Formation of secondary pyrite and carbonate minerals in the Lower Williams Lake tailings basin, Elliot Lake, Ontario, Canada

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ABSTRACT

The Lower Williams Lake tailings, which resulted from U-milling operations during the late 1950s and early 1960s, cover an area of 2 ha in a small bog under partial water cover. The tailings are underlain by a sand unit containing decaying organic material above the natural base consisting of sand, till, and gravel. The tailings are composed predominantly of quartz, muscovite, K-feldspar, plagioclase, and clinochlore. Residual pyrite grains, displaying angular to subangular particles measuring less than 1 to 250 μm, occur in concentrations ranging from trace to approximately 6 wt%. Framboidal pyrite has formed within the tailings basin in association with organic-rich material. The appearance of frambooidal pyrite in the tailings indicates a reversal of the oxidation process and reprecipitation of Fe sulfides. In addition, the tailings include calcite, calcian siderite, Fe-oxyhydroxides, and Fe-Si-oxyhydroxides as secondary precipitates and replacement products. Groundwaters in the tailings and the underlying units are saturated with respect to gypsum and siderite. These and the other saturation indices calculated for calcite, goethite, and barite are consistent with the secondary mineralogy of the tailings. Conditions promoting the formation of pyrite can be described as neutral to weakly alkaline and reducing assisted by microbial activity. This study provides the first account of secondary carbonates and frambooidal pyrite in the Elliot Lake tailings. The existing environmental conditions at the site are favorable for the desired site rehabilitation.

INTRODUCTION

The U ore mined and processed at Elliot Lake contained 3 to 8% pyrite, which ended up in the tailings. Processing of the U ore involved grinding to 50% finer than 75 μm, leaching in hot dilute sulfuric acid, and precipitation of U by anhydrous ammonia or magnesium hydroxide to form ammonium or magnesium diuranate, commonly known as yellow cake. Tailings and acidic mill waste process water were neutralized with lime and were discharged as a slurry to the tailings impoundments. Prior to placing the cover, the surface of the exposed tailings received a limestone amendment to neutralize the resident surface acidity. A seed mixture of agronomic species, Red Top (Agrotis alba) and Creeping Red Fescue (Festuca rubra) grasses, and inoculated Bird’s Foot Trefoil (Lotus corniculatus) legume, was planted in the cover along with an application of an appropriate amount of high-nitrogen and phosphorus-containing fertilizer (diammonium phosphate) (Davé et al. 2000a). Today the basin supports lush vegetation of the planted agronomic as well as native species of grasses, shrubs, and trees of terrestrial, wetland, and aquatic habitats. The area is gradually turning to a natural bog representing a landform transition zone between terrestrial and aquatic habitats.

The present study was conducted as part of a project to evaluate mine-waste decommissioning options for the Denison mine waste-management areas in Elliot Lake. The purpose of the study was to determine the mineralogical composition and geochemical parameters needed in the overall assessment of the status of the geochemical evolution of the tailings site.

SITE DESCRIPTION

The tailings basin, containing approximately 20 000 tons of tailings, occupies an area of about two hectares. Approximately 70% of the area is made up of dry reclaimed tailings,