Babeş–Bolyai University
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Mud Volcanoes from the Eastern and Central Part of the Transylvanian Depression

Extended Abstract of PhD Thesis

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Introduction

Mud volcanoes are one of the world's most dynamic and unstable phenomena. They are distributed worldwide in various tectonic settings onshore and offshore. The most spectacular mud volcanoes in Romania are the ones from the Buzău Subcarpathians (at Berca, Arbănaşi, etc.) [SENCU, 1985]. In the Transylvanian Depression mud volcanoes have been mentioned in 65 localities from which some can't be identified at present (in particular those from cities or the ones from built-up areas.

The aim of this study is to present and synthetize the mud volcanic phenomena from the eastern and central part of the Transylvanian Depression, to study the diversity in morphology and the internal structure (with the help of manual shallow drillings), to establish a new classification and a model for the formation mechanism of different morphological types of mud volcanoes in the study area.

Theoretical Background

The genesis of mud volcanoes has puzzled geoscientists for a long time but it is still an unclarified issue. First of all it has to be clarified whether mud volcanoes related to hydrothermal processes can be considered as such.

According to the opinion of several researchers [e.g. ETIOPE and MARTINELLI, 2009b], only those phenomena are considered to be mud volcanoes which are the result of mud volcanism (as process). Thus, the phenomena which are found in post-volcanic areas and discharge mud resulted by the alteration of rocks at low depth under the influence of acid hydrothermal water can be called mofettes [according to ETIOPE and MARTINELLI, 2009a, b] (hydrothermal or post-volcanic mud volcanoes after SENCU [1985]), but not mud volcanoes. Other authors keep to the classic terms, differentiating two or three fundamental groups from the point of view of genesis. Therefore, we can distinguish first of all the mud volcanoes related to the hydrocarbon deposits and those connected to magmatic complexes (post-volcanic hydrothermal processes) [MAZZINI, 2009], which are completed by the ones of seismic origin. Mud volcanoes associated with hydrocarbon gas eruptions are considered mud volcanoes sensu stricto [ex. ETIOPE and MARTINELLI, 2009a, b]. These occur in hydrocarbon-bearing zones as a result of discharging an overpressured mixture of water, gas and the solid component represented by mud or mud breccia.

Mud volcanoes in the eastern and central part of the Transylvanian Depression

The presence of mud volcanoes in the Transylvanian Depression is favoured first of all by the presence of gas accumulations and associated fossil waters, by the folded and faulted structures and by the potential sedimentary deposits which serve as source layers for mud volcanoes.

The geological conditions and the importance of other factors are integrated in the subchapter "Favouring Factors in the Genesis and Evolution of the Mud Volcanoes in the Eastern and Central Part of the Transylvanian Depression".

In the eastern and central part of the Transylvanian Depression manifestations of mud volcanism have been signaled in the area of 33 settlements, of which the following have been studied: the ones in Atid, Băile Homorod, Băile Seiche, Cobăteşti, Corund, Crăciunel, Dârjiu, Filiaş, Forţeni, Goagiu, Vălişoara (Gloduri), Mihăileni, Morăreni, Porumbenii Mici, Sânpaul, Sângeorgiu de Pădure, Cându, Maia, Monor and Sânger. On the whole 72 microforms of mud volcanoes have been identified, but their number is only an approximation, since some of them can be derivations or manifestations of a single and more complex mud volcano. The observations, morphometric data and details regarding the internal structure of the mud volcanoes identified in the eastern and the central part of the Transylvanian depression in the period 2002-2010 are presented in the subchapter "Case Studies".

Morphological study

In order to study and compare the different morphologies of the studied mud volcanoes a database has been created which includes data concerning dimensions and internal structure (until a maximum depth of 8.5 m) of the subjects, information regarding the surfaces they appear at, the anthropic influences, the degree of activity and vegetation (table no. 1.).

The dimensions that have been taken into consideration are the following: length, width and height of the mud volcanoes and the diameter of the crater.

Referring the internal structure 3 cases have been distinguished according to the form and size of the feeder channel (conduit) and according to the existence or lack of nearsuface mud intrusions:

1. narrow feeder channel (<15 cm), represented by a fissure;
2. feeder channel that widens into mud intrusions;
3. feeder channel that widens in the shape of a funnel.

In case of undrilled mud volcanoes or in the cases when the drilling had un-concluding results, in table no. 1 there is a question mark.

From the point of view of surface inclination (slope) the mud volcanoes have appeared on, two cases have been defined: inclined and flat, the degree of inclination having an important role in the symmetry of the resulted shape and in some cases in the shape itself.

With respect to the activity of mud volcanoes 5 levels have been defined:

1. active mud flows or bubbling (in the case of flat or negative shapes);
2. apparently fresh material, uncovered by vegetation, but without any active flows or bubbling
3. shapes covered by vegetation which can be reactivated by removing the crust and/or the vegetal layer which is obstructing the vent;
4. shapes covered by vegetation with no sign of visible activity, but which quake under one's feet, indicating the presence of very dense mud under the dry crust, being specific to the mud volcanoes in a latent phase;
5. fossils, which show no sign of activity, their shape being the only indicator for the existence of a mud volcano;

Three different forms of vegetal cover have been differentiated:

1. lack of vegetation or low grassy vegetation;
2. low vegetation with small sections of high vegetation, where the morphology is still well outlined;
3. high vegetation, which makes the study of its morphology more difficult.

From the point of view of anthropic influences three cases have been taken into consideration:

1. the evolution of the mud volcanoes have not been influenced by anthropic processes at all;
2. anthropic influences with minor consequences in the evolution of the mud volcanoes;
3. intense anthropic influences, which have led to a radical change in the shape and/or evolution of the mud volcanoes.

Name	Length (m)	Width (m)	Height (cm)	Crater (cm)	Feeder channel*	Degree of activity*	Surface inclination	Anthropic influences*	Vegetation *
Morăreni 1	12	10	130	0	2	3	flat	1	1
Morăreni 2	15	15	60	0	?	5	flat	1	3
Morăreni 3	3.5	3	30	0	?	4	flat	1	1

Name	Length (m)	Width (m)	Height (cm)	Crater (cm)	Feeder channel*	Degree of activity*	Surface inclination	Anthropic influences*	Vegetation *
Mihăileni 1	20	0.4	20	?	?	1	inclined	3	1
Mihăileni 2	15	15	150	0	2	3	inclined	1	3
Cobăteşti 1	9	7	30	6	1	1	inclined	2	1
Cobăteşti 2	20	16	80	2	1	1	inclined	2	1
Cobăteşti 3	2	1	0	100	3	4	flat	2	1
Cobăteşti 4	3	2	10	3	3	2	flat	2	1
Cobăteşti 5	4	0.5	10	?	?	1	flat	3	1
Cobăteşti 6	4	4	100	5	2	3	flat	1	2
Cobăteşti 7	9	8	50	70	?	?	flat	1	2
Cobăteşti 8	5	3	0	300	3	2	flat	1	1
Cobăteşti 9	1.5	1.5	0	100	3	2	flat	1	1
Filiaş 1	28	24	150	1200	3	1	inclined	1	1
Filiaş 2	18.5	14	200	60	2	1	inclined	1	1
Filiaş 3	15.5	12.5	350	2	?	2	inclined	1	1
Filiaş 4	8	4.5	0	150	3	2	inclined	1	1
Filiaş 5	5	3.5	0	100	3	2	inclined	1	1
Filiaş 6	3	3	50	0	2	5	inclined	1	1
Porumbeni 1	20	15	10	2	3	2	flat	1	2
Porumbeni 2	13	9	250	2	2	2	flat	1	2
Porumbeni 3	6	3.5	0	300	3	2	flat	1	1
Porumbeni 4	3	2	0	200	3	2	flat	1	1
Porumbeni 5	1	0.5	0	50	3	2	flat	1	1
Sângeorgiu	15	10	0	1000	?	5	flat	?	2
Atid	14	12	150	1000	3	2	flat	1	2
Forţeni 1	12.5	8	60	0	?	4	flat	3	2
Forţeni 2	2	2	0	150	3	2	flat	1	1
Seiche	10	4	15	?	1	2	inclined	3	1
Corund	1.2	1.2	20	2	1	1	inclined	1	1
Goagiu 1	0.1	0.1	0	10	?	1	inclined	1	1
Goagiu 2	3	2	0	200	3	2	inclined	1	1
Dârjiu	5	5	120	0	?	5	flat	2	3
Homorod 1	17	15	110	5	1	2	flat	2	1
Homorod 2	15	15	140	0	?	5	flat	1	2

Name	Length (m)	Width (m)	Height (cm)	Crater (cm)	Feeder channel*	Degree of activity*	Surface inclination	Anthropic influences*	Vegetation *
Homorod 3	5	4	50	15	1	1	flat	2	1
Homorod 4	1.6	1.4	0	150	3	1	flat	2	1
Homorod 5	10	1.5	0	20	3	2	inclined	1	1
Homorod 6	1	1	0	15	3	1	flat	1	1
Dungo 1	1	1	0	20	?	4	inclined	1	1
Dungo 2	1	0.5	0	50	?	5	inclined	1	1
Dungo 3	100	50	1000	0	?	5	flat	1	2
Sânpaul	5	6	0	5	?	2	flat	2	1
Sânger 1	1.2	1	0	100	3	2	flat	1	1
Sânger 2	1.5	1	0	120	3	2	flat	1	1
Sânger 3	1	1	0	100	3	2	flat	1	1
Sânger 4	3	2	0	200	3	2	flat	1	1
Sânger 5	8	6	10	10	?	2	flat	1	2
Gloduri 1	4	2.5	0	250	3	2	inclined	1	1
Gloduri 2	6.5	4	50	450	3	2	inclined	1	1
Cându	4	3	30	0	1	2	inclined	1	2
Maia 1	1	1	0	0	?	4	flat	3	2
Maia 2	0.5	0.5	5	5	1	2	flat	1	1
Monor 1	23	18	200	2	2	1	inclined	1	1
Monor 2	25	22	250	2	2	1	inclined	1	1
Monor 3	5.5	4	85	2	2	1	flat	1	1
Monor 4	7	5.5	130	0	?	3	flat	1	1
Monor 5	4	4	55	0	?	3	flat	1	1
Monor 6	16	13	60	2	?	1	flat	3	1
Monor 7	22	10	70	800	3	4	flat	1	1
Monor 8	13	10	120	0	?	4	flat	1	1
Monor 9	21	10.5	110	0	?	4	flat	1	1
Monor 10	11.5	11	110	0	?	4	flat	1	1
Monor 11	5	3	25	?	2	2	flat	1	1
Monor 12	2.5	1.7	20	?	2	2	flat	1	1
Monor 13	7.5	6	30	?	2	2	flat	1	1
Monor 14	14	7	15	?	2	2	flat	1	1
Monor 15	8	6	40	2	2	1	flat	1	1

Name	Length (m)	Width (m)	Height (cm)	Crater (cm)	Feeder channel*	Degree of activity*	Surface inclination	Anthropic influences*	Vegetation *
Monor 16	7	5	30	?	2	2	flat	1	1
Monor 17	8.5	4.5	50	?	2	2	flat	1	1
Monor 18	30	25	10	300	3	2	flat	1	1

Table no. 1. Database with the dimensions of the mud volcanoes, information about the morphology of the feeder channel and data regarding the preexistent topographic surface, anthropic influences, degree of activity and vegetation
* explanation in the text

From the 72 micro mud volcanoes which have been studied, those items which have been strongly influenced by anthropic interventions or which are phenomena related to mud volcanism but are not mud volcanoes in the strict sense of the term, have been excluded from the morphological study (9 subjects on the whole).

Based on their height (table no. 1) mud volcanoes with negative or flat shape (including those of maximum 10 cm height) have been distinguished from the ones which have a positive relief. This way 27 mud pools have been differentiated.

From 36 mud volcanoes with a positive relief, 19 subjects lack an obvious crater. Others, 13 altogether, have small craters of a few centimeters diameter (usually 2–5 cm, but in some cases even 60–70 cm), and only 4 subjects with positive relief have very wide craters compared to their basal dimensions. In case of these latter ones the ratio of the crater's diameter – maximum diameter of the base of the mud volcano is 0.37–0.71, compared to the <0.03 values in case of the other subjects. From the point of view of their morphology the 4 mud volcanoes are similar to the Maar volcanoes. The other 32 subjects take a variety of shapes: cones, domes, debris fans, etc.

For a more detailed study of the morphologies of the mud volcanoes, the outlines of the cross section of the different shapes have been drawn. This has been accomplished based on the measurements and observations made on the field and using the photographs taken from profile. The subjects whose morphology was not clearly outlined have been excluded from this analysis.

The outlines of the cross sections highlight the existence of two distinct morphologies: one which is similar to a cone and the other one looking like a dome (see figures no. 1, 2, 3 and 4).

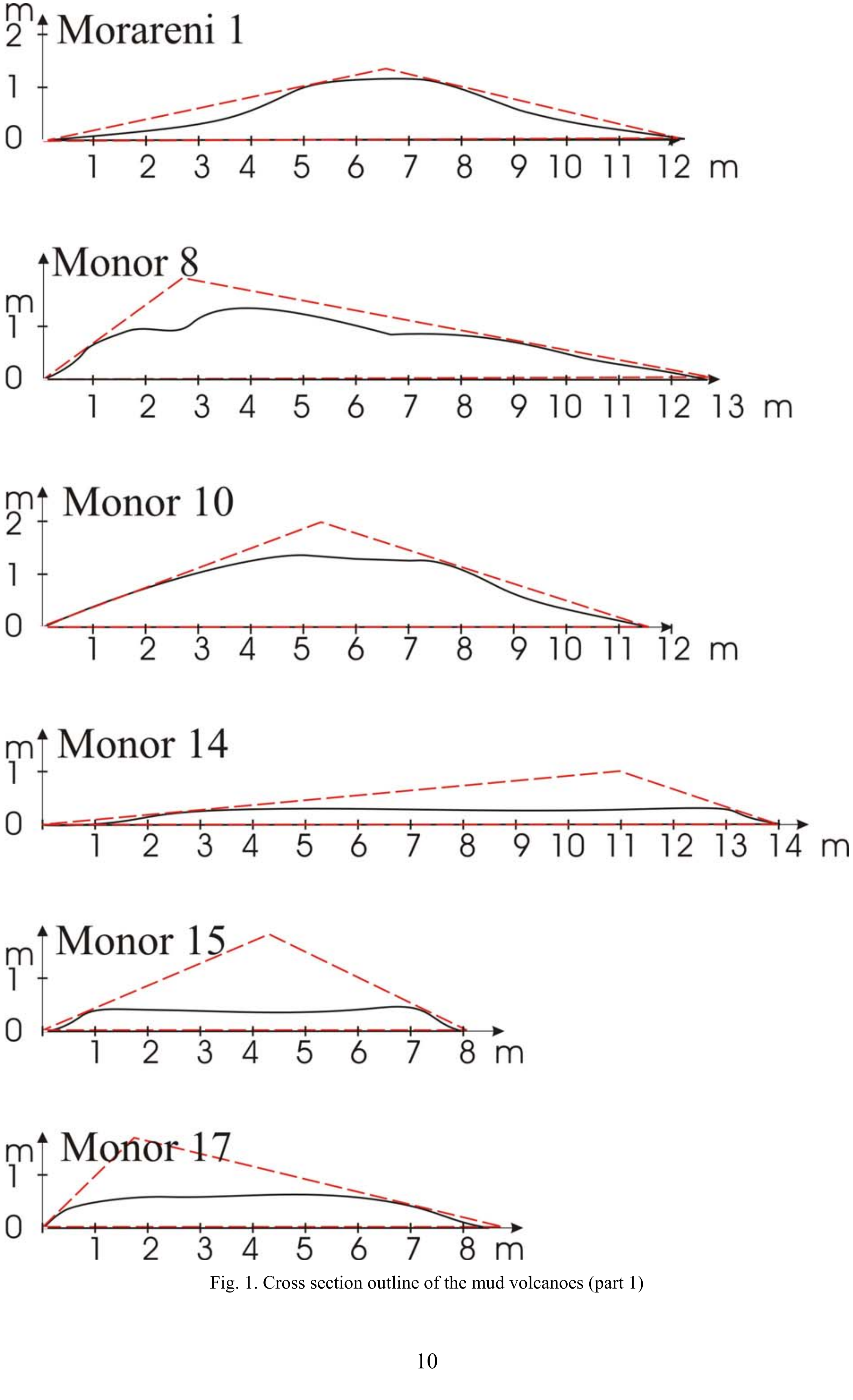

Fig. 1. Cross section outline of the mud volcanoes (part 1)

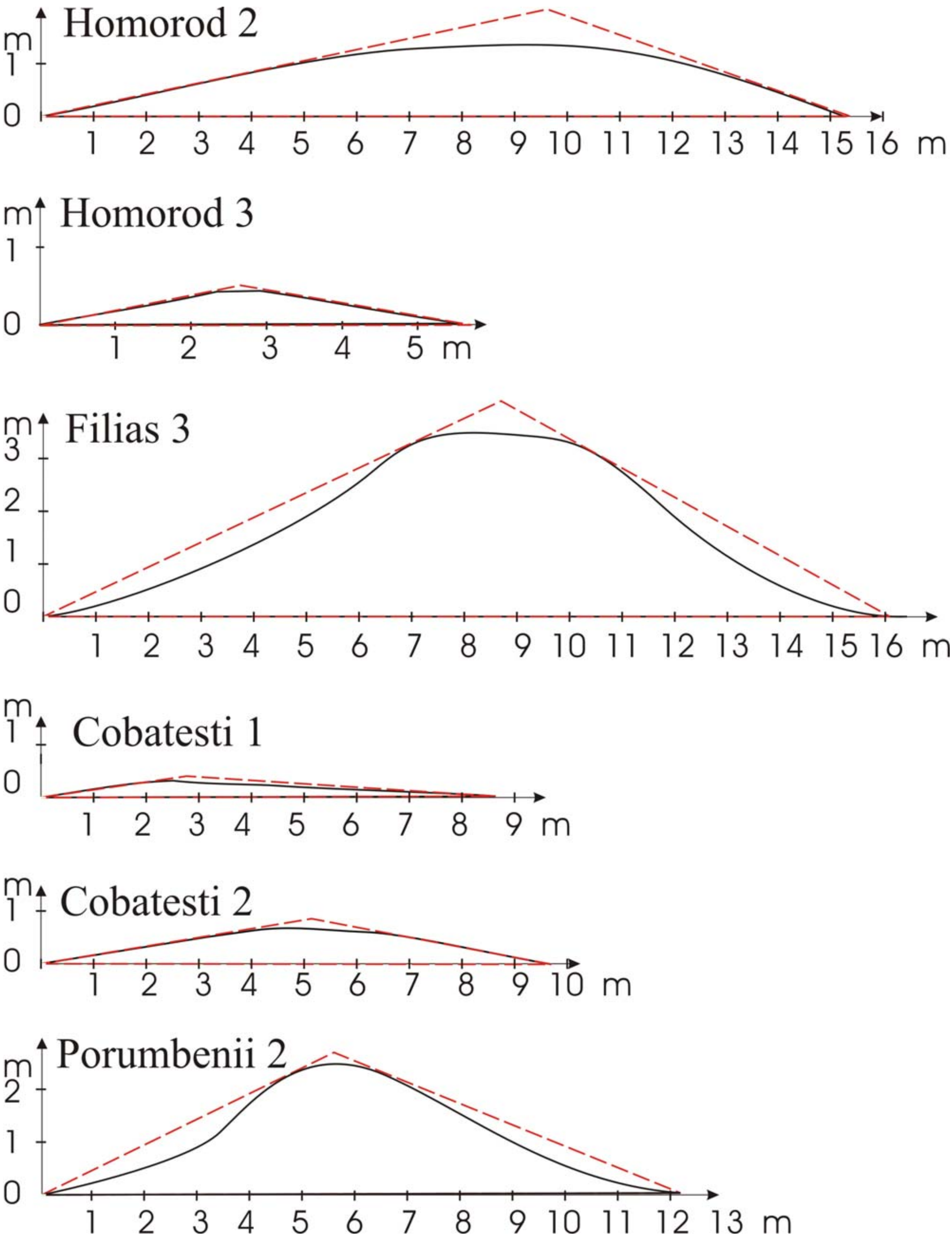

Fig. 2. Cross section outline of the mud volcanoes (part 2)

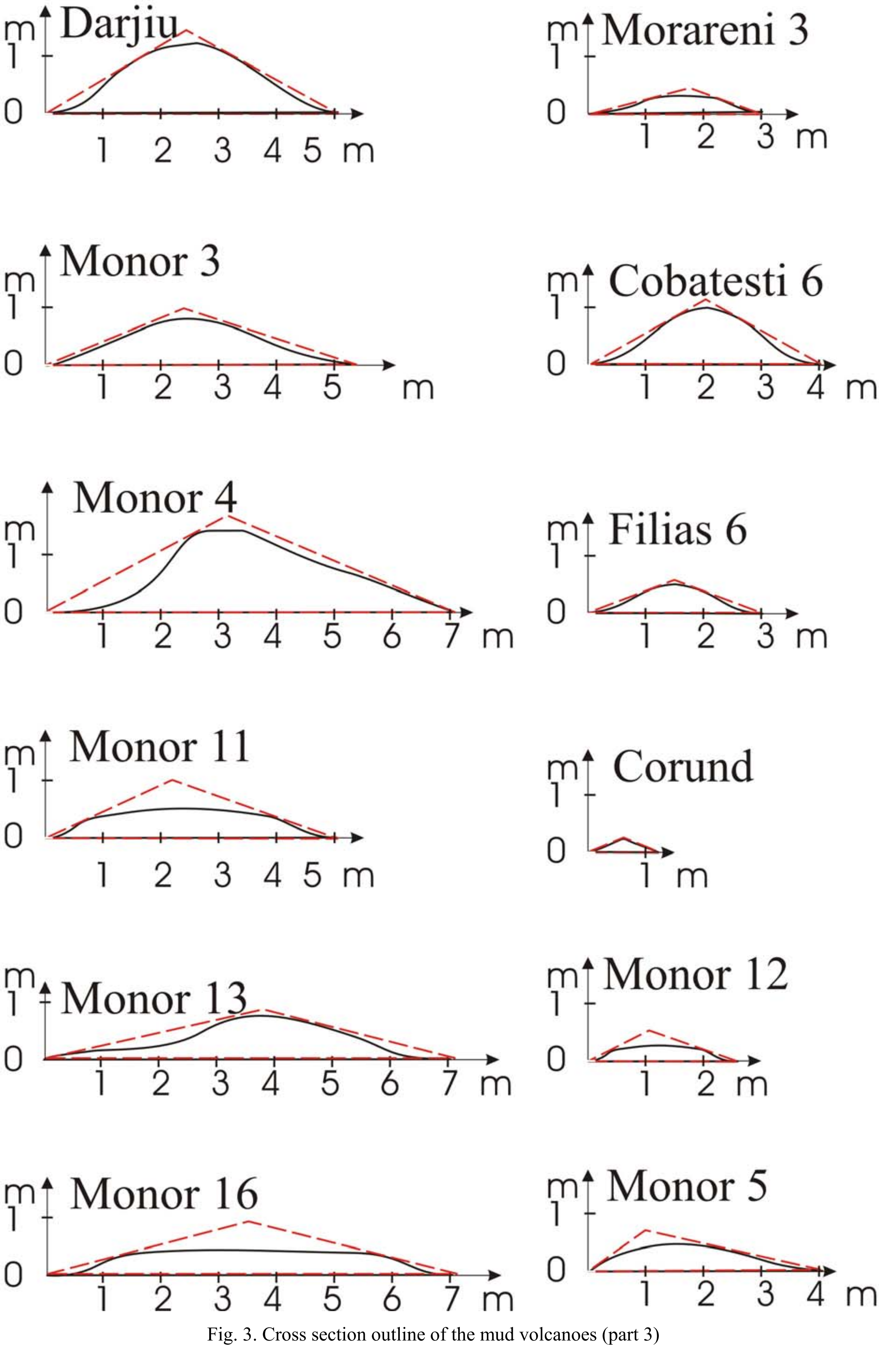

Fig. 3. Cross section outline of the mud volcanoes (part 3)

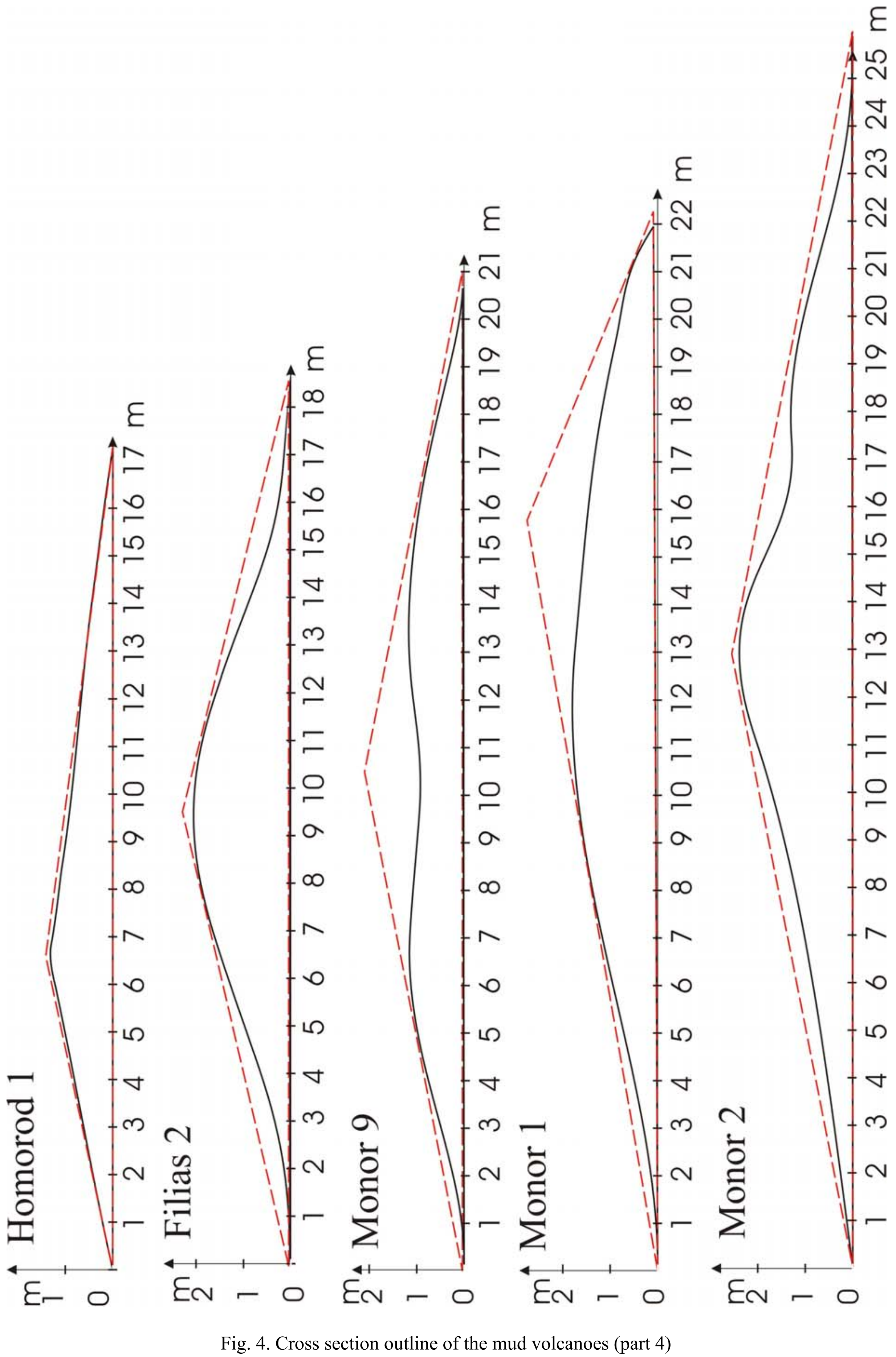

Fig. 4. Cross section outline of the mud volcanoes (part 4)

In cross section the cone shaped mud volcanoes have approximately straight flanks and have the (idealized) shape of a triangle. The dome shaped ones have a vaulted outline with an inflexion on their flanks. To emphasize the differences between the section outlines, these have been inserted into a triangle by drawing their sides tangentially on the flanks of the mud volcanoes.

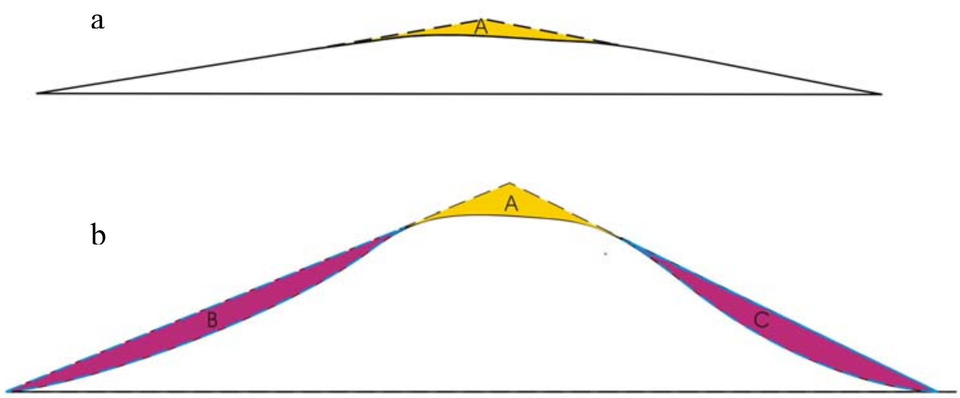

Fig. 5. Mud volcano outline inserted into a minimal triangle and the surfaces individualized between the triangle and mud volcano (a. conical shaped mud volcanoes; b. dome-shaped mud volcanoes)

To highlight even better the differences between the two outlined shapes (cone and dome) the surfaces of the mud volcano sections and the differences between them and the triangle's surfaces have been measured. In some of the cases the sides of the triangle (drawn tangentially on the flanks) separate only one surface (fig. 5/a), in other cases 3 surfaces (surfaces A, B, and C on fig. 5/b). The quantification of the differences between the two morphologies has been accomplished through the calculation of the ratio between the area of surface B+C and the area of the whole surface left between the triangle and mud volcano (area of surface A+B+C).

Thus two categories have been distinguished: the ones where this ratio equals 0 and the ones whose value falls between 2–98. The value 0 is present in case of mud volcanoes with straight flanks, on the other hand the high values show the existence of inflexions on the flanks and of a dome shape. The lower values (2–21) resulted at the mud volcanoes from Monor is justified by the fact that their crest is very flat, being subject to a flattening process, of natural origin on one hand and anthropic on the other hand.

<u>Analysis of the mud volcanic ejecta</u>

The results of the grain size analyses show that the emitted mud is usually fine grained sand and silt, the clay fractions appear only subordinately, being present in only 4 samples in small percentages (15–30 % from the total sample unit). There is a slight correlation between the degree of sorting, the uni- and polimodality of the the grain size curves and the distribution of samples in the 4 morphological categories. This relationship can be a function of the percentage of the material derived from wall-rock erosion and at the same time it can be a function of the size of the contact surface with external factors. The results of the grain size analyses will become more reliable by improving the sampling method with microgeophysical investigations in order to pinpoint the feeder channel with higher accuracy.

The mineralogical analyses demonstrate that the dominant mineral components are the following: quartz, clinochlore, muscovite, calcite, dolomite and albite with no correlation in their distribution.

Typology of mud volcanoes in the eastern and central part of the Transylvanian Depression

As a follow-up to the study of the information presented in chapter 4 (“Morphological study”), in spite of the great diversity concerning the external manifestations of the mud volcanoes, there are characteristic traits in the morphology and structure of the microshapes, this allowing for a new typology to be established. This way, four categories have been differentiated:

- mud pool,
- mud cone,
- mud dome,
- mud caldera

Mud pool

This category includes all the negative and flat shaped mud volcanoes, including the ones that have a small prominence of short-lived character. Mud pools appear as ponds within a marshy area. The material inside the pool is more fluid in case its activity is intense and dense and viscous at the ones that show weak activity or are in a dormant phase. Depending on the degree of activity as well, the material of the pool can be covered by a solid crust and vegetation. If the mud pool has a solid crust, this latter quakes under one’s feet, without visible bubbling only after removing the mud crust. In case of active mud pools which are not covered by vegetation, the liquid mud bubbles and the emanated gases can be easily lit.

Their dimensions vary from less than 1 m until approximately 15 m, and their (measured!) depth from 3 m until more than 8.5 m. The (sampling) augers have submerged in the liquid material which was perceptibly going further deep. The host rock was waterlogged with the liquid mud so the edges were not always easy to delimit.

Fig. 6. Example of mud pool (*Gloduri 1*)

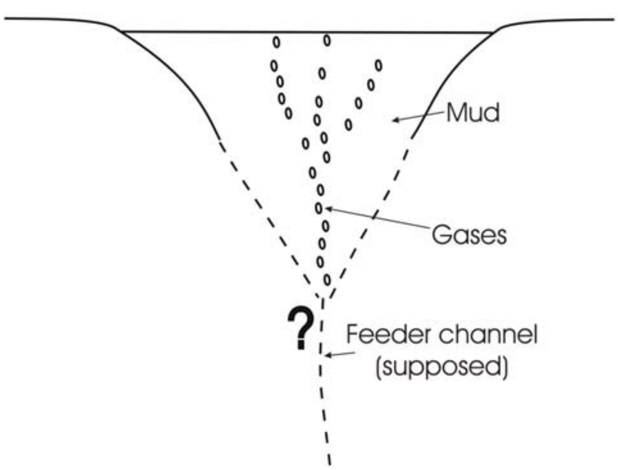

Fig. 7. Idealized sketch of mud pools

Mud cone

Mud cone category relates to all those mud volcano formations with positive shapes that result from venting mud through a narrow feeder channel which is deposited on the preexistent topographic surface. The multiple overlapping of radial mud flows leads to the continuous rise of the mud cone, similarly to shield volcanoes [SIGURDSSON et al., 1999]. Since in case of all the studied mud volcanoes the discharged material is fluid and of low viscosity, the resulted cone is vary flat and rises only a few tens of centimeters above the surface.

The inclination angle of the surface can significantly influence the shape and the symmetry of the cone. In case mud is emitted on a flat surface, this will gain the shape of a cone, on a slightly inclined surface it will be an asymmetric cone with an elongated side in the direction of the inclination, and on a steep slope, the resulted shape will be similar to a debris fan. Mud volcanoes with substantial anthropic influences take the shape of mud flows.

Looking at its cross section, the mud cone has the shape of a triangle, its flanks being almost straight. Gas bubbling is only obvious if the cone disposes of a well outlined crater where the expelled fluids accumulate.

Fig. 8. Example of mud cone (*Cobăteşti 1*)

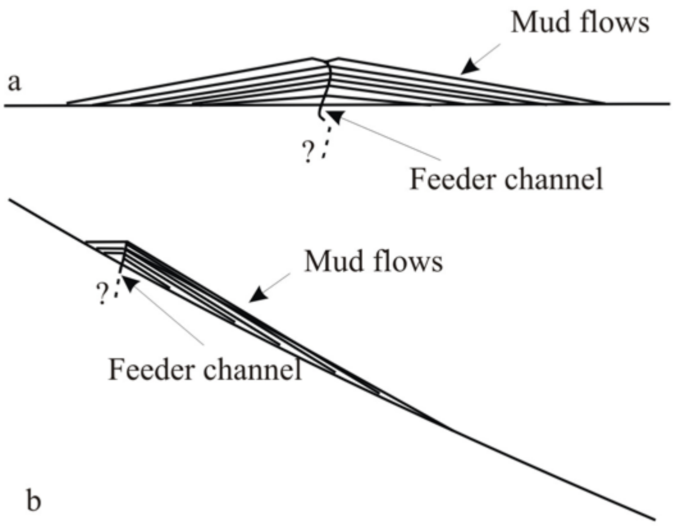

Fig. 9. Idealized sketch of a mud cone a) on a plane surface, b) on a slope

Mud dome

The term "mud dome" is used in literature to designate offshore sedimentary volcanoes, which are the surface manifestations of mud diapirs without material discharging on the seafloor [BARBER et al., 1988; HUGUEN et al., 2004]. In this present work this term has been used to denominate those dome-shaped mud volcanoes with or without an obvious crater which have liquid mud accumulated in form of mud intrusions under the solid crust, and which form similarly to endogenous volcanic domes [WILLIAMS and MCBIRNEY, 1979 quoted by WOHLETZ şi HEIKEN, 1992].

The shape of the mud dome differs from the one of the mud cone, first of all through its vaulted shape and through the inflection existing on the flanks, compared to the almost straight flanks of the mud cones.

The structure of the mud dome is individualized through the widening of its feeder channel near the surface in the shape of mud intrusions where the very liquid material is accumulated. The crater of the mud dome can be represented by a small opening of 1–2 cm, by a crater of approximately 60–70 cm or it can be sealed. In this case also, the bubbling of the gases can be noticed only if there is a crater in which the liquid material accumulates and then flows on the flanks of the mud volcano.

Fig. 10. Example of mud dome (*Filiaş 3)*

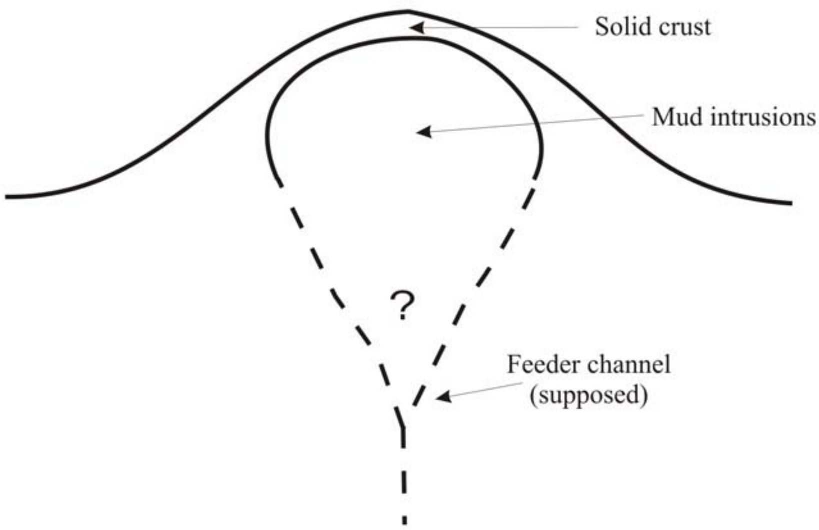

Fig. 11. Idealized sketch of the mud dome

Mud caldera

The term "mud caldera" is used for mud volcanoes with depressions, formed as a result of the collapse of the mud volcanic edifice or as a result of an eruption. [PLANKE et al., 2006; JUDD and HOVLAND, 2007]. This group comprises the mud volcanoes with the biggest craters and with similar morphology and morphogenesis to the volcanic calderas. From the point of view of their dimension, the mud calderas represent the largest mud volcanic structures in the Transylvanian Depression. These have the largest craters in correlation to the dimensions of the mud volcano base, the maximal crater diameter – maximal basal diameter ratio being 0,37–0,71, compared to the less than 0,03 values in case of the other subjects.

Fig. 12. Example of mud caldera (*Filiaş 1*)

The flanks of the mud caldera are characterized by a slight inflection and their crest is presented through a slightly negative surface. The accumulated mud is denser and more viscous compared to that from other types of mud volcanoes, probably due to the bigger evaporation surface.

Depending on the characteristics of the material, its water content and the weather conditions, the caldera can be covered by a semi-solid, in some spots solid crust, or one that quakes below one's feet, and it can be covered by vegetation.

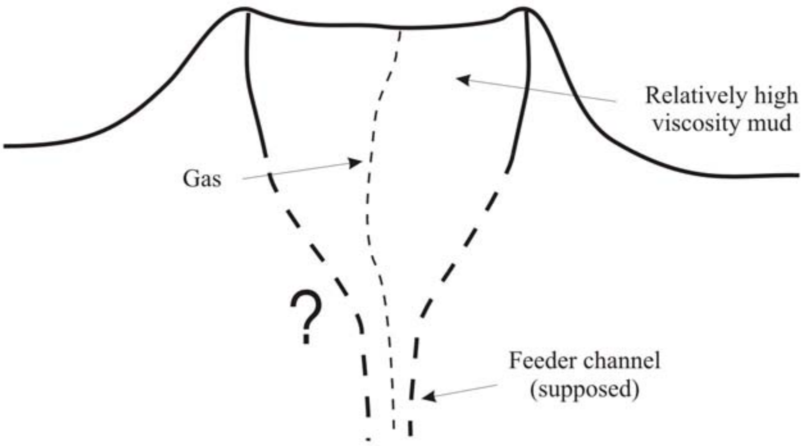

Fig. 13. Idealized sketch of a mud caldera

As far as the internal structure is concerned, the mud caldera has a widened feeder channel which takes the shape of a funnel. Depending on how intense the activity of the volcano is, the flanks of the mud caldera can be composed of fresh mud flows or can be covered by vegetation.

Model for the formation mechanism of the different morphological types of mud volcanoes from the eastern and central part of the Transylvanian Depression

The development and the evolution of the different morphologies of mud volcanoes are determined besides the local geological and geomorphological conditions, by the size and morphology of the feeder channel and by the nature of the material which is due to be expelled. On the basis of the established classification two models have been elaborated for the formation mechanism of the four morphological types of mud volcanoes.

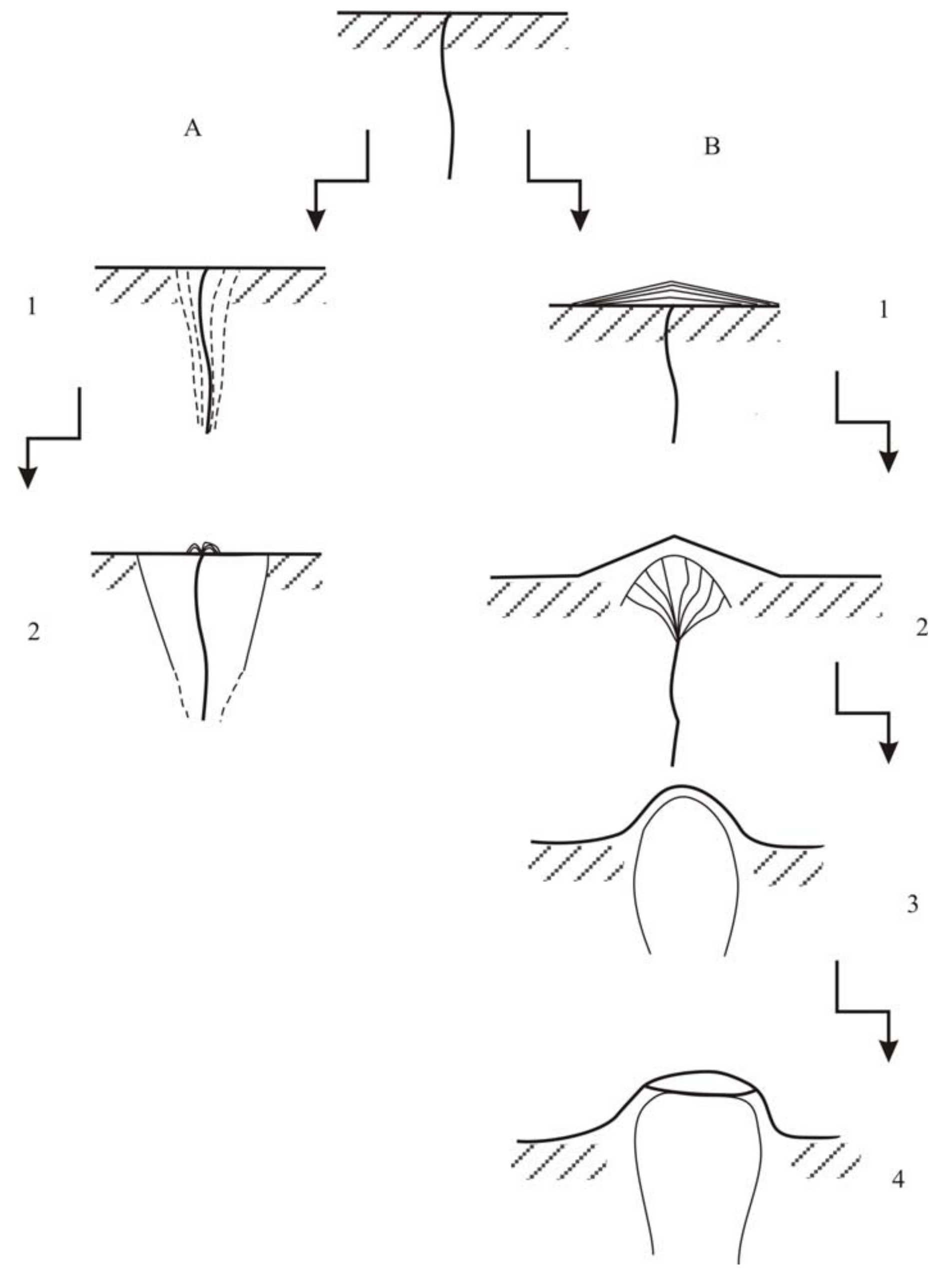

Fig. 14. Schematic evolution of the different types of mud volcanoes (model 1)

The models have as a starting point the existence of source material and a conduit through which the material transfer towards the surface is accomplished. The conduit can be represented by faults, fissures, permeable inclined strata.

The models refer to the formation mechanism of the different morphologies – defined through 4 types – and not to the mechanism of mud volcanism itself. These models apply to the upper part of the mud volcanoes, until a maximal depth of 8.5 m.

The first model distinguishes two cases depending on the water–solid component ratio and presumes that the (4) individual morphologies correspond to different evolution stages.

In case the emitted material is very fluid, having a very low solid part content, the wall-rock will be waterlogged and eroded thus resulting in a mud pool (fig.14, case A, stage 1). Mud pools can develop small prominences of short-lived character (fig.14, case A, stage 2).

In case the feeder channel is represented by a narrow fissure and the ejected mud has a higher percentage of solid component the material will be deposited on the topographic surface in overlapping strata, similarly to shield volcanoes that will result in the formation of a plate mud cone (fig.14, case B, stage 1).

If the activity of mud volcano ceases temporarily the cone will be consolidated that will favor the accumulation of mud as mud intrusions (fig.14, case B, stage 2). The accumulated pressure will cause the updoming of the whole mud volcano edifice resulting in a mud dome (fig.14, case B, stage 3). During or after the updoming small fissures may appear on the mud dome through which the accumulated fluid material will be discharged.

As a consequence of the collapse of the crest (even through a small eruption) the dome will take the shape of a mud caldera (fig.14, case B, stage 4).

Natural phenomena can rarely be fit into a complete evolution model. For this reason we suggest another model for the evolution of the different morphologies of mud volcanoes that presumes an independent evolution of the distinct morphologies.

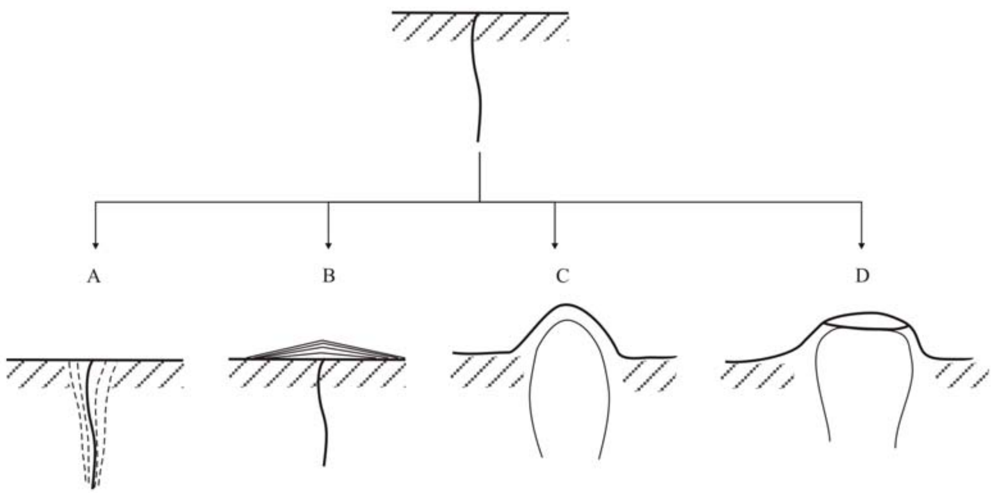

Fig. 15. Schematic evolution of the different types of mud volcanoes (model 2)

The formation of the mud pool (fig.15, case A) and mud cone (fig.15, case B) is identical with that from the first model.

The mud dome type is developed through the deformation of the overburden strata by the overpressured mud accumulated in the form of mud intrusions, similarly to mud diapirs or endogene volcanic domes (fig.15, case C).

Mud calderas form as a result of the upward movement of an overpressured material which not only deforms but pierces (including by eruption) the superficial strata of the host rocks (fig.15, case D).

Conclusions

In conclusion, the studied mud volcanoes present very dynamic evolution, with significant changes in evolution even during the short study period through 2002–2010. Considering the dynamic character of the mud volcanoes it has to be noted that the observations and conclusions refer only to the study period.

The basal dimensions of the studied mud volcanoes vary from less than 1 m to 28 m and the height from 0 m to 3.5 m. The ones that reach the height of 1 m are represented by 25 % of the subjects. Usually the craters of the mud volcanoes have small dimension (2–5 cm) or they even lack one, but we have documented 4 subjects that have very large craters (4.5–12 m) in comparison with the dimensions of the edifice.

The most widespread are the flat or concave structures – mud pools – making up 39 % of all the studied mud volcanoes. Among the positive features mud domes appear in biggest number (35 %), being followed by mud cones (14 %) and mud calderas, the worst represented type (6 %). Because of the distinct morphologies and manifestations and the intense anthropic interventions 6 subjects couldn't be included into any of the 4 categories.

The 4 established types correspond approximately to the evolution stages from the first model and the evolution mechanisms of the second model elaborated for the evolution of different morphologies of mud volcanoes.

The presence of mud volcanoes mostly in valleys refers to a secondary tectonic relationship, as the development of valleys had been determined tectonically (usually by faults) which facilitates the appearance of mud volcanoes as well. At the same time their emplacement is connected to those areas in which the impermeable strata have been removed by fluvial erosion.

Regarding the vegetation it has been noticed that the degree of activity is divulged by the type of vegetation as well. On active mud volcanoes covered by vegetation will grow halophytic species, the best indicator of active mud volcano being the *Schoenoplectus lacustris*.

According to the geological maps and seismic profiles [KRÉZSEK, 2008, pers. com.] from the study zone, mud volcanoes are related to hydrocarbon deposits through extensional faults, lithological boundaries or the Odorhei fault system.

We consider this present work as a starting point for our future studies with modern investigation techniques as mud volcanoes have not only scientific importance, but at the same time economical significance, these being the surface manifestations of hydrocarbon accumulation at depth and last, but not least they can represent touristic potential as well.

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