SUBSIDENCE, SINKHOLES, AND PIPING ASSOCIATED WITH GULF COAST SALT DOMES

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ABSTRACT

Subsidence, sinkholes, and piping are features, which are commonly associated with shallow Gulf Coast salt domes. These features are often the result of various natural processes interacting with the geologic framework of the salt dome. However, human activity can also induce or modify these processes which can then lead to the initiation and/or acceleration of subsidence, sinkhole development, or piping. These activities include salt and sulphur mining; hydrocarbon and ground water extraction; brine production operations; cavern storage operations; and shallow brine disposal.

The geologic framework for a shallow salt dome consists of three physical elements: salt mass, caprock, and enclosing strata. A broad set of processes interact with the geologic framework and with each other. The processes involved include the following:

- Salt movement;
- Fluid flow (spatial distribution of aquifers);
- Dissolution (salt, gypsum, limestone);
- Diagenesis (cementation, caprock alteration i.e. anhydrite to gypsum);
- and Structural deformation.

The interaction of these processes can also lead to subsidence, sinkholes, or piping. The geologic framework often preserves a record of these complex interactions both relict and active and provides the basis for their investigation.

The intent of this paper is to provide a general discussion of the geologic framework commonly associated with shallow Gulf Coast salt domes and the interacting processes which could lead to subsidence, sinkholes, and piping. Each of the various types of human activity and how they can affect or induce changes to this complex natural situation is then discussed.

INTRODUCTION

Subsidence and sinkholes are common surface features associated with coastal salt domes in the Gulf coast region. Figure 1 shows the areal extent of the coastal salt diaper province of Texas and Louisiana and locations of those salt domes on which natural or human induced subsidence phenomena have been reported. These subsidence features result from the lowering of the ground surface as the result of localized downward movement of the sediment or strata overlying the salt diapir. The downward movement can be described in terms of compaction and displacement mechanisms. These two different physical mechanisms vary greatly in terms of the scale at which they operate. Figure 2 is a diagrammatic illustration that illustrates the scale difference between these two mechanisms. Figure 2A shows the compaction of a near surface mud/clay layer overlying an unconsolidated sand. With increasing depth of burial and weight of overburden, a grain-to-grain adjustment towards a tighter grain packing arrangement is produced. Compaction reduces the water filled void space (porosity) between the grains resulting in reduced porosity, water expulsion, and reduction in the bulk unit volume. Displacement (Figure 2B) involves the downward movement of sediment through fractures or fissures (piping); or movement on a much larger scale which results in the sag or collapse of strata due to removal of underlying support, or deformation due to faulting or upward salt movement. Compaction and displacement are naturally occurring processes, but they may also be induced or accelerated by human activity. Many of the salt domes shown on Figure 1 have subsidence features that have been related to human resource exploitation.

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