INVESTIGATION OF RANDOM HETEROGENEITIES IN THE CRUST BY THE KTB

Xiao-Ping Li[1] *and Ru-Shan Wu*[2]
1) Geophysical Institute, University Karlsruhe, Hertzstr.16, 76187 Karlsruhe, Germany
2) Institute of Tectonics, University of California, Santa Cruz,CA 95064, USA

April 6, 1993

Introduction

Acoustic velocity logs (V_P and V_S) of the two deep-drilling boreholes in the KTB (German Continental Deep Drilling Program) -Oberpfalz in Bavaria have been analyzed to estimate the statistical properties of the crustal heterogeneities in this region.

Well-log statistics

The pilot borehole (VB) has an acoustic velocity log down to 4000 m, and the main borehole (HB) down to 6000 m. Both logs have a minimum sampling interval of 15.24 cm (6 inch). Figures 1 and 2 display the acoustic velocities of V_P and V_S for both deep holes.

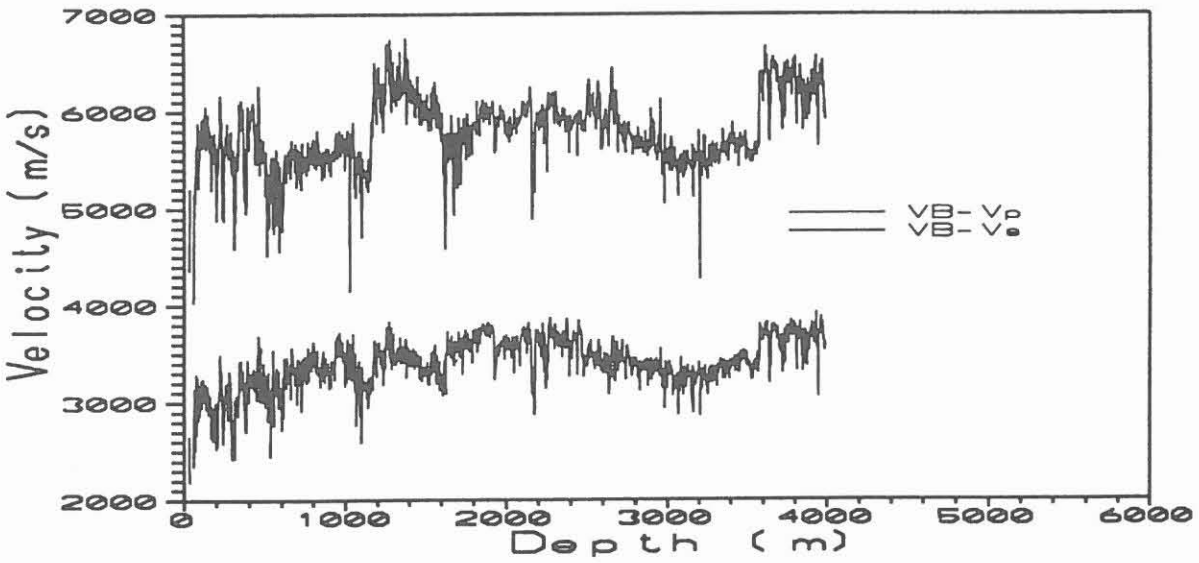

Figure 1: *Sonic-logs of pilot borehole (VB)*

A common feature of the four velocity logs is a general increasing trend of the velocity at increasing depth. This is expected on the basis of increasing consolidation of the crystalline rocks. We have

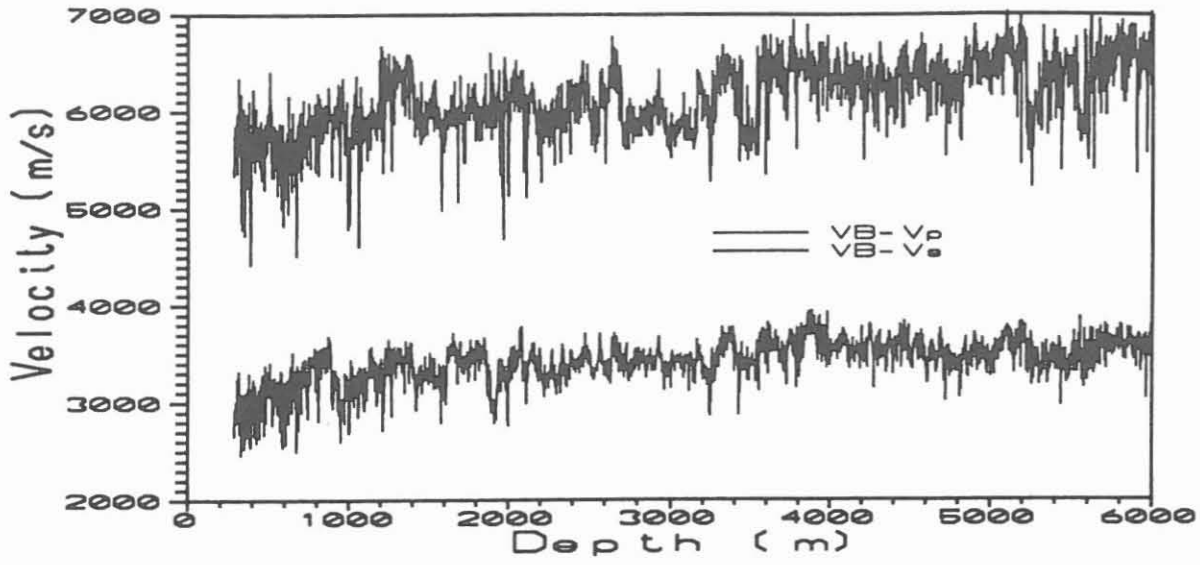

Figure 2: *Sonic-logs of main borehole (HB)*

first calculated the relative variance of the velocity using a Hamming-window averaging. The general trend of the relative variance also tends to decrease at increasing depth, implying a smoother medium deeper down. The autocorrelation function of the four velocity logs can be well described with an exponential form, whose correlation length is on the order of a few tens of meters to some hundred meters. It can be interpreted physically as the scale of the heterogeneity. A typical case of analysis given in figure 3 shows that the exponential correlation function seems to be composed of the sum of a few exponential functions with slightly different correlation lengths.

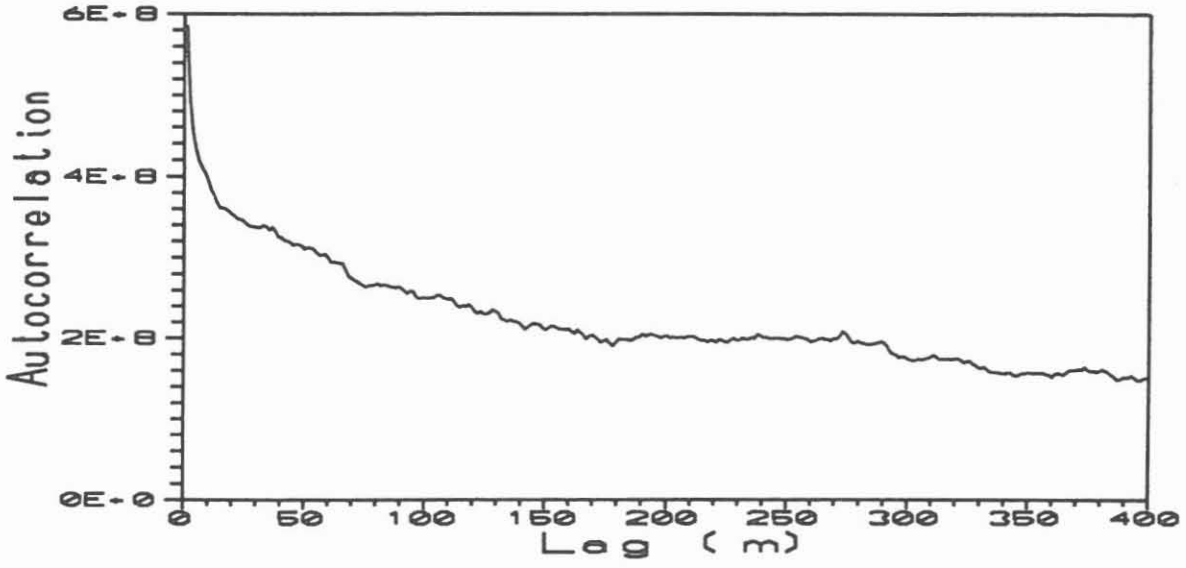

Figure 3: *Autocorrelation function of HB-V_P*

Power-spectrum estimation

After subtracting the average velocities from the records, some techniques of power-spectrum estimation are applied to the random velocity fluctuations. The 1D power-spectra of heterogeneities

seen in these two holes both show two-component heterogeneity characteristics. Figure 4 shows a typical case for V_P of the main borehole. The low-wavenumber component of both spectra can be

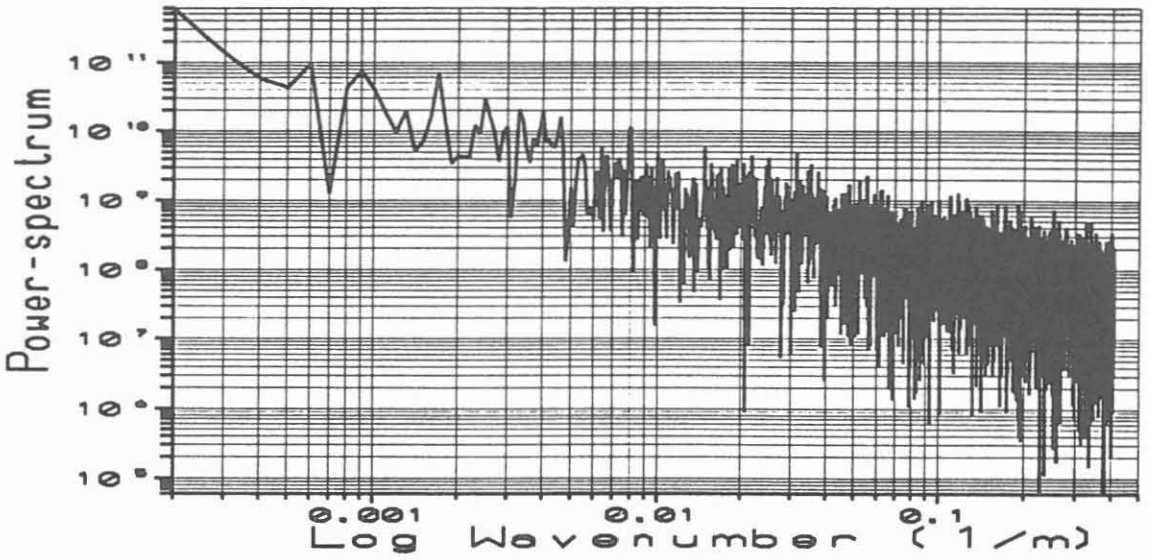

Figure 4: *Power spectrum of HB-V_P*

fit into a power-law spectrum of slope -2, which corresponds to the exponential correlation function, from the longest wavelength to the wavelength of a few tens of meters. The outer scale has not been reached by these two well-logs and therefore must be greater than 1 km. The high wavenumber components (i.e. the small-scale heterogeneities) of the two holes have different characteristics. The high-wavenumber spectrum of the main hole (HB) seems to have a flat-top portion which can be related to the small-scale heterogeneities with an outer-scale of a few meters. The pilot hole (VB) has a high-wavenumber spectrum in form of a power-law spectrum with smaller slopes. The cross-power-spectrum of the two holes, which have a separation of 200 m, is also analyzed in order to have some idea of the spectral anisotropy of the crustal heterogeneities in this region.

Conclusion

The statistical analyses of the acoustic velocity logs from KTB-deep borehole have shown the medium having different scales of heterogeneities. Especially these small-scale heterogeneities will have important influence on the scattering and attenuation of seismic waves in the frequency range used by resources exploration and lithosphere imaging.

ACKNOWLEDGMENTS

This work was supported by the project of the 'Deutsche Forschungsgemeinschaft (DFG)' entitled 'The DFG-priority program of the KTB' under grant No. Hu 413/2-1. We thank the logging section of the KTB (KTB-management, Hannover) for administrative support and data transfer of the sonic data.