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STUDY OF MIXING IN WATER-BRINE SYSTEMS

A Report To

Solution Mining Research Institute

by

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C H A P T E R I

INTRODUCTION

The foundation in the field of mass and heat transfer was laid by Prandtl's introduction (1904) of the concept of the boundary layer. Since then, work has advanced at a very rapid pace, with applications having been made especially in branches of chemical and aeronautical engineering.

The science of mass transfer applied to solution mining is rather young. Over the past ten years, research at the University of Texas has made major contributions to this field.

Previous studies have established the following: The mass transfer of salt takes place from the solid surface to the boundary layer. The under-saturated solution in a cavity is not in direct contact with the salt surface but it is separated from it by the thickness of the boundary layer flow. The boundary layer transfers salt into the bulk fluid by convection. The boundary layer flow originates at the top of the cavity, next to the roof. The different factors controlling the flow of the boundary layer have been evaluated and the rate of salt dissolution has been formulated.

The importance of the concentration of the boundary layer at the top has not been studied in detail. This concentration starts the process of dissolution in the boundary layer.

In a cavity washed with top injection, the injected fresh water spreads horizontally on top of the brine in the cavity. The molecular diffusion is very small so when the water reaches the salt surface, the salt concentration in it is almost zero. Except for this case, in any other type of injection the concentration of the fluid on the top is unknown. In order to evaluate this it is necessary to study the other mass transfer system in a cavity, namely the salt transfer from the brine in the cavity to the injected fresh water.

The purpose of this investigation was to study the mixing effect of fresh water entering a brine solution, or the mass transfer taking place into the fluid flowing along the injection pipe.

C H A P T E R V

SUMMARY

The results of experiments carried out by the injection of fresh water into brine of uniform concentration indicated that the extent of mixing is dependent upon the rate of injection, the concentration of brine and the vertical distance that the mixture travels.

In experiments performed in brine with an initial concentration gradient, portions of mixed fluid came to rest in the course of ascending. The movement created in the bulk fluid due to the ascent of mixed fluid was recorded and the variation analyzed.

The results of the experiments with stratified brine confirmed the existence of a concentration gradient within the ascending fluid.

The combined patterns of mixing of fresh water with brine and salt dissolution were studied. Introduction of dye into the injected water made the patterns distinctly visible.

The startling concentration in the boundary layer is the most important controlling factor in salt dissolution. An empirical relation was derived to evaluate this concentration for given rates of injection, bulk fluid concentration, and height of the cavity. This relation was applied to three prototype cavities and excellent agreement between the measured and calculated concentrations was noted.

The postulated mixing action was used to analyze the results of several experiments.

Over 2000 feet of 16 mm color movie film were taken during the experiments. The time lapse technique permitted observation of long experiments in only minutes. These movie films were edited and titled. The result was 800 feet of film with highlights of almost every experiment. The figures presented are taken from the movie film.