OLD BEDDED-SALT CAVERNS, WHERE ARE THEIR BORDERS?

by
Alfred H. Medley
and
Hans-Günter Haddenhorst

INTRODUCTION

Some of the most interesting, technically challenging, and economically important problems faced by solution miners involve prediction and evaluation of cavern growth, shape and size. Much progress has been made over the past several decades, but most of the attention has been directed toward large caverns in salt domes.

Multi-well caverns developed through layers of bedded salt have received much less attention. These systems involve so many geologic and design variables that model development is extraordinarily expensive. The problem is exacerbated by the lack of measurement tools for theory testing. Tools such as sonar work well in salt-dome caverns but have limited value in thinly bedded cavern systems. To the best of the authors' knowledge, a worldwide search would produce no theories or methods with proven application to the subject of this paper.

Brine wells have been around for a long time. The Chinese were drilling as far back as the eleventh century. Edwin Drake was using brine-field-drilling technology when he set off America's first oil boom at Titusville, Pennsylvania, in 1859. Natural brine produced from wells at Syracuse, New York, supplied the North with salt during the Civil war. The Confederacy boiled natural brine from wells at Saltville, Virginia, until the town was captured near the end of the war.

Natural brine was an existing fluid to be pumped. Some of the wells penetrated naturally flooded salt beds, but most simply tapped saline fluid that had migrated from a distant source. Legally, brine was like water. If the well was on your property, the brine was yours.

Artificial-brine production began in the United States around 1880. Wells began to penetrate salt beds where natural inflows of water were either inadequate, or undesirable, for brine production. Most of the early wells were produced by air lift with water poured into the annulus, often from gravity-fed ditches.

Recognition that artificial brine involved issues of salt ownership came slowly. Efforts by operators to deal with property rights of adjoining land owners grew as the years went by. Early wells failed before caverns grew to significant size, but, by 1900, procedures had improved to the point that wells would have life expectancies of 40-50 years. Some of the resulting coalesced systems grew large enough to undermine several hundred acres. Some grew until their surprised owners had to explain sink holes.

Evaporative salt production consumed most of the brine although some fields provided feed stock for chemical manufacturing. The chemical plants started as producers of soda ash but went on to produce chlorine, caustic soda, and a host of byproducts. By now, most of the early fields have been abandoned and plugged to the extent possible, but many of the surface facilities continue to operate, supplied with brine from newer fields.

Because salt and chemicals were vital to the war effort, some of the fields that began life at the turn of the century continued operations into the 1940s. Wells that should have been plugged or repaired limped on as necessary material and personnel were diverted to the front lines. Some of the facilities suffered lasting damage. Worn-out equipment caused brine and chemicals spills. Caved caverns and corroded casings caused subsurface leakage.

Now, some of the old fields are attracting public attention. Plugged wells may be seeping brine or bubbling gas. Nearby oil-well drillers may think their holes have been impacted. Adjacent property owners may wonder about the perimeters of the subsurface cavities.

Over the last five years, records of 437 wells located in 38 brine fields developed in four states and a province of Canada have been examined. All of the reviewed fields were different. Most of the very early fields were formed by coalesced caverns of air-lift brine wells. Deep-well pumps eventually replaced air-lift systems. In a few instances, casing-to-borehole seals in early wells were adequate for pressure circulation where injected water forced brine to surface, but these were rare.

As oil-field technology improved and moved back to the brine fields, casing cementing and hydraulic fracturing became common. A few examples of air or hydrocarbon padding were found. The amount of salt produced per well increased and caverns developed dimensions that could, at least in part, be viewed by sonar. Some of the recent systems utilized lateral drilling to hasten hydraulic connections between wells.

Most of the younger fields gave up their secrets easily. Records were kept and could be found. Operators had better understanding of how the caverns were developing and took steps to monitor the process. Sonar surveying was common, although the results were of limited value. In recent years, regulations drove the process. The paper trail became so broad that it was sometimes overwhelming.

The early fields, some of which started before the turn of the century, were a different matter. Operators of these facilities produced brine without a good understanding of what was occurring down-hole. Few records were made, and even fewer survived. The Xerox machine did not exist. Tissue paper carbon copies were hard to read when found. Old records had been relegated to "dead files" located in plant areas prone to fire and flood.

In none of these efforts was the exact location of a cavern perimeter established. But, in most cases, probable growth limits could be defined. The techniques used varied, dependent on what the records contained. In essence, each brine field represented a mystery to be solved. All available company records were collected and sifted for clues. Occasionally, an oral history could be assembled by interviewing retired operators. Searches of public libraries sometimes bore fruit. Eventually, a logical scenario of events would evolve. Skill increased with experience. As more and more wells were examined, patterns became apparent. Although control points might be unavailable in a particular field, the basic pattern might match that of another field where control was available.

This paper benefits from the review of many facilities. Although confidentiality agreements prohibit disclosure of specific data or results, the techniques that were developed can be discussed. Fortunately, data from one facility were released for demonstration of example cases.

The evaluation procedures discussed in this paper are appropriate for the released data. They can be applied in other fields where operations were similar. They may not be appropriate for fields that were developed by hydraulic fracturing or lateral drilling.

Like many scientific endeavors, the need for answers fathers theory, but a theory needs proof. Old brine fields contain few control points that can be used as proof. It is rare that a new well can be drilled solely to check a cavern perimeter. If drilled, it cannot establish the perimeter. It can only determine if it is inside or outside of the perimeter.

The solution mining industry should prepare for increasing public scrutiny regarding its old facilities. The authors encourage testing of procedures described in this paper in your own bedded-salt fields. If you find proof that they work, publish the proof. If you develop an improved procedure, publish it.