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Palaeogene and Neogene cold seep communities in Barbados, Trinidad and Venezuela: An overview

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Abstract

Palaeogene and Neogene fossiliferous carbonates from Barbados, Trinidad and northern Venezuela are interpreted to have formed at ancient cold seep sites. The hydrocarbon seepage that fuelled these chemosymbiotic ecosystems was related to tectonic activity in the southern Caribbean region, particularly the subduction of the Caribbean Plate beneath the North Atlantic Plate. The carbonates and fossils from the Scotland District, north-eastern Barbados, are Eocene–Miocene in age and are associated with two distinct tectonic units: the Sub-Oceanic Fault Zone and a diapiric mélange. The Sub-Oceanic Fault Zone is the tectonic junction between accretionary prism sediments and over-lying thrust sheets of fore-arc basin sediments. The loading of the thrust sheets caused methane-rich fluids to be expelled from the accretionary prism sediments and channelled to the sea floor via the Sub-Oceanic Fault Zone, where it supported chemosymbiotic invertebrate communities containing vesicomid, lucinid, thyasirid, solemyid and nuculanid bivalves, a variety of gastropods and possibly vestimentiferan tube worms. The diapiric mélange is considered to represent sediment that failed under pressure in the accretionary prism and was remobilised as a diapir that extruded onto the sea floor, providing a conduit for methane and other hydrocarbons that sustained a chemosynthesis-based community of vesicomid, lucinid and nuculanid bivalves and various gastropods. The geological setting of fossiliferous carbonates known as Freeman's Bay Limestone, in southwest Trinidad, has been less fully investigated. The Freeman's Bay Limestone is a member of the Miocene Lengua Formation, which is believed to have formed in a fore-deep basin on-lapping onto an accretionary prism formed by the subduction of proto-Caribbean crust beneath the South American Plate. The carbonates and fossils of the FBL, including the bivalves *Pleurophopsis unioides* Van Winkle, 1919 and *Thyasira adoccasa* Van Winkle, 1919, lucinids, nuculanids and bathymodiolins, and provannid and other gastropods, are interpreted to have formed at palaeo-seep sites on the accretionary prism. Little is currently known about the geological setting of the fossils collected from the Miocene Huso Member of the Pozon Formation, from northern Venezuela, but a seep origin is strongly suspected based on the taxa present. Like the fossil assemblages from Barbados and Trinidad, the Venezuelan material is dominated by vesicomid bivalves, together with lucinid, thyasirid, bathymodiolin and solemyid bivalves and various gastropods. These taxa are characteristics of modern cold seep communities. Most comparisons between the fossil Caribbean

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and modern seep fauna are necessarily at the generic or family level, although in some cases, individual species are found at both ancient and modern seep sites. For example, the gastropod *Cataegis meroglypta* is found in seep carbonate from the SOFZ of Barbados and the FBL of Trinidad as well as at modern seeps on the Barbados Prism. At the generic level, this study has revealed the first fossil occurrences of *Abyssochrysos* and *Provanna* in the Caribbean. Such temporal and spatial links further the understanding of both local and global patterns of biogeographic distribution of cold seep fauna.

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1. Introduction

Cold seeps are fascinating and unusual environments where hydrocarbons (mainly methane) issue onto the deep seafloor. The methane fuels a series of microbial and abiotic reactions that result in the precipitation of carbonate rocks with distinctive carbon isotope signatures and support invertebrate animal communities via chemosymbiosis. Cold seeps are found in a variety of geological settings, associated with both active and passive continental margins (see Sibuet and Olu, 1998 for review). At active margins, seeps frequently occur on accretionary prisms, where methane is generated in the sedimentary pile by biogenic or thermogenic processes and then expelled by sediment compaction. The first

modern cold seep communities were described from the Florida Escarpment, Gulf of Mexico by Paull et al. (1984) and, on the basis of this discovery, many previously enigmatic fossil assemblages have been recognised as seep-related (e.g. Campbell and Bottjer, 1995). Modern cold seep communities are dominated by vesicomyid and bathymodiolin bivalves and also contain lucinid, thyasirid and solemyid bivalves and vestimentiferan and pogonophoran tubeworms. All these animals are dependant on endosymbiotic chemosynthesising bacteria (methanotrophs and/or sulphide-oxidisers) (Sibuet and Olu, 1998). Some non-chemosymbiotic animals are also common at cold seeps as predators or detritivores. Although extensive research has been carried out into certain aspects of cold seep communities, such as seep ecology and

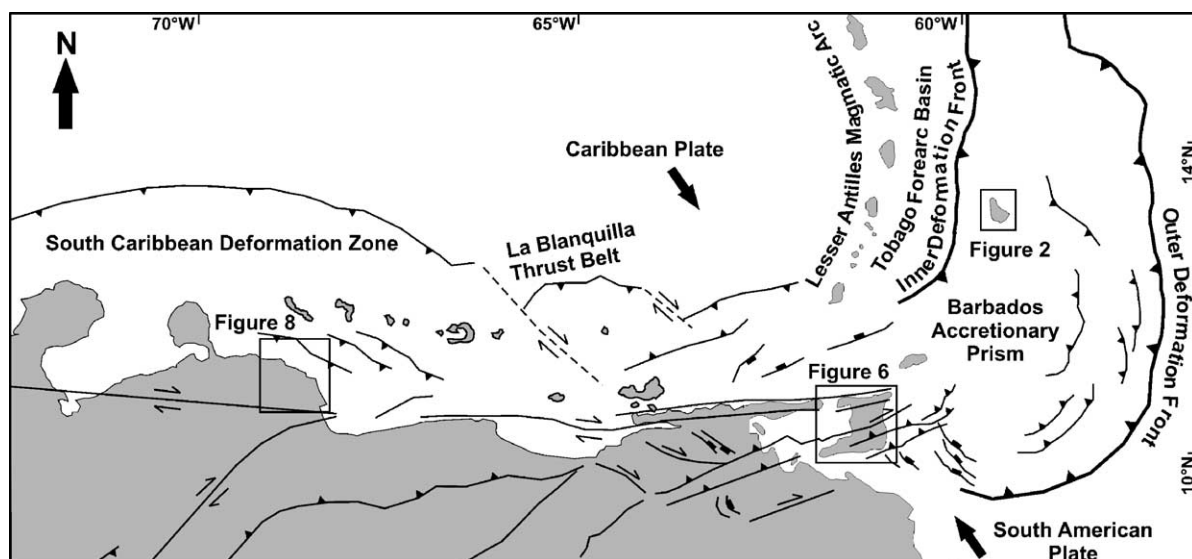


Fig. 1. A tectonic map of the southern Caribbean Sea and northern South America, showing the Barbados Accretionary prism and the positions of Figs. 2, 6 and 8. Based on Pindell and Kennan (2001), Trenkamp et al. (2002) and Jacomé et al. (2003).

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