than sufficient heat would be generated in a mantle having a uniform potassium content equivalent to that of stony meteorites[4]. In either case, however, we have the paradox that if the mantle under the continents is similar to that under the ocean, then the heat flow from the continents should be much higher than the observed value because of the presence of highly radioactive rocks in the outer parts of the continental crust.

A heat flow of $1 \cdot 2 \times 10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$ through the ocean floor should noticeably heat the bottom-water masses as they flow northward from the Antarctic. With a velocity of northward flow of the order of $0 \cdot 1$ cm. per sec., as suggested by Sverdrup, Johnson and Fleming[5], the temperature of a layer of bottom water 1 km. thick would increase by about one-tenth of a degree centigrade on its journey from the region of sinking in the Antarctic to the tropics. This amount of heating would be largely masked by mixing with high-temperature water from above. But with the much smaller velocity of northward flow suggested by some recent workers, there should be a much larger increase in the bottom-water temperature between the Antarctic and low latitudes. Such an increase is not observed. The possibility exists, therefore, that our measurements are not representative of the heat flow through the sea floor. Obviously many more measurements must be taken before reliable generalizations can be made.

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[1] Bullard, E. C., *Nature*, **156**, 35 (1945).
[2] Petterson, H., *Nature*, **164**, 468 (1949).
[3] Jeffreys, H., "The Earth", 85, 2nd edit. (1924).
[4] Birch, F., *J. Geophys. Research*, **56**, 107 (1951).
[5] Sverdrup, Johnson and Fleming, "The Oceans", 754 (1946).

THE preceding communication by Revelle and Maxwell gives a result which is completely unexpected, and demonstrates again how little we know of submarine geology. Their observations do, I believe, demonstrate that the heat flow is roughly the same under the oceans and continents. It seems most unlikely that this is a temporary condition dependent on recent large changes in the temperature of the bottom water, for this is largely determined by the existence of ice in the Arctic and Antarctic. The ice cannot have melted since the last ice age, because the water from it would drown the greater part of the continents. It seems almost certain that the heat found by Revelle and Maxwell must be generated by radioactivity in the rocks beneath the oceans, and therefore that the total amount of radioactivity beneath unit area of continent and ocean is the same when summed down to a depth of a few hundred kilometres (heat generated deeper down has not had time to escape). This would be very surprising if the continents were formed from a primitive sialic layer not present under the oceans, and are underlain by material which is the same under continents and oceans. It would, however, be natural if the continents are continuously expanding by a process of differentiation in which radioactive material is concentrated vertically[1]. The rocks beneath the oceans would then have the same total amount of radioactivity as those beneath the continents, but spread through a greater range of depth; this would give the same heat flow as beneath the continents, but higher temperatures at depth.

As is pointed out by Revelle and Maxwell, some upward concentration is necessary to avoid melting under the oceans. Calculation suggests that if the radioactivity were spread through a depth of 150 km., no impossibly high temperatures would be produced. A possible interpretation of the results therefore appears to be that when the earth solidified most of the radioactivity was concentrated in the upper 150 km. of the mantle; under the oceans this distribution still exists, but under the continents a further concentration has occurred into the top 10 or 20 km. On this view it would be expected that the oceanic ultra-basic rocks would contain more radioactive material than the continental ones. There are few reliable measurements; but those that do exist do not show such a difference. This matter should be further investigated.

Other explanations can be suggested. It might, for example, be supposed that at some not too remote time a convection current rose under the Pacific and brought hot material near the surface, or that the horizontal limb of a convection current had transported material from beneath the continents to the central Pacific. Such suggestions are pure speculation, and there is no other evidence in their favour.

The difficulties may be connected with that of reconciling the oceanic seismic and gravity results. The gravity results suggest that the material beneath the Mohorovičić discontinuity may not be quite the same beneath the continents and oceans in spite of the close agreement in seismic velocities. Some discussion of these matters is given in a book[2] to be published shortly.

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[1] Wilson, J. T., *Trans. Roy. Soc. Canad.*, **43**, 157 (1949).
[2] Bullard, E. C., in "The Solar System", **2**, chap. 3, edit. by G. P. Kuiper (Chicago Univ. Press).

Use of a Gamma-Ray Pinhole Camera for *in vivo* Studies

THE pinhole camera method of taking gamma-radioautographs, though it has been described in the literature[1], has had very little use because of the long exposure times which are necessary even when the most sensitive radiographic films are used. An intensifying screen for use with the pinhole camera has now been developed which has made it possible to reduce the exposure time considerably. The screen consists of a large, flat crystal of thallium-activated sodium iodide. The gamma-rays produce scintillations in the crystal which in turn affect the photographic plate. This method has made it possible to take an *in vivo* gamma-ray pinhole radioautograph of a tumour containing 20 millicuries of iodine-131.

A drawing of the pinhole camera and intensifying screen is shown in Fig. 1. A gamma-ray from the object being photographed goes through the pinhole and travels in a straight line until it enters the sodium iodide crystal, where it may produce a Compton or photoelectric recoil. The recoil electron travels about a millimetre or less in the crystal. The light