



Technical Note

COPPER

▶ **ALS Geochemistry has decades of experience with some of the world’s largest copper projects. We have a range of methods to suit your deposit type, from porphyries to rebeds and massive sulfide bodies to IOCG.**

EXPLORING FOR COPPER

Historically, copper exploration with soils, rocks and drill core has involved a simple aqua regia digestion and ICP-OES or ICP-MS analysis. Aqua regia easily digests common copper-bearing sulfide minerals such as chalcopyrite and bornite, as well as secondary copper minerals often found in association such as malachite, azurite and cuprite. Sediment-hosted Cu, rebeds, and IOCG deposits can be effectively explored using aqua regia digestion.



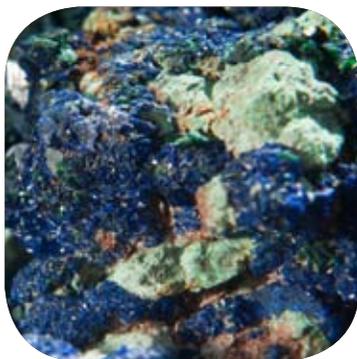
However, there is increasing recognition in the industry that exploration for porphyries may benefit from four acid digestion, despite the traditional use of aqua regia for these projects. Copper porphyries with accessory molybdenum require a four acid digestion for complete recovery in exploration samples. Secondary silicate minerals like chrysocolla show higher recovery of Cu in a four acid digestion. And finally, a database of major element geochemistry from four acid digestion may prove to be exceptionally valuable in alteration mapping. Imagine having your entire geochemical library as a basis for an alteration index, verified by select holes studied with an XRF whole-rock geochemistry method, instead of patchy data and tenuous extrapolation from a handful of drill core samples. Four acid digestion data can deliver this level of insight.

In addition, four acid digestion is generally required for massive sulfide deposits due to the presence of refractory minerals incorporating metals such as nickel, cobalt, lead and zinc. Some samples may be so high in sulfide that an oxidizing fusion is needed to overcome matrix effects inherent to acid digestion.

The instrument finish you choose depends on your goals. Greenfields exploration using trace element pathfinders require the sensitivity and range of the ICP-MS. Economical packages available on the ICP-OES are suitable for ore body drilling with a trace element profile. For more mineralized samples, such as massive sulfide ores, ICP-OES analysis is ideal. The table below sums up the most common methods used in copper exploration at ALS Geochemistry.

DIGEST	TRACE ELEMENTS	LOW GRADE	MINERALIZED
Aqua regia	ME-MS41 51 elements, 0.2ppm-1% Cu	ME-ICP41 35 elements, 1ppm-1% Cu	ME-ICP41a 34 elements, 5ppm-5% Cu
Four acid	ME-MS61 48 elements, 0.2ppm-1% Cu	ME-ICP61 33 elements, 1ppm-1% Cu	ME-ICP61a 33 elements, 10ppm-10% Cu
Fusion			ME-ICP81 16 elements, 50ppm-30% Cu

MINERAL CHARACTERIZATION OF COPPER ORES



Mineral-selective leaches for copper can be useful at many different stages in a project's life. Some understanding of the recovery from common processing methods may be valuable during resource evaluation. Established mines may want to combine early metallurgical characterization with exploration geochemistry when drilling on-site.

ALS Geochemistry offers a variety of the popular processing methods as rapid, low-cost tests on standard pulp samples. Variations in acid strength, temperature, and leach time can be incorporated into these procedures, and they can be combined with sequential leaches for ore characterization. We're happy to work with you on customizing these tests to the particular mineralogy and extraction method of choice at your project.

LEACH TYPE	DESCRIPTION
Citric Acid	Targets oxide/non-sulfide minerals. Used in heap leach and bioleaching.
Sulfuric Acid	Targets oxide/non-sulfide minerals. Widely used in copper processing.
Cyanide Leach	Targets secondary sulfide minerals and some primary sulfides. Useful when the project contains gold.
Others	Other specialty digestions including water leach, ammonium acetate, and modified four acid (perchloric acid replaced with sulfuric acid) are available.

ASSAYING COPPER PRODUCTS

ALS Geochemistry copper assays and related methods cover everything from overlimits on exploration samples to trace components in copper anodes. In order to develop the best analytical program for your ore grade samples, mill concentrates, or other specialized material, please contact Client Services to discuss your needs.

PRODUCT	METHODS	DESCRIPTION
Ore Grade Exploration Samples	Cu-OG46/OG62 - 0.001-40% Cu Cu-AA46/AA62 - 0.001-50% Cu	High grade copper ore assays available on the ICP-OES or the AAS. These may be set to automatically trigger on exploration samples with high copper content.
Native Copper	Cu-SCR21 - 0.01-100% Cu	Metallic screen method for samples containing native copper.
Copper Concentrates	ME-MS41c/MS61c - 2ppm-10% Cu ME-XRF15c - 0.01-50% Cu Cu-CON02 - 0.01-100% Cu	Many methods for copper concentrates are provided, including high precision determination of copper and smelter penalty trace element profiles. Umpire assay is also available.
Specialty Products	Please inquire at your nearest ALS Geochemistry branch.	A variety of highly specialized determinations on products such as copper anodes and cyanide solutions are available.

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