THE SPECIFIC HEAT OF SAMPLES FROM ASTEROID (101955) BENNU. J. Biele[1], A. Alasli[2], H. Nagano[2], C. P. Opeil[3,4], A. King[5], A.J. Ryan[6], R-L. Ballouz[6], R. J. Macke[4], H. C. Connolly Jr.[6,7,8], D. S. Lauretta[2]; [1]RB-MUSC, DLR German Aerospace Center, DLR, 51147 Cologne, Germany (jens.biele@dlr.de); [2]Nagoya University, Department of Mechanical Systems Engineering, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan; [3]Vatican Observatory, V-00120, Vatican City State; [4]Department of Physics, Boston College, Chestnut Hill, MA 02467, USA; [5]Natural History Museum, Earth Sciences/Mineral and Planetary, Cromwell Road, London SW7 5BD, UK; [6]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA; [7]Department of Geology, Rowan University, Glassboro, NJ, USA; [8]Department of Earth and Planetary Sciences, American Museum of Natural History, New York, NY, USA.

Introduction: Specific heat (at constant pressure) $c_P(T)$ depends on temperature and the mineralogic composition of a sample. It is important [1, 2] to know for the construction of precise thermophysical models of B-type asteroid Bennu, where often only the composite quantity of thermal inertia Γ is cited. $\Gamma = \sqrt{c_P k \rho}$, where ρ is bulk density and k is thermal conductivity. Thus, knowledge of $c_P(T)$ of the samples from Bennu is critical for comparing them to thermal inertia values determined from orbit (e.g., [3]). Here we report the results of differential scanning calorimetry (DSC) on a sample of Bennu from 210 K to 450 K. Low-temperature data (2–300 K) will be presented in detail by [4].

Samples: We first performed trials with a powdered test sample, OREX-803121-0 (14.372 ± 0.001 mg), consisting of (loose, unsorted) material that may not necessarily be exactly representative of the sample collection as a whole and with mineralogy that has not been characterized. We optimized the measurement procedure and the drying protocol with his sample. We then measured our definitive sample, OREX-803224-0 (13.804 ± 0.001 mg), a subset of a well-characterized (XRD), homogenized powder OREX-800107-0 that was produced from grinding >6 g of mixed Bennu material for bulk analyses. The sample, in powder form, was containerized in aluminum calorimetry sample pans and left unsealed to allow physisorbed water to evaporate and diffuse out into the dry purging gas (N_2 with a purity of 99.99% plus a dehumidifier connected between the gas tank and DSC device to eliminate any residual humidity in the purge gas).

Analytical Methods: The instrument is a power-compensated Perkin Elmer DSC 8000 measurement system with Intercooler II as cooling system and pure N_2 as purging gas. Reference samples for calibration were sapphire (corundum, α-Al_2O_3) disks. The measurement procedure is the three-curve technique (empty, reference, sample) and uses the step-scan method of [MRaw,5] to eliminate most systematic instrument drifts.

Samples were heated and kept at 130° C (403.15 K) while purged in N_2 for 120 min to evaporate any adsorbed water before starting the measurements. We discovered that water adsorption on Bennu samples is a very critical issue. The sample mass changes significantly by about 4%, and the sample quickly reabsorbs water, with a time constant of ~30 minutes in laboratory air of relative humidity 46%. Even a residual terrestrial water contamination of only 0.2–0.4% is non-negligible, considering the high specific heat (~4200 J/K/kg) and specific enthalpies of sublimation or vaporization of ~$2.7 \cdot 10^6$ J/kg of H_2O.DSC c_P or heat flux measurements for were performed from –50° C to 560°C (high temperature range). Temperatures $T > 450$ K entailed irreversible decomposition with mass loss (not shown here).

Results: DSC c_P data show no detectable transitions or other anomalies (peaks, kinks) from 210 K to 450 K (Figure 1); at low temperatures, the magnetite (Fe_3O_4) Verwey transition lambda peak is seen at 122 K [4].

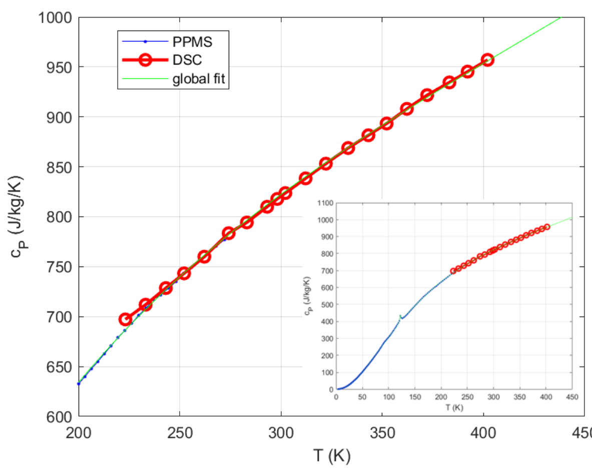

Figure 1. Specific heat of OREX-803224-0: DSC data. For comparison, the low-temperature data from [4] and a global fit are shown (insert).

Relative to the global fit curve, DSC data show a standard deviation of 0.4%. Absolute accuracy is estimated as ±2%. By comparison of these "average sample" data to "trial sample" OREX-803121-0 we conclude that different lithologies on the milligram level can lead to systematic c_P differences of the order of 2%; reversible adsorption of terrestrial humidity lead to systematic changes in c_P of up to ~10%.

Discussion: It was a surprise how rapidly the samples adsorbed water once in a normal (RF ~46%) laboratory atmosphere for handling, and how long it took to remove this physiosorbed water. Otherwise, the specific heat of Bennu in the temperature range investigated looks similar to some carbonaceous chondrite meteorites such as Aguas Zarcas (CM) [6], Tagish Lake (C2 ungrouped), and Orgueil (CI) (both from [1], in vacuum, i.e. "dry"). We will also compare observed specific heat with its theoretical value based on the mineralogical composition, following [7].

Please note the companion abstract [4] on the low-temperature (3–to ~300 K) c_P measurements using a sample from the same batch as OREX-803224-0. In the near future, the results of [4] and this study will be synthesized and compared to the expected values based modal mineralogy from XRD and organics analyses.pw.

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