EARTH'S MANTLE

New Peridotite Layer?

from our Geomagnetism Correspondent

ALTHOUGH the correspondence between mid-oceanic ridges and continental rift valleys may not be as close as is often assumed, the rift valley comes to mind when the landward extension of the oceanic ridge system is considered. The case for a genetic connexion between oceanic ridges and alpine complexes, on the other hand, is less clear, but is beginning to be heard more and more. The latest proponents of this idea are Bonatti *et al.* (*Earth Planet. Sci. Lett.*, **9**, 247; 1970) who back their arguments with sound petrological and geochemical data from samples dredged from the equatorial mid-Atlantic Ridge. To be more specific, most of the samples originated in the region between 2° N and 2° S where the ridge is intersected by major fractures such as the Chain, the Romanche and the St Paul—in other words, where thick crustal sections are exposed and thus where normally inaccessible deep-seated material can readily be recovered.

What emerges from the petrological analysis of these samples—to take the Romanche fracture zone as a case in point—is an approximate stratigraphy for the mid-Atlantic Ridge, at least in this particular locality. Basalt, up to 2 km thick, grades downwards into gabbro and metamorphic rocks which overlie peridotites. This profile is remarkably similar to those of the classical alpine complexes—a similarity which is all the more striking because it is not customary to speak of oceanic ridges and alpine complexes in the same breath.

That this stratigraphic similarity is not merely an unfortunate coincidence is supported by the strontium geochemistry of the dredged samples. For example, whereas the basalts and gabbros have low $^{87}Sr/^{86}Sr$ ratios within the range previously obtained for oceanic basalts, the ultramafic rocks have ratios between 0.706 and 0.723, outside the normal basalt–gabbro range. This is also true for alpine peridotites but not, for example, for peridotite inclusions in basalt nor for peridotites from stratiform sheet complexes. It was the high ratios in alpine ultramafics which some years ago led Strueber and Murthy (*Geochim. Cosmochim. Acta*, **30**, 1243; 1966) to the conclusion that alpine peridotites are residual, having been depleted in lithophile elements at some early stage in their history. And as a result of their own $^{87}Sr/^{86}Sr$ measurements, Bonatti *et al.* draw a precisely similar conclusion for the mid-Atlantic Ridge peridotites.

It would seem to follow from this that the mid-Atlantic Ridge basalts and gabbros are genetically unrelated to the peridotites which they overlie—which means to say that the peridotites are neither the parent material for the basalts nor the residual product after their extraction. What, then, is the origin of the oceanic peridotites? Bonatti *et al.* suggest that they must have been emplaced as solid intrusions from below, which, in turn, must mean that alpine-type peridotite is a common constituent of the oceanic upper mantle, possibly as a continuous layer immediately below the crust. The course of oceanic basalt would then be the mantle below the alpine-type layer.

Assuming that this layer really exists, Bonatti *et al.* go on to speculate that the alpine-type peridotite was left by the differentiation of a continental sialic crust "which had given rise to the predrift continental block subsequently split by the opening of the Atlantic rift". It may be legitimately objected, of course, that the continued existence of such a layer would be unlikely in a region of mantle convection. To this, Bonatti *et al.* bluntly admit that they have no answer. But in support of their hypothesis they point to the apparent lack of peridotite in fracture zones associated with the East Pacific Rise. According to continental drift reconstructions, the Pacific is relatively a much older ocean in which a sialic crust probably never existed and thus in which a residual alpine-type peridotite layer would never have developed. Speculation apart, however, the raw data obtained by Bonatti *et al.* may be taken to support the view that continental alpine massifs are "rinds" of ancient oceanic crust carried to the edge of the continent by seafloor spreading, incorporated into a geosyncline and later uplifted.

Measuring Sea Waves by Radio

A NEW technique to help oceanographers measure sea waves by radio signals is suggested by K. Hasselman in next Monday's *Nature Physical Science* (**229**, 16; 1971). Previously, only seawaves of a few metres in length could be surveyed satisfactorily by radio signals, but Hasselman has discovered a method applicable to longer waves.

When electromagnetic waves are transmitted nearly horizontally over the sea, the water waves interfere with them to produce backscatter which is characteristic of the water wave spectrum. The salient part of the backscatter is caused by the diffraction grating effect of those wave components with precisely half the length of the electromagnetic waves, travelling in the same or opposite direction. (Such components are always present because the sea wave spectrum is continuous.) The resulting signal has a highly tuned Doppler shift of order 10^{-1} Hz, equal to the frequency of the water waves of said length, which is closely defined by gravity. The strength of the signal, suitably calibrated, is a measure of the sea wave spectrum, which can be scanned by varying the transmitted electromagnetic frequency. These facts, first shown by D. D. Crombie of New Zealand (*Nature*, **175**; 681; 1955), have been verified by others, and were used to explain a case of fluctuating television reception near Plymouth. Recently, J. F. Ward (*Nature*, **223**, 1325; 1969) has developed a technique for measuring the backscatter from small areas of ocean at distances of thousands of kilometres with gated signals propagated by the ionosphere.

In principle, this sounds like the answer to a wave-oceanographer's prayer—a land based method of continuously surveying the ocean waves, far more convenient and productive than the usual practice of sending men and instruments to be tossed about by the waves themselves. But the drawback has been that reasonably directional radio beams (which are obviously needed) can be produced only at high frequencies with wavelengths of a few metres, whereas the most important ocean waves have typical lengths of many tens of metres.

Hasselman has now suggested a new way of looking at the backscatter from the longer waves. Besides the highly tuned lines in the Doppler return (and some weaker lines of minor importance) there is also a continuous background spectrum, which shows some structure but whose origin had not yet been explained. Hasselman claims that this background is in fact a fairly direct image of the total sea wave spectrum. His calculations involve second order interaction theory. Although the principal lines may be explained by first order theory in which two waves interact when their wave numbers satisfy certain sum conditions, the second order theory involves triads of wave numbers. The extra degree of freedom causes the whole continuum of sea waves to contribute to the backscatter; for any given sea wave number, a third can be found to balance the sum with the radio wave number. By use of a very reasonable approximation, which appropriately requires the radio wavelength to be short, the spectrum of the backscatter is expressed as the product of an electromagnetic transmission factor, the spectral amplitude of the first order line, the sea wave spectrum, and coupling factor calculable from hydrodynamic theory. The transmission factor can be eliminated by dividing by the first order line, and Hasselman obtains the intriguing result that the ratio of two parts of the same radio signal is a direct measure of the spectral amplitude of sea waves in metres.