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Early capture of a central Apennine (Italy) internal basin as a consequence of enhanced regional uplift at the Early-Middle Pleistocene Transition

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Extensional tectonics in the inner portion of the central Apennines began during the Late Pliocene-Early Pleistocene. It resulted in the formation of chain-parallel normal fault systems, whose activity through the Quaternary led to the formation of intermontane tectonic basins; these represented traps for continental sedimentary sequences. In particular, during the Early Pleistocene most of the central Apennine depressions hosted lakes, testifying to endorheic hydrographic networks. Afterwards, lacustrine environment was replaced by fluvial regimes, aged at the Middle Pleistocene, as the hydrographic systems of the basins were captured by headward regressive erosion coming from the outermost sectors of the chain. This is testified by a strong erosional phase that cut into the lake sequences, due to deepening of streams and river incisions, and the subsequent deposition of embedded fluvial deposits. This environmental change is commonly attributed to a regional relief enhancement, as a consequence of the increase of regional uplift of the central Apennines (and geologically seen in many parts of the Apennine chain), generically aged between the upper part of the Early Pleistocene and the lower part of the Middle Pleistocene [e.g. D'Agostino et al., 2001].
The Subequana Valley and Middle Aterno Valley are part of a cluster of Quaternary tectonic depressions distributed along the current course of the Aterno River - here termed the Aterno basin system - which also includes the L'Aquila and Paganica-Castelnuovo-San Demetrio basins to the north, and the Sulmona basin to the south. They are located in the innermost sector of the central Apennines, in correspondence of the chain divide. These basins are hydrographically connected by the Aterno river, one of the moste important fluvial basins of the "Adriatic domain" which runs south-easterly along the eastern side of the Subequana basin and Middle Aterno Valley and flows to the Sulmona basin through the San Venanzio gorges, where it joins to the Pescara river. The depressions are bounded towards the NE by an active normal fault system that led the formation and the tectonic evolution of the basins [Falcucci et al., 2011].
The analysis of the early Quaternary geological evolution of this depression can represent a significant case study to refine the knowledge of the Early-Middle Pleistocene tectonic/environmental transition, especially in terms of timing, taking into account that uplift rate is defined as having been larger along the chain divide.
We integrated geological, geomorphological, paleomagnetic and radiometric dating with the $^{40}Ar/^{39}Ar$ method to reconstruct the morpho-stratigraphic setting of the Subequana Valley-Middle Aterno river system, defining the paleo-environmental features and chronology of the depositional and erosive events that have characterised the Quaternary geological and structural evolution of these basins.
In detail, a synchronous lacustrine depositional phase was recognised in the Subequana basin and the Middle Aterno Valley. Paleomagnetic analysis performed along some sections of these deposits exposed in the Subequana valley attested a reverse magnetisation, reasonably related to the Matuyama Chron. The lacustrine sequence of the Subequana valley passes upwards to sand and gravel, testifying for the infilling of the lake and the onset of a fluvial regime that displays a direction of the drainage towards the north, i.e. opposite to the present Aterno river flow. At the topmost portion of the lake deposits, two subsequent tephra layers were identified and dated by means of $^{40}Ar/^{39}Ar$ method, at ~890ka, for the lower tephra, and ~805ka for the upper one. It is worth noting that a "short" direct magnetisation event occurred just above the lower tephra, whose significance is still under investigation.
This data constraints the infilling of the lake in the Subequana valley very close to the Early-Middle Pleistocene transition. Subsequent to the infilling of the Subequana basin, a fluvial regime, characterised by a northward drainage direction – i.e. opposite to the current one –, was established. Then, after a strong erosional phase, the presence of a new coeval fluvial depositional phase within the Subequana Valley and the Middle Aterno Valley, with flow direction towards the south-east, indicates the formation of a paleo-Aterno.
We identified a further fluvial sequence, embedded within the lacustrine sequence through an evident erosional surface. These deposits are found at the northern part of the Subequana valley, where they laterally

pass to fluvial deposits that crop out at the southern part of the Middle Aterno river valley; this sequence shows a flow direction consistent with the current direction of the Aterno river. This morpho-stratigraphic setting, schematized in Fig. 1, indicates that after an intense erosional phase, which dissected the lake sequence, the Subequana-Middle Aterno river valley system has been hydrographically connected by the course of a paleo-Aterno river; this river flowed southerly, towards the San Venanzio gorges.

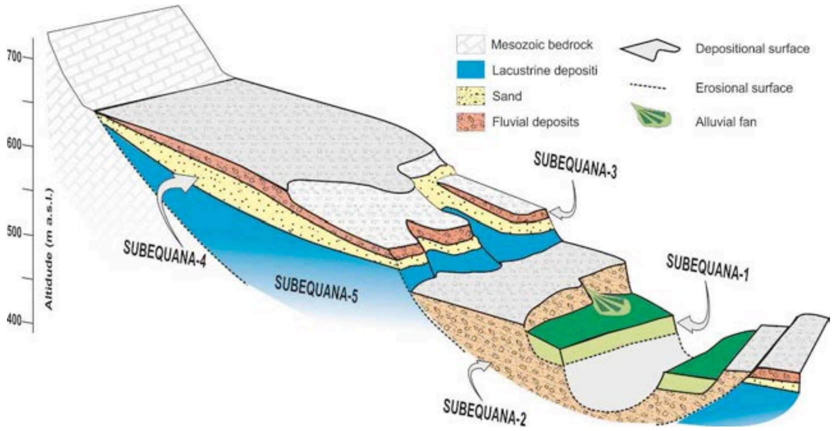

Figure 1. Quaternary morpho-stratigraphic setting of the Subequana Valley.

Such morpho-stratigraphic interpretation is corroborated by geological observations performed in the Sulmona basin. At the outlet of the Aterno river, we found slope derived breccias, commonly attributed to the Early Pleistocene, that lay over the bedrock. Their depositional geometry suggests that the breccias deposited when the Aterno river thalweg was not present yet, that is when the Subequana Valley was hosting a lake and no drainage was hydrographically connecting the valley to the Sulmona basin. Then, an alluvial fan body unconformably overlays the breccias; the fan, suspended over the Aterno river thalweg, was fed by a stream incision coinciding with the paleo-San Venanzio gorges. Lastly, a fluvial deposit is found embedded within the breccias and the alluvial fan, sourcing from the San Venanzio gorges as well. A tephra layer was found interbedded to the sedimentary body. The volcanic deposit was related to the “Pozzolane Rosse” eruption of the Colli Albani district, dated at 456±4 ka BP [Galli et al., 2010]. This fluvial deposit indicates the presence a paleo-Aterno river flowing from the Subequana valley.
Therefore, the described morpho-stratigraphic framework, and the obtained chronological elements constrain the capture of the endorheic hydrographic network of the Subequana valley-Middle Aterno Valley during a time span comprised between ~800ka and ~450ka. In this perspective, it is worth noting that endorheic hydrographic networks of other basins (e.g. the Leonessa basins) located along the innermost portion of the central Apennine chain were captured during the same time span by headward erosion of streams and rivers related to the “Tyrrhenian hydrographic system” [e.g. Fubelli et al., 2009]. This provides new elements for unravelling coupling between river incision potential and capability, and the Apennine chain uplift.

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