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PSUses of Satellite Image, Magnetic and Gravimetric Analysis for Early Identification of Fault Reactivation Risk - Application to the Utica Field, Ohio*

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Abstract

The Utica is an unconventional field located in Ohio; the reservoir unit is an organic rich formation from upper Ordovician. This formation across the Appalachian basin from New York state to northeastern Kentucky, it covers 115,000 square miles, with a prospective area about 85,000 square miles. The structure and thickness of this formation are controlled by basement tectonic. In unconventional field's development, drilling and injected water for hydraulic fracturing near a fault zone can be a major geo hazard. Faults and reactivated faults may act as migration pathway for the fracturing fluid, to lead to the contamination of freshwater aquifer. In Ohio, the 2011 Youngstown event is a clear example of fault reactivation inducing seismicity, early identification of this unknown fault would have allowed to minimize injection at its proximity. The purpose of this study is so to set up a methodology to reduce the risk of reactivating faults during the production of an unconventional field and to preserve freshwater aquifer. Seismic interpretation and imaging may give access to fault structural patterns identification. But onshore seismic data can be very expensive to acquire at large scale. This study illustrates a method very accessible by using potential (gravimetric and magnetic) and satellite data to improve understanding of the local structural geology and identify faults. Combination of these two datasets constraint main faults locations in the Utica basin answer question which could have only been answer otherwise costly seismic acquisition. The study of the regional tectonic give the main stress orientation, here is ENE-WSW. The combination of the regional study and the geo satellite and potential analysis lead to a more precise identification of the main reactivation risk area by delineated them around faults with an ENE-WSW orientation. To validate this method, the risk area model has been compared to the seismicity history map of the Ohio and to the Youngstown case, an example of fault reactivation inducing seismicity. The correlation between the seismic events and the zones delineated with our approach is very strong, the majority of the seism are located in or around risk areas. So is the correlation with the Youngstown related seismic activity. This validation step show that the main reactivation risk zones could be predict quickly thanks to this kind of study leads with free data and bibliographic references.

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Uses of satellite image, magnetic and gravimetric analysis for early identification of fault reactivation risk – Application to the Utica field, Ohio

Introduction

In unconventional field's development, drilling and injecting water near a fault carry important environmental risks. One concern is that the fault may act as migration pathway for the fracturing fluid, leading to the contamination of shallower aquifer. Another risk of unconventional development receiving increasing attention is the potential for reactivation of faults thought hydraulic fracturing in the reservoir or water reinjection in deeper aquifer. In Ohio, the 2011 Youngstown is a clear example fault reactivation inducing seismicity that received wide media attention and community complaints due to its high intensity (4.0). Identification early -on of this unknown fault would have allowed to minimize injection at its proximity.
The aim of this work is to document and understand the organization of the local structural geology which could or could not lead to fault reactivations. This study is based on a large, free and easily accessible, data set made of satellite imaging, remote sensing data and local structural studies. At the end, a methodology allowing the identification of faults without relying on seismic and that may reactivated by nearby water injection will be deliver.

- **Utica Field**

Onshore US (Ohio)
Total 25%

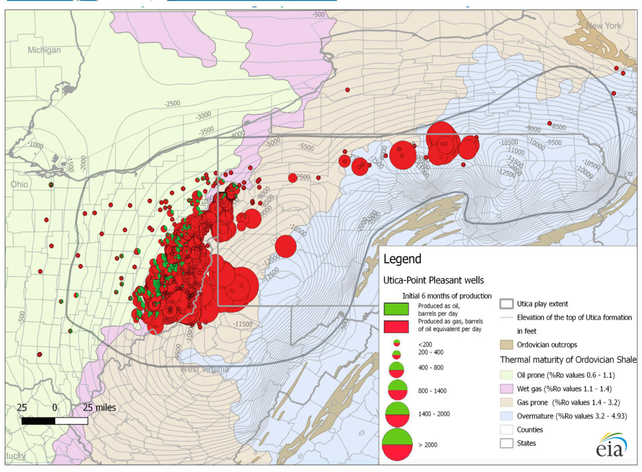

Fig. 1. Utica Field location with Oil & Gas production information

Ohio has been affected by a lot of tectonic events, as the Greenville, Taconian, Acadian and Alleghanian orogeny, related to the Appalachian orogeny.
The Utica Shale is a Middle Ordovician, calcareous, organic-rich shale formation, affected by all these major tectonic events.
The predominant orientation of the maximum horizontal stress for many of these tectonic events is ENE-WSW.

To be continued

- 2nd Validation of the methodology by seismic interpretation of the area
- 3D structural model of the Play
- Set up a usable method by Oil & Gas companies to prevent fault reactivation

Experimental Setup

- **Data Set**

All the data used in this study are easily accessible and free.
Magnetic anomaly maps.
Bouguer and Gravimetric anomaly maps.
Geo satellite images, from Google Earth software.
Bibliography and publications about the structural geology of the area.

- **Methodology**

The analysis of Google Earth and potential data lead to the establishment of surface and basement fault maps.

The study of the local geology and seismology lead to the understanding of the regional stress.
The combination of these two dataset lead to the set up of a model of the area with main fault reactivation risk.

- **Applications**
  - **Prevent the reactivation of faults by fluid reinjection**
  - **Determine the main zone of interest to order seismic data**
  - **Early delineation of an unconventional field**

- **Validation**

By study of the main seismic events affecting the area during fields production.

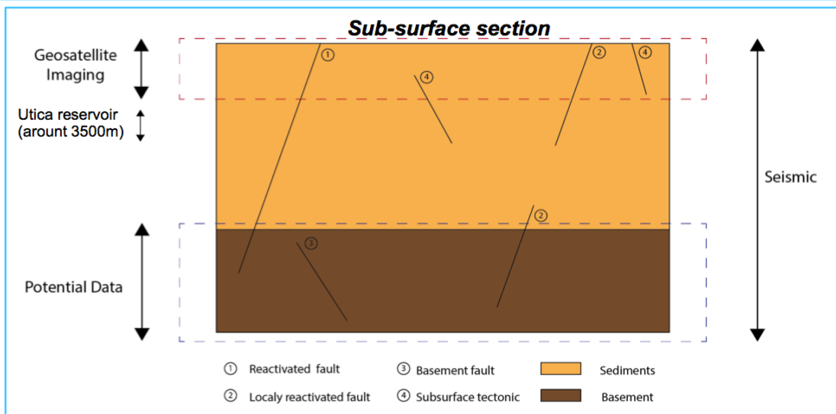

Fig. 2. Information available according to the data source. Seismic data give information about the structure of both the surface and the basement (plus the in-between). The combination of satellite imaging and potential data could allow to acquire these information too without seismic acquisition.

- **Problematic**

All the data used in this study are easily accessible and free.
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- **Objectives**

- Prevent reactivation of faults/natural fracture frac job on development wells in avoiding to drill in fault/lineament zone
- Alert and characterized main faults zone in the development area and support 3D seismic data acquisition if risk exit (allow to reduce acquisition perimeter)
- Early delineation of an unconventional field

Result : *Set up of a* Conceptual model of main faults reactivation zone risk

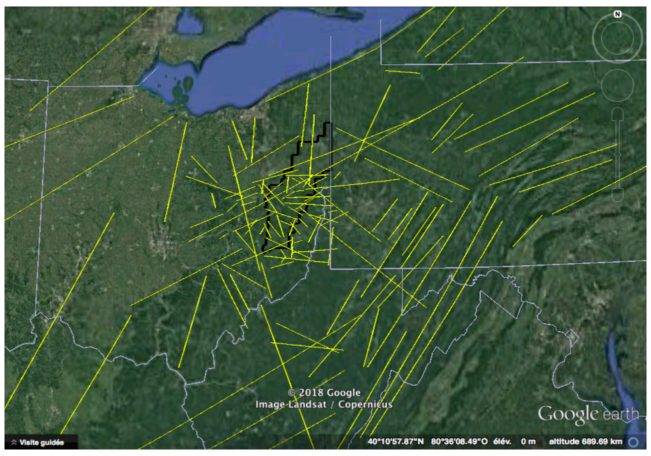

Fig. 3. A. High resolution geo satellite database generated *by identification of the main lineaments. Succession of structural structures and high contrast in the geomorphology are considerated as witnesses of tectonic activity.*

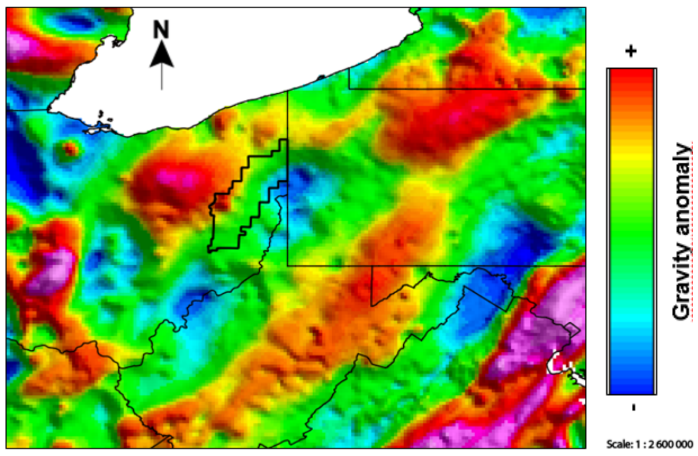

Fig. 3. B. Gravimetric anomaly map, main density variations if the gravimetric field are considered as basement faults, the picking of these main variations leads to the identification of the main tectonic events affecting the basement.

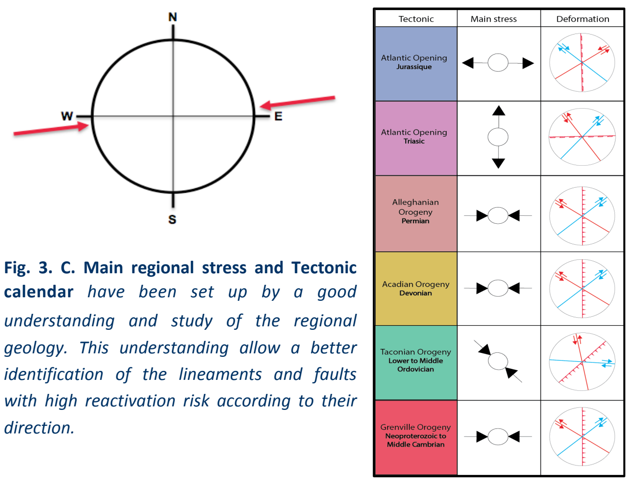

Fig. 3. C. Main regional stress and Tectonic calendar *have been set up by a good understanding and study of the regional geology. This understanding allow a better identification of the lineaments and faults with high reactivation risk according to their direction.*

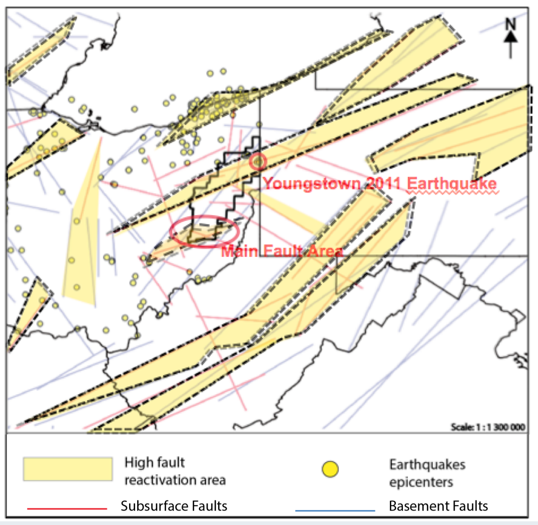

Fig. 3. D. Conceptual model of main fault reactivation zone risk, by combination of the Fig , , and . Zones where basement and surface tectonic witnesses are identified are considered as main fault reactivation risk..
Validation of the model by study of 2 main tectonic events affecting the area during exploitation of the field by different operators (The Youngstown earthquake and an uncontrolled fraking).

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Isostatic residual anomaly map: https://mrdata.usgs.gov/gravity/isostatic/
Magnetic anomaly map: https://mrdata.usgs.gov/magnetic/
Geological map: http://geosurvey.ohiodnr.gov/portals/geosurvey/geologic.pdf
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Utica/Point Pleasant GOR Thermal Maturity: https://www.eia.gov/maps/maps.htm
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