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The Origin of Near-Earth Asteroid 1999 JU_3

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Abstract

Near-Earth asteroid 161273 (1999 JU_3) is the primary target of the Japanese Aerospace Exploration Agency's Hyabusa-2 sample return mission. This object is also considered a potential target for two other sample return missions: the National Aeronautics and Space Administration's OSIRIS-REx and the European Space Agency's Marco Polo-R. This asteroid is likely to have originated in the main-belt and in this work. Our initial dynamical considerations indicate that the source of 1999 JU_3 is in the inner-belt (a < 2.5 AU). We are in the process of using spectral information and albedo to constrain the source further.

1. Introduction

Asteroid 1999 JU_3 and other near-Earth asteroids (NEAs) are not primordial objects; they have dynamical lifetimes much shorter than the age of solar system. NEAs are fragments of larger objects in the main asteroid belt.

A valuable tool for estimating the origin of current NEA orbits is the dynamical method described in Bottke et al. (2002). More specifically, they numerically integrated the orbits of thousands of test particles, starting from the five most efficient source regions of NEOs. These source regions are (1) the ν_6 secular resonance at ~ 2.15 AU, which marks the inner border of the main-belt; (2) the Mars-crossing asteroid population, adjacent to the main-belt; (3) the 3:1 mean-motion resonance with Jupiter at 2.5 AU; (4) the outer main-belt population between 2.8 and 3.5 AU; and (5) the Jupiter-family comets. According to the Bottke et al. (2002) model, about 61% of near-Earth asteroids come from the inner-belt (a< 2.5 AU); so it is not surprising that 1999 JU_3 and the other two spacecraft targets, 1999 RQ_{36} and 1996 FG_3 and, are likely to come from the inner-belt.

In looking for main-belt parent bodies, asteroid families are favored over single objects as the likely source. This is because in asteroid families numerous small fragments have been produced during the family-forming event. Conversely, single objects, which do not have an observable family around them, either never broke up or generated too few and too small fragments to be observed. Hence single asteroids are much less likely to have delivered fragments to resonances, which could eventually put them on near-Earth orbits.

Adding spectral information and albedo to dynamical constraints can be very diagnostic of origin, as illustrated recently by de León et al. (2010). In that publication, we identified main-belt asteroid 2 Pallas as the most likely parent body of NEA 3200 Phaethon and of the Geminids meteor stream. This conclusion resulted from combining the spectral similarities between Phaethon and the Pallas family with a specific dynamical pathway between Pallas and Phaethon. In addition, we identified a connection between NEA 1999 RQ_{36}, the primary target of the OSIRIS-Rex mission, and the Polana family (Campins et al. 2010).

2. Work in Progress

Work on identifying the source of 1999 JU_3 is in progress. We used a source probability code based on the Bottke et al. (2002) model, which yielded the following results: 80% probability of originating from the ν_6 resonance and 20% from the Mars-crossing region. The other sources are unlikely, including the 3:1 mean-motion resonance with Jupiter at 2.5 AU and any source beyond that distance. Hence, the source of 1999 JU_3 is definitely in the inner belt ($a < 2.5$ AU). We are in the process of using spectral information and albedo to constrain the source further.

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