TECHNICAL NOTE

Design of high-extraction panels in evaporite mines

Introduction

High-extraction mining of potash using ‘narrow’ panels consisting of a number of roadways separated by small pillars which are allowed to yield has been most successfully applied in Canadian mines at depths of up to 1100 m. If the method is to be used at other mining locations, then it is necessary to establish how differing geological conditions will affect its application.

The basic concept behind the yield pillar technique concerns the redistribution of stresses away from the worked-out panels and onto adjacent barriers. The redistribution is brought about by mining intermediate pillars within the panels sufficiently narrow that they are unconfined and yield under the high uniaxial loads resulting from the overburden. Yielding of the pillars within a panel creates large deviatoric stress conditions above and below the abutments where shear failure may occur. The stresses in the immediate roof and floor strata are thereby relieved and a destressed zone is created which will protect roof and floor conditions. The success of the technique at an underground location will depend upon a number of factors including the mining layout, sequence and rate of mining operations, which are all factors within the control of mine planning, and geological and rock mechanics factors, which are constraints outside of any control.

This note describes an attempt to model ‘narrow’ high-extraction panels using an approach based upon the mechanical properties of the strata rather than an empirical approach. First, the potential rock mechanics problems that could affect evaporite mining are identified, and then a method for establishing the geometry for high extraction panels which minimizes the effects from the rock mechanics problems is proposed, using linear elastic theory for far-seam strata and the concepts of soft rock mechanics, as proposed by Wilson (1977) for the near-seam strata. The design approach for the high extraction mining panels is necessarily simplistic, treating the strata as possessing idealized mechanical properties based upon laboratory measurements and assumed boundary conditions. However, the restraints generally imposed upon mining require that attempts should be made to predict strata behaviour and estimate optimum opening dimensions.

Key words: Evaporite mining; pillar mining; rock yield; subsidence; rocksalt

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Design of high-extraction workings

In mines where competent strata exist above and below evaporite workings, then the ability of these beds to deform without fracture will control the design of the mine openings. This note looks at the case where the strata sequence is not competent and where failure within the sequence can occur to a significant depth about the workings.

The design approach proposed in this note for the high-extraction workings is as follows.

1. Estimate the induced stress distribution about an opening having overall panel dimensions using a linear elastic model.
2. Determine the zones about the opening where deviatoric stresses exceed a specified failure criteria.
3. Analyse the rock mass bounded by the ‘failed’ zones assuming that shear forces are mobilized along these boundaries in order to determine the required support pressure across the panel width to maintain static equilibrium.
4. Use the post-failure characteristics of the pillar rocks and the required panel support pressure to determine the internal panel dimensions including yield pillar width and roadway span.

The approach adopted in this note for the design of the excavations in evaporites has ignored the traditional concepts concerning the creep behaviour of this rock type. The deformation behaviour of the rock has been considered as a combination of the time-dependent behaviour of the rock in a post-failure state together with the creep effect of the evaporite material caused by stress relief and stress gradient. Actual underground behaviour will depend upon prevailing conditions. Under low deviator stress states, the creep effects of the evaporite material will dominate overall time-dependent behaviour, whereas under high deviatoric stress conditions as will exist around openings in deep evaporite mines, fracture of the rock will occur and behaviour will be controlled by the post-failure characteristics of the material.

Panel geometry

A two-dimensional plane strain linear elastic finite element analysis is used to establish the stress distributions and deformations caused by excavations within a seam. Material failure criteria are then applied to the results in order to estimate the extent of material failure about the openings. These studies can establish the overall panel and barrier dimensions that ensure that surface settlements remain small and that the extent of the ‘failed’ zone about openings does not affect strata away from the openings which may present potential problems.

The material parameters for the strata sequence can be established in a laboratory test programme. The rock materials surrounding potash are generally other evaporites and typical results which indicate both peak and residual strengths for halite are shown in Fig. 1.

Panel support pressures

Once the overall panel geometry has been established the panel support loads which will