TRACING METEORITES TO THEIR SOURCES THROUGH ASTEROID SPECTROSCOPY.
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Introduction: The goal of tracing meteorites to their main-belt sources is seemingly impossible given the inherent uncertainties in relating astronomical remote sensing measurements of asteroids to laboratory measurements of meteorites [e.g. 1]. What's more, the chaotic routes [2] for delivery of meteorites would seem to be sufficient to mask any trace of their points of origin. Yet reasonably compelling links can be made for the origin for two meteorite types: highly reduced enstatite achondrites (aubrites) appear to have a source from the inner most edge of the main-belt known as the Hungaria region [3]; reduced basaltic achondrite howardite-eucrite-diogenite (HED) meteorites are plausibly derived from the large asteroid 4 Vesta [4,5]. Beyond these specific examples, we seek to find additional evidence to more thoroughly pinpoint original locations for the much wider range of meteorite types and the oxidation environments they sample.

Near-Earth Asteroid Connections: Near-Earth asteroids (NEAs), defined as objects having a perihelion of 1.3 AU or less, are the larger kin and astronomically observable analogs of the more frequently arriving meter-scale objects that provide samples for our laboratories. Spectroscopic links between meteorites and NEAs, in conjunction with dynamical links between NEAs and the main belt, provide a traceable path to the origin location for meteorites. Reflectance spectroscopy of NEAs, and a comparison of their mineralogical interpretation [6] with meteorites, provides the NEA-meteorite connection. Statistical dynamical evolution models [7] provide the link between NEAs and their likely point of main-belt origin. Thus spectroscopic observations of near-Earth asteroids are the missing element for tracing meteorites to their sources.

Observations and Results: Modern CCD visible and near-infrared spectra are now available for nearly 400 near-Earth asteroids [8]. Combining these observational results with the dynamical models [7], many traceable trends emerge. A clear origin signature to the inner edge of the asteroid belt is seen for those NEAs having interpreted mineralogies rich in olivine and those being likely analogs to enstatite achondrites. NEAs having interpreted HED-like mineralogies have a distinct origin signature through the nu-6 and 3:1 resonances (as opposed to delivery via Mars-crossing interactions), dynamically requiring they be derived from a low eccentricity orbit source body. Vesta satisfies this dynamical criterion. NEAs interpreted to have the most primitive compositions, which formed under very oxidizing conditions, show traceable evidence for origins in the mid-to-outer range of the main-belt. Most striking is the origin signature of primitive "D-type" NEAs, where the outer main-belt and Jupiter family comet sources are clearly revealed. Source region profiles are indistinguishable for the most common class of asteroids (S-class) and those interpreted to be similar in mineralogy to ordinary chondrites (Q-class). These identical source profiles are consistent with ordinary chondrites being derived from the inner to central part of the main-belt, providing firm observational evidence to fix the solar system location where their varied states of oxidation occurred. This latter result has implications for the reality of space weathering processes, where a distinct size-dependent trend is found. NEAs 5 km and larger generally show evidence of space weathering. Either >5 km objects are large enough (for surviving against collisions) to have sufficiently old surfaces or 5 km represents a threshold where regolith retention and evolution becomes sufficient to enable the space weathering process(es).

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