ORIGIN OF ASTEROID (101955) BENNU AND ITS CONNECTION TO THE NEW POLANA FAMILY

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Introduction: Near-Earth Asteroids (NEAs) are minor bodies that vary in size from meteorite-sized objects to bodies that span tens of kilometers in diameter. One such object is the B-type asteroid (142) Polana, located in the Inner Main Belt (IMB). Polana is the progenitor of the New Polana family [1], which is postulated to be the origin of primitive NEAs like the B-type asteroid (101955) Bennu [2, 3]. To test this theory and further investigate the similarities in composition and aqueous alteration history between Polana and Bennu at the 3-µm band, we examined the spectra of Polana within the ~0.7.0-4.0-µm spectral range, utilizing the NASA Infrared Telescope Facility (IRTF) located in Hawai'i.

Methods: The asteroid Polana's ground-based spectra were measured using the prism (0.7-2.5 µm) and long-wavelength cross-dispersed (LXD: 1.9-4.2 µm) modes of the SpeX spectrograph/imager at IRTF. To account for telluric water vapor absorption features in Polana's spectra, G-dwarf stars with solar-like B-V and V-K colors (HD 216801 and HD 98737) were used as standard stars in both the prism and LXD modes.

Results: Polana's prism spectrum displays a broad concave feature that is centered around 1.2 µm, with a band depth of approximately 11% (Figure 1). Additionally, the spectrum shows a slight positive slope towards wavelengths greater than 1.2 µm. We obtained two sets of prism data from Polana on July 2nd, 2023 at 12:32 UTC and 12:48 UTC. The spectra of both prism sets are similar, indicating no observed compositional heterogeneity in the asteroid. Polana's LXD spectra, however, revealed no significant spectral absorption features in the 2.0 µm to 4.0 µm range, suggesting that the asteroid lacks the 3-µm band and is not hydrated.

Discussion: It is possible that NEA Bennu did not originate from the same parent body as asteroid Polana, as the former is much more hydrated as revealed by the pronounced 3-µm band (Figure 1). Another possibility is that Bennu's parent body had varying levels of aqueous alteration. This could have been caused by factors such as high-pressure shocks and heating during the family-forming impact. Using numerical impact simulations that can track shock heating in the fragments, [4] predicted that only 6% of the debris escaping family forming events (that may go on to produce primitive NEAs) experienced high-impact energy that can degrade their hydration level. Therefore, we expect an aqueously-altered parent body to produce ejecta that is also aqueously altered. The nature of the most significant remnant will depend on the heat generated by the impact and ejecta reaccretion.

Another possible explanation for the difference in the 3-µm band between Polana and Bennu is that the parent body was not uniform throughout, and the family-forming event that created the New Polana family exposed a sub-surface layer of the parent body. The fragments of Bennu that were dislodged from the parent body's crust may contain hydrated silicates, organics, and carbonates that are not present in the exposed sub-surface. This would be consistent with the idea that early heating within the parent body from radiogenic nuclides like ^{26}Al forces water and other volatiles to move outward toward the exterior of the body, leaving behind relatively dehydrated materials in the deep interior [5].

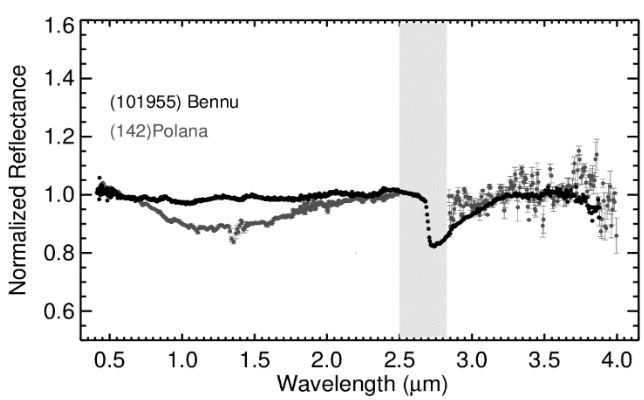

Figure 1: Spectra of asteroids Bennu and Polana. Bennu's spectrum is an average spectrum measured at the 10:00 a.m. station. The ~1.2-µm band in Polana is more pronounced than in Bennu. Unlike Bennu, Polana does not show a pronounced feature at ~3 µm. The gray bar indicates wavelengths of strong absorption by water vapor in Earth's atmosphere.

References: [1] Walsh, K.J. et al. (2013) *Icarus*, 225, 283–297. [2] Campins, H. et al. (2010) *ApJ*, 721, L53. [3] Bottke, W.F et al. (2015) *Icarus*, 247, 191e217.[4] Güldemeister et al. (2022) *PSJ*, 3:198. [5] Grimm, R.E. and McSween, H.Y. (1989) Icarus, 82, 244-280.