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**DETECTION OF MORROWAN CHANNEL SANDS  
BY REFLECTION SEISMOLOGY,  
STEVENS COUNTY, KANSAS**

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**DETECTION OF MORROWAN CHANNEL SANDS BY REFLECTION  
SEISMOLOGY, STEVENS COUNTY, KANSAS**

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## **INTRODUCTION**

Morrowan sandstone production was established in southwestern Kansas with the discovery of the Harper Ranch field in 1953 in southeast Clark County (Waite, 1956). Morrowan production was subsequently extended 20 miles north and 25 miles west (cf. Clark, 1987). These relatively recent discoveries (Lexington field by Mesa in 1977, and Minneola complex by Ladd in 1980) launched several exploration projects which aimed at further westward extension of production from Morrowan sandstones.

Morrowan sandstones are characterized by their channel-like geometry. In most cases, these sandstones are fluvial channel deposits, indeed, and the production is controlled stratigraphically (cf. Mannhard and Bush, 1974). Seismic data became increasingly important after the production was associated with seismic anomalies, and ultimately seismic stratigraphy proved to be an excellent technique to detect Morrowan channel sandstones (cf. Clark, 1987; Halverson, 1988).

The purpose of this study was to detect a Morrowan channel sand body by the use of seismic-reflection methods. The study area is located in northeast Stevens County. The project was sponsored by Mobil Oil Company and was designed to provide a detailed image of the seismic anomaly previously detected in the area. The data were acquired by the Kansas Geological Survey crew in summer, 1987. Exact location is being kept confidential.

## **GEOLOGIC BACKGROUND**

The thickest and most productive Morrowan sandstones are lenticular bodies which were deposited in channels incised into the weathered and eroded Mississippian surface. Such a configuration has created an excellent possibility for stratigraphic entrapment of hydrocarbons. The facies sequence in each sand

body is typical for fluvial deposits; it starts with trough cross-bedded coarse-grained sandstone that grades upward and laterally into rippled fine-grained sandstone and rooted flood-plain mudstone (cf. Krystink et al., 1987). Fluvial sands are capped by transgressive burrowed sandstones and marine mudstones. The sand bodies are associated with regional unconformities and wedge out towards the shelf to the northeast. The Morrowan zone can be characterized by as many as six individual sand bodies in a particular section. Mannhard and Bush (1974) demonstrated a close relationship between the distribution of Morrowan sands and the Early Pennsylvanian drainage pattern. These authors also pointed at differential compaction as an important exploration factor. Most of the observed structures appeared to be small-scale noses and closures associated with compaction of Morrowan shales.

Standard seismic exploration for Morrowan sands is a two-step process (cf. Clark, 1987). In the first place, the position of the Mississippian/Pennsylvanian unconformity is determined. This step can be a difficult one, as the fine-grained calcareous sandstones of the Morrowan Series and silty limestones common in the Chesterian section are lithologically and physically similar. Subsequently, anomalous changes along the interface are mapped. If the interface itself cannot be identified without ambiguity, the character of reflectors present above or under the interface can provide some information on the position of sand bodies. Clark, in the study of Morrowan sandstones in Ford and Clark counties (1987), listed the following types of seismic anomalies associated with sand bodies: Diffractions from the edges of sand body, amplitude anomalies associated with velocity differences between hydrocarbon-saturated sands and adjacent shales, polarity reversals due to the same phenomenon, sagging of the reflections above due to the higher compaction of Morrowan shales, as compared to sand

bodies, and breaking and faulting of the underlying Viola and Arbuckle reflections which controlled the location of sand bodies.

Morrowan sands are within the thin-bed regime, thus the amplitude of associated events can be correlated with the thickness of an individual sand body (cf. Halverson, 1988). The sands are detectable only on seismic data with good signal-to-noise ratio; however, the indirect evidence proved very useful in the studied case.

Acquired seismic data are characterized by generally poor quality. Quality of data is low because of a concentrated cultural noise (60 Hz hum), and because of unfavorable weather (20+ mph and gusty winds; some rain) that prevailed during data acquisition. The field parameters are listed in Table I.

Processing of the data was carried out at the Kansas Geological Survey on a Data General MV20000 computer using SPEX package by the Sytech Corporation. Initial processing steps involved also the use of several original programs. These steps are listed in Table II.

Further processing followed a standard path and included edit, first-arrival mute, deconvolution, preliminary velocity analysis, offset editing, pre-AUTS filter, surface-consistent statics (AUTS), final velocity analysis, residual statics, and finally, filter and display of seismic section. Coherency-enhancing techniques like slant stack or coherency stack were unsuccessful in improving the signal-to-noise ratio. These techniques, when dealing with low-quality data, can cause interpretational problems creating numerous processing artifacts, and thus were not applied.

Problems with data acquisition, which subsequently projected onto the difficulties of the data processing, have shown that inexpensive and fast seismic studies with shallow shots of small charges may not always be possible to carry out, and the geology of the given area is a limiting factor. In case of our Stevens

County study, the shallow presence of acoustically hard anhydrite (Stone Corral), and the necessity to pass through the entire Pennsylvanian-Permian cyclothem sequence, caused the bulk of seismic energy to attenuate by reflection interference and partitioning of energy before reaching the target. Surface-coupling conditions may also have been less than ideal. Inadvertent clipping of the data by the 60 Hz hum also destroyed much of the data. Many traces were rendered useless because of this. Despite these difficulties, the results of this study demonstrate that Morrowan channel sandstones can be detected by the indirect evidence, namely the character of reflections above the target.

## RESULTS

Figure 1 is the final stack of the investigated seismic line. The section shows several prominent reflections between 300 and 600 ms. Below, the seismic events are less visible but still recognizable down to 1100 ms. The stratigraphic data from several exploratory wells in the area suggest that the distinct reflections above 600 ms originated within the Permian sequence. The compilation of stratigraphic data is presented in Table III. The interval of interest is located between 900 and 1100 ms. The target reflection is located at about 1000 ms, and can be identified only at the beginning of the seismic section between CDP 200 and CDP 300. Very low signal-to-noise ratio at that depth makes the stratigraphic analysis of this reflection impossible. Nevertheless, some features of the Permian reflections enable the location of the Morrowan channel. The key is the apparent closure located between CDP 450 and CDP 570. The eastern margin of this feature is associated with a normal fault located at CDP 530. Our interpretation of the closure is that it is a compaction-related structure resulting from the differential compaction of Morrowan shales and channel sandstones. If this interpretation is correct, the asymmetry of the closure may correspond to the

original asymmetry of the channel, and the maximum thickness of the sandstone is thus located adjacent to the eastern margin of the closure.

The above interpretation should be regarded as preliminary. The final recommendation will be possible after the stratigraphic analysis of the 1000-ms reflection.

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TABLE I—DATA ACQUISITION PARAMETERS

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Recording: two 24-channel Input/Output seismic recording systems (pseudo 40-channel arrangement), low cuts 40 Hz, high cuts 120 Hz, some shots with 60 Hz notch.

Record length: 2000 ms

Sample rate: 2 ms

Source: single stick (250 g.) of IreCo I-42 slurry fired in a 2-m deep hole.

Geometry: end-on, gap of 8 between two systems.

Source spacing: 10 m

Receiver spacing: 10 m, system #1: near offset 60 m; far offset 290 m.  
system #2: near offset 380 m; far offset 610 m.

Receiver grouping: ten 30-Hz geophones (Mark Products L-20D).

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TABLE II—PRELIMINARY PROCESSING

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1. Renumbering of seismic traces recorded by the second system from 1-24 to 25-28.
  2. Organization of the data into 48-channel field files.
  3. Removal of the 60-Hz noise using a digital hum filter (see Appendix).
  4. Removal of the system noise caused by the static electricity.
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TABLE III—COMPILATION OF STRATIGRAPHIC DATA FROM BOREHOLES

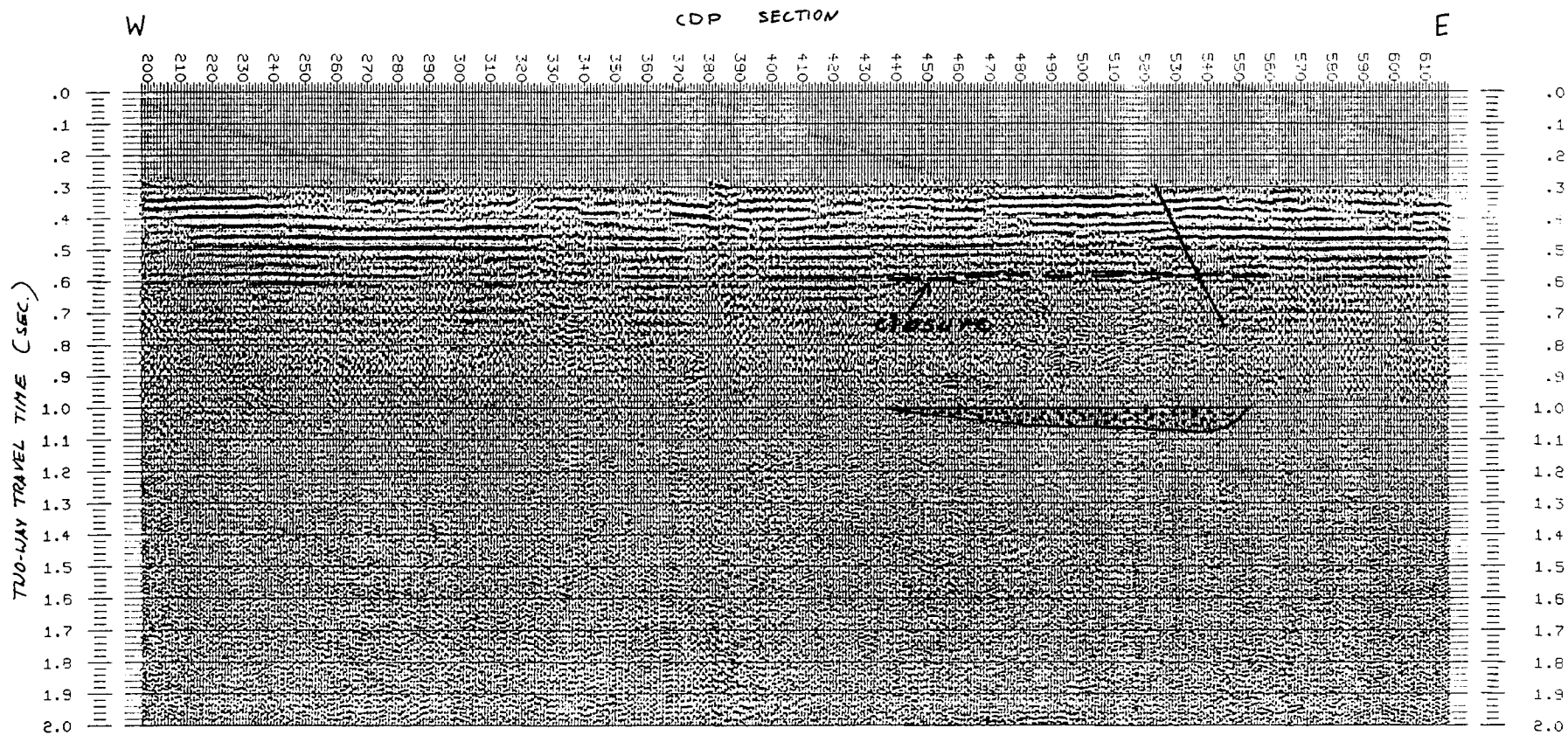
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<u>Name of Unit</u>	<u>Position of Top (meters subsurface)</u>
Stone Corral	349
Chase	786
Council Grove	891
Heebner	1253
Toronto	1269
Lansing	1273
Marmaton	1501
Cherokee	1568
<b>Morrowan</b>	<b>1693</b>
Chester	1815
Arbuckle	2070

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Fig. 2. Final seismic section. The closure and marginal fault, as well as the possible location of Morrowan channel are showed.