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## Water Rock Interaction [WRI 14]

# The Archean granitoid-Paleoproterozoic unconformity: superimposition of alteration events in Archean granitoids, Gabon

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### Abstract

The Archean granitoids of the South Gabon, dated from 3.0-to-2.5 Ga, were examined along the Archean-Proterozoic unconformity. The petrography was based on mineralogical identification using electron microscopy, X-ray diffraction, and the electron microprobe. The geochemistry was based on chemical analyses of major and trace elements, and on isotopic dating. Results of this work show that the granitoids have been affected by superimposed chloritization and illitization events that were dated by monazite U-Th-Pd isotopic data. The granitic basement shows three superimposed alteration events: 3.0-2.9 Ga primary magmatic event, 2.6 Ga propylitic, and a late oxic 1.9 Ga diagenetic event.

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**Keywords** : Archean granite, alteration, clay minerals, isotopic dating, Franceville Basin.

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## 1. Introduction

The previous studies performed on the sedimentary formation-magmatic basement unconformity dated around 1.8 – 2.9 Ga (Paleoproterozoic to Archean) were mainly focused on the top of the magmatic basement. This unconformity was largely studied in the earth surface: Canada, Scotland, South Africa and Finland. The different authors accord to the fact that the deepest granitic basement was affected by metamorphic-to-hydrothermal alterations, and suggest a diagenetic origin of the sericitic alteration that had affected the top of the granitic basement. Only few authors suggest the superimposition of this diagenetic alteration on an early weathering event.

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The present study is focused on the Archean-Paleoproterozoic interface that was drill cored in the Franceville basin (Gabon). The previous studies performed in the Francevillian rocks were focused mainly on the Paleoproterozoic FA and FB sedimentary formations (2.1 Ga) because of the presence of natural nuclear reactor in FA and Mn depot in FB. Lafaye et al. [1], Cuney and Mathieu [2] and Mathieu et al. [3] have demonstrated that the Francevillian deposit was affected by diagenetic event which is characterized by illite and chlorite new-formations, quartz overgrow, accessory mineral dissolution as monazite and zircon.

Mathieu [4] and Sere [5] have observed in the Archean granitic basement chlorite-epidote paragenesis, characteristic of metamorphic and/or hydrothermal alterations.

Now a major question concerns the possible occurrence of the weathering signature expressing a paleosol formation in the Francevillian basement as described in other area in the world [6].

Based on petrographic and geochemical investigations, the objectives of this work is to identify the various types of alteration, to argue on the paleo-fluid circulations which would operate at the sedimentary basin and granitic basement interface between 3.0 and 2.1 Ga and to assess the potential effects of the successive hydrothermal and/or diagenetic events and eventual Archean weathering.

## 2. Geological setting and analytical method

Our investigations were made in the Kiéné region that is located around 60 km north of the reactors region. The granitic basement constitutes the Chaillu Massif that is located on the Northeast part of the Congo craton, and South Gabon. This massif is composed of heterogeneous granitoids and orthogneiss Archean (3.0 – 2.5 Ga) [7]. The granitoids exhibit a large heterogeneity of structure and mineralogy caused by at least two main plutonic events [8-9]. The granitic basement is overlapped by the Paleoproterozoic sedimentary series constituting the 2500 m thick Francevillian basin. This basin is composed by five sedimentary unmetamorphosed sequences labelled FA to FE from the bottom to the top. The petrographic and geochemical investigations were performed on height drills cored through the Paleoproterozoic sediments, the granitic basement unconformity, down to 20-to-40 m into the granitic basement. These studies were mainly focused on the most reactive phases: i.e. clay minerals for the parageneses and monazite for the Pb/U isotopic dating. The petrographic study was based on mineralogical identification performed by optical microscopy, scanning electron microscopy and X-ray diffraction. The mineral micro-chemical analyses were obtained by electron microprobe. The analyses on whole rock were carried by ICP-EAS for major elements and ICP-MS for trace elements. The studied monazites come from two samples located near sandstone interface with basement. They were used to constrain the ages of magmatism and alterations events. The U-Th-Pb isotopic data for the monazites were obtained by laser ablation inductively coupled plasma spectrometry (LA-ICPMS) providing  $^{206}\text{Pb}/^{238}\text{U}$  vs  $^{208}\text{Pb}/^{232}\text{Th}$  Concordia diagrams and ages [10].

## 3. Results and discussion

The granitic basement is affected by an alteration zoning developed from the bottom of the drill core to the FA-granite unconformity. In the bottom of drill core, the granitoids are affected by both green schist metamorphism and early propylitic alteration. The green schist metamorphism is characterized by crystallization of Mg-rich chlorite-allanite-and sphene assemblage. This alteration is only pervasive. The allanite and sphene crystallizations as elongate strip parallel to the layers of the biotites and following the plan of foliation argue on their metamorphic origin. The temperature characteristic of this metamorphic facies can reach 520°C.

The propylitic alteration is characterized by a crystallization of Mg-chlorite and epidote as pervasive and fissural paragenesis and locally late crystallization of calcite in plagioclase replacement and in fissure infilling. Locally the calcite is associated to anhydrite inside the cracks. The chlorites are brungsvigite characterized by Fe/(Fe+Mg) ratio from 0.3-0.5. The chlorite-epidote paragenesis suggests a 200°C-to-350°C temperature range characterising this propylitic event.

The upper part of the granitoids near the unconformity was affected by illitic alteration. This alteration is mainly pervasive and characterized by the illite-phengite assemblage. The crystallo-chemistry of the dioctahedral micas evolves following the different microsites of crystallization and the associated primary phases. The illite has crystallized as plagioclase replacement whereas the phengite has replaced the previously chloritized biotite. Nevertheless the residual chlorite shows the Fe/(Fe+Mg) ratio increasing near the unconformity (0.6 - 0.8) according to the Fe/(Fe+Mg) ratio of the phengite composition. The illitic alteration has affected the granitic basement down to 4-5 m deep underneath the unconformity. The evidence of this illitic event may be found down to 7 m deep through some fractures. Carbonate crystallization affected the basement through cracks that have crosscut the illitized rock. It represents a late stage, locally associated to anhydrite.

The same illitic alteration is observed in the sandstones of FA formation. The illitic matrix has collapsed all the inter-grain porosity and has replaced the feldspars. Many studies shown that illite is stable at temperatures between about 200 and 300°C [11].

The crystallo-chemistry evolution of the illite, phengite, and chlorites associated to the successive parageneses is plotted in the  $MR^{3+}$ - $2R^{3+}$ - $3R^{2+}$  triangle. The Fe/(Fe+Mg) ratio of chlorites evolves from the base of the granitic basement to the FA contact according to migration pathway of the diagenetic fluid (figure 1).

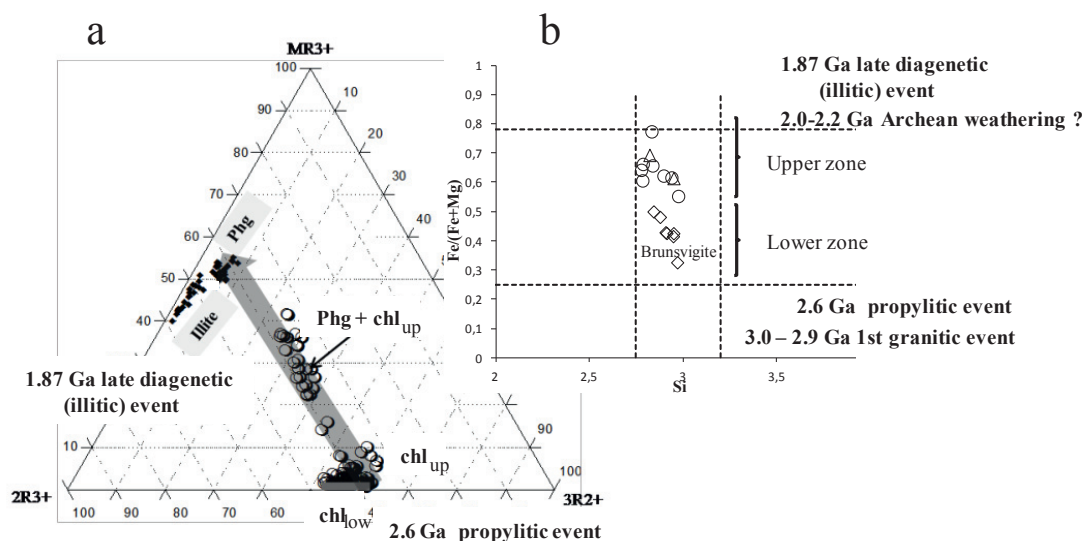


Fig. 1: Representation of the four phyllosilicates domains in the  $MR^{3+}$ ,  $2R^{3+}$ ,  $3R^{2+}$  triangle (Velde, 1985). (a) Evolution of the clay mineral assemblage from the metamorphism or propylitic early events ( $chl_{low}$  = chlorites of the lower zone) to the diagenetic event ( $chl_{up}$  = chlorites of the upper zone; phg = phengite); (b) Evolution of the Fe/(Fe+Mg) ratio in the chlorites from the lower zone to the upper zone of the granitic basement. Ages are obtained by U/Pd isotopic dating on the monazites.

#### 4. Conclusion

This illitic alteration observed in FA sandstones of Franceville basin and in the upper section of grantees suggests that the fluids responsible of this alteration are likely of diagenetic origin and coming from the bottom of the sedimentary sequence. The unconformity could represent a zone of relatively high exchange between the basement and sediments (FA). Moreover, the observed increasing of  $\text{Fe}^{3+}$  and decreasing of  $\text{Fe}^{2+}$  in the illitic zone of the granitic basement suggest oxidative state of fluid responsible of this alteration. This trend could be interpreted like and impact of an eventual weathering. However petrographic and geochemical evidences exclude this hypothesis.

The succession of metamorphic, propylitic, and diagenetic events is confirmed by the geochronological dating. The monazites located near the unconformity show three groups of ages. The oldest measured age ranges from  $2998 \pm 25$  Ma to  $2922 \pm 24$  Ma. This age could be interpreted as the primary magmatic event. The intermediate age of  $2621 \pm 30$  Ma could correspond to a postmagmatic-to-hydrothermal event characterized by the propylitic alteration. Bonhomme et al. [12] have dated the magmatic cooling of the basement on biotites by K-Ar isotopic dating to similar  $2696 \pm 60$  Ma age. The youngest age is  $1870 \pm 26$  Ma. A similar age has been found by Bonhomme et al. [13] and interpreted as recording the last maximum thermal event occurring during the diagenesis of Francevillian basin.

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