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A carbonate platform associated with shallow cold methane seeps in Golfo Dulce, Pacific Costa Rica

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Marine methane seeps are typically observed in cold, anoxic and organic-rich deep-sea environments, such as in the Black Sea, where methane emissions fuel the authigenic accretion of calcium carbonate structures via microbial sulphate reduction and anaerobic methane oxidation (Michaelis et al. 2002). For shallow tropical waters, methane seeps are only known from hydrothermal vents (Nakamura et al. 2006). Here, we report about our recent discovery of a cold methane seep in warm (ca. 29℃) and O_2-saturated (97−100%) Golfo Dulce (8.496450°N, 83.262610°W) that is located at the Southern Pacific coast of Costa Rica, Central America.

In January 2012, we observed gas emissions from a carbonate platform (ca. 100 m^2 in area) formed about 2 m above muddy sediments at 10 m water depth. This carbonate platform exhibited live cover by the encrusting scleractinian coral *Porites lobata* (Fig. 1a, b), and frequent occurrence of typical reef-associated taxa, such as gorgonian corals and calcifying green algae (Fig. 1c, d). Collection and subsequent positive flame tests of the odourless (H_2S-negative) gas samples revealed their high methane content (Fig. 1e, f). This qualitative finding was subsequently confirmed by quantitative gas-chromatographic analyses showing methane contents of ＞85%. The methane seep, although located in a seismically active zone, was clearly not associated with hydrothermal vents as confirmed by water temperatures of 28−31℃ measured in the water streaming out from the platform. This water in contrast to the overlying O_2-saturated water column, exhibited very low O_2 concentrations of 5 μM to below detection limit (0.5 μM) as monitored continuously using O_2 microsensors (OxMicro, Presens) that were placed within the methane emitting pores in the carbonate platform.

First mass-spectrometric stable carbon (C) isotope measurements of the carbonate platform crust samples revealed $\delta^{13}C$ signatures of −47 to −51‰ that indicate their origin from anaerobic oxidation of methane coupled with authigenic carbonate formation. These observations and preliminary analytical findings may thus provide first indication of a

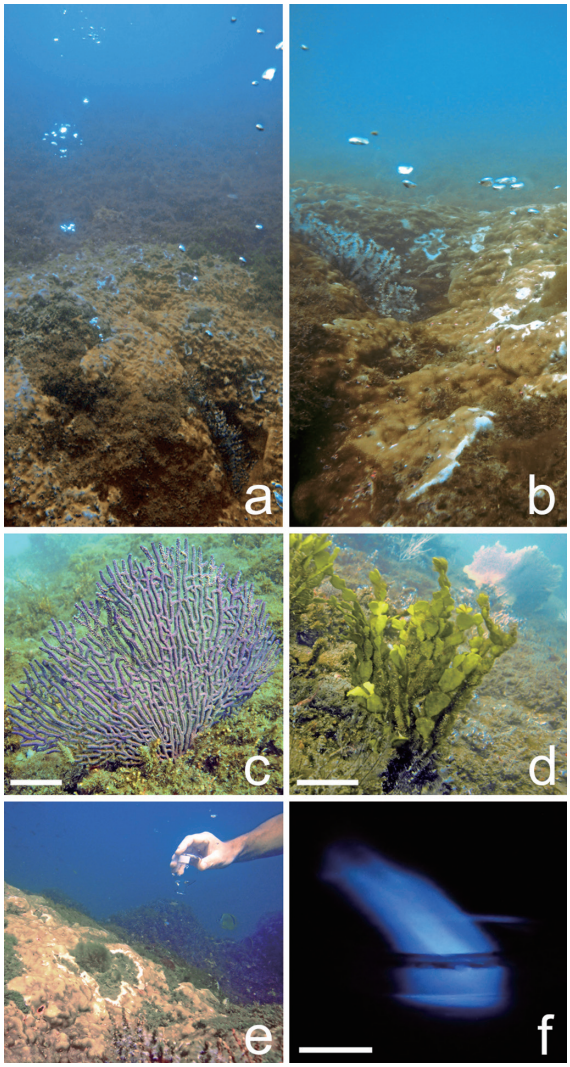

Fig. 1 Top (**a**) and horizontal (**b**) view of the carbonate platform showing high live cover by the scleractinian hard coral *Porites lobata* and rising methane gas bubbles, **c** and **d** Benthic taxa associated with the methane seep (**c** gorgonian coral *Pacifigorgia stenobrochis*, **d** green algae *Halimeda* spp.), **e** Collection of methane gas bubbles in glass vials, **f** Positive (blue) flame test for methane gas; scale bars are 10 cm (**c**, **d**) and 1 cm (**f**).

potential interplay of authigenic and biogenic reef accretion processes occurring at shallow cold methane seep sites.

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