The dolerites of the Naga region, are reservoirs of hydrocarbons (The dolerite of Naga, Tindouf basin)

Souad Bentaalla-Kaced

Postgraduate student
Ecole Nationale Polytechnique
Alger, Algérie
E-mail: souad.bentaalla@gmail.com

Karima Deramchi

Assistant Professor
Ecole Nationale Polytechnique,
Alger, Algérie
E-mail: karimaderamchi@yahoo.fr

Tahar Aifa

Professor
Université de Rennes 1
Rennes, France
E-mail: tahar.aifa@univ-rennes1.fr

Abdelaziz Boutrid

Assistant Professor
Université d'Annaba
Algeria
E-mail: aboutrid@yahoo.fr

Berdoudi Said

Assistant Professor
Ecole Nationale Polytechnique
Alger, Algérie
E-mail: berdoudisaid@yahoo.fr

Samira Boutria

Postgraduate student
Ecole Nationale Polytechnique
Alger, Algérie
E-mail: samiraboutria@yahoo.fr

Abstract
The purpose of this work is the dolerite of Tindouf Basin and particularly the Naga area where few wells drilled have registered gas flow from the dolerite banks and the enclosing levels of the host rock.
By summarizing all the geological data brought by the polls that have recognized these intrusive rocks, we will try in this article to debate about this kind of reservoir which can prove to be in the future a new play.
Keywords: DOLERITE, RESERVOIR, HYDROCARBON, WELL

Introduction

Generally, the igneous rocks have always been considered by the Oil Companies as non-objective, despite some fortuitous discoveries directly or indirectly related to these rocks. We also knew for years that the presence of oil and gas is proven in these non-sedimentary rocks that may act as traps after magma cooling and solidification, giving numerous hydrocarbon fields (Fig.1).

The Tindouf basin

The Tindouf basin is oriented ENE-WSW (Fig. 2) [3], along 800 km (including 540 km in Algeria), it's an asymmetrical basin with a southern slope with a gentle up dip towards Eglabs and narrowband northern flank, very sloped and pleated, it is bordered on the east by the Ougarta chains and Reganne depression, north by the Anti-Atlas and west by El Ayoun basin [1], [2] and [3].

The depot center of Tindouf basin is relatively close to the north flank where the sediment thickness is around 8000 m, while it is around 1500 m (average) to the south. The sedimentary cover is composed mainly of Paleozoic formations, Cambrian to Carboniferous [3] and a thin layer of tertiary is covering almost the entirely surface of the basin.

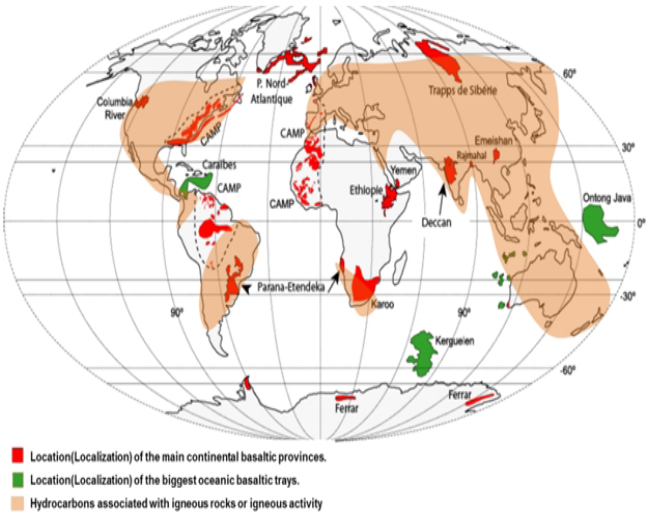

Figure 1. Map showing the geographical distribution of main Continental Flood basalts and oceanic basaltic trays ([1] and [4], Modified)

The dolerite in the Tindouf basin

The paleozoic series of Tindouf basin have experienced dolerite intrusions affecting the Cambrian formations and particularly the upper Devonian (Famennian) (Figure 3). they are set up in the surrounding rock as sills and dykes and are linked to global tectonic characterizing the West African Craton in response to the opening dated Jurassic of the Central Atlantic [1], [2] and [3].

A few meters of metamorphic contact affecting the Paleozoic host rocks proving the intrusive nature of these dolerites, is described by different studies. According to the well results, the magmatism seems to be less pronounced in the southern part of Tindouf basin but it is more prolific in the northern part of the basin where it is reported an intense tectonic activity.

Two major features as structural axis are related in Tindouf basin, the first one trending W-E, (Anti Atlas direction), has been reasonably explored by seismic & drilling & some gas & oil shows are reported.

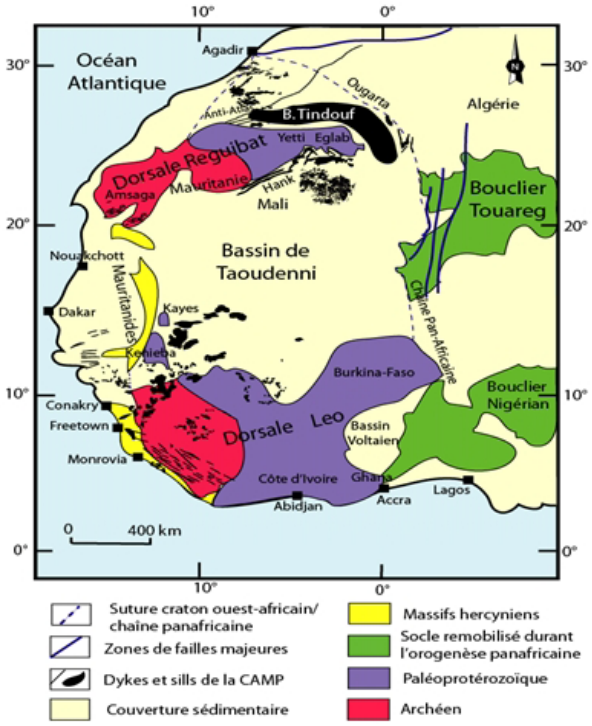

Figure 2. West Africa Simplified geological map showing the distribution of magmatic formations of the of Central Atlantic area [1] and [5]

The second one is located in the south, where drilling, despite absence of traps, revealed also many gas & oil shows. In the central part, another axis oriented NW-SE (Ougarta direction), is described, it was explored by two stratigraphic wells TIN-1 and TIN-2.

A gas coming was recorded from the TIN-1 Upper Devonian (Strunian) sandstones; these sandstones are associated with a thick bench of dolerite (about 67 m). A second bench of dolerite was also identified just above the Strunian-Tournaisian limit (Figure 4) [7].

This gas coming was questionable & according to the TIN-1 survey completion report done in 1962, the geologists have tried to find a relationship between the sandstone strata & the dolerite wall rock. None coming of gas, such as found in TIN-1, was recorded during the drilling of the TIN-2 in 2012; these two holes are 40 km distant from each other.

The description of the TIN-1 sandstone (and dolerite bench) where was recorded gas coming, reported the presence of fractures which improving the gas flow. So it was decided to study all dolerite benches encountered by TIN-1 & TIN-2 wells [7]. For both TIN-1 & TIN-2 wells, two groups of dolerite are recognized in the Strunian and the Famennian. A gas shows were also recorded (master log of TIN-2) during penetrating of the Famennian dolerites benches (Figure 4).

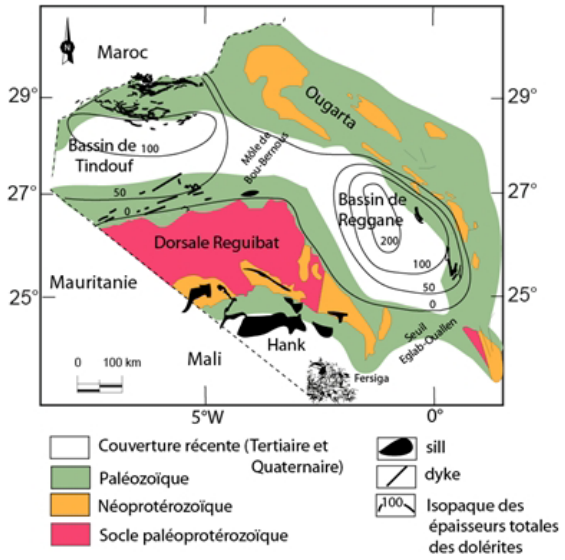

Figure 3. Map isopachs total thicknesses of dolerite subsurface basins of Tindouf and Reggane [1]

When drilling TIN-2 well, they encountered the same dolerite bench occurring at the same level of Famennian of TIN-1; and an unmeasured gas flow was recorded after test achievement [7].

Comparison with intrusion doleritic REG-1 and REG-2 (Basin de Reggane)

The neighbor pericratonic basin Reggane has also experienced an intense activity intrusive affecting the Paleozoic series of Upper Devonian and Carboniferous (Figure 2).

Two wells REG-1 & REG-2 drilled respectively in 1979 and 1980 in the extreme North-West part of the Reganne basin in the vicinity of Bou Bernous saddle are encountered the dolerites [8].

During a test conducted in REG-2, 1500 m^3 of dry gas was recorded from the Famennian affected by 114 m of this diabase intrusion [8].

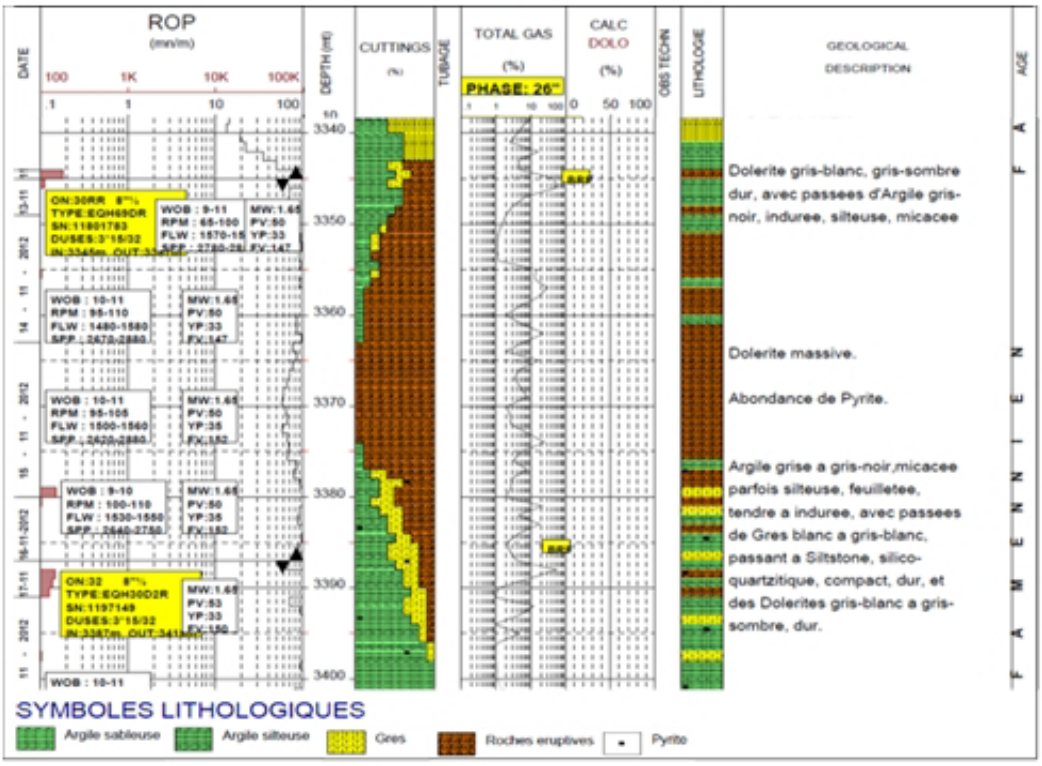

Figure 4. Masterlog -TIN-2 / Dolerite in Famenian @ [3340-3400 m]. (At the Dolerites bench, two (02) peaks of gas when the circulation of the bottom (BRF) of the plug which is rated at the log of total gas)

Comparison with deposit forms by reservoirs granitic of offshore Vietnamese (Cuu Long basin)

The geological setting of these dolerites can be compared and correlated to the granitic reservoirs in the Cuu Long basin of Vietnamese offshore.

This basin is tertiary rift formed in the early Oligocene & located in offshore southern Vietnam [6].

The Miocene inversion has intensified the fracturing of the granite basement where several reservoirs were identified and all give good oil flow after hydraulic fracturing. The porosity is less than 5% and the permeability ranges from 0 md à1000 md, the average depth of the top of these fractured granite reservoirs is from 2500 m to 4000 m.

The source rock of the Mesozoic granitic reservoirs is formed by excellent argillaceous bedrocks.

The reserves of oil are ranging from 100 to 400 mmb with good rates from 2000 to 4000 BBL [6].

The life cycle of this basin is considered as challenge, it's generally ranging from 1 to 13 years and depends on several factors (the importance of fractures, the hydrocarbon column, the reserves in place and the production rate).

The Tertiary clastic reservoirs were the initial exploration objective in this basin, while the granitic reservoir was investigated coincidentally and became after the discoveries, the main target in this area.

The case study of the Cuu Long basin confirms that the magma reservoirs, contrary to the general believe, can be a very good reservoir for gas or/& liquid hydrocarbons [6].

However to evaluate the potential of these reservoirs, the resistivity logs must be analyzed. The resistivity of igneous rocks is generally very high, but in case of presence of fractures and hydrocarbons, the drop in the resistivity is recorded. Furthermore the solidified magma could be more subject to fracture.

It is recommended to look for such reservoirs with such potential: (i) define the area of maximum of fractures and (ii) find the presence of a good source rock adjacent to reservoir.

Recall that these two conditions can be met in South-West Algeria basins Tindouf and Reggane (Chabou, 2001).

Conclusions and recommendations

In this report we have attempted to provide an answer about the behavior of igneous rock and particularly the dolerite as hydrocarbon reservoirs in the NAGA area of Tindouf Basin.

Three paragraphs were discussed: (i) A summary of the results of TIN-1 and TIN-2 wells of Tindouf basin. (ii) A comparison with the neighboring basin of Reggane where the Paleozoic series has logged an intrusive activity affecting mainly the Paleozoic Upper Devonian and Carboniferous. (iii)A case study and a summary for hydrocarbon prone, worldwide,

associated with igneous rocks.

Indeed, the magmatic rocks are spreading throughout the world, but a few are considered as hydrocarbons bearing rocks.

Generally, only shows & very low flow rates are recorded from these kinds of reservoirs. Furthermore, it's well known that the igneous rocks form the best reservoir when they have been exposed on the surface and have undergone any tectonic event that led to the creation of fractures and while remaining in contact with mature source rocks.

Dolerites observed in Tindouf and Reggane basins showed an unmeasured gas flow (TIN-1 / Tindouf) and gas shows or low flow rates (REG-1 / Reggane: 1500 m^3 / Gas Day) [8]. The phenomenon associated with the dolerite is: (i) Magma absorbing layer containing the bedrock. (ii) The host rock and magma became one body. (iii) The gas contained in the source rock form gas bubbles, filling the pores with gas & generating a vesicular porosity.

As soon as the bedrock magma mixing is carried out and after cooling, often fractures appear in these igneous rocks.

In our case, compaction can force the hydrocarbons within the Famennian source rock to move in new formed reservoir.

As a case study the Cuu Long offshore basin, located in Vietnam, shows that the magma reservoirs, contrary to the popular believe, can be a very good reservoir for gas or/& liquid hydrocarbons. To evaluate the potential of these kind of reservoirs, we learn also from this study it is necessary to analyze the resistivity logs. Indeed, the resistivity of igneous rocks stay high, but in the presence of fractures and hydrocarbons, the drop in the resistivity is logged.

After cooling the solidified magma became subject to fractures, it is recommended to search for such potential reservoirs to find the maximum of fractures and the good source rock communicating with these reservoirs. Recall, these two conditions could be met in the Southwest Algerian basins Tindouf and Reggane. Around Naga area (Tindouf Basin), the resisti- vity data of the Strunian and Famennian was analyzed. No resistivity drop is reported. However it should be noted that the Naga region has been the site of intense fracturing. As recommendations, we suggest to explore the North of Naga, it remains an interesting area, structurally faulted. To rule on the existence of oil potential in these igneous rocks, it would be appropriate to take a pilot wells in the area. This would allow for an assessment of the dolerite reservoirs in contact with the source rock using the appropriate logs i.e.: imaging of the resistivity (fractures characterization & fractures orientation), the neutron-capture spectroscopy (measure mineral composition) and the magnetic resonance log (fluid characterization). Following, if the existence of hydrocarbons is confirmed, consider if needed a hydraulic fracturing program.

References

1. Chabou, M.C., 2008. Datation 39Ar-40Ar et Géochimie de la Province Magmatique de l'Atlantique Central dans le Sud-Ouest algérien. Thèse de Doctorat, Ecole Nationale Polytechnique, Alger. 266 p.
2. Chabou, M.C., Sebaï, A., Feraud, G., Bertrand, H., 2007. Datation 40Ar/39Ar de la Province magmatique de l'Atlantique Central dans le Sud-Ouest algérien. Comptes Rendus Géoscience 339, 970–978.
3. Gevin, P., 1960. Etudes et reconnaissances géologiques sur l'axe cristallin Yetti-Eglab et ses bordures sédimentaires. *Service de la Carte Géologique de l'Algérie,* 328 p.
4. Jerram, D.A., Widdowson, M., 2005. The anatomy of Continental Flood Basalt Provinces: geological constraints on the processes and products of flood volcanism. *Lithos*, **79,** 385-405.
5. Peucat, J.J., Capdevila, R., Drareni, A., Mahdjoub, Y., Kahoui, M., 2005. The Eglab massif in the West African Craton (Algeria), an original segment of the Eburnean orogenic belt: petrology, geochemistry and geochronology. *Precambrian Research* 136, p. 309-352.
6. Nguyen Du and Hung Van, 2004, Petroleum Geology of Cuu Long Basin - Offshore Vietnam, Le1 Search and Discovery Article #10062.
7. Final drilling reports of Tindouf Wells.
8. Final drilling reports of Reggane Wells.

Metallurgical and Mining Industry

www.metaljournal.com.ua