Removal of heavy metals from mine water by carbonate precipitation in the Grootfontein-Omatako canal, Namibia

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Abstract Water from the Kombat mine was delivered to the Omatako dam via the 263-km-long Grootfontein-Omatako canal during test runs in 1997. It is intended to supply water from Kombat and other underground mines in the Otavi Mountain Land to the capital Windhoek. The Cu-Pb-Zn orebodies are hosted by carbonate rocks and the mine waters are supersaturated with respect to calcite and CO₂. Along the length of the canal, the CO₂ partial pressure drops from 10⁻² atm at the inlet of the Kombat mine to 10⁻³ atm at the end of the canal. This is accompanied by a drop in Ca concentration from about 60 to about 20 mg/l. The heavy metal concentrations (Cd, Cu, Mn, Pb and Zn) drop along the course of the canal to values far below the national drinking-water standard. Scavenging by calcium carbonate precipitation is the major depletion mechanism.

Introduction

The Grootfontein-Omatako canal is part of the Eastern National Water Carrier, linking the Otavi Mountain Land in northern Namibia and the capital Windhoek (Fig. 1). In 1997 the canal offered a good opportunity to study large-scale heavy metal scavenging by precipitating carbonate. Water from a single source, the copper-lead-zinc underground mine at Kombat, was delivered to the canal in 1997, when the chemical changes along its course were investigated.

The Kombat mine can yield 5 million m³ water per year. Water from other underground mines in the Otavi Mountain Land also constitutes a large potential source of drinking water. The Tsumeb mine, active at the time of sampling but closed since 1998, and the dormant Berg Aukas, Abenab and Abenab West mines have a total yield of about 15 million m³ water per year (Fig. 2, Table 1). The waters from the dormant mines are earmarked to be supplied to the canal. These waters were also sampled in order to make predictions about their chemical behaviour.

This research was conducted under a technical co-operation program between Namibia and Germany, commissioned by the Federal Ministry of Cooperation and Development (BMZ). The partners in the groundwater exploration project were the Department of Water Affairs (DWA, Windhoek), Namibian Water Corporation and the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR, Hannover).

Mines in the Otavi Mountain Land

The Otavi Mountain Land in northern Namibia is a dolomitic massif rising up to 500 m above the surrounding plain. Its four synclines composed of fractured dolomite comprise one of the most important groundwater sources of Namibia despite the fact that their recharge depends on rare, excessive rainfall events. The mean annual rainfall of 550 mm is high compared to the country-wide average of 270 mm (United Nations 1986). It is difficult to construct wells with a high yield in the fractured dolomite. However, the cavities produced by underground mining represent easily accessible groundwater. The polymetallic orebodies were emplaced along hydraulically favourable structures such as paleokarst and fault conduits (Ploethner and others 1998).

The degree of supergene oxidation of the sulphide ore prior to mining varies considerably and may reach unusual depths of 1500 m, as shown by the Tsumeb deposit (Table 1). Despite the relatively high proportion of oxidized ore, mobilisation of heavy metals and hence pollu-
tion of mine waters, is strongly inhibited by the ubiquitous presence of carbonate.

**The Grootfontein-Omatako canal**

The Grootfontein-Omatako canal was built between 1981 and 1987. The Kombat mine is connected to the canal via a 20-km-long pipeline. The length of the canal is 263 km, of which 203 km are open and concrete-lined and the remainder consists of 23 inverted siphons or underground pipeline. The canal has a maximum width of 3.7 m and a maximum depth of 1.65 m. It is a gravity flow canal with a gentle slope of about 1:3000. When full, the flow velocity will be 0.8 m/s. At the time of sampling in March 1997, the estimated flow velocity was 0.4 m/s at km 80.21 (Ploethner and others 1998). Water from the Kombat mine has been delivered to the Omatako dam during test runs in 1997. It is intended to