Progress in understanding the energy and environmental implications of gas hydrates

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Since 2000, the U.S. Department of Energy has collaborated with 6 other agencies of the federal government to study the varied mplications of gas hydrates in nature. This effort includes investigations of both arctic and marine gas hydrates with respect to gas hydrate's role in the global carbon cycle and climate change, its contribution to a range of geohazards, and its potential as a future energy resource.

Going forward, the program will continue to include a wide range of fundamental investigations, from the molecular to the reservoir scale, of the physical nature and behavior of gas hydrate and gas-hydrate-bearing sediments. In addition, the program will pursue large and complex programs in the field designed to assess the occurrenced of gas hydrate and to collect *in situ* data from hydrate accumulations. In recent years, these efforts have found success in both Alaska and in the Gulf of Mexico, where drilling programs have validated the geological-geophysical approach to gas hydrate exploration based on an integration of direct detection with analyses of key component of gas hydrate petroleum systems. The components include not only sufficient pressure and temperature regimes, but also gas sourcing, gas migration pathways, reservoir quality, and time.

In Alaska, the program hopes to initiate, in 2011, a comprehensive and extended term production testing program in partnership with Alaska North Slope operators that will investigate the response of gas hydrate-bearnig sediments to various destabilizing forces. This intial stage of scientific testing will provide insight into the design of future production/environmental monitoring tests, as well as guide the further development of numerical models used to investigate the response of gas hydrate to natural phenomena, including ongoing climate change.

In the Gulf of Mexico, the program, in partnership with an international industrial consortium led by Chevron, conducted 'Leg II' drilling operations in early 2009 that confirmed gas hydrate occurrence in a wide variety of settings. Planning is now underway for a Leg III program in the Fall of 2010 that is designed to collect pressurized core samples of gas hydrate-bearing sediments to enable detailed study on the physical-chemical properties of gas hydrate-bearing sediment and the geological controls on gas hydrate occurrence.

Gold fertility of sulfur-bearing magmas

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It is believed that in the range of oxygen and sulfur fugacities prevailing in the upper mantle and the Earth's crust the geochemical behaviour of highly-siderophile elements (HSE) such as Au and platinum group metals are mainly controlled by the presence of sulfide phases due to extremely high partition coefficients of HSE between sulfide and silicate melts (with $D^{sulfide/silicate}$ up to 10^4). Thus, it is generally assumed that only sulfide-undersaturated magmas are 'fertile' and able to extract HSE from the mantle sources and transport them into the upper crust in the amounts that are necessary to form ore-deposits such as Cu-Au-porphyry or orthomagmatic Ni-Cu-PGE+Au deposits. However, we have found experimental evidence for a dramatic effect of S speciation and redox conditions on the behaviour of Au in S-bearing magmas, which has extremely important implications for the evaluation of HSE mobility and for the interpretation of natural ore-forming magmatic processes.

Our data show an increase in Au content in sulfide saturated magmas of roughly one order of magnitude within the narrow range of redox conditions between FMQ and FMQ+2. The observed excellent correlation of Au solubility in magmas and Au partitioning between silicate and sulfide phases with S speciation and fS_2 implies that 'gold' fertility of natural magmas is expected at redox conditions corresponding to the narrow range of sulfide-sulfate transition. Mantle-derived magmas generated at these conditions (mainly from metasomatized mantle wedges above subduction zones and from hot-spot environments) are expected to be able to mobilize and transport the largest amounts of Au (and presumably other HSE). Progressive oxidation of such magmas by for instance, slab-derived supercritical fluids and/or melts may cause a significant enhancement in Au activity due to destabilization of extracted Au-sulfide components in silicate liquids.