

ALTERATION OF SUEVITIC IMPACTITES AT THE RIES CRATER, GERMANY: STABLE ISOTOPE COMPOSITION OF SMECTITE MINERALS AND FLUID TEMPERATURES. Nele Muttik¹, Kalle Kirsimäe¹, Peeter Somelar¹ and Torsten W. Vennemann², ¹Department of Geology, University of Tartu, Ravila 14a, 50411 Tartu, Estonia (nele.muttik@ut.ee), ²Institute of Mineralogy and Geochemistry, University of Lausanne, Building Anthropole, CH-1015 Lausanne, Switzerland.

Introduction: The 24-km diameter Ries crater in southern Germany exhibits well-preserved crater fill and surficial suevite deposits that are altered to various extents. Earlier studies have shown that hydrothermal alteration of the crater-fill suevite (impact melt-bearing breccias) is pervasive in nature and comprises several distinct alteration phases that vary with depth. There is an early phase of K-metasomatism accompanied by minor albitization and chloritization at temperatures of approximately 200–300 °C [1]. In contrast to the crater-fill suevites, the alteration within surficial suevites at the Ries crater is typically restricted to smectite (composition corresponding to dioctahedral Al-Fe montmorillonite) with minor zeolite (mainly phillipsite) deposition within cavities and fractures suggesting formation under weathering conditions [2].

In this contribution, we study the $\delta^{18}\text{O}$ and δD composition of smectite mineral in crater fill and surficial suevite from the Ries crater. The stable isotope study was undertaken in order to elucidate the origin and temperature of the fluids responsible for alteration of impact glass and primary silicate minerals.

Material and methods: Stable oxygen and hydrogen isotopic composition was measured in clay separates from the suevite matrix at the Stable Isotope Laboratory, University of Lausanne.

Studied material represents surficial suevites, collected from 5 outcrops within and around the Ries impact structure, and drill core material from the Nördlingen 1973 drill core at the suevite sequence 340 m to 525 m interval.

Results and discussion: The $\delta^{18}\text{O}$ values of the smectite in surficial suevites vary narrowly between 17 to 23‰ VSMOW. The hydrogen isotope values exhibit rather similar values between the sampled outcrops, with a mean value of -96 ± 6 ‰. Smectite $\delta^{18}\text{O}$ and δD values in crater-fill suevite samples, however, range from 8‰ to 14‰ and -33 ‰ to -62 ‰, respectively (Figure 1).

According to Vennemann et al. [3] the oxygen isotope composition of impact glasses at the Ries crater sampled from widely spaced localities are very homogeneous with $\delta^{18}\text{O}$ values in the range of 6.7 to 7.4‰. The major modification of the original oxygen values suggests a significant hydrous alteration at large water/rock ratios. The estimated fluid temperatures using isotope fractionation equation for smectite [4] suggests

smectite precipitation in surficial suevites in equilibrium with fluid at temperatures 13.0 ± 4.13 °C (except R32 sample, Amerdingen locality with calculated temperature 27.5 °C), whereas the calculated $\delta^{18}\text{O}$ composition of the fluid (-6.9 ± 1.05 ‰ SMOW) agrees with the long-term variation of the modern precipitation in the area. The crater-fill suevites, however, show a trend of decreasing $\delta^{18}\text{O}$ values and increasing δD values with increasing depth, from 14‰ and -96 ‰ at 360 m to 8‰ and -51 ‰ at 525 m. In crater fill suevites the estimated temperatures vary from 40 °C at 360 m depth to 105 °C at 525 m depth. It is interesting enough that the temperatures of the hydrothermal fluid estimated from the smectite minerals are 80–180 °C lower than estimated from mineral associations earlier (e.g. [1]) suggesting that the smectite formation occurred during the latest phase of the impact cooling.

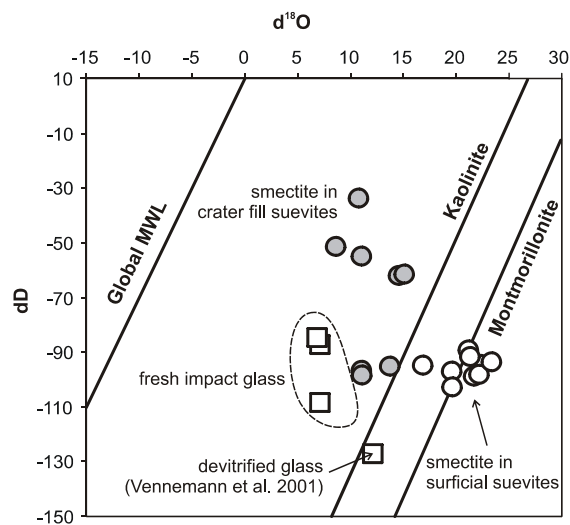


Figure 1. δD vs $\delta^{18}\text{O}$ plot of the measured isotopic composition of clay separates from the suevite matrix of the Ries crater suevites.

References: [1] Osinski G. R. (2005) *Geofluids*, 5, 202–220. [2] Muttik N. et al. (2008) *MAPS*, 43, 1827–1840. [3] Vennemann T. W. et al. (2001) *GCA*, 65, 1325–1336. [4] Delegado A. and Reyes E. (1996) *GCA*, 60, 4285–4289.