FUTURE DEVELOPMENT IN SHALE GAS PROGRAMME:

THE CGS DEEP DRILLING PROJECT AT BEAUFORT WEST

by

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FFF Unconventional Gas Workshop

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(Sourced: http://www.treasurethekaroo.co.za/)
Introduction

- Multidisciplinary 3-year research programme (2015 – 2018)
- Aimed at obtaining new data on:
  - Hydrocarbon potential of the lower Ecca Formations;
  - Karoo deep stratigraphy, lithology and structure;
  - Deep-seated aquifers and their properties;
  - Any microseismic activity.
- To better understand if there is a reserve & what are the potential impacts associate with shale gas activities on the environment.
- Provide scientific evidence to support policy development.
1960s SOEKOR cores confirmed the presence of gas from Ecca Group shales. Based on TOC, shale thickness and vitrinite reflectance values from other gas producing basins, the shales of the **Whitehill Formation** south of 29°S is the ideal target (Cole, 2014).
• From this data, SA is estimated to have 7% of the World’s total recoverable shale gas resources & is promoted as the energy game-changer we need to support economic development.

• **BUT** the estimates are unproven **AND** there are a number of unknowns concerning the impact that utilisation of shale gas will have on the Karoo environment (especially groundwater) and community.

This is why it is so important that such projects are started.

Technically recoverable shale gas (Tcf) (US Energy Administration, 2013)

(Images sourced from [www.dmlawfirm.com](http://www.dmlawfirm.com), [www.gctc.org.za](http://www.gctc.org.za) and [www.sacsis.org.za](http://www.sacsis.org.za))
Pilot Site: Whitehill Sweet Spot and Borehole Site

Whitehill Sweet Spot defined by Cole (2014):

- TOC 3-20%
- Maturity level of shale i.e. vitrinite reflectance <3.5%
- Relative dolerite thickness <20% to Whitehill thickness
- Depth >1500m in order to avoid shallow fractures that could provide pathways to shallow aquifers
In addition, to being in the Whitehill sweet spot the site was also selected because it will be drilled in the transitional zone between dolerite intrusion domain in the north and the shallow folding and listric faulting domain in the south.
The targeted shale is expected to be reached at 3 500 m depth and not be affected by dolerite intrusions.

Proposed borehole log

Baked Whitehill formation shale in contact with dolerite in SOEKOR core AB1/65 at 1951m
Project Progress:
2015-2016

- 1:65 000 scale geological map and cross-section complied for identification of major structures and geological data for a shallow aquifer conceptual model.
Regional studies around the Beaufort West deep borehole
Geophysics Investigations

- Analysis existing *seismic profiles* for defining Whitehill, Dwyka and basement contacts (completed);
- Conduct high resolution airborne *magnetic and radiometric* surveys to enhance regional structures at surface (to be initiated this year);
- *Time Domain Electromagnetics* and *Magnetotellurics* for improving <300 m depth interpretation (to be initiated this year).
Sites for the new Seismograph Network Stations
Baseline hydrogeological studies

• One of the main concerns surrounding shale gas activities in the Karoo is the concern over contamination and/or depletion of groundwater hosted in shallow fractured aquifer systems (<300 m)

• Majority of the farmers and town in the arid Karoo depend on groundwater for their domestic water supply

• Little information is known on the deep-seated aquifer and their quality and based on Soekor data
Sparse information exists on deep groundwater

Deep-seated groundwater information from SOEKOR boreholes (after Kent (1969) in Woodford and Chevallier, 2002)

<table>
<thead>
<tr>
<th>Borehole</th>
<th>Water strikes (mbgl)</th>
<th>Artesian flow (L/s)</th>
<th>Water temperature at surface (°C)</th>
<th>TDS (mg/L)</th>
<th>pH</th>
<th>Lithology intersected</th>
</tr>
</thead>
<tbody>
<tr>
<td>KL1/165</td>
<td>1006 2347 3184</td>
<td>0.3 1.2 1.2</td>
<td>n.d. 77 77</td>
<td>1390 10010 10010</td>
<td>8.9 7.5</td>
<td>Shale (Ecca Group) Sandstone (Table Mountain Group)</td>
</tr>
<tr>
<td>SA1/66</td>
<td>2975 3029 3206</td>
<td>3.7 1.2 3.0</td>
<td>66 43 46</td>
<td>6460 n.d. n.d.</td>
<td>8.0 n.d</td>
<td>Tillite (Dwyka Group) Tillite (Dwyka Group)</td>
</tr>
</tbody>
</table>

n.d not measured

**KFZ-1**
- 560 m deep artisan flow from the brecciated shale
- Deep groundwater EC<70 mS/m and warm (35-40°C)
- Shallow groundwater used by farmers EC>1000 mS/m
The 10 km radius from the drill site was a best guess estimate of the area that may be influenced by shale gas activities. Based on methane contamination from deep-seated shales in the US within a kilometre of a hydraulic fracturing site (Osborn et al., 2011) and the maximum lateral distance of a horizontal fracturing hole is 5 km (M. De Wit, pers. comm, 2015).
Establishing a shallow aquifer baseline

- Parameters investigated on a 3 monthly cycle include:
  - Static water levels;
  - Water quality
    - Physical parameters: T, EC, DO and Eh;
    - Major parameters: Ca, Mg, Na, K, SO₄, HCO₃, NO₃ and Cl;
    - Trace elements: Al, As, NH₄, B, Ba, Be, Cd, Cr, Co, Cu, CN, F, Fe, Pb, Mn, Hg, Mo, Ni, PO₄, Si, Se, Sr, Ti, U, V, Zr and Zn (MSc student);
    - Organic: DOC and TOC
    - Microbiological activity (UFS MSc student)
    - Stable isotopes
    - Dissolved methane, followed up with higher-chain gas analysis & δ¹³C
- Historical data from DWS’ NGA lacked trace element information (n = 230 boreholes)
Phase 2: 2016-2017

- Drilling of 3 percussion boreholes for multi-level monitoring of different aquifers intersected with depth;
- Core drilling of the deep vertical hole.

The three aquifers proposed to intersect in study area based on Dondo & Nhleko (2008) 3D model:
- AQ1: 20 m thick fractured aquifer in sedimentary rocks;
- AQ2: fractured aquifer associated with dolerite intrusions (<50 m deep);
- AQ3: fractured aquifer also associated with dolerite intrusion >90 m depth
Phase 3: 2017-2018

- Core logging, sedimentological analysis, structure and dolerite investigations;
- Geochemistry and gas analysis of carbonaceous shales;
- Down the hole geophysics and water sampling of the hole for geological and hydrogeological information.

http://water.usgs.gov/ogw/bgas/courses/GW2274C/

Example of the wire-line bailer for sampling deep groundwater.
Future work if feasible

- Injection of pressurised water to enhance the permeability of the water-bearing fractures and study the water circulation at depth similar to the Chevallier et al (1993) investigation;

- Conduct socio-economic studies for the study area;

- Develop this site into an educational platform where skills such as deep groundwater monitoring and/or down the hole geophysics can assist in building capacity locally.
• Reported estimations of South Africa’s shale gas potential is based on 1960s work

• Research drilling projects have to take place to answer the unknowns and develop the necessary capacity in South Africa

• This project aims to assess the gas potential in Cole (2014) sweet spot as well as undertake other baseline investigations to better understand the potential impacts associated with shale gas activities
THANK YOU