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Petrographic and Geochemical Features of Seep Carbonates from an Active Gas Vent Site in Bush Hill, Green Canyon Block 185, Gulf of Mexico

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The stable isotope, mineral, and trace element of seep carbonates from Bush Hill, Green Canyon Block 185 (GC185), Gulf of Mexico (GOM), were examined. Bush Hill is an oil and gas seep site located near the boundary of Green CC184 and GC185 (27°46'N; 91°30'W), south of Louisiana of GOM, where water depth is ~540 m, and bottom water temperature is ~7 ℃. Gas venting, gas hydrate, seep carbonate, and the colony of tube worm, mussel, bacteria mat occurs on the seafloor at Bush Hill vent site. This site is one of the most studied areas for gas hydrate and cold seep in the world. However, detailed studies focused on the petrographic and elemental features of seep carbonate are not as common as those taking a chemical and physical approach of gas hydrate and cold seep. The aim of this study is to get insight into the petrographic and geochemical characteristics of carbonate at Bush Hill, in order to understand the sedimentary condition of the seep carbonate at gas vent and hydrate site.

The carbonate from Bush Hill gas vent site exhibit irregular shape mainly consists of bioclasts and matrix cement. There are fossilized tube warm, foraminifer, and bivalve shell (Fig. 1A). X-ray diffraction analysis shows that the seep carbonate at Bush Hill is primarily composed of aragonite (89wt%–99wt%, average 94%, n=7) with minor calcite, and dolomite.

The aragonite in the matrix cement commonly occurs as botryoid and isopachous layer that often show multiple stage of mineral growth, and dark and white band parallel to growth direction (Fig. 1B). In addition, fibrous and botryoidal aragonite cement fills pore space, and fibrous aragonite sometimes forms rosette structure. Clotted microfabric as well as peloid is common in seep carbonate (Fig. 1C). Microfilament, rod, and columnar form of aragonite in micrometer size are also observed.

Pyrite framboid ~3–20 μm in diameter (average ~5 μm) is dispersed within the seep carbonate (Fig. 1D), and sometimes fills foraminifer chamber. This framboid consists of numerous smaller pyrite (white) and aragonite (black) particles ~0.5 μm in diameter. Pyrite particle shows spherical, cubic and pentagonal dodecahedron crystal form.

Carbon and oxygen isotope of seep carbonate can be divided into three groups (Fig. 2). (1) Carbon mainly from seawater: relatively enrichment of ^{13}C ($\delta^{13}C$: -8.0‰ to -2.7‰ PDB) and depleted ^{18}O ($\delta^{18}O$: -0.6‰ to +0.3‰ PDB); (2) seep-related fauna: relatively enrichment of ^{13}C ($\delta^{13}C$: -10.6‰ to -1.4‰) and ^{18}O ($\delta^{18}O$: +3.1‰ to +4.5‰ PDB); (3) carbon mainly from venting fluid: relatively depleted ^{13}C ($\delta^{13}C$: -29.4‰ to -15.1‰ PDB) and enrichment of ^{18}O ($\delta^{18}O$: +2.4‰ to +5.0‰ PDB).

The content of rare earth element (REE) of the 5% HNO_3-treated solution of carbonate minerals (mainly aragonite with minor calcite and dolomite) in the micrite part of seep carbonate ranges from 0.7 to 26.6 ppm. The shale-mormalized REE pattern shows negative to no Ce anomalies (Fig. 3). Strontium content is significantly high, from 5 168 to 9 146 ppm, except three samples (94-363 ppm). Barium content usually ranges from 18 to 93 ppm with one extraordinary high (902 ppm).

Based on these data, the seep carbonate at Bush Hill gas vent and hydrate site seem to be formed at or near the sediment water interface, precipitated from relatively mediate depleted carbon pool that is considered to be the thermogenically gas, mixed gas, biodegrade crude oil or mixture of those carbon pools. Carbonate has different sedimentary fabrics depending on the microbial activities at seep site. The negative to no Ce anomaly of the shale-mormalized REE pattern indicates that the formation condition of the Bush Hill seep carbonate varied from aerobic to anaerobic condition. The negative Ce anomaly corresponds sample deposited on the seafloor while no Ce anomaly corresponds sample precipitated under the sediment water interface. This is also in agreement with the largely range variety of barium content in the seep carbonate.

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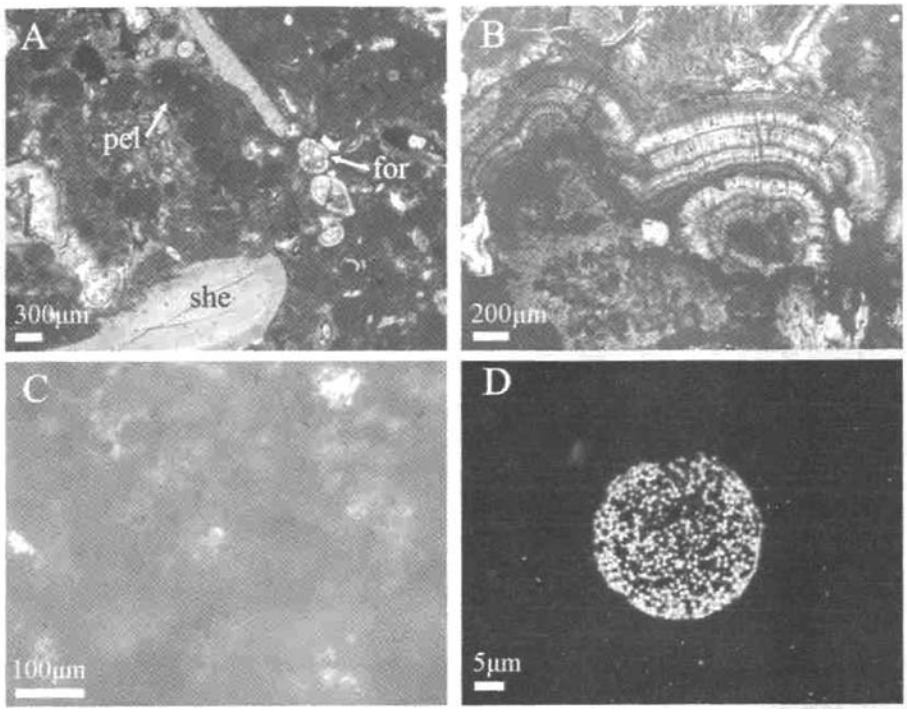

Figure 1. The microscope images of seep carbonate from Bush Hill. (A) Matrix has peloid (labeled "pel"), foraminifer (labeled "for"), and bivalve shell (labelled "she"); (B) aragonite cement occurs as isopachous layer; (C) clotted microfabric has irregular shape and unclear margin; (D) framboidal pyrite consists of numerous small particle of pyrite (white) and aragonite (black) grain. A–C are plane-polarized light, and D is reflected light.

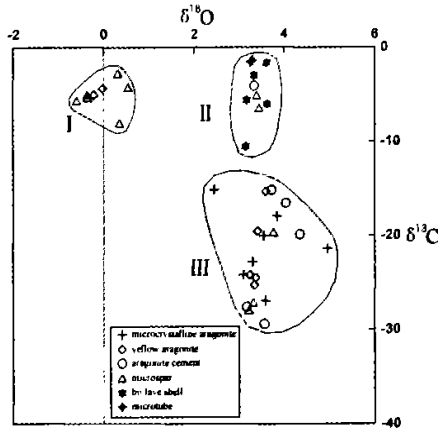

Figure 2. Plot of $\delta^{13}C$ and $\delta^{18}O$ values of seep carbonates from Bush Hill. Group 1. carbon mainly from seawater; Group 2. seep-related fauna; Group 3. carbon mainly from venting fluids.

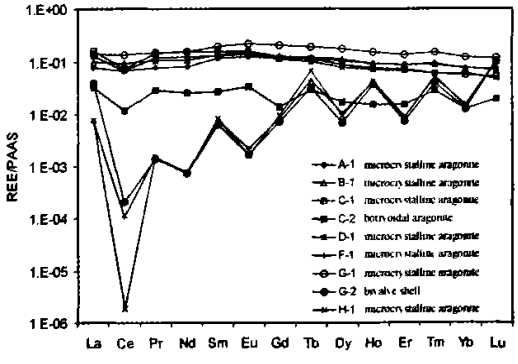

Figure 3. Shale-normalized REE pattern of seep carbonate from Bush Hill.

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