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Chronology of Fluvial Sediments in the Loire River Valley over the Past 8500 Years

Philippe Négrel (p.negrel@brgm.fr), **Wolfram Kloppmann** (w.kloppmann@brgm.fr), **Manuel Garcin** (m.garcin@brgm.fr) & **Denis Giot** (d.giot@brgm.fr)

BRGM, Water Department, 3 Avenue C. Guillemin, 45060, France

Introduction

The impact that lithology and morphology on the one hand, and climate and human activity on the other have on sediment yield and erosion rates in catchments has long been a matter of debate. The most recent studies consider solid matter from major rivers as a key to deciphering general laws of continental erosion. Residual products from chemical and mechanical weathering (i.e. suspended matter and sediments) are transported by rivers and streams and most of this matter is then stored in alluvial valleys for tens to thousands of years. The present study focuses on the distribution of certain trace elements (V, Sr, Pb) together with strontium and lead isotopes in the labile fraction of sediment cores from the middle Loire alluvial plain spanning from present-day to 8500 y. B.P. (Garcin et al., 1999). This study aims to improve the knowledge of the functioning of the catchment basin with respect to human impact. Material and methods The Avaray Valley is situated in the middle course of the Loire River (1010 km long, catchment area of 117,800 km^2) where it incises Aquitanian lacustrine limestone and overlying Holocene alluvium. Geochemical analyses have been performed on 30 samples collected in the M25B core (from 0.8 m [lower limit of agricultural reworking] downwards) that intersects 6.3 m of clays and peats in an oxbow infill. In the present study, the labile fraction was extracted from the sediment load using cold 0.2N HCl (Négrel et al., 2000), a procedure that releases the total inventory of non-residual trace elements, i.e. those associated with hydrous Fe-Mn oxides, those adsorbed on clays and those occurring in carbonates and sulphides in the sediment load. The proportion of the labile fraction (AEM) ranges from 6 to 52% in the M25B core, which is in agreement with values from present-day suspended matter carried by the Loire River (8 to 47%, Négrel et al., 2000). The fluctuations of AEM correlate with the proportion of calcite (determined by XRD), although part of the labile fraction may be derived from the leaching of clays.

Trace elements

Major fluctuations in trace element contents (Mn, V, Rb, Sr, Pb) are observed. The relationships between the labile fraction and trace elements, and amongst the trace elements, provide hints as to the: (i) Carrying phase: Fe-Mn oxyhydroxides act as the principal transport medium for trace elements in the labile fraction during the Holocene, analogous to the present-day suspended matter carried by the Loire River (Négrel et al., 2000), (ii) Silicate weathering index: V, Rb and lead originate from weathering processes of the silicate basement and can therefore be used as a silicate weathering index in the palaeo-fluviatile record. The mechanisms are further constrained by lead isotope results. (iii) Discrimination of input: Sr cannot be used directly to trace the silicate weathering, but the Sr isotopes may reflect variations in the contribution of two main end-members, i.e. hydrous Fe-Mn oxides and carbonates. Isotopic systematic $^{87}Sr/^{86}Sr$ ratios in AEM from the sedimentary record fall into two fields. The first, where AEM is constantly low at about 10% and the $^{87}Sr/^{86}Sr$ ratios are highly dispersed around 0.7086 to 0.710, corresponds to the Fe-Mn hydroxide end-member. The second, where AEM reaches the highest values (20-50%), and the $^{87}Sr/^{86}Sr$ ratios fluctuate least (around 0.709-0.7095), is related to the carbonate end-member. The second end-member, clearly different from present-day carbonates (Négrel & Grosbois, 1999, Négrel et al., 2000), may reflect both authigenic and detrital origins. The authigenic origin would require a low $^{87}Sr/^{86}Sr$ that may be linked to groundwater input. Lead in the sedimentary record originates mainly from silicate weathering. The carbonate, poor in trace elements, only produces a "dilution" of the crustal signature. The two crustal end-members, which act as the lead source, are the granites and basalts from the Massif Central. In a $^{208}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ graph the data define a general trend associating the basalts, Cretaceous carbonate rocks and granites. This relationship demonstrates that most of the AEM lead is derived from granite and basalt weathering according to a binary mixing model.

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