

The Azorean deep-sea hydrothermal ecosystem: Its recent discovery

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Abstract: The Lucky Strike and Menez Gwen hydrothermal vent fields from the Mid-Atlantic Ridge (located between 37°17'N and 37°50.56'N; ca. 1700 and 800 m deep) were explored with submersibles in 1993 and 1994. Different manifestations of hydrothermal activity were recorded and fluid temperatures ranged from 198 °C to 333 °C at Lucky Strike and from 25 °C to 281 °C at Menez Gwen. Mussels from probably an undescribed species dominated the community physiography at Lucky Strike. Filamentous bacteria and bresiliid shrimps were also conspicuous organisms. A commensal polynoid polychaete was found in nearly 95 % of the mussels examined. The Menez Gwen physiography is similar to Lucky Strike but the mussel population (probably a different species from Lucky Strike) is far from attaining the same richness. Some of the invertebrate species (e.g., shrimps) of Lucky Strike were also present at Menez Gwen. At present, no endemic fish fauna has been found at Lucky Strike or at Menez Gwen.

Introduction

The Mid-Atlantic Ridge, south of the Azores Triple Junction in the Portuguese EEZ, has revealed interesting active hydrothermal sites over the last few years. In 1992, in the scope of the French-American Ridge Atlantic project (FARA) and during the French-American Zaps and Rocks cruise (FAZAR Cruise Report 1992), a geological dredging operation brought to the surface massive sulfides with attached yellow mussels and shrimps of hydrothermal vent origin. This material was collected along the slope of a seamount of the rift valley, at 37°17.5'N, between 1700 to 1615 m depth. Furthermore, significant anomalies were detected in the correspondent water column when prospecting for hydrothermal plumes using CTD and manganese sensors (FAZAR Scientific Team 1992). The site was named Lucky Strike and was explored the following year (1993) during an American cruise using the DSRV "Alvin" (LANGMUIR et al. 1993) and involving American and European geologists and biologists. Direct observations from the submersible led to the discovery of a large vent field at the confluent basis of three volcanic structures that form the Lucky Strike Seamount. Six dives were performed. In 1994 the site was extensively re-explored using the French submersible "Nautile". This French DIVA expedition included European and American scientists and comprised two legs (DIVA 1 and DIVA 2), being devoted

predominantly to geology and biology, respectively. During DIVA 2, a total of 26 dives were performed (DESBROYÈRES et al. 1994). During the DIVA expedition a new vent field (ca. 60 km N of Lucky Strike) from the Mid-Atlantic Ridge was explored. It was named Menez Gwen and is located between 37°50.45'N and 37°50.56'N, at depths between 840 m and 870 m. The Lucky Strike vent field is the largest currently known on the Mid-Atlantic Ridge and was the third to be documented, following TAG (26 °N) and Snake Pit (23 °N), both discovered in 1985.

Strong evidence for the existence of other hydrothermal vent fields on the Mid-Atlantic Ridge and in Azorean waters, like Famous and Amar, will lead to promising explorations in the near future.

Observations (mostly in video records) and collected biological material during the above-mentioned expeditions are being studied by a variety of specialists and at the moment, only general accounts on the ecosystem can be given, like those of DESBROYÈRES et al. (1994) and VAN DOVER, DESBROYÈRES, FIALA-MÉDIONI, SEGONZAC, KLUFT, LANGMUIR, (unpubl. manuscript).

The Lucky Strike and Menez Gwen areas

The Lucky Strike hydrothermal vent field extends over approximately one kilometer along the sea floor (at a width of ca. 700 m). It is located in a depression formed by the lower slopes of three extinct volcanoes surrounding a lava lake at ca. 1700 m depth. These volcanoes are at the summit of the Lucky Strike Seamount (37°17.5'N) emerging from the Mid-Atlantic Ridge rift valley. Numerous individual sites are found in the vent field; they display different manifestations of hydrothermal activity, ranging from black smokers to flanges. Chimneys located at the top of mounds attain a total height of up to 20 m. Recorded fluid temperatures ranged from 198 °C to 333 °C. Vent morphology and geology as well as fluid composition and the presence of shell chaff suggest long-lived hydrothermalism and indicate that the vent field has been reactivated (cf. LANGMUIR et al. 1993, COLODNER et al. 1993, HUMPHRIS et al. 1993). Fluid composition showed among other features low chlorinities (440-550 mmol/kg Cl), gas-enrichment (up to 500 ml NTP/kg), high CH₄ and N₂ concentrations (up to 0.89 mmol/kg) and variable CO₂, as well as low concentrations of sulfide (< 3.3 mM) and of many chalcophile elements (cf. COLODNER et al. 1993). The ambient bottom water (bathyal) temperature was around 4 °C.

Compared with Lucky Strike the Menez Gwen hydrothermal field is very modest in size. It is located near the top of a young volcano emerging from

the rift valley and extending over an area of nearly 200 m². Mounds and chimneys are of modest size and the maximum recorded fluid temperature was 281 °C, although diffuse venting attaining 25 °C was observed throughout the area.

The hydrothermal communities

At Lucky Strike the community physiography is dominated by a very rich population of a yellowish mytilid, probably representing an undescribed species (cf. DESBRUYÈRES et al. 1994). Thousands of these animals cover large areas of mound surfaces and chimneys, also penetrating into cracks. They are in the close vicinity of fluid emanation and individuals show a distinct size pattern distribution. Bigger animals are generally located in the inner part of the population patch, while smaller ones are distributed around them. The maximum size observed (shell length) was 113 mm. The mean size of the mussels also varies with the water temperature, the bigger animals being positioned in warmer areas. Finally, the population structure varies from site to site (DESBRUYÈRES et al. 1994). The general appearance of these mytilid populations is that of a rich intertidal mussel bed. The mytilid populations are in water temperatures generally ranging between 5 °C and 18 °C and probably tolerate brief temperature increases as high as 30 °C (cf. VAN DOVER et al. unpubl. manuscript). The mussel gill tissue host both sulfide-oxidizing and methylophilic bacteria.

Another striking physiographic feature are the thick, fibrous, whitish bacterial mats that occasionally cover large areas of the mytilid beds. They often occur in the form of long filaments and are generally under the direct influence of the vent fluid.

Three species of bresiliid shrimps are present: *Chorocaris chacei*, a new species of *Chorocaris*, and a third one related to *Rimicaris* (cf. DESBRUYÈRES et al. 1994, VAN DOVER et al. unpubl. manuscript). They are generally found in small swarms on the mussel beds or on the mound or chimney walls. The bythograeid crab *Segonzacia mesatlantica* is also present and abundant. Amphiloichid and eusirid amphipods were collected from the mussel beds.

A commensal polynoid polychaete, *Branchiopolynoe seepensis*, was found (one to three individuals) in nearly 95 % of the mussels examined. It is an inconspicuous but important element of the Lucky Strike hydrothermal fauna. A new ampharetid polychaete (distinct from *Amphisamytha*), dwelling in tubes on shells and sulfides, was also recorded. A single glycerid polychaete of uncertain taxonomic affinity was found among the mussels.

The collected mollusc material (excluding mussels) comprises seven species of gastropods of which only the skeneid *Protolira valvatoides* was already known. This species, along with a small neritacean limpet, was the most abundant material in the samples. The group of undescribed species comprises a second *Protolira* species, *Lepetodrilus* sp., *Peltospira* sp. (abundant), *Phymorhynchus* sp., and others.

On the edge of the mussel beds in the least hydrothermally-influenced waters a pinkish sea-urchin of the genus *Echinus* (12 cm in diameter) was observed in low densities.

Although many fish species were recorded near or over the vent field, it is difficult at the present time to determine if there is a true vent fish fauna at the Lucky Strike area. A *Gaidropsarus*, probably of a new species, lives in crevices among the mussels. The population density observed in specific sites was about one individual per square meter. One specimen was caught and is currently being studied. Another rarely observed fish, probably a morid, was also present in the mussel bed crevices (pers. observ.). The bythitid *Cataetyx laticeps*, a bathyal species, was abundant in the close vicinity of the mussel beds, sometimes swimming or resting over them. Stomach content analyses of this fish and of *Gaidropsarus* sp. revealed a diet based on hydrothermal shrimps (SALDANHA 1994, and pers. observ.).

At Menez Gwen, mussel beds are also present but they do not attain the dimensions found at Lucky Strike. It is uncertain at this time whether these mussels belong to the same species found at Lucky Strike. Polynoid polychaetes were absent in these mussels. Bresiliid shrimps (*Chorocaris* sp.) were also present, and limpets were attached to mussel shells. Other invertebrates collected are now under study and it will soon be known if they are vent organisms or belong to the surrounding bathyal fauna.

Fishes living on the mussel beds or in their close vicinity, as seen at Lucky Strike, were not observed. The fish fauna recorded around Menez Gwen was already known from bathyal depths (pers. observ.).

Conclusion

The biological communities found at Lucky Strike and Menez Gwen, where the physiography is dominated by mussel beds, are distinct from those recorded for the two other areas of the Mid-Atlantic Ridge: TAG (26 °N) and Snake Pit (23 °N). Mussels, shrimps, and amphipods (and perhaps the occurrence of a sea-urchin occupying the least hydrothermally-influenced waters) account for the above-mentioned distinction. Differences in depth (ca. 1300

m) between Lucky Strike and Snake Pit and TAG have been suggested as a possible factor to preclude the occurrence of certain species (VAN DOVER et al. unpubl. manuscript). The relationships between faunal composition and fluid chemistry are insufficiently known at the present time to explain the observed differences.

New contributions to the understanding of these problems will probably be obtained with future work on recently discovered sites along the Mid-Atlantic Ridge, like Broken Spur (29 °N; 3400 m) and on prospected areas between 36 °N and 37 °N (2800 m) such as AMAR and FAMOUS, which are deeper and close to Lucky Strike - Menez Gwen segments.

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References

- COLODNER, D., LIN, J., VON DAMM, K., BUTTERMORE, L., KOZLOWSKI, R., CHARLOU, J.-L., WILSON, C. and The Lucky Strike Team, 1993: Chemistry of Lucky Strike hydrothermal fluids: initial results. - *Eos, Trans. Am. Geophys. Union* **74**: 99.
- DESBRUYÈRES, D., ALAYSE, A.-M., ANTOINE, E., BARBIER, G., BARRIGA, F., BISCOITO, M., BRIAND, P., BRULPORT, J.-P., COMTET, T., CORNEC, L., CRASSOUS, P., DANDO, P., FABRI, M. C., FELBECK, H., LALLIER, F., FIALA-MÉDIONI, A., GONÇALVES, J., MÉNARD, F., KERDONCUFF, J., PATCHING, J., SALDANHA, L., and SARRADIN, P.-M., 1994: New information on the ecology of deep-sea communities in the Azores Triple Junction area: preliminary results of the Diva 2 cruise (May 31- July 4, 1994). - *InterRidge News* **3**: 18-19.
- FAZAR Cruise Report, 1992. Lamont-Doherty Earth Observatory of Columbia - University Technical Report No. LDEO-92-3. Palisades, NY.
- FAZAR Scientific Team, LANGMUIR, J., KLINKHAMMER, G., BOUGAULT, H., CHARLOU, J.-C., et al., 1992: Rock and watersampling of the Mid-Atlantic Ridge from 32 °N to 45 °N: objectives and a new vent site. - *Eos, Trans. Am. Geophys. Union* **74**: 380.
- HUMPHRIS, S. E., TIVEY, M. K., FOUQUET, Y., and the Lucky Strike Team, 1993: Comparison of hydrothermal deposits at the Lucky Strike vent field with other mid-ocean ridge vent sites. - *Eos, Trans. Am. Geophys. Union* **74**: 100.

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LANGMUIR, C. H., FORNARI, D., COLODNER, D., CHARLOU, J.-L., COSTA, I., DESBRUYÈRES, D., DESONIE, D., EMERSON, T., FIALA-MÉDIONI, A., FOUQUET, Y., HUMPHRIS, S., SALDANHA, L., SOURS-PAGE, R., THATCHER, M., TIVEY, M., VAN DOVER, C., VON DAMM, K., WIESE, K., WILSON, C., 1993: Geological setting and characteristics of the Lucky Strike vent field at 37°17'N on the Mid-Atlantic Ridge. - *Eos, Trans. Am. Geophys. Union* **74**: 99.

SALDANHA, L., 1994: Fishes observed and collected during the Alvin dives at the Lucky Strike thermal vent site (Mid-Atlantic Ridge, 1993). - *Cybium* **18**: 460-462.

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