Amadeus Basin, NT Australia
EL9857 Alice Springs Uranium Project
Airborne Geophysics Interpretation Report

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SUMMARY OF MAIN RESULTS

- Magnetic images have mapped stratigraphic markers caused by the weakly magnetic response of fine grained layers (shale) compared to sandstone, caused by remanent magnetic component of haematite which is generally more common in shaley rocks
- Apparent Remanent Magnetic image marks the general boundary of the redox front from palaeo-groundwater flow from west to east along the Missionary Syncline
- Tectonic compression in the Alice Springs Orogeny resulted in steeper fold limbs at the west end of the Missionary syncline compared to the east end (Brewers Plain), possibly caused by strain shadow where there is a deep seated intrusion in the gap between the Waterford and Ooraminna ranges
- The stratigraphic dip in the Brewers Plain sub-basin are sub horizontal (dip 6 to 8° West) compared to the western end of the syncline where dips on the south limb dip 15 to 17°N (Julia and Mitimba), and 50 to 70S on the north limb at the MacDonnell range front
- The eastern end of the Missionary Syncline is a restricted closed palaeo-groundwater basin which ponded water at the aquitard boundary at the lower (footwall) Undandita Mbr comprising finer grained rocks. This allowed longer residence time of groundwater for chemical reactions which led to precipitation of uranium
- The hangingwall (sandy – aquifer) contact with the footwall (shaley – aquitard) is marked by contrasting radiometric signature, and was the focus of previous exploration
- Known uranium occurrences occur only on the south limb of the Missionary Syncline at the HW-FW contact
- Published geological information on the Angela deposit indicates mineralization deposited at multiple stratigraphic layers and forming an east-west trend which crosscuts the stratigraphy. This suggests some element of structural control, which accounts for upgrading of mineralization to economic grade and dimension
- Follow up targets in the Brewers Plain fold closure at the eastern end of the Missionary Syncline are recommended for detailed exploration. Target characteristics include: shallow dipping stratigraphy, hangingwall side of the main redox boundary in the upper Undandita Mbr, and where there are crosscutting structures interpreted from magnetic lineaments

SCOPE OF WORK

This compilation uses primarily high resolution airborne magnetic and radiometric survey data flown in June 2010 over EL 9857. Available historical exploration data, Government geological mapping, published research and open file satellite imagery were used to relate the airborne geophysics to the geology. The Angela and Pamela uranium deposits within the EL are used as the primary exploration model, with consideration of some characteristics of other types of uranium occurrence.

TENEMENTS

The project comprises one mineral tenement: EL9857 (nominal area of 845km^2, actual area 849.23km^2) granted to Ivanplats Syerston Pty Ltd on 20 July 2007. The southwest corner of the tenement is not specifically defined, and is taken as the road at the foot of the Waterford Range.

The tenement is currently in the second renewal term, which requires reduction of area by 50%. The preliminary results of this airborne geophysics survey were used to reduce the area of EL9857 to retain the most prospective exploration area.

EL9857 wholly encloses EL25758 and EL25826 held by the joint venture between Cameco Corporation and Paladin Energy and covers the Angela-Pamela uranium resource. The Angela-Pamela ore bodies are at the permit stage of development.

DATA SOURCES

Airborne Geophysics Survey

The airborne geophysics survey was conducted by UTS-Aeroquest of Perth Australia, and was flown between 16 to 28 June 2010. Final processed data, maps and reporting were delivered to the Client 12 July 2010.

The survey specifications were as follows:

Aircraft and Instruments

Aircraft	:	Fletcher FU24-950 series fixed wing, registration VH-UTR
Magnetometer	:	Scintrex CS-2 Caesium Vapour tail stinger mount
Compensation	:	3-component fluxgate magnetometer, RMS AADCII compensator
Spectrometer	:	Exploranium GR-820 - 256channel
Detector Crystals	:	32litre Exploranium
Navigation	:	UTS proprietary GPS based navigation
Aircraft Position	:	Novatel differential GPS
Altitude	:	Air DB barometric altimeter, Bendix/King KRA-405 radar altimeter
Diurnal Monitor	:	Geometrics GR-856

Survey Specifications

Flight Line Direction	:	000° True

Flight Line Spacing	:	100m
Control Line Spacing	:	1000m

Data Specifications

Magnetic Interval	:	10Hz
Radiometric Interval	:	1Hz
GPS Interval	:	1 second
Diurnal Interval	:	2Hz

Quality Control of Airborne Geophysics Survey

Quality control throughout the planning, data acquisition and processing phases was monitored by the author of this report.

Summary of Operational issues:

- Revised flight path to accommodate Undoolya Station cut-out during cattle muster, to be flown at end of survey
- No Fly area surrounding the Pine Gap military installation was flown in 7km radius around the main installation, but as this area only partly intersects the EL, the cut-out area should have had straight east and west boundaries, and part of the project area was not flown
- Flight lines at the foot of Waterhouse Range was cut approximately 1Km in front of the topographic rise for aircraft safety, which did not cover a uranium radiometric anomaly at the base of the slope
- Communication from the survey contractor (UTS Aeroquest) with respect to crew and aircraft schedules, flight path changes, preliminary data deliveries for QC and data processing was considered poor, which compromised delivery of regulatory reports to NTGS on schedule and may have implications for the Client's response plan in case of emergency

Limitations on Interpretation by Survey Design and Systematic and Instrument Noise

- Spatial sampling bias of 10:1 ratio of the line spacing versus magnetic reading interval introduces aliasing of linear features, particularly those sub-parallel to flight lines
- Minimum target size which can be discriminated from the gridded data with the inherent sampling bias is theoretically 50 X 100m, but practically 125 X 200
- Residual noise (instrument, spherics, aircraft electrical, cultural) estimated from the 4^{th} difference of the levelled line data is 0.552nT with 20.692nT standard deviation
- The aircraft Figure of Merit (FOM) which is a measure of the residual noise after compensation due to aircraft manoeuvre is 2.43nT
- The residual line-based noise from levelling is estimated from directional filtering as 0.00nT with standard deviation of 0.2nT

Limitations caused by Other Noise Sources

- Power lines, electrified railways, pipelines, fences and buildings all present significant magnetic anomalies. Although these are generally easily recognised, they are difficult to remove from the data and some of the derivative filters are unstable
- Geological factors which introduce noise which partially mask bedrock responses are attributed to detrital magnetite in drainage channels, and possibly dune effects

In general the raw data quality is considered excellent, and there is little remaining noise in the processed data. However, the strong shallow responses of some cultural features, in particular pipelines and electrified railways, cause severe instability of some processed images.

Digital Elevation Model (DEM)

Shuttle Radar Topographic Mission (SRTM) data were downloaded from the USGS web site (http://dds.cr.usgs.gov/srtm/version2_1/SRTM3/Eurasia/) to cover the area bounded by longitude 133 to 135°E/latitude 23 to 25°S. These data are the original DEM observations Version 3, which has been corrected for local spikes, correlated to local control points, and referenced to the WGS-84 ellipsoid.

SRTM degree square tiles were joined into a mosaic and projected onto the MGA94 projection on the GDA94 datum.

The spatial resolution of the SRTM DEM is approximately 90m horizontal and 10m vertical.

Digital Terrain Model calculated from the difference between the aircraft GPS height and the aircraft altitude above ground provides a higher spatial resolution of 25m horizontal and 1m vertical compared to the SRTM, albeit only in the immediate survey area.

Landsat 7 ETM+ Satellite Imagery

Landsat scene P102R077 dated01/08/2000 covers the area of interest. Full spectral bandwidth data were downloaded from the Global Land Cover Facility (GCLF) Web site (http://glcfapp.glcf.umd.edu:8080/esdi/index.jsp). These data are GeoTIFF format registered to the projected onto the MGA94 projection on the GDA94 datum.

Drilling

The drilling database from Northern Territory Geological Survey archives comprises collar location and drilling method, but incomplete geochemical assay data. Geological logs from the holes are also incomplete, as there was little recovery of drill cuttings from the drilling methods used.

Geology

PREVIOUS EXPLORATION

The following summary of the exploration history on EL9857 was taken from a report by Heape (2009) in the regulatory Annual Report to the NT Government.

Uranerz undertook exploration for uranium from approximately 1970 until 1983 across the southern and eastern sectors of the present License area. Agip was similarly engaged in uranium exploration at the same time over the northern and western sectors of the License. The exploration rationale in both cases was sandstone hosted uranium within roll front systems. These systems were presumed to have originated off the outcropping uranium rich basement rocks of the Arunta complex to the north of the Missionary Trough.

At an early stage in this exploration activity Uranerz discovered the Angela and Pamela uranium deposits. Drilling, along the southern edge of the Undandita Sandstone, located additional anomalous uranium occurrences within what is now EL9857. Uranerz named these as Julia, Mitimba, P156, P3/4 and P90, shown in Figure 4.

Agip intersected a value of 500ppm U3O8 near Mulga Dam in one drill hole; however follow up drilling failed to confirm this intersection. Agip failed to locate any other evidence of uranium mineralisation in the western and northern sectors of the present EL.

Exploration techniques employed by these two companies included airborne and car-borne radiometric surveys, vacuum and RAB drilling, percussion and diamond drilling. Radon surveys using track etch and emanometry were employed, in conjunction with the shallow drilling, to locate radiometric anomalies. In addition soil gas and groundwater sampling, were tested as techniques for regional uranium exploration.

GEOLOGY

Regional Geology

Geology of the Amadeus Basin was compiled from several sources (Borshoff and Faris, 1990;Marshall and Dyson, 2006; Laurie et al, 1991; *et alia*).

The oldest formations in the area which form the basement floor of the Amadeus sedimentary basin are the Palaeoproterozoic Arunta Province (exposed to the north), and the Mesoproterozoic Musgrave Province (exposed on the southern margin), and the 1080–1050 Ma Tjauwata Group to the southwest.

The Arunta and Musgrave rocks are primarily crystalline metamorphic and metasediments and represent tectonic cratonic fragments, and form the source of sediments (and uranium mineralization) deposited in the Amadeus Basin

The Amadeus is an intracratonic basin approximately 800km long and up to 300km wide oriented east-west and containing up to 14km of fill. The basin was initiated in the early Neoproterozoic with sedimentation continuing episodically to the Devonian-Carboniferous. Sediments comprise continental, platform and marine sediments and tectonic reworking deposits, ranging from coarse clastics, carbonates and evaporates to fine grained marine and glacial deposits.

The basin was affected by three major tectonic events: Neoproterozoic Areyonga and Souths Range Movements; Cambrian Petermann Orogeny; and the Devonian–Carboniferous Alice Springs Orogeny. These events are reflected as thrusting, block faulting and salt tectonics deformation which affected both existing rocks and subsequent sediment depositional environments.

The area of interest of this report is on the northern margin of the Amadeus Basin in the Missionary Plane Trough, bounded to the north by the Arunta Block and to the south by the Waterhouse Range, which is part of the strike extensive Central Ridge. The Central Ridge is a basement anticline exposed by Recent erosion, but was formed in the Late Proterozoic and continued to grow, primarily due to salt tectonism, into the Late Cambrian. Structures associated with the Central Ridge were further enhanced by late-stage thrusting and wrenching during the Alice Springs Orogeny.

Although the Missionary Trough was initiated in the Late Proterozoic, the phase of basin evolution perhaps most important to this uranium exploration programme occurred during the Alice Springs Orogeny. Uplift of the Arunta Region along the present northern margin of the Amadeus Basin created thick molasse deposits (Pertnjara Group), accumulated in an adjacent foreland basin.

Local Geology

The Missionary Trough was a restricted basin formed as a result of the Alice Springs tectonism, bounded to the north by the Arunta Block and to the south by the Waterhouse Range of the Central Ridge. The Devonian Pertnjara Group formed a sedimentary wedge in the Trough which thinned southward. The youngest unit of the Pertnjara Gp is the Brewer Conglomerate, composed predominantly of polymictic conglomerate with minor pebbly sandstone. The Undandita Member at the top of the Brewer Conglomerate comprises lithic fine and medium grained sandstone, siltstone and conglomerate, and is the primary host to uranium mineralization in the Angela and Pamela deposits.

The Pertnjara Group rocks are asymmetrically folded along a roughly east-west axis, with most known uranium occurrences on the southern fold limb. The Pamela and Angela mineralization are the only known areas of economic interest, and are located at the end of the Missionary Syncline in a local closed basin depocentre.

Source of Uranium

The source of mineralization in the Undandita Mbr is high-uranium granitic orthogneiss of the Iwupataka Metamorphic Complex and the Teapot Granite Complex, part of the Arunta Block.

However, it is unlikely that uranium leached directly from the source rocks was transported into the local groundwater catchment of the Missionary trough, as the flow would have to pass over several major aquifers, notably the Pacoota and Mereenie sandstones (Jones, 1980).

Uranium mineralization in the Undandita is derived primarily from *in situ* leaching of detritus derived from source material in the Arunta Block headlands. Mineralization was deposited late in the basin diagenesis, and occurred after the folding of the Amadeus Basin sequence in the Alice Springs Orogeny.

The widespread stratigraphically controlled reduced level in the Undandita was formed by ponded groundwater chemically reacting with organic material in a closed basin formed between the Arunta Block and the Waterhouse Range.

Angela-Pamela Deposit

The Angela-Pamela project is currently operated by a 50/50% joint venture between Cameco Corporation (CCO:TSX) and Paladin Energy (PDN:TSX). The geology of the Angela and Pamela deposits is best described by Borshoff & Faris, 1990 and is briefly summarised herein.

Uranium mineralization in the Angela and Pamela deposits is hosted by a sequence of late Proterozoic to Carboniferous sequence of sediments deposited in the intracratonic Amadeus Basin. The Pertnjara Group is the latest unit deposited in the Basin, with the Undandita Mbr of the Brewer Conglomerate as the specific host to mineralization.

Mineralization is partially controlled by stratigraphy, structure, and palaeo-groundwater. The Undandita Mbr comprises primarily sandstones formed in a terrigenous braided stream environment. Sandstone is a fertile depositional environment, as it is interlayered aquifer/aquitard layering, which focuses groundwater flow; and is chemically reactive, with both contained organic matter as a reductant and the locus of mixing of connate and meteoric water. Mineralization is a mid- to late-diagenetic event.

The possible structural control on Angela mineralization is an east-west linear element which crosscuts the stratigraphy. It is not clear that this is caused by a structure, it may be simply a groundwater redox front, but nevertheless, the lineament crosscutting the stratigraphy is a locus of mineralization.

Palaeo-groundwater control on mineralization is related to the main recharge area north from the MacDonnell Ranges, and following the Missionary Syncline to the east. Where the oxygenated meteoric recharge water encounters a reducing agent, which may be organic material or sulphides, or formation water trapped during sedimentation, mineralization may be deposited. It is important to note that the formation of the redox boundaries and deposition of mineralization ceased in the Late Carboniferous, probably due to hydrological changes resulting from tectonism and deepening of the Missionary Trough (Lally, 2004).

The primary uranium mineralisation consists of fine grained amorphous uraninite and pitchblende with minor coffinite occurring as grain coatings, void linings and blebs. Secondary minerals include carnotite, autunite, tyuyamunite and metatyuyamunite. Gangue minerals are mainly fine grained to amorphous haematite, (occurring as grain coatings and interstitial infill of the matrix), calcite, minor pyrite and organic material.

Resource estimates by Uranerz were based on borehole radiometric measurements. Resource tonnes and grade are tabulated below:

Category	Grade (%)	Cutoff (%)	eU3O8 (t)	eU3O8 (Mlbs)
Measured	0.13	0.05	4700	10.36
Indicated	0.1	0.05	1950	4.30
Inferred	0.1 to 0.13	0.05	3600 to 6000	7.94 to 13.23

Ore tonnes or methods of resource calculations are not reported by Borshoff & Faris, and it is therefore assumed this resource estimate is not JORC/CIMM compliant. As this resource was reported by Borshoff & Faris prior to 1 February 2001 it is considered “Historical” under NI43-101 regulations. Although Cameco and Paladin Energy have undertaken further drilling to confirm this estimate, an updated resource has not been publically disclosed.

Main Points of Interest of Angela Geology for Exploration:

- Mineralization is strata-bound in the Undandita Mbr, which contains organic and sulphide reductants
- Mineralization is a mid- to late-diagenetic event which ceased in the late Carboniferous
- Deposition is deposited at palaeo-groundwater redox fronts, which is repeated through the alternating aquifer/aquitard layering of the Undandita sandstone
- There is a linear element of mineralization control which crosscuts the stratigraphy, which may be structural or the line of intersection of sub-horizontal sediments with sub-vertical redox front
- There is no surface expression of mineralization from historical exploration, which is covered by 30 to 70m of surfical cover and leached weathered material

Consideration of Other Deposit Types
Using the classical roll front model exemplified by the Angela-Pamela deposits, there are two other possible sites for mineralization: older sediments in the Missionary Trough, and adjacent to the Waterhouse Range front.

Given the thickness of the Pertnjara Group estimated at >4000m, the depth to older formations would inhibit discovery and possibly preclude the economic abstraction of uranium.

Units within the Pertnjara Gp below the Brewer Conglomerate are the Hermannsburg Sandstone, with the lowest unit of the Group the Parke Siltstone.

The Parke Siltstone comprises lacustrine siltstone and evaporate deposited in a period of tectonic quiescence. Because of the lack of porous sediments to allow lateral movement of palaeo-groundwater and absence of material derived from the uranium-rich source in the Arunta headlands, the Parke Siltstone is not considered prospective.

The Hermannsburg Sandstone comprises quartz-rich fluviatile clastics in the lower units, with a generally coarsening upward sequence to coarse sandstone and conglomerate. The earlier sediments are not considered prospective as they lack lithic fragments, which indicate erosion from the uranium-enriched headlands. However, as the intensity of the Arunta Block uplift increased in the Alice Springs orogeny, the lithic components and sediment grain size increased.

The uppermost unit of the Hermannsburg Sandstone is the Ljiltera Member, which is comprised of medium and coarse grained pebbly sandstone. Jones (1981) considers the Ljiltera Member almost certainly the lateral equivalent of the lower portions of the Brewer Conglomerate. The Ljiltera Member by nature of porosity, lithic component and stratigraphic level is a valid target for consideration.

Other types of uranium deposits which may be of interest in this environment include: sandstone-palaeochannel, surficial – duricrust, surficial – laterite, and structural/lithologic.

Uranium in palaeochannels forms elongate lenticular bodies parallel to the depositional trend, with channels incised into underlying basement or earlier deposited sediments, an example of which is the Mulga Rock occurrence in the Officer Basin. Uranium is deposited as a result of reduction of uranium enriched groundwater by organic matter or sulphides collected in drainage channels. The potential resource of palaeochannel deposits is limited due to small volume, and is discontinuous due to meandering braided stream depositional environment.

Surficial – Duricrust type deposits are formed in semi arid to arid climates from weathering of uranium-enriched granitoids, where meteoric water leaches metals, which are transported in groundwater and precipitated in playa (sabkha) environments, or as phreatic groundwater surface deposition.

Duricrusts are secondary cements which may comprise carbonate (calcrete), silica (silcrete), iron (ferricrete), gypsum or salt, and are indicative of groundwater flow. The common uranium mineral in the Duricrust environment is carnotite. Because groundwater levels may change dramatically with palaeoclimate and tectonics, there may be several layers of duricrusts formation in the surface environment.

Duricrust deposits may be of economic interest as they are widespread and are conducive to ISL abstraction. From an exploration standpoint, the occurrence of carnotite at surface will cause a radiometric anomaly, but is generally not related to underlying mineralization except in special cases.

Surficial – laterite deposits are formed by leaching of uranium enriched rocks by percolation of meteoric water, and redeposition and concentration at a deeper level in the soil profile at the redox boundary. This is commonly known as “green zone” enrichment, which may be widespread but seldom reaches economic grade of uranium, but may be accompanied by other metals deposited at the same level which add to the value. As the soil profile development in this area is deeply leached, and the parent material is quartz-rich clastic sediments, this is not expected to form a significant exploration target.

Structural/lithologic type deposits are formed by the intersection of favourable structural and lithologic factors. As an example, where a fault zone acting as a channel for groundwater flow intersects a favourable (reducing) sedimentary layer, it creates a fertile deposition site. There are variations of characteristics of both the structure and the host material in this model, but the resulting geometry is to form stacked elongate bodies at repeated stratigraphic levels, which may coalesce into a compact mineralized body.

The structural/lithological type deposit is an important exploration target in this area, and may in fact be one of the controls on mineralization in the Angela/Pamela deposit.

Other types of uranium deposits which occur in the region but are unlikely in the prospect area include: unconformity type (eg. Ranger and Jabiluka in the Alligator River Basin), vein/structural controlled type in the Arunta Block, and mineralization related to volcanic rocks.

One type of uranium deposit which is of secondary interest is related to granitic intrusives. Although the Missionary Trough is comprised primarily of sediment fill, it will be seen later in the discussion of the modelling of deep magnetic features there is an interpreted intrusive at depth which may indirectly influence mineralizing processes in overlying sediments.

Conceptual Exploration Model

The Sandstone/Roll Front type deposit is considered the primary exploration target by analogy to Angela-Pamela, but the Structural/Stratigraphic scenario is also realistic conceptual target.

The main factors of the conceptual exploration model and exploration techniques are described below.

Factor	Target	Rationale	Exploration Technique
Stratigraphic Level (age in relation to Alice Springs Orogeny)	Undandita Member of the Brewer Conglomerate	uplift and erosion of source area during the peak of the Alice Springs Orogeny	Geological mapping
	Ljiltera Member of the Hermannsburg Sandstone	Perhaps too early in ASO, uranium enriched granitoids of the Arunta Block not exposed or insufficient uplift	
Lithology (lithic component derived from U-enriched source)	Undandita Member of the Brewer Conglomerate	lithic fragments eroded from source rocks act as inherent source of U	Radiometrics and magnetics
	Ljiltera Member of the Hermannsburg Sandstone	less lithic fraction in lower units, upper units facies equivalent of Brewer Conglomerate	
Chemical Reactivity (primarily carbonaceous material, but including detrital and diagenetic sulphides, and hydrocarbon leakage from below)	Undandita Member of the Brewer Conglomerate	Organic matter, including spores, leaves and woody material, is commonly preserved in beds with an early diagenetic carbonate cement	Electrical methods
	Ljiltera Member of the Hermannsburg Sandstone	Little organic material reported	
Porosity/permeability contrast (lateral facies changes, interbedded fine/coarse sediment, duricrusts layers)		Finer grained sediments of low porosity reflected in higher Th response and erosion resistance, coarser sediments with lithic component shown as elevated K response and negative erosion feature	Inferred from magnetic stratigraphic layers
Sedimentary Basin (trough or closed depocentre)	From mapped occurrence of uranium enriched source rocks in the tectonic highlands along		Topographic reflection of erosional patterns and magneto stratigraphic

	depositional path to depocentre		markers
Palaeo-Groundwater Trend (source to depocentre)	Inferred from tectonic structure and topography	from tectonic highland source area along axis of Missionary Trough	DEM and magnetic stratigraphic markers
Structure (faults, fold axes and symmetry)	Intersection of interpreted lineaments with favourable stratigraphy	Faults which crosscut the stratigraphy are more easily recognized, but coincident and coplanar fault-stratigraphy is potential larger resource	Magnetic lineaments
Redox Front (late diagenetic process)	Latest redox front related to mineralization ceased late Devonian	Possible multiple fronts at different stratigraphic levels	Remanent magnetic component
Tectonic Geometry (favourable environment distal from active tectonic front)	South Limb of Missionary Trough Syncline	Southward vergent thrusting of ASO overthrust Arunta block over Missionary Trough sediments not conducive to formation of layered sediments or leach residence time	Magneto-stratigraphic markers
Underlying Formations (basement)	Causal relationship of deep seated intrusive to Pamela-Angela mineralization unknown	Deep syn-tectonic intrusive may introduce hydrothermal fluids or affect both sedimentation patterns and diagenetic fluid flows	Magnetic modelling of basement features

As the surface or subcrop exposure of the Ljitera Member is small and only occurs on the southern fold limb of the Missionary Trough fold, emphasis is on the Undandita Member for targeting.

Discussion of Exploration Methods in relation to Conceptual Exploration Model

As the focus of this report is the detailed airborne magnetics and radiometrics, most emphasis is placed on this to identify targets with analogous response to Angela and Pamela. Additionally, conceptual targets are also discussed, and exploration methods other than the airborne survey are considered.

IP Resistivity (Figures ?? aand ??)
Uranerz Australia conducted test IP/Resistivity surveys over the Angela orebody to determine the type response. Without physical property measurements on representative rocks, alteration and mineralization, the geological interpretation of these data can only be inferred.

No coordinates of the IP/Resistivity test lines are reported, but the surface projection of the mineralization is indicated on the original sections. The IP/Resistivity data were inverted to yield true depth earth sections.

On Line 5 and Line 6, the projection of the Angela mineralization correlates to sub-horizontal layers of relative low resistivity surface layer over relative high resistivity (bedrock) layer. Although the stratigraphy is shallow dipping (approximately 10°N), the horizontal layering in the sections probably represent layers of surficial cover and weathered bedrock zone. Given the low resistivity (<15 ohm-m) fresh bedrock is not seen in the section.

On Line 5, the IP Chargeability response of the mineralization is an apparent vertical low chargeability zone, which could represent the redox boundary where mineralization may be deposited. Organic matter and sulphides are consumed in the reduction reactions, and a low IP Chargeability would be expected. A similar vertical low chargeability zone is evident, which may represent another redox front, but with unknown or no mineralization. However, the IP Chargeability response on Line 6 shows uninterrupted horizontal layering, which is probably the surface cover and soil profile.

Although the geological drill sections were not provided for the IP Resistivity profiles, from the data presented there is no distinctive IP Chargeability response from which the presence of mineralization can be inferred.

Radon Surveys (Track-Etch, soil gas emanometry, groundwater chemistry)
Uranerz conducted extensive radon surveys, both directly over the Angela mineralization to obtain a type response, and along strike of the Undandita stratigraphy. Results indicated erratic or no response over known mineralization which is covered by 30 to 70m of cover, and use of this technique was discontinued.

However, as will become evident in the discussion and presentation of the airborne radiometric results, there is a discernable radiometric response in the uranium channel caused by radon emanation along the stratigraphic marker of the Undandita sandstone. What was not taken into account in the original soil gas surveys is the displacement of radon anomalies away from the source body by groundwater.

Radiometrics
The source of material which formed the Undandita sandstone is the highlands of the MacDonnell Ranges, with the source of metals as high-uranium granitic orthogneiss of the Iwupataka Metamorphic Complex and the Teapot Granite Complex, part of the Arunta Block. The Undandita Mbr contains a proportion of lithic fragments, which would be expected to give a potassium radiometric response due to K-feldspar.

Thorium and Uranium both have an affinity for clay- and manganese-rich materials, and are indicative of surface sediments. Thorium is geochemically less reactive than uranium, and tends to remain where deposited, whereas uranium is soluble in oxygenated water and is relatively mobile in the surface geochemical environment.

Magnetics
Magnetite, by nature of its common occurrence as an accessory mineral of most rocks, and strong magnetic susceptibility, accounts for most of the induced field measured in conventional magnetic surveys. Sediments (with the exception of iron formations) have a generally small magnetic response caused by detrital magnetite which may be detectable from high sensitivity surveys, Iron-rich

igneous and metamorphic rocks have a magnetic response which may be several orders of magnitude stronger than that of sediments due to primary or metamorphic magnetite.

Significantly, sediments may have a significant and characteristic remanent magnetic component caused by haematite. This characteristic is significant as will be shown later in the discussion of results, as the change from detrital magnetite to ferric (haematite) and hydroxide (limonite) phases is indicative of the redox boundary, where uranium and other metals is deposited.

Authigenic magnetite generated from percolation of hydrocarbons below may be a minor contribution to the magnetic signature, but this phenomenon would only have occurred after the latest deformation of the Undandita Mbr and would only be present in surface material unrelated to underlying sediments.

Organic Matter (and sulphate reduction by organic matter to form pyrite) is considered the primary reductant for deposition of uranium. There is no magnetic response directly attributed to organic matter, but the interface between the reduced and oxidized material may show a contrast in the remanent magnetic component.

DATA COMPILATION AND PROCESSING

Map Projection and Datum

The airborne survey was recorded in WGS-84 coordinates with the following parameters:

Datum: WGS84 World Geodetic System 1984
Coordinates: geographic spherical (latitude/longitude)
Semi Major Axis 6378137m
Flattening 1/298.257223563

which was transformed to the following mapping system:

Projection: MGA94 Map Grid of Australia 1994
Coordinates: Universal Transverse Mercator Zone 53S
Datum: Geocentric Datum of Australia
Semi major axis 6378137m
Flattening 1/298.257222101

The GDA94 datum is essentially equivalent to the WGS84 datum at the scale of mapping for this survey and interpretation.

Data Processing Software

The primary software used for mapping and processing is Geosoft OASIS ***montaj*** with the MAGMAP geophysical processing extensions.

Magnetic modelling initially used Geosoft MAGMOD, but this proved inadequate for the 3-D structure of the basin, and the University of British Columbia - Geophysical Inversion Facility (UBC-GIF) MAG3D Version 4 was used for 3-dimensional inversion.

RESULTS OF INVESTIGATIONS

Digital Elevation Model (DEM) (Figure ?, Maps ??)

The area of the Missionary Plain has generally flat relief between 794 to 510m with an average elevation of 586. Surface drainage capture is bounded to the north by the Arunta block, and to the south by the Waterford Rang. At the west end of the Missionary Plain is a drainage divide which directs surface water flow to the east into the Roe Creek/Emly Plain.

The Brewer Plain is a restricted local drainage basin bounded by local topographic highs caused by erosion resistant bedrock.

Surface drainage patterns are primarily a function of weathering and (post-Carboniferous) erosion, modified by the differential erosion of resistant rock types, but there is also a relic tectonic control. The main east-west drainage is parallel to the ASO fold axis of the Missionary Trough sediments, but diverges in the Brewer Plain area where surface erosional highs have restricted the basin.

The coincidence of the ASO fold axis to the present day drainage suggests the modern drainage reflects the groundwater flow lines, which formed the redox boundaries which led to deposition of uranium mineralization.

Correlation of the DEM to the magnetic response indicates that the erosion resistant layers have a relatively low magnetic response, suggesting these are coarser clastics (sandstone and conglomerate) layers. Higher magnetic response correlates to the local topographic lows, which is attributed to finer grained sediments (shales). Although the magnetic response of all sediments (with few exceptions) is generally low, the relative higher iron content of shale compared to sandstone creates an observable induced and remanent magnetic response.

The gap between the Waterhouse Range and the Ooraminna Anticline are part of the Central Ridge, and is a drainage divide which separates the Missionary Trough drainage from the central Amadeus Basin. As will be shown later, this break in the uplift of the Central Ridge may be caused by a deep seated intrusive.

Landsat ETM+ Imagery (Maps 3, 4)

Landsat ETM+ image B321RGB in the near-visible spectral range approximates a colour air photograph, and indicates most of the Missionary Trough area is covered by Quaternary to Recent alluvium, colluvium and aeolean sand. Windows of outcropping and subcropping bedrock have provided the basis for Government geological and structural mapping.

Landsat imagery was used in this interpretation as an adjunct to the geophysics data for qualification of anomalies caused by cultural features.

Magnetics (Figures ?,?, Map ?)

Magnetic features are classified into four types of source bodies: cultural, surficial, sedimentary and intrusive. Examples of each type of source are described below, with the compilation of all sources on the magnetic interpretation map.

Cultural anomalies are more common towards the north, where railways, pipelines and buildings concnetrate around the town of Alice Springs. Cultural anomalies are relatively easily identified by strong, linear or point source magnetic anomalies, often with reversed magnetic polarity. Although the anomalies are easily identified, they are difficult to remove from the data, and cause processing artefacts particularly in FFT type filters and derivatives.

Surficial magnetic sources are shown as relatively strong magnetic anomalies in modern drainage channels, which are caused by detrital magnetite and maghaemite. As the depth extent of detrital magnetite in stream sediments is small, and the braided nature of the streams, the magnetic anomaly is difficult to trace along the length and is of variable strength.

Sedimentary magnetic anomalies are caused by the differences in iron content between coarser grained sediments (sandstone, conglomerate) and fine grained sediments (mudstone, shale). The magnetic response of sediments (with the exception of BIF) is generally small compared to mafic intrusives and granites of particular composition. The contrasting magnetic response between sandstone and shale is due to the weak induced magnetic response of maghaemite, and the remanent magnetic componet of haematite. The magnetic response of shales is not due to detrital magnetite, as this is easily oxidised under diagentetic or weak metamorphism to ferric (haematite) and hydroxide (limonite) phases.

Because of the weak magnetic contrast response, the sedimentary layering cannot be modelled correctly, as the field falls off quickly with depth, so the geometry of the causative layers cannot be uniquely defined. Only the magnetic stratigraphy can be determined, with offsets and changes in layer widths indicating structural features.

In general, the magneto-stratigraphy outlines an asymmetric syncline forming an open fold in the basin sediments, with axial plane oriented East-West. On the west part of the south limb of the fold, the sediments dip shallow 15 to 17°N (cf: Julia and Mitimba). Stratigraphic dip information at the east end of the trough is not recorded, but is thought to steepen into a local sub basin at Brewers Plain.

The Missionary Syncline is asymmetric, with steeper dips on the north limb and shallow dip on the south limb (Alice Springs 1:250,000 scale geology map sheet SF53-14 – 1983 edition). The asymmetry is tectonic, caused by southward vergent overthrust of the Arunta Block south towards the Amadeus Basin.

Structural measurements on the west side of the north limb indicate 45 to 70° dip to the south, increasing to the north approaching the MacDonnell Range. Dip measurements immediately west of the Angela deposit are somewhat shallower, from 6 to 8° West, corroborating the model that the Brewers Plain (where Angela and Pamela deposits are located) is a shallow basin, possibly uplifted by a deep seated intrusive discussed below.

Although the Brewers Plain sub-basin would possibly be uplift by the underlying magnetic intrusive, this is more likely formed by less N-S compression in this area where the Waterford Range and the Ooraminna Anticline do not act as buttresses to southward vergent compression in the ASO. The end result of this compression shadow was the formation of the Brewers Plain sub-basin, where the sediment pile is thicker and because the area was not uplift relative to the western limb of the Missionary Syncline, the upper units (ie. Undandita Mbr) is preserved.

Lineaments interpreted from offsets, changes of strike, or alignment of discordant features represent structural elements. There are two dominant structural trends: East-West, representing the tectonic compressive direction (and partially the stratigraphic direction), and the complementary set ENE-WSW and WNW-ESE, which represent the low angle Reidel set which accommodate the compressive strain. There is a paucity of lineaments in the North-South direction, which although this is the flight line direction which would alias lineaments in this direction, is by comparison the geology map is a valid observation.

The Reidel lineament set are expected to be more conducive to mineralization, as they crosscut the stratigraphic direction, and provide open volume by strain release stepovers, brecciation, and channels for fluid flow for dissolution of diagenetic cement and mineral deposition.

The basement under the Missionary Trough is for the most part magnetically transparent, with the exception of a large strong magnetic body in the south-central part of the area. 3-D modelling of this feature indicates this anomaly is caused by a deep-seated discordant dome shaped body, presumably a syn-tectonic intrusive. As previously mentioned, this body is between the Waterhouse Range and the Ooraminna Anticline, and probably accounts for the interruption of the linear trend of this fold axis.

Depth to top of this deep seated intrusive is estimated at 5km, which is below the estimated thickness of the sediment pile in the Missionary trough, so it is unlikely this intrusive caused any effect on the sedimentation pattern except as a tectonic shadow that caused less compression in the Brewers Plain area exemplified by shallow dip and restricted depocentre. However, as this is assumed to be a syn-tectonic intrusive in the ASO, and was intruded simultaneous with the compressional/folding of the Missionary Trough, it may have some control on localization of mineralization.

Radiometrics (Figures 12,13,14, Maps 18,19,20)

Radiometrics was normalised to identify statistical anomalies by converting to Z-Score factors (measure of how many standard deviations a erading is above mean). The Z-Score factors also allows algebraic combinations of spectral channels to identify areas with particular radiometric signature.

The undandita Mbr has a distinctive radiometric response which can be traced along strike for more than 10km. Footwall units in the Undandita have an elevated Th and U response, which is characteristic of fine grained shales and mudstones. Thorium is probably inherent in the sediments, whereas uranium could be up-dip percolation of uranium in solution and radon soil gas which is displaced from source mineralization down dip. This is unlikely however, as fine grained sediments would not be conducive to soil gas percolation, so the uranium response is likely from uranium associated with clays either during original desposition, or later precipitated during diagenesis.

The concentration of uranium in clay-rich sediments does not reach economic grade, but the clay-rich rocks in the footwall act as aquicludes to groundwater flow in the basin, and may be chemically reactive. Water ponded against the impermeable footwall would have longer residence time for chemical reaction, which is a fertile environment for uranium deposition.

The hangingwall beds in the Undandita Mbr has a low Th and U response, but a strongly elevated potassium response attributed to K-feldspar in detritus derived from the source material. This response is typical of arkosic sandstones with low clay content, which is the palaeo-groundwater reservoir. Groundwater flow during diagenesis (at the time of the ASO) flowed down the hydraulic gradient from west to east, and ponded in the area of Brewers Plain sub-basin against the footwal aquiclude.

Oxegenated meteoric water recharging the groundwater in the trough leaches U from lithic clasts in the Hangingwall sediments. As the fine grained sediments are relatively impermeable, they would impede the flow causing ponding of of groundwater.

Ponded groundwater in the permeable sandstone units of the Undandita gives long residence time for chemical equilibrium, such that dissolved uranium in solution would be reduced by organic and sulphide material in the sequence causing deposition.

It is important to note that uranium mineralization is deposited at redox boundaries both within the hanging wall facies, and at the disconformity between the hangingwall (sandy - aquifer) and footwall (shaley-aquiclude) units.

Uranium deposition may therefore be anywhere along the hangingwall/footwall contact, evidenced by the mineralised occurrences along strike to the west. However, economic grade and dimension mineralization is only known at the Angela occurence, so there is some unique factor acting here. Two factors are proposed: the stratigraphic dip in the fold closure of the Brewers Plain is sub-horizontal, and the mineralization may be partially controlled by structure cross-cutting the stratigraphy.

Z-Score normalised radiometric images can be combined to identify materials with a specific radiometric signature. The contact between the Footwall (shaley – aquitard) and Hanginwall (sandy – aquifer) is shown to only exist in the Brewers Plain sub-basin area at the east end of the Missionary Syncline.

Sub-horizontal stratigraphy (dip 6 to 8° West) in the Brewers Plain depocentre would have greater surface area of contact between the footwall aquiclude and ponded horizontal groundwater table (coplanar). The converse of this is subvertical stratigraphy (eg. north limb of Missionary Syncline dip 45 to 70°S) and horizontal groundwater table, which has a small contact area. Along the south limb ot the Missionary Syncline, the stratigraphic dip is relatively shallow (15 to 17°N at Julia and Mitemba), but the hydraulic gradient is to the east along the Missionary Syncline, so groundwater is not expected to have long residence time for chemical interaction with reducing sediments.

DISCUSSION

The redox boundary at the contact between hanginwall redbeds (oxidized sandstone-arkose) and the footwall fine grained sediments (reduced shales and mudstones) is recognized in the contrasting radiometric response. This was the main factor guiding historical exploration by previous operators along the strike of the contact zone.

However, outside of the original Angela and Pamela occurrences, there has been little economic mineralization of interest. This suggests there is another factor in upgrading mineralization to economic grade.

Most of the known uranium occurrences (with the excaption of Julia, the farthest west occurrence) are at the east end of the Missionary Syncline, in what is called the Brewers Plain sub-basin in this report. Structural information indicates the stratigraphic dip is shallower than the western limbs of the Missionary Syncline, and is a restricted depositional basin by a fold closure at the east end of the syncline. Acidic meteoric water recharging the hangingwall aquifer percolates and leaches uranium from fragments of material from the Arunta Block source area. Groundwater is ponded in the aquifer in the restricted Brewers Plain sub-basin at the east end of the syncline. Longer residence time and coplanar shallow dipping sediments and horizontal groundwater table allows chemical reduction by reaction with organic and sulphides, leading to the deposition of uranium.

The HW Undandita is comprised of multiple layers of sandy and shaley units, although the radiometric signature suggests the primary component is relatively coarser sandstone. The multiple layers of sandstone (porous) and shale (resuced porosity) focus diagenetic fluid flow so that multiple mineralized horizons exist.

It is suggested herein this is a structural factor, which accounts for the east-west linear projection of the Angela mineralization which crosscuts the stratigraphy. The detailed geology of the Angela and Pamela occurrence (operated by Uranerz-Paladin Joint Venture) is not available to this author, so structures can only be inferred from this airborne geophysical survey.

The effect of the deep-seated magnetic intrusive in the gap between the Waterford and Ooraminna on mineralizing processes is unknown, but is likely not a direct factor other than creating a pressure shadow from the North-South compression in the Alice Springs Orogeny, which resulted in formation of the Brewers Plain sub-basin.

RECCOMMENDATIONS

Within the EL9857 area, the focus of exploration should be on the eastern part of the Missionary Syncline where stratigraphy is shallow dipping and groundwater is ponded in a restricted sub-basin.

A structural control on mineralization at Angela is proposed, which accounts for multiple stratigraphic levels of mineralization crosscutting stratigraphy.

The conceptual model exemplified in the Missionary Syncline may be repeated in other areas on the northern margin of the Amadeus basin.

Survey Methods

There is no direct surface expression of mineralization in this airbrone radiometric survey or previous radon or ground spectrometer surveys. No further detailed radiometrics surveys are recommended.

Magnetics has been demonstrated the most effective method of mapping stratigraphy and structure, but the postulated east-west structure partially contolling Angela mineralization is not visible at the scale of this survey. Detailed ground magnetic traverses oriented parallel to the stratigraphic direction should be used to identify crosscutting structures.

Electrical methods suffer from poor penetration in the conductive weathered surface meterial and probably saline groundwater. Previous IP/Resistivity surveys by Uranerz 1977 did not show a distinctive response from mineralization. Further testing of deep-penetrating Electromagnetic (EM) surveys may be warranted, as the sandstone/shale layering in the Undandita may have an electrical contrast, although this is adequately marked by magneto-stratigraphic markers.

Detailed Targets (Maps ??)

Five target areas have been identified for detailed investigations:

Target	Centre Point	Area	Target Characteristics
T-01	380908E/7355833N	16.2km^2	Central axis of Missionary Syncline where startigraphy genetly folded to horizontal. Within oxidized plume of palaeo-groundwater, crosscutting WNW structural lineaments
T-02	390764E/7353128N	4.38km^2	Outside of oxidized palaeo-groundwater plume, but in structurally complex area, possible neck of 2° fold axis separating Missionary from eaastern basin, includes

			strike extension of Angela orebody
T-03	382776E/7350616N	11.56km^2	Inboard of HW/FW contact, within oxidized plume of palaeo-groundwater, dominant structural trends sub-parallel to plane of stratigraphy possible larger volume of fertile structural scenario
T-04	374016E/7351839N	4.18km^2	Along strike of T-03 with similar characteristics
T-05	352566E/7348168N	21.63km^2	Colluvial material at foot of Waterhouse Range, possibly leaching into Brewer Conglomerate and redeposited

Respectfully submitted,

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