sive molehill of knowledge. What distinguishes this study is not only that the results are completely new and compelling in themselves but also that they have a healthy tendency to suggest more new problems than old ones solved. For the twenty years or so since kineticists began to admit that working out mechanistic crossword puzzles was not quite good enough, it has been fashionable to justify the most mundane rate measurements as a high-flown search for the real truth about potential-energy surfaces and the dynamics that takes place on them. For a long time this rang decidedly hollow; but with studies like the Harvard one the point is beginning to be made—one may indeed learn much about the topography of P-E surfaces for unstable systems which is not accessible by spectroscopy or other types of experimental probe.

One of the first messages to come through is almost a truism, though none the less worth stating: contrary to many preconceptions, there is no law that requires potential-energy surfaces to be any less individual, any more regular than the glorious vagaries of chemistry that they underlie.—From our Molecular Physics Correspondent.

PLATE TECTONICS

Finding Old Slabs

from our Geophysics Correspondent

WHEN a lithospheric plate, perhaps 50 km thick, starts its remarkable plunge into the Upper Mantle beneath an island arc, its identity gradually gets lost. It has been formed many million years before at a mid-ocean ridge by some process of fractionation, has travelled laterally as a sort of rigid boundary layer and now finds itself overridden by another plate and being transported downward at a dip of 40° to 50° into material which is several hundred degrees hotter. This process is occurring along about 40,000 km of plate boundary at the moment, and with a typical consumption velocity of 5 cm per year; 100 km^3 of plate is returned every year. If similar processes had persisted for all the 4.5×10^9 years of the Earth's life (there is little evidence either way), the whole of the oceanic plate of the world could have been created and returned tens of times. Is there any way of seeking out some of this material, the oldest of which has possibly seen service as a plate more than once?

The past few million years worth of plate still manifests itself by earthquake activity within it which persists down to a depth of no more than 700 km. Studies of the deepest earthquakes show that the slab at this depth is under compression from above within its plane, and it has been suggested that the slab, which after several million years is beginning to acquire the ambient temperature, is incapable of penetrating further into the mantle and may spread itself out like a carpet at this depth. Seismology seems the most likely way of finding this material, provided it has not been perfectly assimilated, but even though the slabs probably have a different chemical composition from the rest of the upper mantle because of their mode of formation, it is hard to imagine that the seismic velocity contrast amounts to more than 1 per cent at depth. Seismology is becoming increasingly capable of identifying heterogeneities, but the search for old slabs is likely to be arduous and the evidence is less than clear-cut in view of the other more pronounced heterogeneities already known to exist and overwrite the data.

Perhaps the most hopeful place to look for palaeoslabs is near recently inactive boundaries where extrapolation into the past strongly predicts that a region of consumption once existed. Seismicity still helps in some areas where, although the boundary is now no longer consuming, the deeper slab still apparently has not reached equilibrium. For instance, isolated pockets of deep seismicity in Burma, Hindu Kush and Romania seem to be testimony of busier times 20 million years ago when the whole southern edge of Eurasia was actively absorbing the Tethyan ocean. In 1954 a large earthquake 630 km below Spain in a historically aseismic zone was a singular reminder that seismicity is not an absolute term and some equilibrating processes in the Earth, arising from surface movements that ended tens of millions of years ago, must now be running very slowly. Is there any way, without waiting for a deep earthquake, that the palaeoslabs can be easily identified?

A report by McKenzie and Julian (*Bull. Geol. Soc. Amer.*, **82**, 3519; 1971) indicates a possibly powerful technique. The seismic velocity contrast between a fairly recently underthrust slab and the adjacent upper mantle can run as high at 5 to 10 per cent, particularly when the slab passes through the low-velocity zone 100–200 km beneath the Earth's surface. The slab, being colder than its surroundings, has the higher velocity. One of the most striking pieces of evidence in the emergence of plate tectonics was the demonstration by seismologists at the Lamont–Doherty Geological Observatory that elastic waves from deep earthquakes in the Tonga region that had travelled up the slab to stations in Tonga arrived 2 or 3 seconds earlier than waves that had travelled the same distance in the opposite direction.

McKenzie and Julian concern themselves with a slab which has no deep seismicity to it whatever and use travel times of elastic waves from a shallow earthquake on top of the slab to teleseismic stations to show an apparent distortion of seismic velocity. It has been proposed that the Pacific seafloor is either still under-riding the North American continent or has only recently ceased to do so. This activity would occur beneath the Oregon, Washington and North California coast, the slab being created by an ocean ridge that exists a few hundred kilometres off shore. There is some seismicity along the coast line, none is deep, there is no sign of a present trench off the coast line but some seismic reflexion is evidence for under-thrusting and recent volcanic activity in the Cascades region. Evidence is thus mildly in favour of a slab under the region.

The technique used is known as the "residual sphere" method. Seismic residuals, the difference between the observed and theoretical travel time for a ray between an earthquake and a seismic station, are plotted on a notational sphere surrounding the earthquake. The position on the sphere corresponds to the emergence angle of the ray to get to the station in question. A large earthquake in Puget Sound, Washington, is considered and shows a band of negative residuals dipping on the sphere in an easterly direction at about 50°. This implies that somewhere between source and the stations reporting negative residuals is a region of higher than average velocity. A slab beneath Washington is an obvious explanation, but it is desirable to establish that it is a unique explanation. This is done by considering the residual sphere of an earthquake several hundred kilometres away on the Queen Charlotte Islands fracture zone, beneath which a slab would not be expected. The band of negative residuals has disappeared, which is strong evidence for the existence of a high velocity slab beneath the Cascades.

It is presumably going to be possible to outline other defunct slabs. The whole of Tethys might still leave some signs in seismic velocity perturbations. A much longer shot would be the very old slab that disappeared when Siberia and Europe collided to form the Urals. Travel time anomalies seem to be about a factor of two or three above the random "noise" for currently descending slabs. Searching for older slabs may call for much more detailed work. It will probably also call for an inverse approach in which a station rather than an earthquake in the appropriate region is studied for anisotropy of travel time from distant events.