National Uranium Resource Evaluation

**URANIUM POTENTIAL OF SOUTHWESTERN
NEW MEXICO (SOUTHERN HIDALGO COUNTY),
INCLUDING OBSERVATIONS ON CRYSTALLIZATION
HISTORY OF LAVAS AND ASH TUFFS AND
THE RELEASE OF URANIUM FROM THEM.**

FINAL REPORT

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August 1980

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
ASSISTANT SECRETARY FOR RESOURCE APPLICATIONS
GRAND JUNCTION OFFICE, COLORADO

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ABSTRACT

Geological environments present in southwestern New Mexico include thick sequences of sedimentary rock including limestone, conglomerates, sandstone, and shale; igneous intrusions with associated metal deposits; caldera centers, margins, and outflow facies; and basins with marginal faults and thick late Cenozoic sedimentary fillings. Predominant rock types are Paleozoic carbonates, Mesozoic terrigenous rocks and carbonates, and Cenozoic volcanic rocks and basin-filling terrigenous rocks.

Consideration of information available in Preliminary Reconnaissance Reports and in Hydrogeochemical and Stream Sediment Reconnaissance Reports together with 347 new whole rock chemical analyses points to three areas of anomalous uranium abundance in Hidalgo County, New Mexico. The anomalous areas are in the Dog Mountains, in the Apache Hills-Hachita area, and in the Granite Gap-Twelvemile Wells area. In all of these areas, analytical values of uranium content more than two standard deviations above the mean are reported for several kinds of samples. For the Dog Mountains and Apache Hills-Hachita areas, some reports of uranium mineralization are available. High concentrations of uranium are present in 'north' Antelope Pass, the Trail Creek-Burro Pass area and in the Cloverdale-Geronimo Trail area. These areas include ones where an anomalous value of uranium content (>2 standard deviations above the mean for samples of a certain type) is associated with high values of uranium content, 1-2 standard deviations above the mean.

The area has experienced three major periods of igneous activity in Phanerozoic time: one associated with the Laramide cycle of the Late Cretaceous and early Tertiary, mid-Tertiary cycle of silicic volcanism with abundant calderas, and a late Tertiary cycle of mafic volcanism.

Silicic volcanic rocks are the most common exposed rock type in the area, and the most enriched in uranium (range, 0.4-19ppm). The most likely source for any uranium ore-forming solutions lies with this cycle of volcanism. Solutions might have been introduced during volcanism or formed later by groundwater leaching of cooled volcanic rocks.

Our results indicate that groundwater leaching of cooled volcanic rocks was not an effective means of mobilizing uranium in the area. Study of several rhyolite lava flows indicates that they were emplaced in supercooled condition and may have crystallized completely at temperatures well below their liquidus, or they may have warmed as crystallization released latent heat. Statistical comparison of the uranium concentration revealed no differences between vitrophyres and associated felsites. Weathered vitrophyres from lavas were considerably more variable in their uranium content than non-weathered vitrophyres. The Gillespie Tuff, a large welded ash flow tuff was also emplaced at a temperature well below its liquidus and crystallized largely in the supercooled condition. Only some pumice grains were successful at trapping the latent heat released during crystallization. They grew warmer as they converted from magma to crystals. Uranium was removed from the Gillespie during its initial crystallization together with other volatile constituents. These results indicate that neither the lavas nor the ash flows of the region were likely to have been sources of uranium for secondary deposits.

TABLE OF CONTENTS

Abstract	1
Table of Contents	iii
List of Figures	vi
List of Tables	vii
Introduction	1
General Geology	3
Precambrian Rocks	6
Lower Paleozoic Rocks	6
Upper Paleozoic Rocks	8
Mesozoic Rocks	11
Hidalgo Volcanics	14
Laramide Activity	14
Tertiary Volcanic Activity	15
Other Tertiary Events	22
Geological Environments	24
Cauldron-Related environments	24
Older Rocks	26
Late Tertiary Basins	27
Analysis of Pre-Existing Data	29
HSSR Results	29
Available PRR's	32
Favorable Locations	32
Sampling and Analytical Methods	36
Chemical Results	43
Anomalous Samples	48

TABLE OF CONTENTS (CONTINUED)

Uranium Mobility	54
Release of Uranium from Volcanic Rocks	55
Glasses and Supercooled Liquids	57
Crystal Growth	58
Conversion Textures in Volcanic Rocks	59
Lava textures	59
Glass	60
Fibrous textures	60
Granular textures	62
Dendritic textures	64
Snowflake texture	64
Interpretation of Lava Textures	64
Vertical Sequence of Textures	67
Crystallization of Ash Flow Tuffs	68
Glass	70
Fibrous textures	72
Granular textures	76
Microtexture	77
Low temperature textures	77
Vertical Sequence of Textures in Ash Flows	79
Interpretation of Ash Flow Textures	82
Uranium Variation in Some Lava Flows	83
Rhyolite Lavas as Sources of Uranium	96
Uranium Variation in the Gillespie Tuff	96
Ash flows as Sources of Uranium	105
Uranium Mobility in Southwestern New Mexico	106
Recommendations	108

TABLE OF CONTENTS (*Continued*)

References Cited	108
Appendix 1: Sample Code and Numbers	
Appendix 2: Results of Chemical Analyses	
Appendix 3: Cluster Analysis for Entire Data Set	
Appendix 4: Correlation Coefficients for the Entire Data Set	
Appendix 5: Statistical Analysis of Data Subsets	

LIST OF FIGURES

1. Location map	5
2. Radiometric ages determined on rocks for the study area	17
3. Locations of cauldrons in southern Hidalgo County	19
4. Lognormal probability plot of uranium concentration in samples from southwestern New Mexico	44
5. Percentile plots of uranium concentration in samples from southwestern New Mexico	45
6. Locations of samples with high uranium content	50
7. Areas enriched in uranium	52
8. Photomicrographs of textures in rhyolitic lavas	61
9. Photomicrographs of textures in rhyolitic lavas	63
10. Sequence of crystallization textures in rhyolite lavas	69
11. Idealized cross-section of a rhyolite lava flow showing microtextures	71
12. Photomicrographs of textures in the Gillespie Tuff	73
13. Photomicrographs of flabellar textures	75
14. Photomicrographs of ADS textures and flabellar texture	78
15. Vertical and lateral arrangement of microtextures in an idealized welded ash flow tuff	81
16. Results of analysis of variance among the five textural groups within the Gillespie Tuff	100

LIST OF TABLES

1. Geologic maps of southwestern New Mexico	7
2. Caldera Sequences of southern Hidalgo County	20
3. HSSR Results	30
4. Anomalous uranium values in HSSR studies	31
5. Uranium shows in southern Hidalgo County	33
6. Techniques and detection limits of chemical analyses	38
7. Measurements control results: analytical precision	39
8. Summary statistics for chemical analysis	41
9. Genetically defined subsets of the sample set	47
10. Anomalous samples	51
11. U-content of flow rocks	86
12. Tests of similarity of U-content between rhyolite units	87
13. Tests of similarity of U-content between flows of the Rhyolite of Clanton Draw	89
14. Tests of similarity of U-content between textures of the Rhyolite of Clanton Draw	90
15. Comparison of felsite and glass composition for the Rhyolite of Clanton Draw	91
16. Comparison of U-concentration variance between visibly altered and apparently fresh vitrophyrés	94
17. Element concentration in the Gillespie Tuff	97

INTRODUCTION

This report presents the results of an attempt to evaluate the uranium potential of a region in extreme southwestern New Mexico, the southern portion of Hidalgo County. Such reconnaissance efforts are important for two reasons: one is that in the exploration for uranium deposits, the process of actually locating economic grade reserves is tedious and expensive, so it should be concentrated in the places most likely to contain deposits. The other is that an evaluation of the total uranium resources of the United States was mandated by the National Uranium Resource Evaluation Program (NURE), which implies such assessments of potential.

A variety of methods is available for evaluating uranium resources or for assessing favorability of certain regions. Most involve some attempt to detect regions that contain rocks that are anomalously rich in uranium or to find sites where uranium might have accumulated. Methods that try to detect uranium-rich rocks assume that deposits are more likely in areas where uranium is abundant than in areas where it is scarce, a seemingly unassailable assumption if in all environments the uranium is equally mobile at the appropriate time to make deposits, or if the abundance of uranium has the same kind of statistical distribution in all environments. Alternatively, attempts to find geologically favorable sites presume that uranium was available to move into the sites; this is not even so in all favorable segments of major producing districts.

In this project, several conventional methods of evaluation were used. These include consideration of pre-existing shows, study of results of the Hydrogeochemical and Stream Sediment Reconnaissance of the area (Sharp and others, 1978), a small amount of radiometric surveying, and consideration of geological environments (Curtis, 1978; Pilcher, 1979).

Our evaluation is based in part on a set of ideas developed by W. E. Galloway, C. D. Henry and A. W. Walton on the release and mobility of uranium. Walton and others (1980b; in revision) argue, by analogy with source rock evaluations of petroleum potential, that secondary uranium deposits are more likely to be found where likely source rocks have been found to have released uranium for migration and entrapment. In order to evaluate the mobility of uranium during the history of the rocks in the areas that are likely sources of metal, it was necessary to determine the nature of the processes that affected them and how those processes changed the uranium content of the rocks.

Acknowledgments

Edward Erb and Wolfgang E. Elston provided access to unpublished maps of the area that made possible assignment of samples to stratigraphic units. Samples were chemically analysed at Oak Ridge National Laboratory. Ron Helgersen of Union Carbide's staff at Oak Ridge was especially helpful in arranging for these analyses and statistical treatment of the results.

GENERAL GEOLOGY

The area described in this report is the portion of the Douglas 1-by-2 degree quadrangle that is in New Mexico. It lies mostly in Southern Hidalgo County, but extends into Grant County. The Cedar Hills, in Luna County, were not examined. The area includes three major north-south chains of mountains and three north-south valleys between them (Figure 1.).

On the west, the Peloncillo Mountains lie mostly in New Mexico, but cross into Arizona in the southwestern part of the area and northwest of the area. They are bounded on the east by the Animas Valley, in which the town of Animas lies. This valley drains mostly to the north along Animas Creek into a playa lake that lies near Interstate 10, southwest of Lordsburg, New Mexico. The Animas Mountains, which include Animas Peak, the highest point in the study area, 8519 feet, form the central set of ranges of the three. They end just south of Highway 9, the major east-west route near the northern boundary of the area, but the Pyramid Mountains lie on trend with them to the north. The Continental Divide runs down the crest of the Animas Mountains. They do not extend into Mexico, however, but the Sierra San Luis lies on trend with them, south of San Luis Pass. The Whitewater Mountains are a group of hills just east of the Sierra San Luis. The Playas Valley, lies east of the Animas Mountains and drains into Playas Lake, just south of NM Highway 9.

The eastern of the three major mountain groups comprises four separate ranges: The Coyote Hills lie north of Highway 9 and extend north of the study area. The Little Hatchet Mountains extend nearly to the highway and are separated from the Big Hatchet Mountains by a low pass through which NM State Road 81 passes. Finally, the southeastern corner of the area contains the Alamo Heuco and Dog Mountains. This chain of mountains is more disparate geologically than the others, which consist mostly of Tertiary volcanic

eruption complexes. The Coyote Hills, Alamo Hueco and Dog Mountains contain a section of outflow facies sediments and ash flow tuffs. The Big and Little Hachet Mountains expose mostly Precambrian, Paleozoic, and Mesozoic rocks.

Hachita Valley lies in New Mexico east of the Little Hachet Mountains and extends into Mexico east of the Big Hachet Mountains. It is named for the town of Hachita at the intersection of Highway 9 and State Road 81. Two smaller sets of hills lie east of Hachita Valley in the United States: the Apache Hills and Sierra Rica are both east of the Little Hachet Mountains.

Though few faults are depicted along the mountain margins on existing geologic maps, the pattern of these uplifts and valleys is so similar to areas of basin and range country that it is likely that these mountains formed by faulting during regional extension. Truncation of mid-Tertiary structures suggests that the faulting occurred in Miocene or later.

The faults cut a sequence of rocks that ranges in age from Precambrian to Miocene and they may cut rocks as young as Quaternary. These rocks record a long and complex history, including development and filling of sedimentary basins, tectonic activity of both compressive and tensional varieties and a period of intense volcanism. It is this period of volcanism, with accompanying possibilities for mineralization, that led to our effort to assess the uranium of the region.

Figure 1. Location and major geographic textures of the study area.

Figure 1

The rocks exposed in southern Hidalgo County range from Precambrian to Quaternary. Several authors have elucidated the geology and stratigraphy of parts of the area. Efforts by the geologists working for the New Mexico Bureau of Mines and Mineral Resources or the United States Geological Survey, and students at the University of New Mexico have led to almost complete geologic mapping of the area at a scale of 1" - 1 mile or greater (Table 1). Although some of these maps are of a reconnaissance nature or are old enough to predate the current understanding of the stratigraphy of the area and recently developed outlooks on volcanic terrains, they are adequate for location of samples and can be interpreted in terms of more modern ideas.

Precambrian Rocks

Precambrian rocks are exposed at only a few places in Southern Hidalgo County; these places are in the Big Hatchet Mountains in the eastern part of the area and at Granite Gap in the southern part of the Little Hatchet Mountains (Zeller, 1965, 1970; Lasky, 1947). Precambrian rocks are also exposed at Granite Gap in the Peloncillo Mountains, north of the area described in this report (Gillerman, 1958). Rock types include silica-cemented quartzite and coarsely crystalline, porphyritic, medium gray granite. Both are cut by milky veins of quartz. Zeller, (1965, p. 8) cites age determinations on zircons of 605 and 650×10^6 years on rocks from the Little Hatchets.

Lower Paleozoic Rocks

Pre-Devonian rocks crop out in three areas of Southern Hidalgo County: in the Little Hatchet Mountains (Lasky, 1947; Zeller, 1970), in the Big Hatchet Mountains (Zeller, 1965) and in the Northern Animas Mountains (Zeller, 1959; Soule, 1972). Gillerman (1958) describes outcrops in the Peloncillos Mountains, north of the area of this report. The stratigraphic succession includes the Bliss Sandstone of Cambrian age and three Ordovician carbonate units; the

TABLE 1. GEOLOGIC MAPS OF SOUTHWESTERN NEW MEXICO

Area	Boundaries	Scale	Author
1. Southwestern New Mexico	US/Mexico boundary to 106°N to NM/Ariz boundary	1:381,600	Dane and Buchman (1961)
2. Dog Mountains	31°20' to 31°30'N US/Mexico boundary to 108°30'W	1:62,500	Zeller (1958)
3. Southern Animas Mountains	31°20'N to 31°45'N 108°32'W to 108°50'W	1:62,500	Zeller (1962)
4. Walnut Wells Quadrangle	31°30'N to 31°45'N 108°30'W to 108°45'W	1:62,500	Zeller and Alper (1965)
5. Northern Part of Animas Mountains	Not indicated	1:24,000	Soule (1971)
6. Playas Quadrangle	31°45' to 32°00'N 108°30' to 108°45'W	1:62,500	Zeller (1958)
7. Big Hatchet Mountains	31°30' to 31°45'N US/Mexico boundary to 108°30'W	1:62,500	Zeller
8. Little Hatchet Mountains	31°45' to 32°00'N near 108°23' to near 108°32.4'W	1:31,680	Zeller (1970)
9. Coyote Hills			Thurman (1976)
10. Animas Mountains and Southern Peloncillos	US/Mexico boundary to 108°30' to approx 109°8'W	1:62,500	Erb (1979) UNM Dissertation
11. South Central Peloncillos	31°35' to 32°00'N approx 108°52' to approx NM/Ariz boundary	1:62,500	Elston, personal communication (1980)
12. Southern Peloncillos	US/Mexico boundary to 31°45'N approx 108°50' to NM/Ariz boundary	1:62,500	Wrucke and Bromfield (1961)

El Paso Limestone, the Montoya Dolomite and the Fusselman Dolomite. These units thicken generally to the east or south, totalling about 400 m in the Big Hatchet Mountains (Zeller, 1965). The Montoya and Fusselman Dolomites have been progressively eroded before deposition of Devonian rocks that overlap them from the east. The Fusselman extends only a short distance into eastern Hidalgo County and the Montoya is entirely eroded west of a line in extreme southeastern Arizona (Kottlowski, 1963).

Upper Paleozoic Rocks

Devonian and Mississippian rocks crop out in much the same areas as do the earlier Paleozoic ones: in the Big Hatchet Mountains and the northern Animas Mountains and in the Peloncillo Mountains outside the bounds of this study area (Zeller, 1965; Lasky, 1947; Gillerman, 1958; Soule, 1972). They generally thicken toward the south or south southwest, reaching values that must approach 500 m, if the isopach maps of Kottlowski (1963) are correct. Zeller (1965, p. 23) describes the Devonian Percha Shale in the Big Hatchet Mountains as consisting mostly of gray, calcareous shale or silty shale with a basal unit that includes some sandstone and interbeds of black shale and gray shale. The overlying Mississippian System includes the Escabrosa Limestone and the Paradise Formation. Zeller (1965, p. 24-30) describes the Escabrosa Limestone as consisting of three parts: a lower crinoidal limestone that grades downward into the Percha shale; a middle member, greater than 100 m thick, that contains alternating thin beds of limestone, shaly limestone and chert; and a somewhat thicker upper member of nearly white lime grainstone containing abundant crinoid ossicles. The Paradise Formation consists mostly of lime packstones and grainstones composed of crinoid fragments and oolites. Its upper part includes some quartz sandstones that contain plant fossils. The Paradise totals about 85 m in the Big Hatchet Mountains.

Pennsylvanian and Permian strata in Hidalgo County unconformably overlie Mississippian ones and are noticeably thicker in the study area than they are to the north (Zeller, 1965, p. 30, 32; Kottlowski, 1963, p. 39-42). This reflects shifts in areas of rapid subsidence so that most of Hidalgo County lay in the Pedregosa Basin, where more than 800 m of sediment accumulated during the Pennsylvanian. During the earliest Permian, greater thickness of rock accumulated in central Hidalgo County and northeastern Cochise County, Arizona than formed elsewhere in the vicinity. Six hundred to 750 meters of Wolfcamp rocks are present in southern Hidalgo County, Leonard rocks thicken to the SSW from their pinchout against the Burro Uplift in northern Hidalgo and southern Grant counties to a total of 800 m in southern Hidalgo county. Outcrops of Pennsylvanian and Permian rocks are in the Big Hatchet Mountains (Zeller, 1965), the Little Hatchet Mountains (Zeller, 1970; Lasky, 1947), the northern Animas Mountains (Zeller, 1959), in the crest of the Winkler Anticline in the central Animas Mountains (Zeller and Alper, 1965) and at the 'north' Antelope Pass through the Peloncillo Mountains. These rocks are overlain by Tertiary volcanic rocks in places or are juxtaposed against them along cauldron margin faults and consequently have served as hosts for formation of base metal and fluorite deposits. The potential of these units to be hosts for uranium mineralization will be evaluated later.

The Pennsylvanian-Permian sequence is assigned to the Naco Group, which Zeller (1965) divided into six formations, from bottom to top, the Horquilla Limestone, the Earp Formation, the Colina Limestone, the Epitath Dolomite, The Sherrer Fromation, and the Concha Limestone. The Earp is separated from the Horquilla by a local disconformity. Both the lower and upper boundaries of the Naco Group are erosional unconformities.

The Horquilla Formation includes strata of Pennsylvanian through early Permian age and may include some late Mississippian rock. The lower part of the Horquilla is thin- to medium-bedded, gray, bioclastic limestone, including oolites; crinoid, fusilinid, or other fossil grainstones; some black chert; but little or no sandstone, shale, or dolomite (Zeller, 1965, p. 33). Both Zeller (1965) and Gillerman (1958) mention the characteristic pink tinge to the otherwise gray lower Horquilla.

The facies of the upper Horquilla Formation are more complex because of development of reefs along a 5 km-wide belt running NW-SE through the Big Hatchet Mountains. Northeast of this belt is a shelf area, in which medium bedded limestones predominate. In the basin area southwest of the reef belt, especially in the Wolfcamp-age rocks of the Horquilla, dark gray and black shale are present. Reefs are well exposed on Big Hatchet Peak, including not only Wolfcamp beds, but Des Moines, Missouri, and Virgil beds as well. Reef sequences consist of unbedded masses of limestone up to 30 m thick, mostly recrystallized but presenting evidence of primary bioclastic texture on weathered surfaces (Zeller, 1965).

The overlying part of the Naco Group is entirely Permian and is described well by Zeller (1965, p. 45-54). The Earp Formation consists of thick beds of siltstone alternating with thicker beds of white claystone. The Colina Limestone is dark gray to black on fresh surfaces. It characteristically contains a few fossils, but is mostly dark micrite. It is gradational with both the underlying Earp Formation and the overlying Epitath Dolomite. The Epitath Dolomite consists of gray, microcrystalline light to medium gray dolomite in thick beds. It includes some mudrocks and dolomite in the lower part. In the basin area southwest of the Big Hatchet Mountains, the lower Epitath contains anhydrite interbedded with dolomite. The Scherrer Formation consists of sandy

limestone or calcareous sandstone. The Concha Limestone is a cherty, light to medium gray, fine to coarse limestone. Chert nodules make up 30% of many beds and as much as 65% of some others.

Mesozoic Rocks

Lower Cretaceous rocks are widely exposed in the eastern of the three north-south tiers of mountains in Southern Hidalgo County (Zeller, 1965, 1958, 1970; Thorman, 1977). They also crop out in the Northern Animas Mountains (Soule, 1972), and along the east side of the Central Animas Mountains, especially in the area of the Winkler Anticline (Zeller and Alper, 1965; Erb, personal communication, 1979). Outcrops are also present in the Apache Hills in the extreme eastern part of the area and near 'north' Antelope Pass through the Peloncillo Mountains in the far northwestern part (Peterson, 1976, W. Elston, personal communication, 1980). Wherever their contact with the underlying Permian rocks is exposed, it is an erosional unconformity (Zeller, 1965; Zeller and Alper, 1965; Gillerman, 1958). The rock range up to immense thicknesses (2000-4000 m, Kottlowski, 1963) and include predominantly terrigenous clastics in contrast to the carbonates of the Paleozoic beds. The uppermost unit includes various intrusive and extrusive igneous rocks of intermediate to silicic composition. Lasky (1947) described the sequence in the Little Hatchet Mountains, and Zeller (1965) described that in the Big Hatchets and in Mojado Pass south of them. Outside the study area, Gillerman (1958) described the sequence in Peloncillo Mountains and Lasky (1938) and Flege (1959) described that in the Pyramid Mountains and the Lordsburg Quadrangle, respectively. In the Little Hatchet Mountains and Coyote Hills, in the Alamo Hueco Mountains, and in the Animas Mountains, the early Cretaceous sequence is overlain by volcanic rocks or basal Tertiary limestone conglomerates. In these places, the chances for uranium mineralization

were excellent if uranium has been effectively mobilized from overlying volcanic rocks.

Zeller (1965) describes the Lower Cretaceous rocks that crop out in Mojado Pass south of the Big Hatchet Mountains and in Sierra Rica. He assigns Albian or Aptian ages to most of them, but the lower part may be pre-Aptian. These rocks are representative of the lower part of the Cretaceous section in the eastern tier of mountains. Zeller (1965) recognizes three units, from bottom to top, the Hell-to-Finish Formation, the U-Bar Formation, and the Mojado Formation.

The Hell-to-Finish Formation consists of limestone conglomerate and sandstone, shale, mudstone, and siltstone, nearly all stained red. Some andesite flows occur locally in the section. The Hell-to-Finish Formation was deposited over an irregular surface eroded on Paleozoic limestone and consequently changes thickness considerably from place to place. The maximum thickness is about 380 m (Zeller, 1965).

The U-Bar Formation is a resistant limestone, which forms a synclinal ridge in Mojado Pass. The U-Bar consists mostly of alternating beds of limestone and shale. Its lower part includes fine-grained, sparsely fossiliferous limestone, oolite, and some terrigenous clastic beds. A sequence of limestone beds containing abundant fossil oysters and some interbedded shales, sandstone, and gypsum overlies this. The oyster-rich interval includes some beds of massive calcarenite. A limestone-shale member overlies the oyster-rich member. It consists of dense, fossiliferous limestone beds 0.3-5 m thick separated by fissile shale or claystone beds about 2 m thick. The next unit is the reef limestone member, which makes up the top of the U-Bar ridge. It is 30-160 m thick and consists of light gray bioclastic, unbedded limestone that contains fossils of rudists, colonial corals, and gastropods. Thinner bedded limestone

above the reef limestone bed forms the top of the U-Bar Formation. This interval ranges from 1 to 75 m thick and consists of gray, thick bedded fossiliferous limestone with some silicified fossils. Total thickness of the U-Bar Formation is in excess of 1000 m (Zeller, 1965, p. 59-66).

The Mojado Formation lies conformably above the U-Bar Formation. The contact between the two formations lies in a zone of interbedding of limestone and sandstone beds. Zeller (1965, p. 67-68) recognizes two members, a lower nonfossiliferous sandstone and shale member that is about 1200 m thick and an upper unit, 330 m thick that contains thin sandy limestone beds in addition to the purely terrigenous rocks beneath (Zeller, 1965, p. 67-73).

Zeller (1970) has attempted correlation of this sequence with the thicker section in the Little Hatchet Mountains originally described by Lasky (1947). Zeller found that about 1800 m of Hell-to-Finish Formation and 1200 m of U-Bar Formation occur there. The U-Bar is intruded by igneous rocks and serves as a host for ore deposits in some mines in the Little Hatchets. Zeller (1965) also recognized the Mojado Formation in the Little Hatchet Mountains where it is in excess of 1500 m thick and similar to its lithology in the Mojado Pass area except for beds of conglomerate.

The unconformity above the Mojado in the Little Hatchets is overlain by the Ringbone Formation (Zeller, 1970; Lasky, 1947), which is of late Cretaceous or early Tertiary Age. The Ringbone Formation consists of limestone- pebble conglomerates, arkosic sandstones, and gray to black bituminous shale. Its upper third contains flows of basalt and andesite porphyry, shale and conglomerate.

In the Peloncillo Mountains, Gillerman (1958) describes a lower Cretaceous sequence of limestone, shale, and sandstone up to 750 m thick. Zeller (1965) suggests that this sequence is likely to be the same one he describes south of the Big Hatchet Mountains.

Hidalgo Volcanics

The Hidalgo Volcanics is a sequence of andesite and basalt that crop out in the northern part of the Little Hatchet Mountains. Lasky (1947) reports an exposed thickness of greater than 1500 m, but disconformities occur at both the top and bottom of the formation and the thickness varies from place to place. Zeller (1970) reasons that these beds are early Tertiary because of fossil wood collected from a sedimentary bed within it. Marvin and others (1978) report a fission track age of 69.6 ± 3.2 m.y. on zircon collected from Hidalgo Volcanics in the Little Hatchet Mountains.

Superficially similar rocks crop out in the Pyramid Mountains and the northern Peloncillo Mountains, just north of the study area. Gillerman (1958) describes a sequence, up to 1800 m thick, of basalt, andesite, and volcanic sediment in the Peloncillo Mountains. Flege (1959) mentions an early Tertiary sequence in the Pyramid Mountains, up to 1000 feet of andesite flows and breccias. Marvin and others (1978) report ages of 52.7 to 67.3 for Hidalgo Volcanics in the Pyramid Mountains.

Laramide Activity

Late Mesozoic orogenic activity began in southwestern New Mexico in Early Cretaceous time, as indicated by conglomerates in the Mojado Formation in the Little Hatchet Mountains (Zeller, 1970). Erosion before deposition of the Ringbone Formation has removed some 300 m of Cretaceous rock in places. Lava flows and intrusions in several areas mentioned above date from latest Cretaceous and early Tertiary. Major thrust faulting has occurred in the Little and Big Hatchet Mountains and in the northern Animas Mountains. Soule (1972) working in the northern Animas Mountains, has determined that the Ringbone Formation was deposited during deformation of that area, and Zeller (1970) reports that the thrust faults also cut the Hidalgo

Volcanics in the northern part of the Little Hatchets, suggesting that intense deformation continued into the earliest Tertiary. None of these units, however, is well dated and the exact duration of tectonic activity is unknown.

In the northern Animas Mountains, in the Little Hatchets and in Sierra Rica, thrusting emplaced the southern or southwestern blocks over the northeastern. In the Big Hatchet Mountains, the motion was in the opposite direction; blocks from the northeast now overlies those in the southwest with faults that dip northeast (Zeller, 1965, 1970; Soule, 1972). One is left with the picture of a rising, tectonically active welt running WNW-ESE between Sierra Rica and the Big Hatchet Mountains, through Granite Gap in the Little Hatchet Mountains and at least as far west as the Animas Mountains. Northeast of this welt, a deep, but narrow basin received a thick accumulation of sediment and volcanic material, the Ringbone Formation and the Hidalgo Volcanics. Formation of this Late Cretaceous-early Tertiary sequence was interrupted by intervals of erosion and occurred simultaneously with emplacement of thrusts that are now attributed to the Laramide Orogeny.

Tertiary Volcanic Activity

Three periods of volcanic and intrusive activity have occurred in southern Hidalgo County, though the rocks that record one of the periods are not widely exposed there. The first period, also mentioned above, occurred in the Paleocene and early Eocene, and led to intrusion of a number of granodiorites, especially in the Lordsburg area, and extrusion of basalts and andesites and related rhyolite intrusions (Flege, 1959). Lasky (1947) applied the name Hidalgo Volcanics to rocks of similar age in the Little Hatchet Mountains and thought them to be Lower Cretaceous. Subsequent potassium-argon and fission track ages are much younger, 52 to 70 million years (Figure 2; Marvin and others, 1978; Deal and others, 1978). These

ages are latest Cretaceous, Paleocene, or Eocene. Because these rocks are involved in thrusting in the Little Hatchet Mountains, they are part of the Laramide episode of tectonics.

These rocks are generally of intermediate composition. Rogers and Adams (1969) indicate that intermediate volcanic rocks and plutons are not nearly as rich in uranium as are more silicic derivatives. The few analyses we have on these rocks indicates they do not contain as much uranium as the later Tertiary rhyolites. We consider the Hidalgo Volcanics unlikely sources of uranium.

The last period of volcanism is indicated by four ages of less than 7 m.y. (Figure 2) and these are representative of widespread volcanic activity that occurred after the period of basin and range faulting. Similar ages were measured on volcanic rocks of similar composition in the San Bernardino Valley in Arizona, just west of the Peloncillo Mountains. All of these rocks are of mafic composition. Rogers and Adams (1969) indicate that such mafic rocks are not normally enriched in uranium.

The major period of silicic volcanism appears to have extended from about 38 million years ago until about 22 million years, with a break in activity from about 29.4 until 27.7, and major peaks in the periods from 30 to 34 million and 26 to 27.7 million years before present (Fig. 2). These conclusions are based on 46 age determinations published by Marvin and others (1978) and Deal and others (1978). Large parts of southern Hidalgo

Figure 2. Potassium - argon and fission track age determinations on rocks from locations in and near the study area. Filled squares: ages reported by Marvin and others 1978: twenty-seven samples from the Volcanics of Pothook (Coyote Hills), Pyramid Mountains, northern Peloncillo Mountains and vicinity. These exclude Tertiary ages on Precambrian rocks. Open squares: twenty-two ages reported by Deal and others from the study area.

Figure 2

County and several major stratigraphic units are unrepresented in those studies. Many of the ages published by Marvin and others (1978) apply to the Northern Peloncillo Mountains, an area outside the study area but closely related to it in terms of geologic history. Further work may extend the older peak backwards in time and perhaps fill the break at 29.4 to 27.7 m.y., especially if earlier parts of the younger caldera sequences are dated.

The volcanic history of the area is dominated by this mid-Tertiary cycle of activity, a period that was distinctly characterized by the activity of large cauldron complexes and extensive explosive activity, leading to large ash flow tuffs, major rhyolite flows, megabreccias, and some intermediate lavas. The relations of these units make little sense until they are broken into sequences that can be related to the activity of individual calderas. This is precisely the approach that has been used by the group from the University of New Mexico (Deal and others, 1978) and has enabled the development of a general geologic history for the Tertiary volcanic cycle of the region.

Individual calderas leave a record that consists of a major welded ash flow tuff, and closely associated breccias or megabreccias that represent deposits of landslides or mass flows that moved down the walls of the cauldron after it formed. These are followed by extrusive rhyolites and tuffs that welled up along the ring fractures of the caldera. Some caldera sequences are intruded by stocks that may represent resurgent pulses of lavas (Deal and others, 1978) and may include moat deposits that formed around the resurgent domes within the caldera.

Deal and others (1978) recognize eight such caldera sequences in the study area (Table 2, Figure 3). The Tullous, Animas Peak, and Cowboy Rim

Figure 3. Location of cauldrons in Southern Hidalgo County. Boundaries after Deal and others (1978): 1) Tullous, 2) Juniper, 3) Animas Peak, 4) Cowboy Rim, 5) San Luis, 6) Geronimo Train, 7) Rodeo and 8) Apache Cauldrons.

Figure 3

TABLE 2. CALDERA SEQUENCE OF SOUTHERN HIDALGO COUNTY (AFTER DEAL AND OTHERS, 1978)

Name & other references	Major Ash Flow Tuff	Megabreccias & Talus Breccias	Lava Flows	Moat Filling	Intrusives	Ages
Tullous. Zeller and Alper (1965)	Bluff Creek Formation			Bluff Creek Formation		
Juniper	Oak Creek Formation	Bennett Creek Breccia	In Basin Creek Tuff		Walnut Wells Monzonite Animas Quartz Monzonite	34.5+0.8 34.5+0.8 35.2+0.8
Animas Peak	Tuff of Black Bill Canyon					
Cowboy Rim	Gillespie Tuff		Center Peak Latite			32.9+0.7
San Luis	Park Tuff		Rhyolite of the Packers Trail			23.0+0.5
Geronimo Trail	Tuff of Guadalupe Canyon	Breccia of Hog Canyon	Latite of Outlaw Canyon Rhyolite of Clanton Draw			24.2+0.5
Rodeo	Tuff of Black Mountain	Breccia of Hill Ranch	Porphyritic Latite of Owl Canyon Rhyolite of unit of Antelope Pass	Unit of Antelope Pass		26.4+0.7 26.9+0.8 >26 m.y.
Apache (Chapo Formation). Peterson (1976)	Lower part of upper quartz latite		Lower quartz latite Upper part of upper quartz latite	Womel's Pond	Quartz Monzonite	30.6+0.1

Cauldrons intersect and overlies each other in the southern Animas Mountains, making up the bulk of the range from Animas Peak and the Winkler Anticline south to the San Luis Pass. The Tullous Cauldron was the source of the Bluff Creek Formation, a complex of ash flow tuffs, volcanic sediments and some lavas. The Tuff of Black Bill Canyon was the product of the poorly preserved Animas Peak Cauldron. The Cowboy Rim Cauldron is the youngest. It is filled with Gillespie Tuff and probably is the source of that unit (Deal and others, 1978; E. Erb, personal communication, 1979). Just to the north of these three cauldrons lies the Juniper Cauldron. It was the source of the Oak Creek Tuff and is the site of emplacement of the Animas and Walnut Stocks. It was active between the time the Tullous and the Animas Peak Cauldrons were active. The San Luis Cauldron lies south of the Cowboy Rim Cauldron, extending from just south of San Luis Pass an unknown distance into Mexico. This cauldron is thought to be the source of the Park Tuff, which overlies the Gillespie Tuff.

In the Peloncillo Mountains, two cauldrons have been recognized: the Geronimo Trail Cauldron and the Rodeo Cauldron. The absolute ages of these structures is not known, but the Geronimo Trail Cauldron appears to be younger. The Rodeo Cauldron extends from the vicinity of the Geronimo Trail north to 'north' Antelope Pass and from the central part of the Animas Valley to the Chiricahua Mountains (Deal and others, 1978). It is the source of the Tuff of Black Mountain, is the source of the Tuff of Guadalupe Springs (Deal and others, 1978; E. Erb, oral communication, 1979).

Cauldrons are also present in two other areas within or immediately adjacent to the study area: the Pyramid Mountains and the Apache Hills. The cauldron in the Apache Hills has been studied by Peterson (1976) and Deal and others (1978) give ages of 30.7 ± 1.2 m.y. on a quartz latite flow from the base of the section there and about 27 million years on two intrusives.

Material from this center is unknown elsewhere in the area. The Muir cauldron makes up most of the southern part of the Pyramid Mountains. Ages of 35-37 million years on the Pyramid Mountains Volcanic Complex indicate that activity in this area preceeded that in the Animas Mountains to the south (Deal and others, 1978).

Other Tertiary Events

In addition to the volcanic activity, other events occurred in southern Hidalgo County during the Tertiary. The post-Laramide succession in certain places begins with a sequence of conglomerates and sandstones. In the eastern Animas Mountains, Zeller and Alper (1965) called this series of gravels, which ranges from 0-150 m thick, the Timberlake Fanglomerate. It consists of clasts of limestone set in a red matrix. Because this unit overlies Cretaceous rocks with sharp angular unconformity, Zeller and Alper (1965) assign an Tertiary age to it. Evidence that the Laramide deformation extended into the earliest Tertiary, as cited above, suggest an Eocene or Oligocene age for this unit. The huge blocks (up to 60 m) that Zeller and Alper (1965) map as part of the unit suggest that parts of its outcrop area may actually be megabreccias associated with the cauldron margins that run through that area. But certain parts of it clearly are sedimentary rocks laid down before the main episode of volcanism.

Zeller (1958) includes a unit he calls a limestone fanglomerate at the base of the section in the Alamo Hueco Mountains. Deal and others (1978) describe a similar unit at the base of the section in 'north' Antelope Pass, at the margin of the Rodeo Cauldron. The facile correlation of these units with the Timberlake Fanglomerate of the east central Animas Mountains is supported mainly by a similarity of position in association with cauldron sequences rather than by positive evidence of continuity or similar age.

The major topographic character of the southern part of Hidalgo County was set by a period of Basin and Range faulting that uplifted the north-south mountain ranges and left the valleys between them at structurally and topographically lower levels. This faulting clearly postdates formation of cauldrons of the mid-Tertiary volcanic episode, but pre-dates formation of late Tertiary volcanic rocks, indicating only that major activity took place during the period from 22 to 7 million years.

GEOLOGICAL ENVIRONMENTS

Several distinct kinds of geological environments exist in Southern Hidalgo County. The favorability of each for uranium is different because rocks of different character and history occur in each. Uranium deposits in all of these areas is likely to be a byproduct of mid-Tertiary volcanic activity, because most pre-existing rocks are of types that are not likely to contain abundant uranium that could be concentrated into secondary deposits. Ore deposits associated with older volcanic activity contain vanadium, but not uranium, in addition to base metals (Lasky, 1947; Zeller, 1970; Hilpert, 1965). Uranium can either be provided by hydrothermal activity related to mid-Tertiary caldera activity or by leaching of uranium from cooled volcanic rocks and volcanic sediments.

Cauldron-Related Environments

The cauldrons of the study area include some resurgent ones and some that have not been demonstrated to have resurgence. Each of them, however, is filled with a major ash flow sheet and products later of eruptions within the caldera and in adjacent areas. Some, especially the Juniper Cauldron, include a series of stocks. Most of the mineralization of any kind that can be expected in cauldron center environments would be associated with the margins of such intrusive bodies. In the Juniper cauldron, such activity has promoted mild argillic alteration of adjacent ash flows, but no mineralization is evident in volcanic rocks. Resurgent domes do not expose subjacent, pre-cauldron rocks and, consequently, their potential for mineralization is unknown.

Many cauldron margins juxtapose rocks of greatly different chemical composition, limestone, sandstone and various volcanic rocks, for example,

and the marginal fractures are major conduits of fluid migration. The margins of some cauldrons have had history that includes several stages of rejuvenation or reoccupation by later cauldron activity. One area in particular, in the vicinity of the Winkler Anticline, in the east-central Animas Mountains, displays extensive silicification, argillic alteration and some propylization.

Peterson (1976) describes the Apache No. 2 Mining District as occurring in a resurgent cauldron in the Apache Hills. The deposits there occur as skarn deposits in limestone along intrusive contacts and in veins, perhaps related to circulation of hot waters from a cooling magma. This area has a history of production of lead, copper, silver and some bismuth, but is inactive today. Hilpert (1965) reports an occurrence of uranium in a silicified zone, perhaps a vein, in Cretaceous limestone at the Napine Mine, along the southwest face of the Apache Hills in section 25, T29S, R14W, but outside the area Peterson (1976) mapped.

Most of the mining districts in the area lie near cauldron margins. The Gillespie district on the Winkler Anticline lies in the area interpreted by Erb (personal communication, 1979) to be the margin of the Tullous, Juniper, and Cowboy Rim cauldrons. The mines in the east entrance to 'north' Antelope Pass lie near the boundary of the Rodeo Cauldron as indicated by Deal and others (1978). Exceptions to this exist, but the cauldron margin environment certainly is one of the most likely for mineralization because of well developed conduits for fluid migration and diversity of rock types.

Some of the late stage extrusive rocks of the cauldron environment do contain some evidence of low temperature mobility of uranium. The Rhyolite of Clanton Draw, which occurs in the Geronimo Trail Cauldron has a high overall uranium concentration that is quite variable in rocks containing low temperature minerals like opal and chalcedony. In addition, sedimentary

or pyroclastic rocks associated with this unit have very high concentrations of uranium in places, up to 54 ppm. This situation seems to represent the greater chance for local uranium mobility and concentration that occurs in uranium-rich areas, rather than any systematic enrichment that would lead to ore formation.

Outflow facies of the abundant cauldrons make up only a small percentage of the area, restricted today primarily to the Coyote Hills and the Alamo Hueco-Dog Mountains areas. Rocks exposed in these areas are interbedded sequences of ash flow tuffs, and air fall tuffs, and volcanic sediments. Ash flow tuffs are poorly to densely welded, and crystallized parts of them are depleted in uranium with respect to closely associated glasses. Too few samples of air fall tuffs were collected to establish whether they are depleted with respect to uranium. Volcanic sediments, however, do show a noticable concentration of uranium in the outflow facies in the Dog Mountains, according to PRR reports, HSSR water samples, and rock samples.

Older Rocks

The sedimentary rocks that underlie the mid-Tertiary volcanic sequence contain distinctly less uranium than the volcanic rocks do. This is to be expected because such rocks normally do not contain abundant uranium (Rogers and Adams, 1969). Consequently, these rocks should be evaluated as potential hosts for deposits, not sources for the uranium.

Sandstones in the sequence are concentrated in the Cretaceous and early Tertiary parts of the section. The Cretaceous units have been extensively folded and thrust faulted and consequently have probably suffered considerable loss of porosity. Furthermore, they do not directly underlie the volcanic section in most of the area. It is unlikely that they are extensively mineralized.

The limestones of the Cretaceous and late Paleozoic might be hosts for vein type deposits. As was pointed out previously, the limestone are hosts of a variety of mineral deposits in cauldron margin environments. They commonly underlie much of the volcanic section where its contacts with older rocks are exposed. In such environments, uranium content of the limestones is low (a few ppm) and radiometric traverses indicate that the limestone on the average contains far less uranium than the overlying volcanic rocks.

A sequence of gravels and sandstones lies at the base of the mid Tertiary volcanic section in much of the area. This includes the Timberlake Conglomerate of the eastern Animas Mountain and equivalent units in the Alamo Hueco Mountains and at 'north' Antelope Pass. These units are very porous and permeable and some, at least, are well located near areas where uranium has been available. In such situations if uranium is mobile, it could be expected to move through these rocks in groundwater. Outcrops of these rocks displayed little in the way of organic matter and their potential as trapping units is not obvious.

The Little Hatchet Mountains are the site of a number of small mining districts where various base metals occur in veins in limestone beds adjacent to intrusive rocks of the Cretaceous-Tertiary volcanic suite. These deposits, described in Lasky (1947) and Zeller (1970), do not contain any reported uranium mineralization.

Late Tertiary Basins

After cessation of the major period of Tertiary volcanism, Basin-and-Range faulting created a series of basins that extend roughly north - south through southern Hidalgo County. Some of these basins currently are closed basins of internal drainage, and large playas exist southwest of Lordsburg in the Animas Valley and near Playas, in the valley of the same name between

the northern Animas Mountains and the Little Hatchet Mountains. Everywhere, the basins contain a late Tertiary fill of unknown thickness.

These basins, which act as closed systems for water and sediment, probably act as closed basins for uranium as well, if it was released into ground waters or streamwater. The possibility of uranium deposits in these Tertiary basins depends upon two factors. First it requires that uranium have been mobilized from a source, by either partial or complete depletion of the original uranium content of the source, and second it requires that the uranium be concentrated in some trap, rather than disseminated throughout the basin fill. As described below, our investigations do not demonstrate any large scale mobilization of uranium by low temperature depletion of likely sources. Lost uranium likely has been disseminated into the atmosphere during crystallization of ash flows and tuffs. On the other hand, our investigations would not detect minor depletion of large amounts of rocks. Because of the great amount of uncertainty about these basin deposits, it is appropriate to call attention to the fact that they might contain significant amounts of uranium. The uranium may be disseminated throughout the valley fill, or may be concentrated along valley margin faults.

ANALYSIS OF PRE-EXISTING DATA

HSSR Results

Sharp and others (1978) show areas in the Douglas Quadrangle where anomalous uranium concentrations appear in samples from various water sources and in stream sediments Table 3. For neither one is the coverage of the area complete and uniform, instead, it concentrates in the valleys. Of the parts of the area that are generally mountainous, only the Alamo Hueco and Dog Mountains are sampled at densities comparable to those of the valleys.

For all subsets of the data that had more than 20 analyses, the criterion for anomalous concentration of uranium was a value greater than the mean by two standard deviations. Subsets with more than 20 analyses, included water samples from wells or artificial ponds and sediment samples from dry streams and both wet and dry artificial ponds. Too few samples of water or sediment from springs or flowing streams were available to use this criterion. But one of spring had such a high value of uranium (54.10 ppm) in its sediment that it can be also considered anomalous. Sample sites identified by this procedure are indicated in Table 4.

Several of the anomalous values are isolated samples separated from other anomalous or high values by some tens of kilometers. Such values are difficult to interpret and would require confirmation by shows of uranium or anomalous concentrations of uranium in samples collected for the present study in order to be counted as indicating favorable sites for uranium concentration.

The readings that were accepted as indicating favorable areas are those that were confirmed by adjacent high values or anomalous values indicated by other techniques. If two or more anomalous dry stream sediment samples occurred near each other, if adjacent sediment and water samples, or if a

TABLE 3 . HSSR RESULTS (SHARP AND OTHERS, 1978)

Sample type	n	Mean	Standard Deviation	Number of samples 2 S.D. above mean
Water Samples				
All waters	181	3.85ppb	6.30ppb	7
Spring	7	0.82	0.97	*
Stream	7	0.43	0.30	*
Well	124	4.73	6.93	4
Artificial pond	43	2.38	4.55	4
Sediment Samples				
All sediment	237	4.08ppm	3.63	2
Spring	6	11.48	20.90	*
Flowing stream	7	5.29	1.19	*
Dry stream	170	4.01	1.74	5
Wet artificial pond	33	3.64	0.97	1
Dry artificial pond	21	2.82	0.53	0

* too few samples.

TABLE 4 . ANOMALOUS URANIUM VALUES FROM NEW MEXICO PORTION OF THE DOUGLAS 1° x 2° QUADRANGLE. (FRAN, SHARP, AND OTHERS, 1978, APPENDIX B-I AND C-I)

Latitude	Longitude	General area	Sample type	Value
31.8167° N	109.0069 W	E. of Rodeo	Water, Artifical Pond	12.20ppb
31.9322	108.9175	North Antelope Pass	Water, Well	44.50ppb
31.9064	108.3183	Hachita	Water, Well	26.20ppb
31.9292	108.6511	Continentad Divide, Playas Valley	Water, Well	40.90ppb
31.7750	108.4597	Granite Pass	Water, Well	25.30ppb
31.8133	108.1300	NE of Sierra Rica	Water, Artifical Pond	18.90ppb
31.8139	108.1556	NE of Sierra Rica	Water, Artifical Pond	16.70ppb
31.8617	108.1589	NE of Sierra Rica	Water, Artifical Pond	11.10ppb
31.3628	108.4378	W. of Dog Mountains	Sediment, Dry stream	8.40ppm
31.3503	108.3236	Dog Mountains	Sediment, Spring	54.10ppm
31.4856	108.4086	N. Alamo Hueco Mountains	Sediment, Dry Stream	7.80ppm
31.7608	108.8861	Mud Springs, South Central Peloncillos	Sediment, Artifical Pond	5.60ppm
31.4100	108.9392	Cloverdale Southern Peloncillos	Sediment, Dry stream	16.60ppm
31.7664	108.3878	Twelvemile Wells	Sediment, Dry stream	10.60ppm
31.7756	108.4411	Granite Pass	Sediment, Dry stream	7.70

single anomalous sample lay at the center of a cluster of high values (generally one to two standard deviation above the mean), the area in which they lay is indicated as one of the areas most likely to contain uranium deposits.

Available PRR's

Several locations in southern Hidalgo county have been reported as possible sites of uranium mineralization. The greater number of them have been described in Preliminary Reconnaissance Reports made by the Atomic Energy Commission in the 1950's. These include an opal vein in the Dog Mountains Quad and an area of silicified limestone south of the Apache Hills, which actually produced a small amount of ore. The other reports seem to be investigations of areas that had reported mining activity, except for the area in section 9 of T29S, R21W, where a small uranium anomaly occurred in a volcanic breccia. All of the shows of uranium are of secondary types that could have formed by low temperature processes, with the sole possible exception of the silicified zone in the limestone in the area south of the Apache Hills. This is an area of vein-type mineralization on the margin of the Apache Cauldron (Peterson, 1978; Deal and others, 1978). Reports of uranium mineralization are summarized in Table 5.

Favorable Locations

Several areas in the New Mexico portion of the Douglas Quadrangle give indications of being more likely sites for uranium occurrence on the basis of data available before our study began. The probability of finding a deposit in these is unknown and likely to be small, but anomalous uranium in sediment samples and natural waters, and known shows of mineralization point to several regions (Table 4, 5).

The first is in the southern part of Dog Mountain Quadrangle, where anomalous spring sediments at the Dog Spring, uraniferous opal veins about

TABLE 5 URANIUM SHOWS IN SOUTHERN HIDALGO COUNTY, NEW MEXICO

Preliminary Reconnaissance Report File Number	Location			Indications of U-mineralization	Type of Deposit	Property	Production
	Sect.	T.	R.				
DEB-RRA-1437	15	34S	15W	Anomaly up to 30X background on Geiger counter	Opal vein in fault zone.	Opportunity Claims	No report
ASO-127	9	29S (Unsurveyed)	21W	3 X background anomaly. Grab sample: 0.13% eU ₃ O ₈ .	Volcanic breccia	---	No report
DEB-RRA-1196	32	27S	20W	None	Faulted Sandstone and Shale	---	No report
DEB-RRA 1160	--	28,29S	14W	None	Dacite dike	---	No report
NM Bur Mines Bull 87	25	29S	14W	---	Silicified zone in Cretaceous limestone	Napine	9 tons, .19% U ₃ O ₈ .

3 km west of there and anomalous uranium values in stream sediments about 8 km farther west make one of the tightest clusters of independent indicators of anomalous uranium in the study area. This region lies in the outflow facies of ash flow tuffs from the cauldrons of the Animas Mountain and, as such, is comparable to the Peña Blanca region of Chihuahua. Slight enrichment of uranium was also noted in an opal vein sampled in the course of this study, as will be discussed below.

The second region is in the Little Hatchet Mountains and Hachita Valley: in Granite Gap and to the east at Twelvemile Wells, where two anomalous stream sediment samples and an anomalous water sample were collected. Precambrian granites crop out at Granite Gap, and other old granites in the region, such as those of the Burro Uplift, contain concentrations of uranium (Gillerman, 1968), and the anomalous values from Granite Gap could be a reflection of a similar situation.

The Hachita-Apache Hills - Sierra Rica region is indicated to be favorable by a cluster of 4 anomalous water samples, six high values of uranium in water samples (one to two standard deviations about the mean), the reported production of ore nearby, and five samples of dry stream sediments that contain high but not anomalous values of uranium. This area is a small abandoned mining district where copper with silver, lead, and bismuth occur mostly in skarns developed in the U-Bar Limestone adjacent to a monzonite porphyry intrusion and in veins. Peterson (1976) believes that this mineralization is related to the cauldron he mapped in that area. The Napine occurrence, from which ore was shipped, is described as being a silicified zone in limestone, perhaps a vein (Hilpert, 1965). It is located near the southeastern corner of the Apache Cauldron, as indicated by Deal and others (1978) and in Figure 3. The nearby high uranium values in stream sediments are concentrated in the Apache Hills, about five miles NW of the Napine occurrence,

near the mines described by Peterson (1976). The anomalous values of uranium in water samples occur at Hachita and in the valley east of the Apache Hills, where water draining off those hills was sampled in wells and stock tanks. The high, not anomalous values of uranium in water occur in wells in the Apache Hills and east of them.

No other areas in the study area give such strong indications of high uranium concentration or mineralization. Isolated water or sediment samples are quite high, but none is confirmed by data available to us before this study began. There are some areas, however, to which some work might be profitably devoted. These have weaker indications of favorability than do the areas listed above.

One such area which would bear closer examination is the "North" Antelope Pass area where State Highway 9 passes through the Peloncillo Mountains. This is the margin of the Rodeo Cauldron. An anomalous well and one high concentration of uranium in a stream sediment were detected by the HSSR survey. A PRR (#DEB-RRA-1196) is available mentioning an abandoned mine two miles southwest of the pass.

A second area is the Burro Pass-Trail Creek area of the south central Peloncillos, where several high concentrations of uranium were reported and a PRR describes a small radioactive anomaly and a grab sample with 0.13% equivalent U_3O_8 . The PRR does not indicate whether the value was corrected for potassium. A stock tank that lies west of Burro Pass, and probably receives water from near the concentrations described above, also contains an anomalous concentration of uranium.

SAMPLING AND ANALYTICAL METHODS

During June, July, and August, 1979, samples were collected from outcrops of Tertiary volcanic rocks in southwestern New Mexico, and sedimentary or volcanic rocks of Cretaceous, Permian, and Mississippian age that unconformably underlie the Tertiary sequence. Samples were collected from the older rocks in a fashion designed to cover the area of the outcrop of the units that had recently been overlain by the volcanic rocks. In volcanic rocks, the assumption was made that the uranium content was more likely to vary up section than laterally in different horizons, so sampling was concentrated in small areas from which samples were collected through the lower part of the exposed section and in places up to the top of the section. In addition, one major welded ash flow tuff was extensively sampled to make possible a detailed study of uranium variability and perhaps an understanding of uranium mobility in it. Several sections through lava flows were also collected to permit detailed studies of mobility of uranium during and after conversion of the molten lava or glass into a crystalline state. Because this study attempts to detect depletion of uranium from flows and tuffs, vitrophyres and other glassy materials were sampled wherever encountered to give an idea of the original compositions.

Four hundred eighty-four samples of approximately fist-size were collected and, where possible, all obvious weathered material was removed from the outside. Each sample was assigned a serial number, beginning with 0001. From the fist-sized sample, a chip of 50-100 g was split for chemical analysis. Most samples were of fine enough grain that this sample was considered representative. Larger samples of coarser rocks were sent for analysis. Both the hand specimen and the chip were placed in cloth bags. In addition to the serial number, each sample was assigned a code number that indicates

the part of the area from which it was collected, its age, rock type and which of several units of the same type and age it was collected from. Tertiary volcanic rocks were also assigned a cauldron sequence designator which indicated which cauldron they are believed to have originated in, according to the work of Erb (personal communication), Deal and others (1978) and Elston (personal communication) and published maps of the region. Finally, each sample that was sent for analysis was assigned a six-digit Oak Ridge National Laboratory number from a block of numbers provided for that purpose (Appendix 1).

Samples for chemical analysis were forwarded to Oak Ridge National Laboratory (ORNL). There they were prepared and analyzed according to standard procedures described by Arendt and others (1979). The elements for which they were analyzed, the methods of analysis, and the detection limits are listed in Table 6. Results of analysis of control samples run contemporaneously with our samples are given in Table 7 to indicate precision. Procedures for control of analytical accuracy are outlined in Arendt and others (1979).

Uranium concentration was determined by two methods, fluorimetry and neutron activation with delayed counting. Our conclusions are based on the analyses by the neutron activation technique on the basis of advice by Ron Helgersen of Oak Ridge (oral communication, 1980).

Other analyses were made spectrochemically, using an inductively coupled argon plasma source spectrometer, on material that was dissolved into a hot, concentrated mixture of nitric and hydrofluoric acids. Not all minerals dissolve into this caustic mixture. Unfortunately, no data are available on the residue from that treatment. Consequently, the results on some trace elements that form major parts of refractory phases are less reliable than the standards of accuracy and precision might otherwise

TABLE 6. TECHNIQUES AND DETECTION LIMITS

Element	Method	Detection Limit (ppm)
U-FL	Fluorometry	0.25
U-NT	Neutron Activation-Delayed Neutron Count	0.02
Ag	Plasma Source Emission Spectrometry	2
Al	Plasma Source Emission Spectrometry	0.05 ^(a)
B	Plasma Source Emission Spectrometry	10
Ba	Plasma Source Emission Spectrometry	2
Be	Plasma Source Emission Spectrometry	1
Ca	Plasma Source Emission Spectrometry	0.05 ^(a)
Ce	Plasma Source Emission Spectrometry	10
Co	Plasma Source Emission Spectrometry	4
Cr	Plasma Source Emission Spectrometry	1
Cu	Plasma Source Emission Spectrometry	2
Fe	Plasma Source Emission Spectrometry	0.05 ^(a)
K	Plasma Source Emission Spectrometry	0.05 ^(a)
Li	Plasma Source Emission Spectrometry	1
Mg	Plasma Source Emission Spectrometry	0.05 ^(a)
Mn	Plasma Source Emission Spectrometry	4
Mo	Plasma Source Emission Spectrometry	4
Na	Plasma Source Emission Spectrometry	0.05 ^(a)
Nb	Plasma Source Emission Spectrometry	4
Ni	Plasma Source Emission Spectrometry	2
P	Plasma Source Emission Spectrometry	5
Sc	Plasma Source Emission Spectrometry	1
Sr	Plasma Source Emission Spectrometry	1
Th	Plasma Source Emission Spectrometry	2
Ti	Plasma Source Emission Spectrometry	10
V	Plasma Source Emission Spectrometry	2
Y	Plasma Source Emission Spectrometry	1
Zn	Plasma Source Emission Spectrometry	2
Zr	Plasma Source Emission Spectrometry	2

(a) Detection limits expressed in percent.

TABLE 7. RESULTS OF ANALYSES RUN AT ORNL AS CONTROLS.

Element	Method	Batch R-3				Batch S-2			
		No. of Samples	Mean (ppm)	Standard Deviation (ppm)	Coefficient of Variation	No. of Samples	Mean (ppm)	Standard Deviation (ppm)	Coefficient of Variation
U	FL	52	4.15	0.400	0.10	30	9.93	0.871	0.09
U	NT	61	4.86	0.136	0.03	40	10.26	0.276	0.03
Al	PS	53	31,900.0	2,450.0	0.08	32	55,800.0	4,470.0	0.08
B	PS	57	12.0	6.1	0.48	32	49.0	9.7	0.20
Ba	PS	50	416.0	16.1	0.04	35	381.0	20.3	0.05
Be	PS	56	1.0	2.3	1.64	35	2.0	0.6	0.27
Ca	PS	57	2,700.0	440.0	0.16	36	3,500.0	470.0	0.13
Ce	PS	49	62.86	10.815	0.17	32	83.19	22.161	0.27
Co	PS	55	13.0	2.3	0.17	34	22.0	4.1	0.18
Cr	PS	53	27.0	1.7	0.06	34	60.0	4.3	0.07
Cu	PS	53	21.0	2.7	0.13	33	45.0	2.9	0.06
Fe	PS	53	17,700.0	1,150.0	0.06	32	33,600.0	1,580.0	0.05
K	PS	53	9,800.0	810.0	0.08	30	19,400.0	1,580.0	0.03
Li	PS	55	22.0	1.5	0.07	34	34.0	3.4	0.10
Mg	PS	53	2,100.0	130.0	0.06	34	5,300.0	330.0	0.06
Mn	PS	53	1,898.0	112.4	0.06	32	761.0	38.4	0.05
Mo	PS	56	2.0	1.2	0.47	34	27.0	2.4	0.09
Na	PS	55	1,500.0	130.0	0.08	34	2,100.0	200.0	0.10
Nb	PS	57	12.0	3.8	0.31	35	10.0	5.3	0.50
Ni	PS	57	18.0	2.4	0.13	34	56.0	3.3	0.06
P	PS	53	1,808.0	251.0	0.14	32	808.0	88.3	0.11
Sc	PS	55	5.0	0.6	0.10	32	11.0	0.7	0.06
Sr	PS	51	54.39	2.899	0.05	35	79.94	5.693	0.07
Th	PS	57	7.0	4.3	0.60	36	8.0	2.6	0.32
Ti	PS	53	3,197.0	281.1	0.09	36	2,955.0	267.7	0.09
V	PS	53	52.0	4.6	0.09	30	157.0	10.7	0.07
Y	PS	55	19.0	1.6	0.08	34	28.0	1.4	0.05
Zn	PS	51	88.0	7.6	0.09	32	100.0	6.2	0.06

indicate. This applies to all determinations except the uranium analyses conducted by neutron activation--delayed counting methods.

Results of the chemical analyses were analyzed statistically at Oak Ridge and presented as tabulated data (Appendix 2), summary statistics for the area as a whole (Table 8), cluster analysis for the data set as a whole (Appendix 3) and Pearson and Spearman correlation matrices for the data set (Appendix 4). For several subsets of the data, summary statistics are given in Appendix 5, along with results of cluster analyses and correlation matrices. In addition to the statistical analysis of the data set as a whole and of large subdivisions of it that were conducted at Oak Ridge, some data analysis was conducted at the University of Kansas on the units chosen for more detailed analysis.

Samples selected for petrographic analysis include an array that was designed to cover the Tertiary volcanic units that had been sampled, in all of the areas in which they were sampled. In addition, most of the samples of the Gillespie Tuff and the four lava flows that had been collected for detailed study were analyzed petrographically. This process included examination of thin sections with the petrographic microscope at magnifications of 40 to 1000 times. An initial survey detected most of the major textures that were represented in tuffs, lava flows, and volcanic sediments. All samples were then assigned to one or more of the texture types. The textures included all those that developed during conversion of glass or magma to crystalline assemblages or those that were clearly post-emplacement alteration textures. Assignment to particular textures was based on comparison with a set of descriptions of the textures, illustrated with sketches and reference to thin sections that contained the texture. Consultation among the investigators was used to resolve uncertainties. The descriptions and sketches of the textures were refined during

TABLE 8. SUMMARY STATISTICS FOR CHEMICAL ANALYSES

NO. SAMPLES ANALYZED		BELOW									COEFFICIENT		LN TRANSFORMATION			
ELEMENT	VALUES	DETECTION LIMIT	DETECTION LIMIT	MINIMUM VALUE	MAXIMUM VALUE	MEAN	MEDIAN	MODE	STANDARD DEVIATION	OF VARIATION	MEAN	S. D.	ROBUST			
													MEAN	S. D.		
U	347			0.29	96.97	4.92	4.00	3.93	6.100	1.240	1.37	0.64	1.39	0.60		
U-NT	350			0.40	54.10	4.92	4.20	3.60	3.653	0.743	1.41	0.63	1.45	0.58		
U/TU	344			0.49	6.78	0.99	0.96	1.07	0.446	0.450	-0.05	0.25	-0.06	0.18		
AG	19	329	<2	<2	4	2	<2	<2	0.7	0.3	1.03	0.26				
AL	346	2	<0.05	<0.05	7.62	4.85	5.17	5.00	1.778	0.367	1.32	1.07	1.46	1.19		
B	21	327	<10	<10	62	18	<10	<10	14.0	0.7	2.76	0.56				
BA	348			2	1792	338	231	19	329.1	1.0	5.07	1.50	5.14	1.45		
BE	323	25	<1	<1	24	4	3	1	3.6	0.9	1.16	0.71	1.05	0.87		
CA	338	10	<0.05	<0.05	36.56	3.03	0.53	0.27	7.769	2.561	-0.40	1.47	-0.55	1.92		
CO	32	266	<4	<4	32	7	<4	<4	6.5	0.9	1.80	0.57				
CR	277	71	<1	<1	150	3	<1	<1	10.4	2.8	0.72	0.83				
CU	239	109	<2	<2	631	16	<2	<2	59.8	3.7	1.61	1.09				
FE	346	2	<0.05	<0.05	5.83	1.00	0.79	0.57	0.780	0.782	-0.27	0.79	-0.24	0.88		
LI	348			1	176	29	24	11	22.4	0.8	3.10	0.85	3.14	0.93		
MG	305	43	<0.05	<0.05	6.10	0.30	0.16	0.07	0.561	1.872	-1.67	0.84	-1.90	0.99		
MN	348			6	3193	375	302	246	316.9	0.8	5.62	0.89	5.69	0.92		
MO	29	319	<4	<4	18	5	<4	<4	3.3	0.6	1.64	0.39				
NA	311	37	<0.05	<0.05	3.66	1.78	1.82	<0.05	0.645	0.362	0.44	0.67	0.37	1.38		
NB	334	14	<4	<4	108	24	17	14	21.4	0.9	2.96	0.68	2.89	0.86		
NI	118	230	<2	<2	37	3	<2	<2	4.4	1.1	1.16	0.57				
P	344	4	<5	<5	2730	188	88	35	249.9	1.3	4.65	1.10	4.63	1.12		
SC	332	16	<1	<1	20	2	2	1	2.3	0.8	0.85	0.61	0.83	0.63		
TH	332	16	<2	<2	43	18	17	17	7.9	0.4	2.76	0.59	2.75	0.75		
TI	348			15	8244	1221	969	822	1045.0	0.9	6.74	1.00	6.82	1.16		
V	339	9	<2	<2	189	13	7	3	19.9	1.5	2.10	0.93	2.01	1.02		
Y	347	1	<1	<1	107	27	23	17	20.9	0.8	3.00	0.96	3.07	1.11		
ZA	346	2	<2	<2	165	40	33	23	31.4	0.8	3.43	0.79	3.45	0.94		
ZF	344	4	<2	<2	1079	108	57	55	175.8	1.6	4.11	1.05	4.09	1.17		
K	347	1	<0.02	<0.02	5.66	2.64	2.30	2.79	1.203	0.456	0.61	1.27	0.76	1.38		
SF	348			1	3710	153	69	5	279.8	1.8	4.16	1.43	4.20	1.46		
CF	323	25	<10	<10	229	83	70	55	41.5	0.5	4.29	0.56	4.21	0.88		

the study. AWW took primary responsibility for the area as a whole while DZ concentrated on the Gillespie Tuff and TLS examined samples from the four lava flows.

CHEMICAL RESULTS

The uranium content of the samples analysed for this study by the neutron activation - delayed counting technique ranged from 0.40 to 54.1 ppm, with an arithmetic mean value of 4.93 ppm. A natural logarithmic transformation of the data made the distribution of uranium concentration appear more normal. It changed the mean value to 4.14 ppm and lowered the standard deviation from 3.67 to a value equivalent to 1.88 ppm. Coefficient of variation for the data, 0.744, is substantially greater than the analytical coefficient of variation of about 0.03, indicating that the range of uranium values is much greater than the range of values that could be expected for repeated analyses of the same sample (Table 8).

On the log normal probability plot (Figure 4), the uranium values do not form a straight line as a log normal distribution would. Most likely this is a result of the sample population consisting of several moderate-sized groups (perhaps 25 to 60 samples each) with more-or-less log normal distributions, each with its own standard deviation, plus several samples or small groups of samples that cannot be assigned to one of the larger groups. Attempts to subdivide this curve, detecting the individual segments of it and their means and standard deviations by means of the analyses alone is probably not profitable. Four samples with the highest uranium content, however, do lie distinctly on the high-U side of the overall trend of the central part log normal distribution. These samples are probably anomalous. Other anomalous samples will be detected by further consideration of the data.

The samples were grouped into several genetically or stratigraphically defined sets for comparison of uranium values (Table 9). Inspection of the median values of these groups and of the percentile plots (Fig. 5) indicate that the subgroups have greatly different values of uranium content. Even

Figure 4: Lognormal probability plot of results of uranium analyses for the samples collected in southwestern New Mexico.

Sample 5

SW NEW MEXICO VOLCANICS

Figure 5: Percentile plot of uranium content for whole data set and several subgroups of samples. Identify of groups given in Table 9.

groups that represent samples from entire cauldron sequences as defined by Deal and others, (1978) and Erb (personal communication, 1978) and Elston (personal communication, 1980) show great differences in the average content of uranium. Products of the Geronimo Trail Cauldron seem to be particularly rich in uranium and the San Luis Cauldron somewhat less so. Rocks erupted from the Juniper Cauldron, however, and Gillespie Tuff from the Cowboy Rim Cauldron are below the median for the area as a whole.

In part, at least, this represents the nature of the preserved rocks from each cauldron sequence or of the samples that were collected. The Gillespie Tuff represents only the collapse/ash flow emplacement phase of the Cowboy Rim Cauldron, no later rocks from that source were sampled. The samples from the Juniper Cauldron were collected from ash flows and intrusions with the later stage flows under-represented. On the other hand, the later stage fractions of the San Luis Cauldron and Geronimo Cauldron were selectively sampled, partly because they are extensively exposed and partly because the late stage rhyolite flows of those units were selected for intense study; they are the Rhyolite of the Packers Trail and the Rhyolite of Clanton Draw, respectively. The Rhyolite of Clanton Draw, as a unit, is especially rich in uranium.

In order to identify samples that might be enriched in uranium enough to indicate presence of a nearby deposit, samples that had a uranium content greater than the ln-transformation mean plus one ln-transformation standard deviation were identified--i.e. samples that had uranium content greater than 6.0 ppm (Figure 6). This procedure isolated 96 samples, 54 of which had uranium content between 6.0 and 7.9 ppm, one to two standard deviations above the mean, and 42 samples with uranium content greater than 7.9 ppm of which 9 samples had a uranium content of greater than 9.8, representing values

TABLE 9. GENETICALLY DEFINED SUBSETS OF THE SAMPLE SET

Group	Definition	Number of Samples	Uranium Content	
			median	standard deviation
All samples	(arithmetic) (In- transformation	347	4.20	6.117
		347	1.42* (= 4.14ppm)	0.63 (= 1.88ppm)
Group 1	All pre-Tertiary sediments, volcanic rocks of older Tertiary cycle.	33	1.50	
Group 2	Bluff Creek Forma- tion and equivalents. Mostly products of Tullous Cauldrons	24	4.10	
Group 3	Products of Juniper Cauldron	26	3.40	
Group 4	Gillespie Tuff	50	3.80	
Group 5	Products of San Luis Cauldron	23	5.02	
Group 6	Products of Geronimo Trail Cauldron	45	7.50	
Group 7	Products of Rodeo Cauldron	60	3.60	
Group 8	Other rocks of the Mid-Tertiary volca- nic episode, inclu- ding some from Pyramid Mountains	49	4.55	

*mean

greater than two and greater than three standard deviations above the mean, respectively.

Not all of these samples are anomalously enriched in uranium. Instead, a strong stratigraphic bias was evident: 26 of the 42 samples that had uranium content greater than two standard deviations above the mean were drawn from two stratigraphic units that together made up less than 20% of the entire data set. Twenty of the 26 came from one unit, the Rhyolite of Clanton Draw. Because several of these samples are vitrophyres they probably have not undergone any change of uranium concentration since eruption. Thus the most of the high concentrations of uranium in the Rhyolite of Clanton Draw does not indicate mobility of the element of the sort necessary to produce deposits.

The simple procedure of considering the whole data set did, however, indicate the presence of several samples that probably are indeed anomalous. These are listed in Table 10. All of these samples are more than three standard deviations above the mean. Although three of them are from uranium-rich units, the Tuff of Black Mountain, the Rhyolite of Clanton Draw, and the Moonstone tuff, they are so enriched that they are anomalous even in those units. Sample 315, from the Dog Mountains, gave a result of 96 ppm uranium by fluorescence, suggesting it is enriched. Samples 001 and 051 lie well on the uranium-enriched side of the regional curve of Figure 4. Sample 156, from the dump of a prospect pit near 'north' Antelope Pass, is included because it is a limestone sample that has a far higher concentration of uranium than any other non-volcanic rock.

Anomalous Samples

Comparison of these results to the results of the summary of pre-existing data and the consideration of geological environments indicates that they

serve to confirm notions developed on the basis of those other lines of reasoning (Figure 7). One sample, 315, confirms the uranium-rich area in the Dog Mountains. This area lies in the outflow facies from the cauldrons of the Animas Mountains. The sample was collected from an opal vein. The Burro Pass/Trail Creek area that seemed to have a high concentration of uranium was the source of a uranium-rich sample of the Moonstone Tuff (082). A sample of Horquilla Limestone lies within a similar area along the margin of the Rodeo Cauldron in 'north' Antelope Pass (sample 156; Deal and others, 1978).

Samples 001 from the Animas Valley fill, and 467 from the Rhyolite of Clanton Draw indicate local uranium enrichment and mobility along the margin of the Geronimo Trail Cauldron of Erb (Deal and others, 1978). As was pointed out previously, this unit is enriched in uranium as is the entire sequence from the Geronimo Trail Cauldron. However, these samples are so enriched that they must imply some mobility. sample 467 contains opal and chalcedony, indicating low temperature mobility of uranium.

The other two samples, 051 and 189, seem to be isolated samples with high concentration. Nearby samples are not similarly enriched and neither was taken in an area sampled or mentioned in previous information about the area. Neither area shows signs of post emplacement mobility of uranium. They are not counted as indicating favorable areas for further work.

The utility of the program of chemical sampling was limited by three factors. One is extreme variability in the average uranium content of the stratigraphic units sampled. Individual stratigraphic units displayed averages that differed from other units by nearly an order of magnitude: some of the limestone samples containing less than one ppm U, some units of the volcanic

Figure 6

Figure 6: Locations of samples with high U-content: circle 6 to 7.9 ppm; square 7.9 to 9.8 ppm; star greater than 9.8 ppm.

TABLE 10. ANOMALOUS SAMPLES

<u>Sample number</u>					
Oak Ridge	SWNM Serial	unit number	unit name	uranium content	location
150986	0001	9V1	Animas Valley Fill	54ppm	Geronimo Trail 108° 59' 37" W,
150999	0051	1B1	Bluff Creek Fm	19	Northern Animas Mountains. 108° 41' 58" W, 31° 49' 09" N
151022	0082	8T4	Moonstone Tuff	13	South Central Pelloncillos Moun- tains. 108° 57' 40" W, 31° 48' 47.5" N
151164	0315	8VB	Bluff Creek Fm Opal vein in sediment	14	Dog Mountains 108° 19' 12" W, 31° 21' 44" N
151106	0189	7T1	Tuff of Black Mountain	12	South Central Pelloncillos Mtns. 108° 55' 1" W, 31° 42' 25.5" N
151243	0467	6R3	Rhyolite of Clanton Draw	18	Southern Pelloncillos Mountains 108° 59' 29" W, 31° 29' 26" N
151079	0156	YL1	Horquilla Limestone	9.6	'North' Angelope Pass 108° 54' 47.5" W 31° 57' 11.5" N

Figure 7: Areas shown by a variety of means to be enriched in uranium. A: areas anomalously rich in uranium. B: areas of high uranium concentration.

section had uranium values of 8.2 and 9.4 ppm as average concentrations. This makes difficult the task of identifying individual anomalous values. The sampling pattern was selected to sample volcanic units vertically throughout them rather than laterally along their extent. Because of this, samples do not represent the area as well as would the same number of samples collected according to some random sampling pattern. Finally, the number of samples was simply inadequate to cover the area.

URANIUM MOBILITY

A major thrust of this project was to detect areas where uranium had been mobile to form deposits. It was an experimental study because the concept of evaluating uranium potential of an area by locating sources of the metal is by no means firmly established. Nevertheless, Walton and others (1980a, in revision) establish that certain conditions are more likely to produce uranium for secondary deposits than others and occurrence of these situations leaves evidence in the rocks.

Of the rocks present in the study area, the type that is richest in uranium is the silicic volcanic rocks of the Mid-Tertiary volcanic suite. Hence they are most likely the source of any uranium in secondary deposits in the area. However, because previous studies of uranium mobility in volcanic rocks have led to ambiguous results. Consequently, we selected several volcanic units for intensive study of the processes that have affected them since they were emplaced. We collected 60 samples from the Gillespie Tuff, a major ash flow apparently erupted from the Cowboy Rim Cauldron (Deal and others, 1978). We also studied four rhyolite lava units: we collected 24 samples from the Rhyolite of Clanton Draw of the Geronimo Pass Cauldron, 14 samples from the Rhyolite of the Packers Trail of the San Luis Cauldron, 7 samples from rhyolite flows in the Unit of Antelope Pass in the Rodeo Cauldron, and 6 samples from the Pine Canyon Rhyolite, a flow unit exposed in the central Animas Mountains. All of these samples were analysed as part of the regular chemical analysis program of the area. We collected both vitrophyres and crystallized felsites.

Thin sections were cut from most of the samples mentioned above as well as from about 80 of the other samples. Petrographic study of these thin sections was intended to discover the textures that formed during the

processes of conversion from glass or magma to the crystalline state. We then interpreted these textures and minerals formed from them, in light of recent field and experimental studies, to identify the process that was responsible for each.

Finally, the results of chemical analyses should indicate whether uranium was released during the processes. In order to determine if it was, the uranium content of rocks displaying particular textures was compared statistically to that of rocks containing other textures and to vitrophyres. If release of uranium could have been documented, further investigation could have revealed whether it might have occurred in such a fashion that the uranium might be concentrated into economic deposits. The chemical data also allowed us to confirm the nature of the processes of conversion and to demonstrate that other processes, which left little impression on the texture and mineralogy of the rocks, had not been effective in changing their chemical composition. Throughout this study, we have relied on the assumption that vitrophyres represent the best available indication of the chemical composition of the rock at the time it was formed.

Release of Uranium from Volcanic Rocks

Most crystalline felsic volcanic rocks that have been studied are reported to contain less uranium than intimately associated vitrophyres (Rosholt and others, 1971; Zielinski and others, 1977; and Zielinski, 1978; among others). Rosholt and others (1971) reported that two processes that likely accounted for the supposed depletion: Removal of uranium as a volatile fluoride complex, late in the history of primary crystallization, and gradual removal of uranium by groundwater or weathering after cooling of the rock. Rosholt and others (1971) presented results of chemical analyses that supported the loss of uranium during crystallization, especially crude correlations between F1 and U

concentrations and between degree of oxidation of iron and U-concentration. They reported that activity ratios other than unity for nuclei on the uranium decay chain supported their contention of mobility of uranium in crystallized rocks during the past 10^5 years, and presumably, throughout the post-cooling history of the rocks. Fleischer (1980), however, points out that such imbalances are to be expected because of selective leaching of alpha tracks and alpha recoil, even if parent isotopes are not mobile. These processes are dependent on proximity of grain boundaries and would thus affect felsites more than glasses.

Zielinski (1978) plotted depletion of uranium in felsites compared to that in closely associated glasses against age and found evidence that the relative uranium loss increased with time. The depletion was greater for alkaline rocks than for calcalkaline or for rocks of what he called transitional composition. Most of the time dependency of the loss of calcalkaline rocks is based on five samples from one locality, the others show no such relations. No young peralkaline rocks verify the time dependent loss for them, either. Finally, no textural information is presented to indicate the process by which these rocks underwent crystallization.

The importance of textural information was suggested by Henry and Tyner (1978) who found that devitrified or vapor-phase crystallized ash flow tuffs showed little indication of uranium depletion, even in rocks 31 million years old. But rocks that had developed 'granophyric' textures, the textures we describe below as ADS or SDS textures, did indicate some uranium loss. Henry (1978) unfortunately had no glasses against which to measure depletion for many of the units.

In this study, we will report the results of our description and interpretation of crystallization texture. Our results indicate that uranium

content is not significantly different in the glasses and felsites collected from the Rhyolite of Clanton Draw, even though the average content is slightly lower in the felsites. The uranium content of a crystallized ash flow tuff is significantly lower than in vitrophyres from the same unit. The parts of the Gillespie Tuff that display different crystallization textures have significantly different amounts of uranium, suggesting that certain processes of crystallization are more effective than others at releasing uranium, though not as Henry and Tyner (1978) suggested. Before establishing this, it is necessary to describe the textures present in these rocks and establish the process of their crystallization. This cannot be done without reference to some recent experimental and theoretical treatments of the process of crystallization.

Glasses and Supercooled Liquids

Glass and volcanic liquids change into crystalline assemblages by several processes. For artificial glasses, the term devitrification is used for this crystallization. The implication is normally that the process occurs in the solid state, converting a disordered solid, glass, to an array of crystals. It can occur at low temperature, but the rates of its occurrence under that condition are so slow that for practical purposes it is not an important process in commercial silicate glasses. In natural systems, the longer time spans, various modes of occurrence, and several possible processes open new avenues of crystallization. For this reason, the term conversion is applied to any process that changes glass or supercooled magma to crystalline material. Devitrification is restricted to solid state transitions from glass to solid; the analogous process occurring above the glass transition temperature should be called crystallization. Other processes that can occur include growth of crystals from the vapor phase, hydration, hydrothermal alteration, and solution-reprecipitation.

tation as occurs during conversion of glass in diagenetic or soil environments. Each of these processes has a set of variations and the total number of routes from glass to crystal is quite large. All of these are lumped under the heading "conversion". The term "alteration" might be used for a number of them, especially the low temperature processes. Because this report emphasizes the application of understanding of conversion processes to uranium resource evaluation, it is better to avoid use of "alteration" because of its application for a major process by which sandstone uranium deposits are formed.

Crystal Growth

Recent experimental investigation of crystal growth in natural and artificial melts of felsic composition has led to major advances in understanding relations of habit and condition of crystallization (Lofgren, 1971; Fenn, 1977; Swanson, 1976). The habit of crystals grown in a melt or in glass depends in large part on the degree of supercooling, ΔT (liquidus temperature - crystallization temperature), of the melt. Beginning at the liquidus temperature the rate of crystal growth increases with increasing ΔT , reaches a maximum, and decreases as the viscosity of the melt increases and counteracts the increasing free energy advantage of the crystalline state. In addition, because of changes in rate limiting steps as described by Kirkpatrick (1975), the form in which crystals grow differs at differing degrees of supercooling. At the highest temperatures, within a few tens of degrees Celsius of the liquidus, euhedral crystals develop because surface reactions are the rate limiting step. At temperature farther below the liquidus, diffusion of nutrients to the growing crystal and impurities and heat away from it control the rate of growth. This leads to growth of dendritic or skeletal crystals. At still lower temperature, perhaps a few hundred degrees below the liquidus temperature for the melt, fibrous habits with non-crystallographic branches occur, for reasons that are not clear, and spherulitic crystallization is the most important form.

The degree of supercooling at which these different habits occur, and even their occurrence depends upon the system involved. Lofgren (1974) finds spherulites at ΔT of greater than 400°C in plagioclase. Fenn (1977) finds it in alkali feldspar at ΔT or less than 200°C , and did not detect the dendritic or skeletal habits. Kirkpatrick (1976) figures superb examples of single plagioclase and olivine crystals that display several habits in basalt pillows, beginning with skeletal crystals near the center and passing outward into spherulitic exterior segments. Kirkpatrick suggests that this texture reflects decreasing temperature and increasing ΔT during crystallization. Fenn (1977) notes the opposite effect in his isothermal experiments in which crystallization of alkali feldspars began at large ΔT . As consumption of the less soluble components of the melt effectively lowered the liquidus, decreasing ΔT caused reversion from a spherulitic habit to one with larger crystals and euhedral outlines.

Conversion Textures in Volcanic Rocks

The theoretical and experimental background given above provides a basis for the interpretation of textures developed in lavas and ash flow tuffs. Ash flow tuffs crystallize in a system that consists of particles of glass or magma and a vapor phase that can move constituents or heat around in the flow and are thus more complex than lava flows, which can be considered as consisting only of magma. Both lavas and tuffs may contain phenocrysts, but reactions between them and the crystallizing melt are of minor importance. The following analysis first will treat the textures of lavas and then try to interpret them in terms of experiments and theoretical treatments described above.

Lava textures

Petrographic study of samples from four lava flows has led to recognition of five characteristic textures that indicate conditions during primary cooling

of the lava: glass; fibrous texture, including spherulitic texture; granular texture; dendritic texture; and snowflake or micropoikilitic texture.

Glass. Glass occurs only at the base of flows, commonly in association with pyroclastic deposits or older crystallized felsites (Figure 8). It may show relict welded shard or pumice texture, or may be homogeneous. Commonly, it contains microlites of pyroxene or magnetite, but the glass itself is isotropic. The glass may contain perlitic cracks; in some examples these have birefringence along them, indicating the presence of secondary minerals. Glass develops in situations where the magma was made so viscous so rapidly that nucleation and crystal growth were completely suppressed.

Fibrous textures. Spherulites and fibrous textures belong to a set of textures that is characterized by non-crystalline branching of individual fibers (Figure 9). Spherulites, and analogous textures that develop from lines or planes within the rock rather than from points, are the most common crystal habit in rhyolitic lavas from Southwestern New Mexico. The width of individual fibers of these aggregates ranges from submicroscopic to a few tens of micrometers; the length of fibers, or the radius of spherulites, ranges from about ten micrometers to several millimeters. Generally, smaller spherulites have finer internal fibers. These textures include plumose or feather-like textures and fan-like or flabellar textures. All have in common the characteristic of non-crystalline branching: the fibers divide at low angles and adjacent fibers have slightly different orientations of their respective crystallographic planes. Lofgren (1974, Figure 1) figures the common

Figure 8. Photo micrographs of textures in rhyolitic lava flows. a.) dense vitrophyre with perlitic cracks. b.) Vitrophyre with shards preserved. c.) Microphenocryst with dendritic overgrowth. Note branching. d.) Dendritic crystals with crystallographic branching. Scale bar 0.1 mm, a, b, plane polarized light; c, d, crossed polarizers.

members of this diverse group of crystal habits. The fibers may change character along their lengths; some redivide and become narrower or retain nearly constant width along their length. Spherulites and similar radiating forms show extinction crosses between crossed polarizers. In some rocks, spherulitic crystals develop over cores of older, single crystals, either phenocrysts or microphenocrysts. In such situations, it is common for fiber width to decrease outward. Experimental evidence cited above indicates that spherulites and other fibrous habits grow under high degrees of supercooling.

Granular Textures occur as sparry intergrowths and euhedral crystal druses projecting into voids (Figure 9). They are distinct from phenocrysts for two reasons. First, they form intergrowths or occur as clots in which individual crystals grew independently of each other, whereas phenocrysts occur as single crystals or as rosette-like groups. Second, they are formed after other textural elements that develop after intrusion; they are normally the last material to crystallize. Commonly, granular textures are developed in late minerals or are intergrown with late minerals. Phenocrysts, of course, are early minerals and commonly are nuclei on which post-emplacement minerals grow.

Quartz, tridymite, alkali feldspar, biotite, inosilicates and iron oxides occur as grains, but tectosilicates dominate. Individual crystals range from a few microns to about 0.2 mm. Quartz occurs either as sparry, anhedral crystals or as euhedra that line voids. Euhedral alkali feldspar forms either as druses on spherulites or as isolated crystals surrounded by

Figure 9. Photomicrographs of textures developed in rhyolitic lava flows. a.),b.) Plumose or feathering texture with non-crystallographic branching. c.),d.) Spherulitic - drusy - sparry (SDS) texture. Spherulites of alkali feldspar with drusy alkali feldspar overgrowths that pass into sparry masses of quartz. c is taken in plane polarized light; a and d with crossed nicols; scale in a 0.1 mm, in b and d, 0.2 mm, in c, 0.05 mm.

sparry quartz. Grains may contain many inclusions, normally water filled bubbles, or may be clear. Experimental evidence suggests that such coarse textures are common when minerals grow under small degrees of supercooling, from magma, glass or the vapor phase.

Dendritic textures differ from certain kinds of spherulitic, flabellar, or plumose habits in that they branch in a crystallographically controlled fashion. These are the dendrites and skeletal crystals referred to by Kirkpatrick (1975, 1976), Lofgren (1974), and Fenn (1977). Individual crystals generally form masses a few hundredths to a few tenths of a millimeter across that are parts of clumps of such crystals. Fiber or dendrite width commonly decreases outward from the center, or origin, of the mass. Such crystals form at a degree of supercooling intermediate between that at which euhedra or granular masses form and that at which habits form. Crystals of this habit are of feldspar (Figure 8).

Snowflake texture is the same as the micropoikilitic texture of Lofgren (1971), but was first described by Anderson (1967). It consists of a mass of anhedral, slightly interlocking quartz grains of a few hundredths or tenths of millimeters diameter. These grains contain a myriad of one- to ten-micron crystals of alkali feldspar.

Interpretation of Lava Textures

Habits that show non-crystallographic branching, spherulites, axiolites, plumes, or fans, are the first products of post-emplacement crystallization in nearly all samples of lava flows that were studied. These are the result of rapid crystallization at subliquidus temperatures, perhaps a few hundred degrees of supercooling. Fiber thickness and nucleation density might be a crude index of degree of supercooling (Fenn, 1977). A few samples display small, single crystals as the first product of post-emplacement crystalli-

zation. These may be coated by or grade into dendritic or spherulitic crystallites. Such texture is taken to indicate an increase in degree of supercooling with time.

Many samples display only fibrous, plumose, spherulitic, or flabellar textures. The width of the fibers may change, becoming greater or smaller, or may remain the same. These textures indicate that the entire crystallization history of the rock occurred under greatly supercooled conditions.

The implications of the abundance of fibrous textures in lava flows and their interpretation as products of crystallization at highly supercooled conditions are major. Because of the supercooling, the control of the rate of crystallization is not the rate of heat loss, but the rate at which nutrients can be provided to growing crystal and impurities removed or shoved aside. Fenn's (1977) experimental work found maximum growth rates for spherulites of greater than 10^{-6} cm/sec, or in excess of one millimeter per day. Probably lavas that contain only fibrous textures were solid within a few hours of the initiation of crystallization.

Another class of textures, nicely developed in certain of the lavas studied in southwestern New Mexico, indicates a decrease of the degree of supercooling as crystallization proceeded. The most distinctive of these textures we have called SD3 texture because it consists of fine, closed, spherulites (S; Lofgren, 1974) of alkali feldspar, perhaps with quartz between fibers, that pass outward into what Lofgren (1974) would call coarse, open spherulites. Actually, these are durses (D) that coat the spherulites with crystals of alkali feldspar, the feldspar crystals have anhedral terminations. The final stage of crystallization is sparry masses of anhedral quartz, anhedral alkali feldspar, and other minerals that partially or completely fill the voids between spherulites (Figure 9, c, d). These are one kind of granular

texture as mentioned above. SDS texture is only one of a variety of similar textures that include flow bands of spherulitic rhyolite a few millimeters thick separated by sparry bands, or cavities partially filled by sparry quartz or tridymite, alkali feldspars and other minerals. The proportion of the spherulitic, axiolitic or fibrous to the granular textures differs greatly from rock to rock, but few rocks have a preponderance of non-fibrous textures, and in some the coarser or granular textures are absent or make up only a small percentage.

Rocks that are characterized by early fibrous or spherulitic textures, on one hand and later granular textures can be interpreted as forming at successively smaller degrees of undercooling, with the last stage quartz and alkali feldspar forming together at approximately the conditions of the ternary minimum of the Ab-Or-Quartz system. This reduction of ΔT could result from either lowering of the liquidus temperature as the relatively insoluble fraction of the magma is consumed (Fenn, 1977) or the warming of the whole mass of melt and crystals because latent heat of crystallization is released faster than it is transported away. Because the latent heat exceeds the heat capacity by a factor of about 200, warming of the mass during crystallization is probably the major reason for the decline of degree of supercooling.

Fenn (1977) found that growth rates of crystals were two or three orders of magnitude less at near liquidus temperatures than at a few hundred degrees of supercooling where spherulites and fibrous crystals grow. This suggests solidification times of days to weeks for lavas with SDS or other granular textures.

The retention of heat suggests also a retention of volatiles until the latest stage of crystallization. In fact, the coarse parts of SDS or

fibrous-to-granular textures resemble pegmatites on a microscopic scale and the term micropegmatitic might nicely be applied to this texture. However, the term granophyric texture is applied to similar arrays in ash flow tuffs and lavas (Ross and Smith, 1961; Lofgren, 1971; Henry and Tyner, 1978). The process of forming these textures, because it retains both heat and volatiles, may lead to second boiling, or release of a separate vapor phase.

Vertical Sequence of textures

The lavas that were most intensely sampled during this study displayed certain similarities of vertical sequence that suggest the motion of heat within them (Figures 10, 11). The basal parts of flows showed a gradation from uncollapsed pumice and glass shards into welded zones, vitrophyres in which the deformed outlines of the shards are visible. Immediately below the crystallized part of the lava flow, vitrophyres are dense with perlitic cracks and small microlites. The vertical gradation from pyroclastic material to glass suggests that pyroclastic eruptions may be important in nourishing these lavas, at least initially. In fact, they may be rheoignimbites or tuff lavas.

Above the vitrophyre, the lavas commonly are flow banded with light-colored, opaque bands separated by translucent, weakly colored bands. Opaque flow bands correspond to areas of spherulitic crystallization. In the lowest part of the flow, the spherulites are closely spaced, on the order of a few microns in diameter, and the fibers that make them up are below the resolving power of the petrographic microscope. In a few flows, plumose or dendritic habits occur in the basal part of the flow.

The central parts of flows are normally flow banded macroscopically and contain spherulites that are somewhat coarser than those of the lowest crystalline parts of the flow. These spherulites are up to about 0.2 mm in

diameter and individual fibers are a few microns across. The rock is composed of spherulites and most flow bands are marked by changes of average size of the aggregates. Some flow bands developed into lens-like or extended, flat voids that are lined or dotted by coarse crystals of quartz. The central part of one flow consists of fibrous crystals of feldspar arranged in plumes or fans with some spherulites and granular crystals that make up the ground-mass of the rocks. One flow had a layer containing snowflake or micropoikilitic texture between the lower and central parts of its crystallized part (Figure 10).

The upper part of flows is flow banded, and may be flow folded or brecciated. The flow bands are spherulitic masses and the translucent areas between them contain drusy or sparry crystals of alkali feldspar, quartz, and a variety of accessory minerals. These coarser-grained bands may be colored by late mafic minerals like riebeckite. At this level is the best development of SDS texture.

It is evident that the conditions of temperature and degree of supercooling differed through these flows while they crystallized. The glass at the base was so supercooled that it has not been able to form crystals. The lowest part of each flow crystallized completely without major change in degree of supercooling. In the upper part, warming occurred during crystallization and the last stages of solidification occurred at near at near-liquidus conditions.

Crystallization of Ash Flow Tuffs

Ash flow tuffs represent a crystallization system that includes three constituents: phenocrysts and clasts, glass fragments, and pores. Phenocrysts of quartz, feldspar, sphene, and zircon and most rock fragments are inert during the crystallization process, but they may serve as centers of inhom-

RHYOLITE OF CLANTON DRAW: COLVERDALE SECTION		RHYOLITE OF CLANTON DRAW: GERONIMO A & B PENDLETON SECTIONS		RHYOLITE IN UNIT OF ANTELOPE PASS: EVANS RANCH SECTION	
MEGASCOPIC	MICROSCOPIC	MEGASCOPIC	MICROSCOPIC	MEGASCOPIC	MICROSCOPIC
FELSITE	FLOW BAND	FLOW BANDED, BRECCIATED	SPHERULITIC- DRUSY- SPARRY	MASSIVE, MINOR FLOW BANDING AND FOLDING	SPHERULITIC- DRUSY- SPARRY
	FIBROUS TEXTURES; PLUMOSE OR FLABELLAR, WITH SOME GRANULAR	FLOW BAND	SPHERULITIC; DRUSES OR SPARRY MASSES IN VOIDS		SPHERULITIC
	STRUCTURELESS		MICROSPHERULITIC		MICROGRANULAR, MICROPOIKILITIC
VITRO- PHYRE	DENDRITIC CRYSTALS	DENSE VITROPHYRE, PERLITIC CRACKS VITROPHYRE WITH COLLAPSED AND WELDED SHARDS UNCOLLAPSED PUMICE AND SHARDS		FIBROUS: PLUMOSE	

Figure 10

Figure 10: Sequence of crystallization textures in rhyolite lavas sampled in southwestern New Mexico.

geneous nucleation. Biotite, amphiboles, and pyroxenes commonly have reacted during outgassing or crystallization, but the scale of these effects is minor compared to the reactions of conversion that have affected the rock as a whole. Fragments of glass, small, simple shards or large, complex pumice fragments, make up the greatest fraction of the volume of ash flow tuffs. These may have undergone welding or compaction or may have been converted to crystals of quartz and feldspar. Finally, there are pores. These are of two types, primary pores that were left between adjacent glass or crystal fragments, and secondary pores that were developed by concentration of certain constituents of the melt during primary crystallization. Secondary pores may cut across the primary texture of the ash flow, transecting glass shards, pumice textures or other primary textural elements as miarolitic-like cavities or they may be restricted to the center of particular pumice fragments. Secondary cavities are partially to completely filled by crystals. Primary pores are normally filled by crystalline materials in welded tuffs, but some in non-welded ash flow tuffs remain open. At the time of emplacement, these pores contained volatile fluids that may have provided nutrients for growing crystals or may have facilitated transfer of heat and certain elements in the crystallizing system.

Several crystallization texture elements are visible in ash flow tuff; most of them are similar or analogous to those in lavas. They are grouped into assemblages that can be interpreted to indicate the course of crystallization. The textural elements are described below; for those that are present in both kinds of rocks, the description will stress the differences between their appearance in tuffs and in lavas.

Glass. Glass occurs as basal vitrophyre in some of the ash flows studied. Generally, vitrophyres occur above a poorly exposed internal that may be an

Figure 11

Figure 11. Idealized cross-section of a rhyolite lava flow showing crystallization textures that develop in each part.

unwelded lower part of the ash flow. Internally, most vitrophyres of ash flow tuffs display ghosts of the shards that were welded to form them.

Fibrous textures. Fibrous textures, those that show non-crystallographic branching, are as nearly ubiquitous in ash flows from Southwestern New Mexico as they are in lavas, and they have a similar range of appearances in both types of rock (Figure 12). Smith (1960) and Ross and Smith (1961) describe some such textures, which they call axiolitic and spherulitic. Three major types of fibrous texture can be recognized: axiolitic, flabellar, and bounded flabellar. Axiolitic texture consists of crystals that grow from a line in a fashion similar to that in which spherulites grow, complete with branching in a non-crystallographic fashion. Actually, crystallization in shards, to which Smith (1960), following Zirkel, applied the term axiolitic, proceeds from the outside surface inward. "Axiolitic", as defined, is a remarkably poor description of this habit. It is convenient, however, to retain the term because it is entrenched and because, surprisingly, its meaning has not yet become ambiguous. Axiolitic shards consist of fibers of alkali feldspar and perhaps, quartz that form a symmetrical filling of a shard, growing, inward from the margin to meet at a compromise boundary exactly halfway between shard margins. Quartz also occurs along the central axis of shards. The individual fibers of feldspars radiate from centers of nucleation on the shard margin, but interference with growth from adjacent centers ensures that the fibers of the fringe appear to be nearly parallel.

Figure 12. (Opposite Page) Photomicrograph of textures in the Gillespie Tuff: views of axiolitic textures in shards. a, b plane polarized light and crossed polarizers views of same field, c plane polarized light d, crossed polarizer view. Scales 0.05 mm.

Pumice fragments are commonly also partially crystallized into axiolitic textures, but pumice is never completely axiolitic as shards are. Typically, axiolitic fringes in pumice fragments are less than a tenth of a millimeter thick. The fringe of fibrous crystals of feldspar, and presumably quartz, passes inward into other textures, either spherulites or granular textures. Spherulites in pumice or other glass fragments may be close together or dispersed in a sparry matrix. Where they occur, these spherulites closely resemble those that dominate in crystalline lavas. Their arrangement may preserve a hint of the tubular bubbles of the pumice.

Fibrous textures probably form at high degrees of supercooling in ash flow tuffs, just as do those in lavas. The size of spherulites is an index of the conditions of crystallization. In rocks or patches of rocks that are completely crystallized to spherulites, the size of the individual chumps of fibers is a function of nucleation density. The spacing of nucleation centers may be function of temperature and of water pressure (Fenn, 1977). Considering that the maximum fluid pressures that might be realized in an ash flow tuff undergoing crystallization would be less than few hundred bars, nucleation density is most likely controlled by temperature.

Flabellar texture consists of fibers that display non-crystalline branching and form fans that radiate from a center to form a fraction of the arc of a circle in section, presumably a section of a sphere in three dimensions (Figure 13). The fibers of flabellar texture are longer than the fibers or axiolites or spherulites, ranging up to about 2 mm in exceptional samples.

Figure 13. (Opposite Page) Photomicrographs of flabellar textures from the Gillespie Tuff: Scales a: 0.1 mm, b, c, d 0.05 mm.

They also commonly are bent or curved. Flabellar texture cuts across other textural elements, blithely obliterating shards, pumice, and the spaces between them. Commonly, it nucleates on phenocrysts; in some samples flabellar texture occurs among clots of phenocrysts with other textures dominating elsewhere in the rock.

Flabellar texture probably forms at large degrees of supercooling, but the few nuclei mean that it forms under conditions less favorable for nucleation than does axiolitic texture, perhaps smaller ΔT . Because the fibers grow across textural elements, it must form from both liquid or glassy shards and from vapors that fill spaces between them.

Bounded flabellar texture occurs less commonly than either axiolitic textures or flabellar texture. Its fibers resemble those of flabellar texture in that they are curved and form only segments of arcs, but they differ because they form only within shards. This texture differs from axiolitic texture because it does not form the uniform, symmetrical fibrous fringe that is described as axiolitic. Instead, the fibers originate at various points along the shard margin and grow inward until they interfere with fibers from adjacent or opposite fans. These fans resemble those of axiolitic textures, but grow from fewer nuclei per shard, perhaps because crystallization begins at lower degrees of supercooling.

Granular textures. Druses of alkali feldspar occur as discrete layers on margins of spherulites and other fibrous crystals and occur lining the insides of shards and pumice fragments in positions where they might be mistaken for axiolitic texture (Figure 14). They always occur within glass or in miarolitic cavities. Generally, the drusy crystals are less than a tenth of a millimeter long and are distinctly elongated. Like the equivalent crystals in lavas, these drusy crystals probably grow at lower ΔT than the adjacent fibrous varieties.

Sparry, anhedral, equant quartz and euhedral alkali feldspar occur in the centers of some pumice fragments, and in secondary cavities (Figure 14). In some shards, coarse quartz also occurs, but it is unclear whether this is a result of the same processes that produce the well-developed sparry texture of both lavas and pumice in ash flow tuffs. Commonly crystals of quartz range up to tenths of millimeters in diameter. These textures are interpreted to indicate that crystallization took place at small degrees of supercooling.

Microtexture. Many samples of ash flow tuffs, including both highly welded and virtually non-welded varieties, have fine crystal units of quartz and alkali feldspar filling spaces between glass shards. The units of this texture are a few microns across and appear to consist of small masses displaying one index of refraction that are isolated within material of another index perhaps feldspar within quartz. The individual particles may be spherulitic because between crossed nicols, the texture resembles chert. Commonly, the fine textures are masked by intense iron stain that renders them almost opaque. The mode of formation of this texture is not understood, because it occurs with indicators of either high or low ΔT , and its actual habit has not yet been determined.

Low temperature textures. Clay, opal, zeolites, and some feldspar occur together in non-welded ash flow tuffs that have undergone conversion at low temperature. The processes that cause this conversion lead to textures similar to those described for volcanic sedimentary rocks that undergo alteration in open hydrologic systems (Walton, 1975, 1978). The isopachous rims of clay on the glass shards, followed by opal and zeolite, normally clinoptilolite, rarely mordenite, form a distinctive pattern. These minerals almost certainly form from glassy material that has been cooled to near surface temperatures. Because the coatings form isopachous rims that

resemble textures developed in carbonate rocks that were cemented in the phreatic zone, conversion of the glassy shards probably took place in an environment that lay beneath the water table. Walton (1978) and Henry and Duex (1980) concluded that such conversion does not lead to release of uranium for long distance migration.

Several samples do not have textures that can be conveniently categorized into one of the groups listed above. Notable among them is the abundant authigenic, apparently low temperature feldspar that occurs in the Tuff of Evans Ranch at 'north' Antelope Pass.

Vertical Sequence of Textures in Ash Flows

Above its nonwelded basal part and vitrophyre, the Gillespie Tuff displays a particular sequence of textures. It appears to be similar to a lava flow in that heat is lost both downward and upward with the division plane between these two regimes located below the center of the flow (Figure 15). Just above the vitrophyre in the proximal part of the Gillespie, a thick ash flow tuff, flabellar growths, which destroyed primary texture, are common. Where texture was preserved, sparry quartz and alkali feldspar occurred in the shards, axiolitic-drusy-sparry sequences (ADS textures) in the pumice, and microscopic textures, almost rendered opaque by red dots, presumably iron oxide, occurred in the spaces between shards. Distally, the Gillespie displays only flabellar textures at its base. The central part of the flow in both proximal and distal regions displays textures like those in the basal proximal

Figure 14. (Opposite page) Photomicrographs of axiolitic-drusy-sparry (ADS) texture in pumice grains from the Gillespie Tuff: Each example displays an outer rim of axiolitic alkali feldspar, they may grade into a drusy growth of alkali feldspar and, finally, into a final sparry filling of quartz. d.) Flabellar masses of alkali feldspar that have obliterated the primary pyroclastic texture of a sample of the Tuff of Black Mountain. Scale bars: 0.015 mm.

part. It includes ADS textures in pumice and microscopic textures in spaces between them, but the proportion of flabellar textures is greater. The uppermost preserved part of the Gillespie Tuff contains true axiolites and bounded flabellar textures in shards. In samples from the upper part, pumice displays textures, except in distal parts of the flow where flabellar textures replace both shards and pumice. Inter-shard spaces in the upper parts of flow contain flabellar textures. Figure 14 shows the vertical and lateral relations of conversion textures of the Gillespie Tuff. These should be compared to zones of welding proposed by Smith (1960).

The top part of the Gillespie is apparently not preserved because the highest exposures contain partially welded shards. Textures that occur in the uppermost parts of ash flows or in less welded tuffs have been deduced from observations of the Tuff of Black Mountain, which fills the Rodeo cauldron, and from the Bluff Creek Formation. Unfortunately, no exposures of the base of Tuff of Black Mountain flow were visited and samples were collected more in an areal fashion from this unit than vertically through it. Consequently, vertical relations of textures described here are not completely documented.

The Tuff of Black Mountain contains a variety of conversion textures that are made up of alkali feldspar, quartz, opal, clinoptilolite, and clay. Flabellar textures which either destroy all evidence of glass fragments or are associated with ADS pumice fragments are common. Fibers of these fan-like masses range from 0.1-0.8 mm and are not as large as the largest flabellar masses of the Gillespie Tuff. The fans display indistinct areas

Figure 15. Vertical and lateral arrangement of microscopic textures developed in an idealized welded ash flow tuff. Based mostly on the Gillespie Tuff.

Figure 15

of differing grain size or texture that may be ghosts of pyroclastic grains. ADS textures occur in pumice and microcrystalline textures occur in spaces between glass grains in some rocks that contain areas where flabellar textures have obliterated evidence of glass grains. Rocks displaying these textures are only partially welded. The products of conversion are quartz and alkali feldspar.

Rocks in which pumice and glass fragments are not welded generally contain opal and a zeolite, generally clinoptilolite. A few ash flow samples from southwestern New Mexico contain anthigenic feldspar. These minerals occur in poorly displayed paisley textures or in a variety of less easily described arrangements. Zeolites, opal, and clay indicate rather low temperatures of formation, perhaps best described as diagenetic rather than as primary crystallization textures. Some samples display textures that almost certainly developed by solution of the glass followed by reprecipitation of some constituents. These textures form at temperatures low enough for water to be present in liquid form. In some rocks that contain zeolites between shards, the shards themselves are axiolitically recrystallized to quartz and alkali feldspar.

Interpretation of Ash Flow Textures

This vertical sequence of textures suggests that crystallization of the lower parts of these flows was similar to that of lava flows: fine microtextures, fibrous textures with non-crystallographic branching indicate that the degree of supercooling in the lowermost parts was high and remained so, except at the centers of some pumice fragments that appear to have successfully trapped heat and undergone final crystallization at near liquidus conditions. Individual shards contained too little material to warm themselves during crystallization or they lost the latent heat that was

released through their relatively large surface. At the center of ash flows, the lower abundance of microgranular textures implies a lower supercooling, but otherwise similar conditions must have obtained with rapid heat loss because the flabellar textures do not generally revert to coarser crystals outward. Only within pumice grains did heat accumulate and permit growth of coarse crystals. The upper part of ash flows display textures that form at high degrees of supercooling or after the ash flow cooled to near surface temperature.

Uranium Variation in Some Lava Flows

Because of their more simple nature as a crystallizing system, the uranium content and variability of lava flows will be considered first. We have collected enough samples to employ a statistical approach to determine if our results imply significant depletion or might be the result of random sampling. The lava flows under consideration are rhyolites that occur near the top of the thick sequence of volcanic deposits in each of several caldrons. Most are interpreted as products of ring fracture eruptions late in history of calderas in which they occur, (Deal and others, 1978; Erb, personal communication, 1979). Seven sections through four flow units were sampled: one section from each of the Rhyolite of Packer's Trail, the Rhyolite of Pine Canyon, and the Rhyolite of Evans Ranch, and four sections from the Rhyolite of Clanton Draw. Samples were collected from both the crystalline and glassy portions of the flow. Because the unaltered vitrophyre is assumed to represent the primary concentration of uranium (Zielinski and others, 1977; Zielinski, 1978), statistical comparison between the vitrophyre and the crystalline portion of the flow should determine if uranium has been released. Uranium concentrations of the samples are listed in Table 11.

Each sample was examined under a polarizing microscope and assigned to one of four textural types. Each textural type represents a different pro-

cess of formation as explained above:

- 1) Vitrophyres. This category includes volcanic glasses that show no sign of secondary alteration by groundwater. The water content of the glass was not determined, but the vitrophyres did not display the waxy luster characteristic of perlites. Internally, some did have curving 'perlitic' cracks.
- 2) Altered vitrophyres are composed primarily of glass, but also contain secondary, low temperature minerals such as opal or calcedony.
- 3) Fibrous/microspherulitic texture are those that indicate continuous cooling after extrusion. These textures are composed of fibrous alkali feldspar crystals that show no increase in size along their length. The fibers do not form large spherulites (i.e. not greater than 1 mm diameter) and do not grade outward into coarser textures. In many samples, individual mineral fibers are too small to be resolved under the polarizing microscope. The fibers may be arranged into very small spherulites, termed microspherulites, or in plumose or flabellar masses.
- 4) Spherulitic-Drusy-Sparry (SDS) texture is composed of spherulites that grade outward into drusy laths of feldspar and finally into sparry quartz and feldspar. The mineral fibers become progressively coarser away from the center of the spherulite. This texture indicates a rise in temperature during crystallization. The rise in temperature occurs as latent heat of crystallization is released.

Combining the observations from the four flow units would provide a larger sample size and is therefore desirable. However, before combination, the four flow units must be compared to determine whether they contain the same primary uranium concentration. Altered vitrophyres were excluded from the analysis because a study of the effect of crystallization processes on uranium release should not include samples showing obvious low temperature groundwater alteration.

Table 11 presents the raw uranium concentrations for each of the sections. An analysis of variance was used to test for differences between the mean uranium concentrations of the four flow units. Table 12 gives the results of this series of tests. The test for significance was positive, thus rejecting the null hypothesis that the uranium concentrations of the flows are equal. Therefore, the four flow units cannot be combined to test for differences in uranium between textural types.

A Student-Newman-Kuels test was performed to determine which lava flows were significantly different from each other. The results indicate the Rhyolite of Clanton Draw has more uranium than the other three flows. The Rhyolite of Packer's Trail and the Rhyolite of Pine Canyon have equivalent uranium concentrations. The Rhyolite of Evan's Ranch contains less uranium than the other three flows. Bartlett's test homogeneity of variances was performed before the analysis of variance to be sure the samples were homoscedastic.

In the same manner the differences between the four sections of the Rhyolite of Clanton Draw were compared using a one way analysis of variance (Table 13). The Rhyolite of Clanton Draw was selected because it has the largest sample size. The analysis of variance yielded no significant results. Therefore, the null hypothesis that the uranium concentrations of the four sections are equal is accepted. All the sections from the Rhyolite of Clanton Draw can be combined to test for differences in uranium concentrations between textures.

An analysis of variance was used to test for the differences in uranium concentration between vitrophyres (primary uranium concentration), fibrous/microspherulitic texture (continuous cooling), and SDS texture (temperatures rises during crystallization) (Table 14). The results of the analysis of variance were not significant. Therefore, it must be concluded that the processes

TABLE 11. U-CONTENT OF FLOW ROCKS

Rhyolite of Clanton Draw			Rhyolite of the Packers Trail		Rhyolite of Pine Canyon		Rhyolite of Unit of Antelope Pass	
Sample #	U (ppm)	Texture	Sample #	U (ppm)	Sample #	U (ppm)	Sample #	U (ppm)
Geronimo B Section			257	7.6	453	5.6	428	3.9
420	8.0	SDS	259	7.8	456	6.0	430	4.6
421	5.6	FM	261	7.9	459	6.5	432	4.6
423	7.3	SDS	262	8.8	460	6.5	434	3.8
424	8.6	V	263	8.0	461	6.7	436	5.9
418	8.4	FM	334	5.1	462	8.8	437	6.3
417	8.5	V	333	4.7	n = 6		438	6.0
			332	8.2	mean = 6.68		n = 7	
					S ² = 1.238		mean = 5.01	
							S ² = 1.078	
Geronimo A Section			331	4.2				
239	8.2	SDS	330	8.9				
236	6.7	FM	230	7.0				
235	8.7	V	232	4.8				
234	8.6	V	229	5.8				
			228	6.4				
			n = 14					
			mean = 6.80					
			S ² = 2.609					
Pendleton Section								
475	8.6	FM						
474	9.8	V						
472	9.1	FM						
470	7.6	FM						
468	7.8	FM						
465	8.6	V						
Cloverdale Section								
385	7.2	SDS						
387	8.8	SDS						
388	9.6	SDS						
389	7.1	SDS						
390	6.7							
391	10.0	FM						
392	9.5	FM						
393	9.4	FM						
			n = 24					
			mean = 8.27					
			S ² = 1.209					
Textures: SDS = Sphuralitic-drusy-sparry								
FM = fibrous microspherulitic								
V = Vitrophyre								

TABLE 12. TESTS OF SIMILARITY OF U-CONTENT BETWEEN RHYOLITE UNITS

A. Bartlett's test for homoscedasticity (data from Table 11).

Unit	n	S^2
Rhyolite of Clanton Draw	24	1.209
Rhyolite of Packer's Trail	14	2.609
Rhyolite of Pine Canyon	6	1.238
Rhyolite of Evan's Ranch	7	1.078

$$\chi^2 = 3.011 \text{ ns}$$

$$\chi^2_{0.05,3} = 7.815$$

B. Analysis of Variance

Source of Variation	df	SS	MS	F _α
Among Groups	3	64.5396	21.513	13.59***
Within Groups	47	74.3902	1.5828	
Total	50	138.9298		

H₀: $\mu_1 = \mu_2 = \mu_3 = \mu_4$ - rejected

H₁: one or more of the means are different - accepted

C. Student-Newman-Keuls comparison among means

Rank	Mean	$\frac{1}{8.267}$	$\frac{2}{6.800}$	$\frac{3}{6.683}$	$\frac{4}{5.014}$	Rank Group mean
1	8.267	---				
2	6.800	1.467*	---			
3	6.683	1.584*	0.117ns	---		
4	5.014	3.253*	1.786*	1.669*	---	

1 = Rhyolite of Clanton Draw

2 = Rhyolite of Packer's Trail

3 = Rhyolite of Pine Canyon

4 = Rhyolite of Evan's Ranch

Mean uranium concentration: $1 > 2 > 3 > 4$

which have converted the glassy or liquid lava of the rhyolite of Clanton Draw into crystalline material cannot be demonstrated to release uranium.

Most previous studies of uranium mobility in rhyolites have simply compared concentrations in felsite with those in associated glasses. Because of the design of those studies, it is appropriate to compare all of our felsite samples from the Rhyolite of Clanton Draw with all of our glass samples from that unit. This can be done with a t-test, once the similarity of variance of the samples sets is established, by an F-test. Both were conducted using BMDP3D at the KU Academic Computation Center. The F-test results show that the variances are the same ($p = 0.353$) and the t-test indicates that the mean uranium content of the sample groups are not significantly different ($p = 0.17$, Table 15). The mean of the crystalline samples (8.1 ppm) however, is slightly, but not significantly below that of glass samples (8.8 ppm). Previous studies (Rosholt and others, 1971; Zielinski and others (1977; and Zielinski, 1978) have used only one to four analyses of the vitrophyre and up to 5 analyses of the felsite. In none is statistical analysis of the results attempted.

The concentration of twenty major, minor, and trace elements in sample with fibrous microspherulitic texture was compared to that in samples with SDS texture (Table 15). No significant difference exists between the two textures for any of the elements. Therefore, the same final chemical composition occurs regardless of whether the crystallizing flow cools continuously or actually rises in temperature. Comparison of glass with crystalline material, however, shows a variety of changes of composition: lower Ca, Mg, P, Ti, and higher Li in the crystalline material than in the glass.

Finally, vitrophyre containing calcedony or opal was compared to the other textures. All the vitrophyres showing low temperature secondary

TABLE 13. TESTS OF SIMILARITY OF U-CONTENT BETWEEN
FLOWS OF THE RHYOLITE OF CLANTON DRAW.

A. Bartlett's test of homoscedasticity (data from Table 11)

	n	s ²
Geronimo A section	4	0.8567
Geronimo B section	6	1.3187
Pendelton section	6	0.6657
Cloverdale section	8	1.7484

$$\chi^2 = 1.3561 \text{ ns} \quad \chi^2_{0.05, 3} = 7.815$$

B. Analysis of variance between flows of Rhyolite of Clanton Draw

<u>Source of variation</u>	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>Fs</u>
Among Groups	3	3.0829	1.0276	0.8310ns
Within Groups	20	24.7304	1.2365	
Total	23	27.8133		

$$F_{0.05, 3, 20} = 3.10$$

H₀: $\mu_1 = \mu_2 = \mu_3 = \mu_4$ accepted

TABLE 14. TESTS OF SIMILARITY OF URANIUM CONTENT BETWEEN TEXTURES OF THE RHYOLITE OF CLANTON DRAW

A. Data

<u>Vitrophyre</u>		<u>Fibrous/microspherulitic</u>		<u>SDS</u>	
Sample no.	U	Sample n.	U	Sample no.	U
0235	8.7	0391	10.0	0388	9.6
0234	8.6	0392	9.5	0387	8.6
0424	8.6	0236	6.7	0385	7.2
0417	8.5	0418	8.4	0239	8.2
0474	9.8	0421	5.6	0420	8.0
0465	8.6	0393	9.4	0423	7.3
		0472	9.1	0389	7.1
		0475	8.6		
		0470	7.6		
		0468	7.8		
				n=7	
				s ² =0.8624	
		n=10			
		x=8.27			
		s ² =1.87344			

B. Bartlett's test for homoscedasticity.

<u>Texture</u>	<u>n</u>	<u>s²</u>
Vitrophyre	6	0.2440
Fibrous/microspherulitic	10	1.8734
SDS	7	0.8624

$$X^2=5.004ns \quad X^2_{0.05,2}= 5.991$$

C. Analysis of variance between textures for Rhyolite of Clanton Draw

<u>Source of variation</u>	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F_s</u>
Among Groups	2	1.99688	0.99844	0.8586ns
Within Groups	20	23.25529	1.16276	
Total	22	25.25217		

H₀: μ₁=μ₂=μ₃ accepted

TABLE 15. COMPARISON OF FELSITE AND GLASS COMPOSITION
FOR THE RHYOLITE OF CLANTON DRAW.

Element		mean	standard deviation	t-values	
				FM vs SDS	All felsite vs. All glass
Al	FM	5.61%	0.61	0.20ns	-0.26 ns
	SDS	5.54	0.81		
	AF	5.58	0.74		
	V	5.67	0.47		
Ra	FM	1.56 ppm	121	0.32 ns	-2.04 ns
	SDS	135.	158		
	AF	149	135		
	V	267	68		
Ca	FM	0.28%	0.043	1.18 ns	-5.59***
	SDS	0.24	0.079		
	AF	0.27	0.058		
	V	0.41	0.036		
Fe	FM	0.86%	0.17	1.00 ns	-101 ns
	SDS	0.93	0.11		
	AF	0.88	0.14		
	V	0.82	0.014		
Li	FM	49.5 ppm	24	0.03 ns	3.61***
	SDS	43	17		
	AF	44	19		
Mg	FM	0.06%	0.05	0.41 ns	-2.15**
	SDS	0.04	0.05		
	AF	0.05	0.05		
	V	0.10	0.03		
Mn	FM	391 ppm	156	0.03 ns	0.05 ns
	SDS	388	147		
	AF	394	154		
	V	362	18		
Na	FM	2.08%	0.36	-0.88 ns	1.79 ns
	SDS	2.24	0.39		
	AF	2.16	0.36		
	V	1.88	0.18		
Nb	FM	52. ppm	36	-0.72 ns	1.87 ns
	SDS	64.4	34		
	AF	58.	35		
	V	31	3		

TABLE 15. Continued

P	FM	46 ppm	27	0.24 ns	
	SDS	42	22		
	AF	44	25		-2.07**
	V	67	20		
Th	FM	29 ppm	2.9	0.50 ns	
	SDS	28	2.0		
	AF	28	2.4		-1.06 ns
	V	29	2.2		
Ti	FM	837 ppm	298	0.59 ns	
	SDS	731	442		
	AF	788	356		-2.68**
	V	1183	40		
Y	FM	58 ppm	29	-0.50 ns	
	SDS	65	32		
	AF	62	30		1.46 ns
	V	44	2.6		
Zn	FM	54 ppm	28	-0.14 ns	
	SDS	56	36		
	AF	56	31		0.91 ns
	V	43	6		
Zr	FM	136 ppm	40	0.01 ns	
	SDS	136	25		
	AF	137	32		-1.26 ns
	V	155	23		
K	FM	2.96%	0.44	-0.23 ns	
	SDS	3.00	0.46		
	AF	2.97	0.41		0.67 ns
	V	2.85	0.34		
Sr	FM	27 ppm	19	0.57 ns	
	SDS	21	24		
	AF	25	21		-0.57 ns
	V	56	12		
Ce	FM	129 ppm	19	1.85 ns	
	SDS	110	24		
	AF	122	22		-1.21 ns
	V	133	5		
U	FM	8.3 ppm	1.4	ns(Table 14)	
	SDS	8.0 ppm	0.9		
	AF	8.1	1.2		-1.42 ns
	V	8.8			

FM = Fibrous/microspherulitic, SDS = Spherulitic-drusy-sparry,
 AF = All Felsites, V = Vitrophyre. ns = not significant,
 ** significant, ($p < 0.05$), *** high significant ($p < 0.01$)

minerals are from the Rhyolite of Clanton Draw and therefore their uranium content can be compared to that of other textures found in the flow. The mean uranium concentration of the altered vitrophyres at 8.93 ppm, was similar to the uranium concentrations in the other textures. However, the variance of the altered vitrophyres was highly significantly greater than of the other textures. This indicates that low temperature groundwater alteration causes a redistribution of the uranium with no demonstrable net gain or loss. The results of the F-test used to test the variance between textures is presented in Table 16.

The statistical analysis of chemical data for four flow units in Hidalgo County, New Mexico led to the following conclusions concerning the distribution and release of uranium from rhyolitic lavas:

- 1) The Rhyolite of Clanton Draw contains significantly more uranium than the other three flow units considered. The Rhyolite of Packer's Train and the Rhyolite of Pine Canyon contain the same uranium concentration. The Rhyolite of Evans' Ranch contains significantly less uranium than the other three flow units.
- 2) All the sections collected from the Rhyolite of Clanton Draw have the same mean uranium concentration.
- 3) Glass and felsites of the Rhyolite of Clanton Draw do not have significantly different uranium concentration. Consequently, neither primary crystallization nor later reaction with ground water has been shown to release uranium from it.
- 4) The same ultimate distribution of elements will result whether a lava flow cools continuously or rises in temperature due to release of latent heat during crystallization.
- 5) Alteration of vitrophyre by weathering causes a redistribution of uranium, though no clear net gain or loss.

TABLE 16. COMPARISON OF THE URANIUM CONCENTRATION VARIANCE BETWEEN TEXTURES SHOWING NO SECONDARY ALTERATION AND ALTERED VITROPHYRE FOR THE RHYOLITE OF CLANTON DRAW.

<u>Texture</u>	<u>s²</u>	<u>df</u>	<u>F</u>
Vitrophyre	0.2440	5	157.3***
Altered Vitrophyre	38.38	3	
SDS			
Altered Vitrophyre	0.8624	6	44.5***
	38.38	3	
Fibrous/microspherulitic	1.873	9	20.49***
Altered Vitrophyre	38.38	3	

*** Highly significant: Variance within data sets differ greatly

These results are in marked contrast to those of Zielinski (1978), Zielinski and others (1977) and Rosholt and others (1971) because of all of those papers described depletion of uranium in felsites with respect to associated glasses. They are also in conflict with our own preliminary results, which were interpreted to indicate loss of uranium to a vapor phase that formed during crystallization (Walton and others, 1980b).

In general, the lack of significant depletion of uranium indicates that lavas are not good sources of uranium for secondary deposits. Even if the slightly lower concentration of uranium in the felsites (8.1 ppm) were significantly different from that in the glasses (8.8 ppm) it would imply that only about 0.7 grams of U had been removed from each ton of rock. If this had happened during crystallization, the U would have been disseminated into the atmosphere. Had this loss occurred slowly as Zielinski (1978) suggests, it would imply an average leaching of 0.03 gm of U/ 10^6 years/ton of rock for these early Miocene flows, with the result that the uranium would not be concentrated.

According to Lipman (1965) low temperature reactions of groundwater with vitrophyres of alkaline rhyolites result in depletion of Na and concentration of Al compared to associated felsites. Lipman and others (1969) indicate that loss of alkalis, Na and K, was negligible in several sample pairs of vitrophyres and felsites from four calcalkalic rhyolitic lava flows. Our results indicate no significant differences in Na, Al, or K contents when felsites and glasses from the Rhyolite of Clanton Draw are compared, despite the fact that the average sodium content of crystalline material is about 0.3% greater than that of glasses. Perhaps the contradictory results mentioned above are a result of small sample size in both previous reports, rather than a difference between effects of processes on rocks of different compositions.

Assuming, however, that Lipman's (1965) conclusions are correct that reaction with groundwaters at low temperature leads to loss of Na and gain of Al in vitrophyres, we can find no evidence of such reactions in the small changes of Na and Al that we find in our samples. Consequently, weathering has not affected our samples except those with obvious secondary minerals.

The results of our study of the Rhyolite of Clanton Draw indicate it is unlikely to have functioned as a source of uranium for major deposits. Slight redistribution of uranium has occurred at its margins and perhaps within it, but not even a small loss can be demonstrated to have occurred.

Rhyolite Lavas as Sources of Uranium

Several studies have suggested depletion of uranium from rhyolite lavas (Rosholt and others, 1971; Noble, 1969; Shatkov and others, 1970; Zielinski and others, 1977; Zielinski, 1978) compared to coexisting felsites. None of these has shown consistent, large scale depletion and none has included statistical analysis of the chemical results. Because the magnitude of the greatest difference we report (9.8 ppm in one vitrophyre, 5.6 in one felsite) are similar to the greatest reported elsewhere, but our results do not reveal any significant differences, we believe that previous studies may not indicate the true extent of uranium depletion. In general, we believe that the case for felsitic rhyolite lavas being depleted in uranium with respect to associated glasses is not established. No evidence exists that lavas have acted as sources of uranium for secondary deposits in southwestern New Mexico.

Uranium Variation in the Gillespie Tuff

Forty-three samples of the Gillespie Tuff were divided into five groups according to the predominant texture present in the crystallized pumice fragments and the predominant texture present in the crystallized glass shards in each sample (Table 17). These five groups included: (1) samples that

TABLE 17. ELEMENT CONCENTRATIONS IN THE GILLESPIE TUFF

		U ppm	Al %	Na %	Ca %	K %	Ce ppm	Li ppm	Nb ppm	Sr ppm	Th ppm	Ti ppm	V ppm	Y ppm	Zr ppm
All samples n = 43	M	4.17	5.81	1.88	.73	2.64	80	20	12	114	17	1260	13.1	18.4	51
	SD	1.20	.53	.15	.30	.29	16	6	3.7	64	3.7	590	7.9	2.2	9.3
Vitrophyre n = 6	M	5.80	5.45	1.92	.59	2.32	57	10	13	70	18	780	5.5	16.7	44
(1)	SD	.50	.47	.19	.18	.13	8	2	2.4	34	3.8	240	3.8	1.1	2.8
All felsites n = 37	M	3.91	5.83	1.88	.74	2.67	nd	nd	nd	nd	nd	nd	nd	nd	nd
(2,3,4,5)	SD	1.04	.52	.15	.31	.28									
All with ADS texture n = 31	M	4.06	5.81	1.88	.73	2.67	80	20	12	114	17	1290	13.1	18.5	51
(2,3,4)	SD	1.06	.52	.15	.30	.29	15	6	2.7	63	3.6	570	7.8	2.2	9.2
ADS/Spar n = 14	M	3.98	5.89	1.91	.78	2.63	nd	nd	nd	nd	nd	nd	nd	nd	nd
(2)	SD	1.00	.65	.16	.35	.30									
ADS/Axiolitic or ADS/ADS n = 9	M	4.61	5.56	1.86	.70	2.80	nd	nd	nd	nd	nd	nd	nd	nd	nd
(3)	SD	1.10	.30	.16	.26	.23									
ADS/Flabellar n = 8	M	3.59	5.99	1.85	.62	2.61	nd	nd	nd	nd	nd	nd	nd	nd	nd
(4)	SD	.72	.33	.07	.19	.29									
Flabellar only n = 6	M	3.12	5.97	1.90	.81	2.67	81	16	11	178	15	2450	13.8	19.2	49
(5)	SD	.61	.50	.14	.33	.23	15	6	2.8	163	4.6	270	4.2	2.4	4.7

1. Samples 0394, 0303, 0338, 0224, 0374, 0267. 2. Samples 0395, 0396, 0400, 0401, 0403, 0404, 0405, 0342, 0220, 0376, 0379, 0268, 0276, 0221. 3. Samples 0408, 0409, 0411, 0413, 0340, 0266, 0277, 0397, 0337. 4. Samples 0304, 0439, 0442, 0443, 0447, 0448, 0219, 0217. 5. Samples 0223, 0450, 0451, 0339, 0310, 0278. M = Mean, SD = Standard Deviation.

were completely glassy, designated Vitro; (2) samples with ADS textures present in the pumice fragments and sparry preservation of the glass shards, ADS/Spar; (3) samples with ADS preservation of the pumice fragments and either ADS or axiolitic preservation of glass shards, ADS/ADS and ADS/Axio; (4) samples with ADS present in the pumice fragments and glass shard replacement by flabellar growth ADS/Flab; and (5) samples in which flabellar growth was the dominant textural replacement in the pumice fragments and glass shards, Flab. These textures generally occur in this order upward through a section of the Gillespie Tuff, but not all are present in all sections (Figure 16). Textures found higher in the section are the ones most frequently missing. Their presence in other, less densely welded ash flows suggests that erosion has removed the top of the Gillespie.

The average concentrations of various elements in these groups and the standard deviation of these groups are given in Table 17. It is clear from this table that uranium is less abundant in crystallized rock than in glass in the Gillespie Tuff, by about 30%; the vitrophyres containing an average of 5.8 ppm and the felsites containing 3.9. The rocks with ADS textures, however, appear to contain slightly more uranium than those with only flabellar texture by 4.1 ppm to 3.1 ppm, a difference of about 25%. Differences of comparable magnitude between glass and felsite are not visible in the major elements Al, Na, Ca, and K, or the trace elements Nb, Th, Y, or Zr, but large differences are reported for the trace and minor elements Ce, Li, Sr, Ti and V.

Several causes may effect the chemical changes reported in these rocks, among them original magmatic variations, perhaps related to a zoned magma chamber, lateral facies variations, processes that occurred during crystallization, and post-emplacement processes; either local hydrothermal alteration or reactions with cool groundwater or during weathering. Before these processes

can be examined in turn, it is necessary to determine whether the results are to be expected by randomly sampling the Gillespie Tuff or whether the samples were indeed drawn from different populations.

Analysis of variance indicates that the differences of concentration of uranium and several other elements, between groups of samples from the Gillespie Tuff are so great that their being drawn from the same universe is unlikely (Figure 16). However, some elements have concentration differences between groups that indicate they are from the same population. These analyses were done with the Honeywell 66/60 computer at the University of Kansas, using KUACC:ANAV 1 program for one way analysis of variance. As shown in Figure 16, the uranium concentration of samples containing ADS textures is significantly different from those containing only flabellar textures or those containing only vitrophyre. The degree of confidence of the difference was 95% for the difference between the rocks containing only flabellar textures and those containing ADS textures, and 95% between those containing flabellar textures only and glass. Similarly, the lower concentrations indicated for the rocks containing ADS textures compared to glasses is significant at the 99% level.

Samples on which the evidence for depletion is derived came from within the Cowboy Rim Cauldron, the presumed source of the Gillespie Tuff (Deal and others, 1978) and from the outflow areas of the unit, in the Alamo Hueco Mountains and in the Sierra San Luis. Consequently, areal facies differences are unlikely to be the reason for the observed differences of U-content. Furthermore, the depletion of U is found in samples taken a short distance above the vitrophyre as well as stratigraphically quite high above it and consequently the differences cannot easily be traced to original differences of the concentration of U. Finally, the broad area which the samples represent seems to preclude local effects such as hydrothermal alteration related to caldera

<u>Ce</u>		<u>Li</u>		<u>Nb</u>		<u>Sr</u>		<u>Th</u>	
Vitro	] *** [ns	Vitro	] ns [ns	Vitro	] ns [ns	Vitro	] ns [ns	Vitro	] ns [ns
ADS		ADS		ADS		ADS		ADS	
Flab		Flab		Flab		Flab		Flab	
<u>Ti</u>		<u>V</u>		<u>Y</u>		<u>Zr</u>			
Vitro	] ** [**	Vitro	] ** [ns	Vitro	] * [ns	Vitro	] * [ns		
ADS		ADS		ADS		ADS			
Flab		Flab		Flab		Flab			

EXPLANATION:

*** - concentration different at
1% significance level

** - Concentration different at
5% significance level

* - concentration different at
10% significance level

ns - concentration not significantly
different. See Table 17 and text
for definition of groups.

activity as a reason for observed difference.

Analysis of variance done with Ca, Na, and Al, show no significant differences in concentration except that a significant difference in Al concentration occurs between one pair of subsamples of the set containing ADS texture concentration. This can be interpreted to indicate that post emplacement mobility of these major elements has either been the same in all rocks--which seems unlikely considering the disparate nature of the elements--or has not occurred. Potassium is significantly less abundant in vitrophyre than in felsites of the Gillespie Tuff.

Lipman (1965) has shown that weathered volcanic glasses are selectively enriched in aluminum and depleted in sodium compared to coexisting felsites. He attributes this to weathering and other low temperature processes that mobilize sodium from glasses but not aluminum. In order to detect the changes of Al-concentration between glasses and felsites, Lipman (1965) used analyses recalculated on a water-free basis. Our analyses have not been so treated, but show a larger percentage change in the opposite direction - the vitrophyre samples have lower, but not significantly lower, Al-content. Lipman (1965) suggests that K is slightly enriched in glasses relative to felsites. This is the opposite of our result. The lack of appropriate differences of elemental composition in the Gillespie suggest that the effect of weathering and low temperature alteration on this unit has been small. If weathering and low temperature alteration have not affected the major element system, it is difficult to conclude that it has affected the trace element systems. The cause of depletion of U in these rocks must be found elsewhere.

Further information on the geochemistry of the uranium mobility in the Gillespie might come from consideration of the suite of elements as a whole. A correlation matrix for the entire set of Gillespie Tuff analyses, 60 in all, was calculated at ORNL (Appendix 5). This matrix gives both Pearson and

Spearman coefficients. The cluster diagram in Appendix 5 is based on absolute value of correlation coefficients. The Oak Ridge linear correlation matrix shows a significant positive correlation between U on one hand and Nb, Th, Be, and Li on the other and significant negative correlations between U and Al, Ce, Fe, V, Ca, Sr, P, and Mg, in the Gillespie. Uranium and Th behave similarly at high temperatures, but not at low temperatures: The reduced forms of the elements are chemically similar at high temperatures, but the oxidation of U occurs at low temperatures and the two elements commonly are separated by low temperature processes. The correlation between U and Th suggests high temperature mobilization of both, but no low temperature mobility of U. The correlation of these two elements is in fact inhibited because by the low precision of Th analyses by the technique used in this study: the coefficient of variation for Th in two sets of standards run at the same time as our samples are .80 and .26 (Table 6). Niobium, Be, and Li are elements concentrated into late stage magmatic differentiates, into pegmatites, or into volatile-rich concentrates, suggesting that they do not easily fit into lattices of minerals that form early in crystallization or into quartz and feldspar that are major products of main stage. Correlation of these elements with U and Th, which may behave similarly, suggests some form of volatilization as the primary means of U-mobilization.

Experimental and field study has shown that the uranium concentration of vitrophyres is unaffected by weathering and low temperature hydration (Zielinski, 1978, 1979). Because the real differences between U-content of felsites and glass cannot be traced to original differences, to lateral differences or to primary vertical differences within the tuff, or to post-emplacment weathering or reactions with groundwater, they must have come about as a result of the processes of crystallization that have affected the Gillespie.

Traditionally, crystallization processes are described as devitrification, vapor phase crystallization, and granophyric crystallization, following Smith (1960). Our description of the crystallization textures of the Gillespie Tuff do not permit facile classification of rocks according to which into these processes dominated in its crystallization history. Furthermore, our results are somewhat different than those of other studies of U mobility during crystallization of ash flows.

Henry (1978) described U-mobility in volcanic rocks from the Trans-Pecos Volcanic Field of Texas. He found that neither vapor phase crystallization nor devitrification led to noticable depletion of uranium in the ash flows he studied. These processes were probably akin to those that produced axiolitic textures, flabellar textures, and microtextures in the Gillespie. Henry (1978) did find that uranium was noticably reduced in rocks that displayed granophyric textures similar to our ADS textures. Our results differ considerably from those of Henry because we found depletion in all crystallized rocks, with greatest depletion in those in which he demonstrated none: rocks with axiolitic, flabellar, and microtextures.

In terms of U-mobility, the Gillespie Tuff and the Rhyolite of Clanton Draw differ in one major way: it is obvious that the Gillespie has lost some of its original uranium, but no loss can be demonstrated from the Rhyolite of Clanton Draw. Because the two units display analogous textures developed during crystallization, it is likely that the nature of the effects of weathering or low temperature reaction with groundwater upon them is very similar. This is yet another reason for believing that the major release of uranium, if it is going to occur, will take place early in the post-emplacement history of volcanic rocks.

The major difference between the crystallization of a lava flow and that of an ash flow lies in the abundance of the vapor phase in the ash flow. The

vapor is highly mobile and atoms or molecules within it are similarly able to move about. The result is that elements that cannot easily fit into the lattices of growing minerals are not trapped between crystals, but can escape to concentrate in the vapor. If this vapor is released, it will take those elements, or a fraction of them, with it. The difference of concentration between the two textural groups of ash flows, those with ADS texture and those without, might be a result of trapping of the volatiles. The patches of ADS texture lie at the center of pumice shards and are not connected. Because ADS patches are so much coarser than adjacent textures, those areas must have been completely crystallized when the ADS textures formed in pumice at a higher temperature. The small areas where ADS textures occur could have retained volatiles or uranium just as they must have retained heat.

Ash Flows as Sources of Uranium

The implication of our conclusions is that there is little prospect of The Gillespie Tuff acting as a source of uranium for secondary deposits. The high temperature loss is extensive, but probably the uranium moves into the atmosphere along with volatiles and complexing agents, as suggested by Rosholt and others (1971). Weathering and low temperature reaction with ground water have had little noticeable effect on uranium concentration in the Gillespie. Non-welded ash flows will not act as sources if they convert to zeolites and opal in some phreatic diagenetic reaction (Walton, 1978). Only if non-welded ash flows react extensively in the vadose zone will they release large amounts of uranium (Walton and others, in review).

Ash flow tuff is the most common outcropping rock type in the mountaneous regions of the part of Southwestern New Mexico described in this report. Most of the thin sections of these tuff studied during our investigation displayed

either the high temperature textures described from the Gillespie or textures that indicate phreatic diagenesis. A sample of the Tuff of Black Mountain displayed extensive low temperature silicification to opal, but no obvious loss of uranium. No paleosols were observed in the field and no vadose textures detected in thin section in any of the ash flows of the area.

Uranium Mobility in Southwestern New Mexico

The predominant outcropping rock types in the mountains of Southwestern New Mexico are rhyolitic lavas and silica-rich ash flow tuffs. These units contain an average of about 5 ppm U and might therefore function as sources of uranium for deposits. Unfortunately, little evidence supports the idea that they were effective in providing uranium for concentration into deposits:

1) Lava flows that were studied showed no significant loss of uranium. Previous studies that indicated loss of uranium from lavas do not include statistical testing of the data. Our results suggest some local mobility of uranium near uranium-rich lavas, but this could not be confirmed statistically. The small amount of movement appears inadequate to form major deposits.

2) Welded ash flow tuffs are depleted in uranium with respect to associated glasses, but chemical analyses for other elements and comparison with lavas show that the loss occurred while the tuffs crystallized, probably dispersing the uranium into the atmosphere. Not even small scale mobility of the kind that might lead to deposits was detected.

3) Some areas of interbedded air fall tuffs and sediments containing abundant pyroclastic debris occur in the outflow facies of the large caldera complexes, notably in the Alamo Hueco/Dog Mountains area and in the Coyote Hills. Walton and others (in revision) stress that such rocks do not release uranium during diagenesis in the phreatic zone, but rather during soil forming processes and during diagenesis that occurs in the vadose zone. No evidence of soil or vadose textures was discovered in those areas.

These negative results from source rock analysis can be interpreted as suggesting that no secondary deposits would be found in the area that resulted from uranium removed from the volcanic section by low temperature processes. However, this conclusion is tentative for a large number of reasons. By far the most important of these is that the functional source rock method is still under development; in fact, this study is part of that development. Second, the idea that uranium is removed from felsites in low temperature environments is suggested by a number of studies, but not demonstrated in this one. A rigorous, well designed investigation of mobility of uranium and other in volcanic rocks has yet to be conducted. Several such studies of the whole question of element mobility during and after crystallization of lavas and tuffs are desperately needed.

RECOMMENDATIONS

1.) Several areas within the Bootheal region of New Mexico give clear indication of anomalous uranium concentrations: the Dog Mountains area, the Apache Hills, and the Granite Gap-Twelvemile Wells area all are identified by a combination of information from PRR's, HSSR data, and the results of this investigation. Further work in these areas should be directed at confirming and focusing the anomalies, determining which kinds of deposits could be present and attempting to find them on the basis of such exploration models (Figure 7).

2.) Other areas show high concentrations of uranium, especially 'north' Antelope Pass, the Trail Creek - Burro Pass area, and the area of outcrop of the Rhyolite of Clanton Draw. These areas bear further investigation, but give too few indications of uranium to justify them as major targets of exploration in themselves at this time (Figure 7).

3.) The geochemical sampling approach used in this report has not identified any areas of anomalous uranium that were not already known from previous information, and only detected one new area of high uranium concentration. This may be because sampling density was too low, or the sampling design was faulty. More likely, the problems stem from the geological diversity of the area. Some stratigraphic units have uranium contents an order of magnitude greater than that of others. This variability of background conceals anomalies. Surely a geological approach to the problem would be more efficient.

4.) The analysis of local potential sources of uranium suggests that no large deposits of secondary uranium will be found in the area. This is because of the abundance of ash flow tuffs and lava flows in the area. Our investigation of uranium variation in such units revealed no indication of mobility of uranium in those rock types in fashions suitable to release it to form deposits. Consequently, other types of deposits might be more profitably sought, notably

vein type deposits in the Apache Hills or Granite Gap - Twelvemile Wells areas. The possibility exists for secondary deposits in the Dog Mountains, but source rock analysis of the area does not confirm this.

5.) We were unable to confirm a loss of uranium from the Rhyolite of Clanton Draw during or after emplacement. This indicates that the whole question of uranium mobility in volcanic rocks bears considerable study, especially well designed, rigorously tested consideration of abundance of uranium and other elements. From these investigations, the nature of the depletion process, and if one exists at all, can be established.

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APPENDIX I

Sample Codes and Numbers

A. LOCATION AND STRATIGRAPHIC UNIT CODES

Each sample has a four place unit designator that indicates its general location, age, and rock type. For example a number of samples of Gillespie Tuff bear the designator:

44T1.

The first "4" indicates the sample was from the Animas Mountains, north of the Winkler Anticline.

The second "4" indicates that the Gillespie is Tertiary and is thought to come from the Cowboy Rim Cauldron.

The "T" indicates it is an ash flow tuff.

The "1" is a serial number to distinguish it from other tuffs that come from the same source.

1. First Place: sample location

1. Southern Peloncillo Mountains
2. South central Peloncillo Mountains
3. Southern Animas Mountains (South of Winkler Anticline)
4. Northern Animas Mountains (North of Winkler Anticline)
5. Alamo Hueco or Dog Mountains
6. Big Hatchet Mountains
7. Little Hatchet Mountains
8. Coyote Hills
9. Outside study area

2. Second Place: age

- M Mississippian
- Y Pennsylvanian
- P Permian
- K Cretaceous

Tertiary Rocks are assigned a number in the second place which indicates the cauldron from which they are thought to have come (Deal and others, 1978; Erb, Personal Communication, 1979; Elston, Personal Communication, 1980).

1. Tullous Caldron
2. Juniper Cauldron
3. Animas Peak Cauldron
4. Cowboy Rim Cauldron
5. San Luis Cauldron
6. Geronimo Trail Cauldron
7. Rodeo Cauldron
8. Not related to cauldrons in the area
9. Later Tertiary

3. The third place indicated the lithologic type of the sample.

A Andesite or mafic volcanic rock
 B Breccia
 I Intrusive Rock
 L Limestone
 P Air fall Tuff
 R Rhyolite or silica rich volcanic rock
 S Sandstone
 T Ash Flow Tuff
 V Volcanic sediment

4. The fourth place is used to distinguish units of the same age and lithology.

B. STRATIGRAPHIC UNIT CODES

Time Stratigraphic unit	Rock Stratigraphic unit	Code	Reference
Mississippian System	Escabrosa Limestone	ML1	-
Pennsylvanian System	Horquilla Limestone	YL1	-
Permian System	Colina Limestone	PL1	-
Cretaceous System	U-Bar Formation	KL1	-
	Mojado Formation or		
	Johnny Bull Sandstone	KS4	-
	Ringbone Formation	KA5	-
		KS5	-
		KL5	-
Tertiary System	Bluff Creek Formation		
Tullous Cauldron	and equivalents	1T1, 1V1	1
		1B1, 1R1 1S1	
		81A, 8VR	
Juniper Cauldron	Bennett Creek Breccia	2B1	
	Cedar Hill Andesite	2A1	1
	Walnut Wells Monzonite	2I2	1
	Animas Quartz Monzonite	2I1	1
	Rhyolite of Winkler Ranch	2R1	1
	Oak Creek Tuff	2T1	1
	Tuff of Bennett Spring	2T2	1
Animas Peak Cauldron	Tuff of Black Bill Canyon	3T1	1
Cowboy Rim Cauldron	Gillespie Tuff	4T1	1
San Luis Cauldron	Rhyolite of the Packers Trail	5R1, 5T2	1
	Park Tuff	5T1, 5V1	1
	Volcanics of Culberson's Ranch	5R3	1
Geronimo Trail Cauldron	Tuff of Guadalupe Canyon	6T1	1
	Breccia of Cottonwood Canyon	6B2	1
	Dacite of Outlaw Mountain	6A1	1
	Breccia of Geronimo Pass	6B3	1
	Rhyolite of Clanton Draw	6R3, 6T4	1
	Volcanic sediments	6V4, 6T2	1

B. (Continued)

Time Stratigraphic unit	Rock Stratigraphic unit	Code	Reference
Rodeo Cauldron	Tuff of Black Mountain	7T1	2
	Quartz latite of Owl Canyon	7R1	2
	Unit of Antelope Pass	7S3, 7T2, 7R3	2
		7S2, 7V2, 7R2	2
	Latite of Unit of Antelope Pass	7A2	2
	Tuff of Trail Creek	7T4, 7V4	2
Tertiary volcanic rocks not related to cauldron sequences	Mafic flows, Alamo Hueco Mts.	8A4	3
	Moonstone Tuff	8T4	2
	Tuff of Wood Canyon	8TG	3
	Rhyolite of Pine Canyon	8R1	1
	Animas Valley Fill	8VX	1
	Rhyolites at Playas Peak	8RA	4
	Tuffs at Playas Peak	8TA	4
	Air falls of Pothook	8PA	5
	Tuffs of Pothook	8TB	5
		8TC, 8TD	
		8TE, 8TF	
	Tuffs in Pyramid Mountains	8T7	
	Miocene Volcanic Sediments	9V1	

References

1. Deal and others, 1978; Erb, personal communications, 1979.
2. Deal and others, 1978; Elston, personal communication, 1980.
3. Deal and others, 1978.
4. Zeller, 1970
5. Thorman, 1977.

C. ALL SAMPLES COLLECTED

Serial number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
001	150968	19V1	
002		16R3	
003		16R3	
004		16R3	
005	150969	16A1	
006	150970	16A1	
007	150971	16B2	
008	150972	16B2	X
009	150973	16B2	
010	150974	16B2	
011	150975	16T1	X
012	150976	16T1	X
013	150977	16B3	
014	150978	27T1	
015	150979	27T1	

C. (Continued)

Serial number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
016	150980	27T1	X
017	150981	27T1	
018	150982	27T1	X
019		41T1	
020	150983	41T1	
021		41T1	
022	150984	41T1	
023		41R1	
024		41B1	
025		41R1	
026		41B1	
027	150985	41B1	X
028	150986	4ML1	X
029	150987	4ML1	
030	150988	41A1	X
031		41T1	
032		41T1	
033	150989	41R1	X
034	150990	41V1	
035	150991	41V1	X
036	150992	41V1	
037		4ML1	
038	150993	4ML1	
039		4ML1	
040		4ML1	
041		4ML1	
042	150995	4ML1	
043		4ML1	
044		4ML1	
045		4ML1	
046		4ML1	
047	150996	4YL1	
048		4YL1	
049	150997	4ML1	
050	150998	4ML1	
051	150999	41B1	X
052	151000	4ML1	X
053		41R1	
054		41B1	
055	151001	41B1	
056	151002	41R1	
057	151003	4ML1	
058		41B1	
059		42T1	
060	151004	41R1	
061	151005	41T1	
062	151006	27T2	X

C. (Continued)

Serial number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
063		27T2	
064	151007	27T2	X
065	151008	27T2	
066	151009	27T4	
067	151010	27T4	X
068	151011	27T4	
069		27T4	
070		27T4	
071	151012	27T4	X
072	151013	27R3	
073	151014	27R3	X
074	151015	27T4	
075	151016	27R1	
076		27R3	X
077	151017	27T4	X
078	151018	28T4	
079	151019	27R1	
080	151020	27R1	
081	151021	27T1	
082	151022	28T4	X
083	151023	27V2	
084	151024	42T1	X
085	151025	42T3	X
086	151026	42T3	
087	151027	42T1	X
088		42T1	
089		42T1	
090	151028	42T1	X
091		42T1	
092		42T1	
093	151029	42A1	
094	151295	44T1	X
095	151296	44T1	X
096	151297	44T1	X
097		44T1	
098		44T1	
099	151298	44T1	X
100	151030	42T1	
101	151032	42I1	
102	151033	42T1	
103	151034	42I1	
104	151035	42I1	
105		16R3	
106		16R3	
107		16R3	
108		16R3	
109	151036	16T1	X
110	151037	16T1	

C. (Continued)

Serial number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
111	151038	16T1	X
112	151039	16V4	
113	151040	16V4	
114	151041	16V4	X
115	151042	16T2	X
116	151043	27T1	
117	151044	27T1	
118	151045	27V4	X
119	151046	27R3	
120	151047	27T2	X
121	151048	27T2	X
122	151049	27T2	
123	151050	27S2	
124	151051	27T2	X
125		27T2	
126	151052	27T2	X
127	151053	27T2	X
128	151054	27T1	
129	151055	27T1	X
130	151056	27T1	
131	151057	27T1	
132	151058	27T1	
133	151059	27R3	
134		27R3	
135	151060	27R3	
136	151061	27R3	
137	151062	27V2	X
138	151063	27V2	
139	151064	27V2	
140	151064	27T2	
141		27T2	
142	151066	27T2	X
143	151067	28T3	
144		27T2	X
145	151068	27T1	
146	151069	27T1	
147	151070	2YL1	
148	151071	2YL1	
149	151072	2YL1	
150	151074	2YL1	
151	151075	2YL1	
152	151076	2YL1	
153	151077	27T1	
154	151078	2YL1	
155		27T1	
156	151079	2YL1	
157	151080	27T2	
158		44T1	

C. (Continued)

Serial Number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
159		44T1	
160		44T1	
162	151081	42A1	
163	151082	42T2	X
164	151083	42T2	X
165	151084	3KS4	
166	151085	42A1	X
167	151086	42T2	X
168	151087	3KL4	
169	151088	3KL2	
170	151089	3PL1	
171	151090	3PL1	
172	151091	27T1	X
173	151092	27T1	X
174	151093	27T1	
175	151094	27T1	X
176	151095	27T1	X
177	151096	27T1	
178	151097	27T1	
179	151098	27T1	X
180	151099	27T1	
181	151100	27T1	X
182	151101	27T1	
183		27A2	X
184	151102	27A2	
185		27A2	
186	151103	27A2	X
187	151104	27A2	
188	151105	27T1	
189	151106	27T1	
190	151107	27T1	
191	151108	27T1	X
192	151110	7KA5	
193	151110	7KL5	
194	151111	78RA	X
195	151112	78AB	X
196	151113	78RB	
197	151114	78RB	
198	151115	78TA	X
199	151116	78TA	X
200	151117	88VA	X
201	151118	88TB	X
202	151119	88TC	
203	151120	88TC	
204	151121	88TD	
205	151122	88TD	X
206	151123	88PA	
207	151124	88TE	X

C. (Continued)

Serial Number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
208	151125	88TE	
209	151126	88TF	
210	151127	88TF	
211	151128	88TE	
212	151129	8KA5	
213	151130	8KA5	
214	151131	8KA5	
215	151132	88VA	
216	151133	8K85	
217	151299	34T1	X
218		34T1	
219	151300	34T1	X
220	151301	34T1	X
221	151302	34T1	X
222		34T1	
223	151303, 151304	34T1	X
224	151305	34T1	X
225		34T1	
226		34T1	
227		38A3	
228	151219	35R1	X
229	151199	35R1	X
230	151997	35R1	X
231		35R1	
232	151198	35R1	X
233		35R1	
234	151224	16R3	X
235	151223	16R3	X
236	151224	16R3	
237		16R3	X
238	151221	16R3	
239	151220	16R3	X
240	151245, 151246	34T1	X
241	151247	35T1	
242		34T1	
243		34T1	
244		34T1	
245		34T1	
246		34T1	
247	151134	31T1	X
248	151135	31T1	X
249	151136	31T1	X
250	151137	31T1	
251	151293	34T1	
252		34T1	
253		34T1	
254	151294	34T1	
255		34T1	

C. (Continued)

Serial Number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
256		34T1	
257	151215	35R1	X
258		35R1	
259	151216	35R1	X
260		35R1	
261	151191	35R1	X
262	151192	35T2	X
263	151193	35R1	X
264	151138	34T1	
265		34T1	
266	151267	34T1	X
267	151268	34T1	X
268	151269	34T1	X
269		34T1	
270		34T1	
271		34T1	
272		34T1	
273		34T1	
274		34T1	
275		34T1	
276	151270	34T1	X
277	151271	34T1	
278	151272	34T1	X
279	151139	35T1	
280	151140	35T1	
281	151141	35V1	X
282	151142	31T1	X
283	151143	51T1	X
284	151144	58TG	
285	151145	58TG	
286	151146	58VB	X
287	151148	52T1	
288	151149	52T1	X
289	151150	52T1	X
290	151151	52T1	
291	151152	52T2	X
292	151153	52T1	
293	151154	52T1	
294			X
295			
296	151155	58A4	X
297		54T1	
298	151156	5KL2	
299	151157	5KL2	
300	151158	5KL2	
301	151159	5KS4	
302		52T1	
303	15257	54T1	X

C. (Continued)

Serial Number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
304	151258	54T1	X
305		54T1	
306		54T1	
307		54T1	
308		54T1	
309		54T1	
310	151266	54T1	X
311	151160	51T1	X
312	151161	51T1	X
313	151162	58LA	
314	151163	58VB	X
315	151164	58VB	
316	151165	51T1	
317	151166	51B1	
318	151167	51S1	X
319	151168	58TG	
320	151169	58TG	X
321		31T1	
322	151170	31T1	X
323	151171	31T1	X
324		31T1	
325		31T1	
326	151172	31T1	X
327	151173	31T1	X
328		32T1	
329	151174	32T1	
330	151218	35T2	X
331	151196	35T2	X
332	151195	35T2	X
333	151217	35T2	X
334	151194	35R1	X
335	151255	34T1	X
336		34T1	
337	151256	34T1	X
338	151274	34T1	X
339	151275	34T1	X
340	151276	34T1	X
341		34T1	
342	151277	34T1	X
343		34T1	
344	151175	31V1	X
345	151176	31T1	
346	151177	31T1	
347	151178	35R3	X
348	151179	35R3	
349	151180	35R3	X
350		35T1	
351	35R1		
352	35R1		

C. (Continued)

Serial Number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
353		35R1	
354		31T1	
355	151181	31T1	X
356		31T1	
357	151182	32T2	
358	151183	32B1	X
359		32B1	
360	151184, 151185	32B1, 32B1	X
361	151186	32T2	X
362		32T2	
363	151187	32I2	
364	151188	33T1	
365	151189	33T1	
366		3PL2	
367	151190	3YL1	
368	151248	3KL2	
369	151249	3KL2	
370	151250	3KL2	
371	151251	3KS4	
372	151252	3KL2	
373		3KL2	
374	151306	34T1	X
376	151307	34T1	X
377	151308	34T1	X
378		34T1	
379	151309	34T1	X
380		34T1	
381		34T1	
382	151310	34T1	X
383	151253	35T1	
384	151254	35T1	
385	151206	16R3	X
386		16R3	
387	151208	16R3	X
388	151209	16R3	X
389	151210	16R3	X
390	151211	16R3	X
391	151214	16R3	X
392	151213	16R3	X
393	151212	16R3	X
394	151278	44T1	X
395	151279	44T1	X
396	151280	44T1	X
397	151281	44T1	X
398	151282	44T1	
399		44T1	
400	151283	44T1	X
401	151284	44T1	X
402		44T1	

C. (Continued)

Serial Number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
403	151285	44T1	X
404	151286	44T1	X
405	151287	44T1	X
406		44T1	
407		44T1	
408	151288	44T1	X
409	151289	44T1	X
410		44T1	
411	151290	44T1	
412		44T1	
413	151291	44T1	X
414		44T1	
415	151292	44T1	X
416	151231	16V4	
417	151230	16R3	X
418	151202	16R3	X
419	151226	16R3	
420	151225	16R3	X
421	151227	16R3	X
422		16R3	
423	151200	16R3	X
424	151228	16R3	X
425	151229	16R3	
426	151201	16T4	
427		27R3	
428	151232	27R3	X
429		27R3	
430	151233	27R3	X
431		27R3	
432	151234	27R3	X
433		27R3	
434	151235	27R3	X
435		27R3	
436	151236	27R3	X
437	151237	27R3	X
438	151238	27R3	X
439	151259	54T1	X
440		54T1	
441		54T1	
442	151260	54T1	X
443	151261	54T1	X
444		54T1	
445		54T1	
446		54T1	
447	151262	54T1	X
448	151263	54T1	X
449		54T1	
450	151264	54T1	X

C. (Continued)

Serial Number	Oak Ridge National Lab Number	Location and Stratigraphic Unit Code	Thin Section
451	151265	54T1	X
452		54T1	
453	151317	48R1	X
454		48R1	
455		48R1	
456	151318	48R1	X
457		48R1	
458		48R1	
459	151319	48R1	X
460	151320	48R1	X
461	151321	48R1	X
462	151322	48R1	X
463	151323	48R1	
464		78TA	
465	151244	16R3	X
466	151205	16R3	
467	151243	16R3	
468	151204	16R3	X
469		16R3	
470	151242	16R3	X
471		16R3	
472	151203	16R3	X
473	151241	16R3	
474	151240	16R3	X
475	151239	16R3	X
476		88T4	X
477		88TG	X
478		88TG	
479		88TG	
480	151312	88TG	X
481		98T6	
482	151313	98T7	
483	151314	98T8	
484	151316	98T9

Figure 1.1

Figure 1.1. Sample locations. Each dot represents one or more samples on for which a chemical analysis is available.

APPENDIX 2

RESULTS OF CHEMICAL ANALYSES

Methods are described in text and in Arendt and others (1979).

Analytical techniques and precision are listed in Tables 6 and 7.

SW NEW MEXICO VOLCANICS

OR SAMPLE NUMBER	ST	D. O. LAT	E. LONG	NUMBER L TY REP	SECTION 1 OF 3									CR		
					J (PPM)	U-NT (PPM)	U/TU	AG (PPM)	AL (%)	B (PPM)	BA (PPM)	BE (PPM)	CA (%)	CO (PPM)	(PPM)	
150968	40-31.515	-108.994	-3-92-		54.	54.	0.99	<2	5.0	15	100	10	0.37	5		1
150969	40-31.496	-109.083	-3-92-		3.0	3.7	0.81	<2	6.1	<10	610	1	2.2	15		1
150970	40-31.497	-109.080	-3-92-		4.7	6.4	0.73	<2	6.4	<10	650	2	3.0	17		2
150971	40-31.496	-109.080	-3-92-		2.5	3.3	0.75	<2	5.6	<10	920	1	1.4	8		5
150972	40-31.496	-109.080	-3-92-		3.0	3.3	0.91	<2	5.7	<10	750	1	1.7	10		10
150973	40-31.494	-109.080	-3-92-		5.7	5.0	1.1	<2	6.2	<10	610	2	1.5	10		4
150974	40-31.494	-109.080	-3-92-		2.9	2.8	1.0	<2	5.6	<10	520	2	1.2	<4		4
150975	40-31.490	-109.079	-3-92-		4.0	4.6	0.86	<2	5.0	<10	120	2	0.44	<4		<1
150976	40-31.489	-109.077	-3-92-		5.4	6.8	0.79	<2	5.4	<10	150	2	0.25	<4		2
150977	40-31.511	-109.040	-3-92-		2.6	2.7	0.95	<2	7.5	<10	610	2	1.7	4		2
150978	40-31.651	-108.974	-3-92-		4.0	4.3	0.94	<2	6.6	<10	700	2	1.2	5		2
150979	40-31.653	-108.975	-3-92-		4.4	5.2	0.85	<2	5.8	<10	410	2	0.81	<4		3
150980	40-31.654	-108.981	-3-92-		2.6	3.1	0.85	<2	4.7	<10	270	2	0.54	<4		2
150981	40-31.645	-108.985	-3-92-		4.0	3.5	1.1	<2	6.7	<10	450	2	0.70	<4		1
150982	40-31.639	-108.977	-3-92-		10.	9.5	1.1	<2	5.0	<10	63	5	0.43	<4		1
150983	40-31.829	-108.688	-3-92-		3.6	3.8	0.95	<2	5.5	<10	690	1	0.99	5		<1
150984	40-31.661	-108.681	-3-92-		6.3	6.1	1.0	<2	3.8	<10	77	4	0.10	<4		1
150985	40-31.828	-108.679	-3-92-		6.1	6.9	0.89	<2	4.2	<10	110	3	0.35	<4		1
150987	40-31.828	-108.677	-3-92-		1.7	1.7	1.0	<2	0.09	<10	8	1	28.	<4		5
150988	40-31.826	-108.692	-3-92-		2.7	3.3	0.61	<2	6.8	<10	1200	2	0.89	5		<1
150989	40-31.828	-108.691	-3-92-		4.0	4.7	0.86	<2	5.2	<10	240	3	0.50	<4		<1
150990	40-31.828	-108.692	-3-92-		3.5	3.6	0.98	<2	5.3	<10	350	2	0.56	<4		2
150991	40-31.829	-108.691	-3-92-		2.4	2.6	0.92	<2	5.3	<10	1000	3	1.4	<4		2
150992	40-31.829	-108.691	-3-92-		0.44	0.90	0.49	<2	6.7	<10	1500	2	1.8	<4		2
150993	40-31.836	-108.684	-3-92-		2.5	2.5	1.0	<2	0.10	<10	6	<1	30.	<4		8
150994	40-31.839	-108.692	-3-92-		1.8	1.5	1.2	<2	0.12	<10	6	<1	37.	<4		4
150995	40-31.835	-108.697	-3-92-		2.9	3.1	0.93	<2	0.17	<10	10	<1	33.	<4		9
150996	40-31.829	-108.697	-3-92-		3.3	3.6	0.91	<2	0.22	<10	13	<1	24.	<4		10
150997	40-31.825	-108.703	-3-92-		0.95	1.3	0.73	<2	0.20	<10	240	<1	30.	<4		3
150998	40-31.823	-108.702	-3-92-		0.83	0.90	0.92	<2	0.07	<10	6	<1	30.	<4		1
150999	40-31.819	-108.699	-3-92-		15.	19.	0.77	<2	4.8	<10	93	4	0.27	<4		1
151000	40-31.819	-108.701	-3-92-		1.8	1.7	1.1	<2	0.07	<10	36	<1	18.	6		7
151001	40-31.823	-108.715	-3-92-		1.5	1.6	0.91	<2	4.7	<10	1000	2	3.6	26		16
151002	40-31.813	-108.712	-3-92-		5.8	5.4	1.1	<2	5.1	<10	95	5	0.11	<4		1
151003	40-31.819	-108.713	-3-92-		1.7	1.5	1.1	<2	0.09	<10	71	<1	16.	<4		2
151004	40-31.815	-108.694	-3-92-		4.8	5.6	0.85	<2	4.8	<10	56	4	0.08	<4		1
151005	40-31.819	-108.718	-3-92-		3.8	3.8	1.0	<2	7.3	<10	880	2	1.3	<4		1
151006	40-31.835	-108.953	-3-92-		6.9	7.3	0.95	<2	4.3	<10	17	8	0.79	<4		3
151007	40-31.835	-108.956	-3-92-		4.7	6.3	0.74	<2	5.6	<10	25	4	1.1	<4		1
151008	40-31.838	-108.959	-3-92-		6.2	7.3	0.85	<2	4.8	<10	60	8	0.14	<4		<1
151009	40-31.838	-108.959	-3-92-		6.4	6.3	1.0	<2	5.6	<10	130	4	0.27	<4		1
151010	40-31.839	-108.960	-3-92-		2.3	4.5	0.52	<2	5.8	<10	410	5	0.48	<4		<1
151011	40-31.839	-108.960	-3-92-		3.4	5.3	0.64	<2	6.1	<10	390	5	0.44	<4		<1
151012	40-31.847	-108.955	-3-92-		3.9	4.3	0.90	<2	6.8	<10	330	2	0.48	4		1
151013	40-31.844	-108.956	-3-92-		5.5	6.5	0.84	<2	4.8	<10	14	5	0.09	<4		<1
151014	40-31.842	-108.954	-3-92-		6.9	7.9	0.87	<2	4.9	<10	20	7	0.12	<4		<1
151015	40-31.823	-108.959	-3-92-		4.0	4.5	0.39	<2	6.4	<10	490	2	0.69	<4		1
151016	40-31.821	-108.966	-3-92-		3.5	4.5	0.78	<2	5.0	<10	64	6	0.13	<4		1
151017	40-31.822	-108.982	-3-92-		5.8	7.5	0.77	<2	4.3	<10	5	8	0.19	<4		3
151018	40-31.821	-108.986	-3-92-		6.1	8.0	0.76	<2	5.6	<10	18	5	0.09	<4		<1
151023	40-31.810	-108.949	-3-92-		7.1	7.6	0.94	<2	4.5	<10	180	4	1.6	4		4
151024	40-31.711	-108.693	-3-92-		3.1	3.8	0.81	<2	7.5	<10	990	3	1.8	7		2
151025	40-31.704	-108.680	-3-92-		3.8	4.7	0.81	<2	6.3	<10	400	2	0.29	<4		1
151026	40-31.705	-108.677	-3-92-		4.9	4.6	1.1	<2	5.3	<10	670	3	1.2	4		2
151027	40-31.706	-108.678	-3-92-		3.9	5.0	0.78	<2	5.2	<10	550	2	0.09	<4		<1

SW NEW MEXICO VOLCANICS													SECTION 2 JF 3		
OR SAMPLE	CU	FE	LI	MG	MN	MO	NA	NB	NI	P	SC	TH	TI	V	Y
NJMBER	(PPM)	(%)	(PPM)	(%)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)
150968	11	1.5	35	0.31	710	<4	1.1	67	2	90	4	42	1300	13	71
150969	11	2.7	20	0.50	450	<4	2.2	13	<2	680	8	13	3300	47	23
150970	18	2.1	33	1.3	650	<4	2.2	11	6	560	8	12	2200	39	23
150971	5	1.6	21	0.52	460	<4	1.8	25	<2	280	5	16	1900	44	22
150972	8	1.9	49	0.78	510	<4	1.7	19	6	310	5	12	2000	51	19
150973	8	2.0	45	1.0	450	5	1.7	16	3	420	6	18	2500	40	28
150974	3	1.2	14	0.50	300	<4	0.99	11	2	230	3	12	1400	21	16
150975	<2	0.59	20	0.46	140	<4	0.58	22	<2	73	2	24	810	6	17
150976	3	0.53	24	0.12	170	<4	1.7	24	<2	47	2	22	760	4	25
150977	7	1.7	17	0.79	320	<4	1.9	11	4	530	4	18	2500	35	20
150978	9	1.1	17	0.35	400	<4	2.2	18	2	290	5	27	1400	15	26
150979	3	0.71	16	0.15	360	<4	2.1	11	<2	170	2	21	1000	9	21
150980	<2	0.47	20	0.22	300	<4	0.59	13	4	39	1	17	660	4	15
150981	3	0.92	16	0.22	160	<4	1.8	12	2	180	3	17	1200	15	18
150982	8	0.51	37	0.15	290	<4	1.6	29	<2	34	2	24	700	2	25
150983	<2	1.6	45	0.16	280	<4	2.3	15	<2	540	6	10	2900	15	33
150984	4	0.44	19	<0.05	400	<4	1.5	26	<2	24	1	23	460	7	36
150985	2	0.38	31	0.06	360	<4	1.6	31	2	50	1	22	450	5	35
150987	4	0.08	3	0.15	87	<4	<0.05	18	5	96	1	<2	66	7	2
150988	6	1.5	24	0.23	480	<4	2.7	10	<2	560	5	9	2200	19	24
150989	<2	0.67	3	0.09	620	<4	2.2	27	<2	36	3	19	970	2	32
150990	630	1.1	29	0.15	310	<4	0.80	17	4	270	3	9	1400	20	23
150991	2	1.3	13	0.33	250	<4	1.1	15	<2	120	3	14	1500	20	16
150992	2	1.2	16	0.13	230	<4	2.6	5	<2	180	2	5	1300	20	9
150993	<2	0.08	3	0.24	67	<4	<0.05	6	<2	230	1	5	75	2	5
150994	<2	0.09	3	0.24	100	<4	<0.05	10	<2	160	<1	2	64	2	3
150995	5	0.16	3	0.25	380	4	<0.05	8	4	38	1	4	110	6	3
150996	55	0.36	3	3.0	210	<4	<0.05	36	5	18	1	2	110	6	1
150997	2	0.20	4	0.33	200	<4	<0.05	6	<2	20	1	5	150	5	4
150998	<2	0.09	2	0.34	88	<4	<0.05	6	<2	9	1	3	49	3	2
150999	5	0.61	40	0.09	480	<4	1.7	36	2	54	2	30	580	5	56
151000	5	0.96	5	5.8	580	6	<0.05	5	9	110	1	4	58	15	3
151001	12	3.4	41	0.43	1000	<4	1.5	13	17	610	8	8	3000	38	14
151002	<2	0.44	24	<0.05	510	<4	2.6	32	<2	<5	2	25	450	3	22
151003	35	0.47	7	6.1	170	<4	<0.05	16	2	<5	1	<2	30	7	1
151004	<2	0.41	25	<0.05	250	<4	2.4	24	2	14	1	26	350	4	42
151005	2	2.1	20	0.24	280	<4	2.3	11	<2	770	5	10	3200	23	35
151006	4	0.59	15	0.08	390	<4	1.3	38	2	36	2	27	770	2	28
151007	<2	0.64	12	0.19	330	<4	0.80	33	<2	41	1	26	800	3	24
151008	<2	0.79	16	0.05	700	<4	1.4	49	<2	35	3	29	940	2	38
151009	4	0.86	32	0.18	340	<4	2.2	38	<2	160	4	29	1500	8	41
151010	<2	1.2	34	0.17	450	<4	2.5	32	<2	220	4	22	2500	10	38
151011	85	1.0	42	0.17	440	<4	2.4	30	<2	230	5	17	2300	10	35
151012	8	1.0	26	0.22	330	<4	2.4	30	<2	360	6	24	2200	11	51
151013	13	0.53	71	<0.05	340	<4	1.6	29	<2	110	2	25	780	3	26
151014	<2	0.73	16	<0.05	240	<4	1.8	37	<2	30	2	30	1000	2	30
151015	4	1.4	21	0.28	400	<4	2.3	30	<2	330	5	20	3100	16	48
151016	460	0.55	41	0.06	1200	<4	1.7	38	2	44	2	24	840	4	30
151017	3	0.40	34	<0.05	360	4	1.8	32	2	40	2	27	610	2	18
151018	280	0.62	38	<0.05	530	<4	2.2	41	3	79	2	29	740	2	30
151023	14	0.96	31	0.45	540	<4	0.87	29	3	110	3	21	1300	12	38
151024	4	2.6	27	0.60	770	<4	2.4	12	2	720	6	13	3300	49	34
151025	2	0.96	12	0.16	110	<4	1.6	13	2	210	2	18	1100	13	23
151026	12	0.97	39	0.29	410	<4	1.9	14	2	250	3	19	1100	12	22
151027	<2	1.0	15	0.16	150	<4	1.0	16	<2	100	2	21	1100	9	20

SW NEW MEXICO VOLCANICS											SECTION 3 OF 3		
OR SAMPLE NUMBER	ZN (PPM)	ZR (PPM)	K (%)	SR (PPM)	CE (PPM)	TGA4 (CPS)	TOT (CPM)	EK (%)	CPK (CPM)	EU (PPM)	CPU (CPM)	ETH (PPM)	CPTH (CPM)
150968	100	260	3.8	53	130								
150969	48	130	2.3	340	74								
150970	64	110	2.4	380	73								
150971	<2	80	2.7	310	85								
150972	160	74	2.1	460	62								
150973	55	100	3.1	280	70								
150974	32	51	2.2	310	72								
150975	20	51	3.4	35	51								
150976	41	55	3.3	43	67								
150977	41	37	2.1	360	75								
150978	36	72	3.8	160	84								
150979	24	61	2.6	87	69								
150980	24	36	3.2	330	64								
150981	29	59	2.5	120	66								
150982	23	56	3.4	31	40								
150983	39	140	2.8	180	83								
150984	17	85	2.8	14	53								
150985	80	81	3.2	26	44								
150987	6	5	0.06	480	<10								
150988	22	200	2.9	440	130								
150989	33	150	2.9	48	110								
150990	47	92	4.3	130	87								
150991	38	71	3.1	510	79								
150992	30	17	2.2	930	56								
150993	14	5	0.04	260	13								
150994	8	<2	0.03	320	<10								
150995	21	6	0.08	820	13								
150996	47	6	0.05	340	<10								
150997	4	8	0.08	400	17								
150998	3	4	0.03	210	<10								
150999	61	110	4.0	28	59								
151000	74	7	0.02	74	13								
151001	47	89	1.1	340	54								
151002	29	60	3.8	31	54								
151003	<2	3	0.03	93	<10								
151004	24	70	3.5	9	60								
151005	57	190	2.3	200	92								
151006	52	120	2.8	38	52								
151007	69	120	2.2	190	56								
151008	49	160	3.2	17	79								
151009	55	150	4.3	20	120								
151010	65	55	3.6	47	140								
151011	45	56	3.8	51	120								
151012	48	110	4.6	47	190								
151013	44	110	2.9	4	74								
151014	72	140	3.5	6	69								
151015	59	100	4.6	67	170								
151016	64	100	3.3	29	66								
151017	26	78	3.6	2	57								
151018	39	110	3.3	5	63								
151023	55	110	3.1	1000	60								
151024	79	52	2.0	230	110								
151025	38	54	2.3	47	88								
151026	32	55	3.2	110	82								
151027	30	61	3.3	54	83								

SW NEW MEXICO VOLCANICS										SECTION 1 OF 3					
OR SAMPLE	D. O. E. SAMPLE	NUMBER	U	U-NT	U/TU	AG	AL	B	BA	BE	CA	CO	CR		
NUMBER	ST	LAT	LONG	L TY REP	(PPM)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(X)	(PPM)	(PPM)		
151028	40-31.711	-108.682	-3-92-		3.6	3.4	1.1	<2	6.3	<10	770	2	0.73	<4	1
151029	40-31.694	-108.720	-3-92-		3.0	2.7	1.1	<2	6.7	<10	700	1	4.2	29	64
151030	40-31.715	-108.686	-3-92-		2.7	3.7	0.74	<2	6.9	<10	1000	1	1.4	10	1
151032	40-31.727	-108.689	-3-92-		2.1	2.8	0.76	<2	5.5	<10	830	3	0.89	7	<1
151033	40-31.727	-108.689	-3-92-		2.5	3.5	0.72	<2	6.4	<10	770	2	1.2	7	<1
151034	40-31.728	-108.690	-3-92-		2.0	2.9	0.68	<2	5.6	<10	710	3	1.2	7	<1
151035	40-31.737	-108.691	-3-92-		2.1	2.5	0.86	<2	7.3	<10	820	2	1.3	4	1
151036	40-31.406	-108.905	-3-92-		4.3	4.5	0.94	<2	5.3	<10	500	2	0.66	<4	1
151037	40-31.405	-108.905	-3-92-		4.0	3.8	1.0	<2	7.0	<10	770	2	1.1	<4	2
151038	40-31.406	-108.901	-3-92-		6.3	6.6	0.95	<2	5.2	<10	130	3	0.42	<4	1
151039	40-31.411	-108.869	-3-92-		7.1	7.4	0.96	<2	4.4	<10	90	24	1.1	<4	5
151040	40-31.412	-108.869	-3-92-		6.8	6.5	1.1	<2	4.9	<10	160	10	0.44	<4	2
151041	40-31.414	-108.871	-3-92-		5.6	6.4	0.88	<2	5.1	<10	210	13	1.4	7	13
151042	40-31.415	-108.872	-3-92-		3.5	3.5	1.0	<2	4.9	<10	49	11	1.6	<4	2
151043	40-31.984	-108.857	-3-92-		2.9	3.4	0.86	<2	5.2	<10	580	2	0.58	<4	<1
151044	40-31.984	-108.857	-3-92-		9.1	8.9	1.0	<2	5.2	<10	81	5	0.39	<4	<1
151045	40-31.981	-108.858	-3-92-		2.5	2.6	0.95	<2	4.5	<10	52	4	1.6	<4	<1
151046	40-31.906	-108.955	-3-92-		6.1	5.5	1.1	<2	5.2	<10	44	2	0.10	<4	<1
151047	40-31.907	-108.956	-3-92-		3.6	5.3	0.67	<2	5.0	<10	150	4	0.29	<4	1
151048	40-31.907	-108.956	-3-92-		1.6	3.0	0.55	<2	6.9	10	900	2	0.59	<4	2
151049	40-31.910	-108.957	-3-92-		3.8	4.5	0.85	<2	5.0	<10	100	3	0.07	<4	4
151050	40-31.909	-108.958	-3-92-		1.2	1.1	1.1	<2	0.23	<10	25	1	22.	<4	7
151051	40-31.909	-108.959	-3-92-		2.8	3.1	0.89	<2	5.1	<10	610	3	1.1	5	3
151052	40-31.909	-108.964	-3-92-		3.5	3.8	0.93	<2	4.8	<10	400	3	1.5	4	3
151053	40-31.930	-108.929	-3-92-		3.9	3.6	1.1	2	3.5	<10	73	4	<0.05	<4	2
151054	40-31.932	-108.928	-3-92-		2.7	3.2	0.86	<2	5.1	<10	380	4	0.68	5	2
151055	40-31.931	-108.929	-3-92-		4.0	3.9	1.0	<2	6.0	<10	270	4	0.44	<4	3
151056	40-31.931	-108.929	-3-92-		4.3	3.9	1.1	<2	4.3	<10	290	6	0.49	<4	3
151057	40-31.931	-108.929	-3-92-		3.1	3.5	0.90	<2	5.2	<10	140	3	0.11	<4	3
151058	40-31.931	-108.929	-3-92-		4.3	4.5	0.96	<2	6.2	<10	130	2	0.07	<4	3
151059	40-31.893	-108.971	-3-92-		3.4	4.3	0.79	<2	4.2	<10	19	6	0.13	<4	2
151060	40-31.894	-108.943	-3-92-		5.2	5.4	0.96	<2	5.5	<10	44	4	0.24	<4	<1
151061	40-31.894	-108.946	-3-92-		6.0	6.3	0.95	<2	4.6	<10	35	4	0.50	<4	<1
151062	40-31.944	-108.948	-3-92-		6.5	6.0	1.1	<2	5.3	<10	460	2	0.50	4	5
151063	40-31.945	-108.948	-3-92-		1.7	2.3	0.76	<2	6.0	<10	850	3	1.3	5	2
151064	40-31.946	-108.946	-3-92-		2.3	2.6	0.88	<2	5.1	<10	1800	3	1.7	<4	1
151065	40-31.946	-108.946	-3-92-		3.8	3.9	0.97	<2	5.8	<10	280	2	0.28	<4	2
151066	40-31.950	-108.950	-3-92-		4.1	3.8	1.1	<2	4.0	<10	41	2	0.16	<4	1
151067	40-30.956	-108.953	-3-92-		4.1	6.0	0.68	<2	6.6	<10	49	3	0.17	<4	1
151068	40-31.950	-108.942	-3-92-		3.3	3.9	0.85	<2	4.1	<10	50	1	<0.05	<4	2
151069	40-31.945	-108.936	-3-92-		2.9	2.5	1.2	<2	3.9	<10	30	1	<0.05	<4	3
151070	40-31.949	-108.927	-3-92-		1.1	0.40	2.7	<2	0.15	<10	22	<1	35.	<4	7
151071	40-31.953	-108.929	-3-92-		3.2	3.0	1.1	<2	<0.05	<10	5	<1	30.	<4	2
151072	40-31.953	-108.913	-3-92-		1.6	1.8	0.92	<2	0.06	<10	5	<1	29.	<4	4
151074	40-31.957	-108.906	-3-92-		5.1	5.2	0.97	<2	0.14	<10	10	<1	34.	<4	12
151075	40-31.955	-108.925	-3-92-		1.1	1.5	0.75	<2	<0.05	<10	5	<1	32.	<4	2
151076	40-31.953	-108.929	-3-92-		4.1	5.4	0.76	<2	4.7	16	140	2	0.22	<4	2
151077	40-31.947	-108.927	-3-92-		4.8	5.3	0.90	<2	4.4	<10	99	4	1.2	<4	1
151078	40-31.958	-108.917	-3-92-		3.5	3.8	0.91	<2	0.51	<10	97	<1	0.87	<4	24
151079	40-31.953	-108.913	-3-92-		10.	9.6	1.1	3	0.32	<10	48	1	0.25	<4	18
151080	40-31.960	-108.939	-3-92-		2.5	2.8	0.89	<2	5.3	<10	550	3	0.83	5	2
151081	40-31.562	-108.676	-3-92-		3.4	3.4	0.99	<2	6.1	<10	840	3	1.8	17	19
151082	40-31.561	-108.676	-3-92-		3.9	4.6	0.84	<2	5.0	<10	710	2	0.15	<4	3
151083	40-31.558	-108.678	-3-92-		2.5	2.8	0.90	<2	5.4	<10	280	1	0.06	<4	3
151084	40-31.635	-108.685	-3-92-		1.3	1.4	0.94	<2	0.70	<10	35	<1	0.08	<4	3

SW NEW MEXICO VOLCANICS													SECTION 2 JF 3		
OR SAMPLE NUMBER	CU (PPM)	FE (%)	LI (PPM)	MG (%)	MN (PPM)	MO (PPM)	NA (%)	NB (PPM)	NI (PPM)	P (PPM)	SC (PPM)	TH (PPM)	TI (PPM)	V (PPM)	Y (PPM)
151028	<2	1.3	24	0.25	350	<4	2.9	13	<2	350	4	13	2100	23	29
151029	27	4.0	12	2.0	960	<4	2.0	13	14	710	19	15	4100	110	32
151030	4	2.3	33	0.67	900	<4	2.6	21	2	710	8	13	3700	42	32
151032	<2	2.0	12	0.34	760	<4	2.1	22	<2	390	6	14	2600	17	46
151033	13	1.6	16	0.41	550	<4	2.6	32	<2	350	5	17	2200	23	40
151034	3	2.0	17	0.33	650	<4	2.5	17	<2	440	5	15	2700	27	35
151035	3	2.1	12	0.51	710	<4	2.5	14	2	600	5	14	2700	32	35
151036	<2	0.89	17	0.19	250	<4	1.9	18	<2	130	3	23	1300	11	20
151037	3	1.5	28	0.35	430	<4	1.8	12	<2	350	3	17	2100	26	21
151038	<2	0.63	19	0.17	280	<4	1.8	27	<2	29	2	33	820	5	20
151039	5	1.1	30	0.39	550	<4	0.59	87	3	150	2	27	810	8	65
151040	<2	0.69	56	0.13	390	<4	1.2	50	<2	51	1	20	580	6	39
151041	8	1.5	49	0.66	230	<4	0.87	75	7	280	4	27	1700	23	56
151042	3	0.80	23	0.38	510	<4	0.37	65	2	42	1	20	480	4	57
151043	<2	0.78	12	0.22	360	<4	1.6	12	<2	110	2	18	930	8	18
151044	<2	0.55	24	0.09	410	<4	2.2	29	<2	33	2	31	710	3	32
151045	<2	0.50	9	0.44	440	<4	0.85	20	<2	51	2	17	570	3	16
151046	<2	0.22	51	<0.05	76	<4	2.2	15	<2	13	1	15	510	<2	11
151047	<2	0.78	110	0.13	430	<4	1.8	17	<2	130	2	25	800	6	24
151048	6	1.4	75	0.38	290	<4	1.9	7	4	460	3	9	1400	19	8
151049	<2	0.79	15	0.18	260	<4	2.0	19	<2	88	3	13	810	8	20
151050	4	0.14	7	0.12	170	<4	<0.05	8	4	130	1	<2	160	6	5
151051	3	1.3	32	0.42	410	<4	1.8	15	<2	220	3	17	1400	11	27
151052	2	0.87	29	0.49	300	<4	0.75	14	<2	180	3	22	1000	16	13
151053	3	0.13	42	<0.05	300	<4	0.98	18	3	14	1	16	570	2	8
151054	<2	1.1	49	0.45	190	<4	1.0	18	<2	110	3	25	1200	12	26
151055	8	0.67	79	0.49	220	<4	1.1	13	<2	88	2	16	880	9	11
151056	4	0.79	37	0.43	240	<4	0.62	25	4	120	2	22	1100	7	11
151057	<2	0.59	46	0.05	220	<4	0.62	30	<2	96	2	31	650	5	19
151058	2	0.68	45	0.05	200	<4	0.67	24	2	81	1	25	650	6	24
151059	3	0.59	38	0.05	250	<4	2.0	24	2	64	2	19	810	3	18
151060	<2	0.68	35	0.10	380	<4	2.4	24	<2	52	2	26	750	2	21
151061	<2	0.62	17	0.05	390	<4	1.8	25	<2	28	2	22	950	2	30
151062	9	0.93	64	0.14	200	<4	2.0	10	<2	230	2	9	1100	15	11
151063	6	1.5	34	0.33	330	<4	2.1	15	<2	520	3	13	1900	21	18
151064	<2	1.1	31	0.24	280	<4	1.2	18	<2	180	4	18	1700	8	26
151065	2	0.82	61	0.11	330	<4	2.3	18	<2	110	2	17	750	7	21
151066	<2	0.51	180	0.05	160	<4	0.13	13	<2	63	1	16	540	4	18
151067	2	0.92	54	0.07	510	<4	2.1	28	<2	130	3	17	1500	6	47
151068	<2	0.20	140	<0.05	9	<4	<0.05	16	<2	66	2	19	480	3	8
151069	<2	0.15	110	<0.05	7	<4	0.05	15	<2	24	<1	16	320	3	8
151070	<2	0.09	5	0.30	140	<4	<0.05	16	2	46	<1	<2	84	3	1
151071	2	<0.05	3	0.15	50	<4	<0.05	8	2	82	1	3	22	3	2
151072	<2	0.14	5	0.11	120	<4	<0.05	6	<2	35	1	4	49	6	5
151074	10	0.10	2	0.22	93	<4	<0.05	<4	6	57	1	2	56	5	5
151075	<2	<0.05	2	0.13	65	<4	<0.05	15	3	100	<1	4	15	<2	<1
151076	<2	0.20	78	0.33	17	<4	<0.05	23	<2	40	2	30	680	4	14
151077	<2	0.66	49	0.18	180	<4	0.06	21	<2	38	2	30	580	4	21
151078	2	0.12	90	<0.05	16	<4	<0.05	<4	<2	230	<1	<2	170	14	2
151079	9	1.1	130	<0.05	15	4	<0.05	<4	4	170	<1	<2	280	8	3
151080	83	1.4	69	0.37	320	<4	2.5	18	<2	270	3	16	1700	19	21
151081	13	3.5	37	0.83	750	<4	2.4	17	7	750	9	13	4100	68	30
151082	180	0.94	28	0.17	60	<4	0.37	12	<2	350	4	12	2000	27	19
151083	4	0.50	21	0.08	43	<4	1.9	7	2	110	2	15	680	7	10
151084	5	0.22	19	0.05	16	<4	<0.05	<4	3	11	<1	<2	250	9	1

SW NEW MEXICO VOLCANICS												SECTION 3 OF 3	
OR SAMPLE NUMBER	ZN (PPM)	ZR (PPM)	K (%)	SR (PPM)	CE (PPM)	TGAM (CPS)	TOT (CPM)	EK (%)	CPK (CPM)	EU (PPM)	CPU (CPM)	ETH (PPM)	CPTH (CPM)
151028	34	43	3.1	180	100								
151029	72	120	1.6	400	70								
151030	79	57	2.8	280	87								
151032	50	21	2.3	160	130								
151033	47	22	3.0	160	110								
151034	57	16	2.6	180	100								
151035	64	15	2.2	170	120								
151036	29	56	2.9	100	81								
151037	46	51	2.3	160	98								
151038	23	55	3.8	35	61								
151039	75	160	3.3	110	93								
151040	43	81	4.6	56	75								
151041	77	140	3.2	340	81								
151042	74	130	1.5	44	110								
151043	23	49	3.1	100	88								
151044	22	62	2.9	37	68								
151045	41	60	1.3	1700	56								
151046	10	56	5.3	21	45								
151047	50	90	2.9	69	93								
151048	51	27	2.8	300	52								
151049	34	37	2.9	59	40								
151050	7	7	0.12	170	<10								
151051	39	46	3.4	120	86								
151052	24	29	2.9	120	57								
151053	10	79	4.5	14	<10								
151054	30	64	3.3	110	84								
151055	24	48	4.7	88	54								
151056	26	73	4.8	50	33								
151057	17	54	5.5	26	53								
151058	17	56	4.3	20	45								
151059	14	43	4.1	11	45								
151060	39	38	3.5	32	80								
151061	45	91	2.9	51	87								
151062	22	26	3.8	180	54								
151063	50	30	2.3	390	59								
151064	52	230	1.5	3700	150								
151065	50	71	1.7	92	71								
151066	23	60	3.2	14	69								
151067	63	200	3.1	20	170								
151068	6	44	0.08	37	28								
151069	5	24	0.11	17	37								
151070	13	<2	0.04	110	<10								
151071	2	4	0.02	370	12								
151072	7	4	0.03	240	10								
151074	8	7	0.05	740	<10								
151075	11	<2	0.03	330	<10								
151076	26	53	1.1	42	53								
151077	23	53	3.0	26	55								
151078	7	5	0.08	40	<10								
151079	23	12	0.09	83	<10								
151080	52	43	2.1	180	76								
151081	62	110	2.5	240	97								
151082	26	44	5.2	37	88								
151083	15	40	3.1	50	51								
151084	3	6	0.31	5	<10								

SW NEW MEXICO VOLCANICS										SECTION 1 OF 3							
OR SAMPLE		D. O. E. SAMPLE		NUMBER		U	U-NT	U/TU	AG	AL	B	BA	BE	CA	CO	CR	
NUMBER	ST	LAT	LONG	L	TY	REP	(PPM)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	
151085	40-31.639	-108.684	-3-92-				3.8	3.4	1.1	<2	4.2	<10	540	7	0.42	4	2
151086	40-31.639	-108.682	-3-92-				4.3	4.7	0.93	<2	4.3	<10	360	2	0.16	<4	3
151087	40-31.640	-108.674	-3-92-				1.0	1.4	0.71	<2	0.69	<10	320	3	0.05	<4	5
151088	40-31.642	-108.677	-3-92-				1.8	1.9	0.94	<2	0.20	<10	6	<1	31.	<4	1
151089	40-31.645	-108.662	-3-92-				1.9	1.1	1.7	<2	0.25	<10	22	<1	36.	<4	15
151090	40-31.658	-108.667	-3-92-				2.2	2.4	0.93	<2	0.44	13	290	1	0.22	<4	14
151091	40-31.710	-109.003	-3-92-				8.5	8.1	1.0	<2	5.9	<10	60	3	0.40	<4	1
151092	40-31.710	-109.003	-3-92-				6.8	7.2	0.94	<2	5.1	<10	46	4	0.28	<4	<1
151093	40-31.714	-109.005	-3-92-				6.8	8.3	0.82	<2	5.1	<10	52	3	0.26	<4	1
151094	40-30.704	-109.009	-3-92-				4.0	4.7	0.86	<2	4.9	<10	120	3	0.58	<4	4
151095	40-31.702	-109.006	-3-92-				10.	9.0	1.1	<2	5.7	<10	120	3	1.1	<4	3
151096	40-31.701	-109.004	-3-92-				3.2	3.6	0.89	<2	5.1	<10	170	2	0.54	<4	2
151097	40-31.686	-108.984	-3-92-				3.3	3.4	0.96	<2	5.3	<10	140	2	0.37	<4	3
151098	40-31.686	-108.988	-3-92-				5.5	1.1	5.0	<2	5.1	<10	130	5	0.81	<4	1
151099	40-31.687	-108.989	-3-92-				8.5	7.5	1.1	<2	5.0	<10	150	4	0.77	<4	2
151100	40-31.687	-108.990	-3-92-				7.9	7.7	1.0	<2	5.0	<10	120	4	0.52	<4	2
151101	40-31.691	-108.993	-3-92-				7.4	7.5	0.99	<2	5.0	<10	70	5	0.36	<4	1
151102	40-31.819	-108.834	-3-92-				1.5	3.0	0.51	<2	5.8	<10	1200	3	1.9	10	2
151103	40-31.735	-108.825	-3-92-				3.2	4.6	0.70	<2	6.7	<10	1100	2	0.77	<4	1
151104	40-31.739	-108.819	-3-92-				5.6	5.4	1.0	<2	5.9	<10	1300	2	0.54	4	2
151105	40-31.707	-108.921	-3-92-				6.3	7.3	0.86	<2	4.8	<10	50	5	0.31	<4	1
151106	40-31.707	-108.917	-3-92-				6.6	12.	0.58	<2	4.4	<10	140	5	0.46	<4	1
151107	40-31.705	-108.916	-3-92-				5.8	7.3	0.80	<2	4.6	<10	56	4	0.38	<4	<1
151108	40-31.702	-108.916	-3-92-				7.2	7.3	0.98	<2	4.6	<10	48	5	0.31	<4	3
151109	40-31.859	-108.487	-3-92-				0.99	1.2	0.83	<2	6.7	<10	800	1	5.0	27	19
151110	40-31.860	-108.490	-3-92-				4.3	4.3	0.99	<2	0.54	<10	30	<1	21.	<4	3
151111	40-31.862	-108.490	-3-92-				3.8	3.7	1.0	<2	5.3	<10	780	2	0.34	<4	<1
151112	40-31.864	-108.491	-3-92-				6.1	6.9	0.89	<2	7.6	<10	870	2	1.8	5	2
151113	40-31.866	-108.492	-3-92-				1.6	1.5	1.1	<2	7.2	<10	450	2	1.4	5	1
151114	40-31.866	-108.492	-3-92-				4.0	4.8	0.82	<2	6.8	<10	840	2	1.0	5	5
151115	40-31.867	-108.492	-3-92-					4.9									
151116	40-31.867	-108.492	-3-92-				5.3	5.3	1.00	<2	6.2	<10	230	2	0.23	<4	3
151117	40-31.979	-108.461	-3-92-				3.5	3.2	1.1	<2	6.0	12	500	2	0.40	<4	2
151118	40-31.979	-108.461	-3-92-				5.4	5.1	1.1	<2	3.2	<10	250	4	0.24	7	2
151119	40-31.981	-108.459	-3-92-				4.6	5.4	0.86	<2	4.0	<10	61	5	0.10	<4	3
151120	40-31.984	-108.461	-3-92-				2.6	2.8	0.93	<2	3.7	<10	150	3	0.57	<4	3
151121	40-31.984	-108.460	-3-92-				1.8	1.7	1.0	<2	4.8	<10	890	3	2.1	5	1
151122	40-31.985	-108.460	-3-92-				1.7	2.4	0.71	<2	4.7	<10	660	5	1.3	<4	3
151123	40-31.984	-108.455	-3-92-				5.7	5.8	0.98	<2	4.8	<10	120	6	1.3	<4	2
151124	40-31.987	-108.459	-3-92-				3.8	3.4	1.1	<2	4.8	<10	550	3	0.06	<4	1
151125	40-31.992	-108.461	-3-92-				2.9	2.9	1.0	<2	4.9	<10	530	2	0.17	<4	<1
151126	40-31.994	-108.459	-3-92-				3.3	5.2	0.64	<2	4.1	<10	150	4	0.16	<4	4
151127	40-31.994	-108.459	-3-92-				1.3	1.8	0.71	<2	4.8	<10	59	2	0.10	<4	1
151128	40-31.994	-108.458	-3-92-				2.7	2.9	0.94	<2	3.7	16	440	4	0.09	<4	3
151129	40-31.976	-108.456	-3-92-				0.80	0.80	1.0	<2	5.9	<10	450	1	8.0	32	14
151130	40-31.976	-108.456	-3-92-				0.66	0.80	0.82	<2	5.9	<10	1100	1	7.3	23	15
151131	40-31.982	-108.365	-3-92-				2.2	2.2	1.0	<2	6.8	<10	830	1	2.1	28	150
151132	40-31.982	-108.465	-3-92-				3.6	4.1	0.89	<2	5.1	<10	300	3	0.48	<4	<1
151133	40-31.981	-108.467	-3-92-				1.5	1.4	1.0	<2	0.63	<10	320	2	23.	<4	8
151134	40-31.508	-108.534	-3-92-				5.3	5.5	0.97	<2	4.8	<10	220	10	1.4	<4	6
151137	40-31.507	-108.536	-3-92-				4.2	5.9	0.71	<2	4.9	<10	570	3	0.57	<4	1
151138	40-31.506	-108.616	-3-92-				3.0	3.4	0.89	<2	4.3	<10	500	6	1.1	<4	2
151139	40-31.576	-108.714	-3-92-				5.1	6.7	0.77	<2	4.8	<10	41	7	0.13	<4	<1
151140	40-31.595	-108.729	-3-92-				4.4	5.7	0.77	<2	4.0	<10	39	9	0.20	<4	3
151141	40-31.614	-108.735	-3-92-				3.1	3.3	0.95	<2	4.6	<10	220	6	0.92	<4	5

SW NEW MEXICO VOLCANICS												SECTION 2 OF 3			
OR SAMPLE	CU	FE	LI	MG	MN	MO	NA	NB	NI	P	SC	TH	TI	V	Y
NUMBER	(PPM)	(%)	(PPM)	(%)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)
151085	4	1.3	18	0.19	230	<4	2.4	15	<2	350	4	11	1700	19	21
151086	9	0.72	62	0.27	250	<4	0.63	14	4	62	2	14	640	6	18
151087	<2	0.33	34	0.06	45	4	<0.05	<4	<2	45	1	2	260	8	1
151088	3	0.18	3	0.21	160	5	<0.05	23	2	28	1	<2	67	4	1
151089	<2	0.17	3	0.31	150	<4	<0.05	18	2	59	<1	3	190	11	2
151090	4	0.50	43	0.05	6	<4	<0.05	<4	2	33	<1	<2	190	13	1
151091	2	0.50	37	0.09	420	<4	1.8	24	<2	55	2	25	600	4	25
151092	<2	0.31	43	0.07	210	<4	2.4	19	<2	16	1	25	450	2	18
151093	<2	0.33	48	0.06	300	<4	2.7	18	<2	13	1	19	420	2	17
151094	<2	0.56	68	0.28	240	<4	1.7	17	<2	68	2	18	630	6	17
151095	2	0.62	9	0.23	410	<4	1.7	20	<2	73	2	21	740	6	21
151096	<2	0.50	34	0.19	190	<4	2.3	12	<2	83	2	14	750	7	14
151097	<2	0.40	23	0.12	96	<4	2.4	11	<2	57	1	13	530	4	10
151098	4	0.58	45	0.27	440	<4	1.9	28	3	60	2	28	710	9	27
151099	<2	0.65	37	0.15	560	<4	2.1	26	<2	60	2	31	830	6	26
151100	62	0.56	34	0.06	530	<4	2.4	23	<2	54	2	23	710	6	23
151101	<2	0.50	37	0.11	350	<4	2.0	27	<2	41	2	27	610	4	23
151102	20	2.2	19	0.42	390	<4	2.8	16	<2	800	5	11	3700	44	20
151103	2	1.2	12	0.11	750	<4	2.8	10	<2	440	3	12	1700	13	24
151104	5	1.5	19	0.27	510	<4	2.7	19	2	390	4	14	2700	17	23
151105	6	0.52	34	0.05	350	<4	1.9	25	<2	36	2	27	640	4	23
151106	13	0.72	36	0.13	250	<4	2.1	27	<2	99	2	27	1000	10	22
151107	<2	0.48	42	0.17	370	<4	1.8	25	<2	42	2	26	650	3	23
151108	17	0.46	48	0.11	320	4	2.0	27	<2	40	2	33	580	3	24
151109	18	5.3	18	1.3	1000	<4	2.6	13	5	2700	14	5	8000	170	19
151110	190	0.28	24	3.4	480	7	0.07	7	<2	430	1	6	260	29	2
151111	<2	1.1	34	0.13	280	<4	2.6	15	<2	350	3	12	2300	7	27
151112	5	2.3	35	0.34	690	<4	2.6	10	3	580	6	9	3800	52	33
151113	4	2.9	35	0.26	320	<4	3.7	6	4	1000	7	11	3700	29	24
151114	9	2.5	22	0.30	300	<4	2.8	7	3	860	6	12	2800	31	29
151115															
151116	2	0.83	28	0.09	200	<4	2.0	19	<2	120	2	21	1000	11	20
151117	3	0.65	29	0.25	140	<4	0.52	16	<2	210	2	11	1200	15	13
151118	4	0.89	25	0.12	35	<4	0.46	20	26	110	3	13	1100	11	18
151119	5	0.67	23	0.06	180	4	0.40	22	3	74	4	19	800	5	20
151120	4	0.43	54	<0.05	240	<4	0.60	15	3	74	3	14	680	4	21
151121	6	1.5	37	0.21	1100	<4	0.68	25	<2	390	4	17	1700	25	28
151122	5	1.0	39	0.17	170	<4	1.1	12	3	440	5	10	1100	10	26
151123	3	0.78	16	0.36	260	<4	0.74	26	2	54	4	22	860	6	25
151124	6	0.68	56	<0.05	240	<4	0.80	18	<2	50	4	10	870	<2	28
151125	<2	0.54	58	0.07	340	<4	0.87	13	<2	48	3	10	570	2	28
151126	4	0.56	54	<0.05	260	<4	0.72	15	4	140	2	14	670	4	22
151127	<2	0.39	76	0.06	280	<4	0.38	21	<2	210	2	20	490	2	29
151128	4	0.54	52	0.08	240	<4	0.69	15	3	160	2	8	640	2	19
151129	49	5.8	22	0.75	1100	<4	1.4	8	7	1500	18	3	7200	190	17
151130	30	5.5	16	0.78	3200	<4	1.3	12	10	1500	20	9	8200	160	23
151131	23	4.2	36	0.30	1300	<4	2.1	8	37	610	14	<2	4300	92	15
151132	<2	0.65	24	0.28	95	<4	0.78	23	<2	83	3	14	850	6	19
151133	6	0.56	6	0.26	390	6	<0.05	10	4	180	1	<2	600	16	4
151134	6	0.95	59	0.66	910	5	0.60	45	5	140	3	27	1000	11	54
151137	<2	0.72	23	0.14	680	<4	2.4	24	<2	80	3	12	940	4	30
151138	4	1.0	23	0.29	410	<4	2.0	14	4	270	3	11	1400	12	21
151139	<2	0.60	25	0.05	470	<4	2.4	40	<2	160	2	29	770	3	31
151140	4	0.63	21	0.09	350	<4	2.1	31	4	69	2	20	1280	5	27
151141	5	0.93	10	0.35	370	4	0.71	21	5	110	3	17	1200	8	18

SW NEW MEXICO VOLCANICS

SECTION 3 OF 3

OR SAMPLE NUMBER	ZN (PPM)	ZR (PPM)	K (%)	SR (PPM)	CE (PPM)	TGAM (CPS)	TOT (CPM)	EK (%)	CPK (CPM)	EU (PPM)	CPJ (CPM)	ETH (PPM)	CPTH (CPM)
151085	23	62	2.8	120	63								
151086	29	62	4.5	58	54								
151087	38	10	0.20	39	<10								
151088	29	5	0.07	300	<10								
151089	8	<2	0.09	260	<10								
151090	5	7	0.12	34	<10								
151091	24	49	2.3	27	55								
151092	12	36	3.8	31	41								
151093	14	34	3.9	22	40								
151094	16	36	3.1	130	44								
151095	28	46	2.1	75	49								
151096	15	34	3.8	68	55								
151097	11	29	4.3	67	37								
151098	28	54	2.9	60	45								
151099	26	57	2.9	93	63								
151100	25	53	3.4	57	59								
151101	21	53	3.3	26	54								
151102	53	180	2.8	520	110								
151103	52	88	2.8	250	120								
151104	53	51	3.6	310	120								
151105	22	55	2.8	18	54								
151106	19	69	3.0	47	44								
151107	18	55	2.7	26	49								
151108	21	54	2.7	21	66								
151109	120	100	1.4	860	69								
151110	14	10	0.10	780	14								
151111	27	99	3.3	220	90								
151112	67	190	2.1	230	90								
151113	52	160	0.76	350	74								
151114	52	130	2.0	250	87								
151115													
151116	22	49	2.8	110	58								
151117	30	31	2.5	57	77								
151118	110	130	4.2	28	56								
151119	21	100	5.7	6	70								
151120	20	90	5.2	23	60								
151121	34	57	4.8	87	72								
151122	17	40	4.8	100	58								
151123	48	79	1.8	1800	47								
151124	28	70	5.0	23	50								
151125	16	62	5.1	23	45								
151126	5	74	5.5	22	52								
151127	15	60	4.9	12	44								
151128	11	62	5.2	22	30								
151129	87	130	0.73	570	19								
151130	70	170	1.1	320	60								
151131	35	120	1.3	460	99								
151132	30	47	3.1	87	78								
151133	11	14	0.09	370	<10								
151134	44	99	2.6	1000	54								
151137	42	74	2.4	55	50								
151138	16	55	3.3	130	53								
151139	46	98	3.0	16	78								
151140	20	97	3.5	12	69								
151141	28	76	3.4	300	59								

SW NEW MEXICO VOLCANICS														SECTION 1 OF 3			
OR SAMPLE	D. O. E.	SAMPLE	NUMBER	U	U-NT	U/TU	AG	AL	B	BA	BE	CA	CO	CR			
NUMBER	ST	LAT	LONG	L	TY	REP	(PPM)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(PPM)	(PPM)			
151142	40-31.490	-108.385	-3-92-	7.2	6.3	1.1	<2	5.8	<10	140	3	0.36	<4	<1			
151143	40-31.489	-108.384	-3-92-	3.9	5.3	0.74	<2	5.3	<10	190	3	0.17	<4	<1			
151144	40-31.489	-108.384	-3-92-	5.5	5.7	0.96	<2	7.3	<10	740	2	1.4	<4	2			
151145	40-31.488	-108.383	-3-92-	3.4	4.2	0.80	<2	5.5	<10	740	3	1.0	6	1			
151146	40-31.457	-108.341	-3-92-	1.4	1.5	0.93	<2	5.1	<10	460	1	3.0	14	37			
151148	40-31.488	-108.383	-3-92-	4.6	3.7	1.2	<2	4.9	<10	350	6	0.33	<4	4			
151149	40-31.488	-108.382	-3-92-	4.4	3.9	1.1	<2	4.2	<10	260	6	0.38	<4	2			
151150	40-31.458	-108.345	-3-92-	3.0	3.4	0.90	<2	5.1	<10	420	6	0.69	<4	1			
151151	40-31.458	-108.346	-3-92-	3.6	3.6	1.0	2	4.8	<10	360	6	0.64	<4	2			
151152	40-31.457	-108.350	-3-92-	3.2	3.5	0.91	<2	4.9	<10	470	7	0.87	4	2			
151153	40-31.457	-108.348	-3-92-	2.8	3.9	0.71	<2	5.2	<10	450	3	0.88	4	1			
151154	40-31.451	-108.344	-3-92-	3.1	2.9	1.1	<2	5.0	<10	490	6	0.85	<4	2			
151155	40-31.444	-108.346	-3-92-	6.1	6.9	0.89	<2	5.0	<10	220	4	0.57	<4	1			
151156	40-31.468	-108.441	-3-92-	1.7	1.6	1.1	<2	0.12	<10	6	<1	30.	<4	1			
151157	40-31.480	-108.413	-3-92-	0.37	0.60	0.62	<2	0.10	<10	4	<1	32.	<4	2			
151158	40-31.491	-108.400	-3-92-	1.1	1.0	1.1	<2	0.07	<10	2	1	28.	<4	2			
151159	40-31.506	-108.386	-3-92-	1.6	1.4	1.1	<2	0.67	<10	42	<1	<0.05	<4	4			
151160	40-31.385	-108.308	-3-92-	3.2	4.1	0.77	<2	5.6	<10	730	10	0.98	5	1			
151161	40-31.386	-108.306	-3-92-	4.6	4.6	1.0	<2	6.1	<10	140	3	0.17	<4	1			
151162	40-31.360	-108.320	-3-92-	4.2	4.6	0.91	<2	0.05	<10	36	1	30.	<4	1			
151163	40-31.362	-108.320	-3-92-	3.1	3.8	0.81	<2	4.3	<10	590	2	1.2	5	1			
151164	40-31.362	-108.320	-3-92-	37.	14.	6.8	<2	0.27	<10	44	1	0.50	<4	3			
151165	40-31.363	-108.321	-3-92-	8.5	8.5	1.00	<2	4.8	10	16	4	0.06	<4	2			
151166	40-31.430	-108.303	-3-92-	3.6	3.0	1.2	<2	4.6	<10	170	3	0.95	<4	1			
151167	40-31.431	-108.301	-3-92-	2.8	2.5	1.1	<2	6.6	62	880	1	1.2	4	1			
151168	40-31.432	-108.302	-3-92-	5.9	6.1	0.96	<2	5.5	12	350	2	0.57	<4	3			
151169	40-31.432	-108.302	-3-92-	4.0	4.2	0.95	<2	4.9	<10	470	5	0.72	4	6			
151170	40-31.523	-108.786	-3-92-	5.1	7.6	0.67	<2	5.0	<10	110	7	0.22	<4	1			
151171	40-31.523	-108.786	-3-92-	3.6	3.4	1.1	<2	4.8	<10	590	3	0.55	<4	2			
151172	40-31.523	-108.785	-3-92-	5.3	5.3	1.0	<2	4.7	<10	510	5	0.85	<4	3			
151173	40-31.523	-108.785	-3-92-	4.3	5.0	0.87	3	4.3	<10	110	7	0.34	<4	4			
151174	40-31.521	-108.782	-3-92-	2.0	2.6	0.77	<2	5.7	<10	660	2	0.80	6	<1			
151175	40-31.568	-108.613	-3-92-	1.6	1.7	0.94	<2	4.4	<10	380	2	4.2	<4	4			
151176	40-31.568	-108.613	-3-92-	1.3	1.4	0.95	2	4.6	<10	260	11	5.2	12	4			
151177	40-31.567	-108.612	-3-92-	2.9	3.0	0.96	<2	4.8	<10	300	3	0.72	<4	1			
151178	40-31.384	-108.636	-3-92-		6.6												
151179	40-31.384	-108.636	-3-92-	5.9	6.4	0.92	<2	4.4	10	27	16	0.15	<4	2			
151180	40-31.384	-108.637	-3-92-	3.8	4.3	0.88	<2	3.3	<10	18	15	0.06	<4	2			
151181	40-31.569	-108.616	-3-92-	2.7	2.4	1.1	<2	5.0	<10	610	4	0.42	<4	2			
151182	40-31.564	-108.623	-3-92-	2.4	2.9	0.82	2	4.6	<10	520	5	0.66	4	3			
151183	40-31.626	-108.675	-3-92-	3.3	4.8	0.68	<2	5.0	<10	780	2	0.18	4	2			
151184	40-31.624	-108.674	-3-92-	3.1	3.8	0.81	<2	5.0	<10	610	8	1.9	5	2			
151185	40-31.624	-108.674	-3-92-	4.1	5.1	0.81	<2	5.4	<10	700	3	2.2	4	<1			
151186	40-31.622	-108.674	-3-92-	2.7	3.2	0.84	<2	5.3	<10	580	8	1.2	5	1			
151187	40-31.621	-108.682	-3-92-	2.5	3.0	0.84	<2	5.9	<10	740	2	2.4	15	6			
151188	40-31.633	-108.599	-3-92-	3.7	3.7	1.00	<2	6.4	<10	960	3	1.0	4	<1			
151189	40-31.627	-108.599	-3-92-	3.4	3.9	0.88	<2	6.3	<10	940	3	1.3	4	<1			
151190	40-31.646	-108.658	-3-92-	1.8	2.1	0.86	<2	0.25	<10	230	1	14.	<4	19			
151191	40-31.348	-108.759	-3-92-	6.9	7.9	0.87	3	5.4	10	11	9	0.08	<4	<1			
151192	40-31.347	-108.760	-3-92-	6.0	8.8	0.68	<2	4.3	<10	10	10	<0.05	4	<1			
151193	40-31.348	-108.761	-3-92-	6.6	8.0	0.82	3	4.7	<10	12	10	0.09	<4	<1			
151194	40-31.353	-108.766	-3-92-	5.5	5.1	1.1	3	4.3	<10	21	12	0.07	4	1			
151195	40-31.353	-108.766	-3-92-	5.0	8.2	0.61	3	5.3	42	25	10	0.05	<4	1			
151196	40-31.353	-108.766	-3-92-	4.5	4.2	1.1	3	4.0	<10	75	20	0.61	4	2			
151197	40-31.352	-108.769	-3-92-	7.5	7.0	1.1	4	5.1	<10	20	8	<0.05	<4	2			

SW NEW MEXICO VOLCANICS													SECTION 2 OF 3		
OR SAMPLE NUMBER	CU (PPM)	FE (%)	LI (PPM)	MG (%)	MN (PPM)	MO (PPM)	NA (%)	NB (PPM)	NI (PPM)	P (PPM)	SC (PPM)	TH (PPM)	TI (PPM)	V (PPM)	Y (PPM)
151142	<2	0.45	36	0.07	130	<4	1.6	20	5	90	2	13	1100	21	30
151143	<2	0.83	26	0.05	25	<4	1.9	27	<2	92	4	18	1500	17	29
151144	4	1.6	28	0.20	240	<4	2.3	13	3	890	4	17	2400	41	26
151145	7	1.7	34	0.19	170	<4	2.0	17	<2	400	4	13	2500	26	25
151146	13	2.5	21	0.71	250	<4	1.5	11	7	330	7	3	2800	71	11
151148	6	0.77	32	0.10	95	<4	1.6	23	5	100	3	15	1200	11	29
151149	4	0.70	37	0.09	150	<4	1.6	22	2	78	2	13	940	9	26
151150	4	0.93	25	0.28	260	<4	1.6	18	2	240	2	17	1400	11	26
151151	3	0.77	22	0.18	200	<4	1.8	18	3	180	2	16	1100	8	21
151152	7	0.96	15	0.31	400	<4	1.8	17	7	170	3	18	1200	14	32
151153	<2	1.2	17	0.37	310	<4	1.9	17	<2	280	3	18	1300	17	27
151154	3	0.85	8	0.36	470	5	1.7	17	<2	220	3	18	1300	11	30
151155	<2	0.87	23	0.42	440	<4	1.7	29	<2	81	2	23	1100	8	21
151156	45	0.12	3	0.32	37	<4	<0.05	<4	<2	22	1	3	55	4	1
151157	<2	0.12	2	0.82	45	<4	<0.05	4	<2	40	1	4	60	2	1
151158	4	0.06	2	0.50	22	<4	<0.05	7	3	24	1	<2	71	2	1
151159	4	0.15	7	<0.05	53	<4	<0.05	<4	<2	28	1	4	450	5	2
151160	4	2.0	11	0.24	120	<4	2.0	17	<2	410	5	16	2800	35	28
151161	2	0.76	33	<0.05	130	<4	2.2	21	2	480	3	14	1300	10	34
151162	4	0.21	2	0.20	2800	<4	<0.05	6	<2	79	1	<2	39	3	1
151163	3	0.60	6	0.23	65	<4	1.5	17	<2	180	2	9	2100	11	18
151164	<2	0.08	1	<0.05	100	<4	0.09	<4	<2	10	<1	3	85	3	1
151165	2	0.31	34	<0.05	75	<4	1.8	23	<2	64	1	16	580	3	33
151166	2	0.63	5	0.23	380	<4	1.2	19	<2	83	2	13	770	4	19
151167	3	1.6	12	0.34	350	<4	1.6	4	<2	340	3	7	1700	36	12
151168	3	1.0	13	0.32	270	<4	1.5	11	3	200	2	15	1300	16	16
151169	4	1.2	23	0.25	240	<4	1.7	15	5	190	3	15	1400	15	14
151170	<2	0.66	45	0.16	520	<4	1.5	51	<2	44	3	35	540	2	46
151171	28	0.80	82	0.08	380	<4	0.49	14	2	130	3	14	980	7	24
151172	5	0.65	13	0.13	570	5	2.2	19	5	84	3	10	910	3	26
151173	5	0.89	66	0.49	860	<4	1.6	54	3	110	3	29	920	10	56
151174	<2	1.3	51	0.43	200	<4	1.3	13	<2	230	3	13	1500	14	25
151175	2	0.68	29	0.25	830	<4	1.3	13	<2	100	2	7	820	36	13
151176	17	3.7	50	0.57	1100	<4	1.0	7	5	510	8	<2	4000	44	16
151177	<2	0.80	63	0.62	270	<4	0.63	18	<2	73	3	17	1100	3	28
151178															
151179	2	1.8	42	0.14	980	18	2.5	88	<2	100	5	24	2300	9	77
151180	3	1.7	34	0.09	890	15	2.5	87	<2	300	5	19	2400	11	49
151181	2	0.58	40	0.23	370	<4	2.6	15	<2	130	2	15	740	5	21
151182	3	1.2	9	0.42	160	5	1.1	13	2	150	3	18	1500	15	17
151183	2	1.3	15	0.24	150	<4	2.4	17	<2	240	3	13	1700	24	17
151184	4	1.4	31	0.50	470	4	1.4	16	2	270	4	14	1800	14	28
151185	<2	1.1	27	0.36	430	<4	1.6	14	<2	280	4	17	1500	15	29
151186	5	1.6	21	0.33	380	<4	1.9	16	2	330	5	11	2200	19	24
151187	13	3.0	25	0.92	620	6	2.0	13	3	680	8	13	3700	47	27
151188	2	1.7	37	0.46	160	<4	1.7	16	<2	420	4	12	2500	18	28
151189	<2	1.9	22	0.33	230	<4	2.3	18	<2	490	4	16	3100	17	30
151190	2	0.35	56	0.05	63	10	<0.05	<4	2	24	1	2	93	13	20
151191	<2	2.0	45	0.15	880	<4	2.2	75	<2	87	1	26	1100	2	74
151192	36	1.9	53	0.06	960	<4	2.5	83	<2	15	4	22	1100	2	63
151193	3	2.2	50	<0.05	890	<4	2.3	98	<2	93	5	27	1200	7	64
151194	2	2.0	43	0.05	880	<4	2.2	94	<2	35	4	27	1200	8	100
151195	<2	1.9	56	0.07	860	<4	2.4	83	<2	31	1	27	1200	3	61
151196	4	1.8	60	0.08	880	<4	1.5	90	<2	20	4	23	1100	9	76
151197	2	1.7	33	<0.05	790	<4	1.8	79	2	78	<1	25	1000	5	90

SW NEW MEXICO VOLCANICS												SECTION 3 OF 3	
OR SAMPLE NUMBER	ZN (PPM)	ZR (PPM)	K (%)	SR (PPM)	CE (PPM)	TGAM (CPS)	TOT (CPM)	EK (%)	CPK (CPM)	EU (PPM)	CPL (CPM)	ETH (PPM)	CPTH (CPM)
151142	27	120	3.0	20	99								
151143	15	150	3.5	49	98								
151144	47	73	2.4	220	93								
151145	33	73	2.9	190	79								
151146	50	92	1.4	320	36								
151148	19	82	3.9	58	62								
151149	18	70	3.0	53	53								
151150	23	56	3.4	99	60								
151151	23	53	3.3	90	60								
151152	35	54	3.2	130	75								
151153	30	57	2.9	110	79								
151154	20	61	3.1	130	70								
151155	47	87	2.8	130	74								
151156	4	5	0.02	460	<10								
151157	5	5	<0.02	370	<10								
151158	3	4	0.04	340	<10								
151159	6	24	0.10	8	12								
151160	44	90	3.1	170	78								
151161	29	130	2.8	20	96								
151162	3	9	0.05	330	<10								
151163	25	48	1.3	520	70								
151164	13	2	0.10	21	<10								
151165	35	110	2.4	4	49								
151166	26	66	2.8	290	65								
151167	36	28	2.3	650	81								
151168	30	36	2.1	99	42								
151169	25	35	3.5	100	41								
151170	61	100	2.9	71	70								
151171	37	70	5.0	60	57								
151172	31	73	2.8	84	41								
151173	46	110	3.2	58	50								
151174	29	40	3.3	130	94								
151175	33	34	2.5	120	41								
151176	26	84	1.7	310	17								
151177	38	140	2.8	90	89								
151178													
151179	95	1000	3.4	7	200								
151180	67	1100	3.4	4	150								
151181	32	50	2.8	82	42								
151182	24	40	3.7	110	62								
151183	35	55	3.4	170	67								
151184	39	60	2.9	120	73								
151185	37	57	2.7	130	93								
151186	33	61	3.4	110	82								
151187	76	73	2.0	260	86								
151188	49	120	3.1	200	96								
151189	58	120	2.8	280	100								
151190	10	10	0.06	45	19								
151191	160	710	2.4	7	180								
151192	140	300	3.0	3	190								
151193	170	930	2.8	4	210								
151194	150	960	2.8	5	190								
151195	150	740	2.4	6	160								
151196	140	920	3.8	18	150								
151197	110	880	2.8	5	150								

SW NEW MEXICO VOLCANICS										SECTION 1 OF 3							
OR SAMPLE	D. O. E. SAMPLE	NUMBER	U	U-NT	U/TU	AG	AL	B	BA	BE	CA	CO	CR				
NUMBER	ST	LAT	LONG	L	TY	REP	(PPM)	(PPM)	(X)	(PPM)	(PPM)	(X)	(PPM)	(PPM)			
151198	40-31.351	-108.769	-3-92-				4.9	4.9	1.0	4	4.8	<10	31	7	0.07	<4	<1
151199	40-31.353	-108.771	-3-92-				4.2	5.8	0.73	2	5.3	<10	15	10	0.05	<4	1
151200	40-31.506	-109.007	-3-92-				7.7	7.3	1.1	<2	6.5	<10	320	4	0.29	<4	2
151201	40-31.506	-109.007	-3-92-				4.7	4.1	1.1	<2	5.0	<10	270	5	0.93	<4	<1
151202	40-31.511	-109.007	-3-92-				9.1	8.4	1.1	<2	5.5	<10	300	4	0.25	<4	2
151203	40-31.489	-108.996	-3-92-				9.9	9.1	1.1	<2	6.1	<10	150	5	0.26	<4	1
151204	40-31.490	-108.992	-3-92-				5.2	7.8	0.67	<2	4.7	13	140	6	0.27	<4	1
151205	40-31.491	-108.991	-3-92-				7.7	6.5	1.2	<2	3.8	<10	99	3	0.05	<4	1
151206	40-31.403	-108.942	-3-92-				4.3	7.2	0.60	<2	6.4	<10	15	13	0.08	<4	1
151208	40-31.404	-108.941	-3-92-				7.9	8.8	0.90	<2	5.0	<10	2	14	0.21	<4	<1
151209	40-31.404	-108.940	-3-92-				7.6	9.6	0.79	<2	4.9	<10	9	16	0.25	<4	<1
151210	40-31.405	-108.939	-3-92-				5.2	7.1	0.74	<2	4.7	<10	10	18	0.29	<4	<1
151211	40-31.405	-108.939	-3-92-				5.3	6.7	0.79	<2	4.5	<10	7	20	0.25	<4	<1
151212	40-31.405	-108.938	-3-92-				8.4	9.4	0.89	<2	6.2	<10	17	14	0.26	<4	1
151213	40-31.405	-108.938	-3-92-				9.7	9.5	1.0	<2	4.9	<10	9	17	0.38	<4	1
151214	40-31.405	-108.938	-3-92-				11.	10.	1.1	<2	5.0	<10	8	17	0.26	<4	2
151215	40-31.344	-108.758	-3-92-				8.6	7.6	1.1	4	5.8	<10	12	8	0.06	<4	<1
151216	40-31.347	-108.759	-3-92-				5.7	7.8	0.74	3	5.8	11	8	9	<0.05	<4	1
151217	40-31.353	-108.766	-3-92-				3.8	4.7	0.80	3	4.1	26	22	15	0.05	4	2
151218	40-31.353	-108.766	-3-92-				10.	8.9	1.1	4	5.5	10	18	10	0.33	<4	1
151219	40-31.353	-108.770	-3-92-				4.0	6.4	0.63	2	4.5	<10	16	9	0.05	4	1
151220	40-31.516	-109.041	-3-92-				8.1	8.2	0.98	<2	5.0	<10	290	9	0.30	<4	1
151221	40-31.515	-109.040	-3-92-				8.8	8.3	1.1	<2	6.7	<10	310	5	0.30	<4	1
151222	40-31.513	-109.039	-3-92-				7.1	6.7	1.1	<2	5.5	<10	300	5	0.28	<4	<1
151223	40-31.513	-109.039	-3-92-				8.0	8.7	0.92	<2	5.3	<10	290	5	0.36	<4	<1
151224	40-31.513	-109.039	-3-92-				8.5	8.6	0.99	<2	5.5	<10	280	6	0.41	<4	<1
151225	40-31.501	-109.007	-3-92-				8.2	8.0	1.0	<2	6.3	<10	300	4	0.29	<4	<1
151226	40-31.503	-109.004	-3-92-				1.4	0.40	3.5	<2	0.13	<10	16	1	<0.05	<4	1
151227	40-31.503	-109.007	-3-92-				6.2	5.6	1.1	<2	6.5	<10	320	4	0.31	<4	1
151228	40-31.506	-109.007	-3-92-				9.1	8.6	1.1	<2	6.1	10	310	5	0.40	<4	2
151229	40-31.506	-109.007	-3-92-				8.3	7.9	1.1	<2	5.4	<10	330	5	0.53	4	2
151230	40-31.511	-109.007	-3-92-				8.8	8.5	1.0	<2	6.0	<10	300	5	0.43	<4	1
151231	40-31.510	-109.006	-3-92-				8.7	8.7	1.00	<2	5.2	<10	130	5	2.1	<4	<1
151232	40-31.899	-108.948	-3-92-				3.8	3.9	0.96	<2	5.7	<10	38	3	0.16	<4	1
151233	40-31.900	-108.950	-3-92-				4.3	4.6	0.93	<2	5.4	<10	34	4	0.18	<4	1
151234	40-31.899	-108.951	-3-92-				4.4	4.6	0.97	<2	5.6	<10	38	3	0.14	<4	2
151235	40-31.898	-108.952	-3-92-				3.2	3.8	0.83	<2	4.8	<10	28	4	0.30	<4	1
151236	40-31.897	-108.953	-3-92-				6.1	5.9	1.0	<2	5.5	<10	44	4	0.22	<4	1
151237	40-31.897	-108.953	-3-92-				6.2	6.3	0.99	<2	5.1	<10	51	4	0.40	<4	<1
151238	40-31.894	-108.948	-3-92-				6.3	6.0	1.0	<2	5.1	<10	27	4	0.30	<4	1
151239	40-31.489	-108.998	-3-92-				8.8	8.6	1.0	<2	5.6	<10	170	6	0.22	<4	<1
151240	40-31.489	-108.997	-3-92-				9.6	9.8	0.98	<2	5.0	<10	130	6	0.38	<4	1
151241	40-31.489	-108.996	-3-92-				9.2	8.7	1.1	<2	0.09	<10	14	1	<0.05	<4	2
151242	40-31.490	-108.994	-3-92-				7.8	7.6	1.0	<2	6.1	14	150	5	0.26	<4	1
151243	40-31.490	-108.991	-3-92-				18.	18.	0.99	<2	2.3	<10	140	2	0.47	<4	1
151244	40-31.491	-108.990	-3-92-				9.3	8.6	1.1	<2	6.1	<10	290	5	0.46	<4	1
151245	40-31.496	-108.782	-3-92-				4.1	5.7	0.72	<2	4.4	41	410	4	0.12	<4	1
151246	40-31.496	-108.782	-3-92-				3.9	4.6	0.85	<2	4.8	32	130	2	0.31	4	2
151247	40-31.493	-108.772	-3-92-				6.6	6.1	1.1	<2	5.9	<10	54	5	0.10	<4	2
151248	40-31.597	-108.632	-3-92-				0.59	0.60	0.98	<2	0.34	<10	14	<1	28.	<4	5
151249	40-31.597	-108.626	-3-92-				0.95	0.90	1.1	<2	0.22	<10	8	<1	28.	<4	4
151250	40-31.631	-108.686	-3-92-				0.29	0.40	0.72	<2	0.14	<10	120	1	29.	<4	2
151251	40-31.631	-108.687	-3-92-				1.1	1.0	1.1	<2	0.58	<10	36	<1	0.94	<4	4
151252	40-31.626	-108.672	-3-92-				0.75	0.80	0.94	<2	0.13	<10	5	<1	30.	<4	<1
151253	40-31.405	-108.787	-3-92-				5.6	5.2	1.1	<2	5.6	<10	40	5	0.19	<4	2

SW NEW MEXICO VOLCANICS												SECTION 2 OF 3			
OR SAMPLE	CU	FE	LI	MG	MN	MO	NA	NB	NI	P	SC	TH	TI	V	Y
NUMBER	(PPM)	(%)	(PPM)	(%)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)
151198	2	1.8	28	0.07	890	<4	1.9	79	<2	41	<1	26	1100	4	100
151199	2	1.9	45	0.05	890	<4	2.5	71	<2	41	1	23	1100	3	88
151200	4	0.87	24	0.09	240	<4	1.9	27	2	50	2	29	1200	6	38
151201	<2	0.77	25	0.36	260	<4	0.81	28	<2	33	2	23	1100	3	29
151202	3	0.79	14	0.07	300	<4	1.7	25	<2	66	2	24	1100	5	37
151203	2	0.56	36	0.07	280	<4	2.0	28	2	53	2	26	870	3	39
151204	<2	0.83	40	0.08	540	<4	1.8	38	<2	52	3	34	1000	4	53
151205	<2	0.57	88	<0.05	240	<4	0.62	21	<2	32	1	18	750	2	27
151206	2	1.0	56	<0.05	540	4	2.8	89	<2	35	1	25	400	2	34
151208	<2	1.1	52	<0.05	420	<4	2.2	77	<2	31	1	31	360	<2	99
151209	2	0.98	64	<0.05	540	<4	2.6	97	<2	18	1	26	380	5	100
151210	2	0.94	52	<0.05	510	<4	2.5	100	<2	22	1	27	380	4	100
151211	2	0.92	62	<0.05	620	<4	2.4	100	<2	9	1	27	380	3	97
151212	3	1.1	81	<0.05	530	<4	2.5	99	<2	31	1	26	430	3	99
151213	2	1.0	68	<0.05	610	<4	2.6	100	<2	5	1	28	430	<2	100
151214	4	1.1	76	<0.05	580	4	2.6	110	<2	<5	1	30	450	<2	100
151215	2	2.0	51	0.05	890	<4	2.7	86	<2	28	<1	35	1300	4	93
151216	<2	1.9	56	0.06	880	<4	2.8	83	<2	37	1	28	1100	3	110
151217	4	1.9	54	0.08	910	<4	2.8	93	<2	15	4	20	1200	9	44
151218	<2	1.9	61	0.08	910	6	2.5	86	<2	36	<1	30	1300	2	100
151219	5	1.8	54	0.06	920	<4	2.5	79	<2	8	3	21	1000	5	64
151220	3	0.84	31	0.09	240	4	1.8	33	2	69	3	29	1300	7	47
151221	<2	0.76	35	0.08	230	<4	2.1	27	<2	65	2	28	1100	6	41
151222	8	0.81	27	0.10	250	<4	2.1	31	9	46	2	27	1100	2	36
151223	<2	0.81	12	0.08	350	<4	2.1	33	<2	67	3	31	1200	4	44
151224	2	0.84	28	0.16	370	<4	1.8	32	<2	51	3	28	1200	4	45
151225	2	0.78	23	0.10	230	<4	1.9	28	<2	74	2	28	1100	8	39
151226	14	0.07	3	<0.05	11	<4	<0.05	<4	<2	38	<1	<2	26	<2	1
151227	<2	0.79	17	0.14	210	<4	1.8	26	<2	71	2	31	1200	8	36
151228	2	0.84	7	0.08	330	4	2.0	29	<2	83	2	30	1200	5	41
151229	<2	0.92	31	0.12	380	<4	1.7	31	<2	76	3	29	1200	5	42
151230	2	0.82	8	0.09	370	<4	2.0	28	<2	86	2	26	1200	4	42
151231	2	0.73	9	0.59	290	<4	0.10	33	<2	38	2	28	1000	2	31
151232	3	0.57	52	0.05	320	<4	1.9	23	2	46	2	21	740	5	23
151233	62	0.54	57	<0.05	270	<4	2.0	26	<2	64	2	20	660	3	25
151234	3	0.56	65	<0.05	320	<4	1.5	19	2	370	2	20	660	4	27
151235	<2	0.57	57	<0.05	250	<4	2.0	22	<2	24	2	21	670	4	29
151236	84	0.64	41	<0.05	280	<4	2.3	25	<2	46	2	22	740	3	26
151237	<2	0.67	23	<0.05	260	<4	1.5	28	<2	32	2	22	860	2	30
151238	2	0.57	14	<0.05	380	<4	2.7	23	<2	19	2	22	720	2	25
151239	<2	0.86	36	0.07	360	<4	1.7	36	<2	52	3	30	970	2	39
151240	<2	0.82	14	0.07	370	<4	1.8	36	<2	35	3	32	1100	2	48
151241	2	0.06	9	<0.05	14	<4	<0.05	<4	<2	84	<1	6	34	<2	9
151242	2	0.74	40	0.07	250	4	2.0	28	<2	59	2	29	820	3	39
151243	6	0.40	8	0.13	140	<4	0.10	12	<2	31	1	13	500	<2	19
151244	2	0.81	12	0.09	380	<4	1.6	28	<2	81	2	29	1200	4	42
151245	4	0.49	74	0.06	1600	<4	0.85	17	<2	18	2	17	590	5	15
151246	3	0.61	46	0.09	220	<4	1.0	17	<2	60	2	23	720	5	28
151247	2	0.56	23	0.05	400	<4	2.2	26	<2	48	1	26	640	4	31
151248	4	0.48	10	0.41	98	<4	0.05	5	<2	270	1	5	210	14	7
151249	12	0.09	7	0.38	28	<4	0.05	6	<2	11	1	5	50	4	2
151250	<2	0.09	4	0.23	45	<4	<0.05	4	<2	5	1	3	69	3	1
151251	<2	0.29	19	0.10	33	<4	<0.05	4	<2	16	1	5	280	14	3
151252	<2	0.06	3	0.25	410	<4	<0.05	<4	<2	<5	1	2	42	3	2
151253	2	0.60	17	0.05	510	<4	2.1	31	<2	48	1	22	710	3	43

SW NEW MEXICO VOLCANICS

SECTION 3 OF 3

OR SAMPLE NUMBER	ZN (PPM)	ZR (PPM)	K (%)	SR (PPM)	CE (PPM)	TGAM (CPS)	TOT (CPM)	EK (%)	CPK (CPM)	EU (PPM)	CPU (CPM)	ETH (PPM)	CPTH (CPM)
151198	140	940	2.5	7	150								
151199	160	630	2.4	2	160								
151200	35	140	2.8	48	130								
151201	39	140	2.6	380	93								
151202	45	140	2.5	47	120								
151203	28	88	2.9	31	120								
151204	40	99	3.0	28	180								
151205	24	57	4.2	14	77								
151206	48	110	2.7	2	61								
151208	47	100	2.6	1	130								
151209	73	130	3.2	2	110								
151210	130	170	3.1	4	110								
151211	100	150	3.0	3	110								
151212	95	170	2.4	4	120								
151213	89	190	3.0	4	120								
151214	95	190	3.0	4	120								
151215	160	1000	2.6	3	180								
151216	160	750	2.8	4	210								
151217	130	1000	3.1	7	180								
151218	160	1000	2.2	150	210								
151219	140	600	3.2	3	160								
151220	24	160	3.9	50	110								
151221	30	150	3.0	51	150								
151222	32	160	3.9	47	130								
151223	38	170	3.0	49	140								
151224	39	170	2.3	52	130								
151225	33	140	2.7	42	120								
151226	2	4	0.04	2	<10								
151227	35	120	2.8	55	130								
151228	45	160	2.5	63	130								
151229	45	160	3.1	110	130								
151230	54	160	2.4	77	130								
151231	40	150	1.1	110	130								
151232	27	38	2.6	15	85								
151233	35	43	3.1	15	75								
151234	33	36	2.8	16	77								
151235	32	35	2.5	14	79								
151236	44	89	3.0	17	80								
151237	130	96	3.0	92	82								
151238	35	92	2.2	16	73								
151239	41	110	3.4	29	130								
151240	43	110	3.0	51	140								
151241	4	17	0.03	2	13								
151242	35	91	2.6	23	120								
151243	17	70	1.6	36	57								
151244	43	160	2.9	46	130								
151245	22	46	3.3	62	65								
151246	21	48	3.6	25	58								
151247	32	100	2.4	11	56								
151248	14	15	0.08	380	23								
151249	4	7	0.11	430	14								
151250	4	8	0.05	450	13								
151251	12	7	0.17	11	17								
151252	4	8	0.04	370	11								
151253	47	110	2.3	11	66								

SW NEW MEXICO VOLCANICS													SECTION 2 OF 3		
OR SAMPLE	CU	FE	LI	MG	MN	MO	NA	NB	NI	P	SC	TH	TI	V	Y
NUMBER	(PPM)	(%)	(PPM)	(%)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)
151254	<2	0.56	21	0.06	420	<4	2.4	27	<2	53	2	23	750	5	27
151255	2	0.55	22	0.11	230	<4	1.8	11	<2	67	1	16	610	3	18
151256	<2	0.55	28	0.08	170	<4	1.6	15	<2	43	1	20	600	7	19
151257	3	0.55	6	0.14	290	<4	1.8	12	<2	70	1	21	750	5	18
151258	<2	0.52	24	0.14	290	<4	1.9	12	<2	65	1	18	760	4	16
151259	<2	0.55	24	0.14	190	<4	1.9	17	<2	54	2	21	770	5	16
151260	<2	0.60	20	0.18	160	<4	1.9	12	<2	86	2	16	780	5	18
151261	<2	0.52	15	0.26	220	<4	1.8	11	<2	110	2	19	740	7	18
151262	2	1.0	12	0.19	230	<4	1.8	12	<2	110	3	16	1200	12	21
151263	4	0.96	10	0.22	230	<4	1.9	10	3	240	3	15	1300	14	22
151264	2	1.0	10	0.20	250	<4	2.0	10	4	260	2	11	1300	19	18
151265	2	1.0	13	0.19	390	<4	2.0	8	<2	280	3	15	1300	16	23
151266	3	0.93	6	0.20	240	<4	2.1	8	2	300	3	12	1100	13	20
151267	3	0.58	20	0.19	570	<4	1.6	17	2	140	2	25	700	6	22
151268	<2	0.49	11	0.13	280	<4	1.9	16	<2	69	1	27	640	4	18
151269	9	0.69	29	0.09	190	<4	1.8	15	4	63	1	23	600	4	18
151270	4	1.5	7	0.34	500	<4	2.2	9	<2	510	4	14	1900	25	20
151271	2	1.4	13	0.27	380	<4	2.1	11	<2	350	4	13	2100	21	20
151272	3	1.2	12	0.39	300	<4	1.8	11	<2	330	3	11	1800	18	19
151274	<2	0.46	12	0.11	300	<4	2.0	13	<2	53	1	18	620	3	16
151275	<2	0.64	26	0.12	350	<4	1.7	16	<2	54	2	21	850	8	20
151276	34	0.65	24	0.12	290	<4	1.8	16	<2	80	2	24	860	7	18
151277	4	0.59	22	0.10	170	<4	1.9	14	<2	60	2	15	830	4	18
151278	3	0.99	12	0.22	350	<4	2.0	11	<2	200	2	13	1300	14	17
151279	2	1.0	17	0.19	290	<4	1.8	9	<2	210	2	10	1400	15	16
151280	2	1.1	20	0.29	240	<4	2.1	14	2	250	3	12	1500	19	15
151281	2	1.4	18	0.27	250	<4	1.8	13	<2	260	4	14	2000	19	18
151282	6	1.4	21	0.30	370	<4	2.3	12	<2	290	3	12	1700	25	17
151283	4	1.5	25	0.49	330	<4	1.9	8	<2	340	3	11	1900	26	16
151284	4	2.1	27	0.47	420	<4	2.1	13	<2	430	5	17	2700	31	23
151285	8	1.6	19	0.39	250	<4	2.0	8	5	370	3	12	2100	28	15
151286	320	1.3	18	0.28	300	<4	1.8	14	<2	360	4	16	2100	21	19
151287	2	1.1	21	0.29	190	<4	2.0	15	<2	260	3	17	1600	19	18
151288	<2	1.3	22	0.28	540	<4	2.0	11	<2	260	4	15	1800	16	20
151289	79	1.3	21	0.18	260	<4	1.9	17	<2	290	4	18	1900	17	22
151290	3	1.0	24	0.16	200	<4	1.9	15	<2	190	3	18	1400	13	22
151291	2	0.95	35	0.23	620	<4	2.0	13	<2	180	3	18	1200	13	18
151292	<2	0.58	30	0.14	270	<4	1.7	26	<2	61	2	22	770	5	27
151293	<2	0.48	19	0.11	170	<4	1.8	10	<2	35	2	17	630	5	17
151294	<2	0.54	16	0.17	140	<4	1.7	13	<2	65	2	15	800	7	18
151295	4	1.8	6	0.47	430	<4	2.7	7	2	410	3	11	2200	34	18
151296	3	1.9	13	0.37	300	<4	2.0	14	<2	490	5	12	2800	30	23
151297	4	1.4	15	0.28	260	<4	2.3	9	2	440	4	12	2200	25	18
151298	4	1.4	11	0.23	190	<4	2.0	10	2	290	3	16	1600	21	19
151299	2	0.86	12	0.16	220	<4	1.9	9	2	180	2	14	1100	16	18
151300	2	0.64	13	0.14	140	<4	1.7	10	<2	61	2	20	900	9	18
151301	2	0.74	18	0.12	180	<4	1.7	12	<2	62	2	17	960	8	19
151302	2	0.52	15	0.12	170	<4	2.0	10	2	78	1	13	740	5	15
151303	2	0.49	24	0.07	150	<4	1.5	13	2	53	1	19	660	4	14
151304	2	0.53	17	0.07	190	<4	1.8	13	<2	57	1	22	710	9	15
151305	<2	0.46	7	0.08	320	<4	2.2	17	<2	25	1	17	600	3	16
151306	<2	0.53	11	0.14	250	5	1.9	11	2	63	1	16	690	4	15
151307	7	0.70	18	0.11	260	<4	1.6	14	<2	130	2	20	840	5	18
151308	<2	0.53	18	0.16	390	<4	1.8	15	<2	58	1	18	670	6	15
151309	<2	0.51	13	0.12	220	<4	1.8	9	<2	68	1	16	650	6	16

SW NEW MEXICO VOLCANICS										SECTION 1 OF 3							
OR SAMPLE		D. O. E. SAMPLE		NUMBER		U	U-NT	U/TU	AG	AL	B	BA	BE	CA	CO	CR	
NUMBER	ST	LAT	LONG	L	TY	REP	(PPM)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	
151254	40-31.401	-108.785	-3-92-				5.3	6.1	0.86	<2	5.3	<10	38	6	<0.05	<4	<1
151255	40-31.380	-108.589	-3-92-				3.8	3.8	1.0	<2	5.2	<10	310	2	0.52	<4	<1
151256	40-31.379	-108.588	-3-92-				4.0	3.7	1.1	<2	5.1	<10	210	2	0.29	4	1
151257	40-31.447	-108.385	-3-92-				6.0	5.3	1.1	<2	5.8	<10	230	2	0.55	<4	2
151258	40-31.447	-108.385	-3-92-				4.1	3.9	1.1	<2	6.2	<10	270	2	0.44	<4	<1
151259	40-31.447	-108.385	-3-92-				3.2	3.9	0.81	<2	5.0	<10	210	2	0.41	<4	1
151260	40-31.446	-108.386	-3-92-				4.0	3.5	1.1	<2	5.5	<10	380	2	0.51	<4	<1
151261	40-31.446	-108.386	-3-92-				3.6	3.7	0.98	<2	6.2	<10	350	2	0.53	<4	1
151262	40-31.446	-108.386	-3-92-				2.6	3.0	0.88	<2	5.6	<10	730	2	0.82	<4	1
151263	40-31.445	-108.386	-3-92-				2.9	3.1	0.95	<2	6.6	<10	860	2	0.55	<4	1
151264	40-31.445	-108.387	-3-92-				3.6	3.2	1.1	<2	5.9	<10	700	2	0.92	<4	4
151265	40-31.444	-108.387	-3-92-				2.5	2.6	0.96	<2	5.8	<10	840	2	1.1	<4	1
151266	40-31.444	-108.387	-3-92-				2.9	2.8	1.0	<2	6.9	<10	730	2	1.0	<4	<1
151267	40-31.507	-108.618	-3-92-				6.7	6.0	1.1	<2	5.9	<10	170	4	0.62	<4	2
151268	40-31.507	-108.619	-3-92-				8.0	7.4	1.1	<2	5.7	<10	70	3	0.49	<4	2
151269	40-31.508	-108.619	-3-92-				6.3	6.4	0.99	<2	5.7	<10	60	2	0.37	<4	6
151270	40-31.566	-108.671	-3-92-				3.3	2.9	1.1	<2	7.5	<10	1100	2	1.5	<4	1
151271	40-31.568	-108.679	-3-92-				2.9	2.6	1.1	<2	6.1	<10	890	1	1.2	4	<1
151272	40-31.569	-108.683	-3-92-				2.0	2.4	0.84	<2	6.1	<10	990	1	1.1	4	1
151274	40-31.563	-108.594	-3-92-				6.3	6.2	1.0	<2	5.3	<10	160	2	0.45	<4	1
151275	40-31.563	-108.594	-3-92-				4.0	4.2	0.94	<2	5.2	<10	190	2	0.43	<4	1
151276	40-31.563	-108.594	-3-92-				4.3	4.0	1.1	<2	5.3	<10	200	3	0.48	<4	2
151277	40-31.563	-108.596	-3-92-				4.3	3.7	1.2	<2	5.1	<10	260	2	0.44	<4	<1
151278	40-31.663	-108.684	-3-92-				5.9	5.3	1.1	<2	5.9	<10	570	2	0.97	<4	1
151279	40-31.663	-108.684	-3-92-				7.3	5.9	1.2	<2	5.8	<10	610	2	0.73	<4	1
151280	40-31.663	-108.684	-3-92-				4.3	4.8	0.91	<2	5.5	<10	680	1	0.68	5	2
151281	40-31.664	-108.684	-3-92-				5.0	4.8	1.0	<2	5.5	<10	750	1	0.83	<4	1
151282	40-31.664	-108.684	-3-92-				4.5	4.0	1.1	<2	5.7	<10	750	1	0.94	6	4
151283	40-31.664	-108.684	-3-92-				3.7	3.2	1.1	<2	6.3	<10	840	2	1.0	<4	2
151284	40-31.664	-108.667	-3-92-				4.0	4.1	0.97	<2	6.2	<10	910	2	1.3	7	2
151285	40-31.664	-108.683	-3-92-				3.6	3.7	0.97	<2	6.6	<10	810	2	1.1	<4	5
151286	40-31.664	-108.683	-3-92-				3.6	3.8	0.95	<2	6.1	<10	770	1	0.52	4	1
151287	40-31.664	-108.682	-3-92-				2.9	3.2	0.90	<2	5.4	<10	670	1	0.88	5	2
151288	40-31.665	-108.682	-3-92-				3.8	3.9	0.97	<2	5.7	<10	830	2	0.55	4	<1
151289	40-31.665	-108.681	-3-92-				5.3	5.5	0.96	<2	5.6	<10	740	2	0.51	4	2
151290	40-31.666	-108.681	-3-92-				6.5	6.1	1.1	<2	5.5	<10	510	2	0.70	<4	3
151291	40-31.666	-108.681	-3-92-				5.4	4.9	1.1	<2	5.3	<10	590	2	0.84	4	1
151292	40-31.666	-108.680	-3-92-				7.2	9.4	0.77	<2	4.5	<10	91	3	0.36	<4	<1
151293	40-31.479	-108.768	-3-92-				5.1	3.6	1.4	<2	5.0	<10	280	2	0.45	<4	1
151294	40-31.478	-108.772	-3-92-				4.1	4.4	0.94	<2	4.8	<10	380	1	0.45	<4	1
151295	40-31.691	-108.721	-3-92-				4.3	3.7	1.2	<2	6.7	<10	850	2	1.6	4	2
151296	40-31.691	-108.721	-3-92-				3.9	3.7	1.1	<2	6.4	<10	950	2	1.4	6	<1
151297	40-31.690	-108.721	-3-92-				3.6	3.7	0.96	<2	7.6	<10	890	2	1.2	<4	1
151298	40-31.688	-108.717	-3-92-				5.7	4.1	1.4	<2	6.2	<10	720	2	1.0	<4	3
151299	40-31.364	-108.768	-3-92-				3.6	3.2	1.1	<2	6.0	<10	690	2	0.75	<4	1
151300	40-31.364	-108.770	-3-92-				4.0	3.0	1.3	<2	6.0	<10	480	1	0.51	<4	2
151301	40-31.364	-108.771	-3-92-				3.3	3.6	0.92	<2	5.3	<10	380	2	0.44	<4	1
151302	40-31.364	-108.772	-3-92-				4.2	3.3	1.3	<2	5.6	<10	290	2	0.45	<4	1
151303	40-31.366	-108.774	-3-92-				4.0	3.4	1.2	<2	5.5	<10	180	2	0.27	<4	1
151304	40-31.366	-108.774	-3-92-				4.4	3.5	1.3	<2	5.9	<10	190	2	0.28	<4	1
151305	40-31.366	-108.774	-3-92-				9.5	6.6	1.4	<2	4.6	<10	110	2	0.53	<4	<1
151306	40-31.425	-108.782	-3-92-				7.6	5.4	1.4	<2	5.2	<10	140	2	0.43	<4	1
151307	40-31.425	-108.782	-3-92-				3.9	3.8	1.0	<2	4.9	<10	240	2	0.38	<4	<1
151308	40-31.425	-108.782	-3-92-				5.7	3.6	1.6	<2	4.8	<10	230	2	0.41	<4	3
151309	-31.424	-108.780	-3-92-				3.7	3.3	1.1	<2	6.1	12	370	2	0.47	<4	<1

SW NEW MEXICO VOLCANICS

SECTION 3 OF 3

OR SAMPLE NUMBER	ZN (PPM)	ZR (PPM)	K (%)	SR (PPM)	CE (PPM)	TGAM (CPS)	TOT (CPM)	EK (%)	CPK (CPM)	EU (PPM)	CPU (CPM)	ETH (PPM)	CPTH (CPM)
151254	32	96	3.1	8	78								
151255	17	42	3.0	54	67								
151256	15	42	3.3	35	70								
151257	26	47	2.3	98	63								
151258	24	47	2.7	43	67								
151259	16	51	3.1	41	66								
151260	20	48	3.1	66	80								
151261	22	47	2.8	60	92								
151262	28	48	2.9	140	98								
151263	31	51	2.2	150	110								
151264	34	45	2.4	120	86								
151265	24	52	2.7	200	96								
151266	29	50	2.4	150	94								
151267	46	49	2.6	58	62								
151268	31	46	2.2	25	59								
151269	24	45	2.4	18	54								
151270	43	73	2.1	230	99								
151271	28	70	2.8	230	92								
151272	27	55	2.7	520	87								
151274	22	43	2.2	27	55								
151275	26	52	3.0	47	68								
151276	47	51	2.9	48	68								
151277	17	47	3.1	49	66								
151278	33	47	2.3	120	66								
151279	32	48	2.6	110	70								
151280	57	54	3.0	150	62								
151281	34	56	2.6	170	83								
151282	34	62	3.0	160	77								
151283	44	53	2.2	160	79								
151284	56	84	2.5	250	100								
151285	42	53	2.3	170	90								
151286	40	60	2.8	180	95								
151287	46	52	2.7	150	86								
151288	37	50	2.6	180	110								
151289	36	54	2.6	160	100								
151290	29	47	2.8	110	78								
151291	51	48	3.0	110	70								
151292	20	55	2.9	29	43								
151293	16	43	3.2	57	62								
151294	13	42	3.1	62	72								
151295	49	70	1.5	200	90								
151296	51	89	2.6	250	93								
151297	45	64	2.5	220	85								
151298	36	48	2.3	140	88								
151299	35	44	2.4	110	84								
151300	23	42	2.5	80	76								
151301	24	47	2.9	64	69								
151302	21	40	2.6	44	60								
151303	21	44	2.8	30	49								
151304	19	41	2.8	32	55								
151305	7	44	2.3	86	46								
151306	23	39	2.2	31	48								
151307	21	46	3.0	45	69								
151308	24	42	3.2	43	57								
151309	20	43	2.6	64	67								

SW NEW MEXICO VOLCANICS										SECTION 1 OF 3				
OR SAMPLE D. O. E. SAMPLE NUMBER				U	U-NT	U/TU	AG	AL	B	BA	BE	CA	CO	CR
NUMBER	ST	LAT	LONG	L	TY	REF	(PPM)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(PPM)	(PPM)
151310	40-31.425	-108.777	-3-92-	3.6	2.7	1.3	<2	6.8	<10	880	2	0.75	<4	1
151311	40-31.000	-108.000	-3-92-	2.7	3.0	0.89	<2	6.1	<10	740	2	0.96	5	<1
151312	40-31.000	-108.000	-3-92-	4.2	3.3	1.3	<2	7.2	<10	700	2	1.0	<4	<1
151313	40-31.000	-108.000	-3-92-	2.7	3.1	0.86	<2	6.3	<10	390	3	0.65	<4	1
151314	40-31.000	-108.000	-3-92-	2.5	2.7	0.91	<2	5.8	<10	730	2	0.69	4	1
151316	40-31.000	-108.000	-3-92-	4.0	2.8	1.4	<2	6.5	<10	830	2	0.75	<4	<1
151317	40-31.575	-108.730	-3-92-	5.4	5.6	0.96	<2	5.1	<10	37	8	0.25	<4	<1
151318	40-31.577	-108.730	-3-92-	6.6	6.0	1.1	<2	5.6	<10	35	8	0.19	<4	1
151319	40-31.578	-108.728	-3-92-	6.1	6.5	0.94	<2	5.9	<10	44	8	0.18	<4	1
151320	40-31.579	-108.728	-3-92-	6.4	6.5	0.99	<2	6.2	<10	51	8	0.19	<4	1
151321	40-31.579	-108.728	-3-92-	5.2	6.7	0.78	<2	4.9	<10	43	9	0.18	<4	1
151322	40-31.579	-108.728	-3-92-	9.5	8.8	1.1	<2	5.8	<10	57	8	0.15	<4	1
151323	40-31.579	-108.728	-3-92-	6.8	6.4	1.1	<2	5.3	<10	110	7	0.23	<4	2

SW NEW MEXICO VOLCANICS

SECTION 2 OF 3

DR SAMPLE	CU	FE	LI	MG	MN	MO	NA	NB	NI	P	SC	TH	TI	V	Y
NUMBER	(PPM)	(%)	(PPM)	(%)	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)	(PPM)
151310	2	0.75	6	0.15	380	<4	2.0	9	<2	150	2	16	1100	10	20
151311	2	1.5	20	0.22	420	<4	2.0	16	<2	400	4	15	1700	22	36
151312	2	1.4	16	0.32	320	<4	2.1	13	<2	410	4	11	1900	22	32
151313	2	0.70	24	0.23	400	<4	2.0	16	3	190	2	18	1100	10	22
151314	2	0.95	4	0.16	360	<4	2.6	14	2	200	3	9	1200	9	18
151316	<2	0.99	5	0.17	390	<4	2.5	9	<2	260	3	8	1300	12	18
151317	<2	0.73	47	0.06	320	<4	2.2	49	<2	31	2	25	820	2	76
151318	3	0.76	36	0.05	280	<4	2.0	35	<2	110	2	20	670	8	56
151319	<2	0.72	24	<0.05	260	4	2.0	42	<2	230	2	27	910	8	56
151320	3	0.74	28	<0.05	290	<4	2.0	38	<2	78	2	28	840	16	59
151321	3	0.82	24	0.05	290	<4	1.8	48	<2	77	2	28	1000	9	68
151322	2	0.88	30	<0.05	370	<4	2.0	45	<2	100	2	22	930	25	81
151323	2	0.84	31	0.06	580	<4	2.0	59	3	400	2	28	960	10	57

SW NEW MEXICO VOLCANICS											SECTION 3 OF 3		
DR SAMPLE	ZN	ZR	K	SR	CE	TGAM	TOT	EK	CPK	EU	CPU	ETH	CPTH
NUMBER	(PPM)	(PPM)	(%)	(PPM)	(PPM)	(CPS)	(CPM)	(%)	(CPM)	(PPM)	(CPM)	(PPM)	(CPM)
151310	24	46	2.7	140	94								
151311	44	69	3.4	150	96								
151312	43	55	2.5	160	91								
151313	27	51	2.7	85	65								
151314	42	76	3.1	99	65								
151316	41	66	2.6	100	87								
151317	41	120	3.3	8	150								
151318	43	110	2.7	7	200								
151319	47	110	2.8	9	150								
151320	44	110	2.7	10	160								
151321	42	120	3.2	10	190								
151322	48	130	3.1	8	190								
151323	130	150	4.1	17	160								

APPENDIX 3

Cluster Analysis for Entire Data Set

Clusters are calculated from absolute value of correlation coefficient.

SW NEW MEXICO VOLCANICS

25 VARIABLES CLUSTERED USING 353 SAMPLES.

DATE PLOTTED IS 03-12-80

CLUSTERING CRITERION -- COMPLETE LINKAGE

NORMALIZATION -- RAW DATA IS USED

METRIC -- (1. -ABS(PEARSON CORRELATION))

APPENDIX 4

Correlation Coefficients for the Entire Data Set

L-U																
L-U	1.00															
	(347)															
		LUNT														
LUNT	0.92***	1.00														
	(344)	(350)														
		L-BE														
L-BE	0.39***	0.49***	1.00													
	(322)	(321)	(323)													
		L-NB														
L-NB	0.57***	0.64***	0.81***	1.00												
	(333)	(331)	(315)	(334)												
		L-CA														
L-CA	-0.54***	-0.60***	-0.45***	-0.56***	1.00											
	(337)	(335)	(314)	(327)	(338)											
		L-SR														
L-SR	-0.44***	-0.45***	-0.51***	-0.64***	0.73***	1.00										
	(347)	(345)	(323)	(334)	0.85***	(348)										
		L-MG														
L-MG	-0.37***	-0.38***	-0.32***	-0.39***	0.61***	0.69***	1.00									
	(304)	(302)	(282)	(298)	0.75***	0.76***	(305)									
		L-AL														
L-AL	0.37***	0.43***	0.23***	0.20***	-0.64***	-0.12***	-0.18***	1.00								
	(345)	(343)	(323)	(332)	0.05	0.21***	0.15**	(346)								
		L-K														
L-K	0.41***	0.49***	0.39***	0.36***	-0.73***	-0.23***	-0.26***	0.93***	1.00							
	(346)	(344)	(323)	0.38***	-0.53***	-0.37***	-0.30***	-0.00	(347)							
		L-TH														
L-TH	0.61***	0.69***	0.58***	0.68***	-0.70***	-0.48***	-0.38***	0.68***	0.72***	1.00						
	(331)	(329)	(312)	(324)	(323)	(332)	(293)	(330)	0.34***	(331)	(332)					
		L-LI														
L-LI	0.28***	0.38***	0.35***	0.46***	-0.63***	-0.41***	-0.26***	0.52***	0.54***	0.53***	1.00					
	(347)	(345)	(323)	(334)	(338)	(348)	(305)	(346)	(347)	(332)	(348)					
		L-CR														
L-CR	-0.29***	-0.31***	-0.24***	-0.22***	0.38***	0.30***	0.36***	-0.30***	-0.36***	-0.46***	-0.08	1.00				
	(276)	(274)	(253)	(264)	0.34***	0.28***	0.32***	-0.28***	-0.21***	-0.36***	-0.03	(277)	(277)			
		L-CU														
L-CU	-0.13**	-0.10	-0.11*	-0.06	0.17***	0.16**	0.30***	-0.10	-0.09	-0.16**	0.09	0.25***	1.00			
	(239)	(238)	(224)	(228)	0.25***	0.25***	0.34***	-0.13**	0.05	-0.16**	0.13**	0.34***	(239)			
		L-Y														
L-Y	0.50***	0.61***	0.65***	0.70***	-0.61***	-0.35***	-0.29***	0.78***	0.79***	0.76***	0.54***	-0.33***	-0.16**	1.00		
	(346)	(344)	(323)	(333)	(337)	(347)	(304)	(346)	(346)	(331)	(347)	(276)	(239)	(347)		
		L-ZR														
L-ZR	0.42***	0.51***	0.61***	0.69***	-0.58***	-0.34***	-0.27***	0.68***	0.67***	0.63***	0.49***	-0.24***	-0.10	0.85***		
	(343)	(342)	(323)	(330)	-0.32***	-0.25***	-0.16***	0.22***	0.27***	0.47***	0.33***	-0.23***	-0.05	0.76***	1.00	
					(334)	(344)	(301)	(343)	(343)	(325)	(344)	(273)	(239)	(344)	(344)	
		L-ZN														
L-ZN	0.32***	0.42***	0.45***	0.57***	-0.37***	-0.13**	0.08	0.60***	0.55***	0.44***	0.39***	-0.11*	0.03	0.74***	0.74***	
	(345)	(343)	(322)	(332)	-0.06	-0.01	0.17***	0.42***	0.05	0.26***	0.23***	-0.15**	0.02	0.65***	0.65***	
					(336)	(346)	(303)	(344)	(345)	(331)	(346)	(275)	(237)	(345)	(345)	
		L-CE														
L-CE	0.37***	0.45***	0.35***	0.55***	-0.48***	-0.23***	-0.21***	0.67***	0.63***	0.59***	0.25***	-0.36***	-0.09	0.81***	0.70***	
	(322)	(321)	(311)	0.38***	-0.14**	-0.11*	-0.09	0.44***	0.05	0.31***	0.07	-0.38***	-0.14**	0.67***	0.55***	
					(315)	(323)	(286)	(322)	(323)	(321)	(323)	(252)	(222)	(323)	(323)	
		L-MN														
L-MN	0.19***	0.27***	0.38***	0.38***	-0.12**	0.01	0.10	0.44***	0.48***	0.35***	0.18***	-0.11*	0.08	0.58***	0.55***	
	(347)	(345)	(323)	(334)	-0.00	-0.02	0.09	0.22***	0.11**	0.28***	0.20***	-0.13**	0.11*	0.55***	0.49***	
					(338)	(348)	(305)	(346)	(347)	(332)	(346)	(277)	(239)	(347)	(344)	
		L-NA														
L-NA	0.04	0.13**	0.06	0.14**	-0.22***	-0.09	-0.16***	0.66***	0.46***	0.19***	0.01	-0.14**	-0.14**	0.41***	0.28***	
	(310)	(309)	(308)	(310)	-0.08	-0.06	-0.12**	0.43***	-0.10*	0.01	-0.01	-0.23***	-0.08	0.29***	0.17***	
					(305)	(311)	(275)	(311)	(311)	(309)	(311)	(241)	(216)	(311)	(311)	
		L-P														
L-P	-0.26***	-0.22***	-0.30***	-0.39***	0.23***	0.52***	0.53***	0.30***	0.17***	-0.19***	0.00	0.23***	0.16**	0.12**	0.06	
	(343)	(341)	(321)	-0.43***	0.44***	0.55***	0.56***	0.53***	-0.04	-0.42***	-0.11**	0.18***	0.22***	-0.01	0.02	
					(334)	(344)	(303)	(342)	(343)	(329)	(344)	(274)	(237)	(343)	(340)	
		L-V														
L-V	-0.31***	-0.30***	-0.39***	-0.36***	0.26***	0.51***	0.55***	0.21***	0.06	-0.29***	0.01	0.36***	0.18***	0.07	0.01	
	(338)	(336)	(315)	(327)	0.45***	0.56***	0.56***	-0.10*	-0.45***	0.01	0.12**	0.23***	0.22***	-0.07	-0.04	
					(331)	(339)	(303)	(338)	(338)	(324)	(335)	(270)	(233)	(339)	(336)	
		L-BA														
L-BA	-0.12**	-0.11**	-0.51***	-0.43***	-0.01	0.52***	0.29***	0.51***	0.44***	-0.03	0.07	0.01	0.01	0.16***	0.06	
	(347)	(345)	(323)	-0.48***	0.36***	0.56***	0.45***	0.60***	0.08	-0.41***	-0.14***	-0.06	0.08	-0.05	-0.02	
					(338)	(348)	(305)	(346)	(347)	(332)	(348)	(277)	(239)	(347)	(344)	
		L-FE														
L-FE	0.08	0.18***	0.13**	0.18***	-0.24***	0.14***	0.23***	0.70***	0.60***	0.27***	0.36***	0.02	0.07	0.64***	0.64***	
	(345)	(343)	(323)	0.03	0.18***	0.29***	0.37***	0.55***	0.07	-0.06	0.13**	-0.02	0.12*	0.45***	0.48***	
					(338)	(346)	(303)	(346)	(345)	(330)	(346)	(275)	(238)	(346)	(343)	
		L-TI														
L-TI	0.13**	0.21***	-0.02	0.07	-0.35***	0.16***	0.12**	0.84***	0.75***	0.36***	0.36***	-0.06	0.06	0.64***	0.62***	
	(347)	(345)	(323)	(334)	(338)	(348)	(305)	(346)	(347)	(332)	(348)	(277)	(239)	(347)	(344)	
		L-SC														
L-SC	-0.14***	-0.09	-0.19***	-0.07	0.04	0.36***	0.35***	0.45***	0.35***	-0.01	0.15***	0.23***	0.24***	0.33***	0.37***	
	(331)	(330)	(313)	(325)	0.26***	0.38***	0.41***	0.42***	0.15***	-0.20***	0.05	0.06	0.31***	0.28***	0.43***	
					(326)	(332)	(296)	(331)	(325)	(332)	(332)	(265)	(230)	(332)	(332)	

SOUTHWEST NEW MEXICO VOLCANICS
CORRELATION COEFFICIENTS

ALL SAMPLES

EXPLANATION:

UPPER NUMBER = PEARSON COEFFICIENT
MIDDLE NUMBER = SPEARMAN COEFFICIENT
LOWER NUMBER = NUMBER OF SAMPLES

* SIGNIFICANT AT 90% LEVEL
** SIGNIFICANT AT 95% LEVEL
*** SIGNIFICANT AT 99% LEVEL

ALL CORRELATIONS ARE BASED ON LOGARITHMIC
TRANSFORMATIONS OF MEASURED VALUES.

U = URANIUM BY FLUORIMETRY

UNT = URANIUM BY NEUTRON ACTIVATION/DELAYED COUNT

APPENDIX 5

Statistical Analysis of Data Subsets

TABLE 5-1: DATA SUBSETS

Group Number	Unit Codes	Units involved
1	32B1, 42A1, 32I1, 42I1, 42R1 32T1, 42T1, 52T1, 32T2, 42T2	Juniper Cauldron
2	34T1, 44T1, 54T1, 84T1	Gillespie Tuff
3	16R3, 16T4	Rhyolite of Clanton Draw
4	27R2, 27V2, 27T2, 27R3 27T1, 27V1, 27T3, 27R1	Rodeo Cauldron
5	31T1, 41V1, 41B1 51B1, 41T1, 51T1	Bluff Creek Formation

NO. SAMPLES ANALYZED															
BEJJW															
MEASURABLE		DETECTION	DETECTION	MINIMUM	MAXIMUM	COEFFICIENT								LN TRANSFORMATION	
ELEMENT	VALUES	LIMIT	LIMIT	VALUE	VALUE	MEAN	MEDIAN	MODE	STANDARD	OF	MEAN	S. D.	ROBUST		
									DEVIATION	VARIATION			MEAN	S. D.	
U	23			2.01	4.57	3.24	3.08	3.09	0.714	0.220	1.15	0.22	1.16	0.23	
U-NT	23			2.63	5.10	3.57	3.55	3.37	0.742	0.202	1.28	0.20	1.28	0.23	
AL	23			4.17	7.55	5.48	5.20	5.15	0.849	0.155	1.69	0.15	1.69	0.17	
B	0	23	<10	<10	<10		<10	<10							
BA	23			255	1037	604	596	357	215.5	0.4	6.34	0.39	6.35	0.42	
BE	23			1	8	3	2	1	2.3	0.6	1.07	0.66	1.08	0.69	
CA	23			0.06	4.24	1.08	0.76	0.67	0.984	0.914	-0.40	1.12	-0.37	1.18	
CO	13	10	<4	<4	29	9	<4	<4	7.4	0.8	1.97	0.65			
CR	19	4	<1	<1	64	6	2	<1	14.5	2.3	0.99	1.06	0.69	1.77	
CU	18	5	<2	<2	179	16	4	3	41.0	2.5	1.89	1.06	1.36	1.15	
FE	23			0.56	3.99	1.51	1.17	1.29	0.947	0.628	0.26	0.55	0.25	0.60	
LI	23			8	62	25	24	37	12.8	0.5	3.14	0.50	3.14	0.56	
MG	23			0.08	2.04	0.44	0.34	0.41	0.414	0.947	-1.12	0.77	-1.15	0.88	
MN	23			43	963	377	287	143	270.4	0.7	5.64	0.84	5.67	0.95	
MO	4	19	<4	<4	6	5	<4	<4	0.8	0.2	1.60	0.17			
NA	23			0.37	2.93	1.77	1.74	1.94	0.634	0.357	0.49	0.48	0.53	0.49	
NB	23			7	32	16	16	13	5.0	0.3	2.75	0.30	2.75	0.26	
NI	14	9	<2	<2	14	3	<2	<2	3.3	0.9	1.09	0.60			
P	23			62	751	325	256	347	226.2	0.7	5.54	0.74	5.56	0.82	
TI	23			637	4125	1950	1506	4147	1079.6	0.6	7.44	0.53	7.45	0.63	
SC	23			2	19	4	3	3	3.8	0.8	1.33	0.59	1.28	0.68	
TH	23			11	21	14	14	12	2.5	0.2	2.69	0.16	2.68	0.15	
V	23			6	110	25	15	11	24.4	1.0	2.91	0.76	2.88	0.81	
Y	23			10	40	25	26	29	6.7	0.3	3.21	0.30	3.23	0.28	
ZN	23			15	79	33	30	79	20.6	0.5	3.52	0.50	3.52	0.57	
ZR	23			22	124	59	57	61	22.0	0.4	4.03	0.35	4.04	0.39	
K	23			1.59	5.21	3.14	3.08	3.33	0.775	0.247	1.11	0.25	1.12	0.29	
SR	23			37	398	140	119	55	88.8	0.6	4.77	0.63	4.76	0.65	
CE	23			51	111	77	76	111	18.0	0.2	4.33	0.23	4.33	0.27	

SW NEW MEXICO #1
 27 VARIABLES CLUSTERED USING 23 SAMPLES.
 DATE PLOTTED IS 03-24-80
 CLUSTERING CRITERION -- COMPLETE LINKAGE
 NORMALIZATION -- RAW DATA IS USED
 METRIC -- $(1 - \text{ABS}(\text{PEARSON CORRELATION}))$

NO. SAMPLES ANALYZED		BELOW		DETECTION LIMIT		DETECTION LIMIT		MINIMUM VALUE		MAXIMUM VALUE		MEAN		MEDIAN		MODE		STANDARD DEVIATION		COEFFICIENT OF VARIATION		LN TRANSFORMATION		ROBUST	
ELEMENT	VALUES	MEASURABLE	DETECTION LIMIT	DETECTION LIMIT	MINIMUM VALUE	MAXIMUM VALUE	MEAN	MEDIAN	MODE	STANDARD DEVIATION	COEFFICIENT OF VARIATION	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.	MEAN	S. D.
U	60				2.01	9.52	4.44	3.99	3.61	1.496	0.337	1.44	0.31	1.44	0.32										
U-NT	60				2.40	9.40	4.15	3.70	3.75	1.321	0.318	1.38	0.28	1.37	0.28										
AL	60				4.29	7.58	5.72	5.68	5.53	0.714	0.125	1.74	0.12	1.74	0.14										
B	3	57	<10	<10	41	28	<10	<10	<10	14.8	0.5	3.22	0.65												
EA	60				60	1051	511	497	735	290.8	0.6	6.01	0.74	6.05	0.71										
BE	60				1	6	2	2	2	0.8	0.4	0.65	0.34	0.64	0.35										
CA	60				0.12	1.60	0.73	0.70	0.46	0.344	0.469	-0.43	0.52	-0.42	0.49										
CO	15	45	<4	<4	7	4	<4	<4	<4	1.0	0.2	1.52	0.19												
CR	46	14	<1	<1	6	1	<1	<1	<1	1.1	0.7	0.40	0.52												
CU	44	16	<2	<2	318	12	<2	<2	<2	48.7	3.8	1.31	1.01												
FE	60				0.46	2.09	0.93	0.75	0.54	0.426	0.459	-0.17	0.45	-0.18	0.39										
LI	60				6	74	18	18	24	10.5	0.6	2.81	0.49	2.80	0.53										
MG	60				0.06	0.49	0.20	0.18	0.14	0.105	0.519	-1.73	0.51	-1.72	0.55										
MN	60				138	1601	306	259	297	200.4	0.7	5.62	0.42	5.59	0.40										
MO	1	59	<4	<4	5	5	<4	<4	<4	0.0	0.0	1.01	0.0												
NA	60				0.85	2.67	1.33	1.88	1.82	0.260	0.138	0.62	0.16	0.64	0.12										
NB	60				7	26	12	12	13	3.3	0.3	2.50	0.25	2.50	0.26										
NI	15	45	<2	<2	5	2	<2	<2	<2	1.0	0.4	0.92	0.35												
P	60				18	506	187	136	55	139.0	0.7	4.91	0.86	4.93	0.77										
TI	60				586	2840	1227	1068	756	587.0	0.5	7.01	0.46	7.00	0.41										
SC	60				1	5	2	2	2	1.1	0.5	0.77	0.50	0.76	0.56										
TH	60				10	27	16	16	16	4.0	0.2	2.77	0.24	2.77	0.26										
V	60				3	34	12	10	5	8.4	0.7	2.31	0.71	2.31	0.67										
Y	60				14	36	19	18	18	4.0	0.2	2.93	0.18	2.92	0.22										
ZN	60				7	57	30	27	23	11.7	0.4	3.33	0.41	3.34	0.38										
ZR	60				39	89	51	48	47	10.1	0.2	3.92	0.17	3.91	0.17										
K	60				1.52	3.57	2.70	2.69	2.75	0.381	0.141	0.98	0.15	0.99	0.14										
SR	60				18	524	113	105	64	84.5	0.7	4.48	0.74	4.48	0.70										
CE	60				43	111	75	70	66	16.8	0.2	4.30	0.23	4.30	0.23										

SW NEW MEXICO #2.

26 VARIABLES CLUSTERED USING 60 SAMPLES.

DATE PLOTTED IS 03-20-80

CLUSTERING CRITERION -- COMPLETE LINKAGE

NORMALIZATION -- RAW DATA IS USED

METRIC -- (1.-ABS(PEARSON CORRELATION))

L-U																			
L-U	1.00																		
	(60)																		
LUNT	0.86***																		
	0.79***	1.00																	
	(60)	(60)																	
L-NB	0.34***	0.58***																	
	0.33**	0.54***	1.00																
	(60)	(60)	(60)																
L-TH	0.36***	0.43***	0.60***																
	0.36***	0.43***	0.60***	1.00															
	(60)	(60)	(60)	(60)															
L-AL	-0.30**	-0.44***	-0.63***	-0.39***															
	-0.32**	-0.44***	-0.62***	-0.43***	1.00														
	(60)	(60)	(60)	(60)	(60)														
L-CE	-0.60***	-0.57***	-0.47***	-0.42***	0.67***														
	-0.55***	-0.49***	-0.41***	-0.43***	0.65***	1.00													
	(60)	(60)	(60)	(60)	(60)	(60)													
L-ZN	-0.16	-0.11	-0.21	-0.26**	0.60***	0.55***													
	-0.08	-0.02	-0.15	-0.32**	0.57***	0.54***	1.00												
	(60)	(60)	(60)	(60)	(60)	(60)	(60)												
L-FE	-0.36***	-0.31**	-0.32**	-0.62***	0.57***	0.72***	0.74***												
	-0.38***	-0.28**	-0.27**	-0.60***	0.55***	0.72***	0.75***	1.00											
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)											
L-TI	-0.37***	-0.33**	-0.33**	-0.65***	0.57***	0.72***	0.72***	0.98***											
	-0.38***	-0.30**	-0.32**	-0.64***	0.57***	0.73***	0.73***	0.95***	1.00										
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)										
L-V	-0.41***	-0.40***	-0.40***	-0.64***	0.60***	0.74***	0.74***	0.95***	0.95***										
	-0.39***	-0.36***	-0.37***	-0.63***	0.63***	0.74***	0.75***	0.92***	0.92***	1.00									
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)									
L-SC	-0.45***	-0.30**	-0.14	-0.48***	0.39***	0.74***	0.63***	0.87***	0.88***	0.84***									
	-0.43***	-0.26**	-0.14	-0.51***	0.44***	0.76***	0.67***	0.88***	0.90***	0.85***	1.00								
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)								
L-EA	-0.58***	-0.60***	-0.57***	-0.74***	0.57***	0.84***	0.56***	0.81***	0.84***	0.86***	0.79***								
	-0.55***	-0.52***	-0.54***	-0.72***	0.65***	0.85***	0.59***	0.83***	0.86***	0.87***	0.83***	1.00							
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)							
L-SR	-0.47***	-0.46***	-0.45***	-0.70***	0.55***	0.77***	0.55***	0.85***	0.88***	0.86***	0.81***	0.91***							
	-0.45***	-0.40***	-0.42***	-0.70***	0.60***	0.79***	0.64***	0.88***	0.89***	0.86***	0.87***	0.94***	1.00						
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)						
L-CA	-0.32**	-0.36***	-0.48***	-0.65***	0.64***	0.68***	0.63***	0.86***	0.87***	0.83***	0.74***	0.77***	0.86***						
	-0.38***	-0.36***	-0.48***	-0.71***	0.67***	0.71***	0.68***	0.83***	0.85***	0.83***	0.80***	0.86***	0.92***	1.00					
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)					
L-P	-0.39***	-0.38***	-0.41***	-0.63***	0.68***	0.73***	0.75***	0.93***	0.93***	0.90***	0.80***	0.80***	0.83***	0.92***					
	-0.39***	-0.34***	-0.39***	-0.60***	0.71***	0.74***	0.75***	0.90***	0.91***	0.88***	0.83***	0.85***	0.87***	0.92***	1.00				
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)				
L-MG	-0.33***	-0.31**	-0.39***	-0.63***	0.56***	0.65***	0.69***	0.85***	0.87***	0.84***	0.76***	0.74***	0.81***	0.89***	0.88***				
	-0.34***	-0.28**	-0.37***	-0.60***	0.58***	0.65***	0.72***	0.83***	0.87***	0.86***	0.80***	0.80***	0.84***	0.89***	0.85***	1.00			
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)			
L-Y	-0.23*	-0.08	0.26**	0.02	0.16	0.38***	0.24*	0.38***	0.34***	0.31**	0.52***	0.20	0.27**	0.33**	0.36***	0.25*			
	-0.32**	-0.17	0.16	-0.00	0.21	0.33***	0.25*	0.47***	0.39***	0.34***	0.56***	0.34***	0.37***	0.39***	0.42***	0.30**	1.00		
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)		
L-BE	0.23*	0.29**	0.20	0.24*	-0.24*	-0.32**	-0.12	-0.27**	-0.32**	-0.31**	-0.22*	-0.35***	-0.34***	-0.24*	-0.24*	-0.27**	0.13		
	0.22*	0.27**	0.23*	0.31**	0.17	0.32**	0.11	-0.31**	-0.37***	-0.35***	-0.26**	-0.34***	-0.35***	-0.23*	-0.24*	-0.32**	0.11	1.00	
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	
L-MN	0.01	0.12	0.07	-0.13	0.02	0.15	0.34***	0.27**	0.25*	0.24*	0.29**	0.24*	0.32**	0.17	0.21	0.24*	0.15	0.35***	
	-0.01	0.08	0.04	-0.21	0.20	0.22*	0.46***	0.36***	0.35***	0.36***	0.38***	0.35***	0.43***	0.46***	0.41***	0.42***	0.24*	0.24*	1.00
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)
L-LI	0.02	0.27**	0.55***	0.30**	-0.52***	-0.26**	-0.02	-0.14	-0.17	-0.18	0.02	-0.24*	-0.34***	-0.46***	-0.26**	-0.24*	0.05	0.18	0.14
	0.09	0.33**	0.55***	0.36***	-0.46***	-0.26**	-0.08	-0.07	-0.15	-0.16	-0.00	-0.29**	-0.29**	-0.38***	-0.26**	-0.20	0.01	0.18	-0.03
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)
L-K	-0.22*	-0.06	0.53***	0.25*	-0.59***	-0.21*	-0.34***	-0.31**	-0.30**	-0.30**	-0.05	-0.17	-0.27**	-0.46***	-0.35***	-0.36***	0.14	0.04	-0.06
	-0.15	-0.02	0.49***	0.24*	-0.62***	-0.21	-0.40***	-0.24*	-0.26**	-0.26**	-0.08	-0.24*	-0.27**	-0.44***	-0.37***	-0.31**	0.05	-0.01	-0.15
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)
L-NA	-0.00	-0.21	-0.43***	-0.44***	0.53***	0.32**	0.30**	0.47***	0.52***	0.54***	0.48***	0.52***	0.59***	0.73***	0.57***	0.57***	0.02	-0.24*	-0.12
	-0.11	-0.17	-0.37***	-0.56***	0.50***	0.39***	0.47***	0.52***	0.54***	0.54***	0.48***	0.52***	0.59***	0.72***	0.63***	0.58***	0.07	-0.16	-0.34***
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)
L-CR	0.25*	0.21	0.09	0.02	0.05	-0.02	0.30**	0.27*	0.17	0.19	0.04	-0.08	0.01	0.18	0.21	0.20	0.05	0.04	-0.03
	0.26*	0.21	0.16	0.06	0.08	-0.04	0.35**	0.31**	0.19	0.21	0.09	-0.03	0.06	0.20	0.27*	0.23	0.06	0.06	0.05
	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)	(46)
L-CU	0.11	0.23	0.26*	0.19	-0.02	0.15	0.18	0.15	0.17	0.08	0.20	-0.04	0.03	0.04	0.12	0.06	-0.02	-0.02	0.05
	0.16	0.35**	0.17	0.06	0.08	0.09	0.15	0.20	0.20	0.15	0.19	0.10	0.14	0.16	0.24	0.17	0.02	0.02	0.19
	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)	(44)
L-CU	0.06	0.05	0.14	-0.21	0.28	0.15	0.49*	0.54**	0.44	0.52**	0.40	0.31	0.27	0.34	0.40	0.43	0.11	-0.03	0.05
	0.04	0.02	0.10	-0.22	0.32	0.11	0.54**	0.52**	0.23	0.60**	0.37	0.20	0.19	0.26	0.40	0.48*	0.03	-0.09	0.01
	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)
L-ZR	-0.32**	-0.18	-0.03	-0.37***	0.43***	0.52***	0.60***	0.79***	0.80***	0.71***	0.77***	0.54***	0.66***	0.67***	0.71***	0.70***	0.46***	-0.12	0.37***
	-0.34***	-0.12	0.01	-0.39***	0.40***	0.55***	0.64***	0.80***	0.81***	0.73***	0.85***	0.64***	0.73***	0.71***	0.77***	0.76***	0.51***	-0.12	0.50***
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)

NO. SAMPLES ANALYZED														
BELOW														
MEASURABLE		DETECTION	DETECTION	MINIMUM	MAXIMUM					COEFFICIENT		LN TRANSFORMATION		
ELEMENT VALUES		LIMIT	LIMIT	VALUE	VALUE	MEAN	MEDIAN	MODE	STANDARD	OF	MEAN	S. D.	MEAN	S. D.
									DEVIATION	VARIATION			ROBUST	
U	31			1.39	17.74	8.03	8.13	9.16	2.092	0.335	2.02	0.42	2.04	0.50
U-NT	31			0.40	18.00	8.15	8.35	8.61	2.620	0.322	2.00	0.59	2.07	0.26
AL	31			0.09	6.73	5.05	5.35	4.96	1.600	0.316	1.42	0.99	1.53	0.67
B	3	25	<10	<10	14	12	<10	<10	2.1	0.2	2.50	0.16		
BA	31			2	332	170	147	11	129.7	0.8	4.41	1.59	4.49	1.39
BE	31			1	20	7	5	5	5.5	0.7	1.77	0.75	1.79	0.86
CA	29	2	<0.05	<0.05	0.93	0.33	0.29	0.27	0.156	0.476	-1.23	0.53	-1.30	0.76
CC	1	30	<4	<4	4	4	<4	<4	0.0	0.0	1.39	0.0		
CR	21	10	<1	<1	2	1	<1	<1	0.5	0.4	0.20	0.32		
CU	21	10	<2	<2	14	3	<2	<2	2.9	0.9	1.03	0.55		
FE	31			0.06	1.10	0.79	0.32	0.84	0.244	0.309	-0.36	0.67	-0.29	0.65
LI	31			3	88	34	29	35	23.8	0.7	3.27	0.84	3.30	0.62
MG	20	11	<0.05	<0.05	0.36	0.11	0.07	0.07	0.065	0.605	-2.33	0.39	-2.00	0.53
MN	31			11	623	344	340	534	158.7	0.5	5.62	0.91	5.71	0.91
MU	5	25	<4	<4	4	4	<4	<4	0.0	0.0	1.39	0.0		
NA	29	2	<0.05	<0.05	2.82	1.92	1.90	1.97	0.590	0.308	0.54	0.63	0.51	0.69
NB	29	2	<4	<4	108	47	30	26	31.9	0.7	3.68	0.60	3.61	0.76
NI	4	27	<2	<2	9	3	<2	<2	3.5	0.9	1.07	0.75		
P	30	1	<5	<5	88	50	50	32	23.8	0.5	3.77	0.67	3.80	0.72
TI	31			26	1297	623	985	1196	390.8	0.5	6.47	0.94	6.50	0.84
SC	29	2	<1	<1	3	1	2	1	0.8	0.4	0.55	0.44		
TH	30	1	<2	<2	34	26	28	29	5.6	0.2	3.25	0.33	3.24	0.45
V	25	5	<2	<2	3	4	3	3	1.8	0.4	1.34	0.44	1.23	0.56
Y	31			1	103	50	41	39	29.2	0.6	3.70	0.67	3.79	0.72
ZN	31			2	128	46	39	44	28.4	0.6	3.61	0.63	3.67	0.67
ZR	31			4	186	128	141	171	46.4	0.4	4.70	0.77	4.60	0.61
K	31			0.03	4.20	2.75	2.88	3.02	0.871	0.317	0.78	1.12	0.90	0.96
SR	31			1	378	43	33	2	67.5	1.5	2.93	1.51	2.93	1.56
CE	30	1	<10	<10	175	116	124	125	30.5	0.3	4.69	0.46	4.67	0.56

SW NEW MEXICO #3
 25 VARIABLES CLUSTERED USING 31 SAMPLES.
 DATE PLOTTED IS 03-24-80
 CLUSTERING CRITERION -- COMPLETE LINKAGE
 NORMALIZATION -- RAW DATA IS USED
 METRIC -- (1.-ABS(PEARSON CORRELATION))

L-U		LUNT		L-CU		L-NA		L-CA		L-MG		L-P		L-V		L-CR		L-TI		L-SC		L-BA		L-SR		L-Y		L-ZN		L-BE		L-NB		L-LI		L-FE		L-MN		L-AL		L-K		L-ZR		L-TH		L-CE																																																																																																																																																																																																																																																																																																													
L-U	1.00 (31)	LUNT	0.90*** 0.80*** (31)	1.00 (31)	L-CU	-0.38* -0.04 (21)	-0.58*** -0.10 (21)	1.00 (21)	L-NA	-0.44*** -0.14 (29)	-0.33* 0.19 (29)	-0.47** -0.21 (19)	1.00 (29)	L-CA	0.22 0.33* (29)	0.06 0.09 (29)	0.11 0.06 (19)	-0.13 -0.45** (29)	1.00 (29)	L-MG	-0.35 -0.38* (20)	-0.45** -0.38* (20)	0.262 0.282 (12)	-0.39* -0.29 (20)	0.77*** 0.62*** (20)	1.00 (20)	L-P	0.14 0.32* (30)	0.02 -0.04 (30)	0.03 -0.08 (20)	-0.03 -0.40** (28)	0.14 0.37* (28)	-0.39* -0.18 (20)	1.00 (30)	L-V	0.16 0.99 (25)	0.05 0.02 (25)	-0.19 0.08 (16)	0.18 0.08 (25)	0.38* 0.41** (25)	0.10 0.34 (19)	0.41** 0.52*** (25)	1.00 (25)	L-CR	0.20 0.19 (21)	0.13 0.11 (21)	-0.02 0.14 (15)	0.16 0.0 (19)	0.21 0.12 (19)	-0.002 0.0 (14)	0.38* 0.51** (20)	0.38 0.40 (16)	1.00 (21)	L-TI	0.47*** 0.17 (31)	0.52*** -0.08 (31)	-0.34 0.02 (21)	-0.05 -0.48*** (29)	0.36* 0.63*** (29)	-0.01 0.32 (20)	0.28 0.62*** (30)	0.33 0.52*** (25)	-0.06 0.19 (21)	1.00 (31)	L-SC	0.02 0.08 (29)	-0.17 -0.07 (29)	-0.03 -0.01 (19)	0.09 -0.50*** (29)	0.41** 0.41** (29)	-0.18 -0.18 (20)	0.68*** 0.62*** (28)	0.21 0.16 (25)	0.11 0.09 (19)	0.89*** 0.78*** (29)	1.00 (29)	L-BA	0.23 0.08 (31)	0.11 -0.28 (31)	0.03 0.15 (21)	-0.27 -0.47** (29)	0.35* 0.54*** (29)	0.27 0.27 (20)	0.69*** 0.73*** (30)	0.32 0.61*** (25)	0.02 0.18 (21)	0.69*** 0.87*** (31)	0.80*** 0.62*** (29)	1.00 (31)	L-SR	0.27 0.17 (31)	0.16 -0.13 (31)	-0.03 0.06 (21)	-0.33* -0.56*** (29)	0.56*** 0.78*** (29)	0.78*** 0.50** (20)	0.54*** 0.53*** (30)	0.26 0.37* (25)	0.05 0.14 (21)	0.75*** 0.90*** (31)	0.78*** 0.70*** (29)	0.94*** 0.85*** (31)	1.00 (31)	L-Y	0.52*** 0.14 (31)	0.73*** 0.46** (31)	-0.61*** -0.32 (21)	0.62*** 0.55*** (29)	-0.03 -0.10 (29)	-0.45** -0.27 (20)	-0.32* -0.32* (30)	0.08 0.14 (25)	0.03 -0.04 (21)	0.55*** -0.04 (31)	-0.43** -0.12 (29)	-0.16 -0.35* (31)	-0.02 -0.15 (31)	1.00 (31)	L-ZN	0.35* -0.09 (31)	0.57*** 0.22 (31)	-0.53** -0.35 (21)	0.59*** 0.56*** (29)	0.03 -0.14 (29)	-0.09 -0.17 (20)	-0.36** -0.30 (30)	-0.10 -0.13 (25)	0.01 0.18 (21)	0.57*** -0.18 (31)	-0.46** -0.39** (29)	-0.13 -0.34* (31)	0.03 -0.18 (31)	0.93*** 0.72*** (31)	1.00 (31)	L-BE	0.12 -0.07 (31)	0.38** 0.26 (31)	-0.44** -0.33 (21)	0.62*** 0.67*** (29)	-0.16 -0.33* (29)	-0.18 -0.25 (20)	-0.57*** -0.53*** (30)	-0.15 -0.29 (25)	-0.12 -0.18 (21)	0.28 -0.23 (31)	-0.50*** -0.52*** (29)	-0.45** -0.39 (31)	-0.31* -0.30 (31)	0.86*** 0.85*** (31)	0.88*** 0.77*** (31)	1.00 (31)	L-NB	-0.36* -0.14 (29)	-0.03 0.27 (29)	-0.30 -0.19 (19)	0.62*** 0.68*** (29)	-0.22 -0.33* (29)	-0.23 -0.22 (20)	-0.68*** -0.53*** (28)	-0.21 -0.32 (25)	0.03 0.01 (19)	-0.76*** -0.47*** (29)	-0.56*** -0.23 (29)	-0.87*** -0.67*** (29)	-0.82*** -0.55*** (29)	0.90*** 0.80*** (29)	0.88*** 0.73*** (29)	0.98*** 0.95*** (29)	1.00 (29)	L-LI	0.15 -0.19 (31)	0.37** 0.04 (31)	-0.40* -0.17 (21)	0.35* 0.51*** (29)	-0.55*** -0.71*** (29)	-0.00 -0.22 (20)	-0.52*** -0.62*** (30)	-0.32 -0.37* (25)	-0.13 -0.19 (21)	0.20 -0.42** (31)	-0.51*** -0.52*** (29)	-0.40** -0.53*** (31)	-0.33* -0.50*** (31)	0.71*** 0.50*** (31)	0.65*** 0.45** (31)	0.75*** 0.68*** (31)	0.68*** 0.58*** (29)	1.00 (31)	L-FE	0.35* -0.07 (31)	0.55*** 0.26 (31)	-0.41* -0.10 (21)	0.82*** 0.61*** (29)	-0.03 -0.27 (29)	-0.08 0.04 (20)	-0.17 -0.40** (30)	0.09 -0.01 (25)	-0.08 0.21 (21)	0.79*** -0.08 (31)	-0.13 -0.29 (29)	0.13 -0.32* (31)	0.25 -0.23 (31)	0.86*** 0.75*** (31)	0.91*** 0.83*** (31)	0.78*** 0.83*** (31)	0.80*** 0.83*** (29)	0.59*** 0.57*** (31)	1.00 (31)	L-MN	0.36** -0.01 (31)	0.59*** 0.28 (31)	-0.51** -0.40* (21)	0.64*** 0.55*** (29)	-0.13 -0.24 (29)	-0.25 -0.21 (20)	-0.29 -0.40** (30)	-0.31 -0.35* (25)	-0.10 0.03 (21)	0.69*** -0.21 (31)	-0.31 -0.29 (29)	-0.01 -0.47*** (31)	0.12 -0.29 (31)	0.91*** 0.90*** (31)	0.95*** 0.86*** (31)	0.84*** 0.85*** (31)	0.88*** 0.85*** (29)	0.65*** 0.59*** (31)	0.96*** 0.82*** (31)	1.00 (31)	L-AL	0.39** 0.08 (31)	0.54*** -0.06 (31)	-0.41* -0.15 (21)	0.78*** 0.12 (29)	0.01 0.02 (29)	-0.24 -0.16 (20)	-0.03 0.48** (30)	0.33 0.30 (25)	-0.14 -0.03 (21)	0.89*** 0.49*** (31)	0.35* 0.32 (29)	0.32* 0.62*** (31)	0.41** 0.41** (31)	0.77*** 0.08 (31)	0.82*** 0.05 (31)	0.63*** -0.79 (31)	0.13 -0.33* (29)	-0.50*** -0.07 (31)	0.96*** 0.98 (31)	0.90*** -0.09 (31)	1.00 (31)	L-K	0.41** -0.11 (31)	0.57*** -0.06 (31)	-0.37* -0.10 (21)	0.46** 0.05 (29)	-0.39** -0.21 (29)	-0.16 -0.01 (20)	-0.12 -0.25 (30)	-0.25 -0.15 (25)	-0.17 -0.09 (21)	0.87*** 0.24 (31)	0.21 0.21 (29)	0.28 -0.02 (31)	0.38** 0.08 (31)	0.79*** 0.39** (31)	0.82*** 0.11 (31)	0.65*** 0.44** (31)	0.20 0.32* (29)	0.56*** 0.49*** (31)	0.96*** 0.33* (31)	0.91*** 0.30 (31)	0.97*** -0.13 (31)	1.00 (31)	L-ZR	0.54*** 0.18 (31)	0.70*** 0.18 (31)	-0.52** -0.08 (21)	0.57*** 0.38** (29)	0.49*** 0.36* (29)	0.16 0.04 (20)	-0.06 0.04 (30)	0.44** 0.29 (25)	0.07 0.16 (21)	0.81*** 0.41** (31)	0.14 0.02 (29)	0.25 0.16 (31)	0.37** 0.30 (31)	0.88*** 0.60*** (31)	0.88*** 0.55*** (31)	0.64*** 0.50*** (31)	0.40** 0.43** (29)	0.48*** 0.15 (31)	0.92*** 0.59*** (31)	0.89*** 0.48*** (31)	0.90*** 0.22 (31)	0.88*** 0.35* (31)	1.00 (31)	L-TH	-0.26 -0.09 (30)	-0.20 0.09 (30)	-0.07 0.01 (20)	0.84*** 0.03 (29)	0.14 0.06 (29)	-0.35 -0.31 (20)	-0.05 0.16 (29)	0.32 0.26 (25)	-0.21 0.02 (20)	0.74*** 0.38** (30)	0.46** 0.51*** (29)	0.17 0.18 (30)	0.23 0.21 (30)	0.67*** 0.44** (30)	0.71*** 0.14 (30)	0.59*** 0.25 (30)	0.33* 0.26 (29)	0.20 -0.05 (30)	0.92*** 0.31* (30)	0.04*** 0.19 (30)	0.91*** 0.23 (30)	0.06*** 0.24 (30)	0.83*** 0.20 (30)	1.00 (30)	L-CE	-0.10 0.11 (30)	-0.12 0.06 (30)	0.03 -0.05 (20)	0.60*** -0.10 (29)	0.35* 0.29 (29)	-0.44* -0.26 (20)	-0.02 0.34* (29)	0.39* 0.24 (25)	-0.22 0.01 (20)	0.81*** 0.61*** (30)	0.57*** 0.67*** (29)	0.30 0.53*** (30)	0.37** 0.50*** (30)	0.62*** 0.24 (30)	0.66*** 0.01 (30)	0.46** -0.03 (30)	0.04 -0.08 (29)	0.21 -0.28 (30)	0.87*** 0.05 (30)	0.79*** 0.06 (30)	0.91*** 0.45** (30)	0.88*** 0.16 (30)	0.82*** 0.23 (30)	0.95*** 0.76*** (30)	1.00 (30)

SOUTHWEST NEW MEXICO VOLCANICS
CORRELATION COEFFICIENTS

GROUP 3 - RHYOLITE OF CLANTON DRAW

EXPLANATION:
UPPER NUMBER = PEARSON COEFFICIENT
MIDDLE NUMBER = SPEARMAN COEFFICIENT
LOWER NUMBER = NUMBER OF SAMPLES

* SIGNIFICANT AT 90% LEVEL
** SIGNIFICANT AT 95% LEVEL
*** SIGNIFICANT AT 99% LEVEL

ALL CORRELATIONS ARE BASED ON LOGARITHMIC TRANSFORMATIONS OF MEASURED VALUES.

U = URANIUM BY FLUORIMETRY
UNT = URANIUM BY NEUTRON ACTIVATION/DELAYED COUNT

SOUTHWEST NEW MEXICO VOLCANICS
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NO. SAMPLES ANALYZED														
BELOW														
MEASURABLE DETECTION DETECTION MINIMUM MAXIMUM														
ELEMENT VALUES LIMIT LIMIT VALUE VALUE MEAN MEDIAN MODE STANDARD OF														
COEFFICIENT LN TRANSFORMATION														
ROBUST														
MEAN S. D. MEAN S. D.														
U	45			1.52	10.33	5.35	5.48	6.19	2.093	0.391	1.59	0.44	1.61	0.44
U-NT	45			1.10	11.50	5.71	5.95	7.24	2.174	0.381	1.66	0.45	1.68	0.40
AL	45			4.02	6.73	5.24	5.11	5.13	0.655	0.125	1.65	0.12	1.65	0.14
B	0	45	<10	<10	<10		<10	<10						
BA	45			14	1792	250	61	47	403.0	1.5	4.66	1.31	4.62	1.42
BE	45			2	9	3	4	4	1.5	0.4	1.25	0.39	1.24	0.45
CA	45			0.09	1.86	0.38	0.41	0.38	0.438	0.760	-0.82	0.76	-0.82	0.82
CO	7	35	<4	<4	10	5	<4	<4	2.1	0.4	1.61	0.32		
CR	37	5	<1	<1	5	1	<1	<1	1.0	0.6	0.44	0.51		
CU	27	15	<2	<2	84	16	<2	<2	24.7	1.5	2.03	1.20		
FE	45			0.31	2.22	0.74	0.60	0.56	0.363	0.490	-0.39	0.40	-0.40	0.42
LI	45			9	176	38	34	36	27.1	0.7	3.46	0.60	3.45	0.58
MG	38	7	<0.05	<0.05	0.45	0.17	0.11	0.07	0.111	0.604	-2.01	0.68	-2.22	0.97
MN	45			96	753	350	326	322	133.5	0.4	5.79	0.39	5.79	0.40
MC	1	44	<4	<4	4	4	<4	<4	0.0	0.0	1.39	0.0		
NA	45			0.13	2.84	1.93	2.00	2.68	0.571	0.297	0.57	0.51	0.64	0.41
NB	45			10	49	22	23	18	7.9	0.3	3.06	0.36	3.06	0.39
NI	9	35	<2	<2	4	2	<2	<2	0.7	0.3	0.66	0.26		
P	45			13	802	119	58	39	154.4	1.3	4.27	0.94	4.25	1.03
TI	45			422	3674	994	750	740	607.5	0.6	6.78	0.45	6.76	0.43
SC	45			1	5	2	2	2	0.9	0.4	0.74	0.39	0.74	0.38
TH	45			9	33	21	21	27	5.7	0.3	3.02	0.30	3.03	0.30
V	45			2	44	7	4	2	7.6	1.0	1.63	0.79	1.59	0.93
Y	45			10	47	23	23	25	6.7	0.3	3.12	0.29	3.13	0.29
ZN	45			11	127	36	29	51	21.2	0.6	3.46	0.54	3.46	0.56
ZR	45			26	229	73	55	34	46.6	0.6	4.14	0.54	4.12	0.56
K	45			1.49	4.29	3.00	3.00	3.47	0.616	0.205	1.08	0.22	1.09	0.21
SR	45			4	3710	193	49	14	564.1	2.9	4.05	1.38	4.00	1.25
CE	45			37	167	70	65	69	27.3	0.4	4.19	0.34	4.17	0.38

SW NEW MEXICON #4

25 VARIABLES CLUSTERED USING 45 SAMPLES.

DATE PLOTTED IS 03-19-80

CLUSTERING CRITERION -- COMPLETE LINKAGE

NORMALIZATION -- RAW DATA IS USED

METRIC -- (1. -ABS(PEARSON CORRELATION)) ?

L-U	1.00 (45)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				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NO. SAMPLES ANALYZED BELOW													
MEASURABLE DETECTION		DETECTION		MINIMUM		MAXIMUM		STANDARD		COEFFICIENT		LN TRANSFORMATION	
ELEMENT	VALUES	LIMIT	LIMIT	VALUE	VALUE	VALUE	VALUE	DEVIATION	OF	VARIATION	MEAN	S. D.	MEAN
U	24			0.44	14.70	4.51	3.85	3.59	2.850	0.632	1.32	0.69	1.35
U-VT	24			0.90	19.00	4.98	4.10	5.25	3.569	0.716	1.41	0.64	1.41
AL	24			3.75	7.27	5.11	4.82	4.78	0.781	0.153	1.62	0.15	1.62
B	1	23	<10	<10	10	10	<10	<10	0.0	0.0	2.30	0.0	
BA	24			16	1511	431	259	98	382.3	0.9	5.62	1.07	5.67
BE	24			1	11	4	3	3	2.7	0.6	1.28	0.58	1.29
CA	24			0.06	5.20	0.97	0.56	0.56	1.180	1.212	-0.56	1.07	-0.55
CD	4	20	<4	<4	26	12	<4	<4	9.9	0.8	2.24	0.75	
CR	21	3	<1	<1	16	2	<1	<1	3.3	1.3	0.60	0.75	
CU	18	5	<2	<2	631	40	<2	<2	147.5	3.6	1.67	1.44	
FE	24			0.31	3.72	1.12	0.80	0.82	0.888	0.791	-0.10	0.64	-0.12
LI	24			5	82	35	33	40	19.3	0.0	3.38	0.66	3.41
MG	21	3	<0.05	<0.05	0.66	0.25	0.15	0.07	0.192	0.765	-1.66	0.78	-1.86
MY	24			25	1129	423	358	382	301.0	0.7	5.75	0.88	5.81
MO	2	22	<4	<4	5	5	<4	<4	0.0	0.0	1.61	0.0	
NA	24			0.48	2.64	1.63	1.56	1.53	0.635	0.389	0.40	0.48	0.42
NB	24			5	54	22	19	14	12.7	0.6	2.97	0.56	2.99
NI	11	13	<2	<2	17	4	<2	<2	4.3	0.9	1.32	0.65	
P	24			24	772	213	107	121	214.0	1.0	4.93	0.94	4.93
TI	24			454	3968	1415	1009	930	993.6	0.7	7.05	0.63	7.04
SC	24			1	8	3	3	3	1.9	0.0	1.04	0.57	1.04
TH	23	1	<2	<2	35	16	14	13	7.7	0.5	2.70	0.47	2.66
V	24			2	44	13	10	19	11.9	0.9	2.20	0.91	2.20
Y	24			9	56	30	29	56	12.7	0.4	3.33	0.45	3.35
ZN	24			15	80	39	38	60	14.8	0.4	3.61	0.39	3.61
ZR	24			17	194	97	90	142	36.8	0.4	4.50	0.47	4.54
K	24			1.05	4.98	2.90	2.82	2.84	0.800	0.276	1.02	0.30	1.04
SR	24			4	1007	196	82	55	268.7	1.4	4.50	1.35	4.53
CE	24			17	99	65	57	53	21.7	0.3	4.11	0.39	4.15

SW NEW MEXICO VOLCANICS #5
 26 VARIABLES CLUSTERED USING 31 SAMPLES.

DATE PLOTTED IS 03-20-80

CLUSTERING CRITERION -- COMPLETE LINKAGE

NORMALIZATION -- RAW DATA IS USED

METRIC -- (1. -ABS(PEARSON CORRELATION))

U = URANIUM BY FLUORIMETRY
UNT = URANIUM BY NEUTRON ACTIVATION/DELAYED COUNT

SOUTHWEST NEW MEXICO VOLCANICS CORRELATION COEFFICIENTS																													
GROUP 5 - BLUFF CREEK FORMATION																													
EXPLANATION:																													
UPPER NUMBER = PEARSON COEFFICIENT																													
MIDDLE NUMBER = SPEARMAN COEFFICIENT																													
LOWER NUMBER = NUMBER OF SAMPLES																													
* SIGNIFICANT AT 90% LEVEL																													
** SIGNIFICANT AT 95% LEVEL																													
*** SIGNIFICANT AT 99% LEVEL																													
ALL CORRELATIONS ARE BASED ON LOGARITHMIC TRANSFORMATIONS OF MEASURED VALUES.																													
U = URANIUM BY FLUORIMETRY																													
UNT = URANIUM BY NEUTRON ACTIVATION/DELAYED COUNT																													
L-U	1.00 (24)																												
LUNT	0.56*** (24)	LUNT	1.00 (24)																										
L-CU	-0.06 (18)	-0.10 (18)	L-CU	1.00 (18)																									
L-NA	-0.03 (24)	0.07 (24)	-0.60*** (18)	L-NA	1.00 (24)																								
L-CA	-0.68*** (24)	-0.71*** (24)	0.10 (18)	-0.19 (24)	L-CA	1.00 (24)																							
L-MG	-0.34 (21)	-0.42* (21)	-0.03 (15)	-0.32 (21)	L-MG	0.62*** (21)	1.00 (21)																						
L-F	-0.49** (24)	-0.54*** (24)	0.22 (18)	0.11 (24)	L-F	0.62*** (24)	0.37* (21)	1.00 (24)																					
L-V	-0.50** (24)	-0.52*** (24)	0.31 (18)	0.02 (24)	L-V	0.56*** (24)	0.18 (21)	0.73*** (24)	1.00 (24)																				
L-CR	-0.36 (21)	-0.41* (21)	0.30 (18)	-0.21 (21)	L-CR	0.50** (21)	0.49** (18)	0.37 (21)	0.44** (21)	1.00 (21)																			
L-TI	-0.53*** (24)	-0.57*** (24)	0.24 (18)	0.04 (24)	L-TI	0.71*** (24)	0.36 (21)	0.90*** (24)	0.82*** (24)	0.39* (21)	1.00 (24)																		
L-SC	-0.43** (24)	-0.44** (24)	0.33 (18)	-0.06 (24)	L-SC	0.69*** (24)	0.46** (21)	0.78*** (24)	0.59*** (24)	0.46** (21)	0.68*** (24)	1.00 (24)																	
L-EA	-0.68*** (24)	-0.67*** (24)	0.12 (18)	0.07 (24)	L-EA	0.75*** (24)	0.19 (21)	0.57*** (24)	0.47** (24)	0.22 (21)	0.62*** (24)	0.59*** (24)	1.00 (24)																
L-SR	-0.65*** (24)	-0.68*** (24)	0.12 (18)	-0.20 (24)	L-SR	0.87*** (24)	0.61*** (21)	0.49** (24)	0.47** (24)	0.42* (21)	0.55*** (24)	0.57*** (24)	0.74*** (24)	1.00 (24)															
L-Y	0.24*** (24)	0.86*** (24)	-0.05 (18)	-0.04 (24)	L-Y	-0.56*** (24)	-0.07 (21)	-0.34 (24)	-0.40* (24)	-0.27 (21)	-0.40* (24)	-0.22 (24)	-0.59*** (24)	-0.48** (24)	1.00 (24)														
L-ZN	0.18 (24)	0.25 (24)	0.10 (18)	-0.07 (24)	L-ZN	0.16 (24)	0.09 (21)	0.11 (24)	-0.14 (24)	-0.03 (21)	-0.06 (24)	0.05 (24)	0.08 (24)	0.10 (24)	0.31 (24)	1.00 (24)													
L-BE	0.16 (24)	0.16 (24)	-0.06 (18)	-0.21 (24)	L-BE	-0.01 (24)	0.37 (21)	-0.21 (24)	-0.08 (24)	0.14 (21)	-0.14 (24)	0.01 (24)	-0.31 (24)	0.01 (24)	0.31 (24)	0.00 (24)	1.00 (24)												
L-NB	0.76*** (24)	0.80*** (24)	-0.07 (18)	-0.10 (24)	L-NB	-0.59*** (24)	-0.08 (21)	-0.57*** (24)	-0.52*** (24)	-0.13 (21)	-0.60*** (24)	-0.33 (24)	-0.62*** (24)	-0.43** (24)	0.85*** (24)	0.25 (24)	0.36* (24)	1.00 (24)											
L-LI	0.13 (24)	0.12 (24)	0.33 (18)	-0.37* (24)	L-LI	-0.10 (24)	0.15 (21)	0.04 (24)	-0.04 (24)	0.33 (21)	-0.02 (24)	0.15 (24)	-0.19 (24)	-0.19 (24)	0.37* (24)	0.25 (24)	0.10 (24)	0.24 (24)	1.00 (24)										
L-FE	-0.63*** (24)	-0.63*** (24)	0.29 (18)	-0.06 (24)	L-FE	0.82*** (24)	0.54** (21)	0.83*** (24)	0.76*** (24)	0.48** (21)	0.91*** (24)	0.90*** (24)	0.66*** (24)	0.71*** (24)	-0.42** (24)	0.09 (24)	-0.01 (24)	-0.54*** (24)	0.02 (24)	1.00 (24)									
L-MN	-0.13 (24)	-0.16 (24)	0.29 (18)	-0.26 (24)	L-MN	0.50** (24)	0.55*** (21)	0.04 (24)	-0.07 (24)	0.53** (21)	-0.01 (24)	0.21 (24)	0.19 (24)	0.38* (24)	0.03 (24)	0.40** (24)	0.25 (24)	0.06 (24)	0.24 (24)	0.28 (24)	1.00 (24)								
L-AL	-0.33 (24)	-0.28 (24)	-0.12 (18)	0.34* (24)	L-AL	0.23 (24)	-0.15 (21)	0.59*** (24)	0.42** (24)	-0.18 (21)	0.51** (24)	0.33 (22)	0.47** (24)	0.30 (24)	-0.25 (24)	0.05 (24)	-0.36* (24)	-0.48** (24)	-0.18 (24)	0.34 (24)	-0.41** (24)	1.00 (24)							
L-K	0.48** (24)	0.50** (24)	0.24 (18)	-0.27 (24)	L-K	-0.50** (24)	-0.51** (21)	-0.40** (24)	-0.32 (24)	-0.54** (21)	-0.43** (24)	-0.37* (24)	-0.21 (24)	-0.32 (24)	0.41** (24)	0.04 (24)	0.01 (24)	0.38* (24)	0.06 (24)	-0.51** (24)	-0.32 (24)	-0.01 (24)	1.00 (24)						
L-ZR	0.60*** (24)	0.52*** (24)	0.10 (18)	-0.12 (24)	L-ZR	0.07 (21)	0.13 (24)	0.01 (24)	-0.13 (21)	0.19 (24)	0.26 (24)	-0.35* (24)	-0.38* (24)	0.65*** (24)	0.11 (24)	-0.01 (24)	0.44** (24)	0.30 (24)	0.03 (24)	-0.20 (24)	-0.00 (24)	0.10 (24)	1.00 (24)						
L-TH	0.68*** (23)	0.72*** (23)	-0.17 (17)	-0.24 (23)	L-TH	-0.34*** (23)	0.07 (20)	-0.38*** (23)	-0.45** (23)	-0.22 (20)	-0.57*** (23)	-0.31 (23)	-0.65*** (23)	-0.39* (23)	0.81*** (23)	0.19 (23)	0.67*** (23)	0.90*** (23)	0.35 (23)	-0.46** (23)	0.11 (23)	-0.54*** (23)	0.38* (23)	0.40* (23)	1.00 (23)				
L-CE	0.20 (24)	0.22 (24)	-0.02 (18)	0.04 (24)	L-CE	-0.28 (24)	-0.27 (21)	0.07 (24)	0.06 (24)	-0.41* (21)	0.06 (24)	0.01 (24)	0.09 (24)	-0.08 (24)	0.19 (24)	0.01 (24)	-0.49** (24)	0.17 (24)	-0.15 (24)	-0.12 (24)	-0.59*** (24)	0.51** (24)	0.36* (24)	0.39* (24)	-0.12 (23)	1.00 (24)			
L-CG	-0.882 (4)	-0.872 (4)	0.752 (3)	-0.612 (4)	L-CG	0.842 (4)	0.782 (4)	0.692 (4)	0.582 (4)	1.002 (3)	0.322 (4)	0.872 (4)	0.072 (4)	0.562 (4)	-0.952 (4)	0.022 (4)	-0.062 (4)	-0.442 (4)	0.482 (4)	0.872 (4)	0.852 (4)	-0.902 (4)	-1.002 (4)	-0.542 (4)	-0.752 (3)	-0.452 (4)	1.00 (4)		