



2008-09 AAPG Distinguished Lecture

Abstract

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Funded by the AAPG Foundation

Relation Between Volcanism, Tectonism and Hydrothermal Activity Along the Global Mid-Ocean Ridge System

Just over 30 years ago, scientists exploring the global mid-ocean ridge system made the spectacular discovery of black smokers—hydrothermal chimneys made of metal sulfide minerals that vigorously discharge hot, particulate-laden fluids into the ocean. These chimneys are the surface manifestation of convection of seawater through the oceanic crust and water-rock reactions that produce hot, hydrothermal fluids that discharge at the seafloor. This hydrothermal circulation process plays an important role in regulating the chemistry of seawater, building mineral deposits, and supporting chemosynthetically-based ecosystems.

Early studies focused on hydrothermal systems on the fast-spreading East Pacific Rise, where shallow magma lenses beneath the ridge crest provide heat to drive convection of seawater through the oceanic crust. Ten years later, studies of the slow-spreading Mid-Atlantic

Ridge revealed much larger mineral deposits – a surprising result given the lower magma delivery rate and heat availability.

Through the use of different deep-submergence technologies, this talk will explore the characteristics of vents and their associated communities along the mid-ocean ridge, and the varying relations between volcanic and tectonic processes at sites on ridges of different spreading rates. It will focus in particular on how one active hydrothermal system has constructed a large mineral deposit on the Mid-Atlantic Ridge, and how recent experiments at that site have shed light on the role tectonics and faulting play in the evolution of long-lived hydrothermal systems.

Susan E. Humphris

Education:

1977 PhD, MIT/WHOI Joint Program, Chemical Oceanography
1972 BA (1st Class Hon.), University of Lancaster, U.K., Environmental Sciences



Experience:

2004-present Chair, Geology & Geophysics Department
2000-04 Director, Deep Ocean Exploration Institute, WHOI
1998-present Senior Scientist, WHOI
1992-98 Research Specialist, WHOI
1986-92 Dean, Sea Education Association
1979-86 Scientist, Sea Education Association
1976-78 Postdoctoral Researcher, Imperial College, London, UK

Publications and Awards

Over 80 publications in various scientific journals including *Science*, *Nature*, *Journal of Geophysical Research*, *Geology*, *Geochimica Cosmochimica Acta*, *Earth & Planetary Science Letters*, and *Chemical Geology*. Co-creator of the award-winning Dive and Discover website (<http://www.divediscover.who.edu>)

Selected Publications:

Humphris, S.E., Herzig, P., Miller, D.J., and the Leg 158 Shipboard Scientific Party, 1995. The subsurface nature of an active seafloor hydrothermal system, 26°N, Mid-Atlantic Ridge. *Nature*, 377, 713-716.
Humphris, S.E. and Cann, J.R., 2000. Constraints on the energy and chemical balances of the modern TAG and ancient Cyprus seafloor sulfide deposits. *J. Geophys. Res.*, 105, 28,477-28,488.
Humphris, S.E. and Tivey, M.K., 2000. A synthesis of geological and geochemical investigations of the TAG hydrothermal fluid: Insights into fluid flow and mixing processes in a hydrothermal system. In: Dilek, Y.,

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- Moore, E., Elthon, D. and Nicolas, A. (eds): *Ophiolites and Oceanic Crust: New Insights from Field Studies and the Ocean Drilling Program.*: Boulder, CO, Geological Society of America Special Paper 349, p. 213-235.
- Humphris, S.E., Fornari, D.J., Scheirer, D.S., German, C.R. and Parson, L.M., 2002. Geotectonic setting of hydrothermal activity on the summit of Lucky Strike Seamount (37°17'N, Mid-Atlantic Ridge). *G-cubed*, 3(8), 1049, doi: 10.1029/2001GC000284
- Humphris, S.E., Halbach, M. and Juniper, K., 2003. Low-temperature alteration: Fluxes and mineralization. In: Halbach, P.E., Tunnicliffe, V. and Hein, J.R. (eds.) *Energy and Mass Transfer in Hydrothermal Systems*, Dahlem University Press, Germany, 163-181.
- Humphris, S.E. and Bach, W., 2005. On the Sr isotope and REE composition of anhydrites in the TAG seafloor hydrothermal system. *Geochim. Cosmochim. Acta*, 69, 1511-1525.
- DeMartin, B., Reves-Sohn, R., Canales, J.P. and Humphris, S.E., 2007. Kinematics and geometry of detachment faulting beneath the TAG hydrothermal field, Mid-Atlantic Ridge. *Geology*, 35, 711-714.
- Humphris, S.E., Reves-Sohn, R.A., Singh, T. and Edmonds, H.N., 2008. Exploration of hydrothermal vents on the Gakkel Ridge, Arctic Ocean, using autonomous underwater vehicles. In: Collins, K. and Griffiths, G. (eds): *Proc. of International Workshop on AUV Science in Extreme Environments*. London: Society for Underwater Technology, pp. 129-136.
- 1991 Massachusetts Marine Educators Award for Dedicated Service and Outstanding Contributions to Marine Education
- 1992 Ocean Drilling Program Distinguished Lecturer
- 1999 J. Seward Johnson Chair in Oceanography, WHOI
- 2003 Massachusetts Marine Educators' Nap J. Bonaparte Service Award

Professional Memberships:

American Geophysical Union
American Association for the Advancement of Science

Interests:

Susan Humphris studies hydrothermal activity along the global mid-ocean ridge system. Her ultimate objective is to assess the role of hydrothermal fluxes in global geochemical mass balances. This involves combining two lines of research: (i) investigating the volcanic and tectonic controls on the distribution and characteristics of hydrothermal activity at ridges of different spreading rates, and (ii) unraveling the geochemistry of seawater-rock reactions within hydrothermal systems. These interests have resulted in Susan spending more than three years at sea on various oceanographic research ships, including the drilling ships *Glomar Challenger* and *JOIDES Resolution*. She has completed many dives in the submersible, *Alvin*, and has used the remotely-operated vehicle *Jason* and autonomous underwater vehicles for scientific work in the Atlantic, Pacific, Indian and Arctic Oceans.

Susan was also the co-creator of the award-winning *Dive and Discover* website (<http://www.divediscover.whoi.edu>) to bring oceanographic research expeditions in near real-time to students and the general public. The backbone of the site is a series of educational modules that address basic science concepts central to marine science and research being conducted at sea. When a cruise is taking place, the site provides daily updates on the progress of the cruise through still and video images from the seafloor and of shipboard operations, graphical representations of a wide variety of oceanographic data, explanations about the technology being used, and general information about life at sea and the scientists, engineers, and mariners that make oceanographic research possible.