

Contrasting the postglacial morphodynamic evolution of Alpine and Apennine river systems in the central Po Valley, Italy

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SCAN FOR FULL ABSTRACT



AIM & PURPOSE

This study aims to investigate the post-glacial evolution of a sector of the Po Plain (Northern Italy), focusing on the northward migration of the Po River and its role in controlling out-of-phase cycles of incision and aggradation in Alpine and Apennine tributaries. The research focuses on Quaternary geomorphic elements and sedimentary successions across a study area in the central Po Plain (Fig. 1), to reconstruct the architecture of continental depositional systems and associated palaeotopographic features. The approach combines field and remote-sensing mapping of landforms and deposits, dating based on geochronometric and archaeological evidence and facies analysis of both outcropping and subsurface sediments.

STUDY AREA & GEOLOGICAL BACKGROUND

During the Quaternary (~2.6 Ma - present), the global climate experienced rapid and repeated changes, with the Late Pleistocene dominated by glacial conditions culminating in the Last Glacial Maximum (LGM, ~21 ka), followed by the Holocene interglacial. The Po Valley (northern Italy) is a natural laboratory for studying landscape evolution in response to Pleistocene-Holocene climate change. The Po Valley is an asymmetric alluvial foredeep, with rivers draining the Alps to the north and the Apennines to the south, converging into the Po River. The northern drainage network progressively stabilized due to increased sediment input from Alpine glaciations, with extensive sandur deposits forming in the Alpine foreland during the LGM, when the plain experienced its maximum period of aggradation (~26–21 ka; Marchetti, 2002; Fontana et al., 2014). After the LGM, Alpine rivers incised their deposits, flowing within entrenched valleys towards the Po River. Proglacial lakes along the Alpine foreland trapped large amounts of sediment, reducing downstream transport and increasing the erosive power of the rivers (Marchetti, 2002). Meanwhile, in the Apennine sector of the study area, during the LGM, reduced water discharge and enhanced sediment supply under periglacial conditions promoted widespread aggradation (Panizza, 1977). At the end of the LGM, climate warming and increased precipitation led to a phase of localized incision, followed by renewed aggradation, which buried Late Pleistocene surfaces, likely during the Early Holocene (Alessio et al., 1980). Moreover, in the last ~18 ka, the Po River has migrated northward (Fig. 2), eroding distal portions of alpine outwash systems, currently being eroded at their toes. However, this is not observed in the Apennine area, where the coalescing clastic wedge formed by Holocene systems has been undergoing relatively steady aggradation (Benedetti et al., 2003).

Fig. 1: Out-of-phase incision and aggradation in Alpine and Apennine tributaries and the focus area of this study (black rectangle).

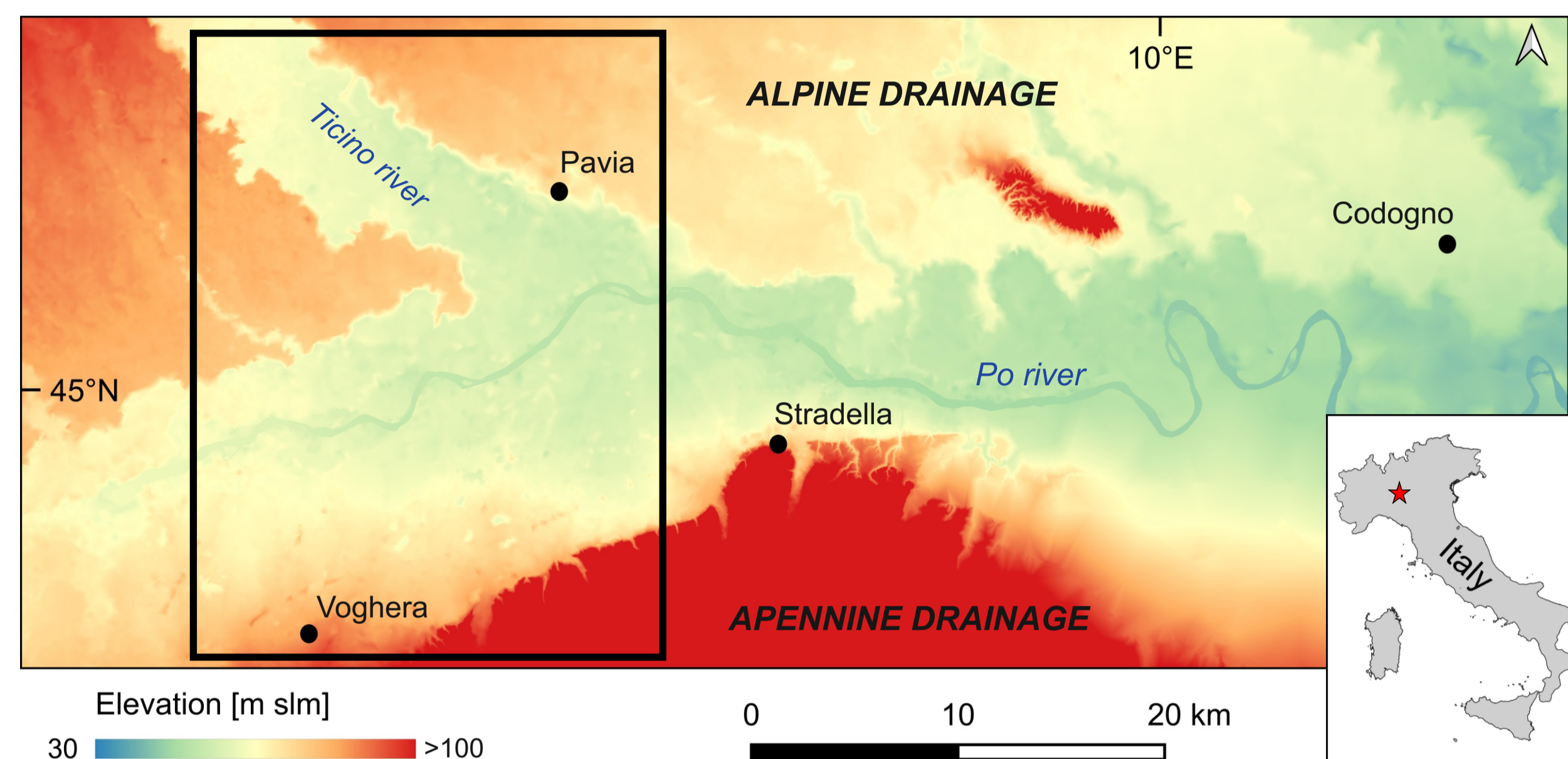
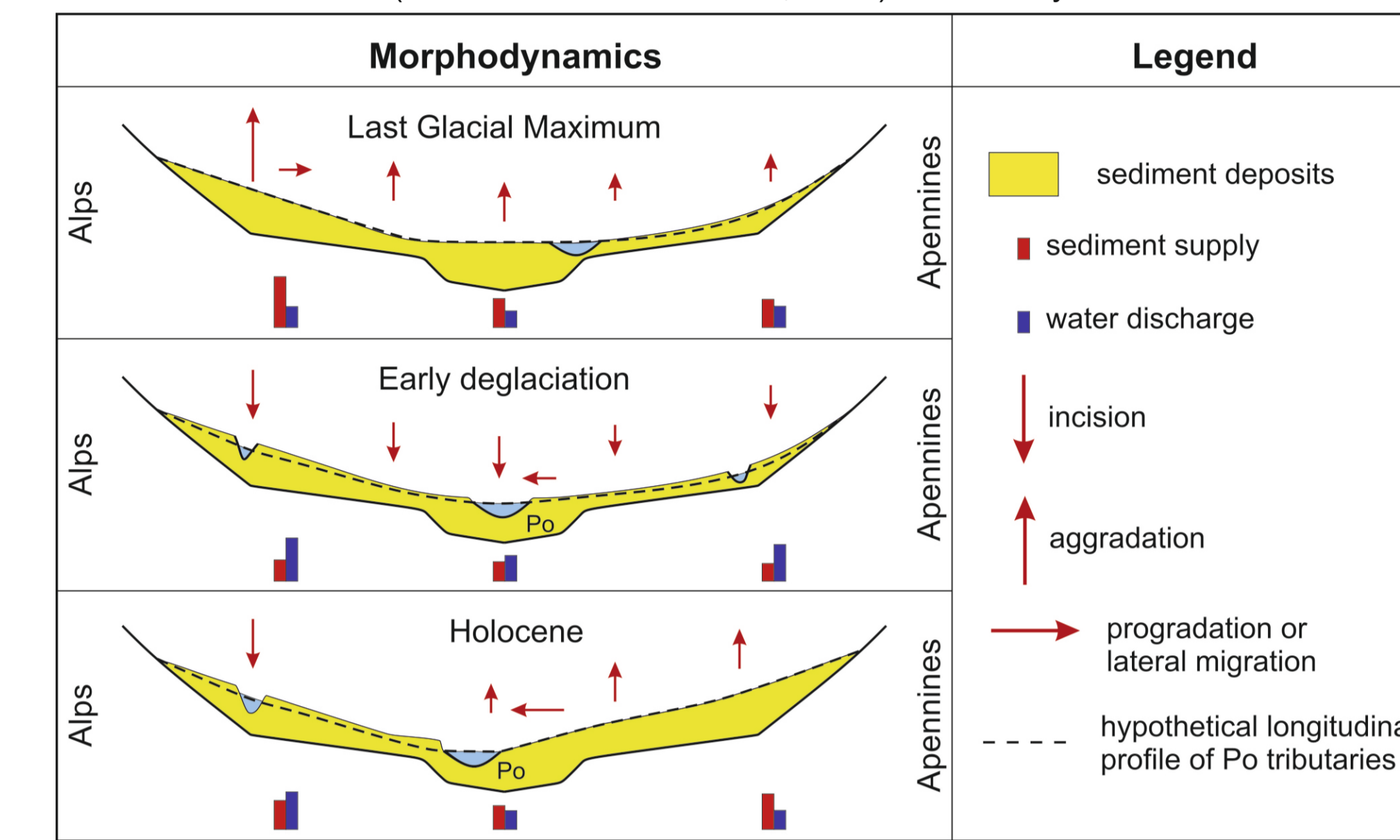


Fig. 2: Sedimentary response of the Po basin river systems (modified after Bruno et al., 2018) in the study area.



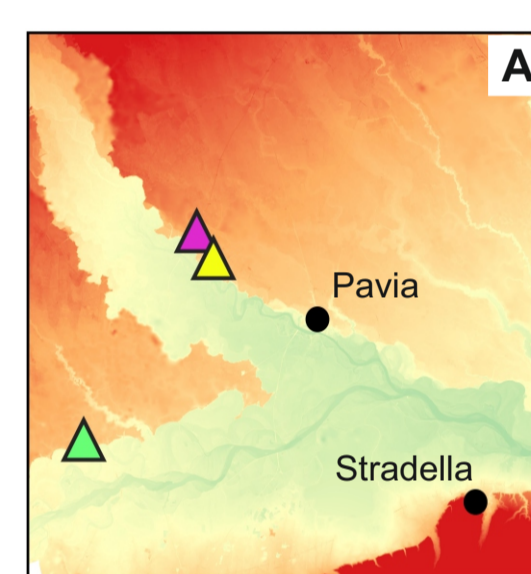
RESULTS & DISCUSSION

The climatic and palaeohydrographic conditions from the pre-LGM to the tardiglacial in the Alpine Po Plain promoted the formation of peaty-pelitic complexes, dated between 36 and 18 ka (Tropeano & Olive, 1993). Field observations in the study area show the lateral continuity of one of these horizons, making it a prospective stratigraphic marker for the Late Pleistocene stratigraphy.

The investigated outcrops (A) are:
 ▲ Casotole (PV): ~15 m succession (organic-rich interval + outwash system + palaeo-Ticino deposits)
 ▲ San Varese (PV): upper ~3 m of gravel deposits (palaeo-Ticino deposits)
 ▲ Pieve Albignola (PV): ~5 m sand quarry (outwash system)

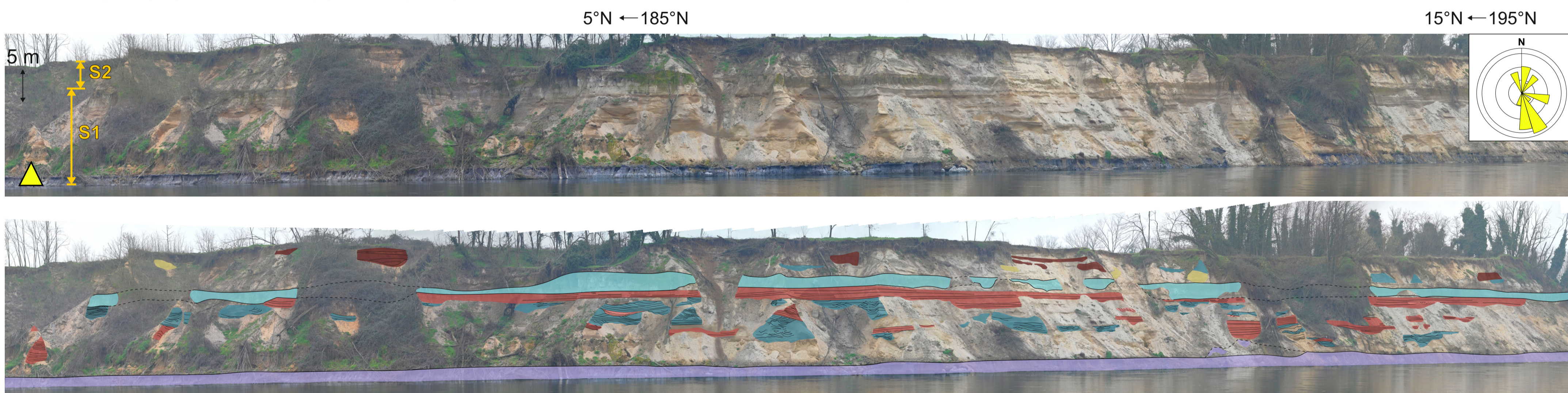
- Two main stratigraphic intervals are identified:
- S1 (outcrops ▲ and ▲): extends from the peaty-pelitic complexes up to the rootlets-inside clay levels with interbedded sandy horizons. It is interpreted as an Alpine outwash system. Palaeocurrent data indicate a dominant NNW-SSE (N = 67) transport direction.
 - S2 (outcrops ▲ and ▲): occurs above the rootlets horizon and is characterized by alternating gravels and coarse sand, interpreted as post-glacial Ticino river deposits. (mean palaeoflow NW-SE, N = 10)

Radiocarbon dates are being processed with which to support these interpretations.

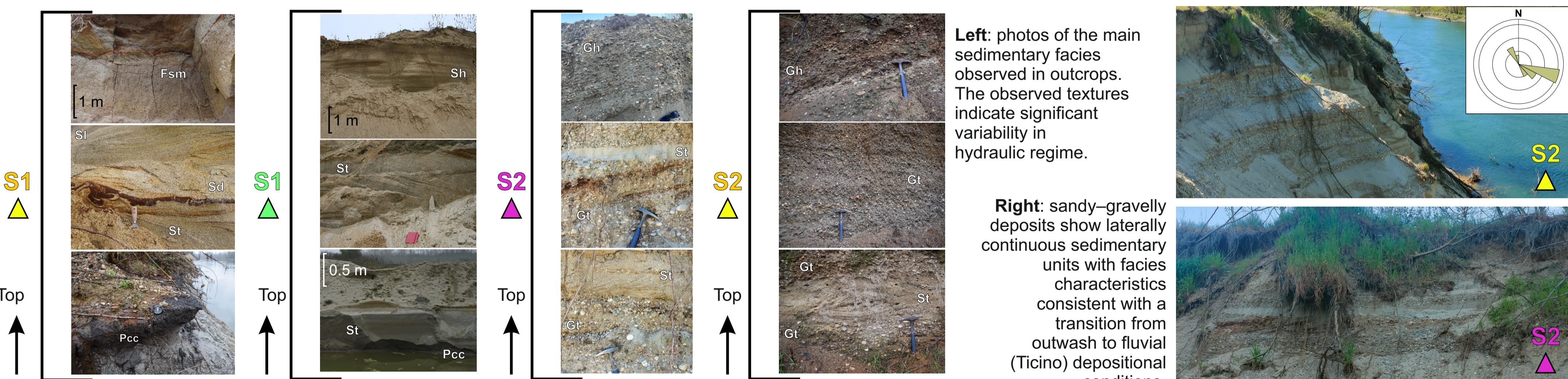


Palaeotopographic constraints, such as the absence of preserved scarps in the Apennine plain, indicates that the southern margin of the Po river system must have positioned much further south than today and have undergone subsequent northward migration, leading to the progressive abandonment of its channel belts. In the subsurface, this evolution is recorded as stacked terraced geometries preserved beneath Apennine-derived alluvial deposits, as shown in the NW-SE section below. In addition, the projection of the main level of the Po Plain (MLP) representing a Late Pleistocene alluvial topography indicates elevations higher than those of the uppermost buried terrace, providing key constraints on the vertical morphodynamic evolution of the system. Along a W-E transect, these buried architectures define a clear longitudinal gradient consistent with a large-scale fluvial system (~0.06%). Overall, the architecture supports a model dominated by aggradation of apennine tributary systems concomitant with the incision of the mobile Po channel belt and the

ensuing degradation of the Ticino, reflecting progressive incision/accumulation sediment cycle during the post-LGM evolution. Archaeological evidence (Soprintendenza Archeologica della Lombardia, 1985–2013) provides further support for this framework, showing contrasting vertical distributions of Bronze Age and Roman Period findings between the Alpine and Apennine sectors. In the northern domain, archaeological levels occur near the present surface, consistent with dominant incision, whereas in the southern sector they are found at significant depth, reflecting strong postglacial sediment accumulation within the Apennine alluvial wedge. This asymmetry is reflected in the regional stratigraphic architecture, whose interpretation using traditional sequence stratigraphic models (lowstand (LST) - transgressive (TST) - highstand (HST) transition) is not applicable due to the dynamic interactions and contrasting evolution of adjacent axial and transverse river systems throughout the Quaternary.



Top: architectural panel of outcrop ▲, highlighting the stratigraphic motif of the Casotole sequence along the Ticino River.



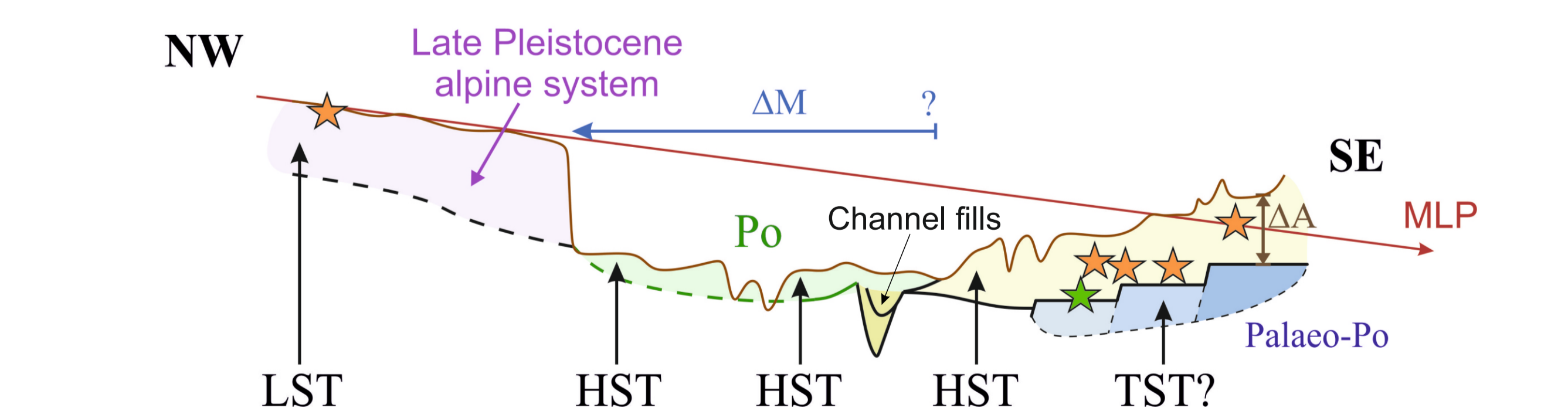
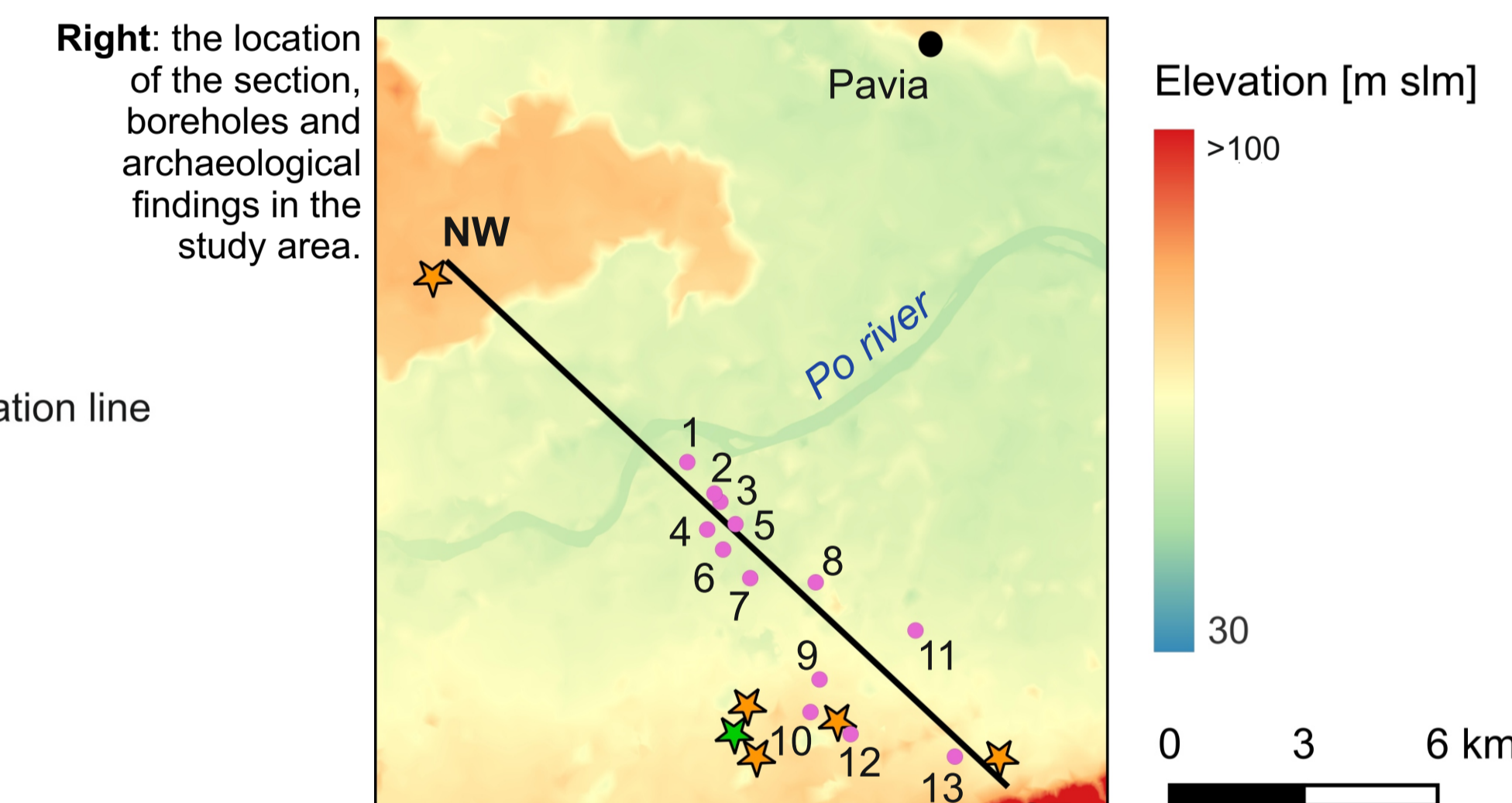
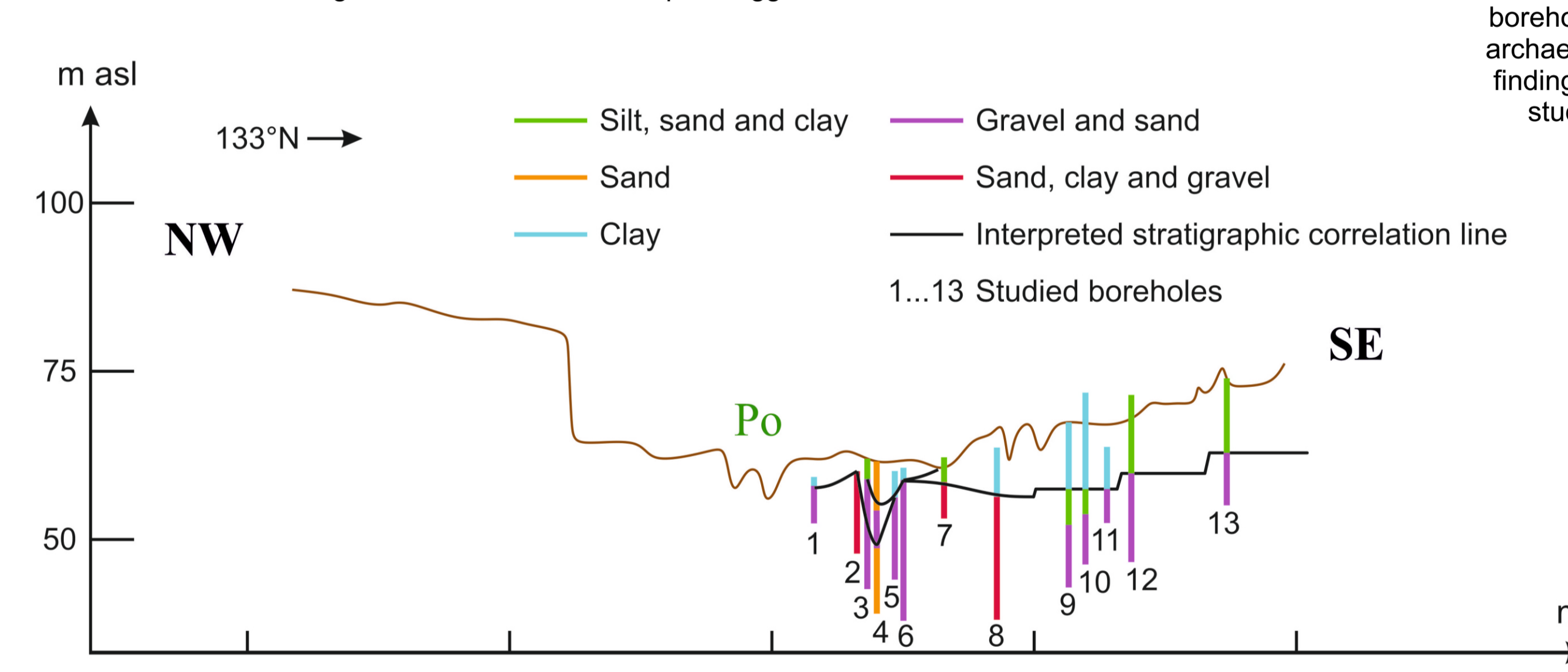
Left: photos of the main sedimentary facies observed in outcrops. The observed textures indicate significant variability in hydraulic regime.

Right: sandy-gravelly deposits show laterally continuous sedimentary units with facies characteristics consistent with a transition from outwash to fluvial (Ticino) depositional conditions.

Left: detailed observation highlights the predominance of low flow regime structures (St) within the outwash deposits.

Right: respective palaeoflows.

Below: NW-SE section of the study area where stratigraphic correlations portray interpreted indicate buried terraced geometries and the subsequent aggradation of the Po river belt.



NEXT STEPS

- Facies successions analysis and stratigraphic analyses of the study area
- Grain-size and petrographic analyses
- Acquisition of new hydrological and palaeohydrological data
- Radiocarbon dating

KEY FINDINGS

- The Alpine sector is characterized by outwash deposits during the LGM followed by aggradation and incision cycles (ongoing);
- The evolution of the Apennine plain is trailing a northward migration of the Po River;
- The Apennine catchments have built a postglacial unit

dominated by widespread aggradation;

- The asynchronous evolution of the Alpine and Apennine systems, also testified by archaeological findings, reflects contrasting sedimentary and geomorphological trends of the analysed systems;
- This work provides a critical assessment of the applicability of sequence stratigraphic models in continental contexts.

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