
Sherry K. Fieber-Beyer\(^a\), Michael J. Gaffey\(^a,\) and Paul S. Hardersen\(^a\)

\(^a\) Space Studies Dept., John D. Odegard School of Aerospace Sciences, University of North Dakota, Grand Forks, ND 58202-9008. \(^1\) Visiting Astronomer at the IRTF, which is operated by the Univ. of Hawaii under Cooperative Agreement with NASA, Science Mission Directorate, Planetary Astronomy Program.

sherryfieb@hotmail.com

**Synopsis**

The research is an integrated effort beginning with telescopic observations and extending through detailed mineralogical characterizations to provide constraints on the albedo, diameter, composition, and meteorite affinity of NEO-PHA 2007 LE. The binary, potentially hazardous near-Earth object, 2007 LE, is the first ever result where a specific meteorite has been linked to a near-Earth Object for which a mainbelt parent body has been identified. In this case the pathway leads from mainbelt asteroid (6) Hebe through NEO-PHA 2007 LE to the meteorite Rose City.

**Spectral Analysis**

![Fig. 1. SpeX [1] near-infrared spectrum of 2007 LE and Gaffey’s [2] spectrum of the black chondrite Rose City. Rose City was normalized to 2007 LE over the 1.5 - 1.7 micron spectral interval.](image)

- Band I absorption feature consistent in position and depth with Rose City.
- Appears 2007 LE is a bit more olivine rich than Rose City.
- Black chondrites contain a fair percentage of olivine, but the shock has disordered the olivine in such a way that made it spectroscopically opaque [3, 4].

**Delivery Stages**

![Diagram showing the delivery stages of the asteroid's journey.](image)

1. The 11 PM fall time and the W - E component of the flight path indicates a prograde orbit with the meteoroid catching up to Earth from behind. The N - S flight direction indicates approach from above the ecliptic plane.

2. The descending node of 2007 LE lies just outside the orbit of the Earth, occurring around June 1 (JPL Horizons). If a fragment of 2007 LE (i = 29.5°) in such a orbit precessed by ~140° and entered the atmosphere, its path would be consistent with the atmospheric entry path of Rose City.

3. Under the influence of perturbations primarily from Jupiter, the orbits of planet crossing asteroids precess as well as vary in i and e. The current precession rate of 2007 LE is ~0.011°/year (NASA SBN) which by itself would produce a precession of 140° in only 12,500 years.

4. Developing a difference of ~140° between 2007 LE and a fragment in a similar but not identical orbit is quite plausible given the ~39 Myr existence of the Rose City meteoroid as an independent body.

5. Once in near-Earth space, the secondary and the Rose City meteoroid could have been liberated from 2007 LE ~39 Myr ago [15] by either
   - a small impact,
   - through a gravitational encounter with the Earth during which tidal forces pulled loose fragments off the surface [e.g., 16, 17], or
   - spinning up the asteroid by the YORP effect until it undergoes rotational fission [e.g., 18].

6. Perturbations by the giant planets transferred the liberated shock blackened 2007 LE into an Earth-crossing orbit through either the slower v6 resonance or the 3:1 resonance. [14]

7. The 11 PM fall time and the W - E component of the flight path indicates a prograde orbit with the meteoroid catching up to Earth from behind. The N - S flight direction indicates approach from above the ecliptic plane.