Structural Geology of the Santa Rita Mountains, Southeast of Tucson, Arizona

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A description of the abundant and locally complex systems of faults, folds, and structurally controlled intrusives and an analysis of their development

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STRUCTURAL GEOLOGY OF THE SANTA RITA MOUNTAINS, SOUTHEAST OF TUCSON, ARIZONA

By Harald Drewes

ABSTRACT

The Santa Rita Mountains and the hills to the southwest are underlain by an extensive sequence of sedimentary, volcanic, and metamorphic rocks of Precambrian to Holocene age. This sequence is more complete than any similar sequence in other mountains of southeastern Arizona. The structural record of the area is also extensive. Faults are the most abundant structural features; intrusive bodies are numerous, and many of them are structurally controlled; and folds are common in some parts of the mountains. The structural features, however, have not obliterated the stratigraphic record, because areas of complexly deformed rocks are separated by areas of only slightly deformed rocks. The succession of structural events is thus decipherable, and many of the events are geologically closely dated by radiometric ages of the igneous rocks and by a few faunal ages of the sedimentary rocks. The Santa Rita Mountains are, therefore, a key area for understanding the regional tectonic development.

The major structural features of the Santa Rita Mountains are the northwest-trending high-angle fault zones—the Santa Rita fault zone to the southwest and the Sawmill Canyon fault zone to the northeast. These fault zones are of Triassic to about Paleocene age. They separate three major structural units whose general attitudes and internal minor structural features differ considerably from each other. The Santa Rita fault zone contains a record of great vertical movement and of possible lateral movement; however, successive plutonic intrusions have obliterated all but small remnants of this zone. The Sawmill Canyon fault zone contains a record of repeated vertical movement, some thrust faulting, and possibly some left-lateral movement.

The southwestern major structural unit, lying southwest of the Santa Rita fault zone, contains two areas in which faulting and magmatic activity are closely related. The first of the two areas, the San Cayetano Mountains–Grosvenor Hills area, was both intruded and covered by a granodiorite-rhyodacite complex of late(?) Oligocene age. After the time of magmatic activity, deep-level intrusives of the San Cayetano Mountains were raised along a large normal fault to the level of the shallow intrusives of the Grosvenor Hills area and the Grosvenor Hills Volcanics. Abundant small normal faults border some of the shallow intrusives, chiefly laccoliths, that were emplaced in the volcanic pile. Several graben blocks foundered into parts of the volcanic pile. In the second of the areas, the Montosa Canyon area, remnants of a thrust plate and tear fault show evidence of both northeastward and southwestward transport during Late Cretaceous to early Tertiary time. The younger southwestward movement was accompanied by the emplacement of an extensive igneous sheet containing abundant and large exotic blocks, believed to be largely foundered remnants of the roof of a shallow sill that was emplaced beneath the thrust plate about the time that the thrust plate moved southwestward. Large stocks intruded the Montosa Canyon area volcanic complex only a few million years after the last major volcanic eruption.

The central major structural unit, between the Santa Rita and Sawmill Canyon fault zones, is for the most part a simple eastward-dipping homoclinal block. In the northeast corner of the unit, Upper Cretaceous rocks are tightly folded along northwestward-trending axes. Several swarms of dikes and one of quartz veins, all of early Tertiary age, trend east to northeast across the unit.

The northeastern major structural unit, northeast of the Sawmill Canyon fault zone, is cut by many northwest-trending tear and normal faults, as well as by thrust faults of two ages. The rocks in thrust plates of late Late Cretaceous age are disharmonically folded, chiefly along northwest-trending axes and southwest inclined axial planes, showing that the plates were transported northeastward. Small stocks cut some of these thrust faults. Other thrust faults and northwest-trending left-lateral tear faults of late Paleocene age show evidence of a northwest transport direction. Some of these faults cut the stocks. Plugs and dikes associated with ore deposits intrude many of the younger faults and the axial planes of some folds. Structural features are especially complex where younger faults that are associated with northwest transport are superposed on segments of older faults or folds associated with northeast transport. Inconspicuous or short range-front faults lie along both flanks of the northern part of the mountains.

The tectonic development of the area, indicated by an analysis of the structural record presented here and the sedimentary record presented in supplementary reports, is similar to that of the surrounding region, and only the local record of the development during the Mesozoic is more complete than the regional record. The most ancient rocks, the Pinal Schist and Continental Granodiorite, show effects of the Mazatzal Revolution, which are typical of central Arizona. Alternating upward and downward epeirogenic movements throughout the Paleozoic Era are recorded by a marine sequence whose continuity is interrupted by several disconformities. Strong vertical movements, largely on faults, occurred at intervals from the Triassic to the Early Cretaceous; two stocks were injected into the rocks of the area, at about the end of the Triassic and during Middle Jurassic time.

During the Laramide Orogeny, which lasted from about 90 to 53 m.y. (million years) ago, the area was severely deformed. The orogeny apparently took place in two phases, an early (Piman) phase and a late (Helvetian) phase, which were separated by a period of tectonic quiescence 10–20 m.y. in duration. The Piman phase began with folding in the early Late Cretaceous and culminated with northeast-directed thrust faulting of what was probably a single relatively thin plate mainly composed of bedded rocks. Abundant subsidiary tear faults and folds deformed the plate during the Piman phase, and some favorably oriented segments of older faults were reactivated. The Piman phase ended with the emplacement of several large stocks in the late Late Cretaceous. The Helvetian phase of late Paleocene age comprised northwest-directed thrust and tear faulting and emplacement of small stocks. At the close of the Helvetian phase, plugs and dikes of quartz latite porphyry intruded the faults, and mineralizing fluids associated with these intrusive rocks spread along the faults.

In post-Laramide time the area was deformed largely by normal faults. Many of these faults were associated with late(?) Oligocene volcanism; others were related to intrusion of several dike and vein swarms into east- to northeast-trending tension fractures. During the late Tertiary the area was tilted gently southeast on a range-front fault, along which the youngest movement was late Pleistocene.

INTRODUCTION

LOCATION AND OBJECTIVES

The geology of the Santa Rita Mountains was intensively investigated during the years 1962–69. Geologic mapping of the Mount Wrightson and Sahuarita quadrangles, lasting a total of about 350 days during 1962–68, showed the mountains to be underlain by a stratigraphic sequence that is unusually complete for southeastern Arizona. Consequently, the structural development of the area may be interpreted in greater detail than is possible elsewhere in this part of the State. An understanding of the succession of structural events in the Santa Rita area can assist similar studies throughout the region and may be especially useful in nearby areas where the geologic record is less complete and the interest in reconstructing that record is greater because of the mining activity.

The Santa Rita Mountains are the first range southeast of Tucson. They extend more than 25 miles (40 km) southward, from Pantano Wash, along which the main highway and railroad east of Tucson lie, to Sonoita Creek, about 12 miles (20 km) from the Mexican border (fig. 1). The mountains commonly reach heights of 6,000–7,000 feet (2,000 m), but Mount Wrightson reaches an elevation of 9,453 feet (2,881 m). The broad valley to the east of the mountains lies at about

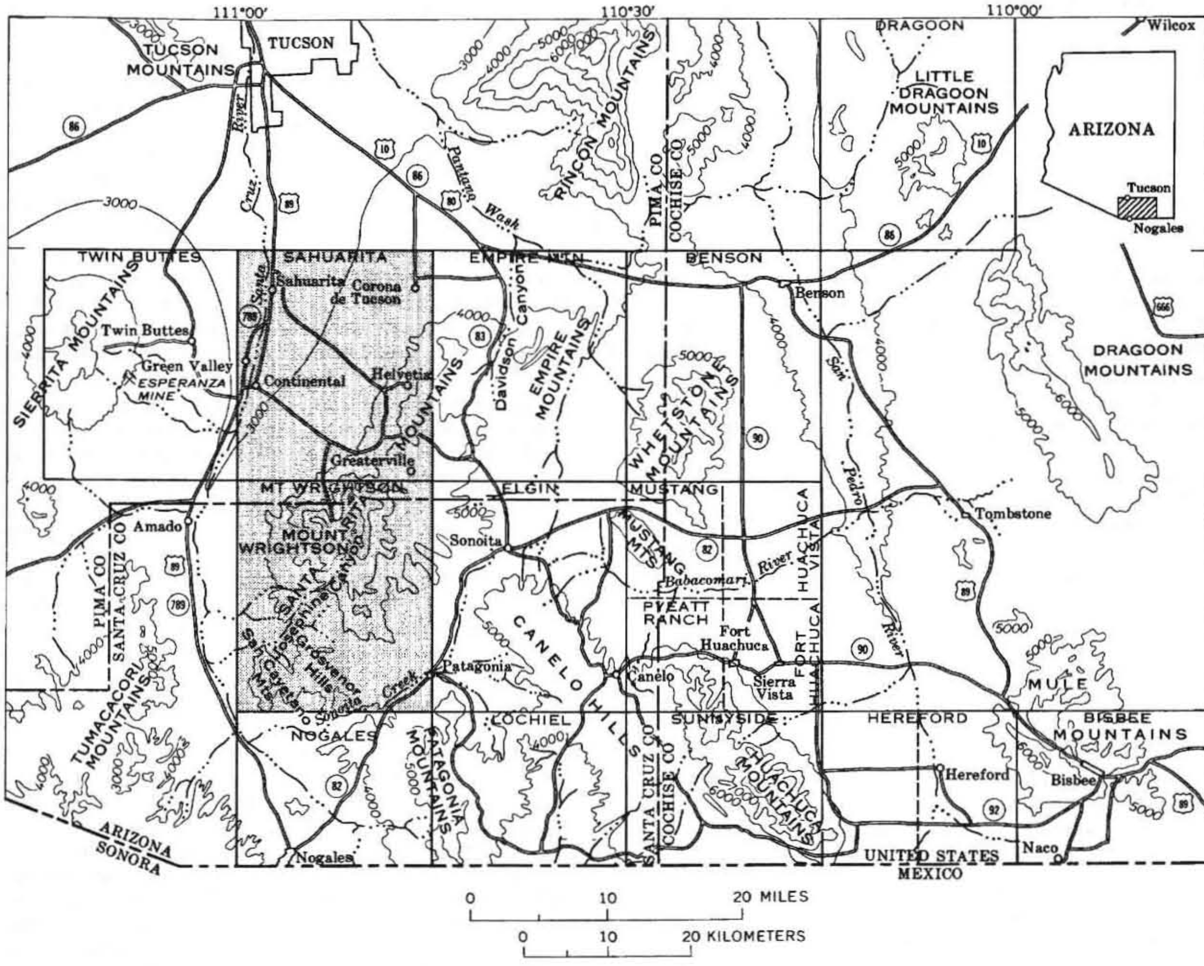

FIGURE 1.—Location of the Santa Rita Mountains in southeastern Arizona. Shaded areas show location of Sahuarita and Mount Wrightson quadrangles.