

A serpulid-*Anodontia*-dominated methane-seep deposit from the upper Miocene of northern Italy

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A limestone deposit with an unusual fauna is reported from the late Miocene of northern Italy (Ca' Fornace site). The petrography of the carbonate and its distinct carbon isotope signature (with $\delta^{13}\text{C}$ values as low as -57.6‰) clearly identify this limestone as an ancient methane-seep deposit. The dominant faunal elements are serpulid tubes belonging to *Protis*, and extremely inflated, medium-sized shells of the lucinid bivalve *Anodontia mioinflata* sp. nov. Also common is the small bathymodiolin *Idas* aff. *tauroparva*, plus some large specimens of the lucinid *Lucinoma*, and poorly preserved, medium-sized specimens of a possible vesicomid bivalve, an arcid bivalve, small gastropods of the genera *Laeviphitus* (Elachisinidae), *Anatoma* (Scissurellidae), as well as desmophyllid and caryophyllid scleractinian corals. This faunal assemblage is quite distinct from the typical Miocene seep faunas in northern Italy, which are dominated by large bivalves of the Lucinidae (*Meganodontia*), Vesicomidae (*Archivesica*), and Bathymodiolinae, possibly due to a shallower depositional depth of the Ca' Fornace site.

Key words: Gastropoda, Scleractinia, Serpulidae, Bivalvia, Lucinidae, Bathymodiolinae, methane seep, Miocene, Apennines.

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Introduction

Miocene methane-seep deposits and their fauna are well-known from northern Italy. They are called “Calcare a *Lucina*” (CAL) due to the superabundance of the large lucinid bivalve *Meganodontia hoernea* (Des Moulins, 1868). Further common faunal elements include the lucinid *Lucinoma perusina* (Sacco, 1901), *Bathymodiolus* mussels, large vesicomid clams of the genus *Archivesica*, and the most common gastropods are the neritid *Thalassonerita megastoma* and the vetigastropod *Homalopoma domeniconii* (Moroni 1966; Taviani 1994, 2011; Kiel and Taviani 2017). Similar faunal associations occur at present-day methane seeps throughout the world's oceans (Sibuet and Olu 1998; Van Dover et al. 2002; Olu et al. 2010; Kiel 2016). The present-day Mediterranean Sea, however, represents an exception from this, its seep faunas being dominated by small bathymodiolins (*Idas*), small vesicomids (*Isorropodon*) and the moderately sized luci-

nid *Lucinoma kazani* (Salas and Woodside 2002; Olu et al. 2004; Zitter et al. 2008; Taviani 2011; Taviani et al. 2013). Also Pliocene seep deposits in northern Italy lack the large bathymodiolins and vesicomids and are dominated instead by smaller lucinid taxa (Monegatti et al. 2001; Cau et al. 2015; Kiel and Taviani 2018). It has been suggested that the present-day Mediterranean seep fauna originated after the Messinian salinity crisis (Taviani 2001, 2003; Olu et al. 2004). Here we report a late Miocene, pre-salinity crisis methane-seep fauna from Ca' Fornace in northern Italy, with a quite different character compared to those presently known.

Institutional abbreviations.—BS, Museo Regionale di Scienze Naturali, Torino, Italy; MGGC, Museo Geologico Giovanni Capellini, University of Bologna, Italy; MSF, Museo Civico di Scienze Naturali, Faenza, Italy; NRM, Swedish Museum of Natural History, Stockholm, Sweden.

Other abbreviations.—CAL, Calcare a *Lucina*.