Reports

Biological Communities at the Florida Escarpment Resemble Hydrothermal Vent Taxa

Abstract. *Dense biological communities of large epifaunal taxa similar to those found along ridge crest vents at the East Pacific Rise were discovered in the abyssal Gulf of Mexico. These assemblages occur on a passive continental margin at the base of the Florida Escarpment, the interface between the relatively impermeable hemipelagic clays of the distal Mississippi Fan and the jointed Cretaceous limestone of the Florida Platform. The fauna apparently is nourished by sulfide rich hypersaline waters seeping out at near ambient temperatures onto the sea floor.*

The Florida Escarpment is the steep western edge of the Florida Platform, sloping upward at 25° to 55° from the nearly level floor of the abyssal Gulf of Mexico (water depths >3000 m) to the continental shelf of western Florida (Fig. 1). The escarpment is the eroded seaward edge of a Lower Cretaceous carbonate platform that rims southeastern North America (*1, 2*). The lower escarpment continues beneath and is buried by rapidly accumulating distal Mississippi Fan sediments (Fig. 1). There is no indication of recent faulting or other tectonic activity along or near the base of this escarpment (*3*).

The deep-sea research vessel *Alvin* visited dense biological communities apparently associated with seeps along the base of the Florida Escarpment near 26°02′N and 84°55′W (Fig. 1). The abyssal plain is composed of tan hemipelagic sediment covered by an easily disturbed whitish flocculant layer. The associated sparse megafauna is dominated by holothurians, starfish, and shrimp. About 30 m from the escarpment's base, the bottom starts to slope gently upward, and an increase in megafauna abundance occurs with the noticeable addition of gastropod shells. Within about 25 m of the escarpment there are occasional patches, 5 to 10 m across, of light charcoal-gray sediment without a flocculant layer, where the bottom is strewn with partially dissolved disarticulated mussel and clam shells that range up to about 20 cm long.

Within 10 to 15 m of the base of the escarpment, densely packed, elongated patches and round clumps of live mussels cover up to half the bottom (Fig. 2). Each mussel has up to 20 small (~1 cm) trochid archeogastropods that are apparently grazing on the surface of the valves. Other fauna associated with the mussel beds are large turrid neogastropods, small limpets, slender purple holothurians, small pink ophiurids, anemones, small transparent shrimp, and zoarcid fish. Interspersed with the mussel beds are vestimentiferans (tube worms) (Fig. 2), varying in density from a few individuals per square meter to dense thickets of 100 or more intertwined individuals per square meter. The vestimentiferans are approximately 0.5 to 1 m long, 1 cm in diameter, and heavily encrusted with colonies of a stoloniferous soft coral, especially those specimens near the escarpment's base. Galatheid crabs and large clams half buried in the sediment are also abundant in this community.

The abundant megafauna is associated with mottled 1- to 5-m patches of black sediment surrounded by lighter brownish-tan or gray sediment (Fig. 3). The contacts between sediment types are frequently sharp. Some of the darkest sediments are covered with a white surface coating (Fig. 2) that appears to be bacterial mats (*4*). Black patches narrow upslope into shallow 0.5-m-wide gullies. These channels either terminate in smooth brown or gray sediment or extend to the foot of the escarpment (Fig. 3). The geometry of the black sediments suggests a drainage pattern generated by fluids seeping out at the heads of the gullies and flowing downslope (Fig. 3).

Bottom water temperatures show no anomalies over the communities, averaging 4.39° ± 0.02°C. A probe inserted approximately 10 cm into the brown sediments in the center of a patch of tube worms measured sediment temperatures equivalent to ambient bottom waters. However, in a mussel bed on black sediment the temperature was 4.80°C immediately after inserting the probe but decayed over several minutes to the stable temperature of 4.50°C. The temperature at the upslope end of the black sediment gullies at about 10 cm depth was 4.55°C without the initially elevated measurements. No shimmering water or other indicators of buoyant hydrothermal discharge were observed. Because mixing rapidly dissipates temperature anomalies, it is difficult to be sure that regions of elevated temperatures do not exist; however, no indications of significant anomalies were found.

The junction between the abyssal gulf sediments and the escarpment wall at 3266 m is sharp, with little or no exposed talus at the base. The basal 50 m of the escarpment slopes at 30° to 60° and is composed of 1-m thick horizontal beds of limestone, which are cut by two prom-

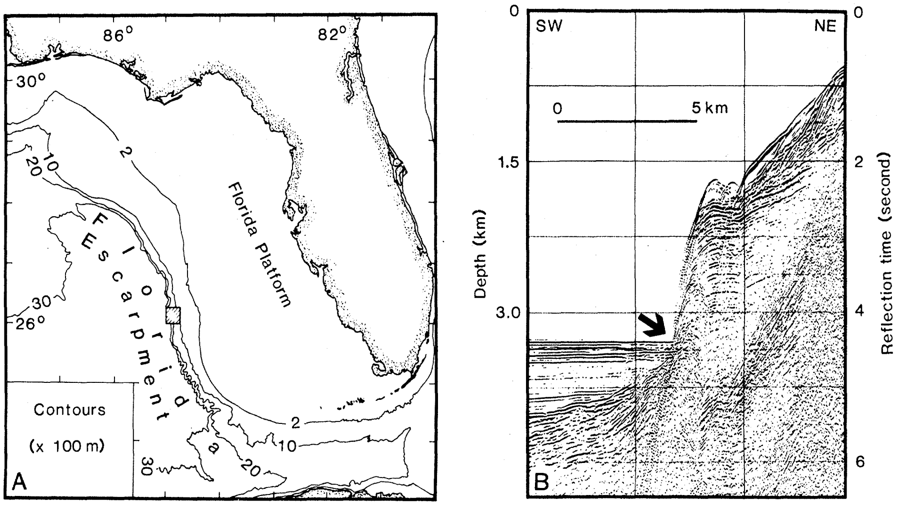

Fig. 1. Bathymetry of the eastern Gulf of Mexico. The square with diagonal lines indicates the area where the seeps and associated biological communities were discovered. (B) A multichannel seismic reflection profile (*15*) across the Florida Escarpment illustrates the abruptness of this topographic boundary. The arrow indicates the location of saline seeps associated with abundant life. Limestones of the Florida Platform crop out from about 2.5 to 4.3 seconds at the face of the escarpment. Horizontally bedded abyssal sediments are seen to onlap or bury the subsurface extension of the escarpment. Vertical exaggeration ×8.

inent, nearly orthogonal, vertical fracture patterns (Fig. 3). Some of the basal ledges form overhangs several meters deep. The surface of the limestones on the lowest meter of the escarpment appears yellow and is solution pitted. Elsewhere the escarpment's face is covered with an iron-manganese crust.

An open vertical fissure was observed at the base of the escarpment, 1 to 2 m wide and up to 3 m high, extending for at least 3 m into the escarpment wall. This large fissure as well as numerous open joints are densely packed with tube worms (Fig. 3). The lower escarpment wall is generally heavily encrusted with the tubes of serpulid polychaetes, small translucent anemones, and a stoloniferous soft coral.

Short core samples of the gray, dark black, and tan hemipelagic sediments were taken. The black sediments contain pore fluids with up to 25.6 g of chloride per kilogram (*5*), a 32 percent enrichment with respect to ambient seawater. These fluids contain large amounts of ammonia (3 to 4 m*M*), but sulfate concentrations are less than seawater. Active seepage must be occurring to maintain such steep chemical gradients. Both gray and black sediment samples had the distinct smell of H_2S when fresh. High concentrations of NH_4^+ and low dissolved SO_4^{-2} in pore waters generally occur in systems where organic matter is decomposed by sulfate-reducing bacteria, resulting in the production of H_2S (*6*). Some H_2S may also come from the maturation of hydrocarbons. Both H_2S and NH_4^+ are potential chemosynthetic energy suppliers (*7*).

The composition of the three sampled sediment types differs dramatically. The black sediments, associated with the hypersaline seeps, consist of over 75 percent sand-sized (>62 μm) material composed of pyritized fecal pellets and other grain aggregates, with secondary amounts of etched and pyritized shell hash and foraminifera. Thirty-eight percent of this sediment is pyrite occurring as authigenic cement (*5*). The gray sediment found on the periphery of the seeps is 95 percent fine silt and clay. The surrounding tan abyssal sediments consist of hemipelagic material and contain 30 to 60 percent foraminiferal sand. The changes in composition and carbonate preservation of the sediment, as well as the etched appearance of the adjacent limestones, suggest substantial carbonate corrosion. The oxidation of H_2S may produce the necessary acid.

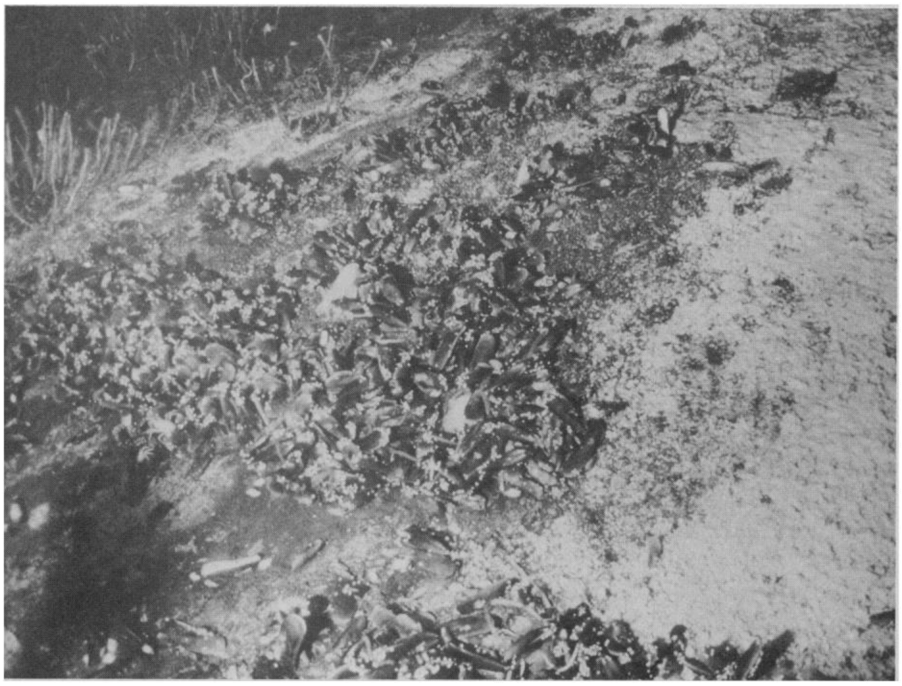

Fig. 2. *Alvin* photograph of the sloping bottom in the seep area where sediments rich in iron sulfide are covered with a white bacterial mat. Numerous small gastropods graze on the surface of mussels in the foreground. In the background are thin patches of tube worms.

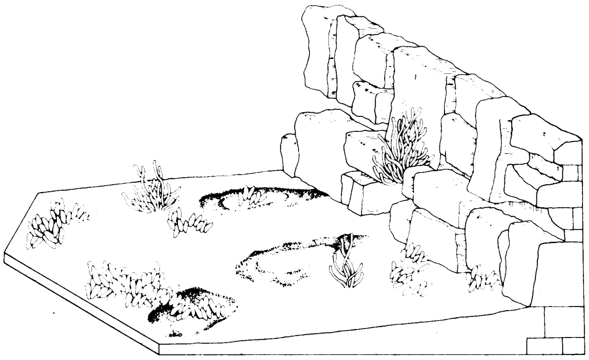

Fig. 3. Sketch illustrating the base of the Florida Escarpment. Jointed limestones are shown on the right and the abyssal sediments to the left. Areas of seepage are indicated with black dots. White areas in the center of the seepages depict bacterial mats. Beds of mussels are restricted to the sediment. Patches of tube worms live both on the sediment and in fissures in the escarpment wall. Horizontal scale is about 5m.

The only unusual mineral, occurring at the 1 percent level, is a strontium–barium sulfate intermediate between celestite and barite, which is found in part as a coating on the periostracum of mussel shells. Although no significant concentration of economically important metals was found, this system provides a model of active sulfide deposition.

The most abundant organisms of this seep community (vestimentiferans and mussels), as well as associated fauna (vesicomyid bivalves, galatheid crabs, zoarcid fish, and limpets), resemble taxa that characterize the hydrothermal vent communities found along the East Pacific Rise (*8*, *9*). The most conspicuous compositional difference between the seep and other deep-sea chemosynthetic communities is the presence of numerous holothurians and the absence of brachyuran crabs at the seep sites.

The elevated salinities of the seeping fluid suggest that it is coming from the adjacent carbonate platform rather than from the abyssal plain sediments. Wells drilled in the Florida Platform penetrated strata of comparable lithology and age to those exposed on the escarpment, which contain fluids with salinities up to 250 of dissolved solids per kilogram, temperatures up to 115°C, and high concentrations of H_2S (*10–13*). Gypsum and anhydrite deposits are common within these limestone units and the high chlorinities suggest that halite may also occur (*10*).

The strata in the interior of the Florida Platform decrease in porosity from 20 to 10 percent over the range of 2 to 3 km subsurface, which suggests that a significant volume of the saline pore fluid must exit the platform as it compacts (*13*). The pore waters collected from the seeps corresponds to a 6 percent mixture of the pure hypersaline platform pore water with seawater. Any mixture of the hypersaline pore fluids and seawater will be denser than pure seawater and will naturally sink. The discharge of saline fluids may be concentrated at the base of the escarpment because the dense pore fluids collect within the limestones behind the impermeable abyssal sediments until they spill out onto the seafloor at the very base of the escarpment.

We found healthy communities or evidence of former communities on four of six dives made to the base of the Florida Escarpment. This suggests that saline seeps may occur frequently along the base of this and possibly other carbonate escarpments. The duration of seepage in these areas may be long in comparison with the duration at ridge crest hydrothermal vents (*14*). If similar seeps are common and persistent, then the corrosion associated with them may exert an effect on the morphologies of carbonate continental margins.

Isolation of chemosynthetic bacterial strains from Pacific ridge crest vent areas has confirmed that primary production occurs based on energy released in the oxidation of H_2S (*7*). Indeed abyssal chemosynthesis remains the only plausible explanation for the existence of these highly productive deep-sea communities. The requirements are a source of reduced inorganic compounds and the presence of molecular oxygen. The waters emanating at the Florida Escarpment seeps appear to be at nearly ambient temperatures when they arrive at the sea floor. Therefore, hydrothermal vents are but one vehicle to bring dissolved reduced inorganic compounds into contact with oxygenated seawater so that chemosynthesis can occur.

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9. The mussels differ from those found at the Pacific vent sites and probably belong to an undescribed species. The clam is a new species of *Calyptogena* (R. Turner, personal communication). The vestimentiferans are congeneric with an undescribed species collected from a hydrothermal spring associated with a strike-slip fault off San Diego [P. Lonsdale, *Nature (London)* **281**, 531 (1979); M. Jones, personal communication]. The limpet is closely related to a species found near Pacific vents (J. Mclean, personal communication).
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15. Profile (collected by the University of Texas, Institute of Geophysics) crosses the escarpment about 90 km north of the seeps in a morphologically similar area.
16. We wish to thank Captain Baker and the crew of the *Atlantis II* Ralph Hollis and the Alvin Group for their efforts and enthusiasm which ensured the success of the cruise. J. Edmond personally gave up one of his scheduled dives on a later cruise so that we could further explore these sites. The *Alvin* dives were funded through NSF grant OCE 82-08177 and by the Naval Ocean Research and Development Activity.

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Salivary Proline-Rich Protein Genes on Chromosome 8 of Mouse

Abstract. *Endonuclease restriction (Hind III) fragments of DNA from Chinese hamster × mouse somatic cell hybrids hybridized with proline-rich protein complementary DNA clones only when the DNA was isolated from cells containing mouse chromosome 8, or a fragment of chromosome 8. The evidence suggests that proline-rich protein genes are located at the proximal portion of chromosome 8 toward the centromere.*

The proline-rich protein (PRP) gene family is large and complex and is important in tooth- and respiratory-related functions (*1, 2*). The PRP genes constitute a single autosomal linkage group in the human as determined by family studies and somatic cell hybridization data (*3, 4*). The rat PRP's are probably also encoded by a multigene family for the following reasons: there are at least ten PRP's for which there is no evidence of interconversion (*5, 6*); all PRP's label with a single amino-terminal $[^{35}S]$methionine during cell-free translations (*7*); and PRP complementary DNA's (cDNA's) hybridize selectively with at least two families of messenger RNA's (mRNA's) (*8*). Some human and rat PRP's show similarities in amino acid composition (*1*) and peptide sequences (*9*).

Treatment of rats with isoproterenol, a β-agonist, causes rapid glandular secretion and dramatic changes in the parotid and submandibular glands (*5, 6*) such as hypertrophy and the induction of synthesis of the PRP's, which are very high in proline (25 to 45 percent), glutamate plus glutamine (19 to 25 percent), and glycine (17 to 19 percent) (*6*). In the parotid glands of isoproterenol-treated rats, a group of ten or more PRP's comprise about 60 to 70 percent of the total soluble protein. A similar induction of PRP's in the parotid glands of rats (*10*) and mice (*11, 12*) is observed after feeding a diet containing tannins.

To determine the chromosomal location of mouse PRP genes, two nick-translated rat PRP cDNA probes (pRP8 and pRP33) were used for hybridization experiments. DNA's were isolated from Chinese hamster × mouse somatic cell hybrids that were differentially lacking mouse chromosomes while retaining all the hamster chromosomes. The preparation and analysis of these hybrids for chromosomal content (*13*) and the preparation (*14*) and analysis (*8, 9*; including sequences) of the rat cDNA clones have been described. The two cDNA's code for different rat PRP's as determined by hybridization selection studies, sequence analyses, Northern blots, and the lack of cross-hybridization under stringent conditions (*8, 9*).

Digestion of DNA's by Hind III results in prominent and characteristic multiple fragments for the mouse and hamster genes. Seven of the mouse fragments hybridize with PRP33 (Fig. 1). The hybrids, called EBS 1, 2, 5, 9, 13,