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OCCURRENCE OF Naturally Occurring Radio-active Materials IN THE KAROO IN RELATION TO HYDRAULIC FRACTURING

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Abstract

All minerals and raw materials contain radionuclides which are natural occurring. The most important for the purpose of protection against radiation are ^{238}U and ^{232}Th decay series. Materials giving rise to these enhanced exposure has become known as naturally occurring radioactive material (NORM). Occurrence of norms in the Karoo is known as there is uranium deposits located around the area. The occurrence of naturally occurring radioactive materials in relation to hydraulic fracturing of shale gas in the Karoo might be a problem when it comes to exposing radiation poison to the environment.

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1. Terms of reference

The task of this report is to locate areas in the Karoo region where radioactive materials are occurring naturally. All this is done in relation to the shale gas prospective areas in South Africa. With the ongoing talks about shale gas exploration in South Africa, it is important to locate areas with naturally occurring radioactive materials to avoid contaminating the environment or radiation exposure to the public and our water resources.

2. Background

This section will explain the process of hydraulic fracturing and its environmental impact in summary. Naturally occurring radioactive materials will be explained in details to give a clear indication of how hazardous it is to the environment. Map 1 show the areas in South Africa where NORM's and the shale gas prospective areas are indicated in the map.

2.1. Hydraulic fracturing

Hydraulic fracturing is the process of transmitting pressure by fluid or gas to create cracks or open existing in hydrocarbon bearing rocks. The purpose of hydraulic fracturing on oil and gas reservoir is to enable the oil and gas to flow more easily from the formation to the well and this process is known as stimulation.

2.1.1. Types of hydraulic fracturing

The type of hydraulic fracturing used is dependent on a number of variables;

- Type of well drilled (it may be horizontal or vertical)
- Properties of rocks in the potential reservoirs
- Depth, temperature, thickness and pressure of the reservoirs
- Well construction (casing and cement)
- Number of fractures to be completed
- Choice of fracturing fluids and materials
- Cost of fracturing and materials

(CSUG. 2010)

2.1.2. Process of hydraulic fracturing

Four steps are essential during this process.

- The 1st step is to pressure the reservoir rock using a fluid to create a fracture.
- The 2nd step is to increase the fracture by continuing to pump fluid into the fracture.
- Pump proppant materials into the fracture in the form of a slurry, as part of the fracture fluid.
- And finally, stop pumping and flow-back to the well to recover the fracture fluids while leaving the proppant in place in the reservoir.

2.1.3. Potential drinking water issues associated with hydraulic fracturing

After the fracking process, flow-back containing the initial fracking fluids return to the surface. Flow-back might also contain naturally occurring toxic and radioactive substances. The flow-back process might continue for several weeks. In the Marcellus shale for example, only 10-30% of the fluid was recovered. The recovered fluids are typically stored either in containment/evaporation pts or storage tanks. Improper well construction presents chances of contamination to drinking water aquifers. And improper pit containment may results in contamination of surface water. (White et al. 2011)

Figure 5 below shows all the potential drinking water issues.

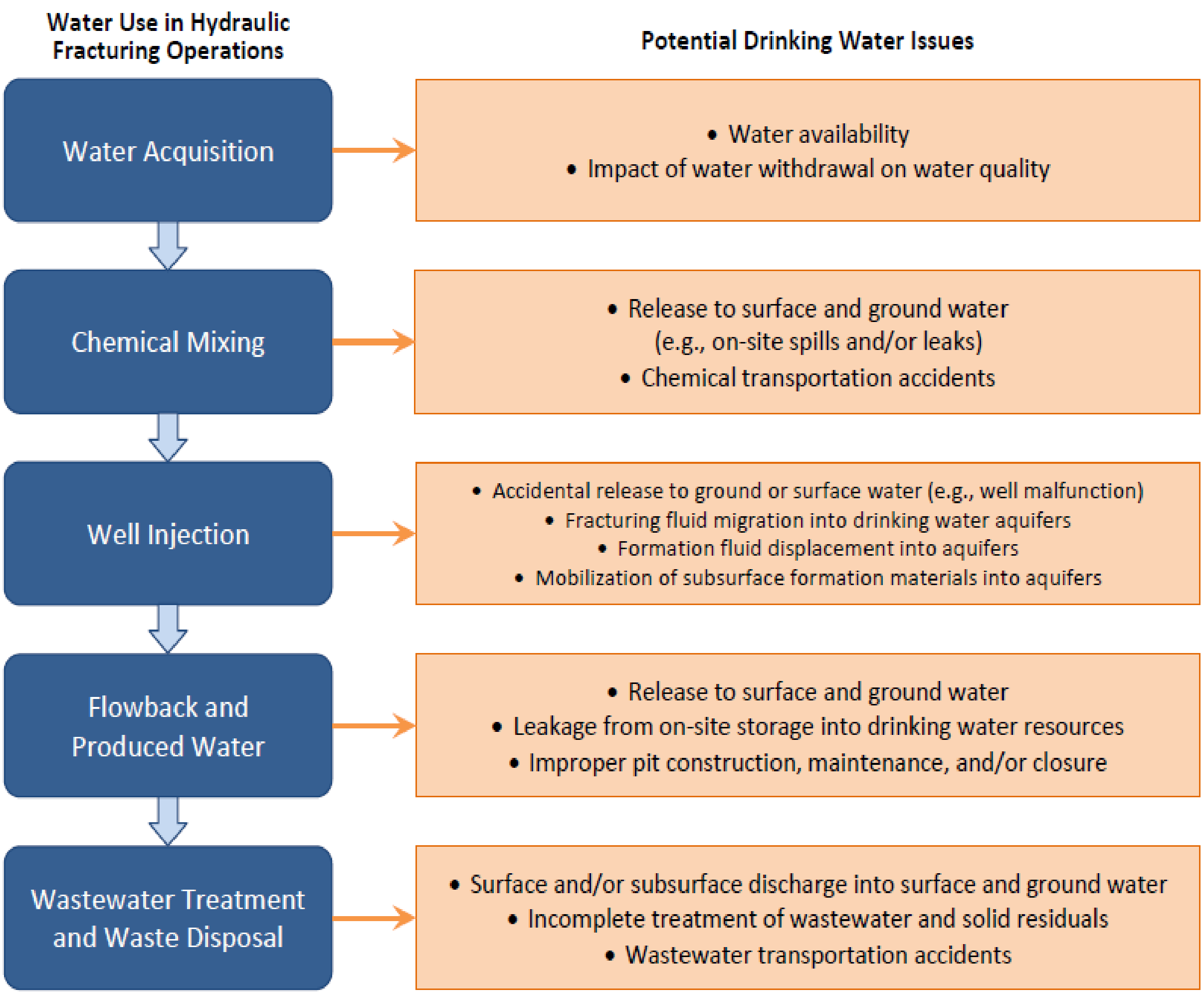


Fig.1: Summary of potential drinking water issue associated with hydraulic fracturing. (EPA. 2011)

2.2. Naturally occurring radioactive materials (NORM'S)

Natural occurring radioactive materials (NORM) are radioactive substances that exist in all natural media including rocks, soil, water and air. Norm's are often common in gas-bearing shale and may be brought to surface through drill cuttings and other waste from an oil or gas well. (Perry. 2011)

2.2.1. Origin of naturally occurring radioactive materials

Radioactive materials such as Uranium and Thorium were incorporated in the earth crust. Uranium and Thorium normally exist at trace elements concentration in rock formation. These are unstable radioactive element and when they decay will produce other radionuclides. Depending on certain conditions like pressure and temperature, radionuclides in the subsurface environment can be mobile and be transported from reservoir to the surface with oil and gas products being recovered.

2.2.2. Health hazard associated with NORM's

Two ways which people can be exposed to these radioactive materials is through irradiation and contamination. Irradiation is an external exposure where the source remains outside the body and contamination refers to internal exposure where radioactive materials are taken into the body via inhalation, ingestion or absorption. (OGP. 2008)

Radiation exposure in the natural and urban environment is focused upon radon, which is the only radioactive gas that is formed by the decay of Uranium and Thorium. (Scholtz.2003) If the gas is inhaled it can cause severe damage as lung cancer. To be exposed to radiation Uranium, a person has to eat, drink, inhale or by skin contact.

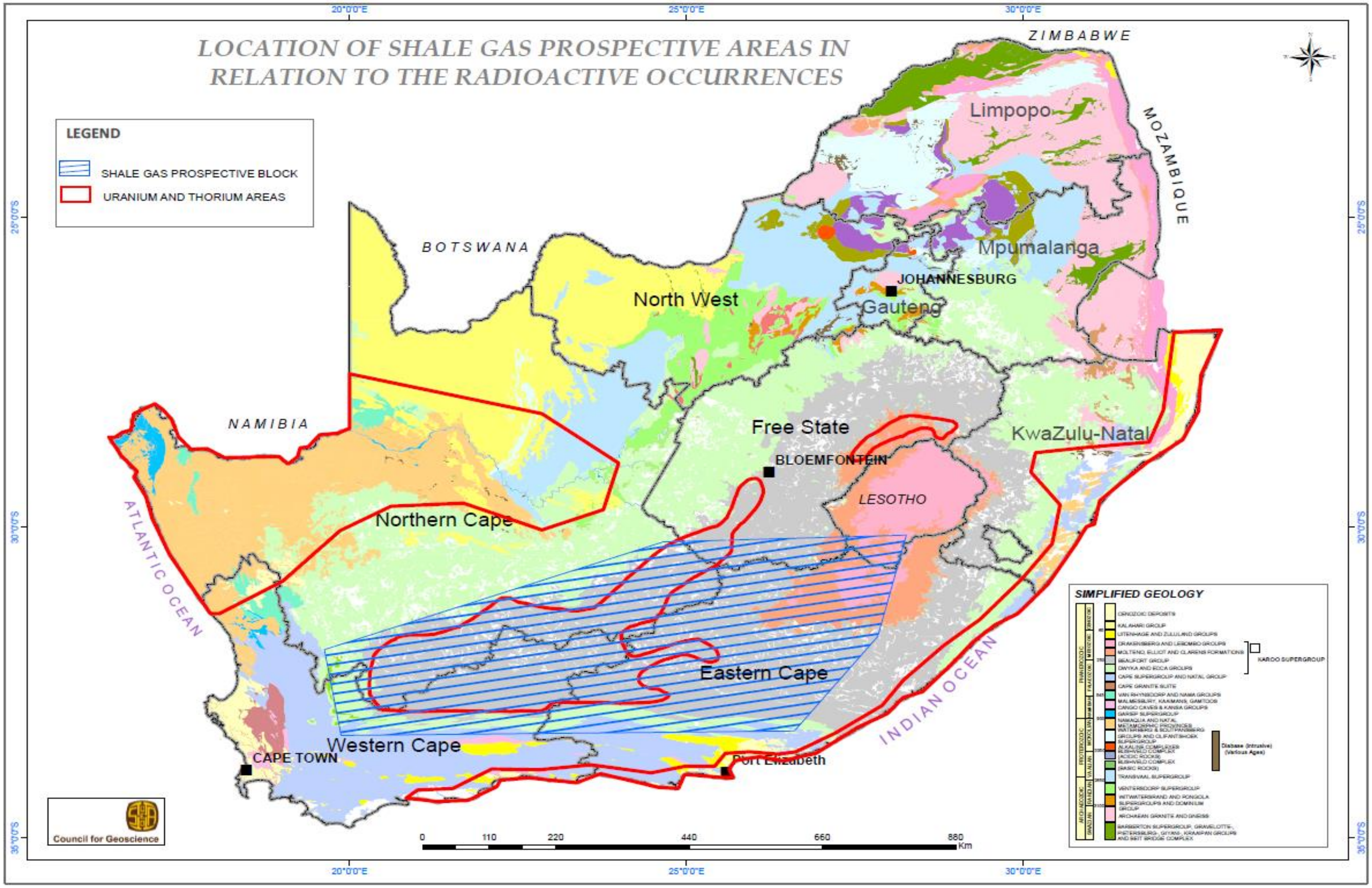
2.2.3. Environmental impacts associated with NORM's

The handling, transportation, storage and the use of Norm's contaminated equipment or waste media with no proper control may lead to the spread of norm's contamination and this may results in contamination of land and therefore potential exposure to the public.

2.3. Possible sources of Uranium in the Karoo

Three possible sources for the Uranium mineralization in the Karoo have been suggested as follow:

- Volcanic fragments in the host sandstone and interbedded tuffaceous materials,
- Precambrian basement granites which were actively shedding deritritus to the depositional basin at that time and
- The surrounding shales in the area. (Scholtz. 2003)



Map 1: location of shale gas prospective areas in relation to NORM's occurrence and geology of the area (council of geosciences)

3. Methods of investigation

Prior to this investigation, an exact location was very important to find. The following were very useful for this report:

- ✓ 1:250 000 Map (3222) Beaufort West 1987
- ✓ 1: 50 000 Map (3222DB) Ryskuil 1971
- ✓ A map by council of geosciences showing location of shale gas prospective area in relation to norm's occurrences.

3.1. Site location

According to map 1 (Council of Geoscience), the proposed area of hydraulic fracturing covers four provinces which are Western Cape, Eastern Cape, Northern Cape and Free State.The exact area under study is the Ryst Kuil and Doorn Kuil farms which are approximately 60 km south east of Beaufort West. The coordinate of the Ryst Kuil farm is S 32° 38' 40.70" and E 22°53'57.79". Figure 2 shows the locality of Ryst Kuil.

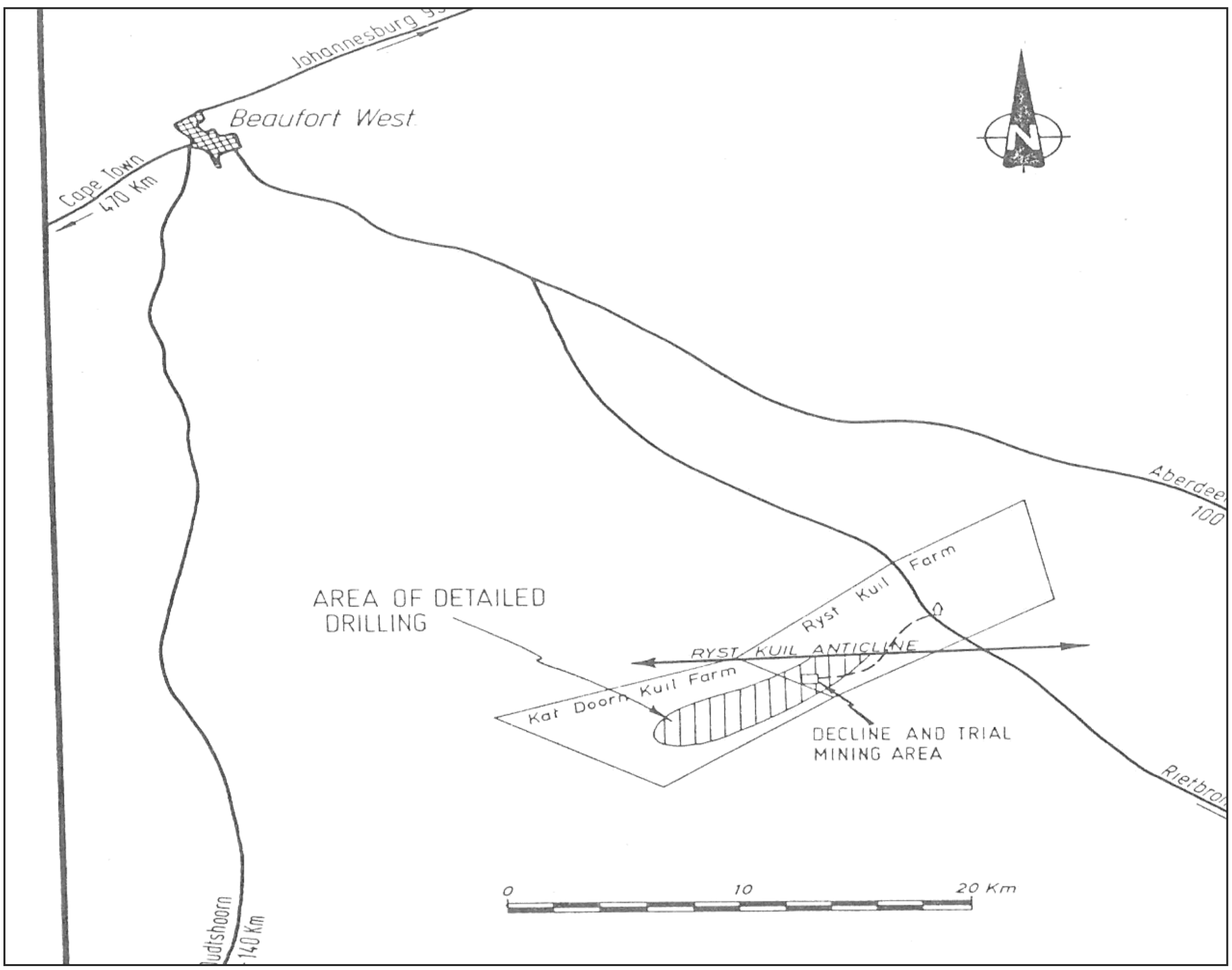
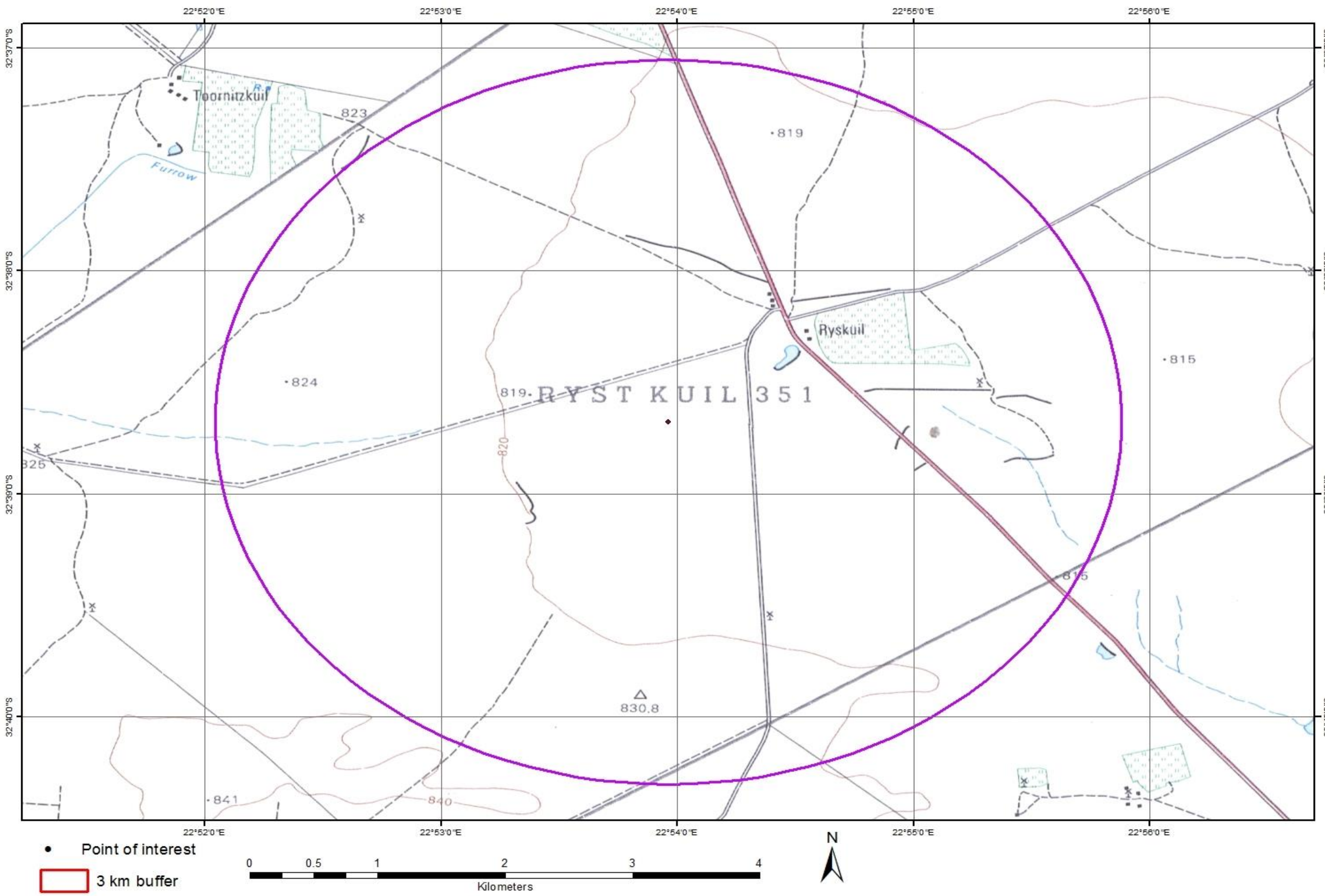


Fig.2: <u>location of Ryst Kuil.</u> (Eddington. 1979)



Map 2: Topographical map of Ryst Kuil. (Source: DWA, 2014)

3.2. General geology

This section will cover from stratigraphy, local and regional setting (geological structures) as well as the Ryst Kuil uranium deposit.

3.2.1. Stratigraphy of the area

The stratigraphy of the area is indicated in map 1. The area is under the Karoo Supergroup. The exact area under investigation falls under the Beaufort Group consisting of two Subgroups namely; Tarkastad and Adelaide.

3.2.2. Regional setting

The deposit occurred in the Ryst Kul sand which forms a small part of the lower Beaufort series of Permo-Triassic age. According to Eddington et al (1979), it is estimated that the Ryst Kuil sand occurs a few thousand meters above the lower Beaufort/Ecca contact. The contact is exposed on the southern edge of the Karoo basin. Ryst kuil lies south of the dolerite line.

3.2.3. Local setting

When it comes to geological structures, the Ryst Kuil area consist of series of east-west trending anticlines and synclines with dips up to 5 degrees on a flack as shown in figure 3. Two large faults have been identified in the area. In the Ryst Kuil anticline there is a normal fault. It is believed that this fault played an important role on uranium mineralization on the down-thrown side and has been protected from erosion and deposition. (Eddington et al.1979). The fault which is in the south is a reverse fault with about 45m of throw. Oxidation of Uranium occurred along this fault.

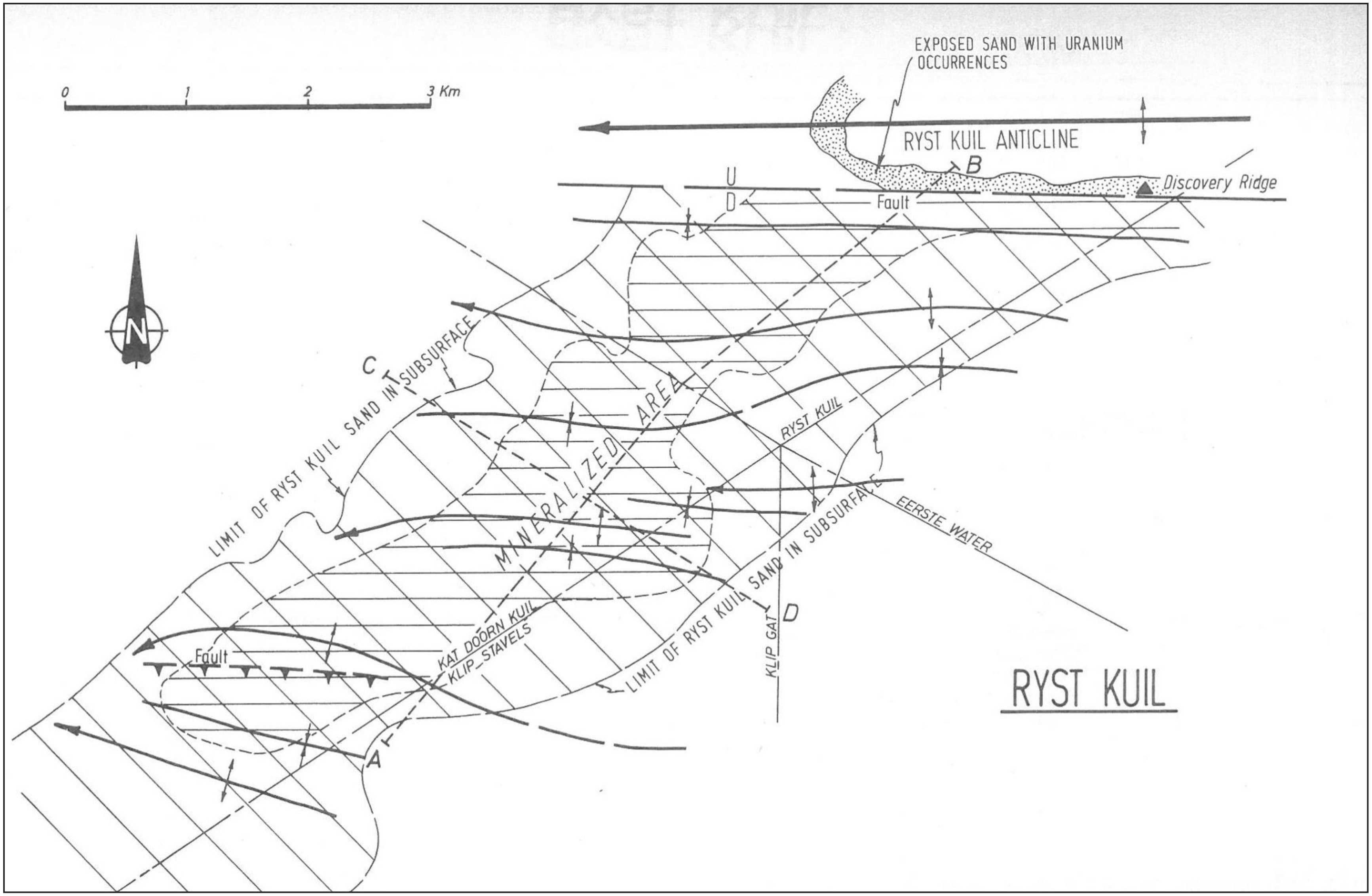


Fig.3: local structures. (Eddington. 1979)

3.3. Ryst Kuil Uranium deposit

The host rock for the Uranium mineralization in the area is a light to dark grey greywacke, which is very-fined-grained to fine-grained. It contains interbeds of siltstone and mud-fragment conglomerates. (Eddington et al.1975)

The Ryst Kuil sand is about 60 meters thick. The river that flowed north easterly into the basin is responsible for the deposition of the Ryst Kuil sand. The sand shows characteristics of point bar complexes, fluvial sand system, abandoned channels, clay plugs and also mud-fragment conglomerates. (Eddington et al.1975) The sandstone consists of two major cycles with Uranium mineralization occurring in the older cycle.

Figure 3 shows the approximate limits of the Ryst Kuil sand in the subsurface as delineated by amount of drilling. Cross sections across the Ryst Kuil deposit is shown in figure 4 & 5. Figure 4 shows cross section A-B while figure 5 shows section C-D. In both figures, the cross-sections at the top show some structures in the areas while the lower cross-section shows variation in thickness in the sand. The distribution of Uranium ore pods is illustrated as well. (Eddington et al.1975)

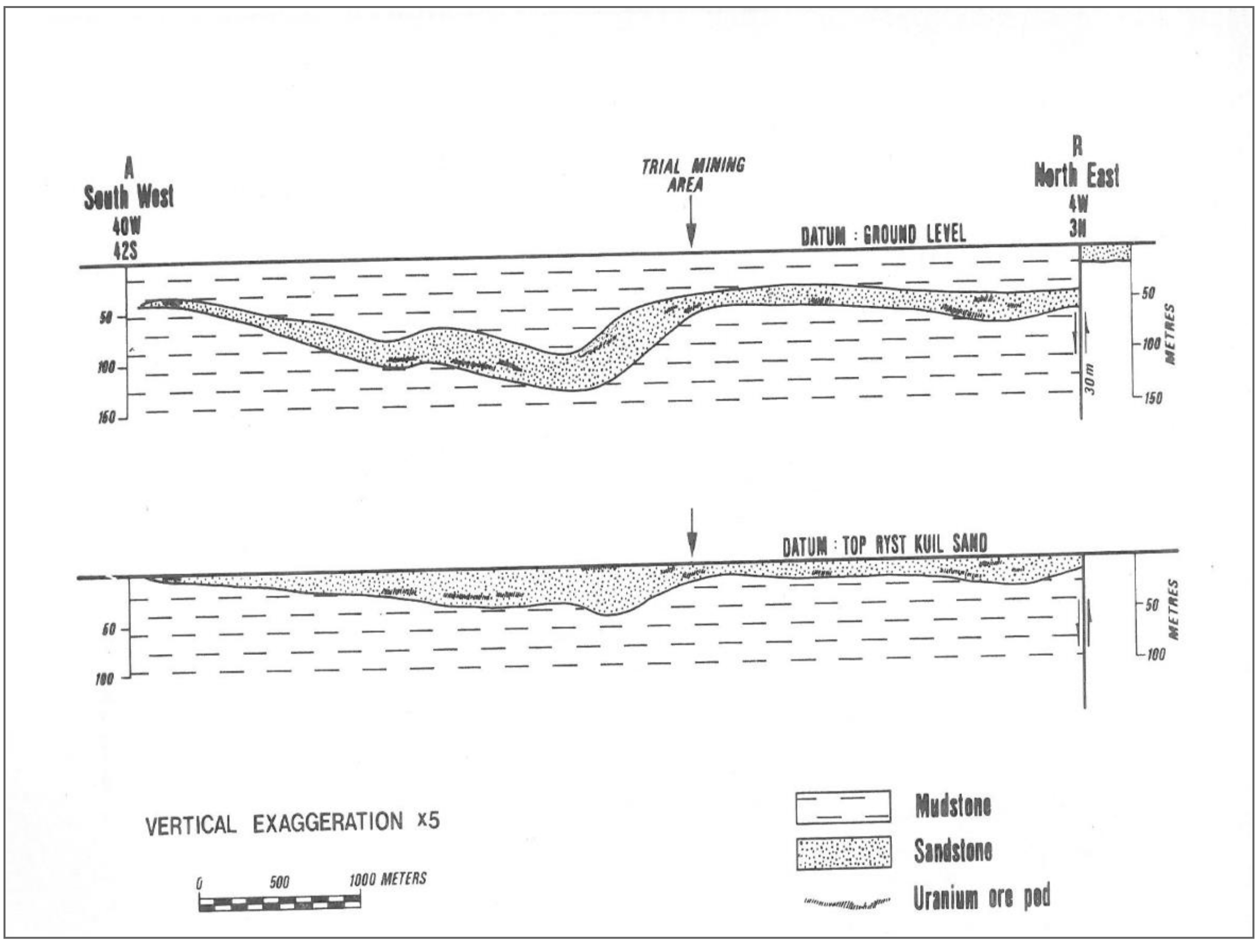


Fig 4: Cross-section A-B. (Eddington. 1979)

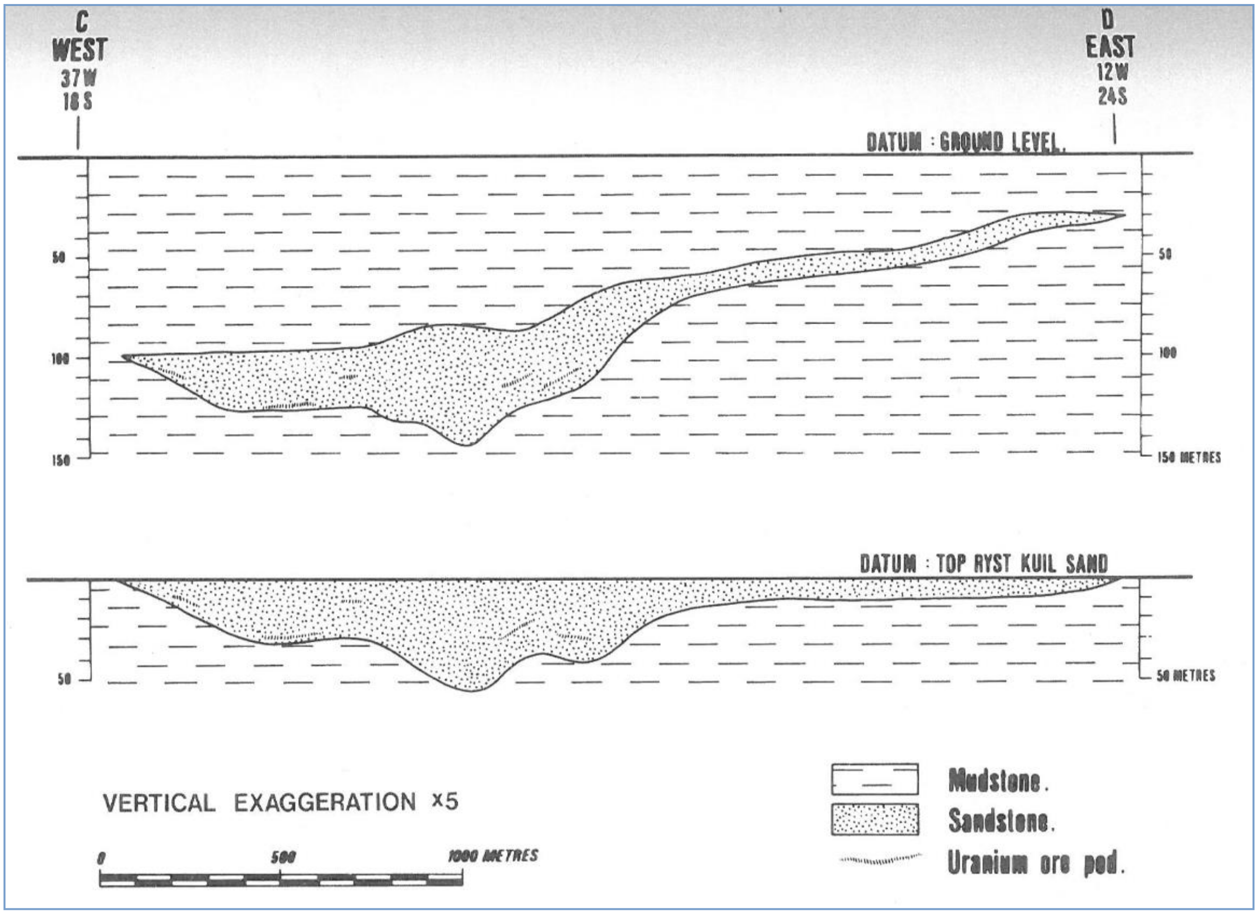


Fig 5: Cross-section C-D. (Eddington. 1979)

4. <u>Conclusion</u>

From the available data (map 1 for example), it is clear that a large portion of the Karoo that contains natural occurring radioactive materials falls under the shale gas prospective area. In Ryst Kuil Uranium deposit, it is clear from figure 4 & 5 that the orientation of the uranium ore pod is orientated horizontally. Chances are that during hydraulic fracturing process, the Uranium ore pods will be encountered and it may lead to Uranium exposure and contamination to groundwater and environment in general.

5. <u>Recommendations</u>

I recommend the following to be considered for this area if shale gas exploration will take place in the vicinity of Ryst Kuil:

- ✓ The use of a hydraulic technique that will not intercept or come into contact with the uranium ore pods. A horizontal drilling method can be used to avoid such.
- ✓ The flow-back and waste water should be transported and stored carefully incase it is contaminated by Uranium.
- ✓ Sampling of all water resources in this area (rivers, springs and groundwater) before explorations, during and after exploration for references purposes.

6. <u>References</u>

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