State of Oregon
Department of Geology and Mineral Industries
910 State Office Building
1400 SW Fifth Avenue
Portland, OR 97201

OPEN-FILE REPORT O-89-06

# BIOLOGICAL RESULTS FROM DSV SEA CLIFF EXPLORATION OF THE NORTHERN GORDA RIDGE

by

Gary L. Taghon
College of Oceanography
Oregon State University
Corvallis, Oregon 97331-5503

Final Report for Contract No. 63-630-8802

Submitted to:

Oregon Department of Geology and Mineral Industries

and the

Gorda Ridge Technical Task Force

Released March 1989

NOTICE

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## INTRODUCTION

Under the support of the Gorda Ridge Technical Task Force, a multi-disciplinary team of scientists participated in a submersible expedition to the northern section of the Gorda Ridge. Between September 15 and September 30, 1988, a series of dives took place to attempt to locate active hydrothermal vents on the Gorda Ridge in the vicinity of the GR-14 site. An active vent field was located on the first dive (42°45.3'N, 126°42.5'W), between depths of 2700 and 2800 m on the east wall about 2.6 km from the ridge axis and 300 m above the floor of the rift valley. This vent field was named the Sea Cliff Hydrothermal Field.

The purpose of this report is to describe the biological communities associated with the Sea Cliff Hydrothermal Field. Preliminary results of biochemical analyses of the chemoautotrophic activity of vent biota are also included.

## METHODS

Descriptions of the biological communities are based on videotapes made using the DSV *Sea Cliff* external video camera and a hand-held video camera used by the scientific observers inside the sphere.

A biological sample was retrieved on dive 769, 26 September 1988, from the Sea Cliff Hydrothermal Field. A clump of vestimentiferan tubeworms and associated fauna was removed from the substrate using the submersible's manipulator and placed in a PVC-box for transport to the surface. On recovery, a portion of the sample was fixed in 10% formalin in seawater buffered with sodium borate. This sample was later transferred to 80% ethanol. The remaining animals in the sample (primarily vestimentiferans and polychaetes; see below) were individually wrapped in aluminum foil, sealed in plastic storage bags, and frozen in liquid nitrogen in preparation for biochemical analyses. These samples were transferred to a -70°C freezer in the shore-based laboratory until analysis.

The chemoautotrophic potential of the vent fauna was assessed by assaying for ribulose-1,5-bisphosphate carboxylase-oxygenase (RuBisCO) activity. RuBisCO is a bifunctional enzyme that catalyzes the addition of $CO_2$ or $O_2$ to ribulose-1,5-bisphosphate (RuBP), forming 3-phosphoglycerate. This reaction is carried out by all green plants and is the first step in converting $CO_2$ to glucose. RuBisCO activity is also present in the chemosynthetic bacteria living symbiotically with certain invertebrate taxa occurring at hydrothermal vents (Grassle, 1986). RuBisCO activity was measured using a slightly modified version of the method of Lilley and Walker (1974). Modifications were: final NADH concentration of 0.2 mM; activation of all reactants for 10 min before addition of RuBP; final RuBP concentration of 0.4 mM. Tissue samples were excised from frozen animals, weighed, and homogenized in a hand-held glass tissue grinder in 1 mM HEPES, 1% Triton X-100 (pH 7.8) at a ratio of 1 part tissue:9 parts buffer (w:v). For comparative purposes, fresh spinach leaves were also assayed. Protein concentrations of all tissue homogenates were measured using the Pierce BCA assay (Smith et al., 1985).

RESULTS and DISCUSSION

Vent communities

The visually dominant organisms at Sea Cliff Hydrothermal Field are vestimentiferan tubeworms of the genus Ridgeia (Jones, 1985). All the individuals in the sample collected on dive 769 appear to be R. piscesae, a species originally described from the Juan de Fuca Ridge. Specimens have been sent to Dr. Meredith Jones at the Smithsonian to confirm the preliminary identification. More systematic sampling will be required to determine if other species of Ridgeia found on the Juan de Fuca Ridge (Tunnicliffe, 1988) are also present on the Gorda Ridge.

Four distinct patterns were seen in the distribution and abundance of vestimentiferans in different areas of the hydrothermal field. In the first pattern, individual tubeworms were sparsely distributed among broken basalt blocks. Tubes were oriented horizontally and were closely associated with the substrate. It seems likely that flow rates of hydrothermal effluents were very low in these areas of the field and the tubeworms were attempting to position their gas-uptake organs (plumes) as near to the venting source as possible. In the second type of pattern, tubeworms occurred in discrete, more-or-less spherical clumps. These clumps of tubeworms, on the order of one meter in diameter, were also associated with broken basalts. The substrate was clearly visible between adjacent clumps. The third pattern was one of extensive thickets of tubeworms extending for tens of meters, so dense as to completely obscure the substrate. In these dense aggregations, many different sizes of tubeworms were present. Often, smaller animals were growing attached to the external tube surfaces of larger animals. Shimmering water was very evidently flowing from these tubeworm thickets, in contrast to the first and second patterns. The fourth pattern was that actively venting chimneys were not colonized by tubeworms. This may arise because the hydrothermal effluent is rapidly expelled up into the water column before appreciable mixing can occur with ambient bottom water, thus preventing the vent organisms from extracting the hydrogen sulfide needed to provide the energy to drive the fixation of $CO_2$ by RuBisCO.

An alvinellid polychaete, Paralvinella palmiformis, was also collected. These worms live among the tubes of the vestimentiferans and are most likely feeding on the free-living bacteria which grow luxuriantly on surfaces bathed by hydrothermal effluents. P. palmiformis also occurs on the Juan de Fuca Ridge (Tunnicliffe, 1988). At least two species of gastropods were also collected; their affinity, if any, to Juan de Fuca gastropods is unknown at present.

Organisms seen at the Sea Cliff Hydrothermal Field but not collected included actiniarians, pycnogonids, numerous octopi observed moving through the vestimentiferan thickets, and brotulid and ophidiid fish.

Enzymic activity

Ridgeia is the only organism recovered from the Sea Cliff Hydrothermal Field that is known to possess symbiotic chemoautotrophic bacteria. Results for RuBisCO activity from samples of the trophosomes from nine individuals are given in Table 1. When normalized to the amount of protein in the tissue extracts, RuBisCO activities of the tubeworms are considerably smaller than

for spinach leaves. These activities for R. piscesae, however, are similar to the RuBisCO activities of the vestimentiferan Riftia pachyptila from the East Pacific Rise and Guaymas Basin (Felbeck et al., 1981).

Table 1. RuBisCO activities of fresh spinach and trophosome samples from Ridgeia piscesae collected from Sea Cliff Hydrothermal Field. Activities expressed as nmoles $HCO_3^-$ fixed $h^{-1}$ $(\mu g\ protein)^{-1}$ assuming 1 nmole of bicarbonate fixed for every 2 nmole NADH oxidized (Lilley and Walker, 1974).

| | | |
|---|---|---|
| Spinach (n=2): | 24.6 | |
| | 20.2 | |
| Ridgeia (n=9): | 0.043 | |
| | 0.326 | |
| | 0.161 | Mean = 0.170 |
| | 0.269 | S.D. = 0.090 |
| | 0.100 | C.V. = 53% |
| | 0.133 | |
| | 0.092 | |
| | 0.218 | |
| | 0.186 | |

Despite the fact that all the tubeworms analyzed were recovered by a single grab with the submersible manipulator, it is evident that there is a fair amount of variability among the individuals (coefficient of variation = 53%). This variability in enzyme activities could be due to size of the individuals or to small micro-scale differences in the chemical environment experienced by each tubeworm. Further studies are needed to determine the causes of individual variability.

Non-vent communities

A variety of taxa typically associated with deep-sea rocky substrates were seen in the axial valley, including crinoids, corals and glass sponges. These forms appear similar to non-vent fauna seen in nearby areas of the northern Gorda Ridge (Carey et al., 1987). These animals were usually attached to pillow basalts and seemed to be most abundant in areas where high concentrations of suspended particulate matter were present, consistent with their predominant suspension feeding mode. The origin of the suspended particulates and the reasons for the spatial variation in their abundance are unknown.

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