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"Radioactivity and Continental Drift." By Professor Arthur Holmes, University of Durham.

The hypsometric curve was interpreted by Wegener to indicate the existence of two dominant kinds of materials in the earth's crust, *sial* corresponding to the lighter continental areas, and *sima* to the denser oceanic floors. This view has now been confirmed by the results of a study of surface seismic waves made by Hiller. The properties of the sima of the Pacific floor correspond to those of gabbro. The effect of compression on gabbro would be, not to produce mountains, but to transform the material into the high-pressure facies, eclogite. Such change of density and the simultaneous action of isostasy would lead to subsidence of the compressed belt and therefore to the formation of oceanic deeps. Applying the principle of isostasy to successive pairs of contrasted columns of the crust, it is easily shown that the average thickness of the sial of the continents should be about 30 km. or a little over. This conclusion agrees exactly with the results of recent work by Jeffreys on near earthquakes. These reveal the existence of an *upper layer* 10 km. thick (identified with granitic rocks) ; an *intermediate layer* 20 km. thick (supposed by Jeffreys to be tachylyte, but identified by Holmes with diorite and quartz-diorite on petrological and thermal grounds), and finally a *lower layer* or substratum which may be eclogite or peridotite or both. The continents are thus to be regarded as thin slabs of sial having a range in composition from granite to diorite, averaging 30 km. thick by about 3,000 km. across, and embedded in and underlain by material which on any interpretation is definitely much more dense than sial.

Thus, for sound physical reasons it becomes as impossible to " sink " a continent as it would be to sink an iceberg floating in the sea. We know that the sites of considerable areas of the Atlantic and Indian oceans were formerly occupied by continental masses, and since these ancient lands are no longer there we are driven to believe that their material has been moved away sideways. Evidence of lateral movement is also forthcoming from tear faults ; overthrust structures of the Alpine type ; the geological history of geosynclines ; the echelon structures of the Asiatic island festoons ; and perhaps most convincingly of all by the opening of the Urals geosyncline at the same geological moment as that which saw the compression of the Caledonian mountains of Britain and Scandinavia. Moving the continental regions back in the directions indicated by the evidence leads to a Permo-Carboniferous reconstruction similar to that made familiar by Wegener's diagrams, a reconstruction which is quite independently called for on palaeo-climatic grounds. Wegener's deduction that the equator of the time ran through the coalfield belt from North America to China is supported by the distribution of Permo-Carboniferous laterites and bauxites. It is concluded that there is now convincing evidence pointing to the former occurrence of continental drift on a scale of the same order as that advocated by Wegener.

Many geologists have hesitated to accept this straightforward and consistent reading of the rocks, because so far it has not been found possible to discover any gravitational force adequate to move the continental slabs in the required directions outwards from Africa towards the Pacific. The dominant forces available tend to set up (*a*) a westerly drift (due to tidal action), and (*b*) a drift from the poles towards the equator (due to the departure of a polar section through the earth from a circle). Jeffreys has recently shown that, given no strength in the substratum, the present viscosity which resists the movement is such that it would take about 3,000 million years for the whole crust to become symmetrical about the equator.

The earth's igneous history suggests that the average viscosity in the past has often been far lower than the present value; whence it follows that there has been time enough for these gravitational forces to have achieved their full effects. Since our actual geography is totally different from the picture thus visualized, we have again an indication that some other agency must have been at work to move the continents into the places they now occupy.

Admitting that the continents have drifted, there seems no escape from the deduction that slow but overwhelmingly powerful currents must have been generated in the underworld at various times in the earth's history. In Joly's hypothesis movements due to expansion and contraction are taken fully into consideration, but the only lateral movements considered are those due to tidal action leading to a westerly lag of the whole outer crust. There remains to be considered a happy suggestion which we owe to A. J. Bull, namely that convection currents may be set up in the lower layer as a result of differential heating by radioactivity. In place of the mobile basaltic magma of Joly, one imagines a highly viscous sima heated unequally down to very great depths. A sheet-like upward current would develop beneath the region of greatest heat output. In turning over at or near the base of the sial it would exercise a powerful drag on the undersurface in two opposed directions, thus leading to the formation of a geosyncline. The return downward current would be naturally looked for just beyond the continental edges. A continental mass would be enabled to move forward by stoping of the heavy ocean floor immediately in front. As this proceeded, mountain building would set in, and ultimately the direction of the currents would be reversed. Convection currents which themselves move their boundaries and the sources of much of the heat responsible for their existence can clearly lead to periodic alternations of heating and cooling in any one region. The particular mechanism advocated by Joly for bringing about alternate accumulation and discharge of heat appears to be unsatisfactory by itself because (*a*) it would lead to abnormal heating of ocean water (this follows if there is no light layer over the Pacific floor); (*b*) it does not explain the great amplitude of movement implied in Alpine structures; (*c*) it is inconsistent with the simultaneous occurrence of tension in the Urals with compression of the Caledonian mountains; (*d*) it does not account for the apparent drift of continental masses radially outwards towards the Pacific and the Tethys in both the northern and the southern hemispheres; (*e*) it has not yet been stated in terms satisfactory to mathematical physicists. It is thought that all these difficulties may be avoided by a development of the conception of large-scale convection currents in stiff material from which the more mobile portions are squeezed out as magmas.