

Post-rehabilitation environmental hazard of Cu, Zn, As and Pb at the derelict Conrad Mine, eastern Australia

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Post-rehabilitation audit of mine reveals ongoing As and Pb environmental hazard enhanced by acid drainage and site geomorphology.

Abstract

A post-rehabilitation audit of the derelict Conrad base metal mine, eastern Australia, indicates ongoing environmental hazard regarding acid mine drainage and concentrations of arsenic and lead to 3 wt% in the soil and sediment. In order to rehabilitate remote contaminated sites effectively, on-site analyses should be carried out to ensure that the materials used to rehabilitate the site are not contaminant-bearing. Understanding the geomorphic setting of the rehabilitated areas is also important in understanding where, and for what period, contaminated materials might be stored in fluvial systems downstream of mine workings. Chemical and geomorphic audits should form a fundamental part of all rehabilitation works to ensure favourable environmental outcomes.

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1. Introduction

Abandoned, unrehabilitated areas of former mining, ore processing and smelting commonly have a complex assemblage of mine wastes including overburden piles, tailings and sludges, and smelter ash and slag (Lottermoser, 2003). These wastes, often steep-sided and free of vegetation, are prone to erosion and fluvial transport. In many places, mine wastes have been discharged directly into streams, a practice that continues today at mines such as Porgera in Papua New Guinea and Grasberg in Irian Jaya (Lottermoser, 2003). As a consequence, mine-generated materials can be traced for many kilometres downstream of mine workings (Hudson-Edwards et al., 1999a,b; Taylor and Kesterton, 2002). Acid generation from sulfidic mine wastes enhances mineral dissolution and the aqueous transport of metals and metalloids,

which can then impact on ecosystems downstream (Hudson-Edwards et al., 2003; Macklin et al., 2003).

Contaminants carried by fluvial systems can be stored within the channel (Taylor and Kesterton, 2002), or for longer-term storage, in floodplains (Marron, 1992; Aslibekian and Moles, 2003). These floodplains contain a “chemical stratigraphy” of uncontaminated substrate overlain by contaminated horizons that reflect periods of deposition of mine waste. Floodplains can act either as a sediment sink or as a future source of contaminants (Li et al., 2000; von der Heyden and New, 2004) when they remobilise. This chemical stratigraphy can often be sharply demarcated, but it can also become indistinct as contaminants remobilise into pristine sediments above or below contaminated units (Hudson-Edwards et al., 1998).

Since the effects of contaminant-rich sediment transport and acid mine drainage can be present both at the mine as well as some distance off-site, environmental contamination should be minimised through rehabilitation of the source areas. A survey of rehabilitation efforts, including chemical analyses of solids and waters, is one way to determine the

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success or otherwise of the works. On-ground post-mining sediment analysis, management and monitoring is typical (ANZMEC MCA, 2000), however, abandoned sites are different because the mine operators who would normally be responsible for post-mining management and monitoring are absent, and it is left to regulators and other stakeholders to fulfil this role. In the case of the State of New South Wales, Australia, derelict mines are managed and government funds allocated for the rehabilitation of priority sites (NSW DPI, 2004). The aim of this study was to audit the metal and metalloid concentrations in soils and sediments of this recently rehabilitated base metal mine, in order to determine whether or not the site met national soil, sediment and water quality guidelines, and identify the fate of contaminated materials eroded from the site.

1.1. Field area: geology and history

The Conrad is a derelict Ag, Pb, Zn, Cu, As and Sn mine 30 km south of Inverell, NSW (Fig. 1). The mine lies 3 km upstream of Copeton Reservoir, an irrigation and domestic water supply (Dawkins, 2002).

The Gilgai Granite hosts 79 polymetallic sulfide veins (Wake et al., 2003). The sulfide vein at the Conrad extends 7.5 km along strike, to >400 m depth with a width of 0.6–0.75 m (Wake et al., 2003). The mineralisation includes silver as tetrahedrite, lead as galena, zinc as sphalerite, copper as chalcopyrite and tetrahedrite, tin as cassiterite and stannite (Slansky, 1979; Dawkins, 2002; Wake et al., 2003), and arsenic as arsenopyrite.

There has been no mining at the site since 1957. The mine produced nearly 109 tonnes of silver with an ore grade of

600 g/t, with by-products of lead (8 wt%), zinc (4–7 wt%), copper (1.2–1.5 wt%), tin (0.9–1.5 wt%) (Wake et al., 2003) and arsenic at around 3 wt%. Ore was treated on-site by crushing followed by flotation (DMR, 1954). Concentrates were shipped away, smelted on-site, or stockpiled on-site. Tailings were left on-site in two piles (Fig. 2). Acidic mine drainage, formed from oxidation of the sulfide minerals, is now generated from adits, tailings and some piles of waste rock.

When the mine was operational, there was no Mining Operations Plan or Security Bond as is required for contemporary mines. As a consequence, when mining ceased in 1957 (Menzies, 1967), there was no remediation plan, nor was allocation of funds for rehabilitation required (DMR, 2002a,b).

The site was divided into five areas (Fig. 2). *Site 1* lies upstream, but downwind, of the mine, and samples from there may reflect contamination by wind-borne dust, smelter emissions or erosion of metal-rich fill from the access road. Borah Creek in Site 1 has visible algae and aquatic invertebrates, and is free of precipitates. *Site 2* includes the sulfide ore vein, the main Conrad Shaft, an ore processing area and the “upper” tailings pile. Large parts of this site have been infilled with ore and waste rock. Borah Creek in Site 2 has no visible flora or fauna. In places, pools are rusty red or have a blue tinge. *Site 3* is located in a confined valley. A large fill batter for the road was built from mixed ore and waste rock. Water drains from “Allwell Shaft” near the stream edge, during wet periods. Borah Creek throughout Site 3 is free of visible flora and fauna. *Site 4* contains a complex ore processing area with The King Conrad Shaft and a collapsed adit that seeps mine water continually, a ground tank where metals were extracted from aqueous solutions, a smelting area, slag pile, and the “lower” tailings pile. Whereas the “upper”

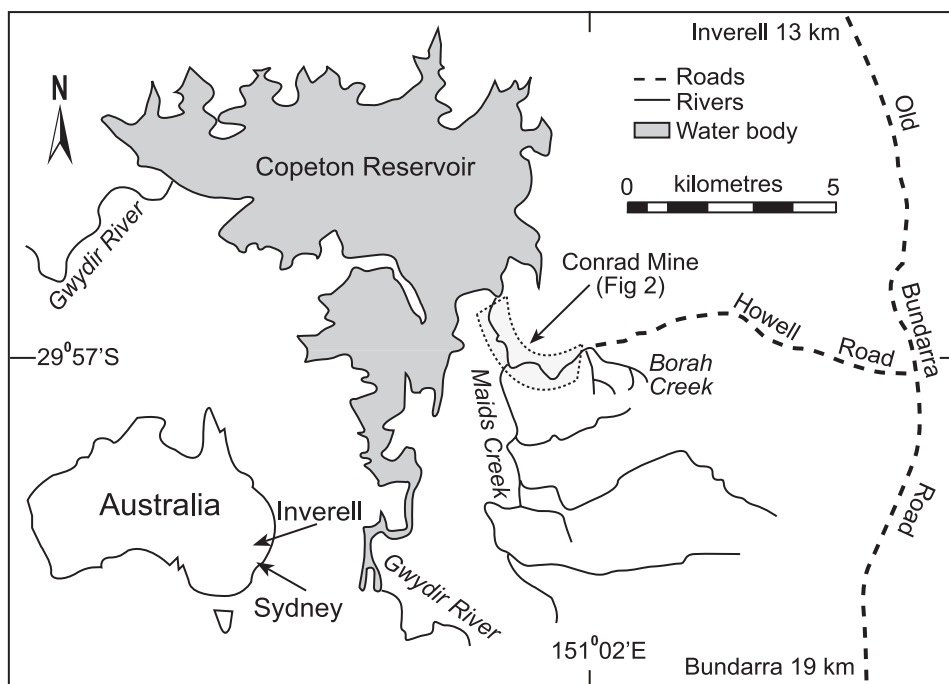


Fig. 1. Location of the Conrad Mine.

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