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Spatially resolved geochemistry of K-Pg impact spherules

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Abstract

Using Laser Ablation Inductively Coupled Plasma Mass Spectrometry, we have conducted spatially resolved analysis of trace elements in both pristine, unaltered micro-tektite glasses and their surrounding 'smectite' alteration phase from Chicxulub proximal ejecta deposits (Beloc, Haiti). This approach is unique amongst previous studies, in that it offers the opportunity not only to study in situ the source and admixture of different target precursors, but also the variation of the trace element budget during alteration processes.

1. Introduction

The 200km-sized Chicxulub crater (Yucatan, Mexico), was formed 65 Ma years ago on the northern Yucatan Peninsula [1]. Despite being one of the most studied craters on earth, questions still arise regarding the origin of Chicxulub melt lithologies. In the proximal ejecta deposits all around the Gulf of Mexico, impact melt occurs predominantly in the form of 'glassy spherules' or 'micro-tektites', which are interpreted as droplets of melt that travelled ballistically from the point of impact and quenched rapidly during flight. In most localities, spherules are severely altered. Pristine, unaltered glass is very scarce and is rarely found in the center of a smectite/chlorite shell [2, 3, 4]. For the Chicxulub crater, glass is best preserved in the Beloc locality (Haiti), and to a smaller extent in El Mimbral and La Lajilla (NE Mexico). Although the micro-tektite glass has been shown to be heterogeneous even on the µm-scale, geochemical data have solely been reported from bulk samples. In addition, previous work has shown that the 'smectite alteration' phases exhibit depleted, almost complete flat CI-normalized REE patterns [3,4]. Although this depletion is generally considered to result from alteration processes [3], some authors [4] have suggested this to represent the condensed silicate fraction of the Chicxulub bolide.

2. LA-ICP-MS on relict and altered glass

We have used a New Wave Research UP193HE ArF* excimer-based laser ablation system coupled to an Element XR (Thermo Scientific) double-focusing sector field ICP-MS to measure *in situ* the trace element content in Beloc glasses (Haiti) and their surrounding alteration rims. We focussed on both rare earth elements and siderophile elements (including Cr, Co, Ni, Cu, Pt, Ir and Au). Small laser spot diameters (30 and 55µm) were chosen to test if both quantitative and spatially resolved information could be obtained. Quantification was achieved by external calibration using certified reference glasses (NISTSRM612, BHVO-2G, GSD-1G, and GSE-1G).

3. Results

Despite small laser spot size, in most samples, sensitivity was large enough to extract quantitative information. All Beloc-glasses analyzed in this study yield CI-normalized REE patterns which resemble those of the continental crust, confirming existing data from bulk samples [4].
For most of the 'smectite' alteration phases we analyzed, our data also yield depleted, almost flat CI-normalized REE patterns. However, parts of the altered 'smectite' shells exhibit REE patterns which - though depleted some orders of magnitude, still reflect the (crustal) signature of the original glass phase.

4. Summary and Conclusions

Our data provide insight into the progressive alteration of tektite glasses and suggest that the presence of a less mature alteration phase of the glass may still yield information on precursor lithologies. This may have important implications for extrapolating this research to the K-Pg spherule layers in NE Mexico, where pristine glass is extremely rare. Major element data indicate that (mostly altered) spherules have a more Mg-Fe-(K)-rich composition, which could either point to a more mafic precursor [5] or alteration. We are currently analyzing pristine and partly altered glasses, and associated Mg- Fe-K rich altered spherules from NE Mexico localities (Mimbral), to constrain the nature of the glasses (melts) expelled from different quadrants in the source crater.

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