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# First hydroacoustic evidence of marine, active fluid vents in the Naples Bay continental shelf (Southern Italy)

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ABSTRACT

We present the first results of a multidisciplinary research aimed at the detection and mapping of Active Fluid Vents (AFVs) at the seafloor of the Naples Bay, Italy. This segment of the Campania continental margin is characterised by severe Quaternary extension and intense volcanism at Ischia and Procida islands, the Campi Flegrei and Somma–Vesuvius volcanic complexes. High resolution hydroacoustic profilers were used to identify and localize fluid emission from the seafloor. ROV direct observation showed that each emission centre is generally composed by the coalescence of several emitting points. CTD probes showed that there are no significant gradients in temperature profiles. The results of this study include the detection and mapping of 54 fluid emission points all located in the −71/−158 m depth range, and spatially distributed into four main clusters. Three of the described clusters are located along the margin of a complex, toe-shaped seafloor morphology southwest of the Somma–Vesuvius, representing the shallow expression of partly buried, coalesced depositional features (namely, two flank collapses and one pyroclastic flow) associated with the Late Pleistocene activity of the volcano. The fourth AFV cluster was detected at the morphological - high, located about 8 km south of Naples (*Banco della Montagna*), represented by a field of volcaniclastic diapirs composed of massive pumiceous deposits originated from the Campi Flegrei intruding rising through the latest Quaternary–Holocene marine deposits. Our study suggests that the occurrence of AFV in this area could be genetically linked to the interaction between volcanic related seafloor morphologies and the main, NE striking faults present in the area, i.e. the Magnaghi-Sebeto line and the Vesuvian fault.



## 1. Introduction

Over the last 35 years, several research programmes have pointed out the importance of Active Fluid Vents (AFVs) and their large geological, biological, biochemical and hazard implications. Is it worth stressing that volcanic AFVs are relatively common features worldwide. They may occur in various geodynamic settings, both in deep marine sectors and in shallow (<200 m below sea level, bsl) depth areas, where they are usually linked to coastal volcanism (Tarasov et al., 2005).

AFV detection and monitoring in active volcanic areas, such as the Naples Bay, is a meaningful tool to discover sector of local weakness, that may help in detecting and monitoring potentially seismogenic or volcanic active faults (e.g. Klusman, 1993), since active tectonic structures are preferential pathways for the rising of fluids from the crust or from the mantle (e.g. Sugisaki et al., 1983; Esposito et al., 2006; Chiodini et al., 2011a, 2011b; Maucourant et al., 2014). Thus, multidisciplinary study, also involving fluid escape, magma chemistry and mapping of known fracture systems, becomes fundamental for a real understanding of magma feeding mechanism in complex volcanic areas. The presence of AFV has been long reported along the volcanic continental margin area of the Campania region, both onland (Caprarelli et al., 1997; Valentino and Stanzione, 2003; Aiuppa et al., 2006; Chiodini et al., 2008; Bagnato et al., 2009; Chiodini et al., 2011a, 2011b, Di Renzo et al., 2011; Tassi et al., 2013) and off the coasts of Pozzuoli (e.g. Segre, 1970; Pescatore et al., 1984; Giacomelli and Scandone, 2012) and Ischia (Hall-Spencer et al., 2008), and it was also expected, but never documented, in the Naples Bay (Sacchi et al., 2001; D'Argenio et al., 2004).

The whole Campanian fluid vent system has been interpreted to be related to $CO_2$ rising up from a common deep source, related to the subducted crust and to the overlain asthenospheric and lithospheric mantles (Moretti et al. 2013) through the major structural discontinuities, locally interacting with buoy magmas. AFVs mainly consist in

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major $H_2O$ and $CO_2$ typical hydrothermal degassing, followed by $H_2$, $H_2S$, $N_2$, $CH_4$ and CO (Chiodini et al., 2001). Thus, a detailed analysis and mapping of emission centres may help to better understand volcano-structural processes of the Campania continental margin and their impact on natural hazards. Despite a general interest in the occurrence and location of vents in the Naples Bay, a systematic study – aimed at understanding the spatial distribution and geochemical composition of the fluid vents at the seabed – is still missing so far.

In this study we present the results of the first survey specifically designed to detect AFV in the Naples Bay, with the objective of mapping and characterising the points of fluid emission located on the seafloor of the Naples Bays between the Campi Flegrei and the distal Somma–Vesuvius volcanic-complexes.

## 2. Geological outline

The Naples Bay is a Neogene–Quaternary basin located between the southern Apennines fold and thrust belt and the Tyrrhenian basin. Since Upper Miocene, the Campanian Plain undergone extension during the development of the Tyrrhenian back-arc basin (e.g. Malinverno and Ryan, 1986; Faccenna et al., 2001) by means of normal NW strike faults and NE transtensive faults (Acocella and Funiciello, 2006 and references therein). This marine sector is characterised by significant Quaternary extension and intense volcanism at the Ischia and Procida islands, the Campi Flegrei and Somma–Vesuvius volcanic complexes (Fig. 1). Volcanic activity started in the latest Pliocene–Early Pleistocene (1.87 Ma; Vezzoli, 1988), controlled by regional NE–SW and subordinately NW–SE fracture systems. The major eruption in this area is the Campanian Ignimbrite (39 Ka; De Vivo et al., 2001), which floors the whole coastal plain and the continental shelf of the Naples Bay, and the Neapolitan Yellow Tuff (NYT, about 15 Ka; Deino et al., 2004). The morphology of the Naples Bay has been controlled by the interaction of sedimentation, tectonics and volcanism, which characterised the area during Quaternary, and by the onset of sedimentary bypass and erosional processes along the continental shelf and slope. Volcano-tectonic processes have likely controlled the seafloor morphology, particularly in the Campi Flegrei area as well as in the Pozzuoli Bay (Vilardo et al., 2010; Passaro et al., 2013). The study of multi-channel reflection seismic profiles demonstrated that Pleistocene–Holocene faults in the Naples Bay exhibit a prevailing NE strike, with many quasi-vertical faults characterised by seismic evidence of volcanic activity (Bruno et al., 2003) while, in addiction to the NE–SW pattern of the whole Naples Bay, CF shows relevant NW–SE striking faults (e.g. Orsi et al., 2004; Selva et al., 2012). In particular, the emplacement of these fault patterns is governed by not only the post-NYT that also ruled the emplacement of basal faults with a prevalent NW–SE and NE–SW strike (e.g. Acocella, 2010), but also NS (Piochi et al., 2005) that can be found on the border of the NYT caldera rim, and should have played a leading role in particular during the last 4.5 Ka, where the NW–SE trending systems become prominent (Acocella, 2010). The combined action of the volcanic activity and the base level changes, associated with the fall and lowstand of the sea level during the last glacial maximum (18 Ka), severely affected the coastal morphology, resulting in a forced regression of the paralic–shallow marine depositional systems (Milia, 1999; Sacchi et al., 2005), later overlain by transgressive and high-stand deposits during the Late Pleistocene–Holocene (Sacchi et al., 2001; Insinga, 2003). The drainage axes represented by Magnaghi and Dohrn canyons have mainly controlled erosional processes and their tributary channels (Fig. 1). Both canyons display a N60°E strike, and may be interpreted as the result of the dynamic equilibrium between high volcaniclastic input from the coastal area and sedimentary bypass and/or erosion across the continental shelf-slope system towards deeper marine environment.

## 3. Materials and methods

Acoustic profiles of the water column, Remote Operative Vehicle (ROV) images, CTD probes and backscatter data were collected during

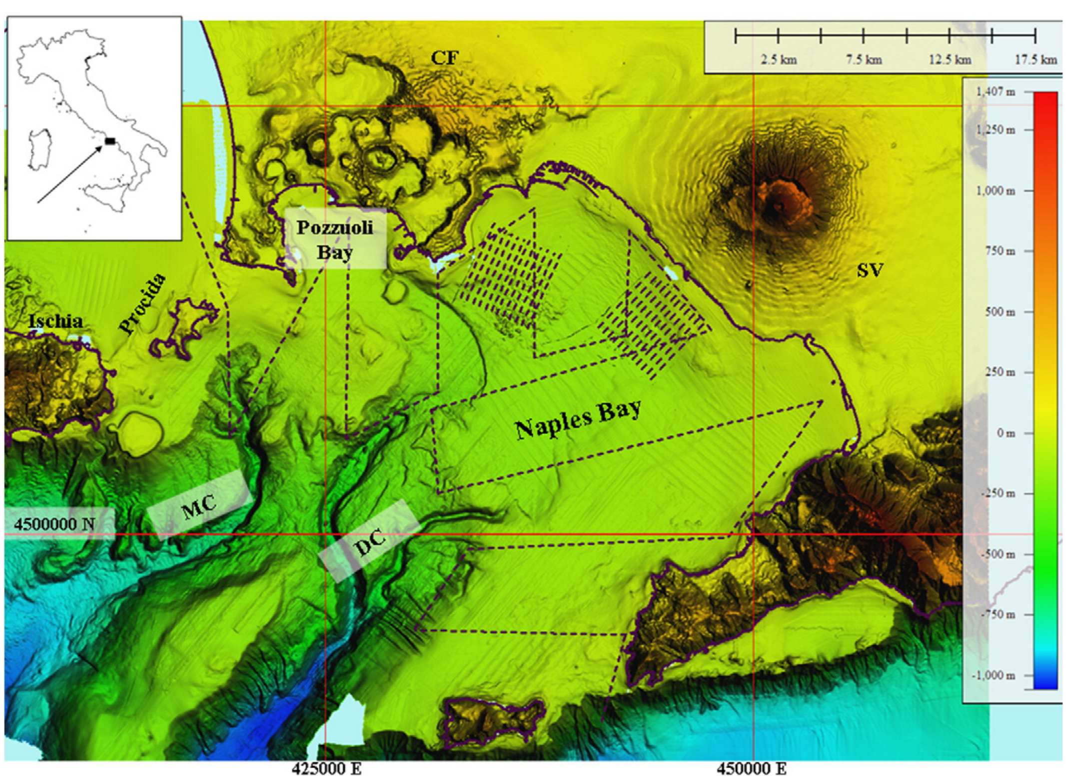


**Fig. 1.** Morphology of the Naples Bay. PF = Campi Flegrei Volcanic Complex, SV = Somma–Vesuvius Volcanic Complex; MC = Magnaghi Canyon; DC = Dohrn Canyon. Dash lines are the survey tracks carried out for the acoustic detection of the Active Fluid Vents. Datum WGS84, UTM33.