A New Moldavite Sub-Strewn Field in Lower Silesia, Poland

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Introduction: Traditionally, the Central European tektites (CETs) a.k.a. moldavites occur in several small areas (sub-strewn fields) reflecting the paleogeography at the time of impact as well as further geological history of the area. These regions include south Bohemia and western Moravia [1, 2], Austria [3], Lusatia [4] and the Cheb Basin [5]. In addition to these larger accumulations several scattered finds were also reported [6–8]. None of these moldavite occurrences exceeds the distance of ~420 km from the center of the Ries crater – the parent impact structure of CETs. Recently, Brachaniec et al. [9–11] found moldavites at three localities in Lower Silesia, Poland: sandpits close to villages Rusko and Mielęcin SW of Wrocław, and sandpits in Gozdnica, NW of Jelenia Góra. The former two occurrences are located at a distance of about 475 km from the Ries crater center significantly extending the entire CET strewn field (***Fig. 1***). Brachaniec et al. [9–11] reported electron microprobe analyses for several of the found moldavites, limited to the determination of the major elements, and based on them together with the mass and size distribution of individual finds they concluded that Polish moldavites were re-deposited from the Lusatian sub-strewn field by fluvial transport in Late Miocene.

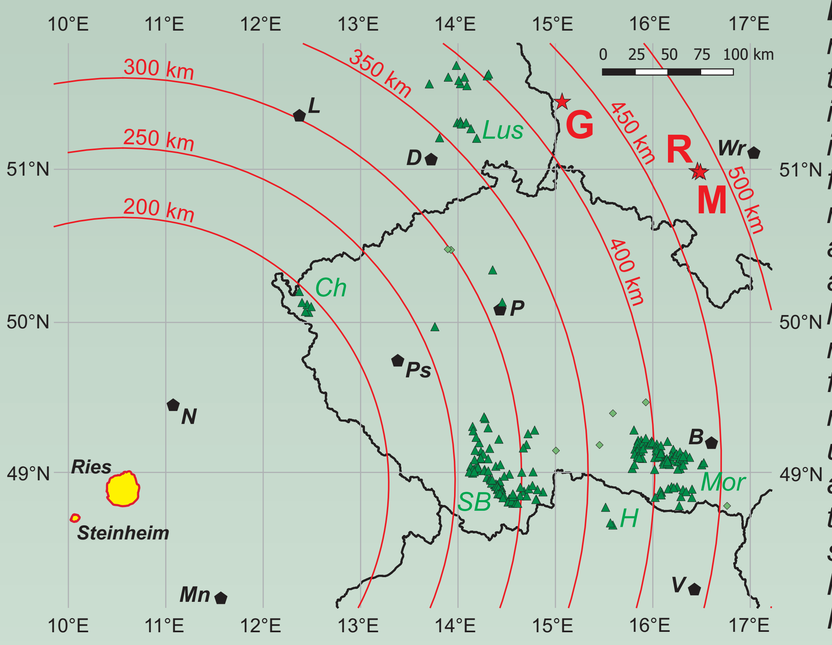


Fig. 1. *Map of Central Europe illustrating the distribution of major moldavite localities. Red stars indicate Polish localities with moldavite finds: R = North Stanisław near Rusko, M = Mielęcin and G = Gozdnica. Green triangles show locations of selected moldavite occurrences across CET strewn field whereas light green diamonds stand for uncertain or unconfirmed finds. The Ries and Steinheim impact structures are also shown. Sub-strewn fields: Ch = Cheb, H = Horn, Lus = Lusatia, Mor = Moravia, SB = South Bohemia.*

Goals: Since the importance of the finds of CETs in Poland for delineating of the strewn field we decided to collect major-, minor-, and trace-element data for a fragment of one moldavite from sandpit near Rusko (sample NS-4). When compared with existing datasets from other sub-strewn fields these new data complemented with the critical revision of local stratigraphy and paleogeography may help to constrain the origin of Polish moldavites, i.e., if they were transported from the Lusatian sub-strewn field as suggested in [9–11] or if they were deposited here directly at the time of impact forming a new separate sub-strewn field.

Methods: The sample surface as well as polished thin section were imaged using a scanning electron microscope TESCAN VEGA 3XM. Major-element data were collected with a CAMECA SX-100 electron probe microanalyzer. Trace-element concentrations were determined on a polished thin section using a high-resolution Thermo Finnigan Element 2 ICP-MS coupled to a 213 nm Nd:YAG laser ablation system UP-213 (New Wave Research).

Results: The surface of the sample displays marked sculpturing (***Figs. 2a,b***). The polished section reveals presence of numerous bubbles and lechatelierite inclusions (***Fig. 2c***). The specimen is chemically heterogeneous with overall fluidal fabric (***Fig. 2d***). Two types of glass are present (***Fig. 3***). The high-Si (76–82 wt. % SiO_2) low-Ca–Mg glass volumetrically dominates whereas the low-Si (~74 wt. % SiO_2) high-Ca–Mg glass is present as thin schlieren. The majority of analyses presented here matches common compositions of moldavites from other sub-strewn fields. The low-Si high-Ca–Mg schlieren, however, are a rather unique group at the edge or even outside the compositional fields defined by ~5000 electron-microprobe analyses of moldavites from other parts of the CET strewn field. Such a composition is duplicated by only several analyses of South Bohemian moldavites.

Chondrite-normalized REE patterns of the specimen match South Bohemian and Cheb Basin moldavites. The spiderplots demonstrate considerable enrichments in Cs, Rb and Li and substantial depletion in W, Pb, Sr, P, Sn, Sc, V, Zn, Cu, Co, Cr and Ni compared to UCC (***Fig. 4***).

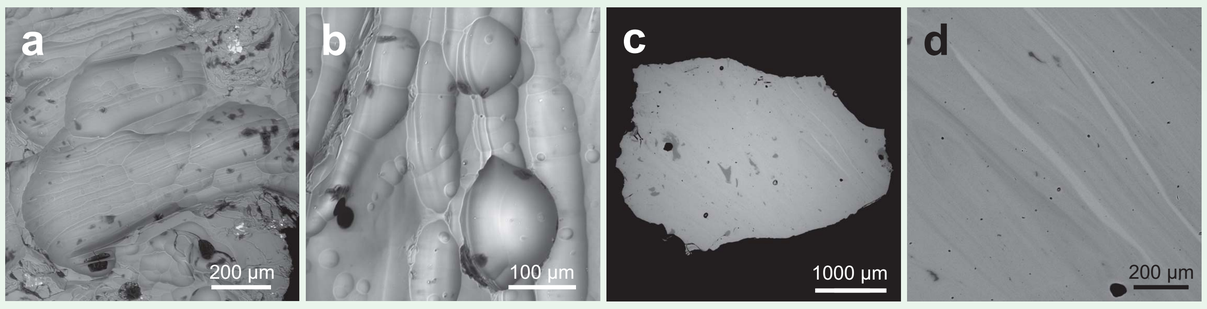
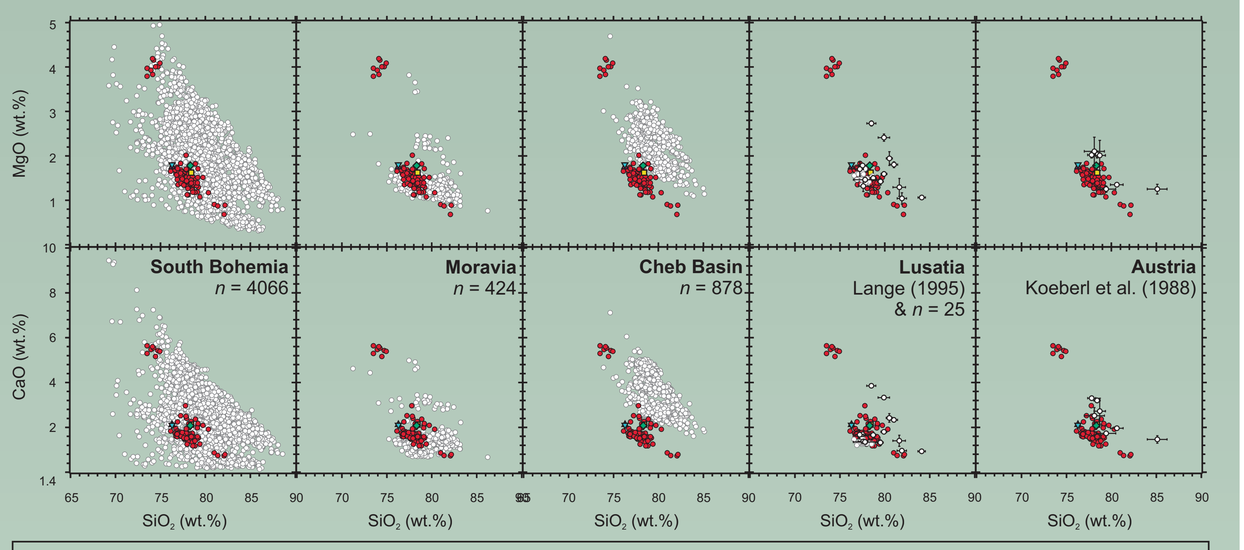
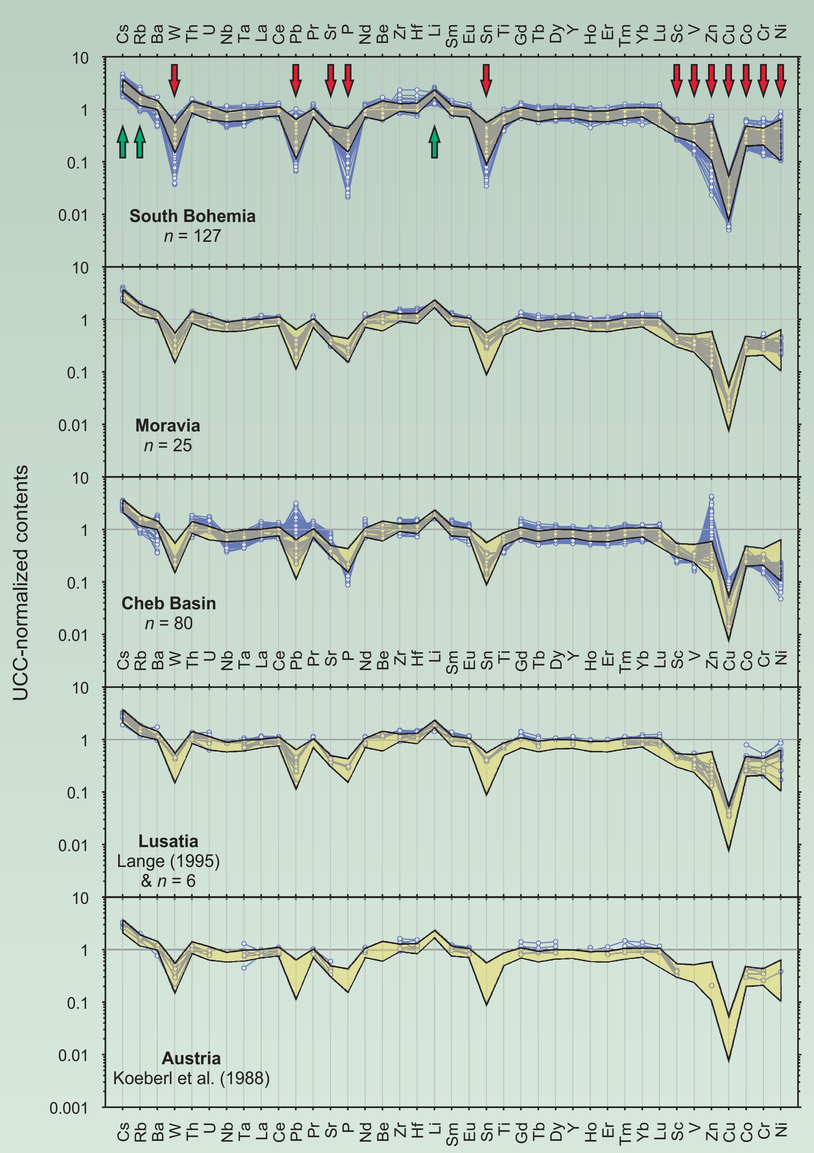


Fig. 2. *Scanning electron microscope images of the surface (a,b) and polished section (c,d) of the moldavite from the North Stanisław sandpit. Some larger pits are possibly relics of former bubbles and may show fine striation on their walls highlighting the overall fluidal fabric (a). Youngest sculpturing is formed by small circular flat depressions mostly less than 5 µm in diameter (b). BSE image of the entire area of the studied polished section illustrates the distribution of lechatelierite inclusions and the overall fluidal fabric (c); detail of fluidal fabric with bright high-Ca–Mg lamellae is shown in (d).*





▲ ***Fig. 3*** *The high-Si-low-Ca–Mg and low-Si-high-Ca–Mg chemical glass compositions of the NS-4 moldavite illustrated in Harker diagrams. Shown for comparison are data presented for other Polish moldavites [9-10], Lusatian moldavites [4], and Austrian moldavites [3]. Data for South Bohemian, Moravian, Cheb and partly Lusatian moldavites either come from Skála et al. [13] and Di Vincenzo and Skála [14] or they represent unpublished authors' analyses.*

◄ ***Fig. 4.*** *Upper continental crust-normalized contents of minor and trace elements in the NS-4 moldavite (yellow field) compared to data for moldavites from the classical sub-strewn fields (light blue circles and connecting lines). Red arrows indicate elements substantially depleted in the sample compared to UCC contents, green arrows denote enriched elements. Data for comparison are from the same sources as those in Fig. 3.*

Discussion: Lange [4] and Bouška et al. [12] showed that the effective transport of tektites in water streams is limited to less than 10 km. Clearly, the Polish moldavites could have hardly resisted re-deposition from Lusatian sub-strewn field for over at least 50 km in case of Gozdnica locality or >160 km in case of Rusko and Mielęcin. In addition, neither in the Late Miocene nor in the Pliocene there was a river heading from Lusatia to Lower Silesia that might have potentially transported moldavites. There are solely fluvial deposits of river courses heading to the North.

Conclusions: The chemical composition does not allow unambiguously linking the Polish moldavites to any other existing CET sub-strewn field. The morphological character of Polish moldavites and paleogeography of Central Europe in the last 15 Ma suggest that they represent pieces fluvially re-deposited from a new so far unknown separate sub-strewn field located south of the place of their recent occurrence.

Acknowledgements: This research was supported through the Czech Science Foundation (GACR) project No. 13-22351S, the Institute of Geology of the CAS Research Plan RVO67985831, and the Polish National Science Centre grant No. 2014/13/N/ST10/04921.

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For details see: DOI: 10.3190/jgeosci.214