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18-21 Oct in Portland, Oregon.
Session: T124 (Wednesday 21-Oct, session start 8am, presentation 11:10am)
Fluid-Driven Geochemical Transformations: In Honor of Harold Helgeson
sponsors: Society of Economic Geologists; Geochemical Society
convenors: Everett L. Shock, Dennis Bird, William Murphy, John Dilles
Topic: Theoretical modeling is ubiquitous in aqueous geochemistry, because most fluids responsible for geochemical transformations no longer exist. This session will highlight theoretical, experimental, field and analytical developments that push the current limits of modeling capabilities.

Modeling Solids in Astrophysical Gaseous (Fluid) Disks as Cosmochemical Indicators

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Cosmochemical transformation (and formation) of the chondrules, amoeboid olivine aggregates, and Ca-, Al-rich inclusions (CAIs) occurred in now-vanished 'fluids', the speciated gas in the transiently heated regions of the early solar system. The refractory/volatile ratios, heavy/light isotope and extinct radionuclide signatures, trace element abundances, element valence states, and mineral identities in these inclusions are all clues to the chemical properties, thermal histories, and spatial and temporal locations of the vanished 'fluids'. Gaseous cosmochemistry and aqueous geochemistry have much in common.

Indeed, gaseous disks are treated as continuum mechanical fluids in many dynamical models of disk evolution. By analogy with fluvial sedimentation, the textural properties of inclusions accreted into different classes of meteorites may also be perceived to result from their concentration in turbulent eddies, or by differential gas drag. Thus 3D meteorite textural analysis further informs us of the vanished nebular 'fluid'.

Recent measurements yield nonzero Na content of chondrule olivine, and no isotopically heavy Mg, Si, Fe or K enrichment in chondrules. Theoretical modeling indicates that this requires very high solid (i.e., dust, condensable element) abundances, relative to H-rich gas, to suppress evaporation of silicate liquids throughout their brief heating and cooling in space. By contrast, experimental evaporation of CMAS liquids, and cutting-edge isotopic measurements, combined with theoretical models, indicate much lower or no dust enrichments, and slower cooling of Mg- and Si-isotopically heavy CAIs, that also record low $f(O2)$ in the mixed valence state of Ti in pyroxene.

Modeling low-P, high-T systems of gaseous fluid + silicate liquid + solids as they condense, evaporate and crystallize requires better mixing models of solid and liquid solutions, and experimental kinetic parameters to describe evaporation. Coupling chemistry to disk magnetohydrodynamics will require parameterization of first order chemical phenomena including solid-gas interactions. Also emergent is the detailed modeling of aqueous alteration histories of meteorites as parts of parent planetesimals containing vanished aqueous fluids that contributed volatile molecules to habitable planets.