Stress Dependence of Elastic Properties in the Crust

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In order to forecast the occurrence of an earthquake, we should know the spatial distribution of the stress in the crust and its changing rate. From a theoretical point of view, the stress in the earth may be monitored by measuring rock properties in the crust whose stress dependences are known. However, it has been practically difficult to monitor the stress by this method, since most rock properties show very week dependences on the stress.

It seems that the recent development of the technology and massive observation networks make it possible to detect weak changes caused by stress changes. Then the knowledge on the stress dependences becomes important for future studies on the stress measurement. We here summarize and compare the stress sensitivities of elastic properties, i.e. wave velocities, Q values, and S wave anisotropies, reported by researchers. The stress sensitivity S of an observable property v is defined here as S [1/MPa] =1/v dv/ds , where s is the stress.

(1) Seismic wave velocities. The velocity changes associated with the earth tides have been reported by many researchers. The calculated sensitivities S strongly depend on the length of the base lines in the experiments; shorter base lines give higher sensitivities. The observational fact indicates that the sensitivity is a rapidly decreasing function of the depth in the crust, as Reasenberg and Aki (1974) suggested. The sensitivity S is of the order of 1 near the surface, decreasing with the depth at a rate of about 1/e per 1~2 km. It is likely that the sensitivity of S wave is higher than that of P wave.

(2) Coda Q. Hiramatsu et al. (2000) report that S is about 10 and that it is much higher than the sensitivity for the wave velocity. Moreover, it is to be noted that this value means a high sensitivity in the lower crust, since coda waves mainly sample a deeper crust.

(3) S wave anisotorpy. Hiramatsu et al. (2005) observe a change in the polarization anisotropy of S wave responding to a static stress change. The calculated value of the sensitivity S is about 1000. This value represents the average sensitivity of the crust to a depth of about 10 km.

The results suggest that using S waves is more advantageous than P waves and that observations of phenomena such as scattering and the anisotropy are most applicable.

References

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