CO_2 Sequestration in Coal Seams

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Sponsors: The Stanford Rock Physics Consortium.

Description: We initiate an extensive rock physics investigation of various coals. The main motivation behind this study is to compile a list of seismic attributes of coal that can be used for measuring, monitoring, and verifying the efficiency and risks of carbon sequestration in the sub-surface. Coal seams have a large potential for CO_2 storage. In turn, CO_2 sequestration in coal seams can enhance methane production. However, since their geophysical properties are not fully understood, indirect monitoring of sequestration success remains a challenge. The main objective of this work is to create a rock-physics database and relevant models of seismic signatures of coals of different ages, geologic basins, and ranks. Several samples of natural coal will be tested in the laboratory to obtain the dependence of their P- and S-wave velocity and density on porosity, maturation, and other key properties.

A special focus of the research will be on changes in rock physics properties of coal during gas (methane and CO_2) sorption and desorption. We will study the relations between seismic attributes and conventional coal petrographic and proximate analyses. We will also develop theoretical models defining seismic velocity-to-physical property transforms in coals. The ultimate goal is to provide key diagnostic technologies for quantitatively interpreting seismic data and linking them with geologic models to estimate risk and efficiency of carbon sequestration in coals.

The non-destructive technique of acoustic imaging has proved to be a powerful tool in mapping macro- and microstructure of cleat systems in terms of elastic impedance at a cm-scale resolution. The opaque nature of the kerogen and the associated pyrite makes optical characterization rather challenging thus making other non-destructive methods necessary.

Figure 1 shows acoustic sounding of a coal sample along with an optical line trace of its main features; the C-scans (Figure 1a) are surface images showing cleats and dull and bright coal bands. The B-scan (Figure 1b) is a zero-offset reflection profile that shows reflections from interfaces with an impedance change and cleats. Figure 1c is a reconstruction of a 30 x 30 x 8 mm volume of the sample created from 40 B-scan images. The dull and bright coal bands with different impedance imaged in the C-scans (Figure 1a) are seen to dip in the B-scans (Figure 1b) and in the reconstructed volume image (Figure 1c). Figure 1c also maps numerous cleats that cut across the dipping layers. “Ground truth” for the scans is seen from the line trace of the features made after cutting the sample to expose the sides (Figure 1d).

Status: This work continues, sponsored by the Stanford Rock Physics Project.

Publications:

Prasad, M., Mapping impedance microstructure in rocks with acoustic microscopy, The Leading Edge, 20, 172-179, 2001.

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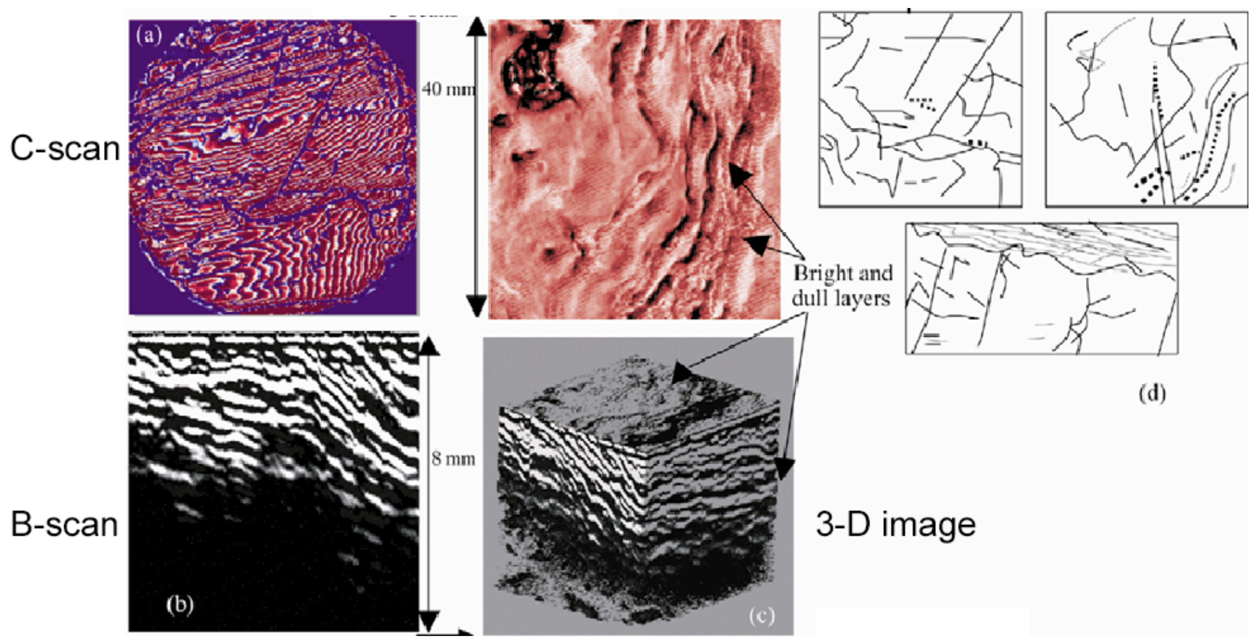

Figure 1. Low-frequency (25 MHz) scans (a-c) and a line trace image of optical features (d) of a coal sample. C-scans of top and bottom faces (a), a representative B-scan (b), and a 3-D image (c) made from consecutive B-scans show the internal structure of the coal. The reconstructed top surface in (c) correlates well with the C-scan image above it and with the optical line traces in upper part of (d). The cleats, dull and bright coal bands, and their alignment at depth can be traced in both B- and C-scan images as well as in the reconstruction volume image. The optical line traces in (d) were made after cutting the sides of the coal sample. They show ground truth for the scans and for the 3-D reconstruction.