DOE/BC/14934--6

"INCREASING WATERFLOOD RESERVES IN THE WILMINGTON OIL FIELD THROUGH IMPROVED RESERVOIR CHARACTERIZATION AND RESERVOIR MANAGEMENT"

BC/14934-6

Cooperative Agreement Number	DE-FC22-95BC14934

Tidelands Oil Production Company (TOPKO), Long Beach, CA
City of Long Beach, Department of Oil Properties
Stanford University, Stanford, CA
Magnetic Pulse, Inc. (MPI), Houston, TX

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Anticipated Completion Date	March 20, 2000
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Principal Investigators	Dennis Sullivan, City of Long Beach Don Clarke, City of Long Beach Scott Walker, Tidelands Oil Production Co. Chris Phillips, Tidelands Oil Production Co. John Nguyen, Tidelands Oil Production Co. Dan Moos, Stanford University Kwasi Tagbor, MPI
Program Managers	Dennis Sullivan, City of Long Beach Don Clarke, City of Long Beach Scott Walker, Tidelands Oil Production Co.
Reporting Period	October 1, 1996 to December 31, 1996

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Objectives

The objectives of this quarterly report are to summarize the work conducted under each task during the reporting period October - December 1996, and to report all technical data and findings as specified in the "Federal Assistance Reporting Checklist".

The main objective of this project is the transfer of technologies, methodologies, and findings developed and applied in this project to other operators of Slope and Basin Clastic Reservoirs. This project will study methods to identify sands with high remaining oil saturation and to recomplete existing wells using advanced completion technology.

The identification of the sands with high remaining oil saturation will be accomplished by developing a deterministic three dimensional (3-D) geologic model and by using a state of the art reservoir management computer software. The wells identified by the geologic and reservoir engineering work as having the best potential will be logged with a pulsed acoustic cased-hole logging tool. The application of the logging tools will be optimized in the lab by developing a rock-log model. This rock-log model will allow us to convert shear wave velocity measured through casing into effective porosity and hydrocarbon saturation.

The wells that are shown to have the best oil production potential will be recompleted. The recompletions will be optimized by evaluating short radius and ultra-short radius lateral recompletions as well as other techniques.

Summary of Technical Progress

- **Reservoir Characterization**

Continued progress has been made on developing rock-log and fluid-log models needed to calibrate, interpret, and understand acoustic log data. Data from earlier tests of Wilmington cores were further analyzed to determine porosity and to refine pulse transmission velocity determinations. Additional cores of Ottawa sand were also tested to verify the source of anelasticity in the Wilmington samples.

Researchers modified the laboratory system to allow static Young's modulus measurements which will be compared to dynamic measures of shear modulus. Core plug samples from well 169-W were subjected to axial stress relaxation tests. These results will be compared to the reference data set we built with Ottawa sand samples. Work also continued on a 3-D viscoelastic constitutive relationship for the static deformation experiments on the sands to model 3-D stress perturbations. This will quantify the elastic properties and viscosity of the samples under either test, while taking into account the actual shape of the samples.

The rock-log model was studied with the help of Lawrence Livermore National Lab. The effects of 3-phase (sand/clay/fluid) systems on the Gassmann relationship was found not to be entirely correct. A determination on the size of the error and its importance is under way.

- **Reservoir Engineering**

Researchers are creating production bubble maps, injection bubble maps, cumulative production bubble maps, and cumulative injection bubble maps in order to find potential bypassed oil. Efforts are concentrated in the Upper Terminal Zone, and Lower Terminal Zone of Fault Block IV.

- **Deterministic 3-D Geologic Modeling**

The deterministic 3-D geologic model continues to be updated and refined. A separate report on the "Hxo" 3-D geologic model will be supplied with the next scheduled report which is the "Project Evaluation Report". The model area was expanded so the horizon surfaces on the east side of the Daisy Avenue Fault could be more accurately represented.

The geologic 3-D model uncovered a flawed interpretation to the west of the Daisy Avenue Fault. An en echelon fault is the newer interpretation and is supported by the distribution of the scattered data of the four modeled horizons. The en echelon fault interpretation is structurally consistent with other part of the Wilmington Oil Field. The fault interpretation is included in our model and provides good consistency for all the modeled layers. A recompletion candidate has been selected

to test this interpretation and will be recompleted in the next budget period.

The deterministic geologic 3-D model for the Upper Terminal Zone Fault Block IV prospect continues to be updated and refined. Our 3-D model suggest there is a structural trap for oil against the Harbor Entrance Fault which can be exploited by the Y-63 recompletion candidate.

- **Pulsed Acoustic Logging**

Log data from recompletion candidates Z-223 and Z-27 were further analyzed for useable acoustic data. Only a few short intervals were found to be useful. Researchers logged both wells with a nuclear device for comparative purposes and found reasonable agreement between acoustically derived results and nuclear derived results.

As discussed in a previous steering committee meeting, the success of acquiring formation signals with the MPI acoustic tool has been greatly hampered by the strong presence of Stonely (tube) waves arriving at the same time as formation signals.

Researchers also found in modelling wave propagation in cased wells that good cement/casing bond can actually *degrade* low frequency waveforms in certain situations. Trapped energy is propagated more efficiently when cement/casing thickness is large and the formation is soft. This effect was exhibited in Wilmington Field logging runs where the old logging tool yielded better results due to its lack of energy output below 1 kHz. The modified newer logging tool has a very energetic low frequency energy band around 600 Hz. This was the tool used in logging the most recent recompletion candidates. MPI is modifying their source and receiver arrangement of the acoustic tool again to eliminate this situation.

- **Recompletions**

Recompletion candidate wells J-120 and J-15 have been successfully extreme overbalanced perforated, steam consolidated, and placed on production. Neither well has made a trace of sand.

Well J-120 is the Fault Block V Upper Terminal Zone recompletion candidate which we perforated across the "Hx_o" sand. This well took 2,989 m^3cwe (18,800 bcwe) cold water equivalent (cwe) of steam injection. J-120 was shut in for soaking in late August, 1996 and was returned to production in October, 1996. Oil production peaked at 37.7 m^3/d net (237 b/d net) with only a 32.3% water cut in early December, 1996 (Fig. 1). As of the end of this reporting period well J-120 is producing 55.5 m^3/d gross (350 b/d gross), 19.7 m^3/d net (124 b/d net), at a 64.5% water cut. The average producer in the Upper Terminal Zone reservoir produces only 3.9 m^3/d net (25 b/d net) with a very high 97.4% water cut. A tremendously encouraging sign is the production temperature is almost back to a pre-steam temperature. We anticipated that when the well cooled off after producing back the injected heat the oil production might fall off quickly. This has not been the case. Gross and net productivities are much higher than our "optimized" waterflood recompletion. With the 3-D geologic model as a tool, we are recompleting other candidate wells and further developing the "Hx_o" reservoir.

Well J-15 is the Fault Block V Tar Zone recompletion candidate which we perforated across the "F_1" and "F_o" sands. This well took 14,754 m^3cwe (92,800 bcwe) of steam injection. J-15 was shut in for soaking in late August, 1996 and was returned to production in late October, 1996. Oil production is steady at 16.1 m^3/d net (101 b/d net) with only a 79.9% water cut in late December, 1996 (Fig. 2). This compares very favorably to the "optimized" recompletion done on well A-173. Well A-173 is completed in the same sands as J-15 and currently produces 3.5 m^3/d net (22 b/d net) with an 82.8% water cut. Production well Z1-7 was also completed in the same sands as wells J-15 and A-173 but with older recompletion techniques. Well Z1-7 produces 1.6 m^3/d net (10 b/d net) with an 87.5% water cut, much lower than well J-15 and slightly lower than well A-173.

Due to the extremely successful results from wells J-120 and J-15, Tidelands Oil is completing all future wells in a similar manner whenever possible.

Recompletion candidate wells Z-223 and Y-63 have been recompleted with our "optimized" waterflood recompletion techniques and placed on production.

Well Z-223 is the Fault Block V Upper Terminal Zone recompletion candidate which we conventionally perforated across the "Hx", "J", "Z", and "W" sands. The

well was placed on production in December, 1996 (Fig. 3) but appeared to be damaged despite our "optimized" recompletion. Well Z-223 was acid stimulated and returned to production. Additional production results will be available in January, 1997.

Well Y-63 is the Fault Block IV Upper Terminal Zone recompletion candidate which we conventionally perforated across the "Hx", "J", "Y", and "K" sands. The well was placed on production in December, 1996 (Fig. 4). Production results are lower than estimated but the well may be cleaning up. If results are dissappointing, we would also acidize this well.

● Technology Transfer

Researchers attended the Society of Professional Well Log Analysts (SPWLA) Symposium on "Petrophysics in 3-D" in Taos, New Mexico in October, 1996.

Amoco visited Stanford University and discussed a collaborative effort on analyzing dipole data.

Researchers presented to the 1996 American Geophysical Union (AGU) Meeting a paper titled: "Anelasticity and Dispersion in Unconsolidated Sands", Chang, Moos and Zoback.

Researchers had accepted to the 1997 American Association of Petroleum Geologists (AAPG) Meeting a paper titled: "Fluid Detection and Porosity Determination using Acoustic Logs in the Wilmington Field, CA", Moos.

Researchers submitted an abstract to the 1997 AAPG Pacific Section Meeting titled: "Hydrocarbon Detection in the Wilmington Field, CA", Moos and Walker.

Researchers presented papers at the November, 1996 Society of Exploration Geophysics (SEG) Annual Meeting in Denver, CO. Also at the meeting, researchers held a workshop on problems associated with data aquisition of dipole and monopole

data at Wilmington in conjunction with the Shear-Wave Special Interest Group of the Log Characterization Consortium.

Researchers made three presentations in November, 1996 on the Waterflood Project status to the Petroleum Technology Transfer Council (PTTC) meetings held in Bakersfield, Ventura, and Long Beach, CA. Researchers also hosted a "point-counterpoint" discussion on oil detection behind pipe.

Researchers submitted an abstract to the AGU fall meeting titled: "Anelasticity and Dispersion in Unconsolidated Sands", Chang, Moos, and Zoback.

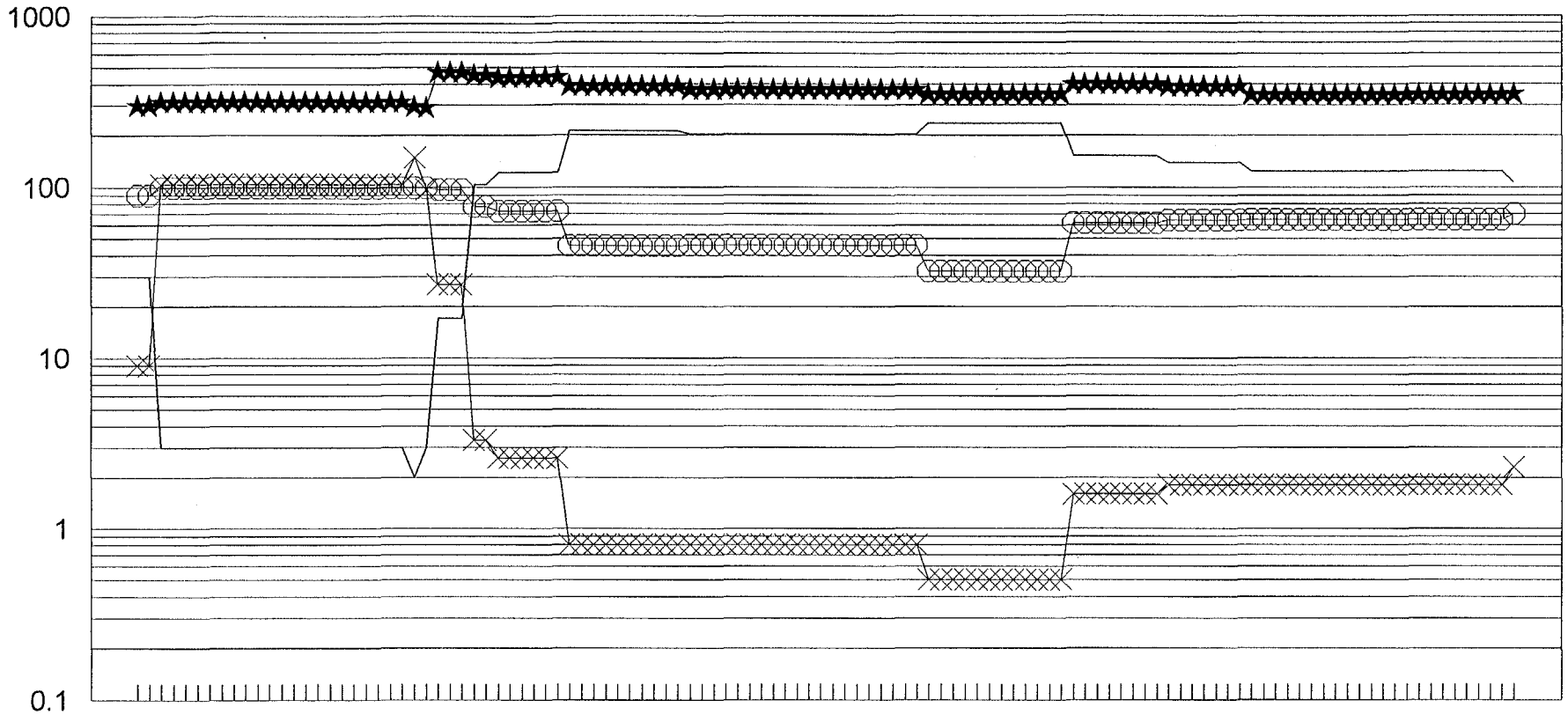
Researchers updated the project's World Wide Web homepage at http://pangea.stanford.edu/~moos/DOE_home.html

References and Publications

None

TIDELANDS OIL PRODUCTION CO.

WELL J-120 RECOMPLETION



10-02-96 THROUGH 01-20-97

★ GROSS B/D — NET B/D ⊖ CUT % ✳ W.O.R.

FIGURE 1

TIDELANDS OIL PRODUCTION CO.

WELL J-015 RECOMPLETION

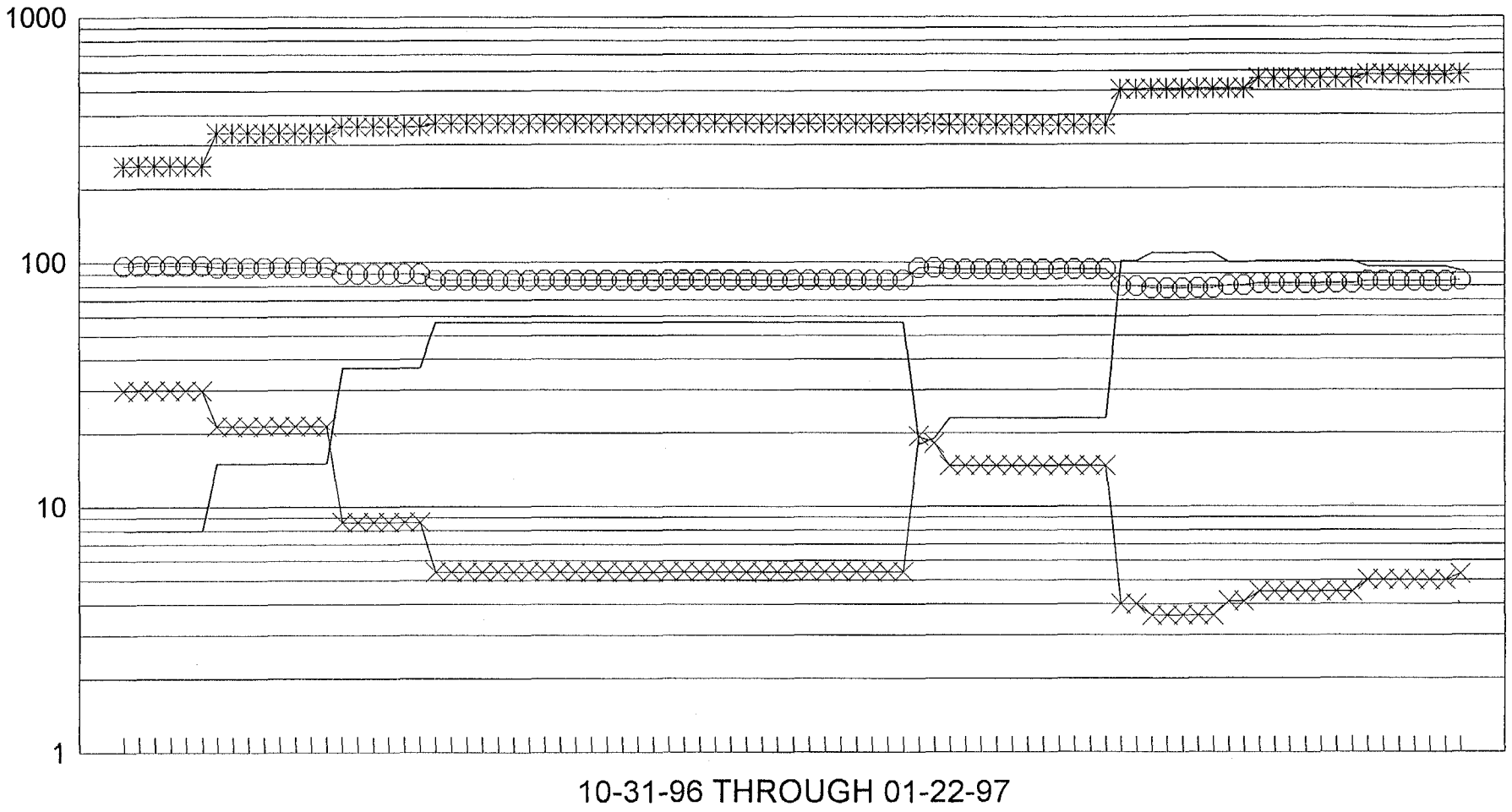


FIGURE 2

TIDELANDS OIL PRODUCTION CO.

WELL Z-223 RECOMPLETION

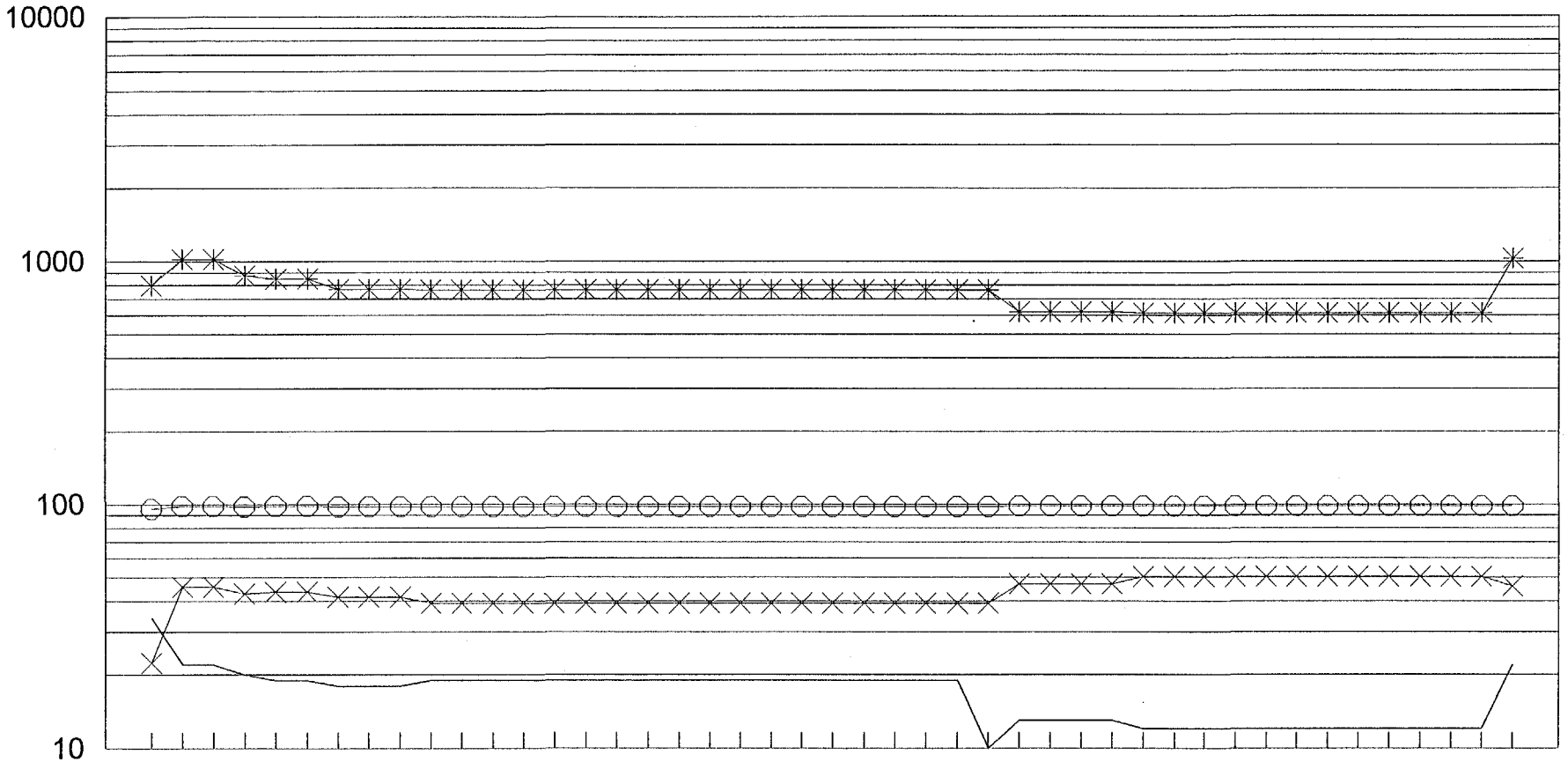


FIGURE 3

TIDELANDS OIL PRODUCTION CO.

WELL Y-063 RECOMPLETION

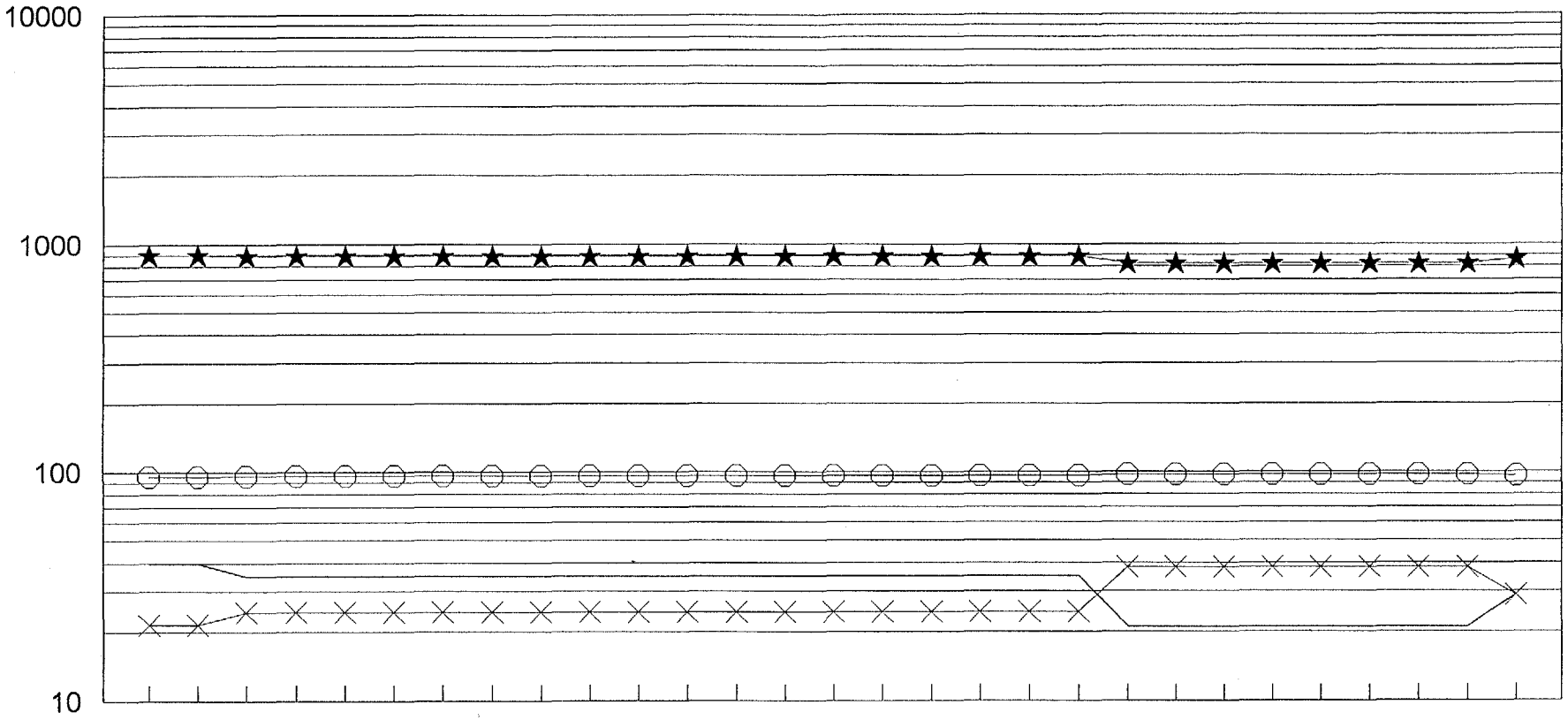


FIGURE 4

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