in the rate of production of new crust, or by a shift in the pole of rotation of the plates. A regional map of the anomalies would reveal a change in the pole of rotation as a reorientation of the trends of the anomalies. A change in spreading rate can only be established by reference to an absolute time scale calibrated by radiometrically or palaeontologically dated samples. Such a time scale may soon be possible.

The east flank profile shows several additional anomalies above 32, although the record here is disturbed by the presence of two sea-mounts. Beyond that area, there is a magnetically quiet zone, 400 km wide. Extrapolation of spreading rates suggests that the western edge of this quiet zone is about 100 m.y. old. On the west flank, no quiet zone is found; pronounced anomalies continue to the margin of the continent. Heirtzler and Hayes[15] described quiet magnetic zones flanking the mid-Atlantic ridge in the North Atlantic and they have suggested that these are produced by continued spreading during a period devoid of magnetic reversals. Drake and others[16], on the other hand, considered the quiet zones of the North Atlantic to be part of the floor of a proto-Atlantic Ocean which predates the onset of the current period of continental drift.

The absence of a quiet zone on the west flank of the CIRCE profile argues against the assumption that it is caused either by the process postulated by Heirtzler or by the effect of the low magnetic latitude. Drake's hypothesis is obviously attractive, but because the fit of the South Atlantic margins is excellent, new difficulties would arise from fitting the Brazilian margin against the westward limit of the quiet zone in the eastern basin. Dickson *et al.*[4] have noted the presence of a quiet zone in the Rio Grande basin, and show anomaly profiles with a quiet zone in the Cape basin, but there are insufficient data as yet to evaluate its regional distribution. The absence of a quiet zone in the western part of the northern South Atlantic indicates a very asymmetric distribution of spreading rates for the earliest spreading phase.

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How Thick is the Lithosphere?

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A rapid decrease in shear velocity in the suboceanic mantle is used to infer the thickness of the lithosphere. It is proposed that new and highly precise group velocity data constrain the solutions and imply a thickness near 70 km.

THE hypotheses of seafloor spreading and plate tectonics have received much attention lately because they explain in a consistent manner the pattern of magnetic anomalies on the seafloor, the distribution of earthquake belts and the thickness and ages of deep-sea sediments. According to these hypotheses the lithosphere (composed of the crust and the rigid cap of the upper mantle) is divided into a number of rigid plates in constant motion. The plates are created along midocean ridges and are destroyed in the process of sinking back into the mantle in the vicinity of deep-sea trenches. The lithosphere is underlain by the asthenosphere—a weak zone coincident with the seismic low velocity layer, and probably the source region of basaltic magma.

This article is concerned with the problem of determining the thickness of the suboceanic lithosphere. Thickness is an important parameter which enters discussions of the mechanism of plate tectonics and the thermal regime in the lithosphere.

The thickness of the lithosphere may be estimated in several different ways. For example, seismic focal depths under Hawaii presumably are coincident with the zone at the base of the lithosphere where magma enters the fissure system which ultimately leads to the surface. A value of 60 km was found[1]. Seismic focal depths at midocean ridges extend to 65 km, this limiting depth presumably marking the base of the lithosphere[2]. The most direct indication of the thickness of the lithosphere is the shear velocity distribution with depth. A reversal in shear velocity in the suboceanic mantle now seems to be uniquely established although the details of the velocity–depth curve are still uncertain. Presumably the high velocity lid to the low velocity zone coincides with the lithosphere and the base of the lithosphere is marked by a rapid decrease in shear velocity. This method has been used by several investigators and values ranging from 40 to 70 km have been reported. Unfortunately these determinations are subject to the well known lack of uniqueness of surface wave methods, especially when density and shear velocity are both allowed to vary.

In this article we use new and highly precise group velocity data to test models found by F. P. using a Monte Carlo procedure and reported in an earlier paper[3]. In the previous work randomly selected models were required to fit Love and Rayleigh wave phase velocities pertinent to oceanic paths, eigenperiod data, mass and moment of inertia of the Earth. In the new test, group velocities

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are calculated for each model and compared with the new group velocity values of H. K.[4] which are based on thirty sets of data for predominantly oceanic paths. These are more data than previously available, leading to good estimates of the errors. This is a stringent test because group velocity is associated with the derivative of phase velocity with respect to period and a slight difference in slope of phase velocity shows up more clearly in the group velocity curve.

The results for Rayleigh waves are shown in Fig. 1. H. K.'s experimental group velocities together with error indications ($\pm\sigma$) are shown with group velocities calculated for various models. Also shown are the early data of Ewing and F. P.[5]. The Haddon–Bullen model HB1 (ref. 6) fails to fit the data between 150 and 200 s. The Gutenberg–Bullen A model (ref. 7) fits the data somewhat better, but this model must be rejected because of its failure to fit the Love wave observations (not shown here). The well known models 8099 (ref. 8) and CIT 11A (ref. 9) do not fit the new Rayleigh wave group velocity data. All twenty-eight models of F. P. fit the Love wave group velocities but only seven fit the Rayleigh wave data within $\pm 2\sigma$. Two of these are shown in Fig. 1 (5·08, 9·71) together with two models which fail (6·21, 7·77).

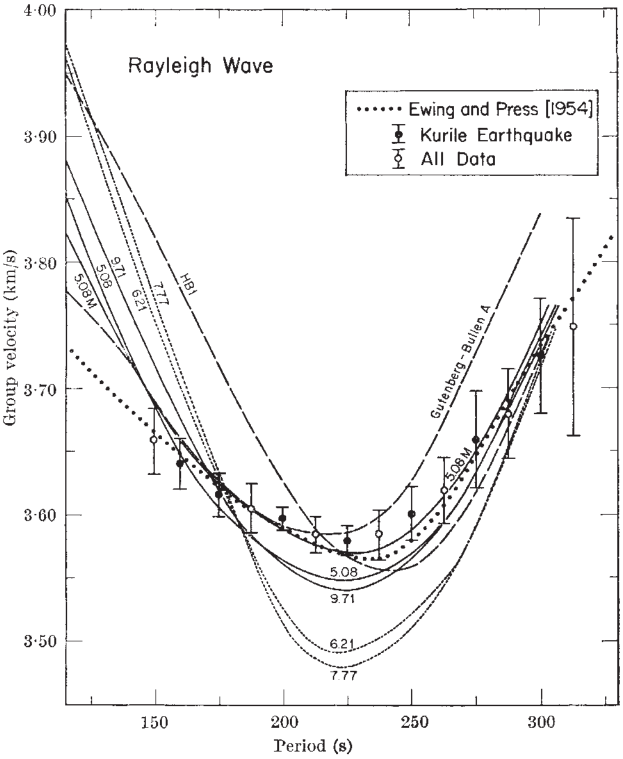

Fig. 1. Rayleigh wave group velocity data compared with several theoretical models; vertical bars indicate $\pm\sigma$.

The seven successful models are illustrated in Fig. 2. All show a large decrease in shear velocity beginning at 70 km. In the absence of an analytical method for establishing uniqueness with the data used, we interpret the narrow envelope formed by the models between 70 and 145 km as strong evidence that the data highly constrain the solutions. Numerical experiments were made in which the models were varied over smaller steps than with the Monte Carlo solutions. What seems to be required to find solutions which fit the group velocity data to $\pm 1\sigma$ is an almost abrupt velocity drop at a depth of 70 km as shown by model 5·08 M in Fig. 3. The fit of this model to the data is shown in Fig. 1. From these results we conclude that the base of the lithosphere is at a depth not much different from 70 km.

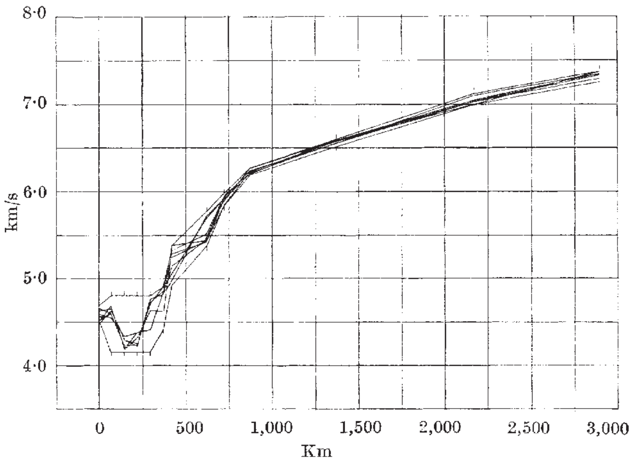

Fig. 2. Shear velocity distributions in the Earth's mantle which fit new group velocity data.

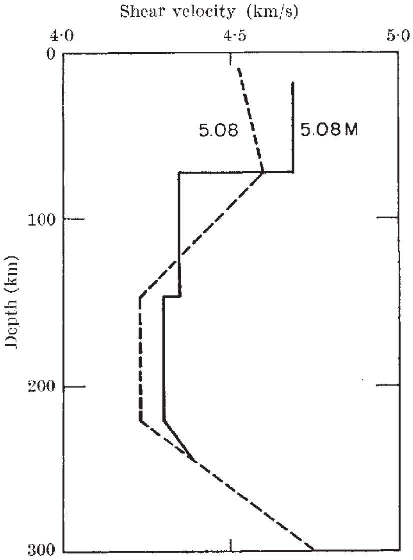

Fig. 3. Modification of model 5·08 to 5·08 M to obtain better fit to group velocity data.

Although several previous investigators (see ref. 10, for example) found similar results, we believe that our procedures remove the uncertainties which accompany surface wave studies. This is based on the agreement between models in which density and shear velocity were randomly selected and subjected to tests against data of known precision.

The sharp decrease in rigidity near 70 km supports the notion that the lower boundary of the lithosphere is determined by the solidus.

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