THE IMPORTANCE OF PHYLLOSILICATE MINERAL FORMATION IN IMPACT CRATERING PROCESSES, A CASE STUDY: THE RIES IMPACT STRUCTURE, GERMANY.

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Introduction: Hydrated phyllosilicate minerals play an important role in understanding the paleoclimate and habitability. Impact craters provide a complex setting for phyllosilicates detected from orbit [1,2]. Pre-impact phases excavated by the impact process can be exposed in bedrock (e.g., walls, terraces or central uplift) and crater-related deposits [e.g. 2,3]. Syn-impact phases form via impact-induced alteration pathways [4,5]. It has been suggested that warm, wet conditions are restricted to the earliest period of Martian history implying that both habitable and phyllosilicate-forming environments are limited to the Noachian Period (~4.5–3.7 Ga) [e.g. 3,6,7]. However, syn-impact phyllosilicates can be formed during spatially and temporally extensive impact-generated hydrothermal systems and through the weathering of impact-derived materials [2]. While impact-generated hydrothermal activity may provide transient, warm, wet conditions associated with phyllosilicate formation and habitability [8,9], the weathering of impact-generated materials arguably continues long after the cessation of impact-generated hydrothermal activity, temporally extending the period of phyllosilicate formation beyond that of habitability. These two mechanisms of phyllosilicate generation; 1) aqueous associated and 2) recrystallization/devitrification of metastable impact-products, have led to the two main models of the Ries post-impact hydrothermal system. Here we present a comprehensive mineralogical assessment of phyllosilicate assemblages suggesting a lateral extent to hydrothermal activity beyond the inner ring over-printed by ambient, surficial weathering.

Hydrothermal deposits at the Ries impact structure: The ~15 Ma [10], ~26 km diameter Ries impact structure, is arguably the best-preserved complex impact structure on Earth [11]. Although there is wide-spread evidence of impact-associated hydrothermal activity at the Ries impact structure [12,13], the spatial extent of the system is debated [14]. It is accepted that there was a high-temperature hydrothermal system within the inner crystalline ring. The alteration assemblages within the crater suevite, as sampled by the Nördlingen 1973 core, are consistent with high-temperature (~200–300 °C) hydrothermal activity [13]. Glass-bearing breccias ejected beyond the inner-rim, surficial suevite, are variably altered. Phyllosilicate minerals dominate the fine-grained matrix and also occur as a larger-grained space-filling phase within fractures and vesicles. These clay minerals have been variably interpreted as products of weathering [15] high-temperature devitrification products [16,17] and secondary hydrothermal precipitates [13,18]. We examined the surficial and crater suevite using a novel application of peak-intensity contour mapping of bulk powder X-ray diffraction data indicating a distinct mineralogical difference in the smectitic phyllosilicate fraction [19]. "Smectitic" phyllosilicates in the surficial suevite at Aumühle were found to be mineralogically distinct from the surficial suevite in the Wörnitzostheim core that were more similar to the pervasively altered crater suevite sampled by the Nördlingen core. Both < 2 µm and < 0.2 µm fractions were collected from a subset of samples to differentiate the fine grained phyllosilicates in the matrix from the larger, space filling phases. Preliminary results of untreated clay fractions analyzed at 54% relative humidity indicate subtle mineralogical differences between size fractions suggesting different generations of phyllosilicate formation.

Conclusions: These results suggest that there is a mineralogical diversity within the phyllosilicate component of the surficial suevite at the Ries not previously reported indicating a spatially extensive and heterogeneous post-impact hydrothermal system overprinted by extended weathering at ambient conditions. Differentiating the phyllosilicate phases associated with a spatially extensive hydrothermal system from those formed by continuous ambient weathering at Ries has implications for understanding planetary habitability following large impact events in addition to paleoclimate implications of phyllosilicates associated with impact structures on Mars.

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