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GEOLOGICAL SURVEY

A Study of Uranium Favorability of Cenozoic Sedimentary Rocks Basin and Range Province, Arizona

Part I

General Geology and Chronology of Pre-late Miocene Cenozoic Sedimentary Rocks

By

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FOREWORD

This report by Robert Scarborough and Jan Carol Wilt summarizes the results of a study made for the U.S. Geological Survey jointly by the Bureau of Geology and Mineral Technology and the Laboratory of Isotope Geochemistry, College of Earth Sciences, University of Arizona, under Grant No. 14-08-0001528. Age dating by the K/Ar method was cost-shared with NSF Grant No. EAR78-11535 which supports volcanic rock studies by the Laboratory of Isotope Geochemistry.

It is considered that this report adequately fulfills the agreement objectives.

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ABSTRACT

This study focuses attention on Cenozoic sedimentary rocks in the Basin and Range Province of Arizona. The known occurrences of uranium and anomalous radioactivity in these rocks are associated with sediments that accumulated in a low energy environment characterized by fine-grained clastics, including important tuffaceous materials, and carbonate rocks. Most uranium occurrences in these rocks appear to be stratabound.

Emphasis was placed on those sedimentary materials that pre-date the late Cenozoic Basin and Range disturbance. They are deformed and crop out on pedimented range blocks and along the province interface with the Transition Zone. Three tentative age groups are recognized: Group I - Oligocene, pre-22 m.y., Group II - early Miocene - 22 m.y. - 16 m.y., and Group III - middle Miocene - 16 m.y. to 13-10 m.y. Regionally, these three groups contain both coarse to fine-grained red clastics and low energy lighter colored "lacustrine" phases.

Each of the three groups has been the object of uranium exploration. Group II, the early Miocene strata, embraces the Anderson Mine - Artillery region host rocks and also the New River - Cave Creek early Miocene beds along the boundary with the Transition Zone.

These three groups of rocks have been tectonically deformed to the extent that original basins of deposition cannot yet be reconstructed. However, they were considerably more extensive in size than the late Cenozoic basins the origin of which deformed the former.

Group II rocks are judged to be of prime interest because of: (1) the development and preservation of organic matter in varying lithologies, (2) apparent contemporaneity with silicic volcanic centers, (3) influence of Precambrian crystalline rocks, and (4) relative outcrop continuity near the stable Transition Zone.

The Transition Zone, especially along its boundary with the Basin and Range Province, needs additional geologic investigation, especially as regards the depositional continuity of Group II sediments.

INTRODUCTION

GENERAL STATEMENT

This report summarizes the uranium related highlights of a general geologic and age-dating study conducted on pre-10 to 13 m.y. old sedimentary rocks of the Basin and Range Province of Arizona. The project began June 1, 1978, and ended April 30, 1979. The study was carried out under the office of Energy Resources, United States Geological Survey, Denver Federal Center, Denver, CO 80225.

The English system of measurement is used throughout this report.

PURPOSE AND SCOPE

This field study is Part I of a larger study designed to assess the uranium favorability of Cenozoic sedimentary rocks of the Basin and Range province of Arizona. Part I is intended to be an overview of the general geology of pre-10 to 13 m.y. old pre-Basin and Range disturbance, Tertiary sedimentary rocks with emphasis on those having known uranium occurrences or anomalous radioactivity. A major objective was the collection and K/Ar dating of 25 volcanic units suitable for providing chronological information regarding closely associated Cenozoic stratigraphic sequences. Other objectives included:

(1) establishment of the character, tectonic position, and state of deformation of the various sedimentary packages,

(2) correlation of Cenozoic events,

(3) compilation of an appropriate bibliography,

(4) evaluation of problems and avenues for additional research, and

(5) preparation of data for an eventual Bureau of Geology and Mineral Technology publication.

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In a problem so regionally extensive it is essential that advantage be taken of various assists wherever possible. Assists in the field were generously provided by Principal Investigator H. W. Peirce, Professor Don Clay of Arizona Western College, Stephen J. Reynolds, University of Arizona, prospectors Tom Howell and Harold Best, and consultant Richard Cribbs. Consultant Edgar B. Heylmun, Tucson, provided important guidance. The age-dating work was conscientiously guided by Dr. M. Shafiqullah of the Laboratory of Isotope Geochemistry, University of Arizona. Discussion of a diversity of geologic problems with colleagues H. Wesley Peirce and Stanley B. Keith proved indispensable. U.S. Geological Survey project officer James K. Otton willingly provided important information. Both the State of Arizona and the University of Arizona provided valuable supports not elsewhere acknowledged.

LOCATION AND PHYSIOGRAPHIC SETTING

It is customary to subdivide Arizona into physiographic-geologic provinces. The subdivision used here is illustrated in Figure 27 (All figures are together near the end of the report). It includes the Colorado Plateau Province to the northeast and the Basin and Range Province to the southwest. In the central part of the state these are separated by a Transition Zone. The southwestern boundary of the Plateau is frequently called the Mogollon Rim.

Whereas the Plateau region is characterized by an erosionally stripped surface cut upon outcropping Mesozoic-Paleozoic sedimentary rocks, the Basin and Range country is typified by alternating ranges and basins. Ranges consist of rocks of sedimentary, igneous, and metamorphic origin whereas intervening valleys (basins) frequently are underlain by thousands of feet of sedimentary materials that infilled the basins as they came into existence as a manifestation of the Basin and Range disturbance 13-10 m.y. ago. Our principal concern here is the nature of the Cenozoic geologic history prior to the Basin and Range disturbance.

The Transition Zone, consisting largely of Precambrian crystalline and Tertiary volcanic and sedimentary rocks, contains a few mountains and valleys. Its post-Precambrian rocks are not severely tectonically disturbed although the region has undergone some late Cenozoic normal faulting. This zone, as regards the Tertiary sedimentary record, bears a closer relationship to the Basin and Range Province than it does the Colorado Plateau Province.

APPROACH

A review of the uranium favorability of Cenozoic sedimentary rocks of the Basin and Range Province in Arizona was stimulated by several factors:

(1) a growing interest in exploring for uranium in this part of Arizona,

(2) uranium occurrence precedents place emphasis on the Cenozoic sedimentary rocks, and

(3) a general paucity of regionally oriented geologic data suitable for developing an overview of Cenozoic geologic history.

For the Phase I study it was decided that attention would be focused on what is here called the pre-basin fill sedimentary sequences. In effect, this limited the study to the older, more deformed, discontinuous, scattered, erratically preserved sections exposed in either range structural blocks or along the more stable southern edge of the

Transition Zone. Emphasis was placed on those sections associated with previously published uranium occurrence data especially the AEC's Preliminary Reconnaissance Reports (PRR). An attempt was made to extract the geologic highlights including: lithology, thickness, state of deformation, extent of outcrop, transport directional parameters, relationship to volcanic products, and age through all available data including new K/Ar dating done for this project. Background radioactivity was checked and anomalous readings noted. These data were synthesized and appropriate regional generalizations made. Our basic data and preliminary conclusions are depicted in this report. Although extensive mapping was not a part of this general study, 26 sketch geologic sections were constructed and constitute an important part of this report.

All radiometric readings were made with a Geometrics model GR-101A single channel gamma ray scintillometer. Readings generally were taken against or very close to a given rock exposure. Readings judged to be twice background or more were considered anomalous.

K/Ar age dates are listed on Table 2 and the sketch geologic sections appear as Figures 1 through 26.

GENERAL CENOZOIC GEOLOGY OF BASIN AND RANGE PROVINCE SEDIMENTS

GENERAL STATEMENT

An outgrowth of this investigation is the overall recognition of four different time packages of sediments that contain uranium occurrences (Figure 36). The youngest, the late Cenozoic basin fill, is believed to be younger than 13 to 10 m.y. in age, depending upon locality. Although this sedimentary group is the object of important uranium exploration, it is not discussed in this report. For a summary of these materials see Peirce, 1976; Eberly and Stanley, 1978; and Scarborough and Peirce, 1978. However, it should be pointed out that we are limiting the Basin and Range disturbance to the block faulting event that produced the depocenters exploited by the late Cenozoic basin fill deposits. This event, and subsequent sedimentation, in places tectonically disrupt and cover the three older uranium-bearing sedimentary sequences.

The three older age group assignments are:

(1) Oligocene sediments interbedded with variable amounts of volcanics, but mostly pre-volcanic in the southeastern part of the state. Includes the Mineta and Pantano formations.

(2) Early Miocene sediments in the central and west central part of the state contemporaneous with much silicic volcanism. Includes the Anderson area host rocks.

(3) Middle Miocene sediments and volcanics in the central part of the state. Includes the Lake Pleasant and Horseshoe dam deposits.

For this report Cenozoic epochal boundaries are taken as: Oligocene 38-22 m.y., Miocene 22-6 m.y., Pliocene 6-1.8 m.y. It is useful to further subdivide the Miocene: early 22-16 m.y., middle 16-11 m.y., late 11-6 m.y.

Some generalized structural and stratigraphic relations of Tertiary volcanics and sediments in the Basin and Range Province are illustrated in Figure 1, a cross-section from the Sierrita Mountains through Tucson, the Rincon Mountains, the San Pedro Valley, the Galiuro Mountains and ending in the Winchester Mountains. The Basin and Range faults are those which lie more or less symmetrically disposed about present valley axes and form the boundaries of the mountain and basin blocks. However, it is easily noticed that the present valleys are now almost always larger than the basin blocks because of pediment backwearing of the mountain block edges. This Basin and Range "process" has had the net effect of deforming and plastering older Cenozoic materials against the older still rocks of the mountains. Thus, units such as the Mineta Fm. (Figure 1) are found at the edge of, but commonly in tectonic contact with, the materials of the mountain blocks. More rarely, the older Cenozoic materials are found in the valleys where recent dissection has exposed pedimented terrains containing these rocks, as in the San Pedro Valley (Figure 1).

Following is a brief geologic summation of the areas and localities identified for this report as containing pre-basin fill Cenozoic sedimentary rocks. Not all contain known anomalous radioactivity. Table 1 is a list of 41 localities having known anomalous radioactivity, 36 of which are largely sedimentary and five of which involve other host rock types. Of these 41 occurrences, 25 were visited.

The order of presentation is from the oldest to the youngest of the three chronological groupings. Where appropriate the number of PRR's associated with either a formation or topic area is shown as is the reference number to Table 1 and Figure B, which list and locate localities with radioactive anomalies.

GROUP I . LOCALITIES WITH RADIOACTIVE ANOMALIES

Mineta Formation
(3PRR's-Nos. 26-28)

The Mineta Fm. crops out on the eastern flank of the Rincon Mountains Figures 1 and 2). It was named and mapped by Chew (1952) and mapped by Clay (1970). Bissett, 1958, Granger and Raup, 1962, and Thorman and Drewes, 1978, have discussed uranium occurrences in the Mineta Fm. It is a 2-3000 ft. thick deformed nonmarine section, dipping ENE at 30-70°, consisting of a basal conglomerate overlain by a red and yellow colored shale-mudstone-limestone sequence which becomes gypsiferous and white colored at the top. The Formation is in both high angle fault contact with older rocks of the Rincon Mountain block, and locally depositional on granite. The entire formation is unconformably overlain by a 27 m.y. old basaltic andesite (Shafiqullah and others, 1978) and hence is considered to be Oligocene or older in age. The sediments are in high angle fault contact to the east with late Cenozoic basin fill materials. A rhyolite which outcrops discontinuously at or near the base of the formation yields a 25 m.y. K/Ar age (this study-Table Z), which overlaps analytical error limits of the overlying basaltic andesite. Hence if the K/Ar dates are to be trusted, deposition of at least 2000-3000 feet of Mineta formation and 40° of eastward homoclinal tilting took place in a very short time.

Two PRR localities were visited. Radioactive zones (100x) of light and dark gray mudstones occur as discontinuous lenses up to 10 feet thick in the basal conglomerate, some of which are very near the basal depositional contact. The granites beneath the contact also contain anomalous radioactivity. One to two hundred (100-200) feet higher in the sequence, radioactivity (to 5x) is associated with slightly fetid limestones and varicolored shale beds (to 100 feet thick). In general, the anomalous zone extends for at least 5 miles along strike but individual anomalous areas are discontinuous at the surface. The section is essentially devoid of intercalated volcanics except for a welded rhyolite tuff bed which outcrops discontinuously at or very near the base of the section for several miles (Clay, 1970).

Cardinal Avenue Sediments
(1PRR-No. 30)

This occurrence mapped by Brown (1939), Wilson and others, (1960), and studied by Grimm (1978), is an isolated outcrop of Tertiary low energy nonmarine sediments which is in the southeast corner of the Tucson Mountain structural block and is exposed as part of a stripped pediment (Figure 1). The limestone outcrop covers less than one square mile and is in fault contact to the west with Cretaceous andesites, and covered to the south and east by coluvium. The contact with older Cretaceous volcanics to the northeast has been interpreted as depositional (Grimm, 1978) but the contact is very poorly exposed. The sediments consist of a mixture of well-bedded strongly fetid limey strata with 1-2 ft. thick beds, with lesser amounts of gypsiferous mudstones and gypsum beds, folded into a symmetrical shallow syncline, the axis of which occupies a knoll at the present time owing to the resistance of the limestones to weathering. No more than 20 feet of section is now visible. The contained hydrocarbons are believed to have been derived from plants. Anomalous radioactivity (to 5x) and carnotite fracture coatings are found in various spots in the limestone beds. Silicification is not noted at this locality. These beds are difficult to place in time because of the limited amount of section visible. The unit can perhaps be best placed within the Oligocene along with the Pantano and Mineta Formations because they all contain similar lithologies. They may represent a once continuous low energy depositional domain.

Téran Basin Sequence
(No PRR-No. 41)

The Teran Basin sequence along the southwestern flank of the Galiuro Mountains is not described in the literature, but was visited during this study (Figures 1 and 3 for general stratigraphy). The sequence is basically a homoclinally eastward dipping high and low energy clastic section whose major lithologies include a lower fanglomerate, a thick mudstone-shale-sandstone section, and apparently an upper thick fanglomerate section. An andesite concordant above the middle fine-grained clastics has a 27 m.y K/Ar date (this study-Table 2). The entire sequence is judged to be Oligocene based on late Oligocene K/Ar ages on Galiuro volcanic flows which unconformably overlie the section (Creasey and Krieger, 1978). The section is here judged to be correlative with the Mineta and Pantano Formations based upon general structural setting and lithologies.

Radioactive anomalies of 2x and 3x were noted in two different mottled yellow and brown gypsiferous mudstone units in the fine-grained clastics.

Anomalous limestone beds that had been rumored to be in the area were not located. Anomalies were very localized, and attempts to develop them along strike failed. Those detected were apparently confined to particular beds and were not notably structurally controlled.

Swisshelm Valley
(No PRR-No. 40)

This region was mapped by Cooper (1959). Figure 7 summarizes the general geologic setting. The valley that lies between the Swisshelm Mountains and the Pedregosa Mountains in southeast Cochise County is here called the Swisshelm Valley. The southwest-flowing Mesa Draw has recently incised its way through basin fill, and a pedimented terrain containing presumed Oligocene rhyolites, tuffs, and pyroclastic bedded deposits has been exposed in an east-west arcuate swath across the valley in the general area of the Bar Boot Ranch, sec 36, T20S, R28E. The pedimented rocks can be seen in channel bottoms in much of this area where they may only be covered by thin, Pleistocene gravel caps. The structure of the area was not investigated except that a high angle basin and range fault was seen separating the eastern Swisshelms from the low relief pedimented terrain in west 1/2 sec 29, T20S, R28E.

The sandine-bearing rhyolite vent complex south of the Bar Boot ranch house counts to 240-300 cps, which is a high count rate for rhyolites. (Similar anomalous rhyolites of the Chiricahua sequence in west Turkey Creek of the Chiricahua Mountains 15 miles north, count to 400 cps). A complexly deformed section of tuffs and tuffaceous sediments north and west of the Bar Boot Ranch count to 200-250 cps which normally would be a value of 2x. Whether or not any anomalous uranium exists in these sediments depends upon the source of the high count rate not only in these sediments but also in the rhyolites nearby.

Adair Park Redbeds
(No PRR-No. 35)

This is an unnamed stratal sequence just north of Yuma in extreme western Arizona. These rocks were mapped by Olmstead and others, (1973) and are depicted in Figure 4. This is a rather thick sequence of steeply SW-dipping redbeds which is exposed in the Southern Laguna Mountains. Assuming the section is not overturned, it appears to represent a generally coarsening upward clastic sequence with lowermost sandstones and partially gypsiferous mudstones, middle fanglomerates and high energy fluvial redbeds with minor lacustrine limestones or calcic soil horizons, and an upper very coarse boulder conglomerate or debris flow deposit. This sequence is apparently unconformably overlain by the nearly flat-lying Kinter Formation, which, in this immediate area, contains a dated 23 m.y. old bentonitic ash bed. Nearby silicic volcanic flows, tilted in a similar fashion as the Adair Park beds, yield 26 and 29 m.y. ages (all age dates reported in Olmstead and others, 1973). Along the north and east boundary of the redbed outcrops, is a high angle fault contact with a gneissic granite terrain shown as Mesozoic in age on the 1969 Arizona State geologic map (scale 1:500,000).

Anomalous radiation (to 3x) was noted within the lower part of the package in some orange and yellow mottled gypsiferous mudstones within 20 feet of the fault contact. The radioactive zone was confined to a 10 foot or so thick interval, but the nearby fault zone itself was not noted to be anomalous. The remainder of the redbeds, particularly the higher energy units, apparently are devoid of anomalous radiation.

East Side of Plomosa Mountains
(2PRR's-Nos. 7-8)

A brief survey was conducted and the general geologic relationships are shown in Figure 5. A SSE dipping Tertiary section is exposed in a dissected pediment area on the east side of the Plomosa Mountains. It is in tectonic contact to the west with, and possibly overridden by, Mesozoic (?) metasediments which in the general area have very similar structural attitudes as the Tertiary section (Jemmett, 1966). Owing to almost certain structural complexities, the Tertiary stratal sequence cannot be described with confidence. Noted were abundant silicic to intermediate volcanic flows with associated lenses of intercalated low energy clastics including buff colored mudstones, 1-3 ft. beds of medium gray limestones, and a few red brown fluvial conglomerates containing clasts of Mesozoic metasediments. The limestones are somewhat fetid and attain local thicknesses of up to 100-150 ft. Eberly and Stanley (1978) report a 24 m.y. age date on a silicic flow that apparently is high in the section.

Radioactivity was noted in three areas. The first is that reported in the PRR report on the Rayvern Claim Gp, namely, a 3 ft. thick white calcareous mudstone layer (9x) with visible carnotite fracture coatings sandwiched in the middle of the 100-150 ft. thick gray limestone section noted above, down which a shaft has been dug. The second occurrence is farther north by 1.0 mile and consists of a mineralized NW trending vertical fault that cuts a dark red-brown fluvial conglomerate along which rather new dozer cuts have been placed. Radioactivity (to 90x) is clearly confined to red clay-rich fault gouge. Nearby surface outcrops of the conglomerate are anomalous (to 5x) but nearby sub-parallel faults are not anomalous. The third occurrence is 0.25 miles farther north and is confined to anomalies (to 4x) in a 4 ft. thick chert nodule-rich light gray limestone bed that, along with a 20-50 ft. thick light colored mudstone layer, is sandwiched into a volcanic-pyroclastic part of the section.

Muggins Mountains
(7PRR's-Nos. 10-16;
Access problems-not visited)

Existing PRR's and reports indicate anomalous radioactivity and uranium occurrences in at least six different sites in the Southern Muggins Mountains. These occur within a SW-dipping Tertiary section and several appear to lie along strike and hence may be sampling an anomalous zone or trend in the Tertiary section. Mineralization appears to be confined to fine-grained clastic and limestone beds in most areas, but, in one, it seems to be related to the margins of a near-vertical dike of dark volcanic rock. Judging from the amount of interest and the number of PRR's located in the vicinity, further recon studies are warranted. (Access problems are governmental). A 22 m.y. K/Ar age has been determined on a tuff bed which is probably intercalated into this general stratigraphic section (Damon and others, 1968). This dated horizon is 400 ft. stratigraphically below a vertebrate fossil locality of Late Arikareean (?) age (24-21 m.y. from Tedford 1974 Land Mammal age compilation) reported by Lance and Wood (1964). They suggest the presence here of a 4000 ft.thick stratal section with dips of up to 60°. The fossil site and the K/Ar dated horizon is in the upper one fourth of the section. An Oligocene age assignment appears reasonable.

Western Gila Bend Mountains
(1PRR-No. 25)

This is the area of the Duke, White and Hyder uranium claims. The general geology is indicated in Figure 6.

The region contains at least two en echelon, tilted, downthrown fault blocks that contain pedimented Tertiary clastic sequences. The sections dip 15-30^{o} NNE, and consist basically of calcareous, fairly well sorted, arkosic sandstones with many thin individual beds (0.5-1 ft. thick) of dark gray fetid laminated limestone. Mudstones and shales are not common in the westernmost block, but comprise greater than 20% of the section in the eastern fault block. Both sections contain a single inter-bedded biotite-bearing silicic volcanic flow dated at 23.7 m.y. (This study-Table 2). An exploration well drilled in the western block pene-trated 270 ft. of sediments before intercepting crystalline basement. An entirely younger clastic and tuffaceous sequence underlies Yellow Medicine Butte, whose capping basalts have not been dated in this area, but similar mesa forming flows farther to the east produce 22-16 m.y. K/Ar ages (Miller and others, 1977). Because these suspected early Miocene volcanics dip 5-10^{o} in this region, and the Tertiary sediments in question dip 20-40^{o}, the sedimentary section is believed to be Oligo-cene in age because it is apparently involved in an older tilting episode that does not affect the early Miocene rocks. These older sedimentary rocks are shown as Cretaceous-Tertiary on existing County and State geologic maps.

Radioactivity in the area is confined to a few thin fetid dark gray colored limestone beds in the western block (to 3x) and is interestingly absent from the mudstones of the eastern block. The arkosic sandstones do not count above general background. The radioactivity of the limestone beds does not continue far along strike.

GROUP I LOCALITIES WITHOUT KNOWN RADIOACTIVE ANOMALIES

Several areas in southeast Arizona are recognized as containing thick clastic sequences of deformed Oligocene sediments, sediments not known to be anomalously radioactive.

Pantano Formation
(1PRR-No. 29)

The Pantano Formation was named by Brennan (1958) and has been mapped and discussed, in part, by Finnell (1970; 1971) and Drewes (1978). It consists of a 6000 ft. or thicker homoclinally dipping sequence of clastics which, according to Finnell, consists of a basal mudflow sequence, overlain in turn by a thin somewhat fetid limestone unit, a fanglomerate unit with minor mudstones, an andesite unit variously thin and thick, and a locally thick relatively pure claystone unit containing gypsum seams and monolithologic "megabreccia" clasts and beds. Several age dates have been obtained on intercalated volcanics that indicate that the Pantano Formation is Oligocene in age (Finnell, 1970). One PRR locality (the Red Hills claims) near Colossal Cave, Rincon Mountains is in a structurally complex terrain where some Pantano (?) fine-grained redbeds are faulted against Rincon Valley granodiorite. However, these sediments may just as well be related to the Miocene Rillito beds of Pashley (1966). Radioactivity (to 2x) was noted in some varicolored sandstones and mudstones at one spot, and in the Precambrian Granite (to 5x) near some of the high angle faults at another nearby locality. (Subsequently, we've been told that some of the thin, fetid limestones count to 4x).

Helmet Fanglomerate
(No PRR-Not visited)

The Helmet Fanglomerate of Cooper (1960) in the eastern Sierrita Mountains is a poorly exposed 10,000 ft. thick sequence of high energy clastics composed of fanglomerate mudflows with intercalated monolithologic megabreccia beds and volcanic flows which have K/Ar dates which place the sequence into Oligocene time. The sequence is notable in that the entire section and juxtaposed older rocks is demonstrably allochthonous, being separated from lower plate rocks by the low angle, shallow eastward dipping "San Xavier thrust fault" (Jansen, 1978; Shafiqullah and Langlois, 1978) (Figure 1).

Threelinks Conglomerate
(No PRR)

The Threelinks Conglomerate of Cooper and Silver (1964) is a pre-volcanic high energy mudflow sequence with minor intercalated limey mudstone beds and undated volcanic flows. It is highly contorted and beveled beneath late Oligocene volcanics of the Galiuro Mountains. It was visited only in the Winchester Mountains (Figure 1), and not in the Steele Hills further south.

Whitetail Conglomerate
(No PRR-Not visited)

The Whitetail Conglomerate (Peterson, 1969) is a unit of variable thickness largely because of a high-relief lower contact. It frequently is faulted and tilted and consists mostly of light to moderate colored high energy fanglomerates and minor low energy tuffaceous beds. It contains a 32 m.y. old K/Ar dated ash bed intercalated high in the section in the Sonora Quadrange (Cornwall and others, 1971), and a 33.5 m.y. old

K/Ar dated ash bed at Aravaipa Creek in the Galiuro Mountains (Krieger and others, 1979).

Redbeds of Babocomari Ranch
(No PRR-Not visited)

These redbeds are exposed in the northern Huachuca Mountains and have been described by Vice (1970). They consist of arkosic gravels and tuffaceous sediments tilted westward and are overlain by a thrust plate of Paleozoic limestones. They apparently contain, according to Vice, late Oligocene K/Ar dated volcanic flows.

Redbeds at Three Buttes
(No PRR-Not visited)

These redbeds, discussed by Banks and others (1977) are a northeast-dipping section of fluvial sediments in the northern Tortolita Mountains, and is composed predominantly of sandstones with a minor component of fine-grained beds. The section contains a basalt flow dated at 21 m.y. and hence likely is Oligocene-Miocene in age (Jennison, 1976).

Hackberry Formation
(No PRR-Not visited)

The Hackberry Formation near Hayden of Schmidt (1971) is a 10,000 ft. thick section of clastics which contains diversified coarse and fine-grained units including massive "megabreccia" lenses (Krieger, 1977). It is folded and unconformably overlain by less deformed Miocene fanglomerates. Ages of 20.5, 23.5, and 25.6 m.y. on biotite, hornblende, and plagioclase, respectively, were obtained from an air-fall ash bed intercalated into a "granite-wash" facies of the unit (Table 2). In this vicinity, the Hackberry Fm. and the Paleozoic and Cretaceous section upon which it is depositional are folded into an assymetric syncline whose west limb is overturned.

Apsey Conglomerate
(No PRR-Not visited)

The Apsey conglomerate of the northern Galiuro Mountains around Aravaipa Creek is a blanket of light colored high energy fanglomerates which sits atop the volcanic tablelands of the area. The underlying Galiuro volcanics date at 28.2-22.5 m.y. (Creasey and Krieger, 1978), while an andesite overlying the Apsey conglomerate at Table Mountain dates at 22.8 $\pm$ 0.5 m.y. (Table 2-this report). This age bracketing of the conglomerate at about 22 m.y. assumes some importance in regional pre-basin fill correlation schemes (see Heindl, 1958). For example, this age casts doubt on the correlation of Apsey Conglomerate with the probable late Cenozoic basin fill Hell Hole Conglomerate of Simons (1964), or the 14-17 m.y. Big Dome Formation of Krieger and others (1974) near Kearny. All of these units are typically coarse textured.

Locomotive Fanglomerate
(No PRR)

The Locomotive Fanglomerate (Gilluly, 1946) at Ajo is a thick SW dipping assemblage of high energy sediments including extensive thick mudflow units and coarse fluvial fanglomerate deposits. See Figure 9 for cross-section.

Sil Murk Formation
(No PRR)

The Sil Murk Formation of Heindl and Armstrong (1963) crops out near Gila Bend. See Figure 10 for cross-section. The Formation as mapped consists of lower, more highly deformed sediments and a less deformed series of overlying volcanics and sediments. Basal well-sorted red arkosic sandstones which are locally depositional on Precambrian granite display large scale trough cross-bedding of aeolian origin, and are 500-1000 ft. thick. Overlying red-brown fanglomerates are 1000-2000 ft. thick, and contain dominant debris flows and subordinate fluvial high energy beds. Together, these two lower units dip SW at 20-60°. The overlying predominately volcanic section dips SW at 3-10° and contains a welded ash flow sheet high in the section dated at 27 m.y. (Eberly and Stanley, 1978) along with andesite flows and poorly exposed high energy fluvial sediments.

Clanton Hills Section
(No PRR)

This section is discussed by Wilson (1933) and Ross (1922). See Figure 8 for cross-section. The section visible in the main watergap (Sec 12, T2S, R12W) consists of the following ascending sequence: a dense rhyolite flow dated at 23 m.y. (Eberly and Stanley, 1978), red arkosic sandstones and mudstones capped by a thin cherty limestone, more red arkosic sandstone that grades upward into a rhyolitic ash fall, and then into a rhyolite explosion breccia or high energy flow breccia, then a capping, partially brecciated, black chert nodule limestone bed about 10-15 ft. thick. The entire sequence is probably no thicker than 300 feet, is highly faulted, but is not generally tilted. However, nearby isolated hills contain a uniformly SW dipping dark volcanic sequence which dates at 28 m.y. (Eberly and Stanley, 1978). The Clanton Hills Limestones are only locally fetid and display anomalies no greater than 1.5x.

Osborne Wash
(No PRR)

Figure 13 shows a cross-section through the area of Osborne Wash, about 10-20 miles east of Parker. A sequence of high to moderate energy fluvial redbeds and a Tertiary limestone section dip to 40° and trend along a large NW-trending antiform, are beveled by pedimentation, and are overlain in the eastern area (see cross-section) by undeformed sediment and basalt series with a basal flow dated at 9.7 m.y. Farther west, the older sediments are apparently in high angle fault contact with other blocks of volcanics and sediments which dip 5-10° SW and have two K/Ar age dates of 16 and 21 m.y. Hence by circumstantial evidence, the older sediments are likely pre-21 m.y. in age.

The older redbeds and limestones in places are in low angle tectonic contact with the cataclastically deformed crystalline rocks of the western Buckskin Mountains. The limestone section is about 1200 ft. thick, dips 30-40° SW, and is the thickest Tertiary limestone sequence observed during this study. It is present in a separate area from the redbeds, and their stratigraphic relationship is unknown at this time. Most limestone units are somewhat recrystallized. Chert nodule horizons are uncommon. Copper-iron-uranium mineralization at the Pride Mine is confined exclusively to the lower plate rocks. Radioactive anomalies of 3x are found in "pods" of limonite rich hydrothermally altered crystalline rocks. Light colored fluvial channel and overbank sediments (locality 2b in Figure 13) underlie and are deformed with the 16-21 m.y. old volcanics. They contain no apparent anomalous radioactivity.

<u>Phoenix Region</u>
(No PRR)

Several areas in the south-central part of the state contain high energy clastic redbed packages which are not known to contain radioactive anomalies.

In the Phoenix metropolitan area (Figure 11), southwest dipping red laminated mudstones are exposed at Tempe Butte where they are overlain concordantly by a 17 m.y old dark volcanic flow (Table 2-this report). Peters (1979) suggests that the Tempe Butte beds represent flash flood deposition on the floodplain of a large fluvial system. Farther north, in Papago Park, a thick sequence of SW dipping mudflow or debris flow deposits, in places containing large rounded boulders of Precambrian granite, are seen to grade downward into the fine-grained Tempe Butte beds. These coarse redbeds are intruded by a series of N25^{o}W trending rhyolite dikes which form some of the rock spires of Papago Park. Farther north, at the west end of Camelback Mountain (total distance from Tempe Butte about seven miles), thick mudflow sequences underlain by red colored laminar bedded granite-derived grus deposits of probable moderate energy piedmont fan origin, are clearly depositional to the east upon Precambrian crystalline rocks. Cordy (1978), who mapped the Camelback Mountain area, has divided the 600 ft. thick Tertiary sedimentary section, which she calls the Camels Head Formation, into four members. The Echo Canyon Member contains considerable evidence of massive landsliding which she likens to some "megabreccia lenses" described in the San Manuel Formation by Krieger (1977). Some of the landslide deposits contain "metarhyolite" clasts which resemble some of the rhyolite dike material of Papago Park mentioned above. She cites earlier workers who correlate some of the Camels Head Fm. sediments with redbeds at Papago Park and Mt. McDowell to the east, based upon lithologic similarities.

A 5400 ft. deep hole (Biery-State #1) was drilled in northern Paradise Valley in 1951. Beneath 4900 feet of fine to coarse-grained clastics occur, in descending order, 80 feet of impure gray limestone with abundant gray and brown chert (see under Miocene sediments), 320 feet of dark volcanics, and 500 feet of redbeds to the bottom of the hole. Eberly and Stanley (1978) K/Ar dated a "basaltic andesite" from the volcanic section at 22 $\pm$ 1.2 m.y. (#62). Peirce (oral communication, 1979) provisionally correlates the redbeds under these volcanics in the drillhole with the outcropping redbeds of the Phoenix area. Hence, some, if not all, of the above outcropping redbeds are likely to be Oligocene in age.

Along the lower Salt River, 24 miles east of downtown Phoenix, is exposed a section of gently westward dipping high energy redbeds with interbedded volcanic flows, which are depositional upon a stack of andesite flows (Figure 12). To the southeast, this section is in high angle fault contact with a sequence of tuffs and pyroclastic units, while to the north the andesites are in high angle fault contact with Precambrian granite. However, the redbeds appear to be depositional upon both the andesite and the Precambrian granite. The redbeds here are a mixture of 2/3 mudflows and 1/3 fluvial beds. Their age is uncertain. None of the other redbed localities previously discussed contain andesite flows beneath the redbeds except at Osborne Wash where the redbed package is circumstantially pre-21 m.y. in age. Andesite beneath redbeds at the Hassayampa locality near Wickenburg date at 16.5 m.y. (Table 2) and demonstrate the presence of likely middle Miocene redbeds at that locality. Thick redbeds of the Sil Murk Formation are pre-26 m.y. in age. At the edge of the Town of Casa Grande, a lone hill upon which the community has built a water tank, is composed exclusively of high energy redbeds which are mostly mudflow units with very thin fluvial sand lenses. These are tentatively correlated with the Oligocene redbeds of the Phoenix area.

GROUP II LOCALITIES WITH RADIOACTIVE ANOMALIES

Black Butte
(4PRR's-Nos. 19-21 - see below)

Black Butte is located in the westernmost Vulture Mountains (Hewett, 1925; Kam, 1964). See cross-section Figure 14. The Black Butte section can be most easily interpreted as a SW-dipping sequence of andesites with a basal thin arkosic conglomerate that is depositional (?) on a leucogranite and overlain by a fine-grained mudstone-air fall ash sequence that is unconformably (?) capped by a volcanic flow K/Ar dated at 15 m.y. (Table 2-this study). The lower andesite volcanic flow (see Figure 14) dates at 20 m.y (this study) and hence the fine-grained uraniferous horizons are indicated to be 20-15 m.y. in age. In one bulldozer trench cut into a 30-50 ft. thick, light colored mudstone-vitric ash sequence, some carnotite was noted as fracture coatings. Low radioactivity (2x) indicates the possibility of uranium disequilibrium. No attempt was made to visit each PRR. Only three of the four, because of location problems, are shown on Figure 8. Farther southeast by two miles or so, other more diversified low energy sediments are seen to occupy a roughly equivalent stratigraphic position as the mudstones. This section includes mudstones containing a ripple marked tuff bed, somewhat fetid limestone beds, one of which is brecciated and contains chert replacements, veinlets, massive pods, and veins. Slope-forming units appear to consist of tuffaceous and pyroclastic units. Radioactivity here was no greater than 2x, and no visible uranium mineralization was noted.

New River
(1PRR-No. 23)

The New River area is the western part of a larger region that represents the interface between the Transition Zone to the north and the Basin and Range Province to the south (Figure 1b). A significant part of this general area contains terrain consisting of a complex assemblage of basalt flows, tuff and pyroclastic beds, and mudstones, overlain by mesa-capping basalts. Thick basalt caps (14-15 m.y Hickey-aged basalts, this report) protect the tuffaceous assemblage on New River Mesa, but the assemblage has been downthrown to the south along high angle east-west normal faults, and pedimented and mostly covered by thin deposits of young gravels in the valleys of the general area.

A PRR locality (No. 23 - Table 1) about nine miles WNW of Cave Creek is an important occurrence at the junction of the two provinces. The Los Cuatros claim group is in the pedimented, low relief zone. It consists of a somewhat faulted and folded sequence of outcropping ledgy dolomites about two feet thick, interbedded with calcareous mudstones, a thin vitric air fall ash bed, and zeolitized units. Recent exploration indicates that the dolomite-bearing sequence is underlain by mudstones. The Los Cuatros sediments are about 200-300 feet thick and overlie dark-colored volcanics. To the west these beds are cut by a high angle fault. At the surface, radioactivity (to 10x) is confined to the thin ledge-forming nonsilicified dolomite beds. No visible uranium minerals are present. Chemical analyses conducted by private parties confirm the presence of uranium in these radioactive beds up to about .07% U_3O_8. Exploration drilling is in progress in the area and more should be expected in the near future.

Two age dates were obtained during this study that relate to the age of these sediments. A basalt flow at a nearby peak (Pyramid Peak), thought to be below the section, dates at 17.7 m.y. (Table 2). A basalt, interpreted to be a dike intruding the mineralized sediments, dates at 13 m.y. (Table 2). According to the scheme used here the sediments are classed as being early Miocene in age.

Cave Creek
(No PRR-No. 42)

About three miles NNE of the community of Cave Creek, exposed along the banks of Willow Springs Wash in a growing residential area, is a poorly exposed section believed analogous to that just described several miles to the west. The exposed beds are a SW-dipping, white colored tuffaceous assemblage containing a thin vitric ash bed, marls and thin limestones with chert stringers and veinlets, and tuffaceous marly beds. Notably, the assemblage here contains but sparse dolomitic zones and much chert. Radioactivity in certain very confined zones in some limestone beds measures 5-8x and chert frequently is radioactive. No visible uranium minerals were noted. These beds, by reasons of analogy, are believed to be lower Miocene in age.

Rifle Range Section
(No PRR-No. 43)

The Rifle Range section is a relatively small northeast tilted basalt capped range block that forms a cuesta near the junction of I-17 and Carefree Highway (Figure 17). There are poorly exposed tilted sediments beneath the capping basalt. However, one south-facing wash, on the rifle range side, exposes about 150-200 feet of section. The arrangement of lithologies is analogous to that at New River (No. 23) in that a carbonate-bearing section overlies a lower, relatively thick clastic zone. There are two dolomitic units each about 20 ft. thick. The lower dolomitic unit is brecciated and contains extensive chert replacements and stringers. The upper unit also contains some chert stringers and replacements. Anomalous radioactivity (to 3x) is associated with the cherty portions of the dolomites. The basalt cap appears to overlie the dolomites with a slight angular unconformity, and has a K/Ar age of 15.9 m.y. (this project-Table 2). The New River locality is about eight miles to the northeast. By a combination of analogy with New River and the 15.9 m.y. minimum date, we assign a lower Miocene age to this sedimentary sequence. Contrasts with New River include some conglomeratic materials in the lower clastic section and much chert at the Rifle Range locality.

Artillery Formation
(5PRR's-Nos. 2-6;
3PRR's not visited)

The Artillery Formation was named, mapped and discussed by Lasky and Webber (1949). More recently Otton (1977, 1978) discussed preliminary results of his continuing regional studies. The general geologic settings of the two localities visited are shown in Figures 18 and 19. The formation ranges up to at least 2500 feet in thickness.

Two localities in the type Artillery Formation as defined by Lasky and Webber were visited, the Masterson Claims and the Lucky Four Claims. The Masterson Claims are west from Artillery Peak, and are contained in the lower part of the westward dipping Artillery Formation (Figure 18). Uranium mineralization is found in laminated mudstone-shale-limestone beds just above a basal 150 ft. thick red arkosic conglomerate believed to be depositional on porphyritic granite. The low energy clastics contain many bright colors, and radioactivity is found in many individual units especially in a bright green colored shale-mudstone sequence (to 5x), but the most pronounced anomaly (16x) was found in a somewhat cherty, dark colored, thinly bedded limestone unit about three ft. thick. Much recent dozer activity and drilling in the area is evident.

The Lucky Four claim group is located south of Artillery Peak in a thick sequence of limestones and marlstones with minor mudstones 2000 ft. or more above the base of the Artillery Formation (Figure 14). Here the section dips generally southward away from Artillery Peak. Much recent drilling and dozer activity has been centered in these limestones. The PRR discusses a black carbonaceous layer that was not relocated in this study, but several wavy-bedded, yellow colored limestones up section from the black layer, count to 5x at the surface. This material, at depth, is probably the target for the drilling. The limestones are overlain by a section of poorly exposed red mudstones. Further south the Artillery beds either underlie some basalt-capped mesas or are in fault contact with younger volcanics at the base of the mesa cliffs.

The geology of the Artillery Peak region is complicated by complex tectonism involving allochthonous stratigraphic sequences. This fact has tended to obscure the age of the Artillery Formation. Between the Masterson claim group low in the Artillery Formation and the Lucky Four group high in the formation there is a densely welded rhyolite flow that outcrops discontinuously along strike. This rock is dated at 19.9 m.y. (this study-Table 2). Some will question the validity of this date on the basis that it is a whole rock determination on silicic material and such material is often thought to incompletely retain radiogenic argon.

However, the material appears densely welded and shows no signs of deuteric alteration. Still younger rhyolite volcanism is noted from 20 miles or so west where Suneson and Lucchitta (1979) have recently reported 15.1-10.3 m.y. K/Ar ages on sanidine and biotite separates from silicic flows, dikes, and domes, thus providing a precedent for middle to late Miocene silicic volcanism in the region.

On the assumption that this date is reliable the Artillery Formation will be considered lower (?) Miocene in age. The Anderson Mine is about 18 miles east of Artillery Peak. The host rocks, low energy carbonaceous and tuffaceous sediments, also are thought to be lower Miocene in age. This is based upon a minimum age of 13.2 m.y. obtained on a stratigraphically higher basalt flow (this study-Table 2) and a paleontological age of 21-17 m.y. (Hemingfordian) for a rhinoceros and a camel (Lindsay and Tessman, 1974). Also, Otton (oral communication, 1979) considers the underlying volcanics to be late Oligocene in age. These data suggest that the Artillery Formation and the Anderson Mine area host rocks may chronologically overlap.

Wickenburg Area
(1PRR-No. 24)

Uranium occurs in rhyolitic volcanic rocks that were extruded onto a Precambrian granitic terrain (Table 1-Figure B). Uranium as visible torbernite and some invisible mineralization is found in various areas in the extrusive complex (to 25x), and concentrated to 8x-10x along shear zones and high angle fault surfaces. No basal arkosic conglomerate was seen in the section, as had been suggested in the PRR report. The rhyolites are undated, but probably relate to the early Miocene rhyolitic volcanics of the Vulture Mountains 12 miles to the west.

Lincoln Ranch Beds
(No PRR-No. 9)

A section of moderately deformed fluvial-lacustrine-tuffaceous strata, largely redbeds, is located in the Lincoln Ranch Basin just south of the Bill Williams River. The exposed partial section is estimated to be 1400 feet thick by Gassaway (1972). At the northeastern boundary these rocks are in the footwall of the NW-trending Lincoln Ranch reverse fault (Wilson, 1962, p. 76), with crystalline rocks of the Buckskin Mountains in the hanging wall. To the southeast the section is in low-angle tectonic contact with cataclastically deformed Buckskin Mountain crystalline rocks. Near this contact the redbeds contain manganese oxide mineralization. Farther northward thin, very light colored tilted beds in the section count 2-3x in a very limited interval. According to Otton (1978), the Lincoln Ranch section contains lacustrine units that intertongue with the coarser Mn-rich strata, the lacustrine rocks containing some uranium in fractures and as uraniferous silica in bedded chert. Gassaway (oral communication, 1979) reports finding Miocene vertebrate tracks in the Lincoln Ranch beds. As noted by Shackelford (1976) the Lincoln Ranch beds are allochthonous above a detachment surface, therefore the beds pre-date the detaching episode. Chronological constraints developed during the present and previous studies indicate that the detachment phenomenon is regional in extent and was developed in the interval 16 to 13-10 m.y. ago (Figure 29). With this in mind, plus regional stratigraphic similarities, we place these sediments in the lower half of the Miocene, tentatively the early Miocene.

GROUP II LOCALITIES WITHOUT KNOWN ANOMALIES

Harcuvar Mountains-Bullard Peak

The general geologic setting of these two localities is shown on Figures 20 and 21 and the positions of these sections is shown on Figure A. In both localities the stratigraphic section is tilted towards the southwest.

Along the southeast "arm" of the Harcuvars, a section (Figure 20) of SW-dipping silicic trachytic flows and pyroclastics with a thin basal red arkosic conglomerate is depositional upon a granite. A flow in the middle of this section K/Ar dates at 17 m.y. (this report-Table 2). Farther west near Bullard Peak, a steeply SW-dipping section (Figure 21) is in probable low angle tectonic contact with the cataclastically deformed rocks of the southern Harcuvars. The section consists (barring structural complications) of a few thin lowermost silicic flows and pyroclastic units, an unstratified cobble and boulder conglomerate, a 3000 ft. thick sequence of andesite flows and flow breccias that grade upward into lahar deposits with some poorly exposed fine-grained redbeds. An andesite flow from the thick sequence has a K/Ar age of 15.8 m.y. (this report-Table 2). The Bullard Peak section appears to be on the order of 8500 ft. thick. Neither of these sections contains detected radioactive anomalies.

The Bullard Peak section is allochthonous above a dislocation or detachment surface. The lower plate consists of brecciated, cataclastically deformed plutonic crystalline rocks. The 15.8 m.y. date within the deformed upper plate Bullard Peak section suggests not only that the rocks involved, both volcanic and sedimentary, accumulated during the lower half of the Miocene (likely lower Miocene), but that the dislocating event took place less than 15 m.y ago. Subsequent to this event the region was arched, the various arches forming the present transverse ranges. Indications are that these tectonic events post-date both the Artillery Formation and the Anderson Mine host rocks. Therefore, any attempt at paleogeographic reconstruction during lower Miocene time must remove the foliation arches (Rehrig and Reynolds, 1977), and restore the affected Miocene rocks to their original accumulation site. Davis and others, (1977) suggest that northeastward directed low-angle transport of analogous upper plate rocks took place in the Buckskin-Rawhide Mountain area between 15 and 13 m.y. ago. Likely, this event was synchronous with the positioning of upper plate rocks in the Bullard Peak region of the Harcuvar Mountains. In the general area of the type Artillery Formation, low-angle tectonism emplaced at least one "slide breccia" (Otton, 1978) either post-21 m.y. (Eberly and Stanley, 1978) or post-15.9 m.y. and pre-9.6 m.y. ago (Shackelford, 1976). The confusion appears to stem from the K/Ar age of and/or the selection of the youngest basalt beneath the overlying tectonically disturbed zone.

GROUP III. LOCALITIES WITH RADIOACTIVE ANOMALIES

Horseshoe Dam
(No PRR-No. 39)

The general geologic setting of the Horseshoe Dam section along the Verde River is depected in Figure 22. The section is tilted towards the southwest, is in fault contact with Precambrian granitic rocks on the west and flat-lying clastic sediments on the south. The partial section exposes about 1000 ft. of light-colored tuffs, marls, mudstones, and sandstones derived from volcanic rocks. An underlying, tilted andesite from the dam spillway gives a K/Ar date of 15 m.y. (this report-Table 2). An indicated mid-Miocene maximum age, and involvement in faulting and tilting, suggest that this sedimentary sequence should be placed in middle Miocene Group 3.

Radioactivity was noted in several places in tuff beds (to 3x) and cross-cutting chalcedonic stringers (to 4x). Minor amounts of carnotite as fracture coatings were noted. Most of the tuffaceous beds are devitrified, some zeolitized (Eyde and Irvin, 1978).

North of Horseshoe Dam by four miles is Chalk Mountain, a relatively flat-lying remnant assemblage of materials similar to the Horseshoe Dam sequence. Tuffaceous and marly beds low in the sequence contain visible carnotite fracture coatings that appear to be local in extent (Tom Howell, personal communication). Because of high water conditions at Horseshoe Dam, the Chalk Mountain area was not visited. Also, a similar appearing remnant assemblage up Lime Creek, a rugged tributary on the west side of the Verde River, was not visited.

Lake Pleasant Region
(No PRR-No. 38)

The general geologic setting of the Lake Pleasant region is shown on Figure 23. It is thought that both groups 2 (early Miocene) and 3 (middle Miocene) are represented in this region bordering the Transition Zone on the south.

Wild Burro Mesa, northeast of Lake Pleasant on the Agua Fria River, consists of a basalt-tuff-pyroclastic-mudstone assemblage very similar to the Group 2 assemblage of the New River area to the east. The capping basalt series is believed to be correlative with

the 15-14 m.y. old basalts of the region. This entire package overlies an older, more tectonically deformed andesite-agglomerate-tuff sequence which yields a 27 m.y. K/Ar age (this report). Unconformably against the basalt-capped mesa terrain is a younger (Group 3?) set of white colored, gently folded beds consisting of tuffaceous sediments, thin to thick gray to brown cherty limestone beds and minor mudstones. And younger still are some fine-grained low energy beds that fill the present basin and probably represent late Cenozoic (post-13-10 m.y.) basin fill.

The Lake Pleasant Group 3 strata are relatively widespread and exposed by tributaries to the Agua Fria River. Initially, some carnotite paint on white tuffaceous bedded material was observed in outcrop. Subsequently, two exploration programs were conducted by drilling. The base of the Lake Pleasant lacustrine beds is irregular, the sequence ranging in thickness from zero to over 1000 feet. Rapid facies change accounts for a wide variance in the amount of limestone present. Apparently, drilling failed to reveal unusual amounts of uranium mineralization.

Just west of Lake Pleasant there is an eastward dipping basalt-tuff-mudstone terrain that projects beneath the Group 3 deposits (Figure 23). A dated basalt in this older sequence, likely Group 2, gives a K/Ar date of 16.6 m.y. (this report). A rough correlation with the Wild Burro Mesa section seems justified.

The gently folded Lake Pleasant Group 3 strata are believed to be no older than 15 m.y. However, direct data that constrain the minimum age are not yet known. Tentatively, we have placed them in Group 3 and therefore generally correlative with the section at Horseshoe Dam. However, they could be younger rocks - possibly late Miocene in age.

Big Sandy Valley
(1PRR-No. 1)

The Big Sandy Valley is north trending and about 40 miles in length, bordering the western edge of the Transition Zone. The valley is noted for its eroded, flat-lying basin fill deposits. However, in places on the east side deformed pre-basin fill rocks are exposed. Ten to 15 miles northeast of Wikieup, along Tule Wash, there is an estimated 6500 feet of NE-dipping section. The section is largely low to moderate energy, light red to light-colored clastics, with occasional dark volcanic flows, devitrified bedded tuffs, and limestones. The sequence is in high angle fault contact to the east with Precambrian crystalline rocks of the Aquarius Mountains.

To the south thin remnants of the section are preserved as eastward dipping downthrown fault blocks. Dip directions of both thin and thick sections coincide, and the most plausible explanation of the observed structures is that the sedimentary package has been rotated along westward-bowing Basin and Range disturbance listric normal faults that served to define this part of the Big Sandy Valley. Figures 24 and 25 depict some of these relationships. The original Catherine and Michael uranium claim is believed to be situated in the easternmost of two small tilted fault blocks. However, limestones with abundant black chert nodules and stringers were noted in both of these fault blocks and counts ranged from 2x to 16x in various places in these limestones. In both areas the limestones are associated with partially devitrified air fall ash beds, mudstones and sandstones. The limestones at the easternmost fault block contain well preserved silicified casts of palm roots (?) in its lower part.

In another tilted fault block just to the north and west of the PRR locality, a 500-1000 ft. section is preserved that contains an intercalated basalt flow that gives a K/Ar date of 12 m.y. (This study-Figure 24). Limestones are included in the section both stratigraphically higher and lower than this volcanic unit. With no reason to doubt this date, and in the absence of confirmatory data, we are assigning these deformed rocks to Group 3. However, they may partially be younger, perhaps late Miocene in age. Deformation, in turn, is younger than these rocks, which are overlapped by the undeformed basin fill sequence.

Anomalous radioactivity was noted in two stratigraphic horizons at Tule Wash. The first was in Toreva (slide) block of clay rich gypsiferous mudstones containing numerous 1/8-1/4 inch thick dark chert stringers where anomalies of 3x were noted. The other (to 5x) was higher in the section in a white colored wavey bedded laminated limestone bed about 10-15 ft. thick. Farther south, in the farthest west outcrop of Figure 24, 2-5x anomalies were noted in gray medium bedded cherty limestones.

GROUP III LOCALITIES WITHOUT KNOWN RADIOACTIVE ANOMALIES

Hassayampa River

Just northeast of Wickenburg a NE-dipping section of predominantly fluvial high energy redbeds unconformably (?) overlies a 500 ft. thick section of andesites and andesite flow breccias. A sample near the top of the volcanic section gave a K/Ar date of 16.5 m.y. (this report). This date, plus the deformation, suggest that the redbeds are middle Miocene in age (Figure 26).

OTHERS - WITHOUT KNOWN RADIOACTIVE ANOMALIES

Biery #1 State

The Biery #1 Federal is a petroleum exploration test hole drilled in 1951 in Paradise Valley to a depth of 5396 feet (Peirce and Scurlock, 1972). The hole is about 10 miles south of Carefree in Sec. 8, T4N, R4E. An apparent stratigraphic thickness of about 150 feet occurs in the interval 4430-4580. The samples indicate a lacustrine sequence containing cherty limestones that overlies about 300 feet of basalts. As mentioned previously, the basalt is underlain by redbeds that we correlate with similar strata that crop out in the Phoenix region. The basalt gives a K/Ar date of about 22 m.y. (Eberly and Stanley, 1978).

Although the age of the lacustrine rocks is not known, the data permit possible correlation with the Group 2 radioactively anomalous rocks of the Cave Creek area. If so, these rocks have undergone structural separation of at least 4500 feet. This could be an example of the preservation of relatively down-faulted older lacustrine strata beneath late Cenozoic basin fill. There is no record of the existence of a gamma ray log and the relatively small volume of well cuttings did not noticeably affect the scintillometer. Chemical tests have not been made. A log of this hole is available from the American Stratigraphic Company (Catalog No. D-3301).

CENOZOIC SEDIMENTS - STRUCTURE - URANIUM FAVORABILITY - EXPLORATION

GENERAL STATEMENT

As previously emphasized the focus of this Phase I study is the chronological ordering of deformed, pre-late Cenozoic sedimentary packages that contain identified anomalous radioactivity. A result of this attempt is the preliminary recognition of at least three age groups: (1) Oligocene, (2) early Miocene, and (3) Middle Miocene (this may spill over into the early late Miocene in areas of youngest Basin and Range disturbance faulting).

The following paragraphs attempt to provide a general summary of our Phase I study and to place in perspective some aspects of relatively recent uranium exploration in the Basin and Range Province of Arizona.

PRE-BASIN FILL CENOZOIC SEDIMENTS

Across the Basin and Range Province of Arizona these Oligocene and Miocene strata have been deformed and are now seen as tilted remnants on the structurally high blocks that characterize the Province. Regionally, each of the three identified sedimentary groups contains two gross lithologic packages: (1) redbed clastics, and (2) low energy, light-colored "lacustrine" clastic and chemical rocks. Thus far, radioactive anomalies favor the low energy clastics and chemical rocks (carbonates). Frequently, outcrops tend to be either redbeds or "lacustrine" deposits. Rare interbedding suggests that these two lithologic types might well be facies in each of the three groups.

Preliminary correlations strongly suggest that the original extent of the basins of sedimentation associated with each of the three groups was much larger and generally unrelated to the basins presently characteristic of the Province. As an example, the so-called Date Creek Basin of much past and present exploration interest, is properly a late Cenozoic structural feature that bears little obvious relationship to the larger basin in which the Group 2 (lower Miocene) Anderson Mine host and related rocks likely were originally deposited. Thus, an important question is the original extent and present buried position of potentially favorable sedimentary host rocks. Because of their state of deformation, they should not be expected to be preserved at depth as flat-lying remnants. In this regard it is important to decipher the number of tectonic events that may have disrupted and deformed original depositional continuity. An obvious question is the relationship, if any, between tilting and the late Cenozoic Basin and Range disturbance. Mounting evidence suggests that much tilting preceded this lastest rifting event. If so, then older Cenozoic rocks covered by generally flat-lying, thick basin fill, may well be tilted and thus be a more difficult subsurface target to locate.

Each of these three groups of sediments is more or less associated with products of volcanism, including flows and air-fall tuffs, many of which are devitrified. However, interbedded tuffaceous rocks are more abundant, perhaps ubiquitous, in the two Miocene groups (2 and 3). Silicic volcanism seems to have been most important in the lower Miocene (Group 2), the Vulture Mountains most likely having been a volcanic center during this time.

Figure 35 is an attempt to depict the "floor" upon which Cenozoic rocks accumulated. It is clear that this floor is quite variable over the Province. South of the Mogollon Rim there is a large region that is floored by a diversity of Precambrian crystalline rocks some of which have relatively high background counts (Malan and Sterling, 1969). Figure 36 shows the distribution of the more alkaline igneous rocks as presently understood. Some of these are floors while others, some of the Cenozoic volcanics, are chronologically related to the various groups.

Figure 34 is a space-time chart of important Tertiary sedimentary and volvanic units. Also shown is the general distribution of uranium and/or radioactive anomalies, including some in late Cenozoic basin fill deposits. The diagram also depicts a younging of subduction related calc-alkaline volcanism towards the northwest.

Figure 37 is a generalized interpretation of transport direction data. Phenomena such as imbrication and cross-stratification are preserved only in the coarser clastic rocks many of which are redbeds. Caution is necessary in interpreting these data because strata of this age are deformed and many localities are allochthonous. The extent to which any of the packages may have been rotated relative to compass directions is not known. It is data such as this that will eventually permit interpretation of regional environmental trends. There is a question as to the regional paleogeographic habit that prevailed during Tertiary time, especially during Oligocene-early Miocene time. There is a tendency to view these redbed-"lacustrine" packages as basin edge and basin center deposits. This interpretation would be analogous to that produced by the late Cenozoic Basin and Range disturbance where relatively small closed basins are the rule. However, it is our impression that these various facies could have resulted from smaller environments within a regional fluvial system of integrated drainage-they need not necessarily represent "intermontane" deposition. Cooley (1977) has worked extensively with Cenozoic drainage directions.

In dealing with favorability the ability of host rocks to produce a reducing environment during fluid passage seems fundamental in the western United States. In Arizona, it seems likely that it is this factor that is the most elusive. Uranium sources appears not to be the priority factor in assessing favorability criteria. Although the chemistry of the various Cenozoic strata is not a part of our Phase I study, generalities are not difficult to identify.

Vegetative debris, in carbonized form, seems to be a preservational rarity. The one exception thus far, the Anderson Mine early Miocene host rocks, contain the uranium mineralization that has, in large part, stimulated exploration and interest in Arizona's Basin and Range Province Tertiary sedimentary rocks. Figure 32 shows the distribution of State prospecting permits in force during 1975-1978. The clustering to the northwest is in the region of the Anderson Mine. If nothing else, the Anderson subsurface lignitic strata demonstrates not only that such materials developed in Arizona but that it is possible to preserve them.

So-called "fetid" strata are not uncommon in the Oligocene "lacustrine" sequences. Significantly, many of the radioactive anomalies and known uranium occurrences are closely associated with these rocks. One of the most "fetid" is the Cardinal Ave occurrence (Grimm, 1978), which is a limestone.

One of the more significant and interesting (perhaps unusual) uraniferous occurrences, presently the object of some exploration, is the New

River (Los Cuatros Group) locality. Aphanitic dolomites (x-ray determination-this study) crop out as resistant ledges that are surprisingly radioactive. Neither mineralization or contaminating minerals or substances are observable-just very light-colored dolomite. One specimen, submitted to a company for characterization, contained a small amount of organic carbon and a U_3O_8 content of .031%. Although not obviously fetid, it seems probable that the uranium content is related to the small amount of organic matter. The petrogenesis of this dolomite, though interesting and probably important, is not a part of this present study, therefore, will not be discussed here. The organic material responsible for "fetidness" is believed to have been vegetable matter.

As has been emphasized, one of the major problems in studying and exploring rocks belonging to the three general groups defined here is the absence of continuity. Many of these rocks have been involved in at least three recognizable tectonic events and perhaps others not yet resolved. The geologic history of the so-called "metamorphic core complexes" includes the widespread development of a detachment zone that renders some of these rocks (perhaps more than are known) allochthonous. This was followed by regional arching along northeast axes all along the zone of complexes (Figure 29). Subsequently, the Basin and Range disturbance rifted the region, causing up to thousands of feet of vertical separation between juxtaposed range and basin blocks (Figure 1). The exact nature of this latter disruption is not well understood. It seems important, from an exploration point of view, to learn the extent to which half-graben (listric normal faulting) type deformation may have been involved.

The Anderson Mine host rocks are instructive in many ways: (1) early Miocene climates encouraged lush vegetative growth, (2) uranium-bearing fluids were available, (3) early Miocene alkaline volcanism likely influenced uranium source, (4) the rocks are positioned near the interface between the tectonically deformed Basin and Range Province and the more stable Transition Zone. It is interesting to note that about 80 miles to the east, from New River to Cave Creek, that there is a belt of "lacustrine" strata that are in several ways similar: (1) early Miocene low energy deposits, (2) contain silicic volcanic tuffaceous materials, (3) contain uranium in which small quantities of vegetatively derived organic matter may be influential, and (4) are positioned at the interface between the Basin and Range Province and the Transition Zone.

This physiographic position, though paleogeographically not understood, provides a measure of continuity not usually available elsewhere in the Basin and Range Province for strata of this age. These low energy rocks, as an age group, extend an unknown distance to the south and thus may occur in the subsurface. Perhaps the Biery State hole in Paradise basin is an example.

The positioning of these early Miocene rocks raises questions as to continuity within the Transition Zone itself. Most likely they are represented there and would occur preserved beneath the extensive areas covered by relatively undeformed middle to late Miocene volcanic rocks (Figure 38). Pre-middle Miocene strata have been found in several places near the base of the present Mogollon Rim (Peirce and others, 1978, in press) along the north edge of the Transition Zone. These factors suggest that this zone is worthy of careful geologic evaluation as a possible region in which to explore for Oligocene-Miocene strata favorable for uranium concentration.

SUMMARY AND CONCLUSIONS

Twenty five localities containing pre-basin fill Tertiary sequences in Arizona's Basin and Range Province were visited. Eighteen of these were observed to display radioactive anomalies believed indicative of some uranium mineralization. The general pattern of uranium occurrence is occasional stratiform epigenetic mineralization closely associated with non-red, low energy, fine-grained clastic and chemical sediments scattered in narrow, discontinuous zones or lenses. At the surface, structural control appears to be subordinate to stratigraphic control at most localities, at least insofar as the anomalies are stratabound.

Available criteria, including K/Ar dating done for this report, suggest a threefold chronologic subdivision of the sedimentary rocks involved in this Phase I investigation: (1) Group I, Oligocene -- pre-22 m.y. in age, (2) Group II, early Miocene-- 22 to 16 m.y., and (3) Group III, middle Miocene -- 16 m.y. to 13-10 m.y.

Group I rocks have been the object of uranium exploration in the Tucson area, especially on the east side of the Rincon Mountains where the Mineta Formation crops out over a distance of several miles. Anomalous radioactivity, though discontinuous, seems to be stratigraphically controlled by dark shales and fetid limestones over a lateral distance of at least five miles. A valleyward dip offers some potential for subsurface exploration.

The Muggins Mountains, east of Yuma, though of considerable interest, have been inaccessible to exploration and general geologic study. Hopefully, this region will one day again be opened for investigation of radioactive anomalies that occur in probable Group I strata.

Many Group I localities consist of coarse-grained clastics, often red, not known to contain anomalous uranium. The regional relationships between high energy clastics and low energy "lacustrine" rocks is not clear. Indications are that each phase originally was developed over a relatively large area of indefinite shape and extent. Paleogeographic controls existent during Oligocene time remain largely obscure. Many of these rocks are allocthonous which substantially hinders interpretation of depositional patterns.

Favorable rocks of Group II of early Miocene age are also of the low energy variety and notably associated with tuffaceous materials that are sometimes zeolitized. Occurrences of this group tend to occur in west central Arizona between the Verde and Colorado Rivers. The Anderson Mine host rocks are placed in this category as is the lower part of the Artillery Formation, both of which have been intensely explored. The Anderson Mine section emphasizes the facts that: (1) large volumes of lignitic materials did accumulate during early Miocene time, (2) these mineralized carbonaceous zones can be preserved, and (3) the "right" rocks are more important than large stratal thicknesses. Anomalous "lacustrine" sections of similar age irregularly crop out from west of the Black Canyon Highway to Cave Creek near the Verde River. An interesting locality is near New

River where almost white aphanitic dolomite of significant thickness is surprisingly, though inconspicuously mineralized. Submicroscopically disseminated organic matter may be related to an unidentified disseminated uranium mineral.

Group II strata, though tectonically deformed, nevertheless tend to cluster along the boundary between the Transition Zone to the north and the Basin and Range Province to the south. Because of the relative stability of the Transition Zone adjacent Group II rocks maintain some continuity that should enhance exploration. Group II rocks in the New River region are closely underlain by Precambrian crystalline rocks. Group I redbeds are absent even though present in the Phoenix region not far to the south. Though not discussed in this report, Group II rocks in the Tucson area are believed to be represented by the largely conglomeratic Rillito Formation.

Group III strata of middle Miocene to possibly early late Miocene age were identified only near the Verde River, tentatively at Lake Pleasant, and in the Big Sandy Valley. Some apparently unsuccessful exploration was undertaken in Group III rocks near Horseshoe Dam and at Lake Pleasant. Both sections are "lacustrine" types containing silicified limestones, marls, shales, and tuffaceous units. Although locally anomalous, the deformed "lacustrine" strata exposed on the east side of the Big Sandy Valley offer limited exploration opportunities. Group III strata also occur along the Transition Zone's southern and western boundaries. At Lake Pleasant Group III strata may overlie Group II rocks.

Group II "lacustrine" rocks are believed to be the most favorable lithologically and, importantly, offer the best opportunities for practical exploration targets.

The presence of Group II and III strata adjacent to the Transition Zone raises a question of depositional continuity within the Transition Zone itself. Many of the relatively flat-lying volcanic rocks of the Transition region are believed to be Group III (Hickey Formation) in age. Group II rocks would underlie these volcanics and overlie Precambrian crystalline rocks. Because of the general regional favorability of Group II strata the relationships of these rocks to the Transition Zone encourages additional attention. Access difficulties and lack of specific interest have, up to now, hindered geologic research.

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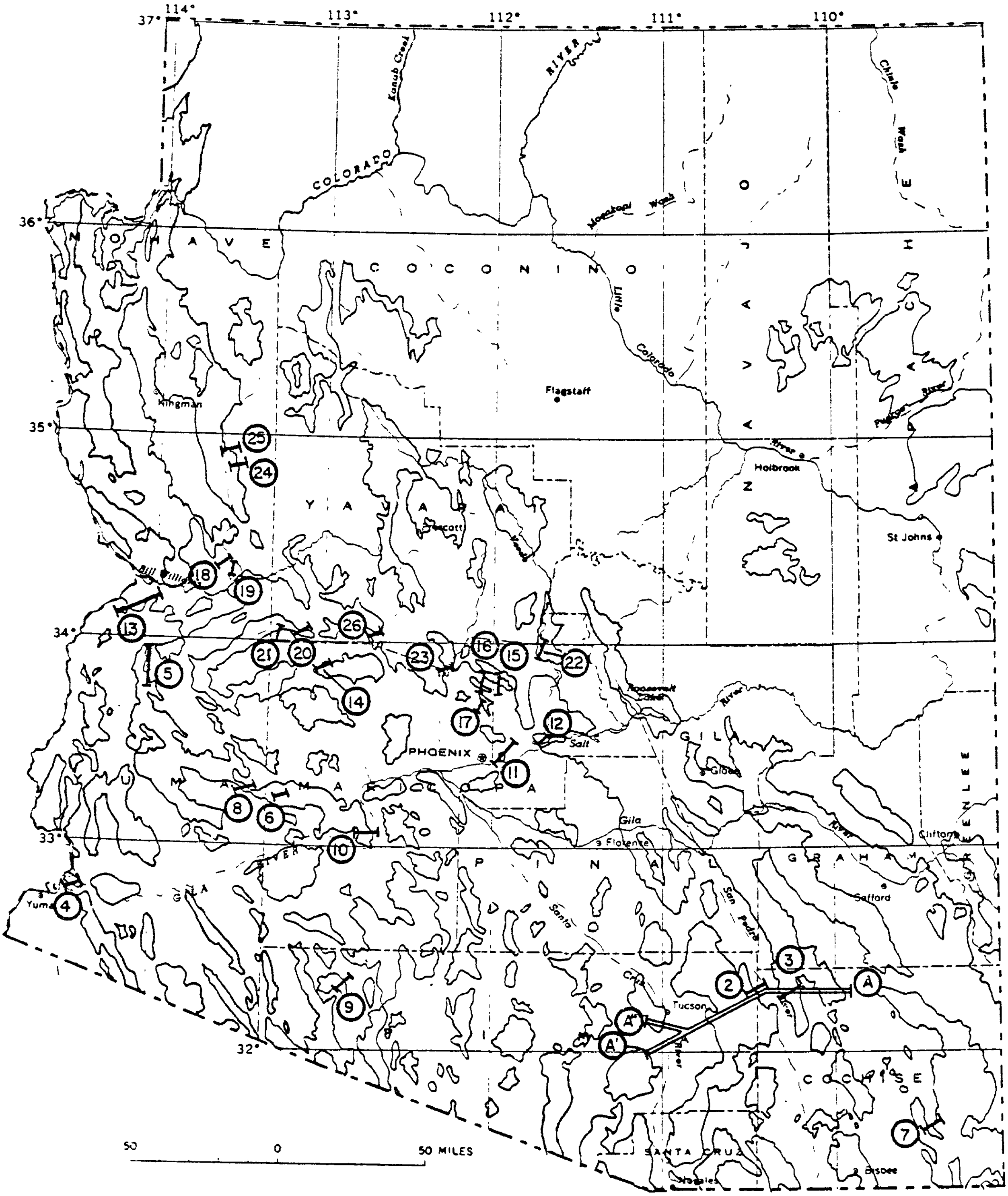


Figure A. Index map showing positions and general trends of the individual cross-sections, Figures 1-26.

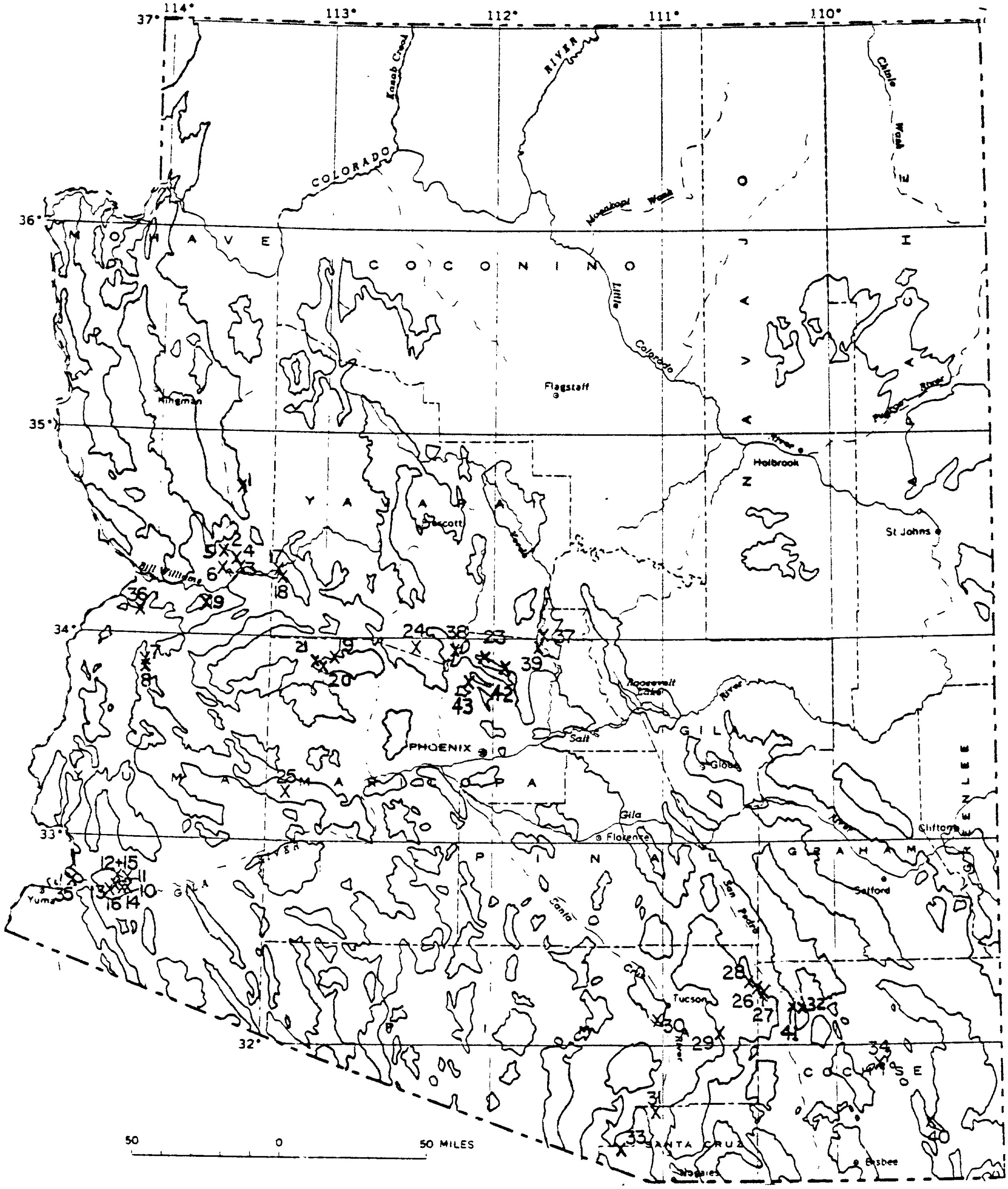
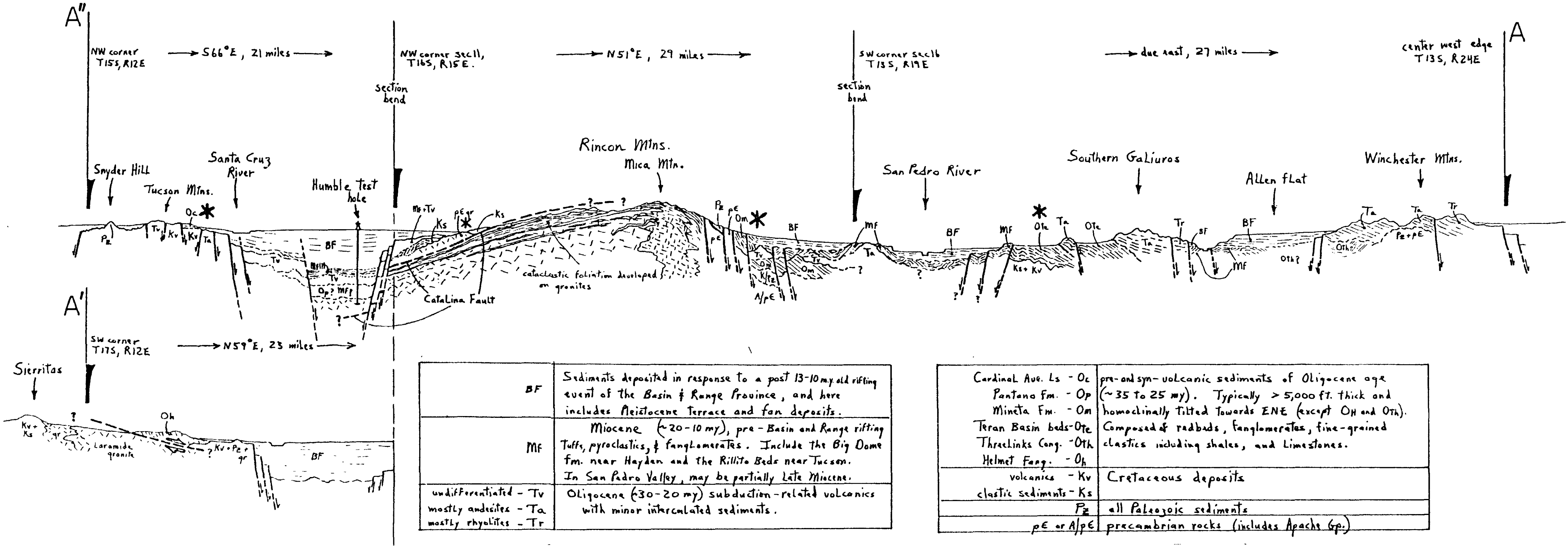


Figure B. Index map of the uranium localities of Table 1.



BF	Sediments deposited in response to a post 13-10 m.y. old rifting event of the Basin & Range Province, and here includes Pleistocene Terrace and fan deposits.
MF	Miocene (~20-10 my), pre-Basin and Range rifting Tuffs, pyroclastics, & fanglomerates. Include the Big Dome fm. near Hayden and the Rillito Beds near Tucson. In San Pedro Valley, may be partially Late Miocene.
undifferentiated - Tv mostly andesites - Ta mostly rhyolites - Tr	Oligocene (~30-20 my) subduction-related volcanics with minor intercalated sediments.

Cardinal Ave. Ls - Oc Pantano Fm. - Op Mineta Fm. - Om Teran Basin beds - Ote Threelinks Cong. - Oth Helmet Fang. - Oh	pre- and syn-volcanic sediments of Oligocene age (~35 to 25 my). Typically > 5,000 ft. thick and homoclinally tilted towards ENE (except OH and OTh). Composed of redbeds, fanglomerates, fine-grained clastics including shales, and limestones.
volcanics - Kv clastic sediments - Ks	Cretaceous deposits
Pz	all Paleozoic sediments
p€ or A/p€	precambrian rocks (includes Apache Gp.)

Figure 1. General WSW-ENE cross-section through the Tucson Basin, San Pedro Valley, and southern Galiuro Mountains, indicating general tectonic positions of Tertiary pre-basin fill sediments and volcanics. * denotes uranium occurrences discussed in text.

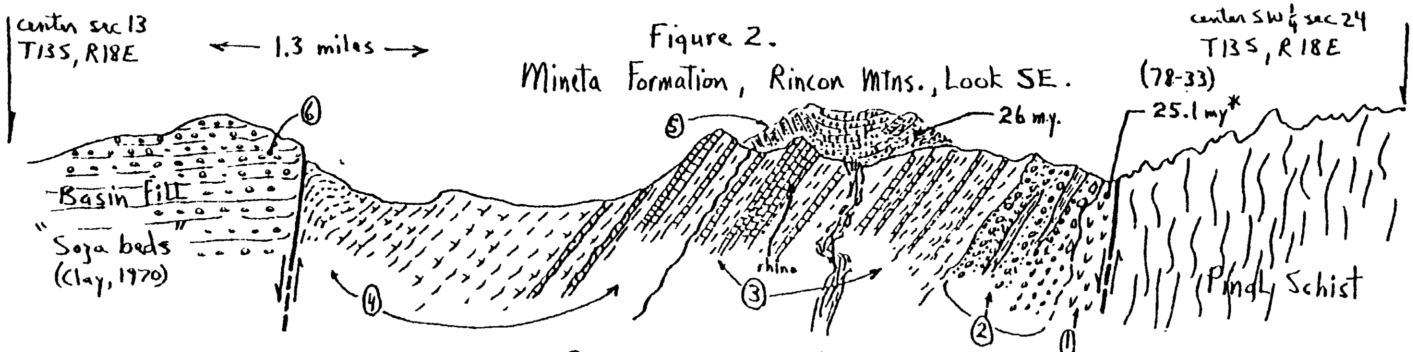


Figure 2.
Mineta Formation, Rincon Mtns., Look SE.

① to ④ is Mineta Fm. of Chew (1952).

① welded sanidine-bearing rhyolite ash flow, persistently at or near base of Mineta Fm. At places, it lies above some limestones which form the base of the formation. Clasts of rhyolite are seen in overlying conglomerates. [K/Ar (WR), = 25.1 ± 0.6 m.y. , this study.]*

② Basal conglomerate of Mineta Fm. Lower part is gray colored, upper part red-brown colored. Imbrication indicates flow direction to W, SW, NW. Contain intercalated lenses of green, gray, dark gray, and limonite-brown shales which in places count 35x, 100x, and > 100x. Hottest shales are near to basal conglomerates depositional on Precambrian granite which counts to 70x locally. Conglomerates 700-1300' thick (Chew, 1952; Clay, 1970).

③ Limestone-shale member of Mineta Fm. Complex assemblage of varicolored well-bedded shales, mixed in with many non continuous limestone beds of variable thickness. Limestones include black fetid units, massive gray units, and gray pisolitic units. Some limestones have gray chert pods, some have red jasperoid blebs. Many local areas near limestones count 1.5x to 3x, especially near minor shear zones. Some limestone beds show beautiful stylolites. Chew (1952) reports a "Late Oligocene - Early Miocene" rhinoceros jaw fragment from one of these limestones. Thickness of ③ is 50-500' (Chew & Clay). Clay reports main lithology of limestones as algal calcarenites.

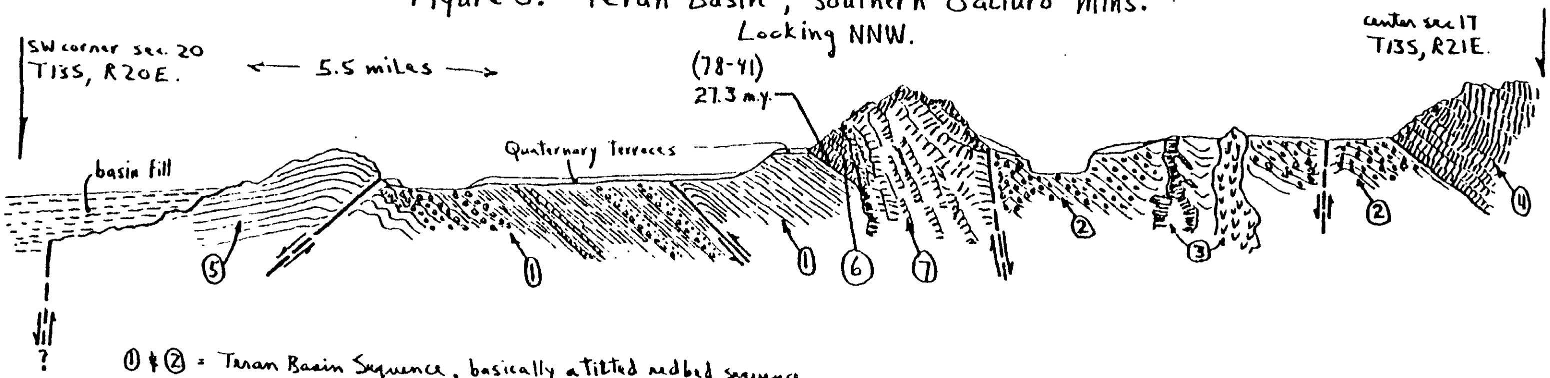
④ reported by Clay (1970) as basal red to maroon arkosic conglomerates grading upwards through mudstones, gray limestone beds, black fetid limestone with algal remains, to a thick very light or white colored gypsiferous siltstone-mudstone sequence with many thin gypsum seams and veinlets. No anomalous radioactivity noted. 1000-1300' thick (Clay).

⑤ vent complex of turkey track andesites. Several N70°E trending vertical dikes of this material noted in NW¼ sec 30. The main vents are in secs 3, 10, 11, 13S, 18E and appear to not be tilted, although Mineta beds in the immediate area dip 25-40° NE. Clay reports a 26.3 ± 2.4 my K/Ar age on a flow of this material. Hence Mineta tilting is apparently pre 26 my. Exact age of rhinoceros, above, becomes important.

⑥ Gently deformed light colored calcareous fanglomerates, mostly fluvial. Probably middle or older basin fill in age. These are seen to lap unconformably upon older (mid-Miocene?) fanglomerates, highly deformed, near the San Pedro River downslope from this area.

* see text — this age is probably reduced from its true value.

Figure 3. Teran Basin, southern Galiuro Mtns. Looking NNW.



① & ② = Teran Basin Sequence, basically a tilted redbed sequence.
⑤ is younger pre-Basin fill fanglomerates, probably Miocene age.

① Lower (?) Teran Basin sequence. Diverse lithologies including basal red-brown and gray colored fanglomerates, with imbrication directions indicating flows toward W and SW, and a thick upper mudstone-shale series. Certain upper members contain 1-3' thick slightly fetid limestone beds, some members are gypsiferous mudstones with pure bedded gypsum units, and upper part of ① includes several fining upward sequences (5-50' thick) of cong → ss → sh. Contains one devitrified 10-15' thick ash bed in upper part. Several yellowish & brown mottling shales count to 2x. Ls is dead. (N30°W strike 25-45°NE)

② Upper (?) Teran Basin sequence is mostly conglomeratic, red to red-brown colored mostly fluvial high energy deposits. Some mudflow deposits noted. Imbrication points to SW as flow direction. Intruded ③ by andesites and rhyolite plugs. No clasts of Galiuro volcanics noted, only Pz limestone, quartzites, Cretaceous rocks in the area. (NW strikes 35°NE.)

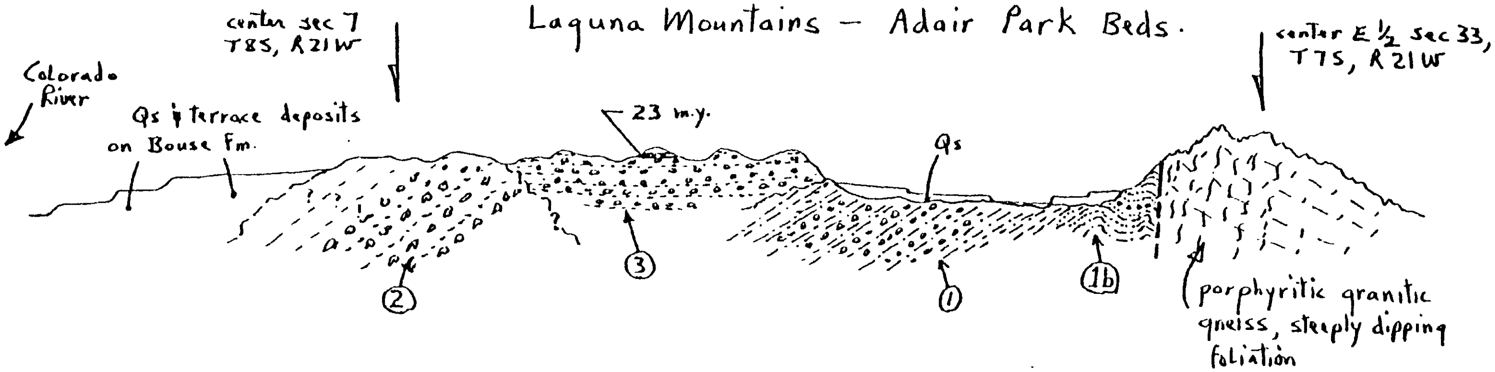
Lower Teran Basin beds ① are concordantly overlain by an andesite sequence ⑥ with K/Ar = 27.3 ± 0.6 m.y. on the lowest flow. These in turn intruded by ⑦, a turkey track andesite vent complex. Upper Teran sequence ② also concordantly overlain by a series of Turkey track andesites. Real relationship between ① and ② unknown — geologic mapping in the area is called for.

⑤ Calcareously cemented light gray colored fanglomerates. Clasts almost entirely of Johnny Lyon granodiorite. Imbrication points to NW as flow direction (Johnny Lyon grodiortite outcrops to the SE from here). Mudflow and debris flow deposits predominate. The sequence now buckled into a NW-SE trending anticline in area of cross section.

The lower part ① of the Teran Basin Sequence is very similar to the Mineta Fm., west across the San Pedro Valley and is here considered a possible equivalent of it. Both these sequences dip homoclinally NE at 20-50°.

Figure 4.

Laguna Mountains — Adair Park Beds.



This area mapped by Olmstead, USGS Prof. Paper 486-H, plate 4.

(1) Adair Park Beds — redbeds, consisting of fanglomerates and high energy fluvial sequences containing Limey horizons which may be relict caliche soil zones. Few thin lenses of gray colored channel gravels, and few beds of greenish calcareous mudstones dispersed through section. Few probable overbank muds and silts. Pebble imbrications to W, NW, and N, few SW directions. Cobbles of nearby xlline rocks predominate. Attitude ; ~N-S strikes, 25-35° dips to west.

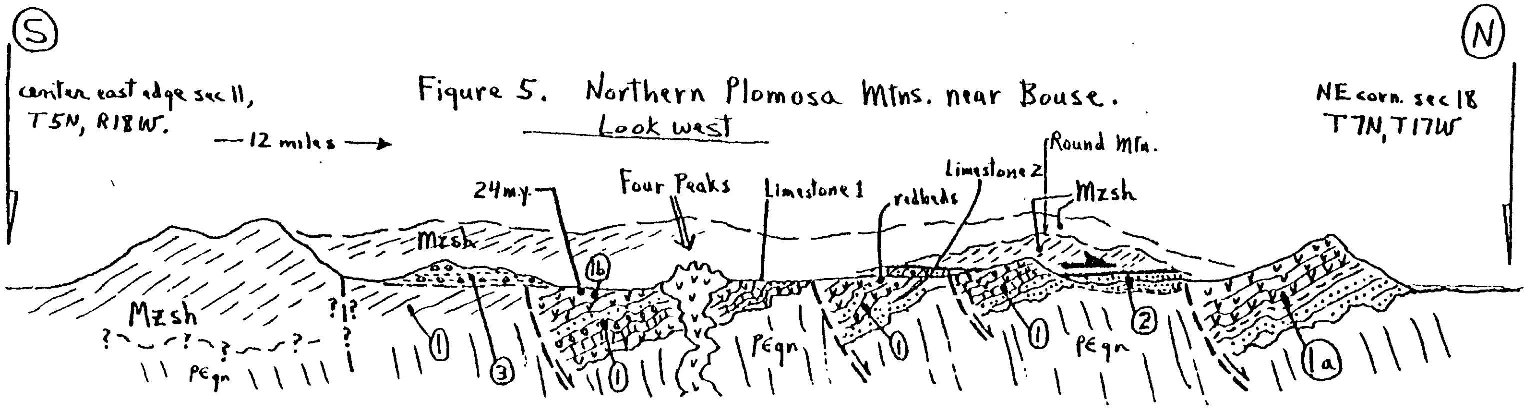
(1b) Green and yellow mudstones - claystones with lowermost beds in section being red gritstones, granite derived. Folded complexly and in high angle fault contact with xlline rocks to the northeast. Thin selenitic gypsum partings in shaley sequence locally. Some green-yellow mudstones with red-orange mottlings counts to 420 cps (3x). The Adair Park beds are capped by a low-level pediment which grades to the Gila River nearby, and capped by young terrace gravels, Qs.

(2) Gray colored cobble to boulder conglomerates with clasts ≅ matrix volume wise. Some 6' dia. boulders are well rounded. Most clasts are ½ - 2' dia. Unit has N-S strike, ~ 35° W dip, very similiar in attitude to Adair Park beds. Unit probably represents proximal alluvial fan and/or coluvial deposits directly adjacent to xlline rock topographic highs. Within the tilted sequences (1, 1b, 2) grain size of clastics decreases eastwardly. If the section is not overturned, it is a coarsening upward sequence.

(3) Buff colored sandy and gravelly beds, dip towards NW at 4-13°, away from the nearby Gila River. Bentonitic ash bed in upper part of section produces K/Ar age on biotite of 23 ± 1.2 m.y. (Olmstead, 1973, p. H-39). The sequence probably represents distal alluvial fans and braided stream complexes. This material is part of Olmstead's Kinter Fm, and is clearly much less deformed than nearby redbeds. Tectonically disturbed volcanics 3 miles to the NW of this cross-section, perhaps time equivalents of redbeds, date at 26.3 - 29.4 m.y. (Olmstead, 1973, p. H-39).

Figure 5. Northern Plomosa Mtns. near Bouse.

Look west



Mzsh = Mesozoic-aged (?) schistose meta sediments, Lines show foliation (and bedding ?) direction.

PЄgn = Precambrian gneiss of Jemmett (1966).

(1) series of southward tilted fault blocks (according to Jemmett, 1966) composed of probable Tertiary sediments and dark volcanic flows. One flow at (1b) above was dated by Eberly and Stanley (#91) as 24 ± 1.6 my on biotite (rock described as welded rhyolite tuff). Jemmett describes the section at (1a) as lower 100' of arkose, overlain by > 200' of thin bedded calcareous shale and limestones with thin felsitic volcanic layers only inches thick, overlain by several hundred feet of flow bx (andesitic ?) with minor arkoses and gneissic cobble conglomerate lenses with a persistent capping welded rhyolite tuff flow (dated sample ?). Intrusion at Four Peaks has come up along bounding fault between pedimented Tertiary section and Mzsh section. Anomalous radioactivity at a white shale bed intercalated into ls section (limestone 1), in a fault or shear zone in a red arkosic conglomerate (redbeds), and in a cherty thin fetid limestone bed in a limestone-shale unit sandwiched into volcanic package (Limestone 2). Limestone 1 Locality: 9x; redbed locality: 90x; Limestone 2 Locality: to 4x. Limestone 1 has some carnotite.

(2) Jemmetts "Plomosa cong. mbr" described by him as coarse breccia and conglomerate deposited at the toe or front end of an advancing thrust sheet which eventually over-rode its own waste. He likens it to the Artillery Conglomerate of Lasky and Webber. He suggests northeastward transport of upper plate Mzsh, with the evidence strongest at Round Mtn.

(3) "Tks" of Arizona State map, a series of medium to dark red brown mudflow-rich fanglomerates with no sand lenses seen. dips essentially depositional. Tafoni weathering and ventana are common. Clasts of Mzsh, PЄgn, no Tertiary seds or volcanics except in several vertically trending clastic dikes in NE¼ SE¼ sec 30, 6N, 17W. rare thin fluvial gravels have imbrication direction pointing to NE as transport direction.

notes: overall interpretation of structure is speculative and is blended from incomplete field observations and conclusions of Jemmett. Jemmett notes that schistosity (bedding ?) in Mzsh has very similar attitude as Tertiary section. This point needs clarification.

Figure 6. Area of western Gila Bend Mtns, near Yellow Medicine Butte. (Dendora Valley 15' quadrangle.

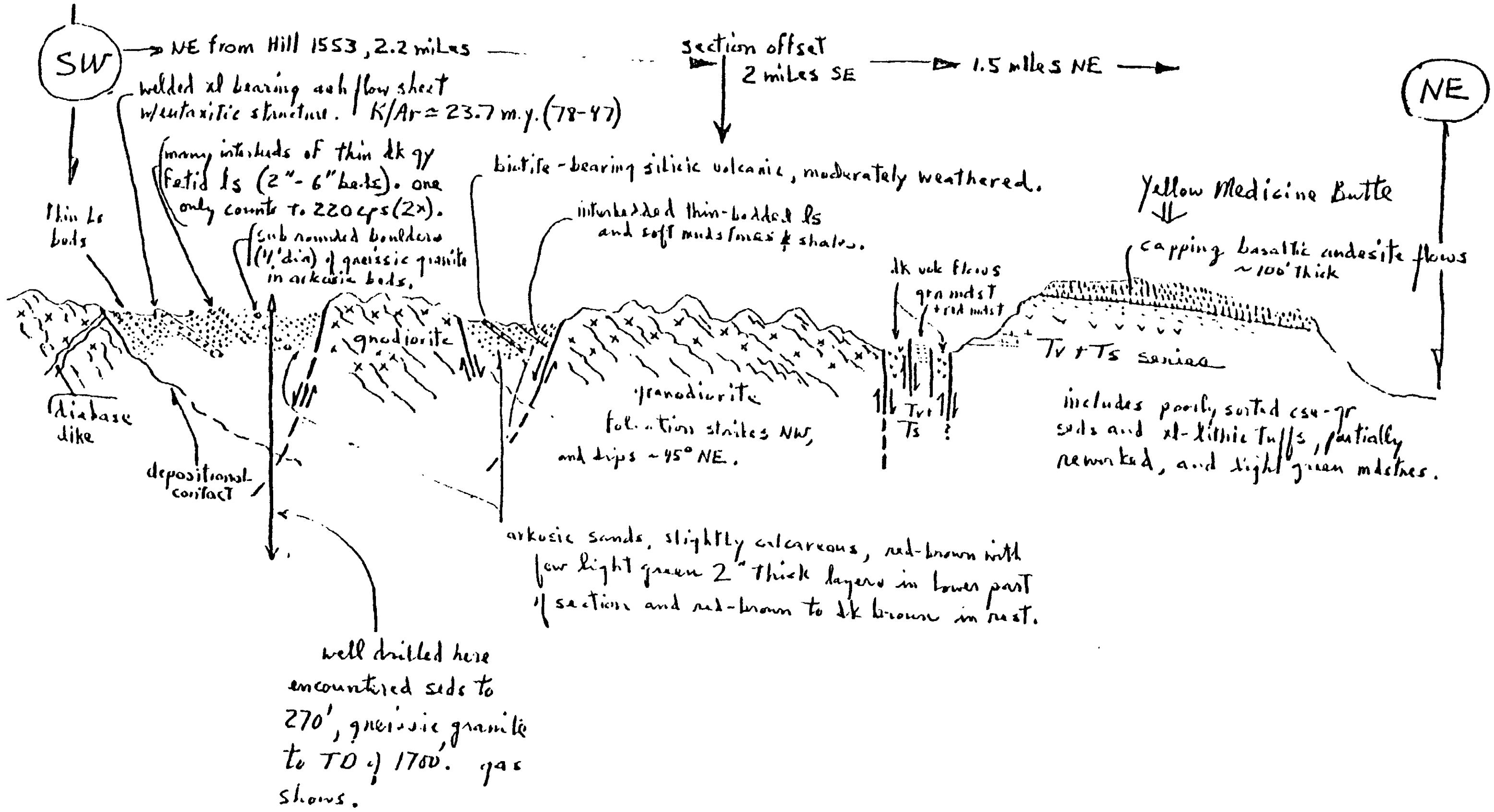
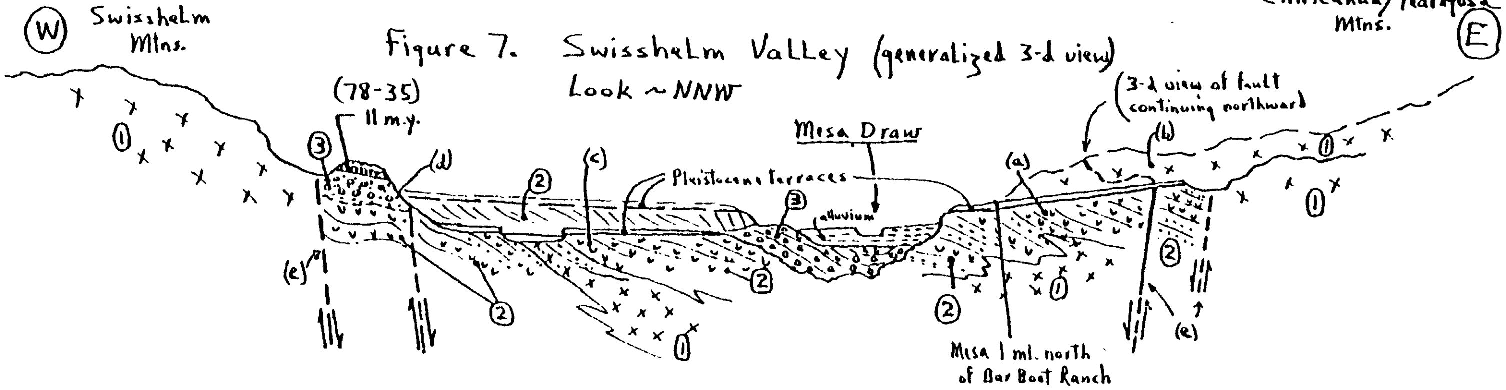


Figure 7. Swisshelm Valley (generalized 3-d view)
Look ~NNW



This is a generalized x-section covering the south ½ T20S, R28E, upon which is projected the area of the K/Ar date which is in Sec 32, T19S, R28E.

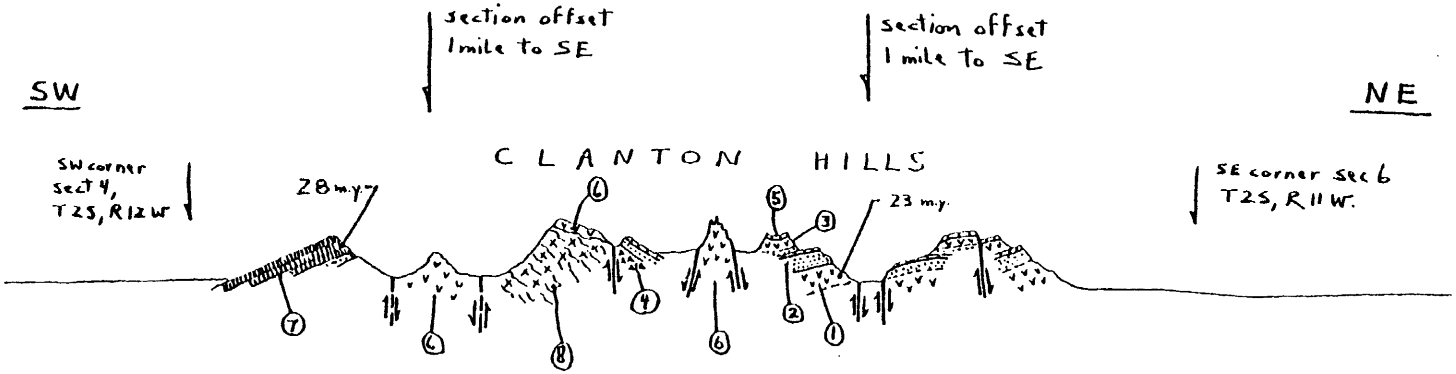
(1) pink, lavender, and gray colored sanidine-bearing rhyolite flows of the Chiricahua sequence recognized to the north are ~29-24 m.y. old. rhyolite flows at (b) above count to 300 cps (~1.5×).

(2) sequence of primary and air-fall rhyolitic (?) tuffs, pyroclastics, and tuffaceous sediments which occupies most of the valley at this position (latitude). The tuff section is complexly faulted and overlain only by terrace gravels in this area. Several tuffs, some of which at locality (a) above appear somewhat hydrothermally altered, count to ~2 or 3× (200-300 cps). These tuffs are in part younger than (1), but perhaps in part synchronous with (1). Pyroclastic units like these are to be expected to accompany massive rhyolite volcanism. Some anomalous counts (~2×) were also noted across the valley at locality (c) in a fine-grained tuff-siltstone unit.

(3) fluvial channel-bottom pebble and cobble conglomerates with some overbank gravelly silts and sands locally abundant. Poor imbrication indicating flow direction of E and NE. Diversified clast assemblage greatly resembling general lithologies present in Swisshelms, but (Totally ?) Lacking rhyolites which are juxtaposed by Basin + Range faulting. An intercalated basalt flow (above) K/Ar dates at 11 m.y. (this study). An enigmatic "fault line scarp" along the NE side of the Swisshelms is the slope labelled (d) above, and may or may not have had Pleistocene-Recent movement. Basin and Range faulting (main pulse) is interpreted here as post-dating 11 m.y., but may be best represented by the faults at (e) rather than the "scarp" at (d).

Basin Fill is found both south and north of this area, but is not preserved in the area. This area may have been a high during main pulse of Basin Fill time.

Figure 8. Clanton Hills, northwest of Gila Bend.



note: many accordant ridge crests in the area suggest the presence of an old, now highly dissected pediment surface about 120-150' above the present flatland elevation, which was cut mainly on the Clanton Hills sediments.

Clanton Hills sediments

① Lower biotite rhyolite (K/Ar on biotite = 23 ± 1.6 my, Eberly & Stanley #101), consisting of massive plug-type rhyolite. To 100' thick in places.

② med-dark red-brown fairly well sorted arkosic sandstones, minimal stratification, with very local indurated mudstone units to 2" thick. The sandstones contain one 6-10' bed of finely laminated Ls (wea. blk) and 4 to 6 beds ~ 1-2' thick of sandy Ls, and a basal 5-10' thick wea gy Ls, with disturbed coarse laminar bedding. Few arkose beds are lgt-med green color, and color is spotty in places. Thickness about 60-120' in most places. Limestones are conspicuous dark mesa-forming units.

③ rhyolite tuff, lithic and unwelded in lower part, grading upward into a flow breccia and/or an explosion breccia containing angular clasts of all units beneath it. 20-60' thick. Grades into flow-banded rhyolite laterally in places, and quartz-filled lithophysae are not uncommon.

④ dark colored andesite flow breccia with 6" dia. hollow andesite spheroids. 15-30' thick.

⑤ capping limestone, with abundant chert nodules and stringers, and consisting of thin gy Ls layers mixed with laminated Ls layers which wea tan-brn color. "pods" in lower part only of this unit are extremely brecciated, and grade directly into the breccia zone of ③. 8-12' thick.

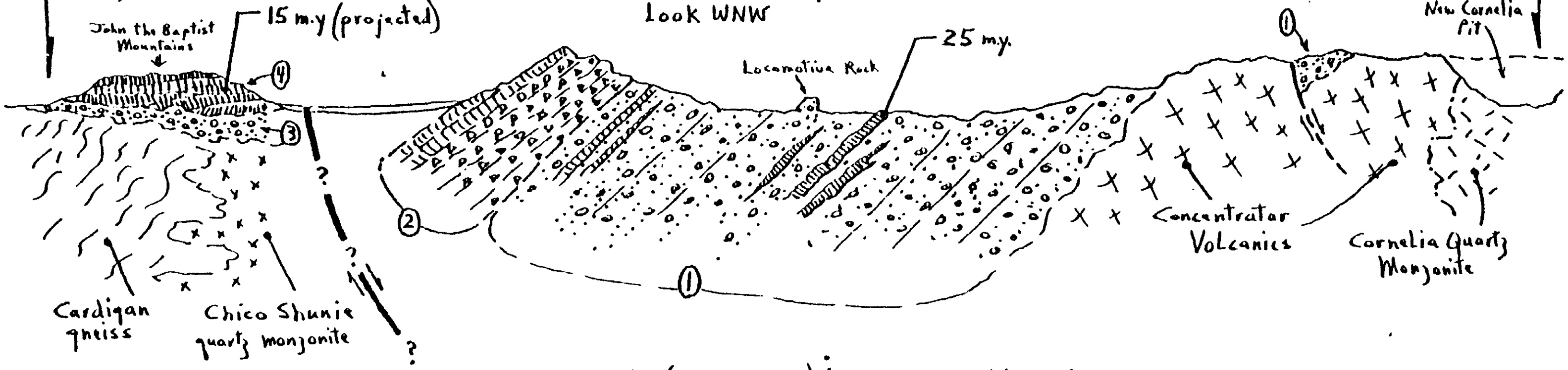
other rocks.

⑥ rhyolite unwelded tuffs of unknown affinity.

⑦ isolated hills capped by SW-dipping basaltic andesites (K/Ar = 28 ± 4.2, Eberly & Stanley #102).

⑧ gneissic granite, lineated in some pieces of float. Foliation dips 30-50° to N or NE.

Figure 9.
Locomotive Fanglomerate near Ajo.
Look WNW



See Gilluly (1937, 1946) for general discussion.

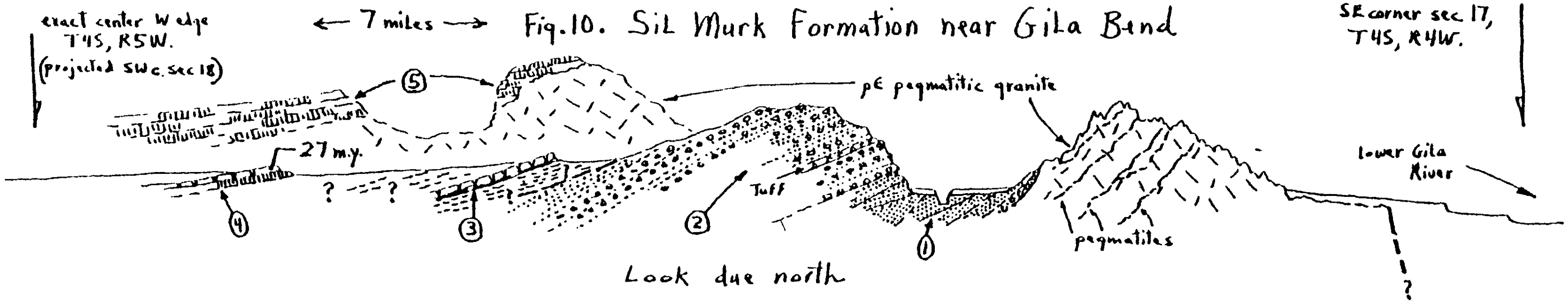
① Locomotive Fanglomerate of Gilluly (1937). Between 6 and 12,000' thick (Gilluly, 1946). Deposited on a surface of high relief, because several thousand feet of fanglomerate pinches out along the basal deposition contact to the NE. Predominately debris flow-and mud flow-rich fanglomerates with clasts of all older volcanic and crystalline rocks in the area, along with Paleozoic limestone and quartzite clasts of unknown special origin. Fluvial deposits probably < 5% of entire volume. Contains flows of andesite which appear similar to the thick overlying Ajo volcanics. One of these was dated at 25 ± 2.7 my (Eberly & Stanley, # 108). The Formation now dips 30-60° SW both north and south of the Copper mine at Ajo. No anomalous counts noted.

② Ajo Volcanics, consist of andesite flows and flow breccias, tuffaceous rocks interbedded in lower parts with Tongues of Locomotive fanglomerate and low energy ripple marked sandstones and mudstones. The proportion of andesite flows increases upward in the section. Thickness is 3500-5000' (Gilluly).

③ Daniels Conglomerate, an only slightly deformed unit, composed of fluvial and mudflow units, light colored. Has a 60' thick interbedded flow of quartz latite at one locality (Gilluly, 1946, p. 43). Rests upon crystalline rocks.

④ Batamote Andesite, here rests unconformably upon the Daniels Conglomerate, and is one remnant of a series of slightly deformed volcanic sections that are found extensively in the area. A K/Ar date of 15 ± 2.2 my was determined on such a series ~15 miles WSW of this cross section by Eberly & Stanley (#109). A silicic tuffaceous section in the northern Ajo Range (~15-20 miles east of Ajo) is not pervasively tilted and dates of rocks in that section lie between 17 and 15 my (W.C. Jones, 1974).

Fig. 10. Sil Murk Formation near Gila Bend



Southern part of Sil Murk Fm of T5S, R5W described and mapped by Heindl and Armstrong (1963).

① Red-brown fairly well sorted arkosic sandstones, non-calcareous. Large scale cross-beds (Thicknesses 10–30′) mostly of trough type noted. Sands underlain by thin red-brown conglomerate with angular clasts, seen to be depositional with vertical contact upon pЄ granites. Most ss beds finely Laminar, some display ½″–3″ thick graded beds, indicative of fluvial action. Sandstones interpreted to represent aeolian and fluvial (prograding deltaic ?) settings. Thickness of sandstones in (projected) sec 24, T4S, R5E is 500–1000′ by dip calculation.

dips of 20–40° SW

② Fanglomerate, locally fingering with, locally deposited on irregular surface cut on the sandstones. Composed of a lower 50′ thick massive debris flow, and 1000–2000′ of debris-mudflows dominated section, with minor fluvial sands and channel gravels. Debris flow matrix and fluvial sands both greatly resemble the lower sandstone unit. The lower 1000′ of section is red-brown color, and contains one 4′ thick devitrified air-fall tuff bed. Fluvial imbrication in general points strongly towards S and SW. Further south, Heindl suggests a section composed of 100′ of red arkosic sandstone of flood plain origin, overlain by ~1500′ of red and an upper gray fanglomerate.

<u>In</u> general, the sandstones and fanglomerates dip 30–40° to SW, but strike directions swing more E-W in NW¼ T4S, R5W.

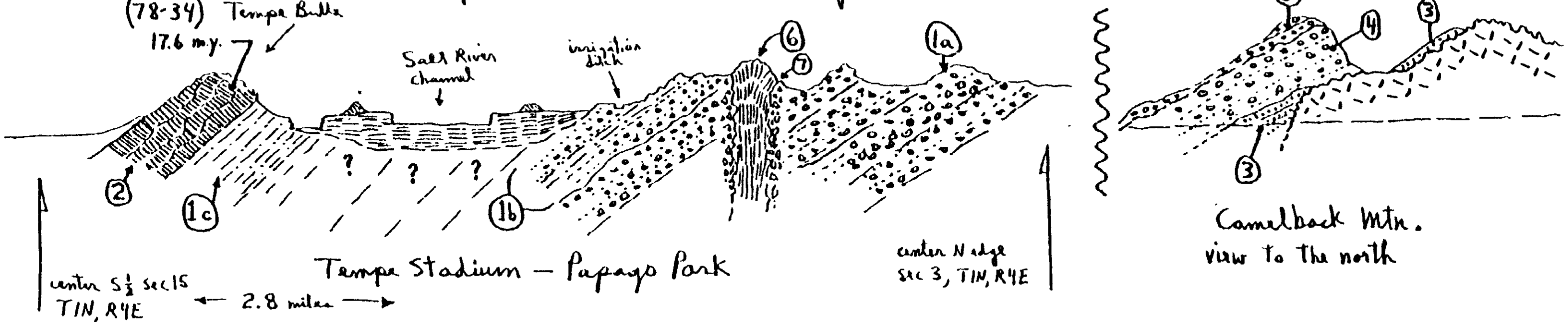
dips of 5–10° SW

③ Low relief cuesta held up by dacitic welded tuff w/ eutaxitic structure and 4′ of basal black vitrophyre, and underlain by light colored cobbley mudstones which do <u>not</u> resemble lower fanglomerates. Dips to SW and W at 5–15°.

④ Low relief cuesta held up by welded rhyolite or dacite tuff and directly underlain by a basaltic andesite. Tuff has been dated by Eberly & Stanley (#99) as 27 ± 3.8 m.y. These units dip ~6° to the SW, but are separated from rest of section by slope-covered areas. General dips of ③ and ④ conform to extensive thick flow sequences in hills to the NW (⑤) which can be seen to be depositional on pЄ granites in SW¼ T3S, R5W where Sil Murk beds are totally missing. These similiar structural attitudes prompted Heindl to suggest that his upper volcanic Sil Murk Fm (③ & ④) may be part of the extensive volcanic terrain to the NW, and separated from his lower Sil Murk sediments (① & ②) by a 5–15° angular discordance. Eberly & Stanley's K/Ar date clearly applies to the upper volcanic sequence, and is only a minimum number on the lower sediments.

Note: A series of K/Ar dates on rocks of ⑤ series 5–30 miles north by Shoumtra, et. al (1976) produce 17–21 my ages, although locally dips on these younger rocks may be 0–25°.

Figure 11. Redbeds in metropolitan Phoenix



attitude N60°W, 40-50°SW.

① Redbeds of Papago Park. (1a) – bouldery fanglomerates, mostly mudflows w/ fluvial sandy beds secondary in importance. Clasts mostly granite; schistose rocks minor. Red-brown colors.
(1b) cobble conglomerate beds mixed with abundant fluvial sandstones, siltstones. Mostly red-brown colors. Some medium-energy sandstone beds with thin clay partings. Sediments here intruded by a series of N25°W trending rhyolite dikes ⑥ with marginal rhy. breccia zones*. These comprise many of the buttes of Papago Park. (1c) – massive to finely laminated silts and clays, well lithified, noncalcareous. Several mudcracked horizons. Predominate particle size is perhaps sandy silts. Environment was probably deltaic to marginal playa. Most colors are light to dark maroon to red-brown.
② series of andesite or basalt flows concordantly overlies the sediments. Lower ~50' or so is weathered red and green colors. These flows strike N50°W, dip 45°SW. K/Ar on lowermost fresh flow = 17.6 ± 0.37 m.y., This report.

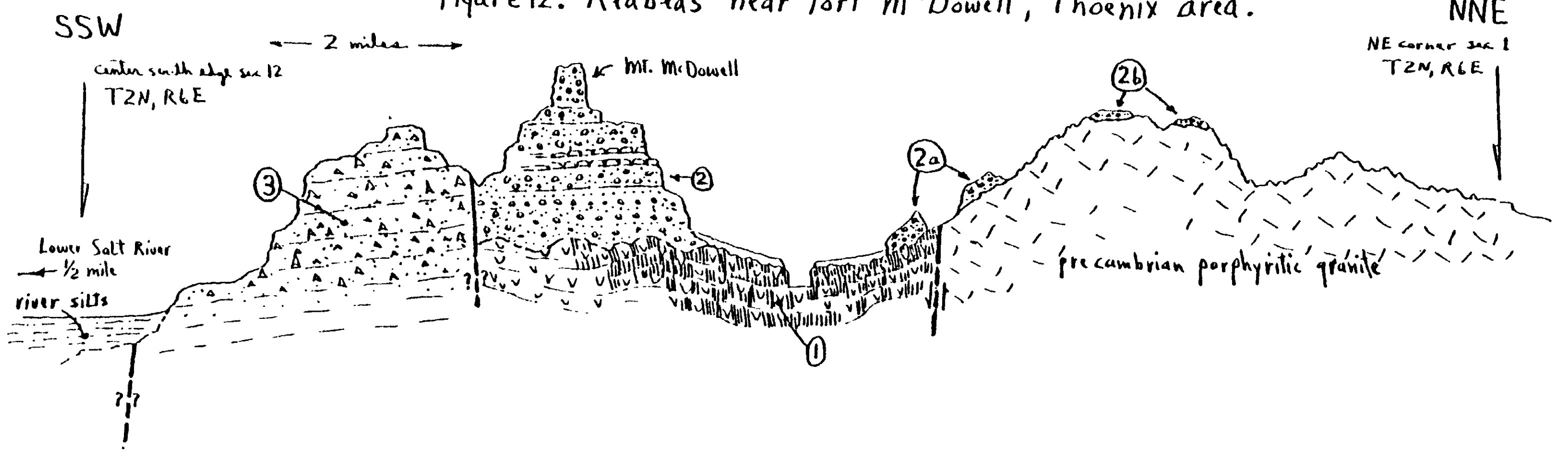
Camelback Mtn. see also Cordy (1978).

dips 20-30° NW.

③ bright red colored clayey grus, laminated; fluvially deposited. Many beds have cobbley or pebbley horizons. Clearly depositional on precambrian granite in several areas. dips 20-30° NW.
④ complex assemblage of debris flows (massive units with ill-defined boundaries) and mudflows (tabular 5-20' thick beds). Pale buff colors only. Granite only rock type noted in clasts. Clasts to 1' diameter.
⑤ not closely examined — appears to be a fluvial series with bouldery beds, sandy beds. buff-brown colors.

* alternate hypothesis of S. Reynolds (May 1979) is that ⑥ is Precambrian metarhyolite upon which (1b) is depositional-contact at ⑦ is a listric fault which allows repetition of (1b) redbeds at (1a). Or, perhaps ⑥ is monolithologic megabreccia intercalated into redbeds similar to parts of ④ above as suggested by Cordy.

Figure 12. Redbeds near Fort M^c^Dowell, Phoenix area.

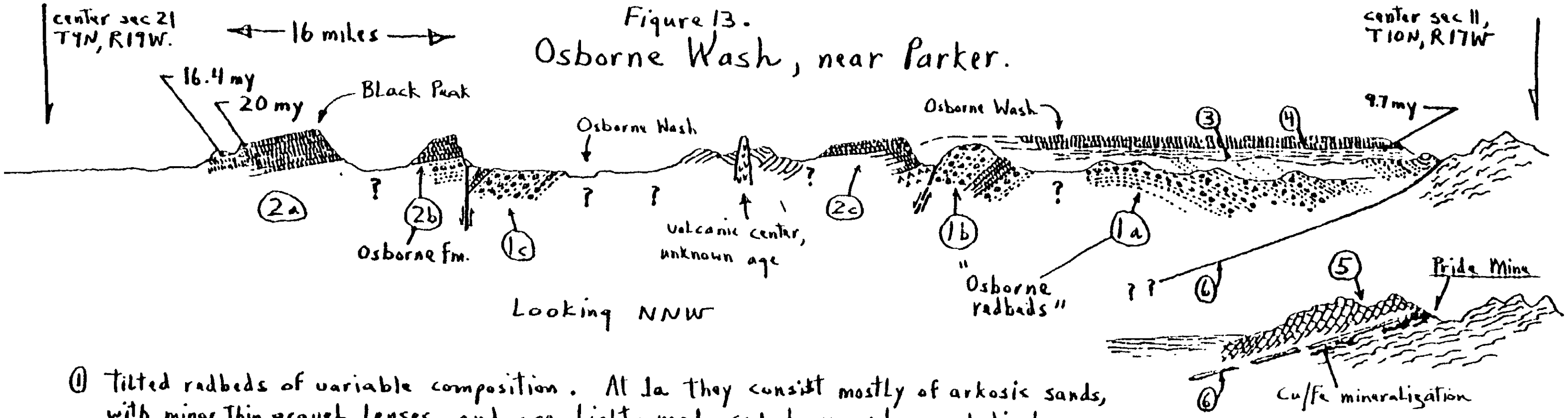


(1) Thick section of andesites and andesite flow breccias, extend to the west at least 2 miles. In fault contact with precambrian granite to the north, with bedded pyroclastics and tuffs to the south.

(2) A ~900' thick section of redbeds, clearly depositional on andesites at one spot, and nearby on granite (area 2A, above). Depositional and nearly flat-lying on granite at (2b). The inference is that the redbeds are post-the faulting involving andesites and granite, and were deposited on an element of paleo-relief that still exists. Younger faulting juxtaposes the redbeds and bedded pyroclastics. The northern of the two faults trends ~E-W, the southern one ~N70°E. The redbeds are basically 3/4 debris and mudflows, 1/4 fluvial. Matrix is medium to bright red-brown colors, poorly sorted but well indurated. Clasts of granitic materials and rare andesites. Redbeds contain two pyroclastic units 1/2 way up. Imbrication in fluvial units points SW to W as downdip direction. Redbeds dip 10-15° towards W.

(3) Well-bedded tuffs, agglomerates, and pyroclastic units, dip 15-20° towards SW, and are clearly in a different attitude than the redbeds. These units are probably part of the Superstition volcanics that predominate to the south, but these particular beds may be younger or older than the redbeds. Hence movement arrows on the fault are not now determined.

Figure 13.
Osborne Wash, near Parker.



① Tilted redbeds of variable composition. At 1a they consist mostly of arkosic sands, with minor thin gravel lenses, and are light-med. red-brown color, and display good laminar and, more uncommonly, cross-bedding. Some cross-beds point to S or SE. Rip-up clasts of hard mudstones noted in some sandy beds. At 1b, the redbeds are calcareously cemented, hard, ledge forming units ½–2' thick of subequal portions of fluvial sands, coarse grained, mudflow units, and sparse fluvial conglomerates. Uncommon imbrication to the north quadrant. Here the redbeds contain a number of interbedded andesite flows, and are in high angle fault contact with a younger basalt–rhyolite pyroclastic assemblage. A very similar assemblage is seen at 1c, but here the andesites sit on top a few hundred feet of redbeds. Calculated thicknesses at 1b are 3600', at 1a, 6000–7000' assuming no fault repetitions. Dips in the redbeds are symmetrical about a NW-trending anticlinal axis which can be observed in the field going through the center of S28, T10N, R17W. Dips of redbeds are 30–40° except near anticlinal axis.

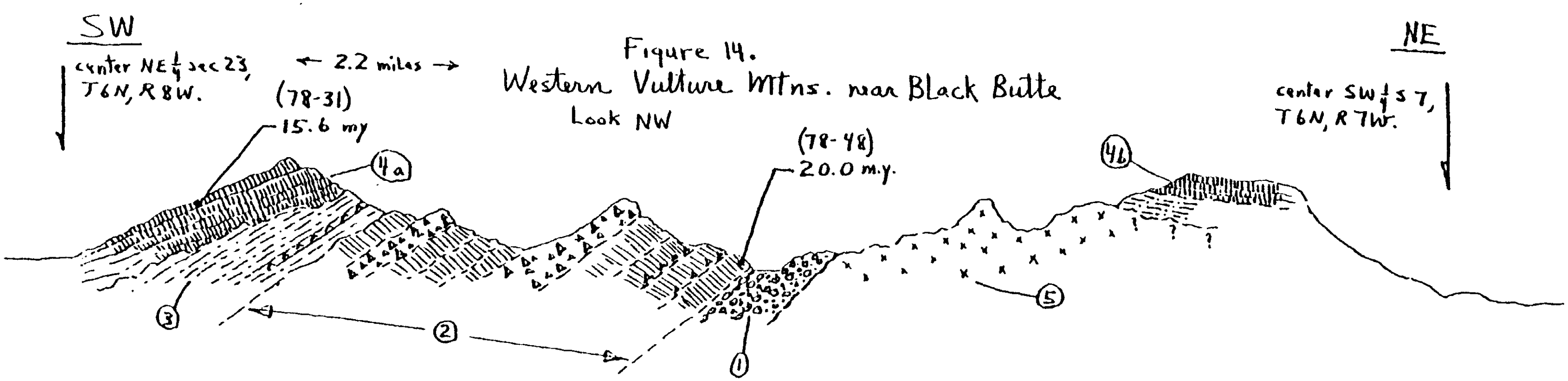
② Thick sections of basalt flows, with 5–10° SW dips. They were observed to overlie light-colored fluvial mudstones and channel gravels at 2b, and a lithic unwelded rhyolite tuff bed at 2c. Two K/Ar dates at Black Peak are on nearly equivalent flows, a 20 ± 3.1 my age (Eberly and Stanley, # 89) and a 16.4 ± 0.7 my age (Damon, et. al., 1970 A.E.C. Rept, p. 42). 2b = Osborne Fm.

③ & ④. An extensive series of sediments (not closely observed) overlain by basalt flows, occupying mesa country both north and south of the *Bill Williams River*, and observed to truncate the red arkosic sand section (1a) in this area. A K/Ar date of 9.7 ± 0.3 m.y. exists for a flow at the base of the basalts, nearly on this cross-section (Armstrong, et. al., 1976).

⑤ Auxilary cross-section ~2 miles SE of main one — consists of a 1200' section of limestones dipping 30–45° SW, separated from a section of gneiss with gently dipping low-angle foliation by a so-called "dislocation surface". Limestones are slightly recrystallized, are mostly light to medium gray colors, and display 1'–5' beds and uncommon chert nodule horizons. Chrysocolla – hematite mineralization common just beneath the dislocation surface, but does not extend above it into the limestones. Limestones and redbeds were not observed together in outcrop anywhere in the area.

⑥ see note about dislocation surface on cross-section about Harcuvar Mtns – Bullard Peak section.

Figure 14.
Western Vulture Mtns. near Black Butte
Look NW



Tilted section

① medium-dark red-brown arkosic conglomerate, about 40-60' thick, apparently depositional upon a granite. cobble clasts are sub-angular to sub-rounded. Some 6"-12" beds are grusy. Few finer grained beds are Lgt. green color. Clasts only of granite - no volcanic clasts noted. Imbrication uncertain.

dips of 20-40°

② andesite flows and subordinate andesite flow breccias, calculated to ~1000' thick. Most flows badly deuterically altered and weathered. Breccias form ledges. The basal andesite, about 10-20' above the conglomerate, dates at 20.0 ± 0.42 m.y. (this report)

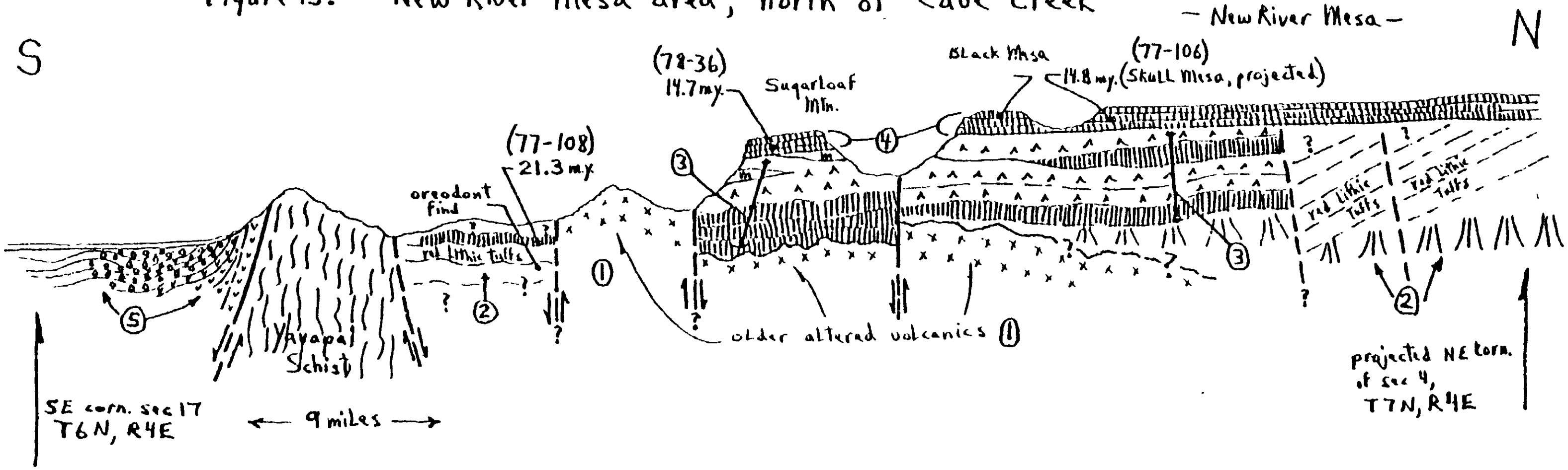
③ Laminated mudstones intercalated with two vitric rhyolitic ash beds, the lower of which is 1.5' thick and fresh except for a basal ½" thick bentonite. Mudstones are light buff colors and somewhat calcareous. gypsum not noted. Certain horizons beneath lower ash bed contain carnotite (?) lined vertical fractures. (to 240 cps). Pit containing the carnotite is marked on Aguila Quad as in SW¼ SW¼ sec 13, T6N, R8W. Mudstones contain thin claystone layers of various colors. Coarser sediments not noted here.

dips of 10-15°

(4a) capping basalt series, dips SW at 10°, and dates at 15.6 ± 0.4 my (this report). Dated sample comes from the basalts about 1 mile SE of the cross section. 4b is presumably same basalt series, nearly flat-lying and apparently overlying a volcanoclastic sequence not seen at 4a.

⑤ Leucogranite with N to NW trending pegmatites and also containing mafic-rich dikes.

Figure 15. New River Mesa area, north of Cave Creek



① Hard, dense, highly fractured, bleached, and locally altered volcanics. Undated here, but very possibly equivalent to the oldest volcanics at Lake Pleasant, which are Oligocene.

② not visited for this study, but a series of tuffs and agglomerates with some very bright red colored lithic tuffs. The section contains a 21.3 ± 0.5 my age date on a tuff very near an Oreodont fossil find (E. Gomez M.S. Thesis, ASU, 1978). To the north, this series more deformed than ③.

③ Basalt—tuff assemblage containing fluvially reworked tuffs, minor mudstone lenses (m, above). No limestones or dolomites noted. No anomalous radioactivity noted. The section is gently warped, beveled, and covered by the upper basalt series. The series at Sugarloaf Mtn. is downdropped 100-200' from the main mesa and tilted ~5° southward.

④ Upper basalt series, essentially flat lying on New River Mesa, but dipping ~5°S on Sugarloaf Mtn, where the entire section gets faulted downward along E-W faults and dips in towards the valley. K/Ar ages of 14.7 ± 0.35 my at Sugarloaf Mtn. and 14.8 my at Skull Mesa indicate middle Miocene age for basalt caps.

⑤ Tuff-conglomerate series in high angle fault contact with schist. Section shows drag effects indicative of normal faulting. Basal rock is silicic volcanic flows (rhyolites ?), overlain by tuff breccia with fragments of hard white tuff and flat chert fragments, overlain by pebbly reworked tuffs (clasts of old volcs, above, and schist), overlain conformably by a pebble-cobble fanglomerate with many sandy, pebbly layers. Unit gently warped and pedimented to the south where it appears to underlie most of the area to Cave Creek townsite. Locally, lower layers contain buff mudstone lenses.

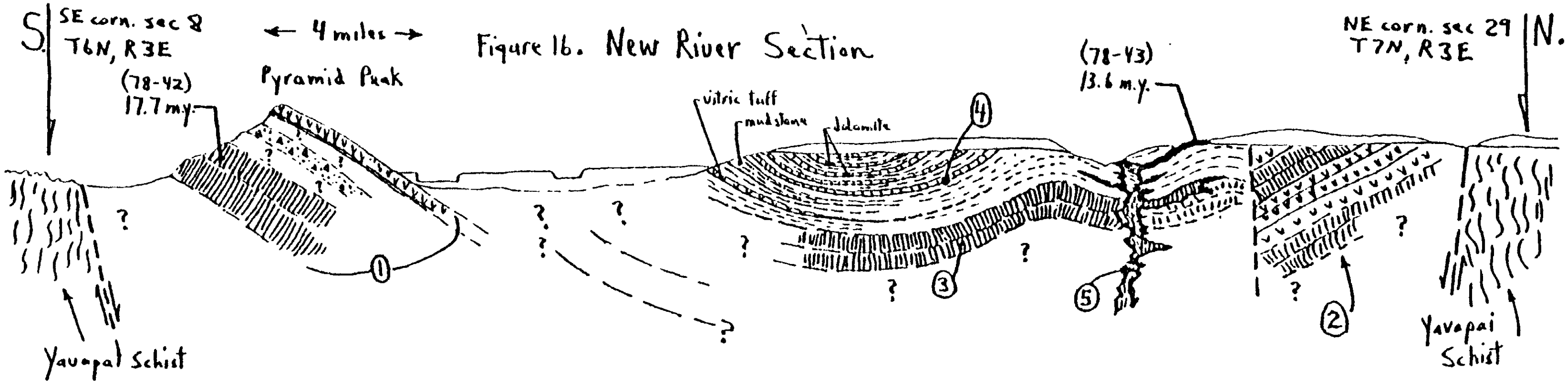


Figure 16. New River Section

① Northward tilted section at Pyramid Peak consists of a lower series of basalt flows, a covered interval containing some probable sediments and silicic volcanics, a 10' thick tuff bed (white, reworked air fall) which counts 1.5X, and a capping ash flow sheet which contains a vitrophyre zone. Section dips NNE at 20°. K/Ar on the uppermost basalt flow = 17.7 ± 0.4 m.y., this report. This section in high angle fault contact with Yavapai schist to the SW. Basalts are black, dense, and amygdaloidal with $CaCO_3$.

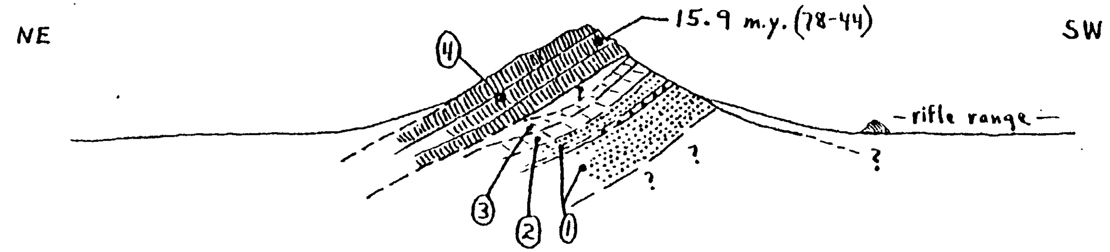
② A sequence of tuffs and basalt flows, southward dipping, and seen in wash along west edge of sec. 32. Tuffs are primary and reworked, and do not count above background.

④ An assemblage of 2 ft. thick dolomite beds rhythmically bedded with calcareous mudstones, and underlain, ③, by andesite flows seen in wash to east of sec. 32. The dolomites are resistant ridge formers, are not silicified to any extent, but count 2X to 5X. The less resistant interbeds do not count much above general background. The section also contains in different areas a lower 2 ft. thick vitric air fall ash bed, and a 10-20 ft thick light green and yellowish mudstone unit capped by a devitrified air fall ash bed which is now altered to clinoptilolite in the area visited. Uranium mineralization is disseminated throughout the dolomites, and not concentrated on fractures.

⑤ dike-like body of basalt with many stringers and pods which have intruded the light-colored sediments and which display chilled margins. K/Ar = 13.6 ± 0.4 m.y., this report.

Sections ① and ② are grossly similiar in that they both contain basalts, white tuffs, and vitrophyres. The section containing ③ and ④ may be younger or older than the others. The tuff-basalt sequence is in high angle fault contact along NW trending faults with Yavapai Schist to the north.

Figure 17. Section at the rifle range, I-17 & Carefree Highway.



section dips NE at ~20-35°. Perhaps 300' of sedimentary section present here.

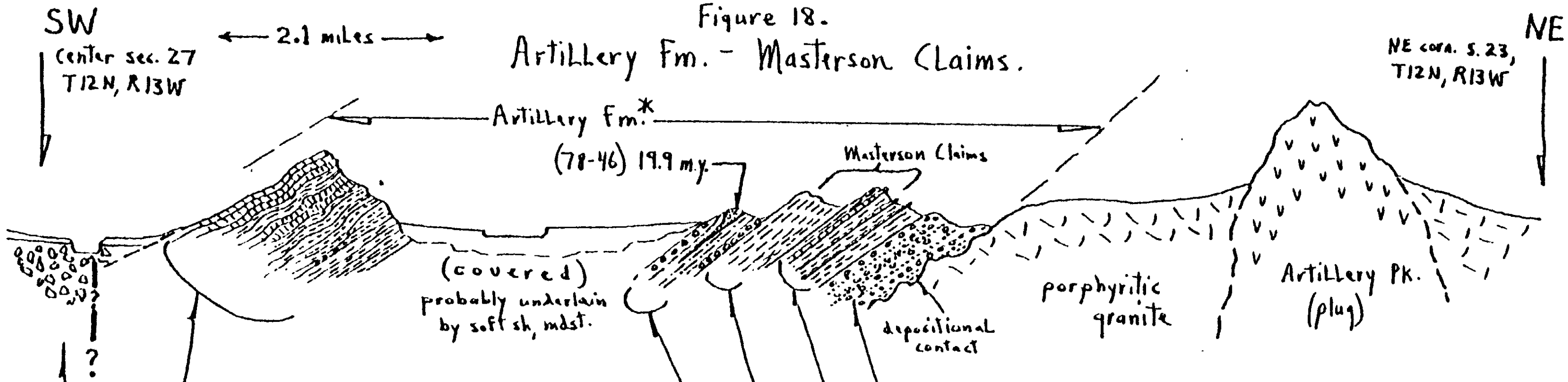
① Poorly sorted fluvial sands, commonly with clasts of pumice fragments and andesite pyroclastic cinders. Deposits display low relief channeling and cross-bedding, not very clay-rich. One thin biotite-bearing devitrified ash bed one-half way up the unit is K/Ar datable (not collected).

② lower 20' thick dolomite bed, with abundant brecciated structure, dark to brown chert pods, veinlets. Counts to 2.5 x. dolomite is aphanitic. light gray chert also appears to replace plant root casts in certain horizons. Brecciation appears related to silicification in places, where silicified dolomite angular fragments are "floating" in masses of gray chert!

③ Upper 20' thick aphanitic light gray to white dolomite bed. Silicification minor compared to lower bed. Counts at or near background for the area.

④ Section of several flows of basaltic andesite, wea red-brown colors. phenocrysts of plagioclase, olivine. Second or third flow up from base sampled for K/Ar dating. Age = 15.9 ± 0.4 m.y., this report. As viewed from the south, the flows appear to truncate lower section gently, and exact contact between the dolomites and volcanics is buried.

Figure 18.
Artillery Fm. - Masterson Claims.



Questa capped by wea. gy to Lgt. tan ls, with chert Lenses and fossil casts. Main material is thin bedded Ls, Limey sh, and mdstnes, all very well Layered. Bottom part of section is soft, friable purple-brn mdst sequence w/ occasional Ls bed. Most of section counts 160-200 cps — hot for Ls! Capping rock in one area is a hard brown noncalcareous arkose.

probable tectonic contact with very coarse grained boulderey beds — in part massive mudflows or debris flows off of high slopes. In places interbedded with fluvial overbank siltstones.

basal arkosic conglomerate, mostly red colors, with few layers green colored. Mostly fluvial bedding. clasts from granite beneath. 150' thick.

shale, mdst, minor ss, minor Ls beds. clastics multi-colored (purple, red, maroon, gray, etc). All units Thinly Laminated and very continuous. One thin Ls bed has assymetric ripple marks, 3 cm. wavelength. Lowest chert nodule Ls counts 1600 cps (~20x). Lacustrine sequence. ~ 100-200' thick.

bright green shale, with minor ss, mdst, thin Ls beds. 1 thin tuff bed. To 200 cps - much dozer activity in this unit. ~ 10- 100' thick.

brown-red fluvial grus conglomerate, enclosing a 30' thick wea. blue-gy mdst sequence, which in turn contains a small rhyolite concordant mass or plug, for K/Ar dating. total ~150' thick. K/Ar (whole rock) = 17.9 ± 0.5 m.y. (this study).

* this indicated thickness from dip calculation is about 2000' assuming 3400' of outcrop length, 36° average dip.

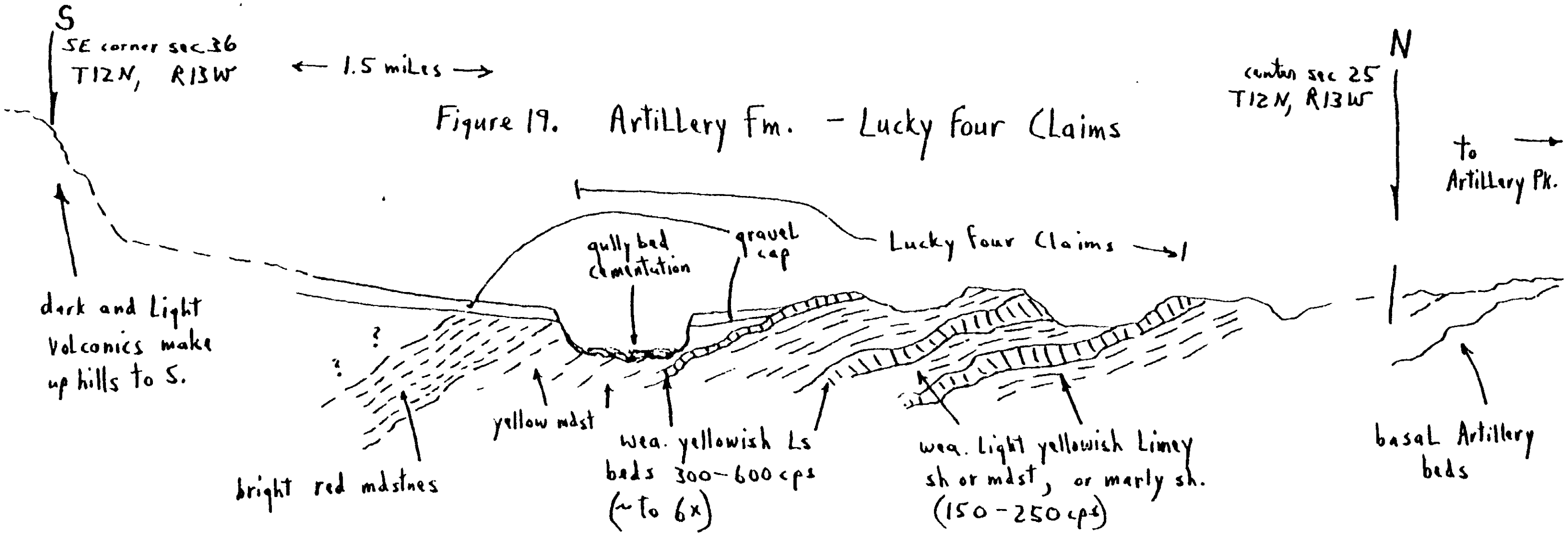
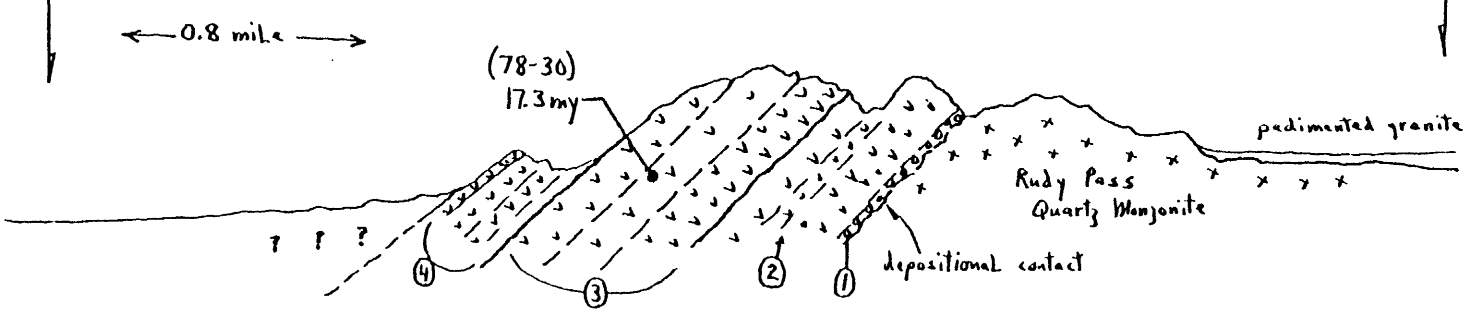


Figure 19. Artillery Fm. – Lucky Four Claims

note: These yellow Ls + mdstnes clearly track to the northwest to become the Ls + mdst that cap the Artillery Fm. there. Scattered drillholes have been placed in the entire Artillery Fm. units in the area.

Figure 20

Harcuvar Mtns. – Southeast arm near Rudy Pass



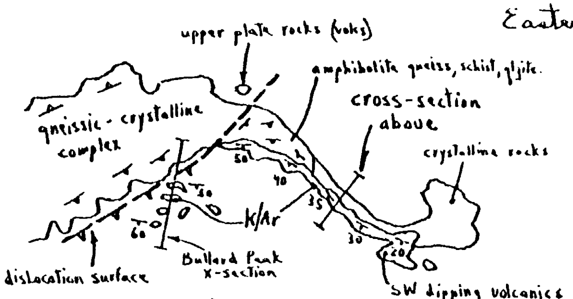
entire section here dips ~ 30–40° SW.

① basal arkosic conglomerate, poorly exposed and < 10' thick. Reddish colors, clasts of granites. Few greenish colored stringers. Mostly mudflows with few well sorted arkosic sand lenses. Parts of unit calcareous, parts are not.

② basal welded ash flows, to 75' thick. Green colors. With lithophases and vapor-phase recrystallized vertical fractures. Volcanics mixed with minor amounts of arkosic sediments.

③ Three Trachytic welded tuffs w/ eutaxitic structure and quartz-filled lithophases. to 120' thick total. The top of the second flow dates 17.3 ± 0.4 my, this report.

④ poorly welded but layered ash flows with intercalated red-brown arkosic sands and possible new andantes. Capped by an andesite flow breccia. to 150' thick.

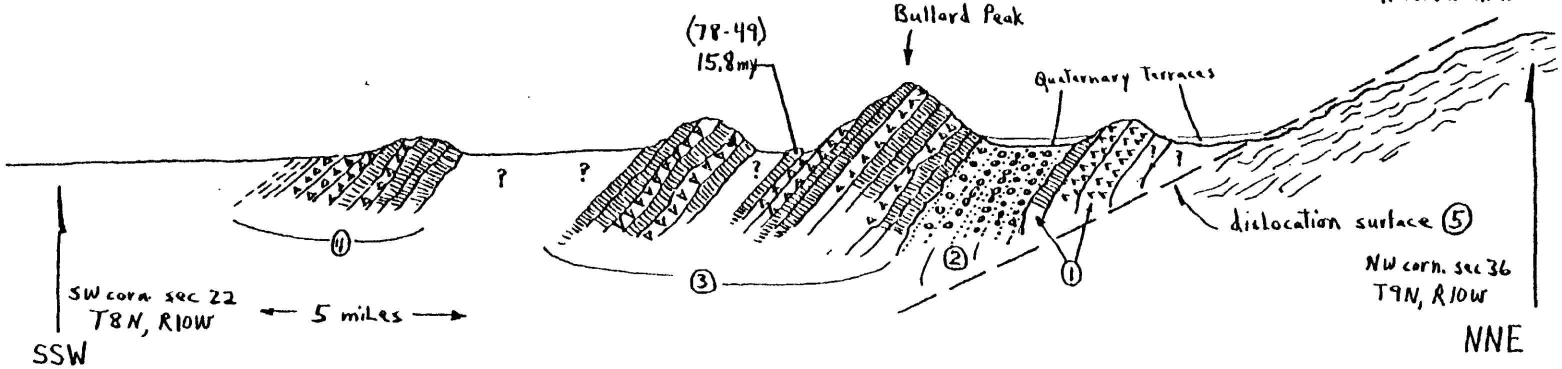


Sketch map, eastern Harcuvars.
oral and written comm., Steve Reynolds.

Eastern Harcuvars – General Geology (S. Reynolds data, March 1979).

In the SE arm of Harcuvars, volcanic section is depositional on metamorphics and Laramide granites. Dips range from 20° SW to the southeast, and steepen to 50° near the main mountains. Volcanics at Bullard Peak rest on a "dislocation surface" under which are the gneissic - crystalline complex rocks of the Harcuvars. An undefined structure separates the two terrains (dashed line at left). The SW dips on the volcanics in the area are part of a regional dip pattern and hence are independent and older than movement on the "dislocation surface," which is probably relatable to the formation of the Harcuvar foliation arch.

Figure 21. Harcuvar Mtns. – Bullard Peak Section.



entire section here dips SSW at 35–70°. See sketch map on Harcuvar – Ruby Pass section for x-section location. Thickness of section ~8500' assuming no fault repetitions, and 40° average dip angle.

① Going up section, a gray lithic tuff, a red lithic tuff, and an andesite flow. dips 50–75° S.

② Red-brown bouldery cobble conglomerate. Very poorly stratified, probably represents debris flows. volume percentage of clasts > 50%. Clasts of pЄ granite, reddish very well rounded hard quartzites, Livingston Hills cong lithologies (unmetamorphosed), rare andesite clasts. clasts sub angular to very well rounded for some quartzites. No fluvial beds noted.

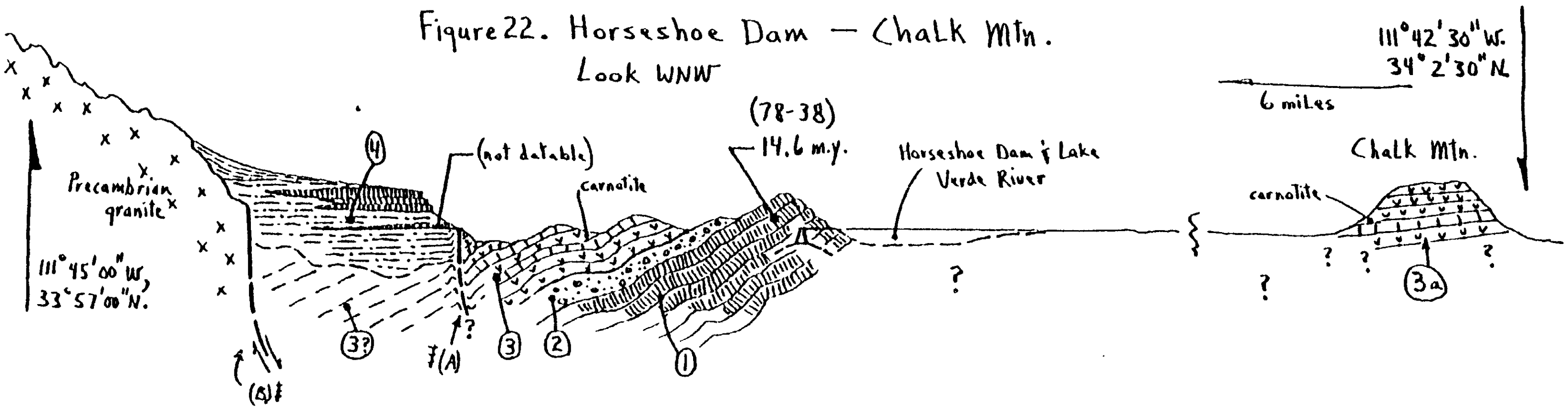
③ 2–3000' of andesites and andesite flow breccias. A hard dense flow from near the center of the andesite stack dates 15.8 ± 0.4 m.y., this report. Copper mineralization (chrysocolla, etc) is common in this terrain in the andesites, and many NW trending mineralized zones were noted. One deposit contains turquoise at and near the Bullard Mine. Another E-W shear zone is lined with barite, with fluorite, manganese oxides, black calcite, and minor copper. No anomalous radioactivity was noted.

④ andesite flows grading upward into lahars which display laminar bedding on a fine scale. Soft lithologies up section are totally covered by Quaternary deposits.

⑤ The dislocation surface is believed to have been warped to its present shape by an event which is not directly related to the event that established the regional SW dip of the upper plate rocks, i.e. the present dip angle of the upper plate rocks appears to be partially attributable to two different "tilting" events.

Figure 22. Horseshoe Dam — Chalk Mtn.

Look WNW



(1) Lower series of dark gray and red brown andesites and flow breccias which forms the abutments of Horseshoe Dam. They dip 20-25° towards SW. K/Ar age of 14.6 ± 0.4 m.y. (this study) places a maximum on the age of the overlying uraniferous tuff-ls beds and on the time of tilting of the section. Perhaps 500-1000' thick.

(2) fluvial gravels with pebbles and cobble clasts exclusively of dark colored volcanics found downsection. perhaps 50-200' thick.

(3) upper tilted beds consist of medium-bedded tuffs, reworked tuffs*, tuffaceous fine-grained sediments mixed in with lesser amounts of limey sediments and small amounts of bedded limestone. Counts to ~4x in mudstones shot through with ½"-2" thick silica seams which trend sub-parallel to the fault (A) above. Elsewhere, carnotite fracture coatings are seen locally and count to ~2-4x where they occur in white tuffaceous materials, probably fluvially reworked airfall pumaceous deposits. Calculated 1000' thick.

(3a) Chalk Mtn. area was not visited but unpublished maps and data of Tom Howell (pers. comm.) suggest these materials are probably the same as (3) above. Carnotite found in fracture coatings in some limey tuffaceous materials at base of mountain. Section here dips 5-10° SW.

(4) younger, essentially untilted section of fine grained clastics with light colors (probably mostly fluvial overbank silts and muds) with several intercalated fresh-looking flows of dark olivine-bearing basalt, and a few thin beds of vitric air-fall ash which are devitrified. A K/Ar age was attempted on a lower flow (above) but had excessively high air argon correction and is undatable. This sedimentary package is assumed to be 10-5 my old based on regional analogy.

notes: * — several tuff beds are not reworked to any degree, but have bright orange-brown or green colors indicative of zeolitization. ‡ Listric faulting has probably caused some tilting in this area, but it is now unclear as to which faults are the listric faults, and which ones are simply high angle Basin-and-Range faults.

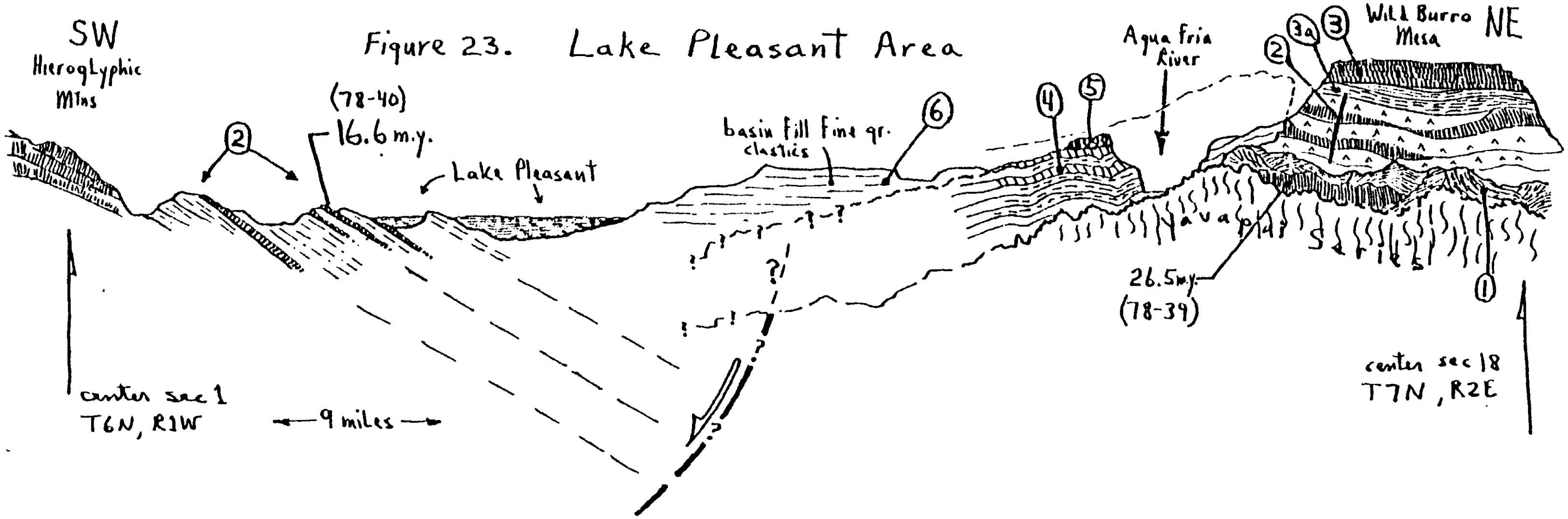


Figure 23. Lake Pleasant Area

① completely deformed assemblage of andesite flows, flow breccias, auto-oxidized cinder cone deposits, and rhyolite primary air fall pumice deposits. K/Ar on a basal chocolate-colored andesite of this series which directly overlies Yavapai schist = 26.5 ± 0.6 m.y., This report.

② basalt-tuff series, with a variety of deuterically altered dark colored basalt flows, primary and fluvially reworked tuffs and tuffaceous sediments, and minor fluvial fine-grained mudstones. Gently folded only under Wild Burro Mesa, in a N-S elongate block west of Lake Pleasant tilted 15-25° East. A basalt tilted 15° E west of the lake dates 16.6 m.y., this report. No anomalous radioactivity noted.

3a buff-colored fluvial sequence under the capping basalts. Uncertain whether it belongs to group ② or ③.

③ Essentially undeformed mesa-capping basalt flows, 50-100' thick; extend to the Cave Creek Area, where the basalts date 13-15 my.

④ tuff-limestone series depositional on Yavapai Series and unit ② deposits, probably younger than ③ basalts. Tuff beds are primary and reworked, beds 2-4' thick. Light tan and yellowish limestones are interbedded and range 2-20' thick in places. Beds count to 2-3x in places. Some carnotite in fractures.

⑤ Cliff-forming calcareously cemented conglomerate with lower part with black matrix. Clasts of everything, (p€ is minor). Probably a proximal basin fill-aged deposit. Perhaps a channel fill remnant.

⑥ Fine grained basin fill mudstones, fluvial overbank origin. Contains carnotite, counts to 3x near the surface in NE¼ section 21, T7N, R1E. As well, carnotite fracture coatings in soils developed on this material, same general area.

Figure 24. Catherine & Michael Claims

T 16½N and 17N; R12W

Big Sandy Valley, NE from Wikieup

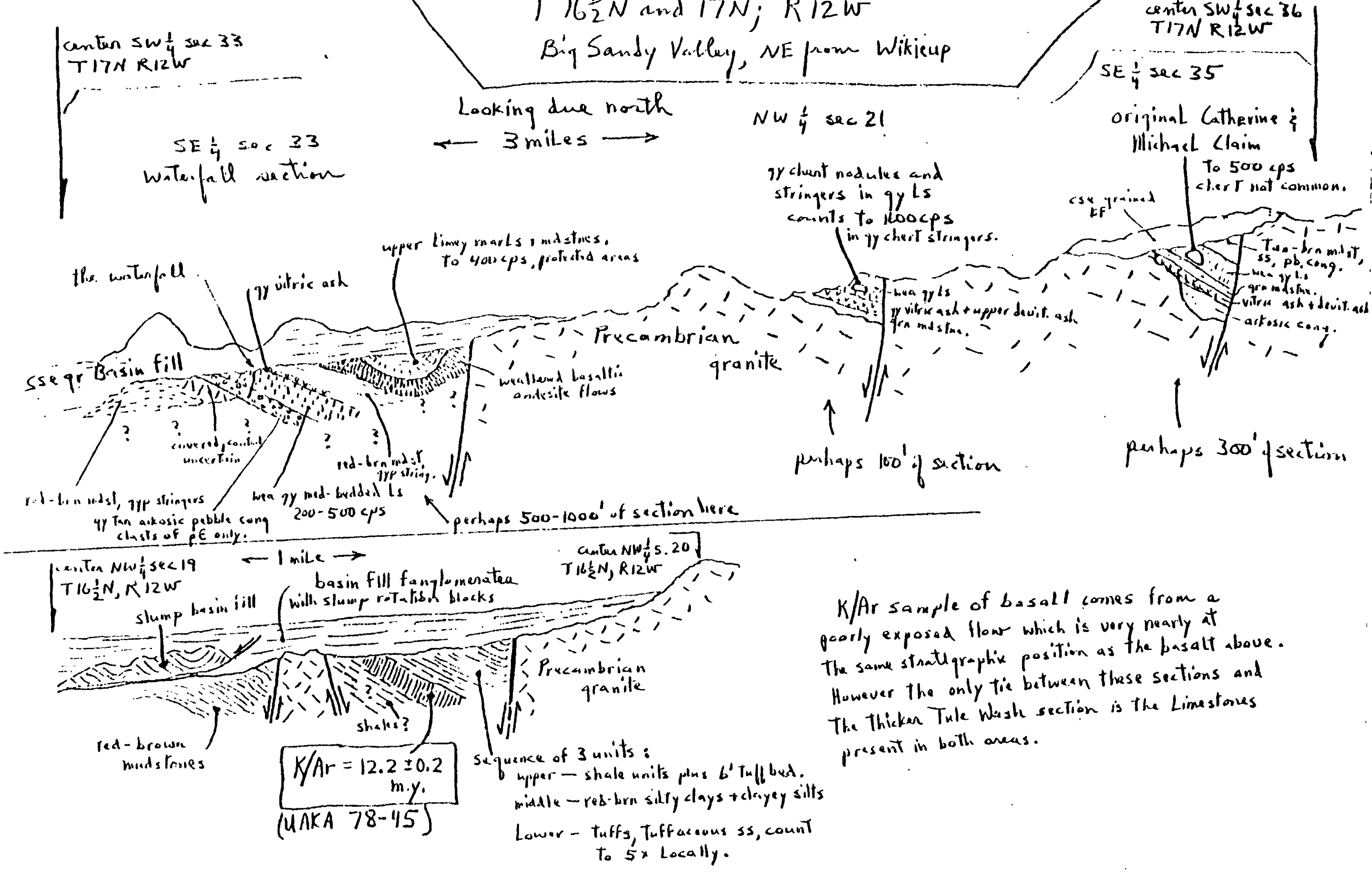
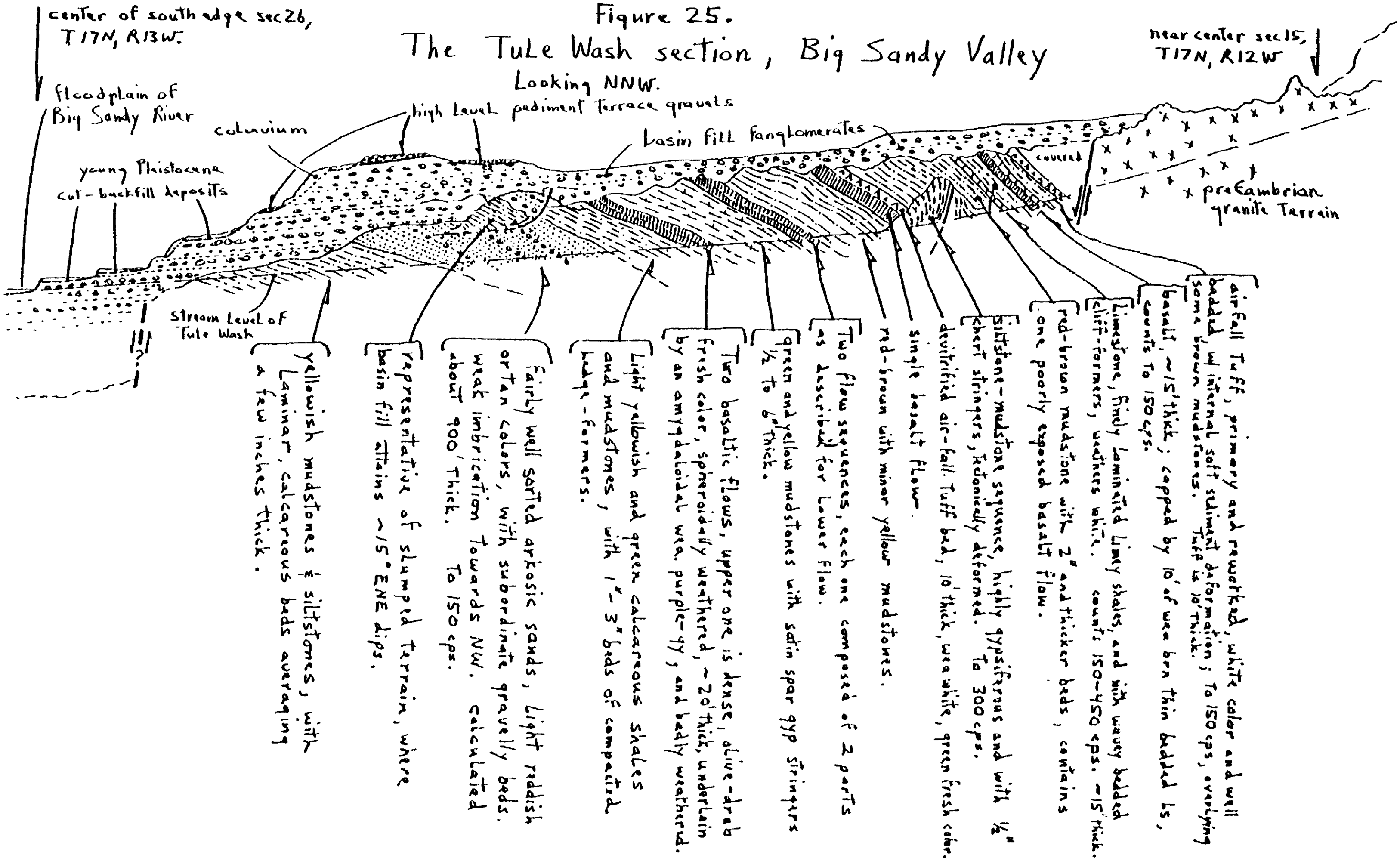


Figure 25.
The Tule Wash section, Big Sandy Valley
Looking NNW.

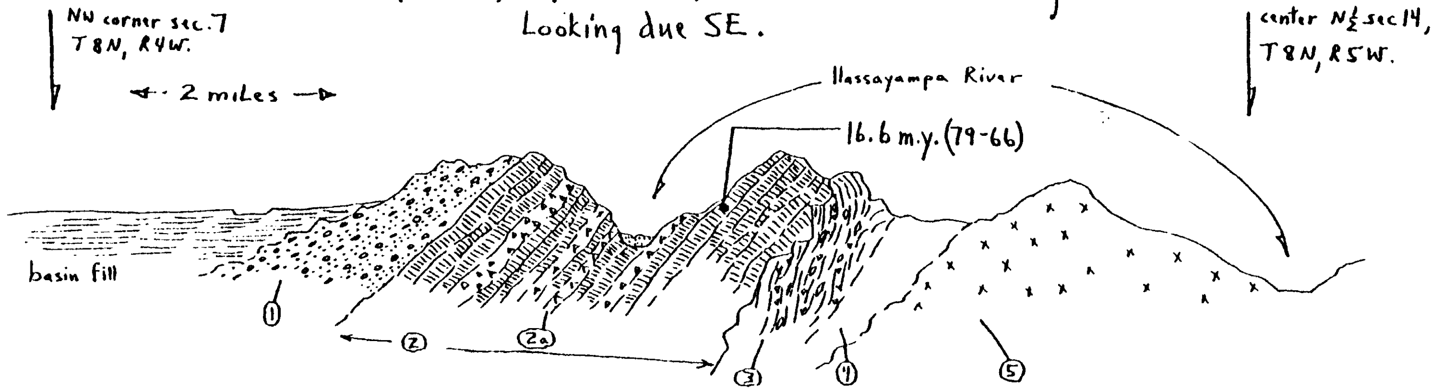


notes: ① Tilted section outcrops along Tule Wash for 3.6 miles. Dips range from ~15° near the valley axis to ~27° near the Basin and range fault. Calculated Thickness is about 6500'.

② Basin fill is up to 150' thick above the pediment cut on Tilted section, and is smoothly graded to the Big Sandy Valley axis. Where it rests upon mudstones, slumping and antithetic rotation towards the valley axis has prevailed over Large Tracts of Land, producing tilts of basin fill slump blocks of up to 30-40°, averaging perhaps 15°. Slumping into main Tributary stream courses is also noted. Basin fill above is herein considered as a coarse pediment facies of the Big Sandy formation of Sheppard & Gude (1972)

Figure 26.

Section along Hassayampa River, northeast of Wickenburg
Looking due SE.



① Redbeds, consist of fanglomerates. bedding 6" - 2' Thick, beds consist of subequal amounts of fluvial channel sands, bar and swale conglomeratic sands, point bar assemblages, & 1½' thick debris flow deposits. Colors are med. red-browns. Imbrication points toward* S and SW. dips ~30° towards N35-45°E. clasts are granites and andesites seen in the area. Paleozoics, Apache Gp, etc. not noted. Red-brown colors. Thickness may exceed 500'. From strike & dip data, there may be ~10° discordance in dips with underlying andesites.

② Andesite flows, flow breccias, pyroclastic units, and Tuffaceous beds. Rather well bedded, with dips of 35-45° Towards N45°E. Section in general not much altered. K/Ar sample of dense flow material about ¼ way up the section from the bottom dates at 16.6±0.4 m.y. (this report). Andesite section by map inspection in main watergap here is 500-800' Thick, and K/Ar sample has at Least 100' of andesites beneath it.

③ Andesitic - intermediate cinder cone or composite cone material, including steeply inclined beds of pyroclastic materials, spatter flows, and elongate (1'- 3.5' Long diameter) bombs. Clearly on the flanks of an intermediate sized andesitic volcano.

④ In places, hypothesized to consist of intermediate, perhaps Trachytic flows (Steve Reynolds, pers. comm.).

⑤ Section is inferred to be depositional upon the Laramide Wickenburg batholith. The contact was not observed.

* Flow direction to the S-SW.

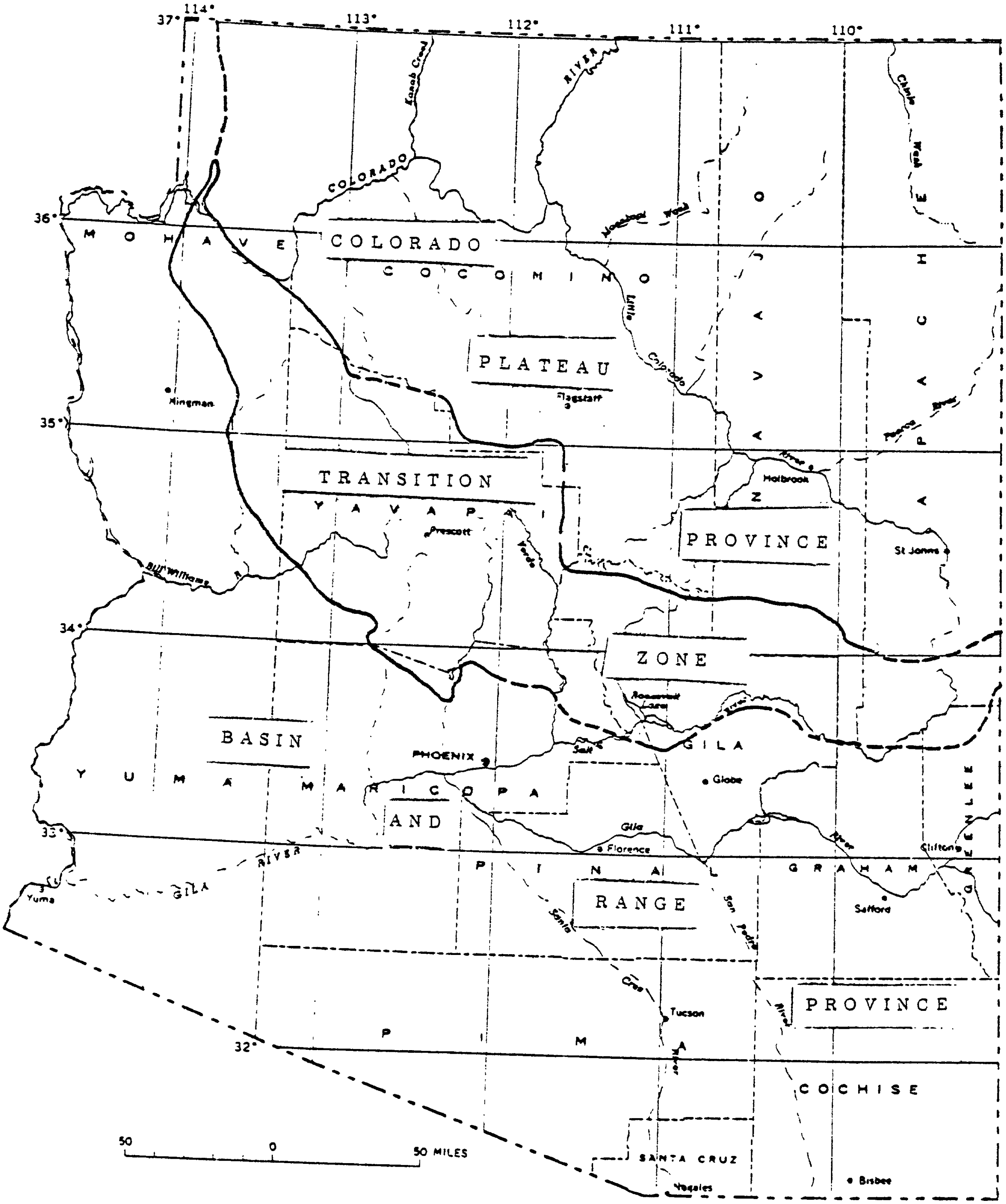


Figure 27. Arizona physiographic provinces used in this report.

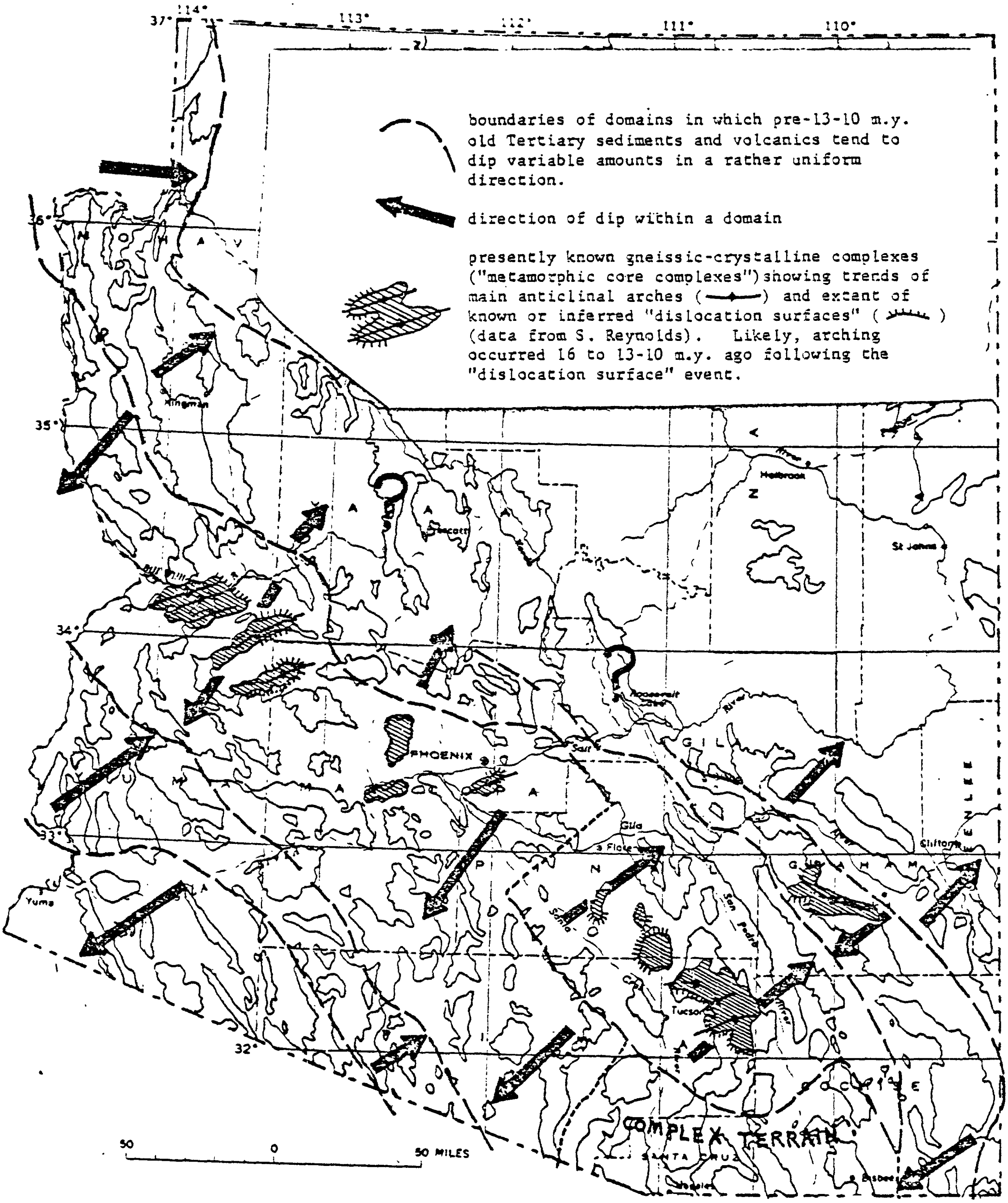


Figure 28. Regional dip directions of pre-13-10 m.y. old Tertiary sediments and volcanics (large arrows) grouped into domains approximated by dashed lines, modified from Rehrig and Heidrick (1976). The domain boundaries may not have changed much during two or three Oligocene-Miocene deformations, thus indicating a fundamental basement control. Note also a geometric relationship within a domain between the main trend of dip directions and the assymetric distribution of dislocation surfaces around gneissic-crystalline complexes.

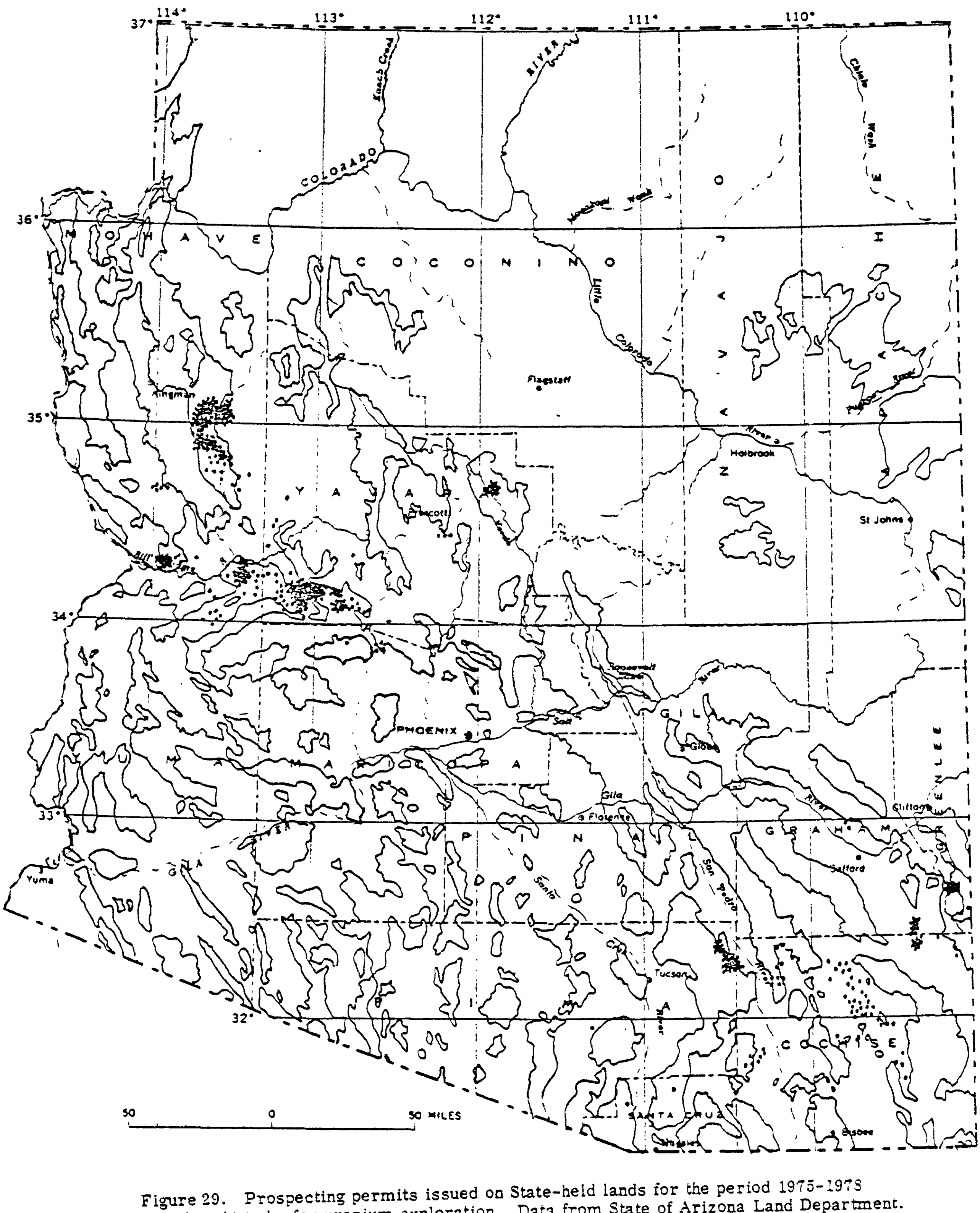


Figure 29. Prospecting permits issued on State-held lands for the period 1975-1978 thought to be for uranium exploration. Data from State of Arizona Land Department.

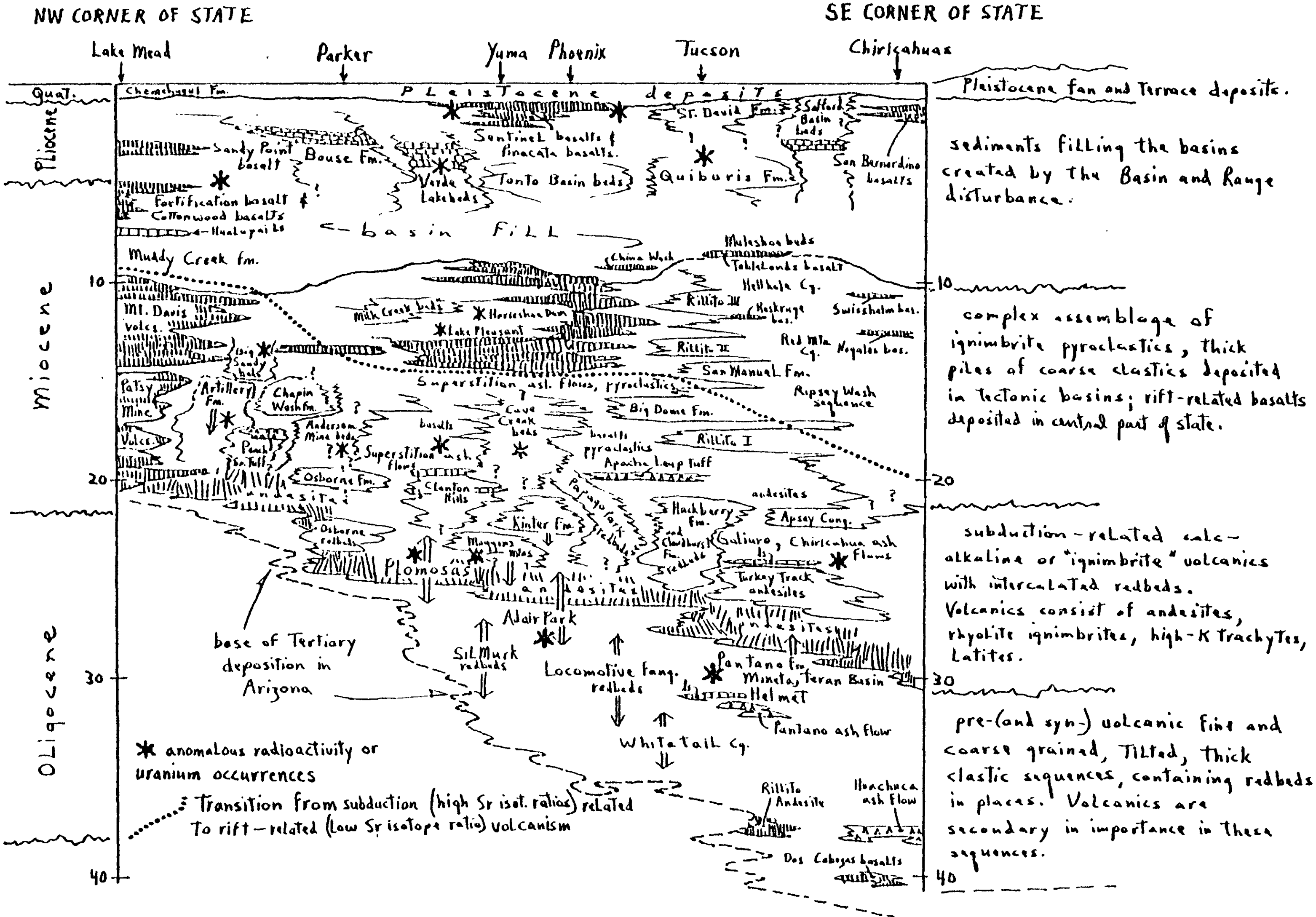


Figure 30. Space-Time frame of Arizona Basin & Range Cenozoic deposits projected to a general NW-SE cross-section Line.

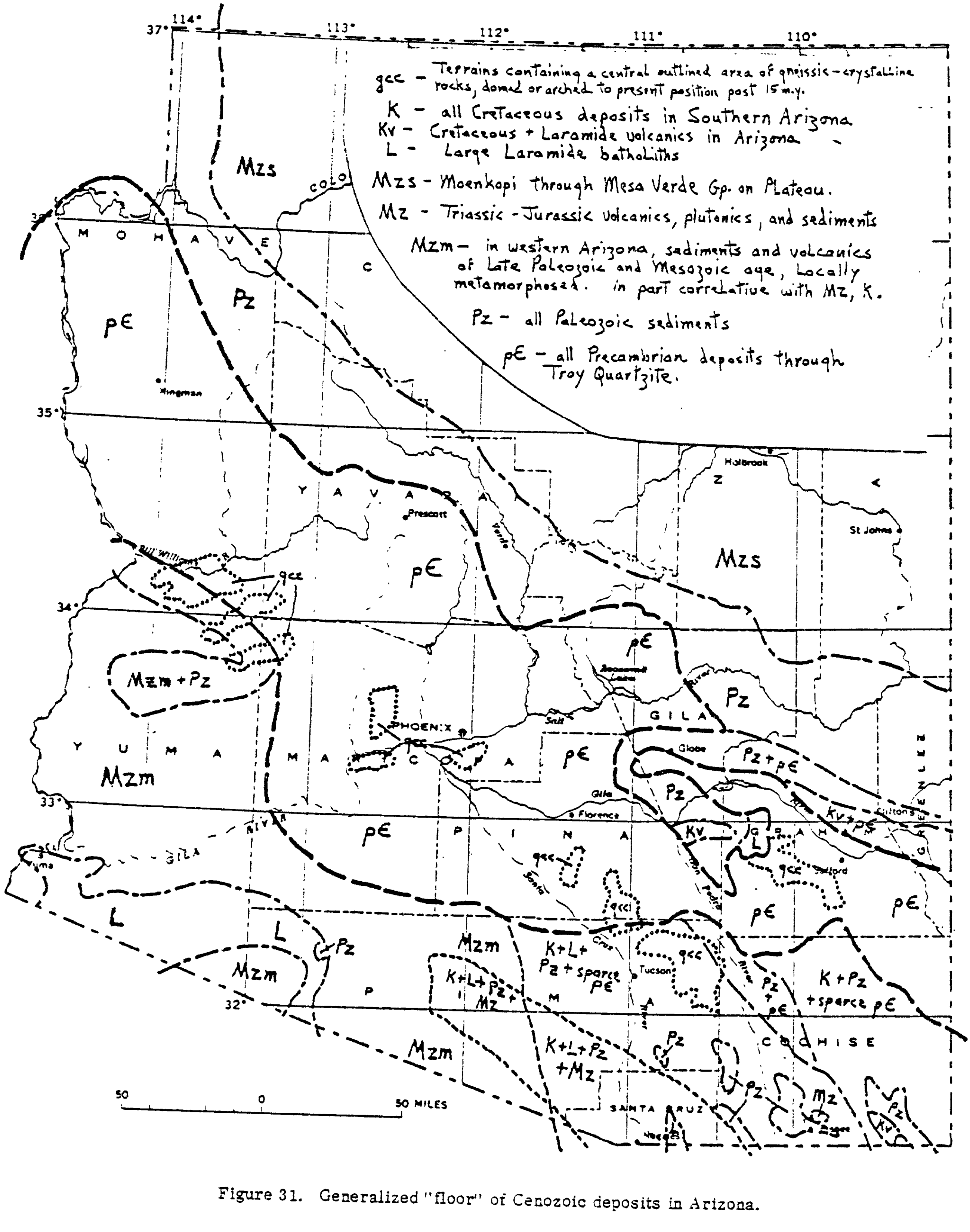


Figure 31. Generalized "floor" of Cenozoic deposits in Arizona.

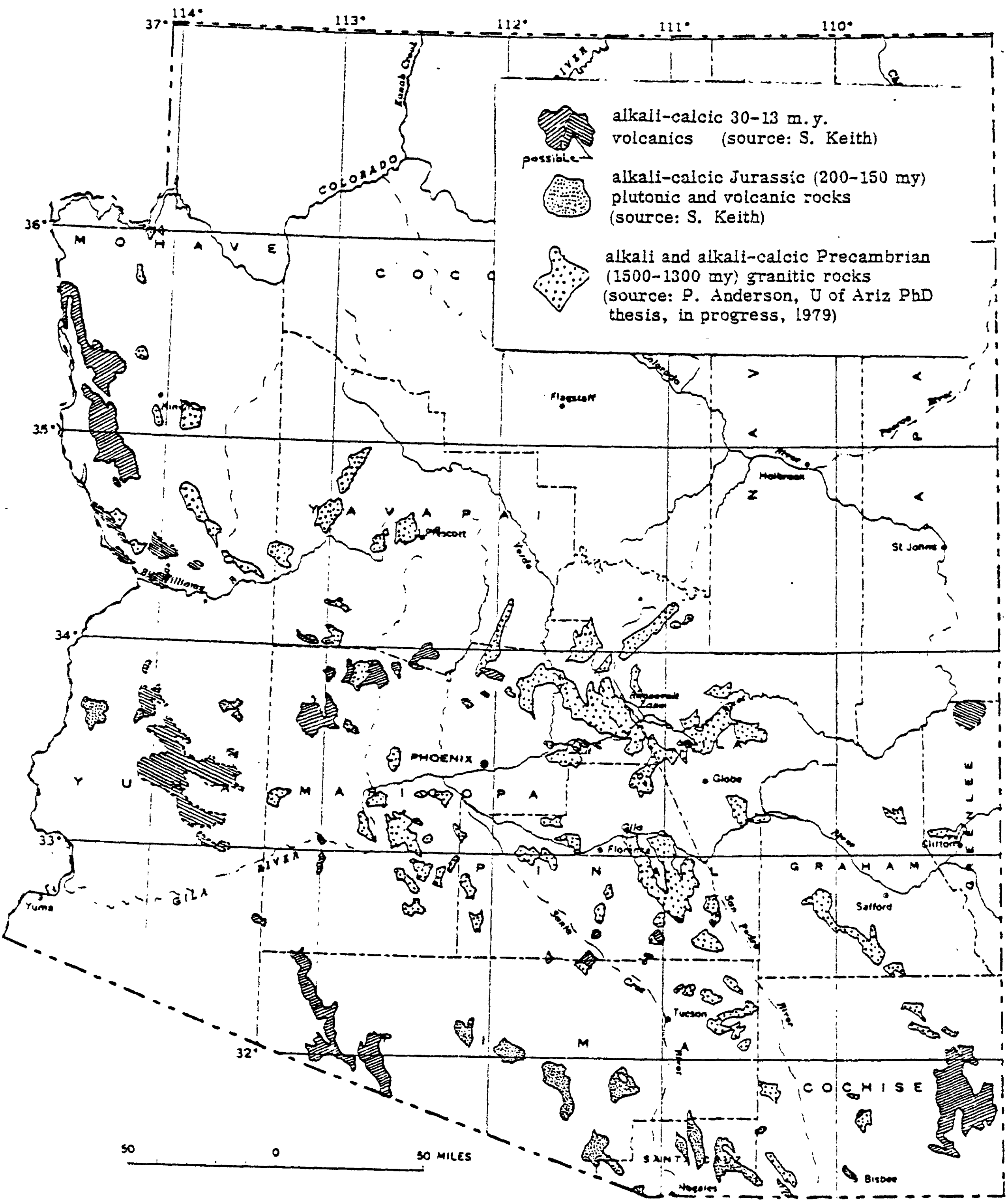


Figure 32. Presently known outcrops of alkaline rocks which might have served as sources of uranium for Tertiary sediments.

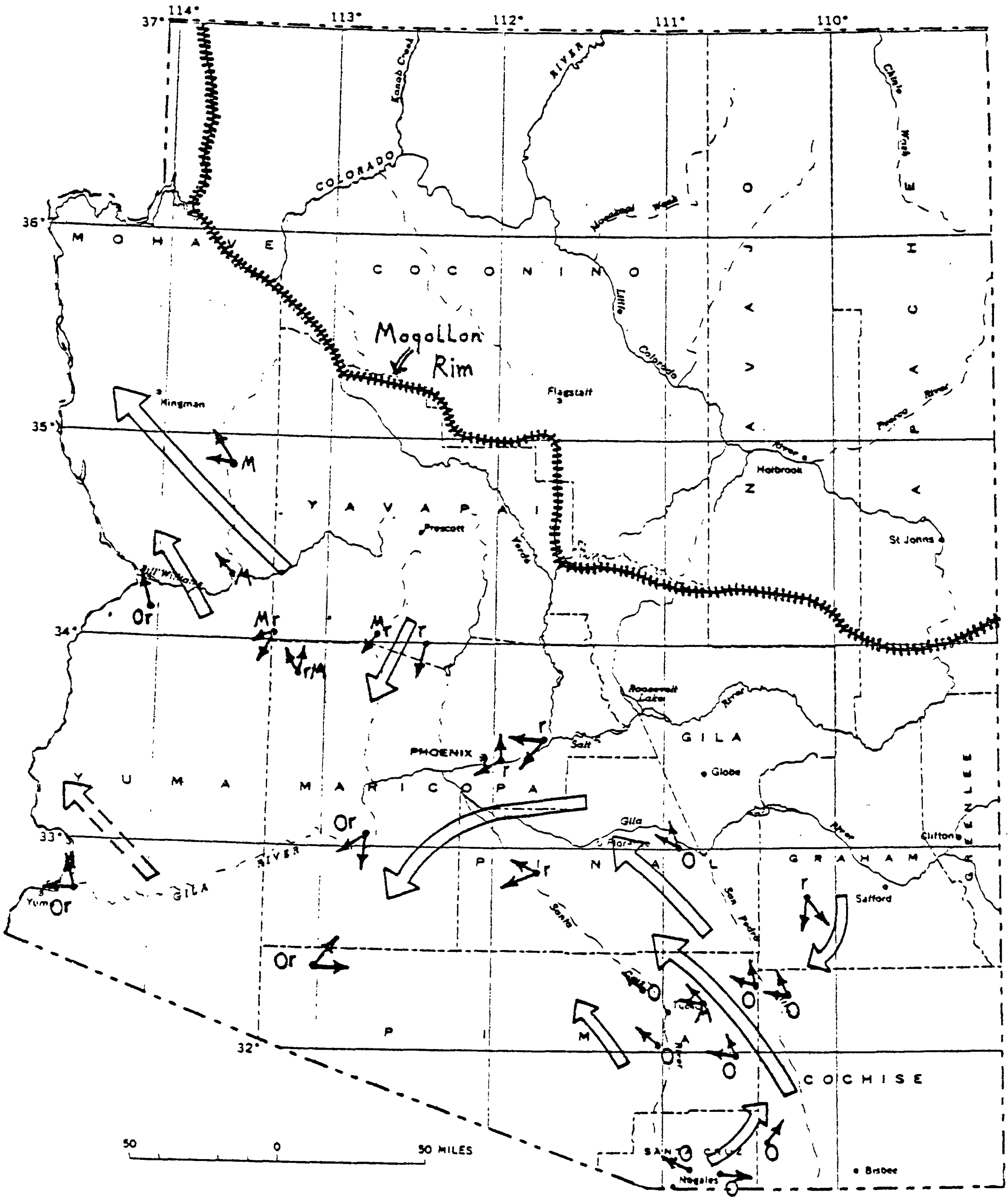


Figure 33. Generalized sediment transport directions of Oligocene and earlier Miocene fluvial sediments in Arizona's Basin and Range province. Data comes from pebble imbrication and cross-bed directions. O = Oligocene aged; M = Miocene aged; r = mostly red-colored sediments. Large hollow arrows are generalized from the specific localities. The Mogollon Rim of today is a paleo-feature probably present in Oligocene time and therefore was a northward limit to Oligocene deposits.

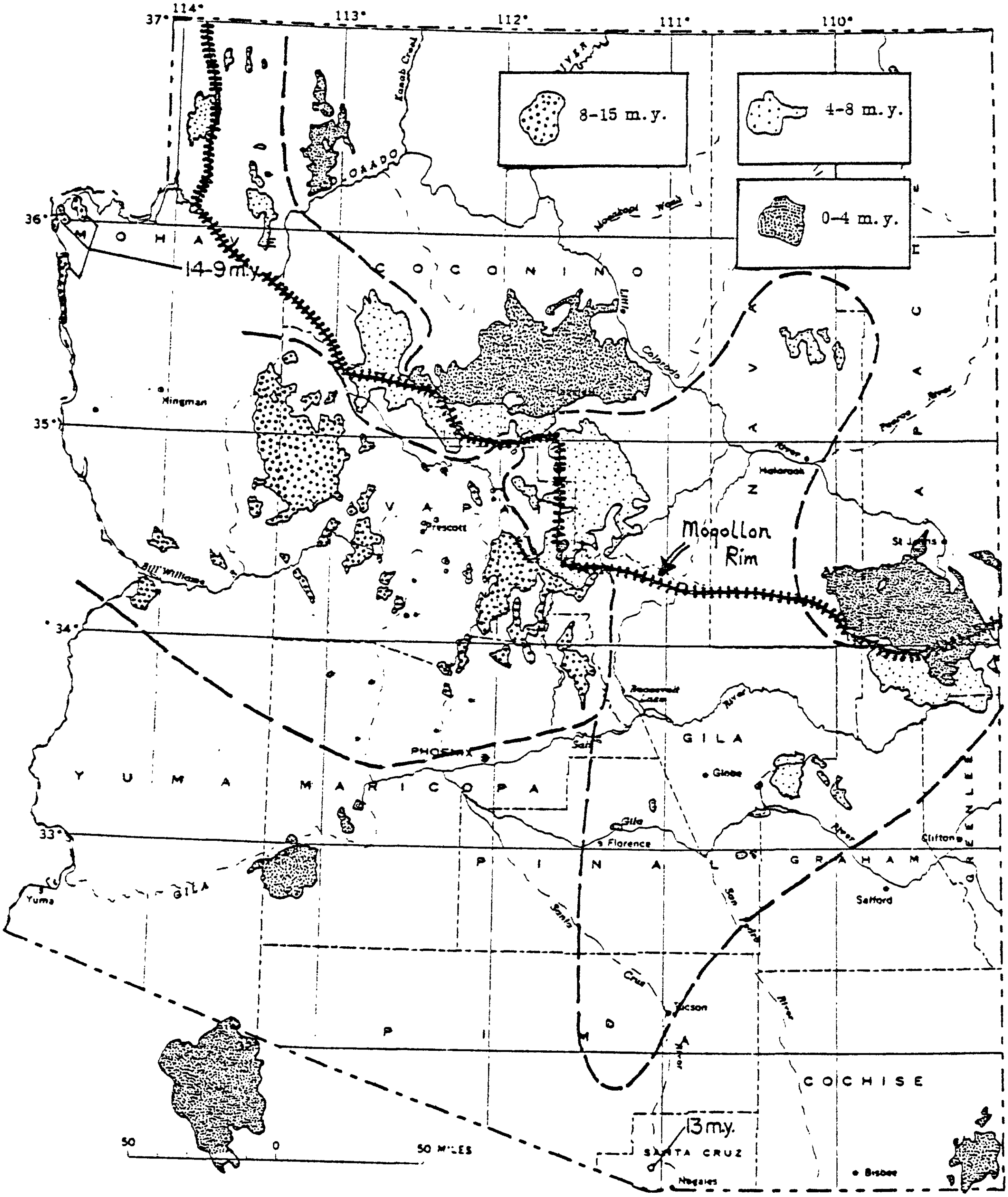


Figure 34. Generalized outcrop map of post-15 m.y. old volcanic fields in Arizona. In places these rocks may be covering and preserving uranium-bearing mid-Tertiary sediments. Sources include Eberly and Stanley, (1978); Luedike and Smith (1978).

TABLE 1. URANIUM LOCALITIES IN PRE-BASIN FILL TERTIARY SEDIMENTS IN THE BASIN AND RANGE PROVINCE OF ARIZONA

(*) denotes areas visited and geologically updated. Otherwise, data comes from references.
(**) See listing at end of table for visited localities containing other than Tertiary sedimentary host rocks.
(+) All measurments for this report were made with a Geometrics model GR-101A single channel gamma ray scintillometer.

Locality	Number on Index Map, Figure B	Cross-Section Fig. No. (See Fig. A for Locations)	Host Rock Characteristics	Uranium Mineralization Associated Minerals Anomalous Radioactivity	Radioactivity and Background. Decimal numbers are % eU_3O_8 2x = 2 times bkg.	References (G&R= Granger and Raup, (1962); Keith = Keith, (1970)
MOHAVE COUNTY						
Big Sandy Valley *Catherine & Michael Claim SE¼ S35, 17N, 12W	1	24, 25	Tilted blocks of fine grained clastics, depositional on p€ granite and tilted by high angle faults. Minor tuff beds and basalt flows in the section.	Counts in limestones with chert nodules and stringers; and in gypsiferous mudstones. PRR reports uraniferous opal.	5x (.013)	PRR (illegible) G&R p. 16-18 Keith, S-27 This report
Artillery Peaks Area *Lucky Four NE¼ S36, 12N, 13W	3	19	Five foot thick carbonaceous bed and several thick-bedded limestone beds in e thick, tilted fluviolacustrine section of the Artillery Fm., probably 1-2000 ft. above base of section.	Counts in light-colored limestone beds and gray mudstones. Chert locally abundant. PRR reports tyuyamunite and carnotite.	5x (.02)	PRR-A-82 Keith, S-29 This report
*Masterson Group Center S22, 12N, 13W	4	18	In tilted section of Artillery Fm.-depositional on Precambrian granite. Probably 2-400 ft. above base of section.	Counts in laminar bedded dark-colored shale-mudstone-limestone sequence just above basal conglomerate of Artillery Fm.	10x (.08)	PRR-A-68 Keith S-30 Finch (1967) This report
Candy Bar Group N½ 12N, 13W	2	--	In Artillery Fm., as above; underlain by red arkosic conglomerate; overlain by red volcanic flow.	3-5 ft. beds of mudstone and ss.	45x (.07)	PRR-A-81 Keith S-28
Navico Group #1 (see PRR)	5	--	In unnamed sediments, irregular lenticular beds of arkose, ash, sand, mud, with basalt capping on ridges to the south.	Carnotite as fracture coatings. Silicified wood present.	7x	PRR-A-83
Red Hills (Tate) W½ S7, 11N, 13W	6	--	Radioactive zones in a fault or sedimentary breccia at or near base of Artillery Formation, where it is in low angle fault contact with crystalline rocks.	Counts concentrated in fractures and/or shear zone intersection with veins; origin believed due to groundwater. Accessory CuO, chalcedony, flourite, Mangsnese oxides.	.06 avg .31 sel	PRR-192 Keith-S-31 Hart (1955) Lasky & Webber (1949); G&R p. 22 Finch (1967) Puchlik and others, (1979)

TABLE 1 (continued)

Locality	Number on Index Map, Figure B	Cross-Section Fig. No. (See Fig. A for Locations)	Host Rock Characteristics	Uranium Mineralization Associated Minerals Anomalous Radioactivity	Radioactivity and Background. Decimal numbers are % eU_3O_8 2x = 2 times bkg.	Reference (G&R= Granger and Raup, (1962); Keith = Keith, (1970)
YUMA COUNTY						
Alamo Area Lincoln Ranch Basin	9	--	Mn-bearing redbeds with low energy rocks; silicified plant remains. Tuffaceous sltst and mdst beds present. Redbeds are in footwall of Lincoln Ranch thrust fault and are allochthonous above older crystalline rocks of the Buckskin Mtns.	Uranium as carnotite in fractures and as uraniferous silice in bedded chert.	--	Wilson (1962) Gassaway (1972) Otton (1978)
Bouse Area *Rayvern NE¼ S13, 6N, 18W W½ S7, 6N, 17W	7	5	In a thick SW dipping Tertiary section on the east flank of Plomosa Mtns. Sequence complexly faulted, contains rhyolite flows, gy ls beds, arkosic conglomerates, green sh beds, and andesite flows forming resistant ridges.	Carnotite fracture coatings in white colored limey shales sandwiched in a thick gy colored limestone sequence; invisible minerals in a fault zone between arkosic conglomerates and andesitic volcanics.	15x (.03-.08)	PRR-A-P-348 Keith, V-80 Jemmett (1966) This report
Bouse Area Lillien #1, 2, 3 of Starlight Gp. (Location uncertain, but probably in N. Plomosa Mtns.)	8	--	Remnants of ls beds, in country rock of older granite, schist, and related x'tline rocks. Recent volcanics and sediments present.	Cu, barite, Mn, Au, Ag noted in the area.	2x	PRR-A-P-230
Yuma Area Muggins Mtns. Dizzy Lizy S10, 7 or 8S, 18W	10	--	4 ft. tuffaceous bed in dipping sedimentary and volcanic series.	Unidentified uranium mineralization.	25x (.08)	PRR-A-46 Keith, S-34
Wooley Gp. S32, 7S, 18W (Keith) S6, 8S, 18W (other rpts)	11	--	Brown water-lain ss and mdst with basic volcanic sills or flows. Sediments dip 25-30°SW.	Uranophane, autinite in hematite-stained sediments close to a probable basic volcanic sill. Some quartz stringers are highly radioactive.	125x (.175) (0.2-0.7)	PRR-A-P-300 Keith, S-35
Lake Bed Claim S2 or 7, 8S, 19W	12	--	Volcanic tuffs overlain by ss. Fault between rhyolite and lake bed sediments.	Uranophane, pryomorphite (?) and chalcedony.	30x	PRR-A-P-34
Red Knob Claim S10, 8S, 19W	13	--	Section consists of highly silicified or porcellanized mdst, lake bed sequences, ss, and some volcanics, apparently tilted.	Uranophane, carnotite or tyuyamunite, weeksite; with strong chalcedony or opal, gypsum, dark calcite. Mineralization in mdst, but localized near a N30W trending fault.	5x avg 100x max	PRR-A-P-302 Keith, S-37

TABLE 1 (continued)

Locality	Number on Index Map, Figure B	Cross-Section Fig. No. (See Fig. A for Locations)	Host Rock Characteristics	Uranium Mineralization Associated Minerals Anomalous Radioactivity	Radioactivity and Background. Decimal numbers are % eU_3O_8 2x = 2 times bkg.	Reference (G&R= Granger and Raup, (1962); Keith = Keith, (1970)
Isley-Lillard S6, 7, 8S, 18W S1, 12, 8S, 19W	14	--	Synclinal structure developed in Tertiary lake bed sequence, consisting of upper gy sandy sh, red ss, lower gy sh with white ash beds. Overlain to the west by obsidian flow and rhyolite (?) flows. These sediments are downslope from the Wooley Claims.	Chalcedonic white ash beds count. Gypsum and opaline material also noted.	6x	PRR-A-P-389 Keith, S-38
St. Louis Gp. S2, 8S, 19W or S35, 7S, 19W. (they lie to NW of Wooley Gp.)	15	--	Tertiary sh, ss, and white ash beds. Basaltic and rhyolitic intrusives. This section capped by "Gila" type cong. with schist boulders.	One dozer cut contains young soil, Pleistocene gravel veneers, and tilted green Tertiary mdst, all with disseminated uranophane (?).	115x (.03) (select 1.7)	PRR-A-P-390 Keith, S-39
Bonnie, Marvin, Jap, William, Edward, HWWR. "B" #1, 2, 3. S2, 12, 8S, 19W	16	--	Gray shale in Tertiary sedimentary series of sh, ss, white ash beds. Basalt and rhyolite intrusives capped by persistent "Gila" type cong.	Counts in folded and faulted chalcedonic shaley mdst beds. Uranophane (?) noted.	7x (.05-.24)	PRR-A-P-391 Keith, S-40
Laguna Mountains *Adair Park Beds SW¼ 7S, 21W	35	4	SW dipping redbed section, in high angle fault contact with Mesozoic (?) gneiss, and overlain by Kinter Fm. fanglomerates. Apparently consists of lower ss-cong. and upper mudflows and breccias.	Counts in lower yellow and brown mottled shale - ss sequence near high angle fault contact with Mesozoic (?) gneiss.	3x	This report
YAVAPAI COUNTY						
Date Creek Area Riverside #1 S9, 11N, 10W	17	--	Gently dipping Tertiary lake beds and tuffs. Uraniferous zone is lignitic or carbonaceous mdst, and is overlain by cong. and a basalt. Tertiary volcanics underlie the ore zone.	Ore zone is associated with chalcedonic materials, lignitic units and abundant plant debris (carbonized); carnotite and uranophane (?) are associated with jasper; urano-silica complexes are found in carbonaceous beds.	(.08)	PRR-A-117 Finch (1967)
Uranium Aire Gp. (Anderson Mine) S9-16, 11N, 10W	18	--			5-160x (.07-.60)	PRR-A-P-394 Keith, S-33 Otton (1977) and (1978). ACS Spring field trip, 1978
Lower Verde River Chalk Mtn. area 34° 02'N, 111° 42.5'W (unsurveyed)	37	22	Flat-lying section of tuffs, fine-grained sediments, and limestones very similar in general character to the tuffaceous section at Horseshoe Dam.	Carnotite as fracture coating in certain units low in the section.	3x ?	This report

TABLE 1 (continued)

Locality	Number on Index Map, Figure B	Cross-Section Fig. No. (See Fig. A for Locations)	Host Rock Characteristics	Uranium Mineralization Associated Minerals Anomalous Radioactivity	Radioactivity and Background. Decimal numbers are % eU_3O_8 2x = 2 times bkg.	Reference (G&R= Granger and Raup, (1962); Keith = Keith, (1970)
*Lake Pleasant N½ S10, 7N, 1E E½ S22, 7N, 1E	38	23	Gently warped and folded light-colored sequence of tuffaceous beds and lacustrine ls with minor sh, depositional on order tuff-basalt sequence and overlain by undeformed low energy beds which are probably basin fill materials.	Carnotite as fracture coatings and invisible disseminated mineralization localized in certain clastic and tuffaceous beds in the sequence. Both the overlying basin fill (?) and the tuff-ls sequence have been explored by drilling.	3x	This report
MARICOPA COUNTY						
Western Vulture Mtns. Milton Ray Group S21, 22, 6N, 7W	20	--	Tertiary section depositional on leucogranite to the east, and tilted to SW, including lower arkosic conglomerate and andesite flows, middle fine grained clastics and tuffs, and capping basalt-sediment series.	Carnotite as fracture coatings in mdst-vitric tuff section; confined to thin zone within otherwise homogeneous 20 ft. thick buff mdst section. Uranium probably out of equilibrium since low count rate is associated with abundant carnotite.	3x 7x (.01 max)	Hewett (1925) PRR-A-P-83 PRR-A-P-342 PRR-A-P-343 G&R, p. 15-. Keith, S-42 Finch (1967) This report
*Jar Claim, Black Butte Uran. Corp. SE¼ S14, and SW¼ S13, 6N, 8W	21	14				
Black Mtn. Gp. S14 (?), 6N, 7W	19	--	100 ft. bed of shaley marl underlain by Precambrian metamorphics, overlain by thin basalt flow.	Carnotite, gypsum, iron and manganese oxides, with carnotite coating fracture surfaces in marls.	(weak)	PRR-189
New River Area *Los Cuatros S32, 7N, 3E	23	16	Area of low-relief pediment cut on Tertiary sediments and volcanics, overlain by young gravel caps. Tertiary secrion consists of buff mdst, bedded dolomites, thin tuff beds, and intercalated basalts. The section is down-faulted against Yavapai schist to the north.	Mineralization is invisible, and concentrated within 1-3 ft. beds of resistant ledge-forming light colored aphanitic dolomite beda. One thin vitric ash bed intercalated into dolomites is not devitrified.	3x 20x max (.03-.06)	PRR-A-76 Keith, S-43 Finch (1967) This report
*Cave Creek Area S½ NW¼ S15, 6N, 4E	42	--	Area along Willow Springs Wash contains a section of low-energy sediments containing mudstone, limey and sparce dolomitic beds, 2 thin vitric ash beds, all dipping 30-50° SW, and overlain by a conglomerate with clasts of Precambrian schist and Tertiary volcanics.	Radioactivity associated with siliceous stringers and veinlets, and also a few thin limey and uncommon dolomitic beds. No visible uranium mineralization.	to 7x	This report

TABLE 1 (continued)

Locality	Number on Index Map, Figure B	Cross-Section Fig. No. (See Fig. A for Locations)	Host Rock Characteristics	Uranium Mineralization Associated Minerals Anomalous Radioactivity	Radioactivity and Background. Decimal numbers are % eU_3O_8 2x = 2 times bkg.	Reference (G&R-Granger and Kaup, (1962); Keith = Keith, (1970)
Pheonix Area *Rifle Range Section S3, 4, 5N, 2E and S33, 34, 6N, 2E	43	17	Isolated hill at I-17 and Carefree Highway consisting of northward dipping section of lower arkosic sediments overlain by 2 lithologically distinct white dolomite beds containing diagenetic silica replacements and an unconformably capping dark volcanic section.	Some radioactivity associated with chert pods, stringers in the 2 dolomite beds. Lower, more cherty dolomite counts to 250 cps. No visible uranium minerals.	to 3x	This report
Gila Bend Mtns. *Duke, White, Hyder Claims *S31, 2S, 9W or S36, 2S, 10W	25	6	Section of Tertiary rocks tilted NE, in downthrown tilted fault block; in depositional and fault contact with gneissic-crystalline rocks. Section includes arkosic cong, ss, mdst, one welded tuff, and thin-bedded ls.	2x radioactivity in slightly fetid, thin bedded gy ls beds intercalated into an arkosic ss port of the section.	to 4x (.01)	PRR-A-P-382 Keith, S-44 This report
Lower Verde River *Horseshoe Dam centered at 33° 58.5'N, 111° 44'W (unsurveyed)	39	22	SW dipping section of basalta overlain by a white colored tuff-mdst-ls sequence, in high angle fault contact to the west with Precambrian granite and to the south with younger flat lying basalt-capped sediments. (see also Chalk Mtn. locality)	Counts concentrated in a few ls beds in the sequence, and in silicified zones near the high angle faults. Silicification in areas is intense.	5x	This report
PIMA COUNTY						
Redington Pass, Rincon Mtns. *Chance Group S½ S10, 13S, 18E	28	1, 2	Oligocene section tilted 30-60° NE, in fault and depositional contact to west with Precambrian and Paleozoic rocks, and in fault contact to the east with younger fanglomerates. Section includes cong, ls beds, mdst, gypsiferous mdst. Section unconformably overlain by late Oligocene andesites.	Counts in dark-colored sh lenses intercalated into basal red cong of Mineta beds, and elsewhere in ls beds and overlying limey shale beds. No visible minerals noted.	100x max	Bissett (1958) p.37 Chew (1952) Clay (1970) G&R, p. 36 Keith, V-39
*Van Hill #7 and 8 NW¼ S24, 13S, 18E	26	1, 2			35x 4x (.01-.02)	PRR-no number Bissett (1958) p.37 Keith, V-39 Grimm (1978)
Roble Spring SW¼ S30, 13S, 19E	27	1	Carbonaceous sh along iron stained fault with ls on footwall, schist on hanging wall. Beds (of Mineta Fm?) strike N 45-60°W, steep dips, and include quartzite, phyllite, cong.	Mineralization controlled by complex faulting and brecciation. No visible minerala.	(.004)	PRR-629 (?) G&R, p. 4 Keith, v-66 Bissett, (1958) p. 48-

TABLE 1 (continued)

Locality	Number on Index Map, Figure B	Cross-Section Fig. No. (See Fig. A for Locations)	Host Rock Characteristics	Uranium Mineralization Associated Minerals Anomalous Radioactivity	Radioactivity and Background. Decimal numbers are % eU_3O_8 2x = 2 times bkg.	Reference (G&R= Granger and Raup, (1962); Keith = Keith, (1970)
Rincon Mtns. Colossal Cave Area *Red Hills claims NE¼ S6, 16S, 17E	29	1	Prospect pits in Precambrian granite, and Tertiary clastics (Pantano or Rillito beds) at different places. Terrain consists of juxtaposed high angle fault blocks containing either Martin Fm, p€ granite with Pioneer Shale (?) veneers, or Tertiary clastics.	Counts in some fine-grained clastics of various colors with no ls or ss present at one area, in weathered red-brown granite near high angle faults in another area.	3x 5x (.08-.38	PRR-A-P-314 Keith, S-54 Drewes (1978) USGS Map I-997 This report
Southern Tucson Mtns. *Dutchess Claim S17, 15S, 13E	30	1	20 ft. thick section consisting of beds of fetid light gray limestone 2-3 ft. thick with lesser amounts of gypsiferous mudstone and gypsum seams, exposed in two dozer cuts. Sequence is folded into a shallow E-W trending syncline.	Mineralization disseminated in fetid limestones, with some carnotite fracture coatings in a few areas.	7x max (0.6)	PRR-A-65 Keith-S-53 Grimm (1978)
SANTA CRUZ COUNTY						
Duranium S20, 20S, 13E (PRR) SW¼ S20, 20S, 14E (Keith)	31	--	Altered arkosic ss within cong, possibly at the base of Cretaceous or in Tertiary deposit. Strike E-W, dip 45°S.	Kaolinite, uranophane, autinite noted. Rocks are faulted and altered.	190x (.05-.8) (2.3 select)	PRR-A-P-285 Keith, S-55
Santa Clara Claim S31, 22S, 11E (PRR) NE¼ S6, 23S, 11E (Keith)	33	--	Steeply dipping ss and cong, mapped as Cretaceous on State Geologic Map, perhaps Tertiary aged.	Sooty uraninite in highly fractured and faulted rocks.	105x (.02-.15)	PRR-A-P-293 Keith, S-56
COCHISE COUNTY						
Southern Galiuro Mtns. *Teran Basin Sequence SW¼ S22, 13S, 20E NW¼ S26, 13S, 20E	41	1,3	Thick steeply eastward dipping coarse and fine grained sedimentary section with cong, ss, mdst, gypsiferous mdst, and some ls. Overlain unconformably by Oligocene Galiuro volcanics.	Anomalous radioactivity in yellow and red-brown mottled gypsiferous mudstones high in the basal half of the Teran Basin sequence. Slightly fetid limestone beds did not count.	3x	This report

TABLE 1 (continued)

Locality	Number on Index Map, Figure B	Cross-Section Fig. No. (See Fig. A for Locations)	Host Rock Characteristics	Uranium Mineralization Associated Minerals Anomalous Radioactivity	Radioactivity and Background. Decimal numbers are % eU_3O_8 2x = 2 times bkg.	Reference (G&R= Granger and Raup, (1962); Keith = Keith, (1970)
**The following localities that were visited contained other than Tertiary clastic sedimentary host rocks.						
YUMA COUNTY						
Parker Area *Osborne Wash W½ S 4 (projected) 9N, 17W	36	13	Tertiary is in low angle fault contact with gneissic lineated crystalline rocks. Limestones are recrystallized, and devoid of mineralization.	Counts in limonite-altered xlline rocks just beneath a low angle fault with Tertiary is above. Associated with copper-iron-Mn (?) mineralization.	3x	This report
COCHISE COUNTY						
Pearce Area *Elanns Claims SW¼ S35, 17S, 25E	34	--	Silicified limey shale near contact with volc. agglomerate.	Silicified shear zone associated with low angle fault and gouge. No visible minerals noted. Rhyolites flows nearby count high compared to average rhyolites.	20x (.20 select)	PRR-A-P-335 Keith, v-76 See also G&R, p.3 for nearby Fluorine Hill deposit.
Johnny Lyon Hills *Inez Ellen Claims NE¼ SW¼ S8, 14S, 21E	32	--	Locality is on a west-facing scarp of east-dipping Paleozoic sediments. The entire Bolsa-Horquilla section is present; an anomalous shear zone appears confined at the surface to the Martin Fm-Percha Fm interval. Precambrian granite under the Bolsa is several hundred yards west. No Cretaceous sediments are present as noted in the PRR.	Anomalous radioactivity in one or more dark red-brown colored shear zones cutting across bedding. Recent exploration includes new dozer roads and cuts and at least 20 drill holes on hillside.	to 5x (.19-.26)	PRR-A-113 Keith, S-57 This report
Chiricahua Mtns. *Swisshelm Valley S½ 20S. 28E	40	7	Section of Chiricahua-type rhyolite welded and unwelded ash flows and possible thick ash falls, underlying a young pediment surface which is dissected by recent streams. Cross-faults complicate the stratigraphy.	Counts appear disseminated through friable white altered air-fall pumiceous devitrified tuffs and tuffaceous sediments.	2x	This report
MARICOPA COUNTY						
Wickenburg Area *Golden Duck Gp. S19, 20, 7N, 2W	24	--	Tertiary rhyolitic domes, plugs, and pyroclastic tuffs in fault contact with Precambrian rocks, overlain by young terrace deposits, which were misidentified as basal arkose in the PRR report.	Visible torbernite with minor copper and iron mineralization as fracture coatings and fault gouge mineralization. Some hydrothermal silica open space fillings in certain rhyolites.	to 60x (0.2-0.6)	PRR-A-77 Keith, S-41 Finch (1967) This report

Table 2. Potassium-argon determinations.

University of Arizona
Isotope Geochemistry Lab
Date: 1 June 1979

Constants used:
$\lambda_\beta = 4.963 \times 10^{-10}\ yr^{-1}$
$\lambda_e = 0.581 \times 10^{-10}\ yr^{-1}$
$\lambda = 5.544 \times 10^{-10}\ yr^{-1}$
$^{40}K/K = 1.167 \times 10^{-4}$ atom/atom

Sample No.	Sample description and location	Individual K analyses	Percent K used	Radiogenic argon-40 $\times 10^{-12}$ mole/g	Percent atmospheric argon-40	Age in million years
76-96	Whole rock, andesite, base of massive flow, middle section of the andesite unit that overlies the Apsey conglomerate of M. Krieger. The conglomerate overlies Hell's Half Acre tuff and Aravaipa tuff in the northern Galiuro Mountains. Table Mountain, Holy Joe Peak quad., Pinal Co., Ariz. Lat 32° 49.74' N, Long 110° 31.26' W (RS-11-76).	1.785 1.798 1.781	1.788	69.66 71.96 71.56	12.0 11.6 11.8	22.78 ± 0.48
76-133	Biotite, airfall silic ash, Jim Thomas Wash. Sample from a 2 m thick white ash bed intercalated into the San Manuel fm. of M. Kreiger. The area is structurally complex. The sediments are synclinally folded. A high-angle fault brings overturned Paleozoic sediments and Cretaceous (?) volcanics into contact with the overturned San Manuel fm. west of the sample site. Cozier Peak quad., Pinal Co., Lat 32° 58.75' N, Long 110° 56.71 W.	6.238 6.176	6.207	210.96 213.82 220.35 225.24	57.5 56.9 55.9 57.6	20.11 ± 0.47
76-133	Hornblende, same as above.	0.566 0.568	0.567	23.23 23.23 22.92	52.7 52.7 54.1	23.4 ± 0.6
76-133	Plagioclase feldspar, same sample as above. Plagioclase contains excess argon-40.	0.786 0.779	0.782	34.98 34.98	24.0 23.9	25.6 ± 0.6
77-70	Whole rock, basalt flow about 3 m thick overlying coarse grained sediments and uranium bearing deformed lake beds containing lignitic units. The lake beds range between 30-60 m in thickness, have a 10° + dip south and are faulted. The overlying coarse grained sediments are about 76 m thick. Elevation 606 m, sampled at outcrop along tributary to Santa Maria River, Arrastra Mtn. SE quad., Yavapai Co., Ariz. Lat 34° 18' 11" N, Long 113° 16' 37" W.	1.124 1.122	1.123	25.70 25.71 25.90	37.88 37.59 38.02	13.19 ±0.29
UAKA-77-106	Whole rock, basalt, dark grey, fine-grained ground mass with abundant olivine, about 10 meters above the first exposure of a series of flows that cap Skull Mesa. Basal contact with the underlying tuff sequence is concealed by 40 meters of talus. The flow presumably correlates with the flows on Black Mesa, Sugarloaf Mesa (UAKA-78-36) and New River Mesa. New River Mesa quad., Maricopa Co. Lat 33° 55.42' N, Long 111° 55.18' W.	0.431 0.431 0.435 0.435 0.430 0.434	0.433	11.16	84.1	14.81 ± 0.79
UAKA-77-108	Whole rock, basalt, approx. 7 meters above unconformable contact between basalt and lithic tuff. Basal portions of flow very "crumbly", well fractured and weathered. Fractures are filled with abundant carbonate material. The underlying lithic tuff sequence is fine- to medium-grained with granules of siliceous volcanic rock. The sample correlates with PED-5-70 (23.2 ± 2.6 m.y.), olivine basalt that overlies Oreodont mammal site at Cave Creek, about 5' above the contact. Cave Creek, New River Mesa quad., Maricopa Co., elev. 731 m, Lat 33° 53.81' N, Long 111° 57.21' W (OL 1.4).	0.655 0.655 0.652	0.654	248.71 240.88 240.82	30.51 31.30 31.47	21.34 ± 0.46
78-30	Whole rock, ultrapotassic trachyte separating lower thin clastic section composed of arkosic conglomerate from overlying lithic tuff, shale, sandstone and volcanic breccia. The lower arkosic conglomerate appears to be depositional on Precambrian (?) basement rocks. The sequence dips 12° to 65° with the steeper dip closer to the Harcuva Mtns. Rudy Pass area, Date Creek Ranch SW quad., Yavapai Co. (#HVKA-78-1) 34° 02.35' N, 113° 9.60' W.	7.945 7.879 7.854	7.892	239.63 238.56 238.18 237.68	12.5 12.4 12.3 12.5	17.35 ± 0.36

Table 2. (continued)

University of Arizona
Isotope Geochemistry Lab
Date: 1 June 1979

Constants used:
$\lambda_\beta = 4.963 \times 10^{-10}\ yr^{-1}$
$\lambda_e = 0.581 \times 10^{-10}\ yr^{-1}$
$\lambda = 5.544 \times 10^{-10}\ yr^{-1}$
$^{40}K/K = 1.167 \times 10^{-4}$ atom/atom

Sample No.	Sample description and location	Individual K analyses	Percent K used	Radiogenic argon-40 x 10^{-12} mole/g	Percent atmospheric argon-40	Age in million years
78-31	Whole rock, basalt flow overlying thin bedded, partly calcareous, uranium-bearing siltstone-claystone and lower volcanics which contain UAKA 78-48. This flow dips 10° SW, underlying sediments and volcanics dip 20-40° SW. Black Butte, Aguila quad., Maricopa Co., T6N, R7, S19. Lat. 33° 50.76'. Long 113° 01.87'.	1.102 1.109	1.105	29.78 30.32	31.8 30.9	15.62 ± 0.35
UAKA 78-32	Whole rock basaltic andesite, underlying the type Gila Conglomerate, merges with a thick volcanic sequence to the south, Lower Bonita Creek, Guthrie q., Graham Co., elev. 3170', Lat 32° 53.21' N, Long 109° 29.84' W (RS-1-77).	3.242 3.193 3.202	3.212	111.34 115.70 116.54 115.85 116.69 116.99	8.86 6.85 6.73 7.12 7.02 6.95	20.62 ± 0.42
UAKA 78-33	Whole rock, rhyolite, 50-100' thick, from Mineta Fm. The rhyolite is in fault contact with Pinal schist to the west and has probable depositional contact with overlying grey conglomerate of the Mineta Fm to the east. Redington Pass, Redington quad., Pima Co., elev. 3750, Lat 32° 17.10' N, Long 110° 27.28' W (RS-1-78).	3.736 3.734 3.721	3.730	163.89 163.82 162.72	40.6 41.2 38.8	25.10 ± 0.55
UAKA 78-34	Whole rock, basaltic andesite, grey-black flow, approx. 80' above base of hill on west Tempe Butte. It overlies fine-grained red-brown sediments which are presumably part of Papago Park fm. Playa-type mud cracks in the sediments indicate the section is not overturned. Tempe Butte, Tempe quad., Maricopa Co., elev. 1300', Lat 33° 25.68' N, Long 111° 56.04' W (RS-2-78).	2.481 2.424 2.431	2.446	74.58 74.94 74.85	22.59 22.46 22.65	17.56 ± 0.37
UAKA 78-35	Whole rock, basalt flow intercalated into pre-basin fill fanglomerate sequence. The sequence dips 4-8° towards NE, is truncated eastwardly by the "fault scarp" of the NE Swisshelm area, and truncated westwardly by a high-angle Basin and Range fault. Swisshelm Mtns. quad., Cochise Co., elev. 5080'. Lat 31° 44.25' N, Long 109° 30.63' W (RS-4-78).	1.350 1.366 1.357	1.358	25.39 26.10 26.79	62.60 61.87 60.41	11.05 ± 0.28
UAKA 78-36	Whole rock, basalt, 30-50', below the top of Sugarloaf Mesa. About a dozen flows cap the mesa and overlie a basalt-tuff sequence. Sugarloaf Mesa is south of New River Mesa. The sequence is only slightly tilted to the south. About 10% mafic minerals removed before analysis. New River Mesa quad., Maricopa Co., Lat 33° 54.72' N. Long 112° 57.78' W.	0.787 0.783 0.779 0.779 0.779 0.778	0.781	20.08 19.93 19.83	75.0 78.0 75.3	14.67 ± 0.35
UAKA 78-38	Whole rock, basalt, from a volcanic-sedimentary sequence exposed at Horseshoe Dam area. Sequence (>2000' thick) is tilted SW at 10-20° and is in fault contact with younger basin fill mudstone to the SW. This basalt flow series is overlain by basalt cobble conglomerates and a higher sequence of white tuffs and marls. The tuffs contain numerous shows of uranium mineralization. Horseshoe Dam quad., Maricopa Co., elev. 2020'. Lat 33° 58.87 N, Long 111° 42.70' W (RS-11-78).	0.537 0.535 0.536	0.536	13.45 13.52 14.02	62.08 61.76 60.89	14.64 ± 0.37
UAKA 78-39	Whole rock, rhyolite (?) trachyte (?) local basal flow, part of an older volcanic series which rests on Yavapai argillites. It is uncomformably overlain by the basalt-tuff conglomerate sediment series that composes the mesas of the area. Eberly and Stanley (sample #63) dated a basalt flow of the younger basalt-tuff-conglomerate series at 20 m.y. Sample collected from basal andesite exposed at Tule Creek north end of Lake Pleasant, New River quad., Yavapai Co., elev. 1720', Lat 33° 58.08 N. Long 112° 14.53' W (RS-6-78).	6.403 6.408 6.371	6.394	286.37 290.41 310.37	16.64 16.39 15.50	26.48 ± 0.56

Table 2. (continued)

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Isotope Geochemistry Lab
Date: 1 June 1979

Constants used:
$\lambda_\beta = 4.963 \times 10^{-10}\ yr^{-1}$
$\lambda_e = 0.581 \times 10^{-10}\ yr^{-1}$
$\lambda = 5.544 \times 10^{-10}\ yr^{-1}$
$^{40}K/K = 1.167 \times 10^{-4}$ atom/atom

Sample No.	Sample description and location	Individual K analyses	Percent K used	Radiogenic argon-40 x 10^{-12} mole/g	Percent atmospheric argon-40	Age in million years
UAKA 78-40	Whole rock, basaltic andesite; flow is one of many exposed along dirt road around west side of Lake Pleasant, and is interbedded into a tuffaceous sediment and volcanic conglomerate sequence which is tilted eastward 10-30°. West edge Lake Pleasant, Governor's Peak quad., Yavapai Co., elev. 1680', Lat 33° 53.78' N, Long 112° 17.97' W (RS-7-78).	1.858 1.858 1.853	1.856	53.37 54.18	14.56 14.39	16.63 ± 0.35
UAKA 78-41	Whole rock, basaltic andesite, lowest flow that overlies about 5000' thick red clastic sequence (Teran Basin sequence). The andesite is cut by Turkey Track dikes and vents. Teran Basin, Galiuro Mtns., Redington quad., Cochise Co., elev. 3850', Lat 32° 17.07' N, Long 110° 16.40' W (RS-12-78).	1.985 1.971 1.969	1.975	94.01 94.28 94.25	15.47 15.90 16.31	27.29 ± 0.57
UAKA 78-42	Whole rock, basaltic andesite in a volcano-clastic sequence homoclinally dipping NE approx. 20°. The andesite appears to be in the same tectonic assemblage as uranium-bearing tuffs, siltsones, and clastics two miles to the north near the locality of 78-43 below. These Tertiary materials are in apparent fault contact with slatey and micaceous Yavapai Series to the west. Pyramid Peak, Cave Creek district, Daisy Mtn. quad., Maricopa Co., elev. 2020', Lat 33° 53.24' N, Long 112° 04.12' W (RS-3-78).	1.580 1.574 1.570	1.575	48.70 48.59 48.75 48.49	30.25 30.39 30.30 30.57	17.72 ± 0.37
UAKA 78-43	Whole rock, basalt dike intrusive into a rock faulted and folded terrain of mid-Tertiary basalts, tuffs, clastics, and limey beds. The section contains uranium mineralization. New River, Daisy Mtn. quad., Maricopa Co., elev. 2220', Lat 33° 54.25' N, Long 112° 03.50' W (RS-13-78).	0.855 0.860 0.853	0.856	20.13 20.33 20.31	60.88 60.73 60.77	13.60 ± 0.34
UAKA 78-44	Whole rock, mesa capping basalt uncomformably overlying about 300' of fluvial sediments including dolomite beds and pyroclastic rocks. The section dips NE 20-35°. Black Canyon Shooting Range section, Biscuit Flat quad., Maricopa Co., Lat 33° 48.70' N, Long 112° 08.87' W.	0.606 0.602 0.611	0.606	16.24 16.24 16.37	50.6 50.5 50.6	15.39 ± 0.40
UAKA 78-45	Whole rock, basalt. The volcanic flow is contained within a section of sediments and pyroclastics which are juxtaposed against Precambrian granites and are pedimented and overlain by basin fill along the eastern margin of the Big Sandy Valley near Wickieup. Uranium mineralization is found in certain horizons in the sediments. Burro Wash, Wickieup district, Tule Wash quad., Mohave Co., elev. 3040', Lat 34° 48.15' N, Long 113° 32.93' W (RS-2-79).	0.579 0.578 0.581	0.579	11.97 12.74 12.14	26.94 28.10 27.87	12.19 ± 0.22
78-46	Whole rock, thin welded rhyolite flow occurring discontinuously about 500-800' above base of type Artillery Formation, west of Artillery Peak. Flow is now thought to be intercalated into the sediments rather than a sill. Artillery Peak 15' quad., Lat 34° 22.13' N, Long 113° 36.13' W (RS-3-79).	3.485 3.533 3.461 3.553 3.548 3.566	3.523	120.71 122.18 123.86	18.8 17.8 18.0	19.90 ± 0.47

Table 2. (continued)

University of Arizona
Isotope Geochemistry Lab
Data: 1 June 1979

Constants used:
$\lambda_\beta = 4.963 \times 10^{-10}\ yr^{-1}$
$\lambda_e = 0.581 \times 10^{-10}\ yr^{-1}$
$\lambda = 5.544 \times 10^{-10}\ yr^{-1}$
$^{40}K/K = 1.167 \times 10^{-4}$ atom/atom

Sample No.	Sample description and location	Individual K analyses	Percent K used	Radiogenic argon-40 x 10^{-12} mole/g	Percent atmospheric argon-40	Age in million years
78-47	Whole rock, partially welded rhyolite flow intercalated into an arkosic sandstone-mudstone-limestone section in Western Gila Bend Mtns. Sediments are in a downthrown tilted fault block, and are depositional on crystalline rocks. Dendora Valley 15' quad., Lat 33° 13.40' N, Long 113° 13.62' W (RS-4-79).	2.550 2.560 2.551	2.554	105.83 105.84 105.48 104.28	39.9 40.0 40.1 37.7	23.64 ± 0.51
78-48	Whole rock, basalt, from near the base of a 10-30° SE dipping 1000' thick volcanic section underlain by 60' of red arkosic conglomerate and overlain by uraniferous low energy clastics. This entire sequence depositional on granite to the east and overlain unconformably by an upper volcanic series containing UAKA 78-31.Black Butte district, elev. 2390', Maricopa Co., Aguila quad., Lat 33° 51.62' N. Long 113° 02.80' W (RS-5-79).	1.016 1.016 1.016	1.016	35.62 35.47 25.30	17.04 16.89 17.12	20.02 ± 0.42
78-49	Whole rock, andesite, from a thick andesite-breccia-silicic flow sequence which is tilted SW and juxtaposed against a cataclastically deformed crystalline complex by a low angle "discoloration surface". Smith Peak 7.5' quad. Lat 34° 02.97' N, Long 113° 17.08' W. (RS-6-79).	4.122 4.112 4.083	4.106	114.08 113.54 113.25 110.22	7.9 9.1 8.0 8.1	15.77 ± 0.32
79-66	Whole rock, basaltic andesite, in a 500-800' thick andesite-conglomerate sequence with 30-40° dip toward the northeast. The sample represents a flow, about 1/5 the way up the sequence. The sequence is overlain by fluvial arkosic red beds. Red beds contain clasts of granites and andesites. Box Canyon on the Hassayampa River, Wickenburg district, Sam Powell Peak quad., Yavapai Co., elev. 2210', Lat 34° 02.72' N, Long 112° 43.60' W (RS-7-79).	1.804 1.800 1.800	1.801	51.75 52.10 52.09	9.35 9.26 9.55	16.57 ± 0.35