Contemporary and relict processes in a coastal acid sulfate soil sequence: macroscopic and geomorphic features

B.P. Thomas[1], R.W. Fitzpatrick[1], R.H. Merry[1], R. M. Poch[2], W.S. Hicks[3] and M.D. Raven[1]

[1]CSIRO Land & Water/ University of Adelaide, Private Bag No. 2, Glen Osmond, S.A., 5064
[2]University of Lleida, Catalonia, 25198, Spain
[3]CSIRO Land & Water, GPO Box 1666, Canberra, ACT, 2601

AIMS - Develop mechanistic models to illustrate:

- stages in soil-landscape evolution at macroscopic scale
- chemical, physical and mineralogical processes
- formation and movement of acidity and contaminants

SOIL - LANDSCAPE EVOLUTION

Barker Inlet is a tidal dominated estuary located 20km north of Adelaide, South Australia. Soil profile BG11 is located at Gillman (Figure 1). Before the bund wall was constructed in 1954, the Gillman area consisted of intertidal mud-flats, mangrove muds and supra-tidal samphire sediments that were conducive to sulfate reduction because there was sufficient organic matter from mangroves and sulfate from seawater. Terrigenous iron was available to form sulfide minerals and tidal flushing both replenished the sulfate pool and removed the bicarbonate produced by sulfate reduction, resulting in formation and accumulation of sulfidic material (Figure 2). These sulfidic soils classify as Histic-Sulfidic Intertidal Hydrosols (Isbell 1996).

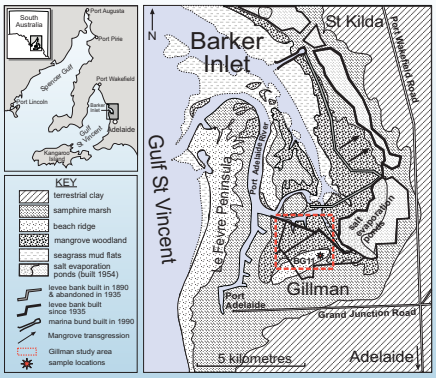
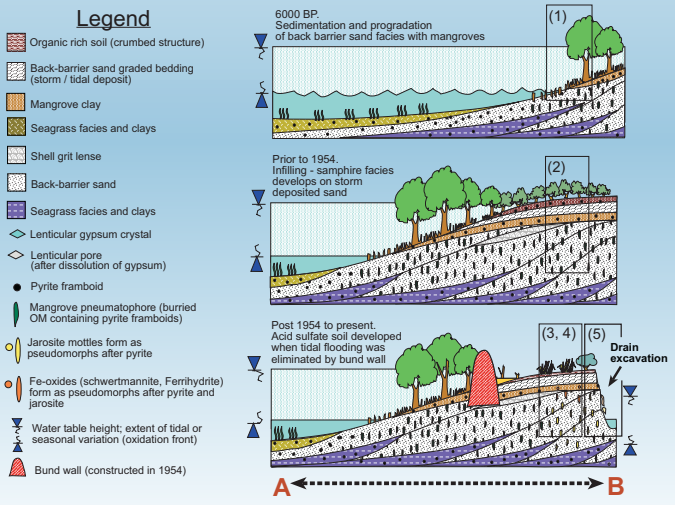
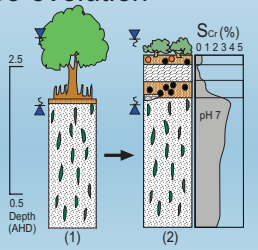
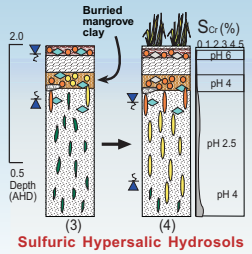


Figure 1. *Reworking of coastal sediments since sea level stabilisation about 7500 B.P. resulted in the northerly extension of Le Fevre Peninsula. Progradation led to back barrier development of marshes and mangrove swamps parallel to the shoreline. Barker Inlet is now mostly infilled except for the Port River estuary.*

Figure 2. *Major stages in soil-landscape evolution*







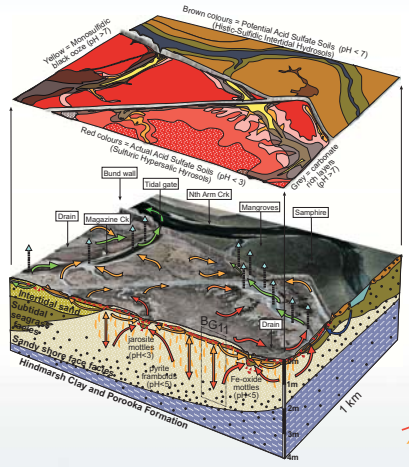
Relict Stages: Tidal

1. **6000 B.P.** - Intertidal zone with mangrove vegetation on back-barrier sand.
2. **Prior to 1954** - Infilling by sandy storm deposits bury mangrove clay and raised land surface from intertidal to supratidal zone, replacing mangroves with samphire vegetation.

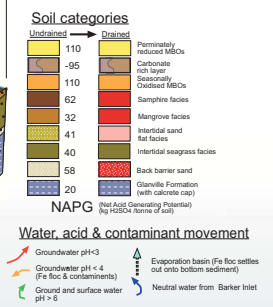
Contemporary Stages: Tidal exclusion

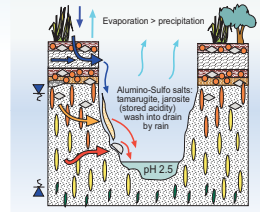
3. **Post 1954** - Buried mangrove clay forms as sulfuric horizon with jarosite mottles and restricts oxygen diffusion restricted to lower sulfidic sands. Organic matter loss and consolidation cause up to 0.5m of land subsidence. Salt tolerant grass. Salt pan.
4. **Current, 2004** - Soil pH increases due to leached carbonates resulting in conversion of jarosite to goethite in the mangrove clay. Sulfide in more permeable sand layer oxidises quickly forming jarosite mottles in a 2m thick sulfuric horizon.

Figure 3. *Movement of acid & metal contaminants*



Geomorphologic-landscape model shows the contrasts between tidal and drained coastal landscapes. Soil acidity is shown by the top layer (ASS risk map). The bottom layer shows the depositional facies and location of pyrite oxidation and the movement of acidic ground water/contaminants (Fe floc) within the site (aerial photograph DEM drape). The arrows represent the flow path of ground and surface water.





Predicted Stages: Local drain excavation

5. **When drained further**, acidity develops deeper in the profile. Iron and aluminium minerals develop on drain walls. Sulfuric acid dissolves clay particles, causing basic cations and associated anions (Na^+ Mg^{2+} Ca^{2+} Ba^{2+} Cl^- SO_4^{2-} SiO_4^{4-}), trace elements and metal ions (Fe^{3+} Al^{3+}) to be released to soil solution then creek beds or drains.

CONCLUSIONS

These 5 stages in soil-landscape evolution, together with soil and terrain mapping were used to construct a regional 3D process model (Figure 3). The model estimates most of the acid in the bunded area (520,000 t) is currently stored in the back-barrier sand and is unlikely to move off site unless the hydraulic or drainage regime of the area is changed. Acid and metal export loads to Barker Inlet are currently low due to containment by bund walls, low hydraulic gradient and interception of groundwater by carbonate rich horizons that fringe the back-barrier sand. Monosulfidic black ooze forms in stormwater ponding (evaporation) basins and is a sink for metal contaminants. These models have been used in land management and State planning policy.

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