GEOLOGY OF COGEMA'S URANIUM DEPOSITS IN NIGER AND GABON

CARISEY, Jean-Claude. COGEMA, Vélizy, France.

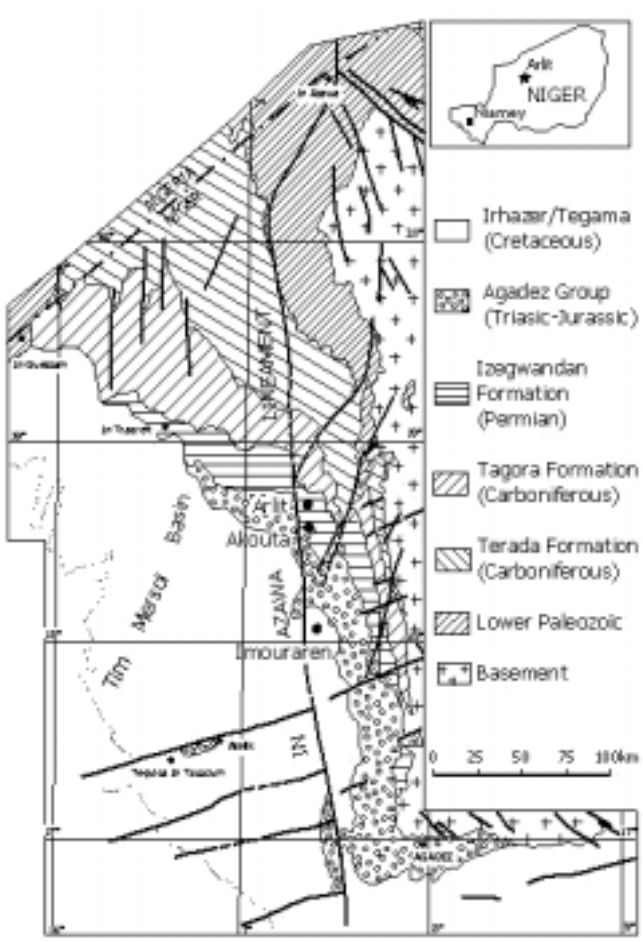
COGEMA, through its subsidiaries COMUF, SOMAIR and COMINAK has been producing uranium since 1961 in Gabon and 1968 in Niger from sedimentary hosted deposits.
This paper will mainly deal with the geology of the Akouta and Arlit deposits in Niger, with a shorter update on Imouraren and on the Franceville Basin deposits (Gabon).

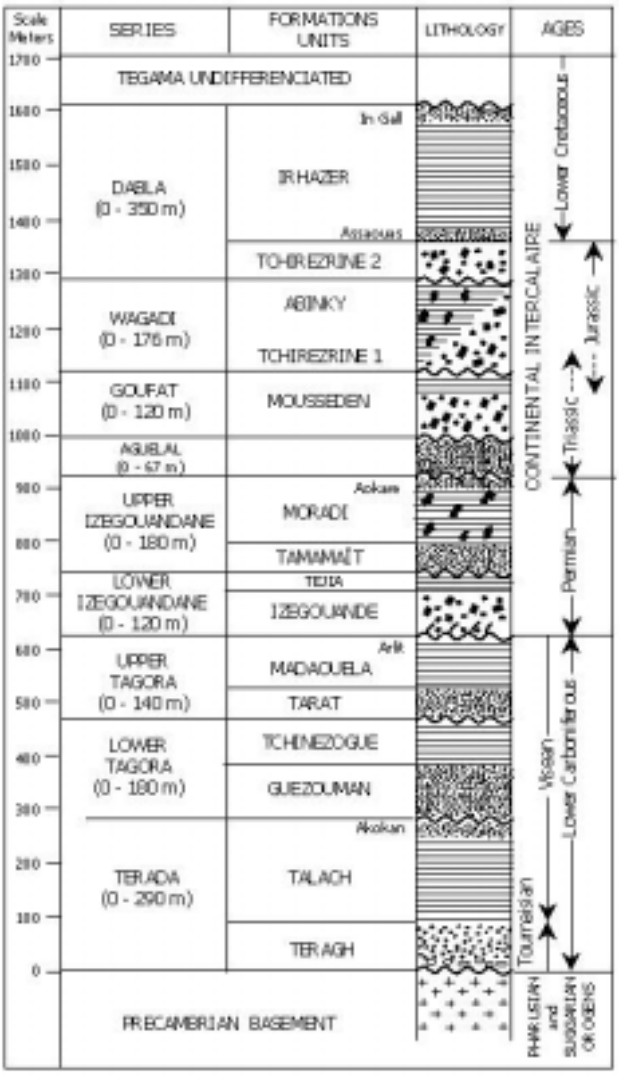
The discoveries

The first uranium showings in the Agades region of Niger were discovered in 1957 by a team from BUMIFOM exploring for copper. CEA took over the following year and started the detailed study of the main showings along with regional airborne geophysics and field reconnaissance. The first discovery occurred in 1963 at Madaouela, then in 1965 on what was to become the Arlette deposit. Subsequent discoveries included Akouta in 1967 and Imouraren in 1969 (Fig. 1).

Fig. 1: Geologic map of the eastern Tim Mersoï Basin (after Joulia, 1963) and location of main deposits.

Regional geology





Niger's uranium deposits are located in the Tim Mersoï Basin, west of the Aïr massif. The stratigraphic section , defined by Joulia, is divided into three main groups from bottom to top (Fig. 2) :

- The Terada Group of upper Visean age
- The Tagora Group of upper Visean to Westphalian age, which consists of two major fluvio deltaic cycles : the lower cycle, formed by the Guezouman sandstone and Tchinezogue silts and sands, the upper cycle formed by the Tarat sandstone and Madaouela silts and shales. The Akouta deposit is hosted in the lower cycle, the Arlit deposit in the upper cycle.
- The "Continental Intercalaire" of Permian to Lower Cretaceous age, consists mostly of fluvio lacustrine redbeds hosting the Imouraren deposit.

A major structural feature of that part of the basin is the in Azzaoua lineament, locally called "Arlit fold-fault".

Fig. 2 : Chronostratigraphic units of the eastern Tim Mersoï Basin (after Cazoulat, 1984).

Guezouman hosted deposits

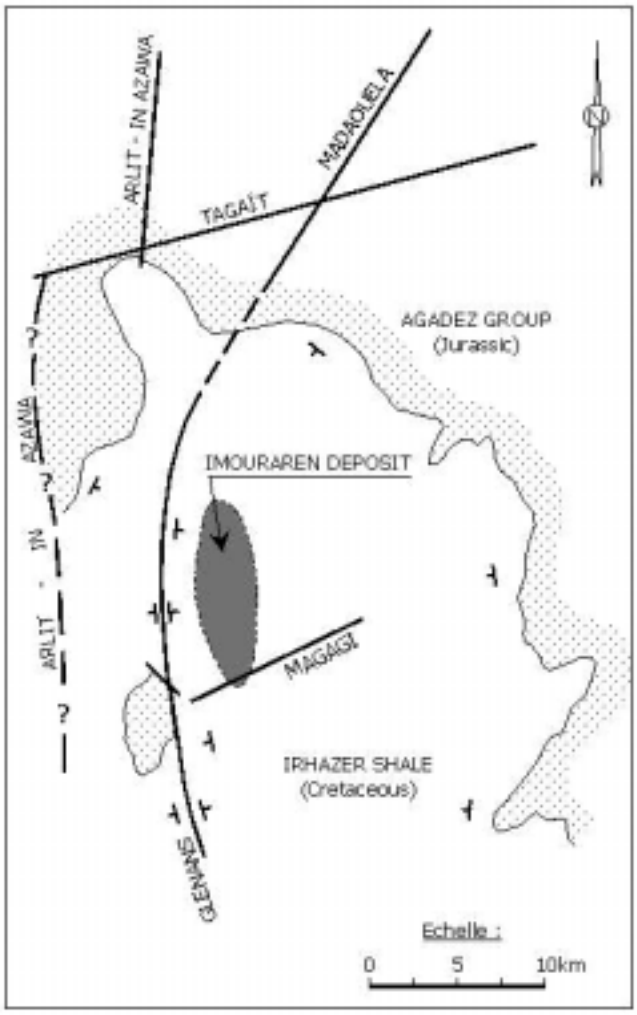
Akouta and surrounding deposits are hosted in the Guezouman sandstone at a depth of 200 to 300 meters. The strong correlation of uranium with zirconium points towards a volcanic source, either in the Air massif of in Permian sediments.

The sands are quartz rich, organic, kaolinitic and show a strong fluviatile character.

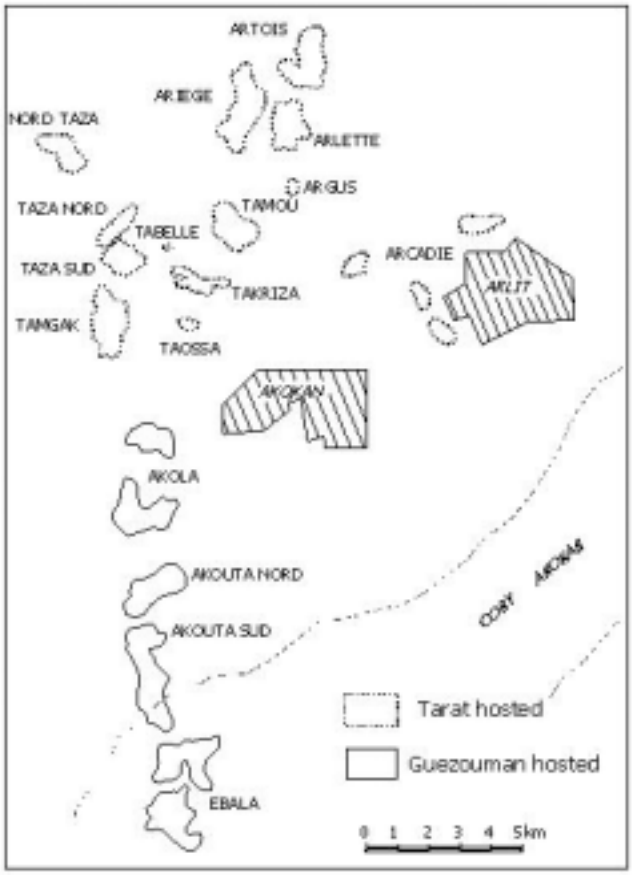
Uranium mineralisation occurs at various levels, both as tabular bodies and as stacked ore zones with sharp contacts. It consists of pitchblende with minor coffinite and associated trace elements (V, Zr, Zn, Pb, Mo and S). The mineralisation and its environment have been the subject of extensives studies by CEA, COGEMA, COMINAK and CREGU geologists, among which M. Cazoulat, H. Sanguinetti, C. Valsardieu, J. Oumarou, P. Forbes and M. Pagel.

A generally accepted model calls for a possible early preconcentration controlled by tectonic, paleogeographic and lithologic factors followed by a major mineralizing (remobilizing ?) event. This later event was triggered by the movement of the Arlit fold-fault during Jurassic time bringing into contact the Permian Izegouandane Formation (to the west) with the Guezouman sandstone (to the east).

Warm oxidised brines expelled from the Permian aquifer into the reduced Guezouman sandstones precipitated uranium and associated trace elements on classical oxido-reduction fronts.



The above hypothesis, proposed by Forbes (1989), is strongly supported by age dating, trace element zonation and general distribution of the mineralisation and



alteration facies.

Fig. 3: Location of Tarat and Guezouman hosted deposits

Tarat hosted deposits

In the Arlit area, mineralisation occurs in a cluster of about fifteen deposits hosted in the Tarat sandstone. These deposits are located north of Guezouman hosted deposits, some of them further away from the Arlit fold-fault (Fig. 3).
Overall, both families show many similarities among which are the depositional environment, the tectonic frame, the lithologies and ore minerals. However, the Arlit mineralisation is somewhat more stratabound and, beeing shallower, shows more supergene alteration.
Unlike Akouta, Arlit has been the subject of very few studies beyond the work of Sempere (1981). Forbes suggests a similar, and probably single mineralising event for both Arlit and Akouta.

The Imouraren deposit

Imouraren is located 80 kilometers south of Arlit. It is hosted by the Jurassic "Tchinezrine 2" unit of "Continental Intercalaire". The main lithologies are channel sandstone bodies interbedded with analcimolitic siltstones and shales. They were deposited in a lacustrine environment within a structure controlled depression (Fig. 4).

Fig. 4: Location sketch of the Imouraren deposit

Uranium mineralisation occurs at a depth of about 100 meters in porous and permeable sandstones. A characteristic of the Imouraren mineralisation is its oxidized character, with uranophane as the main ore mineral and rare pitchblende, associated with primary and secondary copper minerals.
The genesis of the deposit is still poorly understood due to a lack of studies since the early work of M. Cazoulat, G. Hirlemann and JP. Robert. Mineralization was probably leached from the abundant volcanic material and again shows evidence of strong secondary remobilization. The importance of that phase remains to be evaluated, particularly in light of the similar contemporaneous event in the Arlit-Akouta area.

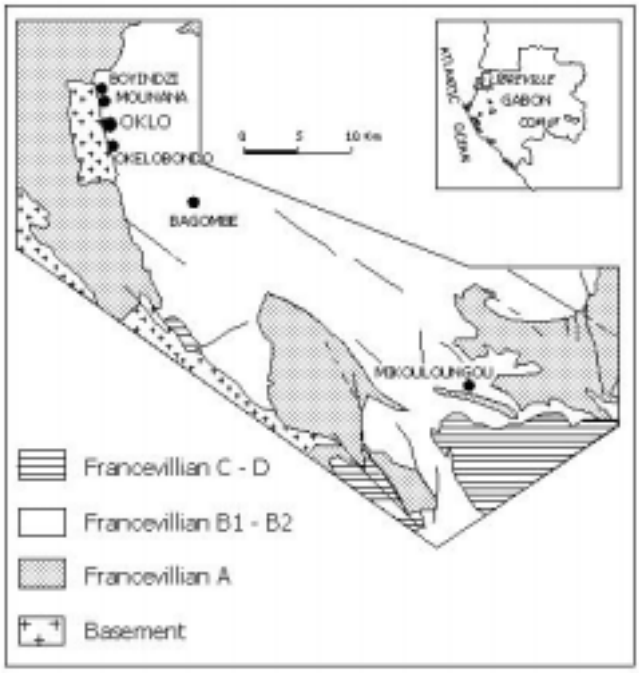
A major uranium district

Production is ongoing at SOMAIR and COMINAK. Since start-up, these companies have produced a total of 80 000 tonnes of uranium. The remaining potential in the same general area have been estimated to 70 000 tonnes, subject to market conditions. An additional resource of over 100 000 tonnes is estimated in Imouraren. The economics of that deposit are currently being studied with special attention being given to the use of In Situ Leaching technology.

Therefore, total production and remaining resources in the eastern Tim Mersoï basin exceeds 250 000 tonnes of uranium.

Uranium in the Franceville Basin

Uranium deposits of the Mounana region are hosted in lower Proterozoic sediments of the intracratonic Franceville Basin in south eastern Gabon. The basin was filled by unmetamorphosed coarse to conglomeratic fluviatile sandstones of the "FA" Formation, overlain by



organic shales of the "FB" Formation and other units. Most studies of the Franceville basin and its deposits are by Weber (1969) and Gauthier Lafaye (1977).

The mineralisation is located in silicified FA sandstone in contact with overlying FB shales, either conformably (Oklo, Okelobondo) or in fault contact (Mounana, Boyindzi, Mikouloungou). Most deposits are located at the periphery of the basin (Fig.5).
Mineralisation, dated 2.05 by, consists mostly of pitchblende. It is always associated with migrated bitumens and obvious structural controls. The deposits show striking similarities with oil traps.

Previous studies by Gauthier Lafaye and more recently by Mathieu (1999) indicate that uranium was mostly leached from altered FA detrital monazites by warm oxidized basinal brines. Mathieu shows that uranium precipitated under impermeable FA shales in zones of mixing of these deep brines with organic rich fluids expelled from FB shales, and deep warm unsalted fluids of meteoric origin.

A unique event was the discovery in 1972 of zones of natural fission reaction within the Oklo mineralisation. Up to 18 zones have been discovered and widely studied for their obvious scientific interest and as natural analogues of nuclear waste repositories.

A total of 28 000 tonnes of uranium has been produced by COMUF over 38 years. All economic reserves being now depleted, production stopped in Mounana in June 1999.

Fig. 5 : Geologic sketch of the Franceville Basin and location of deposits

References

Cazoulat, M. Hirlemann, G. Oumarou, J. Robert, JP. Sanguinetti, H. 1979-1988. Internal reports.

Forbes, P. 1989. Role des structures sédimentaires et tectoniques, du volcanisme alcalin régional et des fluides diagénétiques hydrothermaux pour la formation des minéralisation à U-Zr-Zn- V- Mo d'Akouta (Niger). Thesis, CREGU, 375 pages.

Forbes, P. Landais, P. Bertrand, P. Brosse, E. Espitalié, J. and Yahaya , M. 1998. Chemical transformations of type III organic matter associated with the Akouta uranium deposit (Niger) : geological implications. Chemical Geology, 71, 267-282.

Forbes, P. Pacquet, A. Chantret, F. Oumarou, J. Pagel, M. 1984. Marqueurs du volcanisme dans le gisement d'uranium d'Akouta (République du Niger). CRAS, Paris, t. 298, série II, n°15.

Gauthier Lafaye, F. 1977. Oklo et les gisements d'uranium du Francevillien : aspects tectonique et métallogénique. Thesis, Institut de Géologie, Strasbourg, 81 pages.

Gauthier Lafaye, F. 1986. Les gisements d'uranium du Gabon et les réacteurs d'Oklo. Modèle métallogénique des gîtes à fortes teneurs du protérozoïque inférieur. ULP, mémoire n°78, 206 pages.

Gauthier-Lafaye, F. Weber, F. 1989. The Francevillian (Lower Proterozoic) uranium ore deposits of Gabon. Econ. Geol., 84, 2267-2285.

Joulia, F. 1963. Carte géologique de reconnaissance de la bordure sédimentaire de l'Aïr, 1/500 000. BRGM.

Mathieu, R. 1999. Reconstitution des Paléocirculations Fluides et des Migrations Elémentaires dans l'Environnement des Réacteurs Nucléaires Naturels d'Oklo (Gabon) et des Argilites de Tournemire (France). Thesis, Institut National Polytechnique de Lorraine, 518 pages.

Openshaw, R. Pagel, M. and Poty, B. 1978. Phases fluides contemporaines de la diagenèse des grès, des mouvements tectoniques et du fonctionnement des réacteurs nucléaires d'Oklo (Gabon). In : les réacteurs de fission naturels. IAEA (Vienne) TC. 119/9. 267-296.

Sempere, J. 1981. Le contexte sédimentaire du gisement d'uranium d'Arlit (République du Niger). Thesis, Ecole Nationale Supérieure des Mines de Paris, 382 pages.

Turpin, L. Clauer, N. Forbes, P. and Pagel, M. 1991. U-Pb, Sm-Nd and K-Ar systematics of the Akouta uranium deposit, Niger. Chemical Geology (Isotope Geoscience), 87, 217-230.

Valsardieu, C. 1971. Etude géologique et paléogéographique du bassin du Tim Mersoï Région d'Agadès (République du Niger). Thesis, Faculté des Sciences de l'Université de Nice, 518 pages.

Weber, F. 1969. Une série précambrienne du Gabon : Le Francevillien. Sédimentologie, géochimie, relations avec les gîtes minéraux associés. Thesis, Faculté des Sciences de l'Université de Strasbourg, 367 pages.