



# Aqua Regia or Four Acid Digestion?

## Which method is right for your project?

Often, a primary query is which of ALS's comprehensive multi-element packages is suitable for a project. The technical team at ALS is well-versed in element and mineral behaviour through digestion and instrumentation processes and can guide you through exploration questions and assist with method selection.

When deciding upon a multi-element package the choice is often between a four-acid or aqua regia digestion. Each method has its advantages and ideal uses that need to be considered against drawbacks. In general, aqua regia is a partial decomposition therefore analyses only represent the portion of the sample extracted. Four-acid digestions decompose a larger portion of the sample producing a "near-total" recovery for many mineral types and analytes.

### Why Aqua Regia?

Aqua Regia is a partial extraction using nitric and hydrochloric acids at a 1:3 ratio. The digestion is carried out at relatively low temperatures which allows Hg, which is volatile at higher temperatures, to be analysed at the same time as the multi-element suite. ALS offers aqua regia methods from both small (0.4-0.5g) and large (25g and 50g) sample sizes allowing for a more representative, semi-quantitative reporting of Au. An aqua regia leach is ideal for dissolution of sulphide minerals, and to release elements adsorbed on clay particles; or trapped

in manganese and iron oxides and oxyhydroxides. This can be particularly useful in areas with cover where mineral coatings are of more interest than the mechanically transported silicate minerals.

This digestion is effective at dissolving metal sulphides, most sulphates, carbonates, phosphates, organically bound metals, Au, Pt, Pd, tellurides, selenides and arsenides. Some silicates and alumino-silicate minerals are partially attacked by the digestion, but most remain undissolved so do not form part of the reported results.

### Why Four-Acid Digestion?

A four-acid digestion utilises a combination of nitric, perchloric, and hydrofluoric acids with a final dissolution stage using hydrochloric acid. This digestion breaks down most silicate and oxide minerals allowing for the "near-total" recovery of most minerals and analytes. Proprietary ALS techniques minimise the loss of elements generally considered volatile in four-acid digestions such as As, Se, Sb, Te, and Tl. Even with care to prevent volatilisation, the higher



digestion temperature used in this method means that Hg cannot be reported. A separate aqua regia method to determine Hg can be paired with a four-acid analysis where necessary. If quantitative Ge is required, a digestion specialised to prevent the loss of volatile Ge species should be requested as it is lost during the standard procedure. Due to the very small aliquot of sample used for the four-acid digestion (0.25-0.4g) Au is not reported.

Four-acid multi-element analysis is an effective tool in mineral exploration because of its ability to provide a full pathfinder element suite as well as a cost-effective proxy for mineralogy. When combined with a pXRF analyses to determine Si (not reported by four acid) and other elements not fully recovered (Zr, Ti) it is a powerful tool for alteration, lithology and geometallurgical investigations. For those interested in interpretation using four-acid digestion data please refer to the ALS technical note: Four Acid Digest and Advanced ICP-MS Technology, which details robust datasets for use in lithogeochemical mapping. Four-acid digestion will not fully dissolve some minerals such as barite, chromite, columbite – tantalite, cassiterite, celestite, rutile, scheelite, wolfram and zircon. If the elements of interest are hosted in these minerals a fusion method may be needed to break down all minerals.

## Detection Limits

A general rule of thumb is that a detection level for analyses should be 10 times lower than the expected concentration of an element of interest in order to effectively characterise background values. ALS offers a range of detection limits from both aqua regia and four-acid digests to suit all needs. Our industry leading super trace detection limits from our ME-MS41L™ and ME-MS61L™ methods provide detection levels below or close to crustal abundance for many elements.

ALS Method Code	Description Aqua Regia Methods
ME-MS41L™	Aqua regia digestion of 0.5g sample, paired with leading ICP-MS technologies that provide ALS's lowest, industry-leading detection limits. Suitable for stream and soil samples.
MS41L-REE™	Add-on only to the ME-MS41L™ method for rare earth element analyses
MS41L-PbIS™	Add-on only, to the ME-MS41L™ method for Pb isotope analyses.
AuME-TL43™	Aqua regia digestion of 25g sample, followed by trace Au and multi-element analyses by ICP-MS and ICP-AES.
AuME-TL44™	Aqua regia digestion of 50g sample, followed by trace Au and multi-element analyses by ICP-MS and ICP-AES.
ME-MS41™	Aqua regia digestion of 0.5g sample analysed by a combination of ICP-MS and ICP-AES for trace level, exploration samples.
ME-ICP41	Aqua regia digestion on a 0.5g sample with ICP-AES analyses.
ME-ICP41a	Aqua regia digestion 0.4g of sample with ICP-AES analyses. Method suitable for low grade ore analyses.

ALS Method Code	Description Four-acid Methods
ME-MS61L™	Four-acid digestion of 0.25g sample paired with leading ICP-MS technologies that provide ALS's lowest, industry-leading detection limits. Suitable for stream and soil samples.
MS61L-REE™	Add-on only, to the ME-MS61L™ method for rare earth element analyses.
MS61L-PbIS™	Add-on only, to the ME-MS61L™ method for Pb isotope analyses.
ME-MS61™	Four-acid digestion of 0.25g sample paired with ICP-MS and ICP-AES analyses for trace level, exploration samples.
ME-MS61m™	Package including ME-MS61™ with the addition of Hg determined by aqua regia digestion.
ME-MS61r™	Four-acid digestion paired with ICP-MS and ICP-AES with REE analytes included. Some REE's are only partially recovered with a four-acid digestion.
ME-ICP61	Four-acid digestion on 0.25g sample digestion with ICP-AES analysis.
ME-ICP61m	Package including ME-ICP61 with additional Hg determined by aqua regia digestion.
ME-ICP61a	Four-acid digestion on 0.4g of sample with ICP-AES analyses. Method suitable for low grade ore analyses.

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