UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

A SELF-POTENTIAL SURVEY OF LONG VALLEY CALDERA, MONO COUNTY, CALIFORNIA

Open-file report

1974

This report has not been edited or reviewed for conformity to U.S. Geological Survey standards.

A self-potential survey of Long Valley caldera,

Mono County, California

By Lennart A. Anderson and Gordon R. Johnson

Introduction

A self-potential survey was made in a major part of the Long Valley, Calif., in an attempt to measure potentials related to geothermal reservoirs at depth. The physical extent of the Long Valley caldera as determined from gravity data (Pakiser, Kane, and Jackson, 1964) and the area where sufficient self-potential data were obtained to allow contouring are shown in plate 1.

Field procedure

Potentials were measured between copper-copper sulfate electrodes 300 feet (91.5 m) apart using a high input impedance millivoltmeter. Potential differences were measured along a traverse and individual readings added successively to provide a profile of potentials relative to a predetermined reference point. The reference point for the Long Valley survey is at the junction of old U.S. Highway 395 and Mammoth Lakes Road located approximately 1,000 feet (305 m) south of Casa Diablo Hot Springs. All self-potential data were subjected to a digital filtering computer process to remove the effects of background potentials.

Most measurements were made along closed loop traverses, and a linear adjustment was made in individual readings to compensate for errors which were probably caused by electrode imbalance. To keep electrode effects at a minimum, electrode potential offsets were checked frequently and electrodes selected so as to produce potentials less than 1 millivolt in a side-by-side arrangement.

Profile data

Although most profiles were confined to the caldera, a few profiles did extend across the caldera boundaries. Plate 2 shows a branching profile across the eastern boundary of the caldera. The location of the profile is shown in plate 1. The profiles obtained along the eastern traverses are very similar and show an increase in self-potential as the caldera boundary is approached. The difference in the potential between the caldera boundary and the central part of the caldera is approximately 1 volt. Similar amplitude differences were observed wherever the caldera boundary was crossed.

The observed potential increase near the edges of the caldera may be caused by ground waters moving upward along the fracture system ringing the perimeter of the caldera. However, there is no evidence of spring activity in the perimeter area. More likely, a potential source within the caldera sets up a current that distributes itself according to the resistivity of the various earth materials, and the potentials measured near the caldera boundary reflect contrasting resistivities. A decrease in the potential beyond the limits of the caldera suggests a downward component to the flow of current.

Contoured data

A contour map of the potential relative to the reference point is shown in plate 3 superimposed upon the generalized geology of the area. The largest potentials are on Quaternary and Tertiary volcanic rock of similar resistivity, thus indicating that near surface resistivity variations are not the cause of the observed difference in potential. The dominant features on the contour map are a positive anomaly on the south and a negative anomaly to the north. We have not determined if the high and low anomalies stem from a common source, but the fact that a profile connecting the centers of the individual anomalies is symmetrical suggests a dipolar source mechanism at depth.

The minimum potential difference between positive and negative anomalies is about 900 millivolts. Based on the calculations of Nourbehecht and Madden (1967), diffusion and thermoelectric effects would only contribute to the total self-potential anomaly in a minor way. Streaming potentials, however, may contribute significantly in producing the anomaly although 900 millivolts is much greater than the several hundred millivolts computed for this type of source mechanism. Temperature differences within a moving column of water may cause effects capable of producing large surface potentials. To our knowledge these effects have not been studied on a large-scale basis; therefore, there is virtually no experimental data to draw on in formulating a valid mechanism sufficient to produce large potentials as a result of thermal activity. Possibly the cause of high potentials generated in a thermal area will not be fully understood until a three-dimensional study can be made in an area such as Long Valley by a series of deep drill holes within the anomalous area. However, the intriguing possibility exists that the self-potential anomalies are directly or indirectly related to a major heat source within Long Valley.

References

Nourbehecht, Bijan, and Madden, Theodore, 1967, Irreversible thermodynamics in homogeneous media and geoelectric applications: Unpublished report, MIT, Cambridge, Mass.

Pakiser, L. C., Kane, M. F., and Jackson, W. H., 1964, Structural geology and volcanism of Owens Valley region, California; a geophysical study: U.S. Geol. Survey Prof. Paper 438, 68 p.

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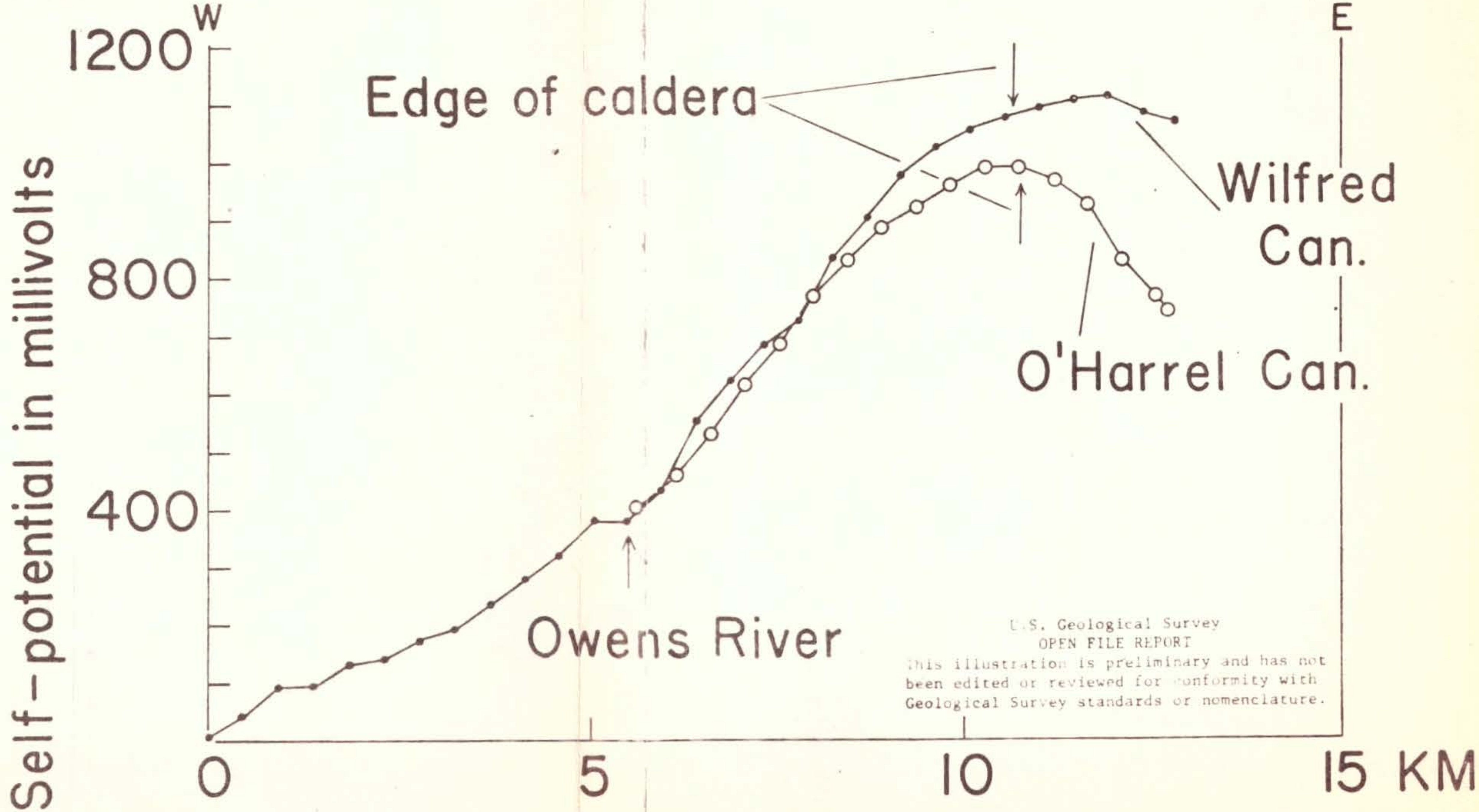

Plate 2.--Self-potential profiles along the eastern caldera traverses, Long Valley caldera, Mono County, California.

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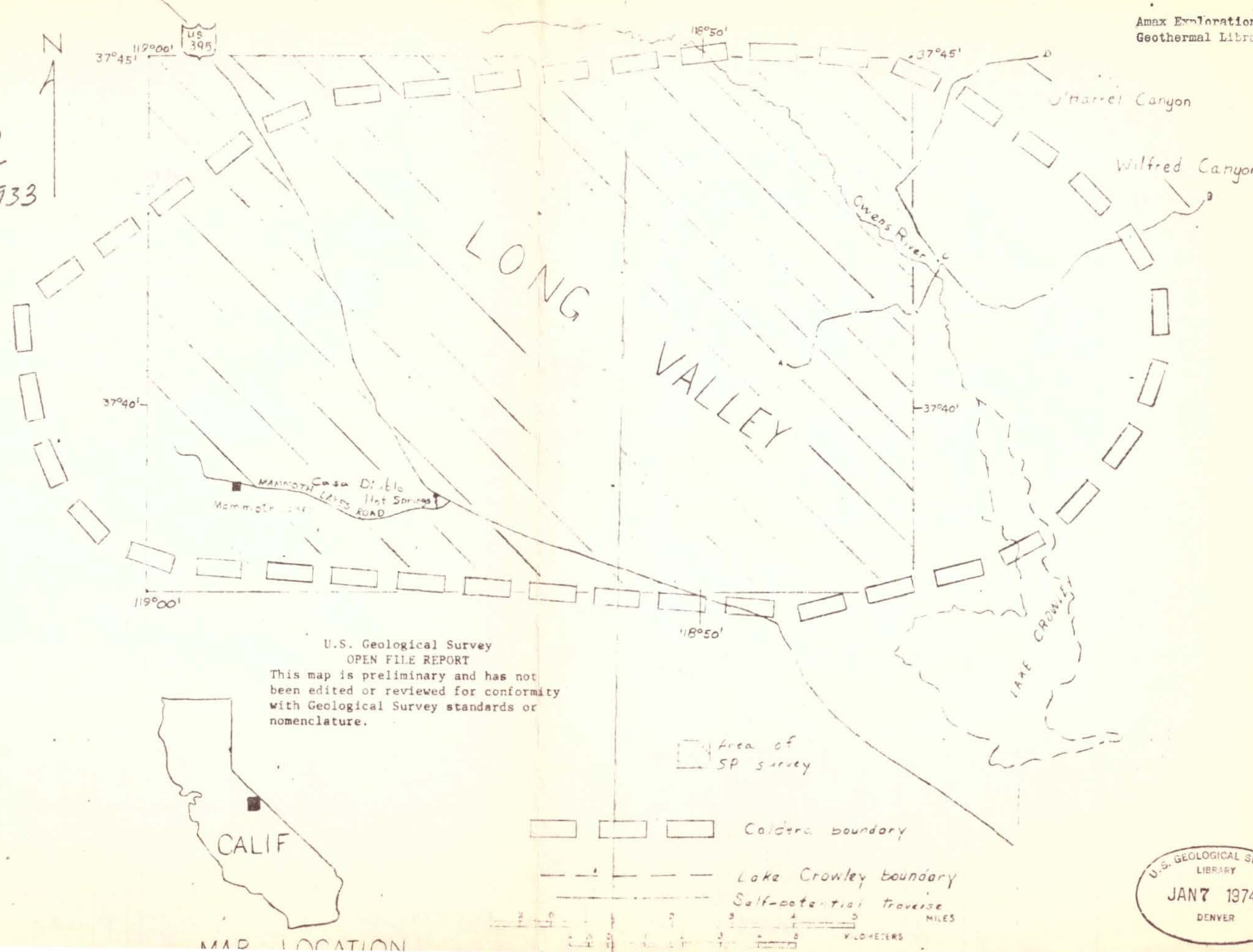

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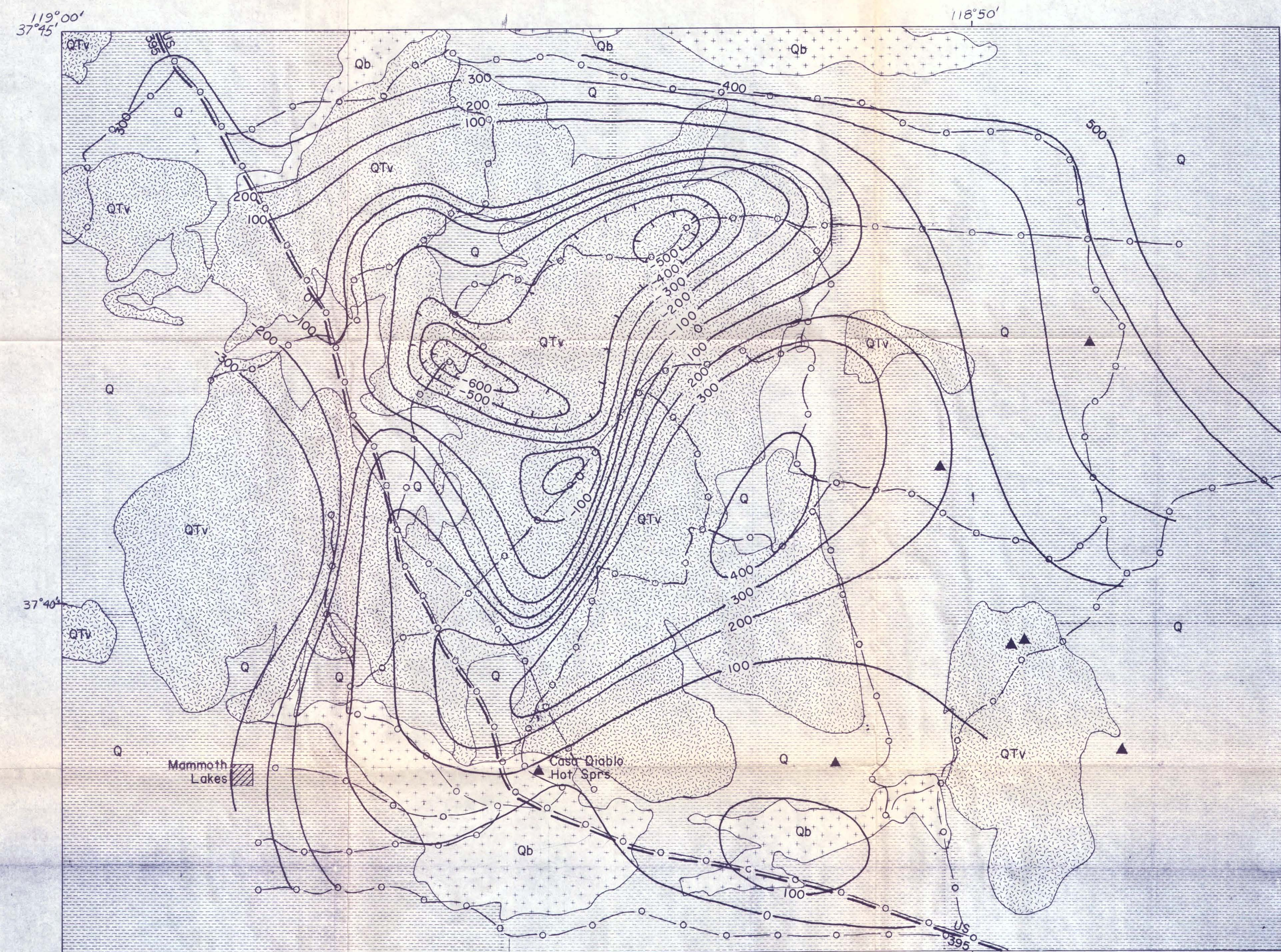

Base from U.S. Geological Survey, Mount Morrison, 1:62,500, 1953

Geology generalized from Pakiser, Kane, and Jackson (1964)

0 1 2 3 4 5 KM

EXPLANATION

Q — Unconsolidated deposits including pumice

QTv — Quartz latite, rhyolite, and andesite

Qb — Basalt

▲ Hot springs

100 — Equipotential contour. Contour interval 100 MV

o—o — Self-potential traverse

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Plate 3.--Self-potential and generalized geologic map of the western part of Long Valley, Mono County, California.

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