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OSTRACOD BED

DEAD COW HILL

Photos & Neg.

APR · 61

Outcropping Bed on Dead Cow Ridge

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GEOLOGIC MAP
OF A
PART OF THE SOUTHERN SECTION
AMOLE MINING DISTRICT
Tucson Mountains
Pima County, Arizona

Geology by: John E. Kinnison, 1958
Topography enlarged from USGS San Xavier Quadrangle.

MINERAL DEPOSITS

The entire Dragoon quadrangle has been included in the Cochise mining district, a large unorganized district, which has never been consistently defined. Portions of the area are commonly referred to by other names that have more definite geographic and geologic significance.

Copper and zinc deposits at Johnson, which by the end of 1955 had yielded nearly 1,000,000 tons of ore with a value of about $20,000,000, are the most important deposits commercially. These deposits are northeast of the quartz monzonite of Texas Canyon and are of the pyrometasomatic type. Metallization was preceded by thermal metamorphism which converted impure carbonate rocks to garnet, diopside, and other silicate minerals, with concomitant loss in volume. Sphalerite, chalcopyrite, and locally bornite have replaced favorable beds in the metamorphosed sequence near fissures and other structures that provided channels for mineralizing solutions. The ore bodies have the form of tabular masses and chimneys in the plane of the beds. Large ore bodies, so far found, have all been within a thin stratigraphic zone in the Abrigo formation.

Tungsten deposits, generally called the Dragoon tungsten deposits, have had a moderate but unknown production. Most of the tungsten has come from veins and lodes in the northeastern part of the quartz monzonite stock of Texas Canyon, and from placers derived from these deposits. The veins trend northeast and consist of huebnerite, scheelite, and traces of base-metal sulfides in a gangue of quartz, muscovite, and fluorite. Rich ore pockets have been mined from shallow workings, but the metallized veins have proved too small and the tungsten content too erratic for profitable deep mining. At the Tungsten King mine on the west side of the Little Dragoon Mountains, about 12 tons of scheelite concentrates have been produced from a contact vein between Precambrian (?) granite and Pinal schist.

Small lead-silver vein and replacement deposits occur in the northern part of the Gunnison Hills. The largest and richest deposit is at the Texas Arizona mine, from which recorded shipments between 1908 and 1928 total 718 tons of ore averaging nearly 40 percent lead and 50 ounces of silver to the ton. These ores were oxidized and occurred as small replacement bodies along beds and fissures in the Escabrosa limestone.

Marble, in the form of rough monumental stone, terrazzo, and roof chips, is produced from deposits at the north end of the Dragoon Mountains. Operations to date have been on a small scale.

STRUCTURE OF THE SAGINAW AREA, TUCSON MOUNTAINS, ARIZONA

John E. Kinnison

INTRODUCTION

The Saginaw area lies immediately south of the Ajo Road at the extreme southern tip of the Tucson Mountains, about 6 miles southwest of Tucson, Arizona (fig. 55). Saginaw Hill (figs. 27, 28) is the site of a porphyry intrusive plug and a surrounding, weakly mineralized area. The general geologic setting of the Tucson Mountains is described elsewhere in this guidebook (Kinnison, 12).

Data presented in this paper were obtained during field mapping in the early 1950's and are discussed in more detail in a University of Arizona thesis (Kinnison, 1958).

LARAMIDE STRUCTURE

Folds and Associated Faults

General Statement

The dominant elements of Laramide structure are folds and associated thrust and tear faults (fig. 27). These structures pre-date the Tucson surface (Kinnison, 12) and were presumably formed during late Cretaceous or early Tertiary time. A complete understanding of these structures is obscured by the stratigraphic uncertainties within the Cretaceous Amole group.

There are four orders of folds: the first order is established by interpretation and three others are observable in the field. I interpret the first order structure to be a synclinorium on which are superposed folds of the other orders. Folds of the second order have wave lengths which range from 200 to over 1000 feet, and their asymmetry is controlled by the inferred synclinorium. On the limbs of these second order folds are smaller, third order, drag folds, not mapped precisely but shown diagramatically on the cross-sections (fig. 28). The asymmetry of each third order fold is controlled by a second order fold. Finally, fourth order drag folds, generally only a few feet in amplitude, are superposed upon and owe their asymmetry to third order folds. These relations should be considered in future studies of this area because, for example, the direction of asymmetry cannot be inferred directly from the orientation of the third order folds.

Associated with the synclinorium are thrust and tear faults, whose presence has been largely inferred from the surface outcrop pattern.

Synclinorium

The existence of a large synclinorium is inferred from the direction of asymmetry and overturning of second order folds. Its axis is indefinitely located, but probably lies between the Five and Burger faults (fig. 28). East of the Five fault the second order folds are asymmetrically inclined and overturned to the east, while west of the Five fault they are overturned and asymmetrically inclined toward the west. West of the Five fault all of the folds plunge southeast, whereas east of it the plunge is northwest. The reason for this is not clear but it may be that the Five fault separated the active forces sufficiently to allow folds on either side of that fault to form separate plunge patterns.

Under the above interpretation, the Permian Snyder Hill formation (Stoyanow, 1936) exposed south of Cat Mountain (fig. 27) is on the east limb of the synclinorium and at Snyder Hill is on the west limb. This interpretation is in disagreement with that of Brown (1939), who considered these Permian outcrops to be klippen.

The steeper dips of the beds on the west limb, compared with the gentler dipping and more open folds on the east limb, suggests that the synclinorium is asymmetrically inclined toward the northeast.

Normal Faults

It is probable that at least some high-angle normal faults were formed shortly after the Laramide folding, but I identified none in the field. The fault extending northeast from Saginaw Hill is occupied by the Saginaw porphyry dike. Movement has occurred along this fault because the beds on either side do not match, but the magnitude is unknown. The displacement of the Tertiary Cat Mountain rhyolite along this fault is slight, if any. This may be, then, a pre-Cat Mountain rhyolite fault which was reactivated in late (?) Tertiary time with very slight displacement. Many of the other faults which cut the Tertiary rocks may have originated during Laramide time, but field mapping neither supports nor disproves this possibility.

TERTIARY STRUCTURE

High-Angle Faults

High-angle faults dominate the Tertiary structure, and, although it is generally impossible to measure dips because few fault outcrops are present, most of them probably are normal faults. Such fault surfaces as are exposed show gently dipping slickensides, suggesting that horizontal movement may have been important. The fault pattern is complex and it is not clear which faults formed first, or whether movement was contemporaneous on all of them.

Some faulting took place during Cat Mountain rhyolite time, and some structural deformation in the form of local tilting slightly preceded extrusion of the upper unit of the Tertiary volcanic pile, the Shorts Ranch andesite. Most of the faulting is probably post-Shorts Ranch andesite, but a minimum age cannot be established. Faults displace the flat-lying basalts of Tertiary-Quaternary age at "A" Mountain (Brown, 1939), but enough time must have elapsed since the previous period of faulting to permit erosion to form the extensive pediment on the western side of the range and remove much of the Tertiary strata. It is noteworthy in this connection that nearly all the faults form obsequent fault line scarps with the downthrown sides topographically high. ?

Tilted Blocks and Folds

The Tertiary rocks generally dip at gentle angles. The measurement of structural tilt in volcanic rocks is subject to error because part of the dip of the flow structure might have been due to original dip of the flow. I have observed, however, that the volcanic flow structure in the Tucson Mountains, as well as surrounding ranges, commonly dips gently, 5 to 35 degrees, in a northeast to east direction. This suggests to me that most of the dip is due to regional tilting. Also, the Ter-

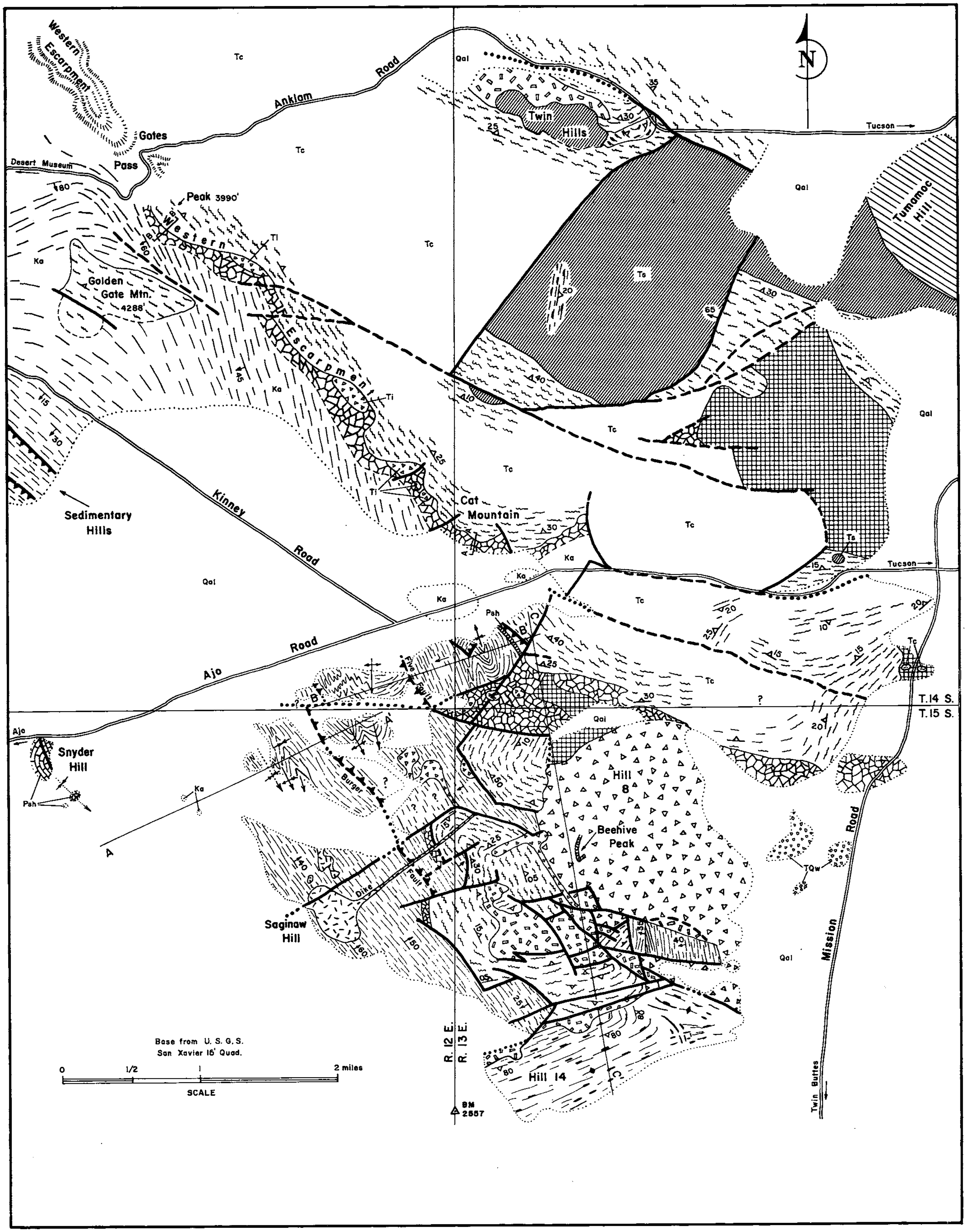


FIGURE 27. Geologic map of the Saginaw area, Tucson Mountains, Pima County, Arizona.

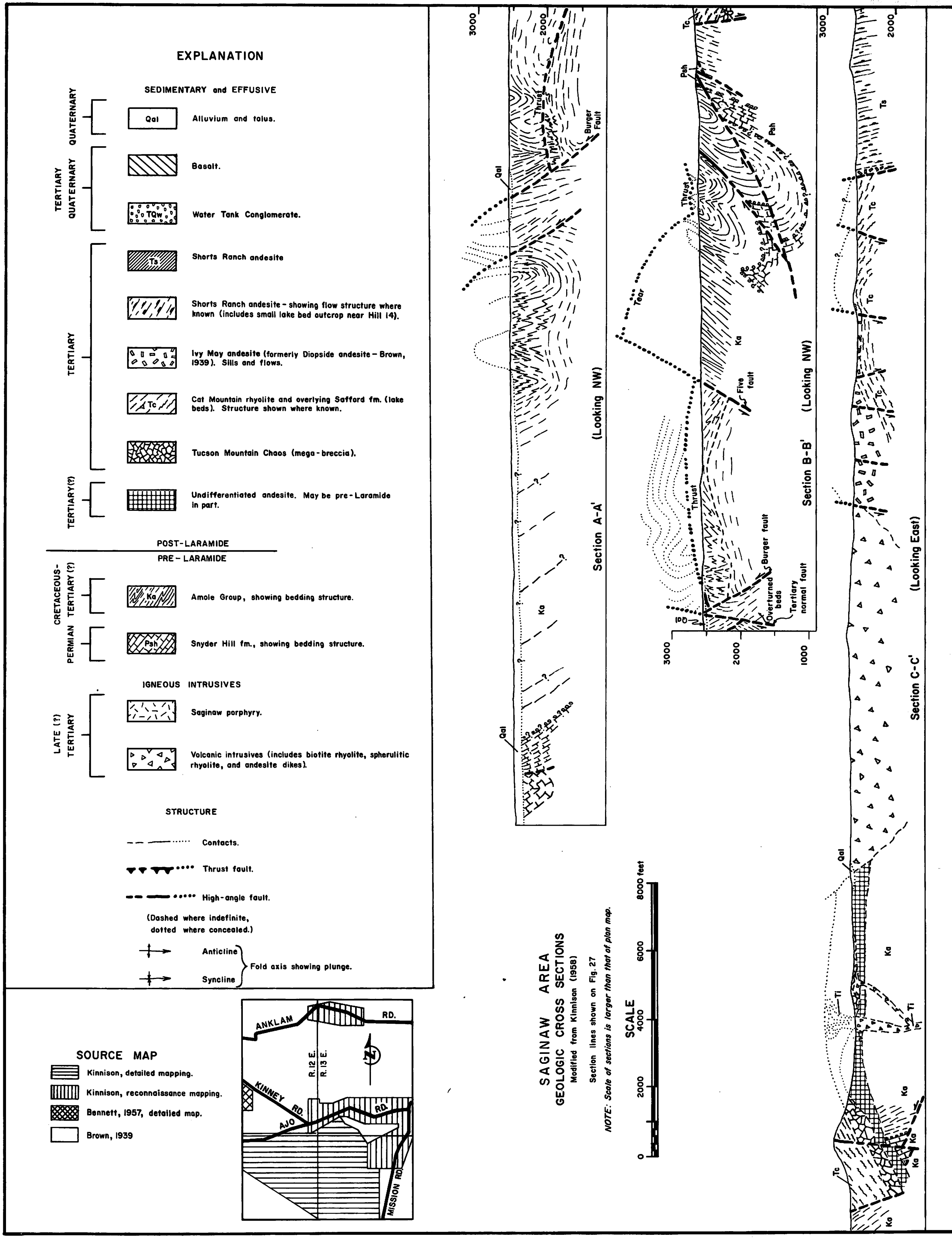


FIGURE 28. Index map, explanation, and cross sections to accompany geologic map of the Saginaw area, Tucson Mountains, Pima County, Arizona (fig. 27).

tiary sedimentary rocks, such as the Safford formation, show this same direction of dip. In consideration of these facts, the flow structure in these areas may be assumed to have been essentially horizontal when formed, and the present dip may be considered to be a measure of the amount of structural tilting.

In the complexly faulted area south of the Ajo Road the Tertiary rocks exhibit folded structures and variable directions of dip, an apparently rare occurrence in other parts of the Tucson Mountains and in surrounding ranges. For the most part, however, these folds are postulated to be the result of fault drag. Some of the small fault blocks show no relation to the adjacent folded structures, and exhibit independent homoclinal dips.

Where the rocks are not affected by these small folds, the dominant direction of dip is northeast to east.

Thrust Faults

Local thrusting may have occurred during the deposition of the Tucson Mountain chaos (Kinnison, 12). A small outcrop of lake beds in the southern tip of the range may be thrust over the Shorts Ranch andesite, a suggestion made by Brown (1939), or they may be deposited on the andesite, as suggested by Kinnison (1958). There are no other indications of Tertiary thrust faulting in the Saginaw area.

RELATION TO REGIONAL STRUCTURE

Laramide

The Amole group is folded into a broad, open syncline in the central part of the Tucson Mountains (Brown, 1939). The intricately folded synclinorium in the Saginaw area may be a part of that structure, but a positive correlation cannot be made with the data at hand.

Brown (1939) noted outcrops of Paleozoic limestone and Cretaceous or early Tertiary volcanic rocks overlying deformed Cretaceous-Tertiary (?) sediments. He believed that these rocks represented klippen from a large thrust sheet which was nearly removed by erosion prior to extrusion of the Cat Mountain rhyolite. Additional work has shown that these conspicuous limestone and volcanic outcrops are part of a tabular breccia (Kinnison, 1958; 12) which contains very large fragments of all the Cretaceous-Tertiary (?) and older rocks. I suggest that this breccia is talus and landslide debris deposited on the Tucson surface which bevels the pre-Laramide rocks. If this interpretation is correct, then there is no direct evidence of large scale overthrusting in the Tucson Mountains.

The tightly compressed folds and local thrusts in the Saginaw area indicate that forces required for overthrusting were present during Laramide diastrophism. As noted previously, the southwest limb of the synclinorium exhibits generally steeper and tighter folds, which suggests that the synclinorium is inclined asymmetrically to the northeast. These features indicate that the Laramide forces produced a tendency for regional overthrust movement toward the northeast. If a large overthrust in the Tucson Mountains resulted from these forces, it was either eroded during the formation of the Tucson surface or lies deeply buried below the rocks of the Cretaceous-Tertiary (?) Amole group.

Tertiary

The post-volcanic Tertiary structure is discussed at some length by Brown (1939), and although I do not concur with all of the implications of his remarks, I refer the reader to them for an excellent presentation of local and regional structure.

The principal elements of Tertiary structure are internal faults, inferred range-boundary faults, and tilted blocks.

The internal faults which displace Tertiary rocks are not mapped precisely or completely enough for detailed analysis, but the degree of accuracy is sufficient for some generalized conclusions. Brown noted (1939) that east or northeast faults are nearly always downthrown to the south. This is not true in detail in the Saginaw area, where many reverse relationships occur, but the aggregate effect may still be a downthrow on the south. Brown (1939) pointed out that this direction of throw was in harmony with the structurally high Tortolita Mountain block to the north.

Reconnaissance observations, in the Roskruge Mountains to the west and the Tortolita Mountains to the north, suggest that those ranges are tilted to the northeast or east. The Tertiary volcanic rocks of the Santa Rita Mountains to the southeast of the Tucson Mountains dip northeast (Schrader, 1915). On physiographic evidence, Davis (1931) believed that the Santa Catalina Mountains also were tilted to the north-east or east. It is probable, then, that the Tucson Mountains are a part of a wide-spread pattern of northeasterly regional tilting. Between the Santa Catalina and Roskruge Mountains, the regional tilt appears to have been broken into blocks which are downthrown progressively to the west. The Tertiary folded structures of the Saginaw area, however, are of local origin.

There is little evidence to indicate that the inferred marginal faults, which are covered by alluvium, are single faults along the borders of the ranges, or are fault zones made up of many faults distributed through the width of the intermontane valleys. Of course, it is also possible that there are two separate systems of faults; those to which the tilting was initially related, and the others, of a later age, which are responsible for the present mountain-valley pattern. But certainly, faults of some kind must be inferred to break the easterly regional tilt and form the mountain ranges.

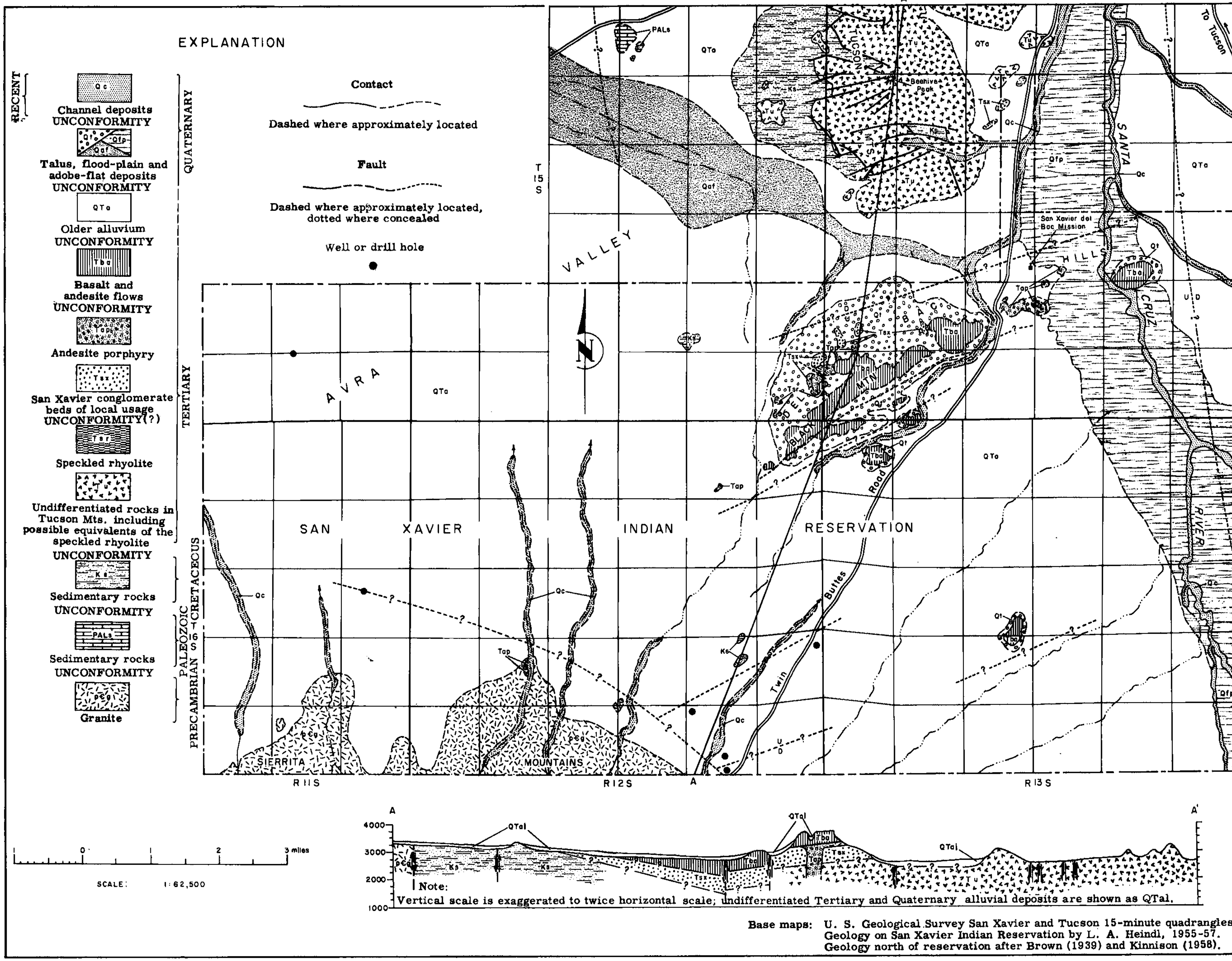


FIGURE 29. Geologic map and cross section of the San Xavier Indian Reservation, Pima County, Arizona.

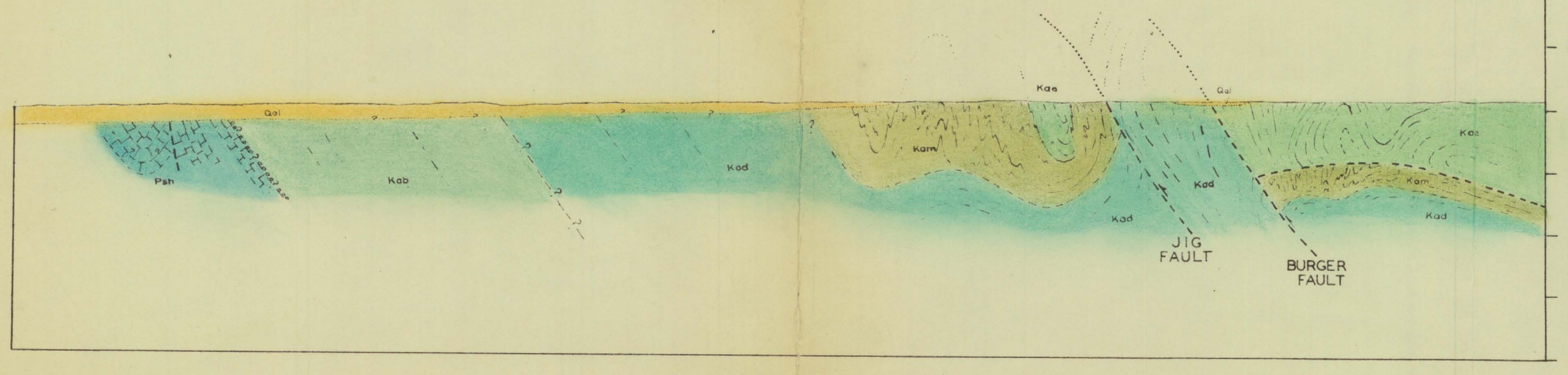
GEOLOGIC MAP
OF A
PART OF THE SOUTHERN SECTION
AMOLE MINING DISTRICT
Tucson Mountains
Pima County, Arizona

Geology by: John E. Kinnison, 1958
Topography enlarged from U.S.G.S. San Xavier Quadrangle.

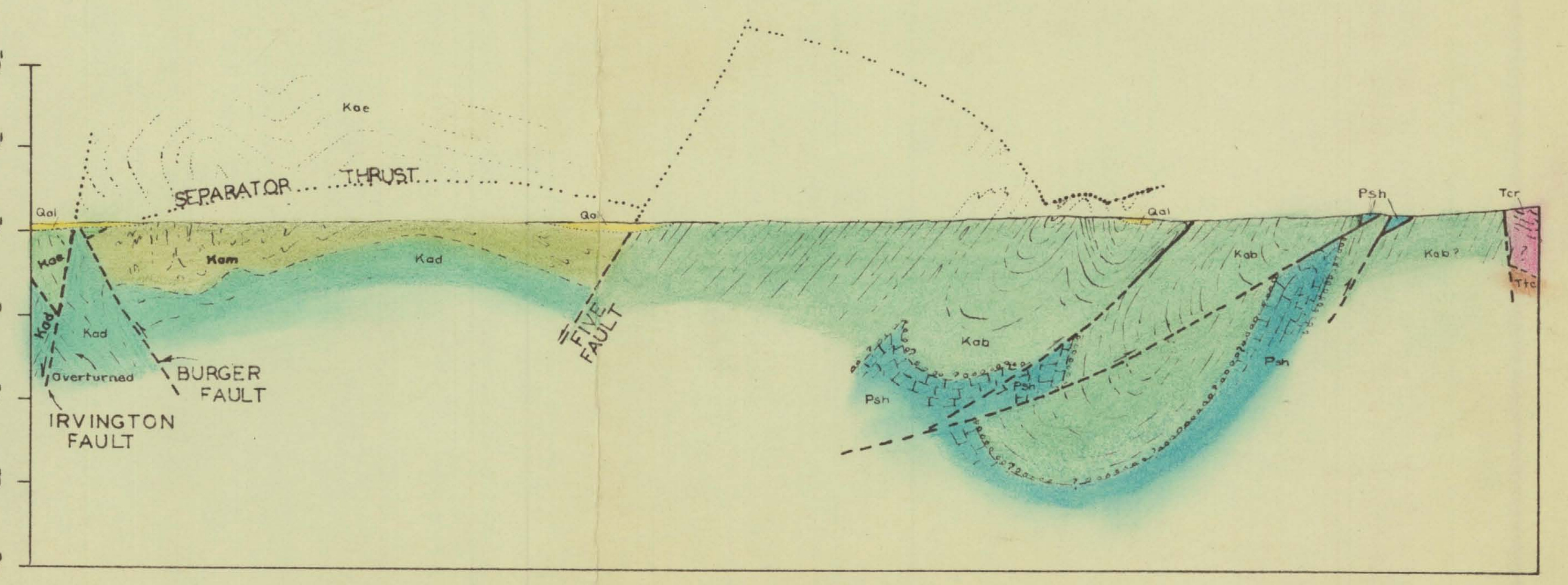
PLATE 3

AJO HIGHWAY
SNYDER HILL
BM 2480
EL PASO GAS LINE ROAD
SAGINAW HILL
BEEHIVE PEAK
BM 2557
STRUCTURE
SEDIMENTARY BEDDING
Strike and dip.
Strike and dip of overturned beds.
General direction of dip in low angle bedding.
Vertical bedding.
Horizontal bedding.
Structural pattern.
IGNEOUS STRUCTURE.
Strike and dip.
Vertical.
Horizontal.
General direction of low angle structure.
Structural trend.
Flow structure.
Strike and dip.
Vertical.
Joints.
Aligned tabular phenocrysts.
FOLDS.
Overturned anticline.
Syncline.
Overturned syncline.
Anticline, showing direction of plunge.
Dashed where approximately located.
Dotted where concealed.
Questioned where inferred.
CONTACTS
Closely located, showing dip.
Vertical.
Obscure, or indefinite.
Inferred.
Covered.
Flat contact on gentle slope showing formation above and below.
FAULTS
Closely located, showing relative vertical movement.
Showing relative strike movement.
Vertical.
Obscure or indefinite.
Inferred.
Concealed.
Thrust fault, showing thrust plate.
CULTURE
Paved road.
Graded road.
Passable road.
House
Mine.
Adit.
Prospect.
EXPLANATION
SEDIMENTARY AND EFFUSIVE ROCKS
Quaternary
Qal Alluvium and talus.
Upper (?) Tertiary
Tl Lake beds.
Tsa Shorts Ranch Andesite. (Intrusive in this area, extrusive elsewhere.)
Tim Ivy May Andesite. (Sill in Safford Formation, extrusive (?) elsewhere.)
Tsf Safford Formation.
Tcr Cat Mountain Rhyolite.
Ttc Tucson Mountain Chaos (A tabular Mega-breccia, showing mappable conglom.)
Tertiary (?)
T(?)ua Undifferentiated Andesite. (May in part be "chaos".)
POST - LARAMIDE
PRE-LARAMIDE
Tertiary (?)
Upper Cretaceous
Kae Echo Valley Formation.
Kam Mouse House Formation.
Amole Group Undifferentiated
Ka
Lower Cretaceous
Kad Dead Cow Formation. (Showing location of 3' limestone bed with astracods.)
Kab Braun Formation.
Basal Conglomerate.
Paleozoic - Permian
Psh Snyder Hill Formation.
TERTIARY INTRUSIVE IGNEOUS ROCKS
Post-Biotite rhyolite
Tia Small dikes and plugs.
Thin dikes.
Undifferentiated Andesite
Post-Ivy May Andesite and Pre-Shorts Ranch Andesite
Tbr Biotite-rhyolite. (In part extrusive.)
Biotite rhyolite; dikes without inclusions, showing flow structure.
Post-Cat Mountain Rhyolite
Probably Post-Shorts Ranch andesite
Tsp Saginaw porphyry.
Ts Spherulitic rhyolite.
SCALE: 1" = 1000'
0 500' 1000' 1500' 2000 feet
Contour interval: 50 feet.
Datum: Mean sea level.
GEOLOGIC MAP
OF A
PART OF THE SOUTHERN SECTION
AMOLE MINING DISTRICT
Tucson Mountains
Pima County, Arizona
Geology by: John E. Kinnison, 1958
Topography enlarged from U S G S San Xavier Quadrangle.

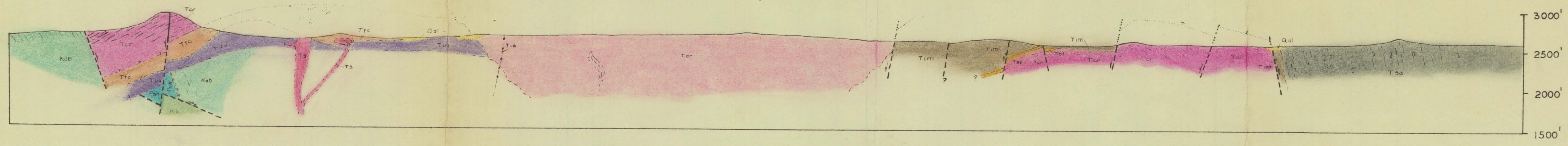
PLATE 3



SECTION A-B, LOOKING NW.



SECTION C-D, LOOKING NW.



SECTION E-F, LOOKING EAST

GEOLOGIC CROSS SECTIONS
FOR PLATE 3

HORIZONTAL & VERTICAL SCALE: 1" = 1000'

PLATE 3-A

COLOR CHART
KINNISON THESIS

Sediments & Volcanic

Qal	D. 1970 MONGOL - 817
Tl	D. 1951
Tsa	Lead pencil gray
Tim	D. 1990
Tsf	D. 1972
Tcr	D. 1985
Ttc	D. 1992
T(?)ba	D. 1980
Kae	D. 1961
Kam	D. 1966
Kad	D. 1960
Kab	M. 868
Ka	D. 1965
Psh	D. 1955

Intrusive Igneous

Tia	D. 1946
Tbr	D. 1942 (Main masses - color lightly
Tsp	D. 1941
Ts	D. 1945
Tbr	D. 1942 (Dikes, color dark)

Special groups -- on Quadrangle Photstat only

Ka	D. 1961
Lsqm	D. 1941
TQb	D. 1995 (Black, color lightly)
TQw	D. 1966
T(?)ba	19[illegible]

Pencils:
D. - Dixon Anadel
M. - Mongol

PEAK