Evidence for superaparamagnetic nanoparticles in limestones from Chiemgau crater field, SE Germany.
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Introduction: Magnetic susceptibility (MS) has been measured at various frequencies and magnetic fields in rocks from craters of the Chiemgau strewn field. These usually small crater-like structures are developed in Quaternary terraces (formed by pebbles of various rocks from Alps) and characterized by disequilibrium very-high temperature and sometimes high-pressure metamorphism along with structural pebble deformation [1]. Anthropogenic origin of the observed phenomena is improbable, out of geological interpretations the role of a Holocene impact event is most cited [1,2,3].

Relatively very high magnetic susceptibility of soils and pebbles in craters, especially limestones, had been documented, as well as anomalously high remanent magnetizations and Koenigsberger ratios [3]. These magnetic properties are incomparable to those of the same rocks far from the craters [3]. The goal of our measurements was detection of superparamagnetic particles, whose formation can be another result of extreme p,T,t paths.

Measurement: MS in specimens from 7 pebbles was obtained on the SM-100 (*ZH Instruments*, Brno, Czech Republic) at frequencies 0.5 – 8 kHz and fields 10 – 320 A/m.

Results: The X_{FD} parameter of silicate rocks is mostly between 1.0 and 2.0 % (3 pebbles with glass coatings and ocassionally veinlets). Quartzite sample with very low MS was penetrated and coated by three types of glass. For this sample X_{FD} reached 12 %. X_{FD} of limestones from the craters reached up to 16 % (Tab. 1). Both MS (not in silicate rocks) and X_{FD} are generally higher in weathering crusts than inside, however weathering obviously explains neither the high MS, nor high X_{FD}.

Discussion and conclusion: The detection of frequency-dependence of MS in limestones is due to presence of superparamagnetic nanoparticles, which can be made of magnetite or maghemite. The fact that they formed in limestones rather than in crystalline silicate rocks indicates their origin mainly from Fe-hydroxides, not from silicates. The HT- and HP-event caused dehydration and only short-term heating, mosty insufficient for growth of larger crystals.

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Tab. 1. Mass susceptibility (mean from all frequencies and field intensities) and the X_{FD} parameter at 160 A/m
X_{FD} = (MS(0.5 kHz) – MS(8 kHz)) / MS(0.5 kHz)
Sample No. 123 is from Kaltenbach crater, the others from crater No. 004 at Emmerting.

Samp. No.	rock type	MS (10^{-6} m^3/kg)	X_{FD} (%)
123	orthogneiss *	0.4848	1.6
dtto incl. weathering crust		0.3471	1.9
406	limestone	1.1530	6.3
409	limestone	0.7741	1.3
417	limestone (brecciated)	0.6238	15.0
dtto incl. bright crust		0.6513	15.9
419	basic rock / slag?*	1.9747	1.1
420	orthogneiss *	1.6342	1.0
421	quartzite * (with dark glass veins)	0.0297	5.4
dtto incl. brown glass on surface		0.0970	12.1

* surface of the pebble is coated by glass

Fig. 1 Frequency-dependet mass susceptibility in the limestone sample 417 (interior) at 20 A/m