

# Spatial Variation of Mercury in Surface Water impacted by Artisanal Gold Mining in Marmato, Colombia

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Figure 1. Artisanal gold miner near Marmato, Colombia.

## Background

Marmato, Colombia has been an important centre of gold mining since before the first Spanish colonisers arrived in 1536 (Redwood, 2011). The district is currently experiencing a surge in both major mining projects and artisanal mining (Figure 1), driven by the high price of gold. Ore from small scale and artisanal mines is processed in numerous small mills or 'entables', which impact surface water quality through the discharge of milled waste rock slurry and highly alkaline cyanide-treated effluent.

An additional environmental concern at Marmato is the use of mercury to amalgamate gold in concentrates from the small mills, which is widespread in other gold producing regions of Colombia. Although not currently illegal, mercury amalgamation poses a direct health risk to miners when gold sponge is heated, while poor re-cycling practices allow mercury to escape into the environment.

## Analytical methods

To investigate the spatial distribution of mercury and other potentially toxic elements, surface water samples were collected around Marmato and analysed for dissolved Hg using atomic fluorescence spectroscopy (AFS), and for other trace metals using ICP-MS. Samples of surface water were collected in January 2012 from sites within and around Marmato, downstream of the mines and metal content determined using ICP-MS.

Separate aliquots were taken to measure total mercury content by atomic fluorescence spectroscopy (AFS) using a Millennium Merlin instrument from PS Analytical Ltd. Hg was present in surface water samples, ranging from below detection level to 140 ng L<sup>-1</sup> total Hg. In comparison to other mining areas, Hg values are very high and indicate extraneous sources.

The Hg content of core samples collected around Marmato by Gran Colombia Gold Corp. ranged from 7 ppm to 0.005 ppm, with a mean value of 0.522 ppm (n = 16,366;  $\sigma = 0.2$ ). As average crustal Hg is around 0.5 ppm it can be concluded that Hg is not enriched within the ore body and anomalous dissolved Hg values in streams around Marmato are likely the result of ore processing and enrichment.

Entables in the Antioquia mining district of Colombia, north of Medellin, are known to extensively use mercury to extract gold from ore. High levels of atmospheric mercury have been recorded in Segovia, Zaragoza and other towns in the district (Cordy *et al.*, 2011), where the ore is processed. UNEP estimates that artisanal gold mining accounts for the global release of over 1,000 tonnes of Hg into the environment every year (Telmer & Veiga, 2009).

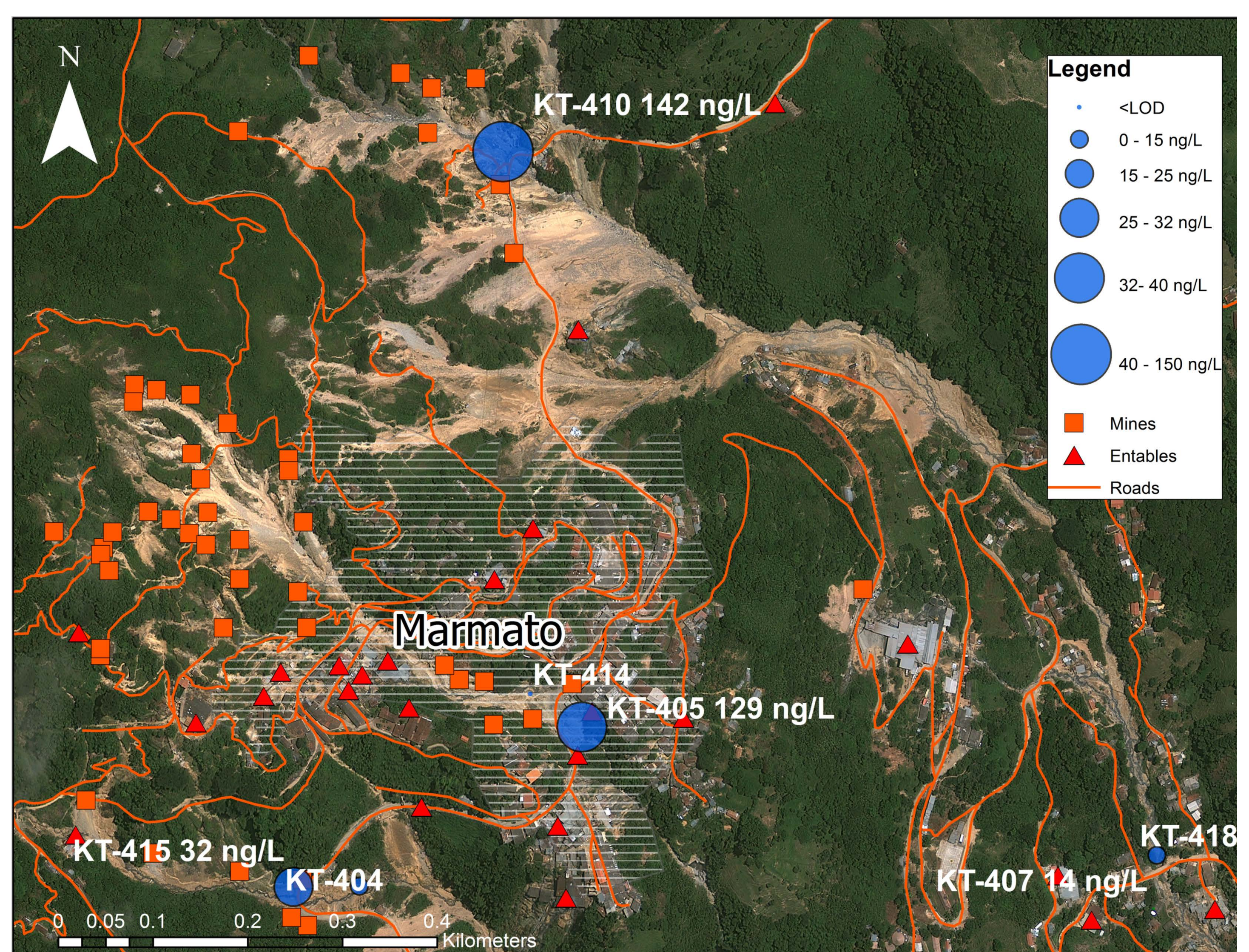


Figure 2. Study area, Marmato, Colombia, showing the location of surface water mercury concentrations with respect to entables and adit gold mines.

## Spatial relationships to potential Hg sources

It was determined that water quality in streams draining Marmato and the adjacent Rio Cauca are severely impacted by artisanal mining, with high levels of dissolved metals and suspended solids. The highest values of dissolved Hg are around the Marmato gold deposit where there is a concentration of small mines and mills. They show a relationship with both entables and small mines. This suggests that mercury is used in the entables as well as by artisanal miners. Promotion of more efficient processing methods, such as chemical leaching, have the potential to significantly reduce mercury use and increase gold recovery.

## References

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