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Water Rock Interaction [WRI 14]

Influences of lithology on water quality: a study of the Ngam and Mou watersheds in West Cameroon (Central Africa)

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Abstract

The Ngam and Mou Rivers belong to the river system of the central part of the Cameroon Volcanic Line. The Ngam River watershed comprises 51 Ma old basalts, while the Mou River watershed comprises younger, < 5 Ma pyroclastic basalts. The physico-chemical characteristics of water samples from both watersheds indicated pH between 4.2 and 8.2, and 4.2 to 7.5, and very low mineralization between 11 and 246 $\mu\text{S}/\text{cm}$ and 45 to 165 $\mu\text{S}/\text{cm}$, respectively, for the Ngam River and the Mou River. Chemical data showed that waters from old, highly weathered plateau basalts (Ngam River watershed) were dominated by calcium and sodium (signatures of feldspars from syenites and orthogneisses), while waters in the Mou River watershed were dominated by magnesium (signature of olivines and pyroxenes from basalts). Mineralizations in the two watersheds are thus primarily controlled by lithology rather than anthropic activities. These results are promising for identifying potential potable water resources in these areas.

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Keywords: geochemistry; river chemistry; watershed chemistry.

1. Introduction

In Cameroon, research on rock-water-human interactions has focused on Precambrian acidic terrains (granites, gneisses) in the Sanaga and Congo basins [1, 2]. No such research has been done in

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the basalt-dominated and heavily populated Cameron Volcanic Line. Herein we report investigations of physical and chemical parameters of two contrasting watersheds (old versus recent basalts). A careful study of the spatial variations of chemical compositions of waters, the role of lithology on water composition, and the detection of anthropogenic inputs was stressed.

1.1. Geographical and Geological Settings

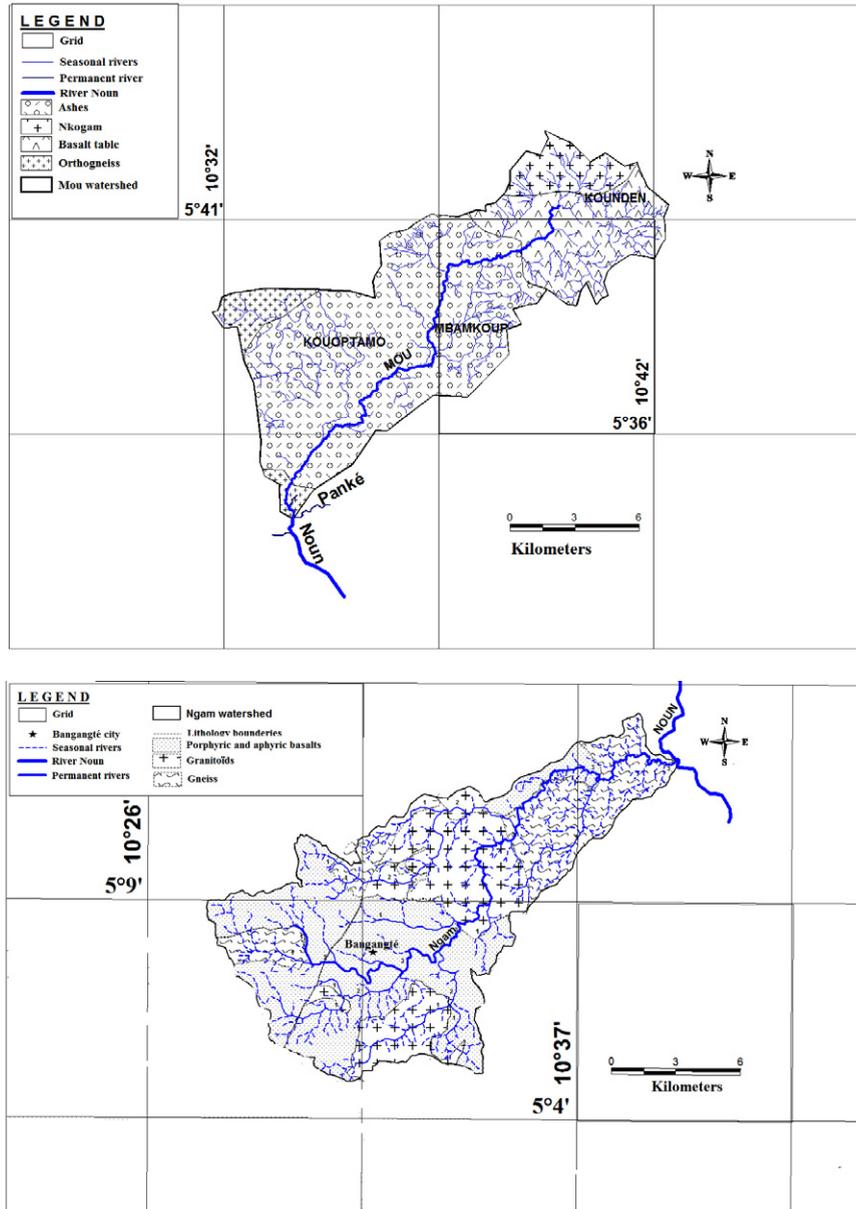


Fig. 1. Mou River watershed (top). Ngam River watershed (bottom).

The Ngam and Mou Rivers are tributaries of the Noun River, one of main rivers of the central part of the Cameroon Volcanic Line. The Ngam and Mou Rivers drain areas of 159.6 km² (mean altitude 1400 m) and 147.3 km² (mean altitude 1200 m) respectively, to the west and east of the River Noun. Geologically, Precambrian granites and gneisses underlie basalts in both watersheds (Fig. 1). The basalts of the Ngam watershed are older (51 Ma) than the basalts of the Mou watershed (< 5 Ma).

2. Methods

Water samples were collected from locations along each river and were transported to the laboratory for filtration (0.45 μm). Physical parameters (temperature, pH, and specific conductance) were measured at the time of collection. Cations were analyzed by inductively coupled plasma emission spectrometry (ICP). Anions were analyzed by ion chromatography.

3. Results and Discussion

The pH varies from 4.2 to 8.2 in the Ngam watershed and from 4.2 and 7.5 in the Mou watershed. The pH of the springs of Ngam River watershed is characteristic of spring water according to the classification of water from the value of their pH. Springs in the Mou watershed, S1 and S2, are acidic (4.2 and 4.3 respectively). Such acidity results from weathering of the parent orthogneissic basement rock of the Mou River watershed. This contrasts with springs in the Ngam watershed, which are more neutral (5.5 to 7.5), would be more consistent with weathering of basalts. Conductivity varies on the Mou River (40-165 μS/cm for rivers and from 45 to 118 μS/cm for springs). In the Ngam watershed, a conductivity value is in the range of 11-246 μS/cm for rivers and 8-118 μS/cm for springs. Waters from the Mou River watershed appear to be less mineralized whereas young basalt is supposed to be more reactive than older. Actually, waters from the Mou river watershed should also interact with Precambrian basement rocks which are less reactive than basalts.

WHO (2004) defines a range of pH for water intended for human consumption between 6.5 and 8.5. Springs along the Ngam River have pH values in this range, but springs along the Mou River are too acidic. Other considerations for potability include concentrations of individual ions. In the Mou and Ngam watersheds, the orders of the concentrations of chemical elements in waters were as follows: $\text{HCO}_3^- > \text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^+ > \text{K}^+ > \text{Cl}^- > \text{SO}_4^{2-} > \text{NO}_3^-$ and $\text{HCO}_3^- > \text{Ca}^{2+} > \text{Na}^+ > \text{Mg}^{2+} > \text{Cl}^- > \text{K}^+ > \text{SO}_4^{2-} > \text{NO}_3^-$, respectively. Mou River waters are enriched in magnesium, which results from weathering of olivines and pyroxenes from the basalts, while Ngam waters are enriched in sodium, highlighting more influence from sodic-plagioclase feldspars.

A Piper diagram (Fig. 2) further discriminates chemical characteristics of waters from the two watersheds. These observations lead us to note that mineralization of waters from the highly altered plateau basalts (Ngam River watershed) is different from that ones from recent basalts (Mou River watershed). The influence of lithology in the mineralization of waters in the Ngam watershed is related to the mineralogy of the rocks, the resistance to weathering of minerals, and the age of the rock. Soil and rock leaching is partly responsible for the solubilization of some elements, such as cations, aluminum or iron. Precipitations are partly responsible for the presence of nitrate, bicarbonate, and sulfate in the water catchment areas of Ngam and Mou watersheds. The anthropogenic influence in both watersheds is shown by the presence of nitrates and sulfates which origin could be also attributed to contamination by waste waters and the use of fertilizers.

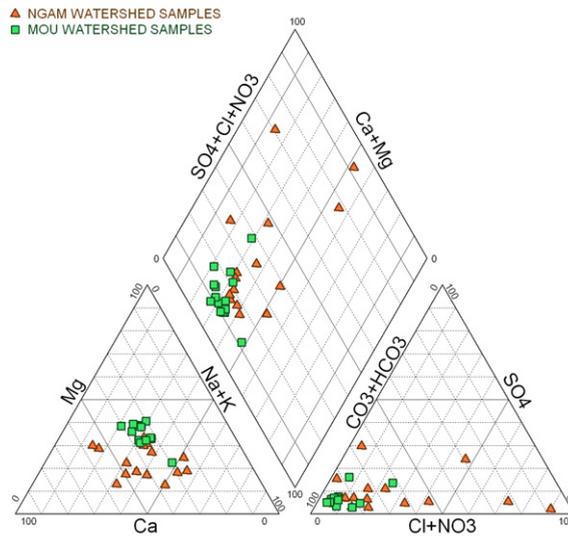


Fig. 2. Chemical facies of waters in rivers Mou and Ngam watersheds. Red (Ngam), green (Mou).

4. Conclusions

Physical and chemical investigations of Ngam and Mou watersheds indicate that pH, chemical compositions of waters are strongly linked to lithology. Waters from Ngam watershed mainly composed of old basalts (tertiary in age) are less mineralized than waters from the Mou watershed (dominant Quaternary basalts).

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