OPEN FILE REPORT 161

PRELIMINARY EVALUATION OF THE MINERAL RESOURCE POTENTIAL OF THE PETACA PINTA WILDERNESS STUDY AREA, CIBOLA COUNTY, NEW MEXICO

Mark J. Logsdon
New Mexico Bureau of Mines and Mineral Resources
Socorro, NM 87801

December 23, 1981

TABLE OF CONTENTS

	Page
Abstract	1
Statement of Purpose	2
Introduction	3
Location and Accessibility	3
Physiography	3
Previous Geologic Investigations	4
Acknowledgments	4
Mining and Exploration History	5
Geologic Setting	5
Stratigraphy	5
Structure	7
Resource Potential	9
Summary	9
Base Metal and Uranium Potential	10
Oil and Gas Potential	13
References	18
Appendices	

FIGURE CAPTIONS

<u>Figure</u>

Figure	
1	Geologic map and stratigraphic column of the Petaca Pinta Wilderness Study Area.
2	Alteration zone in the region of the Petaca Pinta WSA.
3	Uranium concentration in water samples near the Petaca Pinta WSA.
4	Oil tests in the vicinity of the Petaca Pinta WSA.
5	Generalized axes of surface structures (after Wengerd, 1959).

ABSTRACT

The Petaca Pinta Wilderness Study Area (WSA), located approximately 90 km west of Albuquerque, New Mexico, and 20 km southeast of Acoma Pueblo, is in the Acoma sag, an embayment on the southeastern side of the San Juan Basin of the Colorado Plateau tectonic province. Rocks in the Petaca Pinta area range in age from Late Triassic to Holocene. They include the Chinle Formation and Wingate Sandstone of the Triassic System; the Entrada Sandstone, Summerville Formation and Zuni Sandstone of the Jurassic System; the Dakota Sandstone of the Cretaceous System; gravels and basalts of the Tertiary System; and landslide, eolian, alluvial, and spring deposits of the Quaternary System. Stratigraphic relationships of the Jurassic to Quaternary units reflect epeirogenic movements.

A narrow zone of alteration in the Jurassic strata, with some aspects which are similar to alteration patterns associated with uranium mineralization in the Grants District, extends a short distance into the WSA. Uranium values in surface samples are very low, but the alteration zone is a potential exploration target. There is no support in field or geochemical evidence for resource potential in coal, precious metals, base metals, iron and manganese, geothermal energy, high-calcium limestone, fluorite, or barite.

Shows of oil and gas have been reported from eastern Cibola County. The oil and gas potential of the Petaca Pinta region is moderately favorable, particularly for commercial quantities of carbon dioxide.

PURPOSE

The purpose of this study is to compile the known data on geologic setting, mineral exploration history, and mineral resource potential of the Petaca Pinta Wilderness Study Area. The report can be used by the Bureau of Land Management and other interested parties to evaluate the resource potential of the Petaca Pinta as one factor in its potential designation as a wilderness area.

INTRODUCTION

Location and Accessibility

The Petaca Pinta Wilderness Study Area (WSA) is located approximately 90 km west of Albuquerque, New Mexico, and approximately 20 km southeast of Acoma Pueblo. Access to the Petaca Pinta area is poor. Improved gravel roads from El Rito on Interstate-40 or from Coreo on New Mexico Route 6 lead to a poorly maintained dirt road along Arroyo Colorado which gives access to the $\overline{15}$ Ranch of Acoma Pueblo on the southeast border of the WSA. At many times of year, this road is passable only for four-wheel-drive vehicles. Jeep trails and unimproved dirt roads approach the western boundary of the WSA across East, Blue Water, and Victorino Mesas. However, these roads do not provide practical access to the WSA because they deadend above the formidable cliffs which form the western boundary of the WSA.

Physiography

The Petaca Pinta WSA lies within the Acoma-Zuni section of the Colorado Plateau physiographic province. The climate is semi-arid; vegetation is characterized by grama-tobosa-mesquite shrub steppe with some stands of piñon-juniper woodland on the higher mesas (Morain and others, 1977). Elevations in the mapped area range from 1760 m in the extreme northeastern corner of the map to 2230 m on Blue Water Mesa. There are four principal landforms in the Petaca Pinta area: 1) high mesas formed on Mesozoic sedimentary rocks along the western margin; 2) landslides composed of sandstone, basalt, and shale of Jurassic and younger ages which have slid over shales of the Triassic Chinle Formation in the central part of the area; 3) low, basalt-capped mesas (with vent complexes) along the eastern margin; and 4) alluvial lowlands formed along the drainages of Big Sandy Wash and Arroyo Colorado.

Previous Geologic Investigations

Stratigraphic studies in the region include Gregory (1917), Harshbarger and others (1957), Kelley and Wood (1946), Landis and others (1973), Maxwell (1976b), and Silver (1948). Structural geology and tectonics of the region are considered by Kelley (1950, 1955), Kelley and Wood (1946), and Maxwell (1976b). Geologic maps which include part or all of the WSA have been published by Jicha (1959), Kelley and Wood (1946), Machette (1978), and Maxwell (1976b, 1979). Detailed geologic maps of adjacent areas have been prepared by Maxwell (1976), Moench (1963, 1964), and Moench and Schlee (1967). C.H. Maxwell of the U.S. Geological Survey is continuing his field mapping further into the area of the WSA with quadrangle maps of the Broom Mountain, Marmon Ranch, and Cerro del Oro 7.5 minute quadrangles (in preparation).

Acknowledgments

The author gratefully acknowledges the willingness of C.H. Maxwell of the U.S. Geological Survey to share unpublished maps of portions of the Petaca Pinta WSA and chemical analyses of altered Mesozoic sedimentary rocks and Quaternary spring deposits of the WSA. The map of the area and the description of the geology profited from discussion with R.M. Chamberlin of the New Mexico Bureau of Mines and Mineral Resources. The section on oil and

gas potential was prepared by R.A. Bieberman of the New Mexico Bureau of Mines and Mineral Resources. This preliminary mineral resource evaluation was performed under a contract between the New Mexico Bureau of Mines and Mineral Resources and the U.S. Bureau of Land Management. The report was typed by Sue Ness and Lynne McNeil of the New Mexico Bureau of Mines and Mineral Resources.

MINING AND EXPLORATION HISTORY

There has been no mining of metallic or non-metallic minerals in the area of the Petaca Pinta WSA. There is no record of detailed exploration for minerals in the area. Two test wells for oil and gas in the vicinity of the WSA are described in the section on oil and gas (below).

GEOLOGIC SETTING

Stratigraphy

Figure 1 is a geologic map of the Petaca Pinta WSA and adjacent areas, compiled from published maps of Jicha (1959), Machette (1978) and Maxwell (1976b, 1979), unpublished maps of Maxwell (1981, personal communication), and field work conducted for this study.

Rocks in the Petaca Pinta area range in age from Late Triassic to Holocene. The stratigraphic units used on the map are described in the composite stratigraphic column which accompanies the map.

The Petaca Pinta area is located in the region of the Jurassic overlap. The wedge of Jurassic rocks which lies between the Chinle Formation (Upper Triassic) and the Dakota Sandstone (Upper

Cretaceous) disappears southward due to depositional thinning against a positive area and to truncation by pre-Dakota erosional surfaces (Silver, 1948). In terms of mineral resources, the stratigraphic relationships are important, because the principal uranium-bearing Jurassic formations of New Mexico (Todilto Formation and Morrison Formation) are absent in the Petaca Pinta WSA.

The Upper Triassic Chinle Formation is unconformably overlain by Middle Jurassic Entrada Sandstone north of Sec. 3, T. 6 N., R. 7 W. From section 13, T. 6 N., R. 7 W., to the southern end of the map area, the Chinle Formation is unconformably overlain by the Rock Point Member of the Wingate Sandstone (Upper Triassic) (Maxwell, 1976b; 1979).

The Entrada Sandstone unconformably overlies the Rock Point Member of the Wingate Sandstone as far south as sect. 19, T. 6 N., R. 6 W., where the Entrada is truncated by an angular unconformity of the base of the Middle Jurassic Summerville Formation (Maxwell, 1976b). South of the Entrada pinch-out, the Rock Point Member of the Wingate Sandstone is overlain unconformably by the Summerville Formation.

The contact between the Summerville Formation and the overlying Upper Jurassic Zuni Sandstone is gradational. The Zuni Sandstone is truncated by Cretaceous erosion and pinches out very near the Entrada pinch-out (Maxwell, 1976b). South of this point, the Summerville Formation is overlain unconformably by the basal unit of the Upper Cretaceous Dakota Sandstone.

The high mesas along the western boundary of the map are capped by Dakota Sandstone. Tertiary gravels, containing clasts of middle Tertiary Datil Formation volcanics, lie on an erosion surface on the Dakota (Maxwell, 1976b). Tertiary basalt flows on Petaca Pinta, Blue Water Mesa and the unnamed mesa south of Blue Water Canyon cover gravel beds and part of the erosion surface. These basalts may be correlative with the basalts of Cerro del Oro, to the southeast, which have been dated 3.1±0.5 m.y. (D.W. Love, 1981, personal communication). The basalts which cap Gunn Mesa and Middle Tsidu-Weza are on surfaces which are 200 m lower than the surface on which the Blue Water Mesa-Cerro del Oro basalts lie; these basalts may be Quaternary in age.

Quaternary caliche, colluvium, and eolian deposits cover part of Blue Water and East Mesas. Quaternary landslide deposits formed on incompetent Triassic Chinle shales cover much of the WSA per se. Quaternary alluvium fills the valleys of Big Sandy Wash and Arroyo Colorado. Active springs are depositing travertine in the Arroyo Colorado valley at the southern end of the map area.

Structure

The Petaca Pinta area is located in the Acoma sag, an embayment on the southeastern side of the San Juan Basin of the Colorado Plateau tectonic province (Kelley, 1955; Maxwell, 1976b). The changing lithologies and thicknesses of the Jurassic units in the region (Maxwell, 1976b, 1979) reflect recurring epeirogenic movements during the Jurassic (Silver, 1948).

Regional uplift and subsequent erosion in Late Jurassic or Early Cretaceous time truncated older units (Maxwell, 1976b), and the Dakota Sandstone was deposited on the erosional surface. Stratigraphic relationships of the Cretaceous and Tertiary-Quaternary units indicate that at least minor uplift continued into Tertiary time (Maxwell, 1976b).

Although faults within the map area of our study have not been described by earlier workers, at least one area of major faulting is probable. Along Arroyo Colorado, east of the Alcon and south of the WSA and Gunn Mesa, Chinle Formation crops out along a low scarp; the Chinle strikes N78E and dips 10°NW. South of the scarp and its extension to the east are the three active, travertine-depositing springs. The scarp, the strike and dip of the Chinle, and the linear arrangement of the spring deposits (which are up hydrologic gradient from the scarp) suggest that all three features are controlled by a high-angle normal fault, down thrown to the south.

Although the Mesozoic sedimentary rocks appear to be essentially flat-lying, a structure contour map of the Acoma region (Maxwell, 1976b, Fig. 2) and the geologic map in this report show that there has been some folding. The structural high-point of the region is located on Blue Water Mesa in Sect. 13, T. 6 N., R. 7 W., at the crest of a shallow, northeast-trending dome from which the rocks dip away in all directions (Maxwell, 1976b). The northwest-trending Alcon dome was interpreted by Maxwell (1976b) as being formed by intrusion of a basaltic plug. During field work for this project, the author observed a small basaltic plug partially buried by Quaternary alluvium in a small arroyo north of the $\overline{15}$ Ranch in sect. 28, T. 6 N., R. 6 W., near the center of the domal structure shown on Fig. 1. In detail the outcrop pattern of this deformed area is exceedingly complex; it probably represents interference structures formed by the intersection of several small domes of varying individual geometries, each of which is related to a small intrusive plug. The basaltic plug which was observed probably represents a single apophysis from a larger plug which underlies the deformed area.

RESOURCE POTENTIAL

Summary

There is little or no support in field or geochemical evidence for significant resource potential in uranium, coal, precious metals, base metals, iron and manganese, high-calcium limestone, or fluorite and barite.

The Tertiary gravels might be used as aggregate, and the Tertiary basalt could be used for road metal or rip-rap. However, remote location and poor access compared to other sources of aggregate or road-building materials disqualify the Petaca Pinta area as a reasonable source.

Tertiary basaltic activity suggests the possibility of geothermal resources in the area. However, the active springs along Arroyo Colorado discharge cold waters. Although no detailed heat-flow measurements have been made, the potential for geothermal energy in the Petaca Pinta region is poor.

Oil and gas are the only natural resource commodities for which the Petaca Pinta area has significant resource potential. Oil and gas potential are discussed in a following section, prepared by R.A. Bieberman.

Base Metal and Uranium Potential

A zone of alteration is present along the eastern margin of Blue Water Mesa within the WSA (Fig. 2). This zone is along the projection of the north-south-trending alteration zone east of Acoma Pueblo that was described by Maxwell (1976b). As with the zone described by Maxwell, the alteration affects principally the Jurassic Summerville Formation and Zuni Sandstone, with relatively minor alteration in the basal Dakota Sandstone. The alteration is characterized by bleaching, corrosion of sand grains, kaolinitic void-fillings, tabular zones in which carbonaceous or manganiferous material coats sand grains, and cross-cutting concentrations of pyrite, which weather to limonite and goethite. Concentrations of limonite and carbonaceous or manganiferous material cemented by carbonate are abundant in the zone of alteration. Dark-brown and yellowish-brown "liesegang" bands are common along the borders of the alteration zone.

Semiquantitative spectrographic analysis of samples (Maxwell, 1981, personal communication) shows that while the bleached cores of alteration zones are relatively low in most trace metals, concretions in the alteration zones are high (10-500 ppm) in Mn, Ba, Co, Cu, Ni, Pb, Sc, Sr, V, and Zn. The bleached core of one roll-like structure in the Summerville contains 5-30 ppm of Co, Cr, Cu, Mo, Pb, Sr, and V, and 150-200 ppm of Mn and Ba. "Liesegang" banding in the Summerville shows variable enrichment (5 to 300 ppm) in Mn, B, Ba, Cr, Cu, Pb, Sc, Sr, and V. Carbonate- and iron-rich veinlets and fracture or joint fillings show variable enrichment (1.5 to 300 ppm) in Mn, Ba, Co, Cr, Cu, Pb, Sr, V, and Zn. Copies of the analytical results are included in the appendices of this report.

The significance of the alteration zone is problematical. The presence of a very similar larger, north-south-trending alteration zone north of the Petaca Pinta area suggests that the alteration may be regionally significant and that the alteration zone is stratigraphically controlled. The alteration pattern has numerous similarities to the Grants-type sandstone uranium mineralization in the Jurassic system north of the Petaca Pinta area: Eh-pH-controlled mineralogy, elevated concentrations of Cu, Mo, and V, tabular geometry of carbonaceous zones. The most obvious differences are the apparent absence of U and the absence of stream channel sands and conglomerates where the permeability and porosity would be sufficiently high to allow significant ore accumulation. Elevated values of Ba, Sr, Pb and Zn, which are characteristic of sedimentary basin "brines" (Hanor, 1979) together with Cu, Co, Mo, and V, which are easily carried in vadose waters or oxidizing, shallow groundwaters (Garrels and Christ, 1965), suggests that the zone of alteration may represent a redox boundary at the interface of oxygenated, shallow groundwaters and oxygen-poor, deep basin brines, a model recently developed for the formation of some sandstone uranium deposits in southeastern Utah (M.B. Goldhaber, 1981, personal communication). Alternatively, the alteration may be related to deep weathering along fractures buried by the Dakota Sandstone. Unconformity-related uranium deposits in Upper Cretaceous sandstones in the Datil Mountains of west-central New Mexico have been described recently by Chamberlin (1981). The true nature of the alteration zone needs much more work.

Whether U was never present in this alteration zone, or whether U was removed during later leaching of the zone by oxidizing groundwaters cannot be resolved on the basis of the present data. Water from a well on the southeast margin of the WSA (Fig. 3) contains a slightly anomolous concentration of 17 ppb uranium (Planner and others, 1980). This suggests that uranium may have been leached from the near-surface portion of the altered zone. Alternatively, there may be subsurface uranium mineralization that is unrelated to the zone of alteration.

While the alteration zone and the one anomolous water-well U value provide some support for uranium mineralization, the author believes for 3 reasons that the potential is relatively low within the WSA. First, there is no direct evidence for U in the alteration zone. Second, most of the alteration zone lies outside the WSA; it has apparently been removed by erosion along Blue Water and East Mesas. Third, only one of 10 water wells tested shows any U anomaly, and that value is less than a factor of two greater than the 10 ppb value common for waters derived from sedimentary terrains.

Geochemistry of Spring Deposits

Semiquantitative spectrographic analyses of travertine from active springs along Arroyo Colorado (Maxwell, 1981, personal communication), show very high (700-10,000 ppm) Sr and Mn and high but variable (10-150 ppm) values for Ba, Co, Cu, and Ni. Detectible (1-3 ppm) amounts of Ag, Be, and Cr are present. Pb, Zn, and V are at or below the limits of detection. None of the spring deposits contains economic quantities of metals. Potential source areas for the metals are up hydrologic gradient to the south, outside the WSA and the mapped area.

Oil and Gas Potential

Commercial oil and/or gas production has not, as yet, been found in Cibola County, New Mexico. The nearest commercial production to the Petaca Pinta Area is located about 55 miles to the northwest in T. 15N., R. 10W., McKinley County.

Studies made by Foster, 1957, and Wengerd, 1959, have shown that an excellent petroleum possibility exists in eastern Cibola County, New Mexico. Shows of oil and gas have been reported from test wells, and Foster and Grant, 1974, have classified eastern Cibola County as a class 2 exploration area in a system where class 1 is most favorable and class 4 is least favorable. Some modification must be made in Wengerd's study in regard to the thickness of Pennsylvanian marine rocks. Very few control points on the Pennsylvanian existed at the time of Wengerd's work and his map showing the thickness of Pennsylvanian marine rocks suggests that the Pennsylvanian would have a thickness of about 1800 feet in the Petaca Pinta area. Subsequent drilling in the vicinity of the Petaca Pinta area reveals that the Pennsylvanian should have a thickness of about 700 feet.

Cretaceous rocks as potential reservoirs are not present in the Petaca Pinta area. These rocks are the big reservoirs farther north in McKinley, Sandoval, San Juan, and Rio Arriba counties. The Petaca Pinta area has a stratigraphic section approximately

4,800 feet in thickness, comprising Pennsylvanian, Permian, and Triassic rocks of marine and non-marine origin. The Triassic rocks are largely continental in origin and are not considered to have a petroleum potential.

Two test wells have been drilled in the vicinity of the Petaca Pinta area (Fig. 4). In 1959, Spanel & Heinze drilled the #1-M Santa Fe in Section 5, Township 5 North, Range 7 West. The footage location of the test is 700 feet from the South line and 1070 feet from the West line of Section 5. Precambrian granite was encountered at a depth of 4974 feet and the test was abandoned as a dry hole at a total depth of 4992 feet. In 1960, Sun Oil Co. drilled the #1 Pueblo of Acoma in Section 2, Township 7 North, Range 7 West. The footage location of the test is 1900 feet from the South line and 1900 feet from the East line of Section 2. Precambrian granitic gneiss was encountered at a depth of 4702 feet and the test was abandoned as a dry hole at a total depth of 4794 feet.

The Spanel test was spudded in the Cretaceous Dakota sandstone on Half Dome, a structure along the Red Lake Fault. The Permian was reached at a depth of 2005 feet and consisted of, in descending order, 335 feet of limeston, dolomite, sandstone and shale of the San Andres Formation, 240 feet of Glorieta Sandstone, 1130 feet of sandstone, shale, anhydrite, limestone, and dolomite of the Yeso Formation, and 624 feet of siltstone, shale, and sandstone of the Abo Formation. Pennsylvanian rock were reached at a depth of 4334 feet and consisted of about 640 feet of limestone, shale, and sandstone. Igneous sills (diorite?), two and thirty feet and thickness, were encountered in the Triassic and San Andres, and two sills, fifteen and twenty feet in thickness, were found in the Yeso Formation. Slight shows of gas were reported from drill stem tests made at 4430-4533 feet and 4537-4637 in the Pennsylvanian.

The Sun test started in the Triassic on a structure known as the Acoma Nose. The Permian was reached at a depth of 1765 feet and consisted of, in descending order, 425 feet of limestone, dolomite, sandstone, and shale of the San Andres Formation, 150 feet of Glorieta Sandstone, 870 feet of limestone, silty dolomite, and silty sandstone of the Yeso Formation, and 372 feet of siltstone, shale and sandstone of the Abo Formation. The Pennsylvanian, at a depth of 3882 feet, consisted of 820 feet of limestone, shale, and sandstone. An igneous sill (diorite?) was found between 1830 and 1920 feet in the San Andres Formation. A show of gas was reported in the San Andres at a depth of 2096 feet and heavily gas-cut mud was recovered in a drill stem test at 4486-4526 in the Pennsylvanian. Gas from this drill stem test was sent to the Sun Oil Co. Research Laboratory for analysis. It was found to contain 95% carbon dioxide and 0.13% helium. The remaining fraction was not identified.

The petroleum potential of the Petaca Pinta area is in rocks of Permian and Pennsylvanian ages. Suitable source and reservoir rocks occur in the stratigraphic section. Carbonate reservoirs may be expected in the San Andres Formation, Yeso Formation and Pennsylvanian. Sandstone reservoirs may also be expected in these formations as well as in the Glorieta Sandstone.

Numerous fault and anticlinal structures are present in the vicinity of the Petaca Pinta area and some are present within the Petaca Pinta area itself (Fig. 5). In addition to potential structural traps, numerous possibilities for stratigraphic and combination structural-stratigraphic traps exist.

CARBON DIOXIDE POTENTIAL

Carbon dioxide has a great many uses in addition to its use in soft drinks, fire extinguishers, and dry ice and is becoming increasingly important in the enhanced recovery of oil. Carbon dioxide is highly soluble in crude oils and water at reservoir pressures and temperatures. When oil and water contain a substantial amount of dissolved carbon dioxide, their viscosities, densities, and compressibilities are modified in a direction which helps to increase the oil-recovery efficiency.

At present time, oil companies are eager to have under contract a supply of carbon dioxide. The increasing price of crude oil will make it economically more attractive in the coming years to inject carbon dioxide to recover additional oil. Carbon dioxide fields are being developed in northeastern New Mexico and southwestern Colorado. Pipelines will transport the carbon dioxode to oil fields in west Texas and southeastern New Mexico.

The source for carbon dioxode accumulations beneath the surface of the earth is not clearly understood. One theory suggests that it might be generated through thermal action when limestones are intruded by igneous rocks. If this theory is correct, the Petaca Pinta area may have a potential for carbon dioxide production. Numerous volcanic plugs occur in the vicinity, and the Spanel and

Sun test wells revealed the presence of igneous sills at depth and limestone in the Permian and Pennsylvanian. In addition, gas recovered in a drill stem test in the Sun well was found to contain 95% carbon dioxide.

REFERENCES

Chamberlin, R.M., 1981, Unconformity-related uranium deposits in Upper Cretaceous sandstones, Datil Mountains Area, west-central New Mexico (abs.): Rocky Mountain Section-Am. Assoc. Petrol. Geol., 29th Annual Meeting, Program with Abstracts.

Foster, R.W., 1957, Stratigraphy of west-central New Mexico: Four Corners Geol. Soc. Guidebook 2, p. 62-72.

____________, and Grant, P.R., 1974, The future of New Mexico's oil and gas resources: N.M. Bur. Mines Mineral Resources, Resource Map 3.

____________, 1980, Carbon dioxide sources and use for enhanced oil recovery: New Mexico Inst. Mining and Tech., PRRC Report No. 80-4, 73 p.

Garrels, R.M. and Christ, C.L., 1965, Solutions, Minerals and Equilibria: San Francisco, Freeman-Copper, 450 p.

Hanor, J.S., 1979, The sedimentary genesis of hydrothermal fluids, in Barnes, H.L. (ed.), Geochemistry of Hydrothermal Ore Deposits (2nd edition): New York, John Wiley and Sons, p. 137-172.

Gregory, H.E., 1917, Geology of the Navajo Country-A reconnaissance of parts of Arizona, New Mexico, and Utah: U.S. Geol. Survey Prof. Paper 93, 161 p.

Harshbarger, J.W., Repenning, C.A., and Irwin, J.H., 1957, Stratigraphy of the uppermost Triassic and Jurassic rocks of the Navajo Country: U.S. Geol. Survey Prof. Paper 291, 74 p.

Jicha, H.L., Jr., 1958, Geology and mineral resources of Mesa del Oro quadrangle, Socorro and Valencia Counties, New Mexico:

N.M. Bureau of Mines Mineral Resources Bull. 56, 67 p.

Kelley, V.C., 1950, Regional structure of the San Juan Basin: N.M. Geol. Soc. Guidebook 1, p. 101-108.

__________, 1955, Regional tectonics of the Colorado Plateau and relationship to the origin and distribution of uranium: Univ. New Mexico Pubs. Geology No. 5, 120 p.

__________, and Wood, G.H., Jr., 1946, Geology of the Lucero uplift, Valencia, Socorro, and Bernalillo Counties, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 47.

Landis, E.A., Dane, C.H., and Cobban, W.A., 1973, Stratigraphic terminology of the Dakota Sandstone and Mancos Shale, west-central New Mexico: U.S. Geol. Survey Bull. 1372-J, 44 p.

Machette, M.N., 1978, Preliminary geologic map of Socorro 1°x2° quadrangle, central New Mexico: U.S. Geol. Survey Open-file Report 78-607.

Maxwell, C.H., 1976a, Geologic map of Acoma Pueblo quadrangle, New Mexico: U.S. Geol. Survey Geol. Quad. Map GQ-1298.

__________, 1976b, Stratigraphy and structure of the Acoma region, New Mexico: N.M. Geol. Soc. Special Publication 6, p. 95-101.

__________, 1979, Geologic map of East Mesa quadrangle, New Mexico: U.S. Geol. Survey Geol. Quad. Map GQ-1522.

Moench, R.H., 1963, Geologic map of Laguna quadrangle, New Mexico U.S. Geol. Survey Geol. Quad. Map GQ-208.

__________, 1964, Geology of South Butte quadrangle, New Mexico: U.S. Geol. Survey Geol. Quad. Map GQ-355.

__________, and Schlee, J.S., 1967, Geology and uranium deposits of the Laguna district, New Mexico: U.S. Geol. Survey Prof. Paper 519, 117 p.

Morain, S.A., Budge, T.K., and White, M.E., 1977, Vegetation and land use in New Mexico: N.M. Bur. Mines Min. Res. Resource Map 8.

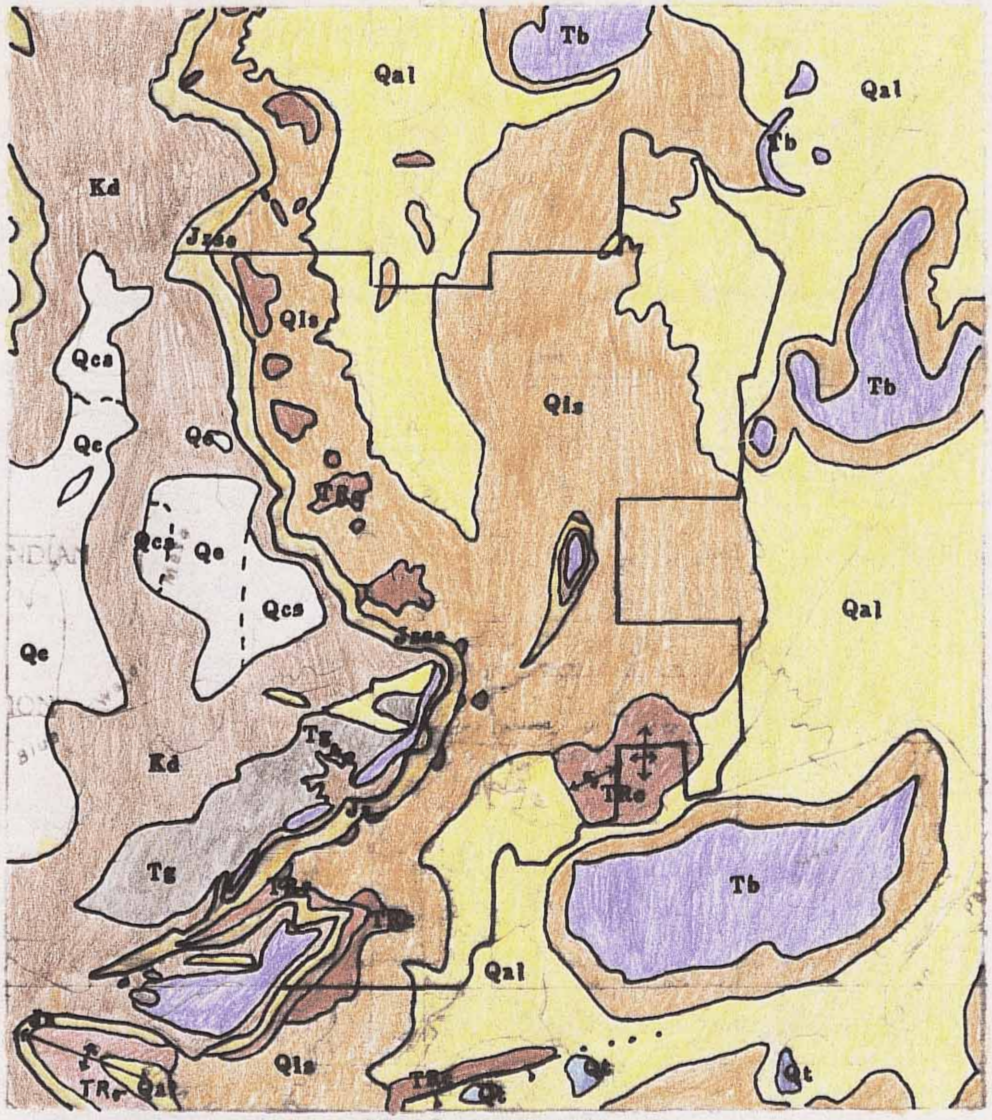
Planner, H.N., and others, 1980, Uranium hydrogeochemical and stream sediment reconnaissance data release for the Socorro NTMS Quadrangle, New Mexico, including concentrations of forty-two additional elements: U.S. Dept. of Energy Open-file Report GJBX-12(80), 145 p.

Silver, Caswell, 1948, Jurassic overlap in western New Mexico: Am. Assoc. Petroleum Geologists Bull., v. 32, p. 68-81.

Wengerd, S.A., 1959, Regional geology related to the petroleum potential of the Lucero Region, west-central New Mexico: N.M. Geol. Soc. Guidebook 10, p. 121-134.

Fig. 1

GEOLOGIC MAP OF THE PETACA PINTA WSA



SCALE 1:100,000

1 0 1 2 3 4 5 6 7 8 9 10
km

EXPLANATION

Qt	Travertine Deposits	Tb	Basaltic Lava Flows	TRr	Rock Point of Wingate Sandstone
Qe	Eolian Deposits	Tg	Conglomerate	TRc	Chinle Formation
Qal	Alluvium	Kd	Dakota Sandstone		
Qc	Colluvium				
Qls	Landslide Deposits	Jzse	Zuni Sandstone, Summerville Formation and Entrada Sandstone		
Qcs	Caliche and Old Soils	Js	Summerville Formation		

Fault, bar and ball on downthrown side

Doubly plunging anticline

OFR-1101 H

COMPOSITE STRATIGRAPHIC COLUMN - PETACA PINTA WSA

Qt TRAVERTINE DEPOSITS (HOLOCENE) - Calcium carbonate (travertine) with minor gypsum and silica, deposited by active springs.

Qe EOLIAN DEPOSITS (HOLOCENE) - Recent windblown sand and silt in sheets and small longitudinal dunes.

Qal ALLUVIUM (HOLOCENE AND PLEISTOCENE) - Fine sand and silt with lenses of coarser sand and gravel. Includes both Qa and Qoa (old alluvial deposits) of Maxwell (1979).

Qc COLLUVIUM (HOLOCENE AND PLEISTOCENE) - Extensive mantle of soil and colluvial and eolian deposits on Blue Water Mesa and East Mesa.

Qls LANDSLIDE DEPOSITS (HOLOCENE AND PLEISTOCENE) - Toreva-block (rotational slump block) slides composed of sandstone or basalt and shale which have slid over shales of the Chinle Formation (TRc). Landslides are generally older than alluvium (Maxwell, 1979).

Qcs CALICHE AND OLD SOILS (HOLOCENE AND PLEISTOCENE) - Partly exhumed caliche pavement; includes some old soil zones and remnants of old alluvium and gravel.

Tb BASALTIC LAVA FLOWS (PLIOCENE) - Black to dark gray, fine-grained to porphyritic, alkali-olivine basalts (Jicha, 1959). Flow tops are scoriaceous to amygdaloidal. Flows are probably 2.5 to 3.1 m.y. (Machette, 1978).

Tg CONGLOMERATE (PLIOCENE? AND MIOCENE?) - Slightly indurated alluvial deposits composed of coarse sand, pebbles and cobbles derived from Precambrian granite, Paleozoic sedimentary rocks and Tertiary volcanics in a matrix of sand and silt, largely cemented by caliche.

UNCONFORMITY

Kd DAKOTA SANDSTONE (UPPER CRETACEOUS) - Comprises both the basal unit and the Oak Canyon Member described by Maxwell (1979). The Oak Canyon Member is composed of light grayish-tan (weathers yellowish tan), fine-grained, lenticular sandstone which is interbedded with dark gray, silty shale. The basal unit is light gray to white (weathers dark brown), medium- to coarse-grained, poorly sorted sandstone and conglomerate. The basal unit truncates the underlying formations.

UNCONFORMITY

Jzse ZUNI SANDSTONE, SUMMERVILLE FORMATION AND ENTRADA SANDSTONE - Formations mapped as a single unit where vertical cliffs make separation of formations impractical at this scale.

ZUNI SANDSTONE (UPPER JURASSIC) - Variably colored (white-gray-green), fine-to medium-grained, eolian sandstone. A basal fluviatile sandstone was mapped separately as the Bluff Sandstone in the Acoma Pueblo Quadrangle (Maxwell, 1976a). The Bluff Sandstone is yellowish-gray to white, very fine-grained to medium-grained, fairly well sorted, quartzose sandstone cemented with calcite. The Zuni Sandstone, truncated by the erosional interval which preceded deposition of the Dakot Formation, is absent south of sect. 19, T. 6N., R. 6W.

Js SUMMERVILLE FORMATION (UPPER JURASSIC) - White to pale brown, very fine-grained, medium-bedded to massive sandstone, intervedded with grayish-green and light maroon siltstone and thin, brick-red to brown mudstone. South of sect. 19, T. 6N., R. 6 W., the Summerville Formation is the only Jurassic unit, and it is labeled as Js in this area.

UNCONFORMITY

ENTRADA SANDSTONE (MIDDLE JURASSIC) - Very pale orange to chalky white, fine- to coarse-grained, well-sorted sandstone with basal pebble conglomerate. The pale colors reflect a wide-spread zone of alteration characterized by eroded sand grains and clots and coatings of kaolinite (Maxwell, 1976b). The Entrada Sandstone is truncated by an erosional interval which preceded deposition of the Summerville Formation and is absent south of sect. 19, T. 6N., R. 6W.

UNCONFORMITY

TRr ROCK POINT MEMBER OF THE WINGATE SANDSTONE (UPPER TRIASSIC) - Pale- to moderate-red, thick-bedded to massive siltstone and shaly mudstone with local bleaching. Present only in the southern half of the map area.

UNCONFORMITY

TRc CHINLE FORMATION (UPPER TRIASSIC) - Grayish-red and moderate reddish-purple, shaly siltstone and mudstone with inconspicuous stratification. Contains lenses of very fine-grained sandstone. Largely covered by landslides.

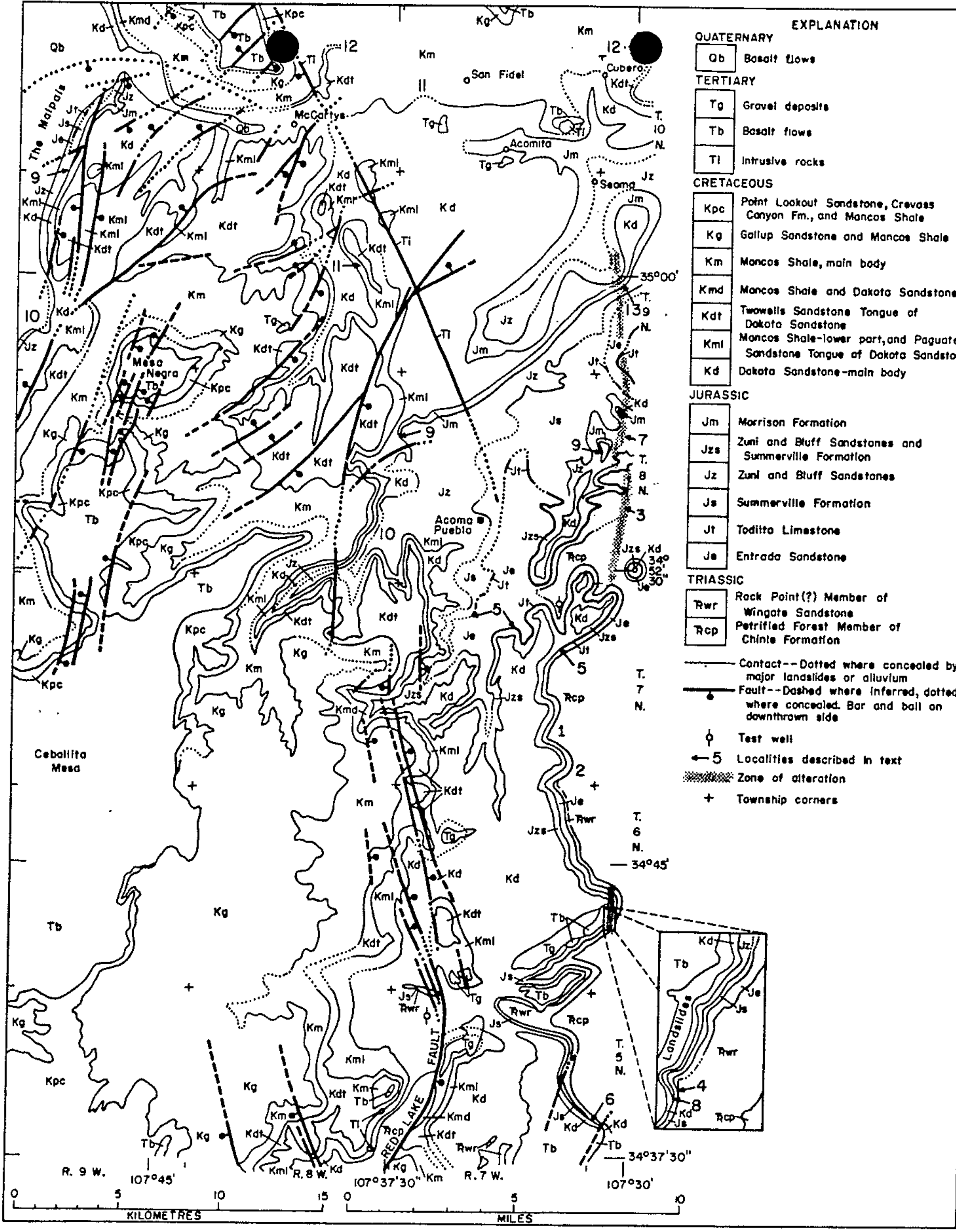
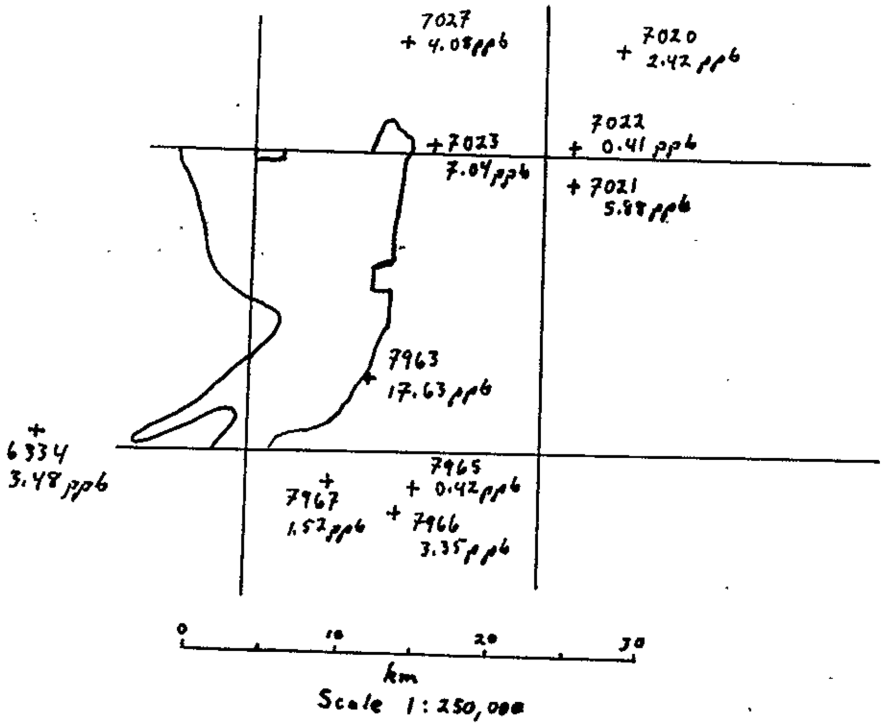


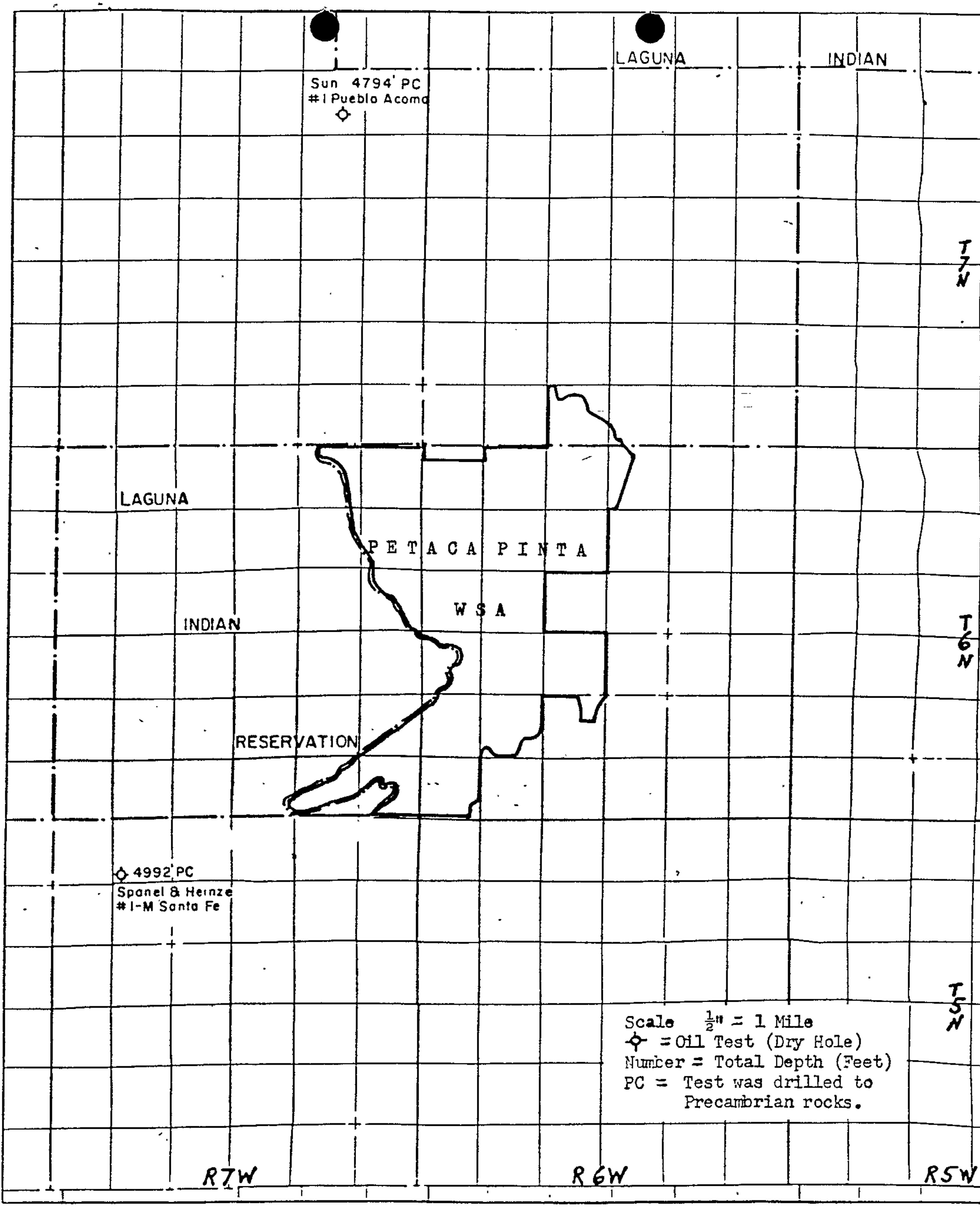
Fig. 2 Alteration zone in the region of the Petaca Pinta [illegible]
(after [illegible], 197[illegible], fig. [illegible]).



Explanation

7967 - LASL sample number
1.52 ppb - Uranium concentration in parts per billion

Fig. 3 Uranium concentration in water samples near the [illegible] Pinta WSA (after Planner and others, 1980)



OIL TESTS IN THE VICINITY OF THE PETACA PINTA WSA

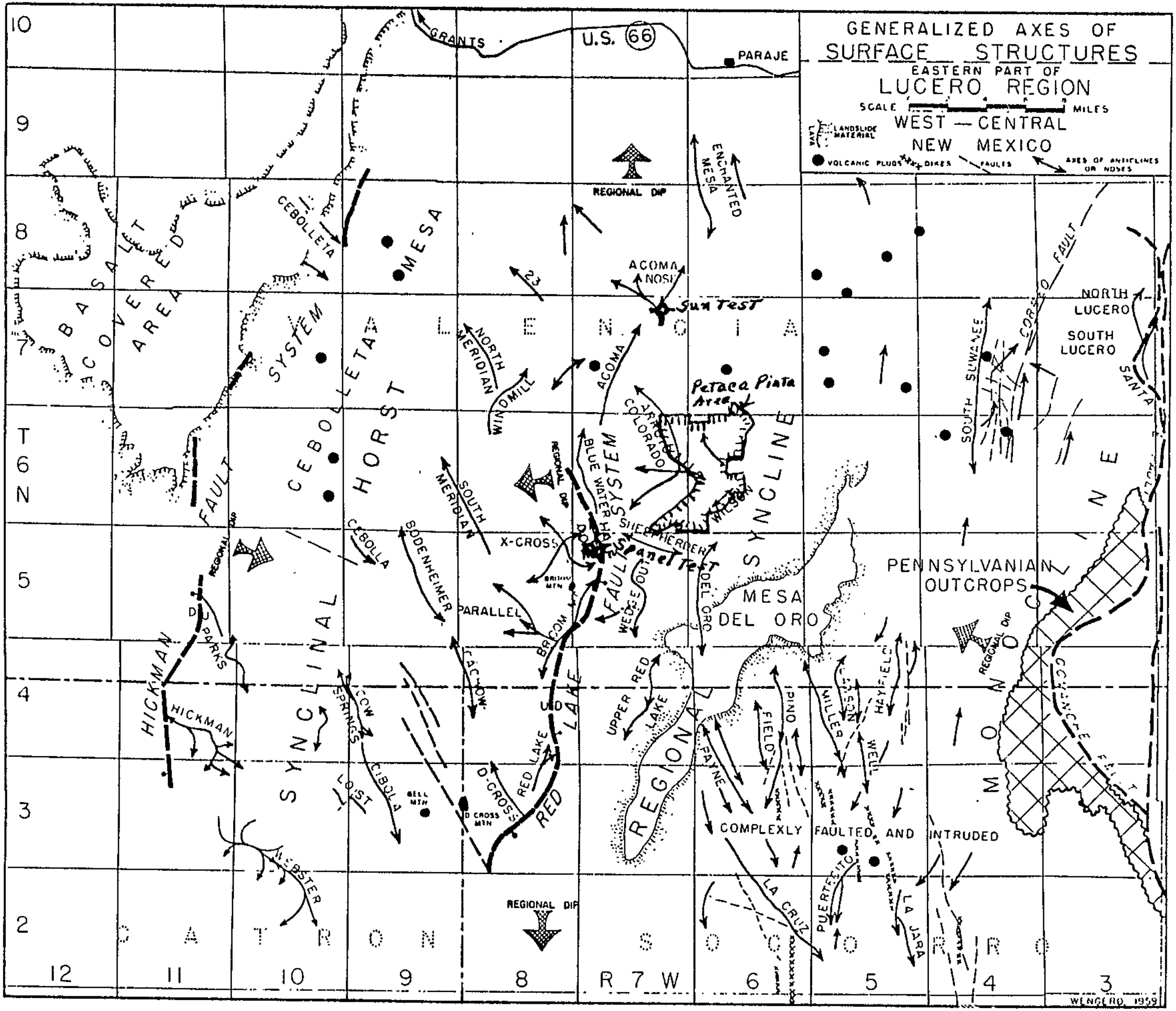
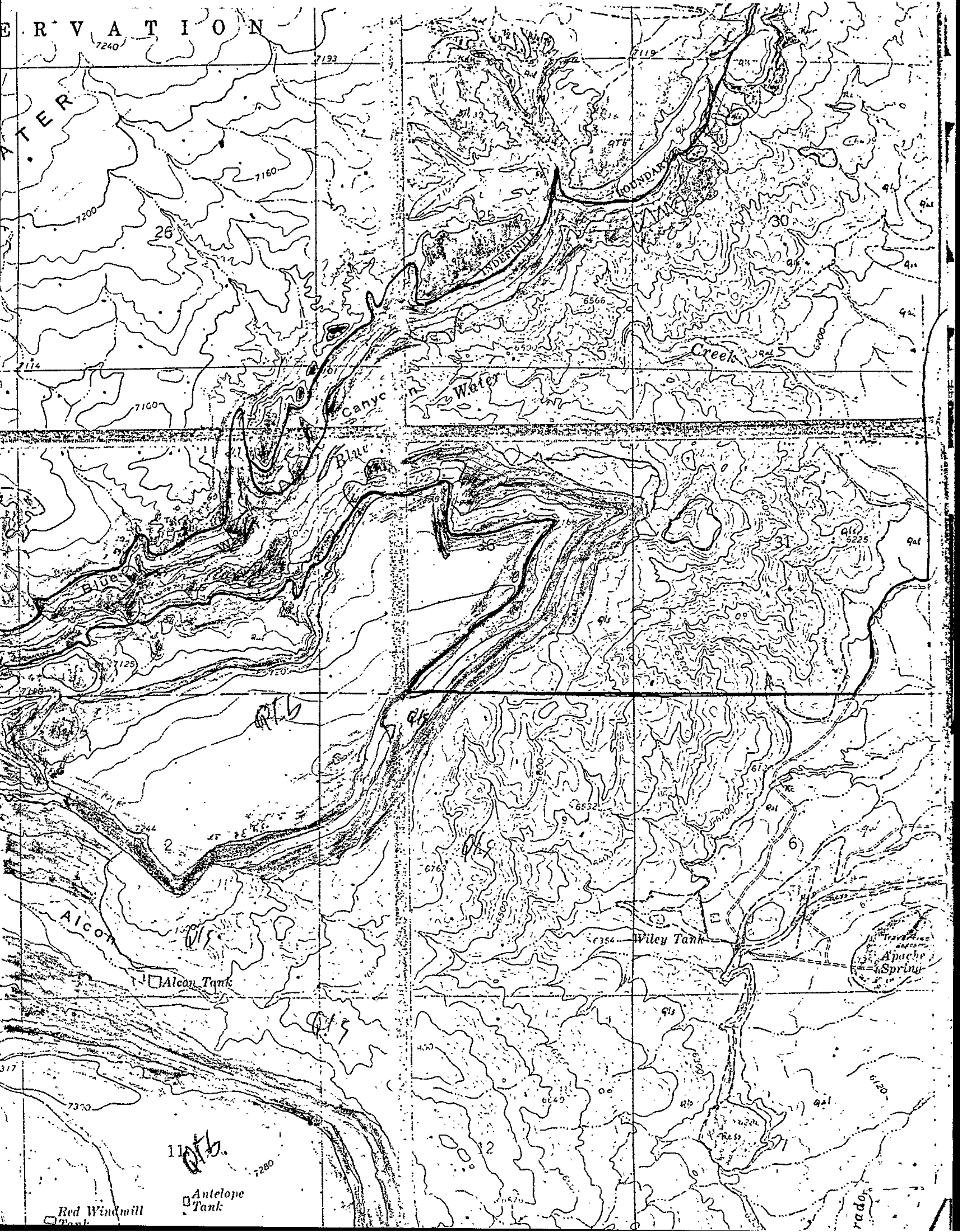
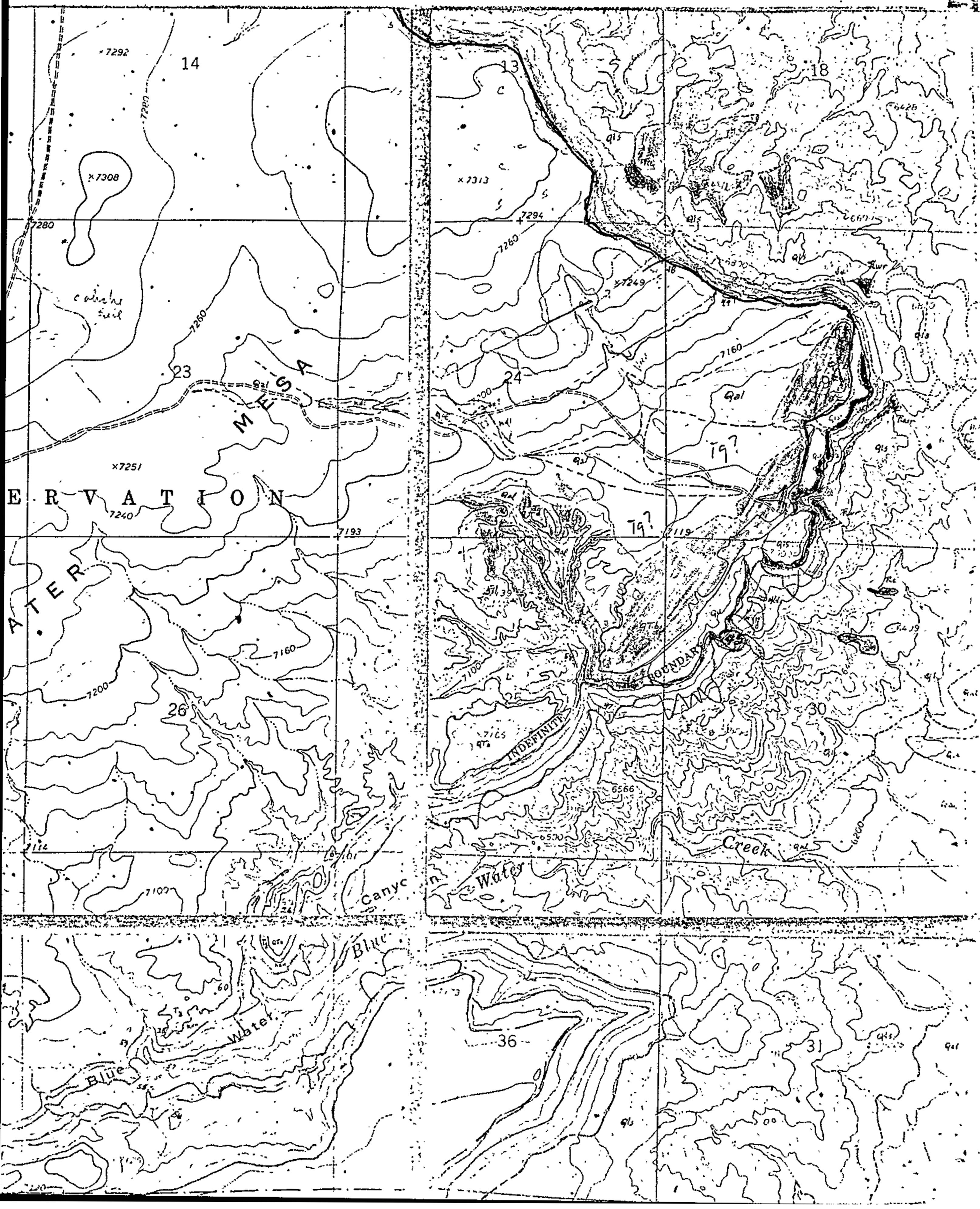
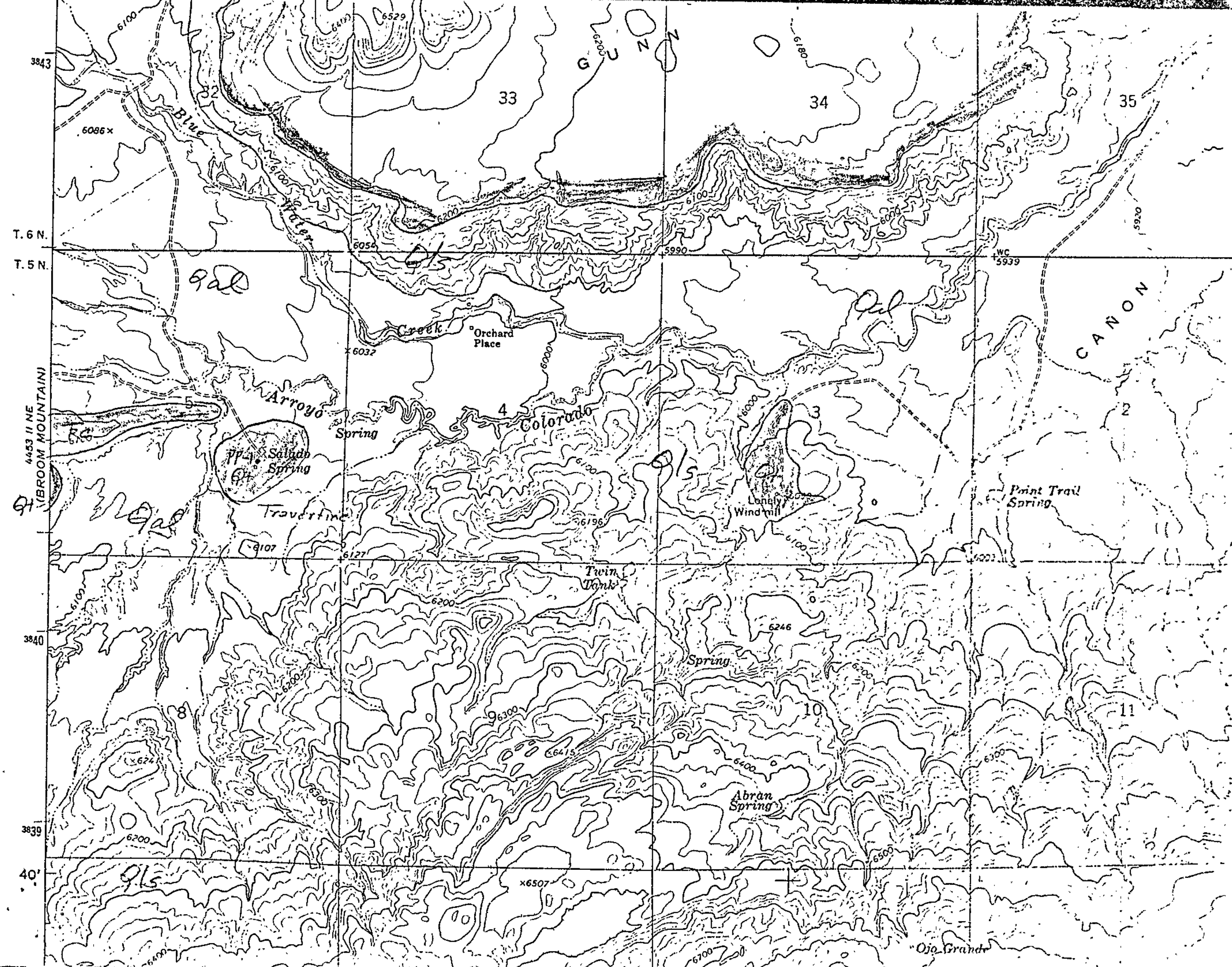


Fig. 5 **GENERALIZED AXES OF SURFACE STRUCTURES** (after Wengerd, 1959)

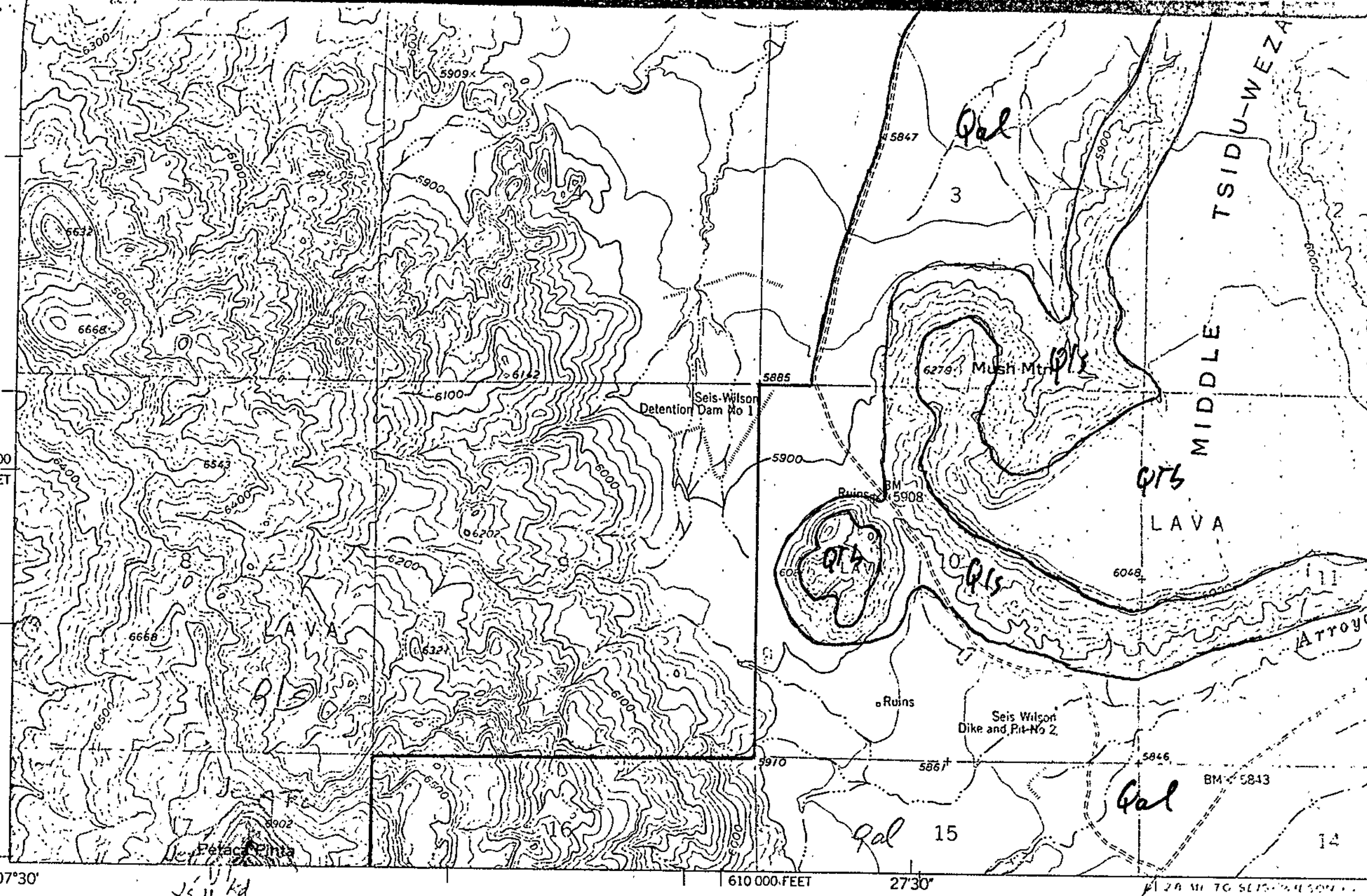


ERVATION
ATER
7240
7193
7119
7160
7200
26
25
30
INDEFINITE
BOUNDARY
6566
6500
Creek
6200
7114
7100
Canyon
Water
Blue
Blue
36
31
6225
7125
7120
6532
7244
2
6
Alcon
Wiley Tank
6354
Apache
Spring
Alcon Tank
7300
11
12
7280
6120
Antelope
Tank
Red Windmill
Tank


14
13
18
×7292
×7308
7280
×7313
7294
7260
×7249
7160
23
24
M E S A
×7251
E R V A T I O N
7240
7193
Tg?
A T E R
7200
26
INDEFINITE
BOUNDARY
30
7165
6566
6500
7100
Creek
Water
Canyon
Blue Water
Blue
36
31
Qal
Qls
7114
7107



GUN
CANON
Blue Water Creek
Arroyo Colorado
Orchard Place
Spring
Salado Spring
Travertine
Twin Tank
Lonely Windmill
Point Trail Spring
Abran Spring
Ojo Grande
T. 6 N.
T. 5 N.
4453 II NE (BROOM MOUNTAIN)
32
33
34
35
2
3
4
5
8
9
10
11
6529
6086
6032
6056
5990
5939
6107
6127
6196
6246
6415
6507
3843
3840
3839
40'
Qal
Qls
Qt



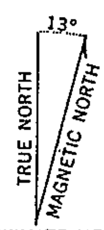
Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1951. Field checked 1961

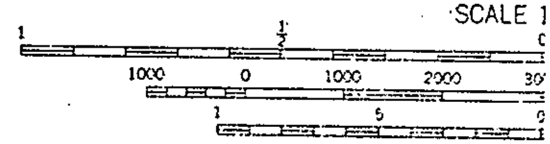
Polyconic projection. 1927 North American datum
10,000-foot grid based on New Mexico coordinate system, west zone
1000-meter Universal Transverse Mercator grid ticks, zone 13, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked



APPROXIMATE MEAN DECLINATION, 1961

SCALE 1



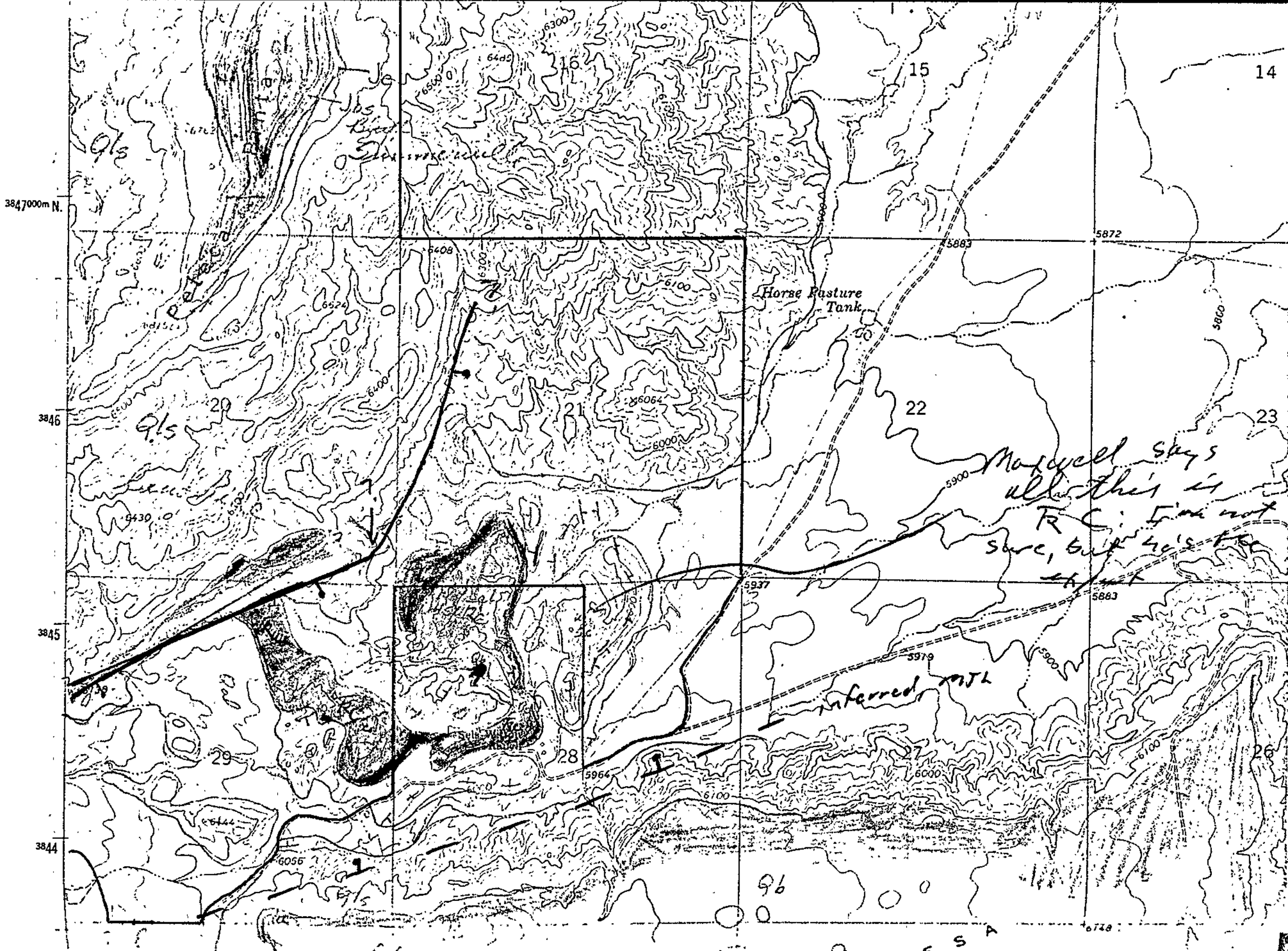
CONTOUR INTE

DOTTED LINES REPRESE

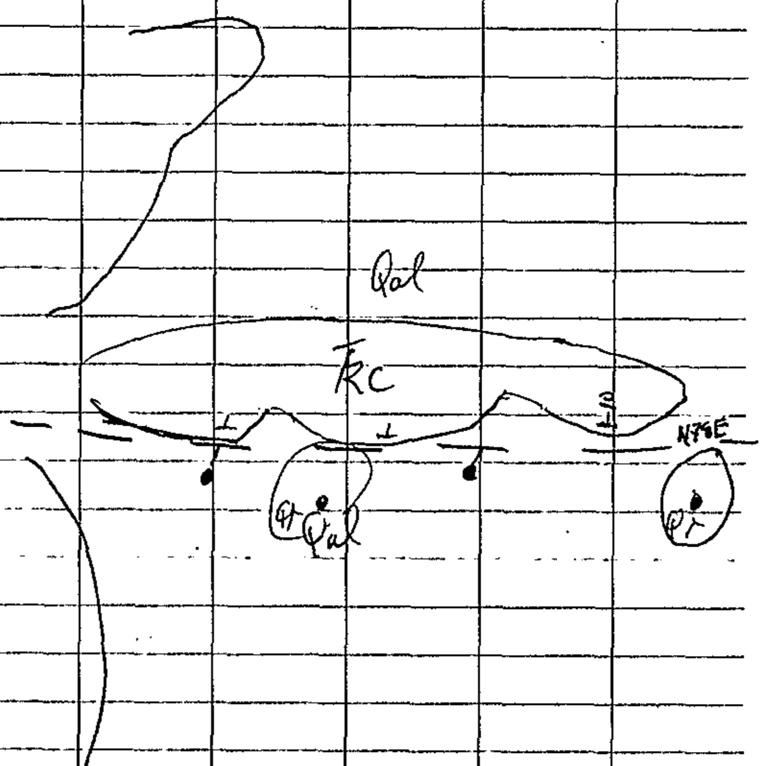
DATUM IS MEA

THIS MAP COMPLIES WITH NATIO

FOR SALE BY U.S. GEOLOGICAL SURVEY, DENV


3847000m N.
3846
3845
3844
14
15
16
20
21
22
23
26
27
28
29
Horse Pasture Tank
5872
5883
5937
5964
5979
6064
6056
6444
MESA
Qls
Qal
Marcell says all this is R C; I'm not sure, but he's the expert
Inferred MTL

Note: Scis-Wilson Ranch now
Tr Pueblo of Ácoma



6 October 1981 1

Petaca Pinta (west)

1. Salado Spring - Qtra PP-1

a spring is active, but not very salty to taste

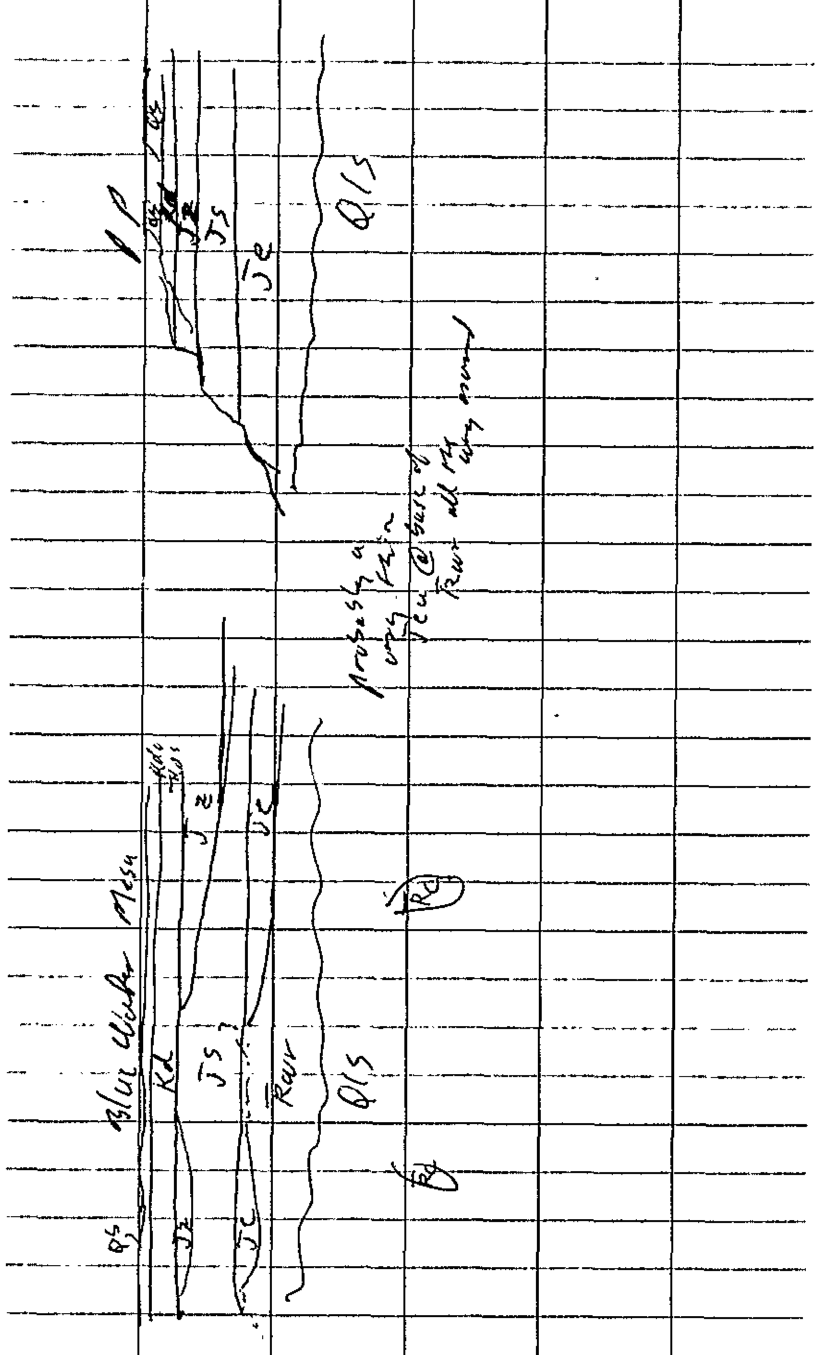
b. 7 ruins of an old building on SE side of Qt mound, but it was made from Rss, not Qt

c mound is poorly consolidated Qt from spring - whitish

travertine as rock only in small pieces - very porous, but texture looks a good deal like Mdel Oro, Kiley

Note: Apache Spring Qt, Salado Spring Qt & Lonely Windmill Qt are linear & just S. of TRc ridge (25 m)

<— Fault ? ?



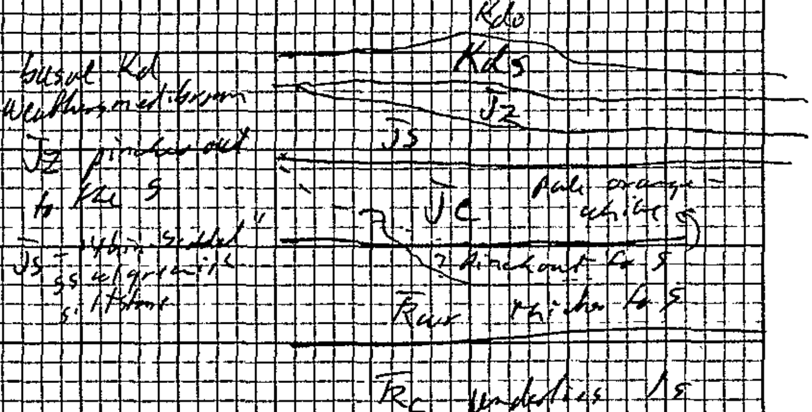
7 October 1981 1

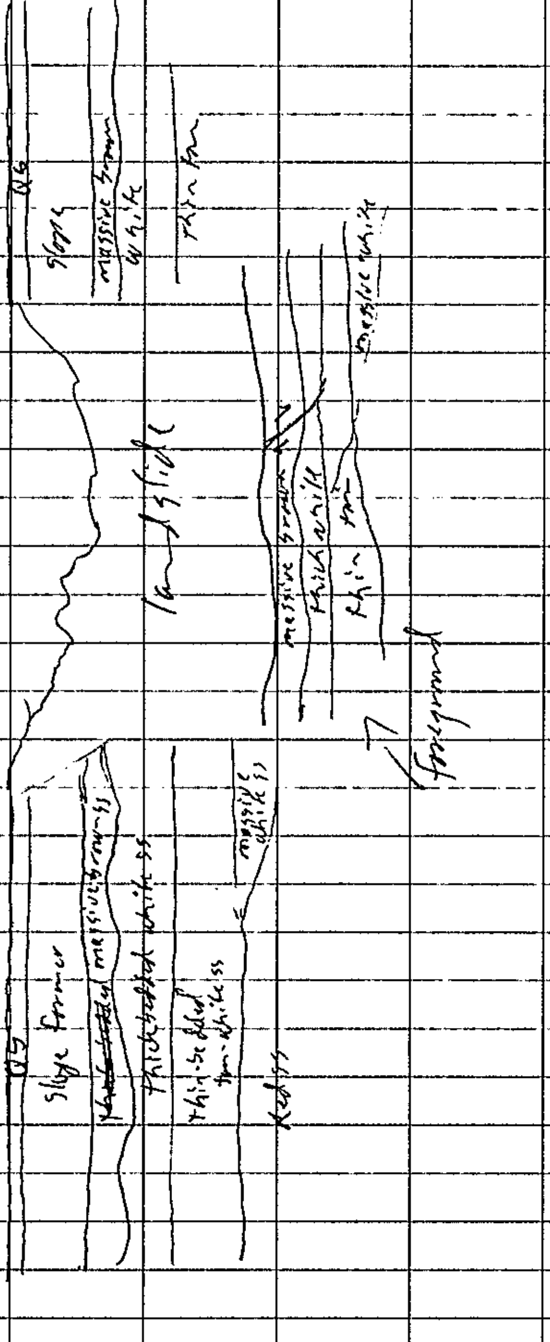
Petaca Pinta - day 2

I. Traverse across dome → Petaca Pinta

1. {
a. dome cored by Rc
b. Rwr outside
c. thin lower Jc
}

2. 1st major ridge in Qls area shows most of the stratigraphy

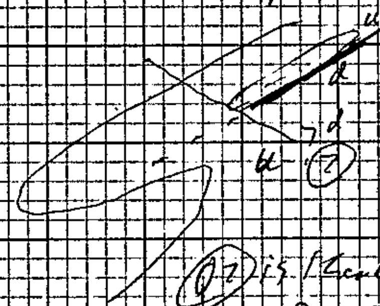




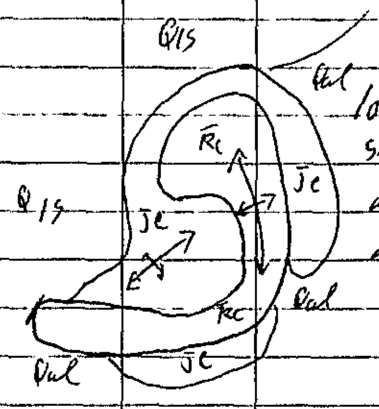
2. Big NE-trending ridge on SE side of Pelaca Mesa

← the big block in foreground is continuous!

(Q.1) is there a fault coming out of Bluewater Canyon? → (1)



(Q2) is there a transverse fault (NW)?



looks like a small dome or doubly-plunging anticline

3. problem area NW of ranch hg

Red-purple siltstone w/ white SS cover
small scale anticline
Rc ?
Flanks are white SS the base of which includes a zone of pebble congl. grades up into "standard" white SS that weathers brown; SS has pink-orange tints
Jc ?

SEMIQUANTITATIVE 6-STEP SPECTROGRAPHIC ANALYSIS

Report No. 72DS-286 12/21/72 For Charles H. Maxwell Spec. Lab. No Date 12-20-72

Lot No 29-061 Analyst [illegible] Plate No. II-6150 [illegible] Job No. M 176

Si, Al, Fe, Mg, Ca, Na, K, Ti, and P are reported in %; all others in ppm. Results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, etc., but are reported arbitrarily as mid-points of these brackets, 1., 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, etc. The precision of a reported value is approximately plus or minus one bracket at 68%, or two brackets at 95% confidence.

Symbols used are:

- G = Greater than 10%, or greater than value shown
- • = Usual limits of determinations do not apply due to use of dilution techniques
- – = Not looked for
- H = Interference
- N = Not detected, at limit of detection or at value shown
- L = Detected, but below limit of determination or below value shown

1 ppm = .0001%

Field No.	BM65 Apache	BM67 Apache	CO 1 Salado	MR 1 Crane				
Lab No.	D159595	D159596	D159597	D159598				
Fe %	5.	3.	2.	1.5				
Mg %	.15	.1	.1	.02		BM-66,67	- SW SE	SE Sec 6
Ca %	G	G	G	G			T5N	R6W
Ti %	.02	.005	.001	.015				
Mn (ppm)	10000	5000	700	70				
Ag	1.5	1	N	N		CO-1 -	SE NW	SE Sec 5
As	N	N	N	N			T5N	R6W
Au	N	N	N	N		MR-1 -	NW SW	SE Sec 20
B	L	N	N	N			T7N	R 6W
Ba	150	70	15	20				
Be	3	3	3	N				
Bi	N	N	N	N				
Cd	N	N	N	N				
Co	100	30	15	L				
Cr	2	2	1	2				
Cu	20	2	L	2				
La	N	N	N	N				
Mo	15	7	7	30				
Nb	L	L	L	L				
Ni	15	10	L	L				
Pb	N	N	N	N				
Pd								
Pt								
Sb								
Sc								
Sn	N	N	N	N				
Sr	700	700	1500	1000				
Te	N	N	N	N				
U	N							
V	L							
W	N	N	N	N				
Y	L	L	L	N				
Zn	N	N	N	N				
Zr	N	N	N	L				

Approved Ray [illegible] Project Leader

Approved [illegible] Branch of Analytical Laboratories

U.S. GOVERNMENT PRINTING OFFICE: 1968 O-292-274 (633-440)

(REV. 12-1967)

SEMIQUANTITATIVE 6-STEP SPECTROGRAPHIC ANALYSIS (CONTINUED)

Report No. ______________ Job. No. M 176

Field No.	BM66 Apache	BM67 Apache	CO 1 Salado	MR 1 Crane				
Lab No	D159595	D159596	D159597	D159598				
Si %	.5	.5	.15	.5				
Al %	.2	.2	.07	.3				
Na %	.7	.15	.3	.1				
K %	N	N	N	N				
P %	N	N	N	N				
Ce (ppm)	N	N	N	N				
Ga	N	N		N				
Ge	L	L		15				
Hf	N	N		N				
In	N	N		N				
Li	N	N	N	N				
Re								
Ta								
Th								
Tl								
Yb								
Looked for only when La or Ce found								
Pr								
Nd								
Sm								
Eu	N	N	N	N				
Looked for only when Y is found above 50 ppm								
Gd								
Tb								
Dy								
Ho								
Er								
Tm								
Lu								
Looked for only when Pd or Pt found								
Ir						Copy to:	Maxwell	
Os							Heyl	
Rh							Flanagan -	2
Ru							GDS	
Looked for only when requested							Spec. Lab.	
Cs								
Rb								
F								
Hg								

* U. S. GOVERNMENT PRINTING OFFICE : 1968 O - 292-274

	Middle of Summerville equivalent		Bluff-Zuni Ss above BM 43 Highly altered area					
	Js - liesegang bands & alteration	Js - bleached core of "roll"	Purple concretions	orchid pink alteration	white alteration	Travertine in joints & cracks in ss.	Fe vein outside area of travertine	Cgl. at base of Kd. overlying BM-44 Bleached and altered cgl
Field No.	BM-43-A	BM-43-B	BM-44-A	BM-44-B	BM-44-C	BM-44-D	BM-44-E	BM-45-A
Lab No.	D159619	D159620	D159621	D159622	D159623	D159624	D159625	D159626
Fe %	1.	1.5	G	.15	.02	.7	3.	.15
Mg %	.1	.1	.05	.015	.015	.3	.07	.02
Ca %	.07	.3	.15	.05	.1	G	7.	.1
Ti %	.1	.05	.02	.02	.02	.015	.007	.1
Mn (ppm)	70	150	100	1.5	L	30	100	1.5
Ag	N	N	N	N	N	N	N	N
As	N	N	N	N	N	│	N	N
Au	N	N	N	N	N	│	N	N
B	30	L	L	L	L	N	L	L
Ba	300	200	150	50	50	70	300	100
Be	N	N	3	N	N	N	L	N
Bi	N	N	N	│	│	N	N	N
Cd	N	N	N	│	│	N	N	N
Co	L	5	15	N	N	L	20	L
Cr	7	30	3	│	L	5	1.5	3
Cu	10	7	100	3	2	7	10	5
La	L	N	N	N	N	N	N	N
Mo	N	10	N	N	N	N	N	N
Nb	L	L	L	L	L	L	L	L
Ni	L	L	20	L	N	7	20	L
Pb	15	10	100	L	N	10	20	L
Pd	N	N	N	N	│	N	N	N
Pt	N	N	N	│	│	│	N	│
Sb	N	N	N	│	│	│	N	│
Sc	5	L	7	│	│	│	L	│
Sn	N	N	N	N	N	N	N	N
Sr	30	30	50	L	L	300	150	7
Te	N	N	N	N	N	N	N	N
U	N	N	N	N	N	N	N	N
V	15	15	70	L	L	7	10	7
W	N	N	N	N	N	N	N	N
Y	15	10	20	L	N	L	15	L
Zn	N	N	500	N	N	N	300	N
Zr	200	50	50	30	30	30	15	150

Approved Ray Harvey
Project Leader

Approved RE Van Loenen
Branch of Analytical Laboratories

ANALYSIS

Date

Job No. M 183

...ults are to be identified with geometric
...t are reported arbitrarily as mid-points
...eported value is approximately plus or

...nce
...ted, at limit of detection
...e shown
... but below limit of determination
... value shown

	cgl at base of Kd. Red ss above BM45A	Dark red nodules in ss. Above 45B.	SW, NE, N T4N, R... Ironstone layer on contact between Kd and Jz	NW, SW, S Sec 13 T5... Nodule in Rock Point Mem. of Wingate
Field No.	BM-45-B	BM-45-C	BM-46-15	BM-65
Lab No.	D159627	D159628	D159629	D159630
Fe %	.15	1.	3.	1.
Mg. %	.1	.1	.1	.7
Ca %	.07	.07	.07	5.
Ti %	.01	.015	.015	.15
Mn (ppm)	L	2	5	150
Ag	N	N	N	N
As	N	N	N	N
Au	N	N	N	N
B	L	L	L	50
Ba	70	70	100	200
Be	N	N	L	L
Bi	|	|	N	N
Cd	|	|	N	N
Co	N	N	L	15
Cr	L	7	2	50
Cu	1.5	7	30	15
La	N	N	L	L
Mo	N	N	N	N
Nb	L	L	L	L
Ni	N	L	L	20
Pb	N	20	15	15
Pd	|	N	N	N
Pt	|	|	N	N
Sb	|	|	N	N
Sc	|	|	L	7
Sn	N	N	N	N
Sr	7	30	20	150
Te	N	N	N	N
U	N	N	N	N
V	L	15	15	50
W	N	N	N	N
Y	N	L	10	15
Zn	N	N	N	N
Zr	30	70	300	150

Approved ____________________ Project Leader

U.S. GOVERNMENT PRINTING OFFICE: 1969 O-292-274 (852-440)

Approved ____________________ Branch of Analytical Laboratories

SEMIQUANTITATIVE 6-STEP SPECTROGRAPHIC ANALYSIS (CONTINUED)

Report No. ______________ Job. No. M 183

Field No.	BM-43-A	BM-43-B	BM-44-A	BM-44-B	BM-44-C	BM-44-D	BM-44-E	BM-45-A
Lab. No	D159619	D159620	D159621	D159622	D159623	D159624	D159625	D159626
Si %	G	G	G	G	G	10.	G	G
Al %	1.5	1.5	1.5	.7	.7	1.	1.	1.5
Na %	.15	.15	L	L	L	.07	L	L
K %	1.	1.	N	N	N	N	N	N
P %	N	N	N	N	N	N	N	N
Ce (ppm)	N	N	N	N	N	N	N	N
Ga	7	5	—			L	L	L
Ge	N	N	N			N	N	N
Hf								
In								
Li	N	N	N	N	N	N	N	N
Re								
Ta								
Th								
Tl	N	N	N				N	N
Yb	1.5	1	—				1.5	1
Looked for only when La or Ce found								
Pr	N							
Nd								
Sm								
Eu	N	N	N	N	N	N	N	N
Looked for only when Y is found above 50 ppm								
Gd								
Tb								
Dy								
Ho								
Er								
Tm								
Lu								
Looked for only when Pd or Pt found								
Ir								
Os								
Rh								
Ru								
Looked for only when requested								
Cs								
Rb								
F								
Hg								

SEMIQUANTITATIVE 6-STEP SPECTROGRAPHIC ANALYSIS (CONTINUED)

Report No. ______ Job. No. M 183

Field No.	BM-45-B	BM-45-C	BM-46-15	BM-65				
Lab. No	D159627	D159628	D159629	D159630				
Si %	G	G	G	G				
Al %	.5	.7	.7	3.				
Na %	.1	.3	L	.7				
K %	N	N	N	3.				
P %	N	N	N	N				
Ce (ppm)	N	N	N	N				
Ga	L	L	L	10				
Ge	N	N	N	N				
Hf	〃	〃	〃	〃				
In	〃	〃	〃	〃				
Li	N	N	N	N				
Re	〃	〃	〃	〃				
Ta	〃	〃	〃	〃				
Th	〃	〃	〃	〃				
Tl	〃	N	N	N				
Yb	〃	L	L	2				
Looked for only when La or Ce found								
Pr			N	N				
Nd			〃	〃				
Sm			〃	〃				
Eu	N	N	N	N				
Looked for only when Y is found above 50 ppm								
Gd								
Tb								
Dy								
Ho								
Er								
Tm								
Lu								
Looked for only when Pd or Pt found								
Ir						Copy to:	Maxwell	
Os							Flanagan	- 2
Rh							GDS	
Ru							Spec. Lab.	
Looked for only when requested								
Cs								
Rb								
F								
Hg								

☆ U. S. GOVERNMENT PRINTING OFFICE : 1968 O - 292-274