Classification of aqueously altered chondrites and implications for geological processing on chemically primitive asteroids

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Carbonaceous chondritic meteorites were classified ~50 years ago into chemical classes such as CI, CM and CO and petrological classes 1-6 [1]. Type 1 and 2 chondrites have experienced aqueous alteration and type 3 are less altered. Typically petrological-chemical pairings were observed: CI1, CM2 and CO3. Since this initial classification system was devised, the total number of named meteorites has increased from approximately 2000 to over 50,000 [2], as more meteorites have been found during desert collection trips. The picture of classification has been muddied by an increasing number of described meteorites that do not fit into the current classification system and by the abundance of meteorite classifications not previously observed, for example there are now only 3 commonly-available unheated CI1 meteorite falls but 19 CM1s [2] and there are several meteorites that appear intermediate between CM and CI. The current system needs reassessment, especially given the increased interest in chemically primitive objects that are targets for the sample return missions Hayabusa-2 and OSIRIS-REx.

Some important processes for type 1 and 2 chondrites that are not considered by [1] include brecciation, heating and terrestrial processing. A significant number of aqueously-altered CI and CM meteorites have experienced post-aqueous heating, which has resulted in the dehydration of phyllosilicates [3]. A complicating issue for chondrite classification, especially for type 1 chondrites, is terrestrial weathering, which can produce major changes in the meteorite even for well-curated falls [4]. This can potentially cause mineralogical changes that can be easily confused with asteroidal processing.

Implications for asteroids: The CO-CM-CI meteorites fall on a complex continuum with varying amounts of heating and metasomatism. This points to them originating on the same or related parent bodies that have experienced complex local geological processes including brecciation, solar interactions and/or impacts.

1] Van Schmus and Wood (1967) GCA 31 747 [2] Meteoritical Bulletin [3] King et al. (2015) GCA 165 148, [4] Gounelle and Zolensky (2010) MAPS **36** 1321.