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Conceptual study of helium in the Renergen Virginia area, South Africa

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1. Executive Summary

We report the results of a conceptual study of the maximum volume of helium produced in the uranium-bearing rocks within Renergen's Virginia Licence area in the Free State.

We calculate:

1) A total volume of between 2,827 to 4,772 billion cubic feet (BCF) of helium at standard temperature and pressure (STP) conditions (14.696 psi or 1.0 atm; 101.325 kPa and temperature of 60°F/15.55°C, based on the standard conditions of petroleum gases), produced since deposition of the Witswatersrand Supergroup, Dominion Group and formation of the Basement Granites.

It is important to convey that only a proportion of this will be accessible from connected pore space within these rocks, and subsequent geological events since deposition may have resulted in substantial loss of this resource.

Hence, we also calculate:

2) A total volume of 1,864 to 3,147 BCF (STP) of helium produced since the Vredefort impact event at 2023 Ma, assuming that this event resulted in the complete loss of previously accumulated helium.

3) A total volume of 253 to 426 BCF (STP) of helium produced since the deposition of the Karoo sediments, assuming that all of the helium accumulated prior to deposition commencing at 274 Ma had been lost due to the absence of a seal to prevent helium escape to the atmosphere.

These resource estimates are based on established helium production rates from literature available in the public domain, estimates of the lower and upper uranium and thorium concentrations and the total masses of the cited geological units, compiled by Shango Solutions in Report Number S0996/20.

Furthermore, based on the assumptions outlined above, we calculate that the volume of helium produced annually within these units is:

- The Witswatersrand Supergroup = 156 to 260 standard cubic feet (SCF) at STP conditions.
- The Upper and Lower Dominion Reef conglomerates = 0 to 19.3 SCF (STP).
- The Basement Granites = 922 to 1,276 SCF (STP).

Hence, we conclude that the annual production of helium is insignificant relative to the quantity in place. The high helium content of the rocks located beneath Renergen's Virginia Prospect are a function of the uranium content, the large rock mass and the extensive time since accumulation commenced in the scenarios outlined above.

2. Background Information

2.1. Helium production in the crust

Helium in nature consists of two isotopes, ^3He and ^4He . ^3He production within the Earth's crust is dominated by thermal neutron capture by ^6Li in the reaction $^6\text{Li}(n,\alpha)^3\text{H}$ (β^-)- ^3He . However, the average crustal production ratio of ^3He to ^4He is $< 1 \times 10^{-7}$ and hence ^3He is not a significant source of crustal derived helium (Ballentine et al., 2002).

^4He production within the Earth's crust is primarily controlled by the radioactive decay of $^{235,238}\text{U}$ isotopes of uranium and ^{232}Th isotope of thorium and their daughter isotopes, via α -particles. The helium concentration in any rock or mineral is dependant primarily on the radioelement concentration and the age of that rock or mineral (Ballentine and Burnard, 2002).

The ^4He production rate from each radioisotope, R is given by:

$$^4\text{He} \text{ (atoms g}^{-1} \text{ yr}^{-1}\text{)} = X_r [R] (N_A/A_r) \times 10^{-6} (e^{\lambda t} - 1) \times \text{yield}_r \quad \text{(Equation 1)}$$

Where: X_r = fractional natural abundance of isotope R

N_A = Avogadro's number (6.023×10^{23})

A_r = molar mass of R (g)

λ_r = decay constant of R (yr^{-1})

yield_r = number of α particles emitted in the complete decay chain

[R] = the concentration of R in ppm

t = age (yr).

Decay of ^{238}U , ^{235}U and ^{232}Th : $\lambda_{238} = 1.55 \times 10^{-10}$, $\lambda_{235} = 9.85 \times 10^{-10}$, $\lambda_{232} = 4.95 \times 10^{-11}$ (Steiger and Jäger, 1977) yield 8, 7 and 6 α particles respectively. The normalised natural abundance of U gives $X_{238} = 0.9928$ and $X_{235} = 0.0072$.

Hence, the number of atoms of ^4He produced in 1 gram of rock per year becomes:

$$^4\text{He atoms g}^{-1} \text{ yr}^{-1} = (3.115 \times 10^6 + 1.272 \times 10^5) [\text{U}] + 7.710 \times 10^5 [\text{Th}] \quad \text{(Equation 2)}$$

This formula allows the maximum volume of ^4He generated within the rock units to be calculated.

2.2. Radioelement half-lives

The half-life of a radioactive element is defined as the time taken for the radioactivity to fall to half its original value. The half-life of ^{238}U is 4.468 billion years and the decay of this radioactive element produces ~40% of the radioactive heat in the Earth. The half-life of ^{235}U is 703.8 million years and that of ^{232}Th is 14.05 billion years, over three times the age of the Earth. The long half-lives mean that the production rate of He has not changed significantly over the lifetime of the Earth.

2.3. Controls on ^4He degassing

The degassing of helium in the crust is controlled by two stages: (1) release from the mineral in which the noble gas was produced/trapped; and (2) transport from the site of production

to the surface. It is important to understand the relative rates of the underlying processes as very different mechanisms control mineral and crustal-scale transport of noble gases. Helium in minerals can be released to the gas phase at grain boundaries or pores by four main mechanisms: α recoil, diffusion, fracturing or mineral transformation.

1. *Recoil loss*: The high kinetic energies generated during radioactive decay result in the displacement of α particles several 10s μm in common minerals from the site of decay. This may result in the ejection of α particles from mineral grains into pore space or adjacent grains. (Fig. 1). The stopping distance of α particles is predominantly determined by the density of host mineral. Water filled pore spaces are more efficient at stopping alpha particles than gas.

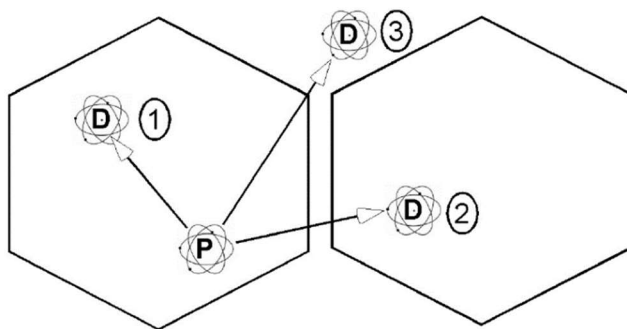


Fig. 1. Illustration of recoil loss where Parent P, decays to daughter, D, with a set recoil distance in the mineral. Depending on grain size and location of the parent mineral the recoiled daughter will come to rest in:

1. The same grain
 2. An adjacent grain
 3. The pore space surrounding the grains
- Figure from Ballentine and Burnard, 2002.

The fraction of ^4He lost from grains by recoil is a function of the effective grain size (surface to volume ratio of the grain). Low surface area/volume ratios of $<0.03 \mu\text{m}^{-1}$ result in $>90\%$ retention of ^4He in all but the most planar or acicular crystal morphologies (Ballentine and Burnard, 2002). Recoil loss will be the dominant mechanism of ^4He loss in rocks and minerals that have suffered a high degree of chemical breakdown and migration of U to grain boundaries.

2. *Diffusive loss*: Diffusion of ^4He plays both a direct role in its release at mineral scale and is often the root process of other release mechanisms such as fracturing or weathering (Fig. 2).

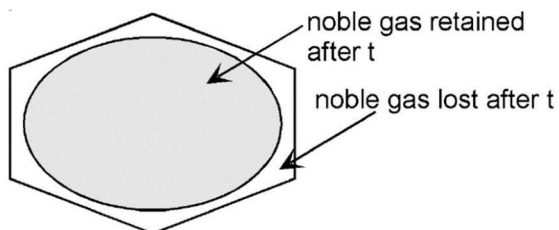


Fig. 2. Illustration of diffusive loss where ^4He is lost by diffusion from the mineral grain. The timescale for release depends on the diffusivity, grain size and morphology. Figure from Ballentine and Burnard, 2002.

The efficiency of release of ^4He from minerals is dependent on D/a^2 (D = diffusivity, a = radius of effective diffusion domain assuming spherical geometry). Diffusivity increases with temperature and diffusion domain size, both of which will result in an increase in the rate of helium loss to grain boundaries (Fig. 3).

For diffusion out of the mineral grain boundaries to occur there must also be a chemical concentration gradient. For noble gases in a mineral-water system, this will occur when the noble gas equilibrium concentration in the mineral is higher than that in the water. Helium

concentrations in groundwaters are generally low, allowing such a chemical gradient to be established quickly (Ballentine and Burnard, 2002). In rocks where the porosity is low, such as crystalline igneous rocks, e.g. granites, where the equilibrium concentration in the available porespace is easily reached, loss of ^4He is then controlled by the rate of diffusion through the rock porespace.

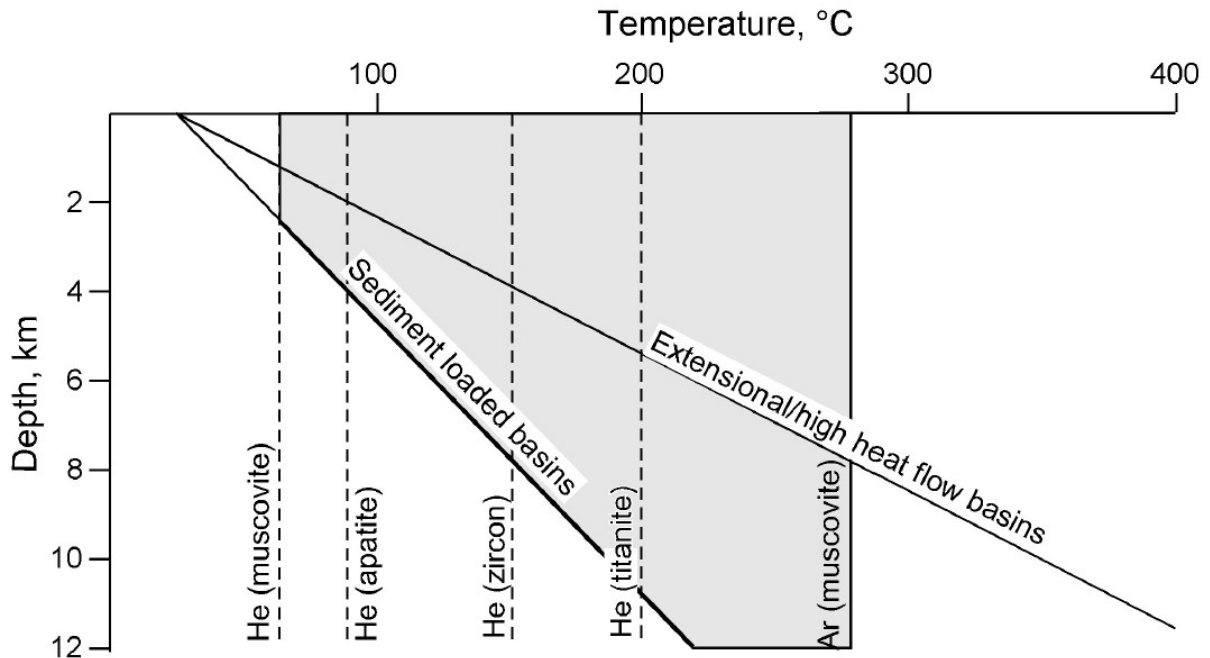


Fig. 3. ^4He closure temperatures of common U-rich minerals compared with closure of Ar in muscovite (which has the lowest closure temperature of common K-bearing crustal phases). For typical crustal grain sizes and mineralogies, the helium closure temperature is lower than that of Ar by over 100°C . At temperatures above the ^4He closure temperature the majority of the ^4He produced in the mineral grains will be released. At temperatures below the ^4He closure temperature the vast majority of the ^4He produced within the minerals will be retained. The ^4He closure temperature of uraninite is $\sim 200^\circ\text{C}$. Figure from Ballentine and Burnard, 2002.

3. Loss through Fracturing: Brittle fracturing of rocks as a result of compressional loading induces micro-fracturing prior to the formation of macroscopic fractures. Experimental work has shown that this process results in the release of ^4He (Honda et al., 1982).

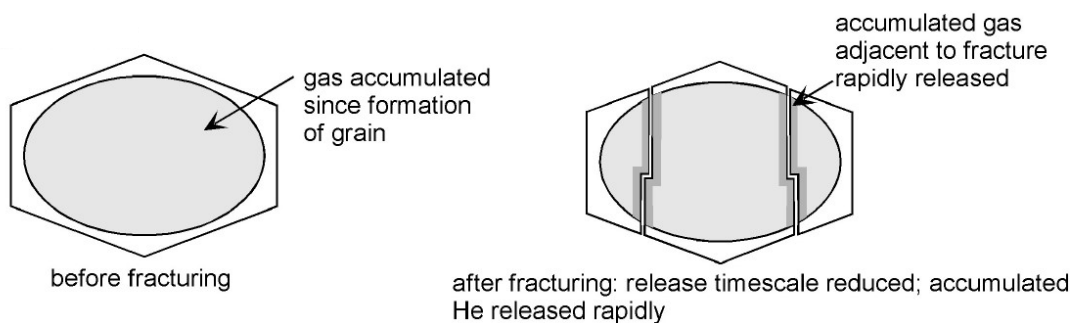


Fig. 4. Illustration of gas loss due to fracturing – helium will be the noble gas that is most readily lost by this process, due its smaller atomic size. Figure from Ballentine and Burnard, 2002.

4. **Mineral Transformation:** Recrystallisation of mineral phases, for instance during diagenesis or hydrothermal alteration release, the radiogenic ^4He trapped within the mineral lattices (Fig. 5). There is abundant evidence for mineral transformation in the Reef lithologies, not least those driven by radiation damage of U-rich phases (Hiemstra, 1968).

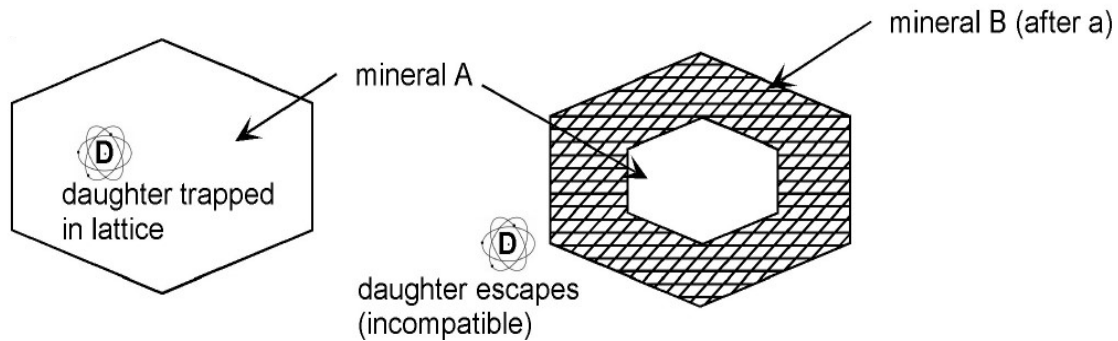


Fig. 5. Illustration of radiogenic gas loss due to mineral transformation – as helium is the most incompatible element, as per the other processes it, will be the noble gas that is most readily lost. Figure from Ballentine and Burnard, 2002.

Typically, concentrations of helium increase in the subsurface over time in stable continental regions, as these act as closed systems with helium either remaining within producing minerals or in the fluid within the porosity of the rocks (Holland et al., 2013). As a result of the different release mechanisms outlined above, the rate of helium release from minerals may not be constant.

2.4. Assessing the efficiency of ^4He release from minerals

Two experimental studies of U- and Th-rich granite have been undertaken in an attempt to constrain the proportion of ^4He released to gas phase. A study of the Carnmenellis Granite from SW England determined that ^4He content of whole-rock samples required $\geq 60\%$ of helium produced since granite crystallisation (273 Ma) is still retained. The bulk of U ($\sim 95\%$) and Th ($\sim 77\text{--}91\%$) and therefore ^4He production is concentrated in uraninite and monazite minerals. Analysis of a single grain of uraninite (1.6 μg) showed ^4He retention of $71 \pm 9\%$ (Martel et al., 1990). However, a study of the diffusion coefficient (D) of helium in this granite identified that the release of helium for the rock was controlled by diffusion and that most of the helium in the reservoir granite resides within grain boundaries and jointing cement and may be easily released (Hussain, 1997).

The in situ helium production and release of radioisotopes has also been studied in the Stripa granite, Sweden. The granite intruded at ~ 1710 Ma but experienced metamorphism at 1400 Ma and 800 Ma (Irwin and Reynolds, 1995). Most of the helium production within the granite is from high U content uraninite deposited within micro-fractures. Whole rock helium concentration measurements from this granite show that, at depths of more than 500 m, the rock retains only $\leq 10\%$ of the helium produced (Andrews et al., 1989). The helium concentration profile in the surrounding groundwater suggests that diffusive loss of helium to the surface via the aqueous phase is the rate limiting step, rather than helium loss from the minerals in which they were produced. This study provided evidence that almost all of the helium produced is released into the surrounding fluid (Andrews et al., 1989).

The prolonged accumulation of radiation induced damage to mineral lattice structure that radically increases the diffusivity of helium. The abundant evidence of severe radiation damage to the main U-bearing mineral phases in the Reef lithologies (Hiemstra, 1968) implies that the diffusion of helium into the free gas phase is likely to be on the higher end of theoretical estimates within the units beneath Renergen's Virginia prospect.

2.5. Transport of helium from the crust to shallower levels

Release of helium resulting from the processes outlined in Section 2.3 controls the amount of helium produced and released into the local water filled pore space. Transport of the produced helium to shallower levels in the subsurface, and eventually the atmosphere depends on the driving force. Helium is not produced in sufficient quantities to generate a free-phase fluid that can migrate through advection alone (Andrews et al., 1989).

Hence, transport of helium from depth will occur by bulk diffusion, the rate of which is influenced by the host rock character such as permeability, tortuosity, and the fluid occupying the pore space. However, diffusion of helium on its own has also been shown to be insufficient to account for the volumes of helium transported from the deep crust to shallow subsurface (Ballentine and Burnard, 2002).

It is known that migration of the fluid within connected pore space will remove accumulated helium from the site of release (Ballentine and Burnard, 2002). Such 'carrier' fluids can be generated within the rock formation itself due to chemical changes, such as hydrocarbon formation or metamorphic volatile loss, or they can originate from an external source, such as an aquifer or a magmatic fluid charge.

Hence, transport of accumulated helium from the crust to shallower levels frequently occurs during major tectonic events, such as orogenesis, due to metamorphic fluid release (Torgersen and Ivey, 1985), or through magmatic fluid addition due to crustal extension or hydrocarbon charge during maturation of organic rich sediments (Ballentine and Burnard, 2002). Deep-seated faults and their associated fracture zones can focus these fluids, allowing them to be transported to porous reservoirs in the shallow crust. It is currently uncertain as to the proportion of the volume of helium generated in the rocks below the Virginia prospect that have been transported to the shallow subsurface, and that remaining within the unconnected pore space or within mineral grains of the deeper rock units.

3. Calculations of potential ^4He resource contained within the rocks below the Virginia Prospect

3.1. Total volume of helium produced since formation/deposition of units

Combining equation 1 or 2 with the lower and upper bounds of U and Th concentrations, depositional/formation ages and rock unit masses constrained by Shango Solutions in Report Number S0996/20 allows calculation of the maximum volume of ^4He produced in each unit since deposition/formation.

Based on this methodology, we calculate the maximum volume of ^4He that has been produced of between 2,827 to 4,772 billion cubic feet (BCF) at standard temperature and pressure (STP) conditions (14.696 psi or 1.0 atm; 101.325 kPa and temperature of 60°F/15.55°C, based on

the standard conditions of petroleum gases), since deposition of the Witwatersrand Supergroup, Dominion Group and the formation of the Basement Granites, as follows:

- 454 to 757 BCF (STP) of ^4He within the Witwatersrand Supergroup since deposition between 2,872 to 2,943 Ma.
- 0 to 59.7 BCF (STP) of ^4He within the Dominion Group since deposition at 3,090 Ma.
- 2,327 to 3,955 BCF (STP) of ^4He within the Basement Granites since their formation at 3,100 Ma.

It is critical to appreciate that only a portion of this will be extractable. This is because only a proportion will have been released from the mineral lattice as 'free helium' within connected pores within the rock units, and only a lesser proportion of that will have been transported from the site of generation to a potential helium reservoir through the processes outlined in the introduction of this report. This estimate does not take into account the effect that any metamorphic or post-depositional tectonic events on expelling the helium produced up to that point in time, and hence is an absolute best-case scenario.

3.2. Total volume of helium produced since the Vredefort impact

The concentration of ^4He increases in the subsurface over time given adequate periods of quiescence, with some of the helium remaining in the minerals and some of it being ejected into the fluid contained within the rock pore space as a consequence of its penetration distance (Andrews et al., 1989). Continental cratons likely act as closed systems that allow helium to accumulate over billions of years, leading to concentrations of helium in pore waters as high as $9.8 \times 10^{-2} \text{ cm}^3\text{g}^{-1}$ water in the Kaapvaal Craton (Western Australia) and $6.2 \times 10^{-4} \text{ cm}^3\text{g}^{-1}$ water in the Greenland Craton (Lippmann-Pipke et al., 2011; Zadnik and Jeffery, 1985).

Furthermore, enriched nucleogenic neon isotope signatures that have been observed in deep fracture waters within deep gold mines of the Witwatersrand Basin, are thought to represent a fluid component present within Archaean age formations and trapped in fluid inclusions ≥ 2 billion years ago (Lippmann-Pipke et al., 2011). This implies the release of this billion year old neon component from the fluid inclusions and its accumulation in exceptionally isolated fracture water systems. Whilst this implies that portions of the Witwatersrand rocks have acted as a closed system for an extremely long time, other Witwatersrand mine waters have residence times in the region of 1-100 Ma (Lippmann et al., 2003) - though these could be explained by mixing of small quantities of younger water with the very old bulk fluids.

The helium closure temperature of crystalline uraninite is 200°C, hence helium will be readily expelled from the mineral lattice when the temperature is close to this level. There is widespread evidence for greenschist facies metamorphism in different rock types within all the Witwatersrand gold mines (Vollbrecht et al., 2002). The silicate mineral assemblages suggest near-uniform peak metamorphic conditions equivalent to the chlorite zone in all the major Witwatersrand gold fields at conditions of $350 \pm 50^\circ\text{C}$ and up to 3 kbars are inferred for the gold fields, with temperatures increasing to around 700°C in granulites of the Vredefort Dome (Phillips and Law, 1994). The age of the Ventersdorp lavas is constrained by zircon ages

of $2,709 \pm 4$ Ma and $2,714 \pm 8$ Ma, placing an upper age limit on metamorphism of the Witwatersrand Supergroup (Phillips and Law, 1994). A multitude of reset ages in the interval of 2500 to 2100 Ma are recorded in Rb-Sr, U-Pb, Pb-Pb methods within the Ventersdorp Supergroup, Ventersdorp felsic meta-volcanics, Carbon Leader Reef, pyrite from Witwatersrand reefs, and alteration minerals in surrounding granitoid, indicating at least one large-scale alteration event during this period (Vollbrecht et al., 2002).

Another major event in the geological history of the region is the Vredefort meteorite impact, forming the world's oldest and largest known impact structure on Earth. This was caused by a >10km diameter asteroid that temporarily made a 40 km deep and 100 wide impact structure, which widened and shallowed as rocks below rebounded and the walls of the crater collapsed (Kamo et al., 1996). A concordant $2,023 \pm 4$ Ma (2σ) age for newly crystallized, unshocked zircon grains from recrystallized pseudotachylitic breccia from the central part of the Vredefort Structure provides a good approximation of the time of impact (Kamo et al., 1996).

Both the metamorphism and impact event may have led to the helium generated up to that point being expelled and hence this is a scenario that requires consideration. Clearly, the impact event post-dates the last recorded metamorphic event, so assuming that this event resulted in the complete loss of previously accumulated helium, we determine that 3,131 BCF of ^4He has been generated since that event at 2,023 Ma, as follows:

- 316 to 757 BCF (STP) of ^4He within the Witwatersrand Supergroup since the impact event at 2,023 Ma.
- 0 to 39.1 BCF (STP) of ^4He within the Dominion Group since the impact event at 2,023 Ma.
- 2,374 to 2,581 BCF (STP) of ^4He within the Basement Granites since the impact event at 2,023 Ma.

3.3. Total volume of helium produced since the deposition of the Karoo sedimentary rocks

The Archean rocks beneath the Virginia Licence areas in the Free State are capped by the Karoo Supergroup (300 to 180 Ma) sediments which overly the Witwatersrand and the Dominion Groups. The Karoo Supergroup consists of coal-bearing sandstones and shales that have been intruded by numerous dykes and sills. Deposition of this supergroup commenced about 300 Ma, during the Dwyka glaciation (350 to 300 Ma). During this event southern Africa was heavily glaciated which carved deep glacial valleys across the sub-continent. These became filled and mountains buried during the subsequent northward movement of Gondwana into warmer climes. Recent dating of U-Pb zircons in volcanic tuffs from the Karoo Basin implies that the maximum age of deposition of the marine Ecca group is 274 Ma (McKay et al., 2015).

As the pre-Karoo rocks are persistently faulted, and these structures are now covered by the Karoo sediments, there is a possibility that helium could have escaped through these faults prior to deposition of the Karoo sediments. These sediments now appear to act as partial seals for the gas migrating up the faults that dissect the Archean units at the present time (Fig 6.). This can be considered as the worst-case scenario in terms of the amount of helium present

within the rocks beneath Renergen's licence area, as it is improbable that all of the helium generated prior to deposition of the Karoo sediments would have been lost.

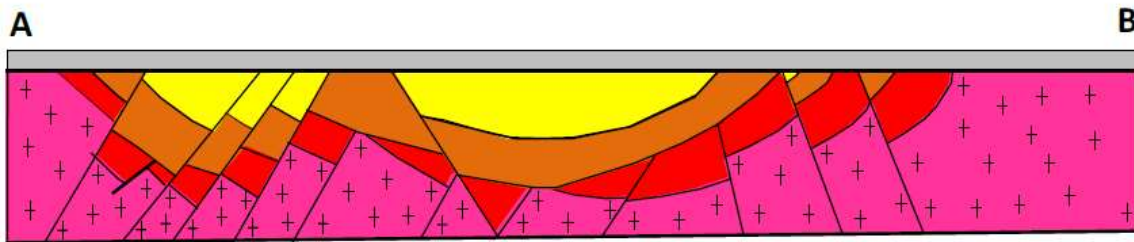
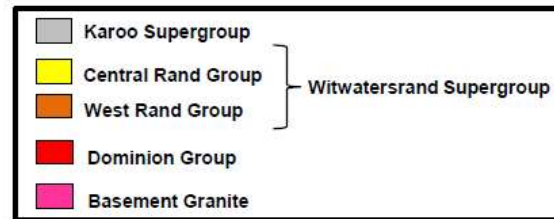


Fig 6. Schematic diagram from Shango Solutions report SS0860/19 illustrating the faulting that is proposed to focus helium-rich gases from the pre-Karoo units, and the relatively undeformed and potential sealing nature of the Karoo sediments.

Based the maximum age of deposition of the Karoo sediments of 274 Ma we determine that 424 BCF (STP) of ⁴He has been generated since, as follows:

- 43 to 71 BCF (STP) of ⁴He within the Witwatersrand Supergroup since deposition of the Karoo sediments at 274 Ma.
- 0 to 5.3 BCF (STP) of ⁴He within the Dominion Group since deposition of the Karoo sediments of 274 Ma.
- 210 to 350 BCF (STP) of ⁴He within the Basement Granites since of deposition of the Karoo sediments of 274 Ma.

3.4. Volume of helium produced annually – is the supply renewable?

Based on the above cited uranium and thorium concentrations, and assumptions outlined we further calculate that the volume of ⁴He produced annually within these units is:

- The Witwatersrand Supergroup = 156 to 260 standard cubic feet (SCF) at STP conditions as previously outlined.
- The Upper and Lower Dominion Reef conglomerates = 0 to 19.3 SCF (STP).
- The Basement Granites = 766 to 1,276 SCF (STP).

Hence, we conclude that the annual production of 921 to 1556 SCF (STP) of ⁴He is insignificant relative to the potential resource in place. The high helium content of the rocks located beneath Renergen's Virginia Prospect are a function of the uranium content, the large rock mass and the extensive time since He accumulation commenced in the scenarios outlined.

4. Conclusions

These calculations demonstrate that the lithologies beneath the Virginia prospect are undoubtedly a potential significant store of helium. However, a precise determination of the amount of helium present in an extractable fluid phase in the basement granite and overlying sedimentary lithologies is hampered by poor knowledge of the physical properties of the rocks (e.g. porosity and permeability), their geological history, uranium concentrations and the proportion of helium content remaining in the host rocks.

To our knowledge, only one study of the extent to which the minerals of the uranium-rich Reef rocks have retained their helium has been completed to date. This shows that uranium-rich gold grains have essentially retained all the helium produced since formation (Yakubovich et al., 2014). However, this is not surprising given the very low diffusion rate of helium in gold and its extreme stability. Nevertheless, it implies that helium loss due to deformation in response to the Vredefort impact and diffusive processes during metamorphic events appears to be low.

On this basis we would suggest that while the gas-phase helium concentration in the lithologies may be locally variable, depending on factors such as proximity to faults that could have acted as conduit for gas loss prior to Karoo deposition, it is probable that it is higher than the conservative worst case scenario outlined in this study. Due to their extremely high uranium and thorium contents, it is highly probable that the Reef lithologies of the Withwatersrand and Dominion groups will contain the highest concentration of helium within their pore spaces relative to the other units examined in this study.

Table 1 – Compilation of compiled data from Shango Solutions Report and results of the calculations of this study

Unit			U conc. range (ppm)*	Th conc. range (ppm)*	Metric Tonnage*	Deposition age (Ma)*	Total ⁴ He resource BCF (STP) since deposition	Total ⁴ He resource BCF (STP) Post Vredefort	Total ⁴ He resource BCF (STP) Post Karoo deposition	Annual ⁴ He production (SCF yr ⁻¹)
Witwatersand Supergroup	Central Rand Group	B Reef	25.3 – 89.6	1.27	789777333	2,872	0.26 – 0.91	0.18 – 0.64	0.02 – 0.09	<i>0.09 - 0.32</i>
		Leader Reef	25.3 – 89.6	1.27	789777333	2,872	0.26 - 0.91	0.18 - 0.64	0.02 – 0.09	<i>0.09 – 0.32</i>
		Basal Reef	87.9 - 158	5.28 – 17.6	568639679	2,872	0.66 – 1.19	0.46 – 0.84	0.06 – 0.11	<i>0.23 - 0.42</i>
		Beisa	23.8 – 83.1	1.19	842278840	2,902	0.26 – 0.92	0.18 – 0.64	0.02 - 0.09	<i>0.09 - 0.32</i>
		Quartzites (CRG)	1.65 – 2.74	2.50 – 4.16	3428502423323	2,780	100 - 167	69.9 - 117	9.47 - 15.8	<i>34.6 - 57.6</i>
	Shales (CRG)	1.78 – 2.94	4.35 – 7.25	241504573215	2,780	8.88 – 14.7	6.19 – 10.3	0.84 - 1.39	<i>3.06 - 5.07</i>	
	West Rand Group	Quartzites (WRG)	1.39 – 2.32	2.58 – 4.30	10111413610611	2,902	265 - 442	185 - 308	25.0 - 41.7	<i>91.3 - 152</i>
		Shales (WRG)	0.82 - 1.37	2.58 – 4.30	4104553431734	2,902	78.0 - 130	53.7 – 89.4	7.27 - 12.1	<i>26.5 - 44.2</i>
						Subtotal	454 - 757	316 - 527	43.7 - 71.3	156 - 260
Dominion Group		Dominion Upper Reef	0.00 - 425	0.00 – 30.1	5976064900	3,090	0.00 - 35.9	0.00 - 23.5	0.00 - 3.19	<i>0.00 - 11.6</i>
		Dominion Lower Reef	0.00 - 563	0.00 – 40.2	2988032450	3,090	0.00 - 23.8	0.00 - 15.6	0.00 - 2.11	<i>0.00 - 7.70</i>
						Subtotal	0.00 - 59.7	0.00 - 39.1	0.00 - 5.30	0.00 - 19.3
Basement		Granites	1.52 - 2.54	7.97 - 13.3		3,100	2374 - 3955	1549 - 2581	210 - 350	<i>766 - 1276</i>
						Total	2827 - 4772	1864 - 3147	253 - 426	921 - 1556

*Compiled by Shango Solutions in Report number S0996/20

5. References

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