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If an oil formation is fracked, how will it drain? Ask a smart rock.

BY GARY BEERS • FOR ENERGY PIPELINE

Precise knowledge about predicted oil and gas movement through rock pores will lead to more efficient placement of fewer wells and effective design of fracking. A concurrent benefit would include reductions in environmental and local societal impacts.

Advances in recent decades focused on moving traditional core analysis into the digital age with the application of computer-aided design (CAD) to create digital rocks. While this improvement is significant, there persists a remaining layer of scientific guessing between actual pore-scale flow behavior and the engineer's mathematical modeling. The extent of guessing increases as predictions were expanded to describe flow through adjacent, different reservoir rocks.

The ideal solution would be to have real-time readings of changes in temperature, pressure and chemicals as oil and gases move through the small pores of reservoir rocks. While it is impractical to install a network of sensors throughout reservoir formations, it should be possible to have above-ground examples of formations with embedded sensors and then introduce flows. One option would be to embed sensors in core samples; the other would be to replicate the core with built-in sensors (i.e., create a smart rock).

3D PRINTED, SENSOR-PACKED SMART ROCKS

A Scottish research team (Heriot-Watt University) is 3D printing replicas of reservoir rocks (1 inch diameter and true-to-scale) with small pores and embedding micro-sensors (with tiny optic fibers) as the layers are laid down. Currently, the selected sensors measure pressure, temperature, flow, pH, and change in fluid/gas composition and are placed where they will not interfere with porous areas under investigation. Smart rocks are being created to directly communicate real-time conditions at the micro-pore level. Professor Maroto-Valer, team

leader, stated-

The problem is that rocks cannot talk to us. Answer is simple: make own rocks that can talk.

By 3-D printing our own core samples we can decide exactly what sort of rock we wish to study, and implanted micro-sensors will be able to tell us directly, in real-time, what is going on as gases and liquids pass through them. This fundamental knowledge at such a tiny scale will feed hugely into our understanding of such processes at the large scale and enable use to maximize the success of industries from oil extraction to water safety and the storage of captured CO₂. (Heriot-Watt University, News, May 25, 2016, Edinburgh, Scotland)

Information from the smart rocks will be input to computer models to more accurately design completions of horizontal shale wells or enhanced recovery oil recovery wells.

Their research continues on which materials (i.e., plastic polymers, glass, metals) with other materials (i.e., calcite) embedded will come the closest to replicating real-world formations.

Incidentally, the prestigious European Research Council recently awarded \$3.3 million, five-year grant to support continuation of this promising research.

3-D PRINTING IN THE GEOSCIENCES

The above creative development of a smart rock is based on adaptations of 3-D printing to the geosciences (Making things geological: 3-D printing in the geosciences, F. Hasiuk, Geological Society of America Today, 24:8:28-29, August 2014). Physical replicas of a rock's micro-features can be scaled up to sizes more easily explored and understood – as opposed to understanding 3-D data on a computer screen even in 3-D visualization. For example, the structure of sandstone can be precisely replicated at various up-scalings (Figure 1) to provide a fabricated porous rock.



For over 50 years, **GARY BEERS**, has worked in numerous fields of environmental science as a consultant, regulator and educator. This career included senior management position with major consulting, nonprofit and public organizations. He has founded several successful firms to capture emerging resource management markets. One of his latest ventures, EnviroScienceINFO, provides content for public media.

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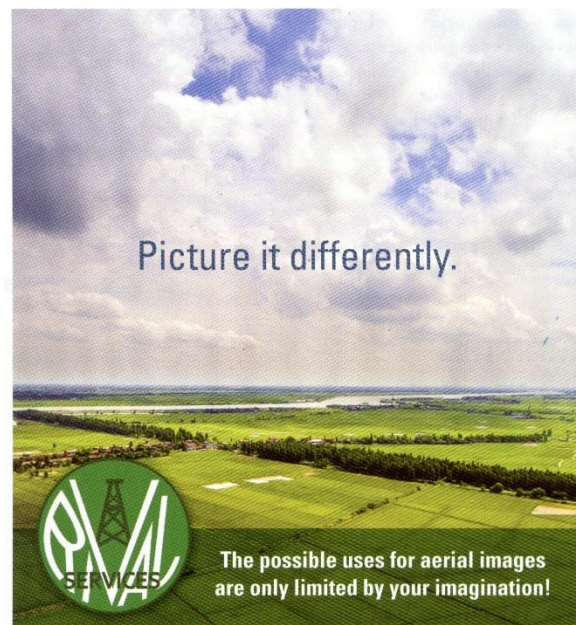
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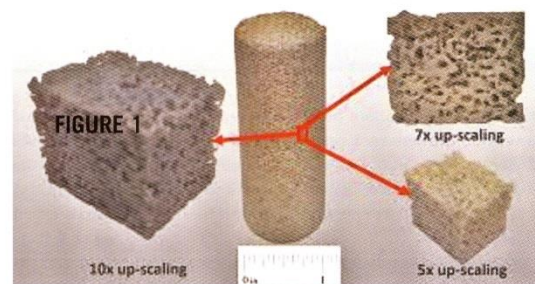
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Making a copy of a natural rock is a simple process (Just like the real thing. T. Smith, GEOExPro 12:5, 2015). The first step is collecting a series of two-dimensional cross-sections of the rock using computed tomography (CT) scans and then assembling these into a 3-D digital rock mode. In the second step, the digital rock is segmented into grains and pores. The last step is to 3-D print the surface representing the boundary between the grains and pores.

A smart rock produced by the research team at Heriot-Watt University would look like one of the printed versions (Figure 1) with many optic fibers sticking out from the embedded sensors. •



3-D Printed samples from core plug of Idaho grey sandstone. (Source: S. Ishutov and F. Hasiuk, GeoFabLab, Iowa State University)

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