MICROTEKTITE-LIKE GLASSES FROM THE NORTHERN CALCAREOUS ALPS (SOUTHEAST GERMANY): EVIDENCE OF A PROXIMAL IMPACT EJECTA ORIGIN., K. Ernstson[1], M. Hiltl[2], A. Neumair[3]. [1]Faculty of Philosophy I, University of Würzburg, D-97074 Würzburg, Germany (kernstson@ernstson.de), [2]Carl Zeiss Microscopy GmbH, D-73447 Oberkochen, Germany (mhiltl@online.de), [3]Institute for Interdisciplinary Studies, D-82205 Gilching (andreas.neumair@arcor.de).

Introduction: Tektites are natural glasses that in the opinion of most researchers have been formed in an impact event by the ejection of melted and/or vaporized near-surface rocks of the impacted target [1]. On re-entering the atmosphere the matter rapidly cooled to form the characteristic shape (spheres, ellipsoids, dumbbells, teardrops, buttons) of tektites deposited in extended distal ejecta strewn fields like the four established Australasian, North American, Ivory Coast and Central European strewn fields. Apart from the layered and larger Muong Nong tektites the common size of tektites is of the order of centimeters defining the special group of *microtektites* that are less than 1mm in size. They occur in deep-sea sediments and on land and are in particular correlated with the Australasian, the North American and the Ivory Coast strewn fields. Microtektites from the Cretaceous-Tertiary boundary and related with the Chicxulub impact are known from several locations [2, 3], and occurrences of microtektite-like glass particles in Late Devonian sediments suggested to be impact-related have been reported from Belgium [4; also see below]. Microtektites are mostly spherical in shape, but splash forms like ellipsoids, dumbbells, teardrops and discs are also common. In contrast to the mostly black, green, brown or gray tektites, microtektites are transparent yellowish to brownish and even colorless.

Here we report on the find and analysis of glass particles that show the typical color, size and shape of microtektites, and we suggest an origin from a nearby Holocene impact event.

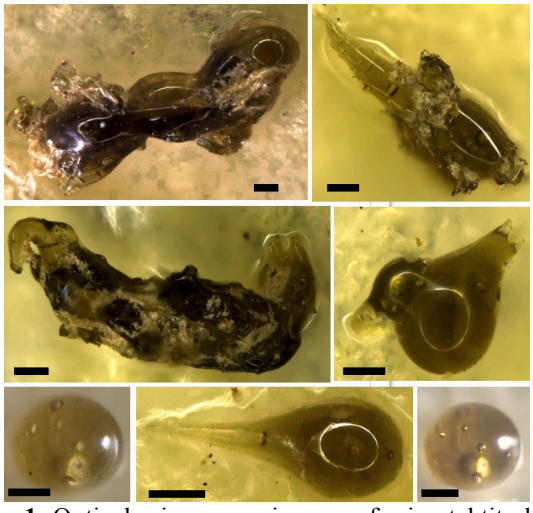

Fig. 1. Optical microscope images of microtektite-like glass particles. 100 µm scale bar in each case.

Results: The glass particles have been discovered and extracted from the soil in the foothills of the Calcareous Alps at some 850 m altitude south of Lake Chiemsee (12.390°E, 47.787°N). The particles described here originate from a total of less than 1 kg soil material, however spot-checked soil samples have shown that the microtektite-like glasses are occurring over at least several kilometers between 550 and 1600 m altitude.

While Fig. 1 shows characteristically shaped examples as optical photomicrographs featuring colors, transparency and single vesicles in the glass, the SEM micrographs in Fig. 2 especially point to the in part very strange surface features and bizarre forms exhibiting micrometer-sized glass filaments and twisted bodies. Apart from these bizarre shapes, the typical spheres, perfect and flattened ones, and splash forms like teardrops known from microtektites are observed.

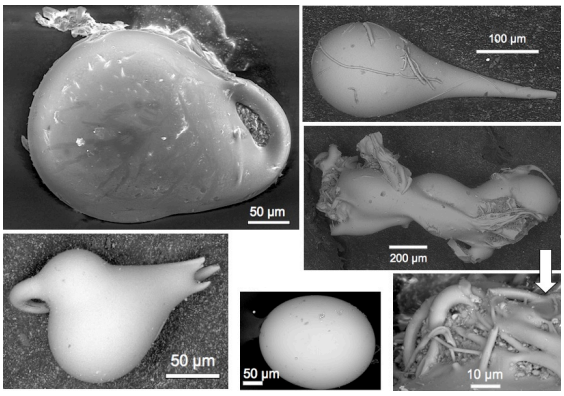

Fig. 2. SEM images of microtektite-like glass particles. Note the tiny, micrometer-sized glass filaments (lower right) of the particle over it.

EDX analyses of four glass particle (Fig. 3) reveal quite similar composition with a surprisingly high carbonate content of roughly 30 wt.% CaO besides 35-40 wt.% SiO_2.

Discussion: The terrestrial formation of tektites and microtektites is strongly supported by their chemical and isotopic composition and by their age that can both be linked to impact craters for at least the North American, Central European and Ivory Coast strewn fields (Chesapeake, Ries, Bosumtwi craters). Age and composition are playing a significant role also for the Alpine microtektite-like glasses. From their occurrence in the uppermost soil layers and with regard to their fine sculpture (Fig. 2) a Holocene deposition without

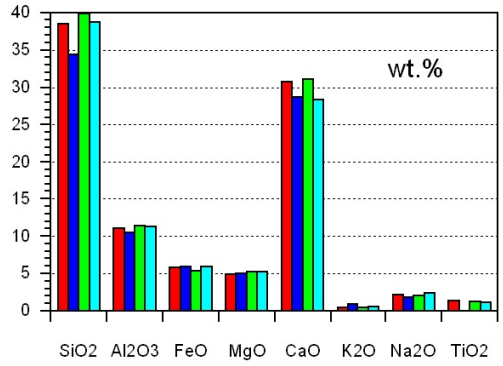

Fig. 3. Composition of four microtektite-like glasses from the soil sampled in the Calcareous Alps.

any substantial reworking is indicated. Compared with the average composition of the strewn field tektites (Tab. 1, b) the strong enrichment in CaO and the depletion in SiO_2 is striking, while the other major components stay within the limits.

	a	b	c
SiO_2	37.9	66.2 - 85.1	44.78
Al_2O_3	11.0	8.1 - 17.7	20.21
FeO (all Fe)	5.7	1.0 - 8.6	5.4
MgO	5.1	0.4 - 7.9	2.1
CaO	29.7	0.4 - 5.1	23.1
K_2O	0.6	1.3 - 3.9	2.16
Na_2O	2.1	0.2 - 2.1	0.55
TiO_2	0.9	0.2 - 1.1	0.6

Tab. 1. Average composition of the Alpine microtektite-like glasses (a) compared to the data for the tektite strewn fields (b) [5]. c: composition of calcium-rich microtektite-like glasses from Senzeille (Belgium) [4].

The at first sight strange composition however must not surprise if local rocks are considered to be the source for the glass particles. Rocks composed of mainly silica and carbonate are a widespread lithostratigraphical and in many cases simply a lithological unit in the Alps called *Kieselkalk* (silica limestone), and silica limestones together with silica marlstones and silica-rich claystones contribute to the *Ruhpolding Fm*. exposed in the region of the glass finds. Natural glasses having in part comparable high calcium and reduced silica contents (Tab. 1, c) are known from the above-mentioned microtektite-like glasses possibly related with a Late Devonian impact event [4].

Provided the Alpine glasses have an impact origin too, the Holocene Chiemgau impact event with the formation of a large meteorite crater strewn field in the Bronze Age/Celtic era [6-9] is a well suitable candidate. The foothills where the glass particles have been discovered belong to the periphery of the crater strewn field, and recent field work gives evidence of impact-induced morphological anomalies and rock destructions even in the foothills under consideration.

More evidence of impact-produced true microtektites is provided by abundant finds of millimeter to centimeter-sized black glass pieces in the strewn field clearly resembling tektite-like glasses. Frequent finds of silica limestone melt rocks embedded in Chiemgau impact layers [10] containing pseudowollastonite, a high-temperature polymorph of wollastonite $CaSiO_3$, substantiate the microtektite nature of the glass particles as a product of impact melting and/or vaporization of Alpine *Kieselkalk* rocks.

An industrial origin of the glass particles has been considered highly improbable. Because of the glass chemistry (Tab.1, a), a Portland cement plant located some 15 km away is discarded, and glass processing industries to have produced this chemically unusual matter do not exist far and wide.

Conclusions: The simplest explanation for the occurrence of these tiny glass particles having the typical attributes of known microtektites is there origin from the nearby Holocene Chiemgau impact event that some 3000-2500 years ago produced a large crater strewn field combined with every high-pressure/high-temperature evidence of meteorite impact implying impact melt rocks, various impact glasses and strong shock like PDFs in quartz and diaplectic glass [6]. Hence, the glasses from the Alpine foothills should be termed true microtektites that, different from the large tektite and microtektite distal strewn fields, were obviously deposited as a proximal fallout from a nearby explosion cloud of melted and/or vaporized local rock material. Further work will show whether this most recent microtektite deposit is able to contribute to a better understanding of the tektite formation process still disputed.

Acknowledgements. - We thank W. Mayer and E. Neugebauer for their meticulous field work and preparation.

References: [1] Koeberl, C. (1994) in: B.O. Dressler et al., eds., pp. 133-152, *Large meteorite impacts and planetary evolution*. GSA Special Paper no. 293. [2] King, D.T., Jr. and Petruny, L.W. (2004) *LPSC XXXV*, Abstract #1804. [3] Smit J. (1999) *Ann. Rev. Earth Planet. Sci*., 27, 75-113. [4] Claeys, P. and Casier, J.-G (1994) *Earth Planet. Sci. Let*., 122, 303-315. [5] Glass, B.P. and Simonson, B.M. (2013) *Distal Impact Ejecta Layers*. Heidelberg etc.: Springer. [6] Ernstson, K. et al. (2010), *J. Siberian Federal Univ., Engineering. & Technology.*, 2010, 3/1, 72-103. [7] Hiltl, M. et al. (2011), *LPSC XXXXII*, Abstract #1391. [8] Ernstson, K. et al. (2011) *Cent. Eur. J. Geosci*., 3(4), 385-397. [9] Rappenglück, M.A. et al (2013) *Meteoritics & Planetary Science*., 48, s1, Abstract #5055. [10] Ernstson, K. et al. (2012) *Mediterranean Archaeology and Archaeometry*, 12, 249-259.