

IMPACT-INDUCED DEVOLATILIZATION OF CaSO_4 ANHYDRITE AND IMPLICATIONS FOR K-T EXTINCTIONS: PRELIMINARY RESULTS.

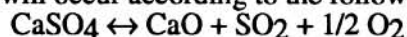
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The recent suggestions that the target area for the K-T bolide may have been a sulfate-rich evaporite and that the resulting sulfuric acid-rich aerosol was responsible for the subsequent cooling of the Earth and the resulting biological extinctions [1,2, but see 3 for a contrasting view] have prompted us to experimentally examine the impact-induced devolatilization of the sulfate minerals anhydrite (CaSO_4) and gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Here we report preliminary results for anhydrite. Up to 42 GPa peak shock pressure, little or no devolatilization occurs, consistent with chemical thermodynamic calculations. Calculation of the influence of the partial pressure of gas species on impact-induced devolatilization suggests that an even greater amount of sulfur than that proposed by Brett [1] could have been released to the atmosphere by an impact into a sulfate-rich layer.

Solid recovery, impact-induced devolatilization experiments were performed on the Caltech 20 mm gun using vented, stainless steel sample assemblies [4,5]. To enhance recovery of solid products after the shock, the sample was sandwiched between Zn discs. The anhydrite shock equation of state results of Simakov et al. [6] were employed. Post-shock analysis consisted of thermogravimetric analysis (TGA) in a He atmosphere to 1500°C and powder X-ray diffraction. During TGA of anhydrite, loss of sulfate begins at about 800°C and is complete by about 1200°C.

In experiments to date, up to 42 GPa peak shock pressure, little or no devolatilization of the anhydrite occurs (Figure 1). For comparison, peak shock pressures for incipient devolatilization of serpentine, calcite, and Murchison carbonaceous chondrite are about 20 GPa [4,5,7]. The greater difficulty of devolatilization of anhydrite relative to serpentine and calcite is consistent with thermodynamic calculations of the stability of these minerals [8].

Decomposition of anhydrite will occur according to the following reaction:



Under standard state conditions ($P_{\text{SO}_2} = P_{\text{O}_2} = 1$ bar), this reaction proceeds to the right ($\Delta G < 0$) at temperatures greater than 1846 K. However, under conditions in which the gas pressures are less than 1 bar, the reaction proceeds to the right at lower temperatures. For example, for $P_{\text{O}_2} = 0.2$ bar and $P_{\text{SO}_2} = 10^{-4}$ bar the equilibrium temperature is 1270 K. Using the shock entropy method of estimating impact-induced devolatilization, and including the effects of gas pressure [5] we have calculated the shock pressures required for devolatilization under each of these gas atmospheres (Figure 1). For $P_{\text{SO}_2} = P_{\text{O}_2} = 1$ bar, incipient devolatilization occurs at about 48 GPa shock pressure and complete devolatilization occurs at about 107 GPa. For $P_{\text{O}_2} = 0.2$ bar and $P_{\text{SO}_2} = 10^{-4}$ bar, incipient devolatilization occurs at about 37 GPa, and complete devolatilization occurs at about 92 GPa. Our experimental results are consistent with these calculations, but do not cover a sufficient shock pressure range to prove their validity.

These calculations suggest that impact-induced devolatilization of anhydrite occurs at shock pressures sufficiently low that significant amounts of sulfur could have been injected into the atmosphere upon impact into a sulfate-rich evaporite environment. Consideration of the influence of partial pressure of gaseous species on the impact-induced devolatilization indicates that the total amount of sulfur released to the atmosphere could be greater than the 2×10^{17} g calculated by Brett [1].

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References: [1] Brett, R., *Geochim. Cosmochim Acta*, 56, 3603, 1992. [2] Sigurdsson, H., D'Hondt, S., and Carey, S., *Earth Planet Sci. Lett.*, 109, 543, 1992. [3] Blum, J. D., and Chamberlain, C. P., *Science*, 257, 1104-1107, 1992. [4] Lange, M. A., Lambert, P., and Ahrens, T. J., *Geochim. Cosmochim Acta*, 49, 1715-1726, 1985. [5] Tyburczy, J. A., and Ahrens, T. J., *J. Geophys. Res.*, 91, 4730-4744, 1986. [6] Simakov, G. V. M. N., Pavlovskiy, N. M., Kalashnikov, N. G., and Trunin, R. F., *Izv. Phys. Solid Earth*, 8, 488-492, 1974. [7] Tyburczy, J. A., Frisch, B., and Ahrens, T. J., *Earth Planet Sci Lett.*, 80, 201-207, 1986. [8] Robie, R. A., Hemingway, B. S., and Fisher, J. R., *U. S. Geol. Survey Bull* 1452, 1979.

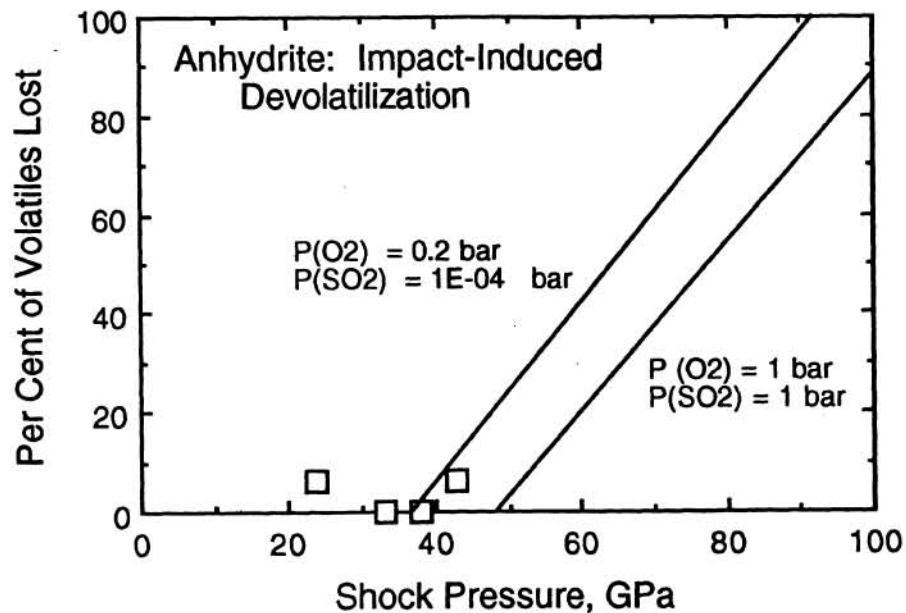


Fig. 1: Impact-induced devolatilization of anhydrite. Open squares; experimental results from this study. Solid lines; calculated devolatilization using shock entropy method assuming different gas compositions.