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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 776804 — H2020-SC5-2017.

NEXT

New Exploration Technologies

SCIENTIFIC ABSTRACTS COMPILATION AND FIELD GUIDE TO RAJA PROSPECT, PERÄPOHJA BELT, FINLAND

Horizon 2020 Project: **NEXT**

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Participants	NEXT members and guests				
Comments	Clustering conference and field meeting to disseminate early results of studies on the Raja prospect test site				

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2	16 October 2019	NDJC	Final revisions and publication as PDF document.

About NEXT

NEXT consortium consists of 16 partners from leading research institutes (3), academia (3), service providers (5) and industry (5). The members come from 6 EU member states (FI, FR, DE, MT, ES and SE) and represent the main metal producing regions of Europe, Fennoscandian Shield, Variscan Belt of Iberia and Central European Belt. These economically most important metallogenic belts of the EU have diverse geology with evident potential for different types of new mineral resource. The mineral deposits in these belts are the most feasible sources of critical, high-tech and other economically important metals in the EU. The project consortium has also a vast international collaboration network, e.g. 50% of the Advisory Board members have been invited from outside EU.

In addition to the variable geology, the vulnerability of the environment and the glacial sedimentary cover in the Arctic regions of northern Europe, and the thick weathering crust and more densely populated nature of the target areas in the Iberian and Central European belts influence the mineral exploration in different ways. New environmentally sound exploration concepts and technologies will be optimised and tested on diverse mineral deposit types.

NEXT will develop new geomodels, novel sensitive exploration technologies and data analysis methods which together are fast, cost-effective, environmentally safe and socially accepted. Methods developed reduce the current high exploration costs and enhance participation of civil society from the start of exploration, raising awareness and trust. Moreover, the reduced environmental impact of the new technologies and better knowledge about the factors influencing social licensing will help promote social acceptance of both exploration and mining and therefore support the further development of Europe´s extractive industry.

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NEXT Exploration Symposium program

KEYNOTE LECTURE – Professor Ferenc Molnár

ABSTRACTS – In alphabetical order

FIELD GUIDE – Nick Cook and Mawson OY Team

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EXPLORATION SEMINAR: COBALT IN OROGENIC GOLD MINERAL SYSTEMS — RAJA TEST SITE AS A SHOW CASE IN PERÄPOHJA BELT

TUESDAY 8TH OCTOBER — KEYNOTE ADDRESS

18:00-18:45	**Ferenc Molnár**, GTK. *Cobalt in orogenic gold mineral systems of northern Fennoscandia*

WEDNESDAY 9TH OCTOBER

8:50-9:00	**Vesa Nykänen and Nick Cook**: *Opening*
9:00-9:30	**Nick Cook**, Ferenc Molnár, Hugh O`Brien, Yann Lahaye, Juho Tapio, Mawson, GTK. *The evolution of the Peräpohja Belt as viewed from within the Rompas-Rajapalot project*
9:30-10:00	**Pentti Hölttä**, GTK: *Metamorphic structure of Northern Finland*
10:00-10:30	***Coffee break***
10:30-11:00	**Simo Piippo**, Smart Exploration, University of Turku: *Structural evolution of the Peräpohja Belt: variations in structural coupling between the Archean basement and the Paleoproterozoic cover strata*
11:00-11:30	**Pietari Skyttä**, Smart Exploration, University of Turku*: The rifted Archaean basement and its influence on the development of the Peräpohja Belt*
11:30:12:00	**Jukka-Pekka Ranta**, University of Oulu: *Geological evolution and gold mineralisation in the northern part of the Peräpohja Belt: Evidence from whole-rock and mineral chemistry, and radiogenic and stable isotopes*
12:00-13:00	***Lunch***
13:00-13:30	**Sara Raic**, Ferenc Molnár, Yann Lahaye, Hugh O`Brien, GTK: *Mineral trace element and sulphur isotope geochemistry from the Raja Au-Co prospect: preliminary results an implications in vectoring to ore*
13:30-14:00	**Mikael Vasilopoulos**, Ferenc Molnár, Hugh O`Brien, Yann Lahaye, Jukka-Pekka Ranta, GTK, University of Oulu*: Discrimination of gold and cobalt mineralising events at the Juomasuo Au-Co deposit, Kuusamo Belt, northeastern Finland*
14:00-14:30	**Pertti Sarala**, NEXT, GTK: *Geochemical sampling at Raja prospect*
14:30-15:00	**Bijal Chudasama**, Johanna Torpp, Vesa Nykänen, Janne Kinnunen NEXT, GTK, Mawson: *Prospectivity modelling for gold in target scale within Raja prospect*
15:00-15:30	***Coffee break***
15:30-16:00	**Alan Butcher** & Quentin Dehaine, GTK: *Update on the geometallurgy of recently discovered cobalt mineralisation at Rajapalot Project*
16:00-16:10	**Jarkko Jokinen**, Loop & Line: *NEXT geophysical surveys at Mawson Rajapalot project area*
16:10-16:40	**Janne Kinnunen**, Mawson: *Evolution of 3D understanding of geophysics and its relation to mineralisation at Rajapalot project*
16:40-17:10	**Nick Cook**, Mawson: *Silicate alteration and whole rock geochemistry of Rajapalot*
17:10-17:40	**Torsten Gorka***, DMT: Q&A Session on New Exploration Technologies*
17:40-18:00	**Mawson**: *Introduction to field trip*
19:00	***Dinner***

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THURSDAY 10TH OCTOBER
NEXT EXCURSION DAY

08:00	Departure to field site via Rovaniemi
12:00 – 13:30	Return to Rovaniemi and lunch
13:30 – 16:00	Mawson drill core shed in Rovaniemi to view Raja prospect drill core
16:00	End of excursion

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COBALT IN OROGENIC GOLD MINERAL SYSTEMS OF NORTHERN FENNOSCANDIA

Keynote address by Professor Ferenc Molnár

Geological Survey of Finland, Ore Geology and Mineral Economics Unit, Espoo

Cobalt is one of the most important battery metals with high criticality in the European Union where Finland and Poland are the only countries producing cobalt from mining. The annual cobalt production refined from Finnish ores is around 2300 metric tons which takes about 1.8% of the World`s global cobalt production. However, the refinery capacity is much higher, and nearly one quarter of cobalt used annually by the global industry is refined in Finland. The most important global sources of cobalt are the sediment-hosted Cu-Co, the magmatic Ni-Cu (-Co-PGE-Mo) (Talvivaara-type black schist hosted sulphide) mines. In the past years, the exploration interest in other types of cobalt bearing ores, especially in epigenetic hydrothermal gold deposits has been increased and led to new discoveries such as the enrichment of cobalt in the Rajapalot prospect.

The orogenic gold deposits occur in several metallogenic belts and districts on the Fennoscandian Shield (Fig. 1A). Most of these deposits can be classified as "typical" orogenic gold deposits with gold-only major commodity. However, epigenetic-hydrothermal gold deposits with potentially economic enrichments of Cu, Co, Ni (±Mo, REE etc.) also occur in the same belts. They are usually also classified as orogenic gold deposits with adding a note that their metal associations are "atypical". This kind of deposits are especially common in northern Fennoscandia, where Paleoproterozoic rift-related basins (e.g. Central Lapland Greenstone Belt, Kuusamo Belt, Peräpohja Belt; Fig. 1B) that have been thrusted, folded and metamorphosed during the Svecofennian orogeny. The occurrence of these deposits in clusters among the "typical" orogenic gold deposits suggests that some local peculiarities related to the basin stage or to the orogenic evolution of these regions, or interplay between these evolutionary stages should have controlled the formation of the peculiar metal association.

In order to better understand geological processes leading to enrichment of cobalt, copper, nickel and other metals in orogenic gold mineral systems, detailed mineralogical-petrological, geochronological, isotope-geochemical and structural studies have been completed or still are under way in several orogenic gold deposits in northern Finland (Fig. 1B). The systematically collected U-Pb and Re-Os age data from hydrothermal minerals suggest that multiple alteration and ore mineralisation events between 1.92 and 1.76 Ga characterise all of these deposits and enrichments of cobalt and/or other base metals together with gold occurred during the 1.81-1.76 Ga late to post-orogenic re-activation of structures that have been formed during the earlier stages of the Svecofennian orogeny or even have potentially inherited from the basin evolution stage. Boron isotope data from tourmaline, a common alteration and vein mineral in these systems indicate multiple sources fluids and this is also reflected by the trace element contents of sulphide minerals, especially pyrite. Several deposits show rather wide ranges of sulphur isotopes and high variation in trace element content of sulphides: these peculiarities also indicate opening up of different fluid and metal reservoirs in the basement during the elongated Svecofennian hydrothermal activity. Evaluation of metal inventory in sedimentary rocks and mafic-ultramafic volcanic rocks as a function of metamorphic grade in the Central Lapland Greenstone belt suggests that copper and part of nickel and gold may have had sourced from black schist, whereas the volcanic rocks were also the sources of nickel and gold. Cobalt mobilisation due to metamorphism cannot be seen in these rocks, but sulphide trace element data rather point towards

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to the role of local fluid-rock interaction in mobilisation and deposition of cobalt. High salinity fluid inclusions and some boron isotope data support involvement of marine evaporites in the hydrothermal systems. However, in addition to those high salinity fluids, low salinity carbonic aqueous fluids, which are typical for orogenic gold deposits, also characterise these ore systems and reflects variable fluid sources.

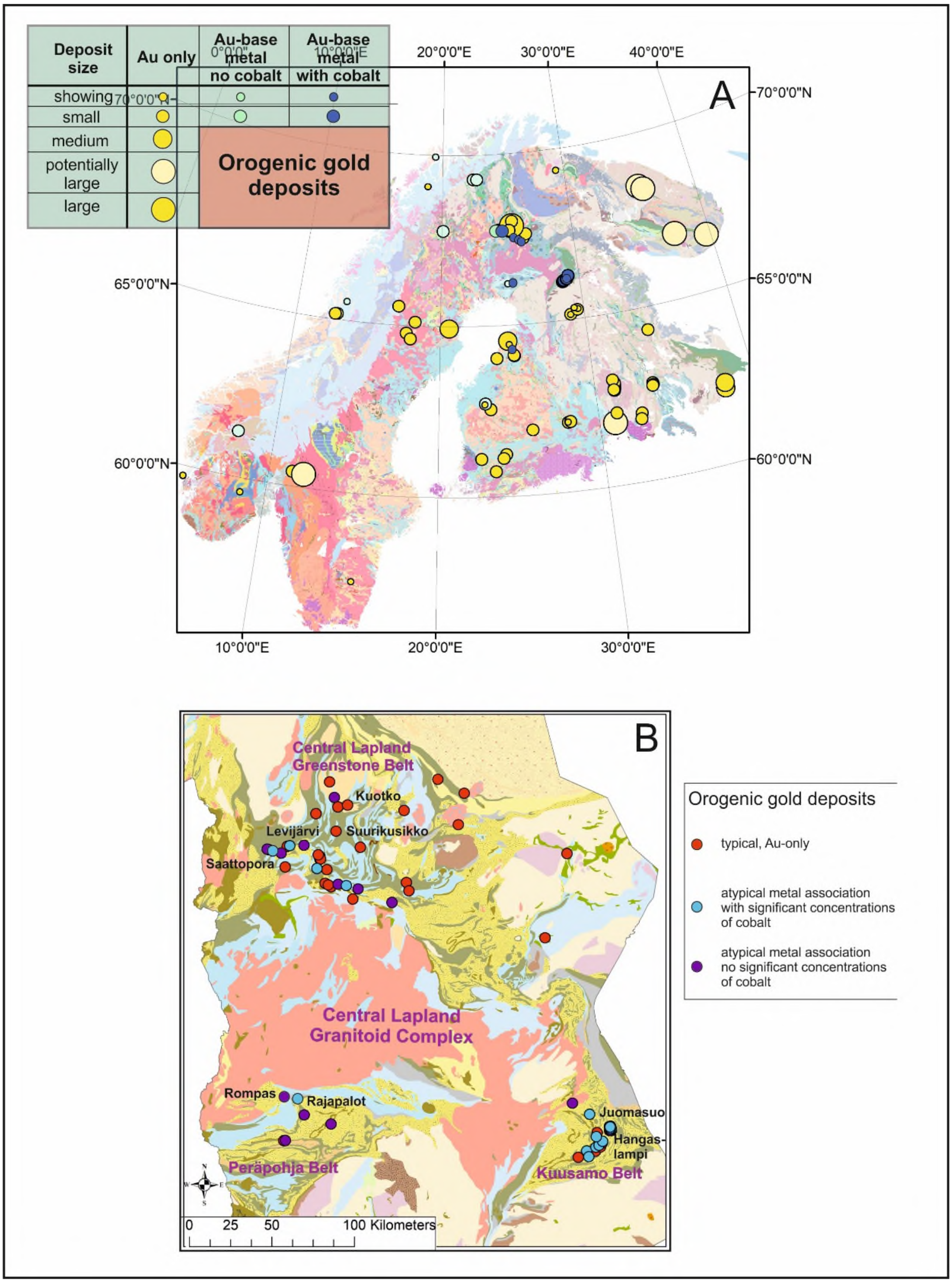

Figure 1: orogenic gold deposits with gold-only and with "atypical", Au-base metal associations in Fennoscandia (A) and in northern Finland (B).

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UPDATE ON THE GEOMETALLURGY OF RECENTLY DISCOVERED COBALT MINERALISATION AT RAJAPALOT PROJECT

Alan R Butcher[#], Quentin Dehaine[#], Jukka Kuva[#], Sayab Muhammad[#], Peter Sorjonen-Ward[#] & Andrew Menzies[+]

[#] Geological Survey of Finland, Espoo; [+]Bruker Nano GmbH, Berlin

Geometallurgy is a useful way of gaining insights into how an ore might behave from a mineral processing perspective (crushing, grinding, separation, & concentration), before it is mined, based on an integrated geological, mineralogical, mining and metallurgy analysis and testwork approach.

In this study, we have developed a new geometallurgical workflow based on drilled intersections that are considered by Mawson Oy to be commercially interesting, either based on their gold-, or cobalt-content (or both), from their Rajapalot Project.

The workflow is novel in that it involves a multi-scale (metres-microns), multi-dimensional (2D-3D), and multi-modal strategy for the analysis of exploration drill core. We have taken lessons learnt from the oil industry — where upscaling and downscaling of commercially-important rock properties enables the modelling of a sedimentary rock mass (reservoir) — and made it applicable to the study of metamorphic, metal-rich rocks (ores). Bridging of various length-scales is achieved by using combinations of geoanalytical techniques, in a certain sequence, which provides the explorationist with lithological, mineralogical and textural information at different scales and dimensions.

The end result is a new perspective on the commercial mineralogy at Rajapalot. Liberation of both ore and gangue minerals can be estimated in 3D (x-CT), and quantified in 2D (automated SEM-EDS). Furthermore, cobalt distribution can be determined directly on cut surfaces of drill core (micro-XRF), requiring no special sample preparation, on areas larger than that normally observed within the area of a conventional thin section. This allows whole-rock exploration chemical assay-style data, necessarily averaged over centimetres of drill, to be given a mineral and textural context at the same length scale. Finally, once areas of specific interest within drill cores have been identified, they can be further investigated by more detailed (EPMA) and invasive (LA-ICP-MS) methods.

This talk will explain how the workflow was developed, and how such an approach is adding to the knowledge of ore deposit formation, mineral processing options, and future exploration strategies at the Rajapalot Project.

The authors would like to acknowledge additional input from the Camborne School of Mines (Gavyn Rollinson), Hippo Geoscience (Pieter Botha), X-ray Mineral Services (Lorenza Sardisco), and Mawson Resources (Nick Cook), in the development of the new workflow.

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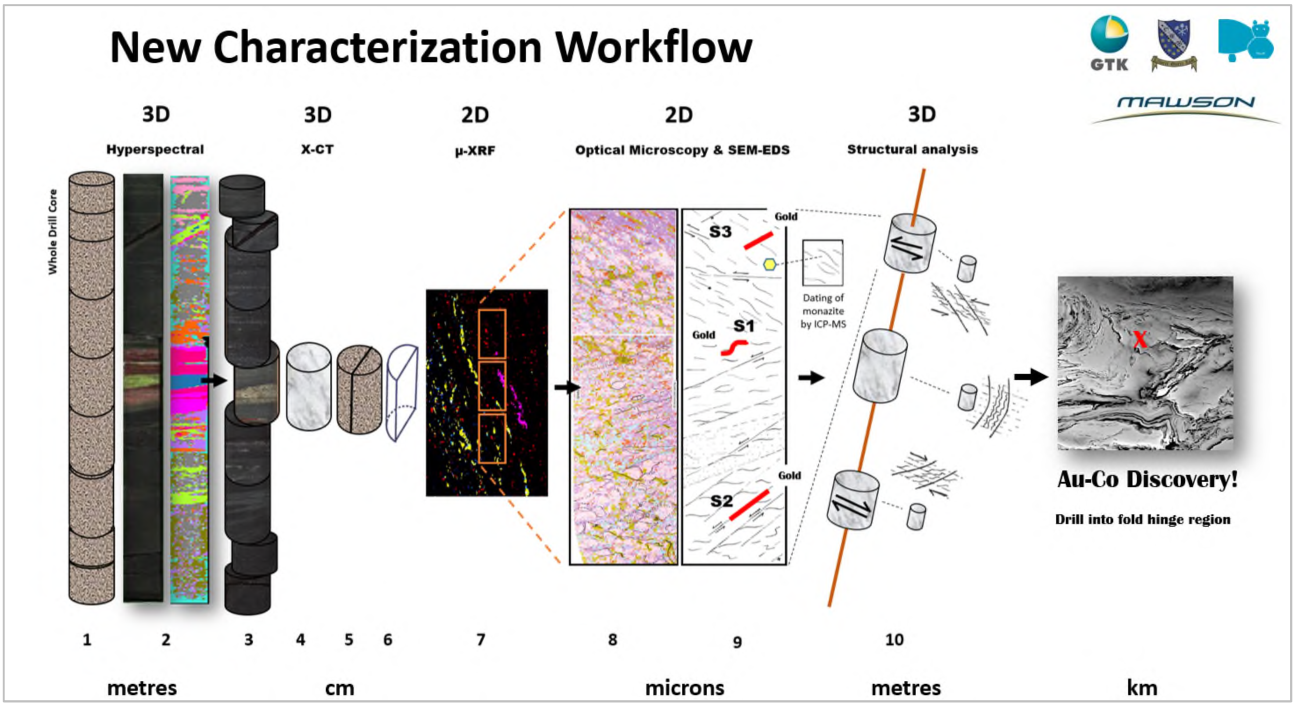

Figure 1. Ten steps in the new geometallurgical workflow which allows for the upscaling and downscaling of mineralogical and textural features in exploration drill cores. The ultimate aim is to improve exploration success and predict processing behaviour of discovered zones of interest.

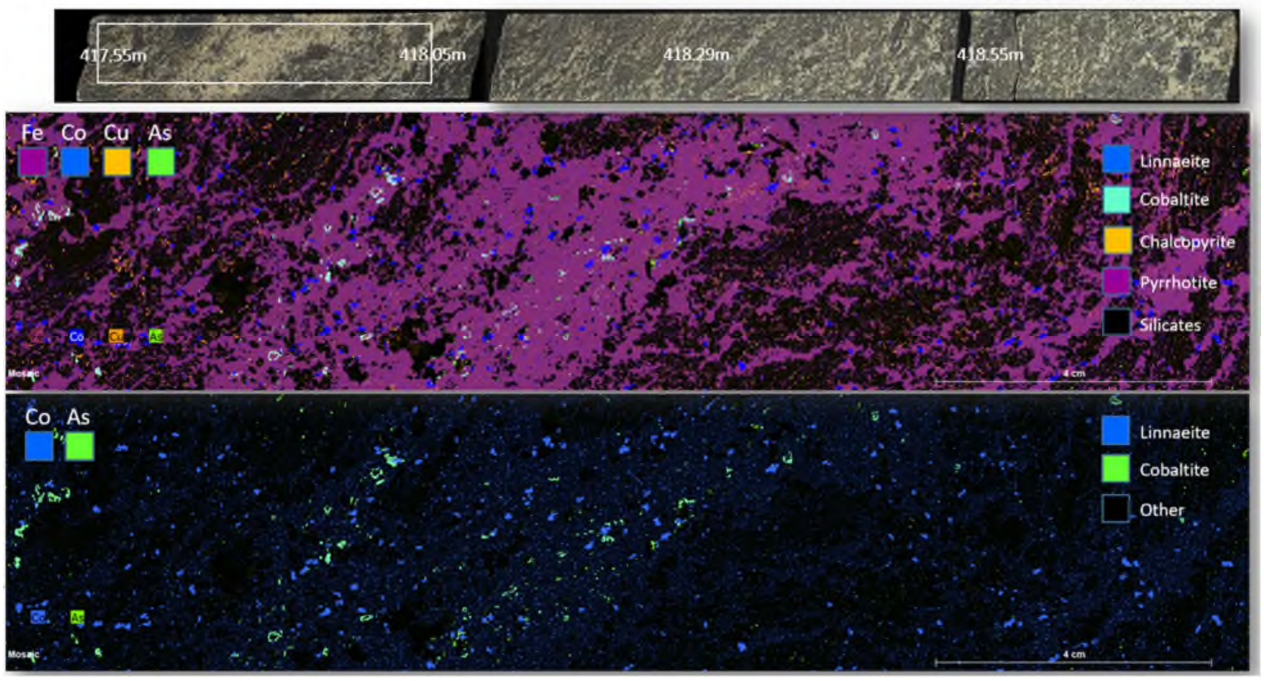

Figure 2. Centimeter-scale elemental mapping of cobalt mineralisation in PAL0163 at a depth of 418 m, by micro-XRF (directly onto a cut surface of a drill core), to reveal the spatial distribution of mineral species and their relationship to the micro-structural fabric.

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TARGET-SCALE PROSPECTIVITY MODELLING FOR GOLD WITHIN THE RAJAPALOT PROSPECT IN NORTHERN FENNOSCANDIAN SHIELD, FINLAND

Bijal Chudasamaa[a], Johanna Torpp[b], Vesa Nykänen[c], Janne Kinnunen[d]

[a] Geological Survey of Finland, Espoo, Finland; [b] Geological Survey of Finland, Kuopio, Finland; [c] Geological Survey of Finland, Rovaniemi, Finland; [d] Mawson Resources Limited, Rovaniemi, Finland

Mineral prospectivity modelling is usually implemented on a regional scale for identification of new exploration targets. One approach towards regional scale mineral prospectivity studies is driven by the mineral systems model, where the emphasis is on identification of all the mineral system components (i.e. the sources, pathways and traps) and the constituent mineralisation processes. However, processes related to each of the mineral system components are controlled by scale-dependent geodynamic processes. When the areal extent of the targeted region decreases from regional-, to belt-, to camp-, to target-scale, the importance of the different mineral system component also decreases. At regional scale, recognition of all the components is imperative for identification of exploration targets. However, when at the target scale, the constituent processes of the trap component become the most important (McCuaig et al., 2010).

This study presents results of target-scale prospectivity modelling for gold in the Rajapalot prospect area. The study area covers appx. 7.5 km^2 within the Kairamaat permit of the Mawson Resources Limited. It is located nearly 35 km west from Rovaniemi, within the Paleoproterozoic Peräpohja Belt in the Northern Fennoscandian Shield, Finland. Important prospects within the targeted area are Palokas and Raja. Using high resolution ground geophysical data, interpreted geological data and 'base of till' geochemical data, this study implements the 'Cosine Similarity Index' (CSI) measurement for recognition of spatial features and patterns related to mineralisation in the study area and to facilitate further demarcation of the ore-body. The predictor maps representative of mineralisation processes used in this study are apparent chargeability, proximity to structures (selected based on the type of features and the deformation generation), density of lithological contacts and the till elemental concentrations. All these layers are representative of processes that comprise the trap component of the mineral system.

Analyses of the till geochemical data using orientation diagrams indicate a strong NW-SW distribution of the gold-path-finding elements in the study area (Fig. 1). Consequently, using a NW-SE directional filter for convolution of the geochemical data, target areas were mapped by subsequent CSI calculation with respect to Palokas and Raja prospects. The CSI for the study area with respect to these two prospects are different, indicative of the presence of different sub-types of mineralisation. Final prospectivity map from geochemical data was generated by the overlay of CSIs with respect to both prospects (Fig. 2). Similarly, CSI was also calculated using high resolution geophysical and interpreted geological data that aided in mapping the prospective zones in the study area, particularly for further delineation of the targeted region around the prospects (Fig. 3). These results also identify the other prospects, viz., South Palokas, Boardwalk, The Hut and Terry's Hammer (that were not used for CSI calculations) within the high prospective zones. This study demonstrates that for target scale prospectivity modelling, even subtle features related to the deposits are important for identification and delineation of ore bodies and other targets in the study area. With the availability of high resolution geophysical, geochemical and geological data, these features can be extracted

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using more feature specific prospectivity modelling methods, such as calculation of CSI, as presented in this study.

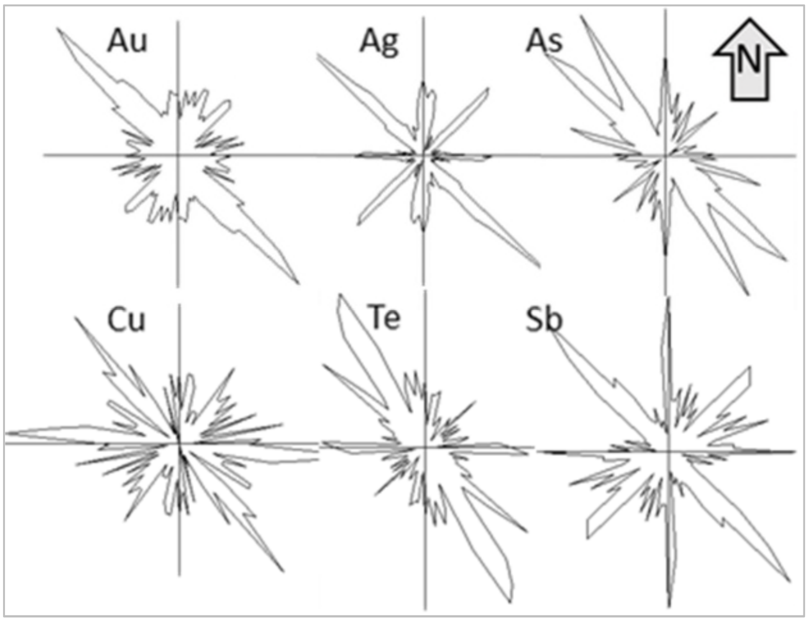

Figure 1: Orientation diagrams for Au and some of the Au-path finding elements

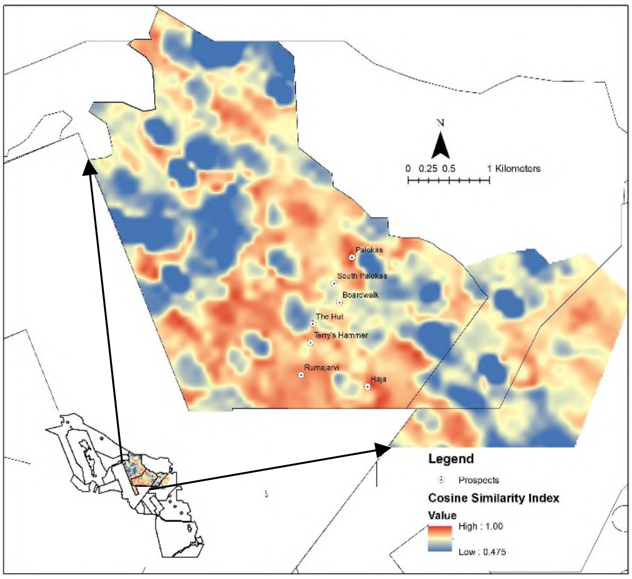

Figure 2: Prospectivity model from base of till geochemistry data. The Cosine Similarity Index ranges from 0 to 1. The closer the values are to 1, the smaller is the angle between the vectors (i.e. the angle between the pixels and the Palokas or Raja prospects) in feature space. Hence values closer to 1 indicate regions of relatively higher prospectivity values. Blue indicates less prospective areas and red indicates highly prospective areas.

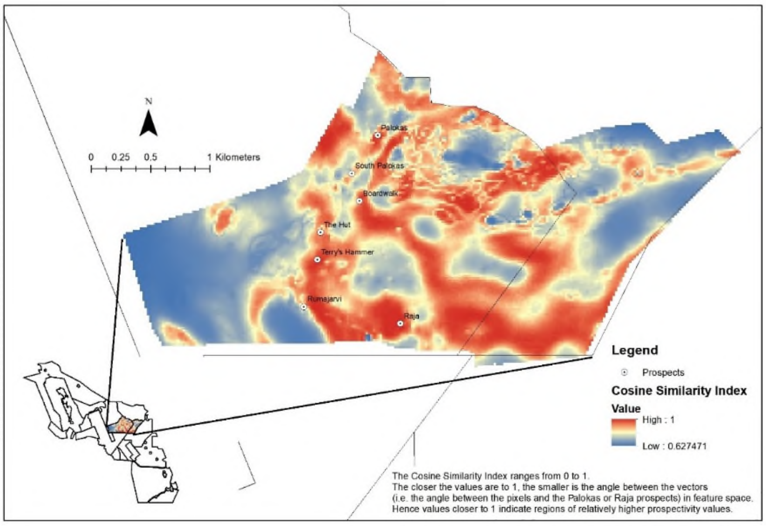

Figure 3: Prospectivity model from high resolution geophysical data. The Cosine Similarity Index ranges from 0 to 1. The closer the values are to 1, the smaller is the angle between the vectors (i.e. the angle between the pixels and the Palokas or Raja prospects) in feature space. Hence values closer to 1 indicate regions of relatively higher prospectivity values. Blue indicates less prospective areas and red indicates highly prospective areas.

Reference

McCuaig, T. C., Beresford, S., & Hronsky, J. (2010). Translating the mineral systems approach into an effective exploration targeting system. Ore Geology Reviews, 38(3), 128-138.

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SILICATE ALTERATION AND WHOLE ROCK GEOCHEMISTRY OF RAJAPALOT

Nick Cook

Mawson Resources Limited

The gold-cobalt mineralisation forming the three resource areas at Rajapalot are enclosed by an alteration halo that is distinctive, however varies depending on bulk composition of the protolith. In addition, both brittle and ductile structures are evident – a function of both the alteration mineral assemblages and the geometric relationship between the dominant planar structures of the poly-deformed amphibolite facies host rocks.

The shape of the Raja Au-Co inferred mineral resource is dominated by the intersection of muscovite-biotite schists with a sub-vertical linear structural control producing high gold and cobalt envelope with a resultant plunge of 34 degrees towards 339°. Pyrrhotite, cobaltite, scheelite and native gold are the key non-silicate minerals forming the resource, with subordinate cobalt pentlandite, linnaeite and pyrite. The hanging wall to Raja high-grade Au-Co is dominated by altered rocks including a thick package of white to grey albitites which is in turn overlain by a grey-green-pinkish actinolite-chlorite-epidote-hematite calcschist. This alteration halo is in many ways similar to that found around classic porphyry copper systems.

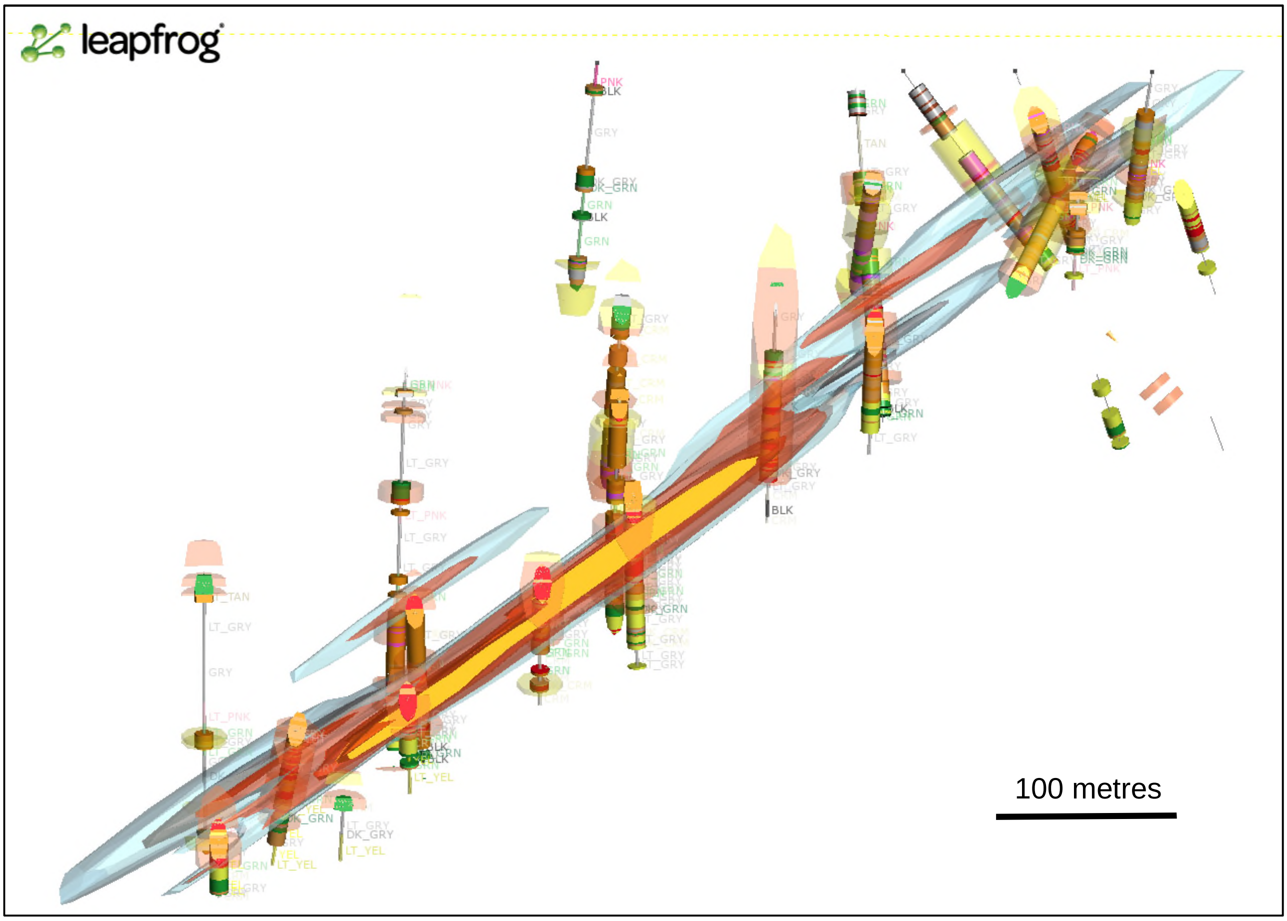

Figure 1: Leapfrog view of the plunging Raja mineralisation looking towards 069° (plunging towards left at 34°/339°), with modelled gold volumes (not used in the resource calculations). Rock types grouped by geochemical modelling form the narrow cylinders, the larger partly transparent cylinders reflect mapped pyrite (yellow) versus pyrrhotite (pinkish).

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The Palokas gold-cobalt mineralisation is a pyrrhotite-dominated system, but in contrast to the potassic-sulphidic Raja resource is hosted by iron- and magnesium-rich rocks. A sub-vertical structural control intersecting with reactive (stratabound) rocks remains the constant in controlling the hydrothermal alteration envelope where cordierite, anthophyllite and chlorite predominate.

All of the gold-cobalt mineralisation is retrograde (with respect to the amphibolite-facies host rocks) and largely texture destructive. A challenge for exploration geologists now revolves around recognition of alteration halos (we want to know when we have a "close miss"!) and deducing the composition of the host rocks prior to the late hydrothermal alteration. Using Mo and V as a tracer for determining oxic to anoxic euxinic protoliths is one such method trialled here.

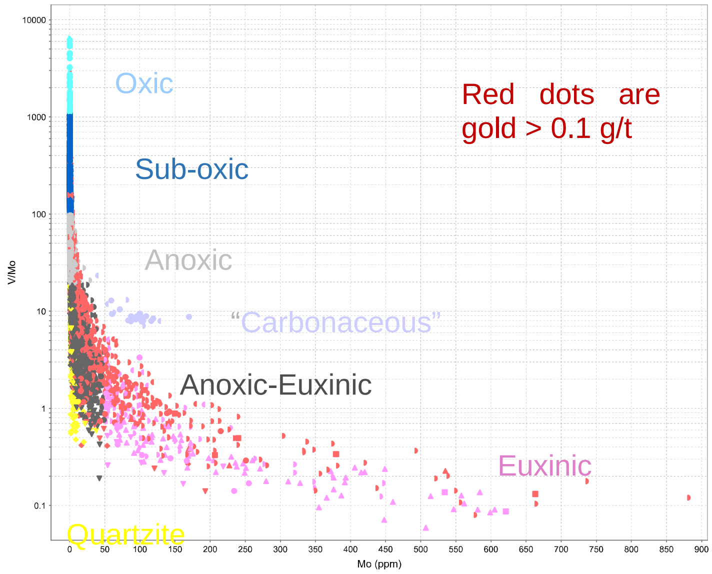

Figure 2: V/Mo versus Mo plot used to show the oxidation and sulphur state of the protolith metasediments.

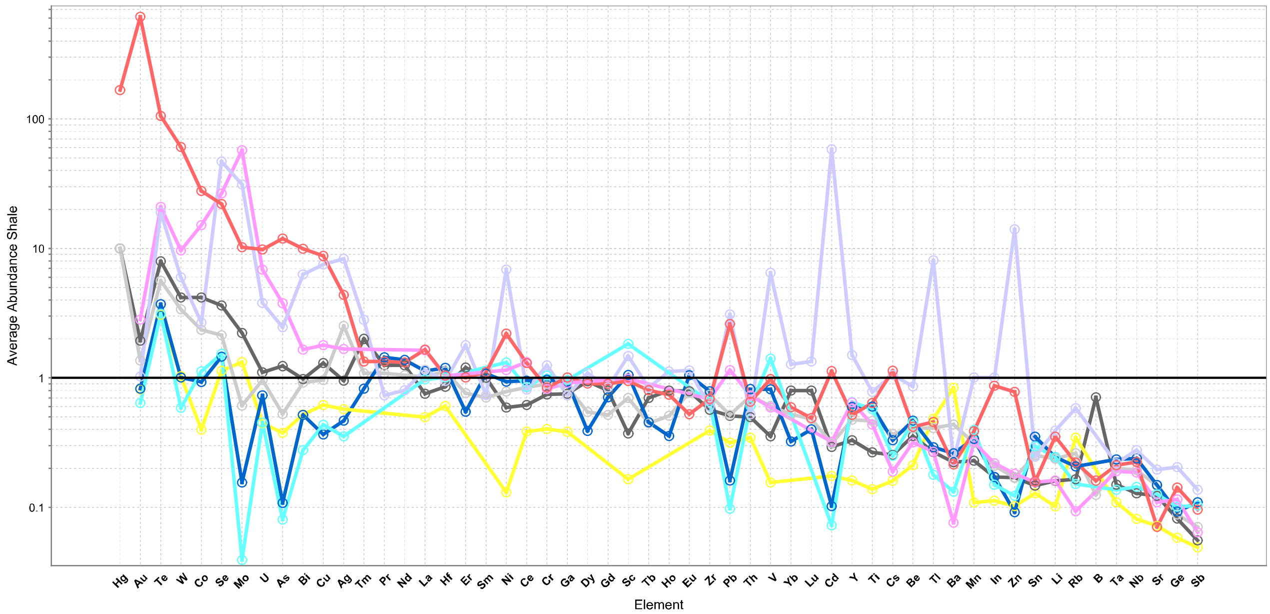

Figure 3: "Spider" plot showing contrasting geochemical character of host rock types. The colours refer to those classifications on Figure 2.

Acknowledgements. We are especially grateful to the geological team at Mawson, fellow researchers from GTK, students and staff of University of Oulu, Tony Prave (St Andrews) and consultants to Mawson who have all provided considerable input to the exploration program at Rompas-Rajapalot.

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THE EVOLUTION OF THE PERÄPOHJA BELT AS VIEWED FROM WITHIN THE ROMPAS-RAJAPALOT PROJECT

Nick Cook[1], Ferenc Molnár[2], Hugh O`Brien[2], Yann Lahaye[2], Juho Tapio[1]

[1] Mawson Resources Limited, [2] Geological Survey of Finland,

One of the principal advantages in drilling over 50 kilometres of diamond drill core within a small area lies in a self-proclaimed apparent advanced level of understanding. To put it another way, "knowing a lot about very little" gives one the opportunity of making sweeping statements and deductions about the nearby enclosing rocks, and for the brave, those much more distal. In contrast to such assertions based on detailed knowledge of small areas, one must be aware of the narrow lens provided by outcrop and sparsely separated drill holes over wider areas. The broad scope of the topic covered in this presentation should be viewed with these thoughts in mind.

The Paleoproterozoic Peräpohja Belt has a particularly long depositional history commencing at approximately 2.4 Ga and continuing through to approximately 1.9 Ga. It includes evidence for significant episodes in earth history, in particular, the "Great Oxidation Event" (GOE) and following this, a phenomenal era of deposition of carbonaceous material. Superimposed on the sequence created during this period are igneous, metamorphic, deformational and hydrothermal events leading to the complex array of compositionally diverse rocks we see today. Drilling at the Rompas-Rajapalot project by Mawson combined with GTK cooperative research forms the basis to the new data and observations presented here. An early view of the regional stratigraphic framework is presented in Figure 1 below.

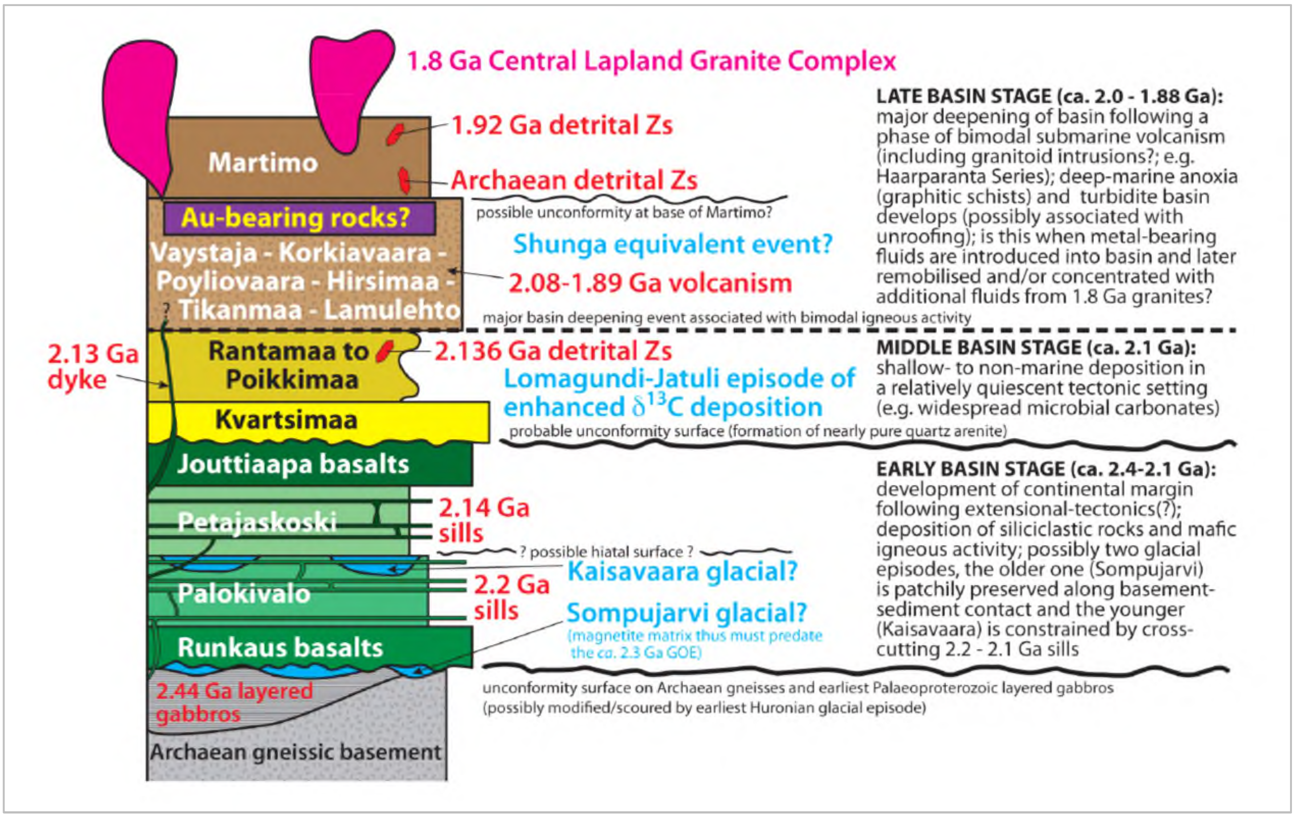

Figure 1: Regional stratigraphic framework for Peräpohja Belt based on a 2013 visit by Tony Prave (University of St Andrews, but data from many sources).

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One of the major questions in Lapland exploration relates to the correlation, or apparent lack thereof, of sequences in the Peräpohja Belt (PB) and the Central Lapland Greenstone Belt (CLGB). As the separation of these two belts is largely formed by the ca. 1.8 Ga granites there appears no reason for strong correlations between the rocks of the PB and the CLGB. On a larger scale, the Far Deep Drilling project in Karelian Russia provides a superb base for regional correlation of Finnish Paleoproterozoic sequences. Across the Rompas-Rajapalot project thick sulphidic organic rocks are mixed with sequence comprising clastic metasediments, marls, carbonates, metabasalts, komatiitic mafic volcanics and Mg-rich intrusives. In Karelian Russia the occurrence of organic-rich ("shungite") rocks, enclosed in clastic sediments, evaporites and mafic volcanics, including komatiitic rocks are the equated with the start of the PB "Late Basin Stage" or "Shunga equivalent event" as shown in Figure 1. Perhaps more controversially, we see no reason not to make similar correlations with the rocks of the Savukoski Group in CLGB.

Recent drilling at the Raja Au-Co prospect has uncovered a package of light purple anhydrite within folded foliated biotite-bearing calcschists. The anhydrite is interpreted as representing primary sulphate evaporites interspersed within dolomitic marls. They lie on the overturned limb of a major fold, structurally above and therefore stratigraphically below a local muscovite-bearing quartzite marker unit. Preliminary stable isotope data show a narrow band of $\delta^{34}S_{VCDT}$ values of 8 ‰. We are not aware of any other preserved sulphate evaporites in the Fennoscandian Paleoproterozoic. The stratigraphic location within the Peräpohja Belt of these anhydrite evaporites appears to be within the "Late Basin Stage".

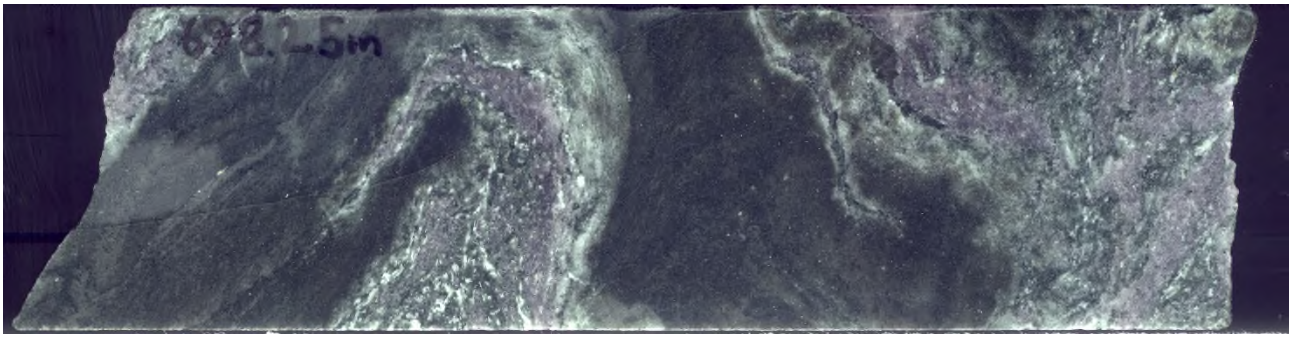

Figure 2a: Folded light purple anhydrite within biotite calcschists from 698.3 metres (drill hole PAL0180).

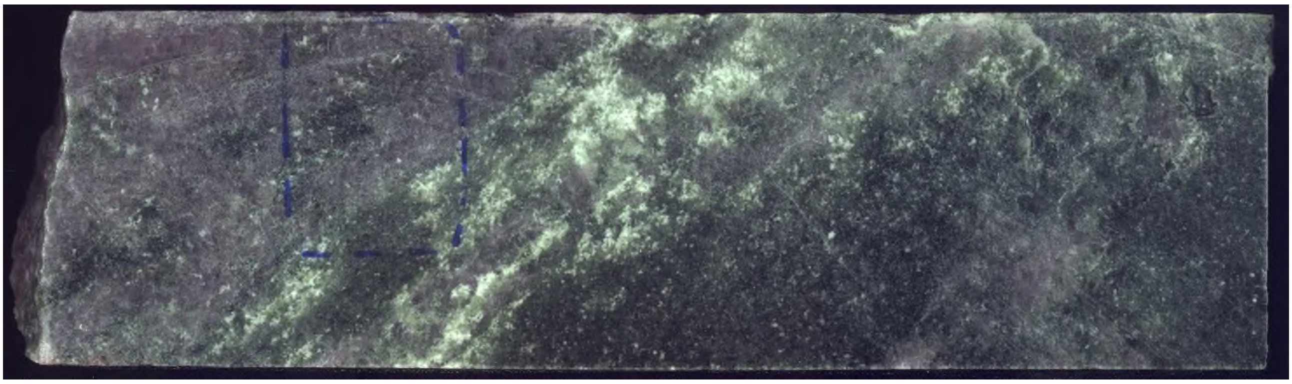

Figure 2b: Light purple anhydrite within biotite calcschists from 727.6 metres (drill hole PAL0180).

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A massive light pink albitised granodiorite occurs within the Rajapalot project area. Monazite from this sample provides a complicated history based on U-Pb data acquired. The oldest monazite age (2016±17 Ma) gives the closest approximation to the crystallisation age of the granite. Several other age population maxima exist in the data, most notably at 1916±11 Ma and 1713±11. Importantly, all of the monazites are likely hydrothermal, even the oldest grains, based on the low U/Th ratios that were measured. Consequently, the oldest age monazite age is a minimum age for this granodiorite.

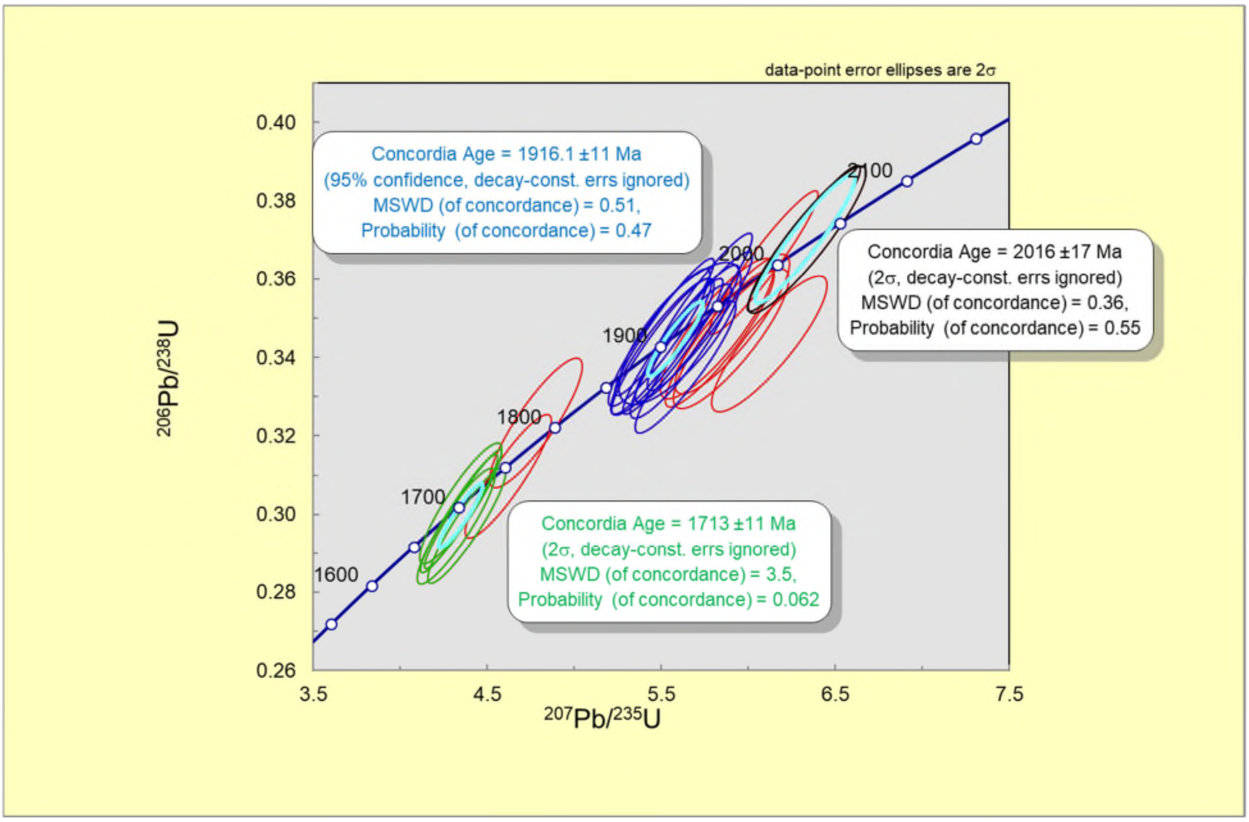

Figure 3: Concordia plot of monazite data from light pink albitised granodiorite from Rajapalot project area.

Mineralising events at Rompas-Rajapalot are likely to have commenced before ca. 2.05 Ga with epigenetic oxidised fluids interacting with reduced carbonaceous matter forming stratabound metal-anomalous black schists and dolomite veins with coarse uraninite porphyroblasts (the oldest uraninite and molybdenite ages are clustered in a band from 2.0-2.05 Ga; Figure 4). Fine molybdenite flakes, Cr- and V-rich muscovite and sphalerite are also described from thick carbonaceous hosts at Rajapalot.

The most significant mineralising event at Rajapalot occurs at ca. 1.77 Ga producing the Au-Co resources at Raja (the test site for the NEXT project), Palokas and South Palokas. A stratigraphic control to the Au-Co mineralisation is evident, but significantly in a polydeformed, amphibolite facies host package the high-grade gold-cobalt is linear reflecting a late structural control on the retrograde hydrothermal fluids. We interpret, in agreement with the views of Jukka-Pekka Ranta that the 1.78 Ga tourmaline-bearing granitoids visible in outcrop to the north, are the drivers of the hydrothermal systems. This so-called “late and straight” control to high grade Au (and cobalt) is not uncommon in Lapland.

The evolutionary history of the Peräpohja Belt at Rompas-Rajapalot reflects a series of distinct episodic events rather than the smoothed history portrayed by many. We look forward to fruitful discussions on the data presented over the NEXT two days.

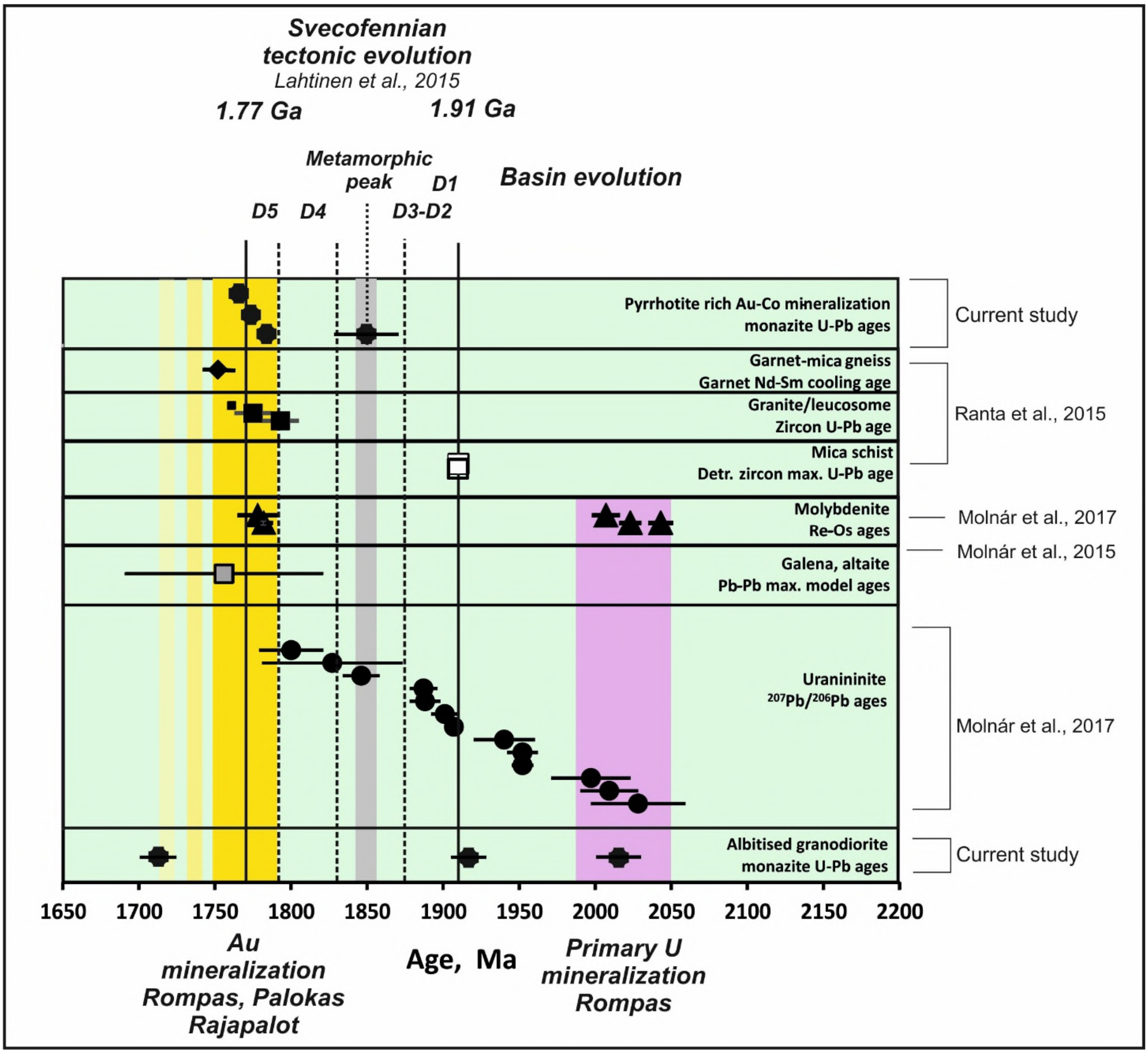

Figure 4: Summary of the ages of mineralising events at Rompas-Rajapalot

Acknowledgements

We are especially grateful to the geological team at Mawson, fellow researchers from GTK, students and staff of University of Oulu, Tony Prave (St Andrews) and consultants to Mawson who have all provided considerable input to the exploration program at Rompas-Rajapalot.

METAMORPHIC STRUCTURE OF NORTHERN FINLAND

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The bedrock of Northern Finland consists both Archean and Paleoproterozoic terrains, both being strongly metamorphosed and deformed over a period of more than 100 Ma at around 1.91-1.77 Ga (Sayab et al. 2019). The metamorphic structure of is characterised by juxtaposition of blocks whose grade changes from greenschist to granulite facies, originally metamorphosed at different crustal levels. The highest grade is represented by the Lapland Granulite Complex and migmatitic amphibolites south of it (including the so-called Tana Belt). South of this zone there are high pressure mid-amphibolite facies rocks (670-700 °C, 8-10 kbar) characterised by local migmatisation and garnet-kyanite-staurolite-biotite-muscovite assemblages in metapelites and garnet-hornblende-plagioclase assemblages in mafic rocks. Further south there are low-pressure mid-amphibolite facies rocks (560-600 °C, 4-5 kbar) with garnet-andalusite-staurolite-chlorite-muscovite assemblages with retrograde chloritoid and kyanite in metapelites and hornblende-plagioclase-quartz±garnet in metabasites. The Central Lapland Greenstone Belt consists greenschist facies rocks (350-400 °C) with white mica-chlorite-biotite-albite-quartz assemblages in metapelites, and actinolite-albite-chlorite-epidote-carbonate assemblages in metabasites. The area east of the Sodankylä township shows prograde metamorphism from low amphibolite facies andalusite-kyanite-staurolite-muscovite-chlorite-chloritoid schists to mid amphibolite facies kyanite-andalusite-staurolite-biotite-muscovite gneisses and upper amphibolite facies garnet-sillimanite-biotite gneisses. In the Central Lapland Granitoid Complex area amphibolite facies metamorphism (640-700 °C, 5-7 kbar) represents low pressure andalusite-sillimanite type but kyanite is locally found, indicating earlier higher pressure. The Peräpohja Belt shows a progressive increase in metamorphic grade from low-pressure greenschist facies schists in the southwest to andalusite-cordierite gneisses in the north, and obviously a fault-related change from these low pressure gneisses to high-pressure kyanite-bearing migmatites in the northeast. Also in the Kuusamo Belt the grade increases from greenschist facies in the SE to migmatites in the NW.

In many places Proterozoic amphibolite facies rocks exhibit clockwise decompressional PT paths where the early metamorphism took place at around 8-10 kbar, followed by nearly adiabatic decompression to 4-5 kbar. This is manifested by decomposition of early garnet, staurolite and kyanite to cordierite and andalusite and by strong zoning in garnet. Similar PT evolution can be seen in the Archean Tuntsa Suite that underwent penetrative Proterozoic deformation and metamorphism. The Northern Finland area underwent a succession of tectonic shortenings (Sayab et al. 2019) and the present metamorphic structure was developed coevally, during a long time. The U-Pb data on metamorphic zircon and monazite show a spread of ages from 1.91 Ga to 1.77 Ga. Most monazites both in the Archean and Proterozoic terrains yield c. 1.80-1.77 Ga ages.

Reference

M. Sayab, F. Molnár, D. Aerden, T. Niiranen, J. Kuva & J. Välimaa (2019). A succession of near-orthogonal horizontal tectonic shortenings in the Paleoproterozoic Central Lapland Greenstone Belt of Fennoscandia: constraints from the world-class Suurikuusikko gold deposit. Mineralium Deposita, published online (https://doi.org/10.1007/s00126-019-00910-7).

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NEXT GEOPHYSICAL SURVEYS AT MAWSON RAJA PROSPECT

Jarkko Jokinen

Loop and Line Oy

The electromagnetic reference measurement was conducted in mid-summer 2019. The FrEM system used consists fixed-loop transmitter antenna and a mobile coil receiver. The arrangement in the Raja prospect site is shown in Figure 1.

During the six measurement days, 140 stations were measured at 41 frequencies between 100 and 10,000 Hz. On the seventh day, the data were lost due to a lack of GPS signal quality. The electromagnetic data has calibrated dB/dt values (nT/s) in 3 orthogonal directions with In-Phase and Quadrature components.

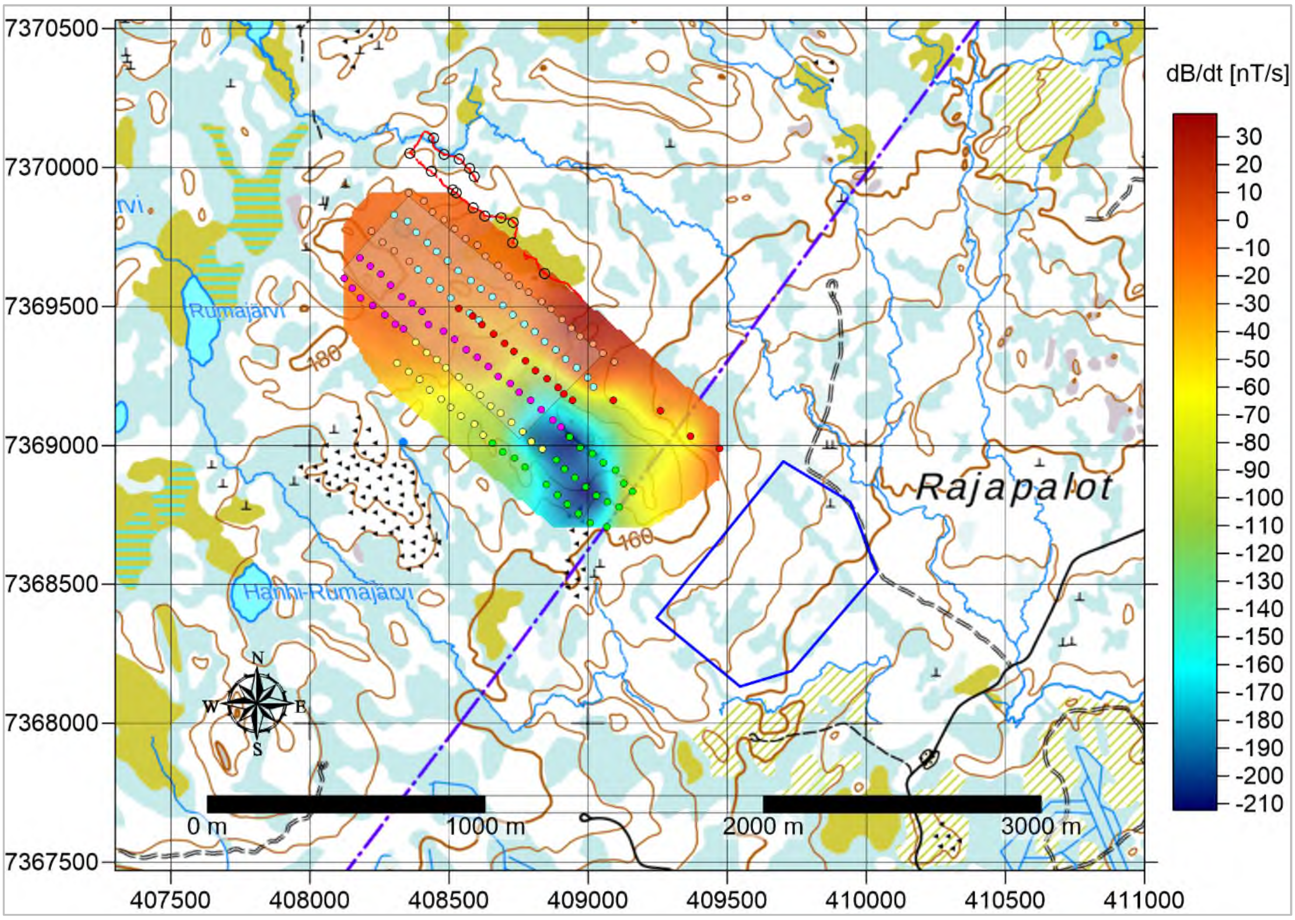

Figure 1. Arrangements for reference measurements at Raja site. Loop size is about 500 m x 750 m (blue line). Receiver stations are marked with circles - different colour for each day. The map and the colour scale represent the variation of a primary tangential EM-field at 6868 Hz.

Conductive mineralisation in the middle of the measured area is detected weakly and only with the highest frequencies. The transmitter's power extended over the entire measuring range. The farthest stations are about 1700 metres from the loop. No clear large-scale conductor structures are observed in the region that would generate induction currents or act as a galvanic conductor. Results are still being processed.

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EVOLUTION OF 3D UNDERSTANDING OF GEOPHYSICS AND ITS RELATION TO MINERALISATION AT RAJAPALOT PROSPECT

Janne Kinnunen

Mawson Oy

Geophysics has long played a role in exploration where cover is extensive and the Rompas-Rajapalot project in southern Lapland is no different. With more than 99 % of the project area covered with fluvioglacial till averaging 5-8 metres thick, remote sensing methods are required to increase the probability of exploration success. When geophysical methods can be combined successfully with surface and drill-based geochemistry both the cost and the impact of exploration are reduced. The evolution of exploration at Rompas and Rajapalot reflects the growth of knowledge based on geophysical methods used in conjunction with a strong geological technical team. Wet bogs, swamps and snow make for challenging survey conditions.

Initial discovery in 2008 at Rompas-Rajapalot was based on national airborne geophysical data using an exploration model based on uranium deposited by oxidized fluids at reductive boundaries. Mawson used a combination of GTK regional magnetic and radiometric surveys to focus on the Rompas area. Ground-based follow-up showed a 6 kilometre-long ridge with gold associated with porphyroblastic uraninite within dolomite-calcsilicate veins hosted by amphibolite facies polydeformed metabasalts. Gradient array induced polarisation and resistivity surveys were a useful tool in mapping the weakly sulphidic metabasalts, but current channeling by graphitic meant careful placement of electrodes was required.

Regional exploration across a broad area during 2012 resulted in the first discovery of gold in outcrop at Palokas approximately 8 kilometres to the east of Rompas. This eastern area is now known as the Rajapalot project. Airborne TEM and magnetics were flown by helicopter in 2013 and have been followed by a wide variety of ground-based methods. These include gradient array IP-resistivity, pole-dipole IP-resistivity, ground magnetics (Figure 1) with line spacings as little as 15 metres, VLF-R, ground TEM, down-hole EM and mise-á-la-masse (MALM). NEXT geophysical surveys are now building on this dataset with a focus on the Raja prospect.

The gold-cobalt mineralisation at Rajapalot is strongly associated with pyrrhotite, providing a conductive, magnetic and chargeable response and is locally associated with slightly elevated U and K (radiometric response). The pyrrhotite at Rajapalot is characterized by strong reverse remanence with correspondingly very high Konigsberger ratios (Q). Both the host pyrrhotite and the immediately adjacent pyrite are the sources of the IP response. The connected nature of the pyrrhotite, varying from massive at Palokas to more foliated at Raja form strong conductors, evident in all of the electrical methods used to date (Figures 2, 3).

The enclosing alteration halo comprises albite-rich rocks, commonly with magnetite in addition to a thick package of muscovite-bearing quartzite. The strong contrast between the conductive pyrrhotite rocks and the adjacent resistive albitic and quartzite has resulted in the ability to track mineralisation to greater than 600 vertical metres. MALM has been successfully used to show continuity from drill holes extending to the surface, in addition to mapping the sub-surface extent of sulphide distribution.

Creation of a combined RGB image comprising reverse remanence, chargeability and conductivity as the three components has been successful in locating further mineralisation intersecting the till-bedrock interface. Palokas, South Palokas and Raja inferred mineral resources all contain the characteristic three component signature.

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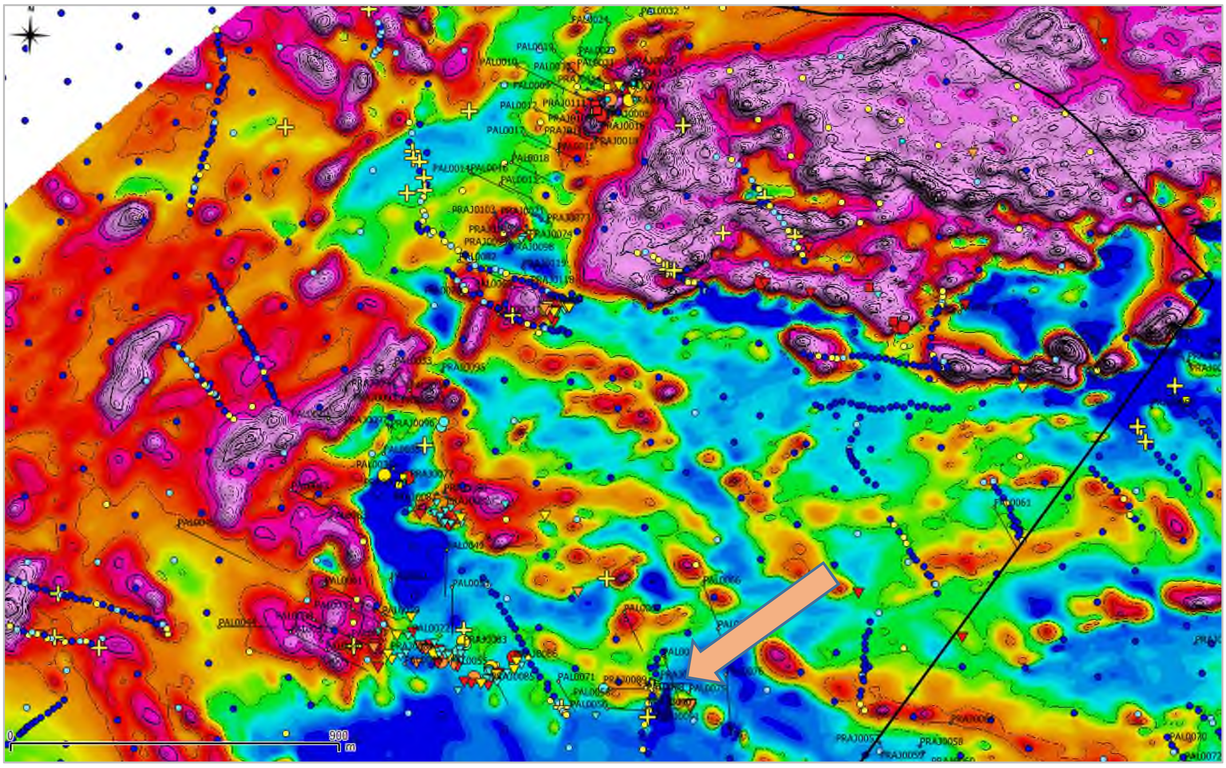

Figure 1: Ground magnetic survey results at Rajapalot – (RTP image). Note the magnetic low associated with Raja mineralisation intersecting till interface (arrow).

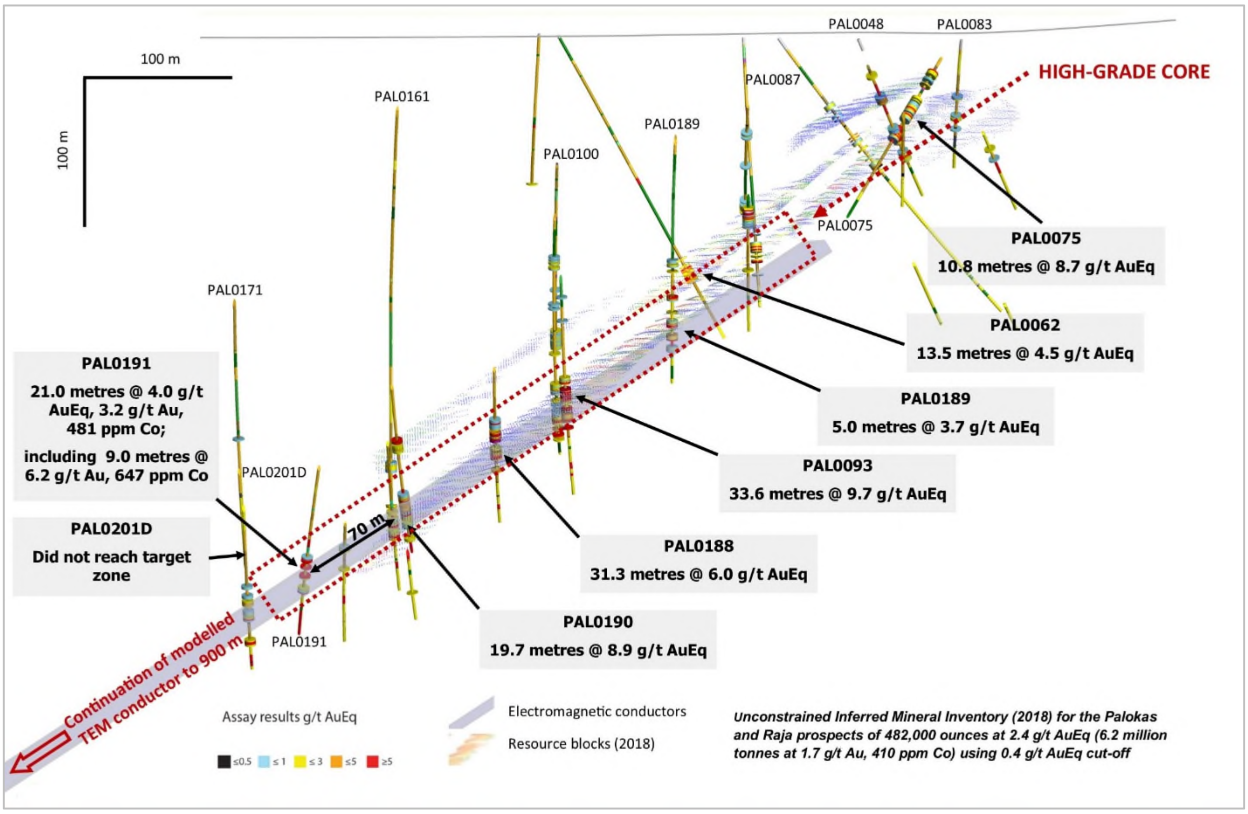

Figure 2: Drill intersections at Raja prospect in gold equivalent (Au & Co) showing modelled electromagnetic conductors (pale blue) and resource blocks. View is towards 070 degrees (location in plan view shown in Figure 3 over page).

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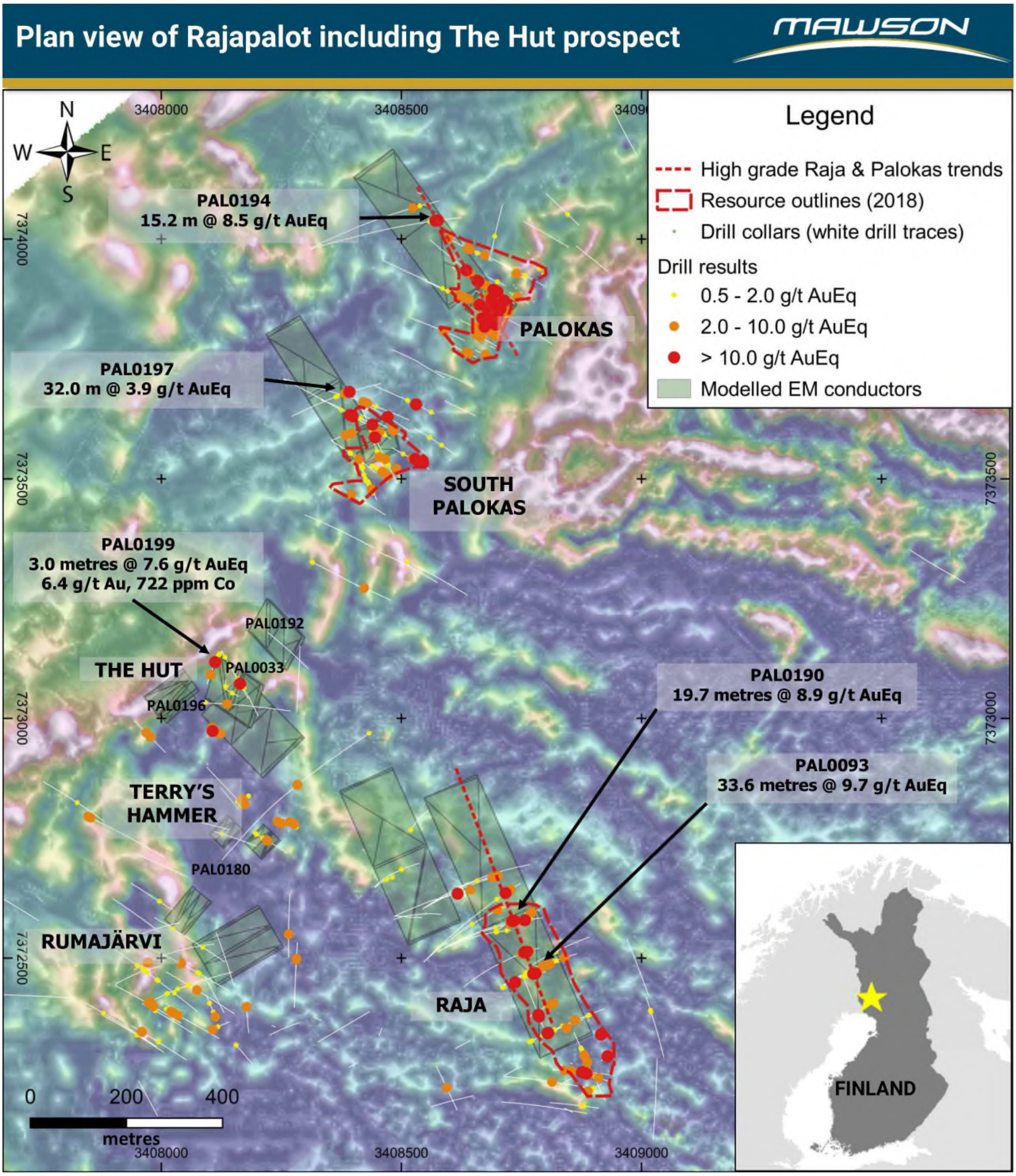

Figure 3: Location of resources and high-grade drill intersections with respect to modelled electromagnetic conductors.

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STRUCTURAL EVOLUTION OF THE PERÄPOHJA BELT: VARIATIONS IN STRUCTURAL COUPLING BETWEEN THE ARCHEAN BASEMENT AND THE PALEOPROTEROZOIC COVER STRATA

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The complex architecture of the Peräpohja Belt has been recently attributed to reactivation of pre-existing belt-scale discontinuities in the underlying Archean basement. The development of large compressional structures was controlled by reverse and thrust faulting of the basement, caused by a basin inversion after a long period of varyingly active rifting between 2.44-1.9 Ga. In addition, the final manifestation of the produced structures was affected by the physical properties of the stratigraphic units that were deposited in the basin during the extension. Analysis of variations in the style of fold and shear structures, combined with reconstructed stratigraphic thicknesses of the supracrustal units throughout the Peräpohja Belt, show two distinctly contrasting types of coupling between the Archean basement and the overlying Paleoproterozoic cover: hard and soft linkage.

The mechanically weak basin-wide Petäjäskoski Formation hosts a detachment surface (Petäjäskoski detachment zone, or PDZ), structurally separating the overlying extensively folded strata from the lowermost supracrustal rocks and the basement. The effect of the detachment is most evident from fold patterns in the southern part of the Belt, near the NE-striking contact of the Archean and Proterozoic rocks: Petäjäskoski Formation is intensely sheared and the fold geometries of the overlying flood basalts of the Jouttiaapa Formation are typical for detachment folds in parallel-style folding.

The PDZ is responsible for the decoupling between the shear structures of the cover and the basement, forming a soft-linked system. Therefore, even abrupt changes in the topography of the Archean basement are only visible from variations of the stratigraphic thicknesses in the cover strata. Moreover, any basement-derived faults beneath the PDZ occur as blind faults. The reconstructed thicknesses show a presence of large-scale block structures in the basement, resembling horsts and grabens also indicated by Bouguer anomalies. A large fault zone (Sihtuuna Fault) north of the basement horst structures juxtaposes the lowermost stratigraphic formations (Sompujärvi and Runkaus Formations) against the youngest unit (Martimo Formation), dividing the entire Belt in two along an E- to NE-striking discontinuity. The stratigraphic thicknesses and the present vertical level of the lowermost units indicate that the Sihtuuna fault is derived from a reactivated fault in the basement, and thus it forms a hard-linked system.

Most of the currently known mineral occurrences (Au, Cu) are located close to the exposed or blind basement discontinuities. A comprehensive structural model of the basement and the cover sequence is therefore a crucial step in understanding the controls of ore mineralisation within the Peräpohja Belt.

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MINERAL TRACE ELEMENT AND SULPHUR ISOTOPE GEOCHEMISTRY FROM THE RAJA AU-CO PROSPECT: PRELIMINARY RESULTS AND IMPLICATIONS IN VECTORING TO ORE

Sara Raic[1], Ferenc Molnár[1], Nick Cook[2], Hugh O`Brien[1], Yann Lahaye[1]

[1] Geological Survey of Finland, [2] Mawson Resources Limited

Analysis of trace element contents of sulphide and other minerals by LA ICPMS has become a widely used method for the definition of vectors to ore during the past decade. In addition to the high spatial resolution and low detection limits, one of the major advantages of the LA ICPMS analytical technique is that analyses can be performed on polished thin sections, thus the textural-paragenetic settings of mineral grains can be considered in interpretation of data. Another advantage of the method is that the trace element data can be paired with sulphur (or other) isotope data from the same mineral grain or even from the same growth zone of a mineral grain. If proper standardisation (matrix matching of the standard with the analyzed mineral) is resolved, the analytical method offers the opportunity to build a robust data base from a large number of samples in a relatively short period of time. Thus the technique has capacities to provide effective support not only to academic research, but importantly, to mineral exploration.

In the framework of the Horizon 2020 NEXT project, we are testing the vectoring capacities of sulphide mineral trace element data and associated sulphur isotope composition at the Raja Au-Co prospect. The motivation behind this research is based on the results of our earlier sulphur isotope analyses from the Rompas Au prospect, which is located just a few kilometers to the west from our current target area. At Rompas, we found that sulphur isotopes distinguish well the gold-bearing and gold-absent hydrothermal zones in a multiply mineralised system. For the purposes of the current study, we collected about 80 samples from drill cores with Co-Au and Au mineralised zones as well as barren zones (Fig. 1). At the current stage of the work, about a quarter of the samples have been analyzed. The major lithologies along the profile of drill cores comprise variously altered and deformed calcsilicates that alternate between albitised metasediments, mafic volcanics, amphibolites and quartzites. Sulphide mineralisation is either disseminated, oriented according to the rock fabric or fracture filling.

Preliminary results show that cobalt contents in pyrite are between 50 and 500 ppm, with a few grains having values of up to 36000 ppm; while most of Ni-contents fall in the range of 20 to 80 ppm, with a few data in the range of 120 to 260 ppm and some exceptional values up to 3500 ppm in fracture-filling pyrite. Au contents usually do not exceed 0.06 ppm. The highest Au values with up 290 ppm are detected in cobaltite, which also shows the highest contents in Te (3502 ppm), Sb (4645 ppm) and Se (3013 ppm). The Co, Ni and other trace element contents and ratios do not discriminate pyrite grains in different textural settings as large variations can be observed within grains (Figure 2). This peculiarity invokes that disseminated and fracture hosted ore was formed synchronously from solutions with fluctuating compositions or under variable redox conditions affecting partitioning of Co, Ni and other metals between pyrite, cobaltite and the hydrothermal solution. It is also possible that both types of ore were overprinted by younger (gold-only?) mineralisation stages.

The range of δ^{34}SVCDT values measured in pyrite, pyrrhotite and chalcopyrite is from -3 to + 14 ‰. The $\delta^{34}S_{VCDT}$ values from sulphide grains from mineralised zones with high Co and Au concentrations are in a relatively narrow range, between 0 and 5 ‰. It is remarkable that a similar range of sulphur isotope data

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characterise the gold rich zones at Rompas. However, this range of S isotope data also occurs in barren zones at Raja prospect. Negative $\delta^{34}S_{VCDT}$ signatures are less common, but some Au mineralised zones which also show copper enrichment are characterised by values higher than 5 ‰. Variations in the sulphur isotopic signature could be the result of different sources, as well as the variation in the oxidation state of the fluids.

Further work will be focused on multivariate statistical analysis of the trace element combined with sulphur isotope data taking into account the textural settings and paragenetic properties of the samples. Variations in redox conditions during fluid-rock interaction and its effect on trace element and sulphur isotope compositions will also be evaluated.

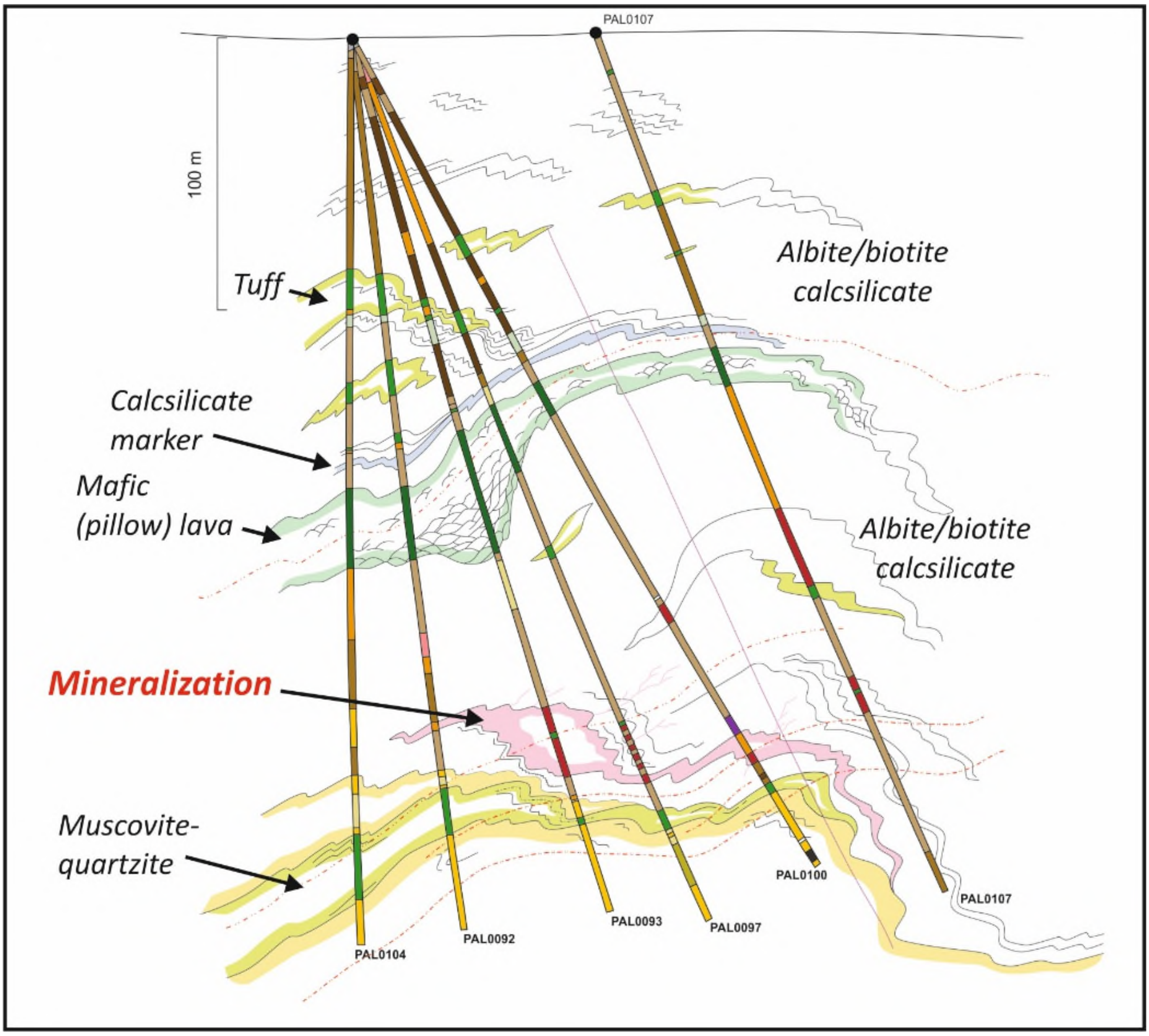

Figure 1: Cross section profile at the Raja prospect with the drill cores sampled (view looking to 340°).

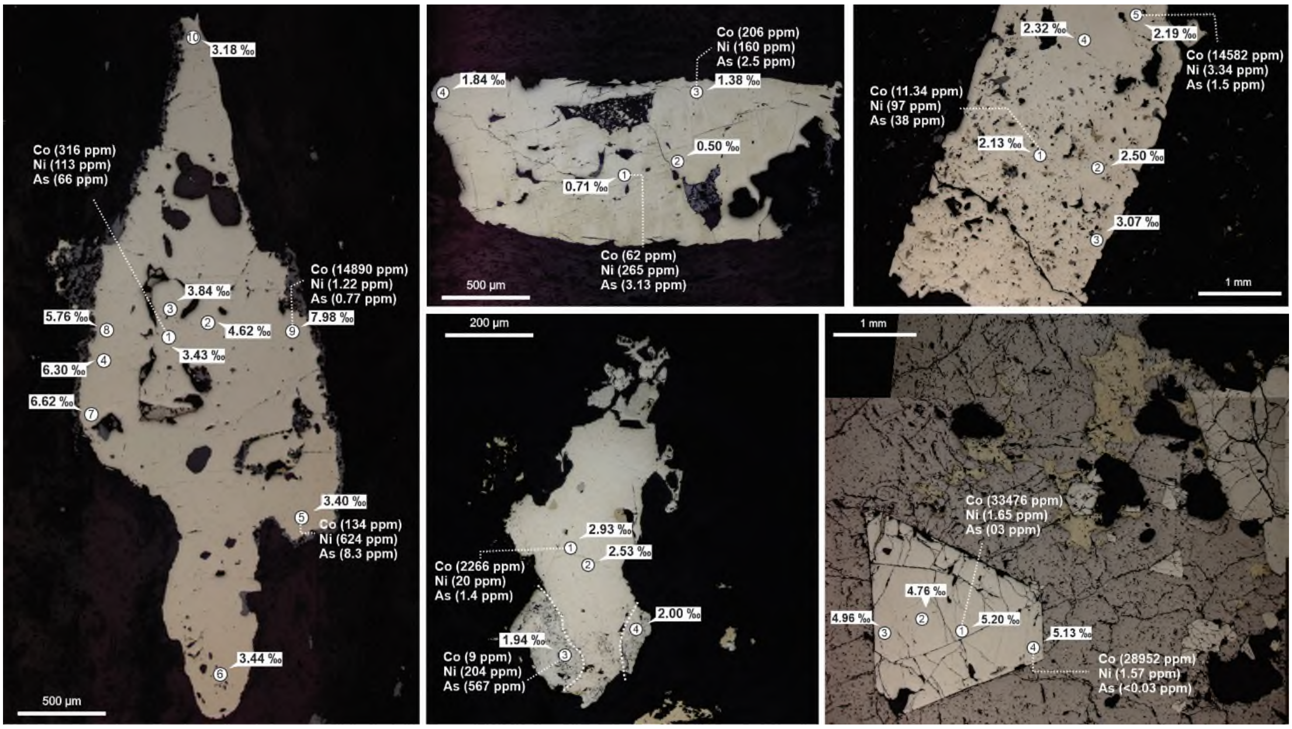

Figure 2: Examples of LA ICPMS trace element and sulphur isotope analyses from pyrite at the Raja prospect. Note the high intragrain variation in the Co and Ni concentrations.

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GEOLOGICAL EVOLUTION AND GOLD MINERALISATION IN THE NORTHERN PART OF THE PERÄPOHJA BELT, FINLAND: EVIDENCE FROM WHOLE-ROCK AND MINERAL CHEMISTRY, AND RADIOGENIC AND STABLE ISOTOPES

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Multiple occurrences of gold mineralisation have been identified during the last decade in the municipality of Ylitornio, southwestern Finnish Lapland. The region enriched in gold is at least 10 by 10 km, and comprises two main parts, Rompas in the west and Rajapalot in the east. Geologically, the Rompas-Rajapalot prospect area is located in the northern part of the Peräpohja Belt, a Paleoproterozoic supracrustal sequence deposited on the rifting Archean basement at ca. 2.4–1.9 Ga and metamorphosed during the Svecofennian composite orogeny at ca. 1.90–1.77 Ga. The aim of this study was to obtain geological, geochemical and geochronological information on the different lithological units of the northern part of the Peräpohja belt and to study the general features of the host rocks for gold, distribution of gold within the host rocks, composition and origin of mineralising hydrothermal fluids, focusing mainly on the Palokas prospect, one of the best gold occurrences in the Rajapalot area. The study presents U-Pb zircon data and whole-rock Sm-Nd isotope data from metasedimentary and intrusive rock units from the northern part of the Peräpohja Belt, petrographic observations and mineral and whole-rock chemical data from the main lithological units associated with gold at Palokas. Furthermore, in order to evaluate the source of gold-bearing hydrothermal fluids, boron isotope compositions were determined for tourmaline from three rock associations: gold-mineralised cordierite-orthoamphibole rocks at Palokas, a 1.78 Ga granitic intrusion, and a metasedimentary rock unit with an evaporitic origin, with the latter two occurring close to the Palokas mineralisation. Using microthermometry and Raman spectroscopy, analyses of fluid inclusions in tourmaline related to gold at Palokas were performed to obtain information on the composition of the hydrothermal fluids and temperature-pressure conditions during the formation of the gold-bearing quartz-tourmaline-sulphide veins. Whole-rock geochemistry from gold-bearing rocks and interlayered calcsilicate-albite rocks was employed to evaluate their potential protoliths.

The host rock type for gold at Palokas is cordierite-orthoamphibole rock, which is distinctly poor in Ca and rich in Fe and Mg compared to the interlayered calcsilicate-albite rocks. Gold occurs in a native form in at least two different textural settings: 1) single, relatively coarse grains disseminated among the rock-forming silicates in cordierite-orthoamphibole rocks and 2) smaller grains occurring in fractures of tourmaline in quartz-sulphide-tourmaline breccias and in fractures of chloritised cordierite-orthoamphibole rocks adjacent to the tourmaline-rich breccias. The latter, fracture-related gold is associated with Bi-Se-S-bearing tellurides, native Bi, molybdenite, chalcopyrite, and pyrrhotite. Coarser, disseminated gold grains were not found to be clearly associated with sulphides nor any fractures. Statistical data show that Au correlates strongly with Te, Cu, Co, Se, Bi, Mo, and Ag (ρ=0.730–0.619), moderately with As, Fe, W (ρ=0.523–0.511) and slightly less with U, Pb, and Ni (ρ=0.492–0.407). Tourmaline occurs as tourmaline-rich veins and individual tourmaline crystals within sulphide-rich gold-bearing rocks. Furthermore, it is abundant in late- to post-orogenic pegmatitic granites and in an evaporitic rock unit (the Petäjäskoski Formation), both located nearby the mineralised rocks. Tourmaline from all the mentioned units belongs to the alkali-group and can be classified as dravite and schorl. The $\delta^{11}B$ values of the three localities lie in the same range from 0 to −4 ‰ (Figure 1). Fluid inclusion compositions from tourmaline in gold-bearing quartz-tourmaline-sulphide veins indicate that the

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veins were formed from H_2O-NaCl-CO_2-CH_4-(H_2S) fluids in a boiling system under pressure conditions ranging from lithostatic to hydrostatic, at depths of ~5 km and the temperature ~300˚C. Based on the studies done in this work and performed by others, there seems to be a temporal, spatial and genetic link between the late-orogenic granitoid magmatism and fracture-related gold at Palokas. Currently, there is no clear genetic classification that can be applied to the gold occurrences in the whole Rompas-Rajapalot area and hence further studies are required.

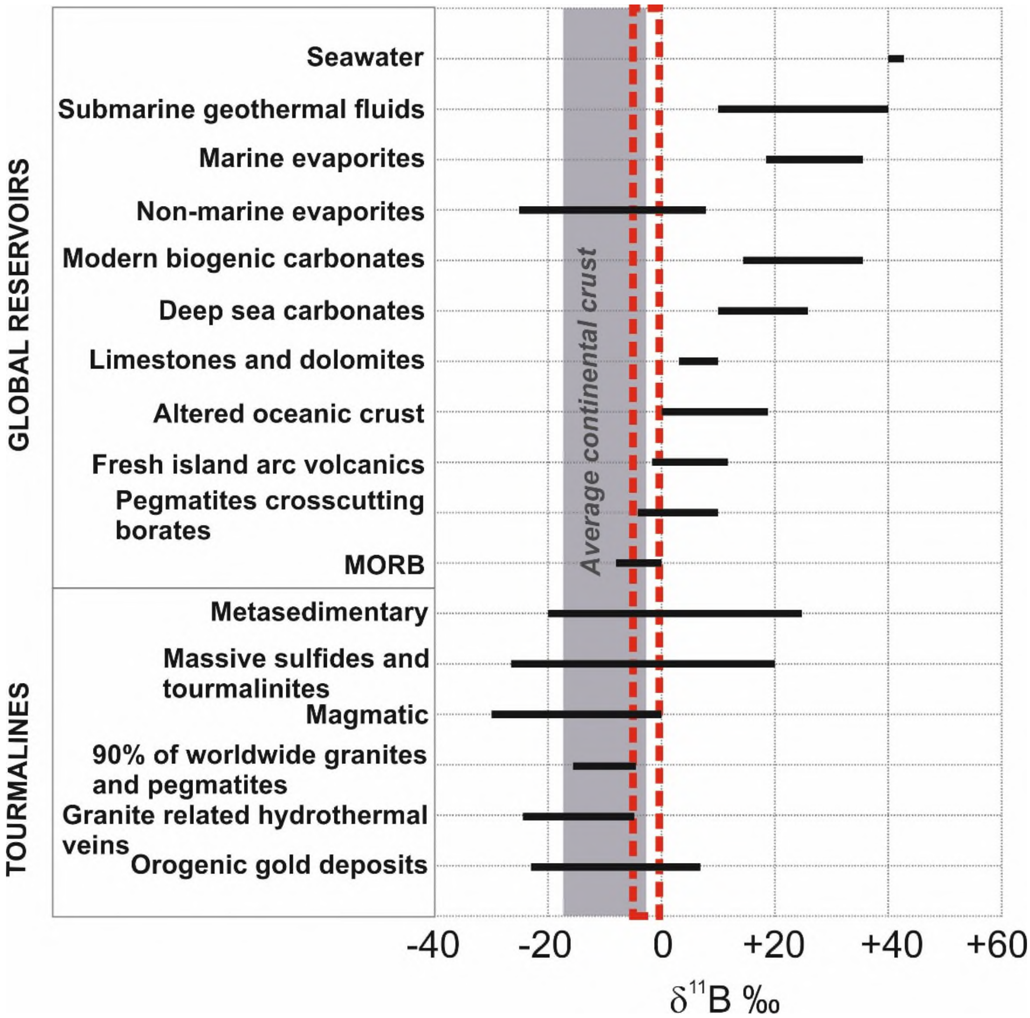

Figure 1: Boron isotope data for tourmaline from different geological settings and global reservoirs are modified after Garda et al. (2009). Boron isotope data from this study are shown in red stippled outline. The $\delta^{11}B$ values in natural reservoirs are after Palmer and Swihart (1996). Compilation of boron isotope data from granite and pegmatite is after van Hinsberg et al. (2011). Boron isotope data for orogenic gold deposits are after Jiang et al. (2002), Krienitz et al. (2008), Garda et al. (2009), and Beaudoin et al. (2013).

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GEOCHEMICAL SAMPLING AT THE RAJAPALOT PROJECT

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Environmentally friendly, low-impact surficial geochemical sampling methods were studied in the Rajapalot project area, in southern Finnish Lapland as a part of the NEXT project. A sampling point network included 92 points covering about 10 km^2 target area. Sample materials included topsoil mineral and organic sediments, plant, snow and transpired fluids. The sampling was supported by soil electrical conductivity and dielectric permittivity and pH measurements as well as portable XRF analyses in the field. For the soil geochemistry B-horizon samples were collected for ionic leach and aqua regia based dissolution analyses and Ah samples for modified aqua regia analyses. In addition, a duplicate sample set of B-horizon mineral soil material was collected for the multi-elemental fine fraction (MEFFA) analyses and about 30 samples were collected for the laboratory method development of the Lorraine University. For the biogeochemical analyses, Norway spruce bark, foliage and resin, Scots pine bark, Common juniper foliage and Northern bilberry foliage were collected. Furthermore, the test set of samples for the transpired fluids of Northern spruce were collected and send to the Mineralogical Laboratory of the Geological Survey of Finland for HR-ICP-MS analyses and the University of Eastern Finland for the water-XRF analyses. During the writing of this abstract, much of the analytical work remains incomplete, and therefore preliminary results are presented in the seminar.

Figure 1: Surface geochemical sampling methods: mineral and organic topsoil, pine bark and snow.

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Figure 2: Supporting field measurements: pH, dielectric permittivity and electrical conductivity.

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THE RIFTED ARCHAEAN BASEMENT AND ITS INFLUENCE ON THE DEVELOPMENT OF THE PERÄPOHJA BELT

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Reactivation of pre-existing geological structures is an important mechanism that provides important controls on the style and localisation of deformation, deposition of the supracrustal successions and, consequently, localisation of mineral deposits. Recent structural analysis of the supracrustal Paleoproterozoic Peräpohja Belt (PB) in Northern Finland has pointed out an intimate relationship between the evolution of the Peräpohja Belt and the underlying Archaean basement through addressing the localisation of the major faults to hard and soft linkages with the reactivated basement discontinuities. Interpretation of the reflection seismic and structural field data within the boundary zone between the Archean and Proterozoic led to recognition of a distinct geological domain where the structural signatures of the initial rifting of the Archean continent at around 2.44 Ga were preserved due to strain partitioning into the underlying gently-dipping deformation zones. Rotational restoration of syn-rift faults within this domain indicates that local NE-SW extension directions prevailed at the time of 2.44 Ga rifting of the Archaean continent. This paleostress field is compatible with development of NW-SE trending normal faults in PB and a structural setting at a left overstepping zone of major sinistral N-S trending deformation zones similar to, for example, the Pajala shear zone. By contrast, development of the E-W to ENE-WSW trending horsts underlying the Peräpohja supracrustal rocks is attributed to the reactivation of the basement structures which according to orientation analysis of the planar deformation structures provides suitable structural anisotropies. Sandbox analogue models were conducted to test the reactivation potential of pre-existing structures within a pull-apart setting. The initial results indicate that suitably oriented old structures get reactivated, and ongoing work further highlights the significance of both the orientation of the reactivated structures with respect to the ambient stress field and the overlapping/underlapping character of the master faults.

These developments in understanding the basement-cover linkages highlight that that structural signatures related to the rifting of the Archean continent are essential in understanding the subsequent structural overprint and mineralisation processes. As many of the supracrustal belts in Northern Finland are relatively shallow the results will be applicable as guidelines to evaluate the structural linkages and inheritance.

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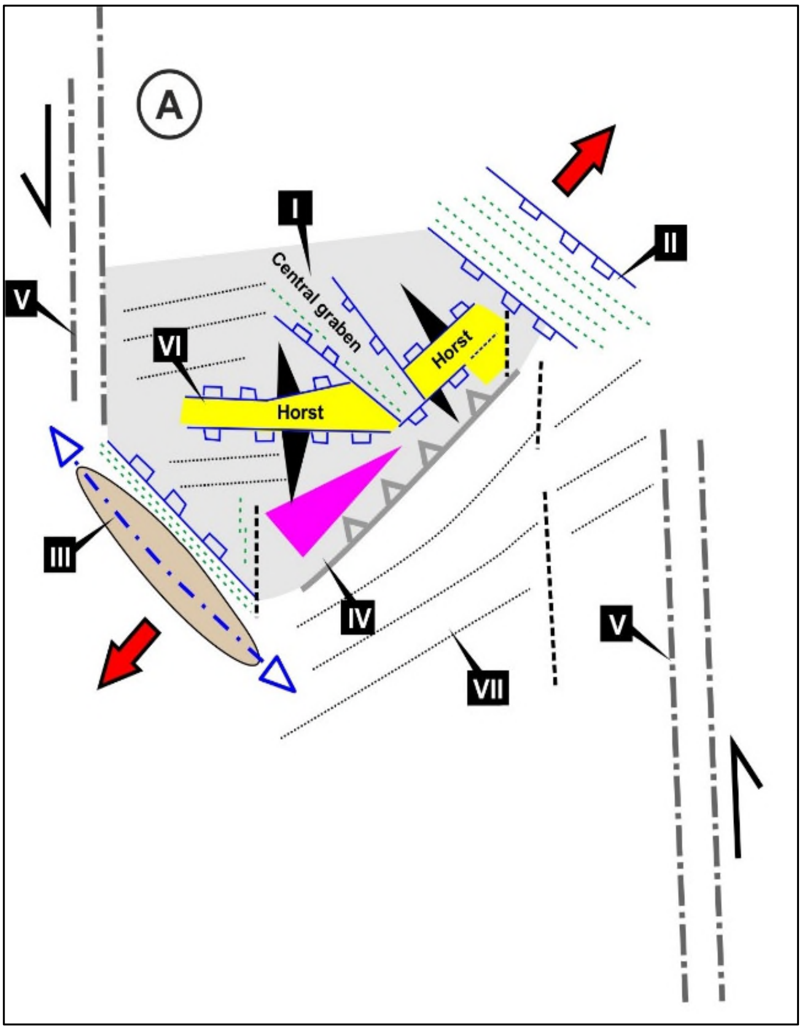

Figure 1: The suggested pull-apart setting for the Peräpohja Belt (modified after Piippo et al., 2019; Skyttä et al., 2019) is supported by the following features. I: The central graben is compatible with NE-SW extension, II & III: Tectonised NE and SW margins (strike-slip & shear & doming) formed be reactivation of primary normal faults. IV: Non-tectonic contact between the Archean and Proterozoic domains in South-East. V: Major N-S deformation with left overstepping geometry accommodated the strike-slip deformation and caused the development of the basin. VI: Reactivated E-W to ENE-WSW trending basement structures control the paleotopography of the top of the Archaean basement, including the development of major horsts and grabens. VII: Anisotropy orientations within the exposed Archean basement.

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DISCRIMINATION OF GOLD AND COBALT MINERALISING EVENTS AT THE JUOMASUO AU-CO DEPOSIT, KUUSAMO BELT, NORTHEASTERN FINLAND

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With the cobalt demand related to rechargeable batteries expected to rise in the following years, a better understanding of the formation processes of the already known Co-rich deposits in the Northern Fennoscandian Shield is needed to enhance successes of exploration for new deposits. This study concentrates on the Juomasuo Au-Co deposit, which is located in northeastern Finland, approximately 45 km north of the town of Kuusamo. The Juomasuo deposit is situated in the Paleoproterozoic Kuusamo belt (KB) and is part of the Kuusamo-Kuolajärvi orogenic gold metallogenic area, comprising several epigenetic Au-Co occurrences. The rocks comprising the KB are part of the Karelian supracrustal formations. Their age ranges from 2.5 to 1.9 Ga. The KB was at least partially formed in an intracratonic failed rift setting related to the Paleoproterozoic breakup of the Archean Karelian craton. The KB consists of several formations of volcanic and sedimentary origin, including three stages of mafic volcanism with associated mafic sills and dykes. The stratigraphic sequence of the KB underwent deformation and regional metamorphism during the Svecofennian orogeny. The metamorphic grades vary from lower greenschist facies in the central parts of the belt to upper amphibolite facies in the western and eastern parts of the KB.

The Juomasuo deposit is the most important known epigenetic-hydrothermal Au-Co deposit in the Kuusamo belt. The host rocks of the Juomasuo deposit are characterised by strong albitisation but the mineralised zones also contain quartz, chlorite, biotite, sericite, carbonate, amphibole and talc in addition to albite. The most abundant sulphide is pyrrhotite followed by pyrite and lesser chalcopyrite. Cobaltite can be found in the Co-rich parts of the ore as inclusions in pyrrhotite and sometimes in pyrite. Cobalt pentlandite is also present mainly as exsolutions in pyrrhotite. Molybdenite, rutile, magnetite, native Au and tellurides (altaite, tellurobismuthite and melonite) are noteworthy accessories in the deposit.

For the purpose of better understanding the hydrothermal processes that led to the Au-Co mineralisation in Juomasuo we applied in situ multi- and single collector LA-ICP-MS analytical techniques to study the sulphur isotope and trace element characteristics of sulphides. Analytical spots for sulphur isotope and trace element determination were placed next to each other. Matrix-matched sulphide standards were used during these analyses. Additionally, we utilised whole-rock geochemical data in order to classify the heavily altered host rocks and to study the control of the alteration mineralogy on the mineralisation types with different metal associations at Juomasuo.

Previous studies have described the heavily altered and metamorphosed rocks at Juomasuo mainly on the basis of the dominating alteration minerals. We combined drill core observations with immobile element ratios and recognised the following six rock types: ultramafic, mafic, intermediate and felsic metavolcanic rock, metasediment and albitite. By studying samples with different degrees of Au and Co enrichment together with our classification of the different rock units at Juomasuo, we conclude that both Au and Co

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mineralisation are present in all of the rock types, apart from the mostly barren albitites and the ultramafic rock.

A second application of the lithogeochemical database was to calculate Molar Element Ratios (MER) to determine the control of the alteration mineralogy on the different types of mineralisation. The MER diagrams show that different types of alteration affected different rock types. By plotting the gold and cobalt grades together with the MER data for the metavolcanic rocks it seems that gold enrichment is mainly associated with sericite alteration and much less with chlorite-biotite alteration. Co enrichment is strongly associated with chlorite-biotite and amphibole alteration and additionally with sericite alteration. Similar trends exist for the metasediments.

The Juomasuo Au-Co deposit is characterised by multi-stage hydrothermal processes that are recorded in the sulphur isotope and trace element characteristics of sulphides. A hydrothermal stage responsible for the accumulation of the Co-only ore and some Au-Co mineralisation deposited pyrite with very high Co/Ni ratios, low Se/S ratios and positive $\delta^{34}S$ values with a relatively narrow range. This stage could be attributed to a single hydrothermal event and a homogeneous sulphur source. Pyrite from another stage of hydrothermal activity that created mostly Au-Co mineralisation is characterised by much lower Co/Ni ratios, a wide range of Se/S ratios, $\delta^{34}S$ values and high Ni, Se and Te contents. These characteristics could indicate a mixing of different fluid and sulphur sources. The distinct sources of parent fluids are also supported by the contrasting alteration parageneses of the same lithologies depending on enrichment type. The Au-Co mineralisation in Juomasuo is mainly controlled by sericite alteration zones whereas the Co-only mineralisation by chlorite-biotite alteration.

FIELD GUIDE TO RAJAPALOT PROJECT AREA

Mawson OY Geological Team
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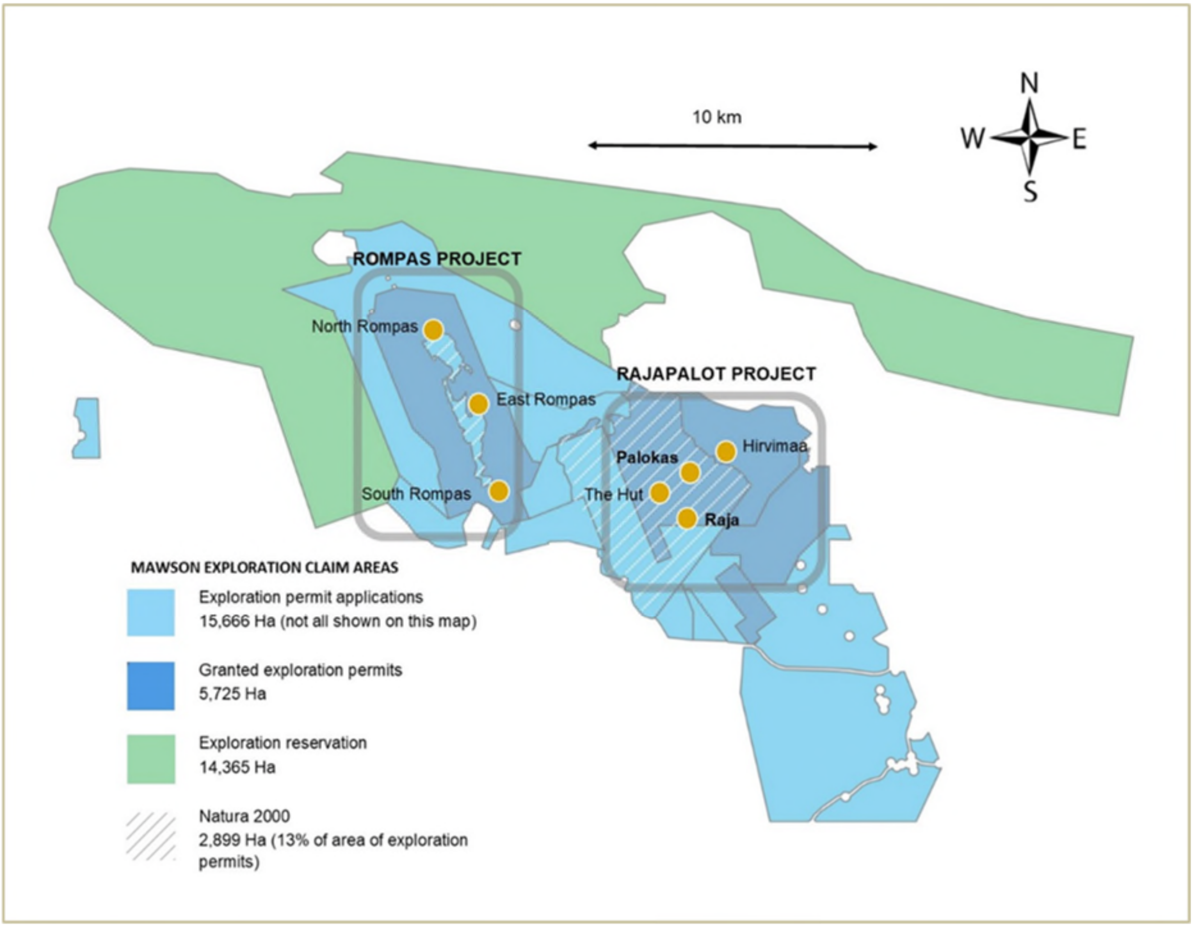
*** This guide is based on published information available through Mawson's website***

The Rompas-Rajapalot project is a discovery in Northern Finland where high-grade gold and cobalt have been found within an area approaching 10 km by 10 km. The nature of the terrain and all-weather access allows year-round exploration work across more than 70% of the area. Winter access is possible in the remaining area when ice and snow conditions permit, usually after mid-December each year.

***Figure 1**: Mawson granted permits, applications and reservations, location of Rajapalot and Rompas project areas and key prospects*



Rajapalot Disseminated Gold - Cobalt Project - Resources

Resource estimations at Rajapalot were completed for the Raja and Palokas prospects by AMC in December 2018. The two prospects lie approximately 2.0 kilometres apart within the same geological host sequence (Figure 2 below). The calculation represents the first resource estimate for the Rajapalot Gold-Cobalt Project. AMC reported both a "constrained" and "unconstrained" resource, where the constrained resource has used spatial restrictions of a Whittle™ pit at a gold price of USD $1,250 per ounce and a cobalt price of $30/lb. The gold equivalent ("AuEq") value was calculated using the following formula: AuEq g/t = Au g/t + (Co ppm/608) with assumed prices of Co $30/lb; and Au $1,250/oz. AuEq varies with Au and Co prices.

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Highlights from the maiden inferred resource calculation include:

1. A pit and underground Constrained Inferred Mineral Resource of 424,000 ounces of gold at 3.1 g/t AuEq (4.3 million tonnes at 2.3 g/t Au, 430 ppm Co) at 0.37 g/t AuEq cut-off open pit and 2 g/t AuEq underground was calculated, within a combined Unconstrained Inferred Mineral Inventory for the Palokas and Raja prospects of 482,000 ounces gold equivalent ("AuEq") at a grade of 2.4 g/t AuEq (6.2 million tonnes at 1.7 g/t Au, 410 ppm Co) at 0.4 g/t AuEq cut-off. The gold equivalent ("AuEq") value was calculated using the following formula: AuEq g/t = Au g/t + (Co ppm/608) with assumed prices of Co $30/lb; and Au $1,250/oz. AuEq varies with Au and Co prices.
2. The Constrained Inferred Resource demonstrates the high grade of Rajapalot with open-pittable grades of 2.8 g/t AuEq (2.1 g/t Au and 420 ppm Co) and underground grades of 5.2 g/t AuEq (4.4 g/t Au and 520 ppm Co) (Table 1).
3. Electromagnetic fixed-loop transient ("TEM") and airborne VTEM*plus* ("VTEM") surveys at least double the potential mineralisation footprints at the Raja, South Palokas and Palokas prospects and form immediate targets.
4. The Inferred Resource has substantial potential to grow, with only 20% (800 metres) of the 4 kilometres known mineralized trend included within the maiden resource to relatively shallow depths (average depth of drilling 88 metres within 34.2 kilometres drilled to date at Rajapalot).
5. The publication of the maiden Inferred gold-cobalt Mineral Resource establishes Rajapalot as a significant and strategic gold-cobalt resource for Finland. The unconstrained maiden inventory places Rajapalot as one of Finland's current top three gold projects by grade and contained ounces and one of a small group of cobalt resources prepared in accordance with NI 43-101 policy within Europe.

***Figure 2**: Plan view of Rajapalot showing areas included in maiden resource calculation, key drill intercepts included in resource and host geological units*

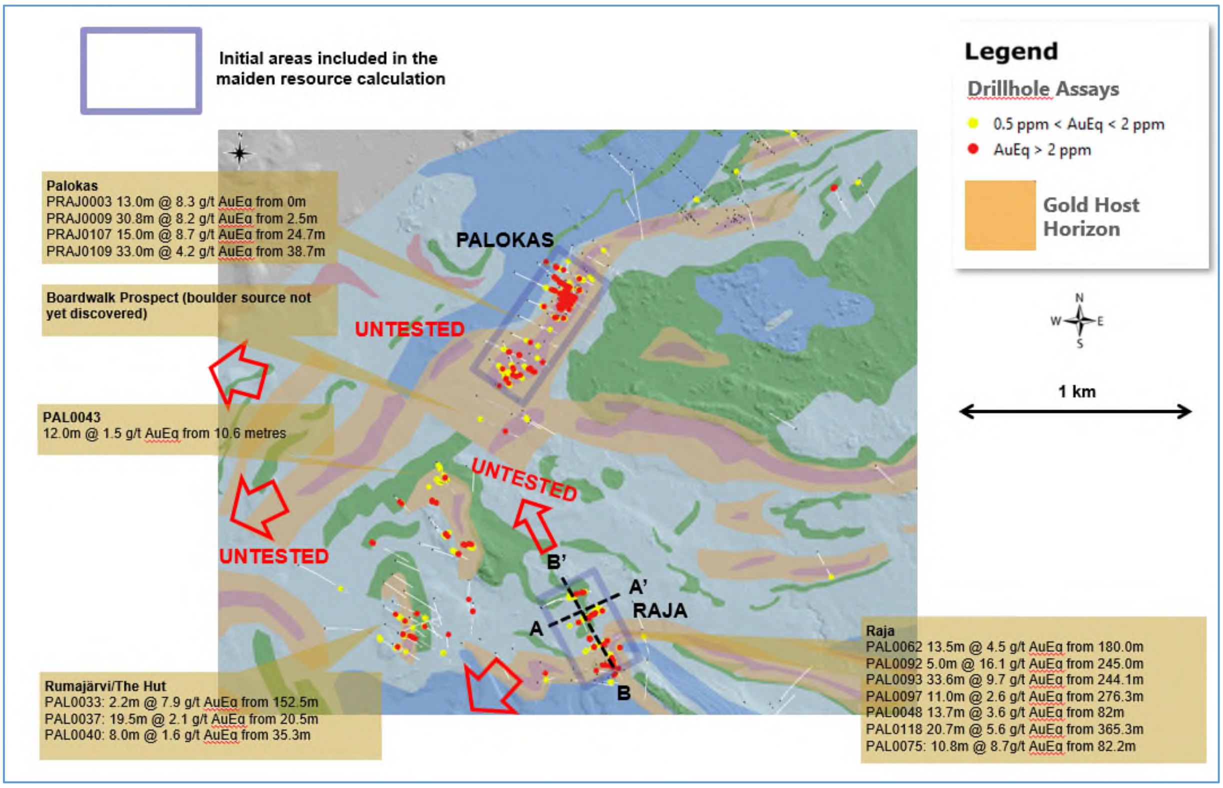

***Table 1:** Total constrained Inferred Mineral Resources Estimate as of December 14, 2018, at the cut-offs listed for constrained open pit and underground resources at Raja and Palokas.*

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Zone	Cut-off (AuEq)	Tonnes (kt)	AuEq (g/t)	Au (g/t)	Co (ppm)	AuEQ (koz)	Au (koz)	Co (tonnes)
Raja Pit	0.37	2,499	3.1	2.4	410	249	197	1,021
Raja UG	2.0	356	5.6	4.8	500	64	55	179
Raja Total		**2,855**	**3.4**	**2.7**	**420**	**312**	**252**	**1,201**
Palokas Pit	0.37	1,306	2.2	1.4	450	92	60	587
Palokas UG	2.0	96	3.6	2.7	560	11	8	54
Palokas Total		**1,402**	**2.3**	**1.5**	**460**	**104**	**69**	**640**
Total Pit	0.37	3,805	2.8	2.1	420	343	257	1,608
Total UG	2.0	452	5.2	4.4	520	76	63	233
Total		**4,257**	**3.1**	**2.3**	**430**	**424**	**320**	**1,841**

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***Table 2**: Total unconstrained Inferred Mineral Inventory estimates as of December 14, 2018, at different AuEq g/t cut-off grades for the combined Raja and Palokas prospects*

Cut-off (AuEq)	Tonnes (kt)	AuEq (g/t)	Au (g/t)	Co (ppm)	AuEq (koz)	Au (koz)	Co (tonnes)
0.2	6,335	2.4	1.7	402	485	347	2,548
0.4	6,156	2.4	1.7	410	482	345	2,522
0.6	5,680	2.6	1.9	429	475	345	2,434
0.8	5,000	2.8	2.1	451	456	339	2256
1.0	4,198	3.2	2.5	482	435	334	2024
1.2	3,555	3.6	2.8	501	416	321	1781
1.4	3,046	4.0	3.2	513	395	313	1564
1.6	2,600	4.5	3.6	522	380	304	1357
1.8	2,222	5.0	4.2	527	360	300	1170
2.0	1,904	5.6	4.7	533	340	290	1016
2.2	1,721	6.0	5.1	534	331	281	918
2.4	1,518	6.5	5.6	533	318	274	810
2.6	1,374	6.9	6.0	539	306	266	740
2.8	1,229	7.5	6.6	539	294	259	662
3.0	1,123	7.9	7.0	550	284	251	617
3.2	1,009	8.4	7.5	565	273	244	570
3.4	932	8.9	8.0	563	266	239	525
3.6	846	9.5	8.6	554	258	233	469
3.8	789	9.9	9.0	545	251	228	430
4.0	728	10.3	9.5	547	242	223	398
4.2	671	10.9	10.1	530	236	217	356
4.4	631	11.3	10.5	526	230	213	332
4.6	586	11.9	11.0	516	223	207	302
4.8	543	12.5	11.6	514	217	202	279
5.0	521	12.8	12.0	511	214	201	266

Resource Methodology

1. Mineral Resource estimates follow the Canadian Institute of Mining, Metallurgy and Petroleum ("CIM") definitions standards for mineral resources and reserves and have been completed in accordance with the Standards of Disclosure for Mineral Projects as defined by National Instrument 43-101.
2. Reported tonnage and grade figures have been rounded from raw estimates to reflect the relative accuracy of the estimate. Minor variations may occur during the addition of rounded numbers.
3. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability.
4. The Mineral Resource Statement complies with the standards for reporting mineral resources as set out under CIM guidelines.
5. Constrained Resources are presented undiluted and in-situ and are considered to have reasonable prospects for eventual economic extraction.
6. Optimized open pit constrained resources are reported at a cut-off grade of 0.37 g/t AuEq; underground resources are reported at a cut-off grade of 2.0 g/t AuEq.

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7. Gold equivalent “AuEq” = Au+Co/608 based on assumed prices of Co $30/lb and Au $1,250/oz.
8. Top cuts were applied to the composites at Palokas. For the low-grade gold domain within the Palokas deposit a gold top cap of 15.9 g/t was used. For the high-grade gold domain within the Palokas deposit a gold top cap of 50 g/t was used. No top caps were required for the Raja deposit.
9. A density value of 2.80 t/m^3 was applied to all lithologies.
10. The three-dimensional wireframe models were generated using AuEq shells. Estimation parameters were determined by variography; all zones were interpolated using Ordinary Kriging (“OK”).
11. Block dimensions were 25 x 10 x 5 metres (Raja) and 20 x 10 x 5 metres (Palokas) with sub-block sizes down to 5 x 2 x 1 metre and 4 x 2 x 1 metres blocks for Raja and Palokas respectively.
12. AMC created the Rajapalot Mineral Resource estimate using the drill results available to July, 2018 from the Raja and Palokas prospects.

Table 3: *Total unconstrained Inferred Mineral Inventory estimates as of December 14, 2018, at different AuEq g/t cut-off grades for the Raja prospect.*

Cut-off	Tonnes (kt)	AuEq (g/t)	Au (g/t)	Co (ppm)
0.2	3,738	2.9	2.2	403
0.4	3,720	2.9	2.2	405
0.6	3,576	3.0	2.3	416
0.8	3,243	3.2	2.5	434
1.0	2,786	3.6	2.9	464
1.2	2,444	4.0	3.2	480
1.4	2,203	4.3	3.5	493
1.6	1,926	4.8	3.9	508
1.8	1,661	5.3	4.5	516
2.0	1,414	5.9	5.1	529
2.2	1,270	6.4	5.5	531
2.4	1,098	7.1	6.2	530
2.6	987	7.6	6.7	538
2.8	870	8.3	7.4	537
3.0	805	8.7	7.8	549
3.2	719	9.4	8.5	566
3.4	660	10.0	9.1	563
3.6	593	10.8	9.9	550
3.8	547	11.4	10.5	535
4.0	503	12.0	11.2	536
4.2	460	12.8	12.0	512
4.4	435	13.3	12.5	504
4.6	406	13.9	13.1	487
4.8	375	14.7	13.9	482
5.0	357	15.2	14.5	476

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Table 4: *Total unconstrained Inferred Mineral Inventory estimates as of December 14, 2018, at different AuEq g/t cut-off grades for the Palokas prospect.*

Cut-off	Tonnes (kt)	AuEq (g/t)	Au (g/t)	Co (ppm)
0.2	2,597	1.64	0.99	401
0.4	2,436	1.73	1.05	417
0.6	2,104	1.93	1.19	450
0.8	1,757	2.17	1.38	483
1.0	1,412	2.48	1.63	518
1.2	1,111	2.86	1.96	547
1.4	843	3.35	2.42	567
1.6	674	3.82	2.89	561
1.8	561	4.24	3.33	558
2.0	490	4.58	3.69	546
2.2	451	4.80	3.91	541
2.4	420	4.99	4.10	542
2.6	387	5.20	4.31	541
2.8	359	5.40	4.50	543
3.0	318	5.72	4.81	552
3.2	290	5.97	5.05	561
3.4	272	6.15	5.22	564
3.6	253	6.35	5.42	563
3.8	242	6.47	5.54	566
4.0	225	6.66	5.72	571
4.2	211	6.84	5.90	570
4.4	196	7.02	6.08	574
4.6	180	7.25	6.30	580
4.8	168	7.43	6.46	585
5.0	164	7.48	6.52	586

Cobalt in Finland

Finland plays a significant role in the global cobalt supply chain. The Democratic Republic of the Congo (“DRC”) mined 54% of the world’s cobalt in 2016 whilst 80% of cobalt used in lithium-ion batteries is refined in China.

Half of the world’s non-Chinese production (10% of total production) comes from Freeport Cobalt, the world’s largest single cobalt refinery, located only 400 kilometres from Mawson’s Rajapalot project in Kokkola, Finland. Freeport Cobalt is a joint venture between Freeport-McMoRan (56%), Lundin Mining Corporation (24%) and La Générale des Carrières et des Mines (20%) (or Gécamines, the DRC state mining company). A significant amount of feedstock for Freeport Cobalt comes via a long-term supply agreement with the Chinese-owned Tenke Fungurume mine in the DRC. A future Finnish domestic source of cobalt from Rajapalot would satisfy the recent announcements by Finland and Sweden that the countries will work together on a traceable ledger for sustainable minerals, which are considered crucial for achieving climate goals.

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Owing to the growth in the electrification of transport and need for storage of renewable energy, the battery sector has become an important driver of cobalt demand. Demand for lithium-ion batteries is surging, which is expected to support both price and volume for the cobalt market for years to come. With cobalt on the European Commission's critical raw minerals list, there is a strong mandate to secure local and ethical supplies of cobalt, which are likely to contribute to further tightened supply.

Rajapalot Disseminated Gold-Cobalt Project — Exploration

The 100% owned gold-cobalt Rajapalot discovery hosts numerous hydrothermal gold-cobalt prospects drilled between 2013 and April 2019 within a 3 by 4 kilometre area. A total 83% of drill metres has been completed in the last 3 years.

Mineralisation at Raja and Palokas prospects occurs as replacement bodies with both structural and stratigraphic controls. Refer to Tables 1-4 above for resources by zone, which remain open in multiple directions. Drilling in 2019 discovered significant down-plunge extensions to the inferred resources at Palokas, South Palokas and Raja prospects.

Rajapalot Diamond Drilling

At the completion of the 2019 winter program, a total of 49,293.4 metres have been drilled at Rajapalot with an average depth of drill holes being 114.0 metres. A total of 32 holes for 6,813.4 metres and 87 holes for 8,354.3 metres (total 119 holes for 15,167.7 metres with an average depth of 127.5 metres) were used within the December 2018 maiden resource estimation at Raja and Palokas respectively. The 2019 drill program, which is not included in the 2018 inferred resource calculation, completed 44 holes for 15,059 metres with two holes abandoned (a total of 30% of drilling at Rajapalot).

Table 5: Drilling history at Rajapalot to August 27, 2019

Drill Program	**Number of Holes**	**Year**	**Drilled (m)**	**Cumulative Average Hole Length (m)**	**Core Diameter**	**Drill Company**
PAL0001-PAL0007	8	2013	757.1	94.6	NQ=47.6 mm, HQ=63.5 mm	ADC
PRAJ0001-PRAJ0120	120	2013-2016	3,431.4	32.7	EW=25.2 mm	Mawson
LD0001-LD0120	120	2014	873.8	20.4	BQ=36.4 mm	Ludvika Borrteknik AB
PAL0008-PAL0025	18	2015-2016	3,290.1	31.4	NTW=56.0 mm	Energold
PAL0026-PAL0082	57	2017	11,139.2	60.3	NQ2=50.7 mm, NTW=56.0 mm	ADC, MSJ Drilling, KATI Oy
PAL0083-PAL0147	65	2018	14,742.8	88.2	NQ2=50.7 mm, WL76=57.7 mm	ADC, MK Core Drilling Oy, KATI Oy
PAL0148-PAL0201D	44	2019	15,059	114.1	NQ2=50.7 mm	ADC, MK Core Drilling Oy, KATI Oy
Total	**432**		**49,293.4**			

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Table 6: *Summary of the top drill intersections from 2019 campaign coloured by grade-width of intersection.*

Prospect	HoleID	from (m)	to (m)	width (m)	Au g/t	Co ppm	AuEq g/t	g-w
Raja	PAL0188	298.3	329.6	31.3	4.3	1030	6.0	**187.8**
Raja	PAL0190**	359.2	390.7	31.5	4.8	724	5.9	**185.9**
Palokas	PAL0194	418.7	433.9	15.2	4.3	2566	8.5	**129.2**
South Palokas	PAL0197**	294.3	326.3	32.0	1.4	1556	3.9	**124.8**
Raja	PAL0191	417.0	438.0	21.0	3.2	481	4.0	**84.0**
South Palokas	PAL0173	264.0	281.0	17.0	3.0	827	4.3	**73.1**
South Palokas	PAL0198	169.7	179.7	9.8	4.2	1208	6.1	**59.8**
Rumajärvi	PAL0182	86.3	93.7	7.4	3.4	597	4.4	**32.6**
Raja	PAL0163	416.6	419.4	2.8	<0.1	6604	10.9	**30.5**
Raja	PAL0159	419.0	437.0	18.0	0.5	547	1.4	**25.2**
South Palokas	PAL0193	273.0	284.0	11.0	0.4	1044	2.1	**23.1**
The Hut	PAL0199	140.4	143.4	3.0	6.4	722	7.6	**22.8**

The true thickness of mineralized intervals at Palokas is interpreted to be approximately 90% of the sampled thickness. The true thickness of the mineralized intervals at Raja, Rumajärvi and The Hut require additional drilling to determine owing to the complicated structural controls.

Combined gold-cobalt mineralized intersections display increased widths and often show better continuity. Mineralogical studies on selected Rajapalot samples indicates that sulphide cobalt mineralisation is hosted in cobaltite and cobalt pentlandite that are conventionally mined and processed in other deposits.

Raja Prospect

The Raja gold-cobalt resource formed 75% of the December 2018 Inferred Mineral Resource and extends 575 metres down plunge, with an average depth of 100 metres and each of the 3 mineralized horizons averaging 10 metres width. Gold-cobalt mineralisation is a potassic-iron type characterized by muscovite-biotite-chlorite quartz pyrrhotite-rich schist with subordinate albite, iron-magnesium amphiboles and tourmaline which is best developed to date at the Raja prospect. Gold and cobaltite along with scheelite, pyrite, chalcopyrite and bismuth tellurides accompany the silicates.

The mineralisation at Raja is concentrated where a sub-vertical linear structure intersects sulphide concentrations in the hinges of minor folds. The gold mineralisation is interpreted to have formed subsequent to the peak of high-grade metamorphism and coincident deformation.

Significant intersections in the 2019 drilling campaign included (see Figure 3 long section for details):

- PAL0191: 21.0 metres @ 4.0 g/t gold equivalent (“AuEq”), 3.2 g/t gold (“Au”) and 481 ppm cobalt (“Co”) from 417.0 metres, including 9.0 metres @ 7.2 g/t AuEq, 6.2 g/t Au and 647 ppm Co from 421.0 metres
- PAL0190: 19.7 metres @ 8.9 g/t AuEq, 7.4 g/t Au and 908 ppm Co from 371.0 metres in May 2019 and located 70 metres up plunge from PAL0191. Additionally, on the same section 30 metres to the east of PAL0190, PAL0118 drilled in 2018 intersected 20.7 metres @ 5.6 g/t AuEq, 3.6 g/t Au, 956 ppm Co from 365.2 metres;
- PAL0188: 31.3 metres @ 6.0 g/t AuEq, 4.3 g/t Au and 1,030 ppm Co from 298.6 metres in April 2019 and located 155 metres up plunge from PAL0191;

Drill holes in a section down plunge of the resource, are inferred to lie either side of the linear high-grade gold-cobalt trend and further drilling is required. Drill hole PAL0161 intersected 4.0 metres @ 2.9 g/t gold from 345

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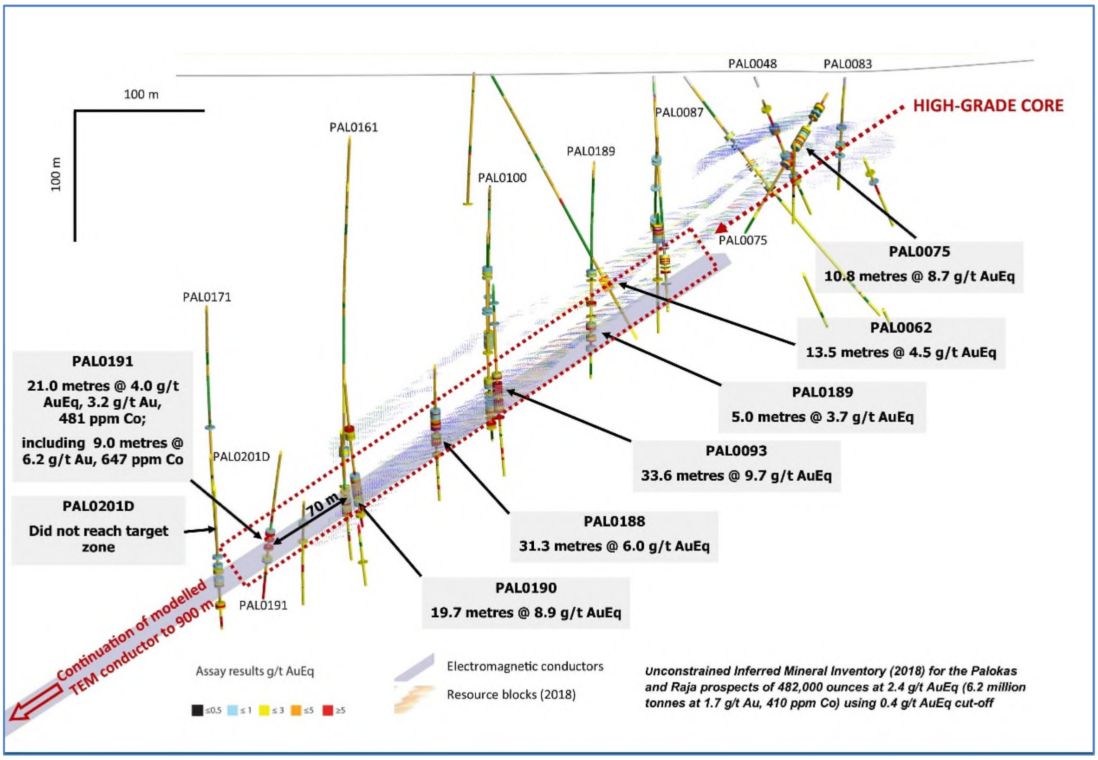
metres and PAL0159 intersected 3.0 metres @ 2.3 g/t gold from 434 metres and 3.5 metres @ 2.4 g/t from 452 metres.

Three key aspects for exploration upside at Raja from the 2019 drill program are:

1. The strong correlation of TEM plates to the resource and their continuation down-plunge well past the drilled intersections.
2. The terminations of the TEM plates are a function of the depth of the model, and not a true representation of the limit of down-plunge extent.
3. The late, linear subvertical structural control that produces the intersection with the reactive reduced rocks to form a continuous high-grade gold-cobalt core that aids targeting of high-grade mineralisation.

Figure 3: *Grade blocks from resource modelling of Raja prospect and location of fixed loop TEM plates showing likely down-plunge extensions to mineralisation — view to NNE. Includes 2019 drilling.*



Palokas and South Palokas Prospects

The Palokas gold-cobalt December 2018 Inferred Mineral Resource extends over two separate bodies (Palokas and South Palokas) with at least two mineralized horizons in each. The dimensions of the Palokas resource are 240 metres of strike, depth of 300 metres and 20 metres width. The dimensions of the South Palokas resource are 180 metres of strike, depth of 220 metres and width up to 20 metres. These dimensions have been significantly extended by the 2019 drill program. Mineralisation forms within a retrograde mineral alteration assemblage include chlorite, iron-magnesium amphiboles, tourmaline and pyrrhotite commonly associated with quartz veining. Subordinate almandine garnet, magnetite and pyrite occur with bismuth tellurides, scheelite, ilmenite, gold and one of cobaltite or cobalt pentlandite.

Both Palokas and South Palokas have been drilled during the 2019 winter campaign and assays remain outstanding. At South Palokas prospect, drill hole PAL0173 intersected 17 metres @ 3.0 g/t gold from 264 metres, including 5 metres @ 4.9 g/t gold from 264 metres and 5 metres @ 4.6 g/t Au from 276 metres.

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Drill hole PAL0194 at Palokas intersected 15.2 metres @ 8.5 g/t gold equivalent (“AuEq”), 4.3 g/t gold (“Au”) and 2,566 ppm cobalt (“Co”) from 418.7 metres and was drilled 275 metres down-plunge from the high-grade gold-cobalt mineralisation previously announced (see Figure 4).

A recently completed electromagnetic geophysical survey has outlined strongly conductive bodies immediately down plunge from both the Palokas and South Palokas gold-cobalt resource areas. The modelled conductive plates extend 250–400 metres down dip beyond the resource areas and doubles (South Palokas) or triple (Palokas) the mineralisation footprint down plunge to the northwest. The strong conductive response evident in the modelled TEM plates shows the likely growth areas for the resources and matches the known gold-cobalt sulphidic zones based on drill data

Figure 4: *Grade blocks from resource modelling of Palokas prospect and location of fixed loop TEM plates showing likely down-plunge extensions to mineralisation - view to NNW.*

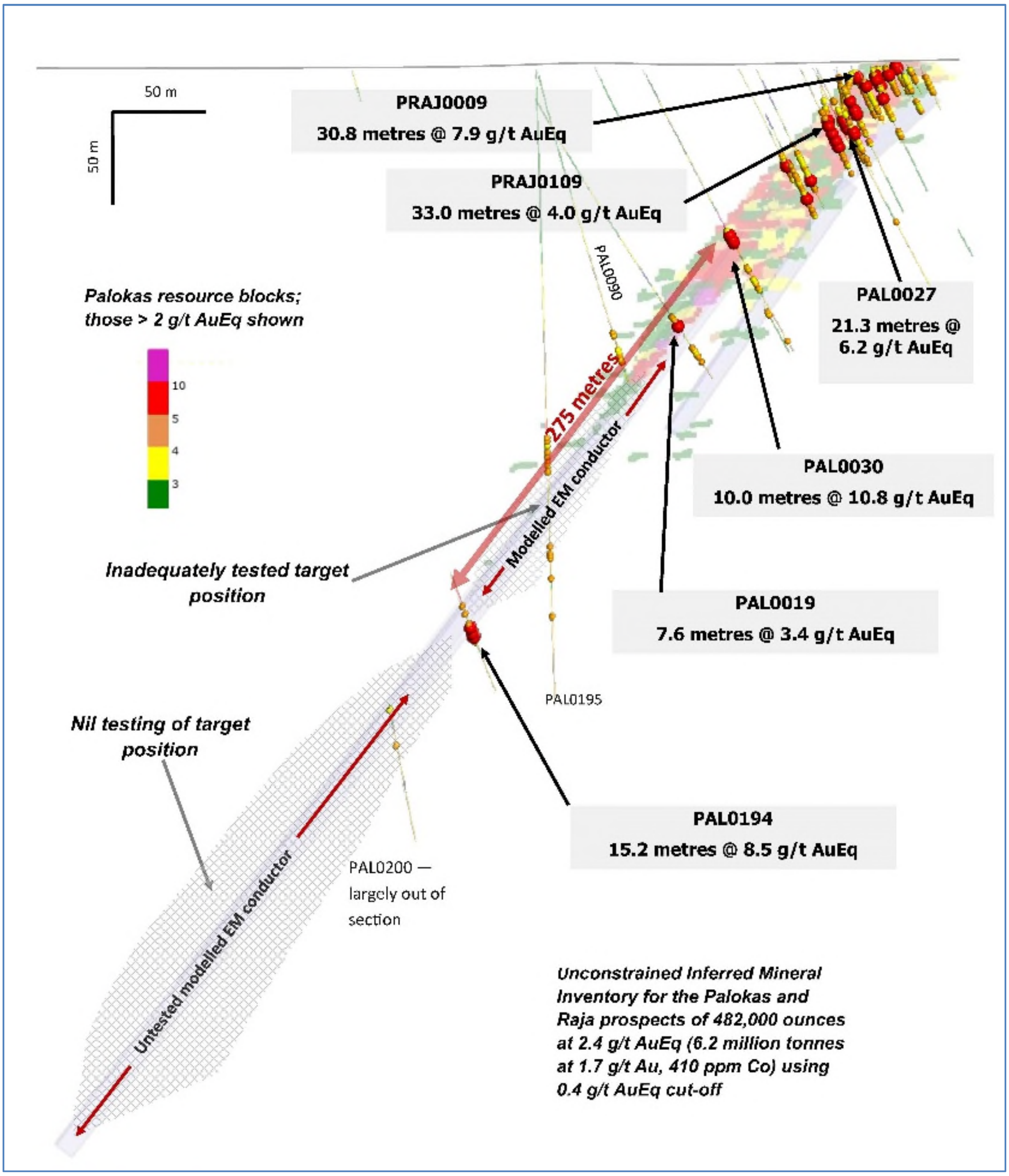

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Figure 5: *Grade blocks from resource modelling of South Palokas prospect and location of fixed loopTEM plates showing likely down-plunge extensions to mineralisation – view to NNW.*

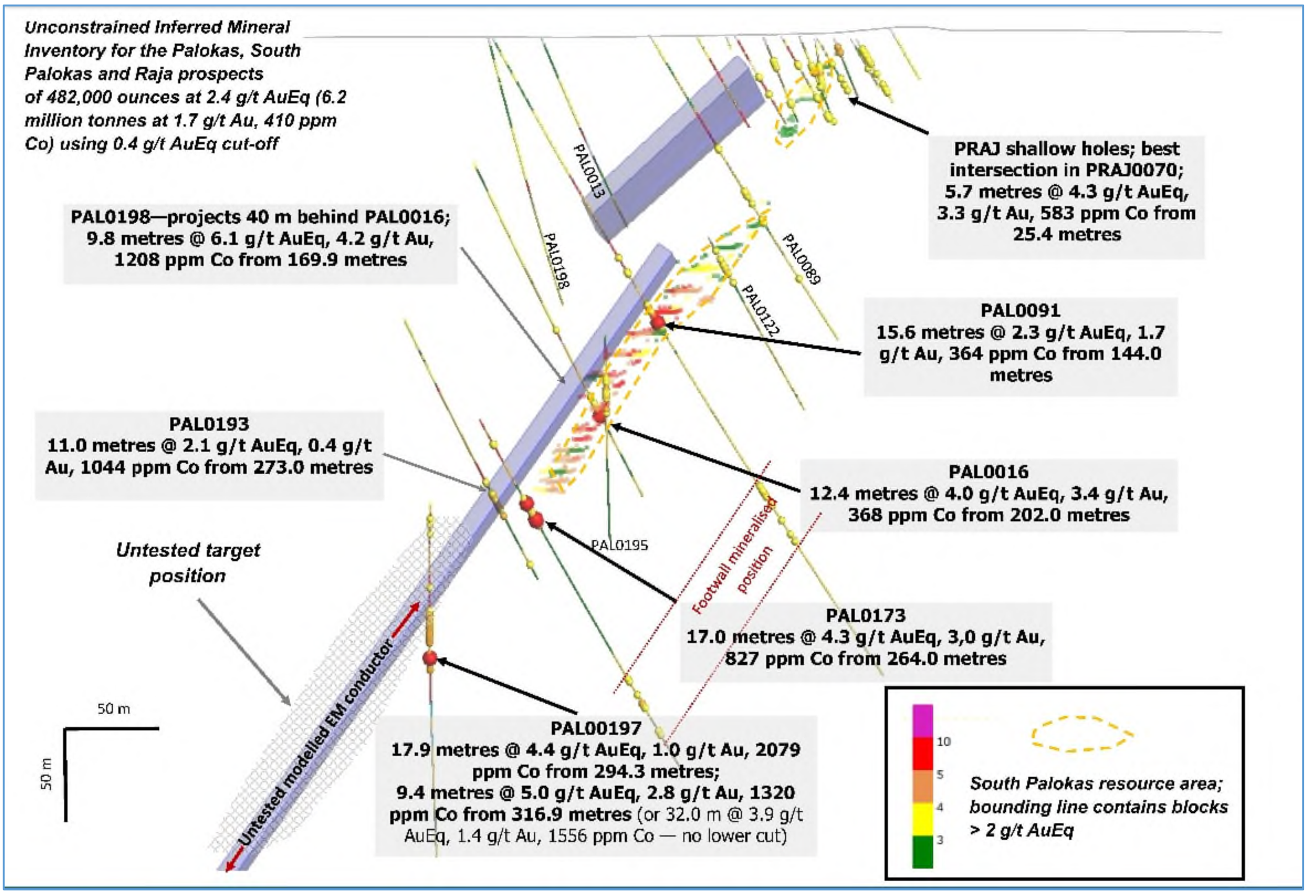

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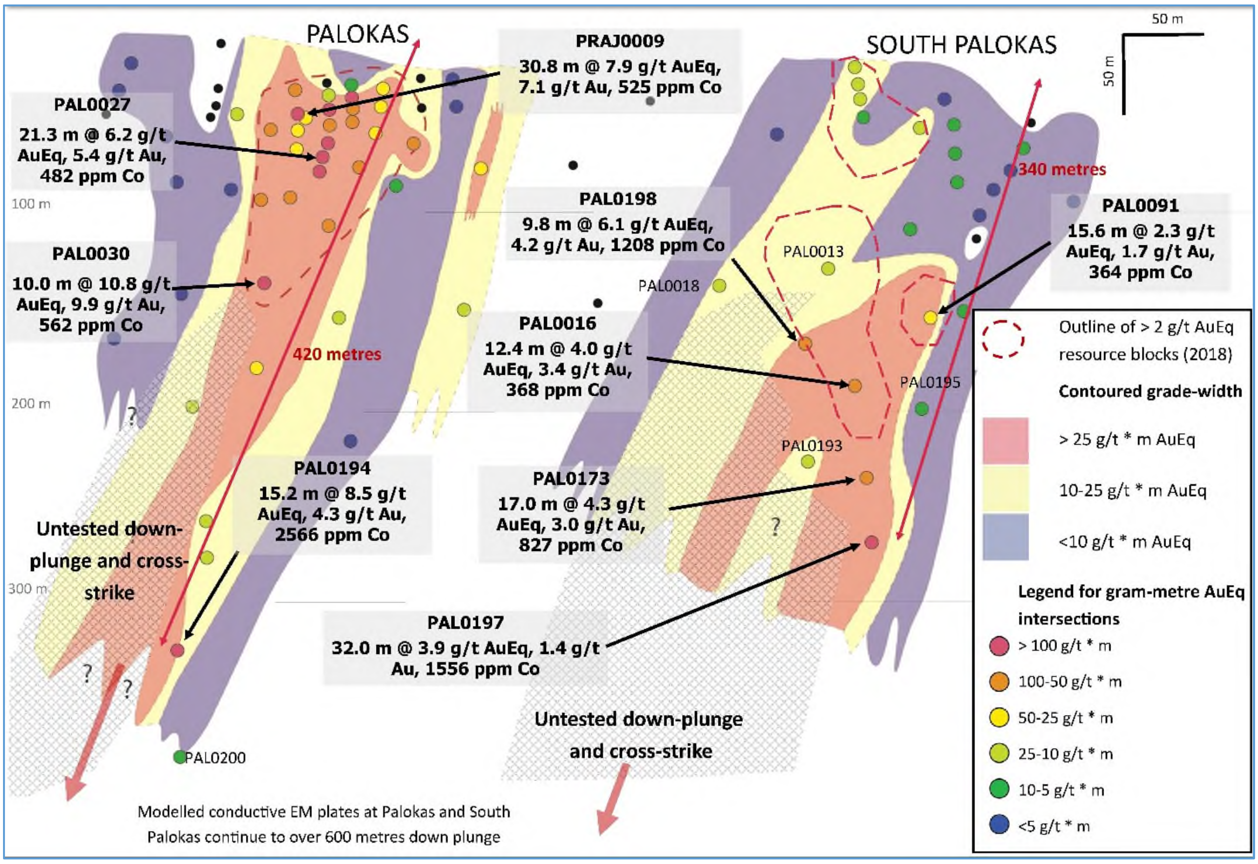
Figure 6: *Contoured projection of grade-width intersections in gold equivalent terms made onto a northwesterly dipping plane (i.e. the view is looking down on an angle (60 degrees) from the northwest towards the southeast). Note the large hatched area in this projection showing the area to the north (left) and down plunge to the NW with just a single drill hole. The TEM conductors have been removed for simplicity, but lie within the surface of this image.*



Other Prospect Areas in Rajapalot

The Raja and Palokas prospects cover only 20% (800 metres) of the 4 kilometres known mineralized trend at Rajapalot. The Hut, Terry's Hammer and Rumajärvi prospects within the same trend are still in the early stages of exploration, but have significant potential, as shallow and deeper geophysical anomalies, surface samples (boulders) and initial drilling indicate the correct stratigraphic host sequence and encouraging assay results. Drilling at Terry's Hammer for example, intersected 4.7 metres at 2.1 g/t gold from 65.7 metres in PAL0099, the first large diameter drill test of a combined remanent magnetic/chargeable/conductive anomaly comprising gold-bearing sulphidic rocks in outcrop.

Winter diamond drilling during 2019 was focussed on the areas where the inferred resources were published (Raja, Palokas and South Palokas). The Hut, Terry's Hammer and Rumajärvi prospects are in an earlier stage of exploration, with approximately 30% of the drill metres completed there. Further fixed-loop electromagnetic surveys are required to search for blind mineralisation across a majority of the project area.

Geophysics

A series of airborne (VTEM*plus*) and ground geophysical surveys have been conducted since 2013 to locate the conductive and magnetic mineralisation at Rajapalot. More recent work indicates that a combination of ground magnetic surveys, electromagnetics (both airborne and ground) and IP-resistivity methods are the most promising for location of sulphidic gold-cobalt mineralisation. The highly conductive nature of the sulphidic host also makes mise-a-la-masse and important tool for tracing the location of near-surface intersections with the ever-present thin glacial till cover. Much of the southeastern portion of Kairamaat 2/3 permit and more than 40 % of Hirvimaa permit is now also covered by gradient array IP/chargeability surveys.

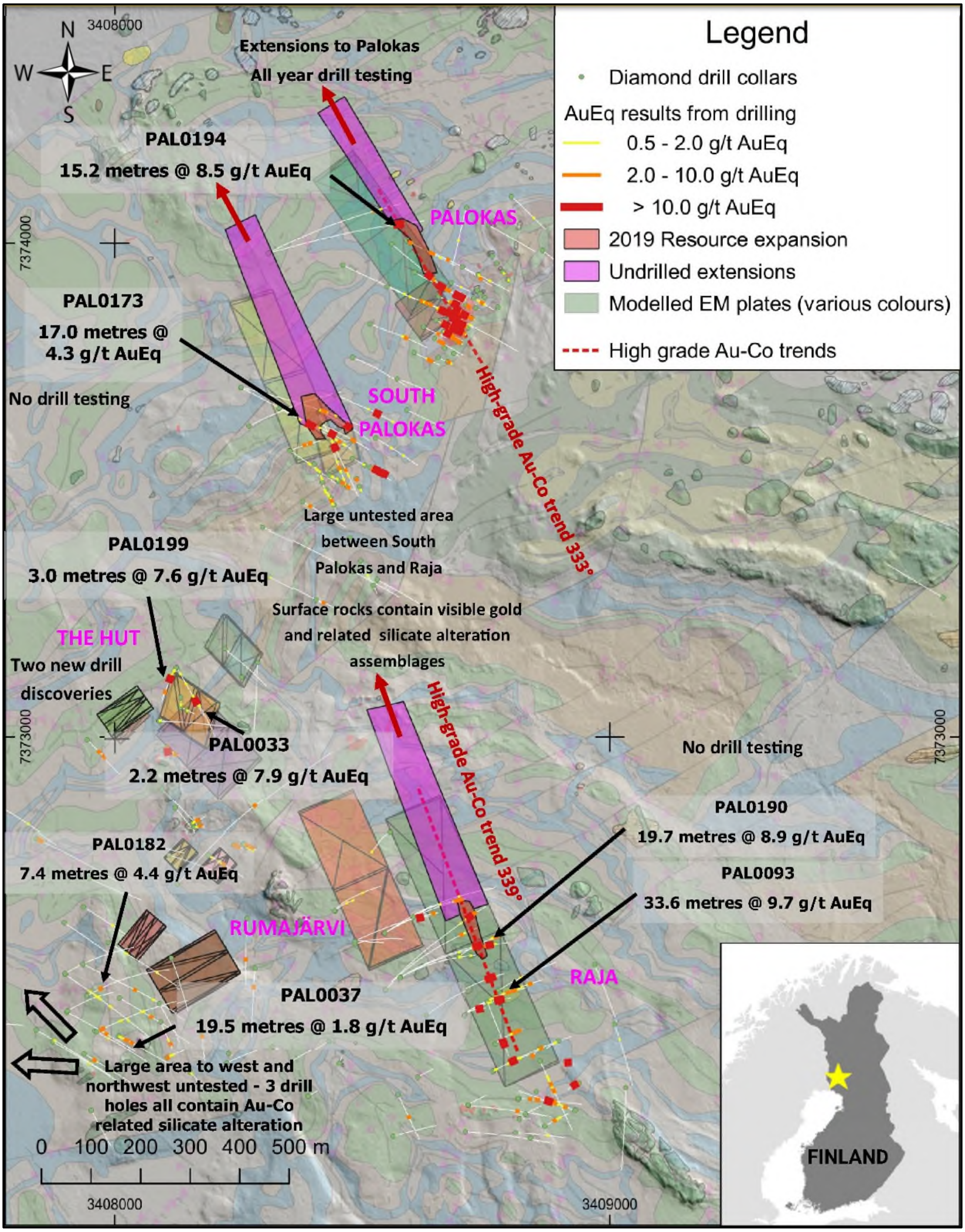
Detailed ground magnetic surveys at line spacings between 100 metres and 15 metres have been completed during 2014-2018. The testing has indicated that 25 metre line spacing is optimum for discovery and geological interpretation. Geological, primarily structural interpretation of the ground magnetic data indicates a complexly refolded and faulted sequence, but still including distinctive and traceable units. Additional magnetic surveys to infill surveys to 25 metres have now been completed across the most prospective portions of Rajapalot.

Magnetic pyrrhotite associated with gold-cobalt mineralisation typically shows reverse remnant magnetism (RRM). Thus, combined RRM-conductive-chargeable anomalies usually represent near-surface sulphides. The coincidence of the three geophysical properties was used to successfully locate the mineralisation at Raja and The Hut, and corresponding anomalies at Palokas, South Palokas and Terry's Hammer indicate the effectiveness of the programs.

A fixed-loop transient electromagnetic ("TEM") corresponds closely with the resource block model at Raja and defines a strongly conductive body that extends 550 metres down plunge beyond the December 2018 maiden resource area (Figure 3). This conductive body more than doubles the potential Raja mineralisation footprint to more than 1 kilometre down plunge and the conductor remains open down plunge to the NNW. Earlier stage airborne VTEM*plus* electromagnetic ("VTEM") data shows a conductive body which more than doubles the Palokas potential mineralized footprint to 450 metres below the surface (Figure 4).

New TEM surveying during Q1 2019 defined similarly oriented conductors at both Palokas and South Palokas, showing over 450 metres of down-plunge extent to the conductive sulphidic rocks at both prospect areas. Drill testing has revealed that the northern margins of the modelled plates are mineralized. Down-hole electromagnetic surveys have also been conducted in drill holes where indications are present of proximity to sulphidic hosts to gold-cobalt mineralisation. Mise á la masse (MALM) surveys to track the surface extent of sulphides show continuity of sulphidic bodies from the deepest drilling to surface at both Raja and South Palokas. Palokas will be tested with MALM later in 2019.

Figure 7: *Map of Rajapalot project showing planned areas of drilling (purple), existing TEM modelled plates, gold-equivalent intersections, high-grade gold-cobalt trends, and new intersections at The Hut (PAL0199) and Rumajärvi (PAL0182) prospects*



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Geology of Mineralised Rocks at Rajapalot

The style of mineralisation at Rajapalot is predominately sulphidic and of a disseminated or replacement style, generally concentrated adjacent to linear, or sub-linear near-vertical structures (faults and veins). Hydrothermal alteration precipitated gold and sulphide in reactive host rocks, typically those already sulphidic. Grade thickness variations occur, and the best intersections to date are those where foliated sulphides in fold hinges and brecciated rocks are present prior to the gold. Most of the mineralisation at Rajapalot consists of sulphide (pyrrhotite>>pyrite), magnetite, biotite, muscovite and chlorite hydrothermal mineral assemblages hosted in predominately muscovite-biotite schists and grey albitites. Variations in gold-cobalt mineralisation style occur, from an end member of sulphidic, potassic iron-rich rocks (K-Fe type, for example at Raja prospect) through to iron and magnesium-rich (Fe-Mg type) hydrothermally altered sulphidic rocks such as those at Palokas. Textures range from veined albitic granofels through fractured and brecciated to locally schistose. Veining and fracture fill minerals include pyrrhotite, magnetite and magnetite-pyrrhotite (+/- quartz). Local retrograde chlorite after biotite and vein-controlled chlorite+/- tourmaline and magnetite are also present. Preliminary hand-held XRF analysis confirms the presence of associated scheelite and molybdenite, the former visible under UV light as tiny veinlets and disseminations. The iron-rich nature of the mineralised rocks is a common theme in either the oxide or sulphide form, with a variably sulphidic and chloritic overprint. The alteration immediately surrounding the mineralised resources is clearly post-metamorphic, reduced, and most likely driven by granitoid intrusions. Distal propylitic alteration is generally oxidised commonly defined by chlorite-actinolite-hematite+/-epidote assemblages. Chlorite, hydrothermal muscovite and quartz are regarded as the lowest temperature silicate minerals with gold, cobaltite, linnaeite, cobalt pentlandite structurally controlled by sub-vertical, linear faults and shears in apparent spatial association with sulphidic fold hinges and planar sulphidic host rocks. Altered rocks enclosing the mineralized package contain locally abundant talc and tourmaline.

The disseminated sulphidic gold-cobalt mineralisation at Rajapalot remains the primary target for the Company. However, the company interprets that the host strata occur across the full extent of the Rompas-Rajapalot project area and therefore the potential for disseminated sulphidic gold-cobalt mineralisation should not be discounted in the Rompas project area.

Surface Sampling

Surface samples from Rajapalot include prospecting grab samples taken from outcrop that returned 2,817 g/t gold, 2,196 g/t gold, 1,245 g/t gold, 933 g/t gold, 151 g/t gold and 135.5 g/t gold. A total of 160 boulders and outcrops with >0.1 g/t gold have been discovered within a 4 kilometre by 3 kilometre area at Rajapalot. Gold grades range from 0.1 g/t gold to 3,870 g/t gold, with an average of 74.9 g/t gold and median of 0.71 g/t gold. Samples from boulders are grab samples, which are selective by nature and are unlikely to represent average grades on the property.

A broad area of 4 by 6 kilometres has been tested by 2,775 base-of-till (“BOT”) drill holes (within the Kairamaat 2-3, Hirvimaa and Raja permit areas). A further 601 BOT drill holes have been completed in the Männistö permit area surround the Rompas prospect searching for the disseminated style of mineralisation.

Metallurgical Testing

During October 2014 the Company announced results from preliminary metallurgical testing on drill core from the Palokas prospect at the Rompas-Rajapalot gold project in Arctic Finland by SGS Mineral Services UK in Cornwall. Excellent gold extraction results of between 95% and 99% (average 97%) were obtained by a combination of gravity separation and conventional cyanidation. Gravity extraction for the four composites responded well with 26%-48% gold extraction. Leaching was performed on the pulverised and blended tailings from the three size fractions after gravity extraction. Samples tested are not classified as refractory. Metallurgical test work indicates gold recovery and processing are potentially amenable to conventional industry standards with a viable flowsheet which could include crushing and grinding, gravity recovery, and cyanide leaching with gold recovery via a carbon-in-pulp circuit for production of onsite gold doré.

Mawson was selected to be a participant of Finland’s BATCircle consortium, a program designed to value-add to the Finnish battery metals circular economy. BATCircle was founded under the leadership of Aalto University to coordinate research on the battery metal circular economy from exploration to recycling. BATCircle includes

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22 companies, four universities, two research institutes and two cities. The project is biennial and has a total budget of over €20 million. According to the European Commission (“EC”), the value of the European battery market could rise to €250 billion by 2025. The goal of the BATCircle project is to enable the creation of a market of least €5 billion in Finland.

R&D funding for the BATCircle research project for Mawson’s Rompas-Rajapalot project is €500,000 (CDN $756,000) including the Company’s contribution of €250,000 (CDN $378,000) on a 50:50 funding basis to conduct advanced exploration and metallurgical studies on the Rompas Rajapalot gold-cobalt project.

Metallurgical testwork for cobalt and gold has begun with liberation studies and QEMSCAN work to investigate the relationships of the cobalt minerals (cobaltite, linnaeite and cobalt pentlandite) to the gold, sulphide and silicate minerals. These studies are being conducted with the Geological Survey of Finland (GTK) and the Camborne School of Mines (University of Exeter).

In the liberation study, five samples, of which four were from the Raja prospect, and one from Palokas prospect, were selected based on representative gold and cobalt grade and host rock. The aim of this study was to qualitatively assess the release of gold and cobalt minerals from the rock matrix during grinding and the resultant products of gravity separation.

The first batch of results are very encouraging, with key results summarized as follows:

- Liberation of gold and cobalt in the two heaviest fractions generally exceeds 90 per cent with 50 micron grinding;
- At the 80th percentile, gold and cobalt grains in the heavy concentrates across the 5 samples average 62 microns and 67 microns respectively;
- The main gold mineral is native gold (>95% pure) and cobaltite was the dominant cobalt mineral;
- Gold reported is dominated by coarse single grains (greater than 95% by volume); and
- Cobaltite grains are well-formed with a dominant single grainsize distribution and more than 90% report as single grains to gravity concentrates.

Rajapalot Global Analogues

As a result of the diamond drilling programs over the 2016-2019 winters, and cooperative research work with the Geological Survey of Finland and Oulu University, Mawson has defined the Rajapalot mineralisation as typical of a Paleoproterozoic gold system. This well-documented deposit style appears to be late tectonic, has a stratabound geochemical control on gold precipitation and commonly has a regional granitoid association in the age range 1.75-1.85 Ga. A global metal contribution of more than 200 million ounces makes for a significant target type. The best analogues to the Rajapalot mineralisation are the Homestake Mine in South Dakota and Tanami mines in Northern Territory (especially Callie), Australia.

The similarities of Rompas-Rajapalot to the Paleoproterozoic Lode Gold±Ironstone-Copper deposit style include:

- similar age host rocks and mineralisation age;
- a similar tectonostratigraphic setting with a Paleoproterozoic sequence with large layered mafic sequence at the base, mature clastic and carbonate platform sediments, including rocks deposited during the Great Oxidation Event (“GOE”) transitional into deeper water, reduced facies including carbonaceous rocks;
- post-peak metamorphic emplacement of large intrusives driving hydrothermal fluids causing metal deposition in a brittle and brittle-ductile regime;
- a strong stratigraphic-structural control including stratabound and fold hinge related mineralisation;
- large retrograde hydrothermal fluid systems carrying significant gold and cobalt; and
- similar iron and magnesium-rich alteration rock types forming a close association with gold mineralisation.

The Rajapalot project continues to evolve with significant advances in the understanding of similar structural-stratigraphic and fluid-rock controls on apparently contrasting mineralisation styles. The adoption of a “mineral systems” approach combined with the results of the recent winter diamond drilling allows us to interpret the entire new mineralized gold camp that Mawson has defined. This new interpretation has led to the definition of more than 65 kilometres of host stratigraphy in the project area. The Paleoproterozoic gold target style is a geological concept and is not necessarily indicative of the mineralisation style that will eventually exist on the

Property. The exploration programs systematically test strike extensions to known resources, in order to test structural and stratigraphic traps that may host this style of gold mineralisation.

Rompas Vein Gold Project

The initial discovery area, Rompas, is a hydrothermal vein style system defined over a 6 kilometres strike and 200-250 metres width. Exploration on the project started in May 2010. During that year, 80 channel samples averaged 0.59 metres at 203.66 g/t gold and 0.86% uranium and during 2011 the weighted average of all 74 channel intervals was 1.40 m at 51.9 g/t gold and 0.13 % uranium. Unrepresentative grab sample results include values up to 33,200 ppm gold and 56.6% uranium oxide at Rompas.

From mid-2011 Mawson drilled 8,164.8 metres in 90 holes at Rompas, comprising 2,462.8 metres in 29 drill holes at North Rompas; 2,436.2 metres in 29 drill holes in the northern block at South Rompas; 2,504.3 metres in 24 holes within the southern block at South Rompas; and 761.5 metres in 8 drill holes at Northern Rajapalot. In August 2012, results from the first drill program at Rompas returned Finland's best gold drill hole, with 6 metres @ 617 g/t gold in drill hole ROM0011 including 1 metre @ 3,540 g/t gold and 1 metre @ 114.5 g/t gold in drill hole ROM0015. These results confirmed the significance of the hundreds of high-grade surface occurrences that were channel sampled during 2010 and 2011. A second drill program commenced in December 2012. At North Rompas the best results include 0.4 metres @ 395 g/t gold and 0.41% uranium from 41.0 metres in drill hole ROM0052, the most southerly drill hole of the program; and 1.1 metres @ 9.8 g/t gold and 0.16% uranium from 78.5 metres in drill hole ROM0053.

The host sequence to the Rompas vein-style mineralisation comprises a package of amphibolite facies metamorphosed basalts, clastic sediments, carbonate rocks and reduced shales of the Paleoproterozoic Peräpohja Belt in southern Lapland. Nuggety mineralized intersections to date are largely within metabasaltic rocks. The company continues to focus on the more favourable disseminated and non-nuggety style of mineralisation at the Rajapalot project.

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