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Detection of deep atmospheric disintegration of a large meteoroid over the northern Adriatic region by a seismic network on July 25, 2007

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An atmospheric disintegration of a large meteoroid over the northern Adriatic region was observed by numerous witnesses and detected by seismographs of the Environmental Agency of Slovenia on July 25, 2007. Analysis of seismic records produced an approximate atmospheric trajectory of the body, its fragmentation sequence and an estimate of the energy released during individual fragmentation events. Seismographs show evidence of two major fragmentation events, confirmed also by eyewitness reports and dust train morphology. Ray tracing analysis of sound wave propagation on an atmosphere model based on regional sounding data show the acoustic signature to be composed of a sequence of point source signatures corresponding to individual fragmentation events, rather than a line source produced by ballistic passage of the meteoroid through the atmosphere. The two major fragmentation events occurred in the vicinity of Jablan village in northwestern Croatia at altitudes of 22 and 30 km. Several minor fragmentation events were also identified as well as a continuous background signal, which suggests near-continuous fragmentation of the meteoroid during its atmospheric passage starting at 38 km and possibly as high as 49 km.

Using empiric relationships for determination of explosive blast yield for ground-coupled atmospheric shockwaves derived from surface and near-surface high-explosive blasts, adapted for high altitude detonations, the released energy by the meteoroid was estimated at 3 x 10^{12} J, equivalent to $\sim$0.7 kt TNT. While seismic records inherently produce estimates accurate only to within an order of magnitude, this is in good agreement with the upper limit constrained using acoustic detections of the detonations by the most distant eyewitnesses. The deep atmospheric penetration implies a strong rocky, rather than a cometary meteoroid, on the order of several meters across.

The derived atmospheric trajectory permits determination of the meteor's radiant. Assuming origin in the main asteroid belt, the pre-atmospheric orbit was determined as an Apollo-type orbit with perihelion distance q$>$0.81 a.u. and aphelion $<$3.36 a.u. The meteoroid encountered the Earth passing its descending node. The low terminal fragmentation point as well as the rather low entry velocity strongly suggests survival of a part of the pre-atmospheric mass as meteorites.