CONSTRAINTS ON THE NATURE OF THE PROJECTILE USING SIDEROPHILE ELEMENTS AND TRIPLE–OXYGEN ISOTOPES: ZHAMANSHIN IMPACT STRUCTURE, KAZAKHSTAN

Š. Jonášová[1,2], L. Ackerman[1,3], K. Žák[1], R. Skála[1,2], T. Magna[3], A. Pack[4] and A. Deutsch[5], [1]Institute of Geology, The Czech Academy of Sciences, Prague, Czech Republic (jonasova@gli.cas.cz, ackerman@gli.cas.cz, zak@gli.cas.cz, skala@gli.cas.cz), [2] Faculty of Science, Charles University, Prague, Czech Republic, [3]Czech Geological Survey, Prague (tomas.magna@geology.cz), Czech Republic, [4] Georg-August-Universität, Göttingen, Germany (Andreas.Pack@geo.uni-goettingen.de), [5] Westfälische Wilhelms-Universität Münster, Germany (deutsca@uni-muenster.de).

Introduction: The chemical composition of glasses produced during impact processes largely reflects that of the rocks present in target area [1] with some differences related to diverse volatility of individual elements [2] and typically very subordinate presence of the projectile matter, e.g., [3]. Abundances and patterns of highly siderophile elements (HSE – Re, Os, Ir, Ru, Pt, Pd) are considered as a useful tool for deciphering of meteoritic veneer to planetary masses and tracing the addition of extraterrestrial materials during the impacts, e.g., [4,5]. Triple oxygen isotope data are equally valuable narrowing npossible projectile type and [6]. The Zhamanshin impact structure in Kazakhstan, with an estimated age of ~1 Ma [7], contains several types of impact-related glasses which bear important information on the behavior of elements during and immediately after the impact.

Results: The tektite-like glasses found in the Zhamanshin impact structure can be divided into two main subtypes based on their SiO_2 contents: (1) basic splash-forms (~53–57 wt.% SiO_2) and (2) acidic irghizites (~70–77 wt.% SiO_2) [8,9]. The basic splash-forms contain low amounts of Ni, Co and Cr, show highly fractionated HSE patterns with common Ir enrichments over Os and Ru (Os_N/Ir_N <0.02 and Ru_N/Ir_N = 0.04–0.7) and typically lower total HSE contents than irghizites. Irghizites are highly enriched in Ni, Fe, locally also in Cr and P, and some highly siderophile elements (e.g., Pt, Pd) in comparison to the basic splash-forms and target rocks. Irghizites exhibit highly fractionated HSE patterns with Os and, in some cases, Ru contents lower than upper continental crust (UCC; [10]) whereas Pt (up to 5.3 ppb) and Pd (up to 11.7 ppb) contents are higher than those of UCC. The $\delta^{18}O$ values for basic splash forms (8.0 to 9.1‰ VSMOW) are lower than those for the irghizites (11.9 to 14.4‰). Combined with the difference in major element chemistry, these results can be interpreted to reflect the difference between the precursor rocks – surficial Paleogene sands and clays or Cretaceous sediments for the irghizites versus deeper-seated Lower Paleozoic volcanosedimentary series for the basic splash forms. The $\Delta^{17}O$ of the basic splash-forms (–0.075 to –0.118‰) mimics common upper crustal range while the irghizites show significantly lower $\Delta^{17}O$ (–0.174 to –0.248‰, defined relative to a RL with slope 0.5305 and zero intercept).

The low $\Delta^{17}O$ values of irghizites, elevated contents of Ni, Co, Cr, and Ru, Pt, Pd compared to the UCC, indicate a significant addition of an extraterrestrial matter through a meteoritic projectile. The nature of the projectile for the Zhamanshin Impact Structure have been a matter of debate for a long time [11-15]. Some authors suggested a chondrite [11-13], L or H type ordinary chondrite [14], iron meteorite [11,12], or primitive achondrite [15]. Our new results show that iron meteorite can be unambiguously ruled out (low Cr contents, oxygen isotope data are unlike). Likewise, primitive achondrite (different Ni/Co, Ni/Cr and other elemental ratios than irghizites) and ordinary or carbonaceous CI chondrites (different oxygen isotopic compositions) do not fit the observed data. Very high bulk Ni contents, Ni/Co and Ni/Cr ratios paralleled by high levels of phosphorus, oxygen isotopic composition and presence of organosiloxanes and organosilanes [16] indicate a Ni-rich carbonaceous chondrite as the most likely projectile type for the Zhamanshin impact structure.

References:

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