Lithology and seismic impedance at KTB - a first correlation

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Seismic investigations in the surroundings of the German Continental Deep Drilling Program (KTB) and seismic borehole experiments (vertical seismic profiling, VSP) are an important contribution towards unterstanding the structure of the continental crust in this area and provide detailed information on position and orientation of seismic reflectors with depth (e.g. KTB-Report 90-6b)

Stimulated by first results of the VSP-experiment carried out in the depth interval between 3000 - 6000 m and the discussion of a "bright-spot" reflector at 8000 m (LÜSCHEN et al., 1993) our paper presents a first correlation of data on the composition of the already drilled rocks and their seismic impedance in order to obtain additional information on the nature of observed seismic reflectors.

Using simple models for the elastic constants of compound solids (after VOIGT, REUSS and HILL; see SCHÖN, 1983 for review) we converted the mineralogical composition of cuttings (sample intervall 1-2 m) and their mean elastic properties to a theoretic impedance-log (Fig. 1.). These models exclusively describe effects of the mineralogical composition on P- and S-wave velocities and do not take into account the influence of varying foliation and fracture zones.

A remarkable result of our investigations is the excellent coincidence between calculated impedances and observed seismic reflectors in the VSP-experiment (Table 1., Fig. 2.), indicating that the changes in the mineralogical composition exert a powerful influence on the seismic impedance. Furthermore, changes in the lithology always result in a more pronouced variability of the P-wave - impedances compared to the S-wave impedances (Fig. 2.).

# reflector	1	2	3	4	5	6
depth interval	3100-3300m	3300-3600m	3800-4500m	4700-4900m	5200-5400m	5500-5700m

Table 1. Preliminary results derived from the VSP-experiment (3000 - 6000 m); depth intervals are given for zones with prominent P-wave reflection (oral communication, LÜSCHEN)

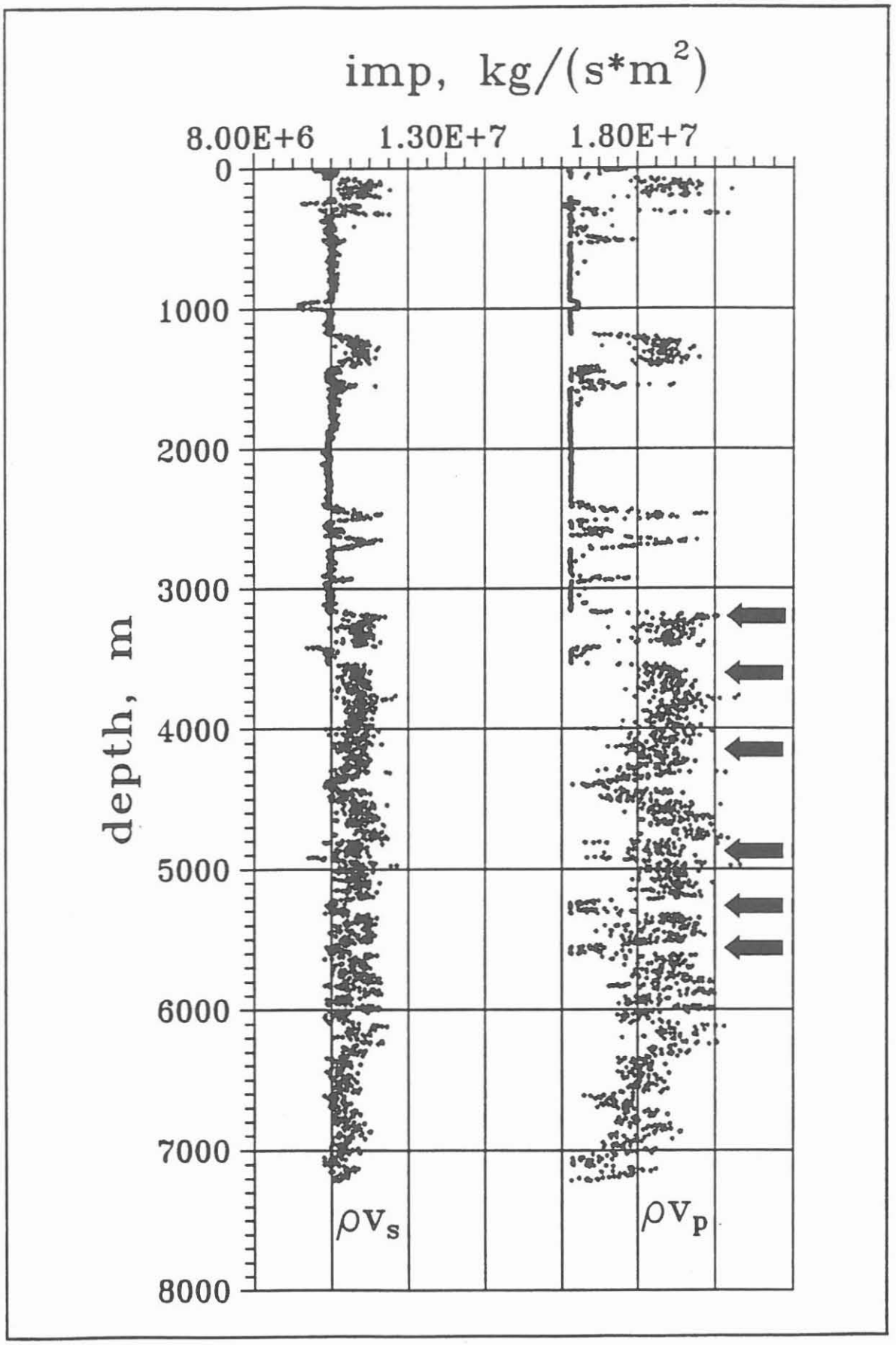

Figure 1. Calculated impedance-log in the KTB-Hauptbohrung; arrows mark horizons with prominent P-wave-reflection (see also Table 1.)

This fact is attributed to differences in the quartz content between gneisses (qtz approx. 50 wt.%) and amphibolites (qtz < 10 wt.%). In comparision to other rock forming minerals quartz possesses a rather small v_p/v_s ratio (approx. 1.5), with P-wave-velocities similar to plagioclase and muscovite and S-wave-velocities in the range of amphiboles (Fig. 3.). The transition between gneisses and amphibolites is, therefore, characterised by strong differences in the P-wave-velocities which are accompanied by only slight changes in S-wave-velocities. Thus the phenomen of suppressed S-wave reflectivity (LÜSCHEN et al., 1993) may be explained simply by changes in the lithology and does not require a fluid/gas interface within porous or fractured rocks.

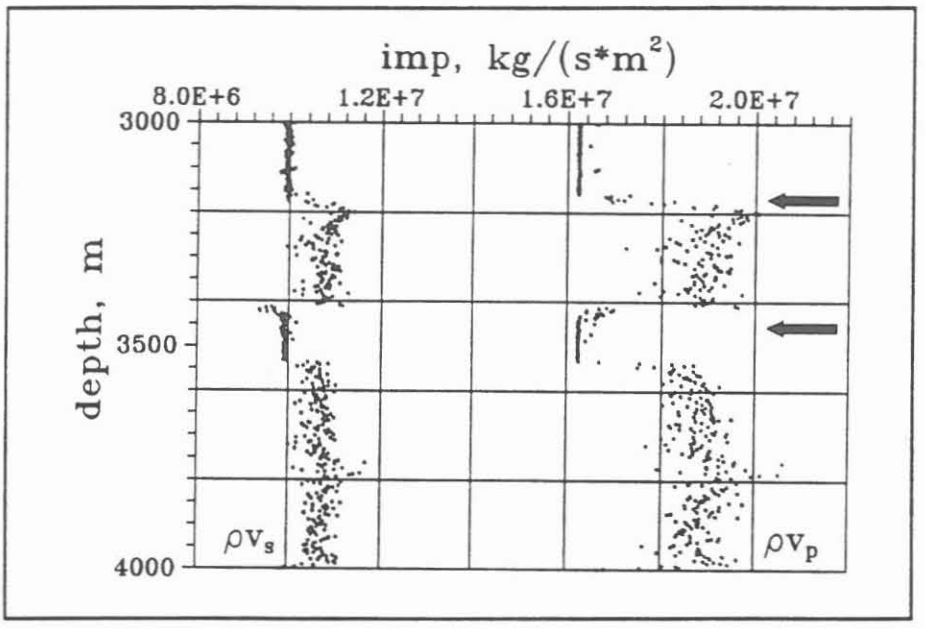

Figure 2. Small extract of the caculated impedance-log covering the depth interval 2000 - 3000 m; arrows mark P-wave reflectors (3200 and 3500 m) observed in the VSP-experiment

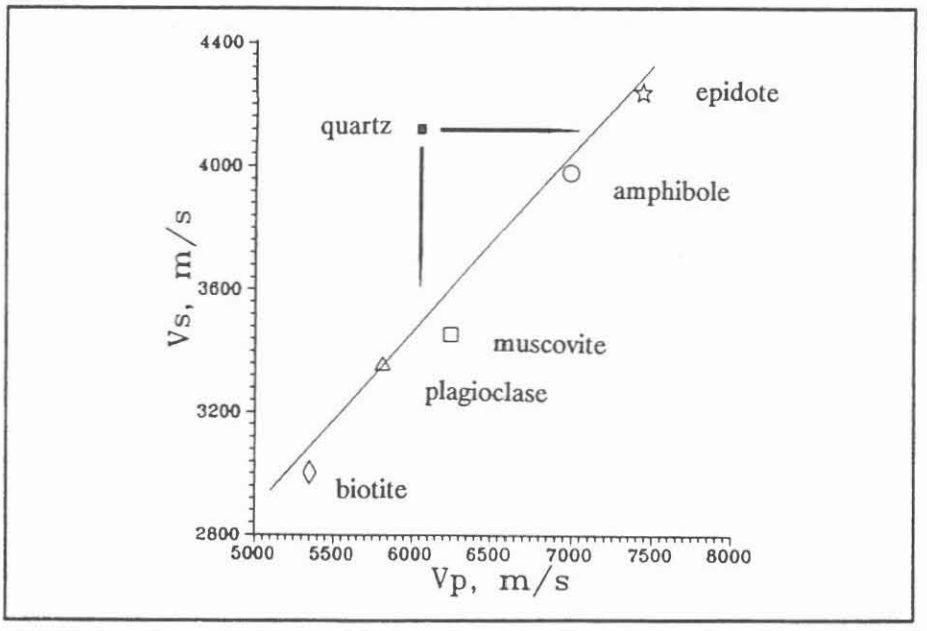

Figure 3. Compilation of P- and S-wave velocities of rock forming minerals in the KTB-Hauptbohrung

Literature

Lüschen, E., Sobolev , S., Werner, U., Söllner, W. Fuchs, K., Gurevich, B. & Hubral, P. (1993): Fluid reservoir (?) beneath the KTB drillbit indicated by seismic shear-wave observations.- Geophy. Res. Lett., in press.

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