IMPACT OF HYDRATES ON PLANETARY EVOLUTION

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There are two end-member models for the evolution of planets: cool clusters warming and hot nebulae cooling. In either case, the hydrate phase could play an important role in a planet's evolution.

If a cool cluster contains enough water and natural gases such as methane, ethane or other simple molecules, hydrates could form and be part of the initial cluster consolidation. Hydrates would then act as a conservative process to retain the gas molecules. They would be distributed globally until the cluster center warmed sufficiently that the hydrates there would begin to dissociate. Hydrates would continue to exist beyond a surface that would migrate outward from the cluster center, following the appropriate thermal environment. As the region of dissociation expands, hydrates could reform at the expanding surface and thereby contribute to formation of an impermeable shell, or "crust", that would retain a growing amount of free gas. This would be similar to what occurs on planet Earth when hydrates form in the interstices between grains of submarine sediment to produce a seal that traps free gas beneath the so-called bottom simulating reflector (BSR). The result would be a planet unusually well endowed with natural gases.

In the converse situation of a hot nebula cooling, the environment must become cool enough for hydrates to form given the ambient pressure. Many of the lighter gas molecules would have "boiled off" by that time, however. Hydrates would form first on the cooling surface, then descend toward the center, again following the appropriate thermal contours. Once they did form, they would serve to conserve the remaining gases. Because hydrate formation would come late in planetary evolution, the total gas volume that could be conserved would be less than that of the former model.

Depending on which thermal model is appropriate for planetary evolution, the surface corresponding to formation of a hydrate phase will migrate either from the interior outward or from the surface inward. Thus the evolving crust and thermal regime will dictate occurrence and extent of hydrate development and impact on conserving gases.

In the evolution of a planet, some process of global tectonics/dynamics is probably inevitable. A common astrophysical assumption is that the principal mechanism for heat generation is gravity-driven compression. Should there be abundant gases throughout the crust, ignition of these could be a contributor to the planetary heat generation. With gas and/or hydrate expansion, contraction, and/or ignition, heat generation could have localized aspects (i.e. heat growing along fractures within the crust) and impacting local and regional tectonics.

On planet Earth, the volume of microbial life deep in the crust appears to rival that on the planetary surface. Food for this web of life may be gases with hydrates containing them. The impact of this life and gas volume to crustal stability and dynamics are not yet even guessed at. Similar dynamics may be routine in hard-rock planetary evolution.