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The first polish tektites: preliminary SEM investigation

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ABSTRACT.

In Lower Silesia, the first Polish moldavites were discovered. To recognize the primary chemical composition and check the morphology of investigated material SE and BSE images were used. The samples show presence of vesicles, which are one of the most typical features of tektite glass. Referring to the preliminary EDS results and comparing them with literature data, it can be assumed that in all cases the base material for all known moldavites was the same.

Introduction

The production of impact melt rocks and glasses is a diagnostic feature for impact identification. Their presence, distribution, and mineralogical characteristics have provided valuable information on the cratering process (e.g. Dence 1971; Grieve et al. 1977; Grieve & Cintala 1992). A wide variety of impact melt products may be found within and around impact craters: 1) crystalline melt bodies in the impact structure; 2) glassy clasts in melt-bearing breccias or suevites, within and outside the structure; 3) injection dykes in the crater floor and walls; 4) distal ejecta (e.g. tektites). The majority of these lithologies represents whole rock melts formed during the shock-induced melting of target rocks in a zone beneath the impact point (Osinski 2003). Impact melt glass may resemble volcanic glass in appearance; however, several properties can be used to distinguish the two: 1) chemical compositions of impact glasses typically match individual lithologies or mixtures of different rock types present in the target sequence (e.g. Dence 1971; Grieve 1975; Grieve et al. 1977); 2) the widespread presence of lechatelierite in impact glasses indicates temperatures far above those of

normal igneous processes ($>1713^{\circ}\text{C}$; Stöffler 1984) and 3) abundant inclusions of shocked mineral and lithic fragments are present in impact glasses (e.g. Engelhardt 1972; Grieve et al. 1977).

Impact glasses from the Ries impact structure have been the subject of many investigations over the last several decades (e.g. Engelhardt 1967, 1972; Engelhardt et al. 1995; See et al. 1998; Vennemann et al. 2001).

Nowadays, only four tektite strewnfields are recognised (Koeberl 2007 and references therein): Central European, North American, Australasian as well as Ivory Coast. The source structure of the first one impact is crater Ries located in Germany, which was dated c.a. 15 Ma.

Results of Stöffler et al. (2002) investigation (see also Artemieva 2002) presents a pattern of moldavite strewnfield in Central Europe. Based on experimental studies simulation of the impact Stöffler suggested, that moldavites may be found up to about 525 km from the crater, but this was not confirmed until the Polish discovery of moldavites in late Miocene sediment, Lower Silesia.

Material & Methods

Two pieces of moldavites were used for further studies. The first piece of the tektites has 0.027 g (Fig. 1A) and the second 0.1651 g (Fig. 1B). In transmitted light, tektites show a light green color. The present-day shape of the tektites is not only the result of their formation caused by impact, but depends on secondary processes as e.g. weathering, transport, etc. Therefore, Baker (1963) divided the evolution of shapes into three stages. First of all, the separate bodies of tektites were formed and cooled. In the second, so-called ablation phase, the shapes were changed by melting of front solid parts during the flight of tektites

through the atmosphere. This phase, however, did not take place in most of the tektites. In the third phase, after falling on Earth's surface, various geological processes finished the morphology of the tektites (see discussion: Trnka & Houzar 2002).

Morphology and preliminary chemical composition of the Polish moldavites was checked by using scanning electron microscope Philips XL30 ESEM/TMP equipped with EDS (EDAX type Sapphire) detector at the Faculty of Earth Sciences, University of Silesia.

SEM investigation

The SEM study shows that surface of tektites, especially the bigger one is corroded. The corrosion is an effect of interaction of the tektite with water and humic substances in the soil (Koeberl et al. 1988). The samples show abundant vesicles varying in size from less than $10\ \mu\text{m}$ up to $200\ \mu\text{m}$ (Fig. 1C-F). Most of the vesicles are elongated. Occurrence of vesicles is one of the most typical features for tektite glass. Most authors considered the formation of bubbles

as a result of internal gas pressure during tektite cooling in environment where the external pressure was very low (e.g. Suess 1951; Chao 1963). In fact, several mechanisms of bubble formation may have been involved. As a result of this, even a single tektite sample may contain several populations of bubbles formed by different mechanisms and containing gases of different compositions and pressures (Jessberger & Gentner 1972; see discussion at Zak et al. 2012).

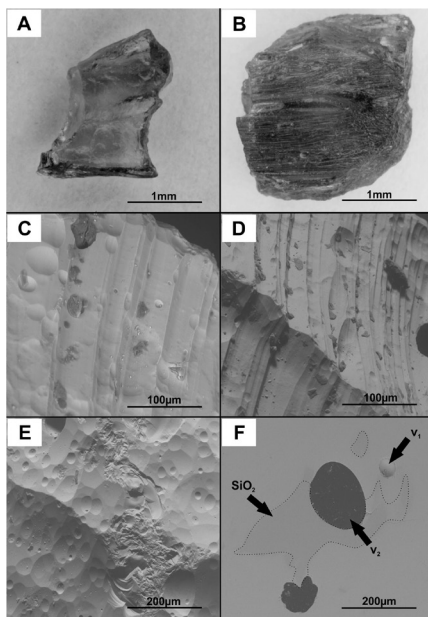


Fig.1. Polish moldavites. A, B) Macroscopic images of studied tektites; C, D, E) The surface of studied moldavites with visible vesicles; F) Lechatelierite inclusions in polish thin section with two types of vesicles: v1 – "empty" vesicles, v2 – vesicles fill in epoxy.

The chemistry of moldavites, like all tektites and impact glasses, was therefore interpreted as a result of melting and incomplete mixing of several components (Magna et al. 2011). The moldavites form the most acidic group of tektites, with SiO₂ contents about 80 wt% (Trnka & Houzar 2002).

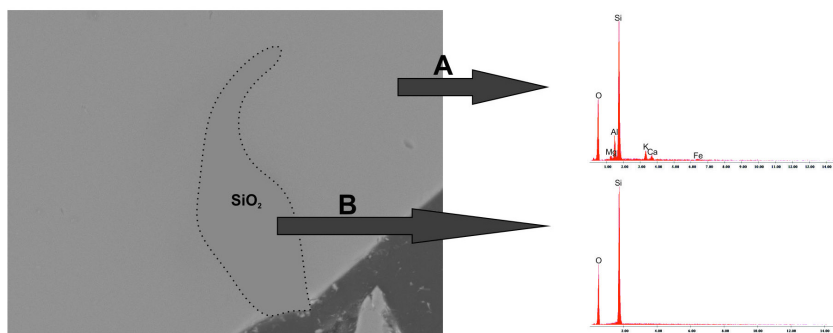
EDS analysis shows that Polish moldavites have relatively high and low content of SiO₂ and Fe, respectively (Fig. 2A). As it was documented by numerous papers (e.g. Engelhardt et al. 2005) despite the close similarity of the chemical composition in terms of the major element contents (Si, Al, Fe, Mg, Ca) of moldavites from different substrewnfields, there are some significant differences in trace element contents, which bind to different source rocks (see discussion at Randa et al. 2008). Substrewnfields are partial areas, that represent a combination of the original distribution in the strewnfield and the subsequent removal and redistribution of moldavites by fluvial erosion and transport. Rare finds of moldavites beyond the limits of the major substrewnfields represent either samples transported by surface fluvial processes over a long distance or very small remains of other original substrewnfields

(Trnka & Houzar 2002; Zak 2009). According to Randa et al. (2008) similar contents of Mg and Ca are evidence of a carbonate origin of source rocks. The low content of these elements may also be evidence of signature of the ash component. High content of Al was no doubt dominated by the clay component (Randa et al. 2008). It can be preliminary suggested that carbonates with lenses of clay and small amount of ash were source rocks of Polish moldavites.

Lechatelierite is present in all samples and occurs mostly in irregular and elongated inclusions (Fig. 1F). The structure of the lechatelierite in the moldavite glass is an indicator for rapid and irregular glass flow during an early formation stage (Koeberl et al. 1988). Other mineral inclusions are lack in the samples. The amount of lechatelierite depends on the temperature conditions of origin. Higher temperature caused a lower abundance of lechatelierite in Czech and German moldavites (Barnes 1969; Konta 1971a; Lange 1995). Lechatelierite in moldavites is represented by very pure silica (Fig. 2B). Chemical analyses show SiO₂ contents of above 99 wt.% (Knobloch 1997).

Summary

Fig. 2. EDS spectrum for: A) Glass from Polish moldavite, B) Lechatelierite inclusion in moldavite, represented by pure silica.



The discovery of moldavites in Poland shows that the strewnfield in Central Europe is not confined to the Czech Republic, Austria and Germany but extends further to north-east than previously assumed (Stöffler et al. 2002). EDS analysis of Polish moldavites compared to literature shows a close similarity with other moldavites. This clearly confirms their impact origin. Pre-estimated source rocks of Polish moldavites may have been carbonates with clay minerals. The main aims of further studies are description of moldavite distribution in south-west Poland and chemical as well as isotopic characterization of the new tektites.

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