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Salt-Ice Grains from Enceladus' Plumes: Frozen Samples of a Subsurface Ocean

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Abstract

We present compositional measurements by Cassini's dust detector [1] of ice particles emitted from Saturn's cryo-volcanic moon Enceladus into the E ring. Since sodium is considered as crucial indicator for an Enceladus ocean [2], our detection of sodium salts within the grains provide the first evidence for mineral enriched liquid water deep below the moon's icy surface [3]. Together with recent Cassini-INMS measurements of Enceladian plume vapour [4], a detailed compositional picture of both gas and solid phases of emitted plume matter is at hand for the first time.

In nearly all particles detected in situ by the Cosmic Dust Analyser (CDA), we found sodium (Na) in varying concentrations. Most spectra also show potassium (K) in lower abundance. In mass spectra that are particularly sodium rich, sodium salts (like NaCl and NaHCO3) are identified as Na bearing components [3]. This is only possible if the plume source is liquid water that is or has been linked to an Ocean in contact with the rocky material of Enceladus' core. The abundance of minerals as well as the inferred basic pH value of those grains exhibit a compelling similarity with the predicted composition of an Enceladus ocean [2]. The Na-rich ice particles expelled through the plumes into the E ring are frozen droplets of a reservoir possibly still in contact with a large Ocean.

Measurements of the solid phase [3,5] and plume gases [4] offer a consistent picture of plume mechanics and chemistry which involves evaporation of liquid water. The results provide strict constraints for plume models which have to include gas and grain production as well as their subsequent ejection into the E ring.

The analysis also allows refinement of models for a water-rock-interaction at the bottom of an Enceladus Ocean.

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