COMPOSITIONAL COMPARISON OF NATURAL OUTBURSTS FROM COMET 9P/TEMPEL 1.
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Introduction: Natural outbursts are a known cometary phenomenon and have been observed on many cometary nuclei. On its approach to 9P/Tempel 1 in 2005, the Deep Impact (DI) spacecraft unexpectedly detected numerous outbursts from Tempel 1, demonstrating that frequent natural outbursts are common, correlated with rotational phase, and are primarily driven by an endogenic process [1]. While the specific driver is unknown, compositional analysis of the outgassed material shows that the outbursts differ from one another and from the ambient coma. We present spectral analysis of the inner coma of Tempel 1 from 1-5µm during two strong outbursts detected with the High Resolution Instrument Infrared Spectrometer (HRI-IR).

Outburst Data: Although many outbursts were detected in the DI photometry data, only two of the strong outbursts were also seen by the spectrometer (Table 1). The comet signal was too weak and not in the field-of-view of the spectrometer until June 20, 2005, and the coma was only sampled by the spectrometer once every 4 hours during the approach phase. Analysis of the 1-5µm spectral data, which includes emission bands of many volatiles such as the 2.66µm H_2O and 4.26µm CO_2 bands, will be used to evaluate the compositional variation between outbursts.

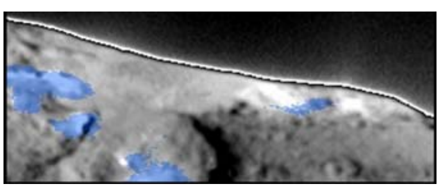

Figure 1. Adapted from Farnham et al. [2]. Nucleus of Tempel 1 showing jets originating from the surface and regions of surface ice deposits [3] near the 0.9 rotational phase periodic outburst detected on July 2, 2005.

The June 22 outburst occurs at a rotational phase of 0.3 while the July 2 outburst occurs at 0.9 phase [2]. (For reference, impact occurred at phase 0.) Active jets are traced back to the nucleus [2] and H_2O ice patches are detected on the surface [3] adjacent to the region of the nucleus which enters into sunlight at 0.9 phase (Fig. 1). A working hypothesis for the periodic outburst occurring at 0.9 phase is that there are subsurface regions enhanced in volatile ices which migrate toward the colder surface region during the night-time temperature inversion, recondense at or near the surface, and explosively release after sunrise.

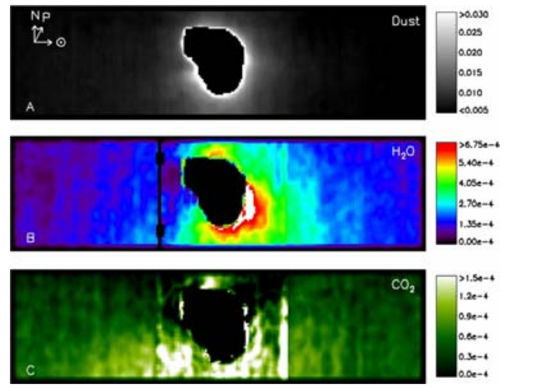

Figure 2. Adapted from Feaga et al. [4]. Compositional heterogeneity of the inner coma of Tempel 1; Panel A is dust, B is H_2O, C is CO_2.

Preliminary analysis of the spectra show differences in the composition between the ambient and outburst coma as well as differences between the two outbursts, pointing to possible heterogeneity in the source regions of the outbursts which occur at different rotational phases of the comet. Compositional heterogeneity has also been quantified in the inner, ambient coma [4]. CO_2 in the inner coma appears to correlate well with a persistent dust jet [4,2] while H_2O is preferentially outgassed in the sunward direction (Fig. 2). Heterogeneity may be due to variable erosion processes across the nucleus, exposing material from different depths at different times, or to compositionally diverse layers throughout the nucleus from accretion processes [5].

Date	Extrapolated Start Time	HRI-IR Pre-outburst Obs Time	HRI-IR Post-outburst Obs Time	Exposure Time (sec)
2005 Jun 22	19:52	13:10, 17:10	21:10, 01:10	5
2005 Jul 02	8:34	05:59, 07:53	09:59, 12:04	8

Table 1. Timing of Tempel 1's outbursts and the HRI-IR observations for June 22 and July 2, 2005.

Implications: Understanding outbursts and the processes interior to the nucleus that produce them helps probe the interior structure and composition of the nucleus, shedding light on the conditions and accretion processes from which the comet formed in the early Solar System.

References: [1] A'Hearn M. F. et al. (2005) *Science, 310*, 258-264. [2] Farnham T. L. et al. (2007) *Icarus, 187*, 26-40. [3] Sunshine J. M. et al. (2007) *Science, 311*, 1453-1455. [4] Feaga L. M. et al. (2007) *Icarus, 190*, 345-356. [5] Belton M. J. S. et al. (2007) *Icarus, 187*, 332-344.