Ablation process of the 1999 Kobe meteorite inferred from shock wave data

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Fireballs or meteoroids passing through the atmosphere with high velocities generate strong shock waves. The shock waves sometimes are detected by ground instruments such as a seismometer. The seismological records provide two kinds of information, the shock wave arrival time and the amplitude of the ground motion generated by the shock wave at each seismic station. The shock wave arrival time data enable us to determine the trajectories of the fireballs. For example, Ishihara et al. (2001) determined the trajectories of the 1999 Kobe meteorite using the arrival times. In this report, we show that the amplitude data are also useful to study fireball phenomena. The amplitude of the shock wave depends on the energy release rate or the reduction rate of the mass and velocity of the fireball. Therefore, it is expected that the amplitude data can be used to study the ablation process of a meteoroid in the atmosphere.

We investigate the ablation process of the 1999 Kobe meteorite using the seismological records. The amplitudes of the ground motions are converted to the amplitudes of the atmospheric shock waves using a conversion formula given by an experiment (see a presentation by Takahashi et al. in this meeting) and a theoretical consideration (Ben-Menahem and Singh, 1981). The obtained amplitudes of the shock waves on the ground are in a pressure ranges from 1 to 40 Pa. The shock wave strengths and representative source dimensions at the sources in the upper atmosphere, whose locations have been determined by the analysis of the arrival times of the shock waves (Ishihara et al., 2001), are calculated by the formula of ReVelle (1976). Then we estimate the radius of the meteorite, adopting a relation R=Md, where R is the representative dimension, d is the radius, and M is the Mach number of the meteorite motion. The results show that the diameter of the Kobe meteorite has changed from 2 ~ 3 m at 70 km to ~1 m at 30 km and that at 30 ~ 25 km the size has rapidly decreased. It is likely that this rapid size change is caused by a fragmentation of the meteoroid.