Contribution ID: **181** Type: **ORAL**

Falea: an unconformity-type polymetallic deposit, Mali, West Africa

Thursday, 28 June 2018 14:00 (20 minutes)

INTRODUCTION

The Falea Project consists of a polymetallic body hosted within the Neoproterozoic portion of the lower-Taoudeni basin, where it overlies a heavily deformed Birimian basement of schists and metasediments. The project consists of three exploration permits covering 225 km2 and is located in Western Mali approximately 350 km west of the capital, Bamako. The Falea permit covers 75 km2 and hosts ore bodies with an Indicated Mineral Resource of 6.88 million tonnes at 0.115% U3O8 (0.098%U) 0.161% Cu, and 73 g/t Ag and an Inferred Mineral Resource of 8.78 million tonnes at 0.07% U3O8 (0.059%U), 0.20% Cu, and 17 g/t Ag using a cut-off grade of 0.03% U3O8. [1]

HISTORY

Uranium mineralization was discovered by COGEMA in 1977, having identified the area of southern Mali and adjoining Senegal and Burkina Faso as having potential as early as 1957. COGEMA drilled 86 holes on a nominal 800m grid over the Falea Permit, and a more concentrated 200m grid on the Central deposit. COGEMA abandoned the project in 1982, at the time of low uranium prices. [1] Delta Exploration obtained the permit in 2006 from the Mali government, with Rockgate Capital, a Canadian company, funding the exploration as of 2007 during the uranium resurgence for equity in the company resulting in acquisition of Delta in 2008. The exploration carried out by Delta/Rockgate, started at the known Central deposit and progressed northward to define the north zone and ultimately defined the current resource. They also carried out hydrological, environmental and social studies [1]. Denison Mines Corp., acquired the project in 2014, and carried out an airborne geophysical survey as well as soil and termite mound sampling. The Falea project was acquired by Goviex Uranium Inc.(GoviEx) from Denison Mines Corp. on June13, 2016.

GEOLOGY

The project is situated in the Falea-North Guinea-Senegal (FSG) sedimentary basin on the southern edge of the western province of the Taoudeni Basin. The Taoudeni Basin is a Neoproterozoic (750 million years) to Carboniferous, intracratonic basin. The FSG consists mostly of the sedimentary rocks of "Supergroup 1"which is the lowermost sequence. This group consists of a basal, predominantly fluvial package grading upwards into a series of shallow shelf sandstones and mid shelf mudstones (total thickness 500 - 550m). The FSG is situated within the West African craton between the Archean rocks to the South East and Birimian rocks to the North, East and West.

In the Falea region this lowermost sequence sits unconformably on the Birimian Basement. The basal package (approximately 10-30 metres thick) consists of conglomerates (VC), the Kania Mudstone with stromatolite (KI), Kania Sandstone (KS) and the ASK mudstones. The ASK is marine but the VC and KS represent a fluvial sequence of channel and inter-channel sedimentation with a minor marine incursion (KI mudstone plus thin stromatolite). The sedimentary rocks are largely unfolded and sub-horizontal with a very shallow dip to the West (<10 degrees). The sequence is intruded by Carboniferous dolerite sill up to 80m thick in places, and make up the spectacular cliffs of the area.

The North and Central zones are bisected by a North-South trending reverse fault, the Road Fault (RF). The RF verge to the west and repeats the stratigraphy and the mineralization in the zone proximal to it. The vertical throw is 70 metres. The main deposits are spatially associated with this fault. The eastern portions of the central and North zones have depths of 180 -280 metres below the plateau whereas the western blocks are at depths of 250 to 350 metres. The Bodi zone is NW of the North zone but only hosts sporadic U mineralisation. The East Zone is located 4 kilometres west of the main deposits and is a small area of Cu-U-Ag mineralisation also spatially associated with NS faulting [1,2].

MINERALOGY

The Falea deposits consist of four separate zones known as Bodi, Central, North, and East. The North and Central deposits have been intercepted at depths of 180 to 300 metres below surface and are the principal deposits. The Bodi, Central, and North zones occur along a three-kilometre-long, north-south trending mineralized corridor. The East Zone is located approximately four kilometres to the east of the Central and North zones. The Falea deposit is interpreted as an unconformity-associated polymetallic deposit with associations of uranium, silver and copper. The deposit shows similarities with historic districts in Cobalt, Ontario and Erzgebirge-Bohemia district, Germany-Czech Republic [3,4,5,6]

The mineralisation is mainly within the KS unit and averages 3.6 metres in width. It is also present in the VC, KI and at the base of the ASK. Mineralisation can be distributed throughout the KS when it is thin (<4 m) but is most commonly seen at the contacts of the KS with VC or KI or at the lower contact with the ASK. The main gangue minerals detected by XRD in the Falea ore are quartz and muscovite / illite. Chamosite, clinochlore, dolomite, calcite and albite are less abundant. Sulfide mineralization consist of argentite (Ag2S), silver copper arsenic sulfide (tennantite (Cu,Ag,Zn,Fe)12As4S13), galena (PbS), sphalerite (ZnS), cobaltite (CoAsS), arsenopyrite (FeAsS) and covellite (CuS) were confirmed by SEM/EDS analysis. The main uranium mineral is uraninite (pitchblende) but includes coffinite and brannerite. [7] Uranium is spatially associated with silver in the North deposit, where native Silver can be seen in core. The copper is low grade but ubiquitous and seen in just about every hole drilled. Uraninite often forms rims around chalcopyrite. Copper mineralisation is also present at the base of the ASK formation for widths of one to four metres.

DEPOSIT TYPE

The Falea deposit has been previously postulated to represent a combination of two mineralization events. The first event was similar to sedimentary exhalative (SEDEX) event and the second event was interpreted to be a roll-front deposit, that is, an epigenetic uranium deposit at a redox interface occurring on top of a SEDEX deposit. [2]

In 2011, Rockgate reinterpreted the Falea deposit as an unconformity-associated uranium deposit, using a polymetallic egress model for the geological model. The unconformity at Falea is between the Birimian and overlying sedimentary sequences. The egress model was applied due to the presence of the Road Fault, which could have introduced fluids into the sandstones. Unconformity-associated deposits are high-grade concentrations of uranium that are located at or near the unconformity between relatively undeformed quartz rich sandstone basins and underlying metamorphic basement rocks. The compositional spectrum of unconformity-associated uranium deposits can be described in terms of monometallic (simple) and polymetallic (complex) end-members on the basis of associated metals. Polymetallic deposits are typically hosted by sandstone and conglomerate, situated within 25 m to 50 m of the basement unconformity. Polymetallic ores are characterized by anomalous concentrations of sulfide and arsenide minerals containing significant amounts of nickel, cobalt, lead, zinc, and molybdenum. Some deposits also contain elevated concentrations of gold, silver, selenium, and platinum-group elements. Deposits with egress halos (Figure 8-2) include both basement-hosted and sandstone hosted types, and the alteration ranges between two distinctive end-member types: 1) quartz dissolution + illite; and 2) silicified (Q1 + Q2) + later illite-kaolinite-chlorite+dravite [8; 9, 1].

WORK COMPLETED AND DISCUSSIONS

There are 231887m of drilling over 944 drill holes were completed over the Falea deposit, most holes were diamond core from surface, with a small amount with RC pre collars. Drilling was completed to define the resource, which leaves us with abundant exploration potential outside of the main deposit area. Other work completed over the area include soil surveys for gold over subcropping Birrimian, as wellas soil and termite mound survey over the Falea deposit; radon cup surveys and geological mapping along the range fronts, which included scintillometer surveys.

Helicopter-borne geophysical data was collected by Rockgate in 2012 and Denison in 2015. They included Airborne magnetics, TEM and Radiometrics. This data was recently remodeled. The structural complexity of the area becomes evident as a series of NS, and conjugate NE-SW and NW-SE fault pattern divide the area into what appears horsts and graben, bringing target horizon of the lower Taoudeni and particularly the Kanya Sandstone closer to the surface. The thick dolerite unite unformtunately does tend to blind the EM and deeper magnetic signatures. In some areas however we can correlation of the Analytical signal trenght of the magnetic data, the EM conductivity and the higher U values from the radiometrics. [10].

Isopach analysis was undertaken in house on the main deposit and concentrated on the sequence between the base of ASK unit to the top of Birrimian (the unconformity surface) and the thicknesses of KS, VC and

KI. The Birrimian surface forms a NS palaeochannel just east of the Road Fault . The VC unit is thicker in this channel whereas the KI unit (thin shale) is only well-developed east of the channel. Similarly, the KS unit attains greater thicknesses (+6m) east of the channel. This evidence suggests that the Road Fault was probably a hinge line or small scarp during sedimentation and created a channel for conglomerate deposition whereas channel edge and interchannel areas were dominated by sand and shale during the brief marine incursion of KI. The channel and interchannel areas formed a sedimentary trap for the focus and the precipitation of metals from saline, metal bearing brines at a later stage. Similarly, the Eastern zone is also spatially associate with a NS structure and has variable VC thickness. The following points are evident from the isopach work:

• There is a clear relationship between the Road Fault and the distribution of the VC conglomerate supporting the fault scarp hypothesis. Using the base of ASK to the top of Birrimian this is the thicker accumulation just east of the fault (paleo-low area) In the field conglomerates next to the fault displayed some boulder sized pebbles.
• The KS sandstone is better developed (thicker) to the east of the fault zone in the paleo-high area. The VC and KS may represent facies changes i.e. channel versus interchannel areas.
• The channel relationship is not so clear if sea level is used as a datum . Base of ASK is considered better because it's the first major marine incursion
• Grade accumulation spans both high and low areas with U and Ag mirroring each other and Cu showing higher concentrations to the east.
• A closer look at the northern zone highlights the strong relationship between a thin KI unit (mudstone and stromatolite) and better grades for Ag and U. Again, Cu shows a preference for a thicker KI as a preferred trap. The KI unit represents a marine incursion which was clearly only thinly developed once it encountered the paleo-high.
• The relationships in the Central zone are not as clear although if the KS is too thin then mineralisation seems to reduce in tenor and quantum .
• The Isopach work is highlighting the importance of the sedimentology in creating a suitable trap for precipitation of metals from metalliferous brines which were mobilised AFTER basin formation and relating to fluid movement triggered by a later deformation event.

Whereas there has not been any proper analysis of alteration patterns of the hanging wall and footwall rocks at Falea, visual inspection of the core reveals that the sandstones contain primary quartz, muscovite and some feldspar (minor); alteration includes chlorite, sericite/illite and carbonates (calcite and Dolomite. Albite and Riebeckite have been observed. Apatite, rutile, zircon and anhydrite are noted. Hematite staining is common. In the east fault zone, there is abundant hematite staining and silicification which has pervaded both basement and HW units. Bleached zones and hematite staining was observed in the HW package. Chlorite and sometimes hematite were noted in the basement rocks.

The delineation of the deposit and comparison to large, rich, historic districts may point to considerably larger resources occurring in the area.

ACKNOWLEDGMENTS

The authors would like to thank previous workers as well as David Reading for their contributions.

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Country or International Organization

Mauritius

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Session Classification: Economic Evaluation of Uranium Projects

Track Classification: Track 5. Economic evaluations of uranium projects