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Weathering of coal mine tailings in Northern France: AMD or not AMD?

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The Northern France – specifically the former Nord Pas-de-Calais mining basin – is famous for its 200 spoil tips, vestiges of coal mining during the 19th and 20th centuries. These tailings mainly composed of Carboniferous black shales have been subject to supergene conditions for several decades. However, it was long accepted that element release processes did not occur from these spoil tips, and no acid mine drainage (AMD) was observable at the regional scale. But is this conclusion, based on studies that are at least 20 years old, still valid today? Can the colonization of spoil tips by vegetation change this state of affairs? Have we looked at the right scale?

We performed a detailed characterization of weathered pieces of black shales from three selected vegetated spoil tips. Through a combination of macro, micro, and nanoscale analyses (XRD, SEM, FIB, TEM, STXM-XANES), we reveal that AMD occurs on at least the first 30 centimetres of the vegetated surfaces of the spoil tips. This AMD forms an “alteration front” at the surface of the shale blocks, consisting of two distinct submicrometric layers: an inner Fe-rich layer composed of iron oxyhydroxides and a few neoformed smectite crystallites, and an outer S-rich layer, featuring jarosite, with a few rosette-like iron oxyhydroxides. Petrographic and textural signatures suggest that these layers form independently and successively, by direct precipitation from fluids enriched with K, Fe(II), Fe(III), and S. This also suggests a sharp change in the physicochemical conditions during the weathering process, particularly pH, and a fixation of S, Fe and K (at least partially) at the shale surface, while other elements are probably transferred into the surrounding environment.

Although our results show the slowness of the AMD process, they also reveal that the release of metals and acidity may be long lasting, leading to long-term effects on soil and ecosystems, and potentially diffuse pollution. A comparison with previous studies highlights that the colonization of spoil tips by vegetation plays a key role in triggering AMD. This is a crucial point, given the large number of spoil tips in the region that have now been vegetated.