PREFACE

Mine closure and pit voids – a personal journey

The twenty-first century brought scientific analysis and technical problem-solving into public view in a way never seen before. As information spread freely via digital cameras feeding electronic media, social pressure for solutions to localised environmental issues began to drive both companies and Governments to demonstrate that they were achieving the results awaited under the 'social licence to operate'. Mine closure was no different, and the most visible issue of mine closure was the question of what happened to the pit voids.

My personal journey through the evolution of pit void science in Australia roughly follows the same trajectory of increasing awareness leading to better investigation and analysis over several decades, resulting, at last, in better solutions. In the early 1980s I visited the Rum Jungle site in the Northern Territory of Australia, an abandoned uranium mine which most readers will know of. Beside two large uncovered wasterock dumps were two blue lakes. At the base of the dumps orange-brown ooze dribbled across the ground towards the lakes. Locals told me the lakes contained no fish, birds visited only occasionally and the water was 'very acid'. A much nicer lake across the highway, the South Lake, was also a uranium mine, but the excavation had struck a 'buried river', so the water was good and served as the community swimming pool. Over the next few years in my first career of mineral exploration, I came across numerous mine pits, including abandoned sand

mines, coal pits, base metal mines and even the Goldsworthy iron ore mine. The standard approach to leaving the pits was that there was still ore in the bottom, so the economics suggested that the pit be left for further mining, and that they were so far away from major towns that there was no social driver to rehabilitate or fill them.

In the 1990s I returned to Rum Jungle, where much scientific research and effort was being applied to rehabilitate the Rum Jungle site. Now it was fenced from public access, the dumps had been capped to limit the percolation of rainwater, and a blend of investigative studies with conceptual chemistry had led to a way of managing the acid generation from the dumps. Vertical profiles were now being recorded of the pit chemistry and physical properties, and a diversion of a local creek now drove a surface flush of fresh runoff through the pits every year. The first flush method had produced a pit that was now sufficiently neutral at the surface that birds were happily landing here, and rumours circulated that in some years crocodiles moved into the pits to live (presumably feeding on the birds and native ground fauna that came to drink). The Northern Territory Government developed a physico-chemical model to explain the vertical profiles in the pit lakes, and CSIRO had instrumented the rock dumps to begin measuring the movement of oxygen and water through the dumps and into the surface or groundwater systems. At the time I was providing some ground geophysical services to trace the mobilisation of contaminant plumes.

By the time the second millennium arrived, pit lakes were becoming a social and political issue. Some, like the abandoned Gandy's Mine in the Northern Territory had become interesting as potential town water supply, old coalmines in the Southwest of Western Australia were now being used as recreational lakes, others in the Eastern States were being forced to rehabilitate (a few at unimaginable cost and complexity). Gold mines abandoned in the WA Goldfields were being rehabilitated under more forceful regulatory regimes.

Western Australia's then Department of Environment (with the support of the Department for State Development, for adoption by Environmental Protection Authority), produced

guidance which reviewed many of the known mine pits in the State. They classified these into groundwater sinks and groundwater flowthrough systems. The assessment was simply that groundwater sinks have only localised impacts with little hydraulic connection to regional groundwater, so they just slowly evapo–concentrate. Flowthrough systems need much more analysis to determine how they interact with the local environment over time. I recognised then that on my first visit to Rum Jungle I had been introduced to both groundwater sinks and groundwater flowthroughs, but that much of the serious site contamination had been coming from surface water flows and the above-ground dumps.

Analytical science was progressing rapidly by this time, with computerised time-variant chemistry models, groundwater flow models and solute transport models all becoming popular, and easier to use. Importantly, but not always recognised, these models were improving the way results could be visualised, and both the press and community groups had become much more able to produce dramatic computer-generated imagery to tell their stories. So by the late 2000s the world was seeing cases of mine void mis-management being debated in 3D coloured imagery on TV shows and in professional society conferences.

The twenty-teens decade is just a third of the way through, and we have seen a better informed community expectation for managed environmental and social outcomes reflected through regulatory standards. Biological factors and observations can now be incorporated into some modelling approaches. Models and visualisations are now required by Governments before mines are approved or finished mines returned to primary landuse. Scientific analysis has progressed to a stage where linked and coupled models are being applied in both predictive and validation modes.

This book is a snapshot of where the scientific understanding is now, and how complicated we can make the models if we have enough information and justification for the effort/expense. The tables are a guide to what physical, chemical and biological parameters need to be measured to make sensible conclusions from any of the models (or linked suites of models). But this is

also much more, it is a library index to the range of analytical methods used around the world, and a partial catalogue of regulatory approaches. The methods of analysis will change from what is described here, but always the predictions will need to be data-driven, and the outcomes observable. This publication puts the current state of both science and regulation in a linked perspective.

For me as a practicing regulatory scientist, the book serves two purposes. Firstly, and obviously, it documents how far along the journey I have come as a passenger on the vehicle of scientific progress, and puts a modern context around what I have seen along the way. Secondly, the book demonstrates that analytical and predictive scientific methods are now expected by community and regulators as being the base level required for endorsement of mining and mine closure.

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