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Oxygen diffusion and geochemical speciation in abandoned gold mine tailings dams of the Witwatersrand

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Nearly 270 unlined and poorly rehabilitated tailings dams are present in the Witwatersrand Basin as a result of gold mining over a period of nearly 130 years. In order to realize both the current and long-term impacts of these tailings dams, it is important to understand the geochemical processes present in these dams.

Seven tailings dams were investigated in the Eastern Basin of the Witwatersrand. Augering, sampling and testing were performed on the oxidised zone (OX), transitional zone (TR) and unoxidised zone (UN). Profiling was performed down to 10 m in terms of oxygen concentration (in the air phase), major and trace elements distribution, acid generation potential, mineralogy and radiation.

Oxygen migration into tailings dams is an important rate-limiting step for acid-mine drainage generation [1]. The depth of oxidation in the tailings dams ranged between 1 to 8 meters depending on the age of the dams as well as the pyrite content of the tailings. Seasonly, the oxygen concentration varied slightly in the OX. This variation was less present in the TR and absent in the UN.

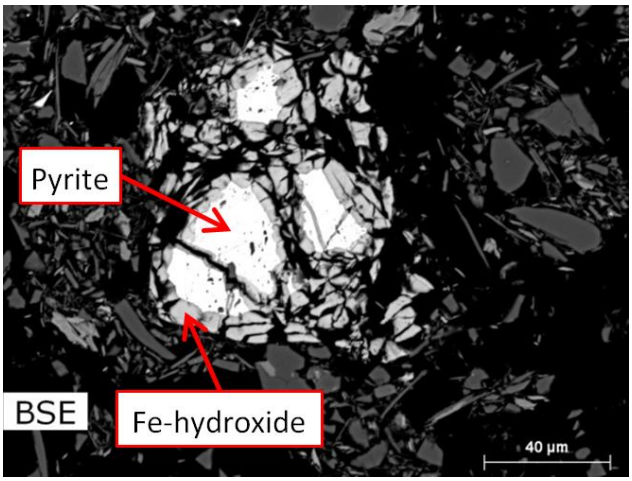

Figure 1: Pyrite with an iron-hydroxide rim in the oxidised zone

Speciation of sulphur between sulphide and sulphate minerals varied according to the degree of oxidation and served as a marker of the different oxidation zones.

Scanning electron microscopy (SEM) indicated that pyrite in the OX was shielded by oxidation products as depicted in Figure 1. In the UN no oxidation products were observed around the pyrite. Calcium sulphate minerals were however identified throughout the tailings dam.

Carbonate minerals are absent or present in trace quantity in the tailings. The tailings therefore have a low neutralisation potential with the result that the paste pH is acidic (pH<4) in the OX and TR.

Sulphides of cobalt, copper, nickel, lead and zinc were identified through SEM in the UN. These metals however showed a significant depletion in the OX and TR due to oxidation and acidification in these

zones. Uranium also showed a significantly depletion in the OX and TR. In contrast, thorium was present throughout the tailings dam due to its relative immobility. Radiation measurements were the highest in the UN and almost at background for the OX.

References:

[1] Davis GB and Ritchie AIM (1986) Appl Math Model 10:314-322