INGRAIN
Digital Rock Physics Lab

CASE STUDY

Properties of Sandstone Drill Cuttings

Challenge

The ability to obtain rock properties from sandstone drill cuttings is often difficult and even impossible using conventional technology, due to sample size, exposure to physical damage, fluid invasion, and irregular shape. A Canadian company asked Ingrain to determine the permeability and porosity of drill cuttings from a candidate water disposal sand.

Solution

Ingrain utilized CT scanning at the micro-meter level of resolution as input to 3D flow computations, delivering a host of physical and flow properties of the reservoir. Ingrain's ability to create a digital rock inside a sample where there is less observable damage makes the analysis suitable for baseline values at ambient conditions.

Results

The client tied Ingrain's results to well log data, SEM, and thin sections that had been performed on similar samples. Ingrain's computations of porosity values corresponded with those obtained with backscatter SEM (BSE-SEM), but no permeability had been previously obtained on those samples. The range of permeabilities provided by Ingrain was reasonable and the client accepted the results.

Imaging and computing on drill cuttings

A Canadian company sent four bags of cuttings of friable, mostly unconsolidated, lithic arenites. Three samples were selected from two different depth intervals, 475 m and 480 m, and all six samples were imaged at high resolution (1.13 microns per voxel) on the micro-CT. High-density minerals (calcite and illite) are represented as white, while minerals such as quartz, feldspar, and plagioclases are represented by different shades of gray. Lower density material, including matrix fill such as kaolinite, appears as dark grey. Pore space and fractures are represented by black.

The three subsamples for sample 475 have a porosity range between 6 to 8 % and permeabilities ranging from 0.75 to 4.22 mD, while the three subsamples corresponding to sample 480 exhibit a broader range of porosities and permeabilities (6 to 13% and 0.73 to 17mD).

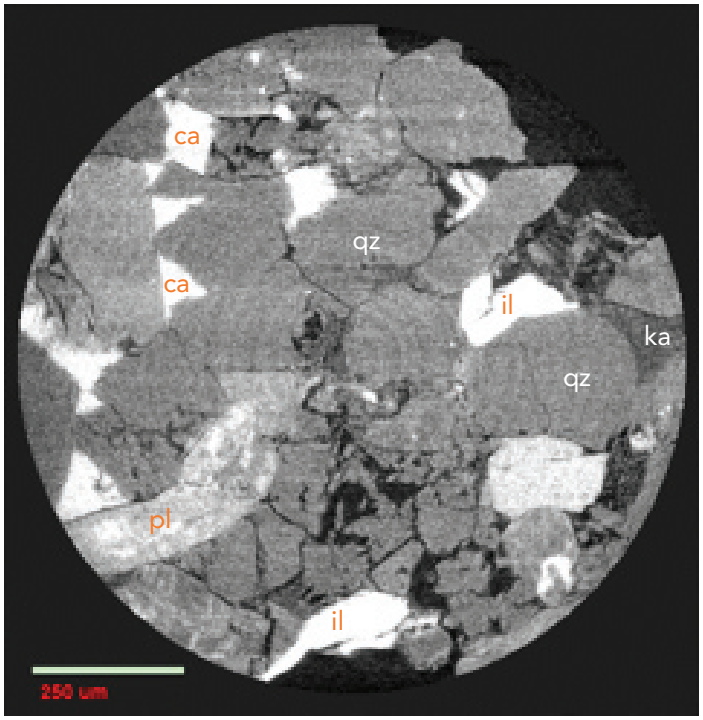

Figure 1: Single axial slices showing minerals with different CT density. Calcite (ca), illite (il), Quartz (qz), Plagioclases (pl), Kaolinite (ka).

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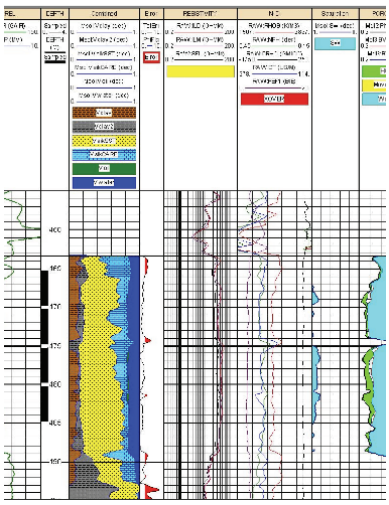

Figure 2: Well log data

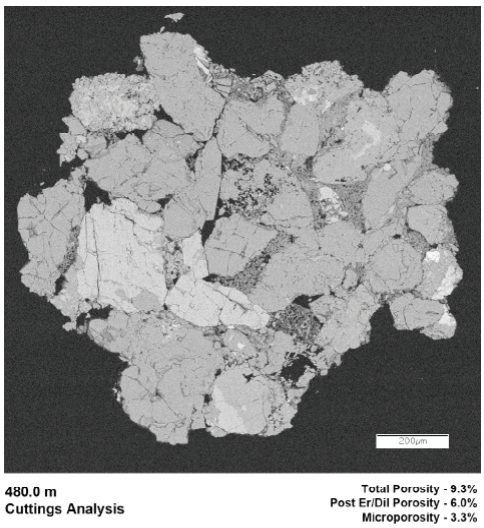

Figure 3: BSE-SEM images

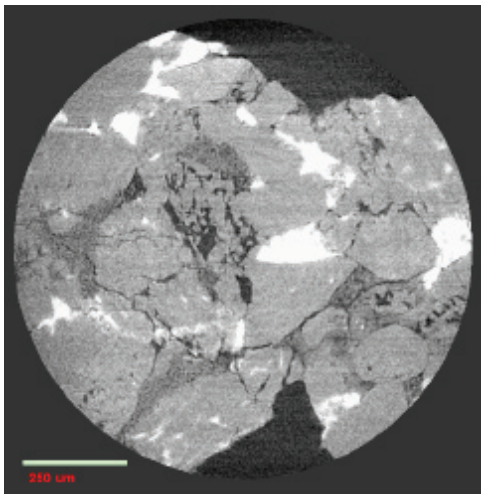

Figure 4: Axial slice

The client provided Figure 2: Well log data and Figure 3: BSE-SEM images. Figure 4: An example of the many axial slices acquired by Ingrain. Porosity obtained by both methods is similar, but in addition to computing porosity, Ingrain's digital rock allowed Apache to obtain permeability and formation factors for all samples in less than one month.

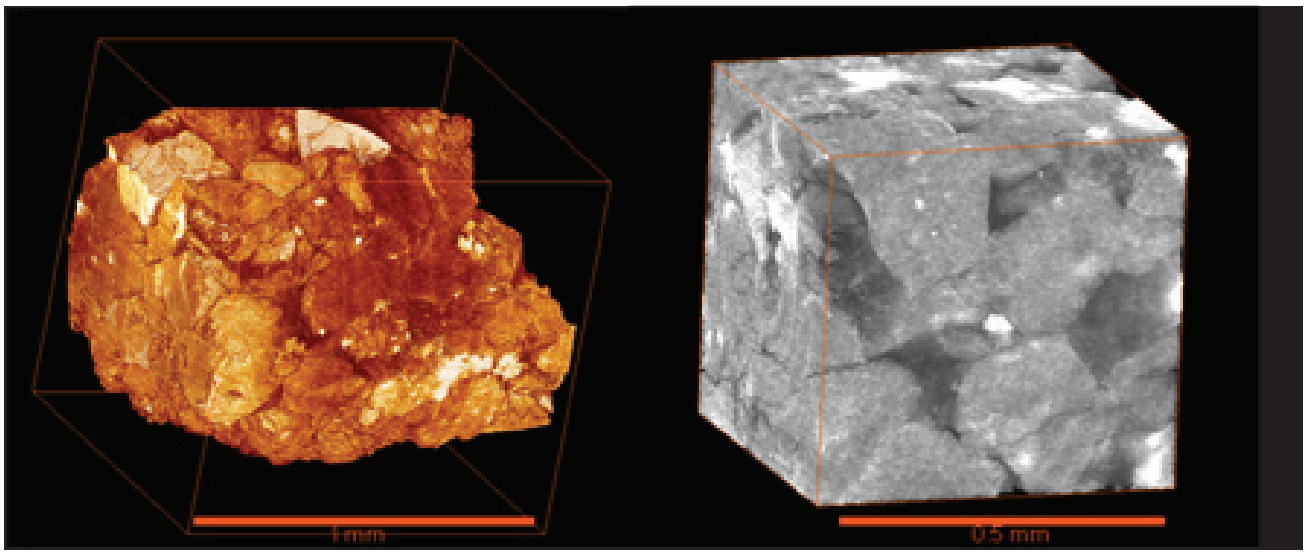

Figure 5: Three-dimensional view of irregular shaped sample

Figure 6: 3D cube extracted from irregular volume

Figure 5 shows a three-dimensional view of the irregularly-shaped sample cutting that was scanned with the micro-CT system. Figure 6 shows the 3D cube that was extracted from inside the irregular volume. It was in this digital rock of regular shape and dimensions that Ingrain performed the fluid flow simulation.

Integrity and Utility of Cuttings

When core is not available for the evaluation of reservoir properties and cuttings are the only rock sample available, the concern is that these properties may significantly differ from those relevant to in-situ conditions.

The client used specific criteria to select the cuttings that could produce the best evaluation of porosity and permeability, and the company was pleased with Ingrain's results. The samples with a higher value of porosity and permeability seem to be mostly associated with fractures that are likely induced by drilling.

Sample Name	475-1	475-2	475-3	480-1	480-2	480-3
Porosity						
Total Porosity	5.8%	6.9%	7.9%	5.9%	8.9%	13.2%
Permeability						
Directional Permeability (X)	1.12	0	3.46	0.73	6.02	14.8
Directional Permeability (Y)	~0	3.54	2.6	~0	6.19	~0
Directional Permeability (Z)	0.75	0.95	4.22	0.75	4.81	16.9
Formation Factor						
Formation Factor (X)	1300	980	300	780	260	48
Formation Factor (Y)	2300	510	250	1600	110	5800
Formation Factor (Z)	1300	2500	300	1200	220	240

Figure 7: Porosity and permeability