Efficiently and comprehensively stress test the caprock overlying thermally stimulated heavy oil reservoirs.

Image the caprock using the FMI* fullbore formation microimager to both identify intervals for testing and document the results of minifrac tests conducted with the MDT* modular formation dynamics tester.

Conclusively determined the minimum stress magnitude from the minifrac test and confirmed the minimum stress orientation from imaging by the FMI microimager of the created hydraulic fracture.

In the Athabasca oil sands of northeastern Alberta, thermal techniques including steam-assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS) are typically required to extract the bitumen reserves. However, the pressure buildup resulting from these processes can potentially compromise the integrity of the overlying caprock seal. It is therefore critical to confirm that the pressure in the sandstone reservoir will not exceed the minimum stress in the shale above. Failure of the caprock would adversely affect the thermal operations, but far more importantly could have a negative effect on the environment.

For stress testing to provide accurate information on the state of stress and breakdown pressure for the shale caprock, the tested interval must have no existing weaknesses, such as natural fractures. Operators need an efficient approach for identifying appropriate intervals for testing and then conducting the tests to collect accurate, useful data.

The FMI fullbore formation microimager provides microresistivity images and dip data in water-base mud. With 80% borehole coverage in 8-in boreholes and 0.2-in image resolution in the vertical and azimuthal directions, imaging with the FMI microimager is the preferred approach for identifying structures—both natural and drilling induced—that are present in the reservoir and in the overlying caprock.

The minifrac test conducted with the MDT tester configured with the Dual-Packer Module achieved a repeat value of 21 kPa/m for the breakdown pressure gradient.
The Dual-Packer Module used with the MDT tester consists of two inflatable packer elements that seal against the borehole wall to isolate an interval, which improves the effectiveness of pressure measurement in low-permeability or laminated formations. The pressure of the fluid between the packers is increased until the rock fails. Ideally a fracture plane is created perpendicular to the minimum stress, and continued pumping propagates the fracture into the formation. The pumps are then shut off to measure the pressure decrease as a falloff test. In addition to the closure pressure and gradient, determining the orientation of the minimum stress is needed to model potential failure of the caprock and the possible route steam and bitumen would follow through the subsurface.

**Imaging confirmation of hydraulic fracturing**

Falloff testing conducted with the MDT tester and Dual-Packer Module achieved a fairly consistent value of 21 kPa/m for the breakdown pressure gradient. Because this value is the same as the overburden stress, it could be assumed that the minimum stress is oriented vertically and exceeding it would result in horizontal failure of the caprock. However, the FMI microimager was run after the minifrac test and confirmed that the hydraulic fracture created was vertical, which means that the minimum stress is actually horizontal. Without the imaged confirmation, the wrong conclusion might have been made about the state of stress of the caprock.

*Comparison of the pre- and postfracturing images from the FMI microimager clearly shows that the fracture induced within the isolated interval is vertical.*