Multi-Surface Visualization of Fused Hydrocarbon Microseep and Reservoir Data

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Summary

Hydrocarbon Microseepage (HM) refers to the active vertical migration of analytically detectable hydrocarbon molecules through microscopic fractures, pore spaces and along mineral grain boundaries from subsurface reservoirs to the earth's surface [1]. Measuring and mapping these microseeps is relatively low-risk, low-cost and complement and support existing seismic and geological methods. HM surveys give no information about reservoir depth, thickness or permeability, but are able to define spatially the size, shape and location of petroleum reserves.

It is important that computational and visualization tools are created to properly integrate the microseep data with existing geophysical and geological data sets. The major challenge of this project involves taking multi-modal and multi-scale data from a variety of disciplines – such as geophysics, geology, geochemistry, GIS – and allowing interactive exploratory analysis. We are investigating and developing novel software solutions deployed for a variety of input/output technologies to achieve this goal, including tablets, multitouch tabletops and touch enabled wall displays. Using these tools we hope to develop generalizable strategies to integrate multi-scale, heterogeneous datasets from surface geochemistry data and subsurface data from geology and geophysics.

Introduction

Detailed, high-resolution HM surveys offer a flexible, low-risk, low-cost and environmentally friendly technology to find hydrocarbon accumulations that naturally complement geologic and seismic methods. The large clusters of samples of very high HM values may indicate the location of discrete structural or stratigraphic trapping conditions within the survey area for future exploratory drilling targets. Consequently, there is a strong need for advanced computational and visualization tools that properly integrate data from HM surveys with subsurface geological/geophysical datasets [2]. This combination of surface/subsurface data can significantly reduce exploration risk by focusing on the areas with greatest petroleum potential. It can also provide an effective method to detect bypassed oil and determine the productive limits of a field. This would lead to the addition of new reserves, drilling of fewer dry or marginal wells, and optimization of the number of development or secondary recovery wells. Raw data include large number of samples representative of the levels of hydrocarbon concentrations breaching the earth's surface, obtained in the low level atmosphere. This attribute ensures a very rapid collection of data over significantly large areas that result in more scalable HM survey and data integration scenarios.

Currently the integration and visualization of HM data involves various software packages for 2D geospatial image processing and Geostatistics [3] and numerous manual steps, creating a clumsy intensive workflow. In addition, interactive visualization systems integrating HM data with subsurface seismic and geological 3D data are in its early stages of research and development [2]. The key challenges is to integrate multi-modal, multi-scale data from different disciplines (geophysics, geology, geochemistry, GIS) in 2D and 3D, allowing fast throughput and interactive exploratory visual analysis and direct manipulation with the data, deployed in a variety of integrated input/output technologies to allow collaborative visual analysis, data exploration and decision-making. The main goal of this project is to develop different exploratory visualization tools deployed in different display technologies to efficiently access and retrieve 2D maps at different scales, probing regions of interest, overlaying different map attributes and annotating maps.

Method

An initial step to developing the system was to gather and organize multiscale 3D maps from geochemical surveys; these include the microseep footprint data, geological and topographic maps, level curves, oil migration pathways and geophysical seismic lines and sections (Figure 1).

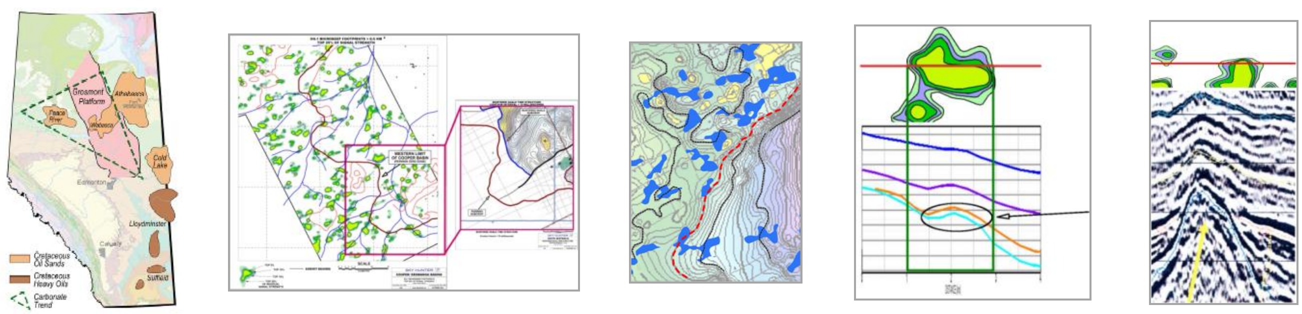


Figure 1: Example of the different modalities and scales of dataset required for an integrated framework for HM visualization and analysis.

Once this was completed we developed a data management framework to store and retrieve the multiscale datasets in a structured way. Exploratory visualization tools can efficiently access and retrieve the maps at different scales, probe regions of interest and overlay different map attributes. These tools are deployed in different display technologies, including multi-touch interfaces and calligraphic display systems. Developing the tools further we support different abstractions and manipulations leading into full multisurface display capabilities.

Examples

Visualizing Microseep Data on a Multitouch Tabletop

The system currently allows for the display of microseep data and geological data on a multitouch tabletop (Figure 2, left). This allows for collaborative and interactive visualizations of reservoir geoscience and engineering datasets [5].

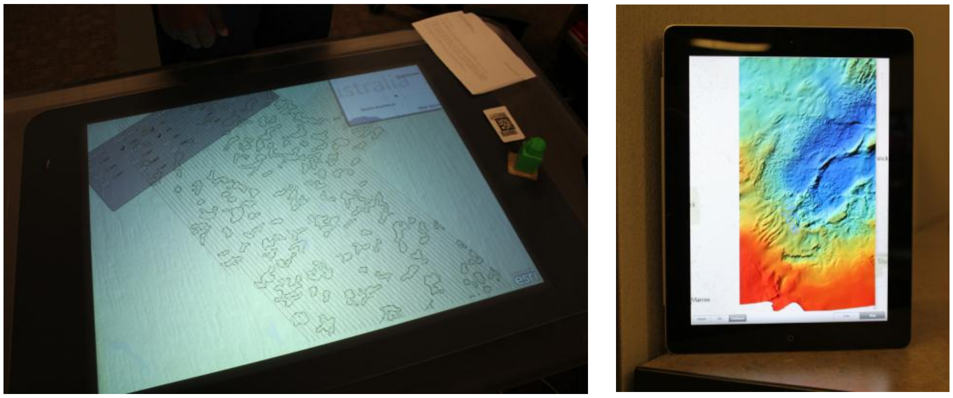
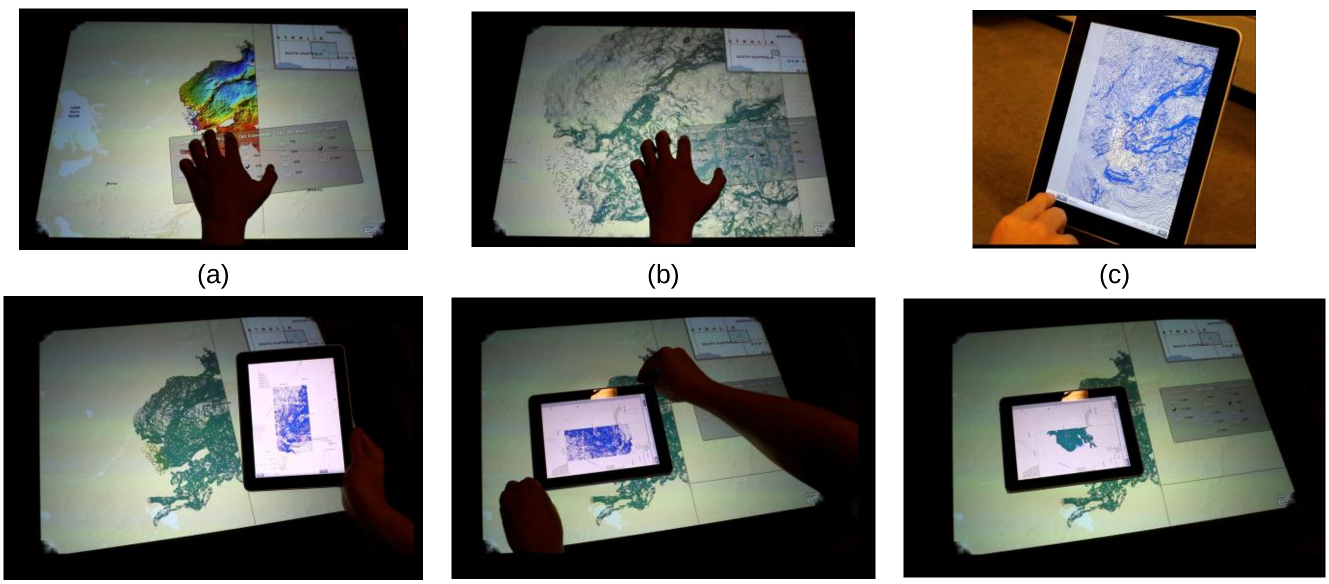


Figure 2: Microseep data display on a multi-touch tabletop (left) and on a commercial tablet (right)

Visualizing Microseep Data on a Tablet Device

This system allows professionals to analyze microseep data in the field. All the visualization capabilities available on the multitouch tabletop are also available on the tablet (Figure 2, right). This allows for mobile visualization of geospatial datasets [4]. In addition, our initial prototypes allow seamless exchange of information between tabletops and mobile visualization devices (Figure 3).



(a) (b) (c)

(d) (e) (f)

Figure 3: (a, b) Different maps integrated with HM data are selected over a tabletop; (c) a different map selected over the mobile device; Integrated communication of HM data between two different interactive display technologies of tabletops and mobile devices:(d) two different maps on each device; (e) placing the mobile device on top of the tabletop; (f) data and visualization from tabletop automatically transferred to the mobile device.

Novel Orientation Preserving Visualization of Seismic

Integrating the tablet with the multitouch tabletop it is possible to view the seismic in a way that preserves the original orientation of the data. When a user places the iPad down on the tabletop is displays the segment of seismic data that corresponds to the geographical area under the iPad.

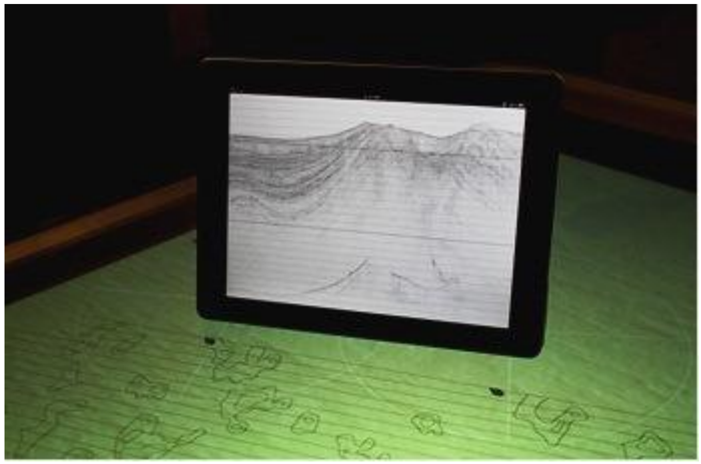


Figure 4: Orientation preserving visualization of seismic data

Conclusions

Microseep data provides a low-cost and effective way to locate future exploratory drilling targets. An advanced visualization tool – which allows for the integration of the microseep data with traditional geological and geophysical data sets – creates an effective combined visualization system. Employing multitouch tabletops and commercial tablets, novel visualizations are possible for visualizing seismic data in conjunction with traditional datasets in a manner that preserves the orientation of the data.

Develop hybrid (automatic and interactive) tools for geoscientists to interpret, explore and analyze integrated HM with seismic volume data. HM data provide information on the hydrocarbons trapped in the rocks. These new tools will allow the HM signal to be matched with various structural/stratigraphic situations demonstrated from different seismic interpretations used to define the hydrocarbon trap.

Acknowledgements

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