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A radon emanometry case study of the Rössing South deposit, Namibia

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ABSTRACT

The ***RadonX™*** technique uses the principle of adsorption of radon, emanating from buried uranium mineralization, onto activated charcoal. The charcoal is contained within a cartridge which is fitted into the base of an inverted cup, and is buried in the ground for a period of approximately 10 days. The technique differs from alpha-sensitive radon detection systems in that it measures the gamma radiation arising from the daughter products of the adsorbed radon, namely ^{214}Bi and ^{214}Pb. The present case study shows that ***RadonX™*** has an improved sensitivity compared to an alpha detection system, in which cups are buried for a period of 30 days.

A case study is presented, in which the ***RadonX™*** radon emanometry technique is sited over the Rössing South uranium deposit. The mineralization occurs under a cover varying between 20 and 80 m, within rocks of the Damara Supergroup and associated leucogranites, in the Central Zone of Namibia. The results show that the deposit, blind in terms of a radiometric signature, has a clear ***RadonX™*** target anomaly signature, making the technique an effective and essential exploration tool in areas of deep cover. An excellent depth of penetration, of 100m or more has been quantified elsewhere in the Central Zone, under favourable permeability conditions.

Key words: radon, emanometry, uranium, exploration

INTRODUCTION

Radon emanometry is based on the ability of radon (^{222}Rn), a gaseous daughter product originating from buried uranium, to migrate to surface together with the ground air. This is facilitated through the pumping action both of diurnal pressure variations and diurnal groundwater tidal variations. A high permeability of the cover strata is a prerequisite for a measurable radon flux at surface. Most instrumentation, used in radon-based uranium exploration, relies on alpha-particle detection. However, detection has also been achieved through the measurement of the gamma emission from radon's daughter products, ^{214}Bi and ^{214}Pb, following adsorption of the radon onto activated charcoal. This technique was initially developed by the SA Atomic Energy Board (Hambleton-Jones and Smit, 1980), and termed Radon-on-Activated-Charcoal (ROAC). ***RadonX™*** is a refinement of this technique through improvement of a number of aspects of sensitivity.

A case study is presented on the Rössing South uranium deposit, using the ***RadonX™*** radon emanometry technique. The deposit, in which the mineralization occurs in rocks of the Damara Supergroup and associated leucogranites, is situated in the central Namib region of Namibia. The present and past studies have shown that the ***RadonX™*** technique has proven to be highly effective through residual and transported surficial cover, with a depth of penetration of 100m or more under favourable permeability conditions. With the Rössing South uranium deposit, an essentially blind targe buried at depths of up to 80 m, the ***RadonX™*** data show a clear anomalous zone associated with the orebody. A radon response is not evident along a narrow linear zone over portion of the ore zone in the north, possibly due to an impervious overlying calcrete, or to flushing along a fault zone, as discussed below.

METHODOLOGY

The field detector essentially comprises activated charcoal, contained within a cartridge fitted into the base of a plastic cup. The inverted cup is buried in a shallow hole, ~40cm deep, so as to minimise solar heating of the charcoal. A plastic sheet is placed over the cup if necessary, prior to filling the hole, to reduce moisture penetration from above. The location is recorded with a GPS receiver and is marked with a survey flag for ease of later recovery. Integration of the daily radon flux, over a period of approximately 10 days, has been found to be adequate to obtain representative and repeatable results. On retrieval, the charcoal-filled cartridges are closed and the exact period of residence in the ground, as well as the exact period from retrieval to measurement, is recorded. The data are normalized to 10 days for all cartridges. All readings are corrected for variations in the time elapsed between retrieval and measurement. A gamma spectrometer is used to measure the gamma radiation arising from the ^{214}Bi and ^{214}Pb daughter products. Measurements are made on site, in areas of low background, immediately after retrieval. Background effects are nevertheless further reduced through the use of a lead castle. The emphasis of all procedures, choice of activated charcoal, and equipment parameter design, was to optimize counting statistics so as to increase sensitivity. The Radon Value (RV) units are in counts per minute (cpm).

Radon (^{222}Rn) arising from uranium has a half-life of 3.824 days, and will decay almost completely in roughly 10 times this period, i.e. ~38 days. This provides sufficient time for ^{222}Rn to migrate to surface, to be adsorbed onto the charcoal, and to remain adsorbed for long enough after retrieval to be measured (through its daughter products ^{214}Bi and ^{214}Pb). A major benefit of the ***RadonX^{TM}*** technique is that thoron (^{220}Rn) arising from thorium that might be contained in the bedrock, is not measured due to its short half-life of 55 seconds which limits its passage to surface.

RESULTS AT RÖSSING SOUTH

The uranium mineralization is bedrock hosted in rocks of the Damara Supergroup and associated leuco-granites. Cover thickness varies from 10 m in the north to 80 m in the south. This blind ore deposit, which has no airborne gamma spectrometric signature over virtually its entire strike length, is divided into two high grade zones as shown in Figure 1. The limits of the ore zones, shown as open polygons, are overlaid onto the ***RadonX^{TM}*** results which are shown as a grid image in Figure 2. A 50 m cup spacing was used along lines 250 m apart over the drilled ore zones. Lines were extended with 100 m cup spacings into background. An excellent correlation is seen between the radon data and the ore particularly in Zone 2 (up to 80 m deep). Some isolated anomalies were also recorded on the lines extended into background. In hindsight the lines could have been extended further. Drilling had also detected localized mineralization away from the ore zones, so the isolated radon highs were not unexpected. Surveys in areas with similar cover thicknesses show background values typically of 500-100 cpm, consistent with the present data. A northeast trending low is seen in the radon responses at the northern end of Zone 1. The reason for this is as yet uncertain but may be due to one of two causes. Firstly, impervious calcrete cover may have prevented radon emanation. No borehole cores were, available, however, to check on this. Secondly, a northeast fault zone, evident in the aeromagnetic data, may have caused flushing of radon or radium. The ***RadonX^{TM}*** anomalies nevertheless constitute a clear target zone in direct association with the ore. The technique would thus be applicable in this environment to the location of similar blind targets. Normalization for depth, using a previously derived depth-RV response curve, further enhances the ***RadonX^{TM}*** anomalies.

In order to assess optimal cup spacings, in terms of anomaly detectability, the data were regridded by progressively desamplimg cup spacings from the original 50x250 m grid, to 100x250 m and 200x250 m in Figures 3 and 4. Although the latter still identifies an anomaly, it is only on the basis of a few cup sites, and would not have been an optimal reconnaissance grid for this deposit type. The data indicate that the 100x250 m grid is still optimal and could possibly be coarsened to a 200x200 m grid for detectability only. Procedurally, infill surveys are recommended as soon as a target zone has been identified. This is achievable with ***RadonX^{TM}*** immediately after a reconnaissance survey while the team is still in the field.

CONCLUSIONS

- The Rössing South bedrock-hosted deposit has a clear ***RadonX^{TM}*** target anomaly signature.
- Loss, or displacement, of a radon anomaly signature is possible if impervious cover is present. This is a possibility at the northern end of Zone 1. Alternatively, flushing along a fault zone my have occurred.
- Target resolution is improved, if not essential prior to drilling, with infill grids. This is readily achievable with ***RadonX^{TM}*** immediately following a reconnaissance survey.
- An excellent depth of penetration, of 100m or more, has been demonstrated under favourable permeability conditions.
- The ***RadonX^{TM}*** technique is an effective and essential adjunct to gamma spectrometric surveys, and provides a unique and important data layer in itself, in areas of cover.
- Sensitivity is significantly improved, in terms of anomaly amplitude with respect to background, compared to 30-day alpha-detection surveys conducted in two case study areas.

ACKNOWLEDGMENTS

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REFERENCES

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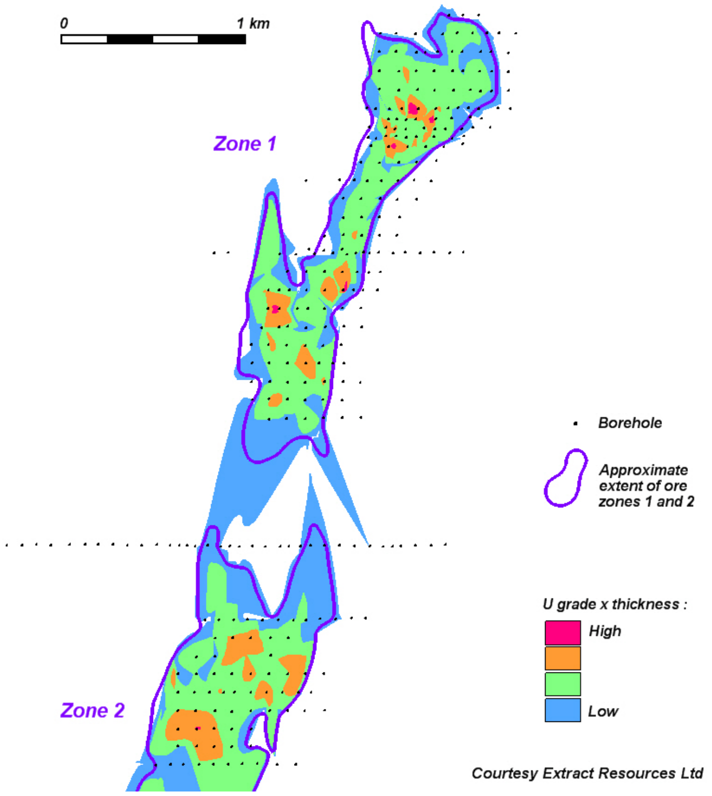

Figure 1. Uranium grade.thickness products in Zones 1 and 2 at Rössing South. The approximate extent of the ore zones, both near surface and at depth, is shown by the purple polygons (Courtesy Extract Resources Ltd).

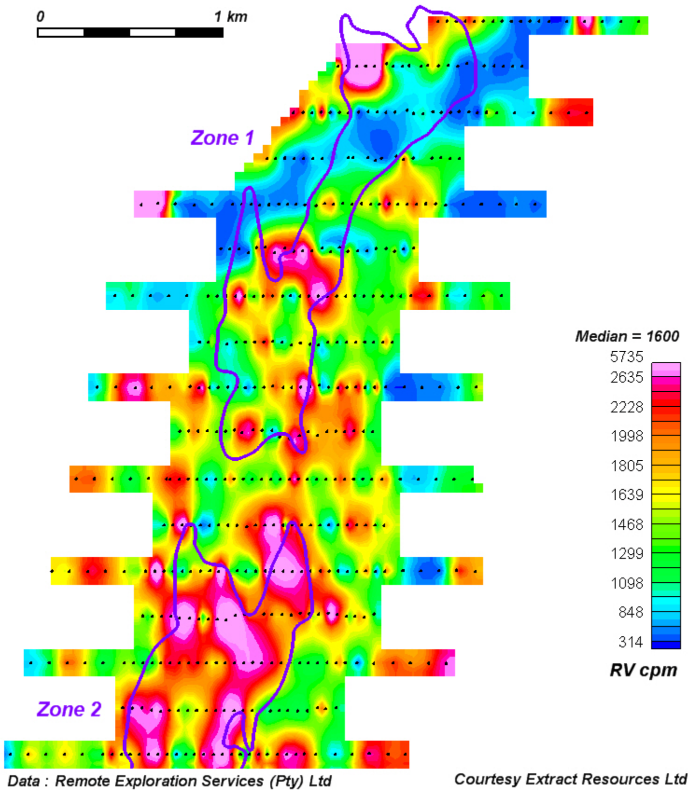

Figure 2. Ore zone extent overlaid onto an image of the *RadonX*^{TM} data, with cup intervals of 50 x 250 m over the ore-body, and 100 x 250 m into background. The anomalies constitute a clear target zone associated with the ore.

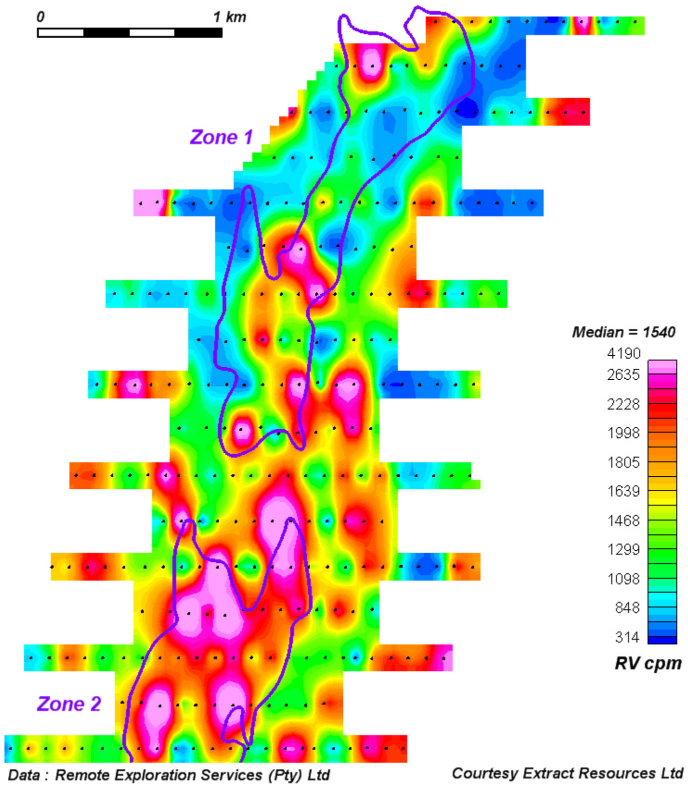

Figure 3. Image of the *RadonX*^{TM} data, with cup intervals desampled to 100 x 250 m spacings. The anomalies still correspond well with the ore horizons and would have constituted a target zone.

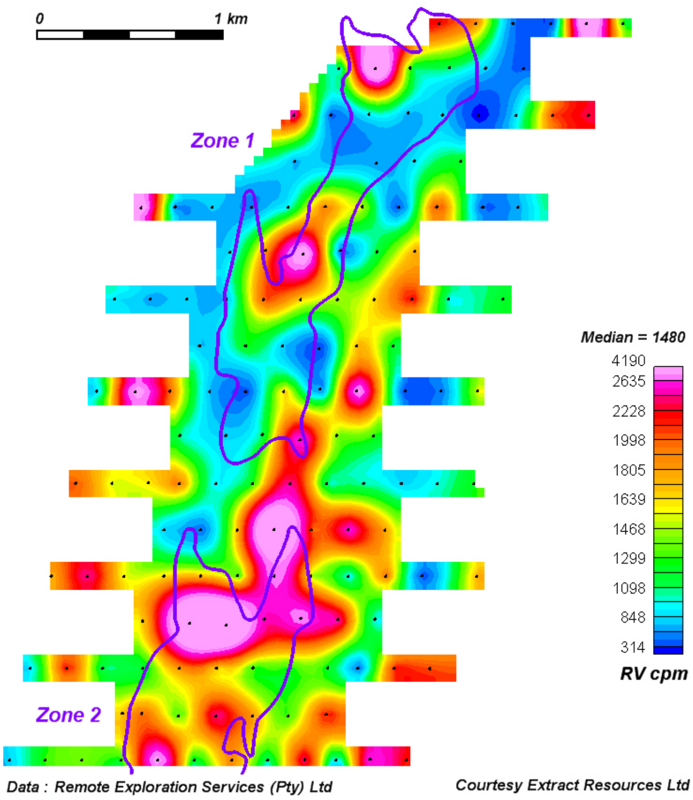

Figure 4. Image of the *RadonX*^{TM} data, with cup intervals desampled to 200 x 250 m spacings. The anomalies are severely degraded to only a few cups. This spacing is at the limit of detectability and is considered to be too coarse for the unambiguous identification of a Rössing South type deposit.