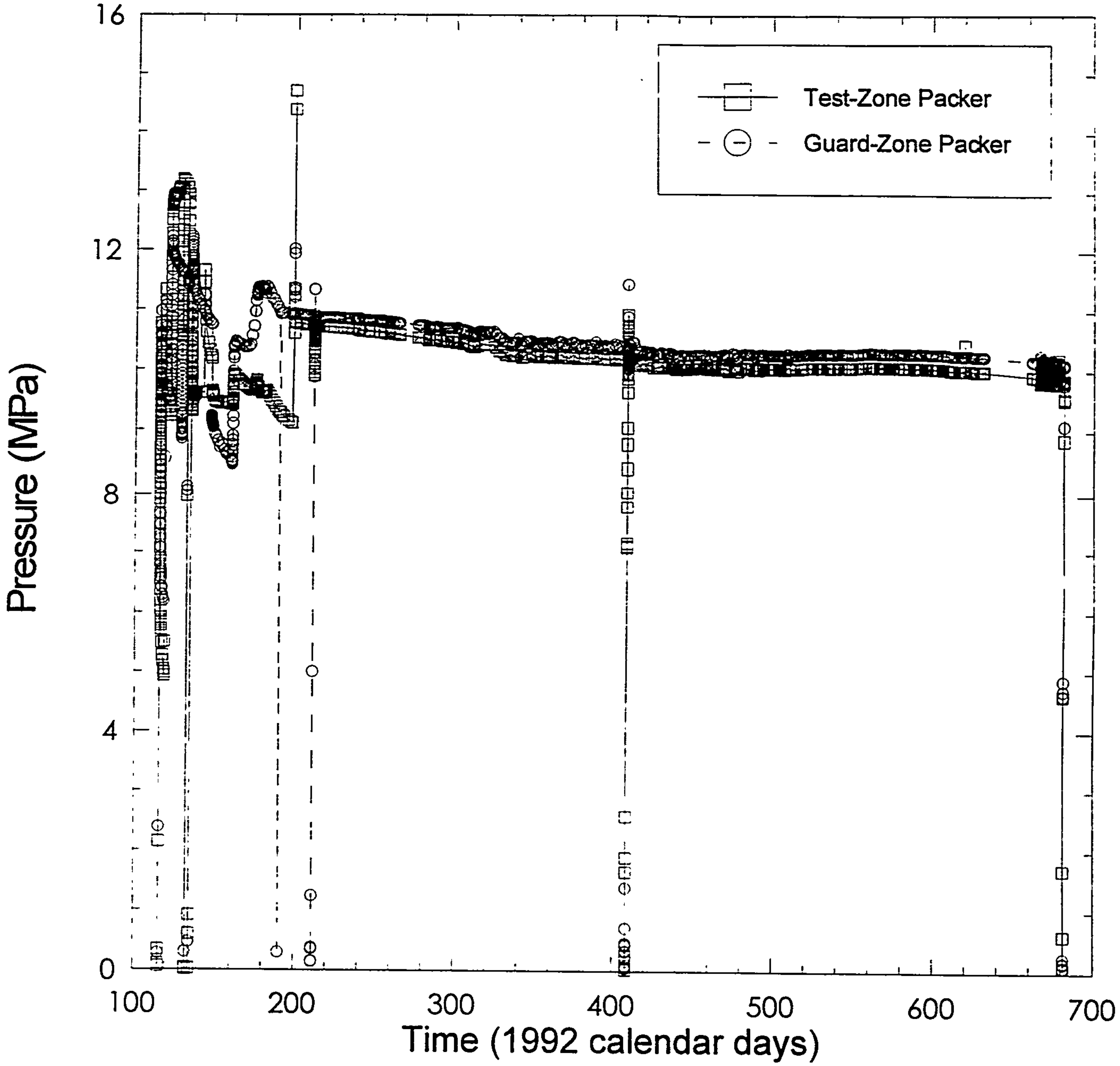

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Figure 3-35. Packer pressures during permeability-testing sequence L4P51-C1.

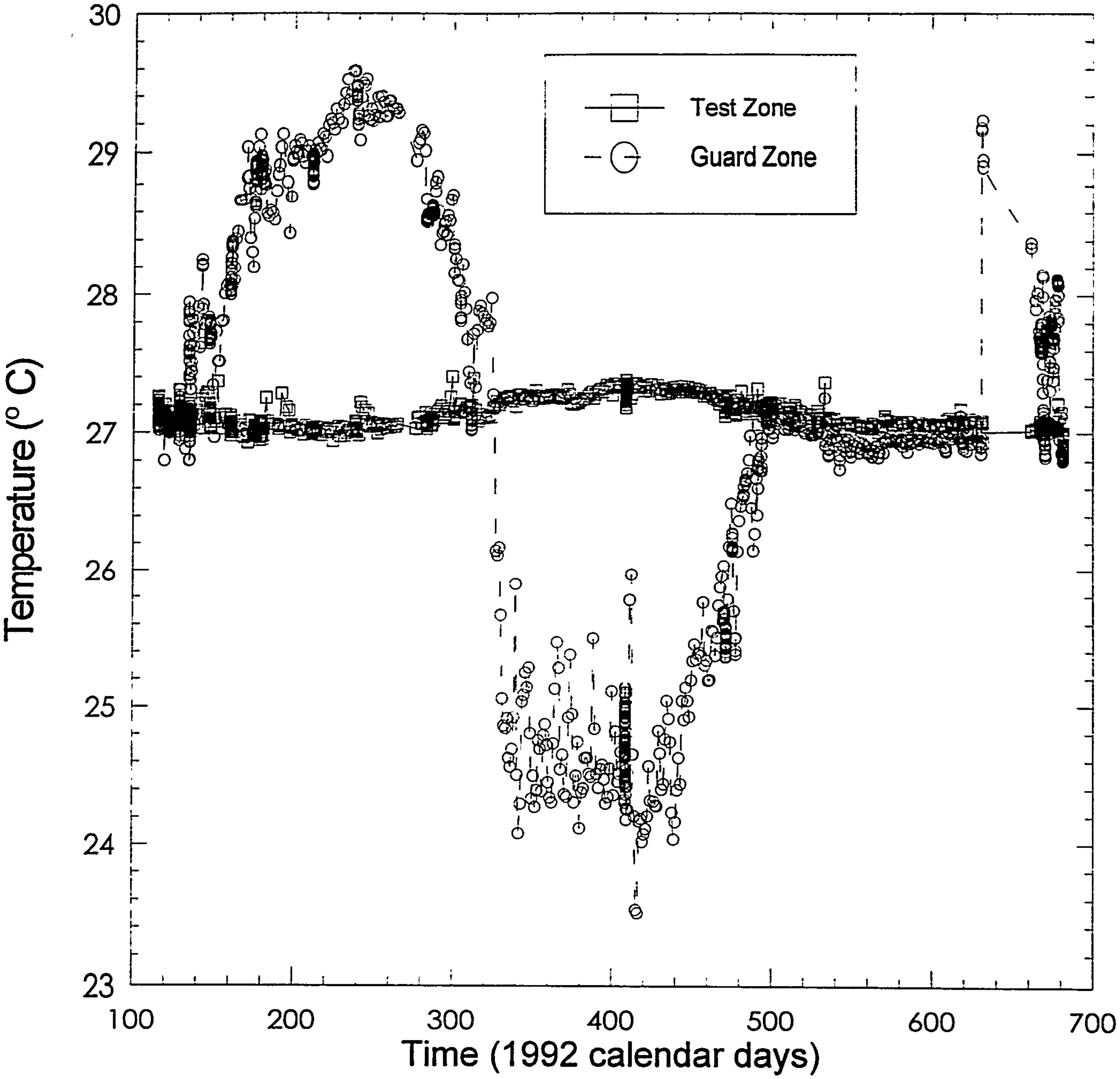

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Figure 3-36. Zone temperatures during permeability-testing sequence L4P51-C1.

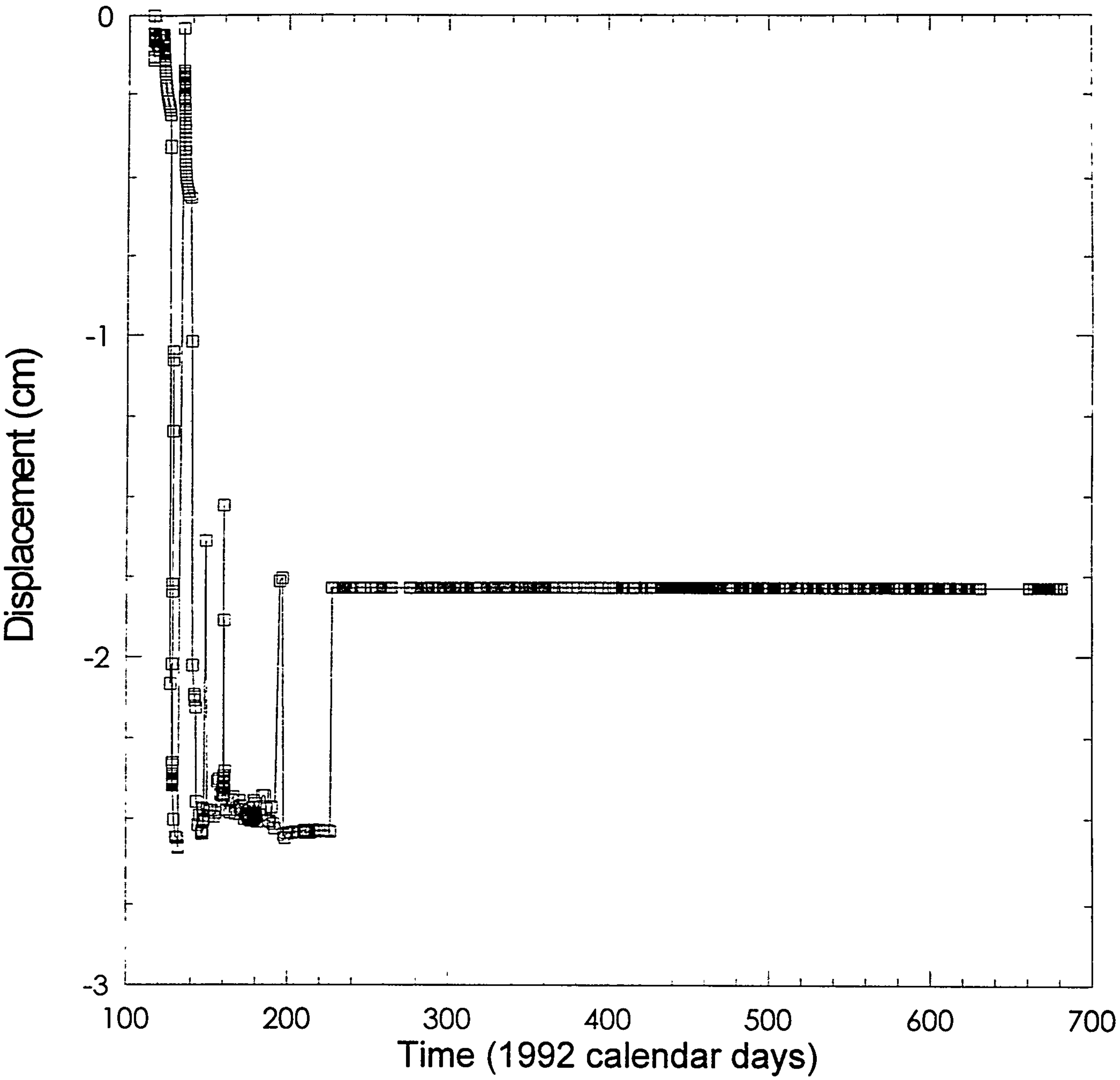

Figure 3-37. Axial-LVDT displacement during permeability-testing sequence L4P51-C1.

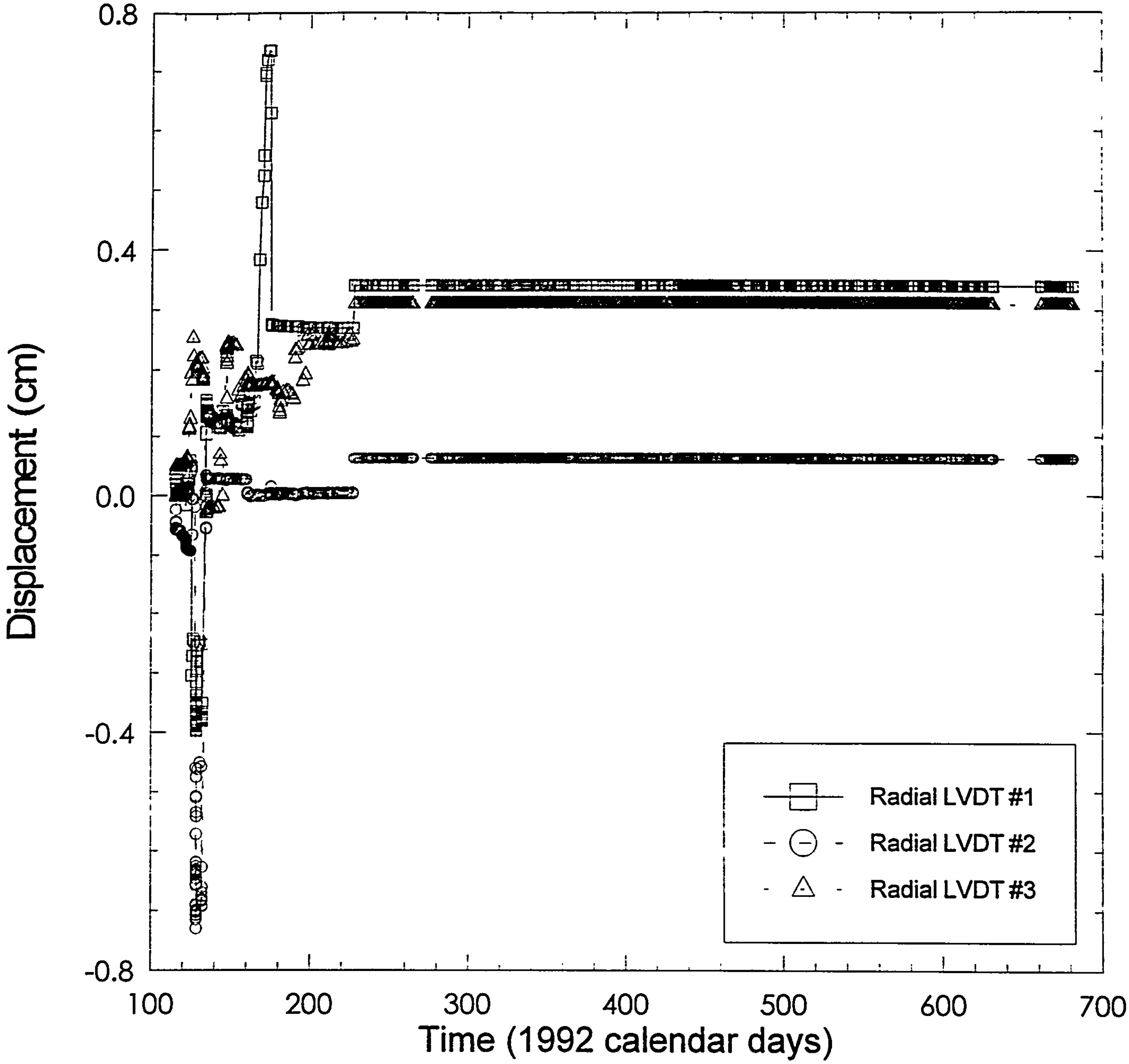

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Figure 3-38. Radial-LVDT displacement during permeability-testing sequence L4P51-C1.

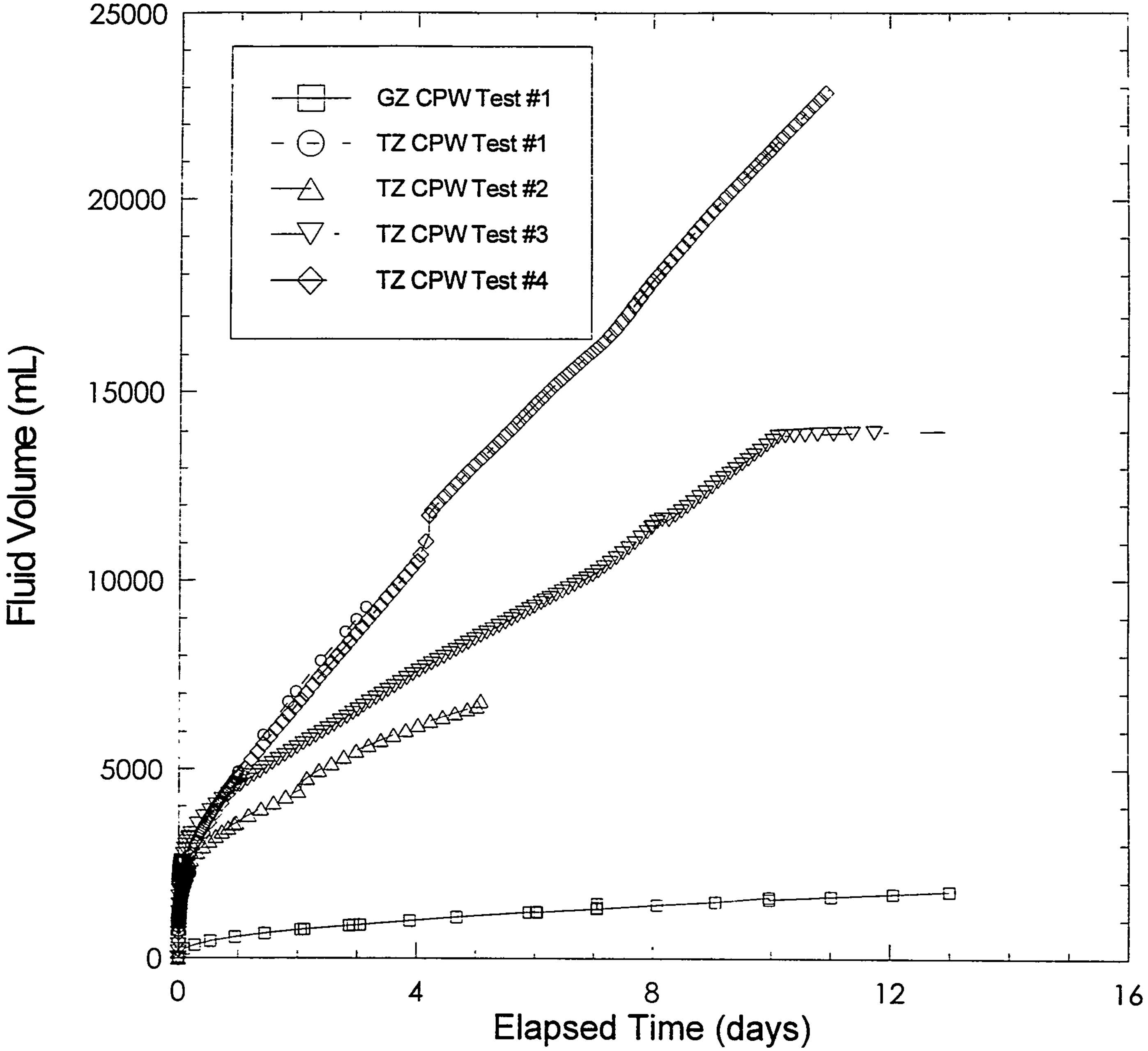

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Figure 3-39a. Fluid production during constant-pressure-flow tests in permeability-testing sequence L4P51-C1.

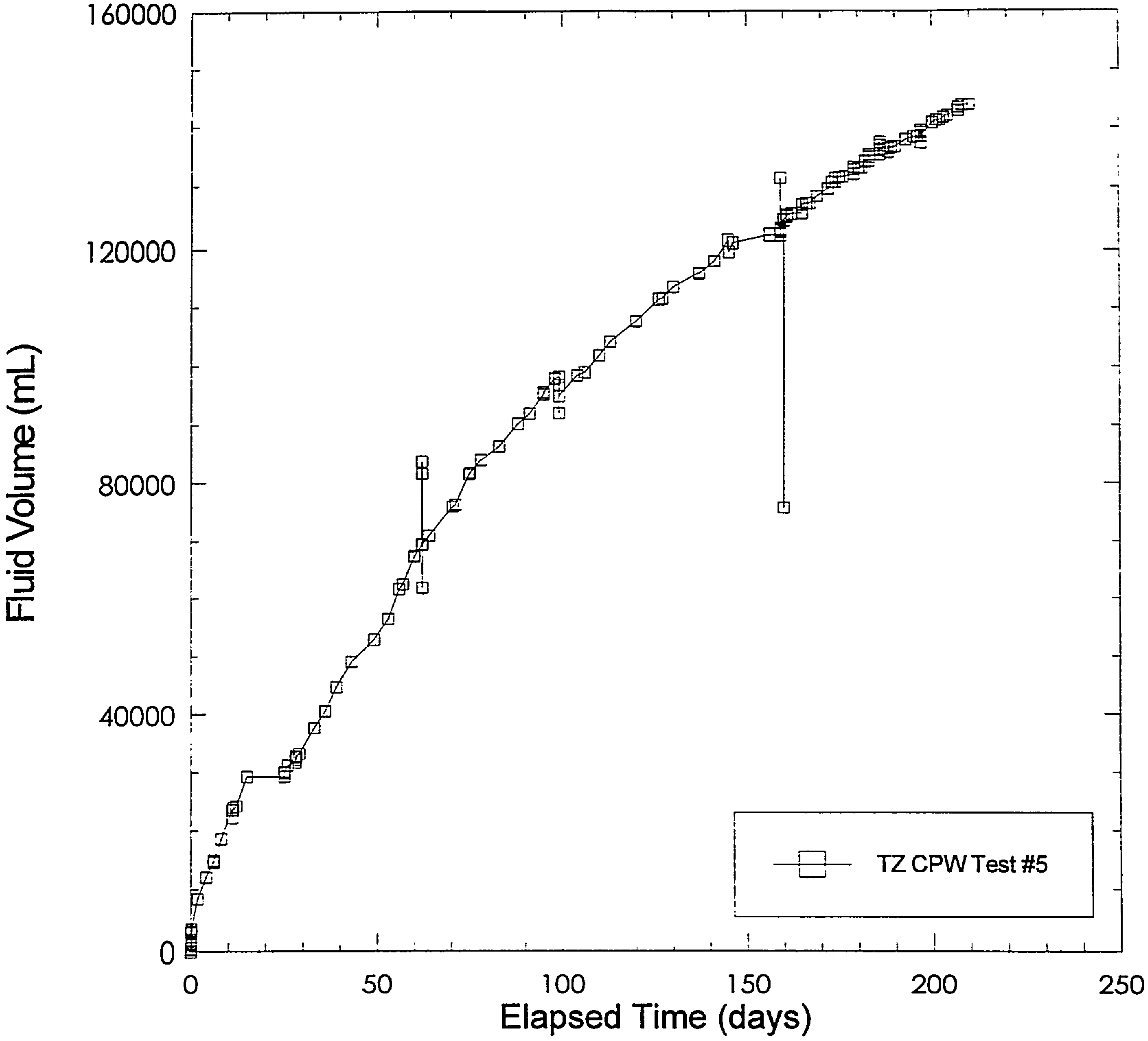

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Figure 3-39b. Fluid production during constant-pressure-flow tests in permeability-testing sequence L4P51-C1 (continued).

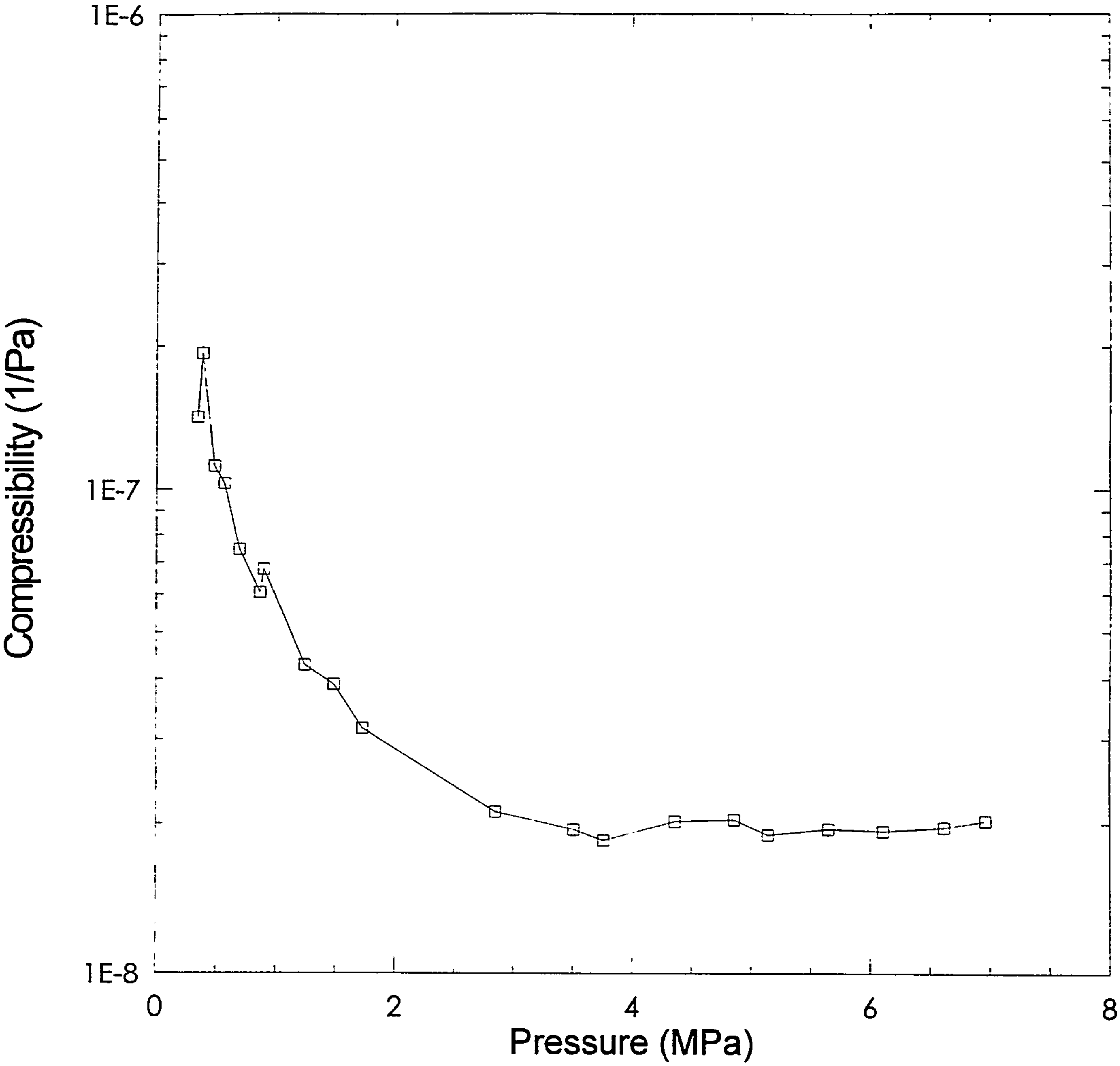

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Figure 3-40. Test-zone compressibility as measured during permeability-testing sequence L4P51-C1.

Table 3-5 indicates the equipment that was used and the duration that each instrument was used during permeability-testing sequence L4P51-C1.

Table 3-5. Permeability-Testing Sequence L4P51-C1 Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	4-24-92	11-11-93
DCU (HP3497A)	N/A	2629a21996	4-24-92	10-2-92
DCU (HP3497A)	N/A	2629a21990	10-2-92	3-25-93
DCU (HP3497A)	N/A	2629a22040	3-25-93	9-6-93
DCU (HP3497A)	N/A	2514a17149	9-6-93	9-22-93
DCU (HP3497A)	N/A	2023a01688	9-22-93	11-11-93
Transducer (Druck PDCR 830)	Guard Zone	246914	4-24-92	11-11-93
Transducer (Druck PDCR 10/D)	Test Zone Packer	211695	4-24-92	11-11-93
Transducer (Druck PDCR 830)	Guard Zone Packer	246920	4-24-92	11-11-93
Transducer (Druck PDCR 10/D)	Test Zone	211690	4-24-92	11-11-93
Transducer (Druck PDCR 830)	DPT Panel	246910	5-26-92	6-10-92
Transducer (Druck PDCR 910)	DPT Panel	322427	8-24-92	9-8-92
Transducer (Druck PDCR 910)	DPT Panel	322427	10-8-92	11-6-93
Transducer (Druck PDCR 910)	DPT Panel	322427	10-22-93	11-11-93
LVDT (Trans-Tek 241)	N/A	R04	4-24-92	5-11-92
LVDT (Trans-Tek 241)	N/A	R16	4-24-92	5-11-92
LVDT Trans-Tek 241)	N/A	R17	4-24-92	5-11-92
LVDT (Trans-Tek 245)	N/A	A02	4-24-92	5-11-92
LVDT (Trans-Tek 241)	N/A	R05	5-13-92	10-22-93
LVDT (Trans-Tek 241)	N/A	R11	5-13-92	10-22-93
LVDT (Trans-Tek 241)	N/A	R12	5-13-92	10-22-93
LVDT (Trans-Tek 245)	N/A	A01	5-13-92	10-22-93
Thermocouple (Type E)	Test Zone	1	4-24-92	11-11-93

Table 3-5 (Continued). Permeability-Testing Sequence L4P51-C1 Equipment

Equipment	Location	Serial #	Installed	Removed
Thermocouple (Type E)	Guard Zone	2	4-24-92	11-11-93
Injection Column	N/A	76	6-23-92	4-14-93
Injection Column	N/A	77	5-26-92	4-14-93
Injection Column	N/A	38	4-14-93	11-11-93
Injection Column	N/A	88	4-14-93	11-11-93
DPT (Rosemount 1151DP)	N/A	1409226	5-20-92	10-12-92
DPT (Rosemount 1151DP)	N/A	1389938	10-12-92	4-12-93
DPT (Rosemount 1151DP)	N/A	1140864	4-12-93	11-11-93

* Installed dates for injection columns refer to dates of initial use rather than date installed.

3.6.1.2 BOREHOLE L4P51, PERMEABILITY-TESTING SEQUENCE L4P51-C2

Permeability-testing sequence L4P51-C2 took place in Room L4 in borehole L4P51. This test sequence was designed to investigate the brine permeability of a halite directly above MB140. Table 3-6 gives a detailed description of the events that occurred during the permeability-testing sequence L4P51-C2.

Table 3-6. Permeability-Testing Sequence L4P51-C2 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Install 4.63 meter volume-displacement device in borehole L4P51 as indicated in the test-tool configuration diagram (Figure 3-24).	11-16-93	320	320	13:18:00
Install multipacker test tool #41 in borehole L4P51 as indicated in the test-tool configuration diagram for permeability-testing sequence L4P51-C2 (Figure 3-24).	11-17-93	321	321	14:00:00
Begin data file L4P51C19.	11-18-93	322	322	12:58:00
Inflate TZ1P to ~ 10.3 MPa.	11-18-93	322	322	13:08:20
Inflate TZ2P to ~ 10.3 MPa.	11-18-93	322	322	13:10:52
Inflate GZP to ~ 10.3 MPa.	11-18-93	322	322	13:13:20
Shut in TZ1.	11-18-93	322	322	13:16:01
Shut in TZ2 and GZ.	11-29-93	333	333	08:58:00
Increase GZ pressure to ~ 4.1 MPa.	12-1-93	335	335	09:59:00
Increase GZ pressure to 5.888 MPa.	12-2-93	336	336	11:48:20
Increase GZP pressure to 11.209 MPa.	12-2-93	336	336	11:50:00

Table 3-6 (Continued). Permeability-Testing Sequence L4P51-C2 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Increase GZP pressure to ~ 12 MPa.	12-8-93	342	342	11:26:27
Open GZ to accumulator at ~ 6 MPa.	12-8-93	342	342	11:30:00
Leaky fitting on GZP.	12-15-93	349	349	09:20:56
Replace gage on GZP.	12-16-93	350	350	09:31:49
Remove gage from GZP.	12-17-93	351	351	08:12:00
Increase GZP pressure.	12-20-93	354	354	09:45:00
End data file L4P51C19.	1-19-94	19	384	12:23:27
Begin data file L4P51C20.	1-19-94	19	384	12:27:49
Open TZ2P to accumulator at 11.175 MPa.	2-8-94	39	404	11:11:00
End data file L4P51C20.	2-24-94	55	420	10:55:13
Begin data file L4P51C21.	2-24-94	55	420	11:07:33
End data file L4P51C21.	3-7-94	66	431	11:11:22
Begin data file L4P51C22.	3-8-94	67	432	12:11:46
Replace junction box on DAS to allow for the use of a DPT.	3-8-94	67	432	12:14:00
Begin constant-pressure-withdrawal test #1 in TZ2 at ~ 0.5 MPa below TZ2 pressure (~ 7.3 MPa).	3-9-94	68	433	11:03:45
Shut in TZ2 from DPT panel terminating constant-pressure-withdrawal test #1 in TZ2.	3-18-94	77	442	10:31:05
End data file L4P51C22.	3-30-94	89	454	08:21:50
Begin data file L4P51C23.	3-30-94	89	454	10:21:58
Begin constant-pressure-injection test #1 in TZ2 at ~ 0.5 MPa above TZ2 pressure (~ 8.4 MPa).	4-4-94	94	459	09:17:00
Shut in GZP from accumulator.	4-7-94	97	462	12:13:00
Open GZP to accumulator at 11.774 MPa.	4-21-94	111	476	08:46:00
Terminate constant-pressure-injection test #1 in TZ2 and end data file L4P51C23.	4-21-94	111	476	12:56:09
Begin data file L4P51C24.	4-21-94	111	476	12:59:10
Begin constant-pressure-injection test #2 in TZ2 at ~ 1 MPa above TZ2 pressure (~ 8.9 MPa).	4-21-94	111	476	13:00:33
Shut in TZ2 from DPT panel terminating constant-pressure-injection test #2 in TZ2.	4-27-94	117	482	10:58:35
DAS was not functioning properly upon arrival (problem occurred on day 117).	4-29-94	119	484	08:31:00
End data file L4P51C24.	4-29-94	119	484	08:41:44
Begin data file L4P51C25.	4-29-94	119	484	09:05:00
End data file L4P51C25.	5-10-94	130	495	11:38:35
Shut in all zones and packers to replace transducers.	5-10-94	130	495	11:52:00
Begin data file L4P51C26.	5-10-94	130	495	14:04:27
Open all zones and packers to new transducers.	5-10-94	130	495	14:06:00
Open TZ1P to accumulator at 11.985 MPa.	5-12-94	132	497	12:40:00
Begin constant-pressure-withdrawal test #2 in TZ2 at ~ 0.5 MPa below TZ2 pressure (~ 7.8 MPa).	5-12-94	132	497	12:47:10

Table 3-6 (Continued). Permeability-Testing Sequence L4P51-C2 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Shut in TZ2 from DPT panel terminating constant-pressure-withdrawal test #2 in TZ2.	5-12-94	132	497	13:44:45
Initiate pulse-withdrawal test in TZ2 dropping pressure from 8.126 to 4.158 MPa removing 38.2 mL of fluid.	5-17-94	137	502	09:14:47
End data file L4P51C26.	6-2-94	153	518	12:08:21
Begin data file L4P51C27.	6-2-94	153	518	12:42:23
Terminate pulse-withdrawal test in TZ2 and end data file L4P51C27.	6-6-94	157	522	10:21:12
Begin data file L4P51C28.	6-6-94	157	522	10:49:54
Begin constant-pressure-withdrawal test #3 in TZ2 at ~ 4 MPa below TZ2 pressure (~ 4.1 MPa) using a pressure controller.	6-14-94	165	530	11:48:15
Shut down power to everything except the pressure controller and the reference transducer in order to maintain test conditions during a power outage.	6-17-94	168	533	08:52:00
Power supplied to entire system.	6-20-94	171	536	09:22:00
Fluid reservoir level altered.	6-23-94	174	539	~ 10:30:00
Return fluid reservoir level to approximate original position.	6-23-94	174	539	13:10:00
End data file L4P51C28.	6-27-94	178	543	11:11:03
Begin data file L4P51C29.	6-27-94	178	543	11:15:46
Shut in TZ2 from DPT panel terminating constant-pressure-withdrawal test #3 in TZ2.	7-6-94	187	552	08:06:25
End data file L4P51C29.	7-18-94	199	564	10:14:19
Begin data file L4P51C30.	7-18-94	199	564	10:35:02
End data file L4P51C30.	7-19-94	200	565	09:01:06
Depressurize all zones.	7-25-94	206	571	09:54:00
Deflate all packers.	7-25-94	206	571	10:03:00
Remove multipacker test tool #41 from borehole L4P51 terminating permeability testing sequence L4P51-C2.	7-25-94	206	571	14:00:00
Perform video-log of borehole L4P51.	7-26-94	207	572	13:03:00

Figures 3-41 through 3-44 illustrate the zone pressures, packer pressures, test-zone temperature, and fluid production during constant-pressure-flow tests, respectively, for permeability-testing sequence L4P51-C2.

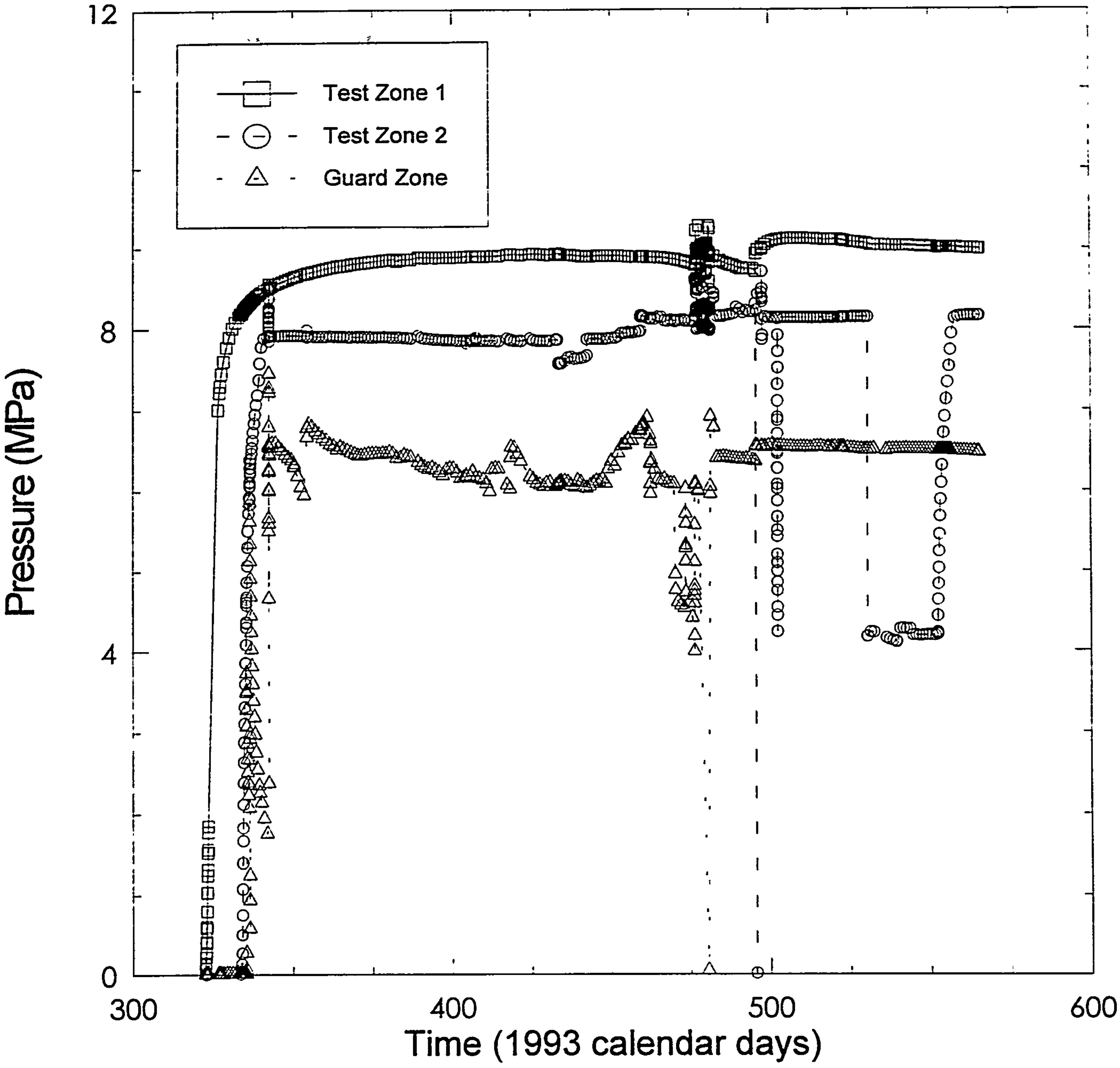

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Figure 3-41. Zone pressures during permeability-testing sequence L4P51-C2.

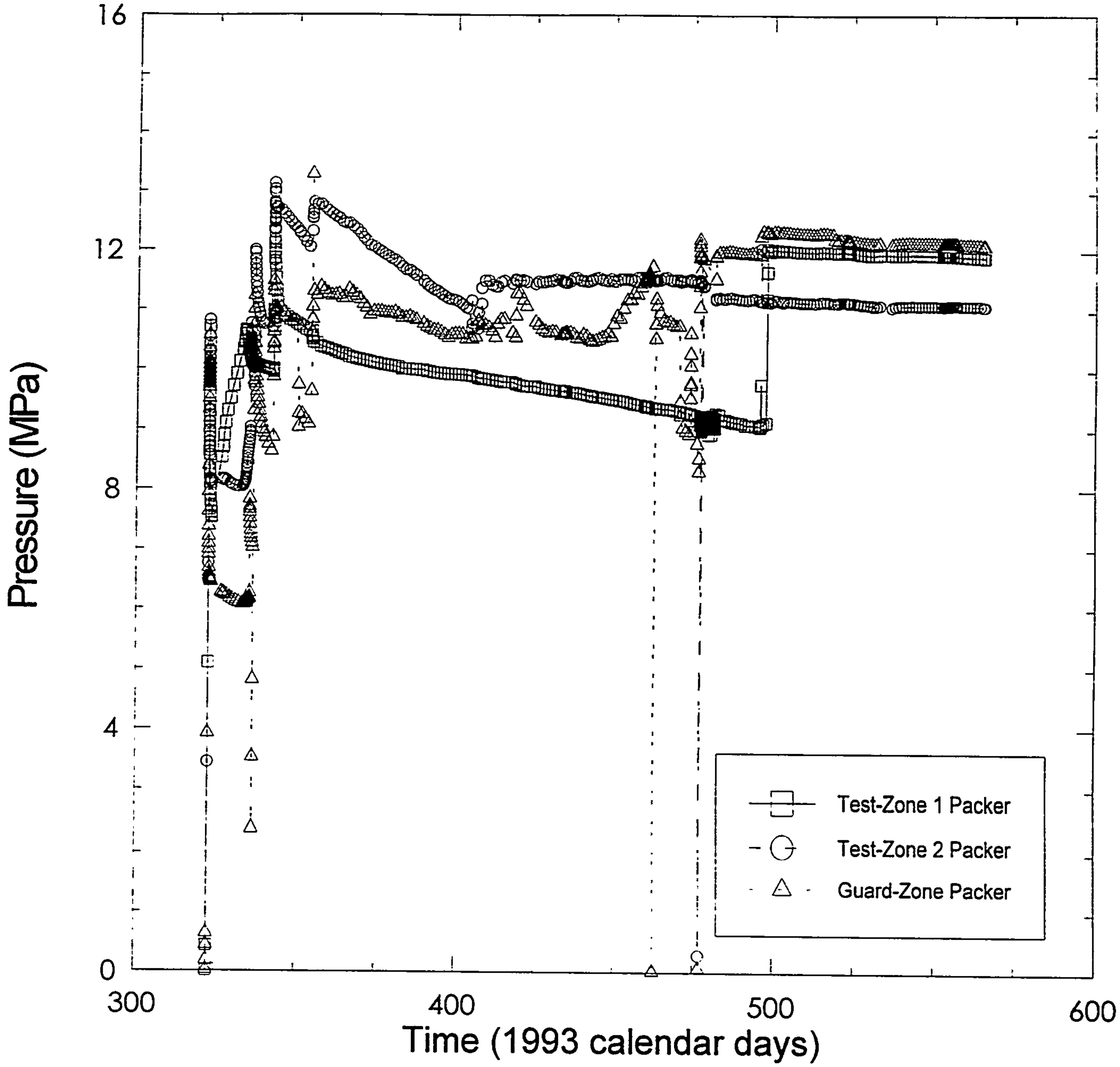

Figure 3-42. Packer pressures during permeability-testing sequence L4P51-C2.

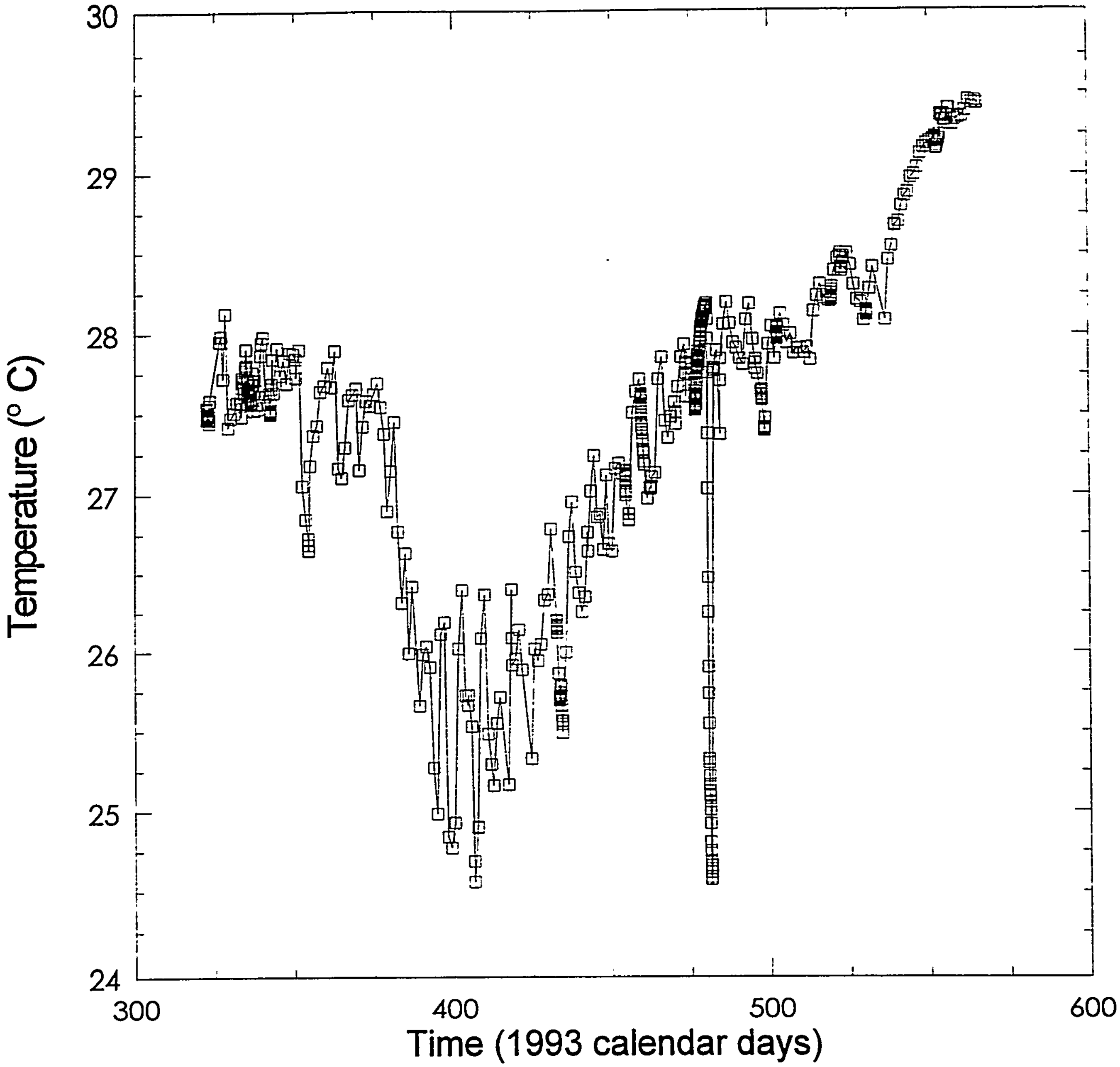

Figure 3-43. Test-zone 1 temperature during permeability-testing sequence L4P51-C2.

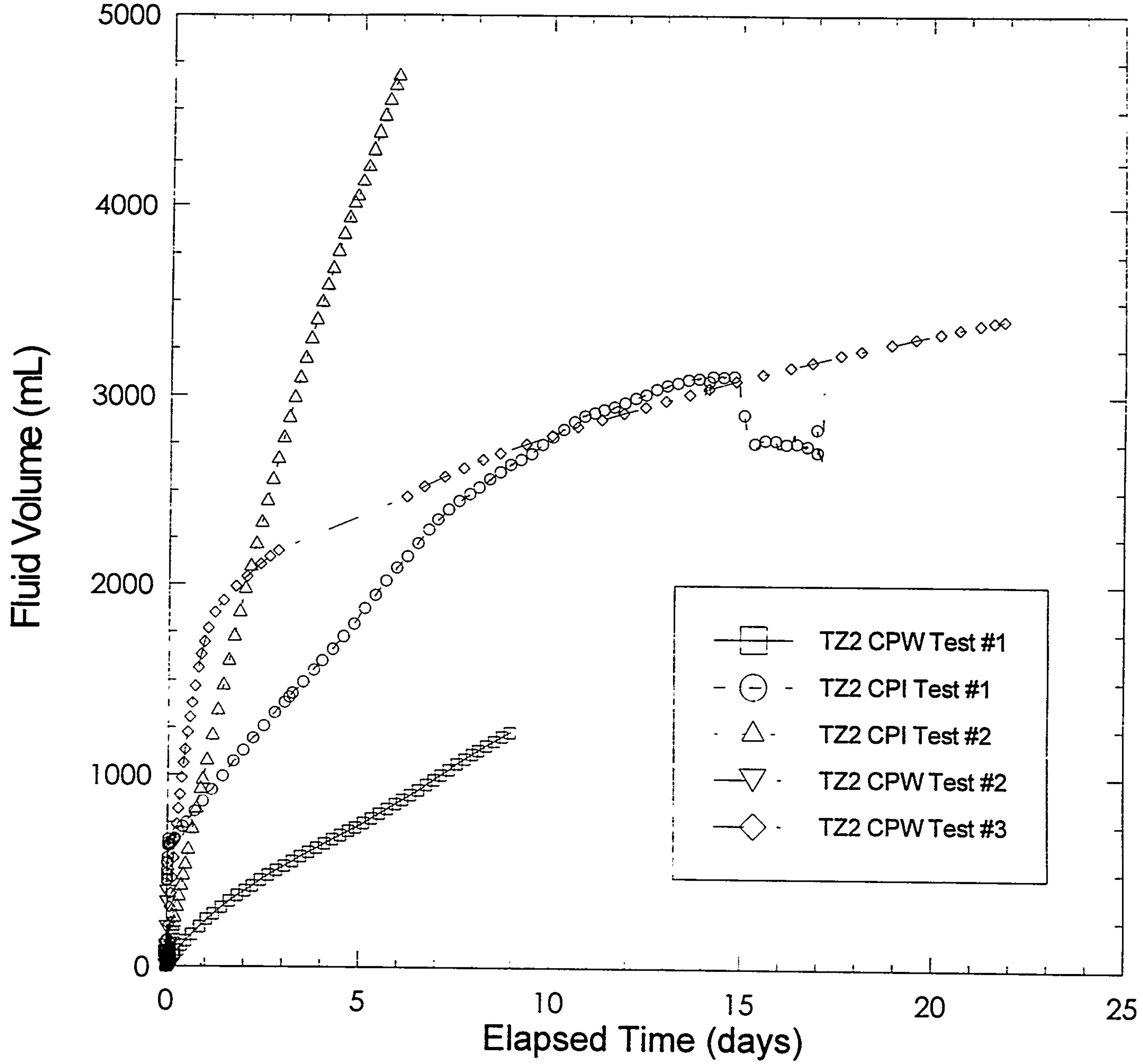

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Figure 3-44. Fluid production during constant-pressure-flow tests in permeability-testing sequence L4P51-C2.

Table 3-7 indicates the equipment that was used and the duration that each instrument was used during permeability-testing sequence L4P51-C2.

Table 3-7. Permeability-Testing Sequence L4P51-C2 Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	11-18-93	7-19-94
DCU (HP3497A)	N/A	2629a21990	11-18-93	3-7-94
DCU (HP3497A)	N/A	2023a01688	3-7-94	5-10-94
DCU (HP3497A)	N/A	2629a21996	5-10-94	7-19-94
Transducer (Druck PDCR 910)	Test Zone 2 Packer	308152	11-18-93	7-19-94
Transducer (Druck PDCR 830)	Test Zone 1 Packer	246919	11-18-93	7-19-94
Transducer (Druck PDCR 830)	Test Zone 2	246910	11-18-93	5-10-94
Transducer (Druck PDCR 830)	Test Zone 1	246912	11-18-93	5-10-94
Transducer (Druck PDCR 910)	Guard Zone	308143	11-18-93	5-10-94
Transducer (Druck PDCR 910)	Guard Zone Packer	322423	11-18-93	5-10-94
Transducer (Druck PDCR 910)	DPT Panel	321768	3-4-94	3-30-94
Transducer (Druck D930-18)	DPT Panel	609364	3-30-94	6-18-94
Transducer (Druck D930-18)	Test Zone 1	609374	5-10-94	7-19-94
Transducer (Druck D930-18)	Test Zone 2	609367	5-10-94	7-19-94
Transducer (Druck D930-18)	Guard Zone	609366	5-10-94	7-19-94
Transducer (Druck D930-18)	Guard Zone Packer	609369	5-10-94	7-19-94
Transducer (Druck PDCR 910)	Pressure Controller	322427	6-2-94	6-18-94
Thermocouple (Type E)	Test Zone 1	1	11-18-93	7-19-94
Injection Column	N/A	264	3-4-94	6-18-94
Injection Column	N/A	265	3-4-94	6-3-94
Injection Column	N/A	88	6-3-94	6-18-94

Table 3-7 (Continued). Permeability-Testing Sequence L4P51-C2 Equipment

Equipment	Location	Serial #	Installed	Removed
DPT (Rosemount 1151DP)	N/A	1140864	3-4-94	6-18-94

* Installed dates for injection columns refer to dates of initial use rather than date installed.

3.6.1.3 BOREHOLE L4P51, PERMEABILITY-TESTING SEQUENCE L4P51-D1

Permeability-testing sequence L4P51-D1 took place in Room L4 in borehole L4P51. This test sequence was designed to investigate the brine permeability of an argillaceous halite approximately 10 m below MB140. Unsuccessful attempts were made to perform permeability tests in the isolated test zone containing the argillaceous halite below MB140 in borehole L4P51 during permeability-testing sequence L4P51-D1. Testing was suspended for permeability-testing sequence L4P51-D1 when the test tool was determined to be unreliable. Table 3-8 gives a detailed description of the events that occurred during permeability-testing sequence L4P51-D1 and gives evidence of the unreliability of the test tool.

Table 3-8. Permeability-Testing Sequence L4P51-D1 Events

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 23.60 m.	9-20-94	263	263	13:29:20
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 24.91 m.	9-21-94	264	264	09:32:10
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 26.25 m.	9-21-94	264	264	10:41:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 27.62 m.	9-21-94	264	264	13:01:00
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 28.85 m.	9-21-94	264	264	13:46:15
Deepen borehole L4P51 with 4-inch (10.16-cm) bit (2-inch (5.08-cm) core) to 30.35 m.	9-21-94	264	264	14:39:40
Face off the bottom of the borehole with 4-inch (10.16-cm) plug bit to 30.45 m.	9-22-94	265	265	10:27:30
Install multipacker test tool #P51-D1A in borehole L4P51 as indicated in the test-tool configuration diagram #1 to begin permeability-testing sequence L4P51-D1 (Figure 3-25).	9-29-94	272	272	12:00:00
Begin data file L4P51D01.	9-30-94	273	273	11:01:51
Circulate fluid through GZP to remove all possible gas.	9-30-94	273	273	11:42:00
Inflate GZP to 13.228 MPa.	9-30-94	273	273	11:45:00
Fill borehole with brine to remove all possible gas.	9-30-94	273	273	11:53:00
Inflate TZ1P to 13.514 MPa.	9-30-94	273	273	12:00:00
Inflate TZ2P to 13.743 MPa.	9-30-94	273	273	12:04:00
Open all packers to accumulator at ~ 13.9 MPa.	9-30-94	273	273	12:13:36
Shut in all zones.	9-30-94	273	273	12:15:17
Increase TZ2 pressure to 4.872 MPa.	10-4-94	277	277	09:45:00
End data file L4P51D01.	10-6-94	279	279	11:08:01

Table 3-8 (Continued). Permeability-Testing Sequence L4P51-D1 Events

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Begin data file L4P51D02.	10-6-94	279	279	11:12:59
Shut in all packer from accumulator.	10-6-94	279	279	11:26:00
Depressurize TZ1.	10-6-94	279	279	11:26:54
Depressurize TZ2.	10-6-94	279	279	11:27:25
Open GZ injection line to atmosphere.	10-6-94	279	279	11:27:44
Deflate TZ1P.	10-6-94	279	279	11:28:46
Deflate TZ2P.	10-6-94	279	279	11:29:56
Inflate TZ1P.	10-6-94	279	279	11:33:43
Inflate TZ2P.	10-6-94	279	279	11:34:48
Shut in TZ1.	10-6-94	279	279	11:39:19
Increase TZ2 pressure to 5.372 MPa.	10-6-94	279	279	11:42:02
DAS was not functioning properly upon arrival.	10-7-94	280	280	10:38:00
End data file L4P51D02.	10-10-94	283	283	10:15:52
Begin data file L4P51D03.	10-10-94	283	283	10:17:14
Depressurize all zones.	10-10-94	283	283	11:38:53
Deflate TZ1P.	10-10-94	283	283	11:43:30
Deflate TZ2P.	10-10-94	283	283	11:44:21
Circulate brine through the system.	10-10-94	283	283	11:55:00
Inflate all packer to ~ 14 MPa.	10-10-94	283	283	12:12:35
Increase pressure in all packers to ~ 16.5 MPa.	10-10-94	283	283	12:13:55
TZ1P appears to be leaking into the TZ2.	10-10-94	283	283	12:20:00
Depressurize all zones.	10-10-94	283	283	13:20:00
Deflate all packers.	10-10-94	283	283	13:28:00
Remove multipacker test -tool #P51-D1A from borehole to fix leak.	10-11-94	284	284	09:04:00
Remove LVDT housing from test tool and put on a volume-displacement device.	10-11-94	284	284	14:21:00
Perform a leak check on test tool # P51-D1B.	10-11-94	284	284	15:00:00
Install multipacker test tool #P51-D1B in borehole L4P51 as indicated in the test-tool configuration diagram #2 (Figure 3-26).	10-13-94	286	286	15:30:00
End data file L4P51D03.	10-14-94	287	287	07:15:21
Begin data file L4P51D04.	10-14-94	287	287	07:27:39
Inflate GZP to 13.357 MPa.	10-14-94	287	287	07:39:00
Circulate brine through the system to remove all possible gas.	10-14-94	287	287	07:45:00
Inflate TZ1P to 13.880 MPa.	10-14-94	287	287	07:49:00
Inflate TZ2P to 14.151 MPa.	10-14-94	287	287	07:54:00
Open all packers to accumulator at ~ 13.8 MPa.	10-14-94	287	287	08:07:00
Increase packer pressure to ~ 16.3 MPa.	10-14-94	287	287	08:09:00
Increase TZ2 pressure to 5.338 MPa.	10-14-94	287	287	08:12:25

Table 3-8 (Continued). Permeability-Testing Sequence L4P51-D1 Events

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Shut in TZ1.	10-14-94	287	287	08:13:08
Switch TZ1 inject and TZ1 vent line due to plugging of TZ1 inject line.	10-14-94	287	287	08:34:51
Decrease TZ2 pressure.	10-14-94	287	287	08:41:00
DAS not functioning properly upon arrival.	10-17-94	290	290	07:58:00
Depressurize TZ1.	10-17-94	290	290	08:07:29
Shut in TZ1.	10-17-94	290	290	08:08:30
End data file L4P51D04.	10-17-94	290	290	09:54:00
Begin data file L4P51D05.	10-17-94	290	290	10:01:50
Depressurize TZ1.	10-19-94	292	292	09:51:55
Depressurize TZ2.	10-19-94	292	292	09:52:51
Depressurize GZ.	10-19-94	292	292	09:53:20
Deflate TZ1P and TZ2P.	10-19-94	292	292	09:59:20
Attempt to circulate brine through the system.	10-19-94	292	292	10:10:00
Inflate all packers via accumulator.	10-19-94	292	292	10:33:29
Shut in GZ.	10-19-94	292	292	10:34:05
Shut in TZ2 and TZ1.	10-19-94	292	292	10:36:44
Depressurize all zones.	10-25-94	298	298	07:30:09
Deflate all packers.	10-25-94	298	298	07:31:58
End data file L4P51D05.	10-25-94	298	298	07:33:36
Remove test tool # P51-D1B from borehole L4P51 to unplug TZ1 inject line.	10-25-94	298	298	14:00:00
Install multipacker test tool #P51-D1B in borehole L4P51 as indicated in the test-tool configuration diagram #3 (Figure 3-27).	10-27-94	300	300	14:00:00
Begin data file L4P51D06.	10-28-94	301	301	07:33:53
Inflate GZP to 16.886 MPa.	10-28-94	301	301	08:02:59
Inflate TZ1P to 14.063 MPa.	10-28-94	301	301	08:15:00
Inflate TZ2P to 14.000 MPa.	10-28-94	301	301	08:20:0
Open all packers to accumulator at ~ 15.5 MPa.	10-28-94	301	301	08:21:41
Shut in all zones.	10-28-94	301	301	09:41:53
TZ1 vent line is plugged again.	10-28-94	301	301	12:14:00
Depressurize all zones.	10-28-94	301	301	12:16:56
Deflate all packers.	10-28-94	301	301	12:20:57
Remove multipacker test tool #P51-D1B from borehole L4P51.	11-1-94	305	305	08:26:00
Perform a video-log on borehole L4P51 to determine what is in the bottom of the borehole.	11-7-94	311	311	10:33:00
Circulate brine through the borehole using the Longyear D-38 drilling rig in an attempt to remove the sediment in the bottom of the borehole.	11-22-94	326	326	10:44:00
Perform a video-log on borehole L4P51 to make sure that the sediment has been removed.	11-22-94	326	326	12:04:00
End data file L4P51D06.	11-23-94	327	327	12:37:32

Table 3-8 (Continued). Permeability-Testing Sequence L4P51-D1 Events

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Install multipacker test tool #P51-D1B in borehole L4P51 as indicated in the test-tool configuration diagram #4 (Figure 3-28).	11-23-94	327	327	12:38:00
Begin data file L4P51D07.	11-23-94	327	327	12:39:30
Inflate all packers and put all packers on accumulator at ~ 15.3 MPa.	11-23-94	327	327	13:55:44
Increase TZ2 pressure to 5.460 MPa.	11-23-94	327	327	13:57:35
Increase TZ2 pressure to 5.369 MPa.	11-23-94	327	327	14:01:00
Shut in GZ and TZ1.	11-23-94	327	327	14:05:12
Leaky fitting g on TZ2.	11-28-94	332	332	11:30:00
Increase TZ2 pressure to 4.845 MPa.	11-30-94	334	334	08:10:20
End data file L4P51D07.	11-30-94	334	334	08:13:23
Begin data file L4P51D08.	12-6-94	340	340	11:18:46
P7 and P8 transducers are not reading correctly.	12-6-94	340	340	14:38:00
P7 and P8 transducers are reading correctly.	12-7-94	341	341	09:00:00
Begin constant-pressure-injection test #1 in TZ1 at 2 MPa.	12-8-94	342	342	12:39:20
Shut in TZ1 from DPT panel terminating constant-pressure-injection test #1 in TZ1.	12-9-94	343	343	09:42:00
Shut in all packers from accumulator.	12-10-94	344	344	10:04:00
Depressurize all zones.	12-10-94	344	344	10:11:09
Deflate all packers.	12-10-94	344	344	10:13:00
Remove multipacker test tool #P51-D1B from borehole L4P51 to fix suspected leak.	12-10-94	344	344	13:30:00
End data file L4P51D08.	12-12-94	346	346	09:15:26
Perform a leak check on TZ1P.	12-14-94	348	348	12:59:00
Install multipacker test tool #P51-D1B in borehole L4P51 as indicated in the test-tool configuration diagram #5 (Figure 3-29).	12-16-94	350	350	14:00:00
Begin data file L4P51D09.	12-20-94	354	354	09:34:52
Circulate brine through TZ1 while inflating TZ1P to ensure all lines remain open.	12-20-94	354	354	10:02:00
Inflate all packers and put all packers on accumulator at ~ 14.5 MPa.	12-20-94	354	354	10:32:03
Shut in all zones.	12-20-94	354	354	10:32:55
Begin constant-pressure-injection test #2 in TZ1 at 2.325 MPa.	12-21-94	355	355	08:38:40
Shut in TZ1 from DPT panel due to empty injection column terminating constant-pressure-injection test #2 in TZ1.	12-21-94	355	355	08:47:47
Begin constant-pressure-injection test #3 in TZ1 at ~ 2.2 MPa.	12-28-94	362	362	12:14:05
Leaky fitting on accumulator.	12-29-94	363	363	08:03:00
Shut in TZ1 from DPT panel terminating constant-pressure-injection test #3 in TZ1.	12-30-94	364	364	08:10:17
Leaky valve on GZ.	12-30-94	364	364	08:10:50
Replace bad gage on TZ2.	12-30-94	364	364	08:37:40
End data file L4P51D09.	1-3-95	3	368	08:57:35
Begin data file L4P51D10.	1-3-95	3	368	09:01:34
End data file L4P51D10.	1-4-95	4	369	10:03:16

Table 3-8 (Continued). Permeability-Testing Sequence L4P51-D1 Events

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Begin data file L4P51D11.	1-4-95	4	369	10:06:10
Tubing string is completely filled with brine.	1-16-95	16	381	08:38:00
Begin constant-pressure-injection test #4 in TZ1 at ~ 2 MPa.	1-18-95	18	383	13:24:30
Shut in TZ1 from DPT panel terminating constant-pressure-injection test #4 in TZ1.	1-19-95	19	384	08:32:10
Begin constant-pressure-injection test #5 in TZ1 at ~4.4 MPa.	1-19-95	19	384	08:54:57
Shut in TZ1 from DPT panel terminating constant-pressure-injection test #5 in TZ1.	1-23-95	23	388	08:05:15
Begin constant-pressure-injection test #6 in TZ1 at ~ 7 MPa.	1-23-95	23	388	08:12:55
DAS was not functioning properly upon arrival.	1-24-95	24	389	09:16:00
End data file L4P51D11.	1-30-95	30	395	08:32:50
Begin data file L4P51D12.	1-30-95	30	395	08:35:56
Increase TZ2 pressure to 5.283 MPa.	2-2-95	33	398	08:53:45
Open TZ2 to accumulator at 4.845 MPa.	2-2-95	33	398	13:08:20
Increase TZ2 pressure via accumulator to 5.152 MPa.	2-2-95	33	398	13:08:59
Shut in TZ1 from DPT panel terminating constant-pressure-injection test #6 in TZ1.	2-6-95	37	402	08:35:52
End data file L4P51D12.	2-10-95	41	406	13:05:55
Begin data file L4P51D13.	2-10-95	41	406	13:08:29
End data file L4P51D13.	2-17-95	48	413	07:36:53
Shut in all packers from accumulator to eliminate temperature effects.	2-20-95	51	416	12:19:00
Shut in TZ2 from accumulator to eliminate temperature effects.	2-20-95	51	416	12:21:00
Begin data file L4P51D14.	2-20-95	51	416	12:43:24
End data file L4P51D14.	3-3-95	62	427	07:57:22
Begin data file L4P51D15.	3-3-95	62	427	07:58:49
Depressurize all zones.	3-20-95	79	444	11:27:00
Deflate all packers.	3-20-95	79	444	11:28:30
End data file L4P51D15.	3-21-95	80	445	08:53:25
Remove multipacker test tool # P51-D1B from borehole L4P51.	3-21-95	80	445	15:00:00

Figures 3-45 through 3-49 illustrate the zone pressures, packer pressures, axial-LVDT displacement, radial-LVDT displacement, and fluid production during constant-pressure-flow tests, respectively, for permeability-testing sequence L4P51-D1. It should be noted that Figure 3-49 (Fluid production during constant-pressure-flow tests in permeability-testing sequence L4P51-D1) consists of two parts (Figures 3-49a and 3-49b). Copies of the video-log associated with testing sequence L4P51-D1 identified in Table 3-8 are provided in the SWCF under WPO #45907.

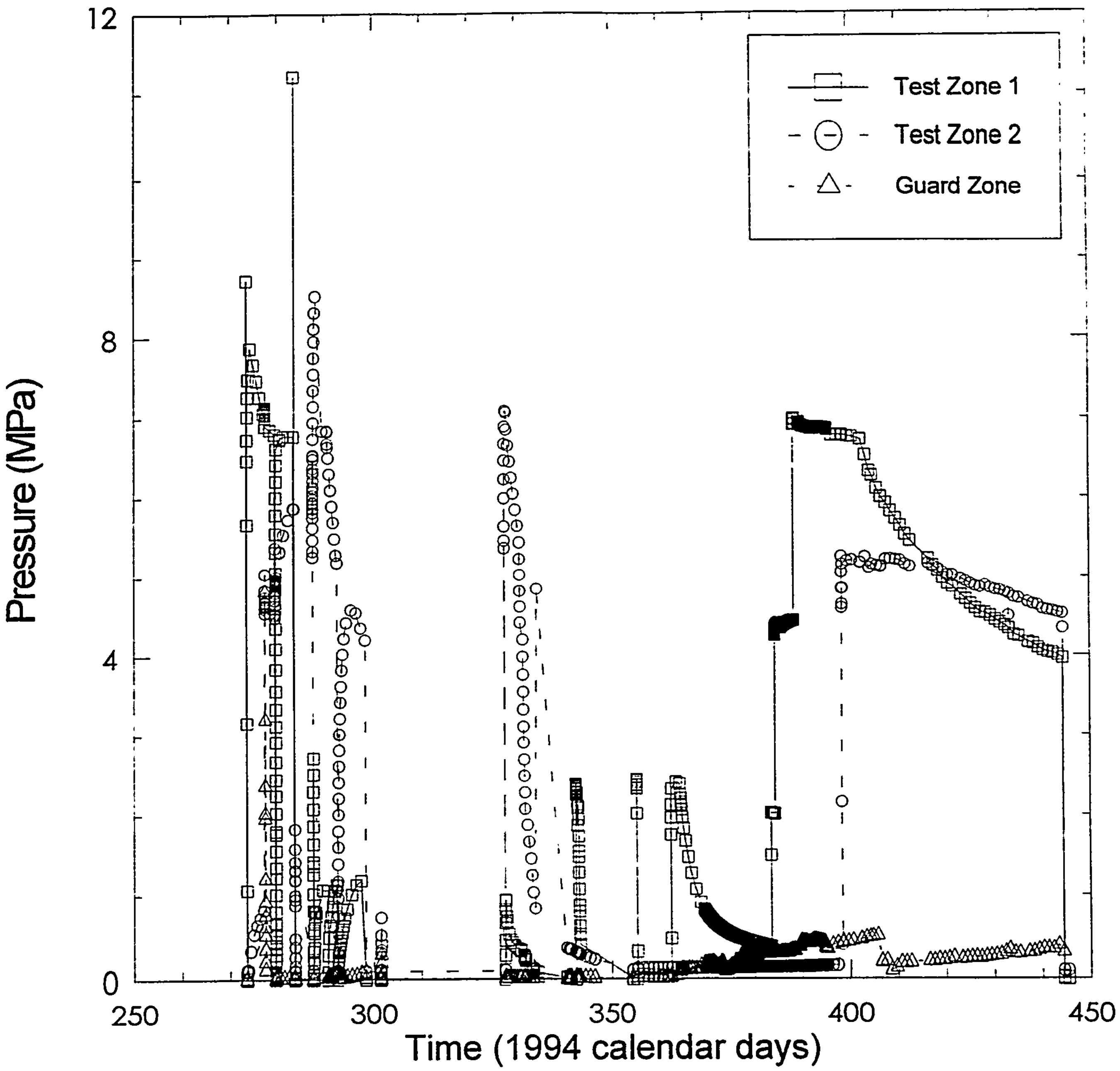

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Figure 3-45. Zone pressures during permeability-testing sequence L4P51-D1.

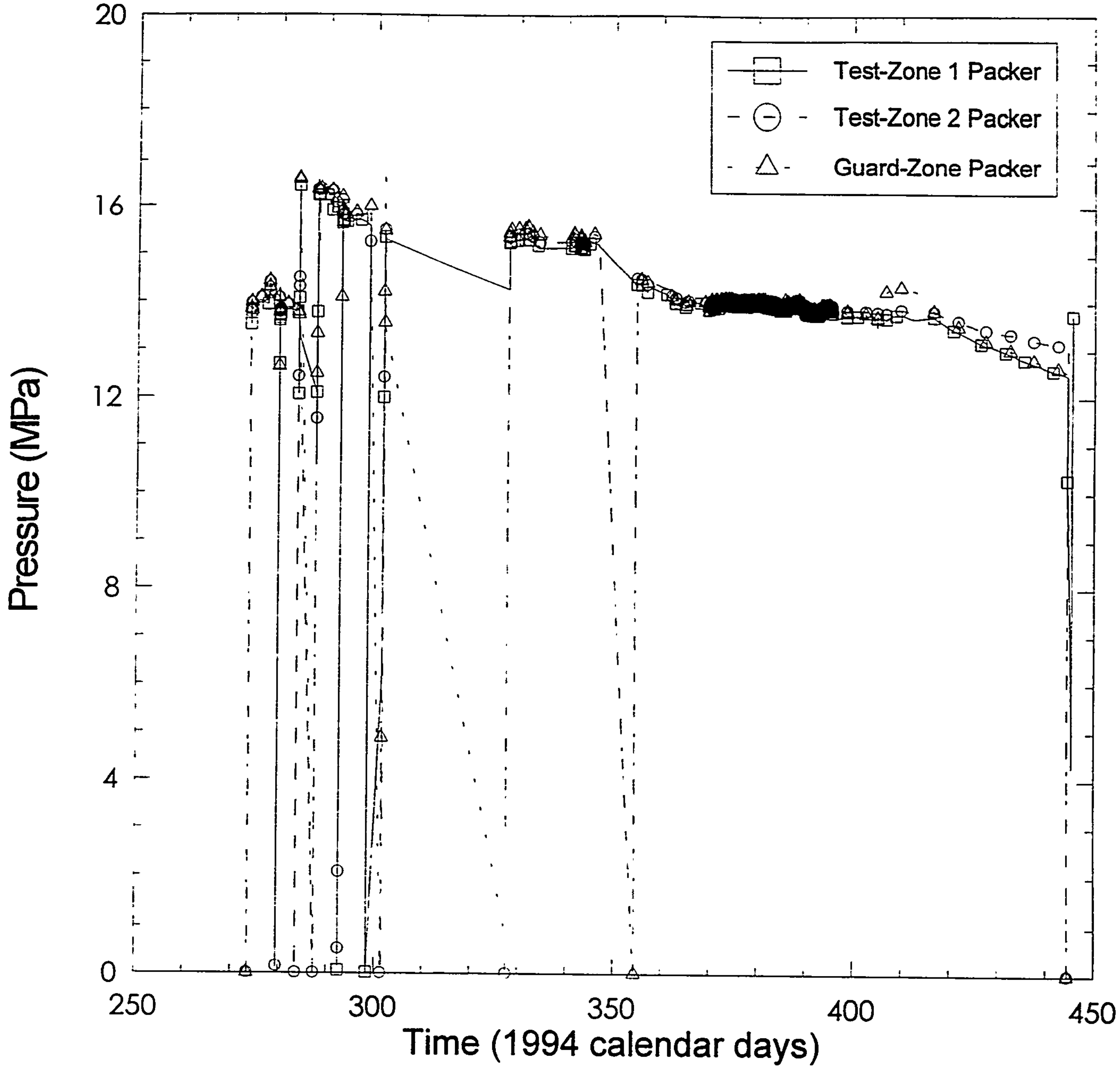

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Figure 3-46. Packer pressures during permeability-testing sequence L4P51-D1.

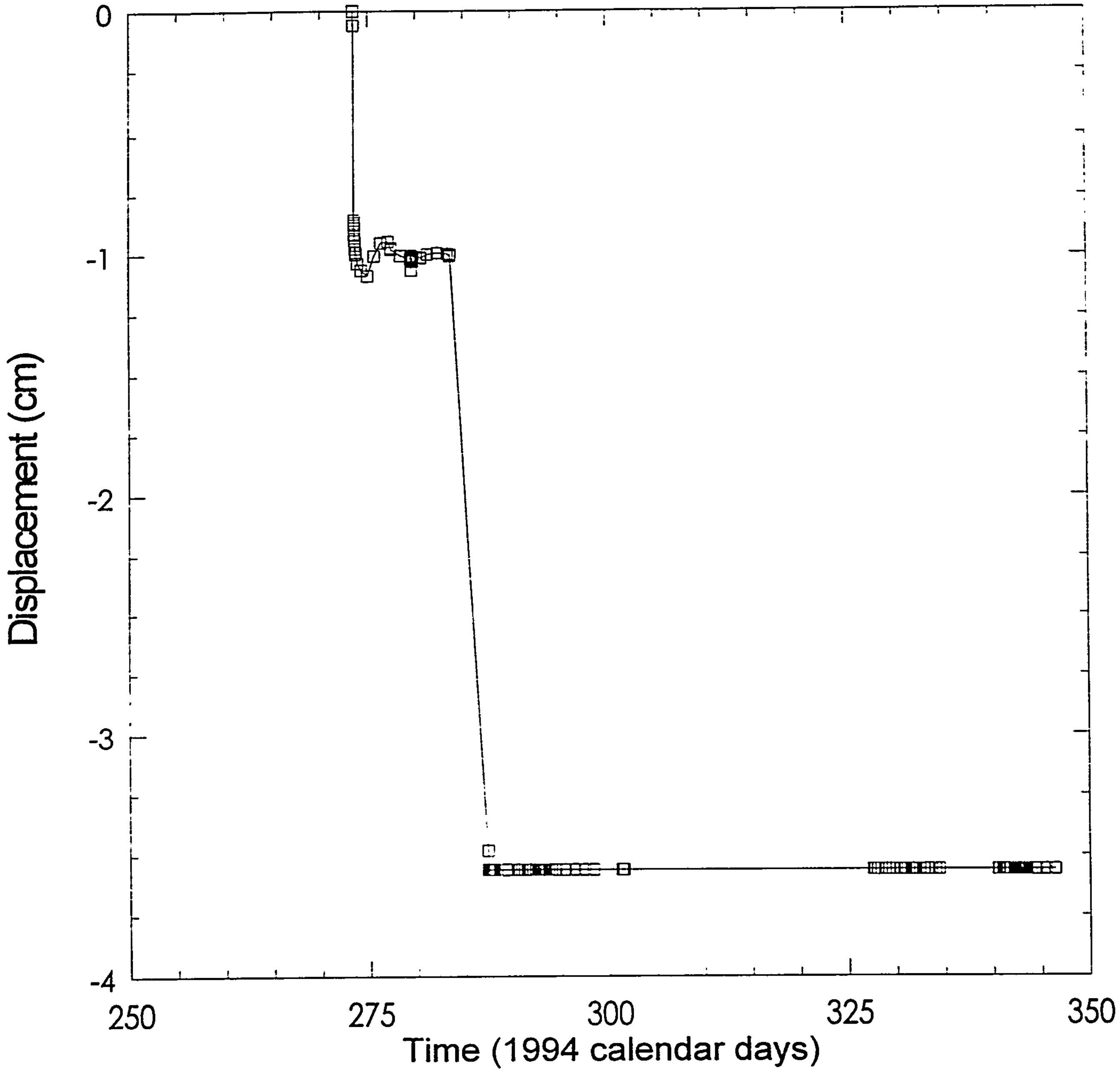

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Figure 3-47. Axial-LVDT displacement during permeability-testing sequence L4P51-D1.

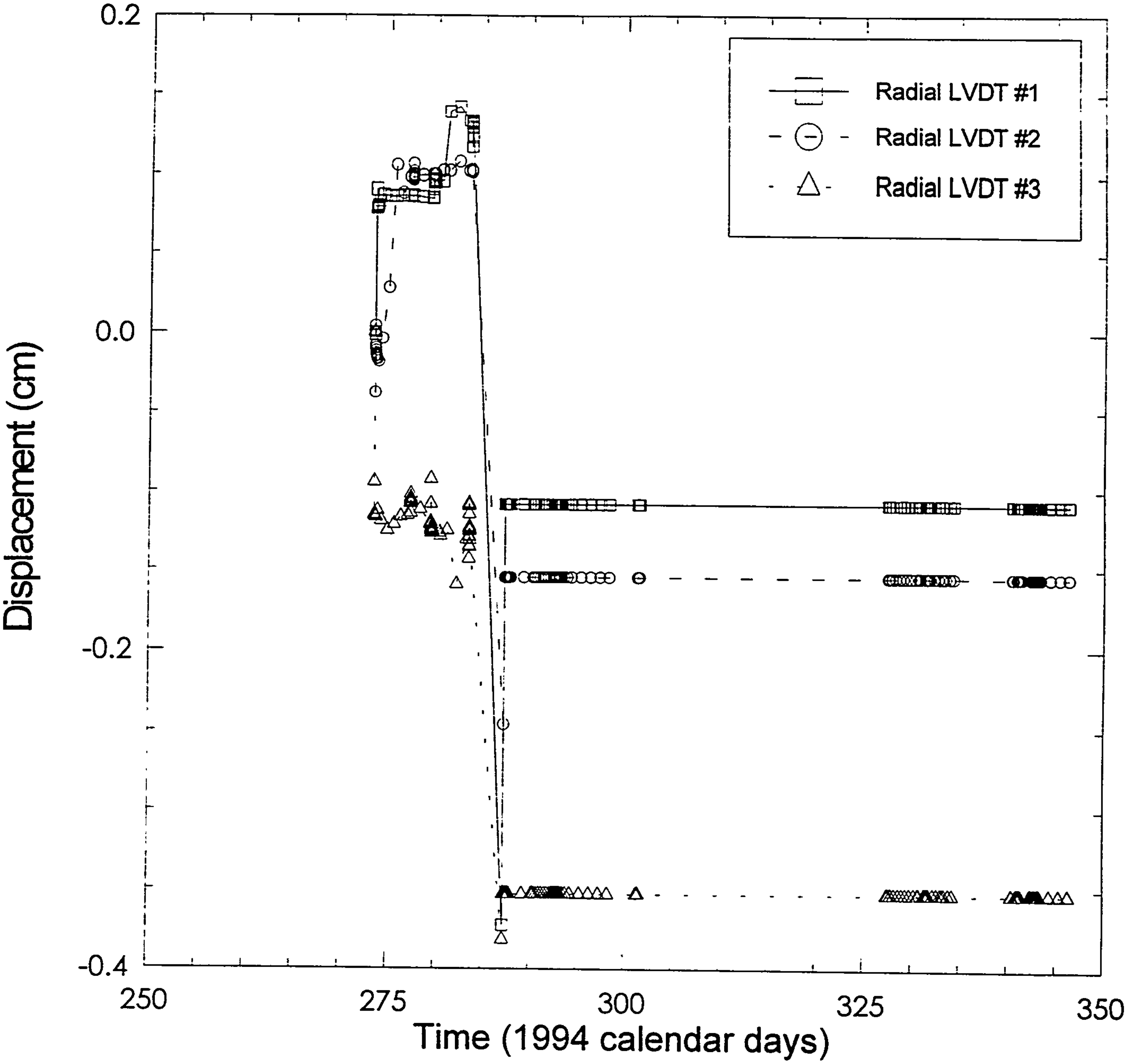

Figure 3-48. Radial-LVDT displacement during permeability-testing sequence L4P51-D1.

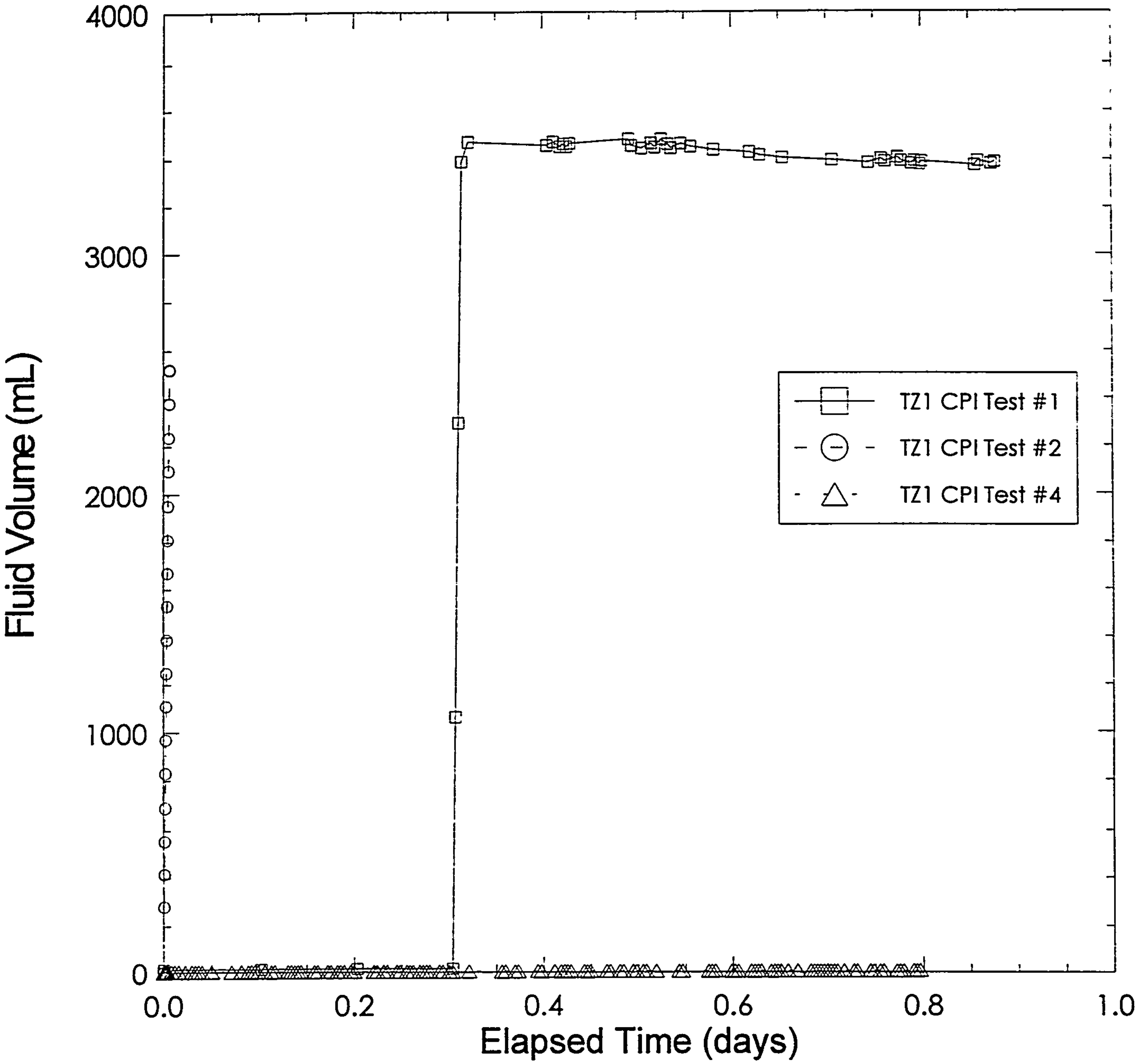

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Figure 3-49a. Fluid production during constant-pressure-flow tests in permeability-testing sequence L4P51-D1.

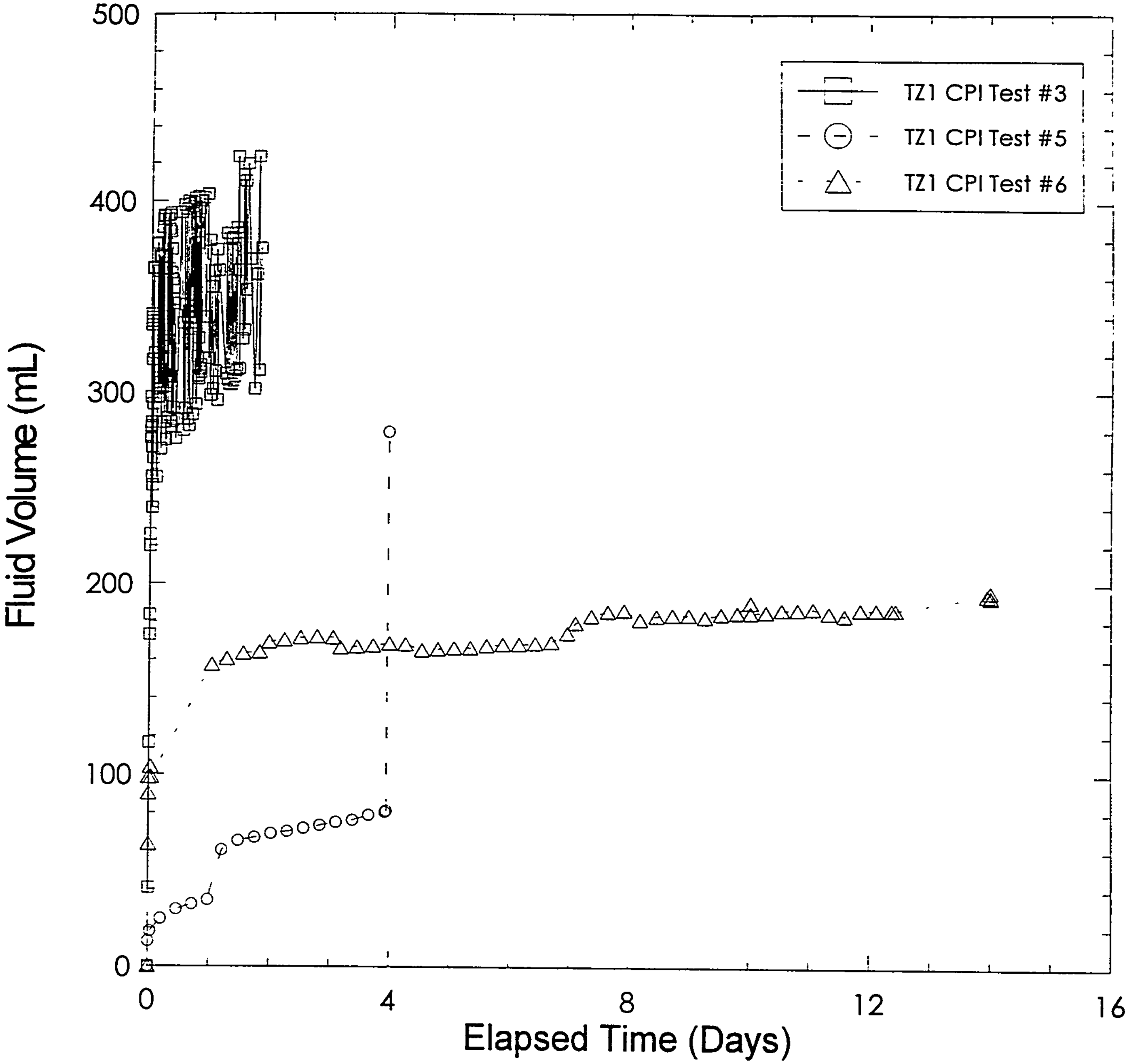

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Figure 3-49b. Fluid production during constant-pressure-flow tests in permeability-testing sequence L4P51-D1 (continued).

Table 3-9 indicates the equipment that was used and the duration that each instrument was used during permeability-testing sequence L4P51-D1.

Table 3-9. Permeability-Testing Sequence L4P51-D1 Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	9-30-94	3-20-95
DCU (HP3497A)	N/A	2629a22040	9-30-94	10-14-94
DCU (HP3497A)	N/A	2629a21996	10-14-94	3-3-95
DCU (HP3497A)	N/A	2629a22040	3-3-95	3-20-95
Transducer (Druck D930-18)	Test Zone 1	609375	9-30-94	3-20-95
Transducer (Druck D930-18)	Test Zone 2	609368	9-30-94	3-20-95
Transducer (Druck D930-18)	Test Zone 1 Packer	609371	9-30-94	3-20-95
Transducer (Druck D930-18)	Test Zone 2 Packer	609374	9-30-94	3-20-95
Transducer (Druck D930-18)	Guard Zone	609366	9-30-94	3-20-95
Transducer (Druck D930-18)	Guard Zone Packer	609369	9-30-94	3-20-95
Transducer (Druck D930-18)	DPT Panel	609372	12-6-94	3-20-95
Transducer (Druck D930-18)	Pressure Controller	609370	12-6-94	1-4-95
LVDT (Trans-Tek 241)	N/A	R04	9-30-94	10-11-94
LVDT (Trans-Tek 241)	N/A	R16	9-30-94	10-11-94
LVDT (Trans-Tek 241)	N/A	R17	9-30-94	10-11-94
LVDT (Trans-Tek 245)	N/A	A02	9-30-94	10-11-94
Injection Column	N/A	265	12-6-94	12-28-94
Injection Column	N/A	264	12-6-94	12-28-94
Injection Column	N/A	88	12-28-94	2-20-95
DPT (Rosemount 1151DP)	N/A	1140864	12-6-94	1-4-95
DPT (Rosemount 1151DP)	N/A	1389938	1-4-95	2-20-95

* Installed dates for injection columns refer to dates of initial use rather than date installed.

3.6.1.4 BOREHOLE L4P51, PERMEABILITY-TESTING SEQUENCE L4P51-D2

Permeability-testing sequence L4P51-D2 took place in Room L4 in borehole L4P51. This test sequence was designed to investigate the brine permeability of an argillaceous halite approximately 10 m below MB140. Table 3-10 gives a detailed description of the events that occurred during permeability-testing sequence L4P51-D2.

Table 3-10. Permeability-Testing Sequence L4P51-D2 Events

EVENT	DATE	CALENDAR DAY	1995 CALENDAR DAY	TIME (HH:MM:SS)
Begin data file L4P51D16.	4-6-95	96	96	12:07:41
Install single-packer test tool #P51-D2 in borehole L4P51 as indicated in the test-tool configuration diagram (Figure 3-30).	4-6-95	96	96	12:10:00
Inflate TZP to ~ 14 MPa.	4-6-95	96	96	12:13:00
Open TZP to accumulator at 14.319 MPa.	4-6-95	96	96	12:17:00
Circulate brine through TZ to remove all possible gas.	4-6-95	96	96	12:18:00
Shut in TZ.	4-6-95	96	96	12:18:34
End data file L4P51D16.	5-17-95	137	137	07:50:35
Begin data file L4P51D17.	5-17-95	137	137	07:51:59
End data file L4P51D17.	9-14-95	257	257	07:06:10
Begin data file L4P51D18.	9-14-95	257	257	07:31:59
Depressurize TZ.	10-25-95	298	298	08:00:00
Deflate TZP.	10-25-95	298	298	08:10:00
Remove test tool from borehole.	10-25-95	298	298	11:00:00
End data file L4P51D18.	10-25-95	298	298	06:49:25

Figures 3-50 and 3-51 illustrate the zone pressure and packer pressure, respectively, for permeability-testing sequence L4P51-D2.

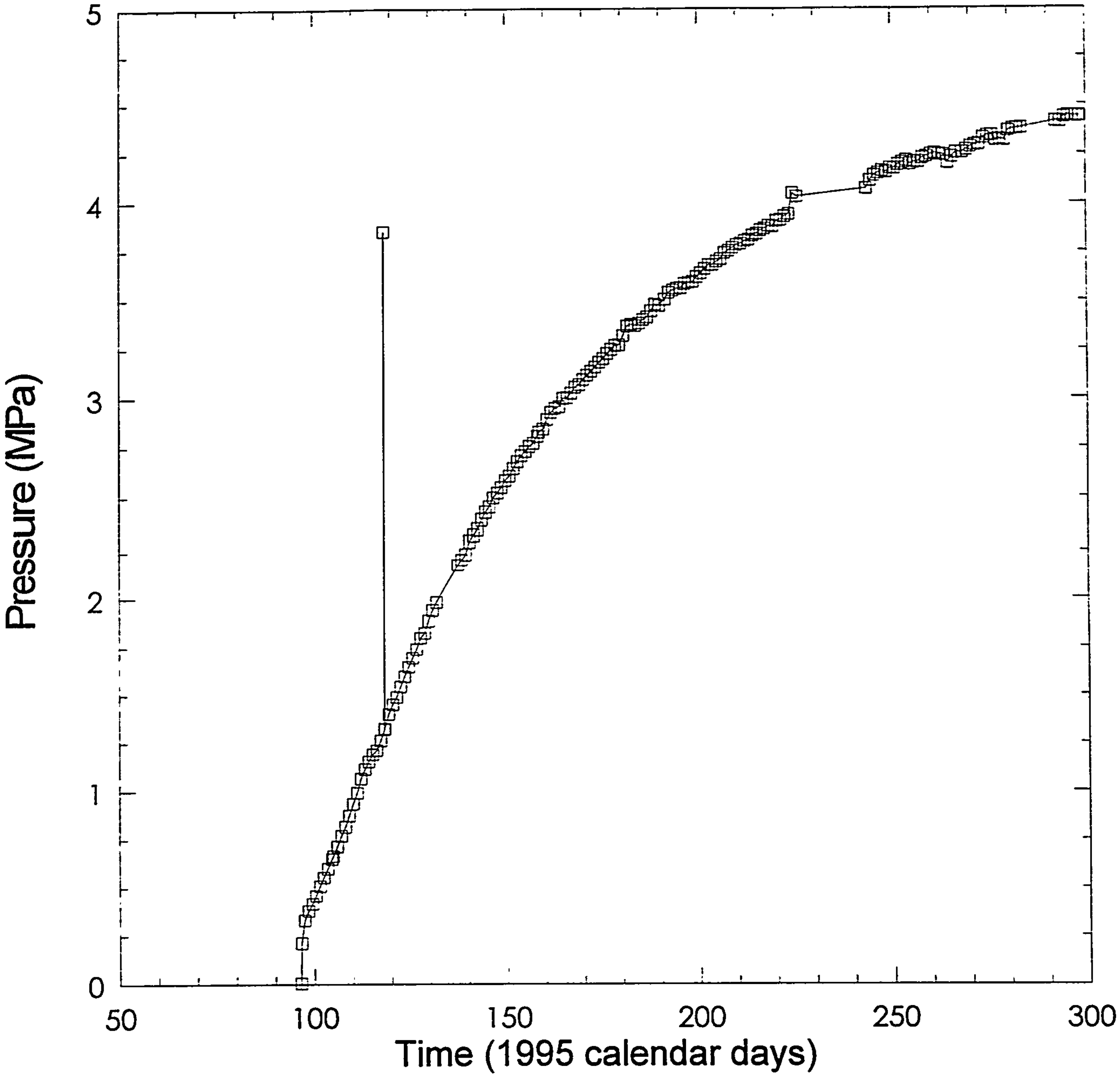

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Figure 3-50. Zone pressure during permeability-testing sequence L4P51-D2.

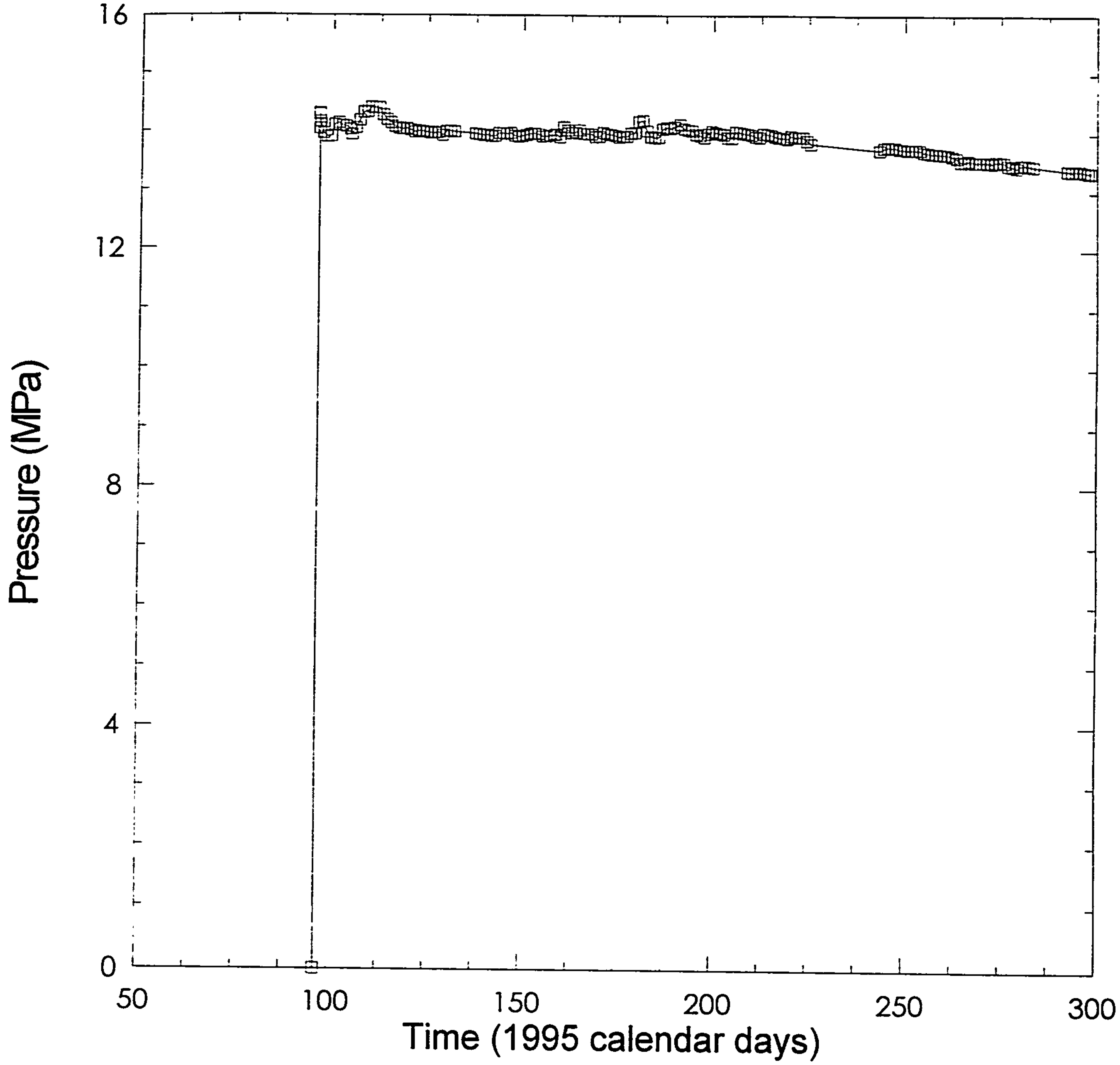

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Figure 3-51. Packer pressure during permeability-testing sequence L4P51-D2.

Table 3-11 indicates the equipment that was used and the duration that each instrument was used during permeability-testing sequence L4P51-D2.

Table 3-11. Permeability-Testing Sequence L4P51-D2 Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	4-6-95	10-25-95
DCU (Hp3497A)	N/A	2629a22040	4-6-95	10-25-95
Transducer (Druck D930-18)	Test Zone	609375	4-6-95	10-25-95
Transducer (Druck D930-18)	Test Zone Packer	609368	4-6-95	10-25-95

3.6.1.5 BOREHOLE L4P52, PERMEABILITY-TESTING SEQUENCE L4P52-B

Permeability-testing sequence L4P52-B took place in Room L4 in borehole L4P52. This test sequence was designed to investigate the brine permeability of MB138. Table 3-12 gives a detailed description of the events that occurred during permeability-testing sequence L4P52-B.

Table 3-12. Permeability-Testing Sequence L4P52-B Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Perform load test on the borehole flanged collar.	12-10-92	345	345	09:00:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 9.024 meters.	12-10-92	345	345	14:00:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 11.89 meters.	12-11-92	346	346	10:20:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 14.18 meters.	12-14-92	349	349	11:00:00
Install multipacker test tool #37 in borehole L4P52 as indicated in the test-tool configuration diagram (Figure 3-31).	12-15-92	350	350	12:00:00
Begin data file L4P52B01.	12-17-92	352	352	11:26:01
Inflate GZP to ~ 10.3 Mpa.	12-17-92	352	352	14:00:00
Deflate GZP.	12_17-92	352	352	14:05:00
Shut in GZ.	12-17-92	352	352	14:20:00
Fill TZ and GZ with Brine.	12-17-92	352	352	14:38:00
GZP pressure decayed to 0.516 MPa due to leaky fitting.	12-18-92	353	353	08:00:00
Inflate GZP to ~10.3 Mpa.	12-18-92	353	353	08:56:00
Inflate TZP to ~10.3 MPa.	12-18-92	353	353	09:04:00
Decrease TZ and GZ pressure to ~0.2 MPa and shut in.	12-18-92	353	353	09:12:00
Increase TZP pressure to !10.3 Mpa	12-18-92	353	353	09:13:00
Decrease GZ pressure to ~0.18 Mpa and shut in.	12-18-92	353	353	09:15:00

Table 3-12 (Continued). Permeability-Testing Sequence L4P52-B Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
No voltage from the power supply card to the transducers .	1-21-93	21	387	08:11:00
End data file L4P52B01.	1-21-93	21	387	11:19:57
Begin data file L4P52B02.	1-21-93	21	387	11:23:00
End data field L4P52B02.	2-10-93	41	407	12:00:54
Begin data file L4P52B03.	2-10-93	41	407	12:02:44
Begin constant-pressure-withdrawal test #1 in TZ at ~1 Mpa below TZ pressure (~8.05 Mpa).	2-11-93	42	408	11:23:00
Repair leaky fitting on the DPT panel.	2-11-93	42	408	16:15:93
Repair leak on the DPT panel.	2-17-93	48	414	13:49:38
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test in TZ.	2-24-93	55	421	09:13:17
DAS not functioning properly upon arrival.	3-19-93	78	444	10:14:55
End data file L4P52B03.	3-23-93	82	448	10:18:38
Begin data file L4P52B04.	-23-93	82	448	11:37:18
Potential problem with P4 transducer.	3-25-93	84	450	09:35:00
Open GZ to accumulator at ~7.1 Mpa.	4-19-93	109	475	13:30:00
End data file L4P52B04.	5-10-93	130	496	09:59:07
Begin data file L4P52B05.	5-10-93	130	496	10:01:58
Shut in GZ from accumulator.	5-12-93	132	498	09:51:58
Open GZ to full accumulator.	5-12-93	132	498	10:28:27
Increase GZP pressure via accumulator.	5-19-93	139	505	11:06:59
Shut in GZP from accumulator.	5-19-93	139	505	11:10:59
Shut in GZ from accumulator.	5-19-93	139	505	11:12:00
Open GZ to full accumulator.	5-19-93	139	139	11:21:00
Shut in GZ from accumulator.	5-20-93	140	506	13:14:00
Begin constant-pressure-injection test #1 in TZ at ~0.4 MPa above TZ pressure (9.598 MPa).	5-7-93	158	524	09:44:24
End data file L4P52B05.	6-8-93	159	525	12:06:46
Begin data file L4P52B06.	6-8-93	159	525	12:56:20
Shut in TZ from DPT panel terminating constant-pressure-injection test #1 in TZ.	6-22-93	173	539	10:03:57
Begin constant-pressure-injection test #2 in TZ at ~1 MPa above TZ pressure (~10.1 MPa).	6-22-93	173	539	10:22:49
Increase TZP pressure to ~13 MPa.	7-7-93	188	554	10:12:00
Increase GZP pressure to ~13 Mpa.	7-7-93	188	554	10:14:00
Decrease GZ pressure to ~8.4 Mpa.	7-7-93	188	554	10:15:00
Shut in TZ from DPT panel terminating constant-pressure-injection test #2 in TZ.	7-7-93	188	554	10:18:00
Begin constant-pressure-injection test #3 in TZ at ~2 MPa above TZ pressure (~11.1 Mpa).	7-7-93	188	554	11:44:00
Shut in TZ from DPT panel terminating constant-pressure-injection test #3 in TZ.	7-19-93	200	566	07:57:00

Table 3-12 (Continued). Permeability-Testing Sequence L4P52-B Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
End data file L4P52B06.	8-2-93	214	580	05:26:34
Begin data file L4P52B07.	8-2-93	214	580	09:13:19
The P4 transducer is giving incorrect readings again.	8-3-93	215	581	09:41:00
DAS not functioning properly upon arrival.	10-7-93	280	646	08:32:00
DAS not functioning for the past 3 days.	11-15-93	319	685	09:03:00
End data file L4P52B07.	12-29-93	363	729	11:48:23

Figures 3-52 through 3-57 illustrate the zone pressures, packer pressures, zone temperatures, axial-LVDT displacement, radial-LVDT displacement, and fluid production during constant-pressure-flow tests, respectively, for permeability-testing sequence L4P52-B.

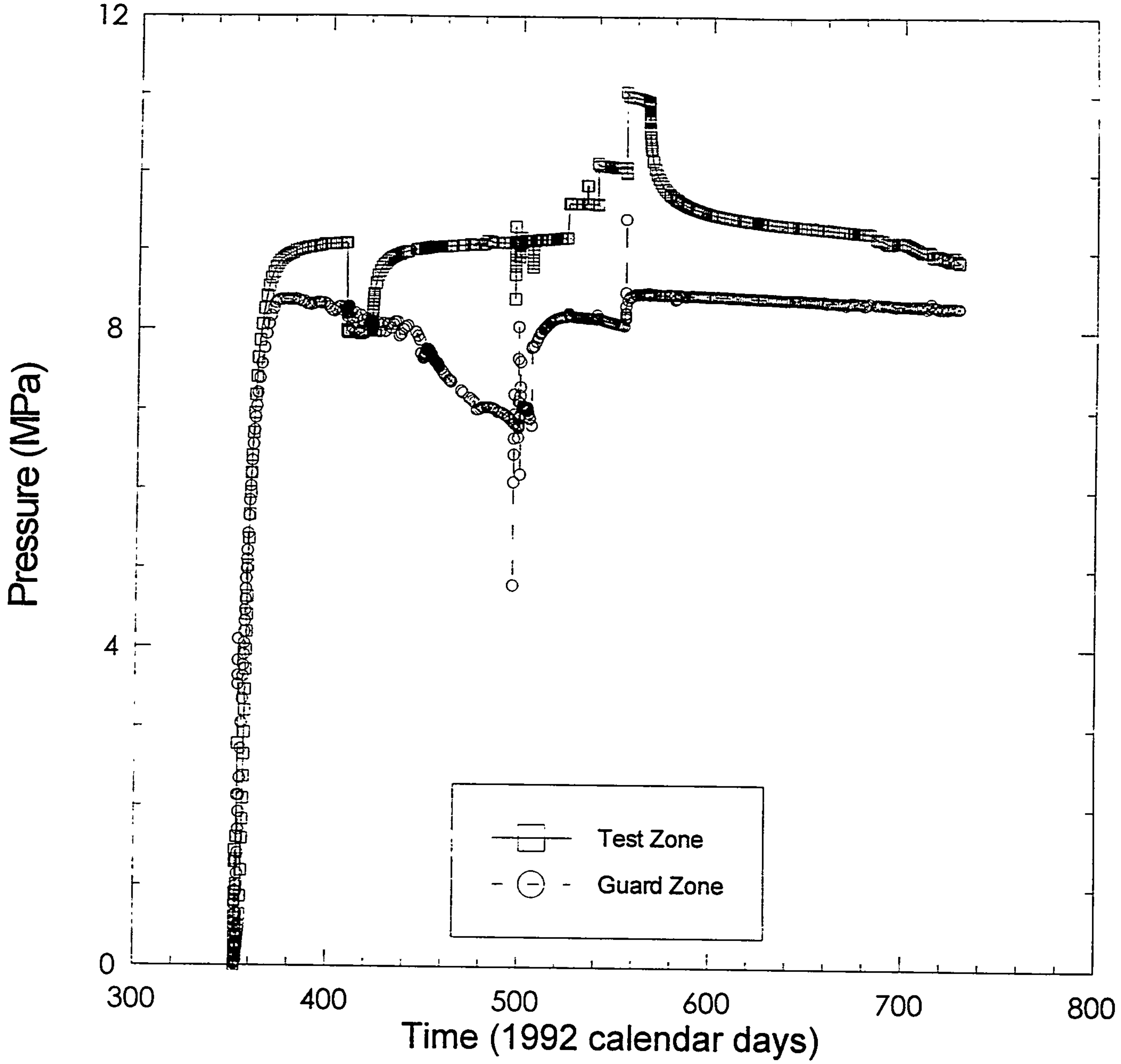

Figure 3-52. Zone pressures during permeability-testing sequence L4P52-B.

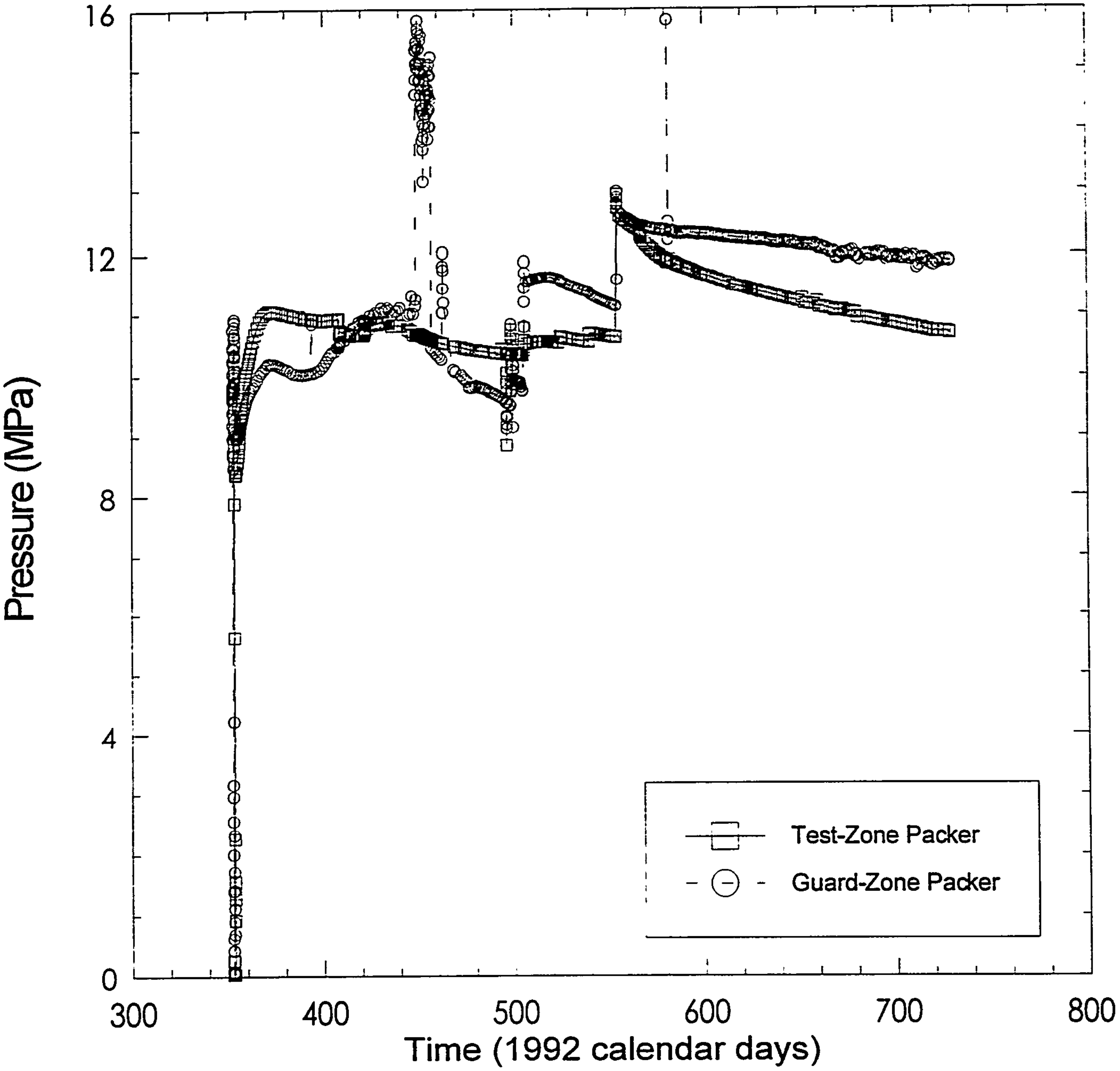

Figure 3-53. Packer pressures during permeability-testing sequence L4P52-B.

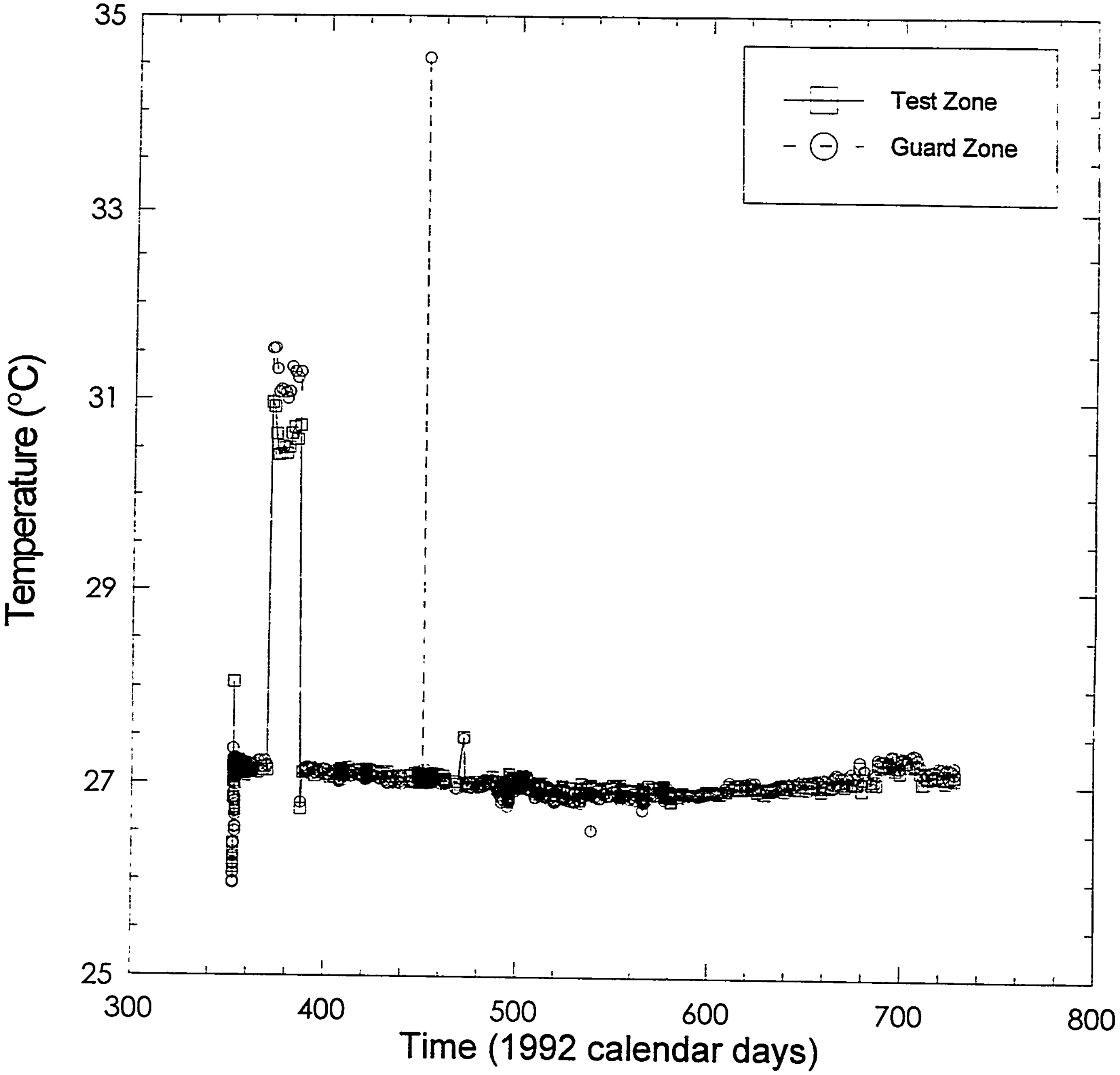

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Figure 3-54. Zone temperatures during permeability-testing sequence L4P52-B.

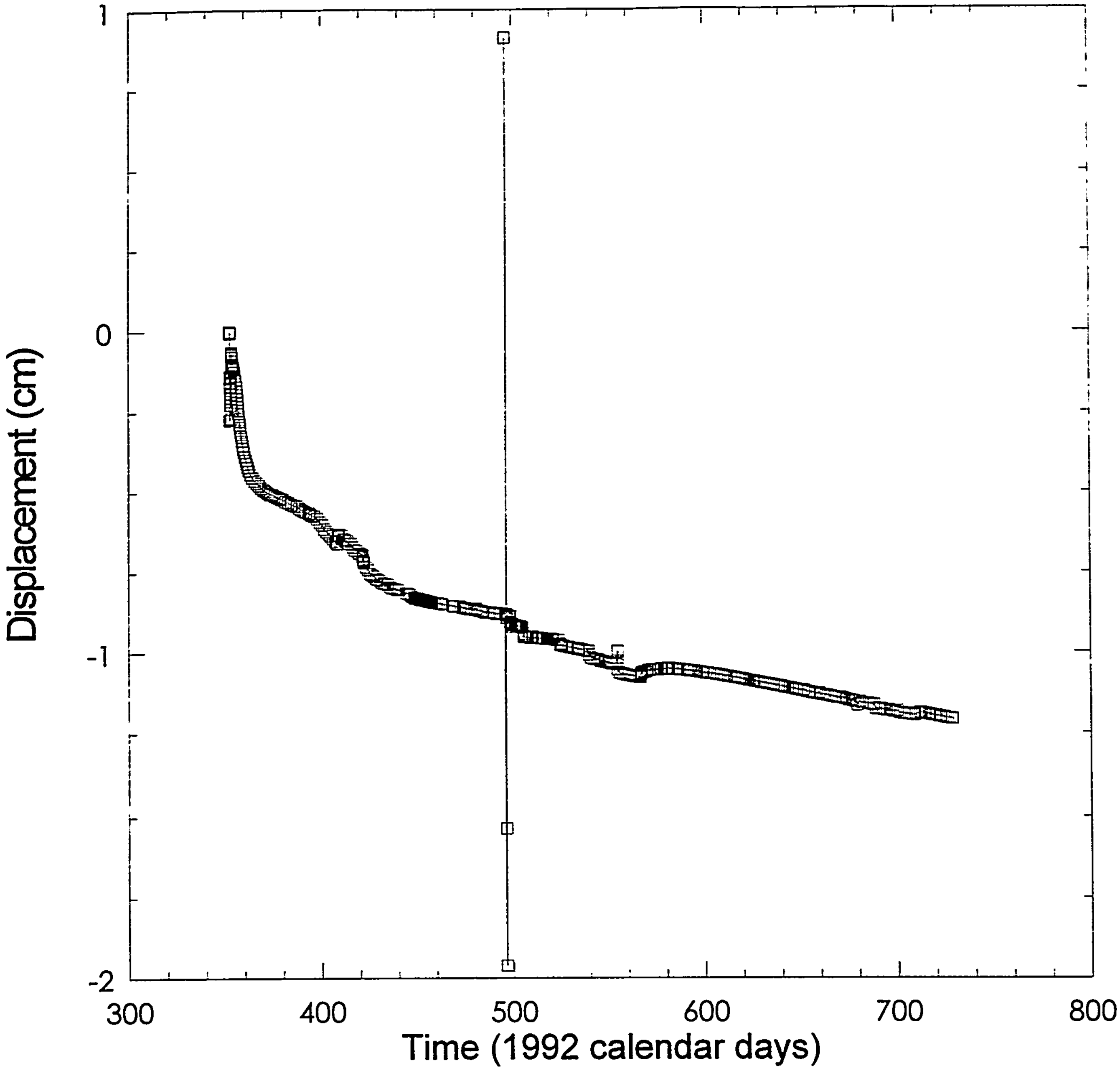

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Figure 3-55. Axial-LVDT displacement during permeability-testing sequence L4P52-B.

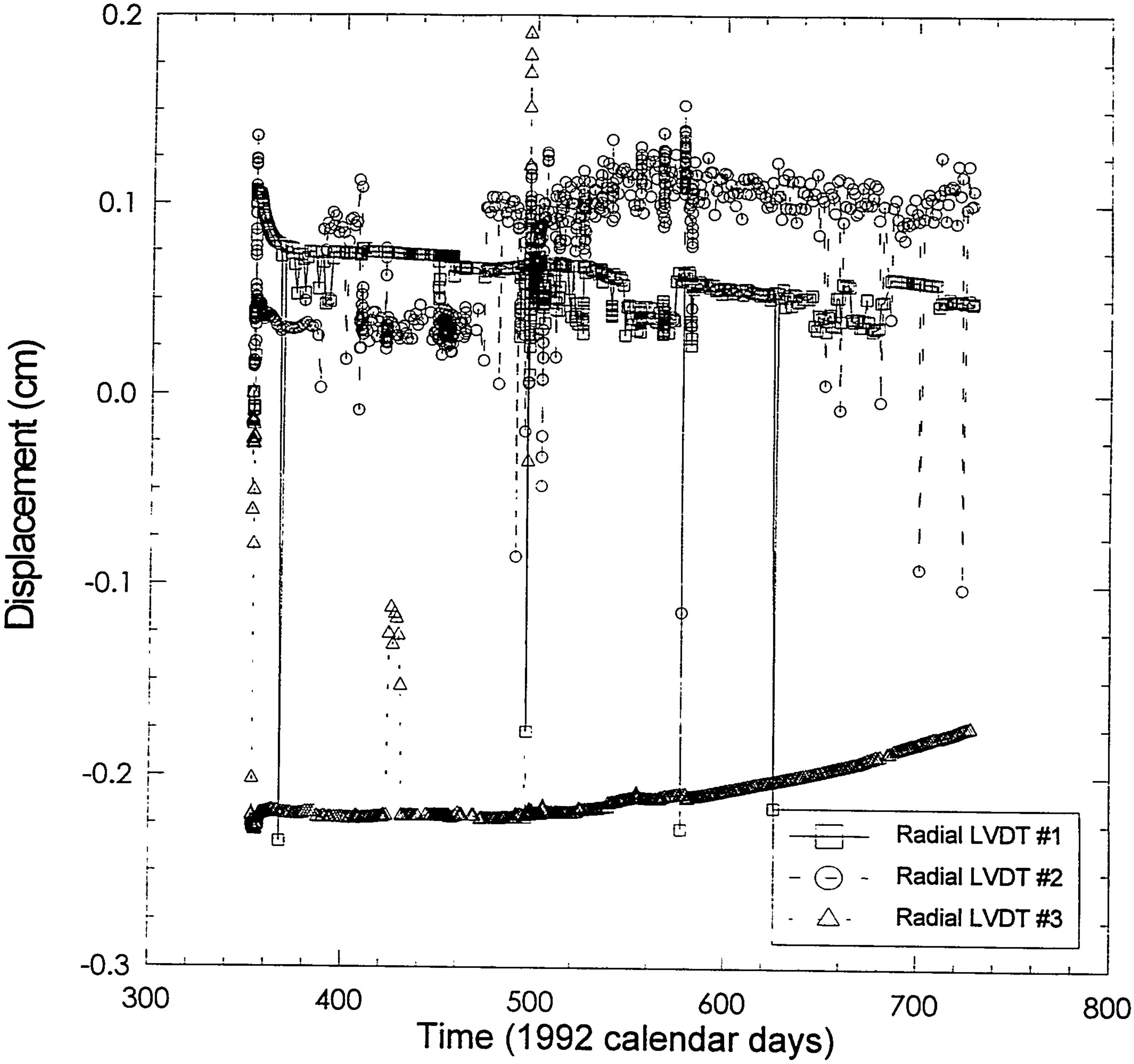

Figure 3-56. Radial-LVDT displacement during permeability-testing sequence L4P52-B.

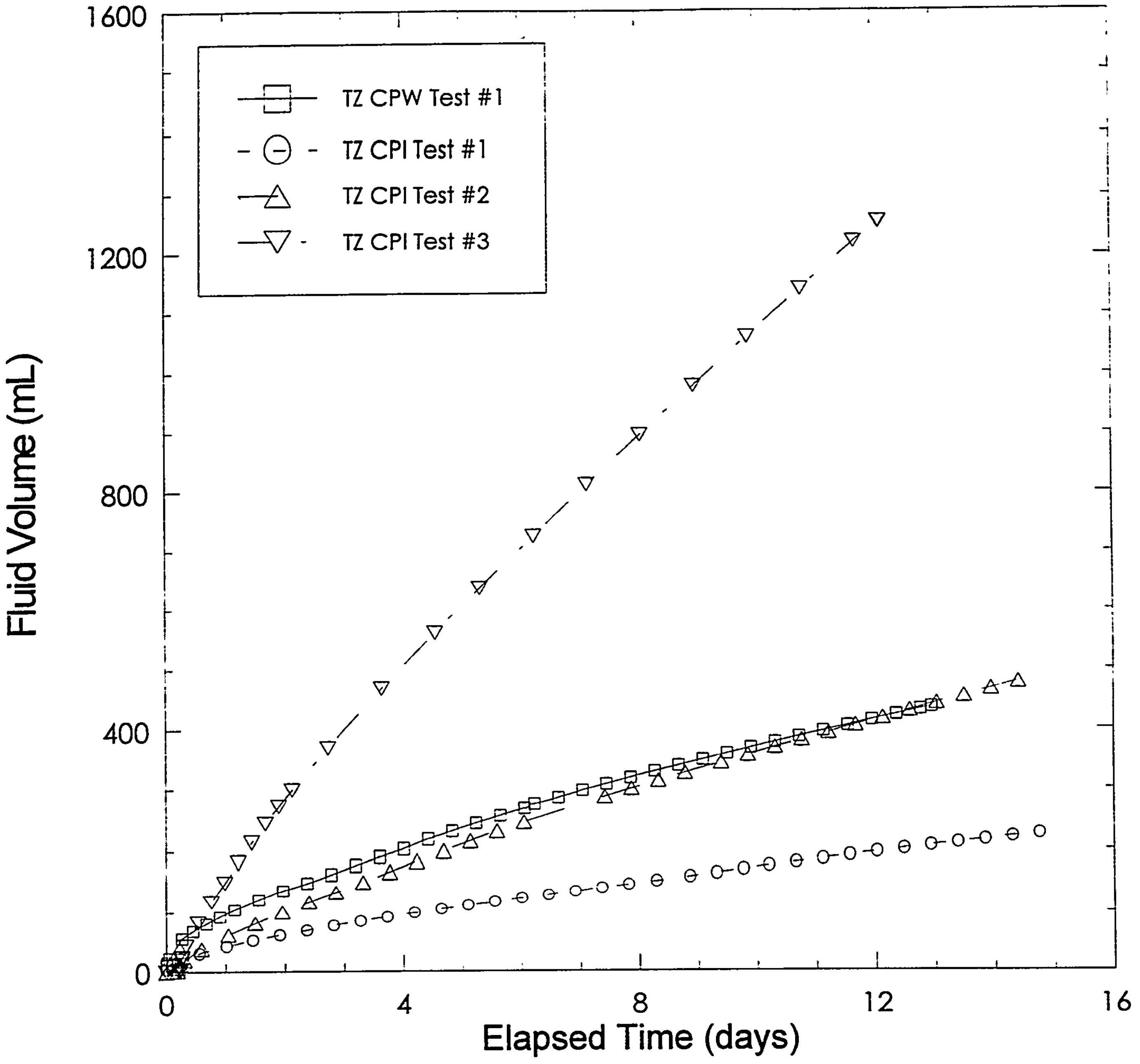

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Figure 3-57. Fluid production during constant-pressure-flow tests in permeability-testing sequence L4P52-B.

Table 3-13 indicates the equipment that was used and the duration that each instrument was used during permeability-testing sequence L4P52-B.

Table 3-13. Permeability-Testing Sequence L4P52-B Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	12-17-92	12-28-93
DCU (HP3497A)	N/A	2629a22040	12-17-92	1-21-93
DCU (HP3497A)	N/A	2629a21996	4-16-93	5-10-93
DCU (HP3497A)	N/A	2629a21990	5-10-93	9-22-93
DCU (HP3497A)	N/A	2629a21989	9-22-93	1-28-93
Transducer (Druck PDCR 830)	Test Zone	214048	12-17-92	12-28-93
Transducer (Druck PDCR 830)	Test Zone Packer	214466	12-17-92	12-28-93
Transducer (Druck PDCR 830)	Guard Zone	246913	12-17-92	12-28-93
Transducer (Druck PDCR 830)	Guard Zone Packer	214470	12-17-92	12-28-93
Transducer (Druck PDCR 910)	DPT Panel	322427	2-10-93	3-23-93
Transducer (Druck PDCR 830)	DPT Panel	211694	3-23-93	8-2-93
LVDT (Trans-Tek 241)	N/A	R09	12-17-92	12-28-93
LVDT (Trans-Tek 241)	N/A	R03	12-17-92	12-28-93
LVDT (Trans-Tek 241)	N/A	R02	12-17-92	12-28-93
LVDT (Trans-Tek 245)	N/A	A03	12-17-92	12-28-93
Thermocouple (Type E)	Test Zone	1	12-17-92	12-28-93
Thermocouple (Type E)	Guard Zone	2	12-17-92	12-28-93
Injection Column	N/A	38	2-11-93	2-24-93
Injection Column	N/A	77	6-7-93	7-7-93
Injection Column	N/A	76	7-7-93	7-19-93
DPT (Rosemount 1151DP)	N/A	1140864	2-10-93	4-1-93
DPT (Rosemount 1151DP)	N/A	1140863	5-10-93	9-1-93

*Installed dates for injection columns refer to dates of initial use rather than data installed.

3.6.2 Permeability Testing in Waste Panel 1, Room 7

3.6.2.1 BOREHOLE S1P74, PERMEABILITY-TESTING SEQUENCE S1P74-A

Permeability-testing sequence S1P74-A took place in Waste Panel 1, Room 7 in borehole S1P74. This test sequence was designed to investigate the brine permeability of anhydrite "a". Table 3-14 gives a detailed description of the events that occcurred during permeability-testing sequence S1P74-A.

Table 3-14. Permeability-Testing Sequences S1P74-A Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Initiate borehole with 7-inch (17.78-cm) core barrel to 0.62 meters in order to set a borehole collar.	7-27-92	209	209	11:15:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 1.65 meters.	7-27-92	209	209	13:50:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 2.15 meters.	7-27-92	209	209	14:30:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 3.07 meters.	7-28-92	210	210	10:15:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 4.04 meters.	7-28-92	210	210	11:30:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 4.88 meters.	7-28-92	210	210	13:30:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 6.00 meters.	7-28-92	210	210	14:05:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 7.06 meters.	7-28-92	210	210	14:44:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 7.67 meters.	7-29-92	211	211	09:35:00
Face off the bottom of the borehole with 4-inch (10.16-cm) plug bit to 7.69 meters.	7-29-92	211	211	10:00:00
Perform video-log of borehole S1P74.	7-30-92	212	212	13:15:00
Install borehole flanged collar.	7-30-92	212	212	14:00:00
Perform load test on the borehole flanged collar.	7-31-92	213	213	12:00:00
Install multipacker test tool #35 in borehole S1P74 as indicated in the test-tool configuration diagram (Figure 3-32).	7-31-92	213	213	14:00:00
Power outage in Waste Panel 1, Room 7: cannot begin data collection.	7-31-92	213	213	14:30:00
Remove test tool #35 from borehole S1P74 in order to extend the TZ vent line to the bottom of the borehole.	8-3-92	216	216	10:00:00
Install multipacker test tool #35 in borehole S1P74 as indicated in the test-tool configuration diagram (Figure 3-32).	8-3-92	216	216	12:00:00
Begin data file S1P741.	8-5-92	218	218	09:27:22
Inflate GZP to~10.3 Mpa.	8-5-92	218	218	09:43:00
Fill TZ and GZ with brine.	8-5-92	218	218	09:54:00
Diagnose leak in the GZ interval.	8-5-92	218	218	10:00:00
End data file S1P741.	8-5-92	218	218	10:18:31
Remove test tool #35 to find and repair leak in GZ interval.	8-7-92	220	220	08:00:00

Table 3-14 (Continued). Permeability-Testing Sequence S1P74-A Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Install multipacker test tool #35 S1P74 as indicated in the test-tool configuration diagram (Figure 3-32).	8-7-92	220	220	10:30:00
Inflate GZP to ~10.3 Mpa.	8-7-92	220	220	14:00:00
Fill TZ and GZ with brine with 0707 MPa check valves in place to maintain pressure head.	8-7-92	220	220	14:10:00
Begin data file S1P742.	8-7-92	220	220	14:16:37
Inflate TZP to ~10.3 MPa.	8-7-92	220	220	14:20:00
Shut in GZ.	8-7-92	220	220	14:25:00
Shut in TZ.	8-7-92	220	220	14:29:00
Depressurize GZ in order to repair leaky fitting.	8-11-92	224	224	09:22:00
Shut in GZ.	8-11-92	224	224	09:30:00
DAS not functioning properly upon arrival.	9-14-92	258	258	10:29:00
Increase TZ pressure to 2.27 MPa.	9-22-92	266	266	14:36:00
DAS has not been functioning properly for the past 3 days.	9-28-92	272	272	11:35:00
End data file S1P742.	10-1-92	275	275	11:00:10
Replace DAS computer.	10-1-92	275	275	11:01:00
Begin data file S1P743.	10-1-92	256	275	12:14:00
End data file S1P743.	11-13-92	318	318	10:46:35
Begin data file S1P744.	11-13-92	318	318	11:26:00
End data file S1P744.	1-25-93	25	391	07:30:59
Begin data file S1P745.	1-25-93	25	391	11:11:47
Begin constant-pressure-withdrawal test in TZ at 1 MPa below TZ pressure (~5.4 MPa).	1-25-93	25	391	13:25:00
Decrease back-pressure on the system.	1-25-93	25	391	14:15:00
Shut in TZ to change flow line from the bottom to the top of the fluid column.	1-26-93	26	392	10:54:00
Open TZ to fluid column.	1-26-93	26	392	11:00:00
Shut in TZ from fluid column terminating constant-pressure-withdrawal test in TZ.	2-1-93	41	407	10:30:00
End data file S1P745.	2-10-93	41	407	10:45:21
Begin data file S1P746.	2-10-93	41	407	10:45:35
Increase GZP pressure to ~10.5 MPa.	6-12-93	193	559	13:04:17
Shut in GZP.	6-12-93	193	559	13:04:47
End data file S1P746	8-3-93	215	581	06:26:19
Begin data file S1P747.	8-3-93	215	581	11:15:14
Perform TZ-compressibility test #1 from 6.542 to 0 MPa.	8-3-93	215	581	13:14:e0
Shut in TZ terminating TZ-compressibility test #1.	8-3-93	215	581	13:53:00
Perform TZ-compressibility test #2 from 0 to ~8.8 MPa.	8-3-93	215	581	13:58:41
Shut in TZ terminatng TZ compressibility teset #2.	8-3-93	215	581	14:02:00
Initiate pulse-withdrawal test removing 498 mL of brine from the TZ in order to decrease the TZ pressure.	8-3-93	215	581	14:07:00

Table 3-14 (Continued). Permeability-Testing Sequence S1P74-A Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Shut in TZ.	8-3-93	215	581	14:07:51
Terminate TZ pulse-withdrawal test.	8-4-93	216	582	11:25:00
Perform GZ-compressibility test #1 from 4.045 to 0 MPa.	8-4-93	216	582	11:25:06
Shut in GZ terminating GZ compressbility test.	8-4-93	216	582	12:06:56
End data file S1P747.	8-4-93	216	582	12:07:31
Begin data file S1P748.	8-4-93	216	582	12:13:53
End data file S1P748.	8-9-93	221	587	11:06:30
Depressurize TZ.	9-8-93	251	617	09:00:00
Depressurize GZ.	9-8-93	251	617	09:05:00
Deflate TZP.	9-8-93	251	617	09:10:00
Deflate GZP.	9-8-93	251	617	09:15:00
Remove multipacker test tool #35 from borehole S1P74.	9-8-93	251	617	10:30:00

Figure 3-58 through 3-64 illustrate the zone pressures, packer pressures, zone temperatures, axial-LVDT displacement, radial-LVDT displacement, fluid production during a constant-pressure-withdrawal test, and test-zone compressibility as a function of pressure, respectively, for permeability-testing sequence S1P74-A. Copies of the video-log associated with testing sequence S1P74-A identified in Table 3-14 are provided in the SWCF under WPO #45907.

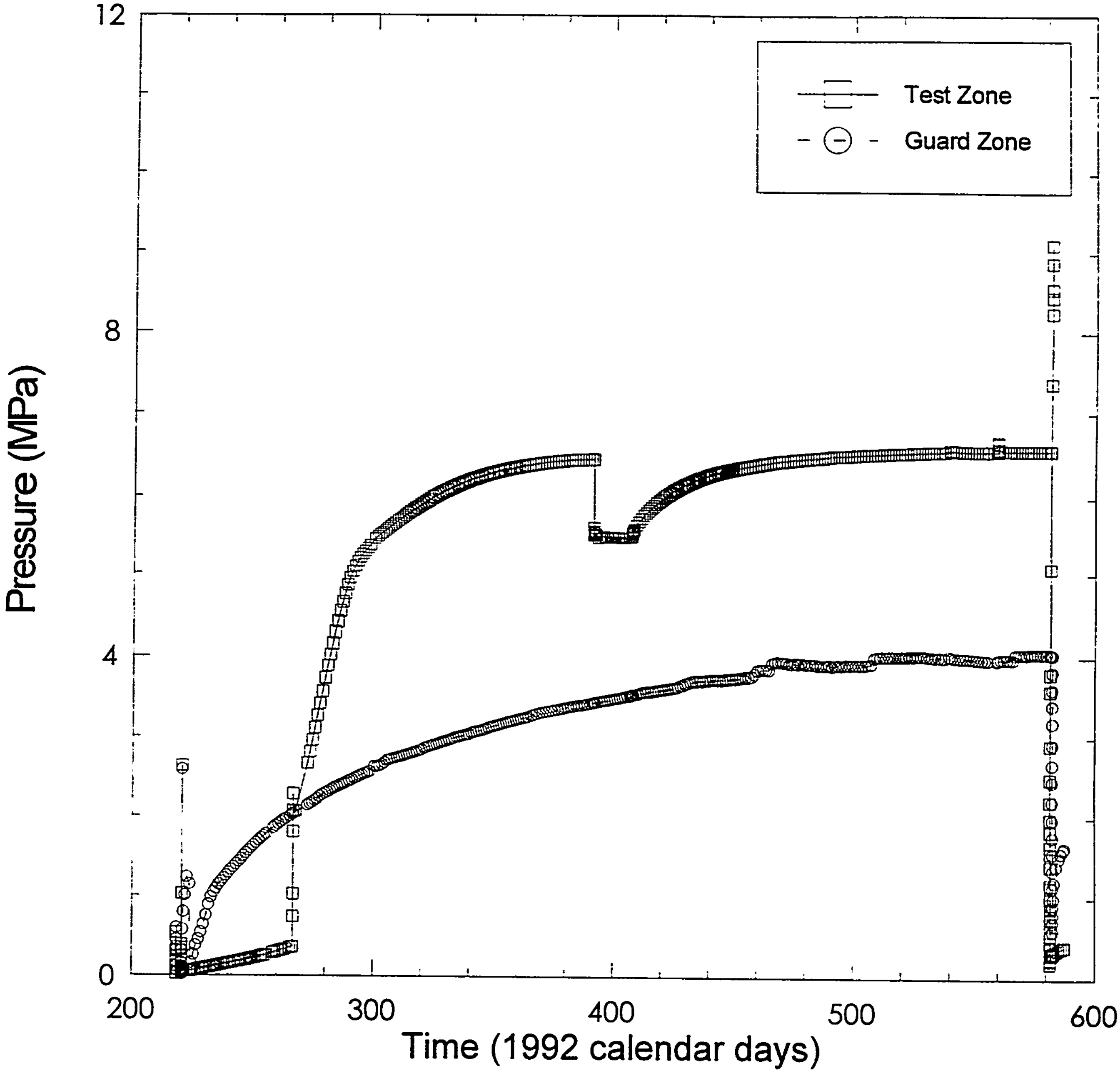

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Figure 3-58. Zone pressures during permeability-testing sequence S1P74-A.

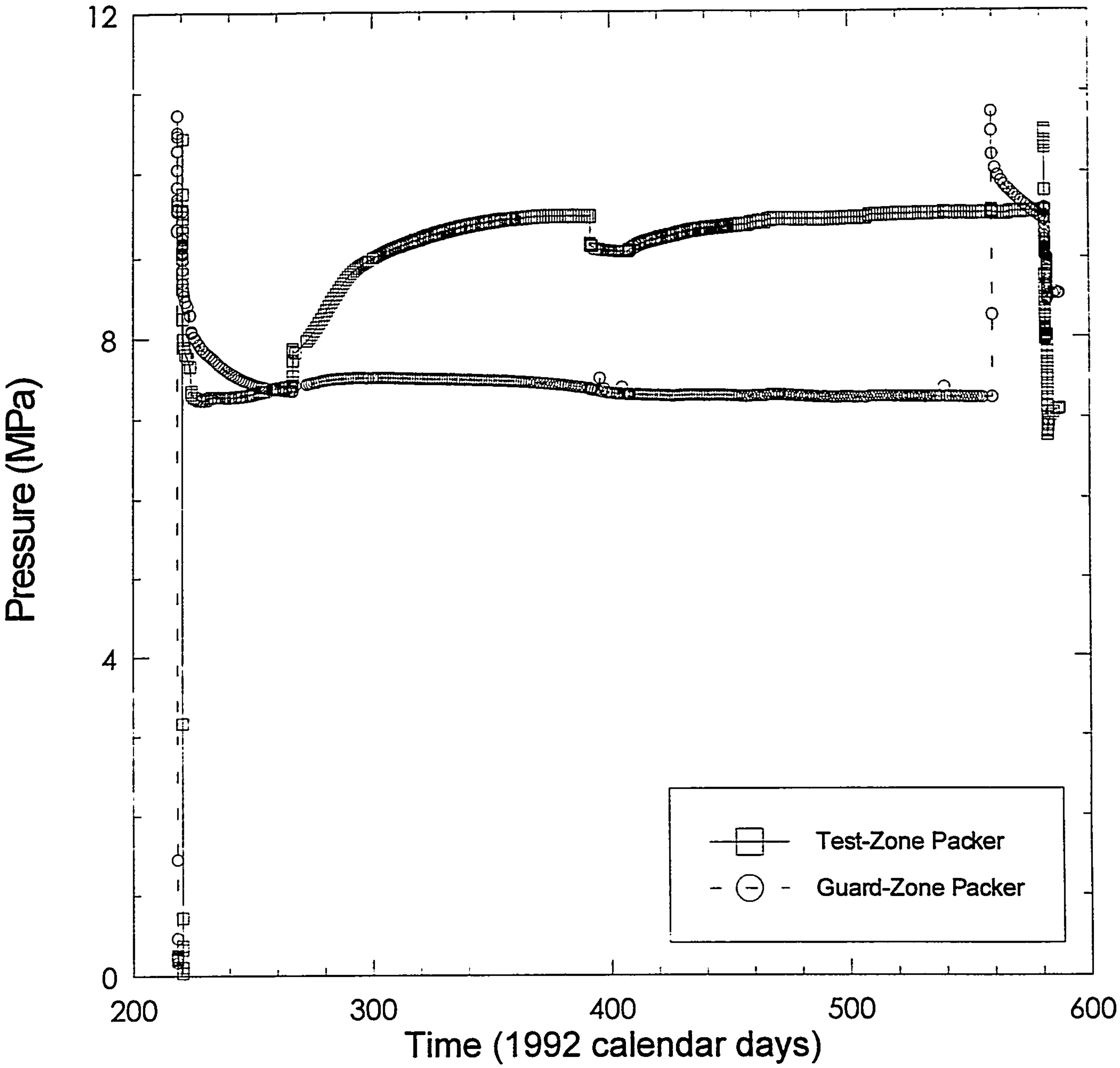

Figure 3-59. Packer pressures during permeability-testing sequence S1P74-A.

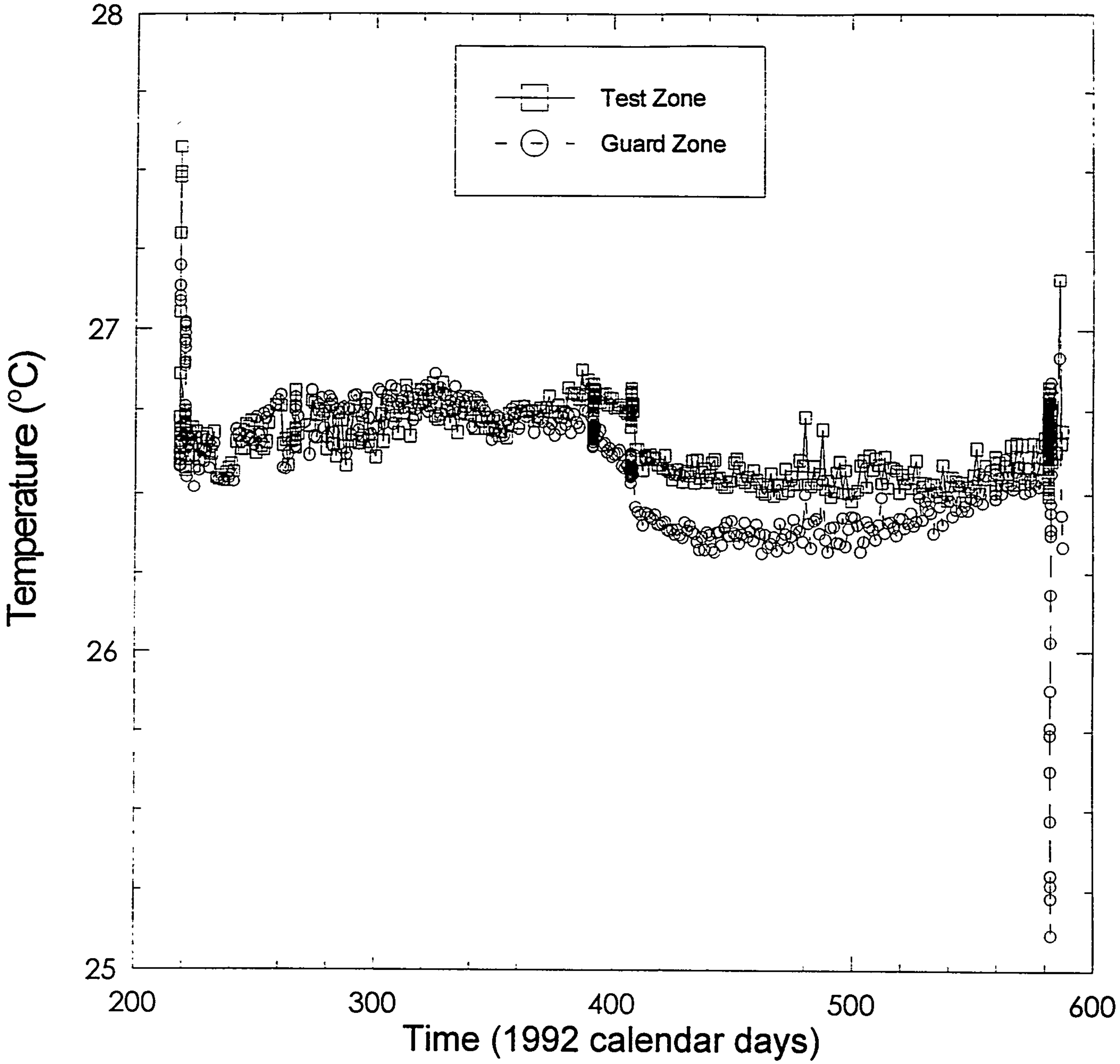

Figure 3-60. Zone temperatures during permeability-testing sequence S1P74-A.

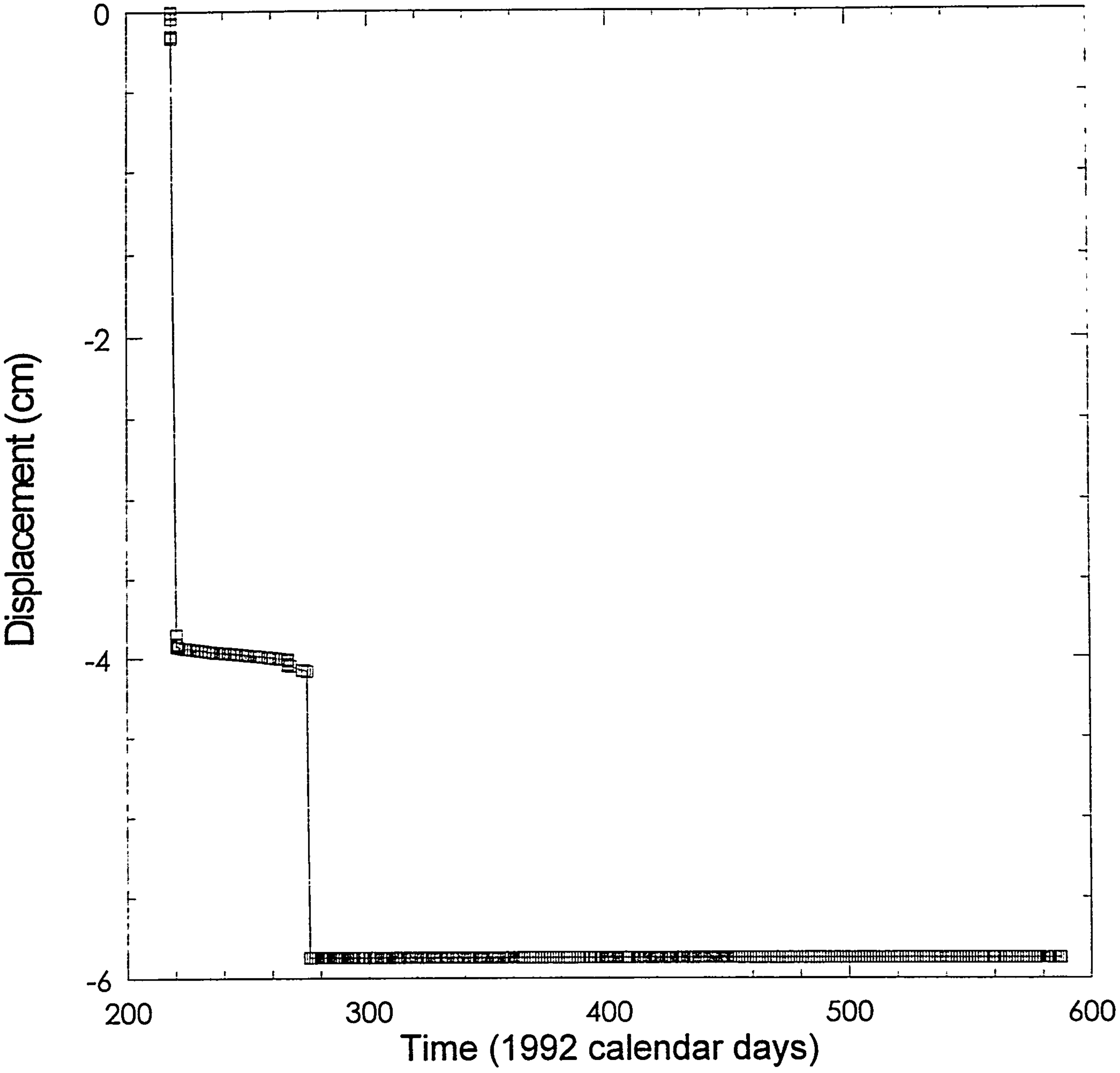

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Figure 3-61. Axial-LVDT displacement during permeability-testing sequence S1P74-A.

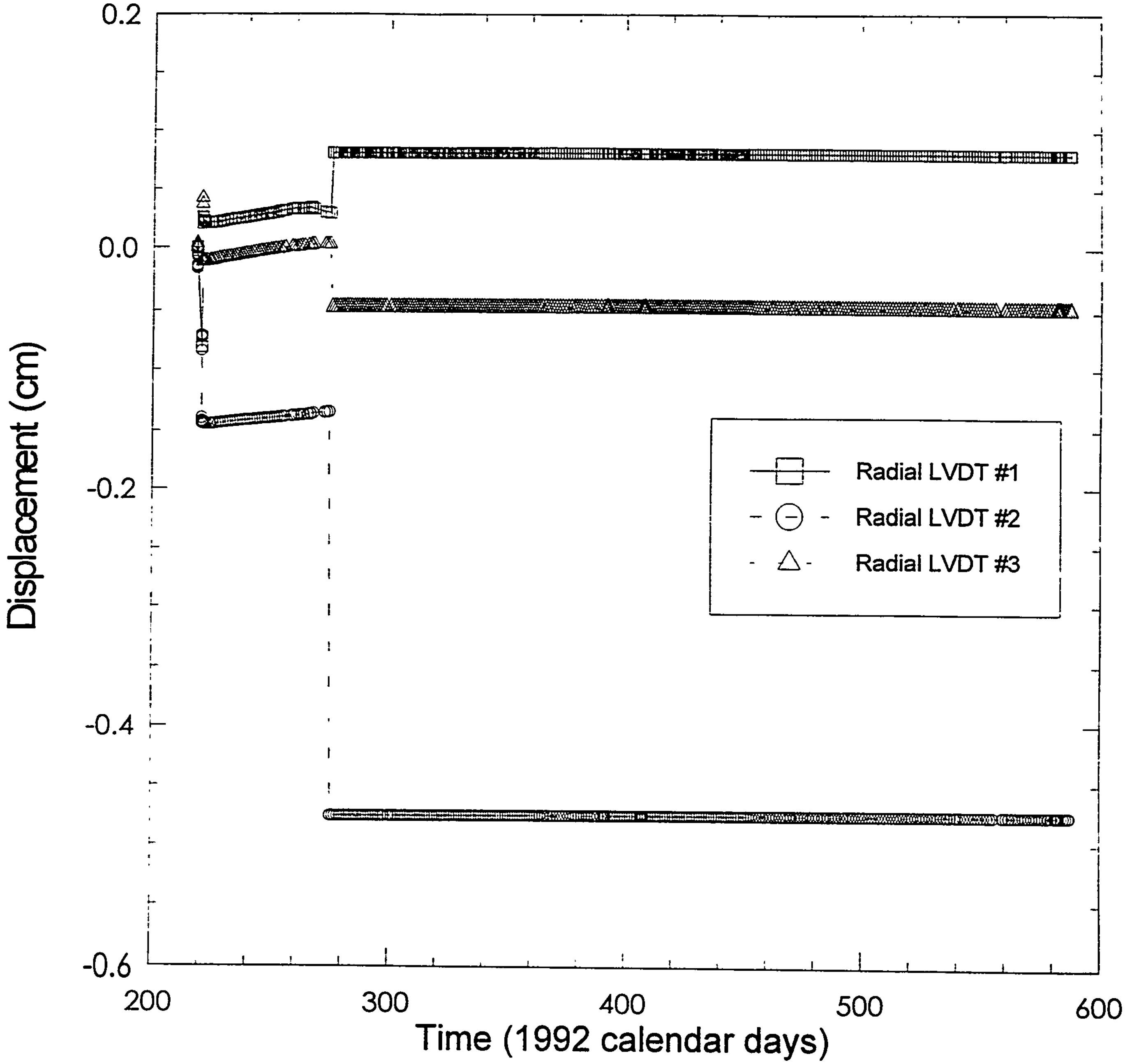

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Figure 3-62. Radial-LVDT displacement during permeability-testing sequence S1P74-A.

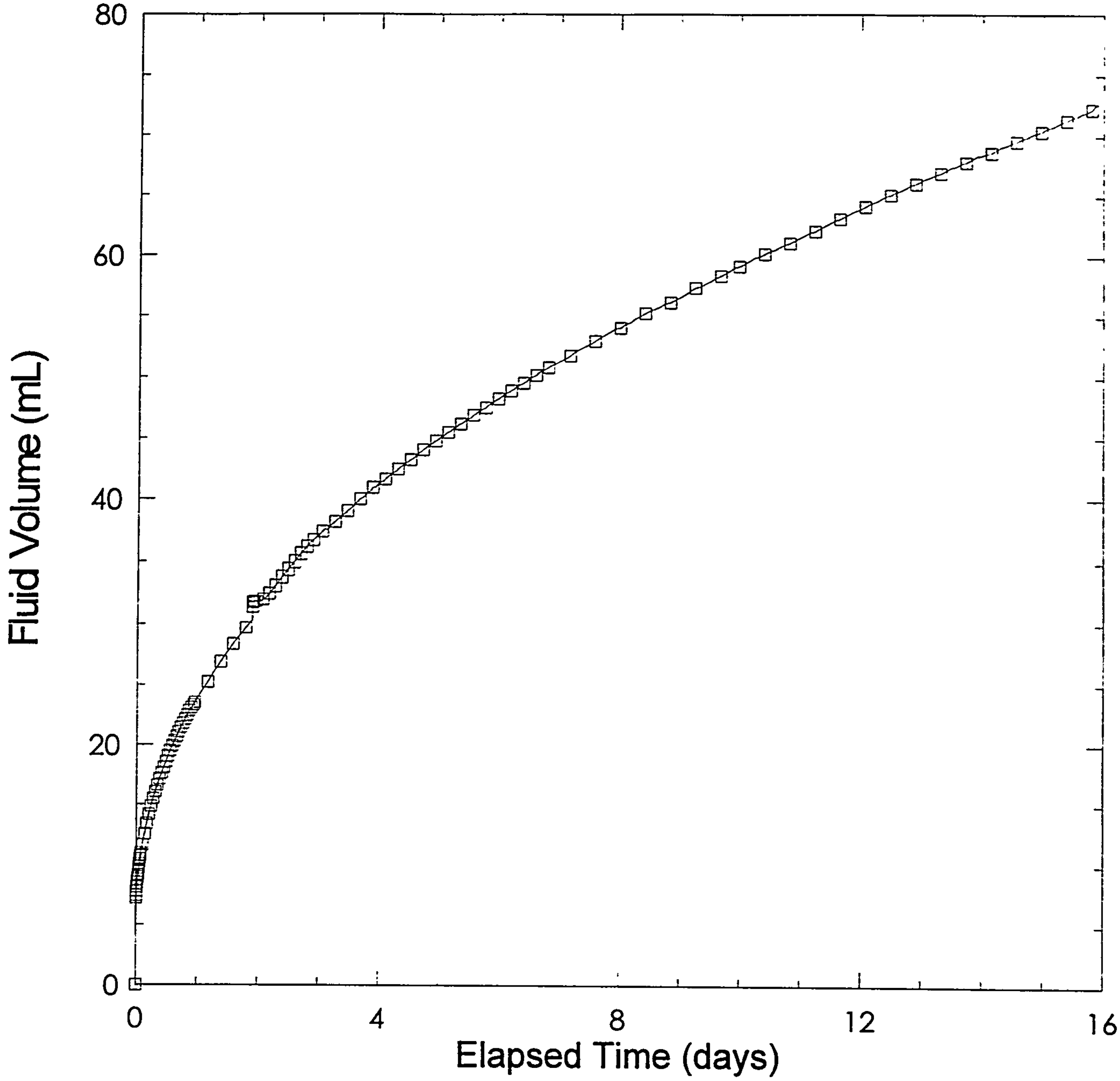

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Figure 3-63. Fluid production during constant-pressure-flow tests in permeability-testing sequence S1P74-A.

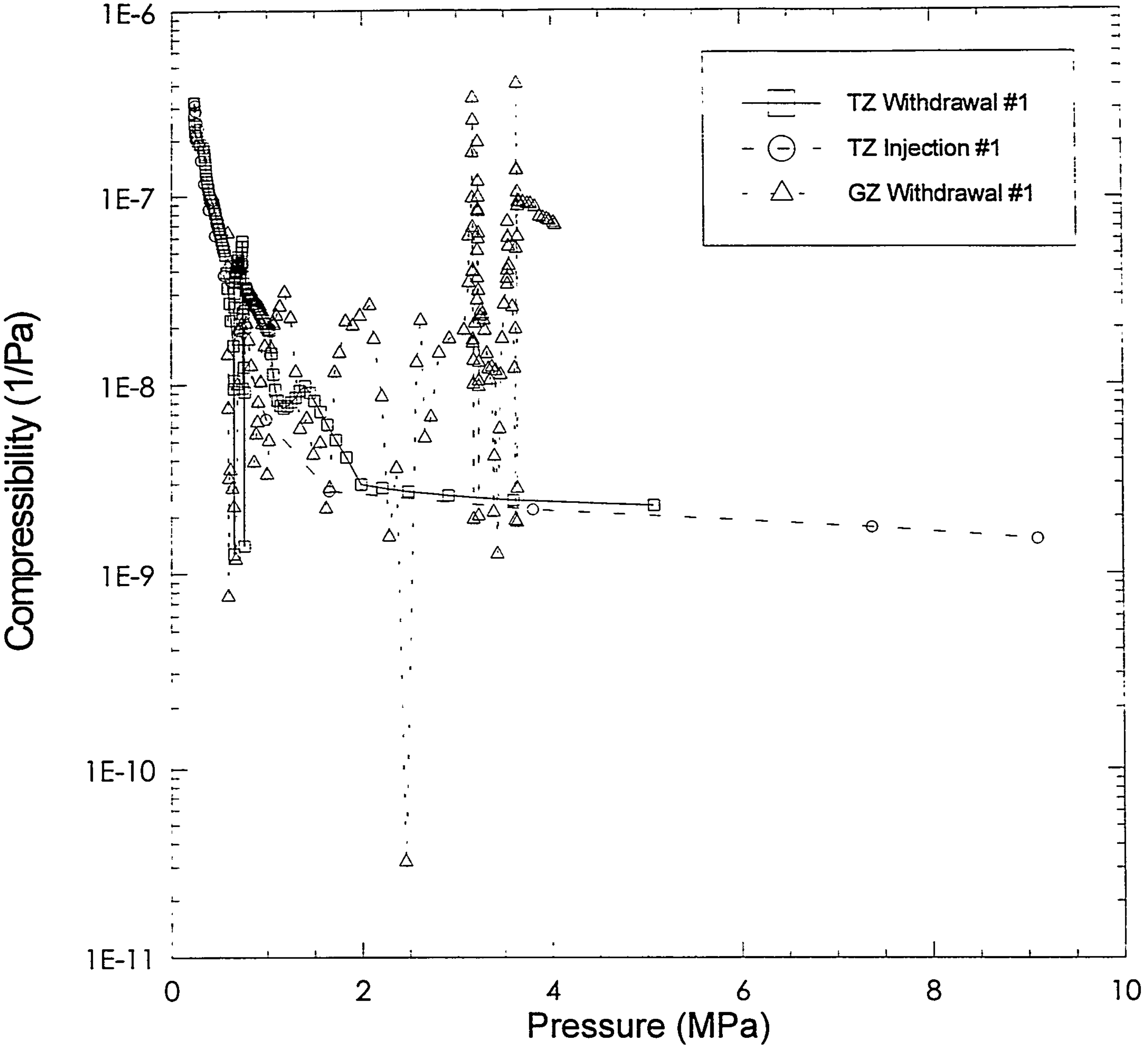

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Figure 3-64. Zone compressibility as measured during permeability-testing sequence S1P74-A.

Table 3-15 indicates the equipment that was used and the duration that each instrument was used during permeability-testing sequence S1P74-A.

Table 3-15. Permeability-Testing Sequence S1P74-A Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4C	8-5-92	10-1-92
DAS Software	N/A	PERM4F	10-1-92	8-9-93
DCU (HP3497A)	N/A	2936a23831	8-5-92	11-13-92
DCU (HP3497A)	N/A	2023a01688	11-13-92	4-20-93
DCU (HP3497A)	N/A	2514a17149	4-20-93	8-9-93
Transducer (Druck PDCR 910)	Guard Zone Packer	322423	8-5-92	8-9-93
Tranducer (Druck PDCR 910)	Test Zone Packer	308152	8-5-92	8-9-93
Transducer (Druck PDCR 830)	Guard Zone	246910	8-5-92	8-9-93
Transducer (Druck PDCR 830)	Test Zone	246912	8-5-92	8-9-93
Transducer (Druck PDCR 910)	DPT Panel	322427	1-25-93	2-10-93
Transducer (Druck PDCR 10/D)	DPT Panel	211694	8-3-93	8-4-93
LVDT (Trans-Tek 241)	N/A	R04	8-5-92	8-9-93
LVDT (Trans-Tek 241)	N/A	R16	8-5-92	8-9-93
LVDT (Trans-Tek 241)	N/A	R17	8-5-92	8-9-93
LVDT (Trans-Tek 245)	N/A	A02	8-5-92	8-9-93
Thermocouple (Type E)	Test Zone	1	8-5-92	8-9-93
Thermocouple (Type E)	Guard Zone	2	8-5-92	8-9-93
Injection Column	N/A	39	1-25-93	2-10-93
Injection Column	N/A	76	8-3-93	8-4-93
DPT (Rosemount 1151DP)	N/A	1140864	1-25-93	2-10-93
DPT (Rosemount 1151DP)	N/A	1140863	8-3-93	8-4-93

*Installed dates for injection columns refers to dates of initial use rather than date installed.

3.6.2.2 BOREHOLE S1P74, PERMEABILITY-TESTING SEQUENCE S1P74-B

Permeability-testing sequence S1P74-B took place in Waste Panel 1, Room 7 in borehole S1P74. This test sequence was designed to investigate the brine permeability of MB138. Table 3-16 gives a detailed description of the events that occurred during the permeability-testing sequence S1P74-B.

Table 3-16. Permeability-Testing Sequence S1P74-B Events

EVENT	DATE	CALENDAR DAY	1995 CALENDAR DAY	TIME (HH:MM:SS)
Ream existing S1P74 borehole with 4-inch (10.16-cm) bit prior to deepening.	1-24-95	24	24	12:31:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 8.55 meters.	1-26-95	26	26	11:03:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 9.50 meters.	1-26-95	26	26	13:05:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 10.36 meters.	1-26-95	26	26	13:38:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 11.15 meters.	1-26-95	26	26	14:32:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 11.92 meters.	1-27-95	27	27	09:07:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 12.88 meters.	1-27-95	27	27	12:25:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 13.80 meters.	1-30-95	30	30	09:56:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 14.45 meters.	1-30-95	30	30	10:42:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 15.32 meters.	1-31-95	31	31	09:43:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 16.18 meters.	1-31-95	31	31	10:39:00
Deepen borehole with 4-inch (10.16-cm) core barrel to 16.82 meters.	1-31-95	31	31	09:43:00
Face off the bottom of the borehole with a 4-inch (10.16-cm) plug bit to 16.88 meters.	1-31-95	31	31	13:30:00
Perform a video-log of the borehole.	2-1-95	32	32	09:06:00
install the multipacker test tool #P74-B until the bottom of the borehole is reached.	2-2-95	33	33	12:30:00
Remove the test tool #P74-B to inspect the TZ vent line to ensure that the vent line reaches the bottom of the borehole.	2-6-95	37	37	09:00:00
Tag borehole depth at 17.04 meters from the collar face.	2-6-95	37	37	10:00:00
Install the mulipacker test tool #P74-B to a depth of 16.960 meters from the collard face as indicated in the test-tool configuration diagram (Figure 3-33).	2-6-95	37	37	13:00:00
Begin data file S1P74B01.	2-7-95	38	38	08:57:47
Pressurize GZP to 13.469 MPa.	3-7-95	38	38	10:03:00
Open GZP to accumulator at 13.419 MPa.	2-7-95	38	38	10:05:00
Fill borehole with brine.	2-7-95	38	38	10:27:000
Pressurize TZ2P to 13.326 MPa.	2-7-95	38	38	10:58:30
Shut in GZ	2-7-95	38	38	10:58:45
Open TZ2P to accumulator at 13.747 MPa.	2-7-95	38	38	11:01:33
Pressurize TZ1P to 13395 MPa.	2-7-95	38	38	11:12:06
Shut in TZ2.	2-7-95	38	38	11:12:27
Open TZ1P to accumulator at 13.435 MPa.	2-7-95	38	38	11:13:54
Shut in TZ1.	2-7-95	38	38	11:17:45

Table 3-16 (Continued). Permeability-Testing Sequence S1P74-B Events

EVENT	DATE	CALENDAR DAY	1995 CALENDAR DAY	TIME (HH:MM:SS)
Leaky fitting on the GZ injection line.	2-7-95	38	38	08:10:00
End data file S1P74B01.	2-10-95	41	41	09:17:04
Begin data file S1P74B02.	2-10-95	41	41	09:28:12
Power outage and UPS failed to respond.	2-10-95	41	41	09:45:00
Determine that the UPS is not functioning properly so it is replaced.	2-10-95	41	41	12:00:00
DAS not functioning upon arrival.	2-13-95	44	44	08:00:00
Shut in GZ to replace leaky fitting.	2-14-95	45	45	08:42:00
Open GZ to system.	2-14-95	45	45	08:49:00
Tighten leaky fitting on the TZ1 inject line.	3-2-95	61	61	08:00:00
Tighten the same leaky fitting on the TZ1 inject line.	3-8-95	67	67	08:00:00
End data file S1P74B02.	3-10-95	69	69	08:47:33
Begin data file S1P74B03.	3-10-95	69	69	08:52:33
End data file S1P74B03.	3-14-95	73	73	09:04:50
Begin data file S1P74B04.	3-14-95	73	73	09:10:64
Shut in all packers from accumulators in order to try to eliminate the temperature-dependent pressure fluctuations in the data.	3-24-95	83	-83	12:10:00
End data file S1P74B04.	4-3-95	93	93	08:07:25
Begin data file S1P74B05.	4-3-95	93	93	08:21:17
Open TZ1P and GZP to accumulator at 113.3 MPa because of pressure decay.	4-3-95	93	93	08:48:00
Replace bad valve on the GZP inflation line.	4-3-95	93	93	09:30:00
Initiate pulse-withdrawal in TZ1 (90.273 to 8,860 MPa) removing ~8.9 mL of brine.	4-10-95	100	100	07:58:00
Open TZ2P to accumulator at ~13.67 MPa.	4-13-95	103	103	07:43:00
Terminate pulse-withdrawal test in TZ1.	4-24-95	114	114	08:23:00
Initiate pulse-withdrawal test #1 in TZ2 (8.801 to 7.083 MPa) removing ~7.1 mL of binre.	4-24-95	114	114	08:23:30
Begin several weeks of power outage.	4-24-95	114	114	09:28:00
Generator supplying power to the DAS broke down.	4-25-95	115	115	13:00:00
Upon arrival the generator was functioning again.	4-26-95	116	116	12:43:00
End data file S1P74B05.	5-9-95	131	131	16:58:52
Begin data file S1P74B06.	5-10-95	132	132	14:20:17
Terminate pulse-withdrawal test #1 in TZ2.	5-13-95	135	135	07:50:00
Initiate pulse-withdrawal test #2 in TZ2 (8.814 to 4.977 MPa) removing ~20.5 mL of brine.	5-13-95	135	135	07:52:42
Terminate pulse-withdrawal test #2 in TZ2.	5-18-95	138	138	07:49:00
Shut in all packers from accumulators.	5-18-95	138	138	07:50:00
Depressurize TZ1.	5-18-95	138	138	08:05:00
Depressurize TZ2.	5-18-95	138	138	08:06:00
Depresurrize GZ.	5-18-95	138	138	08:10:00

Table 3-16 (Continued). Permeability-Testing Sequence S1P74-B Events

EVENT	DATE	CALENDAR DAY	1995 CALENDAR DAY	TIME (HH:MM:SS)
Deflate TZ1P.	5-18-95	138	138	08:20:00
Deflate TZ2P.	5-18-95	138	138	08:25:00
Deflate GZP.	5-18-95	138	138	08:30:00
End data file S1P74B06.	5-18-95	138	138	08:02:43
Remove test tool #P74-B from borehole S1P74.	5-18-95	138	138	14:00:00

Figures 3-65 through 3-67 illustrate the zone pressures, packer pressures, and axial-LVDT displacement, respectively, for permeability-testing sequence S1P74-B. Copies of the video-log associated with testing sequence S1P74-B identified in Table 3-16 are provided in the SWCF under WPO #45907.

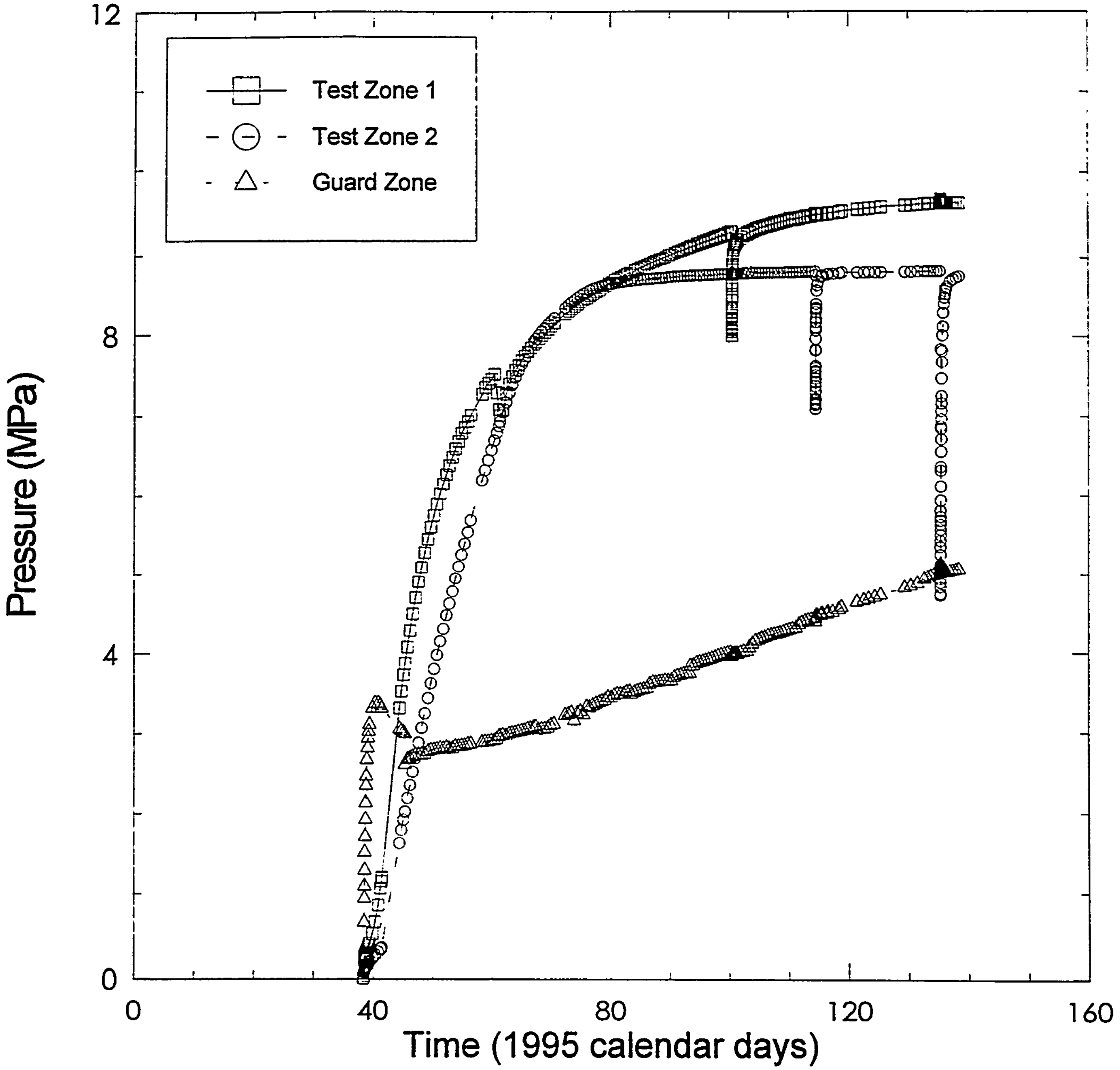

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Figure 3-65. Zone pressures during permeability-testing sequence S1P74-B.

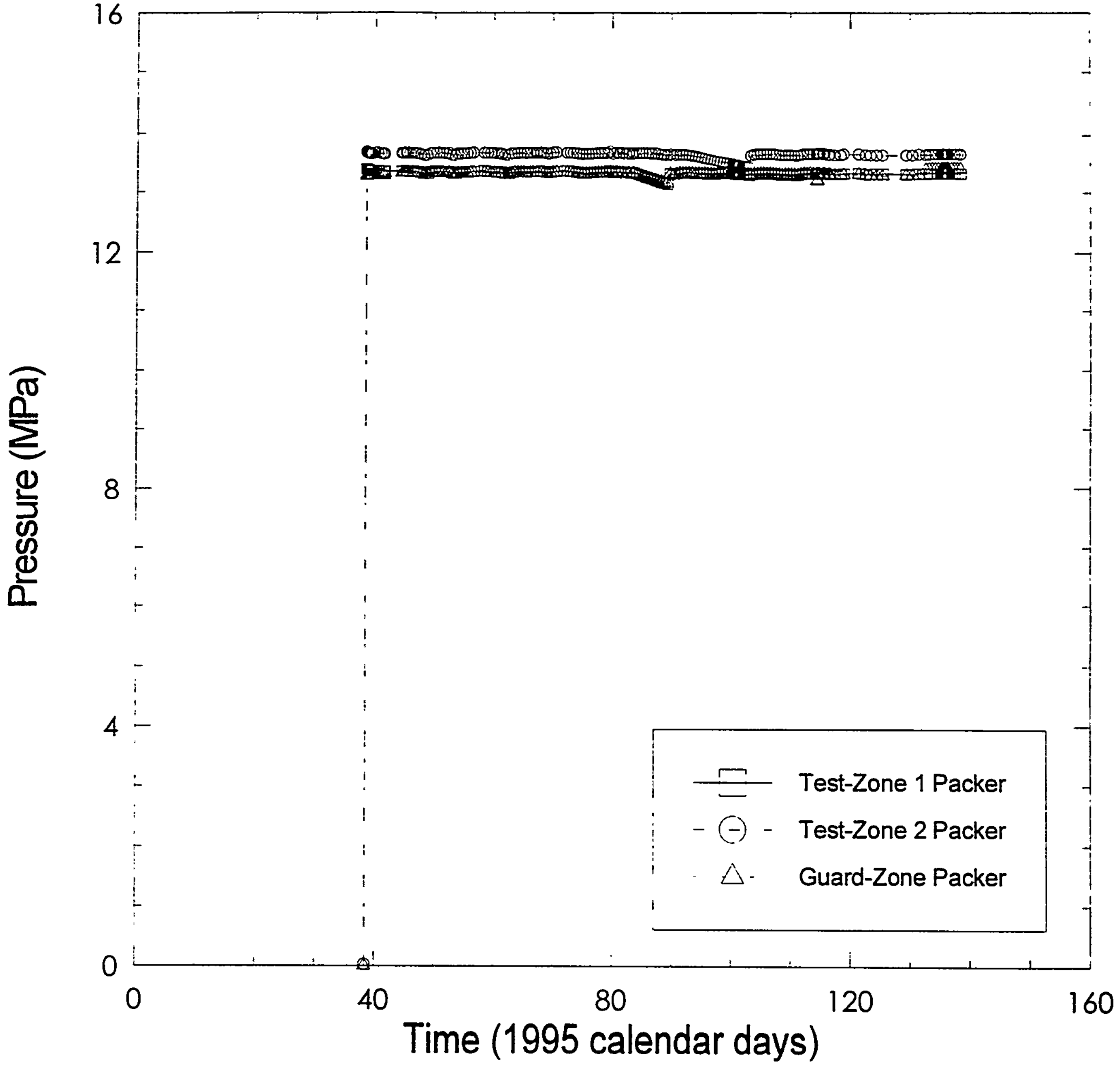

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Figure 3-66. Packer pressures during permeability-testing sequence S1P74-B.

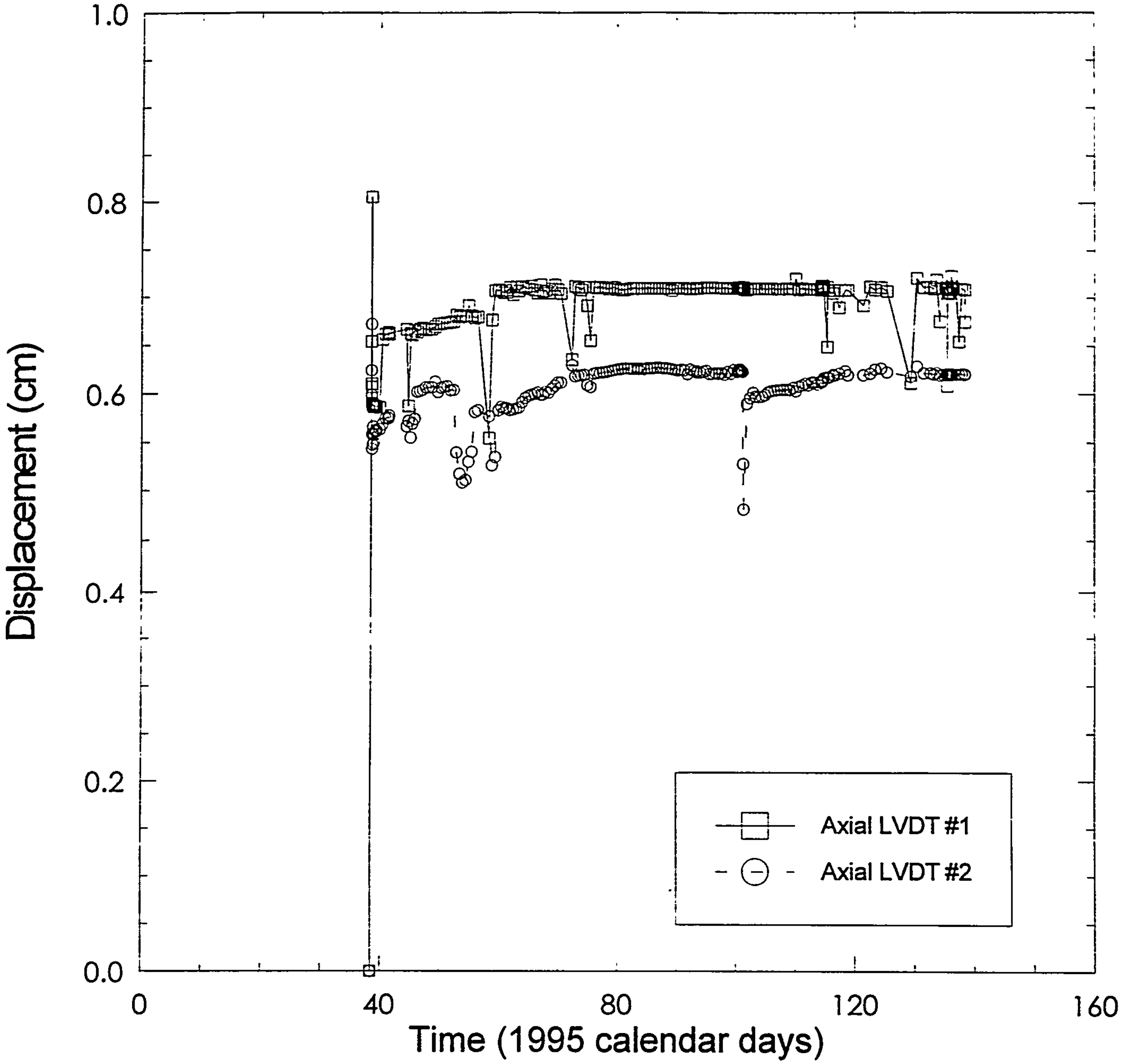

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Figure 3-67. Axial-LVDT displacement during permeability-testing sequence S1P74-B.

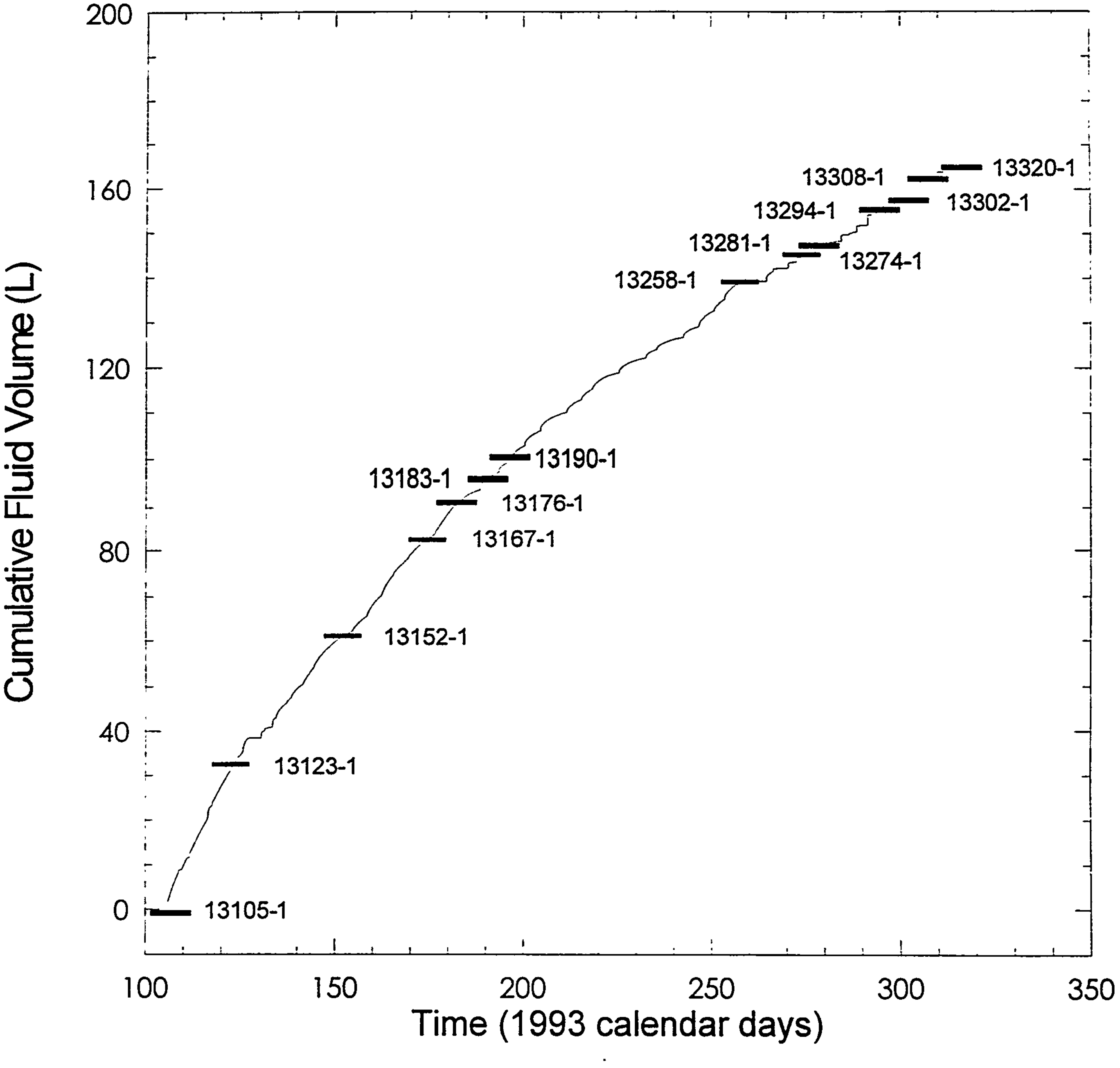

Figure 3-68. Cumulative production from the test zone of borehole L4P51 during the pressurized brine-sampling campaign (sample dates indicated).

4. COUPLED PERMEABILITY AND HYDROFRACTURE TESTING

Complementary hydraulic fracturing and permeability tests were conducted in MB139 and in the deeper MB140 to address the consequences of gas generation in disposal rooms and, specifically, the experimental evaluation of analyses concerning the gas pressurization of anhydrite interbeds such as MB139 (Davies, 1991). Considerable variability was recorded in the measured formation (pore) pressures and permeabilities in MB139 one to two meters below the repository horizon and, to a lesser extent, some six meters below the floor of the experimental area in the WIPP. The observed variability suggests that the properties of MB139 have been altered by the influence of nearby excavations (Stormont et al., 1987; Stormont, 1990a; Beauheim et al., 1991). Because MB140 is located approximately 16 m deeper than MB139 (Holt and Powers, 1984), MB140 was expected to be sufficiently less disturbed to serve as a undisturbed analog of MB139 and other anhydrite interbeds with preexisting, partially healed fractures. Gas flow from the disposal rooms may not be restricted to MB139 immediately below the disposal areas. Therefore, hydraulic fracturing and hydrologic testing measurements in MB139 and MB140 were also intended to provide data useful for the evaluation of anhydrite interbeds above the WIPP horizon (Beauheim et al., 1993).

4.1 Test Objectives

This section presents data collected by the DAS used for permeability testing and to monitor responses to permeability and hydraulic fracturing tests in observation boreholes. A separate DAS was used to monitor and control the hydraulic fracturing tests and the data collected by that DAS are reported by Wawersik et al. (1997). The hydraulic fracturing program had six specific objectives. These objectives were:

- to determine the fluid pressures at which fracturing will occur in anhydrite interbeds, especially MB139, both in a potentially disturbed state and in its undisturbed state;
- to determine whether fracturing would take place by the opening and interconnection of preexisting, partially healed fractures or by the formation of new fractures;
- to determine at what induced pressure (liquid or gas) fracturing might be sustained;
- to determine if fracturing in MB139 involved the development of new fractures, would the fracturing be confined to the anhydrite interbed or would newly created fractures extend across the MB139 contacts;
- to determine if the total stress state (matrix stress plus pore pressure) in MB139 and MB140 is isotropic or not, and can near-field stress measurements around excavations be used to infer the undisturbed state of stress in the interbeds; and
- to determine the magnitude of the smallest principal stress in anhydrite interbeds, if the stress state is anisotropic.

Complementary pre- and post-fracture hydrological measurements were intended to yield the following information:

- reliable values of formation (pore) fluid pressure;
- permeability values of the interbeds before and after hydraulic fracturing; and
- comparison of permeability measurements in MB139 relatively near existing excavations with equivalent data in MB140, which was expected to be essentially undisturbed.

The activities conducted as part of the hydraulic fracturing testing program were motivated foremost by the objectives of hydraulic fracturing tests and attendant studies of fracture formation and fracture growth in anhydrite interbeds. As a consequence, the test sections, i.e., the lengths of the pressurized intervals in all flow tests in the test boreholes, were considerably smaller than the thickness of the interbeds, and flow measurements may not provide good measures of average interbed permeabilities.

4.2 Test Design

The coupled permeability and hydrofracture testing sequences discussed in this report were conducted in two boreholes (C1X10 and C1X05) drilled in Room C1 in the WIPP underground facility. In addition to the test holes, the testing also utilized eight observation boreholes. Boreholes C1H05, C1H06, C2H01, DPD02, and DPD03 were the observation boreholes associated with the C1X10 (MB139) testing sequence. Boreholes C1X10, C2H01, C1H05, C1H06, C1H07, and C1X06 were the observation boreholes associated with the C1X05-A (MB139) testing sequence. Boreholes C1H07 and C1X06 were the observation boreholes associated with the C1X05-B (MB140) testing sequence. Note that during the C1X05-B testing sequence, a pulse-withdrawal test was initiated in borehole C1X06 and monitored in boreholes C1X05 and C1H07. The stratigraphic positions and isolated zones of all of the coupled permeability and hydrofracture testing boreholes are shown in Figure 4-1.

Various combinations of single-, double-, and triple-packer test tools were used during the three coupled permeability and hydrofracture testing sequences. The zones of the test boreholes (C1X10 and C1X05) were filled with a mixture of Chevron Mineral Seal 38 oil and ZL-27A Zyglo penetrant. The zones of the observation boreholes were filled with 1.22 kg/L sodium-chloride brine. After completing the pre-hydrofracture permeability tests, hydrofracturing of the anhydrite in the test zones was performed by pumping the ChevronMineral Seal 38 oil/ZL-27A Zyglo penetrant mixture into the test zone. Post-hydrofracturing permeability tests were performed to determine how fracture development changed the anhydrite permeability and storage capacity and also to determine if post-fracturing permeability and storage were constant or pressure dependent.

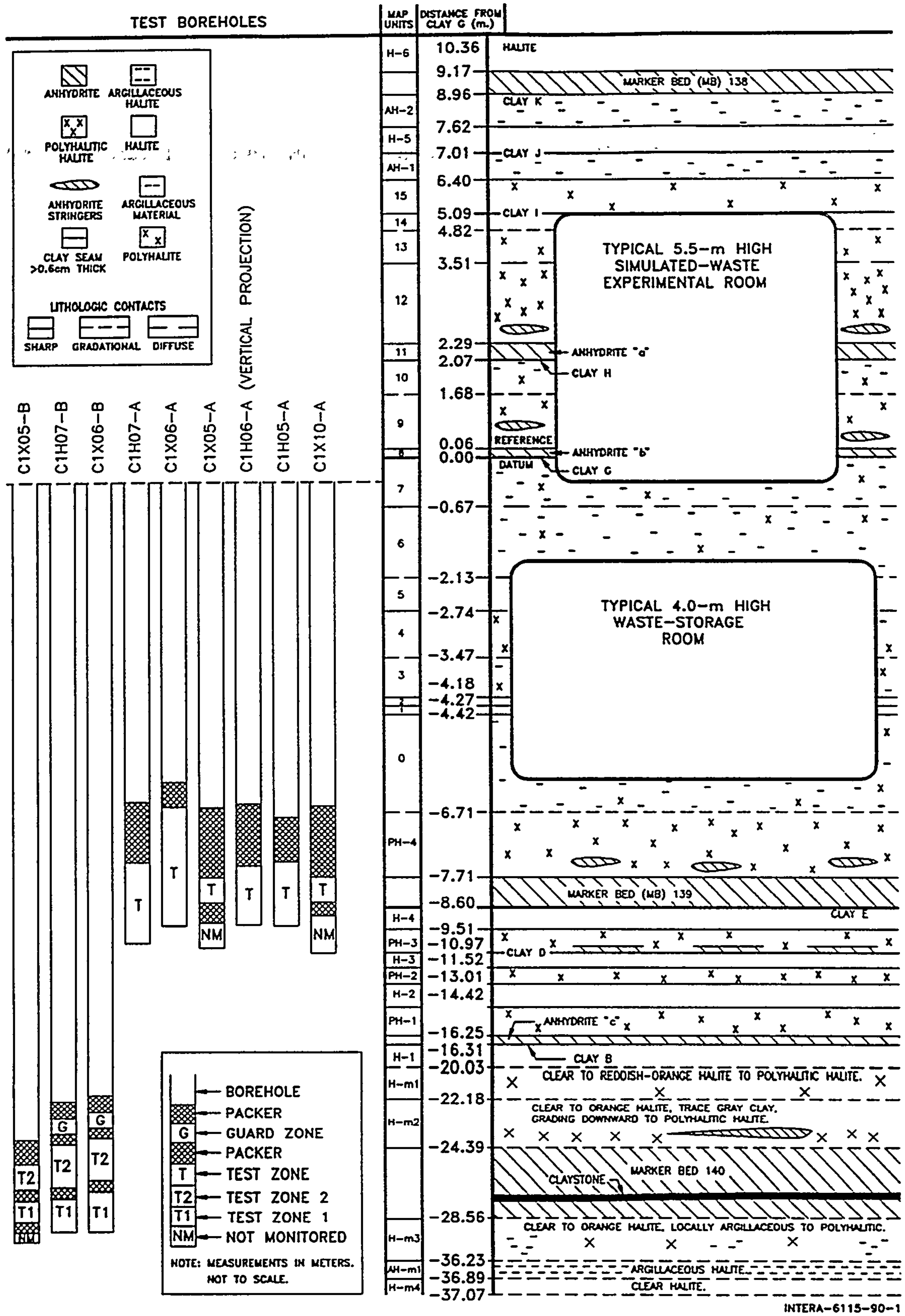

Figure 4-1. Stratigraphic positions of coupled permeability and hydrofracture test and observation boreholes with test zones indicated.

Pulse-withdrawal testing and constant-pressure testing procedures are described in Section 3.4. Tables 4-1 and 4-2 summarize the locations and orientations of the boreholes in which hydrofracture and pre- and post-fracture permeability testing sequences were performed, the dates that the boreholes were drilled, the lengths of the boreholes, and the dates when the borehole locations were excavated.

4.3 Test Equipment for Coupled Permeability and Hydrofracture Testing

The following section (4.3.1) briefly describe the equipment used in the coupled permeability and hydrofracture testing program in the WIPP underground facility. The equipment includes single and multipacker test tools, data-acquisition systems (DAS), pressure transducers, thermocouples, linear variable-differential transformers (LVDT), and a differential-pressure-transmitter (DPT) panel. Equipment specific to individual testing sequences is provided in Section 4.6. More detailed descriptions of the testing equipment and the procedures are presented in Stensrud et al. (1992). Equipment calibration is discussed in Section 4.3.2.

4.3.1 Description of Equipment

4.3.1.1 TEST TOOLS

As described in Wawersik et al. (1997), the coupled permeability and hydrofracture test tools, shown in Figures 4-2 and 4-3, were variations of a conventional two-element straddle packer with stainless steel straddle rod(s) (Wawersik, 1991, 1992, 1993). The inflatable packer elements consisted of 40-inch (102-cm) long, 2-5/8-inch (6.67-cm) diameter slat-type elements acquired from Baker Service Tools with outer and inner packer tube designations #808 and #801, respectively. The length of the elastomer covers on all packers was 76 cm. Figure 4-2 shows the assembly drawing of the tool that was fielded in two sets of combined fluid flow and hydrofracturing measurements in MB139. The straddle rod was machined of 2.5-cm I.D. x 3.8-cm O.D. (1.0 x 1.5-inch) stainless steel pipe. The length of the straddle rod was selected so that each packer element would be centered over the upper and lower contacts of MB139 whose thickness in the test area varied between 0.80 and 0.95 m. The packer ends on the interval side were free to move as the packer elements were pressurized and expanded. One adapter ('sub') of each packer was equipped with a 3000-psi (20.7 MPa) rupture disk. Additionally, the bottom sub of the tool contained a vent to purge the packer of air as it was filled with fluid. The top sub contained ports for separate fluid supply lines to the packers and to the coupled permeability and hydrofracturing interval between the packers. A third port permitted the installation of a pressure gage for downhole measurements of the interval pressure. A 0.953-cm O.D. x 0.775-cm I.D. (0.375 x 0.305-inch) 304 stainless steel supply line to the test interval ensured that the interval volume remained nearly constant with time in order to obtain reliable measurements of the formation pressure before flow or coupled permeability and hydrofracturing tests were initiated. Early test simulations in a steel pipe indicated that this condition could not be maintained with a 23-m (75-foot)-long flexible

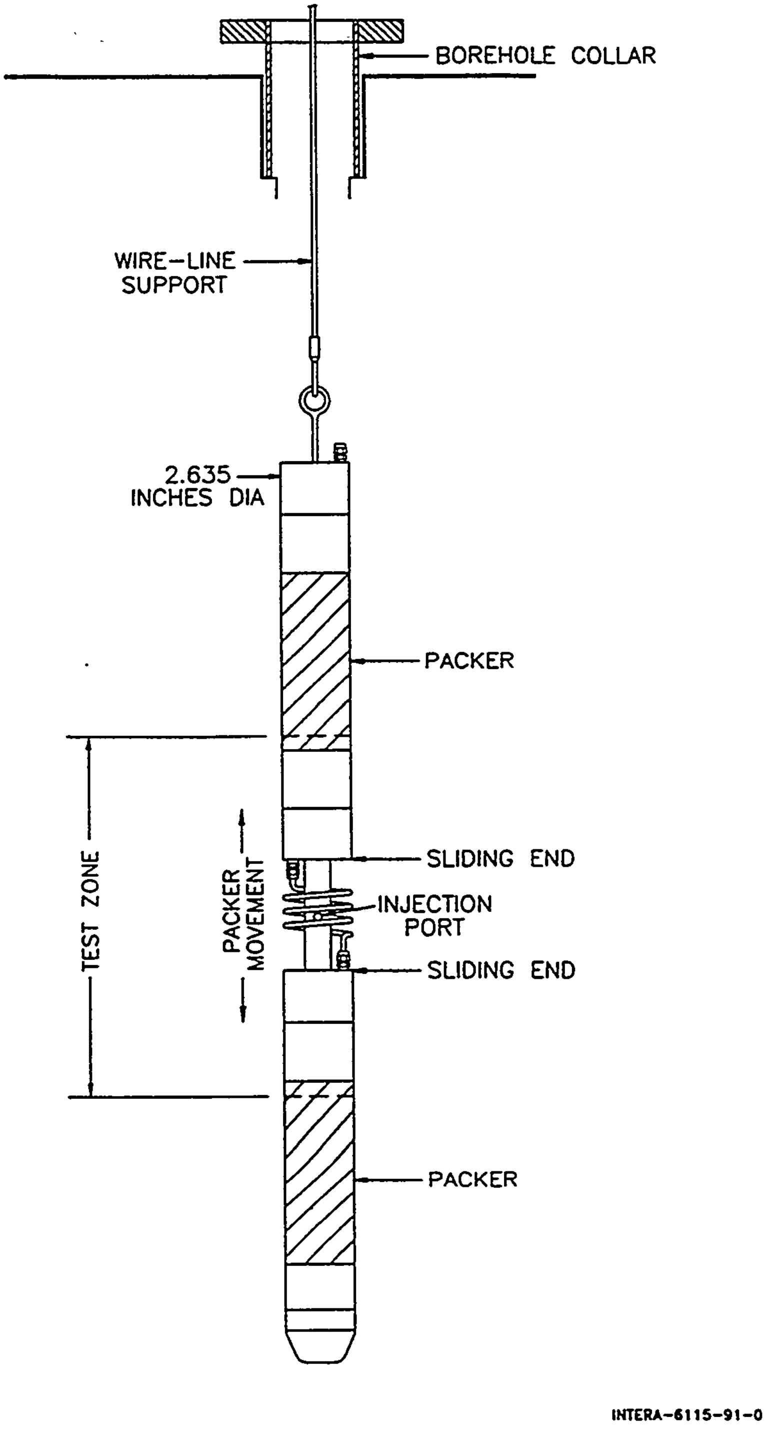

Figure 4-2. Generic double-packer test-tool configuration used for coupled permeability and hydrofracture testing.

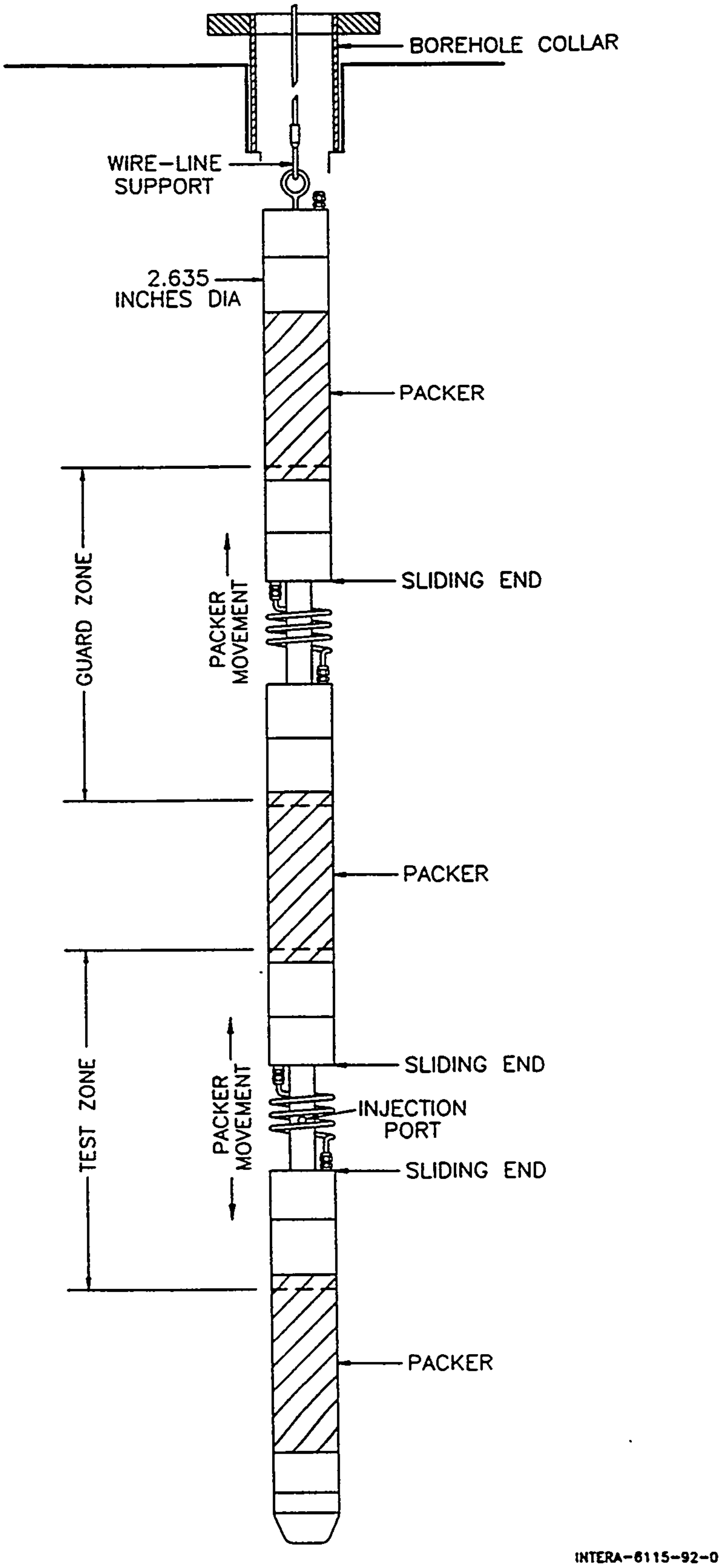

Figure 4-3. Generic triple-packer test-tool configuration used for coupled permeability and hydrofracture testing.

high-pressure hose (Aeroquip No. 2781-04, 0.63-cm/0.25-inch I.D.) whose internal diameter changed steadily with time. Therefore, a stainless Steel supply line was used. Figure 4-3 shows the assembly drawing of the straddle packer configuration that was used in MB140. To control pressure in two zones, the straddle packer in Figure 4-2 was modified in four ways. First, a new (middle) sub was built to incorporate a third packer element. Second, a manifold was mounted on top of the straddle packer, and third, a sliding sub was installed into the new (middle) sub in order to feed an additional, independent fluid supply line to the lower interval. Finally, fourth, the straddle rods between the top, middle, and bottom subs were segmented to facilitate the handling of the tool and the process of inserting and lowering it into boreholes with limited headroom.

The monitor tools, shown in Figures 3-2, 3-3, and 4-4, were designed and built specifically for the permeability-testing program by Baski Inc. in conjunction with SNL and INTERA Inc. Some of the test tools had two sliding-end, 3.75-inch (9.53-cm) O.D. packers mounted on a 1.9-inch (4.83-cm) mandrel with the fixed ends oriented toward the bottom-hole end of the test tool (Figure 3-2). In other instances, the monitor tools had three sliding-end, 3.75-inch (9.53-cm) O.D. packers mounted on a 1.9-inch (4.83-cm) O.D. mandrel with the fixed ends oriented toward the bottom-hole end of the monitor tool (Figure 3-3). The remaining monitor tools had one sliding-end, 3.75-inch (9.53-cm) O.D. packer mounted on a 1.9-inch (4.83-cm) O.D. mandrel with the fixed end oriented toward the bottom-hole end of the monitor-tool (Figure 4-4). Figure 3-4 shows the nominal dimensions of the monitor tools' parts. Other information regarding the monitor tools is presented in Section 3.3.1.1.

4.3.1.2 OTHER EQUIPMENT

The DAS, pressure transducers, thermocouples, LVDTs, DPT panel, and pressure-maintenance system used for the permeability testing aspects of the coupled permeability and hydrofracture testing program are described in Sections 3.3.1.2 through 3.3.1.6 and 3.3.1.8. Wawersik et al. (1997) describes the fluid supply system used in the hydrofracture testing. The fluid and pressure source consisted of an air-driven Haskel pump (model GSF-60-6) in parallel with a 5-gallon (19-liter) Haskel accumulator (Haskel part no. 5-5-100-1). Combinations of compact pressure transducers of Kulite Semiconductor Products (model HKM-365-5000A) and signal conditioners/readouts of Entran Devices Inc. and Beckman Instruments Co. were used throughout. In the MB140 experiments, the pressure in both the upper and lower straddle packer intervals were measured only at the console because the downhole pressure gage had been damaged during packer installation. Fluid flow during hydrofracturing tests was measured by means of a 0.4-11.4 L/min (0.1-3 gpm) flow meter by Flow Technology, Inc. (model FT6-8-NEXB-LED-1). Fluid flow in the range of 1.9-11.4 L/min (0.5-3 gpm) was controlled by means of a Teledyne flow control valve (catalog series 664). Under all other conditions, fluid flow was regulated manually. Documentation associated with the equipment used for the actual hydrofracture tests can be found in the SWCF under WPO #35174.

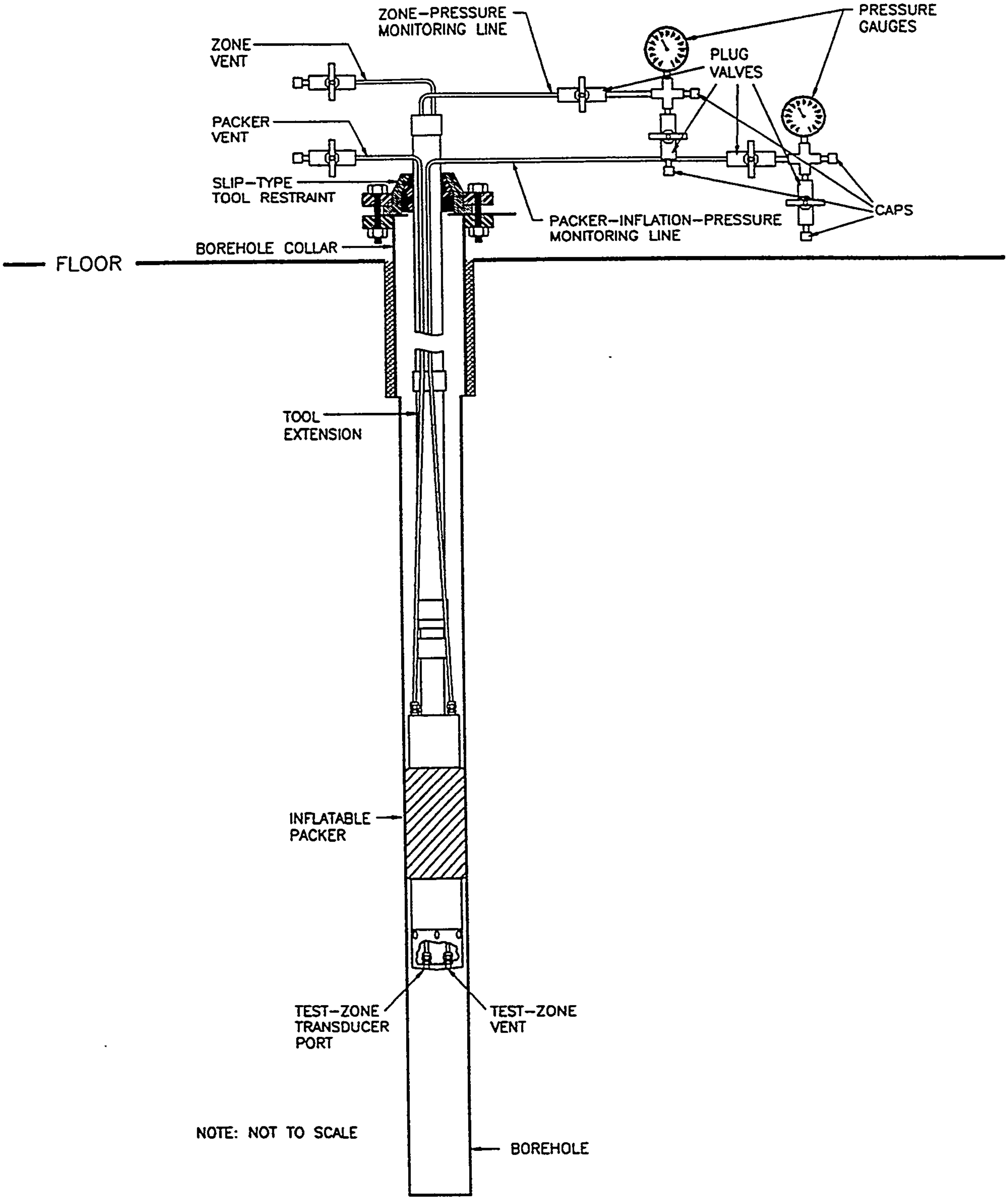

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Figure 4-4. Generic single-packer monitor-tool configuration used for coupled permeability and hydrofracture testing.

4.3.2 Equipment Calibration

Equipment calibration information is discussed in Section 3.3.2.

4.4 Procedures for Permeability Testing Associated with Hydrofracture Experiments

Test and monitor tools were installed as described in Section 3.4.1. Data associated with both test and observation boreholes were collected by the DAS associated with the test borehole. During the C1X05-B testing sequence, borehole C1H07 pressure was monitored for a brief period by a DAS associated with that observation borehole. This was necessary because borehole C1H07 was deepened prior to deepening borehole C1X05 (see Section 4.6.3.1).

During testing C1X05-B, borehole C1X05 was primarily used as the testing borehole. In order to compare the directional pressure response between boreholes C1X05 and C1X06, one pulse-withdrawal test was conducted in which borehole C1X06 was used as the testing borehole and borehole C1X05 and C1H07 were used as the observation borehole. This pulse-withdrawal test is presented in Section 4.6.3.2 in Table 4-23.

One pulse-withdrawal test and multiple constant-pressure injection and withdrawal tests were conducted in association with the hydrofracture experiments. These tests followed the procedures outlined in Sections 3.4.2 and 3.4.3.

4.5 Boreholes and Test-Tool Configurations for Coupled Permeability and Hydrofracture Testing

Figure 2-1 shows the location of Room C1 in the WIPP facility where the coupled permeability and hydrofracture testing took place. Tables 4-1 and 4-2 provide information regarding the test and observation boreholes. To refer to a borehole which was deepened, a letter designation is added to the borehole number to indicate a different testing sequence.

Table 4-1. Coupled Permeability and Hydrofracture Test Borehole Information

Test Sequence	Test Horizon	Time Test Horizon Penetrated	Borehole Diameter (cm)	Test Interval Depth (m)	Borehole Depth (m)	Sequence Started	Sequence Terminated
C1X10	MB139	11-11-91 (13:25)	7.62	7.50 - 8.10	10.16	11-12-91	6-26-92
C1X05-A	MB139	6-29-92 (10:00)	7.62	6.72 - 7.60	9.14	7-1-92	4-12-93
C1X05-B	MB140	6-14-93 (10:00)	7.62	23.09 - 27.14	30.20	6-15-93	4-11-94

Table 4-2 (Continued). Coupled Permeability and Hydrofracture Observation Borehole Information

Test Sequence	Observation Borehole	Test Horizon	Time Test Horizon Penetrated	Borehole Diameter (cm)	Test Interval Depth (m)	Borehole Depth (m)
C1X05-A	C1H05	MB139	1-16-92 (13:30)	10.16	7.002 - 8.255	8.26
C1X05-A	C1H06	MB139	1-21-92 (13:30)	10.16	8.200 - 9.398	9.40
C1X05-A	C1H07	MB139	6-24-92 (12:00)	10.16	6.770 - 7.600	8.18
C1X05-A	C1X06	MB139	9-29-92 (12:30)	10.16	6.430 - 7.320	7.63
C1X05-A	C1X10	MB139	11-11-91 (13:25)	10.16	7.50 - 8.10	10.16
C1X05-A	C2H01	MB139	12-13-89 (12:00)	10.16	6.80 - 7.76	8.97
C1X05-B	C1H07	MB140	5-25-93 to 5-26-93	10.16	22.688 - 23.657 24.277 - 27.880	27.88
C1X05-B	C1X06	MB140	7-9-93 & 8-12-93	10.16	22.973 - 23.945 24.559 - 27.990	27.99
C1X10	C1H05	MB139	1-16-92 (13:30)	10.16	7.002 - 8.255	8.26
C1X10	C1H06	MB139	1-21-92 (13:30)	10.16	8.200 - 9.398	9.40
C1X10	DPD02	MB139	4-86 (N/A)	10.16	11.00 - 13.11	13.11
C1X10	DPD03	MB139	4-86 (N/A)	10.16	11.15 - 13.11	13.11
C1X10	C2H01	MB139	12-13-89 (12:00)	10.16	6.80 - 7.76	8.97

The drilling procedures describes in Section 3.5.2 were followed during the drilling of the boreholes associated with the coupled permeability and hydrofracture testing program. The air-rotary drilling method was used to drill all of the initial boreholes. The brine-rotary drilling method was used to deepen boreholes C1H07, C1X05, and C1X06 prior to the C1X05-B coupled permeability and hydrofracture testing sequence.

Figures 4-5 and 4-6 schematically depict Room C1 in plan and cross-sectional views, and show the positions of all boreholes associated with the testing program. Figure 4-7 schematically depicts Room C2 in plan and cross-section showing the location of

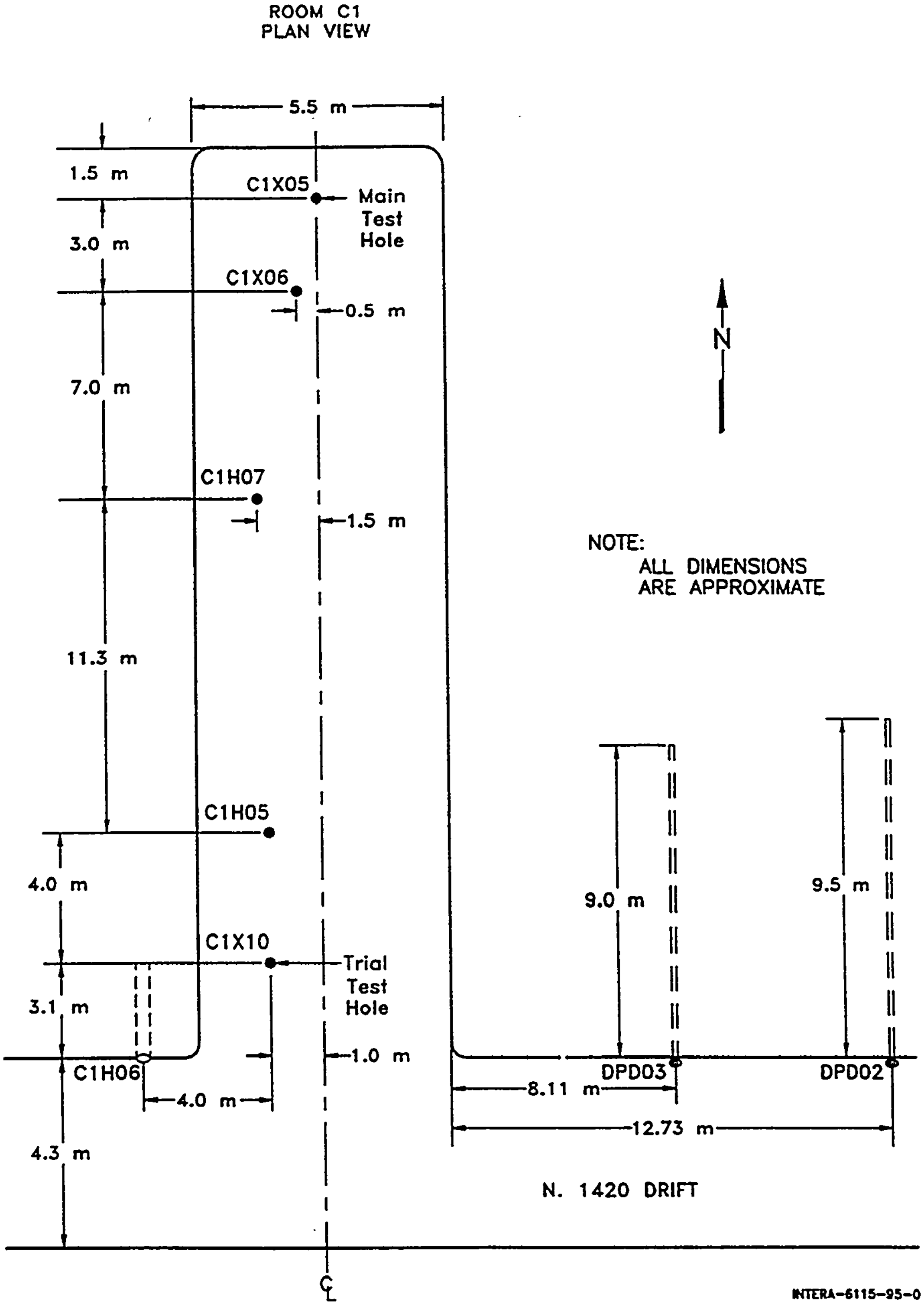


Figure 4-5. Spatial representation of Room C1 showing the locations of test and observation boreholes.

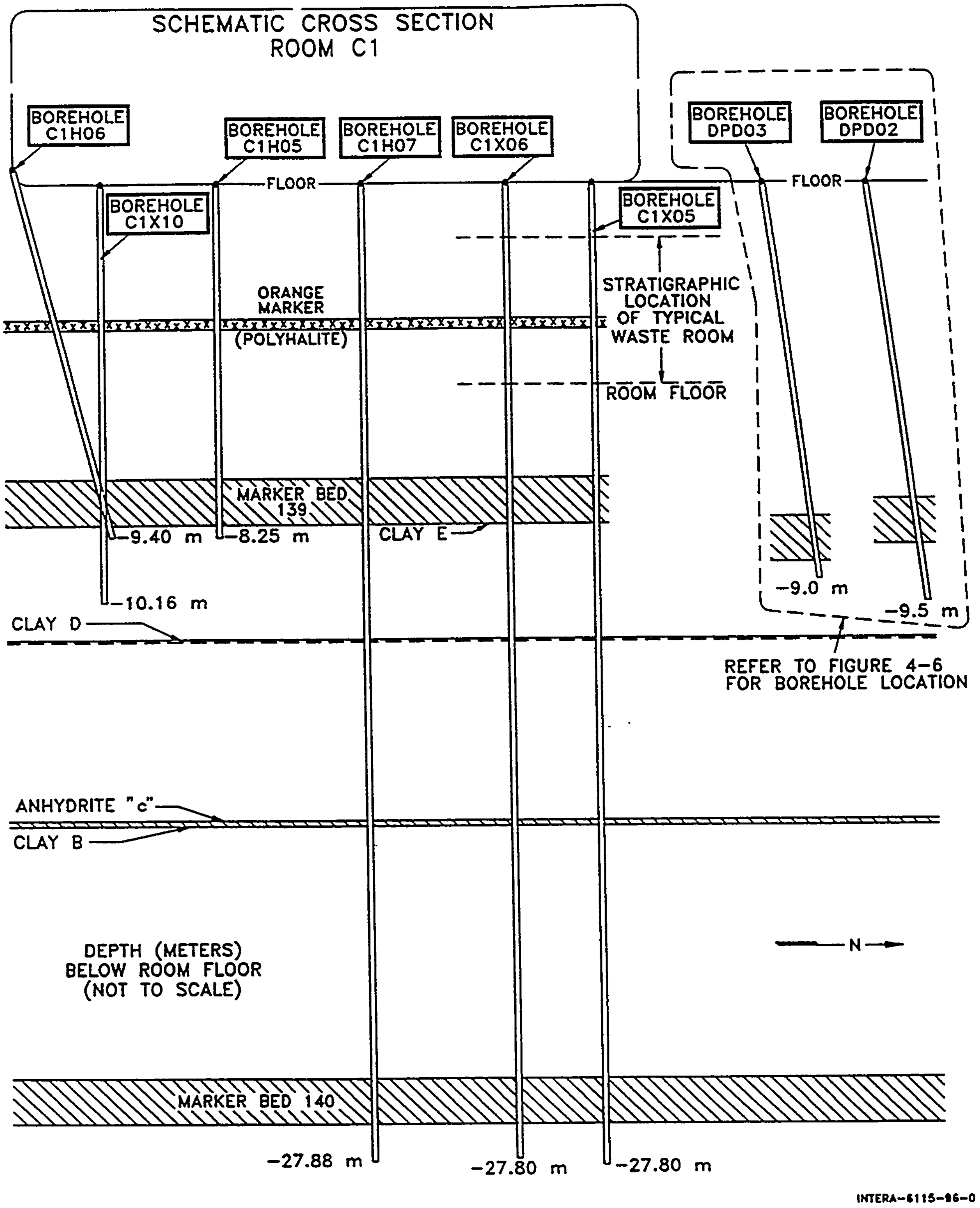


Figure 4-6. Cross-sectional view of Room C1 showing the locations of test and observation boreholes.

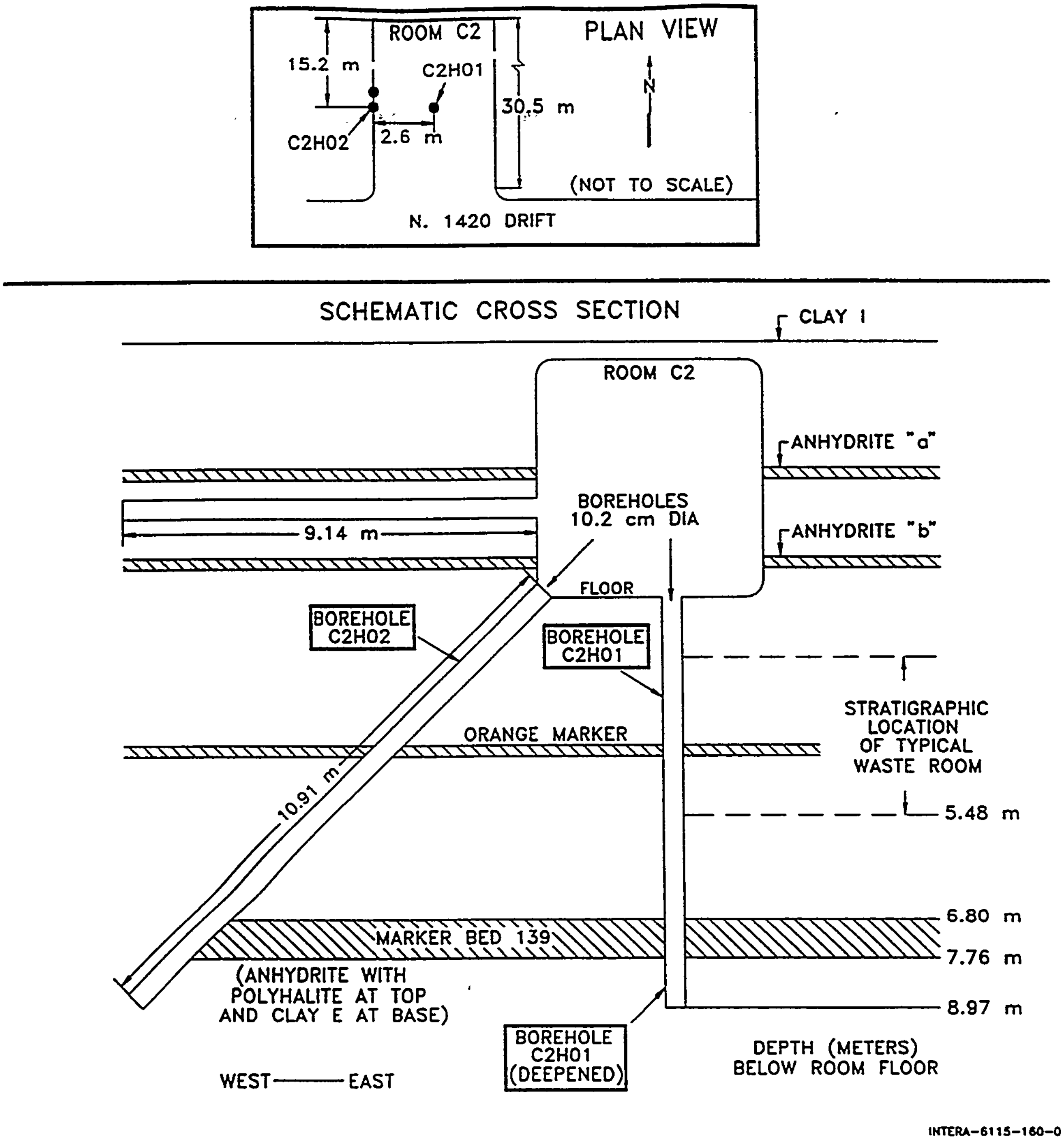


Figure 4-7. Spatial representation of Room C2 showing the locations and orientations of test and observation boreholes C2H01 and C2H02.

observation borehole C2H01. Figures 4-8 through 4-17 show the test- and observation-tool configurations and associated installations that were used during the testing program. It should be noted that Figures 4-15, 4-16, and 4-17 each consist of two parts (ex. Fgiures 4-15a and 4-15b). Test-tool installation diagrams for boreholes C2H01, DPD02, and DPD03 are contained in Section 7.5. Detailed desription of the core that was recovered from observation borehole C2H01 are provided in Saulnier et al., (1991). Observation boreholes DPD02 and DPD03 were constructed by S-CUBED under contract to SNL prior to 1988. Detailed descriptions of the core that was recovered from all of the other boreholes associated with the testing program are given in Appendix A of this report.

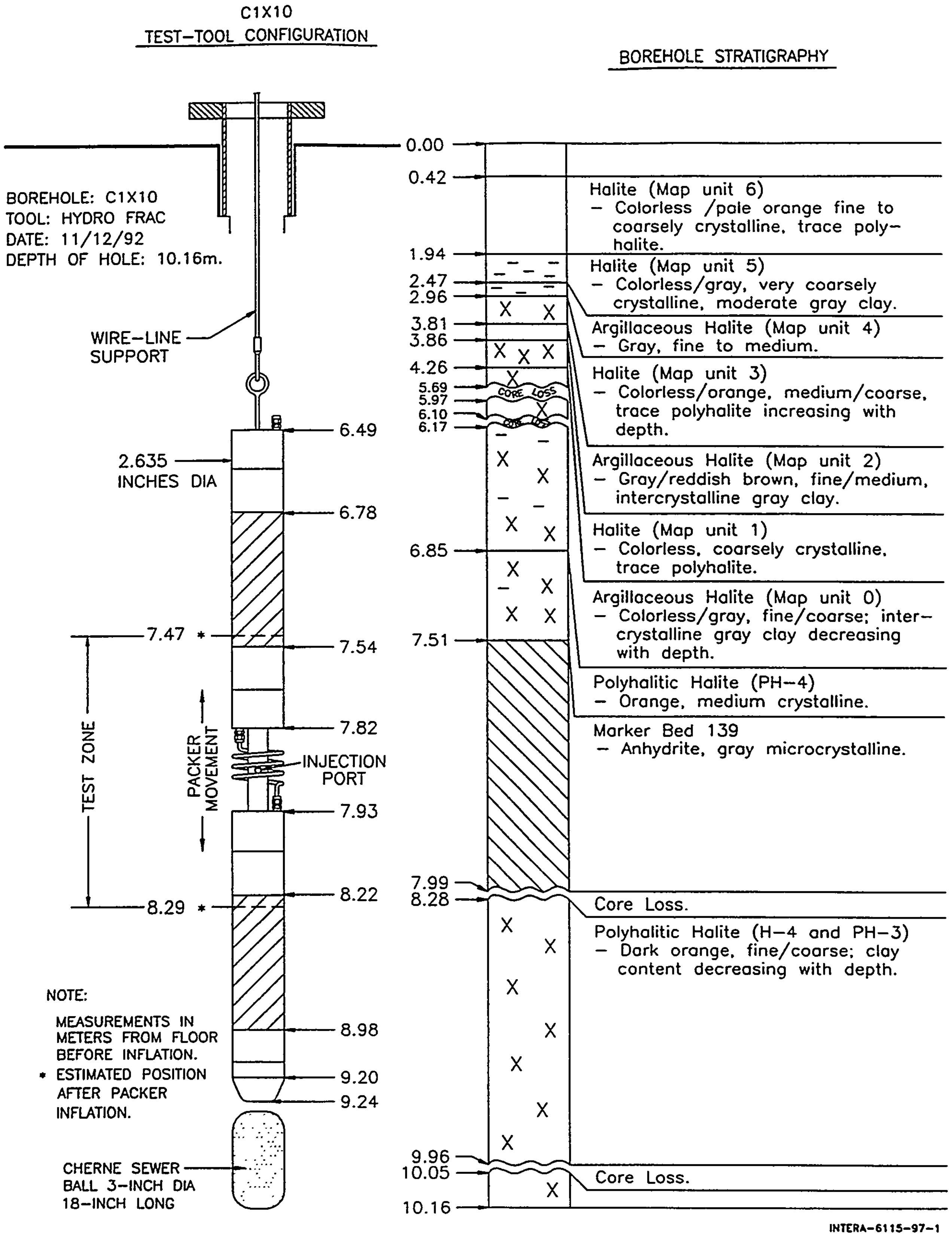


Figure 4-8. Configuration of the tool in test borehole C1X10 for testing sequences C1X10 and C1X05-A.

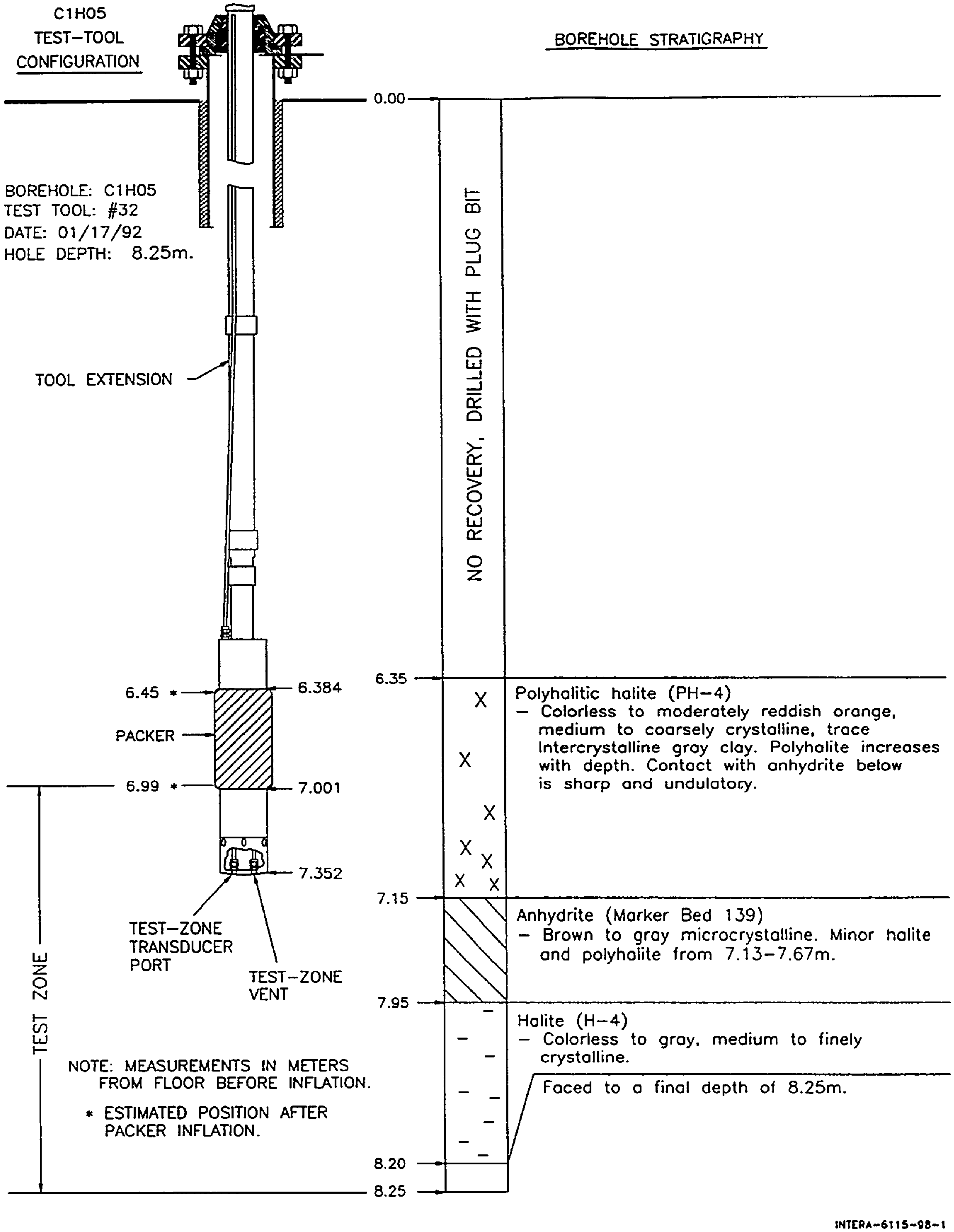


Figure 4-9. Configuration of the tool in observation borehole C1H05 for testing sequences C1X10 and C1X05-A.

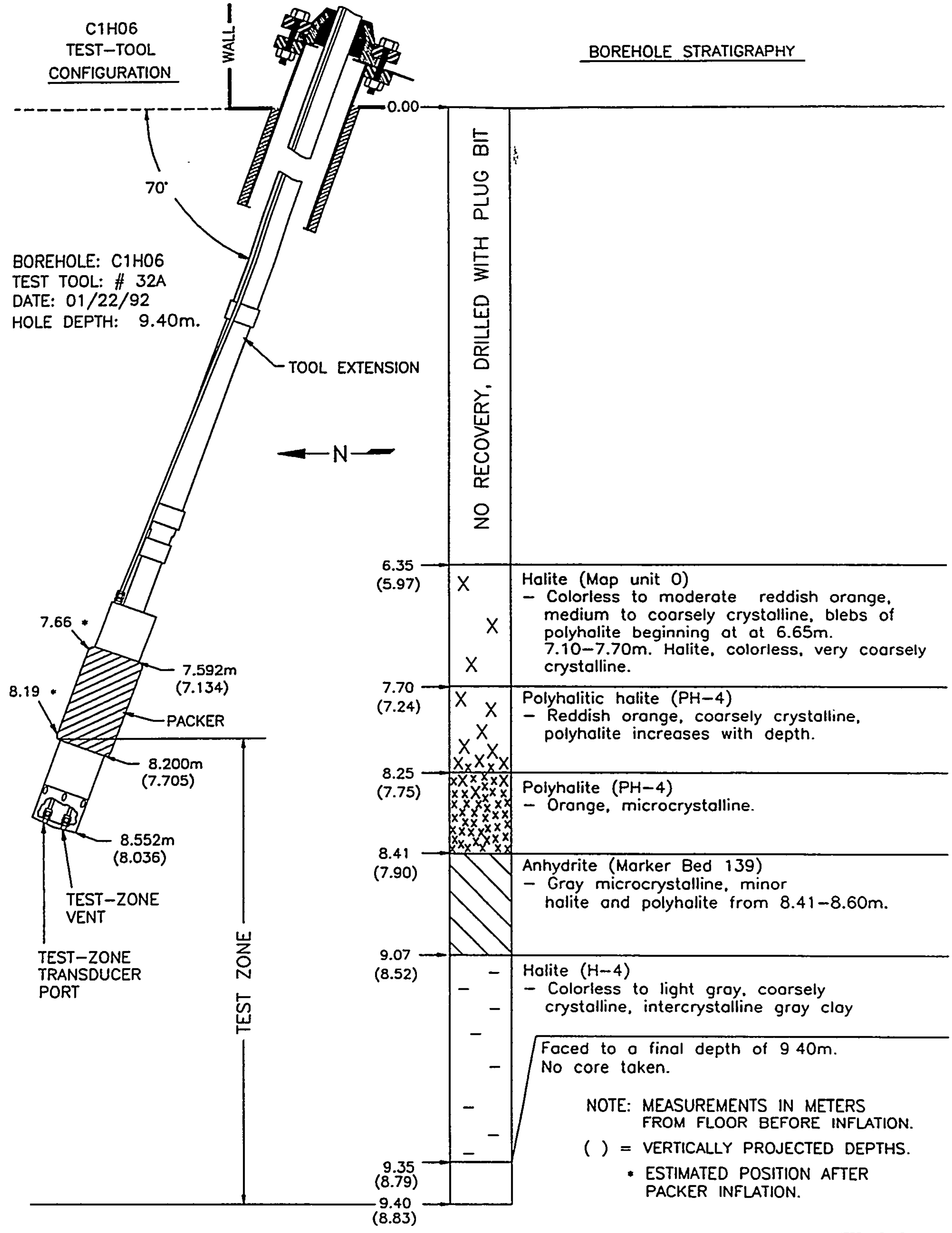


Figure 4-10. Configuration of the tool in observation borehole C1H06 for testing sequences C1X10 and C1X05-A.

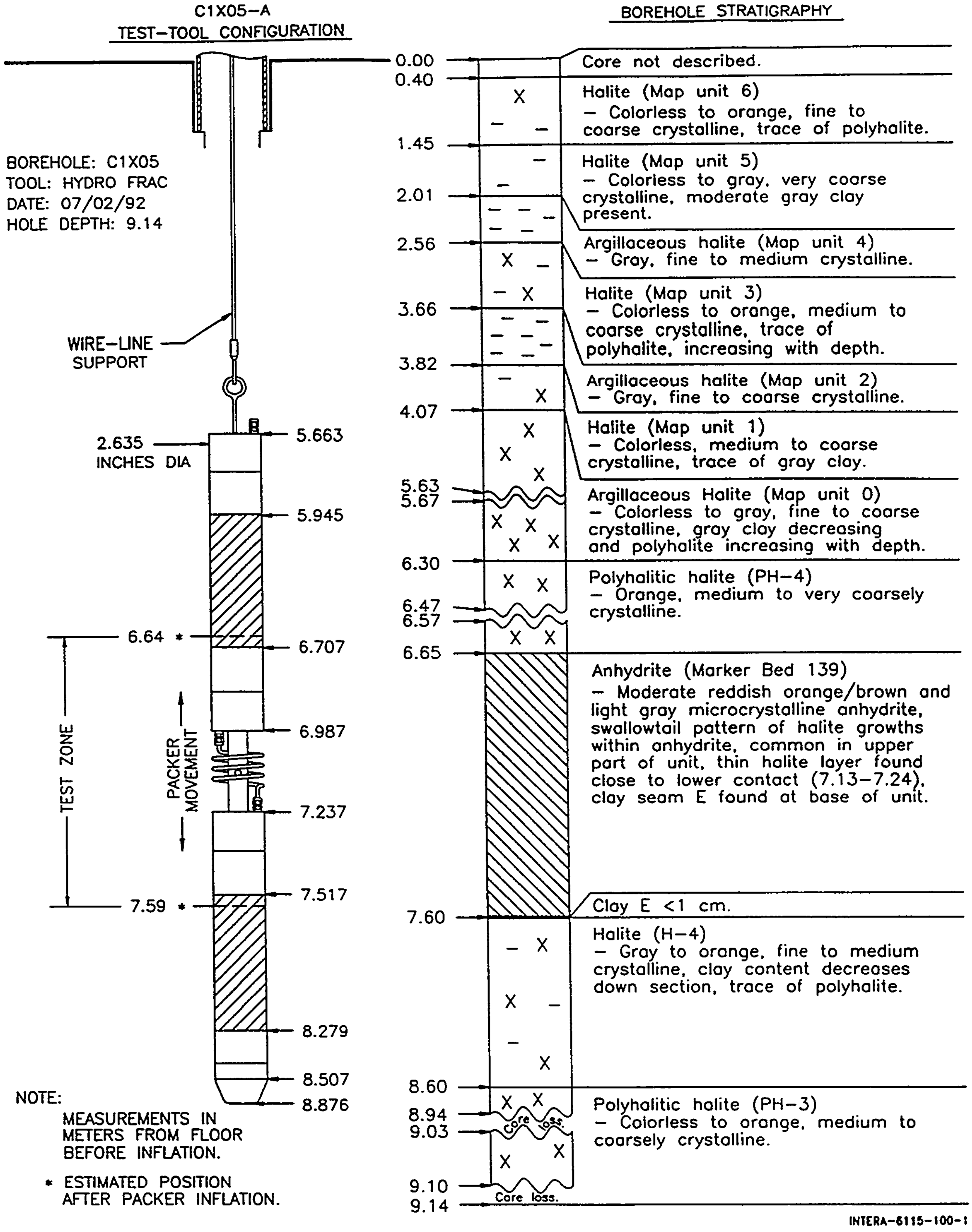


Figure 4-11. Configuration of the tool in test borehole C1X05 for testing sequence C1X05-A.

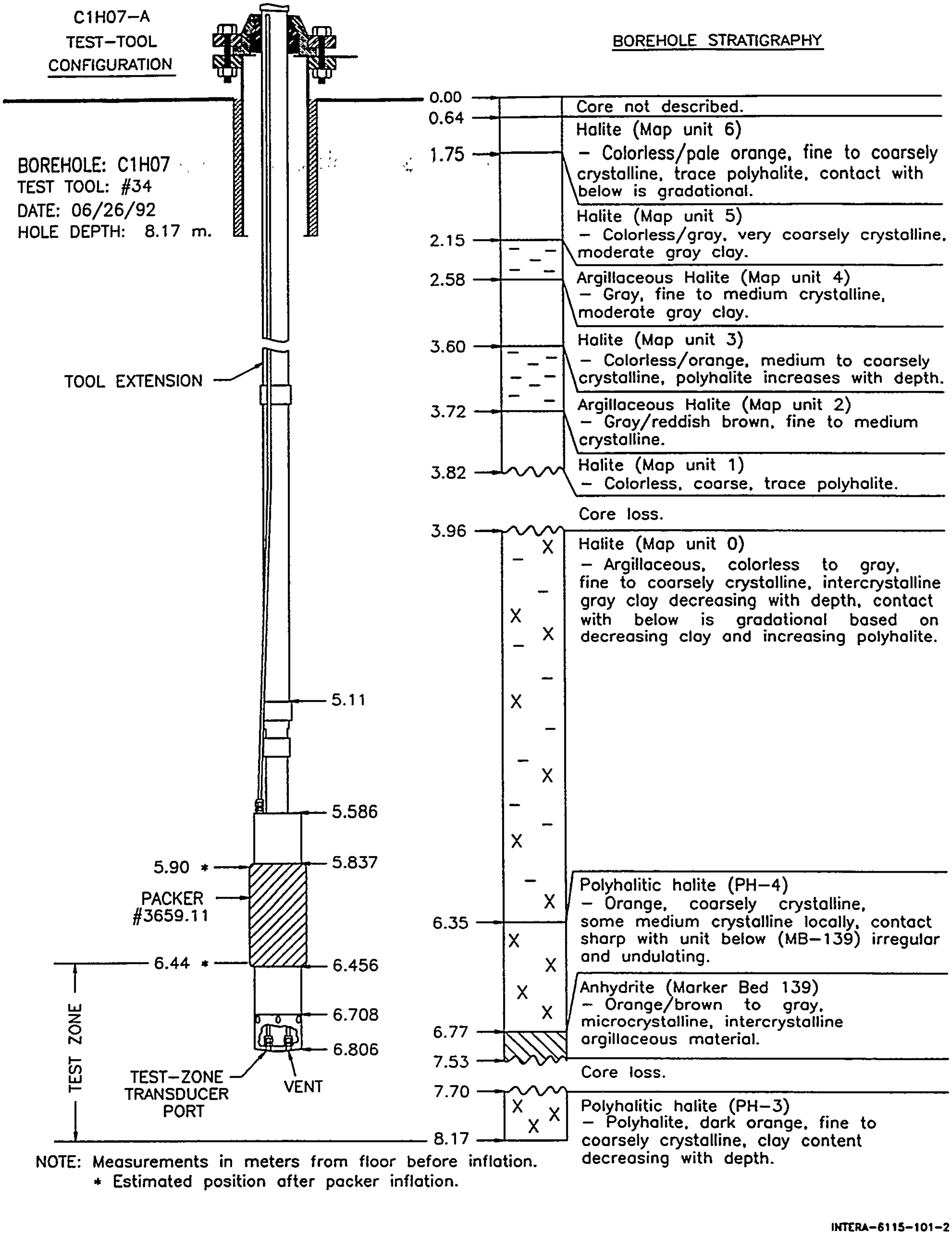


Figure 4-12. Configuration of the tool in observation borehole C1H07 for testing sequence C1X05-A.

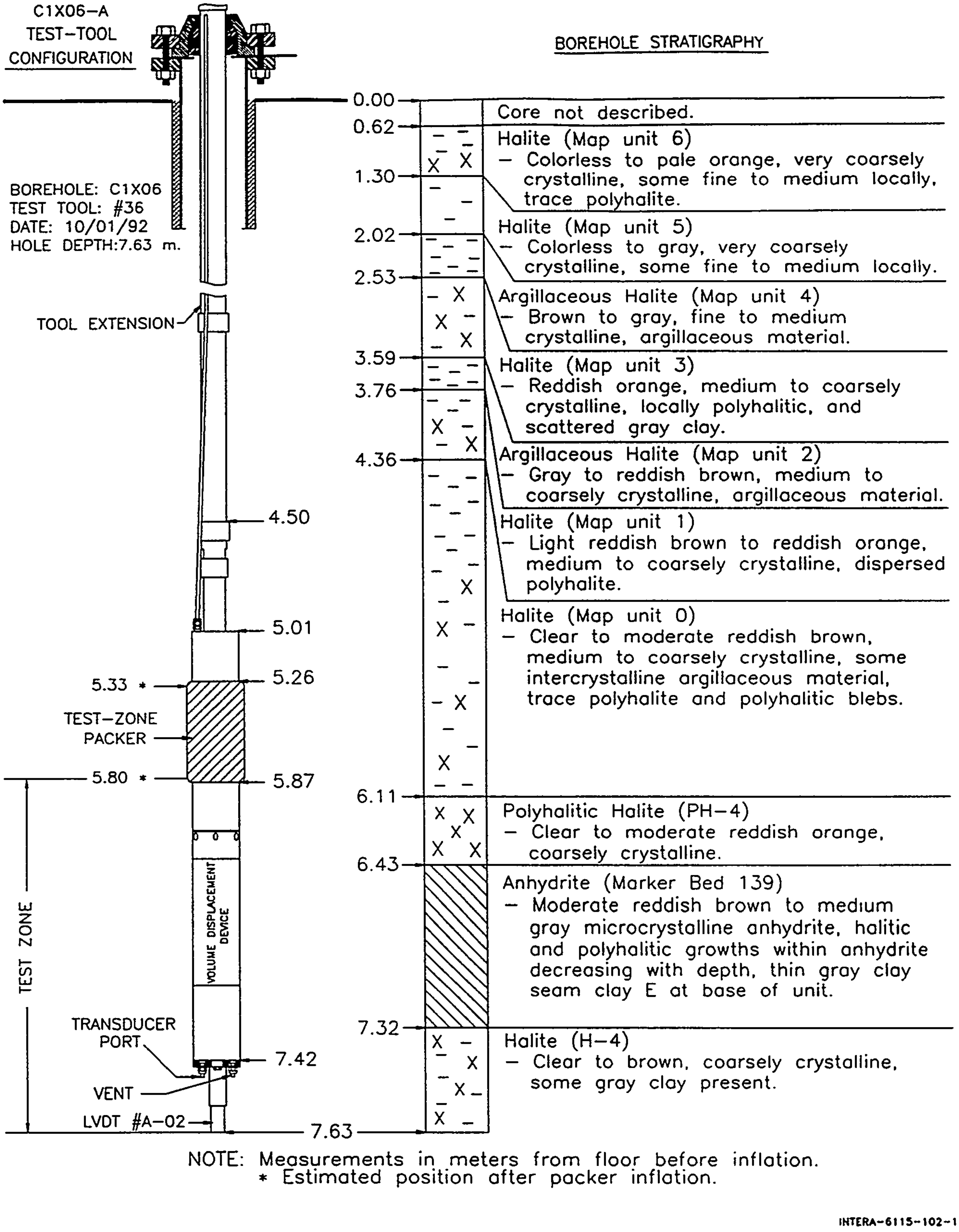


Figure 4-13. Configuration of the tool in observation borehole C1X06 for testing sequence C1X05-A.

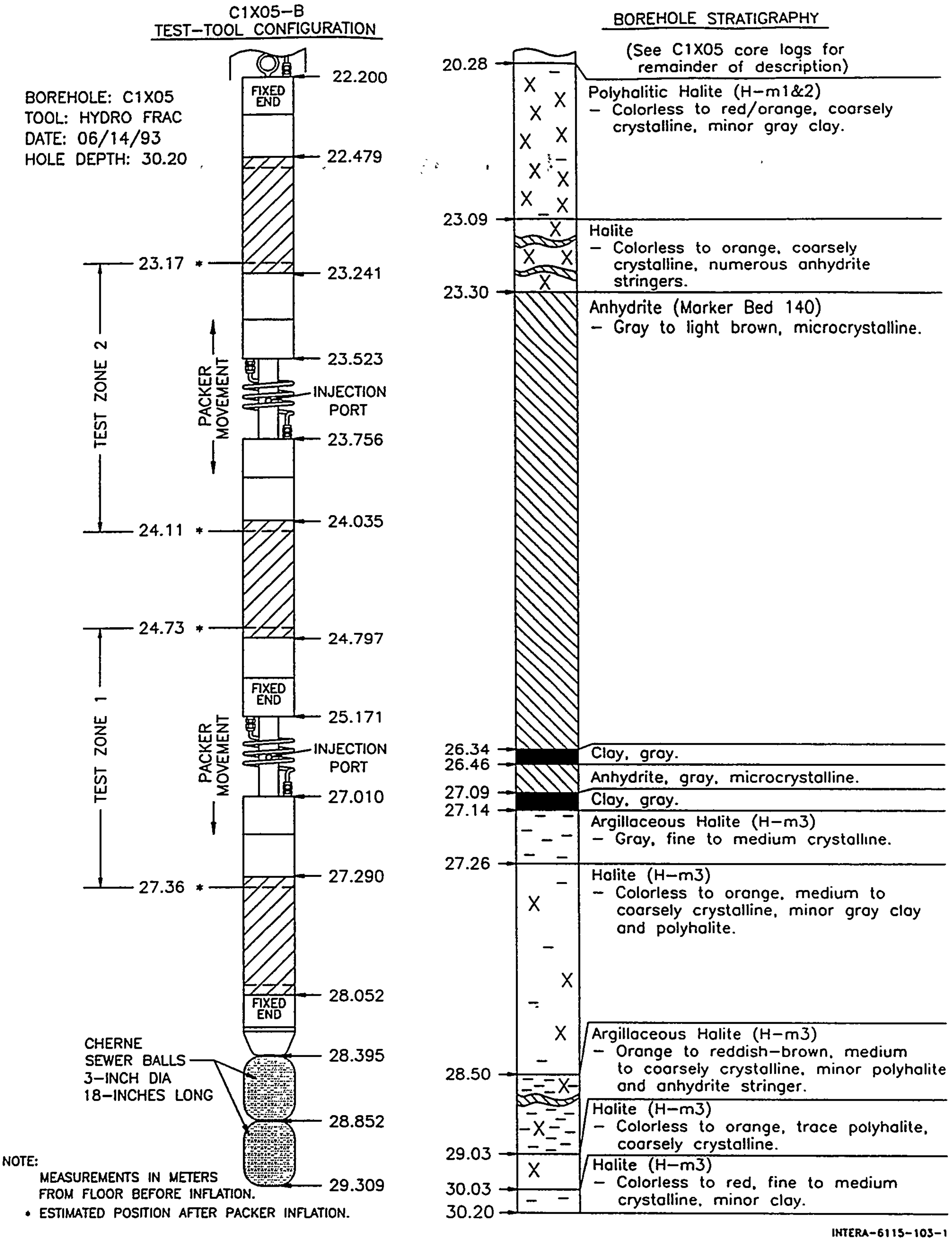
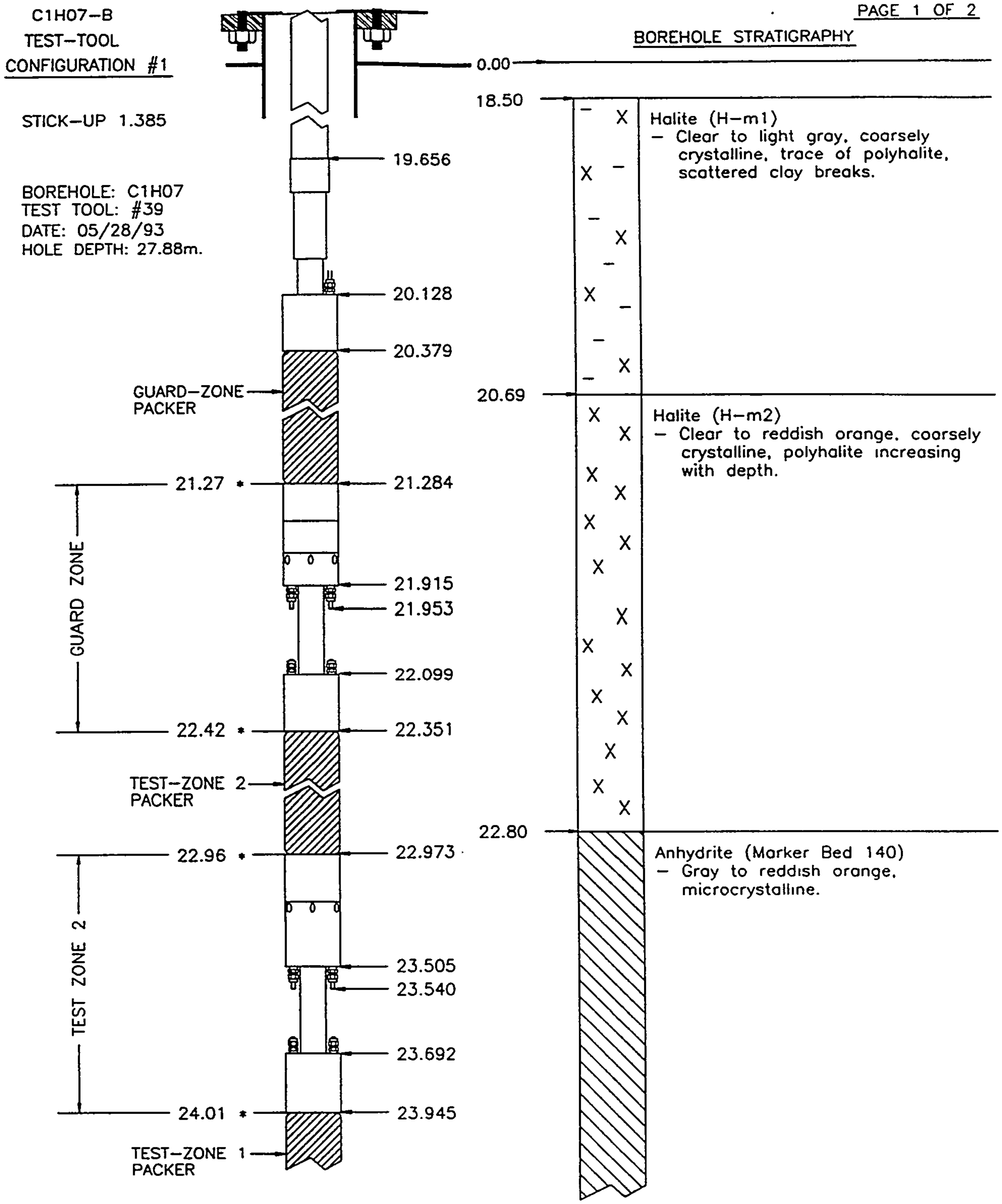


Figure 4-14. Configuration of the tool in test borehole C1X05 for testing sequence C1X05-B.



NOTE: Measurements in meters from floor before inflation.
* Estimated position after packer inflation.

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Figure 4-15a. Configuration #1 of the tool in observation borehole C1H07 for testing sequence C1X05-B.

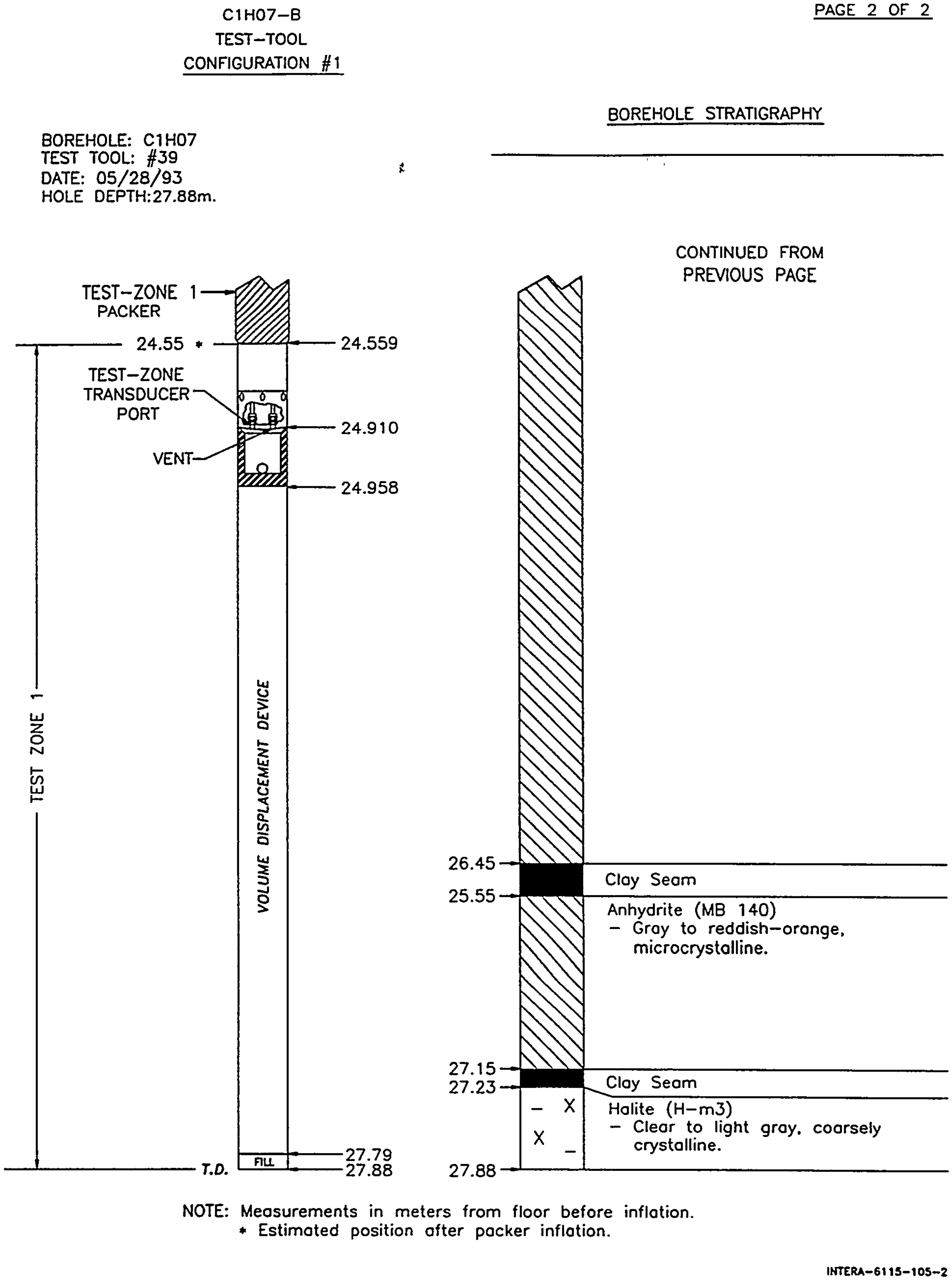

Figure 4-15b. Configuration #1 of the tool in observation borehole C1H07 for testing sequence C1X05-B (continued).

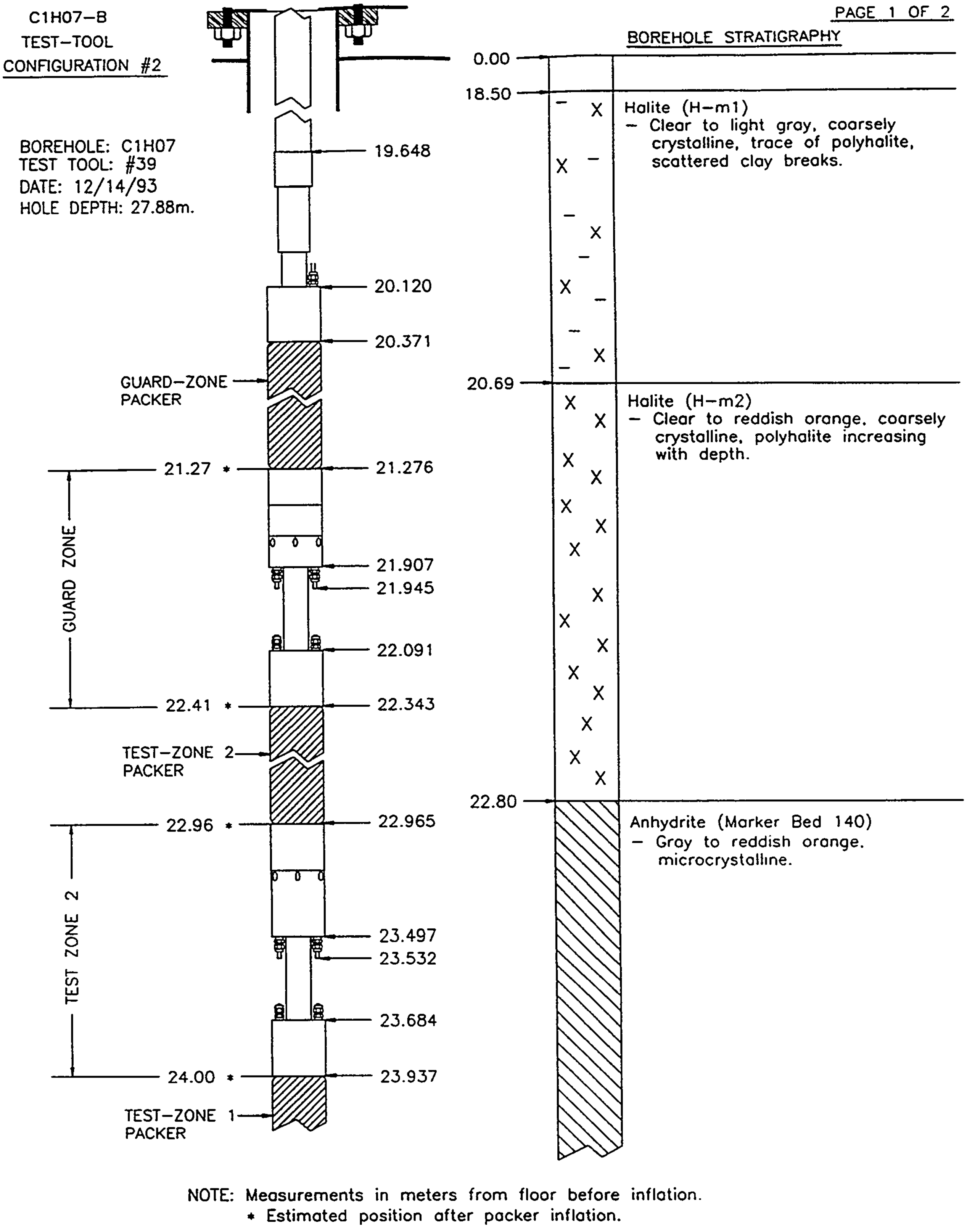

Figure 4-16a. Configuration #2 of the tool in observation borehole C1H07 for testing sequence C1X05-B.

C1H07-B
TEST-TOOL
CONFIGURATION #2

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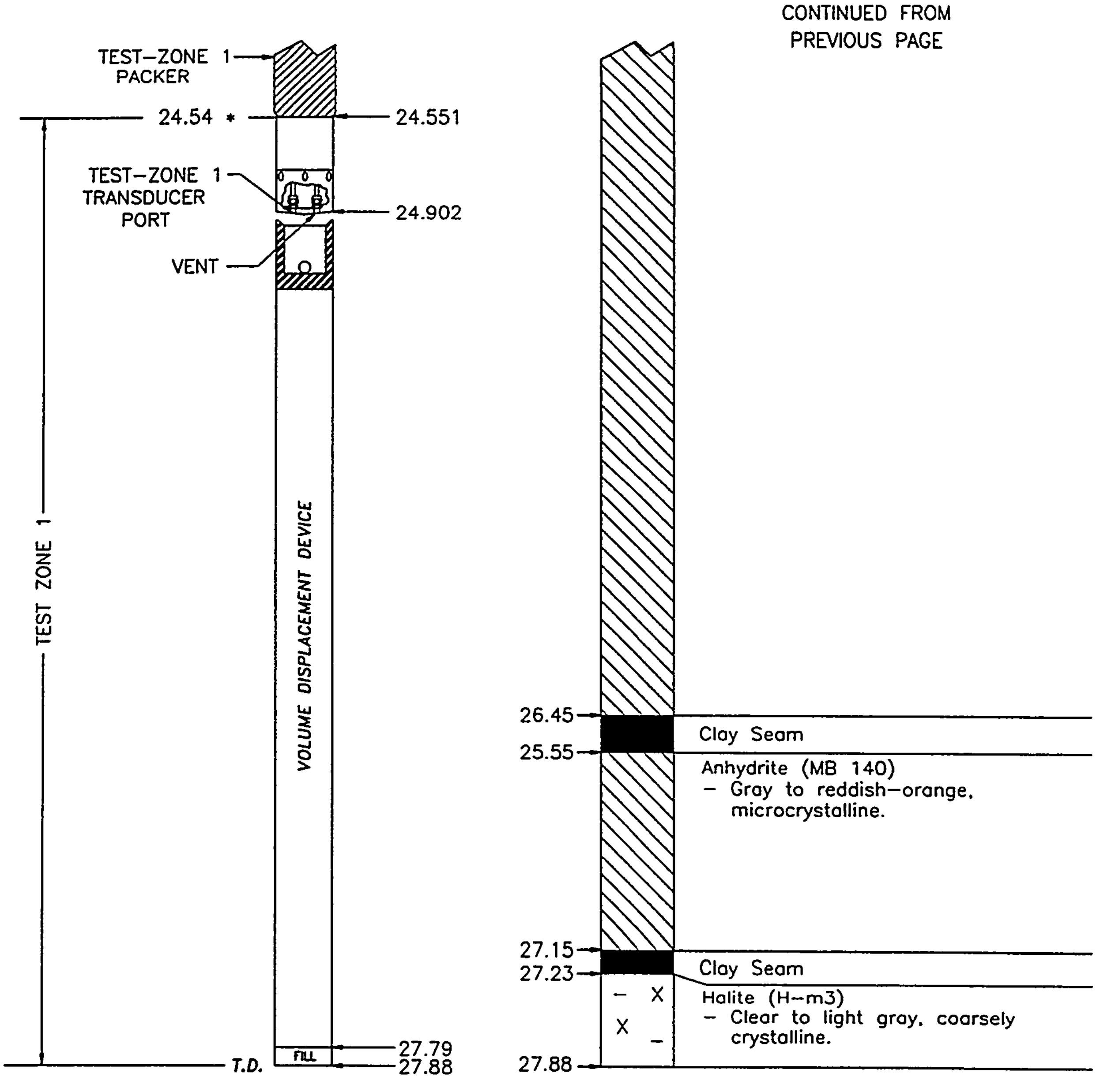
BOREHOLE: C1H07
TEST TOOL: #39
DATE: 12/14/93
HOLE DEPTH: 27.88m.

BOREHOLE STRATIGRAPHY



NOTE: Measurements in meters from floor before inflation.
* Estimated position after packer inflation.

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Figure 4-16b. Configuration #2 of the tool in observation borehole C1H07 for testing sequence C1X05-B (continued).

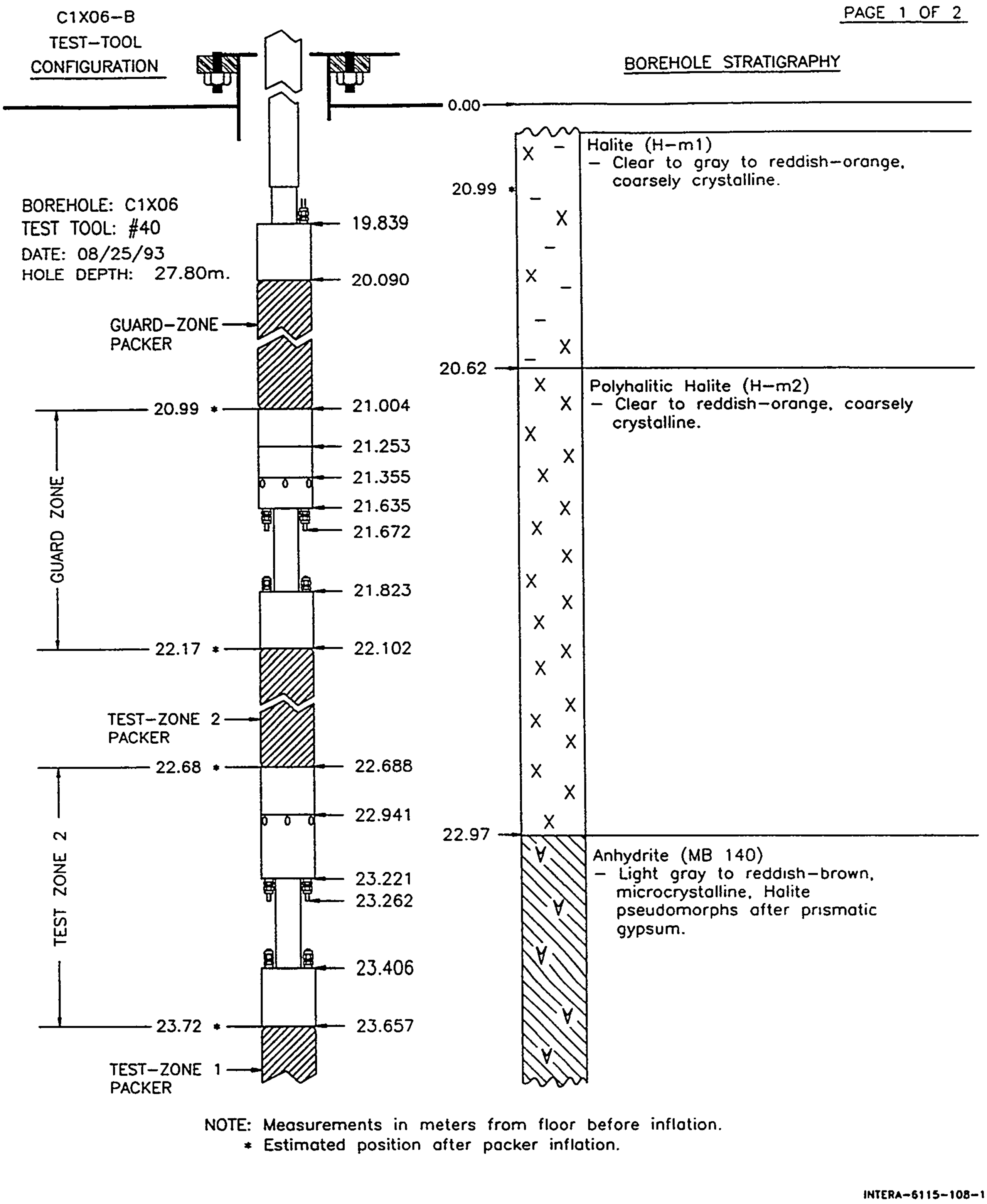
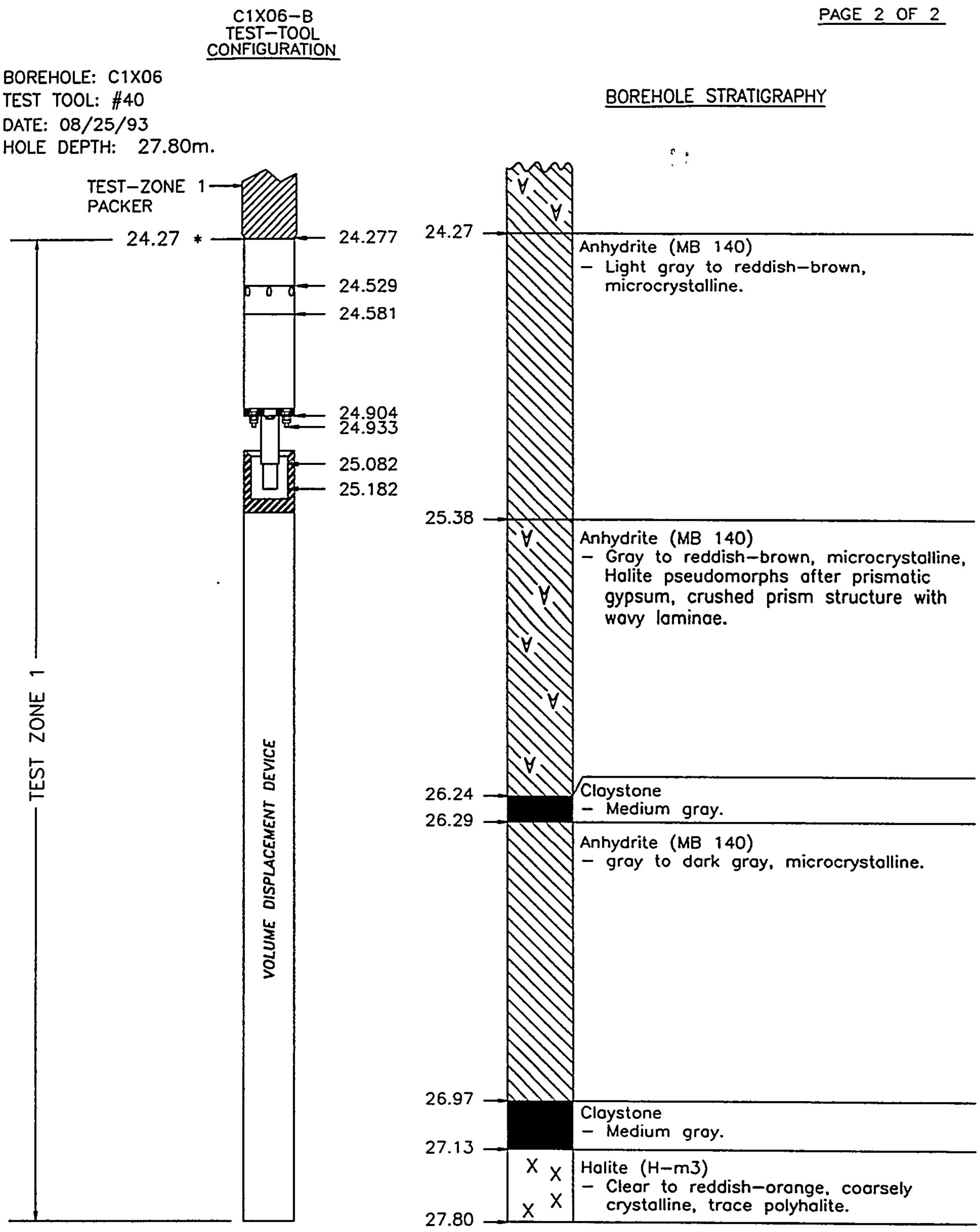


Figure 4-17a. Configuration of the tool in observation borehole C1X06 for testing sequence C1X05-B.



NOTE: Measurements in meters from floor before inflation.
* Estimated position after packer inflation.

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Figure 4-17b. Configuration of the tool in observation borehole C1X06 for testing sequence C1X05-B (continued).

4.6 Test Data

This section presents data from the testing sequences in the two test boreholes that were investigated. One pulse-withdrawal test, 12 constant-pressure-injection tests, and 16 constant-pressure-withdrawal tests were performed.

Acronyms used in the tables presented in this section are as follows:

CPI = Constant-Pressure-Injection Test
CPW = Constant-Pressure-Withdrawal Test
PW = Pulse-Withdrawal Test
TZ = Test Zone
TZP Test Zone Packer
TZ1 = Test Zone 1 (triple-packer configuration)
TZ1P = Test Zone 1 Packer (triple-packer configuration)
TZ2 = Test Zone 2 (triple-packer configuration)
TZ2P = Test Zone 2 Packer (triple-packer configuration)
Zone Fluid Volume = Isolated Zone Volume+Tubing Volume-Tool Volume
* = borehole in which the test was conducted

Table 4-3 summarizes information from these tests. Complete data files and abridged tabulations of the data are stored in the SWCF under WPO #42269.

Table 4-3. Summary of Test Information from Test Boreholes

Hydro-Frac Testing Sequence	Zone	Date Started (mm-dd-yy)	Test Type	Unit	Initial Pressure (MPa)	Final Pressure (MPa)	Fluid Volume Injected (+) Withdrawn (-) (mL)	Zone Length (cm)	Zone Radius (cm)	Tool Volume (mL)	Zone Fluid Volume (mL)
C1X10	TZ	11-15-91	CPI #1	MB139	5.5	6.5	+332	82	3.81	2454	2232
C1X10	TZ	11-19-91	CPI #2	MB139	6.1	6.4	+809	82	3.81	2454	2232
C1X10	TZ	11-26-91	CPI #3	MB139	6.5	9.0	+7098	82	3.81	2454	2232
C1X10	TZ	12-5-91	CPW #1	MB139	8.6	7.5	-19089	82	3.81	2454	2232
C1X10	TZ	12-6-91	CPW #2	MB139	7.7	7.6	-4393	82	3.81	2454	2232
C1X10	TZ	12-11-91	CPW #3	MB139	7.7	7.4	-94	82	3.81	2454	2232
C1X10	TZ	2-6-92	CPI #4	MB139	7.5	9.0	+874	82	3.81	2454	2232
C1X10	TZ	3-18-92	CPW #4	MB139	7.9	6.4	-7831	82	3.81	2454	2232
C1X05-A	TZ	8-4-92	CPI #1	MB139	9.2	9.7	+4	95	3.81	2270	2816
C1X05-A	TZ	8-4-92	CPI #2	MB139	9.7	10.2	+34	95	3.81	2270	2816
C1X05-A	TZ	8-10-92	CPI #3	MB139	9.4	10.2	+32	95	3.81	2270	2816
C1X05-A	TZ	9-16-92	CPW #1	MB139	11.7	9.5	-241	95	3.81	2270	2816
C1X05-A	TZ	9-16-92	CPW #2	MB139	11.5	9.5	-991	95	3.81	2270	2816
C1X05-A	TZ	9-16-92	CPW #3	MB139	11.3	9.5	-1245	95	3.81	2270	2816
C1X05-A	TZ	9-16-92	CPW #4	MB139	10.8	9.2	-3094	95	3.81	2270	2816

Table 4-3 (Continued). Summary of Test Information from Test Boreholes

Hydro-Frac Testing Sequence	Zone	Date Started (mm-dd-yy)	Test Type	Unit	Initial Pressure (MPa)	Final Pressure (MPa)	Fluid Volume Injected (+) Withdrawn (-) (mL)	Zone Length (cm)	Zone Radius (cm)	Tool Volume (mL)	Zone Fluid Volume (mL)
C1X05-A	TZ	9-17-92	CPW#5	MB139	9.3	9.5	-73	95	3.81	2270	2816
C1X05-A	TZ	11-17-92	CPI #4	MB139	9.4	10.3	+6753	95	3.81	2270	2816
C1X05-A	TZ	12-1-92	CPI #5	MB139	10.4	11.5	+21011	95	3.81	2270	2816
C1X05-A	TZ	1-13-93	CPW#6	MB139	9.1	8.1	-37	95	3.81	2270	2816
C1X05-A	TZ	1-18-93	CPW#7	MB139	9.1	8.1	-112	95	3.81	2270	2816
C1X05-B	TZ2	10-21-93	CPI #1	MB140	9.4	10.6	+11	94	3.81	2539	2771
C1X05-B	TZ2	11-22-93	CPW#1	MB140	10.6	10.7	-501	94	3.81	2539	2771
C1X05-B	TZ2	11-22-93	CPW#2	MB140	12.5	10.0	-4807	94	3.81	2539	2771
C1X05-B	TZ2	11-22-93	CPW#3	MB140	20.1	12.2	~1340	94	3.81	2539	2771
C1X05-B	TZ2	11-23-93	CPW#4	MB140	14.0	12.2	N/A	94	3.81	2539	2771
C1X05-B	TZ2	11-23-93	CPW#5	MB140	12.2	10.1	~-13210	94	3.81	2539	2771
C1X05-B	TZ2	1-10-94	CPI #2	MB140	11.7	12.2	+1085	94	3.81	2539	2771
C1X05-B	TZ2	1-20-94	CPI #3	MB140	11.9	12.7	+27442	94	3.81	2539	2771
C1X05-B	TZ2	2-15-94	CPW#6	MB140	11.7	11.2	-3460	94	3.81	2539	2771
C1X05-B	TZ2	3-24-94	PW	MB140	11.8	0.2	-254	94	3.81	2539	2771
C1X05-B *(C1X06-B)	TZ1	4-8-94	PW	MB140	11.7	7.70	-113	353	5.08	20376	8661

4.6.1 Borehole C1X10, Testing Sequence C1X10

Testing sequence C1X10 took place in Room C1 in borehole C1X10 with associated observation boreholes C1H05, C1H06, DPD02, DPD03, and C2H01. This test sequence was designed to investigate the pre- and post-hydrofracture brine permeability of MB139. Table 4-4 gives a detailed description of the events that occurred during the testing sequence C1X10 in borehole C1X10.

Table 4-4. Events Associated with Test Borehole C1X10 During Testing Sequence C1X10

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY	TIME (HH:MM:SS)
Begin drilling borehole C1X10 with 3-inch (7.62-cm) core barrel to 1.5 meters.	8-16-91	228	228	10:33:00
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 2.03 meters.	8-16-91	228	228	11:07:00
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 2.87 meters.	8-16-91	228	228	12:45:00
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 3.68 meters.	8-16-91	228	228	13:30:00
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 4.55 meters.	8-16-91	228	228	14:02:00

Table 4-4 (Continued). Events Associated with Test Borehole C1X10 During Testing Sequence C1X10

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY	TIME (HH:MM:SS)
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 5.46 meters.	11-11-91	315	315	10:18:00
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 6.10 meters.	11-11-91	315	315	11:05:00
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 6.67 meters.	11-11-91	315	315	13:16:00
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 7.56 meters.	11-11-91	315	315	13:35:00
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 8.44 meters.	11-11-91	315	315	13:57:00
Begin data file C1X1001.	11-12-91	316	316	09:41:32
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 9.30 meters.	11-12-91	316	316	10:15:00
Deepen borehole C1X10 with 3-inch (7.62-cm) core barrel to 10.16 meters.	11-12-91	316	316	12:15:00
Perform a video log of borehole C1X10.	11-12-91	316	316	14:00:00
Pour ~ 9 liters of hydrofracture oil into borehole C1X10 and install volume-displacement device.	11-12-91	316	316	15:00:00
Install multipacker test tool into borehole C1X10 as indicated in the test-tool configuration diagram (Figure 4-8).	11-12-91	316	316	15:30:00
Inflate TZP and GZP to ~ 12 MPa.	11-12-91	316	316	16:52:00
Shut in both zones.	11-12-91	316	316	17:00:00
End data file C1X1001.	11-15-91	319	319	11:34:42
Begin data file C1X1002.	11-15-91	319	319	12:35:13
Begin constant-pressure-injection test #1 in TZ at ~ 1 MPa above TZ pressure (~ 6.5 MPa).	11-15-91	319	319	13:44:00
Leaky fitting on TZ.	11-15-91	319	319	13:46:00
Shut in TZ from DPT panel terminating constant-pressure-injection test #1 in TZ.	11-15-91	319	319	14:15:30
No power to DAS upon arrival.	11-18-91	322	322	09:14:00
Begin constant-pressure-injection test #2 in TZ at ~ 0.3 MPa above TZ pressure (~6.4 MPa).	11-19-91	323	323	10:56:30
Shut in TZ from DPT panel terminating constant-pressure-injection test #2 in TZ.	11-19-91	323	323	11:47:48
Begin constant-pressure-injection test #3 in TZ at ~ 2.5 MPa above TZ pressure (~ 9 MPa).	11-26-91	330	330	08:46:40
End data file C1X1002.	11-26-91	330	330	14:46:08
Begin data file C1X1003.	11-26-91	330	330	14:54:00
Shut in TZ from DPT panel terminating constant-pressure-injection test #3 in TZ.	11-26-91	330	330	14:54:40
Performed hydrofracture of MB139.	12-5-91	339	339	12:27:00
Begin constant pressure withdrawal test #1 in TZ at ~ 7.5 MPa.	12-5-91	339	339	14:32:20
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #1 in TZ.	12-6-91	340	340	09:20:00
Begin constant-pressure-withdrawal test #2 in TZ at ~ 7.6 MPa.	12-6-91	340	340	09:24:10
DAS not functioning properly upon arrival.	12-9-91	343	343	10:40:00
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #2 in TZ.	12-11-91	345	345	10:47:00
Begin constant-pressure-withdrawal test #3 in TZ at ~ 7.4 MPa.	12-11-91	345	345	11:03:20
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #4 in TZ.	12-13-91	347	347	08:49:36

Table 4-4 (Continued). Events Associated with Test Borehole C1X10 During Testing Sequence C1X10

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY	TIME (HH:MM:SS)
End data file C1X1003.	1-17-92	17	382	13:59:11
Begin monitoring fluid pressure in MB139 in borehole C1H05.	1-17-92	17	382	14:00:00
Begin data file C1X1004.	1-17-92	17	382	14:14:30
Begin monitoring fluid pressure in MB139 in borehole C1H06.	1-22-92	22	387	14:00:00
Begin monitoring fluid pressure in MB139 in boreholes DPD02, DPD03, and C2H01.	1-29-92	29	394	14:45:00
End data file C1X1004.	1-30-92	30	395	08:55:41
Begin data file C1X1005.	1-30-92	30	395	13:23:46
Begin constant-pressure-injection test #4 in TZ at ~ 1.5 MPa above TZ pressure (~ 9 MPa).	2-6-92	37	402	10:48:17
End data file C1X1005.	2-6-92	37	402	14:46:29
Begin data file C1X1006.	2-6-92	37	402	14:51:00
Shut in TZ from DPT panel terminating constant-pressure-injection test #4 in TZ.	2-6-92	37	402	14:51:40
End data file C1X1006.	3-18-92	78	443	07:37:47
Begin data file C1X1007.	3-18-92	78	443	08:19:00
Begin constant-pressure-withdrawal test #4 in TZ at ~ 1.5 MPa below TZ pressure (~ 6.4 MPa).	3-18-92	78	443	08:32:30
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #4 in TZ.	3-18-92	78	443	14:31:09
Decrease TZ pressure (both oil and gas present).	5-6-92	127	492	09:36:00
Deflate TZP.	5-6-92	127	492	09:54:00
Inflate TZP and shut in TZ.	5-6-92	127	492	10:43:00
End data file C1X1007.	5-7-92	128	493	07:48:42
Begin data file C1X1008.	5-7-92	128	493	10:03:45
Calibrated transducers on P1, P5, and P7.	5-26-92	147	512	12:56:00
End data file C1X1008.	6-26-92	178	543	08:18:34

Figures 4-18 and 4-19 illustrate the zone pressures and fluid production during constant-pressure-flow tests, respectively, in test borehole C1X10. It should be noted that Figure 4-19 (Fluid production during constant-pressure-flow tests during testing sequence C1X10) consists of three parts (Figures 4-19a, 4-19b, and 4-19c). Copies of the video-log associated with testing sequence C1X10 (borehole C1X10) identified in Table 4-4 are provided in the SWCF under WPO #45907

Table 4-5 indicates the equipment that was used and the duration that each instrument was used during testing sequence C1X10 in test borehole C1X10 and in the observation boreholes.

Table 4-5. Testing Sequence C1X10 Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	11-12-91	6-26-92
DCU (HP3497A)	N/A	2629a21989	11-12-91	4-13-92
DCU (HP3497A)	N/A	2629a21990	4-13-92	6-26-92
Transducer (Druck PDCR 830)	C1X10 TZ	246909	11-12-91	6-26-92
Transducer (Druck PDCR 830)	DPT Panel	246910	11-12-91	5-7-92
Transducer (Druck PDCR 830)	C1H05 TZ	246917	1-17-92	6-26-92
Transducer (Druck PDCR 830)	C1H05 TZP	246919	1-17-92	6-26-92
Transducer (Druck PDCR 830)	C1H06 TZ	246916	1-17-92	6-26-92
Transducer (Druck PDCR 830)	C1H06 TZP	246918	1-17-92	6-26-92
Transducer (Druck PDCR 10/D)	DPD03 TZ	211694	1-30-92	5-7-92
Transducer (Druck PDCR 910)	DPD02 TZ	316158	1-30-92	5-7-92
Transducer (Druck PDCR 910)	C2H01 TZ	321768	5-7-92	6-26-92
Injection Column	N/A	76	11-15-91	6-26-92
Injection Column	N/A	77	11-26-91	6-26-92
DPT (Rosemount 1151DP)	N/A	1140863	11-15-91	6-26-92

* Installed dates for injection columns refer to dates of initial use rather than date installed.

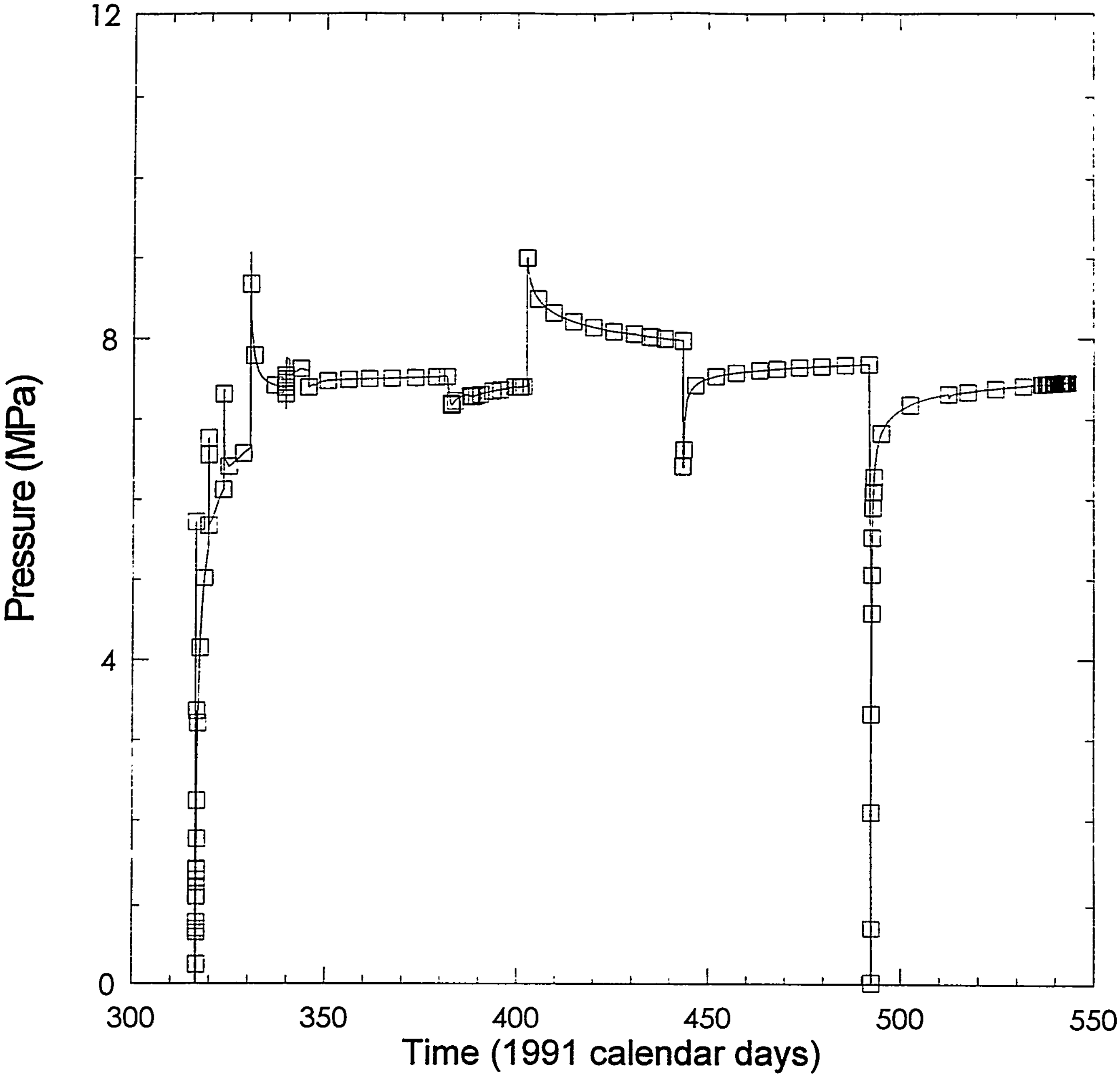

Figure 4-18. Test-zone pressure in test borehole C1X10 during testing sequence C1X10.

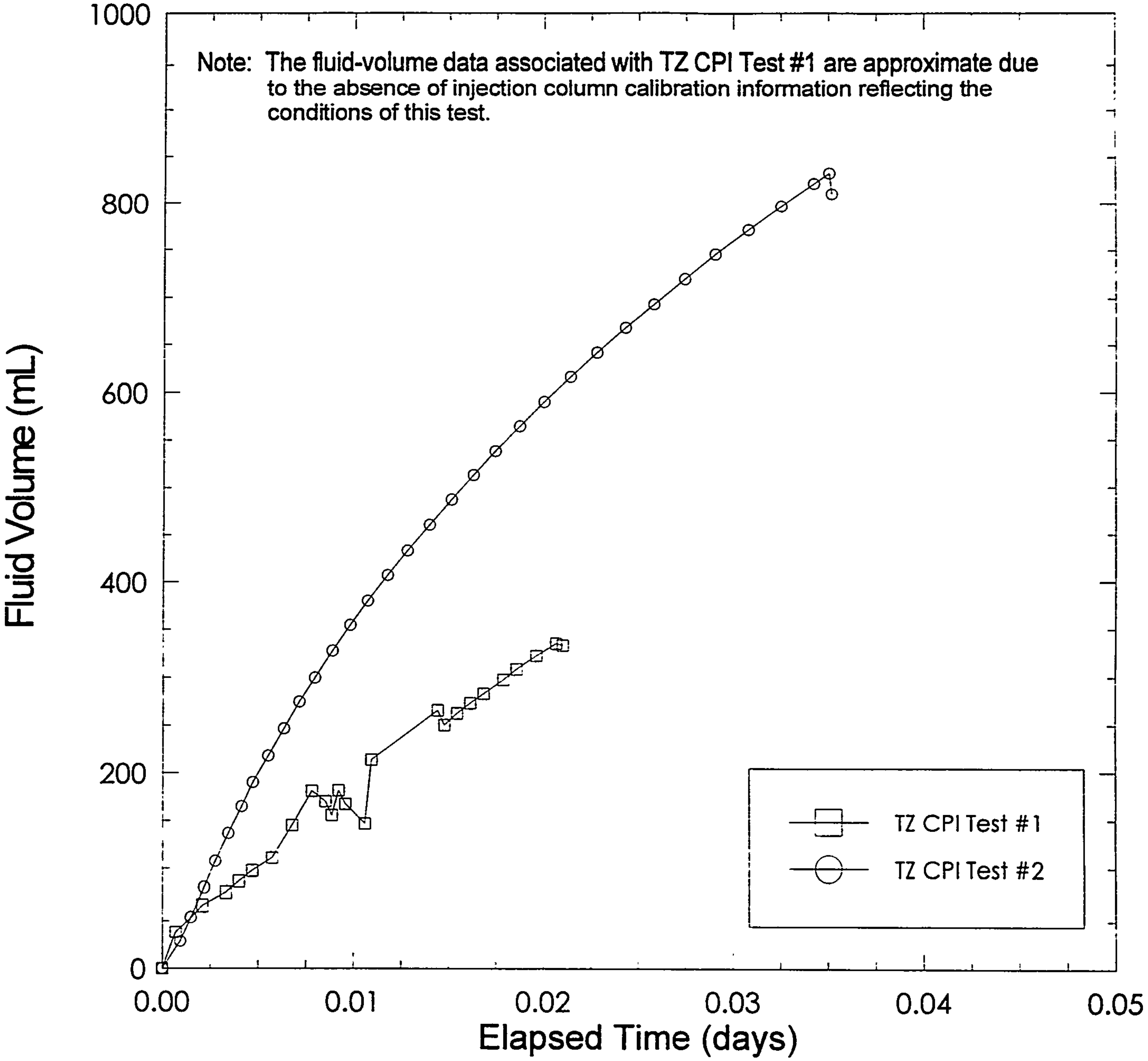

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Figure 4-19a. Fluid production during constant-pressure-flow tests during testing sequence C1X10.

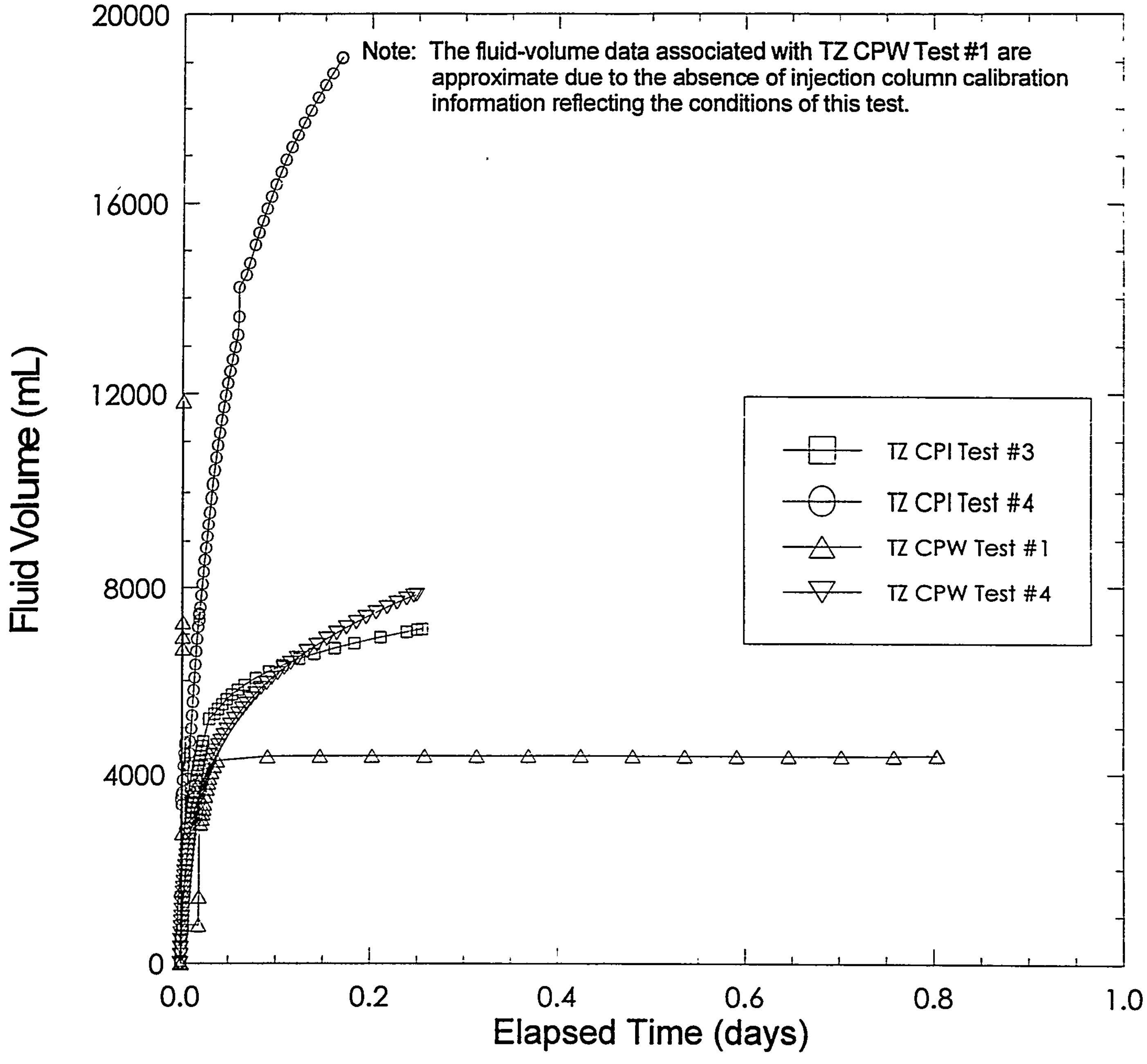

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Figure 4-19b. Fluid production during constant-pressure-flow tests during testing sequence C1X10 (continued).

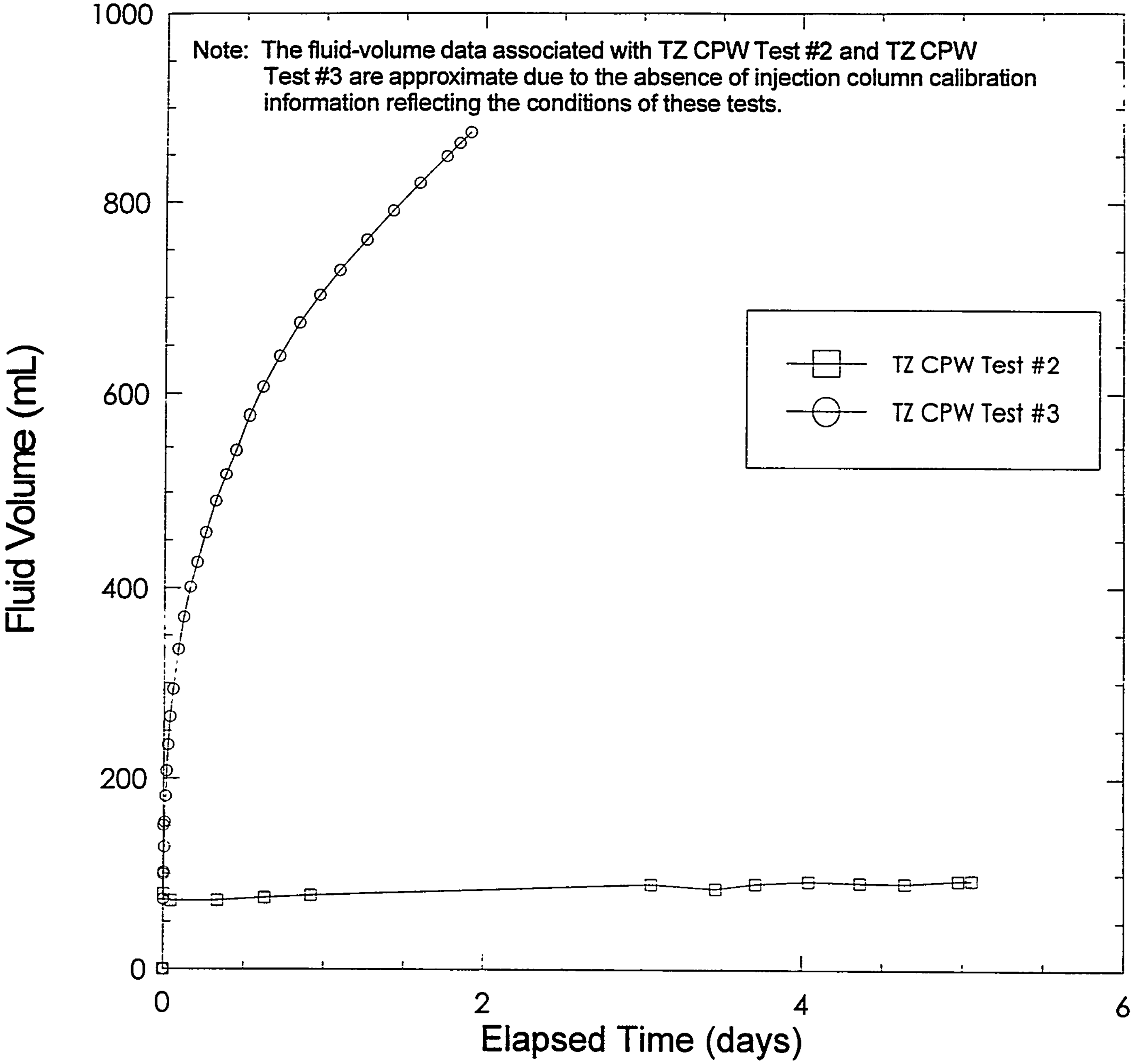

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Figure 4-19c. Fluid production during constant-pressure-flow tests during testing sequence C1X10 (continued).

4.6.1.1 OBSERVATION BOREHOLE C1H05, TESTING SEQUENCE C1X10

Table 4-16 gives a detailed description of the events that occurred in observation borehole C1H05 during testing sequence C1X10.

Table 4-6. Events Associated with Observation Borehole C1H05 During Testing Sequence C1X10

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY	TIME (HH:MM:SS)
Begin drilling borehole C1H05 with 4-inch (10.16-cm) plug bit to 6.350 meters.	1-15-92	15	380	10:15:00
Deepen borehole C1H05 with 4-inch (10.16-cm) core barrel to 6.528 meters.	1-16-92	16	381	13:15:00
Deepen borehole C1H05 with 4-inch (10.16-cm) core barrel to 7.315 meters.	1-16-92	16	381	13:45:00
Deepen borehole C1H05 with 4-inch (10.16-cm) core barrel to 8.204 meters (noticed hydrofracture oil in MB139 core).	1-16-92	16	381	14:20:00
Perform video log of borehole C1H05.	1-17-92	17	382	10:00:00
Face bottom of borehole C1H05 with 4-inch (10.16-cm) plug bit to 8.255 meters.	1-17-92	17	382	10:45:00
Install single-packer monitor tool #32A in borehole C1H05 as indicated in the test-tool configuration diagram (Figure 4-9).	1-17-92	17	382	10:00:00
Inflate TZP to ~ 11 MPa.	1-17-92	17	382	14:29:00
Shut in TZ.	1-17-92	17	382	14:40:30
Terminate data collection.	6-26-92	178	543	08:18:34

Figures 4-20 and 4-21 illustrate the zone pressures and packer pressures, respectively, in observation borehole C1H05 for testing sequence C1X10. Copies of the video-log associated with testing sequence C1X10 (borehole C1H05) identified in Table 4-6 are provided in the SWCF under WPO #45907

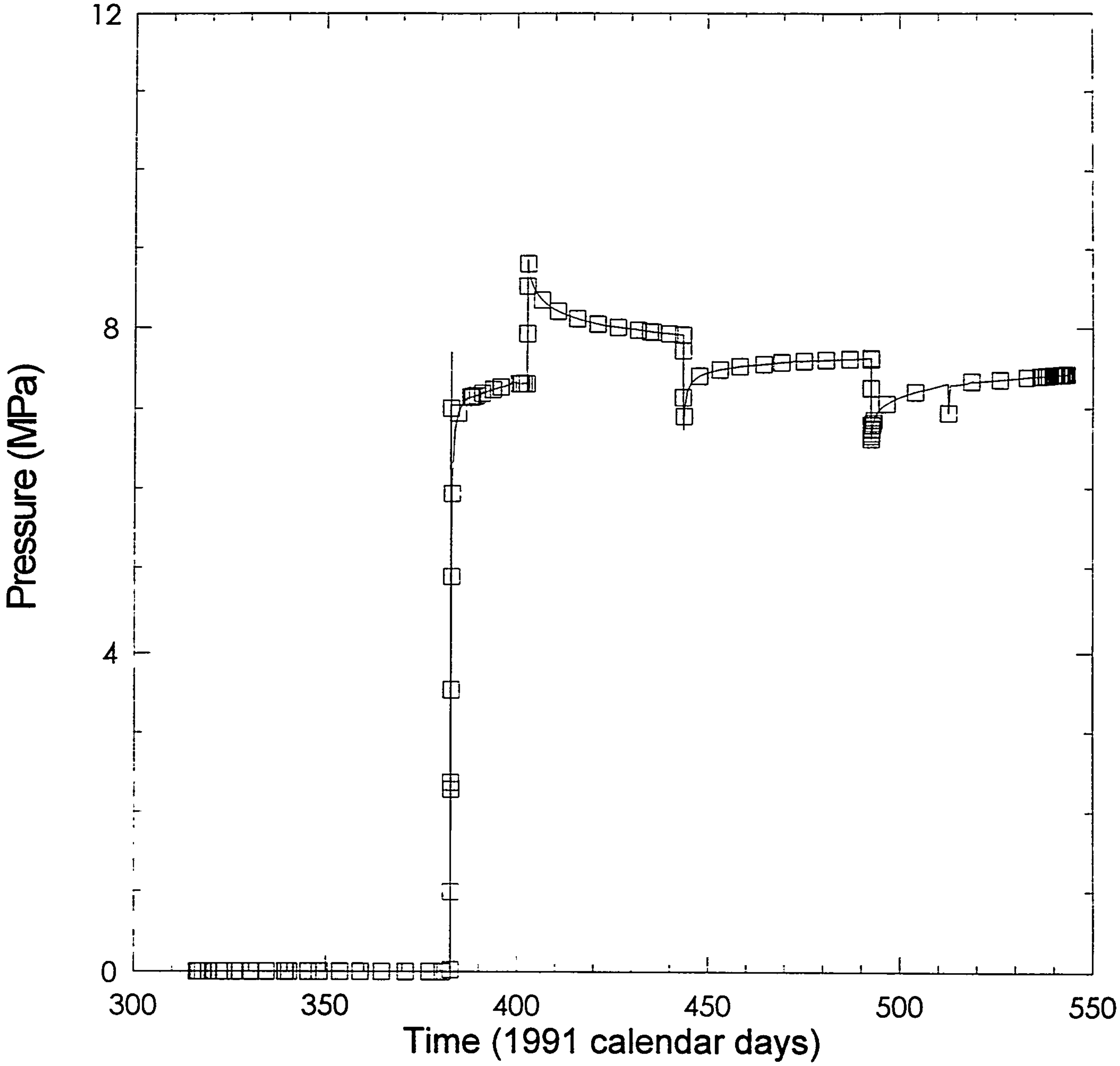

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Figure 4-20. Test-zone pressure in observation borehole C1H05 during testing sequence C1X10.

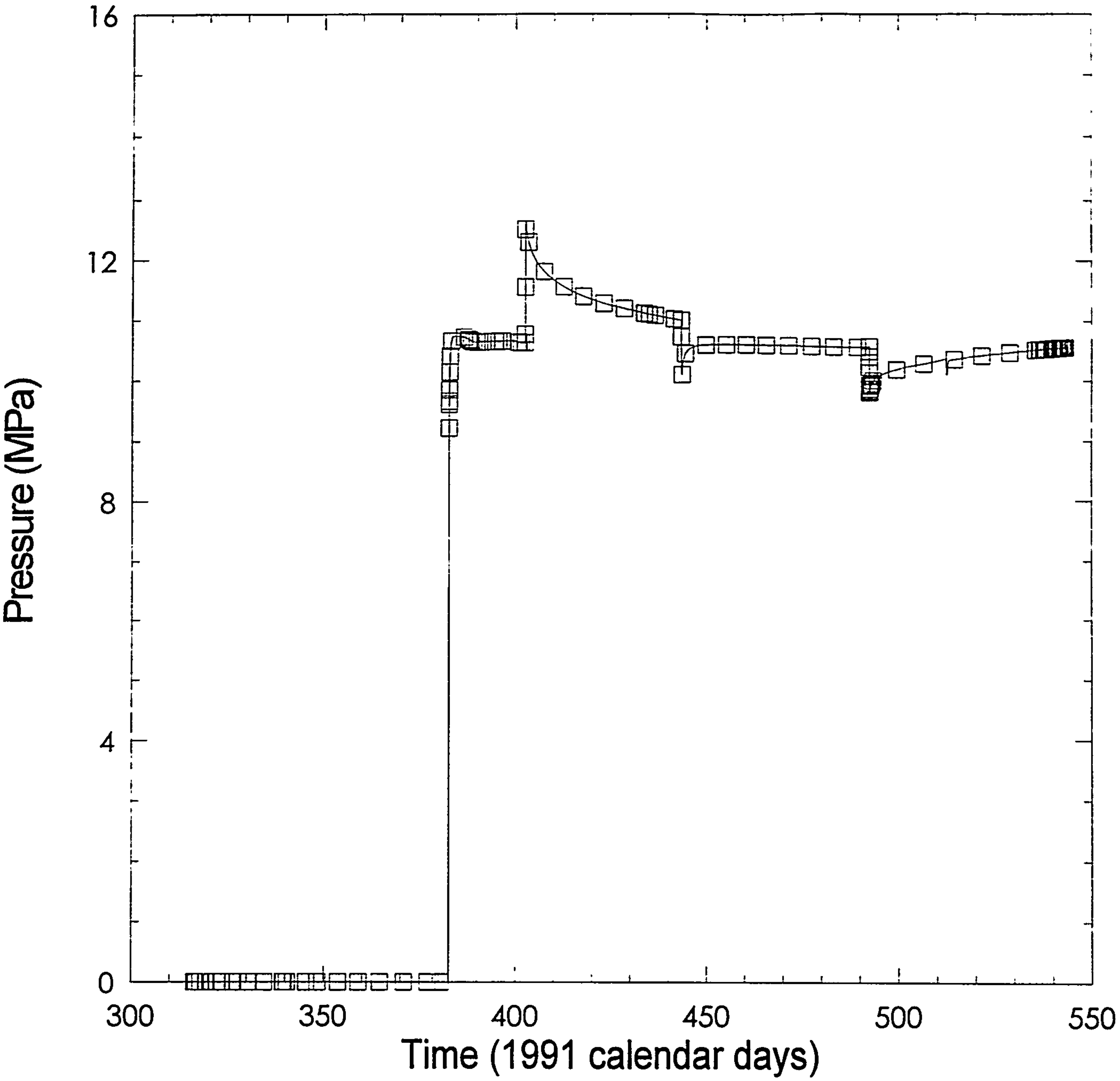

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Figure 4-21. Test-zone packer pressure in observation borehole C1H05 during testing sequence C1X10.

4.6.1.2 OBSERVATION BOREHOLE C1H06, TESTING SEQUENCE C1X10

Table 4-7 gives a detailed description of the events that occurred in observation borehole C1H06 during testing sequence C1X10.

Table 4-7. Events Associated with Observation Borehole C1H06 During Testing Sequence C1X10

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY	TIME (HH:MM:SS)
Begin drilling borehole C1H06 with 4-inch (10.16-cm) plug bit to ~ 6.4 meters.	1-20-92	20	385	14:30:00
Deepen borehole C1H06 with 4-inch (10.16-cm) core barrel to 7.040 meters.	1-21-92	21	386	10:48:00
Deepen borehole C1H06 with 4-inch (10.16-cm) core barrel to 7.874 meters.	1-21-92	21	386	13:00:00
Deepen borehole C1H06 with 4-inch (10.16-cm) core barrel to 8.611 meters.	1-21-92	21	386	13:29:00
Deepen borehole C1H06 with 4-inch (10.16-cm) core barrel to 9.347 meters.	1-21-92	21	386	14:09:00
Face bottom of borehole C1H06 with 4-inch (10.16-cm) plug bit to 9.398 meters.	1-21-92	21	386	15:30:00
Perform video log of borehole C1H06.	1-22-92	22	387	11:30:00
Install single-packer monitor tool #32B in borehole C1H06 as indicated in the test-tool configuration diagram (Figure 4-10).	1-22-92	22	387	10:00:00
Inflate TZP to ~ 10 MPa.	1-22-92	22	387	14:04:00
Shut in TZ.	1-22-92	22	387	14:17:00
Terminate data collection.	6-26-92	178	543	08:18:34

Figures 4-22 and 4-23 illustrate the zone pressures and packer pressures, respectively, in observation borehole C1H06 for testing sequence C1X10. Copies of the video-log associated with testing sequence C1X10 (borehole C1H06) identified in Table 4-7 are provided in the SWCF under WPO #45907

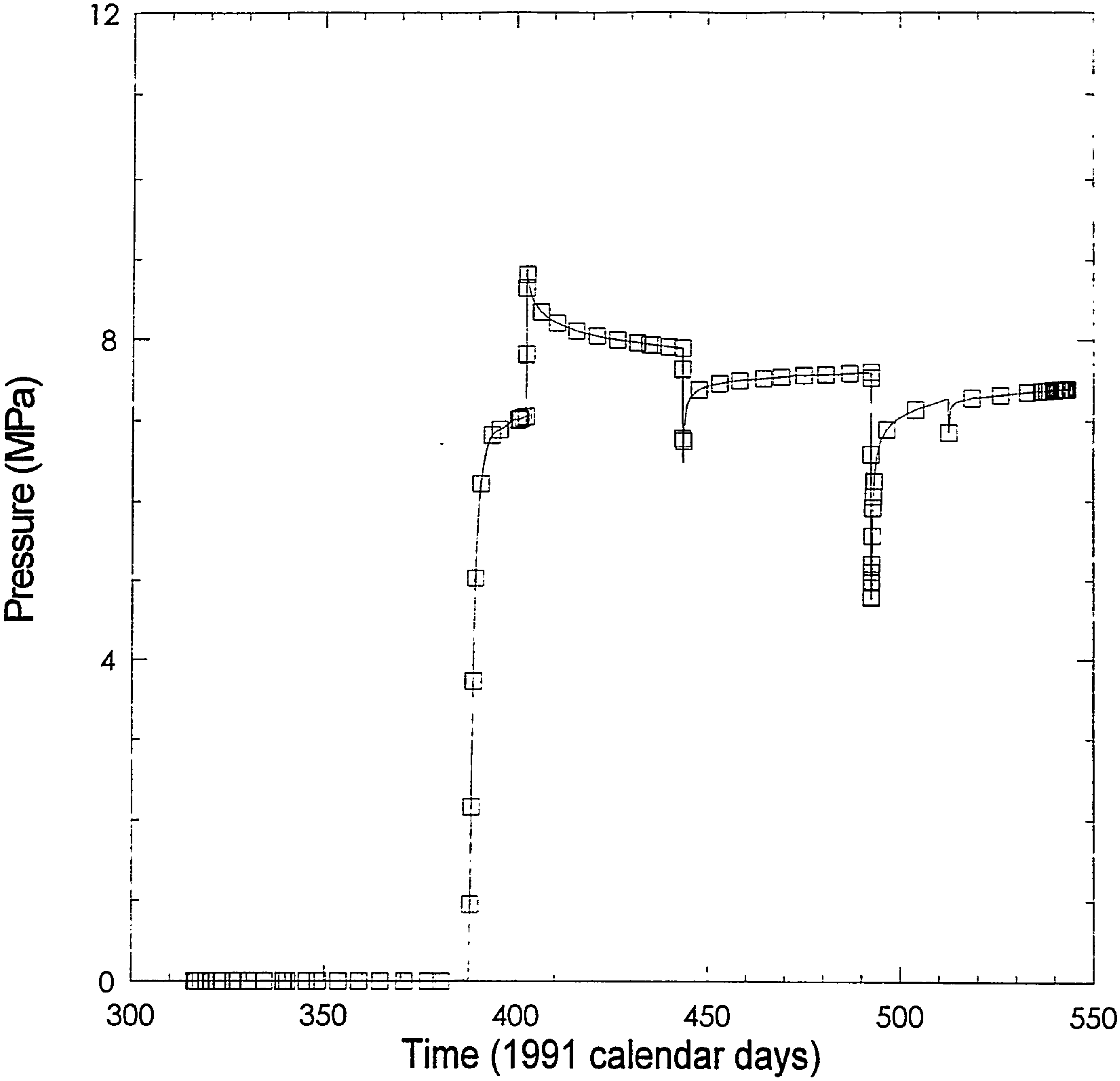

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Figure 4-22. Test-zone pressure in observation borehole C1H06 during testing sequence C1X10.

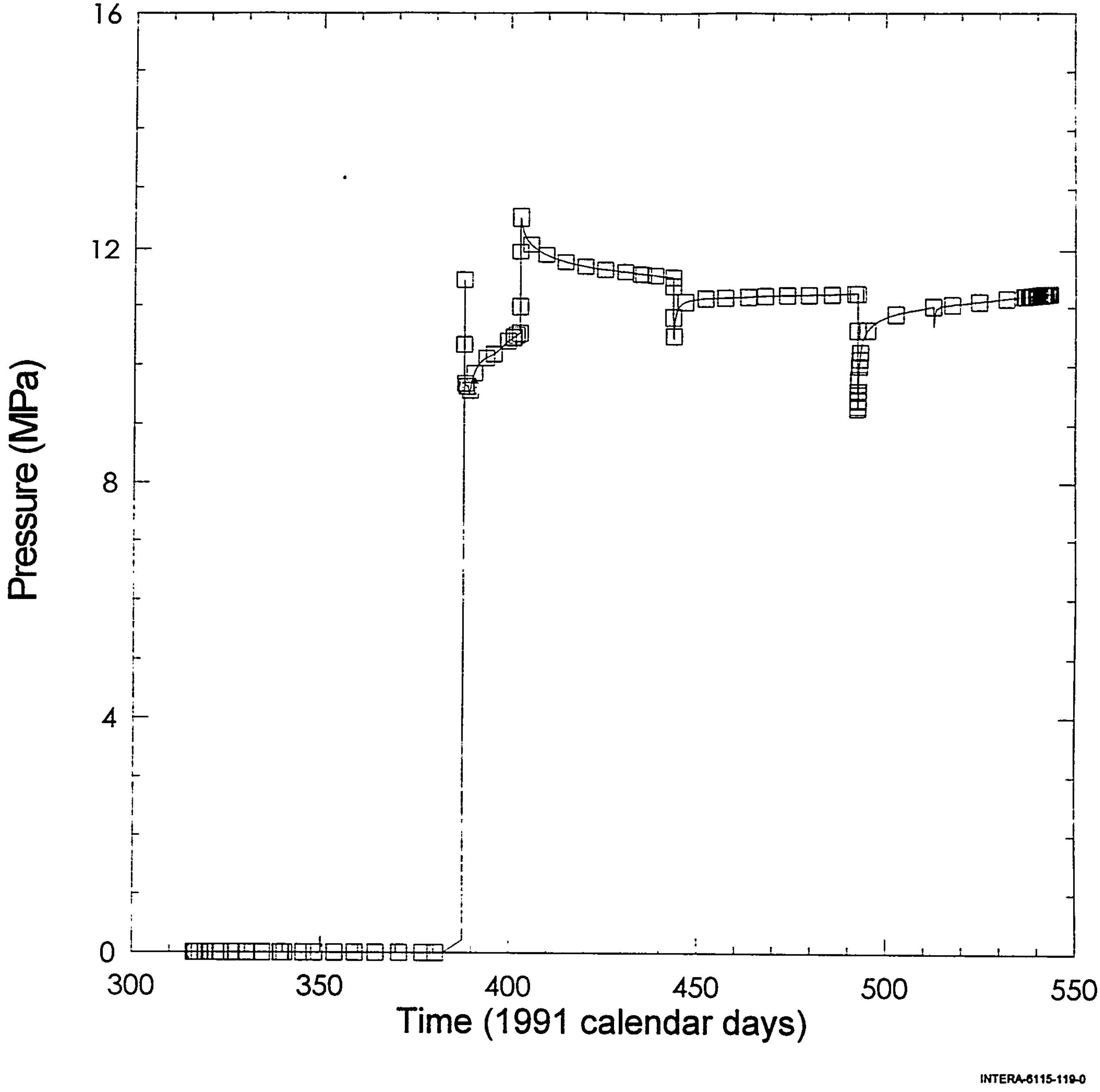

Figure 4-23. Test-zone packer pressure in observation borehole C1H06 during testing sequence C1X10.

4.6.1.3 OBSERVATION BOREHOLE DPD02, TESTING SEQUENCE C1X10

Table 4-8 gives a detailed description of the events that occurred in observation borehole DPD02 during testing sequence C1X10.

Table 4-8. Events Associated with Observation Borehole DPD02 During Testing Sequence C1X10

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY	TIME (HH:MM:SS)
Borehole DPD02 drilled to 13.11 meters.	4-86	N/A	N/A	N/A
Begin long-term fluid-pressure monitoring of MB139.	5-3-89	123	N/A	N/A
Install single-packer fluid-pressure monitoring tool as indicated in the test-tool configuration diagram (Figure 7-20).	12-4-91	338	338	N/A
Begin fluid-pressure monitoring of MB139 associated with testing sequence C1X10.	1-30-92	29	394	14:43:00
Terminate data collection.	5-7-92	128	493	14:02:00

Figure 4-24 illustrates the zone pressure in observation borehole DPD02 for testing sequence C1X10.

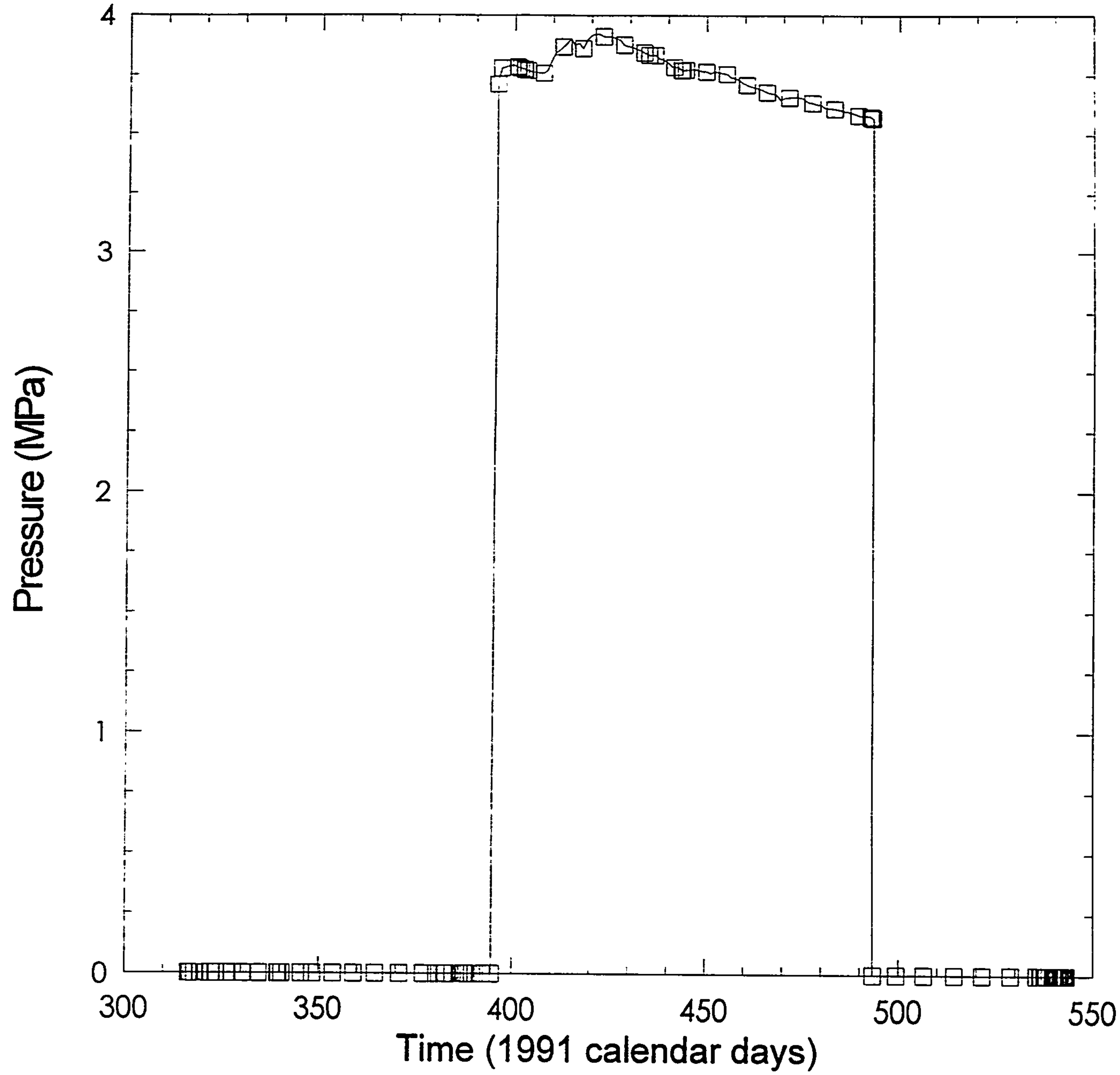

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Figure 4-24. Test-zone pressure in observation borehole DPD02 during testing sequence C1X10.

4.6.1.4 OBSERVATION BOREHOLE DPD03, TESTING SEQUENCE C1X10.

Table 4-9 gives a detailed description of the events that occurred in observation borehole DPD03 during testing sequence C1X10.

Table 4-9. Events Associated with Observation Borehole DPD03 During Testing Sequence C1X10

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY	TIME (HH:MM:SS)
Borehole DPD03 drilled to 13.11 meters.	4-86	N/A	N/A	N/A
Begin long-term fluid-pressure monitoring of MB139.	5-3-89	123	N/A	N/A
Install single-packer fluid-pressure monitoring tool as indicated in the test-tool configuration diagram (Figure 7-23).	12-4-91	338	338	N/A
Begin fluid-pressure monitoring of MB139 associated with testing sequence C1X10.	1-30-92	29	394	14:43:00
Terminate data collection.	5-7-92	128	493	14:02:00

Figure 4-25 illustrates the zone pressure in observation borehole DPD03 for testing sequence C1X10.

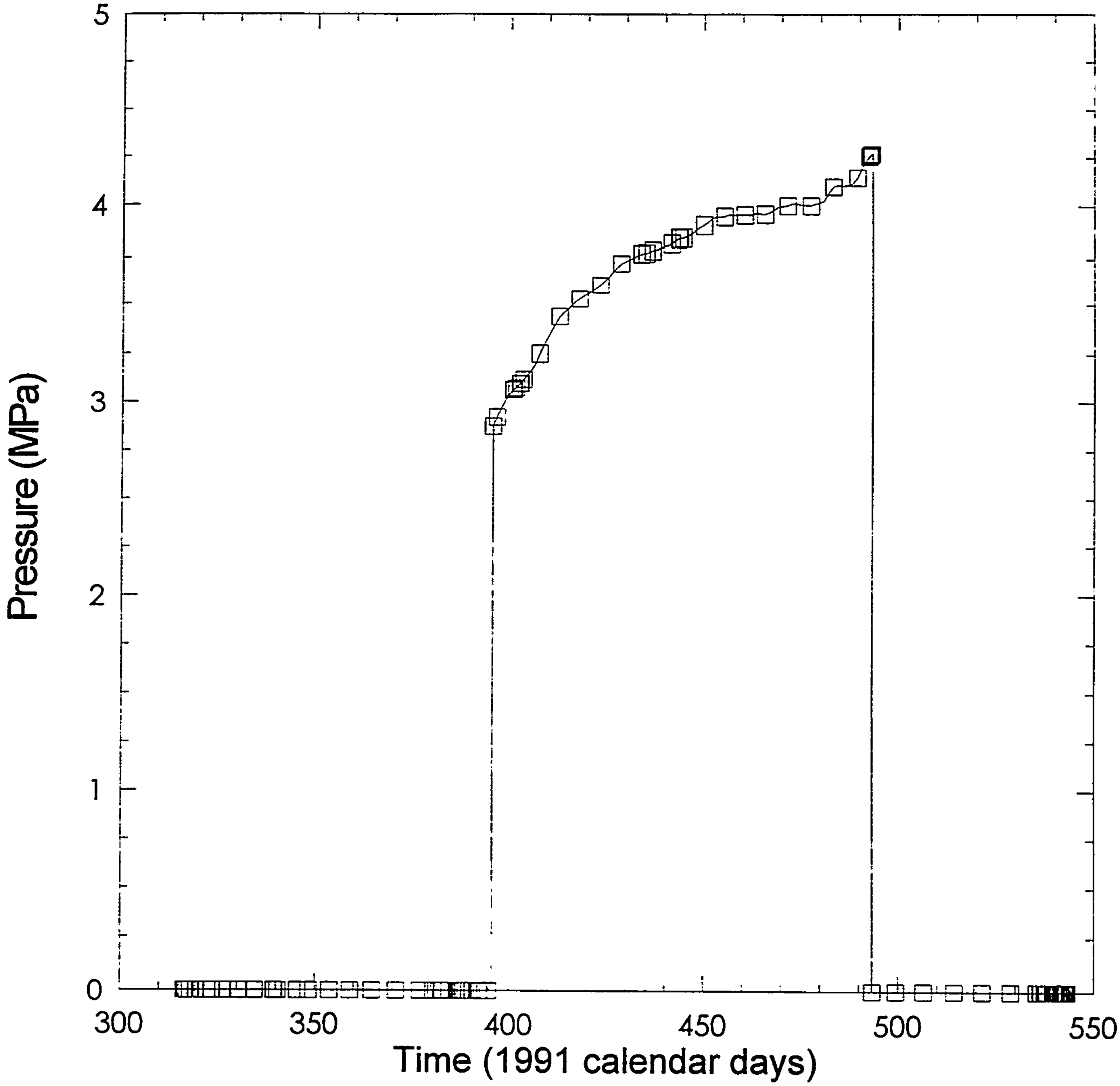

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Figure 4-25. Test-zone pressure in observation borehole DPD03 during testing sequence C1X10.

4.6.1.5 OBSERVATION BOREHOLE C2H01, TESTING SEQUENCE C1X10.

Table 4-10 gives a detailed description of the events that occurred in observation borehole C2H01 during the testing sequence C1X10.

Table 4-10. Events Associated with Observation Borehole C2H01 During Testing Sequence C1X10

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY	TIME (HH:MM:SS)
Borehole C2H01 drilled to 5.58 meters.	8-4-88	217	N/A	N/A
Begin long-term fluid-pressure monitoring.	8-22-89	234	N/A	N/A
Install single-packer fluid-pressure monitoring tool as indicated in the test-tool configuration diagram (Figure 5-9).	3-13-91	72	72	N/A
Begin fluid-pressure monitoring of MB139 associated with testing sequence C1X10.	1-29-92	29	394	14:43:00
Terminate data collection.	6-26-92	178	548	08:18:34

Figure 4-26 illustrates the zone pressure in observation borehole C2H01 for testing sequence C1X10.

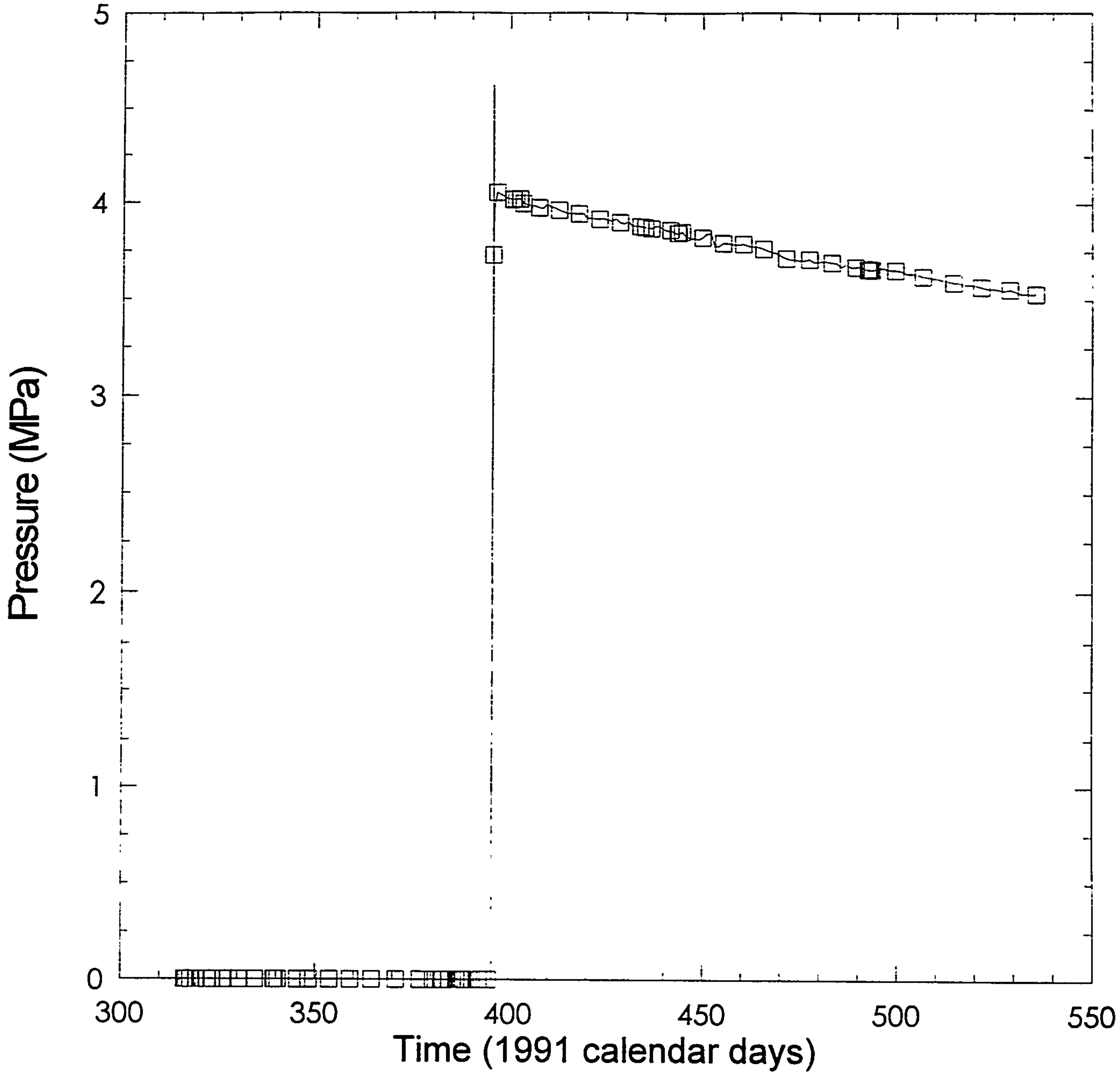

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Figure 4-26. Test-zone pressure in observation borehole C2H01 during testing sequence C1X10.

4.6.2 Borehole C1X05, Testing Sequence C1X05-A

Testing sequence C1X05-A took place in Room C1 in borehole C1X05 with associated observation boreholes C1H05, C1H06, C1H07, C1X06, C1X10, and C2H01. This test sequence was designed to investigate the pre- and post-hydrofracture brine permeability of MB139. Table 4-11 gives a detailed description of the events that occurred in test borehole C1X05 during testing sequence C1X05-A.

Table 4-11. Events Associated with Test Borehole C1X05 During Testing Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Begin data file C1X0501.	6-26-92	178	178	12:03:32
Borehole C1X05 drilled with 3-inch (7.62-cm) core barrel to 9.14 meters.	6-29-92	181	181	12:00:00
Install multipacker test tool in borehole C1X05 as indicated in the test-tool configuration diagram (Figure 4-11).	6-30-92	182	182	12:00:00
End data file C1X0501.	6-30-92	182	182	14:46:37
Begin data file C1X0502.	6-30-92	182	182	15:16:14
Begin data collection from borehole C1X05.	7-1-92	183	183	08:28:00
End data file C1X0502.	7-6-92	188	188	09:19:53
Begin data file C1X0503.	7-6-92	188	188	09:48:15
DAS not functioning properly upon arrival.	7-7-92	189	189	13:27:00
DAS not functioning properly upon arrival.	7-20-92	202	202	13:20:00
End data file C1X0503.	7-30-92	212	212	14:13:04
Begin data file C1X0504.	7-30-92	212	212	14:30:08
End data file C1X0504.	8-3-92	216	216	13:14:19
Begin data file C1X0505.	8-3-92	216	216	16:12:35
Begin constant-pressure-injection test #1 in TZ at ~ 0.5 MPa above TZ pressure (~ 9.7 MPa).	8-4-92	217	217	10:24:00
Shut in TZ from DPT panel terminating constant-pressure-injection test #1 in TZ.	8-4-92	217	217	11:10:28
Begin constant-pressure-injection test #2 in TZ at ~ 1 MPa above TZ pressure (~ 10.2 MPa).	8-4-92	217	217	11:22:00
Shut in TZ from DPT panel terminating constant-pressure-injection test #2 in TZ.	8-5-92	218	218	10:47:00
End data file C1X0505.	8-6-92	219	219	13:57:26
Begin data file C1X0506.	8-6-92	219	219	14:07:23
End data file C1X0506.	8-10-92	223	223	10:54:48
Begin data file C1X0507.	8-10-92	223	223	11:04:38
Begin constant-pressure-injection test #3 in TZ at ~ 1 MPa above TZ pressure (~ 10.2 MPa).	8-10-92	223	223	11:12:37
End data file C1X0507.	8-18-92	231	231	09:14:13
Begin data file C1X0508.	8-20-92	233	233	09:20:34
Shut in TZ from DPT panel terminating constant-pressure-injection test #3 in TZ.	8-20-92	233	233	09:23:00
End data file C1X0508.	9-10-92	254	254	09:08:40

Table 4-11 (Continued). Events Associated with Test Borehole C1X05 During Testing Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Begin data file C1X0509.	9-10-92	254	254	09:43:43
End data file C1X0509.	9-11-92	255	255	09:16:30
Begin data file C1X0510.	9-11-92	255	255	09:48:28
Increase TZP and GZP pressure.	9-11-92	255	255	13:26:00
Increase TZP and GZP pressure.	9-16-92	260	260	10:25:00
Perform hydrofracture of MB139 (injected ~ 0.53 L of fluid into TZ).	9-16-92	260	260	10:31:50
Begin constant-pressure-withdrawal test #1 in TZ at ~ 9.5 MPa.	9-16-92	260	260	10:41:46
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #1 in TZ.	9-16-92	260	260	10:48:36
Decrease TZ pressure to ~ 9.6 MPa.	9-16-92	260	260	11:00:00
Perform hydrofracture of MB139 (injected ~ 2.27 L of fluid).	9-16-92	260	260	11:02:30
Begin constant-pressure-withdrawal test #2 in TZ at ~ 9.5 MPa.	9-16-92	260	260	11:10:34
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #2 in TZ.	9-16-92	260	260	11:43:41
Perform hydrofracture of MB139 (injected ~5.98 L of fluid).	9-16-92	260	260	11:46:33
Begin constant-pressure-withdrawal test #3 in TZ at ~ 9.5 MPa.	9-16-92	260	260	11:57:18
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #3 in TZ.	9-16-92	260	260	12:11:50
Perform hydrofracture of MB139 (injected ~ 8.55 L of fluid).	9-16-92	260	260	12:25:35
Begin constant-pressure-withdrawal test #4 in TZ at ~ 9 MPa.	9-16-92	260	260	12:40:36
Decrease TZP pressure	9-16-92	260	260	13:19:52
Increase TZP pressure.	9-16-92	260	260	13:21:50
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #4 in TZ.	9-17-92	261	261	10:14:54
Begin constant-pressure-withdrawal test #5 in TZ at ~ 9.5 MPa.	9-17-92	261	261	14:05:31
End data file C1X0510.	9-18-92	262	262	09:32:16
Begin data file C1X0511.	9-18-92	262	262	09:36:02
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #5 in TZ.	9-18-92	262	262	09:37:46
End data file C1X0511.	10-1-92	275	275	08:15:21
Begin data file C1X0512.	10-1-92	275	275	10:54:03
End data file C1X0512.	10-19-92	293	293	09:43:19
Begin data file C1X0513.	10-19-92	293	293	11:11:28
End data file C1X0513.	11-17-92	322	322	09:46:07
Begin data file C1X0514.	11-17-92	322	322	10:38:27
Begin constant-pressure-injection test #4 in TZ at ~ 1 MPa above TZ pressure (~ 10.3 MPa).	11-17-92	322	322	10:47:52
Shut in TZ from DPT panel terminating constant-pressure-injection test #4 in TZ.	12-1-92	336	336	11:09:58
Begin constant-pressure-injection test #5 in TZ at ~ 2.2 MPa above TZ pressure (~ 11.5 MPa).	12-1-92	336	336	11:42:17
Shut in TZ from DPT panel terminating constant-pressure-injection test #5 in TZ.	12-1-92	336	336	13:06:48
End data file C1X0514.	1-8-93	8	374	11:14:04

Table 4-11 (Continued). Events Associated with Test Borehole C1X05 During Testing Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Begin data file C1X0515.	1-8-93	8	374	12:38:36
Begin constant-pressure-withdrawal test #6 in TZ at ~ 1 MPa below TZ pressure (~ 8.1 MPa).	1-13-93	13	379	10:39:01
Leak in DPT panel caused TZ pressure decrease.	1-18-93	18	384	10:12:00
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #6 in TZ.	1-18-93	18	384	10:15:00
Begin constant-pressure-withdrawal test #7 in TZ at ~1 MPa below TZ pressure (~8.1 MPa).	1-18-93	18	384	12:50:00
Shut in TZ from DPT panel terminating constant-pressure-withdrawal test #7 in TZ.	1-26-93	26	392	15:14:02
End data file C1X0515.	3-11-93	70	435	14:41:22
Begin data file C1X0516.	3-11-93	70	435	14:52:50
End data file C1X0516.	4-12-93	102	467	11:01:47
Remove multipacker test tool from borehole C1X05.	4-16-93	106	472	09:44:00

Table 4-12 indicates the equipment that was used and the duration that each instrument was used during testing sequence C1X05-A in test borehole C1X05 and in the observation boreholes. Figures 4-27 and 4-28 illustrate the zone pressures and fluid production during a constant-pressure-withdrawal tests, respectively, in test borehole C1X05 for testing sequence C1X05-A. It should be noted that Figure 4-28 (Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-A) consists of five parts (Figures 4-28a, 4-28b, 4-28c, 4-28d, and 4-28e).

Table 4-12. Testing Sequence C1X05-A Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	6-26-92	4-12-93
DCU (HP3497A)	N/A	2629a21990	6-26-92	9-9-92
DCU (HP3497A)	N/A	2023a01688	9-9-92	10-19-92
DCU (HP3497A)	N/A	2629a21996	10-19-92	4-7-93
Transducer (Druck PDCR 830)	C1X10 TZ	246909	6-26-92	8-3-92
Transducer (Druck PDCR 830)	C1X10 TZ	246909	8-6-92	3-11-93
Transducer (Druck PDCR 830)	C1H05 TZ	246917	6-26-92	3-11-93
Transducer (Druck PDCR 830)	C1H05 TZP	246919	6-26-92	10-1-92
Transducer (Druck PDCR 910)	C2H01 TZ	321768	6-26-92	8-3-92

Table 4-12 (Continued). Testing Sequence C1X05-A Equipment

Equipment	Location	Serial #	Installed	Removed
Transducer (Druck PDCR 910)	C1H07 TZ	322426	6-26-92	4-12-93
Transducer (Druck PDCR 10/D)	C1H07 TZP	211691	6-26-92	4-12-93
Transducer (Druck PDCR 910)	C1X05 TZ	322424	6-30-92	4-12-93
Transducer (Druck PDCR 830)	C1H06 TZ	246916	7-6-92	3-11-93
Transducer (Druck PDCR 830)	C1H06 TZP	246918	7-6-92	10-1-92
Transducer (Druck PDCR 910)	DPT Panel	322427	8-3-92	8-18-92
Transducer (Druck PDCR 910)	DPT Panel	322427	9-10-92	9-18-92
Transducer (Druck PDCR 910)	DPT Panel	322427	10-1-92	11-17-92
Transducer (Druck PDCR 910)	C1X06 TZ	308143	10-1-92	4-12-93
Transducer (Druck PDCR 910)	C1X06 TZP	308146	10-1-92	4-12-93
Transducer (Druck PDCR 910)	DPT Panel	316158	1-8-93	4-12-93
LVDT (Trans-Tek 245)	C1X06	A04	10-1-92	4-12-93
Thermocouple (Type E)	C1H07	1	7-6-92	4-12-93
Injection Column	N/A	77	8-4-92	8-6-92
Injection Column	N/A	92	8-6-92	8-24-92
Injection Column	N/A	77	9-16-92	9-18-92
Injection Column	N/A	88	9-16-92	9-18-92
Injection Column	N/A	77	11-17-92	3-11-93
Injection Column	N/A	76	11-20-92	3-11-93
DPT (Rosemount 1151DP)	N/A	1409226	8-3-92	8-18-92
DPT (Rosemount 1151DP)	N/A	1389938	9-15-92	3-11-93

* Installed dates for injection columns refer to dates of initial use rather than date installed.

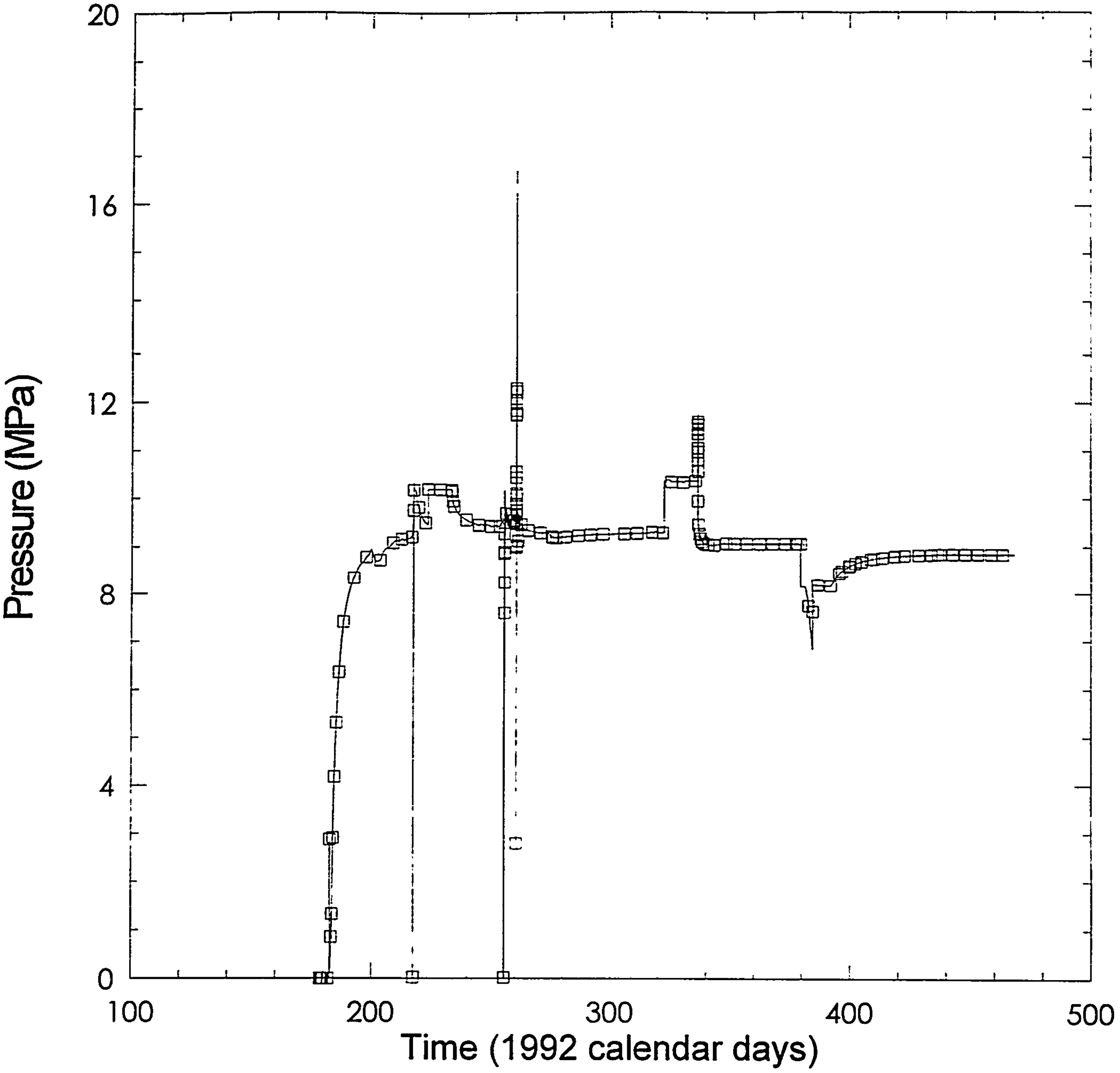

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Figure 4-27. Test-zone pressure in test borehole C1X05 during testing sequence C1X05-A.

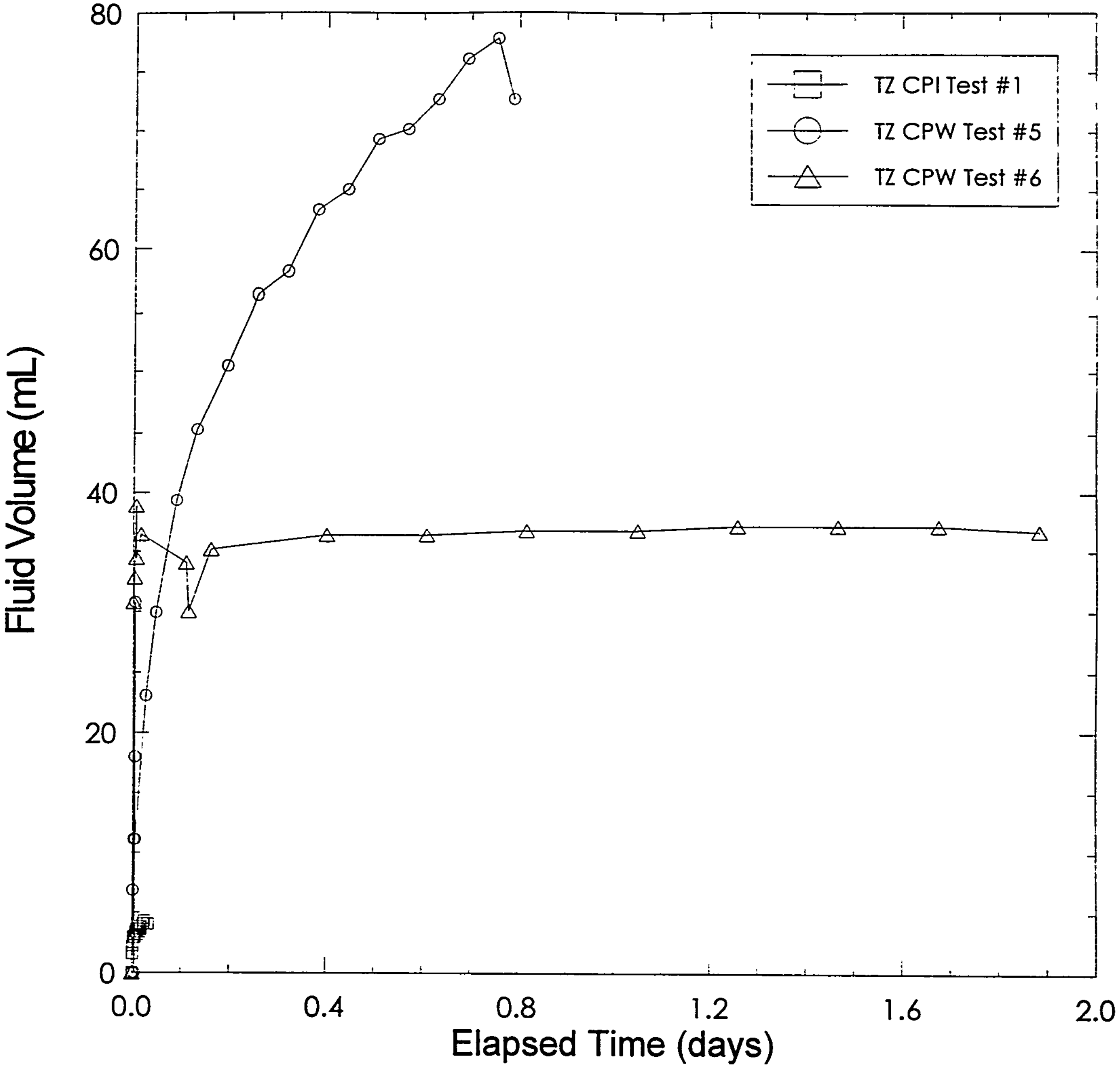

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Figure 4-28a. Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-A.

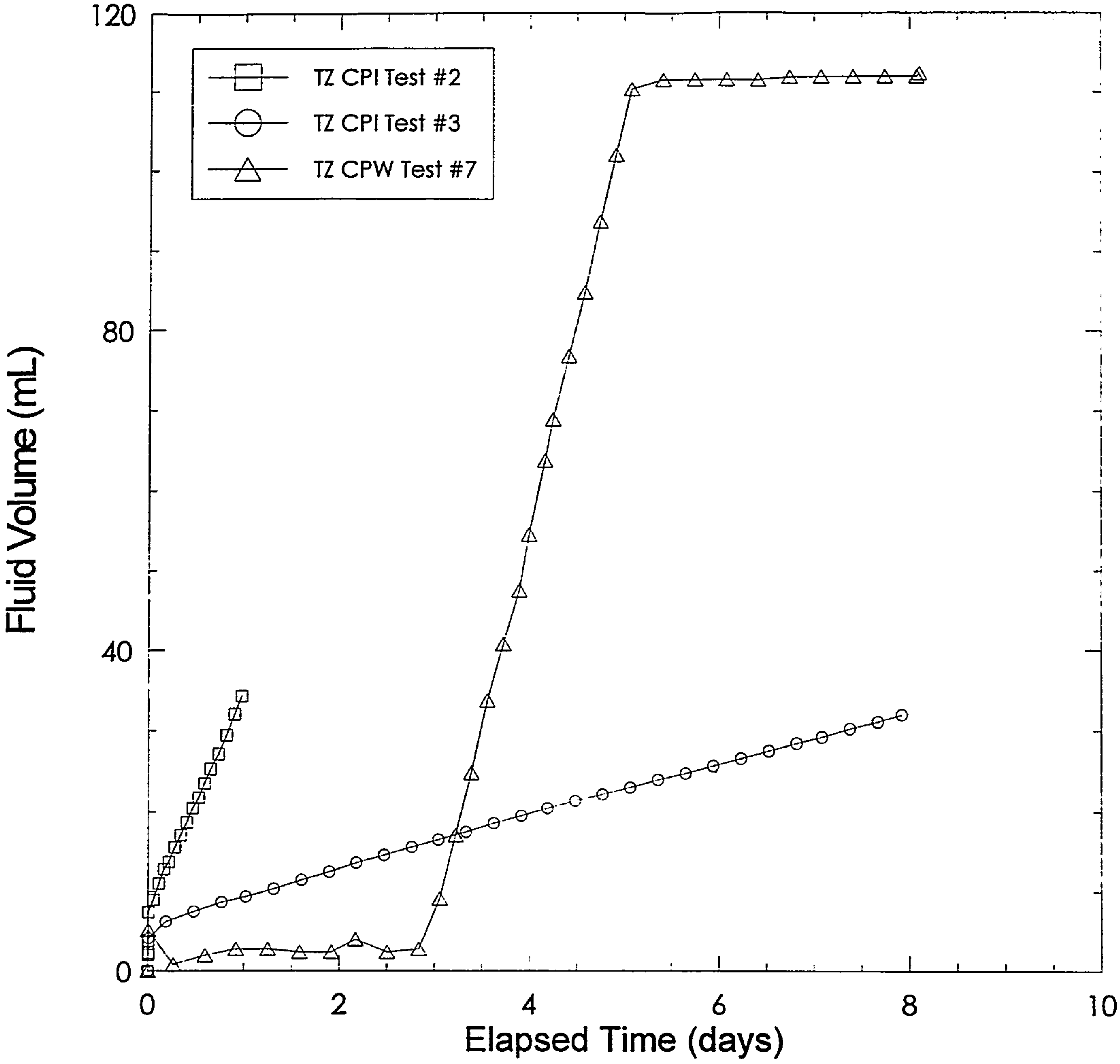

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Figure 4-28b. Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-A (continued).

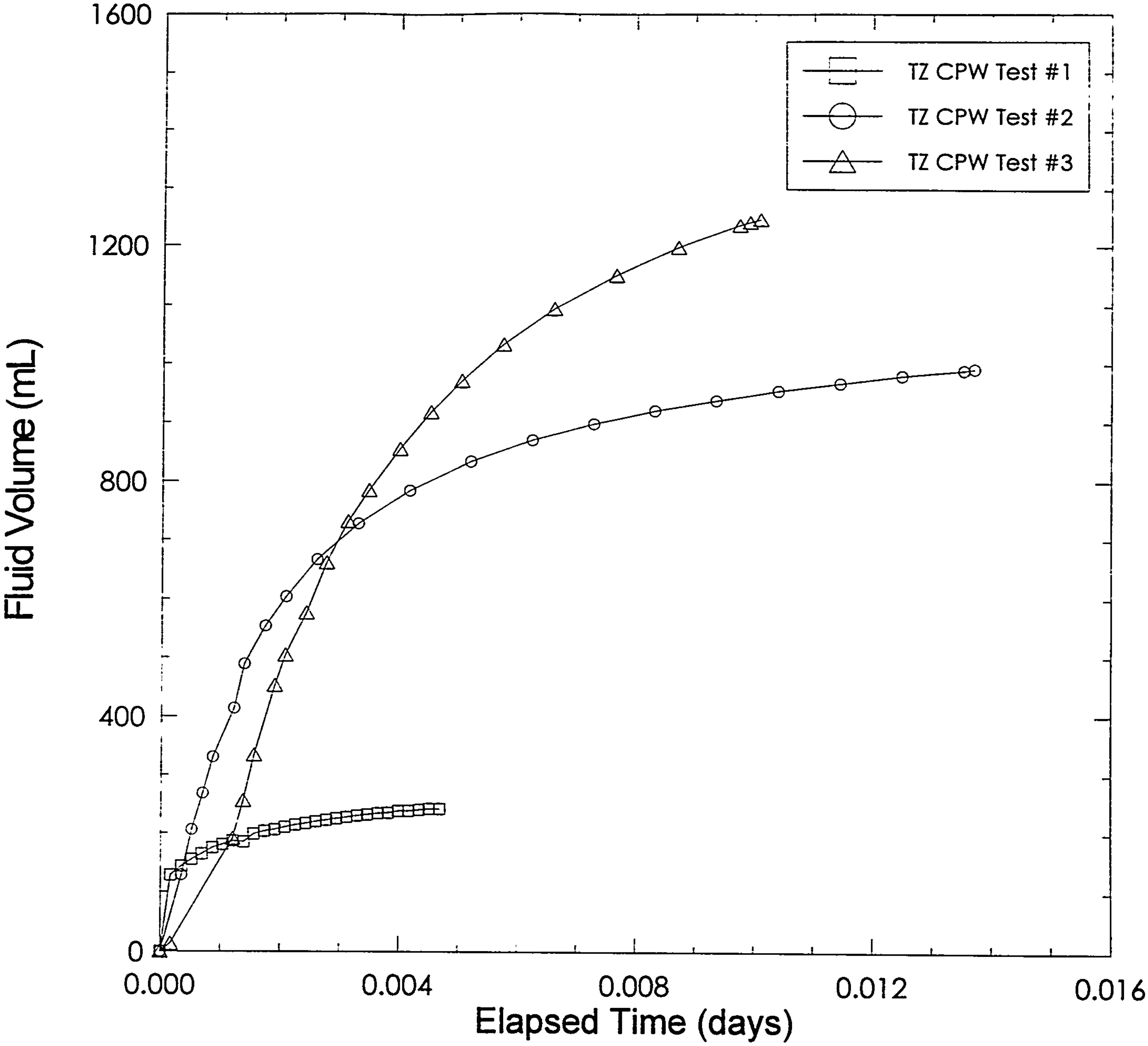

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Figure 4-28c. Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-A (continued).

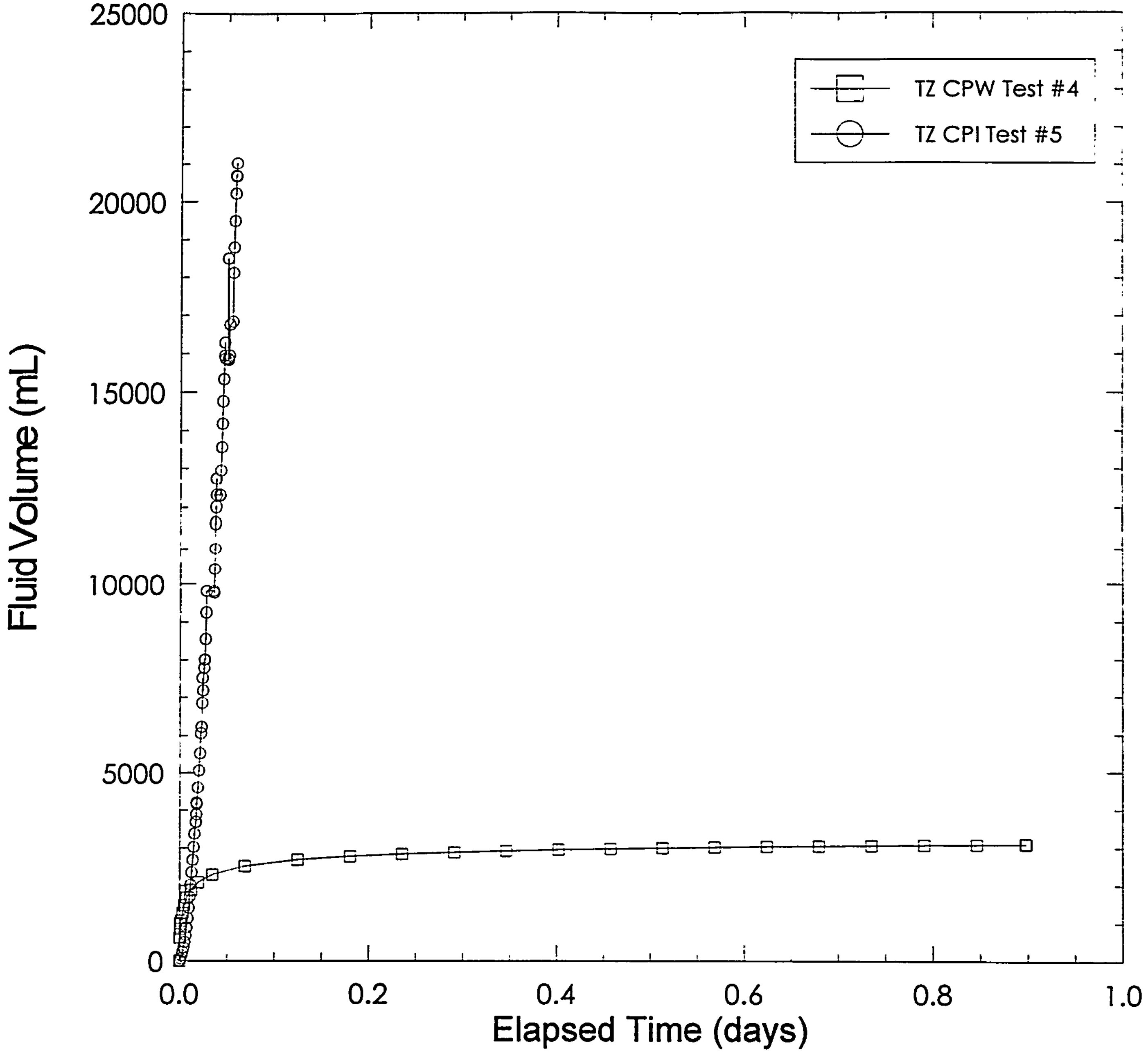

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Figure 4-28d. Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-A (continued).

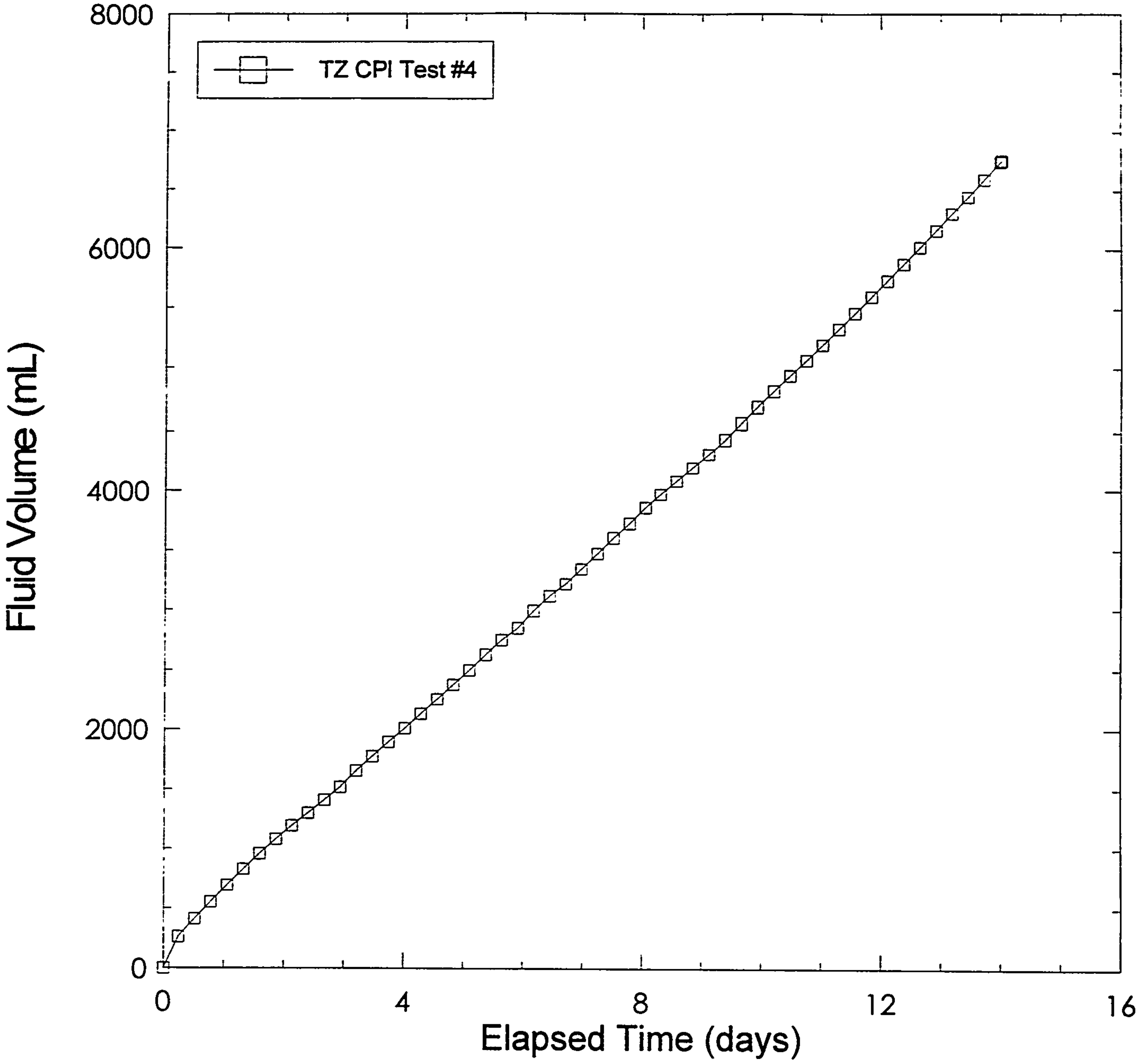


Figure 4-28e. Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-A (continued).

4.6.2.1 OBSERVATION BOREHOLE C1H05, TESTING SEQUENCE C1X05-A

Table 4-13 gives a detailed description of the events that occurred in observation borehole C1H05 during testing sequence C1X05-A.

Table 4-13. Events Associated with Observation Borehole C1H05 During Testing Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Drill borehole C1H05 with 4-inch (10.16-cm) core barrel to 8.20 meters.	1-16-92	16	16	14:20:00
Perform video log of borehole C1H05.	1-17-92	17	17	10:00:00
Face off bottom of borehole with 4-inch (10.16-cm) plug bit to 8.26 meters.	1-17-92	17	17	10:45:00
Install single-packer monitor tool #32A in borehole C1H05 as indicated in the test-tool configuration diagram (Figure 4-9).	1-17-92	17	17	10:00:00
Begin data collection associated with testing sequence C1X10.	1-17-92	17	17	14:30:00
Terminate data collection associated with testing sequence C1X10.	6-26-92	178	178	08:18:35
Begin data collection associated with testing sequence C1X05-A.	6-26-92	178	178	13:00:00
Terminate data collection associated with testing sequence C1X05-A.	3-11-93	70	437	10:30:00
Remove monitor tool from borehole C1H05.	3-12-93	71	437	10:50:00

Figures 4-29 and 4-30 illustrate the zone pressure and packer pressure, respectively, in observation borehole C1H05 for testing sequence C1X05-A. Copies of the video-log associated with testing sequence C1X05-A (borehole C1H05) identified in Table 4-13 are provided in the SWCF under WPO #45907

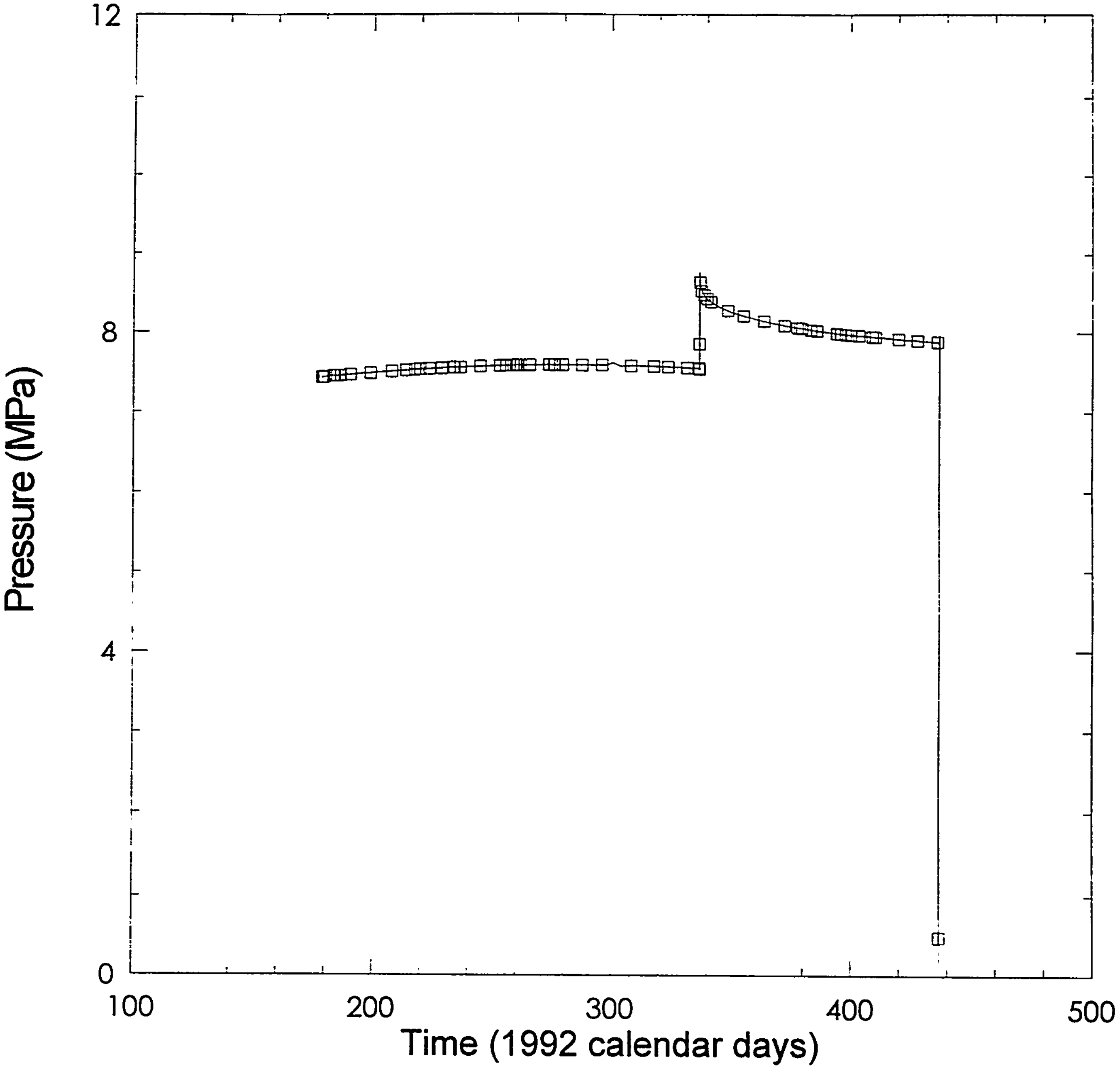
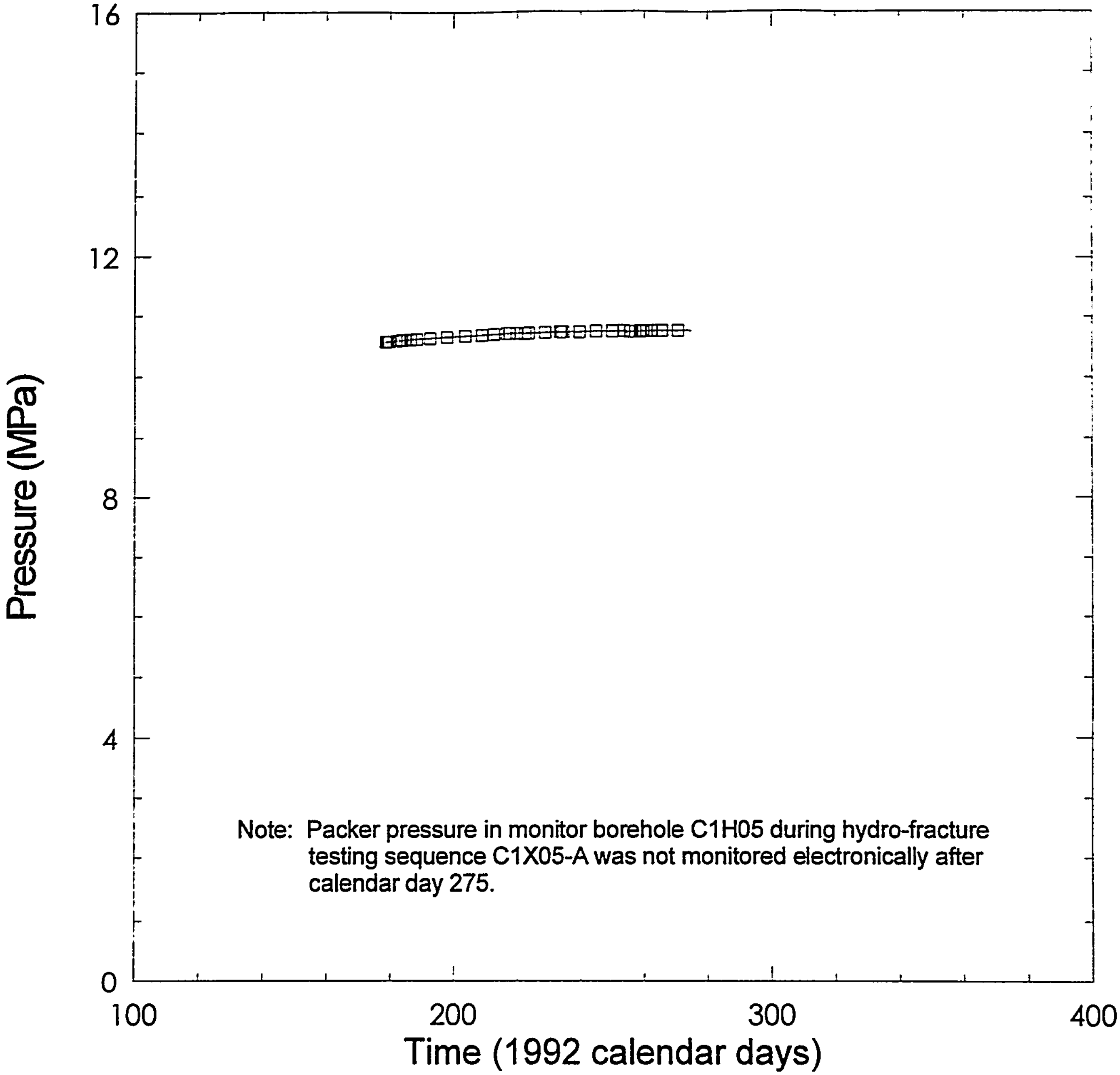


Figure 4-29. Zone pressure in observation borehole C1H05 during testing sequence C1X05-A.



Note: Packer pressure in monitor borehole C1H05 during hydro-fracture testing sequence C1X05-A was not monitored electronically after calendar day 275.

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Figure 4-30. Packer pressure in observation borehole C1H05 during testing sequence C1X05-A.

4.6.2.2 OBSERVATION BOREHOLE C1H06, TESTING SEQUENCE C1X05-A

Table 4-14 gives a detailed description the of events that occurred in observation borehole C1H06 during testing sequence C1X05-A.

Table 4-14. Events Associated with Observation Borehole C1H06 During Testing Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Drill borehole C1H06 with 4-inch (10.16-cm) plug bit to 9.40 meters.	1-21-92	21	21	15:30:00
Perform video log of borehole C1H06.	1-22-92	22	22	11:30:00
Install single-packer monitor tool #32B in borehole C1H06 as indicated in the test-tool configuration diagram (Figure 4-10).	1-22-92	22	22	10:00:00
Begin data collection associated with testing sequence C1X10.	1-22-92	22	22	14:04:00
Terminate data collection associated with testing sequence C1X10.	6-26-92	178	178	08:18:35
Begin data collection associated with testing sequence C1X05-A.	6-26-92	178	178	13:00:00
Terminate data collection associated with testing sequence C1X05-A.	3-11-93	70	437	10:30:00
Remove monitor tool from borehole C1H06.	3-12-93	71	437	11:17:00

Figures 4-31 and 4-32 illustrate the zone pressure and packer pressure, respectively, in observation borehole C1H06 for testing sequence C1X05-A. Copies of the video-log associated with testing sequence C1X05-A (borehole C1H06) identified in Table 4-14 are provided in the SWCF under WPO #45907

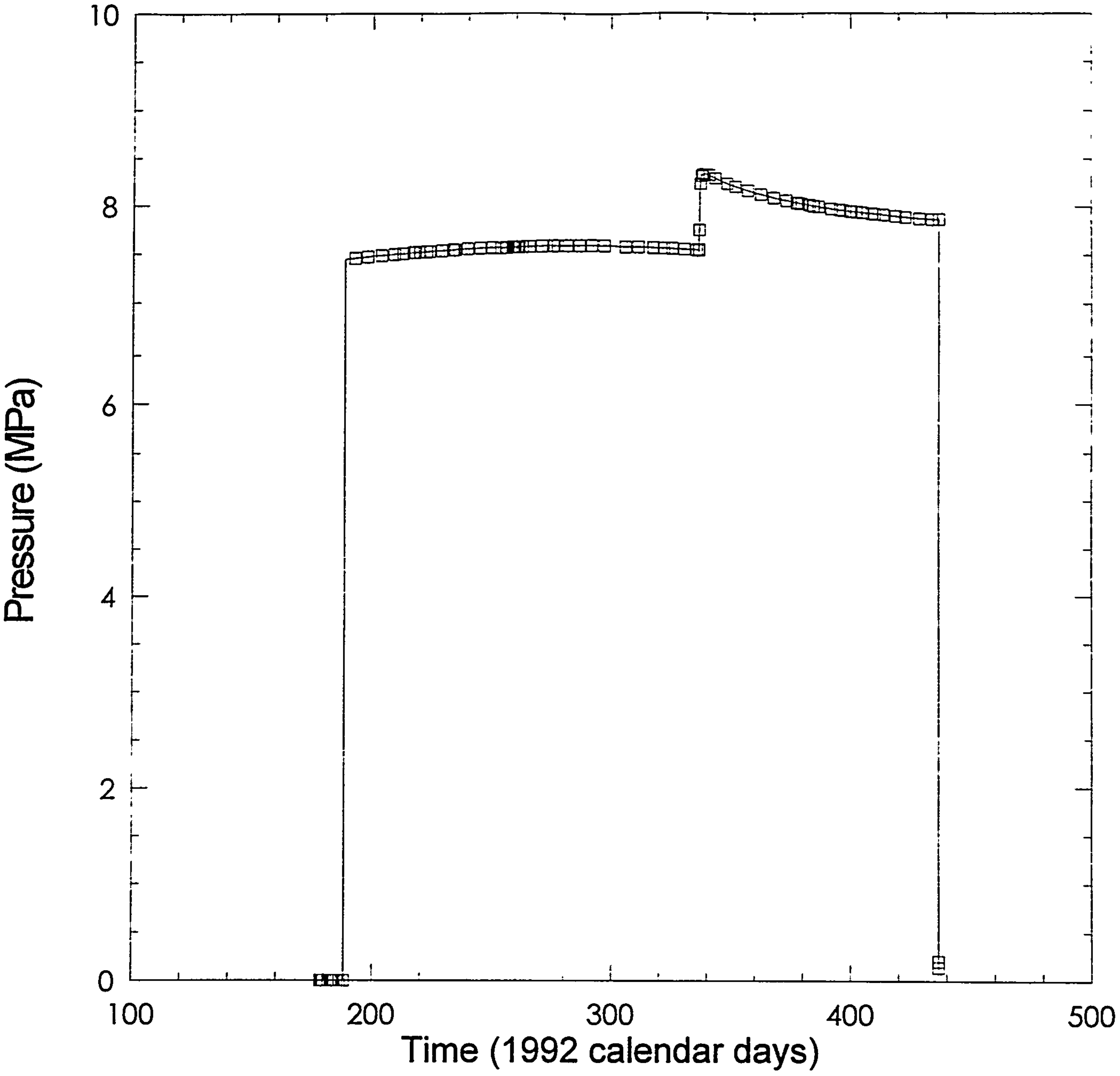

Figure 4-31. Zone pressure in observation borehole C1H06 during testing sequence C1X05-A.

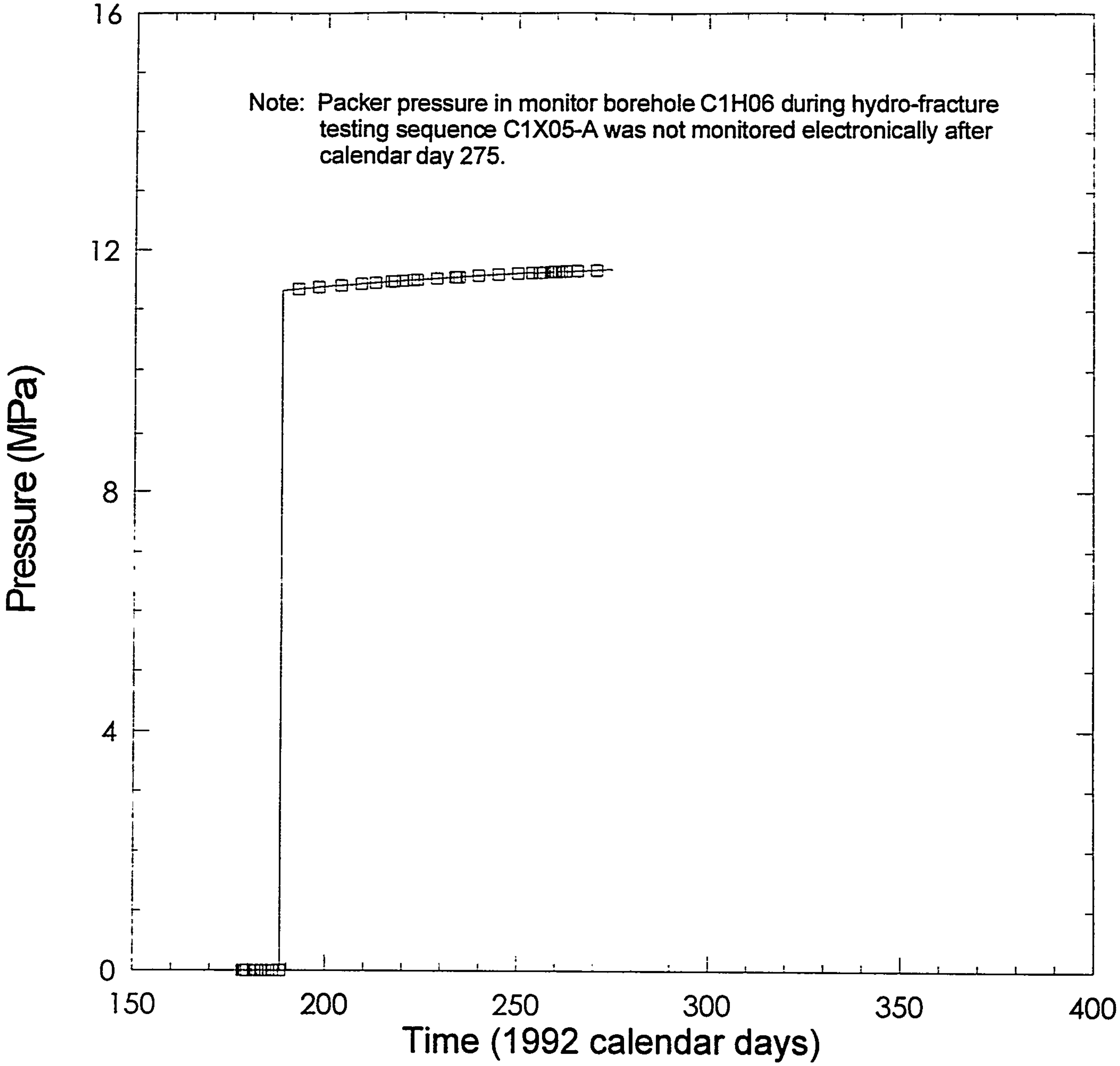

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Figure 4-32. Packer pressure in observation borehole C1H06 during testing sequence C1X05-A.

4.6.2.3 OBSERVATION BOREHOLE C1H07, TESTING SEQUENCE C1X05-A

Table 4-15 gives a detailed description of the events that occurred in observation borehole C1H07 during testing sequence C1X05-A.

Table 4-15. Events Associated with Observation Borehole C1H07 During Testing Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY)	TIME (HH:MM:SS)
Start drilling borehole C1H07 with 4-inch (10.16-cm) core barrel to 1.47 meters.	6-22-92	174	174	10:30:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to 2.47 meters.	6-23-92	175	175	09:18:00
Deepen bore hole C1H07 with 4-inch (10.16-cm) core barrel to 3.10 meters.	6-23-92	175	175	10:00:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to 3.82 meters.	6-23-92	175	175	10:30:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to 4.40 meters.	6-23-92	175	175	13:30:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to 4.91 meters.	6-23-92	175	175	14:25:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to 5.41 meters.	6-24-92	176	176	10:00:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to 6.18 meters.	6-24-92	176	176	10:30:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to 6.88 meters.	6-24-92	176	176	11:10:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to 7.40 meters.	6-24-92	176	176	12:50:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to 8.18 meters.	6-24-92	176	176	13:25:00
Perform video log of borehole C1H07.	6-26-92	178	178	10:30:00
Install single-packer monitor tool #34 in borehole C1H07-A as indicated in the test-tool configuration diagram (Figure 4-12).	6-26-92	178	178	11:15:00
Begin data collection associated with testing sequence C1X05-A.	6-26-92	178	178	13:00:00
Inflate TZP to ~ 10 MPa.	6-26-92	178	178	13:05:00
Shut in TZ.	6-26-92	178	178	13:05:00
Terminate data collection associated with testing sequence C1X05-A.	4-7-93	97	463	09:30:43
Remove monitor tool #34 from borehole C1H07.	4-16-93	106	472	10:00:00

Figures 4-33 through 4-35 illustrate the zone pressure, packer pressure, and zone temperature, respectively, in observation borehole C1H07 for testing sequence C1X05-A. Copies of the video-log associated with testing sequence C1X05-A (borehole C1H07) identified in Table 4-15 are provided in the SWCF under WPO #45907

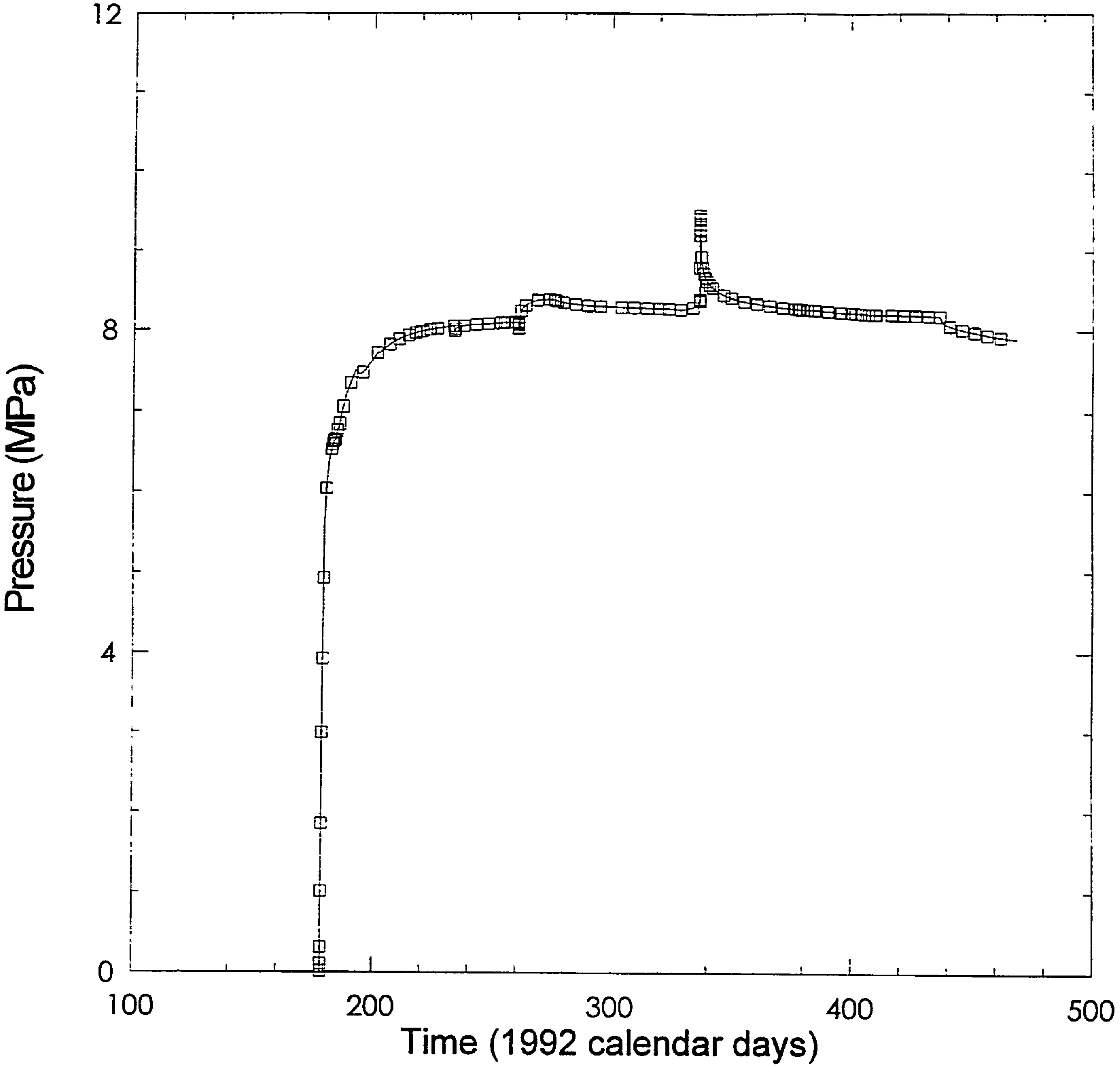

Figure 4-33. Zone pressure in observation borehole C1H07 during testing sequence C1X05-A.

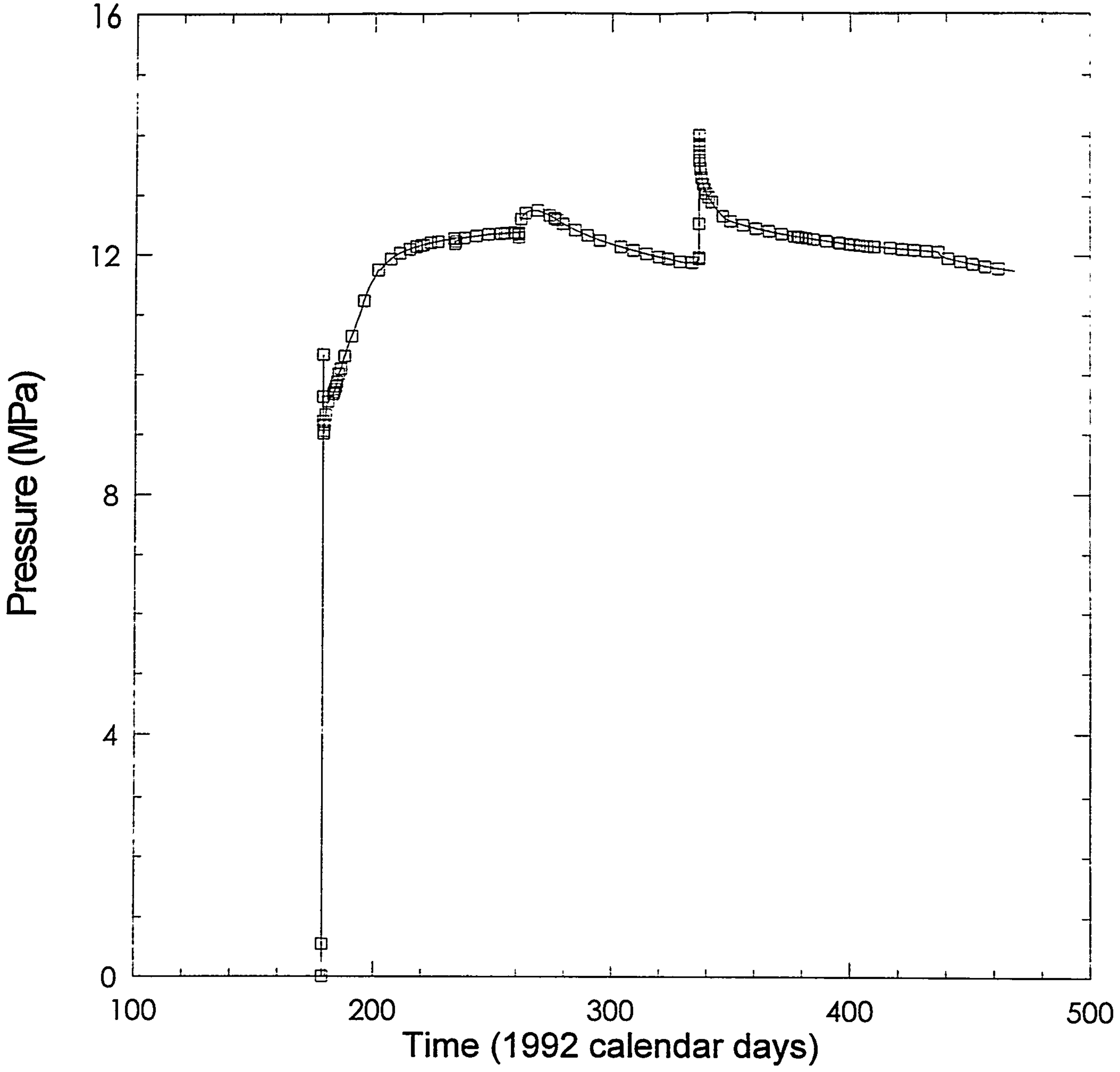

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Figure 4-34. Packer pressure in observation borehole C1H07 during testing sequence C1X05-A.

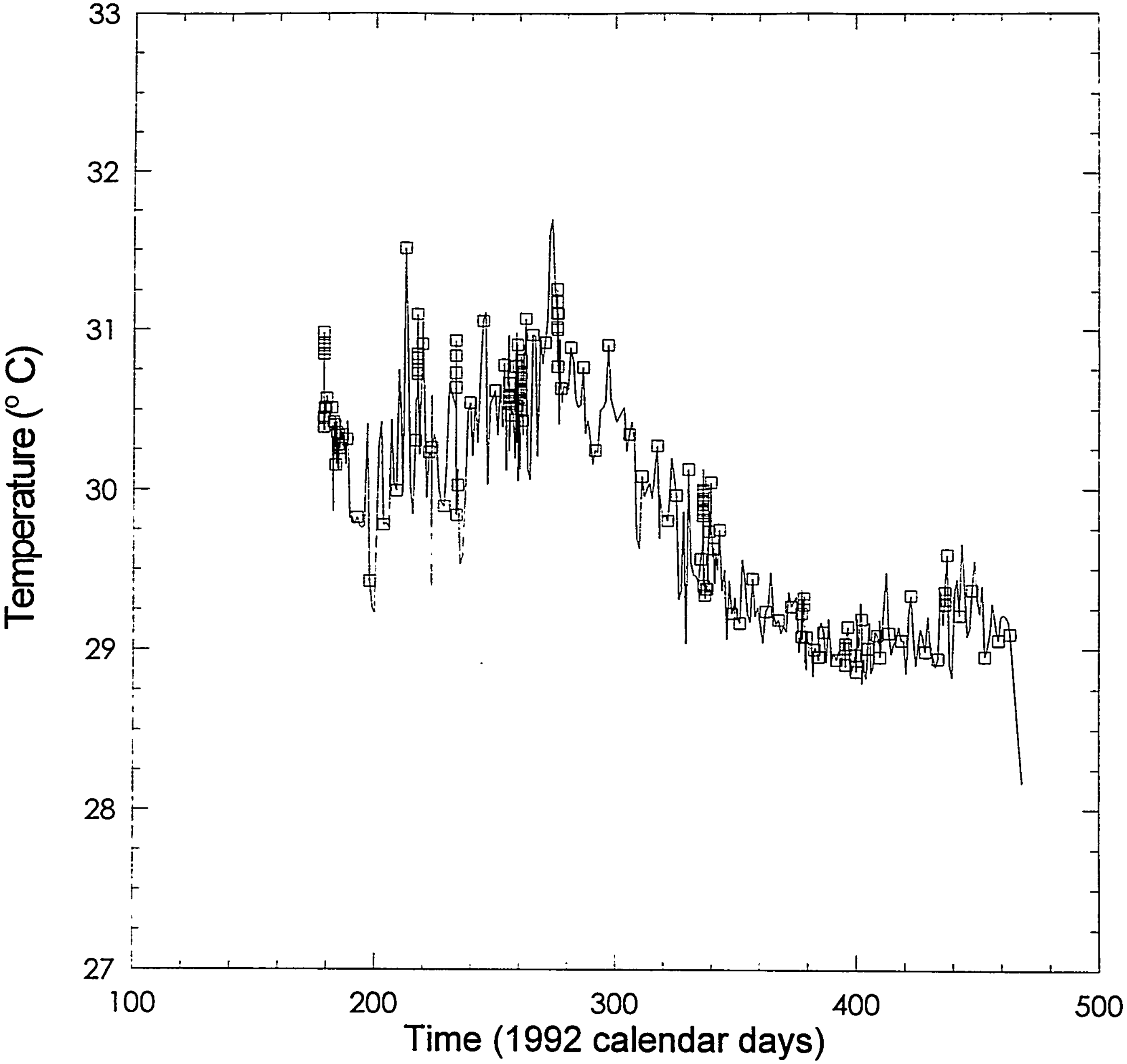

Figure 4-35. Zone temperature in observation borehole C1H07 during testing sequence C1X05-A.

4.6.2.4 OBSERVATION BOREHOLE C1X06, TESTING SEQUENCE C1X05-A

Table 4-16 gives a detailed description of the events that occurred in observation borehole C1X06 during testing sequence C1X05-A.

Table 4-16. Events Associated with Observation Borehole C1X06 During Testing Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Start drilling borehole C1X06 with 4-inch (10.16-cm) core barrel to 1.16 meters.	9-28-92	272	272	10:44:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 2.01 meters.	9-28-92	272	272	11:20:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 2.84 meters.	9-28-92	272	272	12:41:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 3.60 meters.	9-28-92	272	272	13:09:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 4.36 meters.	9-28-92	272	272	13:55:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 5.16 meters.	9-28-92	272	272	14:15:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 6.05 meters.	9-29-92	273	273	09:56:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 6.94 meters.	9-29-92	273	273	12:20:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 7.37 meters.	9-29-92	273	273	13:05:00
Face off bottom of borehole C1X06 with 4-inch (10.16-cm) plug bit to 7.63 meters.	9-30-92	274	274	10:00:00
Install single-packer monitor tool #36 in borehole C1X06 as indicated in the test-tool configuration diagram (Figure 4-13).	9-30-92	274	274	12:00:00
Begin data collection associated with testing sequence C1X05-A.	10-1-92	275	275	11:00:00
Inflate TZP to ~ 11 MPa.	10-1-92	275	275	11:19:05
Shut in TZ.	10-1-92	275	275	11:49:37
Terminate data collection associated with testing sequence C1X05-A.	4-7-93	97	463	09:30:43
Remove monitor tool #36 from borehole C1X06.	4-16-93	106	472	09:55:00

Figures 4-36 through 4-38 illustrate the zone pressure, packer pressure, and axial-LVDT displacement, respectively, in observation borehole C1X06 for testing sequence C1X05-A.

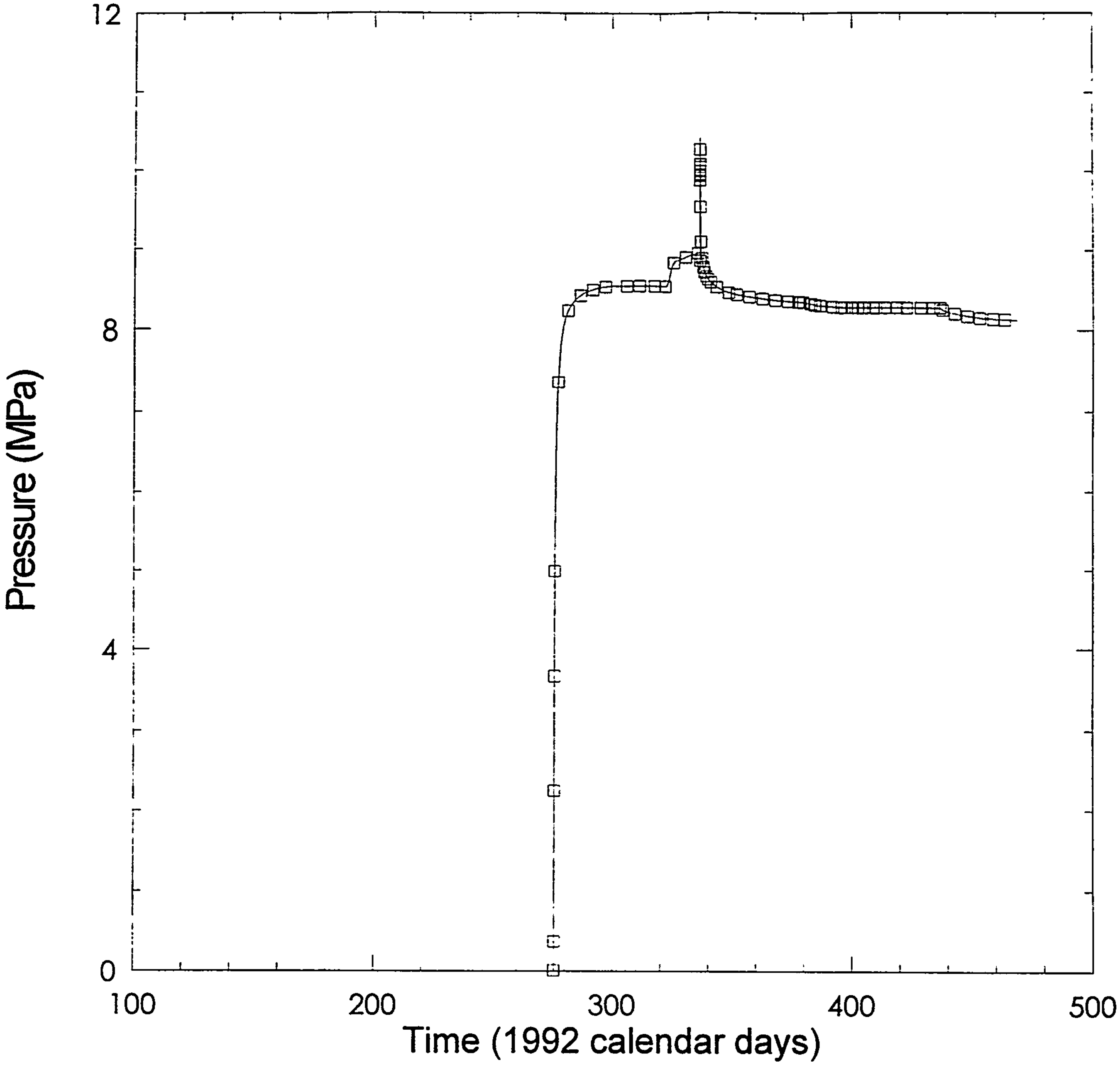

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Figure 4-36. Zone pressure in observation borehole C1X06 during testing sequence C1X05-A.

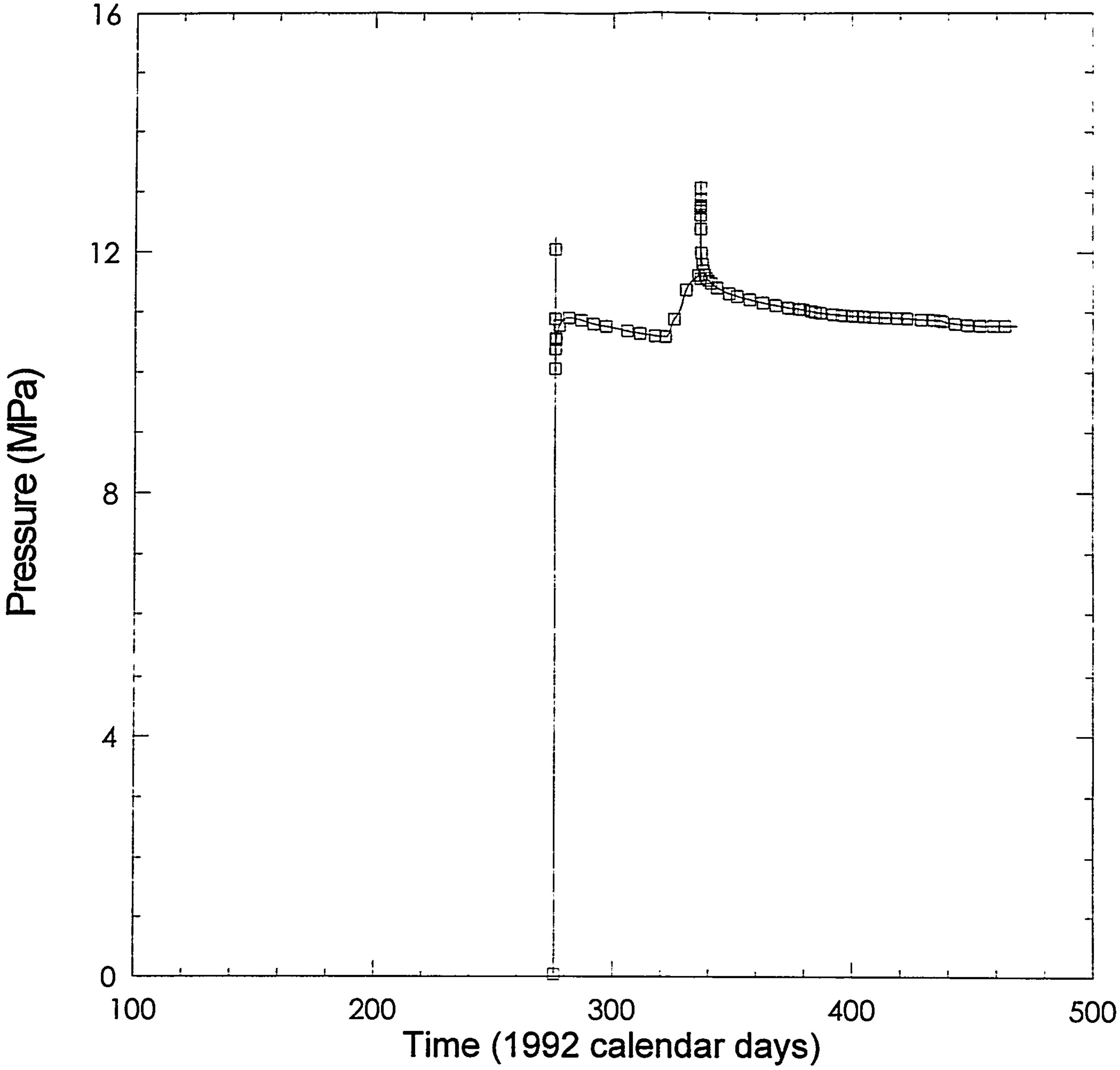

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Figure 4-37. Packer pressure in observation borehole C1X06 during testing sequence C1X05-A.

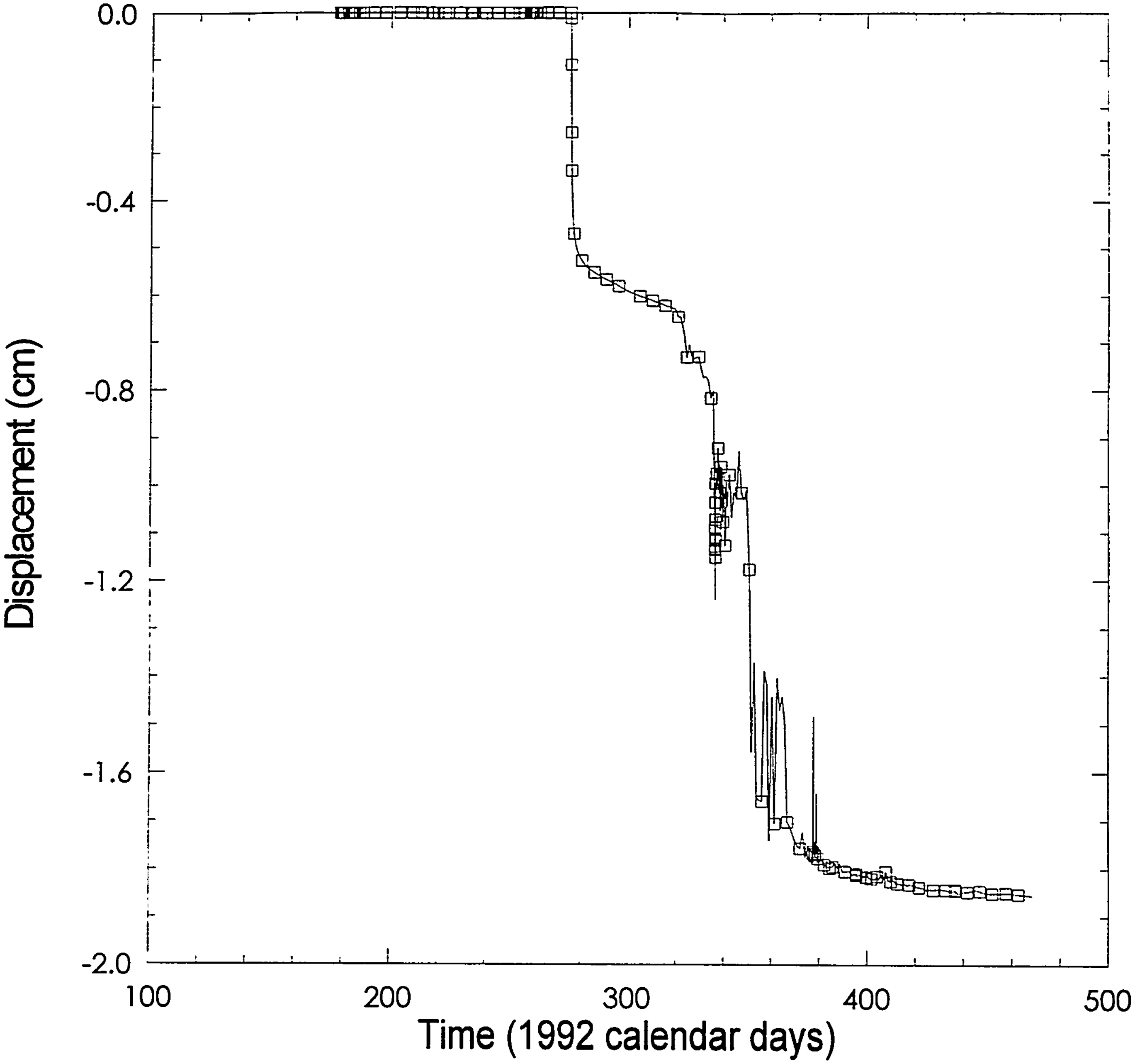

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Figure 4-38. Axial-LVDT displacement in observation borehole C1X06 during testing sequence C1X05-A.

4.6.2.5 OBSERVATION BOREHOLE C1X10, TESTING SEQUENCE C1X05-A

Table 4-17 gives a detailed description of the events that occurred in observation borehole C1X10 during testing sequence C1X05-A.

Table 4-17. Events Associated with Observation Borehole C1X10 During Testing Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Drill borehole C1X10 with 3-inch (7.62-cm) core barrel to 10.16 meters.	11-12-91	316	N/A	14:00:00
Perform video log of borehole C1X10.	11-12-91	316	N/A	15:00:00
Install test tool in borehole C1X10 as indicated in the test-tool configuration diagram (Figure 4-8).	11-12-91	316	N/A	15:30:00
Begin testing sequence C1X10.	11-12-91	316	N/A	16:52:00
Terminate testing sequence C1X10.	6-26-92	178	178	08:18:35
Begin data collection associated with testing sequence C1X05-A.	6-26-92	178	178	13:00:00
Terminate data collection associated with testing sequence C1X05-A.	3-11-93	70	437	10:30:00
Remove monitor tool from borehole C1X10.	3-12-93	71	437	11:30:00

Figure 4-39 illustrates the zone pressure in observation borehole C1X10 for testing sequence C1X05-A. Copies of the video-log associated with testing sequence C1X05-A (borehole C1X10) identified in Table 4-17 are provided in the SWCF under WPO #45907.

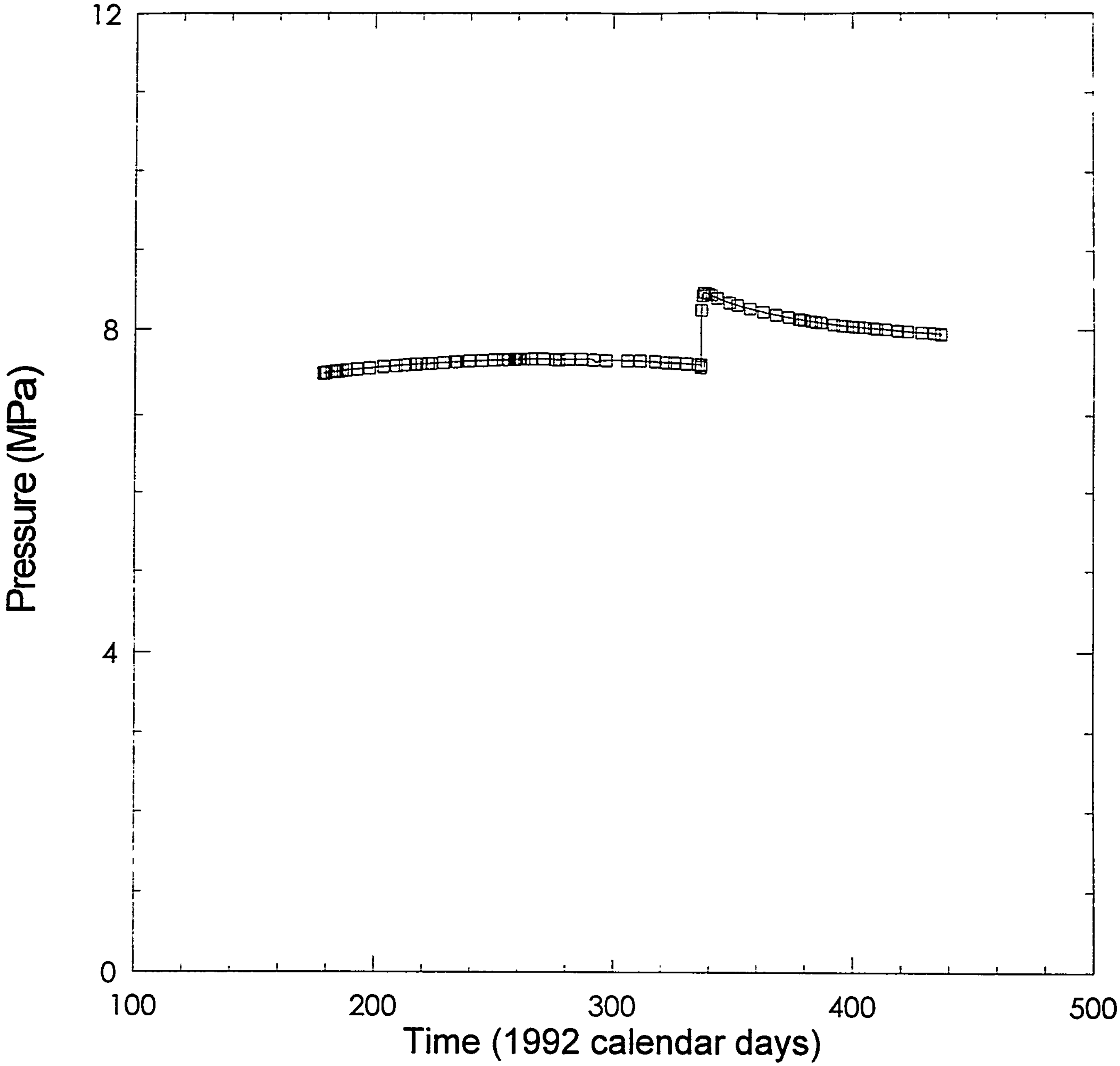

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Figure 4-39. Test-zone pressure in observation borehole C1X10 during testing sequence C1X05-A.

4.6.2.6 OBSERVATION BOREHOLE C2H01, TESTING SEQUENCE C1X05-A

Table 4-18 gives a detailed description of the events that occurred in observation borehole C2H01 during testing sequence C1X05-A.

Table 4-18. Events Associated with Observation Borehole C2H01 During Testing Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Borehole C2H01 drilled to 5.58 meters.	8-4-88	217	N/A	N/A
Begin long-term fluid-pressure monitoring.	8-22-89	234	N/A	N/A
Install single-packer fluid-pressure monitoring tool as indicated in the test-tool configuration diagram (Figure 5-9).	3-13-91	72	N/A	N/A
Begin data collection associated with testing sequence C1X10.	1-29-92	29	29	14:43:00
Terminate data collection associated with testing sequence C1X10.	6-26-92	178	178	08:18:35
Begin data collection associated with testing sequence C1X05-A.	6-26-92	178	178	13:00:00
Terminate data collection associated with testing sequence C1X05-A.	8-3-92	216	216	16:06:00

Figure 4-40 illustrates the zone pressure in observation borehole C2H01 for testing sequence C1X05-A.

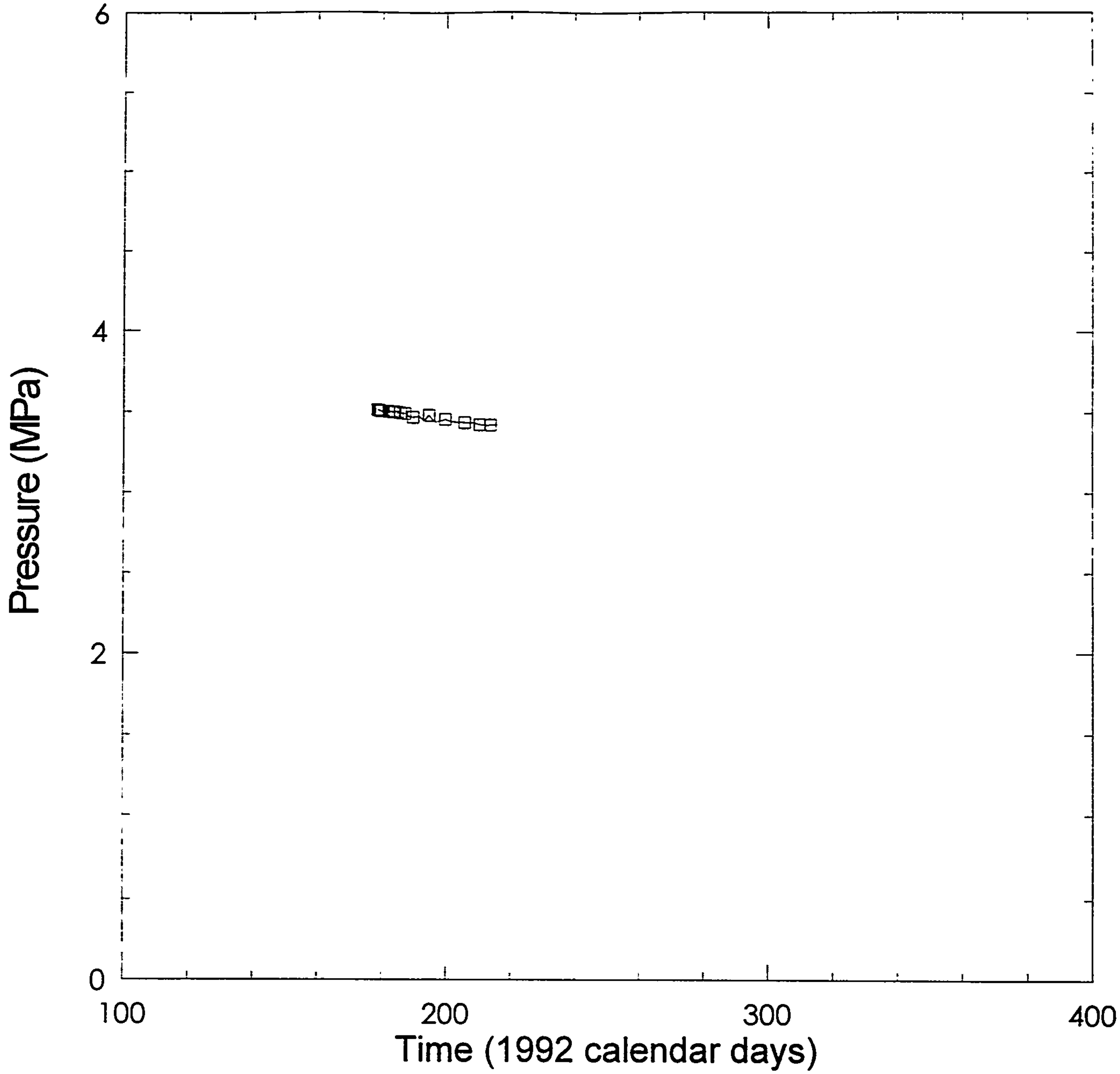

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Figure 4-40. Zone pressure in observation borehole C2H01 during testing sequence C1X05-A.

4.6.3 Borehole C1X05, Testing Sequence C1X05-B

Testing sequence C1X05-B took place in Room C1 in borehole C1X05-B with associated observation boreholes C1H07 and C1X06. This test sequence was designed to investigate the pre- and post-hydrofracture brine permeability of MB140. Table 4-19 gives a detailed description of the events that occurred in test borehole C1X05 during the testing sequence C1X05-B.

Table 4-19. Events Associated with Test Borehole C1X05 During Testing Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Borehole C1X05 drilled with 3-inch (7.62-cm) core barrel to 9.14 meters.	6-29-92	181	N/A	12:00:00
Begin testing sequence C1X05-A.	6-30-92	182	N/A	12:00:00
Terminate testing sequence C1X05-A.	4-7-93	97	97	09:30:43
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 10.62 meters.	6-7-93	158	158	14:25:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 12.04 meters.	6-8-93	159	159	09:20:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 13.51 meters.	6-8-93	159	159	09:50:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 14.94 meters.	6-8-93	159	159	10:20:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 16.33 meters.	6-8-93	159	159	10:45:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 17.78 meters.	6-8-93	159	159	12:45:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 19.19 meters.	6-8-93	159	159	13:05:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 20.68 meters.	6-11-93	162	162	12:30:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 22.10 meters.	6-14-93	165	165	08:25:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 23.44 meters.	6-14-93	165	165	08:51:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 24.92 meters.	6-14-93	165	165	09:35:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 26.34 meters.	6-14-93	165	165	10:30:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 26.59 meters.	6-14-93	165	165	11:20:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 28.09 meters.	6-14-93	165	165	12:30:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 29.54 meters.	6-14-93	165	165	13:05:00
Deepen borehole C1X05 with 3-inch (7.62-cm) core barrel to 30.20 meters.	6-14-93	165	165	13:25:00
Install multipacker test tool in borehole C1X05 as indicated in the test-tool configuration diagram (Figure 4-14).	6-15-93	166	166	12:00:00
Begin data file C1X05B01.	6-15-93	166	166	13:25:20
Increase GZ pressure via accumulator.	6-15-93	166	166	13:28:15
Replace valve on hydrofrac panel.	7-7-93	188	188	11:07:37
Shut in GZ from accumulator.	7-13-93	193	193	10:53:00
Increase TZ1P pressure to ~ 13.8 MPa.	7-15-93	196	196	12:28:51
Increase TZ2P pressure to ~ 11.7 MPa.	7-15-93	196	196	12:32:15
Decreased TZ pressure.	7-15-93	196	196	12:35:25
Remove multipacker test tool for repairs.	7-28-93	209	209	08:23:00

Table 4-19 (Continued). Events Associated with Test Borehole C1X05 During Testing Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Install multipacker test tool to original position.	7-28-93	209	209	14:00:00
End data file C1X05B01.	8-18-93	230	230	12:49:30
Replace gage on GZP.	8-19-93	231	231	09:48:35
Begin data file C1X05B02.	8-19-93	231	231	12:05:02
Remove gage from TZ1.	9-1-93	244	244	10:45:00
End data file C1X05B02.	9-23-93	266	266	04:38:21
Begin data file C1X05B03.	9-23-93	266	266	08:31:50
DAS not functioning properly upon arrival.	10-8-93	281	281	08:08:00
End data file C1X05B03.	10-6-93	292	292	12:23:35
Begin data file C1X05B04.	10-6-93	292	292	12:43:17
Begin constant-pressure-injection test #1 in TZ2 at ~ 1 MPa above TZ2 pressure (~ 10.4 MPa).	10-21-93	294	294	09:29:00
End data file C1X05B04.	10-27-93	300	300	07:38:44
Begin data file C1X05B05.	10-27-93	300	300	08:09:28
Shut in TZ2 from DPT panel terminating constant-pressure-injection test #1 in TZ2.	11-1-93	305	305	09:02:00
DAS not functioning properly upon arrival.	11-8-93	312	312	09:50:00
DAS power supplied by generator.	11-10-93	314	314	09:00:00
End data file C1X05B05.	11-19-93	323	323	12:44:37
Begin data file C1X05B06.	11-19-93	323	323	14:15:00
End data file C1X05B06.	11-22-93	326	326	09:32:21
Begin data file C1X05B07.	11-22-93	326	326	09:35:18
Attempt to perform hydrofracture of MB140 at 22.8 MPa.	11-22-93	326	326	11:20:12
Shut in TZ2.	11-22-93	326	326	11:25:00
Perform hydrofracture of MB140 .	11-22-93	326	326	11:41:06
Shut in TZ2.	11-22-93	326	326	11:45:00
Begin constant-pressure-withdrawal test #1 in TZ2 at ~ 10.3 MPa (~ 650 mL of fluid recovered).	11-22-93	326	326	11:50:46
Shut in TZ2 from DPT panel terminatıng constant-pressure-withdrawal test #1 in TZ2.	11-22-93	326	326	11:58:58
Perform hydrofracture of MB140 (injected ~ 5.7 liters of fluid in TZ2).	11-22-93	326	326	12:04:00
End data file C1X05B07.	11-22-93	326	326	12:42:29
Begin data file C1X05B08.	11-22-93	326	326	14:06:44
Begin constant-pressure-withdrawal test #2 in TZ2 at ~ 10.3 MPa (~5 liters of fluid recovered).	11-22-93	326	326	14:10:40
Shut in TZ2 from DPT panel terminating constant-pressure-withdrawal test #2 in TZ2.	11-22-93	326	326	14:45:00
Perform hydrofracture of MB140.	11-22-93	326	326	15:13:00
Shut in TZ2.	11-22-93	326	326	16:40:00

Table 4-19 (Continued). Events Associated with Test Borehole C1X05 During Testing Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Begin constant-pressure-withdrawal test #3 in TZ2 at ~ 10.3 MPa (~ 1350 mL of fluid recovered).	11-22-93	326	326	16:55:00
Shut in TZ2 from DPT panel terminating constant-pressure-withdrawal test #3 in TZ2.	11-23-93	327	327	08:41:00
Increase packer pressure to 18.3 MPa.	11-23-93	327	327	09:50:00
Perform hydrofracture of MB140 (injected ~8.3 L).	11-23-93	327	327	10:12:35
Shut-in TZ2.	11-23-93	327	327	10:14:20
Drain fluid from TZ2.	11-23-93	327	327	10:21:00
Perform hydro-fracture of MB140 (injected ~ 30.7).	11-23-93	327	327	10:41:30
Shut in TZ2.	11-23-93	327	327	10:47:00
Begin constant-pressure-withdrawal test #4 in TZ2.	11-23-93	327	327	11:42:00
Decrease packer pressure to 15.4 MPa terminating constant-pressure-withdrawal test #4 in TZ2.	11-23-93	327	327	13:30:00
Begin constant-pressure-withdrawal test #5 in TZ2 at ~ 10.0 MPa (~ 13.7 liters of fluid recovered).	11-23-93	327	327	13:44:00
Shut in TZ2 from DPT panel terminating constant-pressure-withdrawal test #5 in TZ2.	11-24-93	328	328	08:30:00
End data file C1X05B08.	12-1-93	335	335	08:26:15
Begin data file C1X05B09.	12-1-93	335	335	08:36:21
End data file C1X05B09.	12-30-93	364	364	07:19:22
Begin data file C1X05B10, C1X05B11, and C1X05B12.	12-30-93	364	364	10:15:56
Begin constant-pressure-injection test #2 in TZ2 at ~ 0.5 MPa above TZ2 pressure (12.2 MPa).	1-10-94	10	375	13:20:00
End data file C1X05B10, C1X05B11, and C1X05B12.	1-13-94	13	378	13:29:22
Begin data file C1X05B13.	1-13-94	13	378	13:32:37
Terminate constant-pressure-injection test #2 in TZ2.	1-20-94	20	385	09:48:00
Begin constant-pressure-injection test #3 in TZ2 at ~ 1 MPa above TZ2 pressure (~ 12.7 MPa).	1-20-94	20	385	09:49:00
Shut in TZ2 from DPT panel terminating constant-pressure-injection test #3 in TZ2.	1-20-94	20	385	13:33:00
End data file C1X05B13.	2-8-94	39	404	11:34:25
Begin data file C1X05B14.	2-8-94	39	404	13:36:36
DAS not functioning properly upon arrival.	2-10-94	41	406	12:35:00
Increase packer pressure.	2-11-94	42	407	12:50:00
Begin constant-pressure-withdrawal test #6 in TZ2 at ~ 0.5 MPa below TZ2 pressure (~ 11.2 MPa).	2-15-94	46	411	09:00:00
DAS not functioning properly upon arrival.	2-17-94	48	413	14:15:00
End data file C1X05B14.	2-18-94	49	414	10:04:23
Begin data file C1X05B15.	2-18-94	49	414	10:07:54
End data file C1X05B15.	2-25-94	56	421	09:34:53
Begin data file C1X05B16.	2-25-94	56	421	13:36:33
Shut in TZ2 from DPT panel terminating constant-pressure-withdrawal test #6 in TZ2.	3-1-94	60	425	11:53:05

Table 4-19 (Continued). Events Associated with Test Borehole C1X05 During Testing Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
DAS not functioning properly upon arrival.	3-3-94	62	427	10:33:00
End data file C1X05B16.	3-15-94	74	439	11:48:09
Begin data file C1X05B17.	3-15-94	74	439	11:53:13
Performed a 11.5 MPa pulse-withdrawal test on TZ2 removing ~ 254 mL of fluid.	3-24-94	83	448	13:04:28
Remove multipacker test tool from borehole C1X05.	4-11-94	101	466	12:00:00
Terminate pulse-withdrawal test in TZ2.	6-7-94	158	523	10:00:00
End data file C1X05B17.	6-7-94	158	523	10:04:17

Figures 4-41 and 4-42 illustrate the zone pressures and fluid production during constant-pressure tests, respectively, in test borehole C1X05 for testing sequence C1X05-B. It should be noted that Figure 4-42 (Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-B) consists of three parts (Figures 4-42a, 4-42b, and 4-42c). Constant-pressure-withdrawal test #'s 3, 4, and 6 are not included due to the short duration of these tests.

Table 4-20 indicates the equipment that was used and the duration that each instrument was used during testing sequence C1X05-B in test borehole C1X05 and in the observation boreholes.

Table 4-20. Testing Sequence C1X05-B Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	6-15-93	6-7-94
DCU (HP3497A)	N/A	2023a01688	6-15-93	9-16-93
DCU (HP3497A)	N/A	2629a22040	9-16-93	2-25-94
DCU (HP3497A)	N/A	2629a22040	2-25-94	6-7-94
Transducer (Druck PDCR 830)	C1H07 TZ1	246909	6-15-93	6-7-94
Transducer (Druck PDCR 910)	C1H07 TZ2	322426	6-15-93	6-7-94
Transducer (Druck PDCR 910)	C1H07 GZ	322424	6-15-93	6-7-94
Transducer (Druck PDCR 830)	C1X05 TZ2	246917	6-15-93	6-7-94
Transducer (Druck PDCR 830)	C1X06 TZ1	246918	8-19-93	6-7-94

Table 4-20 (Continued). Testing Sequence C1X05-B Equipment

Equipment	Location	Serial #	Installed	Removed
Transducer (Druck PDCR 830)	C1X06 TZ2	246916	8-19-93	6-7-94
Transducer (Druck PDCR 10/D)	C1X06 GZ	211691	8-19-93	6-7-94
Transducer (Druck PDCR 10/D)	DPT Panel	211694	10-19-93	3-15-94
LVDT (Trans-Tek 245)	C1X06	A04	8-19-93	6-7-94
Injection Column	N/A	77	10-21-93	10-22-93
Injection Column	N/A	94	10-22-93	11-19-93
Injection Column	N/A	77	11-19-93	11-22-93
Injection Column	N/A	76	11-19-93	11-22-93
Injection Column	N/A	88	11-22-93	12-8-93
Injection Column	N/A	76	1-10-94	3-15-94
Injection Column	N/A	77	1-10-94	3-15-94
DPT (Rosemount 1151DP)	N/A	1389938	10-19-93	11-1-93
DPT (Rosemount 1151DP)	N/A	1140863	11-1-93	3-15-94

* Installed dates for injection columns refer to dates of initial use rather than date installed.

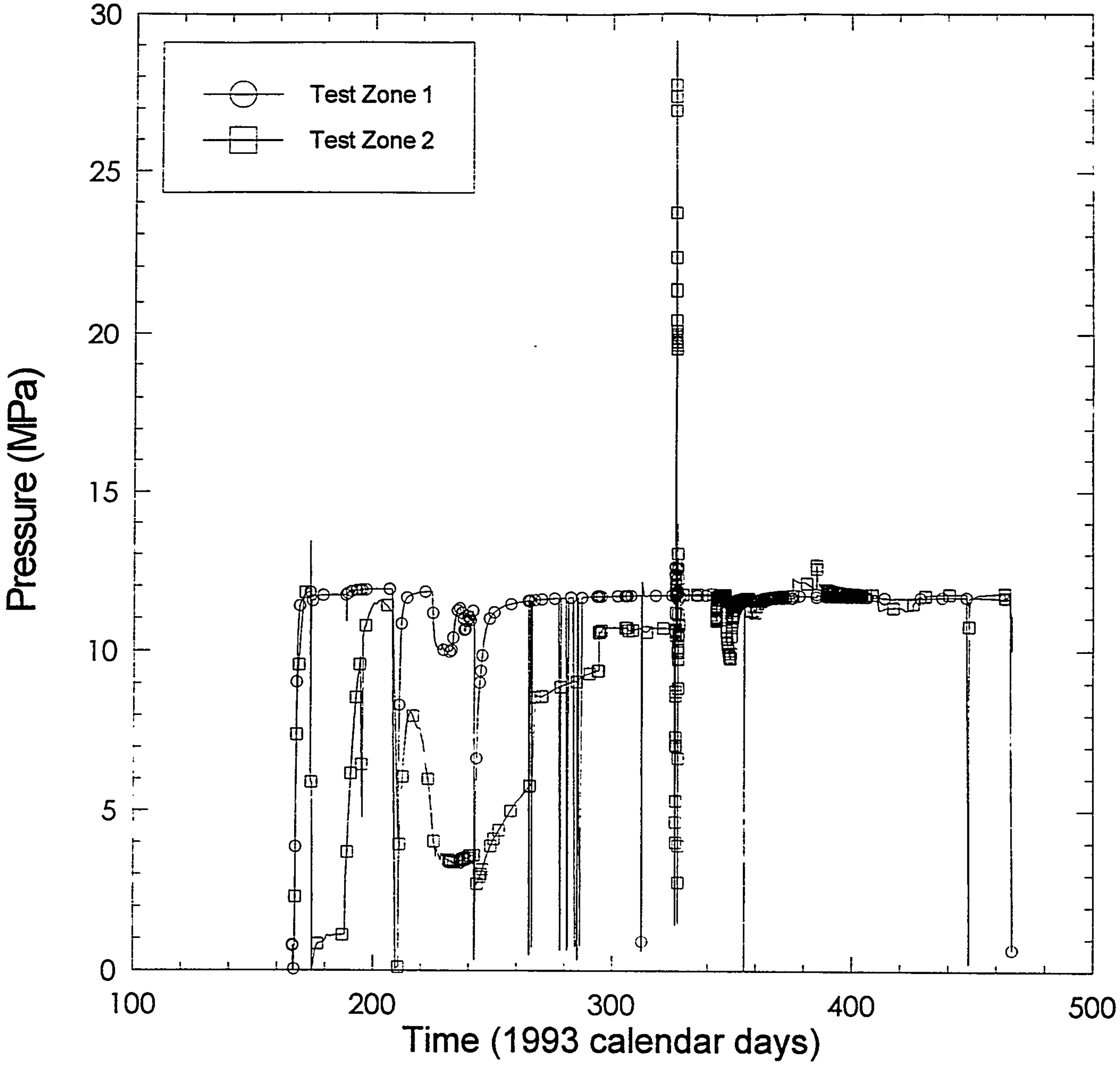

Figure 4-41. Zone pressures in test borehole C1X05 during testing sequence C1X05-B.

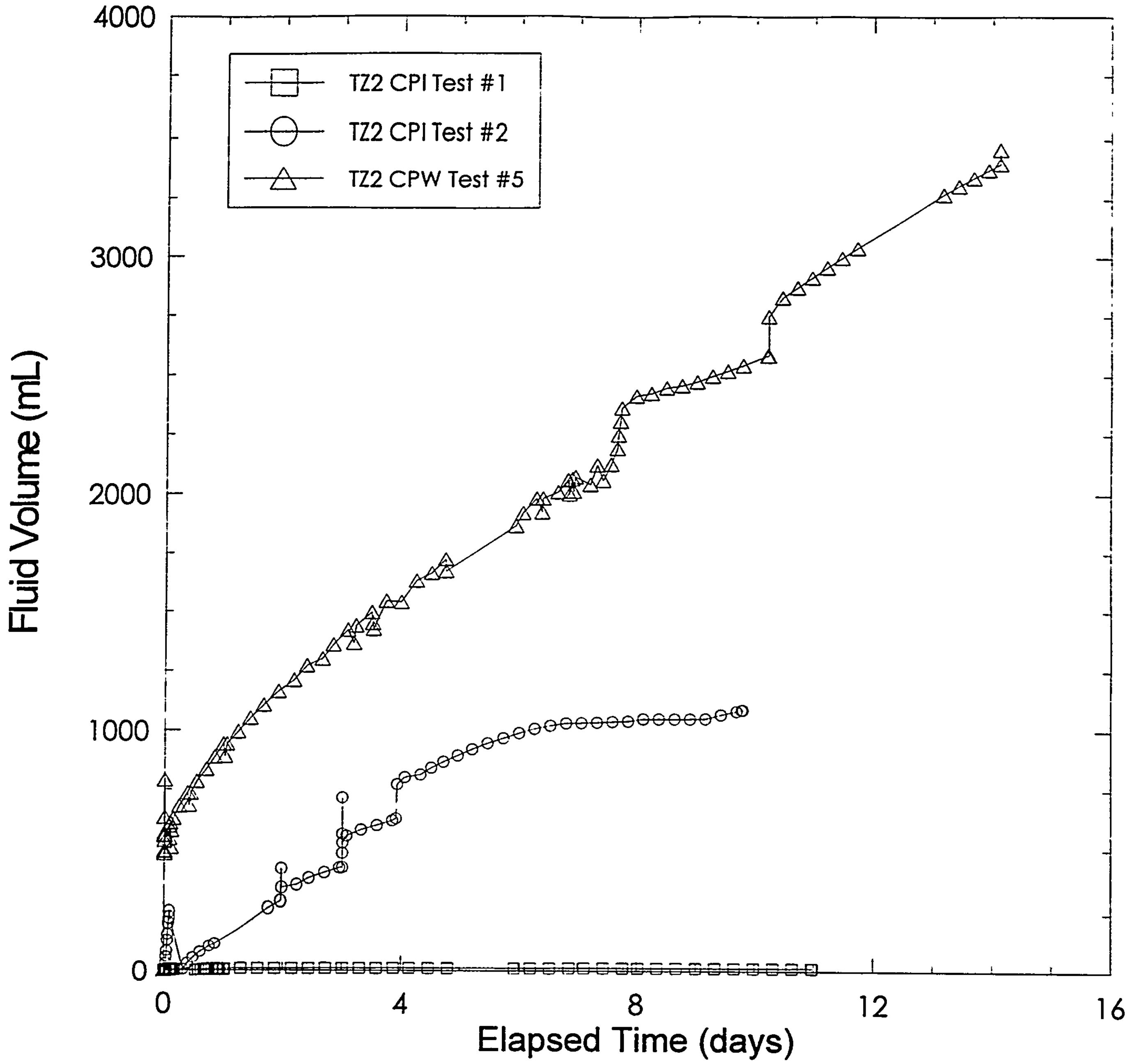

Figure 4-42a. Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-B.

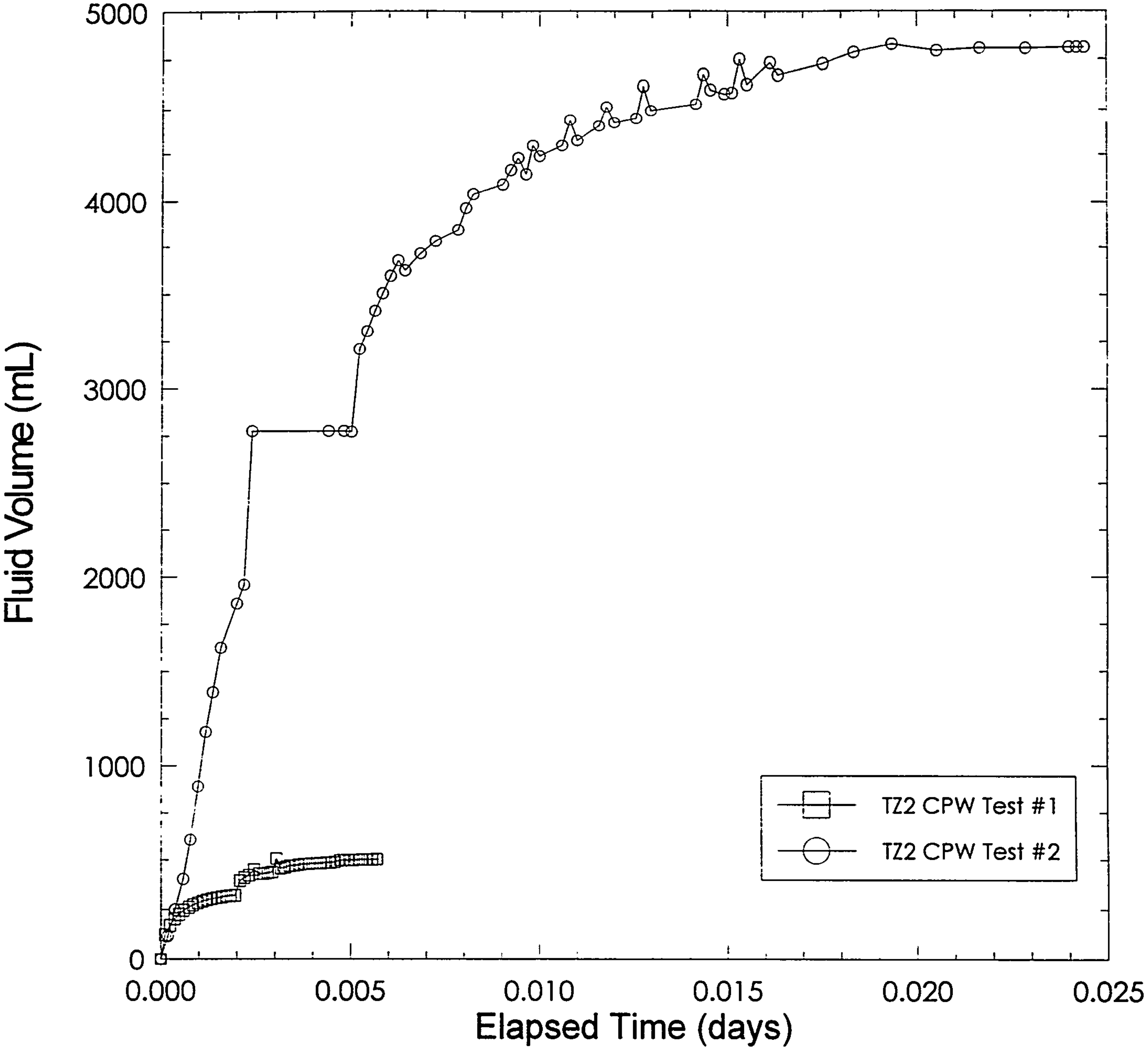

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Figure 4-42b. Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-B (continued).

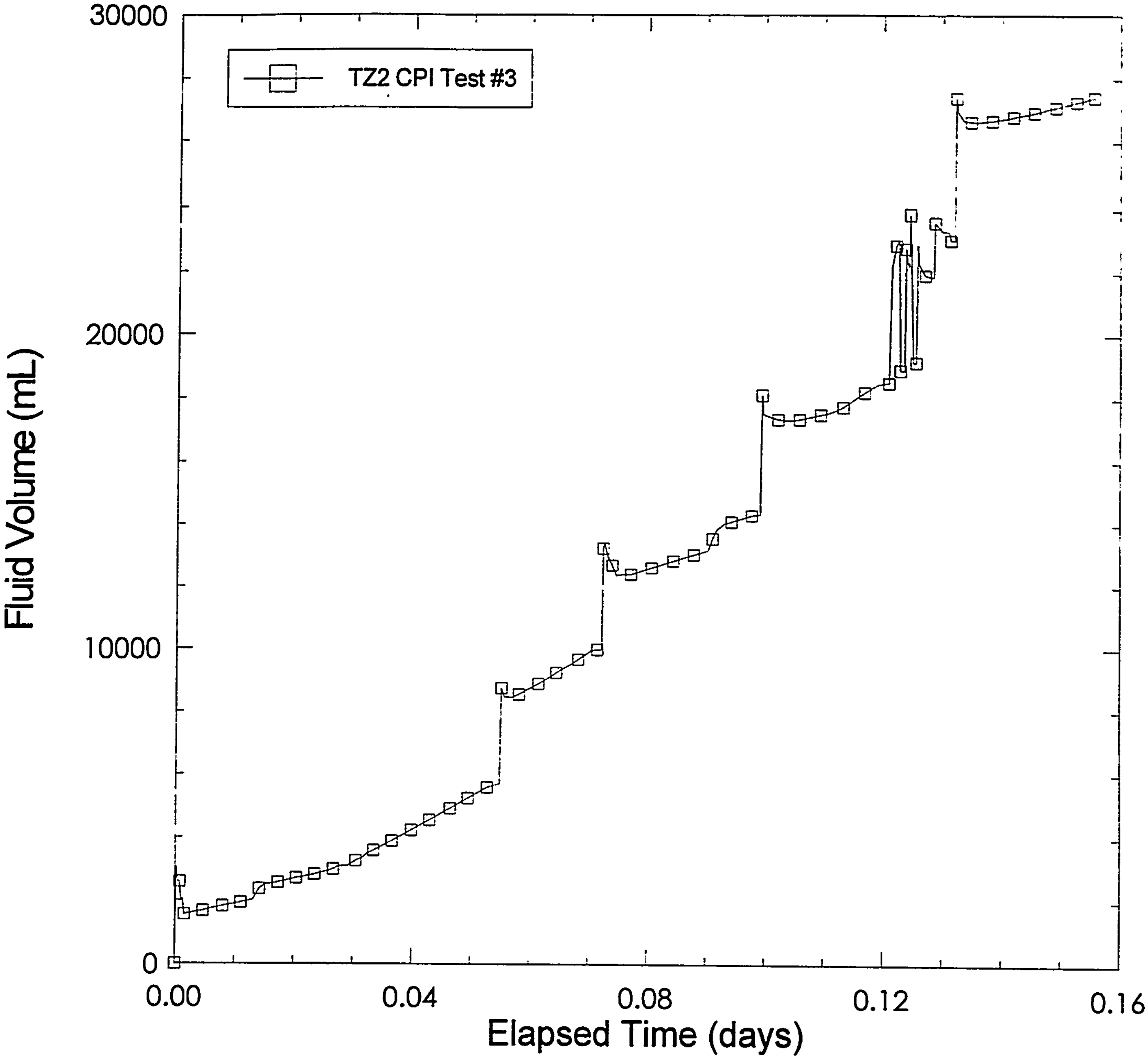

Figure 4-42c. Fluid production during constant-pressure-flow tests in test borehole C1X05 during testing sequence C1X05-B (continued).

4.6.3.1 OBSERVATION BOREHOLE C1H07, TESTING SEQUENCE C1X05-B

Table 4-21 gives a detailed description of the events that occurred in observation borehole C1H07 during testing sequence C1X05-B.

Table 4-21. Events Associated with Observation Borehole C1H07 During Testing Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Drill borehole C1H07-A with 4-inch (10.16-cm) core barrel to 8.18 meters.	6-24-92	176	N/A	13:25:00
Begin fluid-pressure monitoring associated with testing sequence C1X05-A.	6-26-92	178	N/A	13:05:00
Terminate fluid-pressure monitoring associated with testing sequence C1X05-A.	4-7-93	97	97	09:30:43
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 9.37 meters.	5-21-93	141	141	11:05:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 10.58 meters.	5-21-93	141	141	12:45:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 12.05 meters.	5-21-93	141	141	13:25:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 13.58 meters.	5-21-93	141	141	14:45:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 14.99 meters.	5-24-93	144	144	10:35:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 16.52 meters.	5-24-93	144	144	13:30:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 17.52 meters.	5-24-93	144	144	14:30:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 18.73 meters.	5-25-93	145	145	09:30:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 20.51 meters.	5-25-93	145	145	10:05:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 22.04 meters.	5-25-93	145	145	10:25:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 23.55 meters.	5-25-93	145	145	13:00:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 25.09 meters.	5-25-93	145	145	14:00:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 26.05 meters.	5-25-93	145	145	14:40:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 27.21 meters.	5-26-93	146	146	09:25:00
Deepen borehole C1H07 with 4-inch (10.16-cm) core barrel to ~ 27.88 meters.	5-26-93	146	146	09:45:00
Install multipacker test tool #39 in borehole C1H07 as indicated in the test-tool configuration diagram #1 (Figure 4-15).	5-28-93	148	148	14:14:00
Begin data file C1H07B01.	5-28-93	148	148	14:14:16
Add ~ 8 liters of brine to borehole C1H07.	5-28-93	148	148	14:31:19
Inflate TZ1P to ~ 10 MPa.	5-28-93	148	148	14:32:49
Inflate TZ2P to ~ 10 MPa.	5-28-93	148	148	14:36:49
Inflate GZP to ~ 10 MPa.	5-28-93	148	148	14:38:19
Shut in all zones.	5-28-93	148	148	14:40:49
DAS not functioning properly upon arrival.	6-11-93	162	162	08:51:00
End data file C1H07B01.	6-15-93	166	166	11:16:48
Replace gage on GZP.	9-7-93	250	250	09:59:00
Inflate GZP to ~ 8.3 MPa.	9-7-93	250	250	10:15:00
Increase GZ pressure to ~ 3.6 MPa.	9-7-93	250	250	10:22:00

Table 4-21 (Continued). Events Associated with Observation Borehole C1H07 During Testing Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Increase GZP pressure to ~ 8.3 MPa.	9-22-93	265	265	12:07:35
Increase TZ2P pressure to ~ 11.7 MPa.	9-22-93	265	265	12:12:20
Increase TZ1P pressure to ~ 14.5 MPa.	9-22-93	265	265	12:16:59
Increase TZ1P pressure to ~ 15 MPa.	11-2-93	306	306	09:45:00
Power outage.	11-8-93	312	312	09:34:00
DAS powered by generator.	11-10-93	314	314	08:47:00
Open TZ2P to accumulator at ~ 10.3 MPa.	12-1-93	335	335	11:44:30
Shut in all zones from accumulators and depressurized.	12-9-93	343	343	09:30:00
Deflate all packers.	12-9-93	343	343	09:50:00
Partially remove test tool #39 from borehole C1H07 and repaired leaky fitting on TZ1 and returned test tool #39 to original position in borehole C1H07.	12-9-93	343	343	10:46:00
Replace gage on TZ2.	12-9-93	343	343	11:12:00
Inflate TZ1P to ~ 15.9 MPa.	12-9-93	343	343	11:58:00
Inflate TZ2P to ~ 15.9 MPa.	12-9-93	343	343	12:19:00
Inflate GZP to ~ 15.9 MPa.	12-9-93	343	343	12:28:00
Increase TZ1 pressure to ~ 11.5 MPa.	12-9-93	343	343	12:40:00
Increase GZ pressure to ~ 8.5 MPa.	12-9-93	343	343	12:53:00
TZ2 will not hold pressure.	12-9-93	343	343	13:00:00
Increase TZ1 pressure to 11.660 MPa.	12-9-93	343	343	13:20:00
Depressurize all zones.	12-13-93	347	347	09:31:30
Deflate all packers.	12-13-93	347	347	09:35:00
Remove test tool #39 from borehole C1H07 in order to find and repair the leak in the TZ2.	12-13-93	347	347	12:00:00
Test all lines for leaks.	12-14-93	348	348	10:05:00
Install test tool #39 in borehole C1H07 as indicated in the test tool configuration diagram #2 (Figure 4-16).	12-15-93	349	349	11:30:00
Inflate TZ1P to ~ 15 MPa.	12-15-93	349	349	11:55:00
Inflate TZ2P to ~ 15 MPa.	12-15-93	349	349	11:57:00
Inflate GZP to ~ 15 MPa.	12-15-93	349	349	12:14:00
Increase TZ1 pressure to ~ 11.5 MPa.	12-15-93	349	349	12:18:00
Increase TZ2 pressure to ~ 8.5 MPa.	12-15-93	349	349	12:23:00
Increase TZ2 pressure to ~ 8.5 MPa.	12-15-93	349	349	12:27:00
Increase GZ pressure to ~ 8.5 MPa.	12-15-93	349	349	12:32:00
Leaky fitting on GZ gage.	12-16-93	350	350	08:42:00
Increase GZ pressure to ~ 8.5 MPa.	12-16-93	350	350	08:48:00
Increase TZ2 pressure to ~ 8.5 MPa.	12-16-93	350	350	08:50:00
Increase TZ2P pressure to ~ 15 MPa.	12-16-93	350	350	08:56:00

Table 4-21 (Continued). Events Associated with Observation Borehole C1H07 During Testing Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Open TZ2 and GZ to accumulator at ~ 8.5 MPa.	12-20-93	354	354	10:29:00
Leaky fitting on GZP gage.	12-21-93	355	355	08:51:00
Leaks on both TZ1, TZ2, and TZ2P.	12-22-93	356	356	09:17:00
Replace gage on TZ1.	12-28-93	362	362	08:56:00
Shut in TZ2 and GZ from accumulator.	12-28-93	362	362	09:07:00
Replace all zone gages with plugs to avoid any further leaks.	12-31-93	365	365	09:29:00
Open GZ to accumulator at ~ 7.5 MPa.	1-6-94	6	371	12:26:00
DAS not functioning properly upon arrival.	2-10-94	41	406	12:35:00
DAS not functioning properly upon arrival.	2-17-94	48	413	14:15:00
Terminate data collection associated with testing sequence C1X05-B.	6-7-94	158	523	10:00:00
Remove multipacker test tool #39 from borehole C1H07.	6-8-94	159	524	13:50:00

Figure 4-43 illustrates the zone pressures in observation borehole C1H07 for testing sequence C1X05-B.

Table 4-22 indicates the equipment that was used and the duration that each instrument was used in observation borehole C1H07 during testing sequence C1X05-B.

Table 4-22. Borehole C1H07 Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	5-28-93	6-15-93
DCU (HP3497A)	N/A	2023a01688	5-28-93	6-15-93
Transducer (Druck PDCR 830)	Test Zone 1	246909	5-28-93	6-15-93
Transducer (Druck PDCR 830)	Test Zone 1 Packer	246918	5-28-93	6-15-93
Transducer (Druck PDCR 910)	Test Zone 2	322426	5-28-93	6-15-93
Transducer (Druck PDCR 830)	Test Zone 2 Packer	246917	5-28-93	6-15-93
Transducer (Druck PDCR 910)	Guard Zone	322424	5-28-93	6-15-93
Transducer (Druck PDCR 10/D)	Guard Zone Packer	211691	5-28-93	6-15-93

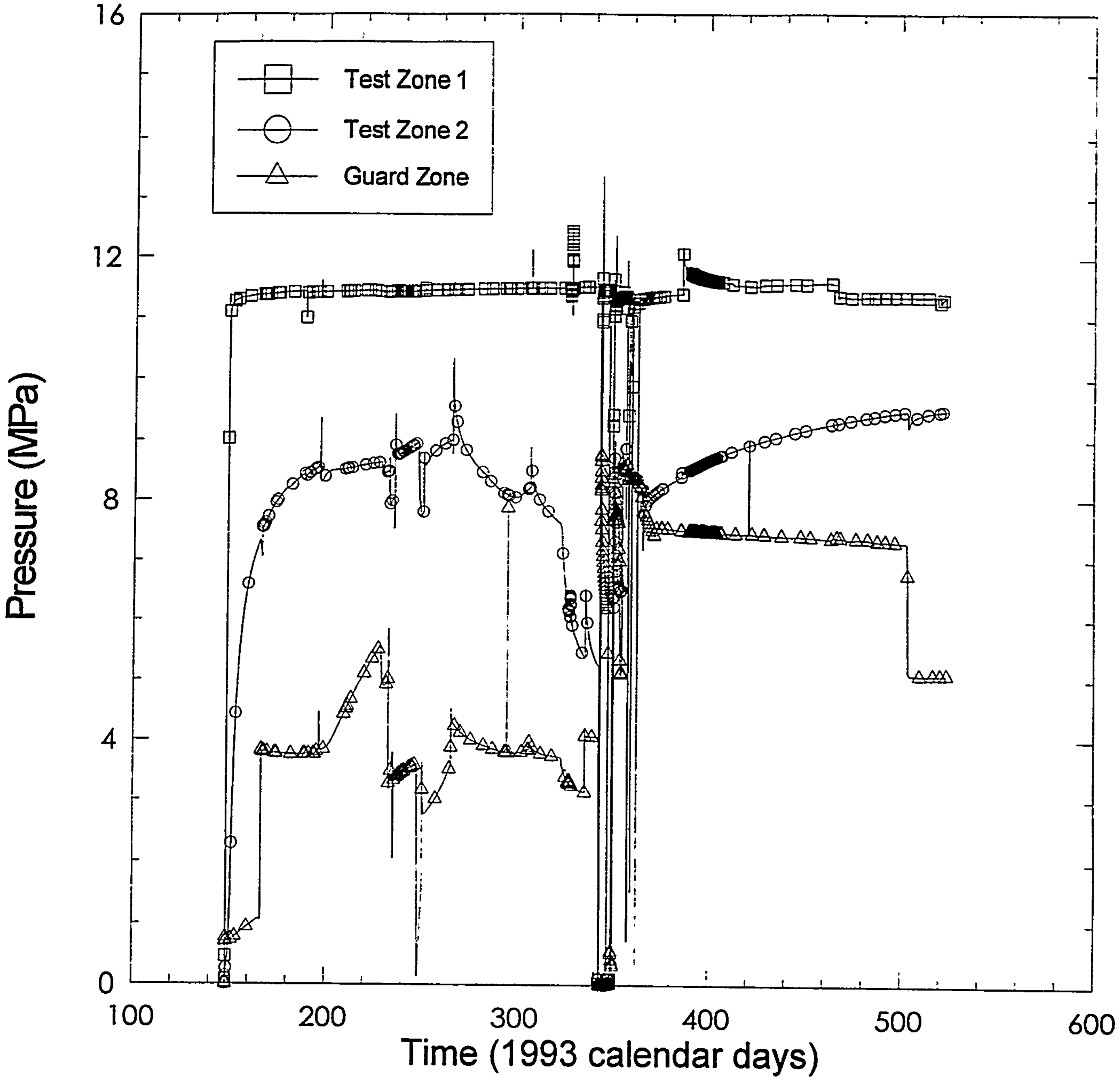

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Figure 4-43. Zone pressures in observation borehole C1H07 during testing sequence C1X05-B.

4.6.3.2 OBSERVATION BOREHOLE C1X06, TESTING SEQUENCE C1X05-B

Table 4-23 gives a detailed description of the events that occurred in observation borehole C1X06 during testing sequence C1X05-B.

Table 4-23. Events Associated with Observation Borehole C1X06 During Testing Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Drill borehole C1X06 with 4-inch core barrel to 7.63 meters.	9-30-92	274	N/A	10:00:00
Begin fluid-pressure monitoring associated with testing sequence C1X05-A.	10-1-92	275	N/A	11:00:00
Terminate fluid-pressure monitoring associated with testing sequence C1X05-A.	4-7-93	97	97	09:30:43
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 9.130 meters.	7-7-93	188	188	13:07:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 10.65 meters.	7-7-93	188	188	14:22:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 12.15 meters.	7-8-93	189	189	09:35:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 13.65 meters.	7-8-93	189	189	10:15:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 15.17 meters.	7-8-93	189	189	10:45:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 16.67 meters.	7-8-93	189	189	12:45:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 18.20 meters.	7-8-93	189	189	13:30:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 19.94 meters.	7-9-93	190	190	09:10:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 21.21 meters.	7-9-93	190	190	10:00:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 22.79 meters.	7-9-93	190	190	11:00:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 24.27 meters.	7-9-93	190	190	14:20:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 25.84 meters.	8-12-93	224	224	11:30:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 27.34 meters.	8-12-93	224	224	12:55:00
Deepen borehole C1X06 with 4-inch (10.16-cm) core barrel to 27.99 meters.	8-12-93	224	224	13:15:00
Install multipacker test tool #40 in borehole C1X06 as indicated in the test-tool configuration diagram (Figure 4-17).	8-19-93	231	231	12:00:00
Begin data collection associated with testing sequence C1X05-B.	8-19-93	231	231	12:05:02
Inflate TZ1P to ~ 12.4 MPa.	8-19-93	231	231	12:15:56
Inflate TZ2P to ~ 12.4 MPa.	8-19-93	231	231	12:29:26
Inflate GZP to ~ 12.4 MPa.	8-19-93	231	231	12:38:27
Shut in all zones.	8-19-93	231	231	12:40:41
Vented gas from all zones.	8-20-93	232	232	12:26:37
Increase TZ2P pressure and shut in TZ2.	8-20-93	232	232	12:38:27
Increase GZP pressure.	8-20-93	232	232	12:43:38
Replace gage on GZ.	8-23-93	235	235	08:57:13
Increase TZ1P pressure.	8-23-93	235	235	09:09:32
Suspect TZ2P is leaking into TZ2.	8-25-93	237	237	08:18:00
Depressurize all zones.	8-25-93	237	237	08:23:00

Table 4-23 (Continued). Events Associated with Observation Borehole C1X06 During Testing Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Deflate all packers.	8-25-93	237	237	08:29:38
Removed multipacker test tool #40 from borehole C1X06 and repair leaky fitting and re-install the test tool to original position with LVDT not connected.	8-25-93	237	237	13:22:00
Inflate GZP to ~ 12.4 MPa.	8-25-93	237	237	13:26:55
Inflate TZ2P to ~ 12.4 MPa.	8-25-93	237	237	13:30:17
Inflate TZ1P to ~ 12.4 MPa.	8-25-93	237	237	13:35:18
Shut in all zones.	8-25-93	237	237	13:38:30
Leak in TZ1 injection line.	8-27-93	239	239	11:34:06
Leaky fitting on TZ2P.	8-27-93	239	239	11:44:47
Vent gas from TZ2.	9-7-93	250	250	09:50:00
Increase TZ2 pressure to ~ 4 MPa.	9-7-93	250	250	09:58:00
Replace gage on TZ2.	9-14-93	257	257	11:02:20
Increase TZ2 pressure to ~ 3.4 MPa.	9-14-93	257	257	11:34:00
Opened GZ to accumulator at 4.233 MPa.	9-22-93	265	265	11:18:00
Increase TZ2 pressure via accumulator.	9-24-93	267	267	09:55:55
Shut in TZ2 from accumulator.	9-27-93	270	270	08:50:00
Replace gage on TZ2.	9-28-93	271	271	12:46:00
Open GZ to accumulator.	9-28-93	271	271	12:50:00
Shut in GZ from accumulator.	10-4-93	277	277	09:21:00
Power outage.	11-8-93	312	312	09:34:00
DAS powered by generator.	11-10-93	314	314	08:47:00
No power supplied to transducers.	1-7-94	7	372	08:46:00
DAS not functioning properly upon arrival.	2-10-94	41	406	12:35:00
DAS not functioning properly upon arrival.	2-17-94	48	413	14:15:00
Initiate pulse-withdrawal test on TZ1 dropping the pressure from 11.747 to 7.680 MPa and removing ~ 113 mL of fluid.	4-8-94	98	463	12:29:26
Terminate data collection associated with testing sequence C1X05-B.	6-7-94	158	523	10:00:0
Remove multi-packer test tool #40 from borehole C1X06.	6-9-94	160	525	14:00:00

Figures 4-44 and 4-45 illustrate the zone pressures and axial-LVDT displacement, respectively, in observation borehole C1X06 for testing sequence C1X05-B.

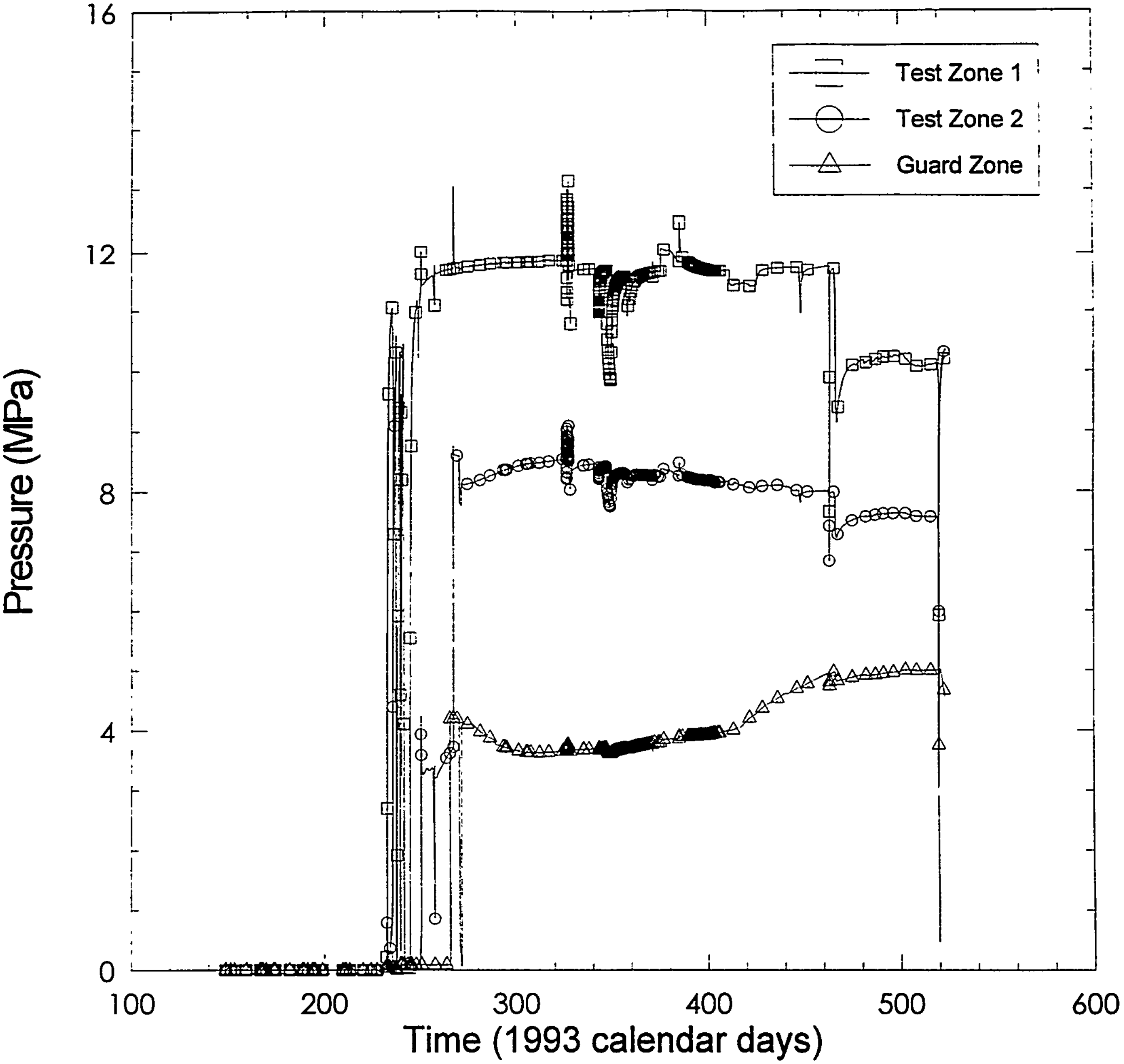

Figure 4-44. Zone pressures in observation borehole C1X06 during testing sequence C1X05-B.

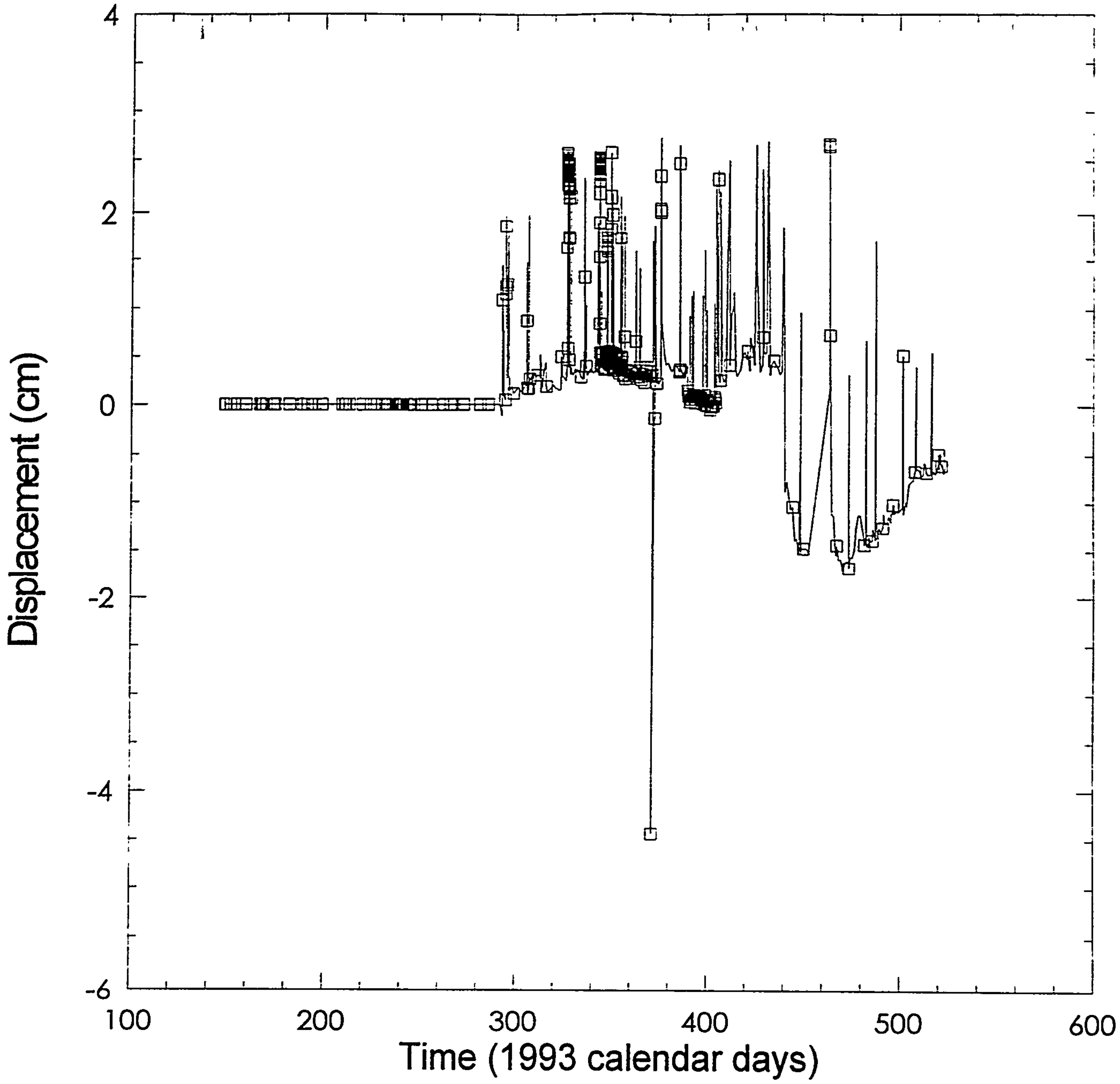

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Figure 4-45. Axial-LVDT displacement in observation borehole C1X06 during testing sequence C1X05-B.

5. GAS-THRESHOLD-PRESSURE TESTING

Post-closure degradation of the organic and metallic material included in the radioactive waste scheduled for burial in the WIPP underground repository is expected to generate gas in quantities potentially sufficient to pressurize the waste/backfill continuum in the underground rooms and drifts to lithostatic pressure (Lappin et al., 1989). Excessive gas pressure could cause fracturing of the formation surrounding the repository unless the generated gas can flow into the surrounding Salado Formation. Gas-threshold-pressure tests (GTPTs), were intended to provide estimates of the pressure at which Salado Formation anhydrite interbeds would allow initial penetration of the gas generated in the repository.

5.1 Test Objectives

The GTPT program in the WIPP underground facility was originally designed with the following objectives:

- to provide information about the far-field gas-threshold pressure in the Salado Formation anhydrite interbeds, particularly Marker Beds 138 and 139;
- to determine, if possible, the far-field gas-threshold pressure in both argillaceous and pure halite beds of the Salado Formation;
- to determine if the gas-threshold pressure varies with distance from the excavation in the WIPP underground facility;
- to determine if the gas-threshold pressure is related to formation permeability; and
- to determine if there will be sustained gas flow into the formation after gas-threshold pressure is reached, and at what rate and what pressure will the gas flow.

No tests of halite strata were ever performed to address the second objective because of concerns that the rock would fracture before accepting gas. The testing program was terminated before the third objective could be met.

5.2 Test Design

The GTPT sequences discussed in this data report were conducted in three boreholes drilled at three locations in the WIPP underground facility (Figure 2-1) and described in Section 5.5. The boreholes were drilled either angled downward or angled upward from the underground rooms. In the experimental area, borehole C2H02 was drilled in Room C2 and L4P52 was drilled in Room L4. In the operations area, borehole SCP01 was drilled in the Core Storage Library. The test boreholes were chosen to allow evaluation of gas-threshold pressures in the Salado Formation interbeds in locations (room pillars) where excavation induced damage was expected to be minimal.

All of the boreholes tested in the GTPT program had previously undergone permeability testing. In boreholes SCP01 and C2H02, long-term fluid-pressure monitoring tools were replaced by multipacker test tools configured for GTPT sequences. In borehole L4P52, the test tool used for permeability testing was used for the GTPT sequence. The multipacker test tools (see Section 5.3.1) were installed in each borehole in such a way that the packers isolated a bottom-hole test zone and a guard zone between the two packers. The zones were filled with 1.22 kg/L sodium-chloride brine. The guard zones were used to detect pressure leakage from the bottom-hole test zone transmitted either through the test tool or through the formation and to reduce the pressure gradient across the test-zone packer. After packer inflation, the zones were shut in and the fluid- pressure buildup was monitored with pressure transducers and recorded on a computer controlled DAS. As fluid pressures stabilized, gas/brine exchanges were performed in the test zones (see Section 5.4). After completing the gas/brine exchange, the GTPT sequences were performed on the isolated, bottom-hole test zones as described in Section 5.4.

A pulse-withdrawal test was performed as part of the GTPT sequence in borehole C2H02 to provide data with which to estimate the compressibility of the zone being tested, formation hydraulic conductivity to brine, and brine pore pressure.

Figure 5-1 illustrates the stratigraphic position of each of the test and observation boreholes and shows which strata were included in the test intervals. Borehole C2H01 was used as an observation borehole during testing sequence C2H02.

5.3 Test Equipment for Gas Threshold-Pressure Testing

The following sections briefly describe the equipment used in the GTPT program in the WIPP underground facility. The equipment includes multipacker test tools, data-acquisition systems, pressure transducers, thermocouples, linear variable-differential transformers, a differential-pressure-transmitter panel, and a flow-control device. Section 5.3.2 discusses calibration of GTPT specific equipment. Calibration of other equipment is discussed in Section 3.3.2.

5.3.1 Description of Equipment

5.3.1.1 MULTIPACKER TEST TOOLS

Three types of multipacker test tools were used for this testing program. The first type of test tool, which was used in sequences SCP01-1, L4P52-B, and C2H02, was the double-packer tool described in Section 3.3.1.1 and illustrated in Figure 3-2. The second type of test tool, which was also used in sequence SCP01-1, had the same overall configuration as the first type of test tool except that inflatable elements constructed of hard rubber by TAM International were used in place of the soft rubber elements manufactured by Baski, Inc. TAM elements were used to try to avoid pressure bypass around the packers as was suspected with the first type of test tool in sequence SCP01-1. The third type of test tool, which was used in sequence SCP01-2, had two sliding end, 3.5-inch (8.9-cm) O.D.

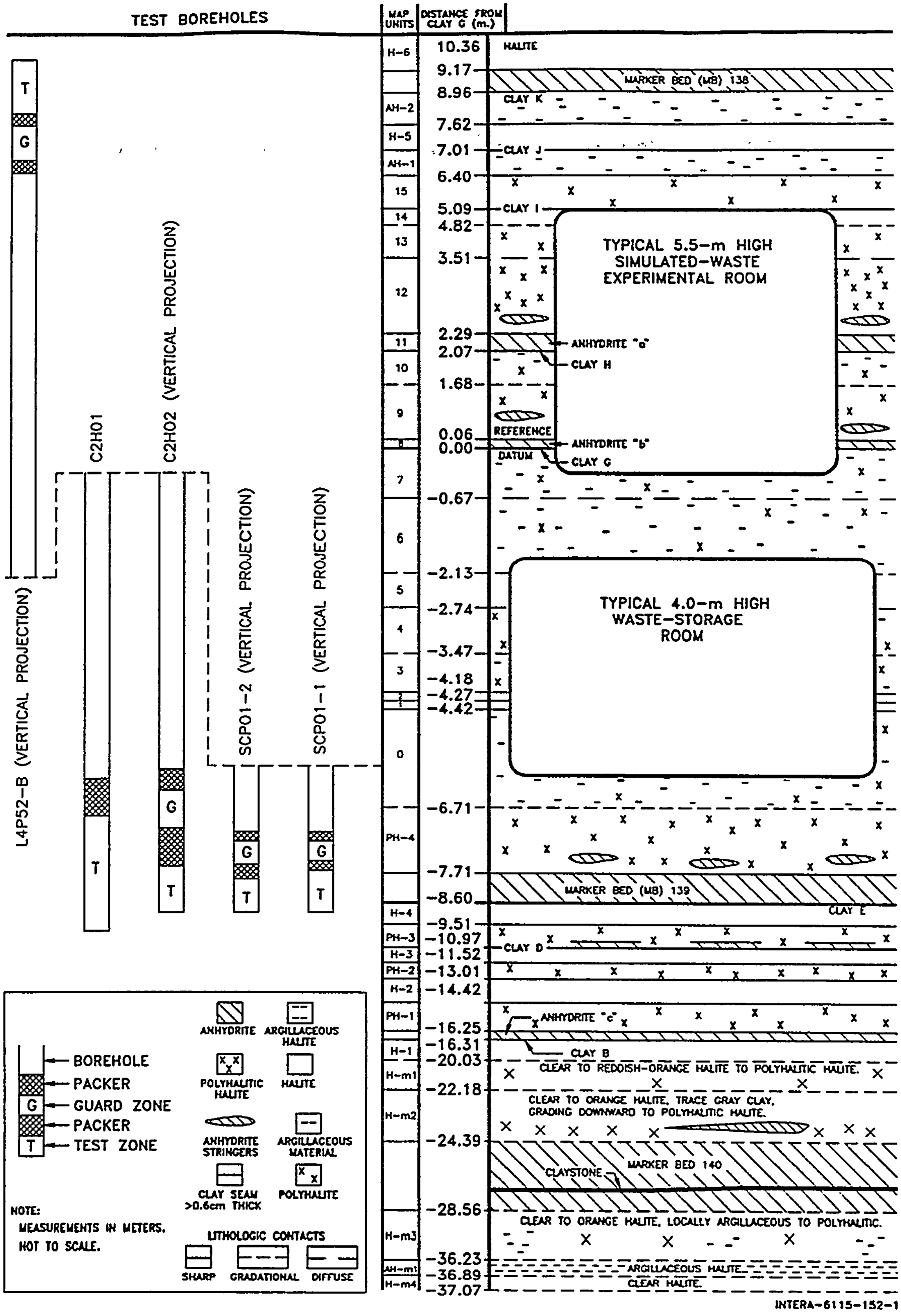

Figure 5-1. Stratigraphic positions of GTPT boreholes with test zones indicated.

inflatable packers manufactured by Baker Oil Tools mounted on a 2.4-inch (6.1-cm) O.D. mandrel oriented with the packers' fixed ends toward the bottom-hole end of the test-tool. The packers have 66-inch (1.7-m) long inflatable elastic elements also composed of natural rubber and synthetic materials. The packer elements have approximately 51-inch (1.3-m) seal lengths when inflated in 4-inch (10.2-cm) diameter boreholes. In all cases, a set of radially oriented tapered jaws or slips that tighten on the test tool mandrel as the tool attempts to move out of the borehole in response to pressure buildup were used to restrain the test tool.

Each multipacker test tool was equipped with three sets of ports to the bottom-hole test zone and the guard zone between the packers. One set of ports was used to transmit pressures from the test and guard zones to the transducers, which were mounted outside of the boreholes. A second set of ports was used to dissipate "squeeze" pressures created during packer inflation and to vent fluid from the isolated intervals to decrease pressure. These two sets of ports were accessed by continuous lengths of 3/16-inch (0.48-cm) O.D. stainless-steel tubing. In some cases (GTPT sequences SCP01-1, C2H02, and L4P52-B), the third set of ports provided access for 1/8-inch (0.32-cm) diameter Type E thermocouples to measure temperatures in the test and guard zones. Packer-inflation pressures were monitored with transducers attached to the packer-inflation lines. Other information regarding the test tools is presented in Section 3.3.1.1.

5.3.1.2 DATA-ACQUISITION SYSTEM (DAS)

A computer-controlled data-acquisition system (DAS) was used to monitor the progress of each test and recorded pressure, in some cases temperature, and in some cases radial borehole closure and axial tool movement (Figure 3-8). Each DAS consisted of an IBM compatible desktop computer for system control and data storage, a Hewlett Packard (HP) 3497A and/or 75000 Data-Acquisition/Control Unit containing power supplies to excite the instruments associated with a given test (transducers, thermocouples, differential-pressure transmitters (DPTs, and LVDTs), a signal scanner to switch and read channels, a 5-1/2 digit voltmeter to measure the output from the instruments associated with a given test (transducers, thermocouples, DPTs, and LVDTs), and an Elgar Model 6000B uninteruptable power supply. The HP-75000 was used only with Labtech (version 4.1.0) data acquisition software. The HP-3497A was used on all other tests in which PERM data acquisition software was used (PERM4F). The data-acquisition software allowed sampling of the instrument output signals at user-specified time intervals ranging from approximately 10 seconds to several days. As data were acquired, they were stored both on the computer's hard disk and on a 3.5-inch diskette. Real-time listing of the data on an auxiliary printer and monitor and/or printer plots of the accumulated data were also possible.

5.3.1.3 MASS FLOW METER

A Bronkhorst Model F-230C-FA-22-V mass flow meter with a high-pressure nitrogen reservoir as the gas source was used to provide constant gas-injection rates during the gas-threshold-pressure testing. This DAS-controlled mass flow meter allowed a constant gas-injection rate of 0 to 5 mL/min to be maintained. The gas injection system used in all of the tests is shown in Figure 5-2. The DAS, pressure transducers, thermocouples, DPT panel, and pressure-maintenance system used for the GTPT program are described in Section 3.3.1.

5.3.2 Equipment Calibration

5.3.2.1 DATA-ACQUISITION SYSTEM (DAS)

The DAS equipment and associated software were tested prior to the start of the GTPT program to ensure proper operation. The procedure consisted of testing the response of the HP-3497A or HP-75000 Data-Acquisition/Control Units (DCU) and the DAS software using known input signals to ensure proper signal conversion. The PERM4F DAS software use in conjunction with the HP-3497A DCU was designed and tested by SNL and INTERA Inc. The Labtech 4.1.0 DAS software use in conjunction with the HP-75000 DCU was commercially available software. The DAS software was baselined and controlled in accordance with the SNL approved INTERA WIPP Quality Assurance Manual. In addition, the HP-3497A and HP-75000 DC voltmeter options were calibrated by SNL WIPP calibration laboratory using WIPP Procedure 182 and 427, respectively.

5.3.2.2 MASS FLOW METER

The Bronkhorst Model F-230C-FA-22-V mass flow meter was calibrated by the SNL calibration laboratory in Albuquerque, NM. No sensitivity values were generated for the instrument as it operated from an input voltage actuating a valve that allowed the desired flow rate to be produced. Flow rates were verified by the SNL calibration laboratory in Albuquerque, NM and the deviations from the input values were as much as ±12.9% of full scale. Calibration information pertaining to the mass flow meter is contained in the SWCF under WPO #42269.

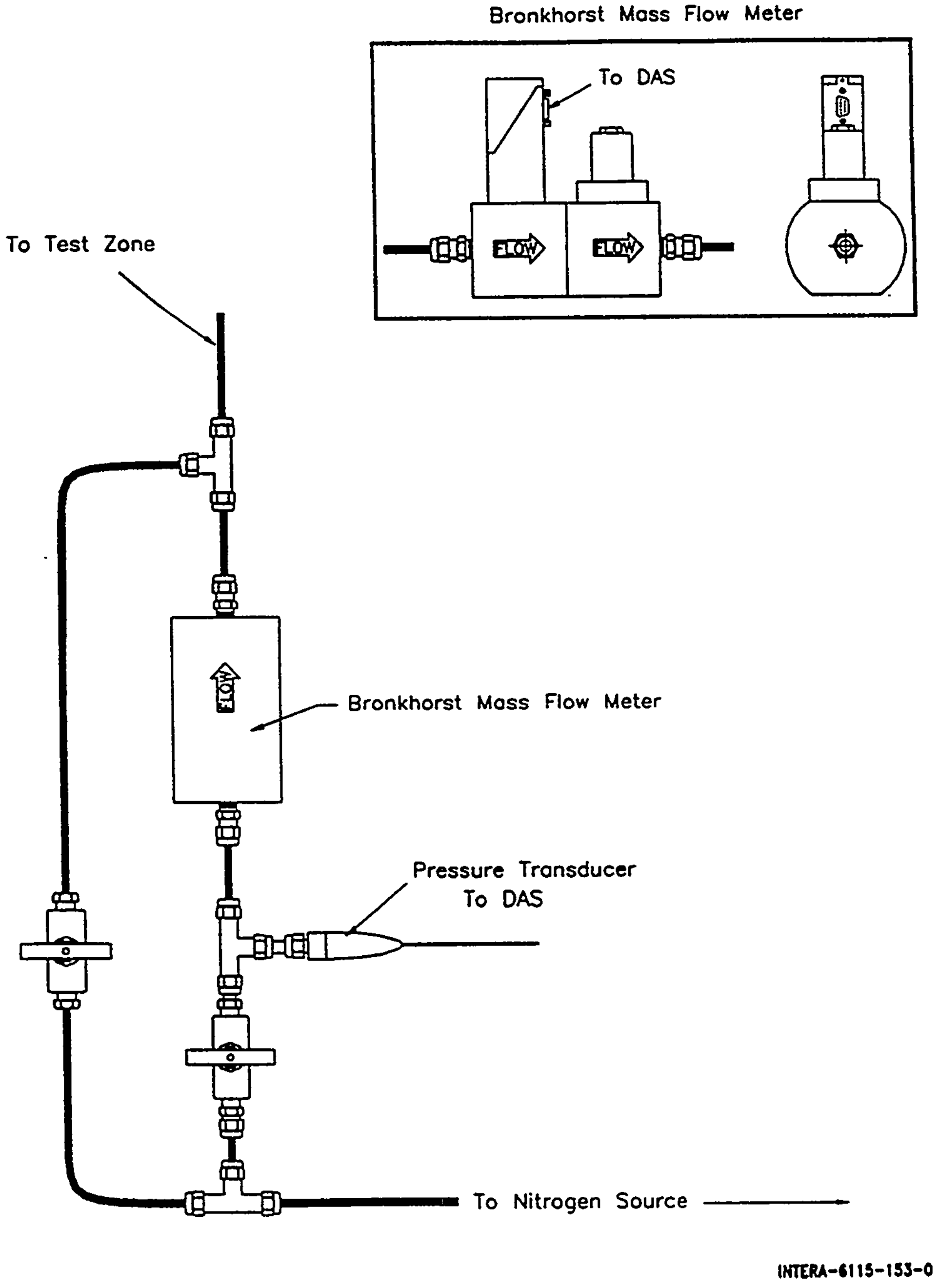

Figure 5-2. Schematic illustration of the constant-rate gas-injection system.

5.4 Procedures for Gas-Threshold-Pressure Testing

Test tools were installed following the procedures described in Section 3.4.1. After the test-zone pressure had stabilized at the assumed formation pressure, the brine in the test zone had to be displaced by gas prior to beginning the constant-rate gas injection into the test zone for the gas-threshold pressure determination. In conducting the gas/brine exchange in a downward-angled borehole, the test-zone packer was deflated to decrease the zone pressure from its stabilization pressure. Nitrogen was injected into the test zone through the test-zone vent line, expelling brine from the test-zone injection line. During the exchange, care was taken to ensure that the gas pressure in the zone did not exceed the pre-exchange fluid pressure. This procedure was carried out until gas flowed from the test-zone vent line, indicating that all fluid in the test zone had been displaced. The volume of fluid displaced from the test zone was measured and recorded. At this point, gas was injected through the test-zone vent line and an additional volume of fluid was removed from the guard zone in order to ensure that the test zone would be absent of fluid when the test-zone packer was re-inflated. Again, the gas pressure was not allowed to exceed the initial fluid pressure in the zone during injection. In conducting the gas/brine exchange in an upward-angled borehole, the test-zone packer was deflated as previously described. However, in this case, nitrogen was injected into the test zone through the test-zone vent line and brine was expelled (and measured) out of the guard-zone injection line until the entire test-zone volume had been removed. Therefore, the test-zone volume had to be known prior to conducting this operation. Once the entire test-zone volume had been removed, the test-zone packer was re-inflated, taking the same precautions as described above.

After displacing the test-zone brine, nitrogen gas was injected at a constant rate into the test zone using a Bronkhorst Model F-230C-FA-22-V mass flow meter and the test-zone pressure buildup was monitored as the injected gas was compressed. The test-zone pressure was monitored closely until it was determined that the gas-threshold pressure was reached. The pressure was monitored closely in order to determine whether or not the test-zone pressure exceeded the hydrofracture pressure, thus creating an artificial pathway for gas entry into the formation. Once it was determined that gas-threshold pressure had been achieved, the gas injection was terminated and test-zone pressures were monitored. After the constant-rate gas injection in borehole C2H02 was completed, the test-zone pressure was decreased by venting gas in a series of steps. After each step-decrease, the test-zone pressure was monitored to determine if it was decreasing, in which case the pressure was still above the threshold value and gas was flowing into the formation, or increasing, in which case gas was flowing from the formation back into the borehole. After the gas testing was completed in borehole C2H02, the gas was vented and the borehole was refilled with brine. After stable pressure conditions were reached, a pulse-withdrawal test was performed to determine if the brine permeability of MB139 had been altered by residual gas saturation. The test was performed following the procedures outlined in Section 3.4.2.

5.5 Boreholes and Test-Tool Configurations for Gas-Threshold-Pressure Testing

Figure 2-1 shows the locations of the boreholes associated with the GTPT program. Tables 5-1 and 5-2 provide pertinent information on the boreholes and test zones associated with the testing program.

Table 5-1. Borehole Test-Zone Information

Test Sequence	Test Horizon	Time Test Horizon Penetrated	Borehole Diameter (cm)	Test Interval Depth (m)	Borehole Depth (m)	Sequence Started	Sequence Terminated
SCP01-1	MB139	3-29-90 (10:30)	10.16	10.50 - 14.78	15.48	3-30-93	7-13-93
C2H02	MB139	4-14-89 (09:00)	10.16	9.20 - 10.68	10.91	8-10-93	3-21-94
L4P52-B	MB138	12-14-92 12:00	10.16	13.89 -14.02	14.12	12-29-93	3-31-94
SCP01-2	MB139	3-29-90 (10:30)	10.16	10.50 -14.78	15.48	4-15-94	6-27-94

Table 5-2. Borehole Locations, Orientations, and Drilling Information

Test Sequence (Orientation)	Interval Drilled/Cored (m)	Date Drilled/Cored	Location	Excavation Date of Room
SCP01-1 (downward 77°) (from vertical)	0 - 15.48	3-26-90 to 3-30-90	Core Storage Library	April & May 1989
C2H02 (downward 45°) (from vertical)	0 - 10.91	4-12-89 to 4-17-89	Room C2	March & April 1984
L4P52-B (upward 40°) (from vertical)	9.02 - 14.12	12-11-92 to 12-14-92	Room L4	February 1989
SCP01-2 (downward 77°) (from vertical)	0 - 15.48	3-26-90 to 3-30-90	Core Storage Library	April & May 1989

Figure 5-3 schematically depicts the Core Storage Library in plan view and in cross section, showing the location and orientation of borehole SCP01. The test-tool configurations, as they were installed for test sequences SCP01-1 and SCP01-2, are illustrated in Figures 5-4 through 5-8.

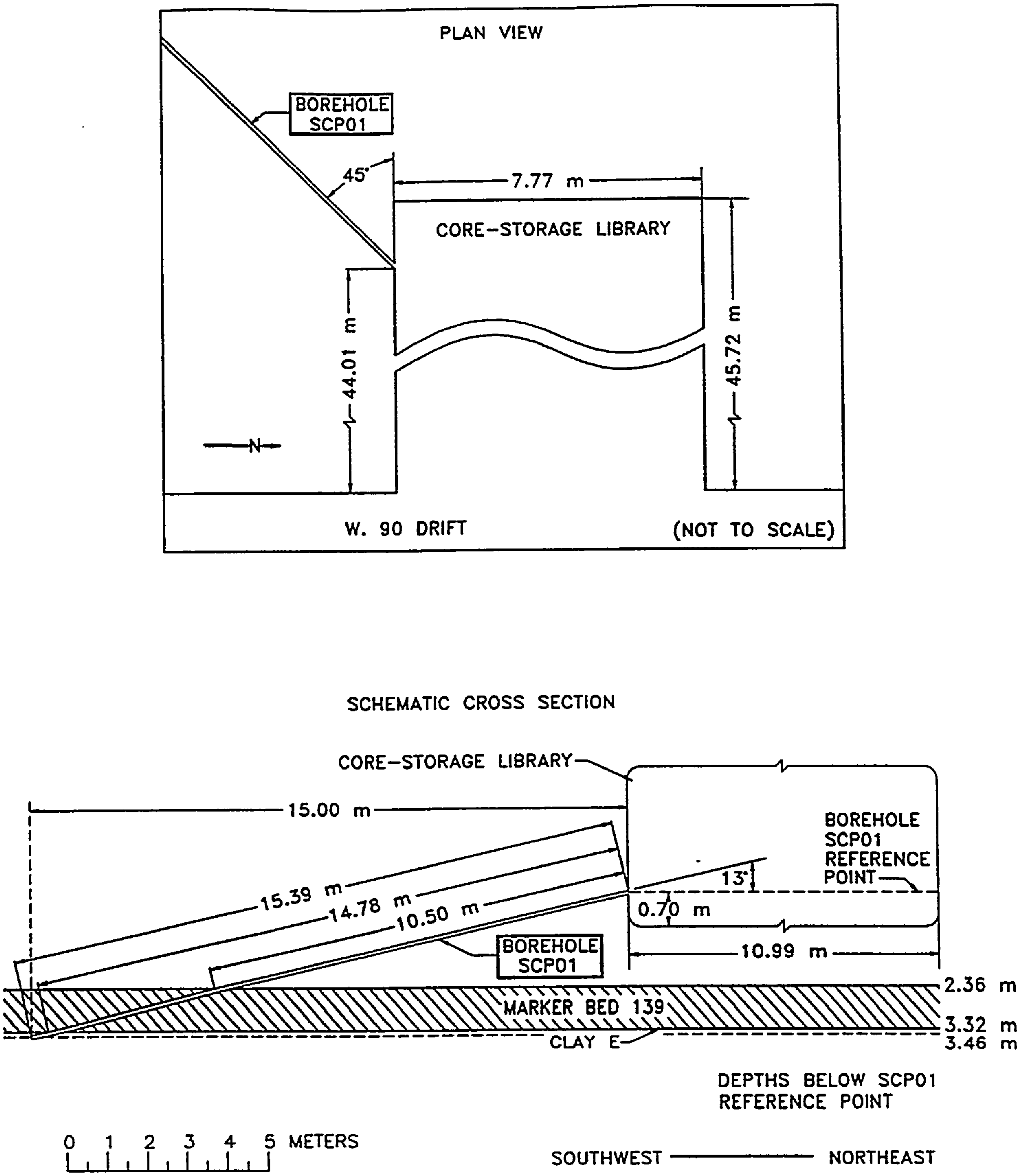

Figure 5-3. Spatial representation of the Core Storage Library showing the location and orientation of test borehole SCP01.

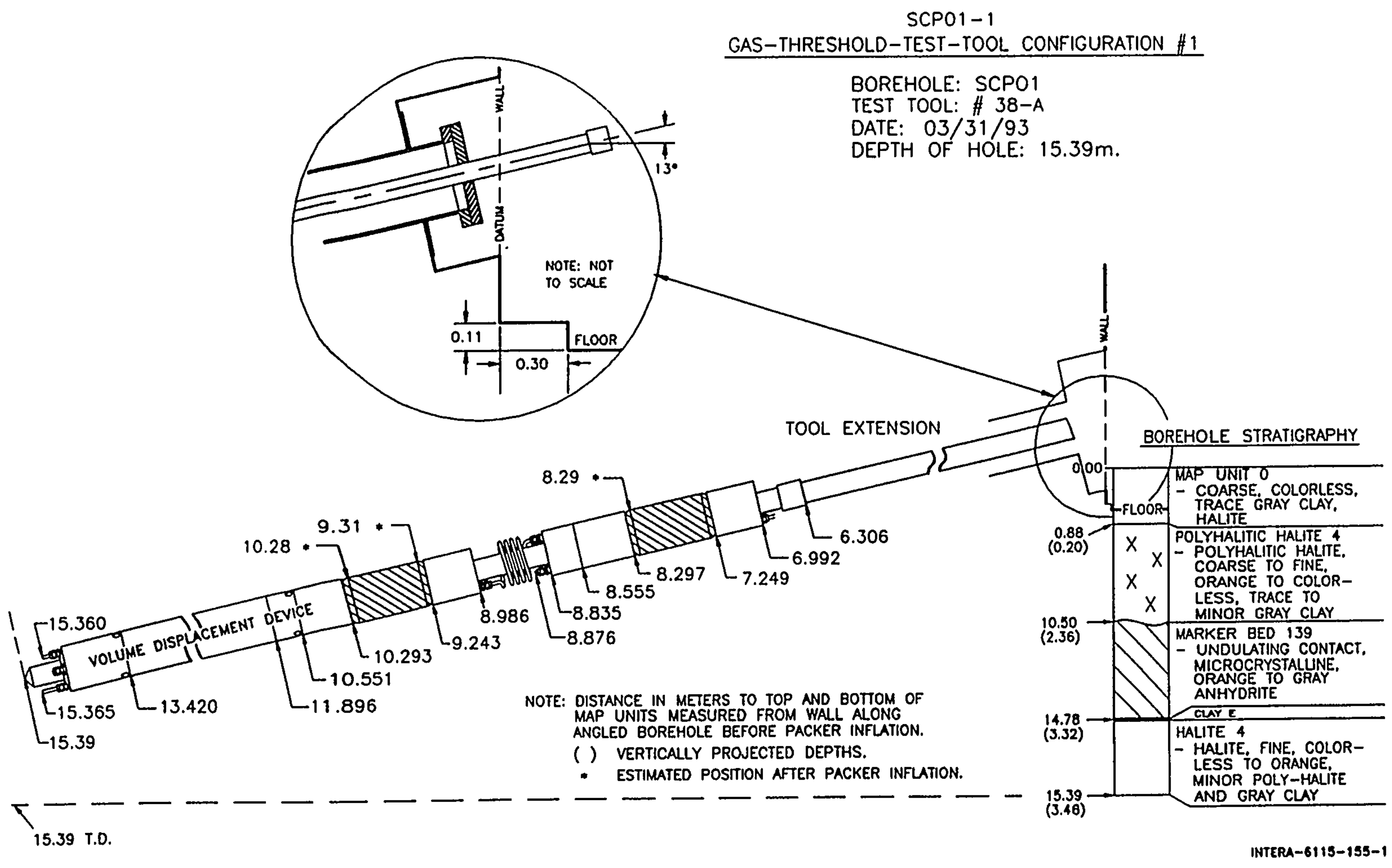

Figure 5-4. Configuration #1 of test tool for sequence SCP01-1.

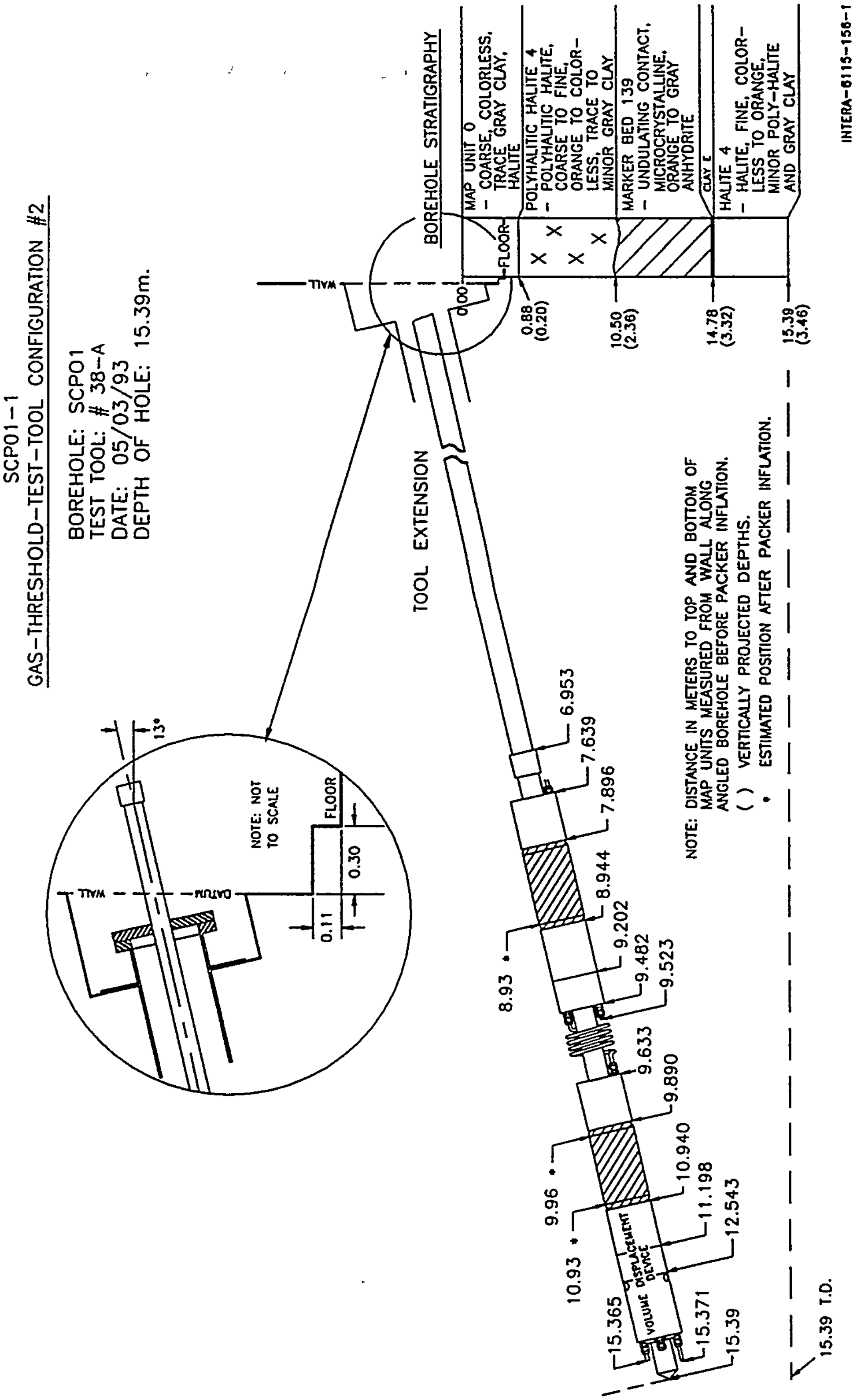

Figure 5-5. Configuration #2 of test tool for sequence SCP01-1.

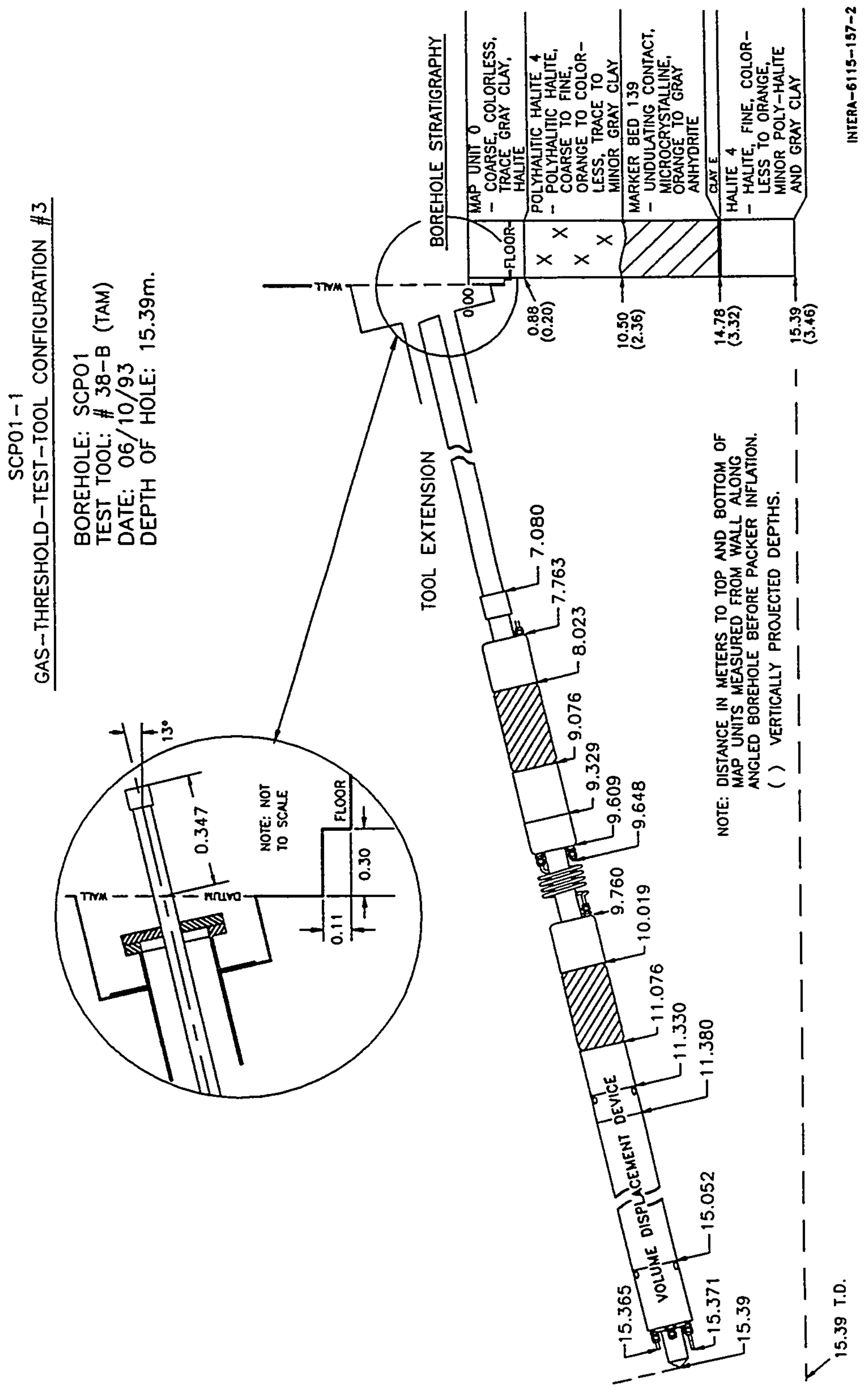

Figure 5-6. Configuration #3 of test tool for sequence SCP01-1.

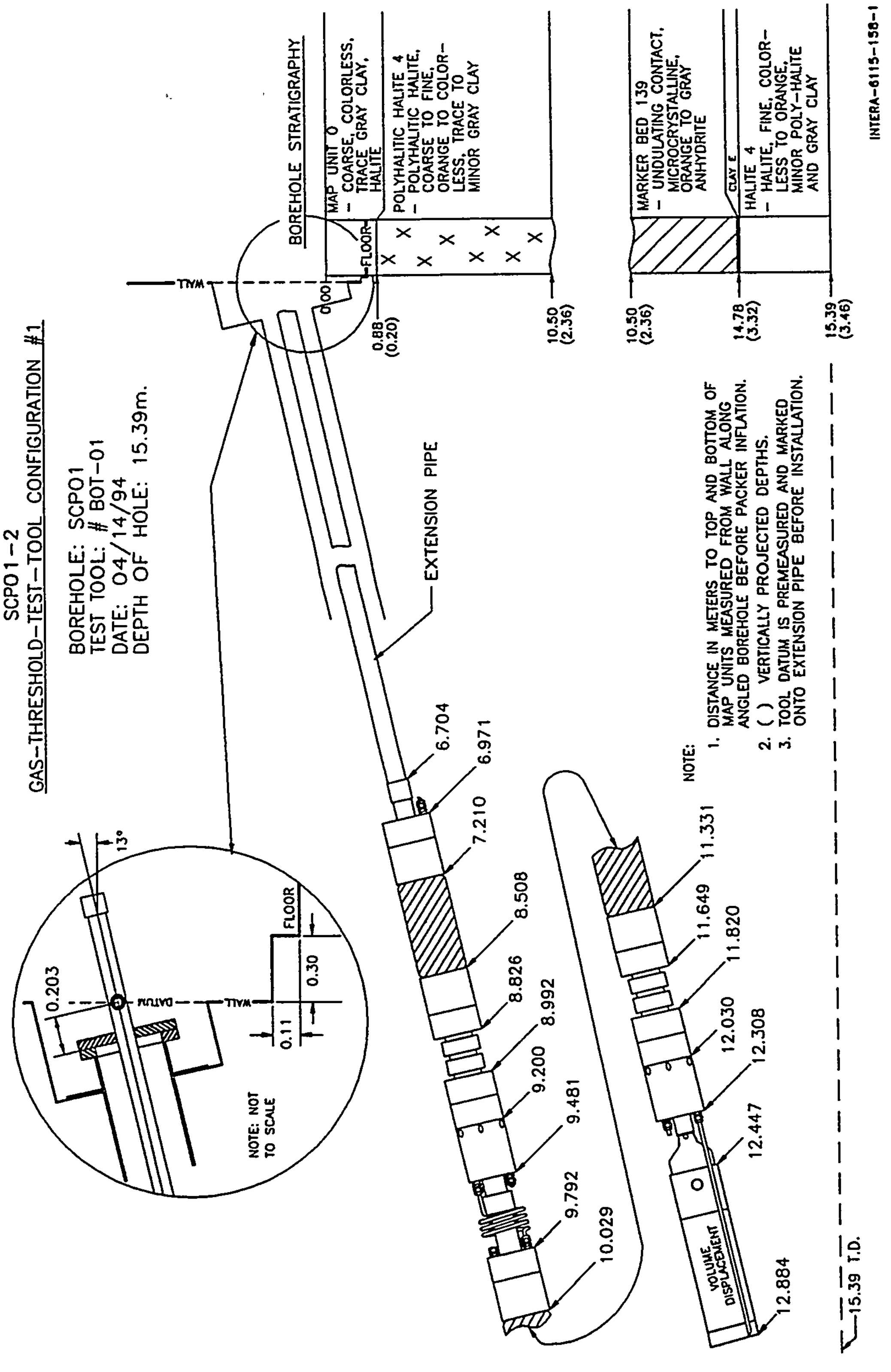

Figure 5-7. Configuration #1 of test tool for sequence SCP01-2.

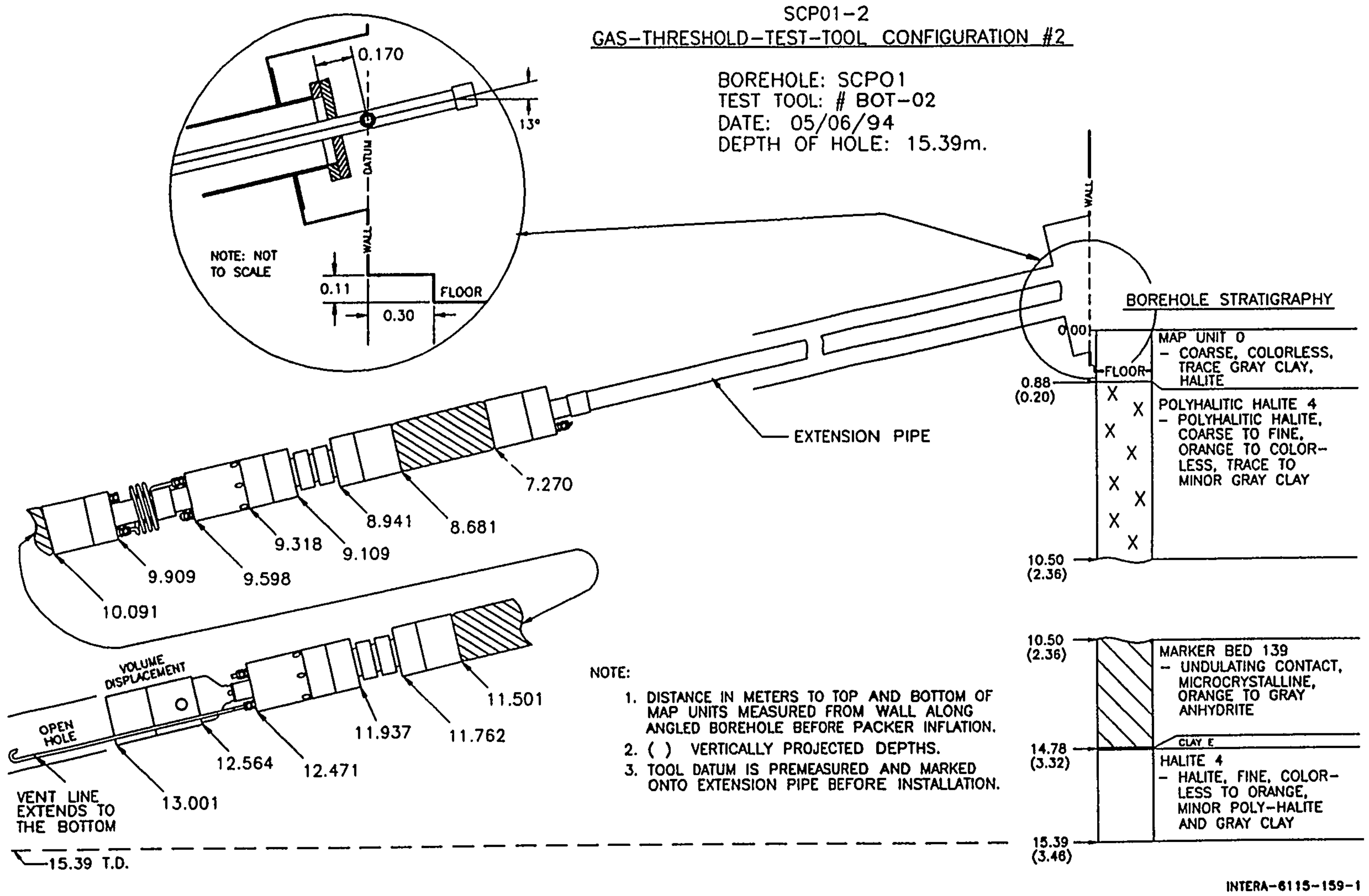

Figure 5-8. Configuration #2 of test tool for sequence SCP01-2.

Figure 4-7 schematically depicts Room C2 in plan view and in cross section, showing the location and orientation of boreholes C2H01 and C2H02. The test-tool configurations for test borehole C2H02 and observation borehole C2H01, as they were installed for test sequence C2H02, are illustrated in Figures 5-9 through 5-11.

Figure 3-20 schematically depicts Room L4 in plan view and in cross section, showing the location and orientation of borehole L4P52. The test-tool configuration, as it was installed for test sequence L4P52-B, is illustrated in Figure 3-31.

5.5.1 Borehole Drilling

The boreholes for the test program (i.e. SCP01, C2H02, C2H01, and L4P52) were drilled according to the procedures for compressed-air drilling outlined in Section 3.5.2. Core was not collected for test and observation boreholes C2H01, C2H02, and SCP01 for GTPTs during the time period covered in this report. Core description for test borehole L4P52 (B-series) are provided in Appendix A. Detailed descriptions of the core that was recovered from C2H01 and C2H02 are given in Saulnier et al. (1991). Additional documentation for boreholes C2H01, C2H02, L4P52, and SCP01 are provided in the SWCF under Group 5: Salado Testing Activities, (WPO #23253).

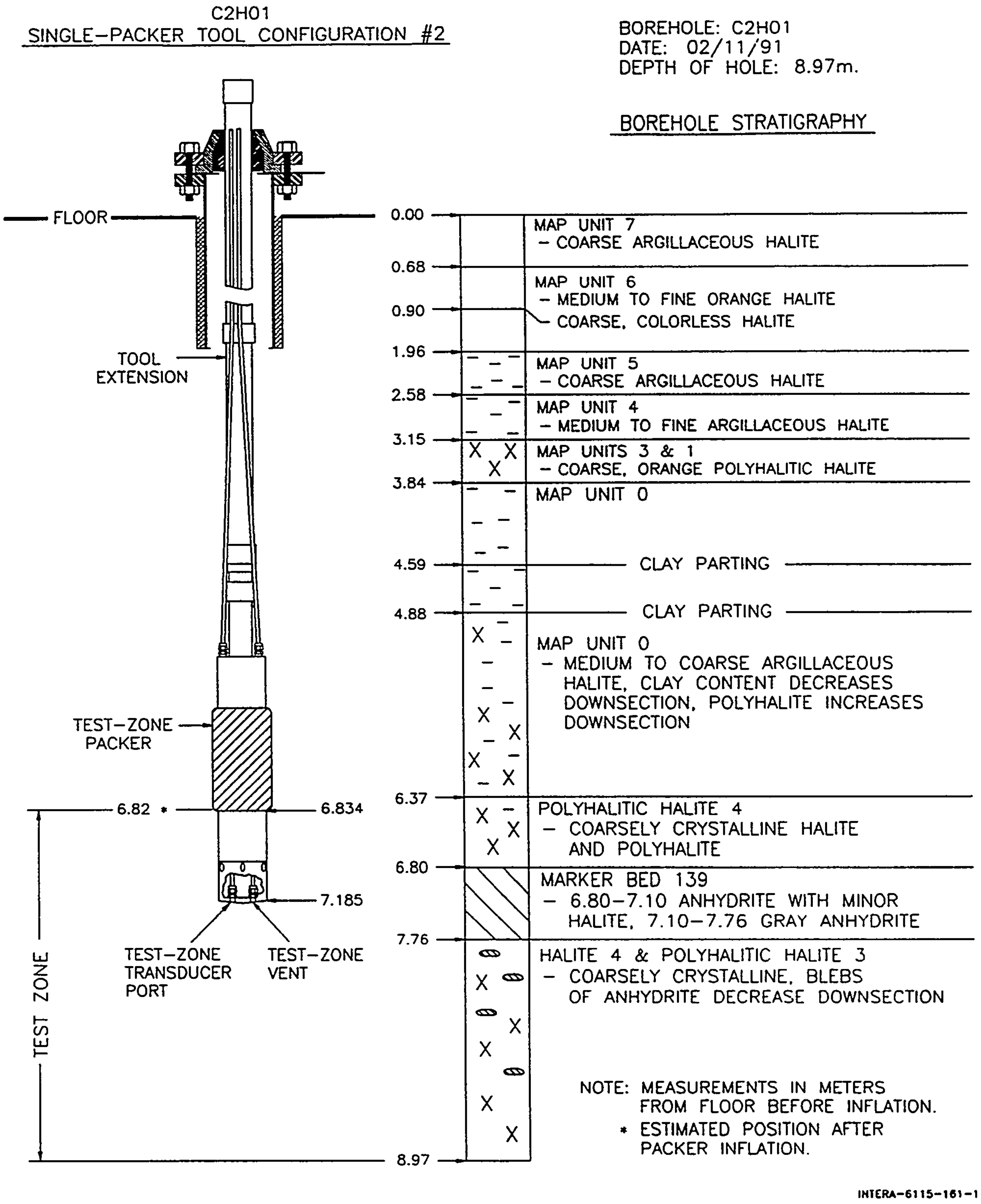

Figure 5-9. Configuration of monitor tool for sequence C2H02 in borehole C2H01.

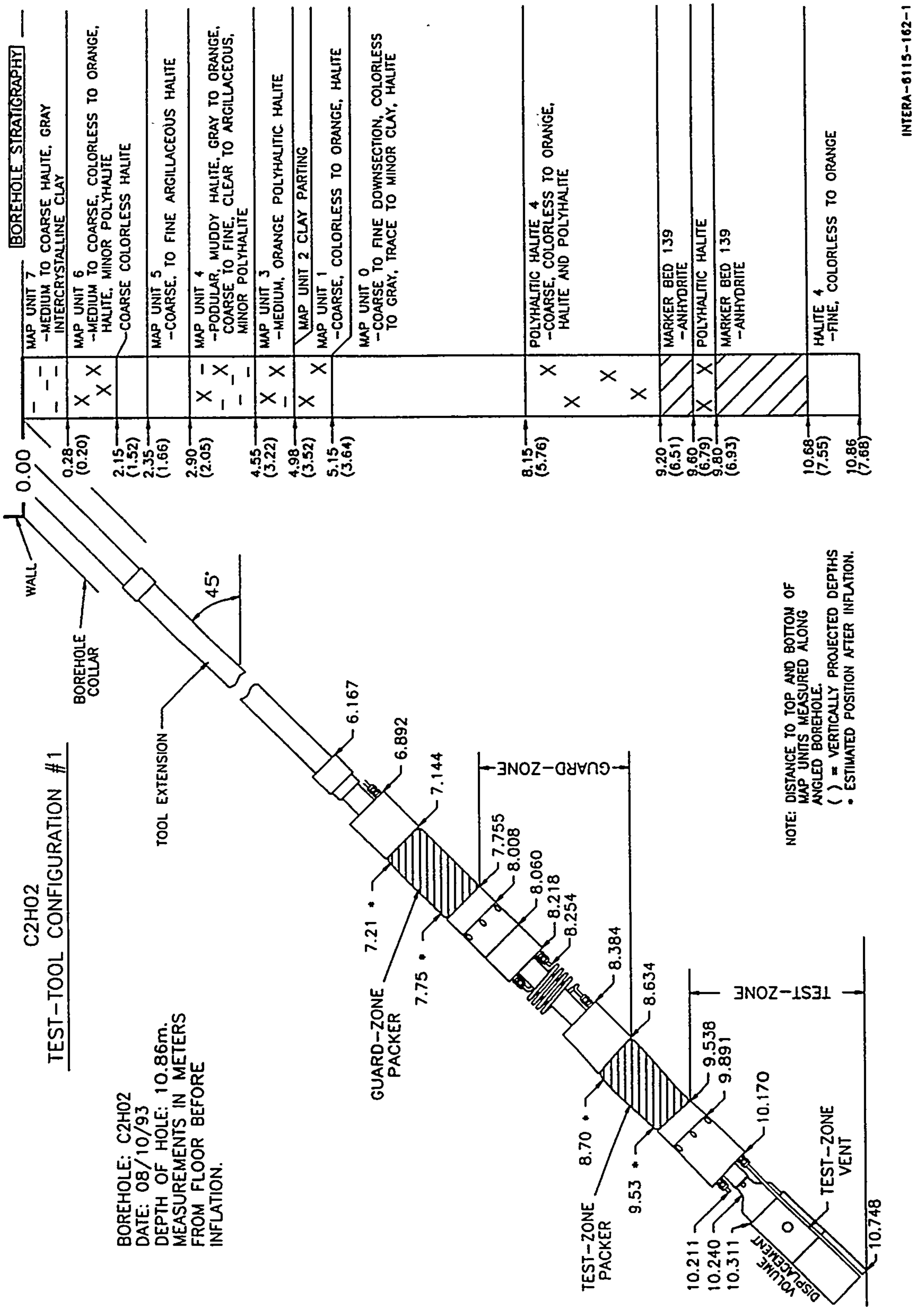

Figure 5-10. Configuration #1 of test tool for sequence C2H02.

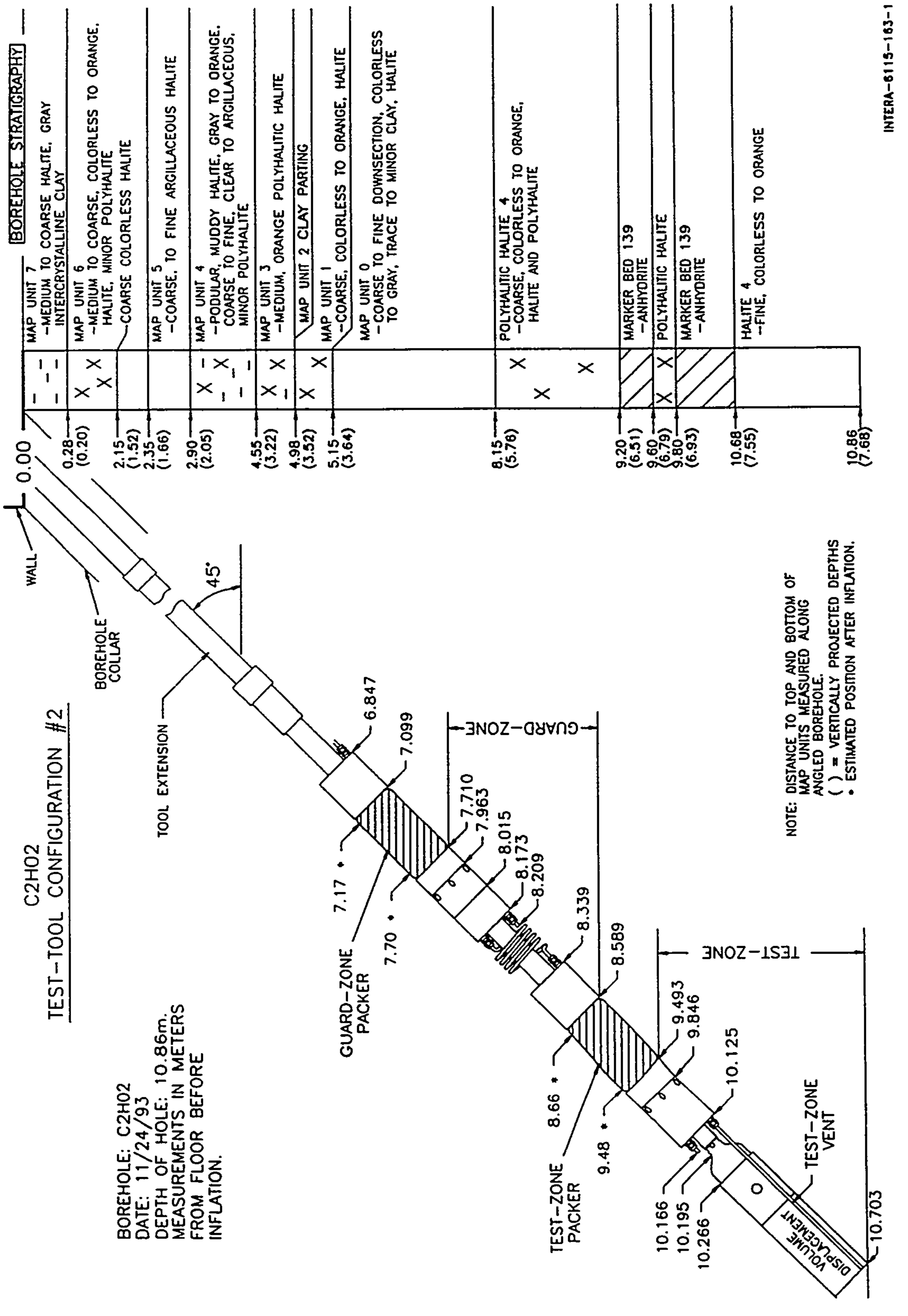

Figure 5-11. Configuration #2 of test tool for sequence C2H02.

5.6 Gas-Threshold-Pressure Test Data

The following section presents the results of the tests in the three boreholes that were investigated. Ten constant-rate gas injection tests, two test-zone compressibility tests, seven gas/brine exchanges, eight depressurization steps, and four pulse-withdrawal tests were performed during the test program.

Acronyms used in the tables presented in this section are as follows:

CMP = Compressibility Test
G/BE = Gas/Brine Exchange
GI = Constant-Rate Gas-Injection Test
PW = Pulse-Withdrawal Test
DPS = Depressurization Step
TZ = Test Zone
TZP = Test Zone Packer
GZ = Guard Zone
GZP = Guard Zone Packer
Zone Fluid Volume = Isolated Zone Volume+Tubing Volume-Tool Volume

Table 5-3 summarizes the results from all of these tests. Complete data files and abridged tabulations of the data are stored in the SWCF under WPO #42269.

Table 5-3. Summary of Tests Associated with the GTPT Program

GTPT Sequence	Zone	Date Started (mm-dd-yy)	Test Type	Unit	Initial Pressure (MPa)	Final Pressure (MPa)	Fluid Volume Injected (+) Withdrawn (-) (mL)	Flow Rate (mL/min)	Zone Length (cm)	Zone Radius (cm)	Tool Volume (mL)	Zone Fluid Volume (mL)
SCP01-1	TZ	3-31-93	CMP	MB139	10.700	0.000	230	N/A	511	13.831	35812	5853
SCP01-1	TZ	4-26-93	G/BE	MB139	9.577	9.577	-6500	N/A	511	13.831	35812	5853
SCP01-1	TZ	4-26-93	GI #1	MB139	9.577	9.577	N/A	1.0	511	13.831	35812	5853
SCP01-1	TZ	4-27-93	GI #2	MB139	9.509	9.509	N/A	4.5	511	13.831	35812	5853
SCP01-1	GZ	5-26-93	PW	Halite	7.950	7.713	-18.5	N/A	102	13.831	6463	1915
C2H02	TZ	9-10-93	G/BE #1	MB139	8.369	8.380	-1760	N/A	133	6.259	7139	4318
C2H02	TZ	9-14-93	GI	MB139	8.359	8.361	N/A	3.0	133	6.259	7139	4318
C2H02	TZ	10-11-93	DPS #1	MB139	10.475	9.970	N/A	N/A	133	6.259	7139	4318
C2H02	TZ	10-15-93	DPS #2	MB139	9.836	9.587	N/A	N/A	133	6.259	7139	4318
C2H02	TZ	10-19-93	DPS #3	MB139	9.565	9.401	N/A	N/A	133	6.259	7139	4318
C2H02	TZ	10-22-93	DPS #4	MB139	9.426	9.227	N/A	N/A	133	6.259	7139	4318
C2H02	TZ	10-26-93	DPS #5	MB139	9.248	9.021	N/A	N/A	133	6.259	7139	4318
C2H02	TZ	11-1-93	DPS #6	MB139	9.073	8.950	N/A	N/A	133	6.259	7139	4318
C2H02	TZ	11-11-93	DPS #7	MB139	8.975	8.856	N/A	N/A	133	6.259	7139	4318
C2H02	TZ	11-23-93	G/BE #2	MB139	8.891	8.154	4350	N/A	133	6.259	7139	4318

Table 5-3 (Continued). Summary of Tests Associated with the GTPT Program

GTPT Sequence	Zone	Date Started (mm-dd-yy)	Test Type	Unit	Initial Pressure (MPa)	Final Pressure (MPa)	Fluid Volume Injected (+) Withdrawn (-) (mL)	Flow Rate (mL/min)	Zone Length (cm)	Zone Radius (cm)	Tool Volume (mL)	Zone Fluid Volume (mL)
C2H02	TZ	11-24-93	DPS #8	MB139	7.891	6.837	N/A	N/A	133	6.259	7139	4318
C2H02	GZ	11-29-93	PW	Halite	6.413	0.000	-1720	N/A	95	6.259	5908	2256
C2H02	TZ	1-24-94	PW	MB139	9.159	6.743	-10.4	N/A	138	6.259	7139	4699
L4P52-B	TZ	12-31-93	G/BE #1	N/A	8.728	8.307	-7330	N/A	141	5.850	8525	2718
L4P52-B	TZ	1-17-94	G/BE #2	N/A	8.737	8.524	-1990	N/A	141	5.850	8525	2718
L4P52-B	TZ	1-27-94	GI #1	MB138	8.602	8.602	N/A	2.0	141	5.850	8525	2718
L4P52-B	TZ	1-28-94	GI #2	MB138	10.543	10.543	N/A	0.8	141	5.850	8525	2718
L4P52-B	TZ	2-14-94	GI #3	MB138	9.391	9.391	N/A	1.1	141	5.850	8525	2718
L4P52-B	TZ	2-16-94	GI #4	MB138	10.455	10.455	N/A	1.1	141	5.850	8525	2718
L4P52-B	TZ	3-9-94	GI #5	MB138	9.791	9.791	N/A	0.6	141	5.850	8525	2718
L4P52-B	TZ	3-14-94	DPS	MB138	9.866	9.560	N/A	N/A	141	5.850	8525	2718
SCP01-2	TZ	4-15-94	CMP	MB139	5.500	5.446	330	N/A	406	13.831	4831	28384
SCP01-2	TZ	5-2-94	G/BE #1	MB139	9.514	9.514	-2390	N/A	406	13.831	4831	28384
SCP01-2	TZ	5-16-94	G/BE #2	MB139	9.512	9.344	-24655	N/A	406	13.831	4831	28384
SCP01-2	TZ	5-17-94	GI #1	MB139	9.261	9.261	N/A	2.0	406	13.831	4831	28384
SCP01-2	TZ	5-26-94	GI #2	MB139	8.708	8.659	N/A	0.2	406	13.831	4831	28384

5.6.1 Gas-Threshold-Pressure Testing in the Core Storage Library

5.6.1.1 GAS-THRESHOLD-PRESSURE TESTING SEQUENCE SCP01-1

The first GTPT sequence to be conducted took place in the Core Storage Library in borehole SCP01. This test sequence was designed to investigate the gas threshold pressure of MB139 in an environment removed from the WIPP excavations. Problems during this testing sequence associated with the inability of the packer elements to form a reliable seal were encountered. These problems were not satisfactorily resolved while the testing sequence was in progress. Table 5-4 gives a detailed description of the events that occurred during test sequence SCP01-1.

Table 5-4. Testing Sequence SCP01-1 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Remove single-packer, long-term test tool from borehole.	3-22-93	81	81	13:19:00
Begin data file SCP01B01.	3-30-93	89	89	14:19:45
End data file SCP01B01.	3-30-93	89	89	14:30:16
Install double-packer test tool #38A in preparation for GTPT as indicated in tool configuration diagram #1 (Figure 5-4).	3-30-93	89	89	14:33:00
Inflate GZP.	3-30-93	89	89	14:34:36
Shut in GZP.	3-30-93	89	89	14:37:50
Inflate TZP.	3-30-93	89	89	14:40:09
Shut in TZP.	3-30-93	89	89	14:44:50
Increase GZP pressure.	3-30-93	89	89	14:47:15
Shut-in GZ and TZ.	3-30-93	89	89	14:48:14
Increase GZP pressure.	3-30-93	89	89	14:55:11
Depressurize both zones and deflate both packers.	3-31-93	90	90	09:00:00
Pull tool out of borehole to the top of GZP.	3-31-93	90	90	11:00:00
Inflate GZP to check for leaks.	3-31-93	90	90	11:05:00
Install test tool to original position.	3-31-93	90	90	11:40:00
Inflate GZP.	3-31-93	90	90	11:41:00
Shut in GZP.	3-31-93	90	90	11:43:00
Inflate TZP.	3-31-93	90	90	11:45:00
Shut in TZP.	3-31-93	90	90	11:47:00
Increase TZP pressure.	3-31-93	90	90	12:03:00
Increase GZP pressure.	3-31-93	90	90	12:06:00
Begin data file SCP01B02.	3-31-93	90	90	15:01:14
Begin pressurization of TZ via DPT panel to ~10 MPa for TZ compressibility test.	3-31-93	90	90	15:08:12
Increase TZP pressure to ~ 13.5 MPa.	3-31-93	90	90	16:04:03
Shut in TZ terminating TZ compressibility test.	4-6-93	96	96	11:44:02
End data file SCP01B02.	4-12-93	102	102	10:54:34
Begin data file SCP01B03.	4-12-93	102	102	11:11:43
Open TZP to accumulator.	4-12-93	102	102	12:56:44
Increase TZP pressure via accumulator.	4-12-93	102	102	12:57:29
Shut in TZP from accumulator due to leak.	4-12-93	102	102	13:07:51
Open GZP to accumulator and increase pressure.	4-12-93	102	102	13:13:42
Open TZP to accumulator.	4-13-93	103	103	11:09:46
Increase TZP pressure via accumulator.	4-13-93	103	103	11:16:30
Increase GZ pressure.	4-13-93	103	103	11:36:56
End data file SCP01B03.	4-19-93	109	109	12:11:52
Begin data file SCP01B04.	4-19-93	109	109	13:16:36

Table 5-4 (Continued). Testing Sequence SCP01-1 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Increase GZ pressure.	4-22-93	112	112	11:10:51
Increase GZP pressure.	4-22-93	112	112	11:28:23
Increase GZ pressure.	4-22-93	112	112	11:36:24
Attempt to begin gas/brine exchange in TZ but encountered a plugged line.	4-26-93	116	116	13:07:00
Shut in zone.	4-26-93	116	116	13:15:00
Remove ~2 liters of brine.	4-26-93	116	116	13:35:00
Remove ~1.7 liters of brine.	4-26-93	116	116	13:49:00
Remove ~1.4 liters of brine.	4-26-93	116	116	14:02:00
Remove ~1.3 liters of brine.	4-26-93	116	116	14:08:00
Gas is coming from the vent line.	4-26-93	116	116	14:11:00
Remove ~100 mL of brine while unplugging the original plugged line.	4-26-93	116	116	15:12:00
Complete gas/brine exchange in TZ.	4-26-93	116	116	15:13:00
Momentarily open TZ to flow meter set at 1 mL/min to test system.	4-26-93	116	116	15:56:00
Begin N_2 injection #1 into TZ at 1 mL/min.	4-26-93	116	116	16:04:00
Shut in TZ due to possible leak terminating N_2 #1 in TZ.	4-26-93	116	116	16:16:00
Perform over night leak check.	4-26-93	116	116	16:28:00
Begin N_2 injection #2 into TZ at 4.5 mL/min.	4-27-93	117	117	11:07:00
Terminate N_2 injection #2 due to incorrect flow meter reading.	4-27-93	117	117	11:23:00
Resume N_2 injection #2 into TZ at 4.5 mL/min.	4-27-93	117	117	11:33:00
Switch from MDT to MST for recording events in the log book.	4-29-93	119	119	N/A
Bypass around TZP is suspected.	4-29-93	119	119	N/A
Terminate N_2 injection #2 into TZ.	4-29-93	119	119	11:22:00
Increase TZP pressure.	4-29-93	119	119	12:31:00
Increase TZP pressure to ~15 MPa.	4-29-93	119	119	12:49:00
Decrease GZ pressure.	4-29-93	119	119	13:18:00
Increase GZ pressure to ~10 MPa.	4-30-93	120	120	11:39:37
End data file SCP01B04.	5-2-93	122	122	11:40:16
Begin data file SCP01B05.	5-2-93	122	122	11:40:17
Test-zone thermocouple is no longer functioning.	5-2-93	122	122	13:38:30
Depressurize TZ (25 to 50 mL of brine).	5-3-93	123	123	08:45:00
Depressurize GZ (~1480 mL of brine).	5-3-93	123	123	08:52:00
Deflate GZP.	5-3-93	123	123	09:01:00
Deflate TZP.	5-3-93	123	123	09:06:00
Remove test tool for inspection (bubble on GZP, brine inside tool).	5-3-93	123	123	11:34:00
Reinstall tool so that TZP straddles the halite/anhydrite contact as indicated in tool configuration diagram #2 (Figure 5-5).	5-3-93	123	123	09:00:00
Inflate GZP to ~12.4 MPa.	5-6-93	126	126	09:25:00

Table 5-4 (Continued). Testing Sequence SCP01-1 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Shut in GZP at ~12.1 MPa.	5-6-93	126	126	09:31:00
Inflate TZP to ~12.4 MPa.	5-6-93	126	126	09:33:00
Shut in TZP at ~11.7 MPa.	5-6-93	126	126	09:35:00
Open GZP to accumulator at ~11.7 MPa.	5-6-93	126	126	09:40:00
Open TZP to accumulator at ~12.4 MPa.	5-6-93	126	126	09:48:00
Circulate brine through TZ.	5-6-93	126	126	09:56:00
Open TZ to accumulator at ~11.7 MPa and observed pressure drop to ~9.0 MPa.	5-6-93	126	126	11:24:00
Increase TZ pressure via accumulator to ~10.3 MPa.	5-7-93	127	127	11:26:00
Shut in TZ from accumulator.	5-10-93	130	130	N/A
Increase TZP pressure via accumulator to 13.134 MPa.	5-17-93	137	137	10:00:36
Increase GZP pressure via accumulator to 13.460 MPa.	5-17-93	137	137	10:08:36
Shut in TZ from accumulator at 10.366 MPa.	5-17-93	137	137	10:14:06
Increase GZ pressure via accumulator to 11.257 MPa.	5-17-93	137	137	10:34:06
Shut in TZP from accumulator.	5-18-93	138	138	08:34:00
Open TZP to accumulator.	5-18-93	138	138	08:38:00
Shut in GZ from accumulator to test for leaks from TZP.	5-19-93	139	139	09:47:00
Open GZ to accumulator.	5-20-93	140	140	09:21:00
Repair TZ thermocouple.	5-20-93	140	140	11:44:00
Shut in GZ from accumulator.	5-24-93	144	144	09:03:00
Vent GZ to expel gas that might have been introduced from the accumulator.	5-24-93	144	144	09:11:00
Perform pulse-withdrawal test in GZ pressure to 7.713 MPa removing ~18.5 mL of brine (testing for gas).	5-26-93	146	146	08:48:00
Shut in TZP from accumulator.	5-26-93	146	146	12:42:00
End data file SCP01B05.	6-1-93	152	152	07:29:25
Depressurize TZ (~460 mL of fluid).	6-1-93	152	152	08:48:00
Depressurize GZ (large amount of gas).	6-1-93	152	152	08:55:00
Deflate GZP.	6-1-93	152	152	09:00:00
Deflate TZP.	6-1-93	152	152	10:00:00
Attempt to remove test tool to examine TZP for leaks but it got stuck in borehole.	6-1-93	152	152	11:00:00
Reinstall test tool #38B with new (hard rubber) TAM elements as indicated in tool configuration diagram #3 (Figure 5-6).	6-10-93	161	161	12:00:00
Begin data file SCP01B06.	6-10-93	161	161	12:45:14
Inflate GZP via accumulator to ~13.5 MPa.	6-10-93	161	161	12:49:00
Circulate fluid through all of the lines.	6-10-93	161	161	14:10:00
Inflate TZP.	6-10-93	161	161	14:20:00
Pressurize TZ via accumulator.	6-10-93	161	161	14:41:00
Shut in GZ.	6-10-93	161	161	14:42:00

Table 5-4 (Continued). Testing Sequence SCP01-1 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Increase TZ pressure via accumulator.	6-11-93	162	162	10:16:00
Shut in TZ from accumulator.	6-11-93	162	162	10:17:00
Open TZ to full accumulator.	6-11-93	162	162	10:42:00
Shut in TZ from accumulator.	6-14-93	165	165	09:28:41
Shut in GZ from transducer to remove leaking gage.	6-22-93	173	173	10:58:00
Open GZ to transducer and accumulator.	6-22-93	173	173	11:09:00
Increase GZP pressure via accumulator.	6-28-93	179	179	11:38:26
Increase GZ pressure via accumulator.	6-28-93	179	179	12:36:38
Shut in GZ from accumulator.	6-28-93	179	179	12:37:30
Increase TZP pressure due to bypass around the packer.	6-29-93	180	180	10:00:04
End data file SCP01B06.	7-1-93	183	183	08:38:57
Depressurize TZ.	7-13-93	194	194	08:55:00
Depressurize GZ.	7-13-93	194	194	08:57:00
Deflate both packers.	7-13-93	194	194	09:02:00
Terminate data collection.	7-13-93	194	194	09:04:00
Remove test tool #38B.	7-13-93	194	194	13:00:00

Figures 5-12 through 5-17 illustrate the zone pressures, packer pressures, nitrogen-injection rate, test-zone temperature, brine-injection volume during the test-zone compressibility test, and the test-zone compressibility as a function of pressure, respectively, during test sequence SCP01-1.

Table 5-5 indicates the equipment that was used and the duration that each instrument was used during testing sequence SCP01-1.

Table 5-5. Testing Sequence SCP01-1 Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	3-30-93	4-19-93
DAS Software	N/A	LABTECH 4.1.0	4-19-93	7-13-93
DCU (HP3497A)	N/A	2629a21989	3-30-93	4-19-93
DCU (HP75000)	N/A	3035a01445	4-19-93	7-13-93
Transducer (Druck PDCR 910)	Test Zone	322422	3-30-93	7-13-93
Transducer (Druck PDCR 910)	Test Zone Packer	308150	3-30-93	7-13-93

Table 5-5 (Continued). Testing Sequence SCP01-1 Equipment

Equipment	Location	Serial #	Installed	Removed
Transducer (Druck PDCR 910)	Guard Zone	507864	3-30-93	7-13-93
Transducer (Druck PDCR 910)	Guard Zone Packer	308145	3-30-93	7-13-93
Transducer (Druck PDCR 910)	DPT Panel/Mass Flow Meter	322427	3-31-93	4-12-93
DPT (Rosemount 1151DP)	N/A	1140864	3-31-93	4-12-93
Injection Column	N/A	38	3-31-93	3-31-93
Thermocouple (Type E)	Test Zone	1	3-30-93	5-2-93
Flow Meter (Bronkhorst F-230C-FA-22-V)	N/A	921209a	4-19-93	6-1-93

* Installed dates for injection columns refer to dates of initial use rather than date installed.

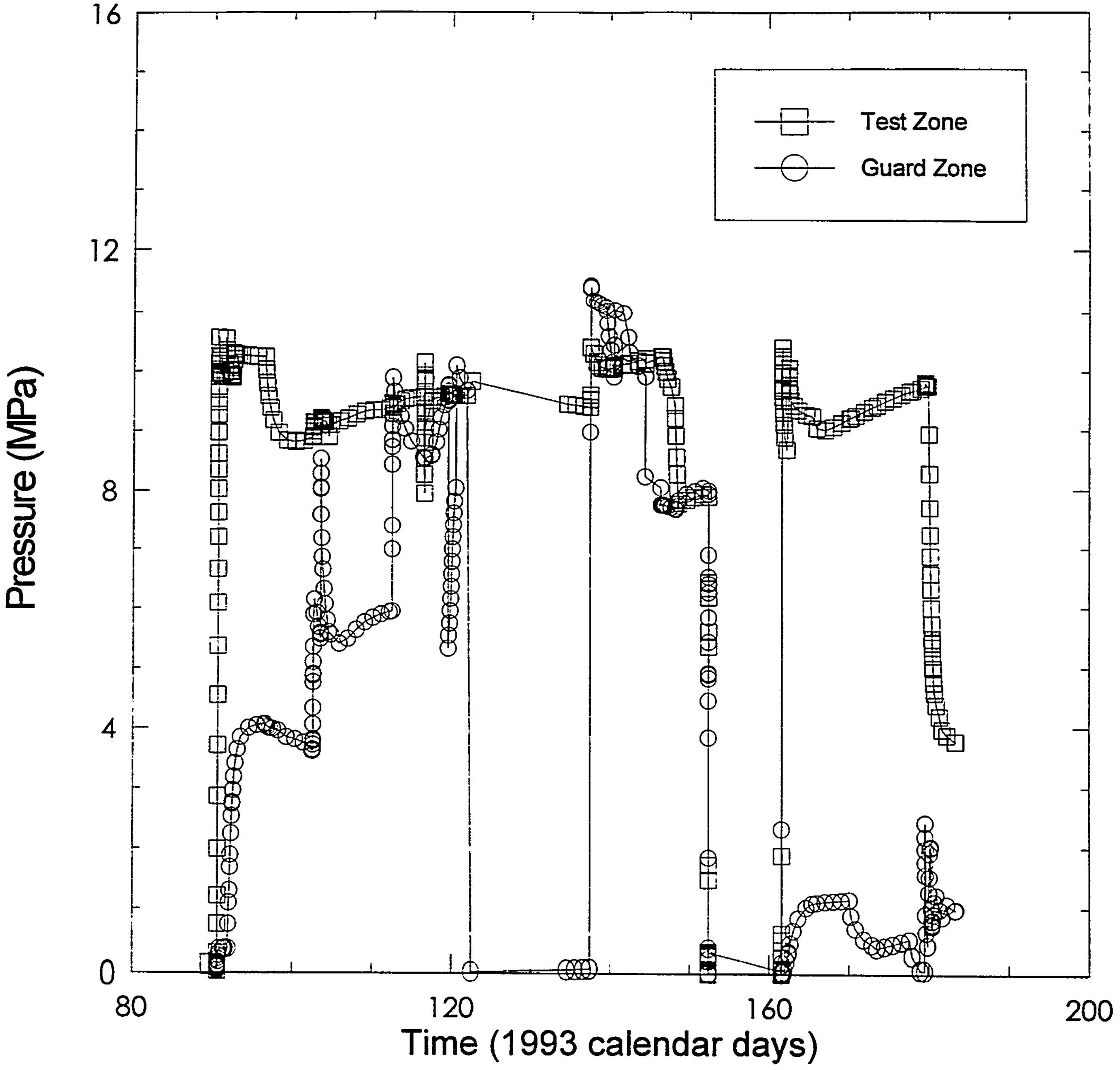

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Figure 5-12. Zone pressures during testing sequence SCP01-1.

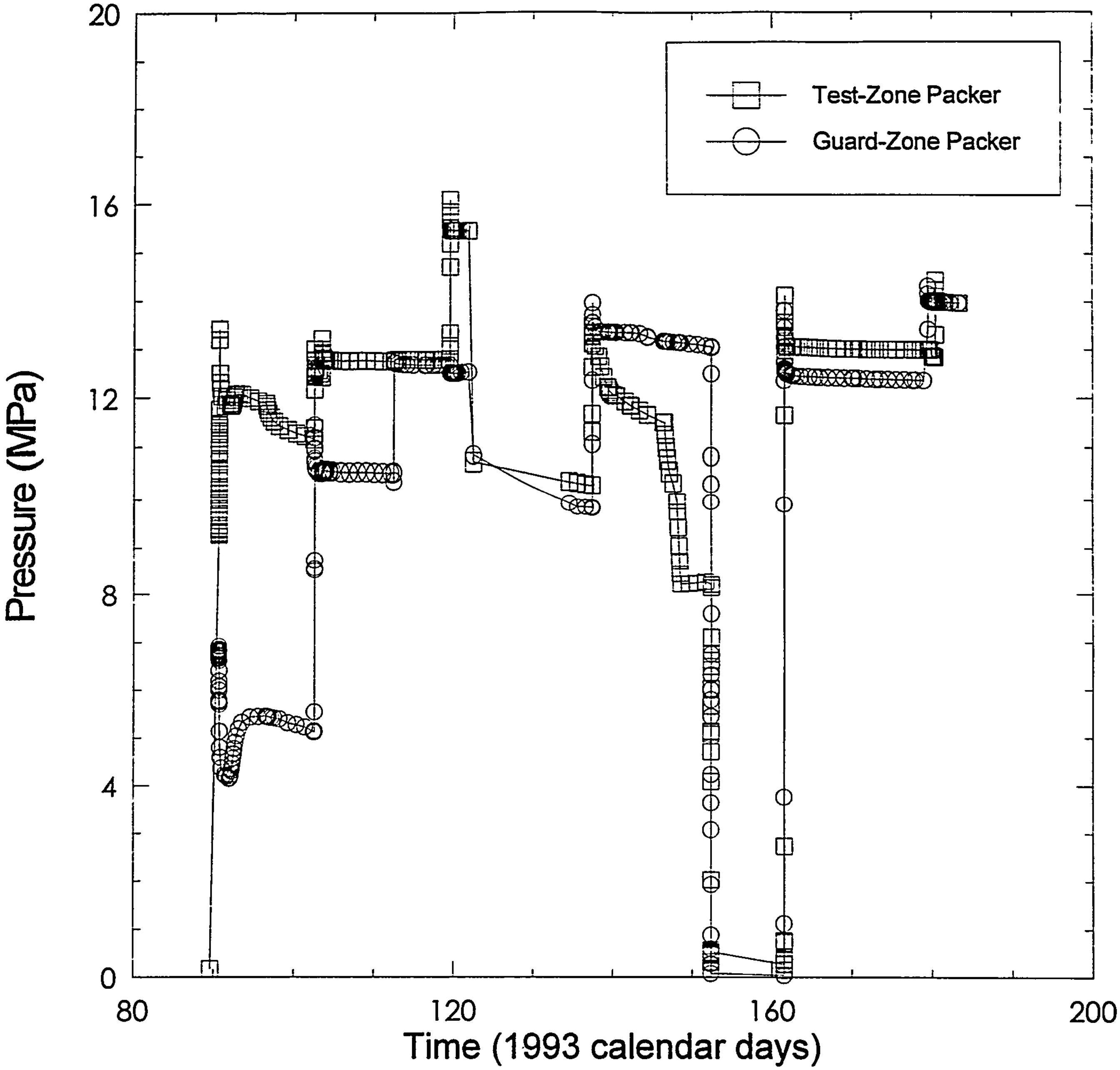

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Figure 5-13. Packer pressures during testing sequence SCP01-1.

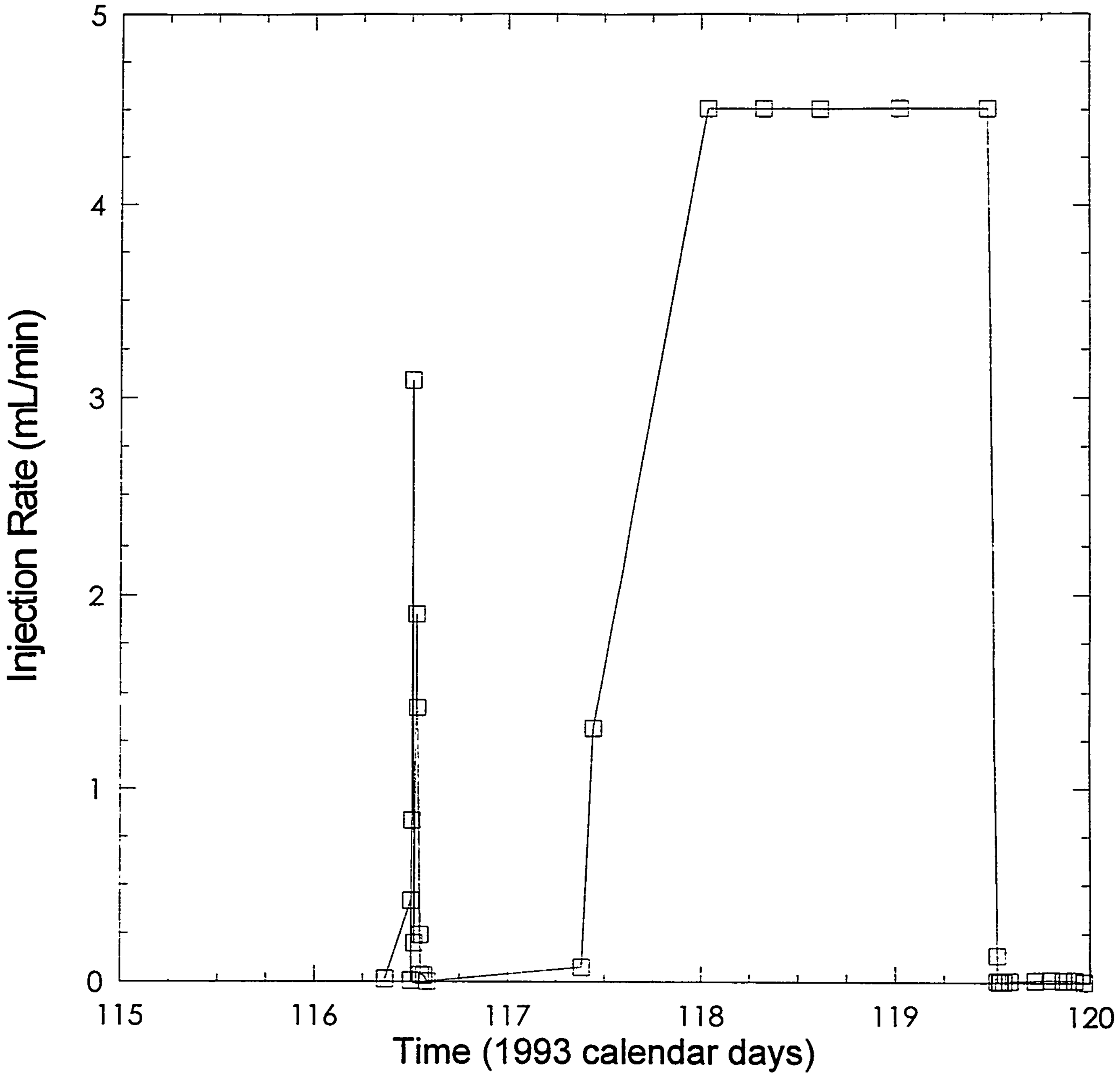

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Figure 5-14. Nitrogen-injection rate during testing sequence SCP01-1.

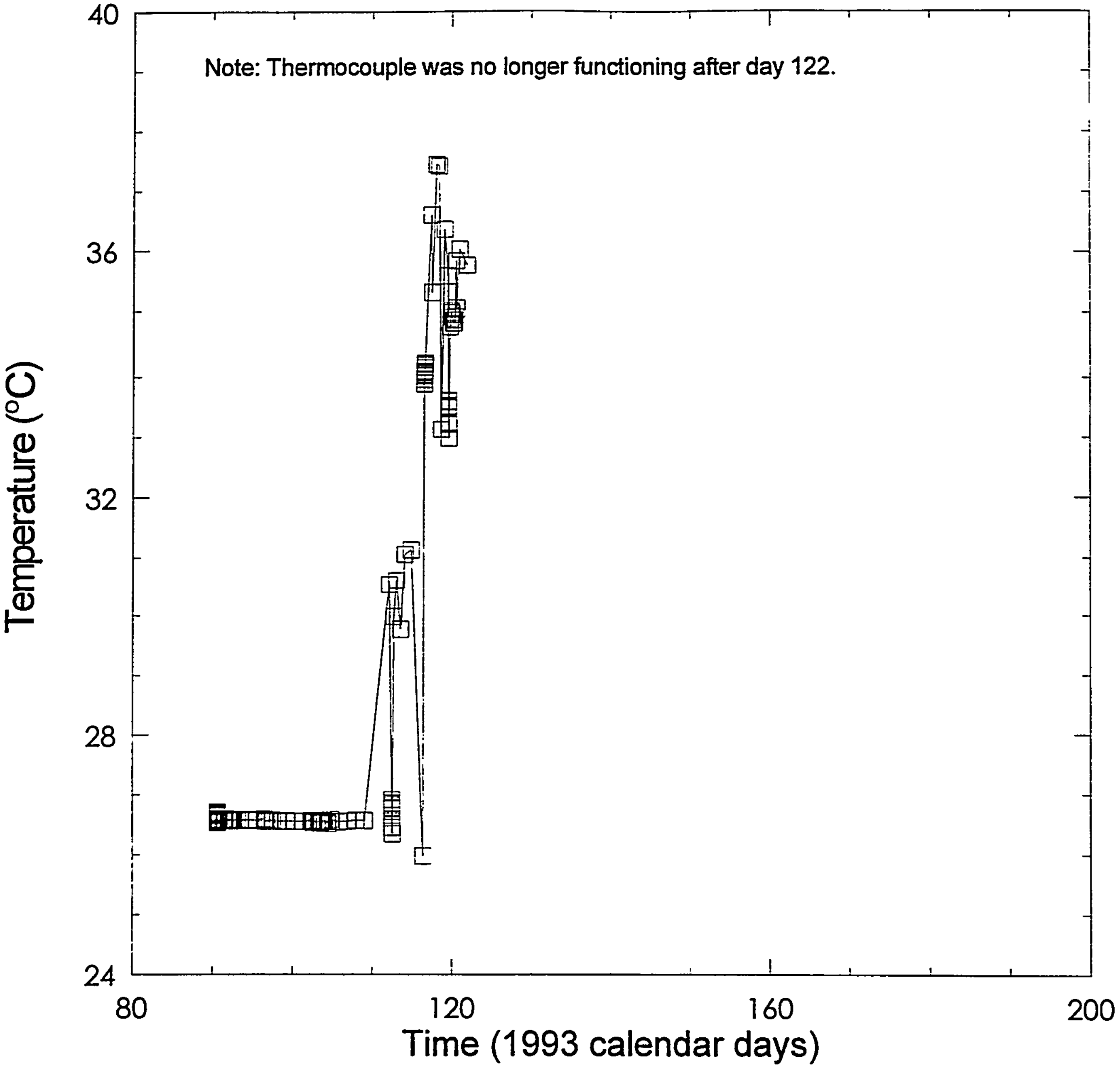

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Figure 5-15. Test-zone temperature during testing sequence SCP01-1.

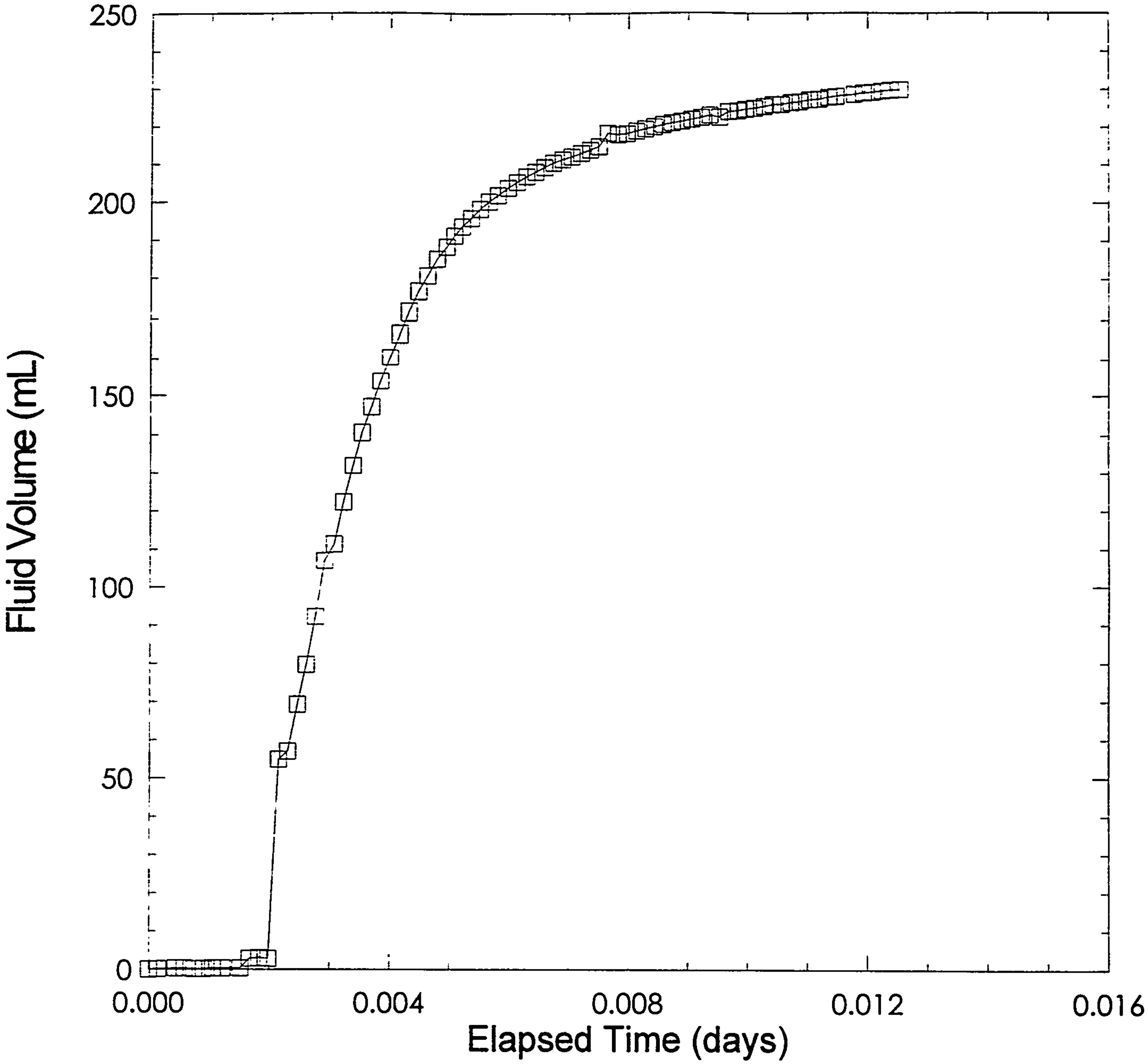

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Figure 5-16. Brine-injection volume of test-zone compressibility test during testing sequence SCP01-1.

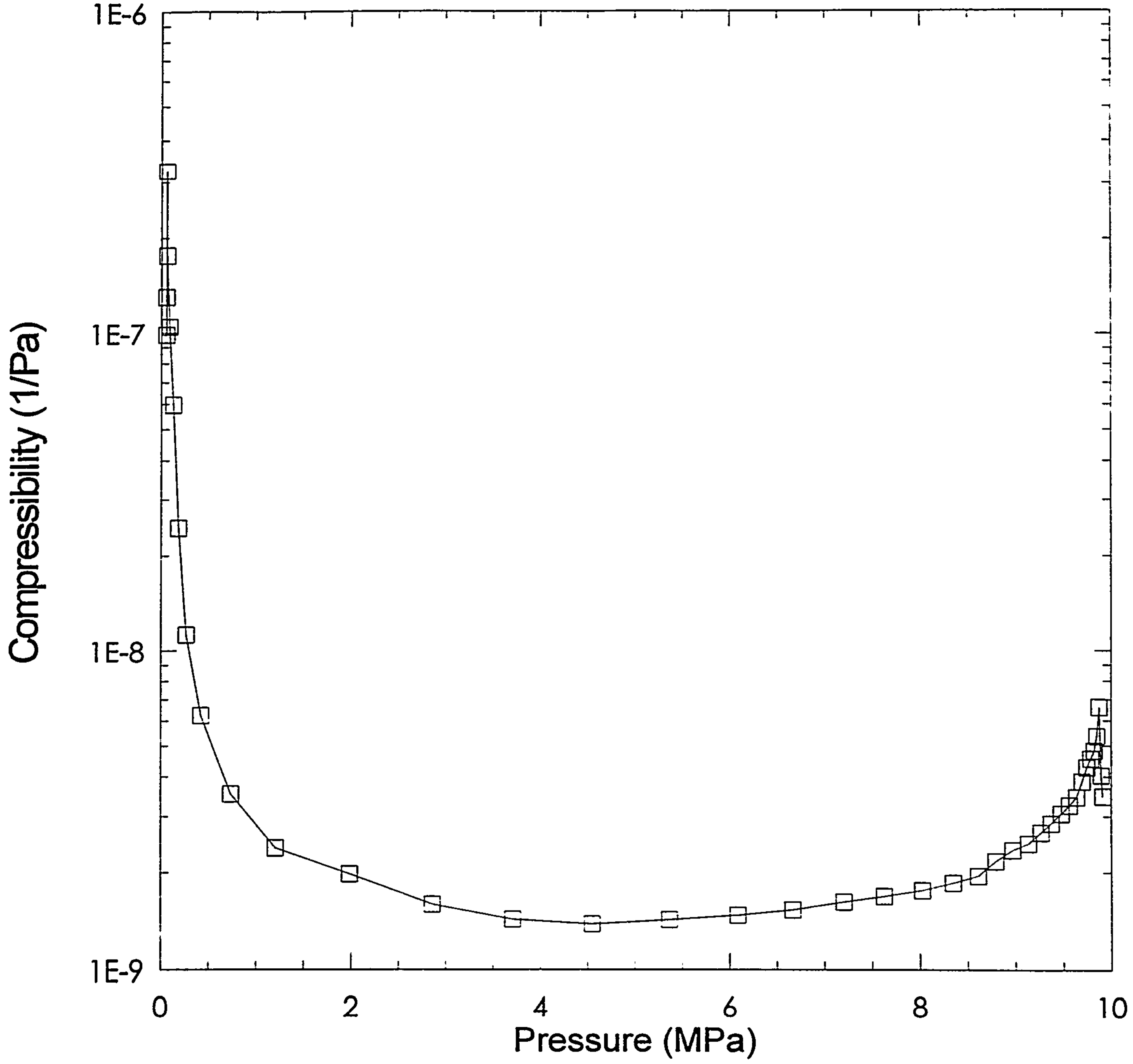

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Figure 5-17. Calculated test-zone compressibility as a function of pressure obtained from test-zone compressibility test during testing sequence SCP01-1.

5.6.1.2 GAS-THRESHOLD-PRESSURE TESTING SEQUENCE SCP01-2

The last testing sequence was also conducted in the Core Storage Library in borehole SCP01. The objective and result of this testing sequence was to conduct a successful test sequence in MB139 in borehole SCP01 where equipment problems were encountered during the previous attempt. In test sequence SCP01-2, Baker packers were used to isolate MB139. It was decided to use these packers rather than Baski or TAM packers because of their longer seal length and on the basis of previous experiences in problematic boreholes. Table 5-6 gives a detailed description of the events that occurred during test sequence SCP01-2.

Table 5-6. Testing Sequence SCP01-2 Events

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Depressurize TZ of the long-term test tool.	4-13-94	103	103	10:22:00
Deflate TZP.	4-13-94	103	103	10:23:00
Remove single-packer, long-term test tool.	4-13-94	103	103	11:30:00
Install double-packer test tool with Baker packers (TZ monitors MB139) as indicated in tool configuration diagram #1 (Figure 5-7).	4-14-94	104	104	14:30:00
Inflate TZP to ~13.8 MPa via accumulator.	4-14-94	104	104	15:00:00
Inflate GZP to ~13.8 MPa via accumulator.	4-14-94	104	104	15:01:00
Begin data file SCP01B07.	4-15-94	105	105	12:27:39
Pressurize TZ via DPT panel to ~5.5 MPa for TZ compressibility test.	4-15-94	105	105	13:21:26
Shut in TZ at 5.446 MPa terminating TZ compressibility test.	4-15-94	105	105	13:44:30
Open TZ to accumulator.	4-15-94	105	105	13:47:45
Pressurize GZ to 5.077 MPa.	4-15-94	105	105	13:55:00
Shut in TZ from accumulator.	4-18-94	108	108	15:04:00
End data file SCP01B07.	4-19-94	109	109	09:32:36
Switch DAS from PERM4F to LABTECH in preparation for GTPT.	4-19-94	109	109	09:34:00
Begin data file SCP01B08.	4-21-94	111	111	12:03:45
Incorrect flow meter readings.	4-21-94	111	111	12:00:00
Shut in TZP and GZP from accumulator.	4-27-94	117	117	11:05:00
Increase TZ pressure via accumulator to ~9.4 MPa.	4-27-94	117	117	11:10:00
Shut in TZ from accumulator.	4-28-94	118	118	07:53:00
Flow meter is operating correctly and will be left over night at 1 mL/min open.	4-28-94	118	118	10:46:00
Shut in flow meter and set rate to 0 mL/min.	4-29-94	119	119	09:13:00
Pressurize N_2 injection line to ~9.5 MPa.	5-2-94	122	122	11:38:00
Open TZ to N_2 injection and open vent line to maintain constant TZ pressure during gas/brine exchange #1 in TZ.	5-2-94	122	122	11:49:00
Significant amount of gas flow with brine.	5-2-94	122	122	12:05:00
Shut in TZ (~1980 mL of brine withdrawn).	5-2-94	122	122	12:14:00
Open TZ to continue gas/brine exchange.	5-2-94	122	122	12:16:00

Table 5-6 (Continued). Testing Sequence SCP01-2 Events

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Shut in TZ (~410 mL of brine withdrawn) terminating gas/brine exchange #1 in TZ.	5-2-94	122	122	12:19:00
End data file SCP01B08.	5-3-94	123	123	08:39:58
Depressurize TZ.	5-3-94	123	123	09:02:00
Depressurize GZ.	5-3-94	123	123	09:04:00
Deflate GZP.	5-3-94	123	123	09:08:00
Deflate TZP.	5-3-94	123	123	09:10:00
Remove test tool to extend vent line to the bottom of the borehole.	5-3-94	123	123	14:35:00
TZP was damaged during removal and cannot be used.	5-3-94	123	123	15:00:00
Install single-packer test tool in borehole so that TZ is not open to atmosphere.	5-5-94	125	125	14:32:00
Inflate TZP to ~13.8 MPa.	5-6-94	126	126	10:22:00
Pressurize TZ to ~9.5 MPa.	5-6-94	126	126	10:30:00
Depressurize TZ.	5-6-94	126	126	08:29:00
Deflate TZP.	5-6-94	126	126	08:30:00
Remove single-packer test tool.	5-6-94	126	126	08:45:00
Install double-packer test tool with new Baker elements to original position with a 2.817 m vent line extension to reach the bottom of the borehole as indicated in tool configuration diagram #2 (Figure 5-8).	5-9-94	129	129	13:00:00
Begin data file SCP01B09.	5-9-94	129	129	13:01:12
Inflate TZP to ~15.2 MPa via accumulator.	5-9-94	129	129	13:07:00
Inflate GZP to ~15.2 MPa via accumulator.	5-9-94	129	129	13:29:00
Pressurize TZ to ~6.9 MPa.	5-9-94	129	129	13:45:00
Open TZ to accumulator at ~9.5 MPa.	5-9-94	129	129	13:55:00
Pressurize GZ to ~5.5 MPa.	5-9-94	129	129	13:58:00
Open TZP to accumulator.	5-9-94	129	129	12:48:00
Shut in TZ from accumulator.	5-10-94	130	130	12:42:00
Shut in TZP and GZP from accumulator.	5-11-94	131	131	09:22:00
Decrease GZ pressure to ~5.5 MPa.	5-12-94	132	132	11:39:00
Begin gas/brine exchange #2 in TZ (~24655 mL of brine withdrawn).	5-16-94	136	136	12:33:00
Shut in TZ terminating gas/brine exchange #2 in TZ.	5-16-94	136	136	14:03:00
Open GZP to accumulator at ~8 MPa.	5-17-94	137	137	12:17:00
Pressurize N_2 injection line to ~TZ pressure.	5-17-94	137	137	12:38:00
Open TZ to flow meter set at 2 mL/min beginning gas-injection test #1 in TZ.	5-17-94	137	137	12:56:28
End data file SCP01B09.	5-18-94	138	138	12:40:35
Begin data file SCP01B10.	5-18-94	138	138	12:55:26
Shut in TZ from flow meter because TZ pressure had surpassed N_2 pressure causing anomalous flow readings terminating gas-injection test #1.	5-20-94	140	140	11:50:00
End data file SCP01B10.	5-20-94	140	140	12:11:57
Begin data file SCP01B11.	5-20-94	140	140	12:14:09

Table 5-6 (Continued). Testing Sequence SCP01-2 Events

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
End data file SCP01B11.	5-23-94	143	143	12:40:38
Begin data file SCP01B12.	5-23-94	143	143	13:32:38
End data file SCP01B12.	5-26-94	146	146	11:04:35
Shut in GZP from accumulator.	5-26-94	146	146	11:11:00
Open GZP to full accumulator.	5-26-94	146	146	11:14:00
Pressurize N2 injection line to ~8.7 MPa.	5-26-94	146	146	11:16:00
Begin data file SCP01B13.	5-26-94	146	146	11:22:27
Open TZ to flow meter set at 0.2 mL/min beginning gas-injection test #2 in TZ.	5-26-94	146	146	11:24:46
End data file SCP01B13.	5-27-94	147	147	12:27:25
Begin data file SCP01B14.	5-27-94	147	147	12:30:39
End data file SCP01B14.	5-31-94	151	151	11:59:20
Begin data file SCP01B15.	5-31-94	151	151	12:19:59
End data file SCP01B15.	6-1-94	152	152	10:42:02
Begin data file SCP01B16.	6-1-94	152	152	10:44:29
End data file SCP01B16.	6-2-94	153	153	13:38:54
Begin data file SCP01B17.	6-2-94	153	153	13:41:09
End data file SCP01B17.	6-3-94	154	154	11:23:42
Begin data file SCP01B18.	6-3-94	154	154	11:26:49
Shut in TZ from flow meter terminating gas-injection test #2 in TZ.	6-3-94	154	154	11:58:00
End data file SCP01B18.	6-20-94	171	171	12:05:04
Begin data file SCP01B19.	6-20-94	171	171	12:25:40
End data file SCP01B19.	6-27-94	178	178	11:07:08
Shut in GZ from accumulator.	8-2-94	214	214	09:01:00
Depressurize TZ.	8-2-94	214	214	09:14:00
Depressurize GZ.	8-2-94	214	214	09:15:00
Deflate GZP.	8-2-94	214	214	09:21:00
Deflate TZP.	8-2-94	214	214	09:22:00
Remove GTPT tool #BOT-02 from borehole	8-2-94	214	214	13:00:00

Figures 5-18 through 5-22 illustrate the zone pressures, packer pressures, nitrogen-injection rate, fluid-injection volume during test-zone compressibility tests, and the test-zone compressibility as a function of pressure, respectively, during testing sequence SCP01-2.

Table 5-7 indicates the equipment that was used and the duration that each instrument was used during testing sequence SCP01-2.

Table 5-7. Testing Sequence SCP01-2 Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	4-15-94	4-18-94
DAS Software	N/A	LABTECH 4.1.0	4-18-94	6-29-94
DCU (HP3497A)	N/A	2629a21996	4-15-94	4-18-94
DCU (HP75000)	N/A	3035a01445	4-18-94	6-29-94
Transducer (Druck D930-18)	Test Zone	609371	4-15-94	6-29-94
Transducer (Druck D930-18)	Test Zone Packer	609370	4-15-94	6-29-94
Transducer (Druck D930-18)	Guard Zone	609375	4-15-94	6-29-94
Transducer (Druck D930-18)	Guard Zone Packer	609372	4-15-94	6-29-94
Transducer (Druck D930-18)	DPT Panel/Mass Flow Meter	609368	4-15-94	6-29-94
DPT (Rosemount 1151DP)	N/A	1140863	4-15-94	4-18-94
Injection Column	N/A	76	4-15-94	4-15-94
Flow Meter (Bronkhorst F-230C-FA-22-V)	N/A	921209a	4-18-94	6-29-94

* Installed dates for injection columns refer to dates of initial use rather than date installed.

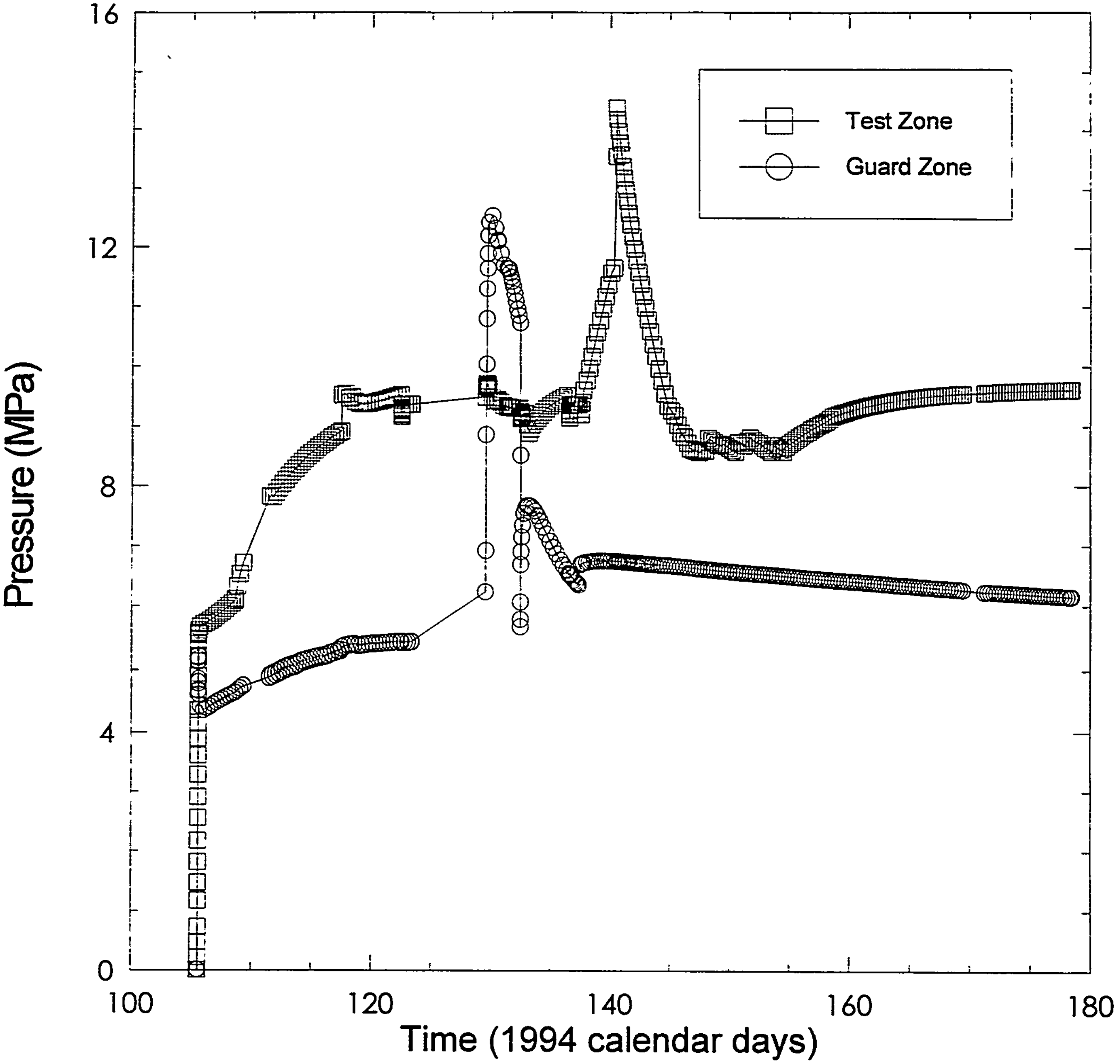

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Figure 5-18. Zone pressures during testing sequence SCP01-2.

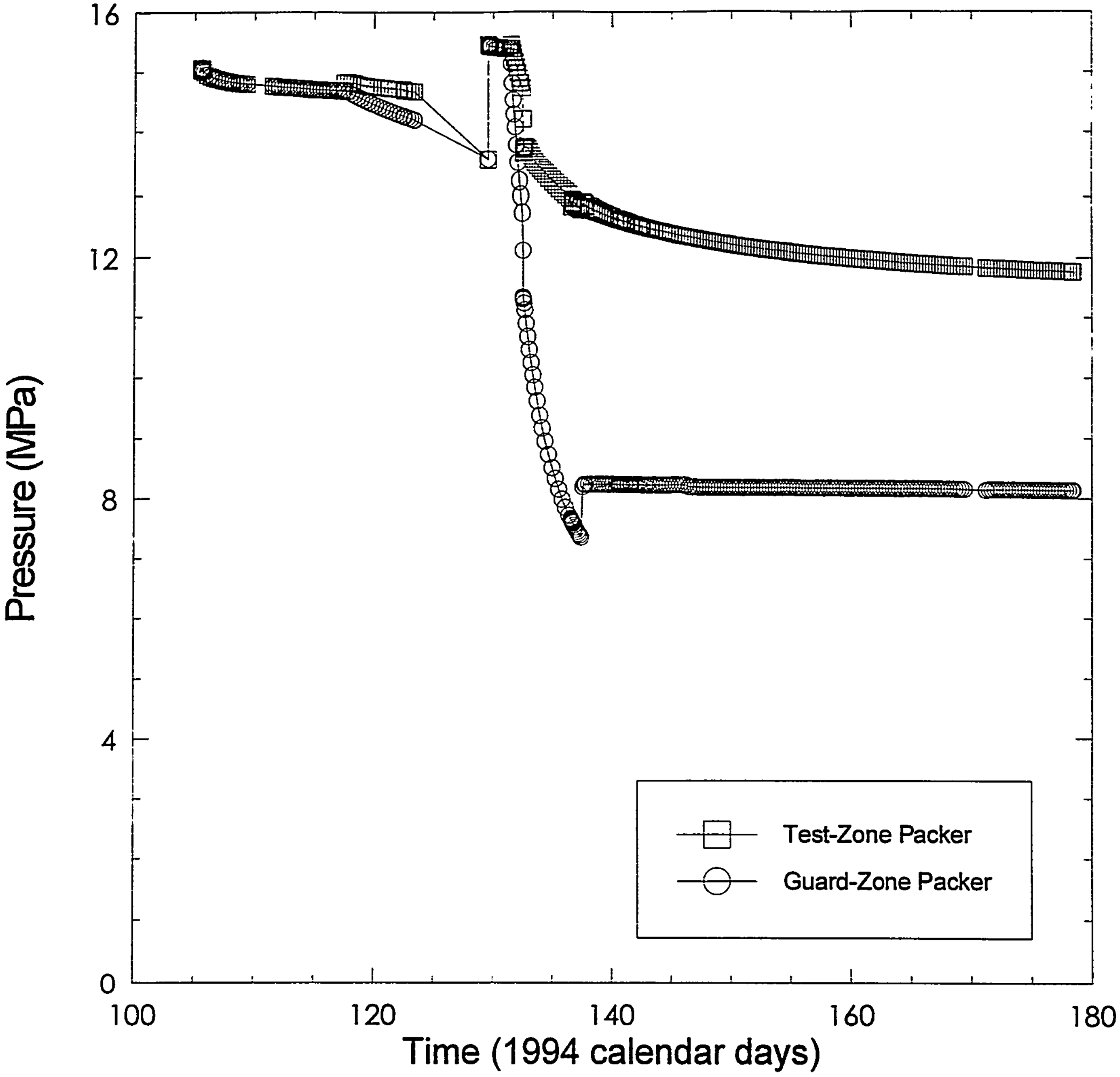

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Figure 5-19. Packer pressures during testing sequence SCP01-2.

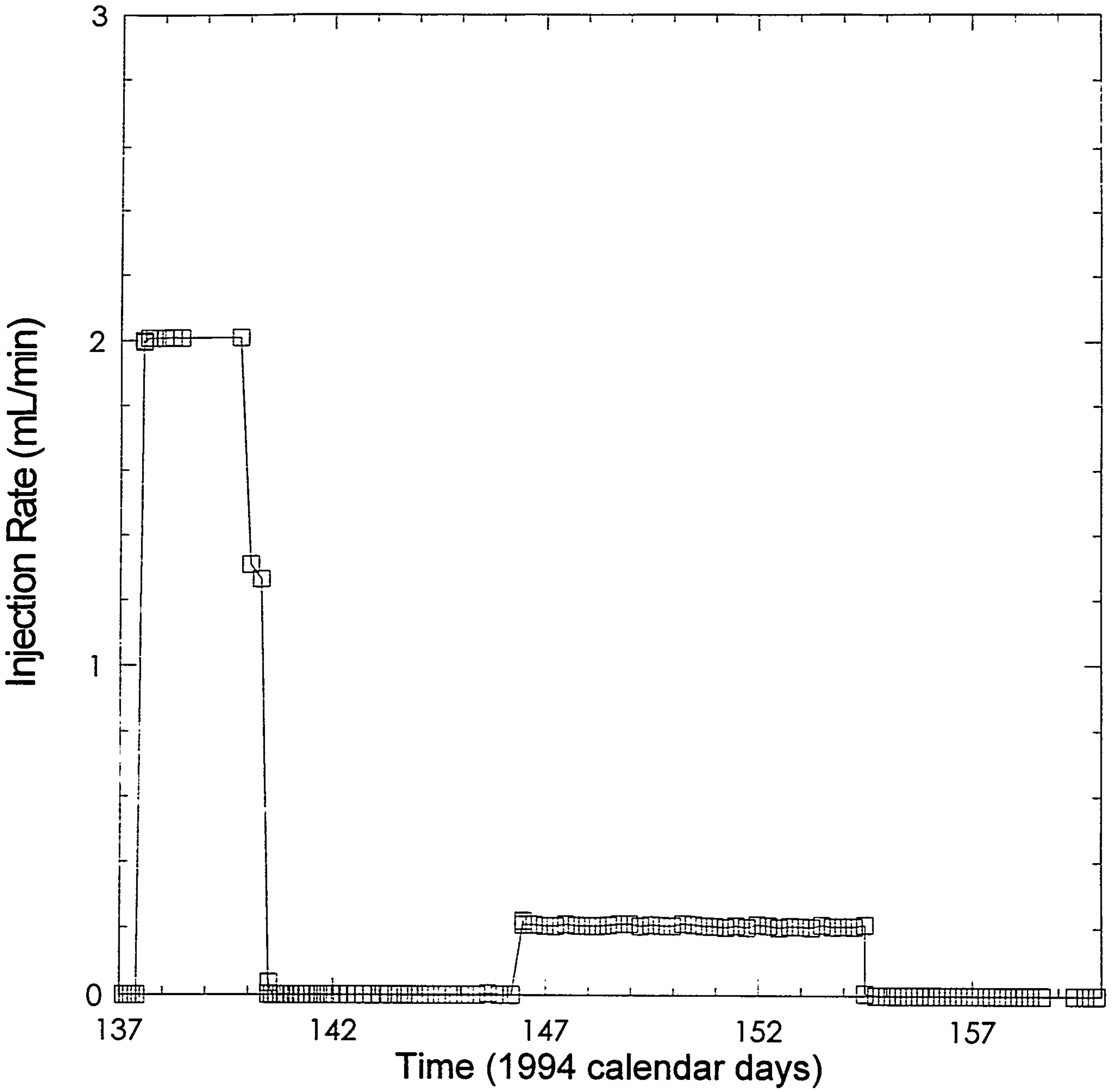

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Figure 5-20. Nitrogen-injection rate during testing sequence SCP01-2.

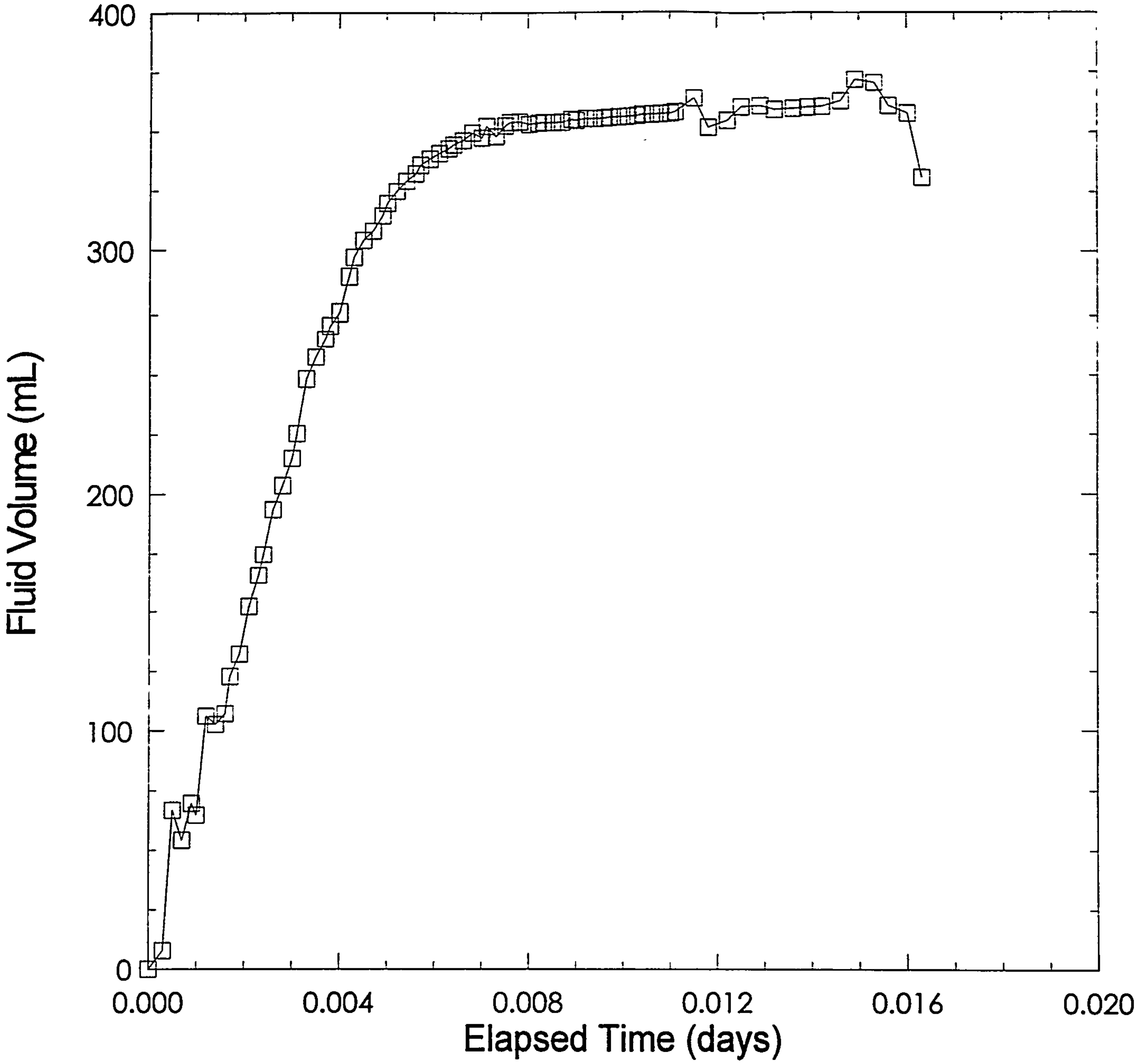

Figure 5-21. Brine-injection volume of test-zone compressibility test during testing sequence SCP01-2.

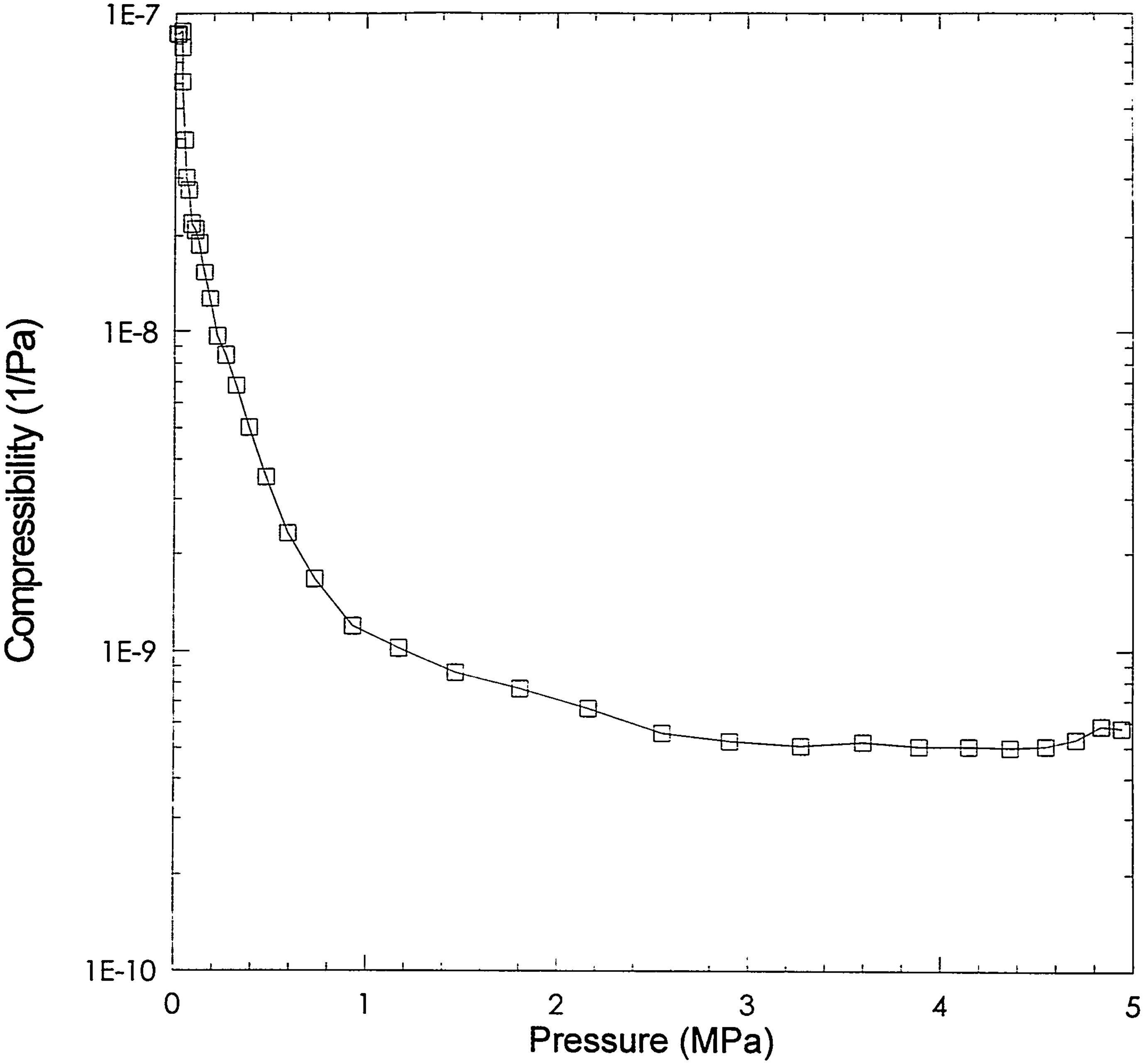

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Figure 5-22. Calculated test-zone compressibility as a function of pressure obtained from test-zone compressibility test during testing sequence SCP01-2.

5.6.2 Gas-Threshold-Pressure Testing in Room C2

Testing sequence C2H02 was also designed to investigate the gas threshold pressure of MB139 in an environment removed from the WIPP excavations. Borehole C2H01 was used as an observation borehole for a portion of testing sequence C2H02. Table 5-8 gives a detailed description of the events that occurred during testing sequence C2H02.

Table 5-8. Testing Sequence C2H02 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Remove long-term tool from borehole.	8-9-93	221	221	08:54:00
Install double-packer test tool as indicated in test-tool configuration diagram #1 (Figure 5-10).	8-10-93	222	222	12:00:00
Begin data file C2H0201.	8-10-93	222	222	12:36:11
Inflate TZP.	8-10-93	222	222	12:36:57
Shut in TZP.	8-10-93	222	222	12:38:57
Inflate GZP.	8-10-93	222	222	12:39:27
Shut in GZP.	8-10-93	222	222	12:42:57
Open TZP to pressure accumulator.	8-10-93	222	222	13:01:27
Open GZP to pressure accumulator.	8-10-93	222	222	13:06:27
Circulate brine through TZ to eliminate all possible gas.	8-10-93	222	222	13:22:27
Pressurize TZ via accumulator to ~7.6 MPa.	8-10-93	222	222	13:40:57
Pressurize GZ to ~ 5.2 MPa.	8-10-93	222	222	13:46:57
Shut in GZ.	8-10-93	222	222	13:53:57
Shut in TZ from accumulator.	8-13-93	225	225	09:33:00
Open GZ to accumulator at ~ 5.3 MPa.	8-17-93	229	229	12:55:30
Shut in GZ from accumulator at 4.365 MPa.	8-23-93	235	235	08:37:25
Open GZ to accumulator at ~ 5.5 MPa (power outage).	8-27-93	239	239	13:49:00
Increase GZP pressure via accumulator by ~ 1.5 MPa to ~ 10.8 MPa.	9-6-93	250	250	10:55:05
Shut in GZ from accumulator at 4.786 MPa.	9-8-93	252	252	11:23:35
Withdraw ~ 2 mL of brine from GZ to observe the pressure response.	9-9-93	253	253	08:11:19
End data file C2H0201.	9-9-93	253	253	12:44:23
Begin data file C2H0202.	9-9-93	253	253	12:47:08
Shut in GZP from accumulator at 10.588 MPa.	9-10-93	254	254	10:10:05
Open GZP to accumulator.	9-10-93	254	254	10:16:21
Open GZ to accumulator.	9-10-93	254	254	10:39:24
Shut in TZP from accumulator at 10.708 MPa.	9-10-93	254	254	10:43:54
Shut in GZ from accumulator at 4.783 MPa.	9-10-93	254	254	10:48:54
Perform leak check on the gas injection system at 12.629 MPa.	9-10-93	254	254	12:31:09
Begin gas/brine exchange #1 in TZ.	9-10-93	254	254	13:12:00
Stop gas/brine exchange #1 due to plugging of the flow valve.	9-10-93	254	254	13:16:00

Table 5-8 (Continued). Testing Sequence C2H02 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Resume gas/brine exchange #1 removing ~1760 mL of brine prior to gas flow.	9-10-93	254	254	13:33:04
Shut in TZ at 8.380 MPa terminating gas/brine exchange #1 in TZ.	9-10-93	254	254	13:40:04
Begin N_2 injection at 3 mL/min.	9-13-93	257	257	10:21:46
Flow meter is not responding properly.	9-13-93	257	257	10:24:26
Shut in TZ.	9-13-93	257	257	10:29:16
Open flow meter to TZ at 8.361 MPa.	9-14-93	258	258	08:52:30
Begin N_2 injection at 3 mL/min.	9-14-93	258	258	08:59:45
Increase TZP pressure via accumulator and leave accumulator on line.	9-20-93	263	263	16:04:12
Shut in TZP from accumulator.	9-21-93	264	264	09:39:00
Switch P5 (#321768) from flow meter to DPT panel.	9-22-93	265	265	11:51:40
End data file C2H0202.	9-24-93	267	267	12:47:09
Begin data file C2H0203.	9-24-93	267	267	13:10:21
Increase TZP pressure via accumulator and leave accumulator on line.	9-24-93	267	267	13:26:19
End data file C2H0203.	9-28-93	271	271	11:15:05
Disconnect flow meter and P5 (#321768) from the DAS.	9-28-93	271	271	12:25:00
Begin data file C2H0204.	9-28-93	271	271	12:52:57
Reconnect the flow meter to the DAS.	9-28-93	271	271	13:14:00
Switch P5 (#321768) from the DPT panel to C2H01 TZ.	9-28-93	271	271	13:30:00
Shut in TZ from the flow meter terminating gas-injection test in TZ.	9-29-93	272	272	13:37:00
Increase GZP pressure via accumulator to 13.500 MPa and shut in.	9-30-93	273	273	10:26:00
Increase GZ pressure via accumulator to 10.120 MPa and left accumulator on line.	9-30-93	273	273	10:45:00
Shut in GZ from accumulator at 9.036 MPa.	10-8-93	281	281	10:05:00
Perform DPS #1 by decreasing TZ pressure ~ 0.5 MPa (P1 = 10.475 MPa).	10-11-93	284	284	14:31:00
Shut in TZ at 9.970 MPa terminating DPS #1.	10-11-93	284	284	14:32:20
Shut in GZ from accumulator.	10-14-93	287	287	07:25:00
Perform DPS #2 by decreasing TZ pressure ~ 0.25 MPa (P1 = 9.836 MPa).	10-15-93	288	288	08:58:00
Shut in TZ at 9.587 MPa terminating DPS #2.	10-15-93	288	288	08:59:20
Perform DPS #3 by decreasing TZ pressure ~ 0.15 MPa (P1 = 9.565 MPa).	10-19-93	292	292	08:04:00
Shut in TZ at 9.401 MPa terminating DPS #3.	10-19-93	292	292	08:04:50
Perform DPS #4 by decreasing TZ pressure ~ 0.2 MPa (P1 = 9.426 MPa).	10-22-93	295	295	09:22:00
Shut in TZ at 9.227 MPa terminating DPS #4.	10-22-93	295	295	09:23:05
End data file C2H0204.	10-26-93	299	299	11:04:43
Begin data file C2H0205.	10-26-93	299	299	11:34:36
Perform DPS #5 by decreasing TZ pressure ~ 0.2 MPa (P1 = 9.248 MPa).	10-26-93	299	299	11:58:00
Shut in TZ at 9.021 MPa terminating DPS #5.	10-26-93	299	299	11:58:20
Perform DPS #6 by decreasing TZ pressure ~ 0.12 MPa (P1 = 9.073 MPa).	11-1-93	305	305	09:42:00

Table 5-8 (Continued). Testing Sequence C2H02 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Shut in TZ at 8.950 MPa terminating DPS #6.	11-1-93	305	305	09:42:20
Perform DPS #7 by decreasing TZ pressure ~ 0.1 MPa (P1 = 8.975 MPa).	11-11-93	315	315	11:41:00
Shut in TZ at 8.856 MPa terminating DPS #7.	11-11-93	315	315	11:41:20
End data file C2H0205.	11-23-93	327	327	09:27:28
Begin data file C2H0206.	11-23-93	327	327	10:16:33
Deflate TZP in preparation for gas/brine exchange (P1 = 3.872 MPa).	11-23-93	327	327	12:37:45
Begin gas/brine exchange #2 in TZ (injected ~ 4350 mL of brine into borehole).	11-23-93	327	327	12:54:32
Shut in TZ terminating gas/brine exchange #2.	11-23-93	327	327	13:00:00
Perform DPS #8 by decreasing TZ pressure to P1 = 6.837 MPa (no gas in TZ).	11-24-93	328	328	09:58:00
Shut in TZ at 6.837 MPa terminating DPS #8.	11-24-93	328	328	09:59:00
Inflate TZP to ~ 5.5 MPa.	11-24-93	328	328	10:23:00
Test tool moved out of the borehole ~ 4.5 cm as indicated in tool configuration diagram #2 (Figure 5-11).	11-24-93	328	328	10:26:00
Deflate TZP.	11-24-93	328	328	11:01:00
Increase TZ pressure to 7.984 MPa by injecting ~760 mL of brine (no gas).	11-24-93	328	328	11:08:45
Perform pulse-withdrawal in GZ to check for gas (~1020 mL of gassy fluid then ~700 mL of fluid).	11-29-93	333	333	09:51:00
Depressurize zone.	11-29-93	333	333	09:58:00
Inflate TZP to ~ 12 MPa.	11-29-93	333	333	10:06:00
Open TZP to accumulator at ~ 12.5 MPa.	11-29-93	333	333	10:10:00
Increase GZ pressure to 6.200 MPa.	11-29-93	333	333	10:14:00
Increase TZ pressure to 9.140 MPa (circulated brine to eliminate all possible gas).	11-29-93	333	333	10:23:00
Shut in both zones (P1 = 8.931, P3 = 6.178 MPa).	11-29-93	333	333	10:25:35
End data file C2H0206.	12-20-93	354	354	08:23:13
Begin data file C2H0207.	12-20-93	354	354	09:29:54
End data file C2H0207 (end PERM4F DAS software).	12-28-93	362	362	08:56:42
Switch DAS from LABTECH to PERM4F (P5 is not responding properly).	12-29-93	363	363	N/A
Begin data file C2H0208.	12-29-93	363	363	13:25:06
End data file C2H0208.	1-10-94	10	375	11:28:53
Begin data file C2H0209.	1-10-94	10	375	11:29:31
End data file C2H0209.	1-23-94	23	388	09:28:58
Begin data file C2H0210.	1-24-94	24	389	12:17:06
Perform pulse-withdrawal in TZ by decreasing TZ pressure to 6.743 MPa (~10.4 mL of brine removed).	1-24-94	24	389	12:31:00
Shut in TZ.	1-24-94	24	389	12:33:00
End data file C2H0210.	2-16-94	46	411	09:20:23
Begin data file C2H0211.	2-16-94	46	411	09:23:44
End data file C2H0211.	3-4-94	63	434	14:20:41

Table 5-8 (Continued). Testing Sequence C2H02 Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Remove transducer 321768 (C2H01) from system.	3-4-94	63	434	14:30:00
Begin data file C2H0212.	3-4-94	63	434	14:49:44
End data file C2H0212.	3-21-94	80	448	11:17:50
Remove test tool from borehole C2H02.	3-23-94	82	450	14:00:00

Figures 5-23 through 5-27 illustrate the zone pressures, packer pressures, nitrogen-injection rate, and test-zone temperature, respectively, during testing sequence C2H02.

Table 5-9 indicates the equipment that was used and the duration that each instrument was used during testing sequence C2H02.

Table 5-9. Testing Sequence C2H02 Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	LABTECH 4.1.0	8-10-93	12-28-93
DAS Software	N/A	PERM4F	12-29-93	3-21-94
DCU (HP75000)	N/A	3035a01445	8-10-93	9-9-93
DCU (HP75000)	N/A	3035a01445	9-9-93	12-28-93
DCU (HP3497A)	N/A	2629a21989	12-28-93	3-21-94
Transducer (Druck PDCR 910)	C2H02 Guard Zone Packer	308145	8-10-93	3-21-94
Transducer (Druck PDCR 910)	C2H02 Test Zone Packer	308150	8-10-93	3-21-94
Transducer (Druck PDCR 910)	C2H02 Test Zone	322422	8-10-93	3-21-94
Transducer (Druck PDCR 910)	C2H02 Guard Zone	507864	8-10-93	3-21-94
Transducer (Druck PDCR 910)	Mass Flow Meter/C2H01 TZ	321768	9-10-93	3-4-94
Thermocouple (Type E)	C2H02 TZ	1	9-10-93	3-4-94
Flow Meter (Bronkhorst F-230C-FA-22-V)	N/A	921209a	9-10-93	9-28-93

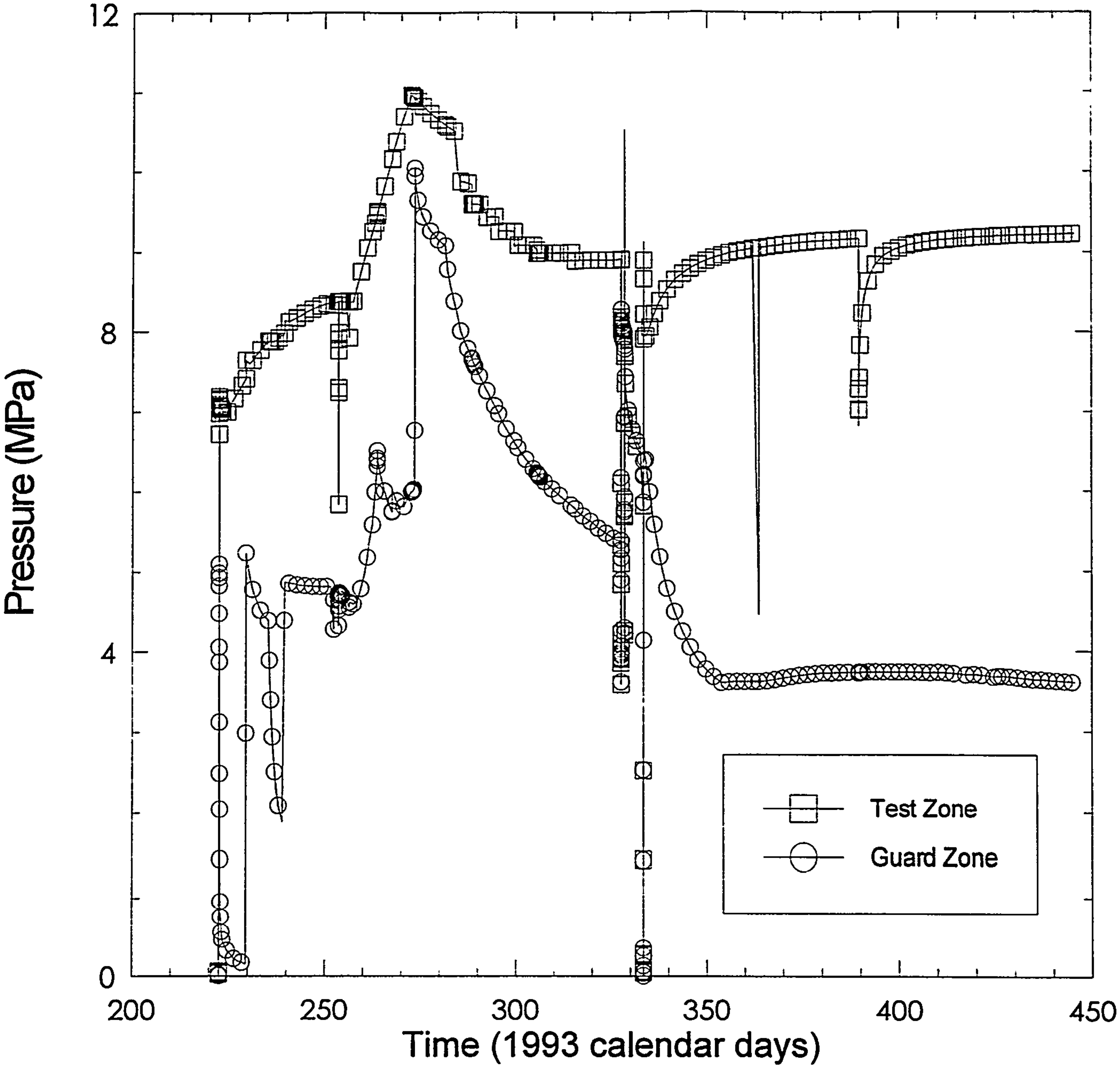

Figure 5-23. Zone pressures during testing sequence C2H02 in test borehole C2H02.

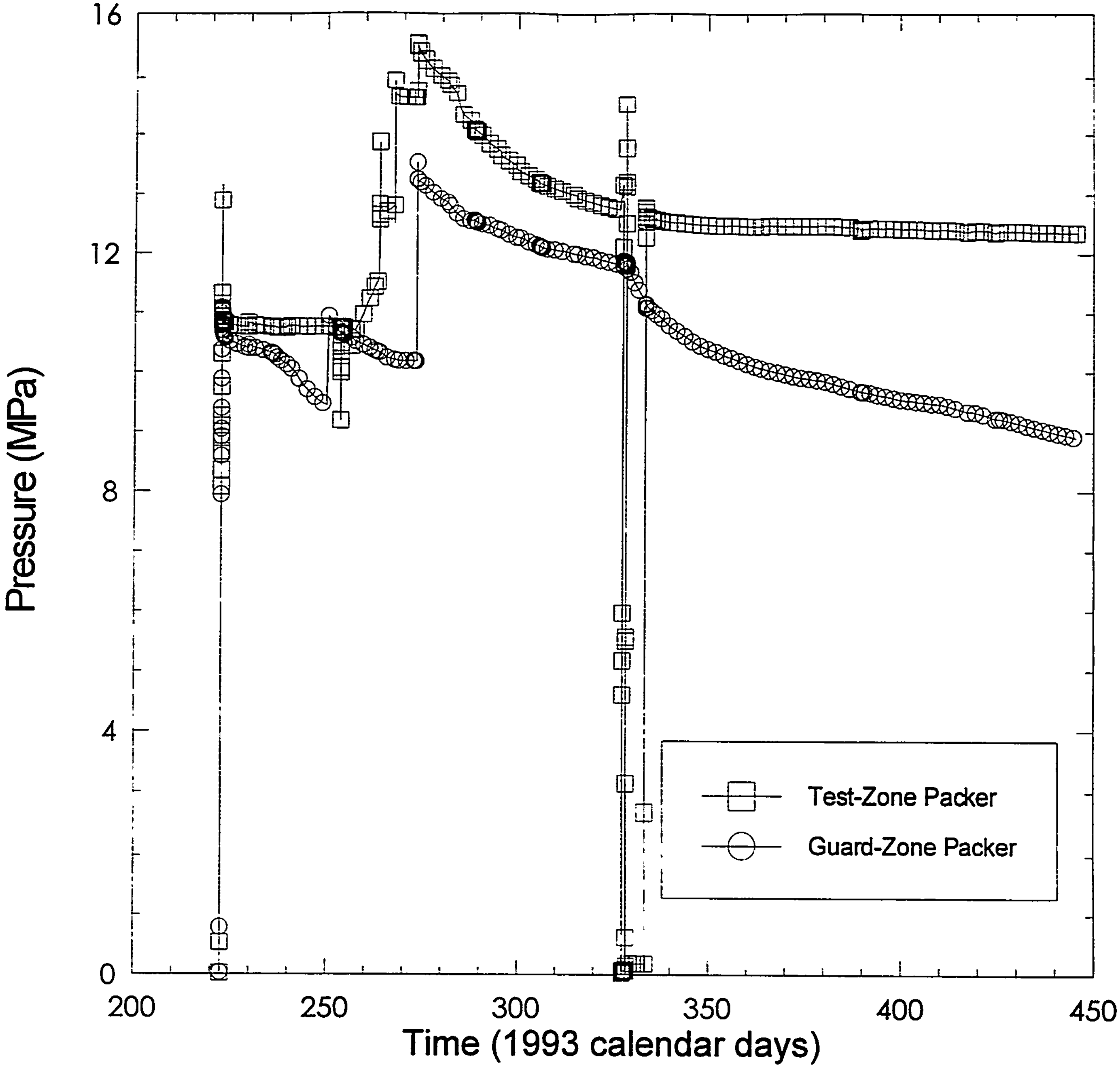

Figure 5-24. Packer pressures during testing sequence C2H02 in test borehole C2H02.

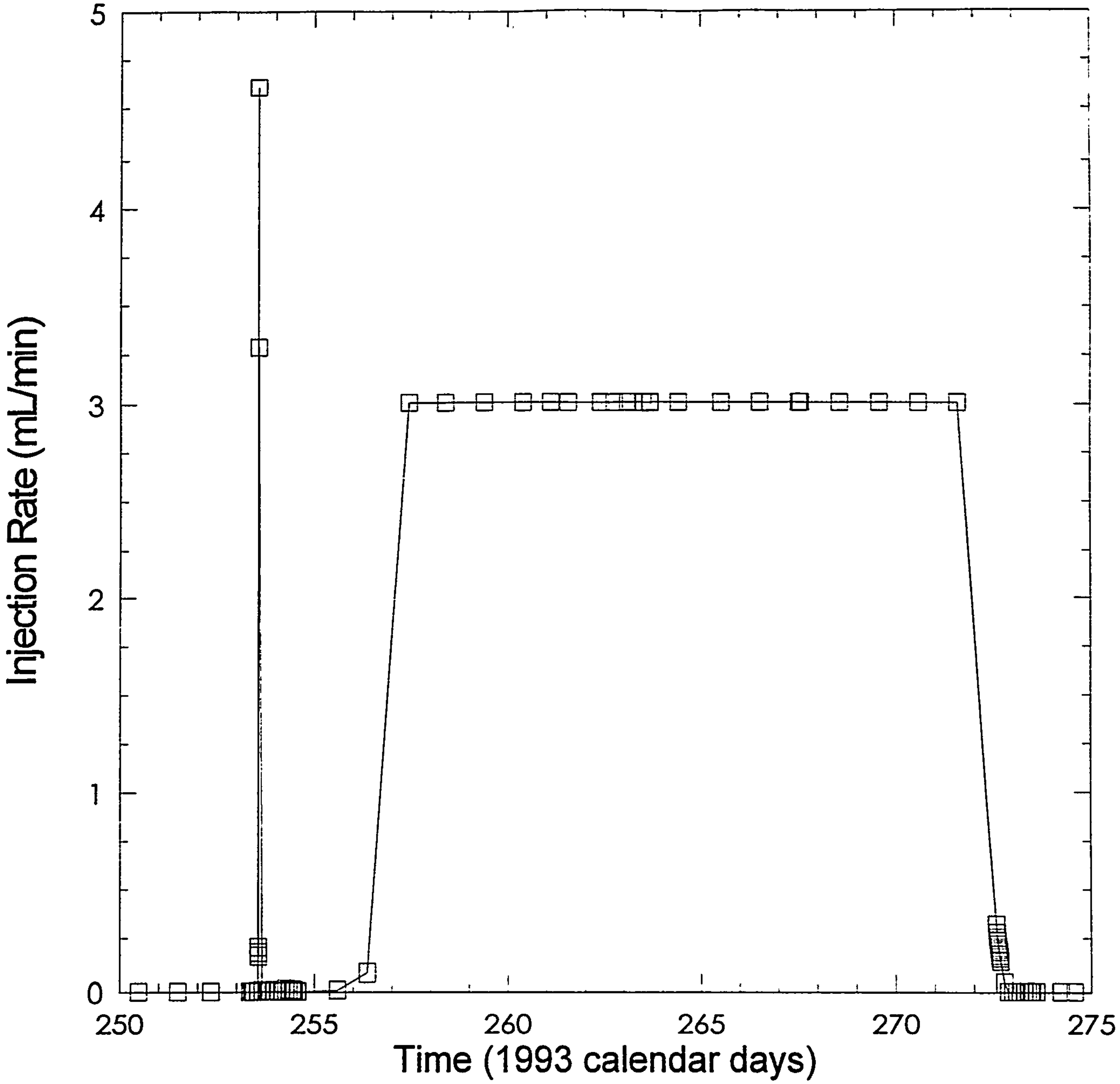

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Figure 5-25. Nitrogen-injection rate during testing sequence C2H02 in test borehole C2H02.

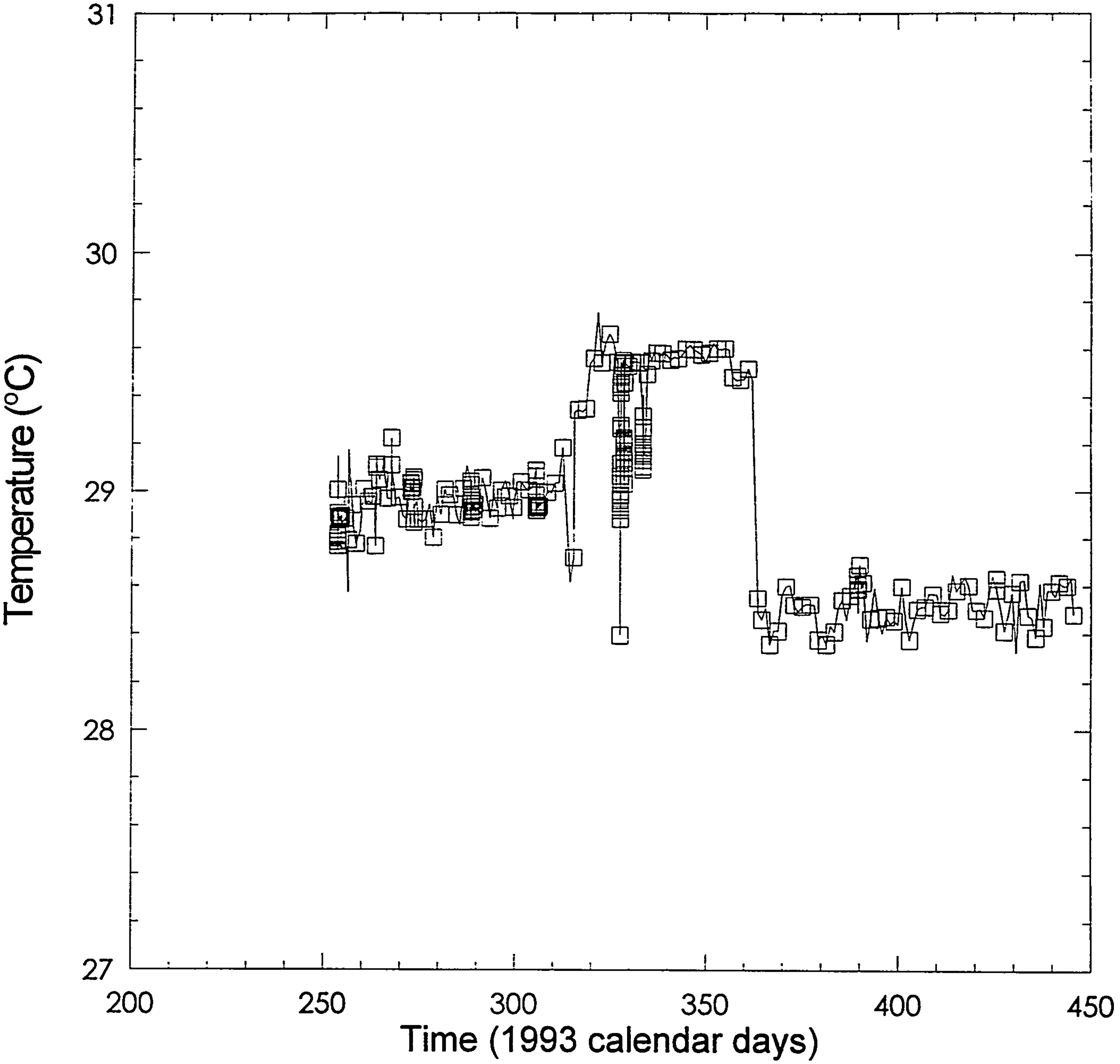

Figure 5-26. Test-zone temperature during testing sequence C2H02 in test borehole C2H02.

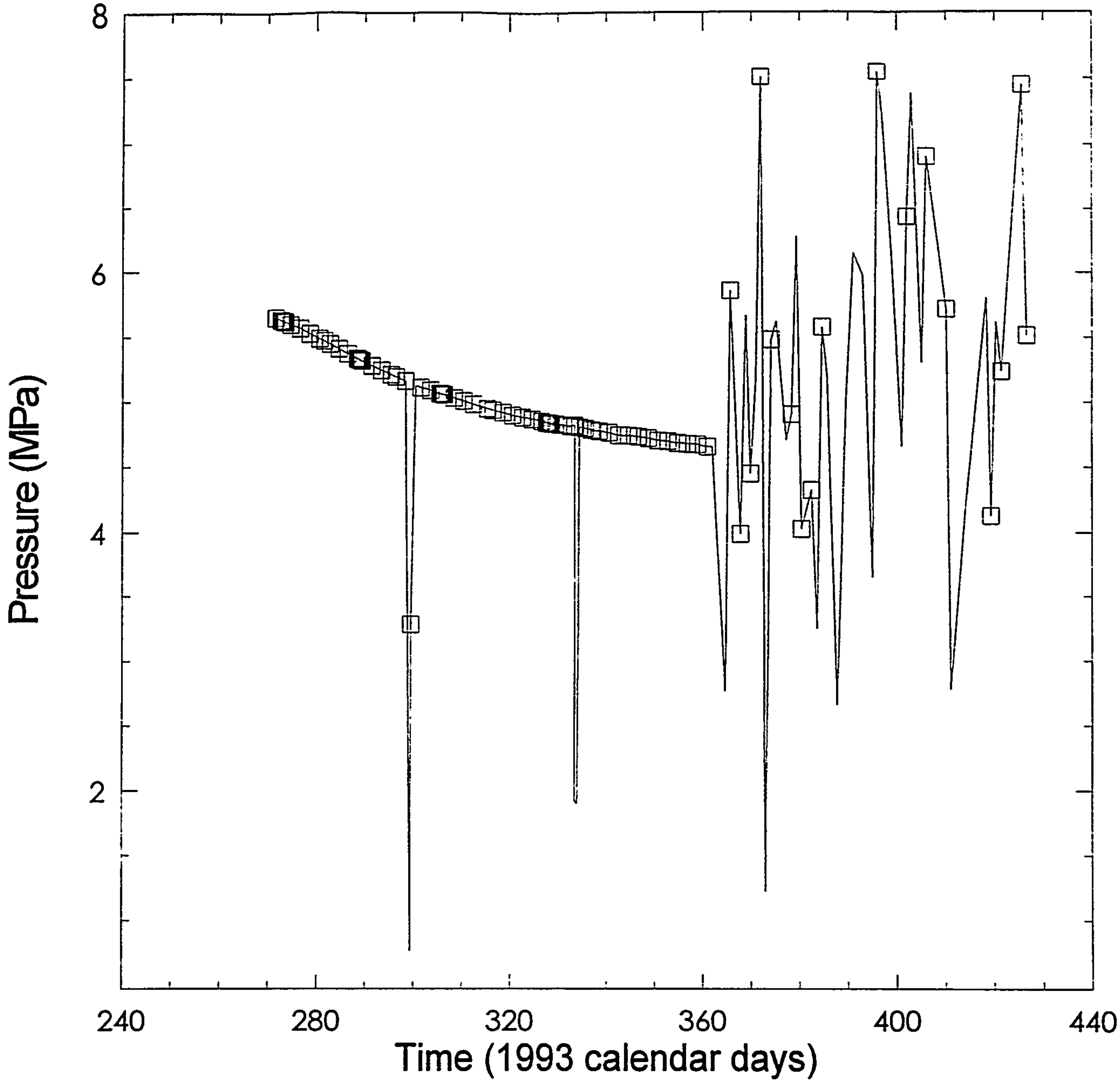

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Figure 5-27. Zone pressure during testing sequence C2H02 in observation borehole C2H01.

5.6.2.1 OBSERVATION BOREHOLE C2H01

Table 5-10 gives a description of the events associated with observation borehole C2H01 during testing sequence C2H02 .

Table 5-10. Events in Borehole C2H01 During Testing Sequence C2H02

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Install single-packer fluid-pressure monitoring tool as indicated in the test-tool configuration diagram (Figure 5-9).	3-13-91	72	N/A	N/A
Switch P5 (#321768) from the DPT panel to C2H01 TZ.	9-28-93	271	271	13:30:00
Remove transducer #321768 from system.	3-4-94	63	434	14:30:00
Terminate data collection.	3-18-94	77	442	11:18:00
Remove test tool from borehole C2H02.	3-23-94	82	447	14:00:00

MB139 in borehole C2H01 was monitored with Druck transducer #321768 during testing sequence C2H02. This transducer was incorporated into the C2H02 DAS and is listed in Table 5-9. Figure 5-27 illustrates the pressure in observation borehole C2H01 during testing sequence C2H02.

5.6.3 Gas-Threshold-Pressure Testing in Room L4

Testing sequence L4P52-B was designed to investigate the gas-threshold pressure of MB138 in an environment removed from the WIPP excavations. Table 5-11 gives a detailed description of the events that occurred during testing sequence L4P52-B.

Table 5-11. Testing Sequence L4P52-B Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Install double-packer test tool #37 as indicated in test-tool configuration diagram (Figure 3-31).	12-16-92	350	N/A	N/A
Change DAS from PERM4F to LABTECH in preparation for GTPT.	12-29-93	363	363	13:01:00
Begin data file L4P52B08.	12-29-93	363	363	13:21:36
Repair a leaking fitting on GZ inject line.	12-30-93	364	364	09:41:00
Deflate TZP in preparation for gas/brine exchange.	12-31-93	365	365	10:35:00
Perform gas/brine exchange #1 by withdrawing ~180 mL of brine.	12-31-93	365	365	11:54:00
Continue gas/brine exchange #1 withdrawing 6300 mL of brine to depressurize zone.	12-31-93	365	365	11:59:00
Deflate GZP.	12-31-93	365	365	13:11:00
Increase GZP pressure via accumulator to ~15 MPa.	12-31-93	365	365	14:00:00
Fill zones with brine.	12-31-93	365	365	14:46:00
Continue gas/brine exchange #1 by withdrawing ~850 mL of brine to expose MB138.	12-31-93	365	365	14:56:00

Table 5-11 (Continued). Testing Sequence L4P52-B Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Increase TZP pressure via accumulator to ~15 MPa.	12-31-93	365	365	15:05:00
Increase TZ pressure to ~8 MPa.	12-31-93	365	365	15:13:00
Increase GZ pressure to ~8 MPa.	12-31-93	365	365	15:15:00
Shut in both packers from accumulator.	1-4-94	4	369	09:45:00
Open both packers to full accumulator.	1-4-94	4	369	10:34:00
Shut in both packers from accumulators, change N_2 bottle.	1-5-94	5	370	13:20:00
Open both packers to accumulator at a higher pressure.	1-5-94	5	370	13:27:00
Increase TZ pressure to ~9.3 MPa.	1-5-94	5	370	13:37:00
Repair leaking fitting on TZ inject line.	1-6-94	6	371	10:22:00
Shut in both packers from accumulator.	1-17-94	17	382	09:58:00
Perform gas/brine exchange #2 by injecting N_2 into TZ to remove ~990 mL of brine because MB138 is not fully exposed.	1-17-94	17	382	10:27:00
Deflate TZP.	1-17-94	17	382	10:33:00
Continue gas/brine exchange #2 by withdrawing ~1000 mL of brine from the zone.	1-17-94	17	382	10:40:00
Inflate TZP to ~15 MPa.	1-17-94	17	382	10:48:00
Pressurize TZ to ~8.7 MPa.	1-17-94	17	382	10:53:00
Pressurize GZ to ~8.3 MPa.	1-17-94	17	382	10:55:00
Open both packers to accumulator at ~15 MPa.	1-17-94	17	382	10:59:00
End data file L4P52B08.	1-25-94	25	390	11:06:19
Begin data file L4P52B09.	1-25-94	25	390	12:12:47
Open TZ to the flow meter for a leak check of the system.	1-25-94	25	390	13:13:40
Open GZ to accumulator at ~10.2 MPa.	1-26-94	26	391	13:23:00
Increase GZ pressure via accumulator to ~9.8 MPa and left N_2 bottle in line.	1-27-94	27	392	09:05:00
Open pressure valve to the flow meter.	1-27-94	27	392	09:16:00
Begin N_2 injection #1 into TZ at 2 mL/min.	1-27-94	27	392	09:18:00
Change N_2 injection rate into TZ to 0.8 mL/min to avoid possible fracture of MB138 terminating gas-injection test #1 and beginning gas-injection test #2.	1-28-94	28	393	14:30:00
Shut in TZ terminating gas-injection test #2.	2-1-94	32	397	10:18:45
Change N_2 injection rate to 0 mL/min.	2-1-94	32	397	10:19:00
End data file L4P52B09.	2-3-94	34	399	10:46:35
Begin data file L4P52B10.	2-3-94	34	399	11:03:58
Recharge GZ accumulator pressure.	2-8-94	39	404	11:14:00
Shut in GZ from accumulator.	2-14-94	45	410	08:52:00
Open GZ to full accumulator at ~14.3 MPa.	2-14-94	45	410	09:12:00
Open pressure valve to flow meter.	2-14-94	45	410	10:53:00
Open flow meter to TZ.	2-14-94	45	410	10:56:00
Begin N_2 injection #3 into TZ at 1.1 mL/min.	2-14-94	45	410	11:00:00

Table 5-11 (Continued). Testing Sequence L4P52-B Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
End data file L4P52B10.	2-14-94	45	410	11:19:06
Begin data file L4P52B11.	2-14-94	45	410	11:42:59
Decrease N_2 injection rate due to faulty regulator on N_2 source terminating gas-injection test #3 in TZ.	2-16-94	47	412	~10:00:00
Correct N_2 injection rate to 1.1 mL/min by tapping on regulator beginning gas-injection test #4 in TZ.	2-16-94	47	412	13:53:00
Shut in TZ terminating gas-injection test #4.	2-18-94	49	414	09:04:00
Change N_2 injection rate to 0 mL/min.	2-18-94	49	414	09:04:20
Inadvertent depressurization of GZ for ~ 2 minutes.	2-18-94	49	414	09:26:00
Repair leaking fitting on GZ accumulator.	2-18-94	49	414	09:34:00
End data file L4P52B11.	2-22-94	53	418	09:52:11
Begin data file L4P52B12.	2-22-94	53	418	10:08:57
UPS malfunction (possible loss of data).	3-3-94	62	427	N/A
Shut in GZ from accumulator.	3-4-94	63	428	12:30:00
Open GZ to full accumulator.	3-4-94	63	428	13:02:00
End data file L4P52B12.	3-4-94	63	428	13:04:12
Begin data file L4P52B13.	3-4-94	63	428	13:39:35
End data file L4P52B13.	3-8-94	67	432	11:36:36
Temporary termination of data collection to calibrate DCU #3035a01445.	3-8-94	67	432	~12:00:00
Replace DCU #3035a01445.	3-9-94	68	433	11:00:00
Begin data file L4P52B14.	3-9-94	68	433	11:53:01
Shut in GZ from accumulator.	3-9-94	68	433	12:44:00
Open GZ to full accumulator.	3-9-94	68	433	13:05:00
Open TZ to flow meter.	3-9-94	68	433	13:09:00
Begin N_2 injection #5 into TZ at 0.6 mL/min.	3-9-94	68	433	13:10:00
Shut in TZ terminating gas-injection test #5.	3-11-94	70	435	13:03:00
Change N_2 injection rate to 0 mL/min.	3-11-94	70	435	13:04:00
Shut in GZ from accumulator.	3-14-94	73	438	09:01:00
Open GZ to full accumulator.	3-14-94	73	438	09:33:00
End data file L4P52B14.	3-14-94	73	438	11:11:06
Begin data file L4P52B15.	3-14-94	73	438	11:21:14
Perform DPS by decreasing TZ pressure from 9.866 MPa to ~9.56 MPa.	3-14-94	73	438	11:25:00
Shut in TZ.	3-14-94	73	438	11:25:42
Shut in GZ from accumulator.	3-18-94	77	442	12:09:00
Open GZ to full accumulator.	3-18-94	77	442	12:23:00
End data file L4P52B15.	3-21-94	80	445	11:36:10
Begin data file L4P52B16.	3-21-94	80	445	12:17:10

Table 5-11 (Continued). Testing Sequence L4P52-B Events

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Shut in GZ from accumulator.	3-24-94	83	448	10:18:00
Open GZ to full accumulator.	3-24-94	83	448	11:02:00
Shut in GZ from accumulator.	3-25-94	84	449	14:03:00
Shut in both packers from accumulator.	3-28-94	87	452	09:55:00
End data file L4P52B16.	3-31-94	90	455	11:27:06
Depressurize TZ.	5-4-94	124	489	10:46:00
Depressurize GZ.	5-4-94	124	489	10:49:00
Deflate GZP.	5-4-94	124	489	10:52:00
Deflate TZP.	5-4-94	124	489	10:54:00
Remove double-packer test tool #37 from borehole L4P52.	5-4-94	124	489	14:26:00

Figures 5-28 through 5-31 illustrate the zone pressures, packer pressures, nitrogen-injection rate, and zone temperatures, respectively, during testing sequence L4P52-B.

Table 5-12 indicates the equipment that was used and the duration that each instrument was used during testing sequence L4P52-B.

Table 5-12. Testing Sequence L4P52-B Equipment

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	LABTECH 4.1.0	12-29-93	4-12-94
DCU (HP75000)	N/A	3035a01445	12-29-93	3-8-94
DCU (HP75000)	N/A	3035a01445	3-9-94	4-12-94
Transducer (Druck PDCR 830)	Test Zone	214048	12-17-92	4-12-94
Transducer (Druck PDCR 830)	Test Zone Packer	214466	12-17-92	4-12-94
Transducer (Druck PDCR 830)	Guard Zone Packer	214470	12-17-92	4-12-94
Transducer (Druck PDCR 830)	Guard Zone	246913	12-17-92	4-12-94
Transducer (Druck PDCR 910)	Mass Flow Meter	308148	1-20-94	4-12-94
Thermocouple (Type E)	Test Zone	1	12-29-93	4-12-94
Flow Meter (Bronkhorst F-230C-FA-22-V)	N/A	921209a	1-20-94	4-12-94

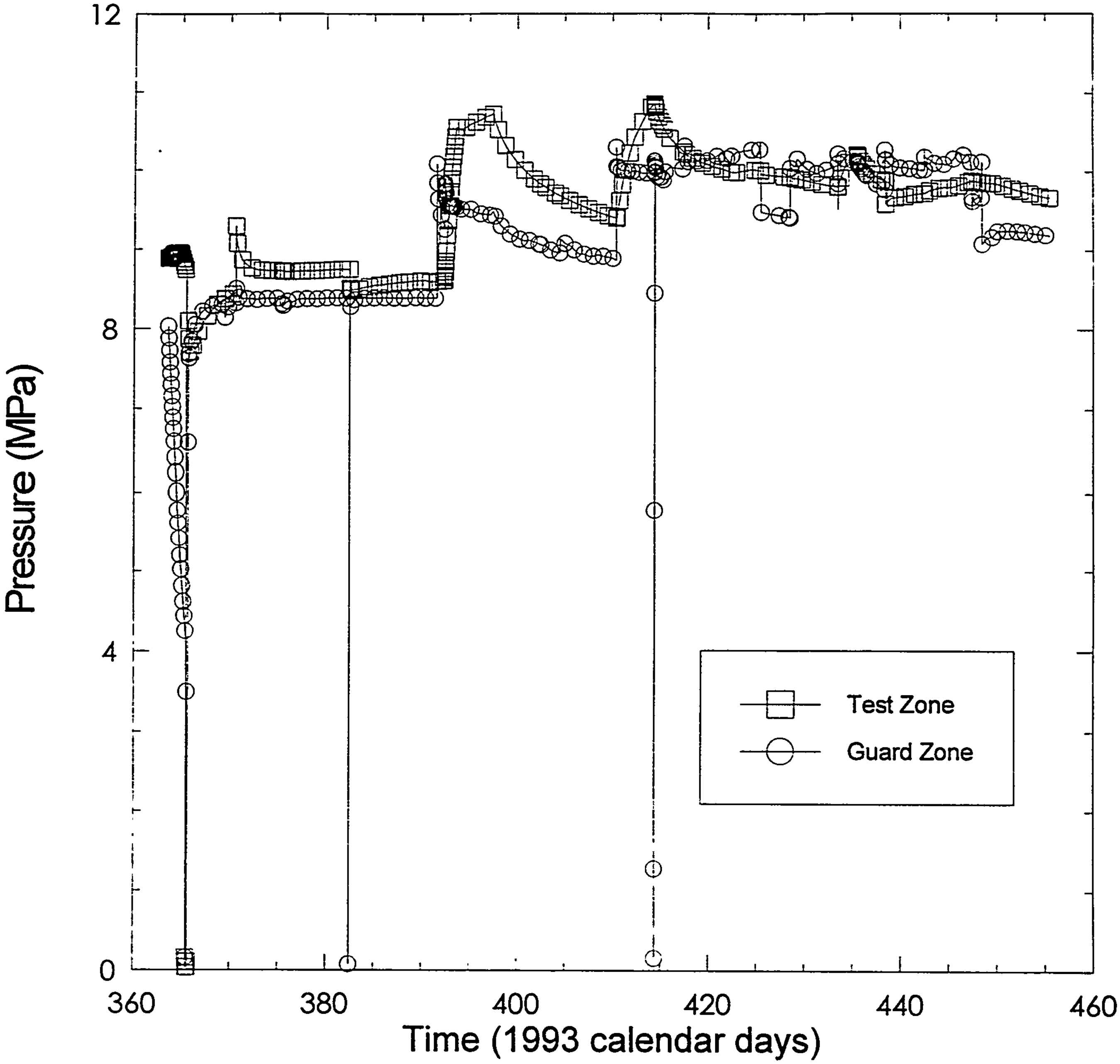

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Figure 5-28. Zone pressures during testing sequence L4P52-B.

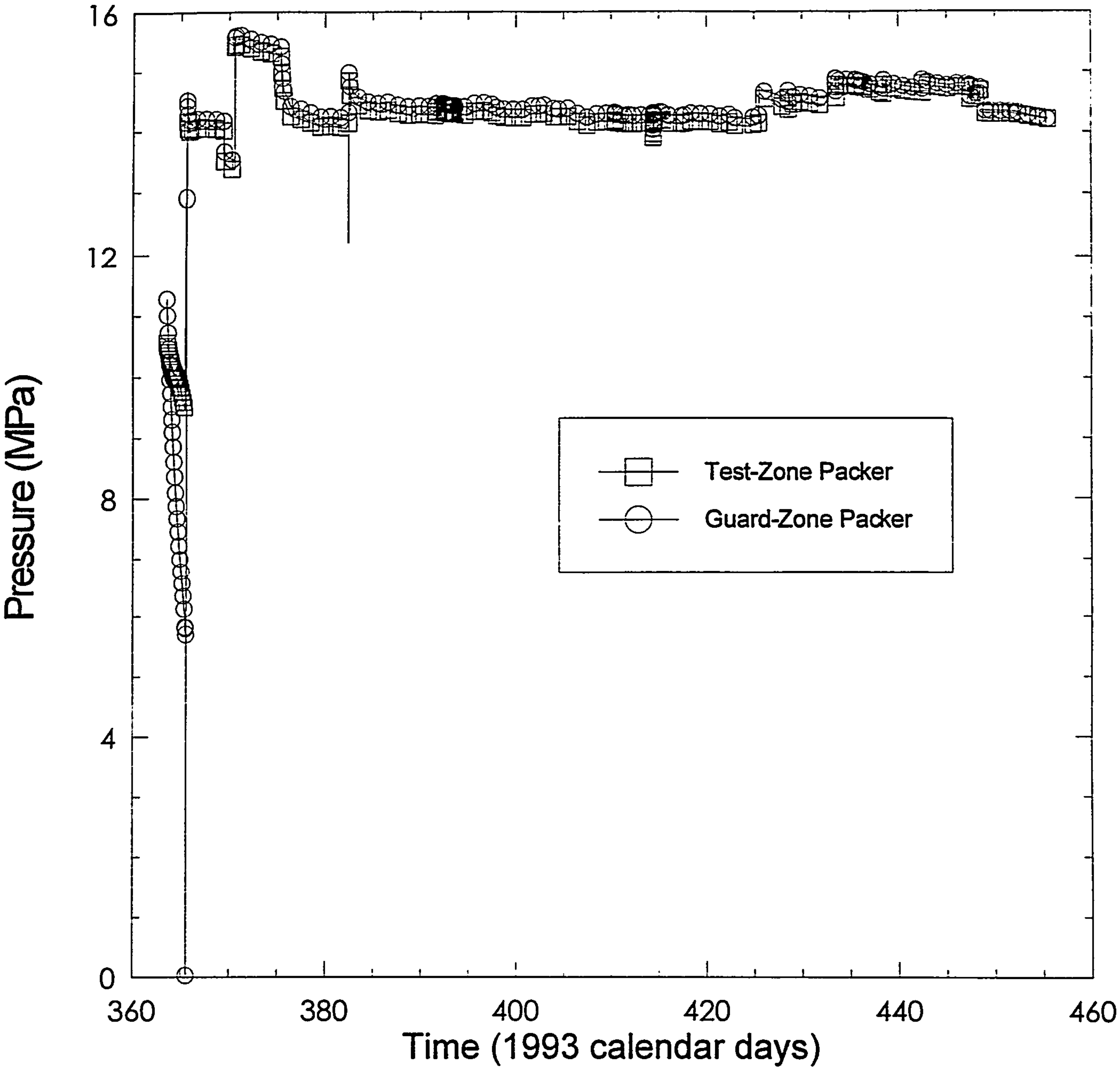

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Figure 5-29. Packer pressures during testing sequence L4P52-B.

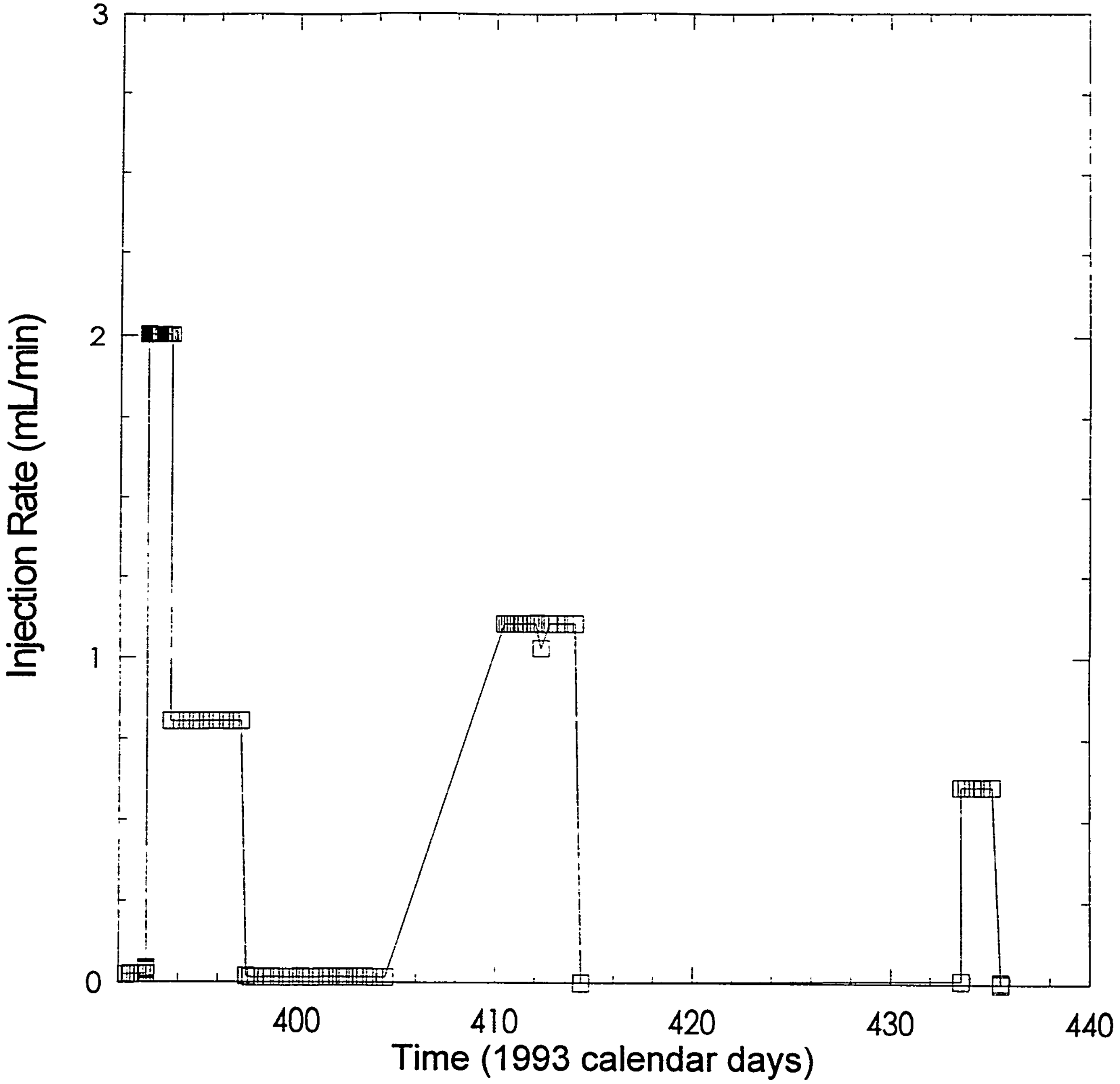

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Figure 5-30. Nitrogen-injection rate during testing sequence L4P52-B.

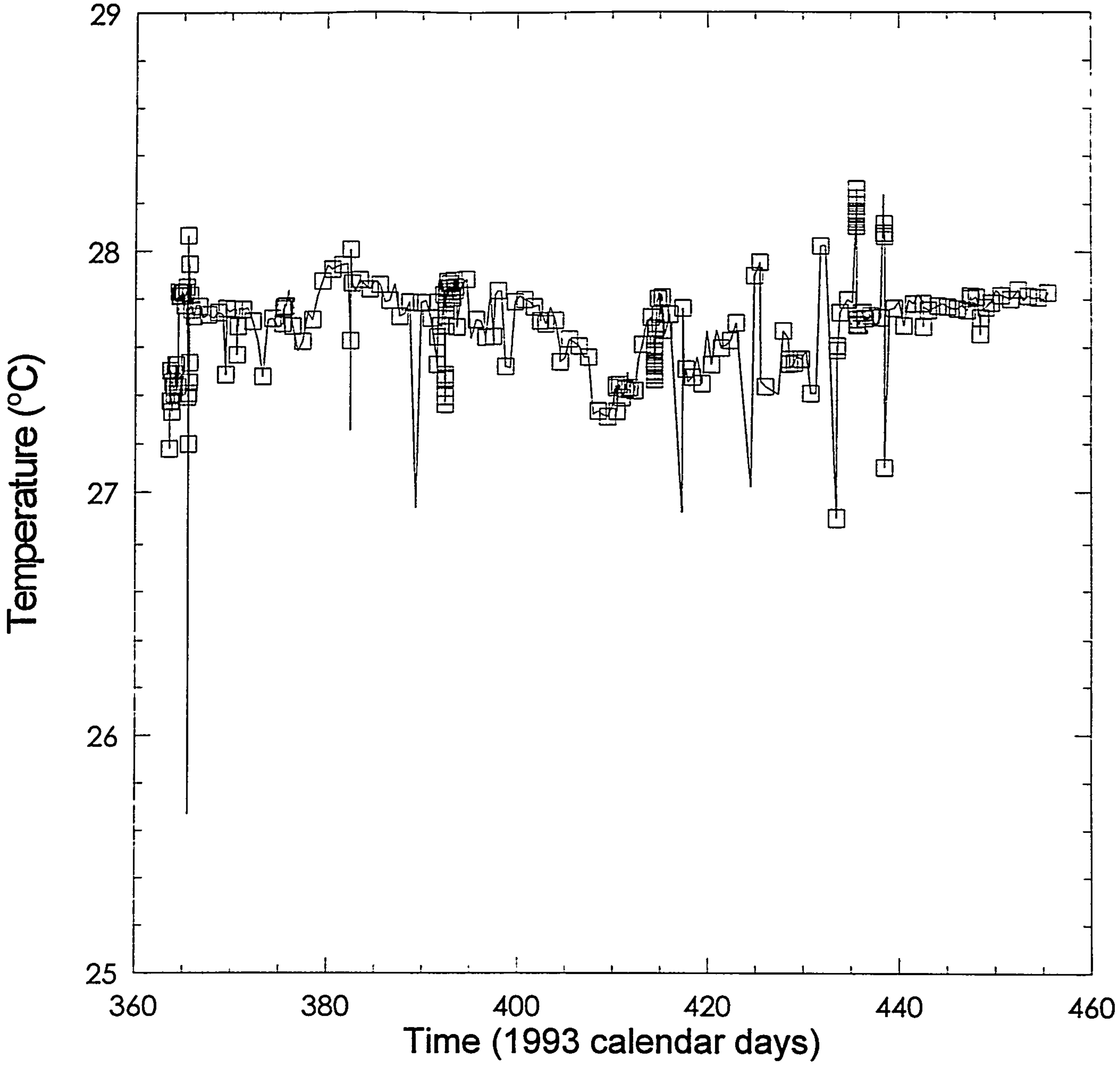

Figure 5-31. Test-zone temperature during testing sequence L4P52-B.

6. COMPLIANCE TESTING

6.1 Compliance-Testing Procedures

Pickens et al. (1987) showed that test-tool movement in response to packer inflation and brine injection or withdrawal can affect fluid-pressure responses in isolated intervals in boreholes in low-permeability media. In particular, packer movement due to packer inflation can cause the packer element to displace brine in isolated intervals. In low-permeability media, such displacement can cause changes in fluid pressure in the test zone. Changes in the shape, volume, or position of the test tool that affect fluid-pressure responses are referred to as compliance. Compliance may also affect the internal pressure of fluid-filled packers as the inflatable synthetic-rubber packer elements stretch or shrink in response to borehole or test-interval changes in pressure or temperature.

To evaluate the magnitude of compliance for the multipacker test tools, compliance tests were performed on each of the test tools prior to installation in test boreholes. The purpose of compliance testing was to (1) establish that the test tools were properly assembled and sealed, (2) to evaluate test-tool responses to packer inflation and applied pressure pulses, and (3) to quantify these test-tool responses by constructing test-zone-compressibility versus pressure relationships. The results of the compliance tests are presented below.

To begin compliance testing, a test tool or portion of a test tool was installed in a pressure-tested stainless-steel chamber that was placed in a borehole in the underground WIPP facility (Figure 6-1). The compliance-testing chamber consisted of a 4.5-inch (11.4-cm) O.D. and 5.1-meter long section of stainless-steel casing. The test chamber was sealed at one end with a welded cap and mated at the other end with a welded blind flange. The test chamber was pressure tested and certified to a maximum allowable working pressure of 1500 psig (10.3 MPa). The test chamber was placed in borehole ENP10 which was drilled in the East 140 drift between the North 1100 and North 1420 drifts for compliance testing (Figure 2-1). The borehole is a 5.5-inch (13.97-cm) diameter, 15.83-meter long borehole, oriented 13° downward from the horizontal. The compliance chamber contained enough brine to completely fill all zones after packer inflation. This testing configuration served to minimize temperature related effects that were previously found to create uncertainty in the compliance-testing results.

After a test tool was installed and before it was secured, all associated monitoring instruments (pressure transducers, linear variable-differential transformers (LVDTs), thermocouples, and differential-pressure transmitters (DPTs)) were connected to the data acquisition system (DAS). The DAS was then activated and the monitoring instruments were checked to verify that they were functioning properly. The test tool was then positioned in the compliance chamber by monitoring the axial-LVDT output signal until the axial LVDT was depressed approximately 5 cm. If no axial LVDT was associated with a given test tool, the test tool was positioned in the compliance chamber to the desired level by test-tool measurements and tubing talleys. The test tool was then secured to the compliance chamber to prevent test-tool movement out of the compliance chamber.

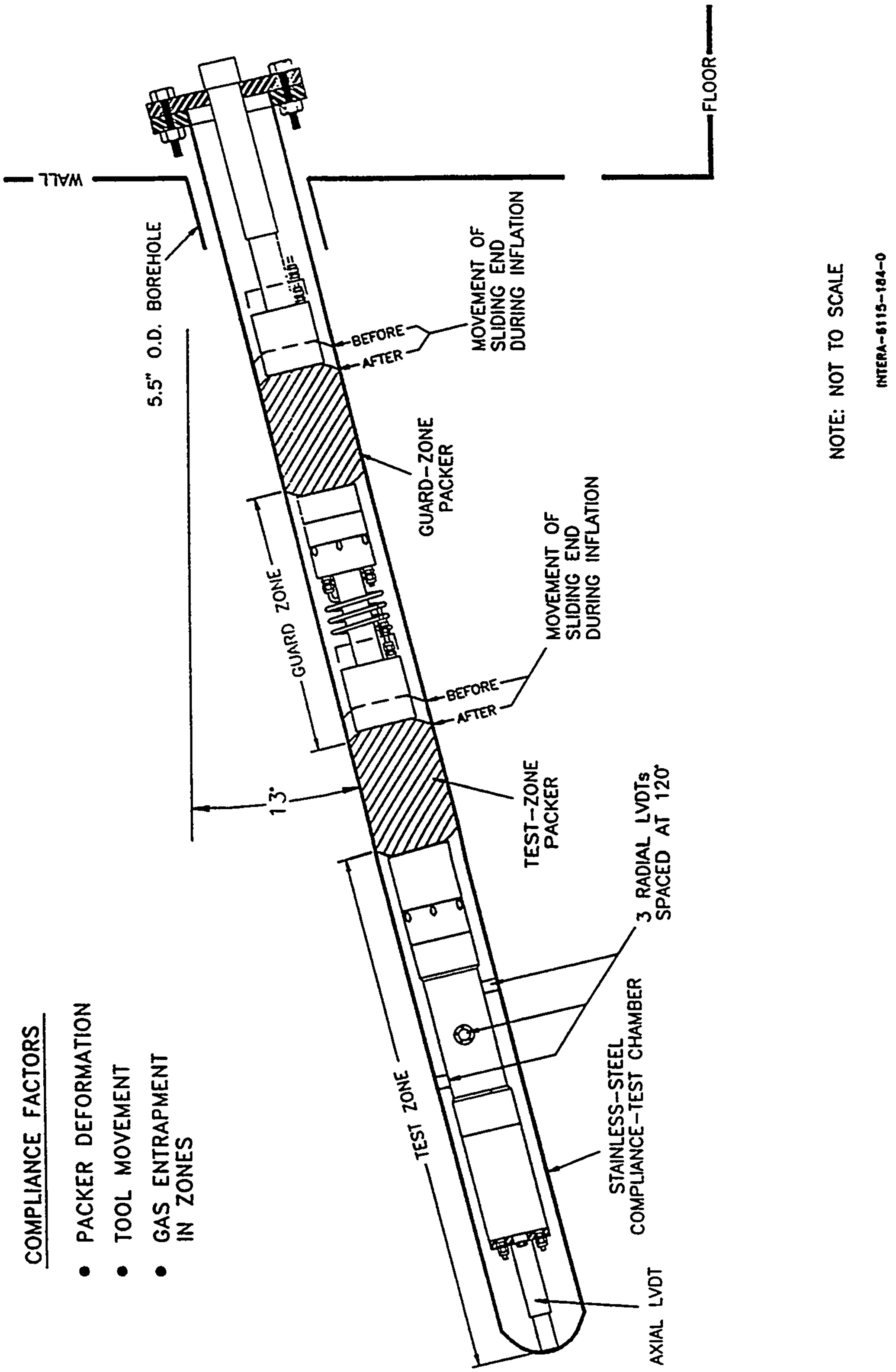

Figure 6-1. Cross-sectional view of stainless-steel chamber for compliance testing.

The test-tool's packers were sequentially inflated to pressures ranging from 10 MPa to 20 MPa with fresh water, uppermost packer first, followed by the next downhole packer, until all packers were inflated. The packer-inflation pressures were monitored for 24 to 48 hours for evidence of leaks or improper performance. Packer-inflation pressures usually decrease during this period due to elasticity of the packer-element material. After monitoring this pressure decay for the 24- to 48-hour period, packer-inflation pressures were usually increased to the approximate original inflation pressure and monitored for an additional 24 to 48 hours.

After satisfactory completion of the leak check/packer-inflation pressure adjustment periods, the packers were usually attached to a pressure-maintenance system prior to applying any pressure to the associated zones. The zones were then subjected to pressure-injection pulses to the maximum pressure that would be expected in the borehole in which the test tool was to be installed (6 MPa to 14 MPa range). The zones' fluid pressure responses were then monitored for evidence of leaks, and the associated packer-inflation pressures were also monitored.

In most instances the test zone, and in some cases the second (guard) zone was subjected to compressibility tests. These tests involved increasing the zone pressure from 0 MPa to maximum expected pressure (6 MPa to 14 MPa range) in a continuous manner while monitoring the fluid volume necessary to provide such a pressure increase through the DPT panel. When maximum pressure was reached, the process was repeated in the reverse direction. Zone compressibility is an important factor in permeability testing performed under shut-in conditions because, given the volume of a zone, the zone compressibility governs the pressure change resulting from the flow of a given amount of fluid into or out of the zone. Beauheim et al., (1993) discusses zone compressibility calculations in detail. These series of tests were generally performed with the packers attached to pressure-maintenance systems. The information obtained from such a series of tests provided the test-zone-compressibility versus pressure relationships for the specific test-tool interval.

6.2 Compliance-Test Data

Table 6-1 provides information pertaining to compliance testing associated with the various testing programs. Complete data files and abridged tabulations of the data are stored in the SWCF under WPO #42269.

Table 6-1. Compliance-Testing Information

Test Tool #	Testing Sequence	Borehole	Testing Performed
none provided	C1X10	C1X10	No
32A	C1X10	C1H05	Yes
32B	C1X10	C1H06	Yes
none provided	C1X10/C1X05-A/C2H02	C2H01	No

Table 6-1 (Continued). Compliance-Testing Information

Test Tool #	Testing Sequence	Borehole	Testing Performed
none provided	C1X10/C1X05-A	DPD02	No
none provided	C1X10/C1X05-A	DPD03	No
33A	L4P51-C1	L4P51	Yes
33B	L4P51-C1	L4P51	Yes
none provided	C1X05-A	C1X05	No
34	C1X05-A	C1H07	Yes
35	S1P74-A	S1P74	Yes
36	C1X05-A	C1X06	Yes
37	L4P52-B	L4P52	Yes
38A	SCP01-1	SCP01	Yes
38B	SCP01-1	SCP01	No
none provided	C1X05-B	C1X05	No
39	C1X05-B	C1H07	Yes
40	C1X05-B	C1X06	Yes
41	L4P51-C2	L4P51	Yes
BOT-01	SCP01-2	SCP01	Yes
BOT-02	SCP01-2	SCP01	No
P51-D1A	L4P51-D1	L4P51	Yes
P51-D1B	L4P51-D1	L4P51	No
P74-B	S1P74-B	S1P74	Yes
P51-D2	L4P51-D2	L4P51	No

Acronyms used in the tables presented in this section are as follows:

TZ = Test Zone
TZ1 = Test Zone 1
TZ2 = Test Zone 2
GZ = Guard Zone

6.2.1 Test Tool #32A (Borehole C1H05, Coupled Permeability and Hydrofracture-Testing Sequences C1X10 and C1X05-A)

Table 6-2 gives a detailed description of the events that occurred during compliance testing of test tool #32A. Figures 6-2 through 6-4 illustrate the zone pressure, packer pressure, and zone temperature, respectively, for test tool #32A. Figure 4-9 illustrates the configuration of test tool #32A as assembled for compliance testing.

Table 6-2. Events Associated with Compliance Testing of Test Tool #32A; Borehole C1H05; Sequence C1X10

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Assemble single-packer test tool #32A to be used in borehole C1H05 during testing sequence C1X10.	1-10-92	10	10	13:43:00
Fill TZ with fresh water.	1-10-92	10	10	14:15:00
Inflate packer to ~10.3 MPa.	1-10-92	10	10	14:30:00
Begin data file COMP32.	1-10-92	10	10	14:32:36
Increase TZ pressure ~6.9 MPa.	1-10-2	10	10	14:35:00
DAS not functioning upon arrival.	1-13-92	13	13	08:55:00
End data file COMP32.	1-13-92	13	13	11:15:20
Begin data file COMP32A.	1-13-92	13	13	11:18:20
End data file COMP32A.	1-15-92	15	15	09:23:01
Remove test tool from compliance chamber and move to borehole C1H05.	1-15-92	15	15	09:25:00

Table 6-3 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #32A. Test tool #32A was used in observation borehole C1H05 during testing sequences C1X10 and C1X05-A.

Table 6-3. Compliance Equipment Associated with Test Tool #32A; Borehole C1H05; Sequences C1X10 and C1X05-A

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	1-10-92	1-15-92
DCU (HP3497A)	N/A	2514a17149	1-10-92	1-15-92
Transducer (Druck PDCR 830)	Test Zone	246917	1-10-92	1-15-92
Transducer (Druck PDCR 830)	Test Zone Packer	246919	1-10-92	1-15-92
Thermocouple (Type E)	Test Zone	1	1-10-92	1-15-92

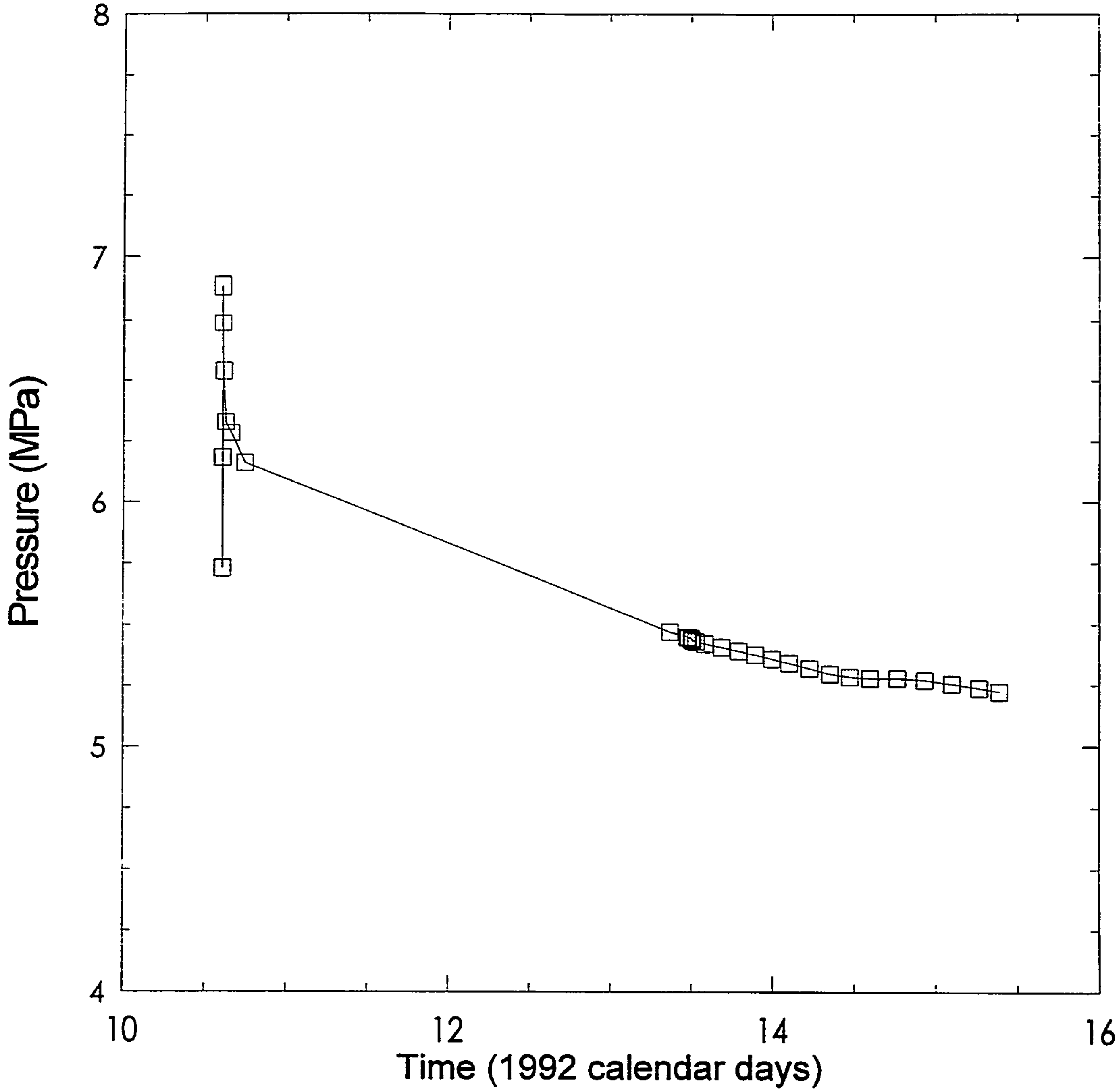

Figure 6-2. Zone pressure during compliance testing of test tool #32A.

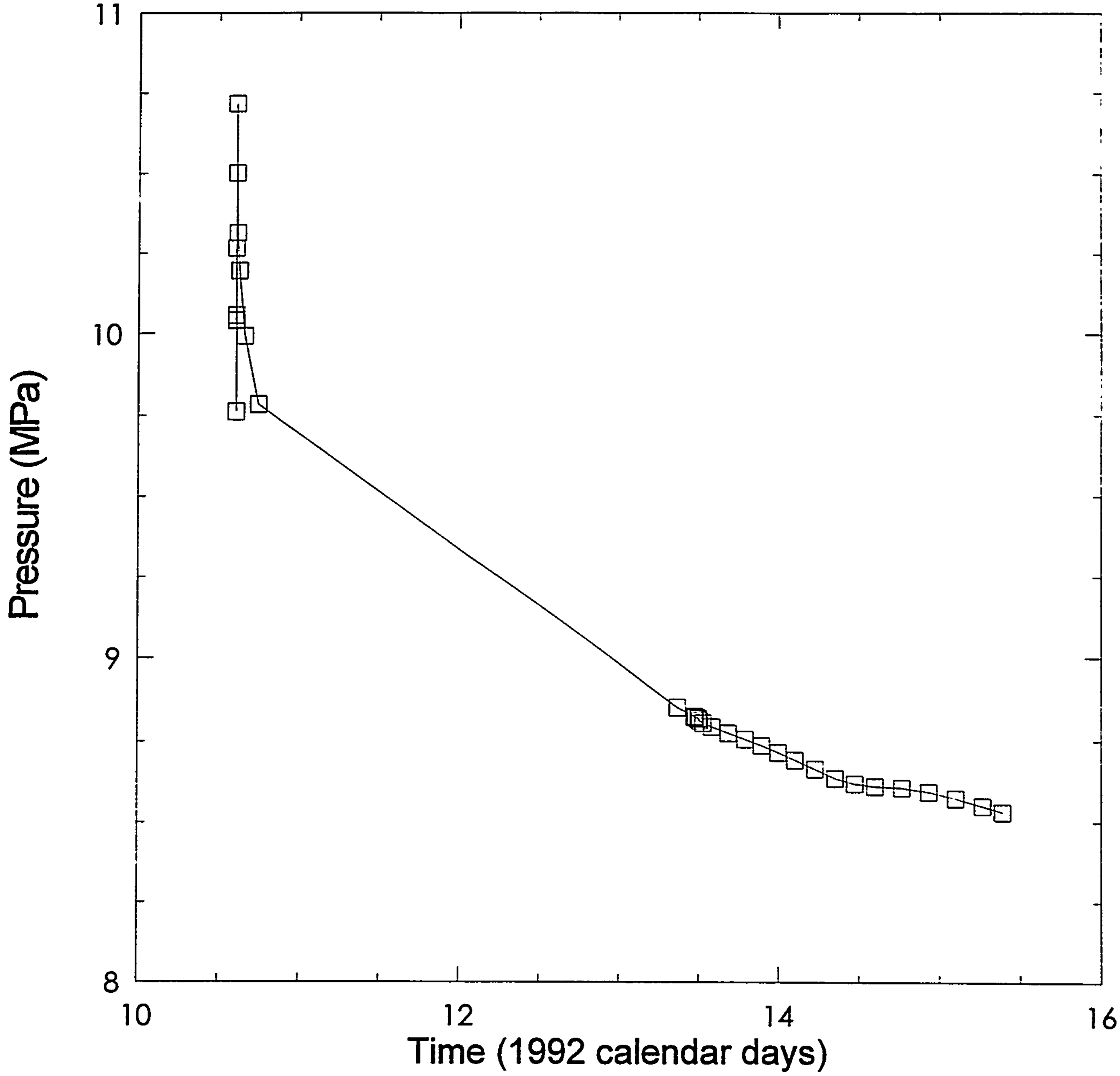

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Figure 6-3. Packer pressure during compliance testing of test tool #32A.

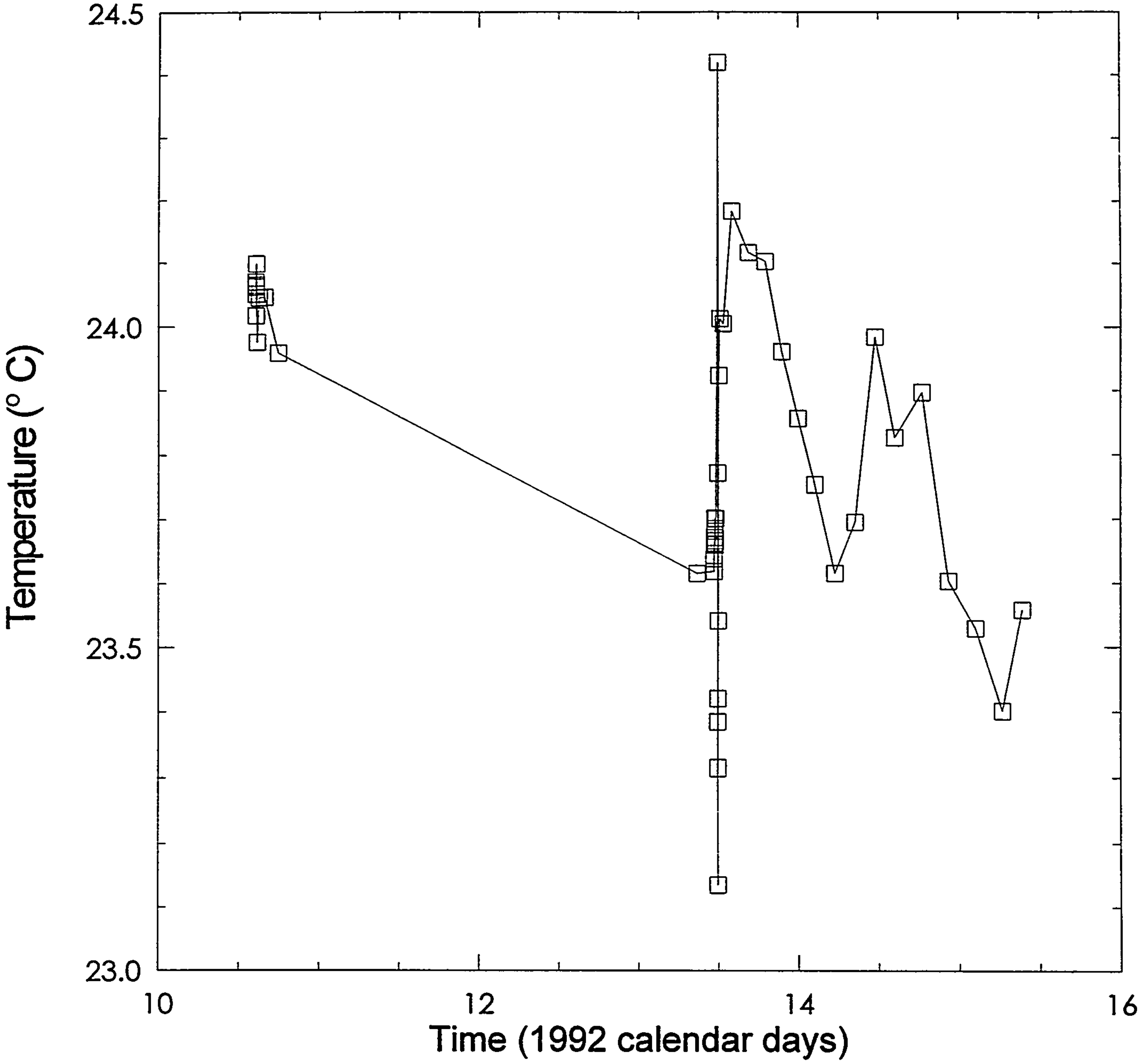

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Figure 6-4. Zone temperature during compliance testing of test tool #32A.

6.2.2 Test Tool #32B (Borehole C1H06, Coupled Permeability and Hydrofracture-Testing Sequences C1X10 and C1X05-A)

Table 6-4 gives a detailed description of the events that occurred during compliance testing of test tool #32B. Figures 6-5 and 6-6 illustrate the zone and packer pressures, respectively, for test tool #32B. Figure 4-10 illustrates the configuration of test tool #32B as assembled for compliance testing.

Table 6-4. Events Associated with Compliance Testing of Test Tool #32B; Borehole C1H06; Sequences C1X10

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Assemble single-packer test tool #32B to be used in borehole C1H06 during testing sequence C1X10.	1-13-92	13	13	11:18:00
Begin data file COMP32A.	1-13-92	13	13	11:18:20
Inflate packer.	1-13-92	13	13	11:22:00
Increase TZ pressure.	1-13-92	13	13	11:27:00
Depressurize TZ and deflate packer.	1-13-92	13	13	11:38:00
Inflate packer.	1-13-92	13	13	11:53:00
Increase TZ pressure.	1-13-92	13	13	11:58:00
End data file COMP32A.	1-15-92	15	15	09:23:01
Remove test tool from compliance chamber and move to borehole C1H06.	1-15-92	15	15	09:25:00

Table 6-5 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #32B. Test tool #32B was used in observation borehole C1H06 during testing sequences C1X10 and C1X05-A.

Table 6-5. Compliance Equipment Associated with Test Tool #32B; Borehole C1H06; Sequences C1X10 and C1X05-A

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	1-13-92	1-15-92
DCU (HP3497A)	N/A	2514a17149	1-13-92	1-15-92
Transducer (Druck PDCR 830)	Test Zone	246916	1-13-92	1-15-92
Transducer (Druck PDCR 830)	Test Zone Packer	246918	1-13-92	1-15-92

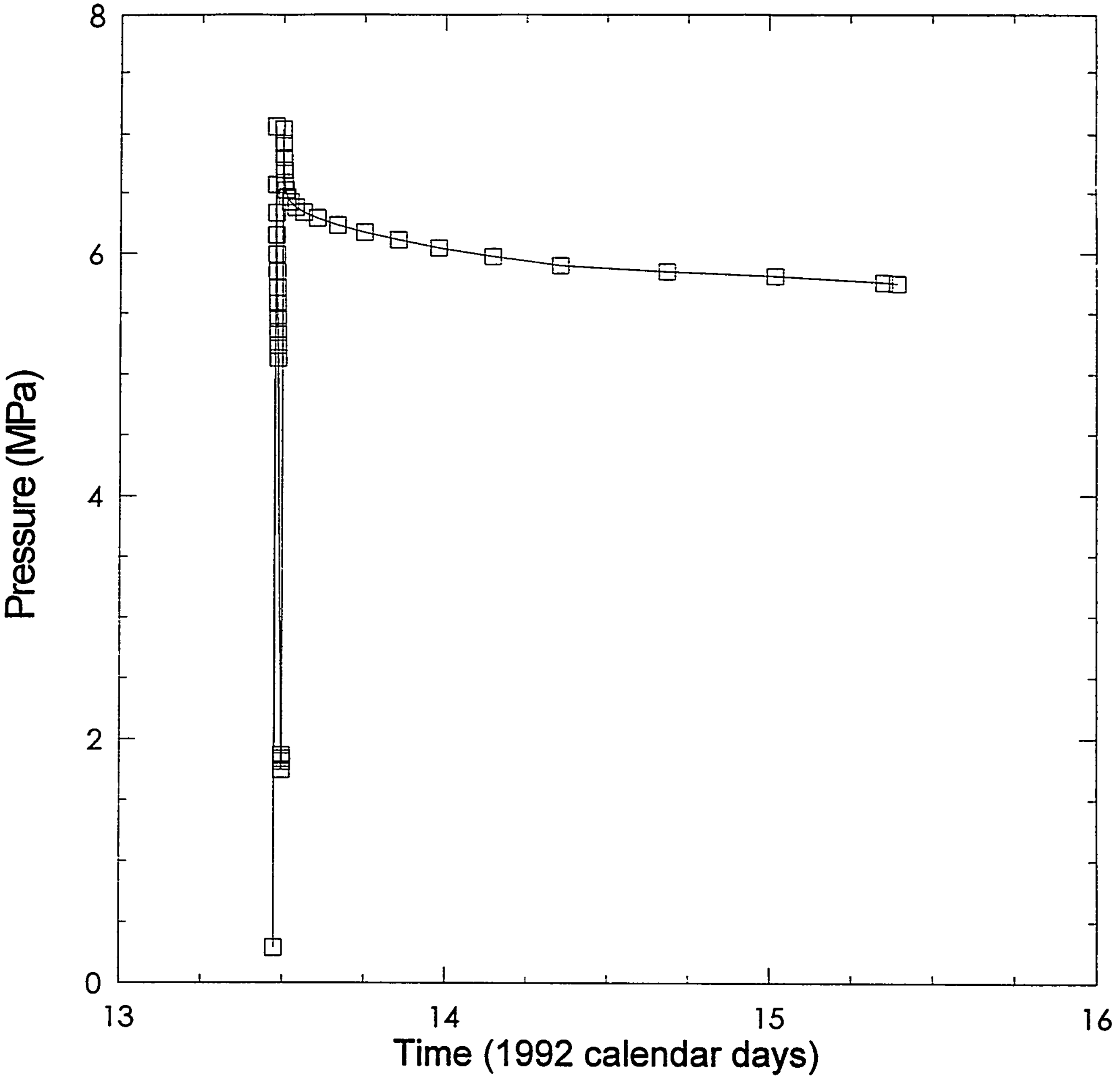

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Figure 6-5. Zone pressure during compliance testing of test tool #32B.

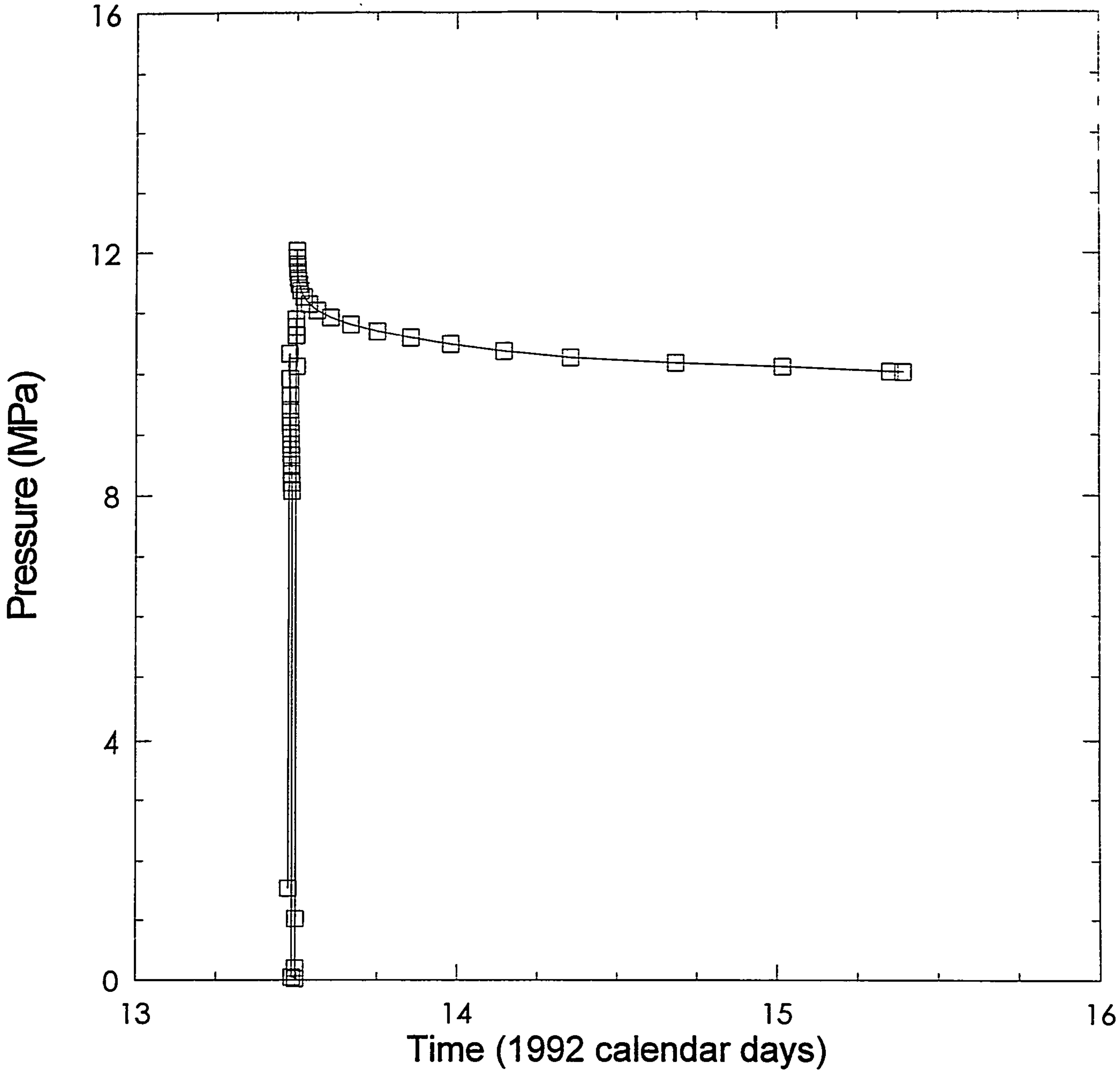

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Figure 6-6. Packer pressure during compliance testing of test tool #32B.

6.2.3 Test Tool #33A (Permeability-Testing Sequence L4P51-C1)

Table 6-6 gives a detailed description of the events that occurred during compliance testing of test tool #33A. Figures 6-7 through 6-13 illustrate the zone pressures, packer pressures, zone temperatures, axial-LVDT displacement, radial-LVDT displacement, fluid-injection volumes during compressibility tests, and test-zone compressibility as a function of pressure, respectively, for multipacker test tool #33A. It should be noted that Figures 6-12 and 6-13 each consist of two parts (ex. Figures 6-12a and 6-12b). Figure 3-22 illustrates the configuration of test tool #33A as assembled for compliance testing.

Table 6-6. Events Associated with Compliance Testing of Test Tool #33A; Borehole L4P51; Sequence L4P51-C1

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #33A to be used in borehole L4P51 during testing sequence L4P51-C1.	2-24-92	55	55	12:00:00
Begin data file COMP33A.	2-25-92	56	56	13:46:11
Inflate GZ packer.	2-25-92	56	56	14:12:00
Inflate TZ packer.	2-25-92	56	56	14:15:00
Open GZ packer to accumulator.	2-26-92	57	57	10:24:30
Open TZ packer to accumulator.	2-26-92	57	57	10:25:15
End data file COMP33A.	2-26-92	57	57	11:51:18
Begin data file COMP33B.	2-26-92	57	57	11:59:44
Increase GZ pressure via DPT panel.	2-26-92	57	57	13:17:00
Depressurize GZ.	2-26-92	57	57	13:24:00
Increase GZ pressure via DPT panel.	2-26-92	57	57	13:27:00
Shut in GZ.	2-26-92	57	57	13:35:45
Increase TZ pressure via DPT panel.	2-26-92	57	57	13:46:13
Shut in TZ.	2-26-92	57	57	14:10:44
Depressurize GZ via DPT panel.	3-3-92	63	63	10:37:00
Increase GZ pressure via DPT panel.	3-3-92	63	63	10:44:52
Shut in GZ.	3-3-92	63	63	10:51:08
Shut in packers from accumulators.	3-3-92	63	63	10:52:53
Increase TZ pressure via DPT panel.	3-3-92	63	63	11:00:00
Decrease TZ packer pressure via DPT panel.	3-3-92	63	63	11:52:39
Shut in TZ from DPT panel.	3-9-92	69	69	09:35:30
End data file COMP33B.	3-24-92	84	84	08:43:52
Begin data file COMP33C.	3-24-92	84	84	09:51:25
Begin TZ compressibility test.	3-24-92	84	84	10:02:00
Shut in TZ.	3-24-92	84	84	12:14:05
Open packers to accumulator.	3-24-92	84	84	12:31:06
Removed ~10 mL of fluid from TZ.	3-26-92	86	86	09:11:00

Table 6-6 (Continued). Events Associated with Compliance Testing of Test Tool #33A; Borehole L4P51; Sequence L4P51-C1

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Increase TZ pressure via DPT panel.	3-31-92	91	91	14:02:52
Depressurize GZ via DPT panel.	4-8-92	99	99	08:42:35
Increase GZ pressure via DPT panel.	4-8-92	99	99	09:18:10
Shut in GZ.	4-8-92	99	99	10:45:36
Depressurize TZ via DPT panel.	4-22-92	113	113	09:51:33
Depressurize GZ via DPT panel.	4-22-92	113	113	10:15:33
Deflate GZ packer.	4-22-92	113	113	10:38:03
Deflate TZ packer.	4-22-92	113	113	10:40:33
End data file COMP33C.	4-22-92	113	113	11:13:49
Remove test tool #33A from compliance chamber and move to borehole L4P51.	4-22-92	113	113	12:00:00

Table 6-7 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test-tool #33A. Test tool #33A was used in permeability-testing sequence L4P51-C1.

Table 6-7. Compliance Equipment Associated with Test Tool #33A; Borehole L4P51; Sequence L4P51-C1

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	2-25-92	4-22-92
DCU (HP3497A)	N/A	2514a17149	2-25-92	4-22-92
Transducer (Druck PDCR 10/D)	Test Zone	211690	2-25-92	4-22-92
Transducer (Druck PDCR 10/D)	Test Zone Packer	211695	2-25-92	4-22-92
Transducer (Druck PDCR 830)	Guard Zone	246914	2-25-92	4-22-92
Transducer (Druck PDCR 830)	Guard Zone Packer	246920	2-25-92	4-22-92
Transducer (Druck PDCR 830)	DPT Panel	246912	2-25-92	4-22-92
LVDT (Trans-Tek 241)	N/A	R04	2-25-92	4-22-92
LVDT (Trans-Tek 241)	N/A	R16	2-25-92	4-22-92
LVDT (Trans-Tek 241)	N/A	R17	2-25-92	4-22-92
LVDT (Trans-Tek 245)	N/A	A02	2-25-92	4-22-92

Table 6-7 (Continued). Compliance Equipment Associated with Test Tool #33A; Borehole L4P51; Sequence L4P51-C1

Equipment	Location	Serial #	Installed	Removed
Thermocouple (Type E)	Test Zone	1	2-25-92	4-22-92
Thermocouple (Type E)	Guard Zone	2	2-25-92	4-22-92
Injection Column	N/A	38	2-25-92	4-22-92
Injection Column	N/A	39	2-25-92	4-22-92
DPT (Rosemount 1151DP)	N/A	1389938	2-25-92	4-22-92

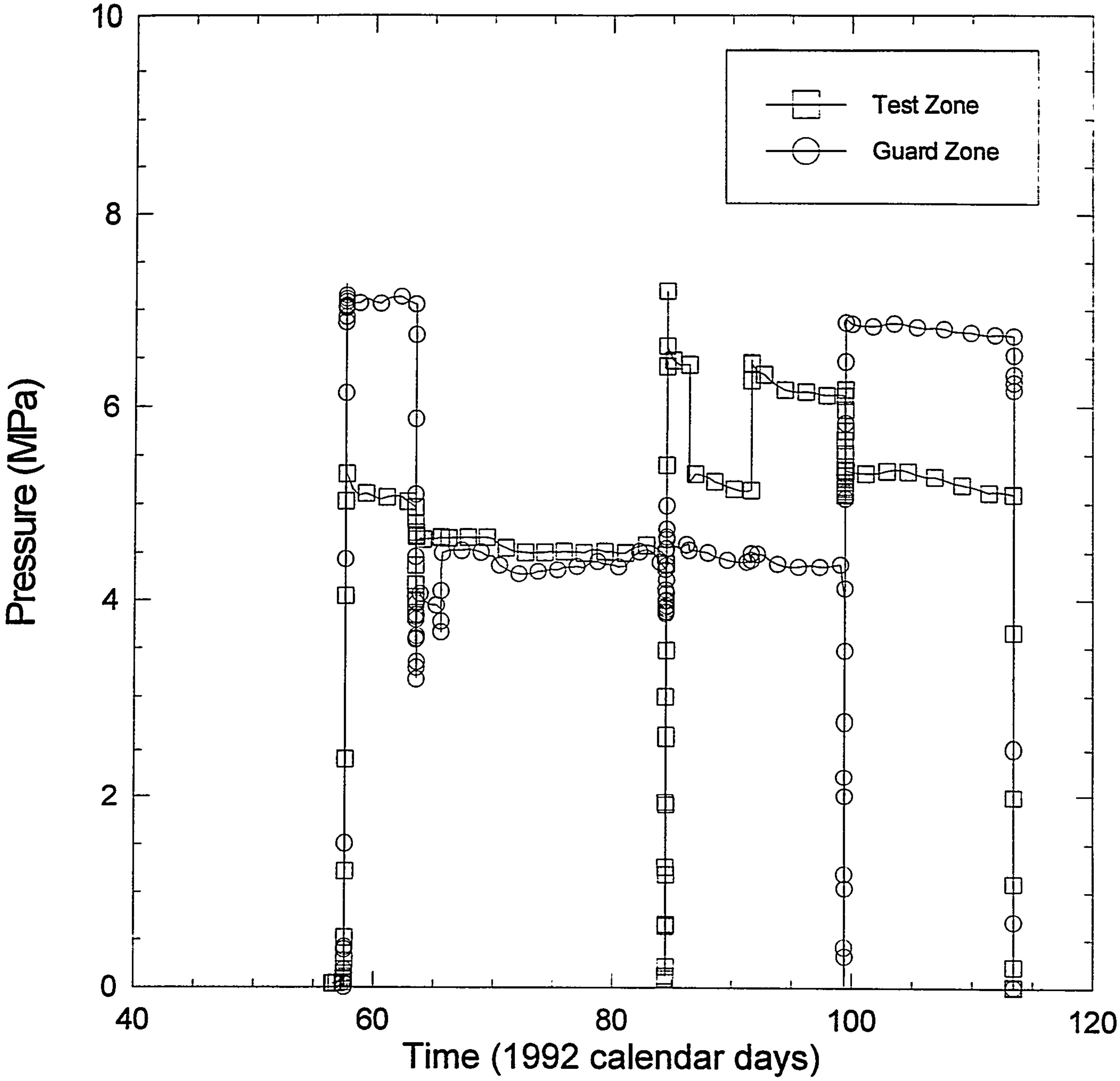

Figure 6-7. Zone pressures during compliance testing of test tool #33A.

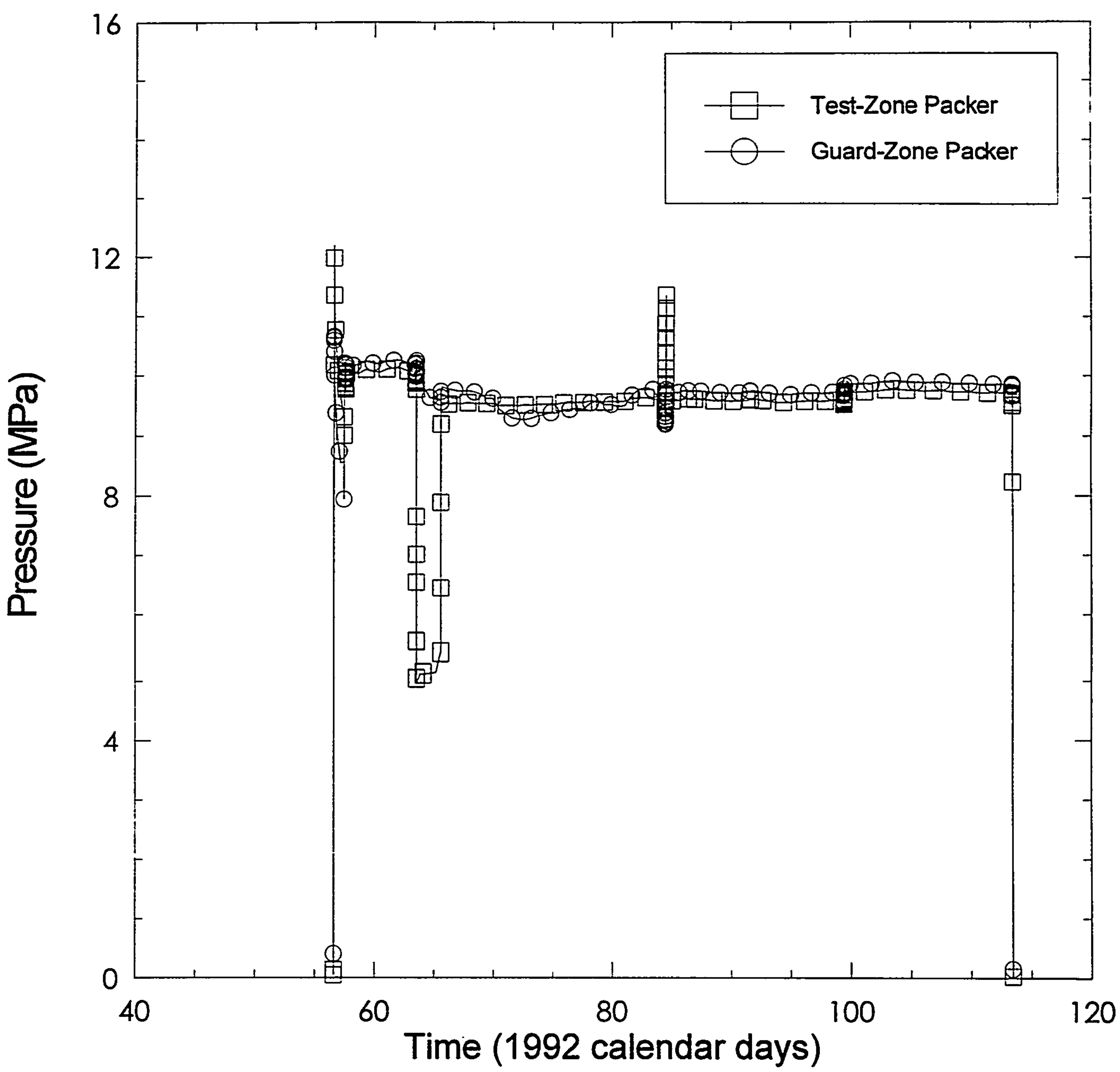

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Figure 6-8. Packer pressures during compliance testing of test tool #33A.

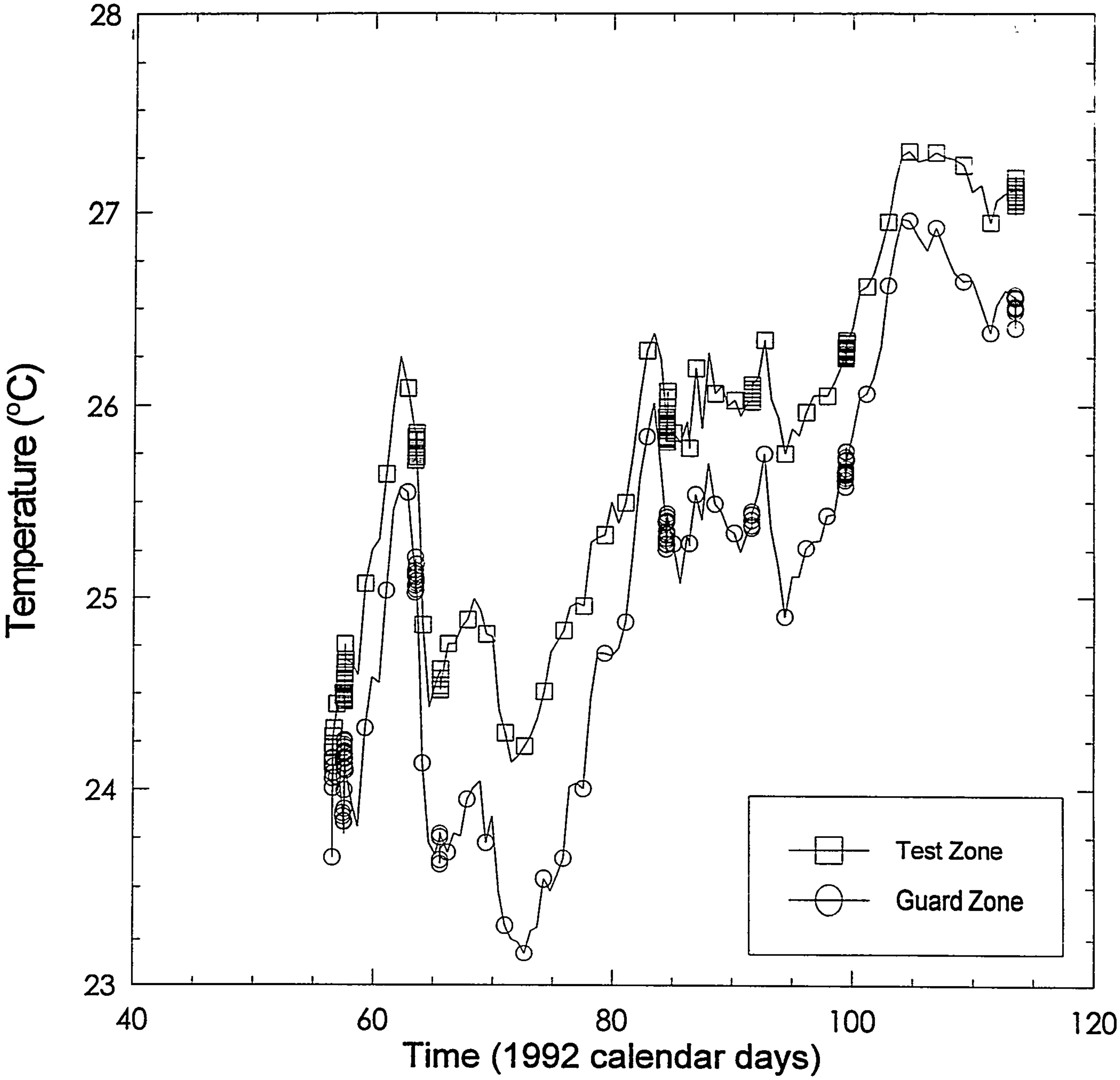

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Figure 6-9. Zone temperatures during compliance testing of test tool #33A.

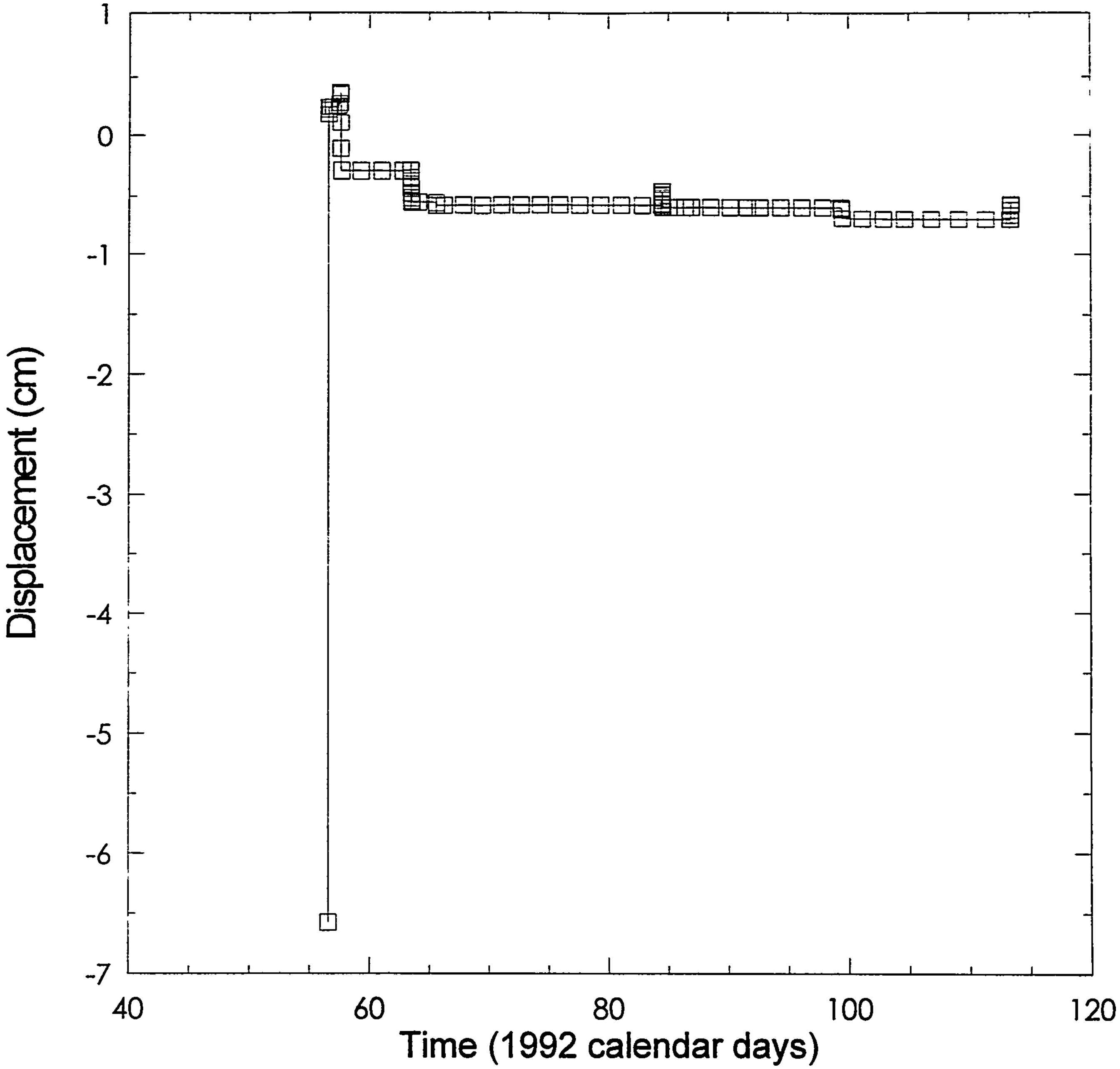

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Figure 6-10. Axial-LVDT displacement during compliance testing of test tool #33A.

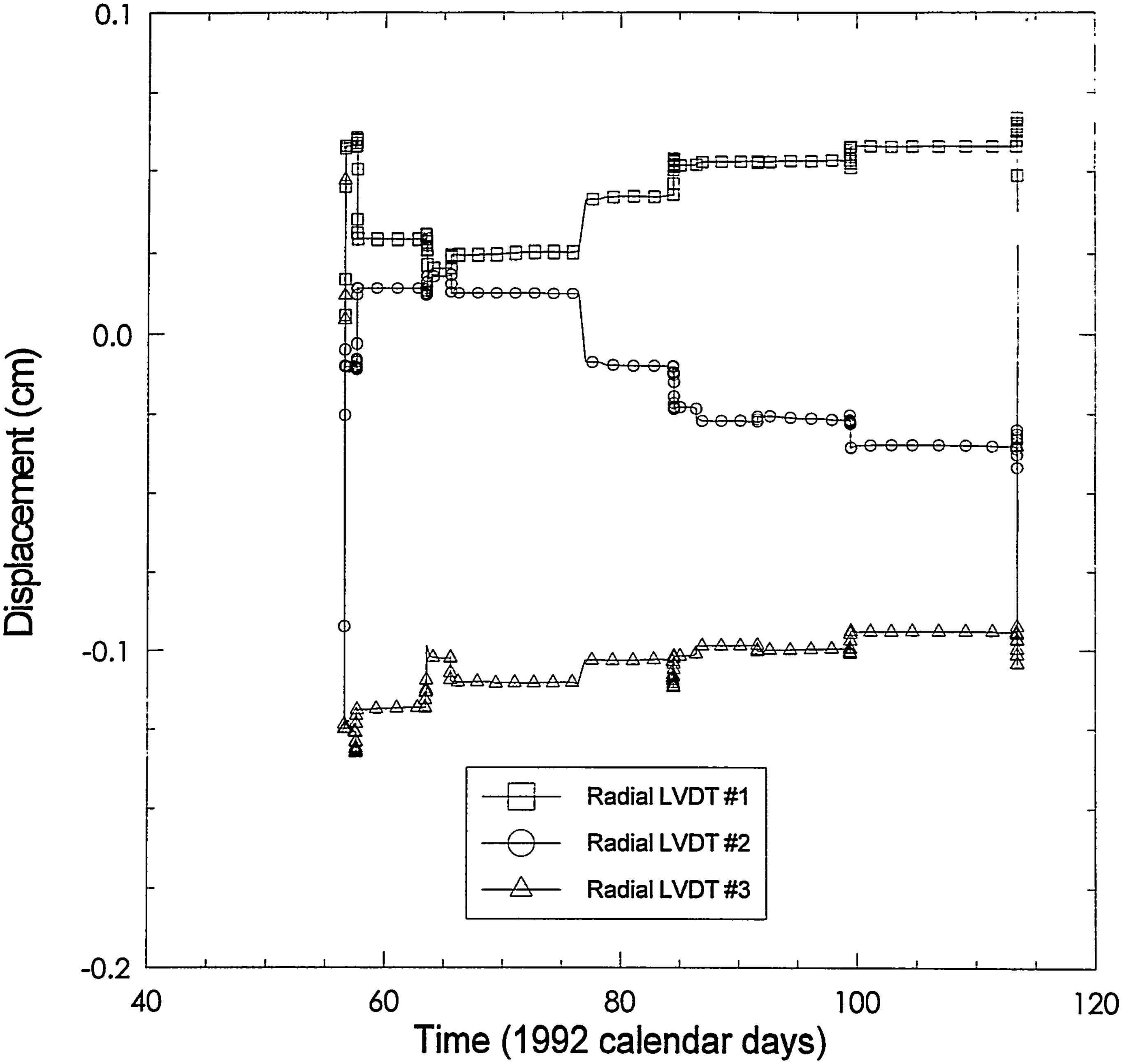

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Figure 6-11. Radial-LVDT displacement during compliance testing of test tool #33A.

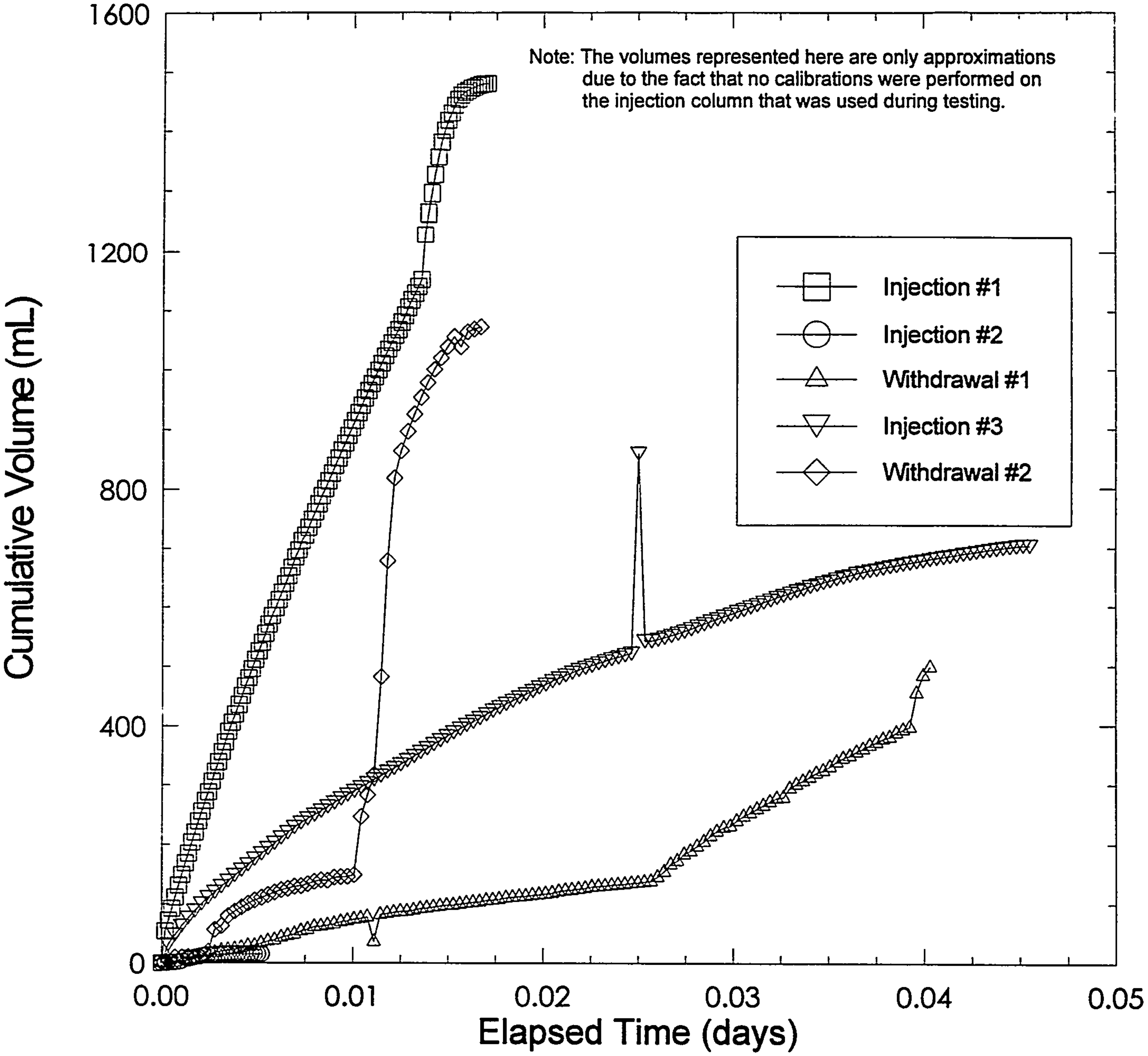

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Figure 6-12a. Test-zone fluid-injection volumes during compliance testing of test tool #33A.

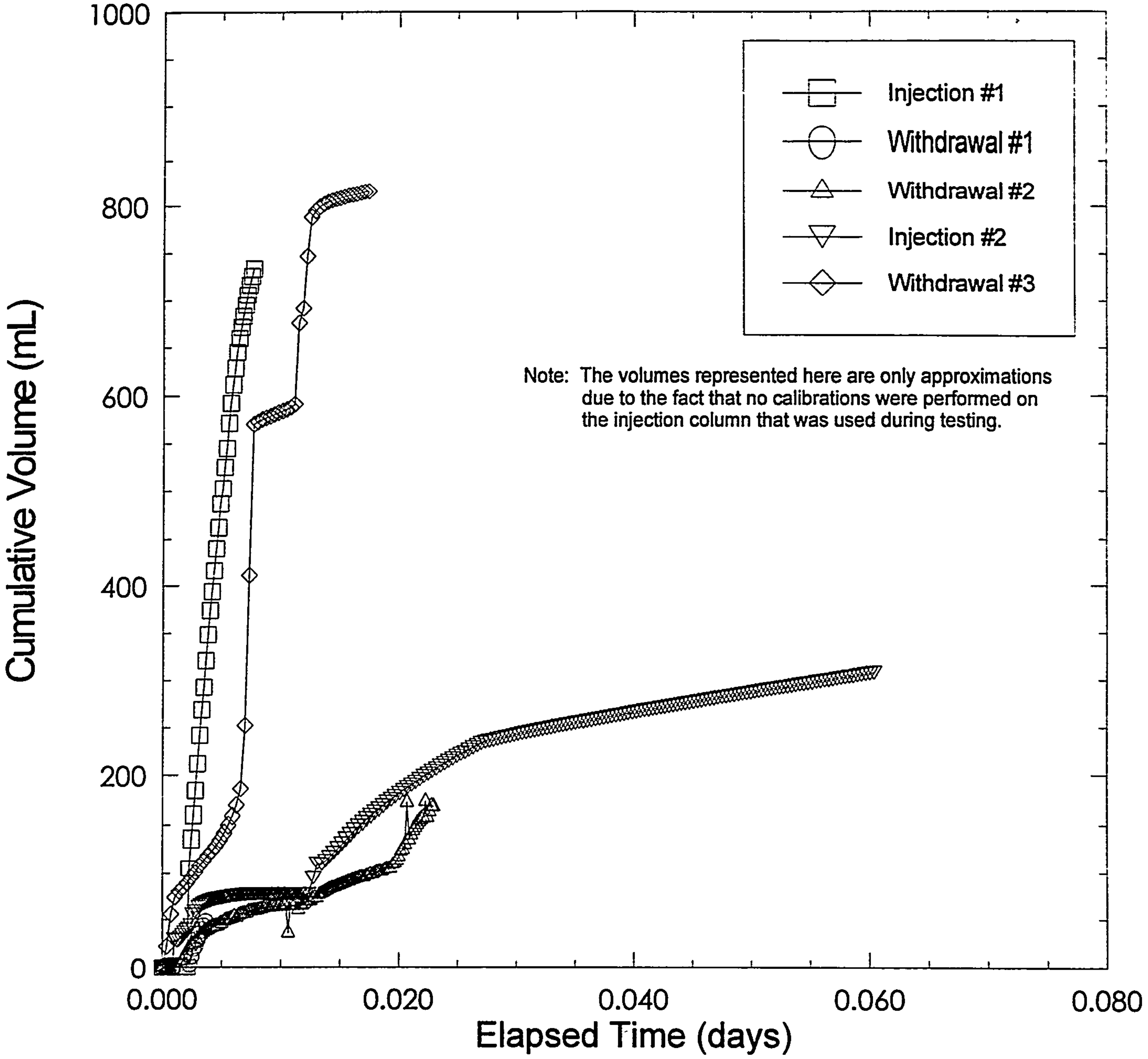

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Figure 6-12b. Guard-zone fluid-injection volumes during compliance testing of test tool #33A.

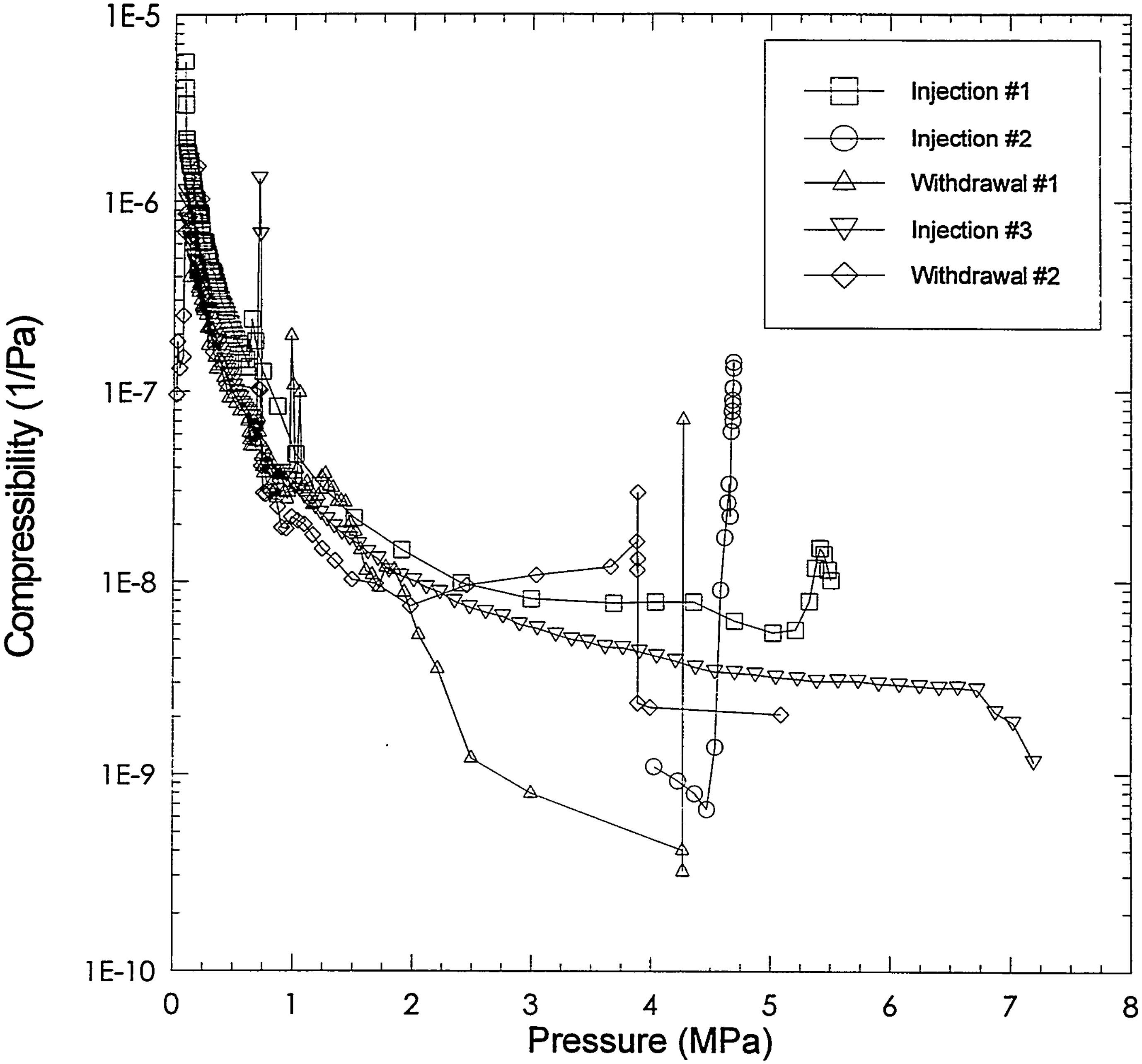

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Figure 6-13a. Test-zone compressibility as measured during compliance testing of test tool #33A.

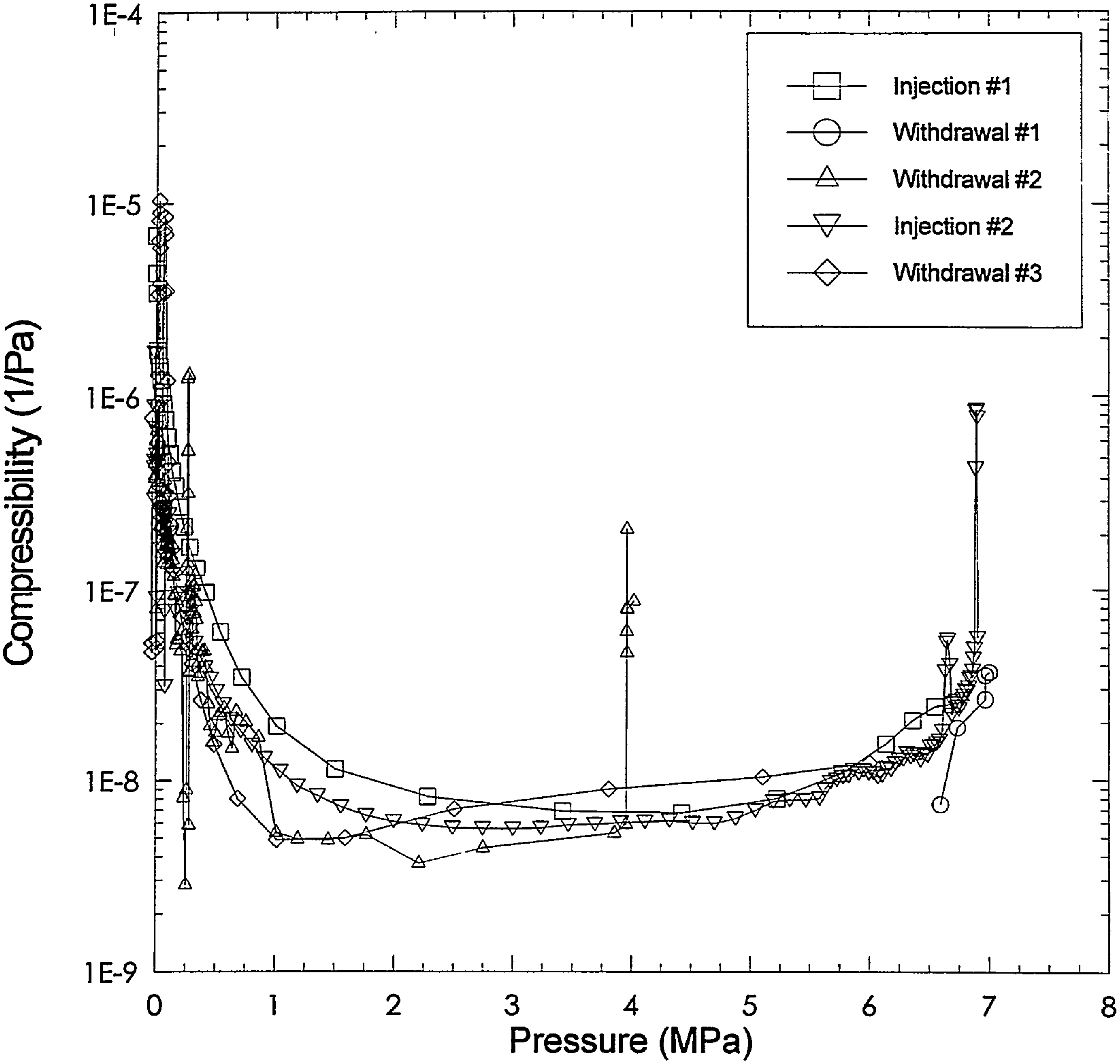

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Figure 6-13b. Guard-zone compressibility as measured during compliance testing of test tool #33A.

6.2.4 Test Tool #34 (Borehole C1H07, Coupled Permeability and Hydrofracture-Testing Sequence C1X05-A)

Table 6-8 gives a detailed description of the events that occurred during compliance testing of test tool #34. Figures 6-14 and 6-15 illustrate the zone and packer pressures, respectively, for test tool #34. Figure 4-12 illustrates the configuration of test tool #34 as assembled for compliance testing.

Table 6-8. Events Associated with Compliance Testing of Test Tool #34; Borehole C1H07; Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Assemble single-packer test tool #34 to be used in borehole C1H07 during testing sequence C1X05-A.	6-2-92	154	154	09:30:00
Begin data file COMP34A.	6-2-92	154	154	09:58:03
Inflate packer to ~10 MPa.	6-2-92	154	154	09:59:13
Shut in packer.	6-2-92	154	154	10:00:43
Increase TZ pressure to ~6 MPa.	6-2-92	154	154	10:06:13
Shut in TZ.	6-2-92	154	154	10:06:43
Increase TZ pressure to ~4.1 MPa	6-4-92	156	156	10:23:00
Shut in TZ.	6-4-92	156	156	10:24:00
End data file COMP34A.	6-17-92	169	169	09:43:42
Remove test tool #34 from compliance chamber and move to borehole C1H07.	6-17-92	169	169	12:00:00

Table 6-9 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #34. Test tool #34 was used in observation borehole C1H07 during testing sequence C1X05-A.

Table 6-9. Compliance Equipment Associated with Test Tool #34; Borehole C1H07; Sequence C1X05-A

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	6-2-92	6-17-92
DCU (HP3497A)	N/A	2629a22040	6-2-92	6-17-92
Transducer (Druck PDCR 910)	Test Zone	322424	6-2-92	6-17-92
Transducer (Druck PDCR 910)	Test Zone Packer	322426	6-2-92	6-17-92

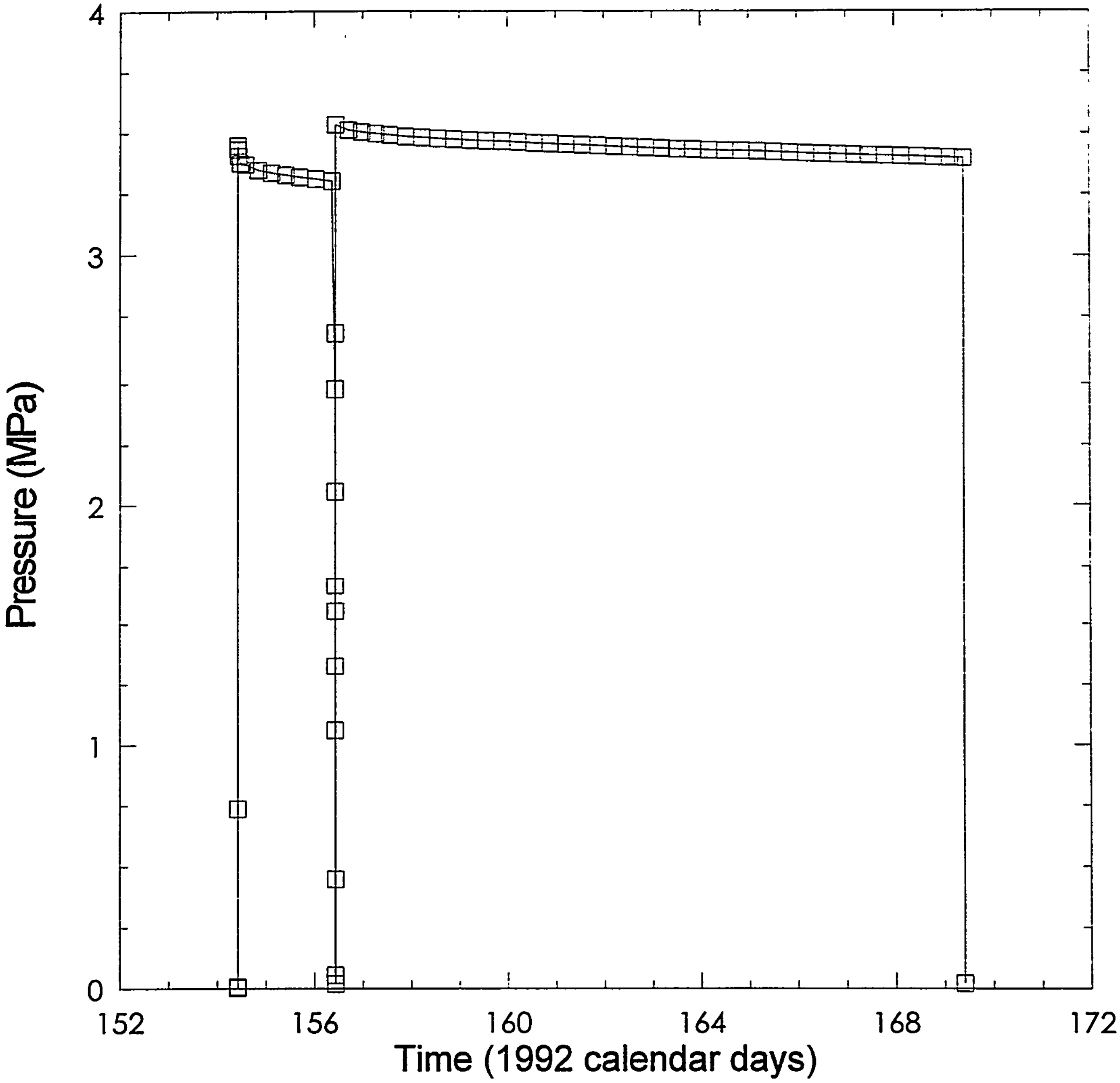

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Figure 6-14. Zone pressure during compliance testing of test tool #34.

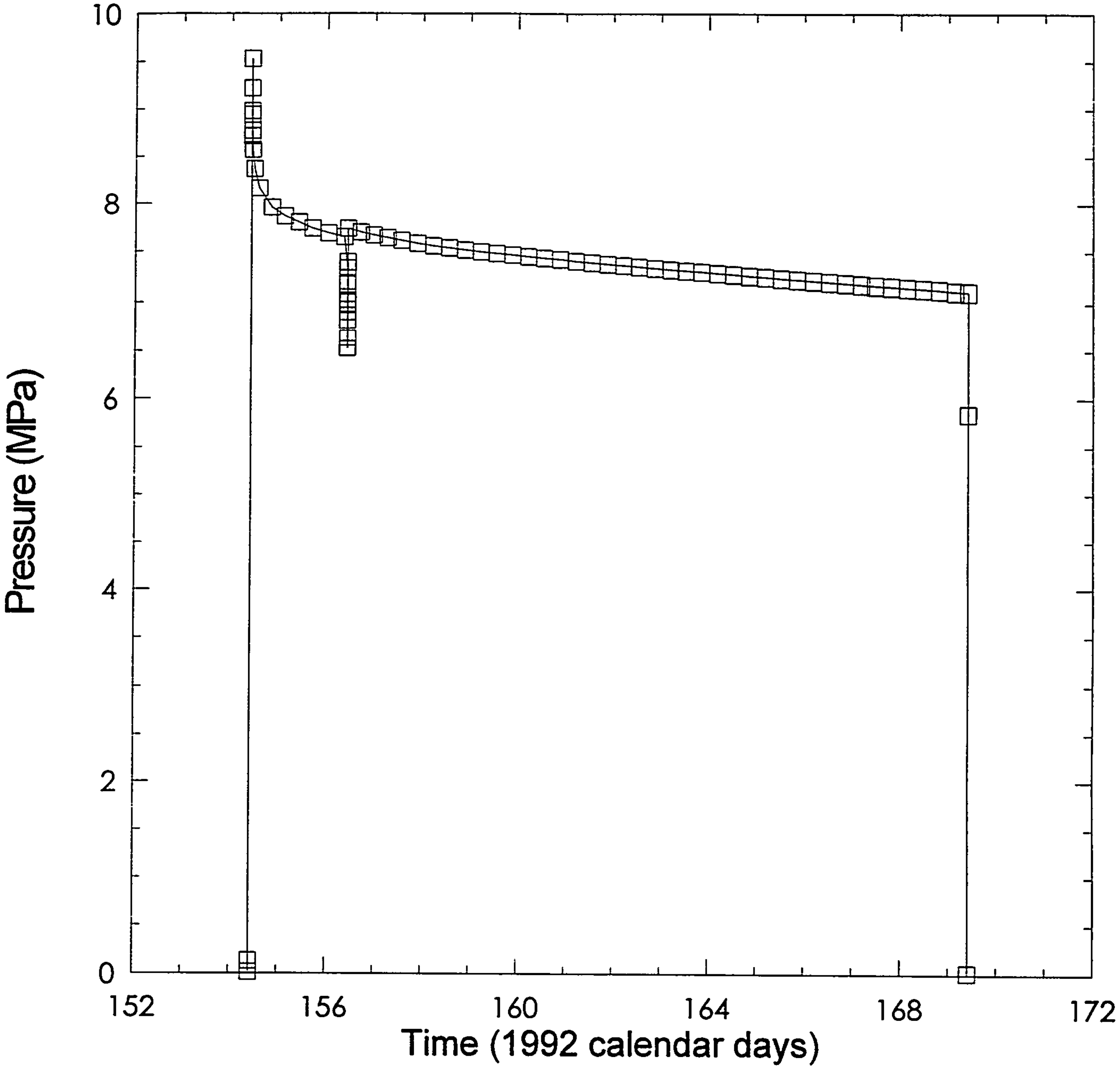

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Figure 6-15. Packer pressure during compliance testing of test tool #34.

6.2.5 Test Tool #35 (Permeability-Testing Sequence S1P74-A)

Table 6-10 gives a detailed description of the events that occurred during compliance testing of test tool #35. Figures 6-16 through 6-22 illustrate the zone pressures, packer pressures, zone temperatures, axial-LVDT displacement, radial-LVDT displacement, fluid-injection volumes during compressibility tests, and test-zone compressibility as a function of pressure, respectively, for multipacker test tool #35. It should be noted that Figures 6-21 and 6-22 each consist of two parts (ex. Figures 6-21a and 6-21b). Figure 3-32 illustrates the configuration of test tool #35 as assembled for compliance testing.

Table 6-10. Events Associated with Compliance Testing of Test Tool #35; Borehole S1P74; Sequence S1P74-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Assembled multipacker test tool #35 to be used in borehole S1P74 during testing sequence S1P74-A.	6-17-92	169	169	12:00:00
Begin data file COMP35A.	6-18-92	170	170	11:02:51
Inflate GZ packer to ~11.0 MPa and shut in.	6-18-92	170	170	11:05:00
Inflate TZ packer.	6-18-92	170	170	11:06:00
Shut in TZ packer.	6-18-92	170	170	11:08:00
DAS not functioning upon arrival.	6-19-92	171	171	08:30:00
Increase GZ pressure to ~4.1 MPa.	6-19-92	171	171	09:01:00
Shut in GZ.	6-19-92	171	171	09:04:00
Increase TZ pressure to ~4.1 MPa and shut in.	6-19-92	171	171	09:05:00
Appears to be a leak in GZ.	6-22-92	174	174	09:00:00
End data file COMP35A.	6-22-92	174	174	11:08:44
Remove test tool from compliance chamber, diagnose and eliminate leak in GZ, and reinstall test tool in compliance chamber.	6-22-92	174	174	11:30:00
Begin data file COMP35B.	6-22-92	174	174	11:42:16
Inflate GZ and TZ packers.	6-22-92	174	174	11:45:00
Increase TZ pressure to ~4.1 MPa.	6-22-92	174	174	12:00:00
Leak on TZ packer caused packer deflation and depressurization of TZ and GZ.	6-26-92	178	178	12:00:00
End data file COMP35B.	6-26-92	178	178	12:30:00
Begin data file COMP35C.	6-29-92	181	181	09:25:15
Inflate TZ and GZ packers.	6-29-92	181	181	09:53:25
Shut in TZ and GZ packers at ~11.0 MPa.	6-29-92	181	181	09:56:50
End data file COMP35C.	6-30-92	182	182	11:25:53
Remove transducers from P1 and P3.	6-30-92	182	182	11:30:00
Install transducers 246912 and 246910, respectively on P1 and P3.	6-30-92	182	182	11:45:00
Begin data file COMP35D.	6-30-92	182	182	13:19:00
Increase GZ pressure to ~4.1 MPa.	7-1-92	183	183	08:22:00
Decrease TZ packer pressure from 12.4 MPa to 10.7 MPa.	7-1-92	183	183	08:25:00

Table 6-10 (Continued). Events Associated with Compliance Testing of Test Tool #35; Borehole S1P74; Sequence S1P74-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Increase TZ pressure to ~4.1 MPa.	7-1-92	183	183	09:11:00
Decrease TZ pressure by removing 20 mL of fluid.	7-8-92	190	190	09:06:00
Decrease GZ pressure by removing 19 mL of fluid.	7-8-92	190	190	09:07:00
End data file COMP35D.	7-8-92	190	190	10:34:44
Begin data file COMP35E.	7-8-92	190	190	11:17:34
Begin TZ compressibility test.	7-8-92	190	190	11:19:05
Shut in TZ.	7-8-92	190	190	11:20:21
Depressurize TZ.	7-8-92	190	190	11:24:43
Begin TZ compressibility test.	7-8-92	190	190	11:28:18
Shut in TZ.	7-8-92	190	190	11:46:52
Begin GZ compressibility test.	7-8-92	190	190	12:29:11
Shut in GZ.	7-8-92	190	190	12:31:00
Depressurize GZ.	7-8-92	190	190	12:34:00
Begin GZ compressibility test.	7-8-92	190	190	12:39:10
Shut in GZ.	7-8-92	190	190	12:51:26
Begin constant pressure withdrawal from TZ at 6.4 MPa.	7-13-92	195	195	10:48:04
Shut in TZ.	7-16-92	198	198	12:59:54
End data file COMP35E.	7-20-92	202	202	13:35:49
Remove test tool #35 from compliance chamber and move to borehole S1P74.	7-21-92	203	203	12:00:00

Table 6-11 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #35. Test tool #35 was used in permeability-testing sequence S1P74-A.

Table 6-11. Compliance Equipment Associated with Test Tool #35; Borehole S1P74; Sequence S1P74-A

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	6-18-92	7-21-92
DCU (HP3497A)	N/A	2629a22040	6-18-92	7-21-92
Transducer (Druck PDCR 910)	Test Zone	322424	6-18-92	6-30-92
Transducer (Druck PDCR 910)	Test Zone Packer	308152	6-18-92	7-21-92
Transducer (Druck PDCR 910)	Guard Zone	322427	6-18-92	6-30-92

Table 6-11 (Continued). Compliance Equipment Associated with Test Tool #35; Borehole S1P74; Sequence S1P74-A

Equipment	Location	Serial #	Installed	Removed
Transducer (Druck PDCR 910)	DPT Panel	322427	7-8-92	7-21-92
Transducer (Druck PDCR 910)	Guard Zone Packer	322423	6-18-92	7-21-92
Transducer (Druck PDCR 830)	Test Zone	246912	6-30-92	7-21-92
Transducer (Druck PDCR 830)	Guard Zone	246910	6-30-92	7-21-92
LVDT (Trans-Tek 241)	N/A	R16	6-18-92	7-21-92
LVDT (Trans-Tek 241)	N/A	R04	6-18-92	7-21-92
LVDT (Trans-Tek 241)	N/A	R17	6-18-92	7-21-92
LVDT (Trans-Tek 245)	N/A	A02	6-18-92	7-21-92
Thermocouple (Type E)	Test Zone	1	6-18-92	7-21-92
Thermocouple (Type E)	Guard Zone	2	6-18--92	7-21-92
Injection Column	N/A	38	7-8-92	7-21-92
Injection Column	N/A	39	7-8-92	7-21-92
DPT (Rosemount 1151DP)	N/A	1140863	7-8-92	7-21-92

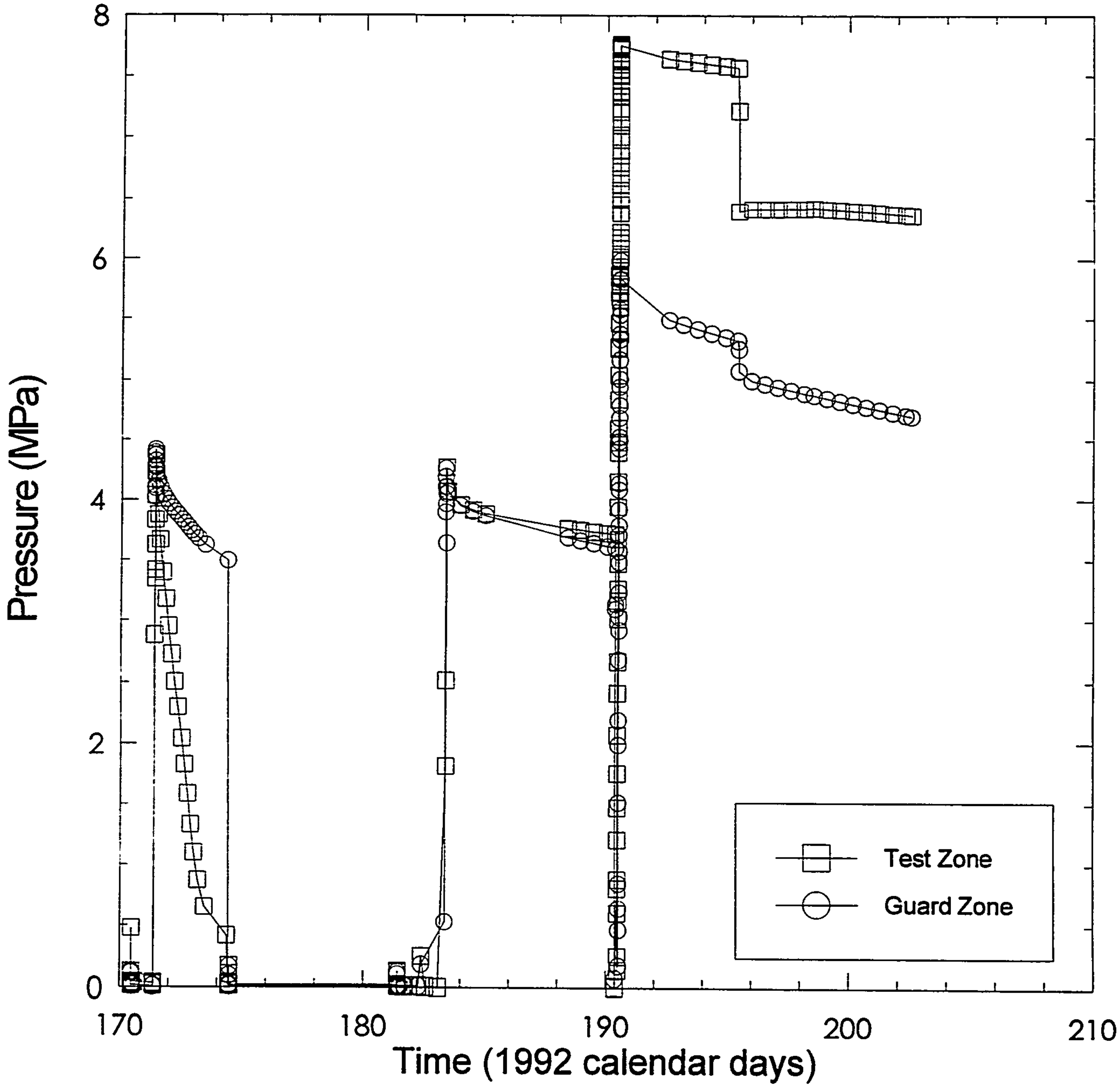

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Figure 6-16. Zone pressures during compliance testing of test tool #35.

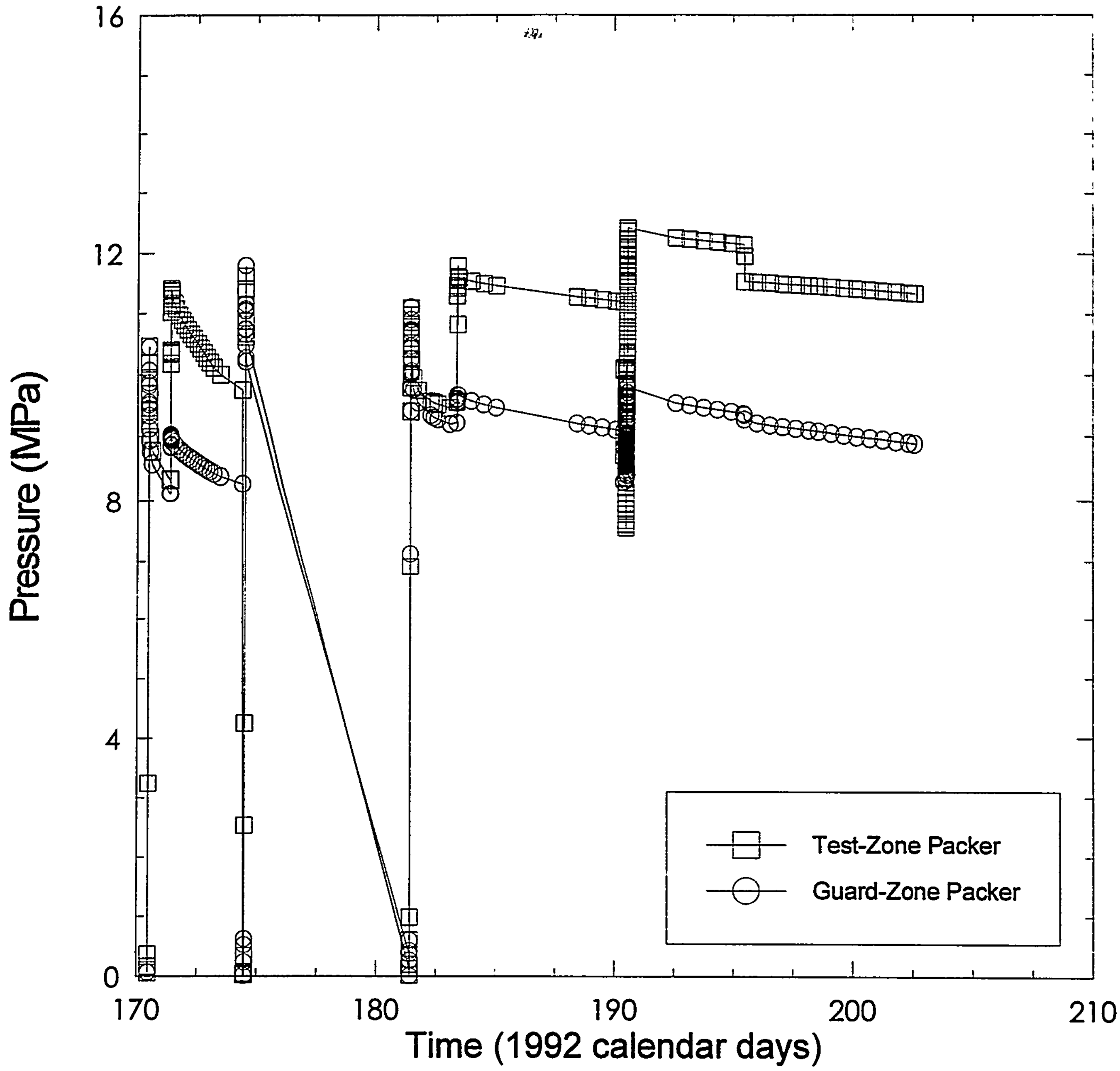

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Figure 6-17. Packer pressures during compliance testing of test tool #35.

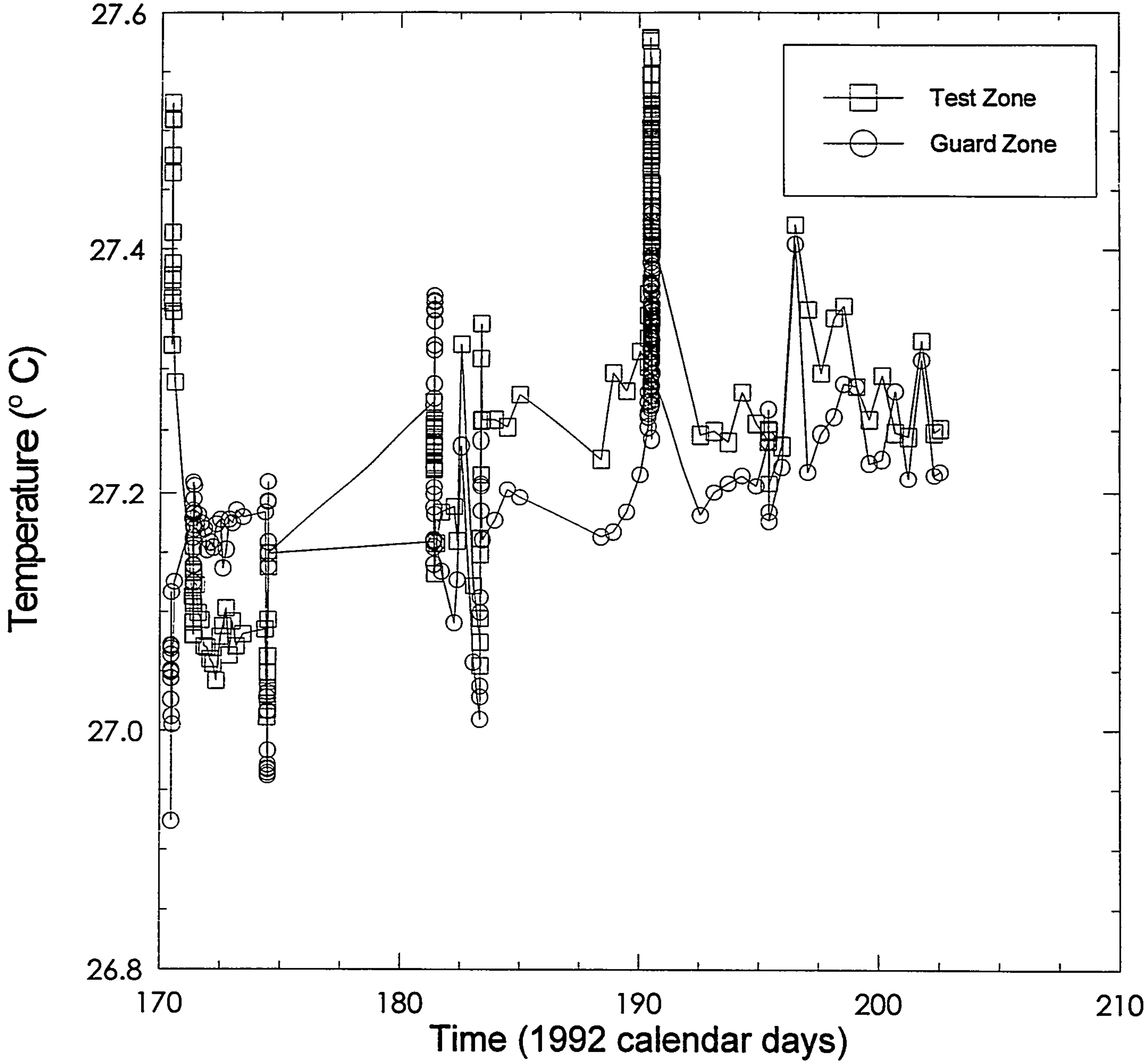

Figure 6-18. Zone temperatures during compliance testing of test tool #35.

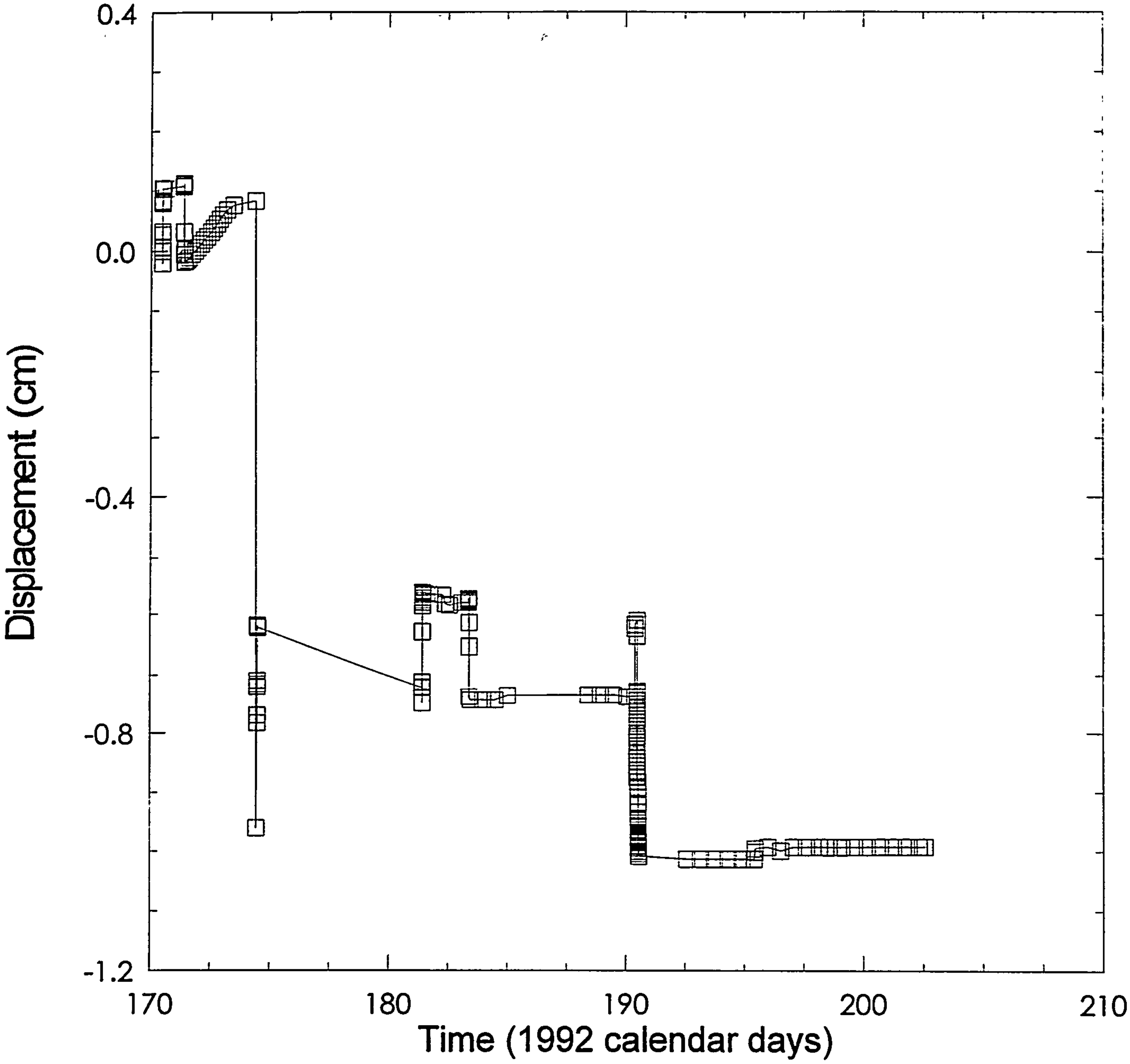

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Figure 6-19. Axial-LVDT displacement during compliance testing of test tool #35.

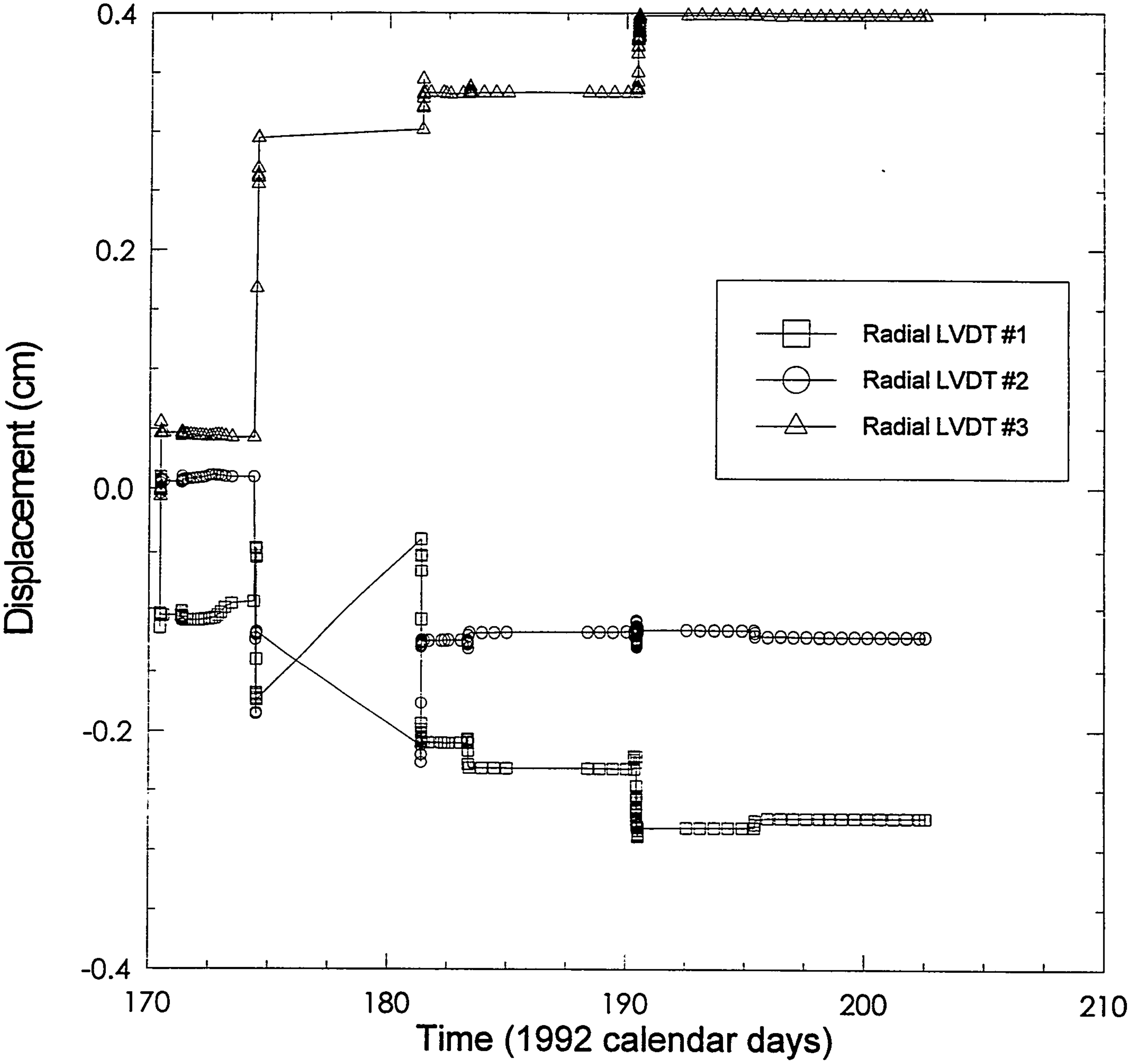

Figure 6-20. Radial-LVDT displacement during compliance testing of test tool #35.

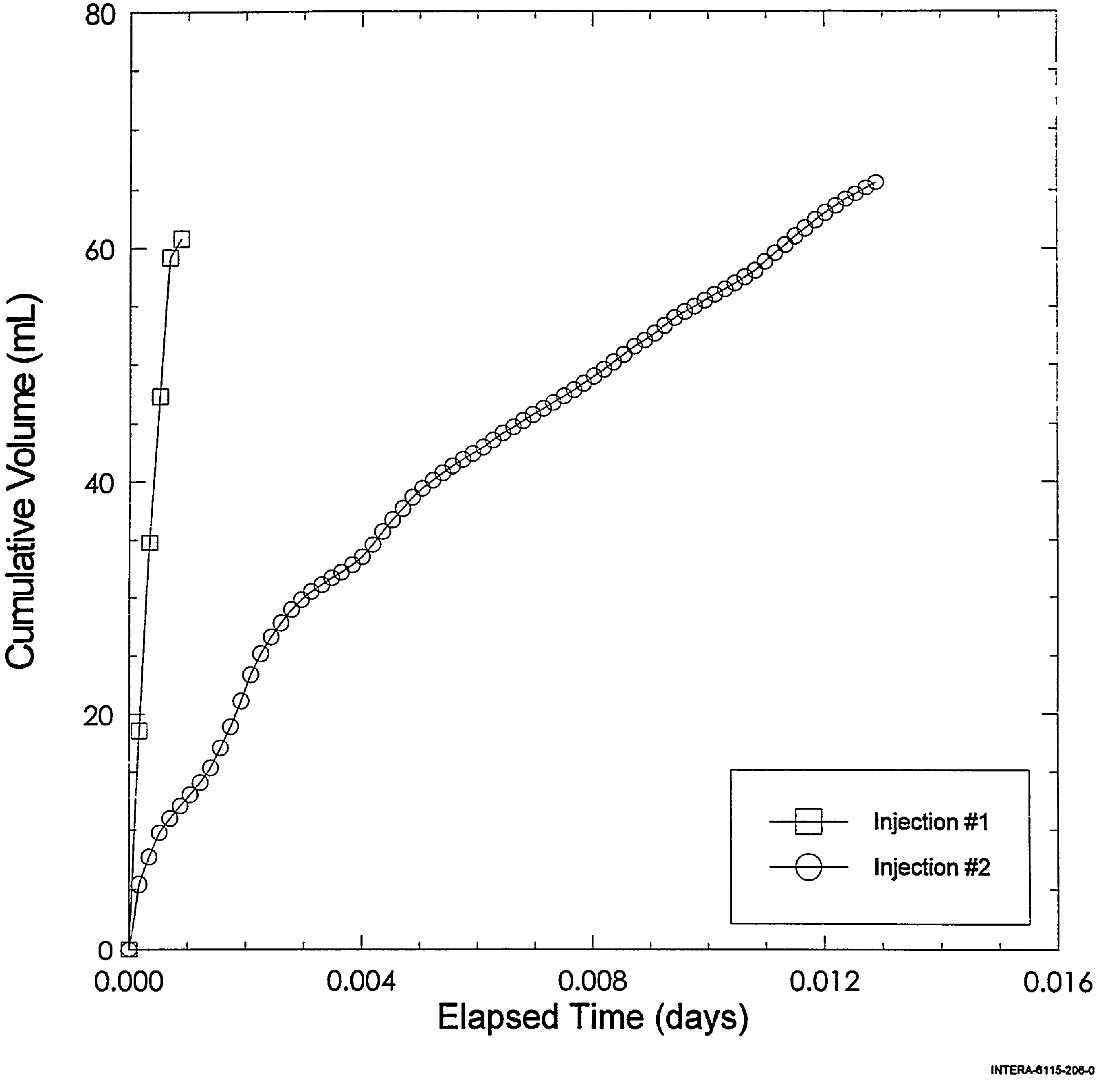

Figure 6-21a. Test-zone fluid-injection volumes during compliance testing of test tool #35.

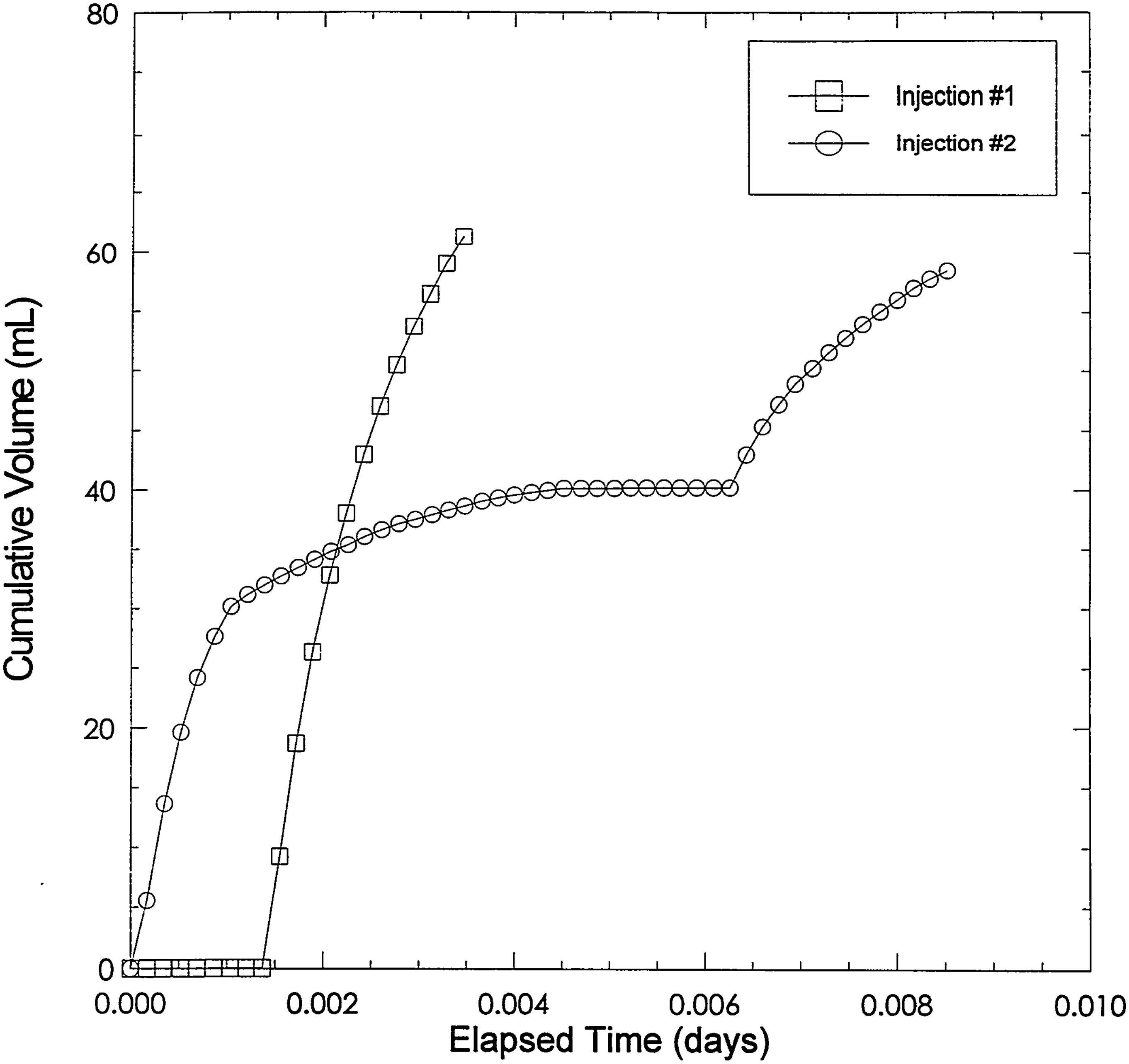

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Figure 6-21b. Guard-zone fluid-injection volumes during compliance testing of test tool #35.

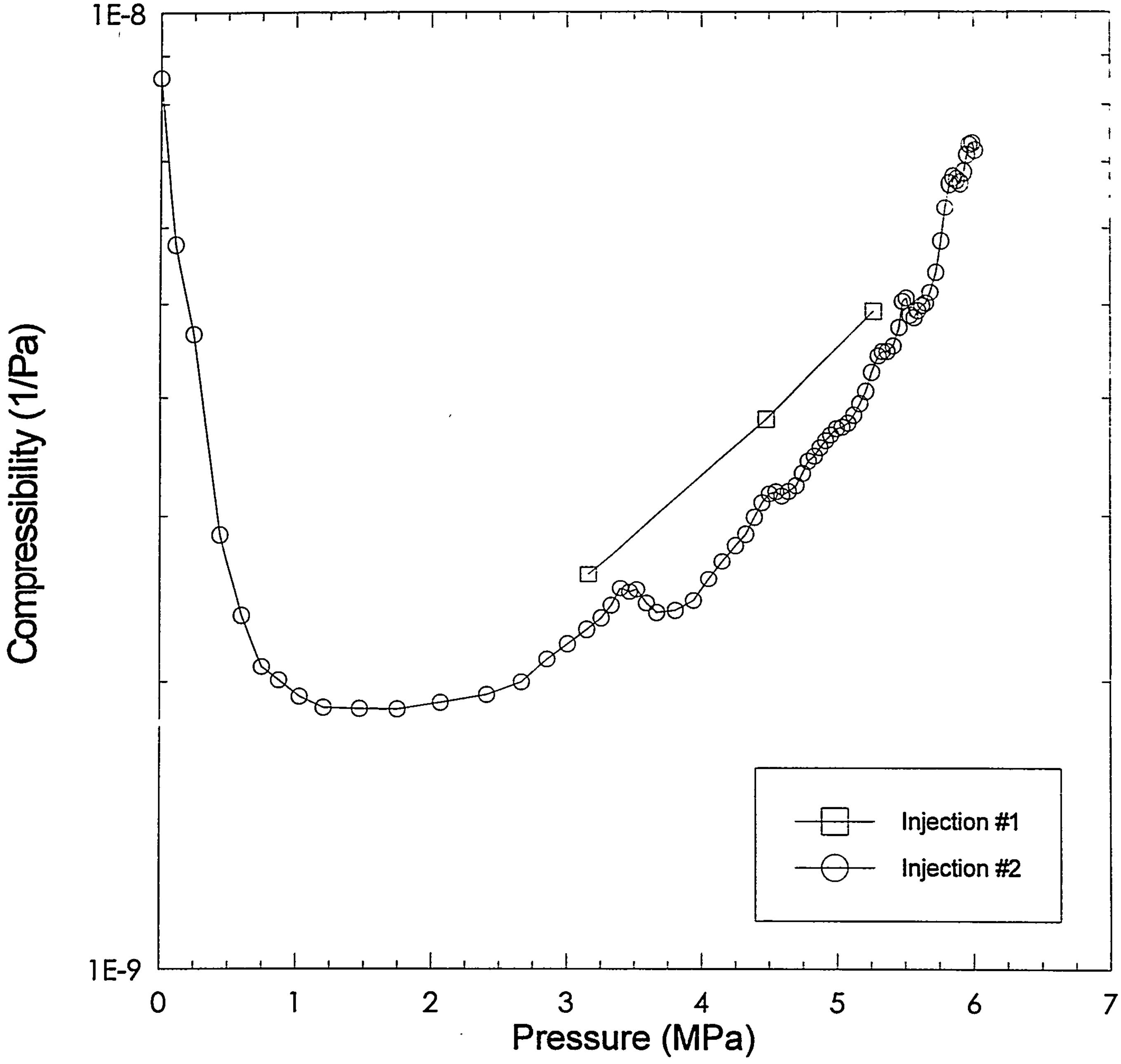

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Figure 6-22a. Test-zone compressibility as measured during compliance testing of test tool #35.

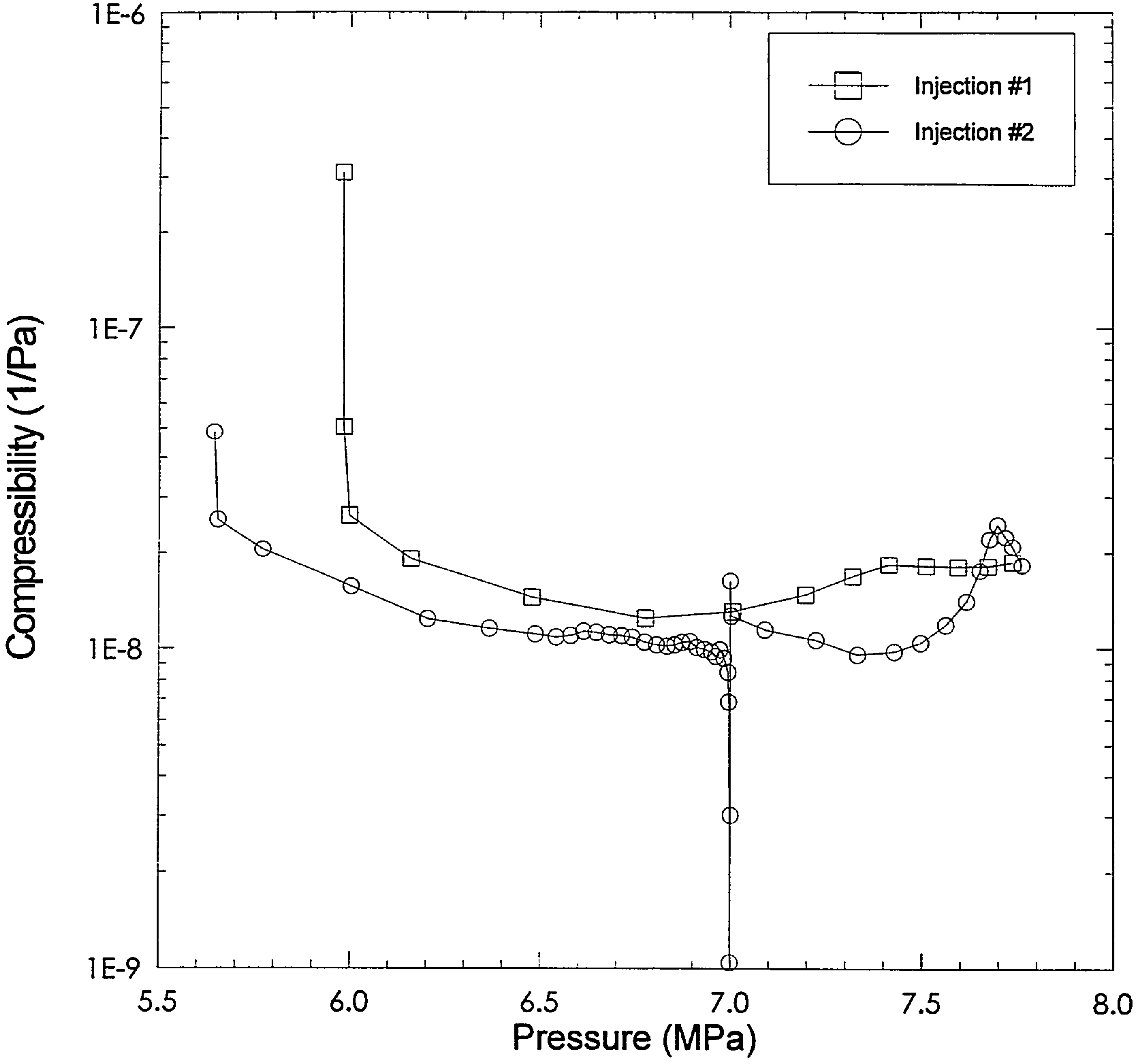

Figure 6-22b. Guard-zone compressibility as measured during compliance testing of test tool #35.

6.2.6 Test Tool #36 (Borehole C1X06, Coupled Permeability and Hydrofracture-Testing Sequence C1X05-A)

Table 6-12 gives a detailed description of the events that occurred during compliance testing of test tool #36. Figures 6-23 and 6-24 illustrate the zone and packer pressures, respectively, for test tool #36. Figure 4-13 illustrates the configuration of test tool #36 as assembled for compliance testing.

Table 6-12. Events Associated with Compliance Testing of Test Tool #36; Borehole C1X06; Sequence C1X05-A

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #36 to be used in borehole C1X06 during testing sequence C1X05-A.	9-24-92	268	268	09:00:00
Begin data file COMP36.	9-24-92	268	268	11:58:47
Inflate packer.	9-24-92	268	268	12:08:56
Shut in packer.	9-24-92	268	268	12:11:26
Increase TZ pressure.	9-24-92	268	268	12:17:56
Shut in TZ.	9-24-92	268	268	12:20:26
End data file COMP36.	9-28-92	272	272	08:27:37
Depressurize TZ, deflate packer, remove test tool from compliance chamber, install axial-LVDT, and reinstall test tool in compliance chamber.	9-28-92	272	272	08:30:00
Begin data file COMP36A.	9-28-92	272	272	14:10:12
End data file COMP36A.	9-30-92	274	274	13:33:04
Depressurize TZ, deflate packer, and remove test tool from compliance chamber and move to borehole C1X06.	9-30-92	274	274	14:00:00

Table 6-13 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #36. Test tool #36 was used in observation borehole C1X06 during testing sequence C1X05-A.

Table 6-13. Compliance Equipment Associated with Test Tool #36; Borehole C1X06; Sequence C1X05-A

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	9-24-92	9-30-92
DCU (HP3497A)	N/A	2629a21990	9-24-92	9-30-92
Transducer (Druck PDCR 910)	Test Zone Packer	308143	9-24-92	9-30-92
Transducer (Druck PDCR 910)	Test Zone	308146	9-24-92	9-30-92

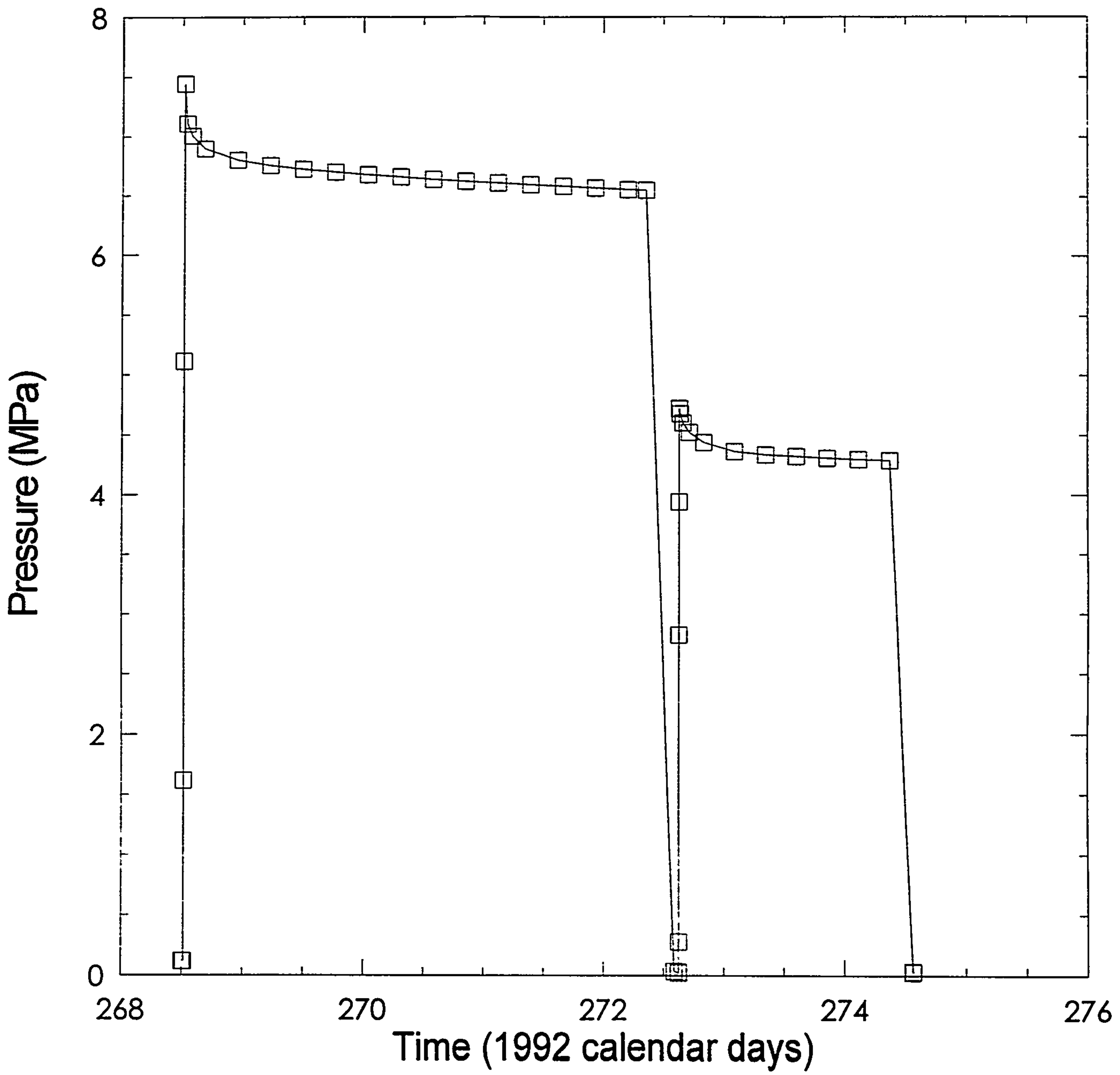

Figure 6-23. Zone pressure during compliance testing of test tool #36.

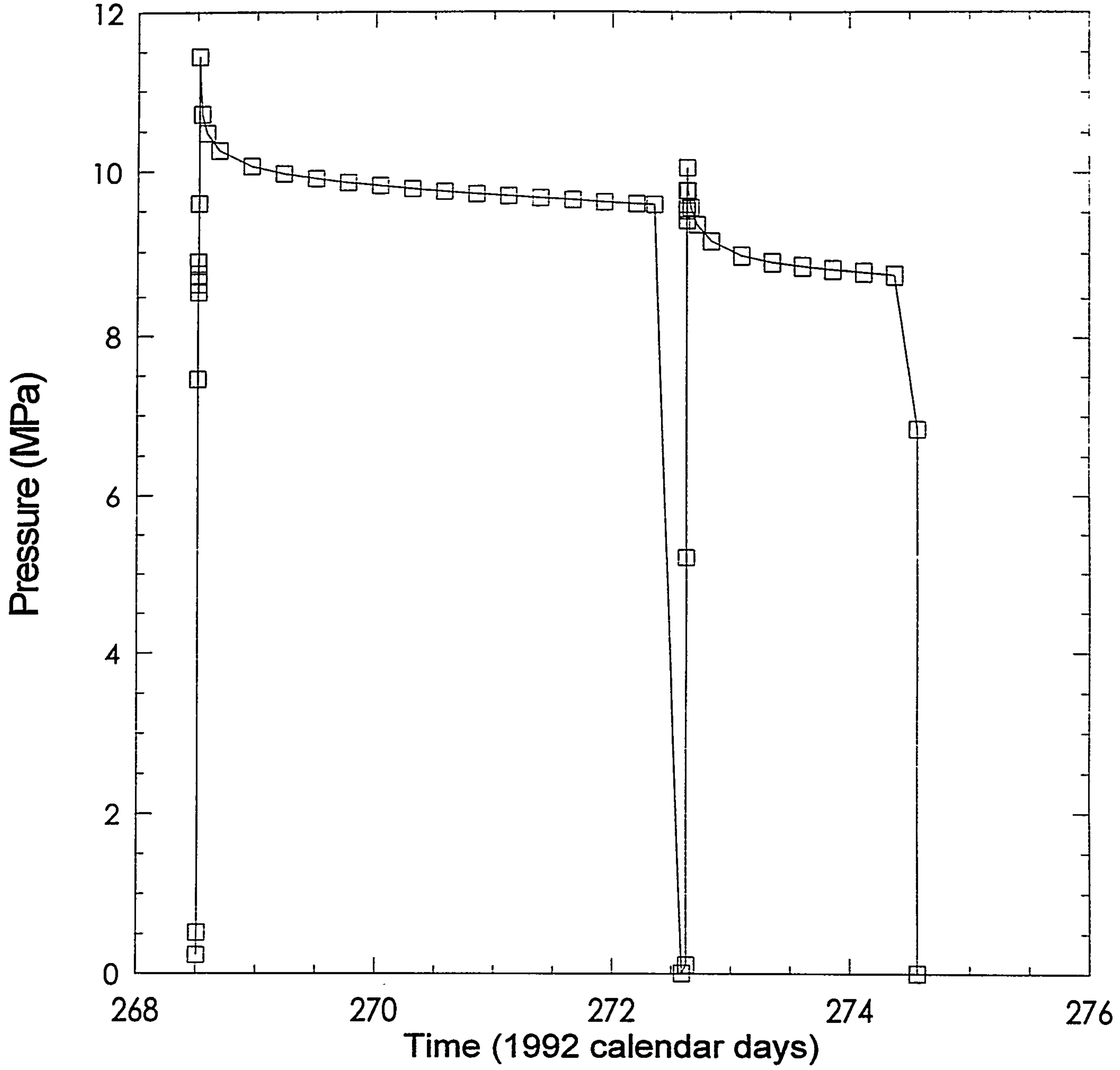

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Figure 6-24. Packer pressure during compliance testing of test tool #36.

6.2.7 Test Tool #37 (Permeability-Testing Sequence L4P52-B)

Table 6-14 gives a detailed description of the events that occurred during compliance testing of test tool #37. Figures 6-25 through 6-31 illustrate the zone pressures, packer pressures, zone temperatures, axial-LVDT displacement, radial-LVDT displacement, fluid-injection volumes during compressibility tests, and test-zone compressibility as a function of pressure, respectively, for multipacker test tool #37. Figure 3-31 illustrates the configuration of test tool #37 as assembled for compliance testing.

Table 6-14. Events Associated with Compliance Testing of Test Tool #37; Borehole L4P52; Sequence L4P52-B

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #37 to be used in borehole L4P52 during testing sequence L4P52-B.	10-30-92	304	304	12:00:00
Inflate TZ packer.	10-31-92	305	305	12:10:06
Shut in TZ packer.	10-31-92	305	305	12:11:07
Inflate GZ packer.	10-31-92	305	305	12:12:37
Shut in GZ packer.	10-31-92	305	305	12:13:37
Increase TZ packer and GZ packer pressure.	10-31-92	305	305	12:19:07
Begin data file COMP3701.	11-2-92	307	307	12:04:57
Increase TZ and GZ pressure to ~4.8 MPa.	11-9-92	314	314	10:11:00
Depressurize TZ and GZ to fix leaky fitting.	11-10-92	315	315	12:38:00
End data file COMP3701.	11-10-92	315	315	14:17:58
Begin data file COMP3702.	11-11-92	316	316	08:57:15
Begin TZ compressibility test.	11-11-92	316	316	10:31:00
Shut in TZ.	11-11-92	316	316	10:52:00
Begin GZ compressibility test.	11-11-92	316	316	11:00:00
Shut in GZ.	11-11-92	316	316	11:18:00
End data file COMP3702.	11-13-92	318	318	10:39:40
Begin data file COMP3703.	11-13-92	318	318	10:43:53
End data file COMP3703.	11-17-92	322	322	07:55:46
Replace valves on TZ and GZ.	11-23-92	328	328	10:19:00
DAS not functioning upon arrival.	11-30-92	335	335	12:00:00
Begin data file COMP3704.	11-30-92	335	335	13:29:08
Increase TZ and GZ pressure.	11-30-92	335	335	13:49:00
Depressurize zones and deflate packers.	12-2-92	337	337	12:00:00
End data file COMP3704.	12-2-92	337	337	12:20:04
Begin data file COMP3705.	12-3-92	338	338	09:55:27
Inflate TZ packer and GZ packer.	12-3-92	338	338	10:12:00
Increase TZ and GZ pressure.	12-4-92	339	339	12:00:00

Table 6-14 (Continued). Events Associated with Compliance Testing of Test Tool #37; Borehole L4P52; Sequence L4P52-B

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY	TIME (HH:MM:SS)
Depressurize TZ and GZ.	12-4-92	339	339	12:01:00
Increase TZ pressure to ~4.5 MPa.	12-4-92	339	339	13:23:00
Increase GZ pressure to ~4.5 MPa.	12-4-92	339	339	13:25:00
End data file COMP3705.	12-7-92	342	342	11:16:27
Remove test tool #37 from compliance chamber and move to borehole L4P52.	12-14-92	349	349	09:40:28

Table 6-15 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #37. Test tool #37 was used in permeability-testing sequence L4P52-B.

Table 6-15. Compliance Equipment Associated with Test Tool #37; Borehole L4P52; Sequence L4P52-B

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	10-31-92	12-7-92
DCU (HP3497A)	N/A	2629a22040	10-31-92	12-7-92
Transducer (Druck PDCR 830)	Test Zone	214048	10-31-92	12-7-92
Transducer (Druck PDCR 830)	Test Zone Packer	214466	10-31-92	12-7-92
Transducer (Druck PDCR 830)	Guard Zone	246913	10-31-92	12-7-92
Transducer (Druck PDCR 830)	Guard Zone Packer	214470	10-31-92	12-7-92
Transducer (Druck PDCR 910)	DPT Panel	322427	11-11-92	11-13-92
LVDT (Trans-Tek 241)	N/A	R09	10-31-92	12-7-92
LVDT (Trans-Tek 241)	N/A	R03	10-31-92	12-7-92
LVDT (Trans-Tek 241)	N/A	R02	10-31-92	12-7-92
LVDT (Trans-Tek 245)	N/A	A03	10-31-92	12-7-92
Thermocouple (Type E)	Test Zone	1	10-31-92	12-7-92
Thermocouple (Type E)	Guard Zone	2	10-31-92	12-7-92
Injection Column	N/A	39	11-11-92	11-11-92
DPT (Rosemount 1151DP)	N/A	1140863	11-11-92	11-13-92

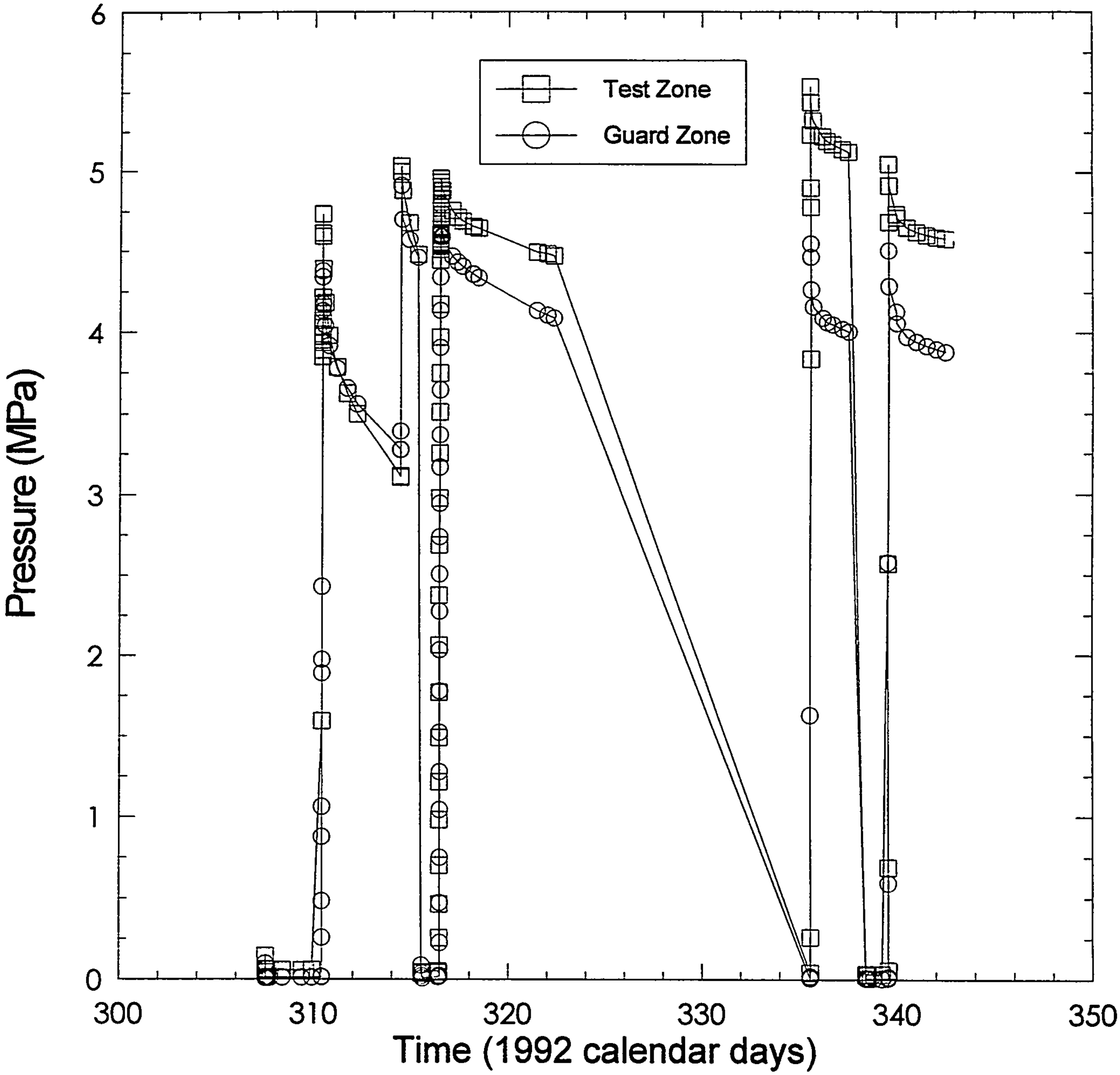

Figure 6-25. Zone pressures during compliance testing of test tool #37.

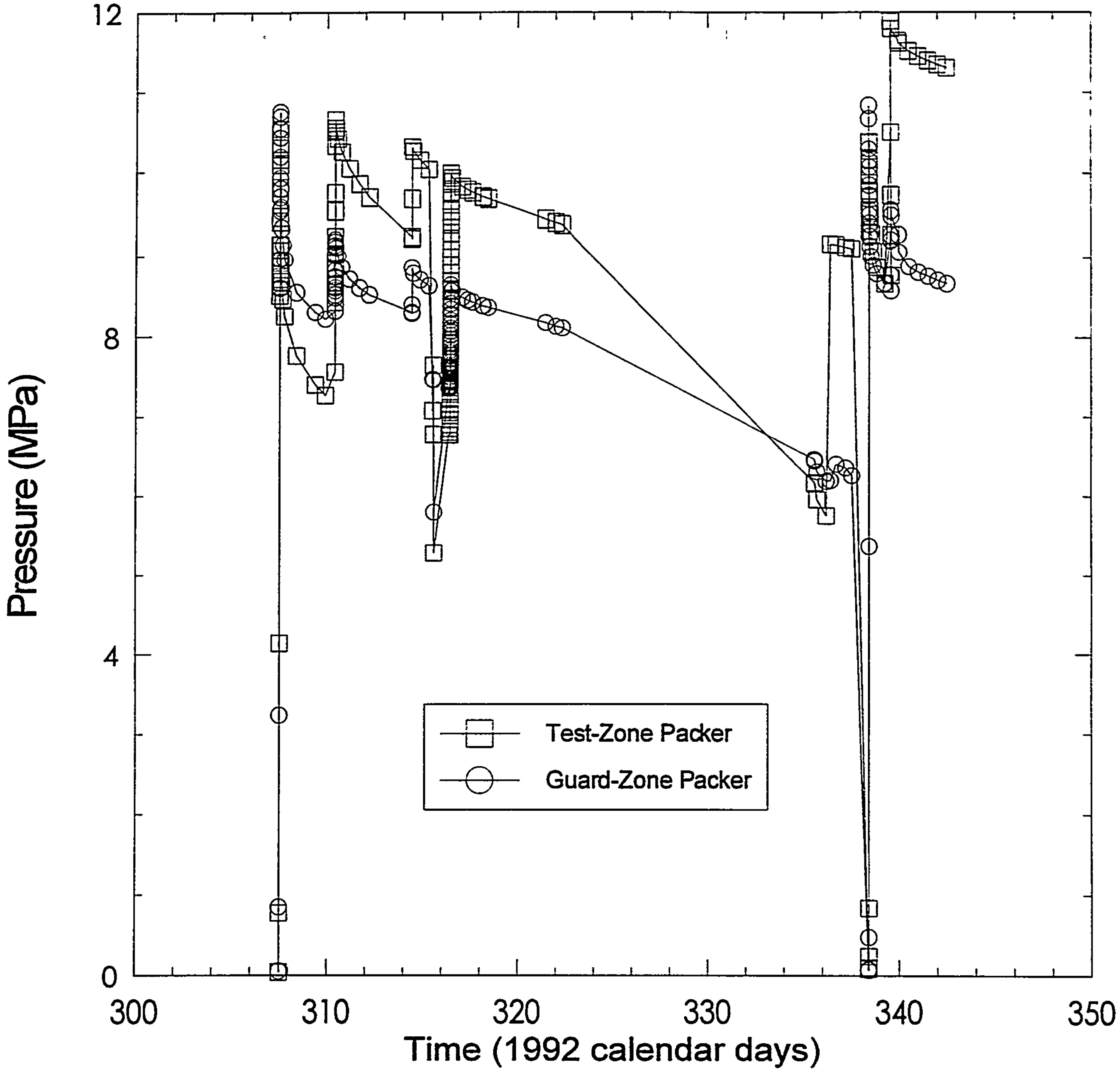

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Figure 6-26. Packer presures during compliance testing of test tool #37.

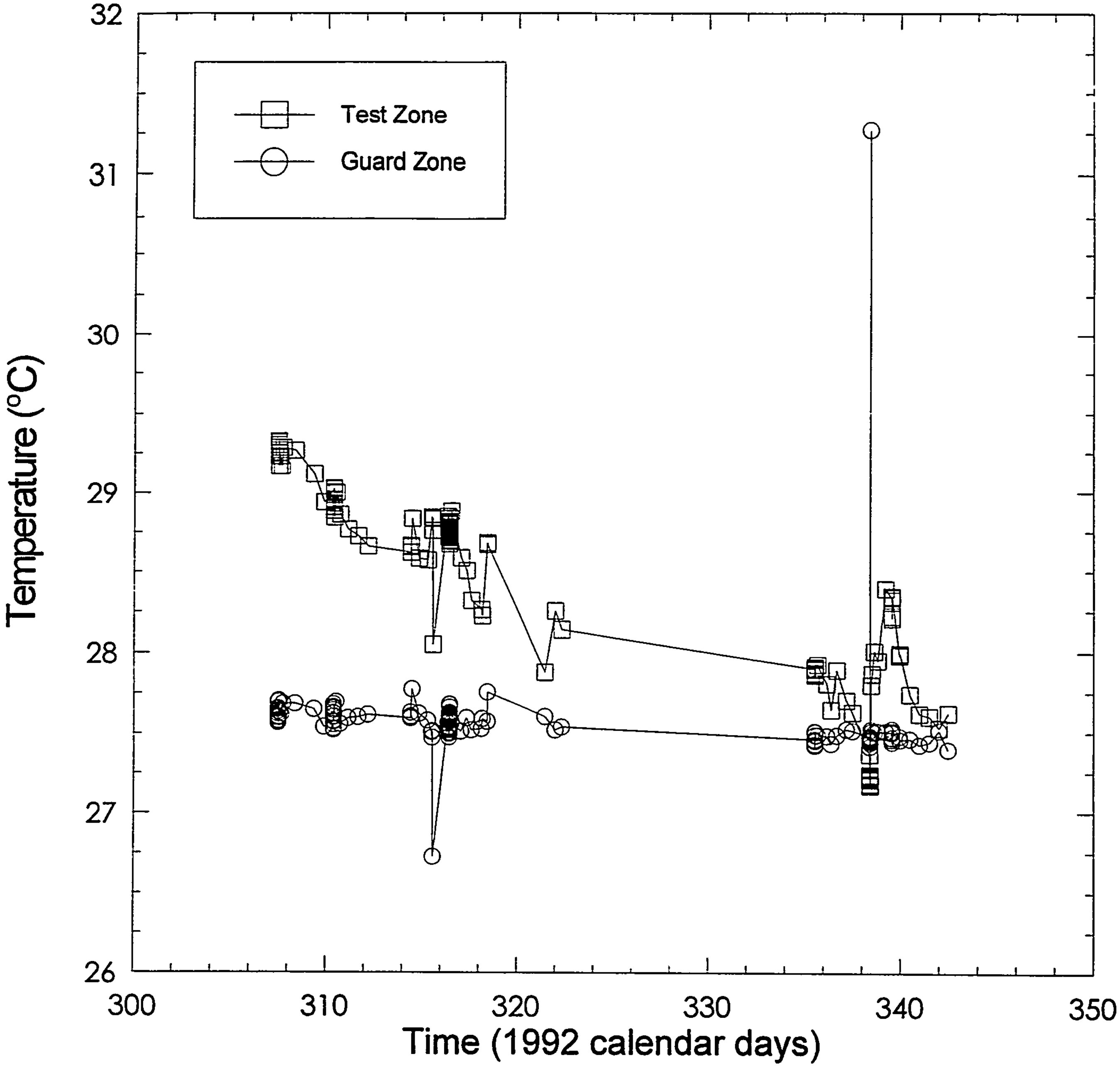

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Figure 6-27. Zone temperatures during compliance testing of test tool #37.

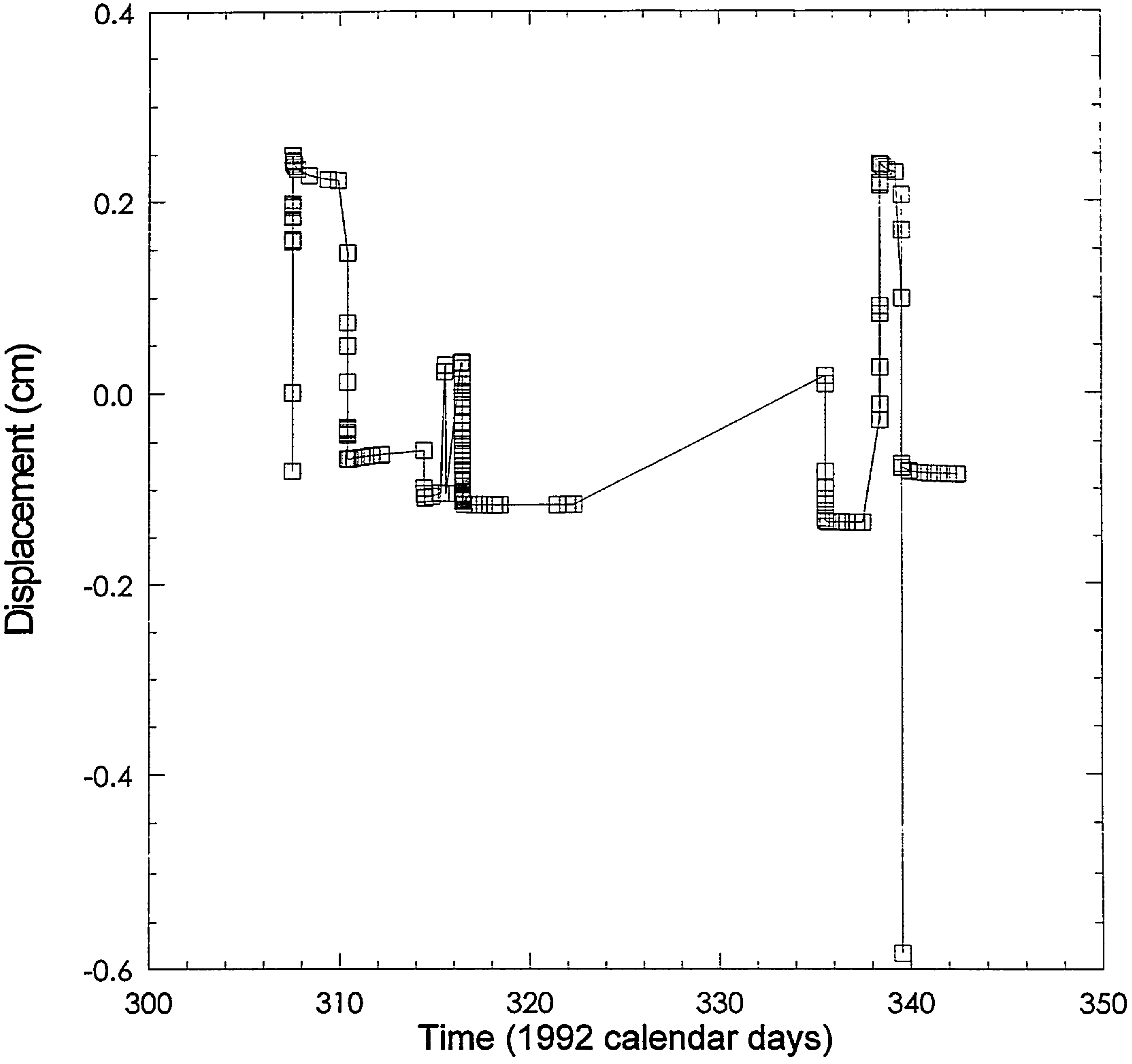

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Figure 6-28. Axial-LVDT displacement during compliance testing of test tool #37.

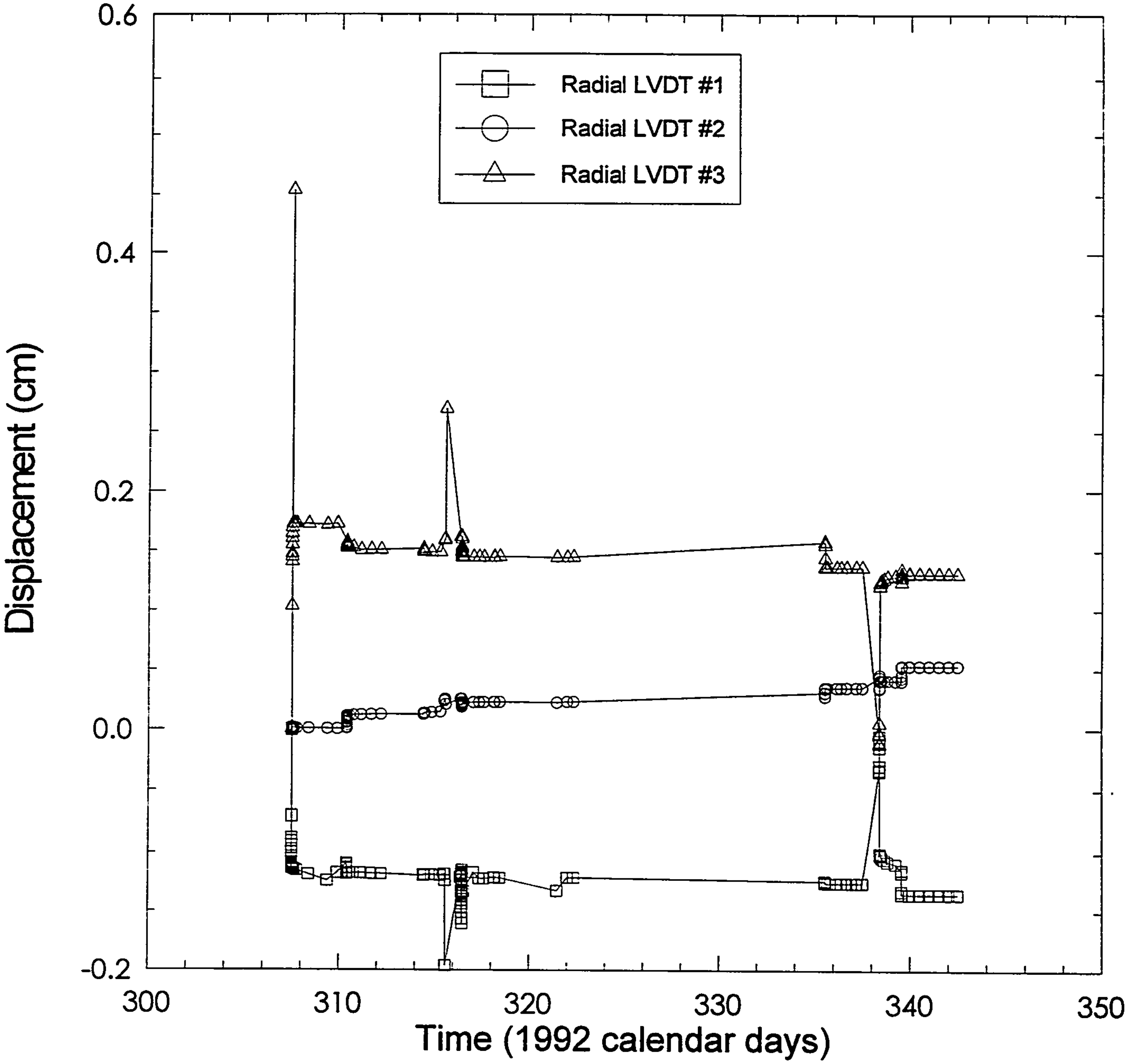

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Figure 6-29. Radial-LVDT displacement during compliance testing of test tool #37.

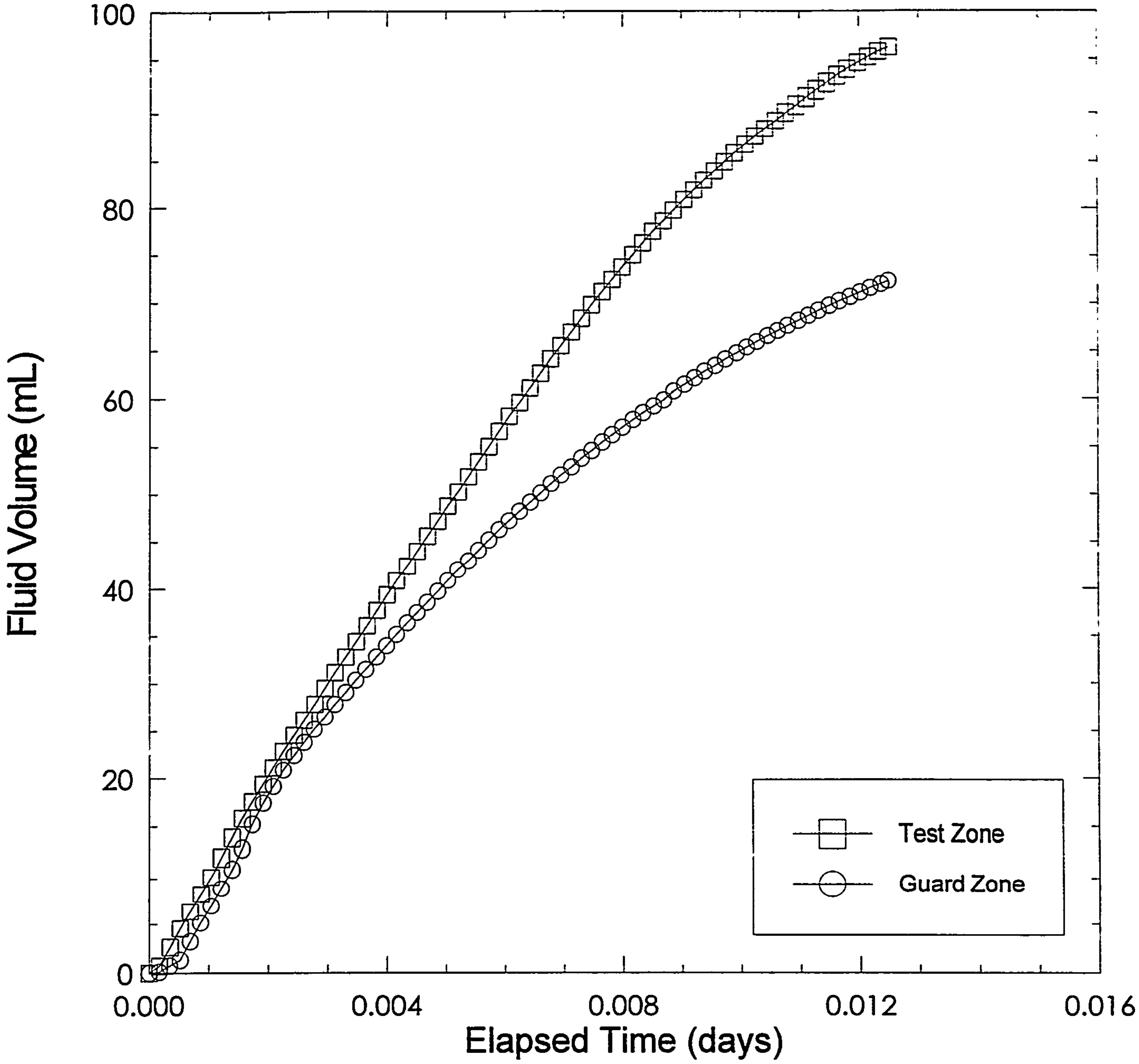

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Figure 6-30. Test-zone fluid-injection volumes during compliance testing of test tool #37.

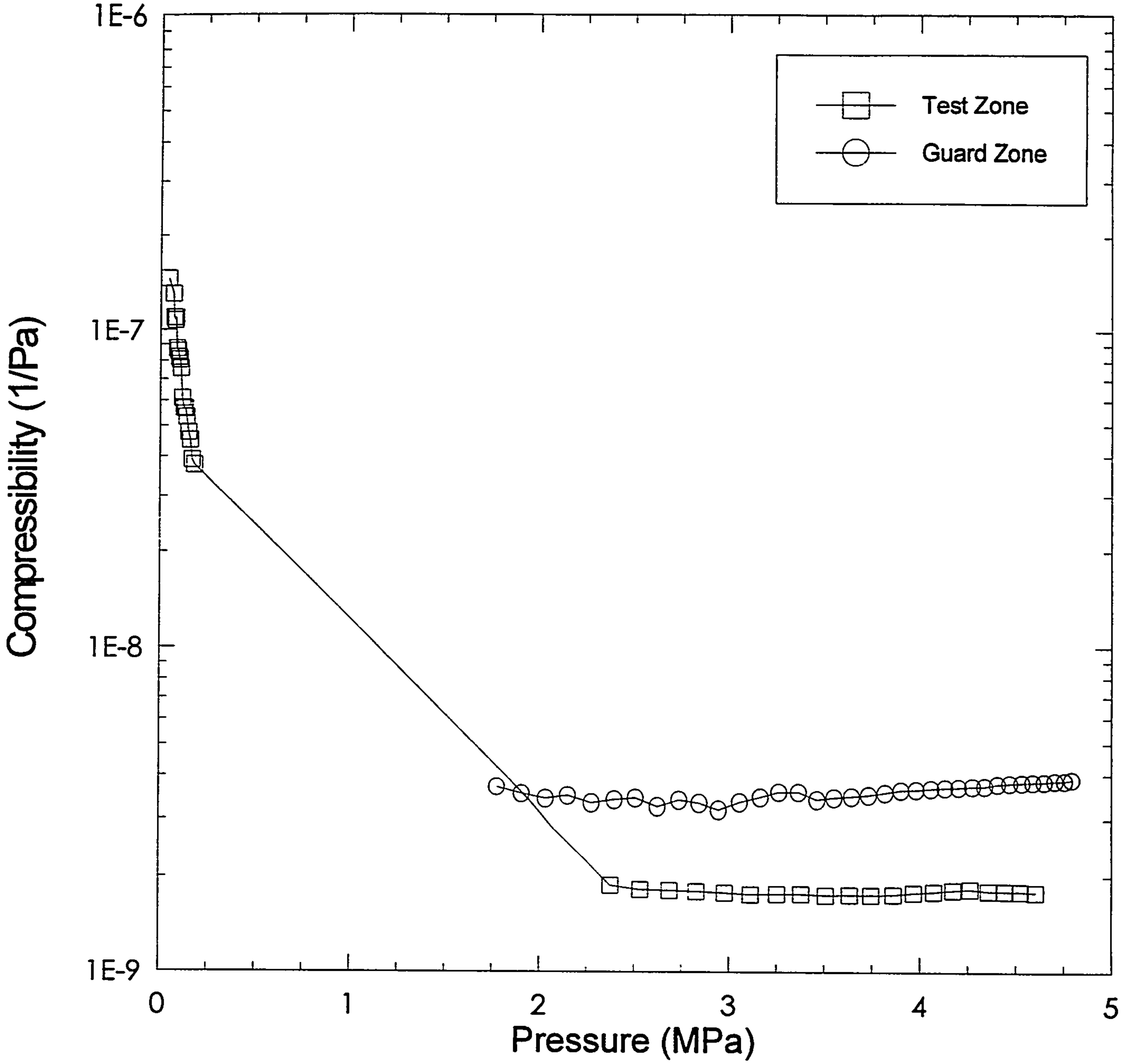

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Figure 6-31. Test-zone compressibility as measured during compliance testing of test tool #37.

6.2.8 Test Tool #38A (Gas-Threshold-Pressure Testing Sequence SCP01-1)

Table 6-16 gives a detailed description of the events that occurred during compliance testing of test tool #38A. Figures 6-32 through 6-36 illustrate the zone pressures, packer pressures, zone temperatures, fluid-injection volumes during test-tool compressibility tests, and test-tool compressibility as a function of pressure, respectively, for multipacker test tool #38A. Figure 5-4 illustrates the configuration of test tool #38A as assembled for compliance testing.

Table 6-16. Events Associated with Compliance Testing of Test Tool #38A; Borehole SCP01; Sequence SCP01-1

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #38A to be used in borehole SCP01 during testing sequence SCP01-1.	1-4-93	4	4	12:00:00
Begin data file COMP3801.	1-5-93	5	5	11:45:21
Inflate TZ packer.	1-5-93	5	5	12:38:40
Fix leak at TZ packer transducer.	1-5-93	5	5	12:41:21
Inflate TZ packer.	1-5-93	5	5	12:50:19
Shut in TZ packer.	1-5-93	5	5	12:53:53
Inflate GZ packer.	1-5-93	5	5	12:55:42
Shut in GZ packer.	1-5-93	5	5	12:58:23
Deflate TZ packer and GZ packer.	1-6-93	6	6	10:18:24
Repair TZ packer.	1-6-93	6	6	11:15:45
Inflate TZ packer.	1-6-93	6	6	11:18:25
Shut in TZ packer at 11.207 MPa.	1-6-93	6	6	11:20:11
Inflate GZ packer.	1-6-93	6	6	11:21:04
Shut in GZ packer at 10.073 MPa.	1-6-93	6	6	11:22:51
Increase TZ packer pressure.	1-6-93	6	6	12:30:53
Increase GZ packer pressure.	1-6-93	6	6	12:31:42
End data file COMP3801.	1-7-93	7	7	10:16:05
Begin data file COMP3802.	1-7-93	7	7	10:49:12
Inject fluid into TZ via DPT panel (no response).	1-7-93	7	7	12:54:26
Inject fluid into TZ via DPT panel (no response).	1-7-93	7	7	13:35:24
Deflate packers.	1-7-93	7	7	14:03:56
Inflate TZ packer.	1-7-93	7	7	14:07:56
Inflate GZ packer.	1-7-93	7	7	14:09:11
Increase TZ pressure via DPT panel.	1-8-93	8	8	10:06:48
Shut in TZ.	1-8-93	8	8	10:07:33
Depressurize TZ.	1-8-93	8	8	10:10:19
Increase TZ pressure via DPT panel.	1-8-93	8	8	10:16:44

Table 6-16 (Continued). Events Associated with Compliance Testing of Test Tool #38A; Borehole SCP01; Sequence SCP01-1

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Shut in TZ.	1-8-93	8	8	10:21:15
Depressurize TZ.	1-8-93	8	8	10:26:16
Increase TZ pressure via DPT panel.	1-8-93	8	8	10:31:16
Shut in TZ.	1-8-93	8	8	10:40:46
Increase GZ pressure via DPT panel.	1-8-93	8	8	11:00:02
Shut in GZ.	1-8-93	8	8	11:08:13
Depressurize TZ and GZ.	1-11-93	11	11	10:40:39
Increase GZ packer pressure to ~11.0 MPa.	1-11-93	11	11	10:43:40
Increase TZ packer pressure to ~11.0 MPa.	1-11-93	11	11	10:45:25
DAS not functioning upon arrival.	1-12-93	12	12	10:34:23
Increase TZ packer pressure.	1-15-93	15	15	10:36:32
Shut in TZ packer.	1-15-93	15	15	10:38:56
Begin TZ compressibility test.	1-18-93	18	18	12:40:00
Shut in TZ.	1-18-93	18	18	12:53:00
End data file COMP3802.	1-19-93	19	19	08:51:50
Begin data file COMP3803.	1-20-93	20	20	10:47:01
Decrease TZ pressure.	1-20-93	20	20	11:00:00
Depressurize TZ.	1-22-93	22	22	09:53:18
Deflate TZ packer and GZ packer.	1-22-93	22	22	09:54:30
Inflate TZ packer.	1-22-93	22	22	11:10:11
Shut in TZ packer.	1-22-93	22	22	11:12:53
Inflate GZ packer.	1-22-93	22	22	11:13:47
Shut in GZ packer.	1-22-93	22	22	11:16:27
Increase TZ pressure.	1-22-93	22	22	13:17:18
Increase GZ pressure.	1-22-93	22	22	13:20:30
TZ, TZ packer, and GZ lost pressure due to leaks.	1-25-93	25	25	11:12:48
Inflate TZ packer.	1-25-93	25	25	11:22:52
Shut in TZ packer.	1-25-93	25	25	11:25:16
Perform gas/brine exchange.	1-25-93	25	25	13:33:54
End data file COMP3803.	1-28-93	28	28	13:04:39
Remove test tool from compliance chamber and move to borehole SCP01.	2-6-93	37	37	12:00:00

Table 6-17 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #38A which was used in testing sequence SCP01-1.

Table 6-17. Compliance Equipment Associated with Test Tool #38A; Borehole SCP01; Sequence SCP01-1

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	1-5-93	2-5-93
DCU (HP3497A)	N/A	2629a21989	1-5-93	2-5-93
Transducer (Druck PDCR 910)	Test Zone	322422	1-5-93	2-5-93
Transducer (Druck PDCR 910)	Test Zone Packer	308150	1-5-93	2-5-93
Transducer (Druck PDCR 910)	Guard Zone	507864	1-5-93	2-5-93
Transducer (Druck PDCR 910)	Guard Zone Packer	308145	1-5-93	2-5-93
Transducer (Druck PDCR 910)	DPT Panel	322427	1-5-93	2-5-93
Thermocouple (Type E)	Test Zone	1	1-5-93	2-5-93
Thermocouple (Type E)	Guard Zone	2	1-5-93	2-5-93
Injection Column	N/A	38	1-7-93	1-18-93
Injection Column	N/A	39	1-18-93	1-20-93
DPT (Rosemount 1151DP)	N/A	1140864	1-7-93	1-20-93

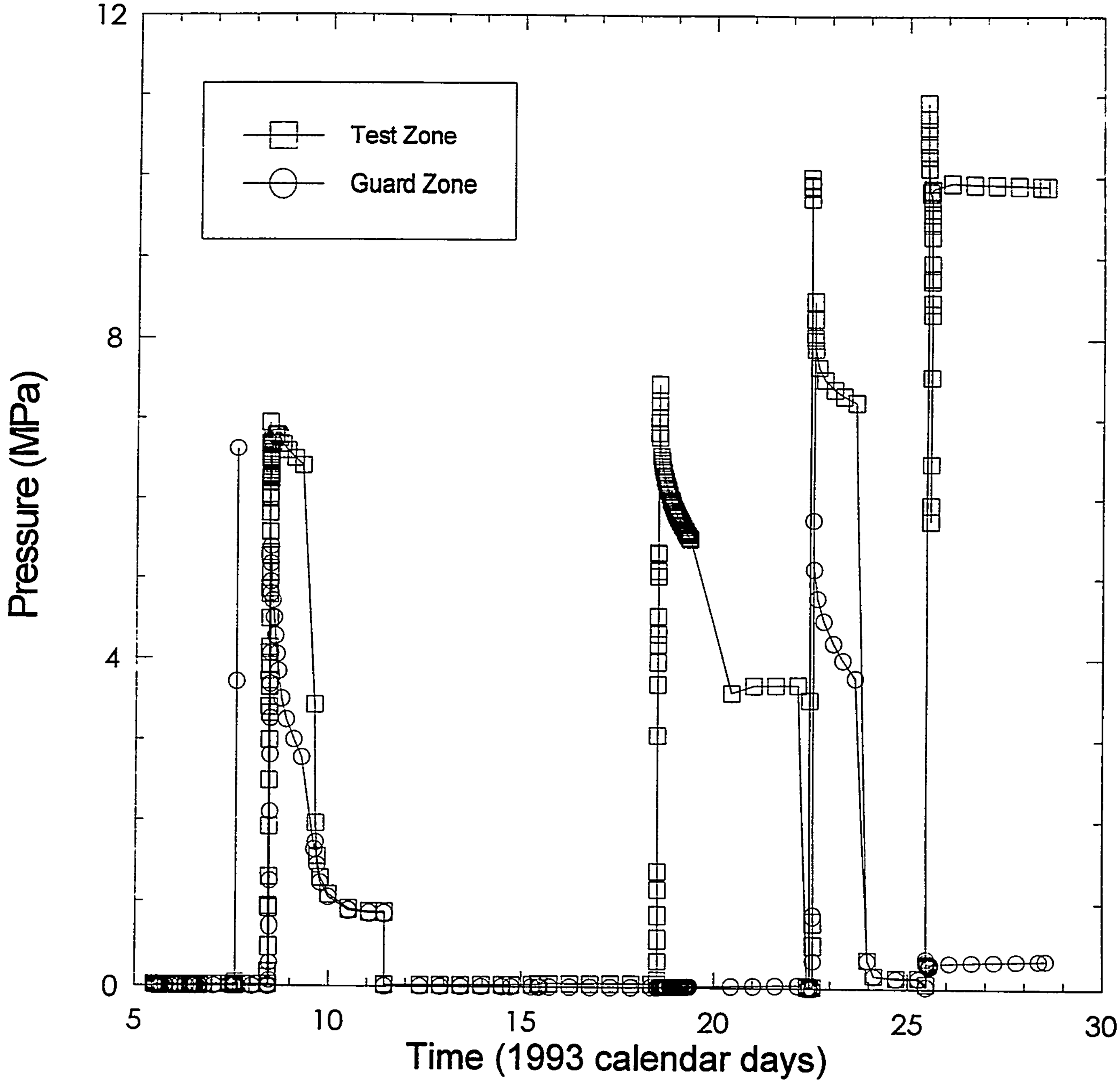

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Figure 6-32. Zone pressures during compliance testing of test tool #38A.

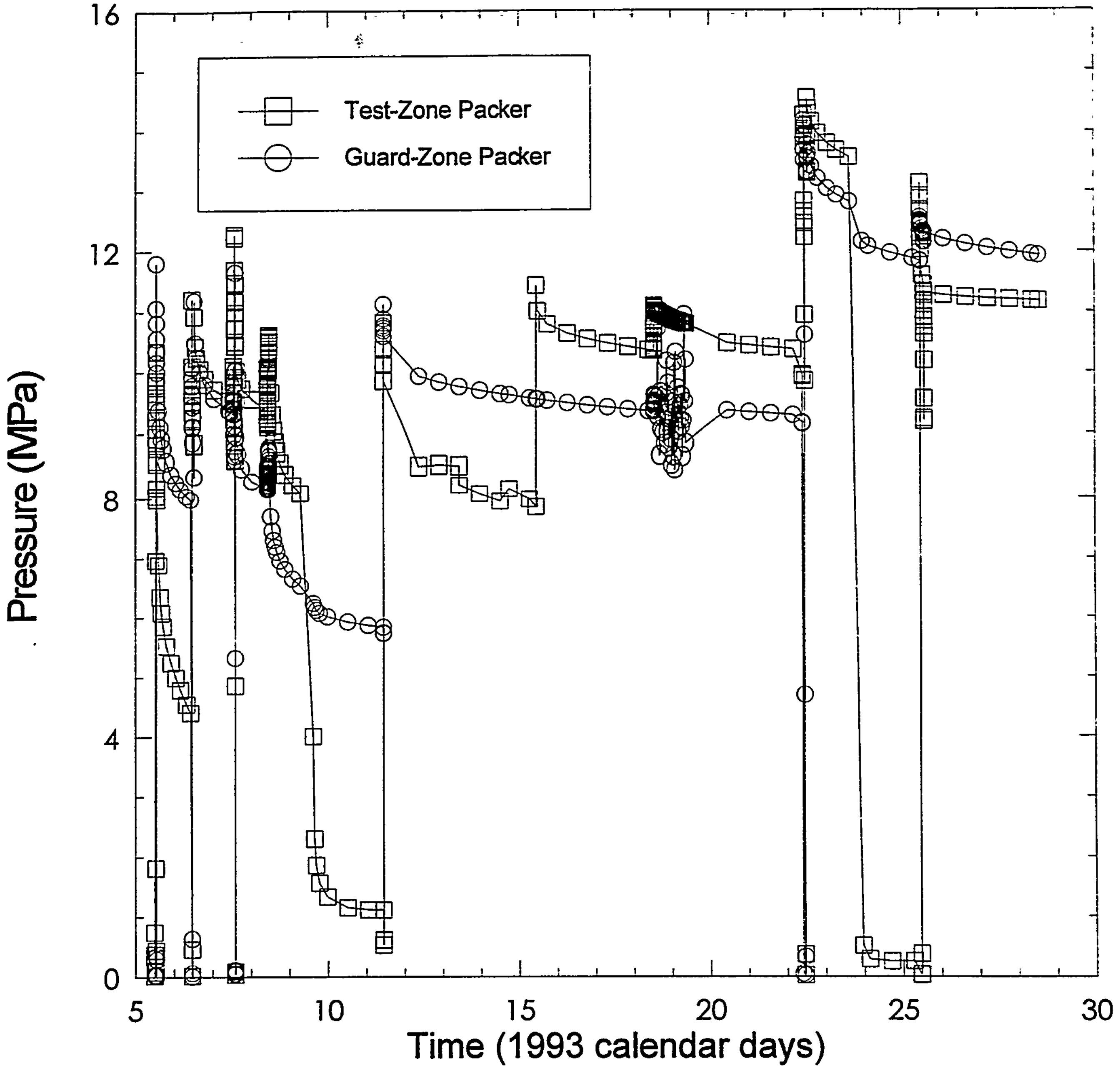

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Figure 6-33. Packer pressures during compliance testing of test tool #38A.

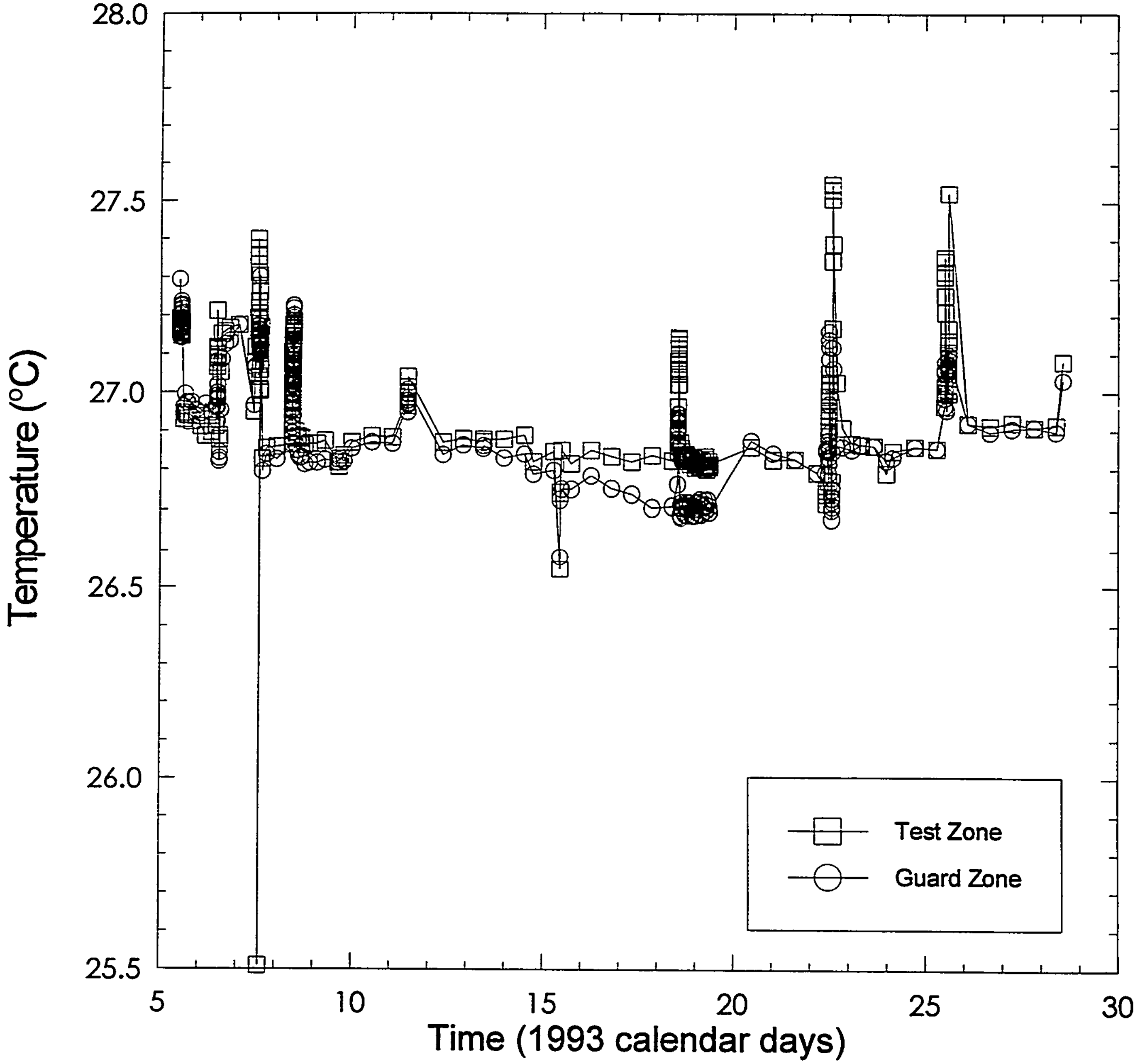

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Figure 6-34. Zone temperatures during compliance testing of test tool #38A.

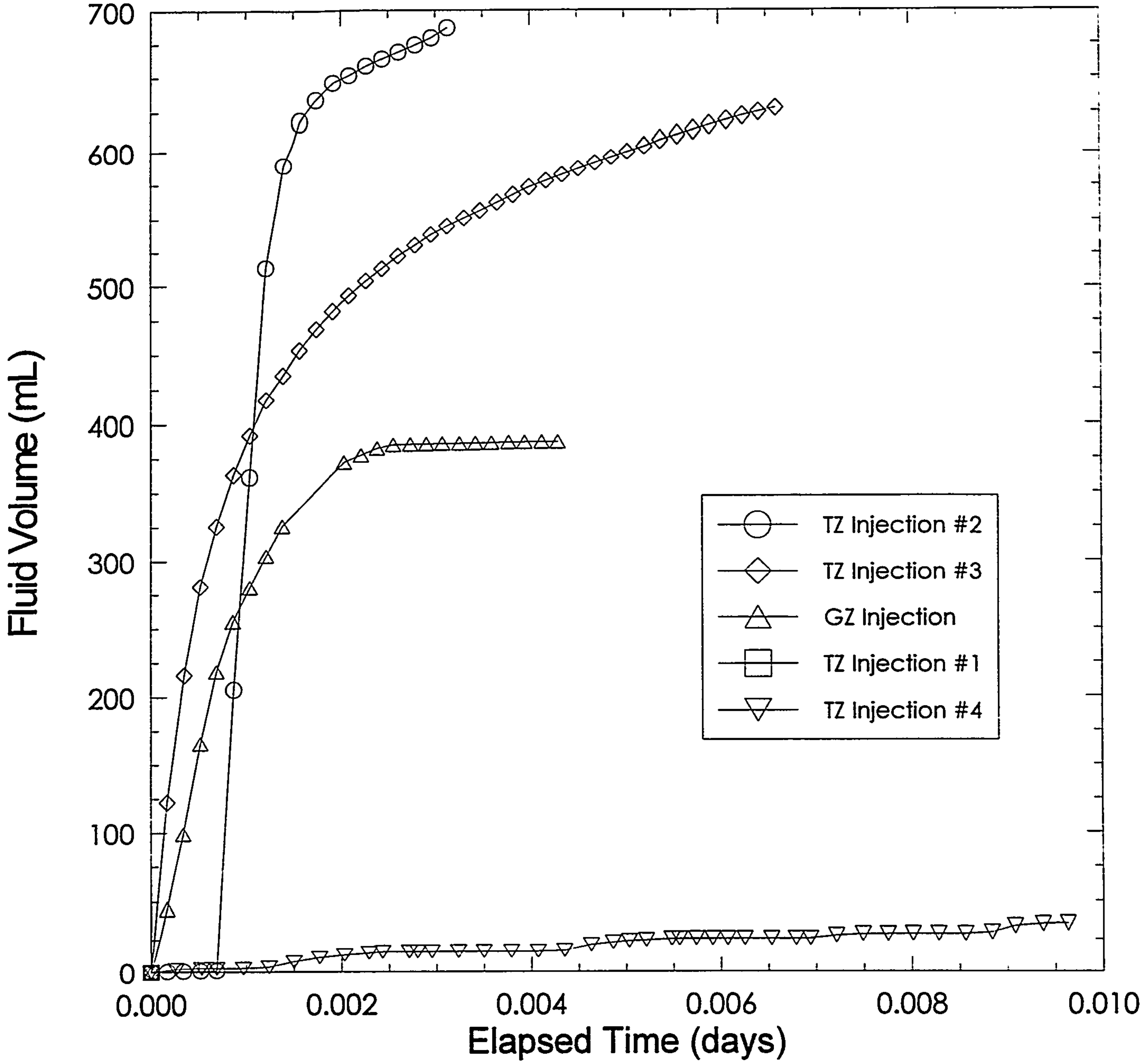

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Figure 6-35. Test-zone fluid-injection volumes during compliance testing of test tool #38A.

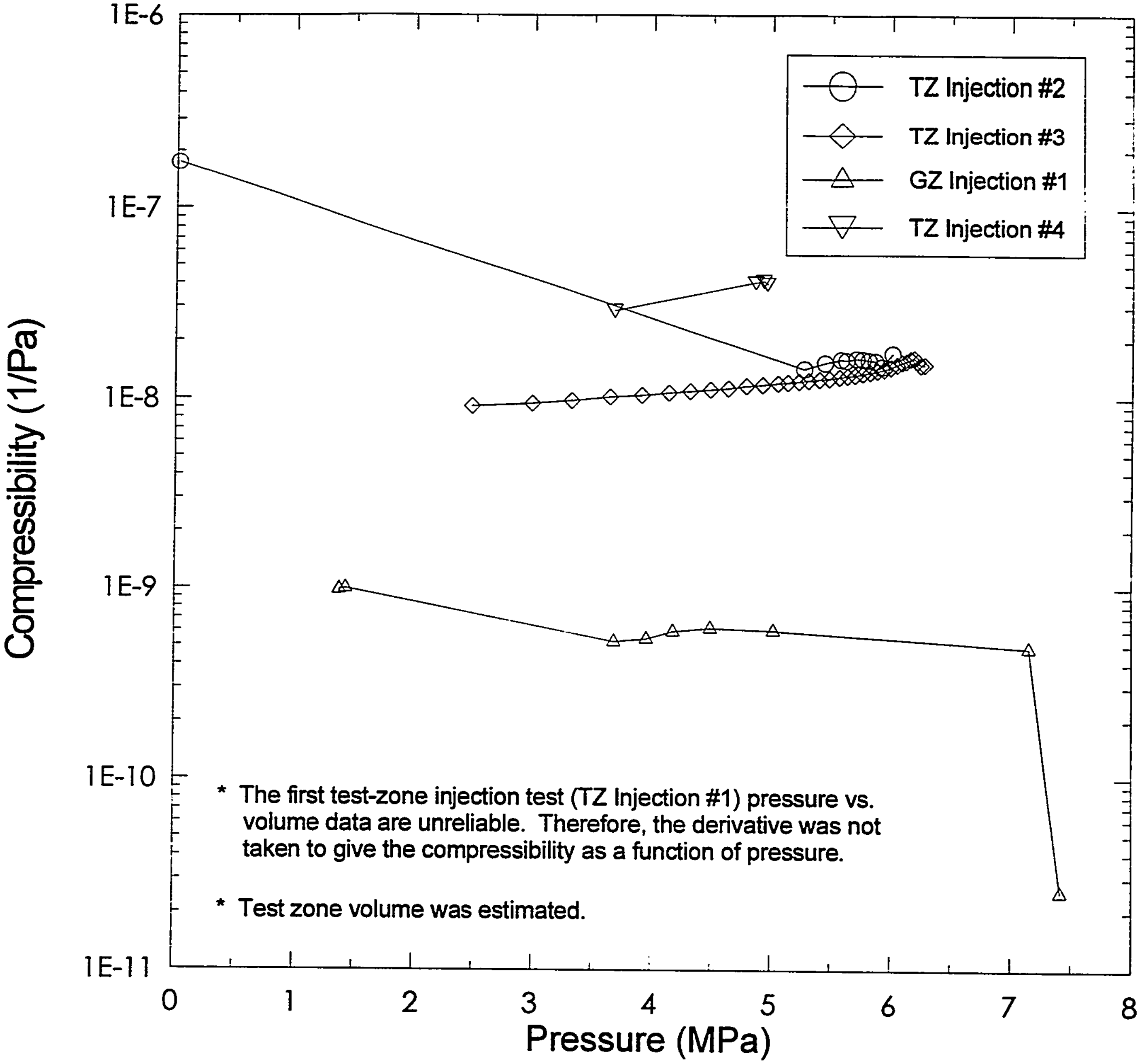

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Figure 6-36. Test-zone compressibility as measured during compliance testing of test tool #38A.

6.2.9 Test Tool #39 (Borehole C1H07, Coupled Permeability and Hydrofracture-Testing Sequence C1X05-B)

Table 6-18 gives a detailed description of the events that occurred during compliance testing of test tool #39. Figures 6-37 and 6-38 illustrate the zone and packer pressures, respectively, for test tool #39. Figure 4-15 illustrates the configuration of test tool #39 as assembled for compliance testing.

Table 6-18. Events Associated with Compliance Testing of Test Tool #39; Borehole C1H07; Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #39 to be used in borehole C1H07 during testing sequence C1X05-B.	5-15-93	135	135	12:00:00
Begin data file COMP3901.	5-18-93	138	138	09:32:59
Inflate packers.	5-18-93	138	138	12:34:00
TZ1 packer appears to be leaking; remove test tool and fix leak.	5-18-93	138	138	13:00:00
Inflate TZ1 packer and shut in.	5-19-93	139	139	11:14:00
Inflate TZ2 packer and shut in.	5-19-93	139	139	11:16:00
Inflate GZ packer and shut in.	5-19-93	139	139	11:18:00
Increase TZ1 pressure.	5-20-93	140	140	11:15:00
Increase TZ2 pressure (no response on transducer).	5-20-93	140	140	12:15:93
End data file COMP3901.	5-20-93	140	140	12:32:14
Remove transducer 308146 and install transducer 322424.	5-20-93	140	140	12:35:00
Begin data file COMP3902.	5-20-93	140	140	12:35:41
Increase GZ pressure.	5-20-93	140	140	13:33:00
Repaired leaky fitting on TZ2.	5-21-93	141	141	10:14:00
Increase TZ2 pressure to 4.4 MPa.	5-21-93	141	141	10:18:00
Increase GZ pressure to 4.3 MPa.	5-21-93	141	141	10:20:00
End data file COMP3902.	5-28-93	148	148	04:07:08
Remove test tool from compliance chamber and move to borehole C1H07.	5-28-93	148	148	12:00:00

Table 6-19 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #39. Test tool #39 was used in observation borehole C1H07 during testing sequence C1X05-B.

Table 6-19. Compliance Equipment Associated with Test Tool #39; Borehole C1H07; Sequence C1X05-B

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	5-18-93	5-28-93
DCU (HP3497A)	N/A	2023a01688	5-18-93	5-28-93
Transducer (Druck PDCR 830)	Test Zone 1	246909	5-18-93	5-28-93
Transducer (Druck PDCR 830)	Test Zone 1 Packer	246918	5-18-93	5-28-93
Transducer (Druck PDCR 910)	Test Zone 2	308146	5-18-93	5-20-93
Transducer (Druck PDCR 830)	Test Zone 2 Packer	246917	5-18-93	5-28-93
Transducer (Druck PDCR 910)	Test Zone 2	322426	5-20-93	5-28-93
Transducer (Druck PDCR 910)	Guard Zone	322424	5-18-93	5-28-93
Transducer (Druck PDCR 10/D)	Guard Zone Packer	211691	5-18-93	5-28-93

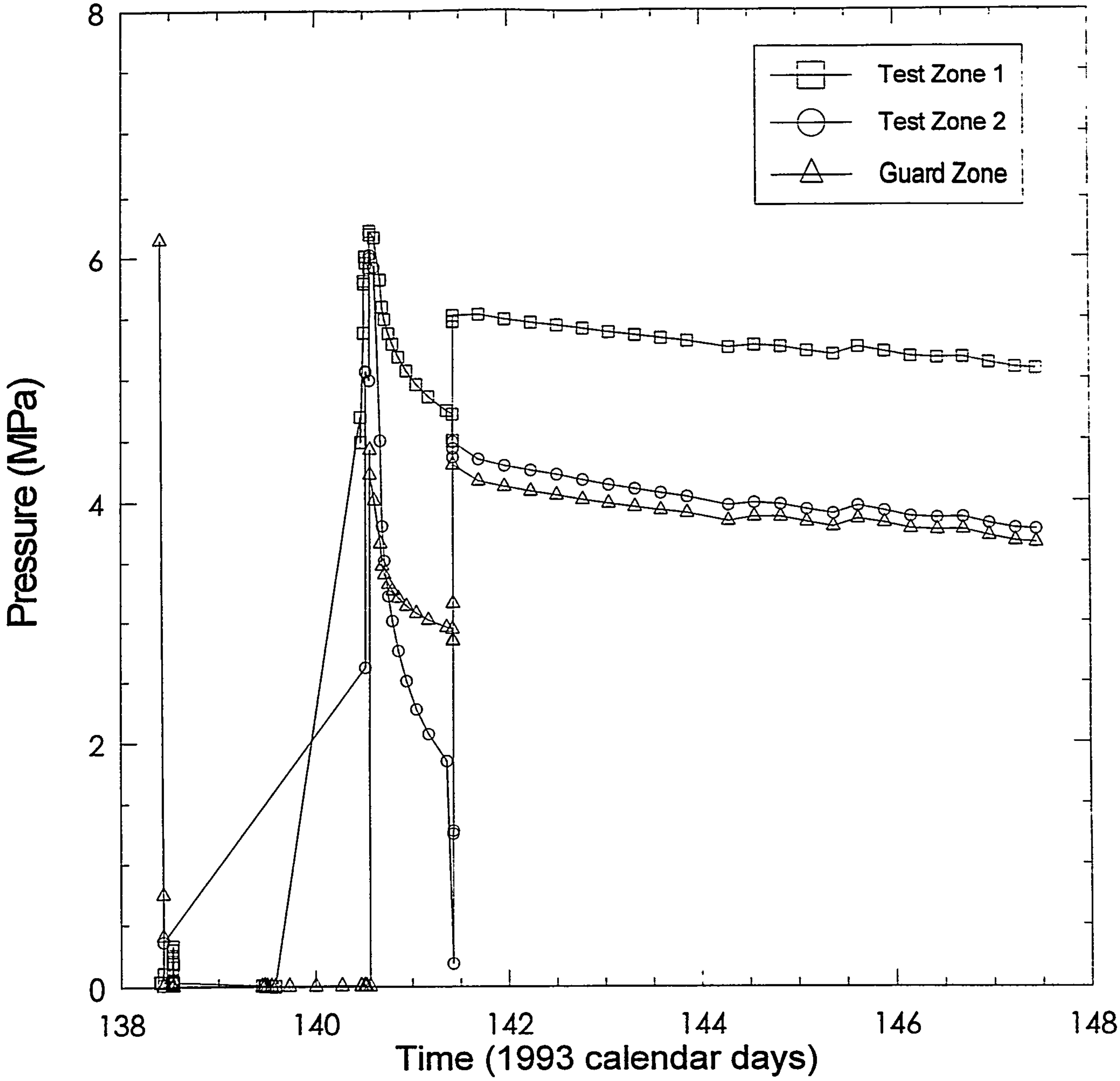

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Figure 6-37. Zone pressures during compliance testing of test tool #39.

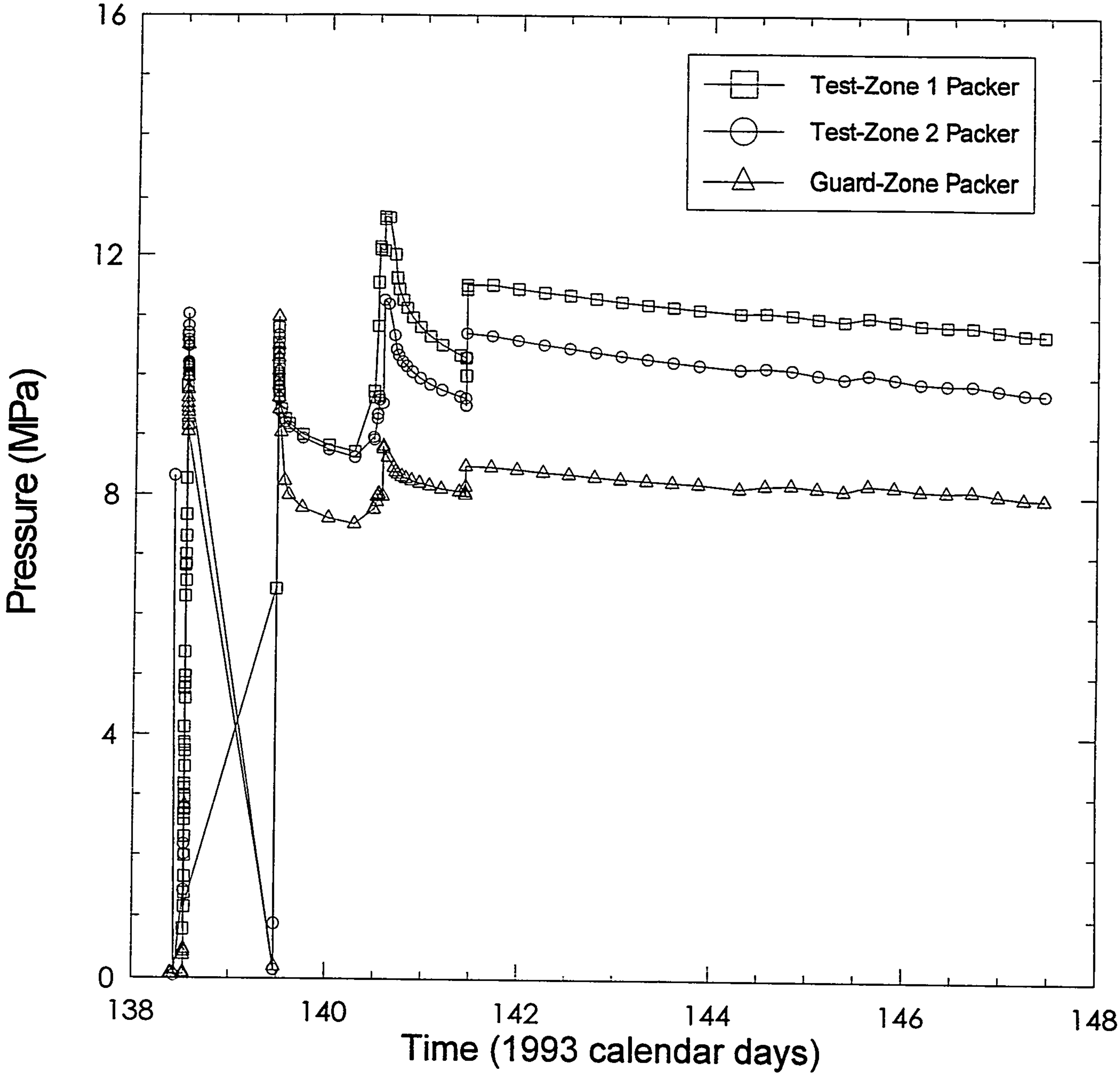

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Figure 6-38. Packer pressures during compliance testing of test tool #39.

6.2.10 Test Tool #40 (Borehole C1X06, Coupled Permeability and Hydrofracture-Testing Sequence C1X05-B)

Table 6-20 gives a detailed description of the events that occurred during compliance testing of test tool #40. Figures 6-39 and 6-40 illustrate the zone and packer pressures, respectively, for test tool #40. Figure 4-17 illustrates the configuration of test tool #40 as assembled for compliance testing.

Table 6-20. Events Associated with Compliance Testing of Test Tool #40; Borehole C1X06; Sequence C1X05-B

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #30 to be used in borehole C1X06 during testing sequence C1X05-B.	7-1-93	182	182	12:00:00
Begin data file COMP4002.	7-2-93	183	183	12:45:22
Inflate TZ2 packer.	7-2-93	183	183	13:13:33
Shut in TZ2 packer.	7-2-93	183	183	13:15:10
Inflate TZ1 packer.	7-2-93	183	183	13:18:02
Shut in TZ1 packer.	7-2-93	183	183	13:19:20
Inflate GZ packer.	7-2-93	183	183	13:19:45
Shut in GZ packer.	7-2-93	183	183	13:21:21
Increase TZ2 pressure.	7-2-93	183	183	13:25:21
Increase TZ1 pressure.	7-2-93	183	183	13:40:30
Shut in TZ2 and TZ1.	7-2-93	183	183	13:40:58
Increase GZ pressure.	7-2-93	183	183	13:44:01
Shut in GZ.	7-2-93	183	183	13:46:00
Increase TZ1 and GZ pressure.	7-30-93	211	211	12:07:14
End data file COMP4002.	8-2-93	214	214	06:59:22
Remove test tool #40 form compliance chamber and move to borehole C1X06.	8-4-93	216	216	12:00:00

Table 6-21 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #40. Test tool #40 was used in observation borehole C1X06 during coupled permeability and hydrofracture-testing sequence C1X05-B.

Table 6-21. Compliance Equipment Associated with Test Tool #40; Borehole C1X06; Sequence C1X05-B

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	7-2-93	8-4-93
DCU (HP3497A)	N/A	2629a21989	7-2-93	8-4-93
Transducer (Druck PDCR 830)	Test Zone 1	246918	7-2-93	8-4-93
Transducer (Druck PDCR 910)	Test Zone 1 Packer	308143	7-2-93	8-4-93
Transducer (Druck PDCR 830)	Test Zone 2	246916	7-2-93	8-4-93
Transducer (Druck PDCR 910)	Test Zone 2 & Guard Zone Packer	308148	7-2-93	8-4-93
Transducer (Druck PDCR 10/D)	Guard Zone	211691	7-2-93	8-4-93

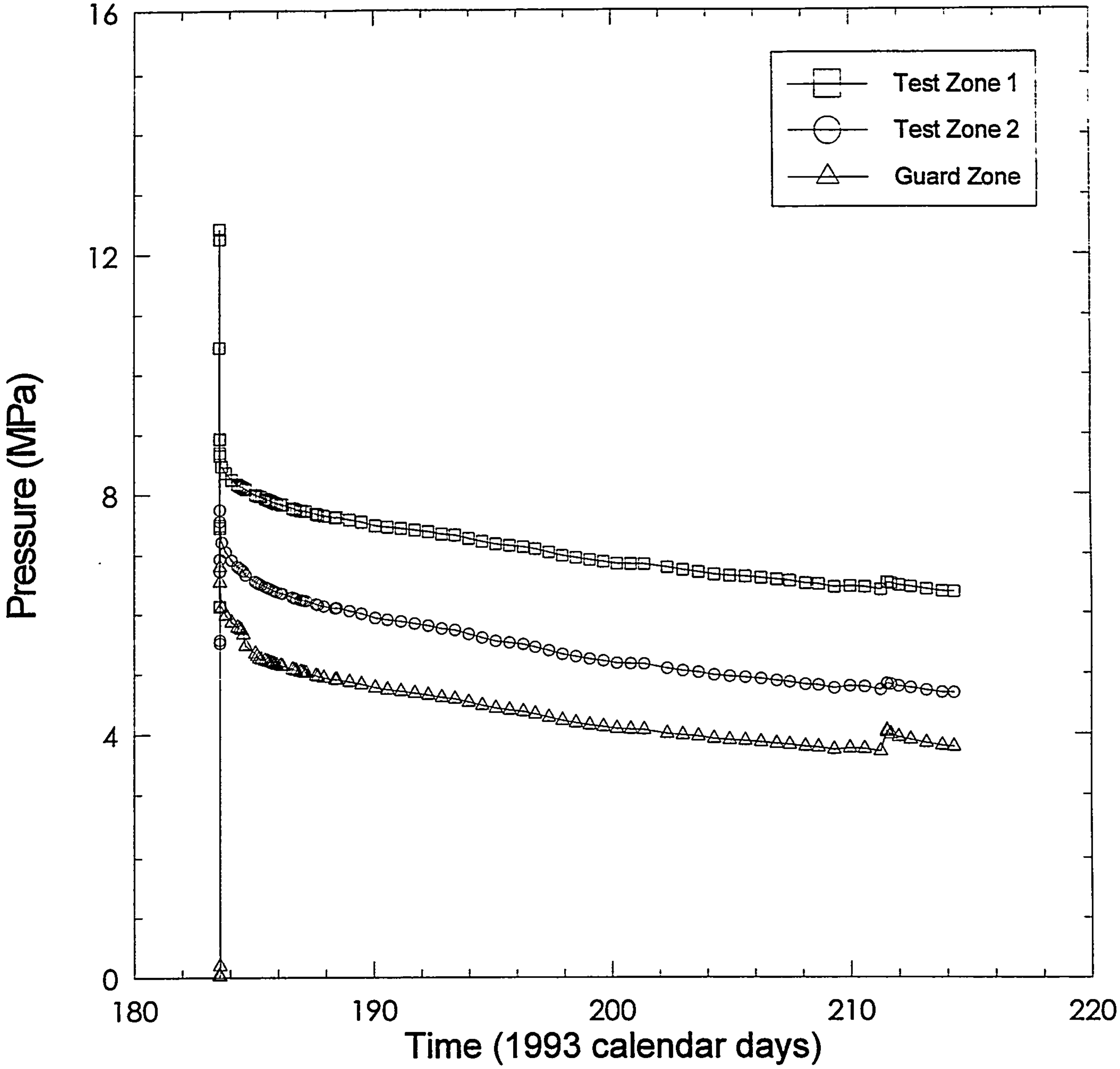

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Figure 6-39. Zone pressures during compliance testing of test tool #40.

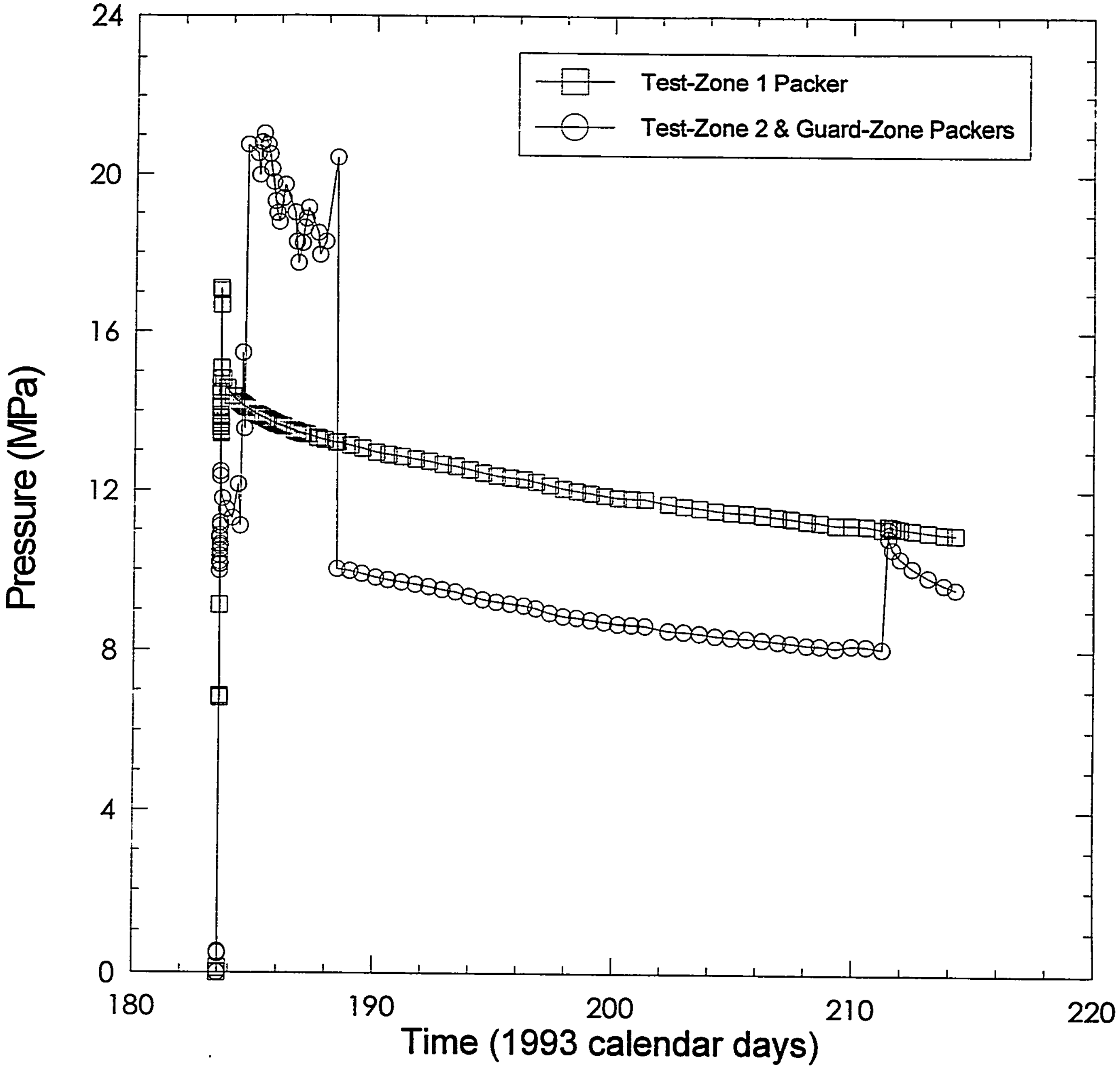

Figure 6-40. Packer pressures during compliance testing of test tool #40.

6.2.11 Test Tool #41 (Permeability-Testing Sequence L4P51-C2)

Table 6-22 gives a detailed description of the events that occurred during compliance testing of test tool #41. Figures 6-41 through 6-43 illustrate the zone pressures, packer pressures, and test zone temperature, respectively, for multipacker test tool #41. Figure 3-24 illustrates the configuration of test tool #41 as assembled for compliance testing.

Table 6-22. Events Associated with Compliance Testing of Test Tool #41; Borehole L4P51; Sequence L4P51-C2

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #41 to be used in borehole L4P51 during testing sequence L4P51-C2.	10-24-93	297	297	12:00:00
Inflate TZ1 packer.	10-26-93	299	299	09:27:29
Deflate TZ1 packer.	10-26-93	299	299	09:28:00
Inflate TZ1 packer.	10-26-93	299	299	09:30:00
Deflate TZ1 packer.	10-26-93	299	299	09:31:00
Inflate TZ1 packer.	10-26-93	299	299	09:37:08
Shut in TZ1 packer.	10-26-93	299	299	09:38:46
Inflate TZ2 packer (incorrect response).	10-26-93	299	299	09:43:25
Removed test tool to find mislabeled inflation lines.	10-26-93	299	299	13:00:00
Begin data file COMP4101.	10-26-93	299	299	13:37:03
Inflate TZ1 packer.	10-27-93	300	300	08:10:00
Inflate TZ2 packer.	10-27-93	300	300	08:25:00
Decrease TZ1 packer pressure.	10-27-93	300	300	08:25:30
Inflate GZ packer.	10-27-93	300	300	08:35:00
Increase TZ1 pressure.	10-28-93	301	301	07:53:00
Increase TZ1 pressure.	10-28-93	301	301	07:55:00
Increase TZ2 packer pressure to ~10.3 MPa.	10-28-93	301	301	08:15:00
TZ1 will not maintain pressure.	10-28-93	301	301	09:00:00
Deflate packers.	10-28-93	301	301	09:02:00
Remove test tool and fix leaky fitting.	10-28-93	301	301	09:30:00
Reinstall test tool in compliance chamber.	10-28-93	301	301	10:02:00
Inflate TZ1 packer.	10-28-93	301	301	11:09:00
Inflate TZ2 packer.	10-28-93	301	301	11:12:00
Inflate GZ packer.	10-28-93	301	301	11:15:00
Increase TZ1 pressure.	10-28-93	301	301	12:22:00
Increase TZ2 pressure.	10-28-93	301	301	12:23:00
Increase GZ pressure.	10-28-93	301	301	12:25:00
End data file COMP4101.	10-28-93	301	301	12:32:39
Begin data file COMP4102.	10-28-93	301	301	12:36:51

Table 6-22 (Continued). Events Associated with Compliance Testing of Test Tool #41; Borehole L4P51; Sequence L4P51-C2

EVENT	DATE	CALENDAR DAY	1993 CALENDAR DAY	TIME (HH:MM:SS)
P5 gage is reading incorrectly (high) as determined by Heise gage.	11-2-93	306	306	10:42:15
End data file COMP4102.	11-11-93	315	315	12:31:36
Remove test tool #41 from compliance chamber and move to borehole L4P51.	11-16-93	320	320	12:00:00

Table 6-23 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #41. Test tool #41 was used in permeability-testing sequence L4P51-C2.

Table 6-23. Compliance Equipment Associated with Test Tool #41; Borehole L4P51; Sequence L4P51-C2

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	10-26-93	11-16-93
DCU (HP3497A)	N/A	2629a21990	10-26-93	11-16-93
Transducer (Druck PDCR 830)	Test Zone 1	246912	10-26-93	11-16-93
Transducer (Druck PDCR 830)	Test Zone 1 Packer	246919	10-26-93	11-16-93
Transducer (Druck PDCR 830)	Test Zone 2	246910	10-26-93	11-16-93
Transducer (Druck PDCR 910)	Test Zone 2 Packer	308152	10-26-93	11-16-93
Transducer (Druck PDCR 910)	Guard Zone	308143	10-26-93	11-16-93
Transducer (Druck PDCR 910)	Guard Zone Packer	322423	10-26-93	11-16-93
Thermocouple (Type E)	Test Zone 1	1	10-26-93	11-16-93

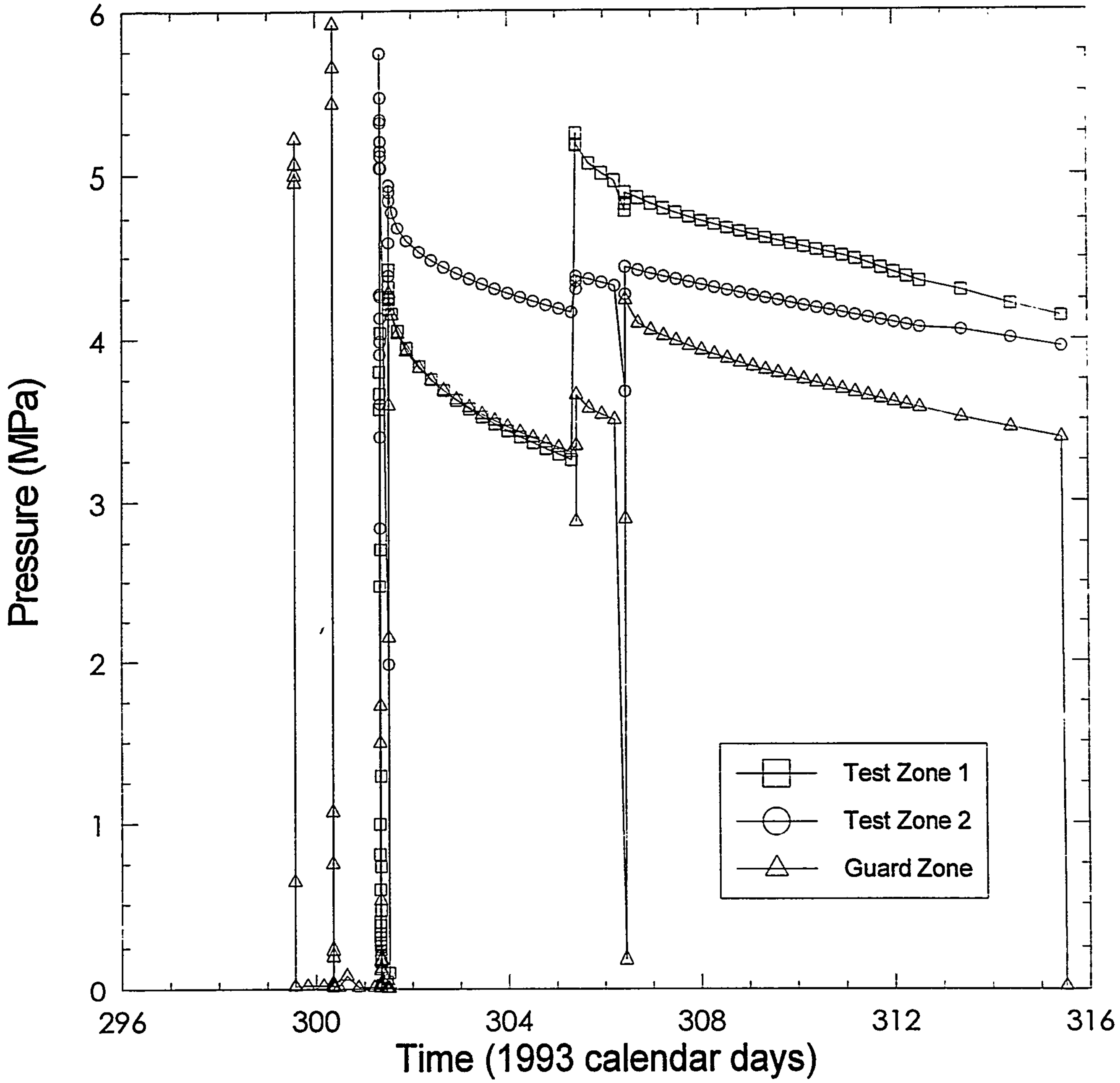

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Figure 6-41. Zone pressures during compliance testing of test tool #41.

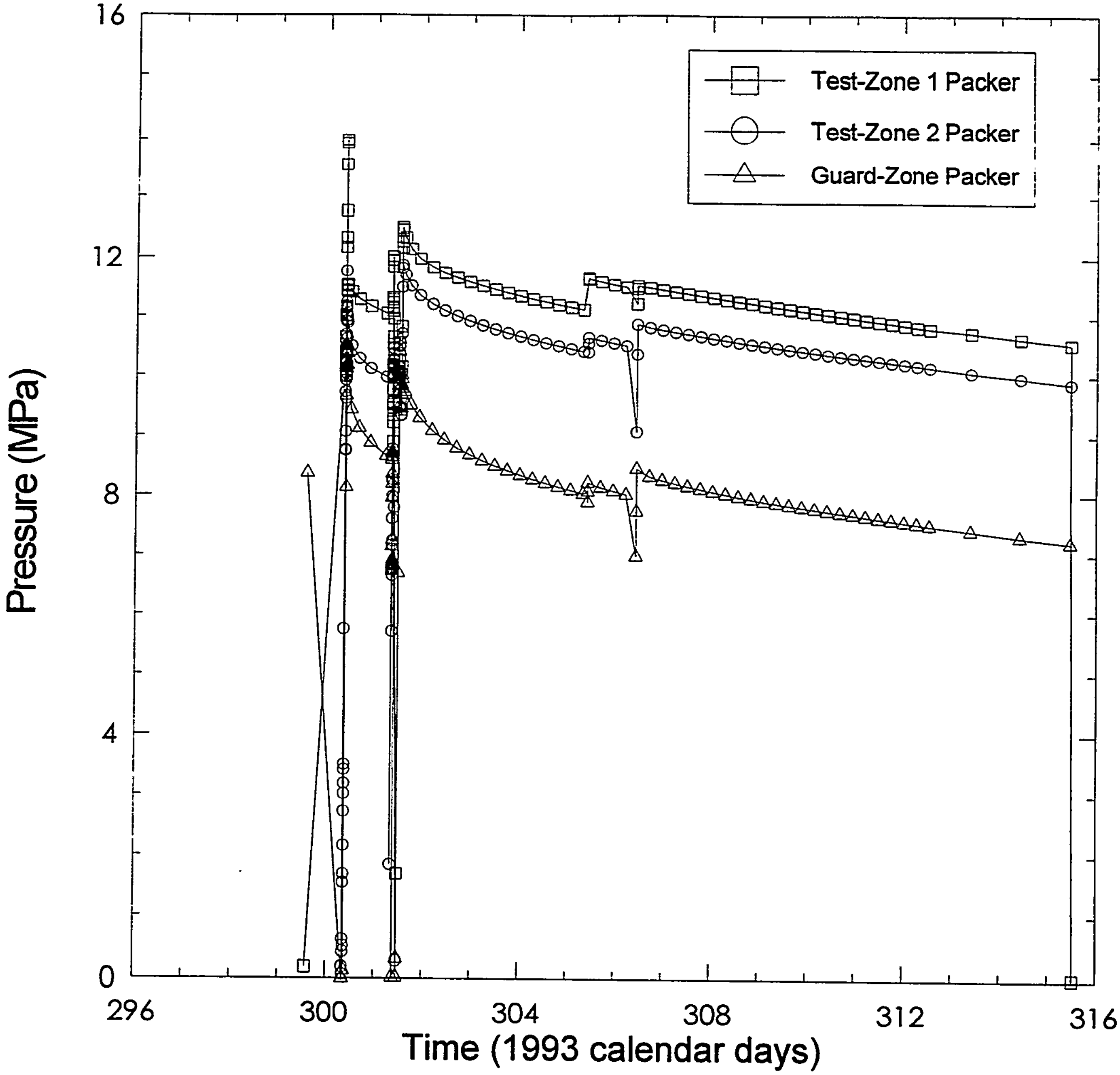

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Figure 6-42. Packer pressures during compliance testing of test tool #41.

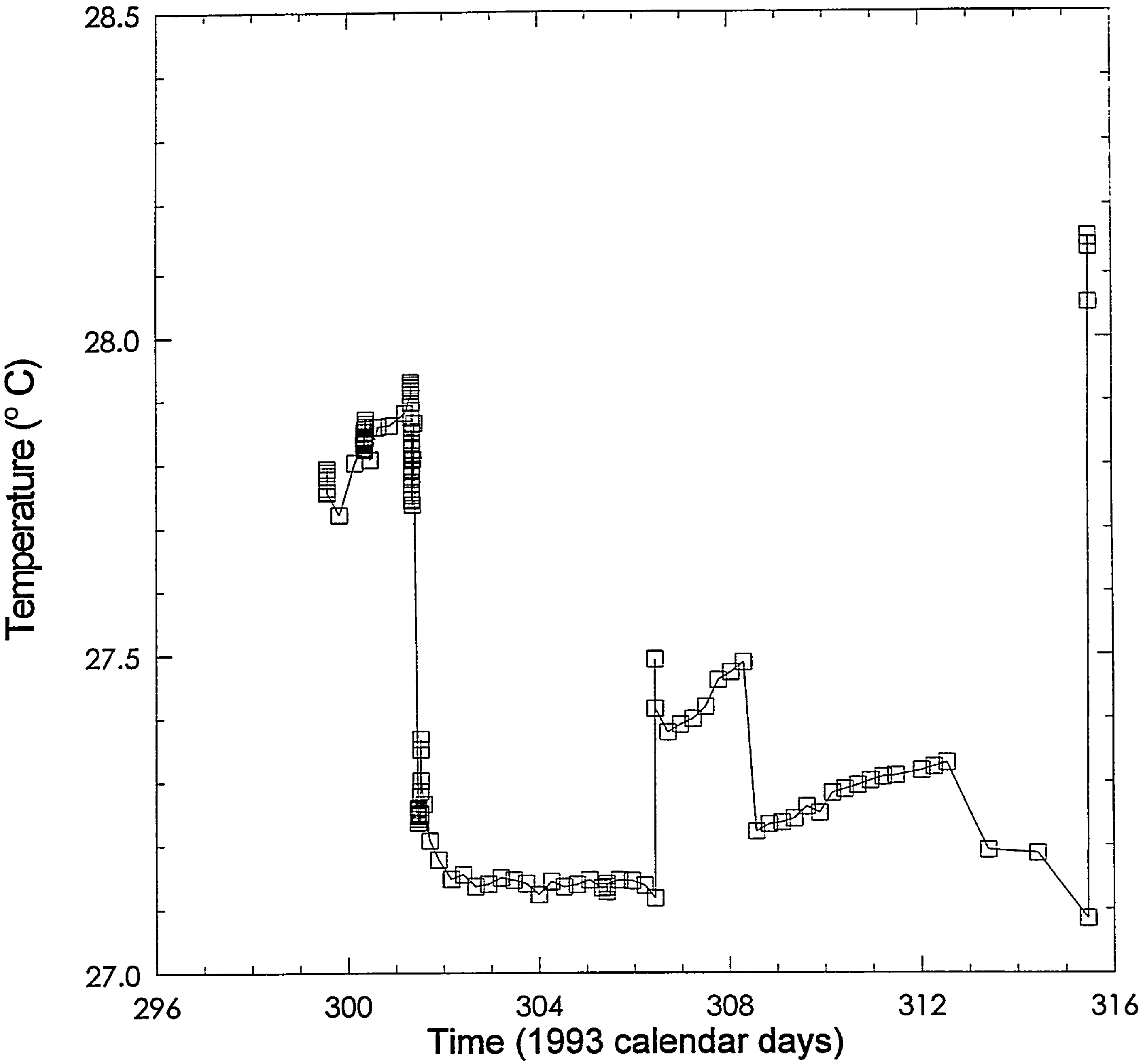

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Figure 6-43. Test-zone 1 temperature during compliance testing of test tool #41.

6.2.12 Test Tool #BOT- 01 (Gas-Threshold Pressure-Testing Sequence SCP01-2)

Table 6-24 gives a detailed description of the events that occurred during compliance testing of test tool #BOT-01. Figures 6-44 through 6-47 illustrate the zone pressures, packer pressures, fluid-injection volumes during test-zone compressibility tests, and test-zone compressibility as a function of pressure, respectively, for multipacker test tool #BOT-01. Figure 5-7 illustrates the configuration of test tool #BOT-01 as assembled for compliance testing.

Table 6-24. Events Associated with Compliance Testing of Test Tool #BOT-01; Borehole SCP01; Sequence SCP01-2

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #BOT-01 to be used in borehole SCP01 during testing sequence SCP01-2.	3-16-94	75	75	12:00:00
Begin data file BAKER1.	3-17-94	76	76	15:05:15
Inflate TZ packer to 17.2 MPa.	3-17-94	76	76	15:15:00
Inflate GZ packer to 17.7 MPa.	3-17-94	76	76	15:25:00
Increase TZ pressure to 13.6 MPa.	3-17-94	76	76	15:28:00
Increase GZ pressure to ~11.0 MPa.	3-17-94	76	76	15:30:00
Depressurize GZ.	3-17-94	76	76	15:35:00
Increase GZ pressure to 10.8 MPa.	3-17-94	76	76	15:42:00
Depressurize GZ.	3-17-94	76	76	15:52:00
Increase GZ pressure to 10.525 MPa.	3-17-94	76	76	15:54:00
DAS not functioning upon arrival.	3-18-94	77	77	09:47:00
Depressurize GZ.	3-18-94	77	77	09:49:00
Depressurize TZ.	3-18-94	77	77	09:50:00
Deflate GZ packer.	3-18-94	77	77	09:54:00
Deflate TZ packer.	3-18-94	77	77	10:05:00
Remove test tool from compliance chamber to fix leak.	3-18-94	77	77	10:10:00
Reinstall test tool in compliance chamber.	3-18-94	77	77	10:40:00
Inflate packers and increase TZ and GZ pressure.	3-18-94	77	77	12:15:00
Increase TZ packer and GZ packer pressure to ~17 MPa, increase TZ pressure to ~13.56 MPa, and increase GZ pressure to ~10.2 MPa.	3-21-94	80	80	13:51:00
Decrease TZ pressure.	3-23-94	82	82	11:42:00
Decrease TZ packer pressure.	3-23-94	82	82	11:44:00
Decrease GZ pressure.	3-25-94	84	84	12:50:40
End data file BAKER1.	3-25-94	84	84	13:15:10
Remove transducer 609364.	3-25-94	84	84	13:16:00
Begin data file BAKER2.	3-25-94	84	84	13:24:06
Increase TZ, GZ, and packer pressures.	3-31-94	90	90	14:04:00
End data file BAKER2.	3-31-94	90	90	14:08:54

Table 6-24 (Continued). Events Associated with Compliance Testing of Test Tool #BOT-01; Borehole SCP01; Sequence SCP01-2

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Install transducer 609370 to monitor TZ packer.	3-31-94	90	90	14:10:00
Begin data file BAKER3.	3-31-94	90	90	14:17:08
End data file BAKER3.	4-7-94	97	97	14:59:36
Incorporate DPT panel with new transducer into system.	4-8-94	98	98	13:11:00
Begin data file BAKER4.	4-8-94	98	98	13:17:59
Depressurize TZ by removing ~65 mL of fluid.	4-11-94	101	101	13:28:00
Increase TZ pressure.	4-11-94	101	101	13:36:00
Begin TZ compressibility test.	4-12-94	102	102	11:46:17
Shut in TZ.	4-12-94	102	102	12:42:44
Begin TZ compressibility test.	4-12-94	102	102	12:45:09
Shut in TZ.	4-12-94	102	102	13:04:08
Begin TZ compressibility test.	4-12-94	102	102	13:05:09
Shut in TZ.	4-12-94	102	102	13:17:18
Depressurize TZ and GZ.	4-13-94	103	103	12:22:00
Deflate packers.	4-13-94	103	103	12:23:00
End data file BAKER4.	4-13-94	103	103	13:18:02
Remove test tool #BOT-01 from compliance chamber and move to borehole SCP01.	4-13-94	103	103	15:00:00

Table 6-25 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #BOT-01. Test tool #BOT-01 was used in testing sequence SCP01-2.

Table 6-25. Compliance Equipment Associated with Test Tool #BOT-01; Borehole SCP01; Sequence SCP01-2

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	3-17-94	4-13-94
DCU (HP3497A)	N/A	2629a21996	3-17-94	4-13-94
Transducer (Druck D930-18)	Test Zone	609371	3-17-94	4-13-94
Transducer (Druck D930-18)	Test Zone Packer	609364	3-17-94	3-25-94
Transducer (Druck D930-18)	Test Zone Packer	609370	3-31-94	4-13-94
Transducer (Druck D930-18)	Guard Zone	609375	3-17-94	4-13-94

Table 6-25 (Continued). Compliance Equipment Associated with Test Tool #BOT-01; Borehole SCP01; Sequence SCP01-2

Equipment	Location	Serial #	Installed	Removed
Transducer (Druck D930-18)	Guard Zone Packer	609372	3-17-94	4-13-94
Transducer (Druck D930-18)	DPT Panel	609368	4-8-94	4-13-94
Injection Column	N/A	94	4-8-94	4-13-94
DPT (Rosemount 1151DP)	N/A	1140863	4-8-94	4-13-94

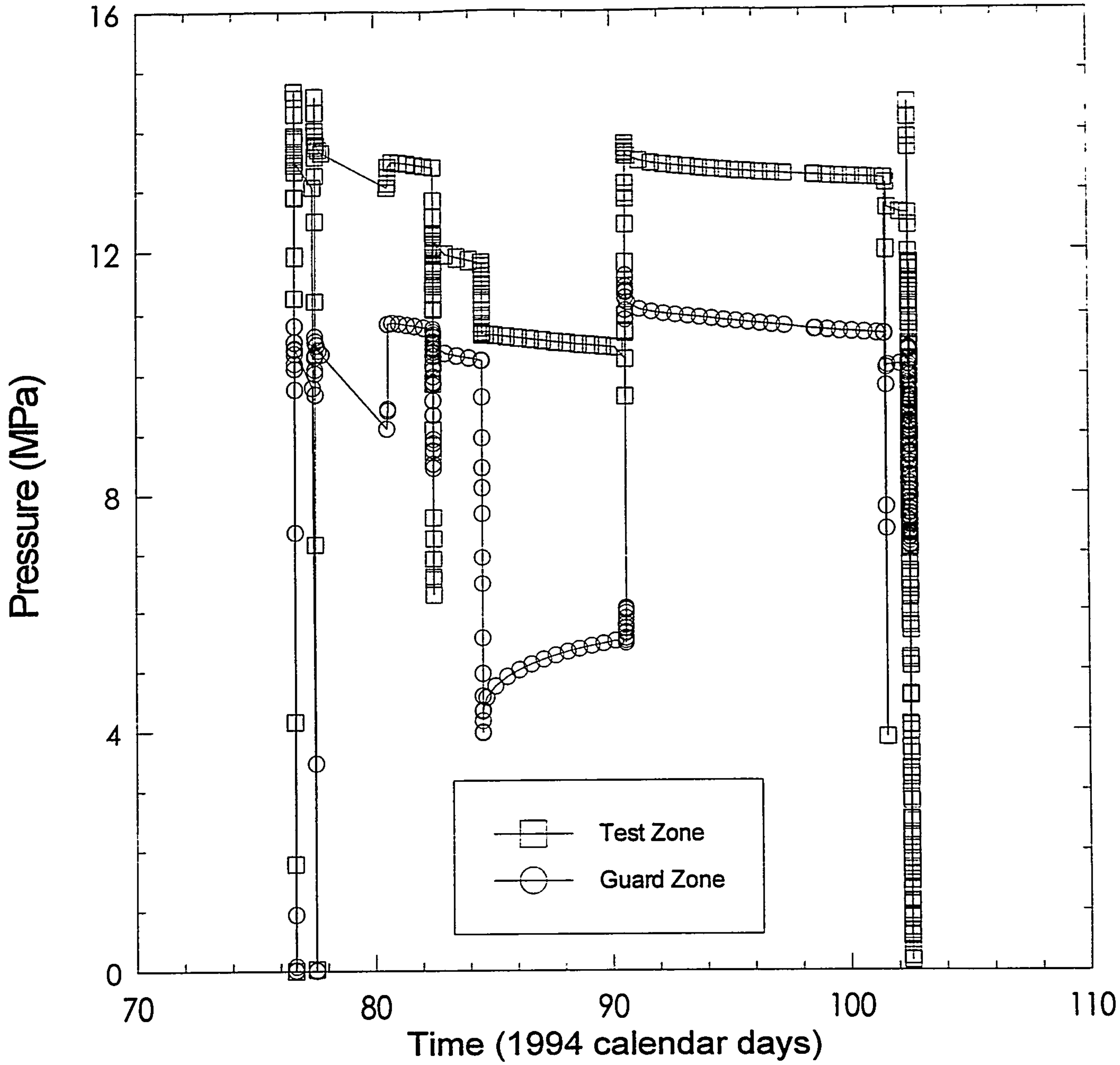

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Figure 6-44. Zone pressures during compliance testing of test tool #BOT-01.

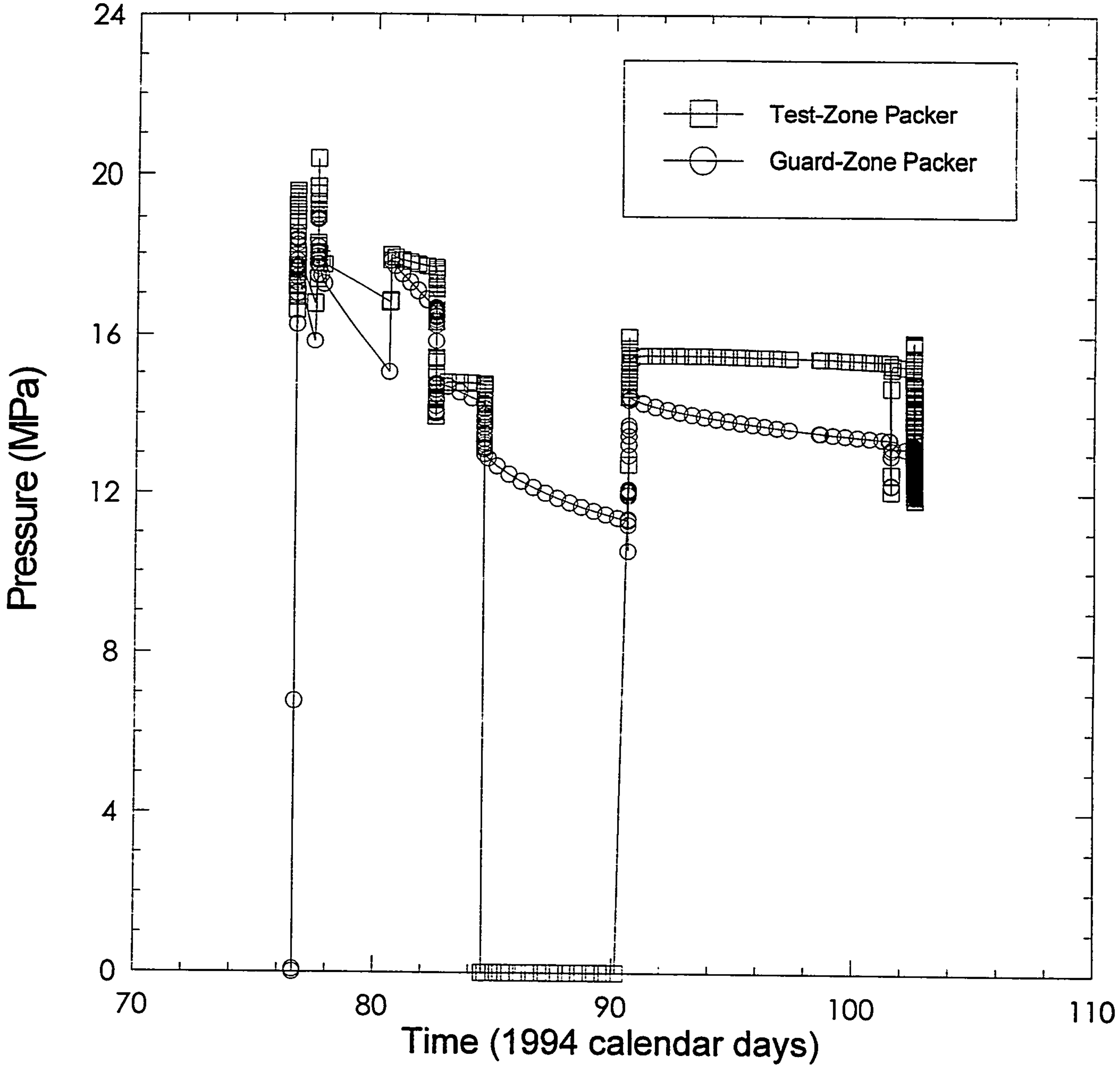

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Figure 6-45. Packer pressures during compliance testing of test tool #BOT-01.

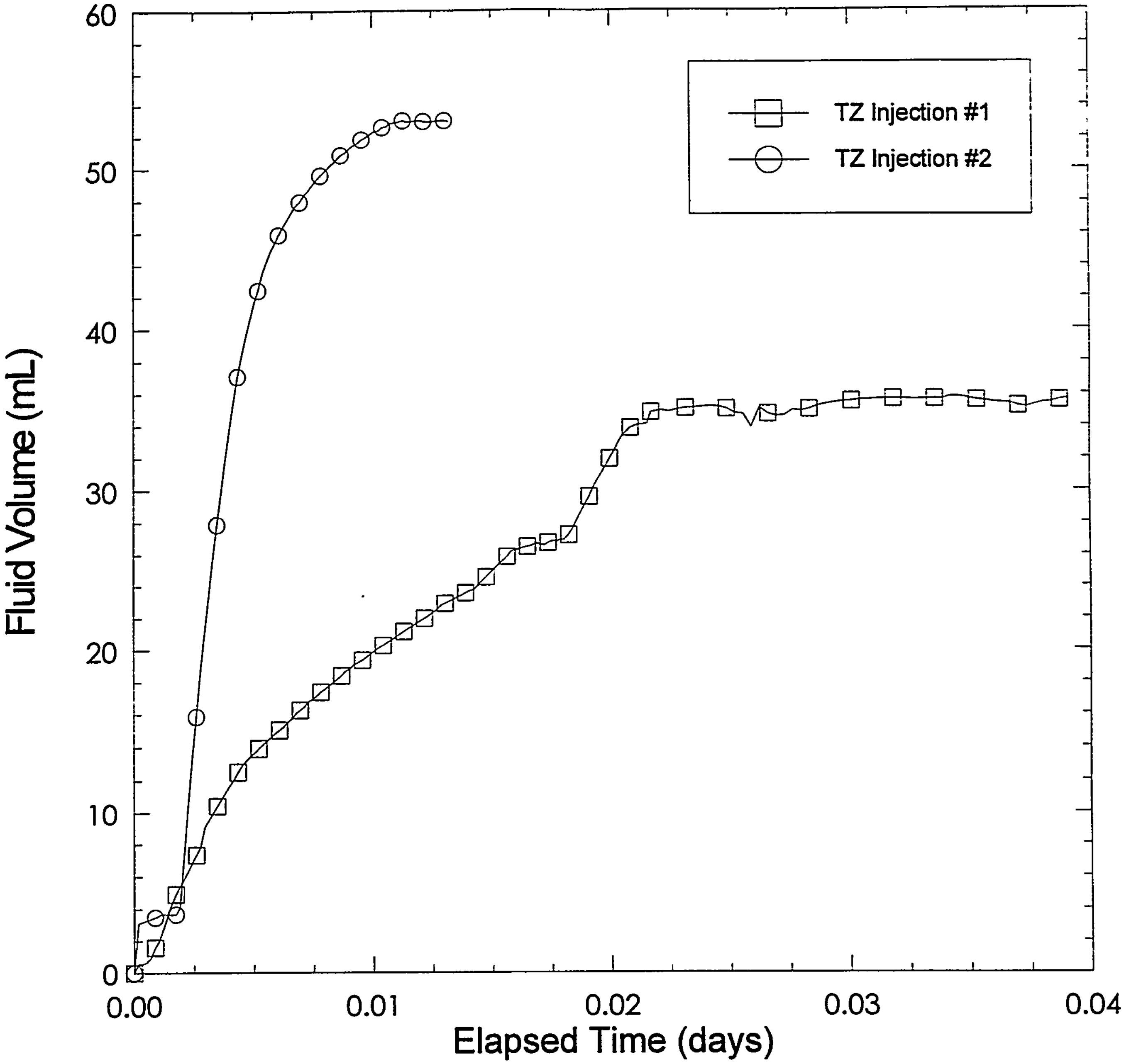

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Figure 6-46. Test-zone fluid-injection volumes during compliance testing of test tool #BOT-01.

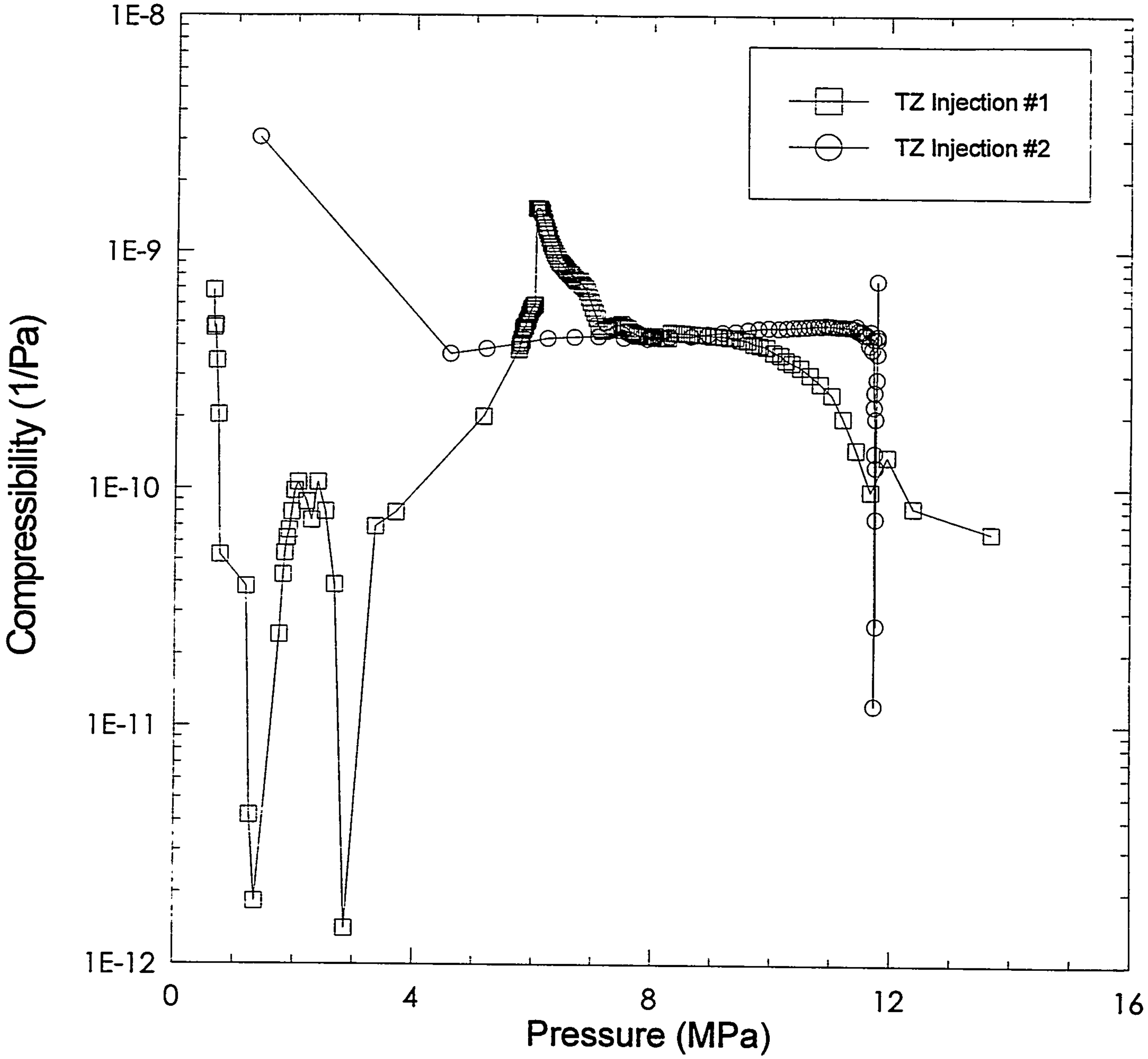

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Figure 6-47. Test-zone compressibility as measured during compliance testing of test tool #BOT-01.

6.2.13 Test Tool #P51-D1A (Permeability-Testing Sequence L4P51-D1)

Table 6-26 gives a detailed description of the events that occurred during compliance testing of test tool #P51-D1A. Figures 6-48 through 6-53 illustrate the zone pressures, packer pressures, axial-LVDT displacement, radial-LVDT displacement, fluid-injection volumes during compressibility tests, and test-zone compressibility as a function of pressure, respectively, for multipacker test tool #P51-D1A. Figure 3-25 illustrates the configuration of test tool #P51-D1A as assembled for compliance testing.

Table 6-26. Events Associated with Compliance Testing of Test Tool #P51-D1A; Borehole L4P51; Sequence L4P51-D1

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #P51-D1A to be used in borehole L4P51 during testing sequence L4P51-D1.	8-26-94	238	238	12:29:00
Install test tool in compliance chamber.	8-30-94	242	242	11:50:00
Inflate TZ1 packer to ~15.2 MPa.	8-30-94	242	242	12:35:00
Inflate TZ2 packer to ~14.5 MPa.	8-30-94	242	242	12:41:00
Begin data file CMPP51.	8-30-94	242	242	12:59:42
Increase TZ2 packer pressure to 15.519 MPa.	8-30-94	242	242	13:02:00
Increase TZ1 packer pressure to 15.960 MPa.	8-30-94	242	242	13:04:00
Deflate packers.	8-31-94	243	243	11:29:00
Inflate TZ1 packer to 15.640 MPa.	8-31-94	243	243	11:36:00
Inflate TZ2 packer to 15.480 MPa.	8-31-94	243	243	11:40:00
Increase TZ1 pressure to 11.881 MPa.	8-31-94	243	243	12:15:00
Decrease TZ1 packer pressure.	8-31-94	243	243	12:19:00
Increase TZ2 pressure to 8.080 MPa.	8-31-94	243	243	12:30:00
Depressurize TZ1 and TZ2.	9-1-94	244	244	07:56:00
Deflate TZ1 packer.	9-1-94	244	244	07:57:00
Deflate TZ2 packer.	9-1-94	244	244	07:57:00
Remove test tool from compliance chamber to inspect for leaks.	9-1-94	244	244	08:30:00
Reinstall test tool in compliance chamber.	9-1-94	244	244	13:19:00
Inflate TZ1 packer to 15.450 MPa.	9-6-94	249	249	08:36:00
Inflate TZ2 packer to 15.710 MPa.	9-6-94	249	249	08:40:00
Deflate packers.	9-6-94	249	249	10:19:00
Inflate TZ1 packer to 15.532 MPa.	9-6-94	249	249	10:21:00
Inflate TZ2 packer to 15.823 MPa.	9-6-94	249	249	10:24:00
Open TZ1 packer to accumulator at 13.992 MPa.	9-6-94	249	249	11:30:00
Open TZ2 packer to accumulator at 14.062 MPa.	9-6-94	249	249	11:31:00
Increase TZ2 pressure to 8.605 MPa.	9-6-94	249	249	12:14:00
Increase TZ2 pressure to 8.744 MPa.	9-6-94	249	249	12:38:00

Table 6-26 (Continued). Events Associated with Compliance Testing of Test Tool #P51-D1A; Borehole L4P51; Sequence L4P51-D1

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
Shut in packers from accumulator.	9-7-94	250	250	07:28:00
Depressurize TZ2.	9-7-94	250	250	07:30:00
Deflate TZ1 packer.	9-7-94	250	250	07:32:00
Circulate fluid from the TZ1 to TZ2.	9-7-94	250	250	07:38:00
Inflate TZ1 packer and open both packers to accumulator.	9-7-94	250	250	07:48:00
Increase TZ2 pressure to 8.683 MPa.	9-7-94	250	250	07:54:00
Depressurize TZ2.	9-7-94	250	250	09:41:00
Increase TZ2 pressure to 8.635 MPa.	9-7-94	250	250	09:51:00
Shut in both packers from accumulator.	9-7-94	250	250	10:13:00
Disconnect all LVDTs from DAS.	9-7-94	250	250	11:20:00
Connect all LVDTs to DAS.	9-8-94	251	251	07:56:00
Increase TZ1 pressure.	9-8-94	251	251	08:06:00
Depressurize TZ1.	9-8-94	251	251	08:08:00
Increase TZ1 pressure to 13.210 MPa.	9-8-94	251	251	08:15:00
Depressurize TZ1.	9-8-94	251	251	11:28:00
Depressurize TZ2.	9-8-94	251	251	11:30:00
Open both packers to accumulator.	9-8-94	251	251	11:43:00
End data file CMPP51.	9-12-94	255	255	07:23:34
Begin data file CMPRES1.	9-12-94	255	255	07:46:19
Increase TZ2 pressure to 8.571 MPa.	9-12-94	255	255	07:49:00
Begin TZ1 compressibility test.	9-12-94	255	255	08:05:00
Shut in TZ1.	9-12-94	255	255	09:12:00
Begin TZ1 compressibility test.	9-12-94	255	255	10:49:00
Shut in TZ1.	9-12-94	255	255	11:22:00
Begin TZ1 compressibility test.	9-12-94	255	255	11:30:00
Shut in TZ1.	9-12-94	255	255	12:13:00
Increase TZ2 pressure to 8.088 MPa.	9-12-94	255	255	12:16:00
Depressurize TZ1.	9-13-94	256	256	08:40:00
Increase TZ2 pressure to 8.165 MPa.	9-13-94	256	256	08:48:00
Begin TZ1 compressibility test.	9-13-94	256	256	09:06:00
Shut in TZ1.	9-13-94	256	256	10:18:00
Depressurize TZ1.	9-13-94	256	256	10:20:00
Begin TZ1 compressibility test.	9-13-94	256	256	10:36:00
Shut in TZ1.	9-13-94	256	256	12:08:00
Increase TZ1 pressure to 12.094 MPa.	9-19-94	262	262	07:07:00

Table 6-26 (Continued). Events Associated with Compliance Testing of Test Tool #P51-D1A; Borehole L4P51; Sequence L4P51-D1

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY	TIME (HH:MM:SS)
TZ2 gage busted out which explains the TZ2 pressure.	9-26-94	269	269	08:07:00
Depressurize all zones and deflate all packers.	9-26-94	262	262	08:09:00
End data file CMPRES1.	9-26-94	262	262	08:09:54
Remove test tool #P51-D1A from compliance chamber and move to borehole L4P51.	9-26-94	262	262	12:00:00

Table 6-27 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #P51-D1A which was used in permeability-testing sequence L4P51-D1.

Table 6-27. Compliance Equipment Associated with Test Tool #P51-D1A; Borehole L4P51; Sequence L4P51-D1

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	8-22-94	9-26-94
DCU (HP3497A)	N/A	2629a22040	8-22-94	9-26-94
Transducer (Druck D930-18)	Test Zone 1	609375	8-22-94	9-26-94
Transducer (Druck D930-18)	Test Zone 1 Packer	609371	8-22-94	9-26-94
Transducer (Druck D930-18)	Test Zone 2	609368	8-22-94	9-26-94
Transducer (Druck D930-18)	Test Zone 2 Packer	609374	8-22-94	9-26-94
Transducer (Druck D930-18)	DPT Panel	609372	8-22-94	9-26-94
Transducer (Druck D930-18)	Pressure Controller	609370	8-22-94	9-26-94
LVDT (Trans-Tek 241)	N/A	R17	8-22-94	9-26-94
LVDT (Trans-Tek 241)	N/A	R04	8-22-94	9-26-94
LVDT (Trans-Tek 241)	N/A	R16	8-22-94	9-26-94
LVDT (Trans-Tek 245)	N/A	A02	8-22-94	9-26-94
Injection Column	N/A	92	8-22-94	9-26-94
DPT (Rosemount 1151DP)	N/A	1140864	8-22-94	9-26-94

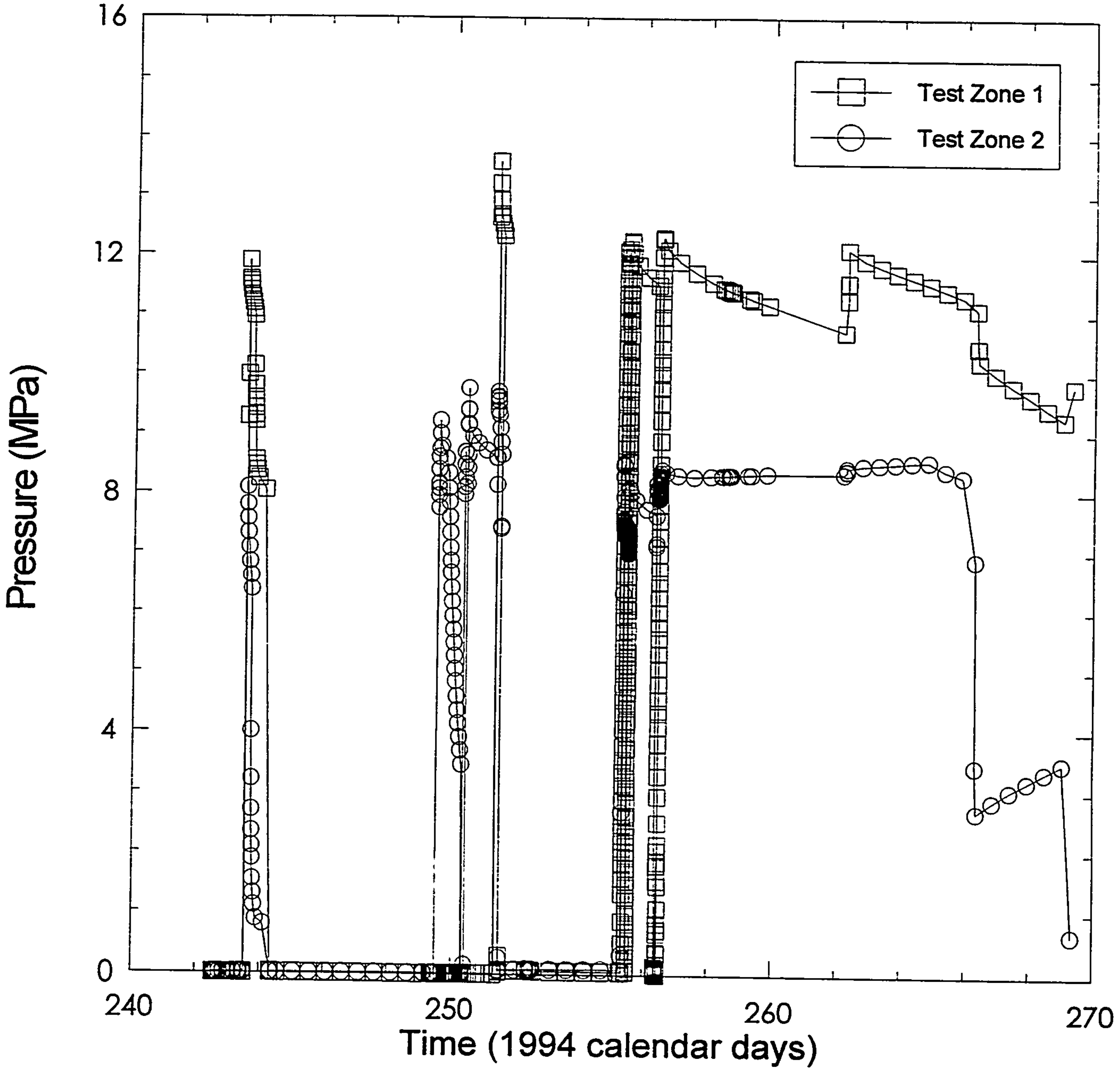

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Figure 6-48. Zone pressures during compliance testing of test tool #P51-D1A.

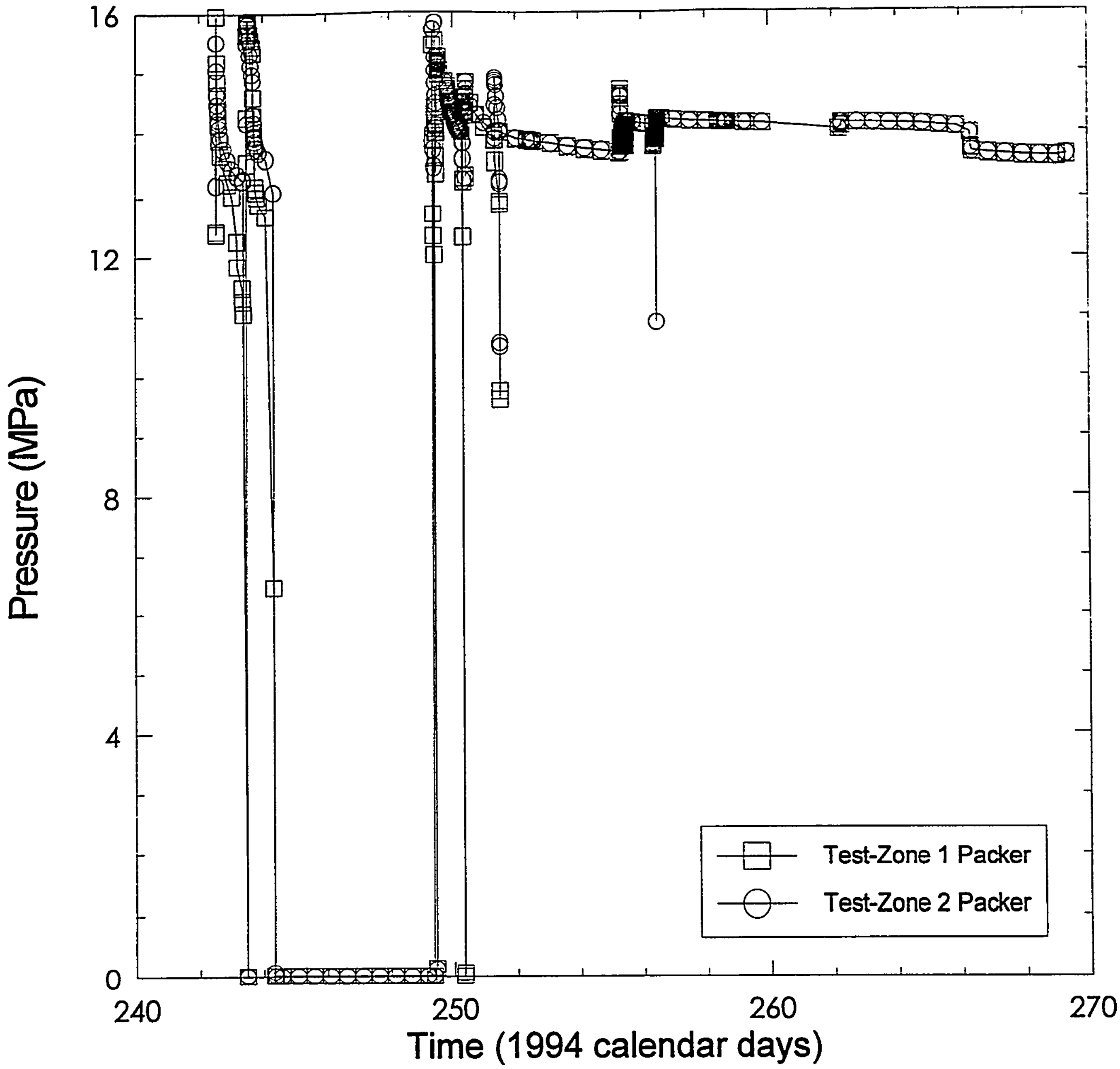

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Figure 6-49. Packer pressures during compliance testing of test tool #P51-D1A.

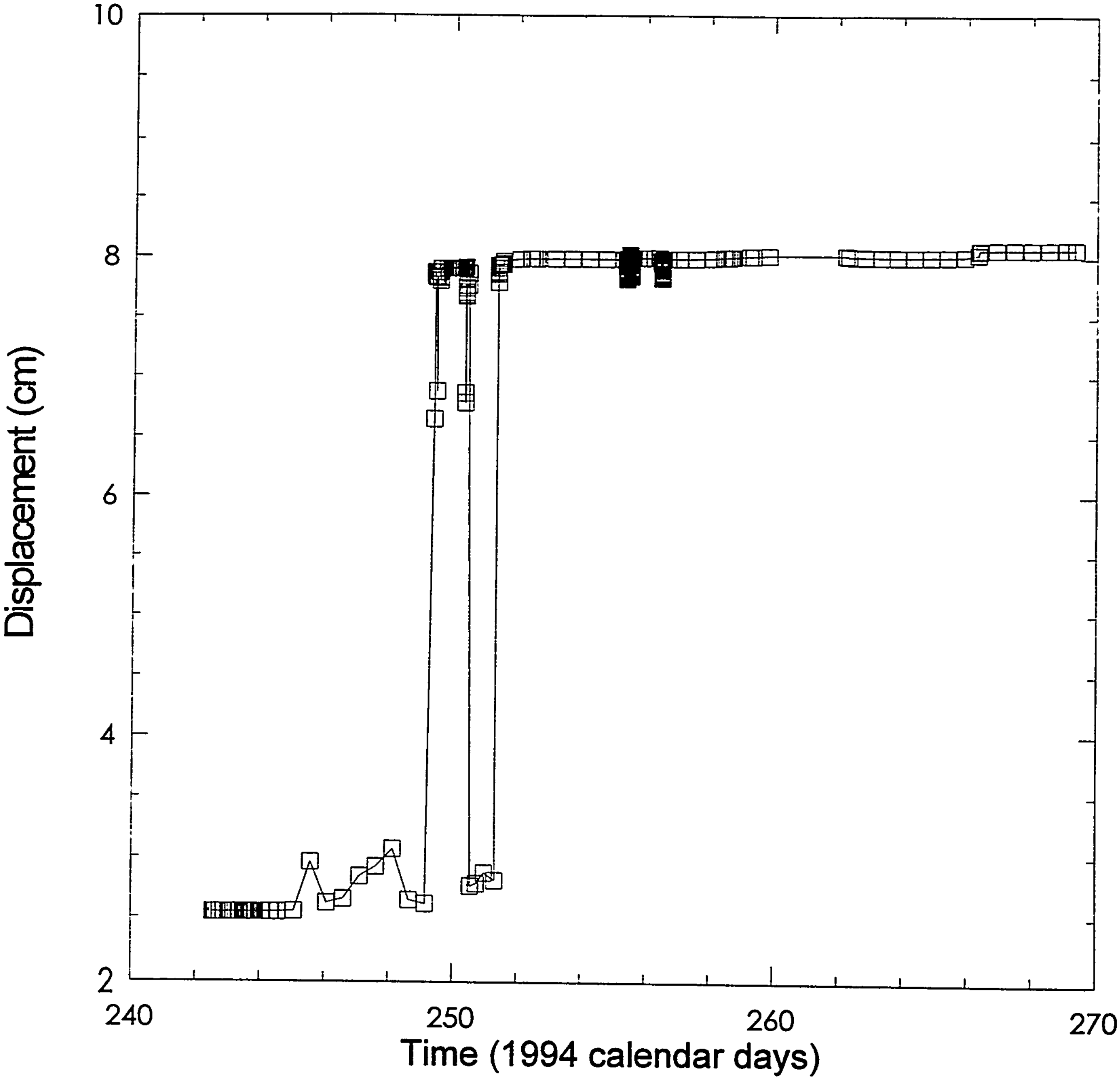

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Figure 6-50. Axial-LVDT displacement during compliance testing of test tool #P51-D1A.

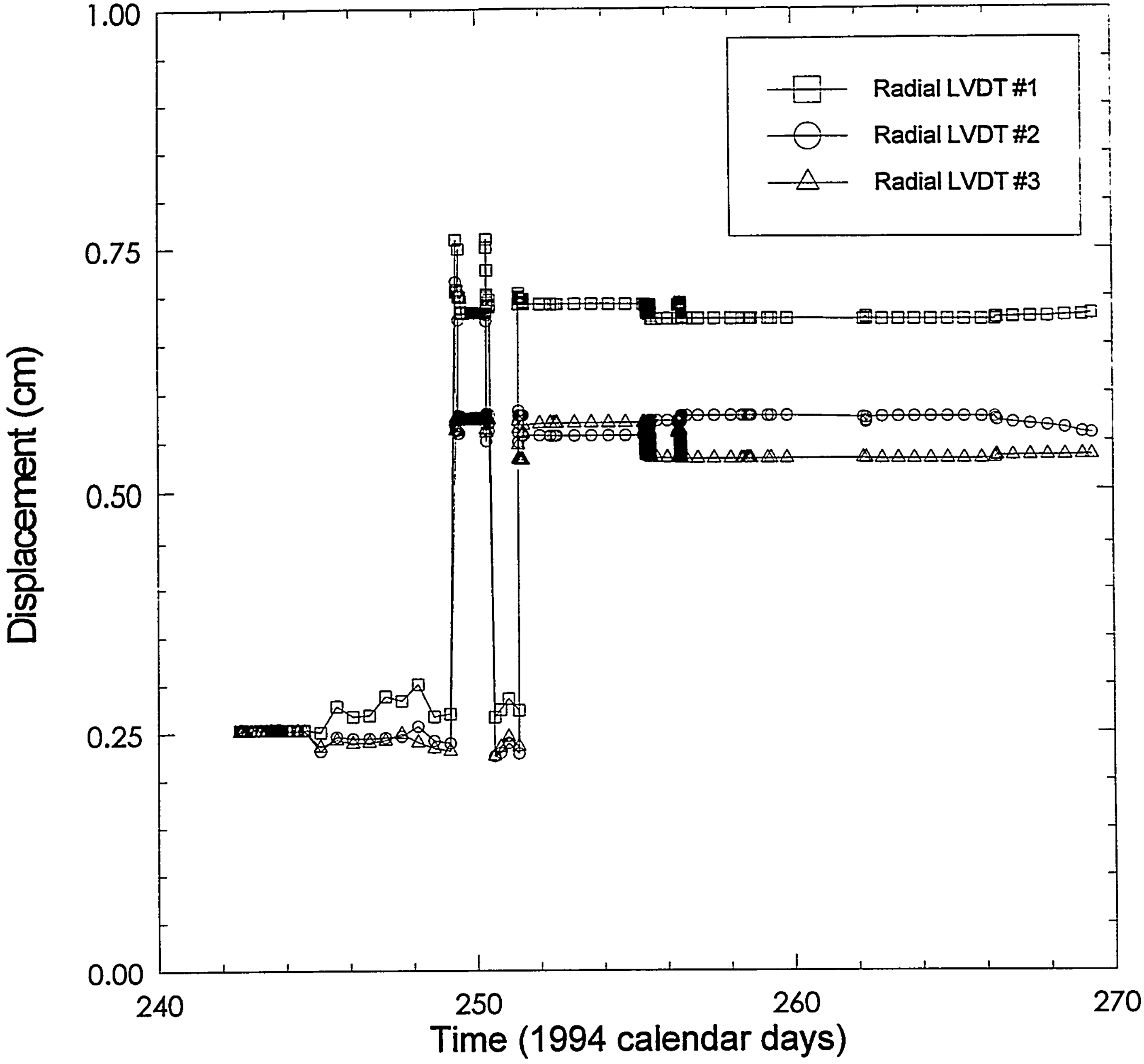

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Figure 6-51. Radial-LVDT displacement during compliance testing of test tool #P51-D1A.

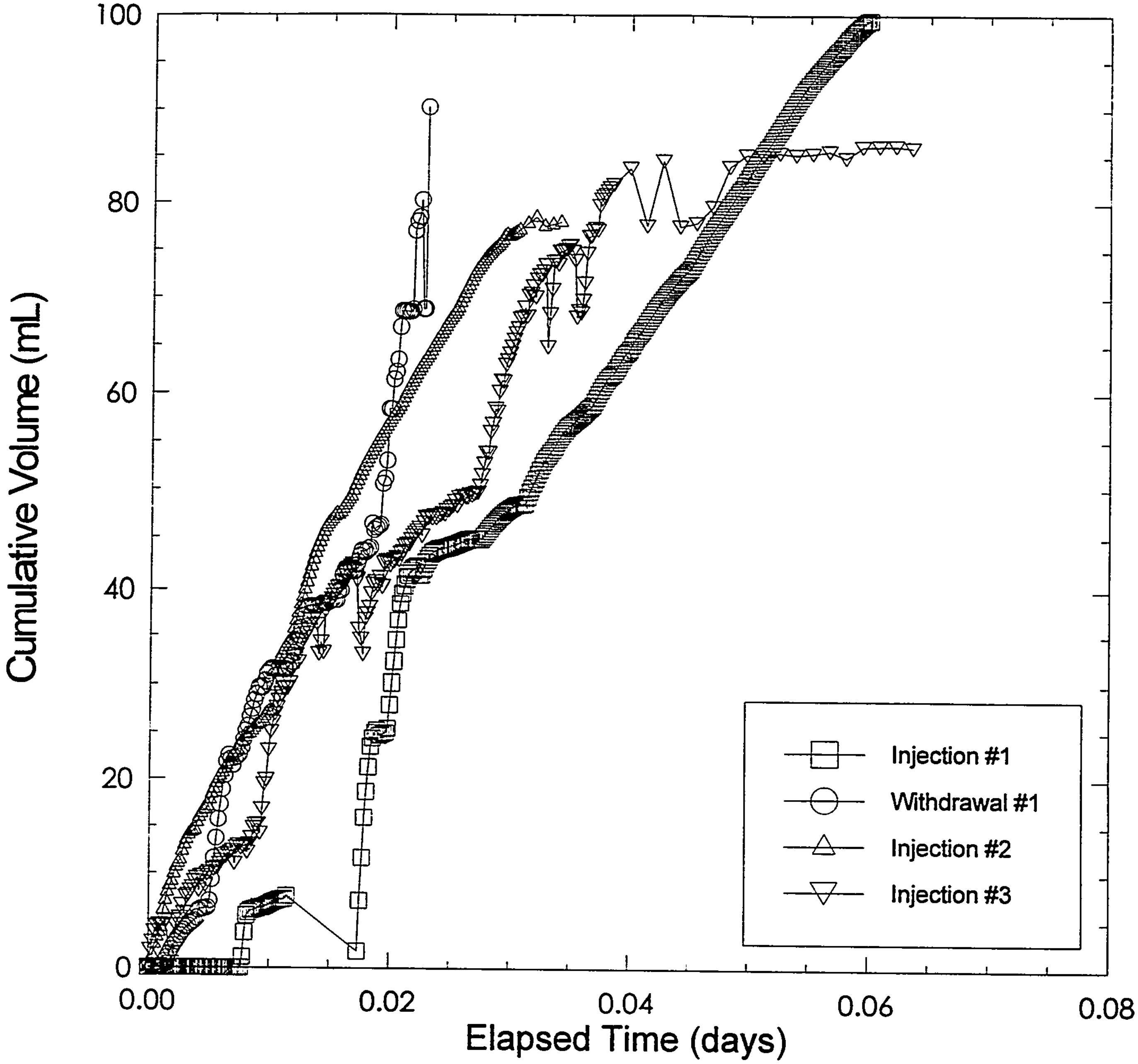

Figure 6-52. Fluid-injection volumes during compliance testing of test tool #P51-D1A.

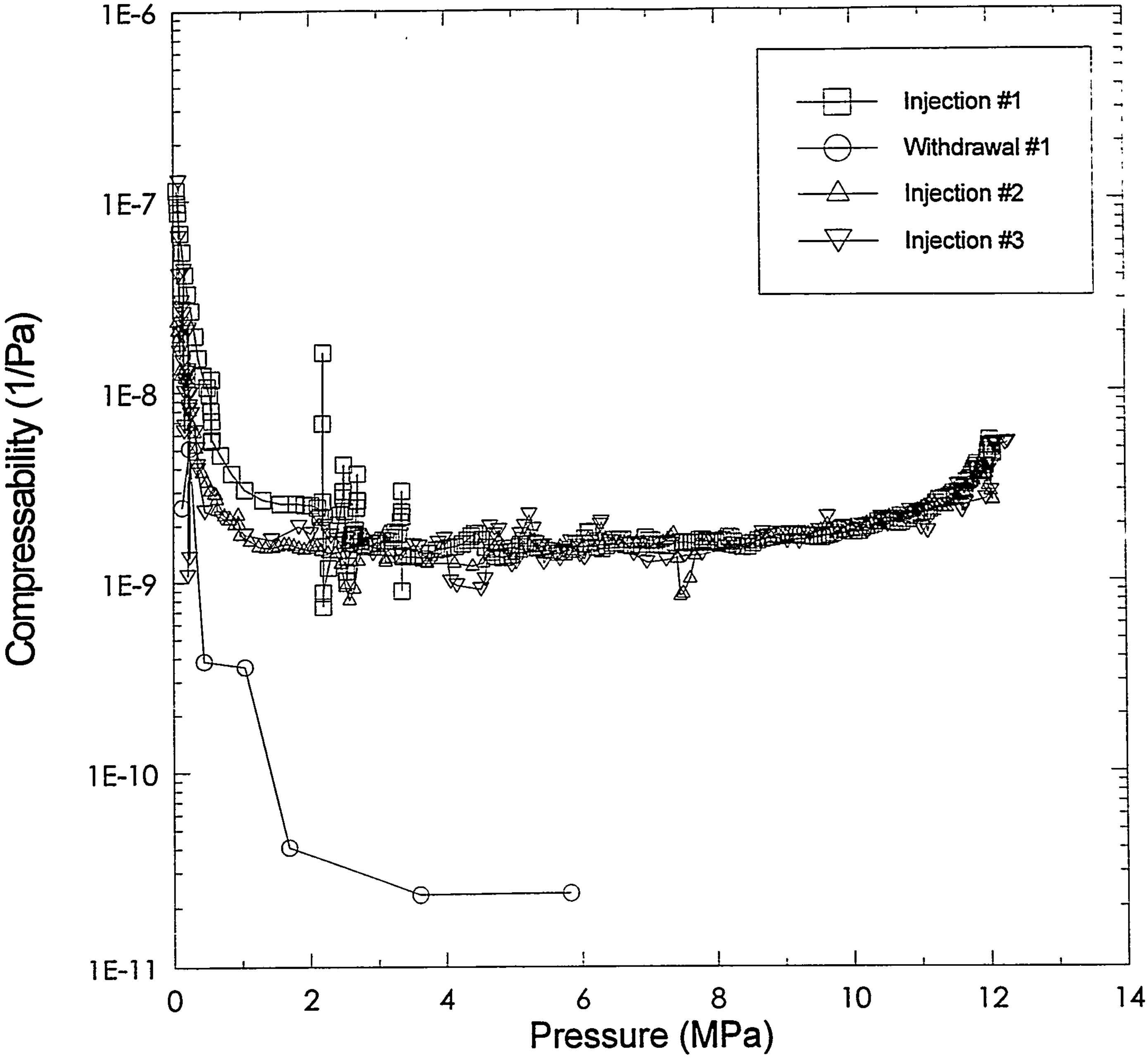

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Figure 6-53. Test-zone compressibility as measured during compliance testing of test tool #P51-D1A.

6.2.14 Test Tool #P74-B (Permeability-Testing Sequence S1P74-B)

Table 6-28 gives a detailed description of the events that occurred during compliance testing of test tool #P74-B. Figures 6-54 through 6-58 illustrate the zone pressures, packer pressures, axial-LVDT displacement, fluid-injection volumes during compressibility tests, and test-zone compressibility as a function of pressure, respectively, for multipacker test tool #P74-B. Figure 3-33 illustrates the configuration of test tool #P74-B as assembled for compliance testing.

Table 6-28. Events Associated with Compliance Testing of Test Tool #P74-B; Borehole S1P74; Sequence S1P74-B

EVENT	DATE	CALENDAR DAY	1995 CALENDAR DAY	TIME (HH:MM:SS)
Assemble multipacker test tool #P74-B to be used in borehole S1P74 during testing sequence S1P74-B.	1-18-95	18	18	12:00:00
Begin data file COMPP74.	1-19-95	19	19	14:18:33
Inflate TZ1 packer to ~13.8 MPa.	1-19-95	19	19	14:20:00
Open TZ1 packer to accumulator at 13.833 MPa.	1-19-95	19	19	14:24:00
Inflate TZ2 packer to ~13.8 MPa.	1-19-95	19	19	14:33:00
Open TZ2 packer to accumulator at 14.058 MPa.	1-19-95	19	19	14:37:00
Inflate GZ packer to ~13.8 MPa.	1-19-95	19	19	14:42:00
Open GZ packer to accumulator at 13.712 MPa.	1-19-95	19	19	14:44:00
End data file COMPP74.	1-20-95	20	20	10:16:46
Begin data file COMPP742.	1-20-95	20	20	11:16:19
Increase TZ1 pressure to 9.909 MPa.	1-20-95	20	20	12:31:00
Increase TZ2 pressure to 10.031 MPa.	1-20-95	20	20	12:35:00
Increase GZ pressure to 9.257 MPa.	1-20-95	20	20	12:39:00
Significant pressure decay in GZ.	1-20-95	20	20	12:46:00
Remove GZ portion of test tool from compliance chamber to find leak.	1-20-95	20	20	14:00:00
Leak caused by broken 1/8-inch fitting with no replacement.	1-20-95	20	20	14:15:00
Reinstall test tool in compliance chamber to test TZ2.	1-20-95	20	20	14:20:00
Inflate TZ2 packer to 12.834 MPa.	1-20-95	20	20	14:30:00
Open TZ2 packer to accumulator at 14.047 MPa.	1-20-95	20	20	14:33:00
Inflate GZ packer to ~13.8 MPa.	1-20-95	20	20	14:37:00
Open GZ packer to accumulator at 13.691 MPa.	1-20-95	20	20	14:39:00
Increase TZ2 pressure to 9.822 MPa.	1-20-95	20	20	14:44:00
Depressurize TZ2.	1-23-95	23	23	09:25:00
Deflate TZ2 packer and GZ packer.	1-23-95	23	23	09:29:00
Replace broken 1/8-inch fitting.	1-23-95	23	23	09:48:00
Inflate TZ2 packer to ~13.8 MPa.	1-23-95	23	23	10:14:00
Open TZ2 packer to accumulator at 14.036 MPa.	1-23-95	23	23	10:15:00

Table 6-28 (Continued). Events Associated with Compliance Testing of Test Tool #P74-B; Borehole S1P74; Sequence S1P74-B

EVENT	DATE	CALENDAR DAY	1995 CALENDAR DAY	TIME (HH:MM:SS)
Inflate GZ packer to ~13.8 MPa.	1-23-95	23	23	10:20:00
Open GZ packer to accumulator at 13.683 MPa.	1-23-95	23	23	10:22:00
Increase GZ pressure to 4.687 MPa.	1-23-95	23	23	10:27:00
Decrease GZ pressure to ~2.7 MPa.	1-23-95	23	23	10:37:00
Increase GZ pressure to 4.459 MPa.	1-23-95	23	23	10:38:00
End data file COMPP742.	1-23-95	23	23	12:42:07
Begin data file COMPP743.	1-23-95	23	23	14:31:39
Increase GZ pressure after replacing leaky fitting.	1-24-95	24	24	10:24:23
Depressurize TZ1.	1-24-95	24	24	10:27:47
Begin TZ1 compressibility test.	1-24-95	24	24	10:50:00
Shut in TZ1.	1-24-95	24	24	11:12:00
Begin TZ1 compressibility test.	1-24-95	24	24	11:17:00
Shut in TZ1.	1-24-95	24	24	11:45:00
Begin TZ1 compressibility test.	1-24-95	24	24	11:52:00
Shut in TZ1.	1-24-95	24	24	12:32:00
Begin TZ1 compressibility test.	1-24-95	24	24	12:35:00
Shut in TZ1.	1-24-95	24	24	12:58:00
End data file COMPP743.	1-24-95	24	24	12:58:51
Remove test tool #P74-B from compliance chamber and move to borehole S1P74.	2-1-95	32	32	12:00:00

Table 6-29 indicates the equipment that was used and the duration that each instrument was used during compliance testing of test tool #P74-B. Test tool #P74-B was used in permeability-testing sequence S1P74-B.

Table 6-29. Compliance Equipment Associated with Test Tool #P74-B; Borehole S1P74; Sequence S1P74-B

Equipment	Location	Serial #	Installed	Removed
DAS Software	N/A	PERM4F	1-19-95	2-1-95
DCU (HP3497A)	N/A	2629a21990	1-19-95	2-1-95
Transducer (Druck PDCR 910)	Test Zone 1	321768	1-19-95	2-1-95
Transducer (Druck PDCR 10/D)	Test Zone 1 Packer	211695	1-19-95	2-1-95

Table 6-29 (Continued). Compliance Equipment Associated with Test Tool #P74-B; Borehole S1P74; Sequence S1P74-B

Equipment	Location	Serial #	Installed	Removed
Transducer (Druck D930-18)	Test Zone 2	609364	1-19-95	2-1-95
Transducer (Druck PDCR 910)	Test Zone 2 Packer	322422	1-19-95	2-1-95
Transducer (Druck PDCR 910)	Guard Zone	507864	1-19-95	2-1-95
Transducer (Druck PDCR 910)	Guard Zone Packer	322426	1-19-95	2-1-95
Transducer (Druck PDCR 910)	DPT Panel	308152	1-19-95	2-1-95
LVDT (Trans-Tek 242)	N/A	1	1-19-95	2-1-95
LVDT (Trans-Tek 242)	N/A	2	1-19-95	2-1-95
Injection Column	N/A	92	1-19-95	2-1-95
DPT (Rosemount 1151DP)	N/A	1689030	1-19-95	2-1-95

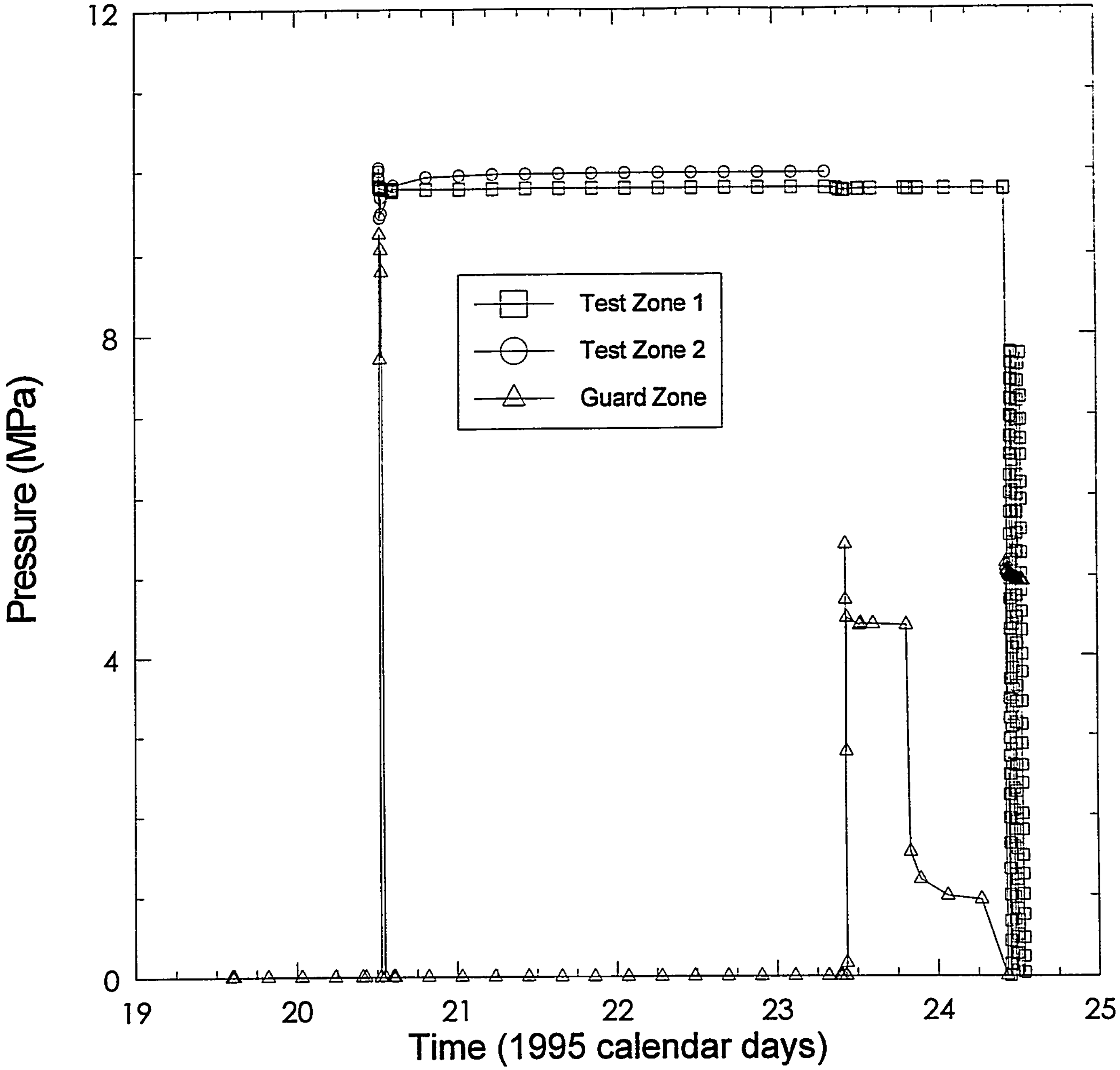

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Figure 6-54. Zone pressures during compliance testing of test tool #P74-B.

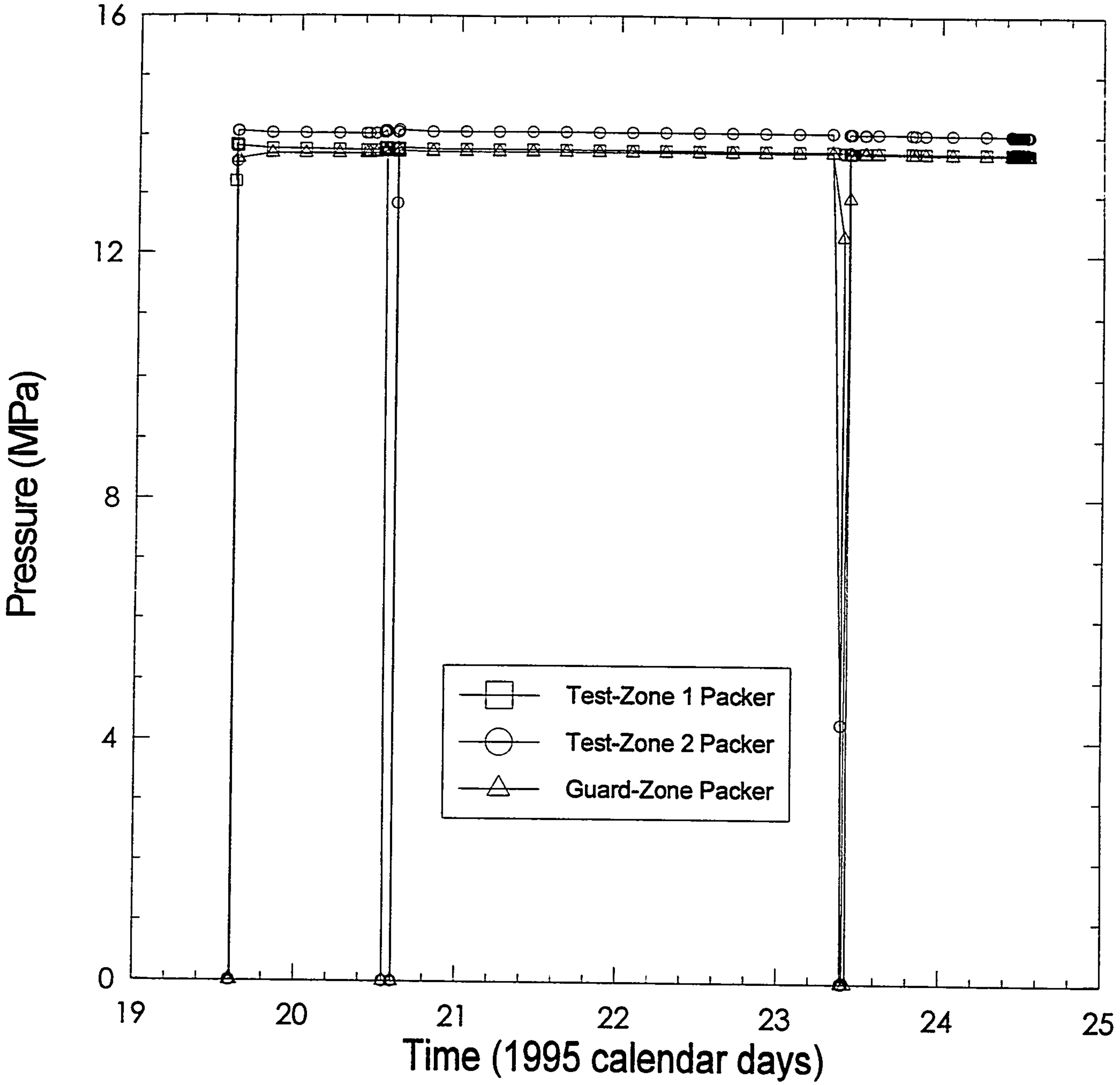

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Figure 6-55. Packer pressures during compliance testing of test tool #P74-B.

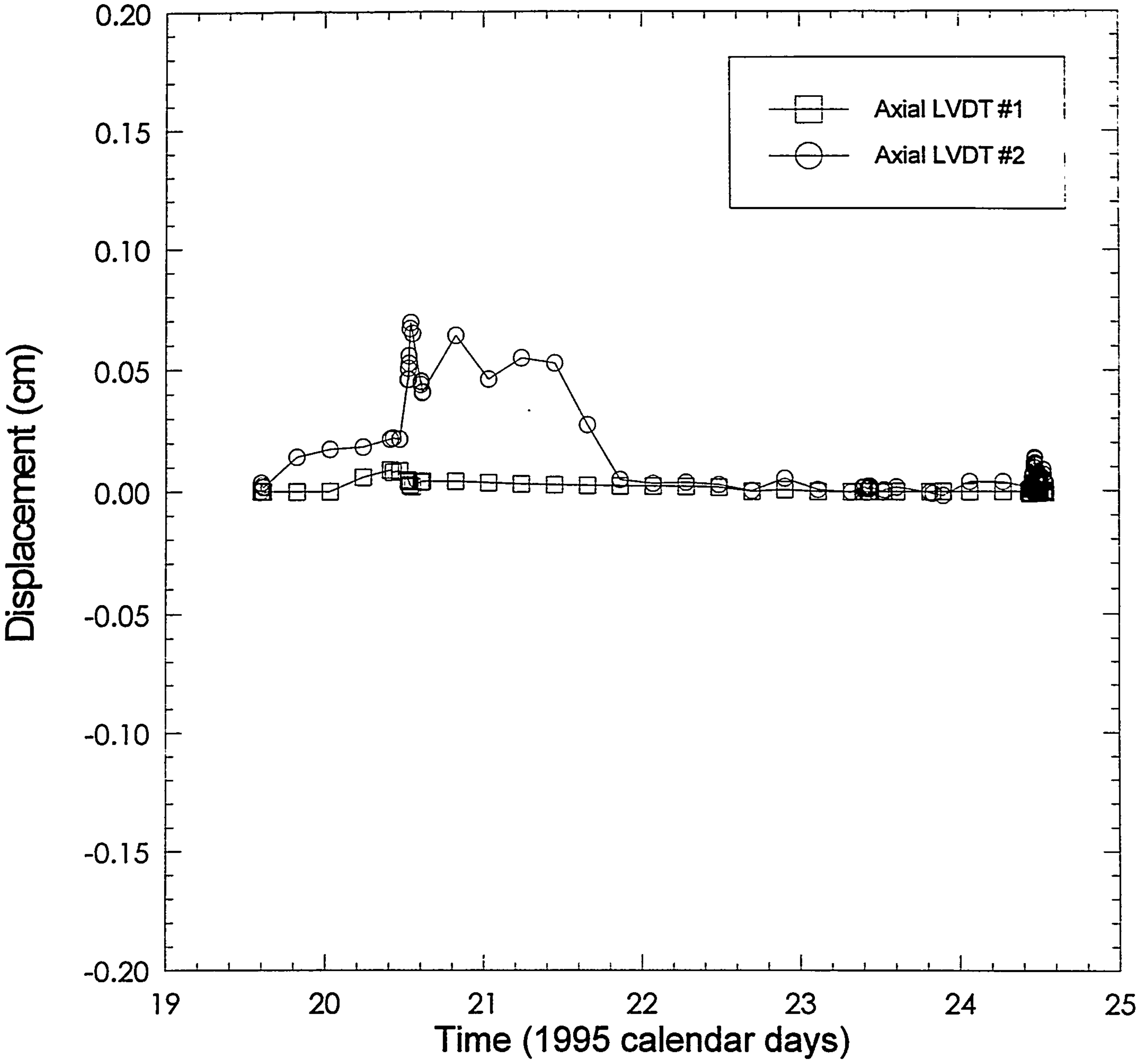

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Figure 6-56. Axial-LVDT displacement during compliance testing of test tool #P74-B.

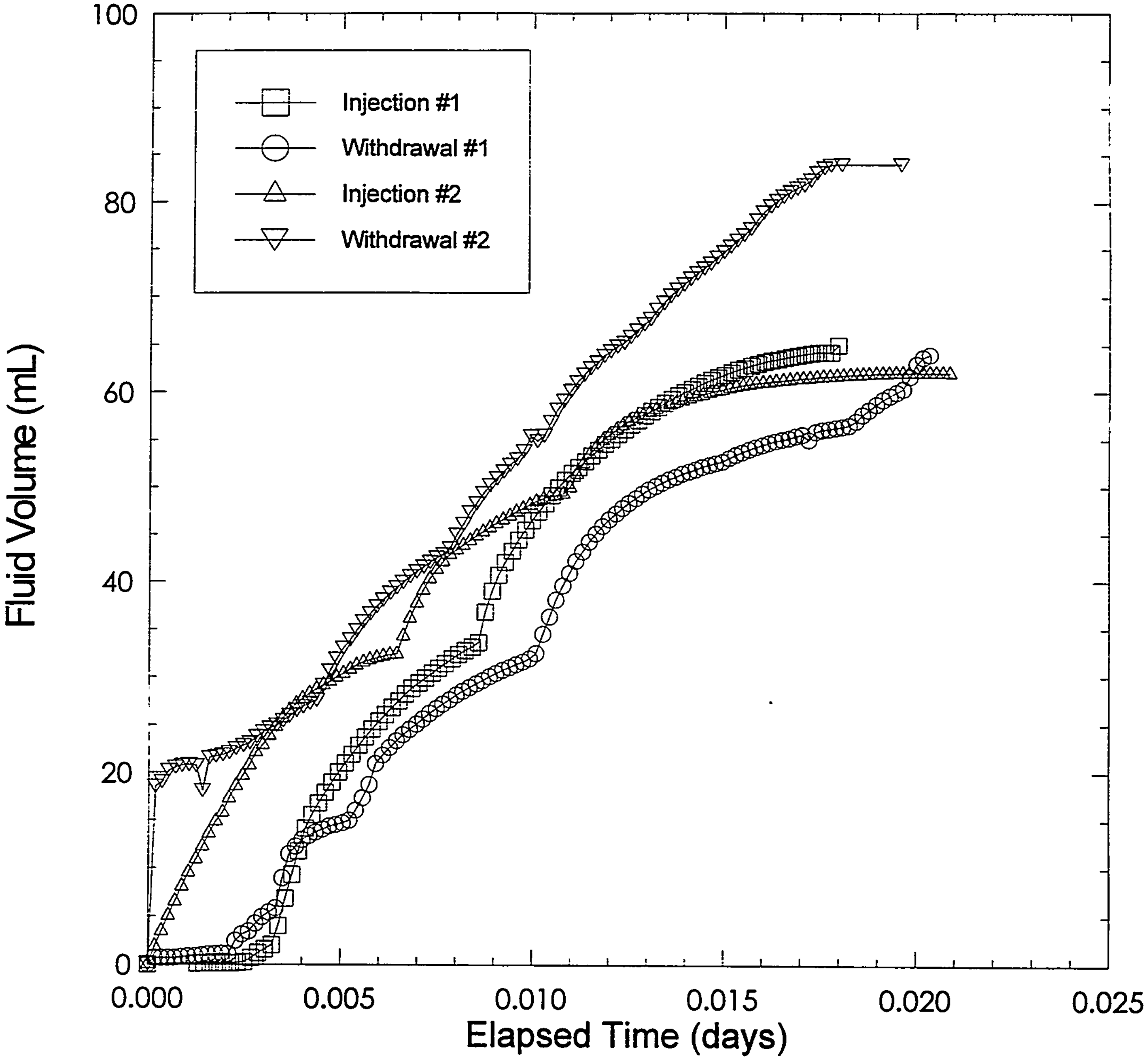

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Figure 6-57. Fluid-injection volumes during compliance testing of test tool #P74-B.

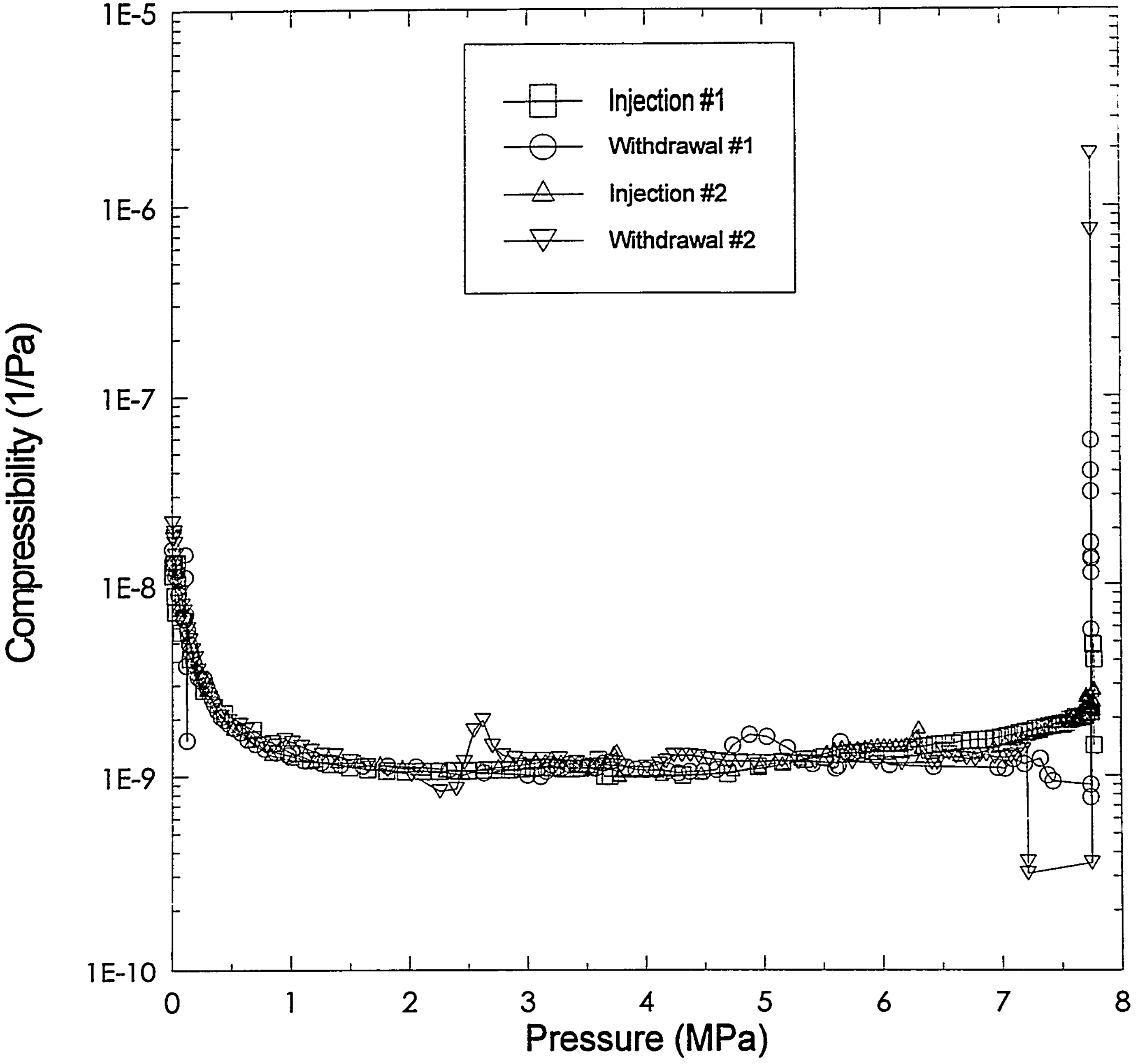

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Figure 6-58. Test-zone compressibility as measured during compliance testing of test tool #P74-B.

7. LONG-TERM FLUID-PRESSURE MONITORING

The fluid-pressure data obtained during permeability testing, coupled permeability and hydrofracture testing, and gas-threshold pressure testing (GTPT) were supplemented with fluid-pressure data from packer-isolated sections of selected boreholes. The specific objectives of the long-term fluid-pressure monitoring were:

- to determine if pore pressures in the various Salado Formation interbeds change as a function of time due to the underground excavation; and
- to determine the relationship between proximity to an excavation and change in formation pore pressure as a function of time.

Single-packer fluid-pressure monitoring tools as described in Section 7.2 were installed in boreholes C2H01, C2H02, DPD01, DPD02, DPD03, L4P52, SCP01, S1P71, and S1P72. Permeability testing was conducted in boreholes C2H01, C2H02, L4P52 (permeability-testing sequences L4P52-A and L4P52-B), SCP01, S1P71 (permeability-testing sequences S1P71-A and S1P71-B), and S1P72. GTPT was conducted in boreholes SCP01 (GTPT sequences SCP01-1 and SCP01-2), C2H02, and L4P52 (GTPT sequence L4P52-B). Permeability-testing sequences C2H01, C2H02, and S1P71-A are described in Saulnier et al. (1991). Permeability-testing sequences L4P52-A, SCP01, S1P71-B, and S1P72 are described in Stensrud et al. (1992). Permeability-testing sequence L4P52-B is described in Section 3.6.1.5 of this report. GTPT sequences C2H02, L4P52-B, SCP01-1, and SCP01-2 are described in Section 5.6 of this report. The dates of permeability testing and GTPT in these boreholes are given in Table 7-1. Figure 2-1 shows the locations of the boreholes involved in the long-term fluid-pressure monitoring.

Note: Fluid pressures associated with the long-term fluid-pressure monitoring were recorded in units of pounds per square inch (psig) and are reported as such.

Table 7-1. Locations and Dates of Testing Performed in Long-Term Fluid-Pressure Monitoring Boreholes

Borehole (Orientation)	**Location**	**Dates Tested**	**Excavation Date of Room**	**Test Type**
C2H01 (vertical down)	Room C2	8-88 to 2-89	March & April 1984	Permeability
C2H01 (Deepened) (vertical down)	Room C2	2-89 to 5-89	March & April 1984	Permeability
C2H02 (downward 45° from vertical)	Room C2	4-89 to 12-89	March & April 1984	Permeability
C2H02 (downward 45° from vertical)	Room C2	8-93 to 3-94	March & April 1984	Gas-Threshold Pressure

Table 7-1 (Continued). Locations and Dates of Testing Performed in Long-Term Fluid-Pressure Monitoring Boreholes

Borehole (Orientation)	Location	Dates Tested	Excavation Date of Room	Test Type
DPD01 (downward 46° from vertical)	North 1400 Drift	N/A	March 1983	N/A
DPD02 (downward 47° from vertical)	North 1400 Drift	N/A	March 1983	N/A
DPD03 (downward 46° from vertical)	North 1400 Drift	N/A	March 1983	N/A
L4P52 (upward 40° from vertical)	Room L4	12-92 to 12-93	February 1989	Permeability
L4P52 (upward 40° from vertical)	Room L4	12-93 to 3-94	February 1989	Gas-Threshold Pressure
SCP01 (downward 77° from vertical)	Core Storage Library	4-90 to 10-90	May 1989	Permeability
SCP01 (downward 77° from vertical)	Core Storage Library	4-94 to 6-94	May 1989	Gas-Threshold Pressure
S1P71 (vertical down)	Waste Panel 1, Room 7	11-88 to 7-89	March 1988	Permeability
S1P71 (vertical down)	Waste Panel 1, Room 7	8-89 to 5-90	March 1988	Permeability
S1P72 (downward 58° from vertical)	Waste Panel 1, Room 7	12-90 to 2-91	March 1988	Permeability

7.1 Implementation

The long-term fluid-pressure monitoring discussed in this data report was conducted in nine boreholes drilled at five locations in the WIPP underground facility shown in Figure 2-1 and described in detail in Sections 7.4 and 7.5. The boreholes were drilled vertically downward, angled downward, and angled upward. In the experimental area, boreholes C2H01 and C2H02 were drilled in Room C2, L4P52 was drilled in Room L4, and boreholes DPD01, DPD02, and DPD03 were drilled on the north rib of the north 1400 drift between Room C1 and Room M. In the operations area, borehole SCP01 was drilled in the Core Storage Library. In the waste storage area, boreholes S1P71 and S1P72 were drilled in Waste Panel 1, Room 7. The monitoring locations were chosen to provide an adequate representation of long-term fluid pressures in the Salado Formation and its interbeds at and near the repository horizon. Figure 7-1 illustrates the stratigraphic positions of each of the monitoring boreholes in relation to the typical WIPP excavation.

The borehole zones isolated by the single-packer tools were MB138 and MB139. Table 7-2 lists the pertinent information for the boreholes and zones.

Table 7-2. Fluid-Pressure Monitoring Boreholes; Test-Zone Information

Borehole	Test Horizon	Test Horizon Penetrated	Borehole Diameter (cm)	Test Interval Depth (m)	Borehole Depth (m)	Monitoring Started	Monitoring Terminated
C2H01	MB139	2-13-89	10.16	6.80 - 7.76	8.97	8-89	4-95
C2H02	MB139	4-14-89	10.16	9.80 - 10.68	10.91	2-91	4-95
L4P52-B	MB138	12-14-92	10.16	13.89 - 14.02	14.12	5-94	5-95
S1P71-B	anhydrite "c"	7-24-89	10.16	9.75 - 9.80	10.15	2-91	5-95
S1P72	MB139	12-13-89	10.16	4.40 - 6.00	6.05	2-91	5-95
SCP01	MB139	3-29-90	10.16	10.50 - 14.78	15.48	10-90	5-95

After drilling or after the completion of another testing sequence, a single-packer tool (see Section 7.2) was installed in each of the boreholes. The packers were used to isolate a selected zone below the packers. The zones of the long-term fluid-pressure monitoring boreholes were filled with 1.22 kg/L sodium-chloride brine. After packer inflation, the zone of each tool was shut in and the fluid-pressure buildup was monitored with manually read Bourdon tube pressure gages (Ashcroft or Wika) and recorded on appropriate data collection forms. No additional testing was conducted in the boreholes after the tools were installed.

7.2 Equipment for Long-Term Fluid-Pressure Monitoring

The following sections briefly describe the equipment used in the long-term fluid-pressure monitoring in the WIPP underground facility. The equipment includes single-packer tools and Bourdon tube pressure gages.

7.2.1 Single-Packer Tool

The single-packer tools installed for this monitoring are shown in Sections 7.4 and 7.5. The tools consist of a sliding-end, 9.5-cm outside diameter (O.D.) inflatable packer mounted on a 4.83-cm O.D. mandrel oriented with the packers' fixed end toward the bottom-hole end of the test tool. The packers have 0.92-m-long inflatable elastic elements composed of natural rubber and synthetic materials. The packer elements have

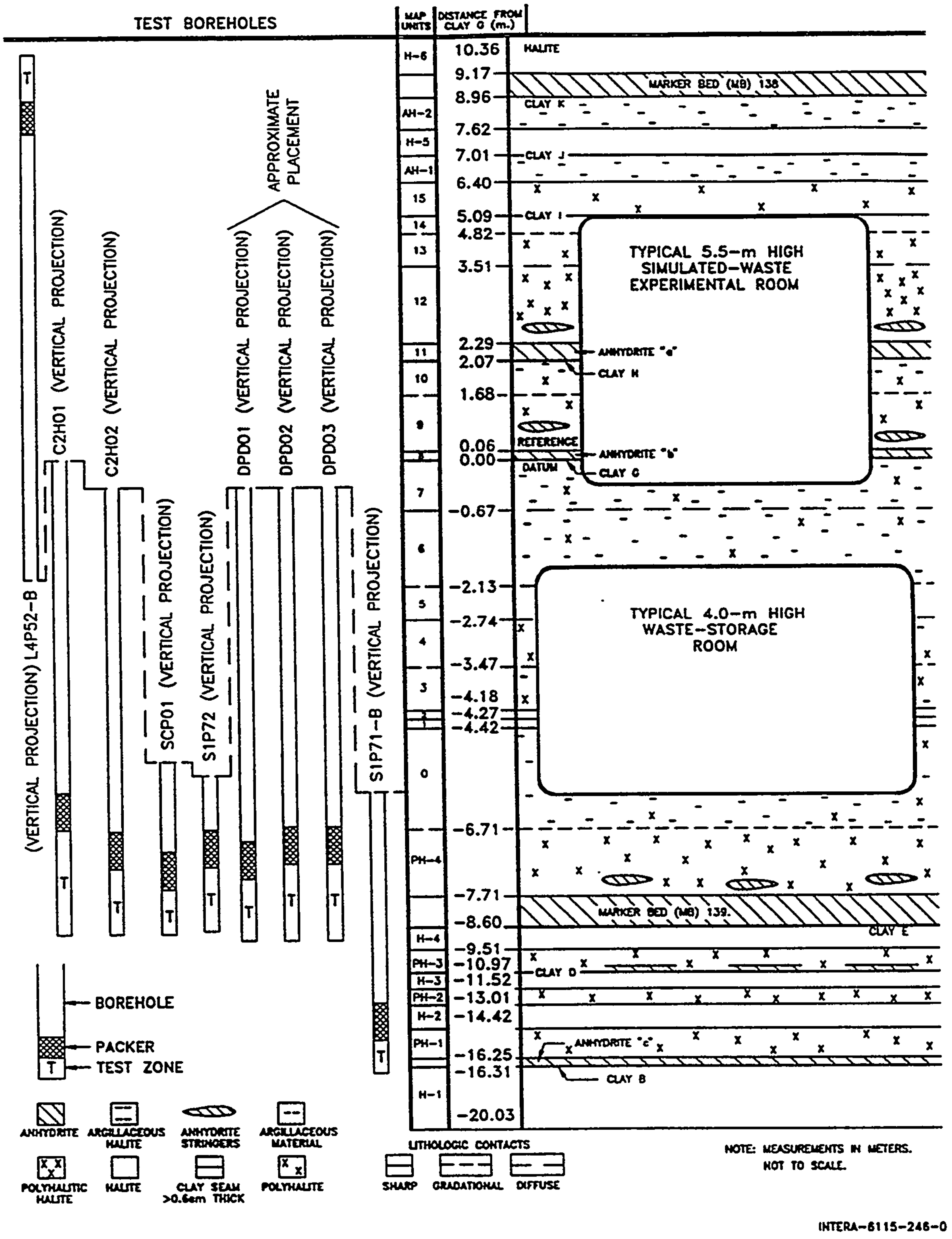

Figure 7-1. Stratigraphic positions of long-term fluid-pressure monitoring boreholes with test zones indicated.

approximately 0.9-m seal lengths when inflated in 4-inch (10.2-cm) diameter boreholes. In all cases, a set of radially oriented tapered jaws or slips that tighten on the tool mandrel as the tool attempted to move out of the borehole, in response to pressure buildup, was used to restrain the tool.

Each single-packer tool was equipped with two ports to the bottom-hole test zone below the packers. One port was used to transmit pressures from the test zones to the Bourdon tube gages, which were mounted outside of the boreholes. The second port was used to dissipate "squeeze" pressures created during packer inflation. These two ports were accessed by continuous lengths of 3/16-inch (0.48-cm) O.D. stainless-steel tubing.

7.2.2 Bourdon Tube Gages

Bourdon tube pressure gages of varying ranges (WIKA and Ashcroft brand) were used for all of the long term fluid-pressure measurements. The pressure range of each gage used was appropriate for the borehole pressure being monitored. Both aone and packer pressures were monitored and manually recorded. The gages were not calibrated and were used for indication purposes only. As such, the pressure measurements obtained from these gages should not be used for data interpretation.

7.3 Procedures for Long-Term Fluid-Pressure Monitoring

7.3.1 Tool Installation Procedure

The following describes a typical tool-installation sequence. Single-packer tools were installed in each of the boreholes as soon after the completion of a permeability-testing sequence or a GTPT sequence as possible in order to minimize depressurization of the formation surrounding the borehole. Prior to initiating long-term fluid-pressure monitoring, a multipacker test tool configured appropriately for either permeability testing or GTPT sequences was replaced by a single-packer tool. All single-packer tools were installed following tool-installation procedures presented in SOP INT-5 (INTERA, 1992) and/or WIPP Procedures for test-tool installation (479, 480, and 481) (see Figures 3-15 through 3-17). Before tool installation in vertically down or angled downward borehole orientations, enough brine was added to the borehole to fill the zone to be monitored, helping to minimize air entrapment. After the single-packer tool was installed, the packer was inflated to an appropriate pressure as indicated on the Bourdon tube pressure gage and the zone was shut in. Both zone and packer pressures were monitored and recorded.

For boreholes oriented vertically or angled upward, the single-packer tools were installed and the packer inflated to an appropriate pressure. The isolated borehole was then filled with brine while a vacuum pump attached to the zone vent line removed entrapped air. In some cases, 10-psi (68.95 kPa) check valves were attached to the vent lines to prevent brine from draining from the isolated borehole interval, assuring fluid-filled zones (Figure 3-18).

7.4 Fluid-Pressure Monitoring

Information and plots of the fluid-pressure monitoring data are presented below. Complete tabulations of the manually recorded data are stored in the SWCF under WPO #42269.

7.4.1 Borehole C2H01

Table 7-3 lists the events associated with borehole C2H01 from the time the borehole was drilled to the termination of all testing and/or monitoring in the borehole with the events associated with the fluid-pressure monitoring emphasized. Descriptions of events that occurred during permeability testing in this borehole and of the core recovered from the borehole can be found in Saulnier et al. (1991).

Table 7-3. Long-Term Fluid-Pressure Monitoring C2H01 Events

EVENT	DATE	CALENDAR DAY	1989 CALENDAR DAY
Drill borehole C2H01 to 5.58 meters.	8-4-88	217	N/A
Begin permeability-testing sequence C2H01-A.	8-6-88	219	N/A
Terminate permeability-testing sequence C2H01-A.	9-1-88	245	N/A
Begin permeability-testing sequence C2H01-B.	9-2-88	246	N/A
Terminate permeability-testing sequence C2H01-B.	2-9-89	40	40
Borehole C2H01 deepened to 8.97 meters	2-15-89	46	46
Begin permeability-testing sequence C2H01-C.	2-16-89	47	47
Terminate permeability-testing sequence C2H01-C.	5-22-89	142	142
Install single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB139 as indicated in Figure 7-2.	8-22-89	234	234
Inflate packer to ~1500 psig.	8-22-89	234	234
Increase packer pressure to ~1500 psig.	8-24-89	236	236
Diagnose that the monitor tool was moving out of the borehole.	10-30-89	303	303
Depressurize test zone.	7-5-90	186	551
Deflate packer.	7-5-90	186	551
Remove long-term fluid-pressure monitoring tool.	7-5-90	186	551

Table 7-3 (Continued). Long-Term Fluid-Pressure Monitoring C2H01 Events

EVENT	DATE	CALENDAR DAY	1989 CALENDAR DAY
Ream borehole C2H01 to 4-inch (10.16-cm) to bottom of borehole.	1-22-91	22	752
Video-log borehole.	2-7-91	38	768
Install single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB139 as indicated in Figure 5-9.	2-11-91	42	772
Inflate packer to ~1500 psig.	2-12-91	43	773
Shut in test zone.	2-12-91	43	773
Depressurize test zone.	3-13-91	72	802
Deflate packer.	3-13-91	72	802
Remove long-term fluid-pressure monitoring tool.	3-13-91	72	802
Re-install single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB139 as indicated in Figure 5-9.	3-13-91	72	802
Inflate packer to ~1500 psig.	3-13-91	72	802
Increase test zone pressure to ~275 psig.	3-14-91	73	803
Install transducer #321768 to monitor pressure during coupled permeability and hydrofracture-testing sequence C1X10.	1-29-92	29	1124
Begin fluid-pressure monitoring of MB139 associated with testing sequence C1X10.	1-29-92	29	1124
Terminate fluid-pressure monitoring associated with testing sequence C1X10.	6-26-92	178	1273
Begin fluid-pressure monitoring of MB139 associated with testing sequence C1X05-A.	6-26-92	178	1273
Terminate fluid-pressure monitoring associated with testing sequence C1X05-A.	8-3-92	216	1311
Resume long-term fluid-pressure monitoring of fluid pressure in MB139.	8-3-92	216	1311
Increase packer pressure.	7-12-93	193	1653
Begin fluid-pressure monitoring of MB139 associated with testing sequence C2H02.	9-28-93	271	1731
Terminate fluid-pressure monitoring associated with testing sequence C2H02.	3-4-94	77	1894
Resume long-term fluid-pressure monitoring of fluid pressure in MB139.	3-4-94	77	1894

Table 7-3 (Continued). Long-Term Fluid-Pressure Monitoring C2H01 Events

EVENT	DATE	CALENDAR DAY	1989 CALENDAR DAY
Depressurize test zone.	4-20-95	110	1935
Deflate packer.	4-20-95	110	1935
Remove long-term fluid-pressure monitoring tool.	4-20-95	110	1935
Terminate long-term fluid-pressure monitoring.	4-20-95	110	1935

Figure 4-7 schematically depicts Room C2 in plan view and in cross section, showing the locations and orientations of boreholes C2H01 and C2H02. Figures 7-2 and 5-9 illustrate both of the tool configurations and associated installations that were used during the fluid-pressure monitoring in borehole C2H01. Figure 7-3 is a plot of the fluid pressure observed in borehole C2H01.

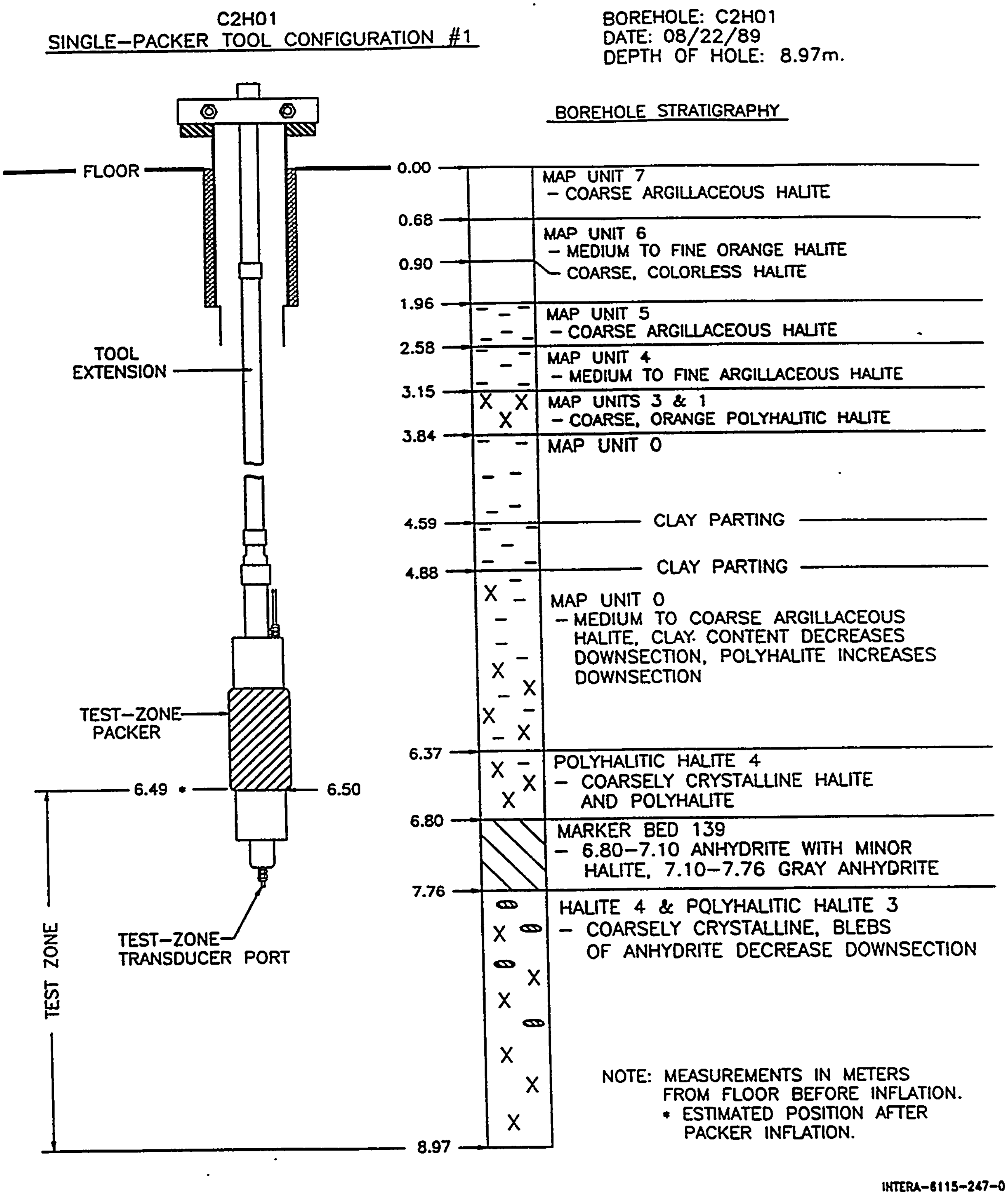

Figure 7-2. Configuration #1 of long-term fluid-pressure monitoring tool in borehole C2H01.

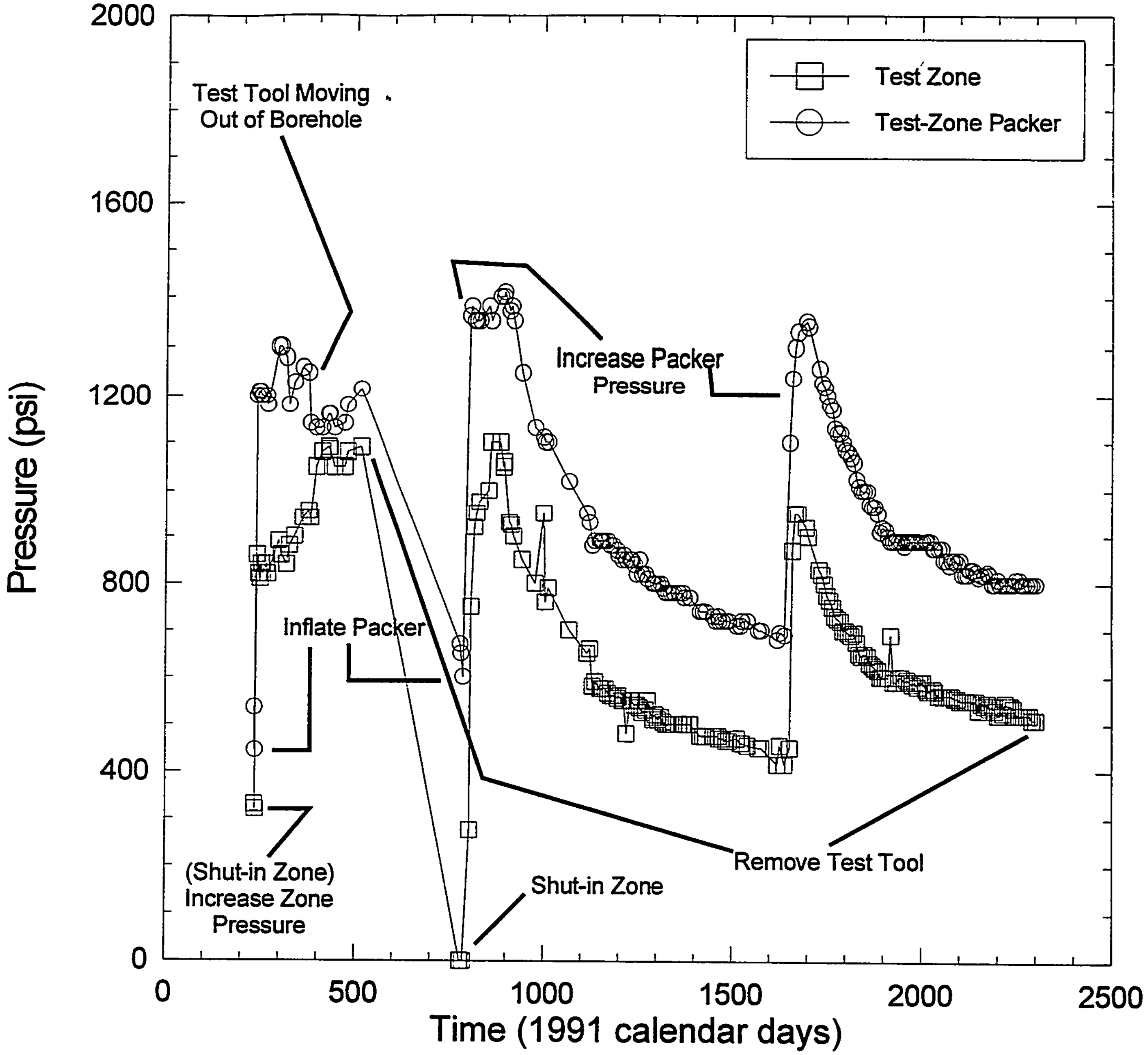

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Figure 7-3. Long-term fluid pressure in MB139 in borehole C2H01.

7.4.2 Borehole C2H02

Table 7-4 lists the events associated with borehole C2H02 from the time the borehole was drilled to the termination of all testing and/or monitoring in the borehole with the events associated with the fluid-pressure monitoring emphasized. Descriptions of events that occurred during permeability testing in this borehole and the core recovered from the borehole can be found in Saulnier et al. (1991). Descriptions of events that occurred during the GTPT in this borehole can be found in Section 5.6.2 of this report.

Table 7-4. Long-Term Fluid-Pressure Monitoring C2H02 Events

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY
Drill borehole C2H02 to 10.86 meters.	4-17-89	107	N/A
Begin permeability-testing sequence C2H02.	4-19-89	109	N/A
Terminate permeability-testing sequence C2H02.	12-12-89	346	N/A
Ream borehole C2H02 4-inch (10.16-cm) to bottom of borehole.	1-22-91	22	22
Video log borehole.	2-7-91	38	38
Install single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB139 as indicated in Figure 7-4.	2-11-91	42	42
Inflate packer to ~1500 psig.	2-12-91	43	43
Shut in test zone.	2-12-91	43	43
Diagnose and fix leak on test zone.	10-9-91	282	282
Replace bad gage on test zone.	1-7-92	7	372
Depressurize test zone.	8-9-93	221	951
Deflate packer.	8-9-93	221	951
Remove long-term fluid-pressure monitoring tool.	8-9-93	221	951
Install GTPT test tool as indicated in Figure 5-10 and begin GTPT sequence C2H02.	8-10-93	222	952
Remove GTPT test tool and terminate GTPT sequence C2H02.	3-23-94	82	1177
Install single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB139 as indicated in Figure 7-5.	3-24-94	83	1178
Add approximately 10 liters of brine to borehole.	3-25-94	84	1179
Inflate packer to ~1750 psig.	3-25-94	84	1179
Increase test zone pressure to ~1080 psig.	3-25-94	84	1179

Table 7-4 (Continued). Long-Term Fluid-Pressure Monitoring C2H02 Events

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY
Depressurize test zone.	4-20-95	110	1570
Deflate packer.	4-20-95	110	1570
Remove long-term fluid-pressure monitoring tool.	4-20-95	110	1570
Terminate long-term fluid-pressure monitoring.	4-20-95	110	1570

Figures 7-4 and 7-5 illustrate the tool configurations and associated installations that were used during the fluid-pressure monitoring in borehole C2H02. Figure 7-6 is a plot of the fluid pressure observed in borehole C2H02.

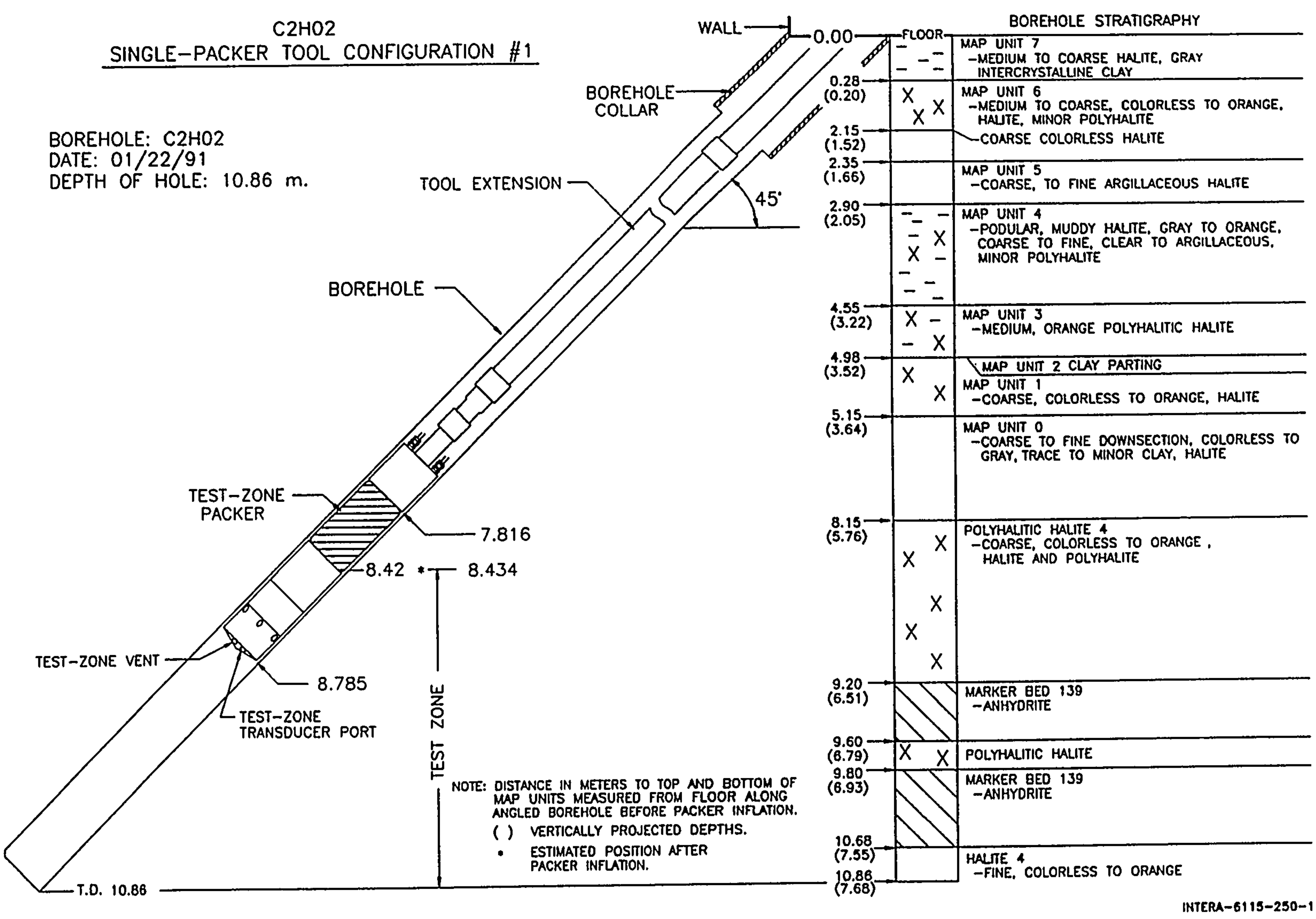

Figure 7-4. Configuration #1 of long-term fluid-pressure monitoring tool in borehole C2H02.

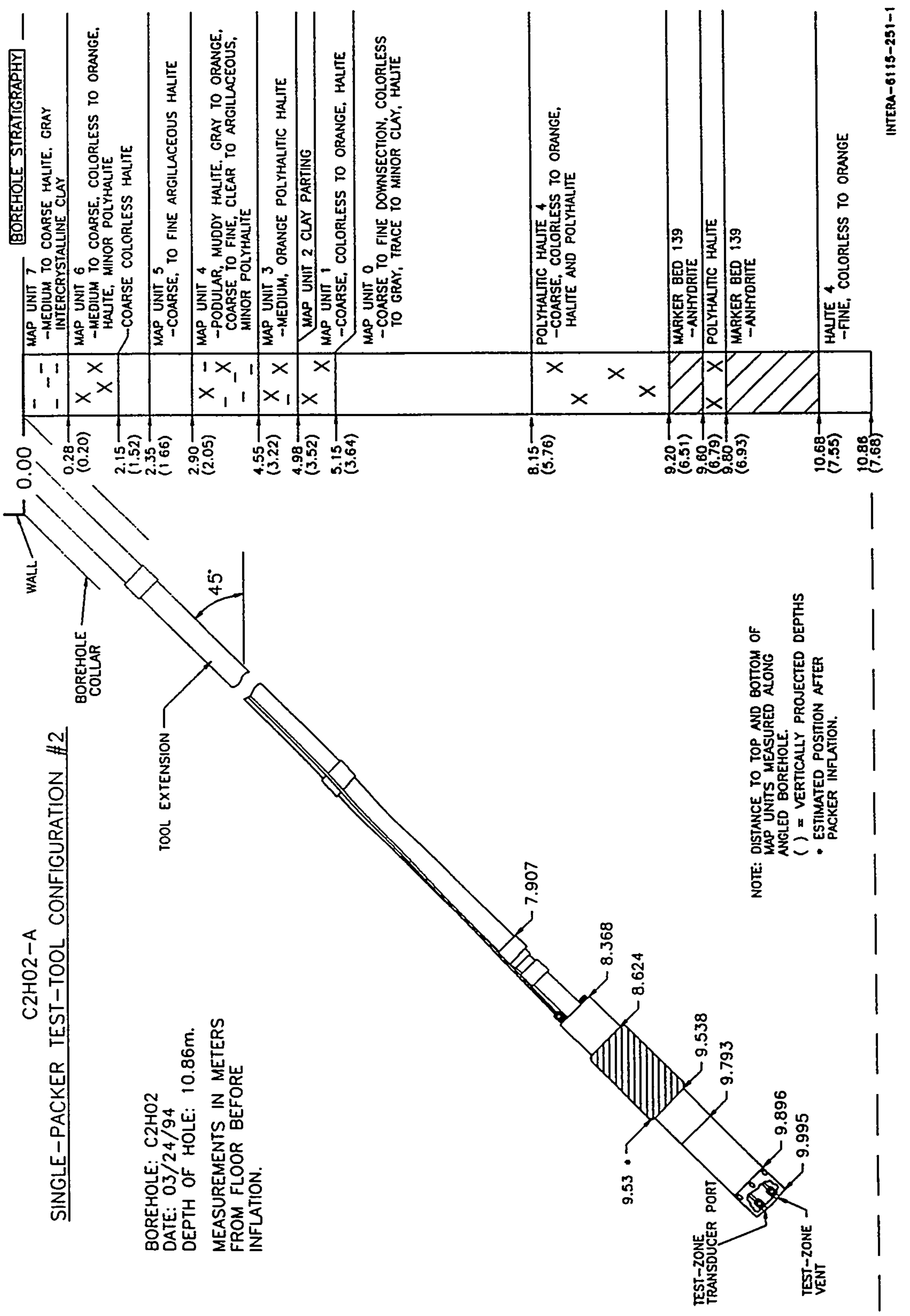

Figure 7-5. Configuration #2 of long-term fluid-pressure monitoring tool in borehole C2H02.

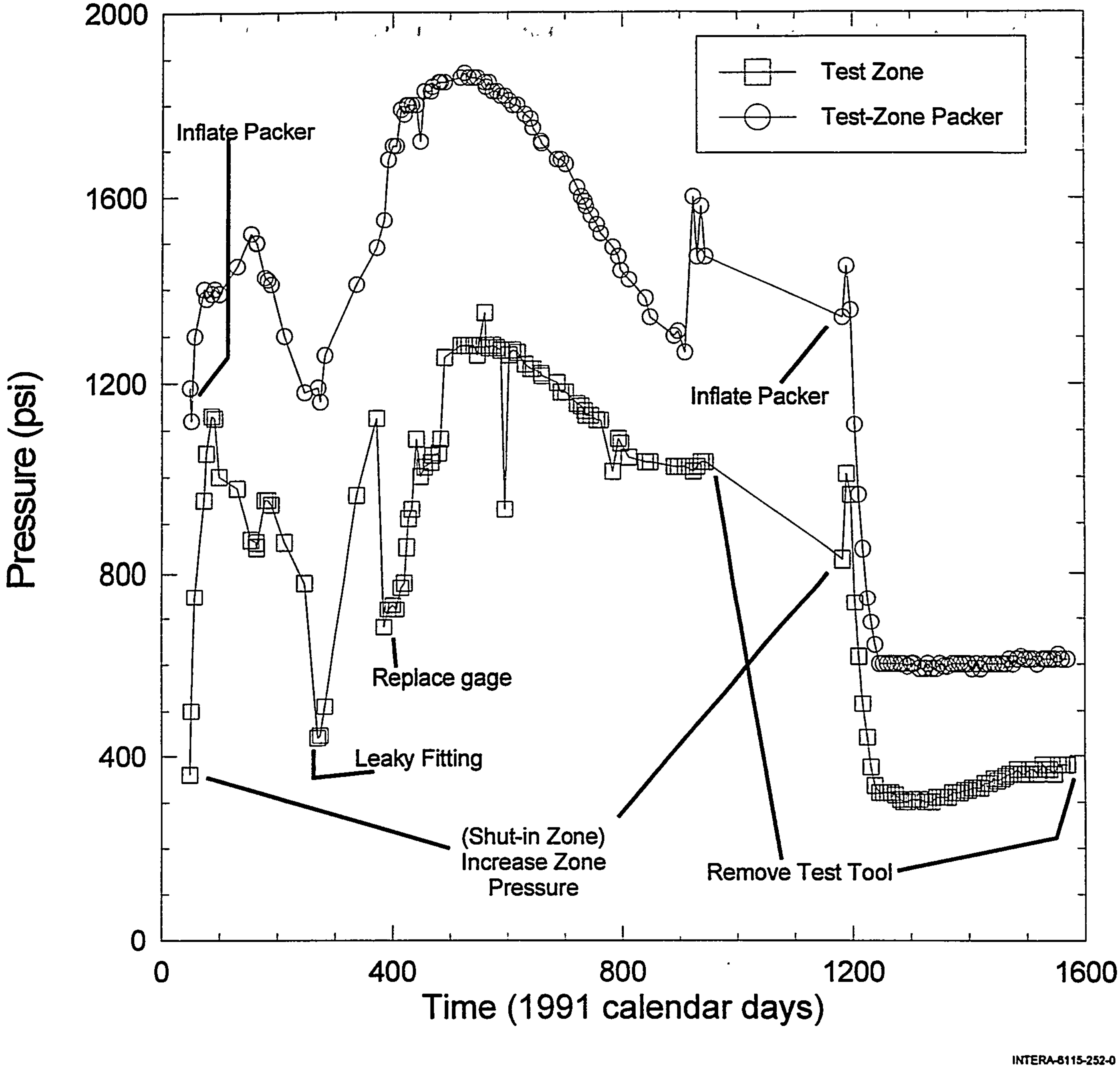

Figure 7-6. Long-term fluid pressure in MB139 in borehole C2H02.

7.4.3 Borehole L4P52

Table 7-5 lists the events associated with borehole L4P52 from the time the borehole was drilled to the termination of all testing and/or monitoring in the borehole with the events associated with the fluid-pressure monitoring emphasized. Descriptions of events that occurred during both the permeability testing and the GTPT in this borehole can be found in Sections 3.6.1.5 and 5.6.3 of this report. A description of the core recovered from borehole L4P52 can be found in Appendix A of this report.

Table 7-5. Long-Term Fluid-Pressure Monitoring L4P52 Events

EVENT	DATE	CALENDAR DAY	1994 CALENDAR DAY
Borehole L4P52 drilled to 5.56 meters.	4-2-91	92	N/A
Video-log borehole.	4-8-91	98	N/A
Begin permeability-testing sequence L4P52-A.	4-12-91	102	N/A
Terminate permeability-testing sequence L4P52-A.	8-11-92	224	N/A
Deepen borehole L4P52 to 14.18 meters.	12-14-92	349	N/A
Install test tool as indicated in Figure 3-31.	12-16-93	351	N/A
Begin permeability-testing sequence L4P52-B.	12-17-92	352	N/A
Terminate permeability-testing sequence L4P52-B.	12-28-93	362	N/A
Begin GTPT sequence L4P52-B.	12-29-93	363	N/A
Remove test tool and terminate GTPT sequence L4P52-B.	5-4-94	124	124
Install single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB138 as indicated in Figure 7-7.	5-4-94	124	124
Inflate packer to ~1500 psig.	5-5-94	125	125
Shut in test zone.	5-5-94	125	125
Depressurize test zone.	5-16-95	136	501
Deflate packer.	5-16-95	136	501
Remove long-term fluid-pressure monitoring tool.	5-16-95	136	501
Terminate long-term fluid-pressure monitoring.	5-16-95	136	501

Figure 3-20 schematically depicts Room L4 in plan view and in cross section, showing the location and orientation of borehole L4P52. Figure 7-7 illustrates the test-tool configuration and associated installation that was used during the fluid-pressure monitoring in borehole L4P52. Figure 7-8 is a plot of the fluid pressure observed in borehole L4P52-B.

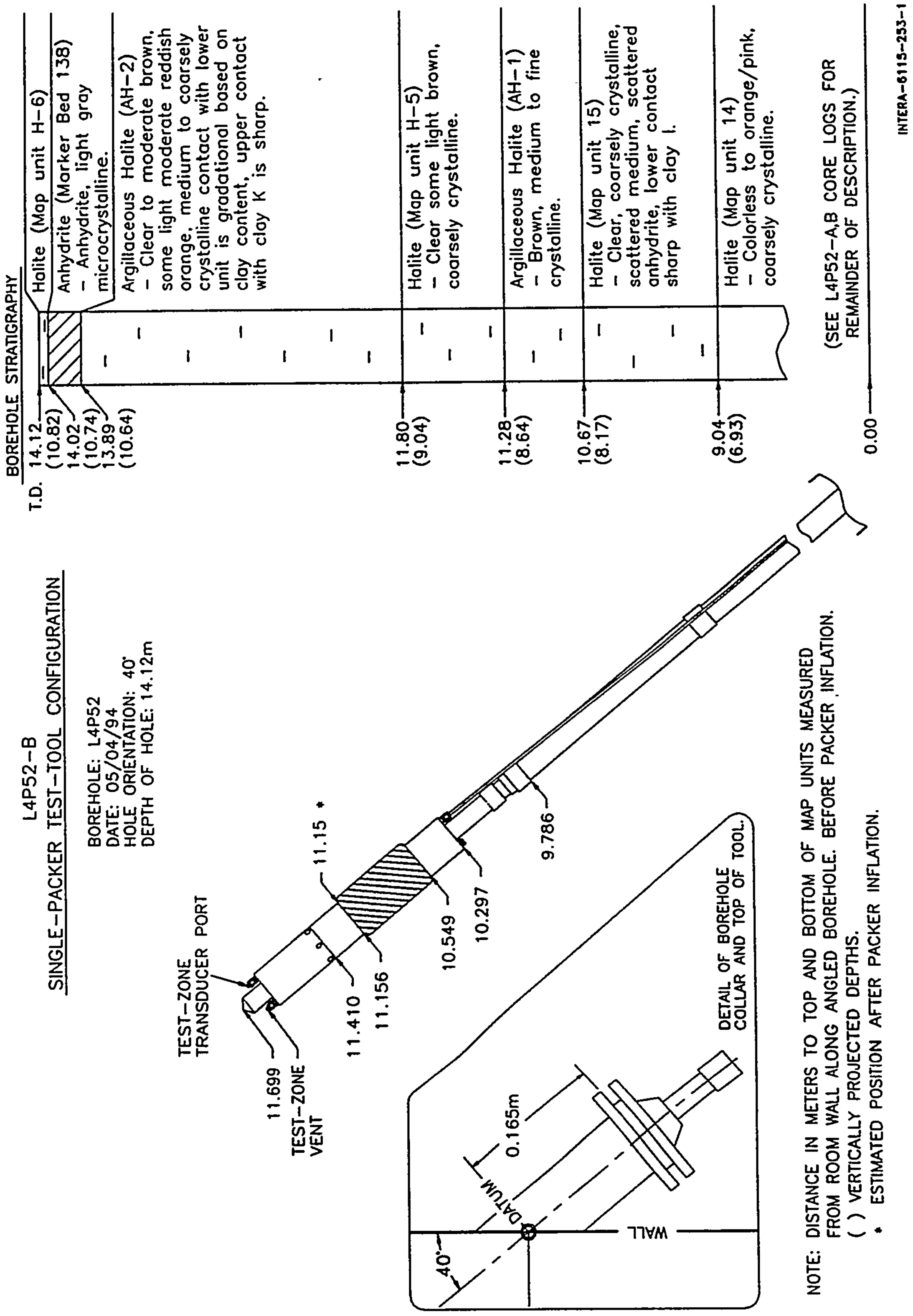

Figure 7-7. Configuration of long-term fluid-pressure monitoring tool in borehole L4P52.

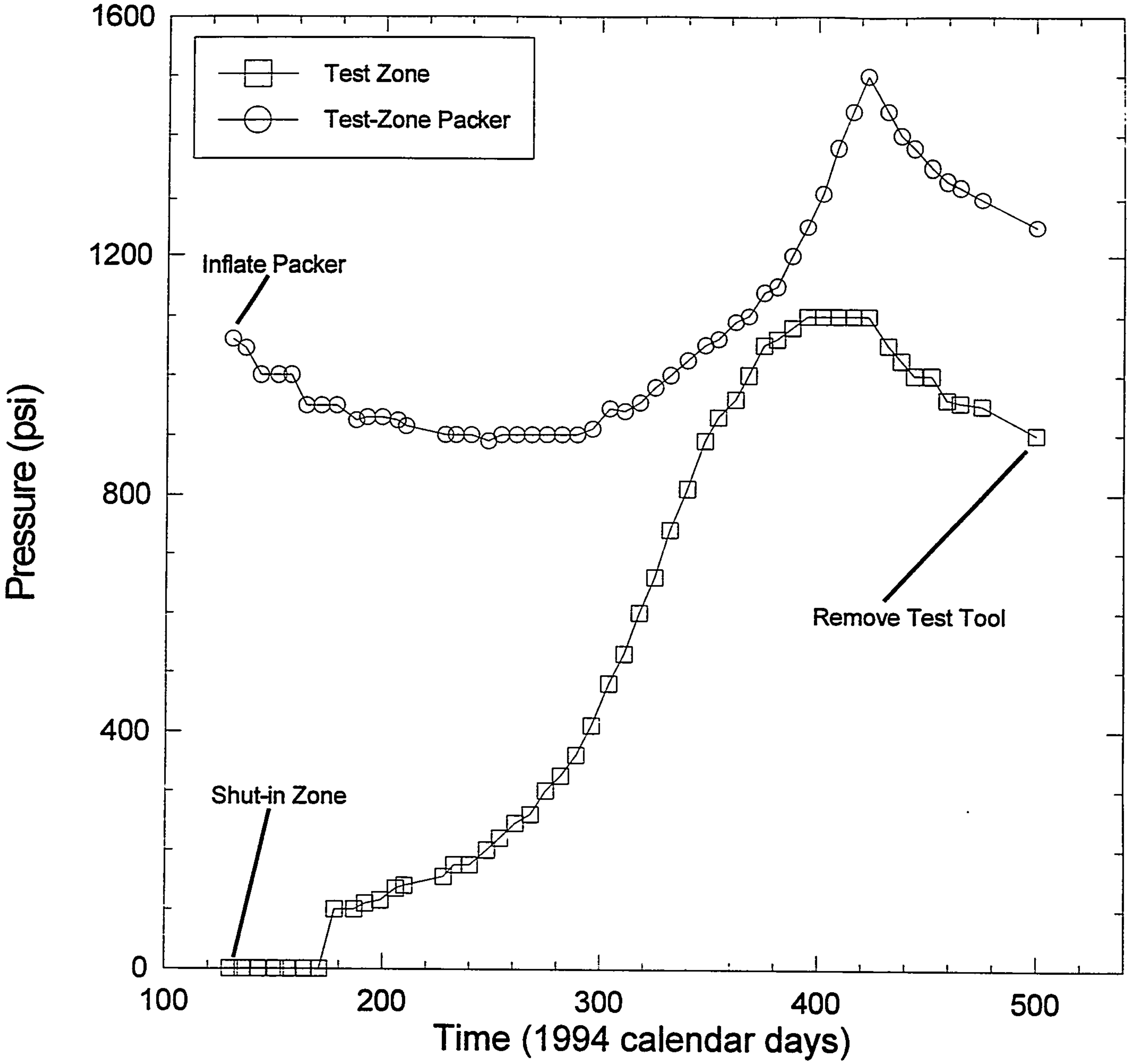

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Figure 7-8. Long-term fluid pressure in MB138 in borehole L4P52.

7.4.4 Borehole SCP01

Table 7-6 lists the events associated with borehole SCP01 from the time the borehole was drilled to the termination of all testing and/or monitoring in the borehole with the events associated with the fluid-pressure monitoring emphasized. Descriptions of events that occurred during permeability testing in this borehole and of the core recovered from the borehole can be found in Stensrud et al. (1992). A description of events that occurred during GTPT in this borehole can be found in Sections 5.6.1.1 and 5.6.1.2 of this report.

Table 7-6. Long Term Fluid-Pressure Monitoring SCP01 Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY
Drill borehole SCP01 to 15.39 meters.	3-30-90	89	89
Begin permeability-testing sequence SCP01.	4-10-90	100	100
Terminate permeability-testing sequence SCP01.	10-11-90	284	284
Install single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB139 as indicated in Figure 7-9.	10-12-90	285	285
Add approximately 30.3 L of brine to borehole.	10-15-90	288	288
Inflate packer to ~1500 psi.	10-15-90	288	288
Re-inflate packer to ~1500 psi.	10-15-90	288	288
Re-inflate packer to ~1540 psi.	10-16-90	289	289
Shut in test zone.	10-16-90	289	289
Monitor tool moved out of borehole 1.2-cm total distance.	11-6-90	310	310
Monitor tool moved out of borehole 1.3-cm total distance.	11-8-90	312	312
Monitor tool moved out of borehole 1.5-cm total distance.	11-9-90	313	313
Monitor tool moved out of borehole 3.0-cm total distance.	11-12-90	316	316
Monitor tool moved out of borehole 4.3-cm total distance.	11-14-90	318	318
Replace restraining device with slip-type to eliminate monitor tool movement.	11-19-90	323	323
Replace bad gages on both test zone and packer.	12-6-90	340	340
Inflate packer to ~1475 psi.	12-6-90	340	340
Depressurize test zone.	12-10-92	344	1075
Deflate packer.	12-10-92	344	1075
Rotate packer 90° clockwise.	12-10-92	344	1075
Inflate packer to ~1500 psi.	12-10-92	344	1075
Shut in test zone.	12-10-92	344	1075

Table 7-6 (Continued). Long Term Fluid-Pressure Monitoring SCP01 Events

EVENT	DATE	CALENDAR DAY	1992 CALENDAR DAY
Depressurize test zone.	3-22-93	81	1176
Deflate packer.	3-22-93	81	1176
Remove long-term fluid-pressure monitor tool.	3-22-93	81	1176
Install GTPT test tool as indicated in Figure 5-4 and begin GTPT sequence SCP01-1.	3-30-93	89	1184
Remove GTPT test tool and terminate GTPT sequence SCP01-1.	7-13-93	194	1289
Install long-term fluid-pressure monitoring tool to monitor fluid pressure in MB139.	7-14-93	195	1290
Inflate packer to ~1500 psi.	7-14-93	195	1290
Shut in test zone.	7-14-93	195	1290
Depressurize test zone.	4-13-94	103	1563
Deflate packer.	4-13-94	103	1563
Remove long-term fluid-pressure monitoring tool.	4-13-94	103	1563
Install GTPT test tool as indicated in Figure 5-7 and begin GTPT sequence SCP01-2.	4-14-94	104	1564
Remove GTPT test tool and terminate GTPT sequence SCP01-2.	8-2-94	214	1674
Install single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB139 as indicated in Figure 7-10.	8-2-94	214	1674
Inflate packer to ~1500 psi.	8-2-94	214	1674
Shut in test zone.	8-2-94	214	1674
Leak in packer.	8-3-94	215	1675
Depressurize test zone.	5-2-95	122	1947
Deflate packer.	5-2-95	122	1947
Remove long-term fluid-pressure monitoring tool.	5-2-95	122	1947
Terminate long-term fluid-pressure monitoring.	5-2-95	122	1947

Figure 5-3 schematically depicts the Core Storage Library in plan view and in cross section, showing the location and orientation of borehole SCP01. Figures 7-9 and 7-10 illustrate all of the test-tool configurations and associated installations that were used during the fluid-pressure monitoring in borehole SCP01 (information regarding configuration #2 is not available and, therefore, there is no associated installation diagram). Figure 7-11 is a plot of the fluid pressure observed in borehole SCP01.

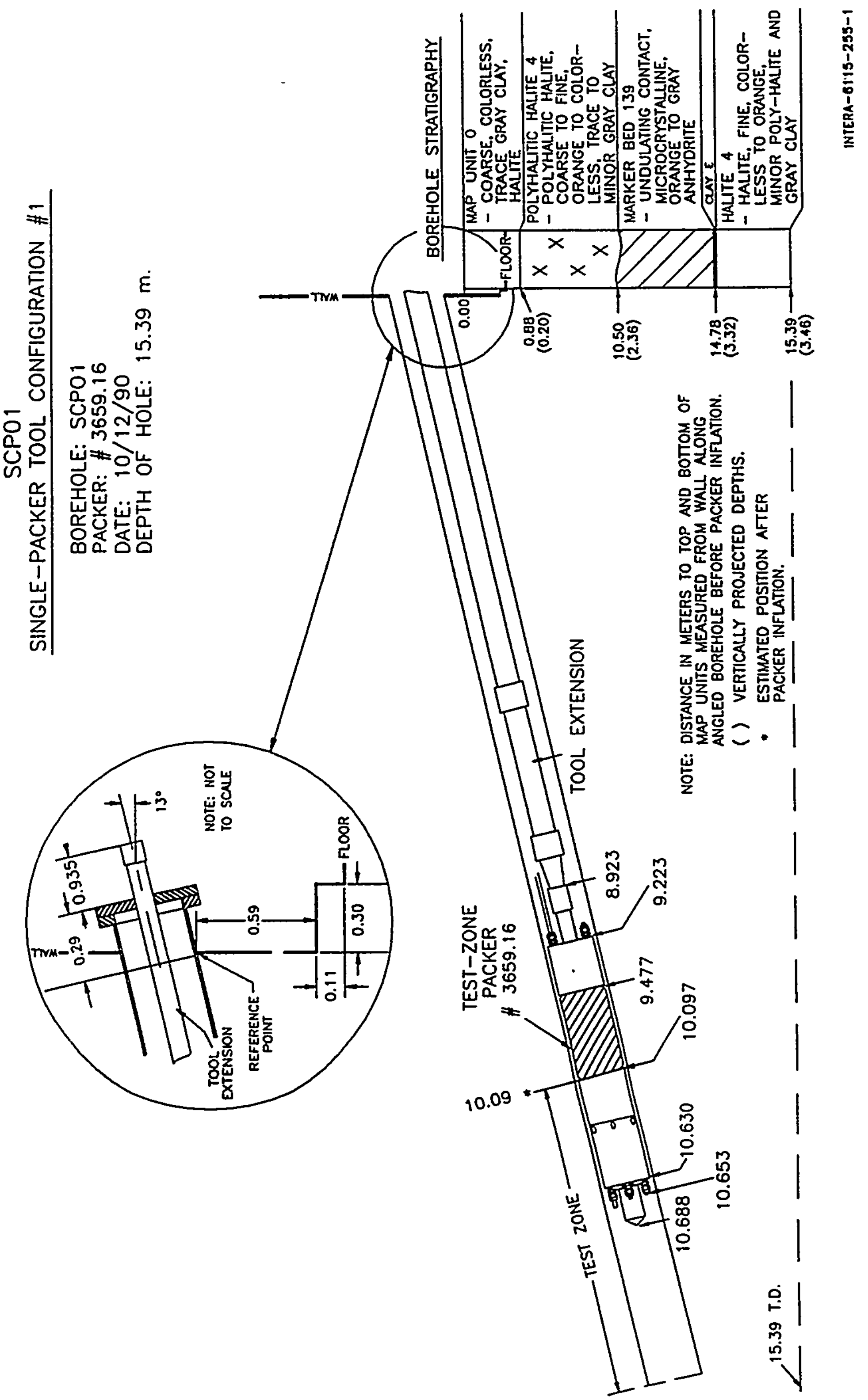

Figure 7-9. Configuration #1 of long-term fluid-pressure monitoring tool in borehole SCP01.

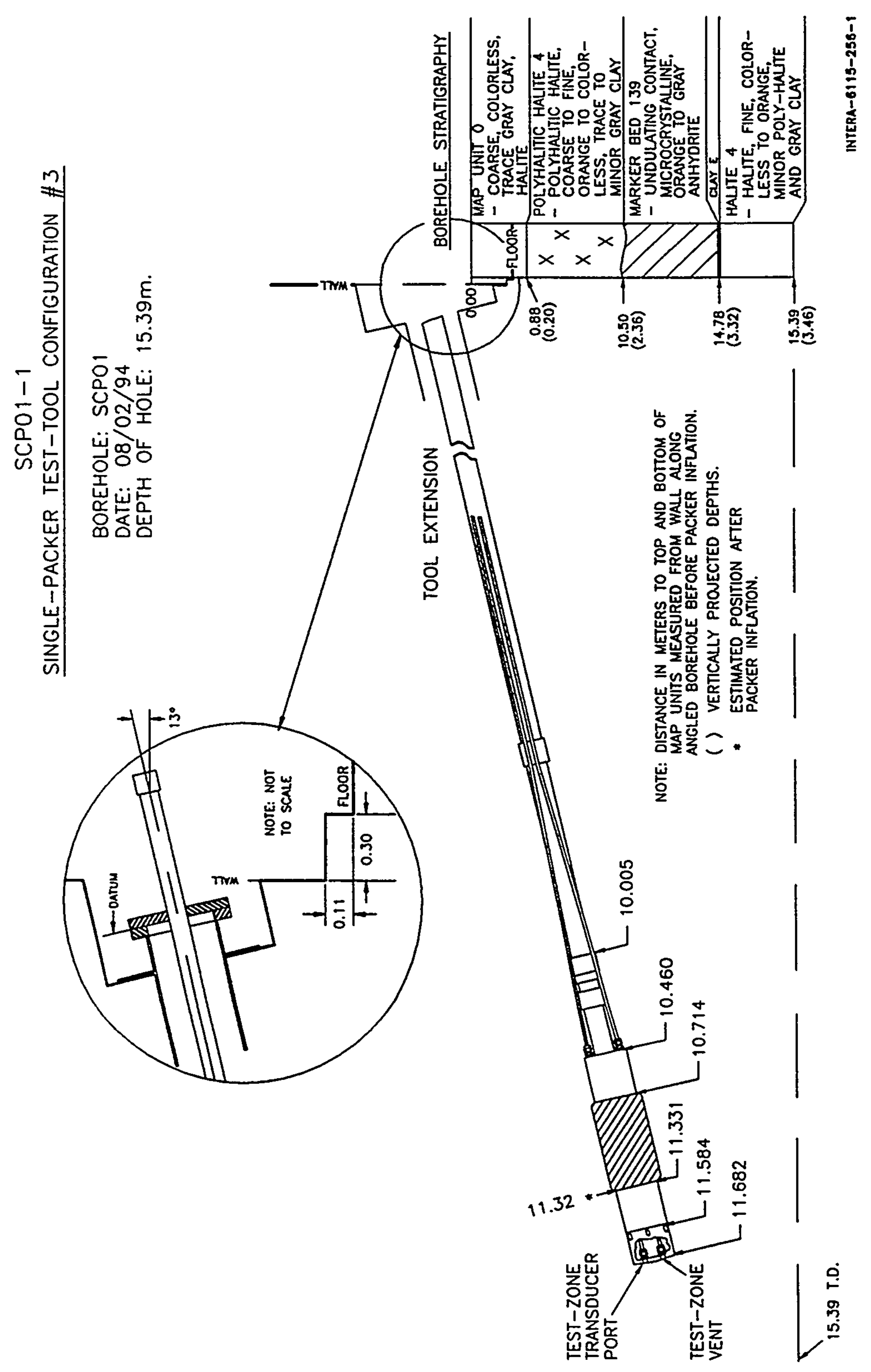

Figure 7-10. Configuration #3 of long-term fluid-pressure monitoring tool in borehole SCP01.

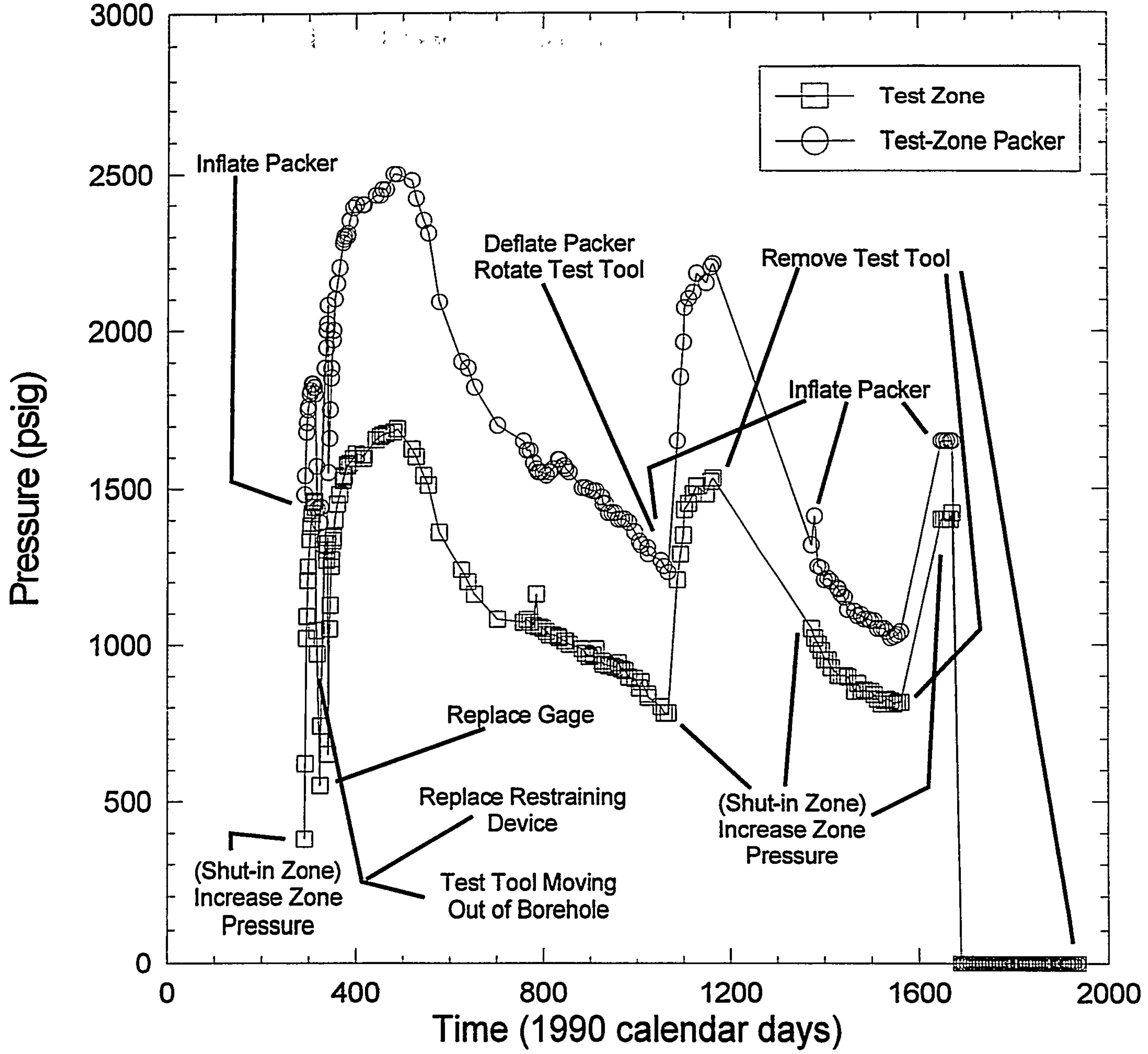

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Figure 7-11. Long-term fluid pressure in MB139 in borehole SCP01.

7.4.5 Borehole S1P71

Table 7-7 lists the events associated with borehole S1P71 from the time the borehole was drilled to the termination of all testing and/or monitoring in the borehole with the events associated with the fluid-pressure monitoring emphasized. A description of events that occurred during permeability-testing sequence S1P71-A can be found in Saulnier et al. (1991). Events that occurred during permeability-testing sequence S1P71-B, as well as core recovered from the borehole, are described in Stensrud et al. (1992).

Table 7-7. Long-Term Fluid-Pressure Monitoring S1P71 Events

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY
Drill borehole S1P71 to 4.56 meters.	11-10-88	316	N/A
Begin permeability-testing sequence S1P71-A.	11-11-88	317	N/A
Terminate permeability-testing sequence S1P71-A.	7-10-89	191	N/A
Deepen borehole S1P71 to 10.15 meters.	7-24-89	205	N/A
Begin permeability-testing sequence S1P71-B.	7-25-89	206	N/A
Terminate permeability-testing sequence S1P71-B.	5-24-90	144	N/A
Ream borehole S1P71 to 4-inch (10.16-cm) to bottom of borehole.	6-7-91	158	158
Set and grout new collar.	6-7-91	158	158
Load test new collar.	6-10-91	161	161
Video-log borehole.	6-11-91	162	162
Install long-term fluid-pressure monitoring tool to monitor fluid pressure in anhydrite "c" as indicated in Figure 7-12.	6-11-91	162	162
Inflate packer to ~1490 psi.	6-13-91	164	164
Deflate packer.	6-13-91	164	164
Re-inflate packer to ~1490 psi.	6-13-91	164	164
Increase packer pressure to ~1580 psi.	6-13-91	164	164
Shut in test zone.	6-13-91	164	164
Increase packer pressure.	7-12-93	193	923
Depressurize test zone.	5-16-95	136	1596
Deflate packer.	5-16-95	136	1596
Remove long-term fluid-pressure monitoring tool.	5-16-95	136	1596
Terminate long-term fluid-pressure monitoring.	5-16-95	136	1596

Figure 3-21 schematically depicts Waste Panel 1, Room 7 in plan view and in cross section, showing the location and orientation of boreholes S1P71 and S1P72. Figure 7-12 illustrates the test-tool configuration and associated installation that was used during the fluid-pressure monitoring in borehole S1P71. Figure 7-13 is a plot of the fluid pressure observed in borehole S1P71.

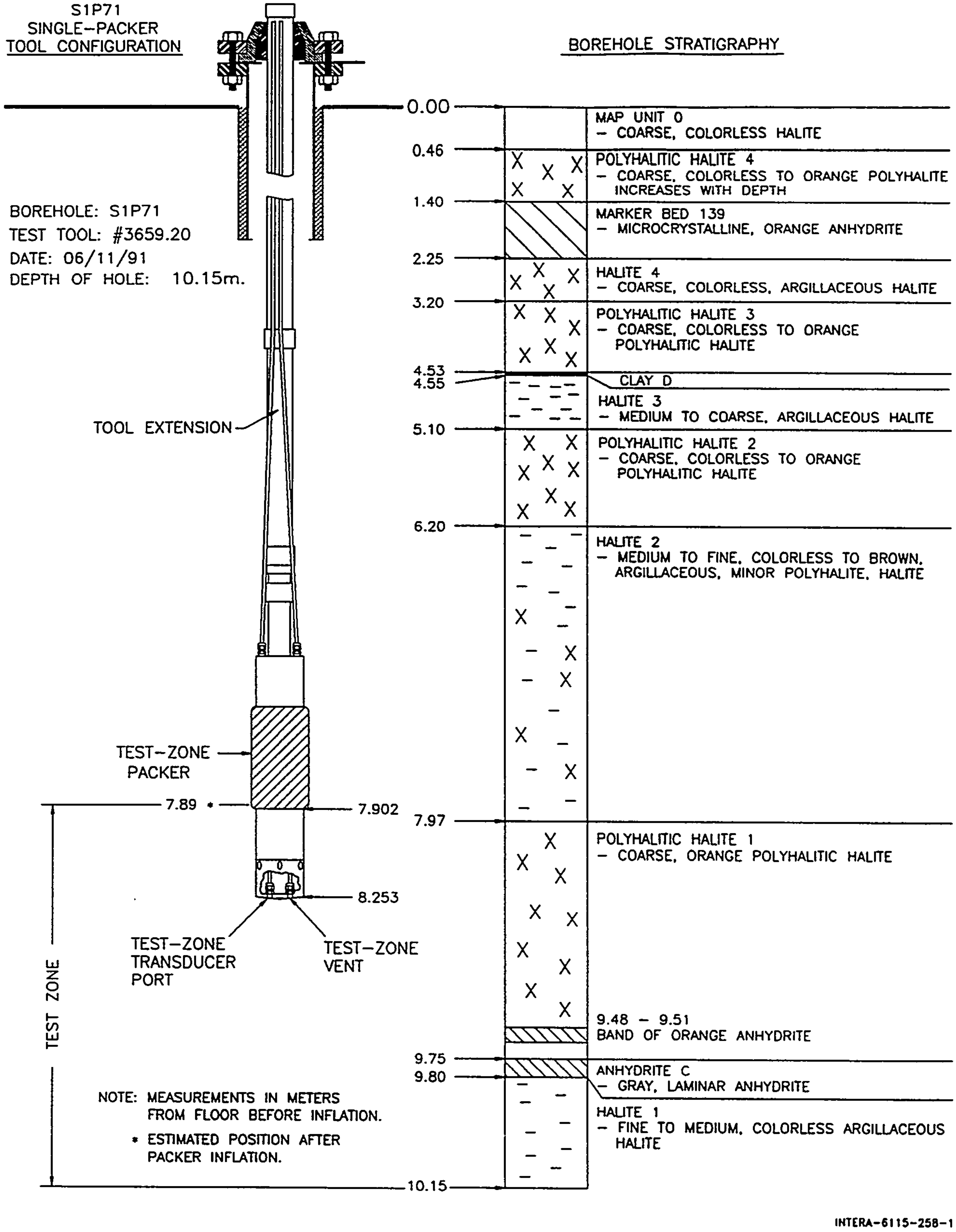

Figure 7-12. Configuration of long-term fluid-pressure monitoring tool in borehole S1P71.

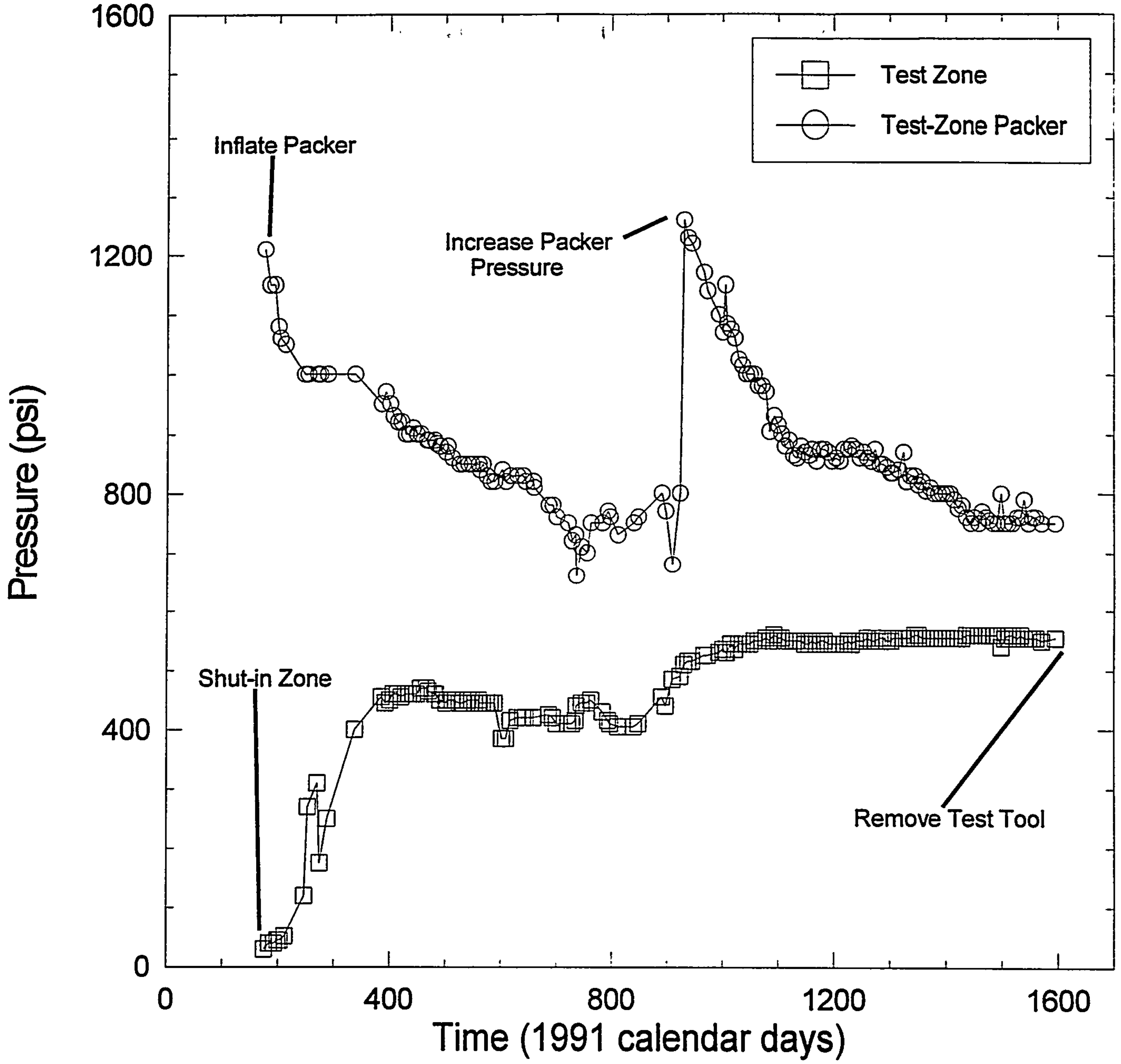

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Figure 7-13. Long-term fluid presure in anhydrite "C" in borehole S1P71.

7.4.6 Borehole S1P72

Table 7-8 lists the events associated with borehole S1P72 from the time the borehole was drilled to the termination of all testing and/or monitoring in the borehole with the events associated with the fluid-pressure monitoring emphasized. Descriptions of events that occurred during permeability testing and of core recovered from this borehole can be found in Stensrud et al. (1992).

Table 7-8. Long-Term Fluid-Pressure Monitoring S1P72 Events

EVENT	DATE	CALENDAR DAY	1991 CALENDAR DAY
Drill borehole S1P72 to 6.05 meters.	12-13-89	347	N/A
Begin permeability-testing sequence S1P72.	12-18-89	352	N/A
Terminate permeability-testing sequence S1P72.	1-30-91	30	30
Install single-packer long-term fluid-pressure monitoring tool to monitor fluid pressure in MB139 as indicated in Figure 7-14.	1-31-91	31	31
Inflate packer to ~1500 psi.	1-31-91	31	31
Shut in test zone.	1-31-91	31	31
Leak in packer.	2-1-91	32	32
Remove long-term fluid-pressure monitoring tool form borehole.	2-1-91	32	32
Fix leak in the packer inflation line.	2-1-91	32	32
Re-install single-packer long-term fluid-pressure monitoring tool to monitor fluid pressure in MB139 as indicated in Figure 7-14.	2-1-91	32	32
Inflate packer to ~1650 psi.	2-1-91	32	32
Shut in test zone.	2-1-91	32	32
Replace bad gage on packer.	10-19-92	294	658
Depressurize test zone.	5-16-95	136	1596
Deflate packer.	5-16-95	136	1596
Attempt to remove long-term fluid-pressure monitoring tool.	5-16-95	136	1596
Terminate long-term fluid-pressure monitoring.	5-16-95	136	1596

Figure 7-14 illustrates the test-tool configuration and associated installation that was used during the fluid-pressure monitoring in borehole S1P72. Figure 7-15 is a plot of the fluid pressure observed in borehole S1P72.

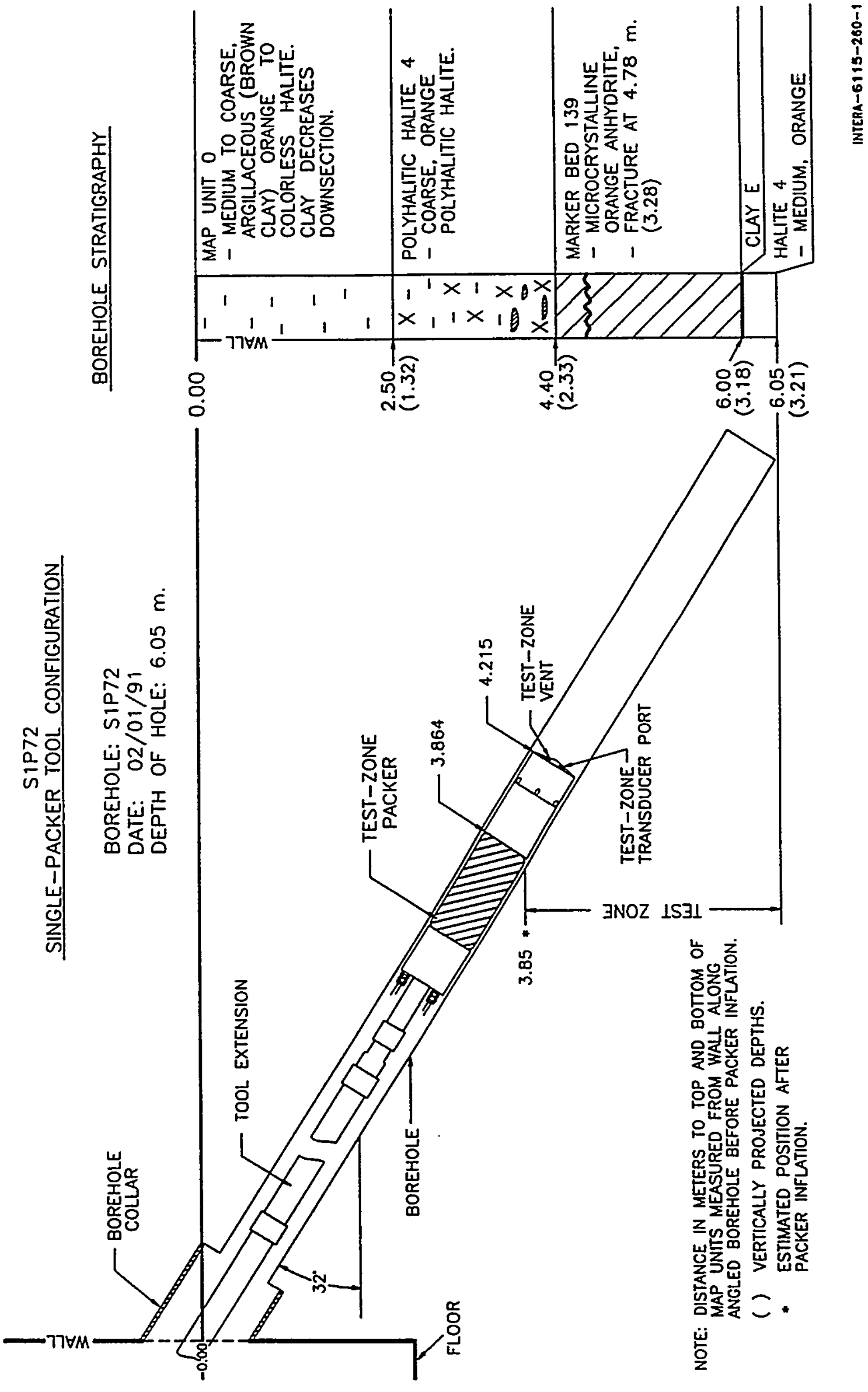

Figure 7-14. Configuration of long-term fluid-pressure monitoring tool in borehole S1P72.

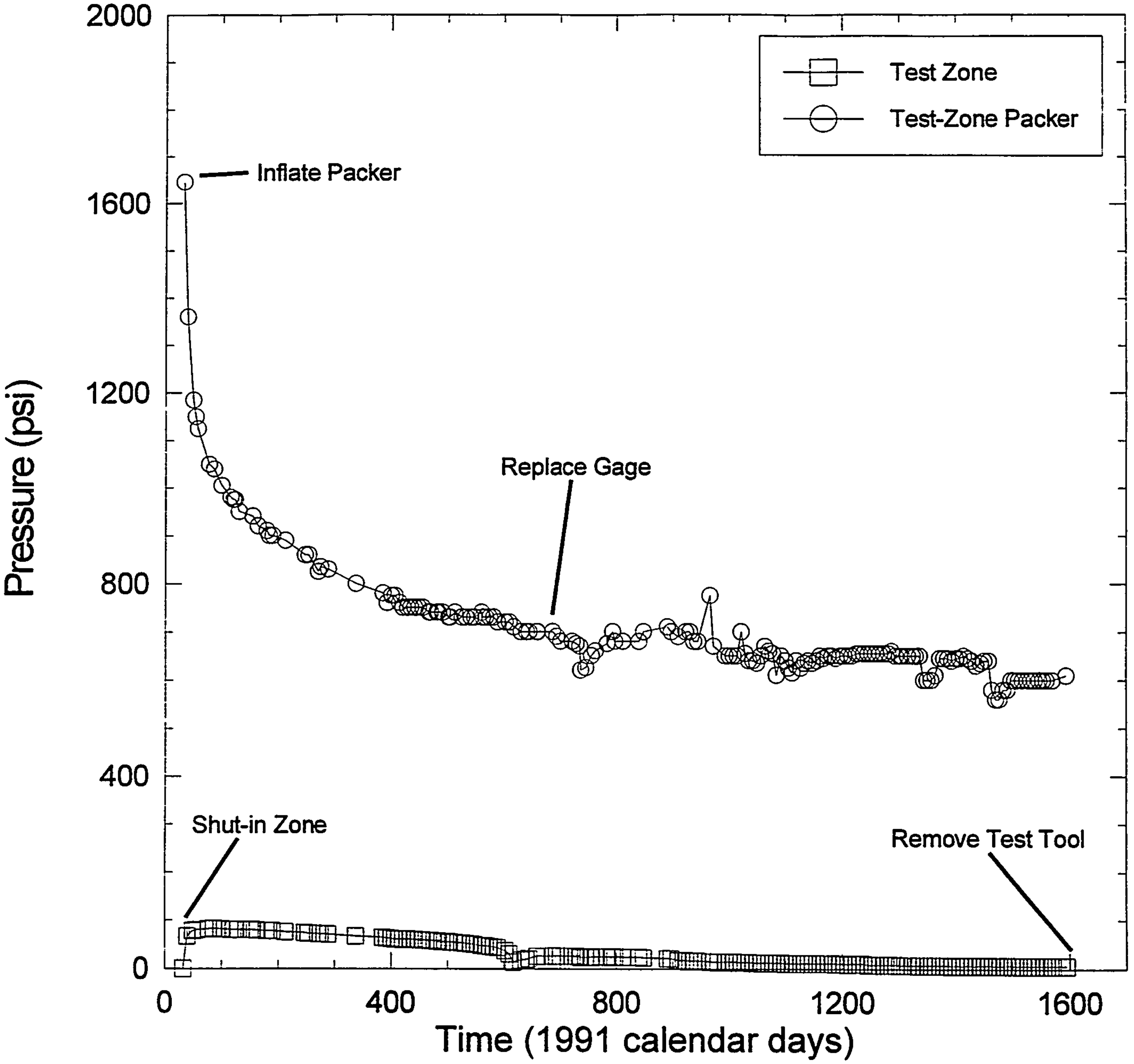

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Figure 7-15. Long-term fluid pressure in MB139 in borehole S1P72.

7.5 Fluid-Pressure Monitoring in Other Boreholes

The long-term fluid-pressure monitoring tools that were used in boreholes DPD01, DPD02, and DPD03 were similar in design to those described in Section 7.2. These monitor tools consisted of fluid-inflatable, 3.5-inch (8.9-cm) diameter packers mounted on a 1.9-inch (4.83-cm) mandrel. 3/16-inch (0.48-cm) stainless-steel tubing was used to access the associated zone and to transmit pressure to pressure gages located outside of the borehole. Prior to installation of the long-term fluid-pressure monitoring tools, the boreholes were filled with WIPP-facility brine (1.22 kg/L) to a level such that the monitor tool was completely submerged. The monitor tools in boreholes DPD01, DPD02, and DPD03 were not restrained from moving out of the boreholes in response to pressure buildup. Table 7-9 lists the pertinent information for the boreholes and test zones monitored in the fluid-pressure monitoring program which had not been previously tested under the permeability and/or the GTPT program. Figure 2-1 shows the location of these boreholes within the WIPP underground facility.

Table 7-9. Fluid-Pressure Monitoring in Other Boreholes; Test-Zone Information

Borehole	Test Horizon	Test Horizon Penetrated	Borehole Diameter (cm)	Test Interval Depth (m)	Borehole Depth (m)	Monitoring Started	Monitoring Terminated
DPD01	MB139	11-84	12.7	10.39	12.34	5-89	8-89
DPD02	MB139	4-86	10.8	11.00	13.11	5-89	4-95
DPD03	MB139	4-86	10.8	11.15	13.11	5-89	4-95

Table 7-10 summarizes the location and orientation of each of the boreholes associated with the long-term fluid-pressure monitoring in which brine permeability and/or GTPT sequences had not been performed. Borehole orientations at an underground location attempt to accomplish two objectives:

- to characterize the interbeds in close areal proximity; and
- to characterize the interbeds at a maximum distance from the excavation.

Table 7-10. Summary of Long-Term Fluid-Pressure Monitoring Borehole Locations and Orientations not Previously Tested

Borehole (Orientation)	Interval Drilled/ Cored (m)	Date Drilled/ Cored	Location	Excavation Date of Drift
DPD01 (downward 46°) (from vertical)	0 - 12.34	November 1984	North 1400 Drift East of Room C1	March 1983
DPD02 (downward 47°) (from vertical)	0 - 13.11	April 1986	North 1400 Drift East of Room C1	March 1983

Table 7-10 (Continued). Summary of Long-Term Fluid-Pressure Monitoring Borehole Locations and Orientations not Previously Tested

Borehole (Orientation)	Interval Drilled/ Cored (m)	Date Drilled/ Cored	Location	Excavation Date of Drift
DPD03 (downward 46°) (from vertical)	0 - 13.11	April 1986	North 1400 Drift East of Room C1	March 1983

Figure 7-16 illustrates the locations and orientations of boreholes DPD01, DPD02, and DPD03 relative to the surrounding area of the WIPP underground facility.

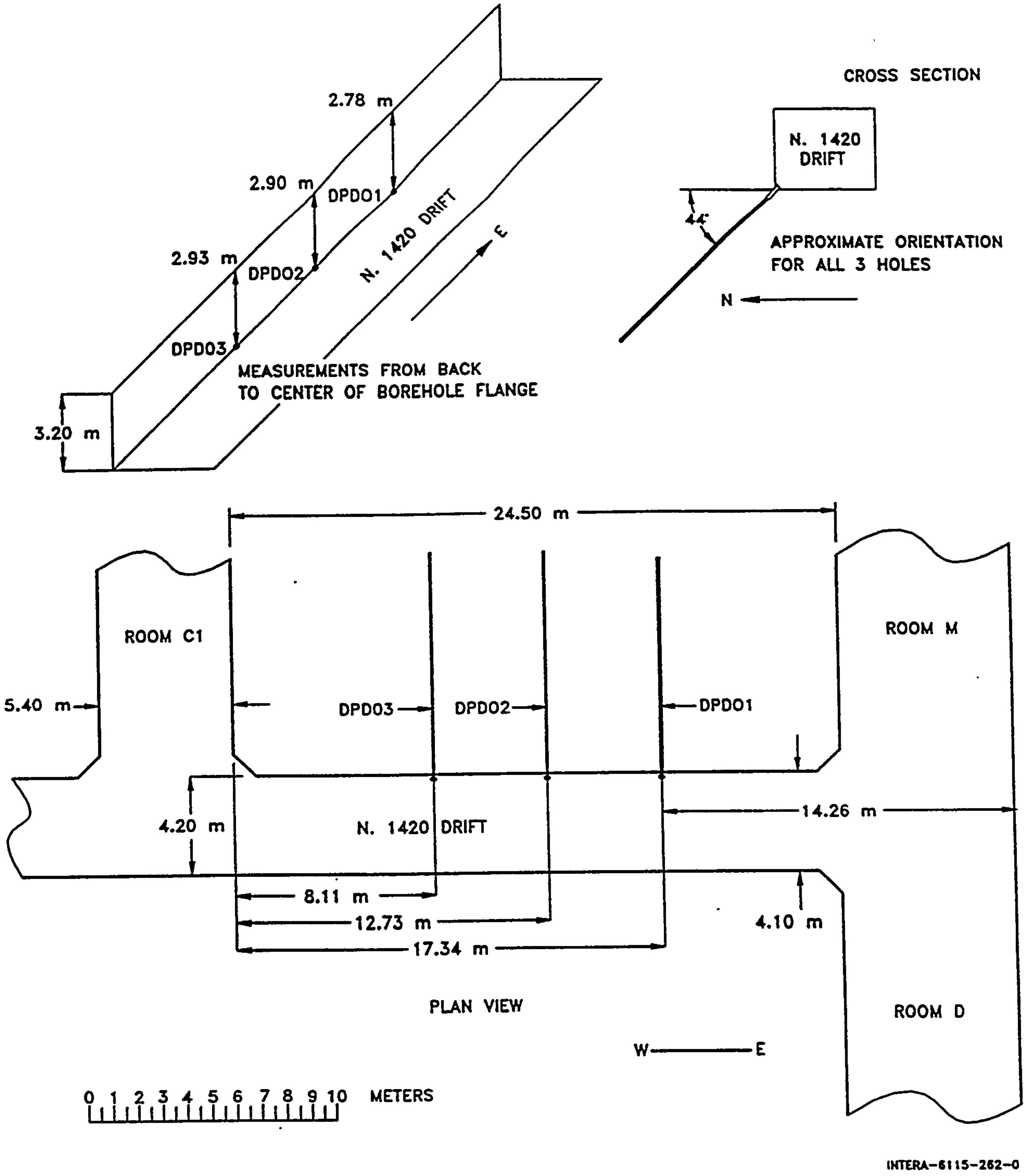

Figure 7-16. Locations and orientations of long-term fluid-pressure monitoring boreholes DPD01, DPD02, and DPD03.

7.5.1 Borehole DPD01

Table 7-11 lists the events associated with the fluid-pressure monitoring in borehole DPD01.

Table 7-11. Long-Term Fluid-Pressure Monitoring DPD01 Events

EVENT	DATE	CALENDAR DAY	1989 CALENDAR DAY
Drill borehole DPD01 to 12.34 meters.	11-84	N/A	N/A
Begin fluid level measurements.	4-27-89	117	117
Video-log borehole DPD01 to determine MB139 position.	4-28-89	118	118
Install single-packer long-term fluid-pressure monitoring tool to monitor fluid pressure in MB139 as indicated in Figure 7-17.	4-28-89	118	118
Survey borehole DPD01 to determine inclination.	4-28-89	118	118
Inflate packer to ~1500 psi.	5-2-89	122	122
Deflate packer.	6-5-89	156	156
Add approximately 18.9 L of brine to the borehole.	6-5-89	156	156
Inflate packer to ~1380 psi.	6-5-89	156	156
Shut in test zone.	6-5-89	156	156
Increase packer pressure to ~1500 psi.	7-18-89	199	199
Remove long-term fluid-pressure monitoring tool.	8-22-89	234	234
Long-term fluid-pressure monitoring terminated.	8-22-89	234	234
Ream borehole DPD01 to 5-inches (12.7-cm).	7-30-91	211	941
Install and grout in new collar.	7-30-91	211	941
Load test new collar.	8-6-91	218	948
Add approximately 18.9 L of brine to borehole.	12-4-91	338	1068
Install new long-term fluid-pressure monitor tool.	12-4-91	338	1068
Inflate packer to ~500 psi.	12-4-91	338	1068
Packer failed.	12-4-91	338	1068
Remove monitor tool from borehole.	12-4-91	338	1068

Figure 7-17 illustrates the tool configuration and associated installation that was used during the fluid-pressure monitoring in borehole DPD01. Figure 7-18 shows that no fluid-pressure buildup was observed in borehole DPD01. Apparently, the packer diameter was too small to seal the observation zone.

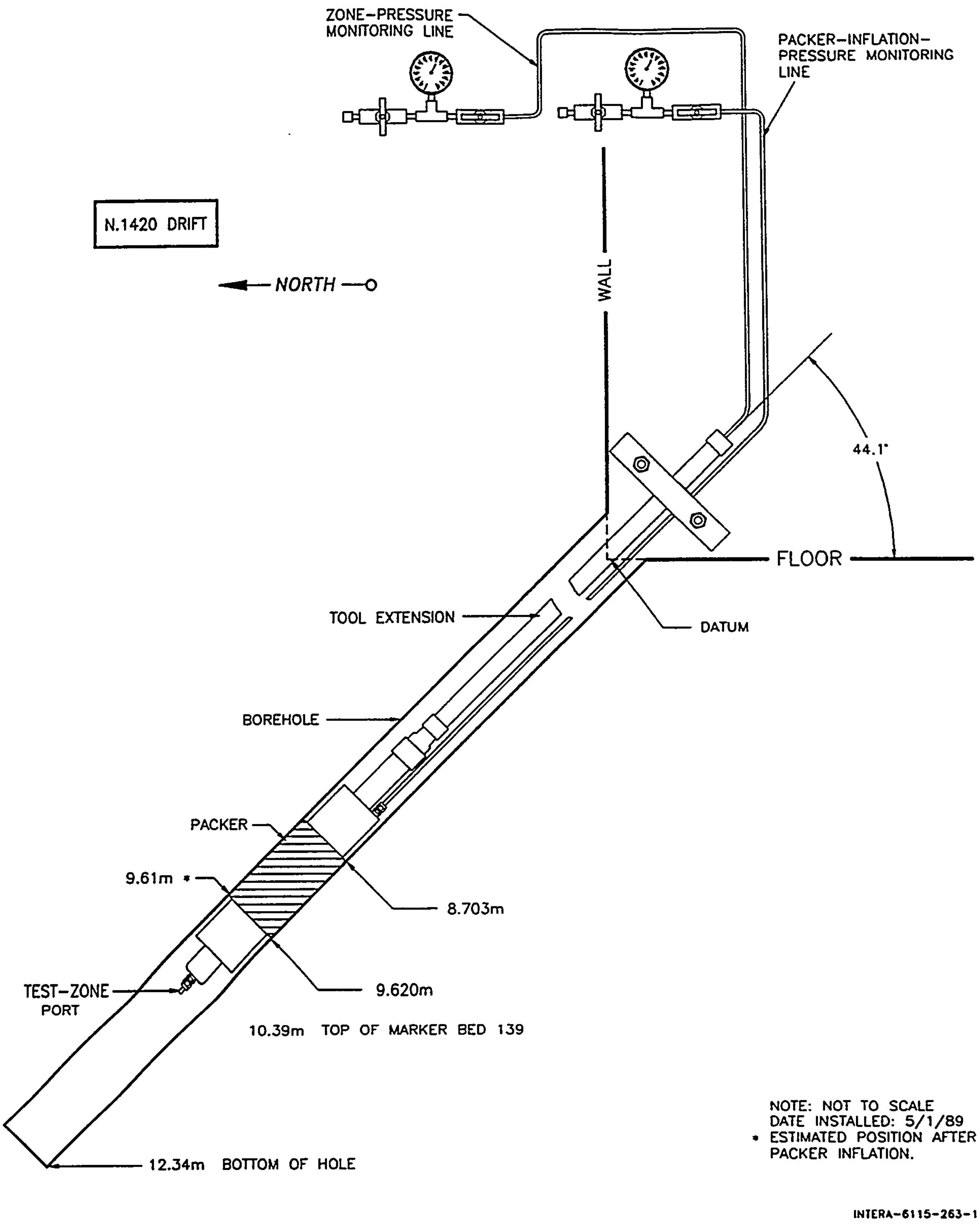

Figure 7-17. Configuration of long-term fluid-pressure monitoring tool in borehole DPD01.

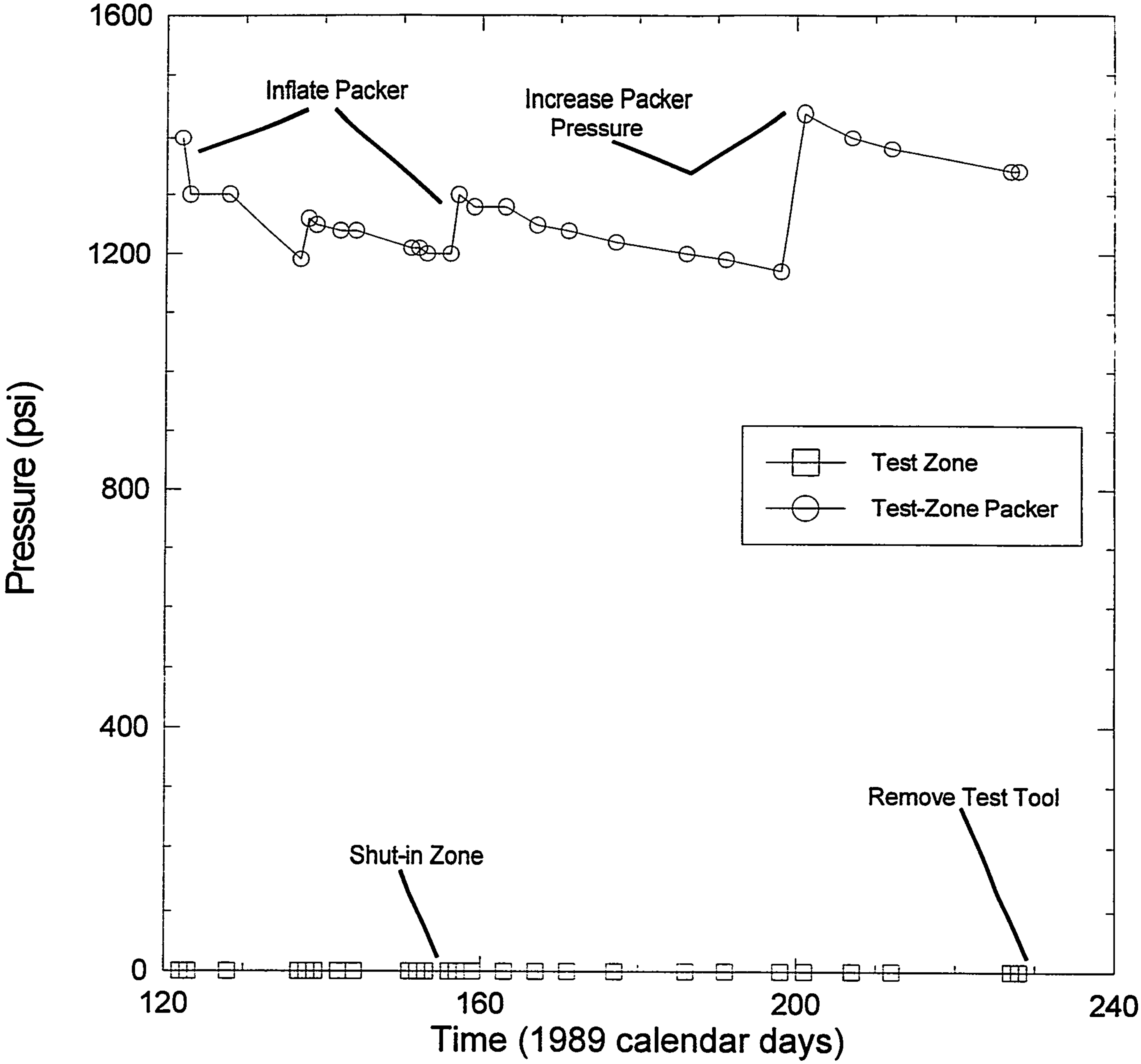

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Figure 7-18. Long-term fluid pressure in MB139 in borehole DPD01.

7.5.2 Borehole DPD02

Table 7-12 lists the events associated with the fluid-pressure monitoring in borehole DPD02.

Table 7-12. Long-Term Fluid-Pressure Monitoring DPD02 Events

EVENT	DATE	CALENDAR DAY	1989 CALENDAR DAY
Drill borehole DPD02 to 13.11 meters.	4-86	N/A	N/A
Begin fluid level measurements.	4-27-89	117	117
Video-log borehole DPD02 to determine MB139 position.	4-28-89	118	118
Install single-packer long-term fluid-pressure monitoring tool to monitor fluid pressure in MB139 as indicated in Figure 7-19.	4-28-89	118	118
Survey borehole DPD02 to determine inclination.	4-28-89	118	118
Inflate packer to ~1500 psi.	5-2-89	122	122
Begin long-term fluid-pressure monitoring in MB139.	5-3-89	123	123
Increase packer pressure to ~1500 psi.	7-18-89	199	199
Diagnose and attempt to fixed a leak in the test zone.	7-26-89	207	207
Test zone continues to leak.	7-31-89	212	212
Replace bad valve on test zone.	8-15-89	227	227
Remove monitor tool from borehole.	7-16-91	197	927
Ream borehole DPD02 to 4-inch (10.16-cm).	8-2-91	214	944
Install and grout in new collar.	8-5-91	217	947
Load test new collar.	8-6-91	218	948
Add approximately 18.9 L of brine to borehole.	12-4-91	338	1068
Install new single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB139 as indicated in Figure 7-20.	12-4-91	338	1068
Inflate packer to ~1500 psi.	12-4-91	338	1068
Increase test zone pressure to ~500 psi.	12-4-91	338	1068
Replace pressure gage on test zone.	12-16-91	350	1080
Install transducer #316158 to monitor pressure during C1X10 coupled permeability and hydrofracture-testing sequence.	1-29-92	29	1124
Begin fluid-pressure monitoring of MB139 associated with testing sequence C1X10.	1-30-92	30	1125

Table 7-12 (Continued). Long-Term Fluid-Pressure Monitoring DPD02 Events

EVENT	DATE	CALENDAR DAY	1989 CALENDAR DAY
Terminate fluid-pressure monitoring associated with testing sequence C1X10.	6-26-92	178	1273
Begin fluid-pressure monitoring of MB139 associated with testing sequence C1X05-A.	6-26-92	178	1273
Terminate fluid-pressure monitoring associated with testing sequence C1X05-A.	8-3-92	216	1311
Resume long-term fluid-pressure monitoring of fluid pressure in MB139.	8-3-92	216	1311
Replace bad gage on test zone.	9-8-92	252	1347
Increase packer pressure.	7-12-93	193	1653
Replace bad gage on test zone.	11-29-93	333	1793
Replace bad gage on test zone.	3-1-94	60	1885
Depressurize test zone.	4-21-95	110	2300
Deflate packer.	4-21-95	110	2300
Remove long-term monitoring tool from borehole.	4-21-95	110	2300
Terminate long-term fluid-pressure monitoring.	4-21-95	110	2300

Figures 7-19 and 7-20 illustrate both of the tool configurations and associated installations that were used during the fluid-pressure monitoring in borehole DPD02. Figure 7-21 is a plot of the fluid pressure observed in borehole DPD02 for the entire duration of the fluid-pressure monitoring.

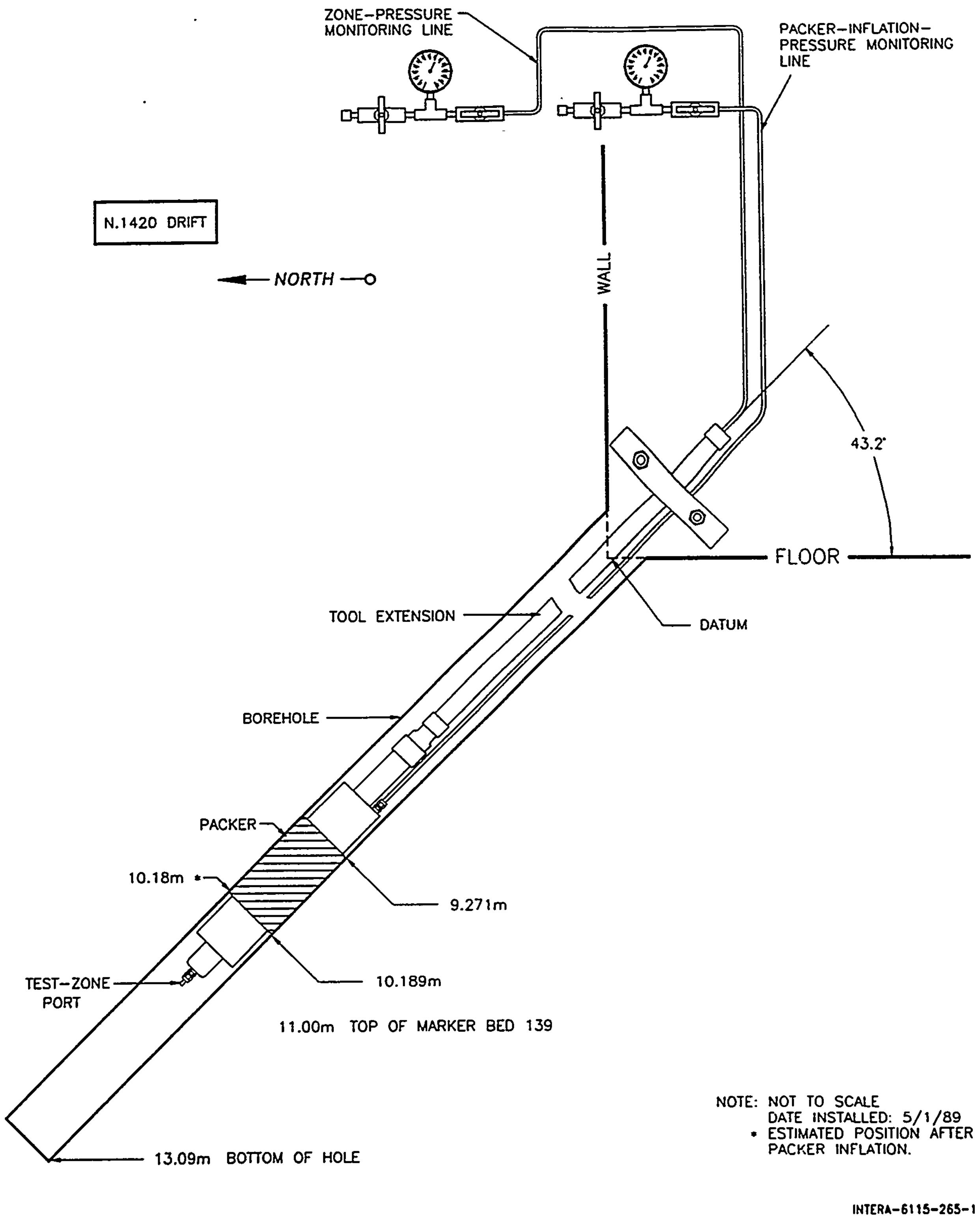

Figure 7-19. Configuration #1 of long-term fluid-pressure monitoring tool in borehole DPD02.

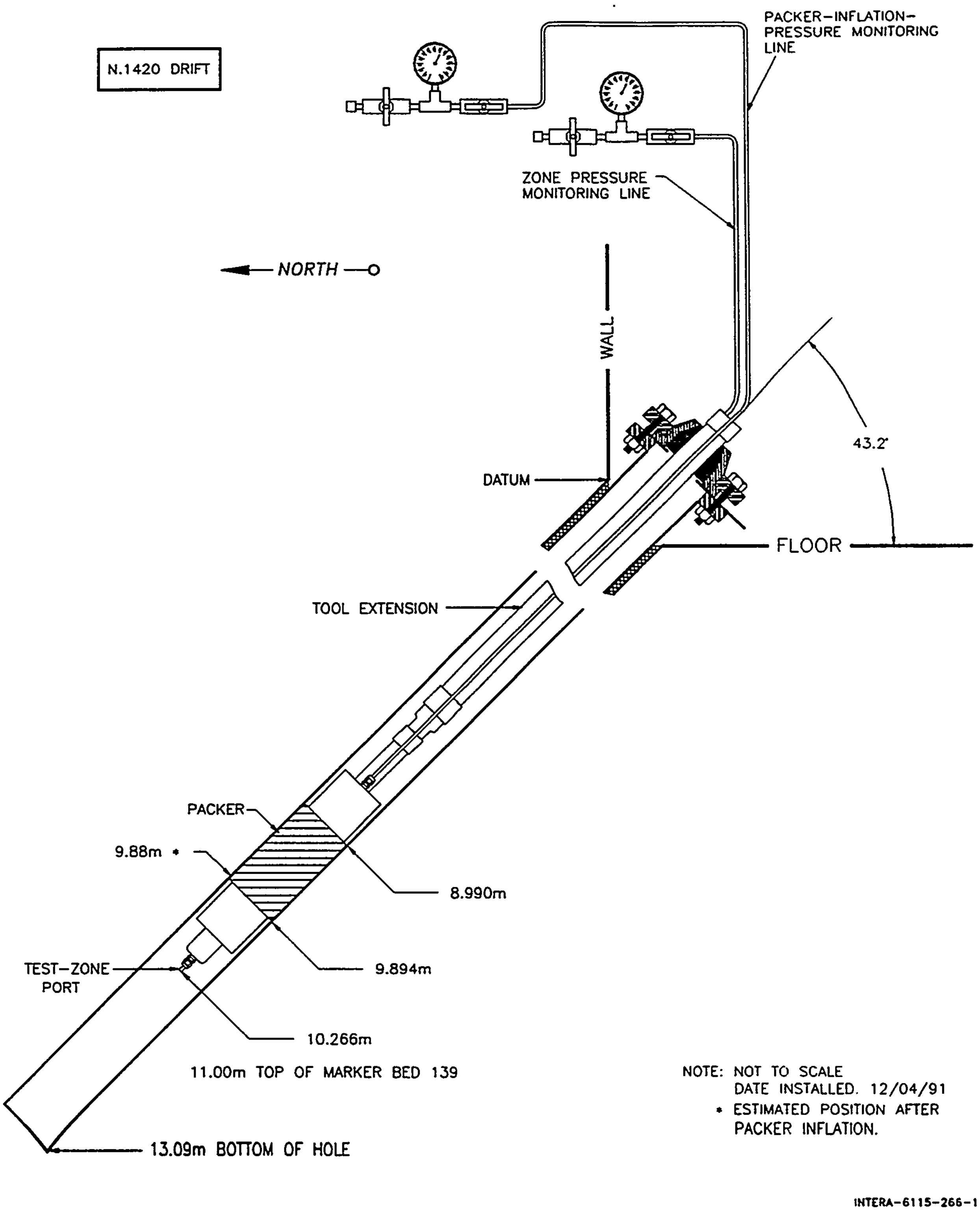

Figure 7-20. Configuration #2 of long-term fluid-pressure monitoring tool in borehole DPD02.

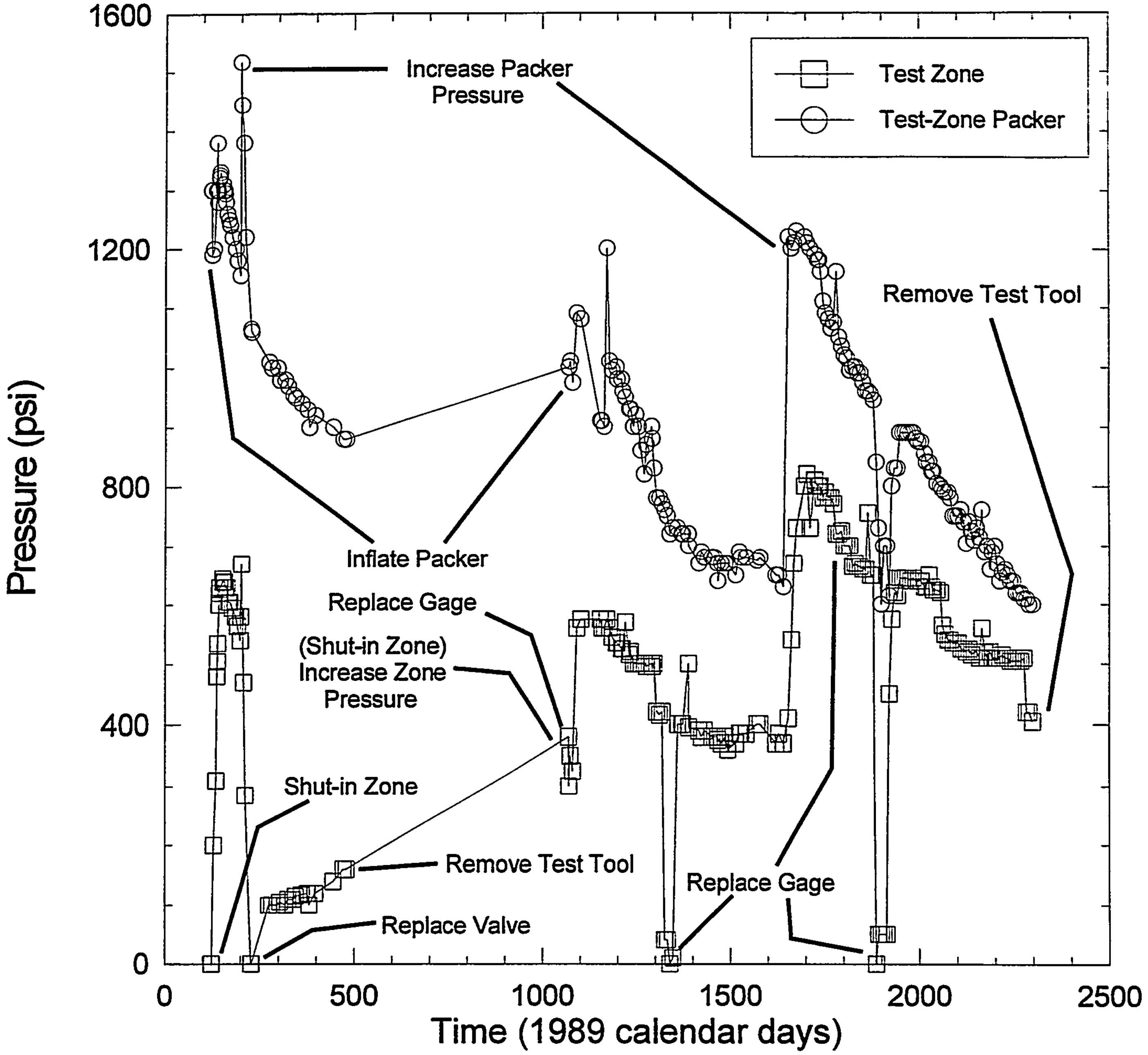

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Figure 7-21. Long-term fluid pressure in MB139 in borehole DPD02.

7.5.3 Borehole DPD03

Table 7-13 lists the events associated with the fluid-pressure monitoring in borehole DPD03.

Table 7-13. Long Term Fluid-Pressure Monitoring DPD03 Events

EVENT	DATE	CALENDAR DAY	1989 CALENDAR DAY
Drill borehole DPD03 to 13.11 meters.	4-86	N/A	N/A
Begin fluid level measurements.	4-27-89	117	117
Video-log borehole DPD03 to determine MB139 position.	4-28-89	118	118
Install single-packer long-term fluid-pressure monitoring tool to monitor fluid pressure in MB139 as indicated in Figure 7-22.	4-28-89	118	118
Survey borehole DPD03 to determine inclination.	4-28-89	118	118
Inflate packer to ~1500 psi.	5-2-89	122	122
Shut in test zone.	5-3-89	123	123
Increase packer pressure to ~1500 psi.	7-18-89	199	199
Attempt to remove monitor tool from borehole.	7-16-91	197	927
Push monitor tool to the bottom of the borehole.	8-2-91	214	944
Ream borehole DPD03 to 4-inch (10.16-cm) to the top of the tool.	8-2-91	214	944
Remove monitor tool from borehole.	8-5-91	217	947
Install and grout in new collar.	8-5-91	217	947
Load test new collar.	8-6-91	218	948
Add approximately 18.9 L of brine to borehole.	12-4-91	338	1068
Install new single-packer long-term fluid-pressure monitor tool to monitor fluid pressure in MB139 as indicated in Figure 7-23.	12-4-91	338	1068
Inflate packer to ~1500 psi.	12-4-91	338	1068
Increase test zone pressure to ~500 psi.	12-4-91	338	1068
Install transducer #211694 to monitor pressure during C1X10 coupled permeability and hydrofracture-testing sequence.	1-29-92	29	1124
Begin fluid-pressure monitoring of MB139 associated with testing sequence C1X10.	1-30-92	30	1125
Diagnose and fix leak in test zone	2-10-92	41	1136

Table 7-13 (Continued). Long Term Fluid-Pressure Monitoring DPD03 Events

EVENT	DATE	CALENDAR DAY	1989 CALENDAR DAY
Terminate fluid-pressure monitoring associated with testing sequence C1X10.	6-26-92	178	1273
Begin fluid-pressure monitoring of MB139 associated with testing sequence C1X05-A.	6-26-92	178	1273
Terminate fluid-pressure monitoring associated with testing sequence C1X05-A.	8-3-92	216	1311
Resume long-term fluid-pressure monitoring of fluid pressure in MB139.	8-3-92	216	1311
Replace bad gage on test zone.	10-19-92	293	1388
Increase packer pressure.	7-12-93	193	1653
Depressurize test zone.	4-21-95	110	2300
Deflate packer.	4-21-95	110	2300
Remove long-term monitoring tool from borehole.	4-21-95	110	2300
Terminate long-term fluid-pressure monitoring.	4-21-95	110	2300

Figures 7-22 and 7-23 illustrate both of the tool configurations and associated installations that were used during the fluid-pressure monitoring in borehole DPD03. Figure 7-24 is a plot of the fluid pressure observed in borehole DPD03 for the entire duration of the fluid-pressure monitoring.

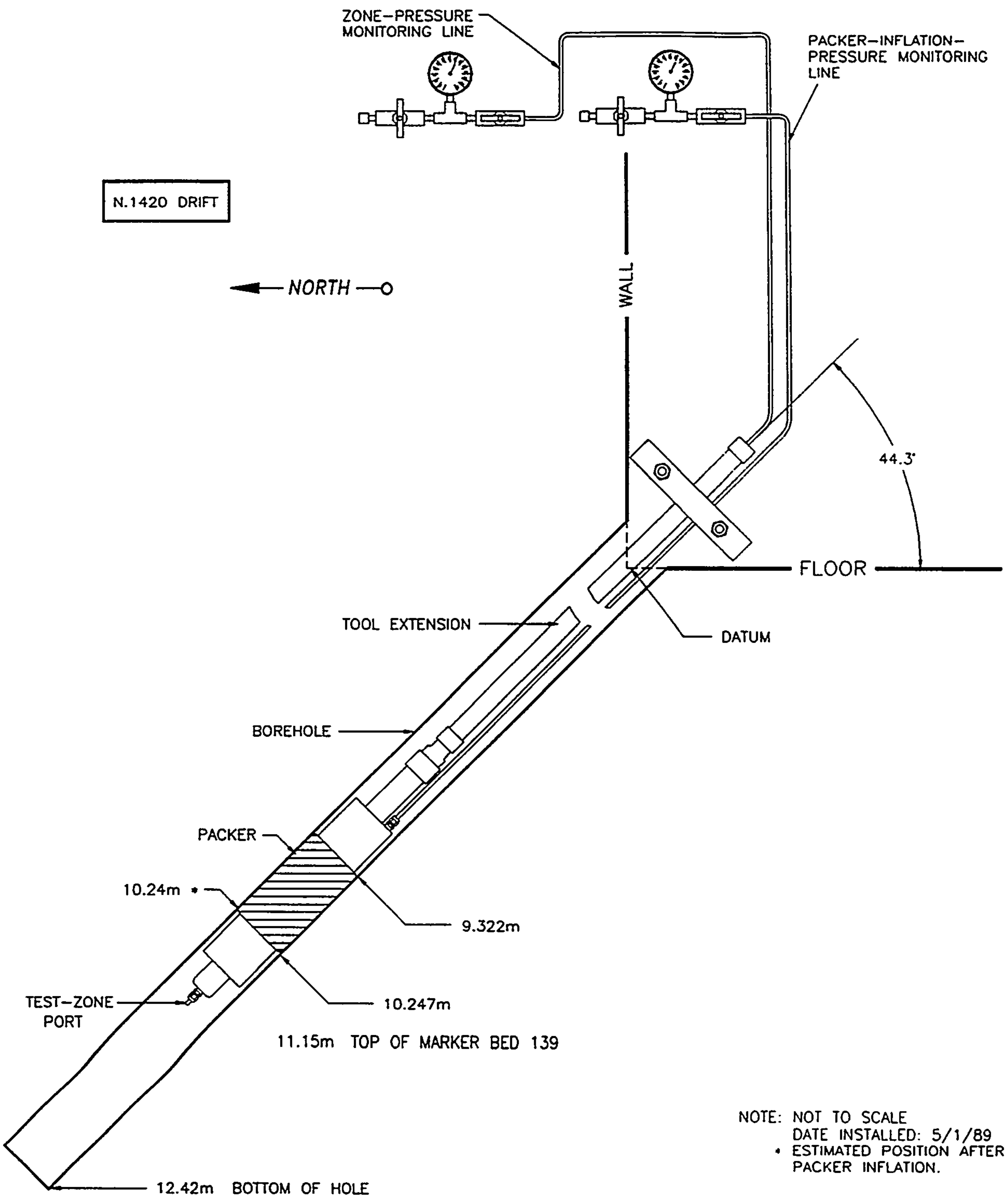

Figure 7-22. Configuration #1 of long-term fluid-pressure monitoring tool in borehole DPD03.

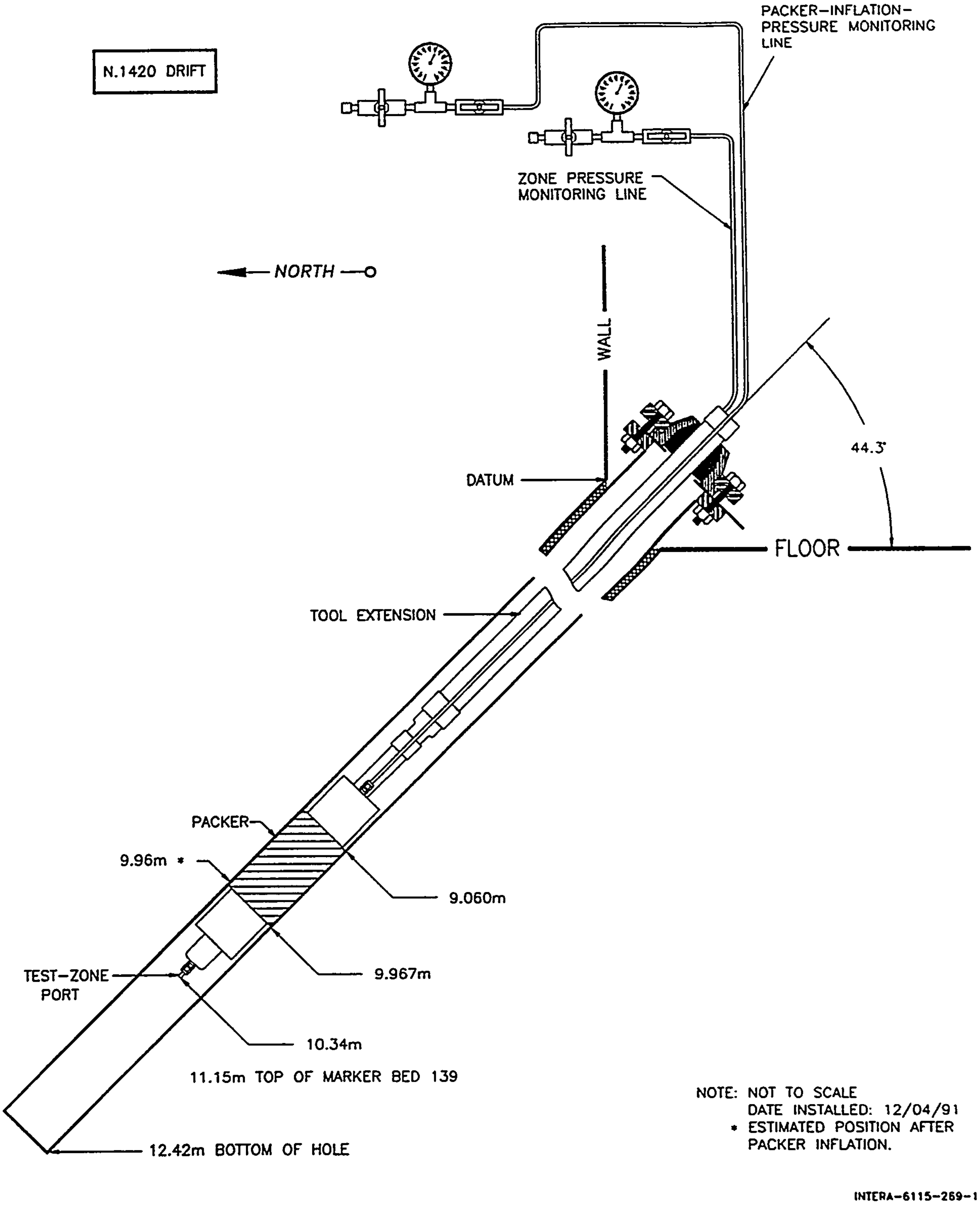

Figure 7-23. Configuration #2 of long-term fluid-pressure monitoring tool in borehole DPD03.

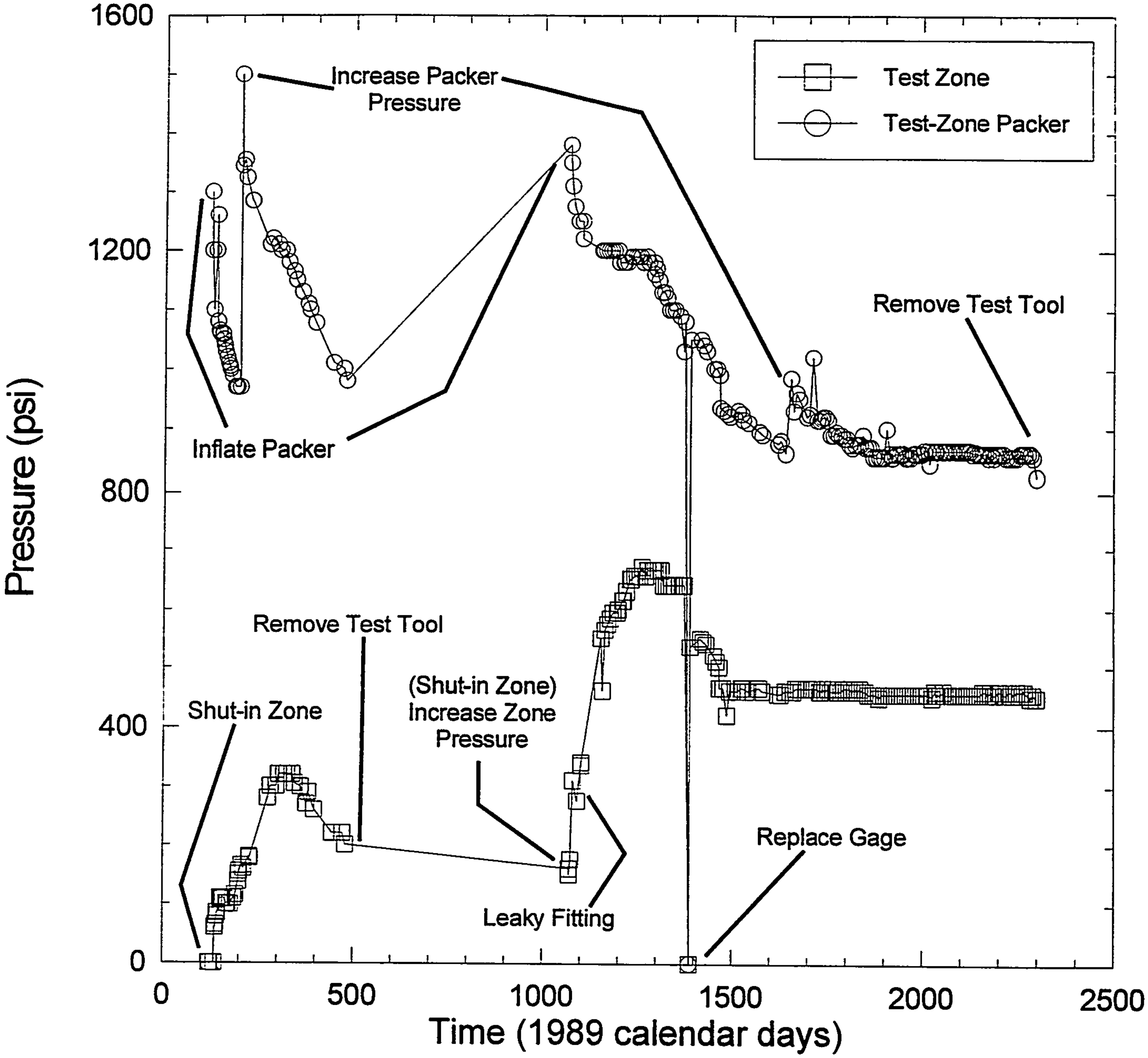

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Figure 7-24. Long-term fluid pressure in MB139 in borehole DPD03.

8. REFERENCES

Beauheim, R.L., G.J. Saulnier Jr., and J.D. Avis. 1991. *Interpretation of Brine-Permeability Tests of the Salado Formation at the Waste Isolation Pilot Plant Site: First Interim Report.* SAND90-0083. Albuquerque, NM: Sandia National Laboratories (SNL). (Available from the National Technical Information Service (NTIS), Springfield, VA as DE92001853/XAB and is on file in the Sandia WIPP Central Files (SWCF), SNL, Albuquerque, NM under WPO #26003.)

Beauheim, R.L., R.M. Roberts, T.F. Dale, M.D. Fort, and W.A. Stensrud. 1993. *Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Second Interpretive Report.* SAND92-0533. Albuquerque, NM: Sandia National Laboratories.

Bechtel National, Inc. 1986. *Interim Geotechnical Field Data Report, Fall 1986.* DOE-WIPP 86-012. Carlsbad, NM: U.S. Department of Energy, Waste Isolation Pilot Plant Project Office. (Available from the NTIS, Springfield, VA as DE87003701/XAB.)

Davies, P.B. 1991. *Evaluation of the Role of Threshold Pressure in Controlling Flow of Waste-Generated Gas into Bedded Salt at the Waste Isolation Pilot Plant.* SAND90-3246. Albuquerque, NM: Sandia National Laboratories. (Available from the NTIS, Springfield, VA as DE91016498/XAB and is on file in the SWCF under WPO #26169.)

Deal, D.E., R.J. Abitz, D.S. Belski, J.B. Case, M.E. Crawley, R.M. Deshler, P.E. Drez, C.A. Givens, R.B. King, B.A. Lauctes, J. Myers, S. Niou, J.M. Pietz, W.M. Roggenthen, J.R. Tyburski, and M.G. Wallace. 1989. *Brine Sampling and Evaluation Program 1988 Report.* DOE-WIPP- 89-015. Carlsbad, NM: Westinghouse Electric Corporation: Waste Isolation Division (WID). (Available from the NTIS, Springfield, VA as DE91008821/XAB.)

Holt, R.M. and D.W. Powers. 1984. *Geotechnical Activities in the Waste Handling Shaft, Waste Isolation Pilot Plant (WIPP) Project, Southeastern New Mexico.* WTSD-TME-038. Carlsbad, NM: U.S. Department of Energy, Waste Isolation Pilot Plant. (Available from the NTIS, Springfield, VA as DE86004328/XAB.)

INTERA, Inc. 1992. "SOP INT-5, Safe Operating Procedures for Permeability Testing in the WIPP-Site Underground Facility." SP-471061, Issue B. Austin, TX: INTERA, Inc.; Albuquerque, NM: Sandia National Laboratories. (Copy on file in the SWCF, SNL, Albuquerque, NM under WPO #6783.)

Jensen, A.L. 1990. *Borehole Closure and Test Zone Volume Determination Program for Brine-Permeability Test Results Within the Waste Isolation Pilot Plant Underground Facility.* SAND90-0228. Albuquerque, NM: Sandia National Laboratories. (Available from the NTIS, Spingfield, VA as DE90013629/XAB and is on file in the SWCF under WPO #26007.)

Lappin, A.R., R.L. Hunter, D.P. Garber, and P.B. Davies, eds. 1989. *Systems Analysis, Long-Term Radionuclide Transport, and Dose Assessments, Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico; March 1989.* SAND89-0462. Albuquerque, NM: Sandia National Laboratories. (Available from the NTIS, Springfield, VA as DE89014586/XAB and is on file in the SWCF under WPO #24125.)

Pickens, J.F., G.E. Grisak, J.D. Avis, D.W. Belanger, and M. Thury. 1987. *"Analysis and Interpretation of Borehole Hydraulic Tests in Deep Boreholes: Principles, Model Development, and Applications,"* Water Resources Research. Vol. 23, no. 7, 1341-1375. (This journal is in the NWM Library collection.)

Saulnier, G.J., Jr., and J.D. Avis. 1988. *Interpretation of Hydraulic Tests Conducted in the Waste-Handling Shaft at the Waste Isolation Pilot Plant (WIPP) Site.* SAND88-7001. Albuquerque, NM: Sandia National Laboratories. (Available from the NTIS, Springfield, VA as DE88014193/XAB and is on file in the SWCF under WPO #24164.)

Saulnier, G.J., Jr., P.S. Domski, J.B. Palmer, R.M. Roberts, W.A. Stensrud, and A.L. Jensen. 1991. *WIPP Salado Hydrology Program Data Report #1.* SAND90-7000. Albuquerque, NM: Sandia National Laboratories. (Available from the NTIS as DE91014564/XAB and is on file in the SWCF under WPO #25746.)

Stensrud, W.A., M.A. Bame, K.D. Lantz, T.L. Cauffman, J.B. Palmer, and G.J. Saulnier, Jr. 1988. *WIPP Hydrology Program, Waste Isolation Pilot Plant, Southeastern New Mexico, Hydrologic Data Report #6.* SAND87-7166. Albuquerque, NM: Sandia National Laboratories. (Available from the NTIS, Springfield, VA as DE88013135/XAB and is on file in the SWCF under WPO #29674.)

Stensrud, W.A., T.F. Dale, P.S. Domski, J.B. Palmer, R.M. Roberts, M.D. Fort, G.J. Saulnier, Jr., and A.L. Jensen. 1992. *Waste Isolation Pilot Plant Salado Hydrology Program Data Report #2.* SAND92-7072. Albuquerque, NM: Sandia National Laboratories. (Available from the NTIS, Springfield, VA as DE93012398/XAB and is on file in the SWCF under WPO #26432.)

Stormont, J.C. 1990. *Summary of 1988 WIPP Facility Horizon Gas Flow Measurements.* SAND89-2497. Albuquerque, NM: Sandia National Laboratories. (Available from the NTIS, Springfield, VA as DE91006099/XAB and is on file in the SWCF under WPO #24044.)

Stormont, J.C., E.W. Peterson, and P.L. Lagus. 1987. *Summary of and Observations About WIPP Facility Horizon Flow Measurements Through 1986.* SAND87-0176. Albuquerque, NM: Sandia National Laboratories. (Available from the NTIS, Springfield, VA as DE87011611/XAB and is on file in the SWCF under WPO #27053.)

Wawersik, W.R. 1991-1993. "Activity-Specific ES&H Standard Operating Procedure Instructions for Hydraulic Fracturing Tests in MB139 and MB140." SP471962, Issue A-C. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #'s 38248, #38249, and #38251.)

Wawersik, W.R., L.W. Carlson, J.A. Henfling, D.J. Borns, R.L. Beauheim, C.L. Howard, and R.M. Roberts. 1997. *Hydraulic Fracturing Tests in Anhydrite Interbeds in the WIPP, Marker Beds 139 and 140.* SAND95-0596. Albuquerque, NM: Sandia National Laboratories. (Copy on file in the SWCF under WPO #45491.)

Westinghouse Electric Corporation. 1990. *Geotechnical Field Data and Analysis Report, July 1988-June 1989.* DOE/WIPP 90-006, Vol. 2. Carlsbad, NM: U.S. Department of Energy. (Available from the NTIS, Springfield, VA as DE91004495/XAB.)

WIPP Technical Operating Procedure 054. 1992. "Hydraulic Pressure Gage and Transducer Repair and Calibration." TOP 054, Rev. 2. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #37062.)

WIPP Technical Operating Procedure 125. 1992. "SNL Experimental Program Work Requests." TOP 125, Rev. 5. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #37996.)

WIPP Technical Operating Procedure 140. 1991. "Underground Drilling Request and Hole Identification System." TOP 140, Rev. 4. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #38011.)

WIPP Technical Operating Procedure 182. 1991. "Calibration of HP-3497A DC Voltmeter Option." TOP 182, Rev. 3. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #38069.)

WIPP Technical Operating Procedure 204. 1988. "Radial Closure Detector Setup and Calibration (Trans-Tek Model 0241-0000LVDT)." Top 204, Rev. 0. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #38112.)

WIPP Technical Operating Procedure 205. 1992. "Radial-Closure Detector Calibration." (Note: the title of this TOP is in error. The correct tile should be "Axial Motion Detector Setup and Calibration" as indicated in step I.A. of the TOP) TOP 205, Rev. 1. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #38113.)

WIPP Technical Operating Procedure 353. 1992. "Manual Calibration of Pressure Transducers." TOP 353, Rev. 2. Albuquerque, NM: SNL. (Copy on file in the SWCF in the Controlled Document Center.)

WIPP Technical Operating Procedure 427. 1993. "HP-75000 Series B 5 1/2 Digit HP (E1326B) DVM Calibration." TOP 427, Rev. 0. Albuquerque, NM: SNL. (Copy on file in the SWCF in the Controlled Document Center.)

WIPP Technical Operating Procedure 467. 1993. "Installation and Retrieval of Pressurized Brine Sample Cylinders." TOP 467, Rev. 0. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #39278.)

WIPP Technical Operating Procedure 470. 1994. "Operation and Use of Pressure Accumulators." TOP 470, Rev. 0. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #39281.)

WIPP Technical Operating Procedure 473. 1994. "Radial LVDT Calibration Measurement." TOP 473, Rev. 0. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #39284.)

WIPP Technical Operating Procedure 476. 1995. "Constant-Pressure Injection/Withdrawal System." TOP 476, Rev. 0. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #39282.)

WIPP Technical Operating Procedure 479. 1995. "Multipacker-Test-Tool Installation for Borehole Drilled Vertically Downward." TOP 479, Rev. 1. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #39289.)

WIPP Technical Operating Procedure 480. 1995. "Multipacker-Test-Tool Installation for Borehole Drilled at an Upward Angle into the Rib or Back." TOP 480, Rev. 2. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #39285.)

WIPP Technical Operating Procedure 481. 1995. "Multipacker-Test-Tool Installation for Borehole Drilled Vertically Upward." TOP 481, Rev. 1. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #39288.)

WIPP Technical Operating Procedure 483. 1995. "Permeability Testing." TOP 483, Rev. 0. Albuquerque, NM: SNL. (Copy on file in the SWCF under WPO #39292.)

APPENDIX A: CORE DESCRIPTION OF TEST AND MONITOR BOREHOLES

TABLE A.1
CORE DESCRIPTION OF BOREHOLE S1P74-A

TABLE A.1

PAGE 1
OF 3

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: S1P74-A **DIA.:** 4-INCH
LOCATION: PANEL-1 ROOM 7
ORIENTATION: UPWARD 40°FROM VERTICAL
COORDINATES: SOUTH 1750.59 EAST 1336.89
ELEVATION: 1264.91 FT. AMSL
DRILL METHODS: AIR / ROTARY

LOG BY: WAS
DATE: 7/29/92
DRILL DATE: 7/27/92 - 7/29/92
DRILLER: RICK BALLEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
10:00 7/27/92 11:15		0.0 0.5	100			0.00 - 0.62 m 7-inch core description not included.	
13:30				- - -		0.62 - 0.93 m Halite; clear to gray coarsely crystalline.	Map unit 5
13:50	1	1.0 1.5	100	- - x - - x -		0.93 - 4.00 m Halite; clear; some moderate reddish/orange coarsely crystalline, some fine to medium gray clay and polyhalite; contact with lower unit is gradational and/or diffuse.	Map unit 6
14:15 14:30	2	2.0	100	- x - - x			
9:45 7/28/92	3	2.5 3.0	100	- - x - - x - -			

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TABLE A.1 (Continued)

PAGE 2 OF 3	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: S1P74-A **DIA.:** 4-INCH
LOCATION: PANEL-1 ROOM 7
ORIENTATION: UPWARD 40° FROM VERTICAL
COORDINATES: SOUTH 1750.59 EAST 1336.89
ELEVATION: 1264.91 FT. AMSL
DRILL METHODS: AIR / ROTARY

LOG BY: WAS
DATE: 7/29/92
DRILL DATE: 7/27/92 - 7/29/92
DRILLER: RICK BALLEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
10:15 10:45 7/28/92 11:30	4	3.0 3.5	100			See previous page for description.	Map unit 6
12:30	5	4.0 4.5	100			4.00 - 4.56 m Halite; light/medium gray; some reddish orange/brown; coarsely crystalline; some fine to medium; grades into polyhalite with sharp contact with clay G.	Map unit 7
				▨		4.56 - 4.64 m Anhydrite "b"; medium gray microcrystalline, scattered halite growths; thin gray clay seam G at base of unit.	Map unit 8
13:30 13:50 14:05	6	5.0 5.5 6.0	100			4.64 - 6.79 m Halite; clear to light gray; clay stringers at top of unit.	Map unit 9

TABLE A.1 (Continued)

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OF 3

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE:	S1P74-A DIA.: 4-INCH	**LOG BY:**	WAS
LOCATION:	PANEL-1 ROOM 7	**DATE:**	7/29/92
ORIENTATION:	UPWARD 40°FROM VERTICAL	**DRILL DATE:**	7/27/92 - 7/29/92
COORDINATES:	SOUTH 1750.59 EAST 1336.89	**DRILLER:**	RICK BALLEW
ELEVATION:	1264.91 FT. AMSL	**DRILL:**	LONGYEAR D65
DRILL METHODS:	AIR / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES		DESCRIPTION	REMARKS
14:10 7/28/92	7	6.0 6.5	100	- - - - - - -			See previous page for description.	Map unit 9
14:44		7.0		X - -		6.79 - 7.15 m	Argillaceous halite; moderate reddish orange/ brown; fine to coarsely crystalline; discontinuous clay stringers locally; contacts lower unit diffuse based on crystal size and clay content.	Map unit 10
9:15 7/29/92	8		100	▨		7.15 - 7.41 m	Anhydrite "a"; light to medium gray sometimes light reddish orange; microcrystalline; halitic growths within; gray clay seam H at base.	Map unit 11
9:35		7.5		X X		7.41 - 7.67 m	Polyhalitic halite; clear to moderate reddish orange; coarsely crystalline; contact sharp with below unit; no clay.	Map unit 12
		8.0				7.69 meters.	Faced off bottom of borehole.	

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TABLE A.2
CORE DESCRIPTION OF BOREHOLE S1P74-B

TABLE A.2

PAGE 1 OF 4

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: S1P74-B **DIA.:** 4-INCH
LOCATION: PANEL 1 ROOM 7
ORIENTATION: UPWARD 40 ° FROM VERTICAL
COORDINATES: S 1750.6' E 1336.9'
ELEVATION: 1246.91 FT. AMSL
DRILL METHODS: AIR ROTARY

LOG BY: RMR
DATE: 3/2/95
DRILL DATE: 1/26/95 - 1/31/95
DRILLER: RANDY WALDON
DRILL: LONGYEAR D38
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
10:27 1/26/95		7.5				See S1P74-A core description.	
11:03	1	8.0 8.5	100			7.69 - 8.97 m Halite; colorless; coarsely crystalline; white anhydrite stringers from 7.725 - 7.88 m; trace polyhalite from 7.88 - 8.06 m; clay content gradually increases from 8.50 - 8.97 m.	Map Units 12 &13
12:47 13:05	2	9.0 9.5	100			8.97 - 11.06 m Podular muddy halite; colorless halite; brown clay; medium crystalline.	
13:19 13:38	3	10.0	100				
13:53	4	10.5	100				

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TABLE A.2 (Continued)

PAGE 2 OF 4	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: S1P74-B **DIA.:** 4-INCH

LOCATION: PANEL 1 ROOM 7

ORIENTATION: UPWARD 40 ° FROM VERTICAL

COORDINATES: S 1750.6' E 1336.9'

ELEVATION: 1246.91 FT. AMSL

DRILL METHODS: AIR ROTARY

LOG BY: RMR

DATE: 3/2/95

DRILL DATE: 1/26/95 - 1/31/95

DRILLER: RANDY WALDON

DRILL: LONGYEAR D38

DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
14:32	4	10.5 - 11.0	100			See previous page for description.	Map Units 12 &13
8:43 1/27/95 9:07	5	11.0 - 11.5	100			11.06 - 11.15 m Brown clay.	Clay I
						11.15 - 11.17 m Anhydrite; white; microcrystalline.	Map Units 14 &15
						11.17 - 12.58 m Halite; colorless; coarsely crystalline.	
12:15 12:25	6	12.0 - 12.5	100			12.58 - 13.49 m Podular muddy halite; brown clay; colorless halite; medium crystalline.	Map Unit AH - 1 (Clay J)
9:20 1/30/95	7	13.0 - 13.5	100				

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TABLE A.2 (Continued)

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OF 4

WIPP CORE-LOG INVENTORY

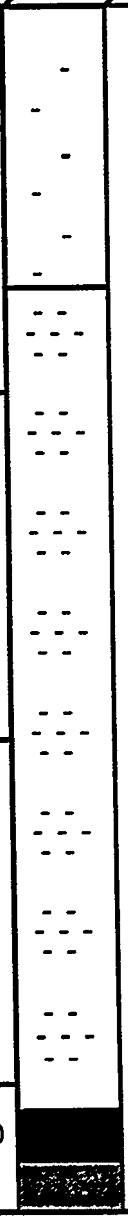
INTERA
FORM 1400

BOREHOLE: S1P74-B **DIA.:** 4-INCH
LOCATION: PANEL 1 ROOM 7
ORIENTATION: UPWARD 40 ° FROM VERTICAL
COORDINATES: S 1750.6' E 1336.9'
ELEVATION: 1246.91 FT. AMSL
DRILL METHODS: AIR ROTARY

LOG BY: RMR
DATE: 3/2/95
DRILL DATE: 1/26/95 - 1/31/95
DRILLER: RANDY WALDON
DRILL: LONGYEAR D38
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED
9:56	7	13.5	100
10:07 10:42	8	14.0	100
9:25 1/31/95 9:43	9	14.5 15.0	100
10:14 10:39	10	15.5 16.0	100
12:30	11	16.5	100

GEO PROFILES



FRACTURES

DESCRIPTION		REMARKS
13.49 - 14.20 m	Halite; colorless; coarsely crystalline; trace clay begins at 13.8 m gradually increasing with depth.	Map Unit H - 5
14.20 - 16.25 m	Podular muddy halite; red/brown clay; colorless halite; medium crystalline; clay lens at 15.63 m; 0.5 cm thick.	Map Unit AH - 2
16.25 - 16.38 m	Clay; gray to brown.	Clay K
16.38 - 16.66 m	See next page for description.	MB 138

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TABLE A.2 (Continued)

PAGE 4 **OF** 4	**WIPP CORE-LOG INVENTORY**		**INTERA** **FORM 1400**
BOREHOLE:	S1P74-B **DIA.:** 4-INCH	**LOG BY:**	RMR
LOCATION:	PANEL 1 ROOM 7	**DATE:**	3/2/95
ORIENTATION:	UPWARD 40 ° FROM VERTICAL	**DRILL DATE:**	1/26/95 - 1/31/95
COORDINATES:	S 1750.6' E 1336.9'	**DRILLER:**	RANDY WALDON
ELEVATION:	1246.91 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	AIR ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
13:00	11	16.5	100	▨		16.38 - 16.66 m Anhydrite; gray; microcrystalline.	MB 138
						16.66 - 16.82 m Halite; pale orange; coarsely crystalline; trace polyhalite.	Map Unit H - 6
		17.0				16.88 m. Borehole faced off.	

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TABLE A.3
CORE DESCRIPTION OF BOREHOLE C1H05

TABLE A.3

PAGE 1 OF 1	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: C1H05 **DIA.:** 4-INCH
LOCATION: ROOM C-1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1456.61 E 1586.53
ELEVATION: 1304.1 FT. AMSL
DRILL METHODS: AIR / ROTARY

LOG BY: RMR & TFD
DATE: 1/23/92
DRILL DATE: 1/15/92 - 1/16/92
DRILLER: DARREL MILLER
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION		REMARKS
10:15 1/15/92 14:30		6.0				0.00 - 6.35 m	No core taken.	Drilled with a 4 inch diameter plug bit.
13:05 1/16/92 13:15	1	6.5	100	X X		6.35 - 7.15 m	Polyhalitic halite; colorless to moderately reddish orange; medium to coarsely crystalline; trace intercrystalline gray clay; polyhalite increases with depth; contact with anhydrite below is sharp and undulatory.	PH - 4
13:33 13:45	2	7.0	100	X X X X X X X				
14:10	3	7.5	73			7.15 - 7.95 m	Anhydrite; brown to gray; microcrystalline; minor halite and polyhalite from 7.13 - 7.67 m.	MB 139 Core loss from 7.32 - 7.56 m. Dyed mineral oil in fractures at 7.75, 7.77, and 7.85 m.
14:20		8.0				7.90 - 8.20 m	Halite; colorless to gray; medium to finely crystalline.	H - 4
		8.5				8.25 m	Borehole bottom was flat faced.	No Core

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TABLE A.4

CORE DESCRIPTION OF BOREHOLE C1H07-A

TABLE A.4

PAGE 1 OF 3	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE:	C1H07-A **DIA.:** 4-INCH	**LOG BY:**	WAS & TFD
LOCATION:	ROOM C1	**DATE:**	6/25/92
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	6/18/92 - 6/24/92
COORDINATES:	N 1493.12 E 1583.34	**DRILLER:**	RALPH McGARY
ELEVATION:	1303.48 FT. AMSL	**DRILL:**	LONGYEAR D65
DRILL METHODS:	AIR / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
6/18/92		0.0 0.5				0.00 - 0.64 m Borehole cored for placement of flanged collar; core not described.	
10:15 6/22/92 10:30	1	1.0	88			0.64 - 1.75 m Halite; colorless/pale orange; fine to coarsely crystalline; trace polyhalite; contact with below is gradational based on color change and clay content.	Map Unit 6
9:08 6/23/92	2	1.5 2.0	94	- - - -		1.75 - 2.15 m Halite; colorless/grey; very coarsely crystalline; moderate gray clay; contact with below based on grain size, color, and clay content.	Map Unit 5
9:18		2.5		- - - - - - - -		2.15 - 2.58 m Argillaceous halite; gray; fine to medium crystalline; contact with below based on color; change in clay content gradational.	Map Unit 4
9:40	3	3.0	100	x x x x		2.58 - 3.60 m Halite; colorless/orange; medium to coarsely crystalline; polyhalite increases with depth; contact with below based on color; change in clay content gradiational	Map Unit 3

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TABLE A.4 (Continued)

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OF 3

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1H07-A **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1493.12 E 1583.34
ELEVATION: 1303.48 FT. AMSL
DRILL METHODS: AIR / ROTARY

LOG BY: WAS & TFD
DATE: 6/25/92
DRILL DATE: 6/18/92 - 6/24/92
DRILLER: RALPH McGARY
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES
10:00		3.0		X	
10:10 10:30	4	3.5	100	X X X X X - -	
12:30 13:30	5	4.0	76	- - - -	
14:00 14:25	6	4.5	100	- - - - -	
9:50 6/24/92 10:00	7	5.0	100	- - - - -	
10:20	8	5.5 6.0	100	- - X - - X	

	DESCRIPTION	REMARKS
	See previous page for description.	Map Unit 3
3.60 - 3.73 m	Argillaceous halite; gray/reddish brown; fine to medium crystalline; clay contact with below.	Map Unit 2
3.73 - 3.82 m	Halite; colorless; coarse trace polyhalite.	Map Unit 1
3.82 - 3.96 m	Core loss.	
3.96 - 6.35 m	Argillaceous halite; colorless to gray; fine to coarsely crystalline; intercrystalline gray clay decreasing with depth; contact with below is gradational based on decreasing clay and increasing polyhalite.	Map Unit 0

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TABLE A.4 (Continued)

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OF 3

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1H07-A **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1493.12 E 1583.34
ELEVATION: 1303.48 FT. AMSL
DRILL METHODS: AIR / ROTARY

LOG BY: WAS & TFD
DATE: 6/25/92
DRILL DATE: 6/18/92 - 6/24/92
DRILLER: RALPH McGARY
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
10:30	8	6.0	100	- - x		See previous page for description.	Map Unit 0
11:00	9	6.5	100	x x x x		6.35 - 6.77 m Polyhalitic halite; orange; coarsely crystalline; some medium crystalline locally; contact sharp with unit below (MB - 139) irregular and undulating.	PH - 4
11:10 12:40 12:50	10	7.0	100	▨		6.77 - 7.53 m Anhydrite; orange/brown to gray; microcrystalline; intercrystalline argillaceous material. 6.77 - 6.92 halite crystals	MB 139
13:15		7.5				7.53 - 7.70 m Core loss (Video indication of depth to bottom of Marker bed 139).	
13:25	11	8.0	78	x - x x - x		7.70 - 8.17 m Polyhalitic halite; dark orange; fine to coarsely crystalline; clay content decreasing with depth.	PH - 3
		8.5					

07/20/95-GJM-EXCEL-CLC1HO7A

TABLE A.5
CORE DESCRIPTION OF BOREHOLE C1H07-B

TABLE A.5

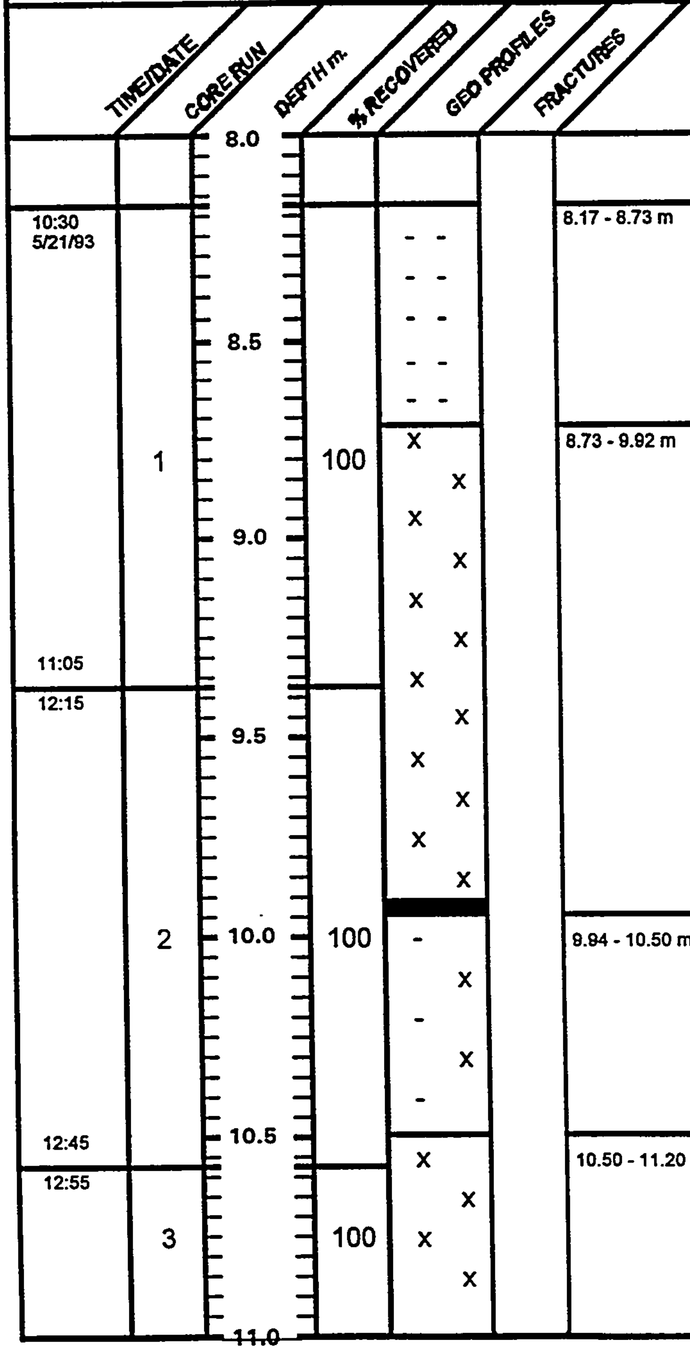
PAGE 1
OF 7

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1H07-B DIA.: 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1493.12 E 1583.34
ELEVATION: 1303.48 FT. AMSL
DRILL METHODS: BRINE / ROTARY

LOG BY: WAS
DATE: 6/10/93
DRILL DATE: 5/21/93 - 5/26/93
DRILLER: RONNIE LEWIS
DRILL: LONGYEAR D38
DRILL CO.: EXP. OPS.



TIME/DATE	CORE RUN	% RECOVERED
10:30 5/21/93 11:05	1	100
12:15 12:45	2	100
12:55	3	100

DESCRIPTION		REMARKS
	See C1H07-A core description.	
8.17 - 8.73 m	Halite; clear to grayish to medium orange; medium to coarsely crystalline; hard; gray clay; < 1% scattered clay breaks.	PH-3
8.73 - 9.92 m	Polyhalitic halite; clear to medium reddish-orange; coarsely crystalline; hard; irregular polyhalite seams and gray clay at base of contact.	
9.94 - 10.50 m	Halite; clear to light gray; fine to coarsely crystalline; medium hard to hard; trace polyhalite and gray clay.	H-3
10.50 - 11.20 m	Halite; clear with some medium reddish-orange; coarsely crystalline; hard.	

07/21/95-GJM-EXCEL-CLC1HO7B

TABLE A.5 (Continued)

PAGE 2 OF 7

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1H07-B **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1493.12 E 1583.34
ELEVATION: 1303.48 FT. AMSL
DRILL METHODS: BRINE / ROTARY

LOG BY: WAS
DATE: 6/10/93
DRILL DATE: 5/21/93 - 5/26/93
DRILLER: RONNIE LEWIS
DRILL: LONGYEAR D38
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
	3	11.0	100			See previous page for description.	
13:25		11.5 12.0				11.20 - 12.30 m Polyhalitic halite; clear to medium reddish orange-brown; coarsely crystalline; hard; < 1 to 5 % polyhalite; trace clay.	PH-2
14:10 14:45	4	12.5 13.0 13.5	100			12.30 - 13.58 m Halite; clear to medium orange; medium to coarsely crystalline; medium hard to hard; trace polyhalite; scattered clay breaks.	H-2
10:15 5/24/93	5	14.0	100			13.58 - 14.27 m Halite; clear to reddish-orange; coarsely crystalline; hard; < 1 % polyhalite.	PH-1

07/21/95-GJM-EXCEL-CLC1H07B

TABLE A.5 (Continued)

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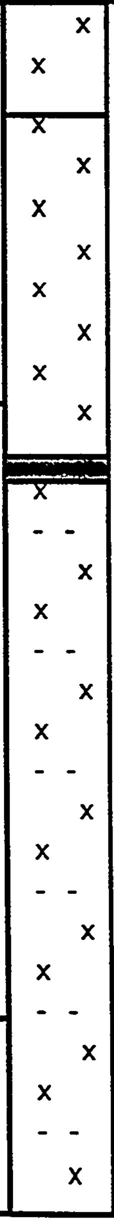
OF 7

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1H07-B **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1493.12 E 1583.34
ELEVATION: 1303.48 FT. AMSL
DRILL METHODS: BRINE / ROTARY

LOG BY: WAS
DATE: 6/10/93
DRILL DATE: 5/21/93 - 5/26/93
DRILLER: RONNIE LEWIS
DRILL: LONGYEAR D38
DRILL CO.: EXP. OPS.



TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
	5	14.0	100			See previous page for description.	
		14.5				14.27 - 15.12 m Polyhalitic halite; clear to medium reddish-orange-brown; coarsely crystalline; hard; < 1 to 5% polyhalite.	PH-1
10:35 10:42	6	15.0	100			15.12 - 15.18 Anhydrite; very light gray to very gray anhydrite mixed with halite; microcrystalline; hard; trace of clay at base of contact.	Anhydrite "C
		15.5				15.18 - 17.64 m Halite; clear to light gray; coarsely crystalline; medium hard to hard; trace of polyhalite; scattered clay breaks.	H-1
		16.0					
13:30 13:35	7	16.5	100				
		17.0					

07/21/95-GJM-EXCEL-CLC1HO7B

TABLE A.5 (Continued)

PAGE 4 **OF** 7	WIPP CORE-LOG INVENTORY	**INTERA** **FORM 1400**

BOREHOLE:	C1H07-B **DIA.:** 4-INCH	**LOG BY:**	WAS
LOCATION:	ROOM C1	**DATE:**	6/10/93
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	5/21/93 - 5/26/93
COORDINATES:	N 1493.12 E 1583.34	**DRILLER:**	RONNIE LEWIS
ELEVATION:	1303.48 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
14:30	8	17.0	100	X - -		See previous page for description.	H-1
9:00 5/25/93		17.5		X X - - X X			
	9	18.0	100	X X - - X X - - X		17.64 - 18.50 m Halite; clear to light gray to medium reddish orange; coarsely crystalline; < 1 % polyhalite; scattered clay breaks.	
9:30		18.5		X - -		18.50 - 20.69 m Halite; clear to light gray; coarsely crystalline; medium hard to hard; trace of polyhalite; scattered clay breaks.	H-m1
9:40	10	19.0 19.5 20.0	100	X X - - X X - - X X - - X X - - X			

07/21/95-GJM-EXCEL-CLC1HO7B

TABLE A.5 (Continued)

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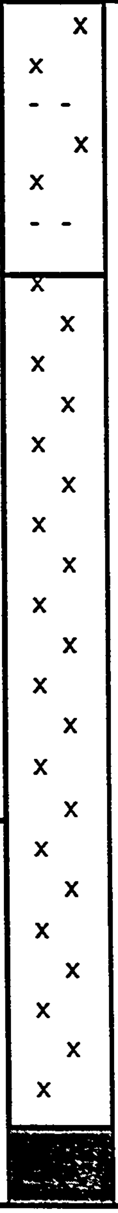
WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1H07-B **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1493.12 E 1583.34
ELEVATION: 1303.48 FT. AMSL
DRILL METHODS: BRINE / ROTARY

LOG BY: WAS
DATE: 6/10/93
DRILL DATE: 5/21/93 - 5/26/93
DRILLER: RONNIE LEWIS
DRILL: LONGYEAR D38
DRILL CO.: EXP. OPS.



TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
		20.0				See previous page for description.	H-m1
	11		100				
10:05							
10:15		20.5					
						20.69 - 22.80 m Halite; clear to reddish orange; coarsely crystalline; hard; polyhalite increasing with depth.	H-m2
		21.0					
	12		100				
		21.5					
10:25							
12:30		22.0					
	13	22.5	100				
						22.80 - 27.23 m See next page for description.	MB 140
		23.0					

TABLE A.5 (Continued)

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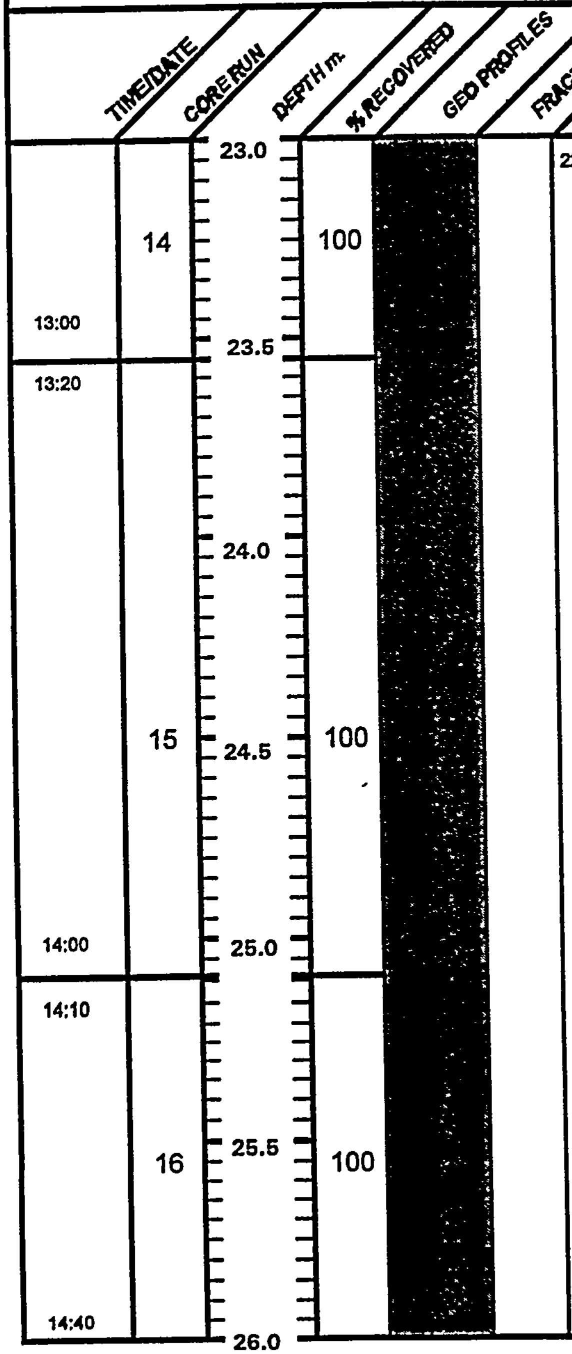
WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1H07-B **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1493.12 E 1583.34
ELEVATION: 1303.48 FT. AMSL
DRILL METHODS: BRINE / ROTARY

LOG BY: WAS
DATE: 6/10/93
DRILL DATE: 5/21/93 - 5/26/93
DRILLER: RONNIE LEWIS
DRILL: LONGYEAR D38
DRILL CO.: EXP. OPS.



DESCRIPTION

22.80 - 27.23 m Anhydrite; very light gray to light reddish-orange with swallow tail halite crystals; micro-crystalline anhydrite; hard; some polyhalite present; clay seams at 26.45 - 26.55 m and 27.15 - 27.23 m.

REMARKS

MB 140

TABLE A.5 (Continued)

PAGE 7 OF 7	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE:	C1H07-B **DIA.:** 4-INCH	**LOG BY:**	WAS
LOCATION:	ROOM C1	**DATE:**	6/10/93
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	5/21/93 - 5/26/93
COORDINATES:	N 1493.12 E 1583.34	**DRILLER:**	RONNIE LEWIS
ELEVATION:	1303.48 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
8:48 5/26/93	17	26.0	100			See previous page for description.	MB 140
		26.5				26.45 - 26.55 m Clay Seam.	
						See previous page for description.	
9:25		27.0				27.15 - 27.23 m Clay Seam.	
9:30	18	27.5	100			27.23 - 27.88 m Halite; clear to lightly gray; coarsely crystalline; hard.	H-m3
9:45							
		28.0					

07/21/95-GJM-EXCEL-CLC1HO7B

TABLE A.6
CORE DESCRIPTION OF BOREHOLE C1H06

TABLE A.6

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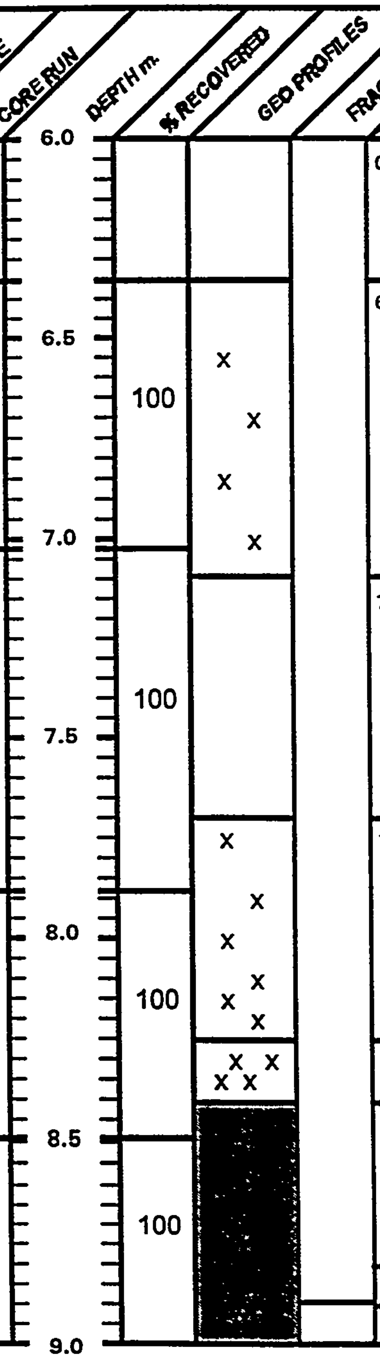
OF 2

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1H06 **DIA.:** 4-INCH
LOCATION: N 1420 DRIFT NEAR ROOM C - 1
ORIENTATION: 70 DOWN FROM HORIZONTAL
COORDINATES: N 1432.01 E 1574.18
ELEVATION: 1306.1 FT. AMSL
DRILL METHODS: AIR / ROTARY

LOG BY: RMR & TFD
DATE: 1/12/92
DRILL DATE: 1/21/92
DRILLER: RICK BALLEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.



TIME/DATE	CORE RUN	% RECOVERED
12:30 1/20/92 14:00		
10:48 1/21/92 12:25	1	100
12:45 13:00	2	100
13:15 13:29	3	100
13:50	4	100

	DESCRIPTION	REMARKS
0.00 - 6.35 m	No core taken.	
6.35 - 7.10 m	Halite; colorless to moderate reddish orange; medium to coarsely crystalline; blebs of polyhalite beginning at 6.65 m.	Map Unit 0
7.10 - 7.70 m	Halite; colorless; very coarsely crystalline.	
7.70 - 8.25 m	Polyhalitic halite; reddish orange; coarsely crystalline; polyhalite increases with depth.	PH - 4
8.25 - 8.41 m	Polyhalite; orange; microcrystalline.	
8.41 - 9.07 m	Anhydrite; gray microcrystalline; minor halite and polyhalite from 8.41 - 8.60 m.	Marker Bed 139
8.9 m	Fracture with dyed mineral oil.	Core loss from 8.95 - 9.07 m.

07/28/95-GJM-EXCEL-CLC1H06

TABLE A.6 (Continued)

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OF 2

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1H06 **DIA.:** 4-INCH
LOCATION: N 1420 DRIFT NEAR ROOM C - 1
ORIENTATION: 70 DOWN FROM HORIZONTAL
COORDINATES:
ELEVATION:
DRILL METHODS: AIR / ROTARY

LOG BY: RMR & TFD
DATE: 1/12/92
DRILL DATE: 1/21/92
DRILLER: RICK BALLEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION		REMARKS
14:09	4	9.0	100	- - -		9.07 - 9.35 m	Halite; colorless to light gray; coarsely crystalline; intercrystalline gray clay.	H - 4
		9.5				9.40 m	Borehole faced to final depth of 9.40 m.	No Core

TABLE A.7
CORE DESCRIPTION OF BOREHOLE C1X05-A

TABLE A.7

PAGE 1
OF 4

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1X05-A **DIA.:** 3-INCH
LOCATION: ROOM C-1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1526.39 E 1590.25
ELEVATION: 1301.73 FT. AMSL
DRILL METHODS: AIR / ROTARY

LOG BY: TFD & WAS
DATE: 7/6/92
DRILL DATE: 6/25/92 - 6/29/92
DRILLER: RALPH McGARY
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
6/25/92	1	0.0	0			0.00 - 0.40 m No core taken.	
	2						
6/26/92	3	0.5	100			0.40 - 1.45 m Halite; colorless to orange; fine to coarse crystalline; trace of polyhalite.	Map unit 6
12:30 12:40	4	1.0	100				
12:55 13:05	5	1.5	100			1.45 - 2.01 m Halite; colorless to gray; very coarse crystalline; moderate gray clay present.	Map unit 5
13:15	6	2.0 2.5	100	- - - -		2.01 - 2.56 m Argillaceous halite; gray; fine to medium crystalline.	Map unit 4
		3.0				2.56 - 3.66 m Halite; colorless to orange; medium to coarse crystalline; trace of polyhalite increasing with depth.	Map unit 3

TABLE A.7 (Continued)

PAGE 2 OF 4	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: C1X05-A **DIA.:** 3-INCH

LOCATION: ROOM C-1

ORIENTATION: VERTICAL DOWN

COORDINATES: N 1526.39 E 1590.25

ELEVATION: 1301.73 FT. AMSL

DRILL METHODS: AIR / ROTARY

LOG BY: TFD & WAS

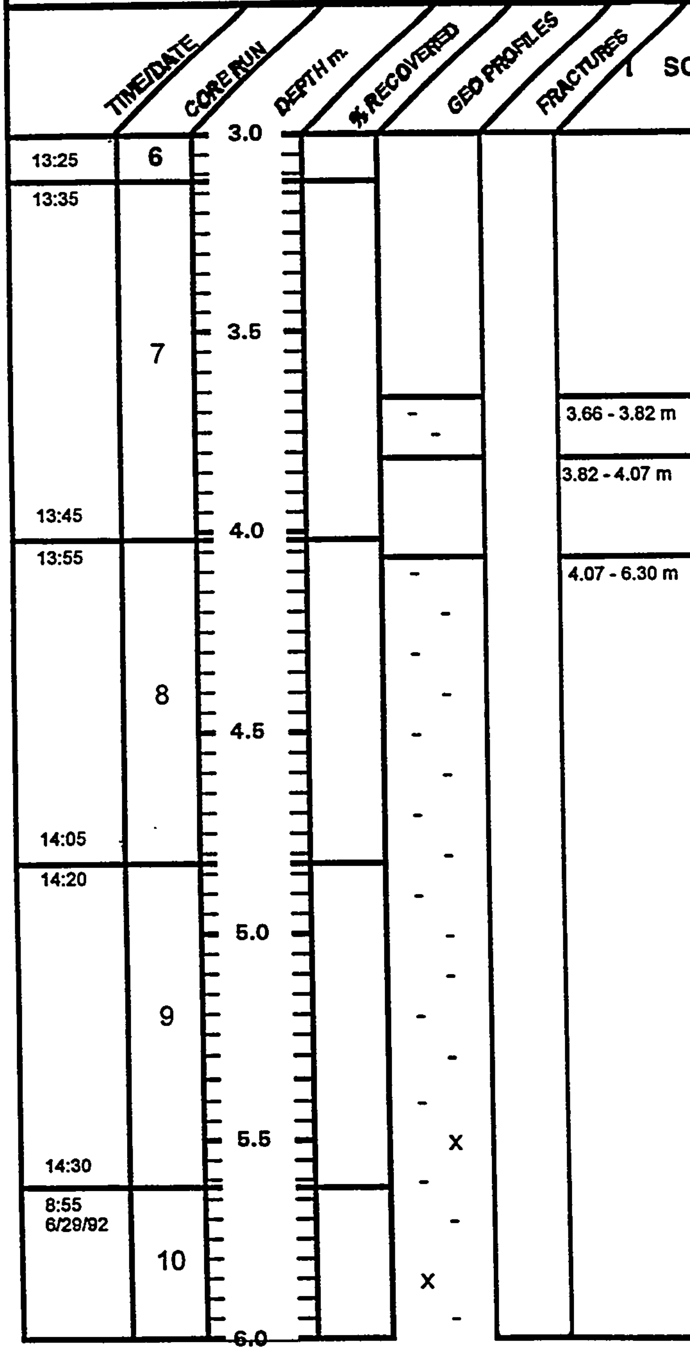
DATE: 7/6/92

DRILL DATE: 6/25/92 - 6/29/92

DRILLER: RALPH McGARY

DRILL: LONGYEAR D65

DRILL CO.: EXP. OPS.



	DESCRIPTION	REMARKS
	See previous page for description.	
3.66 - 3.82 m	Argillaceous halite; gray; fine to coarse crystalline.	Map unit 2
3.82 - 4.07 m	Halite; colorless; medium to coarse crystalline; trace of gray clay.	Map unit 1
4.07 - 6.30 m	Argillaceous halite; colorless to gray; fine to course crystalline; gray clay content decreasing and polyhalitic content increasing with depth; bottom contact is gradational based on clay and polyhalite content.	Map unit 0 Core loss from 5.63 - 5.67 m.

05/23/95-GJM-EXCEL-CLC1X05A

TABLE A.7 (Continued)

PAGE 3 OF 4	WIPP CORE-LOG INVENTORY	INTERA	FORM 1400

BOREHOLE: C1X05-A **DIA.:** 3-INCH

LOCATION: ROOM C-1

ORIENTATION: VERTICAL DOWN

COORDINATES: N 1526.39 E 1590.25

ELEVATION: 1301.73 FT. AMSL

DRILL METHODS: AIR / ROTARY

LOG BY: TFD & WAS

DATE: 7/6/92

DRILL DATE: 6/25/92 - 6/29/92

DRILLER: RALPH McGARY

DRILL: LONGYEAR D65

DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	SCRIPTION	REMARKS
9:05	10	6.0				See previous page for description.	
9:15 6/29/95	11						
9:25						6.30 - 6.65 m Polyhalitic halite; orange; medium to very coarse crystalline; lower contact is missing.	PH-4 Core loss from 6.47 - 6.57 m.
9:35	12	6.5					
		7.0				6.65 - 7.60 m Anhydrite; orange to gray; fine to medium crystalline; swallow tail pattern consisting of halite growths within anhydrite units; lower contact is missing (Clay E).	MB 139
9:50							
10:05	13	7.5					Clay E
10:20						7.60 - 8.60 m Argillaceous halite; gray to orange; fine to medium crystalline; clay content decreases down section; trace of polyhalite.	H-4
12:03	14	8.0					
		8.5					
12:15						8.60 - 9.10 m Polyhalitic halite; colorless to orange; medium to coarse crystalline.	PH-3 Core loss from 8.94 - 9.03 m.
12:25	15	9.0					

05/23/95-GJM-EXCEL-CLC1X05A

TABLE A.7 (Continued)

PAGE 4 **OF** 4	WIPP CORE-LOG INVENTORY	**INTERA** **FORM 1400**

BOREHOLE: C1X05-A **DIA.:** 3-INCH

LOCATION: ROOM C-1

ORIENTATION: VERTICAL DOWN

COORDINATES: N 1526.39 E 1590.25

ELEVATION: 1301.73 FT. AMSL

DRILL METHODS: AIR / ROTARY

LOG BY: TFD & WAS

DATE: 7/6/92

DRILL DATE: 6/25/92 - 6/29/92

DRILLER: RALPH McGARY

DRILL: LONGYEAR D65

DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	SCRIPTION	REMARKS
12:35	15	9.0		X		See previous page for description.	Core loss from 9.10 - 9.14 m.
		9.5					

TABLE A.8
CORE DESCRIPTION OF BOREHOLE C1X05-B

TABLE A.8

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OF 8

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1X05-B **DIA.:** 3-INCH
LOCATION: ROOM C-1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1526.39 E 1590.25
ELEVATION: 1301.73 FT. AMSL
DRILL METHODS: ROTARY BRINE

LOG BY: RSK & WAS
DATE: 6/7/93
DRILL DATE: 6/7/93 - 6/14/93
DRILLER: TROY PIDALLA
DRILL: LONGYEAR 38
DRILL CO.: EXP. OPS.

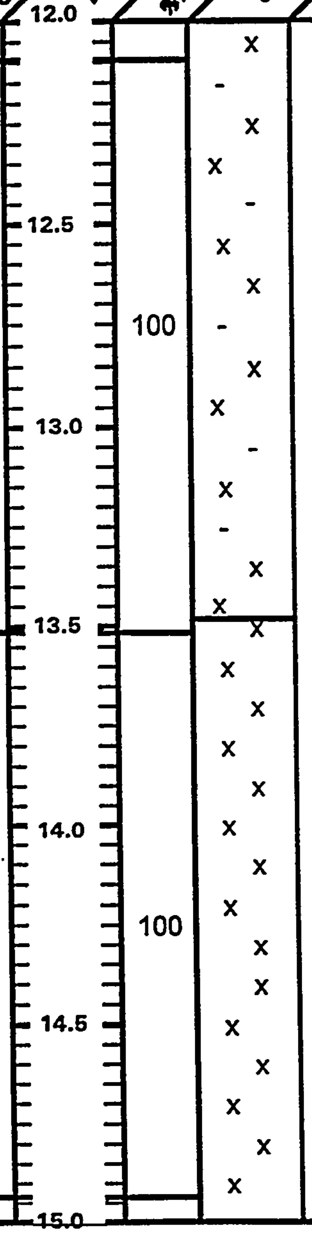
TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION		REMARKS
		9.0					See C1X05-A core description.	
14:00 6/7/93	1	9.5 10.0	100	X x X x X x X x X		9.14 - 10.12 m	Polyhalitic halite; clear to medium reddish-orange; medium to coarsely crystalline; hard; scattered clay breaks.	PH-3
		10.5		X x - -		10.12 - 10.57 m	Halite; clear to light gray to medium reddish orange; medium to coarsely crystalline; hard; scattered gray breaks; trace polyhalite.	H-3
14:25 9:00 6/8/93	2	11.0 11.5	100	X X x X x X x X x X x		10.57 - 11.70 m	Halite; clear with trace of medium reddish orange; coarsely crystalline; hard; trace polyhalite.	PH-2
		12.0		X -		11.70 - 13.48 m	Halite; clear to reddish orange brown and light gray; medium to coarsely crystalline; hard gray clay; polyhalitic zones.	H-2

05/23/95-GJM-EXCEL-CLC1X05B

TABLE A.8 (Continued)

PAGE 2 OF 8	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE:	C1X05-B **DIA.:** 3-INCH	**LOG BY:**	RSK & WAS
LOCATION:	ROOM C-1	**DATE:**	6/7/93
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	6/7/93 - 6/14/93
COORDINATES:	N 1526.39 E 1590.25	**DRILLER:**	TROY PIDALLA
ELEVATION:	1301.73 FT. AMSL	**DRILL:**	LONGYEAR 38
DRILL METHODS:	ROTARY BRINE	**DRILL CO.:**	EXP. OPS.



TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
9:20 9:30 9:50	3	12.0 - 13.5	100			See previous page for description.	H-2
10:00 10:20 10:30	4	13.5 - 15.0	100			13.48 - 15.25 m Polyhalitic halite; clear to reddish-orange; coarsely crystalline; hard; irregular polyhalitic seams.	PH-1

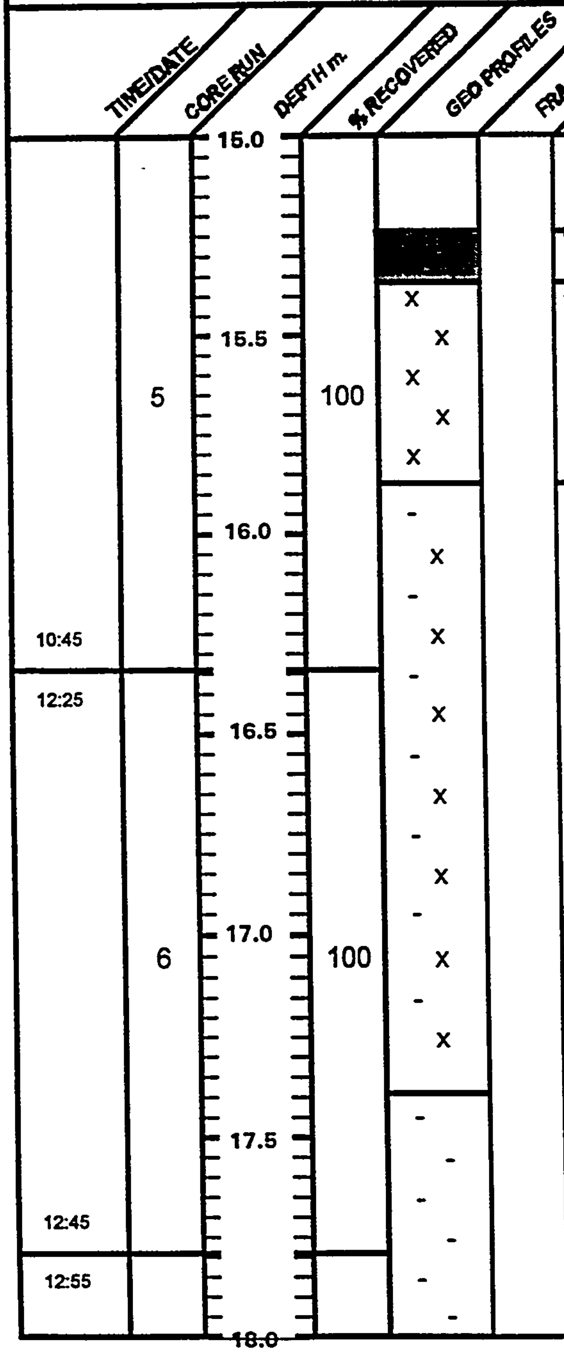
05/23/95-GJM-EXCEL-CLC1X05B

TABLE A.8 (Continued)

PAGE 3 OF 8	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: C1X05-B **DIA.:** 3-INCH
LOCATION: ROOM C-1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1526.39 E 1590.25
ELEVATION: 1301.73 FT. AMSL
DRILL METHODS: ROTARY BRINE

LOG BY: RSK & WAS
DATE: 6/7/93
DRILL DATE: 6/7/93 - 6/14/93
DRILLER: TROY PIDALLA
DRILL: LONGYEAR 38
DRILL CO.: EXP. OPS.



	DESCRIPTION	REMARKS
	See previous page for description.	
15.25 - 15.35 m	Anhydrite; light gray to gray; microcrystalline; hard and massive.	Anhydrite "C
15.35 - 15.87 m	Halite; clear to reddish-orange; medium to coarsely crystalline; trace of polyhalite.	H-1
15.87 - 17.39 m	Halite; clear to light gray; medium to coarsely crystalline; trace of clay.	
17.39 - 18.00 m	Argillaceous halite; clear to gray and reddish-orange/brown; fine to coarsely crystalline; medium hard; scattered clay and clay seam breaks.	

05/23/95-GJM-EXCEL-CLC1X05B

TABLE A.8 (Continued)

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OF 8

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1X05-B **DIA.:** 3-INCH
LOCATION: ROOM C-1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1526.39 E 1590.25
ELEVATION: 1301.73 FT. AMSL
DRILL METHODS: ROTARY BRINE

LOG BY: RSK & WAS
DATE: 6/7/93
DRILL DATE: 6/7/93 - 6/14/93
DRILLER: TROY PIDALLA
DRILL: LONGYEAR 38
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION		REMARKS
13:05	7	18.0 18.5 19.0	100	-		18.00 - 20.28 m	Halite; clear to light gray; coarsely crystalline; hard; trace of gray clay.	H-1 & H-m1
12:15 6/11/93 12:30	8	19.5 20.0	100	-				
		20.5		x x x x		20.28 - 23.09 m	Polyhalitic halite; clear to gray to reddish-orange to brown; coarsely crystalline; hard; trace of clay; polyhalitic stringers and clay stringers.	H-m1 & H-m2
8:10 6/14/93		21.0		x x -				

TABLE A.8 (Continued)

PAGE 5 OF 8	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE:	C1X05-B **DIA.:** 3-INCH	**LOG BY:**	RSK & WAS
LOCATION:	ROOM C-1	**DATE:**	6/7/93
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	6/7/93 - 6/14/93
COORDINATES:	N 1526.39 E 1590.25	**DRILLER:**	TROY PIDALLA
ELEVATION:	1301.73 FT. AMSL	**DRILL:**	LONGYEAR 38
DRILL METHODS:	ROTARY BRINE	**DRILL CO.:**	EXP. OPS.

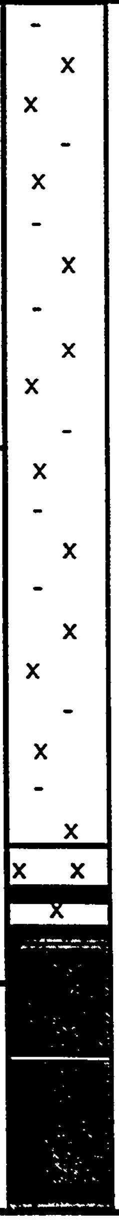
TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
		21.0				See previous page for description.	H-m1 & H-m2
	9	21.5	100				
8:25		22.0					
8:36							
		22.5					
	10		100				
		23.0					
						23.09 - 23.30 m Halite; clear to gray to reddish orange; coarsely crystalline; hard; anhydritic stringers; anhydrite content increases with depth; trace polyhalite.	H-m2
8:51						23.30 - 23.64 m Anhydrite; light gray to gray to light reddish orange; microcrystalline; hard; trace polyhalite; alternating light and dark bands from 23.44 to 23.64 m.	MB 140
9:00		23.5					
	11		100			23.64 - 24.43 m Anhydrite; clear to light gray to light reddish orange to light brown; microcrystalline; hard; swallow tail halitic crystals; trace polyhalite; core broken 24.10 - 24.20 m.	MB 140
		24.0					

TABLE A.8 (Continued)

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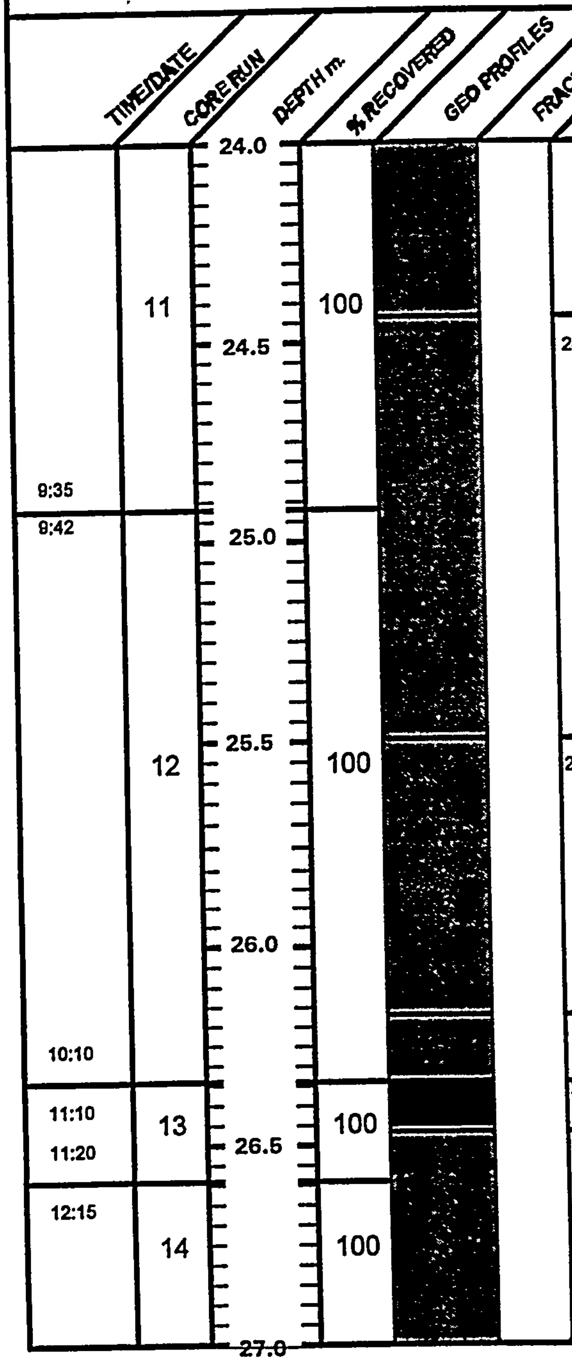
OF 8

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1X05-B **DIA.:** 3-INCH
LOCATION: ROOM C-1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1526.39 E 1590.25
ELEVATION: 1301.73 FT. AMSL
DRILL METHODS: ROTARY BRINE

LOG BY: RSK & WAS
DATE: 6/7/93
DRILL DATE: 6/7/93 - 6/14/93
DRILLER: TROY PIDALLA
DRILL: LONGYEAR 38
DRILL CO.: EXP. OPS.



DESCRIPTION		REMARKS
	See previous page for description.	MB 140
24.43 - 25.50 m	Anhydrite; gray to light reddish orange to light brown; microcrystalline; hard; trace polyhalite; polyhalite/halite content increases with depth.	MB 140
25.50 - 26.18 m	Anhydrite; gray to light reddish orange to light brown; microcrystalline; hard; stylolitic or sutured halitic and polyhalitic crystals increasing downward.	MB 140
26.18 - 26.34 m	Anhydrite; light gray to gray; microcrystalline; hard; scattered clay breaks bedded.	MB 140
26.34 - 26.46 m	Clay; gray; soft; broken.	MB 140
26.46 - 27.09 m	Anhydrite; light gray to gray; microcrystalline; bedded; have alternating light and dark bands.	MB 140

05/23/95-GJM-EXCEL-CLC1X05B

TABLE A.8 (Continued)

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OF 8

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1X05-B DIA.: 3-INCH
LOCATION: ROOM C-1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1526.39 E 1590.25
ELEVATION: 1301.73 FT. AMSL
DRILL METHODS: ROTARY BRINE
LOG BY: RSK & WAS
DATE: 6/7/93
DRILL DATE: 6/7/93 - 6/14/93
DRILLER: TROY PIDALLA
DRILL: LONGYEAR 38
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
	14	27.0	100	■		See previous page for description.	MB 140
				■		27.09 - 27.14 m Clay; soft; gray.	MB 140
				- -		27.14 - 27.26 m Argillaceous halite; clear to light gray; fine.	H-m3
12:30 12:35	15	27.5 28.0	100	X - X X - X X - X X - X		27.26 - 28.50 m Halite; clear to light gray to reddish orange; medium to coarsely crystalline; hard; clay breaks and polyhalitic seams; contact gradational with lower unit based on color.	
		28.5		- X X - X		28.50 - 29.03 m Argillaceous and anhydrite halite; orange to reddish brown; medium to coarsely crystalline.	
13:05 13:10	16	29.0 29.5 30.0	100	- X X - X - X X -		29.03 - 30.03 m Halite; clear to light reddish orange; hard; trace polyhalite; large enhedral halite.	

05/23/95-GJM-EXCEL-CLC1X05B

TABLE A.8 (Continued)

PAGE 8 **OF** 8	**WIPP CORE-LOG INVENTORY**	**INTERA**	**FORM 1400**

BOREHOLE: C1X05-B **DIA.:** 3-INCH

LOCATION: ROOM C-1

ORIENTATION: VERTICAL DOWN

COORDINATES: N 1526.39 E 1590.25

ELEVATION: 1301.73 FT. AMSL

DRILL METHODS: ROTARY BRINE

LOG BY: RSK & WAS

DATE: 6/7/93

DRILL DATE: 6/7/93 - 6/14/93

DRILLER: TROY PIDALLA

DRILL: LONGYEAR 38

DRILL CO.: EXP. OPS.

TIME/DATE	**CORE RUN**	**DEPTH m**	**% RECOVERED**	**GEO PROFILES**	**FRACTURES**	**DESCRIPTION**	**REMARKS**
13:25	16	30.0		- -		30.03 - 30.20 m Halite; clear to reddish-brown to brown; fine to medium crystalline; hard; clay present.	H-m3
		30.5					

TABLE A.9
CORE DESCRIPTION OF BOREHOLE C1X06-A

TABLE A.9

PAGE 1
OF 3

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1X06-A **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1516.63 E 1587.78
ELEVATION: 1302.22 FT. AMSL
DRILL METHODS: AIR / ROTARY

LOG BY: WAS
DATE: 9/30/92
DRILL DATE: 9/28/92 - 9/30/92
DRILLER: R. LEWIS/R. BALEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION		REMARKS
9:00 9/25/92 9:15		0.0 0.5				0.00 - 0.62 m	No core taken.	
9:41 9/28/92 10:44	1	1.0	100	- - x - - x		0.62 - 1.30 m	Halite; colorless to pale orange; fine to coarsely crystalline; trace polyhalite; contact with below is gradational based on color change.	Map Unit 6
11:00 11:20	2	1.5 2.0	100			1.30 - 2.02 m	Halite, colorless to gray; very coarsely crystalline; some fine to moderate locally; contact with lower unit is sharp with clay F.	Map Unit 5
12:20	3		100	- - - - - - - - - -		2.02 - 2.53 m	Argillaceous halite; gray to brown; fine to medium crystalline; argillaceous material; contact with below based on color; change in clay content gradational.	Map Unit 4
12:41 12:47		2.5 3.0		- - - x - - x		2.53 - 3.59 m	Halite; reddish/orange; medium to coarsely crystalline; locally polyhalitic scattered gray clay, contact with lower unit is sharp.	Map Unit 3

07/20/95-GJM-EXCEL-CLC1XO6A

TABLE A.9 (Continued)

PAGE 2 **OF** 3	**WIPP CORE-LOG INVENTORY**		**INTERA** **FORM 1400**
BOREHOLE:	C1X06-A **DIA.:** 4-INCH	**LOG BY:**	WAS
LOCATION:	ROOM C1	**DATE:**	9/30/92
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	9/28/92 - 9/30/92
COORDINATES:	N 1516.63 E 1587.78	**DRILLER:**	R. LEWIS/R. BALEW
ELEVATION:	1302.22 FT. AMSL	**DRILL:**	LONGYEAR D65
DRILL METHODS:	AIR / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION		REMARKS
13:09	4	3.0 3.5	100	X X - - X			See previous page for description.	Map Unit 3
13:30	5		100	- -		3.59 - 3.76 m	Argillaceous halite; gray/reddish brown; fine to medium crystalline argillaceous material. Contact with lower unit is sharp.	Map Unit 2
13:55		4.0		X X X X X		3.76 - 4.36 m	Halite; light reddish brown to reddish orange; medium to coarsely crystalline; dispersed polyhalite.	Map Unit 1
14:05 14;15	6	4.5 5.0	100	- - - - X - - - -		4.36 - 6.11 m	Halite; clear to reddish brown; medium to coarsely crystalline; intercrystalline argillaceous material; trace of polyhalite and polyhalitic blebs; contact with lower unit gradational based on polyhalitic content.	Map Unit 0
9:34 9/29/92	7	5.5 6.0	100	X - - - X - - X				

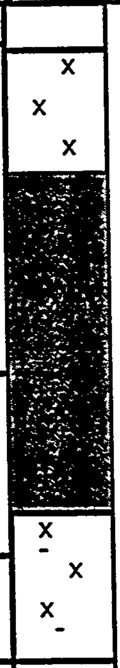
07/20/95-GJM-EXCEL-CLC1XO6A

TABLE A.9 (Continued)

PAGE 3 OF 3	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: C1X06-A **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1516.63 E 1587.78
ELEVATION: 1302.22 FT. AMSL
DRILL METHODS: AIR / ROTARY

LOG BY: WAS
DATE: 9/30/92
DRILL DATE: 9/28/92 - 9/30/92
DRILLER: R. LEWIS/R. BALEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.



TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
9:56		6.0				See previous page for description.	
10:40 12:20	8	6.5	100			6.11 - 6.43 m Polyhalitic halite; clear to reddish orange; coarsely crystalline; contact sharp with unit but irregular.	PH - 4
						6.43 - 7.32 m Anhydrite; moderate reddish brown to medium gray; microcrystalline anhydrite; halitic and polyhalitic growths within anhydrite decreasing with depth; thin grey clay seam (clay E) at base of unit; contact with lower unit is sharp.	MB 139
12:35 13:05	9	7.0	95				
10:00 9/30/92 10:05	10	7.5	93			7.32 - 7.63 m Halite; clear to medium and moderate brown; coarsely crystalline; polyhalitic and some gray clay present.	Map Unit A-4
		8.0					

07/20/95-GJM-EXCEL-CLC1XO6A

TABLE A.10
CORE DESCRIPTION OF BOREHOLE C1X06-B

TABLE A.10

PAGE 1
OF 7

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: C1X06-B **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1516.63 E 1587.78
ELEVATION: 1302.22 FT. AMSL
DRILL METHODS: BRINE / ROTARY

LOG BY: WAS & RSK
DATE: 8/20/93
DRILL DATE: 7/7/93 - 8/12/93
DRILLER: TROY PIDALLA
DRILL: LONGYEAR D38
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
		7.0 7.5				See C1X06-A core description.	
12:30 7/7/93	1	8.0 8.5	100			7.63 - 8.56 m Halite; clear to grayish to medium orange; medium to coarsely crystalline; hard; < 1% gray clay.	H-4
13:07		9.0				8.56 - 9.72 m Polyhalitic halite; clear to medium reddish-orange; coarsely crystalline; irregular polyhalite seams and gray clay at base of contact.	PH-3
13:42	2	9.5	100				
		10.0				9.72 - 10.21 m Halite; clear to light gray to medium reddish orange; medium to coarsely crystalline; trace of polyhalite and gray clay.	H-3

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TABLE A.10 (Continued)

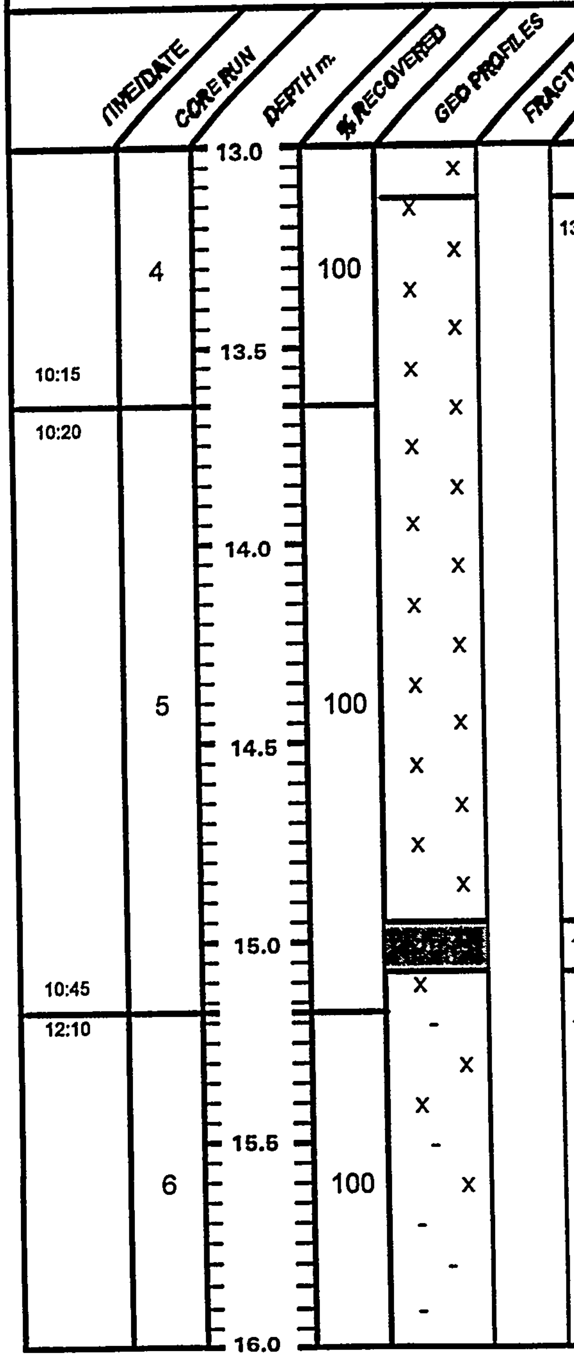
PAGE 2 **OF** 7	WIPP CORE-LOG INVENTORY	**INTERA** **FORM 1400**

BOREHOLE:	C1X06-B **DIA.:** 4-INCH	**LOG BY:**	WAS & RSK
LOCATION:	ROOM C1	**DATE:**	8/20/93
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	7/7/93 - 8/12/93
COORDINATES:	N 1516.63 E 1587.78	**DRILLER:**	TROY PIDALLA
ELEVATION:	1302.22 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
	2	10.0	100	x -		See previous page for description.	H-3
14:22		10.5		- x - x		10.21 - 10.65 m Halite; clear to light gray to reddish orange; coarsely crystalline.	
8:50 7/8/93	3	11.0 11.5	100	- x - x x - x - x		10.65 - 11.57 m Polyhalitic halite; clear to medium reddish orange-brown; coarsely crystalline; hard; < 1 to 5% polyhalite; trace of clay.	PH-2
9:35 9:45	4	12.0 12.5	100	x - - x x - - x x - - x x		11.57 - 12.60 m Halite; clear to reddish-orange brown; medium to coarsely crystalline; scattered clay breaks.	H-2
		13.0		x - - x x		12.60 - 13.13 m Halite; clear to gray to reddish orange; medium to coarsely crystalline; some polyhalite and clay.	

TABLE A.10 (Continued)

PAGE 3 OF 7	WIPP CORE-LOG INVENTORY		INTERA FORM 1400
BOREHOLE:	C1X06-B DIA.: 4-INCH	LOG BY:	WAS & RSK
LOCATION:	ROOM C1	DATE:	8/20/93
ORIENTATION:	VERTICAL DOWN	DRILL DATE:	7/7/93 - 8/12/93
COORDINATES:	N 1516.63 E 1587.78	DRILLER:	TROY PIDALLA
ELEVATION:	1302.22 FT. AMSL	DRILL:	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	DRILL CO.:	EXP. OPS.



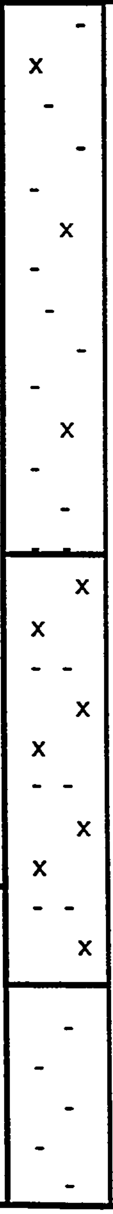
	DESCRIPTION	REMARKS
	See previous page for description.	
13.13 - 14.95 m	Polyhalitic halite; clear to medium reddish-orange-brown; coarsely crystalline; hard; polyhalitic seams 3 - 4 cm thick.	PH-1
14.95 - 15.08 m	Anhydrite; light gray to gray; microcrystalline; thin clay seam < 1 cm.	Anhydrite "C"
15.08 - 17.37 m	Halite; clear to light gray to light reddish orange; medium hard to hard; trace polyhalite with scattered clay breaks; badly broken.	H-1

07/21/95-GJM-EXCEL-CLC1XO6B

TABLE A.10 (Continued)

PAGE 4 OF 7	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE:	C1X06-B **DIA.:** 4-INCH	**LOG BY:**	WAS & RSK
LOCATION:	ROOM C1	**DATE:**	8/20/93
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	7/7/93 - 8/12/93
COORDINATES:	N 1516.63 E 1587.78	**DRILLER:**	TROY PIDALLA
ELEVATION:	1302.22 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
12:45	6	16.0 16.5	100			See previous page for description.	H-1
12:50 13:30	7	17.0 17.5 18.0	100			17.37 - 18.45 m Halite; clear to reddish-orange to brown; medium to coarsely crystalline; medium hard to hard; trace polyhalite and some argillaceous halite; clay breaks.	
8:45 7/9/93	8	18.5 19.0	100			18:45 - 19.13 m Halite; clear to gray; coarsely crystalline; hard; some clay breaks.	H-m1

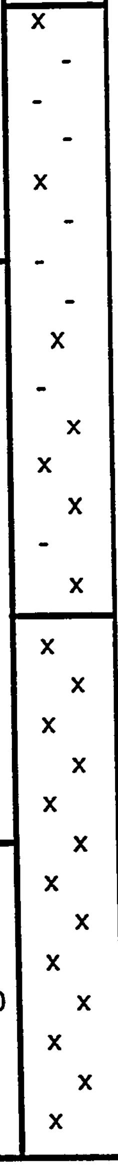
07/21/95-GJM-EXCEL-CLC1XO6B

TABLE A.10 (Continued)

PAGE 5 OF 7	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: C1X06-B **DIA.:** 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1516.63 E 1587.78
ELEVATION: 1302.22 FT. AMSL
DRILL METHODS: BRINE / ROTARY

LOG BY: WAS & RSK
DATE: 8/20/93
DRILL DATE: 7/7/93 - 8/12/93
DRILLER: TROY PIDALLA
DRILL: LONGYEAR D38
DRILL CO.: EXP. OPS.



TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
		19.0				See previous page for description.	
9:10	8	19.5	100			19.13 - 20.64 m Halite; clear to gray to reddish orange; coarsely crystalline; hard; trace of clay and polyhalite; polyhalite increases with depth; clay breaks.	H-m1
9:15 10:00	9	20.0 20.5 21.0	100			20.62 - 22.97 m Polyhalitic halite; clear to reddish orange; coarsely crystalline; hard.	H-m2
10:20	10	21.5 22.0	100				

07/21/95-GJM-EXCEL-CLC1XO6B

TABLE A.10 (Continued)

PAGE 6 **OF** 7	WIPP CORE-LOG INVENTORY	**INTERA** **FORM 1400**

BOREHOLE:	C1X06-B **DIA.:** 4-INCH	**LOG BY:**	WAS & RSK
LOCATION:	ROOM C1	**DATE:**	8/20/93
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	7/7/93 - 8/12/93
COORDINATES:	N 1516.63 E 1587.78	**DRILLER:**	TROY PIDALLA
ELEVATION:	1302.22 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
11:00	10	22.0 22.5	100			See previous page for description.	H-m2
12:10 14:20	11	23.0 23.5 24.0	100			22.97 - 24.27 m Anhydrite; light gray to gray to reddish light brown; microcrystalline; hard; halitic and polyhalitic pseudomorphs to gypsum.	MB 140
10:30 8/12/93	12	24.5 25.0	100			24.27 - 25.38 m Anhydrite; light gray to gray to reddish brown; microcrystalline; hard.	MB 140

TABLE A.10 (Continued)

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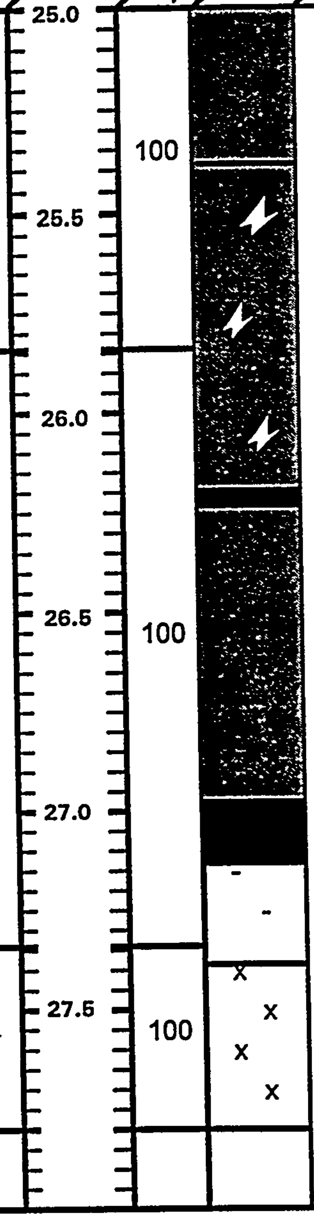
OF 7

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE:	C1X06-B **DIA.:** 4-INCH	**LOG BY:**	WAS & RSK
LOCATION:	ROOM C1	**DATE:**	8/20/93
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	7/7/93 - 8/12/93
COORDINATES:	N 1516.63 E 1587.78	**DRILLER:**	TROY PIDALLA
ELEVATION:	1302.22 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	% RECOVERED
11:30	12	100
12:05 12:55	13	100
13:00 13:15	14	100



DESCRIPTION		REMARKS
	See previous page for description.	MB 140
25.38 - 26.24 m	Anhydrite; gray to reddish brown to brown; microcrystalline with halitic and polyhalitic pseudomorphs; some laminar dissolution along bedding.	MB 140
26.24 - 26.29 m	Clay Seam.	MB 140
26.24 - 26.97 m	Anhydrite, gray to dark gray, microcrystalline hard, some laminar dissolution along bedding.	MB 140
26.97 - 27.13 m	Clay Seam.	MB 140
27.13 - 27.38 m	Halite; clear to gray; coarsely crystalline; hard; clay breaks; traces of polyhalite.	MB 140
27.38 - 27.80 m	Halite; clear to reddish orange; coarsely crystalline; hard; trace of polyhalite.	H-m3

07/21/95-GJM-EXCEL-CLC1XO6B

TABLE A.11

CORE DESCRIPTION OF BOREHOLE C1X10

TABLE A.11

PAGE 1 OF 4	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: C1X10 **DIA.:** 4-INCH

LOCATION: ROOM C1

ORIENTATION: VERTICAL DOWN

COORDINATES: N 1443.18 E 1586.74

ELEVATION: 1313.58 FT. AMSL

DRILL METHODS: AIR / ROTARY

LOG BY: RMR & MDF

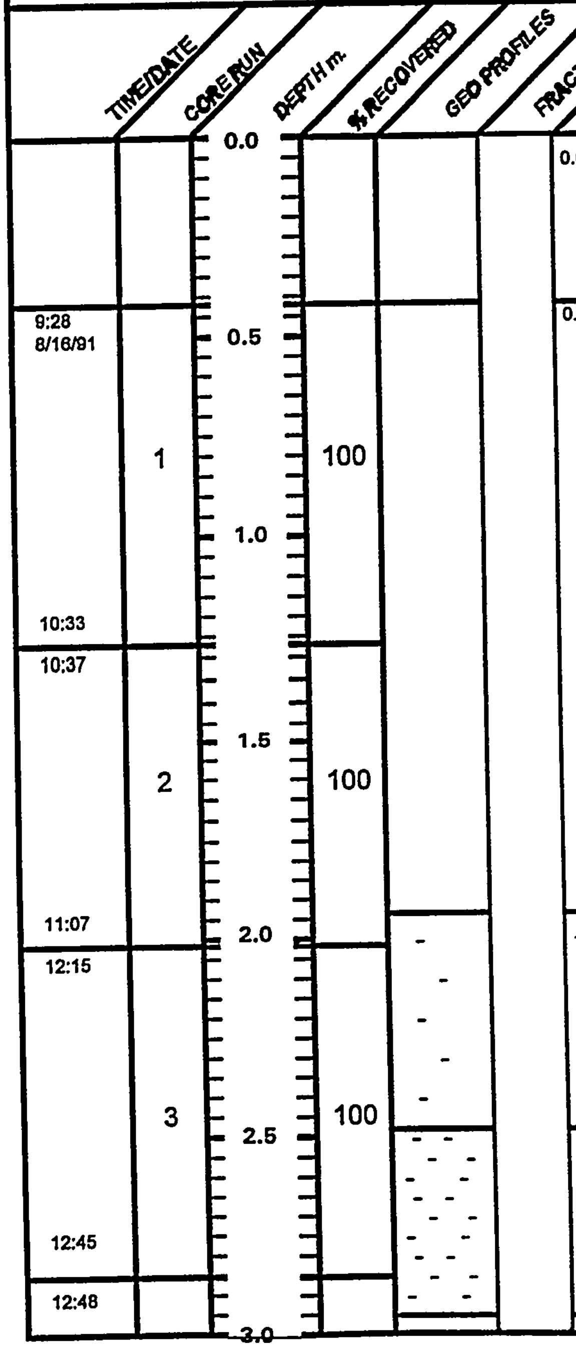
DATE: 5/21/92

DRILL DATE: 8/16/91 - 11/11-12/91

DRILLER: RICH BALLEW

DRILL: LONGYEAR D65

DRILL CO.: EXP. OPS.



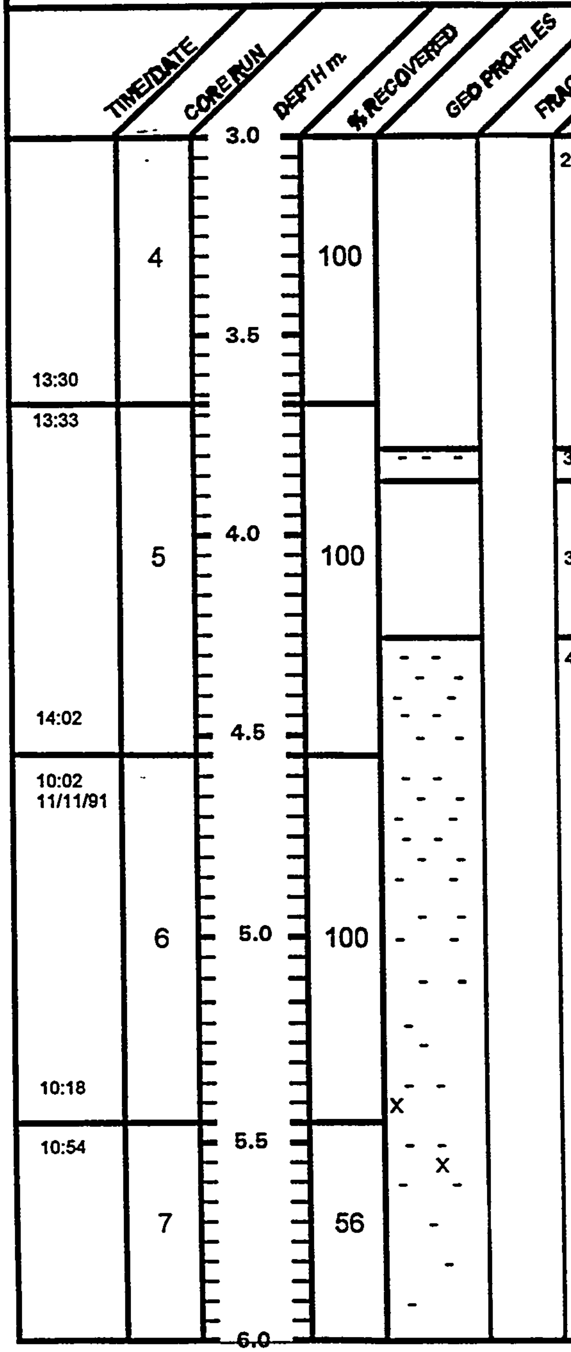
DESCRIPTION		REMARKS
0.00 - 0.42 m	Borehole cored for placement of flanged collar; core not described.	
0.42 - 1.94 m	Halite; colorless/pale orange; fine to coarsely crystalline; trace polyhalite; contact with below is gradational based on color change and clay content.	Map Unit 6
1.94 - 2 47 m	Halite, colorless to gray; very coarsely crystalline; moderate gray clay; contact with below is gradational based on grain size, color, and clay content.	Map Unit 5
2.47 - 2.96 m	Argillaceous halite; gray; fine to medium crystalline; lower contact is gradational based on color change and clay content.	Map Unit 4

07/20/95-GJM-EXCEL-CLC1X10

TABLE A.11 (Continued)

PAGE 2 OF 4	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: C1X10 DIA.: 4-INCH
LOCATION: ROOM C1
ORIENTATION: VERTICAL DOWN
COORDINATES: N 1443.18 E 1586.74
ELEVATION: 1313.58 FT. AMSL
DRILL METHODS: AIR / ROTARY
LOG BY: RMR & MDF
DATE: 5/21/92
DRILL DATE: 8/16/91 - 11/11-12/91
DRILLER: RICH BALLEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.



DESCRIPTION		REMARKS
2.96 - 3.81 m	Halite; colorless/orange; medium to coarsely crystalline; polyhalite increases with depth; contact with below is sharp based on color and clay content.	Map Unit 3
3.81 - 3.86 m	Argillaceous halite; gray/reddish brown; fine to medium crystalline; intercrystalline clay contact with below is sharp.	Map Unit 2
3.86 - 4.26 m	Halite; colorless; coarsely crystalline; trace polyhalite; contact with unit below is sharp based on color, clay, and grain size.	Map Unit 1
4.26 - 6.85 m	Argillaceous halite; colorless to gray; fine to coarsely crystalline; gray clay decreases with depth; contact with unit below is gradational based on decreasing clay and increasing polyhalite.	Map Unit 0 Core loss from 5.69 - 5.97 m.

07/20/95-GJM-EXCEL-CLC1X10

TABLE A.11 (Continued)

PAGE 3 OF 4	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: C1X10 DIA.: 4-INCH

LOCATION: ROOM C1

ORIENTATION: VERTICAL DOWN

COORDINATES: N 1443.18 E 1586.74

ELEVATION: 1313.58FT. AMSL

DRILL METHODS: AIR / ROTARY

LOG BY: RMR & MDF

DATE: 5/21/92

DRILL DATE: 8/16/91 - 11/11-12/91

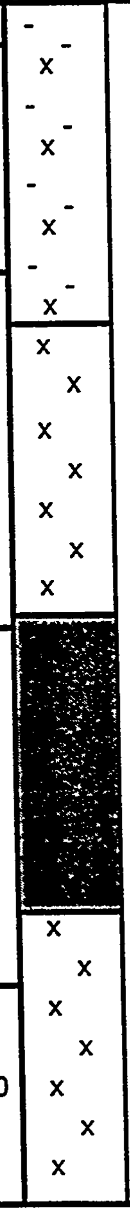
DRILLER: RICH BALLEW

DRILL: LONGYEAR D65

DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED
11:05		6.0	
12:57 13:16	8	6.5	88
13:20 13:35	9	7.0	100
13:42 13:57	10	7.5 8.0	67
9:50 11/12/91	11	8.5 9.0	100

GEO PROFILES



FRACTURES

	DESCRIPTION	REMARKS
	See previous page for description.	Core loss from 6.10 - 6.17 m.
6.85 - 7.51 m	Polyhalitic halite; orange; medium crystalline.	PH - 4
7.51 - 8.26 m	Anhydrite; microcrystalline; depth to lower contact of MB 139 was determined from video survey.	Marker Bed 139 Core loss from 7.99 -8.28 m.
8.26 - 10.16 m	Polyhalitic halite; dark orange; fine to coarsely crystalline; trace clay and anhydrite from 8.60 - 9.00 m.	H - 4 and PH -3

07/20/95-GJM-EXCEL-CLC1X10

TABLE A.11 (Continued)

PAGE 4 **OF** 4	WIPP CORE-LOG INVENTORY	**INTERA** **FORM 1400**

BOREHOLE:	C1X10 **DIA.:** 4-INCH	**LOG BY:**	RMR & MDF
LOCATION:	ROOM C1	**DATE:**	5/21/92
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	8/16/91 - 11/11-12/91
COORDINATES:	N 1443.18 E 1586.74	**DRILLER:**	RICH BALLEW
ELEVATION:	1313.58 FT. AMSL	**DRILL:**	LONGYEAR D65
DRILL METHODS:	AIR / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
10:05	11	9.0	100	X X X		See previous page for description.	H - 4 and PH -3
12:00 12:15	12	9.5 10.0	90	X X X X X X X X			Core loss from 9.96 - 10.05 m.
		10.5					

TABLE A.12
CORE DESCRIPTION OF BOREHOLE L4P51-C

TABLE A.12

PAGE 1 OF 5	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE:	L4P51-C **DIA.:** 4-INCH	**LOG BY:**	RMR & TFD
LOCATION:	ROOM L-4	**DATE:**	4/20/92
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	4/1-3/92 to 4/14-15/92
COORDINATES:	N 1476.22 W 642.23	**DRILLER:**	RON LEWIS
ELEVATION:	1294.23 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
14:00 4/1/92	-	10.0				10.06 - 10.18 m Halite; colorless; medium crystalline.	H-1
	1	10.5	100			10.18 - 11.85 m Halite; colorless to orange; fine to medium crystalline; minor gray clay and trace polyhalite.	
14:30							
10:00 4/2/92		11.0					
	2	11.5	86				
		12.0				11.85 - 12.95 m Polyhalitic halite; orange; fine to medium crystalline; minor gray clay.	
10:30							Core loss from 12.19 - 12.41 meters.
12:50	3	12.5	90				H-1
		13.0				12.95 - 15.59 m See next page for description.	

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TABLE A.12 (Continued)

PAGE 2 OF 5	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE: L4P51-C DIA.: 4-INCH

LOCATION: ROOM L-4

ORIENTATION: VERTICAL DOWN

COORDINATES: N 1476.22 W 642.23

ELEVATION: 1294.23 FT. AMSL

DRILL METHODS: BRINE / ROTARY

LOG BY: RMR & TFD

DATE: 4/20/92

DRILL DATE: 4/1-3/92 to 4/14-15/92

DRILLER: RON LEWIS

DRILL: LONGYEAR D38

DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
		13.0		- -		12.95 - 15.59 m Halite; colorless to gray; medium to coarsely crystalline; minor gray clay decreasing with depth; minor polyhalite beginning at 15.15 m.	H-m1
	3		90	- -			Core loss from 13.40 - 13.50 m..
		13.5		- -			H-m1
13:20				- -			
13:30		14.0		- -			Core loss from 13.90 - 14.35 m..
		14.5		- -			H-m1
	4		75	- -			
		15.0		- x			
14:20		15.5		x x			
8:45 4/3/92	5		73	x x		15.59 - 16.10 m Halite; colorless to orange; medium crystalline; trace gray clay; polyhalite increasing with depth.	H-m2
		16.0		x x			

05/23/95-GJM-EXCEL-CLL4P51C

TABLE A.12 (Continued)

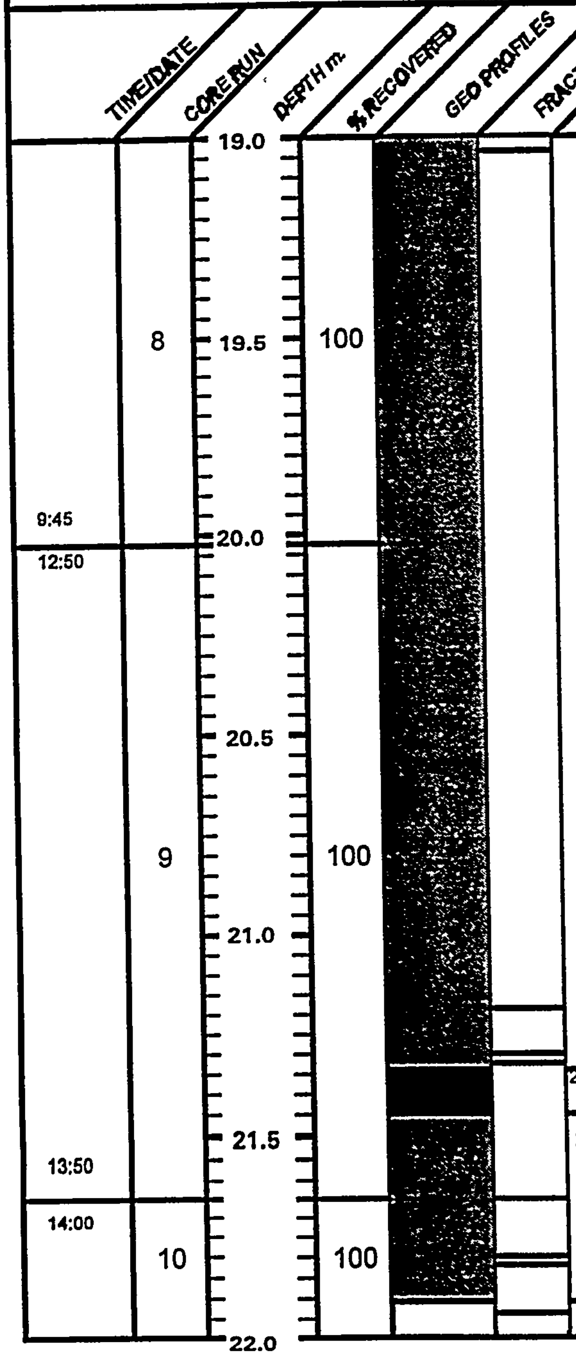
PAGE 3 OF 5	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE:	L4P51-C **DIA.:** 4-INCH	**LOG BY:**	RMR & TFD
LOCATION:	ROOM L-4	**DATE:**	4/20/92
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	4/1-3/92 to 4/14-15/92
COORDINATES:	N 1476.22 W 642.23	**DRILLER:**	RON LEWIS
ELEVATION:	1294.23 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
		16.0		X		See previous page for description.	
							Core loss from 16.10 - 16.50 m..
9:22	5	16.5	73	X X X X X X X X X X X X X		16.50 - 17.80 m Polyhalitic halite; orange; medium crystalline; anhydrite stringers starting at 17.05 m.	H-m2
10:55 4/14/92 13:40	6	17.0 17.5	100				
14:00 14:22	7	18.0	100			17.80 - 21.34 m Anhydrite; gray/orange/red; microcrystalline; halite pseudomorphs after gypsum from 18.23 - 19.00 m; dark red halite abundant from 19.40 - 20.02 m; halite not present by 21.15 m; clean gray anhydrite from 21.15 - 21.34 m.	MB 140
8:50 4/15/92	8	18.5 19.0	100				

TABLE A.12 (Continued)

PAGE 4 OF 5	WIPP CORE-LOG INVENTORY	INTERA FORM 1400	
BOREHOLE:	L4P51-C **DIA.:** 4-INCH	**LOG BY:**	RMR & TFD
LOCATION:	ROOM L-4	**DATE:**	4/20/92
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	4/1-3/92 to 4/14-15/92
COORDINATES:	N 1476.22 W 642.23	**DRILLER:**	RON LEWIS
ELEVATION:	1294.23 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.



	DESCRIPTION	**REMARKS**
	See previous page for description.	MB 140
	Fractures visible in intact core at 21.19, 21.30 and 21.33 m.	
21.34 - 21.44 m	Claystone; gray subhorizontal bedding planes lower contact is sharp and undulating.	MB 140
21.44 - 21.97 m	Anhydrite; gray microcrystalline; fractures at 21.60; 21.84 m and at contact with halite below.	MB 140
	See next page for description.	

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TABLE A.12 (Continued)

PAGE 5 **OF** 5	**WIPP CORE-LOG INVENTORY**	**INTERA**	**FORM 1400**

BOREHOLE:	L4P51-C **DIA.:** 4-INCH	**LOG BY:**	RMR & TFD
LOCATION:	ROOM L-4	**DATE:**	4/20/92
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	4/1-3/92 to 4/14-15/92
COORDINATES:	N 1476.22 W 642.23	**DRILLER:**	RON LEWIS
ELEVATION:	1294.23 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
14:30	10	22.0	100	- -		21.97 - 22.20 m Halite; pale orange; medium crystalline; intercrystalline gray clay from 21.97 - 22.05 m; thin (<1 mm) gray clay visible at contact with above.	H-m3
		22.5					

TABLE A.13
CORE DESCRIPTION OF BOREHOLE L4P51-D

TABLE A.13 (Continued)

PAGE 3 OF 3	WIPP CORE-LOG INVENTORY	INTERA FORM 1400

BOREHOLE:	L4P51-D **DIA.:** 4-INCH	**LOG BY:**	RMR
LOCATION:	ROOM L-4	**DATE:**	3/2/95
ORIENTATION:	VERTICAL DOWN	**DRILL DATE:**	9/20/94 - 9/22/94
COORDINATES:	N 1476.22 W 642.23	**DRILLER:**	RANDY WALDON
ELEVATION:	1294.23 FT. AMSL	**DRILL:**	LONGYEAR D38
DRILL METHODS:	BRINE / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
13:46	5	28.0 28.5	100	x x x x x x x		See previous page for description.	H-m3
14:13						28.77 - 28.85 m Anhydrite; gray to white; microcrystalline; cubic halite inclusion, 1 mm clay at base.	
	6	29.0 29.5	100	x x x x x x x		28.85 - 29.64 m. Halite; pale orange; coarsely crystalline; minor polyhalite.	
14:30		30.0		- - - - - -		29.64 - 30.30 m Argillaceous halite; brown; medium to coarsely crystalline.	AH-m1
						30.30 - 30.38 m. Halite; colorless; medium crystalline.	H-m4
10:26 10:27	7					30.38 - 30.48 m No core; bottom of hole faced.	
9/22/94		30.5					

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TABLE A.14
CORE DESCRIPTION OF BOREHOLE L4P52-B

TABLE A.14

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OF 4

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: L4P52-B **DIA.:** 4-INCH
LOCATION: ROOM L-4
ORIENTATION: 40° OFF VERTICAL UPWARD
COORDINATES: N1493.6 ft., W647.2 ft.
ELEVATION: 1306.6 ft. amsl
DRILL METHODS: AIR / ROTARY

LOG BY: WAS
DATE: Dec. 15, 1992
DRILL DATE: 12/10/92 - 12/14/92
DRILLER: RICK BALLEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
		5.0 - 5.5				See Stensrud et. al. (1992) for description.	
10:25 12/10/92 10:40	1	5.5 - 6.0 - 6.5	100	X X X X X X X X		5.56 - 6.95 m Polyhalitic halite; clear to moderate reddish-orange; coarsely crystalline; anhydrite stringers; contact sharp with unit below.	Map unit 12
12:10 12:50	2	6.5 - 7.0	100	X X X X X X			
		7.0		X - X -		6.95 - 7.92 m Halite; clear to reddish-orange; medium to coarsely crystalline; some fine; traces of gray clay; dispersed polyhalite; contact with below gradational based on clay and polyhalite content.	Map unit 13
13:05	3	7.5	100	X - X - X			
		8.0				See next page for description	Map unit 14

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TABLE A.14 (Continued)

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OF 4

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: L4P52-B **DIA.:** 4-INCH
LOCATION: ROOM L-4
ORIENTATION: 40° OFF VERTICAL UPWARD
COORDINATES: N1493.6 ft., W647.2 ft.
ELEVATION: 1306.6 ft. amsl
DRILL METHODS: AIR / ROTARY

LOG BY: WAS
DATE: Dec. 15, 1992
DRILL DATE: 12/10/92 - 12/14/92
DRILLER: RICK BALLEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
13:30		8.0				7.92 - 9.04 ±.03m Halite; clear to grayish orange-pink; coarsely crystalline; some medium scattered discontinuous gray stringers; clay I is along upper contact; contact with lower unit is diffuse.	Map unit 14
13:45 14:05	4	8.5	100				
9:10 12/11/92 9:50	5	9.0 9.5	100			9.04 - 10.67 m Halite; clear; coarsely crystalline; scattered anhydrite seams; lower contact sharp with clay I.	Map unit 15
12:30	6	10.0 10.5	100				
		11.0				10.67 - 11.28 m Argillaceous halite (clay J); brown; medium to fine crystalline.	AH-1

TABLE A.14 (Continued)

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OF 4

WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE:	L4P52-B **DIA.:** 4-INCH	**LOG BY:**	WAS
LOCATION:	ROOM L-4	**DATE:**	Dec. 15, 1992
ORIENTATION:	40° OFF VERTICAL UPWARD	**DRILL DATE:**	12/10/92 - 12/14/92
COORDINATES:	N1493.6 ft., W647.2 ft.	**DRILLER:**	RICK BALLEW
ELEVATION:	1306.6 ft. amsl	**DRILL:**	LONGYEAR D65
DRILL METHODS:	AIR / ROTARY	**DRILL CO.:**	EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION		REMARKS
		11.0					See previous page for description.	
14:00	6	11.5	100			11.28 - 11.80 m	Halite; clear to light brown; coarsely crystalline with clay J.	H-5
9:20 12/14/92 10:00	7	12.0	100			11.80 - 13.89 m	Argillaceous halite; clear to moderate brown; some light moderate reddish orange; medium to coarsely crystalline; contact with lower unit is gradational based on clay content; upper contact with clay K is sharp.	AH-2
10:20 11:10	8	12.5 13.0	100					
12:42	9	13.5 14.0	100			13.89 - 14.02 m	Anhydrite; light gray; microcrystalline.	MB 138

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TABLE A.14 (Continued)

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WIPP CORE-LOG INVENTORY

INTERA
FORM 1400

BOREHOLE: L4P52-B **DIA.:** 4-INCH
LOCATION: ROOM L-4
ORIENTATION: 40° OFF VERTICAL UPWARD
COORDINATES: N1493.6 ft., W647.2 ft.
ELEVATION: 1306.6 ft. amsl
DRILL METHODS: AIR / ROTARY

LOG BY: WAS
DATE: Dec. 15, 1992
DRILL DATE: 12/10/92 - 12/14/92
DRILLER: RICK BALLEW
DRILL: LONGYEAR D65
DRILL CO.: EXP. OPS.

TIME/DATE	CORE RUN	DEPTH m.	% RECOVERED	GEO PROFILES	FRACTURES	DESCRIPTION	REMARKS
14:00		14.0				14.02 - 14.12 m Halite.	H-6
		14.5					

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Box 87
Anthony, TX 79821

Internal

MS	Org.	
1324	6115	P. B. Davies
1320	6831	E. J. Nowak
1322	6121	J. R. Tillerson
1328	6849	D. R. Anderson
1328	6848	H. N. Jow
1335	6801	M. Chu
1341	6832	J. T. Holmes
1395	6800	L. Shephard
1395	6821	M. Marietta
1324	6115	R. L. Beauheim (5)
1324	6115	A. R. Lappin
1330	6811	K. Hart (2)
1330	4415	NWM Library (20)
9018	8940-2	Central Technical Files
0899	4916	Technical Library (5)
0619	12690	Review and Approval Desk (2), For DOE/OSTI