EARTHQUAKES

Phase Changes

from our Geomagnetism Correspondent

LATE last year, Barton *et al.* (*Nature*, **234**, 293 ; 1971) drew attention to the possibility that some earthquakes may be the result of phase transitions at depth. The idea was certainly not new; but it has never gained much support, partly because it has not been easy to understand how a transition in the Earth's mantle could be rapid enough to produce the required shock.

As Barton and his colleagues pointed out, however, explosive phase transitions on a laboratory scale have been known to chemists since at least 1908, when Weston (*Chem. News*, **98**, 27 ; 1908) reported on the crystallization of sulphite from a supersaturated aqueous solution. More recent examples include the crystallization of nickel and bismuth from supercooled melts, the polymorphic transitions of antimony, arsenic, iron (austenite–martensite) and lead azide (β–α), and the polymerization of maleic anhydride.

Obviously, these particular reactions are not likely to take place in the Earth's mantle; but Barton *et al.* were simply pointing out that detonative phase transformations are not unknown and thus should not automatically be excluded as earthquake mechanisms. This is particularly relevant to deep earthquakes, for it is not entirely clear that under the conditions of temperature and pressure which obtain at, say, 700 km depth the conventional explanation in terms of shear phenomena is applicable.

Quite independently, Ringwood (*Earth Planet. Sci. Lett.*, **14**, 233 ; 1972) has now reconsidered the question of rapid phase transitions in the light of global tectonic processes. In the days when the mantle was regarded as static it was indeed difficult to visualize explosive phase transformations in the mantle because such transformations involve a change from a metastable to a stable state and it was not obvious how the required metastable state would arise in the first place.

In a dynamic mantle, on the other hand, there is no such problem. A sinking lithospheric slab may well be 1,000° C colder than the surrounding mantle, and this suggests that low pressure mantle minerals such as olivine may be carried down into the equilibrium field of the corresponding high pressure phases as long as the temperature of the descending slab does not exceed 700–800° C. In this way a metastable state may develop which, once induced to transform to the stable state, will do so in less than a second. In the mantle the phase change will take place in a volume of the order of cubic kilometres with the change spreading throughout the volume accompanied by a shock wave. Barton *et al.* consider that the transition is induced by the shock wave and adds energy to it. Thus although the energy density is small, the total energy released is extremely large.

As for the geochemical nature of the phase transitions, much depends on the temperature in the descending lithospheric slab. At a depth of 400 km, this could easily be lower than 600° C, in which case metastabilities could arise for the basalt–eclogite and eclogite–garnetite transitions in the depth range 100–300 km, and for the olivine–spinel–βMg_2SiO_4 and pyroxene–garnet transitions in the range 300–400 km. Ringwood considers that the temperature could easily be low enough to give metastability of βMg_2SiO_4 and garnet also. But even if these transitions do not proceed sufficiently rapidly to produce earthquakes themselves, it still does not follow that no earthquake will result. A phase change may develop slowly; but the resulting contraction in volume could produce large stresses in the surrounding material and thus lead to secondary earthquakes by stress-induced failure.

The second traditional objection to phase transformations as deep earthquake sources is that the relevant seismic radiation patterns are more consistent with shear failure than with explosion mechanisms. Ringwood now largely discounts the importance of this point on the grounds that nuclear explosions also generate seismic waves with large shear components. The explanation that nuclear explosions generate shear components by inducing failure in pre-existing stressed regions also applies to a sinking slab which, if descending under gravity, is stressed uniaxially.

The reason why a lithospheric slab descends under gravity in the first place is that the density of the slab is higher than that of the surrounding mantle—a density contrast which is produced largely by the presence of the two major phase transitions at 400 km and 650 km. The alternative view, that a nuclear explosion produces shear waves because of failure in the bomb-cavity wall, also applies to phase transformations by way of the secondary earthquake mechanism mentioned earlier.

INSTRUMENTS

Scanning Microscopy

from a Correspondent

THE pattern of the fifth annual scanning electron microscopy symposium, which was held in Chicago on April 25 and 26, was different from previous years in that there were no contributions dealing solely with the application of scanning microscopy. Instead, several interesting papers stressed the analytical capabilities of scanning electron microscopes (SEM) and clearly pointed the directions in which instrumentation development is proceeding.

Dr K. C. A. Smith (University of Cambridge), who opened the instrumentation session, while noting the high resolution capabilities of field emission

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Qβ Replicase as a "Repressor"

IN *Nature New Biology* next Wednesday (June 7), Weissman and his several associates report another step in their most impressive analysis of the replication of the single stranded RNA genome of coliphage Qβ. This is a direct sequel to the work of Kolakofsky and Weissman (*Nature New Biology*, **231**, 42; 1971) which showed that the Qβ replicase acted as a "repressor" of the translation of the Qβ coat protein cistron and hence of the succeeding replicase-subunit cistron. They found that Qβ replicase, by binding to Qβ plus strand RNA, blocks the binding of ribosomes to the initiation sequence at the start of the coat protein cistron and hence prevents the initiation of synthesis of further coat protein molecules without, however, stopping the completion of synthesis of coat protein molecules already started.

Pursuing this lead Weissman's group have now isolated the internal fragment of Qβ RNA to which the replicase binds by allowing replicase to bind to Qβ RNA molecules labelled for different extents from the 5′ end of the molecule and then digesting the complex with ribonucleases. This procedure, derived from that developed by Steitz to isolate RNA phage ribosome binding sites, depends on the replicase molecule protecting from nucleolytic attack that part of the Qβ RNA to which it is bound. Once isolated the protected fragment, which must include the replicase binding sequence, was then sequenced by conventional methods.

Weissman and his colleagues found that the fragment protected by the replicase includes the ribosome binding site of the coat protein cistron up to the initiation triplet AUG. It seems therefore that Qβ replicase acts as a "repressor" of gene expression by directly competing with ribosomes for the initiation site of the coat protein cistron. Moreover, the replicase probably binds at this position before it interacts with the 3′ end of the Qβ plus strand RNA which serves as template for the initiation of synthesis of the 5′ end of a complementary minus strand.