AMERSFOORT PROJECT

The Amersfoort Gas Project is located in the extensive Permian age coal fields of South Africa’s Main Karoo Basin (Figure 1). The area is at the heart of South Africa’s existing coal based energy and power generation infrastructure and within close proximity to major industrial, mining and manufacturing areas. The Amersfoort Project tenure consists of over 1,600km² of granted exploration rights (ERs) (Figure 1).

The Amersfoort Project is currently operated as a joint venture between Kinetiko Energy (49% and operator) and Badimo Gas Ltd (51%). Badimo is a South African company that qualifies as a Black Economic Empowerment (BEE) controlled entity.

Figure 1 Location of the Amersfoort Project Exploration Rights

GEOLOGY AND GAS POTENTIAL

The most productive coal measures of Southern Africa are Permian in age contained within the extensive Permo-Triassic basins containing the Karoo Supergroup. These temperate climate coals are generally equivalent to the similarly aged coals of Eastern Australia. In the northern part of the Main Karoo Basin of South Africa (Figure 1) the most significant coal seams are contained within the Vryheid Formation of the Ecca
The coal rank is typically sub-bituminous. The shales and sandstones of the Vryheid in the northern part of basin are intruded by extensive dolerite sills and dykes.

Coal has been mined from numerous open cut and shallow (mainly 100-200m deep) underground collieries for over 100 years located around the periphery of the Main Karoo Basin (Figure 1). Coal from the Witbank, Ermelo, Highveld and Utrecht and nearby coalfields is used to power a major part of Southern Africa’s electrical generation capacity located in this area. Exploration drilling for coal over the last 30 to 40 years has demonstrated that the coal seams extend much deeper (500m+) into the Main Karoo Basin than just the deposits currently being mined on the shallow periphery of the basin. In the Amersfoort Project area over 800 coal exploration holes drilled mainly in the 1980s intersected coal in multiple seams over almost all of the area at depths of 300 to 400m and with cumulative thicknesses of 1 to 16m.

The deeper underground collieries and coal drilling commonly encounter signs of methane gas not only in the coals as adsorbed gas but also in the adjacent sandstones. Spontaneous gas emissions from the during drilling is common in the northern Main Karoo Basin. Shafts and exploration drilling targeting gold deposits in the basement beneath the Karoo Basin in this region also encounter significant amounts of methane gas where they penetrate through the overlying Permian coals and sediments.

With methane gas widely distributed through the Karoo coals and sediments the extensive dolerite sill and dyke intrusions of this part of the basin compartmentalise the sequence both laterally and vertically. Low permeability mudstones are also interbedded with the sandstones and provide further barriers to gas migration through the sequence. In addition conventional style gas traps are created where the sediment sequences are gently deformed into flexural closures or are terminated against impermeable unconformities.

Historically gas occurrences have been noted as particularly pronounced in the Evander, Smaldeel and Heilbron areas. The latter two occurrences also having a significant helium content in addition to methane. Helium has been produced in minor commercial quantities at times during the 20th century. The source of the helium would appear to be from fractures in the Proterozoic basement below the Karoo sediments where uranium decay in the Witwatersrand sediments has produced helium as a decay product. The helium migrating up the basement fractures is then captured in the same Karoo gas traps that have accumulated methane released during the maturation process of the coal and other organic sources within the Karoo sequences.

The amount of methane retained in the Karoo coals is dependent primarily on the confining hydrostatic conditions. At higher pressures more gas is held in the coals. As methane in excess of the adsorption capacity of the coals was released during coal maturation the excess gas has migrated from the coal to form conventional gas accumulations in porous traps within the adjacent sandstones. Locally in proximity to
basement fractures helium has also migrated into the same porous traps. Figure 2 is a schematic illustration of the gas occurrences in the northern Karoo basin.

In the context of the basin gas model shown in Figure 2 the Amersfoort Gas Project is ideally situated. Coal seams are at depths of 300 to 500m which means that confining pressures result in high gas contents in the coals, but not so deep that pressures have begun to collapse the permeability of the coals. In addition there are major dolerite sills and dykes creating sandstone gas traps at depth and consequently with significant reservoir pressures.

Figure 2 Gas exploration model for the northern main Karoo Basin of South Africa.

Figure 2 Coal bed methane and shallow conventional gas model for the Northern part of the main Karoo Basin of South Africa.
EXPLORATION DRILLING AT AMERSFOORT

The over 800 historical coal exploration holes at Amersfoort defined the wide extent, depths and thicknesses of the coal. This has enabled the Amersfoort Joint Venture to cost effectively carry out further drilling to explicitly determine the gas content of the coal. Since beginning exploration in 2010 the JV has to date drilled 21 core holes from which coal samples have been recovered for gas desorption test work (Figures 3, 4, 5, 6 and 7).

Figure 3 Amersfoort Project, exploration and pilot well drilling.
Geophysical logging of the exploration core holes has also been carried out. The logged geophysical parameters have included neutron and density log measures of porosity. Divergence between the two measures of porosity, commonly referred to a “gas crossover”, is an indicator of gas in the sandstones sequences (Figure 4).

**Figure 4** Down hole neutron and density logs showing gas cross overs.
Figure 5 Core drilling rig operating on the Amersfoort Project. Note the major electrical power transmission line.

Figure 6 Amersfoort Project coal core showing vigorous gas desorption before being sealed in desorption canisters.
Figure 7 Loading coal and carbonaceous mudstone core samples into desorption canisters.

Figure 8 Independently audited core desorption facility at Amersfoort.
The coal seams in the project area were found to typically contain between 2 and 11m$^3$/t of methane. All 21 core holes (Figure 3) exhibited gas cross over intervals for the neutron and density logs over many 10s of metres. These exploration coring results demonstrate that the coal seams and sandstones of the Amersfoort Project area contain widespread gas in both coals and porous sandstones. The drill hole defined gas prone zone is shown in Figure 3.

**GAS RESOURCES AT AMERSFOORT**

The combination of historical drilling defining coal distribution and thickness and the latter core drilling providing gas content trends in the coals has provided the basis for gas in place (GIP) estimations and the calculation of contingent resources for the project. Gas in conventional accumulations in the sandstone porosity can be inferred from the gas crossovers.

Gas in place (GIP) and contingent resources have been estimated for the Amersfoort Project by independent oil and gas consultants Gustavson Associates of Denver, Colorado, USA. The basis for these resource estimates is:

1. The geometry and distribution of the coal seams provided by the over 800 historical coal exploration holes,
2. The gas content of the coal as determined from the core sample desorption data, and
3. Estimates of conventional gas contained in the sandstones supported by the down hole neutron and density log gas cross overs.

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<td></td>
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Table 1 Amersfoort Project gas resources, Gustavson Associates
AMERSFOORT PILOT WELL TESTING

The distribution of coal seams is well established by the historical coal drilling over the Amerfoort Project area, and widespread gas has been demonstrated by the Joint Ventures exploration core drilling. On-going pilot well testing is now establishing the commercial potential of the Amersfoort Gas Field. Up to November 2013, 8 pilot wells have been drilled over 12 month period. The pilot wells represent single spot tests of the gas flow potential from the coal seams and the adjacent sandstones (Figures 3 and 9). These single spot pilot well tests will be used to locate multiple spot pilot well arrays.

Figure 9 Pilot well KA-03PT flaring gas.
Well Design and Completions

The pilot wells have all been designed as low cost vertical “barefoot” completions intended to access both the gassy sandstones and coal seams. Steel casing of up to 220m in each hole has been set and cemented from surface to below the main extent of dolerite sills. “Barefoot” refers to the uncased bottom portion of the well. No stimulation of the target seams or sandstones was undertaken. Down hole EPCP water pumps were set below the level of the deepest target coal seam. Flow skids at the well head control and measure water and gas production (Figure 10).

The pilot wells were drilled with a modified mineral exploration drilling rig. Well drilling and equipping costs for this simple well design are around A$200,000-$240,000/well. With production well drilling efficiencies well costs are expected to reduce significantly.

Figure 10 Flow skid process control display KA-03PT
Summaries of Pilot Well Results to Date

Pilot well locations are shown in Figure 3, active links in the figure connect to well description and videos of gas flaring. All eight wells drilled to date have been subjected to initial water extraction and gas flow tests. All wells produced gas flows, seven produced sustainable gas flares. Gas flows of up to 350,000scf/day were obtained. Gas content was consistently above 95% methane. Gas pressures in dewatered wells tended to approach 17 bar, which is consistent with measured gas pressures obtained for deep (300 to 350m) coal seams in this part of the Karoo Basin.

These results are extremely encouraging and demonstrate widespread and recoverable gas in both the coal seams and the adjacent sandstones. As single spot pilot wells, dewatering of a large area of coal seam to achieve peak production flows could not be expected. Multiple spot pilot well arrays are now planned to fully test the production capacities with by hydrostatic unloading of the coals and sandstones over a wider area. Further single spot pilot wells will still be used to further scope out the gas production potential of the rest of the Amersfoort Project Area.

Water influx from fractures limited gas production in several single spot holes. This indicates that “work over” capabilities are needed to conduct spotting cement jobs on selected fractures and other minor remedial actions. Accordingly a well work over program is being considered for up to 4 of the pilot wells.

AMERSFOORT REGION EXPLORATION

In only 2 years Kinetiko Energy has used its advantage as an early mover to position itself as a significant part of the nascent but rapidly evolving onshore gas industry in South Africa. Evaluation of the entire northern part of the Main Karoo Basin has led to the company seeking an even stronger tenure position centred on the 1,600km² of the two Amersfoort Exploration licenses with applications over another 10,508km². Demonstrated coal depths in these areas range from equivalent to the Amersfoort Project to over 800m.

As shown in Figure 11, following comprehensive desk top studies of historical drilling and other data, three applications have been lodged for Exploration Rights (ERs) covering 4,288km². Applications for two Technical Co-operation Permits (TCPs) covering 6,517km² have also been lodged. TCPs enable access to historical drill holes and other data held by Government Agencies, and confer a unique right to apply for ERs.

Badimo Gas also has a further 7,086km² of gas exploration tenure either granted or under application. Badimo and Kinetiko have a memorandum of understanding to extend their current JV to cover the additional Badimo tenure and applications.
Figure 11 Location of the Amersfoort Project and other tenure in the northern coalfields of the Main Karoo Basin.