

Remember Basement in your Oil and Exploration: Examples of Producing Basement Reservoirs in Indonesia, Venezuela and USA

Tako Koning*
Tullow Oil Angola, Luanda, Angola
takokoning@nexus.ao

Basement rocks are important oil and gas reservoirs in a number of countries and serve as a reminder that in areas where basement is not too deep, basement should be considered as a valid exploration objective.

The term 'basement rocks' generates a variety of definitions by geologists depending on the specific sedimentary basin discussed as well as the individual's experience in that area (Koning, 2003). The "standard" definition of basement can be found in the classic paper by Lands et al (1960) which stated 'the only major difference between basement rock and the overlying sedimentary rock oil deposits is that in the former case the original oil-yielding formation (source rock) can not underlie the reservoir'.

Basement reservoirs include fractured or weathered granites, fractured quartzites, and metamorphic rocks such as fractured schists or argillites.

- In South America, basement reservoirs produce oil in Venezuela and Brazil.
- Oil is produced in the USA from basement in California, Kansas and Texas.
- In North Africa, basement oil and gas production occurs in Morocco, Libya, Algeria and Egypt.
- In the Middle East, important oil reservoirs have been discovered in basement in the last decade in Yemen.
- Significant basement reservoirs occur in the West Siberia Basin as well as in China.
- In Southeast Asia, very prolific basement reservoirs are the main contributor of oil production in Viet Nam.
- In Indonesia, the basement oil pools have been modest in size. The Beruk Northeast Field in Central Sumatra has produced about 2 million barrels of oil. The Tanjung Field in the Barito Basin in southern Kalimantan has produced about 25 million barrels of oil. Offsetting these modest oil reserves, however, has been the discovery of giant-size gas fields in pre-Tertiary basement in South Sumatra. The gas reserves of these fields is in the order of 5 TCF and the gas is now being delivered by pipeline to the Caltex Duri steam flood project in Central Sumatra as well as to Singapore for power generation.

The tendency in many oil plays worldwide has been to terminate drilling prior to penetrating into basement. Therefore it is possible that there are oil and gas fields "left behind" in areas where

basement was not entered by the drill bit but where mature oil or gas source rocks are close to basement and where basement is fractured or weathered and occurs within structural closure.

In Western Canada, no oil or gas has been produced from basement. However, there should be studies made in areas where known hydrocarbon source rocks are in contact with basement. For example, in northern Alberta's granite wash play, the oil production is from the sands eroded off Pre-Cambrian basement. Was the basement drilled deep enough and thoroughly evaluated, by electric logs, sidewall cores, and conventional cores, as a possible hydrocarbon reservoir?

Based on the author's experience with working on basement reservoirs and also based on his two decades of ongoing review of the available literature on basement reservoirs, he has made the following recommendations which are discussed in more detail in the author's paper in the Geological Society's Special Publication 214 on "Hydrocarbons in Crystalline Rocks".

- 1) Oil and gas fields in basement are usually found "by accident". In most drilling campaigns, it is not necessary to drill into basement since it is too deep to be considered as economically viable, but in some cases, there is a desire to "tag into basement" in order to give the geophysicist a reliable "seismic pick" on basement. Usually when oil or gas has been found in basement, it was a case where oil or gas shows were encountered when tagging into basement and the decision was made to test the zone, resulting in a discovery. For example, the Beruk Northeast field in Central Sumatra was discovered on that basis. Beruk Northeast-1 was targeted for oil in the Tertiary sediments but oil shows were noticed in fractured basement quartzites which resulted in a drill stem test on the top of basement. This led to discovery of the Beruk Northeast Field and subsequent exploration for similar "look alikes".
- 2) Basement reservoirs can be very prolific if basement is very faulted and fractured, as in the case of quartzite reservoirs. Quartzites are brittle and fracture readily and accordingly serve as excellent basement reservoirs. In comparison, basement argillites tend to be ductile and do not fracture readily and typically are not good basement reservoirs. In the Beruk Northeast Field, the quartzites are by far the best reservoirs.
- 3) Fractured granite also can be an excellent reservoir. For example, the Bach Ho (White Tiger) field in Viet Nam produced in the range of 130,000 BOPD from such reservoir rocks.
- 4) Weathered granite can also be an excellent reservoir. Weathering of granite, especially under tropical conditions, can result in very porous secondary porosity penetrating 100 – 200 meters into the granite. These weathered granites can appear like coarse sandstones (granite wash sandstones) in hand specimens or core.
- 5) Due to the fractured nature of many basement reservoirs, initial test rates can be very high, indeed deceptively high. The reservoirs could deplete rapidly. There are some cases where the development projects including pipelines, oil gathering facilities, etc were overbuilt and led to uneconomic development of the reservoirs due to rapid influx of water.
- 6) Basement reservoirs are typically complex with multiple lithologies, possible two or more fracture systems and multiple oil-gas and oil-water contacts. Accordingly, these reservoirs need to be studied closely. Extensive core coverage is warranted as are full log suites. Coring is typically difficult due to the fractured nature of the reservoirs (Lamb, 1997). These are challenging reservoirs for the geoscientists and reservoir engineers.

- 7) Drilling programs should allow for enough depth to fully penetrate basement, including a minimum of 100 meters. In some cases, the top of basement may be tight but porosity may be developed beneath the tight zone. Due to insufficient drill depth into basement, the giant Suban gas field in South Sumatra was undiscovered for many years since many wells had simply 'tagged' into the top of basement and the explorationists did not recognize the potential of the huge underlying gas reservoir.
- 8) There needs to be a paradigm shift in the mentality regarding basement. Indeed, in oil patch "folk lore" there is the view that anything in or near basement is non-economic and that it is time to "shut down" the drilling. In oil patch folk lore, any sands near basement were termed the "suitcase sands" since at that point it was time for the drilling engineer on the wellsite to plug off the well, pack up his suitcase and go home. However, prolific oil and gas fields worldwide serve as a reminder to evaluate, if possible, the underlying basement, especially if the basement is structurally high and indications from seismic or regional geology shows that the basement is weathered or faulted.

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