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A TRUNCATED COAL SEAM FROM A SEISMIC PERSPECTIVE

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**A truncated coal seam
from a seismic perspective**

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Abstract

Six-fold, high-resolution seismic data were acquired across a coal mining property in the Meigs County study area, southeastern Ohio with a view to differentiating the Clarion Coal Member and truncating channel sandstones prior to longwall mining and without the need for a costly drilling program. The seismic technique, as is illustrated by our example data, was successfully used to map those areas where the coal is present, as well as those places where the ore was eroded by incising fluvial streams. Our results demonstrate that the seismic reflection method, using an engineering seismograph, can be a cost-effective way to define discontinuities associated with coal ores.

Introduction

The Pennsylvanian age, Clarion Coal Member is longwall mined in the Meigs County study area, southeastern Ohio (Figure 1). This ore is regionally extensive, typically about 1.2 meters thick, and at depths of between 60 and 90 meters. In places this coal was eroded by incising fluvial channels. In such settings the coal seam terminates abruptly against what are predominantly channel sandstones (Figure 2). These channel sediments are a problem for the mining companies for several reasons: 1)

they are relatively hard and can damage or wear mining equipment excessively, particularly if they are encountered unexpectedly; 2) they are potential aquifers and can create severe water leakage problems; and 3) they are expensive to delineate using patterned drill holes.

In an effort to evaluate the potential of the seismic technique with respect to the mapping of these channels, a seismic line was recorded across a suspected (on the basis of well data and geological trends) channel sandstone.

Geological overview

Bedrock in the Meigs County area is Pennsylvannian in age and is overlain by a thin veneer of residual and/or transported soil. These Pennsylvannian strata consist principally of stacked, ordered sedimentary sequences called cyclothems. A complete cyclothem, as described by Sturgeon et al. (1958), consists from bottom to top, of underlying non-marine sandstone, shale, freshwater limestone, underclay, coal, and overlying marine sandstone, limestone and shale. these cyclothems are the depositional product of an oscillatory sea level and are generally separated by local disconformities. Frequently, either as a consequence of either non-deposition or erosion, one or more units of the composite cyclothem are

absent (Sturgeon et al., 1958).

The coal of economic interest in the study area, the Clarion Coal Member, is part of the Clarion Cyclothem. As illustrated in Figure 2, this coal is underlain by underclay, and overlain by a succession of shales, limestones and sandstones. As illustrated, the overlying sandstone encountered by the 1516 well is interpreted to be fluvial channel sediment. The purpose of the seismic survey was to determine if the channel truncates the coal seam immediately to the west of the 1516 well location.

Data acquisition and processing

Six-fold CMP data were obtained along a 163.8 m long seismic profile passing through wells number 1515 (trace number 5; Figure 2) and 1516 (trace number 82; Figure 2). Walkaway noise tests, conducted prior to acquisition of the profile were used to determine shot-to-closest-geophone distances, geophone spacings, and the type of source. The spread was an off-end spread, with source and geophone spacing of 1.52 m, and a near offset of 41.1 m. Data were recorded using single geophones of 40 Hz natural frequency, and the EG&G Geometrics engineering seismograph Model ES-2401. To ensure good geophone/ground coupling, and to minimize the effects of air-coupled

waves, the geophones were planted at the bottom of 0.3 m deep holes. The seismic source was a blank 8-gauge shotgun shell, detonated at the bottom of a 1 m deep hole tamped with water. The diameter of the hole was 8 cm. Firing a gun with its barrel in a borehole diminishes effects of air-coupled waves (source generated sound waves that travel to receivers through air) and increases amplitude and dominant frequency of the recorded seismic energy (Steeple et al., 1987). The records are 102 ms long with a sampling interval of 0.1 ms. To attenuate ground-roll, the records were bandpass filtered (200-1000 Hz) before digitization. Figure 3, is an example of field data (with 24 traces) showing a strong reflection from the limestone/coal interface at about 70 ms.

Data were processed on a desktop microcomputer using the EG&G software Geometrics. The processing sequence is as follows:

1) refraction statics (source and receiver statics were calculated from a separate refraction survey);

2) CMP sort;

3) bandpass filter;

4) NMO correction;

5) hand statics; and

6) stack.

To ensure correct identification of reflected events on the stacked section., all coherent events observed on the field records were visually inspected after each step of the processing flow.

Interpretation of the example seismic line

As an aid to the interpretation of the seismic data (Figure 4), the geological cross-section of Figure 2 was iteratively developed using borehole data, well logs, and the example seismic line as control. The velocities used in the model are consistent with both sonic log control for wells 2 miles from the test site, and the stacking velocities used to process the data. The cross-section correlates well with the field data and is presented as a reasonable representation of the subsurface.

The more prominent reflections on the seismic line of Figure 4, are identified on the basis of the geological cross-section and well log control.

Of particular interest is the seismic signature of the truncating channel sandstone. These sandstones are characterized by the absence of the Limestone A reflection, the presence of events originating at both the top and base of the channel, and up to 2 milliseconds of drape.

The abrupt termination of the reflection from Limestone A against the flanks of the seismic image of the channel sandstone is interpreted as indicating that the coal seam is also truncated. The events from the top and base of the channel define the shape of the channel sandstone, and suggest that it is more-or-less lense shaped in cross-section. The time-structural drape across the channel is attributed to the differential compaction of the channel sandstone and regional facies.

Summary

In the Meigs County area, southeastern Ohio, high-resolution, shallow seismic reflection data has been successfully used to differentiate coal ore and truncating channel sandstones. In similar good data quality areas, this technique could be a cost-effective alternative to the employment of patterned drill holes.

References

Sturgeon, M.T., and associates, 1958, The Geology and mineral resources of Athens County, Ohio: Ohio Geol. Surv. Bull. 57.

Steeple, D.W., Miller, R.D., and Knapp, R.W., 1987, Downhole .50-caliber rifle--an advance in high resolution seismic sources, [Exp. Abs.]; in Technical Program Abstracts and Biographies: Soc. Explor. Geophys. 57th Ann. Mtg., p.76-78.

Figure 1. Map showing the location of the Meigs study area.

Figure 2. Geologic section depicting the relationship between the Clarion 4A coal seam and the truncating channel sandstone. Both the 1515 (trace 5) and 1516 (trace 82) wells were drilled through the Clarion 4A coal. The correlations in the interwell areas were constrained by the seismic data (Figure 4).

Figure 3. An example of a typical field record (with 24 traces) showing a strong reflection from the limestone/coal interface at about 70 ms.

Figure 4. Six-fold CMP data. A geological model of these data is presented as Figure 2.

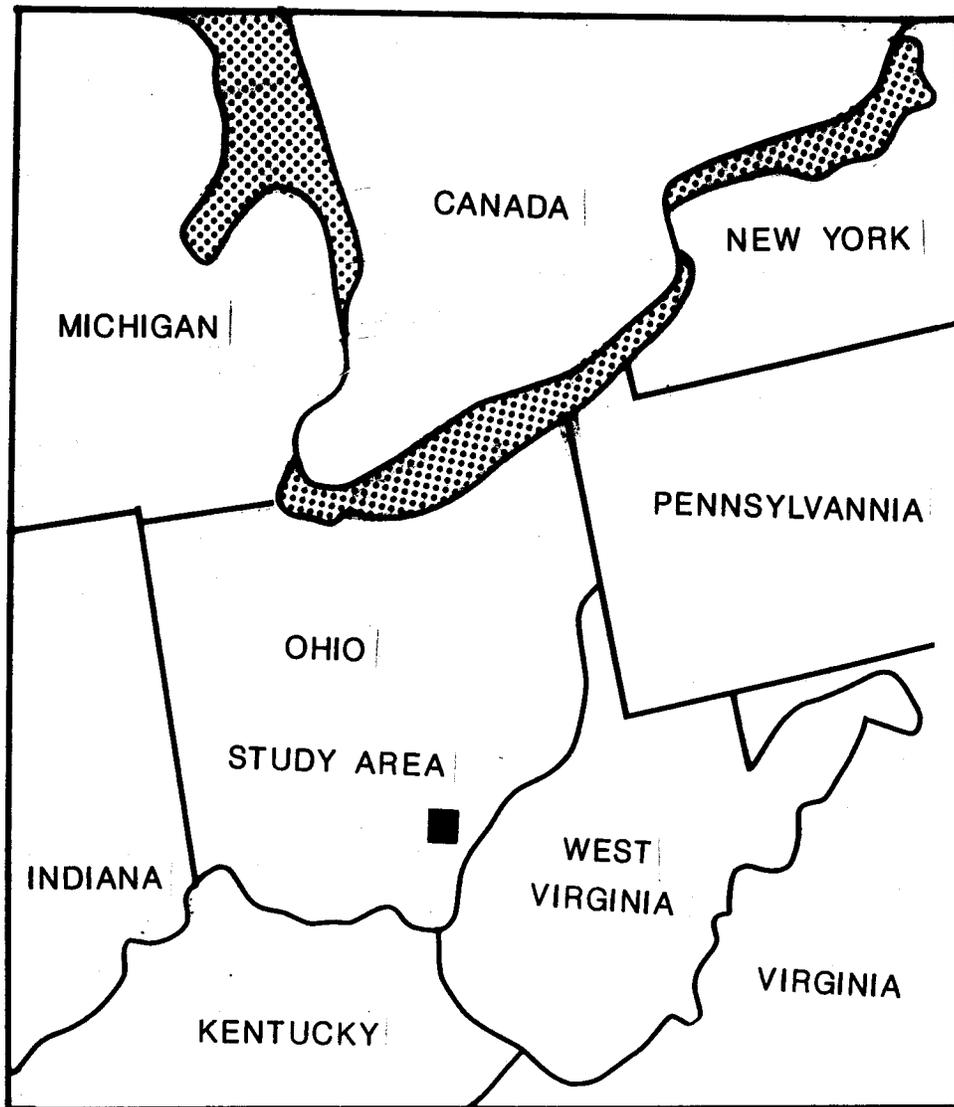
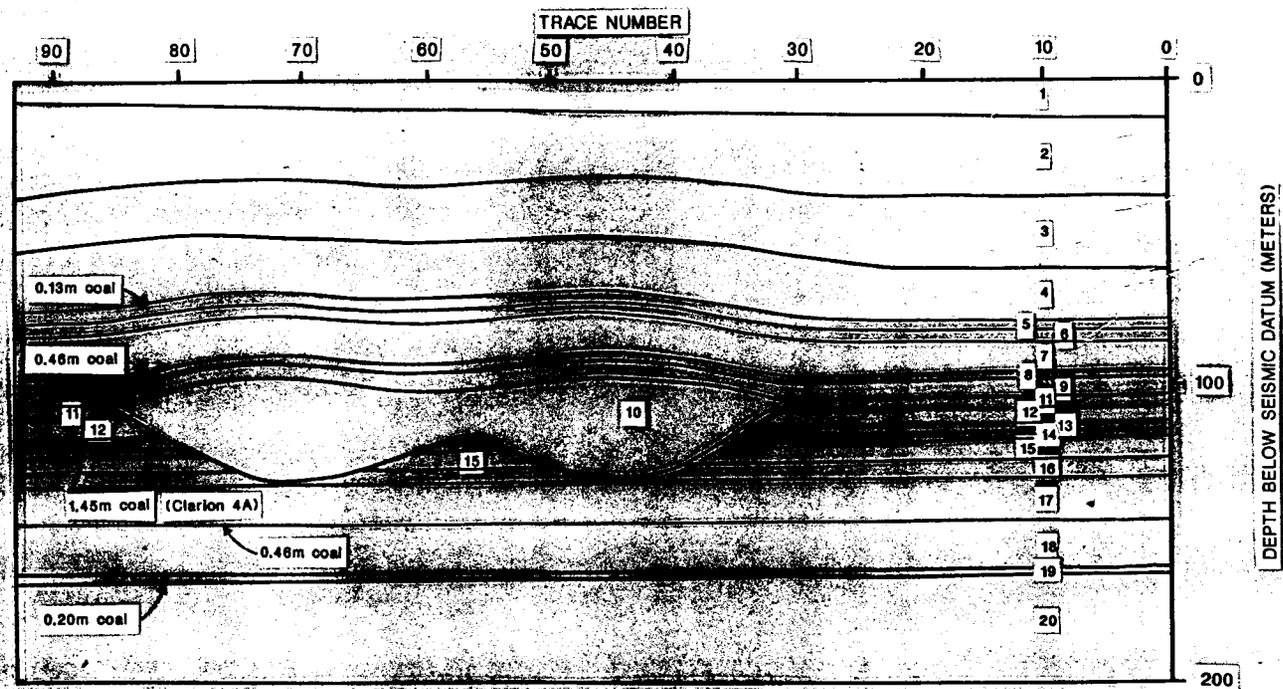


Figure 1

Figure 2



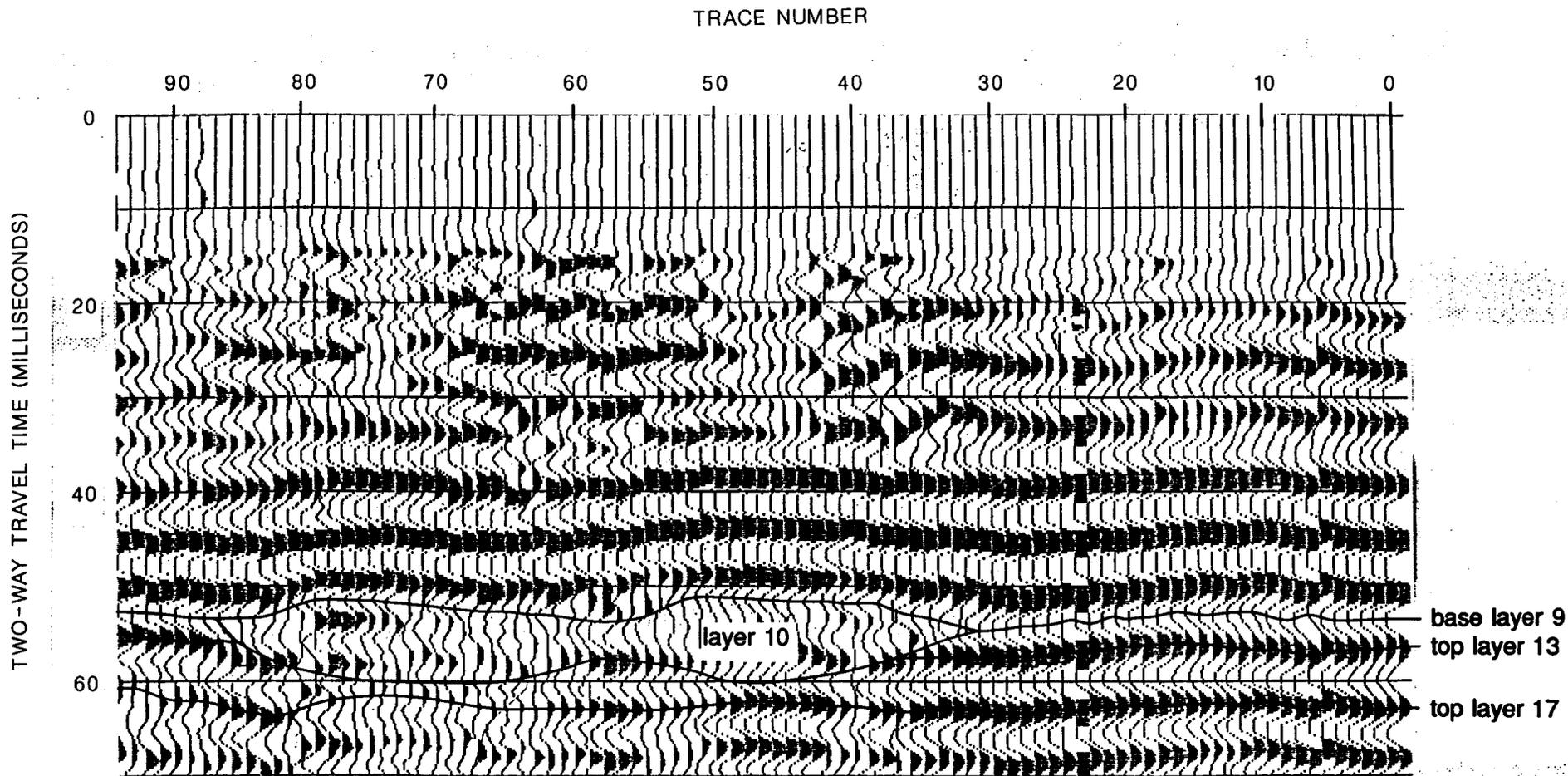
0 METERS 20

- 1) unconsolidated soil, Vp @ 1800 m/s
- 2) claystone and carbonaceous shale, Vp @ 2400 m/s
- 3) sandstone and sandy shale, Vp @ 2500 m/s
- 4) sandy shale, Vp @ 2600 m/s
- 5) shale, Vp @ 2400 m/s
- 6) sandstone, Vp @ 2700 m/s

- 7) carbonaceous shale, Vp @ 2850 m/s
- 8) claystone, Vp @ 2400 m/s
- 9) sandy shale, Vp @ 3200 m/s
- 10) sandstone, Vp @ 2900 m/s
- 11) claystone, Vp @ 2600 m/s
- 12) carbonaceous shale, Vp @ 3200 m/s

- 13) limestone, Vp @ 5400 m/s
- 14) Clarion 4A coal, Vp @ 2400 m/s
- 15) claystone, Vp @ 2700 m/s
- 16) sandstone, Vp @ 3050 m/s
- 17) sandy shale, Vp @ 3350 m/s
- 18) sandstone, Vp @ 3050 m/s
- 19) siltstone, Vp @ 3350 m/s
- 20) shale, Vp @ 3650 m/s

Figure 3



9) sandy shale, V_p @ 3200 m/s

10) channel sandstone, V_p @ 2900 m/s

13) limestone, V_p @ 5400 m/s

17) sandy shale, V_p @ 3350 m/s

0 METERS 20

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 LOW CUT 200 HZ NOTCH OUT HIGH CUT 1000 HZ ACC WINDOW 20 MS

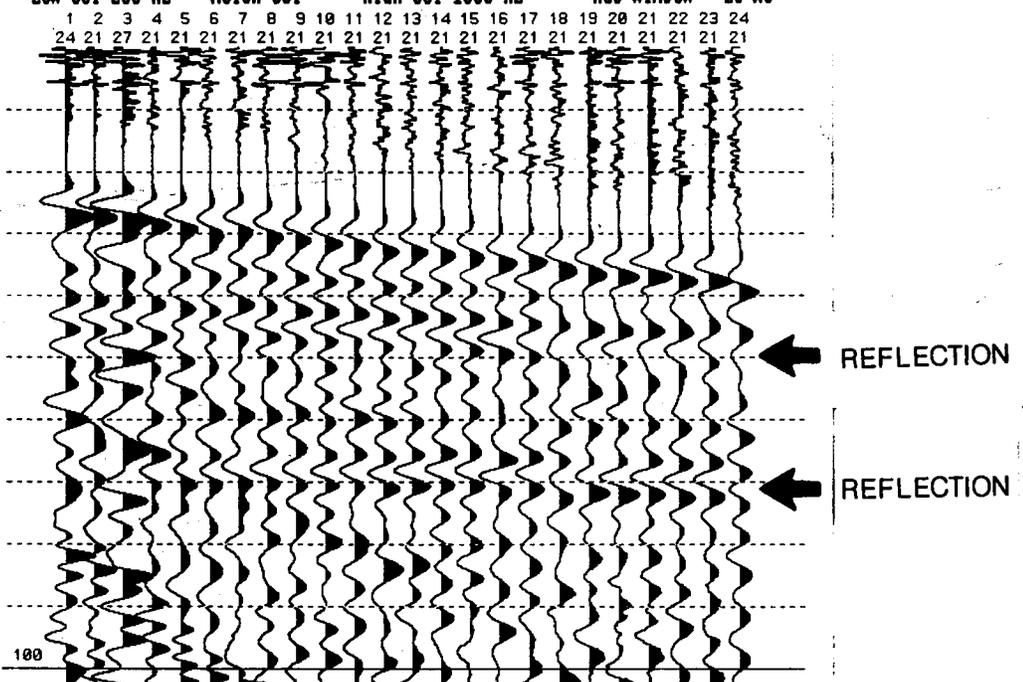


Figure 4