Environmental Scanning Electron Microscope

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The University of Oklahoma

Integrated Core Characterization Center

IC³

The University of Oklahoma now owns and operates the industry's leading and renowned rock physics lab developed originally at Amoco's research center in Tulsa. This facility, known as the Integrated Core Characterization Center (IC³), is now available to the industry for R & D projects and rock property measurements.

While the laboratory is capable of making a vast number of routine measurements, the greatest strength of IC³ is its capability to customize experiments and measurements to meet the needs of geoscientists/engineers in addressing a multitude of E&P industry problems in a cost effective manner. While the centerpiece of IC3 has been to understand the seismic response of rocks and fluids and seismic relationships with petrophysical parameters, data can also be generated for reservoir quality evaluation, seismic characterization, petrophysical evaluation, and reservoir mechanical/chemical stability evaluation. For more information visit:
www.ou.edu/mewbourneschool/cfrp/ic3/cfrp.htm

Sample Preparation Capabilities

- Plugging frozen state core
- Controlled humidity/critical point plug drying to preserve original clay fabric
- Sample cleaning using soxhlet extraction
- Whole core slabbing
- Plugging using brine, kerosene or liquid nitrogen (.5" to 2.5" diam., consolidated and unconsolidated)

Anisotropy Measurement System

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Sample Measurement Capabilities

- Compressional and polarized shear wave velocities at elevated pressure (10,000 psi pore pressure and 10,000 psi confining pressure)
- Velocity anisotropy (elastic anisotropy)
- Mineralogy (Fourier Transform Infared Spectroscopy, (FTIR), X-ray diffraction, and modal analysis)
- Thin section study for modal analysis, textural analysis, macro and micro porosity, grain fracture, and fluid inclusion
- Plug fluid content and extraction (solvent reflux, centrifuge, and oven drying)
- Gamma Ray scanning
- Cathodoluminescence analysis
- Magnetic Susceptibility (continuous core and discrete plugs)
- Minipermeameter scanning (continuous core and discrete plugs)
- Digital Photography (thin sections, plugs and continuous core)
- Digital image analysis on thin sections for grain size, porosity, and sand/shale ratio
- Scanning Electron Microscope analysis for fabric, clay habitat, microfractures, cementation, and micro porosity
- Particle size analysis using laser diffraction (particle sizes from 0.375µm to 2000µm)
- Porosity & Permeability (to 10,000 psi)
- Hg Injection (to 60,000 psi)
- Elemental analysis using X-ray fluorescence for elements with atomic weight higher than sodium
- Static Moduli (Young's modulus, shear modulus, and Poisson's ratio)
- Compressive Strength (unixial, triaxial stress and plane strain)
- Hydrostatic Crushing Strength (to 145,000 psi)
- NMR Porosity, Bound Water and T2 Relaxations
- Total Organic Carbon
- Bulk Density
- Grain Density
- Boyles' Law Porosity

Sample Measurement Capabilities

Anisotropic Elastic Constants of Shales...

We assume hexagonal symmetry or transverse isotropy to prevail when measuring the anisotropic elastic constants. Measurements require the core plugs to be extracted parallel and perpendicular to fabric and a third plug to be cut at an angle (preferably 45 degrees) to fabric. Compressional and polarized shear velocities are measured on each plug as a function of pressure. Densities, mineralogy, and TOC are measured on each plug to assess heterogeneity. Results are reported as tensor components of compliance (Cijs) and Thomsen parameters epsilon, gamma and delta. Graphs of phase and group velocity dependencies on angle are also available.

Applications;

Anisotropy properties affect many aspect of seismic prospecting, e.g., time to depth conversion, migration, synthetic generation, logging tool response, closure stress calculations, fracture mapping and AVO calculations.

Circumferential Velocity Analysis...CVA

CVA involves measuring the P-wave velocity across a diametrical path at various azimuthal locations along the circumference of a core. Current measurement conditions are ambient pressure and temperature. If the material is perfectly isotropic, the velocity is a constant and displays no variation when plotted against azimuthal angle. However, anistropy produces a sinusoidal variation with angle. The period of the function gives symmetry directions. The amplitude variation can yield a measure of crack density or mineral alignment.

Uses:

Detection and quantification of anisotropy caused by cracks or mineral fabric.

Applications

1. Robust method to deduce in-situ stress directions from old core.
2. Quantifying cleat directions and densities in coals.

Anelastic Strain Relaxation...ASR

ASR measures the dimensional change in fresh recovered cores. Requires oriented core and must be deployed at a well site. Core expands when it is cut from a formation due the creation of a free surface with no stresses. The elastic response is instantaneous and cannot be measured. Core continues to expand for many hours, even days, after being cut. The process by which it expands is known to be anelastic and involves microcracking. The intensity of this process decays with time. Deformation observations are fit to a strain ellipsoid resulting in the definition of principal strains and their orientations. These strains can be converted into stress when the appropriate elastic constants are known.

Applications:

Determine in-situ stress directions and magnitudes.

Nuclear Magnetic Resonance...NMR

We have a 2 MHz NMR instrument capable of performing ambient measurements on saturated core samples. Combined with our capabilities to saturate with any pore fluid we can provide calibration for in-situ NMR log responses.

Applications:

Calibration of NMR logging tools, estimates of bound and free water and total porosity. Evaluation of the effects of invasion or hydrocarbons on NMR signatures.

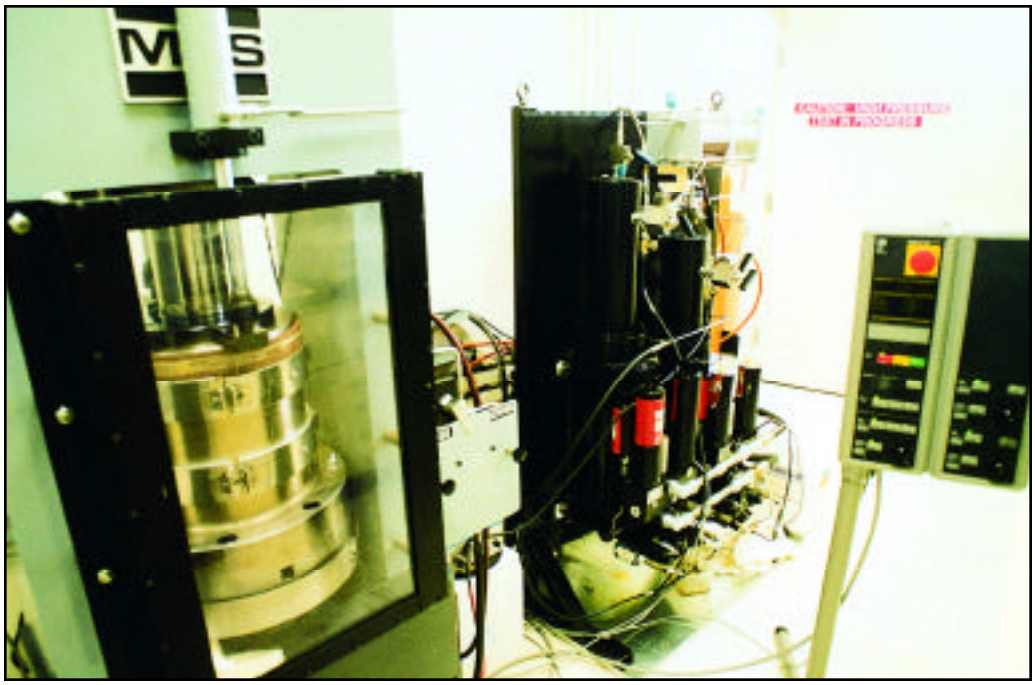
IC^3 Laboratory

The laboratory is equipped with modern analytical instruments that can be used to address a multitude of exploration, production, and development problems. The lab is equipped for extensive core handling, cleaning and plug preparation. There is an environmental scanning electron microscope, several petrographic microscopes, Fourier transform infrared spectrometer, x-ray diffractometer, x-ray fluorescence and cathodoluminesence for mineralogical and textural analysis, and clay and micro-fracture habitat. The lab can perform grain size analysis, and total organic carbon analysis. We are equipped to perform a wide array of petrophysical measurements such as density, porosity, permeability, capillary pressure, pore size distribution from NMR, and electrical resistivity. The laboratory has a number of equipment for seismic characterization. We can measure compressional wave velocity, shear wave velocity, and velocity anisotropy as a function of saturation and confining and pore pressure. Both confining and pore pressures can be varied to 10,000 psi. We have extensive capabilities to perform mechanical testing under uniaxial or triaxial stress conditions. These measurements provide essential parameters needed for borehole stability analysis, reservoir performance and well completions.

Velocity Measurement System

Center for Rock Physics

We are taking this opportunity to make you aware of a new resource located in Tulsa dedicated to the needs of the petroleum industry. One of the challenges in our ever-changing industry is keeping your skills current while meeting the obligation of your current assignment. We are proud to offer a new Tulsa-based master's degree program in geological engineering. This program is designed to meet the needs of professional geoscientists, petroleum engineers and businessmen working in teams to solve petroleum industry problems. The program stresses practical training and the application of new and existing technologies. The courses will be given at the new OU Schusterman Center located at 4502 East 41st Street, Tulsa. This location is also home to the Center for Rock Physics. The Center is part of the Mewbourne School of Petroleum and Geological Engineering, University of Oklahoma Courses will be taught in Tulsa and broadcast via live video to the Norman campus.



Triaxial Load Frame

Students interested in enrolling in the course must be admitted to the University of Oklahoma. They may be admitted to the master's degree program or may be admitted as an unclassified graduate student. Forms and information on the admissions requirements and process may be obtained from the OU office at the OU/OSU Research and Graduate Education Center, located at 700 North Greenwood, or by calling 918/594-8370.

In addition to this exciting opportunity, the Center has unique and unparalleled capabilities in core characterization, seismic modeling and interpretation. These capabilities are housed in a world-class laboratory facility donated to the University of Oklahoma by BP Amoco. An extensive description of the laboratory capabilities, industrial course offerings and consulting services may be found on our Web page: http://www.ou.edu/mewbourneschool/cfrp/ic3/cfrp/htm. Please contact us if you would like to learn more about the Center. We would be glad to give a seminar at your site.

Rock Properties Data Applications

- Seismic Amplitude Analysis and Calibration (AVO)
- Reservoir and Equity Evaluation
- Time-lapse Seismic Calibration
- Basin Analysis and Modeling (Source, Seals, Migration Pathways)
- Lithology Inversion and Facies Analysis
- Constrained Seismic Migration
- Pore Pressure Prediction
- Empirical Systematic Development (Seismic and Geology)
- Basin Stress Analysis
- Seismic Target Analysis
- Petrophysical Evaluation
- Subtle Trap Delineation
- Reservoir Quality Evaluation
- Reservoir Mechanical/Chemical Stability Evaluation
- Formation Damage Evaluation
- NMR Calibration
- Source Rock Evaluation
- Rock Typing

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