

Restriction on 2008 TC₃ asteroid properties from study of the Almahata Sitta meteorites

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Abstract

Based on physical properties of the Almahata Sitta meteorites and shape model of the 2008 TC_3 asteroid we set the 27 ton upper limit on the 2008 TC_3 pre-entry mass. This mass estimate is considered as the maximum value and will be most likely smaller due to the presence of macroporosity within the asteroid.

1. Introduction

On October 6 2008 a small asteroid 2008 TC_3 was discovered in space 20 hours prior to impact on Earth. So far over 600 fragments (designated Almahata Sitta meteorites) were recovered at impact site in Nubian Desert, Sudan. We characterized these meteorites through measurement of their bulk and grain density and porosity and set restriction on internal structure and properties of the 2008 TC_3 asteroid.

2. Density and porosity of the Almahata Sitta meteorites

Most of the Almahata Sitta meteorites were classified as ureilites. However, significant amount of various chondritic compositions has been found within the recovered meteorites originating most likely also from asteroid 2008 TC₃ impact.

The results of the measurements done on Almahata Sitta ureilites reveal the bulk density in range of 2800-3200 kg/m³ and the grain density in range of 3600-4000 kg/m³ respectively resulting in microporosity of 15-20%. This is higher compared to other ureilites reported in [1]. The properties of the chondritic meteorites match the trend of their classes as reported in [2].

3. Restriction on 2008 TC₃ asteroid properties

Based on our findings the 2008 TC₃ asteroid may represent a compositionally heterogeneous body composed of ureilites with mix of chondrite materials and is most likely an assemblage of material left after a catastrophic collision between ureilite and chondrite parent bodies. The internal structure and porosity is hard to estimate due to uncertainty in the asteroid volume and mass. However, based on the physical properties of the Almahata Sitta ureilites as the dominant lithological fraction of the 2008 TC₃ asteroid, we can state that the bulk density of the asteroid should not exceed that of meteorites. Thus, the upper density limit of the asteroid is 3000 kg/m³ and this already includes 15-20% microporosity observed in the Almahata Sitta ureilites.

The asteroid had to have additional macroporosity as it was observed to have low strength and disintegrated early after the atmospheric entry. However, it was not completely strengthless body due to its high rotation rate with period of 100 s (P. Scheirich).

Rough comparison of the Almahata Sitta ureilite albedo of 0.1 (T. Hiroi) with that of the asteroid and the shape model (P. Scheirich) gives asteroidal volume of approximately 9 m³. Taking into account our highest bulk density limit 3000 kg/m³ for the asteroid the maximum asteroid mass is 27 tons. This mass estimate is considered as the maximum value and will be most likely smaller due to the presence of macroporosity within the asteroid.

This is for the first time we can combine the astronomical observations of an asteroid with the laboratory studies of meteorites recovered after the impact of the asteroid on the Earth.

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