Deep-Sea Research I 104 (2015) 122–133

Contents lists available at ScienceDirect

Deep-Sea Research I

journal homepage: www.elsevier.com/locate/dsri

Effect of depth and vent fluid composition on the carbon sources at two neighboring deep-sea hydrothermal vent fields (Mid-Cayman Rise)

Sarah A. Bennett [a,b,*], Cindy Van Dover [c], John A. Breier [d], Max Coleman [a,e]

[a] NASA Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA
[b] NERC Isotope Geosciences Laboratory, British Geological Survey, Keyworth, Nottingham NG12 5GG, England
[c] Marine Laboratory, Nicholas School of the Environment, Duke University, 135 Marine Lab Rd, Beaufort, NC 28516, USA
[d] Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA
[e] NASA Astrobiology Institute, 4800 Oak Grove Drive, Pasadena, CA 91109, USA

ARTICLE INFO

Article history:
Received 12 September 2014
Received in revised form
6 June 2015
Accepted 10 June 2015
Available online 15 June 2015

Keywords:
Hydrothermal
Seeps
Food Web
Stable Isotopes
Cayman

ABSTRACT

In this study, we have used stable isotopes of megafauna, microbial mats and particulate organic matter to examine the effect of depth and vent fluid composition on the carbon sources at two proximal, chemically distinct hydrothermal vent fields along the Mid-Cayman Rise. The basalt hosted Piccard vent field (4980 m) is twice as deep as the ultramafic hosted Von Damm vent field (2300 m) and has very different faunal assemblages. Of particular note is the presence of seep-associated fauna, *Escarpia* and *Lamellibrachia* tubeworms, at the Von Damm vent field.

We identify a greater range of carbon sources and a suggestion of increased photosynthetic inputs to the Von Damm vent field compared to Piccard vent field. *Rimicaris hybisae* shrimp are the only abundant species shared between the two vent fields with $\delta^{13}C$ values ranging between −22.7 and −10.1‰. Higher concentrations of hydrogen sulfide in the vent fluids at Piccard is proposed to be responsible for varying the relative contributions of the carbon fixation cycles used by their epibionts. Seep-associated fauna at Von Damm rely on elevated, thermogenic hydrocarbon content of the vent fluids for their carbon source ($\delta^{13}C$ values ranging from −21.3 to 11.6‰). They also derive energy from hydrogen sulfide formed by the microbial reduction of sulfide ($\delta^{34}S$ values ranging from −10.2 to −6.9‰). The tubeworms have very short roots (buried at most a centimeter into rubble), suggesting that microbial sulfate reduction must be occurring either in the shallow subsurface and/or in the anterior part of the tube. Overall, megafauna at Von Damm vent field appear to have a smaller food chain length (smaller $\delta^{15}N$ range) but a greater breadth of trophic resources compared to the megafauna at the Piccard vent field.

1. Introduction

In the late 1970s, discovery of dense communities of megafauna at deep-sea hydrothermal vents revolutionized our understanding of life on Earth and the potential for life to exist elsewhere in the universe (Lonsdale, 1977; Corliss et al., 1979; Chyba and Hand, 2001). In these complex ecosystems, chemoautotrophic bacteria provide primary production in the absence of sunlight (Jannasch and Wirsen, 1979). Both free-living and symbiotic bacteria harvest energy from oxidation of reduced chemicals coming from the seafloor to fix inorganic carbon, forming dissolved and particulate organic carbon (DOC and POC). This provides a food source to endemic consumers and occasional background fauna. Additional contributions to the food web come from degradation of biomass of either chemosynthetic or photosynthetic origin, abiotic chemical processes and particulate organic matter (POM) from the subsurface or water column (Limen et al., 2007; Govenar, 2012).

The recent discovery of adjacent basalt- and ultramafic-hosted vent fields (21 km apart) on the Mid-Cayman Rise, provides us with a field opportunity to compare the megafauna and investigate carbon sources to two chemically distinct vent fields in close proximity to each other (German et al., 2010; Connelly et al., 2012; Kinsey and German, 2013). The basalt-hosted Piccard hydrothermal vent field (4987 m) in the rift valley of the Mid-Cayman Rise is the deepest vent field known to date. The shallower Von Damm ultramafic-hosted hydrothermal vent field (2300 m) is

* Correspondence to: School of Life Sciences, University of Warwick, CV4 7AL, England.
E-mail address: S.Bennett.1@warwick.ac.uk (S.A. Bennett).

http://dx.doi.org/10.1016/j.dsr.2015.06.005
0967-0637/

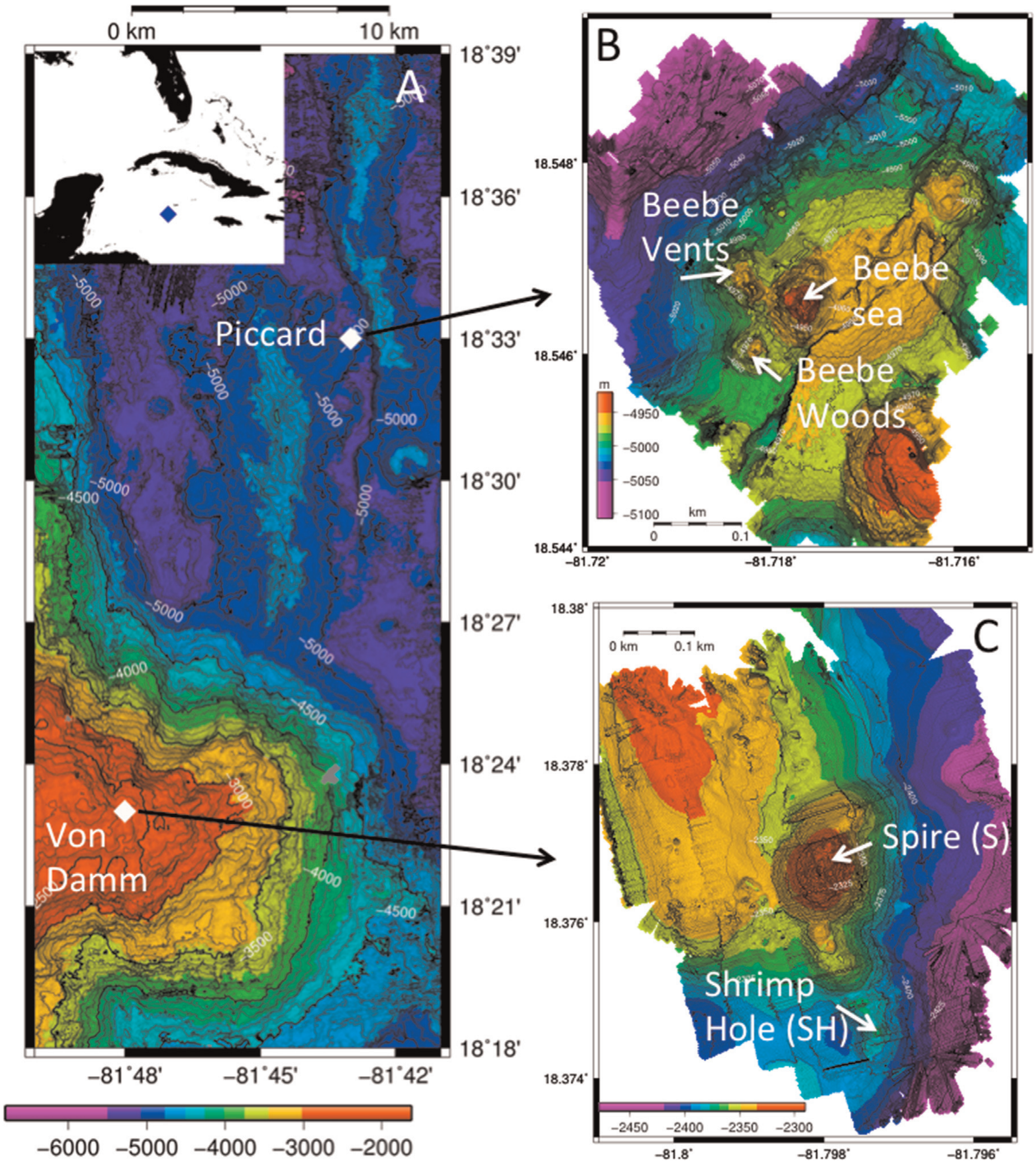

Fig. 1. (A) Map of the Mid-Cayman Rise, (B) map of the Piccard vent field with Beebe Vents, Beebe Woods and Beebe Sea and (C) map of the Von Damm vent field with the Spire and Shrimp Hole.

located 21 km south-southwest of Piccard, on the shoulder of an oceanic core complex (Fig. 1A). The chemistry of hydrothermal fluids in ultramafic environments differs from that in basalt hosted mid-ocean ridge (MOR) settings, as a result of varying rock type (German and Von Damm, 2003). For example, ultramafic hydrothermal activity is generally associated with high concentrations of methane and hydrogen in the fluids (Charlou et al., 1998).

The Piccard hydrothermal field comprises seven sulfide mounds, three of which are actively venting (Fig. 1B) (Kinsey and German, 2013). Two of the mounds, Beebe Vents and Beebe Woods, are venting high temperature black smoker vent fluids rich in metals, hydrogen sulfide (12 mM) and hydrogen (21 mM) (max 398 °C at Beebe Vents and 354 °C at Beebe Woods) and the third mound, Beebe Sea, is venting cooler, diffuse flow fluids (max 111 °C) (Fig. 1B). The large metazoan species are arranged zonally, with dense swarms of *Rimicaris hybisae* in the warmest water and with peripheral anemones and gastropods (*Provanna* sp.) in cooler water (Nye et al., 2012; Kinsey and German, 2013; Plouviez et al., 2015). Exposed rocks are covered in white filamentous bacteria, reminiscent of sulfur oxidizing bacteria (Jannasch et al., 1989); squat lobsters (*Munidopsis* sp.) are occasionally observed interspersed with shrimp and anemones. Within 50 m of Beebe Woods, thick patches of orange sediment suggest the presence of iron-oxidizing bacteria (Emerson and Moyer, 2002).

The Von Damm vent field is a large conical mound on the edge of the Mt Dent oceanic core complex (Fig. 1C) (Connelly et al., 2012). Von Damm vents emit cooler (max *T*: 226 °C) clear fluids, which are very low in metals, and rich in hydrogen sulfide (3.2 mM), hydrogen (19 mM) and methane (2.8 mM). The fluids also have elevated ethane and propane concentrations relative to basalt hosted systems (German et al., 2010; Connelly et al., 2012; McDermott et al., 2012; Seewald et al., 2012; Bennett et al., 2013;