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Mud volcano fields in the Mt. Etna area (eastern Sicily)

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Abstract

In this paper we describe briefly the activity and evolution of four mud volcano fields located in eastern Sicily, around the Mt. Etna edifice. Three of them, called “Salinelle dei Cappuccini”, “Salinelle del Fiume” and “Salinelle del Vallone Salato” based on their location, occur on the southwestern flank of Etna, between the Paternò and Belpasso villages, and are presently active. The fourth one, today extinct, was active on the far east northeastern sector of Etna, along the Ionian Sea coastline. It was called “Salsa di Fondachello” after the name of the closest village.

Geologic surveys and well drillings suggest that fluids uprise through pre-existing volcanic necks in the “Salinelle dei Cappuccini” and “Salinelle del Fiume”, while for the “Salinelle del Vallone Salato” an alternative pathway through a fault plane is also proposed. The morphologic evolution of the Etnean mud volcano fields depends mainly on the density of the emitted muds and secondarily on the preexisting ground topography. Chemical analyses revealed that the water coming out from the mud volcanoes originates from a deep aquifer confined in the carbonatic rocks of the Etna basement and that the most abundant escaping gas is CO₂ of magmatic origin.

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The “Salsa di Fondachello” first activity is associated with the occurrence of the destructive Val di Noto earthquake, on January 11th, 1693. It was again active from 1795 to 1832. Its last activity, started in March 1847, came to an end with the collapse of the mud volcano. Today a weak methane emission is the only evidence of endogenous activity in this area.

Extended Abstract

1. Introduction

The term “mud volcano” indicates a pseudo-volcanic feature characterized by emissions of cold, muddy and frequently salty water. Their formation is due to the presence, in the subsoil, of over-pressured gases that escape upward through permeable rocks and structural and lithologic discontinuities, carrying to the surface a mixture of water, mud, hydrocarbon fluids and lithoid fragments that is emitted either as a flowing liquid or spattered into the air.

Mud volcanoes exhibit different morphologies depending on the density of the mud emitted to the surface, ranging from conic edifices, with more or less inclined slopes, to subcircular negative structures fed by a less, or not at all, muddy water. These features are instable and ephemeral and can be modified in a short period of time due to following emissions and weathering. Insolation causes in fact contractional fracturing of their surface that is easily eroded by the rain water.

The water emitted at mud volcanoes frequently contains salty solutions that precipitate forming incrustations. For this reason, in certain areas of Italy they are named “Salinelle” or “Salse”. In Sicily, mud volcanoes can be observed in the provinces of Catania, Agrigento and Caltanissetta, where they are also known with the term “Macalube” or “Macalube”, of Arabic origin. Some of them are characterized by a nearly continuous activity, while in others it is sporadic or absent at the present.

In this paper the activity and evolution of mud volcanoes in the Etna area are briefly described: three of them, named “Salinelle dei Cappuccini”, “Salinelle del Fiume” and “Salinelle del Vallone Salato”, occur south-west of Etna, between the villages of Paternò and Belpasso. Another mud volcano, today extinct, is reported to have been active until 1847 on the north-eastern sector of Etna, along the Ionian Sea coastline. It was called “Salsa di Fondachello” after the name of the closest village (Fig. 1).

Mud volcanoes, sometimes characterized by a spectacular activity, deserve the attention of the administrators of the territory where they occur because of the positive spillover effect that these geologic phenomenon might have in terms of geotourism.

2. Mud volcanoes located on the southwestern Etna slope

Three groups of mud volcanoes occur in the southwestern Etna area, within a distance of few kilometers from each other. They are characterized by emission of cold, muddy and salty water and gas. The gas analysis results are very consistent through time (*e.g.*, Silvestri, 1866; 1867; Valenza & Nuccio, 1991; D’Alessandro *et al.*, 1993), indicating that the released gas are mostly dioxide carbon of magmatic origin with a less percentage of methane of crustal origin. Chemical analyses indicate that the water originate from a deep aquifer confined in the carbonatic rocks of the Etna basement (D’Alessandro *et al.*, 1996). Their activity is presently characterized by alternating paroxysmal phases and quiescent periods.

Salinelle dei Cappuccini or Salinelle dello Stadio – The *Salinelle dei Cappuccini*, also known as *Salinelle dello Stadio*, are located on the western periphery of Paternò, on the northern slope of a hill called *Conetto dei Cappuccini* (Fig. 2), where lava flows ascribed to the Ellittico Eruptive Centers outcrop (Romano *et al.*, 1979). The oldest reports of paroxysmal activity are found in Silvestri (1866; 1879). The events described by this author occurred in 1866 and 1878 after a sequence of earthquakes felt locally and were characterized by ejection of water jets with temperature around 50° C. During following eruptions, Cumin (1954) measured a higher water

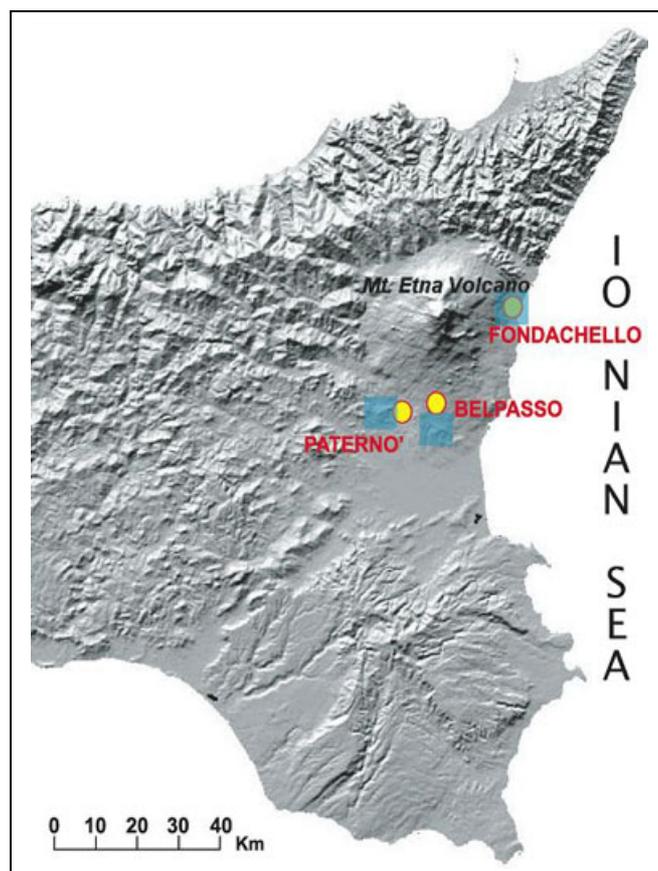


Figure 1 – Map of eastern Sicily (North upward) showing the sites where the mud volcanoes described in this paper are located (blue areas).



Figure 2 – Photograph of one of the active mud volcanoes of the *Salinelle dei Cappuccini* site.

temperature only in vents emitting sulphidric acid that, besides, was present only during the paroxysmal phases.

Well drillings carried out in 1958 for hydrocarbons research indicate that in this site the thickness of the lava exceeds 400 m (Accordi, *in* Cristofolini, 1967), that is significantly larger than elsewhere in the study area. This finding, along with the morphology of the hill and the pattern of the lava flows, radial with respect to the topographically higher central zone, led Carveni *et al.* (2001) to hypothesize that the Cappuccini Hill is a separate volcanic edifice and that its conduit has been encountered by the drilling. It is reasonable that the pre-existing volcanic conduit represents the pathway for the uprising mud. The emission activity in this site is presently characterized by a continuous formation of new springs.

Salinelle del Fiume – They occur in a flat area formed by alluvial terraced deposits of the Simeto river. Between november and december 1999, this site was characterized by the uprising of water enriched of carbonate minerals that formed the travertine deposits (Fig. 3). The water outflowed through the thermal contractional fractures that affect the outcropping lava unit, probably uprising, as the mud in previous phases of activity, through the pre-existing volcanic neck of a small monogenic volcanic edifice (Carveni *et al.*, 2001). The emission of mud at this site is low at present.

Salinelle del Vallone Salato or Salinelle di San Biagio – In this site, mud volcanoes extend over an area of several thousand square meters on a substrate of sandy clays of Lower Pleistocene age. They are characterized by a number of springs of high-salinity water that, although uprising from nearby emission points, have different temperature (ranging from 16° to 19° C), composition and amount of suspended clay particles. The activity of the numerous mud volcano vents, whose diameters rarely exceed 1 m, causes a continuous morphologic evolution of this area. Here it is possible to recognize three main conic edifices with a maximum height of 10 m, aligned in a NNE-SSW direction. This is the direction of other morphostructural elements recognized by aerophotographs (Carveni *et al.*, 2001). A dense mud flow (Fig. 4) was emitted in the early 2002.

3. Mud volcano on the northeastern Etna slope

The northeastern periphery of the Etna volcano, along the Ionian Sea coastline, is characterized by a wide alluvial plain interrupted by low heights. Here, the NNE-SSW trending Giardini-Mascali normal fault system (Carveni *et al.*, 2005) originated a series of horst and graben that have influenced the drainage pattern as well as the coastline. In particular, the Fondachello Fault caused the formation of several coastal ponds, today partly reclaimed or extinct, the most important of which is the *Gurna di Fondachello* (Carveni *et al.*, 2006). Following Boccone (*in* Alibrandi, 1985), during the destructive Val di Noto earthquake of January 11th, 1693, a mud volcano formed along the western border of the *Gurna*, ejecting muddy water up to 32 m of height. It was called *Salsa di Fondachello* after the name of the closest village.

Recupero (1815), that explored this area before the 1778, does not mention the presence of a mud volcano and this suggests that it was completely eroded at that time and that there was no memory of its previous activity in the local population. The *Salsa di Fondachello* was reactivated in december 1795, when the inhabitants of Fondachello were awaked by several seismic events. The morning after, they observed a fountain of water about 6-7 m high along the southeastern border of the pond. Emissions progressively decreased and the water continued to gush out from the crater of a tronco-conic edifice that meanwhile was formed, gurgling inside the lacustrine basin (Mercurio, 1847). When this phase of activity ended, in 1832, the mud volcano was 3,6 m high with respect to the water level of the pond and about 6 m high with respect to the sea level (Mercurio, 1847).



Figure 3 – Travertine deposits in the *Salinelle del Fiume* site.



Figure 4 – Photograph of a mud volcano (height ~ 30 cm)
at the *Salinelle del Vallone Salato* site.

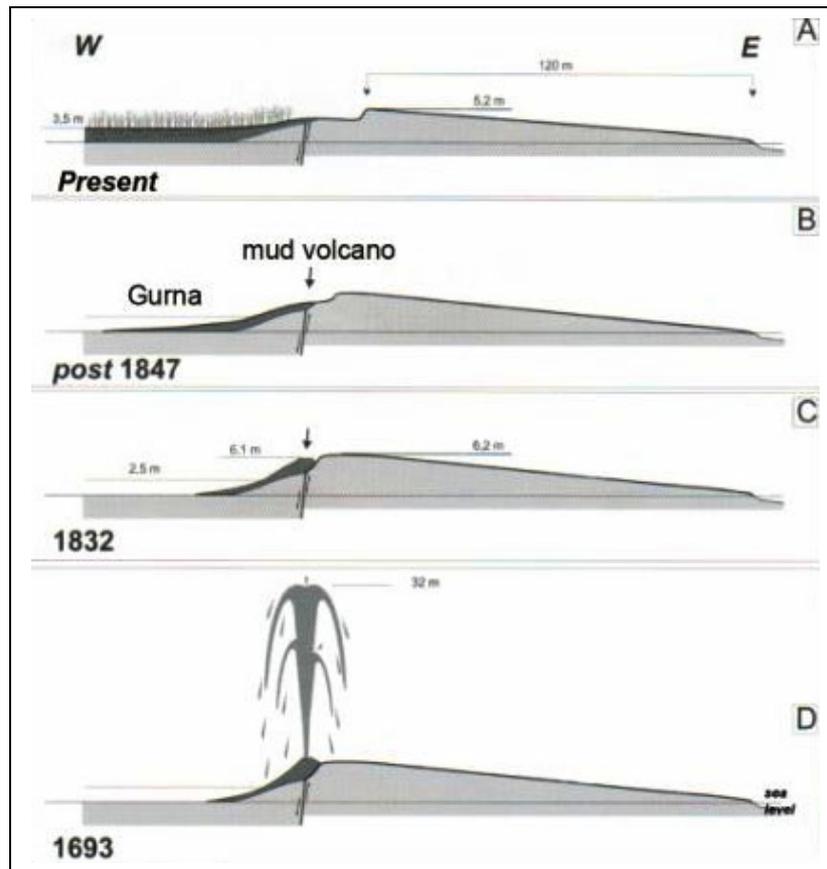


Figure 5 – Evolution of the *Salsa di Fondachello* proposed by Carveni *et al.* (2006).

A new phase of activity, that was also the last one, occurred in march-april 1847 following a sequence of earthquakes, the strongest of which was felt in Catania. During the night of april 9th, the inhabitants of Fondachello felt a strong explosion and as soon as they visited the *Gurna*, they observed that the eastern sector of the mud volcano had collapsed forming an elliptical cavity. Today there is no evidence of the mud volcano and a weak methane emission along a drainage channel (D’Alessandro *et al.*, 1997) is the only evidence of endogenous activity in that area. Moreover, it is located along the western border of a marsh area that represents what is left today of the *Gurna*, while the *Salsa di Fondachello* was located on the southeastern border of the *Gurna*, according to Mercurio (1847). Above (Fig. 5) is shown the reconstruction of the morphologic evolution of the *Salsa di Fondachello* (panels A-D) as proposed by Carveni *et al.* (2006).

Given that the *Salsa di Fondachello* has been active at least three times in the past, its reactivation today should be considered as a serious element of hazard for the surrounding, increasingly urbanized area.

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