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Diana Chourio-Camacho

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Thesis abstract

LATE QUATERNARY INCISION DYNAMICS AND VALLEY BOTTOM GEOMETRY WITHIN THE SEINE RIVER CATCHMENT

Résumé de thèse

DYNAMIQUE D'INCISION DU QUATERNAIRE SUPÉRIEUR ET GÉOMETRIE DES FONDS DES VALLÉES DANS LE BASSIN VERSANT DE LA SEINE



Diana CHOURIO-CAMACHO^{1,2}

1 - INTRODUCTION

Within the sediment routing system, river valleys are part of the transfer zones that export sediments eroded in landscapes to their final deposition area in sedimentary basins. Thus, constraining the alluvial infill storage and its controls (e.g., tectonic deformation, climatic variations) on valley bottom geometry would allow to better understand the response time of the transfer zone in source-to-sink systems. The geometry of the alluvial infill is inherited from various episodes of incision and aggradation during valley formation in the Quaternary. These episodes led to the creation of strath terraces, which were abandoned along valley slopes. These terraces are used to infer incision rates. This PhD is a contribution to the understanding of valley evolution and alluvial deposition within the Seine River catchment during the Late Quaternary period and more precisely on the erosion geometry and alluvial infill at the bottom of the Seine River and its major tributaries such as the Oise, Marne, Aube, Yonne, Loing and Eure rivers (fig. 1).

2 - METHODS

This PhD combined (i) the dating of strath and bottom valley terraces based on Electron Spin Resonance (ESR) and Optically Stimulated Luminescence (OSL) methods and (ii) the development and application of a kriging method to reconstruct the large-scale geometry at the bedrock alluvium interface. Samples positioned at

different relative elevations (RH) above the maximum river incision level were collected and dated in 22 sites along the Seine River and its tributaries (Oise, Marne and Loing rivers) (fig.1). The alluvial infill geometry of the Seine catchment was determined using 4 817 boreholes from the Banque du Sous-Sols (BSS) that intersect the alluvium at the bottom of valleys. These boreholes were used to apply the kriging method at the scale of the Seine catchment using stochastic partial differential equations (SPDE) (Lindgren *et al.*, 2011; Fuglstad *et al.*, 2015; Pereira *et al.*, 2022; Grimaud *et al.*, submitted).

3 - AGES ALONG THE VALLEYS OF THE SEINE CATCHMENT

The results of ESR/OSL dating provide the chronology of fluvial evolution of the Seine catchment for the Middle and Lower Pleistocene. Ages of strath terraces and valley bottoms were tentatively correlated with the Marine Isotopic Stage (MIS, fig. 2). The obtained results suggest that at least two Marine Isotopic Stage are recorded MIS 6 and MIS 2 along the valley bottom of the Seine catchment, highlighting that MIS 6 deposits in valley bottoms were not entirely removed during the Weichselian glaciation MIS 2. Finally, the obtained ages determined in this PhD allowed to calculate incision rates upstream and downstream of Paris, highlighting a decrease of incision rates after ca. 600-400 ka.

¹ Sorbonne Université, CNRS, EPHE, UMR 7619 METIS, F-75005 Paris, France. *Email:* diana.chourio_camacho@sorbonne-universite.fr, ing.dianachourio@gmail.com

² PSL University/MINES Paris/Centre de Géosciences, 35 rue St Honoré, Fontainebleau, 77305, CEDEX, France.

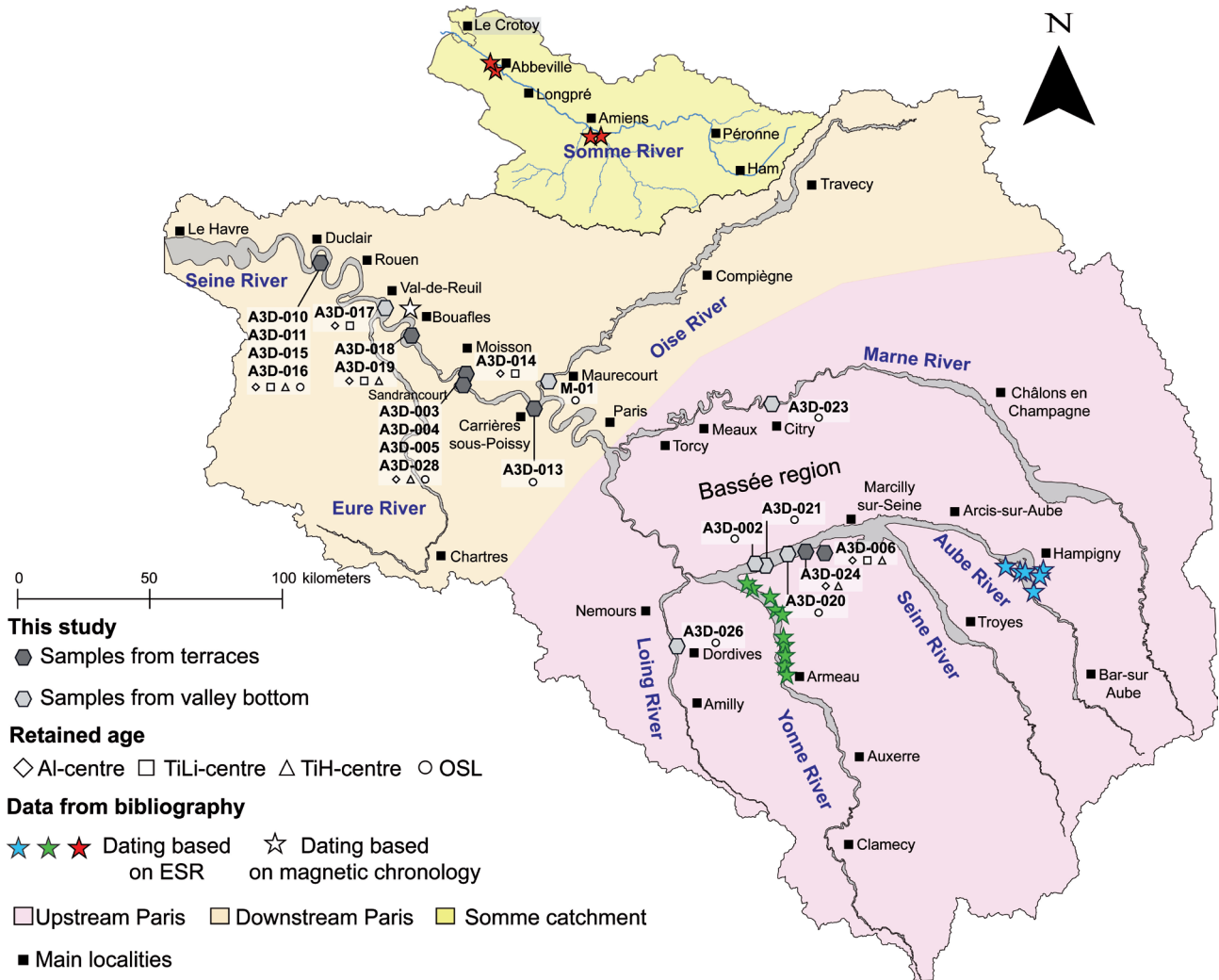


Fig. 1: Location of the Seine and Somme catchments and previous work with the location of chronology of fluvial deposits.

Fig. 1: Localisation des bassins versants de la Seine et de la Somme et travaux antérieurs portant sur la chronologie des dépôts fluviaux.

4 - GEOMETRY AND VOLUME OF ALLUVIUM IN THE VALLEY BOTTOMS

Alluvium thickness distributions estimated from the kriging show contrasted geometries along the valley bottom. The estimated thickness of the alluvial deposits varies from 0 to approximately 30 m. The thickest alluvium is observed in the estuarine area, after the Poses dam (fig. 3). In details, a great variability of alluvial fill geometry is observed with evidence for braided or meandering-like riffle-pool patterns. Total volume estimations (i.e., including backfill above the intact alluvium) is about 10.13 km³. The Paris area accounts for 32% of the total backfill volume in the catchment (fig. 3-b and c). Based on known erosion rates and assuming MIS 6 age for the valley bottom, these results suggest that the valley bottoms store about 1.2 % of the eroded material. This calculation does not consider smaller

scale valleys. Nevertheless, a minimum estimation of a 16.65 km³ can be proposed when including these valleys. It would therefore take about 3.4 ka to evacuate all the alluvium with the known sediment export rate within the Seine catchment (Castelltort and Van Den Driessche, 2003). Interestingly, this duration is similar to the one obtained in the Himalaya valley bottoms (3 ka; Blöthe and Korup, 2013).

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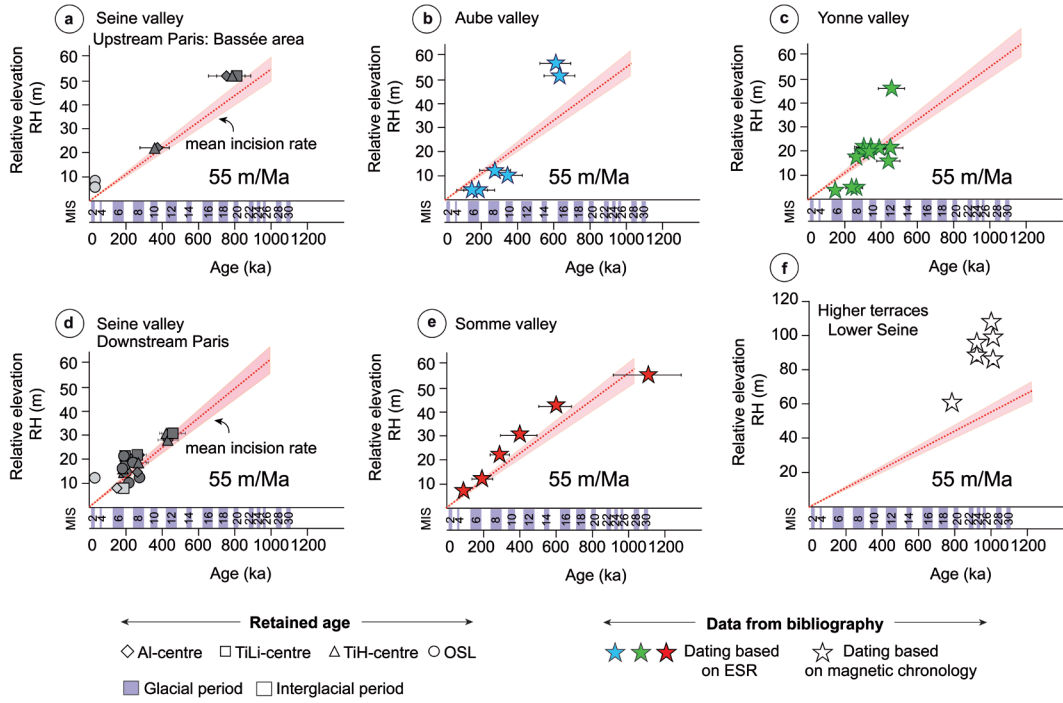


Fig. 2: Results of ESR and OSL dating methods.

(a) Samples of this study upstream of Paris. (b) Data available in the Aube valley (Voinchet *et al.*, 2015). (c) Data available in the Yonne valley (Chaussé, 2003; Chaussé *et al.*, 2004). (d) Samples downstream of this study of Paris. (e) Data available in the Somme valley (Antoine *et al.*, 2007; 2010). (f) Data available from higher terraces in the Lower Seine valley (Nehme *et al.*, 2020). Red line indicates the mean of incision rates of the Seine catchment at 55 m/Ma (Antoine *et al.*, 2007; 2010).

Fig. 2 : Résultats de méthodes de datations ESR and OSL. (a) Datation des échantillons de cette étude en amont de Paris. (b) Données disponibles dans la vallée de l'Aube (Voinchet *et al.*, 2015). (c) Données disponibles dans la vallée de l'Yonne (Chaussé, 2003; Chaussé *et al.*, 2004). (d) Datations des échantillons de ce travail en aval de Paris. (e) Données disponibles dans la vallée de la Somme (Antoine *et al.*, 2007; 2010). (f) Données disponibles sur les terrasses supérieures de la basse vallée de la Seine (Nehme *et al.*, 2020). La zone rouge indique la moyenne des taux d'incision du bassin versant de la Seine à 55 m/Ma (Antoine *et al.*, 2007; 2010).

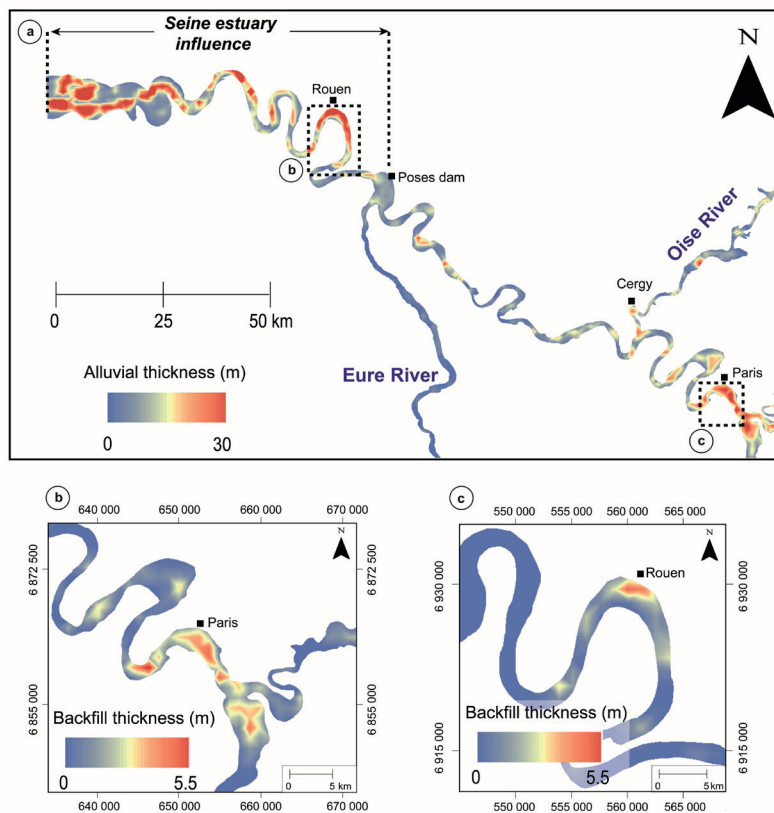


Fig. 3: Results of the SPDE kriging model downstream Paris.

(a) Applied to alluvium thickness between Paris and Le Havre. Applied to the backfill thickness near Paris (b) and Rouen (c).

Fig. 3 : Résultats du modèle de krigeage SPDE en aval de Paris. (a) Appliqué à l'épaisseur des alluvions entre Paris et Le Havre. Appliqué à l'épaisseur de remblais à Paris (b) et Rouen (c).

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