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IMPLICATIONS OF ASTEROID COMPOSITION FOR THE GEOCHEMISTRY OF THE ANCIENT TERRESTRIAL PROJECTILE FLUX

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Introduction: The discovery of enhanced siderophile abundances at the Cretaceous/Tertiary boundary has provoked many searches for geochemical signatures which could reveal other catastrophic impacts in Earth's history. These searches implicitly assume that most large impactors are of chondritic, iron, or stony-iron composition, with a greatly enhanced abundance of siderophile elements. Impactors composed of asteroidal crust or mantle rocks analogous to the achondritic meteorites would not leave a distinct geochemical trace since their siderophile abundances are grossly similar to those of the Earth's crust. In recent years studies of the mineralogical composition of the current asteroid belt have suggested that the composition of impacting projectiles may be highly variable with both projectile size and time. In particular it seems possible that in the distant past projectiles derived from asteroid mantle material may have caused a large fraction of the cratering events on Earth. Such impacts would be missed by any geochemical search relying on iridium or any other siderophile element.

Does projectile composition vary with size?: The meter-size projectiles observed to fall today (i. e. meteorites) are predominantly of chondritic composition. But the kilometer-size projectiles which we observe passing close to the Earth (i. e. Earth-approaching asteroids) appear to contain a much smaller proportion of chondritic objects with relatively far more stony-iron and iron objects. In the current sample of >25 kilometer asteroids in the inner main asteroid belt, no ordinary chondrite bodies are found; this population is predominantly stony-irons with a few achondrites. This trend strongly suggests that the current projectile population varies strongly in composition with size. This effect is probably due to the much greater strength of iron-dominated objects and their longer collisional lifetimes (as shown many years ago by the much longer cosmic-ray exposure ages of irons relative to stones). Fortunately, since chondrites and stony-irons both have enhanced siderophile abundances, this effect is not likely to conceal many terrestrial impacts from geochemical snoopers.

Did projectile composition vary with time?: Main-belt asteroids (the presumed source of most projectiles striking the Earth) show a striking anomaly: crustal and mantle rock types are very rare relative to iron and stony-iron objects which must have come from the deep interiors of the same differentiated parent bodies (C. R. Chapman, *Mem. Soc. Ast. Italiana,* **57**, p. 103-114, 1986). Where did all these olivine-pyroxene rocks go after they were stripped off their parent bodies to expose the cores we see today? Again, differential fragmentation seems to provide the answer. Once the original parent planeteismals were disrupted, the silicate asteroids derived from the crusts and mantles were quickly broken down into small fragments, while the metal-rich asteroids derived from deeper layers were much more resistant to collisions and mostly survive as large bodies today. Thus it is likely that silicate asteroids may have comprised a much larger fraction of the main-belt asteroids (and therefore the terrestrial impactorsderived from them) in the distant past.

Could there be a significant number of "hidden" impacts in Earth's history that current geochemical searches are missing? It is virtually certain that at least a small fraction of impacts leave no siderophile signature, since there are several Earth-approaching asteroids known to be of basalt or dunite composition. The considerations noted above suggest that this fraction may have been much larger at some ill-defined time in the past. It is as yet impossible to say when this period may have occured in terms of the terrestial geologic timescale. Thus it is likely that some geological discontinuities without associated siderophile anomalies are actually the results of impacts. With our current level of understanding of asteroid evolution we cannot rule out the possibility that major changes in the geochemistry of the impacting flux have occurred, and that current methods of searching for impact signatures will fail to detect a significant fraction of the actual number of major cratering events on Earth.