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SUMMARY

Exploration License (EL) 25556 is located about 1200 km SW of Darwin, and has been explored for uranium mineralisation. The tenement was granted to Element 92 Pty Limited on 23 August 2007, and was expected to expire on 22 August 2013. However, on 8 May 2013, the tenement was surrendered due to low prospectivity. Currently, it has 11 blocks covering about 28.05 km². Underlying cadaster belongs to Mt Doreen Pastoral lease.

Project area is situated within the Ngalia Basin which is known for its uranium potential. It is an east-west trending intracratonic basin and contains a thick succession of Neoproterozoic to Ordovician shallow marine and fluvi-glacial clastic, carbonate and evaporitic rocks, overlain by Devonian and Carboniferous fluvial to continental sandstone, siltstone & shale. Geology of the project area is dominated by the Mount Eclipse Sandstone which is medium to coarse-grained arkosic sandstone, containing conglomerate lenses. Sandstones may be broadly divided into three types. Coarse-grained, poorly bedded sandstone is predominant and is interbeded with medium-grained, well-bedded along with quartz pebbles in places. Grey-purple hematitic sandstone is mainly confined to the base of the formation.

During the term of EL 25556, historical exploration data were retrieved from NTGS repository. An assessment of previous data was undertaken along with interpretation of geological, geophysical and structural data. In addition a number of field visits were undertaken for ground-truthing and future planning. In 2010-2011, Thundelarra Exploration Ltd/Element 92 Pty Ltd participated in collaborative study of the Ngalia Basin covering the project area in order to understand basin architecture, utilising high resolution geophysics, geochemistry, sedimentology, mineralogy and petrology. In addition, the project area was flown by NT Government funded regional high resolution AEM survey (TEMPEST) and helicopter-assisted high precision gravity survey. Modeling of geological, geophysical and structural data of EL 25556 did not reveal well-defined palaeovalleys and paleochannels which could provide encouragement for drilling. As a result of that uranium potential of the project area was downgraded, and ultimately EL 25556 was surrendered on 8 May 2013.
TABLE OF CONTENTS

SMMARY 2
1.0 Introduction 4
2.0 Tenement Status 4
3.0 Location and Access 4
4.0 Geological Setting 6
5.0 Uranium Mineralisation and Exploration Model 8
6.0 Previous Exploration Activity 11
7.0 Exploration Activity during Term of the Tenement 12
8.0 Conclusions and Recommendation 17
9.0 References 17

LIST OF FIGURES

Figure 1: Tenement Location Map
Figure 2: Geological Setting of the Project Area
Figure 3: Schematic cross section through the Ngalia Basin looking west (modified after Young et al 1995) showing target uranium mineralisation styles.
Figure 4: Sandstone-percentage map of the Oakville (Miocene) bedload fluvial system, South Texas Coastal Plain, illustrating coincident distribution of uranium mineralisation and coarse grain size (Modified from Galloway and Hobday 1999). The gravity ridge that runs through Project area is thought to have been a basement high that resulted in an analogous grain size distribution in the Mt Eclipse Sandstone.
Figure 5: Simplified alluvial-fluvial deposition model with impact of water saturation on uranium mineralisation.
Figure 6: Bouger Tilt Derivative (TDR) image of the regional gravity data (NTGS)
Figure 7: AEM Conductivity Depth Image (CDI) from approximately 125 m depth Red colours indicate electrical conductors and blue colours indicate resistive units.
1.0 INTRODUCTION

EL 25556 is located in the Ngalia Basin and has been explored for uranium mineralisation. The tenement is located about 1200 km SW of Darwin, Northern Territory (Figure 1). Element 92 Pty Ltd, a wholly owned subsidiary of Thundelarra Exploration Limited, is exploring the region for uranium mineralisation and related commodities. This is the final and annual report on the project area due to surrendering of EL 25556 in May 2013.

2.0 LOCATION AND ACCESS

EL 25556 is located about 330 km NW of Alice Springs and 1200 km SW of Darwin (Figure 1) on the Mt Doreen (1:250,000) sheet. It can be approached by Stuart Highway, which turns into Tanami Road at about 110 km north of Alice Springs. Tanami Road is partly sealed and then on formed gravel tracks either via Newhaven or Yuendumu-Nyirrpi roads. Vehicle access within the tenements is possible by station tracks.

The Mount Doreen has a semi-arid climate with low and erratic rainfall. The average rain fall is about 280 mm per year. Most of the rain falls during summer months. Evaporation from exposed water is generally 10 times the annual rainfall. Winters are generally cold with some frost days during June and July.

3.0 TENEMENT DETAILS

The tenement was granted to Element 92 Pty Limited on 23 August 2007, and was expected to expire on 22 August 2013. It then had 27 graticule blocks with an area of 63.36 km². To meet NT Mining Act requirements, 4 blocks were surrendered on 23 August 2010. Again, on 23 August 2011 further 11 blocks of the EL were surrendered, leaving behind only 11 blocks with an area of 28.05 km². During the reporting period a thorough review of the project area was undertaken and due to low prospectivity, EL was surrendered on 8 May 2013. Underlying cadastre belongs to MT Doreen Pastoral lease.
Figure 1: Location of the Project area
4.0 GEOLOGICAL SETTING

The Ngalia Basin is an east-west trending intracratonic basin which contains a thick succession of Neoproterozoic to Ordovician shallow marine and fluvio-glacial clastic, carbonate and evaporitic rocks, overlain by Devonian and Carboniferous fluvial to continental sandstone, siltstone & shale. Seismic data indicate that the basin is asymmetric and attains a maximum thickness of approximately 4.5km. Sedimentation was terminated by the Alice Springs Orogeny, which was initiated in the Early Carboniferous.

This orogenic event produced widespread folding and faulting, with deformation being focussed on the northern margin of the Basin. Mesoproterozoic post-tectonic granitoids of the Southwark Granitic Suite and older, high grade metamorphic rocks (together representing the Arunta Inlier), form the basement to the Ngalia Basin. The granitic rocks are known to be anomalously rich in uranium, and are likely to be the ultimate source of the widespread uranium mineralisation in the Basin.

In the central and southern portions of the basin the Proterozoic and Palaeozoic rocks are covered by a veneer of discrete Cretaceous to Tertiary basins that locally exceed 220m in thickness. The Tertiary sequence in this area is poorly described; however other such basins in the Alice Springs area are thought to be the result of two distinct periods of deposition (Senior et al 1994). The Lower Tertiary consists of an upward fining sequence, with flowing channel sands at the base locally capped by dark grey & black carbonaceous mudstones and green swelling clay. A zone of calcrete, silcrete or laterite separates this sequence from pervasively oxidised and locally magnetic Upper Tertiary sands and gravels.

Geology of the project area is dominated by the presence of the Mount Eclipse Sandstone (Figure 2). Uplift and erosion of the Arunta Region rocks bordering the Ngalia Basin at 350 – 370 Ma marked the start of deposition of the Mount Eclipse Sandstone, the youngest unit preserved in the basin (Young et al., 1995). The Mount Eclipse Sandstone is dominated by medium to coarse-grained arkosic sandstone, containing conglomerate lenses, which may be broadly divided into three types. Coarse-grained, poorly bedded sandstone is predominant and is interbeded with medium-grained, well-bedded along with quartz pebbles in places. Grey-purple hematitic sandstone is mainly confined to the base of the formation (Young et al., 1995). Carbonaceous material is common, and 7 m of lignite has been intersected in drilling (Spark, 1975). Deposition is interpreted to have occurred in a continental fluvial environment, sourced mainly from uplifted rocks of the Arunta Region. Sporadic Tertiary sand and gravels are also present.
Figure 2: Geological Setting of the project area

LEGEND

Quaternary
Qs Sand, silt, minor gravel: alluvial
Qs Sand: aeolian
Qg Gravel, sand: colluvial
Quaternary

Cenozoic
Cuf Foraminiferal grainstone
Carboniferous
Csp Mount Stirling Sandstone
Arctic sandstone and conglomeratic sandstone, greywackes, minor conglomeratic breccia

Neoproterozoic

Vulcan Springs Quartzite
Thickly bedded mudstone, shale, quartz sandstone, minor greywacke sandstone

Mesoproterozoic

Southwest Granite Suite
Megacrystic biotite and biotite-muscovite granite, minor biotite granite, biotite muscovite granodiorite

Palaeoproterozoic

Lander Rock beds
Gneiss, schist, migmatite: mainly retrogressed to greenschist or amphibolite facies
5.0 URANIUM MINERALISATION AND EXPLORATION MODEL

The principal target of Thundelarra’s exploration efforts within the Western Ngalia Basin is uranium mineralisation that is amenable to ISR and which is hosted by the Tertiary sediments that cover large portions of the basin. A secondary target is Bigrlyi-type uranium mineralisation hosted by the Carboniferous Mt Eclipse Sandstone (Figure 3).

Figure 3: Schematic cross section through the Ngalia Basin looking west (modified after Young et al 1995) showing target uranium mineralisation styles.

Tertiary-hosted uranium deposits
Thundelarra has discovered significant and widespread uranium at depth within the basal Tertiary channelling sands where they come into contact with carbonaceous mudstones and sandy clays (more below).

Tertiary sediments cover large portions of the central and southern Ngalia Basin, and indeed around 99% of the Thundelarra tenure. The Tertiary sequence has been found to exceed 220m in drilling conducted by AGIP close to the southern margin of the Basin (hole SR9R). The Tertiary sediments have two excellent uranium source rocks – the Mt Eclipse Sandstone, and the older Southwark Suite granites. The Mt Eclipse is a particularly good source rock because:

- It hosts widespread uranium anomalism (see Figure 2).
- It was exposed throughout the Tertiary to erosion (i.e. reworking into Tertiary sediments) and oxidation.
- The uranium is physically accessible to oxidising ground-waters as it is found within the Mt Eclipse coating sand grains.
- The uranium is in the form of uraninite, which can be easily leached by oxidised waters.
- The Mt Eclipse is exposed in the north, and groundwater flow is to the south, and into the Thundelarra licenses.

Thundelarra will actively search for suitable hydro-geological & chemical traps within this Tertiary sequence. To this end, Thundelarra has:
• Mapped a substantial & structurally controlled Tertiary sub-basin in the south-eastern part of the Ngalia Basin.
• Processed satellite (ASTER night-time) temperature mapping data.
• Conducted a airborne magnetic/radiometric surveys.
• Conducted 1km-spaced gravity survey,
• Commenced follow-up mud rotary & diamond drilling.

Across the Project, a number of paleochannel targets have been interpreted from the ASTER and airborne magnetic data. Visual porosity estimates from core samples indicates that excellent hydro-geological conditions exist for in-situ recovery (ISR) mining techniques, with mineralised sands being capped by an impervious mudstone.

Good potential therefore exists for ISR-amenable paleochannel-style deposits within the Tertiary sediments of the Ngalia Basin. Similar deposits are found in the Frome Embayment of South Australia (Beverley, Four Mile, Honeymoon etc), and these mines tend to have low operating costs and very low environmental impact. Recent AEM survey has been able to detect the paleochannel systems that host the Tertiary mineralisation. This survey has provide direct targets for stratigraphic drilling in areas of thick cover where the conductivity data suggests the presence of channels (dendritic patterns) and carbonaceous mudstone units (high conductivity layers). A regional map of the thickness of the Tertiary sediments will be interpreted, along with the location of channel systems, and this will target further drilling across the Project area.

**Carboniferous sandstone-hosted uranium deposits**

Bigryli-type uranium mineralisation, hosted by coarse feldspathic sandstones in the Mt Eclipse Sandstone is another target. Significant uranium is also known at the Minerva (2.43 Mlbs U3O8 - AGIP 1983), and Walbiri occurrences (1.49 Mlbs U3O8 – NTGS Orestruck Uranium Factsheet, Nov 2009).

The principal host to uranium mineralisation in the Ngalia Basin is the Mt Eclipse Sandstone – a thick, synorogenic sequence of non-marine sandstone and shale, deposited in piedmont and subaerial deltaic environments (Questa, 1989). The uranium mineralisation at Bigryli is known to be related to those parts of the Mt Eclipse Sandstone that contain abundant carbonaceous material. However other parameters, related to fluid flow during the mineralising event (e.g. alteration, paleo-porosity & structural setting) are also important facets of the Thundelarra exploration program.
The Bigrlyi deposit has been described as a tabular deposit formed by the interaction of uranium-bearing, oxidising fluids with reducing carbonaceous matter in a permeable sandstone formation. Fidler et al. (1990) have suggested that Bigrlyi was formed in the Mt Eclipse Sandstone prior to the completion of diagenesis. Uranium-bearing fluids are proposed to have originated from weathering profiles of granites in the exposed Arunta complex and to have migrated into the Ngalia Basin. Within this model, diagenesis of the Mt Eclipse Sandstone would have ‘fixed’ the uranium deposits. Subsequent faulting and fracturing have modified the distribution of mineralisation to a limited extent.

Significantly, the final stages of deposition of the Mt Eclipse Sandstone occurred synchronously with the culmination of major structural movements in the Ngalia Basin, during the Alice Springs Orogeny (ASO); a tectonic event with widespread & profound structural / metallogenic significance. It appears that the ASO-related thrusting within the Ngalia basin might have played a critical role in the formation of these deposits in a variety of ways such as:

Acting as the driving force for the movement of fluids responsible for alteration and mineralisation,

- Creating favourable conduits for the movement of fluids,
- Producing repetitions of the favoured traps (e.g. carbonaceous horizons) within the Mt Eclipse Sandstone,
- Acting as a tectonic “fixing” agent, creating a fossilised redox system by dewatering action of structural tilting.

The uranium mineralisation within the Mt Eclipse is likely the result of a variety of processes acting in concert, and consequently a variety of deposit styles can be expected as these processes compete for relative dominance. This is certainly the case in other sandstone-hosted uranium provinces such as the Colorado Plateau in the USA or the Frome Embayment in South Australia. One fundamental parameter, however, is the porosity of the host rocks. In clastic sediments the porosity is initially a function of grain size. A classic demonstration of the control that grain-size may have on mineralisation is found in South Texas (Figure 4), where uranium deposits are spatially associated with the coarser sediment, the distribution of which is controlled by the overall structure of the basin. This primary porosity can be markedly reduced during diagenesis and compaction as ground waters fill the pore space with carbonate cement. This diagenetic event is likely.
6.0 PREVIOUS EXPLORATION ACTIVITY

No previous exploration for uranium has been conducted within the Waite Bore License area. Magellan Petroleum and its joint venture consortium secured an Oil Permit (OP165) in 1981 and shot the Newhaven & Mt Allan Vibroseis seismic surveys in late 1981. One line from the Newhaven survey crosses the northern part of the Waite Bore License (Questa, 1989).

After taking the control of EL 25556, Element 92 Pty Ltd commenced to acquiring the historical data covering the project area. It included geological and exploration data including the recovery of digital seismic data from Magellan Petroleum. In addition, a study of uranium
mineralisation in Ngalia Basin, a Joint project in conjunction with CSIRO and two other ASX listed exploration companies commenced.

7.0 EXPLORATION ACTIVITY DURING TERM OF THE TENEMENT

During term of the exploration license 25556, historical geological, geochemical and geophysical data retrieval was undertaken. This included historical exploration reports, remote sensing imagery and Aster geophysical data along with magnetic and radiometric data from NTGS. An assessment of previous data was undertaken along with interpretation of geological, geophysical and structural data. In addition a number of field visits were undertaken for ground-truthing and future planning. EL 25556 is located in the western part of the Ngalia Basin which offers good potential for uranium mineralisation. Towards east, drilling campaign has successfully intersected high grade uranium mineralisation at Afghan Swan (EL 25334), where uranium mineralisation is confined to undercover ancient paleochannel system. Processing and interpretation of geophysical data identified extensive paleochannel system at shallow depth within unconsolidated Tertiary sediments with uranium mineralisation. In 2010-2011, Thundelarra Exploration Ltd/Element 92 Pty Ltd participated in collaborative study of the Ngalia Basin covering the project area in order to understand basin architecture, utilising high resolution geophysics, geochemistry, sedimentology, mineralogy and petrology. In addition, the project area was flown by NT Government-funded regional high resolution AEM survey (TEMPEST), and helicopter-assisted high precision gravity survey. All data have been delivered to Department of Mines and Energy (Bajwah and Maloney, 2011; Bajwah and Mill, 2012).

Modeling of Gravity and AEM data demonstrate that the present Ngalia Basin overlies what were originally much smaller separated graben and half graben structures that were later concealed beneath the much broader sedimentation of the main basin. The 3D model of the basin indicates that it is a very complex architecture (Schmid et al. 2011). The main architectural features are:

- A central high area which is cut by numerous reverse faults. Many of these faults only affect the higher layers in the sequence (Horizon A, not C).
- A western basin which initially had two main depocentres, one related to the Yuendumu Fault and the other related to the Mt Doreen faults. The Mt Doreen Faults appear to have been inactive during the deposition of the Mt Eclipse Sandstone. Overall the western section of the basin forms a wedge shape which thickens considerably towards the north and is deepest around the junction of the Yuendumu and Waite Creek thrusts.
- An eastern basin which is dominated by a very distinct E-W structural trend. This includes the Bloodwood Trough and shallower troughs that lie along its northern and southern flanks.
The basin is characterised by the presence of large faults along the northern margins and appear to control the internal structure of the basin. These faults may have been formed on reactivation of basement structures.

Within the basin, Mt Eclipse Sandstone is the dominant lithology which appears vertical dipping ridges, whereas mudstones are commonly eroded and form depressions (Young et al.1995). Faults or fractures in sandstones are narrow and show local displacement of sediments and mineralisation. Sediments below the mineralised zone tend to have a higher abundance of gravel and cobble size rounded clasts at the base of channels. Carbonate cemented sandstones are distributed heterogeneously throughout the Mt Eclipse Sandstone. Faults within granites trend parallel to basin margin and are highly mylonitic.

Sedimentological study indicates that deposition of Mt Eclipse Sandstone took place in high relief continental basin dominated by episodic rainfall and semi-arid environment. The majority of the fluvial deposits were accumulated in the distal parts of alluvial fans in a semi-arid environment. The common occurrence of groundwater calcrete suggests that evaporation greatly exceeded precipitation. Episodic tectonic activity during the Alice Springs Orogeny led to thick, immature, stacked fluvial channel deposits intercalated with flood plain playa deposits during time of stagnation.

Mineralogical and petrographic studies indicate that sandstones were mainly derived from a granitic source (Schmid et al. 2011). Uranium mineralisation took place early in the sedimentation cycle before calcite cementation. Uranium is only present in samples that contain V-minerals. Uranium mineralisation occurred in fluvial sandstones with abundant iron-rich detrital clasts (roscoelite, heavy minerals and biotite) prior to carbonate cementation and compaction. Vanadium originates from vanadium-bearing detrital mica (roscoelite) that was transported as clasts and in suspension into the Bigrlyi channels. Oxidising conditions released vanadium out of mica and precipitated as montroseite prior and/or with the onset of calcite precipitation. Compaction and Alice Springs Orogeny reduced porosity and permeability to low or none and caused soft clasts, such as roscoelite clasts, to deform and alter to smectitic/illitic/chloritic roscoelite and remobilise vanadium and uranium towards the grain contacts. Uranium re-precipitated along adjacent quartz grains and caused them to etch. Radiation damage in detrital quartz and K-feldspars started possibly with the initial mineralising event.

Weathering and transport in meteoric/groundwater lead to deposition of vanadium-rich micas and precipitation of uranium (Figure 5). First-stage uranium mineralisation is most likely to occur from lower slopes of an alluvial fan and towards distal extension of the alluvial fan system intercalated with floodplain deposits, where flow rates are slow. Dispersion into overlying units or other parts of the depositional system may occur as secondary re-mobilisation (e.g. Tertiary uranium deposits).
Figure 5: Simplified alluvial-fluvial deposition model with impact of water saturation on uranium mineralisation.

Geophysical Interpretation

Figure 6 shows Tilt Derivative (TDR) gravity profile of the Ngalia Basin with Element 92 projects. EL 25556 is located at the central east of Figure 6. In this diagram significant differences in texture between different parts of the basin can be noted. In the NE part of the basin, Proterozoic rocks either crops out or present under shallow depth. However, in the western part of the basin there seems to thick cover (EL 25556) which masks the response from deeper basement feature.
AEM (TEMPEST) geophysical survey was flown over the Ngalia projects area during 2010-2011 and during the current reporting period data were interpreted (GDF formatted data have already been lodged, Bajwah and Maloney 2011). Figure 7 shows a conductivity depth image (CDI) from about 125 metres depth. Red colours represent conductors while blues are resistors.

Interpretation of AEM data identified coherent conductive features that were interpreted to be the lower Tertiary paleochannels thought to be the primary hosts of uranium mineralisation. Drilling results appeared to support this theory with mineralisation intersected in holes drilled into the conductor, and no (or minor) mineralisation intersected outside the feature. However, drilling undertaken within Ngalia project tenements has shown that EM conductors did not always represent the position of the paleochannels. Many drill holes intersected Devonian and Carboniferous rocks such as Mt Eclipse Sandstone and Vaughan Quartzite at relatively shallow depth.
Experience with gravity and AEM (Tempest) data provided an opportunity to image the subsurface geology where AEM anomalies caused by deep incision of basement rocks by Tertiary age palaeovalleys and paleochannels. A combined image of gravity (TDR) and AEM geophysical data from the project areas held by Element 92 Pty Ltd revealed broad conductors. However, within EL 25556 these palaeovalleys and paleochannels were poorly defined and, therefore, downgraded potential of the tenement for uranium mineralisation.
8.0 CONCLUSIONS AND RECOMMENDATIONS

Element 92 Pty Ltd has developed an understanding of subsurface geological and structural framework of the Ngalia Basin with the help of geophysical data, which is an important step towards exploring the project area. Modeling of geological, geophysical and structural data with EL 25556 did not reveal well defined palaeovalleys and paleochannels which could provide encouragement for drilling. As a result of that uranium potential of the project area was downgraded and ultimately EL 25556 was surrendered on 8 May 2013.

9.0 REFERENCES


SF52-12, Northern Territory, 1:250,000 Geological series – explanatory notes, NTGS, AGSO, Darwin, 55 p.