

# NEW DATA ON THE CHRONOLOGY OF THE VALE DO FORNO SEDIMENTARY SEQUENCE (LOWER TAGUS RIVER TERRACE STAIRCASE) AND ITS RELEVANCE AS FLUVIAL ARCHIVE OF THE MIDDLE PLEISTOCENE IN WESTERN IBERIA

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The stratigraphic units that record the evolution of the Tagus River in Portugal (study area between Vila Velha de Ródão and Porto Alto villages; Fig. 1) have different sedimentary characteristics and lithic industries (Cunha et al., 2012):

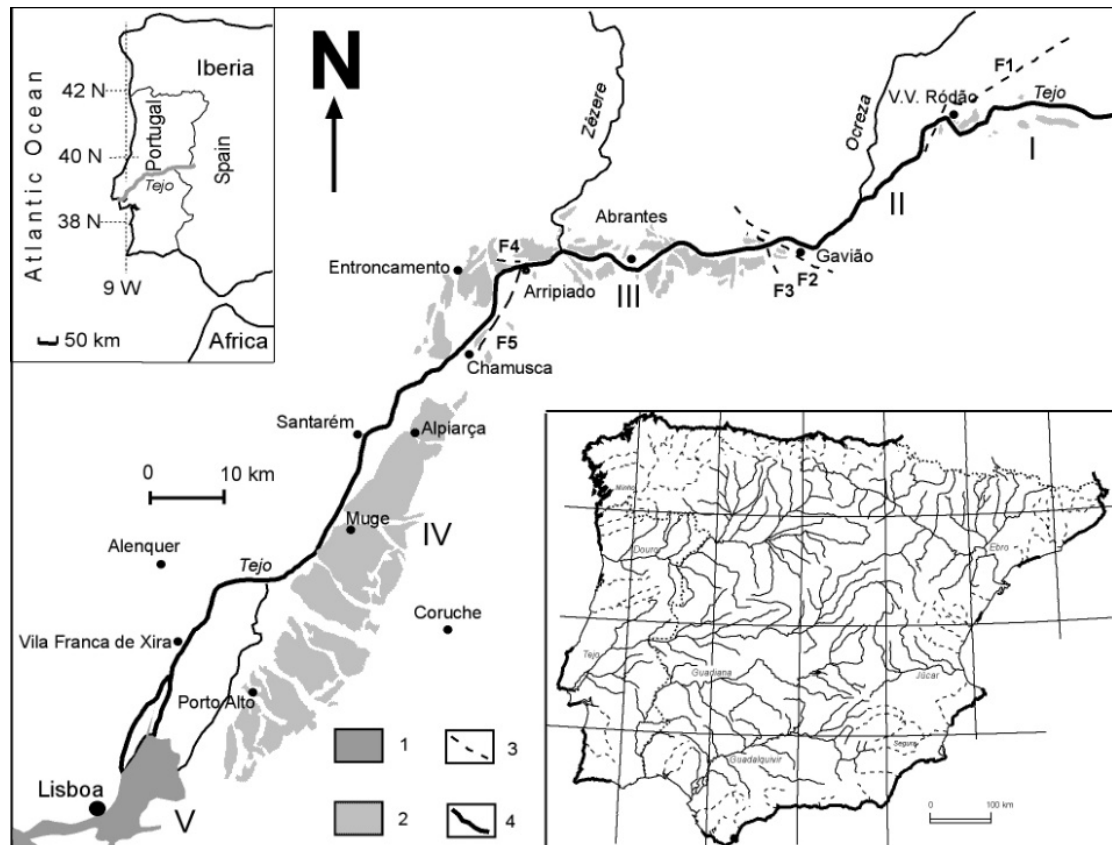
- a culminant sedimentary unit (the ancestral Tagus, before the drainage network entrenchment) – SLD13 (+142 to 262 m above river bed – a.r.b.; with probable age ca. 3,6 to 1,8 Ma), without artefacts;
- T1 terrace (+84 to 180 m; ca. 1000? to 900 ka), without artefacts;
- T2 terrace (+57 to 150 m; top deposits with a probable age ca. 600 ka), without artefacts;
- T3 terrace (+43 to 113 m; ca. 460 to 360? ka), without artefacts;
- T4 terrace (+26 to 55 m; ca. 335 a 155 ka), Lower Paleolithic (Acheulian) at basal and middle levels but early Middle Paleolithic at top levels;
- T5 terrace (+5 to 34 m; 135 to 73 ka), Middle Paleolithic (Mousterian; Levallois technique);
- T6 terrace (+3 to 14 m; 62 to 32 ka), late Middle Paleolithic (late Mousterian);
- Carregueira Sands (aeolian sands) and colluvium (+3 a ca. 100 m; 32 to 12 ka), Upper Paleolithic to Epipaleolithic;
- alluvial plain (+0 to 8 m; ca. 12 ka to present), Mesolithic and more recent industries.

The differences in elevation (a.r.b.) of the several terrace staircases results from differential uplift due to active faults.

Longitudinal correlation with the terrace levels indicates that a graded profile ca. 200 km long was achieved during terrace formation periods and a strong control by sea base level was determinant for terrace formation. The Neogene sedimentary units constituted the main source of sediments for the fluvial terraces (Fig. 2).

Geomorphological mapping, coupled with lithostratigraphy, sedimentology and luminescence dating (quartz-OSL and K-feldspar post-IRIR290) were used in this study focused on the T4 terrace, which comprises a Lower Gravels (LG) unit and an Upper Sand (US) unit.

The thick, coarse and dominantly massive gravels of the LG unit indicate deposition by a coarse bed-load braided river, with strong sediment supply, high gradient and fluvial competence, during conditions of rapidly rising sea level. Luminescence dating only provided minimum ages but it is probable that the LG unit corresponds to the earlier part of the MIS9 (ca. 335 to 325 ka), immediately postdating the incision promoted by the very low sea level (reaching ca. -140 m) during MIS10 (362 to 337 ka), a period of relatively cold climate conditions with weak vegetation cover on slopes and low sea level.



**Fig. 1.** Main Portuguese reaches in which the Tagus River can be divided (Lower Tagus Basin): I – from the Spanish border to Arneiro (a general E–W trend, mainly consisting of polygonal segments); II – from Arneiro to Gavião (NE–SW); III – from Gavião to Arripiado (E–W); IV – from Arripiado to Vila Franca de Xira (NNE–SSW); V – from Vila Franca de Xira to the Atlantic shoreline. The faults considered to be the limit of the referred fluvial sectors are: F1 – Ponsul-Arneiro fault (WSW–ENE); F2 – Gavião fault (NW–SE); F3 – Ortiga fault (NW–SE); F4 – Vila Nova da Barquinha fault (W–E); F5 – Arripiado-Chamusca fault (NNE–SSW). 1 – estuary; 2 – terraces; 3 – faults; 4 – Tagus main channel. The main Iberian drainage basins are also represented (inset).

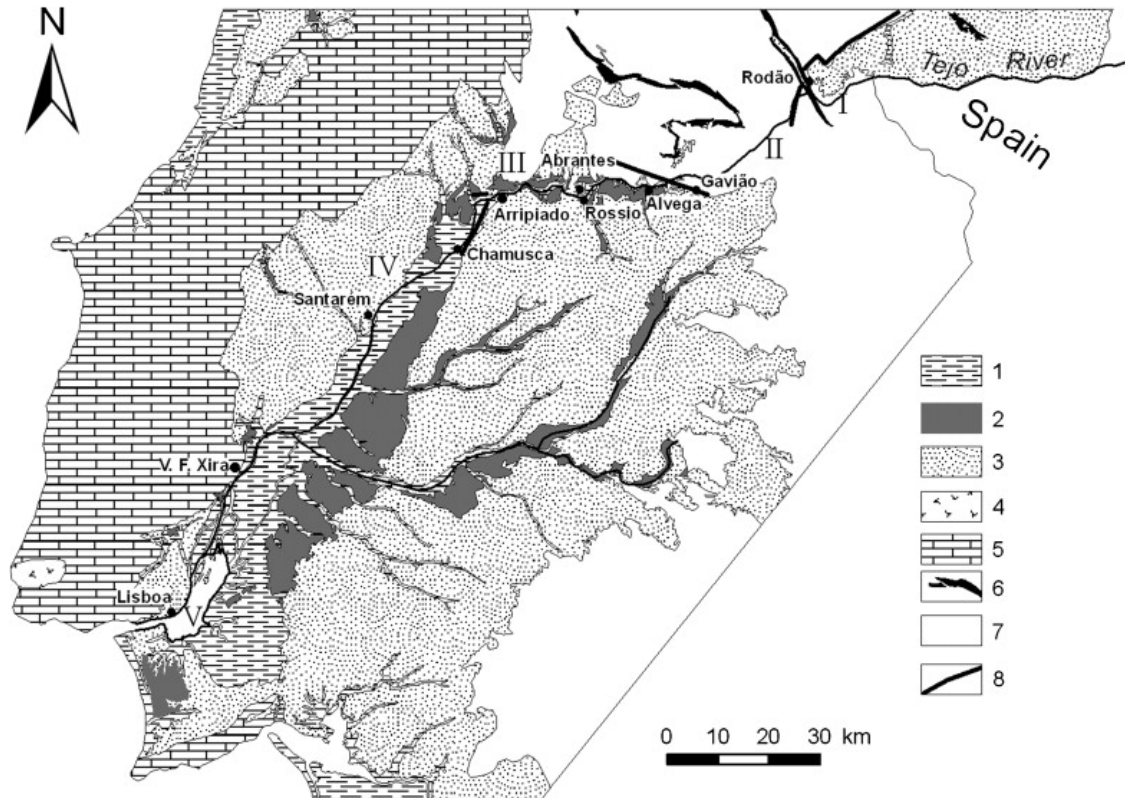
The lower and middle parts of the US unit, comprising an alternation of clayish silts with paleosols and minor sands to the east (flood-plain deposits) and sand deposits to the west (channel belt), have a probable age of ca. 325 to 200 ka. This points to formation during MIS9 to MIS7, under conditions of high to medium sea levels and warm to mild conditions.

The upper part of the US unit, dominated by sand facies and with OSL ages of ca. 200 to 154 ka, correlates with the early part of the MIS6. During this period, progradation resulted from climate deterioration and relative depletion of vegetation that promoted enhanced sediment production in the catchment, coupled with initiation of sea-level lowering that increased the longitudinal slope.

The Vale do Forno and Vale da Atela archaeological sites (Alpiarça, central Portugal) document the earliest human occupation in the Lower Tagus River, well established in geomorphological and environmental terms, within the Middle Pleistocene. The Lower Palaeolithic sites were found on the T4 terrace (+26 m, a.r.b.).

The oldest artefacts previously found in the LG unit, display crude bifacial forms that can be attributed to the Acheulian, with a probable age of ca. 335 to 325 ka.

The T4 US unit has archaeological sites stratigraphically documenting successive phases of an evolved Acheulian, that probably date ca. 325 to 300 ka. Notably, these Lower Palaeolithic artisans were able to produce tools with different sophistication levels, simply by applying different strategies: more elaborated reduction sequences in case of bifaces and simple reduction sequences to obtain cleavers.



**Fig. 2.** . Simplified geologic map of the Lower Tagus Cenozoic basin, adapted from the *Carta Geológica de Portugal*, 1/500000, 1992). The study area (comprising the Vale do Forno and Vale de Atela sites) is located on the more upstream sector of the Lower Tagus River reach IV, between Arriplado and Chamusca villages. 1 – alluvium (Holocene); 2 – terraces (Pleistocene); 3 – sands, silts and gravels (Paleogene to Pliocene); 4 – Sintra Massif (Cretaceous); 5 – limestones, marls, silts and sandstones (Mesozoic); 6 – quartzites (Ordovician); 7 – basement (Proterozoic to Palaeozoic); 8 – main fault. The main Portuguese reaches of the Tagus River are identified (I to V).

The VF3 site (Milharós), containing a Final Acheulian industry, with fine and elaborated bifaces) found in a stratigraphic level located between the T4 terrace deposits and a colluvium associated with Late Pleistocene aeolian sands (32 to 12 ka), has an age younger than ca. 154 ka but much older than 32 ka.

In the study area, the sedimentary units of the T4 terrace seem to record the river response to sea-level changes and climatically-driven fluctuations in sediment supply.

## REFERENCES

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