GJBX-72(77)

URANIUM FAVORABILITY OF THE SAN RAFAEL SWELL AREA, EAST-CENTRAL UTAH

BENDIX FIELD ENGINEERING CORPORATION
Grand Junction Operations
Grand Junction, Colorado 81501

MASTER

October 1977

ISSUED BY THE U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE
UNDER CONTRACT NO. EY-76-C-13-1664

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D. G. Mickle, C. A. Jones, G. L. Gallagher,
Patti Young, and W. S. Dubyk

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SUMMARY

The San Rafael Swell project area in east-central Utah is approximately 3,000 sq mi and includes the San Rafael Swell anticline and the northern part of the Waterpocket Fold monocline at Capitol Reef. Rocks in the area are predominantly sedimentary rocks of Pennsylvanian(?) through Cretaceous age.

Important deposits of uranium in the project area are restricted to two formations, the Chinle (Triassic) and Morrison (Jurassic) Formations. A third formation, the White Rim Sandstone (Permian), was also studied because of reported exploration activity.

The following conclusions were reached:

1. The White Rim Sandstone is considered generally unfavorable on the basis of lithologic characteristics, distance from a possible source of uranium, lack of apparent mineralization, and the scarcity of anomalies on gamma-ray logs or in rock, water, and stream-sediment samples. Exceptions to the general unfavorability of the White Rim Sandstone are: (1) the asphaltite-impregnated rock in the McKay Flats area and (2) the upper drainage basin of Straight Wash where prospecting along faults and fractures may be warranted.

2. The lower Chinle from the Moss Back Member down to the base of the formation is favorable because it is a known producer. New areas for exploration are all subsurface. The Moss Back Member is considered favorable on the north, west, and south sides of the so-called interbelt area where the Moss Back is less massive and is interbedded with finer-grained sediments. The Temple Mountain and Monitor Butte Members, here referred to as the sub-Moss Back members, are favorable in two areas: (1) in the interbelt area on the west side of the swell where recent exploration has discovered mineralized channels and (2) on the lower east and south side of the swell where high, possibly anomalous peaks on gamma-ray logs are frequently associated with sandstone lenses.

3. Both Salt Wash and Brushy Basin Members of the Morrison Formation are favorable. The Salt Wash Member is favorable because it is a known producer. Four channel systems or trunks are identified in the northern part of the San Rafael Swell. Three of these are favorable: the White Star, Price, and Woodside trunks. The area between Cainville Reef and Little Wild Horse Mesa is also favorable. All of these areas contain thick channel sandstones interbedded with mudstone. The Brushy Basin Member is favorable as a low-grade resource. Where occurrences are known, the host rock is a tuffaceous, organic-rich mudstone that crops out over a wide area. Anomalies are present in the Brushy Basin on several gamma-ray logs at the Grassy Trail oil field and elsewhere. Several mines and prospects have been abandoned because they did not contain high-grade ore. As economic conditions change, these low-grade deposits may become important resources.

INTRODUCTION

PURPOSE AND SCOPE

The purpose of this study was to delineate new areas favorable for uranium exploration in the San Rafael Swell region of east-central Utah. Emphasis was placed on the sandstone and siltstone members of the lower Chinle Formation (Triassic) and on the Salt Wash and Brushy Basin Members of the Morrison Formation (Jurassic). The White Rim Sandstone (Permian) was also studied, but not extensively.

This project began in January 1976 and was completed in March 1977. Field work was conducted during the five-month period from February through June 1976.

GEOGRAPHIC SETTING

The area covered by this report extends from Hanksville and the Fremont River on the south, to the Emery-Carbon County line in the north, and from about 10 mi west of Green River, Utah, westward to Utah State Highway 10. Project boundaries are shown in Figure 1. Total area of the project is about 3,000 sq mi.

Two important topographic features are included in the project area. Largest of these is the San Rafael Swell, a large anticline in east-central Utah. The greatest topographic expression of the San Rafael Swell is in Emery County, but structural influence of the swell extends into adjoining counties as well.

The second feature is the Waterpocket Fold, a large monoclinal structure southwest of the San Rafael Swell. Only the northern part of the Waterpocket Fold in the Capitol Reef National Park is included in this project.

PREVIOUS WORK

General geology and stratigraphy of the San Rafael Swell have been described by Gilluly and Reeside (1928), Baker (1946), Hunt and others (1953), Stokes and Cohenour (1956), and Hawley and others (1968). Baars' (1962) stratigraphic interpretation and terminology for the Permian are used in this paper. Stewart and others (1972) comprehensively described Chinle stratigraphy across the Colorado Plateau, and a recent report by Lupe (1976) interpreted depositional systems in the Chinle of the San Rafael Swell. Morrison stratigraphy was described by Craig and others (1955) and Mullens and Freeman (1957).

Uranium deposits in the Chinle of the San Rafael Swell were discussed by Hawley and others (1968); deposits in the Salt Wash Member of the Morrison were discussed by Craig and others (1955). Geology and uranium occurrences in the Capitol Reef area were described by Smith and others (1963). U.S. Atomic Energy Commission Preliminary Reconnaissance Reports (PRRs), open-filed at the Grand Junction Office of U.S. Energy Research and Development Administration, were used to locate mines and prospects that date from the 1950s.

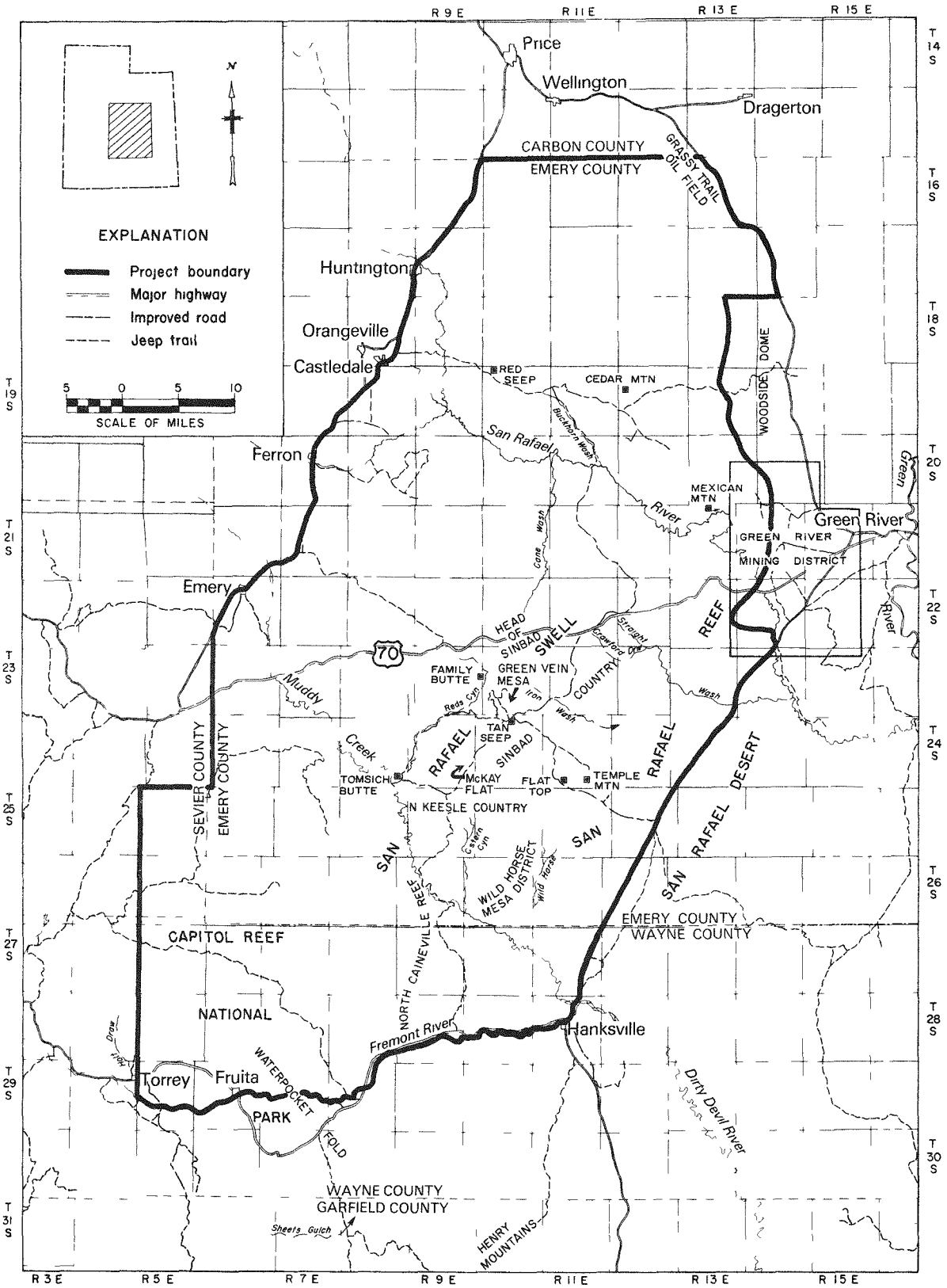


Figure 1. Index map of project area.

ACKNOWLEDGMENTS

Many mines and claims were visited during the field work period of this project. Cooperation of the claim and mine owners is gratefully acknowledged.

PROCEDURES

FIELD WORK

A list of 117 mines and claims was compiled from literature and U.S. Atomic Energy Commission PRRs (App. A.; Pl. 1). About half of the mines and claims, including all the larger ones, were visited to obtain information, such as presence and extent of channeling, channel orientation, presence of faults, other structural controls, size and stratigraphic position of the orebody, and type and extent of alteration. Most mines and claims were in the Chinle and Morrison Formations.

Although difficult to obtain in the project area because of the dry climate and low water table, water samples were collected wherever possible. All samples were acidified and, when necessary, filtered in the field. Locations of samples and results of uranium analyses are shown on Figures 2, 3, 4, and 5. Raw data are presented in Appendixes B, C, and D. Most springs were located in the Morrison Formation.

Surface study of the Morrison Formation emphasized the Brushy Basin Member. Sections were measured in the Brushy Basin Member at known uranium deposits and in the same stratigraphic interval at an adjacent but unmineralized area. Rock samples for petrographic and chemical analyses were collected from each major unit in the measured sections. Channel-type samples were collected in the Brushy Basin Member from many units with higher than background radiation. These samples were used to determine thickness and grade of mineralization.

Stream-sediment samples were collected from the deep canyons incised into the White Rim Sandstone in the interior of the San Rafael Swell. Sediment samples were sieved to obtain a 100-mesh (0.15 mm) fraction for analytical work. Stratigraphic sections of the White Rim were measured in several canyons and a representative rock sample was collected from each unit for petrographic and chemical analyses. Uranium content of White Rim sediment and rock samples is shown in Figure 2 and Appendixes B and C.

ANALYTICAL TECHNIQUES

Petrographic and chemical analyses were performed in the laboratories of the Grand Junction (Colorado) Office operated for the U.S. Energy Research and Development Administration by Bendix Field Engineering Corporation. Equivalent uranium, thorium, and potassium (eU, eTh, and eK) were determined by gamma-ray spectroscopy with a sodium iodide detector. Precision of this method is ±5 percent. Chemical U_3O_8 was determined by colorimetric analysis and is considered to have a precision of ±5 percent. The precision of

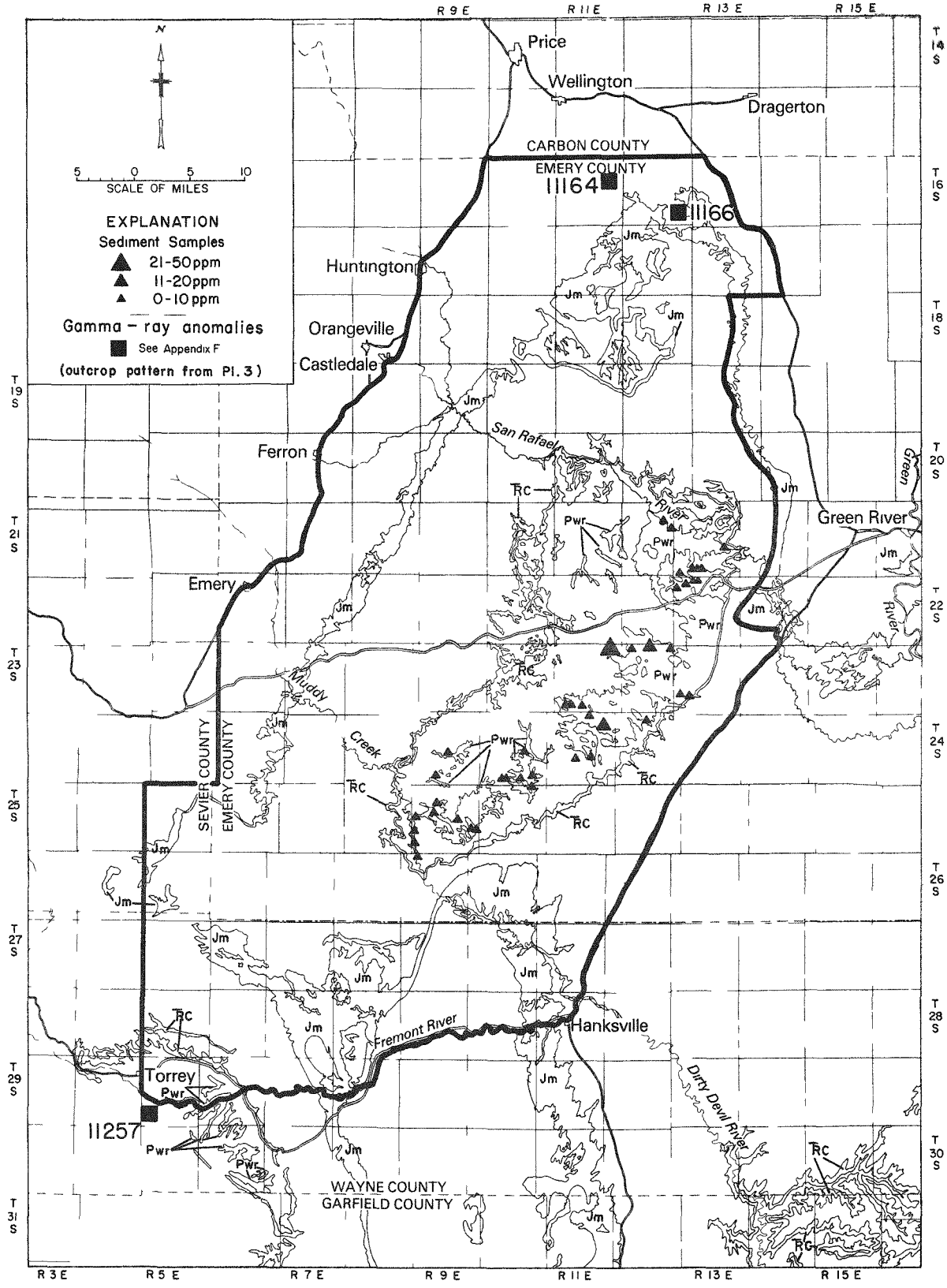


Figure 2. Location of gamma-ray anomalies and stream-sediment samples, White Rim Sandstone.

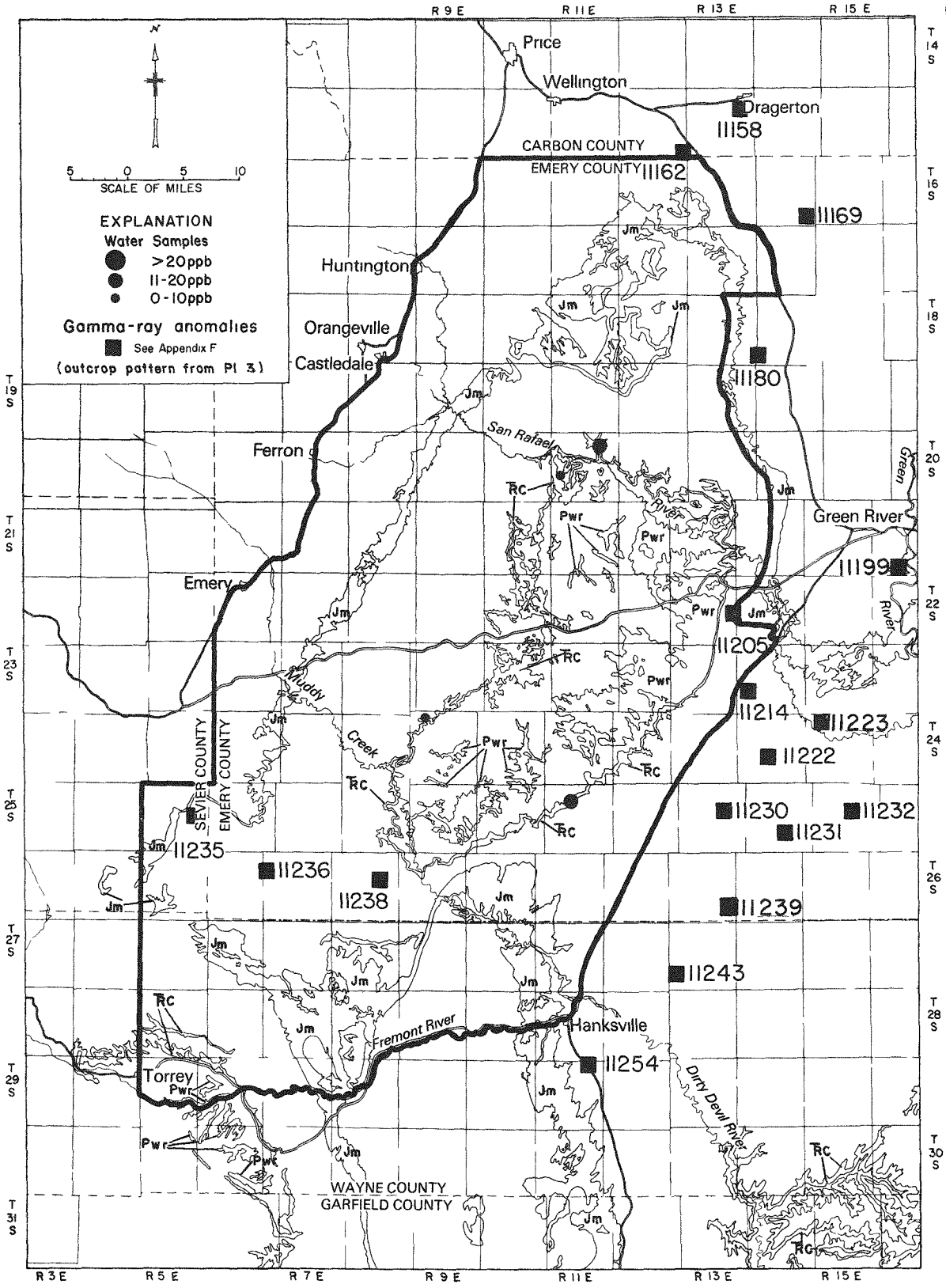


Figure 3. Location of anomalies and water samples, Chinle Formation

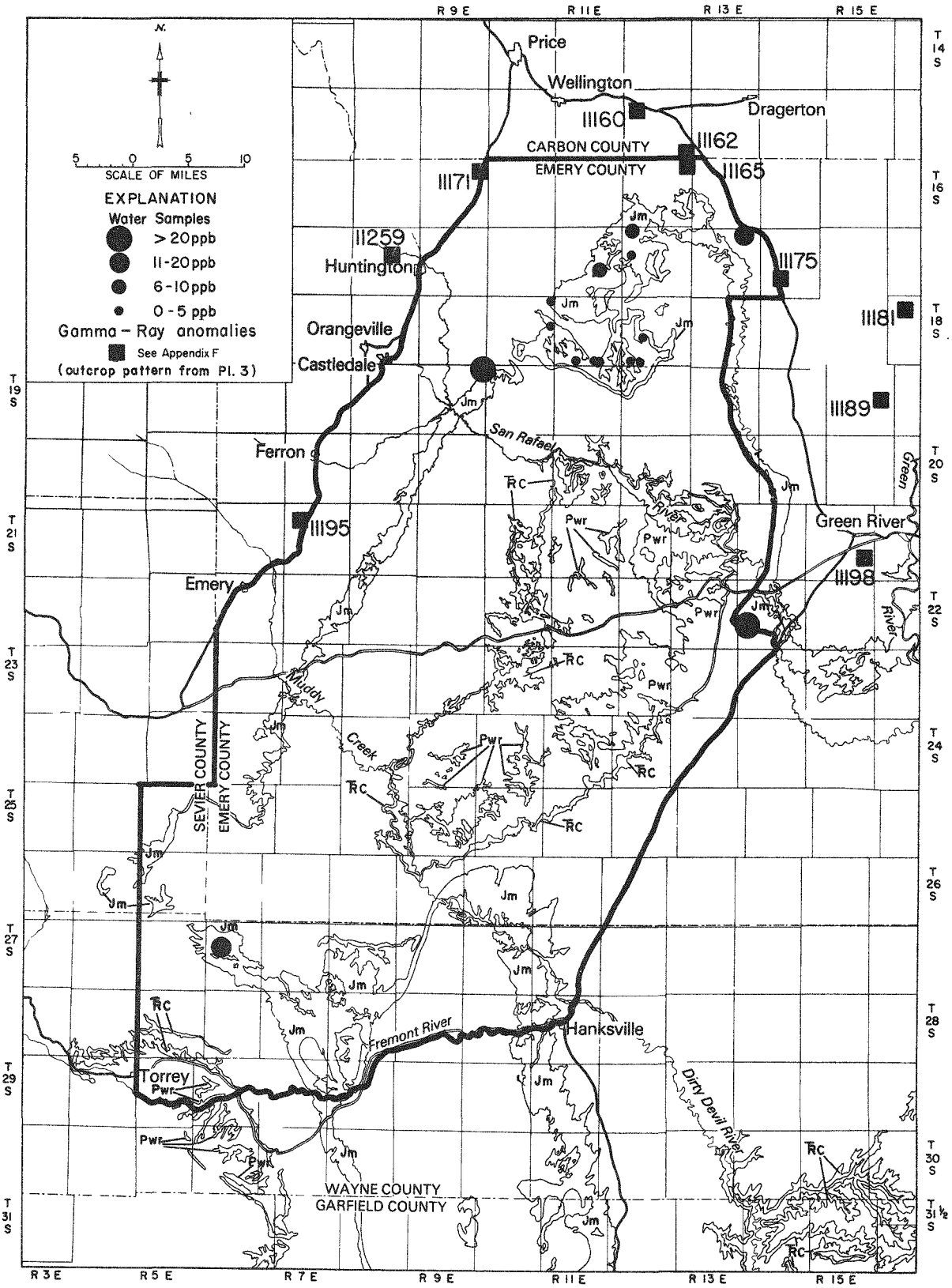


Figure 4. Location of gamma-ray anomalies and water samples, Morrison Formation

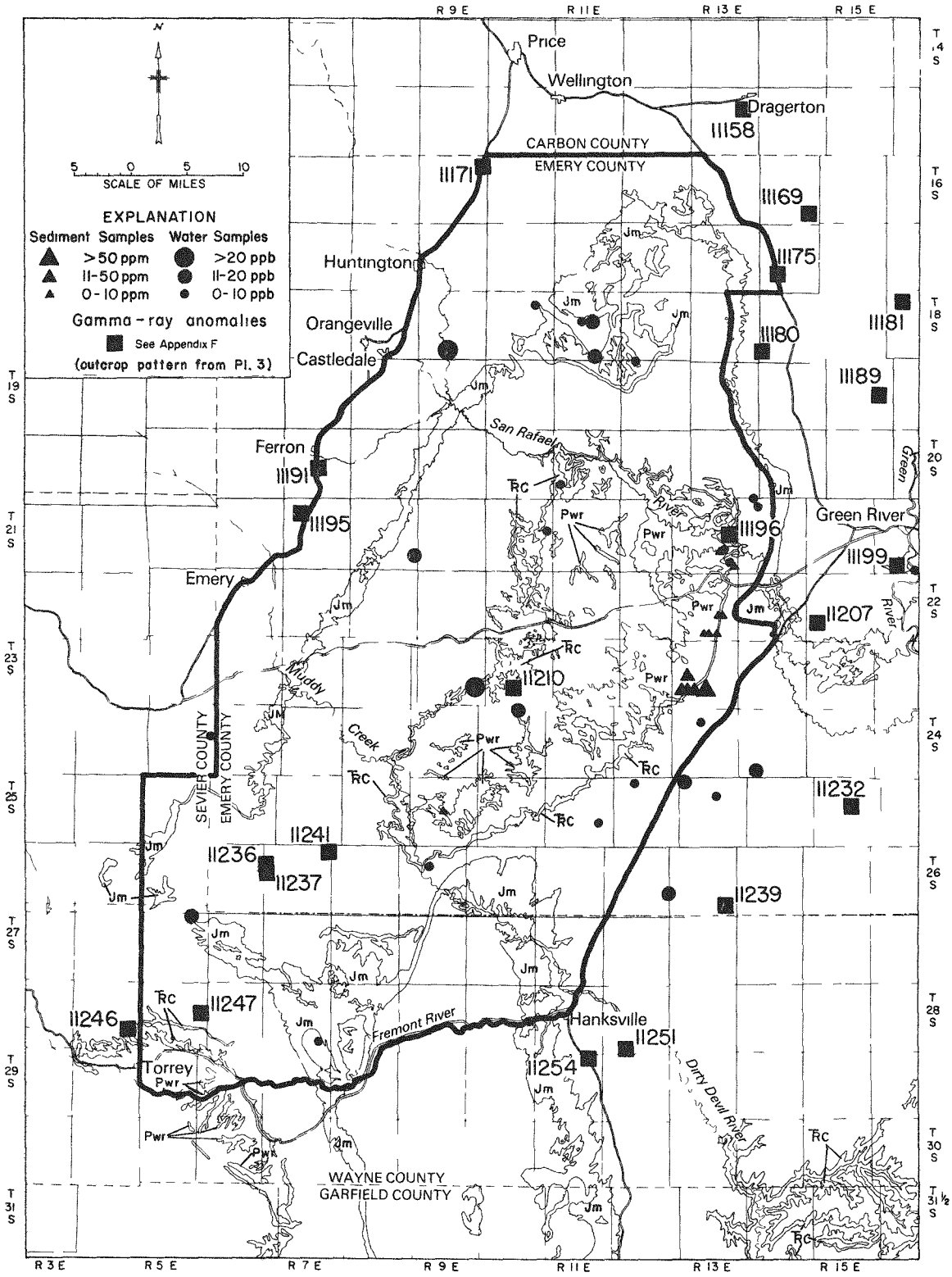


Figure 5. Location of gamma-ray anomalies, stream-sediment samples, and water samples from formations other than Morrison, Chinle, and White Rim.

fluorometric uranium analysis of water samples containing less than 10 ppb is ±100 percent and ±20 percent for water samples containing more than 10 ppb.

Analyses for silver, copper, zinc, vanadium, and selenium were conducted using atomic absorption spectroscopy and are precise to ±5 percent. Organic carbon values are accurate to ±0.5 percent. All other elements were determined by emission spectroscopy and may vary by as much as three places in the reported digit.

SUBSURFACE METHODS

Gamma-ray logs from 128 test wells were used for correlation and to construct the isopach and lithologic maps for the Chinle and Morrison Formations. These wells are listed in Appendix E; their locations are shown on Plate 2.

Gamma-ray logs were interpreted as shale logs (Dresser Atlas Div., 1975, p. 6-1). Low gross-gamma counts indicate nonshales such as sandstone and limestone; relatively high gross-gamma counts indicate shales and muddy sediments with high potassium content in the clay fraction. This interpretation is consistent with the lithologies of the formations studied. Very high gross-gamma counts (2X to 3X shale background) possibly indicate mineralized horizons and are referred to as anomalies.

Figures 2, 3, 4, and 5 show locations of test wells that contain anomalies. Values of anomalies, converted to API units where possible by using the conversion factors given by Pirson (1970, p. 245), are listed in Appendix F.

Characteristics of gamma-ray log curves used to delineate contacts and correlate formations are described in the stratigraphy section of this report.

GEOLOGY

GENERAL

The San Rafael Swell is a large anticlinal structure in east-central Utah. The greatest topographic expression of the swell is in Emery County. The outer rim of the San Rafael Swell is composed of resistant sandstones of the Glen Canyon Group. On the eastern flank of the swell, where the rocks dip steeply, these sandstones form an impressive hogback, known as the San Rafael Reef. The central part of the swell, known as Sinbad Country, is an area of mesas and deep canyons eroded into the Chinle, Moenkopi, Kaibab, and White Rim Formations.

Capitol Reef at the northern end of the Waterpocket Fold dominates the topography southwest of the swell. The Waterpocket Fold is an easterly dipping monocline on the east flank of the High Plateaus region of south-central Utah. Like the outer rim of the swell, the crest of the Waterpocket

Fold consists of resistant sandstones of the Glen Canyon Group. The Chinle and Moenkopi Formations are exposed on the lower slopes and on the canyon and valley floors.

Most rocks of the San Rafael Swell and Capitol Reef are sedimentary. They consist of continental and marine sandstones, mudstones, siltstones, and shales with a few marine limestones low in the section. These rocks range in age from Pennsylvanian(?) through Cretaceous (Fig. 6). The outcrop pattern of these rocks is shown on Plate 3, a generalized geologic map modified from Hintze and Stokes (1964) and Williams and Hackman (1971).

STRATIGRAPHY

Pre-White Rim Rocks

The oldest rocks exposed in the San Rafael Swell area are in a deep and inaccessible part of Straight Wash in the San Rafael Swell (sec. 19, T. 23 S., R. 13 E.). These rocks consist of about 100 ft of limestone and dolomite overlain by 260 ft of sandstones interbedded with carbonates (Hawley and others, 1968). Hintze and Stokes (1964) and Williams and Hackman (1971) mapped these rocks as the Hermosa Formation or Group (Pennsylvanian), but Hawley and others (1968) considered the rocks to be the Elephant Canyon Formation (Baars, 1962), with the Hermosa Group(?) present at the base.

White Rim Sandstone

A thick sequence of massively bedded sandstone overlies the Elephant Canyon Formation. These sandstones exhibit large-scale cross-bedding throughout except for subordinate plane-bedded sandstone at intervals, especially in the upper part. Thicknesses of 650 and 880 ft are reported by Hawley and others (1968), but only the upper 200 to 300 ft were studied for this report.

Most previous work referred to this sandstone sequence as Coconino, which inferred correlation with the Coconino Sandstone at the Grand Canyon. Baars (1962) separated rocks in the Moab area correlative with those in the swell into three units: Cedar Mesa sandstone at the base, intervening red beds of the Organ Rock shale, and the overlying White Rim Sandstone. In the swell the Organ Rock red beds are absent, and Cedar Mesa and White Rim sandstones are indistinguishable (Baars, 1962, p. 155, 191). Because only the upper 200 to 300 ft of these sandstones were of interest to this study, the term "White Rim" is used in this report.

As expected of a clean, probably eolian sandstone, the White Rim is characterized on gamma-ray logs by uniformly low gross-gamma counts. Usually the top of the formation is marked by an abrupt increase in radiation followed by gradually decreasing radiation in the more calcareous and thinly bedded Gamma member sandstones at the base of the overlying Kaibab Formation. In some wells, the radiation increase at the top of the White Rim is considered anomalous.

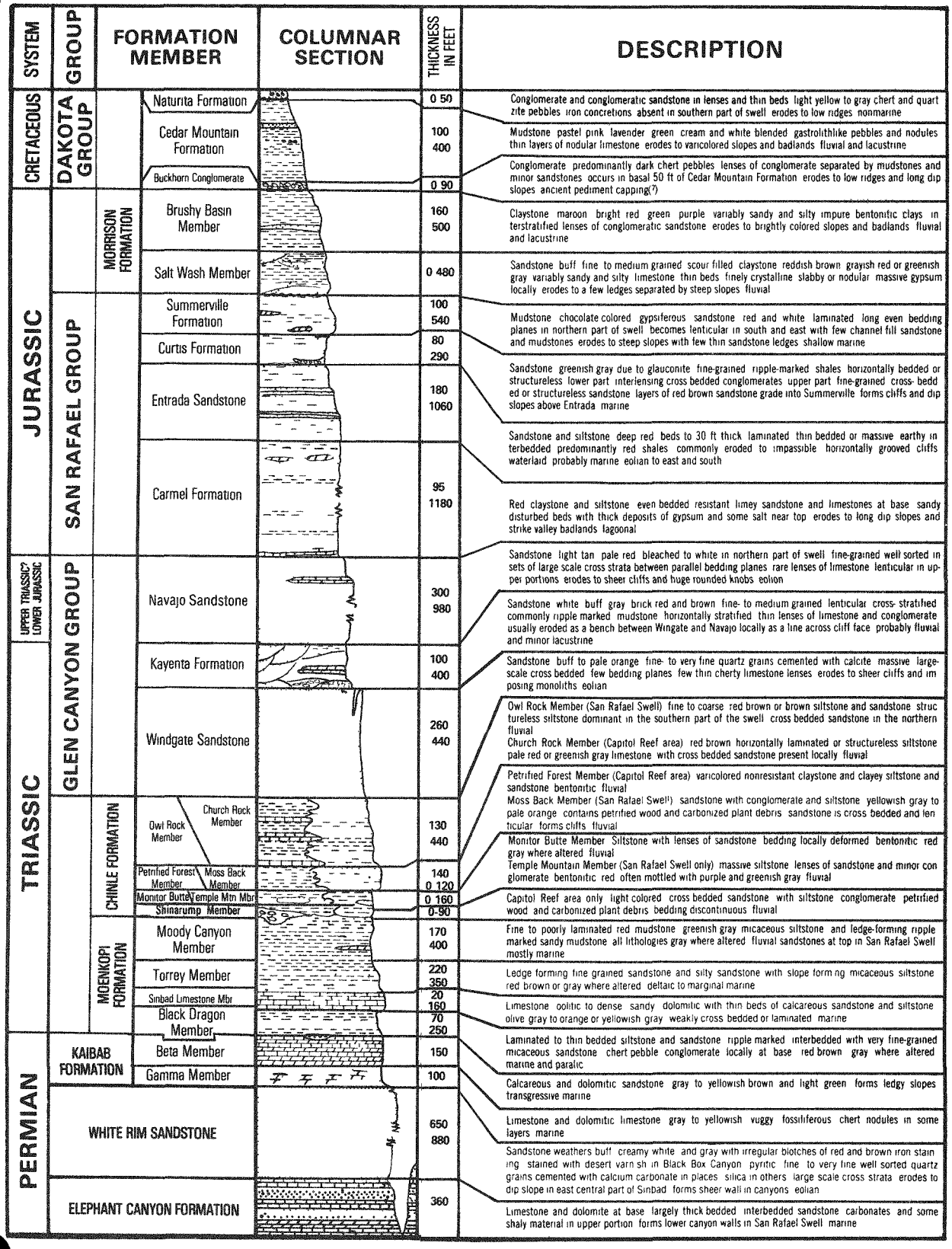


Figure 6. Generalized stratigraphic column, San Rafael Swell and Capitol Reef, Utah.

Kaibab Formation

McKee (1938) divided the Kaibab Formation in the Grand Canyon area into three members: a lower Gamma member (transgressive phase), a middle Beta member (stable-shelf carbonate phase), and an upper Alpha member (regressive phase). Field work for this study and the work of Irwin (1971) indicate that only Beta and Gamma members are present in the project area.

The Beta member is dolomitic limestone or dolomite. Certain layers are fossiliferous, others contain chert nodules or geodes. Some geodes contain a material similar to asphalt that has the odor of petroleum.

The Gamma member, at the base of the Kaibab, consists of calcareous or dolomitic sandstone. These sandstones are soft and weather to form ledgy slopes that are partly covered by soil. Beds in the Gamma member, which typically range from 1 to 3 ft in thickness, contrast markedly with the more massively bedded, resistant, and well-exposed sandstone in the underlying White Rim formation.

Davidson (1967), Irwin (1971), and Girdley (1974) place the dolomitic sandstones of the Gamma member at the top of the White Rim Sandstone rather than in the lower Kaibab. However, for this project, Gamma sandstones are assigned to the Kaibab following McKee's original usage. In outcrop and on gamma-ray logs, the contact between the White Rim and Gamma sandstones is sharp and easily recognizable. On gamma-ray logs the contact is marked at the base of the abrupt increase in radioactivity at the top of the White Rim. Radiation in the Gamma member usually decreases upward to a minimum at the base of the Beta member of the Kaibab. Gamma radiation in the carbonate layers of the Beta member is as low or nearly as low as in the White Rim Sandstone.

The Kaibab Formation ranges from less than 10 ft to more than 220 ft in thickness, and is missing in some test wells. Where present, the Gamma member is as thick as 100 ft, and the Beta member is as thick as 150 ft. Thickness of each member varies irregularly and independently of the other. Variation in thickness of the Gamma member may be due to relief on the top of the underlying White Rim Sandstone at the time of deposition of the Gamma member. Much of the thickening and thinning of the Beta member is due to relief on the Permian-Triassic unconformity at the top of the member.

Moenkopi Formation

The Moenkopi Formation, of Early and Middle(?) Triassic age, is exposed over much of Sinbad Country in the central part of the San Rafael Swell. The Moenkopi is also exposed west of Capitol Reef to the west and south of Fruita, Utah. Thickness of the Moenkopi ranges from 410 to more than 1,100 ft in the San Rafael Swell and is as much as 970 ft thick at Capitol Reef. The thickest Moenkopi is in the northwest part of the swell.

The Moenkopi, with the exception of the Sinbad Limestone Member, is a series of red-brown shale, siltstone, and sandstone red beds. In Sinbad

Country the lower and much of the upper Moenkopi has been bleached from red-brown to shades of gray, greenish-gray, and yellowish-gray.

Four members of the Moenkopi are present throughout the project area. In ascending order, these members are the Black Dragon, Sinbad Limestone, Torrey, and Moody Canyon. The Black Dragon, Torrey, and Moody Canyon members were informally named (Blakey, 1974).

The Black Dragon member is a series of nonresistant, evenly laminated to thinly bedded siltstones and very fine-grained sandstones. Locally, chert-pebble conglomerate is at the base. The Black Canyon is marine and paralic in origin (Blakey, 1974). The upper contact intertongues with and is gradational with the Sinbad Limestone Member.

The Sinbad Limestone Member is a prominent cliff-forming unit that caps mesas and underlies dip slopes in both the San Rafael Swell and Capital Reef. The member consists of less than 20 to more than 160 ft of gray limestone, pale-orange to yellowish-gray dolomite, and thin beds of calcareous sandstone and siltstone. Some carbonate layers are oolitic, and some are fossiliferous. The Sinbad Limestone is a tongue of shallow marine carbonates that extends eastward from western Utah (Blakey, 1974). The Sinbad Limestone Member thins and pinches out eastward near the Colorado River, but it is a reliable marker in the project area.

The Torrey member is a series of siltstones, sandy siltstones, and fine-grained sandstones that is commonly ripple marked. The sandstones and coarse siltstones are resistant and weather to form ledges, whereas the softer, finer-grained beds form slopes. The Torrey intertongues with the underlying marine Sinbad Limestone and is interpreted by Blakey (1974) to be a deltaic and marginal-paralic marine deposit. Contact between the Torrey and overlying Moody Canyon member is at the change from the ledgy sandstone and siltstone below to a sequence of even-bedded, slope-forming siltstone above. The contact may be hard to place at some localities where the lithologic change between the two members is transitional.

The Moody Canyon member, the uppermost member of the Moenkopi in the project area, is a homogeneous sequence of siltstone and mudstone at the base with resistant, ledge-forming sandy mudstone at the top. These siltstones and sandy mudstones appear to have been deposited adjacent to or in a shallow sea. Thus, all four members of the Moenkopi are interpreted as marine, paralic, tidal-flat, or deltaic deposits.

An exception to the general marine character of the Moenkopi may be the sandstone sequence that occurs at the top of the Moody Canyon member in the San Rafael Swell. These sandstones are found only in the extreme northeastern and southwestern parts of the swell. The sandstones are lenticular in beds 1 to 7 ft thick. They are cross-bedded and fine to coarse grained. Lenticularity and cross-bedding of these sandstones indicate that they are fluvial. They may represent the initial phase of continental sedimentation that was to continue through the Late Triassic into Early Jurassic time during which the Chinle Formation and Glen Canyon Group were deposited (Blakey, 1974).

Chinle Formation

The Chinle Formation (Upper Triassic) is one of the two main uranium-producing formations in the project area. The Chinle crops out in a continuous belt around the San Rafael Swell and on isolated buttes in the Sinbad Country of the swell. In the Capitol Reef area, the Chinle is exposed on the west side of the Waterpocket Fold and in the cliffs north of Torrey and Fruita.

Stewart and others (1972) divided the Chinle into a lower, bentonitic part and an upper, nonbentonitic part. The bentonitic part is represented by five members: Shinarump, Temple Mountain, Monitor Butte, Moss Back, and Petrified Forest; the upper part is represented by the Owl Rock and Church Rock Members. Not all members are present everywhere in the project area. In the San Rafael Swell, the Temple Mountain, Monitor Butte, Moss Back, and Church Rock Members are present. Shinarump, Monitor Butte, Petrified Forest and Owl Rock Members make up the Chinle in the Capitol Reef area (Figs. 6, 7).

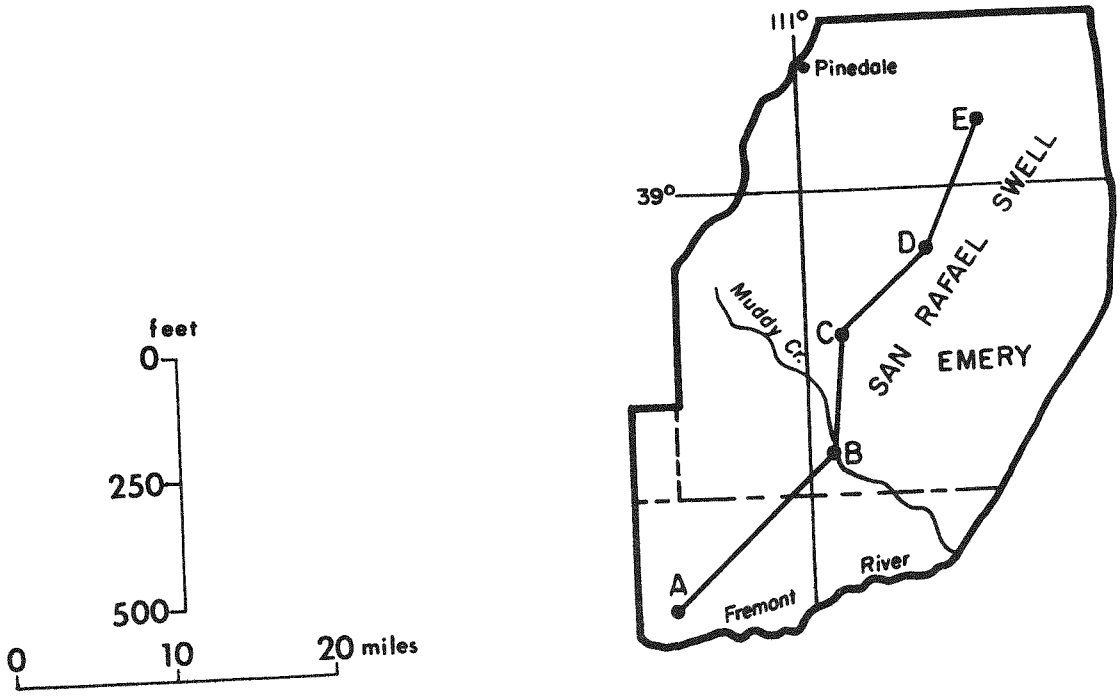
The distinction between lower (bentonitic) and upper (nonbentonitic) parts of the Chinle may be significant because bentonite is a clay, chiefly montmorillonite, derived from devitrification and alteration of glassy igneous material, usually tuff or ash. It is widely believed that volcanic ash is the source of uranium for many deposits (Adler, 1974, p. 145). All mines, claims, and prospects in the Chinle (App. A) are in the lower, bentonitic part of the Chinle in channel-fill sandstone and surrounding siltstones of the Shinarump, Temple Mountain, Monitor Butte, and Moss Back Members.

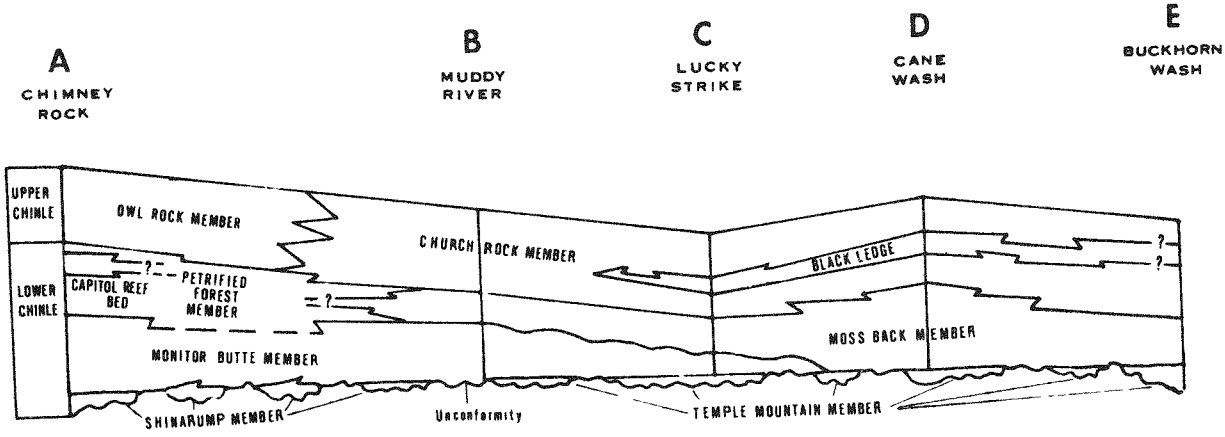
Over most of the project area, the Shinarump is absent; and the basal Chinle consists of the Temple Mountain and Monitor Butte Members (Hawley and others, 1968). Because distinction between the Temple Mountain and the Monitor Butte Members is difficult and because distinction is not important here, the two members are informally referred to as the sub-Moss Back member of the Chinle.

Representative gamma-ray logs for the Chinle are shown in Figure 8. The base of the Chinle is usually marked by a high gross-gamma count. In some cases, this count is anomalously high (log A, Fig. 8). A sandstone is usually found also near the base. On log A (Fig. 8) this sandstone is the Moss Back; on log B, the sandstone is a lens in one of the sub-Moss Back members. In the Capitol Reef area, the basal sandstone may be the Shinarump Conglomerate. The top of the Chinle is easily identified by the uniformly low gross-gamma counts of the Wingate Sandstone above the higher and more variable counts of the Church Rock and Owl Rock Members.

The upper, nonbentonitic part of the Chinle consists of two members, the Church Rock Member in the San Rafael Swell and the Owl Rock Member in the Capitol Reef area. These strata are either nonbentonitic or less bentonitic than the mudstone and siltstone facies of the lower Chinle (Stewart and others, 1972).

The Church Rock Member overlies the Moss Back Member throughout the swell and may overlie the Petrified Forest Member for a short distance south





(modified from Stewart and others, 1972)

Figure 7. Generalized north-south cross section showing correlation of members in the Chinle Formation.

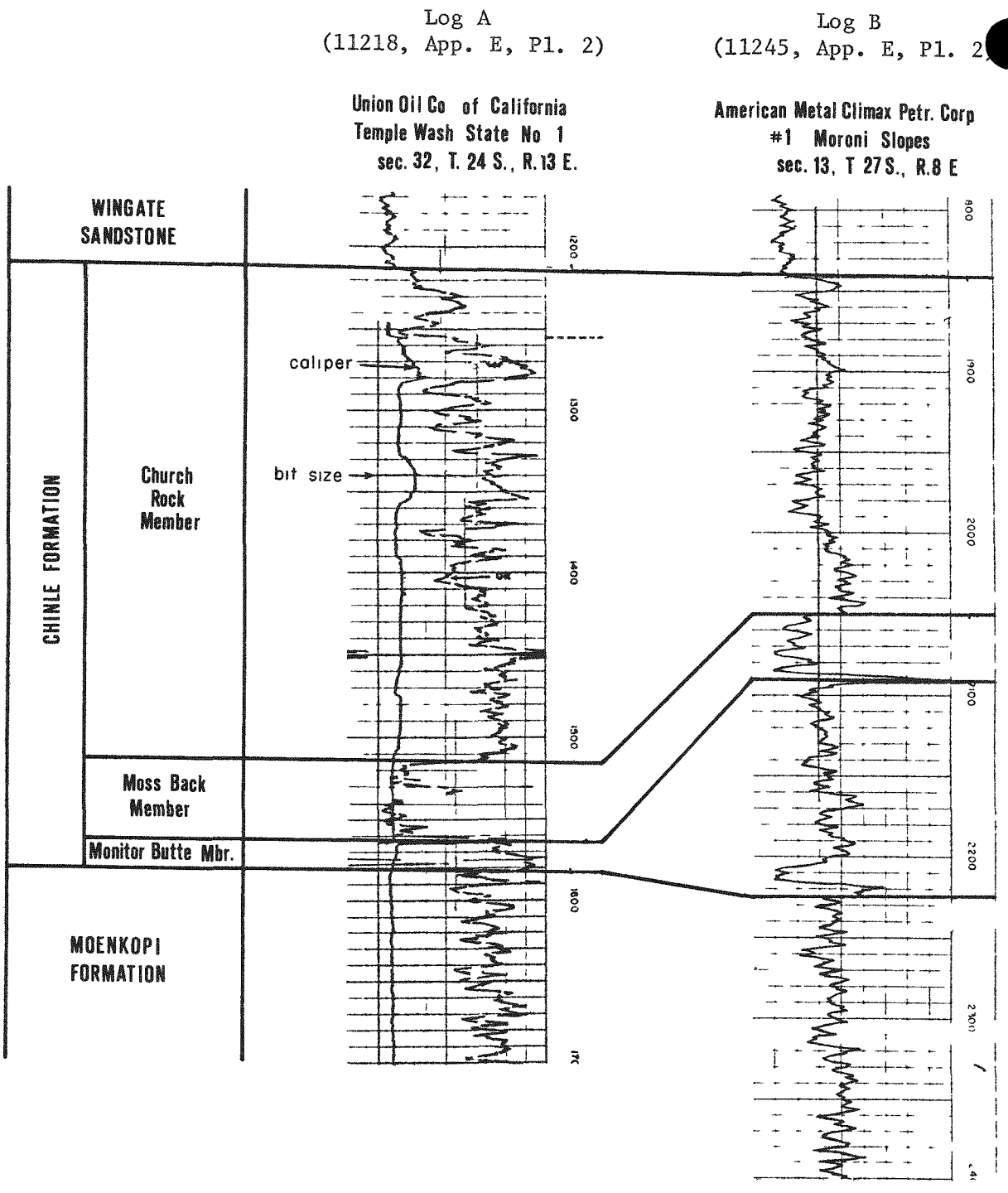


Figure 8. Representative gamma-ray logs of the Chinle Formation.

of the Moss Back pinchout in the subsurface (Fig. 7). The Owl Rock Member overlies the Petrified Forest Member at Capitol Reef and intertongues with the Church Rock Member farther north. Contact of both Church Rock and Owl Rock with the overlying Wingate Sandstone is a flat plane considered to be a disconformity.

Shinarump Member. The Shinarump Member is present only at Capitol Reef where it crops out as a white band, discontinuous at places, between the fine-grained red beds of the underlying Moenkopi and the varicolored beds in the overlying part of the Chinle. The dominant lithology of the Shinarump in the project area is light-colored, medium- to coarse-grained, cross-bedded sandstone. Also present are lenses of gray and greenish-gray siltstone, beds of clay or mudstone, conglomerate, alunite layers, carbonized plant fragments, and fossil logs that are either carbonized or silicified. Pyrite nodules, 3 to 6 in. in diameter, have been found in Holt Draw (sec. 35, T. 28 S., R. 4 E.). Iron oxide "freckles" are common locally and are probably derived from pyrite. A 4-in.-thick layer of radioactive red chert is reported near a pinchout of the Shinarump in sec. 36, T. 29 S., R. 6 E. This chert layer has small coatings of petroliferous material and blue and green stains of secondary copper minerals (Smith and others, 1963).

Plant remains are either scattered throughout the sandstone or are concentrated in pockets or along bedding planes. Smith and others (1963, p. 17) describe some of these concentrations as highly carbonaceous beds and lenses of coal from 1 in. to more than 1-1/2 ft thick, but such concentration of organic debris is apparently exceptional. Smith and others further report that carbonized logs are more abundant than silicified logs, and some of the silicified logs have thin coatings of black carbonaceous material.

The Shinarump ranges in thickness from 0 to 90 ft. In the vicinity of Fruita and southeast of Fruita, the Shinarump is discontinuous. The Oyler mine (86, App. A, Pl. 1) is in one of these discontinuous outcrops.

The basal contact of the Chinle is an erosional unconformity. The unconformity is evident wherever basal sandstones, such as the Shinarump, occupy stream-cut channels and scours eroded into the underlying Moenkopi Formation. Notable Shinarump channel fills are at the Oyler mine, in the area south of Holt Draw, and in the area north of Sheets Gulch. Channels, 15 and 25 ft deep, were eroded into the Moenkopi and filled with Shinarump sandstone at the last two localities. Lenticularity of the beds, nature of the cross-bedding, transported logs, accumulations of smaller plant debris, and conglomerate stringers in the sandstone are further evidence of the fluvial origin of the Shinarump.

The subsurface extent of the Shinarump north and east of the Capitol Reef is unknown. No Shinarump is recognized in outcrops of the San Rafael Swell; thus, the pinchout is somewhere between Capitol Reef and the San Rafael Swell. Basal Chinle sandstones could be correlated with the Shinarump in only one or two test holes north and northeast of the Shinarump outcrops. One test hole, Texaco's No. 2 Thousand Lake Mountain unit (11246, App. E, Pl. 2), is located less than 1 mi from the nearest Shinarump

outcrop. A sandy interval which may be Shinarump is also present at the base of the Chinle at a depth of 863 ft in the Phillips Petroleum Co. Spring Canyon Start No. 1 (11247) test. No other test holes revealed sandstones that could be correlated with the Shinarump.

Temple Mountain and Monitor Butte Members. Basal Chinle throughout the project area north of Capitol Reef is composed of two members: Temple Mountain and Monitor Butte. Both units are thin and range in thickness from 0 to as much as 160 ft but are usually 30 ft or less. Either or both members may be present at a given place. Locally they interbed or intergrade with each other. In the subsurface they cannot be distinguished and, therefore, in this report, they are referred to as the "sub-Moss Back member".

The Temple Mountain Member consists of massive mottled siltstone, lenses of medium- to coarse-grained quartz sandstone, and minor conglomerate. Some of the mottling in the siltstone appears to be highly weathered carbonaceous material, at least in part. At places, this siltstone is stained brown by what appears to be weathered humic material. The Monitor Butte is characterized by less massive siltstone; by thin interbeds of ripple-marked, fine-grained sandstone; and by well-sorted, fine-grained feldspathic sandstone. Locally, the Monitor Butte is characterized by steeply dipping beds of siltstone and sandstone. Deformation of these beds was apparently caused by slumping before overlying beds were deposited. Slumping may indicate proximity to a paleochannel and channel-fill sandstone within the Monitor Butte Member (Hawley and others, 1968).

The Monitor Butte Member correlates with rocks in the lower Chinle to the south of the project area. The Temple Mountain is formally recognized only in the San Rafael Swell, although it too may have correlatives elsewhere (Hawley and others, 1968). Both members are locally altered. The nature and extent of alteration is discussed by Hawley and others (1968).

Siltstones of both Temple Mountain and Monitor Butte Members are varicolored, but red is the dominant color. Where alteration has occurred, the rocks are purple and greenish-gray. Silty and clayey beds are nonresistant and weather to a frothy or "popcorn" textured surface, which is indicative of high bentonite content in the clay fraction of the rocks.

Sandstones in the sub-Moss Back member are lenticular channel sandstones that fill either intraformational scours or scours eroded into the underlying Moenkopi. Most of the uranium is in these lenticular channel-fill sandstones, which are several feet thick. At the Delta mine, the sandstone in the Monitor Butte is 30 ft thick. The Monitor Butte Member contains mineralized sandstones at many localities, including Delta mine, Lucky 7 prospect, Green Vein Mesa, the Cistern Canyon Annex - Lower Wild Horse Point area, and Mexican Mountain.

The basal unit of the Chinle in the southern part of the San Rafael Swell south of Temple Mountain is assigned to the Monitor Butte (Hawley and others, 1968, p. 19). In the northern part of the swell, the basal unit is Temple Mountain. In the intervening area, both members can be recognized, but where the two interfinger or intergrade, distinction may be difficult to make.

Moss Back Member. The Moss Back Member of the Chinle overlies the Temple Mountain and Monitor Butte Members except for a few places where the latter have been removed by erosion at the base of Moss Back channels. At Capitol Reef the Moss Back is not present because it pinches out north and east of the reef (Fig. 7).

The Moss Back is composed of sandstone with subordinate conglomerate and splits of claystone and clayey siltstone. Because the Moss Back is more resistant to erosion than the underlying and overlying rocks, it stands out as a resistant bench or ridge. Where it is thin-bedded, the Moss Back is less prominant, and upper and lower contacts are less easily defined. In the project area, thickess ranges from 0 to 120 ft.

Hawley and others (1968) divided the Moss Back in the San Rafael Swell into three northwest-trending areas. In the southwest, the Moss Back is massive, but it thickens and thins abruptly as a result of extensive channel scouring at the base. In the central area, the Moss Back is massive but thicker than in the other two areas. Generally, it exceeds 80 ft in thickness and thickens gradually toward the northwest. This central area of thick Moss Back probably represents the position of the main system of channels during Moss Back deposition. In the northeastern area, the Moss Back is no longer massive but consists of thin-bedded sandstone interbedded with siltstone.

The massive facies in the central and southern part of the swell consist of an upward-fining sequence of quartz-pebble conglomerate; massive fine- to medium-grained sandstone; limestone-pebble conglomerate; and, near the top, a fine-grained, platy-weathering cross-bedded sandstone (Hawley and others, 1968). Lupe (1976) identified three such cycles of upward-fining sequences in the Chinle of the San Rafael Swell. Each of the three cycles begins with a conglomerate or sandstone at the base. The thickest cycle is the lower two-thirds of the Chinle. The sandstone and conglomerate at the base of this cycle appear to be the Moss Back. The upper two cycles are in the uppermost part of the Chinle and are uraniferous even though they are lithologically similar to the lowest cycle (Lupe, 1976, Fig. 2).

The conglomerates contain coalified and silicified logs. Smaller plant debris is often concentrated along bedding planes in the conglomerate at the base of the member or in the coarsest sandstone just above the base. Higher in the member, plant debris is much less abundant although logs may be conspicuous. Petroleum is found in the massive sandstones that overlie the basal quartz-pebble conglomerates.

Over most of the San Rafael Swell, the top of the Moss Back is taken where the resistant sandstones of the Moss Back are overlain by red siltstone and sandstone of the Church Rock Member. Where the upper part of the Moss Back consists of fine-grained, platy-weathering thin-bedded silty sandstone, these silty sandstones appear to be transitional with siltstones of the Church Rock Member. At such places, the contact between the Moss Back and the Church Rock Members may be difficult to place.

Petrified Forest Member. The Petrified Forest Member consists of varicolored, nonresistant claystone, clayey siltstone, and clayey sandstone. The clay fraction is rich in montmorillonite derived from alteration of volcanic material, probably wind-blown ash. The clay expands on contact with water and develops a frothy "popcorn" texture on weathered surfaces.

The Petrified Forest Member is exposed only in the Capitol Reef area where it overlies the Monitor Butte Member and is overlain by the Owl Rock Member. Stewart and others (1972) suggested that the Petrified Forest is, at least in part, the lateral equivalent of the Moss Back (Fig. 7).

Thickness of the Petrified Forest Member is about 140 ft at Chimney Rock in the Capitol Reef area. The northern pinchout is along an east-northeast line a few miles north of the Capitol Reef outcrops. The northern pinchout is not exposed. South and southwest of Capitol Reef, the Petrified Forest gradually thickens.

Owl Rock Member. The Owl Rock Member is pale red or pale reddish-brown, horizontally laminated or structureless siltstone interstratified with pale red or light greenish-gray limestone beds. Ripple-laminated siltstone with sandstone, cross-bedded sandstone, and siltstone-pebble conglomerates are present locally.

Limestone makes up 5 to 10 percent of the member. Limestone consists of relatively resistant, sometimes nodular beds that weather to form escarpments which interrupt the smooth but steep slopes on weathered siltstone. Much of the limestone was apparently formed by replacement of volcanic ash beds (Stewart and others, 1968), although volcanic ash is not typical of the upper Chinle.

Church Rock Member. The Church Rock Member is composed of 130 to 440 ft of fine to coarse, red-brown to light-brown siltstone and sandstone. Most siltstone is massive or structureless, but some is horizontally bedded and ripple marked. Sandstones are fine grained and horizontally laminated or cross-bedded on a small scale. Locally, sandstones contain gravel.

Siltstone is the characteristic lithology of the Church Rock Member in the southern part of the swell. North from about Tomsich Butte on the west and Temple Mountain on the east, the dominant lithology is sandstone which is often thick-bedded and persistent.

One of these persistent sandstones, informally called the Black Ledge bed, is present in a northwest-trending belt that extends across the swell. Like many other sandstones in the upper Chinle, the Black Ledge has features in common with the producing sandstones in the lower Chinle. However, none of the upper Chinle sandstones have been proven to be a rewarding target for exploration.

Glen Canyon Group

The Glen Canyon Group consists of three formations: the Wingate Sandstone of Late Triassic(?) age, the Kayenta Formation of Late Triassic(?) age, and the Navajo Sandstone of Late Triassic(?) to Jurassic age. Rocks of

this group form the resistant cliffs, including the San Rafael Reef, that encircle the San Rafael Swell. They also form the high crest of the Waterpocket Fold in the Capitol Reef area.

The Wingate Sandstone is a pale-orange to tan, fine-grained eolian sandstone with large-scale cross-bedding. At places, as at Temple Mountain, thin mudstone splits, some of them mud-cracked, are present near the top. The Wingate ranges from 260 to 440 ft in thickness. It is mineralized only in the Temple Mountain collapse where high-grade vanadium ore is found in rocks that are fractured, faulted, and petroliferous.

The Kayenta Formation is composed of sandstone interbedded with siltstone, limestone, and siltstone-pebble conglomerate. The sandstone is cross-bedded on a small scale, and bedding is much thinner than in either the Wingate or overlying Navajo Sandstones. Scour and fill channels indicate a fluvial origin for the Kayenta. The Kayenta varies from less than 100 to more than 400 ft in thickness.

The Navajo Sandstone consists of tan to light-gray fine-grained sandstone that is both massive and cross-bedded. Large-scale cross-bedding, presumably eolian in origin, is dominant and conspicuous. Lenticular limestone is present at places near the top. The Navajo ranges from less than 300 to as much as 980 ft in thickness. The only notable mineralization in the Navajo is the weakly uraniferous copper ore at the Copper Globe mine (sec. 21, T. 23 S., R. 9 E.).

San Rafael Group

The San Rafael Group comprises four formations of Middle to Late Jurassic age, which are, in ascending order: Carmel Formation, Entrada Sandstone, Curtis Formation, and Summerville Formation.

The Carmel Formation is 95 to 1,180 ft thick. Resistant, fossiliferous marine limestone and calcareous sandstone are at the base. Marine or lagoonal shale and gypsiferous beds are at the top.

The Entrada Sandstone consists of 180 to 1,060 ft of thin- to thick-bedded, red-brown silty or earthy sandstone. Even and continuous sandstone beds and thin, persistent shale layers indicate a marine origin. East and south of the project area, where the Entrada Sandstone is more massive, better sorted, and cross-bedded, it appears to be eolian in origin.

The Curtis Formation is composed of 80 to 290 ft of greenish-gray, glauconitic sandstone and siltstone with a conglomerate layer at the base. Glauconite and scattered fossils indicate a marine origin for the Curtis.

At the top of the San Rafael Group is the Summerville Formation, which consists of 100 to more than 540 ft of thin-bedded, red-brown sandstone and shale. Interbedded with the thin-bedded sandstone and shale are thin alternating beds of chocolate-colored gypsiferous mudstone and well-laminated sandstone and gypsum beds, which are often nodular. Some red claystones are found near the base, and lenticular sandstone occurs toward the south. The thin-bedded facies is shallow marine, and the lenticular sandstones indicate

a fluvial contribution from the south (Gilluly and Reeside, 1928). The Salt Wash Member of the Morrison Formation unconformably overlies the Summerville; in many places the unconformity is angular.

In the project area, none of the four formations in the San Rafael Group have produced ore. Johnson (1959a) reports only minor occurrences in the Entrada and weak radioactivity in the Summerville near Cedar Mountain in the northern part of the swell. In contrast to the continental strata of the uranium-producing Chinle and Morrison Formations, the San Rafael Group includes a large proportion of marine tidal flat and sabkha strata, which are generally less favorable for uranium than continental sediments.

Morrison Formation

The Morrison Formation (Upper Jurassic) crops out on all sides of the San Rafael Swell except on the southeast, in an area known as the San Rafael Desert, where it has been eroded away. In the Capitol Reef area, the Morrison is present on the northern and eastern side of the Waterpocket Fold between Capitol Reef on the west and Caineville Reef on the east (Pl. 3). In the project area, the Morrison varies from 290 to 780 ft in thickness and consists of two members: the Salt Wash Member below and the Brushy Basin Member above.

Salt Wash Member. The Salt Wash Member consists of light-colored fluvial sandstone interbedded with subordinate red and green mudstone. Sandstone is typically fine- to medium-grained, moderately sorted, light-colored, quartz or lithic arenite, and is cemented by carbonate or silica. Sandstone beds, which may be thin or as much as 40 ft thick, erode to form persistent ledges. Most sandstone layers exhibit festoon cross-bedding and, at their base, fill channels scoured into the underlying mudstone.

The mudstones are generally reddish-purple or reddish-brown. In many places, they are bleached gray or light greenish-gray. Bleaching is most common just beneath sandstone beds. The clay fraction of the mudstone consists of illite, chlorite, and mixed-layer clays. Thin, fresh-water limestones are rarely present in the mudstone. In the San Rafael Swell, the base of the Salt Wash Member is marked by a thick gypsum layer that, locally, is pure and is as much as 20 ft thick.

Thickness of the Salt Wash Member ranges from 0 to 480 ft. The member thins toward the west and is absent from outcrops along the soutwest flank of the swell. Contact of the Salt Wash with the underlying Summerville Formation is an unconformity (Gilluly and Reeside, 1928), whereas contact with the overlying Brushy Basin Member is conformable and represents a change in depositional conditions rather than a major gap in geologic time. Study of the Salt Wash Member on a regional scale indicates that it was deposited as a large alluvial fan by aggrading braided streams. These streams appear to have diverged from a common source in south-central Utah (Johnson, 1959b).

Brushy Basin Member. In the project area, the Brushy Basin Member is 160 to 500 ft thick and is composed of slope-forming, variegated mudstone with subordinate siltstone, sandstone, and fresh-water limestone. Montmorillonite is abundant in the mudstone and produces a frothy "popcorn" texture on weathered surfaces. The mudstone is variegated in distinct white, green, red, purple, pink, gray, and bluish-gray bands that typically parallel the bedding but that may merge or change stratigraphic position along outcrop. An uncommon yellowish-tan or yellowish-brown (buckskin) color is considered by local prospectors to be a guide to favorable ground because it is frequently associated with mudstone and sandstone containing higher than average amounts of uranium. The buckskin color may be due to weathering of organic material in the carbonaceous mudstones.

Lenses of poorly sorted, dark-colored sandstone and calcareous siltstone are present locally in the Brushy Basin Member. Some of these lenses are as much as 10 ft thick, but they thin rapidly and have little continuity. Festoon cross-bedding is common in the sandstones, and some contain conglomerate layers or scattered pebbles.

Thin beds of lacustrine limestone are occasionally found in the Brushy Basin Member. In contrast to the discontinuous character of the siltstone and sandstone lenses, these limestones are persistent and evenly bedded over large areas and serve as excellent marker beds.

The Brushy Basin conformably overlies the Salt Wash Member except at places in the western part of the San Rafael Swell where the Salt Wash thins. Some of the thinning appears to be due to erosion along the top of the Salt Wash sandstones. In the southwestern part of the swell, the Salt Wash is absent and the Brushy Basin Member unconformably overlies the Summerville Formation. The Brushy Basin Member is conformably overlain by the fluvial Buckhorn Conglomerate Member of the Cedar Mountain Formation.

Where the Salt Wash is predominantly light-colored sandstone and the Brushy Basin is variegated mudstone, the contact between the two is easily recognizable. However, where the contact is not obvious, the Salt Wash and Brushy Basin Members can usually be distinguished by clay mineralogy and character of the sandstones. Clay in the various Brushy Basin facies is chiefly expansible montmorillonite, whereas Salt Wash clays are mostly illitic with lesser amounts of chlorite or mixed-layer clays (Keller, 1962). Brushy Basin sandstones are dark, poorly sorted, and lenticular. Salt Wash sandstone is light, moderately sorted, and continuously and persistently bedded.

Like the Salt Wash Member, the Brushy Basin is continental in origin. Fluvial channel, flood-plain, and lacustrine environments are represented. Whereas the Salt Wash consists mostly of channel sandstone, the dominant lithology of the Brushy Basin is a flood-plain mudstone. Thus, the change in character from Salt Wash to Brushy Basin represents a change in regime from sediment-choked, high-energy braided streams during Salt Wash deposition to low-gradient streams carrying mud and fine sand across broad flood plains during Brushy Basin deposition. Fluvial origin of the massive mudstone is demonstrated by poor sorting (rounded detrital quartz grains in a muddy matrix), illite and mixed-layer clays, carbonaceous debris, and bone of terrestrial

dinosaurs. Evidences of the presence of volcanic ash at the time of deposition are the fresh books of biotite, euhedral zircon grains, angular zoned feldspar grains, and the dominance of montmorillonite over other clays (Keller, 1962). The montmorillonite indicates that volcanic ash was a volumetrically important constituent of the fine-grained material deposited during Brushy Basin time.

Cedar Mountain Formation

The Cedar Mountain Formation (Lower Cretaceous) crops out in the San Rafael Swell parallel to the underlying Morrison. It is present on the west, north, and northeast flanks of the swell, but absent from the south side and from the southeast, or San Rafael Desert section, of the swell. Thickness of the formation ranges from less than 150 ft on the east to over 1,110 ft on the west side of the swell. The Cedar Mountain Formation is considered by some to be unconformably overlain by the Dakota Sandstone, but Young (1960) considers it a basal formation of the Dakota Group. The Cedar Mountain is composed of a lower conglomerate member and an upper, so-called shale member, both of which are fluvial in origin (Stokes, 1944, 1950).

The Buckhorn Conglomerate Member, at the base, is composed of quartz, chert, and limestone pebbles. It varies from 0 to 90 ft in thickness, but is usually less than 50 ft thick. Carbonaceous material is rare, but silicified wood is occasionally found. The Buckhorn Conglomerate is a resistant unit that forms a conspicuous cliff or ridge between mudstones of the underlying Morrison and mudstones of the upper part of the Cedar Mountain Formation.

The upper, so-called shale member consists of variegated gray, green, and purplish-red shale, mudstone, sandstone, and conglomerate. In many respects the shale member resembles the Brushy Basin Member of the Morrison Formation; where the intervening Buckhorn Conglomerate is absent, as in the southwestern part of the swell, the contact between the Cedar Mountain and the Brushy Basin is difficult to discern. However, compared with Brushy Basin mudstones, Cedar Mountain mudstone contains numerous small irregular nodules of pink to gray limestone that may be siliceous. These nodules seem to be peculiar to the Cedar Mountain and are not found in the Brushy Basin (Young, 1960).

At Capitol Reef and around the northern part of the Henry Mountains, the Cedar Mountain Formation is absent above the Morrison. At these places, the Morrison is overlain either by a discontinuous sandstone mapped as Dakota Sandstone (Upper Cretaceous) or by the Tununk Shale Member of the Mancos Shale (Upper Cretaceous) (Hintze and Stokes, 1964). The Naturita Formation in the San Rafael Swell is similar to, or the same as, the Dakota Sandstone in the Capitol Reef and Henry Mountains area. The Naturita unconformably overlies the Cedar Mountain Formation in the northern and western part of the San Rafael Swell. Like the Dakota Sandstone, the Naturita Formation is a transgressive unit that consists of sandstone, mudstone, and, in places, coal (Young, 1960).

STRUCTURE

Two major structures are present in the project area: the San Rafael Swell anticline and the Waterpocket Fold monocline. Both structures are Laramide in age and origin.

San Rafael Swell

The San Rafael Swell is a large, doubly plunging anticline in the northwest part of the Colorado Plateau. Rocks of the swell are locally faulted and fractured, cross-folded, and at places involved in pipelike collapse structures.

Folds. The San Rafael Swell anticline, like other large upwarps in the Colorado Plateau, is asymmetric. Rocks on the west dip gently westward while those on the east, along the San Rafael Reef, dip steeply to the east. At one place 2-1/2 mi north of Straight Wash, the east limb of the anticline is overturned so that beds of the Chinle dip as much as 85° W.

The crest line of the San Rafael Swell anticline trends about N. 30° E. in the south, N. 65° E. near Tan Seep, and approximately north in the northern half of the swell. The crest line divides into three major anticlinal folds in the south, one in the south-central or Tan Seep area, and two in the northern part of the swell. Cross warps or cross folds crenulate the crest line at two places: at the Family Butte syncline in the west-central part of the swell and on the southeast side of the swell near Temple Mountain. Each of these cross warps projects into a major bend in the crest line (Hawley and others, 1968, Pl. 2, Fig. 6).

The San Rafael Swell in considered a Laramide structure that formed early in Tertiary time (Hunt, 1956). The present structure is superimposed on an older northwest-trending anticline that was active during Traissic and, perhaps, Permian times (Hawley and others, 1968). McKeown and Orkild (1958) first traced a northwest-trending anticline from south of the Colorado River to the San Rafael Swell in the Hermosa and Rico Formations. The pattern of regional alteration in the Moenkopi and the thinning of both the Moody Canyon member in the Moenkopi and sub-Moss Back members in the Chinle are evidence that the northwest-trending anticline of McKeown and Orkild extended into the swell and influenced patterns of erosion and deposition of the upper Moenkopi and lower Chinle Formations. This northwest-trending fold was probably related to the northwest-trending salt anticline structures of the Paradox Basin, which lies southeast of the San Rafael Swell.

Faults. Faults in the San Rafael Swell can be grouped into two categories: (1) bedding-plane and associated low-angle faults and fractures and (2) high-angle faults. Most faults shown on Plate 3 are high-angle faults.

Bedding-plane and related low-angle faults and fractures lie at or just below certain lithologic contacts. Of chief interest are those near the Moenkopi-Chinle contact. For example, in the Temple Mountain and Monitor

Butte Members of the Chinle, shears are present in mudstone or claystone where these fine-grained rocks lie between massive siltstone below and Moss Back Sandstone above (Hawley and others, 1968).

These bedding-plane shears or fractures overlie low-angle fractures that die out downward. Displacement along either bedding-plane shears or low-angle fractures is probably small. The strike of these fractures is about N. 25° E. (Hawley and others, 1968), which is in close agreement with the general axial trend of the swell.

The bedding-plane shears and fractures may have induced a secondary permeability in relatively tight, fine-grained sediments. By serving as conduits for uranium-bearing ground waters, these fractures were apparently a control in the localization of ore.

High-angle faults and fault sets were divided into five groups by Hawley and others (1968): (1) east-striking faults in the south, (2) northwest-striking faults near Tomsich Butte, (3) the Family Butte fault, (4) northwest-striking faults north of Temple Mountain and Family Butte, and (5) northeast-striking faults on the west side of the swell. Most high-angle faults are normal faults with displacements of less than 200 ft. Two faults on the west side of the swell are high-angle reverse faults. Thrust faults are uncommon but are known at Farnham dome, Woodside dome, and north of Iron Wash.

A series of lineaments is shown on Plate 3. These lineaments, taken from LANDSAT imagery, were not ground checked, but are presumed to be high-angle normal faults. Most of the lineaments have about the same orientation as the north-northeast set of mapped faults and are obvious extensions of some of them. Thus interpreted, the north-northeast structural trend or fabric is not limited to the western side of the swell but is impressed across the entire swell.

The north-northeast-striking set of faults and lineaments roughly parallels the axis of the swell. These faults probably formed or were rejuvenated at the same time as folding of the swell, which is considered a Laramide structure (Late Cretaceous or early Tertiary time). Other faults, whether new or inherited from an earlier period of deformation, probably also experienced movement during the Laramide. Age determinations for uranium mineralization range from 80 to 110 m.y. (Stieff and others, 1953; Stieff and Stern, 1956; and Miller and Kulp, 1963), thus mineralization was either contemporaneous with or slightly older than Laramide folding and faulting in the swell.

If mineralization and faulting were concurrent, or if there were preexisting faults, mineralizing fluids might have utilized the faults as permeable conduits. Thus, uranium deposits would be expected along or near faults, and faults would then be a guide for exploration. Such is apparently not the case for the high-angle faults. High-angle faults are present at a few mines, such as Dexter 7 (6 , App. A, Pl. 1) on Calf Mesa and Dirty Devil 6 (63) on Tomsich Butte; but there is no apparent correlation between faulting and mineralization.

Collapse Structures. Fourteen collapse structures were mapped by Hawley and others (1968); six are uraniferous, but only the large collapse structure at Temple Mountain has produced important quantities of ore. These downward-displaced plugs vary from less than 100 ft to about 3,000 ft in diameter and involve rocks of the Moenkopi, Chinle, and Wingate Formations. Origin of these collapse features is apparently related to removal of underlying strata by solution. The chief ore in these collapse structures is asphaltite enriched in uranium, vanadium, selenium, arsenic, and lead. Hawley and others (1968) described these structures, particularly those at Temple Mountain, in detail.

Capitol Reef

The principal structural feature in the Capitol Reef area is the Waterpocket Fold, a monocline on the east side of the High Plateaus of south-central Utah. Dips along the Waterpocket Fold range from 10° to 35° E.

Faults in a zone north of Fruita and Torrey in the Capitol Reef area trend west-northwest. The faults are high-angle to vertical normal faults. As is true for most high-angle faults in the San Rafael Swell, there is no known uranium mineralization along the faults in the Capitol Reef area. Collapse structures, such as those in the San Rafael Swell, are not known at Capitol Reef.

ANALYTICAL RESULTS

WHITE RIM SANDSTONE

Appraisal of White Rim favorability is based on data from: (1) analyses of stream-sediment samples (-100-mesh fraction), (2) measured stratigraphic sections and analyses of rock samples, and (3) radiometric anomalies observed on well logs. Because of certain similarities with the White Rim, the Gamma member of the Kaibab is included in the discussion of measured sections and gamma-ray logs.

Sediment Sampling Results

Forty-one stream-sediment samples were collected from several of the deep inner canyons that dissect the White Rim Sandstone in the interior of the San Rafael Swell (Fig. 2; App. C). Results of fluorometric analyses for uranium are shown on the histogram in Figure 9. U_3O_8 in the sediment samples ranged from 1 ppm to 47 ppm with a mean value of 4.6 ppm. A threshold of 10 ppm was selected graphically from a histogram of the data (Fig. 9). The background population had a mean of 2.8 ppm and a standard deviation of 1.3 ppm. The values of 13, 18, and 47 ppm U_3O_8 are considered anomalous.

Two of the anomalous stream-sediment samples are from the upper part of the Straight Wash drainage system. The sample containing 47 ppm U_3O_8 (MAE 069, App. C) was collected in Crawford Draw where the White Rim Sandstone

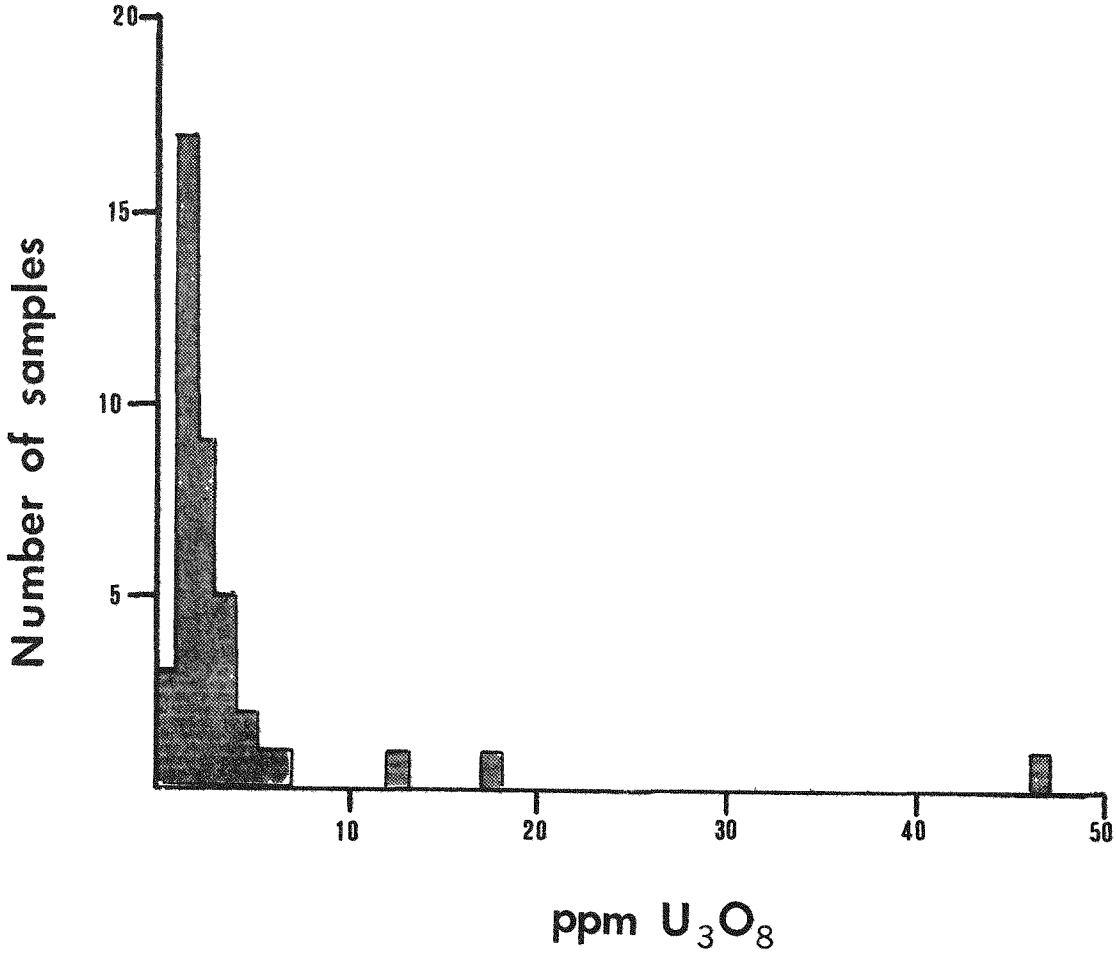


Figure 9. Uranium content of 41 stream-sediment samples, White Rim Sandstone, San Rafael Swell, Utah.

is a clean, massive, cross-bedded, buff to tan sandstone with no sign of alteration or mineralization. A high-angle north-trending fault intersects the canyon at this location and offsets the stream at right angles for about 450 yds. No vertical displacement was apparent along the fault, and only slight brecciation was noticed at a few places. A follow-up hand-held scintillometer survey was conducted near the site of sample MAE 069. Although fractures and rocks within a 100-yd radius of the anomaly were checked, no ground anomaly or mineralization was found.

Sample MAE 067, (13 ppm U_3O_8) was from the main canyon of Straight Wash about 4 mi east of the 47 ppm U_3O_8 anomaly. No alteration, uranium mineralization, or ground anomaly was found near the sample site.

Sediment sample MAE 050 (18 ppm U_3O_8) was collected from Iron Wash where the White Rim is a clean, massive, cross-bedded sandstone as at the sites of the other anomalous samples. Again, no sign of alteration or mineralization was found.

Measured Sections

Five stratigraphic sections of the White Rim Sandstone were measured and sampled from the base of the Kaibab down to the canyon floor. Sections were measured in Straight Wash (Fig. 10), at Lone Man Butte (Fig. 11), in Iron Wash (Fig. 12), in East Little Ocean Draw (Fig. 13), and in North Keesle Country (Fig. 14). In addition to brief lithologic descriptions, uranium and organic carbon content are given for most units.

The exposed White Rim was subdivided into four units on the basis of gross lithologic features observed in outcrop. Unit 1 at the top of the White Rim is generally less than 20 ft thick and is a gray massive sandstone that lacks internal structures. Units 2 and 4 are tan, massive sandstones that are cross-bedded on a large scale. These cross-bedded sandstones make up greater than 95 percent of the White Rim observed in the swell. Unit 3 is a thin band (10 to 15 ft thick) of iron-stained, reddish- or yellowish-brown sandstone. It is flat-bedded with some small-scale cross-bedding and is probably water laid rather than eolian like units 2 and 4.

A few generalizations can be made from the stratigraphic sections and chemical analysis of the rock samples. The most striking observation is the lithologic and chemical consistency of the White Rim Sandstone. It is everywhere a clean, well-sorted, and massive sandstone that shows little variability in the low uranium content. Rock samples from the White Rim range from 1 to 9 ppm U_3O_8 with an average U_3O_8 content of 2.9 ppm. An important chemical parameter is the organic carbon content. Four of the five measured sections showed only minor organic carbon (0.01 to 0.19%). In the North Keesle Country section, isolated pods and stratiform masses of asphaltite were found in the White Rim. Sample MAE 089 of asphaltite-impregnated sandstone from North Keesle Country contained greater than 1 percent organic carbon, although the U_3O_8 was only 5 ppm. Sample MAE 072 from west of the Big Ridge (T. 24 S., R. 9 E.) was heavily impregnated with asphaltite and contained over 9 percent organic carbon and 9 ppm U_3O_8.

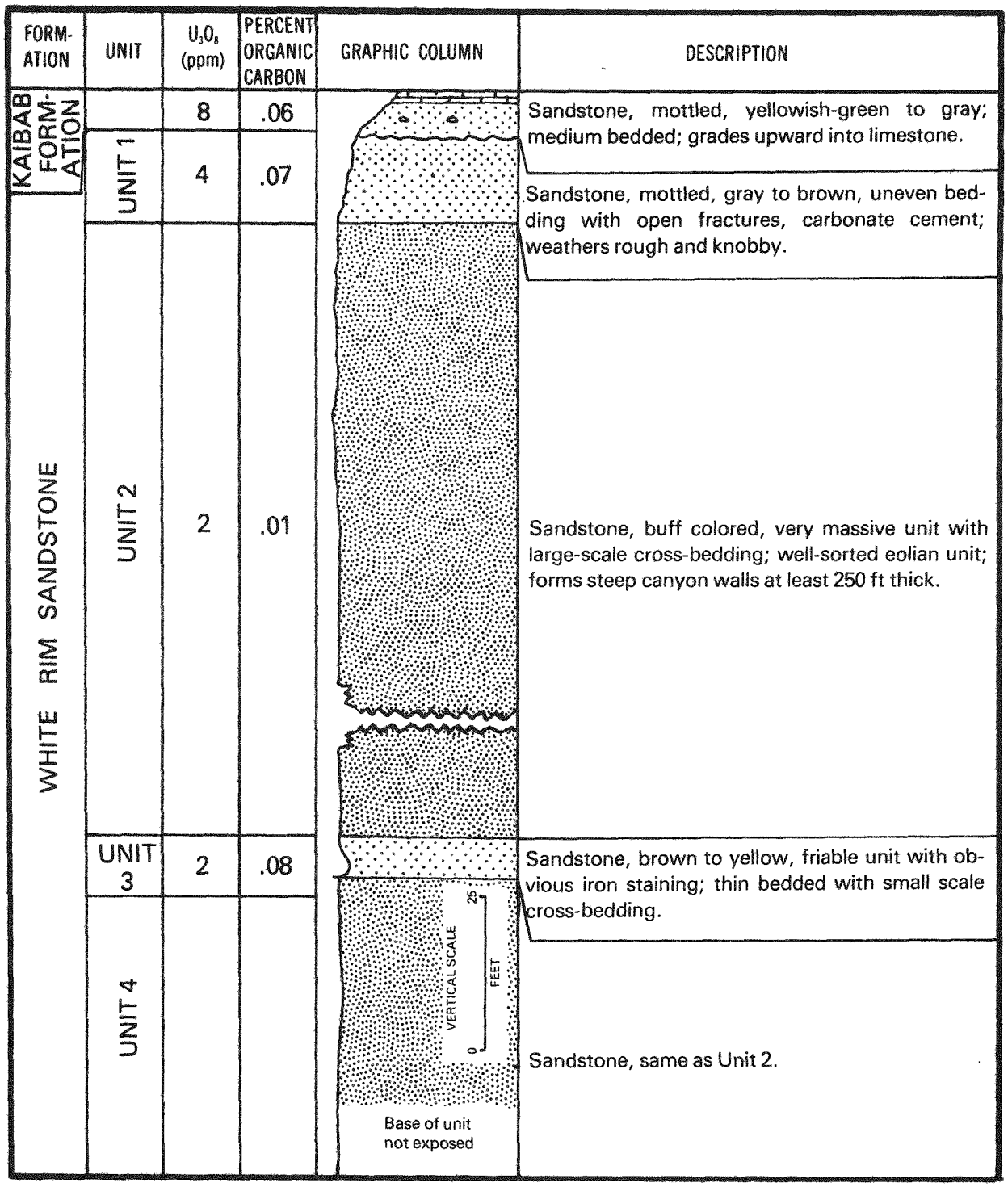


Figure 10. Stratigraphic section, uranium analysis, and organic carbon analysis of White Rim Sandstone at Straight Wash (123, App. E, Pl. 2).

FORMATION	UNIT	U_3O_8 (ppm)	PERCENT ORGANIC CARBON	GRAPHIC COLUMN	DESCRIPTION
KAIBAB FORMATION					Shale, reddish-brown, silty, calcareous, slope-forming with occasional thin beds (to 2 ft) of sandstone, light gray with abundant siliceous nodules.
WHITE RIM SANDSTONE	UNIT 1	4	.11		Sandstone, light gray and brownish-orange mottled, medium grained, well sorted, friable; weathers rough and knobby, generally structureless but occasionally cross-bedded.
	UNIT 2	2	.05		Sandstone, typical cross-bedded White Rim; white to light gray, medium grained, well sorted, clean sand with distinctive eolian cross-bedding; fairly well indurated but friable in places; occasionally mottled with brown and reddish oxides; maximum thickness approximately 400 ft.

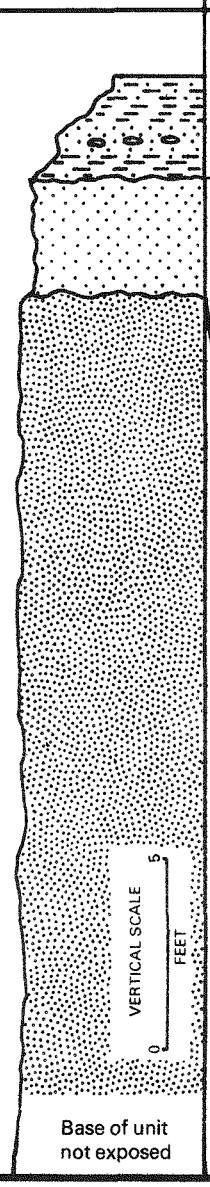


Figure 11. Stratigraphic section, uranium analysis, and organic carbon analysis of White Rim Sandstone at Lone Man Butte (124, App. E, Pl. 2).

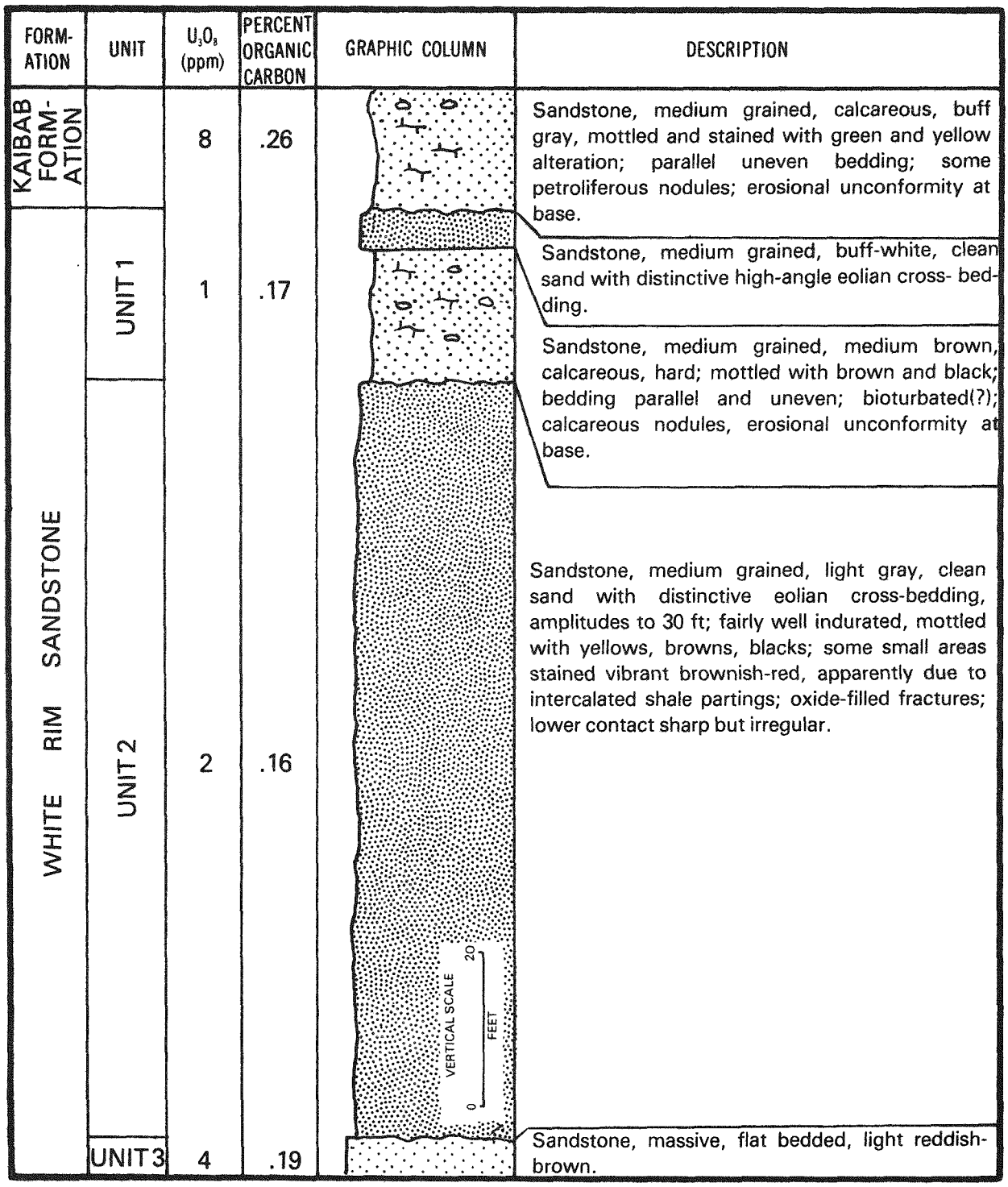


Figure 12. Stratigraphic section, uranium analysis, and organic carbon analysis of White Rim Sandstone at Iron Wash (125, App. E, Pl. 2).

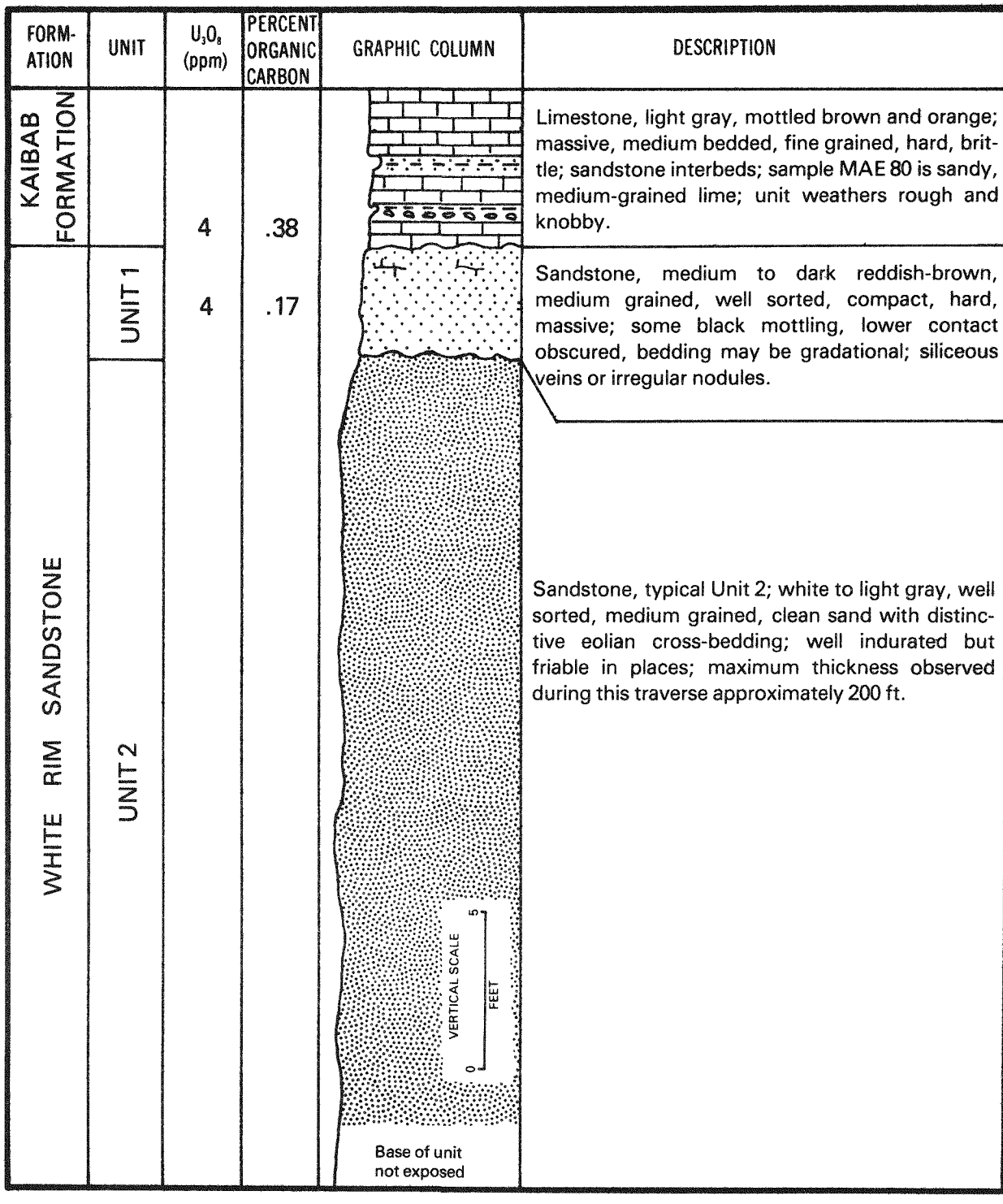


Figure 13. Stratigraphic section, uranium analysis, and organic carbon analysis of White Rim Sandstone at East Little Ocean Draw (126, App. E, Pl. 2).

FORMATION	UNIT	U_3O_8 (ppm)	PERCENT ORGANIC CARBON	GRAPHIC COLUMN	DESCRIPTION
KAIBAB FORMATION					Shale, reddish-brown; interbeds of limestone and sandstone; chert nodule horizon; slope-forming.
WHITE RIM SANDSTONE	UNIT 1	5	1.01	oil	Sandstone, mottled grayish-white to reddish-brown, medium grained, hard, brittle, thin to medium bedded; occasional interbeds of siltstone, especially at top; stained with brown and yellow oxides; sample MAE 89 is high graded petroliferous sand; petroleum occurs as blebs infilling pores.
	UNIT 2	2	.08	oil; VERTICAL SCALE 0 5 FEET	Sandstone, typical Unit 2; light gray to buff-white, well-sorted clean sand, medium grained with distinctive eolian cross-bedding; well indurated to friable, mottled with brown, yellow, and red oxides; traces of dead oil in blebs; maximum thickness of this unit observed here approximately 180 ft.

Figure 14. Stratigraphic section, uranium analysis, and organic carbon analysis of White Rim Sandstone at North Keesle Country (127, App. E, Pl. 2).

The Gamma member of the Kaibab Formation was measured and sampled with the White Rim. Generally, sandstones of the Gamma member showed higher uranium and organic carbon values than did the White Rim Sandstone. Gamma member sandstone is poorly cemented, poorly sorted, and at places muddy. The Gamma member is gray, but large patches or individual beds may be light green. Some beds, especially those near the top of the member, contain silica nodules, some of which are petroliferous. Organic carbon values in the Gamma member range from 0.06 to 0.38 percent, and U_3O_8 content ranges from 4 to 8 ppm.

Gamma-Ray Logs

One radiometric anomaly was noted on gamma-ray logs of the White Rim Sandstone. This anomaly is located in the Argo Oil Corporation No. 1 Government Hickman test hole approximately 15 mi southeast of Bicknell (11257, App. E, Pl. 2). This anomaly was recorded 770 ft beneath the surface and 160 ft below the top of the White Rim. The anomaly has a value of 289 API units or about 5X background for the White Rim Sandstone in that test hole. No other anomalies were noted in test holes that penetrated the White Rim Sandstone. Somewhat anomalous gross-gamma counts were recorded on a few logs in the Gamma member of the Kaibab. These anomalous counts may represent weak mineralization.

CHINLE FORMATION

Evaluation of the Chinle Formation is based on analysis of water samples, isopach and lithofacies maps, and gamma-ray logs from test wells.

Analysis of Water Samples

Location of spring-water samples from the Chinle is shown on Figure 3 and Appendix B. The highest uranium content was recorded in samples from Buckhorn Wash (19 ppb U_3O_8, MAE 007) and Wild Horse Spring (19 ppb U_3O_8, MAE 112).

None of these values are very high in comparison to values from spring waters of other large uranium districts (Young and Mickle, 1976; Rich and others, 1975). The sample from the vicinity of the Lucky Strike mine (MAE 002) was only 10 ppb U_3O_8, and the Lucky Strike is one of the largest mines in the project area. Perhaps because of the few available samples, water sampling did not prove a useful evaluation method.

Isopach and Lithofacies Data

Isopach and lithofacies data were obtained from gamma-ray logs. Figure 15, an isopach map of the sub-Moss Back, shows variations in thicknesses across the project area. The sub-Moss Back is thinnest, generally less than 30 ft thick, across the middle of the San Rafael Swell. The sub-Moss Back thickens to 100 ft or more in the northeast corner of the swell and abruptly thins again

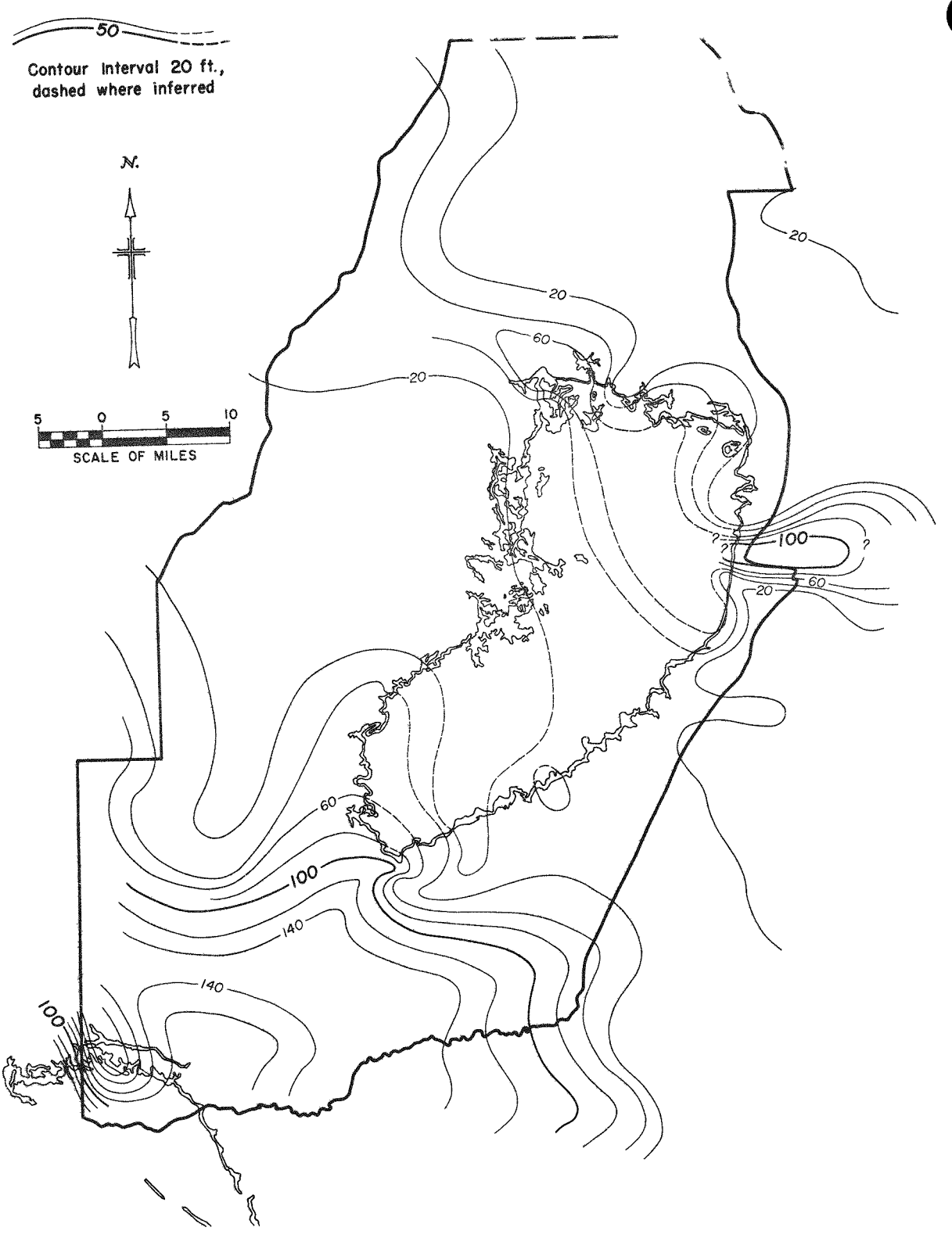


Figure 15. Isopach map of the sub-Moss Back member of the Chinle Formation.

beyond the northern outcrop of the Chinle. Toward the southern tip of the swell the sub-Moss Back thickens to more than 100 ft in the subsurface north of Capitol Reef. The broad area of thin sub-Moss Back that extends across the middle of the San Rafael Swell coincides approximately with the interbelt area of Hawley and others (1968).

Outcrop study and examination of gamma-ray logs show that the sandstone-to-shale ratio in the sub-Moss Back is low. However, many of the logs indicate that sandstone lenses are present in the sub-Moss Back, and high, possibly anomalous peaks on gamma-ray logs are associated with most of these sandstone lenses.

Thickness of the Moss Back Member is shown on Figure 16. The Moss Back is thickest in the northern half of the San Rafael Swell where it is as thick as 120 ft on the east and 166 ft on the west side of the swell. This area of thick Moss Back coincides approximately with the interbelt of Hawley and others (1968) and with the area of massive, proximal braided stream deposits discussed by Lupe (1976).

North of the Chinle outcrop in the swell, the Moss Back thins rapidly and becomes discontinuous. Stewart and others (1972) described the Moss Back as pinching out north of the San Rafael Swell outcrop. Although the Moss Back is no longer present as a massive sandstone, many logs show one or more thin sandstones at the stratigraphic position of the Moss Back. These sandstones, much thinner than the Moss Back that crops out to the south, are probably part of the Moss Back depositional system and are probably the distal braided stream deposits of Lupe (1976) interbedded with flood-plain mudstone and siltstone. The Moss Back thins southward from the Chinle outcrop at the southern end of the swell until it pinches out north of Capitol Reef.

The most favorable areas for uranium exploration are north, south, and west of the thickest Moss Back where the Moss Back sandstone becomes both thinner and interbedded with finer-grained rocks (Lupe, 1976). Fine-grained rocks may contain an abundance of organic debris to serve as reductants and may also impede the flow of uranium-bearing ground water. The impeded water flow would allow precipitation to take place before the uranium is flushed from the permeable sandstones (Eargle and others, 1975, p. 778).

Anomalies on Gamma-Ray Logs

Gross-gamma peaks are present on most gamma-ray logs of the Chinle. Only peaks of 2X background or greater are shown on Figure 3 and listed in Appendix F. Counting rates of 2X background do not necessarily, but may, indicate weak mineralization or proximity to an orebody.

Gross-gamma peaks are present on gamma-ray logs from eight test holes in the sub-Moss Back (11158, 11180, 11199, 11205, 11222, 11236, 11239, 11254; App. F). On the basis of accompanying neutron logs, some peaks in the sub-Moss Back appear to be in fine-grained rocks, either mudstones or siltstones. Field studies show that mineralization may occur along the contact between fine-grained rocks and the more transmissive sandstones, or within fine-grained rocks if they are fractured or sheared.

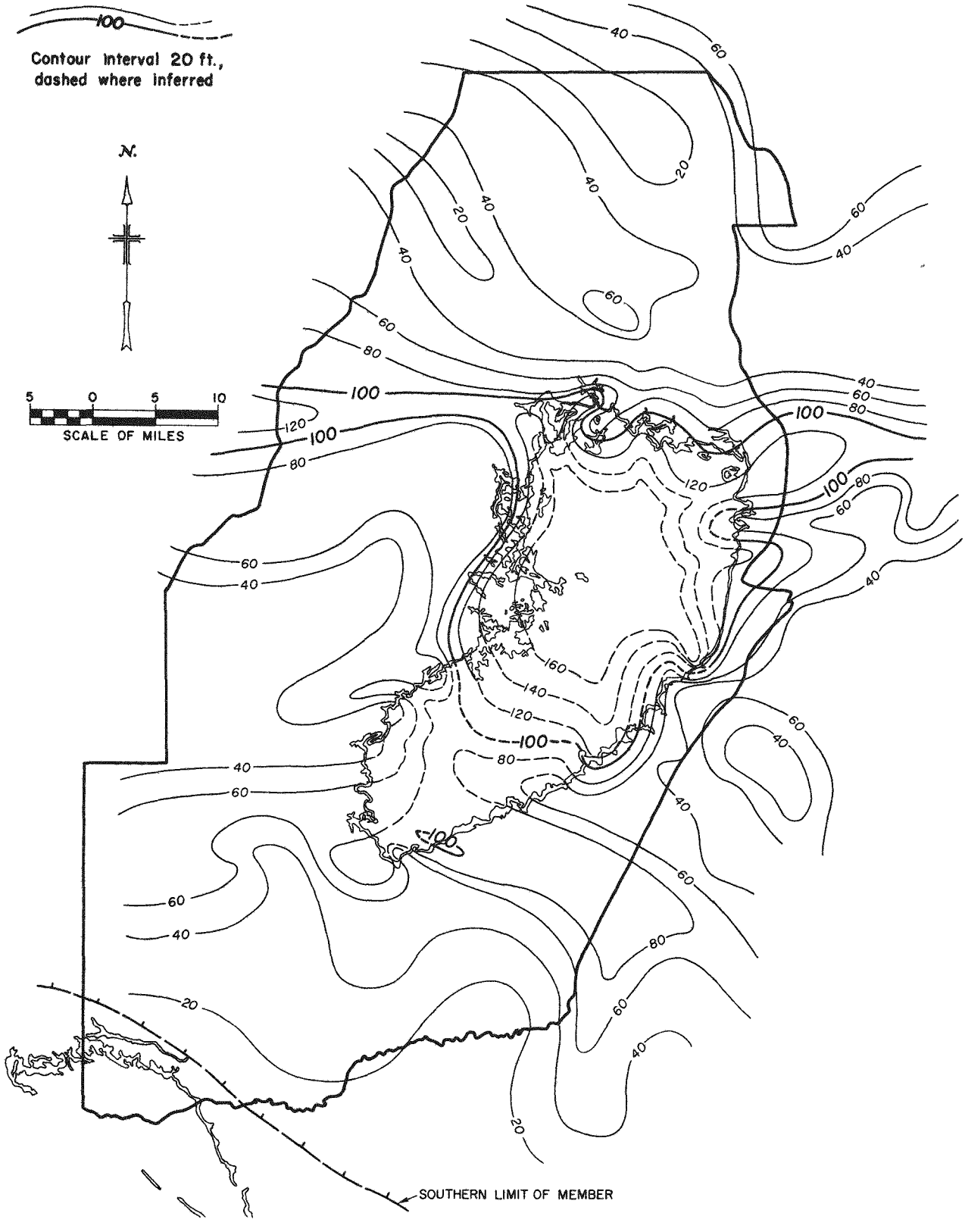


Figure 16. Isopach map of the Moss Back Member of the Chinle Formation.

Test holes with high gross-gamma counts in the sub-Moss Back are widely scattered along the east and southwest sides of the swell. No sedimentary or mineralization trend is apparent. If the anomalies do represent uranium mineralization, the mineralization may be a northern or northwestern extension of the mineralization in the Orange Cliffs (McKeown and Orkild, 1958) or White Canyon areas (Young, 1964). Four, possibly five, of the holes (11158, 11180, 11199, 11205, and possibly 11222) are in the favorable North belt of Hawley and others (1968), and two (11236 and 11257) are in the South belt. One hole (11239) is in the center of the relatively unfavorable interbelt area. None of the peaks in the sub-Moss Back are exceptionally large. The largest (11254) is less than 2.5X background.

Stratigraphic position of peaks in the sub-Moss Back and the number of peaks within the unit are not predictable. In some test holes (11199, 11222, 11231, 11239, 11254) the peak is at the base of the sub-Moss Back. In others (11222, 11231, 11236, 11254), the peak may be just below the Moss Back Member or somewhere in the middle of the sub-Moss Back. Three test wells in the sub-Moss Back have more than one peak: hole 11231 has two, and holes 11222 and 11254 have three.

Eight gamma-ray logs show peaks in the Moss Back Member of the Chinle (11214, 11222, 11223, 11231, 11232, 11236, 11238, 11243). These are much less scattered in their distribution than peaks in the sub-Moss Back. Five (11214, 11222, 11223, 11231, 11232) are clumped on the east, one (11243) is on the southeast, and two (11236 and 11238) are on the southwest side of this swell. Four test holes (11214, 11222, 11223, 11232) with peaks in the Moss Back are along the south margin of the favorable North belt, two (11236 and 11238) are in the South belt, and two (11231 and 11243) are in the unfavorable interbelt area of Hawley and others (1968).

MORRISON FORMATION

Work on the Salt Wash Member was limited to interpretation of lithofacies maps. Appraisal of the Brushy Basin Member of the Morrison Formation is based on studies of known deposits, measured sections, analyses of rock and water samples, and interpretation of isopach and lithofacies maps.

Salt Wash Member

Thick, elongate accumulations of sandstone are indicated on both the net thick sandstone (>20 ft thick) and sandstone-to-shale maps of the Salt Wash Member (Figs. 17 and 18). These thick accumulations are interpreted as major paleochannel systems or trunks. From west to east they are: the White Star, Huntington, Price, Woodside, and Tidwell trunks.

The Tidwell trunk trends northeasterly through an area of slight structural deformation. Trimble and Doelling (1977, in prep.) described this area in detail. The Woodside trunk apparently was deposited by a northwesterly flowing stream, perhaps a branch of the Tidwell trunk. The Woodside trunk flows northward around the Woodside dome. This indicates that the Woodside dome was a positive area in pre-Laramide time.

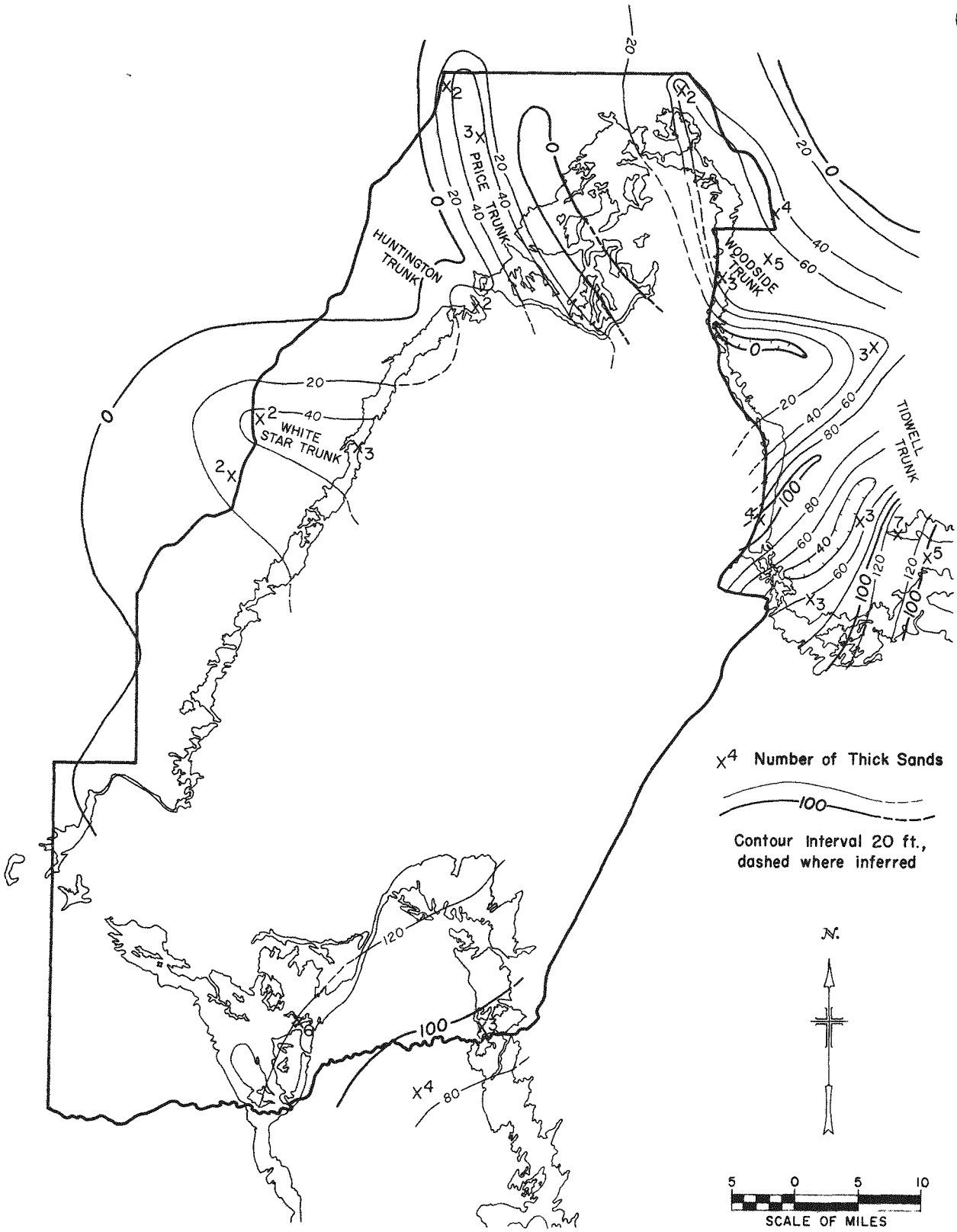


Figure 17. Net thick sandstone map of the Salt Wash Member of the Morrison Formation.

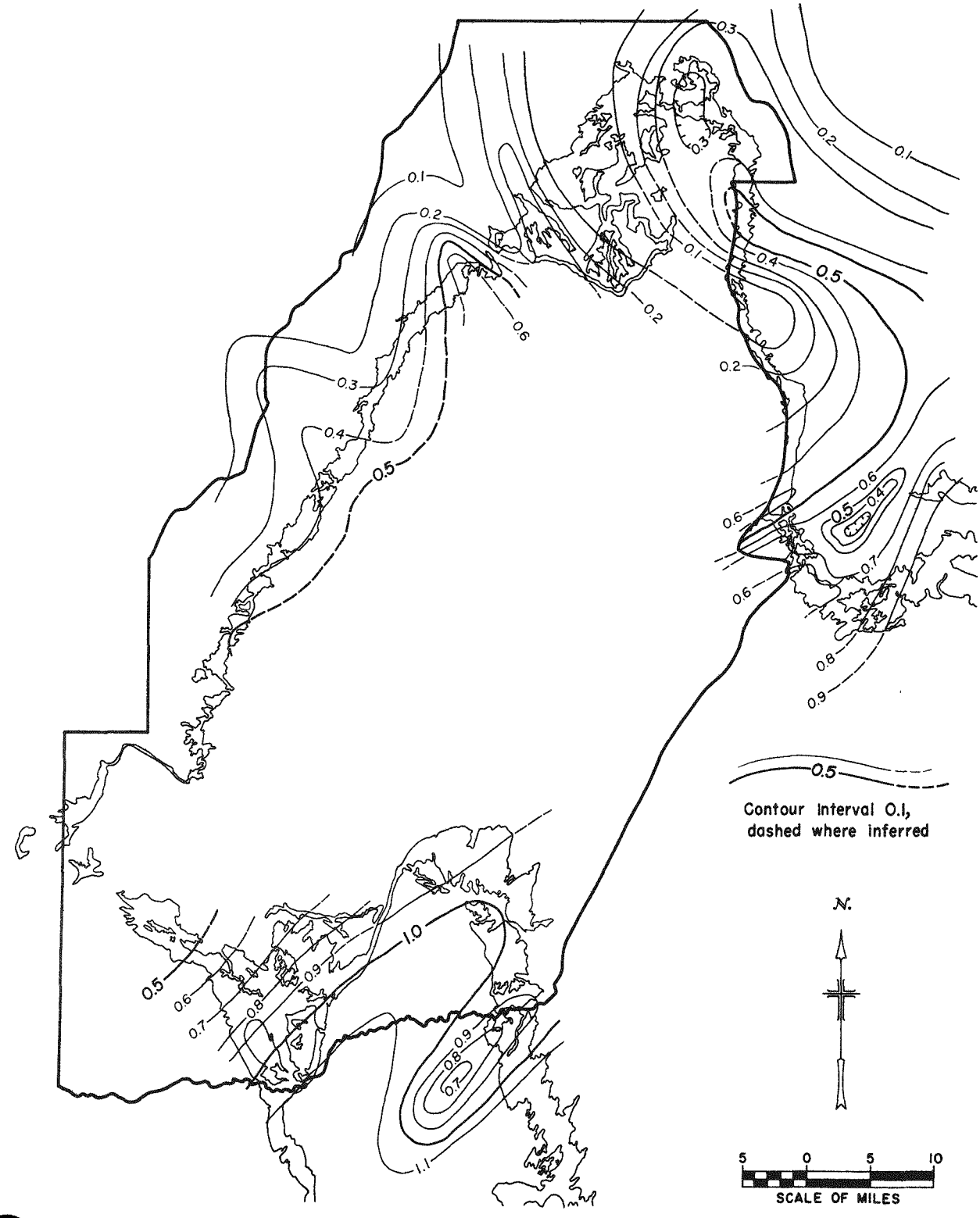


Figure 18. Sandstone-to-shale ratio map of the Salt Wash Member of the Morrison Formation.

The Price trunk trends northwest from this Woodside positive area, and was perhaps deposited by a stream deflected away from the Woodside paleohigh. The Huntington trunk is a minor trunk south of the Price trunk. The White Star trunk, farther to the southwest, is composed of thick individual sandstone beds and is well defined.

A sandstone-to-shale ratio (Fig. 18) of 1:1 is considered the most favorable environment for uranium deposits (Trimble and Doelling, 1977). In the Tidwell district the ratio approaches 1:1, but elsewhere in the project area, except in the extreme south, shale predominates. Both the Woodside and the small Huntington trunks have relatively high sandstone-to-shale ratios; the high ratio at the Huntington trunk may be influenced by a thin stratigraphic section resulting from post-Salt Wash erosion rather than by an actual concentration of channel sands. At the southern end of the San Rafael Swell, the sandstone-to-shale ratio approaches 1:1 in the vicinity of the Wild Horse Mesa deposits.

The presence of organic debris is a major factor in the formation of uranium deposits in the San Rafael River mining area (Trimble and Doelling, 1977) and is an important criterion for ruling on the favorability of an area. Organic debris is present in Salt Wash sandstone and siltstone in the Tidwell area and at other mining areas such as at the Alpha, White Star, and Cottonwood claims. North of the Tidwell area and the Tidwell trunk system, organic debris is reportedly less abundant. It is not known whether organic debris is preserved along the change in course of the Woodside trunk. Trimble and Doelling (1977) mentioned that, although organic debris may be common in thin (>20 ft) sandstones, ore deposits in thin Salt Wash sandstone typically are not economic.

Brushy Basin Member

Johnson (1959a) has briefly discussed uranium deposits in the Brushy Basin Member on the northwest side of the swell, but no detailed description of these deposits has been published. Three deposits were studied for this report in order to determine the geologic setting and mode of uranium occurrence. At each deposit a section was measured and sampled in detail. A nearby unmineralized section was also measured and sampled through the same stratigraphic interval. Measured sections, quantitative analyses for selected elements, and mineralogy of the clay fractions are shown in Figures 19 through 24. Detailed petrographic descriptions and field observations are included in Appendix G. Results of semiquantitative emission-spectrograph analyses of trace elements are also discussed in the following descriptions of the deposits. Locations of the three sampled deposits and all other known Brushy Basin uranium deposits in the project area are listed in Appendix A.

Cedar Mountain No. 1 Prospect. At the Cedar Mountain No. 1 prospect on the south side of Cedar Mountain, the Brushy Basin Member is predominantly purple, red, green, and gray variegated mudstone with minor amounts of calcareous sandstone and limestone. In a section measured through the deposit (Fig. 19), the Brushy Basin is 339 ft thick. Uranium occurs in the upper 180 ft of the member, where the radioactivity ranges from 80 to 1,600 counts per second (cps) and U_3O_8 content ranges from 3 to 100 ppm. In the lower 159 ft of the member, the radioactivity is 60 to 80 cps and the U_3O_8 content is less than 20 ppm.

Fm.	Member	Thk (ft)	cps	Sample No. (MAE)	U_3O_8 (ppm)	Se (ppm)	V_2O_5 (%)	Organic Carbon (%)	Clay Type (%) M	K	I	C	Description (see Appendix G) (MAE)
Cedar Mtn.	Buck-horn	22											
Morrison	Brushy Basin	47	60	A 169	4	2	.01	.65	40	60			169 - Congolmerate
			120	170	3	2	.01	.23	80	10	10		170 - Mudstone
			120	171	10	1	.03	.59					171 - Limestone, micrite
			180	172	13	2	.02	.21	100				172 - Mudstone
			250	173	84	2	.03	.09	90	10			173 - Mudstone
			400	174	51	1	.03	.02	95	5			174 - Mudstone
			1600	175	50	2	.06	.06	50			50	175 - Mudstone, ore zone
		62	120	A' 176	102	5	.02	.08	100				176 - Mudstone
		71	550	177	79	5	.03	.11	100				177 - Mudstone
			80	178	72	2	.03	.63	90	10			178 - Sandstone, calcareous quartz arenite
			180	179	17	3	.03	.03	95	5			179 - Mudstone
			275	180	44	1	.03	3.64					180 - Limestone, micrite
		159	60	181	5	1	.02	.04	60	40			181 - Sandstone, calcareous quartz arenite
			60	182	4	1	.02	1.17					182 - Limestone, micrite
			80	183	3	< 1	.02	.10	95	5			183 - Mudstone
	Salt Wash		50	184	3	< 1	.01	.50	40	20	20	20	184 - Sandstone, lithic arenite
			80	185	12	< 1	.05	.08			100		185 - Mudstone

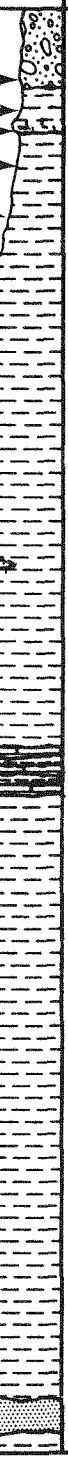


Figure 19. Measured section, mineralized zone, Cedar Mountain #1 prospect (128, App. E, Pl. 2).

Fm.	Member	Thk (ft)	cps	Sample No. (MAE)	U_3O_8 (ppm)	Se (ppm)	V_2O_5 (%)	Organic Carbon (%)	Clay Type (%) M	K	I	C	ML	Description (see Appendix G) (MAE)
Cedar Mountain	Buckhorn Conglomerate	~ 20												
				A										
Morrison	Brushy Basin	~ 59	70	189	1	5	.03	.11	100					189 - Mudstone, clay galls, organic debris
			90	188	2	1	.02	.07	80				20	188 - Mudstone
			100	187	6	1	.04	Nil	100					187 - Mudstone
				A′										
			100	186	3	1	.03	.17	95				5	186 - Mudstone

Figure 20. Measured section, unmineralized zone, Cedar Mountain #1 prospect (129, App. E, Pl. 2).

Fm	Member	Thk (ft)	cps	Sample No. (MAE)	U_3O_8 (ppm)	Se (ppm)	V_2O_5 (%)	Organic Carbon (%)	Clay Type (%) M	K	I	C	Description (see Appendix G) (MAE)
Cedar Mtn	Buck-horn	6	60	190	1	< 1	.01	.19	40	60			190 - Conglomerate
			90	191	1	< 1	.06	.02	60	40			191 - Mudstone
		196	60	192	2	< 1	.01	.62	30	50	20		192 - Sandstone, quartz arenite
			80	193	4	< 1	.03	.03	100				193 - Mudstone
			90	194	4	< 1	.02	.06	100				194 - Mudstone
			60A	195	5	< 1	.02	.19	60	30	10		195 - Sandstone, lithic arenite
			100	196	4	< 1	.02	.39	100				196 - Limestone, micrite
			6000	197	540	29	.03	1.60	80			20	197 - Mudstone, ore zone
			4000	198	127	20	03	.92	100				198 - Mudstone, ore zone
			5000	199	250	7	.03	1.46	50			50	199 - Mudstone, ore zone
		34	260	200	8	< 1	.03	1.23					200 - Limestone, micrite
			3000	201	520	6	.03	1.99	80			20	201 - Mudstone, ore zone
			240	202	9	1	.02						202 - Sandstone, quartz arenite
			340	203	11	1	.02	.07	100				203 - Mudstone
			120A'	204	9	20	.03	.05	80			20	204 - Mudstone
Morrison	Brushy Basin		80	205	4	1	.02	1 58	90			10	205 - Sandstone, quartz arenite
			90	206	4	1	.02	.16	90			10	206 - Mudstone
		230											
	Salt Wash		50	207	2	< 1	.01	.11			50	50	207 - Sandstone
			70	208	5	14	.03	.35			60	40	208 - Mudstone

Figure 21. Measured section, mineralized zone, Red Seep prospect (130, App. E, Pl. 2).

Fm.	Member	Thk (ft)	cps	Sample No. (MAE)	U_3O_8 (ppm)	Se (ppm)	V_2O_5 (%)	Organic Carbon (%)	Clay Type (%) M	K	I	C	ML	Description (see Appendix G) (MAE)
Morrison	Brushy Basin	144	55	A 212	5	1	.01	.16	70	10		10	20	212 - Sandstone, quartz arenite
			180	211	5	< 1	.02	Nil	95			5		211 - Mudstone, ore zone correlative
			80	A' 210	4	2	.02	.20			10	60	30	210 - Sandstone, quartz arenite
			90	209	6	< 1	.02	.04	95			5		209 - Mudstone, deeply weathered
				A°										

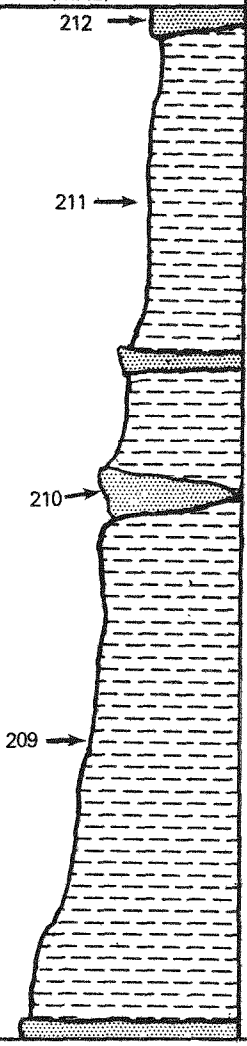


Figure 22. Measured section, unmineralized zone, Red Seep prospect (131, App. E, Pl. 2).

Fm	Member	Thk (ft)	cps	Sample No (MAE)	U_3O_8 (ppm)	Se (ppm)	V_2O_5 (%)	Organic Carbon (%)	Clay Type (%) M	K	I	C	ML	Description (see Appendix G) (MAE)
Cedar Mtn	Buck horn	10												
Morrison	Brushy Basin	105	70	213	3	1	02	18	100					213 - Mudstone, light gray, silty
			90	214	4	< 1	02	05	100					214 - Mudstone, deeply weathered
		14	60	215	4	< 1	02	12	100					215 - Sandstone, calcareous quartz arenite
		37	120	216	5	12	01	01	100					216 - Mudstone
			140	217	5	13	01	32	100					217 - Mudstone
			2600	218	660	295	02	Nil	95			5		218 - Mudstone, ore zone
			425	219	4	31	02	Nil	100					219 Mudstone
			100	A' 220	2	130	03	1 31	100					220 - Mudstone
		66												
		Salt Wash												

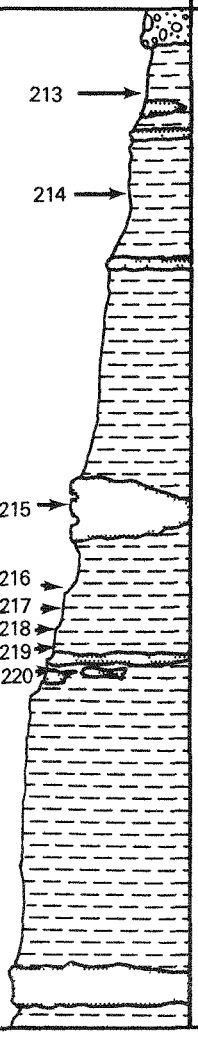


Figure 23. Measured section, mineralized zone, Eagle prospect (132, App. E, Pl. 2).

Fm.	Member	Thk (ft)	cps	Sample No. (MAE)	U_3O_8 (ppm)	Se (ppm)	V_2O_5 (%)	Organic Carbon (%)	Clay Type (%) M	K	I	C	ML	Description (see Appendix G) (MAE)
Morrison	Brushy Basin	51	100	221	2	8	.02	1.18	100					221 - Mudstone
			100	222	5	25	.03	.38	60	20			20	222 - Mudstone, silty, deeply weathered
			180	223	14	4	.02	.93	95			5		223 - Mudstone, ore zone correlative
			120	224	4	1	.03	4.12	100					224 - Limestone, micritic

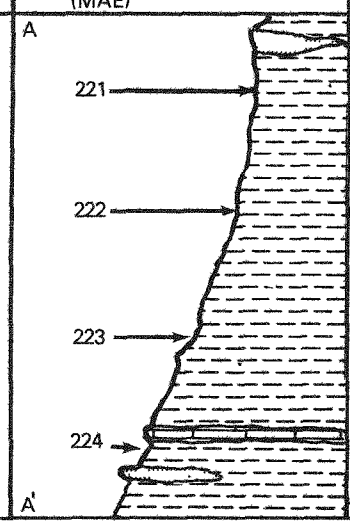


Figure 24. Measured section, unmineralized zone, Eagle prospect (133, App. E, Pl. 2).

Uranium minerals fill fractures and are disseminated in light-gray mudstones within the variegated mudstone sequence. Flakes of meta-autunite are concentrated along fracture surfaces, and metatyuyamunite was identified in a sample from a small stockpile near the outcrop. A yellow mineral coats fractures and stains the mudstone for as much as several inches from the fractures. On weathered exposures, this yellow mineral changes the light-gray mudstone to dark yellowish-orange (buckskin color) throughout the mineralized zone. Megascopically, the yellow mineral resembles limonite, but petrographic data indicate that it is iron-rich chlorite.

As shown in Figure 19, selenium content is 1 to 5 ppm in the upper uraniferous part of the section and 1 ppm or less in the lower, barren part. Vanadium, on the other hand, is uniformly distributed throughout the section. Organic carbon content varies widely and is not correlative with uranium content. Montmorillonite is the predominant clay mineral throughout the section, and kaolinite and illite generally constitute the remainder of the clay fraction. Chlorite is abundant in the most radioactive sample.

The mineralized zone, of which the section in Figure 19 is typical, extends for about 2,000 ft along the cliff that forms the south edge of Cedar Mountain. Drilling by a major petroleum company indicated that mineralization extends into the subsurface under Cedar Mountain over an area of about 5.5 sq mi. Test holes intersected mineralized zones that range from 0.5 to 65 ft thick and that contain 0.01 to 0.25 percent U_3O_8.

Figure 20 shows an unmineralized section of the upper Brushy Basin Member 0.25 mi east of the section in Figure 19. Here the mudstones, which are stratigraphically equivalent to those in the mineralized section, are purple, white, or very light gray; the buckskin color, characteristic of the mineralized section, is absent. Radioactivity ranges from 70 to 100 cps, and U_3O_8 content is 1 to 6 ppm. Selenium content is low, about 1 ppm, but one sample contained 5 ppm. Vanadium content is 0.02 to 0.04 percent, as in the mineralized section, and organic carbon does not exceed 0.17 percent. Montmorillonite is the predominant clay mineral but mixed-layer clays are in two samples; chlorite is absent.

Red Seep Prospect. Uranium-bearing mudstone near the middle of the Brushy Basin Member has been exposed by trenching at the Red Seep prospect (Fig. 21). Most of the uranium is in a 34-ft-thick zone of carbonaceous, normally gray mudstone which is highly fractured and altered from light olive-gray to dark yellowish-orange along fractures. At the top of this zone, a lens of carbonaceous debris which contains abundant plant remains and mineralized dinosaur bone assayed 570 ppm U_3O_8. Lower in the mineralized zone, megascopic plant remains are less apparent, but gypsum and iron-rich chlorite are abundant as fracture fillings. Anomalous amounts of selenium and organic carbon are characteristic of the mineralized zone, but vanadium is uniformly distributed throughout the Brushy Basin section (Fig. 21). The uranium-bearing mineral is meta-autunite, which occurs as flakes that fill fractures and replace organic material.

In a nearby unmineralized section of mudstone (Fig. 22), organic carbon and selenium contents are low, and chlorite is rare. Vanadium content is about the same in the unmineralized section as in the uranium-bearing zone.

As at the Cedar Mountain No. 1 property, yellow chlorite mixed with gray mudstone results in a buckskin color throughout the mineralized zone. At the Red Seep property this color is pervasive over an area of about 1,000 ft by 800 ft. Uranium, with ore grades higher than those found in outcrop, has reportedly been detected by an independent company as a result of recent drilling near this property.

Eagle Prospect. The Eagle prospect is geologically similar to the Cedar Mountain No. 1 and Red Seep prospects. Meta-autunite flakes associated with chlorite and gypsum fill fractures in highly fractured gray mudstone. Selenium and minor chlorite occur with the uranium, but vanadium content is uniform throughout the Brushy Basin section. However, organic carbon varies inversely with uranium content both in the ore zone (Fig. 24) and in a lower-grade section nearby (Fig. 25). The mineralized zone, characterized by limonite-stained buckskin-colored mudstone, crops out for several hundred feet along strike of the Brushy Basin Member.

Measured Sections. In addition to the Cedar Mountain No. 1, Red Seep, and Eagle prospects, most of the Brushy Basin uranium deposits listed in Appendix A were briefly examined and all are similar. Secondary uranium minerals, chiefly meta-autunite but including metatyuyamunite, uranopilite, and andersonite, coat small fractures and are disseminated in carbonaceous mudstone or, rarely, siltstone. Uranium content is low; the highest concentration measured was 660 ppm U_3O_8. Vanadium content ranges from 0.01 to 0.06 percent V_2O_5, and no enrichment of vanadium is associated with uranium. Radiometric equivalent uranium (eU) was determined by gamma-ray spectrometry for seven surface samples (Table 1). Five samples were approximately in equilibrium, and two had strong disequilibrium in favor of radiometric uranium. Samples from exploration trenches are reported to be out of equilibrium in favor of chemical uranium (R. O. Warner, 1976, personal commun.). Some drill holes on Cedar Mountain have higher uranium concentrations than the outcrop samples. The presence of higher grade uranium in the subsurface indicates that some uranium may have been leached from the outcrop. Possibly, vanadium content is insufficient in these rocks to form insoluble uranium-vanadium minerals.

Ore zones are enriched in many elements (particularly beryllium, lithium, iron, manganese, molybdenum, titanium, and yttrium). Selenium occurs in appreciable concentrations (295 ppm at the Eagle prospect). Typically a dispersed element, selenium is commonly associated with uranium in strata-bound deposits. Some volcanic ashes are slightly enriched in selenium (Davidson, 1963), and it has been suggested that both uranium and selenium were leached from volcanic ash in Brushy Basin sediments.

Iron-bearing chlorite coats fractures and stains the gray mudstone a buckskin color in the vicinity of uranium mineralization. Similar enrichment in chlorite relative to montmorillonite is noted in the ore zones of the Grants Mineral Belt (Brookins, 1976).

Water Sampling Results. Figure 4 shows water samples taken from springs within the Morrison Formation. Springs in the Cedar Mountain area are located at the Brushy Basin/Buckhorn Conglomerate contact. In this area the Brushy Basin is an aquaclude, and spring water probably does not percolate through

TABLE 1. COMPARISON OF CHEMICAL VS. RADIOMETRIC URANIUM ASSAYS FOR BRUSHY BASIN MUDSTONE SAMPLES.

Sample no.	Deposit	Chemical U_3O_8 (ppm)	Radiometric eU (ppm)
MAE 175	Cedar Mtn. No. 1	133	230
MAE 197	Red Seep	540	986
MAE 198	Red Seep	127	131
MAE 199	Red Seep	250	233
MAE 200	Red Seep	600	616
MAE 218	Eagle	660	681

mudstone of the Brushy Basin Member. One sample from Red Seep (MAE 006, App. is from a spring within the Brushy Basin. This spring is on a fault, and is the only sample that shows enrichment in uranium (49 ppb). In general, water sampling provided little useful data for the Brushy Basin because the member is a relatively impermeable unit.

Gamma-Ray Logs. Gamma-ray logs from eight wells show gross-gamma counts greater than twice average background for the Brushy Basin. All of these wells are in the northern half of the San Rafael Swell (Fig. 4; App. F). These anomalies seem to represent uranium mineralization or enrichment because they are much higher than counts for known bentonite layers in the Brushy Basin Member Evaluation of the Brushy Basin in the southern part of the swell is difficult because so few gamma-ray logs are available.

An example is the anomaly at a depth of 830 ft in Cities Service Oil Company's Government No. 1 well (11165, Fig. 4, App. F). This anomaly spans a 20 ft interval about 110 ft below the top of the Brushy Basin. Data from this hole and three others nearby, Cities Service No. 1-B State (11162), Cities Service No. A-1 State (not seen), and Cities Service No. 1-C (not seen), indicate that mineralization is in mudstone or muddy sandstone. The spontaneous-potential (SP) curve for this zone shows little character, probably because of its fresh-water content, but the resistivity corresponds to sandy shale or silty sandstone. Data from these four wells delineate a 1/2-mi-wide paleochannel that trends in a northeasterly direction (R. G. Young, 1977, personal commun.). Two other test holes in the vicinity, Shell Oil Company's No. 1-A unit (11160) and Pure Oil Company's No. 1 Washboard Wash unit (11171), show an anomaly at about the same stratigraphic position, that is, in the middle of the upper half of the Brushy Basin.

Most Brushy Basin anomalies on gamma-ray logs occur in an interval only a few feet thick. The anomaly at Cities Service Oil Company's Government No. 1 well, which spans an interval of about 20 ft, is exceptional.

From north to south along the west side of the San Rafael Swell, the uranium-bearing carbonaceous mudstones generally occur in the lower part of the Brushy Basin Member. At the Helm mine, the southernmost recorded deposit, the Salt Wash member is absent, and the altered carbonaceous mudstone fills channels in the underlying Summerville Formation (R. G. Young, 1976, personal commun.).

Isopach and Lithofacies Maps. One isopach and three lithofacies maps were prepared for the Brushy Basin Member utilizing data from gamma-ray logs and measured sections (Pl. 2). The isopach map (Fig. 25) shows that the Brushy Basin varies in thickness from less than 150 ft in the southwest to nearly 500 ft in the extreme northwestern part of the project area. Variations in thickness are abrupt so that a regional trend, other than thickening in the north-central and in the extreme northwestern part of the swell, is not apparent. Along the western side and in the extreme northwestern part of the project area, the Brushy Basin is greater than 400 ft thick.

As a result of erosion, the Brushy Basin is absent across a large area in the central and eastern parts of the project area. Thickness trends projected across this area are shown by dashed isopachs (Fig. 25).

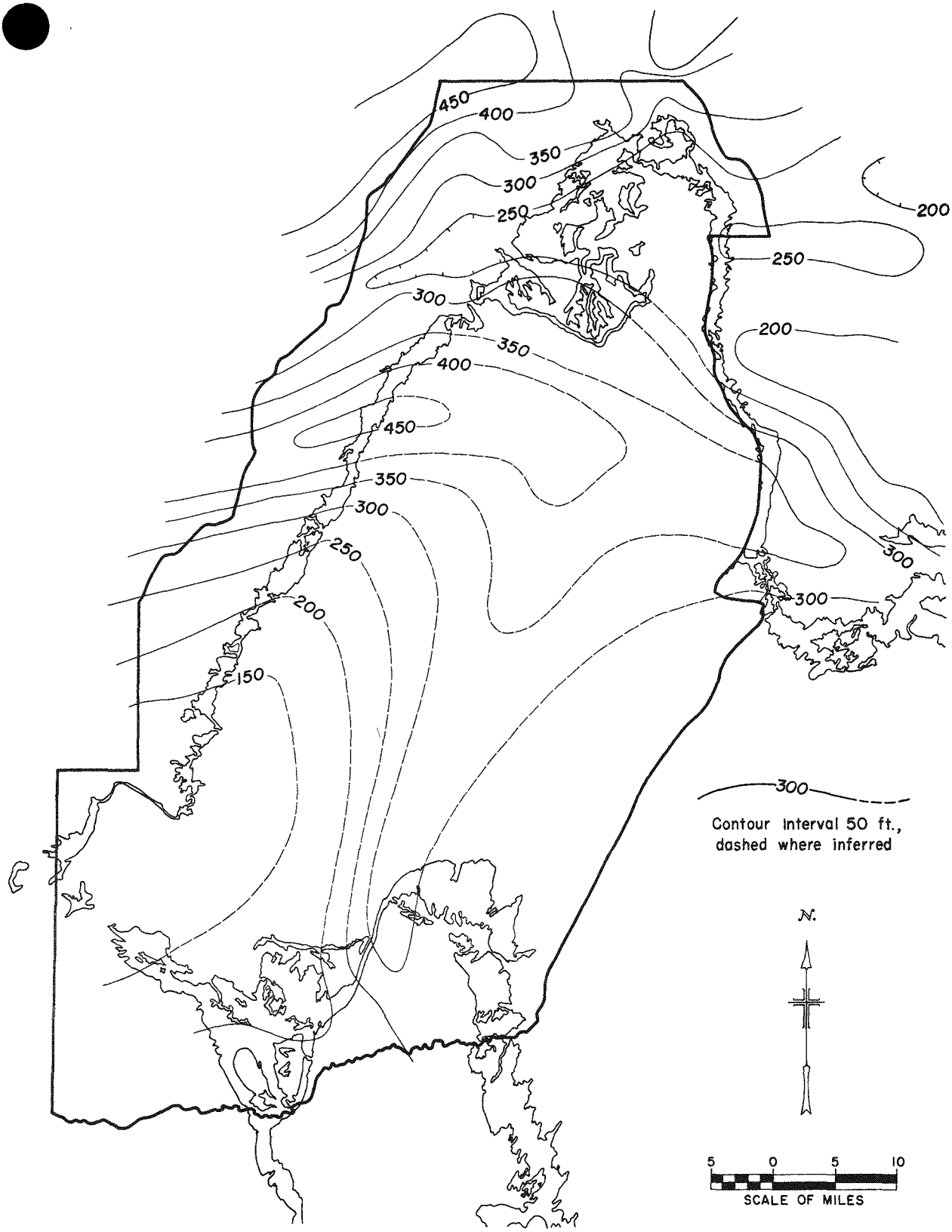


Figure 25. Isopach map of the Brushy Basin Member of the Morrison Formation.

Sandstone-to-shale ratios for the Brushy Basin are small (Fig. 26). A ratio of 0.52 (about 33% sandstone) is present on one log (11206, App. E) from the east side of the swell, and ratios of 0.33 and 0.34 (25% sandstone) are present on logs (11163, 11259) from the extreme northwestern part of the swell. Values of 0.33 (25% sandstone) and above are considered high for the Brushy Basin Member; values of 0.25 (20% sandstone) or less are more typical of the member. In the vicinity of mines, claims, and prospects, the sandstone-to-shale ratios are all about 0.1 (10% sandstone) or less.

URANIUM FAVORABILITY

The two uranium-producing formations in the project area are the Chinle and Morrison. Because of reported exploration activity in the White Rim Sandstone, it was included in this study also. Favorable areas discussed in this section are shown on Figure 27. Conclusions presented here are based on the analytical results in the preceding section.

WHITE RIM SANDSTONE

The White Rim Sandstone contains no known uranium deposits except at Temple Mountain, where a mineralized zone lies at the contact of the White Rim and the Moenkopi, as shown in several test holes (Hawley and others, 1965). Except at places like Temple Mountain where structure is an important control of mineralization, the White Rim is not considered a favorable host rock.

Drilling by a major company during the mid-1960s was reported in the McKay flats area in the southern part of Sinbad Country in the San Rafael Swell (E. P. Beroni, 1976, personal commun.). Zones of up to 0.03 percent U_3O_8 were reported, but efforts to trace the location of the drilling and to verify the results were unsuccessful. There is no record of further exploration or development.

Evaluation of uranium favorability in the White Rim Sandstone is based on surface and subsurface data and on a comparison of the White Rim with uranium-bearing sandstones. Data from stream-sediment samples and radioactivity logs yield only two distinct anomalies and two possible anomalies (Fig. 9). On the basis of the results of stream-sediment sampling, the upper canyons of Straight Wash, especially Crawford Draw, are considered possible sites for a uranium occurrence. The 47 ppm U_3O_8 anomaly in Crawford Draw may be related to a north-trending fault. Petroleum or gas migrating upward along this fault may have been the source of a reducing agent, and uranium-enriched solutions migrating downward from ash-rich strata in the lower Chinle Formation may have been the source of uranium. The two possibly anomalous sediment samples (13 and 18 ppm U_3O_8) from Straight Wash and Iron Wash may also be near faults or fractures.

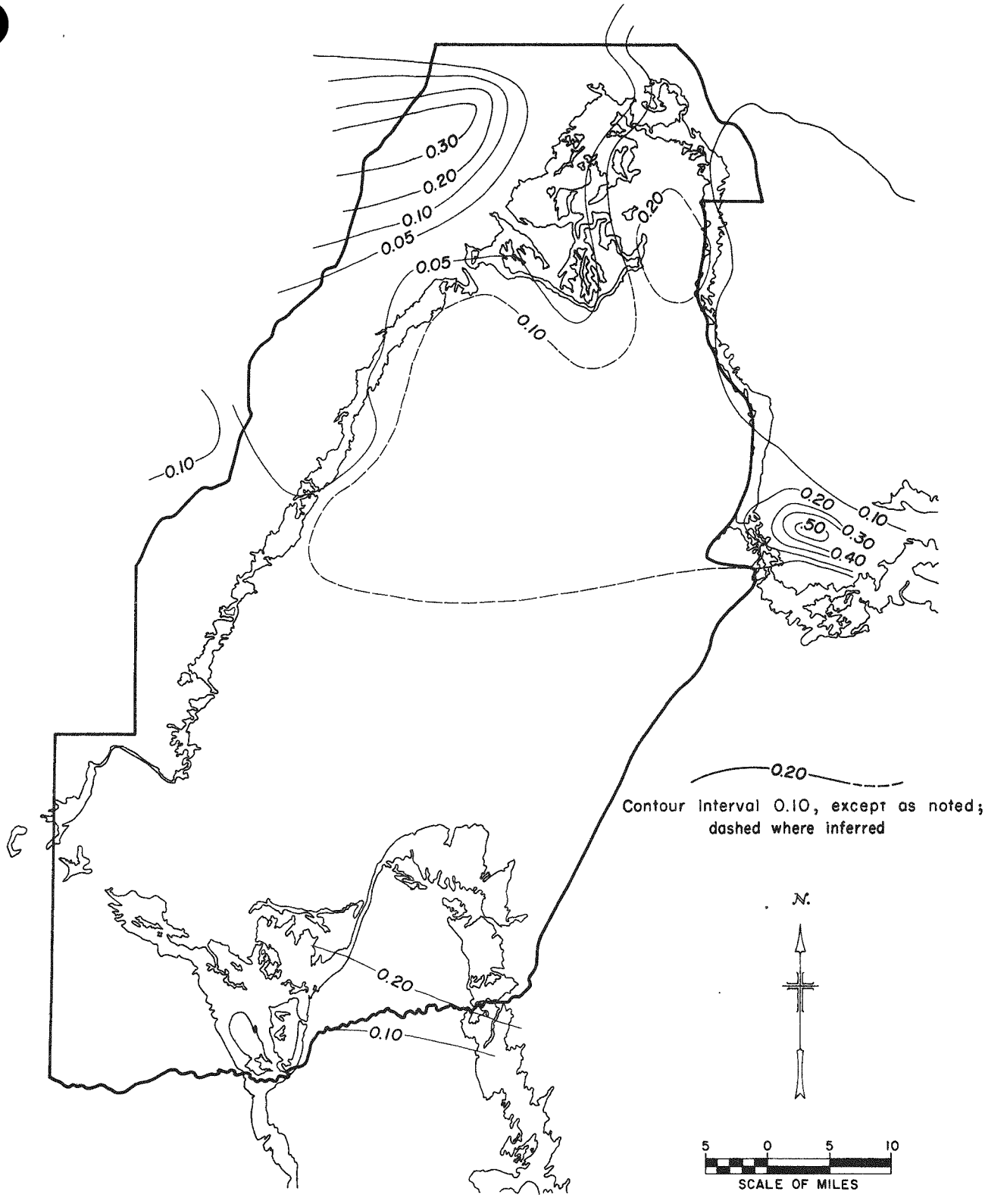


Figure 26. Sandstone-to-shale ratio map of the Brushy Basin Member of the Morrison Formation.

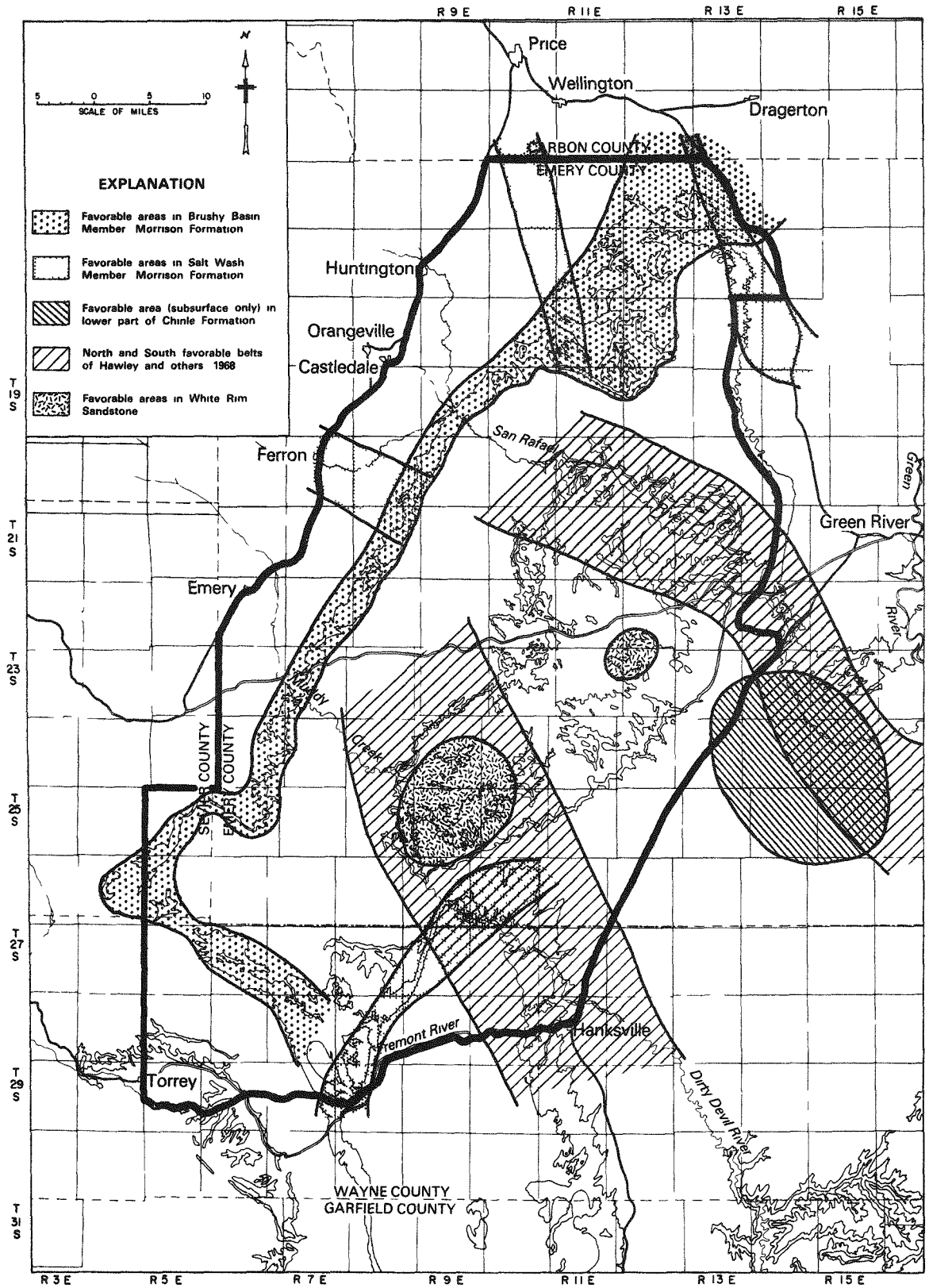


Figure 27. Areas favorable for uranium deposits, San Rafael Swell, Utah.

Because asphaltite is associated with uranium at Temple Mountain, Flat Top, and other locations in the San Rafael Swell (Bell, 1960), the presence of asphaltite in North Keesle Country and elsewhere in the McKay Flats area (Ritzma, 1973) is considered favorable and may be the reason for exploration in the McKay Flats area during the 1960s. However, a sample of asphaltite-impregnated rock from North Keesle Country recorded only 5 ppm U_3O_8. On the basis of the asphaltite occurrences, the White Rim Sandstone in North Keesle Country and the McKay Flats area is considered marginally favorable for uranium exploration.

Subsurface data show a significant anomaly in the White Rim Sandstone in only one test hole. Depth of the White Rim anomaly is 770 ft; in other test holes at the White Rim-Kaibab contact or within the Gamma member of the Kaibab, anomalies are also deep. The paucity of large anomalies and the depth of the anomalies decreases the favorability of the White Rim Sandstone and the Gamma member.

Grutt (1972) compiled a list of empirical criteria for favorable sandstones based on characteristics of uranium-bearing sandstones in the uranium-producing areas. Only fluvial, marine deltaic, and lagoonal sandstones are likely to contain reductants, such as plant debris, or are likely to be interbedded with shales that contain carbonaceous matter. Sandstones interbedded with gray or green (unoxidized) mudstones and shales are common in all nine uranium-producing areas. Sandstone-to-shale ratios of 1:1 to 4:1 were optimum. Comparison of the White Rim with uranium-bearing sandstone shows that the White Rim is relatively unfavorable. The White Rim is a very clean and uniformly well-sorted quartzose eolian sandstone without interbeds of mudstone or shale.

Tuffaceous sediments overlying or interbedded with sandstone are widely accepted as a source of uranium in sandstone-type deposits. The nearest tuffaceous or bentonitic strata are in the lower Chinle, and are stratigraphically separated from the White Rim by 300 to 600 ft of strata, most of which is tight siltstone and shale of the Moenkopi Formation. Migration of uranium-bearing ground water downward along the faults and joints is possible, but the stratigraphic distance between the Chinle and White Rim lessens the likelihood of large deposits forming this way.

The White Rim Sandstone is considered unfavorable because it contains few favorable lithologic characterists, it is too far removed from a possible uranium source (the bentonitic lower Chinle), mineralization is not apparent, and few anomalies were found in the field or on well logs. Exceptions to the overall unfavorability of the White Rim are (1) the McKay Flats area, where asphaltite is present and where drilling is reported to have located isolated uranium concentrations, and (2) the upper drainage basin of Straight Wash, where prospecting along faults and fractures may be warranted.

CHINLE FORMATION

The chief uranium-producing formation in the San Rafael Swell project area is the Chinle Formation. With two exceptions, the Temple Mountain collapse and the Dexter 7 mine, all important deposits are at the base of the Chinle in the Shinarump, sub-Moss Back, or basal part of the Moss Back. At Temple Mountain,

deposits are present in the overlying Wingate Sandstone, probably because of the influence of structural disturbance on mineralization. The only known deposit near the top of the Moss Back Member is at the Dexter 7 mine, which is located near one of several northeast-trending high-angle faults. The fault may not have influenced mineralization, but the association with the fault of the only important deposit high in the Moss Back raises the question. Because the ore is concentrated in the basal part of the Chinle, the basal Chinle is considered the best target for further exploration.

With the exception of the structure-controlled deposits at Temple Mountain, uranium deposits in the basal Chinle are grouped into two belts (Hawley and others, 1968). The South belt extends from just south of Temple Mountain and Flat Top Mesa on the southeastern side of the swell to the north end of Green Vein Mesa on the western side. The South belt contains all the large uranium deposits of the swell, except for those at Temple Mountain. Included in the South belt are the Cistern mine, Delta mine, the Dirty Devil mines at Tomsich Butte, Lucky Strike mine, Consolidated (Washington Uranium) mine, and Hertz mine (Pl. 1). As of 1957, all of these mines had produced more than 1,000 tons of uranium ore each (Hawley and others, 1968). Only the Lucky Strike mine is currently producing uranium.

The North belt extends from T. 22 S., R. 13 E. on the northeastern side of the swell to Calf Mesa on the northwestern side. Orebodies in the North belt are fewer and much smaller than those in the South belt. No mine in the North belt had produced as much as 1,000 tons by 1957. The Dexter 7 mine on Calf Mesa produced more than 500 tons by 1957 and is the largest producer in the North belt (Hawley and others, 1960).

The North and South belts coincide with the area in which the sub-Moss Back members (Temple Mountain and Monitor Butte) are relatively thick and the Moss Back is relatively thin or irregular in thickness. The South belt coincides with the area in which the Moss Back varies in thickness because of scour channels at the base. In the South belt, channel sandstone lenses are locally present in the Monitor Butte Member.

In the North belt, the Moss Back becomes thinner and less massive until it breaks up into a series of sandstones and muddy siltstones in the subface north of the northern Chinle outcrops. Sub-Moss Back channel sandstones in the North belt are locally present in the Temple Mountain Member.

In the interbelt area, the Moss Back is thick and massive, and the sub-Moss Back is thin. The interbelt area has long been considered unfavorable for large uranium deposits (Hawley and others, 1968; Lupe, 1976). Recent discoveries in the interbelt by Earth Resources Company and their successor, Idaho Mining Company, disproved this conclusion (A. N. Yater, 1976, 1977, personal commun.). The Idaho Mining Company properties are located in the Head-of-Sinbad area of the San Rafael Swell (25, App. A., Pl. 1). The deposits are in a sub-Moss Back member, probably Temple Mountain. The ore is in a complex of channel sandstone and siltstone deposited in a northeast-trending channel. In the area of the initial discovery, the sub-Moss Back varies from less than 20 ft to nearly 40 ft in thickness. Data from closely spaced drilling defined a northeast-trending channel scoured to a depth of at least 20 ft. Subsequent drilling along the channel trend to the southwest showed intermittent mineralization.

The northeast-southwest orientation of the Idaho Mining Company channel does not fit the regional north or northwest trend of other channels mapped in the area. Hawley and others (1968, Pl. 1) show northwest-trending sub-Moss Back channels to the north and east (T. 21 S., R. 10 E., and T. 22 S., R. 11 E.) to the south. Mapped segments of these channels are short because of limited exposures, and it is not clear if they are part of a single large channel system.

At the southern end of the San Rafael Swell the Tomsich Butte channel in the Moss Back Member swings north and then northeast before heading northwest where it is joined by another northwest-trending channel in the Moss Back (Hawley and others, 1968, Pl. 1). The Moss Back Member is stratigraphically higher than the sub-Moss Back member, but drainage controls for channels in the Moss Back may have been similar to controls for the underlying members. If so, the channel trend for the lower part of the Chinle in the northern two-thirds of the San Rafael Swell is to the northwest. Both the Idaho Mining Company channel and the north-trending Green Vein Mesa channel may also swing northwest at either end. This possibility should be considered for future exploration of either channel.

Significantly, the Idaho Mining Company's discoveries indicate that the western part of the interbelt area is favorable for uranium deposits although the sub-Moss Back member is thin in this area. The Moss Back Member is thick and massive over much of the interbelt area and may be unfavorable. However, the sub-Moss Back should be given further consideration.

Favorable areas elsewhere in the subsurface are indicated by anomalies on gamma-ray logs. Of the eight logs with anomalies in the sub-Moss Back, depths to the anomalies range from 1,683 to 5,595 ft. Only four of the anomalies are less than 2,500 ft deep (11222, 11236, 11239, 11254), and two of these are in the unfavorable interbelt area. Depths to anomalies in the Moss Back Member range from 1,472 to 2,045 ft. Although these depths are great in view of expectable grade and thickness of possible orebodies, these depths may not be beyond the capabilities of solution mining technology in the near future.

The most favorable location for exploration by relatively deep drilling is in the vicinity of holes 11214, 11222, 11223, 11231, and 11232 on the east flank of the swell (Fig. 3). Here, five test holes show anomalies in the Moss Back Member, and one hole (11222) also has an anomaly in the sub-Moss Back. These five holes are closely spaced compared to others (Fig. 3) and thus provide control points already drilled. Total drilling depth for a test hole in this area should be about 2,000 ft or less.

MORRISON FORMATION

Salt Wash Member

Uranium production for the Morrison Formation in the project area has come chiefly from the Tidwell area of the Green River mining district on the east side of the San Rafael Swell. As of July 1, 1977, the Tidwell area has produced

nearly 2.4 million pounds U_3O_8 from Salt Wash sandstone. The most important target in the Green River district is the upper continuous sandstone of the Salt Wash Member. The Green River mining district has been studied recently by the Utah Geological and Mineralogical Survey (Trimble and Doelling, 1977) and was not studied further for this report. Locations of known Salt Wash deposits, both within the Green River mining district and in the project area, are shown on Plate 1 and are listed in Appendix A.

Outside the Green River mining district, Salt Wash sandstone shows mineralization at several places. Uranium mineralization in the Wild Horse Mesa area was first discovered in the early 1950s. An outcrop study of the area by Hinckley and Volgamore (1953) concluded that uranium ore of commercial grade was not abundant enough to warrant further exploration or development. Mineralization at Wild Horse Mesa is confined to Salt Wash remnants of limited areal extent. Farther to the south along Caineville Reef there is a small prospect in the Salt Wash at about 111°05'N., 38°26'W.

Uranium in the Salt Wash was discovered in the northern part of the swell also in the 1950s. The White Star claim east of Ferron, Utah, and the Hey Joe and Cottonwood claims were located at that time. Only the White Star and Cottonwood deposits have shipped ore. None of the deposits, either at Wild Horse Mesa or in the northern part of the swell have produced more than a few hundred tons of ore.

The ash-derived bentonitic rocks of the Brushy Basin Member have been suggested as a source of the uranium in the Salt Wash Member (Grutt, 1972; Adler, 1974). The source, however, has long been a matter of debate.

Favorability criteria for the Salt Wash Member have been described by Craig and others (1955) and Grutt (1972). These criteria are similar to those for the Brushy Basin Member. For this report, favorability in the Salt Wash is based on (1) the presence of known deposits and (2) the distribution and number of thick, potentially ore-bearing sandstones. Thick Salt Wash sandstones are considered to be favorable host rocks for uranium deposits, especially where organic debris, clay galls, and clay splits are present. Johnson (1959a) stated that in the Cedar Mountain area, where individual sandstone lenses in the Salt Wash are less than 20 ft thick, ore deposits of appreciable size are not expected. Where sandstone lenses are 30 to 40 ft thick, small but economic deposits of uranium have been found.

Thick sandstones favorable for uranium mineralization are found in or adjacent to major trunk paleochannels in the Salt Wash alluvial fan. Uranium mineralization occurs where major stream channels break up into a complex of splays and meanders that provide lithologic heterogeneity and an abundance of preserved organic trash.

On the basis of these criteria, the area between the Caineville Reef, north of Caineville, and Little Wild Horse Mesa is considered favorable for small economic uranium orebodies. Here, several thick sandstones are interbedded with an optimum amount of mudstone. Minor uranium deposits are present on the east and west side of this trend.

In the northern part of the project area, the most favorable areas are along the White Star and Price trunk systems. Only the White Star trunk is favorable for uranium mineralization according to the favorability criteria of Johnson (1959a). Individual sandstone lenses within this trunk are greater than 20 ft thick and as much as 40 ft thick. Sandstones elsewhere in the northern San Rafael Swell are considered to be unfavorable because they are usually thin (<20 ft thick) and argillaceous (Johnson, 1959). However, uranium mineralization occurs in the Price trunk in two areas: at the Cottonwood claim and at the Hey Joe claim. These prospects are small and have produced no significant amount of ore.

The White Star and Price trunks dip gently to the west and northwest, respectively. Primary or secondary migration of uranium down these trunks may have formed deposits at depth. Thick sands are present in both trunks, and minor deposits are situated along these trends. The sandstone-to-shale ratios decrease rapidly to the unfavorable point (<0.3) downdip and would be a limiting factor in drilling for economic deposits.

The Woodside trunk appears to be favorable because several thick sands are present. The entire Woodside trunk is known only in the subsurface with a minimum depth of 500 ft. Maximum depth is over 2,500 ft. No radiometric anomalies were noted on gamma-ray logs of holes drilled through the Salt Wash sandstone of the Woodside trunk.

Brushy Basin Member

Favorability in the Brushy Basin Member is limited to those areas on the surface where outcrops are altered to buckskin color. Buckskin-colored areas seem to be coincident with weak uranium mineralization. In the subsurface, uranium mineralization is indicated on several logs in the northern part of the project area. There are few test holes in the southwestern and southern parts of the project area that have been logged with the gamma tool through the Brushy Basin interval. The subsurface situation in these areas is mostly unknown. In all parts of the project area, the Brushy Basin Member should be considered a large-volume, low-grade resource.

REFERENCES CITED

Adler, H. H., 1974, Concepts of uranium ore formation in reducing environments in sandstones and other sediments, in Formation of uranium ore deposits: Internat. Atomic Energy Agency, Athens, Greece, 6-10 May 1974, STI/PUB/374, LSBN 92-0-040274-F, p. 141-168.

Baars, D. L., 1962, Permian system of Colorado Plateau: Am. Assoc. Petroleum Geologists Bull., v. 46, no. 2, p. 149-218.

Baker, A. A., 1946, Geology of the Green River Desert-Cataract Canyon region, Emery, Wayne, and Garfield Counties, Utah: U.S. Geol. Survey Bull. 951, 122 p.

Bell, K. G., 1960, Uranium and other trace elements in petroleum and rock asphalts: U.S. Geol. Survey Prof. Paper 456-B, p. 45-65.

Blakey, R. C., 1974, Stratigraphic and depositional analysis of the Moenkopi Formation, southeastern Utah: Utah Geol. and Mineralog. Survey Bull. 104, 81 p.

Brookins, D. G., 1976, Uranium deposits of the Grants, New Mexico, Mineral Belt: U.S. Energy Research and Devel. Adm., GJBX-16(76), Open-File Rept., 153 p.

Craig, L. C., 1959, Measured sections of the Morrison and adjacent formations: U.S. Geol. Survey Open-File Rept., v. 1-5.

Craig, L. C., Holmes, C. N., Cadigan, R. A., Freeman, V. L., Mullens, T. E., and Weir, G. W., 1955, Stratigraphy of the Morrison and related formations, Colorado Plateau region, a preliminary report: U.S. Geol. Survey Bull. 1009-E, 168 p.

Davidson, D. F., 1963, Selenium in some oxidized sandstone-type uranium deposits: U.S. Geol. Survey Bull. 1162-C, 33 p.

Davidson, E. S., 1967, Geology of the Circle Cliffs area, Garfield and Kane Counties, Utah: U.S. Geol. Survey Bull. 1229, 140 p.

Dresser Atlas Division, 1975, Gamma-ray and neutron logging, in Log interpretation fundamentals: Houston, Texas, Dresser Industries, Inc., Chap. 6, p. 1-7.

Eargle, D. H., Dickinson, K. A., and Davis, B. O., 1975, South Texas uranium deposits: Am. Assoc. Petroleum Geologists Bull., v. 59, no. 5, p. 766-779.

Gilluly, James, and Reeside, J. B., Jr., 1928, Sedimentary rocks of the San Rafael Swell and some adjacent areas in eastern Utah: U.S. Geol. Survey Prof. Paper 150-D, p. 61-110.

Girdley, W. A., 1974, Kaibab limestone and associated strata, Circle Cliffs, Utah: Utah Geology, v. 1, no. 1, p. 5-20.

Grutt, E. W., Jr., 1972, Prospecting criteria for sandstone-type uranium deposits, in Bowie, S.H.U., Davis, Michael, and Ostle, Dennis, eds., Uranium prospecting handbook: London, Inst. Mining and Metallurgy, p. 47-78.

Hallgarth, W. E., 1962, Upper Paleozoic rocks exposed in Straight Wash Canyon, San Rafael Swell, Utah: Am. Assoc. Petroleum Geologists Bull., v. 46, no. 8, p. 1494-1501.

Hawley, C. C., Wyant, D. G., and Brooks, D. B., 1965, Geology and uranium deposits of the Temple Mountain district, Emery County, Utah: U.S. Geol. Survey Bull. 1192, 154 p. [1966].

Hawley, C. C., Robeck, R. C., and Dyer, H. B., 1968, Geology, altered rocks, and ore deposits of the San Rafael Swell, Emery County, Utah: U.S. Geol. Survey Bull. 1239, 155 p.

Hinckley, D. N., and Volgamore, J. H., 1953, Reconnaissance of Little Wild Horse Mesa, Green River Desert, Emery County, Utah: U.S. Atomic Energy Comm., RME-43, Tech. Inf. Service, Oak Ridge, Tenn., 14 p.

Hintze, L. F., and Stokes, W. L., 1964, Geologic map of southeastern Utah: Utah Geol. and Mineralog. Survey, scale 1:250,000.

Hunt, C. B., 1956, Cenozoic geology of the Colorado Plateau: U.S. Geol. Survey Prof. Paper 279, 99 p.

Hunt, C. B., Averitt, Paul, and Miller, R. L., 1953, Geology and geography of the Henry Mountains region, Utah: U.S. Geol. Survey Prof. Paper 228, 234 p.

Irwin, C. D., 1971, Stratigraphic analysis of Upper Permian and Lower Triassic strata in southern Utah: Am. Assoc. Petroleum Geologists Bull., v. 55, no. 11, p. 1976-2007.

Johnson, H. S., Jr., 1959a, Uranium resources of the Cedar Mountain area, Emery County, Utah: U.S. Geol. Survey Bull. 1087-B, p. 23-55.

_____1959b, Uranium resources of the Green River and Henry Mountains district, Utah: U.S. Geol. Survey Bull. 1087-C, p. 59-104.

Johnson, H. S., Jr., and Thordarson, William, 1966, Uranium deposits of the Moab, Monticello, White Canyon, and Monument Valley districts, Utah and Arizona: U.S. Geol. Survey Bull. 1222-H, 53 p.

Keller, W. D., 1962, Clay minerals in the Morrison Formation of the Colorado Plateau: U.S. Geol. Survey Bull. 1150, 90 p.

Lupe, Robert, 1976, Depositional environments as a guide to uranium mineralization in the Chinle Formation, San Rafael Swell, Utah: U.S. Geol. Survey Open-File Rept. 76-283, 19 p.

McKee, E. D., 1938, The environment and history of the Toroweap and Kaibab Formations of northern Arizona and southern Utah: Carnegie Inst. Washington Pub. 492, 268 p.

McKeown, F. A., and Orkild, P. P., 1958, Orange Cliffs area, Utah, in Geologic investigations of radioactive deposits, semiannual progress report, December 1, 1957, to May 31, 1958: U.S. Geol. Survey Rept. TEI-740, p. 47-57, issued by U.S. Atomic Energy Comm. Tech. Inf. Service, Oak Ridge, Tenn.

Miller, D. S., and Kulp, J. L., 1963, Isotopic evidence on the origin of the Colorado Plateau uranium ores: Geol. Soc. America Bull., v. 74, no. 5, p. 609-630.

Mullens, T. E., and Freeman, V. L., 1957, Lithofacies of the Salt Wash Member of the Morrison Formation, Colorado Plateau: Geol. Soc. America Bull., v. 68, no. 4, p. 505-526.

Pirson, S. J., 1970, Geologic well log analysis: Houston, Gulf Pub. Co., 370 p.

Reyner, M. L., 1950, Preliminary report on some uranium deposits along the west side of the San Rafael Swell, Emery County, Utah: U.S. Atomic Energy Comm., RMO-673, Tech. Inf. Service, Oak Ridge, Tenn., 32 p.

Rich, R. A., Holland, H. D., and Petersen, Ulrich, 1975, Vein-type uranium deposits: U.S. Energy Research and Devel. Adm., GJO-1640, Open-File Rept., 380 p.

Ritzma, H. R., 1973, Oil-impregnated rock deposits of Utah: Utah Geol. and Mineralog. Survey Map 33, scale 1:1,000,000.

Smith, J. F., Jr., Huff, L. C., Hinrichs, E. N., and Luedke, R. G., 1963, Geology of the Capitol Reef area, Wayne and Garfield Counties, Utah: U.S. Geol. Survey Prof. Paper 363, 102 p.

Stewart, J. H., Poole, F. G., and Wilson, R. F., 1972, Stratigraphy and origin of the Chinle Formation and related Upper Triassic strata in the Colorado Plateau region: U.S. Geol. Survey Prof. Paper 690, 336 p.

Stieff, L. R., and Stern, T. W., 1957, Interpretation of the discordant age sequence of uranium ores, in Page, L. R., Stocking, H. E., and Smith, H. B., comps., Contributions to the geology of uranium and thorium by the U.S. Geological Survey and Atomic Energy Commission for the United Nations International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, 1955: U.S. Geol. Survey Prof. Paper 300, p. 549-555.

Stieff, L. R., Stern, T. W., and Milkey, R. G., 1953, A preliminary determination of the age of some uranium ores of the Colorado plateaus by the lead-uranium method: U.S. Geol. Survey Circ. 271, 19 p.

Stokes, W. L., 1944, Morrison Formation and related deposits in and adjacent to the Colorado Plateau: Geol. Soc. America Bull., v. 55, p. 951-992.

_____1950, Pediment concept applied to Shinarump and similar conglomerates: Geol. Soc. America Bull., v. 61, p. 91-98.

Stokes, W. L., and Cohenour, R. E., 1956, Geologic atlas of Utah, Emery County: Utah Geol. and Mineralog. Survey Bull. 52, 92 p.

Trimble, L. M., and Doelling, H. H., 1977, Geology and ore deposits of the San Rafael River mining area, Emery County, Utah: Utah Geol. and Mineralog. Survey Open-File Rept. 20, 246 p.

Williams, P. L., and Hackman, R. J., 1971, Geology, structure, and uranium deposits of the Salina quadrangle, Utah: U.S. Geol. Survey Misc. Geol. Inv. Map I-591.

Young, Patti, and Mickle, D. G., 1976, Uranium favorability of Tertiary rocks in the Badger Flats - Elkhorn Thrust area, Park and Teller Counties, Colorado: U.S. Energy Research and Devel. Adm., GJBX-54(76), Open-File Rept., 30 p.

Young, R. G., 1960, Dakota Group of Colorado Plateau: Am. Assoc. Petroleum Geologists Bull., v. 44, no. 2, p. 156-194.

_____1964, Distribution of uranium deposits in the White Canyon-Monument Valley district, Utah-Arizona: Econ. Geology, v. 59, p. 850-873.

APPENDIX A

PROSPECTS AND MINES, SAN RAFAEL SWELL PROJECT AREA

APPENDIX A. PROSPECTS AND MINES, SAN RAFAEL SWELL PROJECT AREA

Name	Location	Member	Production to 1-1-77	Reference
		Chinle Formation		
1. Buckhorn 1-7	sec. 10, T. 20 S., R. 11 E.	Temple Mountain	a	PRR ED:R-662
2. Mayflower	sec. 20, T. 20 S., R. 11 E.	Moss Back	a	PRR ED:R-663
3. Re-entrant Mine	sec. 31, T. 20 S., R. 11 E.	Moss Back	a	PRR ED:R-668
4. Douglas Clark 1	sec. 31, T. 20 S., R. 11 E.	Moss Back	a	PRR ED:R-669
5. Blue Bird	sec. 32, T. 20 S., R. 11 E.	Moss Back	a	PRR ED:R-665
6. Dexter 5 & 7	sec. 5, T. 21 S., R. 11 E.	Moss Back	a	PRR ED:R-198, PRR ED:R-199
7. Lone Tree Group	sec. 33, T. 20 S., R. 11 E.	Moss Back	a	PRR ED:R-220
8. Deep Snow - Joy Ride	sec. 13, T. 21 S., R. 10 E.	Moss Back	a	PRR ED:R-670
9. Jubilee	sec. 23, T. 21 S., R. 10 E.	Temple Mountain	a	PRR ED:R-672
10. Macober-Dille Butte	sec. 19, T. 21. S., R. 11 E.	Temple Mountain	a	PRR ED:R-671
11. High Boy	sec. 35, T. 21 S., R. 13 E.	Moss Back	a	
12. Five Star	sec. 23, T. 22 S., R. 10 E.	Temple Mountain	a	PRR ED:R-676

APPENDIX A. (continued)

Name	Location	Member	Production to 1-1-77	Reference
		Chinle Formation (continued)		
13. Unknown	sec. 30, T. 22 S., R. 11 E.	Temple Mountain	a	
14. Donna B. 1	sec. 30, T. 22 S., R. 11 E.	Temple Mountain	a	PRR ED:R-241
15. Cancer Cure 1 & 10	sec. 19, T. 22 S., R. 11 E.	Temple Mountain	a	PRR ED:R-674
16. Virginia Lou	sec. 30, T. 22 S., R. 11 E.	Moss Back	a	PRR ED:R-675
17. Red Claim 6	sec. 21, T. 22 S., R. 11 E.	Temple Mountain	a	
18. Unknown	sec. 21, T. 22 S., R. 11 E.	Moss Back	a	
19. Wickiup Mining Co.	sec. 22, T. 22 S., R. 11 E.	Moss Back	a	PRR ED:R-673
20. Bird Eye 13	sec. 23, T. 22 S., R. 13 E.	Temple Mountain	a	PRR ED:R-721
21. Koa Uneva	sec. 23, T. 22 S., R. 13 E.	Temple Mountain	a	PRR ED:R-720
22. Pilling Bros.	sec. 36, T. 22 S., R. 10 E.	Moss Back	a	PRR ED:R-678
23. Marcy Exploration	sec. 35, T. 22 S., R. 13 E.	Temple Mountain(?)	a	PRR ED:R-446
24. Cliff Dwellers	sec. 35, T. 22 S., R. 13 E.	Moss Back	a	PRR ED:R-722
25. Sinbad	sec. 35, T. 22 S., R. 10 E., also secs. 3, 4, 9, 10, T. 23 S., R. 10 E.	Temple Mountain	a	E. P. Beroni (1976, pers. commun.)

APPENDIX A. (continued)

Name	Location	Member	Production to 1-1-77	Reference
		Chinle Formation (continued)		
26. Hunt Oil Co.	sec. 1, T. 23 S., R. 10 E.	Moss Back	a	PRR ED:R-211
27. Fiesta Uranium	sec. 1, T. 23 S., R. 10 E.	Temple Mountain	a	PRR ED:R-679
28. Fiesta Uranium	sec. 12, T. 23 S., R. 10 E., sec. 7, T. 23 S., R. 11 E.	Temple Mountain	a	PRR ED:R-679
29. Moroni Hunt	secs. 16, 17, T. 23 S., R. 10 E.	Moss Back	a	PRR ED:R-681
30. Lost Canyon Mine	sec. 19, T. 23 S., R. 11 E.	Moss Back	a	PRR ED:R-680
31. Pay Day	secs. 19, 20, T. 23 S., R. 10 E.	Monitor Butte	a	PRR ED:R-684, PRR ED:R-685
32. Green Vein 5	sec. 20, T. 23 S., R. 10 E.	Monitor Butte	b	PRR ED:R-683
33. Fairfox & Fairmont	secs. 21, 22, T. 23 S., R. 10 E.	Moss Back(?)	a	PRR ED:R-219
34. Thunderbird - Gray Fox	sec. 19, T. 23 S., R. 10 E.	Monitor Butte	a	PRR ED:R-689
35. Nelson 3	sec. 20, T. 23 S., R. 10 E.	Moss Back	a	PRR ED:R-682
36. Green Vein 4	sec. 20, T. 23 S., R. 10 E.	Monitor Butte	a	Reyner, 1950

APPENDIX A. (continued)

Name	Location	Member	Production to 1-1-77	Reference
		Chinle Formation (continued)		
37. Sheba Uranium	sec. 24, T. 23 S., R. 9 E.	Moss Back	a	PRR ED:R-690
38. Green Vein 2	sec. 30, T. 23 S., R. 10 E.	Monitor Butte	a	Reyner, 1950
39. Hertz 1	secs. 30, 31, T. 23 S., R. 10 E.	Monitor Butte	b	PRR ED:R-686
40. Dolly	sec. 31, T. 23 S., R. 10 E.	Monitor Butte	a	PRR GJEB:R-194, PRR ED:R-688
41. Washington Uranium	secs. 31, 32, T. 23 S., R. 10 E.	Monitor Butte	a	PRR ED:R-687
42. Johnson Claims	sec. 26, T. 23 S., R. 9 E.	Monitor Butte	a	PRR ED:R-691
43. King Group	sec. 27, T. 23 S., R. 9 E.	Monitor Butte	a	PRR ED:R-694
44. Little Joe	sec. 28, T. 23 S., R. 9 E.	Moss Back	a	PRR ED:R-693
45. Staker and Elder #8	sec. 33, T. 23 S., R. 9 E.	Monitor Butte	a	PRR ED:R-695
46. Magic Valley	sec. 32, T. 23 S., R. 9 E.	Monitor Butte	a	PRR ED:R-696
47. Apex	sec. 32, T. 23 S., R. 9 E.	Monitor Butte	a	PRR ED:R-698
48. Royal Uranium	sec. 5, T. 24 S., R. 10 E.	Monitor Butte	a	PRR ED:R-697

APPENDIX A. (continued)

Name	Location	Member	Production to 1-1-77	Reference
		Chinle Formation (continued)		
49. Lucky Strike	sec. 5, T. 24 S., R. 9 E.	Moss Back	b	PRR ED:R-701
50. Lucky Seven 1	sec. 4, T. 24 S., R. 9 E.	Monitor Butte	a	PRR ED:R-236, PRR ED:R-242, PRR ED:R-699
51. Common Wealth	sec. 5, T. 24 S., R. 9 E.	Moss Back	a	PRR ED:R-700
52. Conrad 1 & 2	sec. 7, T. 24 S., R. 9 E.	Moss Back	b	PRR GJEB:R-112
53. Chimney Rock	sec. 8, T. 24 S., R. 9 E.	Moss Back	a	PRR ED:R-702
54. Paleface 21	sec. 7, T. 24 S., R. 9 E.	Moss Back	a	PRR ED:R-703
55. Unknown	sec. 18, T. 24 S., R. 9 E.	Moss Back	a	PRR GJEB:R-192
56. Adams Uranium	sec. 7(?), T. 24 S., R. 9 E.	Moss Back	a	PRR ED:R-705
57. Standard Ore & Alloys	sec. 18, T. 24 S., R. 9 E.	Temple Mountain	a	PRR ED:R-706
58. Unknown	sec. 24, T. 24 S., R. 8 E.	Moss Back	a	PRR GJEB:R-193
59. Joshua 1	sec. 18, T. 24 S., R. 9 E.	Moss Back	a	PRR ED:R-707
60. Green Dragon	sec. 24, T. 24 S., R. 8 E.	Moss Back	a	PRR ED:R-464

APPENDIX A. (continued)

Name	Location	Member	Production to 1-1-77	Reference
		Chinle Formation (continued)		
61. Green Dragon 3	sec. 24, T. 24 S., R. 8 E.	Monitor Butte	a	PRR ED:R-708
62. Rio Colorado	sec. 25, T. 24 S., R. 8 E.	Moss Back	a	PRR ED:R-710
63. Dirty Devil 6	sec. 25, T. 24 S., R. 8 E.	Moss Back	a	PRR ED:R-711
64. Dirty Devil 2	sec. 36, T. 24 S., R. 8 E.	Moss Back	b	PRR ED:R-712
65. Twilight Group	sec. 23(?), T. 24 S., R. 12 E.	Moss Back	a	PRR GJEB:R-122
66. Flat Top	sec. 32, T. 24 S., R. 11 E.	Moss Back	a	Hawley, 1965
67. Temple Mt. Dist.	secs. 26, 27, 34, 35, T. 24 S., R. 11 E.	Moss Back	d	Hawley, 1965
68. Muddy Group & Ute Group	secs. 35, 2, Tps. 24, 25 S., R. 8 E.	Moss Back	a	PRR ED:R-235
69. Eagle	sec. 2, T. 25 S., R. 8 E.	Moss Back	a	PRR ED:R-714
70. Window Rock	sec. 25, T. 24 S., R. 8 E.	Moss Back	a	PRR ED:R-713
71. Rainbow	sec. 2, T. 25 S., R. 8 E.	Temple Mountain	a	PRR ED:R-715

APPENDIX A. (continued)

Name	Location	Member	Production to 1-1-77	Reference
		Chinle Formation (continued)		
72. Selecto Claims	sec. 12(?), T. 25 S., R. 8 E.	Moss Back	a	Unnumbered PRR
73. Black Beauty 1 & 2	sec. 3(?), T. 25 S., R. 11 E.	Moss Back	a	PRR GJEB:R-128
74. Arrowhead	sec. 9, T. 25 S., R. 11 E.	Temple Mountain	a	PRR GJEB:R-127
75. Virginia Valley	sec. 8, T. 25 S., R. 11 E.	Temple Mountain(?)	a	Unnumbered PRR
76. First Chance 1	sec. 18, T. 25 S., R. 11 E.	Temple Mountain	a	PRR GJEB:R-126
77. Desolation	sec. 18, T. 25 S., R. 11 E.	Temple Mountain(?)	a	PRR GJEB:R-129
78. Blue Lady	sec. 24, T. 25 S., R. 10 E.	Moss Back	a	PRR GJEB:R-124, PRR GJEB:R-125
79. Little Erma	sec. 24, T. 25 S., R. 10 E.	Moss Back	a	PRR GJEB:R-123
80. Chute Canyon Mine	sec. 24, T. 25 S., R. 10 E.	Moss Back	a	Unnumbered PRR
81. Ryan 101	sec. 22, T. 25 S., R. 8 E.	Moss Back	a	PRR ED:R-717
82. Little Susan Mine	sec. 6, T. 26 S., R. 9 E.	Moss Back	a	PRR ED:R-463
83. Bluebird	sec. 8, T. 26 S., R. 9 E.	Monitor Butte	a	PRR LD:R-196

APPENDIX A. (continued)

Name	Location	Member	Production 1-1-77	Reference
		Chinle Formation (continued)		
84. Delta Mine	sec. 9, T. 26 S., R. 9 E.	Monitor Butte	c	RME-59, PRR GJEB:R-1010, Hawley, 1968
85. Golden Rod 1-3	sec. 8(?), T. 29 S., R. 4 E.	Shinarump(?)	a	R.R. 142
86. Oyler Mine	sec. 26, T. 29 S., R. 6 E.	Shinarump	a	
87. Vanadium King	sec. 34, T. 24 S., R. 11 E.	Moss Back	a	PRR ED:R-61
		Morrison Formation		
88. Dead End	sec. 4, T. 17 S., R. 13 E.	Brushy Basin	a	PRR ER:R-534
89. Rock Island	secs. 8, 9, T. 17 S., R. 13 E.	Brushy Basin	a	PRR ED:R-448
90. Cottonwood 1	sec. 26, T. 17 S., R. 11 E.	Salt Wash	a	
91. Unknown	sec. 8(?), T. 19 S., R. 12 E.	Salt Wash	a	Johnson, 1959a
92. Unknown	sec. 4(?), T. 19 S., R. 12 E.	Brushy Basin	a	Johnson, 1959a
93. South Rim Mine 1	sec. 36, T. 18 S., R. 10 E.	Brushy Basin	a	PRR ED:R-217

APPENDIX A. (continued)

Name	Location	Member	Production 1-1-77	Reference
		Morrison Formation (continued)		
94. Cedar Mountain 1	sec. 36, T. 18 S., R. 10 E.	Brushy Basin	a	PRR ED:R-216
95. Rhonda	sec. 8(?), T. 20 S., R. 9 E.	Brushy Basin	a	Johnson, 1959a
96. White Star 1-10	sec. 20, T. 20 S., R. 9 E.	Salt Wash	a	PRR ED:R-294
97. Rebecca Knolls	sec. 26 or 35, T. 20 S., R. 8 E.	Brushy Basin	a	PRR ED:R-250
98. Unclaimed ground anomaly	secs. 15, 22, T. 21 S., R. 8 E.	Salt Wash	a	PRR ED:R-378
99. Incline 4	sec. 21(?), T. 21 S., R. 14 E.	Salt Wash	a	
100. Unknown	sec. 8(?), T. 22 S., R. 8 E.	Brushy Basin	a	Johnson, 1959a
101. Eagle	sec. 12, T. 22 S., R. 7 E.	Brushy Basin	a	
102. Northern Green River District	Tps. 20, 21, 22, 23 S., R. 14 E. Tps. 21, 22, 23 S., R. 15 E.	Salt Wash	d	E. P. Beroni (1976, pers. comm.)
103. Ceciliaite 1	sec. 35(?), T. 22 S., R. 14 E.	Brushy Basin	a	PRR ED:R-744
104. Last Chance Helm	secs. 11, 14, T. 25 S., R. 6 E. secs. 10, 15, T. 25 S., R. 5 E.	Brushy Basin	a	R. G. Young (1976, pers. comm.), PRR ED:R-543
105. Alpha 1	sec. 10, T. 26 S., R. 10 E.	Salt Wash	a	PRR GJEB:R-1021

APPENDIX A. (continued)

Name	Location	Member	Production 1-1-77	Reference
		Formations other than the Chinle and Morrison		
106. Cedar Ridge	sec. 5(?), T. 18 S., R. 11 E.	Cedar Mountain	a	Johnson, 1959a PRR ED:R-266
107. Dog Group	sec. 23, T. 20 S., R. 8 E.	Cedar Mountain	a	PRR ED:R-542
108. Copper Rock 1 & Bell View	sec. 31 or 32, T. 20 S., R. 9 E.	Entrada	a	Johnson, 1959a PRR ED:R-292
109. Darlina	sec. 19(?), 20(?), T. 20 S. R. 9 E.	Entrada	a	PRR ED:R-447
110. Unknown	sec. 22, T. 21 S., R. 8 E.	Summerville	a	Johnson, 1959a
111. Unknown	sec. 6, T. 22 S., R. 8 E.	Cedar Mountain	a	Johnson, 1959a
112. Nelson 5-10	sec. 5, T. 22 S., R. 8 E.	Summerville	a	PRR ED:R-218
113. Unknown	sec. 4, T. 22 S., R. 8 E.	Summerville	a	PRR ED:R-293
114. Copper Globe	sec. 21, T. 23 S., R. 9 E.	Navajo	a	PRR GJEB:R-107
115. Unknown	sec. 24, T. 24 S., R. 13 E.	Entrada	a	PRR GJEB:R-1020
116. Copper Queen	secs. 18, 19(?), T. 28 S., R. 12 E.	Entrada	a	PRR GJEB:R-98

APPENDIX A. (continued)

Name	Location	Member	Production 1-1-77	Reference
		Chinle and Morrison (continued)		
117. Tunison and Linda Group	sec. 11, T. 29 S., R. 4 E.	Lower Moenkopi(?)	a	PRR-R.R.177
118. Unknown	sec. 31(?), T. 29 S., R. 6 E.	Moenkópi - Sinbad Member	a	USGS D-301

[a]0-10,000 pounds U_3O_8 or unknown.

[b]10,000-100,000 pounds U_3O_8.

[c]100,000-1,000,000 pounds U_3O_8.

[d]Greater than 1,000,000 pounds U_3O_8.

APPENDIX B

CHEMICAL ANALYSES OF WATER SAMPLES, SAN RAFAEL SWELL PROJECT AREA

APPENDIX B. CHEMICAL ANALYSES OF WATER SAMPLES, SAN RAFAEL SWELL PROJECT AREA.

Sample no.	Location	Formation	U_3O_8 (ppb)	Total sulphur (ppm)	Total dissolved solids (%)
MAE 001	Tan Seep sec. 3, T. 24 S., R. 10	Moenkopi	15	448	0.02
MAE 002	Lucky Strike sec. 5, T. 24 S., R. 9 E	Chinle	10	458	0.02
MAE 003	Buckskin Spring sec. 23, T. 25 S., R. 11 E.	Entrada	4	409	0.02
MAE 004	Willow Spring Creek sec. 13, T. 24 S., R. 5 E.	Mancos	5	215	0.01
MAE 005	Huntington Creek sec. 33, T. 18 S., R. 9 E.	Mancos	25	853	0.03
MAE 006	Red Seep sec. 1, T. 19 S., R. 9 E.	Morrison- Brushy Basin	49	75	0.01
MAE 007	Buckhorn Wash T. 20 S., R. 11 E.	Chinle	19	505	0.02
MAE 014	sec. 29, T. 23 S., R. 13 E.	Moenkopi	0	16	0.01
MAE 023	Black Dragon Seep sec. 36, T. 21 S., R. 13 E.	Wingate	2	262	0.15
MAE 026	Swazy Seep sec. 4, T. 25 S., R. 12 E.	Carmel	1	477	0.18

APPENDIX B. (continued)

Sample no.	Location	Formation	U_3O_8 (ppb)	Total sulphur (ppm)	Total dissolved solids (%)
MAE 027	sec. 9, T. 24 S., R. 13 E.	Navajo	<1	172	0.12
MAE 028	Cottonwood Well sec. 10, T. 25 S., R. 13 E.	Carmel	<1	182	0.10
MAE 029	Dry Wash Well sec. 36, T. 28 S., R. 7 E.	Mancos	<1	249	0.16
MAE 059*	Iron Wash sec. 32, T. 23 S., R. 11 E.	White Rim	<1	962	0.02
MAE 076	Delta Mine sec. 9, T. 26 S., R. 9 E.	Moenkopi	<0.1	487	0.4
MAE 078	Iron Wash sec. 11, T. 24 S., R. 11 E.	White Rim	0	4	0.01
MAE 099	Sulphur Spring sec. 23, T. 21 S., R. 13 E.	Moenkopi	2	288	0.1
MAE 100	N. Reds Canyon sec. 25, T. 23 S., R. 9 E.	Moenkopi	27	654	0.2
MAE 109	Secret Spring sec. 25, T. 21 S., R. 8 E.	Moenkopi	13	952	0.3
MAE 110	Jeffery Well sec. 19, T. 26 S., R. 13 E.	Entrada	15	518	0.2

*This sample also contained 7 ppm As.

APPENDIX B. (continued)

Sample no.	Location	Formation	U_3O_8 (ppb)	Total sulphur (ppm)	Total dissolved solids (%)
MAE 111	Temple Spring sec. 6, T. 25 S., R. 13 E.	Entrada	15	1,065	0.2
MAE 112	Wild Horse Spring sec. 9, T. 25 S., R. 11 E.	Chinle	19	189	0.1
MAE 113	Cottonwood Spring sec. 32, T. 24 S., R. 14 E.	Entrada	13	593	0.2
MAE 128	Crystal Geyser sec. 34, T. 21 S., R. 16 E.	Summerville	1	--	0.4
MAE 129	Clay Seep sec. 27, T. 17 S., R. 11 E.	Morrison-Brushy Basin	8	--	0.2
MAE 130	Lucky Flats Spring sec. 18, T. 17 S., R. 12 E.	Morrison-Brushy Basin	5	--	0.1
MAE 131	sec. 6, T. 17 S., R. 12 E.	Morrison-Brushy Basin	7	--	0.08
MAE 132	Bull Hollow Spring sec. 11, T. 18 S., R. 10 E.	Cedar Mountain-Buckhorn Conglomerate	2	--	0.04
MAE 133	Goat Spring sec. 1, T. 18 S., R. 10 E.	Morrison-Brushy Basin	1	--	0.04

APPENDIX B. (continued)

Sample no.	Location	Formation	U_3O_8 (ppb)	Total sulphur (ppm)	Total dissolved solids (%)
MAE 134	Staker Spring sec. 13, T. 18 S., R. 10 E.	Morrison-Brushy Basin	3	--	0.04
MAE 135	Bob Hill Spring sec. 34, T. 18 S., R. 11 E.	Morrison-Brushy Basin	5	--	0.07
MAE 136	Calf Mesa Spring sec. 30, T. 20 S., R. 11 E.	Moenkopi	6	--	0.3
MAE 137	sec. 19, T. 20 S., R. 11 E.	Chinle, near base of Moss Back	8	--	0.3
MAE 138	Cane Wash Seep lat 38°59'N., long. 110°44'W.	Moenkopi	9	--	0.2
MAE 139	sec. 5, T. 21 S., R. 14 E.	Carmel	4	--	0.06
MAE 140	sec. 5, T. 21 S., R. 14 E.	Carmel	4	--	0.08
MAE 141	sec. 2, T. 27 S., R. 5 E.	Entrada	19	494	0.2
MAE 142	sec. 20(?), T. 27 S., R. 6 E.	Morrison-Salt Wash	16	178	0.1
MAE 143	Staker Spring sec. 34, T. 18 S., R. 11 E.	Cedar Mountain-Buckhorn Conglomerate	2	17	0.05

APPENDIX B. (continued)

Sample no.	Location	Formation	U_3O_8 (ppb)	Total sulphur (ppm)	Total dissolved solids (%)
MAE 144	sec. 34, T. 18 S., R. 11 E.	Morrison-Brushy Basin	13	78	0.1
MAE 152	Coon Spring sec. 2, T. 17 S., R. 13 E.	Morrison-Brushy Basin	14	272	0.1
MAE 153	Sahara Mine sec. 14, T. 22 S., R. 14 E.	Morrison-Salt Wash	1,100	104	0.1
MAE 225	Wimmer Spring sec. 16, T. 18 S., R. 11 E.	Cedar Mountain-Buckhorn Conglomerate	3	20	0.04
MAE 226	Ware Spring sec. 15, T. 18 S., R. 11 E.	Cedar Mountain-Buckhorn Conglomerate	12	48	0.07
MAE 227	Gooseberry Spring sec. 5, T. 19 S., R. 12 E.	Cedar Mountain-Buckhorn Conglomerate	<1	14	0.05
MAE 228	Huff Spring sec. 32, T. 18 S., 12 E.	Morrison-Brushy Basin	2	20	0.04
MAE 229	Birch Spring sec. 31, T. 18 S., R. 12 E.	Morrison-Brushy Basin	1	33	0.06

APPENDIX B. (continued)

Sample no.	Location	Formation	U_3O_8 (ppb)	Total sulphur (ppm)	Total dissolved solids (%)
MAE 230	Wiregrass Spring sec. 20, T. 18 S., R. 12 E.	Morrison-Brushy Basin	5	64	0.09
MAE 231	Mud Spring sec. 32, T. 18 S., R. 11 E.	Morrison-Brushy Basin	3	27	0.05

APPENDIX C

CHEMICAL ANALYSES OF STREAM-SEDIMENT SAMPLES, SAN RAFAEL SWELL PROJECT AREA

Appendix C. Chemical analyses of stream-sediment samples, San Rafael Swell project area.

Sample no.	Location	Formation	U_3O_8 (ppm)
MAE 008	Straight Wash sec. 27, T. 23 S., R. 13 E.	Entrada	135
MAE 009	Straight Wash sec. 28, T. 23 S., R. 13 E.	Navajo	13
MAE 010	Straight Wash sec. 28, T. 23 S., R. 13 E.	Chinle	6
MAE 011	Straight Wash sec. 20, T. 23 S., R. 13 E.	Moenkopi	8
MAE 012	Straight Wash sec. 29, T. 23 S., R. 13 E.	Moenkopi	5
MAE 013	Straight Canyon sec. 29, T. 23 S., R. 13 E.	Moenkopi	5
MAE 015	sec. 35, T. 22 S., R. 13 E.	Carmel/Navajo	3
MAE 016	sec. 35, T. 22 S., R. 13 E.	Chinle	15
MAE 017	sec. 34, T. 22 S., R. 13 E.	Moenkopi	3
MAE 018	sec. 34, T. 22 S., R. 13 E.	Moenkopi	5
MAE 019	sec. 23, T. 22 S., R. 13 E.	Navajo	4
MAE 020	sec. 23, T. 22 S., R. 13 E.	Chinle	4
MAE 021	sec. 23, T. 22 S., R. 13 E.	Moenkopi	3
MAE 022	sec. 36, T. 21 S., R. 13 E.	Carmel/Navajo	2
MAE 024	Black Dragon Wash sec. 36, T. 21 S., R. 13 E.	Chinle	12
MAE 025	Black Dragon Wash sec. 34, T. 21 S., R. 13 E.	White Rim	2
MAE 031	Black Dragon Canyon sec. 33, T. 21 S., R. 13 E.	White Rim	4
MAE 032	sec. 31, T. 21 S., R. 13 E.	White Rim	3

APPENDIX C. (continued)

Sample no.	Location	Formation	U_3O_8 (ppm)
MAE 033	sec. 4, T. 22 S., R. 13 E.	White Rim	3
MAE 034	sec. 5, T. 22 S., R. 13 E.	White Rim	2
MAE 035	sec. 6, T. 22 S., R. 13 E.	White Rim	2
MAE 036	sec. 5, T. 22 S., R. 13 E.	White Rim	2
MAE 038	sec. 30, T. 23 S., R. 13 E.	White Rim	2
MAE 046	Iron Wash sec. 33, T. 23 S., R. 11 E.	White Rim	3
MAE 047	Lone Man Canyon lat 38°46'N., long. 110°W.	White Rim	6
MAE 050	Iron Wash sec. 11, T. 24 S., R. 11 E.	White Rim	18
MAE 051	sec. 33, T. 21 S., R. 13 E.	White Rim	7
MAE 052	sec. 33, T. 21 S., R. 13 E.	White Rim	3
MAE 055	Iron Wash sec. 31, T. 23 S., R. 11 E.	White Rim	5
MAE 058	sec. 32, T. 23 S., R. 11 E.	White Rim	4
MAE 064	Straight Wash sec. 1, T. 23 S., R. 12 E.	White Rim	4
MAE 067	Straight Wash sec. 3, T. 23 S., R. 12 E.	White Rim	13
MAE 068	Crawford Draw sec. 5, T. 23 S., R. 12 E.	White Rim	3
MAE 069	Crawford Draw sec. 2, T. 23 S., R. 11 E.	White Rim	47
MAE 071	T. 24 S., R. 9 E.	White Rim	4
MAE 073	T. 24 S., R. 9 E.	White Rim	1
MAE 074	N. Keesle Country T. 25 S., R. 9 E.	White Rim	2

APPENDIX C. (continued)

Sample no.	Location	Formation	U_3O_8 (ppm)
MAE 075	N. Keesle Country T. 25 S., R. 9 E.	White Rim	2
MAE 079	Iron Wash sec. 3, T. 24 S., R. 11 E.	White Rim	2
MAE 082	East Little Ocean Draw lat 38°44'N., 110°47'W.	Kaibab/White Rim	2
MAE 083	Chute Canyon lat 38°42'N., 110°47'W.	White Rim	1
MAE 084	Chute Canyon lat 38°40'N., long. 110°46'W.	White Rim	1
MAE 085	Chute Canyon lat 38°41'N., long. 110°46'W.	White Rim	3
MAE 086	Chute Canyon lat 38°41'N., long. 110°47'W.	Kaibab/White Rim	4
MAE 087	Chute Canyon lat 38°41'N., long. 110°47'W.	Kaibab/White Rim	3
MAE 090	Muddy Creek T. 25 S., R. 9 E.	White Rim	2
MAE 093	Muddy River T. 25 S., R. 9 E.	White Rim	5
MAE 094	Muddy Canyon T. 25 S., R. 9 E.	White Rim	2
MAE 095	Muddy River T. 25 S., R. 9 E.	White Rim	2
MAE 096	Black Box Canyon T. 21 S., R. 12 E.	White Rim	2
MAE 097	Black Box Canyon T. 21 S., R. 12 E.	White Rim	2
MAE 098	Sulfur Spring sec. 23, T. 21 S., R. 13 E.	Moenkopi	3

APPENDIX C. (continued)

Sample no.	Location	Formation	U_3O_8 (ppm)
MAE 101	Middle Temple Wash sec. 22, T. 24 S., R. 11 E.	White Rim	3
MAE 102	N. Temple Wash sec. 21, T. 24 S., R. 11 E.	White Rim	3
MAE 103	S. Cistern Canyon T. 25 S., R. 9 E.	White Rim	2
MAE 104	Cistern Canyon T. 25 S., R. 9 E.	Kaibab	3
MAE 105	S. Cistern Canyon T. 25 S., R. 9 E.	White Rim	2
MAE 151	Straight Wash sec. 30, T. 23 S., R. 13 E.	White Rim	2

APPENDIX D

CHEMICAL ANALYSES OF ROCK SAMPLES, SAN RAFAEL SWELL PROJECT AREA

APPENDIX D. CHEMICAL ANALYSES OF ROCK SAMPLES, SAN RAFAEL SWELL PROJECT AREA.

Sample no.	Location	Formation	U_3O_8 (ppm)	eU (ppm)	eTh (ppm)	eK (%)	V_2O_5 (%)	Se (ppm)	Cu (ppm)	Total carbon (%)	Organic carbon (%)
MAE 030	Black Dragon Canyon sec. 34, T. 21 S., R. 13 E.	White Rim	4	1	0	0.4	0.012	1.9	30	0.22	--
MAE 037	sec. 21, T. 23 S., R. 13 E.	Kaibab	22	--	--	--	0.018	0.7	38	3.8	--
MAE 045	Lone Man sec. 23, T. 23 S., R. 11 E.	White Rim	4	2	1	0.29	0.003	1	52	0.11	0.11
MAE 049	Lone Man lat 38°46'N., long. 110°37'W.	White Rim	2	2	0	0.11	0.005	0.1	17	--	0.053
MAE 053	Cedar Mountain sec. 36, T. 18 S., R. 10 E.	Brushy Basin	1,220	--	--	--	--	--	--	--	--
MAE 054	West Mesa sec. 15, T. 22 S., R. 16 E.	Brushy Basin	360	--	--	--	--	--	--	--	--
MAE 056	Iron Wash sec. 32, T. 23 S., R. 11 E.	Kaibab	8	6	2	0.83	0.005	3	22	0.26	0.26
MAE 057	Iron Wash T. 23 S., R. 11 E.	White Rim	2	0	1	0.15	0	1	21	0.17	0.17
MAE 060	sec. 32, T. 23 S., R. 11 E.	White Rim	2	0	1	0.10	0	<1	21	0.19	0.16
MAE 061	Hyde Draw sec. 36, T. 22 S., R. 12 E.	White Rim	4	1	0	0.52	0.004	Nil	18	--	0.072
MAE 062	Hyde Draw sec. 36, T. 22 S., R. 12 E.	Kaibab	8	4	1	0.86	0.007	0.2	13	--	0.059
MAE 063	Straight Wash sec. 2, T. 23 S., R. 12 E.	White Rim	2	0	0	0.24	0	0.1	13	--	0.081
MAE 066	Straight Wash sec. 2, T. 23 S., R. 12 E.	White Rim	2	0	0	0.28	0	Nil	10	--	0.010
MAE 070	Crawford Draw sec. 2, T. 23 S., R. 12 E.	White Rim	3	0	0	0.15	0	0.1	11	--	0.121
MAE 072	T. 24 S., R. 9 E.	White Rim	9	1	0	0.11	0.008	0.2	35	--	9.164

APPENDIX D. (continued)

Sample no.	Location	Formation	U_3O_8 (ppm)	eU (ppm)	eTh (ppm)	eK (%)	V_2O_5 (%)	Se (ppm)	Cu (ppm)	Total carbon (%)	Organic carbon (%)
MAE 080	lat 38°44'N., long. 110°47' W.	Kaibab	4	4	0	0.36	0.007	0.3	10	--	0.378
MAE 081	East Little Ocean Draw lat 38°44'N., long. 110°47' W.	White Rim	4	2	1	0.35	0.005	1.7	16	--	0.172
MAE 088	N. Keesle Country T. 25 S., R. 9 E.	White Rim	2	0	0	0.07	0.004	0.5	11	--	0.077
MAE 089	N. Keesle Country lat 38°38'N., long. 110°55'W	White Rim	5	0	0	0.13	0	Nil	12	--	1.009
MAE 091	Muddy Creek T. 25 S., R. 9 E.	Kaibab	1	--	--	--	Nil	1	32	--	0.28
MAE 092	Muddy River T. 25 S., R. 9 E.	Kaibab(?)	1	--	--	--	0.005	<1	9	--	0.47
MAE 107	Black Dragon Canyon sec. 34, T. 21 S., R. 13 E.	White Rim	2	--	--	--	Nil	<1	21	--	0.27
MAE 108	Black Dragon Canyon sec. 34, T. 21 S., R. 13 E.	White Rim	2	--	--	--	Nil	<1	46	--	0.15
MAE 154	Sahara Mine sec. 14, T. 22 S., R. 14 E.	Morrison-Brushy Basin	418	480	3	0.74	0.13	47	--	--	--
MAE 155	sec. 4, T. 19 S., R. 12 E.	Cedar Mountain-Buckhorn Conglomerate	8	--	--	--	0.01	1	--	1.48	0.20
MAE 169	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Cedar Mountain-Buckhorn Conglomerate	4	--	--	--	0.01	2	--	0.91	0.65
MAE 170	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	3	--	--	--	0.01	2	--	0.29	0.23
MAE 171	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	10	--	--	--	0.03	1	--	6.69	0.59
MAE 172	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	13	--	--	--	0.02	2	--	0.82	0.21
MAE 173	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	84	--	--	--	0.03	2	--	0.10	0.09
MAE 174	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	51	--	--	--	0.03	1	--	0.04	0.02
MAE 175	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	50	--	--	--	0.06	2	--	0.06	0.06

APPENDIX D. (continued)

Sample no.	Location	Formation	U_3O_8 (ppm)	eU (ppm)	eTh (ppm)	eK (%)	V_2O_5 (%)	Se (ppm)	Cu (ppm)	Total carbon (%)	Organic carbon (%)
MAE 176	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	102	--	--	--	0.02	5	--	0.58	0.08
MAE 177	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	79	--	--	--	0.03	5	--	0.14	0.11
MAE 178	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	72	--	--	--	0.03	2	--	3.41	0.63
MAE 179	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	17	--	--	--	0.03	3	--	0.47	0.03
MAE 180	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	44	--	--	--	0.03	1	--	12.90	3.64
MAE 181	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	5	--	--	--	0.02	1	--	1.84	0.04
MAE 182	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	4	--	--	--	0.02	1	--	8.02	1.17
MAE 183	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	3	--	--	--	0.02	0	--	2.80	0.10
MAE 184	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Salt Wash	3	--	--	--	0.01	0	--	0.76	0.50
MAE 185	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Salt Wash	12	--	--	--	0.05	0	--	2.34	0.08
MAE 186	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	3	--	--	--	0.03	1	--	0.37	0.17
MAE 187	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	6	--	--	--	0.04	1	--	0.34	Nil
MAE 188	Cedar Mountain #1 sec. 36, T. 18 S., R. 10 E.	Morrison-Brushy Basin	2	--	--	--	0.02	1	--	0.07	0.07
MAE 189	Cedar Mountain #1 sec. 36, T. 18 S,. R. 19 E.	Morrison-Brushy Basin	1	--	--	--	0.03	5	--	0.16	0.11
MAE 190	Red Seep sec. 13, T. 20 S., R. 8 E.	Cedar Mountain-Buckhorn Conglomerate	1	--	--	--	0.01	<1	--	1.8.	0.19

APPENDIX D. (continued)

Sample no.	Location	Formation	U_3O_8 (ppm)	eU (ppm)	eTh (ppm)	eK (%)	V_2O_5 (%)	Se (ppm)	Cu (ppm)	Total carbon (%)	Organic carbon (%)
MAE 191	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	1	--	--	--	0.06	<1	--	5.41	0.02
MAE 192	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	2	--	--	--	0.01	<1	--	0.68	0.62
MAE 193	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.03	<1	--	0.09	0.03
MAE 194	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.02	<1	--	0.07	0.06
MAE 195	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	5	--	--	--	0.02	<1	--	0.76	0.19
MAE 196	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.02	<1	--	3.40	0.39
MAE 197	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	540	840	10	0	0.03	29	--	1.60	1.60
MAE 198	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	127	110	9	0.14	0.03	20	--	1.18	0.92
MAE 199	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	250	200	7	0.11	0.03	7	--	1.46	1.46
MAE 200	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	8	--	--	--	0.03	<1	--	5.57	1.99
MAE 201	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	600	520	11	0.12	0.03	6	--	0.49	0.40
MAE 202	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	9	--	--	--	0.02	1	--	1.58	1.23
MAE 203	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	11	--	--	--	0.02	1	--	0.07	0.07
MAE 204	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	9	--	--	--	0.03	20	--	1.14	0.05
MAE 205	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.02	1	--	4.14	1.58

APPENDIX D. (continued)

Sample no.	Location	Formation	U_3O_8 (ppm)	eU (ppm)	eTh (ppm)	eK (%)	V_2O_5 (%)	Se (ppm)	Cu (ppm)	Total carbon (%)	Organic carbon (%)
MAE 206	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.02	1	--	0.42	0.16
MAE 207	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Salt Wash	2	--	--	--	0.01	<1	--	1.17	0.11
MAE 208	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Salt Wash	5	--	--	--	0.03	14	--	0.52	0.35
MAE 209	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	6	--	--	--	0.02	<1	--	2.57	0.04
MAE 210	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.02	2	--	0.41	0.20
MAE 211	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	5	--	--	--	0.02	<1	--	2.27	Nil
MAE 212	Red Seep sec. 13, T. 20 S., R. 8 E.	Morrison-Brushy Basin	5	--	--	--	0.01	1	--	0.24	0.16
MAE 213	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	3	--	--	--	0.02	1	--	0.29	0.18
MAE 214	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.02	<1	--	1.16	0.05
MAE 215	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.02	<1	--	1.81	0.12
MAE 216	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	5	--	--	--	0.01	12	--	0.14	0.01
MAE 217	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	5	--	--	--	0.01	13	--	0.65	0.32
MAE 218	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	660	580	10	0.75	0.03	295	--	0.02	Nil
MAE 219	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.02	31	--	0.33	Nil
MAE 220	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	2	--	--	--	0.03	130	--	6.71	1.31

APPENDIX D. (continued)

Sample no.	Location	Formation	U_3O_8 (ppm)	eU (ppm)	eTh (ppm)	eK (%)	V_2O_5 (%)	Se (ppm)	Cu (ppm)	Total carbon (%)	Organic carbon (%)
MAE 221	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	2	--	--	--	0.02	8	--	6.51	1.18
MAE 222	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	5	--	--	--	0.03	25	--	2.29	0.38
MAE 223	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	14	--	--	--	0.02	4	--	1.07	0.93
MAE 224	Eagle Claim sec. 7, T. 22 S., R. 8 E.	Morrison-Brushy Basin	4	--	--	--	0.03	1	--	4.47	4.12

APPENDIX E

TEST WELLS AND MEASURED SECTIONS, SAN RAFAEL SWELL PROJECT AREA

TABLE E-1. MEASURED SECTIONS

Measured section no.	Reference	Locality	Location	County	Elevation (ft)
63	Stewart and others, 1972 (U-43)	Chimney Rock	SE¼SE¼ sec. 28, T. 28 S., R. 6 E.	Wayne	6,800
64	Smith and others, 1963	Sulphur Creek	C W½ sec. 8, T. 29 S., R. 6 E.	Wayne	6,136
65	Smith and others, 1963	Pleasant Creek	SW¼S½ sec. 30, T. 30 S., R. 7 E.	Wayne	6,800
67	Smith and others, 1963	N. Pleasant Creek	N½ sec. 30, T. 30 S., R. 7 E.	Wayne	6,400
68	Craig, 1959	Buckhorn Flat	E½NE¼SE¼ sec. 34, T. 18 S., R. 9 E.	Emery	5,560
69	Craig, 1959	Little Cedar Mtn.	C S½ sec. 4, T. 19 S., R. 10 E.	Emery	6,414
70	Craig, 1959	Cainville	SE¼SW¼SE¼ sec. 15, T. 28 S., R. 8 E.	Wayne	4,800
72	Craig, 1959	Factory Butte	sec. 33, T. 26 S., R. 9 F.	Emery	5,200
73	Craig, 1959	Flattop Buttes	NE¼ sec. 27, T. 26 S., R. 13 E.	Emery	5,600
75	Craig, 1959	Hanksville	C E½ sec. 18, T. 28 S., R. 11 E.	Wayne	4,400
76	Craig, 1959	Last Chance	SW¼NE¼NE¼ sec. 12, T. 25 S., R. 5 E.	Sevier	6,223
77	Craig, 1959	Little Grand B	C sec. 29, T. 21 S., R. 16 E.	Emery	4,320
78	Craig, 1959	Little Grand A	NW¼NE¼ sec. 33, T. 21 S., R. 16 E.	Emery	4,400
79	Craig, 1959	Mounds Section C	sec. 13, T. 15 S., R. 11 E.	Carbon	5,600
80	Craig, 1959	Mounds Section B	sec. 17, T. 16 S., R. 12 E.	Emery	5,480
81	Craig, 1959	Mounds Section A	SW¼NE¼ sec. 27, T. 16 S., R. 12 E.	Emery	5,600
82	Craig, 1959	Muddy River	sec. 17, T. 23 S., R. 7 E.	Emery	5,800
83	Craig, 1959	San Rafael River	C S½ sec. 28, T. 22 S., R. 14 E.	Emery	4,400
84	Craig, 1959	Summerville Draw	sec. 12, T. 18 S., R. 13 E.	Emery	4,800
85	Craig, 1959	Summerville Draw	sec. 23, T. 18 S., R. 13 E.	Emery	5,000
86	Craig, 1959	Summerville Draw	E½ sec. 22, T. 18 S., R. 13 E.	Emery	5,200
87	Craig, 1959	Summerville Draw	S½ sec. 21, T. 18 S., R. 13 E.	Emery	5,120

TABLE E-1. (continued)

Measured section no.	Reference	Locality	Location	County	Elevation (ft)
90	Craig, 1959	Tidwell Ranch B	N½ sec. 27, T. 21 S., R. 14 E.	Emery	4,640
91	Craig, 1959	Tidwell Ranch A	S½ sec. 21, T. 21 S., R. 14 E.	Emery	4,640
93	Blakey, 1974	Black Dragon	SW¼ sec. 35, T. 21 S., R. 13 E.	Emery	6,060
94	Blakey, 1974	Torrey	C sec. 30, T. 29 S., R. 5 E.	Wayne	7,400
95	Stewart and others, 1972 (U-3)	Buckhorn Wash	SE¼ sec. 3, T. 20 S., R. 11 E.	Emery	5,400
96	Stewart and others, 1972 (U-4)	Cane Wash	NE¼ sec. 23, T. 22 S., R. 10 E.	Emery	6,720
97	Stewart and others, 1972 (U-5)	Lucky Strike	sec. 6, T. 24 S., R. 9 E.	Emery	6,200
98	Stewart and others, 1972 (U-6)	Muddy River	NW¼NW¼ sec. 6, T. 26 S., R. 9 E.	Emery	5,520
99	Stewart and others, 1972 (U-7)	Straight Wash	C sec. 29, T. 23 S., R. 13 E.	Emery	5,200
100	Stewart and others, 1972 (U-8)	Temple Mountain	SE¼SE¼SE¼ sec. 27, T. 24 S., R. 11 E.	Emery	6,600
102	Stewart and others, 1972 (U-9)	Spring Canyon	sec. 23, T. 25 S., R. 17 E.	Grand	4,000
104	Gilluly and Reeside, 1928 (2)	Muddy River	SW¼ sec. 26, T. 24 S., R. 8 E.	Emery	5,400
106	Gilluly and Reeside, 1928 (4)	Salt Gulch	C E½ sec. 2, T. 24 S., R. 7 E.	Emery	5,600
107	Gilluly and Reeside, 1928 (5)	Willow Springs	NW¼NW¼NW¼ sec. 26, T. 24 S., R. 6 E.	Emery	6,200
109	Gilluly and Reeside, 1928 (7)	Saddle Horse	C E½ sec. 4, T. 21 S., R. 10 E.	Emery	6,200
110	Gilluly and Reeside, 1928 (8)	Horn Silver	C E½ sec. 35, T. 20 S., R. 8 E.	Emery	5,680
112	Gilluly and Reeside, 1928 (10)	Sawtooth Butte	C sec. 23, T. 20 S., R. 11 E.	Emery	5,800
115	Gilluly and Reeside, 1928 (13)	Red Canyon	C sec. 32, T. 20 S., R. 12 E.	Emery	5,600
117	Gilluly and Reeside, 1928 (15)	Black Box Canyon	NW¼NW¼ sec. 9, T. 21 S., R. 12 E.	Emery	5,040
122	Gilluly and Reeside, 1928 (20)	Woodside	C W½ sec. 17, T. 19 S., R. 14 E.	Emery	5,080
123	this report	Straight Wash	NE¼, T. 23 S., R. 12 E.	Emery	--
124	this report	Lone Man Butte	W½ sec. 25, T. 23 S., R. 11 E.	Emery	--

TABLE E-1. (continued)

Measured section no.	Reference	Locality	Location	County	Elevation (ft)
125	this report	Iron Wash	NW¼ sec. 32, T. 23 S., R. 11 E.	Emery	--
126	this report	East Little Ocean Draw	NE¼, T. 24 S., R. 10 E.	Emery	--
127	this report	North Keesle Country	C, T. 25 S., R. 9 E.	Emery	--
128	this report	Cedar Mountain #1 prospect	sec. 36, T. 18 S., R. 10 E.	Emery	--
129	this report	Cedar Mountain #1 prospect	sec. 36, T. 18 S., R. 10 E.	Emery	--
130	this report	Red Seep prospect	sec. 13, T. 20 S., r. 8 E.	Emery	--
131	this report	Red Seep prospect	sec. 13, T. 20 S., R. 8 E.	Emery	--
132	this report	Eagle claim	sec. 7, T. 22 S., R. 8 E.	Emery	--
133	this report	Eagle claim	sec. 7, T. 22 S., R. 8 E.	Emery	--

TABLE E-2. TEST WELLS

Test well no.	Company	Well name	Location	County	Elevation (ft)
11155	Amerada Petroleum	USA-Abbott no. 1	NW¼NE¼ sec. 29, T. 14 S., R. 9 E.	Carbon	6,324
11156	Shell Oil Company	No. 1 N. Springs-Fed	C SE¼SW¼ sec. 27, T. 15 S., R. 9 E.	Carbon	6,143
11157	Shell Oil Company	No. 1 Miller Creek	C NE¼NE¼ sec. 26, T. 15 S., R. 10 E.	Carbon	5,514
11158	Pan American Petroleum	USA No. 1 Cullen	C SE¼SE¼ sec. 11, T. 15 S., R. 13 E.	Carbon	5,887
11160	Shell Oil Company	No. 1-A Farnham	C SW¼SW¼ sec. 8, T. 15 S., R. 12 E.	Carbon	5,701
11162	Cities Service Petroleum	No. B-1 State	C NE¼SW¼ sec. 36, T. 15 S., R. 12 E.	Carbon	5,464
11163	Chevron Oil Company	No. 1 Willson	SE¼SW¼ sec. 28, T. 16 S., R. 10 E.	Emery	5,671
11164	Pan American Petroleum	No. 1 Federal Mounds	NW¼SW¼ sec. 11, T. 16 S., R. 11 E.	Emery	5,363
11165	Cities Service Oil	No. 1 Govt.	C NE¼NW¼ sec. 1, T. 16 S., R. 12 E.	Emery	5,435
11166	Carter Oil Company	No. 1 Govt. Wheatland	C NW¼NE¼ sec. 27, T. 16 S., R. 12 E.	Emery	5,772
11167	True Oil Company	Federal 44-8	SE¼SE¼ sec. 8, T. 16 S., R. 13 E.	Emery	5,238
11169	Forest Oil Corporation	No. 25-1 Arnold	SW¼SW¼ sec. 25, T. 16 S., R. 14 E.	Emery	6,660
11170	Chevron Oil Company	Nelson Unit no. 1	SE¼NW¼ sec. 3, T. 16 S., R. 15 E.	Emery	6,647
11171	Pure Oil Company	No. 1 Washboard	NE¼NW¼ sec. 12, T. 16 S., R. 9 E.	Emery	5,852
11172	Pure Oil Company	No. 1 Desert Lake	NW¼SE¼ sec. 1, T. 17 S., R. 10 E.	Emery	5,583
11173	R. H. Reed	No. 1 Suckle-Govt.	NW¼NW¼ sec. 1, T. 17 S., R. 12 E.	Emery	5,640
11174	True Oil Company	No. 44-30 Federal	SE¼SE¼ sec. 30, T. 17 S., R. 13 E.	Emery	5,157
11175	Placid Oil Company	No. 1 Marsh Flat	SW¼NE¼ sec. 29, T. 17 S., R. 14 E.	Emery	4,765
11177	Austral Oil Company	No. 1-27 Federal	SW¼NE¼ sec. 27, T. 18 S., R. 11 E.	Emery	7,084
11179	Modern Minerals Corporation	No. 1 Federal	NE¼NE¼ sec. 25, T. 18 S., R. 12 E.	Emery	5,463
11180	Humble Oil and Refinery	No. 2 Woodside	SW¼SW¼ sec. 30, T. 18 S., R. 14 E.	Emery	5,131
11181	Gulf Oil Company	No. 1 Norris-Fed	NE¼NW¼ sec. 8, T. 18 S., R. 16 E.	Emery	6,285

TABLE E-2. (continued)

Test well no.	Company	Test well	Location	County	Elevation (ft)
11182	Lemm-Maiatico	No. 1 Woodside Govt.	SW¼SW¼ sec. 8, T. 18 S., R. 14 E.	Emery	4,847
11184	Hancock-Utah Development	No. 1 Cedar Mountain	C SW¼SW¼ sec. 9, T. 19 S., R. 12 E.	Emery	6,103
11185	Reynolds Mining Corporation	No. 1 Unit	SW¼NE¼SW¼ sec. 29, T. 19 S., R. 12 E.	Emery	6,181
11186	Humble Oil and Refining	No. 1 Woodside	SE¼SE¼ sec. 12, T. 19 S., R. 13 E.	Emery	5,505
11188	Carter Oil Company	No. 1-A Sphinx	S½SW¼NW½ sec. 35, T. 19 S., R. 14 E.	Emery	4,654
11189	Clinton Oil Company	Federal 1 US T-Walsh	SE¼SE¼ sec. 14, T. 19 S., R. 15 E.	Emery	6,075
11190	Modern Minerals Corporation	No. 2 Skyline Fed.	NW¼NE¼NE¼ sec. 9, T. 19 S., R. 12 E.	Emery	6,123
11191	Pan American Petroleum	No. 3 Ferron	SE¼NE¼ sec. 21, T. 20 S., R. 7 E.	Emery	5,948
11192	True Oil Company	No. 34-7 Federal	SW¼SE¼ sec. 7, T. 20 S., R. 10 E.	Emery	5,568
11193	Toledo Mining Company	No. 1 Federal-Tol	NE¼NW¼ sec. 33, T. 20 S., R. 14 E.	Emery	4,620
11194	Pan American Petroleum	No. 4 Ferron 14-2	SW¼SW¼ sec. 2, T. 20 S., R. 7 E.	Emery	5,949
11195	Pacific National Gas Express	No. 42-9 Ferron	NW¼SE¼NE¼ sec. 9, T. 21 S., R. 7 E.	Emery	6,224
11196	Wainoco Inc.	No. 33-1 Sky Fed	SW¼SE¼ sec. 1, T. 21 S., R. 13 E.	Emery	4,501
11197	Amax-McCulloch Oil	No. 1 Black Dragon Govt.	NE¼SE¼ sec. 32, T. 21 S., R. 13 E.	Emery	5,763
11198	Superior Oil Company	No. 14-24 Unit	C SW¼SW¼ sec. 24, T. 21 S., R. 15 E.	Emery	4,224
11199	Skyline Oil Company	No. 1 Green River	NE¼NW¼ sec. 33, T. 21 S., R. 16 E.	Emery	4,282
11201	True Oil Company	No. 14-10 Federal	NW¼SW¼SW¼ sec. 10, T. 22 S., R. 8 E.	Emery	6,067
11202	Utah Plateau Uranium	No. 1-X Federal	sec. 11, T. 22, S., R. 8 E.	Emery	5,494
11204	Reynolds Mining Corporation	No. 1 Unit	C NW¼NE¼ sec. 26, T. 22 S., R. 12 E.	Emery	6,702
11205	Amax Petroleum Corporation	No. 24-1 Green River	C NE¼NE¼ sec. 24, T. 22 S., R. 13 E.	Emery	4,741

TABLE E-2. (continued)

Test well no.	Company	Test well	Location	County	Elevation (ft.)
11206	Amax Petroleum Corporation	No. 9-7 Green River	C SW¼NE¼ sec. 9, T. 22 S., R. 15 E.	Emery	4,442
11207	Amax-Sinclair Oil	No. 29-4B Nine Mile	C NW¼NW¼ sec. 29, T. 22 S., R. 15 E.	Emery	4,419
11208	Amerada Petroleum	No. 1 Green River	SE¼NW¼NW¼ sec. 2, T. 22 S., R. 16 E.	Emery	4,091
11209	Skelly Oil Company	No. 1 Emery Unit	C SW¼SE¼ sec. 34, T. 22 S., R. 5 E.	Emery	6,354
11210	Amerada Petroleum	No. 1-354 Strat	SW¼NE¼ sec. 28, T. 23 S., R. 10 E.	Emery	6,827
11212	Kerr-McGee Oil	1TP-Utah-27	C SE¼NE¼ sec. 7, T. 23 S., R. 13 E.	Emery	6,588
11213	Equity Oil Company	No. 1 Forrest Govt.	NE¼NE¼ sec. 11, T. 23 S., R. 14 E.	Emery	4,381
11214	Lion Oil Monsanto	No. 1 Federal-Hatt	C SE¼SE¼ sec. 19, T. 23 S., R. 14 E.	Emery	4,378
11215	Shell Oil Company	No. 1 Unit	NE¼NW¼ sec. 21, T. 23 S., R. 15 E.	Emery	4,687
11216	Amerada Petroleum	USA Colman no. 1	NW¼SW¼ sec. 17, T. 23 S., R. 9 E.	Emery	7,052
11217	Texas Gas Exploration	No. 1 Federal 11-24-1	SE¼NE¼ sec. 11, T. 24 S., R. 13 E.	Emery	4,749
11218	Union Oil Company	No. 1 Temple Wash	NW¼NW¼ sec. 32, T. 24 S., R. 13 E.	Emery	4,854
11219	Amerada Petroleum	No. 1-362 Strat	NE¼SE¼ sec. 7, T., 24 S., R. 9 E.	Emery	5,651
11220	Amerada Petroleum	No. 1 USA-Elliot	SE¼SE¼ sec. 14, T. 24 S., R. 9 E.	Emery	6,679
11221	Blackwood and Nichol	No. 1-28 San Rafael	SW¼NE¼SW¼ sec. 28, T. 24 S., R. 10 E.	Emery	6,740
11222	Carter Oil Company	No. 1 Dugout Creek	NE¼SE¼ sec. 21, T. 24 S., R. 14 E.	Emery	4,330
11223	General Petroleum	No. 45-5-G	NE¼NE¼SW¼ sec. 5, T. 24 S., R. 15 E.	Emery	4,271
11225	Security-Flying Diamond	No. 1 Iron Wash	NW¼SE¼ sec. 3, T. 24 S., R. 13 E.	Emery	4,511
11226	American Metal Climax	No. 1 Govt.	NW¼NW¼ sec. 27, T. 25 S., R. 9 E.	Emery	5,925
11227	Union Oil Company	No. 019-1 Temple	SW¼SE¼ sec. 1, T. 25 S., R. 12 E.	Emery	4,858
11228	Pan American Petroleum	No. 1 USA-Brown	C NW¼NW¼ sec. 24, T. 25 S., R. 12 E.	Emery	5,044

TABLE E-2. (continued)

Test well no.	Company	Test well	Location	County	Elevation (ft.)
11229	Union Oil Company	No. 998-A-1 Temple	NW¼NW¼ sec. 11, T. 25 S., R. 13 E.	Emery	4,753
11230	Texaco Incorporated	No. 1 Temple Springs	C NW¼NW¼ sec. 14, T. 25 S., R. 13 E.	Emery	4,898
11231	Texaco Incroporated	No. 2 Temple Springs	SE¼SW¼ sec. 22, T. 25 S., R. 14 E.	Emery	4,779
11232	Superior Oil Company	No. 31-15 North Springs	C NW¼NE¼ sec. 15, T. 25 S., R. 15 E.	Emery	4,973
11233	Standard Oil of California	No. 1 Unit	C NE¼SW¼ sec. 32, T. 25 S., R. 15 E.	Emery	5,116
11235	Mountain Fuel Supply	No. 1-A Desert Wash	NW¼SE¼ sec. 14, T. 25 S., R. 5 E.	Sevier	5,982
11236	Energetics Incorporated	No. 23X-7 Reserve	NE¼SW¼ sec. 7, T. 26 S., R. 7 E.	Emery	6,027
11237	Mountain Fuel Supply	No. 1-A Last Chance	NW¼SE¼NW¼ sec. 18, T. 26 S., R. 7 E.	Emery	6,109
11238	Texaco Incroporated	No. 1 Govt.-Steven	SE¼NW¼ sec. 14, T. 26 S., R. 8 E.	Emery	6,493
11239	Pan American Petroleum	No. 9 Nequoia Arch	NW¼SW¼ sec. 25, T. 26 S., R. 13 E.	Emery	5,414
11240	Odessa Natural Gas	No. 1 Shannon	C NW¼NW¼ sec. 7, T. 26 S., R. 14 E.	Emery	5,122
11241	Shumway Mining Company	No. 1 Parker	NE¼SE¼ sec. 1, T. 26 S., R. 7 E.	Emery	5,805
11242	Carter Oil Company	No. 1 Blackburn	NE¼NE¼ sec. 9, T. 27 S., R. 12 E.	Wayne	5,038
11243	Superior Oil Company	No. 31-30 Hanksville	C NW¼NE¼ sec. 30, T. 27 S., R. 13 E.	Wayne	5,041
11244	Continental Oil Company	No. 1 South Hanksville	C SE¼SW¼ sec. 36, T. 27 S., R. 13 E.	Wayne	5,235
11245	American Metal Climax	No. 1 Maroni Slope	NE¼NE¼ sec. 13, T. 27 S., R. 8 E.	Wayne	5,002
11246	Texaco Incroporated	No. 2 Thousand Lakes	W½NW¼ sec. 25, T. 28 S., R. 4 E.	Wayne	7,927
11247	Phillips Petroleum	No. 1 Spring Canyon	NW¼SE¼ sec. 13, T. 28 S., R. 5 E.	Wayne	7,080
11249	Colt Oil Company	No. 1-33 Federal	SE¼SW¼ sec. 33, T. 28 S., R. 8 E.	Wayne	4,824
11250	Tenneco Oil	No. 1 USA-Pinto	SE¼SW¼ sec. 5, T. 28 S., R. 11 E.	Wayne	4,630
11251	Kimbark Operating	No. 1 State-Buck	NE¼SE¼ sec. 32, T. 28 S., R. 12 E.	Wayne	4,580

TABLE E-2. (continued)

Test well no.	Company	Test well	Location	County	Elevation (ft)
11253	Amerada Petroleum	No. 1 Blue Mesa	NW¼SW¼SW¼ sec. 8, T. 29 S., R. 10 E.	Wayne	4,845
11254	Amerada Petroleum	No. 1 Utah State	C NE¼NE¼ sec. 2, T. 29 S., R. 11 E.	Wayne	4,504
11255	Kimbark Operating	No. 1 Penitentiar	NW¼NE¼ sec. 30, T. 29 S., R. 12 E.	Wayne	4,724
11256	Tennesse Gas	No. 1-A USA-Sorre	SW¼NE¼ sec. 33, T. 29 S., R. 12 E.	Wayne	4,627
11257	Argo Oil Corporation	No. 1 Govt. Hickman	NW¼SE¼ sec. 30, T. 29 S., R. 5 E.	Wayne	7,299
11258	Pure Oil Company	No. 1 USA-Teasdale	NW¼NE¼ sec. 8, T. 30 S., R. 6 E.	Wayne	7,790
11259	Phillips Petroleum	No. 1 Unit	S½SE¼NW¼ sec. 15, T. 17 S., R. 8 E.	Emery	6,128

APPENDIX F

ANOMALIES ON GAMMA-RAY LOGS FROM PETROLEUM TEST WELLS, SAN RAFAEL SWELL PROJECT AREA

APPENDIX F. ANOMALIES ON GAMMA-RAY LOGS FROM PETROLEUM TEST WELLS, SAN RAFAEL SWELL PROJECT AREA

Test Hole No.	Location	Formation or Member	Value of anomaly (API units unless specified)	Depth to anomaly (ft)
11158	sec. 11, T. 15 S., R. 13 E.	Church Rock Member	247	4,634
		Sub-Moss Back	214	5,591
		Sub-Moss Back	206	5,595
11160	sec. 8, T. 15 S., R. 12 E.	Brushy Basin Member	300 cps	1,128
11162	sec. 36, T. 15 S., R. 12 E.	Brushy Basin Member	184	1,065
		Church Rock Member	224	3,430
		Church Rock Member	200	3,437
11164	sec. 11, T. 16 S., R. 11 E.	Gamma Member	180	4,853
11165	sec. 1, T. 16 S., R. 12 E.	Brushy Basin Member	5X background	830
11166	sec. 27, T. 16 S., R. 12 E.	Gamma Member	511	3,889
11169	sec. 25, T. 16 S., R. 14 E.	Cedar Mtn. Formation	198	4,777
		Summerville Formation	198	5,562
		Church Rock Member	184	7,321
		Black Dragon Member	198	8,519
11171	sec. 12, T. 16 S., R. 9 E.	Brushy Basin Member	151	3,055
		Entrada Sandstone	157	4,134
		Beta Member(?)	120	7,572
11175	sec. 29, T. 17 S., R. 14 E.	Brushy Basin Member	248	1,124
		Brushy Basin Member	224	1,138
		Brushy Basin Member	170	1,150
		Summerville Formation	175	1,537
11180	sec. 30, T. 18 S., R. 14 E.	Church Rock Member	176	2,348
		Sub-Moss Back	180	2,664
		Beta Member	185	3,601
11181	sec. 8, T. 18 S., R. 16 E.	Brushy Basin Member	198	6,358
		Gamma Member	140	9,755
11189	sec. 14, T. 19 S., R. 15 E.	Brushy Basin Member	320	4,950
		Moody Canyon Member	270	7,618
11191	sec. 21, T. 20 S., R. 7 E.	Summerville Formation	140	2,570
		Gamma Member	162	7,275
11195	sec. 9, T. 21 S., R. 7 E.	Cedar Mtn. Formation	130	1,961
		Brushy Basin Member	288	2,228
		Brushy Basin Member	240	2,558
		Salt Wash Member	185	2,633
		Entrada Sandstone	210	3,270

APPENDIX F. (continued)

Test Hole No.	Location	Formation or Member	Value of anomaly (API units unless specified)	Depth to anomaly (ft)
11196	sec. 1, T. 21 S., R. 13 E.	Sinbad Limestone Member	195	367
11198	sec. 24, T. 21 S., R. 15 E.	Salt Wash Member	198	966
11199	sec. 33, T. 21 S., R. 16 E.	Sub-Moss Back	188	2,530
		Beta Member	186	3,023
		Gamma Member	168	3,218
11205	sec. 24, T. 22 S., R. 13 E.	Sub-Moss Back	160	2,610
11207	sec. 29, T. 22 S., R. 15 E.	Sinbad Limestone Member	272	3,463
11210	sec. 28, T. 23 S., R. 10 E.	Gamma Member	216	339
11214	sec. 19, T. 23 S., R. 14 E.	Moss Back Member	289	1,940
11222	sec. 21, T. 24 S., R. 14 E.	Moss Back Member	223	1,630
		Sub-Moss Back	214	1,683
		Sub-Moss Back	198	1,693
11223	sec. 5, T. 24 S., R. 15 E.	Moss Back Member	3X background	1,727
11230	sec. 14, T. 25 S., R. 13 E.	Church Rock Member	256	1,486
11231	sec. 22, T. 25 S., R. 14 E.	Moss Back Member	187	1,472
11232	sec. 15, T. 25 S., R. 15 E.	Church Rock Member	220	1,579
		Moss Back Member(?)	164	1,761
		Black Dragon Member	176	2,287
11235	sec. 14, T. 25 S., R. 5 E.	Church Rock Member	124	3,063
11236	sec. 7, T. 26 S., R. 7 E.	Moss Back Member	352	2,046
		Sub-Moss Back	288	2,115
		Torrey Member	314	2,802
		Sinbad Limestone Member	260	2,913
11237	sec. 7, T. 26 S., R. 7 E.	Gamma Member	2X background	3,145
11238	sec. 14, T. 26 S., R. 8 E.	Moss Back Member	485	1,642
11239	sec. 25, T. 26 S., R. 13 E.	Sub-Moss Back	160	2,023
11241	sec. 1, T. 26 S., R. 7 E.	Moody Canyon Member	165	1,948
11243	sec. 30, T. 27 S., R. 13 E.	Moss Back Member	200	1,694

APPENDIX F. (continued)

Test Hole No.	Location	Formation or Member	Value of anomaly (API units unless specified)	Depth to anomaly (ft)
11246	sec. 25, T. 28 S., R. 4 E.	Gamma Member	206	1,870
11247	sec. 13, T. 28 S., R. 5 E.	Gamma Member	181	2,096
11251	sec. 32, T. 28 S., R. 12 E.	Gamma Member(?)	238	2,441
11254	sec. 2, T. 29 S., R. 11 E.	Sub-Moss Back	.264	2,233
		Sub-Moss Back	288	2,272
		Sub-Moss Back	206	2,291
		Gamma Member	198	2,781
11257	sec. 30, T. 29 S., R. 5 E.	White Rim Sandstone	289	770
11259	sec. 15, T. 17 S., R. 8 E.	Salt Wash Member	3X background	3,820

APPENDIX G

PETROGRAPHIC DESCRIPTION OF SAMPLES FROM THE MORRISON FORMATION, SAN RAFAEL SWELL PROJECT AREA

APPENDIX G

PETROGRAPHIC DESCRIPTION OF SAMPLES
FROM THE MORRISON FORMATION, SAN RAFAEL SWELL

Sample no.	Petrographic description
	Cedar Mountain No. 1, mineralized section
MAE 169	Buckhorn Conglomerate, quartz arenite, conglomerate, cobbles to 5 in. diameter. Cobbles composed predominantly of chert and quartz. Highly cemented with silica and calcite cement. Frequent discontinuous cross-bedded sandstone lenses. Abundant silicified tree fragments.
MAE 170 *	Mudstone, expansive, deeply weathered. Grayish purple 5 P 4/2 to 5 RP 4/2.
MAE 171	Limestone-micrite; infrequent detrital grains, fairly continuous, ledge-forming. Mottled, grayish blue 5 PB 5/2 to light gray N7.
MAE 172	Mudstone, expansive, deeply weathered; silty, contains fresh, zoned feldspars. Greenish gray 5 GY 6/1 to light brownish gray 5 YR 6/1.
MAE 173	Mudstone, slightly weathered. Fresh, zoned feldspars, minor micas (biotite and muscovite), and zircon. Light gray N6 to light olive gray 5 Y 6/1, weathers to light green 5 GY 8/1.
MAE 174 *	Mudstone, expansive, deeply weathered; very poor exposure. Light gray N7, altered in patches to pale yellowish orange 10 YR 8/6 (buckskin color).
MAE 175	Mudstone, ore zone, slightly weathered, highly fractured and altered. Medium to very light gray N6 to N8, altered along fractures to dark yellowish orange 10 YR 6/6, weathers as a mass to pale yellowish orange (buckskin) 10 YR 8/6. Fractures filled with gypsum and limonite (perhaps in part iron-rich chlorite) with minor amounts of uranium minerals, chiefly meta-autunite.
MAE 176	Mudstone, deeply weathered, expansive. Minor authegenic chlorite found as vein filling. Grayish blue 5 PB 5/2 to medium gray N5 weathers to pale purple 5 P 6/2.
MAE 177 *	Mudstone, expansive, deeply weathered. Iron concretions to 1/2 in. diameter. Yellowish gray 5 Y 8/1 to grayish orange 10 YR 7/4; occasional small patches of buckskin color, pale yellowish orange 10 YR 8/6.

* No petrographic work performed on this sample.

Sample no.	Petrographic description
MAE 178	Sandstone, calcareous quartz arenite. Fine to medium grained, generally massive with minor pebble and clay-gall lenses; poorly sorted, highly lenticular, and discontinuous. Light gray N7 to greenish gray 5 G 6/1; weathers to light gray N7 to light brown 5 G 6/1.
MAE 179 *	Mudstone, expansive, deeply weathered. Gray N7.
MAE 180	Limestone, micritic. Thin bedded though continuous. Minor intraformational clay rip-ups, ostracod-like shapes. Authegenic silica segregations; limestone layers in part recrystallized. Medium light gray N6, weathers to moderate yellowish brownish 10 YR 5/4.
MAE 181	Sandstone, calcareous quartz arenite. Very fine to fine grained, generally massive with some faint laminae, highly lenticular and discontinuous, well sorted. Light olive gray 5 Y 6/1; weathered surfaces are desert varnished, shiny dark brownish black 5 YR 2/1.
MAE 182	Limestone, micritic. Silty, massive with minor pebbles and clay galls, highly lenticular. Light gray N7; weathers light brownish gray 5 YR 6/1.
MAE 183 *	Mudstone, poorly exposed. Light brownish gray 5 YR 6/1 to pale reddish purple 5 RP 6/2.
MAE 184	Sandstone, lithic arenite. Medium to coarse grained, generally massive with some festoon cross-bedding, very even bedded and continuous, moderately well sorted. Typical Salt Wash sand.
MAE 185	Mudstone, typical Salt Wash underclay, light purple bleached to light gray green.
	Cedar Mountain No. 1, unmineralized section
MAE 186 *	Mudstone, expansive, deeply weathered. Purple 5 P 6/2.
MAE 187 *	Mudstone, expansive, deeply weathered. Very light gray N8.
MAE 188	Mudstone, well indurated, blocky. Ore zone correlative. White N9 to light gray N8.

* No petrographic work performed on this sample.

Sample no.	Petrographic description
MAE 189	Mudstone, deeply weathered, poorly exposed. Slightly silty, rare organic debris. Purple 5 P 6/2.
MAE 191 *	Mudstone, slightly expansive. Grayish red 10 R 4/2; weathers to grayish reddish purple 5 RP 4/2.
MAE 192	Sandstone, quartz arenite. Fine to medium grained, moderately sorted with much clay matrix and silica cement, graded and trough-type cross-bedding; lenticular though fairly continuous. Occasional pebble lenses and scouring at base. Pale reddish brown 10 R 5/4, weathers to dark reddish brown 10 R 3/4.
MAE 193 *	Mudstone, expansive, deeply weathered. Barite roses common in this interval. Pinkish gray 5 YR 8/1.
MAE 194 *	Mudstone, slightly expansive. Variegated light brownish gray 5 YR 6/1 to brownish gray 5 YR 4/1.
MAE 195	Sandstone, lithic arenite. Fine to coarse grained, poorly sorted with much clay matrix and calcite cement; poor cross-bedding; highly lenticular though continuous, grades downward into 1 to 2 ft of fine pebbly conglomerate. White N9, weathers to reddish brown 10 R 4/2.
MAE 196	Limestone, micritic. Grayish pink 5 R 8/2 to pale red 5 R 6/2.
MAE 197	Mudstone, ore zone. Well indurated, highly fractured and altered with abundant gypsum meta-autunite and limonite fracture filling, some organic matter. Light olive gray 5 Y 6/1; altered to dark yellowish orange 10 YR 6/6.
MAE 198	Mudstone, ore zone. Similar to sample MAE 197, but with abundant quartz, feldspar, and carbon trash. Mineralized bone, sample MAE 232, from this outcrop. Light brownish gray 5 YR 6/1, alters to dark yellowish orange, as in MAE 197.
MAE 199 *	Mudstone, ore zone. Carbon-rich seam from edge of trash pile. Abundant carbonized plant remains.
MAE 200	Limestone, micritic. Three beds, to 1 ft thick; fairly continuous; boudinage-like compression features, interbedded with mudstone. Light gray N8, weathers to greenish gray 5 GY 6/1.

* No petrographic work performed on this sample.

Sample no.	Petrographic description
MAE 201 *	Mudstone, ore zone. Expansive, very weathered. Similar to sample MAE 197. Fresh color(?) is pale yellowish brown 19 YR 6/2; alters to light brown 5 YR 5/6 and dark yellowish orange, as in MAE 197.
MAE 202	Sandstone, quartz arenite. Fine to medium grained, moderately well sorted abundant calcareous cement, finely laminated, graded, cross-bedded, lenticular. Yellowish gray 5 Y 8/1, weathers, light brownish gray 5 YR 6/1.
MAE 203	Mudstone, ore zone. Expansive, weathered; highly fractured and altered with abundant gypsum and limonite fracture fillings as sample MAE 197. Light olive gray altered to dark yellowish orange, as in sample MAE 197.
MAE 204 *	Mudstone, expansive, deeply weathered. Slightly reddish, light brownish-gray 5 Y 6/1.
MAE 205	Sandstone, quartz arenite. Fine grained, moderately well sorted, abundant calcareous cement, muddy matrix; massive, highly lenticular, with occasional pebble lenses. Freckling due to oxidation of iron-bearing minerals. Pinkish gray 5 YR 8/1, weathers pale red 10 R 6/2.
MAE 206	Mudstone, expansive, deeply weathered. Light olive gray 5 Y 6/1.
MAE 207	Sandstone, calcareous quartz arenite. Typical Salt Wash sand.
MAE 208 *	Mudstone, silty, well indurated. Typical Salt Wash underclay.
	Red Seep, unmineralized section
MAE 209 *	Mudstone, expansive, deeply weathered. Light gray N7 to light olive gray 5 Y 6/1.
MAE 210	Sandstone, quartz arenite. Fine to coarse grained, poorly sorted, muddy matrix, siliceous cement; occasional pebble lenses, faint cross-bedding, highly lenticular. Pinkish gray 5 YR 8/1; weathers light brownish gray 5 YR 6/1.
MAE 211 *	Mudstone, ore-zone correlative, weathered; variegated; medium gray N5 to light purple 5 Y 6/2.

* No petrographic work performed on this sample.

Sample no.	Petrographic description
MAE 212	Sandstone, quartz arenite. Medium to coarse grained, poorly sorted, siliceous cement, sedimentary rock and bone fragments; indistinct cross-bedding, lenticular-though fairly continuous, pebble conglomerate at base. Pale red 5 R 6/2; weathers grayish red 5 R 4/2.
	Eagle Prospect, mineralized section
MAE 213 *	Mudstone, expansive, deeply weathered, silty. Very light gray N8.
MAE 214 *	Mudstone, expansive, deeply weathered. Grayish purple 5 P 4/2.
MAE 215	Sandstone, calcareous quartz arenite. Fine to medium grained, moderately sorted, calcareous cement; trough cross-bedding, abundant pebble lenses and shale splits; highly lenticular. Very light gray N8; weathers grayish red 10 R 4/2.
MAE 216	Mudstone, expansive, deeply weathered. Traces of volcanic rock fragments. Medium dark gray N4.
MAE 217 *	Mudstone, expansive, deeply weathered. Very light gray N8.
MAE 218	Mudstone, ore zone. Weathered, highly fractured and altered. Similar to sample MAE 197, although no gypsum is apparent. Light olive gray 5 Y 6/1, altered to dark yellowish orange 10 YR 6/6.
MAE 219 *	Mudstone, expansive, deeply weathered. Mottled buckskin color, yellowish gray 5 Y 7/2 to light gray N8.
MAE 220 *	Mudstone, expansive, deeply weathered. Olive gray 5 Y 6/1.
MAE 221 *	Mudstone, weathered, silty. Purple 5 P 4/2.
MAE 222 *	Mudstone, expansive, deeply weathered. Light olive gray 5 Y 6/1.
MAE 223 *	Mudstone, ore-zone correlative. Expansive, weathered, variegated. Yellowish brown 10 YR 6/2 to grayish purple 5 P 4/2.
MAE 224	Limestone, micritic; sedimentary rock fragments. Light gray N7 to moderate yellowish brown 10 YR 5/4.

* No petrographic work performed on this sample.

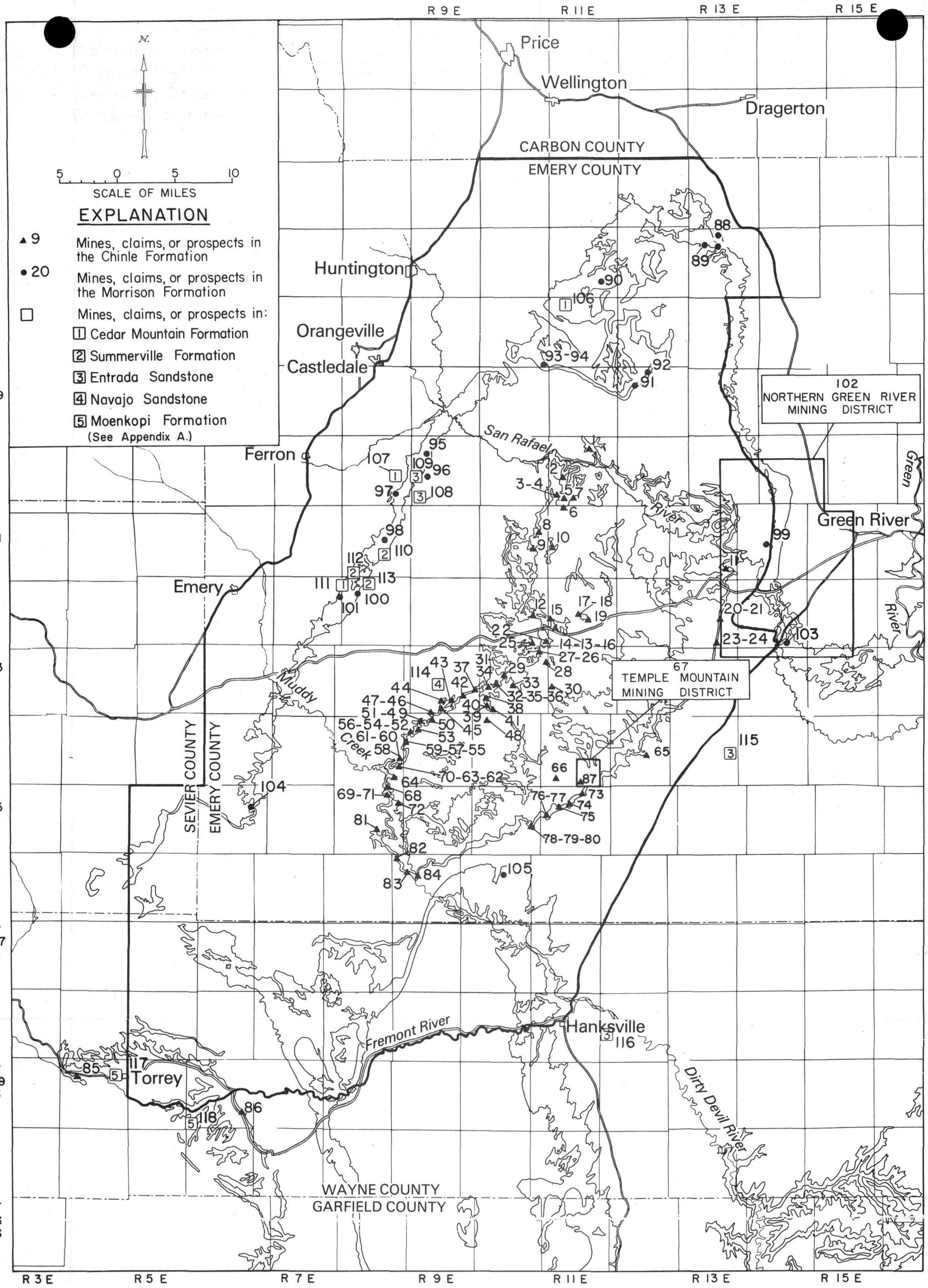


PLATE I. LOCATION OF MINES, CLAIMS, AND PROSPECTS IN THE SAN RAFAEL SWELL AREA, UTAH.

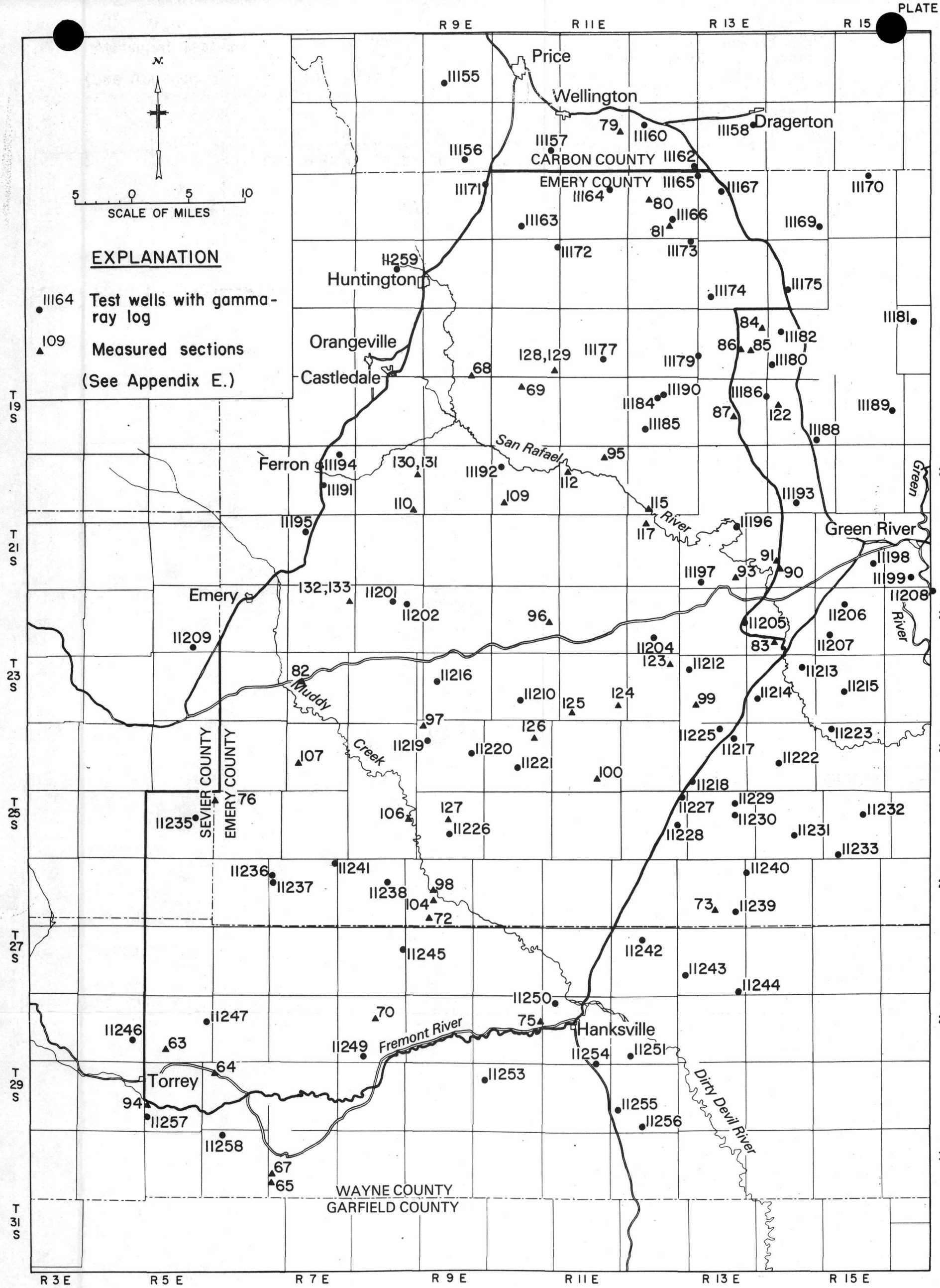


PLATE 2. LOCATION OF TEST WELLS AND MEASURED SECTIONS, SAN RAFAEL SWELL AREA, UTAH.

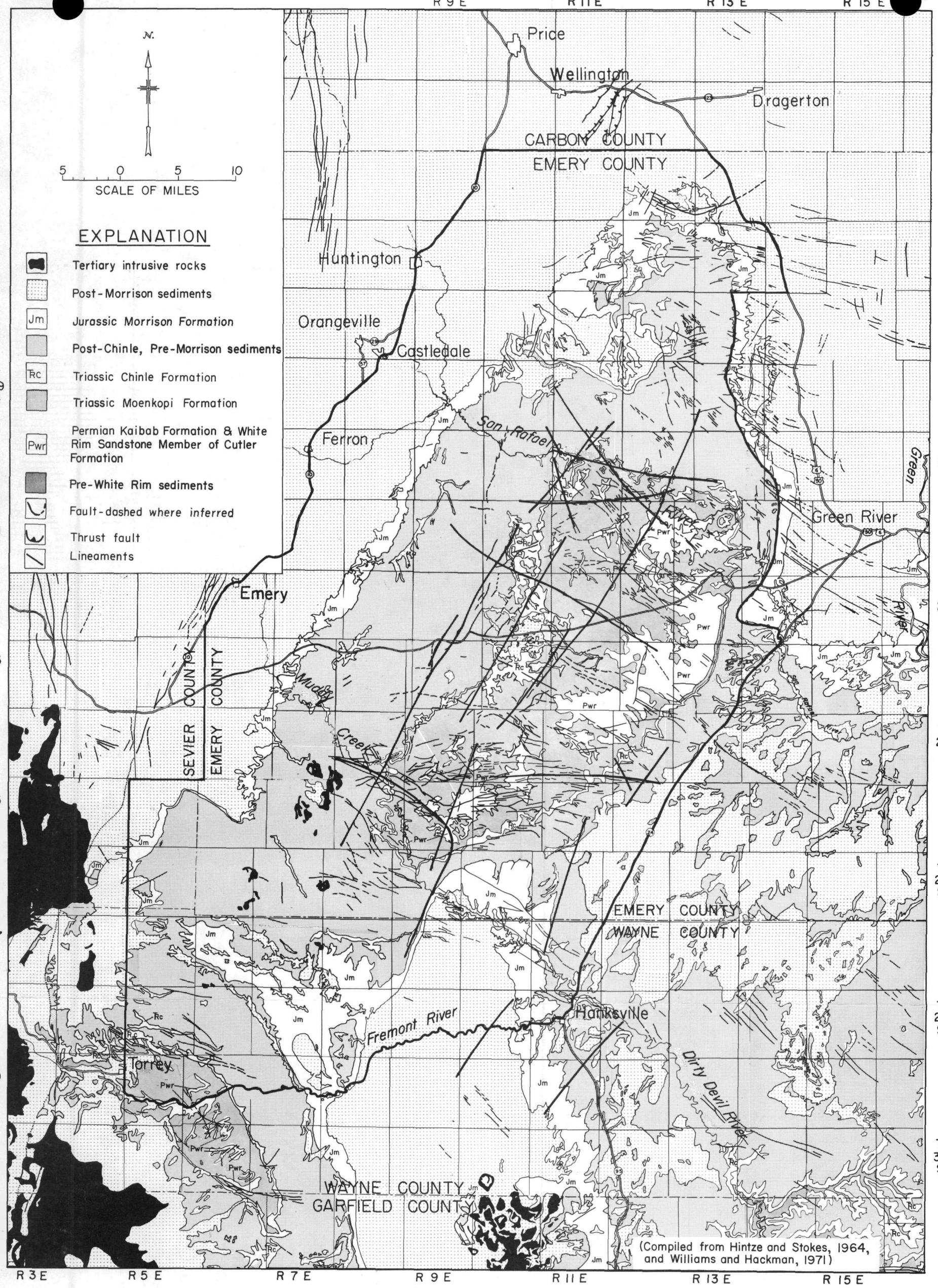


PLATE 3. GENERALIZED GEOLOGIC MAP, SAN RAFAEL SWELL AREA, UTAH.