(*Reprinted from Nature, Vol.* 229, *No.* 5286, *pp.* 549–550, *February* 19, 1971)

Shear Wave Propagation in Rocks

We have demonstrated striking similarities in elastic wave propagation through rocks and single crystals in recent experiments. In particular, we find that two shear waves with displacements perpendicular to one another and with differing velocities are often propagated through rocks. This is illustrated in Fig. 1 at 5 kb pressure for samples of slate and dunite; an ultrasonic technique described by Birch[1] was used. One MHz AC-cut quartz transducers generated and received the shear waves, and an electrical pulse of 50 V was used to excite the transducers. The rock samples were cylinders 2.54 cm in diameter and approximately 6 cm long.

For the slate the propagation direction of the shear waves was parallel to the cleavage. The transducers were rotated in steps of 15° such that shear waves were first propagated with a displacement direction parallel to the cleavage. Fabric study of the dunite shows a strong concentration of olivine *a* crystallographic axes and girdles of *b* and *c* axes. Propagation in the sample shown in Fig. 1 was normal to the *a* axes concentration.

Two shear waves with differing velocities are obviously propagated through both rocks. Velocities for the two shear waves in the slate differ by approximately 1 km s^{-1}, whereas velocities of the two waves in the dunite differ by 0.3 km s^{-1}. The latter value seems to be quite typical for shear velocity anisotropy in dunites. The phenomenon is common in metamorphic rocks and has been observed in several igneous rocks. The time resolution did not always permit clear identification of the two shear waves, but a rotation of the transducers produced a change in shape of the first arrival which strongly suggests the presence of this type of anisotropy. In all cases the observed anisotropy seems chiefly to be the result of preferred mineral orientation.

The importance of this study for shear wave propagation within the Earth remains to be established. The recognition of two shear wave arrivals would, clearly, provide unequivocal evidence for seismic anisotropy in regions of the upper mantle where longitudinal waves appear to vary in velocity with

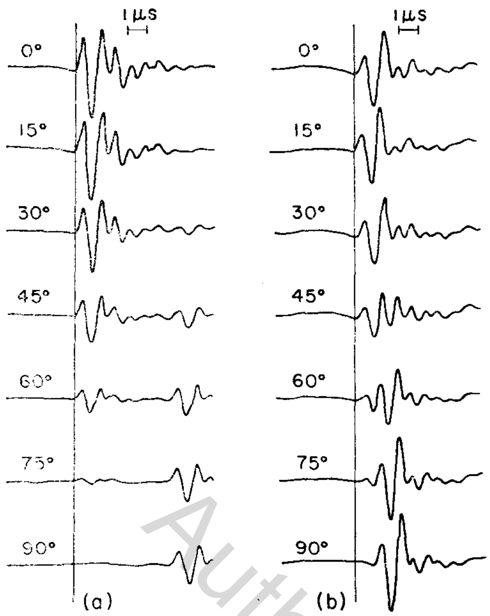

Fig. 1 Oscilloscope traces for shear wave propagation through (*a*) slate from Poultney, Vermont, and (*b*) dunite from Twin Sisters Peaks, Washington. The transducers are oriented at 0° to receive the higher velocity shear wave. Rotation of the transducers through 90° emphasizes the first arrival of the slower of the two shear waves.

azimuth. It is highly probable that many regions of the Earth's crust and mantle are anisotropic and, hence, two shear waves should be propagated through these regions. It is possible that the arrival of one of the shear waves is often masked by the arrival of other energy.

This work was supported by a US National Science Foundation grant.

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Received September 1; revised November 9, 1970.

[1] Birch, F., *J. Geophys. Res.*, **65**, 1083 (1960).

Printed in Great Britain by Fisher, Knight & Co., Ltd., St. Albans.