Rapid Characterization of Salt Domes for Underground Storage

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Abstract

The Energy Policy Act of 2005 calls for expansion of the U.S. Strategic Petroleum Reserve from ~700 million to its full authorized storage capacity of one billion barrels. At least one new salt dome site will need to be selected and developed. All together, we were faced with the task of evaluating rapidly five salt domes for underground storage potential, in time to meet the required deadline for the Secretary of Energy to make a recommendation to the President.

Our evaluations have used existing data, enhanced by recent advances in the understanding of salt-dome geology. Well locations and total depths were obtained from vendors of oil-industry data, supplemented by examination of on-line well records maintained by state agencies. Well logs, particularly electrical logs were obtained from commercial vendors and log libraries. Information was also gleaned from well-completion cards. Searches for existing non-exclusive 2-D and 3-D seismic surveys were performed by a seismic broker.

Information was interpreted in light of concepts of salt dome development via movement of quasi-independent salt spines separated by boundary shear zones. Direct intercepts of salt and caprock were supplemented by indirect data such as the TD of wells that were terminated without documented evidence of salt in areas overlying a salt diapir. Even a lack of salt indications observed during pre-purchase quality-control examinations of existing seismic lines provides an indirect constraint on the size and extent of an otherwise poorly constrained salt interpretation.

The geologic evaluation focused on generating hand-contoured structure maps of the top of caprock, top of salt, and caprock thickness as the mechanism to define diapir geometry and likely internal structure. Construction of these maps over the top of the salt stock used a more refined contour interval to capture elevation and thickness variations that help to define salt spines and associated boundary shear zones that may affect construction and operation of storage caverns.

Manually generated structure contour maps were converted to a three-dimensional computer model of the salt and caprock geometry. This conversion is possible even in the presence of minimal “hard” data that would otherwise produce geologically unrealistic numerical artifacts that render the models uninterpretable. Such three-dimensional modeling enforces geometric consistency of the overall geometric configuration of the dome.

Three-dimensional modeling of salt geometry is particularly amenable to evaluation of possible designs for a future cavern field. The extent of salt available for cavern development at various depths and over various vertical intervals can be computed easily. The impact of regulatory stand-off distances from salt flanks and buffer zones adjacent to boundary shear zones can be defined and visualized. The positions and shapes of any existing caverns may be included, and the locations and desired shapes of new caverns may be indicated as well.

We illustrate the process of rapid characterization of salt domes, for purposes of SPR expansion, with examples taken from our actual case studies.