**ASTEROIDAL WATER: THE EVIDENCE FROM THE AQUEOUS ALTERATION EXHIBITED BY CHONDRITIC METEORITES.** M.E. Zolensky, SN2, NASA Johnson Space Center, Houston, TX 77058 USA (michael.e.zolensky1@jsc.nasa.gov).

**Mineralogical Products of Aqueous Alteration:**

The mineralogical products of aqueous alteration most commonly encountered within primitive extraterrestrial materials include phyllosilicates, hydroxides, tochilinites, sulfates, oxides and carbonates. Most of these alteration products are matrix phases, although alteration of larger components (e.g. chondrules, aggregates and inclusions) also figure prominently.

The least equilibrated chondrites (type 3) contain limited, though significant, direct evidence of asteroidal aqueous alteration. Matrix, chondrules and CAIs in the type 3 carbonaceous and ordinary chondrites contain variable amounts of phyllosilicates, principally smectites, serpentine, micas and halite [1]. Some meteorites also contain feldspathoids (nepheline and sodalite) of proposed metasomatic origin.

The products of aqueous alteration are ubiquitously present in the type 2 carbonaceous chondrites, in amounts far greater than within the type 3s, and in all components (matrix, phenocrysts, chondrules, CAI). These minerals include abundant serpentines, smectites, clinochlore, Mg-Fe sulfates, tochilinite, tochilinite-serpentine intergrowths and carbonates [2-4]. Abundant evidence of replacement reactions are evident, including olivine and glass being replaced by serpentine, metal and sulfides being replaced by tochilinite, and Fe-rich serpentine being replaced by Mg-rich serpentine [3-5]. Carbonates (calcite and dolomite), and lessor sulfates, intimately intergrown with matrix phyllosilicates and tochilinite have been notably reported in numerous type 2 chondrites [6-9]. The occurrence of aragonite in some meteorites [7] is particularly interesting because of its metastability with respect to calcite. The organic compounds found within these meteorites [10&11] are believed to have been processed during asteroidal evoution, with the present compounds being produced by aqueous and hydrothermal activity. More work on organics will probably be shortly forthcoming based on the recent fall of the organic-rich chondrite, Tagish Lake [12].

The type 1 chondrites are composed almost entirely of secondary phases, with the bulk being phyllosilicate consisting of intergrown serpentine and saponite, pyrrhotite, Ca-Mg-Fe carbonates, Ca-Mg-Fe sulfates, and magnetite [13]. The morphologies of magnetite in these meteorites include framboids, spherulites and plaquettes, delicate structures which experimental work indicates may have crystallized from gels or aqueous solutions [14]). Type 1 chondrites frequently display crosscutting veins of Ca-Mg carbonates. Studies have revealed the presence of alkanes, aromatic hydrocarbons, aliphatic carboxylic acids, purines, pyrimidines, amino acids [15], and insoluble aliphatic and aromatic/olefinic structures [10], all taken to have formed from aqueous solutions.

**Textural Evidence for Asteroidal Alteration:** Aqueous alteration within meteorite parent bodies is required by the common occurrence of alteration minerals with the following special textures: (1) mineral grains bridging chondrules, aggregates, and phenocrysts with matrix, (2) veins bridging chondrules, aggregates, and phenocrysts with matrix, (3) secondary phases being distributed throughout most, or all, constituents of a meteorite, often with near identical composition everywhere, (4) displays of relict chemical zoning or correlations within matrix and altered chondrules and aggregates, (5) linings in fractures and cracks, and (6) high-temperature pseudomorphs after low-temperature hydrous mineral assemblages.

**Fluid Inclusions:** Recently, we have begun to locate and examine actual samples of asteroidal aqueous fluids. These are briny fluid inclusions present within halite and carbonates in ordinary and carbonaceous chondrites [16]. The value of these primitive water samples cannot be overestimated, and their study will revolutionize our understanding of asteroidal history.

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