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SIGNIFICANCE OF THE MORPHOLOGICAL AND STRATIGRAPHIC SURFACES IN THE QUATERNARY PO PLAIN: THE SAN COLOMBANO TECTONIC RELIEF (LOMBARDY, ITALY)

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ABSTRACT: The recent geological, geomorphological, pedological and structural surveys performed at the San Colombano tectonic relief document a Late Quaternary tectonic activity of the structure, located at the Po Plain-Northern Apennine border in Lombardy (Italy). The new maps, corroborated with (palaeo-) geopedological analyses, allow to unravel the composite nature of the morphological and stratigraphic surfaces bounding the observed units and landforms, and to relate them to the climatic and tectonic events that interacted during the Late Quaternary at the Apennine-Po Plain border.

KEYWORDS: Northern Apennine, Po plain, Quaternary, San Colombano hill, soil, stratigraphy

1. INTRODUCTION

The interaction between tectonics and climate cycles has determined the mobility of depositional settings at the border between the Apennines and the Po plain during the Quaternary, which results in a great complexity of geomorphological and stratigraphic features. Stratigraphic boundaries and morphological surfaces are fundamental elements to recognize the periods and sites of surface stabilization and pedogenesis (morphological surfaces) from those where mostly erosion and/or aggradation occur (stratigraphic boundaries). Paleosol analysis helps to characterize these two different types of surfaces, which might represent also palaeoclimatic and palaeoenvironmental markers, providing additional chronological constraints to the Quaternary geological and morpho-tectonic processes (Costantini, 2017). Hence, the integration between detailed geological mapping of the Quaternary sediments and the sedimentological and geopedological characterization of the stratigraphic boundaries is necessary to unravel the origin of landscape in complex mobile settings.

From this perspective we focus on the San Colombano hill in the Po Plain of Lombardy (Fig. 1; Desio, 1965), as one of the main evidences of Late Pleistocene N-Apennine tectonics affecting the S-Alpine sourced alluvial systems. Here, the available regional geological maps (Anfossi et al., 1971; Boni, 1967) and pedological studies (ERSAF, 2013) have never been integrated in a comprehensive Quaternary stratigraphic framework, and the Late Quaternary geological evolution of the structure, mainly based on regional geomorphological studies (Benedetti et al., 2003; Burrato et al., 2003; Pellegrini et al., 2003), is still under debate. Starting from the new geological, geomorphological and structural surveys carried out on the hill (Zuffetti et al., 2018), and accounting for the new geopedological data which have been recently submitted for publication, here we focus on the characterization of the stratigraphic boundaries and morphological surfaces of the San Colombano hill area. The main aim is to highlight their role as indicators of the incremental morpho-tectonic changes at the origin of the hill landforms during the Late Quaternary, and to unravel the most effective controlling factors on their origin.

2. MATERIALS AND METHODS

Detailed geological and geomorphological mapping at 1:10.000 scale have been carried out in the San Colombano hill area. UBSU (ISSC, 1987) classification was applied when possible to the Quaternary continental units, following the criteria adopted in the recent mapping projects of Italy. Sedimentological, geomorphological and structural analyses accompanied field surveys and the results are presented in Zuffetti et al. (2018). The geopedological characterisation of the stratigraphic boundaries relies on a distributed mapping of soil textures and colours, integrated by detailed analyses on five soil profiles, selected as reference for the features of the top boundary of the mapped Late Pleistocene stratigraphic units and for the most prominent morphological surfaces. Geopedological field description, laboratory analyses and micromorphological observations were performed following the conventions of WRB (2015), Ministero per le Politiche Agricole (1999), Stoops et al. (2010), respectively. Age constraints are based on new and available OSL and radiocarbon datings (Baio et al., 2004; Bersezio et al., 2004; Panzeri et al., 2011).

3. RESULTS

The San Colombano hill exposes the uplifted and folded marine Miocene and Calabrian units (Sant'Agata Fossili Marls and San Colombano Fm.; 'M' in Fig. 2), unconformably overlain by the Late Pleistocene alluvial

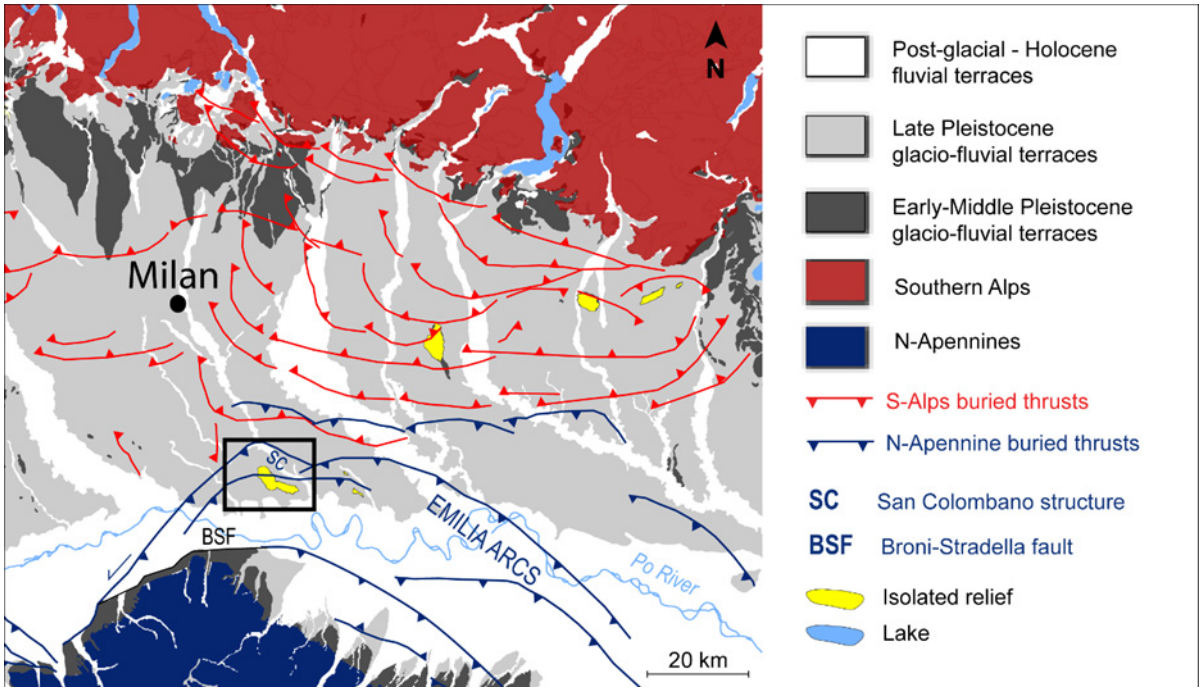

Fig. 1 - Location of the San Colombano hill in the structural framework of the Central Po Plain (Italy). The San Colombano structure (SC) corresponds to one of the northernmost thrusts of the buried front of the Northern Apennine Emilia Arc. Buried N-Apennine thrusts from Bigi et al. (1990); buried S-Alpine thrusts simplified from Fantoni et al. (2004).

pedogenised and deformed deposits (Cascina Parina Synthem, 'CPS' and Invernino Synthem, 'INS', Fig. 2). The sequence is in turn modelled by the Late Pleistocene to Holocene processes and covered by sediments, which belong to the Monteleone Synthem ('MLS', Fig. 2) and are located along the slopes and within the valley network of the hill. The eastern sectors of the hill consist of fault blocks (Fig. 2) laterally dissected by conjugate faults while the northern and southern slopes develop from WNW-ESE directed normal faults stepping towards the adjacent plain (Zuffetti et al., 2018).

The lower boundary of CPS (Late Pleistocene) is a high rank angular unconformity, composed by the progressive terracing of CPS alluvial systems on the uplifting substratum (Zuffetti et al., 2018). This Middle-Late Pleistocene unconformity encompasses the regional regressive sedimentary cycles recorded in the subsurface of the Central Po Plain (Ghielmi et al., 2013). Geopedological analyses performed on both CPS, INS and on the loess deposits at their top, result in the identification of some surfaces of morphological, tectonic and depositional stabilization, differently preserved and dissected throughout the San Colombano hill. The most complete sequence is observed in the lowermost hill sector, where a highly developed and red paleosol is covered by two stacked loess-paleosols to soil sequences (buried loess L1, exposed loess L2; Fig. 2). The oldest loess (L1) is ascribed to the end of CPS depositional cycle (pre-LGM), the youngest (L2) to the end of LGM, post-dating the deposition of INS. Age constraints are provided by OSL and radiocarbon datings (Panzeri et al., 2011; Bersezio et al., 2004; Zuffetti et al., 2018). The associated soils (Fig. 2) mark two phases of climatic stabilization under interglacials. A comparable interpretation was proposed for soils and paleosols described on loess covers at both the northern (Zerboni et al., 2014) and southern fringes of the Po Plain (Cremaschi et al., 2015; Maestrelli et al., 2018). Hence, the surface at the top of CPS in the lowermost hill sector corresponds to a geomorphic surface of stabilization (S, Fig. 2), covered by loess L2. A comparable interpretation is deduced from the sections studied at the uppermost fault blocks, where the late-LGM L2 loess covers a geomorphic surface of planation, subsequently stabilized ('E+S' surface, Fig. 2). Layers of colluvium reworking pedorelicts of highly weathered material rest on the unconformity, below the loess cover of the intermediate fault block (Fig. 2). In the northern fault block, both alluvial INS and L2 are preserved and no paleosols were observed (Fig. 2); the evidence of paleosol redeposition in this interval consists of colluvial sediments derived from developed and hydromorphic paleosols, interposed between alluvial INS and L2 by means of a low rank stratigraphic boundary (Fig. 2). In this sector, the unconformity bounding the bottom of INS is a high rank erosional surface, resulting from alluvial terracing during the LGM depositional cycle, as confirmed by stratigraphic correlation to the adjacent dated sediments north of the relief (Bersezio et al., 2004; Zuffetti et al., 2018).

4. DISCUSSION AND CONCLUSIONS

The new maps (Zuffetti et al., 2018), combined with detailed pedo-stratigraphic analyses, provide a useful framework to discuss the interaction between tectonic

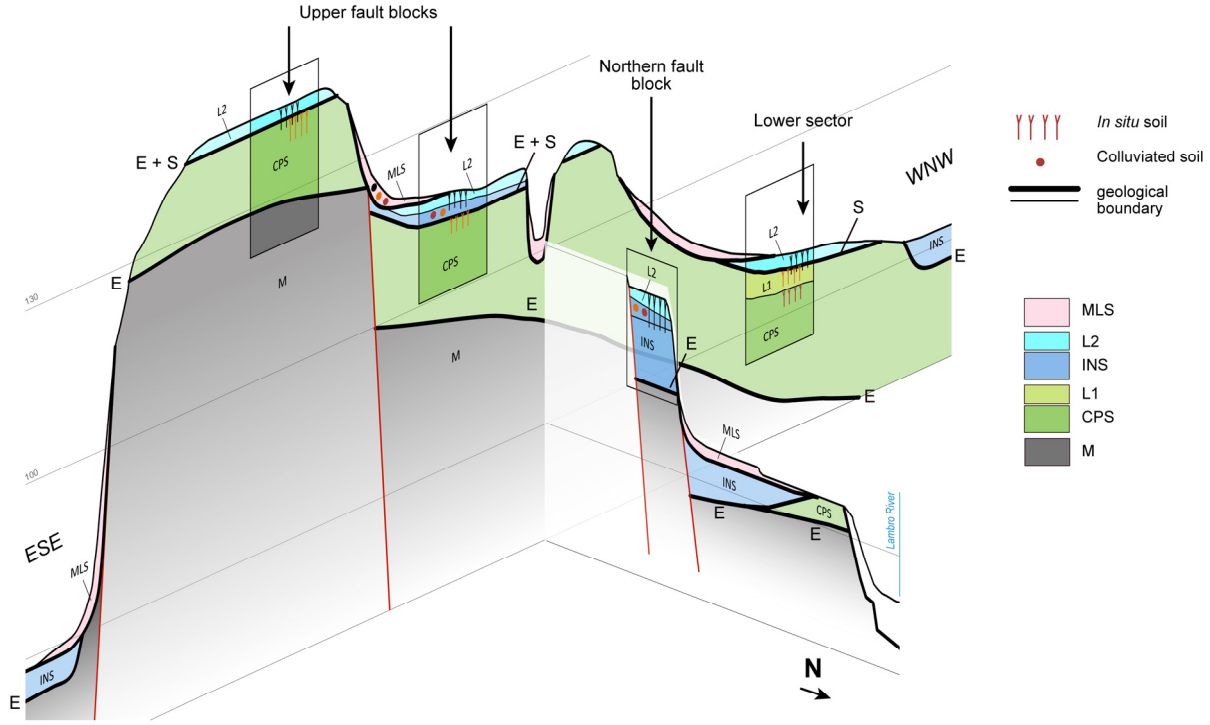

Fig. 2 - N-S and E-W sections showing the relations between the Late Quaternary soils and paleosols and stratigraphic boundaries across the San Colombano hill. M: undifferentiated Marine units (Upper Miocene to Calabrian); CPS: Cascina Parina Synthem (Late Pleistocene); L1: pre-LGM loess; INS: Invernino Synthem (Latest Pleistocene); L2: late-LGM loess; MLS: Monteleone Synthem (Late Pleistocene-Holocene). Thickness of the lines representing the stratigraphic boundaries is proportional to their rank. S - buried and/or exposed stabilization surface; E - erosional surface.

and climatic controls at the origin of the stratigraphic and morphological surfaces that characterize the San Colombano hill. The Late Quaternary Synthems mapped on the hill are bounded by composite unconformities that originated in part during tectonic displacement and, in part, during periods when specific sites where stabilized. In situ paleosols testify the existence of locally non-erosional unconformities during the late Pleistocene, related to surface stability, where the main controlling factor was climatic. L1 and L2 loess are mostly preserved at these sites. Conversely, truncated and redeposited paleosols dominate in sites of active tectonic displacement, as observed in the easternmost fault blocks; here, Latest Pleistocene tectonic increments (Zuffetti et al., 2018) acted in soil erosion and mobilization. The basal unconformity of the LGM INS is composed by erosional surfaces which join progressively deposited along the dissected fault blocks.

The present work outlines the importance of considering how tectonics interacts with climate-driven depositional and soil-forming processes to produce stratigraphic and geomorphological surfaces. Their significance is relevant for mapping purposes and to constrain correlation of continental successions within the stratigraphic framework of the Late Pleistocene Po Basin infill. The regional meaning of the correlative surfaces detected in the subsurface of the Basin is the object of the wider ongoing research.

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