The production of alumina from bauxite by the Bayer process generates a large volume of residue (red mud). This residue contains a percentage of complex zeolitic sodium aluminium silicates, formed by the precipitation of silica from the Bayer liquor and are known as the desilication product or DSP. The presence of DSP in red mud contributes significantly to making the residue highly alkaline and high in sodium and therefore a potential environmental hazard upon disposal.

This thesis documents the findings of a study with the objective of examining the nature and behaviour of a DSP-type mineral, determining its stability, including the way in which the release of sodium occurs and the potential for cation exchange. By so doing, a clearer picture of the DSP in red mud and its reaction to environmental factors, such as the pH of water percolating through the red mud disposal sites, was sought. An insight into the possibility of pre-disposal treatments, such as mixing the mud with acid waste or with material that would induce a favourable cation exchange was similarly gained.

A laboratory-synthesised DSP mineral was used in these studies, because of the difficulty of working with red mud, in which DSP is cloaked with other residue minerals. The similarity of various synthetic DSPs (including the synthetic material used for this work) to that found in red mud was examined. It was found that the DSP formed at Alcoa’s Kwinana plant (Western Australia) was a composite of the minerals noselite/nosean and sodalite, with sulphate being the main
anion incorporated into the DSP. The synthetic mineral used in the study was therefore a mixture of the three aforementioned minerals.

The sensitivity of synthetic and non-synthetic DSP to the citrate-bicarbonate-dithionite (CBD) method, used in leaching away the iron oxide that masks the DSP in red mud was examined. No significant effect on the DSP after leaching by CBD was observable. This confirmed that studies of DSP in red mud after removal of iron oxides by the CBD method were valid.

In the study of DSP stability, its behaviour at various levels of acidity and alkalinity was noted, to determine under what disposal conditions the potentially harmful release of sodium is most likely to occur and to provide information relevant to acid-waste treatment of red mud before or at disposal. Synthetic DSP samples were subjected to a range of pH conditions, from very alkaline to very acidic, over a range of time periods up to three weeks duration. The results of these tests indicated that DSP is stable to pHs as low as 8.5, with no significant release of sodium to the environment after 3 weeks.

The study of cation exchange behaviour in DSP was undertaken to determine if exchanging sodium (which is toxic to plants) for some likely cations such as potassium or ammonium (plant nutrients) may feasibly be used to rehabilitate red mud, since zeolitic minerals like those in DSPs are noted for their ion exchange properties. The exchange of sodium from within synthetic DSP for potassium, ammonium and calcium ions was investigated. It was concluded
that the cubic crystal habit of the DSP examined restricted the exchange of sodium ions with cations such as calcium, but allowed other cations (particularly potassium) to penetrate and replace up to 30% of the sodium ions contained within the lattice. Therefore treatment of red mud with waste solutions high in potassium prior to disposal would be beneficial. The exchangability of sodium for ammonium was also significant (16%), meaning that treatment of red mud with waste solutions containing ammonium would also be beneficial to revegetation of the red mud lakes.

Overall the study shows that red mud could be neutralised to a pH of 8.5 and treated with a waste solution high in potassium and/or ammonium in order to make the disposal sites more amenable to rehabilitation and revegetation.