8. THE NATURE OF CIMA DOME *

By Robert P. Sharp †

INTRODUCTION

In the Mojave Desert of southeasternmost California is a remarkably smooth, symmetrical rock-alluvial dome which takes its name from Cima on the Union Pacific Railroad. Lawson (1915, pp. 26, 33) cited Cima Dome as a prime example of a panfan, but Thompson (1929, p. 550) later showed that its upper part is bare rock. Davis (1933, pp. 240-243) considered it a fine example of a convex desert dome evolved from back-wearing of a fault block, but this concept is contradicted by the geological relations (Hewett, 1954), which throw more light on the nature and origin of Cima Dome than do geomorphological theories.

Field studies reported briefly herein suggest that Cima Dome is essentially an upwarped, stripped, and slightly eroded part of an extensive prevolcanic erosion surface, probably of late Pliocene age (Hewett, 1954). It is not convex, except in slight degree at the very summit, and owes its existence largely to the nature of the underlying bedrock. These are tentative conclusions as the work is still in progress.

The list of persons contributing to this study includes D. F. Hewett, C. H. Dix, G. W. Potapenko, William Otto, C. R. Allen, R. L. Nelson, J. R. Reese, C. W. Faessler, Pierre St. Amand, G. I. Smith, A. R. Sanford, G. P. Eaton, M. F. Meier, Carel Otte, and Jean T. Sharp. Appreciation is expressed for their aid, counsel, and assistance.

Location and Physical Setting. Cima Dome lies near the California-Nevada border and is clearly visible 12 miles southeast of U. S. Highway 91 between Baker and Las Vegas and six miles northwest of the Union Pacific Railroad at Cima. The form of the dome is expressed in generalized fashion in T. 14 N., R. 13 E. of the Ivanpah quadrangle map (1/250,000). It lies on the axis of an upland that comprises the Ivanpah and Kelso Mountains. Slopes of the dome drain east to Ivanpah Valley, south to Kelso Valley, and north to Kingston Wash and the Amargosa River.

Topographic Relations. A conservative measure of the area of Cima Dome is 75 square miles. Its summit is 5,795 feet above sea level, and the generally ill-defined base of the dome lies at altitudes of approximately 5,000, 4,400, 4,500, and 4,000 feet respectively on the northeast, north, west, and south. Cima Dome thus rises 800 to 1,800 feet above its base. Angles of slope measured by transit range from as little as 0° 57′ near the base to 4° 40′ near the summit. The slopes are remarkably smooth except for a local relief of 5 to 25 feet toward the top, and symmetry of the dome is impressive (fig. 1). A few bedrock residuals rise on the flanks, of which Teutonia Peak on the northeast is the largest, being 300 to 400 feet high. Other knobs rise 50 to 200 feet above the south and southwest slopes.

The profile form of Cima Dome is a critical point. Viewed from a distance it looks distinctly convex, and Davis (1938, pp. 1389, 1413) states that the uppermost 700 feet, about half the height, is convex. Bryan (1940, pp. 261-262) questioned the inferred convexity of Cima Dome, and to settle the matter two 10-mile profiles have been surveyed by transit and stadia across Cima Dome (fig. 2). These show clearly that the dome consists of concave or nearly straight slopes intersecting in a slightly blunted crest. Essentially,

* Contribution No. 645, Division of the Geological Sciences, California Institute of Technology.

† Professor of Geomorphology, California Institute of Technology.

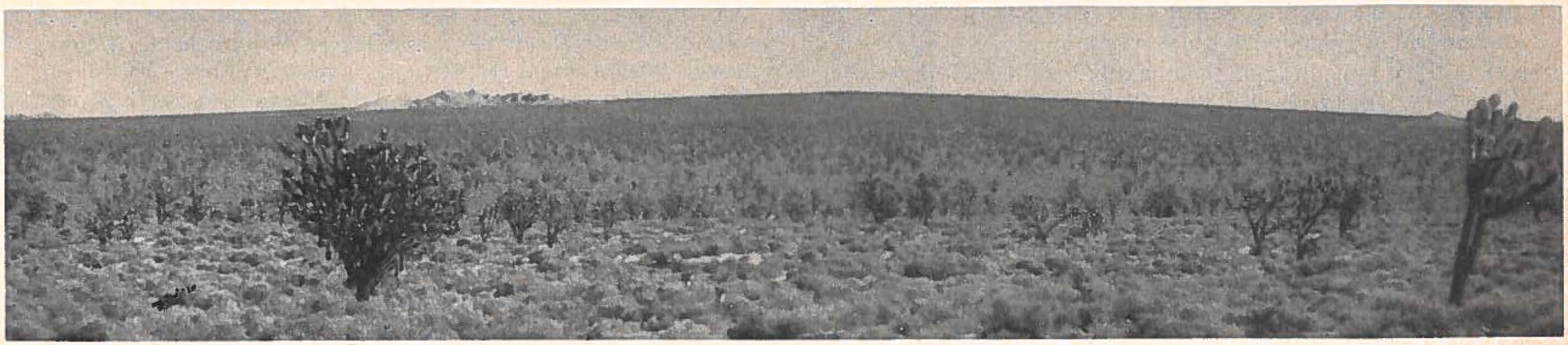

Figure 1. Cima Dome viewed from the southwest, showing residuals of resistant rock on its flanks.

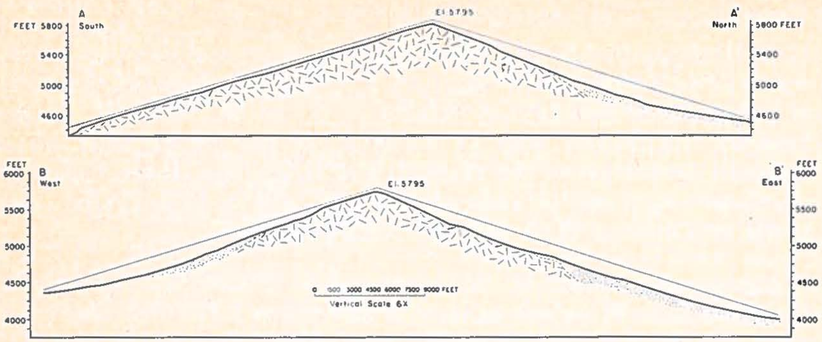

FIGURE 2. Transit-stadia profiles across Cima Dome, location shown on figure 3. Straight reference lines above surface reveal concavity of slopes. (These surveyed profiles are not compatible in detail with the contours in figure 3, which are adapted from an earlier map.)

no convexity is recorded in the north-south profile, and the east-west profile shows local convexity only in the uppermost 25 feet. The complicated argument development by Davis (1938, pp. 1391-1392) to explain convex domes has no application here.

BEDROCK-ALLUVIUM RELATIONS

The bedrock-alluvium contact has been mapped in some detail on air photos, and these data are represented in grossly generalized form on figure 3. This contact lies at altitudes 600 to 700 feet below the crest, roughly half way down the slope, and approximately 30 percent of the dome is bare rock.

The thickness of the alluvium and the form of the buried bedrock surface are of interest, particularly on the south and southeast flanks of the dome, for the bearing they may have on the possible fault-block nature of the Cima Dome mass (Davis, 1933, p. 240), and on the existence of a suballuvial bench (Lawson, 1915, p. 34). In an attempt to learn something of these matters, an electrical resistivity survey was made along the southeast part of the profile BB′ (fig. 2), Subsequently this same ground and the area farther east-southeast were surveyed by seismic refractions and reflections. Interpretation of the geophysical data is not completed, but preliminary results indicate that the only faults discovered or inferred have the upthrow on the wrong side to support Davis' fault-block argument. The buried rock floor appears to be somewhat irregular and shows no form suggestive of a convex suballuvial bench. The greatest depth of alluvium recorded is 500 to 600 feet, and near the southeastern end of the profile it is underlain by a wedge of sedimentary or possibly volcanic material resting upon the crystalline rocks, which lie about 1,350 feet beneath the surface at the point of greatest depth.

BEDROCK GEOLOGY

Pre-Tertiary Crystalline Rocks. The principal rock exposed on Cima Dome is a coarse, locally porphyritic quartz monzonite which disintegrates rapidly and uniformly under desert conditions. With one or two minor exceptions, all projecting knobs, hillocks, and ridges on the flanks of the dome are composed of other rocks. These include a uniform medium-grained granite, a distinctive highly porphyritic gneissic granite, a gneissic complex, aplite, pegmatite, and trap dikes, quartz veins, and silicified zones in the monzonite. These rocks are all more resistant to weathering and erosion than the quartz monzonite. It is clear there would be no Cima Dome were it not for the existence of this large homogeneous body of monzonite with its property of rapid and uniform disintegration.

Tertiary (?) Rhyolitic Tuff. Along an abandoned road leading west from Cima toward Marl Spring are two small exposures of rhyolitic tuff unlike any other rocks seen in this area. The tuff rests uncomformably on a complex of crystalline rocks resembling the so-called pre-Cambrian material near and south of Cima (Hewett, 1954). These exposures of rhyolitic tuff are probably related to the fault extending west-southwest through Cima (fig. 3).

Cenozoic Volcanics. West of Cima Dome is an extensive volcanic field of at least 26 cones with associated lava flows (Hewett, 1954). Two stages of vulcanism, probably both of Quaternary age, are represented. Most of the cones and some of the flows are very young, possibly late Pleistocene to Recent, and they are built in places on a platform of older flows and pyroclastics, possibly early Pleistocene.

In the eastern part of this volcanic field the older sequence consists of olivine basalt flows and layers of pyroclastics totaling 100 feet in thickness and resting upon a smooth granitic rock floor. This contact has been studied in a dozen different places. In general, the granite shows signs of extensive weathering in the form of a mantle of highly disintegrated, calichified, and locally clay-rich grüs underlain by partly disintegrated granite to depths of 50 to 60 feet. In places, the granite is overlain by 50-75 feet of grüs, bouldery grüs, fanglomerate, or mixed grüs and pyroclastics. The basal volcanics are pyroclastics in some places and flows in others.

The older volcanic sequence has been dissected as much as 200 feet and has been stripped from a considerable area. The younger volcanics consist of cinder cones and basalt flows extruded in part onto platforms of the older volcanics and in part onto a granitic rock surface lying at a lower level.

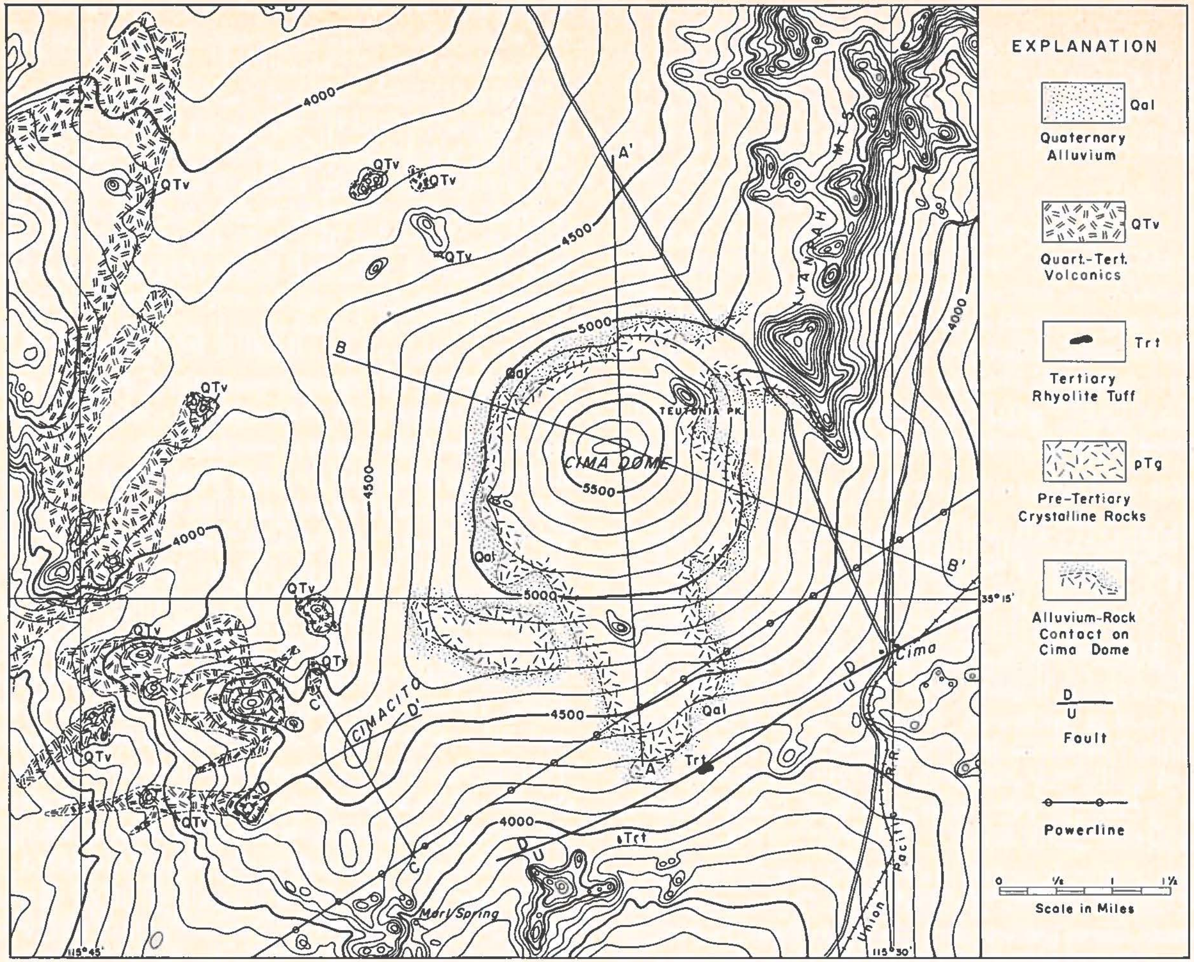

FIGURE 3. Generalized map of pertinent geological relations at Cima Dome.

The significant relations here are: (1) The older volcanics rest on a smooth granitic rock floor mantled with weathered debris which lies 50 to 150 feet above a rock floor graded to the present slopes of Cima Dome. (2) Dips measured in the volcanics suggest deformation by broad, gentle warping, and this impression is confirmed by distant views. (3) The wide distribution of similar volcanics resting on an erosion surface of low relief (Hewett, 1954) suggests that they formerly covered a large area and have been subsequently dismembered by dissection and stripping.

The exposure of volcanics nearest Cima Dome lies at the northwest base, 4.5 miles from its crest (fig. 3). One mile farther northwest is what appears to be a vent of eruption for the older volcanics. More extensive remnants of the volcanics lie west and southwest of Cima Dome at a minimum distance of 6 miles from its summit (fig. 3).

A careful search for volcanic remnants on Cima Dome itself was relatively unproductive. Three small fragments of basalt were found at widely separated places well up on the dome, but one was clearly part of an Indian grinding stone, and they all may be aberrant. A number of trap dikes intrude the quartz monzonite on the west and southwest flanks of the dome, but they are principally hornblende latite or trachyte, and hence probably are not related to the basaltic volcanics.

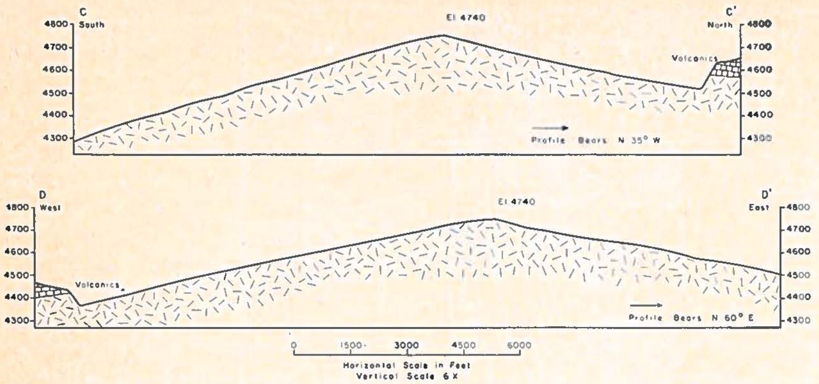

FIGURE 4. Transit-stadia profiles across Cimacito. (These surveyed profiles are not compatible in detail with the contours in figure 3, which are adapted from an earlier map.)

Faults. The only significant fault identified on the surface trends west-southwest through Cima and in essence determines the south base of Cima Dome. Its course is marked by a series of bedrock knobs and ridges and by small outcrops of rhyolitic tuff. A well 700 feet deep in alluvium about 1,600 feet north of rock exposures near Cima confirms the conclusion, drawn from bedrock relations, that the south side of the fault is upthrown. Suggestions of a fault with similar but much smaller displacement lying about one mile farther north have been picked up by the geophysical work. Neither of these faults satisfies Davis' (1933, p. 240) postulate that Cima Dome is the remnant of an uplifted fault block.

THE TESTIMONY OF CIMACITO

Seven miles southwest from the summit of Cima Dome is a much smaller granitic dome herein called the Cimacito for purposes of identification (fig. 3). With minor exceptions, Cimacito is a small-scale counterpart of Cima Dome. It covers only 6 square miles and rises 200 to 400 feet above its base. The slopes of Cimacito are almost straight and intersect without noticeable crestal convexity, as shown on transit-stadia profiles (fig. 4). They are even smoother than the slopes of Cima Dome, local relief hardly exceeding 5 feet anywhere. The cover of detrital grüs is so thin, even on the lower flanks, that the dome can be considered an essentially continuous rock surface. The symmetry is also excellent save for longer slopes to the west and south.

The significant features at Cimacito are remnants of Cenozoic volcanics perched on low hills on its southwestern and northwestern flanks (fig. 4). The volcanic layers dip gently off the dome and rest on a smooth, weathered granitic rock floor 50 to 75 feet above the present surface of Cimacito.

These relations suggest that Cimacito was at least partly covered by volcanics which, following deformation, were dissected and stripped away. The granitic surface was lowered 50 to 100 feet in the process. It seems entirely possible and likely that the volcanics completely covered the dome, but there is no direct proof of this. Noteworthy is the fact that not a single fragment of volcanic rock was found on Cimacito more than 200 feet away from the present volcanic outcrops.

ORIGIN OF CIMA DOME

Data reported above lead to the following interpretations concerning development of Cima Dome. A period of erosion, culminating in the late Pliocene(?), produced an extensive surface of low relief on certain areas of granitic rock in the eastern Mojave Desert. At this time the site of Cima Dome and the region to the west was one of exceptional smoothness owing to the homogeneity and rapid weathering of the coarse quartz monzonite there exposed. Quaternary pyroclastics and lavas were extruded over at least parts of this surface, and subsequent gentle deformation produced broad warps among which was a symmetrical, dome-shaped uplift at the site of Cima Dome. Erosion, initiated by the deformation, stripped the volcanics from large areas and modified slightly the pre-volcanic erosion surface. At Cima Dome perhaps 100 feet of weathered granitic debris and rock were removed, and the slopes of the uplift were converted to smoothly graded concave surfaces. A second period of volcanism did not materially affect the history of Cima Dome.

Briefly, Cima Dome is a remnant of an extensive late Pliocene(?) erosion surface deformed into domical shape and modified slightly by subsequent erosion. The perfection of the dome reflects in large degree the uniformity and nature of the underlying bedrock.

REFERENCES

Bryan, Kirk, 1940, The retreat of slopes: Assoc. Am. Geographers Annals, vol. 30, pp. 254-268.

Davis, W. M., 1933, Granitic domes of the Mohave Desert, California: San Diego Soc. Nat. Hist., vol. 7, pp. 211-258.

Davis, W. M., 1938, Sheetfloods and streamfloods: Geol. Soc. America Bull., vol. 49, pp. 1337-1416.

Hewett, D. F., 1954, Geology and mineral resources of the Ivanpah quadrangle, Nevada-California: U. S. Geol. Survey Prof. Paper, in press.

Lawson, A. C., 1915, The epigene profiles of the desert: Univ. California Dept. Geol. Sci. Bull., vol. 3, pp. 23-48.

Thompson, D. G., 1929, The Mohave Desert region, California: U. S. Geol. Survey Water-Supply Paper 578, 759 pages.