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Magnetic properties of tektites and other related impact glasses

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ABSTRACT

We present a comprehensive overview of the magnetic properties of the four known tektite fields and related fully melted impact glasses (Aouelloul, Belize, Darwin, Libyan desert and Wabar glasses, irghizites, and atacamaites), namely magnetic susceptibility and hysteresis properties as well as properties dependent on magnetic grain-size. Tektites appear to be characterized by pure Fe^{2+} paramagnetism, with ferromagnetic traces below 1 ppm. The different tektite fields yield mostly non-overlapping narrow susceptibility ranges. Belize and Darwin glasses share similar characteristics. On the other hand the other studied glasses have wider susceptibility ranges, with median close to paramagnetism (Fe^{2+} and Fe^{3+}) but with a high-susceptibility population bearing variable amounts of magnetite. This signs a fundamental difference between tektites (plus Belize and Darwin glasses) and other studied glasses in terms of oxygen fugacity and heterogeneity during formation, thus bringing new light to the formation processes of these materials. It also appears that selecting the most magnetic glass samples allows to find impactor-rich material, opening new perspectives to identify the type of impactor responsible for the glass generation.

1. Introduction

Magnetic properties provide a rapid and versatile technique to characterize non-destructively the composition of rare materials in terms of content of magnetic elements (mostly Fe, but also Mn, Cr, Ni, and other trace magnetic elements), as well as oxidation state and distribution of these elements among various phases. Such an approach has been exemplified in meteorites (e.g., Rochette et al., 2008, 2012) where magnetic properties, mostly susceptibility, have been used for classification purposes. Magnetic measurements allow to screen large collections, in museums in particular, and to single out anomalous samples worth of further investigations.

High velocity impacts on Earth are able to generate high temperature melted material that can be subsequently ejected away from the crater and quenched as natural glasses (Dressler and Reimold, 2001). These impact glasses have specific composition and properties with respect to volcanic glasses, due to the nature of their source materials and high temperature and pressure formation conditions. Tektites have been identified as a specific type of natural glass, obsidian-like but unrelated to volcanism (Suess, 1900; Koeberl, 1986; Glass, 1990; McCall, 2001). Tektites are homogeneous materials made only of glass, not or poorly vesiculated, that can be found geographically spread over a large strewnfield (500–5000 km size range). The natural shape of tektites usually demonstrates flight in liquid state in the atmosphere (splash-forms). Initial examples were the central European moldavites and the Australasian tektites (Suess, 1900), but soon two other strewnfields were identified, in Ivory Coast and North America (Glass, 1990; Koeberl et al., 1997). An impact origin has been established based on various arguments, including connection with large (>10 km diameter, see Table 1) impact craters (except in the Australasian case). Besides these four canonical examples, a fifth central American strewnfield has been proposed (e.g., Povenmire and Cornec, 2015), originally named Tikal glass (Sentfle et al., 2000), although its characteristics are not as well defined as for the other four cases. Here is it will be named Belize glass as hundreds of specimens have been found in soils from this country. No consensus has been reached yet to rank the Belize glass among tektites. However, it yields redox state and water content typical

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