GEOLOGICAL SURVEY RESEARCH 1966

Chapter B

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Scientific notes and summaries of investigations by members of the Conservation, Geologic, Topographic, and Water Resources Divisions in geology, hydrology, and related fields

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GEOLOGIC STUDIES

GEOLOGICAL SURVEY RESEARCH 1966

This collection of 43 short papers is the first published chapter of "Geological Survey Research 1966." The papers report on scientific and economic results of current work by members of the Conservation, Geologic, Topographic, and Water Resources Divisions of the U.S. Geological Survey.

Chapter A, to be published later in the year, will present a summary of significant results of work done during fiscal year 1966, together with lists of investigations in progress, reports published, cooperating agencies, and Geological Survey offices.

"Geological Survey Research 1966" is the seventh volume of the annual series Geological Survey Research. The six volumes already published are listed below, with their series designations.

Geological Survey Research 1960—Prof. Paper 400
Geological Survey Research 1961—Prof. Paper 424
Geological Survey Research 1962—Prof. Paper 450
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UNCONFORMITY BETWEEN GNEISSIC GRANODIORITE AND OVERLYING YAVAPAI SERIES (OLDER PRECAMBRIAN), CENTRAL ARIZONA

By P. M. BLACET, Beltsville, Md.

Abstract.—Granodiorite older than isoclinally folded schists of the Yavapai Series is uniquely exposed in the core of an upfaulted anticline at Brady Butte southeast of Prescott, Ariz. A folded unconformity at the base of the Alder Group of the Yavapai Series is well exposed in an area of about 3 square miles, providing the only known exposure of the depositional contact between the older Precambrian Yavapai Series and a still older basement. The herein named Brady Butte Granodiorite predates the Mazatzal revolution, during which the overlying Alder Group was metamorphosed, and represents a plutonic event older than any previously recognized in Arizona.

Detailed geologic mapping has revealed the occurrence of gneissic granodiorite unconformably below the older Precambrian [1] Yavapai Series (Yavapai Schist of former usage) in the Bradshaw Mountains, Yavapai County, central Arizona. The granodiorite is exposed along a high ridge approximately 15 airline miles southeast of Prescott and 6 miles southwest of Mayer (fig. 1). This gneissic granodiorite is well exposed at Brady Butte, the most prominent geographic feature in the area, and the name Brady Butte Granodiorite is here introduced for this unit. A continuous section through the granodiorite is provided by the canyon of Wolf Creek immediately northeast of Brady Butte; this area serves as the type locality of the formation.

The unconformity between the gneissic granodiorite and basal arkosic metasedimentary rocks of the Yavapai Series represents a major break in the stratigraphic record of the older Precambrian in Arizona. This unconformity is marked by a coarse basal conglomerate that contains large subangular blocks of gneiss indistinguishable from the underlying Brady Butte Granodiorite. The unconformity is exposed in an area of less than 3 square miles, and is the only known exposure of the depositional contact at the base of the Yavapai Series. The Brady Butte Granodiorite represents part of an ancient basement upon which the older Precambrian schists of central Arizona were deposited.

The Yavapai Series consists of metamorphosed sedimentary, pyroclastic, and other volcanic rocks, which are largely included within the greenschist facies. In the Jerome area, Anderson and Creasey (1958, p. 9) have divided the Yavapai Series into the Ash Creek Group and the Alder Group, and have recognized about a dozen formations on the basis of relict textures and structures. In keeping with their usage, the prefix "meta" has been omitted from descriptive terminology used for these older Precambrian rocks.

STRUCTURAL SETTING

The Brady Butte Granodiorite is exposed in the core of a major faulted anticline that plunges gently north-northeast, and that trends approximately parallel to the strike of foliation in the granodiorite and in the overlying Alder Group (fig. 1). The surface trace of the unconformity between the granodiorite and the Alder Group has a general northwest trend, where it is well exposed along the northeastern wall of the canyon of Wolf Creek for a distance of about 2 miles downstream from the confluence with Little Wolf Creek. North of Brady Butte, along Wolf Creek, the unconformity has been tightly folded, with attenuation of the fold limbs evidenced by flattening and elongation of cobbles in the basal conglomerate. The Brady Butte Granodiorite was mylonitized in the area of tight folding.

Southeastward from locality 46, about 0.8 mile north-northeast of Brady Butte, the folds rapidly diminish in amplitude, and relict sedimentary textures and structures are remarkably preserved in the conglomerate and arkose above the unconformity; the granodiorite beneath is only slightly foliated. The intensity of deformation increases rapidly northeastward away from

[1] The age designation "older Precambrian" has only local significance, and is used in Arizona to distinguish older metamorphic and plutonic rocks from the overlying, unmetamorphosed "younger Precambrian" sedimentary rocks of the Apache Group and the Grand Canyon Series.

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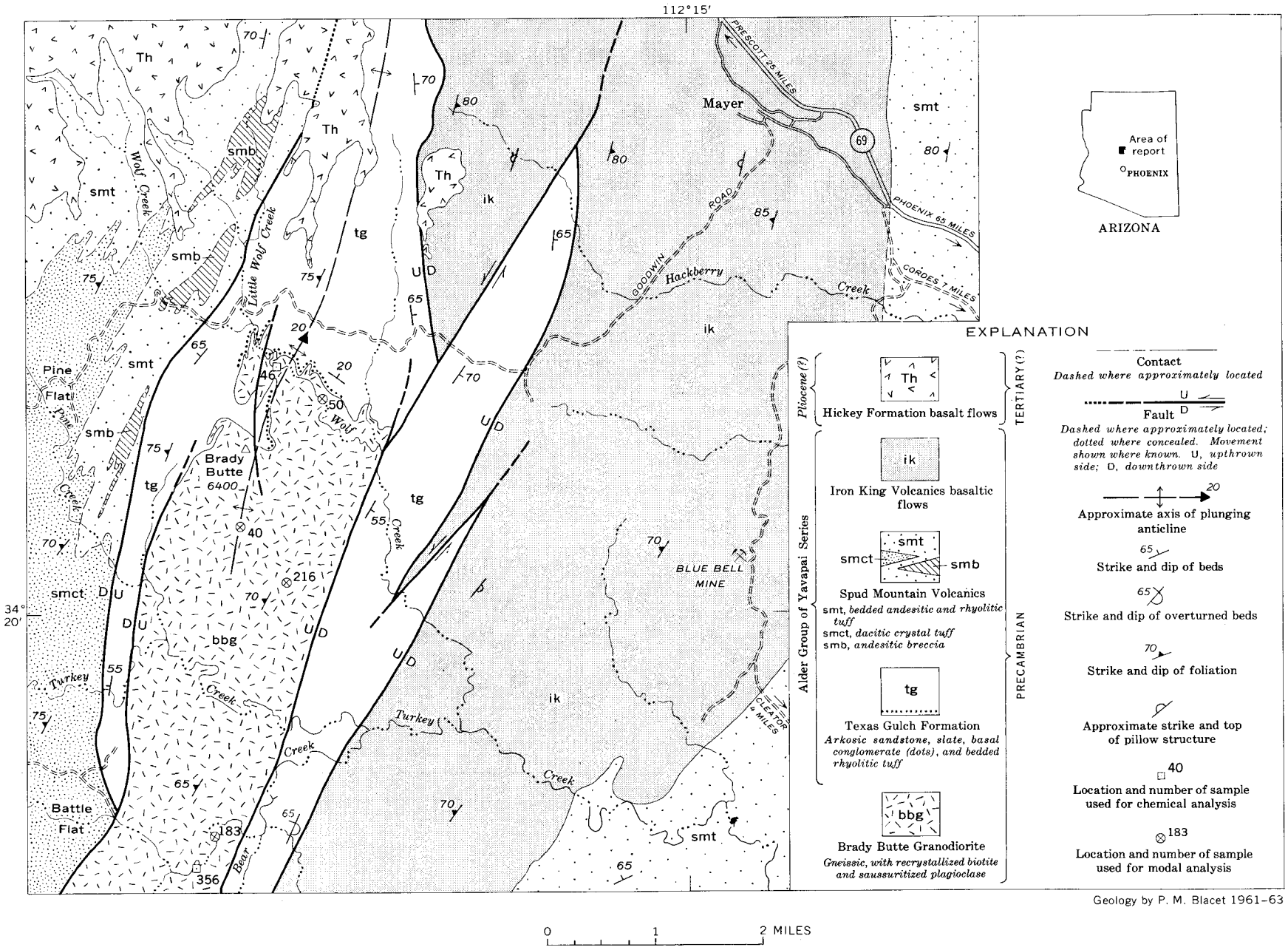

FIGURE 1.—Generalized geologic map of the Brady Butte area, Yavapai County, central Arizona, illustrating the unconformity between the gneissic Brady Butte Granodiorite and the overlying Texas Gulch Formation. Distribution of the deformed basal conglomerate is indicated by stippling along the folded unconformity.

this segment of the unconformity. The remarkable preservation of the rocks near this part of the unconformity indicates that this small area was shielded from the stresses that intensely deformed the adjacent rocks. This small region of low strain directly overlies the relatively undeformed interior of the granodiorite core, which apparently acted as a rigid block deflecting tectonic stresses during metamorphism.

Except where the unconformity is exposed north and northeast of Brady Butte, the contacts between the Brady Butte Granodiorite and the overlying Texas Gulch Formation of the Alder Group are steeply dipping, north-northeast-trending faults. The fault bounding the granodiorite on the west either dies out northward, west of Brady Butte, or diverges from the contact and is undetected within the schists of the Texas Gulch Formation. The fault east of the granodiorite has a left-lateral separation of about 1½ miles, where it offsets the shear zone constituting the contact between the Texas Gulch Formation and the Iron King Volcanics.

The anticlinal block, consisting of the granodiorite and overlying sedimentary rocks, has apparently been squeezed upward along two shear zones which bound the Texas Gulch Formation on the east and west. The displacements on these two major faults are unknown, but the minimum stratigraphic throw along the eastern fault probably exceeds 10,000 feet. Structural and stratigraphic relationships within the isoclinally folded Alder Group suggest that the upfaulted anticline has been elevated several miles with respect to the adjacent volcanic rocks. Erosion has breached the anticlinal core at Brady Butte, providing a unique exposure of the ancient basement beneath schists of the Yavapai Series.

South of the map area (fig. 1), the Brady Butte Granodiorite is truncated by large plutons which are intrusive into the Alder Group. Northward, the Texas Gulch Formation, crudely defining the anticlinal axis, narrows to form a schistose belt several hundred feet wide and disappears beneath Tertiary sedimentary rocks about 10 miles north of Brady Butte (C. A. Anderson and Blacet, unpub. data).

The summit of Brady Butte lies approximately along the axis of the anticline, and a thin cover of arkosic sandstone and the basal conglomerate is draped over the northern shoulder of the butte, between the summit and locality 46 (fig. 1). The unconformity near the summit of Brady Butte is 1,100 feet above its altitude in the canyon of Wolf Creek, indicating that here the anticline plunges approximately 28° north-northeast. Axes of the minor folds in the overlying Texas Gulch Formation generally plunge approximately parallel to the main anticlinal axis.

BASAL CONGLOMERATE

A remarkable exposure of boulder conglomerate lying directly on the Brady Butte Granodiorite is found 1,000 feet east of the summit of Brady Butte, at an elevation of 6,000 feet. In most places the conglomerate above the unconformity is less than 10 feet thick, but here its thickness is more than 30 feet. Well-rounded cobbles and boulders of leucocratic granophyre as much as 18 inches in diameter are abundant and are mixed with even larger subangular gneissic blocks indistinguishable from the underlying granodiorite (fig. 2). Clasts of chert, argillite, siltstone, and quartzite are also abundant and are commonly flattened or elongated, contrasting with the tough nearly spherical granophyre clasts, which have apparently escaped shear deformation by rotation within the schistose matrix. In the attenuated limbs of the tight folds, north of Brady Butte, the length-to-width ratios of the deformed clasts are commonly as high as 8:1, with the granophyre clasts retaining their original sphericity.

The matrix of the basal conglomerate is poorly sorted arkosic sandstone with angular to subrounded relict grains of quartz, plagioclase, and microcline. Muscovite is the predominant metamorphic mineral, but green biotite is abundant. Foliation is generally apparent and is nearly parallel to the long dimension of deformed clasts, to the foliation in the gneissic blocks, and to the foliation in the Brady Butte Granodiorite.

The basal conglomerate, although widespread, is not evenly distributed along the unconformity, and may have been deposited in channels and depressions on the

FIGURE 2.—Boulder conglomerate at the base of the Texas Gulch Formation exposed on a high spur 1,000 feet east of Brady Butte. The compass rests about 5 feet stratigraphically above the Brady Butte Granodiorite. Light-colored, well-rounded granophyre and felsite clasts are in a schistose matrix of poorly sorted arkose. The compass points to a large angular block of gneissic granodiorite indistinguishable from the Brady Butte Granodiorite.

GRAPTOLITE-BEARING SILURIAN ROCKS OF THE HOULTON-SMYRNA MILLS AREA, AROOSTOOK COUNTY, MAINE

By LOUIS PAVLIDES and WILLIAM B. N. BERRY, Beltsville, Md., Berkeley, Calif.

Abstract.—One of the most complete Silurian graptolite sequences in the United States, spanning early Llandovery to early Ludlow time, occurs in the Houlton-Smyrna Mills area of northeastern Maine. Graptolites of similar Early Silurian age occur close to, and both above and below, the conformable and gradational contact that separates the dominantly clastic rocks of the Smyrna Mills Formation of Silurian age from the underlying limy rocks of the ribbon rock member of the Meduxmekeag Formation of Middle Ordovician to Early Silurian age. The Taconic orogeny, therefore, did not affect this belt of rocks, which regionally makes up the Aroostook-Matapedia anticlinorium in the northern Appalachians.

One of the most complete Silurian graptolite sequences presently known in the United States occurs in the Houlton–Smyrna Mills area, in southeastern Aroostook County, Maine (fig. 1). The general geology of most of this area has been summarized elsewhere (Pavlides and others, 1964; Pavlides and Canney, 1964), and only a short review will be given in this report.

Glacial drift covers the region, and bedrock is exposed in small irregular outcrops that in many places are polished pavements. The terrane of the Houlton–Smyrna Mills area consists of closely folded Paleozoic rocks locally intruded by postkinematic granitic plutons. Steep to vertical bedding and cleavage characterize the region, the sedimentary rocks being closely folded along east- and northeast-trending fold axes with steep to vertical axial planes. Near Smyrna Mills, fold axes in a belt several miles wide have been warped convexly to the north, a result of the emplacement of the Cochrane Lake pluton and of the Hunt Ridge pluton and its associated bordering injected zone (fig. 1) after the regional folding of the Acadian orogeny (Pavlides and others, 1964).

The postkinematic granitic plutons have been intruded into terrane that is in the chlorite grade of regional metamorphism and have imprinted a local thermal metamorphism on this terrane; consequently, they are enclosed by hornfels aureoles. Where limy rocks of the Meduxnekeag Formation are thermally metamorphosed, as around the Nickerson Lake and Cochrane Lake plutons and along the north side of the Hunt Ridge pluton, various types of calc-silicate hornfels were developed. In thermally metamorphosed rocks of the Smyrna Mills Formation which were orginally quartzose and pelitic, biotite, and biotite-cordierite and biotite-garnet hornfels were formed, as around the Pleasant Lake pluton and parts of the Hunt Ridge and Cochrane Lake plutons. Where ferruginous manganese deposits can be traced into parts of the thermal aureoles, as on the east side of the Hunt Ridge pluton, magnetite has formed in these deposits. The hornfels terrane around the Cochrane Lake, Hunt Ridge, and Pleasant Lake plutons in the Smyrna Mills quadrangle generally has appreciable magnetic anomalies associated with it (Dempsey, 1962), and some of these may be caused by magnetite-bearing ironstone within thermally metamorphosed manganese deposits. Tremolite-bearing hornfels is also present locally and was developed from calcareous quartzose and pelitic rocks.

Despite the thermal metamorphism that these rocks have undergone, graptolites are locally preserved within them. At locality 12, southwest of Oakfield, they occur in biotite hornfels, and at locality 13, southeast of Oakfield, in tremolitic biotite hornfels; graptolites at locality 13, in sulfide-bearing rocks, are pyritized. The graptolites establish the Silurian age of the rocks.

STRATIGRAPHY

Silurian(?) and older rocks

Phyllite, quartzite, and volcanic rocks of the Grand Pitch Formation of Cambrian(?) age and volcanic rocks of the Dunn Brook Formation of Ordovician or Silurian age, or both, occur in the Lunksoos Lake–Weeksboro anticline (Pavlides and others, 1964). The southeast limb of this fold, which extends across the northwest

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