the higher radial modes produce all the direct, reflected, refracted and diffracted body phases, as well as the higher-mode surface waves. Stoneley-wave propagation along the core-mantle boundary introduces a large number of interesting phenomena into the propagation of the spheroidal overtones. The confinement of the Stoneley modes to the vicinity of this boundary is responsible for the discontinuities in the spectra and the relative difficulty in the excitation of long-period P and SV diffracted arrivals, as compared with the corresponding SH phases. The trapping of body-wave energy for sources within a velocity inversion is demonstrated. The particle motion ratio at the surface may be as useful as phase velocity in the understanding of the physical properties beneath a recording site; realistic curves of this parameter are presented for a wide range of periods and radial orders.

Order No. 72-27,293, 73 pages.

SEISMIC VELOCITY ANOMALIES IN THE UPPER MANTLE BENEATH THE TONGA-KERMADEC ISLAND ARC

Walter MITRONOVAS, Ph.D.
Columbia University, 1969

A detailed analysis of travel-time residuals of P waves from numerous earthquakes (depth about 600 km) in the Fiji-Tonga area indicates that the travel times for the upgoing rays traveling beneath and through the seismic zone of the arc are 5 ± 1 sec less than the travel times of rays through the normal aseismic mantle for equivalent distances. A less well-determined difference in the travel times of S waves is about 11 to 12 sec. Thus, on the average, the P and S velocities in the anomalous seismic mantle beneath the arc are about 6% and 7% higher than for the adjacent portion of the aseismic mantle beneath the Fiji Islands. These differences in velocities can be explained by differences in temperature of the upper mantle material on the order of 1000 C°. The basic experiment on which the quantitative results are based involves (1) the determination of epicenters of the deepest earthquakes using only the travel times of the horizontal and downgoing rays of P waves through the presumably relatively homogeneous lower mantle to distant stations, and (2) comparison of the travel times of the upgoing rays of P and S through the heterogeneous upper mantle to local stations. The travel-time residuals and the character of the seismic phases at local and regional stations indicate that the zone of abnormally high velocities in the upper mantle beneath the Tonga-Kermadec arc coincides with the slab-like zone of anomalous low attenuation (high Q) associated with the inclined seismic zone of the island arc. The contrast in velocities appears to extend down to considerable depths, perhaps down to the deepest earthquakes (~ 650 km). There is no indication that such a contrast extends below the deepest earthquakes. A sharp contrast in seismic parameters between the upper surface of the high-velocity slab and the mantle above is indicated by the presence of secondary phases that are believed to be P to S and S to P converted phases at this boundary. The data for the converted phases indicate that, for depths between 50 km to 100 km beneath the Tonga ridge, the upper boundary of the anomalous high-velocity slab approximately coincides with the top of the seismic zone which dips westward beneath the ridge at about 45°. The slab-like configuration of the high-velocity zone associated with the dipping seismic zone of the Tonga-Kermadec island arc is also supported by the travel times of the downgoing P waves from numerous earthquakes near the upper portion of the seismic zone (0 - 250 km depth) to local and distant stations and by the travel times to local stations from events located outside the Fiji-Tonga area.

Order No. 72-33,441, 117 pages.

178

THE VERTICAL DISTRIBUTION OF HEAT PRODUCTION AND HEAT FLOW IN NORTHWESTERN MEXICO

Douglas Lee SMITH, Ph.D.
University of Minnesota, 1972

Analyses by gamma ray spectrometry of over two hundred 1 kg samples representing 2.5 km of topographic relief from the Sierra San Pedro Martir in Baja California, Mexico, reveal uranium, thorium, and potassium abundances capable of producing 2-4 hgu (1 hgu = 10^{-13} cal/cm^3 · sec). A geological study of the late Cretaceous, quartz diorite - granodiorite massif indicates an uplifted northwesterly trending block, faulted on both sides, and consisting of at least four separate igneous units, distinguished by mineralogy, texture, and age. The multiple intrusions and faulting preclude consideration of the samples as a group for variations in heat production with depth. However, heat production values from twelve groups of samples of limited vertical extent from within major fault blocks of uniform rock show a rapid decrease of heat generation with depth. Calculations indicate a least squares straight line slope of about 10 hgu/km and, for a curve of exponentially decreasing heat production, a shallow logarithmic decrement of 3-6 km is computed.

Nine heat flow values reported herein from Baja California and Sonora represent the first determinations of heat flux from Mexico and, in general, justify southerly extensions of the thermal provinces in southwestern United States. Two heat flow values from Baja California, 0.8 and 1.2 hfu (10^{-6} cal/cm^2 · sec) are similar to the low to normal values known for the Sierra Nevada and Southern California batholiths. Seven measurements (two over 3 hfu and five averaging 2.0 hfu) of heat flow in Sonora are similar to Basin and Range values and have reduced heat flow values, q*, greater than 1.5 hfu.

The heat flow measurements in Sonora suggest a slightly lower heat flux in the eastern part of the state which may indicate a lateral narrowing of the Basin and Range thermal province in Mexico. The high heat flow of the Basin and Range Province is modeled as having resulted from behind arc extension associated with the termination of Cenozoic subduction off western North America. Opening of the Gulf of California and sea floor spreading therein has provided a vent for release of heat accumulated under northwestern Mexico. Thus, according to the model, the southern tip of the Basin and Range Province is cooling and narrowing, while that portion in the United States remains thermally unstable.

Order No. 73-1061, 189 pages.