[PS]Petrographic and Facies Analysis of Pleistocene Travertines in Southern Tuscany, Central Italy*

Federica Barilaro[1], Giovanna Della Porta[1], Marco Ripamonti[1], and Enrico Capezzuoli[2]

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[1]Earth Sciences Department, University of Milan, Milan, Italy (federica.barilaro@unimi.it)
[2]Earth Sciences Department, University of Siena, Siena, Italy

Abstract

A travertine unit (Upper Pleistocene-Holocene) in Southern Tuscany (Saturnia, Albegna Valley, central Italy) was investigated in an active quarry in terms of carbonate fabrics, geometry of the sedimentary bodies, and spatial evolution. Travertines were precipitated by H_2S-rich hydrothermal water in an extensional tectonic setting. The quarry facies exhibit a travertine terraced slope system (30-35 m thick) in which terrace walls (several cm to 2 m high), pools (1-10 m wide), pool rims (few cm to 1 m high) and waterfalls (2-3 m high) were identified.

Thirteen carbonate fabrics at the cm-scale were distinguished: 1) crystalline crusts; 2) micritic precipitates including bubbles, irregular mm-size voids; 3) mm-thick microsparitic laminae; 4) cm-tick layers with carbonate mud and travertine lithoclasts representing erosional surfaces; 5) shrubs consisting of clotted peloidal micrite in bush-like structures that locally form dm-thick bioherms; 6) aggregates of mm shrubs and mm-thick lamination; 6) elongated rafts; 8) transitional forms from shrubs to feather crystals; 9) fragments of shrubs and pisoids in a micritic matrix with irregular cavities; 10) sub-mm stromatolite-like laminae; 11) veined micrite with local bubbles and lamination; 12) microbreccia with a dense matrix, typically organized in cm pockets; 13) mm elongated reed stems floating in micrite. Ostracodes, probably larval cases, reeds and gastropods occur within the travertines.

The travertine fabrics can be subdivided between those occurring in areas of fast flowing water and those precipitating in horizontal, a few cm-deep pools. Pool rims and cascades consist of sub-vertical crystalline crusts dominated by feather crystals. In pools, different fabrics occur including: shrubs, elongated rafts, undulated sub-mm stromatolites-like structures, pisoids, micrite layers, and coated bubbles.

The Saturnia travertines exhibit 5-20% primary porosity (1-15 mm in diameter) that is mainly produced by coated bubbles, biomolds of encrusted reeds, interparticle space in between shrubs (where meteoric sparite did not completely occlude it), and irregular elongated pores in between stromatolitic laminae.

The study of Saturnia travertines provides fundamental information about the depositional facies, fabric types, their diagenesis, and spatial distribution. This can improve the understanding of comparable carbonate reservoirs in the subsurface.

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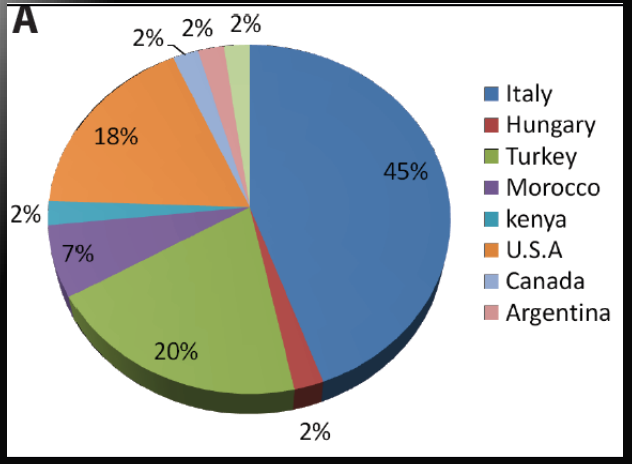
Petrographic and Facies Analysis of Pleistocene Travertines in Southern Tuscany, Central Italy

Federica Barilaro 1, Giovanna Della Porta 1, Marco Ripamonti 1, Enrico Capezzuoli 2

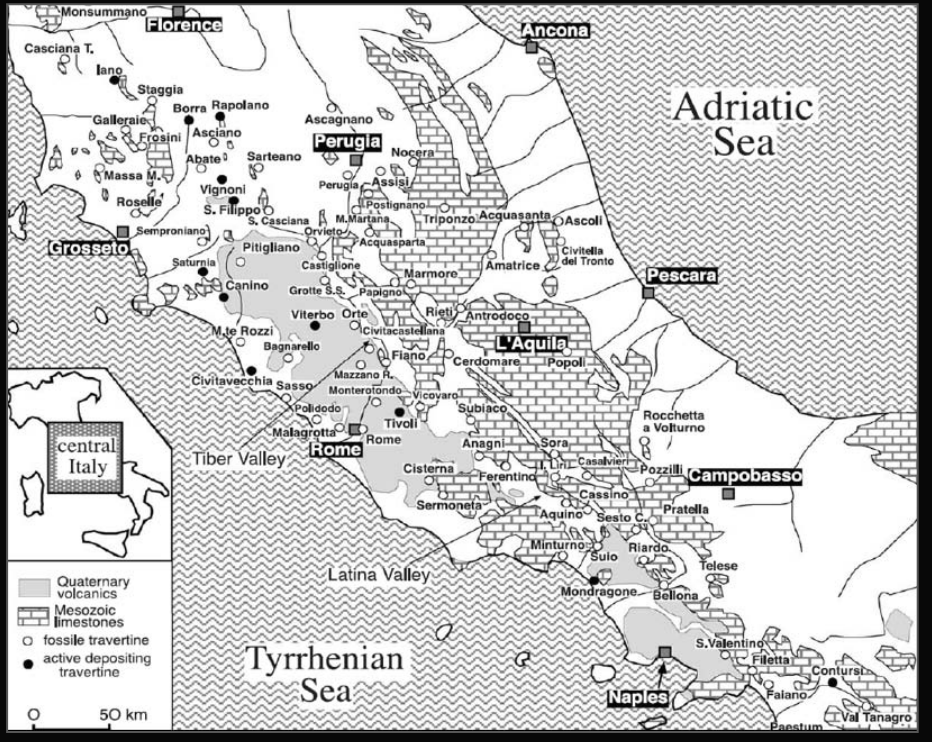
(1) Earth Sciences Department "Ardito Desio", Università degli Studi di Milano, Via Mangiagalli, 34 – 20133 MILANO – Italy. **E-mail: federica.barilaro@unimi.it**

(2) Earth Sciences Department, Università degli Studi di Siena, Via Laterina, 8 - 53100 SIENA – Italy

1. Introduction

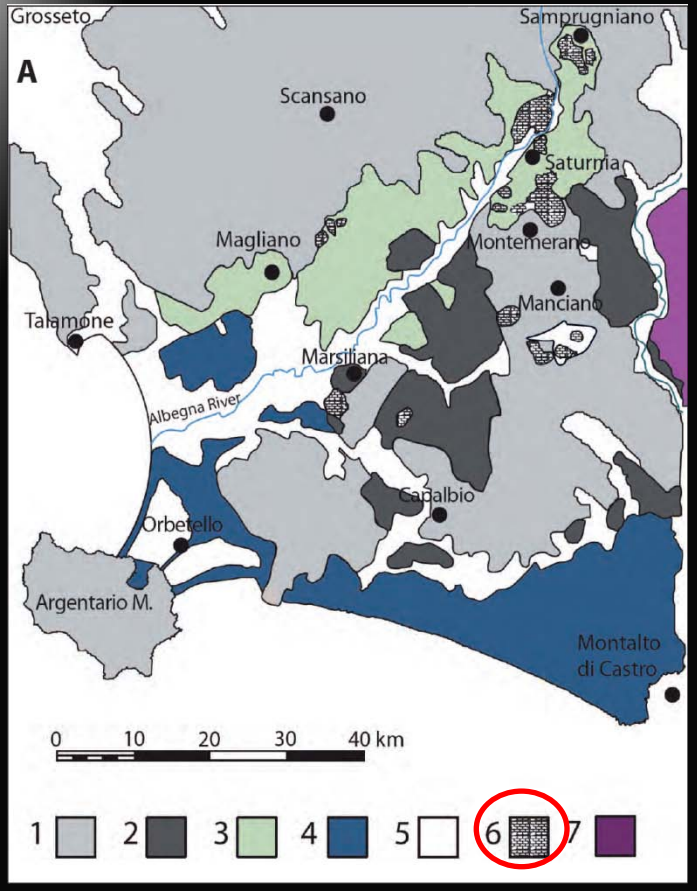


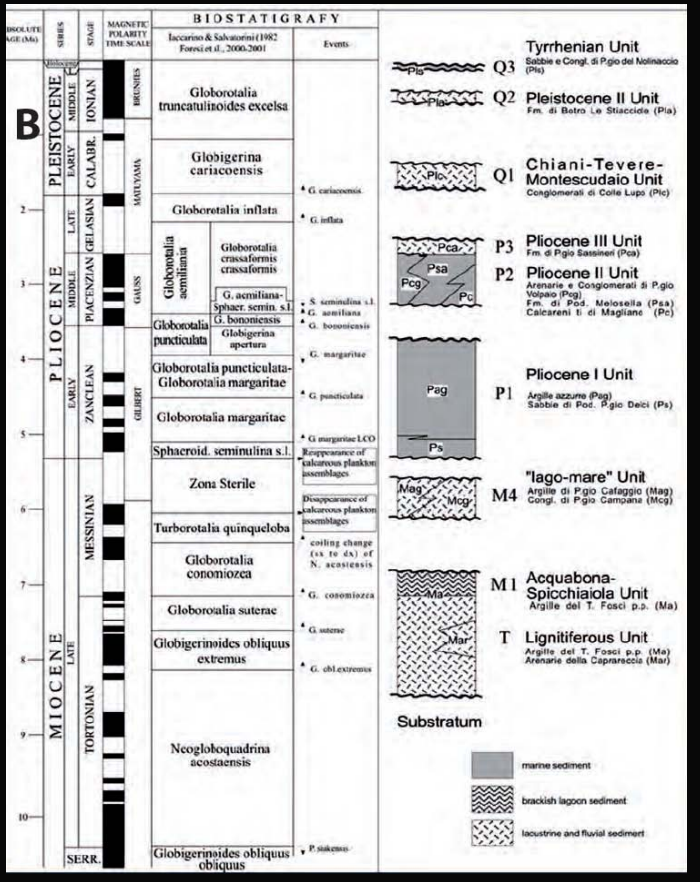
Geographic distribution of thermal travertines. A) Pie chart based on number of scientific papers on literature review data. B) Rapolano Terme fissure ridge, Tuscany, Italy.



Map of central– southern Italy showing location of active precipitating and fossil travertine deposits. From Minissale, 2004.

2. Geological Setting of Albegna Valley





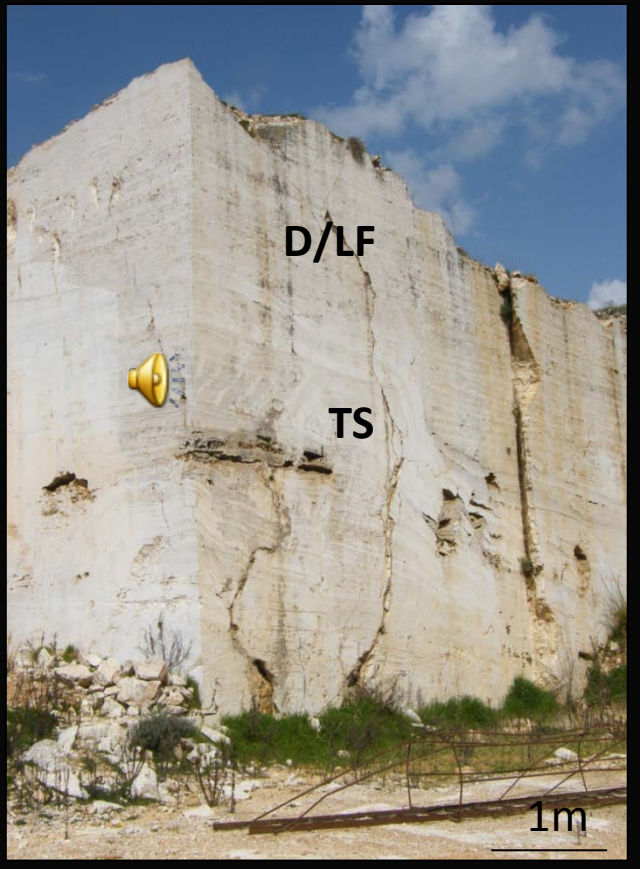
A) Simplified geological map of Albegna Valley. Legend:
1) Tuscan series and allochthonous units;
2) 2) Messinian continental, brackish and marine sediments; 3) Pliocene marine sediments;
4) Pleistocene marine and coastal sediments;
5) Alluvial-colluvial deposits;
6) From Miocene to Holocene Travertines;
7) Volcanic deposits of Vulsini Mounts. (Modfied after Bosi et al. 1996).
B) Depositional units and hyatus of the Neoautochthonous Succession of the Albegna River Basin. Bossio et al., 2004.

Saturnia travertine quarry

An interesting fossil travertine body (Upper Pleistocene-Holocene?) is well exposed along an active quarry situated on the Manciano sector of the Albegna Valley.

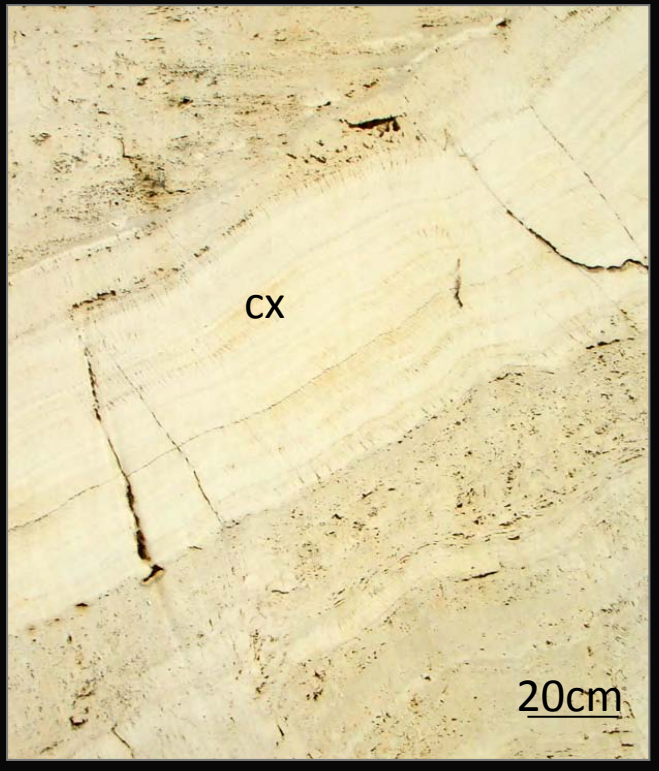
Saturnia travertine quarry with an area of 38 hectares and with a depth of excavation of 30-35 m allows the investigation of the travertines in terms of carbonate fabrics, geometry of the sedimentary bodies and lateral and vertical evolution.

Depositional systems



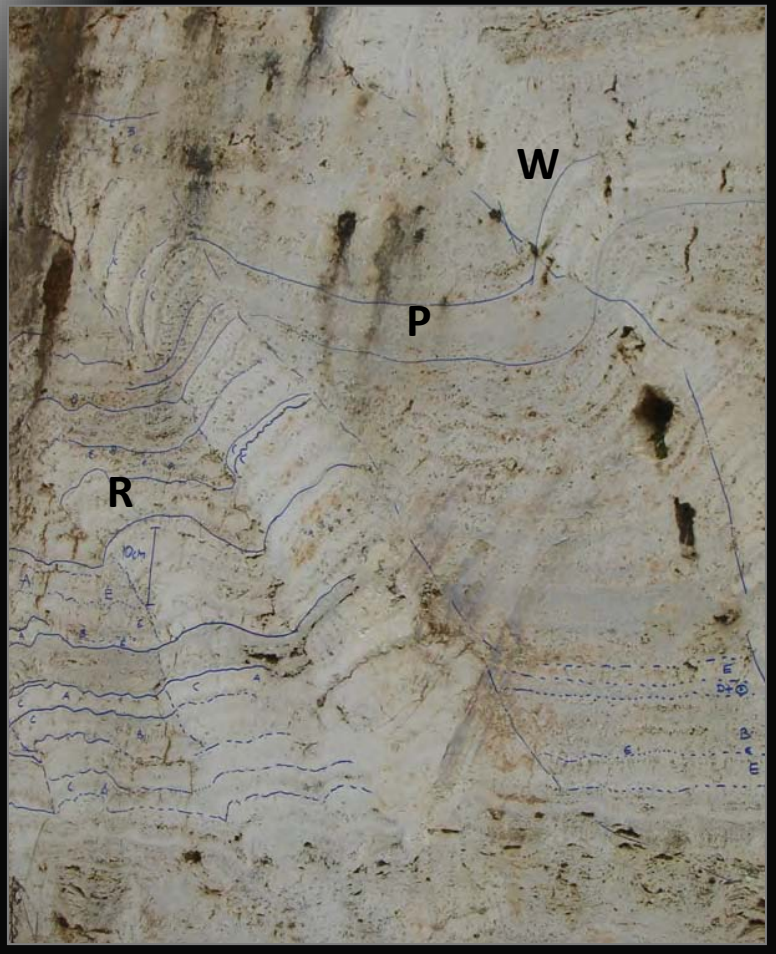
The quarry faces (30-35 m) a travertine terraced slope (TS), smooth slope (SS) and depression/lateral at depositional systems (D/LF) .

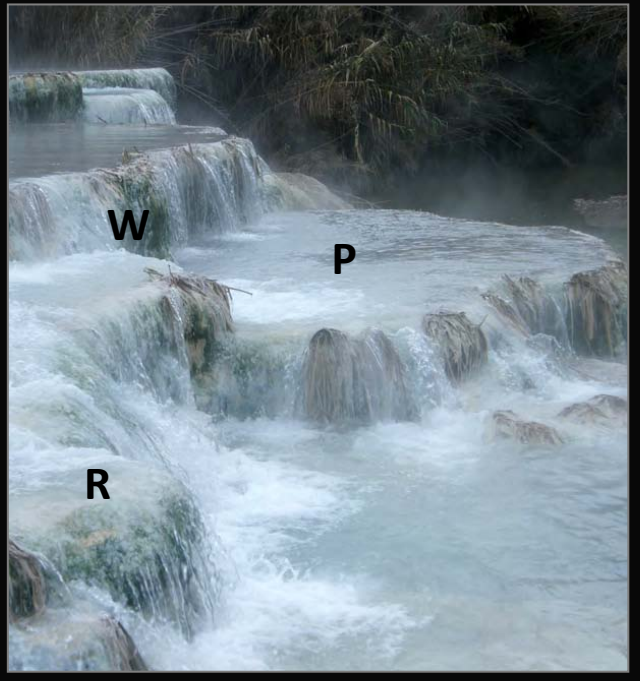
Depositional systems: smooth slope



Smooth slope (SS) consisting of non-terraced systems formed mainly by crystalline crusts (cx). Saturnia Travertine Quarry.

Depositional systems

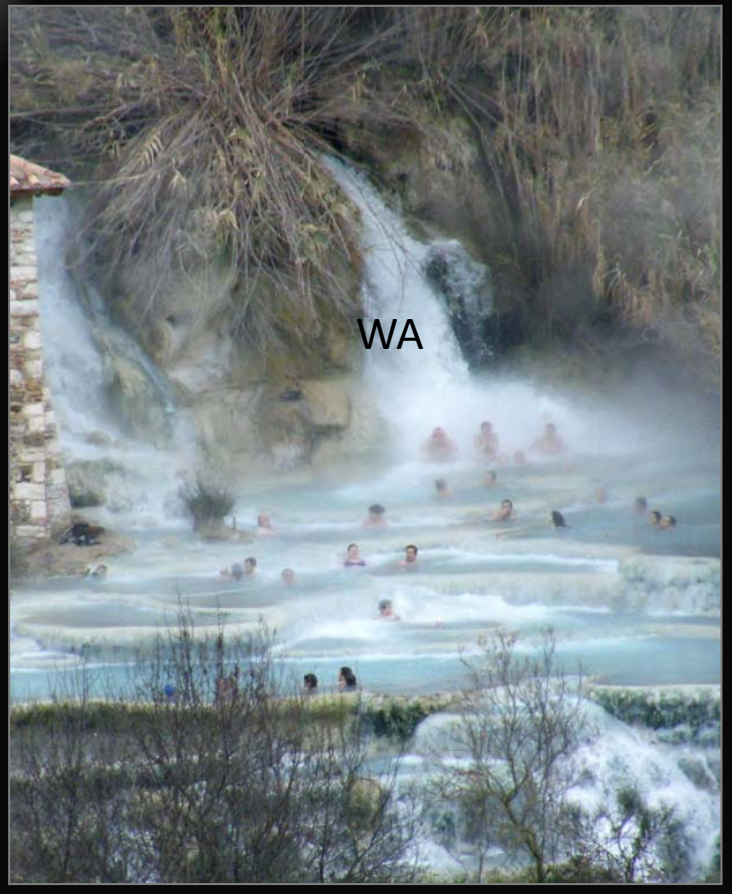


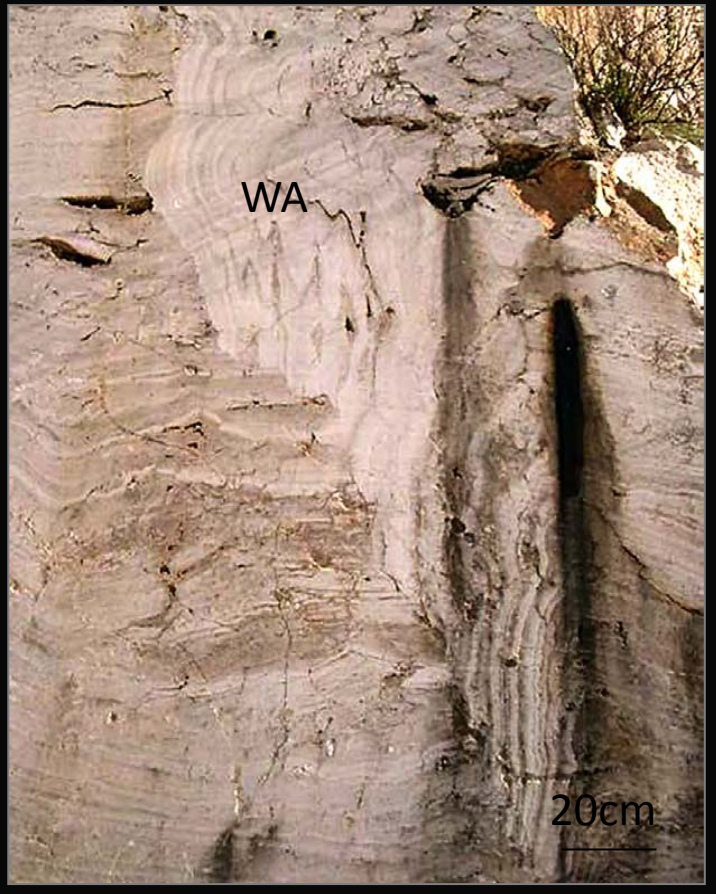


TS consists of vertical terrace walls (W), pools (P) and rims (R) confining the margins of the pools; rare waterfalls are present.

Terraced slope (TS) compared with the modern counterpart of Bath of Saturnia

Depositional systems: terraced slope



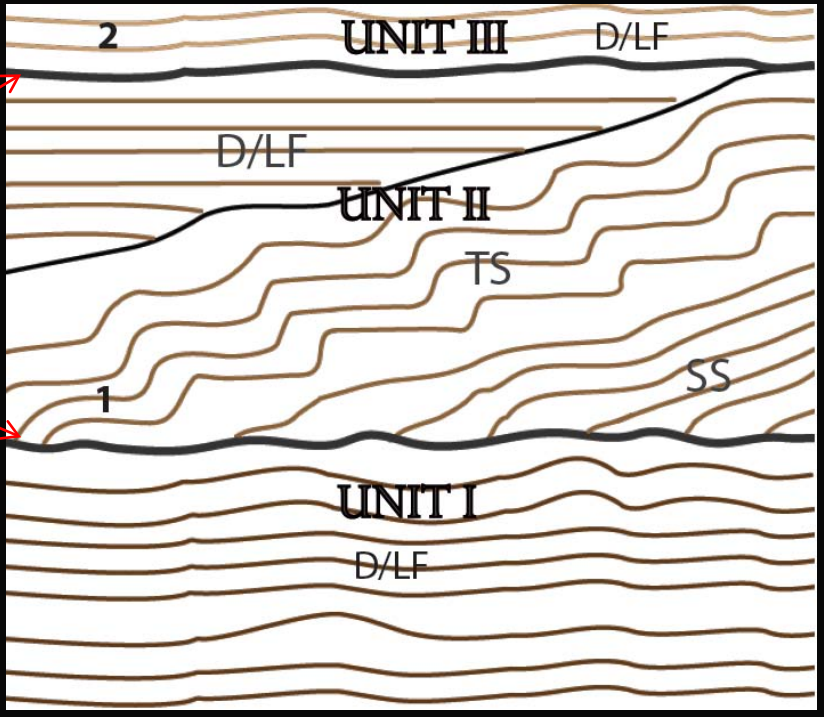


Modern terraced slope with pool, walls, rim and waterfalls (WA) of Bath of Saturnia (located 14 Km far from the Pleistocene/ Holocene? travertine).
B) Waterfall consists mainly of crystalline crusts. Saturnia Quarry.

Geometry

Within the travertine deposit different **stages of non deposition/erosion** (clay layers 1 and 2) are recognized. These are present at different stratigraphic heights (9-16 m respectively), and suggest **an intermittent accretion of the travertine body.**

Geometry



Interpretative sketch of travertine geometry. Travertine Unit are numbered I, II and III. Unit boundaries are marked by two clay layers.

Geometry

Unit III consists of sub-horizontal travertines of D/LF depositional system.

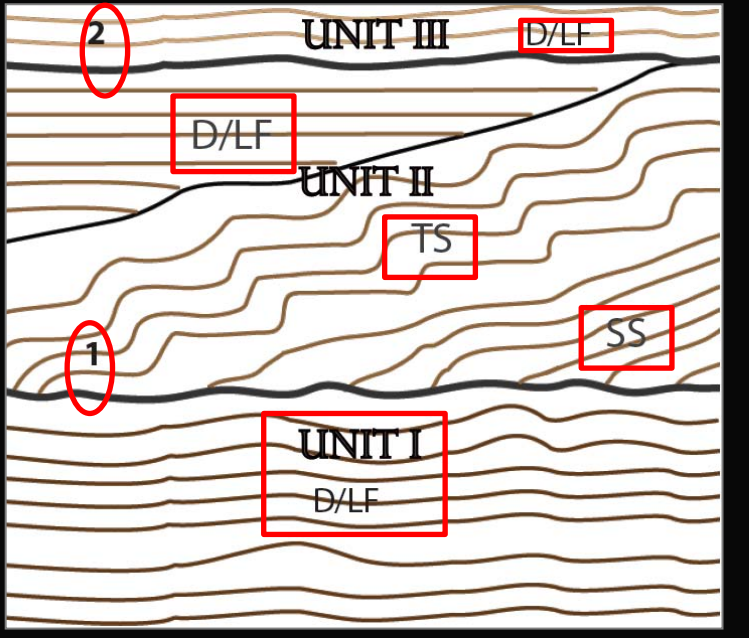
Clay layer(2) between Un

Terraced slop

Smooth sl

Hoard in depre

Depressional, lateral flat (D/LF) depositional systems.



Interpretative sketch of travertine geometry. Travertine Unit are numbered I, II and III.

Fabric Types

Thirteen carbonate fabrics were distinguished in field:

1) crystalline crusts (A);

2)micritic precipitates including bubbles, irregular mm-size voids (B);

3) mm-thick microsparitic laminae (C);

4)cm-tick layers with carbonate mud and travertine lithoclasts representing erosional surfaces (D);

5)Shrubs consisting of clotted peloidal micrite in bush-like structures that locally form dm-thick bioherms (E);

6)aggregates of mm shrubs and mm-thick lamination (F);

7) elongated rafts (G);

8) transitional forms from shrubs to feather crystals (H);

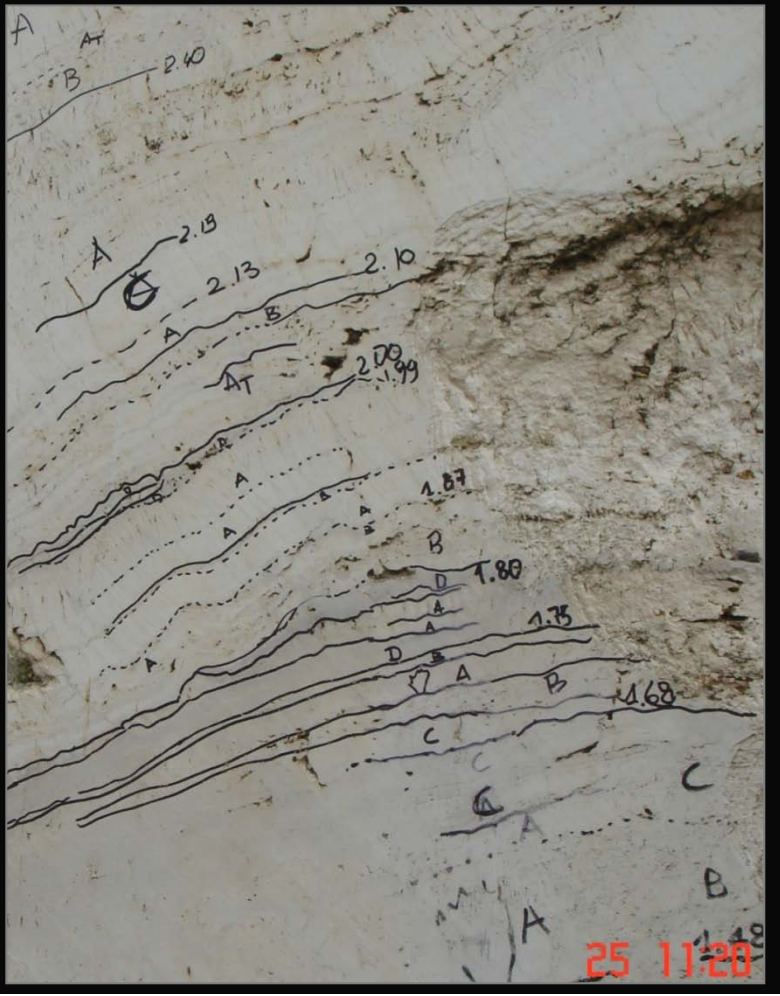
9)fragments of shrubs and pisoids in a micritic matrix with irregular cavities (I);

10) sub-mm stromatolite-like laminae (J);

11)veined micrite with locally bubbles and lamination (K);

12)microbreccia with a dense matrix, typically organized in cm pockets (L);

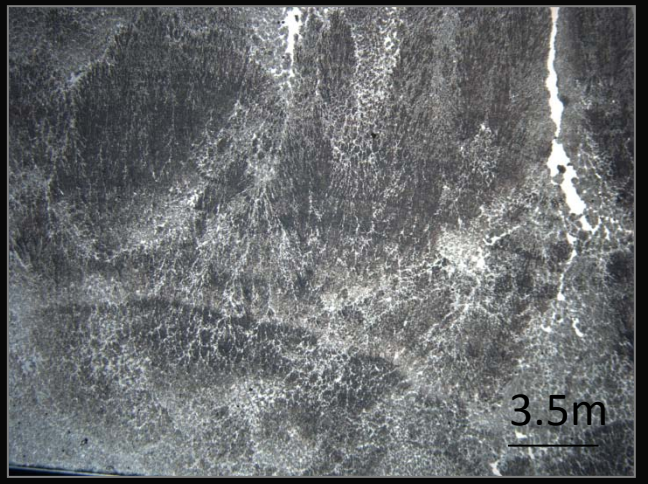
13)mm elongated reed stems floating in micrite (M).

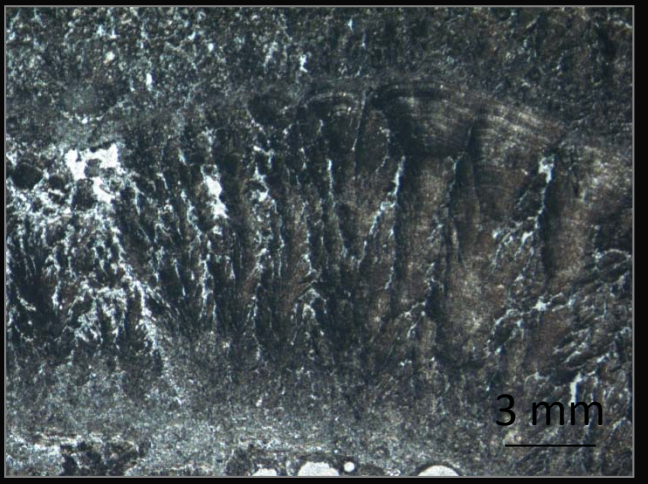


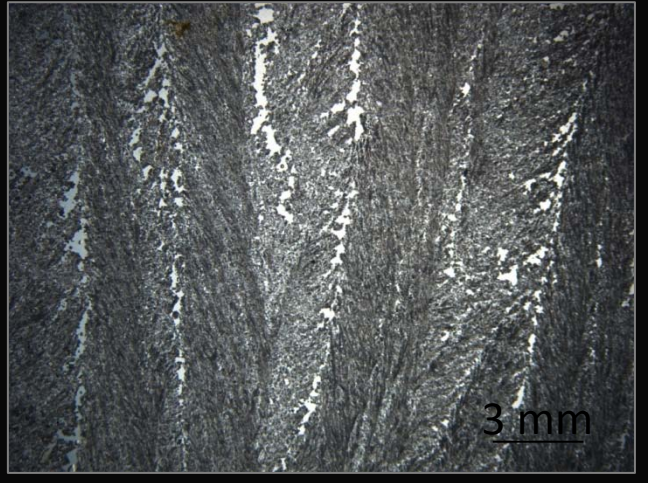
Name: Crystalline crusts.

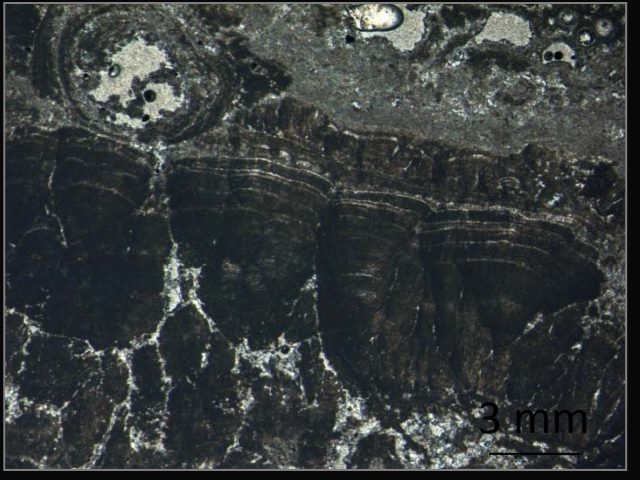
Description: consisting of elongate *calcite crystals (from 1 to 25 cm)* perpendicular to the depositional surface.

Interpretation: rapid precipitation from **fast flowing water.**





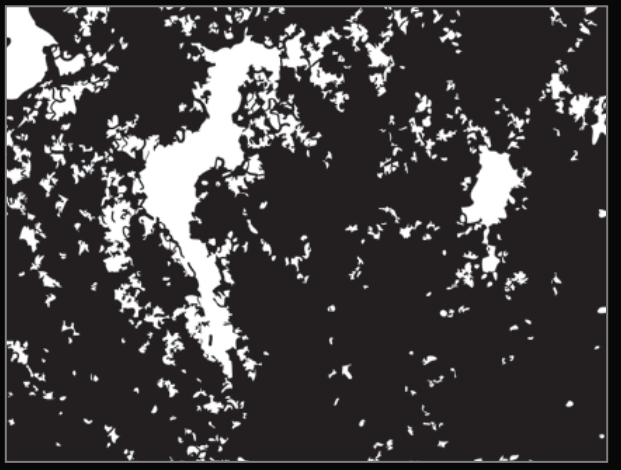


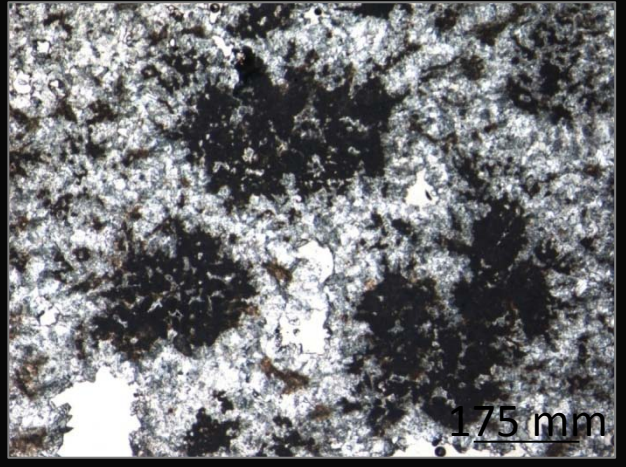


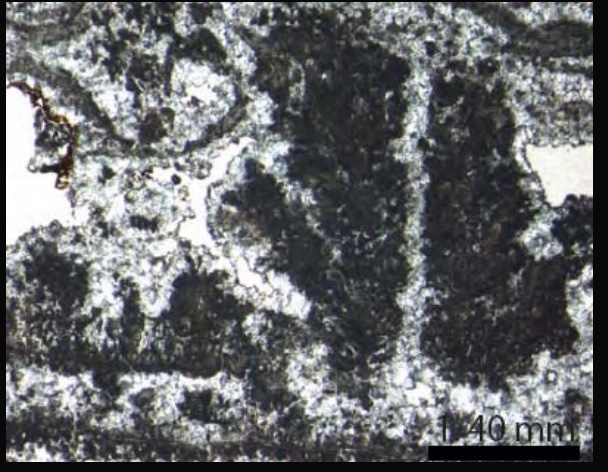
Name: Shrub

Description: bush-like structures ranging from a few mm to 10 cm. Commonly grow from the same surface and form horizontal-undulate alternate layers.

Interpretation: form in pool and horizontal layers from sluggish flow of water.

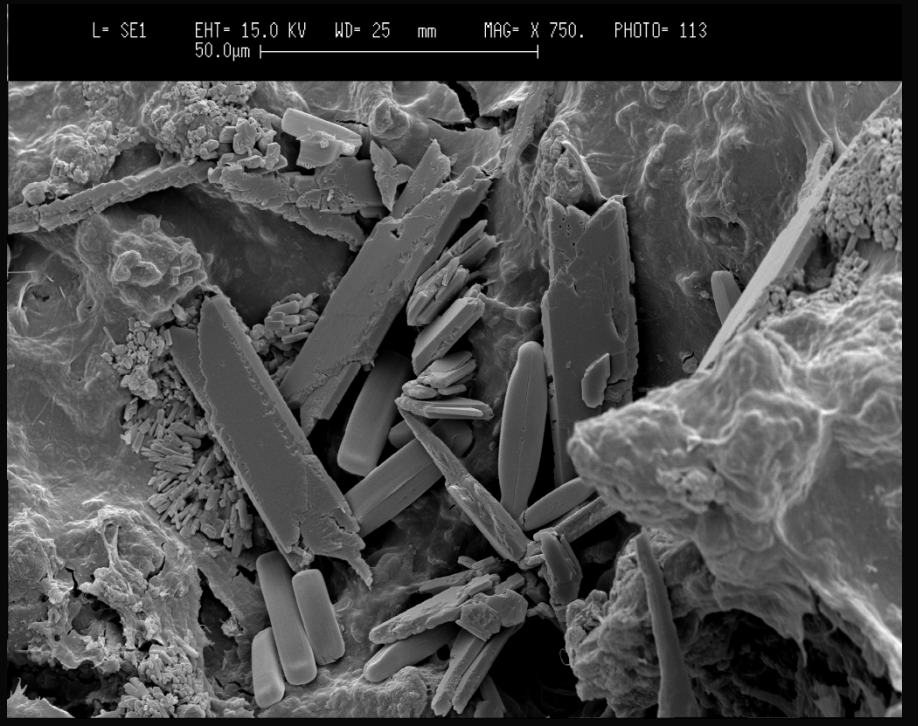






Conclusions

1) Three travertine Units at field scale.
2) Slope (terraced and smooth) and depression depositional systems were distinguished.
3) 13 travertine fabrics occur in different depositional enviroments (i.e., fast- vs. flowing water).
4)Crystalline crusts are common of fast flowing areas (smooth slopes, rims and walls of the terrace pools, vertical surfaces of waterfalls). Shrub, pisoid, raft, bubble honeycomb and stromatolitic-like fabrics are typical components of the depression depositional systems (low-energy pools and ponds).
5) Petrographic analyses display 15-30% porosity, partially closed by spar calcite (likely meteoric), micrite and microspar on probable organic structures. The occurrence of EPS in present-day travertine at Bagni di Saturnia confirms the hypothesis of the presence of an organic framework in the fossil travertines. These modern travertines improve our ability to properly interpret the systems of the ancient travertines.



SEM image of present-day travertine at Bagni di Saturnia.


Thank you for your attention