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Long-term behaviour of salt caverns

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Thousand of deep caverns have been leached out from salt formations. They are used to store hydrocarbons. These caverns will be abandoned some day. There is growing concern about the long-term behaviour of such caverns when they are sealed and abandoned. Comon experience proves that brine pressure builds up in a closed cavern, raising fears that cavern pressure actually exceeds geostatic pressure, leading to fracture creation and rapid brine seepage to shallow water-bearing formations.

Physical mechanisms governing pressure build-up were identified. They include cavern creep closure, brine thermal expansion and brine permeation through the cavern wall. Each of these mechanisms has been quantified through both lab and field tests. The agreement between field data and predictions is good in the case of thermal phenomena, which are governed by conduction in the salt mass and convection in the brine-filled cavern; it is fair in the case of mechanical phenomena, which are governed by transient and steady-state creep of the salt formation; it is relatively poor in the case of brine permeation through the rock, as salt permeability is exceedingly low and difficult to precisely assess.

In order to assess the overall behaviour of an actual cavern, in which the three above-mentioned phenomena combine, a one-year long test was performed in a 8,000 m^3 cavern at a 1,000-m depth. In this old cavern, thermal phenomena were negligible. Before the test it was predicted that cavern pressure should reach an “equilibrium pressure” when cavern creep closure rate exactly balances brine outflow through the cavern walls. The test basically consists of a “trial and error” process: different pressure levels are tested successively and the pressure evolution following each pressure change is observed. Possible leaks through the well casing were a concern, as they lead to an overestimation of rock permeability; a special system was designed to as-

sess these leaks. The test proved that brine pressure had reached an equilibrium value significantly lower than geostatic: salt permeability can prevent large pressure build-up, avoiding fracture creation.