The depositional architecture of the Pleistocene deposits of the Roman Basin (Italy)

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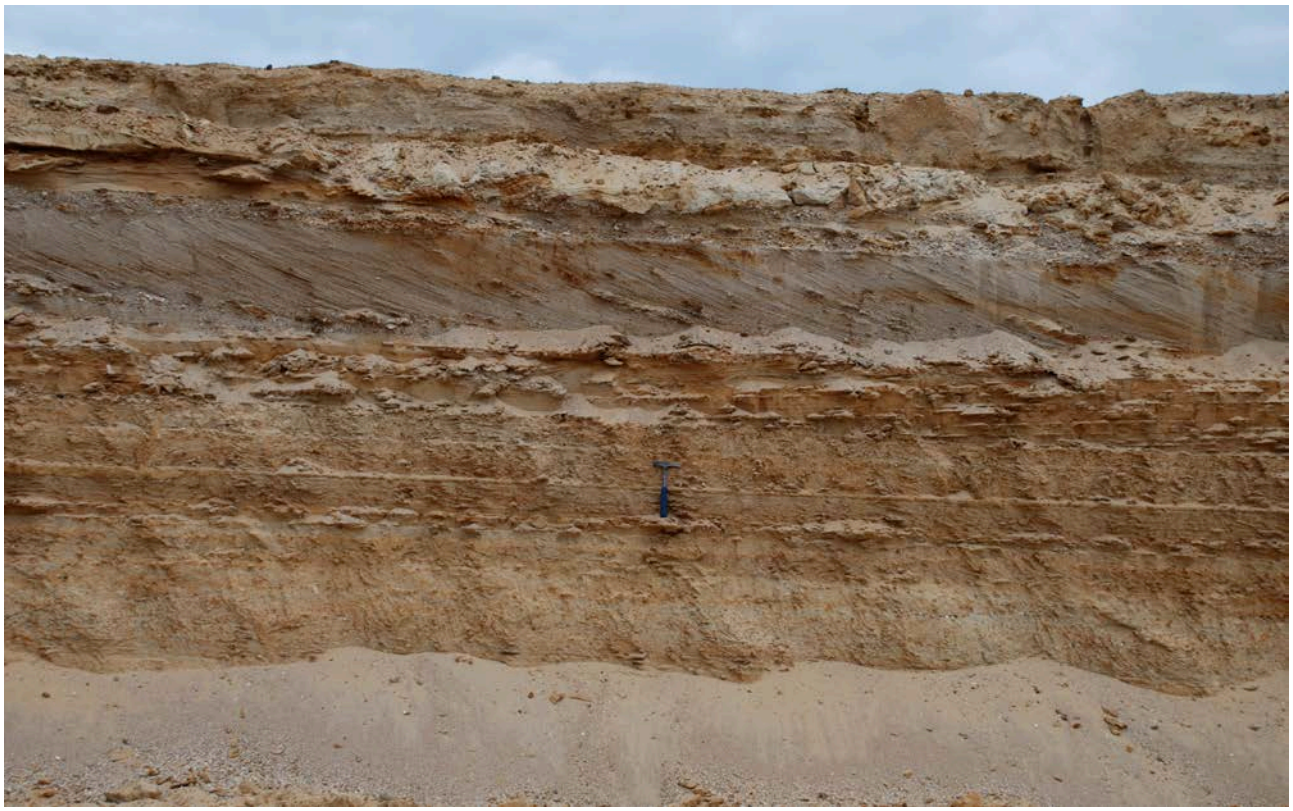
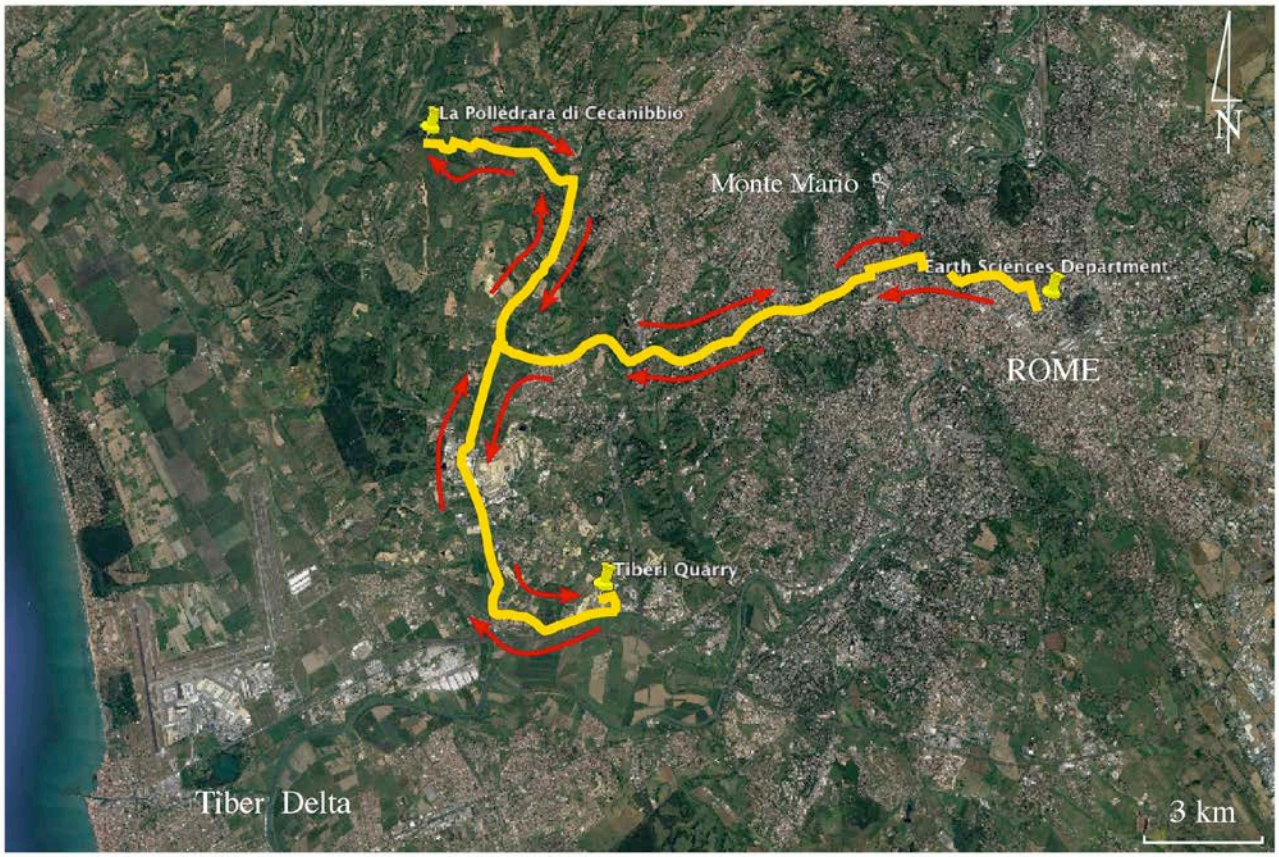


FIELD ITINERARY



Objectives and strategy

This field trip will provide to show the main facies and physical stratigraphic features of Pleistocene deposits of the Roman Basin; a basin formed along the extentional Latium Tyrrhenian margin and whose sedimentation was controlled by tectonic uplift, volcanism, and glacio-eustatic sea-level changes. We will discuss about the origin and provenance of the deposits as well as of the relationships between tectonics and sedimentation. Finally, the stratigraphic architecture of this basin will be discussed and framed in the context of the Pleistocene evolution of the Tyrrhenian basin.

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INTRODUCTION

The Quaternary depositional sequences constitute, among the sedimentary successions, those where the climatic and glacio-eustatic signals and the local effects of tectonics are better recorded. Thus, it is possible to produce depositional models of considerable accuracy which can be used in a predictive sense.

The Pleistocene deposits of the Roman area record the climatic and sedimentary cyclicity through a continuous modification of the natural landscape and depositional environments where the alternation between cold, hot and humid phases is well evidenced by the vegetational changes and the populations of large mammals (Milli and Palombo 2005; Milli *et al*., 2008; Palombo and Milli, 2010; Di Rita *et al*., 2015).

In the Quaternary deposits of the Roman area different types of depositional systems, from fluvial, to fluvio-lacustrine, deltaic, coastal-barrier lagoon, and shelfal systems have been recognized. The facies and sequence stratigraphic analyses that have been carried out on these deposits allowed to subdivide the entire Pleistocene succession into high and low rank depositional sequences the stacking pattern of which records the close interaction among climate, glacio-eustatic sea-level changes, volcanism and tectonic uplift. These processes were also responsible for the compositional variations found in the deposits of the high and low rank sequences (Tentori *et al*., 2016).

REGIONAL GEOLOGICAL SETTING

The extensional tectonics that affected the Latium Tyrrhenian margin since the Upper Miocene in connection with the opening of the Tyrrhenian basin, allowed the formation of a series of half-graben basins, mainly NW-SE oriented, which were filled, during the Pliocene and Pleistocene, with sin-rift and post-rift clastic sediments to which volcaniclastic deposits are associated (Funiciello *et al*., 1976; Cavinato *et al*., 1992; Barberi *et al*., 1994) (Fig. 1).

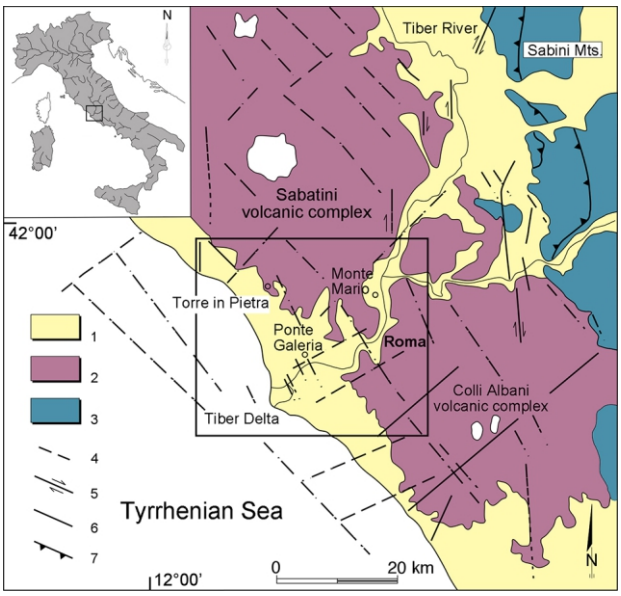

Fig. 1 - Geological sketch of the Central Italy Tyrrhenian margin: (1) Messinian-Holocene sedimentary deposits; (2) Pliocene-Pleistocene lavas and volcaniclastic deposits; (3) Meso-Cenozoic sedimentary deposits; (4) main buried faults; (5) strike-slip faults; (6) normal faults; (7) major thrusts. The black square indicates the study area.

The Roman Basin is one of these extensional basins extending north and south of Tiber River for about 135 km (Fig. 1). The development of this basin started in the late Pliocene, and was accompained by a continuous regional tectonic uplift (Milli, 1997; Bordoni and Valensise, 1998; Giordano *et al*., 2003) and intense volcanic activity, reaching its climax in the middle-late Pleistocene, when the volcanic complexes of the Roman Magmatic Province developed (Locardi *et al*., 1976; Cioni *et al*., 1993; De Rita *et al*., 1993; 1995; Karner *et al*., 2001; Peccerillo, 2005). The stratigraphic setting of the Roman Basin is the result of the close interaction among tectonic uplift, volcanic activity, and glacio-eustatic sea-level fluctuations related to the Quaternary climatic changes (Cavinato *et al*., 1992; De Rita *et al*., 1991; 1994; Milli, 1994; 1997; Giordano *et al*., 2003; Mancini and Cavinato, 2005; Milli *et al*., 2008 and references therein). Its stratal architecture is characterized by several depositional units constituting low-rank (high-frequency) depositional sequences (*sensu* Mitchum and Van Wagoner, 1991; Catuneanu *et al*., 2009; 2011) with variable duration, from 30,000 yr to 120,000 yr, stacked to form two composite high-rank sequences: the Monte Mario Sequence (MMS; lower Pleistocene) and the Ponte Galeria Sequence (PGS; late lower Pleistocene–Holocene), respectively (Milli, 1997; Milli *et al*., 2013; 2016 and references therein) (Figs 2, 3).

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Field Trips - GUIDE BOOK
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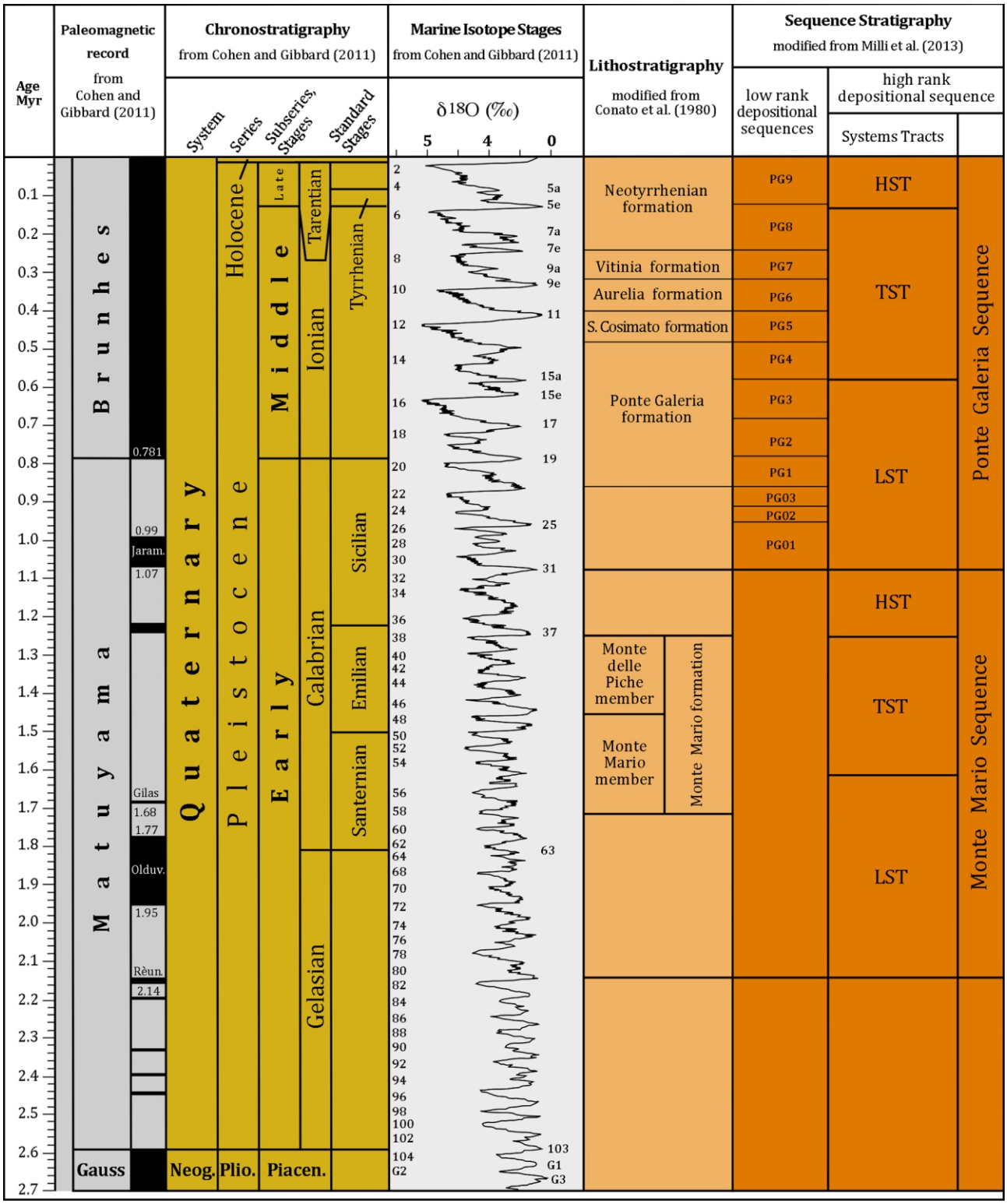

Fig. 2 - Chronostratigraphic and sequence-stratigraphic scheme of the Quaternary deposits of the Roman Basin. HST, Highstand Systems Tract; TST, Transgressive Systems Tract; LST, Lowstand Systems T; PG, Ponte Galeria.

The MMS deposits are essentially known through the stratigraphies of several wells and outcrops of limited extent. These deposits are referable to coastal and offshore-transition depositional systems, developed during the late lowstand and transgressive systems tracts of the MMS. The PGS strata contain fluvial, fluvio-lacustrine, barrier island–lagoon, and offshore-transition depositional systems, organized to constitute the lowstand (LST), transgressive (TST), and highstand (HST) systems tracts of the PGS (Fig. 2). Well-dated volcaniclastic deposits belonging to the Albani and Sabatini volcanic complexes (Sottili *et al.*, 2010; Marra *et al.*, 2011; 2014 and references therein) were used to constrain the age and duration of the low-rank depositional sequences.

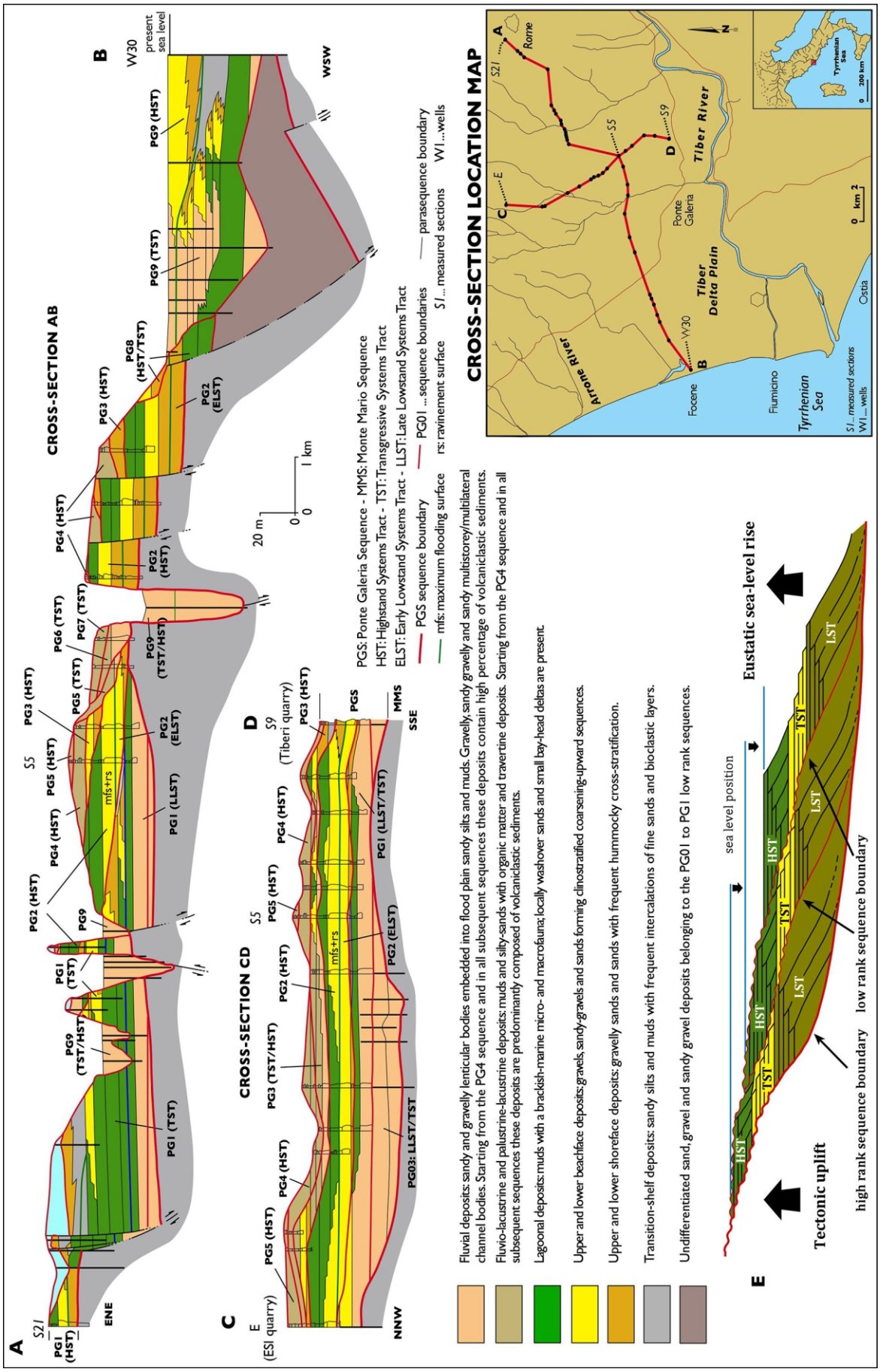

Fig. 3 - A-B; C-D) Stratigraphic cross-sections showing the depositional architecture of the composite high-rank Ponte Galeria Sequence. E) Conceptual sketch showing the stratigraphic relationships among the low-rank sequences in the Roman Basin related to the interaction between tectonic uplift of the Latium Tyrrhenian margin and eustatic sea-level changes during the development of the high-rank Ponte Galeria Sequence. Note the downward and seaward migration of the sequences due to the tectonic uplift of the continental margin.

Our field trip is focused on PGS; this sequence is from 10 to 110 m thick and lies above shelfal mud of the MMS through a polygenic erosional surface (Figs 2, 3). This composite sequence consists of twelve low-rank sequences from 5 to 80 m thick, the boundaries of which are expressed by sharp erosional surfaces recording basin and downward shifts of facies, and subaerial exposure and paleosols in the interfluvial areas. The low-rank sequences (from PG01 to PG3) stack to form the LST of PGS. Sequences from PG4 to part of PG8 are referable to the TST, while the sequence PG9 (also known as Tiber Depositional Sequence, TDS) developed entirely during the HST of PGS (Figs 2, 3). The PGS shows a general seaward stacking of the low-rank depositional sequences (Fig. 3). This trend is opposite to the trend that the PGS would have displayed if controlled by glacioeustasy alone. Consequently, the present setting of the PGS is thought to have been controlled by the interaction between eustatic sea-level changes and regional tectonic uplift; the latter forced the seaward migration of the low-rank sequence equilibrium points, thus helping to define the final stacking pattern of PGS (see more details and discussion in Milli, 1997; Milli *et al*., 2008; 2016).

From a paleogeographic point of view the deposits of the first low-rank sequences occupied half-graben basins, formed along the Latium coastline due to the extensional tectonics. Normal faults, mainly NW-SE direction and dipping towards SW and NE, conditioned the general depositional setting of the area, characterized by a coastal plain with incised valleys oriented, essentially, in NE-SW direction. With the onset of volcanic activity (around 700,000 years ago), tectonic mobility increased dramatically and this led to a change in the organization of fluvial drainage basins. The watercourses of the north-western sectors of the studied area continued to flow towards the sea within NE-SW oriented valleys; the others were forced to flow towards the SE, into valleys controlled by NW-SE oriented faults (Milli *et al*., 2008). Both these incised valleys were mainly filled with fluvial, lacustrine and locally lagoonal deposits, during the TST and, subordinately, the HST of low rank sequences. Within these sediments most of the fossil remains of terrestrial mammals have been found (Milli and Palombo, 2005; Milli *et al*., 2008).

In the Ponte Galeria area, the richest and most diversified faunas (Local Faunal Assemblages - LFA) of the middle Pleistocene come from the deposits of the sequences PG2, PG3, PG4, PG6 and PG7, while the vertebrate fossil record of the upper Pleistocene deposits (PG8 and PG9 sequences) is less known and studied (Milli *et al*., 2004, 2008; Milli and Palombo, 2005; Palombo and Milli, 2010).

From a compositional point of view the deposits of the PGS have been recently analyzed in detail by Tentori *et al*. (2016) sampling all the low-rank sequences forming the PGS (Fig. 4). In particular, sampling focused across sequence boundaries and in facies associations related to the various systems tracts of the low rank sequences in order to detect changes in composition due to evolving paleogeography and time-dependent factors. Among the most recent low-rank sequences, the Tiber Depositional Sequence (PG9) was investigated with greater detail and its HST, was sampled both in the hinterland and along the coast (Tentori *et al*., 2018).

The results deriving from this analysis show that the PGS was fed by the paleo-Tiber and its tributaries, thus suggesting that the origin and composition of the sediments reflects the same characters of the rocks cropping out in the present Tiber River drainage basin. Such deposits include sediment derived from carbonate to siliciclastic Meso-Cenozoic rocks and from Pleistocene volcanic complexes of the Roman Magmatic Province. Three main sand petrofacies (A, B, C) were defined that have a good correspondence with lowstand (LST), transgressive (TST), and highstand (HST) systems tracts of PGS (Fig. 5). These petrofacies reflect changes in sand composition and sand provenance under the effects of tectonism, volcaniclastic input, sedimentary processes, and relative sea-level variations.

Petrofacies A is feldspatho-litho-quartzose to feldspatho-quartzo-lithic in composition. It records the erosion and

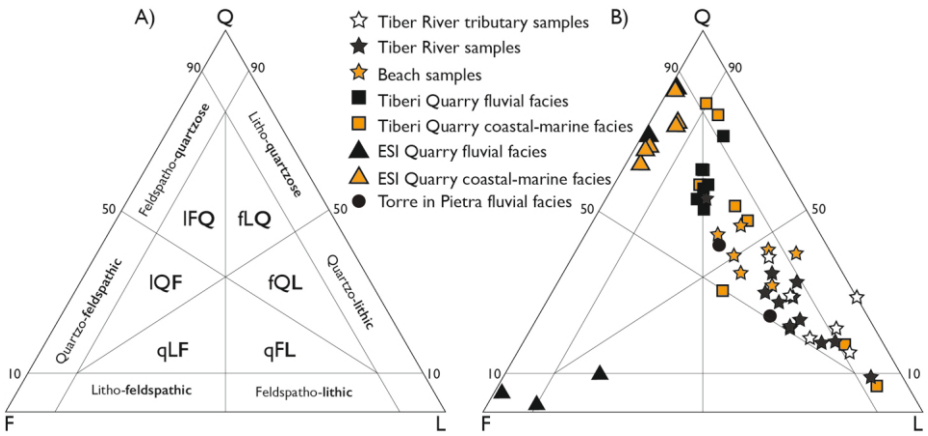

Fig. 4 - Ternary plots used for the petrographic classification of the studied sand samples from PGS. Scheme A is from Garzanti (2016).Q = quartzose; F= Feldspathic; L= Lithic; lFQ = litho-Feldspatho-Quartzose; fLQ = feldspatho-Litho-Quartzose; lQF = litho-Quartzose- Feldspathic; fQL = feldspatho-Quartzo-Lithic; qLF = quartzo-Lithic-Feldspathic; qFL = quartzo-Feldspatho-Lithic (from Tentori et al., 2016).

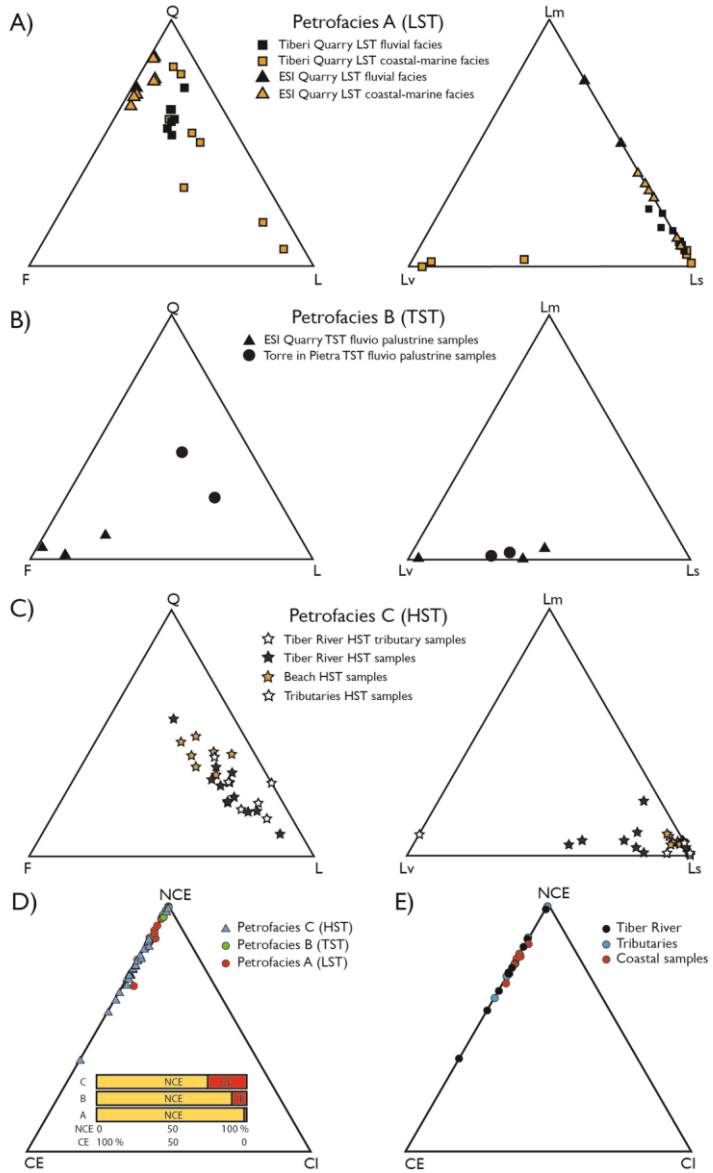

Fig. 5 - A, B, C) Ternary plots for the PGS petrofacies associated LST, TST, and HST deposits. (Q) Quartz, (F) Felspar, (L) Lithic, (Lm) metamorphic, (Lv) volcanic, and (Ls) sedimentary; D) NCE-CE-CI ternary plot for the PGS petrofacies; histograms relative percentage of NCE vs CE. CI values are minimal (< 1%) and not considered in the histograms; E) NCE-CE-CI ternary plot for the PGS highstand-systems-tracts samples (from Tentori et al., 2016).

influx of siliciclastic and carbonate rock detritus with sporadic volcaniclastic input into the LST fluvial and coastal sands of the PGS. Petrofacies B is characterized by a modal composition varying from feldspathic to litho-feldspathic and feldspatho-quartzo-lithic. It characterizes the TST of the PGS and reflects the abrupt and rapid introduction of volcaniclastic sediment into the system. Petrofacies C is feldspatho-quartzo-lithic in composition. This petrofacies characterizes the HST of PGS and, with respect to the other two petrofacies, better records the effects of downstream transport and river-mouth sedimentary processes. Sand samples collected from ancient deposits are similar in composition to the modern Tiber River, suggesting provenance from a similar river system. Results show that the middle-late Pleistocene volcanic activity of the Sabatini, Cimini, and Vulsini volcanic complexes played a major role in controlling stream-network reorganization in the Tiber drainage basin and resulted in enhanced volcaniclastic input from ash fall and recycling of pyroclastic flows. Volcanic input and postdepositional alteration during paleosols development define pre-, syn-, and post-volcanic compositions in the high-rank Ponte Galeria depositional sequence. In low-rank depositional sequences, several processes produced variable quartz/feldspar and quartz/lithic ratios, as well as textural changes; these include hydraulic sorting during fluvial and coastal transport and postdepositional in situ weathering processes. Weathering and pedogenic processes in the source area (catchment) potentially remove provenance information, reducing correlation potential of petrographic signatures of proximal successions in the Tiber River sedimentary basin.

All these considerations highlight the complexity of interpreting compositional signatures applied to sequence stratigraphic interpretation. While compositional signals

are clearer when analyzing stratigraphic units developed on a long temporal scale (high-rank sequences, about one million years), the interpretation of compositional trends is more complex when considering stratigraphic units developed on short temporal scales (low-rank sequences, 100 ka or less). However, comparing detrital signatures in the low-rank sequences helps defining provenance, paleogeographic evolution, and the role of postdepositional weathering in the PGS succession. The important implication is that the Quaternary successions, being more complete and with a major control on facies, stacking pattern, and chronology of the stratigraphic units (low-rank and high-rank sequences), may allow a better understanding of the genetic factors responsible for petrographic changes that characterize the depositional sequences developed at various spatial and temporal scales along continental margins.

Field itinerary

The field itinerary (Fig. 6) is located in the south-western area of Rome in a sector characterized by the presence of numerous quarries for the extraction of gravel and sand. The presence of these quarries has favored the stratigraphic reconstruction of the Pleistocene succession due to the three-dimensional view offered by quarry fronts. The field trip consists of two stops and is aimed to show the main stratigraphic and sedimentological features of the deposits of the middle-upper Pleistocene of the Roman area.

Stop 1 Tiberi Quarry

In this quarry, gravelly-sand and sandy-gravel deposits crop-out, which have been attributed mainly to braided fluvial depositional system and to coastal depositional system with well-developed beaches (PG1 and PG2 sequences). The top deposits of the quarry are represented by transition-shelf and lacustrine-lagoonal deposits belonging to PG3 and PG4 sequences, respectively (Fig. 7). The Fig. 8 shows two older fronts of the Tiberi quarry oriented perpendicularly and parallel to the paleoshoreline. Both the paleocurrent in the fluvial deposits (PG1 sequence) and the clinostratification in the beach gravel deposits (PG2 sequence) suggest a progradation of the coast towards the western sectors. This also suggests that the paleoshoreline had an orientation similar to the present shoreline.

Stop 2 The Polledrara di Cacanibbio paleontological site

The second stop is a palaeontological site of considerable importance. The musealization of the site occurred at the beginning of this century. In this site there are several remains of large mammals and prevalently *Palaeoloxodon antiquus* and *Bos primigenius* (Fig. 9). These faunal remains are distributed with variable density over a paleosurface referable to the bed of a small watercourse, cut into a bank of compact granular tuffite (Figs 10 and 11). Faunal remains are often associated with lithic and bone

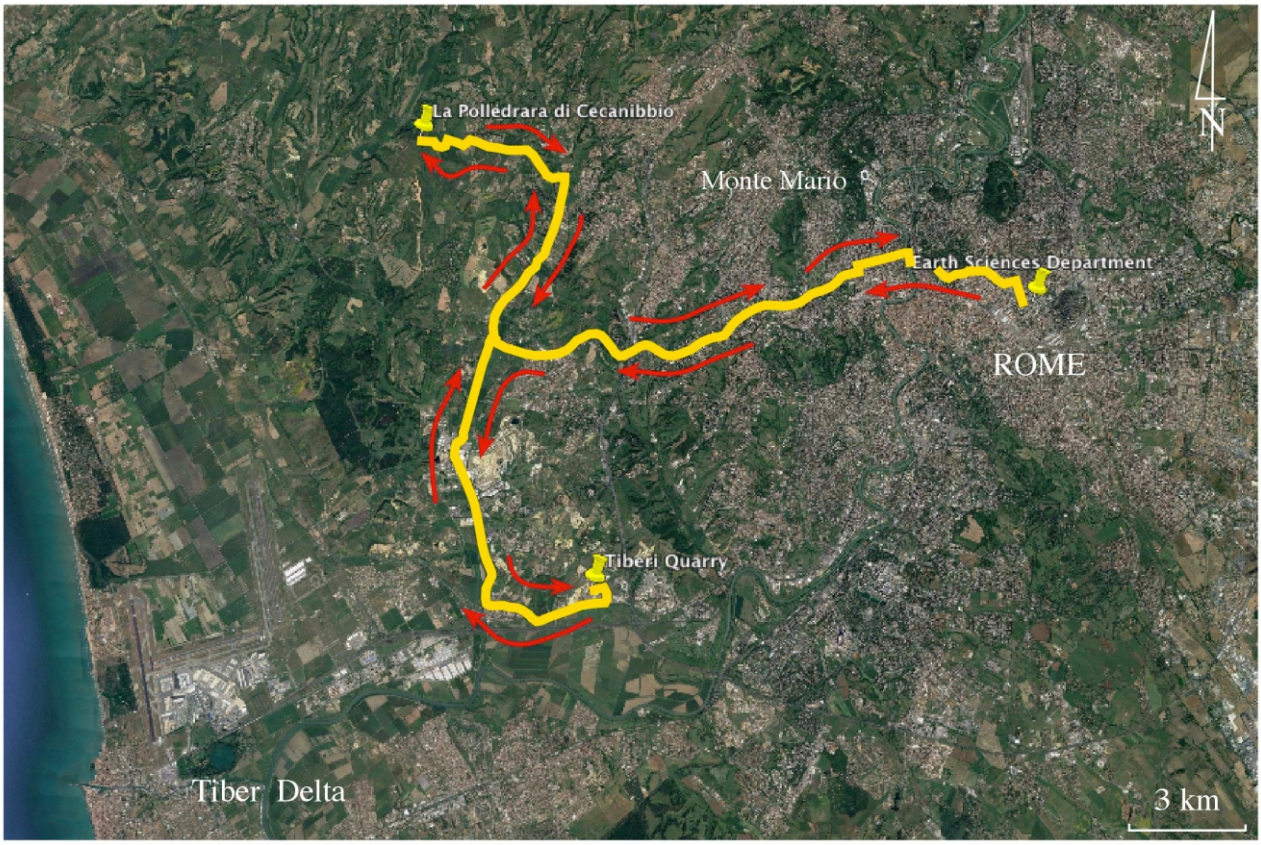

Fig. 6 - Field trip itinerary. About 25 km (approximately one hour in the traffic of Rome) is the distance from the first stop; about 18 km separate the Tiberi quarry from the paleontological site of La Polledrara di Cecanibbio.

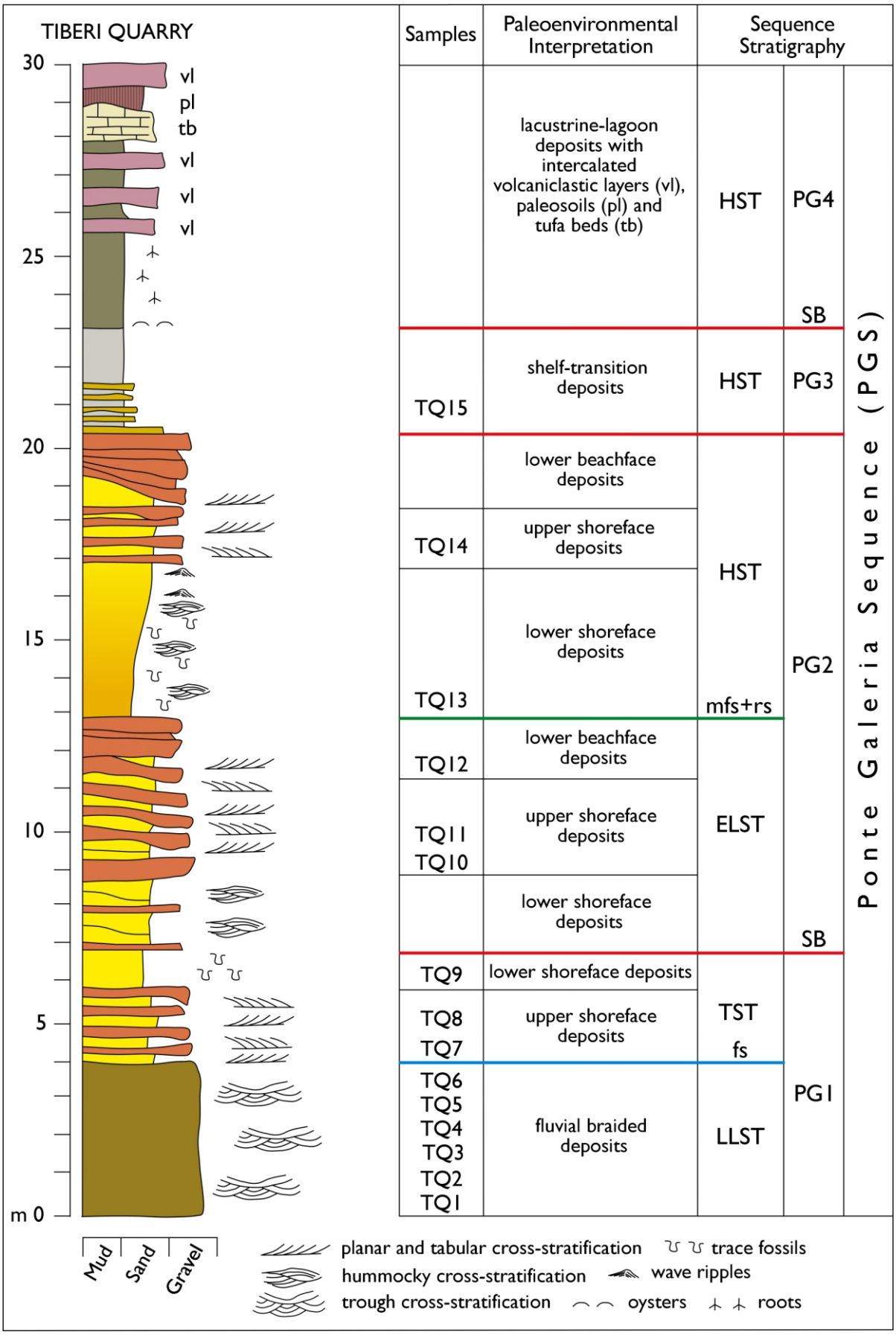

Fig. 7 - Stratigraphic column of the Tiberi quarry showing the sampled intervals (TQ) utilized for compositional analysis, the inferred depositional environment, and the sequence -stratigraphic interpretation.

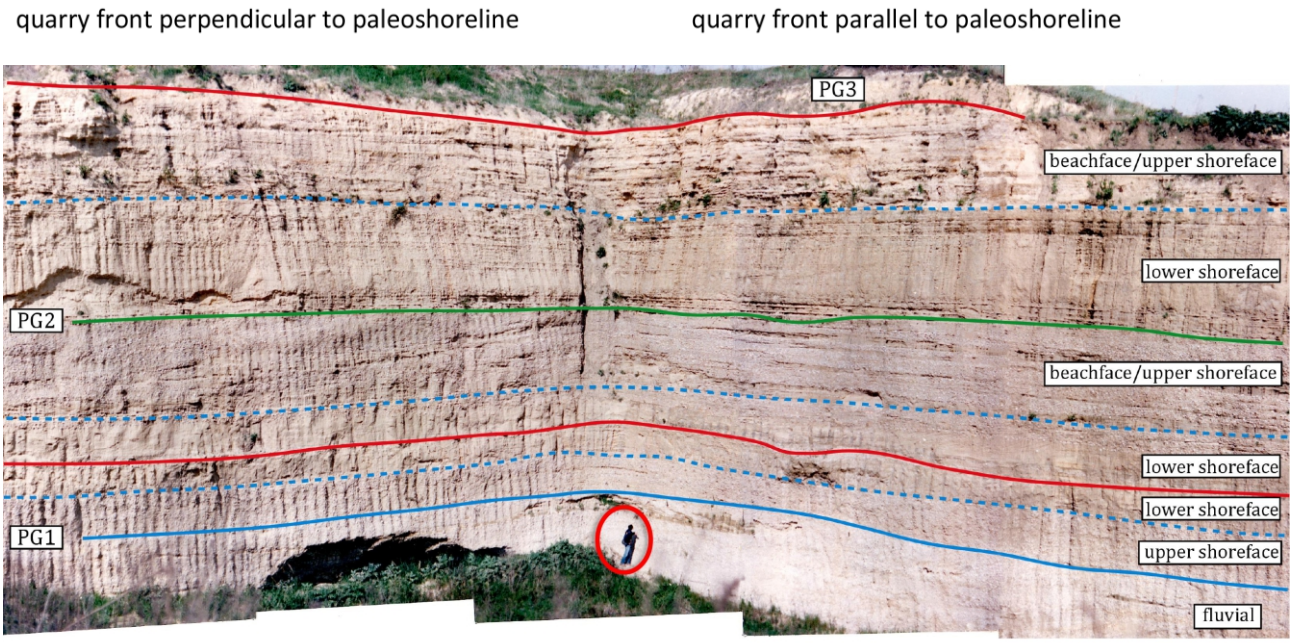

Fig. 8 - Old fronts of the Tiberi quarry oriented perpendicularly and parallel to the paleoshoreline. The paleoenvironments and the sequence stratigraphy interpretation are reported. To note the thick sandy gravel beach deposits forming two coarsening-and-shallowing upward facies sequences. Red lines indicate the sequence boundaries; green line indicates the mfs of the PG2 sequence; blue dashed lines indicate vertical facies changes; blue line indicates a transgressive surface. Man in the red circle for scale.

Fig. 9 - A general view of the paleontological site where it is possible to observe the arrangement and orientation of the large bones that follow the direction of fluvial current.

Fig. 10 - Local scours produced as effect of turbulence on channel bed and filled with skeletal remains.

Fig. 11 - Rill mark oriented perpendicular to main channel margin forming during the falling stage of a flood. Flow moving along the rill mark transports the skeletal remains and deposits them where the rill enlarge, giving rise to a lobe-shaped deposits.

artifact indicating that the site was also a place of frequentation by Homo. The Polledrara site developed at the beginning of oxygen isotopic stage 9 and have an age of about 330 kyr (Anzidei *et al*., 2012). On the site we will have a guide, a colleague, an archeozoologist, Eugenio Cerilli who will introduce us to the history of the site.

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Program Summary

The field trip is planned as short walks and includes two stops: one in a quarry in the western suburban area of Rome, and one in a vertebrate paleontological site located NW of Rome. The distance between Piazzale Aldo Moro, the square in front of the entrance of the SAPIENZA University and the first stop of the field trip is about 25 km (one hour in the traffic of Rome); about 18 km separate the Tiberi quarry from the paleontological site of La Polledrara di Cecanibbio.

Safety

Safety in the field is closely related to awareness of potential difficulties, fitness and use of appropriate equipment. Safety is a personal responsibility and all participants should be aware of the following issues. The participants will be carried with two minivans. All participants require comfortable walking boots. Trainers or running shoes are unsuitable footwear in the field. A waterproof coat/jacket is essential. In september weather conditions are good; anyway a waterproof coat/jacket is recommended as well as a bottle of water and a backpack. Sun protection can be useful as well a hats or a headscarves. Participants should inform the excursion leaders (in confidence) of any physical or mental condition, which may affect performance in the field (e.g. asthma, diabetes, epilepsy, vertigo, heart condition, back problem, ear disorder, lung disease, allergies etc.), and of problems related to particular diets or food. Each vehicle will carry one basic first aid kit.
Mobile/cellular phone coverage is good but could be limited in same place.
The emergency telephone number for police is **112** and **113**.
The emergency telephone number for ambulance is **118.**

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