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Managing Risks on an Active Haul Road Adjacent to a Propagating Subsidence Zone at Telfer Gold Mine

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Abstract

The Telfer underground sub-level cave (SLC) operations are located approximately 600 to 1000 m below the west wall of Main Dome open pit at the Telfer Gold Mine, Australia. The Telfer SLC commenced caving in 2006 and broke through to the surface in 2009 forming a large subsidence zone that has progressively developed above the SLC operation. Surface deformations within the subsidence zone continue at a rate of 500 mm to 2000 mm per month and are dependent to the rate of underground mining in the SLC operation. Underground and open pit operations have continued concurrently with the progressive enlargement of the SLC subsidence zone. The stage 4 open pit orebody was solely accessible via the West Ramp, which is located adjacent to the SLC subsidence zone with notable steady state ductile deformation occurring on ramp. Risks were managed by understanding the cave propagation mechanism through modelling and monitoring, and the use of comprehensive TARPs (trigger-action-response-plans) and an array of real-time surface and sub-surface deformation monitoring instruments. This paper discusses the monitoring systems used to track the cave subsidence and monitor ground deformation. These include slope stability radar, automatic total stations with survey prisms, shape-accel arrays, time-domain reflectometers, seismicity monitoring arrays, networked SMART markers, surface extensometers, automated crackmeters and monthly aerial surveys. These monitoring systems were used to determine the cave subsidence zone shape, location, rate of propagation and the direct response in the slopes adjacent to the West Ramp. The monitoring systems and TARPs are critical for identifying approaching hazards and taking proactive risk mitigation measures.

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Keywords: Sub-level cave subsidence zone; slope stability monitoring

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1. Introduction

Underground sub-level cave (SLC) operations commenced in 2006 and caving began to propagate towards the surface from approximately 800 m below the pit [1]. In preparation for the SLC operation, a large bench was established in preparation for the initial cave breakthrough area (i.e. 'Breakthrough Bench' or predicted subsidence crater extents) as illustrated in Figure 1a. In order to reduce the likelihood of future high wall instability above the subsidence crater, the Breakthrough Bench was backfilled with 1.1Mt of rock fill (Figures 1b & 1c). The life of concurrent open pit and SLC operations was anticipated to be a further five years.

Fig. 1. Preparations for Cave Breakthrough Bench (a) Breakthrough bench & high wall in 2008; (b) Commencement of backfilling to buttress high wall in February 2009; (c) Completion of backfill buttress in October 2009 and initial cave breakthrough (cracking) observed on slope below breakthrough bench.

At the completion of backfilling in October 2009, pit wall movement and major cracking was occurring on the slope below the Breakthrough Bench (Figure 1c) in response to continued SLC mining underground. The Upper West Ramp was located directly below this area and is illustrated in Figure 2d. A comprehensive deformation monitoring programme and trigger-action-response-plan (TARP) were utilized for the early detection of potential hazards or instabilities. With continuing SLC operations and the progressive growth of the subsidence crater, the Upper West Ramp became unserviceable in 2011 following a nearby slope collapse and extensive cracking on the ramp. As illustrated by Figures 2d and 2e, the subsidence zone continued to expand over the next five years. Significant cracking was identified on and adjacent to the Lower West Ramp in 2014 which resulted in it being designated as a restricted access area for dewatering activities only.

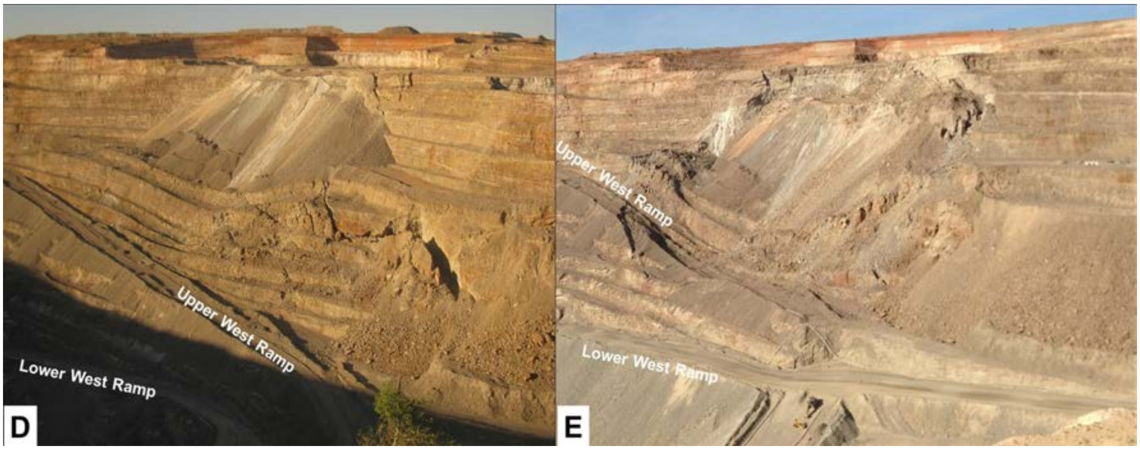

Fig. 2. Cave Subsidence Zone (d) 2011 (2 years after breakthrough) Cracking and deterioration of Upper West Ramp commenced; (e) 2016 (7 years after breakthrough) Cracking becoming visible adjacent to Lower West Ramp; Upper West Ramp not-serviceable but did not catastrophically collapse.