

TOPOGRAPHIC, PHYSIOGRAPHIC, AND STRUCTURAL
SUBDIVISIONS OF ARIZONA

By

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INTRODUCTION

Many recent reports on the geology of Arizona have shown the physiographic settings of the areas with which they were concerned by means of a variety of schemes. These schemes in part are inconsistent, and their variety is confusing to the ordinary professional reader. The schemes fall into two groups--the classical delineations of topographic or physiographic provinces by Ransome (1904; 1923) and Fenneman 1931 and those that deviate from these older systems in several ways. The (classical) systems used by most authors who follow Ransome and Fenneman are adequate for regions typical of the Colorado Plateau and basin-and-range countries, but differ considerably in the placement of the boundary between the two. In addition, several recent attempts to define regional boundaries on criteria other than topography or physiography indicate that the classical systems are no longer everywhere compatible with present understanding of the structural relationships of the Colorado Plateau and basin-and-range parts of Arizona. The area in which there is disagreement as to the proper placement of the boundary forms a zone of varying width extending from the northwestern to the east-central part of the state.

This paper briefly reviews the existing schemes of topographic, physiographic, and structural boundaries in Arizona and proposes the use of a boundary based on structural differences, as they are now understood, to separate the Colorado Plateaus and Basin and Range provinces.

The authors gratefully acknowledge the many helpful suggestions and criticisms made by Messrs. C. A. Repenning and A. F. Shride of the U. S. Geological Survey, J. W. Harshbarger and M. A. Melton of the University of Arizona, R. T. Moore of the Arizona Bureau of Mines, and many others. These men, however, are not necessarily in accord with the opinions presented in this paper.

SUBDIVISIONS OF RANSOME AND FENNEMAN

Ransome (1904) divided Arizona into three physiographic divisions which he called the Plateau, Mountain, and Desert regions (fig. 1 A). He contrasted the nearly horizontal structure of the strata and the plateaulike topography of the Plateau region with the Mountain region, which he characterized as consisting of "nearly parallel short ranges, separated by valleys," and the Desert region, which he described as a region in which "the ranges are separated by broad desert plains." These divisions continue to be used, although sometimes they are referred to as "topographic" rather than "physiographic," probably because they are greatly generalized.

The 1904 boundaries were changed and redefined by Fenneman (1914). In 1916 a committee of the Association of American Geographers, with Fenneman as chairman, further refined these boundaries in the form shown on the map compiled by the Physiographic Committee of the U. S. Geological Survey (Fenneman, 1931). (fig. 1B.) In keeping with the modifications made by the 1916 committee, Ransome (1923, fig. 2) divided Arizona into parts of two regional provinces--the Colorado Plateaus and Basin and Range provinces (fig. 1B).

The boundaries between the two major divisions shown by Ransome (1923) and Fenneman (1931) were essentially the same, but their subdivisions of the Basin and Range province differed. Ransome (1923) subdivided the Arizona part

of the Basin and Range province into the Mountain and Plains regions, and Fenneman (1931) divided the same area into parts of the Mexican Highland, Sonoran Desert, and Great (Nevada) Basin sections. The principal differences are between the Mountain region and Mexican Highland section, which in general cover the zone between characteristic plateau and basin-and-range countries. The Mountain region of Ransome (1923) consists of two parts--a broad wedge in the central and eastern parts and a smaller area in the northwestern part of the State. The two areas were separated in west-central Arizona, where the Plains region was shown in direct contact with the Plateau province. In contrast, Fenneman (1931) showed the Mexican Highland section as a broad swath that everywhere separated the Colorado Plateaus province from the Sonoran Desert section, essentially similar to the Mountain region of Ransome (1904). The reasons for the differences are nowhere discussed by the authors.

In southeastern Arizona, both Ransome (1904) and Fenneman (1931) draw virtually the same boundaries between the Mountain and Desert regions or Mexican Highland and Sonoran Desert sections, and state that they are largely arbitrary and based on topographic rather than structural differences.

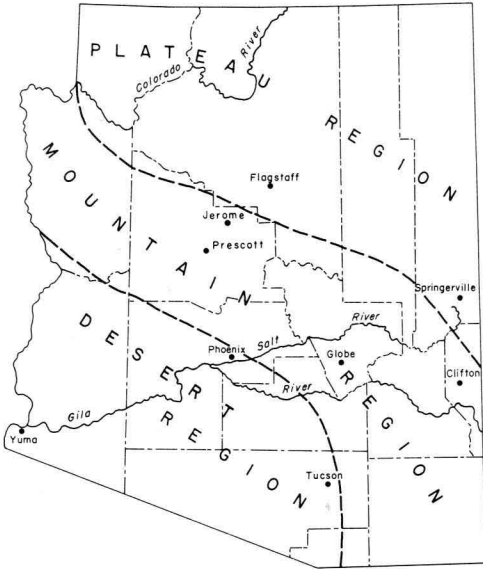
Butler and Wilson (1938) included the Mountain and Desert regions as delineated by Ransome (1904) in a subsequent definition of the Basin and Range physiographic province in Arizona, apparently preferring these boundaries to those shown by Ransome (1923) and Fenneman (1931).

RECENT CONTRIBUTIONS TO THE PROBLEM

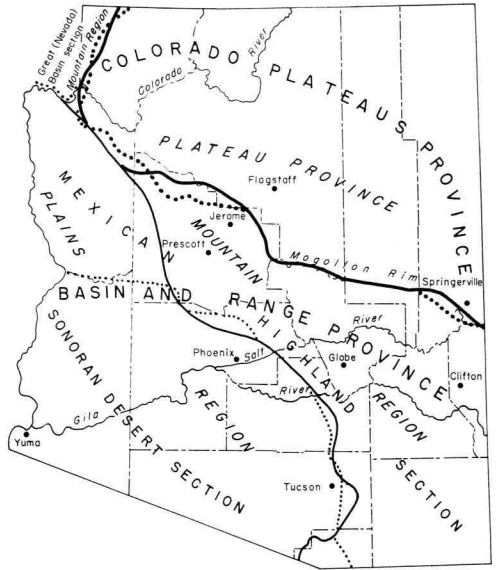
The Mogollon Rim in central and eastern Arizona was shown by Ransome (1923) and Fenneman (1931) as the boundary between the Colorado Plateaus and Basin and Range provinces. As early as 1940, it was pointed out that the Mogollon Rim is an eroded scarp and that the nearly flat lying horizontal structure, characteristic of the Colorado Plateaus, extends south of the Mogollon Rim (Sharp, 1940). Halpenny and others (1952) recognized that the Mexican Highland section as described by Fenneman (1931) did not extend into the northwestern part of the State, and they modified slightly the divisions of Ransome (1923). Kelley (1955) noted that in southwestern Colorado the boundaries of the Colorado Plateaus structural and physiographic provinces are in considerable variance, but his tectonic map ~~ping~~ did not carry far enough to the southwest to show the relationships in Arizona.

Bromfield and Shride (1956, fig. 76) divided Arizona into two major provinces (fig. 1C) along a somewhat different line from that shown by Ransome (1923) and Fenneman (1931). The reasons for the changes were given only for the area of their report, a part of the east-central Arizona. In this area, the division between the Colorado Plateaus and Basin and Range provinces was made (Bromfield and Shride, 1956, p. 615) by contrasting "the general high level of its (Colorado Plateaus province's) surface and by the approximate horizontal position of its rocks" to the "broad intermontane alluvium-filled valleys and several northwest-trending mountain ranges (that) characterize the (Basin and Range) area."

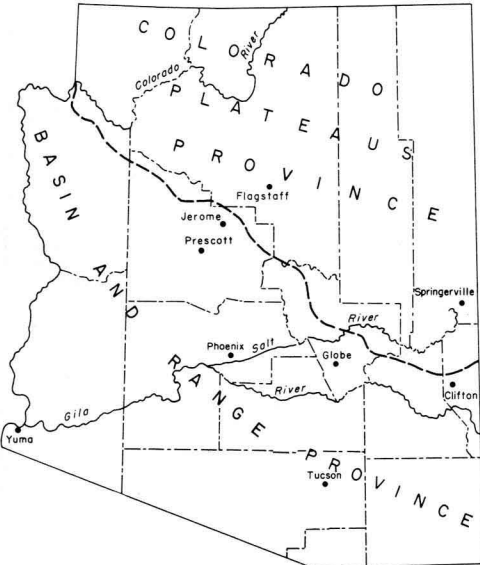
Another division on structural grounds was made by Wilson and Moore (1959) who divided the State into two structural provinces and a restricted "Transition Zone" (fig. 1 D). Wilson and Moore (1959, p. 89) point out that: "The boundary separating the Basin and Range province from the Plateau (Colorado Plateaus province) is sharp in northwestern Arizona but in the central and southeastern parts of the State the structural features by which the provinces are differentiated cannot be so clearly defined. . . . We have delimited a transitional belt within which the strata, although locally folded, tend to be relatively flat." The necessity of the Transition Zone is open to question, and Wilson and Moore (oral communication, 1959) consider it to be related, structurally, more closely to the Colorado Plateaus province than to the Basin and Range province. The boundary between the Transition Zone and the Basin and Range province is generally sharp (A. F. Shride, oral communication, 1959).



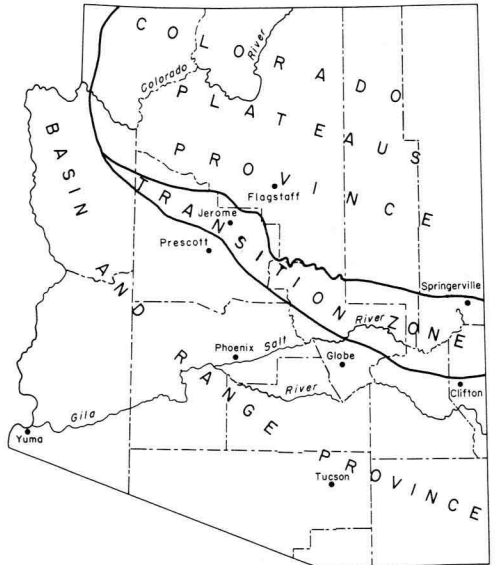
A. Physiographic divisions by Ransome (1904).



B. Comparison of the physiographic provinces of Ransome (1923) and Fenneman (1931). Boundaries and names after Ransome (1923) shown by solid lines and slanted lettering; boundaries and names after Fenneman (1931) shown by dots and vertical lettering.



C. Structural boundary of physiographic provinces by Bromfield and Shride (1956).



D. Structural provinces by Wilson and Moore (1959).

Figure 1.--Index maps showing some previously suggested physiographic and structural divisions in Arizona.

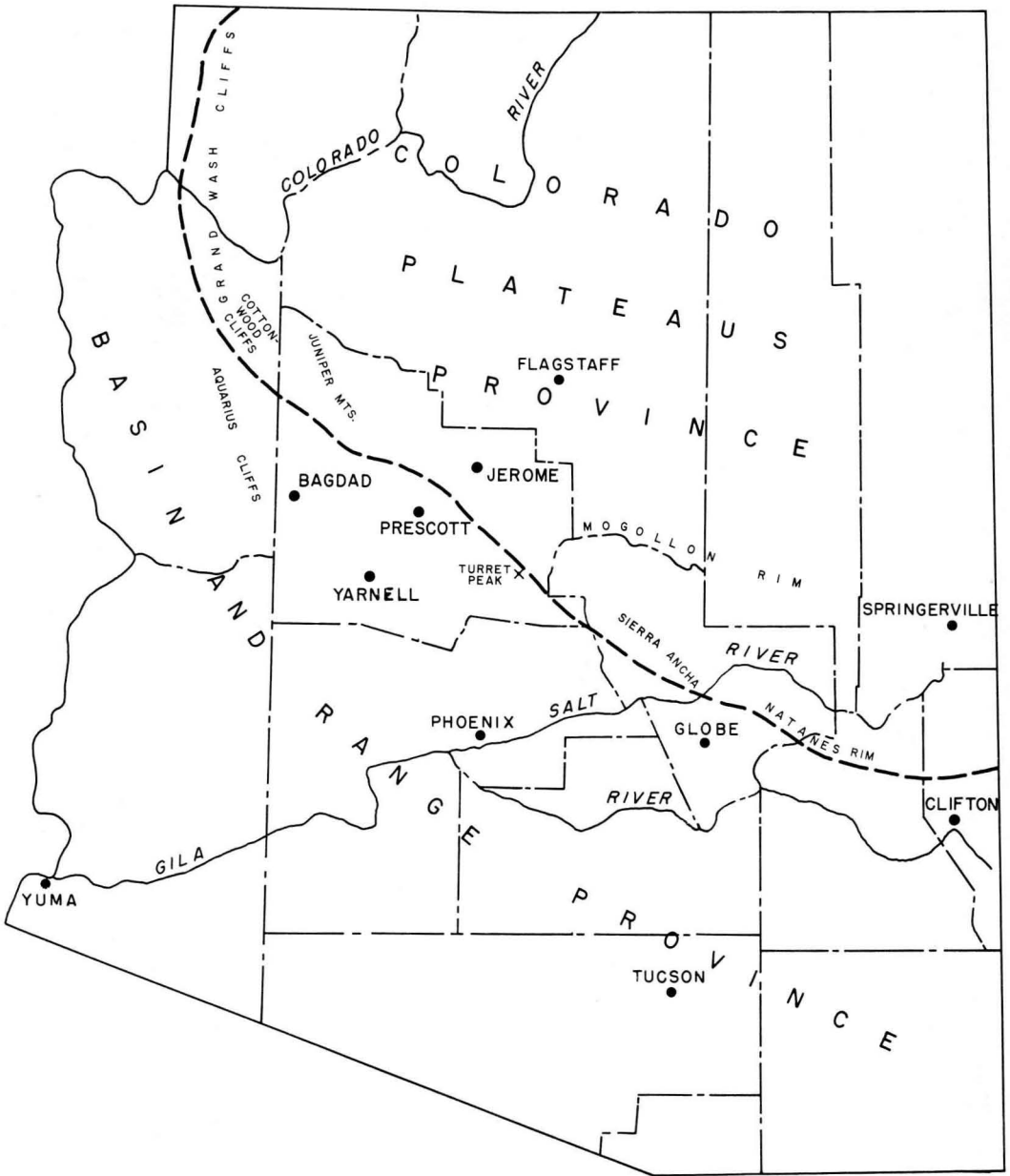


Figure 2.--Index map of Arizona showing suggested boundary between the Colorado Plateaus and Basin and Range provinces.

A STRUCTURAL SUBDIVISION OF ARIZONA

The broad purpose of physiographic classification is the ready characterization of large areas for identification, comparison, and contrast, and for the purposes of this discussion such classification is considered to be based primarily on geologic structure and secondarily on erosional process and geomorphic stage. The purpose of defining structural provinces is the delineation of areas of similar geologic structure. A physiographic province may be considered to be a structural province further classified as to its erosional stage or topographic expression. Therefore, a physiographic classification that does not set an area into its correct structural and topographic settings defeats its purpose. Similarly, if it includes areas of strongly contrasting structures, it becomes misleading.

The preceding review of the literature indicates that a division of Arizona into two major physiographic provinces is inherently correct and generally accepted. The structural boundary between the Colorado Plateau and the basin-and-range regions in Arizona can now be drawn on a large scale with reasonable accuracy. Much geologic information had not yet been gathered when the boundaries of the early divisions were drawn, and the unavoidable inconsistencies along the boundary between the major provinces now can be resolved largely with the structural data at hand. It is therefore proposed that the boundary between the Colorado Plateaus and Basin and Range provinces be made along the line shown on figure 2. The principal criteria for distinguishing the structural differences between the two provinces and a brief discussion of structural features along the line are given below.

1. The post-Precambrian structure of the Colorado Plateaus province is essentially simple, and the Paleozoic and Mesozoic strata are either nearly flat lying or broadly warped. In contrast, the structure of the Basin and Range province is complex. Uplift associated with this deformation resulted in the stripping of Paleozoic and Mesozoic strata, so that in many areas Tertiary deposits lie on Precambrian beds.
2. In post-Precambrian time the Colorado Plateaus province was affected chiefly by epeirogenic oscillations until Mesozoic and Tertiary time, when broad warping, monoclinical flexing, large-scale normal faulting, and some volcanic activity occurred. In contrast, the Basin and Range province was subject to intense compressional deformation, intrusion, and widespread and long-lasting vulcanism in Mesozoic and Tertiary time.

The large-scale high-angle faulting and associated warping of late Tertiary time is evident in both provinces and does not serve to distinguish between them in Arizona, although the dramatic topographic expression of this deformation has served to give the Basin and Range province its name. Extensive movement along high-angle faults in post-Laramide time appears to have been confined largely to the extreme western and southern edges of the Colorado Plateaus province as here defined.

The boundary between the two provinces shown in figure 2 is almost along the line between the Basin and Range province and Transition Zone and the Colorado Plateaus province drawn by Wilson and Moore (fig. 1D). In the northwestern part of the State, the boundary is drawn along the front of the Grand Wash and Cottonwood Cliffs. From the Cottonwood Cliffs to the south edge of the Sierra Ancha north of Globe, the southeast-trending boundary is not so closely defined as elsewhere because of the absence of Paleozoic strata. However, in this stretch Cretaceous-Tertiary intrusives are reported at Bagdad (Anderson, Scholz, and Strobell, 1955) and about 6 miles southwest of Prescott (Wilson and others, 1958). Along this part of the boundary, nearly flat lying Paleozoic strata occur at the southern end of the Juniper Mountains about 15 miles north of Prescott, west of Jerome (Anderson and Creasey, 1958), and a few miles east of

Turret Peak (Wilson and others, 1958). East of Globe the line is drawn along the front of the Natanes Rim (Bromfield and Shride, 1956) and south of the gently tilted Paleozoic strata about 5 miles north of Clifton (Lindgren, 1905). The boundary obviously is generalized and locally there may be sizable offsets along it, mainly as a result of Tertiary faulting.

A case should be made for extending the boundary from the south end of the Cottonwood Cliffs south and east along the Aquarius Cliffs to Yarnell and thence eastward along an irregular line to the south end of the Sierra Ancha. This would coincide in part with a zone of faulting shown on the Tectonic Map of the United States (King and others, 1944). This alternate boundary would add to the Colorado Plateaus province a large area containing Tertiary volcanic deposits resting directly on Precambrian intrusive and metamorphic rocks which do not show much evidence of Mesozoic and Tertiary compressional deformation. However, it would include small areas of Mesozoic and Tertiary intrusive rocks, as at Bagdad and south of Prescott, that would be local exceptions to the criteria for the Colorado Plateaus province as here defined.

The definition of subprovinces based on erosional process and geomorphic stage is left to the future.

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