

## **PHYSICOCHEMICAL PROPERTIES OF SEDIMENTS: LOVEDAY DISPOSAL BASIN, SOUTH AUSTRALIA.**

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### **INTRODUCTION**

The Loveday Basin, near the village of Cobdogla, South Australia, was historically a naturally flooded semi-permanent wetland adjacent to the River Murray (Walter, 2005). Since 1972, the wetland was used as a disposal basin for saline irrigation water from the surrounding agricultural area. The disposal of irrigation water in this basin led to increasing salinisation, and the accumulation of sulfidic sediments (Lamontagne et al., 2004; Welch et al., 2005). More efficient irrigation practices resulted in a reduction in the volume of water received by the basin leading to its decommissioning as a saline disposal basin. Decommissioning, coupled with drought, meant the basin dried, exposing the sulfide rich sediments and sulfidic material (potential acid sulfate soils) to the atmosphere. This led to environmental problems because of the oxidation of sulfidic materials and the release of noxious odors from the basin (Lamontagne et al., 2004; Welch et al., 2005; Walter, 2005). Due to the reduction in water captured by the basin, and community interest, it was deemed appropriate by land managers to begin remediation of the site (Walter, 2005).

### **THE BASIN POST DECOMMISSIONING**

As a consequence of the dry conditions experienced following decommissioning, a network of deep desiccation cracks and pedal structures formed in the drained sediments in the basin. The cracks are now partially infilled with sediments and water. As a result of this, there now exists extreme heterogeneity in terms of the physical and chemical properties of the sediments over extremely small distances, from centimeters to metres. The large pedal structures exhibit shrink-swell behavior to a greater extent than the material found in the cracks (Welch *et al.*, 2005; Beavis et al., 2006). The surface of the basin is covered in salt efflorescence composed primarily of gypsum and halite. The purpose of this project is to characterize the mineralogical composition of the sediments; ascertain the salt budget stored in sediments; and, to determine effects remediation will have on the basin. At the time of writing, three remediation strategies are proposed:

1. **Flooding:** by flooding the basin it is hoped to reduce the exposure of the sediments to the atmosphere, and control the oxidation of sulfidic materials within the basin. This, however, could result in the build up of sulfidic materials in the basin.
2. **Drying:** by allowing the basin to remain dry, the hope is that all sulfidic material will oxidize and reduce the risk of subsequent acidification over time.
3. **Flooding/Drying:** by flooding the basin and then allowing it to dry, it is hoped that the build up of sulfidic materials can be mitigated by the oxidation of these sediments during drier periods. Flooding the site will mitigate the release of noxious odours from the basin.

### **METHODS**

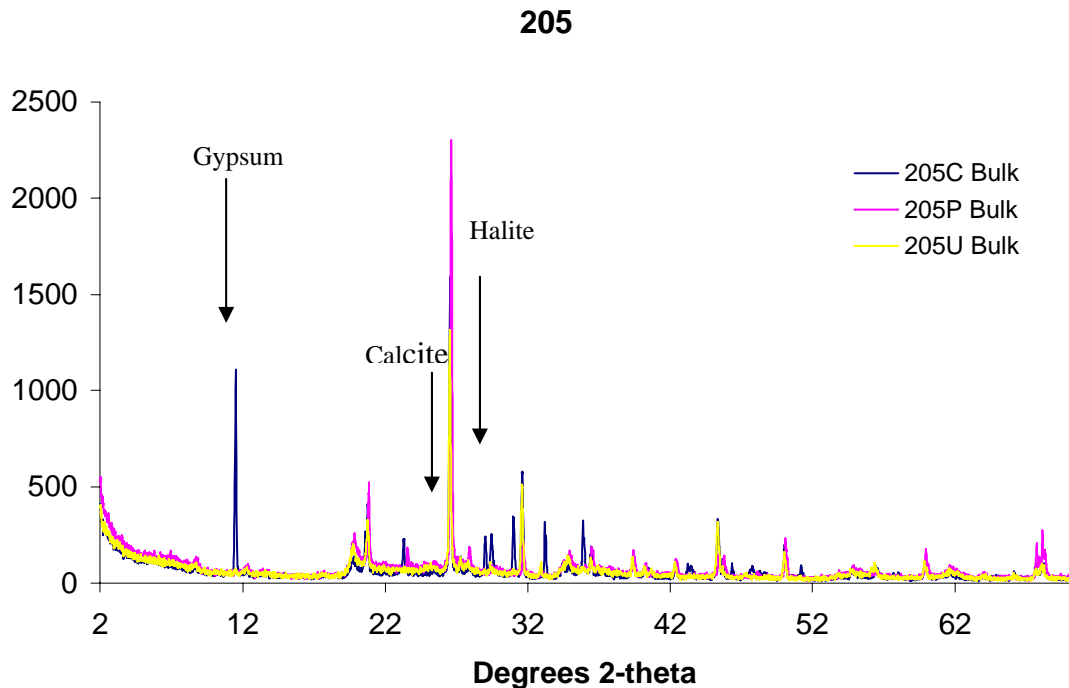
Field sampling took place in April 2006 and was carried out along 2 W-E trending transects, one in the north of the basin and the other in the south. Three further sites were sampled: one with an abundance of jarosite, one from the very southern end of the basin, and a third from the north that was completely inundated. At each point, 4 samples were gathered, one from the pedal structures, one from the infilled crack material, the surface salt crust, and the sediment underlying the pedal structures. Transects were designed to incorporate three zones at the basin; a wet zone, a wet/dry zone, and a dry zone. In all 35 samples were collected.

Sediments were analysed for acidity and salt content in 1:5 sediment to water extracts. Samples were analysed using x-ray diffraction techniques on bulk samples and the clay fraction. Bulk geochemistry was analysed using x-ray fluorescence, with exchangeable cations determined after washing, then displacement by ammonium chloride with the exchangeable cations measured using inductively coupled plasma atomic emission spectroscopy (ICP-AES).

## RESULTS AND DISCUSSION

### Mineralogy

Bulk sediment mineralogy determined by powder x-ray diffraction revealed that the dominant salts in the basin are gypsum and halite, with minor amounts of calcite (Figure 1). The gypsum is located preferentially on the surface and in the cracks, while halite is found in the peds and underlying sediment. The distribution of calcite appears random, but where present, it can act as a significant acid buffer.



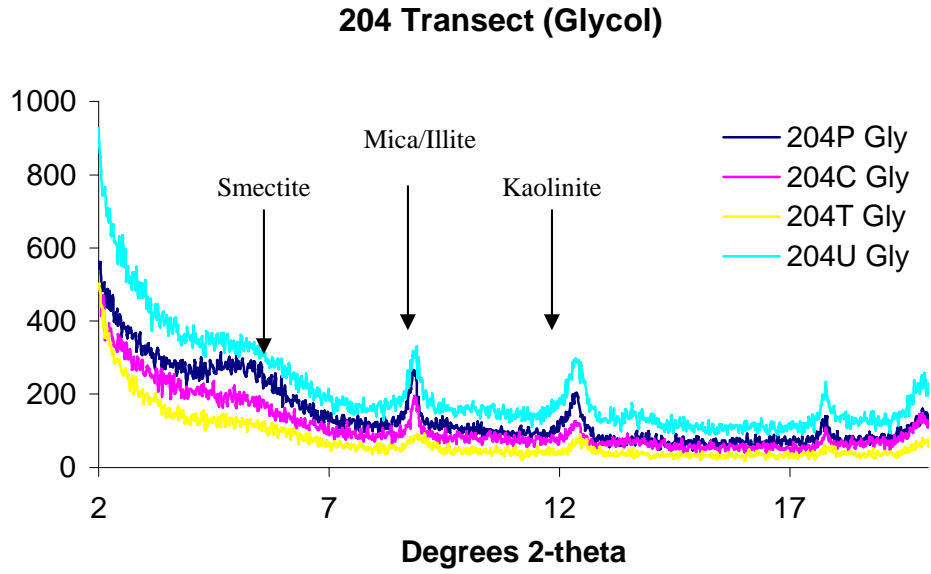
**Figure 1:** XRD bulk scan results for site 205

Clay mineralogy was determined using x-ray diffraction on the clay fraction. Results show that the peds and underlying sediment were composed of montmorillonite/smectite, kaolinite and illite. In contrast, Montmorillonite/smectite in the sediments from surface and cracked samples was absent (Figure 2). The ped material and underlying sediment routinely showed a higher percentage clay than that found in the crack material and surface sediments (Figure 2).

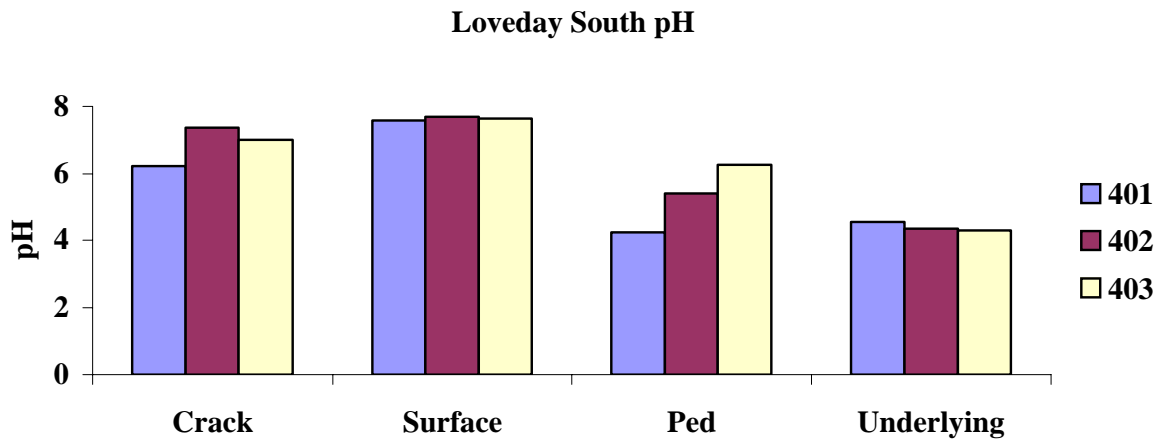
These differences in clay mineralogy and clay content will affect the salt stores as montmorillonite/smectite can readily exchange ions from its interlayer, with the shrink/swell characteristics influencing the flux of salts from the peds and underlying sediments to solution. These physical properties of the sediments may be exacerbated by the different wetting/drying regimes used in remediation.

### Acidity

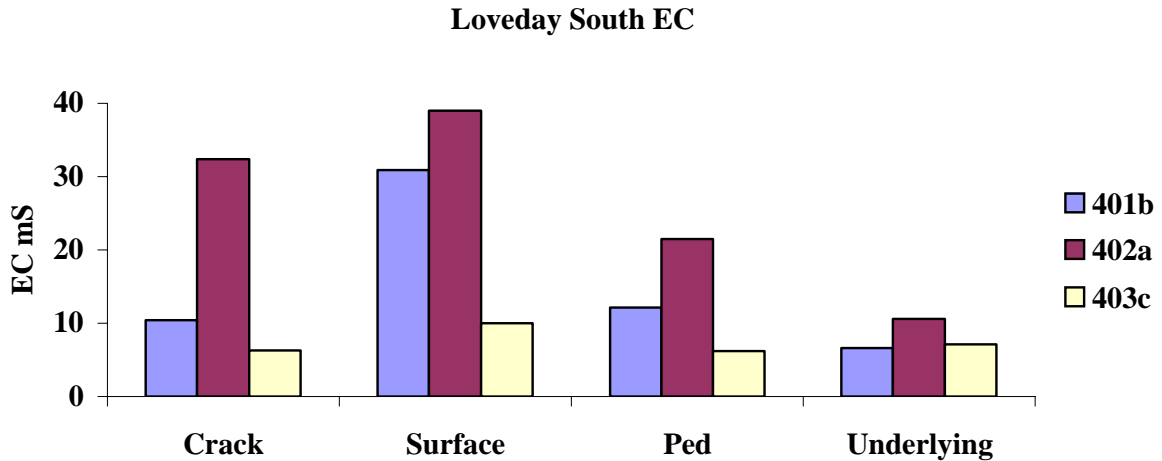
pH measurement from the 1:5 sediment to water extracts showed that pH was lowest in the underlying sediment and in the ped material. This is probably caused by the oxidation of sulfidic material in the peds and underlying sediment. This may explain why there is no noticeable gypsum in the peds and underlying sediment with calcite being confined to the surface as small shells buffering the acidity at these points. Pyrite and jarosite were predominantly found with XRD techniques in the underlying sediment, and the macropeds. The implication for management is that this is a store of acidity which, coupled with the clay mineralogy, may result in a flux of salt and acidity into solution if the site is reflooded.



**Figure 2:** Qualitative XRD scans for the clay fraction at site 204.



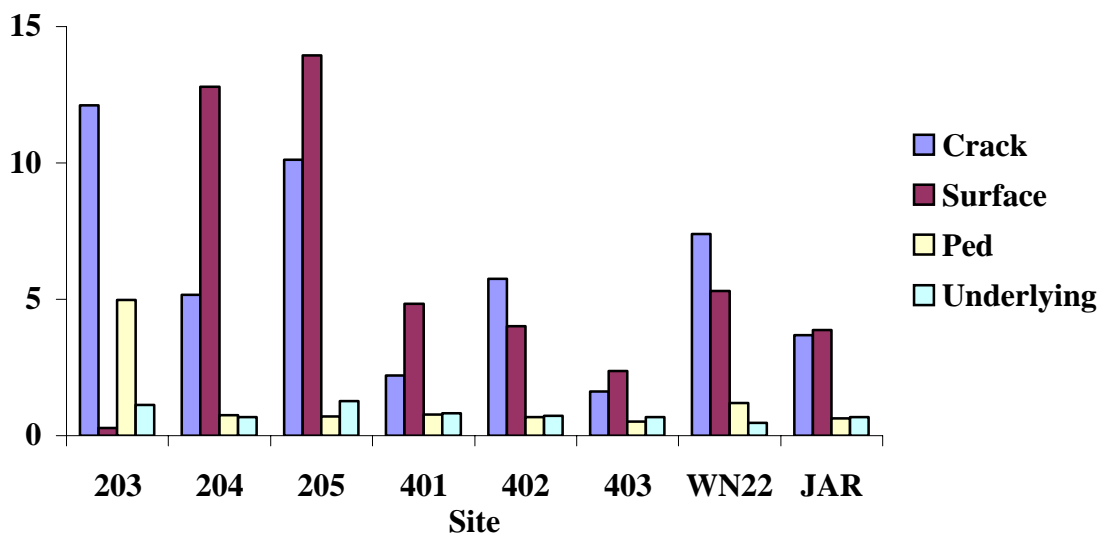
**Figure 3:** pH 401 Transect. From left to right: cracked material, surface materials, ped material, and underlying sediment.



**Figure 4:** Electrical conductivity of 1:5 extracts for the southern (400) transect

Electrical conductivity (EC) shows a similar trend to the pH. Values are highest in the surface material, and lowest in the ped and underlying material. A low pH corresponds to a low EC, suggesting that acidity is stored on exchange sites, and not in solution.

The bulk geochemistry from XRF (figure 5) concurs with the data from XRD that gypsum is most abundant in the crack and surface sediments. The high calcium content at site 203 was determined to be a function of calcite. It would be expected to find a high proportion of polyvalent cations in the ped materials due to the degree of flocculation. However, as shown in figure 5 this is not the case. The calcium percentage is actually lowest in the ped and underlying sedimentary material, which suggests that another process or cation is controlling the flocculation of the sediments.



**Figure 5:** % Calcium Oxide from XRF

**CONCLUSION**

Gypsum is the predominant sulphate salt present in the Loveday sediments. It is largely confined to the surface sediment and to the cracks in the macroped network, suggesting that the precipitation of gypsum is controlled by evaporation. The high percentage of expandable clays such as smectite in the macropeds suggests that these pedal structure will be propagated by wetting and drying cycles and influence the flux of salt from the sediments into solution. The peds and underlying sediment contain stores of pyrite and jarosite, and so continued wetting and drying could result in increased acid and salt flux to overlying water.

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