6 The Geochemistry of the Paraná River: An Overview

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6.1 Introduction

River basins are not inert continental features. Moreover, it can be said that rivers have a life, and their evolution is usually predictable. In biological terms, for example, rivers are processors of materials as the biota they contain take up, convert, use, and release resources that come to them. In other words, rivers are active biological systems that metabolize the organic matter they transport. From a geological point of view, rivers transport sediments and solutes whose dynamics is also determined by a set of complex interacting variables, such as lithology, climate, and relief. Consequently, the water that reaches a river's mouth is far different, both qualitatively and quantitatively, from the water that entered the system as rain or snowfall. Summarizing, the chemical signatures of rivers are reflections of complex natural and interdependent relationships involving the chemistry of precipitation, the weathering of minerals, the cycling of vegetation, and the evolution or history of its water. The recently published geochemical treatise (Drever 2005) is a major step towards the elucidation of such complexities.

Not only natural factors intervene in the functioning of river basins. Human activities also affect rivers in many ways: directly, through dams, pollution, or eutrophication; indirectly, through the use of the land; and in much more subtle ways, by means of global warming and acid rain. Built to foster increased development, the Upper Paraná River, for example, has in operation about 130 reservoir dams (dam height >10 m), of which 14 are considered "major dams" (dam height >150 m) (Ravenga et al. 1998) that modulate its discharge, sequester sediments, and alter its biogeochemistry.

In this chapter on the Paraná’s geochemical character, we wish to overview what we consider the major aspects that determine the geochemical nature of a river, probing into its natural functioning: the dynamics of its dissolved components, the chemical imprint of weathering, the provenance of its sediments, and its more conspicuous biogeochemical nature. In this manner, we expect to contribute to the better understanding of its natural functioning.
as well as on the impact of anthropogenic alterations, which have been occurring in the Paraná River with increasing rate for the last 40 years.

### 6.2 Geological and Hydrological Framework

The Paraná River drainage basin (Fig. 6.1), with an area of $2.783 \times 10^6$ km$^2$ (Tossini 1959), is the most important river system in the Río de la Plata basin because it accounts for about 88% of its drainage area ($3.170 \times 10^6$ km$^2$; Tossini 1959) and almost 80% of its total discharge to the SW Atlantic Ocean ($\sim 21,500$ m$^3$ s$^{-1}$). The Paraná’s drainage covers almost the entire South American continental width at 21°S. Its northernmost water sources are located in Brazil, at ~15°S, and ~45°W, whereas the western water sources are close to the Andes, at ~65°W, in the headwaters of the Pilcomayo and Bermejo Rivers. The Paraguay’s upper catchments are in the Gran Pantanal (Brazilian Mato Grosso, ~15°S, and ~55° to ~60°W). The Salado (or Juramento) River is a middle-sized tributary with sources by the Eastern Cordillera that joins the Paraná in its middle course. Finally, the Carcarañá River has its headwaters in the Sierras Pampeanas of Córdoba, ~33°S, and meets the Paraná north of the city of Rosario, in the lower reach. Several authors have considered the geomorphological features of the Paraná River (e.g., Iriondo 1972, 1988; Orfeo and Stevaux 2002; Thorne 2002). Araújo et al. (1999) examined the characteristics of the Guaraní aquifer system, which is closely associated with the Paraná drainage basin. More information on other physical features of the Paraná River can be found elsewhere in this volume.

As it happened with the remaining of South America’s major drainage nets, the Paraná’s developed after South America’s separation from Africa, 130 My ago (Early Cretaceous). In the initial syn-rift phase, extension was accompanied by strike-slip faulting and block rotation; subsequent extension went together with the extrusion of very large volumes of basaltic lava (i.e., the Serra Geral Formation), in the Late Cretaceous (Potter 1997; Potter and Hamblin 2006). Clearly, such extended flood basalts and the adjoining Cretaceous sandstones are the most conspicuous features of the Phanerozoic mantle that covers a significant portion of the Río de la Plata drainage basin (Fig. 6.1). Another outstanding attribute is the thick Quaternary layer of sediments that extends from Mato Grosso and the Gran Pantanal, in the north (~18°S), to the loess-mantled Pampa plains in the south (~35°S). The headwaters of the Bermejo and Pilcomayo Rivers exhibit thick beds of marine and continental sediments as well as outcrops of Precambrian metamorphic rocks, along with volcanic rocks of Quaternary age. Steep slopes, along with the abundance of friable sedimentary formations in humid to semiarid climates, are crucial factors determining the high sediment load that has been recorded mainly in the Bermejo drainage basin. The most important geologic characteristics are schematically presented in Fig. 6.1.