STRUCTURE OF THE SAGINAW AREA, TUCSON MOUNTAINS, ARIZONA

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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 dip 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-

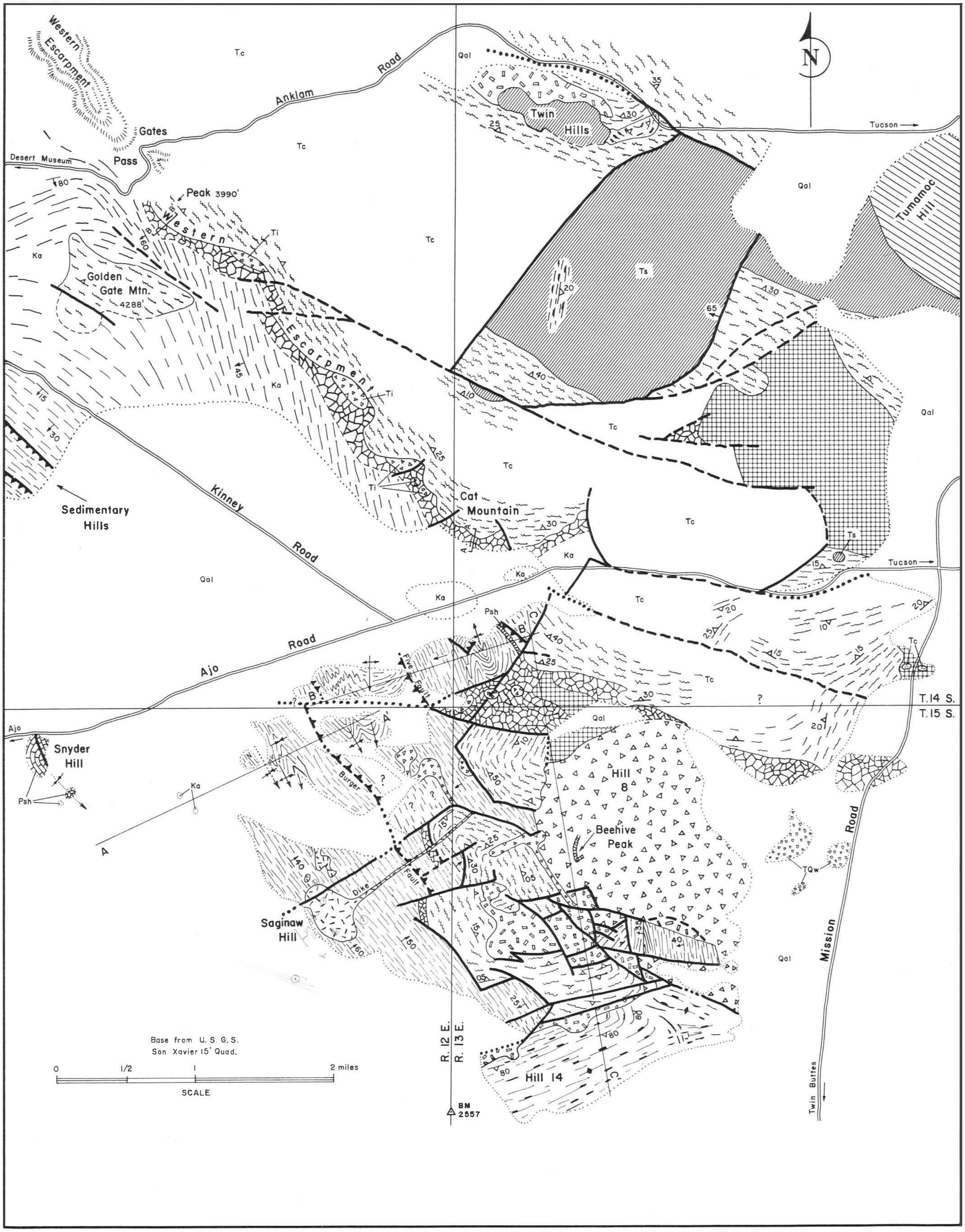

FIGURE 27. Geologic map of the Saginaw area, Tucson Mountains, Pima County, Arizona.

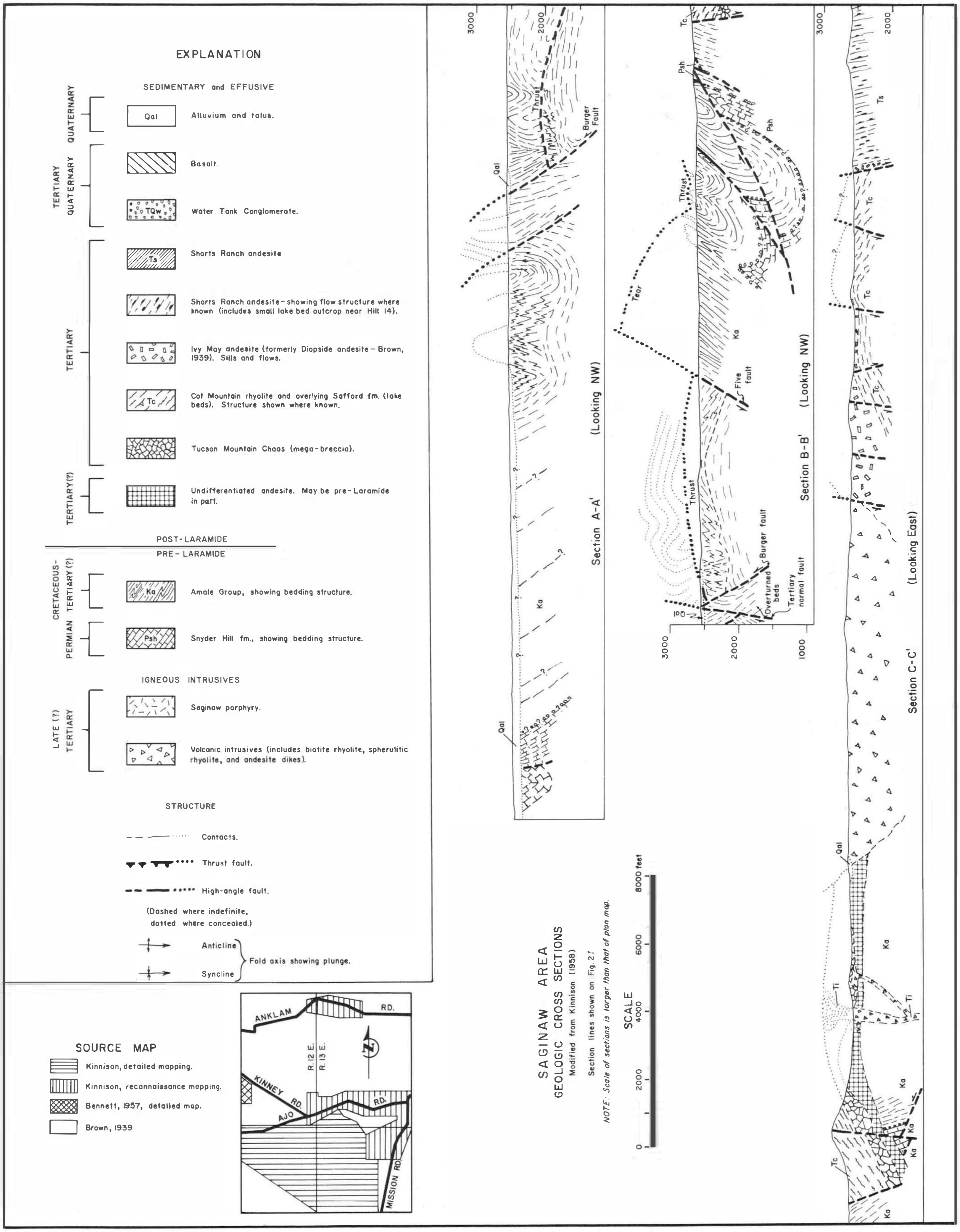

FIGURE 28. Index map, explanation, and cross sections to accompany geologic map of the Saginaw area, Tucson Mountains, Pima County, Arizona (fig. 27).

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.