Explosive Instability of Ice Under Pressure

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Excitation of explosive instabilities (Bridgman’s effect) can arise in many solid dielectrics under the condition of slow uniaxial compression in the area of high pressures on the anvil with open boundaries\(^1\),\(^2\). The effect is accompanied by shock waves and the high-speed ejection (\(\sim 0.5 \sim 2\) km/s) of the sample material outside the limits of the compression system. This threshold phenomenon is conditioned by rapid relaxation of mechanical energy having been accumulated during slow compression of the sample material to the point where the critical value of pressure is achieved. In this paper I have presented the experimental results, demonstrating excitation of similar explosive effects arising in ice in a wide range of temperatures of 100–244 K.

At the temperatures higher than 244 K ice does not experience any explosive effect, it is just smoothly squeezed out of the compression system. According to my assessments, sometimes the similar explosive effect can arise in the ice shells of Jupiter’s satellites, Europa and Ganymede, as their shells (thickness is about 100 – 150 km)\(^3\) can have very deep fractures\(^4\), which leads to creation of open edges belonging to the layers, which are under a rather high pressure.

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**Fig. 1.** Schematic representation of the system of uniaxial compression with Bridgman’s anvils. The system is shown at the moment of the explosive instability at the critical pressure \(P_c\) with ejection of the most part of the sample material in disperse fractured form (a usual particle size is \(\sim 0.1 – 5\) \(\mu\)m) outside the limits of the system. Before the explosive stage of compression thickness of ice disks with diameter \(\approx 10\) cm was \(\approx 0.4\) mm.
In the experiments under discussion the compression system (Fig.1) with Bridgman’s anvils was used; the WC-8 super hard alloy insert has the form of frustum of a cone with the work area diameter \( d = 10 \) mm.

Fig. 2. The curve of temperature critical dependence of the excitation threshold of the explosive instability of ice (open circles) is superimposed on a well-known ice phase diagram\(^6\), \(^7\). The areas of phase metastability are indicated by dotted line.

The rate of loading under the uniaxial compression was fixed, and it made up \( \frac{dP}{dt} \approx 0.02 \text{ GPa/s} \). The results of the experiments are given in Fig. 2.

References