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Sclater J G & Francheteau J. Implications of terrestrial heat flow observations on current tectonic and geochemical models of the crust and upper mantle of the Earth. *Geophys. J. Roy. Astron. Soc.* 20:509-42, 1970.
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The heat flow through both the continents and oceans decreases with age, though at a different rate, to a roughly constant value. These observations are compatible with the theory of plate tectonics. A single model of the oceanic lithosphere accounts for the decrease in heat flow and the subsidence of the ocean crust with increasing age. [The *SCI*® indicates that this paper has been cited in more than 455 publications.]

Terrestrial Heat Flow and Plate Tectonics

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Scripps Institution of Oceanography (SIO) was an exciting place to be in the late 1960s, with research time available for those willing to go to sea. We were both more than willing to go join the ships in exotic ports, to participate in a program of worldwide measurements. When not taking measurements, we spent the long days at sea trying to make sense of them. John Sclater had been a graduate student at Cambridge in 1964 when J. Tuzo Wilson first presented the basic concept of plate tectonics.[1]

However, the theory was controversial and, initially, we did not see how to apply it. In the fall of 1967, Dan P. McKenzie and Bob L. Parker, who were both at SIO, quantified the concept.[2] Immediately, we realized how to tackle our observations. No one had systematically analyzed the heat-flow data from a plate tectonic framework. On the contrary, opponents had used the heat-flow data to raise two objections to this theory. They argued, first, that the equality between the oceanic and continental means was difficult to reconcile with the concept of moving plates and, second, that no one had constructed a self-consistent model that could explain both the subsidence of the ocean floor and the decrease in heat flow with age.

Using a technique initially applied by two Russian scientists,[3] and pointed out to us by Victor Vacquier, we showed that the important factor in the heat flow was not the equality of the means but the decrease with age, shown by both the oceanic and continental values. Further, we found that the oceanic values decreased away from a spreading center, as predicted by the theory of plate tectonics.[4] Ignoring the lowermost values, most of which occurred near the spreading centers, we found that this decrease lay close to that predicted by a model that also accounted for the subsidence of the ocean floor.

We believe that our paper has been widely cited because we showed that (a) the equality of the mean heat flows was not a significant physical parameter, (b) the heat flow through both continents and oceans was compatible with plate tectonics, and (c) a single model explained both the subsidence of the ocean floor and the decrease of heat flow with age. Later, Clive R.B. Lister, of the University of Washington, demonstrated the existence of hydrothermal circulation in the porous basalt near the ridge axis, which justified our removing the low values from the heat flow analysis.[5]

Plate tectonics originated as a kinematic explanation of how plates moved. Our analysis added a dynamic component by showing that the plates were really the rigid thermal boundary layer on top of a convecting upper mantle. Further work showed that the creation of this layer was the dominant way in which the Earth loses heat.[6] This realization has led to a reevaluation of the approach Lord Kelvin took to determining the age of the Earth. The conventional wisdom is that he was wrong by two orders of magnitude because he ignored radioactivity, which had not yet been discovered. This is not correct. His mistake was to ignore the possible effects of heat loss by convection, about which he should have been aware. However, even though he was off by two orders of magnitude for the age of the oldest continents, Kelvin's approach, and his insistence that the age was finite and measurable, forms the basis of all current geophysical fluid dynamic models of the Earth.[7]

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