The Kamil Crater in Egypt

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Abstract. We report on the discovery in southern Egypt of an impact crater 45 m in diameter with a pristine rayed structure. Such pristine structures have been previously observed only on atmosphereless rocky or icy planetary bodies in the Solar System. This feature and the association with an iron meteorite impactor and shock metamorphism provides a unique picture of small-scale hypervelocity impacts on the Earth's crust. Contrary to current geophysical models, ground data indicate that iron meteorites with masses of the order of tens of tons can penetrate the atmosphere without significant fragmentation.

Impact craters up to a few hundreds of meters in diameter are common structures of solid surfaces of planetary bodies in the Solar System. Statistics predicts that impacts producing small craters on Earth occur on decadal to secular time scales (*1*, *2*). However, small craters are rare on Earth because they are rapidly eroded, and the few identified so far [15 <300 m in diameter out of 176 craters up to 300 km in diameter (*3*)] have lost most of their primary features.

We report the detection in southern Egypt of a rayed impact crater 45 m in diameter (Fig. 1) on a Cretaceous sandstone target. The ejecta rays highlight the exceptional freshness of the structure. The crater was identified by V. De Michele during a Google Earth survey and named Kamil Crater after the nearby Gebel Kamil. A geophysical expedition undertaken (SOM) in February 2010 revealed that the crater is bowl shaped and has an upraised rim (~3 m above pre-impact surface) (Fig. S1 and S2) typical of simple craters (*4*). The true crater floor depth is 16 m and is overlain by a ~6 m-thick crater-fill material (Fig. S2). Morphometric parameters agree with those predicted by models (*5*) for a transient crater generated by an iron meteorite 1.3 m in diameter (equivalent to 9.1 x 10^3 kg) impacting at a velocity of 3.5 km s^{-1}, assuming an average meteoroid entry velocity and entry angle of 18 km sec^{-1} and 45°, respectively. Centimeter-scale masses of scoriaceous impact melt glass (Fig. S3) occur in and close to the crater, and indicate local shock pressures >60 GPa (*4*). We identified 5178 iron meteorite specimens totaling ~1.71 tons in the crater and surrounding area during systematic searches (SOM). They consist of <34 kg shrapnel produced by the explosion of the impactor upon hypervelocity collision with the target (Fig. 2), except one individual fragment of 83 kg (Fig. S4). This indicates that the Kamil Crater was generated by an impactor that landed nearly intact without substantial fragmentation in the atmosphere. The meteorite is classified as an ungrouped Ni-rich ataxite [Ni = 19.8 wt%, Co = 0.75 wt%, Ga = 49.5 μg g^{-1}, Ge = 121 μg g^{-1}, Ir = 0.39 μg g^{-1}: data following (6); Fig. S5]. Magnetic anomaly data show no evidence of buried meteorites larger than some tens of centimeters (Fig. S1).

Based on systematic meteorite searches, the estimated total mass of the impactor is of the order of 5-10 x 10^3 kg, corresponding to a pre-atmospheric mass of ~20-40 x 10^3 kg (*2*). According to geophysical models (2, *7*), iron masses <3 x 10^6 kg normally fragment upon impact with the Earth's atmosphere, thereby reducing the energy of the impact at the Earth's surface.. The present statistics, which include the recently discovered Whitecourt Crater (*9*) and the Kamil Crater, suggest however that ~35% of the iron meteorites in the above mass range are not disrupted in the atmosphere.

References and Notes

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Fig. 1. QuickBird satellite image (2005, October 22; courtesy of Telespazio) of the Kamil Crater.

Fig. 2. A ca. 3 kg shrapnel of the associated iron meteorite.