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Environmental History of Sediment Knowledge and Regulation in the Rhône River 19th- 20th Centuries

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Abstract : This project investigated the history of knowledge and management of sediment in the Rhone basin during the nineteenth and twentieth centuries. This was accomplished through the systematic review and analysis of hydrological, forestry, and engineering literature as well as relevant archival collections from national and departmental archives. The project has shed light on the emergence and development of two main models, which shaped in turn two distinct approaches to sedimentary management in the Rhône River basin. Both, however, converged on the effort to reduce the sediment transported by the Rhône.

Context and objectives

Sediments are essential component of river systems. Human interventions on rivers have altered sediment fluxes significantly over the last two centuries, often with detrimental consequences on rivers' morphology and ecology as well as on coastal land, including the retreat of many the world's deltas. The size and scope of these physical changes is tightly linked with economic growth, technological change, and political choices and conflicts over multiple spatial and temporal scales. In order to make sense of the morphological alterations of river systems and the responses to these changes (or lack thereof) it is thus essential to investigate the mutual influence between social drivers and geomorphic processes.

This project aimed to investigate the historical dimensions of sediment transport in river systems in the case of the Rhône River, thus contributing to the first priority theme of the AAP 2020-21 "Trajectoire géo-historique et ruptures". By the time the project was designed, there was already a great wealth of excellent scholarship on the geo-history of the Rhône River development and an important part of this scholarship was produced within the framework of the OHM Vallée du Rhône. This is also true of sediment fluxes, including a clear outline of drivers of change and their timing. Compared to the abundance of information on the river's geo-history however, we knew relatively less about how sediments were factored in (knowledge) and managed (regulation) by the actors of the river's domestication. The project therefore focused not on quantitative and geomorphological evidence on sedimentary changes in the Rhône, but on the ways of understanding and managing the sediment of the Rhone river.

Methodologies

The project adopted a historical methodology, based upon archival and library research, and the analysis of written sources. The first axis of the project concerned the history of sediment knowledge, reconstructed through learned literature on rivers from the late eighteenth to the early twentieth century. This literature, which often covers multiple river-related topics, has been

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analyzed looking specifically at the Understanding of sedimentary processes it revealed. Most specifically, the project has looked at handbooks and treaties of river management, river hydrology, reforestation and torrent correction. Alongside these sources, moreover, the project also investigated at the nineteenth century and early twentieth century series of *Annales des Ponts et Chaussées* (1833-1940), *Annales forestières* (1842-1865), *Revue des Eaux et Forêts* (1862-1940), *Génie Civil* (1880-1940), and *Houille Blanche* (1902-1940).

The second axis focused on the study of sediment management, by looking at how the theories and models developed and discussed in the learned literature and specialized journals of engineers and foresters shaped and was shaped by the management practice on the ground. To do so, the project focused on the records of the Service Special du Rhône, at the Archives Departementales in Lyon, as well as on records on the public works service as well as on forest and mountain restoration management kept at the National Archives in Paris. The Service Special du Rhône was indeed the main public institution charged with managing the main stem of the river and as such directly concerned with sediment. The forestry service, on the other hand, was entrusted with managing sediment production in the upstream tributaries of the rivers. The project has specifically looked at sediment management actions and controversies that were documented in these records between the early nineteenth and the early twentieth century.

Main results

Treatises on river management were concerned with sediment since the Early Modern period. It is only at the end of the eighteenth century that the idea of sedimentary continuity between mountains and plains start to be associated to the will to govern sediment. While it has a longer tradition in Italy, in France, the first systematic formulation of this idea is present in the treatise by Ponts et Chaussées engineer Jean-Antoine Fabre. It was articulated in the most coherent form by another Ponts et Chaussées engineer, Alexandre Surell forty years later. While Surell is remembered for its plea for sediment management in mountain soils, we have found that his proposal was in fact ultimately aimed at governing sedimentation at the scale of the entire Rhône River basin, in the name of navigation improvement and flood control. Both Fabre and Surell were indeed claiming that flooding was the outcome of aggradation due to sediment excess. This was in turn the consequence of upstream erosion. The management of rivers thus demanded to intervene upstream as much as downstream.

Ponts et Chaussées engineers, however, remained for the most part skeptical about aggradation and did not espouse such view of sediment continuity. Instead, the debate among engineers favored localized interventions of sediment management aimed at controlling erosion and deposition in the river channel to clear its thalweg. These debates are thoroughly documented in the *Annales des Ponts et Chaussées*, which recurrently published papers that were in part or entirely concerned with sediment. The challenge of sedimentary deposits that extended the delta and clogged the waterway led to the first experiments to estimate solid transport and the rate of deposition and sea filling by the sediments of the Rhône. In 1749, Bélidor had already estimated the rate of progradation of the Rhône delta at over 100 meters per year. A century later, Alexandre Surell estimated anew the rate of progradation and envisioned to improve the mouths by narrowing the main channel and concentrating the flow.

These interventions were not only theorized, but also put into practice most notably by the engineers working at the Service Special du Rhône, as documented in the records of the Service Special kept at the Archives departementales de Lyon and, in part, at the Archives Nationales in Paris. Established in 1836, this service aimed to improve navigability (not so much flooding, not at the beginning) by controlling solid transport. Over the decades, the Special Service perfected methods to deepen the river by narrowing its channel and flushing out the sediments. The outcome of these methods were the well-known «Casiers Girardon ». The casiers, however, had in fact been developed earlier by Girardon's predecessor Jaquot. The casiers, moreover, were only the last iteration of technologies developed by the Service Special to control erosion and deposition for much of the second half of the nineteenth century. These techniques were aimed at making the river run clear to the advantage of navigation and the success of their action was measured on the gradual but visible reduction of sediment in the riverbed. This is amply documented in archival records of the Service Special.

Fabre's and Surell's vision of basin-scale sediment continuity and river management through mountain soils, while mostly ignored or rejected by fellow Ponts et Chaussées engineers had a long-lasting influence among foresters. As documented in the debates on the *Annales Forestières*, *Revue des Eaux et Forêts* and, to an extent, in records kept at

the Archives Nationales, members of the forest administration embraced with conviction sediment continuity and aggradation. They consistently claimed that only through basin-scale reforestation it would be truly possible to govern sediment downstream. In their approach, curbing sediment production through massive upland reforestation had to become a core principle of river management. This principle was at the hearth of the French forest law of 1860, which initiated a century-long state-funded program of sediment reduction, combining reforestation with other sediment-reducing techniques such as check dams. While the 1860 law and the subsequent legislative interventions on the matter focused only on upstream reaches of rivers, the actors of these interventions explicitly framed their actions as ultimately aiming at governing sedimentation at the scale of the whole river basin, both in published treaties such as *Costa de Bastelica*, and in reports such as that by forester Charlemagne from the Isère department (AN, 19890610/36). In many cases, they did so in explicit opposition to the approach of engineers, which they considered ultimately ineffective because focused only on downstream consequences and not on upstream causes.

The project also observed another significant difference between the approach of foresters and that of engineers during the nineteenth century. Foresters shared for the most part an entirely negative vision of sediment, which they considered solely a nuisance. Engineers, on the other hand, would typically argue that while coarse sediment was an impediment for navigation fine sediment was beneficial to agriculture. It should thus not be eliminated altogether from rivers. Engineers of the *Service Special du Rhône* would also be attentive to the consequences of erosion and deposition on arable land along the river and defended an approach to sedimentary engineering which sought to consolidate land – if not create new one – along the river banks to the advantage of agriculture. This more nuanced view of sediment among engineers, however, seems to recede to the background in the twentieth century.

By the turn of the twentieth century, the mode of action of both corps had evolved in technical means, but it remained based on the same premises: the need to make the river run clear. Engineers continued to do so along the river channel, although increasingly relying on mechanical dredging, while foresters continued to do so in the uplands of the Rhone tributaries, increasingly relying on check dams more than on forests themselves. In both cases, they were operating on an understanding of sediment which had emerged and consolidated in the nineteenth century and reproducing a management approach and geography which had also consolidated in that period. We believe that the history of this epistemologies and the practices that they justified are important to understand the geo-history of the Rhône River basin and its sediments.

Perspectives

This project opened two main perspectives. On the one hand, this project has laid the foundation for a larger study of sediment knowledge and management in the Rhône River in the nineteenth century. By charting the existence of two epistemological traditions and showing the centrality of sediment management in engineering and forestry practices, it paves the way for a more systematic and comprehensive study of such practices at the scale of the entire basin of the Rhône. The *Service Special du Rhône* operated in four local sections, each with its own dedicated archive. A systematic investigation of these archives could allow us to reconstruct sediment management practices across the whole nineteenth century and for the entire main stretch of the Rhône. Such study could be combined with the study of two or more selected districts of reforestation and mountain restoration within the basin of the Rhône's tributaries like the Isère and the Durance.

Furthermore, this study opens new path of investigation into the way the management and knowledge practices of public works engineers and foresters have been taken up – and possibly revised and/or transformed in the twentieth century. This would entail on the one hand an investigation into the theory and practice of twentieth century *Restauration des Terrains de Montagne* with a focus on the Rhône River basin. On the other hand, it would entail a study of the main river management agency of the twentieth century, that is, the *Compagnie Nationale du Rhône*. This would amount to writing a sedimentary history of the Rhône River basin, hence revising deeply the existing historiographical accounts on the river by foregrounding the geomorphological dimension of river management by state and non-state actors.

Operational contributions

- Reinforce and expand our knowledge of the history of the basin by shedding light on a little-known aspect.
- Reconstructs the emergence and consolidation of a vision of sediment as nuisance to be removed from rivers.
- Allows to better understand the deep roots of sediment management approaches that have shaped the morphology of the Rhone.
- Suggests the need for a shift toward a different sedimentary culture – of sediment as an ecological resource - by all actors involved in sediment management.

Publications

- *Souquet Titouan, (2022). Au-delà de l'eau. Le « souci sédimentaire » dans l'aménagement du bassin du Rhône (1835-1940), Memoire de M2, IEP Paris, 2022.*
- *Souquet, Titouan, Santiago Gorostiza, and Giacomo Parrinello (2022). "A War on Sediment? Understanding and Managing Solid Transport in the Rhone Watershed (1840-1920)." International Symposium of LabEx DRIIHM 2022. https://hal.science/OHM-VALLEE_DU_RHONE/hal-03754599v1*

Metadata sheet

- *Textual archive dataset on sediment knowledge and regulation in the French Rhône River (early 19th c. - early 20th c.) ([Lien URL vers la fiche de métadonnées](#))*