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CONTRIBUTION TO THE CHARACTERIZATION OF THE HOST FORMATION OF THE FRANCEVILLIAN URANIUM MINERALIZATION (HAUT OGOOUÉ PROVINCE, GABON): PETROGRAPHY, SEDIMENTOLOGY, STRATIGRAPHY, AGE AND NEW ISOTOPIC DATA

Thursday 28 June 2018 14:00 (20 minutes)

INTRODUCTION

Five uranium deposits, within the Francevillian mineral lease, trapped in the paleoproterozoique sandstone of the non-metamorphosed Francevillian basin in Gabon has been explored starting in the 60's and exploited by the company COMUF. A total of 26,600t of uranium metal have been exploited during 38 years in open-pit and underground mines (Mounana, Boyindzi, Oklo, Okélobondo and Mikouloungou).

Recent exploration drill cores, done by AREVA, in Bagombé, Mikouloungou and Suly district (close to Oklo deposit), have highlighted undescribed geological features as pluri-centimetric fine grained yellow sedimentary layers interbedded in the tidal FA sandstone formation, host of the main mineralization. These original layers have been found in several drill cores on each explored area and then have been studies to identify their origin.
New mineralization types of occurrences have also been discovered as uranium mineralization veins in the basement. This discovery arouses interest on the genetic model of theses occurrences and a general review of the uranium metallogeny of the district has been launched, using modern technics for isotopic dating and trace elements measurement.

YELLOW LAYER CHARACTERISATION

One of the remarkable lithologic and petrographic features of the Mikouloungou and Bagombé Francevillian sandstone FA formation is the presence of yellow strips ("YS"), interbedded in the sandstone series. At the macroscopic scale, the "YS"are marked by their contrasting yellow color and fine to medium grained texture with strong lamination, as well as sliced contacts. It can be founded within medium to coarse sandstone, conglomerate or at the unconformity between the granito-metamorphic basement and the sedimentary cover. These "YS"have a thickness of a few centimeters and disintegrate easily because of the lamination which seems to be rich in phyllitic material (micas and clays).

Assumptions made by onsite geologists for the "YS"origin were: (i) kind of small scale "mylonitic"zones resulting from horizontal glide accommodation; (ii) bottom set of dune or (iii) volcanic layers (cineritic type).

Around ten occurrences of this these formations have been sampled in three areas distant from each other of about thirty kilometers. Thin sections have been made in each sample and have been studied using optical microscopy and SEM.

All the sections present the same main characteristics:

- the matrix constituted by fine micas and clays is dominant. The clay result from the alteration and give the yellow color of the formation at the macroscopic scale.

- all the elements are floating in the matrix and orientated, highlighting the stratification.
- the major elements are mainly quartz and few feldspar. The quartz are limpid and often flat, angular sometime as splinters and often cup-shaped on the edges. Some quartz are slightly stocky and present evidence of crystalline hiatus (rhyolitic).
- there is a strong concentration of accessory heavy minerals as zircons and monazites, as observed in volcanic tuffs.

All these specific observations argue for characteristic volcanic quartz and for local cineritic deposits (hypothesis iii). They possibly represent good stratigraphic marker at the regional scale and additional studies could be necessary to attempt a correlation. This could help to better constrain the discussed age of the Francevillian basal FA formation. This identified volcanic contribution within the FA sandstone could be a supply for the uranium stock in the basin.

URANIUM MINERALIZATION

• SAMPLING & ANALYTICAL METHODS

Following the discovery of fractures filled with uranium mineralization in the basement, at the contact with the sedimentary FA formation in Mikouloungou deposit, several mineralization of different type of uranium occurrences have been sampled. To compare them with known mineralization, samples from Oklo deposit have also been collected to be reanalyzed with the same modern technics. Samples have been studied using traditional optical and electronic microscopy for petrographic observation, ion microprobe (CAMECA IMS1280) for punctual U-Pb isotopic dating. For Oklo samples, laser ablation (LA-ICP-MS) for punctual REE analyze on uranium oxides has also been applied.

• MIKOULOUNGOU RESULTS

The UO2 mineralization occupies three types of habitus: (i) in the porosity of sandstones, (ii) included within organic matter (O.M.) or in relation with it, and (iii) filling of micro-fractures affecting unconformity basement samples with associated sulfides (chalcopyrite, galena and pyrite).

346 punctual isotopic U-Pb analyses have been measured on several thin sections. This set of measures gives the following group of age:

- Around 800 Ma, between 860 and 750 Ma, mainly in basement fractures;
- Around 520 Ma, between 630 and 410 Ma, for pitchblende in the porosity or uraninite crystals in organic matter, with some isolated values around 246 Ma or around 1730 Ma, the latter being linked to micro-inclusions of galena in the uraninite crystals.
- The Concordia diagrams show sometimes low intercept around 120 Ma indicating a reset of the system at that time. All the dated mineralization in this work on Mikouloungou give only the younger ages described so far [1] for Oklo deposit. However the oldest ages described in Oklo deposit [2] has not been found.

• OKLO RESULTS

In order to confirm the oldest ages obtained on Oklo mineralization with punctual analyzes some samples of massive pitchblende and uraninite from Oklo natural reactors were recently studied with the ion probe for isotopic U-Pb data. Three samples from the quarry outcrop (supposed to be out of the reactors) presenting uranium mineralization in cracks or associated with O.M., have also been analyzed.

Isotopic disequilibrium

Oklo mineralization has been, in some places, affected by a natural fission reaction which has consumed a part of the 235U, called natural reactor, leading to a disequilibrium compared to all the natural uranium on the Earth [3-4]. The set of isotopic analyze measured with the IMS 1280 ion probe, has been adapted for these special samples, to measure more precisely the 235U and calculate the isotopic disequilibrium.

Standard used for calibration is an uraninite from Zambia. The 235U/238U of the standard is constant and gives a value of 0.007104. The ratio (235U/238U) sample/(235U/238U)standard, should be 1 if the uranium isotopes are at the equilibrium. Results from 4 samples from the drill hole D73-S2 intersecting the reactor n°10 give statistic results between 0.88 and 0.73, which confirm the disequilibrium.

Age

For the reactor samples, Concordia diagrams show dispersed high intercept of the Discordia around 1700 ± 100 Ma without 235U correction. Considering the 235U loss, it is possible to apply a correction factor which changes the slope of the Discordia giving focused range of high intercepts distributed between 1979 ± 18 Ma and 2028 ± 30 Ma.

The three samples coming from the quarry present younger ages ranging from 533 ± 27 Ma to 557 ± 6 Ma, similar to main group of age from the sandstone uranium mineralization of Mikouloungou.

REE signature

On the Oklo reactors samples, rare earths elements have measured by laser ablation ICP-MS. The rare earths spectra, normalized to the Chondrite C1, show reproducible spectra with identical forms, characterized by high LREE and low HREE and a gadolinium negative anomaly. Theses spectra show a double "tetrad effect" in the LREE and low REE as already described in previous works [5].

• DISCUSSION

All the dated mineralizations for this work on Mikouloungou give younger ages than those historically established for the mineralization of the Francevillian basin [2]. The older ages close to 2 Ga are always linked, in his study, to natural nuclear reactors. No evidences of these older ages have been seen in the other type of mineralization. These ages are younger than the emplacement of dolerite veins (955-970 Ma [6]), and part of them are synchronous with the phase of pan-African deformation between 500 and 600 Ma. The last group of age, linked to the lower intercept in the Concordia diagram could results from a resetting of the isotopic system link to opening event of the Atlantic Ocean.

CONCLUSION

These works issued from exploration staff of Orano Mining Group (Areva) combined with specific sedimentological, petrographic and metallographic works in the R&D programs, conduct to original results, (i) on specific volcanic origin for yellow strips constituting possible regional stratigraphic marker and possible synsedimentary source for at least a part of the uranium in the basin; (ii) ages of different mineralization types in Mikouloungou younger than the first mineralization event in Oklo; (iii) 235U loss in the uraninite crystals of Oklo reactors due to the natural fission and conducting to an old age around 2 Ga as given by former data, with other analytical technic [7] and (iv) the original spectra with double "tetrad effect"for the same Oklo reactors uraninite crystals.

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