

PROPOSAL FOR PRESERVATION AND PROTECTION OF THE MARCHE REGION MUD VOLCANOES (CENTRAL ITALY)

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ABSTRACT: P. Farabollini et al., *Proposal for preservation and protection of the Marche region mud volcanoes (central Italy)*. (IT ISSN 0394-3356, 2005).

have been in the past the subject of several studies by different Authors; mentioned in classical scripts, they have been treated more in detail starting from the 17th century in naturalistic studies published by Scientific Academies or Cultural Associations.

In the Marche region, these phenomena have been observed only in the peri-Adriatic sector where Pliocene and Pleistocene formations crop out; they are well represented with respect to typology, number and extension.

The present paper proposes several strategies for their preservation and protection: in particular these aim to avoid the characteristic morphologies, produced by leaking mud (also several times per year in some cases), being suddenly demolished by anthropic or natural agents. Mud leakage generally occurs on a flat surface called "piano della salsa" prevalently on a thalweg or along a very gentle portion of the slope.

Typical, in mud volcano morphology, is the presence of one or more cones of different height and extension with emission of mud with different fluidity; sometimes natural boundaries exist and the leakage remains confined inside a depression, but in other cases the mud emissions can reach the hydrographic network.

The Marche Region Administration, as those of other Italian Regions, have no rules yet (except for some indications in the PPAR-Regional Plan for Landscape and the Environment) for preventing and protecting these geo-sites. The procedure for safeguarding them should start from an analysis of the territory and a study of its resources, in particular defining characteristics, potential risks, and the objectives to be reached; in addition, it should formulate proposals for their use and enhancement, also indicating possible thematic routes (geological and geomorphologic pathways) in particularly significant areas.

RIASSUNTO: P. Farabollini et al., *Proposte per la conservazione e tutela dei vulcanelli di fango delle Marche (Italia centrale)*. (IT ISSN 0394-3356, 2005).

I "vulcani di fango" o "vulcanelli di fango" o "salse", sono stati oggetto, in passato, di studi da parte di numerosi Autori; se ne ritrovano tracce a partire dagli scrittori classici e, più diffusamente, dal '600 in poi con la ripresa dell'attività conoscitiva degli aspetti naturalistici da parte delle Accademie Scientifiche e delle Associazioni culturali.

I vulcanelli di fango, nella loro configurazione tipica, sono stati osservati nella regione marchigiana solamente nell'area periadriatica, caratterizzata dall'affioramento di depositi terrigeni pliocenici, anche se ben rappresentati, sia come tipologia che come numero che come estensione. Per citarne solamente i maggiori, si ricordano quelli presenti nelle Marche centro-settentrionali, nei pressi di Maiolati Spontini (AN) e San Paolo di Jesi (AN); oppure quelli nelle Marche centro-meridionali presenti nei pressi di Petriolo e Loro Piceno (MC), nei pressi di Montegiorgio (AP), Falerone (AP), Offida (AP) e nelle vicinanze del Monte dell'Ascensione (AP).

Nel presente lavoro, oltre a riportare alcuni dati desunti da osservazioni effettuate sui vulcanelli di fango dell'area delle Marche meridionali (Offida), si propongono alcune azioni volte alla loro conservazione e tutela in quanto, nonostante le emissioni si ripetano per diverse volte nell'arco di un anno, anche se in maniera discontinua nel corso di più anni, le forme originate dal fango fuoriuscito, vengono quasi sempre demolite dagli agenti esogeni e, soprattutto, dall'azione dell'uomo, pochissimo tempo dopo la loro formazione.

Le emissioni fangose avvengono in genere su una superficie pianeggiante chiamata "piano della salsa"; in quasi tutti i casi osservati, esse risultano presenti sul fondo valle e/o su superfici pianeggianti che interrompono il pendio e indipendente dal reticolo idrografico presente; tuttavia non mancano casi, peraltro molto rari, in cui invece è possibile osservarle lungo il talweg del reticolo idrografico secondario.

La Regione Marche, così come la quasi totalità delle regioni italiane, ad eccezione di alcune indicazioni contenute nel cosiddetto PPAR (Piano Paesistico Ambientale Regionale), non è dotata di norme che prevedano in qualche modo azioni di conservazione e tutela di tali geositi.

Il procedimento per giungere alla salvaguardia dei geositi dei "vulcanelli di fango", e delle aree ad esse connesse, dovrebbe prendere inizio dalla fase di analisi del territorio e delle sue risorse, che valuti le aree in base agli aspetti di ogni singolo sito ed alla sua vocazione, individui le minacce e ne definisca gli obiettivi da perseguire e che, infine, indichi le proposte di fruizione e valorizzazione di ogni geosito, includendo anche la possibilità di individuare percorsi tematici specifici (sentieristica geologico-geomorfologica) per zone particolarmente significative.

Tale Piano potrebbe risultare composto dalle seguenti fasi:

- Fase di Analisi;
- Fase di Valutazione e Definizione;
- Fase Propositiva (di tutela e di valorizzazione).

In particolare, gli strumenti per la tutela e la gestione di questo peculiare geosito potrebbero essere rappresentati da:

- ripristino delle condizioni naturali dell'affioramento e promozione di attività di conservazione del geosito;
- pannelli di avvicinamento e/o segnalazione del luogo mentre, sul posto, pannelli interpretativi che spieghino il fenomeno che si ha davanti, la sua genesi e la sua evoluzione spazio-temporale, anche con ricostruzioni 3D del suo stato iniziale confrontato con quello attuale;
- zona di sosta, supportata da idonea tabellazione esplicativa, strutturata in maniera tale da rappresentare un polo di attrazione alla stessa stregua di un museo naturale all'aperto.

Key words: Mud volcanoes, Pliocene sediments, Periadriatic area, Defence and preservation, Marche Region.

Parole chiave: Vulcanelli di fango, Sedimenti pliocenici, Fascia periadriatica, Tutela e Conservazione, Regione Marche.

1. INTRODUCTION

Mud volcanoes (also known as “vulcanelli di fango”, “salse”, “macalube”, or “bollitori”) have always been the object of study, both on account of their particular conformation and morphology and of the curiosity and, in some cases, the fear that they can cause in society. Mention of them can be found in works by classical writers (Marinelli, 1904; Biasutti, 1907; Bonasera, 1952; Damiani, 1964), and more widespread accounts are present beginning from the 17th century with the revival of interest in natural phenomena on the part of scientific academies and cultural associations. To explain the genesis of these phenomena, which can display different morphological aspects and characteristics according to different geological and hydrogeological conditions, various hypotheses have been put forward regarding the regional seismic activity, the presence of gas, the rainfall regime, the morphological and geohydrological conditions of the area surrounding the mud volcanoes, etc. (Marinelli, 1904; Biasutti, 1907; Bonasera, 1952; Damiani, 1964; Nanni & Zuppi, 1986; Martinelli, 1999; Scalella, 2000). More in particular the presence of these phenomena in the area, has been related (Bonasera, 1952; Damiani, 1964; Nanni & Zuppi, 1986), to the uprising of deep hot waters along preferential lines (faults and/or joint systems, structural boundaries, etc.). In their typical configuration, the mud volcanoes in the Marche Region have been observed only in Pliocene sediments; to mention only the major phenomena: those in the central-northern Marche are in the neighborhood of Maiolati Spontini and S. Paolo di Jesi (in the Province of Ancona); those in the central-southern Marche are near Petriolo and Loro Piceno (Province of Macerata), and Montegiorgio, Falerone, Offida and the Monte dell’Ascensione (Province of Ascoli Piceno).

The mud volcanoes present in Offida area (Province of Ascoli Piceno) are studied and described in this paper. Moreover it proposes several strategies for the preservation and protection of the Marche Region mud volcanoes (Fig.1).

The presence of these mud-emission vents offers a wide view of the different mud volcano morphologies and typologies, which even though not presenting particularly exciting characteristics, all the same are an environmental heritage which is extremely vulnerable, above all since the ever increasing anthropic activity, especially of an agricultural kind, is rapidly canceling it.

2. GEOLOGICAL AND HYDROGEOLOGICAL SETTING OF THE MARCHE REGION MUD VOLCANOES

Mud volcanoes have only been found in the peri-Adriatic area where Pliocene-Pleistocene terrigenous deposits exclusively crop out.

From the geological standpoint, the peri-Adriatic area is characterized by a stratigraphic succession typical of one or more transgressive-regressive cycles, made up of alternations of conglomeratic, arenaceous, and arenaceous-pelitic deposits, often with considerable facies variation, both laterally-vertically and longitudinally in transgressive contact, with frequent onlap joints, with Pliocene pelitic and pelitic-arenaceous

deposits cropping out in the innermost areas (Centamore & Deiana, 1986; Ori *et al.*, 1991). The thickness of the deposits, also determined during petroleum and hydrogeological prospecting research (ENI, 1972), reaches 1500 to 2000 m in the westernmost portion and 3500 to 4000 m in the easternmost one.

This sedimentary succession represents the fore-deep filling sediments, migrating little by little eastward, or else piggy-back-type basins (Ori *et al.*, 1986; Ori *et al.*, 1991). It is affected by small-sized thrusts placed on the top of the carbonatic succession, if not indeed inside the Pliocene deposits themselves (Argnani *et al.*, 1991). In the majority of cases, these are not outcropping thrusts, and so at the surface the setting is almost always a monoclinical one (Fig. 2). However, some positive structures are present, such as the Polverigi anticline and the so-called coastal ridge which includes, amongst other things, the Conero and Porto San Giorgio structures (Bigi *et al.*, 1995).

The Quaternary tectonic activity can be identified above all in the Quaternary deposits that closed the Plio-Pleistocene cycle; these, in addition to displaying considerable reduction in the thickness of the series in the proximity of the anticline structures (Porto San Giorgio), prove to be dislocated both by direct and inverse faults.

From the hydrogeological standpoint, the system of folds, faults, thrusts, and fracture zones that characterizes all the peri-Adriatic area, gives rise to a complex geological-structural feature from which are derived different small- and large-scale hydrogeological structu-

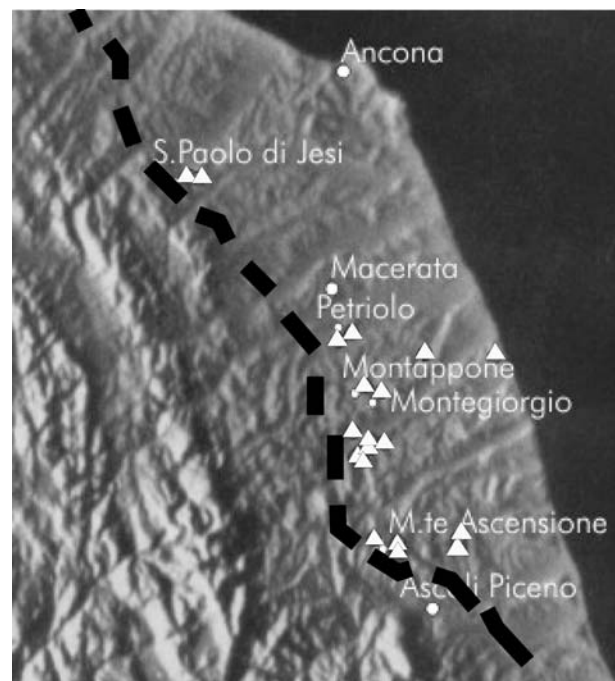


Fig. 1 – Location of mud volcanoes in the Marche Region and in the Offida area. Black line indicates the stratigraphic transition from the Miocene to the Plio-Pleistocene. White triangles indicate main areas affected by mud vent phenomena.

Ubicazione dei vulcanelli di fango della regione Marche e dell’area di Offida. La linea nera rappresenta il passaggio stratigrafico Miocene-Plio/Pleistocene. I triangoli bianchi indicano le maggiori aree di emergenza dei vulcanelli di fango.

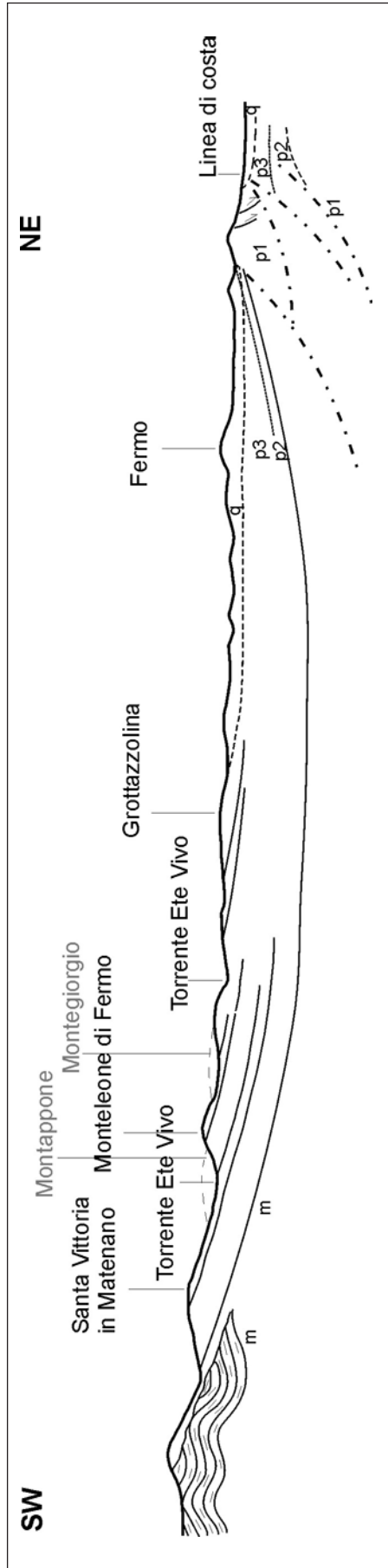


Fig. 2 – Schematic geological cross section of the peri-Adriatic area: m = Messinian; p1 = Lower Pliocene; p2 = Middle Pliocene; p3 = Upper Pliocene; q = Quaternary (modified from Scalella, 1996).

Sezione geologica schematica dell'area periadriatica: m- Messiniano; p1- Pliocene inferiore; p2 Pliocene medio; p3- Pliocene superiore; q- Quaternario (modificata da Scalella, 1996).

res. The former can give rise to surface-type water circulation, considerably variable both in trend and amount, conditioned by prevalently local morphological and bedding factors; instead, the latter generally generate a deeper regional-type circulation, uniform in direction of flow and amount, and mainly regulated by tectonic and structural factors.

With respect to water springs, in the stratigraphic sequences characterized by intercalations of arenaceous, arenaceous-conglomeratic, arenaceous-pelitic, and pelitic-arenaceous units, the numerous perennial water springs testify to the presence of aquifers inside the permeable units and that are mainly filled by rainfall (Scalella, 1996; Nanni & Vivalda, 1998). As for the structural setting, the water circulation in the arenaceous horizons can even reach considerable depths and come into contact with the brackish and salt waters present in the Miocene and Pliocene deposits (ENI, 1972). According to some Authors (Nanni & Zuppi, 1986; Nanni & Vivalda, 1998), arenaceous bodies belonging to the Lower and Middle Pliocene sequence are frequently saturated with brackish and salt waters, and more rarely with freshwater, while the latter prevails in Pleistocene deposits.

3. MORPHOLOGICAL CHARACTERISTICS OF THE MUD VENT PHENOMENA IN THE OFFIDA AREA

The mud vent phenomena and other characteristic morphological features (flows, fractures, cones, etc.) are essentially found in the Fosso del Lago valley bottom, in the point where the bed widens out and displays a decidedly asymmetric shape due to the monoclinial bedding of the bedrock (Fig. 3). Generally, this area, notwithstanding the considerable farming activities practiced there, can almost always be recognized by its vegetation which, at the point of mud emission, is always more luxuriant, due to the water permanence.

The mud volcano morphology is extremely variable and in continuous evolution. Long-term observations, apart from evidencing a more intense activity in the periods of greater rainfall, have shown that with the passing of the years new mud vents can open up, at times with the formation of new small cones.

In particular, for almost all the phenomena observed in the Marche Region, the morphology of the areas with mud volcanoes is characterized by the existence of a zone where one or more emission point(s) are located (with the presence of emitted mud) and by one or more small cones of different height and extent, at the summit of which mud of varying fluidity is emitted (Fig. 4).

Mud emission generally occurs over a flat surface, called "piano della salsa"; in most cases, it occurs on the valley bottom and/or on nearly flat morphologies that interrupt the slope. It generally leads to the formation of a cone, usually circular in shape, to the presence of topographic surfaces with reduced angle of slope, and with a good speed of emission and a fair density of mud emitted. In some cases, when their density is higher, the emission itself, is confined inside a depression that prevents its propagating, whereas in others it develops by means of flows that sometimes ends up

into the hydrographic network.

Often, the landforms originating from the mud emitted, above all due to their intermittent nature, are demolished by external agents and above all by the action of man (Fig. 3).

In addition to displaying varying size, the mud volcanoes in the study area are characterized by an intermittent activity with time intervals even of a few years between one emission and another. This activity means that whenever the phenomenon occurs, it is immediately remodeled by anthropic activity that, for agricultural purposes, tends to restore a surface that can be utilized within a brief period of time. In fact, for many of the situations occurring in the Marche region, the immediate actions of man have always prevented the development of these phenomena, and even canceled the least evidence of such activity, and at times not even allowing the formation of new emissions.



Fig. 3 – Panoramic view of mud volcanoes area of Offida (June 1996). The considerable farming activity should be noted; this led to the disappearance of the mud volcano morphology, even though it can still be recognized by the more luxuriant vegetation due to the water permanence.

Foto panoramica delle zone dei vulcanelli di fango di Offida (Giugno 1996); da evidenziare la notevole attività antropica che ha portato alla scomparsa della morfologia del vulcanello di fango, anche se riconoscibile a causa della vegetazione più lussureggiante dovuta a ristagni di acqua.

4. HYPOTHESES OF FENCING, MANAGEMENT, AND SAFEGUARDING OF THE MUD VOLCANO AREAS OF MARCHE REGION

In this context of an extremely various typology of mud volcanoes present in the Marche Region territory, we wish to propose certain actions aimed at preserving and safeguarding them, also on the basis of what has been done for those in the Municipality of Fiorano Modenese, where specific regional regulations in 1982 set up the Natural Reserve of “Salse di Nirano”. The Marche Region, as almost all the other Italian regions, with the exception of certain guidelines contained in the law called PPAR, is not equipped with legislation that foresees in some way actions of preservation and safeguard for these geosites. However, inspired by the above-mentioned laws, the Marche Region has published a volume “Le emergenze geologiche e geomorfologiche della Regione Marche” (Geological and geomorphologic emergency in the Marche) (Various Authors, 1991) in which the geosites were listed, using very simplified and easy-to-read census forms, as an important characteristic element of the Marche geological and geomorphological landscape, and thus worthy of being “respected”. In addition to these actions of characterizing the geosites, establishing them at a level of geological diversity (Bertacchini *et al.*, 1999; Farabollini *et al.*, 2002; Sampaolesi & Farabollini, 2002), and spreading information on them, it is of paramount importance to identify specific actions aimed at:

- restoring natural outcrop conditions;
- promoting activities to preserve the geosites;
- defining specific regional legislation for preserving and safeguarding them.

With the aim of attaining a really binding set of legislation for preserving these particular features, a greater awareness of their importance, but above all of their fragility, is obviously needed, not only on the part of technicians and administrators operating in the field of territorial planning, but also on that of the social community itself. The procedure to be followed for achieving an adequate safeguard of the geosites in question should start from the phase of analyses of the territory and its resources, such as to assess the area on the basis of the aspects and utilization potential of each site, identifying the threats and defining the objectives to pursue, and, finally, indicating the proposed means of exploiting and appraising it. The last of these stages would deal with the possibility of identifying specific thematic routes (geological-geomorphological trails) for the particularly significant ones, both from the tourist and educational-scientific standpoints.

Thus, each individual area characterized by the presence of mud volcanoes could be defined, in zones of various levels of environmental protection:



Fig. 4 – Detail of mud volcanoes in the Offida area (area of the figure 3): the mud emitted between December 1959 and March 1960 together with the relative morphology (after Damiani, 1964).

Dettaglio dei vulcanelli di fango dell'area di Offida (area della figura 3): emissione di fanghi avvenuta tra il dicembre 1959 ed il marzo 1960 e relativa morfologia (da Damiani, 1964).

1. Areas of total protection: to be set up exclusively in a significant setting where mud volcanoes can evolve naturally; in these areas, all types of activity would be forbidden.
2. Areas of planned protection: these areas would include the previous group, and only those activities for conserving, managing and appraising the geosite would be allowed.
3. Protected areas: these would include the areas of the previous two groups and aim at a more significant outward-going context in which non-destructive farming activities would be permitted.

The above-mentioned proposal to fence the areas implies that the owners of the land where the geosite is located, and all the protected areas, should keep more or less large areas of land uncultivated, and additional farming practices should be carried out with respect to those followed beforehand (for instance, a different drainage pattern for collecting rainwater would be required). Therefore, the legislation could contain norms for safeguarding the rights of the owners, with funds aiming at compensating them for any loss of income and/or additional expenses they had to meet due to modified farming practices.

In this way, also for the mud volcanoes in the Marche, a specific legislation would be set up aimed at safeguarding and preserving, so that these geosites that for years have had the role of being “prodigious natural phenomena”, will not disappear for ever, not even from human memory.

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