

GEOCHEMISTRY, HIGHLY SIDEROPHILE ELEMENTS AND RE-OS ISOTOPE SIGNATURES OF IMPACT GLASSES FROM THE ATACAMA DESERT, CHILE. C. Koeberl¹, A. P. Crósta² and T. Schulz¹, ¹Department of Lithospheric Research, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria (christian.koeberl@univie.ac.at) (toni.schulz@univie.ac.at), ²Institute of Geosciences, University of Campinas, R. Carlos Gomes, 250, 13083-855 Campinas, SP, Brazil (crosta@unicamp.br).

Introduction: Existing data on the natural glass occurrences of the Atacama Desert, the atacamaïtes, indicate an impact origin related to a hypervelocity impact and hint at the composition of the impactor [1-5]. Here, we present new geochemical data on the high-siderophile elements (HSE) and Re-Os isotope signatures of these impact glasses based on the analyses of three samples, providing more context regarding the nature and origin of these materials, as well constraining the nature of the impactor.

Previous work: Several thousand glass fragments have been recovered from a ~650 km² area of the Central Depression of the Atacama Desert, in Chile, as reported by [1, 2, and 5]. Glass specimens are black, cm-sized, and mostly spherically or droplet-shaped, some of them with abraded surface due to transport/sand blasting. The atacamaïtes were initially interpreted as tektites by [1], based on shapes, high formation temperature, and low water content. However, [2] used the Fe³⁺/Fe²⁺ ratio to compare them with other tektite occurrences and concluded that they were regular impact glasses, similar to, for example, irghizites. In addition, the compositional heterogeneity and H₂O contents suggest the atacamaïtes to be impact glasses rather than tektites [4]. A meteoritic component in the atacamaïtes was identified by [5], who pointed out similarities and differences between atacamaïtes and known tektite occurrences.

Samples and Methods: A mass of ~0.2 g of homogenized sample powder was spiked with a tracer composed of mixed ⁹⁹Ru-¹⁰⁵Pd-¹⁹¹Ir-¹⁹⁴Pt spike and digested in 7 mL inverse aqua regia (HNO₃-HCl: 5+2 mL) acid mixture at 250°C and 100-130 bars in an Anton-Paar high pressure asher for 12 hours. After digestion, Os was separated from the other HSE using a CHCl₃/HBr liquid extraction procedure. Osmium was further purified using a H₂SO₄/H₂CrO₄ microdistillation technique. After Os extraction, all other HSE were separated. Osmium was loaded as a bromide on Pt Ribbon filaments covered with a NaOH/Ba(OH)₂ activator. The ¹⁸⁷Os/¹⁸⁸Os isotope ratio and Os concentration measurements were carried out at the University of Vienna in negative mode using a TRITON thermal ionization mass spectrometer (TIMS). Mass fractionation was corrected offline using ¹⁹²Os/¹⁸⁸Os = 3.083. Contents of the HSE were

measured using a Thermo Element XR SF-ICP-MS in single collector mode.

Results and Discussion: The bulk trace element composition of the three analyzed atacamaïtes is comparable to values for a larger dataset [5]. Especially, the chondrite-normalized rare earth element (REE) abundance patterns, including the negative Eu anomaly, are within the range reported by these authors (Fig. 1).

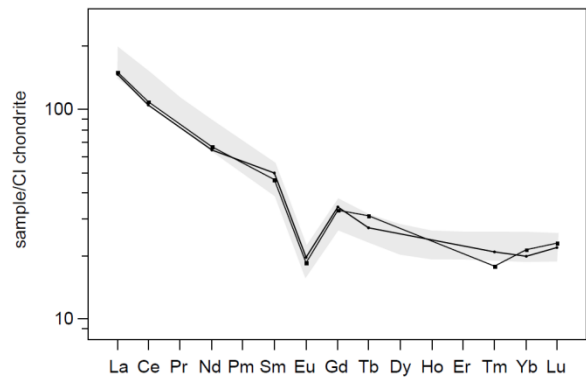


Figure 1. REE abundance patterns of atacamaïte glasses from this study (normalized to CI chondrites; [6]) in comparison to results from [5] - grey shaded area).

The possible nature of the projectile was discussed by [5] based on moderately siderophile element (MSE) enrichments in the atacamaïtes, especially Ni and Co in comparison to suspected target lithologies and correlations between Fe, Ni, and Co contents. A dacitic target was postulated by these authors. Figure 2 summarizes the correlated whole-rock Ni and Co abundances of Atacama glasses. A regression line yielded an average Ni/Co ratio of 12.3, supporting the hypothesized iron meteoritic impactor (most likely of IIAB iron meteorite type). Abundances of Os, Ir, and Pt in one of the analyzed Atacama glasses (A1-BLG) are up to three orders of magnitude higher compared to typical crustal values, strongly supporting a significant meteoritic contribution. Sample A2-DPZ analyzed in the present study has a highly fractionated HSE pattern (Fig. 3) when normalized to CI chondrite abundances, with negative Os and Ir anomalies and elevated Pt (and Re) contents. The Pt concentration is roughly two orders of magnitude higher than that in the upper continental crust (UCC) and can best be explained by a

substantial extraterrestrial admixture. Therefore, the data support a scenario in which a substantial extraterrestrial component of probably IIAB iron meteoritic composition was admixed to the Atacama glass precursor rocks, followed by different magnitudes of I-PGE-loss (Os, Ir, and, to a lesser extent, Ru) within the ejecta plume. As stated above, such a scenario is supported by the observation that meteoritically contaminated irghizites from the Zhamanshin impact structure have similar variations in the magnitude of I-PGE depletion (in conjunction with apparent enrichments in Pt and Pd) that were attributed to impact fractionation [7].

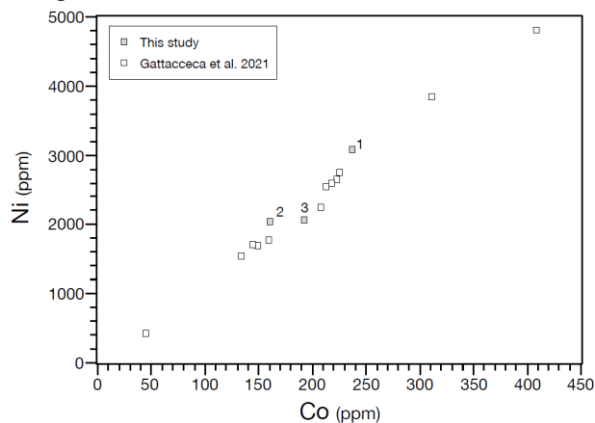


Figure 2. Diagram, showing the correlation of the abundances of Ni and Co in the atacamaites samples, resulting in a rather uniform Ni/Co ratio of ~12, comparable to that in IIAB iron meteorites.

Figure 3 shows the HSE pattern of the analyzed samples from this study in comparison to similar trends for glasses from the Zhamanshin area [7]. Furthermore, the $^{187}\text{Os}/^{188}\text{Os}$ ratios of the analyzed atacamaites provide evidence for a predominantly meteoritic origin of Os in both analyzed samples. Thus, the Os in the analyzed samples can be interpreted to be predominantly meteoritic in origin. The data obtained so far seem to rule out a chondritic impactor and agree much better to an iron meteoritic impactor.

Conclusions: Our results for the HSE and $^{187}\text{Os}/^{188}\text{Os}$ isotope data reinforce the proposal of an impact origin for the Atacama glass. In addition, the IIAB iron meteoritic impactor postulated by [5] is also supported by our data. According to our mixing calculations (which, in conjunction with results provided by [5], based on MSE, rule out high-Os IIA meteorites), we prefer the IIB iron meteorite clan as the most likely impactor material, supporting the 1-5 wt% meteoritic admixture to the atacamaites precursors suggested by [5]. Low Os and Ir contents (UCC-like)

in the least radiogenic atacamaites sample argue for impact volatilization in the ejecta plume, similar to earlier observations made on meteoritically contaminated irghizites from the Zhamanshin impact structure [7].

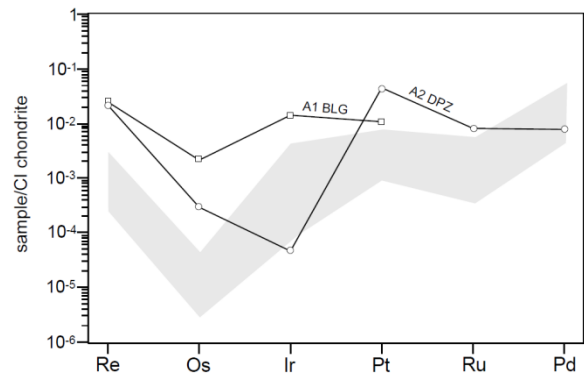


Figure 3. HSE patterns of atacamaites from this study (normalized to CI chondrites [8]) in comparison to results obtained for meteoritically contaminated irghizites from the Zhamanshin impact structure [7] (grey shaded area). Irghizite data illustrate the effect of postulated impact volatilization of Ir and Os in the ejecta plume.

Acknowledgments: P. Rochette is acknowledged for providing the samples used in this study.

References: [1] Devouard B. et al. (2014) *MetSoc 77th Ann. Mtg.*, Abstract #5394. [2] Rochette P. et al. (2015) *Earth Planet. Sci. Lett.*, 432, 381-390. [3] Dos Santos E. et al. (2015) *MetSoc 78th Ann. Mtg.*, Abstract #5074. [4] Koeberl C. et al. (2019) LPSC 50th, Abstract #2132. [5] Gattacceca J. et al. (2021) *Earth Planet. Sci. Lett.*, 569, 117049. [6] Barrat J.A. et al. (2012) *Geochim. Cosmochim. Acta*, 83, 79-92. [7] Jonasova S. et al. (2016) *Geochim. Cosmochim. Acta*, 190, 239-264. [8] Tagle R. and Berlin J. (2008) *Meteorit. Planet. Sci.*, 43, 541-559.