Moldavite from Chlum, Czech Republic: Mining and Gem Properties

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ABSTRACT: One of the most well known and popular natural glasses is moldavite, which formed during a meteorite impact about 14.8 million years ago. Today, moldavite is mainly obtained from the Czech Republic. In spring 2022, the authors visited the largest mine currently in operation, a sand-and-gravel quarry near the small village of Chlum in the southern Czech Republic, where moldavite is found as a by-product. This article reviews the formation and distribution of moldavite, gives an overview of current mining activities and reports the gemmological characteristics of samples collected by the authors.

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Tektites (from the Greek *tektos* = molten) are natural glasses that formed by meteorite impacts on the earth's surface. One of the most well-known tektite varieties is moldavite (Figure 1), which is named after the main occurrence along the Vltava (or *Moldau* in German) River in the Czech Republic. This tektitic glass originated during a meteorite impact around 14.8 million years ago in the region of today's Nördlinger Ries in Germany (Schmieder *et al*. 2018). The impact created temperatures that melted the rocks on the surface and blasted the glassy droplets eastward over 400 km to the upper reaches of the Vltava River and into Moravia in today's Czech Republic. Occasionally, moldavites have also been found in Austria, Germany and Poland (Brachaniec *et al*. 2014; Schmieder *et al*. 2018).

Moldavite has been used by humans since prehistoric times, as sharp-edged pieces for numerous tools and as amulets. The earliest finds were in Austria in the Gudenus cave near Krems, as well as near Willendorf; they date back to Palaeolithic time (Bayer 1921).

During the modern era, moldavite was particularly popular during the Art Nouveau period (1890–1910). Subsequently interest declined, coincident with the increased use of green bottle glass as an imitation. Later, during the early 1950s and 1960s, moldavite experienced a renaissance as a gem and collectable material, which spurred exploration to discover additional mining sites in what is today the Czech Republic. As a result of this geological survey, the sand-and-gravel layers near Chlum nad Malší (hereafter,

Figure 1: This moldavite shows a valuable 'hedgehog' shape and comes from the Besednice locality in the South Bohemian Region of the Czech Republic. Photo by Jan Loun.

Figure 2: The main moldavite deposits in the Czech Republic lie in the southern part of the country in the regions of South Bohemia and South Moravia. Moldavite occurrences are also known in Germany, Austria and Poland. Map adapted from Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Czech-regions.svg).

simply 'Chlum'; Figures 2 and 3) in the South Bohemian Region were identified as a source of moldavite (Bouška *et al.* 1985).

Today, a large sand-and-gravel pit is actively being operated near Chlum, and moldavite is recovered there as a by-product. In addition, another smaller quarry was opened in 2022 just north of the nearby village of Besednice, where moldavite is the only product that is mined (Dr Vít Kršul, pers. comm. 2023).

In May 2022, the authors had an opportunity to visit the Chlum deposit in order to witness the mining process and collect samples. In this article, we review the formation of moldavite and its main localities, and then examine the current mining techniques and describe the results of our examination of the collected samples.

MOLDAVITE FORMATION

Moldavite most likely originated during the meteorite impact responsible for the Nördlinger Ries crater in Bavaria, Germany. This crater formed approximately 14.8 million years ago, during the Miocene (Bouška & Konta 1999; Böhme *et al.* 2002; Di Vincenzo & Skála 2009; Schmieder *et al.* 2018; Schwarz *et al.* 2020). Gentner (1971) performed age determination using the K/Ar method, and showed that moldavite and the Ries event both have the same age, thus linking their origins. Graup *et al.* (1981) geochemically identified the pre-impact sediments as upper freshwater molasse (i.e. terrestrial clastic sedimentary rocks).

According to Pösges and Schieber (2009), the Ries crater resulted from the impact of a meteorite with a diameter of around 1 km that hit with a speed of about 70,000 km/h, corresponding to the energy of 250,000 Hiroshima bombs. The impact body and the surrounding rock were compressed to about a quarter of their previous volume, creating a pressure of 4 Mbar and temperatures up to 30,000°C. Melted rock materials were ejected from the crater, and a mushroom-shaped ash cloud formed to a height of 100 km. A total of 1,000 km^3 of material was moved by the impact, with 150 km^3 of rock ejected ballistically at up to 25 times the speed of sound. While in flight, the ejected molten rock droplets cooled rapidly and solidified into a glassy substance (moldavite) that was thrown as far as 400 km eastward in the direction of today's Czech Republic. The resulting crater had a diameter of about 15 km and an original depth of 4 km, but it filled relatively quickly due to gravitational collapse that occurred during subsequent basement uplift and displacement by vertical and lateral movements (see also Stöffler *et al.* 2013).

MOLDAVITE DEPOSITS AND MINING

The moldavite deposits are located in southern Bohemia, western Moravia and the Cheb Basin in the Czech Republic, Lusatia in Germany, Waldviertel in Austria (Trnka & Houzar 2002; Hanus 2016) and Lower Silesia in Poland (Brachaniec *et al.* 2014). The largest deposits

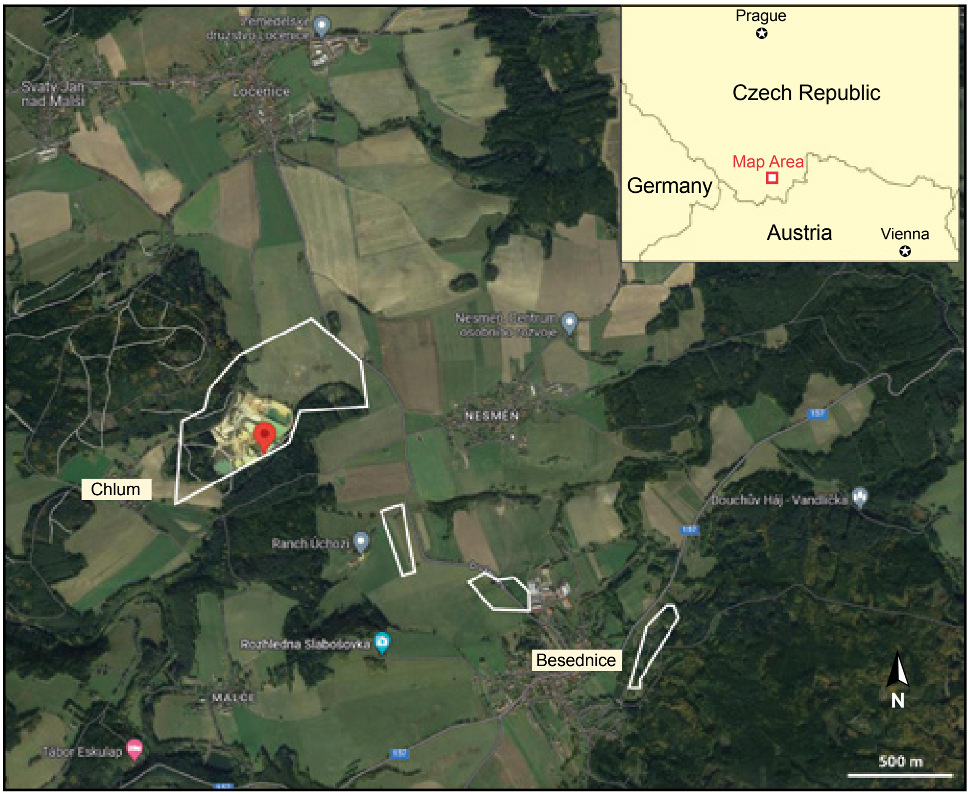

Figure 3: This satellite image (from Google Maps) shows the locality of the sand-and-gravel quarry (red pin) near Chlum. The additional white outlines indicate officially recognised moldavite deposits in the Chlum-Besednice area (taken from a map supplied by Dr Vít Kršul, July 2023). The illegal mining pits mentioned in this article were seen in the forest at the top-centre of the image.

are spread over the regions of South Bohemia and South Moravia (Figure 2).

The most important moldavite deposits form a belt of separate occurrences between Písek and Nové Hrady (again, see Figure 2). The stones were concentrated by gravity and water on the south-west margin of the South Bohemian basin. They occur in sedimentary deposits such as the Koroseky sands and gravels (KSG) in southern Bohemia (e.g. Chlum; see Figure 4) and the Vrábče beds (VB; Trnka & Houzar 2002). The dating of individual sedimentary deposits that contain moldavite is a matter of debate, as are the topographical, morphological and chronological connections among the sites. The deposition of the moldavite-bearing sediments possibly occurred during the Pliocene and early Pleistocene (Bouška & Konta 1999), but the Miocene is often mentioned (Trnka & Houzar 2002). Most of the sediments are colluvial-fluvial sandy clays and/or clayey sands, which fill stream depressions and ravines or form dejection cones. Their thickness is usually around a few metres. The main components of these sediments are quartz and feldspar. At the Chlum site, there is a broader association of moldavite with gravel layers containing 'heavy minerals' such as zircon, rutile, leucoxene and kyanite, while those discovered at Besednice include andalusite, tourmaline and kyanite (Trnka & Houzar 2002).

Various shapes and morphologies are typical for moldavite from different localities. Stones from the KSG deposits in southern Bohemia (e.g. Chlum and Besednice) appear to be less rounded than those from northern KSG locations such as Koroseky. The average weight of VB stones is approximately 2 g, whereas KSG moldavites tend to be larger. Alluvial transport of the moldavite from the original point of impact affected the size and, often, shape of the material. This transport effect can also be observed on coexisting quartz pebbles, which vary from angular fragments to rounded shapes (Trnka & Houzar 2002). This leads to the assumption that the KSG deposits are a polygenetic formation that includes material of different origins. Moldavite from the VB deposits typically shows deeper surface corrosion lines and depressions formed by the chemical action of groundwater in an acidic, permeable environment. A simplified explanation is that after deposition in the host sediments, the less-resistant zones of the moldavite surfaces experienced greater etching due to the influence of differently saturated waters (see Bouška *et al.* 1985).

Thus, the overall shape of moldavite pieces results from a combination of the original fragmentation of the melt, aerial flight, alluvial transport and, finally, post-depositional chemical etching. A rare and quite valuable shape of moldavite from the Besednice locality resembles that of a hedgehog (again, see Figure 1), which mainly results from post-depositional chemical etching. The distinctive surface features of many moldavites are especially useful because careful observation of them

Figure 4: (**a**) The sand-and-gravel quarry near Chlum is expansive. The sediments lie on top of gneissic bedrock (exposed as the dark area on the far side of the smaller pit to the left). (**b**) Mining involves the use of excavators and trucks. A claystone horizon (indicated by the arrow) forms a darker brown layer in the pit wall in the foreground. (**c**) Moldavite is found in subhorizontal gravel layers. (The vertical lines are from the excavator used to mine the sediments.) Photos by T. Stephan.

can help distinguish genuine moldavite from the many glass imitations (e.g. Tay 2007; Tay *et al*. 2008; Hyršl 2015; Hanus & Hyršl 2018).

Today, moldavite specimens are housed in various museums, research facilities and private collections worldwide. The world's largest public collection of moldavite is found at the National Museum in Prague (see Box A).

Moldavite Deposit near Chlum

The small village of Chlum nad Malší is located about 200 km south of Prague (Figure 2). North-east of the village is a quarry where sand and gravel are mined (again, see Figures 3 and 4). The approximately 700 × 400 m pit contains several layers of sand and gravel, tens of metres thick, lying on gneiss bedrock. The sand-and-gravel layers are crossed by a claystone horizon at several metres depth, but which does not run horizontally throughout the deposit. Moldavite is always found above this horizon.

The sand-and-gravel layers are dug with excavators and taken by trucks to a nearby washing plant. There the material is transported by conveyor belts to various washing and sieving stations for sorting into different grain-size fractions for industrial uses (Figure 5a). After removing the smaller fractions, the moldavite is hand-picked at an intermediate facility (Figure 5b), which we were not allowed to visit.

According to the on-site geologist, about 100,000–150,000 tonnes of sand and gravel materials are mined annually from the quarry. The average moldavite recovery is 2.5–3 g/tonne, although the grade of the different horizons varies. Most of the moldavite specimens weigh 0.1–15 g each, but about 20% of them are larger.

On the day of our visit, we were allowed to search a particular area of the pit to a depth of about 5 m below the surface. The sand layer in this area was interspersed with several coarser-grained gravel horizons with clast sizes up to about 1.5 cm (Figure 6). We found moldavite specimens in these layers, and also on the surface, especially along the transportation routes of the trucks. Within 90 minutes of searching, we collected about 150 g of moldavite samples, consisting of fragments of

BOX A: MOLDAVITE IN THE NATIONAL MUSEUM OF THE CZECH REPUBLIC

The National Museum in Prague contains the largest public collection of moldavite in the world. Currently, its tektite collection includes 20,702 moldavite specimens from South Bohemia and 1,988 samples from Moravia. It is valuable not only for the great number of specific localities represented (140), but also for showing such extensive variability in morphology, colour and size. Here we review the history and the most interesting moldavite specimens in the permanent exhibition there, as well as some samples that are stored in depositories. Another (private) moldavite museum is located in Český Krumlov, close to the moldavite deposits, and is highly informative.

The tektite collection of the National Museum was founded in 1930 by the purchase of František Hanuš's collection of about 6,000 moldavites of excellent quality from Bohemian and Moravian localities (Velebil 2020). Until then, the museum had only a few moldavite specimens, including the oldest documented one in the collection: a 38 g specimen from Dolní Chrášťany that was acquired by Josef Kořenský (1847–1938). This moldavite is curiously perched on a flat pebble with which it was allegedly found (Figure A-1). An open cavity on one side of the moldavite is apparently the remnant of a large gas bubble.

In 1936, the purchase of 350 moldavites from Arnošt Hanisch of Třebíč expanded the National Museum's collection significantly with specimens from Moravia. In subsequent years, additional Moravian moldavites were purchased from collectors J. Fiala and J. Krejčí, also of Třebíč. It is important to realise that, at this time, moldavites were mostly regarded as mere glass, so they did not become very valuable until the mid-1960s. This is why the collection continuously added fine specimens (e.g. Figure A-2) during most of the twentieth century, including the acquisition of 1,972 moldavite specimens collected in 1972–1974 by B. Hrabě of České Budějovice. In the following decades—during the 1980s and especially after the millennium—donations and purchases of moldavites from collectors and mining companies became less frequent. Nevertheless, one of the most valuable of these donations took place in 2005 by collector S. Langer, who provided 16 Moravian moldavites, including some relatively large specimens.

Figure A-1: The oldest documented moldavite specimen in the National Museum's collection is a 38 g specimen from Dolní Chrášťany, sitting on a pebble. Reportedly, the piece was found like this. Collection of Josef Kořenský; photo by D. Velebil.

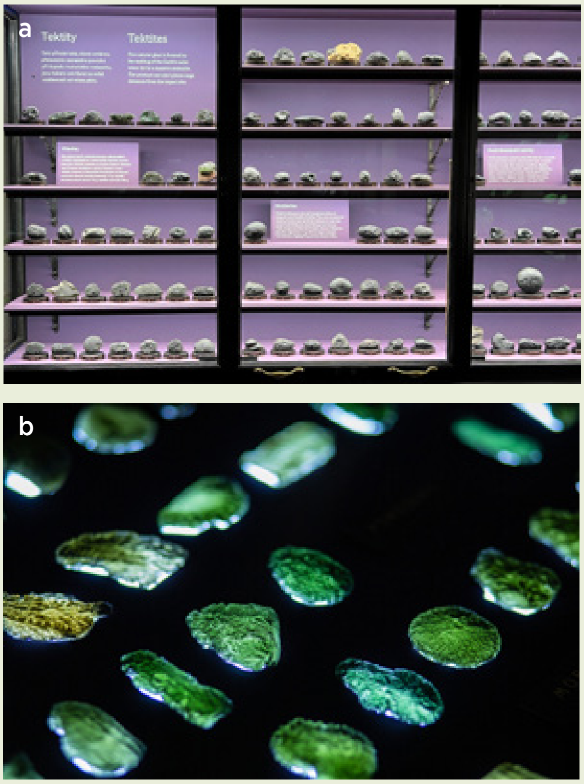

Figure A-2: (**a**) Many of the moldavites at the National Museum are displayed in their original showcases, which have been restored. (**b**) The backlit specimens seen here are a small sample of the more than 20,000 moldavites in the museum's collection (image width approximately 13 cm). Photos by L. Zahradníček.

The National Museum's best moldavite specimens are on display in its Hall of Meteorites (e.g. Figure A-2). The largest South Bohemian moldavite in the collection is a 111 g specimen from Strpí, near Vodňany (collection of B. Hrabě, 1972). The largest Moravian moldavite in the collection weighs 235 g (collection of S. Langer, 2005) and comes from Kožichovice. The next largest Moravian moldavites are also from Kožichovice: 147 g (collection of A. Hanisch, 1942), 124 g (collection of S. Langer, 2005) and 104 g (collection of K. Žebera, 1980). Three noteworthy moldavites in the National Museum's collection were found (and thoroughly documented) in Central Bohemia: two came from the Kobylisy sand quarry in Prague, and the third came from another sand quarry in Jeviněves near Mělník. These are extremely uncommon localities for moldavite.

Moldavite most likely initially became popular during the Land Jubilee Exhibition in Prague in 1891, which featured a display of jewellery set with faceted moldavite and complemented with pearls from the Vltava and Otava rivers. Unfortunately, interest in faceted moldavite promptly declined because jewellery manufacturers in the 1890s did not take the gem seriously. In addition, they often confused moldavite with cut green bottle glass. Because of this, there are relatively few (42) faceted moldavites in the National Museum's gem collection (Figure A-3a). Their largest cut Bohemian moldavite weighs 48.25 ct and the largest faceted Moravian one is 27.25 ct.

Unfortunately, it is now difficult for the museum to acquire better cut moldavites, because collectors keep most such gems for themselves, and the museum does not have the budget to purchase fine specimens when they become available. Interestingly, during a review of the collection in 2016–2022, several samples of cut bottle glass were discovered, with typical air bubbles and star-shaped flux inclusions (Figure A-3b, c).

Figure A-3: (**a**) The entire collection of cut moldavites at the National Museum consists of these 42 stones. (**b**) These two faceted samples (15.02 and 19.45 ct) were identified as bottle glass in 2018 during a review of the collection. (**c**) Typical inclusions in bottle glass are gas bubbles and star-like devitrification features (magnified 50×). Photos by L. Zahradníček.

Figure 5: (**a**) The mined sediments are processed in this washing and sorting plant. (**b**) After screening out smaller size fractions, the moldavites are hand-picked in the green building. Photos by T. Stephan.

a few millimetres to pieces 4–5 cm long. Notably, we found some flat, disc-shaped specimens, always with the etched surfaces mentioned above. Special highlights were a teardrop-like piece and a curved sample (Figure 7), shapes which are relatively rare.

Illegal Mining

Moldavite is one of the most sought-after stones in the Czech Republic. The deposits are located relatively close to the surface, so it is easy to reach the moldavite-bearing layers using hand tools. Also, it is not uncommon to find moldavite on the surface of farmed fields, especially after ploughing or heavy rains. These conditions are ideal for illegal mining. Moldavite is classified as state property in the relatively few deposits recognised by mining authorities that have been documented by official geological surveys. Elsewhere, moldavite mining is not directly forbidden, but in the Czech Republic digging is not allowed without official government permission, even on one's own private property. In short, without permits, mining is not allowed. Despite these regulations, surface disturbances related to the informal extraction of moldavite are common (e.g. Figure 8).

In some agricultural fields and, especially, in the surrounding forests, moldavite is mined by digging shallow pits up to 2–3 m deep. The pits are dug vertically until the moldavite-containing layer is reached, and then excavated horizontally. Since the pits are dug in soft sediments, the workings are quite unstable. Furthermore, they are not properly reclaimed after digging. The excavations also damage the roots of forest trees, causing them to die and/or be uprooted by the wind. In addition, wild animals may fall into the deeper pits and be unable to escape. There were so many illegal pits in some areas that the nearby communities decided to go through legal extraction procedures and then restore the disturbed areas.

Illegal mining is a punishable offence, and police

Figure 6: (**a**) The authors were allowed to search for moldavite around the rim of the pit as deep as 5 m below the surface, where we focused on areas of coarser grain size. (**b**) The dark specimen seen here is a 2.5-cm-wide moldavite, shown where it was found *in situ*. Photos by T. Stephan.

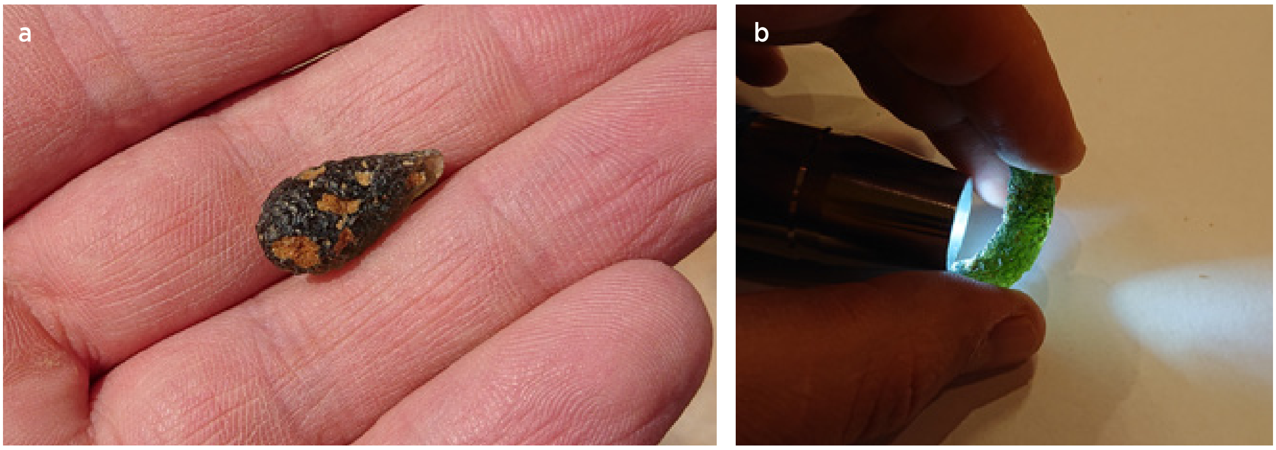

Figure 7: Among the moldavites recovered on the day of the authors' mine visit were (**a**) one drop-shaped and (**b**) one curved moldavite. These shapes are relatively rare. Photos by T. Stephan.

officers frequently patrol the moldavite-bearing localities. In addition, the sand-and-gravel quarry near Chlum has a modern security system. Penalties are mostly in the form of bans.

MATERIALS AND METHODS

Four moldavite samples collected during the field trip described above were polished on one side to measure RIs with a standard refractometer. Their SGs were determined hydrostatically, and microscopic observations were undertaken with a gemmological microscope equipped with Zeiss Stemi2000 optics and an immersion cell containing paraffin oil. Ultraviolet-visible-near infrared (UV-Vis-NIR) spectra were recorded with a PerkinElmer Lambda 950S spectrometer in the range of 200–2500 nm. Chemical composition was measured by energy-dispersive X-ray fluorescence (EDXRF) using a Thermo Scientific ARL Quant'X spectrometer.

For comparison, several other samples from the reference collection of the German Gemmological Association (DGemG) were studied by the same techniques described above, including four faceted moldavites, three artificial green glasses (two faceted and one rough), a green artificial glass that was donated to DGemG as 'green transparent obsidian' and two pieces of greenish slag glass (Figure 9).

RESULTS AND DISCUSSION

Standard Gemmological Properties

Refractive index measurements of the moldavite varied from 1.480 to 1.500, and SG values were 2.33–2.35. The RI values were in the known range for moldavite (1.480–1.525), while the SGs were slightly low (cf. 2.36–2.44 g/cm^3 density; Henn *et al*. 2020). By comparison, the RI and SG values of the artificial glasses were 1.510–1.522 and 2.42–2.51, respectively, and for the slag glasses 1.622–1.629 and 2.80–2.84, respectively.

The inclusions in moldavite are unique and distinct from those in other natural and artificial glasses (see,

Figure 8: Illegal mining for moldavite is a widespread problem, especially in the forests. (**a**) Hand-dug pits up to 2–3 m deep are excavated vertically and horizontally, (**b**) causing damage to trees as well as leaving hazards for wildlife. Photos by T. Stephan.

Figure 9: Samples from the DGemG reference collection analysed for this report include: one uncut (31.32 g) and two cut (2.79 and 7.65 ct) artificial glasses (left); four cut moldavites (top centre, 8.67–33.34 ct), as well as four rough moldavites (polished on the back side, 0.61–5.97 g) that were collected during the 2022 field trip (bottom centre); two pieces of pale green slag glass (top right, 5.88–7.68 g); and one artificial glass that was donated to DGemG as obsidian (bottom right, 14.22 ct). Photo by T. Stephan.

e.g., Bouška *et al.* 1985). Our study samples often contained tiny gas bubbles, usually smaller than 1 mm diameter, but also some as large as 1 cm or more. The gas bubbles were usually round, but some were oval to elongated (Figure 10a–d). They were usually distributed irregularly, but sometimes followed the swirls described below. According to Žák *et al.* (2012), the gas inside the bubbles is usually composed of carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen (H_2), with minor amounts of other gases also present.

Often seen in the moldavites were distinct swirls (i.e. flow structures, Figure 10a, b) that indicate variations in chemical composition (Okrusch & Matthes 2014). Also common were round to elongated, partial zig-zag to curl-like inclusions of the silica glass lechatelierite (Figure 10a–c and e), which are diagnostic of moldavite (see, e.g., Bouška *et al.* 1985) and are not found in imitations. The lechatelierite inclusions represent molten quartz grains and indicate temperatures of glass formation above 1,730°C (Okrusch & Matthes 2014). The lechatelierite inclusions were more obvious when viewed with crossed polarisers, and were often surrounded by a dark cross-like extinction pattern (Figure 10f).

The inclusions in the artificial glasses consisted of typical round to oval gas bubbles as well as swirl marks. The slag glasses were almost opaque, but gas bubbles were observed close to and at the surface, as well as a swirly colour distribution.

UV-Vis-NIR Spectroscopy

The colour of moldavite is due to iron (Bouška *et al.* 1985). Depending on the Fe content, the colour varies from green to brownish green to brown. Most other tektites are richer in Fe and are, therefore, typically dark brown to black.

The optical spectrum of moldavite (Figure 11) is dominated by a strong Fe^{2+} absorption band centred around 1100 nm. Towards the UV range the absorption increases strongly, and the two broad absorption features form a transmission window at about 550 nm in the green spectral region. By comparison, artificial glasses resembling moldavite may show a much different absorption spectrum (Hyršl 2015; Hanus & Hyršl 2018), although some artificial glasses have spectral features very similar to those of moldavite (again, see Figure 11).

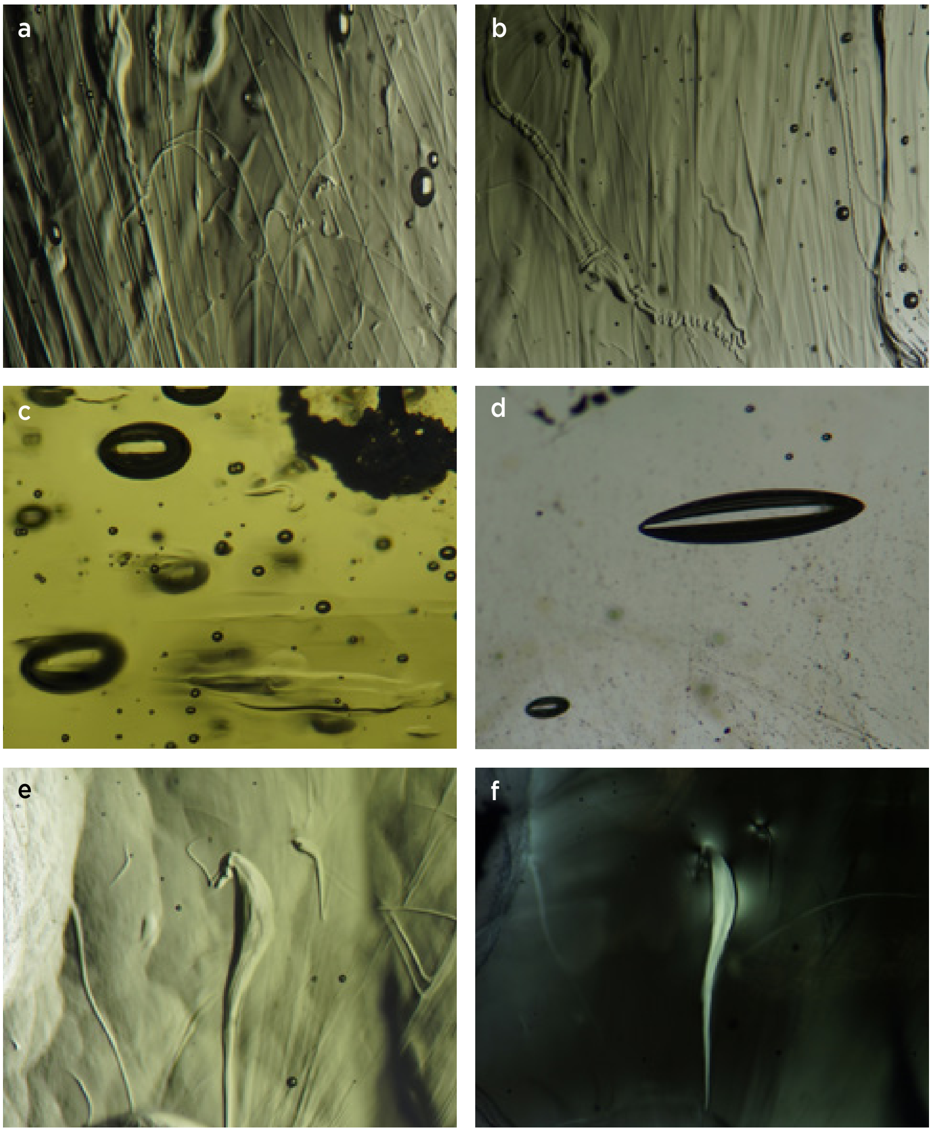

Figure 10: Typical inclusions in moldavite, photographed in the samples shown in Figure 9 that were collected by the authors, are: (**a**, **b**) round to oval gas bubbles, as well as straight or curved swirls (flow structures) and elongated lechatelierite inclusions showing high relief (both magnified 40×); (**c**) oval gas bubbles and lechatelierite inclusions (magnified 32×); (**d**) elongated, marquise-shaped gas bubbles (magnified 10×); and (**e**, **f**) a lechatelierite inclusion shown in plane-polarised (e) and cross-polarised light (f, surrounded by an anomalous extinction pattern; both magnified 20×). All images were taken in immersion. Photomicrographs by T. Stephan.

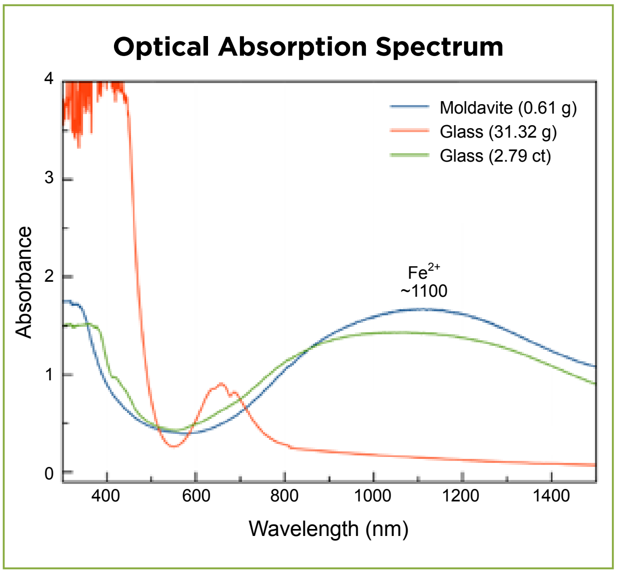

Figure 11: The optical absorption spectrum of moldavite is shown in comparison with spectra obtained from two artificial glasses, one of which shows features quite similar to moldavite.

Chemical Analysis

Table I shows the results of EDXRF chemical analysis of the moldavites analysed for this study, along with the compositions of the green artificial glasses and slag glasses shown in Figure 9.

Tektites such as moldavite typically have a chemical composition similar to that of granite, with high SiO_2 and Al_2O_3, lower K_2O, CaO, MgO and Fe_2O_3, and traces of Na_2O. However, the artificial glasses and slag glasses analysed for this study possessed a distinctly different compositional range. The artificial glasses were of the soda-lime (crown) type and had higher CaO and Na_2O contents than moldavite, while the slag glasses were highly enriched in CaO. The compositions of the artificial glasses and slag glasses obtained for this study are consistent with unpublished reference data from the databases of DGemG and the German Foundation for Gemstone Research.

Table I: Chemical composition of moldavite, artificial glass and slag glass from the DGemG reference collection.*

Sample type	Moldavite		Artificial glass		Slag glass
Description	Rough (from Chlum)	Faceted	Rough and cut	Cut 'green obsidian'	Rough
Oxide (wt.%)					
SiO_2	62.37–76.57	76.69–77.38	61.33–70.81	69.69	40.63–40.93
Al_2O_3	10.33–12.57	11.41–11.60	1.04–7.86	2.24	17.84–17.97
K_2O	3.30–3.93	2.92–3.14	2.95–6.59	0.66	2.08–2.10
CaO	2.63–3.21	2.77–3.32	8.65–11.02	8.93	23.77–24.21
Na_2O	0.33–0.51	bdl	11.27–12.79	15.39	0.60–0.67
MgO	2.37–2.68	2.70–3.27	0.35–2.16	0.91	7.12–8.22
Fe_2O_3	1.81–2.14	1.58–1.65	0.02–1.68	0.82	0.21–0.32

* The samples are shown in Figure 9. Abbreviation: bdl = below detection limit.

CONCLUSION

Moldavite (tektite glass) was produced by a spectacular meteorite impact event, and this origin adds to the contemporary popularity of moldavite (and other tektites). A resurgence in demand for moldavite began in the 1950s and has been growing steadily since then. In its rough state, moldavite is sought-after by collectors. In addition, natural uncut moldavite is often set in silver or gold, and faceted material is sometimes mounted in jewellery with Czech pyrope (e.g. Figure 12). Moldavite is especially popular in tourist jewellery.

Figure 12: (**a**) Natural uncut moldavite is set in this silver ring. (**b**) Faceted moldavite is commonly mounted in jewellery with Czech pyrope. Rings by Granát Turnov, the largest producer of Czech garnet jewellery; photos by L. Aranyosiová, www.

Gemmologically, moldavite can be identified by a combination of RI and SG values, and it is easily differentiated from artificial glasses by its characteristic inclusion pattern. In cases of doubt, the absorption spectrum can be helpful, and clear identification is also possible by chemical analysis.

It is likely that the sand-and-gravel layers in the Chlum-Besednice area of the Czech Republic will continue to supply the market with moldavite for the next several years.

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