Geochemical contribution to study of chemical and mechanical weathering of a Mediterranean watershed: The Hérault Basin, S France

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Rock and soil erosion by rainwater and rivers are the major geological processes which modify the earth's surface morphology [1]. One way to estimate the current erosion rates of watersheds is to study of the loads transported by rivers to the oceans[2]. The transported load can be subdivided into the dissolved load (<0.2 μm) which results from the chemical weathering and the particulate load (>0.2μm) which originates from the mechanical erosion processes.

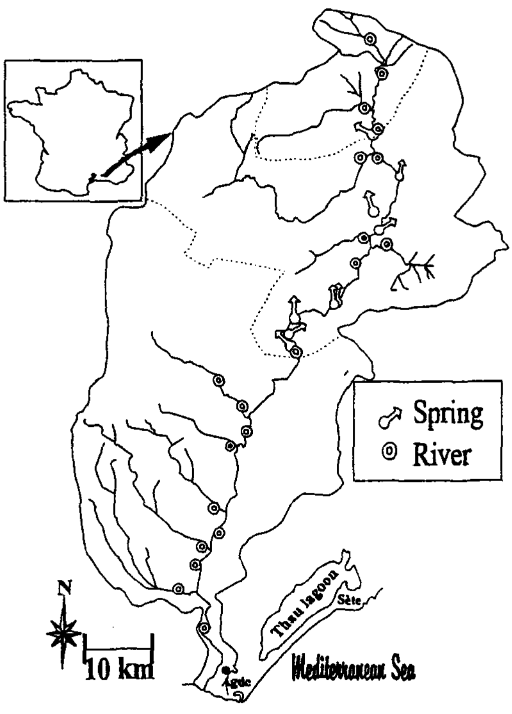

FIG. 1. Sampling map ot the Hérault watershed.

This study is only one part of a global geochemical approach on the Hérault watershed carried out to better understand the complex relations between groundwaters and surficial ones.

Studied sites and geochemical tools

The Hérault basin measures 2500 km^2 and can be divided into 3 sub-basins according to the contrasted lithologies: the Palaeozoic granite, schists and dolomites to the north (300 km^2), the Jurassic and Cretaceous highly karstified limestones in the middle part (700 km^2) and the Tertiary-Quaternary alluvial plain downstream to the south (1500 km^2)(Fig. 1). Six sampling campaigns have been performed in various hydrological conditions (high, low flows and flood) at 10 sites along the Hérault stream, on its 9 main tributaries and 16 karstic springs in the middle part.

Analyses have been done on both particulate and dissolved loads. Major and trace elements (especially alkalis, alkali-earths and heavy metals) have been analysed by Capillary Ion Electrophoreses and ICP-MS respectively. Sr and Pb isotopes were measured, after chemical separations, on a VG Sector Mass Spectrometer. Stable isotopes of the water molecule ($\delta^{18}O$, δD) were also analysed.

Results and discussion

We have established the flux-discharge relations, according to the six sampling campaigns, for various dissolved components. It was also established for SPM through the sampling which was done in subsurface and only one liter of water was taken, these two reasons probably induce an underestimation of the particulate transported load. These relations allow to extrapolated our data to the annual mean discharge and thus to estimate the mean annual chemical and mechanical erosion rates of each part of the watershed.

The mean suspended transported material flux at the outlet of the Hérault watershed (2500 km^2) is 675 g/s which corresponds to 8.5 $T/km^2/year$. This solid exported rate is in very good agreement with the rate of exported material calculated in the Congo watershed [3] and of the same order of magnitude as the mean value estimated at the European scale using the measured sediments fluxes [4].

The global dissolved Ca exported at the outlet of the watershed reaches 3080 g/s i.e. 39 $T/km^2/year$ and is of the same order of magnitude as fluxes of small [5] or large [3] basins. The upper sub-basin (300 km^2), the assimilation of the basement to the granite alone (CaO = 2.21%), gives a mean Ca flux about 21.5 $T/Km^2/year$ which corresponds to a chemical erosion rate of 500 μm/year (d~2.7) i.e. higher than one order of magnitude than the erosion rates proposed for granites in continental climate [6]. This rate is probably overestimated because the basement is not only composed of granite. So it seems that an estimation based on Na flux would provided a better approximation for this upper sub-basin. The mean Na_2O concentration is 4.4% and the Na flux gives a chemical dissolution rate about 34 μm/year of the same order of magnitude of values proposed by Small *et al.*[6]. In the middle part of the basin, the karstified limestones (700 km^2) can be assimilated to $CaCO_3$ and thus chemical erosion estimated according to Ca Flux. To evaluate the Ca flux from this sub-basin, we have subtracted the Ca flux coming from the upper Palaeozoic sub-catchment. The value 1307 g/s (Fig. 2) is equivalent to a chemical dissolution rate of 59 μm/year. A smaller sub-catchment also draining limestone gives a chemical erosion rate of 46 μm/year in good agreement with the previous value. The same calculation cannot be performed on the third sub-basin (alluvial plain, 1500 km^2) as the lithologies are very complex and different and this part of the watershed is the more anthropized one.

The six sampling campaigns in various hydrological conditions give a good vision of the behaviour and the functioning of the Hérault watershed. In this way, we try to establish a dynamical scheme based on these six sampling campaigns and the various geochemical tools: major and trace elements coupling with Sr isotopes and water molecule stable isotopes. We have constrained geochemical endmembers more or less variable according to the hydrological conditions and in good agreement with previous field observations. In this way, in the middle part of the basin (Mesozoic cover), the karstic springs indicate a mixing between three geochemical endmembers (Cambrian dolomites, Jurassic dolomites and Jurassic-Cretaceous limestones). Up to now, because of the very complex aquifers geometry, we could quantify the various mixing proportions in term of mixing of geochemical signatures and not in terms of mixing of water masses.

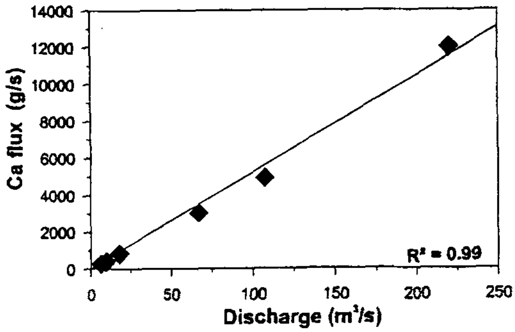

FIG. 2. Ca flux-discharge relation in the Mesozoic sub-basin.

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