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Oil search in the heart of Africa: A working hypothesis

by J. W. SCHROEDER *

Equatorial Africa with its luxuriant vegetation and its lack of roads presents a formidable challenge for an oil exploration, however the accessibility exists through rivers and swamps. On the basis of only the present day topographical and geological data, one can formulate a sound working hypothesis which should lead to an oil exploration activity.

In this article we want to deal particularly with the vast area lying to the west of the Congo and Oubangui rivers, between latitude 4° South and latitude 3° North. This area is part of the territory of the P. R. of the Congo (ex former French Congo) and constitutes the western fifth of the large intracratonic depression called the „Cuvette Congolaise". The area about 750 km long and 250 km broad is practically devoid of outcrops and presumably covered by Quaternary alluvial deposits. However the river navigation charts indicate in some places sandstones, rocks and even in one place an „oyster bed" (?), but the geological map at the scale 1 : 2.000.000 does not reveal any feature of interest.

Our bloc diagram (Fig) very roughly exposes how the subsurface structure of the area can be conceived. Unfortunately the available geological maps cover only the areas were granito-gneissic basement and Middle and Upper Precambrian are outcropping. This is due to the explorations focused on minerals conducted during the last century by various French agencies. From these maps, several basement highs separated by vast expanses of Middle and Upper Precambrian deposits (Precambrian B and A) can be outlined. With the help of two young able colleagues (A. MALANDE and R. LOMBA) a geomorphological map was established using topographical maps at the scale 1 : 200.000. As these topo maps were drawn on the basis of air photographs, we surmised that any straight morphological line, course of a river or any other topographical feature, if sufficiently long and conspicuous, is corresponding to a lineament of unknow origin or to a fault.

From South to North, on the Western border of the area under investigation, the following economic basement features can be recognized: 1) The West Congolian Panafrican Orogen, which has been considerably studied in the Mayombe. This old orogeny closed a Late Precambrian, at that time equatorially oriented, proto-Atlantic ocean. 2) Linking this orogen with its foreland is the huge Niari synclinorium, axially dipping to the SE, with late Precambrian platform deposits (Precambrian A = Infracambrian = Riphean = Vendian). 3) Below the northeastern flank of the Niari synclinorium is emerging the old basement of the Chaillu (1.8 million years). This granito-gneissic basement high is also dipping axially to the SE and is finally bounded by a NE oriented Bouenza fault, with the downthrow to the SE. 5) After a boundary fault, eventually linked to the Stanley Pool fault, follow the large expanses of the Francevillian (Middle Precambrian = Precam-

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brian B), in the headwaters of the Ogoue river. 5) The Gabon shield (2.7 to 3.4 million years) is then present on the western border of the Cuvette. Again the general configuration suggests a south-easterly dip for the granito-gneissic basement area. The Chaillu and the Gabon shield are often referred to as the Congo Craton, although only a very small part of it lies in the Congo. 6) The next tectonic unit is represented by the extensive expanses of the Sembe-Ouesso-Nola-Dja late Precambrian (and Middle Precambrian?). In this area tillite (Bandja Tillites) are reported. (The Bandja Tillite area corresponds to the Paleo South Pole's position 350 million years ago.) In the area to the north of Sembe where tillites outcrops are reported a sample was collected and geochemically analysed as a poor source rock. Unfortunately the outcrop corresponding to this interesting find could not be again located, which is not astonishing under the severe equatorial climatic conditions. The contact between the Gabon shield and the Sembe-Dja area is marked by an uplift (boundary fault for 300 kilometers) of the Gabon shield against the Dja-Sembe-Ouesso unit and is indicated even today by the water divide between the Congo river and the Northern Ogoue basin. This Dja boundary fault marks the contact between a stable old craton (often called the Congo Craton) and areas tectonically reactivated during the Pan African Orogeny. 7) The next tectonic element is a granito-gneissic spur bordering the Sembe Ouesso areas in the northeast. 8) We meet further northeastwards what we think should be interpreted as the Carnot Graben. This geological unit, the cartography of wich suggests a northwest oriented gulf within the basement bounded by two major faults, mapped in the field, which we call the Lipo (on the West) and the Tokele (on the northeast flank). The floor of this graben is gradually deepening to the southeast and in the north its link with Yola, Mbere and d'Archambault Wealdian grabens has been erased by the recent uplift of the Yade massif (Cahen, 1954, p. 420). The graben of Carnot ist bounded on the east by various elements of a granito-gneissic basement and of the Middle and Upper Precambrian of the area of Bangui.

In trying to outline lineaments in the area covered by Quaternary deposits we wish to attract the attention to the extraordinary hydrography of the „Cuvette Congolaise": Between Lat 4° S and Lat 2° N, every river is flowing into the Congo, either from the East, from the West or from the North. In the eastern sector: counterclockwise, the Kasai, the Ruki, the Ikelemba and the Lulonga are flowing westwards into the Congo for over thousand kilometers. From the north, the Oubangui, having flowed also westwards for thousand kilometers, is flowing southwards for 150 kilometers parallel to the Congo before emptying itself into this great collector. From the western sector, we note the Ibenga and the Motaba (emptying themselves into the Oubangui) the Likouala aux Herbes, the Sangha, the Likouala and the Alima, all bringing the waters from the western sector into the Mainstream, the Congo. If for a distance of seven hundred kilometers all the waters are finally concentrated into this almost rectilinear huge stream it means that this hydrographic feature corresponds to a depressed lineament towards which all the waters are bound to flow, either from the West, the North or the East. A lineament of such magnitude is the consequence of a major tectonic feature: we suggest that the Congo flows in the axis of a reactivated Infracambrian Aulacogen: This Bakongo Aulacogen* is marked on its oceanic side by the Matadi geosynclinal arc of the West Congolian Pan African Orogen between the Shiloango and the Luvituku in Angola, thrusted towards the Northeast. It is also indicated by the postorogenic Inkisi formation,

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* See definition page 37.

the distribution of which in the Bakongo area is located between the Comba fault and the Luvituku faults pointing respectively to the western and eastern flanks of the aulacogen.

Regarding this problem one has to mention the excellent approach of SCOLARI (1965, fig. 11) where the area of the „Plateau des Cataractes" clearly corresponds to the Bakongo aulacogen and (SCOLARI, fig. 13) where the subsiding area for the post orogenic exogeosynclinal Mpioka formation also delineate nicely this aulacogen. In the territory of the Republic of Zaire a subtle alignment of gentle topographic highs, parallel to the Congo depressed lineament 30 to 60 kilometers away, and this for 700 kilometers, is indicating the eastern flank of the aulacogen. The western flank is remarkably indicated by the Comba and the Bouenza faults. The strike of these faults, at right angle to the West Congolian orogen has always puzzled the geologists who pioneered in the area, but this type of accident is now well understood on the flanks of aulacogens. These two faults (Comba and Bouenza) can be followed morphologically in a NNE direction for a great distance, respectively 300 and 450 kilometers. They very likely point to an assymetry for the aulacogen. On Fig. No 1 the vertical plane AB follows approximately the axis of the supposed aulacogen.

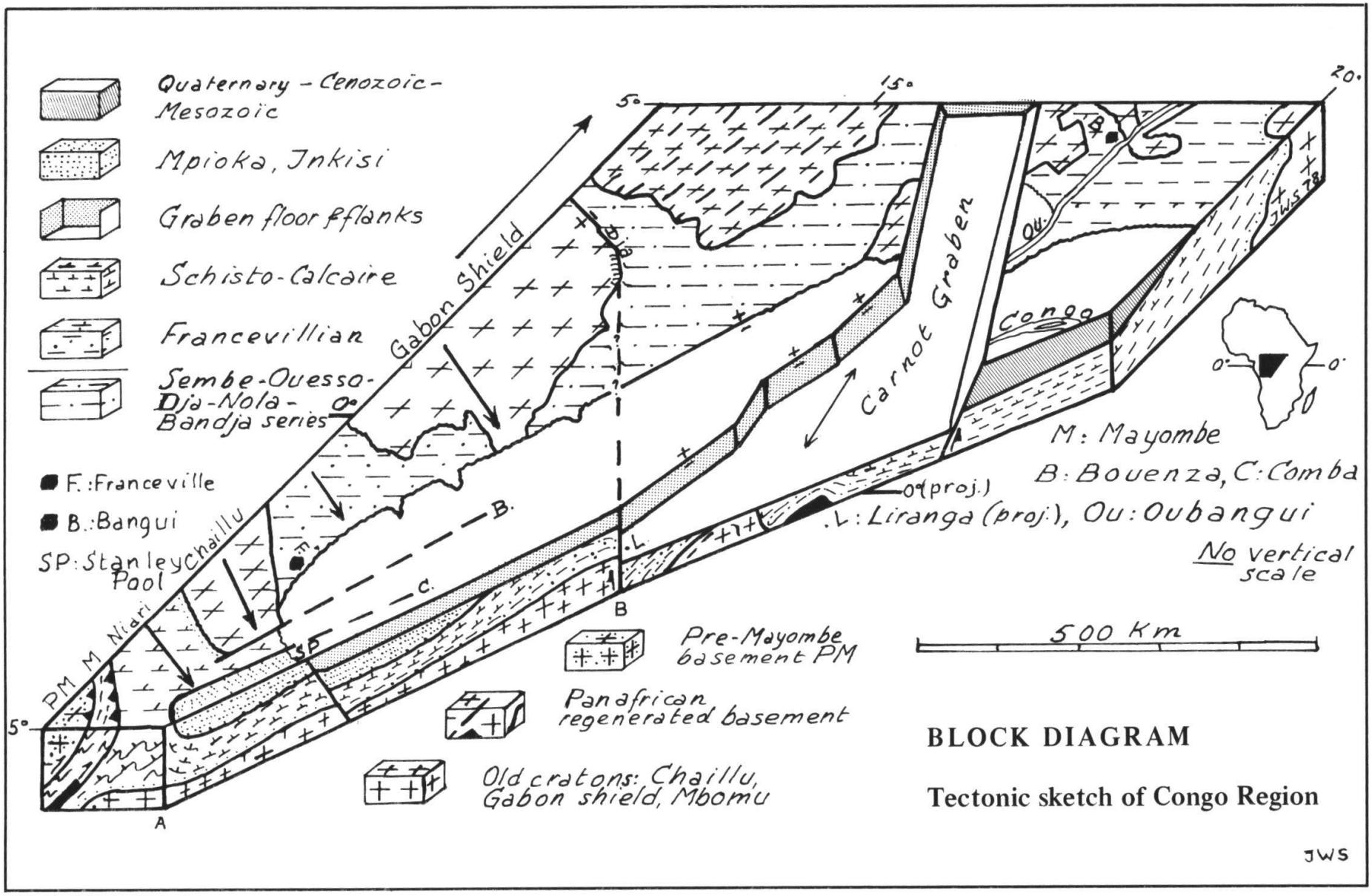
Major transverse faults can be surmised from the presence in the Congo and Sangha rivers of constrictions, from N to S: Northern tip of the Bondo Island, Liranga, Lukolela and Bolobo. It is interesting to note that the river navigation charts precisely indicate the presence of „rocks" at the location of these constrictions. The major Dja boundary fault is possibly connected with the northern tip of Bondo Island and the Liranga constriction. Such a link would outline the eastern extension of the old rigid Gabon shield against, in subsurface a Pan African pliable reactivated basement, more likely to allow folds in its overlying sedimentary cover. As a consequence perhaps of this type of basement at depth, a subtle NW oriented morphological high in the mysterious area of Mobenzele, between the mysterious Lake Telle and the Oubangui loop south of the Giri's embouchure, suggests the presence of a large scale structure wich could be of interest. This structure is eventually the result of compressive forces applied to the area (membrane tectonic) since Neogene times, as this part of Africa moved about 10° northwards and crossed the Equator to occupy its present position at 1° Lat N.

Outlining the possible tectonic of the area, we have suggested the presence of two depressions, one being an Infracambrian aulacogen within a very old basement, reactivated during the Wealdian and the other being a graben within a more pliable basement, branching out of the former near Liranga. Are source rocks present in these depressions? From the fetid dolomitic limestones of the Infracambrian of the Comba area, a sample has been collected and analysed geochemically as a very poor source rock. SCOLARI (1965, p. 42) has described dolomitic bituminous limestones from the same area. This sample was collected in the Upper part of the Infracambrian „Schisto-Calcaire" formation and as this formation is filling the aulacogene of Bakongo in great thickness, hydrocarbon generation cannot be ruled out. In the area North of Sembe was collected another poor source rock, geochemically analysed (see above). For the moment one can make only hypothesis as to the stratigraphic position of this sample. It appears to be in relation with the Tillitic Complex of Bandja, and as this complex includes such facies as „carbonates noirs indurés" and „black to grey calcschists with pyrite", the possibility of the presence of a source rock cannot be excluded. The fetid limestones of Fatima near Bangui (Late Precambrian?) should also be mentionned. All these facies could be present at depth in the Graben of Carnot. During the

Mesozoic several facies can be considered as likely source rocks: First, one should mention the well known Upper Jurassic (Kimmeridgian) bituminous shales (so called „argilites calcareuses") of Stanleyville in the northeastern part of the Republic of Zaire. An exact equivalent of this facies was also discovered in the area of Kinshasa (EGOROFF and LOMBARD, 1962); this important discovery point to the unavoidable presence of this formation also at depth between Brazzaville and Stanleyville, presumably in the depressed lineament of the Congo between Brazzaville and Mbandaka (Coquilhatville). This formation could also be present in the Carnot graben which is branching northwestwards from the postulated aulacogen. In the Cameroon, five hundred kilometers from the Carnot graben, Wealdian bituminous shales are known since long time. Contemporaneously, in the Lower Cretaceous grabens of the present South Atlantic offshore (in Gabon, Congo, Cabinda and Angola) source rocks are known to have been deposited. In Southern Tchad, in the area of Moundou, 500 km north of the Graben of Carnot, production is proven, presumably from Lower Cretaceous formations. Similar conditions probably exist in Southern Sudan (Abu Gabra, Bahr el Ghazal) in a depressed area separated from the area under review by the large recent basement uplift of the Oubangui; production is also proven in the Abu Gabra depression. Finally, in the Zairian part of the „Cuvette" several bituminous layers are recorded in the Loia formation (Weald) (LOMBARD 1967, p. 57/58). In the Middle Cretaceous two formations could contain potential source rocks, at Molimba in the North of the Cuvette and at Kipala in the Kwango in the Southwest. These deposits are very thin and it is not sure if they are likely to attain greater thicknesses in the Graben of Carnot or in the Bakongo aulacogen, as at that time subsidence may have ceased in the depressed areas and the flat bottom of the Cuvette may have witnessed only an extensive but short and shallow epicontinental marine invasion, although distension accompanied by subsidence might have occured in our area while compression was taking place contemporaneously on the eastern margin of the Benoue rift and in the mylonite zones of Cameroon.

Up to now, consulted petroleum geologists have been rather pessimistic in what regard the oil potential of the Cuvette. However our analysis shows that one can think differently and that grabens filled with possible Upper Jurassic to Wealdian source rocks can be hidden below an Upper Cretaceous and Tertiary blanket. Even in this respect it is also interesting to quote LEPERSONNE (1958, p.39) who writes, after so many fruitful years spent elucidating the geology of the Congo: «L'existence de couches anterieures au Jurassique supérieur déjà connues au bord est n'est donc pas non plus exclue au bord ouest de la Cuvette congolaise. Dans ce cas on pourrait s'attendre à rencontrer à l'intérieur de la Cuvette, en dessous du Crétacé et du Jurassique supérieur, un important tapis de couches plus anciennes, appartenant soit au Jurassique anté-Kimmeridgien, soit au Triasique, soit à l'un de ces systèmes seulement, sans préjudice de la présence éventuelle du Permien.»

Of course further geochemical studies and geological interpretations of Landsat images are needed. But what is imperative in such a virgin area, is the first step of an oil exploration, i.e. and aeromagnetic survey in order to obtain data on thicknesses. On the basis of my working hypothesis (Carnot Graben and Bakongo aulacogen), such a survey has been performed in 1980 for the Republic of Congo (Brazzaville) by an international financial aid agency. This aeromagnetic survey no doubt, will reveal highly interesting geological features.


Quaternary - Cenozoic - Mesozoic
Mpioka, Jnkisi
Graben floor & flanks
Schisto-Calcaire
Francevillian
Sembe-Ouesso-Dja-Nola-Bandja series
F.: Franceville
B.: Bangui
SP: Stanley Pool
PM
M
Niari
Chaillu
Gabon Shield
Carnot Graben
Congo
Ou
Dja
JWS 78
5°
15°
20°
0°
A
B
C
M: Mayombe
B: Bouenza, C: Comba
Ou (proj.)
L: Liranga (proj.), Ou: Oubangui
No vertical scale
500 Km
Pre-Mayombe basement PM
Panafrican regenerated basement
Old cratons: Chaillu, Gabon shield, Mbomu
BLOCK DIAGRAM
Tectonic sketch of Congo Region
JWS

Map Index

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* An aulacogen is an intracontinental basin, of long duration, of a particular type considered to have its origin in a failed arm of a triple junction generated by a hot spot.

Aulacogen are usually oriented to the edges of present continents or to the edges of protocontinents. Aulacogen become deeper towards the present edge of a continent, opening themselves towards an ocean or deepening towards the former edge of a protocontinent where in that case they join at right angle with a geosyncline and its subsequent orogen. (See BURKE and DEWEY 1973, Journ. of Geol., 81/4; see HOFMANN 1974, Soc. Econ. Pal. and Min., Sp. Publ. No 19; see SCHATSKI 1961, Akademie Verlag, Berlin.)