ICE ON LOW ALBEDO ASTEROIDS: MORE WIDESPREAD THAN PREVIOUSLY THOUGHT?. A. S. Rivkin[1], J. P. Emery[2], E. S. Howell[3], [1]JHU/APL, Laurel MD USA [2]University of Tennessee, Knoxville TN USA, [3]Arecibo Observatory, Arecibo PR USA

Introduction: Low albedo asteroids are associated with the carbonaceous chondrites. They dominate the asteroid belt, with the C complex the majority spectral class in the middle to outer belt [1]. Recent work suggests low albedo objects outnumber high albedo objects even in the inner belt [2], consistent with C asteroids as the most common spectral complex there as well.

Water/OH as ice or bound into minerals strongly absorbs in the 3-µm spectral region. While water in the Earth's atmosphere makes this spectral region a more difficult one to work in than the visible and near-IR wavelengths commonly used for asteroid observations, decades of successful observations have been obtained [3-6]. These observations have mostly been made at the NASA IRTF on Mauna Kea, with the SpeX instrument the main workhorse during the 21st century [7].

Previous studies have [8,9] showed evidence of ice on the surface of 24 Themis, interpreted as a thin layer on silicate grains. This is consistent with the observations of the "activated asteroids" (also called "main belt comets"), whose cometary activity can only be explained by sublimation of recently-exposed water ice [10,11]. Compositional modeling of the spectrum of 65 Cybele by [12] also found evidence for water ice.

Recent dynamical modeling [13] suggests that many objects now in the asteroid belt may have formed in the 4-8 AU region, well into the region where significant amounts of ice could be accreted. In light of this modeling, and of the findings on Themis and Cybele, we consider the question: How common are icy surfaces in the asteroid belt?

Results: Through the L-band Main-belt/Neo Observing Program (LMNOP), we have made nearly 150 observations of over 90 low albedo asteroids since 2002. This survey has led to the identification of ice on the surface of 24 Themis [8] and the identification of brucite and carbonates on the surface of 1 Ceres [14,15]. It has also demonstrated the diversity of hydrated material in the asteroid belt, with spectral shapes ranging from CM-like to Ceres-like, and other yet-unidentified materials. There appear to be at least 4 plausible spectral classes, including one "anhydrous" group, as independently found by others [16].

One of the prospective asteroid groups is the "Themis class", consistent with the spectrum of 24 Themis. We will present spectra of 16 additional asteroids that show spectral similarities to 24 Themis in the 3-µm region, and are similarly interpreted as having surfaces containing some ice. One of these objects, 65 Cybele, has been previously identified as ice-bearing as noted above [12]. Most of the objects in this work are in the outer asteroid belt (a > 3 AU) but several are in the mid-belt near 2.7 AU, much closer to the Sun than expected. We present evidence that the ice is not exogenic. Near-surface ice apparently exists to the present day in objects unrelated to the Themis family, suggesting that it is widespread in the asteroid belt. This is also consistent with the Themis family forming in the same area as other C-complex asteroids rather than being imported from the TNO region.

We will also present preliminary compositional models for these objects and (hopefully!) plausible scenarios for maintaining ice at the surfaces of objects as warm as mid-belt C-class asteroids.

References: [1] Bus S. J and Binzel R. P. 2002, *Icarus* 158:146-177. [2] Masiero, J. R., et al. 2011, *Astroph. J.* 741:68 [3] Lebofsky L. A. 1978, *Mon. Notes Royal Ast. Soc.* 182:17-21. [4] Feierberg, M. A. et al. 1981, *Geochem Cosmochem. Acta* 45:971-981. [5] Jones T. D. et al. 1990, *Icarus* 88:172-192. [6] Rivkin A. S. et al. 2003, *Met. Plan. Sci.* 38:1383-1398. [7] Rayner, J. T. et al. 2003, *Pub. Ast. Soc. Pac.* 115:362-382. [8] Rivkin, A. S. and Emery, J. P. 2010, *Nature* 464:1322-1323. [9] Campins, H. et al. 2010, *Nature* 464:1320-1321. [10] Hsieh H. H., et al. 2010, *Mon. Notes Royal Ast. Soc.*403:363-377 [11] Jewitt, D. 2012, *Ast. J.* 143:66 [12] Licandro, J. et al. 2011, *Astron. Astroph.* 525:A34. [13] Walsh, K, J. et al. 2011, *Nature* 475:206-209. [14] Rivkin A. S. et al. 2006, *Icarus* 185:563-567. [15] Milliken, R. E. and Rivkin, A. S. 2009, *Nature Geosc.* 2:258-261. [16] Takir, D. and Emery, J. P. 2011 *LPSC* 42, abst. 1182