

Oliver J & Isacks B. Deep earthquake zones, anomalous structures in the upper mantle, and the lithosphere. *J. Geophys. Res.* 72: 4259-75, 1967

Seismic waves show that the material of the deep earthquake zone of the Tonga-Fiji arc is very different from that of aseismic parts of the mantle at comparable depths elsewhere. It appears that the lithosphere has been thrust or dragged to great depths beneath island arcs. This result implies mobility for the lithosphere everywhere, and suggests new approaches to a variety of major geological and geophysical problems. [The SCJ® indicates that this paper has been cited 176 times since 1967.]

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January 25, 1978

"The prominence of this paper is in large measure due to good fortune and favorable timing, for it came at a time, and was a part, of a suite of new ideas and ferment that led to the plate tectonics revolution in geology. For encouragement in subsequent endeavors, I like to believe, however, that its success was to some extent dependent upon sound research strategy and some very hard work.

"In the early 1960s Bryan Isacks and I set out to make a contribution to the major international effort of that period in the solid earth sciences, the Upper Mantle Program. Isacks was then a promising young scientist who had just received the Ph.D. under my direction at Columbia. We have, incidentally, been colleagues ever since, most recently at Cornell.

"We reasoned that to investigate the upper mantle it would be wise to study in detail those events currently occurring there, the deep earthquakes. That meant installation of a network of seismographs in an appropriate locality. After considering many sites around the globe, we settled on the Fiji-Tonga area of the South Pacific, largely because deep earthquakes take place much more frequently there than elsewhere, and so we were assured of accumulation of large quantities of data in a short time. Neither of us had been to Fiji or Tonga, and we knew little of the field conditions for operating the

instruments, which had to be set up in remote areas. We had no shortage of friends who chided us about tropical island paradises, however.

"With the financial support of NSF, the help of various institutions and individuals, and the hard work of Isacks, who spent 15 months in the South Pacific, we were able to establish and operate, under strange and sometimes difficult field conditions, a seismograph network that produced data of quantity and quality.

"At that time it was generally held that the earth's mantle was laterally homogeneous. I had the hunch that the materials and properties of the deep earthquake zones must in some way be different from the surroundings and urged Isacks to search the observations for evidence that might support that hypothesis. He soon reported that waves traveling in the deep earthquake zones were strikingly anomalous. Once assembled, the evidence was, in fact, incredibly clear.

"In retrospect, the final interpretation of the data in terms of earth structure seems obvious, but we pondered the problem for months. Then, one day, we related our observations from Fiji-Tonga to some data on West Indian shocks recorded at Palisades, New York. Almost immediately, the well-known picture of the downgoing slab beneath island arcs appeared on the blackboard. In the air of ferment on sea-floor spreading that existed at the time, it quickly became clear that the island arcs had to be the places where sea floor was being consumed. Other previously unrelated facts suddenly fell into place, a very convincing sign of a correct hypothesis. The paper was one of those presented at the exciting and unique meetings of the American Geophysical Union in 1967 when plate tectonics caught on with a large segment of the profession.

"Shortly thereafter, Lynn Sykes, another Lamont Geological Observatory seismologist who had been working on sea-floor spreading and seismology, Isacks and I wrote a comprehensive paper called 'Seismology and the new global tectonics,' which is perhaps still more widely known, but I have always felt that the deep earthquake project, from initiation through the discovery phase to completion in the form of this paper was a uniquely rewarding experience, an experience for which I am most thankful."