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Mount Rose, Northern Carson Range, Nevada: New Light on the Late Cenozoic Tectonic History of the Sierra Nevada from a Classic Locality

Abstract: The eastern border of the northern Carson Range, at Mount Rose, is important for the study of regional Sierran tectonic and faulting chronology. There Louderback indicated that more than 5000 feet of post–Miocene-Pliocene displacements occurred along the eastern front of the Carson Range at the Mount Rose cross section. He concluded that the entire Carson Range (hence the Sierra) was uplifted as a block along that frontal fault in post–late Miocene time.

The structural evidence at Mount Rose has been re-examined. It may be reinterpreted as the result of formation of a strato-volcano over a rough terrain, and its subsequent deep erosion, as contrasted with the earlier interpretation involving major fault displacement after agglomerate and flow deposition. The new structural evidence and interpretation indicates that there has been little significant faulting along the Sierra Nevada front at Mount Rose since Miocene-Pliocene volcanism.

Introduction

Mount Rose, elevation 10,778 feet, is the highest peak in the northern Carson Range, a north-trending spur of the Sierra Nevada (Figs. 1, 2). This is the classic locality where Louderback (1904) first advanced evidence of major (5000 feet) Pliocene-Pleistocene ("Cascadian") frontal faulting (*compare* Lindgren, 1897). Subsequently, Louderback (1907, 1924) supported this temporal interpretation with additional observations there and in the Basin and Range Province. Within the present decade his interpretation has been further supported by Thompson and White (1964) and widely accepted (Hunt, 1967, p. 380–381; Burnett, 1968, p. 3; Morrison, 1965, p. 265).

In spite of this apparent agreement, my work indicates that the question of the date of major uplift of the Sierra Nevada is still unsettled. Although most students of this problem agree that vigorous differential uplift occurred in late Pliocene and early Pleistocene (Hudson, 1960) the actual amount of vertical displacement is in dispute (Lydon, 1962, p. 23). Not the existence but the age of faulting along the Sierran front is questioned herein. This problem is also important because the Cenozoic uplift of the Sierra Nevada may be part of the broader problem of Basin and Range structure (Bateman and Eaton, 1967, p. 1413).

New observations of several kinds (Curry, 1966; Bateman and Eaton, 1967, p. 1413; *compare* Billings, 1960, p. 391; Christensen, 1968; Thompson and Sandberg, 1958, p. 1280; Lovejoy, 1964) are changing somewhat our concepts of the timing of the structural events. A detailed study at McGee Mountain (Fig. 1) on the Sierra front some 135 miles south-southeast of Mount Rose (Lovejoy, 1964, 1966, 1968a) shows that the Sierra front at that place is no less than 2.6 m.y. old, and none of the evidence precludes its being much older.

This paper reports further on work done at the classical Mount Rose locality (Figs. 3, 4). In 1959 the Steamboat Hills (Fig. 5) were mapped on a scale of 1 mile to 1 inch; the Mount Rose summit block was also studied in 1959 and 1962. Hill 9400 on the Mount Rose cross section was mapped by Brunton compass and pacing in 1963 and restudied and cross sectioned, using a plane table, in 1966 (Lovejoy, 1968b; Figs. 6, 7).

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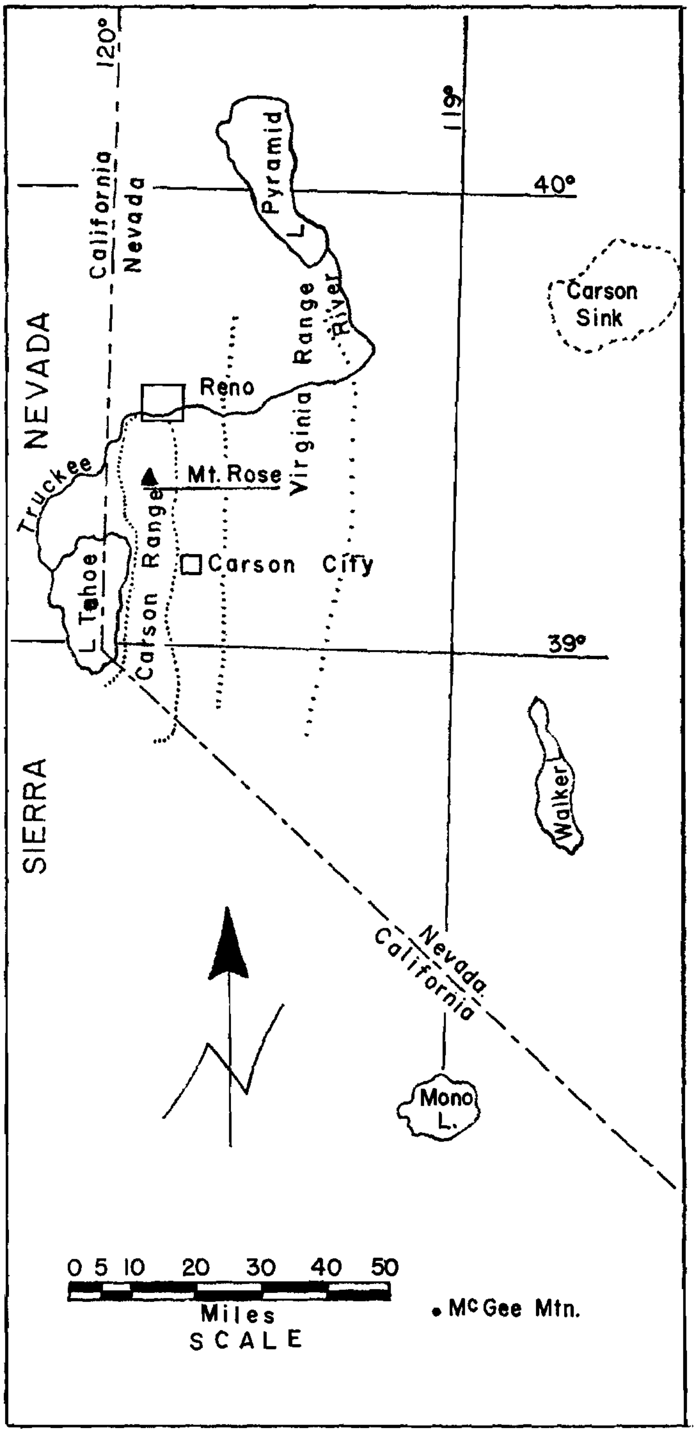

Figure 1. Regional index map of north-central Sierra Nevada and northwestern Nevada.

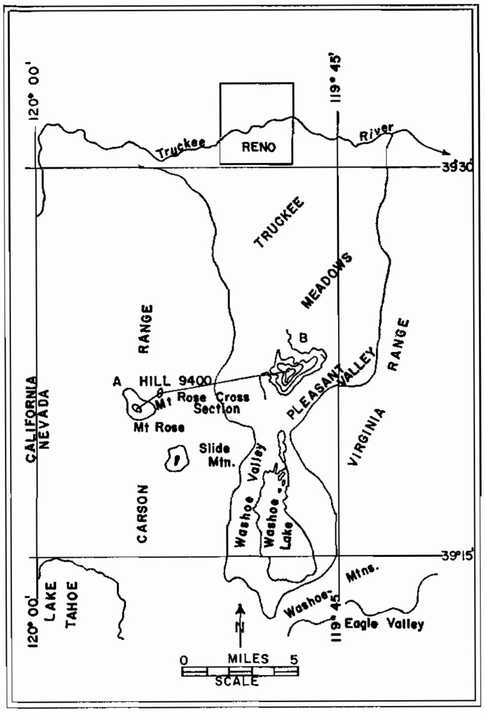

Figure 2. Local index map of northern Carson Range, Washoe County, Nevada.

John Hills, and Aaron C. Waters made suggestions that improved the manuscript. Miss Rachel Lopez typed it and Robert Sepulveda prepared most of the illustrations.

Geologic Evidence along the Mount Rose Cross Section

This section (Figs. 2, 5) has been constructed from the Mount Rose summit block east-northeastward across Hill 9400 and Hill 7720 (Fig. 8) into sec. 2, T. 17 N., R. 19 E., hence east-southeastward across part of the Steamboat Hills. The section thus consists of two segments (D-D′ and E-E′, Fig. 5) that will be discussed separately (Fig. 9).

Faults in the Carson Range. Fault No. 1 (Fig. 5) mapped by Thompson and White (1964, Pl. 1) extends 2 miles north-northwesterly from a point in the NW¼ sec. 24 to NW¼ sec. 11, T. 17 S., R. 18 E. I have followed this line from its southern end to the trail west of Mount Rose. Unlike Thompson and White, I found no evidence that the Kate Peak Formation, of late Miocene to early Pliocene (Mio-Pliocene) age, has been displaced by a major fault. On the contrary, south of Tamarack Lake (Fig. 5) basal tuffs of the Kate Peak Formation bury a rugged granodiorite terrain with relief of several hundred to 1000 feet. In Galena Creek these tuffs were mapped as Truckee Formation by Thompson and White (1964, Pl. 1; sec. 23). The Truckee Formation, however, overlies and intertongues the top of the Kate Peak volcanics; it does not underlie the flows; hence these tuffs must be the basal part of the Kate Peak. These basal tuffs extend south to the high ridge in the SE¼ sec. 23 but were not separately mapped as Truckee Formation there by Thompson and White. They also can be traced readily from the SE¼ sec. 23 to their position in Galena Creek. They have not been faulted; their difference in elevation between Galena Creek (8800 feet) and on the ridge in the SE¼ sec. 23 (9840 feet) is the result of deposition of the basal tuffs upon a very rugged terrain. The tuffs came from a volcano (*see* below) on Hill 9400. They covered the steep contact between the deeply eroded granodiorite and the andesites. Accordingly, fault No. 1 did not displace the Kate Peak Formation with respect to the granodiorite. The rugged subtuff granodiorite surface is evidence, however, that a preandesite scarp or cliff may have resulted from preandesite faulting extending along the western side of Mount Rose. Evidence of significant postandesite displacements is lacking; so, if a fault is present here, it must be of pre–Kate Peak age.

Fault No. 2 (Thompson and White, 1964, p. A35, Fig. 15; Figs. 3, 4; this is the same structure described in 1904 by Louderback) was also traced, but no structural evidence of a fault was found. The western wall similar to many hill slopes in the granodiorite is a steep hillside (steeper than 35°) formed on granodiorite, but grus covers the slope. At first glance, Hill 9400 (Figs. 3, 4) appears to be a down-dropped block composed of the same gently dipping volcanics as those seen on the summit of Mount Rose. The dips in Hill 9400 even appear to be gently westward, toward Mount Rose, as though the block had rotated slightly as it dropped. This appearance is an illusion; the hill itself is composed of steeply dipping dikes (Figs. 6, 7) of dense andesite. The andesite is not gently dipping flows, as thought by Louderback. Moreover, there are andesite dikes in Hill 9400 that are dissimilar to the andesite flows in the Mount Rose summit block.

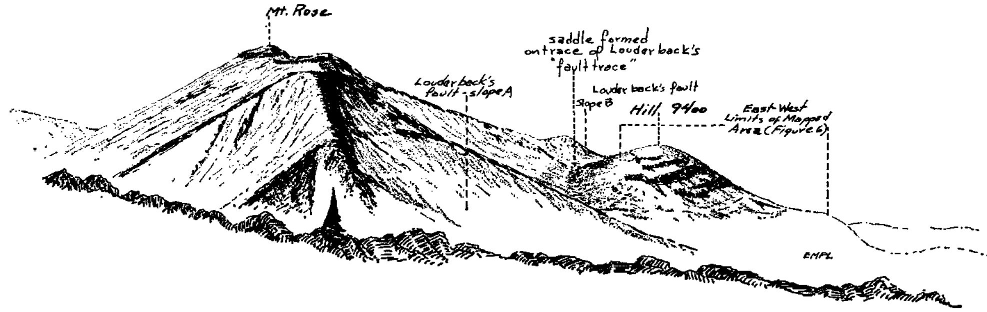

Figure 3. View toward northwest, approximately normal to Mount Rose–Hill 9400–Steamboat Hills cross section from northern flank of Slide Mountain. Slopes A and B are the scarps considered by Louderback and Thompson and White to have resulted from post–Kate Peak faulting.

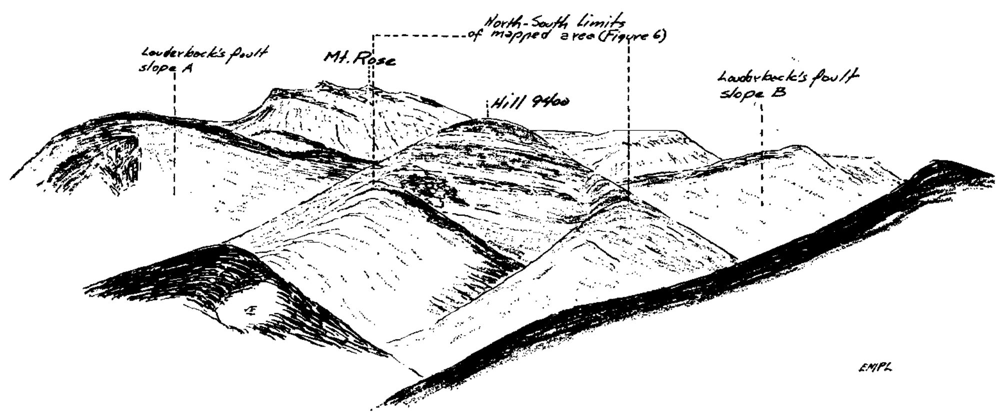

Figure 4. View toward southwest along the Mount Rose–Hill 9400–Steamboat Hills cross section from base of Carson Range. Slopes A and B correspond to those shown in Figure 3.

I interpret Hill 9400 as a deeply eroded dike-zone neck of a Kate Peak strato-volcano that was composed of tuffs and flows spread out beyond a breccia-agglomerate-dike complex near the vent. Hematite veins, hematite-coated cinders, and andesite scoria abound in the top of Hill 9400.

Thus, the only evidence of fault No. 2 appears to be a geomorphic illusion. Thompson and White (1964, p. A34) also state: "It is interesting to note that this fault, which was described by Louderback . . ., has little direct topographical expression."

Faults 3 and 4 were also examined. Fault No. 3 of Thompson and White (Fig. 6) passes west of Hill 7720 (Fig. 8) along the contact of the Kate Peak Formation with the granodiorite in sec. 8, T. 17 N., R. 19 E. There is little stratigraphic or geomorphic evidence to indicate the nature of this contact. East of the saddle (AB in Fig. 8), grus lies in the andesite slope wash, which indicates a gently eastward-dipping Kate Peak agglomerate-granodiorite contact rather than a steep contact. This seems to be another depositional contact sloping gently east eroded so as to form a cuestalike hill (7720).

Fault No. 5 could not be found in the field. The outcrop pattern of the agglomerate on the granodiorite, as interpreted here, indicates a depositional contact similar to that of the western fault but curved as the result of the gentle eastward dip of the tuff-breccia agglomerates.

Faults in the Steamboat Hills. Thompson (1952) interpreted the Steamboat Hills as an intrusive domal uplift. This may be true in part, but some reinterpretation of the structure can be offered through further subdivision of the Kate Peak Formation according to rock type beyond that attempted by Thompson and White (1964, Pl. 1). The Kate Peak For-

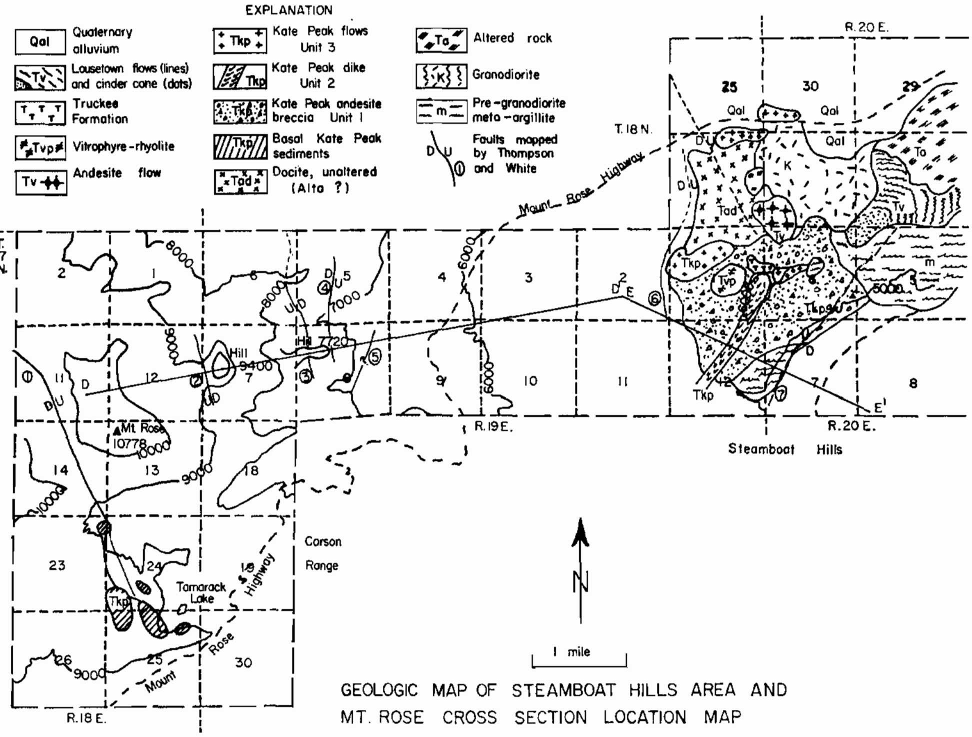

Figure 5. Geologic map of Steamboat Hills area, Washoe County, Nevada, showing outcrops of the basal Kate Peak Formation tuffs south of Mount Rose.

mation in the Steamboat Hills (Fig. 5) consists of andesite agglomerates (unit 1), dikes (unit 2), and flows (unit 3). The backbone ridge of the hills, extending southward from the peak, is a vertical andesite dike (unit 2). A flow (unit 3) from this dike caps the hill east of the peak. This flow is gradually breaking up by mass movement, and huge blocks (the size of houses) are creeping down the eastern side of the hills into Pleasant Valley. The agglomerate (unit 1) was probably erupted from a source that later produced the dike (that cuts the agglomerate); such is commonly the situation in the volcanic terrain of this part of Nevada and California (Curtis, 1954). The dip of the agglomerate away from the central part of the hills, and from the dikes as well, may therefore be due to original dip instead of to doming as stated by Thompson (1952). The agglomerate varies in thickness and covers pre-Tertiary metamorphic rocks; it is thin over the hilltops.

Faults that may cut the metamorphic rocks were not found as displacements of the Kate Peak andesitic flows or agglomerates. Along the western edge of the hills fault No. 6 (Fig. 5) is a minor fault scarp 15 feet high. The gentle western slopes of Truckee Meadows between the Carson Range and Steamboat Hills are cut by many such scarps, most of which are difficult to trace in the field; the displacements on them may seldom amount to as much as 20 feet. But, since displacements are down on the eastern sides of many of these scarps and down on the west in about an equal number of others, there does not appear to be any significant structural dislocation caused by the zone.

If a post–Kate Peak fault exists along the eastern side of Steamboat Hills as mapped by Thompson and White, it is minor. Fault No. 7 extends up and across the eastern edge of the hills and passes through a small cinder cone; the scarp is less than 15 feet high. No important post–Kate Peak andesite or postbasalt displacement is observable.

The Steamboat Hills thus consist of a metamorphic and granodioritic core, the remnant of a fault block between the Carson

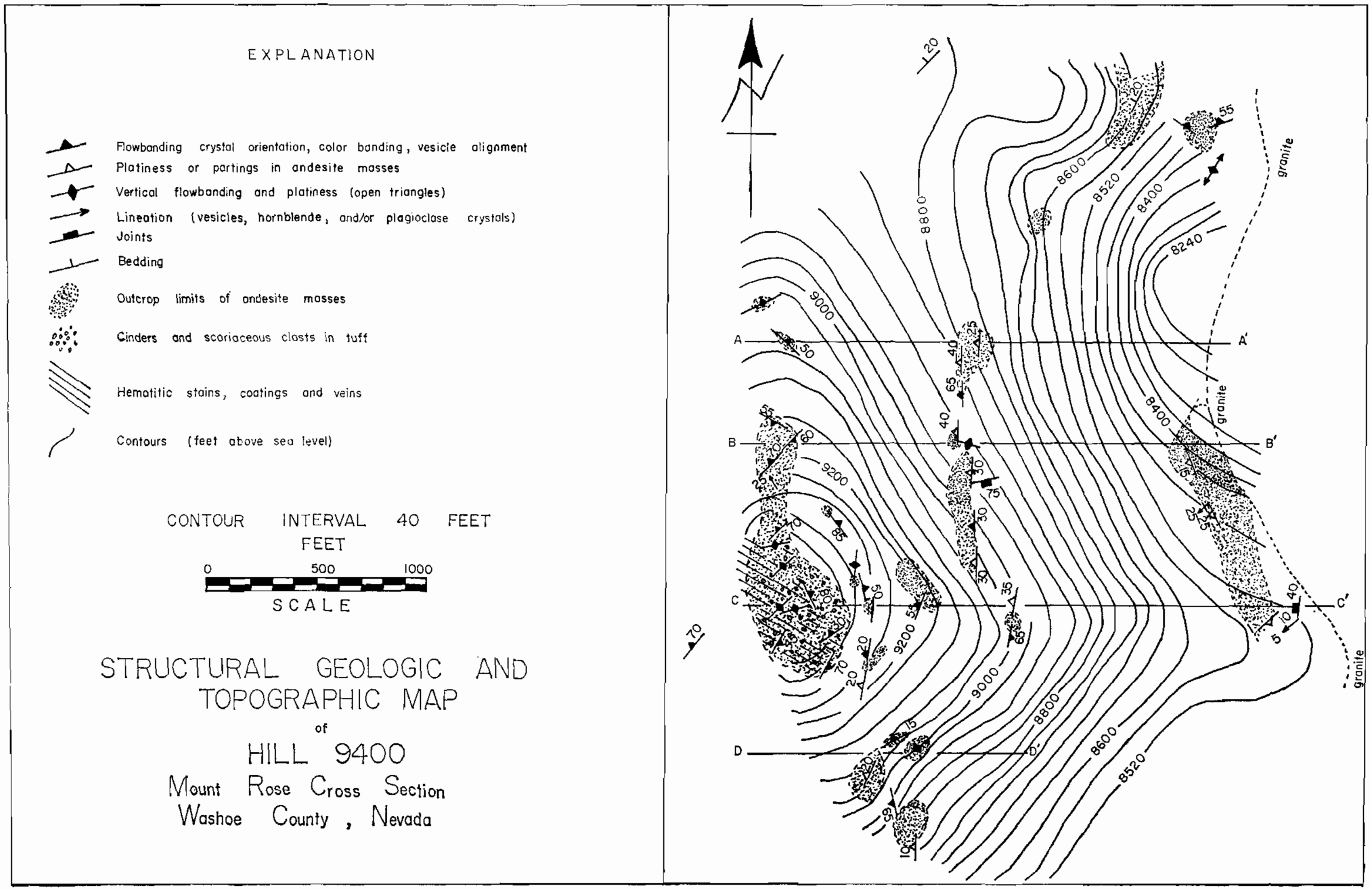

Figure 6. Structural geologic and topographic map of Hill 9400, Mount Rose cross section, Washoe County, Nevada.

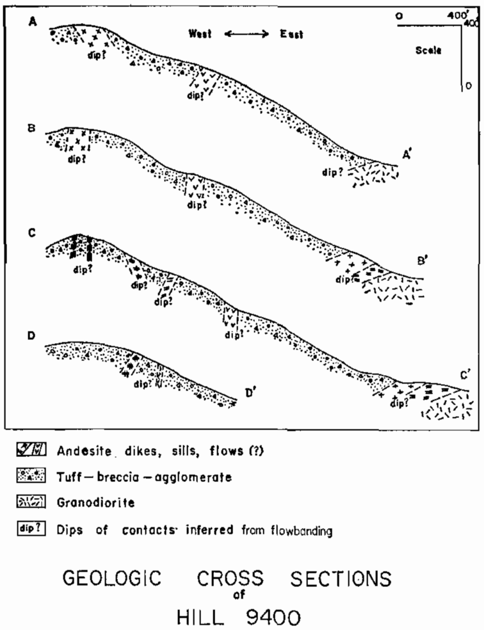

Figure 7. Cross sections of Hill 9400 derived from the geologic map (Fig. 6).

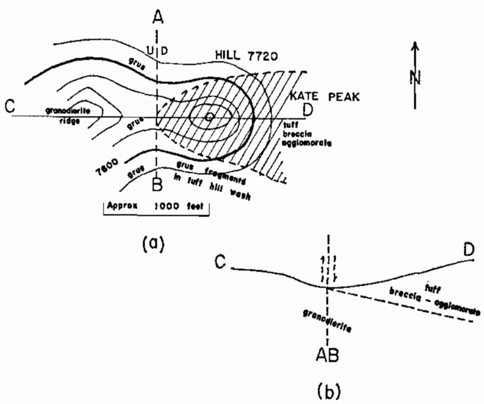

Figure 8. Sketch geologic map of Hill 7720, sec. 8, T. 17 N., R. 19 E., on the Mount Rose cross section (Fig. 9). Cross section C–D shows the interpretation considered to be more probable.

and Virginia Ranges, which may be the surface expression of an igneous-generated uplift (similar to that proposed by Thompson, 1952) of pre–Kate Peak, not post–Kate Peak, age. On that uplift are remnants of the pre–Kate Peak Alta Formation (of Oligocene-Miocene age) that appear to have participated in the structural deformation of the hills. Intruded into this pre–Kate Peak rock are several pre–Kate Peak cylindrical intrusions, the surface flows from which are not found in the area. On top of the pre–Kate Peak rocks are thin to thick agglomeratic accumulations, cut by a large Kate Peak andesitic dike that forms the high peak of the hills. Remnants of flows that emanated from that dike remain on the Steamboat Hills.

As such, the Kate Peak andesite agglomerates, dikes, and flows of the Steamboat Hills constitute a local volcanic assemblage associated only generally in time with the much greater Kate Peak accumulation in the Carson Range deposited there by that great volcano, the remnant of whose throat is found in Hill 9400.

Conclusions

Remapping along the Mount Rose section does not reveal any structural or geomorphic evidence of major post–Kate Peak Formation (late Miocene to early Pliocene) faulting. Instead, the detailed geologic data indicate that: (1) Mount Rose was part of the western flank of a Kate Peak volcano; (2) the throat of that volcano is at the present site of Hill 9400, east of Mount Rose; and (3) Steamboat Hills are the remnant of a separate, local source of dikes, flows, and agglomerates. Because the flows and pyroclastics erupted from these volcanoes buried a rugged topography, correlation (for purposes of determining secondary structural deformation) of the many separate units of the Kate Peak Formation under the assumption that they were a once subhorizontal, essentially continuous planar unit that has been subsequently greatly displaced by faulting is untenable.

At two classic localities of supposed major late Cenozoic normal displacements along the eastern face of the Sierra Nevada, more detailed field work at McGee Mountain (Lovejoy, 1964) and Mount Rose (this paper) has eliminated the necessity of postulating major Pliocene-Pleistocene ("Cascadian") dip-slip faulting. Other explanations appear to fit better with the observed geological and geomorphological relations at these important places, and therefore I suggest that the other parts of the eastern front of the Sierra Nevada should be re-examined in detail to determine whether the hitherto accepted Pliocene-Pleistocene displacements actually took place.

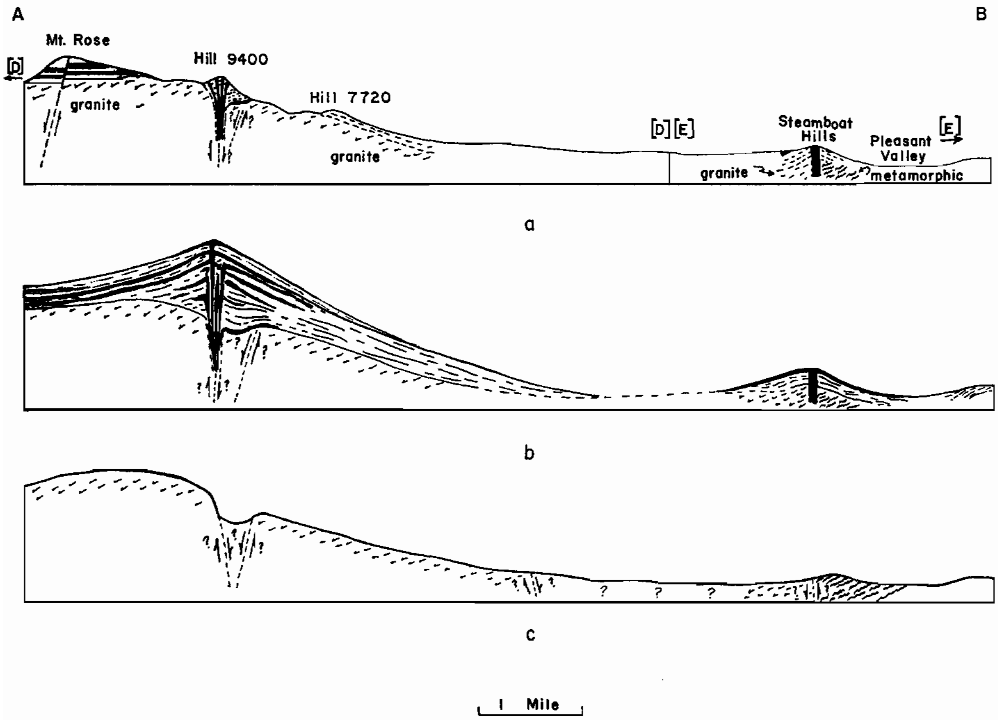

Figure 9. (a) A generally east-west cross section (natural scale) through Mount Rose and the Steamboat Hills. Topography from Thompson and White's (1964, Pl. 1) cross sections D–D′ and E–E′. Their cross section D–D′ extends farther to the left (west) and their cross section E–E′ extends farther to the right (east). The line of cross section (A–B) is shown on Figure 2. The geologic interpretation is that described in this paper. *Compare* Thompson and White's cross sections. The minor normal fault observable in the Mount Rose summit block is shown on Thompson and White's map but is not extended to their line of section. (b) Cross section showing reconstructed, hypothetical structures along the Mount Rose–Steamboat Hills cross section in Kate Peak time. The Hill 9400 volcano may well have risen to an elevation of from 11,000 to 13,000 feet. There does not appear to have been great topographic modification of the Steamboat Hills structure, however. This is probably because (1) Mount Rose receives more rain and snow, and weathering and erosion of its thick agglomerates permitted much more rapid downwearing there than at the lower elevations and more arid climate of Steamboat Hills; (2) the relief between Mount Rose and Truckee Meadows was in excess of 5000 feet (possibly as much as 7000 to 8000 feet in the early Pliocene). (c) Cross section showing reconstructed, hypothetical pre–Kate Peak topography and structure of the Sierran granitoidal rocks. The fault positions and dips are conjectural.

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