NÄRKE URANIUM PROJECT

COMPETENT PERSON’S REPORT ON THE EXPLORATION POTENTIAL OF THE NÄRKE URANIUM PROJECT, OREBRO COUNTY, SWEDEN

Prepared by The MSA Group (Pty) Ltd on behalf of:

Svenska Skifferoljeaktiebolaget
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Date: 8 August 2013

Project Code: J2559

Copies: Svenska Skifferoljeaktiebolaget (1)
The MSA Group (Pty) Ltd (1)

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SUMMARY

The MSA Group (Pty) Ltd (MSA) was requested by Svenska Skifferoljeaktiebolaget, a subsidiary of URU Metals Limited, to prepare a SAMREC-compliant Competent Person’s Report (CPR) on several early-stage uranium exploration properties located in southern Sweden.

The exploration properties are located in Örebro County, Närke Province, in south-central Sweden, around 150 km west-southwest of the capital city of Stockholm. They lie close to the regional center of Örebro, and within the smaller municipalities of Örebro, Kumla, Hallsberg and Lekeberg. The areas of exploration interest lie mostly on the Närke Plain, a flat to gently undulating lowland generally between 50 to 70 m above sea level that is mainly devoted to agriculture, and surrounded by large areas of forest.

The 6 properties cover 7 087 ha and are held in terms of valid Exploration Permits by the Svenska Skifferolje AB (Swedish Shale Oil Company). The properties are grouped into three areas, Latorp in the west (West Närke), and Kvarntorp-Bresätter and Asker to the south and southeast (East Närke). Five of the permits are valid until 14th September 2015, and the remaining permit is valid to 1st July 2014. The six permit areas, from west to east, include:

- **Latorp area**: 1 permit (Latorp No. 1) immediately east of the town of Garphyttan, about 10 km long and up to 3.3 km wide, and adjoins the Kilsbergen escarpment.
- **Kvarntorp area**: 4 permits (Kvarntorp No. 5, 6 & 7, Bresätter No. 1) that lie some 7 km east of Kumla, forming a semi-contiguous block about 10 km by up to 6 km in size.
- **Asker area**: 1 permit (Asker No. 1) that lies 5 km south and southwest of the village of Odensbacken near to Lake Hjälmaren, and is about 10 km long and up to 2.4 km wide.

The properties lie over Cambrian-age black (carbonaceous) oil shales known as the Alum Shale Formation. This formation contains Sweden’s major potential resource of fossil energy (as kerogen) and represents Europe’s largest potential source of low-grade uranium. In addition, it hosts remarkable and significant levels of other heavy metals, notably vanadium, nickel, zinc, molybdenum and rare earth elements. The Alum Shale Formation is found at several widely separated localities in Scandinavia, and is considered to be one of Sweden’s most important undeveloped potential mineral resources.
From around the beginning of the 20th century, oil was reported from the Alum Shale at different localities throughout Sweden. In 1941 the Swedish government established the Swedish Shale Oil Company to commercially recover oil from the Alum Shale at Kvarntorp in Närke. This operation produced petrol, fuel oil, LP gas, sulphur, burned lime and ammonia, and reached a production peak in the early 1960s and ceased in 1966. Kvarntorpshögen, an environmentally sensitive, 145 m high tailings dump of processed shale located near Kumla, is a reminder of this. Due to its industrial and mining past, Kvarntorp is reported one of Sweden’s most contaminated areas. Between 1950 and 1961 a small plant at Kvarntorp reportedly produced more than 62 tonnes of uranium.

In Närke the Alum Shale Formation occurs in two areas, west and south-southeast of Örebro, known as the West Närke and East Närke outliers respectively. Both areas are down-faulted sedimentary remnants consisting mainly of limestone, shale and sandstone surrounded by Precambrian basement, and completely covered by soil and glacial moraine. The stratigraphy is relatively flat-lying, except close to the major faults zones, which occur in the area. The Alum Shale Formation varies from 12 m to 19 m in thickness and is divided into a thin (1 m to 2 m) Lower Member that contains abundant stinkstone, and a thick Upper Member that comprises a lower Oil Shale unit (<10 m thick) and an upper Uraniferous Shale unit (6 m to 8 m thick). The Alum Shale is overlain by Lower Ordovician limestone and underlain by Middle Cambrian grey-green shale.

Very little is known about the oil shale and uranium exploration that was carried out in the general Närke area during the 1940s and 1950s but considerable effort must have gone into defining the resources for the Kvarntorp oil-from-shale industry. Numerous boreholes were drilled and geological logs are in existence but borehole locations are not accurately known. It is likely that these records could be found at the Swedish Geological Survey (SGU). At this time none of the old borehole data can be interpreted and verified. While the nature of the uranium mineralisation (and other metals) is unknown, typically in black shale-hosted deposits, the uranium is uniformly distributed and is probably adsorbed onto organic material.

At this stage no reliable estimate can be given for the uranium resources that potentially exist within the Alum Shale outliers in the Närke area. Nevertheless on the basis of available information from Svensson (2010) an “order of magnitude” estimate has been attempted for the 4 drilled areas (Latorp, Kvarntorp, Bresätter and Asker) using 37 boreholes. No uranium assays are provided, however, grade estimates are provided in the historical data, which are
assumed to have been estimated using a Geiger Muller Counter. The uraniferous Upper Shale has an average drilled thickness of 10.2 m to 11.6 m and underlies an estimated combined area of 5 490 ha. From the data available (Svensson, 2010), it is calculated that the total in-situ Alum Shale resource amounts to around 1 471 million tonnes at an average grade of 175 ppm U. This amounts to about 303 000 tonnes of contained U\textsubscript{3}O\textsubscript{8}. This is not a SAMREC-compliant Mineral Resource estimate.

The main conclusions of this study are:

- All available information suggests that Sweden’s Alum Shale Formation, a widespread black oil shale, may be a major regional uranium (and associated metals) resource and an attractive exploration target.
- A very large uranium (and associated metals) in-situ resource potentially exists within the Alum Shale of the West and East Närke outliers.
- Drilling information (at least 37 boreholes) originating from earlier exploration (1940s/1950s) reveals that meticulous borehole logging and assays were carried out but borehole co-ordinates are uncertain, and uranium values need verification.
- Future mining and treatment of pyrite-rich, heavy metal-bearing black shale will pose the same environmental challenges that are being experienced at Kvarntorpshögen dump, and there may be considerable environmental opposition to new developments.

The main recommendations for the production of a compliant Mineral Resource Estimate are:

1. Establish a working relationship with the SGU (probably the only organisation that can assist with archived information) and procure historical drilling data and geological maps
2. Produce a provisional mineral resource estimate on the basis of the historical data.
3. Drill a number of core boreholes to twin selected old boreholes to verify geology and uranium assay values. Typically 10-20% of the boreholes would need to be twinned. Should these boreholes not confirm the occurrence of uranium; a more extensive drilling programme will need to be considered.
4. As all the “hard” information is in Swedish it will be necessary to either obtain translations or the services of a bi-lingual Swedish-speaking geologist.
2 INTRODUCTION AND PURPOSE

2.1 Scope of Work

Mr. Roger Lemaitre, CEO of Svenska Skifferoljeaktiebolaget (Svenska Skifferolje), a wholly owned subsidiary of URU Metals Limited, requested The MSA Group (Pty) Ltd (MSA) to prepare a Competent Person’s Report (CPR) for several early-stage uranium exploration properties located in southern Sweden. It was envisaged that the CPR would meet the listing requirements of the Alternative Investment Market (AIM) of the London Stock Exchange. The funds raised will be used for the purpose of exploration and evaluation of the property portfolio. It was therefore decided to prepare a CPR on the Exploration Potential that comments on the information that is available, and to give an indication of what will be needed for further work. The general location of the project area is shown in Figure 1-1.

This CPR has been prepared according to the guidelines and format set forth in the South African Code for the Reporting of Exploration Results, Mineral Resources and Mineral Reserves (The SAMREC Code) 2007 edition.

All monetary figures expressed in this report are in United States of America dollars (US$) unless otherwise stated. A glossary of all technical terms and abbreviations is attached as Appendix 1.

The properties are based on a sequence of Cambrian-age black shale known as the Alum Shale Formation. This formation contains Sweden’s major reserve of fossil energy and represents Europe’s largest source of low-grade uranium, plus significant resources of several other heavy metals. It was agreed that no site visit would be necessary at this stage and it is noted that limited technical and related data is available in the public domain.
2.2 Principal Sources of Information

This report is based largely on technical information made available by Svenska Skifferolje’s Swedish associate, Minexp AB, augmented by other technical reports and information available from the internet. A listing of the principal sources of information is included in Section 15 of this CPR. The authors have endeavoured, by making all reasonable enquiries, to confirm the authenticity and completeness of the technical data upon which the Technical Report is based. A final draft of the report was also provided to Svenska Skifferolje, along with a written request to identify any material errors or omissions prior to lodgment.

No site visit to the properties was undertaken to the properties that form the subject of this CPR. Since no exploration activity is currently underway, and very little geological outcrop occurs, the authors consider it unnecessary at this time.

The Närke Uranium Project is considered to represent an early stage exploration project which is inherently speculative in nature. However, the authors consider that the property has been acquired on the basis of sound technical merit. The property is also generally
considered to be sufficiently prospective, subject to varying degrees of exploration risk, to warrant further exploration and assessment of its economic potential, consistent with the proposed programmes.

This CPR has been prepared on the basis of information available up to and including 8th August 2013 (“effective date”).

2.3 Qualifications, Experience and Independence

The MSA Group is an independent provider of exploration, evaluation and environmental consulting and contracting services, which has been providing services and advice to the international minerals industry and financial institutions since 1983. This report has been compiled by Mr. Gavin Whitfield and peer reviewed by Mr. Michael Lynn.

Mr. Whitfield is a professional geologist with greater than 40 years’ experience in mineral exploration throughout Africa and Europe. He is a Fellow of the Geological Society of South Africa and a Professional Natural Scientist (Pr.Sci.Nat) registered with the South African Council for Natural Scientific Professions. Mr. Whitfield has the appropriate relevant qualifications, experience, competence and independence to act as a “Competent Person” as defined in the SAMREC Code.

Peer review has been undertaken by Mr. Michael Lynn, a registered professional geologist with 27 years’ experience in mineral exploration throughout Africa and India. He is a Fellow of the Geological Society of South Africa, a Member of the Society of Economic Geologists and a Professional Natural Scientist (Pr.Sci.Nat) registered with the South African Council for Natural Scientific Professions.

Neither MSA, nor the authors of this report, have or have previously had any material interest in Svenska Skifferolje or the mineral properties in which Svenska Skifferolje has an interest. Our relationship with Svenska Skifferolje is solely one of professional association between Svenska Skifferolje and independent consultant. This report is prepared in return for professional fees based upon agreed commercial rates and the payment of these fees is in no way contingent on the results of this report.

3 PROPERTY DESCRIPTION AND LOCATION

The exploration permits are held by Svenska Skifferoljeaktiebolaget (Swedish Shale Oil Company) and are located in Örebro County, Närke Province, in south-central Sweden, around 150 km west-southwest of the capital city of Stockholm, and close to the regional center of Örebro (Figure 3-1). The six named and numbered Exploration Permits granted by
the Swedish Bergsstaten (Mining Inspectorate) are listed in Table 3-1 and shown in Figure 4-1.

**Figure 3-1**
Combined map of Sweden and Örebro County showing prospecting permit areas
The six permit areas form three separate blocks of ground, namely from west to east:

- **Latorp area**: 1 permit area (Latorp No. 1) immediately east of the town of Garphyttan, about 10 km long and up to 3.3 km wide, and adjoins the Kilsbergen escarpment (refer to the glossary of terms at the end of this report).

- **Kvarntorp area**: 4 permit areas (Kvarntorp No. 5, 6 & 7, Bresätter No. 1) that lie some 7 km east of Kumla, forming a semi-contiguous block about 10 km by up to 6 km in size.

- **Asker area**: 1 permit area (Asker No. 1) lies some 5 km south and southwest of the village of Odensbacken near to Lake Hjälmarer, and is about 10 km long and up to 2.4 km wide.

In terms of Swedish mineral legislation (based on the Swedish Minerals Act, 1991:45) the permits allow exploration to be carried out for an initial period of 3 years. The permits are renewable for consecutive periods of 3 years and 4 years if suitable exploration work has been carried out, and in exceptional cases for a further period of 5 years. This means that an Exploration Permit could conceivably be valid for up to 15 years. The administrative cost for an Exploration Permit is levied at SEK 20 (approximately US$ 3) per hectare for the first 3 years and increases slightly thereafter.
4 PHYSIOGRAPHY, ACCESSIBILITY, INFRASTRUCTURE, LOCAL RESOURCES AND CLIMATE

4.1 Physiography and Accessibility

Sweden, like the rest of Scandinavia, was covered by an ice sheet during the Quaternary Ice Age that ended around 11,000 years ago. The weight and movement of the ice sheet had a profound effect on the landscape. Bedrock outcrops were eroded and polished into rounded shapes and valley-type depressions, and the ice left thick deposits of glacial till or moraine (also known as drift) on the surface. As a result, bedrock outcrop is extremely limited for most parts of Sweden.

Most of the area of exploration interest lies on the Närke Plain, a flat to gently undulating lowland generally between 50 to 70 m above sea level, surrounded by large areas of forest. In the west, in the Garphyttan area, the small Latorp limestone plateau reaches around 100 m to 120 m above sea level. To the west a fault-related escarpment known as the Kilsbergen rises up from the Närke Plain to somewhat higher ground, around 100 m to 200 m. In the south and south-east another gentle fault-related escarpment exists, rising to over 100 m in the Bresätter area.

The name for the historic town of Örebro means “bridge over gravel banks” as it is located strategically on the Svartån River where it drains eastwards into Lake Hjälmaren – the fourth largest lake in Sweden. East of Kumla the flat landscape of the Närke Plain has been modified by isolated man-made feature called Kvarntorshögen. Covering an area of approximately 45 ha, and rising to about 145 m, this is the old tailings dump of the Kvarntorp oil-from-shale mine.

4.2 Infrastructure and Land Use

The project areas are located in Örebro County (län) and specifically in the smaller municipalities (kommuner) of Örebro, Kumla, Hallsberg and Lekeberg (Figure 4-1). Since the Middle Ages the town of Örebro has been a trading and manufacturing town, and gives its name to the county as well. Örebro is located on the main land travel route between Stockholm in the east and Göteborg and Oslo on the west coast. There are daily train and bus services, and flights from these cities. Access to the project areas to the west and south is excellent via a good network of national, regional and local roads. There are numerous small nature reserves and some national parks in Örebro County.
The Latorp area (West Närke) consists mainly of a forested plateau located west of Örebro, bounded to the west by the Kilsbergen escarpment. The Kvarntorp, Bresätter and Asker areas of East Närke are mostly farmland, and almost certainly have numerous land-owners. There are many small villages in the general area, and notable smaller towns and places of interest close to the project area include:

- **Kumla** (Kumla Municipality, population +20 000) – Kvarntorp is in this municipality and since the 1940s has been the focus of Sweden’s oil shale industry
- **Hallsberg** (Hallsberg and Kumla Municipalities, population +15 000) – notable as southern Sweden’s main railway hub with country-wide rail connections.
- **Fjugesta** (Lekeberg Municipality, population: +7000) – mostly farmlands and forest to the west of Orebro.
- **Garphyttan National Park** (111 ha, Lekeberg Municipality) – an ancient cultural landscape along the slopes of the Kilsbergen, and noted for its woods and meadows.

![Figure 4-1](image)

**Figure 4-1**
Plan showing Örebro County, municipalities, main roads and prospecting permit areas
4.3 Climate

Considering its relatively high latitude (59° N at Örebro), this part of south-central Sweden enjoys a relatively temperate, almost oceanic, climate due to the moderating influence of the Gulf Stream that touches Sweden's west coast. However, the relatively high latitude of southern Sweden results in long summer days and equally long winter nights. Rain occurs throughout the year peaking in the summer months. Half-yearly average temperatures and rainfall for Örebro are:

- January – High: 0°C, Low: -4°C, Precipitation: 38 mm
- July – High: 22°C, Low: 11°C, Precipitation: 94 mm
- Annual precipitation: 604 mm
5 MINING AND PRODUCTION HISTORY

The Alum Shale Formation (Anderson et al, 1985) has been recognised for more than 350 years as a natural source of the mineral alum (hydrous potassium aluminium sulphate, KAl(SO₄)₂·12H₂O). Mining the shales for alum began in 1637 in Skåne (southern Sweden) and it found use in the leather tanning and textile dyeing industries, and as a pharmaceutical. The Alum Shale was mined at several localities during the 18th and 19th Centuries and was recognised as a source of fossil energy. Towards the end of the 19th Century attempts were made to extract and refine hydrocarbons by the gas combustion retort process (refer to the glossary of terms at the end of this report).

In 1941 during World War II, the Swedish government established the Swedish Shale Oil Company (Svenska Skifferoljeaktiebolaget) for the purpose of recovering oil from the Alum Shale at Kvarntorp in Närke, using a retorting process. Despite many shortages during the war, production started in 1942 and involved at least two retorting (destructive distillation) processes: an above-ground “Kvarntorp retort” process (70% of production) and an in-situ below-ground “Ljungstrom method” (30% of production). This operation produced petrol, fuel oil, LP gas, sulphur, burned lime and ammonia (Table 5-1). Production reached a peak in the early 1960s when about 3 million tonnes of shale was mined per year. Production ceased in 1966 due to the availability of cheaper supplies of crude oil. During the period 1942 – 1966 about 50 million tons of shale were mined and processed at the Kvarntorp plant. Electric energy was also produced using heat generated by combustion, and about 1200 people were employed. Details of the mining methods are not reported.

A relict of this industry is the Kvarntorpshögen, a polluting tailings dump of processed shale material left over from the oil recovery process, which is of considerable environmental concern and a future liability. Alum Shale was also used in the Swedish construction industry. Shale was burned with limestone to manufacture “breeze blocks”, a light-weight porous building block, but production stopped when it was realised that the blocks were radioactive and were also emitting radon.
Using the shale as feed-stock a small plant at Kvarntorp reportedly produced more than 62 tonnes of uranium between 1950 and 1961. Higher-grade ore (hosted in the same Alum Shale) was later found at Ranstad in Västergötland where an open-pit mine and mill were established, and about 50 tonnes of uranium per year was produced between 1965 and 1969. This became uneconomic and the Ranstad plant finally closed in 1989.

In addition to uranium at an average grade of 175 ppm U, considerable research was done on the extraction of other important elements, the typical concentrations of which are as follows: $\text{Al}_2\text{O}_3$ – 12.2 %; $\text{K}$ – 3.6 %; $\text{V}_2\text{O}_5$ – 0.12 %; $\text{Mo}$ – 0.027 %; $\text{Ni}$ – 0.016 %; $\text{S}$ – 6.7 % and $\text{Mg}$ – 0.5 %. In the Närke region a report mentions the following average metal concentrations: $\text{U}$ – 150 ppm; $\text{V}$ – 500 ppm; $\text{Ni}$ – 200 ppm; $\text{Zn}$ – 200 ppm.

Apparent in 2004 a new company also called Svenska Skifferolje AB (SSAB) was founded with the objective of extracting oil and metals from the Alum Shale in Närke using in-situ leaching (ISL) technology. It is reported that the Alum Shale will need to be pre-fractured by explosives to create enough permeability for the method to work. It is also reported that SSAB intends to use microwave technology to heat the shale and extract the oil using CO2 fluid. Progress on implementation of this technology has not been reported.

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*Note: full production for the last 4 years*
6 GEOLOGICAL SETTING

6.1 Overview of the Alum Shales (Westergård, 1940; Anderson et al, 1985)

During Middle Cambrian to Early Ordovician times the crystalline basement of the Baltoscandian Platform was a region of great geological stability. Offshore this provided a very stable marine shelf environment for the extensive deposition of between 10 m and 55 m of organic- and sulphur-rich black muddy sediment. This accumulation of organic material took place over millions of years in shallow, very poorly circulating, anoxic waters that were little disturbed by wave-action or bottom currents. The adjacent land areas had a very low relief and provided little sedimentary input. The reducing nature of these organic-rich sediments resulted in sulphur forming as sulphide minerals, either marcasite (FeS) or pyrite (FeS$_2$). A range of trace elements were deposited syngenetically by adsorption from sea water onto organic material. There is also a remarkable correlation of shale geochemistry and biostratigraphic zones.

This organic-rich unit became the Alum Shale Formation of Scandinavia and it covered a vast area. Today the Alum Shale is only present as outliers, partly bounded by local faults, which account for its preservation. These outliers lie on Precambrian rocks in southern Sweden, and occur within the tectonically disturbed Caledonides of west Sweden and Norway (Figure 5-1). In the Caledonides the shale reaches thicknesses of 200 m or more in sequences that are repeated by thrust faults. Black shales, partly equivalent to the Alum Shale, are present on the islands of Öland and Götland, underlie parts of the Baltic Sea, and crop out along the north shore of Estonia where it forms the Dictyonema Shale Formation.

In parts the Alum Shale Formation also contains subordinate grey shales, siltstone and thin sandstone beds. Discontinuous layers of bituminous limestone called “stinkstone” are a characteristic feature, as well as small rounded lenses of coaly organic material called “kolm”. The Alum Shale is generally overlain by a thin (<1 m) sandy phosphatic limestone, followed by a covering of Ordovician limestone or grey shales continuing upwards into the Silurian sequence.

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1 Stinkstone: A variety of black, bituminous limestone that emits a strong fetid odour when struck; the smell originates from decayed organic matter. It is also known as anthracnite or “orsten”.

2 Kolm is a term for small erratic lenses of coal-like hydrocarbon containing high concentrations of uranium; uranium and radon was found in kolm as far back as 1983. Uranium content may reach up to 5000 ppm U.
The Alum Shale has also been divided into numerous individual Upper Cambrian biostratigraphic zones and subzones, on the basis of its fossil content. These biostratigraphic zones have been conveniently used for borehole logging. For practical purposes these bio-zones correspond to the lithostratigraphic formation members (see Figure 6-1). The bottom stinkstone unit has been used as a limit for mining.

**Figure 5-1**
Regional distribution of Alum Shale formation in Sweden (adapted from Dyni, 2005)
6.2 Organic Carbon and Metal Potential (Dyni, 2005)

The organic- and sulphide-rich Alum Shale contains Sweden’s major source of fossil energy and is Europe’s largest low-grade source of uranium. The most uraniferous shales occur in the Billingen – Falbygden area of Västergötland, and the most kerogen- and oil-rich shales occur in the Närke area.

The organic content of the Alum Shale is commonly in the order of 10% but locally it may exceed 20%, and occasionally reaches nearly 30%. The highest carbon content is in the upper part of the shale sequence. However oil yields are not in proportion to the organic content, and vary from one area to another because of the geothermal history of the areas underlain by the formation. Närke, Östergötland and Kinnekulle are regions that have not been much influenced by higher temperatures and the oil content is therefore relatively high. At Skåne and Jämtland in west-central Sweden, the Alum Shale is over mature and oil yields are nil, although the organic content of the shale is 11% to 12%. In areas less affected by geothermal alteration oil assay yields range from 2% to 6% but hydroretorting can increase the assay yields by as much as 400%.

The Alum Shales are remarkable for their syngenetic concentration of a variety of trace and minor metals, As well as, uranium, vanadium, molybdenum, zinc and nickel, and some rare earth elements are found in elevated concentrations. The Alum Shale is thus an important resource of fossil and nuclear fuel, sulphur, fertiliser material, metal alloy elements and aluminium products for the future.

6.3 Alum Shales in the Närke region

In Närke the Alum Shale occurs in two areas, west and south-southeast of Örebro, known as West Närke and East Närke respectively. Both areas are remnant outliers of mainly shale and limestone surrounded by Precambrian basement. To a very large extent the bedrock is covered by soil and glacial drift (moraine). The formations range in age from Lower Cambrian sandstones at the base to Lower Ordovician limestones at the top, and include the full sequence of carbonaceous Alum Shale. The sequence is faulted along the western and southern margins and is influenced by subordinate east-west and north-south faults but nevertheless the stratigraphy is more or less flat-lying, except close to the faults (Figure 6-1).
Figure 6-1 A

Mainly bedded rocks in the youngest bedrock unit (660–340 Million years)
- Carbonate-rich sedimentary rock (limestone, dolomite, marble etc.)
- Quartz-feldspar-rich sedimentary rock (sandstone, greywacke etc.)
- Mafic to ultramafic rock (gabbro, peridotite etc.)

Mainly gneissic rocks in the Sveconorwegian orogen (1740–010 Million years)
- Acidic intrusive rock (granite, granodiorite, monzonite etc.)
- Acidic intrusive rock (granite, granodiorite, monzonite etc.) Porphyroblastic or augen-bearing
- Ultrabasic to ultramafic intrusive rock (gabbro, dolerite, diorite etc.)
- Isotropic rocks, younger than the Svecofennian orogeny (1740–010 Million years)
- Ultrabasic, basic and intermediate intrusive rock (gabbro, dolerite, diorite etc.)

Partly gneissic rocks in the Svecofennian orogen (1000–1740 Million years)
- Acidic intrusive rock (granite, granodiorite, monzonite etc.)
- Acidic intrusive rock (granite, granodiorite, monzonite etc.) Porphyroblastic or augen-bearing
- Ultrabasic, basic and intermediate intrusive rock (gabbro, dolerite, diorite etc.)

Partly gneissic rocks in the Svecofennian orogen (1260–910 Million years)
- Acidic intrusive rock (granite, granodiorite, monzonite etc.)
- Acidic intrusive rock (granite, granodiorite, monzonite etc.) Porphyroblastic or augen-bearing
- Ultrabasic, basic and intermediate intrusive rock (gabbro, dolerite, diorite etc.)
- Invasive rock, unclassified composition
- Acidic volcanic rock (rhyolite, dacite etc.)
- Acidic volcanic rock (rhyolite, dacite etc.) Porphyroblastic or augen-bearing
- Ultrabasic, basic and intermediate volcanic rock (basalt, andesite etc.)
- Carbonate-rich sedimentary rock (limestone, dolomite, marble etc.)
- Quartz-feldspar-rich sedimentary rock (sandstone, greywacke etc.)
- Metamorphic rock, unspecified composition (calcite, micaite, micaite, granite etc.)
The Alum Shale Formation overlies greenish shale of Middle Cambrian age. Notably the formation as a whole contains a relatively high organic content, up to about 28% (average 20%) and a relatively low stinkstone content (around 15%). In thickness it varies from 12 m to 19 m (a maximum of 19.3 m at Hynneberg) and is divided into a thick **Upper Member** that comprises a lower Oil Shale unit and an upper Uraniferous Shale unit; and a thin **Lower Member** that contains abundant stinkstone ("orsten"). The relationship between geology, thickness, uranium content, and oil content is shown schematically in Figure 6-2.

The geology can also be sub-divided on the basis of well-defined biostratigraphic zones and sub-zones, as shown below. The typical oil content of the Alum Shale decreases from top to bottom, while the uranium content follows an inverse pattern, being highest in the *Ps* unit and lowest in the *Cf* unit e.g.

- **Top – Peltura scarabaeoides (Ps)** – 3.3% to 4.5 % oil content, U up to 245 ppm
- **Middle – Peltura acutidens (Pa)** – 4.5% to 6.0 % oil content, U around 135 ppm
- **Bottom – Ctenopyge flagellifera (Cf)** – 6.0% to 7.0 % oil content, U averages 100 ppm
Figure 6-2
Schematic representation of geology, uranium, oil content and kerogen content for the Alum Shale in Närke

West Närke: The Alum Shale outlier occurs over an area of 30 km², is faulted against crystalline basement to the west, and is completely overlain by a 20 m to 30 m thick layer of limestone which places a limitation on the potential for open-cast mining. The Alum Shale Formation follows essentially the same sequence and varies in thickness from 12 m in the north to 18 m in the south, and both the (lower) Oil Shale unit and the (upper) Uraniferous Shale unit are more variable in thickness and quality compared to East Närke. Locally the Uraniferous Shale contains about 230 ppm U over a thickness of 3 m, and the Oil Shale approximately 5.5 % oil over a 7 m thick interval. A schematic east-west geological cross-section through the area of the Latorp permit is illustrated in Figure 6-3.
**East Närke:** The Alum Shale outlier reportedly occurs over an area of 30 km$^2$, is faulted against crystalline basement to the south, and is partly overlain by thin (<15 m) layer of limestone. The **Lower Member** is about 1.5 m to 2.0 m thick and dominated by abundant stinkstone. In the thicker **Upper Member** the (lower) Oil Shale unit shows considerable differences in thickness (accounting for the overall variation of the formation) but is not more than 10 m thick and contains 6% to 8% oil. The (upper) Uraniferous Shale unit is between 6 m and 8 m thick, is bounded by thin shale beds and contains 4% to 5% oil. On average the Upper Member contains 175 ppm U with the Oil Shale unit averaging 135 ppm U and the Uraniferous Shale unit averaging 235 ppm U. The uranium-rich part of the latter reaches 245 ppm U. Where erratic kolm lenses are present uranium content may exceed 300 ppm. The Hynneberg borehole, located south of Kvarntorp, illustrates the relationship between geology, uranium, carbon content and oil yield (Figure 6-4). An idealised north-south geological cross-section through the area of the Kvarntorp and Bresätter permits is illustrated in Figure 6-5.
Figure 6-4
Hynneberg borehole: geology, uranium, oil and carbon content (adapted from Anderson et al, 1985)
Figure 6-5
Idealised cross-section through the East Närke (Kvarntorp and Bresätter) permit areas
(adapted from Svensson, 2010)
7 URANIUM DEPOSIT TYPE AND EXPLORATION MODEL

Black shale-hosted uranium mineralisation of syngenetetic origin is found in marine organic-rich shales or coal-rich pyritic shales that form very large, low-grade resources of uranium. In addition to the black shales of Scandinavia there are numerous world-wide examples, such as the Rudnoye and Zapadno-Kokpatasskaya deposits in Uzbekistan, the Chattanooga shale in the USA, and the Gera-Ronneburg deposit in Germany. The Ranstad (Västergötland) deposit in Sweden appears to have been the only primary deposit that has produced significant amounts of uranium (reported at 254,000 tonnes U). In the recent past none of these uranium deposits have been exploited due to low grades. In Germany the Ronneburg deposit is an exception as it has been enriched by hydrothermal and supergene processes, and about 100,000 tonnes uranium have been produced.

The low-grade uranium resources of Sweden’s Alum Shale of Sweden are enormous and constitute the largest uranium resource in Europe. In Västergötland the Billingen – Falbygden region has traditionally been the biggest resource; In the Ranstad area the uranium-rich shale unit in the upper member of the formation contains over 300 ppm U and includes concentrations of 2000 ppm to 5000 ppm U in small scattered black coal-like lenses of kolm. Alum Shale in the Ranstad area underlies about 490 km$^2$, of which the 8 m to 9 m thick upper member contains an estimated 1.7 million tonnes of uranium.

The more recent uranium discoveries in substantially thicker intersections of Alum Shale in the Jämtland region may be set to overtake this. There is considerable exploration interest in this type of deposit demonstrated by Aura Energy’s advanced Häggån Project in the Storsjöön district of west-central Sweden. This project area is reported to contain a JORC-compliant Inferred Mineral Resource of 800 million pounds U$_3$O$_8$ (about 363,000 tonnes U$_3$O$_8$) with Mo, V, Ni and Zn co-products. A positive Scoping Study has recently been completed and metallurgical test work and pre-feasibility planning is underway. The preferred processing route is via bacterial heap leaching. This deposit is considered to be world-class and is said to be in the top five of current and planned uranium producing operations.
8 URANIUM EXPLORATION IN NÄRKE

Very little is known about oil shale and uranium exploration that was carried out in the general Närke area during the 1940s and 1950s. Considerable effort must have gone into defining the resources for the Kvarntorp oil-from-shale industry. Numerous boreholes were drilled and geological logs are in existence but the exact borehole locations are not known. A number of the old borehole logs (all in Swedish) are available (37 have been supplied by Minexp AB) and reveal that very detailed geological and uranium assay work (probably by Geiger-counter) was carried out. There are no available records of where drilling was carried out, how sampling and sample preparation was done, methods of analysis and of quality control, if any. At this time none of the old borehole data can be interpreted and verified.

A diligent search at the Swedish Geological Survey (SGU) might however unearth the required information which would need to be translated into English. The area has been covered by airborne radio metrics and this map is shown as Figure 8-1. The uranium-rich Alum Shale units are clearly evident despite being covered by glacial drift.

![Figure 8-1](Swedish Geological Survey, 2012)

**Figure 8-1**
Radiometric (eU) map of the alum shale outliers in Örebro County (Swedish Geological Survey, 2012)
URANIUM MINERALISATION AND BLACK SHALES

The actual mineralogical nature of the black shale-hosted uranium (and other metals) is not known at this time. However in black shales uranium is generally uniformly distributed (excluding within uranium-rich concentrations e.g. kolm) and it apparently occurs adsorbed onto organic material, without discrete primary uranium minerals. The practical result is that uranium values are very consistent throughout the shale. The black oil shale host rock, also known as marinite, is of marine origin in which the chief organic components are derived chiefly from marine phytoplankton. Potential by-products, particularly other heavy metals such as vanadium, zinc, nickel and molybdenum, plus industrial minerals such as alumina, phosphate, sodium carbonate minerals, ammonium sulfate and sulphur, potentially add additional value to the deposits.
RESULTS OF PREVIOUS DIAMOND DRILLING

Svensson (2010) shows that for exploration diamond drilling it was customary to report the geology of the Alum Shale using biostratigraphic zones based on their Late Cambrian fossil assemblages. Previous boreholes were logged and measured using three recognized biostratigraphic zones i.e. *Peltura scarabaeodies* (*Ps*); *Peltura acutidens* plus *Peltura minor* (*Pa*) and *Ctenopyge flagellifera* (*Cf*). These zones correspond to the Upper Member of the Alum Shale. Drilling results presented in the Tables below indicate the combined thicknesses of the *Ps* + *Pa* + *Cf* zones less the internal stinkstone. Thin beds of internal stinkstone, making up around 10% to 20% of the shale sequence, have been excluded.

- **Latorp** (West Närke)

Twelve boreholes are listed in Svensson (2010). In summary the area is covered by 4 – 15 m of glacial drift (overburden) and about 20 m of overlying limestone. The thickest recorded limestone is 28.3 m from a borehole east of Garphyttan. The Alum Shale has a maximum thickness of 15.6 m near Garphyttan and decreases both north and south, and is approximately 12 m thick. Latorp boreholes (12) are listed in Table 10-1, but no uranium assays are provided. Svensson estimates that the Alum Shale underlies an area of 2,000 ha. Approximate borehole locations are shown in Figure 10-1. A potential resource estimate is given in Table 10-5. This is not a SAMREC Code-compliant mineral resource estimate.

<table>
<thead>
<tr>
<th>BOREHOLE NO.</th>
<th>PLACE NAME</th>
<th>THICKNESS OF ALUM SHALE UNIT (m)</th>
<th>ALUM SHALE LESS ST/STONE (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>Filipshyttan#</td>
<td>10.2</td>
<td>8.9</td>
</tr>
<tr>
<td>55</td>
<td>Filipshyttan#</td>
<td>10.8</td>
<td>9.4</td>
</tr>
<tr>
<td>56</td>
<td>Örsta</td>
<td>10.8</td>
<td>9.9</td>
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<tr>
<td>57</td>
<td>Latorp</td>
<td>10.9</td>
<td>8.7</td>
</tr>
<tr>
<td>58</td>
<td>Rastorp</td>
<td>11.8</td>
<td>9.9</td>
</tr>
<tr>
<td>59</td>
<td>Lanna#</td>
<td>11.6</td>
<td>10.6</td>
</tr>
<tr>
<td>60</td>
<td>Garphyttan</td>
<td>11.8</td>
<td>10.6</td>
</tr>
<tr>
<td>62</td>
<td>Lannafors#</td>
<td>12.2</td>
<td>11.0</td>
</tr>
<tr>
<td>63</td>
<td>Elgkärr</td>
<td>11.3</td>
<td>10.7</td>
</tr>
<tr>
<td>64</td>
<td>Hidinge</td>
<td>13.3</td>
<td>11.2</td>
</tr>
<tr>
<td>67</td>
<td>Sanna</td>
<td>17.9</td>
<td>15.5</td>
</tr>
<tr>
<td>68</td>
<td>Fjugesta</td>
<td>&gt;15.4</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Average thick. **10.8**

Boreholes marked # were listed in the old logs provided.
• **Kvarntorp** (East Närke)

  Thirteen boreholes are listed in the Svensson report. In summary the area is covered by 3.5 m to 8.5 m of glacial drift and 0 m to 8 m of overlying limestone but 15 m to 18 m in the south and east. The Alum Shale is generally 9 m to 17 m thick and has a maximum thickness of 19.3 m at Hynneberg. The Kvarntorp boreholes (13) are listed in Table 10-2, but no uranium assays are provided. The Svensson report estimates that Alum Shale underlies an area of 1500 ha. Approximate borehole locations are shown in Figure 10-2. A potential mineral resource estimate is given in Table 10-5. This is, however, not a SAMREC Code-compliant mineral resource estimate.
### Table 10-2
Previous drilling results of alum shale in the Närke area: Kvarntorp permit area
(Svensson, 2010)

<table>
<thead>
<tr>
<th>BOREHOLE NO.</th>
<th>PLACE NAME</th>
<th>THICKNESS OF ALUM SHALE (m)</th>
<th>ALUM SHALE LESS ST/STONE (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17a</td>
<td>Testa#</td>
<td>13.5</td>
<td>11.6</td>
</tr>
<tr>
<td>17b</td>
<td>Testa#</td>
<td>13.4</td>
<td>12.6</td>
</tr>
<tr>
<td>18</td>
<td>Ösby</td>
<td>13.8</td>
<td>12.0</td>
</tr>
<tr>
<td>19</td>
<td>Siggetorp#</td>
<td>14.2</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td>Alaborg</td>
<td>15.0</td>
<td>12.9</td>
</tr>
<tr>
<td>36</td>
<td>Sörsätter#</td>
<td>16.0</td>
<td>13.3</td>
</tr>
<tr>
<td>38</td>
<td>S Mossby</td>
<td>8.8</td>
<td>8.3</td>
</tr>
<tr>
<td>39</td>
<td>Norra Mossby#</td>
<td>16.1</td>
<td>7.4</td>
</tr>
<tr>
<td>40</td>
<td>Helgeholmen</td>
<td>16.4</td>
<td>14.6</td>
</tr>
<tr>
<td>41</td>
<td>Yxhult</td>
<td>16.0</td>
<td>12.5</td>
</tr>
<tr>
<td>42</td>
<td>Hällabrottet</td>
<td>16.5</td>
<td>13.0</td>
</tr>
<tr>
<td>43</td>
<td>Hynnesberg</td>
<td>16.4</td>
<td>12.7</td>
</tr>
<tr>
<td>44</td>
<td>Hjortsberga</td>
<td>8.7</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td><strong>Average thickness</strong></td>
<td><strong>10.8</strong></td>
<td></td>
</tr>
</tbody>
</table>

Boreholes marked # were listed in the old logs provided.

- **Bresätter** (East Närke)

Six boreholes are listed in the Svensson report. The area is covered by 1.5 m to 10 m of glacial drift (overburden) and 0 m to 6 m of overlying limestone. The Alum Shale is 6 m to 16 m thick. Bresätter boreholes (6) are listed in Table 10-3, but no uranium assays are provided. The Svensson report estimates that Alum Shale underlies an area of 290 ha. Approximate borehole locations are also shown in Figure 10-2. A potential mineral resource estimate is given in Table 10-5. This is, however, not a SAMREC Code-compliant mineral resource estimate.

### Table 10-3
Previous drilling results of alum shale in the Närke area: Bresätter permit area
(Svensson, 2010)

<table>
<thead>
<tr>
<th>BOREHOLE NO.</th>
<th>PLACE NAME</th>
<th>THICKNESS ALUM SHALE (m)</th>
<th>ALUM SHALE LESS ST/STONE (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>Tynninge#</td>
<td>6.0</td>
<td>5.2</td>
</tr>
<tr>
<td>46</td>
<td>Bresätter 4</td>
<td>15.9</td>
<td>14.2</td>
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<tr>
<td>47</td>
<td>Bresätter 5</td>
<td>16.0</td>
<td>13.9</td>
</tr>
<tr>
<td>49</td>
<td>Bresätter 6</td>
<td>16.1</td>
<td>13.0</td>
</tr>
<tr>
<td>50</td>
<td>Bresätter 7</td>
<td>16.1</td>
<td>13.3</td>
</tr>
<tr>
<td>51</td>
<td>Oxebacken</td>
<td>6.0</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td><strong>Average thickness</strong></td>
<td><strong>10.8</strong></td>
<td></td>
</tr>
</tbody>
</table>

Boreholes marked # were listed in the old logs provided.
Asker (East Närke)

Fourteen boreholes are listed in the Svensson report. The area is covered by 1 m to 4 m of glacial drift and 0 m to 10 m of overlying limestone. The Alum Shale is 15 m to 16 m thick below the limestone and approximately 10 m in areas where the limestone is missing. Asker boreholes (14) are listed in Table 10-4 but no uranium assays are provided. The Svensson report estimates that Alum Shale underlies an area of 1700 ha. Approximate borehole locations are shown in Figure 10-3. A potential mineral resource estimate is given in Table 10-5. This is, however, not a SAMREC Code-compliant mineral resource estimate.
### Table 10-4

**Previous drilling results of alum shale in the Närke area: Askern permit area** (Svensson, 2010)

<table>
<thead>
<tr>
<th>BOREHOLE NO.</th>
<th>PLACE NAME</th>
<th>THICKNESS ALUM SHALE (m)</th>
<th>ALUM SHALE LESS STINKSTONE (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a</td>
<td>Vilhelmsberg#</td>
<td>11.8</td>
<td>9.9</td>
</tr>
<tr>
<td>3b</td>
<td>Vilhelmsberg#</td>
<td>12.2</td>
<td>9.9</td>
</tr>
<tr>
<td>4</td>
<td>Bunksätter</td>
<td>11.9</td>
<td>10.4</td>
</tr>
<tr>
<td>5a</td>
<td>Tångsätter#</td>
<td>11.9</td>
<td>9.3</td>
</tr>
<tr>
<td>5b</td>
<td>Tångsätter#</td>
<td>12.1</td>
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</tr>
<tr>
<td>6</td>
<td>Sand#</td>
<td>15.4</td>
<td>10.6</td>
</tr>
<tr>
<td>7</td>
<td>Asker</td>
<td>12.7</td>
<td>11.1</td>
</tr>
<tr>
<td>8</td>
<td>Asker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Bernstorp#</td>
<td>12.6</td>
<td>10.6</td>
</tr>
<tr>
<td>10</td>
<td>Bernstorp#</td>
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<td></td>
</tr>
<tr>
<td>11</td>
<td>Menigasker#</td>
<td>6.5</td>
<td>5.7</td>
</tr>
<tr>
<td>12</td>
<td>Menigasker#</td>
<td>15.7</td>
<td>10.8</td>
</tr>
<tr>
<td>13</td>
<td>Lundby</td>
<td>12.8</td>
<td>11.6</td>
</tr>
<tr>
<td>14</td>
<td>Köpsta#</td>
<td>12.7</td>
<td>12.6</td>
</tr>
<tr>
<td>15</td>
<td>Köpsta#</td>
<td>12.3</td>
<td>10.7</td>
</tr>
<tr>
<td>16</td>
<td>Skruke#</td>
<td>12.7</td>
<td>10.1</td>
</tr>
</tbody>
</table>

**Average thickness** 10.2

*Boreholes marked # were listed in the old logs provided*

---

### Figure 10-3

**Approximate Askern borehole locations** (adapted from Svensson, 2010)

Considering the various permit areas described above, at this stage, no reliable estimates can be given for the uranium resources that potentially exist within the Alum Shale outliers in the Närke area. Nevertheless on the basis of available information from Svensson (2010) an “order of magnitude” estimate has been made (Table 10-5). These
estimates use an indicated area of Alum Shale (in ha), the average shale thickness (excluding stinkstone layers) calculated from the above Tables, an average shale density of 2.46 tonne / m³, and an average uranium content of 175 ppm (206 ppm or 0.0206% U₃O₈). The estimates are not SAMREC Code-compliant mineral resource estimates.

Table 10-5
Estimated potential in-situ mineral resources of alum shale and uranium in the Närke outliers (Svensson, 2010)

<table>
<thead>
<tr>
<th>PERMIT NAME</th>
<th>SHALE AREA (ha)</th>
<th>AVERAGE THICKNESS* (m)</th>
<th>ALUM SHALE (million tonnes)</th>
<th>URANIUM (tonnes U₃O₈)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATORP</td>
<td>2000</td>
<td>10.8</td>
<td>531.4</td>
<td>109 460</td>
</tr>
<tr>
<td>KVARNTORP</td>
<td>1500</td>
<td>11.6</td>
<td>428.0</td>
<td>88 176</td>
</tr>
<tr>
<td>BRESÅTTER</td>
<td>290</td>
<td>10.8</td>
<td>78.3</td>
<td>16 130</td>
</tr>
<tr>
<td>ASKER</td>
<td>1700</td>
<td>10.2</td>
<td>433.5</td>
<td>89 301</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1471.2</td>
<td>303 067</td>
</tr>
</tbody>
</table>

* Excluding stinkstone layers within Alum Shale which usually account for approximately 15%
MINERAL PROCESSING RESEARCH

To quote from Svensson (2010): “From the end of the 1950s and until 1985, research testing and development of different processes for extracting uranium (principally) and various other products from the Alum Shale were performed at the Ranstad plant. The concept, which was finally tested in laboratory and [on] bench scale [at] 50 kg per day, was named the DMS process (Direct Medium Strong sulphuric acid leaching process). The process was never fully developed. The various recoveries from the DMS process were as follows.”

- Uranium – 85 %
- Aluminium, as Al₂O₃ – 54 %
- Potassium, K-sulphate and K-Mg-sulphate – 36 %
- Magnesium, as K-Mg-sulphate – 75 %
- Vanadium, as V₂O₅ – 65 %
- Molybdenum, as MoO₃ – 18 %
- Nickel - not recovered
- Rare Earth Elements – not recovered

Alternative extraction and processing technologies are available and need to be considered. Svenska Skifferolje AB has been investigating in-situ leaching of uranium and others metals, and an in-situ microwave process for the extraction of oil. Aura Energy at their Häggån Project in west-central Sweden is conducting very encouraging metallurgical test work using bacterial heap leaching, a process that is being used commercially at the Talvivaara shale-hosted Cu-Ni-U mine in Finland (Aura Energy 2012, website, www.auraenergy.com.au).
12 ENVIRONMENTAL CONSIDERATIONS

12.1 Kvarntorpshögen

Sweden started production of oil-from-shale at Kvarntorp in the 1940s. Due to its mining industrial past Kvarntorp is today reported as one of Sweden’s most contaminated areas, with the principal contaminants in the area are heavy metals and hydrocarbons. This is partly attributed to the natural leaching of heavy metals and sulphides within the Alum Shale, but industrial activity at Kvarntorp also played a major role in heavy metal leaching due to the exposure of shale to weathering processes.

A crucial factor regarding pollution by heavy metals, and probably for many of the contaminating hydrocarbons in the area, is the Kvarntorpshögen dump, which is located 7 km east of Kumla. This heap of processed waste material, mainly ash and semi-coke, is the remaining residue from the oil distillation recovery process. The heap covers about 45 ha and is 40 million m$^3$ in volume. It is noted that the Kvarntorp No. 5 Exploration Permit apparently covers the old mine workings and the Kvarntorpshögen dump. On-going environmental management is likely to be an issue.

The Kvarntorpshögen dump has very high internal temperatures (reportedly up to 500°C) due to on-going internal chemical reactions. Owing to the heat being generated at present, relatively little water infiltrates and percolates the heap and the drainage of leachate from the dump is therefore very limited. With progressive of the dump, it is predicted that the water will increasingly penetrate and the run-off of leachate (“Acid Mine Drainage”) will increase, which will increase heavy metal contamination. It is estimated that this process will take place over a period of 50 to 150 years.

An EU-sponsored environmental research station was established at Kvarntorp in 2011, in collaboration between Kumla Municipality, the MAN Research Centre at Örebro University and Bergskraft Sweden. The aims are to investigate and identify the processes occurring within Kvarntorpshögen, and to find measures to minimise the environmental impact.

12.2 Regional Aspects

Future mining and treatment of pyrite-rich, heavy metal-bearing black shale will pose similar challenges to those currently being experienced by the community at Kvarntorpshögen. It is speculated that any future mining or extraction process in the Närke area can be expected to face considerable environmental opposition. In particular
mining on the partly forested Latorp plateau west of Örebro is likely to be faced with strong resistance.
MARKETING CONSIDERATIONS

Taking into consideration the various metal products that can potentially be recovered from Alum Shale mineralisation, as mentioned in Section 11; a brief market analysis was conducted (Intierra, 2012). The aim of the market analysis was to:

- establish a sense of the global demand for uranium and the associated metals,
- establish a sense of the uranium supply quantum entering the global market, and
- to establish a comparison of grade values that are typical for other economically viable uranium mining operations.

Historically, the uranium market has been dominated by the liquidation of existing inventories, both from a commercial perspective as well as the requirements for military consumption. As a result, the uranium price has been depressed and the production and exploration efforts have declined. Over the past several years as production has been relatively stagnant, the nuclear reactor requirements for electricity production have been gradually increasing. This has been as a result of the utilities that were able to increase their capacity and upgrade their reactors. More recently, though, the new demand is emerging from China, India, and Russia, as these countries seek to dramatically increase their nuclear power capabilities. According to the International Atomic Energy Agency (2010), it forecasted that the annual demand for uranium with reach 80,000 tonnes within the next 10 years.

From a supply perspective, the top 20 uranium producing mines generate a total annual uranium production of 40 000 to 50 000 tonnes per year. Where information was available, the larger mines have in-situ uranium mineral resources ranging from 1 million tonnes to 10 million tonnes. The Närke prospects have in-situ mineral resource potential of approximately 303 thousand tonnes. The average uranium recovery from these existing operations is in the order of 80%. The Närke prospects, from the research of the historical technical papers, suggest a recovery potential of 75%. Also, according to Intierra (2012), the average in-situ uranium grade ranges from 500 ppm to >1000 ppm. The Närke prospects have grades that range from 100 ppm to 350 ppm, which is considered relatively low grade.

Therefore, the in-situ mineral resource, the recovery percentage and the low grades suggests an operation with a relatively small economy of scale, which will need to be carefully evaluated so as to find that optimum equilibrium between production rate,
extractable grade, plant recovery and the associated economics, i.e. costs versus revenue.
CONCLUSIONS

Considering the extent of the information available that describes the general geology and mineralisation in the Närke area, the following opportunities and risks have been identified:

Opportunities

• All available information appears to indicate that Sweden’s Alum Shale Formation is a major potential uranium resource and as such, represents an exploration target.
• A very large (~ 300 000 t) uranium (and associated metals) in-situ resource potentially exists within the Alum Shale of the West and East Närke outliers.
• The Alum Shale is also an oil shale and forms a major potential resource of kerogen suitable for the production of shale oil, and other industrial mineral products.
• Detailed geological mapping of bedrock (below several metres of recent glacial drift) is readily available from the Swedish Geological Survey. There is good geological control that can be incorporated into mineral resource modelling.

Risk Exposure

• The depth of this resource varies from being very shallow beneath an overburden of glacial drift to moderately covered by up to 30 m of overlying limestone. It will be important to establish the borehole collar elevations.
• Historical drilling information originating from earlier exploration (1940s – 1950s) reveals that meticulous borehole logging and assays were carried out. However the borehole locations are uncertain and will require validation. All records are in Swedish and require translation.
• Without accurate information on the existing borehole locations and reliable uranium sampling and assay information, it is not possible to produce a SAMREC compliant mineral resource estimate. However, if the missing information can be accessed, then it may be possible to produce a compliant mineral resource by twinning some of the historical boreholes to validate the historical data.
• Recovery of uranium (and associated metals) from this type of low-grade ore, by conventional methods, has been done in the past and should not pose a technical challenge. However, environmental challenges are likely. New in-situ extraction and recovery technologies may possibly be able to eliminate or minimise and partly mitigate environmental challenges.
15  RECOMMENDATIONS

In order to improve the level of confidence in the information summarized in this report, the following work programme is suggested:

1. A working relationship needs to be established with the Swedish Geological Survey (SGU) who is believed to be the only organisation that can assist with archived information.

2. Accurate co-ordinates of all historical boreholes and all available geological and assay information should be obtained from the SGU. If co-ordinates are not available, then geo-referencing of maps with the borehole locations would produce approximate locations.

3. Once borehole sites can be established with a reasonable accuracy, then a provisional mineral resource estimate can be made. Geological maps should be produced using SGU information.

4. Uranium values of core (apparently taken every 10 cm, probably by Geiger counter) may need to be scaled off from borehole plots. This should give a reasonable precision when aggregated over a metre.

5. The borehole logs and all accompanying reports are in Swedish. It will be necessary to either obtain translations or recruit a bi-lingual Swedish-speaking geologist.

6. A number of twinned core boreholes need to be drilled at the sites of selected historic boreholes, and core assayed for all relevant metals, as well as carbon and oil content. Boreholes should be geophysically logged down-hole. It will be important to verify uranium results. If the historic data can be validated against the twinned borehole data, the historic data can be used to produce a SAMREC Code-compliant mineral resource estimate.
17 REFERENCES


5. Intierra Resource Intelligence (2012), website: www.intierra.com


This report titled “COMPETENT PERSON’S REPORT ON THE EXPLORATION POTENTIAL OF THE NÄRKE URANIUM PROJECT, OREBRO COUNTY, SWEDEN” with an effective date of 8th August 2013, prepared by The MSA Group (Pty) Ltd on behalf of Svenska Skifferoljeaktiebolaget dated 8th August 2013 was prepared and signed by the following author:

Gavin Whitfield
MSc Geology, PrSciNat, FGSSA
Consulting Geologist
The MSA Group (PTY) Ltd

Dated at Johannesburg, South Africa

8th August 2013
APPENDIX 1:

Glossary of Technical Terms
Glossary of Technical Terms

adsorption  A molecular process whereby an element is attracted and bound to a surface of some other material; in the case of uranium (and other heavy metals) it was probably attached to decaying organic material from sea water.

alum  A hydrous potassium aluminium sulphate mineral that occurs naturally in black shale. It is a secondary product formed by the decomposition of pyrite and reaction with silicate minerals. The soluble mineral has the chemical composition of KAl(SO₄)₁₂.12H₂O.

Baltoscandian platform  An extensive geological terrane that existed in the late Precambrian to early Palaeozoic in what is now Scandivania. It extended east from Sweden into Russia and comprised of the Baltica craton.

basement  Ancient rock formations, invariably of igneous or metamorphic origin, that formed the early crust of the Earth, and the foundation on which younger sedimentary formations were deposited.

bedrock  Solid rock formations underlying surface deposits of gravel, sand, clay, drift etc. Bedrock may be totally obscured by young surface deposits.

biostratigraphic  A form of stratigraphic rock classification in which biological zones, as reflected by their characteristic fossil content, are used as the prime criteria.

bituminous  A rock containing much organic or carbonaceous material, often in the form of tarry hydrocarbons usually described as bitumen or mineral pitch.

black shale  A fine-grained sedimentary rock rich in organic carbon, largely of algal or bacterial origin. Such shales have the potential to produce shale oil and shale gas when heat treated.

burned lime  Oxide of calcium, chemical composition CaO, made by strongly heating or calcining limestone, CaCO₃.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caledonides</td>
<td>A major mountain (orogenic) belt of early Palaeozoic age that lies to the west of the Baltoscandian platform, occurring in western Sweden and Norway, and extending into Great Britain.</td>
</tr>
<tr>
<td>Cambrian</td>
<td>The first geological time period of the Palaeozoic area, from 541 to 485 million years ago. This period is noted for the explosion of multi-cellular marine life, and is subdivided into Lower, Middle and Upper divisions.</td>
</tr>
<tr>
<td>carbonaceous</td>
<td>Rocks that contain abundant free carbon of organic origin and often with plant remains, and generally found as shales and limestones.</td>
</tr>
<tr>
<td>crystalline</td>
<td>Generally refers to basement geological formations that are invariably coarser-grained rocks of igneous or metamorphic origin; often used in the term “crystalline basement”.</td>
</tr>
<tr>
<td>diamond drilling</td>
<td>An exploration method of obtaining a measured cylindrical core of rock by drilling with a diamond-impregnated bit; produces good quality rock used for detailed examination and analysis.</td>
</tr>
<tr>
<td>drift</td>
<td>A common term for all rock debris and clay that has been transported and deposited by glaciers, ice-sheets and glacial melt water; the debris is usually remarkably unsorted and mixed (see moraine).</td>
</tr>
<tr>
<td>equivalent uranium (eU)</td>
<td>A measure of uranium concentration using an instrumental technique that measures related radiation. The uranium radiation detected is calibrated to reflect the amount of uranium actually present.</td>
</tr>
<tr>
<td>escarpment</td>
<td>A long, prominent and more or less continuous line of steep slopes or cliffs, due to differential erosion or faulting, or both; the term scarp is often used.</td>
</tr>
<tr>
<td>exploration information</td>
<td>In a broad sense it means available geological, geophysical, geochemical, sampling, drilling, trenching, analytical testing, assaying, mineralogical, metallurgical and other similar information concerning an exploration property that is derived from activities undertaken to locate, investigate, define or delineate a mineral prospect or mineral deposit.</td>
</tr>
</tbody>
</table>
fault
A major break in the continuity of a rock formation, along which there has been displacement that may vary very considerably in amount. There are various types of faults depending on the sense of movement.

fossil energy
All forms of naturally occurring carbon of biological origin such as coal, petroleum, peat and natural gas, formed as a result of the decomposition and geological processes acting on the remains of prehistoric plants and animal organisms.

Geiger counter
An old-style electronic instrument used for detecting and recording radioactivity; also called a Geiger-Müller counter.

geochemistry
A broad term used here in the sense of the presence and amount of a range of minor and trace elements within rock formations.

geothermal
Meaning the heat of the Earth's interior; here used in association with the internal heat that was involved in the Caledonide orogenic event.

glacial
The action of natural ice, either a large ice field, ice sheet or a glacier. These result in erosion of underlying bedrock and the formation of glacial deposits such as moraine or drift.

hydrocarbon
Naturally occurring organic compounds composed of essentially of carbon and hydrogen that occur in solid, liquid or gaseous form, and originating from decomposed vegetable and animal matter.

hydroretorting
This process utilises a hydrogen-rich gas atmosphere for the retorting of oil shale to dramatically improve oil recovery. This overcomes the deficiency of contained hydrogen to improve the fraction of kerogen that can be converted to recoverable hydrocarbons.

hydrothermal
The movement and action of hot water within the crust of the Earth, especially in respect to producing changes to minerals and rocks.
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>in-situ leaching (ISL)</strong></td>
<td>An extractive method whereby economically important minerals or metals can be recovered from their host rocks without the need for mining; this is done by drilling boreholes into the target zone, shattering the rocks by explosives or hydraulic fracturing to create permeability, and pumping in a solution to leach out the minerals or metals; also called solution mining.</td>
</tr>
<tr>
<td><strong>kerogen</strong></td>
<td>A term applied to bituminous material found in oil shale, from which crude petroleum can be produced by destructive distillation or retorting.</td>
</tr>
<tr>
<td><strong>kolm</strong></td>
<td>Small erratic, circular lenses of coal-like hydrocarbon containing high concentrations of uranium; uranium and radon were found in kolm as far back as 1893.</td>
</tr>
<tr>
<td><strong>limestone</strong></td>
<td>A sedimentary rock containing at least 50% calcium or calcium-magnesium carbonates, and usually of marine organic origin.</td>
</tr>
<tr>
<td><strong>lithostratigraphic</strong></td>
<td>A form of stratigraphic rock classification in which rock types, as reflected by specific Units, Members, Formations and Groups, are used as the prime criteria.</td>
</tr>
<tr>
<td><strong>marine shelf</strong></td>
<td>An extensive and relatively shallow, gently sloping platform that exits under the sea, adjacent to land, on which sediment may be deposited and accumulate over time; may also be called the continental shelf.</td>
</tr>
<tr>
<td><strong>mineralisation</strong></td>
<td>A broad term used here in the sense of the existence of minerals of economic importance and having the ability to create a potential ore deposit.</td>
</tr>
<tr>
<td><strong>moraine</strong></td>
<td>An accumulation of heterogenous and unconsolidated debris derived from terminating or retreating glaciers or ice-sheets; there are various types moraine, such as terminal, lateral, medial and ground (see drift).</td>
</tr>
<tr>
<td><strong>oil shale</strong></td>
<td>A fine-grained sedimentary rock that contains abundant organic matter or kerogen which yields substantial amounts of oil and combustible gas on distillation. Oil shales have considerable economic potential as sources of fossil energy.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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</tr>
<tr>
<td>open-cast</td>
<td>A method of surface mining or quarrying that does not require underground development but which may result in considerable disruption to the surface.</td>
</tr>
<tr>
<td>Ordovician</td>
<td>The second geological time period of the Palaeozoic area, from 485 to 443 million years ago.</td>
</tr>
<tr>
<td>outlier</td>
<td>An area of younger rock formation entirely surrounded by older formations, or a remnant of younger formation preserved by some geological event such as faulting, folding or erosion.</td>
</tr>
<tr>
<td>overmature</td>
<td>Oil shales that have, by tectonic Earth processes, been subjected to high temperatures and pressures, and which have lost their ability to produce significant oil by conventional retorting.</td>
</tr>
<tr>
<td>Palaeozoic</td>
<td>One of the large divisions or eras of geological time, lasting 288 million years, from the start of the Cambrian (541 million years ago) to the end of the Permian (253 million years ago).</td>
</tr>
<tr>
<td>phosphatic</td>
<td>Rocks that contain relatively high amounts of phosphate; used here for sandstone that probably contains calcium phosphate as cement, that is probably of marine origin.</td>
</tr>
<tr>
<td>Precambrian</td>
<td>Pertaining to all rocks formed before the geological time period known as the Cambrian, and older than 541 million years.</td>
</tr>
<tr>
<td>primary</td>
<td>Refers to the original characteristics of a geological unit or to minerals existing within a rock at the time of its formation.</td>
</tr>
<tr>
<td>Quaternary</td>
<td>The most recent period of geological time, from 1.8 million years ago to the present, and characterised by poorly and unconsolidated surface deposits, including glacial drift.</td>
</tr>
<tr>
<td>radiometric</td>
<td>The instrumental method used for the detection and measurement of radioactivity in rocks, often done from the air, and leading to the production of maps.</td>
</tr>
<tr>
<td>remnant</td>
<td>A remaining small area of an outcropping geological formation, such as found in an outlier.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------</td>
</tr>
<tr>
<td>retorting</td>
<td>A process whereby oil shale is subjected to heat under controlled conditions to recover hydrocarbons by destructive distillation.</td>
</tr>
<tr>
<td>sandstone</td>
<td>A sedimentary rock composed of cemented or compacted detrital minerals, principally quartz and lesser feldspar grains.</td>
</tr>
<tr>
<td>shale</td>
<td>A fine-grained, layered sedimentary rock formed by deposition of clay and mud, generally deposited in deep water.</td>
</tr>
<tr>
<td>siltstone</td>
<td>A sedimentary rock intermediate in grain-size between fine-grained shale and coarser-grained sandstone.</td>
</tr>
<tr>
<td>stinkstone</td>
<td>A carbon-rich limestone that emits a fetid odour when struck owing to the decomposition of organic material; also called anthraconite or &quot;orsten&quot; in Swedish.</td>
</tr>
<tr>
<td>supergene</td>
<td>Refers to ore minerals that have been formed by downward enrichment from lower grade proto-ore.</td>
</tr>
<tr>
<td>syngenetically</td>
<td>A term used for mineralisation and ore deposits that formed at the same time as the enclosing rock.</td>
</tr>
<tr>
<td>tailings</td>
<td>The rejected part of an ore that remains after removal of the valuable portion; relatively worthless residue left after concentration of ore minerals.</td>
</tr>
<tr>
<td>uranium (U)</td>
<td>A naturally occurring element with atomic weight 238. It is metallic, hard, has an SG of 18.7 and is slightly radioactive; naturally occurring uranium consists of about 99.3% of the isotope $^{238}\text{U}$ and 0.7% of the strongly radioactive isotope $^{235}\text{U}$.</td>
</tr>
<tr>
<td>$U_3\text{O}_8$</td>
<td>Triuranium octoxide, usually called yellowcake; uranium production and sales are generally made in this form. To convert 1 unit of U to 1 unit of $U_3\text{O}_8$ multiply by 1.1792.</td>
</tr>
</tbody>
</table>
APPENDIX 2:

Résumé of Gavin Whitfield
Résumé of Gavin Whitfield

Geological & Mineral Exploration Consultant

Explorers for Africa CC
P.O. Box 943, Pinegowrie 2123, South Africa
Tel/Fax: +27 (0)11 886 8722
Cell: +27 (0)83 289 4039
E-mail: explorers@mweb.co.za

Languages: English, Afrikaans
Nationality: South African
Professional Membership: Fellow (retired) of the Geological Society of South Africa

PROFILE

After graduating Gavin spent six years in a geological research laboratory, gaining considerable experience in this area, and completing a M. Sc. Thereafter, twenty-eight years of hands-on mineral exploration experience, mostly in southern and central African geology and dealing with the African environment, has provided a wealth of knowledge and practical experience, as well an extensive network of regional contacts.

Considerable experience was gained in target generation, developing exploration strategies, exploration planning, and motivating and managing base and precious metal exploration teams for major international mining corporations. This work involved considerable travel throughout Africa. Gavin also has qualifications in small business management and marketing.

Following a corporate re-organisation in 1999, Gavin decided on early retirement and established a geological consulting business. Always keen on travel, he recognised the potential for geotourism in South Africa, and has operated many specialist geotours in this field. Recently he co-authored a popular book on South African geology, titled “Geological Journeys”, which has been very well received.

KEY EXPERIENCES

• Employed by several world-class mining companies (including internationally) and directly involved in several significant exploration successes, including three mines that are now (or were) in production.

• Corporate career culminated in appointment as General Manager: Central Africa for Billiton’s Exploration & Development Division, based in Zambia, and Director of the local Lusaka-based company.
• Successively held positions of Chief Geologist and Exploration Manager with both Shell Minerals SA Ltd (part of the Billiton Group) and later Gencor Ltd. The latter included being a member of the Mineral Resources Division Executive Committee.

• Has experience in a wide variety of prospective geological and metallogenic terranes, with operational emphasis being on the Precambrian of southern and central Africa (see page 3 for listing of project experience).

• Focused mineral deposit experience has been extensive, on greenstone gold, banded iron formation, metamorphosed sedex base metals, carbonate-hosted zinc-lead, intrusive-related iron-copper-gold systems and skarns, stratiform sediment-hosted copper-cobalt, sedimentary-hosted uranium, and heavy mineral sands.

• Well versed in most exploration techniques and current technology, as well as practical methodologies ranging from research and target generation, through successive exploration stages, to evaluation and resource estimation.

• Considerable and varied experience in exploration planning, budgeting, logistics and administration, and human resource and legal issues; generally conversant on mineral ownership and prospecting rights.

• Exploration approach is through teamwork & integrated multidisciplinary effort, using expert support for specialised tasks, working cost-effectively and without compromising quality.

• Also a trained and registered National Tourist Guide with a geological speciality, and has an interest in developing and promoting geoconservation and geotourism in South Africa, where he has operated as “Geological Heritage Tours”.

• Ventured into book-writing by co-authoring (together with geologist Nick Norman) a guide-book on the geology and landforms of South Africa, aimed at travellers and tourists. This book, over 300 pages, was published in 2006 and has been very well-received.

### EMPLOYMENT SUMMARY

<table>
<thead>
<tr>
<th>EMPLOYED BY</th>
<th>POSITION</th>
<th>PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explorers for Africa CC (Member)</td>
<td>Geological Consultant &amp; Specialist geotourism organizer/guide</td>
<td>1999 - Present</td>
</tr>
<tr>
<td>Billiton South Africa Ltd.</td>
<td>Manager: Projects</td>
<td>Part of 1999</td>
</tr>
<tr>
<td>Billiton Development (Zambia) Ltd</td>
<td>General Manager: Central Africa</td>
<td>1997 – 1999</td>
</tr>
<tr>
<td>Gencor Ltd and later Billiton SA Ltd</td>
<td>Exploration Manager</td>
<td>1995 – 1997</td>
</tr>
<tr>
<td>Shell South Africa Ltd, Minerals Division</td>
<td>Chief Geologist &amp; Exploration Manager</td>
<td>1989 – 1995</td>
</tr>
<tr>
<td>Shell South Africa Ltd, Minerals Division</td>
<td>Senior &amp; Regional Geologist</td>
<td>1984 – 1989</td>
</tr>
<tr>
<td>Shell South Africa Ltd, Metals Division</td>
<td>Regional Geologist</td>
<td>1979 – 1982</td>
</tr>
</tbody>
</table>
CPR on the Exploration Potential of the Närke Project
Appendix 2 – 8 August 2013

<table>
<thead>
<tr>
<th>Company/Position/Role</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phelps Dodge of Africa Ltd (South Africa)</td>
<td>Project Geologist 1973 – 1978</td>
</tr>
<tr>
<td>Anglo American Prospecting Services</td>
<td>Staff Geologist 1971 – 1973</td>
</tr>
<tr>
<td>Anglo American Research Laboratory</td>
<td>Mineralogist/Petrographer 1965 – 1971</td>
</tr>
</tbody>
</table>

**MAJOR PROJECT & RELATED EXPERIENCE**

- **Lutzputs Cu – Ag deposit (Northern Cape):** *Intrusive vein-type deposit.* Geological mapping, geochemistry, follow-up on airborne and ground geophysics, exploration drilling and sampling, manual resource estimation.

- **Rozynenbosch Pb – Zn deposit (Northern Cape):** *Complex high-grade metamorphic geology.* Geological mapping, geochemistry, resource drilling and sampling, followed by manual resource estimation. Now owned by **Miranda**.

- **Karoo U exploration (Western Cape):** *Sediment-hosted mineralization.* Follow-up of airborne radiometric targets, percussion drilling, reporting. Follow-up review of all Karoo uranium deposits in Southern Africa done recently (2005).

- **Zandrivierspoort Magnetite deposit (Limpopo):** *Banded Iron Formation.* Supervision of geological mapping, major resource drilling and sampling programme, followed by manual resource estimation. Now owned by **Kumba**.

- **Pering Zn – Pb deposit (North-West):** *Carbonate-hosted.* Supervision of geological mapping, regional exploration, geochemistry, major resource drilling and sampling programme, followed by manual resource estimation. Including Feasibility Study reporting. Later mined by **Shell Minerals SA**.

- **Figaro Au deposit (Mpumalanga):** *Greenstone-type gold.* Supervision of geological mapping, geochemistry, exploration drilling and sampling programme, followed by manual resource estimation. Included Feasibility Study reporting.

- **Doornhoek Au deposit (Limpopo):** *Greenstone-type gold.* Supervision of geological mapping, geochemistry, trenching, resource drilling and sampling programme, followed by manual resource estimation. Included Feasibility Study reporting.

- **Goldridge Au deposit (North-West):** *Greenstone-type gold.* Overseeing exploration, including geological mapping, geochemistry, resource drilling and sampling programme, followed by computer resource estimation. Later mined open-pit by **Harmony Gold**.

- **Hillendale and Fairbreeze deposits (Kwa-Zulu Natal):** *Dune-hosted heavy minerals.* Overseeing of major resource drilling and sampling programme, followed by manual and computer resource estimations. Has been mined by **Ticor Minerals (Exxaro)**.

- **Kabwe Zn – Pb deposits (Zambia):** Overseeing exploration, including geological mapping, geochemistry, extensive exploration drilling and sampling programme in the area around the old Kabwe mine workings.
- **Big Concession area - regional exploration programme (Zambia):** Following Olympic Dam-type exploration model. Target generation and overseeing of exploration including geological mapping, geophysical follow-up, geochemistry, exploration drilling and sampling programmes.

- **Uranium investigations and reviews (Southern and Central Africa):** Covering all types of uranium deposits in the region. Compilation of various reports, and monitoring of recent developments in uranium exploration and mining in the region; a considerable on-going database exists for most deposits in the region (up to mid-2008).

- **Exploration consulting and contract work:** For several companies including The MSA Group (Pty) Ltd, Minex Projects, Snowden Mining Industry Consultants and Cameco Corporation.

- **Geological Tours and Geoheritage:** Has organized and run numerous specialist geological tours (e.g. for conferences) and local geoheritage meetings and outings.