Exploration & Mining of Porphyry Deposits Using Thermo Scientific Portable XRF Analyzers

Example from the Miner Mountain porphyry Cu deposit, British Columbia, Canada

Introduction

Porphyry deposits are very attractive exploration and mining targets due to their high tonnage and relatively easy open pit mining. They are commonly associated with porphyritic intrusive rocks, i.e., granite porphyry. The term "porphyry" refers to any igneous rock that has coarse-grained crystals in a relatively fine-grained matrix.

Copper (Cu), molybdenum (Mo), silver (Ag), and gold (Au) are the common metals of economic value found in these deposits. As mentioned, an important feature of porphyry ore deposits is their large tonnage. For example, an individual porphyry copper deposit can contain several billion tons of Cu at 0.4-1%, making these deposits the largest source of copper ore. Ideal for open pit mining, they are commonly found close to the surface and can be mined on a large scale at a low cost. Although these deposits have low grades, the superior detection limits of a Thermo Scientific portable x-ray fluorescence (XRF) analyzer allow easy measurement of the base metal concentrations.

Application

A common feature of porphyry deposits is spatial zoning of hydrothermal alteration and mineralogy (see Figure 1). This is controlled primarily by a magma type and varies from deposit to deposit. The zoning can be used as an exploration tool to locate mineralized zones.

Some of the common applications of these elements assayed by a Thermo Scientific portable XRF analyzer are shown in Table 1.

Portable XRF Analyzers

Thermo Scientific portable XRF analyzers can be used at any stage of exploration and mining of various metals in porphyry deposits, such as Cu, Au, Ag, Mo, lead (Pb), zinc (Zn), antimony (Sb), bismuth (Bi), etc. Detections limits for base metals in these instruments is low enough to allow even non-geologists to analyze any geological sample from outcrops to drill cores to soil specimen. In addition to base metals, other elements, such as potassium (K), calcium (Ca), and light elements [magnesium (Mg), aluminum (Al), silicon (Si), phosphorus (P), and sulfur (S)] can be assayed as well, which helps geologists in mapping the hydrothermal alteration of the exploration/mining area or 3D modeling of the alteration and mineralization.

To investigate the application of portable XRF in the porphyry Cu exploration, core samples were analyzed by a Thermo Scientific Niton XL2 GOLDD XRF analyzer.

Elements	Indicates	Suggests
High metal concentrations (Cu, Au, Ag, Mo, Pb, Zn, Sb, Bi) in a specific horizontal or vertical direction	Proximity to the center of the mineralized zone	Trend analyses using a portable XRF is strongly recommended
High concentrations of potassium (K)	Presence of K-feldspar, which is the main mineral of potassic alteration	The potassic alteration zone commonly hosts a major part of the ore deposit
High concentrations of calcium (Ca)	High carbonate alteration	– Locally, high Ca may be part of the propylitic alteration zone, which envelopes the ore mineralization – This is not extensive in the porphyry systems
High concentrations of sulfur (S)	Presence of sulphate or sulphide minerals	– May indicate close proximity to the mineralized zone – Not widespread in porphyry
High concentrations of arsenic (As)	Presence of arsenide or sulpharsenide minerals (such as arsenopyrite – FeAsS)	– These zones may be spatially associated with Au mineralized in the porphyry deposits – Sampling for lab assays for low (sub ppm) concentrations of gold is needed

Table 1. Common applications of portable XRF in porphyry Cu-Mo exploration. There can be other applications, depending on the geology and characteristics of each deposit type.

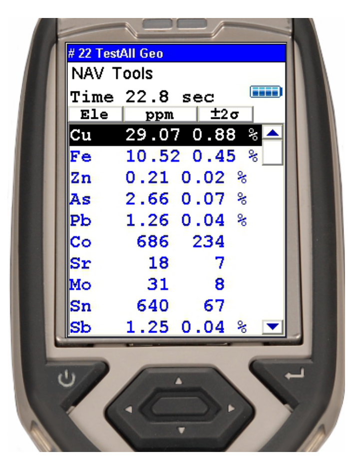
Methodology

This case study was carried out in the Miner Mountain porphyry deposit in British Columbia, Canada. This copper deposit is an "alkalic" type (Cu-Au ± Ag, PGE) porphyry deposit and is located in a belt of late Triassic to early Jurassic trachybasaltic/trachy-andesitic volcanic rocks and is associated with sub-volcanic microdioritic-dioritici intrusions. Because the rocks are under-saturated with silica and over-saturated with calcium, typically they do not have the quartz vein abundance, or acidic alteration (particularly the large pyrite halo and extensive sericite-argillic alteration) of the calc-alkaline systems. Instead, they are marked by progression from chlorite – epidote ± magnetite (propylitic) to an albite-epidote-chlorite dominated zone, and then to a K-feldspar, secondary magnetite ± diopside/biotite potassic core. Mineralization progresses from pyrite to chalcopyrite/pyrite to bornite-chalcopyrite with bornite/covelite/chalcocite locally present in the cores of the systems.

To investigate the application of portable XRF in the porphyry Cu exploration, core samples were analyzed by a Thermo Scientific Niton XL2 GOLDD XRF analyzer. Each analysis represents 1 - 1.5 meters of core sample assayed by a direct shot using the analyzer. These samples were also analyzed by routine ICP analyses in a commercial lab.

Results

Strip logs were plotted using assay data from the commercial lab, as well as the on-site data of the portable XRF analyzer. Three representative copper strip logs for three drill holes are shown in Figure 2. Visual examination of these logs not only indicates high correlation between these two sets of assay data, but also the efficiency of the Niton® XL2 GOLDD instrument in identifying mineralized zones. Such real-time identification of anomalous zones is crucial for drill program planning and 3D block modeling of the ore deposit, saving you time and costs.



Thermo Scientific Niton XL3t GOLDD+ analyzers are among the range of Thermo Scientific portable XRF analyzers that can give fast, accurate results, such as this analysis of a sample from a porphyry deposit.

Conclusions

Due to high tonnage, porphyry deposits are one of the most attractive exploration targets in the mining industry. A large percentage of portable XRF units are utilized for discovery of these deposits. This application note summarizes successful use of portable XRF analyzers in strip logging. Such real time analyses combined with having access to real time strip logs are very important for effective drilling and 3D modeling of the ore deposits.

To discuss your particular applications and performance requirements, or to schedule an on-site demonstration, please contact your local Thermo Scientific Portable XRF Niton Analyzer representative or contact us directly by email at niton@thermofisher.com, or visit our website at www.thermoscientific.com/niton.

Reference

John, D.A. (ed.) (2010): Porphyry Copper Deposit Model. Scientific Investigations Report 2010.5070.B, U.S. Department of the Interior/U.S. Geological Survey, 186p.

We would like to thank Sego Resources, especially Mr. Andrew Watson, for his technical and geological support.

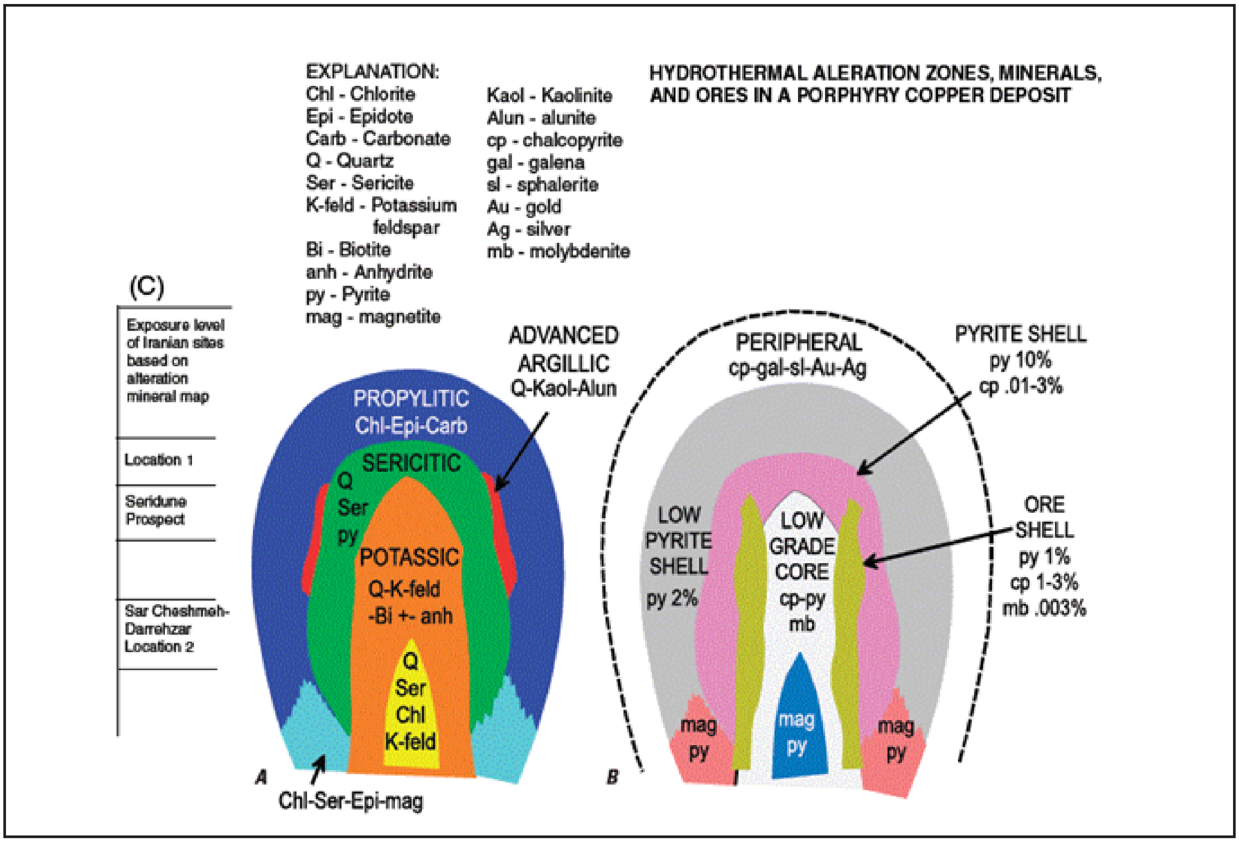


Figure 1. Porphyry copper deposit model (John et al., 2010). A) Schematic cross section of hydrothermal alteration minerals and types. B) Schematic cross section of ores associated with each alteration type. C) Scale showing level of interpreted exposure for a few well-known porphyry deposits.

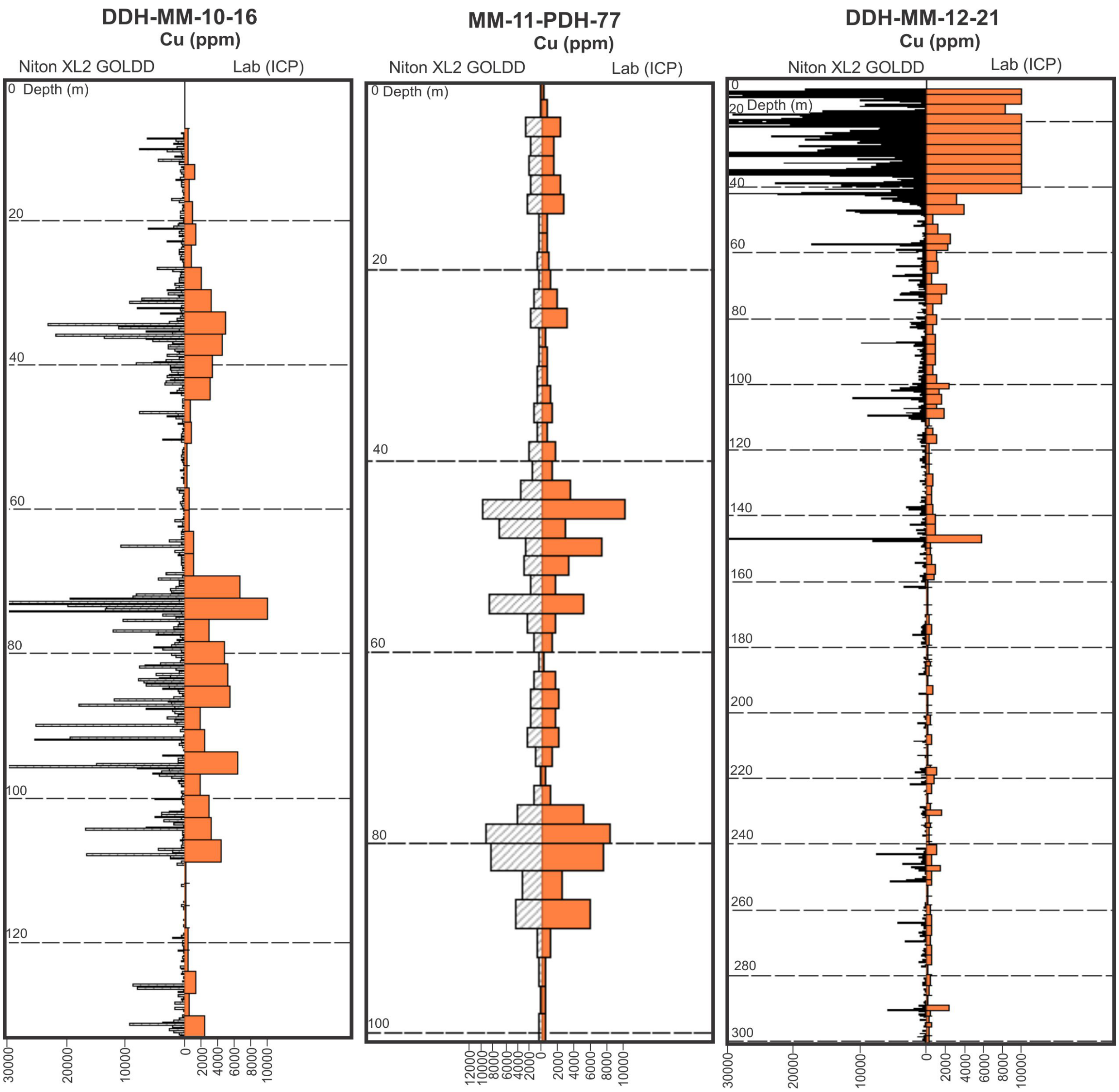


Figure 2. Strip logs for three drill holes in the Miner Mountain porphyry Cu deposit.

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5-324 06/2012