THE EMPIRE MOUNTAINS—A THRUST FAULT?

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Geology of the Empire Mountains of Arizona is briefly reviewed. Evidence indicating thrust faults at other sites (Santa Rita Mountains and Tortolita Mountains) are presented. The Empire Mountain "thrust fault" has been analyzed for usual marks of tectonic activity. Negative results are reported. Therefore, it is concluded that no such "thrust" has occurred in the Empire Range, and that Permian (Paleozoic) rocks lying above are actually younger than the cretaceous (Mesozoic) layer beneath! Implications of these inferences for uniformitarian geology and evolution theory are evaluated. It is suggested that presence or absence of thrust faulting be judged hereafter solely upon the physical criteria, aside from any evolutionary preconceptions.

Introduction

The Empire Mountains occupy about 30 square miles in southeastern Pima County, Arizona, and consist of two parallel ridges trending north-northeast. They are connected with the Santa Rita Mountains to the west by low rolling foothills and are separated from the Whetstone Mountains to the east by the broad floor of Cienega Wash Valley.

Dr. F. W. Galbraith[1] gives the following description of the Empire Mountains:

> The Empire Mountains are made up of marine limestone, shale, and quartzite, of Cambrian, Devonian, Mississippian, Pennsylvanian, and Permian age, aggregating approximately 5,700 feet in thickness, and a series of Cretaceous (?) continental elastic deposits possibly 18,000 feet in thickness. The sedimentary rocks are intruded by stock-like bodies of quartz-monzonite and granodiorite and by dikes ranging in composition from rhyolite to basalt.
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> The range has two structural parts–an underlying block of Cretaceous (?) rocks, and an overthrust block of Paleozoic and Cretaceous (?) rocks which is divided into four segments by northwesterly striking tearfaults. The thrust fault is exposed along the western edge of the mountains and dips to the east at a low angle. Within the overthrust block there are at least three separate imbricate thrust sheets. Domes, anticline, and overturned folds have been formed in the Paleozoic rocks.
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> The central part of the Empire Mountains is occupied by the Sycamore quartz-monzonite which extends for about two miles along the trend of the range as a roughly elliptical body less than one mile wide. The quartz-monzonite is light gray and medium to coarse grained.
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> The Empire Mountains are divided into two structural parts, a basement block of Cretaceous rocks, in part folded into a series of broad anticline and synclines with east-west axes, and in part dipping steeply to the east; and an overthrust block of Paleozoic strata which dip eastward. East-west and north-south faults have added to the structural complexity of the range.
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> Small bodies of granodiorite, rhyolite-porphyry are exposed near the Sycamore stock and small dikes of aplite, syenite, trachyte, rhyolite, diorite, andesite, and basalt occur throughout the Empire Mountains.

The purpose of the present investigation was to verify or reject the Empire overthrust hypothesis as mapped (Figure 1). This particular area was selected because the "thrust-plane" contact is especially visible in the Empire Mountains, and can be subjected to physical analysis contrasting structural interpretation with fossil evidences.

The method used in this study was that of comparing known small overthrusts in terms of amount of brecciation, gouging, slickensides, and other mechanical features proving rock movement, with the Empire "thrust" fault where rock containing fossils from the Permian clearly overlies rock having typically Cretaceous fossils.

Analysis of Known Thrust Faults

(1) Known Thrust Fault in Santa Rita Mountains

On the west side of the Santa Rita Mountains, in the Montosa Canyon area, Santa Cruz County, Arizona, occurs a large granite intrusive, or so-called "pluton." South of this granitic structure the Permian limestone blocks tilt away from the granite at angles between 10 and 25 degrees. These blocks rest on igneous rock.

A graduate student at the University of Arizona wrote a thesis on that area, and has indicated in personal conversation that the limestone blocks had been thrust about half a mile. The blocks themselves probably average half a mile in length.

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Note: The authors wish to express appreciation to the Creation Research Society for a grant made in partial support of the research presented in this report.

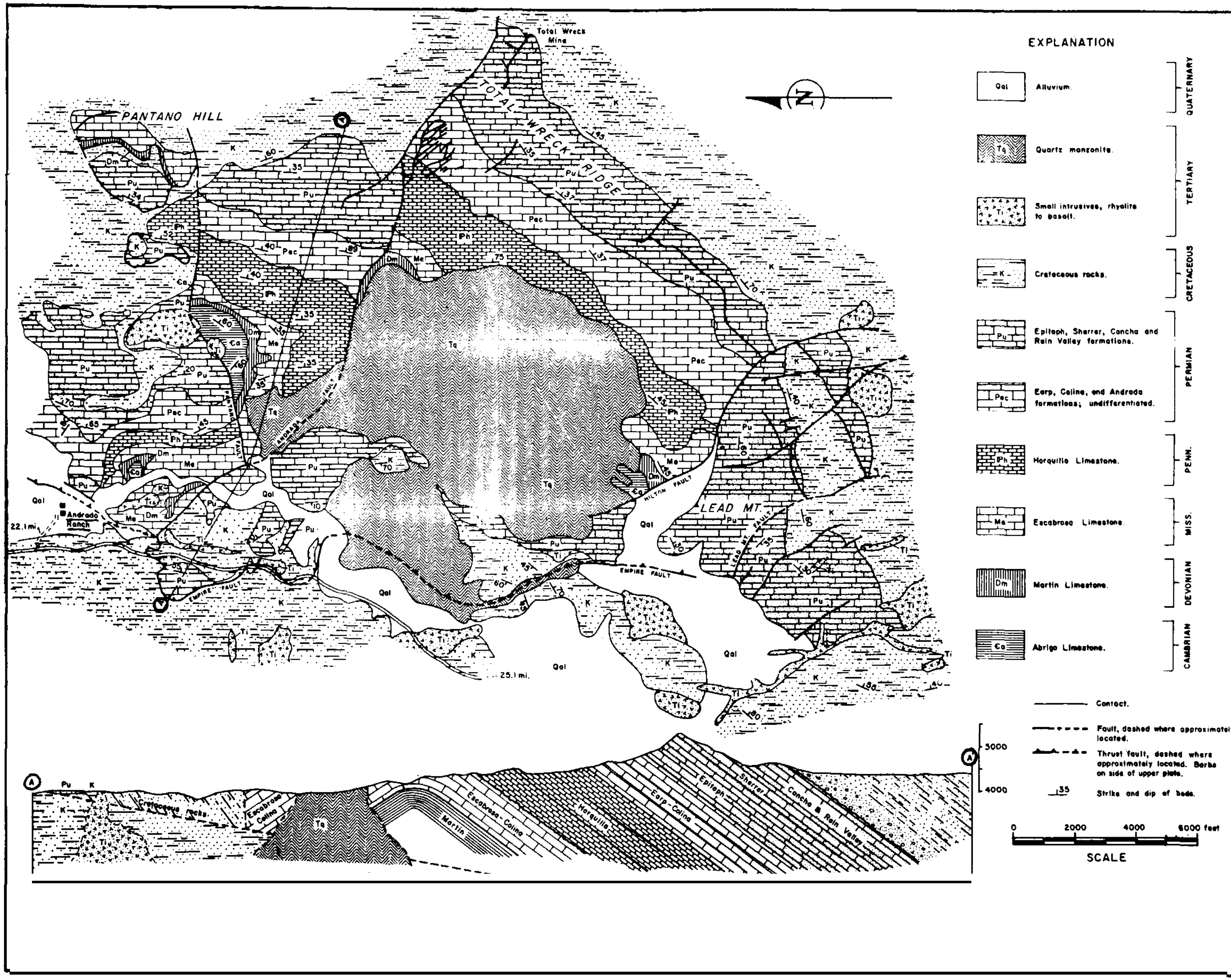

Figure 1. Generalized geologic map and cross section of the Empire Mountains, Arizona. Note location of the Andrada Ranch near the left edge of the general geologic map. The "thrust-plane" contact discussed in this paper is located at the left edge of the cross section (A to A'), where Permian (Pu) rock is found overlying Cretaceous (K) rock.

As proof of his contention, the graduate student designated a gouge layer about three feet thick composed of ground up rock powder separating the underlying igneous layer from the overlying thrust block. The authors have studied this evidence and detected indications that there was a drag of one block over the other. We feel that he proved his case for thrust-faulting in that particular instance.

(2) Known Thrust Faults in Tortolita Mountains

The senior author made a study of this range when preparing a thesis for the University of Arizona. The lithological type is granodiorite, diorite, monzonite and granite. Most of the range has been subjected to regional metamorphism, forming a granite gneiss. On the north side of the mountains, where compression formed mica schist, some blocks of rhyolite were thrust southward over the underlying andesite. There is no fossil evidence here for thrusting, but very strong mechanical indication.

Between the andesite and the rhyolitic cap rock occurs a layer (from 15 to 20 feet thick) of tectonic breccia–crushed and ground pieces of rock fragments. One notably large piece of rock, a boulder, shows marked fluting or "slickensides" much like the striae or scratches caused by glaciers (Figure 2).

Problem of Empire "Thrust Fault"

The geologic map (Figure 1) shows the outcrop of the fault plane along the western edge of the Empire Mountains, visible for about four miles. In only one or two places, however, can the contact between the Permian (Paleozoic) and the Cretaceus (Mesozoic) be seen clearly. Accompanying photographs show the contact along the wash just south of the Andrada Ranch. Here the dark, blue-gray, Permian limestone caps the underlying Cretaceus (Figures 3, 4, 5, and 6).

Figure 2. A thrust block in Tortolita Mountains, Pima and Pinal Counties, Arizona. This detached rock was along the thrust plane. It shows the "slickensides grooves" which point toward previous tectonic activity. This is a close-up, showing a section about 10 by 10 feet.

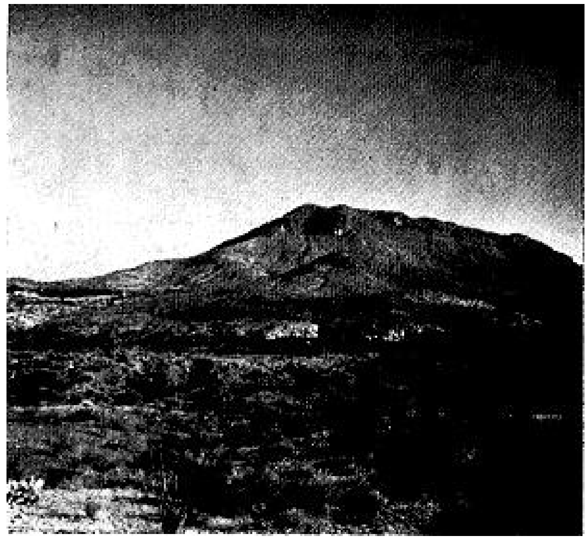

Figure 3. Overall view of "overthrust" (near "A" in cross section in Figure 1). This picture shows the north end of the Empire Mountains looking eastward. Most of the mountain is Paleozoic (Permian). The center of the picture-light part along the wash—is the locale of the "overthrust" depicted in more detail in Figures 4, 5, and 6.

The lithology of the Cretaceus varies from place to place, but at this point along the wash the Cretaceus has been metamorphosed. On the extreme left side of the geologic map and cross section intrusive igneous rock is shown in direct contact with the Cretaceus. This caused a "contact metamorphosis," which bleached and marbleized the limestone. Presumably then, the presence of hot intrusive igneous rock converted Cretaceus strata to a light buff colored marbleized limestone. Further south this white marble is being quarried.

Metamorphic rock is usually considered to be older than rock which has not been so altered. Since metamorphism is a more advanced stage of petrogenesis, it should normally be considered older than unaltered rock. Oddly enough, the Permian capping rock (which is supposed to be much older) overlies the Cretaceus metamorphic limestone. Although it is slightly fractured, the Permian cap rock is **not metamorphosed.** From these data one can reasonably infer that the metamorphosed Cretaceus rocks beneath are indeed older than the Permian capping rock!

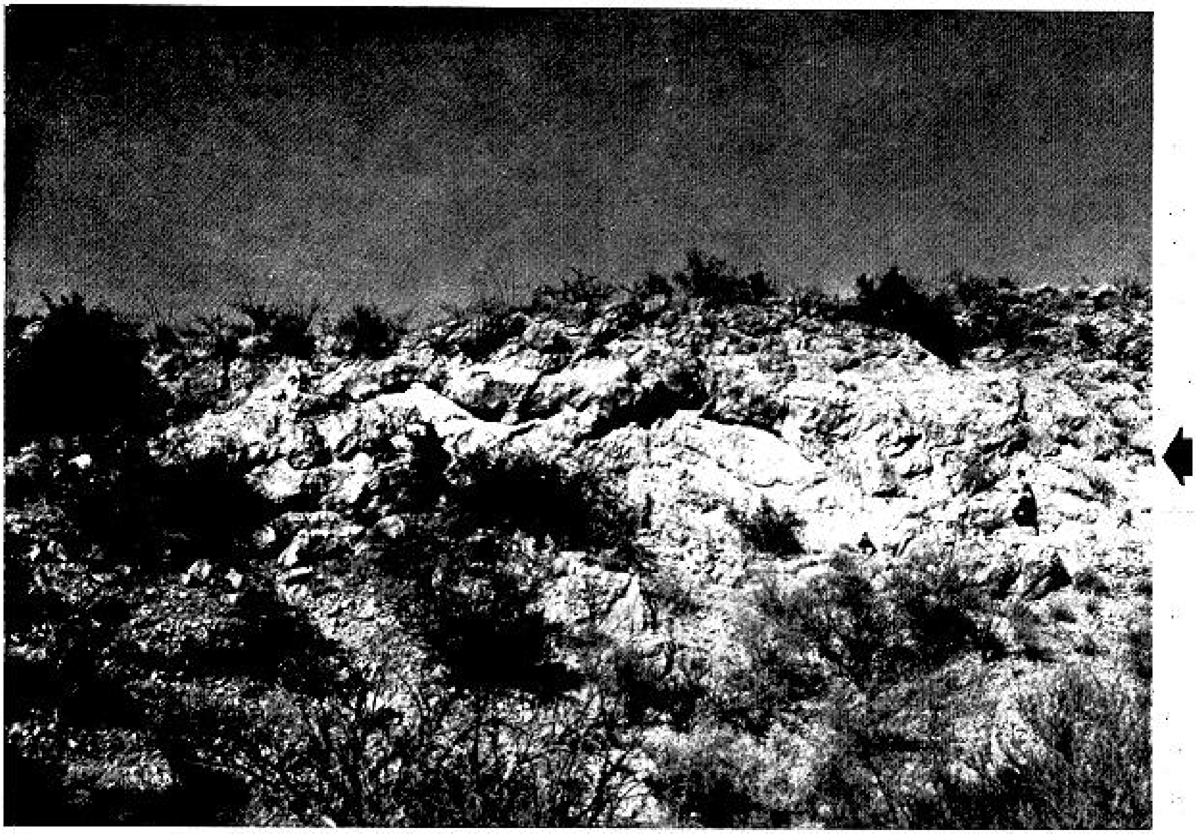

Figure 4. "Thrust-plane" contact, Empire Mountains. A closer view of the supposed "thrust-plane" is seen above Dr. Hamara and his son. The line of "thrust," which is supposed to have traveled to the left (west) is plainly visible here.

Other Physical Evidence Considered

But are there other lines of physical evidence to the contrary which would support the validity of the thrust idea at this Empire Mountain site? If so, one should find tectonic breccia, ground rock powder, mylonite, gouge layers, slickensides, or striae as noted previously in references to the two known thrust fault areas.

The authors have examined the exposure of the fault contact carefully and no such evidence was located. The buff-colored bed rock had been eroded so that an angular unconformity exists between the two formations. But the capping Permian rock fits into the deep grooves eroded in the Cretaceus like a glove on a hand, or like material poured into a mold (Figures 4, 5, 6, and 7).

If the Permian cap rock had been thrust over the Cretaceus (as uniformitarian geologists assert), all sharp projections would have been planed off because they would have been directly in the line of thrust from the west! The contact appears, rather, to be a purely depositional one and would be difficult to explain otherwise. The Permian above is apparently younger than the underlying Creataceous material—the fossils and uniformitarian theory notwithstanding to the contrary!

Rocks Carefully Classified

With the help of Doctor Oma Hamara of the University of Arizona, and his two sons, much time has been spent verifying the classification of the "thrust block" in the Empire Mountains as Permian. We were unable to find any very large fossils, nor any complete or perfect ones, but we did find parts of brachiopods which should definitely belong to the Paleozoic Era. Fragments of coiled gastropod showed up plainly, but we were unable to name any genus.

We did find some beautiful specimens of tiny horn corals, perhaps too small to identify for sure but they did resemble the *Lophophyllidium*, which are typically Pennsylvanian or Permian. Some horn type corals belong to earlier periods of the Paleozoic, such as Devonian and Mississippian, but many types overlap from one Period to another.

We were able to find many pieces of crinoinal stems, belonging to the attached type of Echinoderms, having a water-vascular system. These are all Paleozoic, although they could not be placed in any particular Period. We found

Figure 5. "Thrust-plane" contact, Empire Mountains. This close-up of the supposed "thrust contact" shows the darker Permian limestone above the Cretaceus marble. Figure of young Deter Hamara gives size perspective.

Figure 6. "Thrust-plane" contact, Empire Mountains. Another view of the supposed "thrust contact" shows how the two layers fit nicely against each other without the usual evidences of thrust faulting. Roy Kingman is seen here.

nothing that could have been classified as later than Paleozoic or Permian.

This Permian "thrust block" has a very dark gray color, indicating a large amount of organic material was buried with the fossils. We have no reason to doubt the classification of the various formations of the Empire Mountains. The only point at issue is whether there was a thrust, whether an "older" and lower stratum of rock of the Permian was raised up and thrust over the "younger" Cretaceus.

Are we to trust the evolutionary build-up of the fossils, or say that the Permian limestone was laid down later and on top of the Cretaceus? All the physical evidence would indicate the latter conclusion.

Discussion

In the past, stratigraphers have been inclined to correlate strata and formations primarily on the basis of the fossil evidence–as if that were an all-important criterion. In some instances physical evidence was ignored.

As an illustration of the supreme confidence some scientists have placed in the evolutionary order of fossils, Professor Henry A. Nicholson[2] flatly declared:

> It may be said that in any case where there should appear to be a clear and decisive discordance between the physical and the paleontological (fossil) evidence as in the age of a given series of beds, it is the former that is to be distrusted rather than the latter.

A time has arrived, however, when the physical evidence can no longer be overlooked, even if it cuts across lines of popular theory.

Validity of evolutionary geology rests upon the concept of invariableness in the fossil order. There are many places on earth, however, where fossils do not occur in the order predicted by the evolution theory. To save the theory in face of such evidence, giant overthrusts (thousands of square miles of sedimentary strata) have been postulated–often without proper regard to the physical improbability of such tectonic activity.

Sir Archibald Geike was a leading British geologist and authority on the Alps. Nappes and overthrusts had been postulated to account for the inverted order of the fossils, but Geike[3] candidly commented:

> The strata could scarcely be supposed to have been really inverted, save for the evidence as to their true order of succession supplied by their enclosed fossils. . . . Portions of Carboniferous strata appear as if regularly interbedded among Jurassic rocks, and indeed

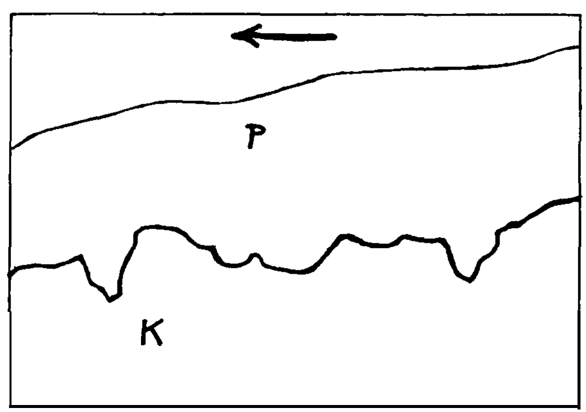

Figure 7. Cross-section of assumed Empire Mountain overthrust. This drawing of the contact shows the jagged fit between the two layers. Arrow indicates the direction that the thrust is supposed to have taken. One may wonder how the overlying Permian limestone could have been thrust over the Cretaceus without planing off the rough edges, and grinding rock powder! (P — Permian blue limestone; K — Cretaceus formation, in part buff colored marble.)