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Geochemical Characteristics of River Fluxes in the Cuyuni Tropical Basin (southern Venezuela): Importance of the Organo-colloidal Control on Elements Behavior

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The Cuyuni basin

The Cuyuni basin located in the South-Eastern part of Venezuela in the Guyana Precambrian shield extends in a large 140.000 Km^2 area. The vegetation cover in the basin is typical tropical rain forest and savanna. Population density is low and limited to some mining areas. Thus this basin offers the opportunity to analyze the elements behavior in conditions with limited anthropogenic effects.

Two geologically distinct formations are found in the basin: large granitic areas with intercalated greenstone belts at the north and west side (Supamo complex, Pastora Supergroup) and sedimentary formations composed principally of quartz sandstone in the southern part (Roraima Formation).

Fifteen sampling points located along the main tributaries and the main river channel were chosen to get a good estimate of the water compositions of the basin. Major and trace elements were analyzed in filtered water and suspended load separated using a 0.22 μm millipore membrane.

Suspended material load

The two main geologically distinct sources of suspended load material (north-west and south) can be distinguished using ratios of elements known as the less mobile ones along weathering processes (such as Ge/Al, Ti/Al and Zr/Nb).

The intensity of the weathering was evaluated on the suspended material using "weathering indexes" calculated as the ratio (Upper Crust normalized) of a relatively immobile element to a highly mobile one ((Th/Ba)ucc, (Sm/Ba)ucc). In this respect interesting observations are done: (a) significant differences were found between the weathering indexes of the north-west and the southern zones. This difference is not related to source effects. (b) significant variations of the calculated weathering indexes are observed as a function of the rivers dissolved organic content (DOC). As shown later, these variations may be indicative of elements redistribution between the suspended and dissolved phases in the river medium as a consequence of complexing effects of organic colloids.

Dissolved load

The waters display relatively high DOC (Dissolved Organic Carbon) contents (from 1.4 to 7.8 mg/l) and are characterized by low pH ranging from 3.4 to 6.4. These low pH values can be related to the presence of organic matter. The Na, Cl contents of most of the rivers are similar to those of other tropical rivers such as the Congo and Amazon. However two of the rivers, the Yuruari and the Botanamo, display fairly more elevated contents. These rich Na and Cl contents can be related to hydrothermally enriched zones generally found in greenstone belts (evaporites are unknown in this area).

Suspended/Dissolved load compositional relationship

The proportion of the elements in the dissolved load relative to the total material load is highly variable along the distinct rivers of the basin, with extraordinary elevated values in some rivers (around 90% for most elements) to lower proportions (40%-20%) in other rivers. Dissolved/Total element ratio are not related to the source. However, a linear relationship is found for a large range of elements between the Dissolved/Total load ratio and the SS/DOC ratio (SS= suspended material content in solution) among the various rivers of the basin. Whatever its exact significance, this simple relationship indicates the importance of the organo colloidal control on the elements behavior. It is interpreted as indicative of the existence of adsorption or complexing equilibrium reactions of the type:

SS-M + DOC = DOC-M + SS POC-M + DOC = DOC-M + POC

where M represents a cationic species, SS-M, DOC-M and POC-M represents adsorbed or complexed species and POC represent the particulate organic content. Formation of ternary organic colloidal complexes such as SS-DOC-M can be also advocated.

As many other elements, the distribution of the rare earth elements (REE) between the dissolved and the particulate phases in the river waters is function of the SS/DOC ratio (figure 1). In agreement with the observed REE contents in other organic rich rivers (Congo, Amazon), the La dissolved content in the Cuyuni rivers extends from 100 to 800 ppt. Compared to the dissolved REE contents, a relative enrichment of the light REE relatively to the heavy ones is noticed in the suspension material. This may be the consequence of the organic-colloid control on particulate over dissolved element contents.