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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Implications of a Magnetic Model of the Long Valley Caldera, California

by

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Open-file report 76-439

1976

This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

INTRODUCTION

This report contains a summary of the results and interpretations of a rigorous quantitative modeling of the magnetic anomalies associated with the Long Valley caldera (figure 1). It is designed to supplement the more qualitative interpretations reported in Kane et al (1976). The data available to constrain the model can be found in that report and 13 additional reports which were recently published in the Journal of Geophysical Research, Vol. 81, no. 5 and 8. The available aeromagnetic maps are shown in figures 2 and 3.

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MODELING SOFTWARE

The magnetic modeling computer program is from J. G. Rosenbaum (written communication, 1976). The program analytically integrates Talwani's (1965) two dimensional polygons over the third dimension. In very general terms. the technique is simply to sum the individual magnetic fields calculated for a set of right polygonal prisms. Each prism must be assigned a direction and magnitude of magnetization. The output of each of our various modeling attempts was summed on an 18 by 23 grid, each grid increment being a 2 km square. Then, to facilitate comparison, these were triple splined and contoured at an elevation corresponding to the aeromagnetic map in figure 2.

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RESULTS OF THE MODEL

The model delineates several major structural and magnetic features. The most significant result is to confirm that much of the magnetic field above the caldera is dominated by the magnetic effects of one major rock type, the Bishop tuff.

The source of the magnetic high in the eastern half of the caldera appears to be thick sequence (up to 2.7 km) of Bishop tuff bounded on the west by the projection of the Hilton Creek fault. Figure 4 illustrates the location and defines its boundaries. It requires a magnetization of about $3X10^{-3}$ emu/cm^3 to fit the data and a volume of about 170 km^3. This volume compares with the estimated total volume of the fill of 700 km^3, of which roughly half (350 km^3) is Bishop tuff. We find that most of the remaining 180 km^3 of intra-caldera Bishop tuff lies beneath the resurgent dome (figure 4) and has a magnetization of $7X10^{-4}$ emu/cm^3 or less and leads to the magnetic low in the eastern half of the caldera.

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Another magnetization contrast in the fill is a NE-SW trending region of reduced magnetization. It is the cause for the double peaked nature of the Long Valley magnetic high (figure 3). The region roughly coincides with a gravity high interpreted by Kane et al (1976) as a basement ridge. Hydrothermally altered and densified Bishop tuff would also cause similar gravity and magnetic anomalies. Densification, caused by hydrothermal processes, is frequently observed in the rocks surrounding hot springs. There are numerous hot springs in this region and DC resistivity soundings show this to be an area of intense alteration. The rest of the fill which, in general, lies above the Bishop tuff and consists of volcanics and periglacial and lucustrene sediments has an average magnetization of less than $1X10^{-4}$ emu/cm^3.

We were also able to delineate the structure of two major features beneath the fill. The first is under the central and south-central portions of the valley (figure 4). It roughly coincides with a gravity high reported in Kane et al (1976). We interpret this to be the downdropped portion of a pre-caldera mountain. Its magnetization is approximately $8X10^{-4}$ emu/cm^3, which closely resembles the Round Valley Peak granodiorite, the batholith rock of the mountains immediately south of the valley floor.

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The second feature is beneath the northeastern valley floor. The magnetic model indicates the fill is quite thin in this area, whereas the gravity model of Kane et al (1976) shows it as one of the thickest parts of the fill. This discrepancy results from the inability of the gravity model to distinguish between low density caldera fill and the low density Glass Mountain rhyolite. Glass Mountain is a large pre-caldera mountain and it was apparently cut nearly in half by the caldera collapse (figure 4). Its downdropped portion now lies beneath the fill.

The basement rocks beneath most of the western half of the caldera have a low magnetization and few discernible magnetization contrasts. They could be hydrothermally altered Sierra Nevada granites and metavolcanics, hydrothermally altered intrusives associated with the Long Valley caldera, or as suggested by Kane et al (1976), simply a downdropped portion of the belt of low magnetization metasediments found both north and south of the Long Valley. Similarly, in the eastern half of the caldera, aside from the Glass Mountain rocks, the basement showed few observable magnetization contrasts.

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CONCLUSIONS

The primary cause of the observed intracaldera magnetization differences appears to be related to extensive hydrothermal alteration of the resurgent dome Bishop tuff in contrast to unexpectedly high magnetization for the remainder of the intracaldera Bishop tuff. A secondary cause could be a present day temperature difference, the rocks in the east being cooler.

From this analysis, the most likely place to find a hot, permeable fluid filled geothermal reservoir is in and possibly beneath the thick sequences of Bishop tuff west of, but adjacent to, the Hilton Creek fault projection in north-central Long Valley.

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REFERENCES CITED

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Kane, M. F., Mabey, D. R., and Brace, R. L., 1976, A gravity and magnetic investigation of the Long Valley caldera, Mono County, California: J. Geophys. Res., v. 81, p. 754-762.

Talwani, M., 1965, Computation with help of a digital computer of magnetic anomalies caused by bodies of arbitrary shape: v. 30, p. 797-817.

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Figure 1. Tectonic map of Long Valley-Mono basin area. Heavily dotted area is zone of "reverse drag" on Sierra Nevada front. Lined area is resurgent dome in Long Valley caldera. Solid lines represent faults (ball on downthrown side). From Bailey et al (1976).

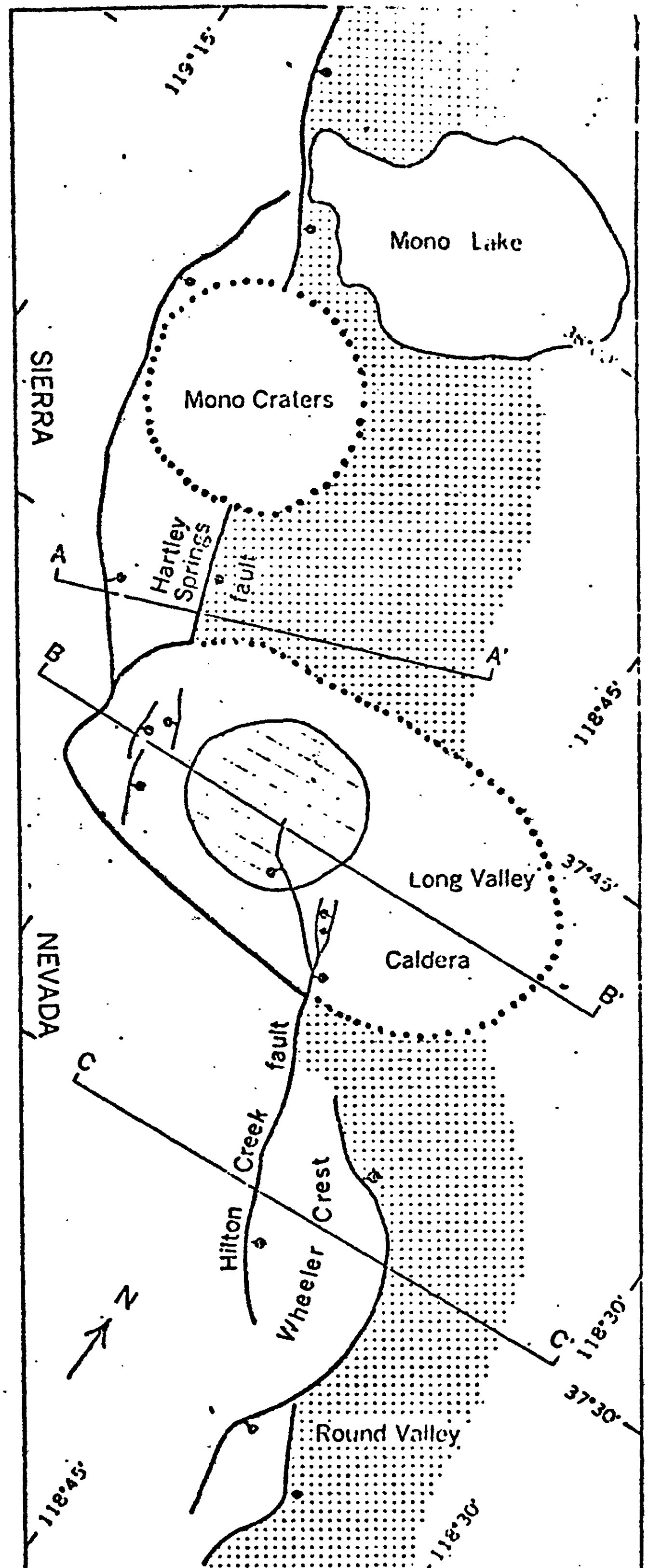

Fig. 1(?). Tectonic map of Long Valley–Mono basin area. Heavily dotted area is zone of 'reverse drag' on Sierra Nevada front. Lined area is resurgent dome in Long Valley caldera. Solid lines represent faults (ball on downthrown side). From Bailey et al. (1976).

Fig 1

Figure 2. Combined generalized geology and low-level total magnetic map of Long Valley Caldera. From Kane et al (1976).

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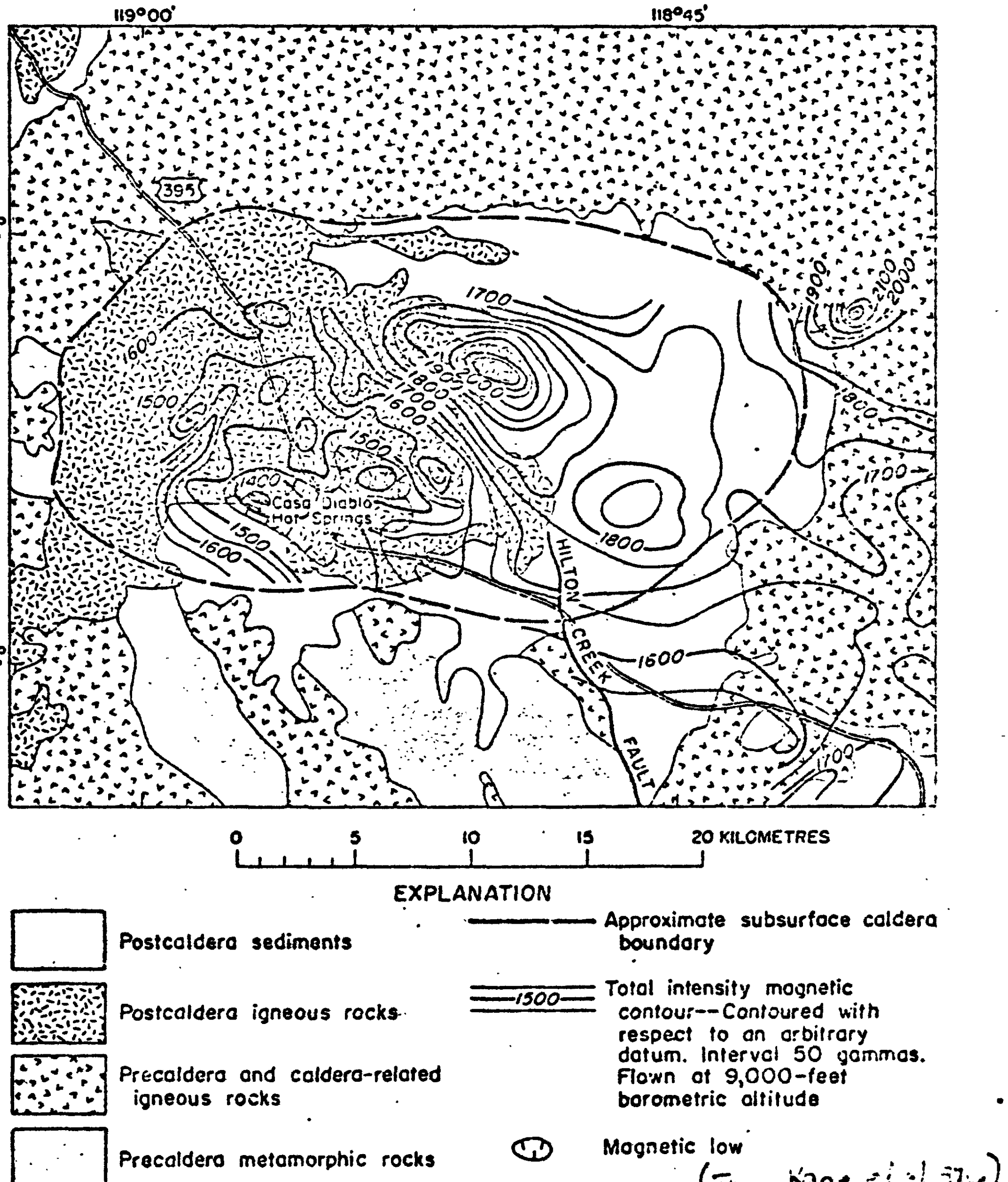

(From Kane et al [illegible])

~~Fig. 6.~~ 2 Combined generalized geology and low-level total magnetic intensity map of Long Valley caldera. ~~Magnetic contours from [illegible] et al. (1964).~~

Figure 3. Combined generalized geology and high-level residual magnetic intensity map of Long Valley area. From Kane et al (1976).

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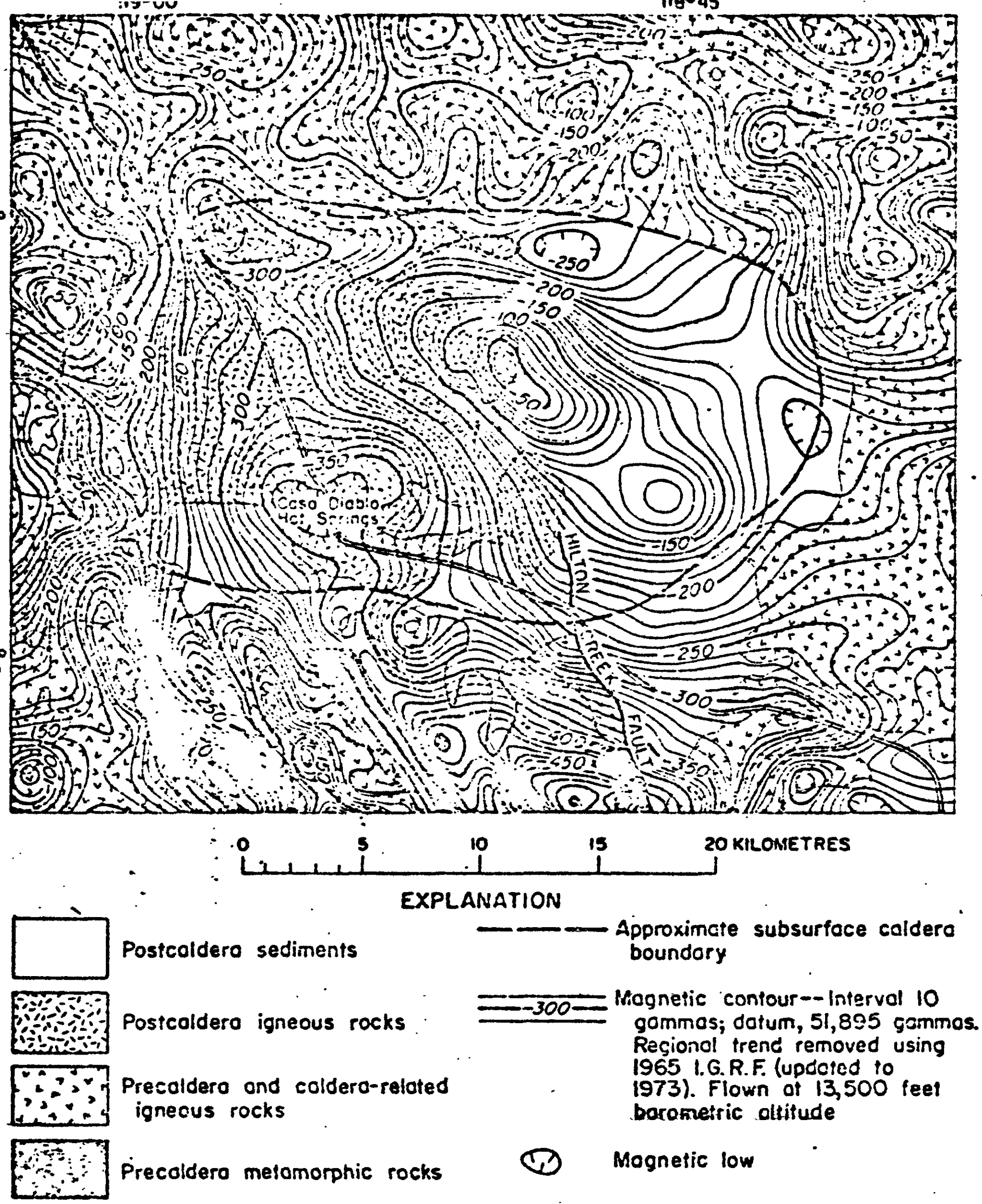

Fig. 3. Combined generalized geology and high-level residual magnetic intensity map of Long Valley area ~~[U.S. Geological Survey, 1974]~~.
(From Kane et al. 1976)

Figure 4. Isometric drawings showing the location of the major magnetic contrasts: (a) view looking northwest from 45° above the horizontal; (b) view looking northwest from 45° below the horizontal.

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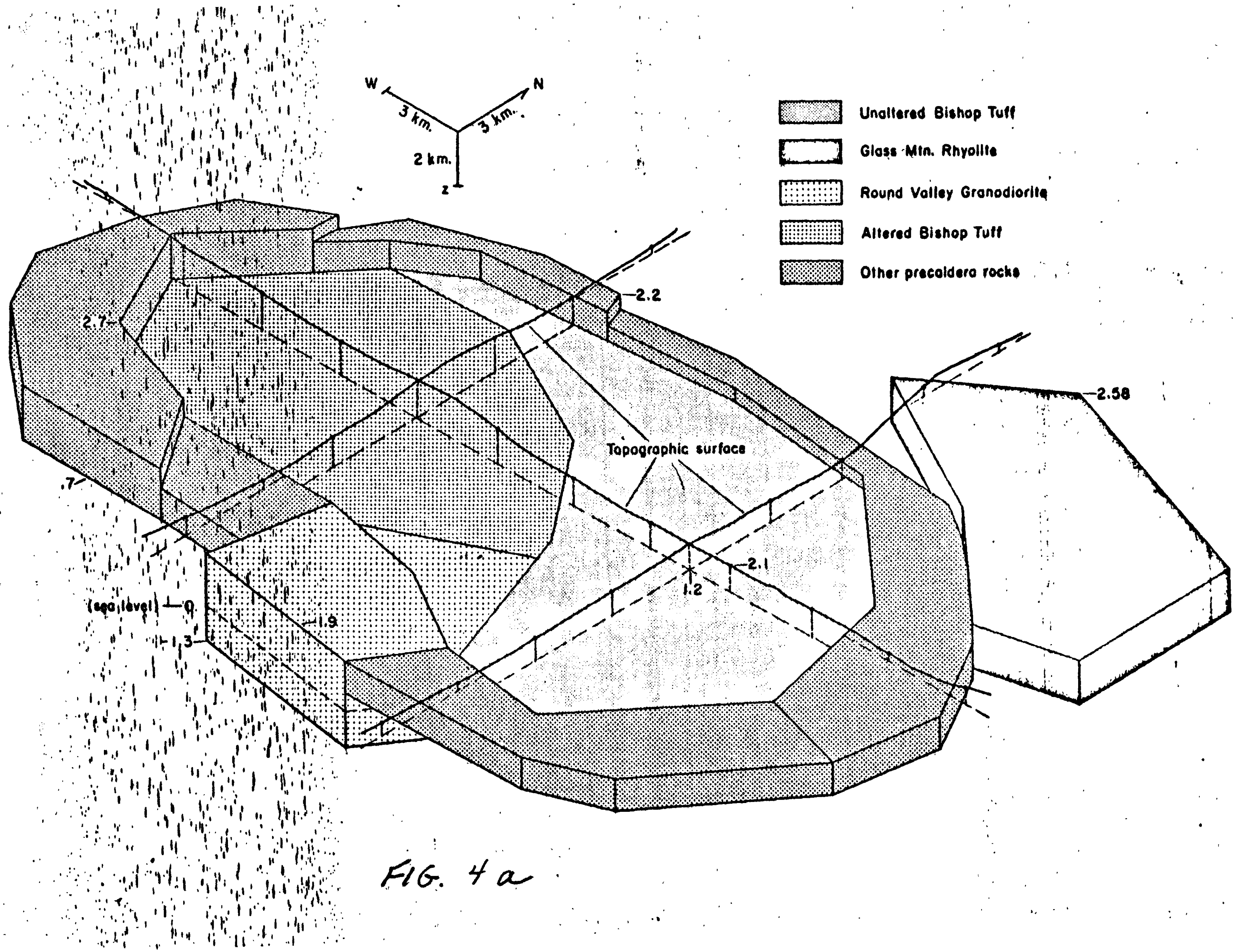
W
3 km.
N
3 km.
2 km.
z
Unaltered Bishop Tuff
Glass Mtn. Rhyolite
Round Valley Granodiorite
Altered Bishop Tuff
Other precaldera rocks
2.2
2.7
2.58
Topographic surface
.7
2.1
1.2
(sea level) 0
1.9
-3

FIG. 4a

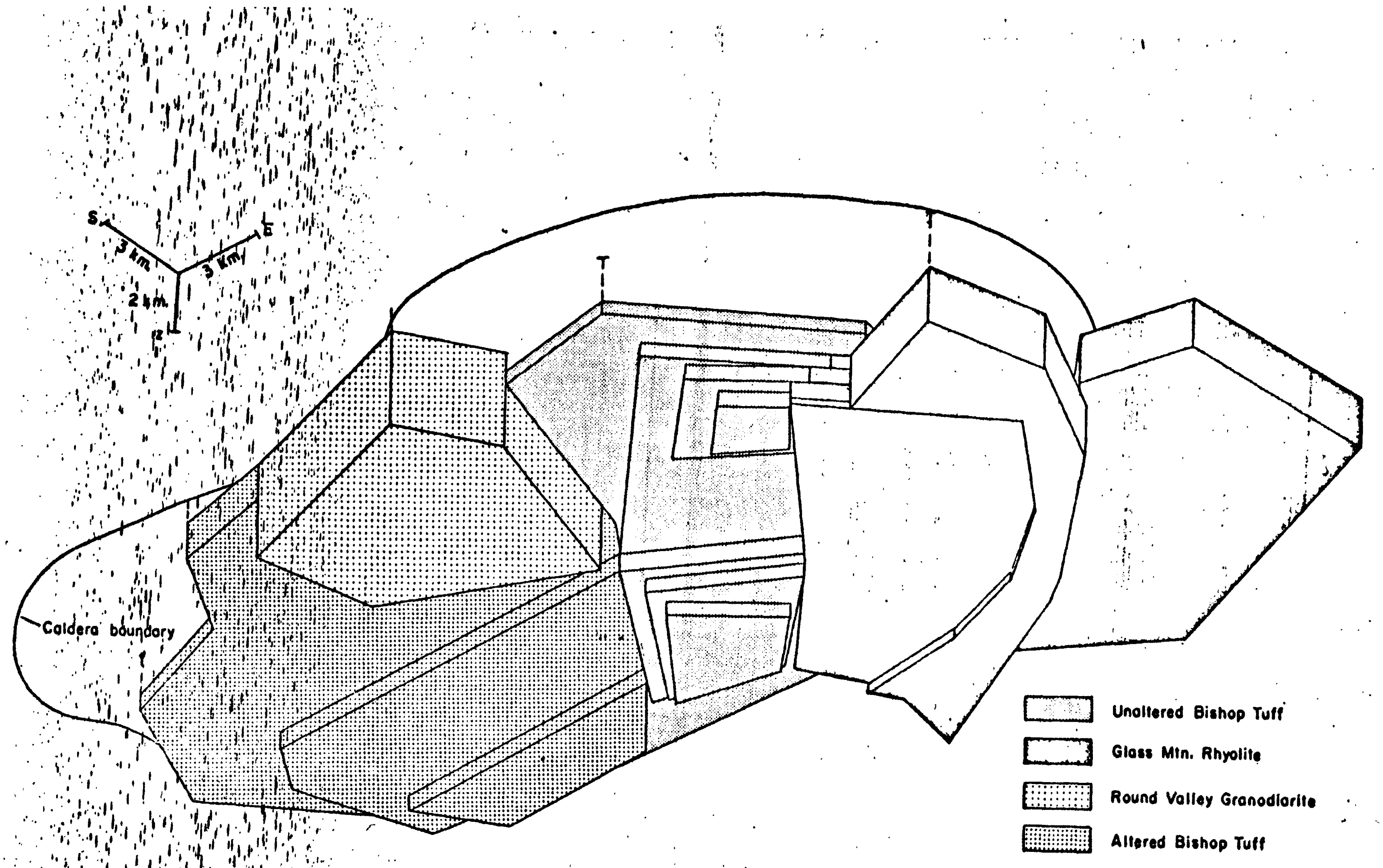
S
3 km
3 km
E
2 km
Z
T
Caldera boundary
Unaltered Bishop Tuff
Glass Mtn. Rhyolite
Round Valley Granodiorite
Altered Bishop Tuff

FIG. 4 b