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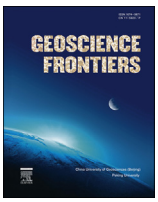

Research paper

Chronological constraints on the Paleoproterozoic Francevillian Group in Gabon

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ABSTRACT

The Francevillian Group in Gabonese Republic was recently established as a typical sedimentary sequence for the Paleoproterozoic. However, its age is rather poorly constrained, mainly based on Rb-Sr and Nd-Sm datings. This study reports new zircon data obtained from Chaillu massif and N'goutou complex, which constrain the protolith age of the basement orthogneisses and the igneous age of an intrusive granite, respectively. Most zircons from the orthogneisses are blue and exhibit oscillatory zoning in cathode-luminescence images. Zircons with lower common lead abundances tend to be distributed close to the concordia curve. Two age clusters around 2860 Ma and 2910 Ma are found in zircons plotted on the concordia curve. Based on the Th/U ratios of zircons, these ages correspond to the protolith ages of the orthogneisses, and the zircons are not metamorphic in origin. Syenites and granites were collected from the N'goutou complex that intrudes into the FA and FB units of the Francevillian Group. The granitoids exhibit chemical composition of A-type granite affinity. Half of zircons separated from the granite are non-luminous, and the remaining half exhibit obscure internal textures under cathode-luminescence observation. All zircon grains contain significant amounts of common lead; the lead isotopic variability is probably attributed to the mixing of two components in the zircons. The zircon radiogenic $^{207}Pb/^{206}Pb$ ratio is 0.13707 ± 0.0010, corresponding to a $^{207}Pb/^{206}Pb$ age of 2191 ± 13 Ma. This constrains the minimum depositional age of the FA and FB units. Furthermore, the FB unit consists of manganese-rich carbonate rocks and organic carbon-rich black shales with macroscopic fossils. Based on our age constraints, these organisms appeared in the study area just after the last Paleoproterozoic Snowball Earth event, in concert with global scale oxidation event encompassing the Snowball Earth.

1. Introduction

The Paleoproterozoic is one of the most important periods through Earth's history and is characterized by numerous geological events such as the emergence of eukaryotes (e.g., Han and Runnegar, 1992), Snowball Earth events (e.g., Kopp et al., 2005), and the oxygen level increase in the ocean-atmosphere system (e.g., Rye and Holland, 1998; Holland, 1999, 2005). Recently, macroscopic structures, which can be interpreted as colonial organisms and microbial/algal consortia, were reported from Paleoproterozoic sedimentary rocks (Francevillian Group) in Gabonese Republic (Albani et al., 2010; Moussavou et al., 2015). Several geochemical proxies were measured in the sediments in order to decipher the surface paleoenvironmental conditions at that time (Gauthier-Lafaye and Weber, 2003; Préat et al., 2011; Canfield et al.,

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2013). The Francevillian Group, in particular, attracted significant attention from many scientific fields, because it contains the well-known Oklo natural reactors (Neuilly et al., 1972; Gauthier-Lafaye et al., 1989) and excellent manganese-rich carbonate rocks (Weber, 1968) in the FA and FB unit. Nevertheless, the chronological constraints on the sedimentary sequences are still insufficient. Especially, the maximum and minimum depositional ages of sediments containing the above macroscopic structures and natural reactors have been only poorly constrained by the ages of the basement rocks and intrusive granitoids (Bonhomme et al., 1982; Caen-Vachette et al., 1988; Moussavou and Edou-Minko, 2006). Here, we report new precise protolith zircon ages of the basement gneiss and the igneous age of the intrusive granite in the N'goutou complex. These more precise documentations will allow correlating the Francevillian Group with sedimentary sequences in other areas, which is important to understand the order of events occurring in the Paleoproterozoic.

The basement beneath the Francevillian Group is mainly composed of granitoids including granite, monzonite, syenite, diorite, and gneiss. The extensive work by Caen-Vachette et al. (1988) has considerably enhanced our knowledge of the geological history of these basement rocks. Based on the Rb-Sr isochron method and U-Pb isotope systematics, they suggested the following phases: (1) 3000–2850 Ma; high-grade metamorphism in the eastern Makokou area and formation of the Chaillu gneisses; (2) 2850–2700 Ma; high-grade metamorphism of the western Makokou gneisses and the main magmatic phase in the Chaillu area; (3) 2700–2600 Ma; epizonal metamorphism and later magmatism in the Chaillu area. The data from all zircon grains, however, were plotted far from the concordia curve. Therefore, the ages for the individual granitoids, based on the discordia lines, are still rather uncertain. Moreover, this previous work did not include descriptions of the internal zircon structures obtained through cathode-luminescence (CL) observations and consideration for common Pb.

Plutonic rocks of the N'goutou complex intrude into the Paleoproterozoic Francevillian Group. Therefore, determining its intrusive age is important to constrain the minimum sedimentary age of the Francevillian Group. The age of the N'goutou complex was estimated through Rb-Sr (Bonhomme et al., 1982) and U-Pb datings (Moussavou and Edou-Minko, 2006) of syenites and pegmatite. The former gave an isochron age of 2143 ± 143 Ma, but a possibility of mixing (erroneous isochron) was not well discussed in this previous work. In addition, initial $^{87}Sr/^{86}Sr$ ratio of 0.7006 calculated from the isochron is too low for the 2.1 Ga in view of the secular evolution in the mantle $^{87}Sr/^{86}Sr$ ratio. On the other hand, Moussavou and Edou-Minko (2006) provided an upper intercept age of 2027 ± 55 Ma based on discordant zircon U-Pb data. Some zircon grains included a certain level of common Pb ($^{204}Pb/^{206}Pb > 0.0002$), and internal structures in zircon were not checked by conventional CL image.

In the present study, we collected basement orthogneisses of Chaillu massif from pluri-metric blocks enclosed in the FA units, northwest of Francevillian basin (GPS position: S1°43′14.4″, E13°18′24.5″), and an intrusive syenite and granite from the N'goutou complex in order to acquire chronological data that are more precise (Fig. 1). Our *in situ* U-Pb isotopic data were obtained through multi-collector, inductively coupled plasma mass spectrometry (MC-ICP-MS). The age data are discussed here together with CL observations and an evaluation of the common Pb abundance.

2. Geological background

2.1. Geological setting and isotopic history

Paleoproterozoic sedimentary sequences, named the Francevillian Group, are widespread in eastern Gabon Republic and rest unconformably on an Archean basement referred to as the East Gabonian block (Fig. 1a). The basement rocks are mainly composed of Mesoarchean granitoids and greenstone (Bonhomme et al., 1982; Caen-Vachette et al., 1988; Thiéblemont et al., 2014). Granitoids near Koulamoutou and Chaillu are dated at 2888 ± 40 Ma, 2765 ± 39 Ma, and 2637 ± 33 Ma based on Rb-Sr isochron (Fig. 1a; Caen-Vachette et al., 1988). The Paleoproterozoic Ogooué orogenic belt is located west of the Francevillian Group.

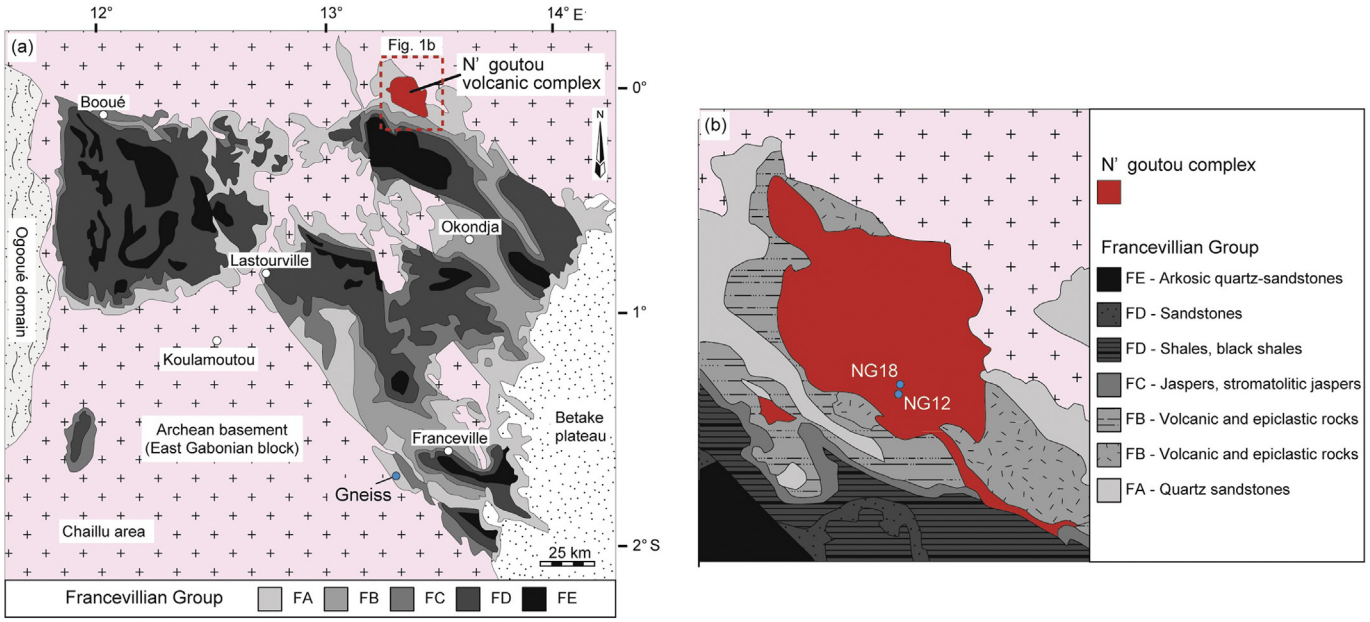

Figure 1. (a) Geological map of SE Gabon, including the distribution of the Francevillian Group (modified after Thiéblemont et al., 2014). (b) Simplified geological map around the N'goutou complex, showing the locations of granite and syenite (NG12 and NG18).

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