Lucky Strike — A Newly Discovered Hydrothermal Site on the Azores Platform

Lucky Strike Team†

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In the fall of 1992, a joint U.S.-French cruise (the FAZAR expedition) surveyed and sampled the Mid-Atlantic Ridge between 33°N and 42°N in order to identify potentially active ridge segments of the Mid-Atlantic Ridge that might be sites of hydrothermal activity. During this cruise, a dredge haul recovered sulfides and live hydrothermal animals, including mussels and shrimp, from the top of a large seamount on the Azores Platform. In late May/early June 1993, a team of U.S., French and Portuguese scientists carried out a six-dive, multidisciplinary *Alvin* program to find and sample the active hydrothermal vent sites within the "Lucky Strike" vent field. Eight discrete active vent sites and a large area of relict sulfides were discovered. Massive sulfides, basalts, hydrothermal fluids and biological samples were collected, and have proved to be strikingly different in many respects to samples from the other known Mid-Atlantic Ridge hydrothermal sites.

The Lucky Strike hydrothermal field is located in a depression between three cones that form the summit of Lucky Strike seamount. This seamount is at the mid-point of a long, broad ridge segment extending from 37°00'N to 37°35'N. It is a composite feature about 5 km in diameter that rises 400 m above the valley floor to a depth of 1570 m (Figure 1). Many of the basalts recovered from this seamount are geochemically enriched in the alkali elements relative to normal mid-ocean ridge basalts due to their proximity to the center of the Azores hot spot, 200 km to the north. A dredge on the southern cone recovered fresh, glassy lavas exhibiting low vesicularity; samples recovered from the eastern cone are older, highly vesicular, and plagioclase phyric. Active vent sites have been mapped along a north-south trend from the southwest side of the eastern cone to the northeast side of the southern cone at water depths ranging from 1630 m to 1730 m. The discrete sites of active venting are dispersed over an area about 700 m long and 300 m wide; however, the boundaries of the entire vent field have not yet been determined.

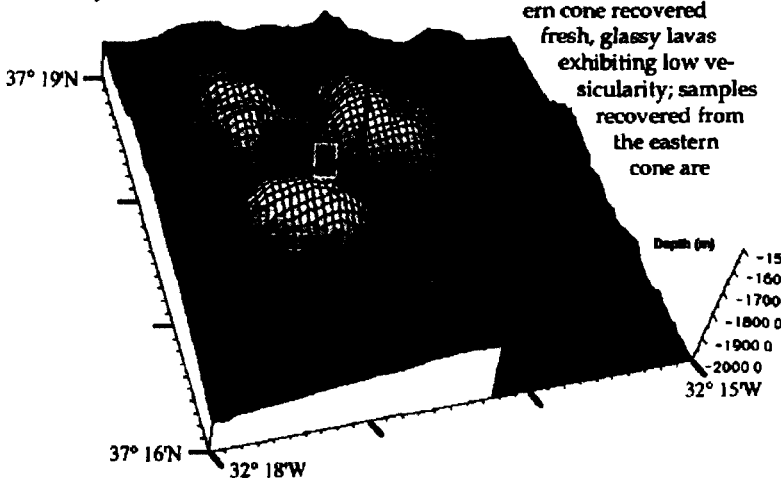

Figure 1. Sea Beam bathymetric map shown as surface model (80 m gridded data) of the Lucky Strike seamount. The hydrothermal field (box) is located in a depression between three cones that form the summit of the seamount. Heavy black line shows track of the dredge that recovered the massive sulfides and mussels during the 1992 FAZAR cruise.

Differences exist between the northern and southern parts of the vent fields. Much of the northern area is covered with relict sulfides, and two active areas were investigated. "Sintra" is a tall spire (about 5 m) that is active on one side but inactive on the other. The active side, where fluid temperatures of 212°C were measured, is composed dominantly of pyrite, marcasite and barite, with sphalerite and minor amounts of chalcopyrite. Massive sulfide talus from the inactive side consists of massive pyrite and chalcopyrite covered with an outer oxidized layer that includes atacamite. The "Statue of Liberty" site is a large, complex structure with an active barite-dominated flange forming a 2 m wide ledge around the base of inactive massive sulfide spires (Figure 2). The measured temperature of the fluid pooled beneath the flange was 200°C. Colonies of small mussels and occasional sea urchins — the first observation of these organisms at a vent site — inhabit the upper surface of the flange. A difference in chlorinity was also observed between the sites, with fluids from the Statue of Liberty site exhibiting a chloride content indistinguishable

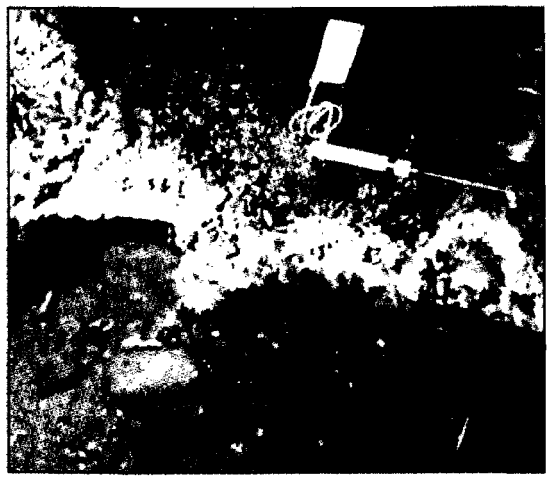

Figure 2. A barite-dominated flange at the Statue of Liberty site. Mussels inhabit the upper surface; a sea urchin is visible on the edge of the flange. A fish trap and temperature probe are shown deployed on top of the flange; another probe (bottom right) can be seen monitoring the temperature of the hot water pooled beneath.

from seawater, while fluids from Sintra are ~3% depleted with respect to seawater.

In the southern area, active vent sites sit on top of slabs of hydrothermal conglomerates, which are variably silicified and are comprised of sulfide and basalt debris with layers of manganese oxide. Diffuse flow emanates from cracks in the conglomerate layers, supporting populations of mussels and white flocculant material assumed to be bacteria. Small active black smoker chimneys (<0.5 m high with outer diameters of <10 cm) situated on top of small sulfide mounds with diameters of <1 to 3 m were observed in this area. The smokers have typical anhydrite exteriors and chalcopyrite interiors and vent fluids with temperatures ranging from 303-333°C. A noticeable feature of these black smokers is the lack of biological activity which, when taken with the small size of the chimneys, suggests that hydrothermal activity at these sites has only recently been renewed. One large, 20 m high spire was observed in the southern area, and was named "Eiffel Tower". Venting fluids have temperatures of 321-325°C, and the chimney samples are mineralogically similar to those collected from the small black smokers in this area. In terms of chlorinity, fluids from the vents in the southern area form an indistinguishable group with a chloride depletion of ~20% relative to the seawater value. Lucky Strike is thus the only site yet discovered in the Atlantic where chlorinities less than the seawater value are observed. It is difficult to envision a mechanism to deplete the chlorinity by ~20% with respect to the seawater value without invoking phase separation.

This site provides some interesting comparisons with the other known Atlantic hydrothermal vent sites. As discussed above, relict sulfides are very abundant at Lucky Strike, particularly in the northern area, and this, together with the settings of the currently active sites, suggests that hydrothermal activity has been episodic in this region. Abundant relict sulfide material is similarly observed at the TAG and Snakepit hydrothermal fields to the south and, based on dating by Lalou et al (1990; 1993), episodicity in venting activity is also a characteristic seen at these two areas. However, the dispersed nature of hydrothermal activity at Lucky Strike contrasts with the more localized flow observed on the eastern ridge at the Snakepit site, and with the vigorous well-focused flow observed at the center of the active TAG mound (Thompson et al., 1988; Fouquet et al., in press).

Lucky Strike also displays some striking differences in tectonic setting, hydrothermal activity, and biological communities from the other Atlantic vent sites. It is the first large hydrothermal deposit to be found located on a part of a mid-ocean ridge that exhibits a high magmatic budget and basalt geochemistry that is directly influenced by the proximity of the site to a mantle hot spot. The hypothesis that the enriched crust exerts an influence on the fluid compositions is supported by the preliminary barium results from the fluids, which suggest that barium concentrations are higher than previously encountered in ridge crest hydrothermal systems. In addition, Lucky Strike is the only Atlantic site at which barite is present in the vent deposits. In this regard, and in terms of vent structure morphology and distribution, the site bears a stronger resemblance to vent sites on the Endeavour Segment of the Juan de Fuca Ridge, and in the Guaymas Basin, Gulf of California (Stakes and Moore, 1991; Delaney et al., 1992; Peter and Shanks, 1992). Lucky Strike also differs from the other Atlantic sites in displaying significant variations in fluid composition between the northern and southern parts of the field. Finally, the biological community is also distinctly different from that observed at the other Atlantic sites being dominated by a new species of mussel (bathymodiolid-like) rather than shrimp.

In 1994, French and invited U.S. scientists will continue detailed studies of the Lucky Strike hydrothermal field with a *Nautile* diving program. Preliminary results of the *Alvin* dive program will be presented at the AGU Fall Meeting.♦