Wave Velocities in the Outer Part of the Earth's Mantle

HITHERTO, wave velocities V in the earth's interior have been calculated from the travel times t of earthquake waves in shallow shocks computed as a function of the epicentral distances Δ. This procedure fails if at any depth the velocity V decreases with depth at a rate in excess of $dV/dr = V/r$, where r is distance from the centre. In this case a portion of the travel-time curve is formed by the arrival of diffracted waves; if these are misinterpreted as direct waves, incorrect velocities are found not only for the low-velocity layer, but also (with decreasing errors) for all deeper layers. Moreover, discontinuities may be inferred when none actually exists.

In 1914, in a different form, the following equation was developed by S. Mohorovičić[1]: $V = V^* r/R$, where R is radius of the earth, V is velocity at the depth $h = R - r$ of the focus, and V^* is apparent velocity $(d\Delta/dt)$ at the point of inflexion (distance Δ^*) of the travel-time curve for longitudinal (P) or transverse (S) waves in a given shock. Apparently it has not been realized that this equation can be used to calculate the velocities of the two waves at a depth corresponding with the focal depth. Neither the time of origin of the shock nor the distance Δ^* enters the calculations. The focal depth h of the shock must be known, and a sufficient number of reliable time observations at distance from about 500 km. less to 500 km. greater than Δ^* must be available for finding V^*.

About eighty earthquakes were found listed in the International Seismological Summary for which the necessary conditions for application of the method are fulfilled. Most of them occurred in the Japanese area between 1930 and 1940 at depths from 20 km. to 600 km. For years later than 1940 the Summary has not yet been issued. Data for a few shocks in the eastern and central Mediterranean (depths between 100 km. and 300 km.), in Roumania (150 ± km.) and in the Hindu Kush (250 ± km.) do not indicate any appreciable regional differences in velocity at the depths involved. Average velocities V (longitudinal) and v (transverse) in km./sec., and values of Poisson's ratio σ at the depths h in km. are as follows:

h	50	100	150	200	250	300	400	500	600
V	8·0	$\leqslant$7·8	$\leqslant$7·9	8·1	8·3	8·5	9·0	9·6	10·2
v	4·45	$\leqslant$4·4	$\leqslant$4·35	$\leqslant$4·4	4·45	4·6	4·95	5·3	5·65
σ	0·26	0·27	0·27	0·28	0·29	0·29	0·29	0·29	0·29

These new values agree well with those which had been found by application of the older method to times of travel of shallow shocks; but they bring out much more prominently the low-velocity layer at depths near 100 km. This had been indicated previously by observations of amplitudes, especially 'shadow zones'[2], at epicentral distances of about 1,000 km. The new velocity data do not indicate any discontinuity within the range of depth given above. A sudden increase in velocity at a depth of about 400 km. has been assumed by some to explain the so-called 20°-discontinuity in the travel-time curve. However, this discontinuity is a consequence of 'ray optics' produced by the low-velocity layer. The actual velocities in the low-velocity layer may be somewhat smaller than those given in the table, since the resulting decreases in V and v possibly exceed the critical rates of 0·13 and 0·07 km./sec. per 100 km. respectively. Local temperature or other relatively small differences at the depths involved may result in a decrease of velocity less than the critical rate in one area and in excess of it in another. Thus P or S or both may show 'shadow zones' of different extent (including zero) depending on the region, and even noticeable differences in time of travel. This could explain the appreciable local differences in the observed amplitudes of P and S in recorded shocks of a given magnitude at epicentral distances between 500 km. and 2,000 km., even when the velocities at the depths involved are practically the same in all such regions.

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[1] Mohorovičić, S., *Gerlands Beitr. z. Geophys.*, **13**, 225 (1914).
[2] Gutenberg, B., *Bull. Seis. Soc. Amer.*, **38**, 121 (1948).

Band Spectrum of AsH

IN a letter to *Nature*, Kimball and Bates[1] stated that they have succeeded in obtaining the band spectrum of AsH. The spectrum was excited in a carbon arc run in an atmosphere of hydrogen. The lower electrode formed the cathode of the arc and contained the arsenic. Two bands with origins at 32,380·2 cm.$^{-1}$ and 31,639·9 cm.$^{-1}$ were observed and attributed to AsH. The lines of the band at 32,380·2 cm.$^{-1}$ are represented by the formula

$$\gamma = 32{,}380{\cdot}18 - 11{\cdot}186\,m - 4{\cdot}47\,m^2 + 0{\cdot}0485\,m^3 + 0{\cdot}01027\,m^4.$$

We have tried to photograph the bands mentioned by Kimball and Bates but without success, although a large range of excitation conditions has been used.

It seems probable that Kimball and Bates have been confused by the P and R branches of the $^2\Sigma - {}^2\Pi$ system of CH. Using the frequencies of the lines for the R_1 and R_2 branches of the (0,0) CH band, as listed by Heimer[2], a close fit of the alternate lines is obtained with the lines calculated from the formula given by Kimball and Bates. This is illustrated in the table for a number of lines.

COMPARISON OF THE AsH LINES WITH ALTERNATE CH LINES

R branch of AsH	R_2 branch of CH	P branch of AsH	R_1 branch of CH
32,364·6	32,366·4	32,386·9	32,388·5
340·5	340·6	384·4	384·2
308·5	307·6	373·0	377·1
269·6	268·4	352·9	355·7
224·9	224·6	324·6	325·7
175·8	177·2	289·1	289·1
124·0	126·6	247·3	247·5
071·3	073·7	200·6	201·4
019·9	019·3	150·5	152·1

The other AsH band mentioned by Kimball and Bates was probably confused with the P branches of the 0,0 band of CH and the Q branch of the 1,1 band. The 1,1 band of CH forms a Q head at the approximate frequency of the AsH head mentioned by Kimball and Bates.

Pearse and Gaydon[3] have directed attention to the fact that the band attributed to As_2 by Kimball and Bates is probably identical with the Q branches of the 0,0 CH band.