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TO: J. H. COURTRIGHT

FROM: J. D. SELL

POSSIBLE CORRELATION OF SOME TERTIARY UNITS--GLOBE (GILA COUNTY) TO GILA BEND (MARICOPA COUNTY), ARIZONA

General Statement

Mapping by various geologists has resulted in the identification of some Tertiary units correlatable along a zone 130 miles in length. The zone extends from the Globe-Miami area to the Gila Bend area. The rock units are correlatable on the basis of rock type, structural involvement, and sequence; but, the units may not be time equivalents.

All the units are post-mineral (post-Laramide) occurrences and thus are cover rocks for mineral deposits.

The following areas, maps, and reports, were used in this study. The area locations are shown on Attachment A. They are listed from the Globe area (east) to the Gila Bend area (west).

1. Peterson, N. P., 1962, Geology and ore deposits of the Globe-Miami district, Arizona: USGS Prof. Paper 342, 151 p.

2. Peterson, D. W., 1962, Preliminary geologic map of the western part of the Superior quadrangle, Pinal County, Arizona: USGS Mineral Investigations Field Study Map MF-253, 1 sheet.

3. Blucher, A. G., Jr., 1958, Porphyry copper reconnaissance, Globe-Superior region, Pinal-Gila Counties, Arizona: ASARCO Report, File No. Aa-7.7.0, 12 p.

4. Blucher, A. G., Jr., and Kinnison, J. E., 1960a, Diagrammatic cross-section. Arnett Canyon: ASARCO Reconnaissance, File No. Aa-0.0.19E, 1 sheet.

5. Blucher, A. G., Jr., 1960, Blackwater and Posten Butte prospects, Blackwater mining district, Pinal County, Arizona: ASARCO Report, File No. Aa-16A.2.0, 18 p.

6. Blucher, A. G., Jr., and Kinnison, J. E., 1960b, Diagrammatic cross-section, showing interpretation of Tertiary conglomerate depositional basins, San Tan Mountains, Arizona: ASARCO Reconnaissance, File No. Aa-0.0.19E,, 1 sheet.

7. Kinnison, J. E., 1964, Sacaton-Santa Cruz area, Pinal County, Arizona: ASARCO Preliminary Geologic Map, File No. Aa-16.3.19C, 1 sheet.

8. Wojcik, J. R., 1964, Santa Cruz drilling, October, 1964: ASARCO Drilling Memorandum, File No. Aa-16A.3.19C, 2 p.

9. Sell, J. D., 1964, Table Top region, geological reconnaissance mapping, Pinal County, Arizona: ASARCO Report, File No. Aa-16A.3.20A, 18 p.

10. Sell, J. D., 1965, Sand Tank region, geological reconnaissance mapping, Maricopa County, Arizona: ASARCO report in preparation.

11. Babcock, H. M., Kendall, K. K., and Hem, J. D., 1948, Geology and ground-water resources of the Gila Bend basin, Maricopa County, Arizona: USGS Open-File Report, 27 p.

12. Heindl, L. A., and Armstrong, C. A., 1963, Geology and ground-water conditions in the Gila Bend Indian Reservation, Maricopa County, Arizona: USGS Water-Supply Paper 1647-A, 48 p.

Divisions

In the areas discussed, the Tertiary sequence can be subdivided into six major divisions based on rock type and structural complexities. From the base upward the divisions are:

- I Lower conglomerates
- II Older volcanics
- III Older basalts
- IV Younger conglomerates
- V Tuffs and ignimbrites
- VI Late basalts

All divisions are not represented in each area; however, the stratigraphic-structural break representing these divisions have been noted and commented on by the various workers. Structural complexities indicate continuous depositional-readjustment-volcanic activity for the entire time span. Hence, any post-mineral Tertiary unit may be in depositional contact with any lower Tertiary unit or rest on any unit of the "basement" pre-mineral sequence.

I. Lower conglomerates. The lower conglomerates are generally tuffaceous and contain large quantities of locally derived, pre-mineral debris; but does not contain extrusive volcanic flow material. The gravels range from pebble to boulder size, angular to rounded, unsorted to poorly sorted. In the east side of the study area the conglomerates appear to occupy restricted basins whereas westward they were deposited in more widespread sheets.

II. Older volcanics. The lower units of the older volcanics may inter-finger ~~fringe~~ with the underlying conglomerates but rapidly the change occurs from one dominated by sedimentation to one dominated by volcanism. At the base of the unit is a restricted brown to red-brown cinder and ash bed, and a white pumice bed, which often show water-lain characteristics. Overlying the cinders are non-vesicular andesite or basalt units characterized by abundant red specks which are probably iddingsite derived from the alteration of olivine.

The cinder and ash beds have been noted from the Superior area to the Gila Bend area and constitute a very good marker bed even though it is thin and restricted.

III. Older basalts. A dark gray or black vesicular basalt lies disconformable on the underlying older, predominantly andesitic, volcanics in the western part of the study area. Associated with the basalt is a complex sequence of andesitic, rhyolitic, and latitic flows. In the eastern part of the study area the group is a complex of trachyte, andesite, rhyolite, glassy lavas, and other flows, which, in Arnett Creek, are known to overly the "red-speckled" basalt and red-brown cinder-ash beds.

IV. Younger conglomerates. The younger conglomerates appear to occupy very restricted basins and contain abundant debris derived from the older andesite and basalt volcanics. The units appear to be the result of eroding and reworking the nearby older volcanic-lower conglomerate material.

V. Tuffs and ignimbrites. A vast amount of ash material, ranging from rhyolitic to dacitic in composition, of soft light colors, was extruded throughout the region. The material characteristically produced a welded tuff or ignimbrite which often has a dense black vitrophyre layer near the base. The structural complexities of the ignimbrites are minor compared to the underlying units (especially the older basalts) although they are cut by large faults.

VI. Late basalts. Black, dense basalts occur overlying the ignimbrite material. They often form isolated "caps" throughout the region, or continuous, though dissected, sheets.

Areas

The areas covered in this study were listed earlier in the report and the rock sequences are shown on Attachment B. Each area will be discussed, traveling from the Globe area westward to the Gila Bend area.

Globe-Miami (Peterson, N. P.)-- Resting on the pre-mineral rocks in the Globe-Miami area is the Whitetail Conglomerate. The Whitetail would be the Division I, Lower Conglomerates. The conglomerate is composed of coarse, bouldery diabase detritus with subordinate amounts of Pinal Schist, Apache Group, and Paleozoic Limestones. Peterson (1962, p. 37) writes: "the lower part is wholly unsorted and unstratified. Higher in the section crude stratification can be recognized, and lenses of poorly sorted gravel occur that undoubtedly represent temporary stream channels. Approximately the upper 50 feet of the formation is well stratified and is composed by layers of dark sand and gravel interbedded with layers of white tuffaceous sand."

The older volcanics, Division II, are not represented in the Globe-Miami area and the older basalts of the complex Division III rest directly on the Whitetail. The correlation of Peterson's "Earlier Volcanics" with Division III is based on Blucher's work further west.

The "Earlier Volcanics" (III) is a complex assemblage of bedded tuffs, felsitic and glassy lavas, and perlitic glass. The volcanics are separated from the overlying "Later Volcanics" by an "interval during which some erosion of the rocks of the first eruption occurred." (Peterson, 1962, p. 37).

This interval is Division IV, Younger conglomerates, and with no remains of any conglomerate being found, the "Later Volcanics" rest unconformably on the Earlier Volcanics.

The Later Volcanics (Division V, Tuffs and ignimbrites) have a base of white to gray crystal-tuff which grades upward into a black vitrophyre, which in turn is overlain by the massive welded tuffs or dacite which have a uniform light brownish-gray color.

The dacite is overlapped by the Gila Conglomerate (Tertiary-Quaternary) which is intercalated with two or more basalt flows in parts of the area.

North Superior (Peterson, D. W.)-- The subdivisions of this area are identical to the divisions in the Globe-Miami area--Divisions I, III, and V, are present and the others are absent. The quotes are from the map of D. W. Peterson, 1962, who actually conducted his investigations much later than N. P. Peterson. Peterson (D. W., 1962) subdivided the Tertiary(?) into three groups-- Whitetail Conglomerate, Rhyolite, and Dacite.

Division I -- "Tw, Whitetail Conglomerate: Fluvial deposits composed of angular to subangular fragments derived from all older rocks, mainly from underlying or nearby rocks. Most fragments pebble size, some larger. Matrix is coarse-grained, poorly sorted arkosic to lithic sandstone, moderately well cemented; bedding planes poorly defined or absent."

Division III - "Tr, Rhyolite: Lava flows composed of rhyolite and perlitic obsidian. Light to medium-gray rhyolite...generally prominent flow laminations, locally contorted. Perlitic obsidian generally forms top or bottom of rhyolite flows.... Includes minor deposits of tuff, tuff breccia, and flows of andesite and trachyte."

Division V -- "Td, Dacite: Ash-flow sheet; nonwelded tuff at the base grades upward to densely welded black vitrophyre that is overlain by densely welded tuff with cryptocrystalline groundmass. Progressively upward from the vitrophyre the welding gradually decreases, the amount of crystallization in the groundmass increases and the color changes from light brown to moderate red to very light gray."

Superior (Blucher, A. G.) -- ASARCO's reconnaissance by Blucher (1958) was one of the earliest in which various mappable units within the Tertiary dacite volcanics were recognized. Again, Divisions I, III, and V are present, with Division III being a complex sequence of tuff, vitrophyre, and rhyolite.

Separating the sequence from the overlying dacite and welded dacite tuff was a break which Blucher suggested was an "unrecognized erosion cycle."

<u>Arnett Creek</u> (Blucher, A. G. and Kinnison, J. E.) -- The sequence of units in Arnett Creek at the base of Picket Post Mountain, so clearly diagrammed by Blucher and Kinnison (1960a) provides the key correlation tie in for the eastern area.

In the next canyon north Whitetail Conglomerate (Division I) rests unconformably on Pinal Schist and is overlain by the brown and red-brown ash beds (Division II).

At Arnett Creek the ash beds rest directly on either Pinal Schist or Laramide granite and in turn is overlain by "massive blue-black basalt with altered red crystals--the "Blue Basalt." In hand specimens the Blue Basalt of this region is identical to the red-speckled andesite of the Table Top-Sand Tank regions as well as to the correlatable unit in the Blackwater area.

Blucher and Kinnison recognized a disconformity separating the Division II red ash and blue basalt units from the overlying complex (Division III) of tuff, spheroidal agglomerate with perlite, and rhyolite.

Overlying the complex volcanics are massive beds and stratified tuffs with overlying massive dacite beds (Division V).

~~Blackwater (Blucher, A. G.)~~

<u>Blackwater</u> (Blucher, A. G.) -- At Blackwater, Blucher found three of the old divisions, dropped one, and established two new ones. The post-mineral Tertiary formations including (Blucher, 1960, p. 12) "...a conglomerate, a basalt flow, a younger conglomerate, a series of dacitic volcanic rocks, a younger basalt flow..."

Equivalent to the Whitetail is the Division I lower conglomerates named the Yellow Peak Conglomerate. The Yellow Peak "...is a poorly sorted, poorly indurated, fluvial deposit...made up principally of pebbles, cobbles, and boulders of Coolidge granite in a silty matrix."

The red-brown cinders and ash beds ("Olberg Beds") overlain by the bluish-gray Blue Basalt (all Division II) rest on the Yellow Peak Conglomerate.

Overlying the ash and blue basalt units is a thick sequence of tuffaceous sandstone, siltstone, and conglomerate, named the Rock Peak Conglomerate. The conglomerate has been correlated with the younger conglomerates of Division IV. The intervening complex of volcanics of Division III is missing in the Blackwater district.

Overlying the conglomerates are the dacitic volcanic rocks of Division V, consisting of basal black vitrophyre, and welded tuff or tuff agglomerate which are correlatable with the dacite to the east.

The late basalts (Division VI) cap many of the buttes in the area and are known as the Walker Butte Basalt.

San Tan (Blucher, A. G., and Kinnison, J. E., 1960b) -- The diagrammatic cross-section of the San Tan region, as well as several other sketches of features in the area, portray the sequence very well. As the two areas are essentially a continuous one--the sequence is the same as at Blackwater. Reconnaissance was conducted only around the edge of the post-mineral cover and it may be that the entire sequence of the six divisions would be found preserved elsewhere in the range.

Table Top (Sell, 1964) -- The basal post-mineral unit is the Pebble Conglomerate (Division I). The conglomerate appears to have been deposited in more widespread sheets than in the Blackwater area, even though present outcrops are restricted to small preserved outcrop areas.

Overlying the conglomerate is a thick sequence of andesite, scoria-agglomerate and dacite tuff. Preserved in a few places are red cinder-ash and white pumice beds resting on the conglomerate and overlain by the andesite (red-speckled). This group of units is Division II and directly correlatable to the Olberg Beds and Blue Basalt of the Blackwater-San Tan area.

Disconformably over the Older Volcanics is a sequence of basalt, which has been assigned to Division III. The basalt sequence is not as complex as the Division III units in Globe-Miami-Superior areas; however, to the west the basalt is in near proximity to a very complex volcanic sequence.

The Younger Conglomerates (Division IV) are probably represented by a caliche-cemented sediment which occupies elevated fans in the Table Top region. The conglomerates are post-basalt and do not contain rhyolite ignimbrite fragments and undoubtedly are correlatable with the Rock Peak Conglomerate of the San Tan area.

Occurring as a few isolated outcrops is a rhyolite ignimbrite. Although its true position is not pinpointed in the Table Top region, its position is known in the Sand Tank region where it overlies the complex volcanics and has a few conglomerate beds beneath it.

Sand Tank (Sell, 1965) -- Division I conglomerates are widespread in the Sand Tank region and have a source area to the south. They are very similar to the Table Top region and contain abundant pebbles to boulders of Precambrian granite, Pinal Schist, and Apache Group and smaller amounts of Paleozoic Limestones and Laramide Granites--all in a sandy-silty-tuffaceous matrix. The interfingering of the conglomerates with the first phases of extrusive igneous action is well demonstrated. However, the change from dominate sedimentation to volcanic action is sharp and complete.

The basal member of Division II is the brown-red cinders and ash with white pumice, which is overlain by the red-speckled andesite and scoria-agglomerate volcanics.

A minor amount of basalt and a large amount of complex volcanics of andesite-rhyolite-latite overlie the sequence of red-speckled and scoria-agglomerate andesites and are assignable to Division III.

Conglomerates of Division IV were not positively identified in the Sand Tank region. Conglomerates were found beneath the ignimbrites of Division V, but they appeared to be the Division I type.

A tan tuff, black basal vitrophyre, and a thick sequence of distinctive pinkish rhyolite ignimbrite cap all units in the area and belong to the Division V sequence.

No dense black basalt of the Division VI type was found in the area although much volcanics of this type may be present further west in the Gila Bend-Ajo volcanic field.

Gila Bend (Heindl, 1963) -- The work of Heindl based on the previous work of Babcock (1948), was a very rapid reconnaissance on which he based some conclusively written concepts. Additional work in the area, with the knowledge gained from better outcrop exposures to the east, would undoubtedly unravel Heindl's Sil Murk Formation into the various divisions as proposed here. However, for this discussion I will use his sequence with some additional comments.

Division I conglomerates are mapped over much of the Gila Bend area and were named the "Sedimentary Member" of the Sil Murk Formation.

The "Volcanic Member" overlies the conglomerates and is a sequence which is broken into the following types: Eolian tuffaceous sandstone, brownish-red ash, black vitrophyre, and dacitic welded tuff; all of which are assigned to Division II.

Division III is reflected by a fine-grained black basalt, which is overlain by a conglomerate (Division IV) containing both gneissic and volcanic rocks.

A lavender tuff, possibly dacitic was noted by Heindl. Also found on the northwest side of the area (but not mentioned by Heindl) is the distinctive pink rhyolite ignimbrite of Division V which is underlain by conglomerates of Division IV.

Santa Cruz-Sacaton Area -- Between the San Tan and Table Top areas is the large exposure of area called Santa Cruz-Sacaton. Positive information in the area is lacking for the most part but two reports are included here. The reported sequence is shown on Attachment C.

Santa Cruz Drill Hole SC-5 (Wojcik, 1964) -- This drill hole is of particular interest in that it provides some positive information on the lower divisions in the large alluvial basin east of the Table Top region. Division I conglomerates were in fault contact with the pre-mineral granites. Overlying the conglomerate was the red-speckled andesite of Division II. Above the andesite is a thick (2000+ feet) sequence of conglomerates. Two core runs were taken in the upper conglomerates and one each in the Division II and I units.

Santa Cruz-Sacaton (Kinnison, 1964) -- On a preliminary map Kinnison shows the conglomeritic sediments of Division I underlying the Older Volcanics of Division II and capped by Division III basalt. Three valley conglomerates were identified in the Sacaton drilling. The younger Gasline Conglomerate and the underlying Sacaton and Burgess Peak Conglomerates. The relative age of the last two is not established. As the Sacaton Conglomerate has been involved with the block faulting within the Sacaton ore-body area, it is possible that it belongs to the Division I conglomerates. Similarly, the Burgess Peak Conglomerate contains only rare volcanic material but is composed primarily of granitic and schistose pebbles in a granitic sand matrix and may also be Division I type. However, until further work is finallized on the conglomerate problem, any conclusions are speculative.

JAMES D. SELL

Sil Murk Formation
Sand Tank (J.D. Sell) (10)
Table Top (J.D. Sell) (9)
San Tan (A.G. Blucher & J.E. Kinnison) (6)
Blackwater (A.G. Blucher) (5)
Arnett Creek (A.G. Blucher & J.E. Kinnison) (4)
Superior (A.G. Blucher) (3)
N. Superior (D.W. Peterson) (2)
Globe-Miami (N.P. Peterson) (1)
19 miles
22 miles
35 miles
Same Area
30 miles
5 miles
Same Area
13 miles
Tsv, Volcanic Member
V tuff
IV conglomerate
III basalt
dacite welded tuff
black vitrophyre
II
brownish-red ash
eolian sandstone
Tsm, Sedimentary Member
gray boulder conglomerate,
indurated fanglomerate;
brick-red arkosic sandstone
Tri, Rhyolite ignimbrite
black vitrophyre
tan tuff
Tic, Indian Butte Conglomerate
Younger Volcanics
Tb, basalt
Tu, undifferentiated
Tdv, Double Buttes Volcanics
dacite tuff (?)
scoria-agglomerate
red-speckled andesite
Tfb, Freeman Beds, red cinders
Tac, Antelope Peak Conglomerate
rhyolite ignimbrite
(Qs), Caliche-cemented Sediments
Tb, Basalt
Tov, Older Volcanics
dacite tuff
scoria-agglomerate
red-speckled andesite
red cinders and ash
Ts, Pebble Conglomerate
Twb, Walker Butte Basalt
Dacite
black dacitic vitrophyre
tan dacite tuff
"Rock Peak Conglomerate"
"Blue Basalt"
"Olberg beds", red-brown ash
"Yellow Peak Conglomerate"
Twb, Walker Butte Basalt
Td, dacite
welded tuff or tuff agglomerate
black vitrophyre
Trc, Rock Peak Conglomerate
Tbb, Blue Basalt
red-brown cinders
Tyc, Yellow Peak Conglomerate
Dacite
Massive beds & stratified tuffs
Brown rhyolite
spheroidal agglomerate with perlite
Tan water-lain tuffs
"Blue Basalt"
Brown to red-brown ash
Tw, Whitetail Conglomerate (Arboretum Area - Sell)
Td, Dacite
Dacite and/or Welded Dacite Tuff
Rhyolite
Vitrophyre
Tuff
Tw, Whitetail Conglomerate
Td, Dacite
very light gray dacite
moderate red dacite
light brown dacite
black vitrophyre
non-welded tuff
Tr, Rhyolite
lava flows of rhyolite and perlite obsidian, including tuff, tuff breccia, and flows of dacite and trachyte.
Tw, Whitetail Conglomerate
Later Volc.
Dacite
black vitrophyre
white to gray crystal-tuff
Earlier Volc.
Complex of bedded tuffs, felsitic and glassy lavas, and perlite glass.
Tw, Whitetail Conglomerate
POST-MINERAL
PRE-MINERAL

Attachment C

11 miles to Table Top

Santa Cruz Drill Hole
SC-5
(JR Wojcik)
(8)

6 miles.

Santa Cruz - Sacaton
(JE Kinnison)
(7)

15 miles to Blackwater

0 - 360 alluvium
360 - 2480 Quaternary sediments
2480 - 2680 Red-speckled andesite
2680 - 3550 Pebble conglomerate
3550 - fault, prominent below

Zones at 1913-1918,
2264-2271
2660-2666
3124-3141

Volcanics

Tb, Basalt

Tov, Older volcanics (andesite-basalt)

Ts, Sediments below Tov (mostly conglomerate).

Valley Conglomerate

TG, Gaslino Conglomerate

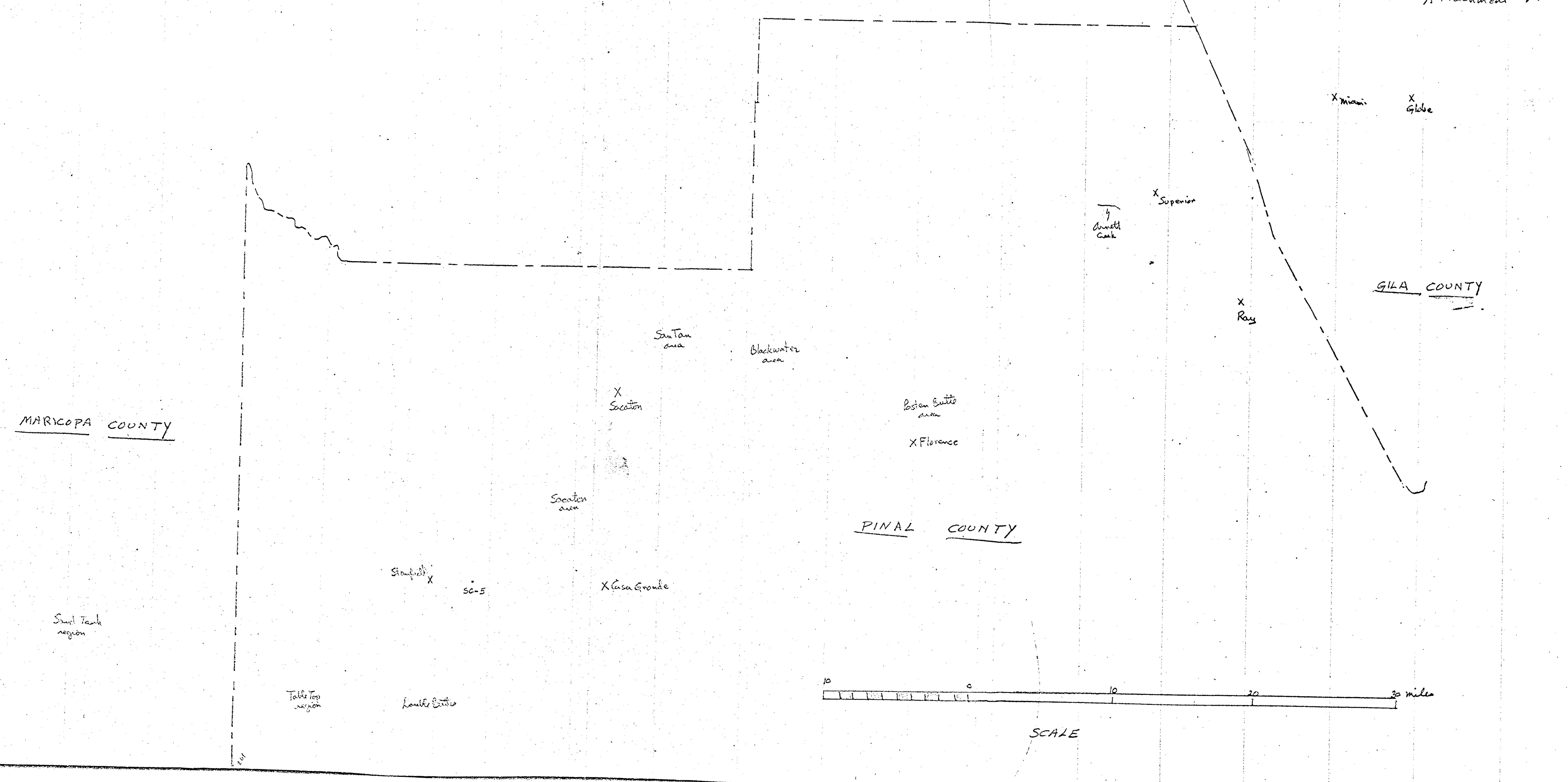
TSc, Sacaton Conglomerate
TBp, Burgess Peak Conglomerate
relative age not established.

Pre-mineral

X Sil Murk

X Gila Bend

Attachment A



J. E. KINNISON

John:
I'd like to present this to the AGS Cordilleran GSA meeting Guidebook. What do you think?

Jim

PRECAMBRIAN, PALEOZOIC, AND MID-TERTIARY SEDIMENTATION IN SOUTHWEST PINAL COUNTY AND ADJACENT PART OF MARICOPA COUNTY, ARIZONA

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Geologic mapping in the Table Top Mountain region (Sell, 1964) and the Sand Tank region (Sell, 1965) of south-central Arizona revealed outcrops of some Precambrian Apache Group sediments, parts of the Paleozoic section, and the basal conglomerate member of the Mid-Tertiary post-Laramide intrusive time sequence of sediments and volcanics.

The Precambrian and Paleozoic outcrops are some of the most southward exposures of unmetamorphosed and decipherable units in southern Arizona. A survey of the geological literature indicates that few of these outcrops were previously reported. The Pinal County (Wilson and Moore, 1959) and Maricopa County (Wilson, Moore, and Peirce, 1957) geologic map series of the Arizona Bureau of Mines reported only the Precambrian and Paleozoic sediments west of the Vaiva Hills, and the Apache Group sediment on Table Top Mountain and the undifferentiated Tertiary sediments throughout the region.

The Table Top-Sand Tank region and the generalized outcrop patterns is shown on Attachment A. Attachment A is modified from the Ajo AMS sheet (NI 12-10) and encompasses 450 square miles in southwestern Pinal County and the adjacent portion of Maricopa County, south-central Arizona.

Precambrian Apache Group and Troy(?) Quartzite

The Apache Group, in many parts of southern Arizona, is comprised of (ascending) Scanlan Conglomerate, Pioneer Shale, Barnes Conglomerate, Dripping Spring Quartzite, Mescal Limestone, and an unnamed basalt. The

2)

Apache Group is Younger Precambrian in age.

From the Table Top-Sand Tank region the nearest published mapping with stratigraphic sections and discussions is in the Vekol Mountains (Carpenter, 1947) to the south, and the Slate Mountains (Hogue, 1940; Hammer, 1961) to the southeast. The Vekol Mountains and the Slate Mountains contain excellent exposures of the pre-Tertiary sedimentary sequence. Several general reports and one large detailed stratigraphic description has been published for the Vekol-Slate Mountain portion of the Papago Indian Reservation (McClymonds, 1959; Heindl and McClymonds, 1964; and McClymonds and Heindl, 1965).

Scanlan Conglomerate. In the Table Top region pebble conglomerate beds assigned to the Scanlan Conglomerate are found in many places south of Table Top Mountain and west of the Vaiva Hills. Where observed the unit is generally less than three feet thick before grading upward into typical Pioneer Shale. An exceptional thickness was noted in the SW1/4, Section 1 (T 9 S, R 2 E) where the Scanlan attains a thickness of ten or more feet and is predominantly composed of granitic fragments.

To the west in the Sand Tank region, where the base of the Pioneer Shale was observed, no conglomerates of Scanlan type were observed. However, Scanlan may be present in some of the areas of covered contacts.

As reported in the Vekol Mountains (Carpenter, 1947) the Scanlan Conglomerate is of very local occurrence and its thickness is measured in inches, whereas in the Slate Mountains (Hammer, 1961) the Scanlan was not observed.

Pioneer Shale

Maroon siltstone and mudstone, containing cream-colored spots typical of the Pioneer Shale, crop out extensively at the base of the Apache Group sediments in the Table Top-Sand Tank region, especially in the Table Top region in a belt of Precambrian and Paleozoic sediments through unsurveyed

3)

Sections 10, 11, 14, 15, 22, 26, 27 (T8S, R3E) west of the Vaiva Hills. It crops out also in SE1/4, Section 27 (T8S, R2E) under the volcanic cap of Little Table Top Mountain, and extends southeastward as a chain of isolated outcrops into the N1/2, Section 12 (T9S, R2E). Pioneer Shale is also found in several places under the cliffs of the volcanic flows capping Table Top Mountain.

In the Sand Tank region Pioneer Shale is noted in scattered outcrops south and west of Johnson Well in the S1/2, Sections 21, 22, and NW1/4, Section 27 (all in T8S, R1W), and as the basal exposed unit of the sedimentary sequence found in a belt in the SW1/4, Section 35 (T7S, R1W) and extending into the NE1/4, Section 3, (T8S, R1W), northeast of Maricopa Peak.

Elsewhere, in areas of outcropping sediments of the Sand Tank region, the Apache Group sediments are missing and the Younger Precambrian Troy(?) and/or Cambrian Bolsa(?) rests directly upon the Precambrian Pinal Schist.

Barnes Conglomerate

Fragments of typical Barnes Conglomerate are found in many of the drainages from the Apache Group outcrop areas in the Table Top region but none were noted in the Sand Tank region. The Barnes attains a thickness of 8 to 10 feet in a good exposure in the W1/2, unsurveyed Section 15 (T8S, R3E). The thickness is only one-half to one-fourth the thickness recorded for the Barnes in the adjacent Vekol and Slate Mountain areas.

Although the full thickness of the Barnes is rarely exposed, it does appear that the Barnes Conglomerate is thinning westward in the Vaiva Hills-Table Top areas and disappears by the time the Sand Tank outcrops of Apache Group sediments are reached.

Dripping Springs Quartzite

Massive beds of cream to light orange quartzite and siltstone crop out between the Vaiva Hills and Table Top Mountain in the W1/2 of T8S, R3E. The massive Dripping Spring Quartzite is the thickest of the mapped Apache Group sediments, and though no direct measurements were taken, may approach

1000 feet in thickness in this area.

The overlying Dripping Spring helps to protect the weaker underlying Pioneer Shale from erosion, and thus is generally found wherever the Pioneer outcrops. Dripping Spring outcrops are also found on Table Top Mountain, Little Table Top Mountain, and in the Apache Group sediment area southeast of Little Table Top Mountain.

In the Sand Tank region southwest of Johnson Well the Dripping Spring Quartzite is found overlying the Pioneer Shale as a relatively thin reddish quartzite unit, but is missing in the sedimentary exposures to the north.

Measured sections indicate 800-1100 feet of Dripping Spring in the Vekol and Slate Mountains areas. Again, it is the thickest member of the Apache Group sediments.

With the thick sections in the Slate-Vekol-Table Top areas, it is reasonable to suggest the thin to missing section of Dripping Spring Quartzite in the Sand Tank region is the result of erosion during late Precambrian-early Cambrian time rather than being attributed to non-deposition.

Mescal Limestone

The upper most sedimentary unit of the Apache Group is the Mescal Limestone. Thickness of 200-300 feet of Mescal are measured in the Vekol and Slate Mountains but no remnants of Mescal type were found between the underlying Dripping Spring and the overlying sedimentary units in the Vaiva Hills-Table Top-Sand Tank regions. Again, this missing member of the Apache Group is believed to have been destroyed by erosion rather than non-deposition.

Troy(?) Quartzite

A thick, 600 foot, sequence of yellow-buff quartzite beds is found between typical Dripping Spring Quartzite and sandy-limey beds of probable Cambrian age in the Table Top region. The exposure of Troy(?) Quartzite in the SW1/4, Section 22 (T8S, R3E) contains abundant quartz granules and interstitial feldspar.

In Sections 2 and 11 (T9S, R2E) the Troy(?) rests on Dripping Spring and, in one area, is in contact with diabase but the actual contact is covered and the Troy(?)-diabase relationship cannot be observed. Isolated outcrops, apparently stratigraphically higher than the Troy(?) exposures, show Abrigo-type (Cambrian) limestones.

Southwest of Johnson Well, a white to buff sandstone-quartzite overlies the Dripping Spring Quartzite. The exposures contain fair to abundant pebble layers, interstitial clay spots, and some cross-bedding features. Again, based on the few features as known, the quartzite unit has been assigned to the Troy(?) Quartzite. In these exposures (N1/2, Section 28, T8S, R1W), the Troy(?) rests on Dripping Spring Quartzite, whereas to the southeast of Johnson Well, in NE1/4, Section 35 (T8S, R1W), assigned Troy(?) units were deposited on Pinal Schist.

To the north in the sedimentary sequence found in the SW1/4, Section 35 (T7S, R1W) and NE1/4, Section 3 (T8S, R1W), the Troy(?) rests on Pioneer Shale.

The diverse rock types on which the Troy(?) Quartzite now rests attests to the active pre-Troy erosion that has taken place in this portion of the Sand Tank region. The apparent missing of the total Mescal Limestone and much of the Dripping Spring Quartzite in comparison to the sections preserved further east in the Table Top and Vekol-Slate Mountains areas is a result of this active pre-Troy erosion forces.

Precambrian-Cambrian Boundary Problem

The break between Precambrian and Cambrian time, with the assignment of formational units, has long been a speculated problem in Central and Southern Arizona. Workers of the USGS have been mapping quadrangles in Central Arizona for the past decade and interest in the stratigraphic correlation problems has been renewed.

Shride, working in the asbestos region north of Globe, renewed the question of the relationships between the nonfossiliferous Troy Quartzite of his area and the fossiliferous Cambrian sandstones, also referred to as Troy, which were found in the southern part of the region. Shride (1958) suggested a Precambrian age for the nonfossiliferous units with a separation of them from the fossiliferous Cambrian units.

Krieger (1961), mapping the Holy Joe Peak quadrangle south of Globe, found the two units in contact and established the stratigraphy and age relationships of the nonfossiliferous Precambrian Troy Quartzite and the fossiliferous Cambrian Bolsa Quartzite.

Continued work by Shride (1961) established similar relationships for the quartzites and established the position of the diabase in relation to the quartzites. The diabase intrudes the Troy and in turn is overlain by the Bolsa. Age determinations by Silver (1960), on differentiates of the diabase sills north of Globe, places a Precambrian age on the diabase, Apache Group, and the Troy Quartzite of the region. Damon, et al (1962), reports a similar age for the diabase in the Sierra Anche region.

Peterson (1962) separated the Troy Quartzite from the Cambrian rocks in the Superior quadrangle west of Globe, on the basis of lithology and structural relationships.

In the Vekol Mountains, Carpenter (1947) mapped and described the Troy Quartzite as two members. The lower member is unfossiliferous and is intruded by diabase while the upper cross-bedded fossiliferous member has a ".....definite basal conglomerate consisting largely of diabase pebbles, cobbles and fragments in a cross-bedded sandy, cherty and calcareous matrix" (Carpenter, 1947, p.23). The contact zone is also represented by a shaley zone which contains numerous Cambrian brachiopods.

A three-fold Troy Quartzite division is reported by Hammer (1961) with abundant Scolithus in some of the upper units. Hogue (1940) reports poorly preserved brachiopod remains from the upper units of the Troy in his area of the Slate Mountains.

Heindl and McClymonds (1964) comment on the boundary nomenclature problem and refer all the quartzites above the Mescal Limestone to the Bolsa(?) Quartzite of Cambrian age.

The problems of nomenclature and boundary markers for the basal Cambrian was treated by Lochman-Balk in her comprehensive regional paper. She writes (17, p.548):

> "Throughout most of the region the basal Cambrian sandstone lies with clear-cut angular unconformity upon pre-Cambrian metamorphic or igneous rocks. But in Central Arizona from the Santa Catalina Mountains northward across the Gila River into the Sierra Ancha Range a series of late pre-Cambrian moderately indurated sediments, the Apache group of Ransome (1903), has been preserved. This series is comprised of a basal conglomerate, shales, quartzites, limestones, and thick basalt flows, and is entirely unfossiliferous. The thickness varies from 1000 to nearly 1800 feet depending upon the depth of erosion of the upper unit, the Troy quartzite and the underlying Mescal limestone. Throughout this area the material of the basal Cambrian sands was derived from the weathered products of Troy quartzite and consequently shows a marked lithologic similarity. In individual sections the Cambrian beds rest upon the Troy with apparent conformity. These two features added to the discontinuous and thin exposures of the fossiliferous Upper Cambrian sands in the area have caused geologists to confuse the two formations and frequently to lump all the sands and quartzites together as a single lithic unit. Thus an arenaceous lithic unit called the Troy quartzite has been variously assigned to the pre-Cambrian and the Cambrian ever since the name Troy was first proposed."

During the reconnaissance mapping in the Table Top-Sand Tank regions no detailed stratigraphic sections were measured and described for the questionable quartzites of the region. However, based on the criteria of Krieger (1961) and Peterson (1962, personal communication) the quartzites were separated into Precambrian Troy(?) and Cambrian Bolsa(?). No diagnostic fossils suggesting Cambrian age were found to validate the age designation.

The Troy(?) Quartzite of the Table Top-Sand Tank regions rests on Dripping Spring, Pioneer Shale, and on Pinal Schist in various exposures. The lack of any Mescal Limestone and the diverse rock units underlying the Troy(?) suggests strong pre-Troy erosion in the region. Carpenter (1947) found marked channeling of the Apache basalt and the Mescal Limestone of the Apache Group in the Vekol Mountains. Also, the basalt is locally missing and the Mescal is radically thinned where overlain by the non-fossiliferous Troy. In the Slate Mountains, Hammer (1961, p.24) reports the absence of basalt (Apache) flows, no pre-Troy channeling of the Mescal Limestone, and the lack of erosion surfaces within the sequence of named Troy beds.

Paleozoic Units

The Paleozoic units in the Vekol Mountains (Carpenter, 1947) contain ages of Cambrian, Devonian, Mississippian, and Pennsylvanian and have been subdivided into a number of members. In the general reconnaissance of the Table Top-Sand Tank regions, the exposures were only divided into the broadly recognized terms although in places they probably could be broken down into the finer subdivision nomenclature.

Cambrian Bolsa(?) Quartzite and Abrigo Limestone

Outcrop exposures of these units are confined to low hilly areas on dip slopes of some of the large hills in the Table Top region. Typical sandy Bolsa-type quartzite, ranging in color from cream to reddish, grades rapidly into the sandy-limey beds characteristic of the Abrigo Limestone. However, the Cambrian sequence is never extensively exposed and good sections were not found. The major exposures are found in unsurveyed Sections 22, 27, 34 (T8S, R3E) where they rest on either assigned Troy(?) Quartzite or Dripping Spring Quartzite and underlie fossiliferous beds of the Devonian Martin Limestone.

Beds of typical Abrigo Limestone (showing intraformational conglomerate structure) are found in isolated outcrops in the center of Section 11 (T9S, R2E) south of Little Table Top Mountain.

In the Sand Tank region, a red, hard, vitreous, cross-bedded quartzite is found in several places. In Sections 35, 36 (T8S, R1W) the vitreous quartzite rests on white to buff Troy(?) Quartzite and grades upward into limey quartzites which underlie Devonian limestones. To the north in a belt in Sections 6, 8 (T8S, R1E) the quartzite underlies Devonian but rests on Pinal Schist. To the west in the outcrops of Section 35 (T7S, R1W) and Sections 2, 3 (T8S, R1W) the quartzites again rest on Troy(?).

Thick sections of Cambrian units, especially the Abrigo-type limestones, are found in both the Vekol and Slate Mountain areas. The small amount of Cambrian sedimentation preserved in the Table Top-Sand Tank regions and the diverse rock types they presently rest on suggest that structural unrest was still a major feature in this region during Cambrian time. In part, the lack of section may be due to non-deposition but part may be attributed to pre-Devonian erosion.

~~Devonian Martin Limestone~~

Devonian Martin Limestone

Medium-bedded, medium-gray, fossiliferous limestones typical of the Martin form most of the Paleozoic outcrops in the Table Top region. Where in contact with an underlying unit the limestones rest on the limey quartzites of the Bolsa(?)-Abrigo types. The larger exposures are in unsurveyed Sections 27, 34 (T8S, R3E) with some isolated blocks. The NW1/4, Section 11 (T9S, R2E) also contains several exposures.

In the Sand Tank region, the medium-bedded, medium-gray limestones containing some beds of abundant fossiliferous material --- crinoid stems, brachiopods, and bryozoans --- overlie the vitreous red Cambrian quartzites. The larger outcrops are in the SE1/4, Section 23, and SW1/4, Section 24 (both in T8S, R1W) and in Sections 35, 36, (T8S, R1W). Other outcrops are in Sections 6, 7, 8 (T8S, R1E), SW1/4, Section 20 (T8S, R1W), NW1/4, Section 2 (T8S, R1W), center of Section 3 (T8S, R1W), and an isolated block of Devonian(?) in the SW1/4, Section 27 (T7S, R1W).

Bryan (1925) examined the outcrop in Sections 23, 24 (T8S, R1W) and from his fossil collection Edwin Kirk (Bryan 1925, p. 56) reported that "......the crinoid (~~Jim, you have crynoid??~~?) [?, you are right!] fragments.....are of such nature that they could not be any older than Devonian nor younger than Carboniferous."

Based on visual comparison of Devonian outcrops in the Vekol and Slate Mountains, the relationship of the limestone to the underlying quartzites, and the occurrence of lacy bryozoans, the limestone units are correlated with the Devonian Martin Limestone.

As in the Table Top region, the clean deposition of limestone and the occurrence of crinoid and bryozoa suggests that during Devonian sedimentation the area was extensively covered by marine waters and the shoreline of the Devonian seas was located much further west.

In a study of the Toroweap and Kaibab formations of Northern Arizona, McKee (1938, p.142) writes:

> "The association of brachiopods, corals, bryozoa, crinoids, and pecten-like pelecypods in the areas of open seas and the confinement of most mollusks, scophopods, trilobites, and cephalopods to deposits of the restricted water bodies of more saline or more brackish character are clearly demonstrated."

The association of crinoid and bryozoas does not determine absolute water depth but signifies only that the seas were probably shallow, open and of a clear water environment.

Mississippian Escabrosa Limestone

Although more than 400 feet of Escabrosa Limestone are measured and described in both the Vekol and Slate Mountain areas, only a few isolated outcrops were found in the Table Top-Sand Tank regions. Capping the Devonian hill in unsurveyed Section 27 (T8S, R3E) is a thin remnant of massive light-gray limestone beds suggestive of Mississippian-type. A short distance to the west, in a down-faulted block, another small outcrop of similar limestone is found.

West of Johnson Well in the SW1/4, Section 20 (T8S, R1W) a small block of massive gray limestone containing abundant bulbous chert is found overlying the Martin Limestone containing bryozoan beds. The contact between the two limestones is marked by a thin-bedded shaley unit. Based on the bulbous character of the chert, the massive-bedded limestones are believed to be part of the Escabrosa Limestone of Mississippian age.

Pennsylvanian Naco Limestone

The southernmost exposure above the Escabrosa Limestone and ending in Section 29 (T8S, R1W) is composed of alternating thin-bedded limestones and shale beds suggestive of belonging to the Pennsylvanian Naco Limestone.

As with all the units discussed previously, no detailed stratigraphic sections of the units nor fossil collections from the units have been obtained for additional control on the age of the Paleozoic units as assigned.

Mid-Tertiary Sedimentation

Throughout the Table Top-Sand Tank regions, no remnants of possible Mesozoic sedimentation was found. Carpenter (1947) describes Cretaceous(?) units of siliceous red beds and quartzites in the Vekol Mountains. Also in the Vekol Mountains, Heindl (1965) in a recent publication named several formations of probable late Mesozoic age. No Mesozoic units are found in the Slate Mountains (Hogue, 1940; Hammer, 1961).

In the Table Top-Sand Tank regions are numerous outcrops of tuffaceous conglomerates which contain fragments of Precambrian granites, schist, Apache Group and Paleozoic sediments, Cretaceous conglomerates, various Laramide(?) granites, latites, and volcanic porphyries. The tuffaceous conglomerates everywhere underlie mappable units of volcanics. The upper units of the conglomerate intrabed with the volcanics and the lower units of the volcanics are also highly deformed and tilted as are the conglomerates (Sell 1964, 1965, 1967). Observations on the imbrication of the pebble layers in the conglomerate suggest the source area for the material lies south and southwest of the Table Top-Sand Tank regions.

Good exposures are found in the cliff areas under the Tertiary volcanic flows in the higher mountains of the Table Top region. The unit has been designated the Antelope Peak Conglomerate for the excellent exposure on Antelope Peak (SE1/4, unsurveyed Section 20, T7S, R2E). The Antelope Peak section is not the thickest found but it is complete in the fact that it rests on an eroded surface of Precambrian granite and is overlain by one of the basal units of the volcanic outpourings.

Under the volcanic cap of Table Top Mountain, the conglomerate was deposited on Pinal Schist, Pioneer Shale, and Dripping Spring Quartzite. In the exposures in unsurveyed Sections 29, 30 (T7S, R3E) the conglomerate rests on Pinal Schist. Further north at the large hill in the N1/2, Section 15 (T7S, R2E) the conglomerate rests on Precambrian granite.

In the Sand Tank region the conglomerate was deposited on Devonian limestones and Cambrian quartzites in Sections 35, 36 (T8S, R1W). In the area of Sections 35, 36 (T7S, R1W) and Sections 1, 2, 3 (T8S, R1W) the conglomerates overlie Pinal Schist, Troy(?) Quartzite, Bolsa(?) Quartzite, Martin Limestone, and Laramide granite and diorite. To the northwest in

Sections 27, 28 (T7S, R1W) the conglomerate covers Devonian(?) limestones and Laramide granite.

Elsewhere, as north of Freeman Underpass (Section 1, T7S, R1W), and the large expanses shown in T6-7S, R2-3W, the conglomerate forms the basal unit and interfingers with the complex volcanic sequence deciphered for the region.

A small patch of conglomerate is at Sand Tank Well (Section 11, T8S,R2W) where it rests on Precambrian granite. The outcrop of Tertiary tuffaceous conglomerate in the wash was measured by Bryan (1925, p. 61) who concluded:

> "It is evident from the section that these rocks were formed after volcanism had begun in the neighborhood. The pre-Tertiary rocks were exposed, and at this place streams deposited poorly assorted debris derived from the erosion of the pre-Tertiary volcanic rocks, mixed with the material of ash showers."

In addition to the imbrication of the pebble layers as showing the stream direction from the south and southwest quadrants, an excellent example on Squaw Tits (Section 4, T7S, R2W) is exposed where the conglomerate passes over a buried ridge of Precambrian granite. On the northeast side (leeward) of the ridge the conglomerate suddenly becomes virtually loaded with debris from the distinctive orange-weathered granite whereas on the southwest side of the ridge the conglomerate has relatively few fragments of this distinctive granite.

Addendum and Acknowledgement

The above discussion covers the major sedimentary outcrops within the outlined area of Attachment A. On the far southwest side, just outside the mapped portion in the E1/2, T7S, R3E, a fairly thick sequence of quartzites and limestones was observed from a distance, with the basal unit apparently resting on schist and granite.

Publication permission has been extended by ASARCO and is gratefully acknowledged

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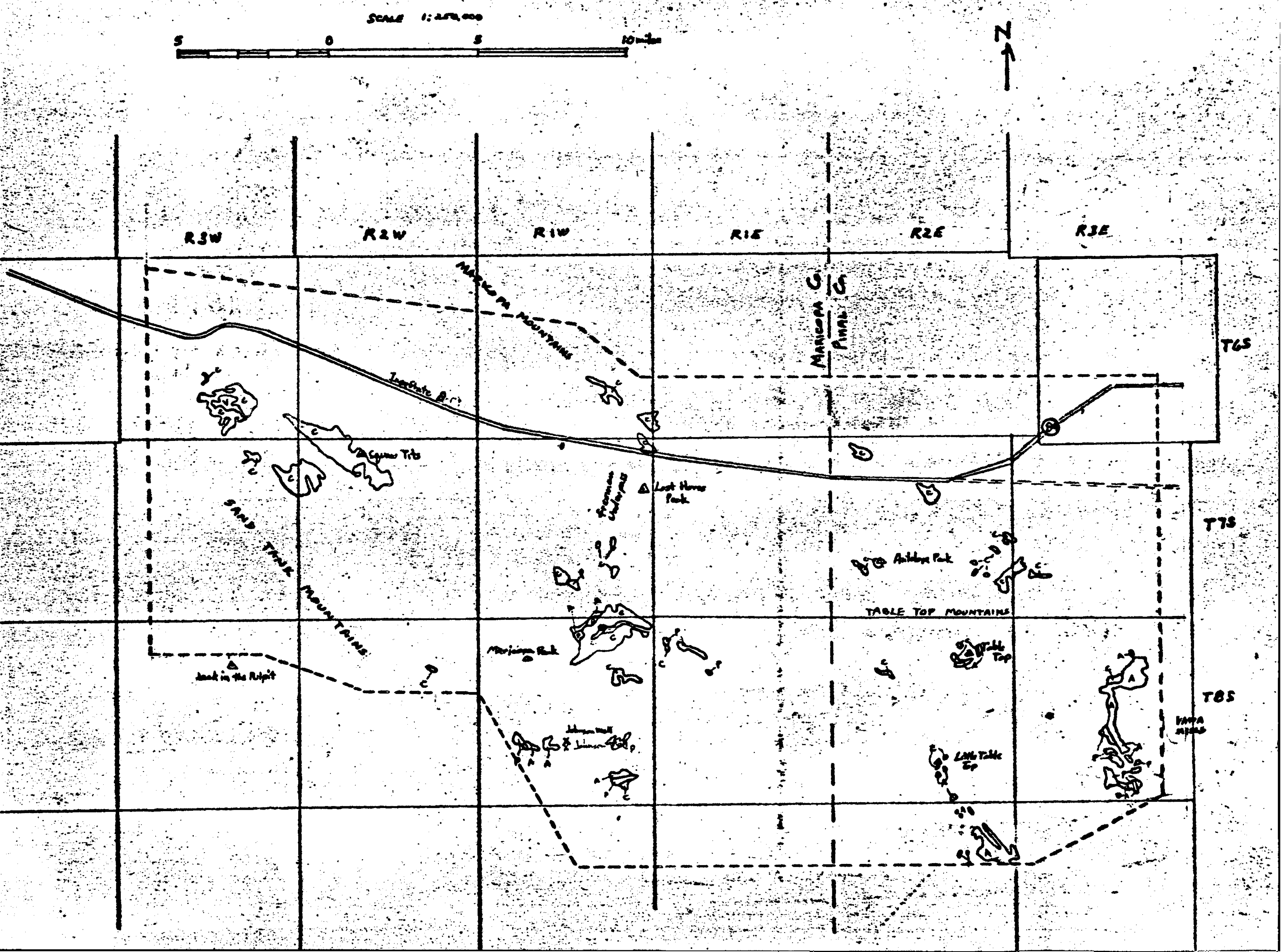

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Pinal Co
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Lost Horse Peak
Antelope Peak
TABLE TOP MOUNTAINS
Table Top
Little Table Top
Maricopa Peak
SAND TANK MOUNTAINS
Jack in the Pulpit
Johnson Well