APPENDIX 6

Unconventional Gas Potential in the Ordovician of The Amadeus Basin- The Horn Valley Siltstone fractured shale play

Central Petroleum Limited Technical Note 270607 Greg Ambrose

Synopsis

The Amadeus Basin, is a multiphase rift - foreland basin, with major thrusting occurring in the Late Neoproterozoic and Devonian-Carboniferous. The basin hosts thick sequences of Proterozoic to Carboniferous sediments. The most important petroleum system yet commercially produced from is the Ordovician Horn Valley Siltstone source rock which has charged the Ordovician Pacoota and Stairway Sandstone units; these reservoirs produce oil and gas from both conventional matrix porosity and fractured reservoirs in the Palm Valley and Mereenie oil and gas fields.

Elsewhere in the world, gas saturated shales and siltstones, for example the Baxter Shale of southwest Wyoming, are becoming increasingly important sources of gas from unconventional reservoirs in the USA. In Australia Coal Bed Methane (CBM) is playing an increasingly important role in the sourcing of sales gas and potentially providing feedstock for Gas to Liquids plants (GTL).

Continuous or basin-centred gas plays not obviously tied to structure or stratigraphic facies are also becoming more important in various parts of the world.

The Horn Valley Siltstone, covering a total area of c.40,000 km^2 in the northern Amadeus Basin is mature into the gas window over a total area of c.$10,000^2$ km and is estimated to host, based on reasonable assumptions c. 12,67 and 90 TCF of Original Gas Equivalent in Place (OGEIP) in primary porosity, fractures and adsorbed gas in kerogens at "low", "best" and "high" estimates, a proportion of which may be accessible by drilling fracture zones, fracture stimulation and/or horizontal drilling techniques so far not evaluated in this context in the Basin.

Additional potential OGEIP could be present in the Pacoota and Stairway in out of closure resources categorised as "indirect" Basin Centred Gas formed by transformation of original oil into gas at Vitrinite Reflectance values (Vr) of 1.35 to 1.75. This potential is not addressed in this Technical Note.

Although the Company is aiming to develop potential from oil prospects initially, it plans to evaluate these prospective resources as part of its plans going forward which include further feasibility studies of a large centrally located Gas to Liquids plant (GTL) to produce ultra-clean diesel, jet fuel and naphtha.

Discussion

It should be emphasized that unstimulated commercial production from shales has been achievable in only a small proportion of shale wells drilled in the USA, ie those that intercept natural fracture networks. Generally less than 10% of shale gas wells are completed without some form of reservoir stimulation, usually hydraulic fracturing. Gas in shales occurs as sorbed hydrocarbons, as free gas in fractures and intergranular porosity, and as gas dissolved in kerogen and bitumen. The degree of natural fracture development is critical to deliverability. Naturally occurring fracture systems have neither been mapped or targeted in any Horn Valley drilling to date.

The potential Horn Valley Siltstone shale gas system, which covers a very wide area (c.10,000 km^2), most of which is operated by Central Petroleum, falls into the continuous thermogenic category defined by widespread gas saturation, subtle trapping mechanisms, seals of variable lithology and relatively short migration distances (Curtin, 2002).

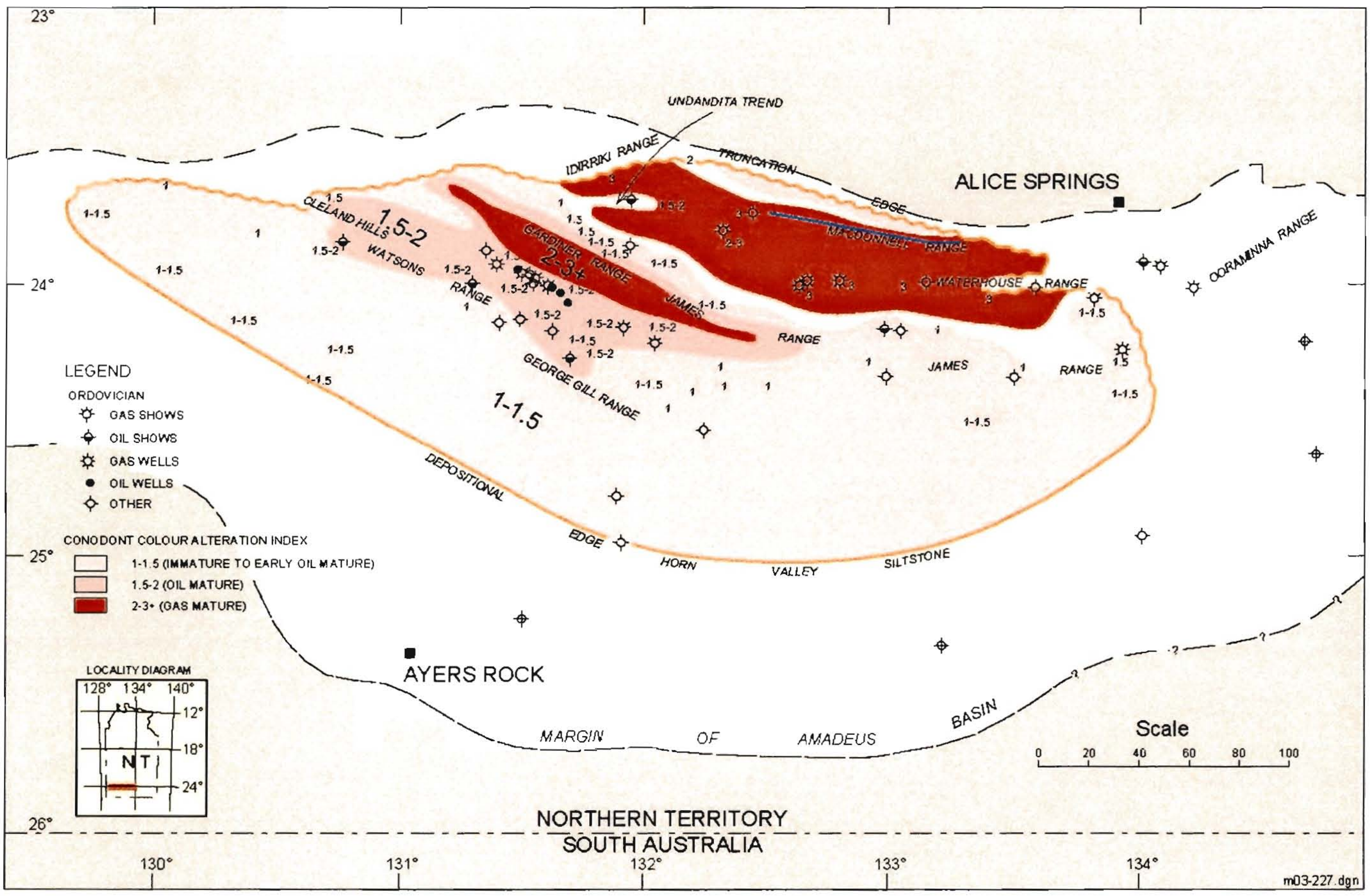

Figure 1 Regional extent of the Horn Valley Siltstone at varying thermal maturities

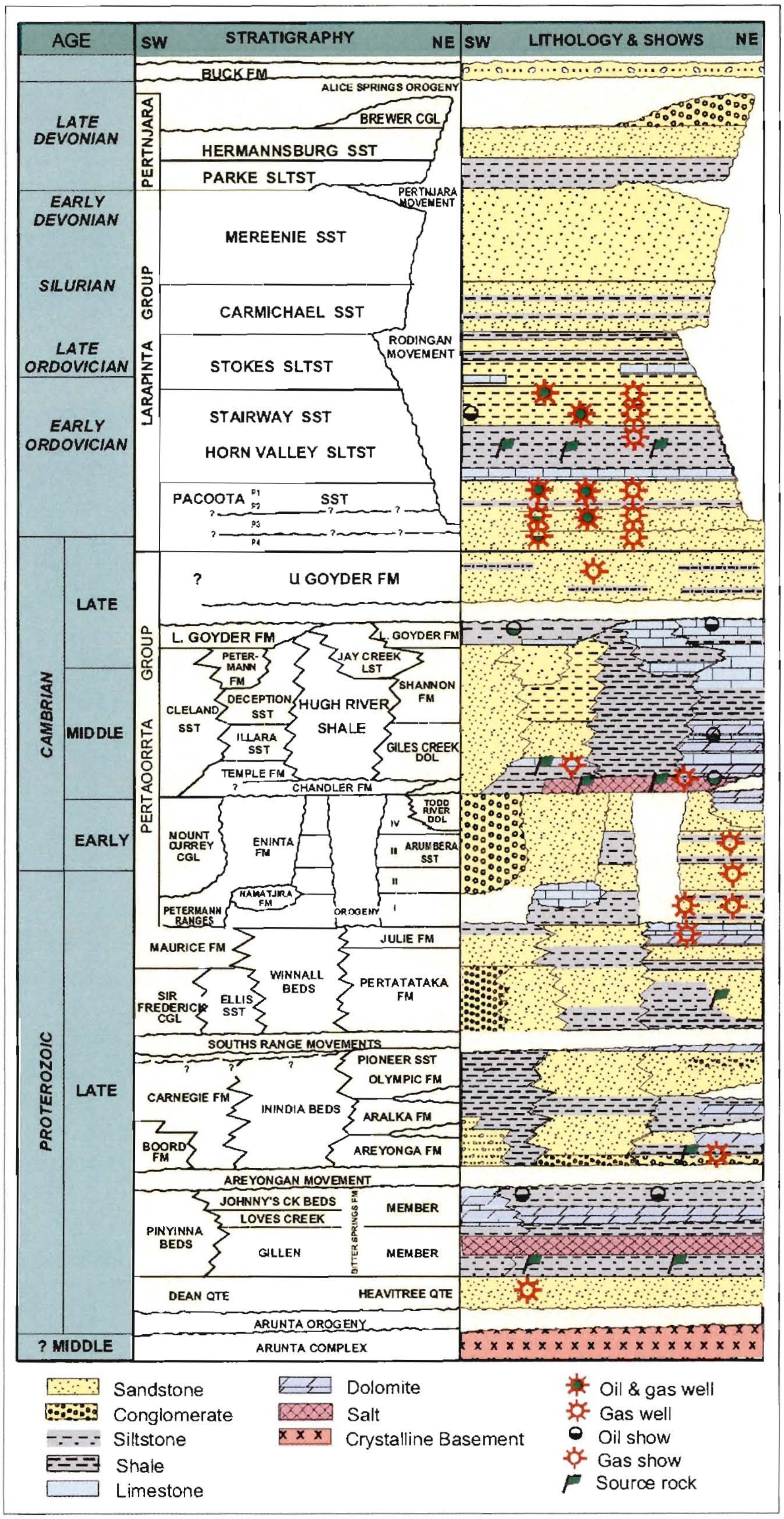

Figure 2 Stratigraphy of the Amadeus Basin

By world standards, the Horn Valley Siltstone (HVS) is certainly sufficiently organically rich to qualify as a gas shale. Details of its source rock characteristics occur in Gorter (1983) and Marshall (2004). Amorphous microbial sapropel is a major component of the HVS kerogen. TOC's largely lie between 0.5 to 1.5% and range up to 2.9%. The shale has been fractured over wide areas of the northern Amadeus Basin during the Alice Springs Orogeny (Devonian-Carboniferous), but many of these fractured areas which may have capability of un-stimulated production, have not been drilled.

A review of all existing log data and hydrocarbon shows/recoveries, has confirmed the HVS as a rich, oil prone marine source rock often characterised by high Total Gas readings while being drilled. However, it's potential to reservoir and produce hydrocarbons in its own right remains unevaluated. A number of air drilled exploration wells have penetrated the HVS but to date no hydrocarbons have been recovered from this zone. Gas shows, fluorescence and occasional bleeding hydrocarbons in core are occasionally recorded but appear at this stage to be more indicative of an excellent source rock than a potential tight reservoir/fractured shale play. Future exploration should carefully monitor gas flares whilst air drilling this unit. It is possible that water influx during air drilling could have obscured small gas flows from the HVS, but as far as the author is aware no gas flares have been recorded in exploration drilling to date although 150 units of gas was recorded during coring in Tent Hill-1 from a thin band of brecciated shale, and minor gas and oil bled from the core. Occasional hairline fractures were recorded in the HVS but these were largely sealed by calcite.

Preliminary Estimate of Exploration Potential- Horn Valley Siltstone

Assumptions : Total area in the gas window = 10,000 km2
Average shale thickness = 45 m net
Average shale density = 2.0 gm/cc
Average gas content of shale = 14 "low", 75 "best" and 100 "high" scf/ton*

Total GROSS OGEIP OVER GAS MATURE REGION = 12, 67 and 90 TCF

* This value is that assigned to the Ohio shale, a fractured Devonian shale play in the US, analogous to the Horn Valley in terms of organic content and thermal maturity. Recoverable GEIP (gas equivalent in place) has not been calculated as not enough data is available.

"Indirect" Basin Centred Gas Systems

The oil prone chemistry of the Horn Valley Siltstone is important when considering basin centred gas systems (BCGS) as it sets the stage for what are referred to as "indirect" BCGS's (Law, 2002). It is believed by the author that the Amadeus Basin Horn Valley Siltstone has considerable potential for this type of unconventional gas deposit and a preliminary discussion occurs below.

Unconventional gas deposits, whether they be basin centred or otherwise are usually denoted by some/all of the following criteria:

- Low permeability and abnormal pressure regime (low or high),
- Absence of a downdip water contact with gas underlying adjacent water zones in some cases.
- Deposits are often regionally pervasive covering hundreds/thousands of km2.
- Vertically stacked reservoirs may be up to 1000m thick; water bearing and gas reservoirs may be interbedded.

In the Amadeus Basin one very important petroleum system dominates the Ordovician sequence (Horn Valley Siltstone). It is predominantly an oil prone source rock with some gas potential. In the Mereenie Field the oil leg is supermature ie the oils are the product of protracted thermal transformation and substantial gasification in the reservoir (Havord,1991).

As a result of the transformation of oil to gas, fluid volume increases up to two times the original fluid volume (Tsuzuki, 1999). The pressuring fluid phase is gas. The transformation results initially in the development of overpressured gas-saturated reservoirs.

Oil generation from the Horn Valley Siltstone (HVS) occurred during foreland loading associated with the Alice Springs Orogeny (ASO). The oil was transformed to gas in the reservoir in the latter stages of the ASO. Gibson et al (2004) recognise subsequent cooling events (related to initial tectonic uplift succeeded by erosion/cooling) in the Carboniferous/early Permian, the Early Jurassic, the Late Cretaceous and the Late Tertiary. This led to basin unroofing and the progressive decline in geothermal gradients from the late ASO to the recent has probably caused overpressured gas bearing reservoirs to evolve into subnormally/normally pressured gas reservoirs.

The basic mechanism for initial over-pressuring occurs during the cracking phase of the oil (VR 1.35-1.75) when expelled gas migrates to low permeability reservoirs. Under these conditions of changing fluid volume and pressure, the capillary pressure of the water-wet pore system is exceeded and gas replaces free water in the pore space (Law, 2002).

The Horn Valley Siltstone fits the "indirect" model for the formation of Basin Centred Gas Systems (BCGS's), being a hydrogen rich, oil prone source rock. This type of BCGS's (ie those pertaining to the cracking of the oil phase) usually results in single , discrete reservoirs. The reservoirs always exhibit low porosity (< 13%) and low permeability (<0.1 md). Capillary pressure seals form as a result of small pore throats in these tight rocks. A case in point is the Ordovician reservoirs in the Mereenie Field where oil and gas have been detected up to **230 m below the structural spill point.** Permeability and capillary entry pressure variations are believed to be responsible. In general the hydrocarbon migration pathways and distances are highly variable but in the case of the Horn Valley petroleum system they are probably quite short.

Other examples may occur in Northwest Mereenie -1 and Waterhouse-1.

A low pressure gas flare, probably emanating from tight rock in the Lower Stairway Sandstone, probably resulted from capillary seal. Tight sandstone reservoirs above and below the zone (Pacoota and Stairway Sandstones respectively) are water wet. A gas flare was also recorded from the upper Pacoota Sandstone in West Waterhouse-1. Overlying reservoirs in the Stairways Sandstone were water wet.

Conclusions

The Horn Valley Siltstone qualifies as a potential unconventional shale-gas reservoir in terms of its average organic carbon content, thickness and regional extent, thermal maturity, and the regional overprint of a compressive, fracture-prone structural regime.

Although it is disappointing that air drilling has to date failed to record any gas flows from the HVS, it is possible small gas flows could have been masked by water influx into the well bore. Certainly early exploration in the area was not focussed on this unit and the potentialities of shale-gas in general, were largely unknown. Preliminary calculations put the total potential gas-in-place resource for the HSV in the Northern Amadeus Basin at 70 TCF. It is recommended in future that the Ordovician HVS be carefully monitored during drilling. Blowing the borehole clear of water and cuttings, followed by an open hole DST over the whole HVS section, may provide a methodology to establish embryonic gas flows which could be enhanced by fracture stimulation and or horizontal drilling techniques. This data needs to be supported by elogs capable of clearly defining fractures in the borehole.

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