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Microseismic Monitoring of a Carbon Sequestration Field Test

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Introduction

Microseismic monitoring was implemented as part of a comprehensive carbon sequestration monitoring program at the Midwest Regional Carbon Sequestration Partnership's geologic field test site in Otsego County, Michigan. The field test itself consisted of the injection of ~10,000 tonnes of CO_2 over 31 days in early 2008 at injection rates ranging from several hundred to approximately 600 tonnes per day of CO_2. The intent of the overall monitoring program was to evaluate a variety of monitoring technologies and understand their potential for verifying cap rock integrity and identifying the position of the CO_2 plume. This paper describes techniques and results of the microseismic portion of the monitoring activities at the site.

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Method

Microseismic monitoring was achieved using two temporary downhole eight-level triaxial geophone arrays located in observation wells within 750m of the injection well.

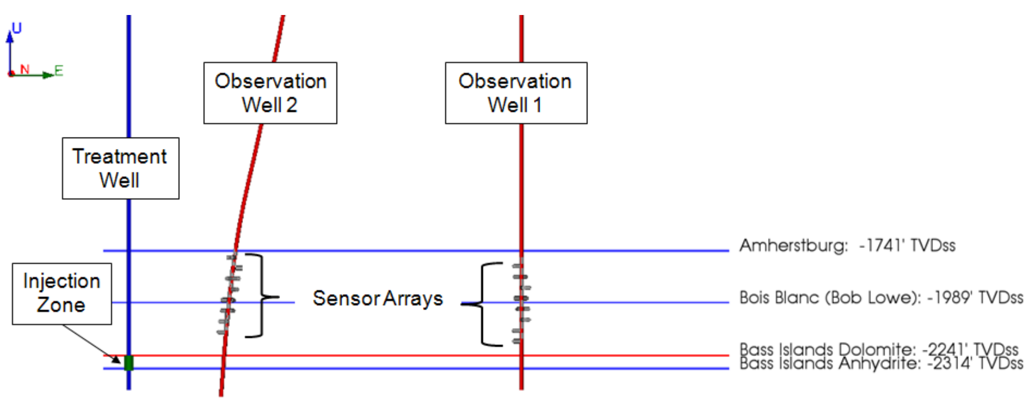

Figure 1: Michigan Field Test CO_2 Injection Site (depth view)

During the deployment period, a total of 2974 triggers were recorded, of which 100 microseismic events were located, ranging in magnitude from -2.5 to 0, including 7 orientation shots. One of these events, recorded during a period of high relative injection rate, was located at the base of the cap rock during the permitted injection interval, suggesting a possible linkage with pressure change or fluid mobilization caused by CO_2 injection processes. All other events, although microseismic in nature, are considered to be the result of other process in the field and not related to the permitted injection of CO_2.

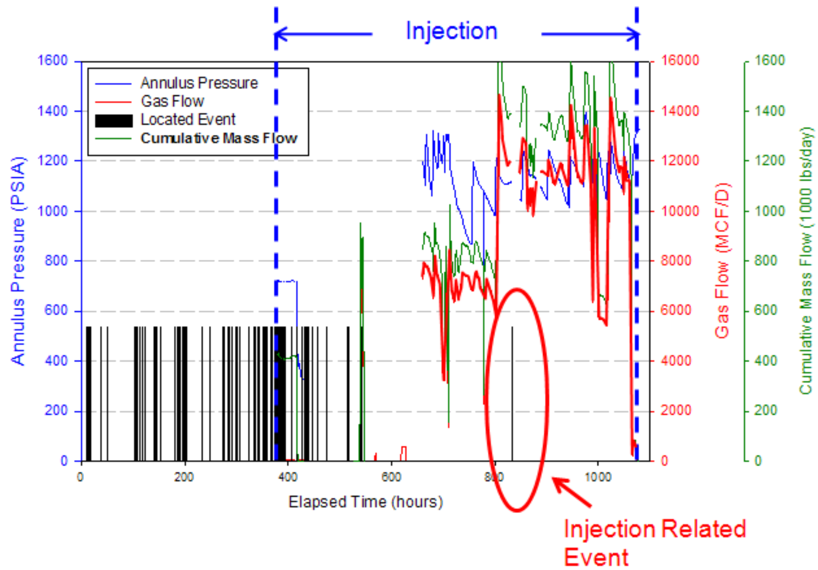

Figure 2: Microseismic Event Distribution and CO_2 Injection Data

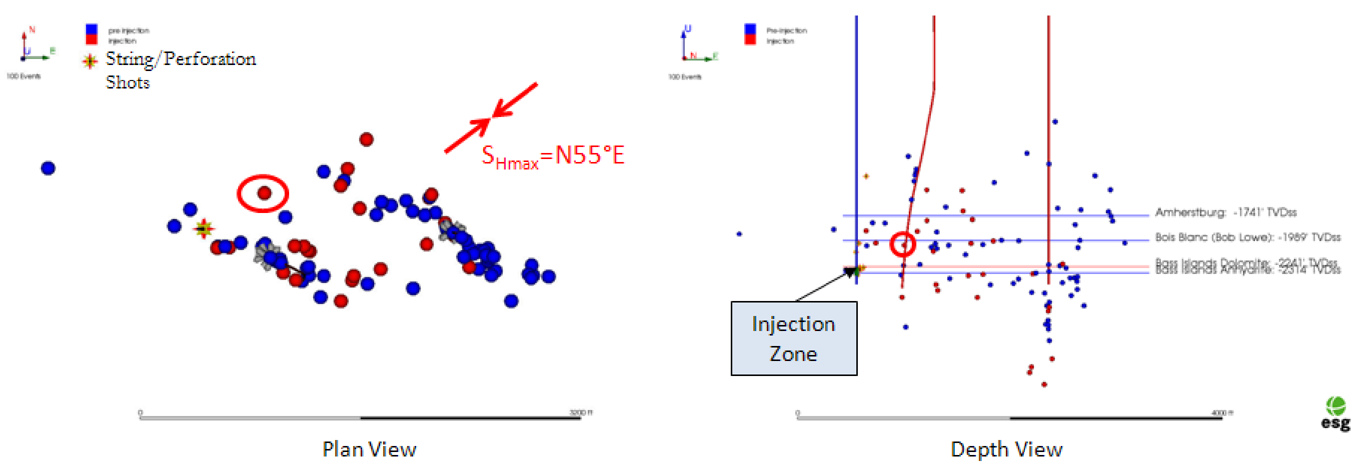

Figure 3: Microseismic Event Locations; red events were recorded during the period of injection into the Bass Islands Dolomite formation, while blue events were recorded prior to injection.

Seismic Moment Tensor Inversion (SMTI) analysis performed on the injection related event revealed a complex failure mechanism (25% istropic, 54% CLVD, and 21% double couple) that is consistent with a crack opening. Potential failure planes are oriented at N160°E or N24°E, which is supported by the orientation of the maximum horizontal stress in the region. In this context, complex failure mechanism is taken to be the description of the motion of the rock system.

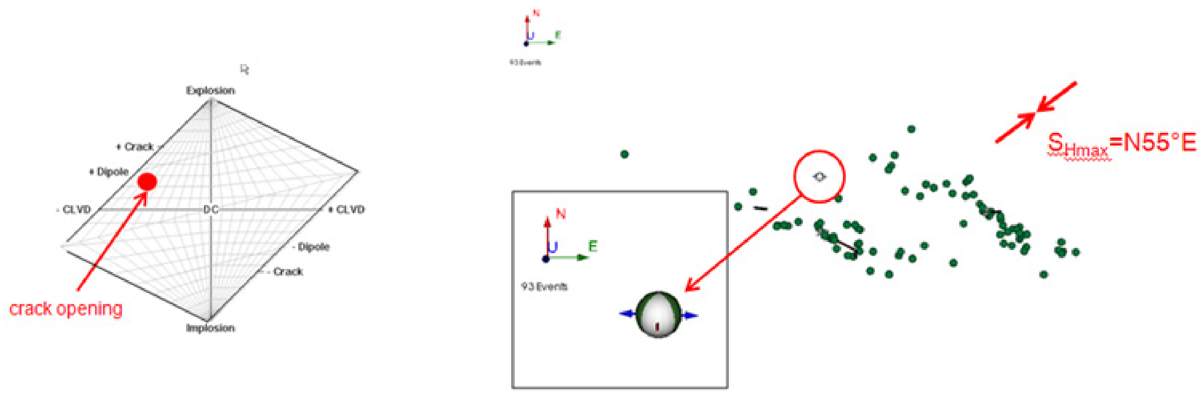

Figure 4: Seismic Moment Tensor Inversion (SMTI) Analysis indicates mechanism of failure consistent with a crack opening, and with potential failure planes oriented at N160°E or N24°E.

Conclusions

Microseismic monitoring has proved to be a valuable tool for monitoring CO_2 injections. During this field test, one injection related event was recorded and located during the permitted injection interval (below the base of the cap rock) during a period of high relative injection rate. Moment Tensor Inversion analysis provided insight into the failure mechanism and orientation of the failure plane for this event, supporting its relationship to the CO_2 injection.

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