ODP REVEALS THE ANATOMY OF AN ACTIVELY FORMING SEAFLOOR MINERAL DEPOSIT

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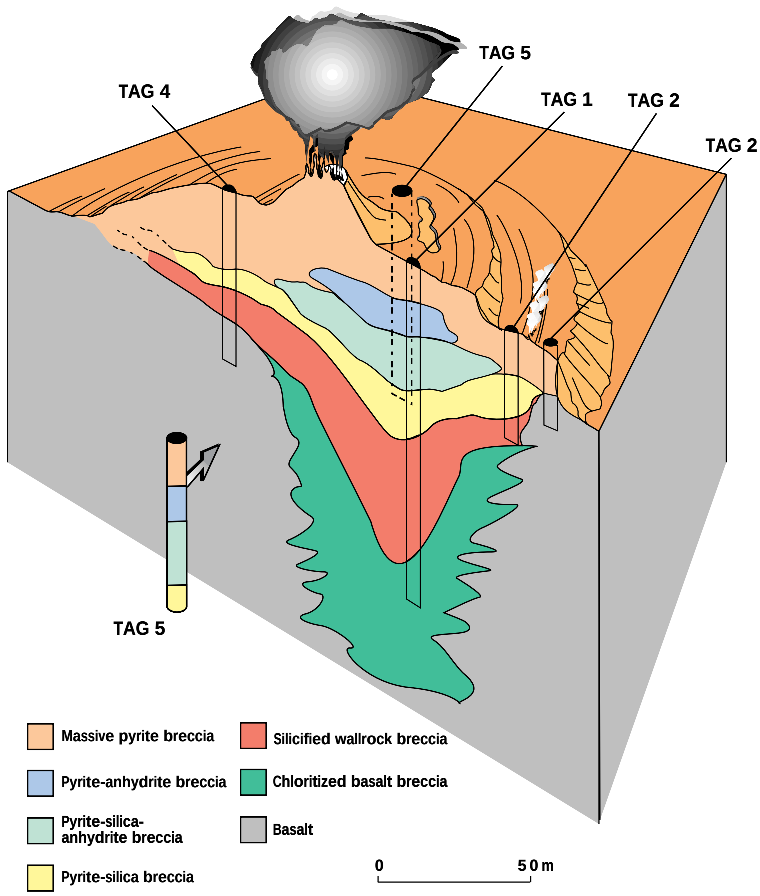
Metal ore bodies contained within massive sulfide deposits, such as on the island of Cyprus, are thought to have formed long ago and at great depths in the ocean. There, hydrothermal circulation of seawater through oceanic crust at mid-ocean ridges gives rise to complex rock-water interactions that produces sulfide deposits. To better understand their origin, characteristics, and distribution, we study actively forming deposits by drilling into them. Our results enable us to test and revise models that have been put forward to explain the genesis of these sulfide deposits. Such models may be used to prospect for ore bodies**.**

Drilling during ODP Leg 158 in 1994 at the Trans-Atlantic Geotraverse (TAG) site on the Mid-Atlantic Ridge revealed for the first time the size and internal structure of an active massive sulfide deposit and the underlying stockwork that is forming on young, unsedimented oceanic crust. The stockwork is a three-dimensional deposit of dense mineral veinlets. With an estimated 30,000-60,000 metric tons of copper in the deposit, the TAG site is comparable in size to the largest 30% of the Cyprus-type ore deposits. The bulk of the deposit consists of a heterogeneous assemblage of cemented angular rock fragments (breccias) composed of pyrite/marcasite, chalcopyrite, quartz, and anhydrite (calcium sulfate). This deposit records a complex depositional history reflecting multiple cycles of active growth, separated by periods of dissolution of anhydrite, dislodgement and downslope transport, and brecciation [*Humphris et al.,* 1995]. Material deposited during earlier episodes of hydrothermal activity is overgrown by later generations of minerals, and is progressively cemented or replaced by quartz, sulfides, and anhydrite. Over long periods of time, hydrothermal reworking remobilizes metals from the massive sulfides and concentrates them at the top of the deposit.

New evidence from the internal structure of this TAG deposit has been used to reinterpret the origin of several important ore types. A key observation is the abundance of anhydrite, a mineral that is saturated in seawater at temperatures of 150°C or greater, but undersaturated below that. As such, anhydrate is uncommon and poorly preserved in fossil deposits. Circulation of seawater within the deposit, and precipitation of anhydrite as the seawater is heated both by mixing with hydrothermal fluid and by conduction of heat from below, plays a critical role during the construction of the TAG deposit. However, during periods of inactivity and cooling, anhydrite dissolution leads to collapse of the mound and extensive brecciation. The possible magnitude of this effect is indicated by the estimate, based on the drilling results, that the TAG mound currently contains about 165,000 metric tons of anhydrite. This important mechanism for the formation of breccias provides a new explanation for the origin of similar breccia ores observed in ancient massive sulfide deposits.



Sketch of the active Trans-Atlantic Geotraverse (TAG) hydrothermal mound showing the generalized internal structure and mineralogic zones as revealed by drilling (modified from Humphris et al., [1995]).

Reference:

Humphris, S.E., P.M. Herzig, D.J. Miller, J.C. Alt, K. Becker, D. Brown, G. Brugmann, H. Chiba, Y. Fouquet, J.B. Gemmell, G. Guerin, M.D. Hannington, N.G. Holm, J.J. Honnorez, G.J. Iturrino, R. Knott, R. Ludwig, K. Nakamura, S. Petersen, A.-L. Reysenbach, P.A. Rona, S. Smith, A.A. Sturz, M.K. Tivey, X. Zhao, The internal structure of an active seafloor massive sulphide deposit, *Nature, 377,* 713-716, 1995.