INVESTIGATION OF POST-IMPACT HYDROTHERMAL ALTERATION IN THE RIES EJECTA DEPOSITS WITH COMPARISONS TO EARLY MARS. C. M. Caudill[1], R. N. Greenberger[2], H. M. Sapers[2,3,4], L. L. Tornabene[1], G. R. Osinski[1,5], B. L. Ehlmann[2,3]. [1]Centre for Planetary Science and Exploration / Dept. Earth Sciences, University of Western Ontario, Canada, [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA, [3]California Institute of Technology, Pasadena, California, USA, [4]Dept. of Earth Sciences, University of Southern California, USA, [5]Dept. Physics and Astronomy, University of Western Ontario, Canada.

Introduction: The Ries impact structure (~24 km-diameter, Germany) has arguably the best preserved ejecta deposits on Earth. Widespread hydrothermal alteration has been observed at the Ries [e.g., 1, 2, 3], though the spatial extent particularly within the ejecta deposits is still debated [4]. One style of hydrothermal alteration observed in the top-most, impact melt-bearing ejecta unit at the Ries is found as disseminated, ephemeral systems associated with vertical degassing pipe structures [5, 6, 7]. As hot melt-rich ejecta deposits are emplaced over volatile-bearing material, a degassing of the underlying layer is proposed to have occurred forming the pipe structures [6, 8]; this is also the preferred interpretation of pitted material observed in Martian crater fill and ejecta deposits [9, 10, 11]. A systematic characterization of the extent and evolution of the hydrothermal system in the melt-bearing breccias at the Ries may therefore have implications for Martian crustal materials. Furthermore, recent identification of biogenic tubular features within the melt-bearing breccia unit at the Ries [12] underscore the importance of understanding the thermal and geochemical evolution of these systems as potential planetary astrobiological targets.

Methods: The melt-bearing impactites at the Ries were investigated through hyperspectral imaging acquired with a Headwall Photonics Inc. instrument utilizing two sensors: a visible-near infrared (VNIR) sensor at 5 nm spectral resolution and a shortwave infrared (SWIR) sensor at 6 nm spectral resolution. Spectral parameters were then produced to map minerals and phases. The spectral parameter mapping was supported by laboratory-based micro X-ray diffractometer (μXRD) analysis of representative hand samples of the breccias. Size-fraction separation (<0.2μm and <2μm), cation saturation, and dehydration was carried out to differentiate the fine-grained material.

Results: The degassing pipes are spectrally characterized by a 2.2μm feature (representative of Si-OH or Al-OH bearing minerals such as montmorillonite) and/or a 2.30μm feature (representative of Fe/Mg-OH bearing minerals [13], consistent with nontronite). Calcite is indicated by a 2.34μm feature [14], present within the altered zone of the degassing pipes and is also finely disseminated through the degassing pipes. Iron oxides are also abundant.

Multiple clay phases were observed in the laboratory μXRD analyses, including mixed-layer smectites. Chlorite or hydroxyl-interlayers were consistent with the failure of collapse upon dehydration [15, 16].

Discussion: The melt-bearing unit at Ries has been altered through various processes [7, 17] and is dominated by phyllosilicate minerals. The mineralogic diversity in the phyllosilicates of the melt-bearing unit of the Ries indicates a more pervasive hydrothermal system than has been previously described. Spatially extensive, yet sporadically distributed, degassing pipes indicate major localized, higher intensity systems. This ongoing work indicates extended hydrothermal activity and hence timeframes for habitability. Furthermore, we suggest that the novel, high resolution in situ spectral mapping of such deposits may be beneficial to quantitatively evaluate the friable amorphous components of the hydrothermal degassing pipe features.

In situ spectral mapping offers promising comparisons to orbitally-derived spectral data (e.g., CRISM [18]) for Mars as well as rover-derived spectral data (e.g., Curiosity's MastCam [19]) of hydrothermal mineral assemblages. Such comparative study may elucidate mineral provenance in the Martian crust, and thus past processes and environments that may have been habitable. Ongoing work involves comparing spectral data from the Ries to the heavily cratered Noachian terrain of Mars, focusing on crater-related pitted material. This strategy may identify mineral assemblages indicative of localized, sporadically distributed post-impact hydrothermal systems as well as near-surface exposures which provided potentially habitable niches for future exploration.

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