SOLUTION MINING RESEARCH INSTITUTE

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RESEARCH PROJECT REPORT

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DESIGN VARIABLES FOR EXCAVATION AND UTILIZATION OF SOLUTION CAVERN FIELDS IN BEDDED SALT FORMATIONS

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SUMMARY

Geomechanical stability analysis of a solution cavern field is essential for operational and safety optimization of the cavern field design. Such analysis requires assessment of stress and strain intensities, intercavern pillar behavior, room closure, and surface subsidence. Because the salt exhibits both viscoelastic and viscoplastic properties, cavern field stability must be ascertained over a protracted time period, also taking into account the historical development of the cavern field. Use of the finite element method in such studies is well established, but it is necessary that the computer code be sufficiently realistic to achieve a close match with the field observations.

In the present study, Serata Geomechanics, Inc. (SGI) applied its proprietary code REM® based on Serata's rheological model to ascertain the long-term stability of a solution cavern field in bedded salt. In order to demonstrate a practical application, the cavern facility planned by International Salt Company (ISCO) at St. Clair in the Michigan Basin was analyzed. ISCO made available the necessary design specifications as well as geological and behavioral data. Within the overall objective of developing a set of design criteria for excavation and operation of solution cavern fields, the following factors were examined:

1. <u>Ground behavior mechanism</u>. Deformation of the ground surface was evaluated to determine the influence of various parameters, and its relation to the phenomena of roof failure, pillar yielding, and surface subsidence was established.

2. <u>Stability effectiveness of proposed design criteria</u>. For different ground conditions, the long-term stability of cavern roofs and ground surface was assessed based on the predictions of the REM computer program.

3. Stress Control Method. Effectiveness of the principles of the Stress Control Method for optimization of the proposed cavern field design was examined.

4. Parametric study. The geological data were retained without change throughout the study. Other important parameters for safe design -- overburden (H), time delay in excavation (t), material properties (P), and stress state (σ) -- were varied so that mining operators elsewhere could benefit from the analysis. The significance of allowing for excess lateral stress in the formations has been demonstrated in recent studies conducted for SMRI, particularly in the bedded salt formations of the Michigan Basin.

5. Recommended design guidelines. The cavern design studied is only a theoretical plan and, in practice, some modifications may be necessary in the layout due to property restrictions and other field conditions. However, the study has shown that the cavern dimensions and overall approach of sequential solutioning is likely to provide high productivity and a safe facility. Similar layouts would also be feasible at other sites, as demonstrated by the case studies with different overburden depths. The analysis provides useful guidelines even for the hypothetical cavern plan. These include:

   - Cavern and pillar dimensions. The geometry of the caverns should be chosen so as to yield maximum production under a safe operating environment. The size of the intervening pillars will be dictated by the overburden depth, extent of stress redistribution, and the type of geological formation.

   - Sequence of solutioning. The delay in solutioning between the outer and inner rows of the caverns can affect stability in some cases. It is recommended that the outer caverns be solutioned first,