

**ZINC AND COPPER ISOTOPES IN CENTRAL EUROPEAN TEKTITES AND SEDIMENTS FROM THE RIES IMPACT AREA – IMPLICATIONS FOR MATERIAL SOURCES AND LOSS OF VOLATILE ELEMENTS DURING TEKTITE FORMATION.** Z. Rodovská<sup>1,2</sup>, T. Magna<sup>1</sup>, C. Kato<sup>3</sup>, P.S. Savage<sup>3,4</sup>, F. Moynier<sup>3</sup>, K. Žák<sup>5</sup>. <sup>1</sup>Czech Geological Survey, Prague, Czech Republic. E-mail: zuzana.rodovska@geology.cz. <sup>2</sup>Faculty of Science, Charles University in Prague, Czech Republic. <sup>3</sup>Institut de Physique du Globe de Paris, Université Paris Diderot, France. <sup>4</sup>Department of Earth Sciences, Durham University, United Kingdom. <sup>5</sup>Institute of Geology, v.v.i., Academy of Science of the Czech Republic, Czech Republic.

**Introduction:** Tektites are natural silica-rich glasses produced during hypervelocity impacts of an extraterrestrial projectile onto the Earth's surface [1–3] and as such, they represent a unique source of information about conditions existing during flash melting of near-surface terrestrial materials taking place shortly after the collisions. At present, four geographically distinct tektite strewn fields are recognized: North American, Central European, Ivory Coast and Australasian. However, a link between tektites and their sedimentary parentage remains under-explored [4,5].

The Central European tektites (moldavites) are assumed to have been formed by reworking of chemically variable sediments during the 14.7 Ma impact [6] in the Ries area in south-eastern Germany (centered close to Nördlingen). The Ries impact structure has been accepted as the parent crater to moldavites, based on coincidence of their ages [7]. We present preliminary Zn and Cu abundance and isotope data for a suite of various sediments from the Ries area as well as for moldavites from four different strewn subfields in order to provide new information on (i) Zn and Cu elemental and isotope variability in the possible parental materials and link these variations to their bulk chemistries, and (ii) the extent of Zn and Cu isotope fractionation between the source sediments and tektite melts [cf. 5,8].

**Results and discussion:** The Ries area sediments show a remarkable range in Zn contents (4.6–186 ppm), exceeding the range of Zn concentrations found for moldavites (Fig. 1). The clay fractions from three sediments have from 94 to 161 ppm Zn and are always enriched in Zn relative to bulk sediments. The single sample of a residual glass, formed during combustion of organic matter in a power plant (“straw glass”) and analyzed for a comparison, shows 133 ppm Zn which is within the range of Zn contents in plants [9] although p–T conditions of formation of tektites and straw glass are very different. The moldavites show a range in Zn abundance from 1.9 to 108 ppm, extending towards both lower and higher Zn contents compared with earlier data [5]. The high Zn abundance in some moldavites is comparable to Zn-rich sediments and largely precludes a major loss of Zn through volatilization after the impact. Instead, Zn-rich source sediments

for some moldavites are invoked. The  $\delta^{66}\text{Zn}$  (permil variation of the  $^{66}\text{Zn}/^{64}\text{Zn}$  relative to the JMC-Lyon standard) values in the Ries area sediments (–0.1‰ to 0.6‰) are clustered around the typical bulk silicate Earth composition and do not show systematic variations related to protolith chemistry. The clay fractions are always isotopically lighter than the corresponding bulk sediments beyond the analytical uncertainty with a  $\Delta^{66}\text{Zn}_{\text{clay-bulk sediment}}$  of  $\sim -0.6\text{‰}$ , implying uniform intra-sample Zn isotope fractionation between clays and sand component of the sediments. The  $\delta^{66}\text{Zn}$  of the straw glass (0.2‰) is identical to that of the sediments, attesting to generally limited Zn isotope fractionation at the soil–plant interface. A significant range in  $\delta^{66}\text{Zn}$  is found for moldavites in this study (1.8 to 3.6‰), i.e., a distinctly larger variation than observed previously [5]. This results from incorporation of a wider range of bulk chemical compositions of moldavites relative to previous studies. The moldavites from different strewn subfields are isotopically somewhat distinct. However, the mean values for individual strewn subfields may be considered rather similar given the large uncertainties of  $\sim 1\text{--}1.6\text{‰}$  ( $2\sigma$ ). All samples follow mass-dependent Zn isotope fractionation, plotting on a straight line with a slope of  $\sim 2$  in a  $\delta^{68}\text{Zn}$  vs.  $\delta^{66}\text{Zn}$  plot (Fig. 2). However, two resolved trends are apparent, likely operating at low and high temperatures, respectively. Sediments and clay fractions follow a mass-dependent fractionation with a slope of  $\sim 1.91$  whereas moldavites and other tektites [5] plot on a mass-dependent fractionation line with a slope of  $\sim 1.97$ . This likely implies distinct processes of Zn isotope fractionation for samples modified at high temperatures (kinetic fractionation) versus those that underwent only low-temperature diagenesis (equilibrium fractionation). This is similar to Mg isotope systematics, for example [10].

The  $\delta^{65}\text{Cu}$  values in the Ries area sediments (–0.4 to 0.7‰) are in the range of common crustal lithologies. They broadly correlate with carbonate contents, implying important non-silicate carrier phase of the isotopically heavy Cu. The Cu isotope composition of moldavites extends towards significantly heavier values than reported previously [8], with the Cheb Basin moldavites showing some of the highest  $\delta^{65}\text{Cu}$  values

(up to 12.5‰) ever observed in natural samples. This indicates that homogeneous nature of sedimentary sources cannot represent a possible fingerprint and that Cu isotope fractionation is solely related to processes of moldavite formation.

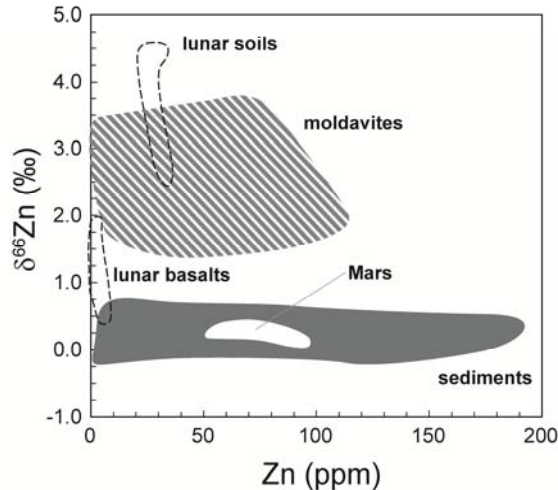


Fig. 1. Zinc contents versus  $\delta^{66}\text{Zn}$  in sediments from the Ries area and moldavites. Lunar and martian values are also shown [12, 13].

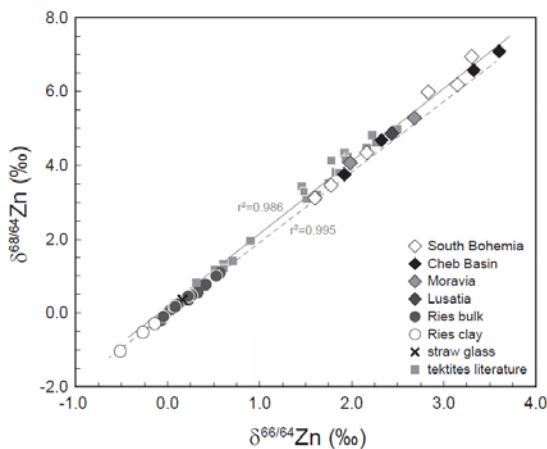


Fig. 2. Triple-zinc isotope plot for moldavites, sediments, clay fractions and the straw glass.

The coupled Cu–Zn isotopes in sediments and moldavites show correlated systematics (Fig. 3). This may suggest similar behavior of Cu and Zn at high temperatures although Cu isotopes fractionate at a significantly larger scale than Zn despite higher condensation temperature of Cu relative to Zn [11]. These findings are consistent with earlier observations [5,8] and suggest a diffusion limited isotopic fractionation [8] but an apparent lack of Zn depletion in some moldavi-

tes [cf. 5] and a more constrained trend between Cu contents and  $\delta^{65}\text{Cu}$  values (not shown) in moldavites may imply somewhat disparate processes of Cu and Zn isotope fractionation in moldavites, with perhaps a more pronounced loss of Cu relative to Zn. This could be related to dramatic changes in redox conditions which would inherently involve isotope fractionation during  $\text{Cu}^{2+}$  to  $\text{Cu}^+$  conversion [see also 8], coupled to slightly different geochemical behaviour of Zn and Cu.

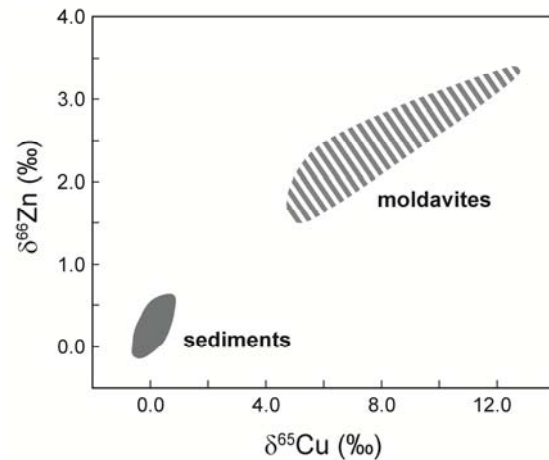


Fig. 3. Coupled Cu–Zn isotope plot for the moldavites and sediments from the Ries target area, analyzed in this study.

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