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Controls on initial oxbow sedimentation as observed within recently cut-off channels of the Ain River, France

Pauline Dieras (1), Herve Piegay (2), and Jose A. Constantine (1)

(1) Cardiff University, School of Earth and Ocean Sciences, Cardiff, Wales, United Kingdom (DierasP@cardiff.ac.uk), (2) CNRS, UMR 5600 EVS, Site ENS - LSH, Lyon, France (herve.piegay@ens-lyon.fr)

Understanding the processes controlling the evolution of oxbow lakes is essential for ensuring their sustainable presence as aquatic habitat within the floodplains of freely meandering rivers. Oxbow persistence as aquatic habitat depends upon the initial open-water volume they inherit from their formation; oxbows with a large open-water volume can persist as aquatic habitat for centuries. The initial open-water volume of an oxbow depends on the degree of bed-material deposition that occurs during the transition of the oxbow from a cut-off channel with continuous hydraulic connection. The limbs of oxbow lakes are often disconnected from the river by bed-material deposition, forming wedges of sediment, or plugs, just after cut-off. Sediment plugs are therefore a key feature for determining oxbow lake longevity because they act as a barrier preventing the infilling of lakes by further bed-material transport, notably once they are encroached by vegetation. Despite the importance of sediment-plug formation to the initial oxbow volume, however, we understand little about this early stage of oxbow lake sedimentation. To improve our understanding of this important process, we have investigated sediment-plug formation at two distinct oxbows (Lake Mollon and Lake Martinaz) on the floodplain of the Ain River, France. Both lakes cut-off within the last ten years and are separated by a distance of just 1 km. The lakes are distinct in that one exhibits a much more advanced terrestrialisation (near complete conversion of aquatic habitat into permanently sub-aerial habitat) than the other. In order to assess sediment aggradation, we conducted a topographic survey of both sites in the summer of 2010 and compared these data with a longitudinal profile taken at the sites in 1999, cross sections taken at the sites in 2004, and Lidar data from 2008. Aerial photographs were also used to observe lake geometry and channel change at a yearly scale. Results indicate significant differences in the extent of coarse-grained sedimentation within the limbs of each lake. Lake Mollon exhibits a much more advanced terrestrial stage, and our study shows that a volume of 3500 m3 of sediment was deposited within the lake between 2008 and 2010 (average annual bedload transport is 24000 m3). On the contrary, about 2500 m3 of sediment was eroded from the entrance of Lake Martinaz during the same period. The difference in plug formation between the two oxbows is due to the difference in the upstream angle between the former and the new channel, called the diversion angle. It is significantly lower for Lake Mollon than for Lake Martinaz; 10° for the first and 50° for the later. The high diversion angle of Lake Martinaz has therefore limited plug extension, and it has preserved a more significant open water area than the one of Mollon. In conclusion, we have found that two oxbow lakes from the same location and thus for which hydrology and river sediment load are identical can have very different sedimentation histories when only diversion angles differ. The initial geometry of oxbows and also their location relative to the river channel are critical factors for explaining the life span of such perifluvial aquatic ecosystems.