PERUVIAN EARTHQUAKE

Price of New Sea Floor

from our Geophysics Correspondent

THE earthquake in Peru in June may well have claimed more than 50,000 victims and the number could be much greater. The earthquake is thus comparable with the most catastrophic known—the Lisbon earthquake of 1775, which claimed about 50,000 lives, and the Kwanto earthquake of 1923, which killed 100,000. The epicentral region was about 300 miles north of Lima and the damage wrecked four cities, one, Chimbote, on the coast and three, Caraz, Yungay and Huaraz, about 75 miles inland. Several other villages in the same canyon as these three cities were also wrecked. Two mountain ranges, the Negra and Blanco ranges, rise up on each side of the canyon. The access roads have been destroyed and reaching the region by air has been made impossible by the flooding of the only airport in the region at Caraz. It seems likely that much of the damage was done by the rupturing of the walls of a dammed lake, Lake Llanganuco.

The magnitude of the event was recorded as 7·75 on the Richter scale, a figure which can only be an approximation because such a huge disturbance drives seismometers off scale practically all over the world. The figure is somewhat smaller than that for the San Francisco earthquake of 1906 and that in Alaska of 1964, but the damage, of course, is determined much more closely by the relative positions of epicentre and the centres of population. Thus an earthquake of comparable magnitude in the Aleutian islands in 1965 drew no attention at all because of its remoteness.

The cause of the circum-Pacific earthquakes is now fairly well understood. New sea floor is created along the East Pacific Rise, a mid-ocean ridge running from south of Australia to Mexico. More, in fact, than just sea floor appears to be created—the outer 50 to 100 km of the Earth, called the lithosphere or plate, is formed by solidification of molten regions along the rise and lateral transport away from the region of creation of new plate. The sources of energy for this process, while almost certainly convective, have not yielded to any simple approach to the problem. The East Pacific plate (in this case) moves eastwards at about 5 cm/yr until it encounters the leading edge of western South America, which is part of the South Atlantic plate. Just offshore, the plate is bent through 45° (the source of much seismic activity), underrides the Andes (this is probably the most destructive region) and continues to show sporadic activity down to several hundred kilometres along this dipping plane. The deep ocean trench just off the South American coast is undoubtedly a surface manifestation of the start of the downward plunge.

The sliding of one plate past another is a potentially dangerous process. The San Andreas fault in California is an example of such sliding along a vertical fault plane. The sliding occurs along the 45° dipping plane under South America and in many other regions round the Pacific. It seems that in many regions this relative motion of a few centimetres a year is accommodated by some sort of lubrication (ground water has been suggested) or by repeated small earthquakes, but certain regions (well known in California but practically unmapped elsewhere) stick for periods of tens of years while the stresses build up. Strain energy can be stored in the vicinity of these locked faults until the relative displacements between two points far from the fault reaches ten metres, but then stresses exceed the elastic limit and a catastrophic breakdown occurs along the fault plane with the surrounding region jumping to its new unstrained position. A large number of smaller aftershocks usually occur as readjustment continues, and in Peru at least 100 aftershocks have been reported. It is likely that the width of the region of accumulated stress in this case was about 100 km parallel to the coast line and the length of the fault down the dip was between 20 and 50 km. The Chile earthquake of 1960, somewhat larger, appeared to have a width of about 1,000 km.

Does a huge earthquake in Peru cause other earthquakes, or does it release strain and reduce the chances of an earthquake elsewhere? As far as anyone can tell, the answer to both these questions is no. There has been some speculation that one earthquake may trigger another, but the evidence is slight beyond the region of local strain readjustment (perhaps 1,000 km).

Could such an event have been predicted or even controlled? This is a topic which is receiving growing attention in the United States where the problem in California is more severe than many are prepared to acknowledge. Research around the San Andreas fault is beginning to pinpoint the regions of large strain accumulation where the size of the future earthquake grows with every year that it is postponed. But although it is known that some regions have large amounts of potential energy stored in them, premonitory signs are very difficult to come by. There is some evidence of dramatic strain changes before earthquakes and, rather surprisingly, of very small magnetic fluctuations, but the science is a long way from being sufficiently well established to deliver credible warnings. On the control side, some very interesting developments are occurring with fluid injection experiments. These are in an early stage but seem to bear promise that regular lubrication of a fault would encourage more frequent small slippages. All this, of course, is cold comfort for the residents of South America and Japan where the faults are rarely accessible and there is certainly no money for even pilot experiments in fault lubrication.