FIELD TRIP GUIDE TO IRON CREEK, LEMHI COUNTY, IDAHO

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INTRODUCTION AND GEOLOGIC SETTING

The Idaho Cobalt belt (ICB) is a northwest-trending belt of cobalt ± copper-bearing deposits and prospects in the Salmon River Mountains of east-central Idaho, and is an important domestic cobalt mineral resource (fig. 1A; Landis and Hofstra, 2012). The host rocks of the ICB are part of the Belt–Purcell Supergroup, a Mesoproterozoic meta-sedimentary succession extending across the Idaho–Montana border into southern Canada (Perron and others, 2023).

The Iron Creek deposit is a strata-bound Co-Cu deposit in the southeastern portion of the ICB. Mineralization is hosted within a lower greenschist grade succession of interbedded siltite–argillite with quartzite-rich units of the lacustrine Mesoproterozoic Apple Creek Formation (Ristorcelli and Schlitt, 2019). The banded siltite member is the principal host rock to mineralization and contains abundant quartz, muscovite, biotite, and chlorite, with minor amounts of apatite, plagioclase, and Fe-Mn-oxides. Pyrite, pyrrhotite, chalcopyrite, and magnetite are associated with thin, cross-bedded quartzite layers in the banded siltite member. Cobalt is mainly held in pyrite, and Cu in chalcopyrite.

Current indicated mineral resources at Iron Creek are 4.5 million tonnes grading 0.19% cobalt and 0.73% copper, and inferred mineral resources are 1.2 million tonnes grading 0.08% cobalt and 1.34% copper (Perron and others, 2023). Ongoing research within the Center to Advance the Science of Exploration to Reclamation in Mining (CASERM) is striving to improve our understanding of the geologic framework of the ICB and its cobalt mineral resources in three dimensions and to aid exploration and assessments of (critical) mineral resources. The aim of this study is to better understand the mineralization and alteration mineralogy, geochemistry, and magnetic susceptibility of the subsurface and deposit-forming processes at Iron Creek.

HISTORY

The history of the Iron Creek Property is summarized from the technical report by Ristorcelli and Schlitt (2019). The first mining claims were staked in the Iron Creek area in 1967 on copper-stained material in what later became known as the "No Name" Zone and is now considered to be the upper zone of the broader Iron Creek mineralization. In 1970, these claims were leased to Sachem Prospects Corporation (Sachem) of Salt Lake City, Utah. Sachem completed 11 diamond-core drill holes and excavated three underground exploratory drifts. Hanna Mining optioned the Iron Creek Property in 1972 through its wholly owned subsidiaries, Coastal Mining Co. and Idaho Mining Co., and then acquired it outright in 1973 from Sachem.

From 1979 through 1996, the Property was explored by Noranda Exploration, Inc., Inspiration Mines, Inc., Centurion Gold, and Cominco American Resources, Inc. Various campaigns of drilling, geophysical surveys, and surface and underground geochemical sampling were conducted. Between all these programs, a total of 57 holes were drilled on the property prior to 1996.

Between 1996 and 2016, the patented and unpatented claims were acquired by the Chester Mining Company. Scientific Metals Corp. optioned the Iron Creek patented property from Chester Mining Company in 2016 and staked claims surrounding the Iron Creek patents. Scientific Metals Corp. changed its name to U.S. Cobalt in 2017. U.S. Cobalt conducted exploration drilling in 2017 and 2018 prior to being acquired by First Cobalt in 2018. First Cobalt acquired the patented claims and continued the exploration drilling into 2019. First Cobalt subsequently changed its name to Electra Battery Materials Corporation and completed a drill program in 2021.

ONGOING RESEARCH

Samples for an ongoing study within CASERM and in collaboration with the U.S. Geological Survey and Electra Battery Materials Corporation were collected from two drill holes: one from the Iron Creek Project (IC-17-28) and one from the nearby Ruby Zone (IC-22-02) intercepting high-grade Cu-Co mineralization (fig. 1B; Schmidt and others, 2023). Thirteen additional field samples representing host rock units in the ICB were also collected.

Based on continuous X-ray fluorescence data, the 293-m-long drill hole from the Iron Creek Project intersects the high-grade portions of the Cu-Co-rich mineralized zone between 63 and 87 m and two Co-rich ore zones between 116 and 145 m and 178 and 216 m, respectively. The 374-m-long drill hole from the Ruby Zone intersects

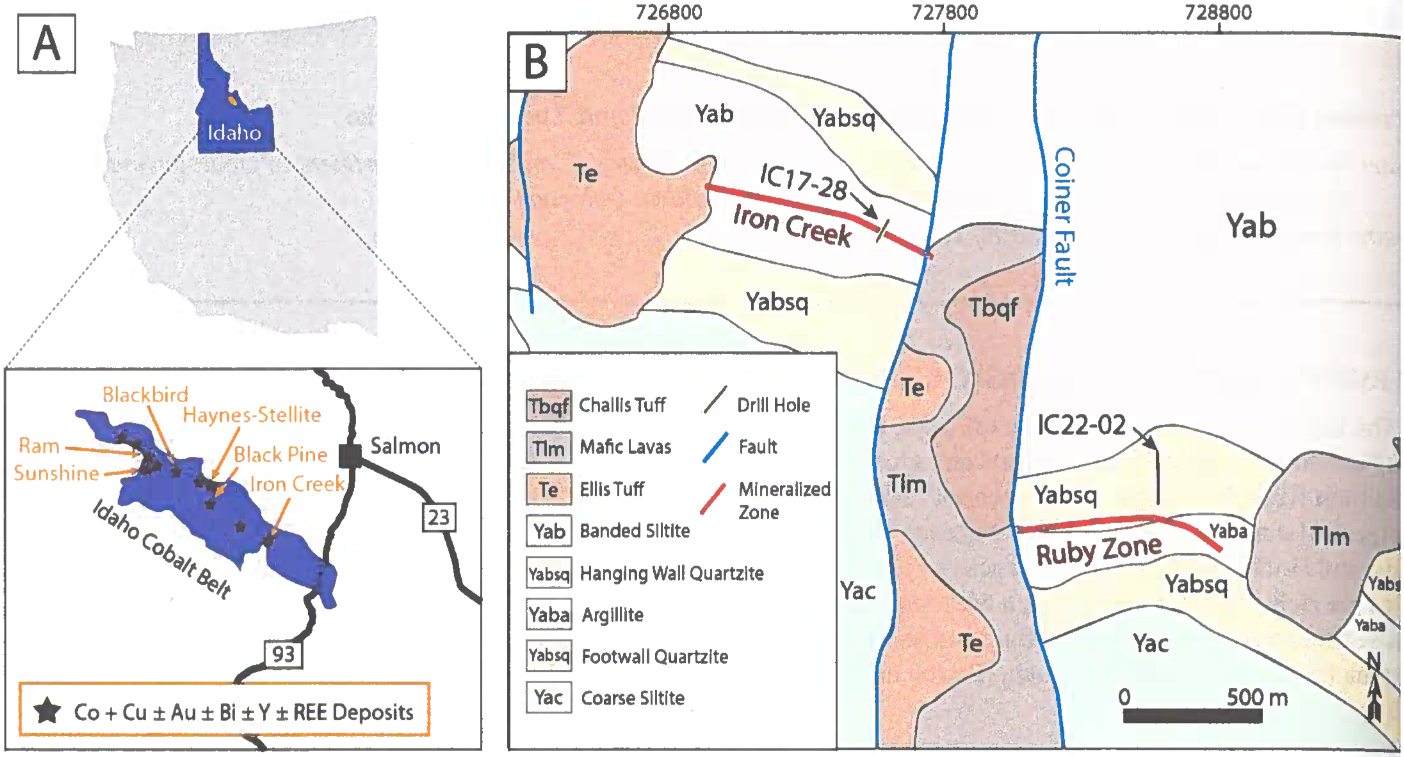

Figure 1. (A) Idaho Cobalt belt and (B) Iron Creek deposit with the Iron Creek Project and the Ruby Zone drill collars indicated (after Schmidt and others, 2023).

two Co-rich mineralized zones between 308 and 313 m and between 364 and 365 m. This dataset also indicates that Co has a strong positive correlation with As and Se, whereas Cu shows positive correlations with Te, Pb, and Zn. A detected Cr and Ni halo around the Co mineralized zones could represent a useful tool for vectoring toward Co mineralization. Short-wave infrared core scanning revealed a significant increase in Fe-rich chlorite-group minerals around mineralized zones, whereas muscovite and illite are predominant in unmineralized host rocks.

Magnetic susceptibility data show a significant property contrast between the host rock above and below the mineralized zones, and the mineralized zones themselves. At Ruby, values acquired on core outside the mineralized zones range from 0.85 x 10^{-3} to 0.002 x 10^{-3} SI, whereas values from the mineralized zones range from 1.37 x 10^{-3} to >2000 x 10^{-3} SI. The magnetic susceptibility data acquired on mineralized intercepts are consistently high across the entire ore zone.

Petrographic observations on high-grade ore samples by Schmidt and others (2023) show a distinct succession of ore and alteration minerals, including five discrete pyrite generations. Early cobaltiferous pyrite predates the main mineralization stage and is ubiquitous in samples from mineralized zones in the Iron Creek Project, whereas early magnetite and lesser pyrite are abundant in samples from mineralized intercepts in the Ruby Zone. Both early pyrite and early magnetite are associated with abundant biotite. Main stage ore minerals are represented by cobaltiferous pyrite with ubiquitous Bi-telluride inclusions, and chalcc pyrite with minor cattierite–vaesite accompanying pyrite Post-mineralization pyrite forms a porous overgrowth or main-stage pyrite. Main-stage alteration consists of Fe-ri chlorite and muscovite. Late-stage, possibly syn-metamo phic silicification and quartz veining is host to cobaltifer pyrrhotite and minor galena and sphalerite. Subsequent a teration caused pyrrhotite to be replaced by marcasite/py and goethite. Supergene oxidation and weathering of pyr led to the formation of jarosite, hematite, and other secon ary minerals. Cobalt and Ni originally hosted in primary pyrrhotite was liberated during the pyrrhotite breakdown and form discrete cobaltite–vaesite minerals.

At Iron Creek, Co-Cu mineralization is hosted in int layered siltite, biotite phyllite, and quartzite of the bande siltite member of the Apple Creek Formation. Sediment position in the area is bracketed between ~1445 Ma (U-I on detrital zircons from the underlying Hoodoo Formatic Link and others, 2007) and ~1409 Ma (U-Pb on detrital z cons from the uppermost part of the banded siltite memb Aleinikoff and others, 2012). Based on these ages as wel the findings of Bookstrom and others (2016), Saintilan a others (2017), and Schmidt and others (2023), it is proposed that early cobaltiferous pyrite at the Iron Creek Pr ect and early magnetite at the Ruby Zone formed before the main stage of mineralization and was followed by a epigenetic main-stage mineralization forming event link to the emplacement of a ~1383–1359 Ma suite of bimod gabbro-granite intrusions: Big Deer Creek, bordering the northeastern margin of the ICB, dated at ~1377 ± 4 Ma (

Pb on xenotime and monazite; Aleinikoff and others, 2012; Slack, 2012). Re-Os dates on cobaltite from the Blackbird Mine, the Haynes–Stellite Mine, and the Black Pine Mine (fig. 1A; located to the northwest of Iron Creek in the ICB) led Saintilan and others (2017) to propose a mineralization model involving the influx of Mesoproterozoic evaporitic brines and magmatic-hydrothermal fluids and multi-stage REE-Y-Co-Cu-Au mineralization at around 1370 to 1349 Ma.

MINERALIZATION PROCESSES

According to Schmidt and others (2023), main-stage mineralization (cobaltiferous pyrite and chalcopyrite) at the Iron Creek deposit might be comparable to the formation of the sediment-hosted Black Butte Co-Cu deposit on the eastern side of the Belt–Purcell Basin. The Black Butte Cu-Co deposit is considered to have formed by moderate-temperature, reduced basinal brines, which entered pre-mineralized horizons and caused the formation of main-stage pyrite and chalcopyrite (Graham, 2011; Pfaff and Graham, 2013; Saintilan and others, 2021). Saintilan and others (2021) suggested that Cu mineralization at Black Butte coincided with an increased thermal gradient in the eastern portion of the Belt–Purcell Basin caused by intrusion of a tholeiitic dike swarm around 1455 Ma (Re-Os isochron age). Studies at Iron Creek agree with a Mesoproterozoic origin of main-stage Cu-Co mineralization. Cretaceous metamorphism in the ICB led to a greenschist (Iron Creek) to amphibolite (Blackbird) facies overprint (Lund and others, 2011) and associated silicification and quartz veining found in the Iron Creek deposit and elsewhere in the ICB (Nash and Hahn, 1989; Aleinikoff and others, 2012). Evidence put forward by Saintilan and others (2017) suggests that Cretaceous deformation and metamorphism during the Cordilleran Orogeny remobilized metals in the ICB, as represented at the Iron Creek deposit by cobaltiferous pyrrhotite, sphalerite, and galena deposited together with quartz in late structures.

FIELD TRIP STOPS

Figure 2 shows the locations of the field trip stops on a geologic basemap. This field trip begins officially at the road junction near the confluence of the North and South Forks of Iron Creek. This location is reached by travelling 24.3 mi south on Highway 93 from the Intersection of Highways 93 and 28, and then turning west off of the highway and proceeding roughly 8 mi in a generally westerly direction up the Iron Creek Road (USFS Road 45). The road trip proceeds in a generally northerly direction along USFS Road 45, which follows the North Fork of Iron Creek up to patented claims held by Electra Battery Materials, which will be the final stop on this road trip.

Figure 2. Iron Creek field trip stops, Geology from Lewis (2021).

STOPS 1a–1b—0 mi
Junction of North and West Forks of Iron Creek
(USFS roads 45 and 456, respectively)

(45.9256°N, 114.1142°W)

This is an example of steeply northeast-dipping strata of the coarse siltite member of the Apple Creek Formation. The lower part of the coarse siltite member is characterized by tabular beds of quartzite up to 30 cm in thickness (fig. 3). These are readily visible from the road junction.

Figure 3. Steeply dipping tabular beds of quartzite exposed along the West Fork of Iron Creek a short distance west of the road junction.

STOP 2—0.3 mi
On North Fork of Iron Creek Road

(45.9214°N, 114.1097°W)

This stop is at the trace of the northerly trending Coiner fault, which coincides with the contact between the Apple Creek Formation and the Tuff of Ellis Creek Unit of the Eocene Challis Volcanics (fig. 2).

STOP 3—1.4 mi

45.9406°N, 114.1194°W

The road leaves the Challis Volcanic stratigraphy about 1.1 mi north of the Coiner fault and once again traverses the coarse siltite member of the Apple Creek Formation (fig. 4). There is a Quaternary landslide mapped near this contact. This is the upper part of the coarse siltite member of the Apple Creek Formation, and mud cracks occur in this vicinity between this point and Jackass Creek. The banded siltite member of the Apple Creek Formation begins about 0.3 mi below Adit 1 on the Iron Creek patents. The banded siltite member is the host for the Iron Creek deposit and other prospects

Figure 4. Stop 2 looking south along North Fork of Iron Creek Road, contact between Challis Volcanic and Apple Creek Formation.

and deposits in the area. It contains frequent occurrences of rhythmic couplets of argillaceous and coarser silty material, and frequent sand diking and other soft sediment bedding disruptions.

STOP 4—3.1 mi
The Laydown Area Near the Portals at the No Name Deposit (Final Stop)

(45.9622°N, 114.1161°W)

The tour concludes at the laydown area near the adit portals at the No Name Zone of the Iron Creek Deposit. This location is within the Banded Siltite Member stratigraphy and portions of the No Name Zone are exposed in outcrop in this vicinity. There are two historic adits dating from the early 1970s in this vicinity.

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