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NORMAL FAULTING IN THE DRAGOON PASS AREA, COCHISE COUNTY, ARIZONA

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INTRODUCTION

An exploration program aimed at the covered part of the Dragoon pass, an area of about ten square miles, was conducted by the Western Exploration Office of Phelps Dodge Corporation in 1965 and 1966. The program included geologic mapping along the edges of the valley at a scale of one inch to 200 feet, detailed gravity and induced polarization surveys, and ten widely spaced exploratory drill holes totaling about 10,000 feet. The new information suggests a new model of the structure: that the Precambrian, Paleozoic and Mesozoic rocks are cut by a few steep normal faults rather than the imbricate thrust faults pictured by Cooper and Silver (1964, p. 104-106, Pl. 1 and 2).

The ideas presented herein have benefitted from the work, comments and criticism of the staffs of the Western Exploration Office and the Copper Queen Branch. The responsibility, however, for the manuscript rests with the writer. The comprehensive professional papers of Cooper and Silver (1964) and Gilluly (1956) provided an invaluable starting point. Permission of Phelps Dodge Corporation to publish this work is gratefully acknowledged.

This paper is confined to structural interpretation of the covered part of Dragoon Pass and the cited works should be consulted for the regional setting.

STRUCTURE

Laramide Deformation

The proposed structural hypothesis is shown in Figures 1 and 2. Along the west side of the valley, on the flank of the Little Dragoon Mountains, the major faults are inferred from stratigraphic and structural criteria, except for the clear-cut Centurion fault, which has been explored by mine workings to a depth of 515 feet. The faults have possible subsidiaries in a set striking N 35° W and having separations of up to 200 feet in either a left- or right-lateral direction (or either the west or the east block respectively down-thrown.)

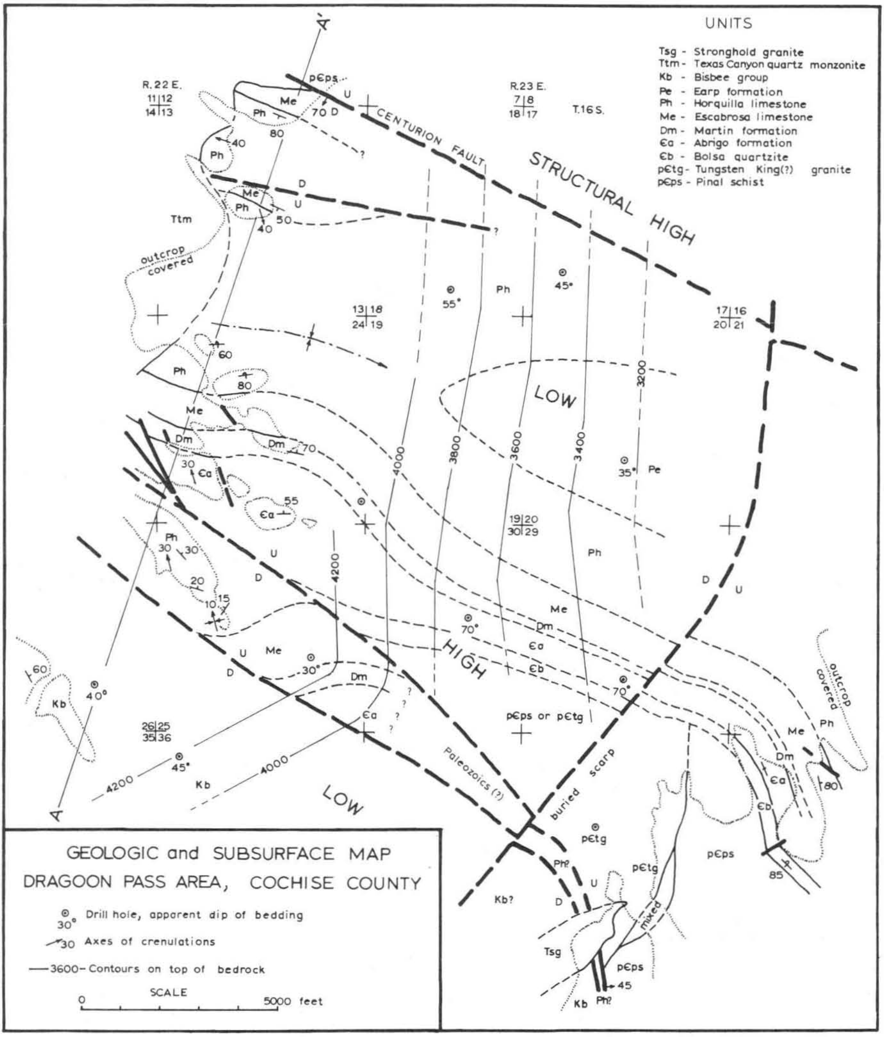

Figure 1.--Geologic and Subsurface Map, Dragoon Pass Area, Cochise County, Arizona.

The Paleozoic and Mesozoic rocks along the east side of the valley, in the Dragoon Mountains, are nearly vertical in attitude. They are cut by many small steep faults, commonly bedding plane faults (many are east of this map area), having uncertain directions and magnitudes of movement.

I am substantially in agreement with the distribution of the various units shown by Cooper and Silver (1964, Pl. 1 and 2), except that I consider their Earp and Horquilla thrust slices in the southwest quarter of Section 24 to be the Martin formation and Escabrosa limestone parts of a conformable sequence.

The contact between the Precambrian Tungsten King (?) granite and the Pinal schist in my opinion, is not a fault (Cooper and Silver, 1964, Pl.1), but is a steeply dipping zone as wide as 500 feet. Within this zone are several schist septa in the granite and abundant concordant and discordant granite, pegmatite and aplite dikes in the schist. However small faults are present within the zone.

The net vertical and horizontal strain across the blocks can be approximated by reconstructing a convenient contact, such as the Escabrosa-Horquilla[1] contact, along the 20,900 feet length of section A-A' (Fig. 2). The crustal shortening implicit in folding and tilting and the lengthening implicit in normal faulting are each about 5,500 feet. By reconstructing the contact in various ways, differences of about 500 feet, or 2.5 percent, can be obtained. Since the error inherent in the assumptions is much larger than ± 2.5 percent, the best that can be said is that the shortening and lengthening nearly balance each other and that the net horizontal strain is small.

The net vertical displacement from one end of A-A' to the other is equal to the thickness of at least the entire Paleozoic section divided by the cosine of its inferred dip at A. This is at least 7000 feet or, over the horizontal distance, at least 30 percent.

The deformation is Laramide, as it involves Cretaceous Bisbee group rocks and is truncated by the Texas Canyon stock, dated at 54 M. Y. (Damon et al., 1964, Table 2), and the Stronghold granite, dated at 22 ± 3 M. Y. (Damon and Bikerman, 1964, p. 72). This agrees with the "late Cretaceous or early Tertiary" age assigned by Cooper and Silver (1964, p. 104), even though our interpretations differ.

Texas Canyon Deformation

The Texas Canyon quartz monzonite stock has contact metamorphosed the rocks along the west side of the valley. As stated by Cooper and Silver (1964, p. 105):

> Contact metamorphism, everywhere evident in the form of recrystallization and mineralogical reconstitution, has healed fault zones and destroyed some primary

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1. The Black Prince formation is included in the Escabrosa limestone herein.

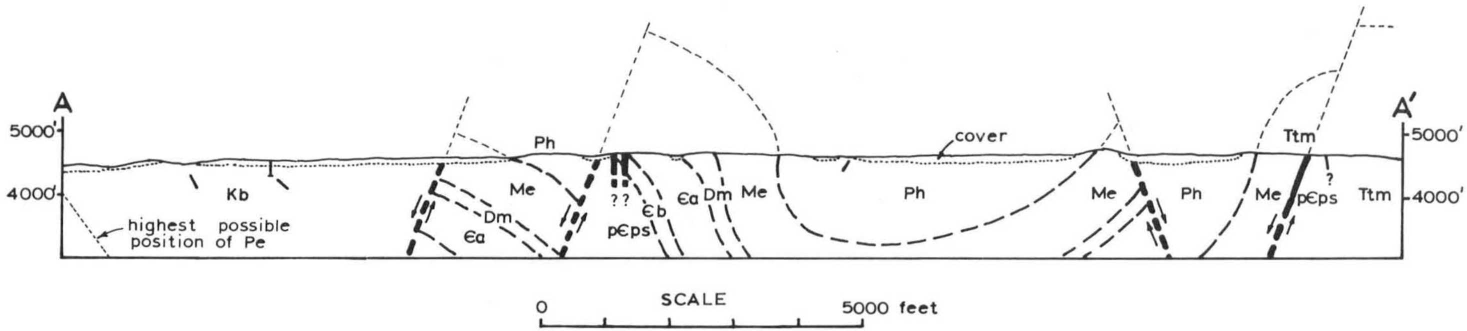

Figure 2.--Structural Cross-section Through the Dragoon Pass Area, Cochise County, Arizona.

> sedimentary features such as fossils and the original color and texture of beds. Thus many of the ordinary criteria for structural interpretation are lacking, and some doubt must remain even in the recognition of formations.

Despite the loss of fossils and original lithology, bedding is preserved and individual beds or sequences of beds can be walked out. The 200-scale mapping, with good survey control, allowed obvious advantages in this respect.

The structural elements peculiar to the west side of the valley include: (1) a set of silicated fracture zones striking N25°-45°E, (2) local, small faults of diverse attitudes and separations of ten feet or so, and which defy grouping into sets, (3) small bedding plane faults, and (4) sets of crenulations in certain thinly bedded tactite units in the middle Abrigo formation and the Horquilla formation.

The crenulations in Sections 24 and 25 trend N20°W and plunge 10°-30° and are drag folds having the sense of lying on the northeast flank of a northwest plunging anticline. In Section 13, they trend northwest or southeast and plunge about 40° and appear to lie on the southwest flank of a doubly plunging anticline.

The deformation has an erratic, heterogeneous style that can be classed only into tectonic domains on the order of 160 acres. Within the limits of stratigraphic control, there is a distinct correlation between the intensity of faulting and plastic deformation, the metamorphic rank, the relative abundance of products of aqueous retrograde metamorphism, and the amount of metallization. In thin section, the calc-silicates and hydrous retrograde minerals have a variety of pre-, syn- and post-kinematic relations, which taken with the field data give the impression that recrystallization and deformation proceeded simultaneously over a period of time.

The foregoing suggests that much of the deformation along the west side of the valley is directly attributable to the emplacement of the Texas Canyon stock. Some of the minor features may be due to shrinkage during contact metamorphism, which Cooper (1957) reported to have been as much as 30 percent in the Johnson Camp area to the north.

This deformation would be the same age as the Texas Canyon stock, 54 M. Y. (Damon et al., 1964, Table 2).

Basin-Range Features

The trace of the basin-range fault fronting the Dragoon Mountains has been pin-pointed by gravity and resistivity surveys and by drilling (Fig. 1). The valley floor has a remarkably even 7° slope eastward. A wedge of well indurated boulder fanglomerate, nearly 1000 feet thick in one place, extends west from the buried fault scarp. This fanglomerate does not crop out along the front of the Dragoon Mountains or the Gunnison Hills.

No new evidence was obtained on the time span of the basin-range faulting.

CRITICISM OF THE IMBRICATE THRUSTING HYPOTHESIS

The imbricate thrusting hypothesis has a serious weakness. The left side of cross-section P-P', by Cooper and Silver (1964, Pl. 2, see also p. 105), shows six hypothetical, rooted, high-angle thrust faults cutting the bedding at nearly right angles. Five of these faults have younger rocks in the hanging wall and older in the footwall. These tectonics are geometrically possible, but are hard to imagine. Successive thrust slices would have to travel up in the stratigraphic section, then down, and then back up to a horizon short of their origins (truncating a syncline-anticline pair would allow this movement along a straight path, as shown by Billings, 1933, p. 145); and they would have to come to rest with the attitudes of bedding roughly parallel from one slice to another. It would appear unlikely for such mechanically anisotropic rocks as the Paleozoics and Mesozoics of southeastern Arizona to withstand this complicated scheme of origin and transport and still come to rest in a neat one-two-three order. Instead the strain would probably dissipate as a disordered welter of bedding plane faults.

I consider two of these six faults to be valid, but I consider them normal. Figure 2 is along the same line as section P-P' of Cooper and Silver (1964, Pl. 2).

SIGNIFICANCE OF THE ALTERNATIVE HYPOTHESIS

A broad tectonic hypothesis is beyond the scope of this paper; however, the Dragoon pass area fits with Jones' (1963; 1966) re-examination of the central Dragoon Mountains and other southeastern Arizona ranges, in which a cogent case is presented for a history of vertical tectonics in place of rooted thrusts. Jones presents evidence that several klippen, formerly considered rooted thrusts and thus providing part of the basis for hypotheses of regional crustal shortening, are gravity overthrusts with no such implications.

Across the strike of the large asymmetric blocks the net horizontal strain is too small to be measured. On the other hand, the net vertical strain over the horizontal distance is on the order of 30 percent. The Laramide structure of the Dragoon pass area thus reflects a relative uplift along the north edge of the west and northwest-trending zone of deformation, shown in Figure 1. The Laramide structure does not appear to fit a regional hypothesis of rooted thrust faulting and crustal shortening. The ancestral Dragoon Mountains, in Laramide time, were linked structurally with the Little Dragoon Mountains. The present alignment of the Dragoon Mountains and the Gunnison Hills is a function of the basin-range fault along their western fronts.

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