

## ***In situ* neutralization of bauxite residue mud ('red mud') by cross layer leaching with carbonated mud**

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Untreated bauxite residue mud ('red mud') has a long-term leachate pH of *ca.* 13 when deposited in residue storage areas. Pre-deposition treatment of bauxite residue mud with CO<sub>2</sub> gas ('carbonation') lowers leachate pH to *ca.* 10.5. Carbonation has been implemented as standard practice at Alcoa's Kwinana refinery; however, previously deposited uncarbonated residues still require amelioration. This study investigated the potential to lower porewater pH of uncarbonated residue deposits *in situ* by downward leaching from an overlying layer of carbonated residue ('cross layer leaching'). Leachates from layered columns of uncarbonated and carbonated residues were analysed for pH, electrical conductivity (EC), CO<sub>3</sub><sup>2-</sup> and HCO<sub>3</sub><sup>-</sup> content, and element concentrations by ICP-OES during 400 pore volumes of leaching with deionised water. Leached and unleached residues were analysed by X-ray diffraction (XRD) and electron microprobe analysis (EMPA) of resin-impregnated thin sections. PHREEQC modelling was also undertaken to compare observed and predicted changes in leachate chemistry and residue solids mineralogy during leaching.

Cross layer leaching is an effective treatment for the *in situ* neutralisation of uncarbonated bauxite residue deposits. Leachate pH was significantly lower ( $p < 0.05$ ) in dual layer residue systems than single layer uncarbonated residue systems over the entirety of leaching. Dawsonite and calcite were identified as soluble sources of HCO<sub>3</sub><sup>-</sup>, which may account for the significant pH reduction in dual layer leachates. A relatively steady state of pH and EC decrease was achieved after 20 pore volumes of leaching. Na<sup>+</sup> and K<sup>+</sup> were dominant cations and Al(OH)<sub>4</sub><sup>-</sup>, PO<sub>4</sub><sup>3-</sup> and SO<sub>4</sub><sup>2-</sup> were dominant anions in leachates. Carbonate was the main source of leachate alkalinity. No element analysed exhibited a significantly higher leachate concentration in dual layer systems than in single layer systems. The implementation of cross layer leaching in the field poses no additional environmental risk beyond that of existing uncarbonated or carbonated residue deposits, and warrants further consideration.

## **The analysis of evaporites from the area around Boulby, North Yorkshire**

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Evaporites deposits are widespread throughout the world yet the evaporites themselves can only form in arid or semi-arid conditions – this makes evaporites a crucial tool in reconstructing paleo-environmental condition at the time of formation [1]. This paper examines the results of analysis conducted on samples taken from Boulby in NE England.

These evaporites were formed in the Permian in an area known as the Zechstein Sea which once covered the North Sea and parts of Europe, and was formed when the northern rim of an inland drainage basin was breached [2, 3].

The mine at Boulby is the sole commercial operation exploiting potash minerals within the United Kingdom and produces both potash and halite, it is also the deepest mine in Europe. As part of the Boulby Geoscience Research Project, Durham University has been given unprecedented access to both samples and exploration information.

This paper examines the results of the analysis of these samples and as such includes spatial analysis to geochemical modelling which allows for a more comprehensive understanding of the water chemistry from the various deposits around Boulby as well as conversion of minerals due to environmental conditions.

[1] Benison & Goldstein (1999) *Chemical Geology* **154**, 113–132. [2] Milne (1978) *The potash deposits & their associates in the area of the Boulby Mine, Cleveland*. PhD. [3] Taylor (1984) *Introduction to the petroleum geology of the North Sea*, pp.61–83.