Detection of Geologically Recent Deformation Near the Northern Terminus of the New Madrid Seismic Zone Using High-Resolution Seismic Reflection and Drill Hole Information

Annual Project Summary

External Grant Award Number 01HQGRO126

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Program Element: ELEMENT II. Research on Earthquake Occurrence and Effects

Key Words: Neotectonics, Reflection Seismology, Quaternary Fault Behavior, Tectonic Structures

Investigations Undertaken

Much of the New Madrid seismic zone (NMSZ) and some of the area immediately surrounding it has been intensively studied using a variety of geophysical and geological techniques, including high-resolution seismic reflection. On the other hand, the area projected to the north-northeast in southern Illinois and adjacent western Kentucky, over the western "prong" of the northern NMSZ, has received relatively little attention. The lack of information on the northern terminus of the NMSZ has become increasingly critical since recent seismological studies have indicated that a distinct zone of epicenters can be delineated farther to the northeast than previously recognized. This northern zone of epicenters is located along a northeast-trending segment of the Ohio River between Illinois (Pulaski Co.) and Kentucky (Ballard Co.), which constitutes the proposed study area. The study area includes the site of the 1984 Olmsted earthquake swarm (located approximately under the Ohio River, immediately northeast of Ohio River Lock and Dam #53), which had more than 150 events recorded and included body-wave magnitudes up to 3.6. One fault, the Olmsted fault (Fig. 1), has been mapped on the basis of borehole data. Test drilling for the new Ohio River lock and dam at Olmsted indicates numerous faults that displace Paleozoic bedrock. Such faults are not known to be at the surface, being concealed by soil and vegetation.

To date, we have acquired high-resolution seismic reflection profiles on both sides of the northeast continuation of the NMSZ epicentral pattern in Pulaski Co., Illinois and Ballard Co., Kentucky. This program will fill in a gap in our knowledge of geologically recent deformation in an area covering the northeasternmost continuation of the NMSZ. Using an elastic weight-

drop source and a 48-channel recording system, we acquired 12,660 m of seismic reflection profile at four separate sites (Fig. 1) over two five-day periods (including mobilization and demobilization between Champaign, Illinois and the study area) (see Tables 1-5).

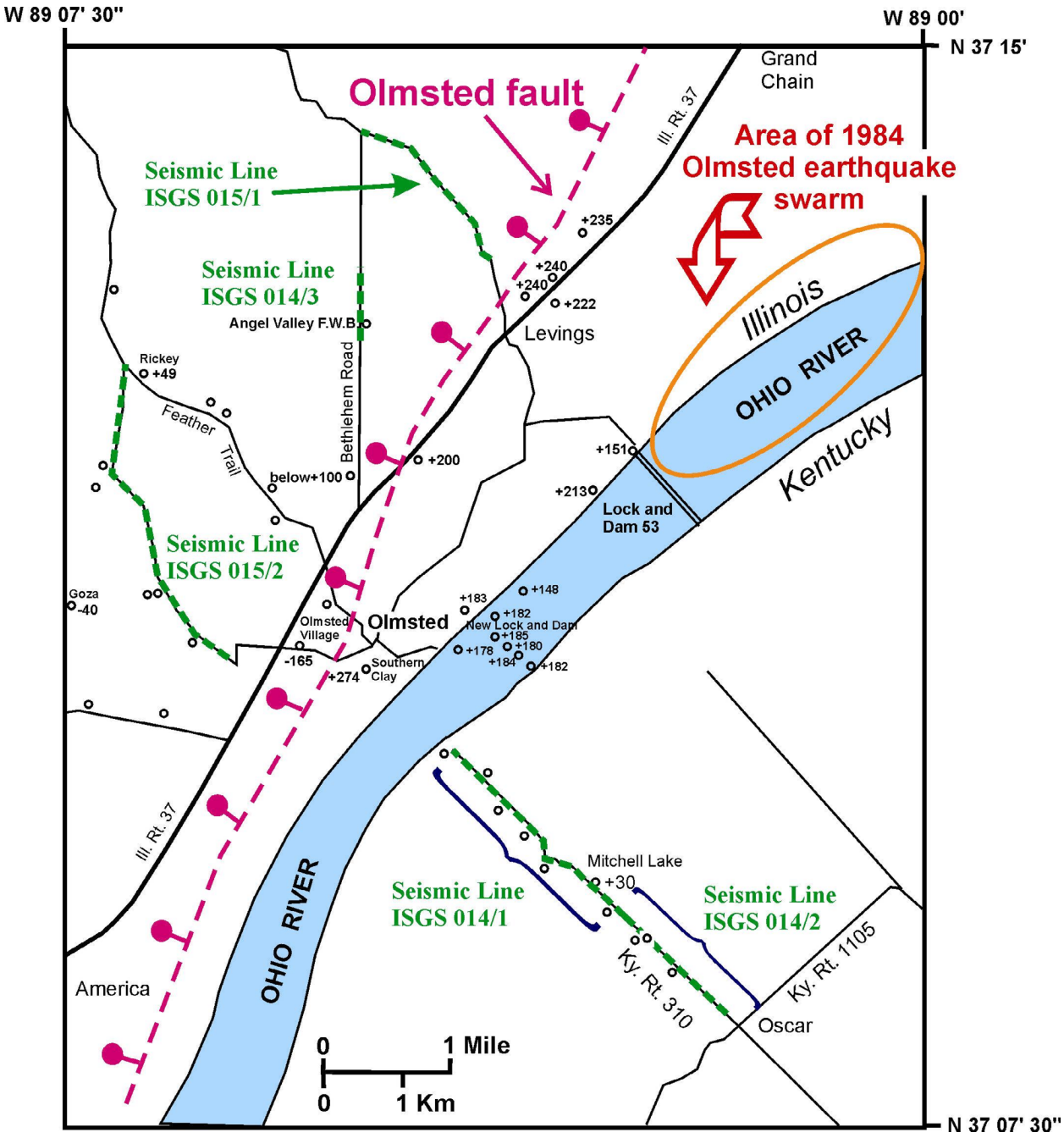

Figure 1. Map of Olmsted, Ill.-Ky. Quadrangle, showing roads and key pre-existing wells (small circles). Elevation of top of Paleozoic bedrock (in feet relative to Mean Sea Level) is indicated for each well. Wells lacking numbers did not reach bedrock. Seismic lines (green dashed lines) are shown with labels corresponding to Tables 1-5.

Channels	48
Group interval	3 m
Geophone type	40 Hz
Geophones/array	1
Shot interval	3 m
Source	50 kg Weight dropper, Digipulse
Stack	1
Bin size	1.5 m
Max. fold	24
Recording system	Strataview
Sampling rate	0.25 ms
Record length	0.512 s
DSP filters	LC: 35 Hz; HC: 500 Hz
Line direction	SE
Line length	4190 m

Table 1. ISGS 014/1, Oscar, KY (09/10/01 – 09/13/01)

Channels	48
Group interval	3 m
Geophone type	40 Hz
Geophones/array	1
Shot interval	3 m
Source	50 kg Weight dropper, Digipulse
Stack	1
Bin size	1.5 m
Max. fold	24
Recording system	Strataview
Sampling rate	0.25 ms
Record length	0.512 s
DSP filters	LC: 35 Hz; HC: 500 Hz
Line direction	SE
Line length	907 m

Table 2. ISGS 014/2, Oscar, KY (09/13/01)

Channels	48
Group interval	3 m
Geophone type	40 Hz
Geophones/array	1
Shot interval	3 m
Source	50 kg Weight dropper, Digipulse
Stack	1
Bin size	1.5 m
Max. fold	24
Recording system	Strataview
Sampling rate	0.25 ms
Record length	0.512 s
DSP filters	LC: 35 Hz; HC: 500 Hz
Line direction	N
Line length	907 m

Table 3. ISGS 014/3, Angel Valley, IL (09/14/01)

Channels	48
Group interval	3 m
Geophone type	40 Hz
Geophones/array	1
Shot interval	3 m
Source	50 kg Weight dropper, Digipulse
Stack	1
Bin size	1.5 m
Max. fold	24
Recording system	Strataview
Sampling rate	0.25 ms
Record length	0.512 s
DSP filters	LC: 35 Hz; Notch: 60 Hz
Line direction	SE
Line length	2418 m

Table 4. ISGS 015/1, Olmsted, IL (09/24/01 – 09/25/01)

Channels	48
Group interval	3 m
Geophone type	40 Hz
Geophones/array	1
Shot interval	3 m
Source	50 kg Weight dropper, Digipulse
Stack	1
Bin size	1.5 m
Max. fold	24
Recording system	Strataview
Sampling rate	0.25 ms
Record length	0.512 s
DSP filters	LC: 35 Hz; Notch: 60 Hz
Line direction	NNW
Line length	4238 m

Table 5. ISGS 015/2, Olmsted, IL (09/26/01 – 09/28/01)

RESULTS

The data quality of the seismic profiles is quite good (Fig. 2), with resolution sufficient to recognize fault offsets as small as a few meters, as well as sedimentary features such as channels.

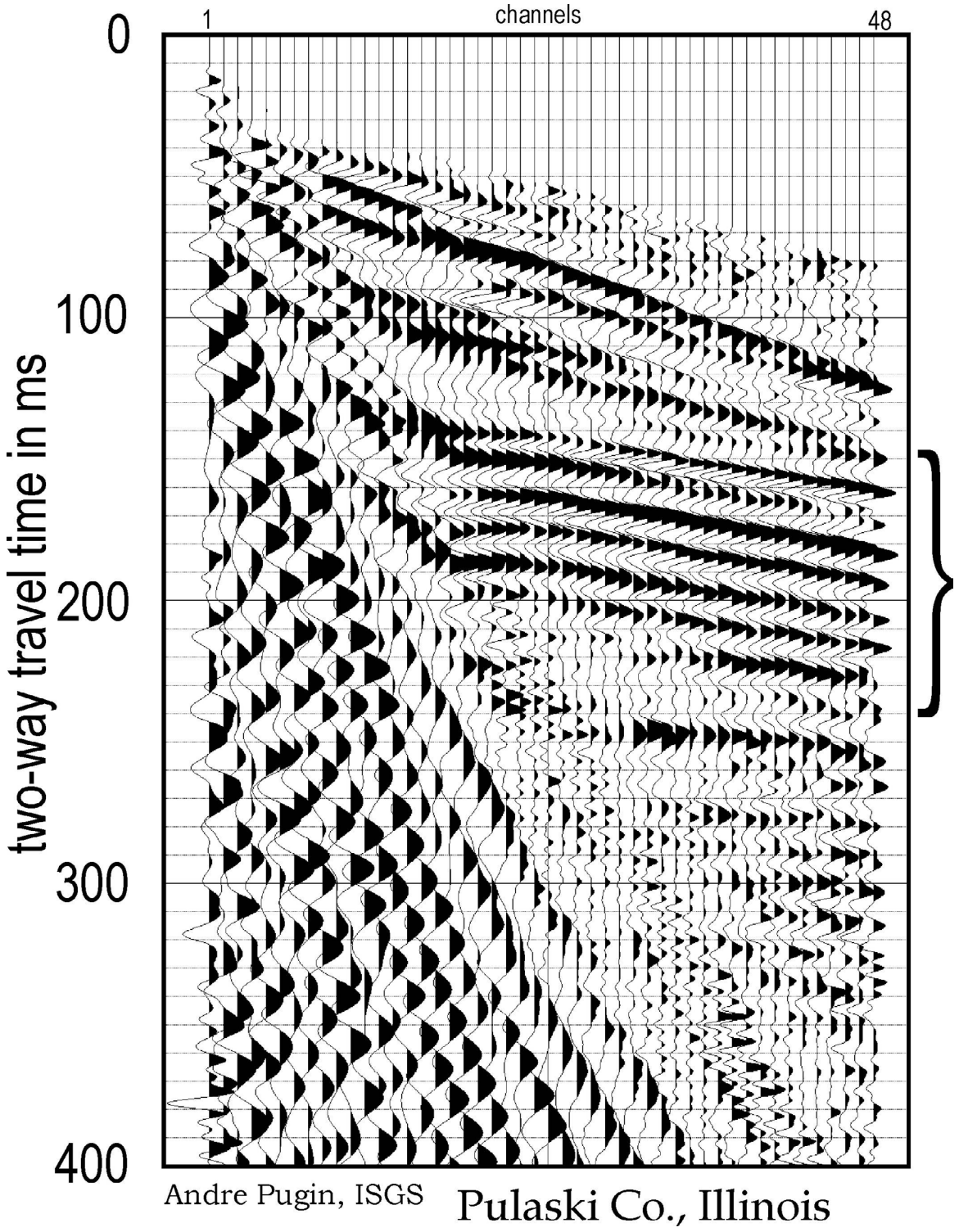

Figure 2. Example of P-wave shot record from Pulaski Co., Illinois (from southern part of line 015/2) showing well-developed Cretaceous and bedrock (Mississippian) reflections (indicated by bracket).

On the seismic profiles acquired so far, interpreted fault offsets that cut shallow sub-horizontal reflectors are visible on most of the profiles, but are most prominent on the Illinois side of the Ohio River, especially on lines 15/2 and 14/3 (Fig. 1). For example, on line 15/2 (Fig. 3), which was surveyed just west of the Olmsted fault in the hanging wall, high-angle to vertical faults can be drawn on the basis of offset top-bedrock and shallower Cretaceous and Paleocene reflectors and, in places, on the basis of diffraction hyperbolae associated with edges.

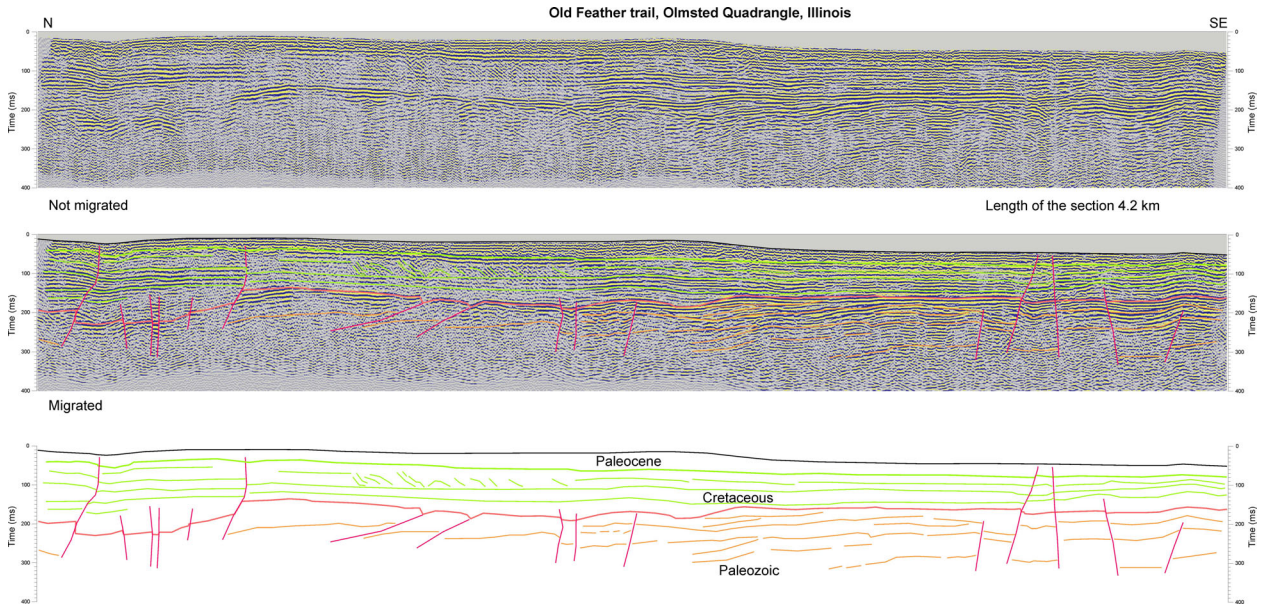

Figure 3. Preliminary section of seismic line 15/2 with interpretation.

Future work under this contract will include further seismic reflection acquisition in Pulaski Co., Illinois, drilling of shallow holes along or near the seismic lines (based on our interpretations of the seismic data), mapping of observable faults or other geologic deformation at or near the surface, and integration of the interpretation of all data.

NON-TECHNICAL SUMMARY

During the autumn of 2001, ~12.7 km of shallow high-resolution p-wave seismic reflection data were acquired by the Illinois State Geological Survey along four separate profiles in Ballard Co., Kentucky and Pulaski Co., Illinois. Preliminary processing and interpretation of the profiles indicate evidence for abundant faulting of base-of-Cretaceous bedrock and younger strata on either side of the possible northeast continuation of the New Madrid seismic zone, along a straight, northeast-trending segment of the Ohio River.

REPORTS PUBLISHED

No reports have been published at this time.

AVAILABILITY OF DATA

Enquiries regarding availability of seismic reflection and other data may be directed to J. H. McBride, tel. 217 333 5107, **mcbride@isgs.uiuc.edu**.