SOME GEOLOGIC FEATURES OF THE DRAGOON QUADRANGLE, ARIZONA

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INTRODUCTION

The Dragoon quadrangle (fig. 26, 48) in the northwestern part of Cochise County, Arizona, provides an excellent sample of basin-and-range geology -- particularly the type of basin-and-range geology found on the site of the old Sonoran geosyncline (McKee, 1951, pl. 3). Sedimentary, igneous, and metamorphic rocks, which range in age from early Precambrian to Recent, are well displayed. The structure indicates repeated orogenic and epeirogenic deformations and includes large Laramide thrust faults and some large steep faults that trend west-northwest and appear to be elements of the Texas lineament. Mineral deposits include copper, zinc, and tungsten.

Published geologic information on the quadrangle deals largely with the Johnson area and includes a preliminary summary of the geology (Cooper, 1950), and discussions of an exploratory drilling project (Romslo, 1949), a geochemical prospecting experiment (Cooper and Huff, 1951), localization of the ore (Baker, Arthur, 1953), and metamorphism of the carbonate rocks (Cooper, 1957). The geology of the tungsten deposits is summarized by Wilson (1941, p. 41-45). The structure of part of the quadrangle is discussed by Enlows (1941); and the Late Paleozoic stratigraphy is described by Gilluly, Cooper, and Williams (1954).

A study of the geology of the quadrangle was started in 1944 by the U. S. Geological Survey, and field work in the area was carried on at intervals until 1953.

Topographic Setting

The Dragoon quadrangle straddles the drainage divide between two major valleys, the San Pedro Valley on the west and the Sulphur Spring Valley on the east. Both valleys extend north-northwest from the Mexican border for more than 100 miles into Arizona. A mountain barrier separates the valleys at most places. The Dragoon quadrangle contains one of the lowest points in the mountain barrier, Dragoon Pass, which is the main route of the Southern Pacific Lines, and, earlier, of the Butterfield Stage.

In the south-central part of the Dragoon quadrangle are the Little Dragoon Mountains (fig. 54B). In the eastern part are the north tip of the Dragoon Mountains, the Gunnison Hills, Steele Hills, and the south tip of the Winchester Mountains. In the west-central part are the Johnny Lyon Hills, from which a ridge extends northward and joins the Galiuro Mountains about 20 miles north of the quadrangle boundary.

ROCK UNITS

Stratified rocks exposed in the Dragoon quadrangle probably total about 40,000 feet in thickness. Half of this estimated thickness is represented by meta-sedimentary and meta-volcanic rocks of the lower Precambrian Pinal schist, and half is represented by all the younger stratified rocks. Intrusive igneous rocks include dikes and sills of diabase and lamprophyre and large bodies of granodiorite, quartz monzonite, and granite. The sequence of rock units is summarized in table 7.

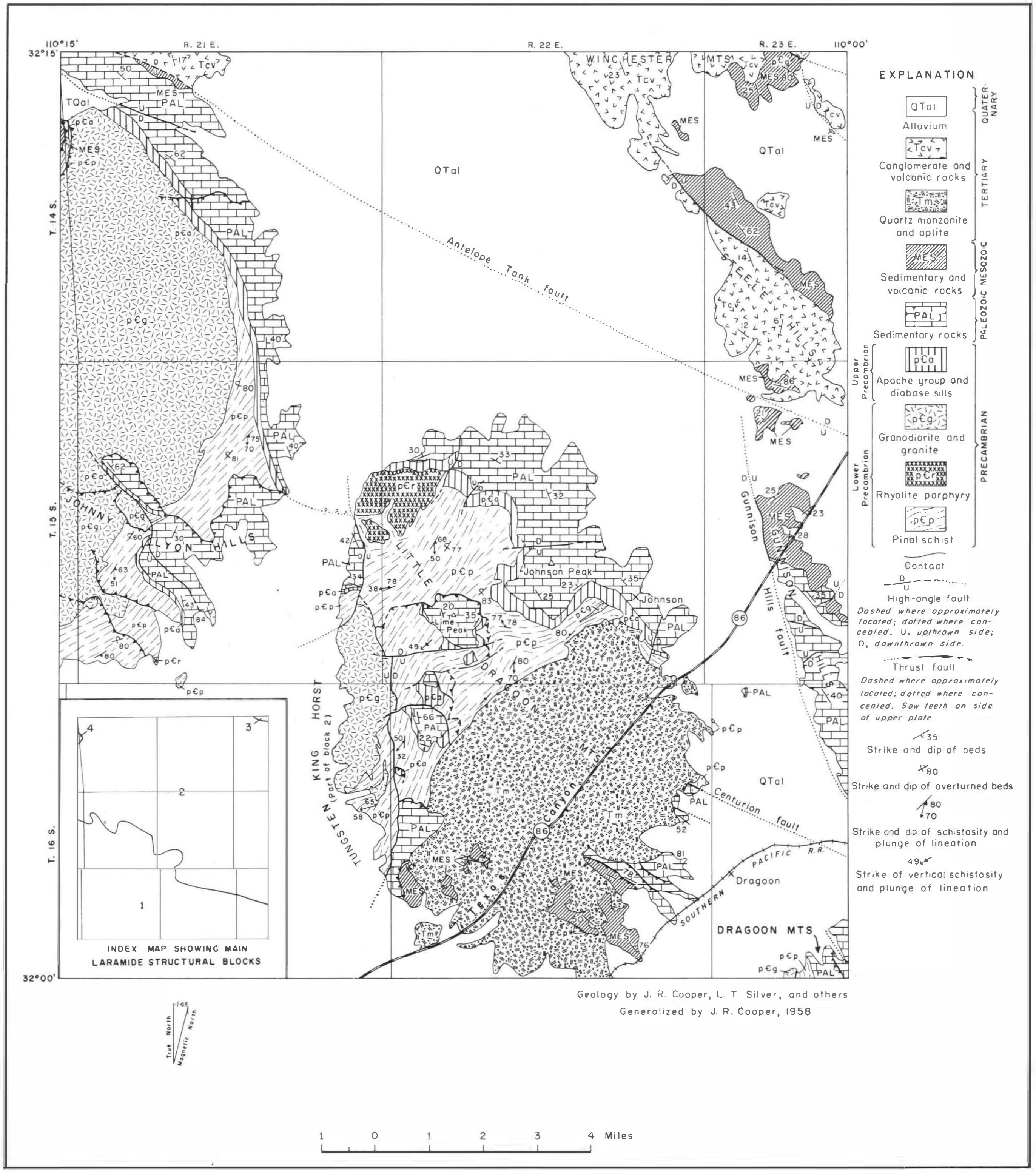

FIGURE 26. Generalized geologic map of the Dragoon quadrangle, Arizona.

Precambrian Rocks

Lower Precambrian rocks include the Pinal schist and silicic intrusions. The Pinal schist is a thick series of regionally metamorphosed graywacke, shale, and a few lava flows of rhyolitic and basaltic composition. These rocks, together with intrusive sheets and stocks of rhyolite porphyry, are now represented by slates and schists of the greenschist facies and locally of the epidote-amphibolite facies. Although these rocks show conspicuous boudinage structures and other effects of intense dynamic metamorphism, some primary depositional features, such as graded bedding, are still preserved.

Also early Precambrian are large post-tectonic masses of granodiorite near the Johnny Lyon Hills and granite in the Winchester Mountains. Granite masses on the west side of the Little Dragoons and in the Dragoon Mountains are assigned to the early Precambrian but could be younger.

Upper Precambrian rocks, which are generally unmetamorphosed, consist of the lower part of the Apache group, and also sills of diabase. The Apache group, which rests with angular unconformity on the lower Precambrian rocks, is represented by the Scanlan conglomerate, Pioneer shale, Barnes conglomerate, and Dripping Spring quartzite -- all very similar in lithology to the type sections of these formations in central Arizona. Sills of diabase, which unquestionably pre-date the Bolsa quartzite of Cambrian age, cut the Apache group. The upper Precambrian rocks are found in the Little Dragoon Mountains and in the areas to the northwest but are absent at the south end of the Winchester Mountains and in the Dragoon Mountains, where Cambrian rocks lie directly on the crystalline basement. No occurrences of the Apache group are known in the areas south and east of the Little Dragoons.

Paleozoic Rocks

In slight angular discordance on the upper Precambrian formations are about 6,000 feet of Paleozoic sedimentary rocks with no angular discordances in the sequence. The Cambrian system is represented by the Bolsa quartzite of Middle Cambrian age and the overlying Abrigo formation of Middle and Late Cambrian age. The Martin formation of Late Devonian age rests with apparent conformity on the Abrigo. The Escabrosa limestone of Early Mississippian age rests on the Martin and is followed by the Black Prince limestone, which is of Late Mississippian or Early Pennsylvanian (?) age. The Pennsylvanian and Permian systems are represented by the Naco group, which is here nearly 4,000 feet thick and is divisible into 6 formations. These formations are, in ascending order, the Horquilla limestone (Early Pennsylvanian and early Late Pennsylvanian), the Earp formation (Late Pennsylvanian and earliest Permian), and the Colina limestone, Epitaph dolomite, Scherrer formation, and Concha limestone (all Permian). The Epitaph dolomite has not been recognized north of the Dragoon Mountains.

Mesozoic Rocks

Mesozoic rocks include: (1) a locally occurring sequence of andesitic and dacitic volcanic rocks referred to the Triassic or Jurassic and not previously reported in Arizona; (2) the Glance conglomerate and finer-grained clastic beds of the Bisbee group (Early Cretaceous); and (3) a sequence of andesite and feldspathic sedimentary rocks, which are in fault relation to older formations at the south end of the Winchester Mountains, and which are referred tentatively to the late Early Cretaceous or Late Cretaceous. Exposures do not permit piecing together a complete Mesozoic section. Conspicuous unconformities occur at the base of (1) and (2), but the angular discordance is slight. All the Mesozoic units have been folded and thrust faulted to the same degree as the Paleozoic formations.

Tertiary and Quaternary Rocks

The quartz monzonite of Texas Canyon was intruded after deformation of the Mesozoic and older rocks, probably in early Tertiary time. Aplite and lamprophyre dikes were intruded after the quartz monzonite was emplaced. Still later, probably in middle Tertiary time, conglomerate and an overlying sequence of volcanic rocks were laid down unconformably on the older rocks. The volcanic rocks, which range in composition from basaltic andesite to rhyolite, are confined to the northern part of the quadrangle and are part of the great volcanic pile that makes up the Winchester and Galiuro Mountains. Late Tertiary and Quaternary rocks comprise probable Pliocene and early Pleistocene stream and lake deposits and younger pediment gravels and alluvium.

STRUCTURE

The rocks of the Dragoon quadrangle record 2 major orogenies and at least 5 lesser disturbances.

The earliest and most intense deformation, evidently the Mazatzal revolution of Wilson (1939), took place in Precambrian time before the Apache group was deposited. During this orogeny the Pinal schist and intrusive rhyolite porphyry were deformed into isoclinal folds with axial plane schistosity and lineations parallel to the fold axes. In the Johnny Lyon Hills and northern part of the Little Dragoon Mountains the folds are commonly overturned to the northwest and the fold axes are steep. Elsewhere the structure is more erratic and has not been deciphered in detail.

The old structures in the Pinal schist have had little apparent effect in localizing later faults and folds; but major intrusive bodies, from early Precambrian to Tertiary in age, are elongated parallel to the old trend.

Slight warping and probably minor faulting near the close of Precambrian time are shown by the relations of the Bolsa quartzite to the Apache group and Precambrian diabase. Steep faults of at least two ages between early Permian and Early Cretaceous, and with hundreds of feet of displacement, are truncated by unconformities at the base of the Bisbee group and the pre-Bisbee volcanic rocks. No significant folding accompanied this faulting. There was rather an apparent random jostling of fault blocks that did not result in very great structural relief in the Dragoon quadrangle.

Another major orogeny, probably the Laramide revolution of the Rocky Mountains, took place in Late Cretaceous or early Tertiary time. The general structural trend is northwest, nearly perpendicular to the pre-Apache structures. Four major structural blocks are recognizable (fig. 26).

Block 1, in the southwestern part of the quadrangle, is characterized by great thrust plates of Precambrian, Paleozoic, and Mesozoic rocks which have overridden from the southwest. The continuity of the block is broken by the Tungsten King horst from which the thrust plates have been eroded, by the Tertiary quartz monzonite of Texas Canyon, and by alluvial cover.

Table 7. Generalized sequence of rock units in the Dragoon quadrangle

SYSTEM	SERIES	GROUP	ROCK UNIT	THICKNESS (feet)
Quaternary			Alluvium	0-600+
			Unconformity	
Tertiary			Rhyolite dikes	---
			Volcanic rocks	1,850±
			Conglomerate	50-2000(?)
			Unconformity	
			Lamprophyre dikes	---
			Aplite dikes and plugs	---
			Quartz monzonite	---
Cretaceous	Upper or Lower		Volcanic and clastic sedimentary rocks	4,900(?)
	Lower	Bisbee group	Cintura and Morita formations undifferentiated	2,500+
			Glance conglomerate	500+
			Unconformity	
Jurassic or Triassic			Andesitic and dacitic volcanic rocks	0-500+
			Unconformity	
Permian	lower	Naco group	Concha limestone	130
			Scherrer formation	690
			Epitaph dolomite	0-150(?)
			Colina limestone	440
			Earp formation	1,130
Pennsylvanian	Upper / Lower		Horquilla limestone	1,600
Mississippian	Upper		Black Prince limestone; beds of Pennsylvanian(?) age may be included locally	120-170
	Lower		Escabrosa limestone	585-750
Devonian	Upper		Martin formation	210-270
Cambrian	Upper / Middle		Abrigo formation	700-800
			Bolsa quartzite	20(?)-480
			Unconformity	
Precambrian	Upper		Diabase sills	---
		Apache group	Dripping Spring quartzite	300
			Barnes conglomerate	3-15
			Pioneer shale	150-300
			Scanlan conglomerate	0-30
			Unconformity	
	Lower		Aplite dikes and plugs	---
			Granodiorite and granite	---
			Rhyolite porphyry stocks and intrusive sheets	---
			Pinal schist	20,000(?)

Block 2, which is structurally below block 1 and was overridden by it, makes up most of the northeastern two thirds of the Dragoon quadrangle. Its dominant structure is a major tilt to the northeast. The Precambrian basement is exposed only along the southwest side of the block. Along the northeast side, at the south end of the Winchester Mountains, the Precambrian basement is probably many thousands of feet below the surface.

The great tilted block is modified by folds and faults. The folds trend north to northwest. They are generally broad and open, but in the Steele Hills, are closed and locally overturned to the northeast. There are several sets of steep faults, most of which are too small to show at the map scale. Thrust faulting is minor and different in direction from that in block 1. The few small thrust plates known in block 2 evidently overrode from the east.

Block 2 is bounded on the northeast, at the south end of the Winchester Mountains, by a zone of major thrust (?) and wrench (?) faults which trend N. 65°-70° W. North of this fault zone is block 3, in which Precambrian basement rocks are exposed. Block 2 is bounded on the west, about 6 miles northwest of the Johnny Lyon Hills, by a zone of thrust faults which trend north. Along this fault zone, lower Precambrian rocks of block 2 have been thrust westward over Mesozoic rocks of block 4. There are only small exposures of the fault zone northwest of the Johnny Lyon Hills and the one in the Winchester Mountains, but the indicated structural relief in both zones is great.

Two episodes of important block faulting and gentle folding post-date the middle Tertiary volcanic rocks and are largely responsible for the basins and ranges of the present. One of these deformations preceded, and the other followed, deposition of the older alluvium. The most conspicuous faults and folds are parallel to the long axes of the ranges and basins. These include a syncline in the volcanic rocks of the Steele Hills and the Gunnison Hills normal fault, along which the Paleozoic formations of the Gunnison Hills appear to have been uplifted several thousand feet relative to the same formations west of the fault. Minor faults oblique to the topographic trend are common, and one large oblique fault, the Antelope Tank fault, appears to be of regional importance. This fault, which trends N. 65°-70° W., was active in late Tertiary or Quaternary time, when the north side was downthrown an indeterminate amount. There are indications that the Antelope Tank fault was also active during the Laramide revolution. The fault is parallel to the great Laramide fault between structural blocks 2 and 3 in the Winchester Mountains, and both faults are regarded as elements of the Texas lineament, which is a broad and not well defined zone of faults and other tectonic features that extends west-northwest from southern Texas to the vicinity of Los Angeles, California, oblique to the general Cordilleran trend (Hill, 1902, p. 173; Ransome, 1915, p. 295; Baker, C. L., 1934, p. 206-214; Moody and Hill, 1956, p. 1229).

Deformation that post-dates the older alluvium is particularly conspicuous near the Gunnison Hills, Steele Hills, and Winchester Mountains. The older alluvium is turned up on the flanks of these ranges and is cut by more than a dozen faults, including the Gunnison Hills fault. No evidence for such late uplift is found near the other mountain blocks in the Dragoon quadrangle, suggesting that these blocks were uplifted earlier. Possibly they are outlined by faults which have been bevelled by pediments and are now concealed beneath the alluvium.

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.