CAMECO AUSTRALIA PTY LTD

Eighth Annual and Final Report – Mamadawerre Project

EL24992

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Period 2 September 2008 to 19 August 2016

Target Commodity Uranium

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Tenement Manager Austwide

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Abstract

The Mamadawerre Project is a uranium exploration project consisting of Exploration Licence 24992 (EL24992) which was granted on the 2nd September 2008 for initial period of 6 years to Cameco Australia Pty Ltd (Cameco). The tenement consists of 105 blocks with a total area of 306.3 km². EL24992 was surrendered on 19th August 2016.

On the 27th June 2011, Alligator Energy Limited (Alligator), through its wholly owned subsidiary Northern Prospector Pty Ltd (NPPL) entered into a joint venture agreement with Cameco. Under the agreement, NPPL was appointed as the operator. NPPL exited the joint venture on 1st March 2016 and Cameco resumed responsibility as operator.

This is the final and annual report for EL24992 and summarizes exploration work conducted on the tenure from 2nd September 2008 to 19th August 2016.

No exploration was completed during the 2015 – 2016 reporting period.
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1. Introduction

This is the final and annual report for EL24992 which was surrendered on 19th August 2016. This report summarises the exploration activities conducted across EL24992 during the period from 2nd September 2008 to 19th August 2016.

Exploration completed on the tenement has been for unconformity style uranium mineralisation similar to deposits in the Athabasca Basin (Canada) and the Alligator Rivers Uranium Field (Ranger / Jabiluka).

No exploration activities were completed on EL24992 during the 2015 - 2016 reporting period.

1.1. Location and Access

The tenement is located in western Arnhem Land, Northern Territory on the Millingimbi (SD-5302) 1:250 000 scale topographic map sheet and the Goomadeer (5673) 1:100 000 scale topographic map sheet. The tenement is centred approximately 90 km northeast of Jabiru and 40 km southeast of the Nabarlek Mine.

Field reconnaissance and sampling programs have been principally conducted via helicopter support from Myra Camp, located approximately 50 km due west of the target areas.

Access within the tenement has been a limiting factor for cost effective exploration in previous seasons. Following discussions facilitated through the NLC with local owners, a suitable track was constructed in 2014 to allow vehicle access into the north eastern area of the tenement.

![Figure 1: Tenement location map](image-url)
1.2. Tenure

EL24992 was granted to Cameco on 2nd September 2008 for an initial period of six years and covers an area of 105 blocks for 306.3 km². On the 27th June 2011, Alligator Energy Limited (Alligator), through its wholly owned subsidiary Northern Prospector Pty Ltd (NPPL) entered into a Joint Venture (JV) agreement with Cameco Australia. Under the JV, NPPL was appointed as the operator. Renewal of the tenure by 2 years until 1st September 2016 was granted by the DME on 4th December 2014. NPPL exited the JV on 1st March 2016 and Cameco resumed responsibility as operator.

The Mamadawerre project is located within Arnhem Land Aboriginal Reserve and is subject to an Exploration Consent Deed with the Northern Land Council (NLC) on behalf of the Traditional Owners. The licence contains areas that are sensitive or have cultural and/or social significance to the Traditional Owners (‘No Go Areas’) and are excluded from exploration access.

2. Regional Geology

The Mamadawerre Project area is located within the eastern margin of the Neoarchaean and Palaeoproterozoic Pine Creek Orogeny, and is in a region that has been subdivided into the Nimbuwah Domain of the Alligator Rivers region.

The following regional geological overview is largely based on the work by Needham et al. (1988), Needham (1998, 1990), and Needham and Stuart-Smith (1980). Information that is not based on these references is indicated below.

The Bureau of Mineral Resources (now Geoscience Australia) completed 1:250 000-scale geological maps of the Pine Creek Orogeny between the 1940s and 1960s following the discovery of uranium at Rum Jungle. The Alligator Rivers region was systematically mapped by the Bureau of Mineral Resources and the Northern Territory Geological Survey between 1972 and 1983. This later work produced 1:100 000-scale geological maps and reports for the region from Darwin to Katherine to the Alligator Rivers region.

The oldest exposed rocks in the Alligator Rivers region are within the Neo-Archaean (ca. 2500 Ma) Nanambu Complex. The complex consists of paragneiss, orthogneiss, migmatite, and schist forming domical structures that are unconformably overlain by Palaeoproterozoic metasedimentary and metavolcanic rocks, which were formerly included in the Pine Creek Geosyncline. Recent collaborative research work by the Northern Territory Geological Survey (NTGS) and Geoscience Australia (GA) indicates that SHRIMP U-Pb age dating of areas of previously mapped Myra Falls Metamorphics outcropping within the Myra Inlier and to the northwest of the Narbalek minesite are Neo-Archaean in age with two age groups 2.53-2.51 Ga and 2.67-2.64 Ga (Hollis et al., 2009a). These quartzfeldspathic gneiss are now referred to as the ‘Kukalak Gneiss’ and ‘Arrarra Gneiss’ respectively (Hollis et al., 2009b). Palaeoproterozoic rocks in the Alligator Rivers region are amphibolite facies psammites assigned in the Mount Howship Gneiss and the Kudjumarndi Quartzite. These formations are included in the Kakadu Group and are probably correlatives of the Mount Basedow Gneiss and Munmarlary Quartzite, respectively (Ferenczi et al., 2005). The group appears to onlap Neoarchaean basement highs, with gneissic variants thought to pass transitionally into paragneiss of the Nanambu Complex.

The Cahill Formation of the Namoona Group conformably overlies the Kudjumarndi Quartzite. The lower part of the Cahill Formation (informally referred to as the Lower Cahill Formation) hosts the Nabarlek, Ranger and Jabiluka uranium deposits. The Lower Cahill Formation consists of a structurally lower calcareous marble and calc-silicate gneiss, which is overlain by pyritic, garnetiferous and carbonaceous schist, quartz-feldspar-mica gneiss, and minor proportions of amphibolite.

The informally named Upper Cahill Formation is psammitic and consists of feldspar-quartz schist, quartzite, lesser proportions of mica-feldspar-quartz-magnetite schist, and minor proportions of metaconglomerate and amphibolite. The Upper Cahill Formation is magnetic and significantly so at
the base of psammitic unit in what is informally known as ‘hanging wall sequence’. The magnetic characteristic of this unit is due to the presence of mafic sills or magnetite and it is a useful characteristic used to distinguishing the Cahill Formation from surrounding less magnetic rocks (Kendall, 1990). Mafic sills and dykes assigned to the Goodparla and Zamu Dolerites intruded the Cahill Formation prior to metamorphism.

The Nourlangie Schist overlies the Cahill Formation and consists of argillaceous to quartzose phyllite and quartz-mica schist that locally contain garnet and staurolite.

The supercrustal rocks of the region are structurally complex, having been affected by at least three deformation events before deposition of the late Palaeo- to Mesoproterozoic Kombolgie Subgroup. The rocks have also been locally migmatised during the ca. 1870 Ma Nimbuwah Event. In addition, there is a broad trend of increasing metamorphic grade from southwest to northeast in the Nimbuwah Domain. This gradient is thought to reflect the synchronous emplacement of ca. 1865 Ma granites in the Nimbuwah Complex.

The Kombolgie Subgroup is the basal unit of the late Palaeo- to Mesoproterozoic Katherine River Group of the McArthur Basin (Sweet et al., 1999a; Sweet et al., 1999b). The subgroup consists of sandstone units called the Mamadawerre Sandstone, Gumarrinbang Sandstone, and Marlgowa Sandstone, which are divided by thin basaltic units called the Nungbalgarri Volcanics, and Gilruth Volcanics. The Mamadawerre Sandstone has a minimum age of ca. 1700 Ma, which is the minimum age of the intrusive Oenpelli Dolerite. Detrital zircon SHRIMP data from the GAOZCRON database constrain the maximum age of the sandstone at ca. 1810 Ma.

The Oenpelli Dolerite is the most pervasive mafic intrusive suite to affect the Alligator Rivers region and is the youngest Proterozoic rock unit exposed. It intrudes various Neo-Archaean, Palaeoproterozoic, and the Kombolgie Subgroup units, forming magnetic sills, dykes, lopoliths, and laccoliths. The Oenpelli Dolerite has a SHRIMP U-Pb baddeleyite date of 1723 ± 6 Ma (Ferenczi et al., 2005) or by approximately 1690 Ma by concordant Rb-Sr whole-rock and mineral age (Page, et. al. 1980). Geochemical and geophysical data suggests several phases of intrusion throughout the region. These intrusive events had a pronounced thermal effect within the Kombolgie Subgroup, with the promotion of fluid flow and aquifer or aquitard modification. Localised effects in the sandstone include silicification, desilicification, chloritisation, sericitisation, and pyrophyllite alteration. A characteristic mineral assemblage of prehnite-pumpellyite-epidote has formed in the quartzofeldspathic basement rocks adjacent to the intrusions.

Deformation since deposition of the Katherine River Group includes transpressional movement along steep regional-scale strike-slip faults and possibly some shallow thrusting.

These regional faults follow a pattern of predominantly north, northwest, and northeast strikes, giving rise to the characteristic linearly dissected landform pattern of the Kombolgie Plateau. Another significant structural trend strikes east – west which includes both the Ranger and Beatrice Faults.

The Bulman Fault Zone is a principal regional feature and is considered to represent a longlived deep crustal structure. However, it appears that post-Kombolgie displacements along this and other faults have not been great, because the Arnhem Land Plateau is essentially coherent and offsets along lineaments are generally minor. Field investigations of many interpreted ‘faults’, including those with a marked geomorphic expression, show no displacement, and are best described as joints or lineaments.

Erosional remnants of flat-lying Palaeozoic Arafura Basin and Cretaceous Carpentaria Basin are present as a veneer throughout the coastal zone of the Top End. Various regolith components are ubiquitous as cover throughout much of the region.
3. Local Geology

Sedimentary rocks of the Kombolgie Subgroup (Sweet et al., 1999a) unconformably overlie (and obscure) basement in the central, southern and western parts of the tenement. The basal formation, the 100-250 m thick Mamadawerre Sandstone forms a deeply dissected plateau surface. This area is composed largely of bare rock with sparse areas of shallow sandy soil supporting spinifex and scrub. Sandstone is quartzose to lithic and fine- to very coarse-grained with a variety of fluviatile to shallow high-energy marine bedforms, including trough and planar cross-beds (Ojakangas, 1979).

Mamadawerre Sandstone is unconformably overlain by the Nungbalgarri Volcanics. The contact is expressed locally as 100-500 m diameter sub circular depressions ('dome and basins'), with the upper sandstone surface interpreted to represent the palaeotopographic surface of giant lunate current ripples or aeolian sand dunes with the volcanic draped over the top (Nott and Ryan, 1996). It may also represent large dewatering structures formed as a result of hot volcanic rocks draped over water-saturated sediments, which were deposited in estuarine conditions (Needham, 1978). The Nungbalgarri Volcanics consist of multiple vesicular and amygdaloidal basaltic flows. The regional stratigraphic thickness of the volcanic unit is variable between 50 m and 130 m, however, it may also be locally absent (Carson et al., 1999).

The Gumarrinbang Sandstone, which occupies approximately one quarter of the tenement, unconformably overlies the volcanics, comprising fine- to coarse-grained quartz sandstone with scattered pebbly units. Sedimentary structures include planar and trough cross-stratification, ripples and horizontal planar stratification, suggesting a proximal to distal fluvial braided stream and estuarine depositional environment (Sweet et al., 1999b).

Sills and dykes of Oenpelli Dolerite occur in the Mamadawerre Project area. In outcrop, the dolerite ranges from fresh magnetic coarse-grained subophitic dolerite to pervasively altered chlorite-
hematite rock. The most visibly obvious structures in the tenement are deeply incised linear features of various orientation and significance, including fractures, joints and small faults.

Figure 3: Local geology map

4. Previous Exploration

EL3347 was granted to the Kunbohwinjgu Joint Venture on 28th July 1997 with Afmeco Mining and Exploration Pty Ltd (AFMEX) as the operator. Exploration activities included a helicopter-borne magnetic radiometric geophysical survey (8,500 line km), followed up by ground reconnaissance over 67 selected radiometric anomalies (Alonso and Kastellorizos, 1998) and (Fabray et al., 2000). During 1998 and 1999 heli-supported diamond drilling (10 holes) took place by AFMEX. The best results were: KBW004, 174 ppm U in clay altered sandstone below the Nungbalgarri Volcanics and 60 m above the unconformity; KBW002 in the SW part of the tenement contains an interval of 180 ppm U immediately above the unconformity, proximal to the NNW Ponting fault. NanoTEM ground electromagnetic geophysical surveys were conducted across the Daniel Fault. These lines show a number of offsets related to the fault. A helicopter supported regional stream sediment survey and limited radiometric anomaly follow up was also carried out. Results were low-order and no further follow-up was conducted (Ewington, 2001). The eastern portion of the licence was relinquished in 2001.

The Kunbohwinjgu Joint Venture was dissolved in 2003 and Cameco acquired 98% of EL3347. The remaining 2% remained with the Kunbohwinjgu Land Council Pty Ltd. Cameco was granted a two year extension in July 2003. Exploration conducted by Cameco included re-logging and sampling of several of the historical drill holes, and an airborne hyperspectral survey over the entire EL3347 using the Hymap Mark 1 system.
The licence expired in July 2005 and Cameco retained 6 blocks which formed ERL 25896, and relinquished EL3347. The area covering EL3347 was re-applied for by Cameco in 2005.

5. Work Completed During Tenure (EL24992)

5.1. Exploration 2008 – 2012 (Operator - Cameco)

EL24922 was granted to Cameco Australia on 2nd September 2008.

A helicopter supported outcrop sampling program was conducted on the project in late 2008. Sampling was concentrated along structural trends and following up weak hyperspectral clay anomalies identified from the Hymap survey to determine if weak geochemical or alteration patterns could identify the uranium mineralisation potential of the major lineaments. Fifty-two samples were collected from across the project.

Sample MM080407 returned the best result of 0.074 % U3O8. The sample was from a hematite altered Gumarrinbang Sandstone stream transported cobble discovered in a creek bed in the southeast of the project area. The area has been named Steptoe and a northwest trending fault through it is called the Steptoe Fault.

During 2009, helicopter-supported outcrop sampling, mapping and reconnaissance was conducted to follow up the anomalous sample collected during the 2008 program. Work was focussed in the Steptoe area to determine the background geochemical signatures, alteration patterns, extent and controls to the mineralisation. A total of 10 stations were mapped and 19 rock samples were collected during the program. This program identified uranium mineralisation stretching over 1,000 m within the Gumarrinbang Sandstone along the northwest trending Steptoe Fault. The best results along the Steptoe Fault included 3400, 961 and 723 ppm U3O8 in hematite altered Gumarrinbang Sandstone. The mineralisation is located within a discrete structural zone of the Steptoe Fault. Anomalous uranium results have been returned from sampling along the Pigeon Fault with best results of 1150 ppm U3O8 in what is interpreted to be Cretaceous sediment and 509 ppm U3O8 in ferruginous Gumarrinbang Sandstone, however in case of the Pigeon Fault, mineralisation was not able to be directly associated with Pigeon Fault structure. Anomalous 206Pb/204Pb isotope ratios of up to 1889.3 indicate that substantial radiogenic lead (206Pb) is present in the area tested by rock sampling.

During 2010 exploration included an airborne electromagnetic (TEMPEST) survey, helicopter-supported outcrop sampling, mapping and reconnaissance. Sixty-five samples were collected with 10 samples returning U3O8 values over 100 ppm. These 10 samples were collected in 3 areas, the Pigeon Fault area with previously known mineralisation, and two areas previously not known to be mineralised; the northwest arm of the Steptoe Fault and the south part of the Nepal-Tibet Fault where 188 ppm U3O8 (sample C007148) was obtained in altered Nungbalgarri Volcanics (near the contact with Mamadawerre Sandstone).

During the 2011 and 2012 exploration programs tenement wide reconnaissance was conducted, with a focus on the Pigeon and Steptoe Fault sets. In 2011 a total of 25 rock chip samples were submitted for geochemical assay. Seven samples returned U3O8 values over 200 ppm, and 3 samples over 500 ppm U3O8. The best result returned was 5612 ppm U3O8 in sample MW002. In 2012 the focus shifted to follow the structural valleys away from the observed mineralisation to establish extent of anomalisim. A total of 35 rock chips were taken and submitted for analysis. Two samples returned values over 150 ppm U3O8. The best result of 3501 ppm U3O8 was returned in sample 18271, hosted in a medium grained silicified sandstone with light green secondary uranium visible. Sample 18272 returned values of 171 ppm U3O8 and was located over 3 km north of the previously identified anomalous zone within the Steptoe and Pigeon Fault, and is hosted in brecciated chloritic oxidised sandstone within a north trending fault.
5.2. Exploration 2013 – 2015 (Operator - Alligator)

During the 2013 – 2014 field season a field reconnaissance program was carried out on 16 of the 31 identified targets within the Mamadawerre Project. The targets, which were primarily defined utilising existing airborne radiometric data, magnetic data and historic surface geochemistry results, were difficult to explain in most instances as minimal anomalism was observed on the ground. Typical anomalies were associated with pisolites in alluvial channels or volcanic flats. The presence of fine mafic dyke material was observed in many of the narrower valleys. Where uranium occurrences were observed, it was predominantly associated with small scale fractures in larger valleys such as the Steptoe Fault.

In addition to the heli-supported outcrop sampling (71 rock chip samples) and reconnaissance work, Alligator also completed a 30 sample-soil geochemistry survey, acquired high resolution aerial photography over the tenement and established a 28 km access track into the tenement area to allow for more cost effective exploration in the future.

During the 2014 – 2015 field season a reconnaissance program including rock chip sampling (81 samples) and ground radiometrics surveying was completed. An additional 30 soil samples were collected infilling the 2013 -2014 broad spaced soil sample survey. Water sampling was completed at four locations, only one sample was suitable for analysis for radioisotopes. This sample returned elevated $^{226}$Ra at 75 mBq/kg.

Three VTEM grids were flown over the Mamadawerre Project area in November 2014. Principal geophysical sensors included a versatile time domain electromagnetic (VTEM max) system, and a caesium magnetometer. Ancillary equipment included a GPS navigation system and a radar altimeter. A total of 533 line-kilometres of geophysical data were acquired during the survey.
5.3. Exploration during Reporting Period 2015 - 2016

No exploration work was completed during the 2015 -2016 reporting period.

6. Conclusion

Work completed during the period 2nd September 2008 to 19th August 2016 mainly comprised reconnaissance rock chip sampling and geophysical surveys. Anomalous uranium results have been returned from sampling along the Steptoe and Pigeon Faults. Focussed targets have not been identified for drill testing, resulting in the decision to surrender the tenement.
7. References


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