SH-Wave Imaging of Potential Near-Surface Geologic Controls on Contaminant Plume Migration — Fluorspar Area Fault Complex, Western Kentucky

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Abstract

We acquired 18.5 km of: near surface SH-wave seismic reflection profiles to evaluate the post-Paleozoic sediment that overlies the southwestern projection of the Fluorspar area fault complex (FAFC) in western Kentucky for neotectonic deformation in the area of an anomalously migrating contaminant plume. Our previous investigations showed that the late-Precambrian–early Paleozoic FAFC has been reactivated and extends above the Paleozoic carbonate bedrock into the approximately 100 meters of low-velocity unlithified Cretaceous, Tertiary, and Quaternary sediment. Newly integrated reflection images indicate deformation from two northeast striking high-angle bedrock fault strands, extending into the lower part of a Pleistocene-Pliocene sand and gravel aquifer, bound and are coincident with the highest concentrations of the TCE-contaminant plume, suggesting the potential for a preferential groundwater flow path. Ongoing shear-wave birefringence experiments will further evaluate the azimuthally anisotropic properties of the sediment at these sites.

Acknowledgments

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Regional Geology and Site location

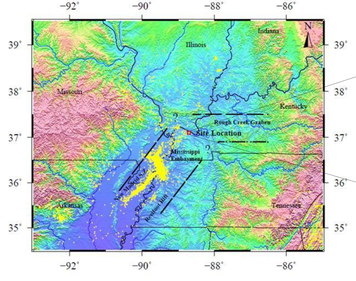

Exhibit 1. The red square indicates the location of site location in relation the Mississippi Embayment in the central United States. The small yellow stars represent the epicenter of seismic activity surrounding the study site. Also, the exhibit shows two late-Precambrian and early-Paleozoic rifts (Reelfoot Rift and Rough Creek Graben).

Site Stratigraphy

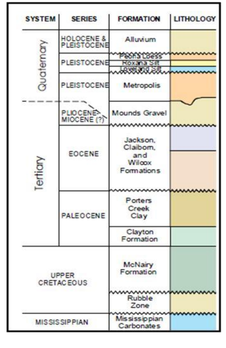

Exhibit 2. Stratigraphic section of the study site. Modified from (Woolery et al, 2010).

Seismic Data

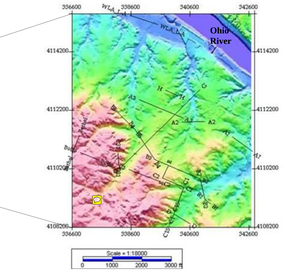

Exhibit 3. The study site and the seismic reflection profiles locations.

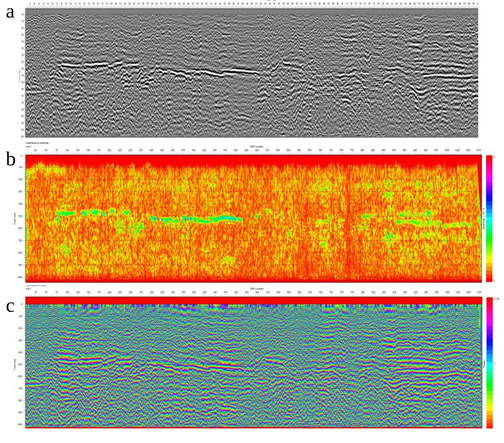

Exhibit 4. a) Final stack seismic profile of line-B, E-W. The conventional seismic data processing procedure was applied using Seismic data Processing Workshop package (SPW 2.1.20). **b)** Post stack instantaneous amplitude section of the same seismic profile. **c)** Post stack instantaneous phase section of the seismic profile. Note, the same seismic data processing procedure was applied to all seismic profiles, and this profile is an example of final stack and post stack processing.

Wavelet Analysis

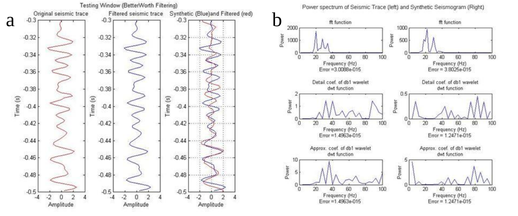

Exhibit 5. Wavelet analysis, **a)** BetterWorth band pass filter matching between a seismic trace and the corresponding acoustic impedance log. **b)** The error associated with transforming the data from the time domain to frequency domain using Fourier and Desecrate Wavelet transforms. The figure shows that the associated error using Fourier transform is larger than desecrate wavelet transform.

Interpretation and Conclusions

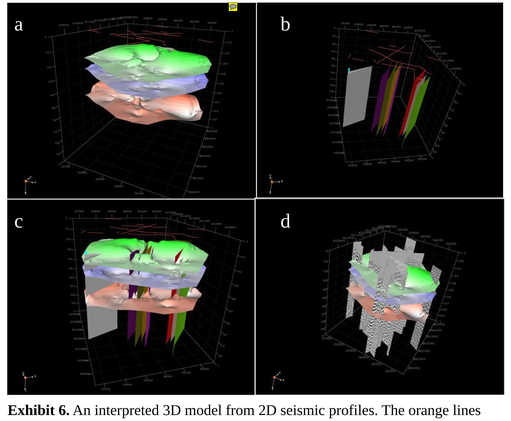

Exhibit 6. An interpreted 3D model from 2D seismic profiles. The orange lines indicate the surface location for seismic profiles. **a)** Interpolated grids of the seismic reflectors, the reddish grid is the Paleozoic bedrock, the bluish gird is the Cretaceous McNairy formation, and the greenish grid is the Pleistocene Mound Gravel aquifer. Note, the continental deposits base does not exist in all of seismic profiles, so that it is undisplayed in this 3D model. The manual picking mode was used in Kingdom Suite (8.6). **b)** The interpreted high angle faults trending northeast are shown **c)** This model demonstrates the location of the fault in relation the formations tops. d) A 3D view of gathered 2D seismic profiles as well as the picked formations tops.

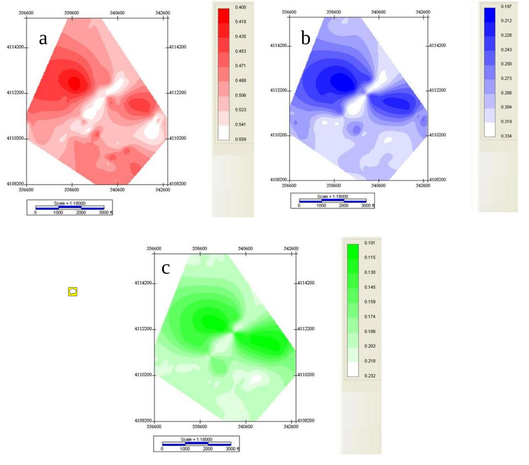

Exhibit 7. Isochronal maps, **a)** the red-fill contours are Paleozoic bedrock, **b)** the blue-filled contours are the Cretaceous McNairy, **c)** and the green-filled contours are the Pleistocene Mound Gravel aquifer. As it is noticeable in all isochronal maps, the the white areas correspond to the deepest places due to the faults offsets. Specifically, the faults trends control the migration of a contamination plume toward northeast direction in the Mound Gravel Aquifer.

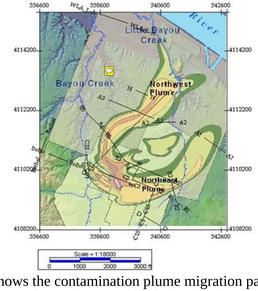

Exhibit 8. A map shows the contamination plume migration paths according to groundwater samples analysis of intense boreholes distribution across the plume. Modified from (Blits, 2008).