Sample Preparation: Making the Most of Fractured Core

Customer Need

The acquisition of high-quality fracture-free core is a challenge when working with unconventional reservoir rock. The tendency of shale core to crack during the coring process limits where samples are taken. The extraction of plugs, particularly vertical plugs (i.e. bedding orthogonal to axis), is especially difficult because of stresses formed around the plugging bit. Premier has developed several sample preparation techniques that produce better results on fragile shale core.

Sample Potting

Flow-through permeability tests such as steady state and pulse decay, are strongly affected by the presence of small cracks in the plug. These small cracks potentially skew permeability values orders of magnitude greater than the actual matrix perm. Increased confining pressure on these samples help to close some of the fractures but testing has showed that some cracks seldom seal completely.

Two years of research and development led to a sample potting technique wherein crack-free portions of rock are encapsulated in a resin enclosure that creates cylindrical samples for permeability testing. Crack-free sections of rock are identified with Micro-CT screening. Damaged portions of the rock are carefully removed and the crack-free prism is cast in resin.

There are multiple considerations when casting unconventional rock samples in resin:

1. potential for stresses formed during the exothermic reaction between the resin and its hardener,
2. how to achieve a perfect bonding with the sample,
3. imbibition of resin solvents into the sample, and
4. transfer of confining stress to the sample during flow-through testing.

The development of Premier's resin potting technique addressed all of these concerns. Micro-CT scans on samples after resin potting verified that no new cracks were produced during and that a strong bond was achieved. Chemical analysis of the effluent after flow-through testing did not find evidence of solvents in the sample. Permeability measurements at multiple confining pressures verified that stresses were effectively transferred to the sample.

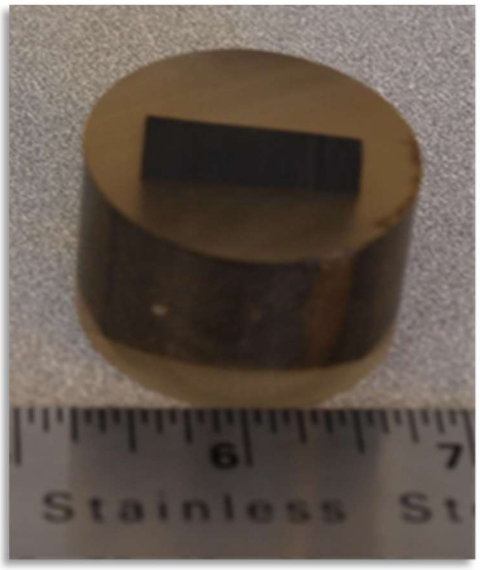

Figure 1: Example of a resin potted plug used for flow-through permeability testing.

The development of this technique allowed Premier to sample sections of core once thought impossible to work with, thereby increasing the amount of usable samples for flow-through permeability tests.

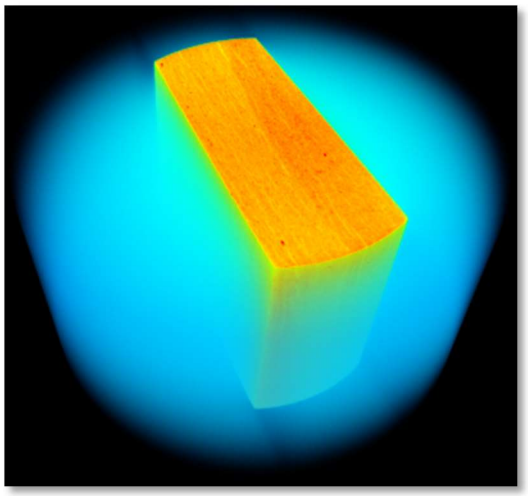

Figure 2: Micro-CT of a potted prism. Micro-CT is used to determine plug volume and cross sectional area for flow-through tests.

Vertical Plugs

The extraction of intact vertical plugs, i.e. plugs where bedding is orthogonal to the long axis, is extremely difficult for unconventional reservoir rock. The problem is that many of these rocks fail along bedding under low tensile loads. The kerf of the plugging bit creates a tensile field causing most vertical plugs to "poker chip" or fall apart.

The difficulty extracting high-quality vertical plugs from unconventional reservoir core complicates the measurement of anisotropic flow and mechanical properties.

Premier has multiple approaches for extracting vertical plugs in fragile rock. In the most troublesome rock, Premier takes a different approach from conventional plugging techniques. Instead of trying to take the appropriate size plug with a bit, we take a chunk of the core and, with small precise linear cuts, form a cylindrical plug.

Taking plugs with this method improved successful vertical plug sampling in one particularly troublesome core from 5% to 95% for a project that required both vertical and horizontal plugs.

Discussion

Sample preparation is critical for successful testing. The examples presented are two techniques for taking samples from difficult core. Development of these techniques was driven by the necessity of collecting representative measurements for lithologies that are underrepresented in most sampling strategies.

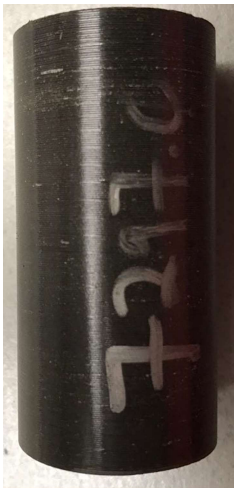

Figure 3: Vertical plug for geomechanical testing created using Premier's technique for fragile core. In this example, perfect cylindrical samples were made from core that could not be plugged by conventional methods.

The sample preparation techniques developed at Premier allow for more frequent sampling providing better representation of the geology and enable measurement of anisotropic flow and mechanical properties.