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Exploring in the USA and Canada for Oil and Gas in Fractured Precambrian Crystalline Basement – a Geologically High Risk but Potentially High Reward Hydrocarbon Play

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INTRODUCTION

This presentation is focused on the potential for significant resources of oil and gas in crystalline basement in the USA and Canada. Only minor amounts of oil and gas have been produced to date in the USA, as detailed below. Rather surprisingly, although the Western Canada Sedimentary Basin (WCSB) is one of the most prolific sedimentary basins in the world, no oil or gas has ever been produced from basement in the WCSB.

Major volumes of oil and gas are produced from reservoirs in fractured and weathered basement in China, Vietnam, Indonesia, India, Libya, Venezuela and Russia. The volumes of oil and gas produced from the basement fields worldwide varies from barely economic volumes to giant-size fields. For example, oil is produced from Jurassic schists in California with some of the basement-reservoired oil pools having reserves as little as only 2 million barrels of oil. On the other end of the scale are basement fields like Auguila - Naafora in Libya with estimated reserves of 1.8 billion barrels of oil in basement. The Bach Ho-White Tiger oil field, offshore Vietnam has approximately 1.4 billion barrels of oil produced from basement. Other “high-end” examples include the Suban gas field in South Sumatra which has reserves of over 5 TCF gas. Suban is in an area where 8 gas fields were found in basement with gas reserves totaling 15 TCF. The Renqiu oil field onshore China has reserves of approximately 2.3 billion barrels of oil and is the world’s largest oil field in basement.

The basement lithologies of some of these fields includes fractured Precambrian granite in Libya’s Auguila-Naafora oil field. in Vietnam’s Bach Ho field oil production is from fractured Precambrian granites. The gas production from the Suban field in South Sumatra is from fractured pre-Tertiary age granites. Oil production from China’s Renqiu field is from Cambrian and Ordovician basement dolomitic carbonates located in a “buried hill” type of structural closure.

Production from these fields is mainly from natural fractures in the basement. These are the result of regional or local tectonism. The La Paz field in Venezuela which has produced over 300 million barrels of oil from basement. Fractures in the basement of La Paz are associated with a prominent reverse fault. The Auguila-Naafora oil field in Libya has fracturing associated with normal faulting. The Suban field is the result of regional wrench (strike-slip) faulting. With some basement oil and gas fields like Auguila-Naafora and Suban, weathering at the top of basement has also created excellent basement reservoirs.

USA: Production of Oil and Gas from Basement

Orth Oil Pool, Kansas: Minor volumes of oil have been produced from the Orth field, central Kansas. Approximately 1 million barrels of oil have been produced from basement from 15 wells. The reservoir in Orth is Precambrian fractured quartzites. The source rocks are adjacent and overlying Pennsylvanian-age shales. Oil is produced from the top of Precambrian buried hills, at a depth of about 1,000 meters (3,300 feet).

Apco Oil Pool, Texas: A few wells have produced from fractured Precambrian basement in the Apco field, onshore Texas.

Ames Oil Pool, Oklahoma: A single well produced at an IP of about 1,500 BOPD from fractured crystalline basement in the Ames oil pool. About 15 wells produced oil from fractured Ordovician carbonates. This field resulted from a meteorite strike in late Ordovician time which formed a circular structure.

Minimal published information is available on the American fields. The oil produced from these fields is nowhere near the volumes of oil produced in countries like Vietnam and China. However, the existence of extensive onshore infrastructure (pipelines, gathering stations, nearby refineries, excellent production contracts with minimal taxation) can make small amounts of oil or gas to be very profitable.

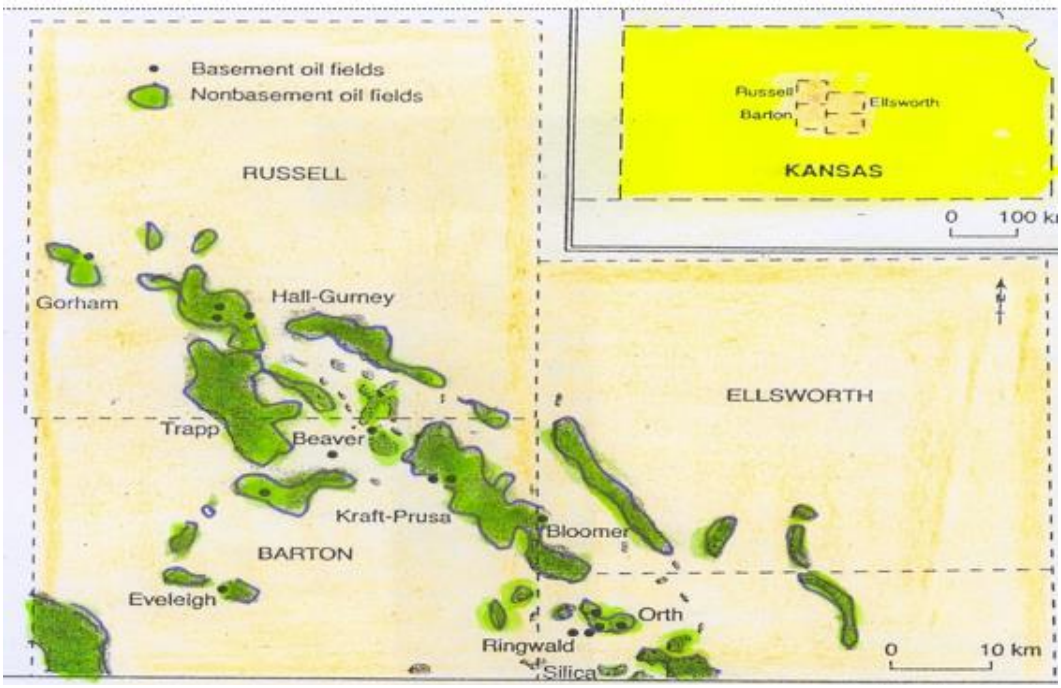

Figure 1. Kansas, USA – Fractured Precambrian Quartzite Buried Hill Oil Pools. From: K.K. Landes et al., 1960, Petroleum Resources in Basement Rocks, AAPG Bulletin, Vol.40, No. 10 (October 1960), PP 1682-1691.

Production of up to 20 million barrels of oil has been produced from basement in fields in California although typically those pools have produced little more than 2 million barrels of oil. However, the reservoirs are Jurrasic-age schists and meta-sandstones so these are not geologically equivalent to the oil pools which have produced in Kansas and Texas.

Canada: Unexplored but Significant Potential

I have always been perplexed that there has never been oil or gas produced from the basement in the WCSB. I believe this is because this play is little known within the Calgary "oil patch" which is entirely focused on the WCSB and know little about an "exotic" play like oil and gas in basement. Also, most exploration wells avoided basement since it was traditionally known as "tight" or "tombstone". Consequently, there has never been a deliberate, basement-focused exploration program in the WCSB. The closest to this was an exploration well drilled in 1994 just west of Fort McMurray, AOC Granite 7-32-8-W4 which drilled through over a mile of granite 1,822 meters (5,978 feet) to a total depth of a total depth of 2,363 meters (7,688 feet).

This well was also known as the "Hunt Well" since it was promoted by Calgary geologist Charles Warren Hunt. The Hunt Well will be reviewed in my presentation as an example of a basement exploration well which I would have never recommended. In my view, a better area to explore for oil or gas in Precambrian basement in the WCSB is the Red Earth – Nipisi area where oil is produced from Devonian-age Gilwood sands overlying Precambrian basement. This is an area where the focus of the geologists was on the Gilwood and the potential of oil and gas in basement was unrecognized to this very day.

Conclusions and Recommendations

Prospective areas exist in the USA and Canada for oil and gas in basement. These areas have never been the subject of deliberate, highly-focused exploration in the underlying basement. Exploring for oil and gas in basement rocks takes a special "mind set" since this is much different to exploring in sedimentary rocks. Worldwide analogues need to be studied in order to understand the geological ingredients necessary for commercial successes in basement and to understand why some of such fields ultimately can turn into commercial disasters. Leading edge 3D and 4D seismic is critical in this exploration and requires teams of experienced geoscientists (geologists and geophysicists) and reservoir engineers to ensure success.

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Figure 2. Granitic core from the deepest section of the Hunt Well (below 2,300 m, 7,590 ft). The diameter of the core is 4 inches (10 cm). Note the absence of fractures, this granite is totally tight. From: Majorowicz, J., et al, 2014, Geophysical Journal International.

BIOGRAPHY

I am Holland-born but Alberta-raised with a B.Sc. in 1971 from the University of Alberta and a B.A. in Economics in 1981 from the University of Calgary. I first learned about basement oil and gas reservoirs forty years ago when I worked in Sumatra on the development of the Beruk Northeast field which produced oil from fractured basement. I subsequently published on Beruk Northeast in the 1984 proceedings of the Annual Convention of the Indonesia Petroleum Association in Jakarta. Thereafter, I wrote a paper in the special publication "*Hydrocarbons in Crystalline Rocks*" of the Geological Society of London published in 2003. I have continued to closely follow basement oil and gas activity for over four decades and have presented and written on it at numerous conferences, conventions, and symposiums worldwide. Locations were as follows:

Asia: Jakarta & Singapore
Middle East: Istanbul
Europe: London & Kazan-Russia
Africa: Lagos, Abuja, Luanda & Cape Town

North America: Calgary, Houston, & Pittsburgh
South America: Buenos Airies

I worked for 30 years worldwide with Texaco until Texaco was taken over by Chevron. I have worked for 15 years in Canada, mainly in Calgary although I initially spent 2 years working as a mud-logger on the drilling rigs on the Grand Banks, offshore Newfoundland. I lived and worked for 30 years in Sumatra, Nigeria, and Angola. In Angola, I worked for Texaco and consulted for Tullow Oil and the American-British consultancy of Gaffney, Cline & Associates. I am a long-term member of the CEGA-CSPG, CSEG, AAPG and APEGA including fifty years nonstop (a half century!) with CEGA-CSPG and APEGA. For more information, I can be contacted at tako.koning@gmail.com or 1-587-284-3411.