IMPACT ORIGIN OF THE "DOMAINE DU METEORE"-CRATER, FRANCE. COMPELLING MINERALOGICAL AND GEOPHYSICAL EVIDENCE FOR AN UNRECOGNIZED DESTRUCTIVE EVENT IN THE HEART OF EUROPE.

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Introduction: Small impact craters (< 300m) are quite rare, and proof of an impact origin is difficult to obtain[1-5], especially if remnants of the impactor material are missing. The EarthImpactDatabase (EID), hosted in the Planetary and Space Science Centre (PASSC) at the University of New Brunswick, Canada, and recent reviews[6-7] lists only three, though much larger, structures in West and Central-Europe as confirmed high velocity impact crater, namely Rochechouart (France), Nördlinger Ries and Steinheimer Becken (both in Germany). Although smaller impact structures should be much more frequent, no proof for even a single confirmed small crater structure is reported[6-7].

In this contribution, for the first time, we present compelling mineralogical and geophysical evidence for a small crater structure (about 200m wide) in Southern France, which might be part of a crater field, the Herault impact structure[6]. The data presented here were collected for the largest structure, the "Domaine du Meteore"-crater formally known as "le Clot"[8-10].

"Domaine du Meteore" crater: First mentioned more than 70 years ago[8], the 200m wide crater structure located south of Cabrerolles in southern France in the ground of the "Domaine du Meteore"-vineyard was almost ignored for more than half a century. Based on its shape and a strong magnetic anomaly, Gezè and Cailleux[8] were the first to suggest an impact origin of the crater. Only one year later Janssen[9] published the first paper in an international journal and supported the idea as he saw similarities to craters on the Moon's surface. In 1964 Beals[10] rejected the idea based on two simple observations. First, the crater doesn´t show any elevated rim; second, no evidence of a magnetic anomaly was found. This rejection led scientists to almost ignore the crater for more than half a century. No mineralogical nor geophysical work on the crater was ever performed until last year when our team started detailed field work on the crater structure after some promising preliminary findings the year before.

Topography: The current crater has a 200m wide and about 30m deep circular shape with two stream beds crosscutting from north to south. The original size of the crater is difficult to assess as the overall topography is quite complex and intensive erosion from the nearby Montagne Noire might have eroded not only part of the crater rim. It is also possible that the impact struck already intensively shaped terrain. However, the distribution and extend of the current crater infall breccia suggest that the original size was not much larger. The size to depth ratio fits closely to the mean values of simple impact craters worldwide[10].

Geophysical study: Our geophysical study includes radar (GPR)-, geoelectric- and geomagnetic-measurements. From GPR it turns out that the layering of the schist-quartzite unit was intensively folded during regional metamorphism preventing from any meaningful result regarding a systematic change of the inclination around the crater. The geoelectric data processing is work in progress. The most interesting data are measurements of the magnetic field in and around the crater.

Magnetic structure: The most striking geophysical structure comes from the spatial distribution of the geomagnetic field strength implying a systematic decrease towards the bottom of the crater. We measured several profiles from the area surrounding of the crater through the crater rim towards its center. All data were corrected for time variations of Earth´s magnetic field. Within the crater, we found a significant magnetic low of about 100 nT, a feature typical for small impact crater[11].

Mineralogical study:

Impact spherules: Impact spherules in small craters are quite rare and have been reported from only a few occurrences worldwide[12]. A comprehensive study about magnetic spherules found in and around the Kamil crater in Egypt showed that even in small crater structures they can be quite frequent, with the potential of becoming one of the most important tools to detect and confirm new impact craters in the future[12].

Our search was performed by screening the soils by using a plate packed with high-energy magnets. We isolated more than a hundred Fe-oxide spherules showing a large variety of textures, from dentritic, ashlar to smooth surfaces was found. The sizes range from a few 10s of microns to more than a mm, with a mean size of about 200 microns. In addition, we detected several compound spherules which might be indicative of high-speed collisions. Several larger spherules were broken apart showing a core-rim structure. The largest 1.2 mm-sized spherule was polished through the middle for further studies. The rim is composed of Si, Al-bearing Fe-oxides with remnants of Ni-rich Fe-metal. The core is composed of fragments of quartz, feldspar, mica, carbonate, TiO_2, and carbonaceous material, similar to mineral phases found in the target rocks of the schist-quartzite unit. In between these minerals a large amount of micro-diamonds was detected by Raman spectroscopy. The peak broadening as well as the shift towards lower wave numbers indicate a shock origin. No other high-pressure polymorph has been detected so far.

Impact breccia: Some pieces of an impact breccia were found close to the impact crater. Quartzite fragments always show a high grade of deformation, including undulatory extinction, subgrain formation and mosaicism. Narrow crosscutting planar features in quartz might indicate the presence of planar fractures, and planer deformation features. Melt pockets around the rims of some of the quartzite fragments contain nano-graphite and shock diamonds.

Schist-quartzite unit: No clear evidence of shatter cones have been found so far. A small piece of schist found close to the center of the crater show numerous crosscutting cataclastic to pseudotachylite veins which might represent shock veins.

Conclusions: The finding of a magnetic low inside the crater structure together with the occurrence of impact spherules containing target fragments set in a shock diamond matrix surrounded by Si, Al-containing Fe-oxide and remnants of Ni-rich Fe-metal confirms the impact origin of the “Domaine du Meteore”-Crater in southern France. Further proof comes from shock diamonds, mosaicism, planar fractures and planar deformation features in quartz of rare impact breccia.

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