GeoConvention 2015
GEOSCIENCE
new horizons
Telus Convention Centre • 4-8 May 2015 • Calgary, AB Canada

# Exploring & Developing Fractured Basement Opportunities - Globally & Locally

*Tako Koning.*
*Gaffney, Cline & Associates*

## Introduction

Fractured and weathered basement rocks are important oil and gas reservoirs in various basins world-wide. This author has followed this subject very closely for over thirty years and hereby shares his knowledge and experience. This paper focuses on important oil and gas fields in Indonesia, Vietnam, China, Venezuela, USA and the UK to explain how these fields were eventually discovered despite their complicated geology. Also reviewed is how the operators of these fields are able to efficiently and economically produce oil and gas from the basement reservoirs.

In a general sense, fractured granites and quartzites are the optimum reservoirs. Weathered "rotten" granites can also be excellent reservoirs as can be observed in outcrop in tropical areas. Rocks such as schists and gneisses are less attractive since they are ductile and tend to "smear" and not fracture when subjected to tectonic stress. The high mafic content of schists also negates the creation of secondary porosity by weathering. Likewise, granites and quartzites are more likely to provide attractive, highly porous "granite wash" sands whereas eroded schists to not produce such good reservoirs.

## Analogues

For anyone exploring for basement reservoirs or developing an oil or gas field contained in basement, studying analogues is imperative.

### Select Analogues

1.) **Vietnam** Most of Vietnam's oil production is from fractured granite basement in the Cuu Long basin with six major oil fields producing primarily from basement. Overlying and adjacent Oligocene lacustrine shales generated the oil which migrated into the fractured basement. The Bach Ho (White Tiger) is a giant field with recoverable volumes of 1.0 – 1.4 billion barrels of oil. Other fields include Rong, Rang Dong, Ruby and Su Tu Den with oil volumes ranging from 100 to 400 million barrels.

The Ca Ngu Vang (CNV) field, discovered in 2002 is the deepest oil-bearing structure in the basin, where the top of basement is at a depth of 3,700 meters. Indeed, the SOCO-operated CNV-3X well was the longest measured depth well drilled in Vietnam (6,123 meters) with over 2,000 meters of basement penetrated in a near-horizontal well emplacement and was tested at 13,040 boepd (barrels of oil equivalent per day).

2.) **China** The Dongshenpu field, onshore central China is an example of a Chinese "buried hill" basement oil field. This field was discovered in 1983 and the reservoir consists of PreCambrian granites, granulites, diabases and hornblendic metamorphics. The rocks have no primary porosity but the porous reservoirs are due to weathering and fracturing. The discovery well tested at 1,570 bopd and subsequent development drilling has proven the oil column to be 400 meters thick.

3.) **Indonesia** To date in Indonesia, oil production from basement rocks has been minimal but major gas discoveries in South Sumatra including the giant-size Suban gas field have been made in pre-Tertiary basement reservoirs. Gas volumes in the basement are estimated in the range of 5 TCF (trillion cubic feet). This has led to further exploration for gas in basement due to the need for more gas as the Indonesia economy continues to rapidly expand.

The largest basement oil pool in Indonesia is the Tanjung oil field in Kalimantan. This field has produced over 70 million barrels of oil from overlying Eocene sandstones and conglomerates but it has also produced over 20 million barrels of oil from pre-Tertiary basement rocks including weathered volcanic, pyroclastics and metasediments.

4.) **North Africa** Major gas volumes have been found in basement reservoirs in Libya and Algeria. Oil has been produced from basement reservoirs in the Egypt's offshore Zeit Bay field, Gulf of Suez.

### Best Practices for Exploring & Producing Basement Reservoirs

Best practices include the following:

1.) Production wells should be drilled near-perpendicular to the dominant fracture system.

2.) Exploration wells should also be drilled highly deviated rather than vertical in order to optimally intersect the dominant fracture systems.

3.) Highly focused 3D seismic such as CBM (Controlled Beam Migration) is needed to define the fracture systems in basement.

4.) Extensive core coverage is necessary to provide critically important information on the lithologies and reservoir parameters. Some of the cores should also be radiometrically age dated in order for the geologists to understand the complexities of the basement reservoirs they are dealing with.

5.) Exploration wells should not just "tag" into the top of basement. Rather they should be drilled 100 – 200 meters into the basement in order to fully evaluate it.

6.) Development wells must be sufficiently deep to fully drain the reservoir. For example wells in the La Paz field, Venezuela which produces from basement were typically drilled 500 meters into the basement.

## Acknowledgements

The author appreciates the approval of his employer, Gaffney, Cline & Associates to present this paper. He has been following the subject of fractured and weathered basement reservoirs since 1982 when he worked on such a field in Sumatra, Indonesia. He has retained an abiding interest in such oil and gas accumulations since that time and has presented papers worldwide at conferences and symposiums on these reservoirs. The author has had papers published in the proceedings of the Indonesian Petroleum Association in Jakarta in 1984 and in a book published in 2003 by the Geological Society of London on *Hydrocarbons in Crystalline Rocks*.

The author is Holland-born and Canada-raised. He graduated in 1971 with a B.Sc. in Geology from the University of Alberta and in 1981 with a B.A. in Economics from the University of Calgary. He joined the oil industry in 1971 and has 44 years of experience which includes 30 years overseas in Indonesia, Nigeria and Angola. He is a long-term member (about 40 years) of the CSPG. He lives in Luanda, Angola where he is an active member of the boards of directors of the AAPG, SPE, and SPWLA. He frequently leads geological field trips north of Luanda for oil industry professionals, university students and the public-at-large to study Cretaceous sedimentary rocks and robust seepages of pre-salt oil which occur along the eastern margins of the Kwanza Basin. Fractured and weathered outcrops of Pre-Cambrian granites are also studied on his field trips.