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Ecology of the Menez Gwen hydrothermal vent field (Mid-Atlantic Ridge/Azores Triple Junction)

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Introduction

The Menez Gwen area was discovered during the DIVA 1 cruise and is located on the volcanic segment north of the Lucky Strike segment between 37°35'N and 38°N (Mid-Atlantic Ridge/ATJ). The hydrothermal area is located between 37°50.45'N and 37°50.56'N at 840-870 m water depth (Fouquet et al., 1994). One of the characteristics of this segment is the absence of a central rift. The main volcanic feature is a circular volcano at the central part of the segment. This volcano is 700 m high, with a diameter of 17 km. Its top is an axial graben 6 km long, 2 km wide and 300 m deep. The graben is open both at its northern and southern parts, and thus is not considered a simple caldera system. A new volcano (600 m diameter, 120 m high) is currently growing at the northern end of the graben. The Menez Gwen site is situated near the top of the young volcano at the bottom of the graben. The volcano is composed entirely of extremely fresh pillows with no sediment cover (Fouquet et al., 1994).

The chimneys are typically small and essentially composed of white anhydrite, formed by the mixing of seawater and hydrothermal fluid. Around these small white chimneys, mounds with hot water diffusing through the surfaces can be found. These mounds are rich in barite (Fouquet et al., 1994). Around this small white mountain, very fresh pillow lavas make the bullet of this area. The fluids of these small chimneys are very clear, and flow vigorously.

The Menez Gwen fauna is similar to the Lucky Strike fauna, but it differs markedly from the fauna previously described from other MAR hydrothermal areas. The aim of this study is to describe the Menez Gwen fauna and to compare it with other shallow water hydrothermal areas.

Material and methods

Seven dives were made on the Menez Gwen area during the DIVA2 mission in 1994. The videos made during this mission were analysed to describe the faunal composition and the microdistribution of the community. Faunal density was estimated whenever an instrument could be used as a scale. The temperature measurements were made with the temperature probe from *Nautile* (punctual ones) and with the HOBO probes (temperature time series). The study area consisted of 200 m^2 of the volcano flank.

Results and Discussion

I. Composition and microdistribution

At 840 m depth there is a small active area, called «Homem em Pé». This area consists of a little white mountain, with a row of small chimneys on its west side (15 cm high), and a taller chimney (70 cm high) on its top. Ripple marks are observed at «Homem em Pé», all of which are facing north suggesting a strong bottom current, which was felt by the divers during all the dives.

Only mussels were observed at «Homem em Pé», in three patches near the row of small chimneys. Each patch with approximately 0.04 m^2, and composed of around 50 mussels of different sizes (< 1 cm - 6 cm)

The fluid of the main chimney had a temperature of 269ºC, while ambient water was at 8.8ºC. The main hydrothermal field is between 850 and 870 m deep.

Several chimneys and areas of diffuse venting were found on the slope, where patches of mussels are over anhydrite and barite precipitates, while others are covering the pillow lavas. Near the pillows the mussel density seems to be higher and the bythograeid crab (possibly *Segonzacia*

mesatlantica Williams, 1988) and the alvinocarid shrimp *Mirocaris fortunata* (Martin and Christiansen, 1995) were observed here.

Mussels were never found near the sides of the largest chimneys on this slope. They are present on the slope above these chimneys and are covered by white filamentous bacterial mats, a unique feature in the study area. In this setting they can be bathed by the fluids on one side and avoid lethal temperatures on the other.

Menez Gwen mussel patches had different sizes, ranging between 0.09-1.5 m^2, with densities between 400 and 700 ind m^{-2}. Individuals of different size could be seen in each patch. Contrary to the mussels, shrimps are found at high densities on the sides of large chimneys. Hydrothermal decapods at Menez Gwen are less abundant than at Lucky Strike.

Deep-sea fauna was frequently observed in and around this hydrothermal vent site. For example the geryonid crab *Chaceon affinis* Milne Edwards & Bouvier, 1894 was observed at the periphery of the site and was making incursions into the active zone. Most of the specimens were observed at the border of the active field, very near the mussel clumps on rocky bottom. On one occasion, one specimen was observed eating on an open shell of *Bathymodiolus* sp., less than 20 cm away from live specimens. A few others were observed a little further away over pillow lava. The maximum temperature registered near a specimen was 20ºC near a mussel clump (Biscoito and Saldanha, subm.). The presence of several specimens in the inner periphery seems to indicate that this species can profit from the abundant available biomass (Biscoito and Saldanha, subm.).

Although not many deep-sea organisms were observed making incursions into the active area, several fish were seen in the close vicinity. The spiny scorpionfish (*Trachyscorpia cristulata echinata* Koehler, 1896) was observed and captured lying over a pillow lava (Saldanha and Biscoito, 1997). Macrourid fish (*Malacocephalus* sp.) were observed swimming over the area, close to the fluid emission. Beryciform fish were observed over the mussel clumps. Cephalopods were also observed swimming over the sites, and two dead ones were found near the active sites.

According to Charlou et al. (1996), it is likely that phase separation processes occur in the fluid, which is consistent with gas content observed. As these would be depleted in metals and sulphides (Fouquet et al., subm.) they would be less toxic to the non-vent fauna, therefore explaining their presence near the active area.

II. Temperature

Several punctual measurements of temperature were done. Temperature among mussels can vary by several degrees (Table 1). This may be either due to the mixing of the vent fluids with the sea water, or due to an intrinsic variability of the fluid temperature.

Table 1. Punctual measurements of temperature at Menez Gwen field during the DIVA2 cruise in 1994.

Menez Gwen area		
Local	Place	Temperature range in °C
sea water		7.3-7.7
« Homen en Pé »	fluid	259-278
	mussels	10
Main field	fluid	224+281
	mussels	7.2-20.4
	mussels cover with bacterial mat	7.2-8.5
	bacterial module colonization	44-81

Two HOBO temperature probes were deployed. One was placed outside the mussel beds (three hours deployment) and another one was placed over some mussels covered with bacterial mats (four day deployment). The former recorded temperatures between 8.2- 8.6ºC, whereas the latter recorded temperatures between 34-50 ºC (Fig. 1).

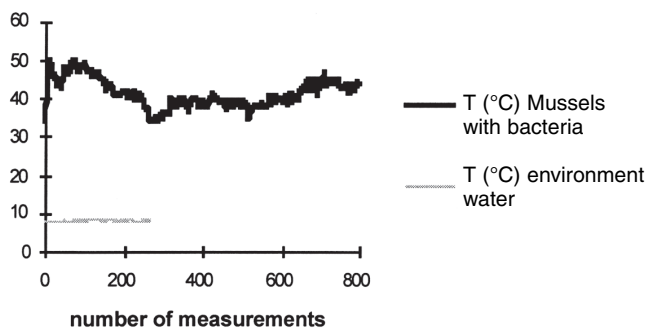

Figure 1. Data from the temperature probes deployed at Menez Gwen field during DIVA2 cruise in 1994.

These values are extremely high compared with measurements taken with the submersible's probe. Assuming these measurements are correct, then it is another observation indicating the tolerance of the organisms to high temperatures (Chevaldonné et al., 1992). However, bad placement of the probe cannot be ruled out in explaining these values. The probe could have been put inside the sediment, where shimmering water is coming out, therefore registering not the temperature among mussels, but that of the shimmering water from the sediment.

III. Comparison between sites

As shown in Table 2, mussels dominate the fauna of the shallower sites, while alvinocarid shrimps dominate the fauna of the deeper ones. This depth distribution could be controlled by the composition of the fluids, which is depth dependent, as shown in Fig. 2.

Table 2. Dominant fauna and localization of the different Mid-Atlantic Ridge known hydrothermal areas and the Minami-Ensei Knoll site.

Fricke et al., 1989. *Marine Biology,* **102**: 425-429. Desbruyères et al., 1994. *Interridge news,* **3** (2): 18-19. Murton et al., 1995. in *Hydrothermal vents and Processes*. (Parson et al. eds), Geological Society Special Publication, **87**: 33-41. Williams & Rona, 1986. *Journal of Crustacean Biology* **6**: 446-462. Mevel et al., 1989. Comptes Rendus de l'Académie des Sciences, Paris, **308** (II): 545-552. Hashimoto et al., 1995. *Deep-Sea Research* **1**(4): 577-598.

Name	Localization	Depth	Dominant fauna	Reference
Kolbeinsey	67° 05'N	100-106 m	• Surrounding non vent fauna	Fricke *et al.,* 1989
Menez Gwen	37° 51'N	840-870 m	• Mussel patches and shrimps on warm waters	Colaço *et al., pers. observ.*
Lucky Strike	37°18'N	1700 m	• Mussels ⇒ sulphide surface of chimneys. Shrimps ⇒ chimney walls and among mussels Bythograeid crabs	Desbruyères *et al.,* 1994 Colaço *et al., pers. observ.*
Broken Spur	29°N	3900 m	• Shrimps ⇒ proximal regions of hot vent. Worms, mussels, anemones and ophiuroids ⇒ peripheral Crabs and fish	Murton *et al.,* 1995
TAG	26°N	3600 m	• **Shrimps** ⇒ warm waters. Anemones, chaeopteridae worm tubes ⇒ peripheral	Williams and Rona, 1986
Snake Pit	23°N	3600 m	• **Shrimps** ⇒ chimneys Sea anemones, polychaeta, gastropods, galatheid crabs, mussels and zoarcid fish	Mevel *et al.,* 1989
Logatchev	14° 45'N	3100 m	• **Shrimps** ⇒ warm waters Mussel beds ⇒ shimmering waters	Colaço *pers. observ.*
Minami Ensei Knoll	28° 24'N - Okinava Trough - Southwest Japan	720 m	• **Mussels** ⇒ assemblages composed by various size classes Limpets on the shells Bresiliid shrimp and bythograeld crab ⇒ small hollows on chimneys and among mussels	Hashimoto *et a*l., 1995

Conclusion

The Menez Gwen fauna which is thriving within the vent field is mostly composed of patchy mussel beds (*Bathymodiolus* sp., also occurring at Lucky Strike), some little swarms of Bresiliid shrimps [*Mirocaris fortunata* and *Chorocaris chacei* (Williams & Rona, 1986)] and a few

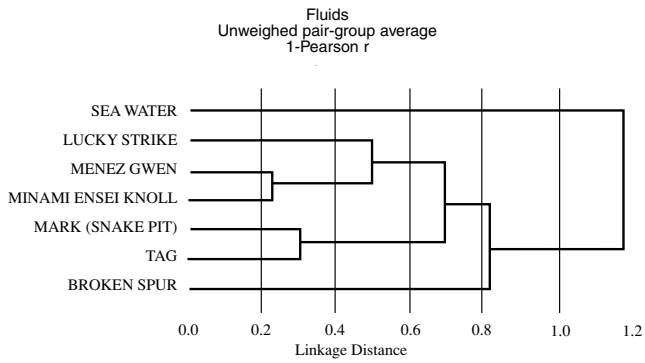

Figure 2. A comparison between the composition of the hottest fluids of each site clearly separates the shallower sites from the deepest ones.

Bythograeid crabs (*Segonzacia mesatlantica*). The commensal worm *Branchipolynoe seepensis* Pettibone, 1986 is never observed within the mussels. The most prominent feature is the presence of bathyal fauna (fishes, cephalopods and crabs) making incursions to the vent field area, possibly to feed. Of this fauna the most abundant species is the geryonid crab *Chaceon affinis* which is concentrated around the vent field. Mussels are the dominant fauna as in the other shallower sites.

Note: During the Marvel cruise from AMORES program in 1997, a new hydrothermal site was discovered on the Menez Gwen hydrothermal field (markers pp 30, 31,32,33). Mussel populations are very important and cover almost all the available surfaces, with no size segregation. Contrary to the other Menez Gwen site, in this one, the commensal worm *Branchipolynoe seepensis* is present, with a quite low infestation rate, approximately 10% (Desbruyères et al., subm.).

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