THE THEMIS ASTEROID FAMILY: A POTENTIAL SOURCE OF ICE-RICH NEAR-EARTH ASTEROIDS. H. H. Hsieh[1,2], N. Schörghofer[1], K. J. Walsh[3], B. Novaković[4]; [1]Planetary Science Institute, USA; hhsieh@psi.edu; [2]Academia Sinica Institute of Astronomy and Astrophysics, Taiwan; [3]Southwest Research Institute, USA; [4]University of Belgrade, Serbia.

Introduction: The outer main asteroid belt (OMB) may contain many ice-rich asteroids. One large group of OMB asteroids that is specifically thought to be ice-rich is the Themis collisional family [e.g., 1,2]. We investigate the possibility that Themis family asteroids could evolve onto orbits characteristic of Jupiter Family Comets (JFCs), at which point any near-surface ice could cause cometary activity, potentially leading to confusion with JFCs with outer solar system origins [3]. We also model their thermal history to assess the level of ice retention expected in such objects [4]. Given that the evolution of OMB objects onto JFC-like orbits may also make some of them near-Earth objects (NEAs), which can then, in principle, be mined for resources, such as water ice that can be utilized as propellant [e.g., 5,6], this work is highly relevant to the subject of in situ resource utilization (ISRU).

Dynamical Integrations: We performed numerical integrations of 4782 current Themis family asteroids for 100 Myr under the gravitational influence of the 7 major planets other than Mercury using the hybrid integrator in the `mercury` N-body integration package [7]. We find that on the order of a few percent of the objects we considered escape the family every 100 Myr due to eccentricity excitation from nearby mean-motion resonances and subsequent close planetary encounters, and evolve onto orbits with the dynamical characteristics of both JFC and NEA orbits. We estimate that at any given time, there may be tens of objects from the Themis family on JFC- and NEA-like orbits that may be icy and even potentially active, but also find evidence that this could be an underestimate of the total number of potentially icy objects from the OMB in the JFC and NEA populations [3].

Thermal Modeling: For the thermal modeling component of this work, we model temperature and sublimation-driven ice loss for dynamically evolving asteroids originating from the OMB as they become NEAs or evolve onto orbits typical of JFCs. We find that the majority of ice loss for most objects occurs long before they reach NEA- or JFC-like orbits. The least ice loss occurs at the polar regions of bodies with small axis tilt (Figure 1), where temperatures remain so cold that ice does not retreat beyond the influence of the seasonal thermal wave (often <5 m) by the time the objects reach NEA- or JFC-like orbits. Axis tilts must remain continuously small for ice to remain this shallow to the surface, as ice is expected to retreat faster for large tilt angles [4].

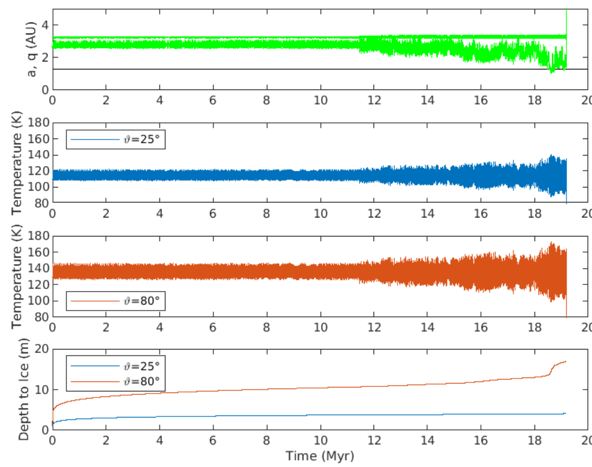

Figure 1: Time evolution for Themis family member (12360) Unilandes, which dynamically evolves onto a NEA orbit. a) Semi-major axis a and perihelion distance q. The horizontal black line represents q = 1.3 au; b) Annual mean surface temperature at the pole for a thermal inertia of 400 tiu, an axist tilt of θ = 25° and a precessing orbit. c) Same as (b) for θ = 80°; d) depth-to-ice at the pole for axis tilt 25° and 80°. For comparison, the thermal skin depth for a = 3 au is 4.4 m.

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