Svartliden, Sweden

Resume

The Svartliden gold deposit is situated along the Gold Line, SW of the Skellefte District (Fig. 1) and is considered a structurally controlled epigenetic lode gold deposit. The ore bodies extend over 1 km along strike with a vertical extent of approximately 300 m.

Figure 1: *The gold ore deposit of Svartliden, mineralization of the "Gold Line" situated in northern Sweden.*

Mine project history

As the Skellefte VMS district is a well-known metallogenic province in the Västerbotten county, the Swedish Geological Survey (SGU) decided in the 1980's, to explore also in the neighboring area. In 1985, a team of SGU geologists found a couple of mineralized boulders at some distance from Svartliden. They continued to sample river- and stream sediments, and gold was found in several sites.In 1995, what was to become Lappland Goldminers AB, owner of the Fäboliden gold deposit, performed a boulder tracing campaign in the same area and found boulders with up to 88 g/t Au. During the same year, 4 diamond drill holes intersected significant gold mineralization (with grades up to 50 g/t Au and 5 m at 4-9 g/t Au). Hence, the Svartliden gold deposit was found. In 1996, Lappland Goldminers AB formed a joint venture with the Canadian company Viking Gold Corporation, and between 1996 and 1998 the Canadian company undertook different geophysical surveys and drilled an additional 45 diamond drill holes to delineate a gold mineralization with an extent of > 1000 m. The deepest intersection of the gold lode was found at 110 m. In 1999, Viking Gold Corporation was bought by Dragon Mining AB which today exploits the Svartliden deposit. The construction of the processing plant and the open pit started in 2002 and the production in March 2005. The company now plans to end production from the open pit in October 2012, and to focus their operation underground, which started in late 2011 (Fig. 9). The remaining resources are expected to last until 2015. Since 2005, Dragon Mining has mined more than 2.1 Mt of ore, at a grade of 4.5 g/t Au (Dragon Mining, 2011).

Geology and mineralization

The orogenic gold mineralization at Svartliden occurs in a Palaeoproterozoic volcano-sedimentary sequence consisting of meta-basalts and turbiditic sediments that have been metamorphosed to an amphibolite facies metamorphic grade. The mineralization is hosted by a banded iron formation on the contact between the sediments and meta-basalts and is closely associated with a sulphide assemblage dominated by pyrrhotite and arsenopyrite. A number of alteration styles are present in the sequence, but only silicification appears to be proximal to the mineralization. The entire host sequence is strongly deformed, initially subjected to tight folding followed by dextral shearing. Both of these events occurred after the mineralizing event and have disrupted continuity of the host units. The mineralization at Svartliden represented a new style of mineralization for the broader district, in an area not previously recognized for its gold potential due to a poor appreciation of the prospectivity of the geology.

Exploration at the Svartliden gold deposit

Since 2006, Dragon Mining has implemented an exploration strategy to identify additional resources proximal to the Svartliden Production Centre. This resulted in the delineation of the underground resource at Svartliden and the identification of gold mineralization in the near mine area at the Far East, Svartliden West and Björkliden (Fig. 2).

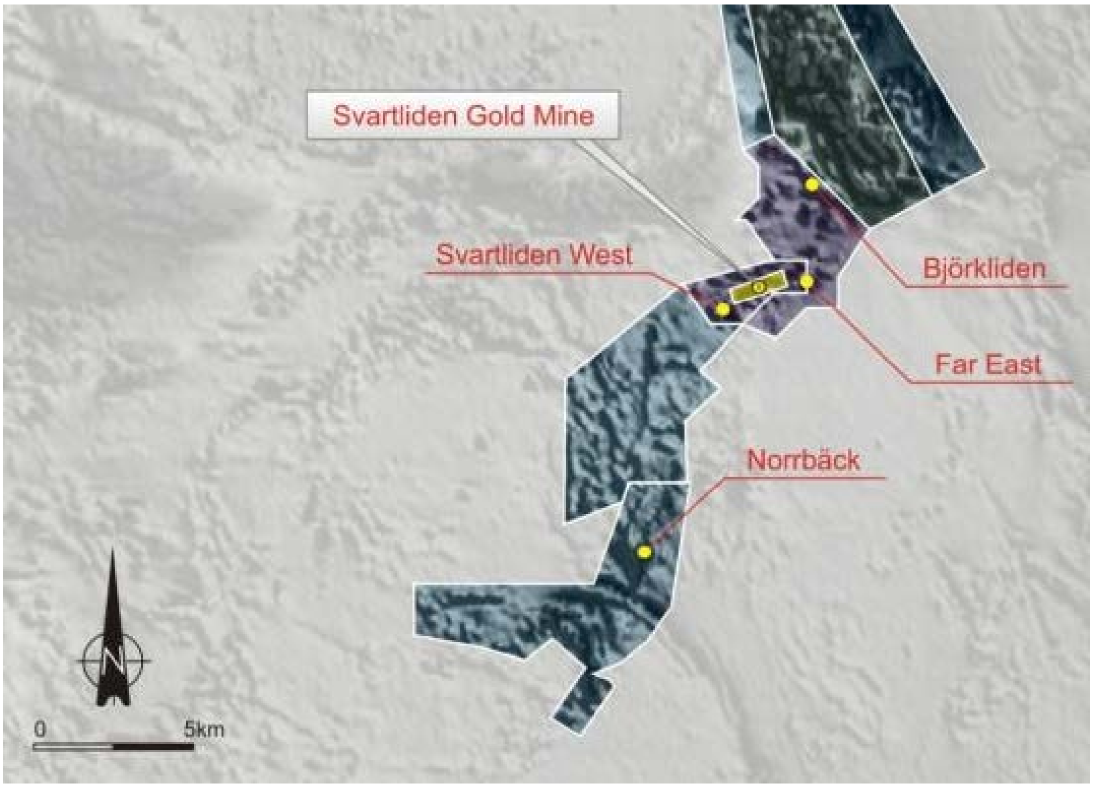

Figure 2: *Exploration program at the Svartliden gold deposit*

The Far East target is located approximately 800 meters east of the Svartliden open pit and was identified through an ongoing program of geological and geophysical modelling of the near mine area. Drilling has intersected rock type's characteristic of the Svartliden host sequence and returned a number of promising gold intercepts including 6.00 meters at 6.69 g/t gold, 1.00 meters at 22.40 g/t gold, 2.00 meters at 8.74 g/t gold and 2.00 meters at 9.57 g/t gold.

Drilling in the Svartliden West area that was designed to test the westerly extensions of the Svartliden host sequence at depth returned a best intercept of 6.00 meters at 2.72 g/t gold. A program of drilling has also been completed in the Björkliden area, approximately 3,500 meters northeast of the Svartliden open pit. Assays have been received from all holes returning a narrow high grade intercept of 1.00 meters at 34.50 g/t gold.

Project Description

In the mine of Svartliden, gold is extracted by cyanide leaching from inclusions in arsenopyrite. The major ore mineral assemblage consists of pyrrhotite and arsenopyrite-loellingite. Effluents from the gold extraction were treated with $Fe_2(SO_4)_3$, with the aim to form stable As-bearing Fe-precipitates (FEP).

Table 1: *Mining methods, amount of ore, waste rock and tailings produced/year at Svartliden*

Method	Ore production (Mton)	Wasterock (Mton)	Tailings (Mton)
Underground, open pit	0.32	0.15	0.17

Tailings content of As and S was 1000 ppm and 20.000 ppm respectively. The major environmental concern regards high levels of arsenic (As) exceeding regulatory guidelines in outlet tailings slurries. The general aim for this study is therefore to make it possible to develop more effective ways of managing As-bearing tailings that will prevent the occurrence of high As concentrations in the mine drainage. The study could be divided into two parts:

1. The stability of As in tailings originating from mine processes in Svartliden is evaluated by performing static and dynamic leaching tests. More specific aims included the suppression of these tailings into simulated flooded conditions, accelerated weathering and evaluate the effects on As-leaching. Speciation of As in ore and tailings were conducted to get knowledge about the origin of As.

2. In the second part of the study, the use of a method called cemented paste backfill (CPB) was evaluated for management of As-rich cyanided tailings. The use of CPB-mixtures containing cement, fly ash, slags and tailings could decrease leaching of arsenic according to previously conducted studies. However, in these studies, the proportions of cement, various slags and ashes ranged from 4-7 %. Demands of strength in these mixtures were determined by the mine processor to maximize the amount of extracted ore. When less strength is needed in tailings management, lower proportions of binders could be added. The primary objective for this part of the study was to evaluate the effects of cementation on arsenic leaching. For cost-reduction, low proportions of cement and biofuel fly ash (1-3 wt. %) were used as amendments. The effect of cementation on As-leaching was evaluated by comparing CPB-materials and un-amended tailings.

Conclusions

In tailings, As occurred primarily as secondary minerals as a consequence of the gold extraction process. A majority of As in tailing was associated with Fe-hydrates as Fe-As-precipitates. These precipitates were stable in tailings where pH was >4. Conducted leaching tests suggested that As is more stable in simulated flooded conditions. Cumulative leaching of As in these leaching tests represented, however, very small proportions of the total content of As.

The inclusion of As-rich tailings into a cementitious matrix using CPB increased leaching of As. Alkaline conditions in CE and CE-FA during leaching tests caused a small proportion of As to desorb from the Fe-hydrates. Desorbed As could then have been incorporated into the cementitious matrix and/or re-precipitated as Ca-arsenates. The addition of binders increased the neutralization capacity of the tailings causing less Fe and S to dissolve. The addition of acid increased As-leaching most significantly in CE that had the lowest proportion of binders.

These studies has been presented in articles and at conferences during 2014-2015.