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The structure of the oceanic lithosphere

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Sea-floor spreading requires that new ocean floor be generated at mid-ocean ridges and that along with the underlying oceanic crust it move laterally away from its site of generation. In so far as it is unlikely that the 5 km thick oceanic crust moves independently of the underlying upper mantle, the horizontal mass motion associated with spreading extends at least some way into the mantle. The lithosphere is the crust and that part of the upper mantle to which it is mechanically coupled; together they form the brittle and relatively 'strong' outermost part of the Earth; velocity gradients within the lithosphere are negligible.

The thickness of the lithosphere is thermally controlled; near the ridge axis where an ascending flow from the mantle is required to feed the lateral horizontal flows observed at the surface, the geotherms are high and little more than the oceanic crust is cool enough to have rigid, brittle properties; as material moves away from the ridge progressively greater depths are affected by conductive cooling to the surface, and a steadily thickening cold thermal boundary layer develops. At low pressures, the mechanical properties of silicate materials are strongly temperature dependent and the cold boundary layer forms the brittle lithosphere which thickens away from the ridge. The lower boundary of the lithosphere is ill-defined and gradational but has an average depth of 100 to 150 km corresponding to the seismic low velocity zone.

The theory of plate tectonics has shown that the lithosphere is laterally discontinuous, in the sense that it is broken into a series of plates which are continually in motion with respect to each other; although they may have horizontal dimensions of thousands of kilometres and are relatively very thin, the plates appear to be almost unaffected by internal deformation.

These observations allow important constraints to be placed on the dynamics of plate motion. Various ideal mechanical models are outlined: (1) a frictionless bearing beneath the plates, and plates (*a*) pushed from ridges (*b*), pulled by the material descending at trenches; (2) a frictionless bearing beneath plates which slide off ridge flanks under body forces; (3) plates carried passively by the uniform traction of a subjacent horizontal flow. To some extent these models are characterized by different states of stress within the lithosphere which may be assessed from seismic observations and may be expected to give somewhat different topographic expressions.