Comment on: "The dark nature of Somma-Vesuvius volcano: evidence from the ~ 3.5 ka BP Avellino eruption" by Milia A., Raspini A., Torrente M.M.

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Abstract

We present here some criticism to the scientific content of the paper of Milia et al. (2007) published in Quaternary International. Milia et al. (2007) interpreted seismic lines in the Gulf of Naples (southern Italy), and inferred the presence of deposits from a large debris avalanche which occurred just before the Avellino eruption of Somma-Vesuvius volcano. The authors supported their seismic profile interpretation with on-land stratigraphies and logs. However, we present here different on-land data that demonstrate the inconsistency of the occurrence of any debris avalanche before or after the Avellino eruption, and we provide also an alternative interpretation for the observed seismic facies offshore of Somma-Vesuvius.

Keywords: *Somma-Vesuvius; Avellino eruption; debris-avalanche; seismic lines; explosive eruptions*

1. Introduction

The growing interest in studying large explosive eruptions of Somma-Vesuvius is noticeable, since new data can produce improvement of the current understanding of the eruptive processes and volcano behaviour. This is especially true when techniques not routinely used in volcanology (as in the case of marine seismic profiles) are used to investigate poorly accessible areas such as the submerged western part of the Somma-Vesuvius. In this framework, the work of Milia et al. (2007) represents a valuable effort for correlating marine and on-land deposits of one of the most powerful eruption of Somma-Vesuvius. Nevertheless, the paper of Milia et al. suffers from incorrect stratigraphic interpretations of on-land deposits that lead to misleading conclusions. We present here stratigraphic, lithologic and chemical data to demonstrate the inconsistency of the hypothesized occurrence of a debris avalanche just before the Avellino eruption, and we supply a different model fitting the marine seismic profiles and cores.

As a whole, our criticisms of the work of Milia et al. (2007) can be summarised in two main points: i) the paper suffers from diffuse inaccuracies throughout the text; and ii) the marine-on land correlations are based on incorrect stratigraphic correlations, and this leads to an erroneous model.

Another main point of criticism is that the manuscript cites a large amount of volcanological data with poor (and often absent) attention to previous works on Somma-Vesuvius. As an example, the age of the Avellino eruption is reported at ~ 3.5 ka BP, without any reference to support it and even without any information about the dating method. The age of Avellino eruption is still a matter of debate in the scientific community, and it has great relevance also in archaeology (e.g. Albore-Livadie, 1994) and quaternary sciences (e.g. Ramrath et al., 1999; Magny et al., 2007). Variable ^{14}C ages have been reported by several authors in the past (Vogel et al., 1990; Pantosti et al., 1993; Rolandi et al., 1993; Southon et al., 1994; Terrasi et al., 1994; Andronico et al., 1995; Di Vito et al., 1998; Wulf et al., 2004), and the range is between about 3.4 and 3.9 ka BP (not calibrated). Therefore, some more details about the chosen age would have been useful for the reader.

2. Discussion

2.1 Stratigraphic correlations

One of the main faults of the work of Milia et al. (2007) is that it is based on correlation of drilling logs with poor description of lithology and/or without reporting any composition of juvenile fragments. Furthermore, it is not clear what stratigraphic markers were used for correlating the different stratigraphic successions. Without this crucial information the proposed correlations are highly speculative.

Actually, more than 60 cores and drilling logs collected along the Napoli-Salerno motorway (Fig. 1a; Di Vito et al., 1998), tell a different story about the geological evolution of the western sector of the volcano. The lithology of juvenile fragments collected in the cores was described and XRF chemical analyses carried out on selected samples from the different stratigraphic units recognised (Di Vito et al., 1998). The reconstructed cross-section (Fig. 2) shows the accumulation of pyroclastic density current (PDC) deposits from Pomici di Base to AD 1631 eruptions, with sporadic interbedding of historical lava flows and scoriae toward the top of the succession. PDC deposits of AD 79 (Pompeii) eruption were ubiquitously drilled along the investigated area, and they represent the uppermost deposit in the southern sector (from well A10 to B2; Figs. 1 and 2c). Cored deposits are here dominated by littoral and lacustrine-brackish environments with inter-fingering of some pre-Pomici di Base lava flows and scoriae (Di Vito et al., 1998). The segment between A1 and S8 drillings (Figs. 1 and 2) cuts the area indicated by Milia et al. (2007) as affected by the pre-Avellino debris-avalanche (yellow dashed lines in Fig. 1). Inspection of the reconstructed cross-section shows an undisturbed and laterally continuous stratigraphic succession, both before and after the Avellino deposits, which in one case reaches the Somma lavas (drilling point S8; Fig. 2). The stability of the area through time is also testified by the interbedding of thick paleosols in the stratigraphic succession (Fig. 2a). A ^{14}C age carried out on organic material from the paleosol cored at site A16 below the Avellino deposits yielded an age of 3,920 ± 55 BP (4,350 ± 80 cal. BP; calibrated using CalPal program, Jöris and Weninger, 1998). This age is in agreement with the maximum ages (i.e. those obtained from paleosols underneath the pyroclastic deposits) reported for the Avellino deposits (Rolandi et al., 1993; Andronico et al., 1995; Santacroce et al., 2007), and indicates that nothing occurred in the area before the emplacement of the Avellino PDCs.

It is noteworthy that two of the authors published a paper (Milia et al., 2003) in which they support the occurrence of a debris avalanche after the Avellino eruption. Irrespective of changes in interpretation of seismic profiles from the same area, the geologic profiles shown in Figure 2 also exclude this different hypothesis.

Milia et al. (2007) supported the occurrence of a debris-avalanche before the Avellino eruption using a stratigraphic log from the Novelle di Scappa area, located on the western slopes of the Somma-Vesuvius just below the Piano delle Ginestre area (Fig. 1). This log was reported from Rolandi et al. (2004), but it contains a misleading interpretation of the basal portion of the Avellino deposits, which are related to the emplacement of a volcaniclastic debris flow. Figure 1 b and c shows two outcrops of the Avellino deposits exposed in the Novelle di Scappa area. They show an undisturbed stratigraphic succession that, starting from the paleosol developed at the top of the Pomici di Base fall deposits (Bertagnini et al., 1998), comprises deposits of the opening phase of the eruption (EU1), the main Plinian fall deposits (EU2, EU3 and EU4) and the PDC deposits of the final phreatomagmatic phase (EU5; Fig. 2b; Cioni et al., 1994; 2000; Sulpizio et al., 2007). The exposed deposits are coarse grained and contain lithic blocks, since they are very proximal to the vent (grey circle in Fig. 1a). EU1 deposits show massive coarse grained to faintly stratified lithofacies (Fig. 1c), interpreted as deposited by small volume PDCs (Cioni et al., 1994; Sulpizio et al., 2007). The main fallout deposits (EU2-4; Fig. 1b) show poor sorting and comprise large ballistic blocks. They can be correlated with other fall deposits exposed on the northern and eastern slopes of the Mt Somma using stratigraphic markers such as the EU3pf and EU5 deposits (Cioni et al., 1994; 2000; Sulpizio et al., 2007). Also, chemical variation vs. stratigraphic height (Fig. 3; Cioni et al., 1994; 2000; Sulpizio et al., 2007) shows the same trend of the more distal fall deposits, and provides compelling evidence that the Novelle di Scappa outcrops represent coarse grained, very proximal breccia-fall deposits. Similar deposits were described at Somma-Vesuvius for the Subplinian eruption of the Greenish Pumice (Cioni et al., 2003). The best preserved example of this type of deposit is certainly represented by the Novarupta deposits of the 1912 eruption (Alaska, Fierstein and Hildreth, 1992; Houghton et al., 2004). The eruptive mechanism suggested for explaining the Novarupta deposits includes emplacement of ballistic blocks and deposition from column margins, with interbedding of small-scale and near-vent dispersed PDCs (Houghton et al., 2004). The high rate of deposition and limited transportation of the pyroclasts together account for the thickness and the poor sorting of the deposits. These eruptive mechanisms surely acted during the Avellino eruption, and can be suggested as responsible for the observed stratigraphic and lithologic characteristics of the breccia-like deposits of the NW sector (reddish shaded area in Fig. 1a). Furthermore, the eccentric position of the Avellino vent probably contributed to the preservation of these deposits, because they were not affected by later caldera forming processes that occurred at Somma-Vesuvius (i.e. during the AD 79 eruption; Cioni et al., 1999).

2.2 An alternative interpretation

The data presented for the southern and western sectors of the volcano demonstrate the absence of any compelling evidence for the occurrence of debris avalanches in the last 22 ka BP (calendar age of the Pomici di Base eruption; Santacroce et al., 2007). Indeed, volcaniclastic mass flows occurred frequently in the past, but they are rain-triggered debris flows and hyperconcentrated flows, whose deposits crop out widely along the cliffs of the western coastline separated by variously developed soils or erosive surfaces (Fig. 4; Lirer et al., 2001; Sulpizio et al., 2006). These deposits are generally coarse grained and rich in lithic blocks, and frequently are several metres thick (Fig. 4; Lirer et al., 2001; Sulpizio et al., 2006), and can be correlated with the pyroclasts with lava blocks described in the Herculaneum log (Fig. 3b of Milia et al., 2007). This represents a simpler explanation without the need to claim any catastrophic failure of the volcano edifice.

Figure 5a shows a cross-section reconstructed using drillings in the Volla Plain (Di Vito et al., unpublished data). The stratigraphic succession comprises lava flows and scoriae of Mt Somma at the base, overlain by the pyroclastic deposits of the Neapolitan Yellow Tuff. Black littoral sands were drilled ubiquitously at the top of the Neapolitan Yellow Tuff deposits, and at the top of the succession close to the coastline (Fig. 5a). However, the most prominent sedimentary bodies reconstructed from drilling logs and cores are those associated with the Mercato and Avellino eruptions, which comprise both pyroclastic and syn-eruptive volcaniclastic flow deposits. In particular, the deposits associated with the Mercato eruption have thickness sometimes greater than 20 m, and the Avellino deposits rest more or less continuously at its top. The succession of sedimentary bodies is similar to that of Figure 5 of Milia et al. (2007), but with fundamental differences in their interpretation and correlation with Somma-Vesuvius eruptions. It is not difficult on the basis of the cross-section of Figure 5a to hypothesize that the submarine bodies recognized by the survey of Milia et al. (2007) are the prosecution of the terrestrial pyroclastic/volcaniclastic units. This is also supported by the observation that the seaward distribution of the debris avalanche proposed by Milia et al. (2007) is at the mouth of the Sebeto river basin (Fig. 5b). Therefore, the simpler explanation is that the thick sedimentary bodies recognised in marine seismic profiles are the result of high sediment discharge periods that followed the major explosive eruptions of Mercato and Avellino, which delivered thick pyroclastic deposits on the northern Mt Somma slopes facing the Sebeto river basin. In particular, volcaniclastic debris flows can have thickness, blocks content and frontal shape that can resemble those of mid distal deposits of a debris avalanche, making difficult their discrimination on the exclusive basis of seismic profiles and few log data.

3. Conclusions

The presented data provide an alternative model for correlating and interpreting the marine seismic profiles carried out in the Gulf of Napoli. In particular, on land stratigraphies and drilling cores and logs demonstrate that undisturbed accumulation of pyroclastic deposits, paleosols and lava flows characterises the western slopes of the volcano, at least for the last 22 ka. Occurrence of volcaniclastic flows (debris flows and hyperconcentrated flows), exposed along the coastal cliff and in the apron of Somma-Vesuvius, can account for the recognition of lava block-rich deposits described by Milia et al. in the Hercolaneoum and in the Volla Plain drilling logs. Finally, the high sediment discharge of the Sebeto River after the major explosive eruptions of Mercato and Avellino can account for the observed thick sedimentary bodies at the mouth of the Sebeto drainage basin.

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Figure captions

Figure 1 – a) Location map of the studied cores (red dots and white stars) along the Napoli-Salerno motorway (solid black line). Yellow dashed lines highlight the area affected by the debris avalanche as reported by Milia et al. (2007). Red line with triangles identifies the Avellino-related caldera rim (Cioni et al., 1999). Reddish shaded area show the area in which the coarse-grained breccia-fall deposits crop out. The grey circle indicates the inferred vent of the Avellino eruption (Cioni et al., 1994; 2000); b) Picture of one of the most proximal outcrops of the Avellino deposits in the Novelle di Scappa area (about 1 km from the inferred vent). PdB: Pomici di Base fall deposits; EU1: opening phase; EU2-4: magmatic Plinian fall deposits (with interbedding of the small volume PDC deposit of EU3pf; EU5: final phreatomagmatic PDC deposits (Cioni et al., 1994; 2000; Sulpizio et al., 2007); c) Close view of the opening phase deposits of the Avellino eruption (EU1a and EU1b), the white Plinian fall (EU2) and the base of grey Plinian fall (EU3) in the Novelle di Scappa area (about 1 km from the inferred vent).

Figure 2 – Composite cross-section obtained from cores and logs shown in Figure 1a. Legend is shown in the figure.

Figure 3 – Variation vs. normalised stratigraphic height of selected major and trace elements of the Plinian fall deposits (EU2 and EU3; from Cioni et al., 1994; 2000). Stratigraphic section A12 is that shown in Figure 1b.

Figure 4 – Pictures of volcaniclastic flows exposed along the coastline at Torre Bassano site (see Figure 1 for location). DF: Debris flows; HF: hyperconcentrated flows. Labels on Figure 4b are lithofacies codes (from Sulpizio et al., 2006).

Figure 5 – a) Cross-section of the subsurface of the Volla Plain (Sebeto drainage basin) reconstructed using cores and logs along the trace shown in Figure 5b; b) Location map of the cross-section shown in Figure 5a. Yellow lines identify the boundaries of the three main drainage systems of the plain surrounding the Somma-Vesuvius volcano (Sebeto river basin, Acerra plain and Sarno river basin). Yellow dashed lines highlight the on land area affected by the debris avalanche as reported by Yellow dashed lines highlight the area affected by the debris avalanche as reported by Milia et al. (2007). The solid black line identifies the seaward limit of the debris avalanche deposits reported by Milia et al. (2007). The blue arrow indicates the main direction of discharge of Sebeto river sediments.

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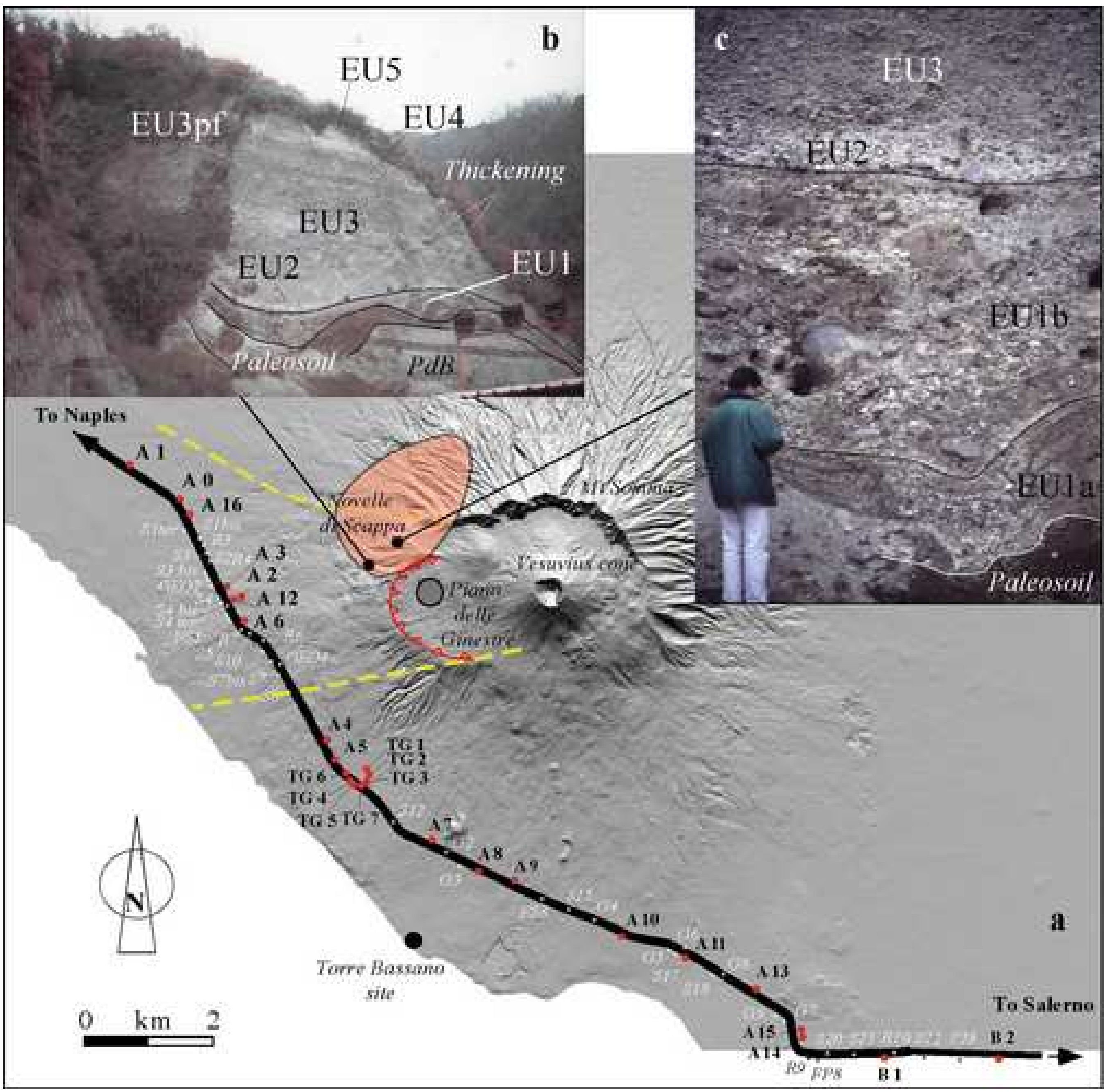

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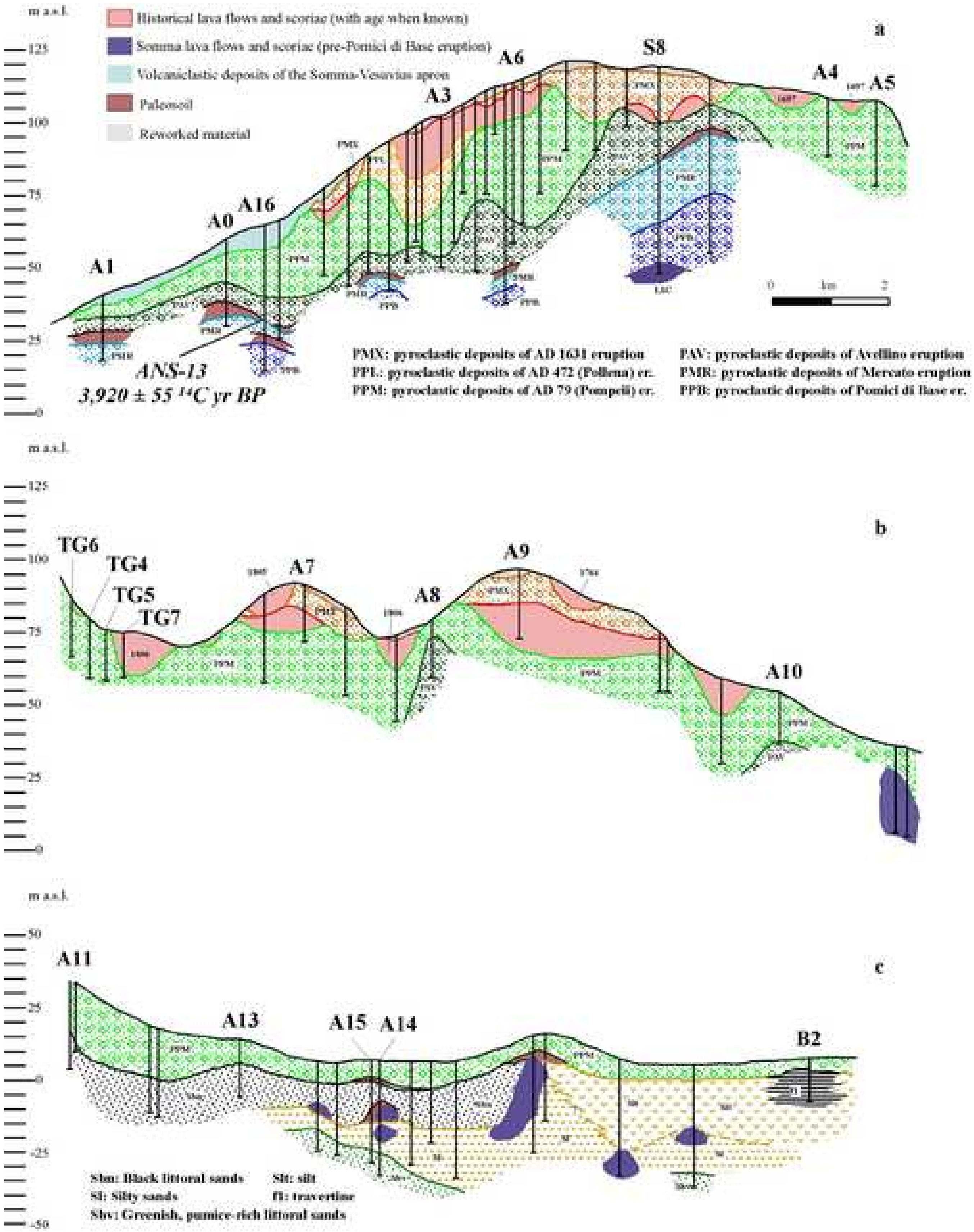

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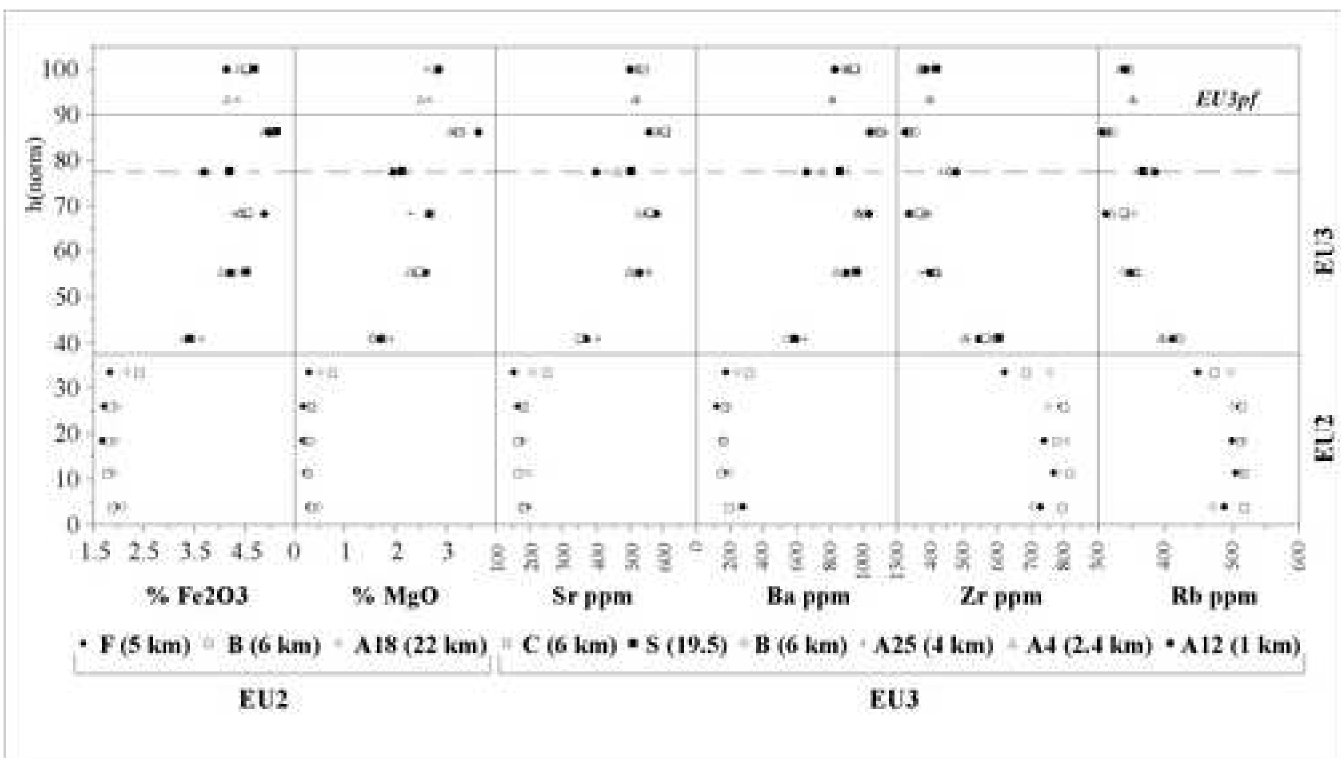

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