Could Some of the Existing Asteroid Taxonomic Classes be Explained as Space Weathered Samples of Other Classes?

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Asteroids are remnants of the early Solar System formation, representing relics from the era when dust and ice accreted into planetesimals. These small bodies then coalesced to form the planets, with asteroids remaining as the vestiges of this process. Most solid matter in the Solar System was swept into planets, leaving asteroids as passive witnesses of these formative events. However, space weathering, which alters asteroid surface properties and colors over time, complicates our interpretation of the Solar System's history. Current taxonomies, which are not based on intrinsic properties such as mineralogical composition, geological history, and Earth-based meteorite analogs, but on extrinsic properties like spectral slope and band position, may be influenced by surface-altering processes. Therefore, we conducted an investigation into the robustness of asteroid taxonomy, given that even low albedo asteroids respond to space weathering by changing color.

Two recent spacecraft missions to asteroids have detected this color-changing in progress: NASA's OSIRIS-REx mission to asteroid (101955) Bennu and the Japanese Aerospace Exploration Agency's (JAXA's) Hayabusa2 mission to asteroid (162173) Ryugu. Both Bennu and Ryugu are primitive, organic- and volatile- rich assemblages of minerals that preserve material from the earliest phases of planet formation in our Solar System. We need to understand if they are "cloaking" themselves (or disguising themselves), and causing confusion as we develop our understanding of the asteroid population as a record of Solar System formation.

To investigate this, we analyzed color changes across multiple wavelengths (visible and infrared) to capture the full range of space-weathering effects on asteroid surfaces. These asteroids serve as ideal candidates due to their known organic-rich compositions and the availability of direct observational and sample data. We then use this information to study how asteroid color changes with age might explain some of the known color variation between asteroids in our Solar System and how this would impact the compositional mass distribution of the asteroid regions of the Solar System.
Currently, most known asteroids fall into either the S-complex (composed of S, Sa, Sq, Sr and Sv-types) or the C-complex (composed of C, B, Cb, Cg, Cgh, Ch, and sometimes P and D-types in the Bus-DeMeo taxonomy[1]). However, this classification primarily relies on spectral data from the surface's topmost millimeter. If the subsurface composition of an asteroid differs spectrally from the surface, this could significantly alter our interpretation of remote sensing data and our understanding of asteroid compositions. Now that we know how dark asteroid spectral properties change through time, can some of the existing taxonomic classes be explained simply as space weathered samples of other taxonomies? Here we report our efforts to understand the consequences of space weathering, a test of taxonomy robustness and implications for the compositional mass distribution of the asteroids.

References

[1] DeMeo, F.E. and Carry, B., 2013. The taxonomic distribution of asteroids from multi-filter all-sky photometric surveys. *Icarus*, *226*(1), pp.723-741.