COMPARISON OF THREE ASTEROID LIMB PROFILES. A. R. Conrad[1], C. Dumas[2], W. J. Merline[3], J. D. Drummond[4], R. D. Campbell[1], R. W. Goodrich[1], D. Le Mignant[1], F. H. Chaffee[1], S.H. Kwok[1], R. I. Knight[5], [1]W.M. Keck Observatory, 65-1120 Mamalahoa Highway, Kamuela, HI, 96743, [2]ESO Very Large Telescope (VLT), European Southern Observatory, Alonso de Cordova 3107, Vitacura Casilla 19001, Santiago 19, Chile, [3]Southwest Research Institute, 1050 Walnut Street, Suite 400, Boulder, CO 80302, [4]Starfire Optical Range, Directed Energy Directorate, Air Force Research Laboratory, Kirtland AFB, New Mexico 87117-5776, [5]University of Hawaii, Hilo, 200 W. Kawili St., Hilo, HI 96720-4091

Introduction: We present limb profile analyses for 3 asteroids, 511 Davida, 52 Europa, and 7 Iris. Each of these was observed with the second generation near infrared camera (NIRC2) utilizing the first generation Keck adaptive optics system on Keck II. For Davida, we have completed a thorough analysis [1]. For 52 Europa and 7 Iris the analysis presented here is preliminary. We compare these observed limb profiles with special attention given to the large facets seen on Davida and also possibly detected on Europa and Iris.

The Resolved Asteroid Program: Adaptive optics on large telescopes allows us to take resolved images of asteroids from the ground. We can obtain diffraction-limited infrared images of these bright objects using minimal telescope time, typically less than ten minutes per rotational phase. Our technique of finding the dimensions and pole of an asteroid from its changing projected size and shape is powerful because it can be done with data collected in a single night.

By studying the size and shape of these bodies, we hope to learn more about their gross structure and better understand asteroid collisions, the major geological process shaping these objects.

Accurate size is crucial for determining volume and, in some cases, density (e.g., from the presence of a satellite [2]). Knowledge of density, and the resulting porosity determination [3], assists in understanding the internal structure of an asteroid. An accurate size measurement also leads to an improved albedo measurement, a parameter that is key to understanding composition.

A precise shape measurement can help us understand the history of large, but subcatastrophic, impacts on a body and how the body's response to such impacts may relate to its internal structure and composition. It has been hypothesized [4] that very porous asteroids, such as C-type 253 Mathilde, have a very different response to giant impacts than denser targets (e.g. S-types), with the crater being formed largely by compaction rather than ejection of material.

511 Davida: We acquired 165 images taken at 11 epochs over the 5.1 hr rotation of the large C-type asteroid 511 Davida. We analyzed the changing shape during rotation to estimate the triaxial ellipsoidal dimensions and to look at departures from an ellipsoid that might be idendified as topographic features. We mapped each putative topographic feature onto our latitude/longitude grid to monitor its position as the body rotates. Using this technique, we confirmed the existence of several features visible in relief on Davida's limb (Fig. 1) [1]. These features include at least one facet which may indicate existence of a large crater ('c' in the Fig. 1). We refer here to craters of this size, those with diameters comparable to the radius of the object, as "giant" craters. Evidence of giant craters on asteroids was first provided by data collected during the NEAR flyby of asteroid 253 Mathilde [2].

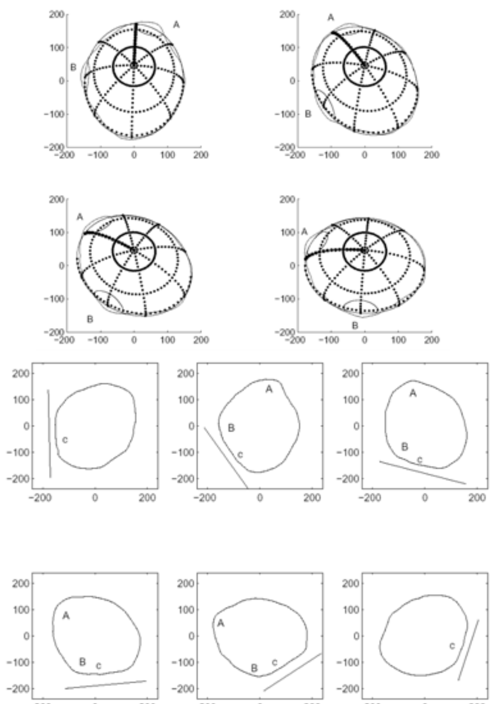

Figure 1. Two representations taken from analysis of Davida (diameter 293 km) [1]. The upper shows limb features visible in relief; in particular, promontories A and B rotating appropriately in epochs 6-9 of the 11 total. The lower representation highlights facet 'c' that leads promontory B and appears in epochs 5-10. Units are in km.

52 Europa and 7 Iris: We acquired 84 images at 7 epochs over the 5.6 hr rotation of the large C-type asteroid 52 Europa (Fig. 2) and 64 images at 4 epochs over the 7.2 hr rotation of the large S-type asteroid 7 Iris (Fig. 3). The limb profiles extracted from these images (Figs. 2 and 3), indicate, for both asteroids, possible facets. Rotational analysis, similar to that provided for Davida above, will be necessary to determine if these observed facets indicate the existence of surface features.

Giant Craters: The facets seen on Davida may be manifestations of giant craters. One can see similarities in our images of Davida with those of Mathilde [5] shown in Fig. 4 and the only C-type asteroid to be imaged at high resolution by spacecraft. For example, the profile of Mathilde shows very large, flat facets, which turn out to be the tops of large craters, seen edge-on. Davida is much larger than Mathilde and it is reasonable to ask whether the yet larger craters implied could even be possible on Davida.

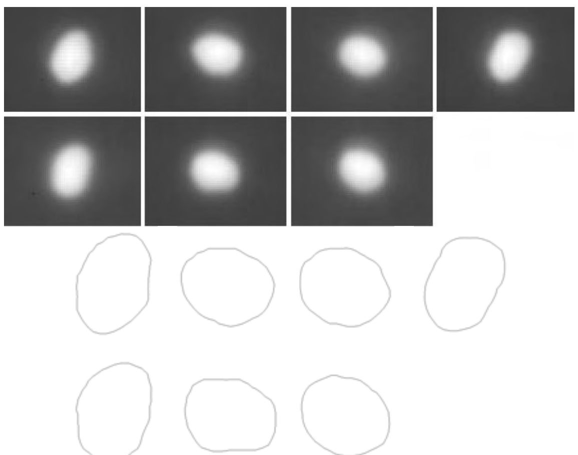

Figure 2. Images of 52 Europa (diameter 300 km), followed by our corresponding limb outlines, determined by discrete differentiation operator. For each epoch 6 separate K-band (2.1 micron) images were averaged to produce the images shown here.

We demonstrated [1], using the known main-belt size distribution for impactors [6], and scaling crater sizes from Mathilde (as in Davis [7]) that giant craters, of size roughly 150 km, could be expected on Davida, without likelihood of catastrophic breakup. That such giant craters are retained on Mathilde, in reasonably pristine condition, is remarkable. It would be even more remarkable if craters as large as the asteroid radius could also be maintained on Davida. We suggest that the flat facets on Davida may be analogues of those on Mathilde. In fact, such giant craters may be characteristic of C-types, and may be clues to the internal structure and porosity. To test this, we have acquired additional AO imaging of other C- and S-type asteroids, two examples of which are shown here, Iris and Europa. Europa has a size nearly the same as Davida, so if these facets (or craters) are characteristic, we might expect to see them also in our images here. Although there appear to be some flat facets, some nearly the size of the body's radius, so far it is hard to be definitive before our full rotational analysis is complete.

Another issue is whether S-types are different from C-types in terms of their retention of giant craters. First, one might expect smaller craters from a given impactor than on C-types. In the many images of S-type asteroids from spacecraft, there are many apparent flat facets, when seen in profile, but few, if any, of them seem to be related directly to a well preserved giant crater, and the large craters do not seem to result in such distinct profiles as on Mathilde. For our S-type Iris, there do appear to be some flat facets, possibly even of order the body radius. But with only 4 epochs it is hard to track them, and arguing for their existence or non-existence would be premature. More data will be required to be able to relate Iris and other S-types to the profiles seen for Davida.

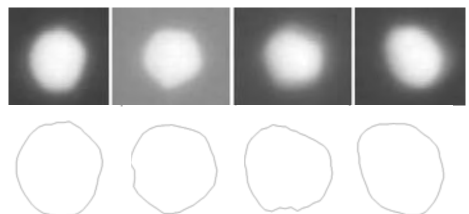

Figure 3. Images of 7 Iris (diameter 200 km) at 4 epochs, displayed as in Fig. 2.

Figure 4. NEAR image of asteroid 253 Mathilde (diameter 53 km) showing large facets, in profile, which turn out to be giant craters seen edge-on .

Conclusion: We have compared the limb profiles of three asteroids observed with the Keck adaptive optics system. For the asteroid 511 Davida we have confirmed, via rotational analysis, the existence of a large facet and provided evidence indicating that this facet may be a giant crater reminiscent of those observed on Mathilde by NEAR. In our preliminary analysis of the limb profiles of 52 Europa and 7 Iris we see evidence of possible large facets. Further analysis will be necessary to determine if these facets can be rotationally confirmed and whether, particularly for the S-type Iris, they are manifestations of giant craters.

Acknowledgements: Work was supported in part by the NASA Planetary Astronomy grant to C. Dumas.

References: [1] Conrad, A.R., et al. (2007) *Icarus, submitted*. [2] Merline, W.J., et al. (2002) *Asteroids III*, 289. [3] Britt, D.T., et al. (2006) *LPSC 37*, 2214. [4] Housen, K.R., et al. (1999) *Nature 402*, 155. [5] Veverka, J., et al (1999) *Icarus 140*, 3. [6] Bottke, W.F. (2005) *Icarus 179*, 63. [7] Davis, D.R. (1999), *Icarus 140*, 49