

## Medical X-Ray Techniques, 3D Visualization Might Hold Key to Untapping Oil Reserves

Throughout the world, oil fields are being abandoned, even though as much as 70 percent of their original oil remains untapped.

Petrobras is working to change that scenario. Brazil's largest oil supplier is using medical x-ray technology and advanced visualization software to better understand oil flow inside porous rocks of petroleum reservoirs.

### A Tricky Sponge

Contrary to the familiar images of oil geysers, most oil does not sit underground in big pools. The source is usually within rocks or sandy soil. The trick is getting it out of the ground. Most oil recovery involves pumping water, often mixed with chemicals similar to soap, to force oil out of rocks. But this method extracts only about 30 percent of the oil inside a rock.

According to Petrobras engineers, rocks from which oil is extracted are like "tricky sponges." There are large pores that are easy to extract oil from and smaller pores that are not so easy to extract from. Characteristics such as pore connectivity and rugosity - the roughness of a borehole wall - allow each type of rock to have unique flow patterns, even if they are similar in appearance.

Traditionally, rock permeability and porosity have been determined with a procedure that measures how much water is injected and how much oil gets out under specific conditions of temperature and pressure. But that method does not provide any information about behavior of the fluid displacement inside the rock sample and what the rock structure looks like as the fluid flows through it.

Advanced technologies have given the researchers a way to view these properties in 3D.

### 3D Technology Meets Geology

Researchers at Petrobras use medical tomography equipment, similar to that used to x-ray human bones, to scan a rock sample that has been injected with water. They then construct a 3D model of oil-bearing rock from the scans and use computer simulations to numerically characterize the properties inside. This is a major advance over previous methods, where porosity and permeability were contrived rather than obtained from actual samples.

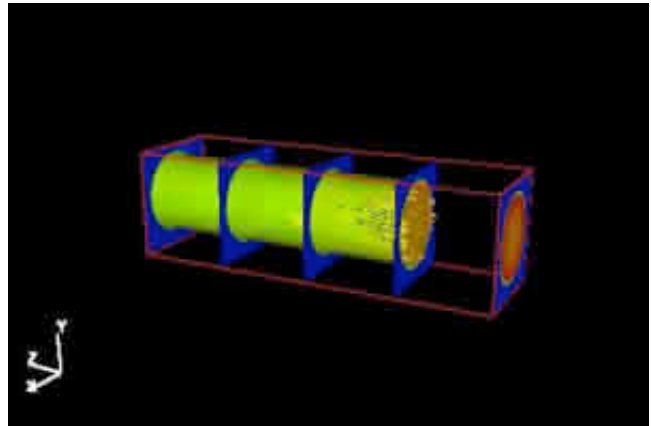
Petrobras researchers load the computer simulation data into EnSight software from CEI ([www.ensight.com](http://www.ensight.com)), which generates 3D animations that show fluid behavior inside the rock.

EnSight enables Petrobras to create different isosurfaces to represent the displacement inside the rock. The fluid behavior is tracked by analyzing an isosurface over different time steps. These representations give Petrobras engineers a good qualitative analysis of the permeability and porous properties inside the rock sample.

EnSight animations are used at Petrobras to visually communicate findings to other teams involved in the reservoir recovery, making it easy to see and understand what is happening inside the rock.

### The Small and Big Pictures

In addition to new methods of simulating and visualizing the microscopic details of oil flow within porous



rock, Petrobras is also making progress in large-scale reservoir modeling. Another Brazilian company, Engineering Simulation and Scientific Software (ESSS), has developed software called Ciclope that enables Petrobras to read, visualize, edit and convert 3D grid data (geometry and properties) from software used in reservoir characterization and simulation. Simulation data from Ciclope can be fed directly into EnSight software to get the bigger picture of what is occurring throughout an entire oil field.

3D modeling and visualization technologies are providing valuable clues to Petrobras researchers in their quest to squeeze more oil from reservoirs. It is a major improvement over earlier studies where the specialists didn't know the rock sample structure and the behavior of the fluid displacement inside. For Petrobras and other companies in the industry, it could mean greater efficiency in oil recovery, which would have a huge economic impact worldwide.

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