MAGNETOTELLURIC INVESTIGATIONS IN THE NORTHERN ALTIPLANO OF BOLIVIA

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The Altiplano is characteristic of the structural and orographic device of the central Andes (1, 2). It is a high plateau having elevations of 3500-4000 m over an area about 200 km wide and 1500 km long. Although the plateau seems clearly associated with the subduction of the Nazca plate beneath western South America, its structure remains ill-known because of the lack of geophysical data. During 1989 August and September, magnetotelluric (MT) measurements at periods from 10 to 5000 s were made at nine locations in the Bolivian Altiplano (Fig. 1) along a 200 km SW-NE profile, approximately perpendicular to the dominant surface structures. A four channel digital MT system was used in this survey and the horizontal components of the electric and magnetic fields were measured at each site. The MT traverse was designed primarily to provide detailed information concerning the structure, thickness and extent of the sedimentary provinces and examine the use of the method in a region in which not much is known. The field tapes were analyzed following a procedure described by Vozoff (3). Tensor apparent resistivities and phases were rotated to their principal directions corresponding to the geoelectrical strike and perpendicular to it.

For most sites rotation angles were well defined and the average electrical strike obtained from the impedance principal directions is N 140°E, roughly parallel to the dominant trends of the study area. The MT responses appear to fall into three distinct groups which are consistent with separating the sites according to locality, i.e., the western group with sites 1, 2, 3, and 4, the central group with sites 5, 6, and 7, and the eastern group with sites 8 and 9. Typical sounding curves are shown in Figure 2, which gives the MT responses in the parallel-to-strike (TE mode) and perpendicular-to-strike (TM mode) directions, observed at sites 2, 7, and 9. All of the curves from these sites reveal some two- and three-dimensional characteristics. The data for site 2 show a very pronounced parallel split between the TM and TE amplitude curves, which is caused by small, local, near-surface inhomogeneities (4).This

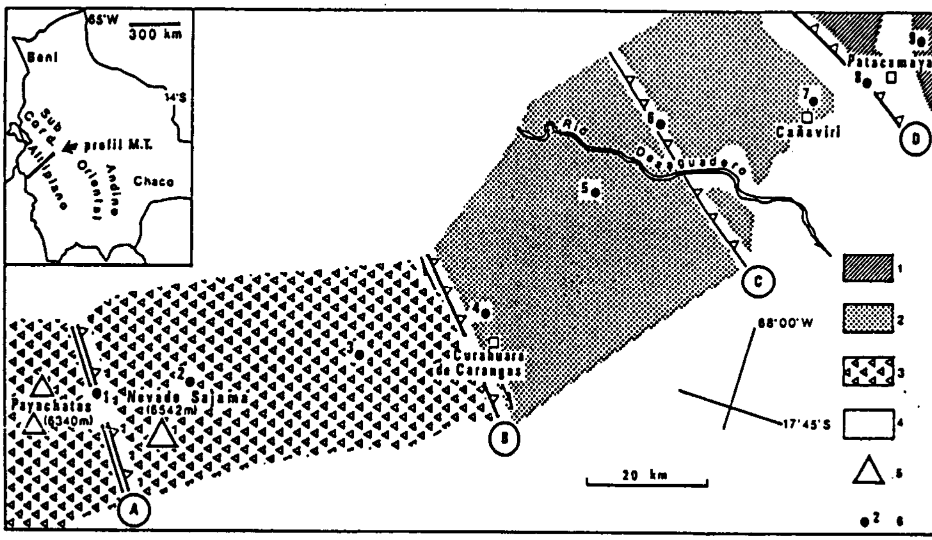

Figure 1. MT site locations superimposed on geology of the northern Altiplano in Bolivia. 1: Paleozoic; 2: Mio-Pliocene sediments; 3: Plio-Quaternary volcanic overburden; 4: Quaternary sediments; 5: major volcanoes; 6: location of MT sites. A: Intra-Andean Boundary Fault, B: San Andres Fault; C: Sivinca Fault; D: Coniri thrust.

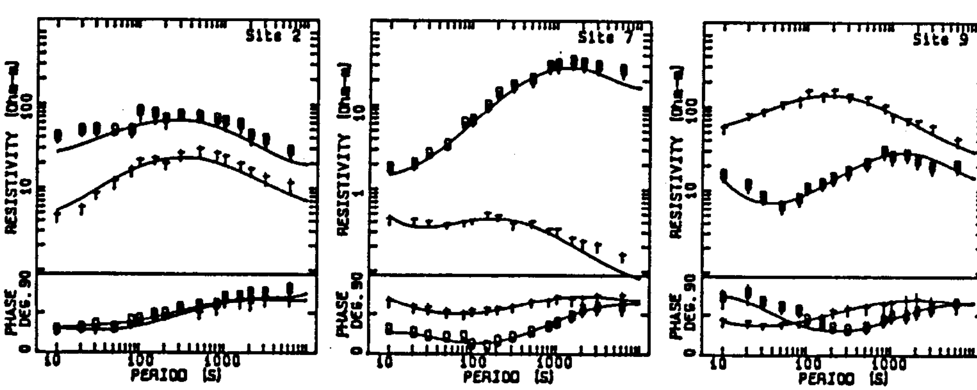

Figure 2. MT responses for three typical sites with error bars. Tensor apparent resistivity and phase plots for the TE and TM directions are shown by the dots and crosses, respectively. The solid curves through the observed MT data are theoretical curves computed from the 2-D model given in Figure 3.

distortion is seen only on the resistivity data, and the phase data are unaffected as indicated in Figure 2. The MT responses for sites 7 and 9 appear to be little affected by the static shift effects of near-surface inhomogeneities and the geological structures beneath the sites along the eastern half of the profile (sites 5-9) can be described as two-dimensional (2-D).

Near-surface distortions are present at the four western sites and to determine the major structures responsible for our observations, we used the phase of the determinant of the MT impedance tensor (5) which is unaffected by static shift, and truly represents the phase of the impedance tensor itself. However, an interpretation based completely on phase gives no information regarding absolute resistivities. Thus, we used the phase in a qualitative sense only for most of our sites, and undertook a 1-D interpretation (6) based on the determinant parameters of the impedance tensor for some sites considered to be free of static shift effects. The layered electrical models generated in this way provide a starting point for 2-D modelling (7) across the whole traverse.

Results of 2-D modelling are shown in Figure 3. This model was iterated until a reasonable fit to phase data for westernmost sites was achieved. The geoelectrical model shows the presence of thick conductive layers with resistivities in the range of 1 to 8 ohm-m except at sites 8 and 9 on the east end of the traverse where the resistivity is 30 ohm-m. The base of the sequence of low-resistivity sediments lies at a maximum depth of 5 km and contains depressions and uplifts to within 200-700 m of the surface. Below the sedimentary units, the crustal units are characterized by resistivities less than 200 ohm-m. On the northeast portion of the traverse, MT data give evidence for NW-SE faults which can be associated with known structural features namely, Coniri thrust (near sites 8 and 9) and San Andres fault (west of site 4). A significant lateral discontinuity can be detected again west of site 2. This discontinuity is an important element to locate the Intra-Andean Boundary Fault (FLIA), which has been individualized by tectonostratigraphic data (8, 9). At depths in excess of 43 km there is a general trend toward lower resistivities, the transition from 200 ohm-m to less than 8 ohm-m occuring in the depth range 43 to 52 km. Schwarz et al. (10) indicated a similar general decrease in resistivity at about 40 km beneath the Altiplano in southern Bolivia. Finally, the geoelectrical model suggests that three units are present below the Altiplano: very low resistivity units in the upper 5 km, high resistivity units in the middle crust, and low resistivity units in the lower crust or upper mantle.

References

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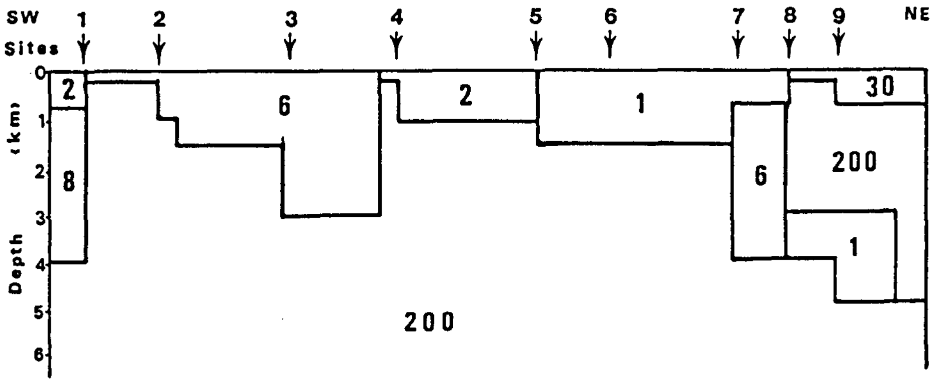

Figure 3. Two-dimensional resistivity model computed to model the MT traverse along the Bolivian Altiplano. Numbers indicate resistivities in ohm meters.