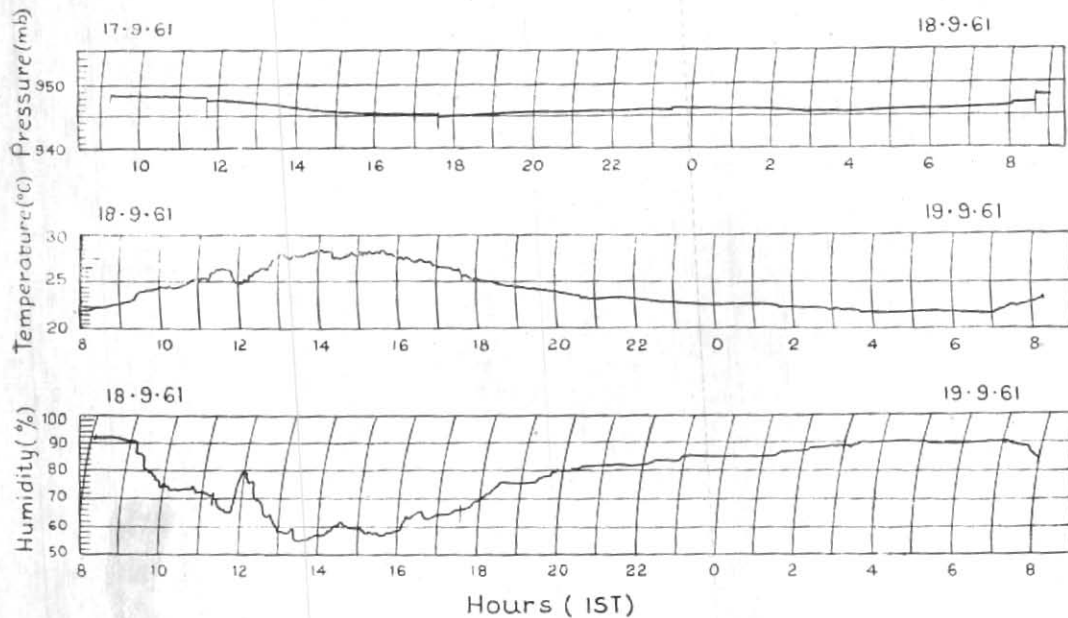Fig. 1

Hours (IST)

Fig. 2

540.341.4

PcS OR ScP PHASE AND THE DEPTH OF EARTHQUAKE FOCUS

Recently Caloi (1961) has pointed out that the recording of PcS (or ScP) waves is even more rare than that of ScS waves in the case of normal depth. The observation of such waves is very difficult also in the case of earthquakes at a higher depth (Gutenberg and Richter 1939). Therefore, it is evident that there is particular importance in the precise examples of PcS or ScP waves recorded at seismological observatories. Recently a conspicuous phase of the PcS or ScP type was recorded by the short period Benioff Seismograph ($T_0=1\cdot0$ s and $T_g=0\cdot18$ s) at Shillong on account of an earthquake in the Halmahera region on 8 October 1961. A copy of the record is reproduced in Fig. 1.

The epicentre and other particulars of the earthquake as given by the U.S.C.G.S. in their epicentre data cards are as follows—

Epc. $1°\cdot6$ N and $127°\cdot3$ E, the focal depth is about 102 km. The origin time was 23^h 41^m $32^s\cdot2$.

Richter (1958) has pointed out that the core reflections are quite strong when $\triangle$ ranges from 30° to 40° and the seismogram has a very complicated appearance; ScP is sometimes taken for S, sometimes (because

of its prevailing short periods) as the beginning of a separate earthquake. An examination of the recorded trace in Fig. 1, at once reveals the characteristics pointed by Richter and the author is inclined to identify the phase as PcS or ScP.

The times obtained at Shillong is: 8 October 1961, PcS (or ScP) 23^h 54^m 47^s, $\triangle = 41°\cdot5$.

We shall now examine whether the travel time agrees with the times calculated by Jeffreys and Bullen (1948) and whether the depth indicated by U.S.C.G.S. agrees with the observed travel time. In the case of surface focus, the travel times for the PcS or ScP phases are identical and accordingly it is not possible to discriminate whether the recorded phase is PcS or ScP from the travel time data. But the travel time for these phases becomes different in the case of earthquakes having depth of focus and the phases could be differentiated whether the recorded phase is PcS or ScP without any reference to the vibration characteristics. In the case of PcS or ScP phases no ready made depth allowances are available in the J.B. tables. Jeffreys and Bullen has, however, pointed out that for core phases other than PKP, SKS, PcP and ScS the allowance for depth may be taken as equal to those for these phases at distances where $dt/d\triangle$ is the same. Thus if we want the time of PcS (or ScP) at $41°\cdot5$ for depth of $0\cdot01$ R we notice that $dt/d\triangle$ is $4^s\cdot0/1°$ which is
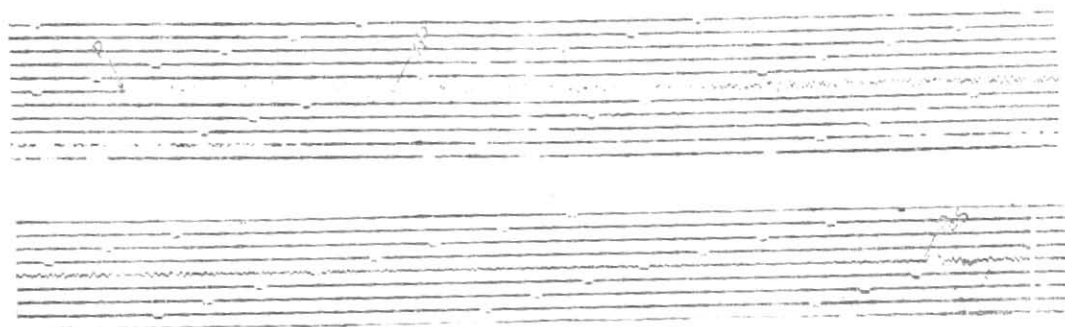

Fig. 1. Section of Shillong Vertical Benioff seismogram of 8 October 1961 (in two parts)
Time scale: 60 mm/min

matched by PcP at 60° and ScS at 25°. The depth allowance is then for PcS —13·1 sec and —23·1 sec for ScP. The travel time for PcS for depth of 0·01 R becomes (13^m 42^s·8)—13^s·1 = 13^m 29^s·7 and the travel time for ScP for same depth becomes (13^m 42^s·8)—23^s·1 = 13^m 19^s·7. But the observed travel time is 13^m 15^s.

Accordingly the identification of the phase as ScP appears more reasonable from the consideration of the travel time data. The error of —4^s·7 might be due to the uncertain factors like the depth, epicentre etc.

Alternatively if, the recorded phase is identified as PcS, the depth works out to be of the order of 0·03 R. In that case we should have pP phase at 47 sec after the P phase. On examination of the record (Fig. 1) it is noticed that there is a clear phase at 49 sec after P and the phase could be identified as deep focus pP phase. This at once suggests that the approximate depth of the earthquake is of the order of 0·03 R (=224 km) and the recorded phase is PcS and not ScP. No pP phase corresponding to depth of 0·01 R at 23 sec after P, however, appears to have been recorded.

It is concluded from the above study that in case of earthquake shocks having depth of focus, the recorded PcS or ScP phase is a good criterion to check the depth determination which is a very important parameter for the earthquake focii and there are very few methods with the help of which the depth parameter could be determined accurately.

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