[PS]Ocean Bottom Multi-Physics Nodes – Next Reservoir Monitoring Step Forward?*

Andrea Zerilli[1], Adriano Viana[2], Julio Lyrio[2], Jorlivan Correa[2], Emanuel Capechi[2], and Paulo Menezes[2]

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Abstract

An in-depth study performed in the RO-300 Jubarte's reservoir (Campos Basin, Brazil) has demonstrated that time-lapse marine Controlled Source Electromagnetics (4D CSEM) could complement time-lapse seismic in reservoir-monitoring applications. Indeed, one of the potential uses of time-lapse CSEM is its ability to sense changes in water saturation without the interference of the pressure effects, to which seismic data are more susceptible.

Production effects and associated changes in saturation were translated into changes of the reservoir's resistivity structure over time. In our studies, 5 years of production have shown detectable changes up to 10% of anomaly amplitude around the reservoir edges, although limited by current acquisition and interpretation methods. Inversion techniques were applied to reliably recover reservoir production-related resistivity changes in the presence of repeatability issues.

It is fair to say that CSEM could play an important role in improving our knowledge of reservoir properties in time-lapse applications. What lies beyond its adoption is its perceived value and cost relative to seismic, lack of definitive case studies and most significant of all, lack of game-changing developments and investments in new concept 4D acquisition systems.

New multi-, wide-, and full azimuth towed streamers, ocean-bottom cables (OBCs), ocean-bottom nodes (OBNs), and PRM have brought 4D seismic to a new level of data quality with unprecedented repeatability and detailed multi-azimuth sampling of the seismic wavefield. The last decade has seen highly repeatable streamer surveys and OBNs exponential improvement in cost efficiency, with cost per trace being reduced by approximately 50% every two years.

The transformation of marine CSEM into an accepted and cost-efficient 4D integrated technology should start from the operational side bringing a total rethink in:

- Re-engineered all-in-one modular multi-physics receiver nodes (EM – seismic bundled) inspired by current ocean bottom seismic strive and technology.

- Optimization, higher sensitivities, and miniaturization of the companion electric and magnetic sensors.
- Broadband, multi-component source delivering the greatest impact on efficiency resulting in drastically increased data density and full-azimuth imaging.

As demands for deep water reservoir monitoring around the world become more challenging, integrated 4D multi-physics ocean bottom technologies can optimize output from existing reservoirs.

Ocean bottom multi-physics nodes–
Next reservoir monitoring step forward?

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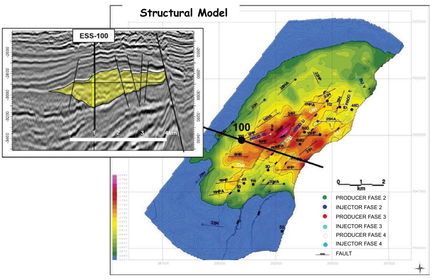
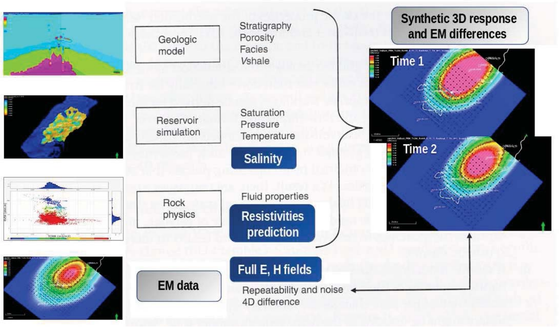
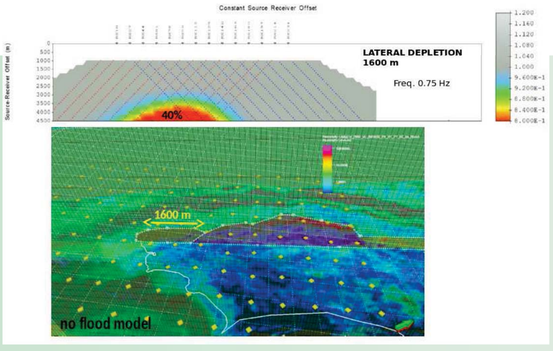


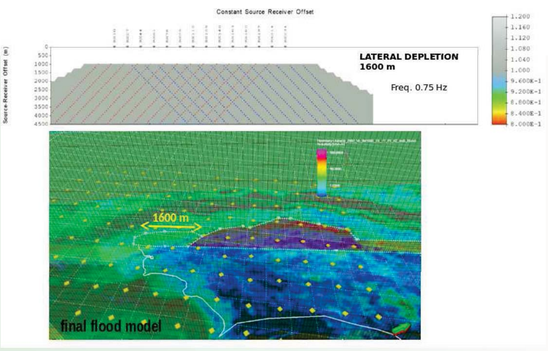


EM simulation modeling workflow

Production effects and associated changes in saturation predicted from fluid simulator were translated into changes of reservoir's resistivity structure over time. In our studies, a 5 years of production have shown detectable changes up to 10% of anomaly amplitude around the reservoir edges, although limited by current acquisition and interpretation methods.

New localized Inversion was applied to reliably recover reservoir production-related resistivity changes in the presence of repeatability issues.

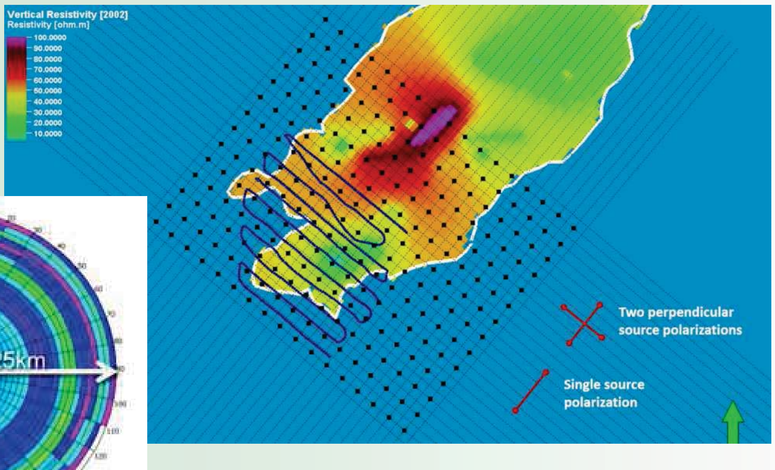


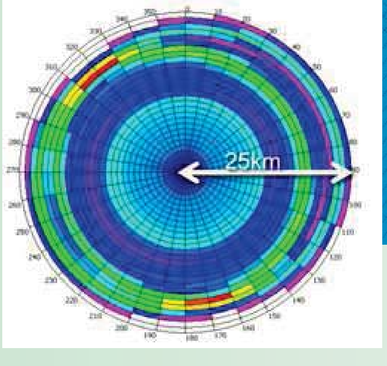


- More accurate flood estimates
- Minimal repeatability issues
- Cost and turnaround time reductions

It is fair to say that CSEM could play an important role in improving our knowledge of reservoir properties in time-lapse applications. What lies beyond its adoption is its perceived value and cost relative to seismic, lack of definitive case studies and most significant of all, lack of game-changing developments and investments in new concept 4D acquisition systems.

- Perceived value *vs* cost
- EM has been struggling with:
  - *Inefficient technologies*
  - *Limited marketplace*
- Going back to basics rethinking:
  - *Instruments design*
  - *Resolution to operational and cost efficiency*
  - *Integration*





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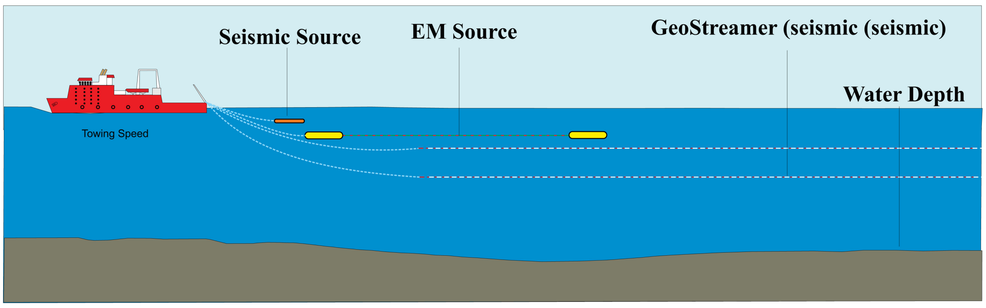
Current state-of-art Towed Streamer EM delivers high density 3D CSEM data with exceptional acquisition efficiency. It acquires 2D GeoStreamer® data simultaneously with EM data, or 3D EM data over existing or planned 3D seismic.



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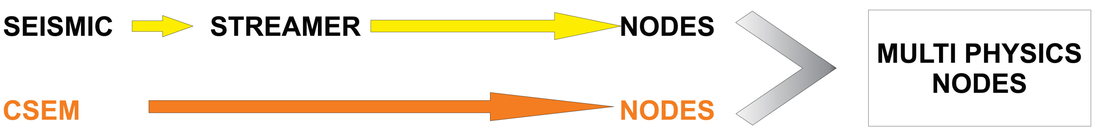
TIMELINE



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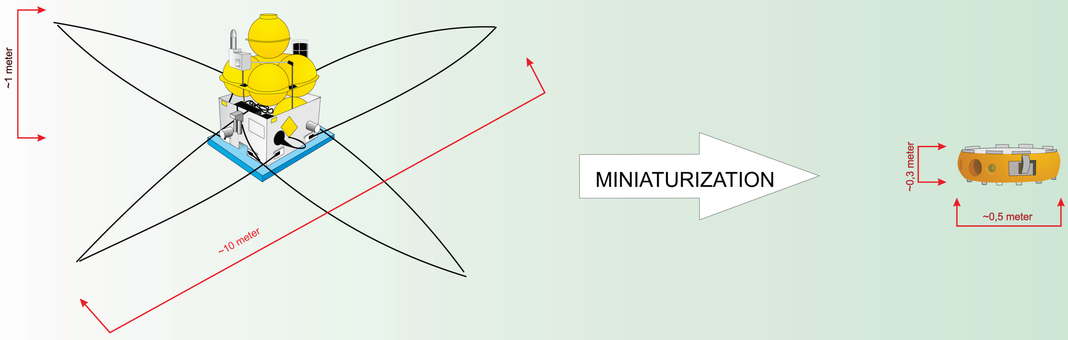

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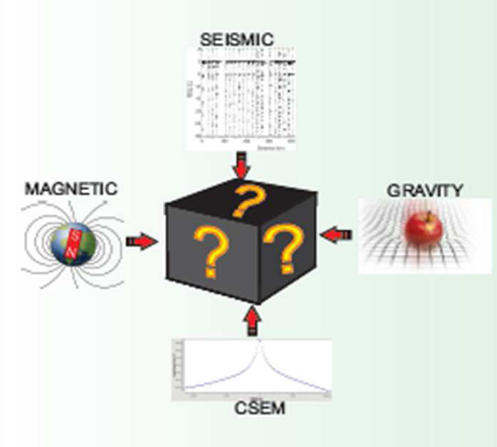

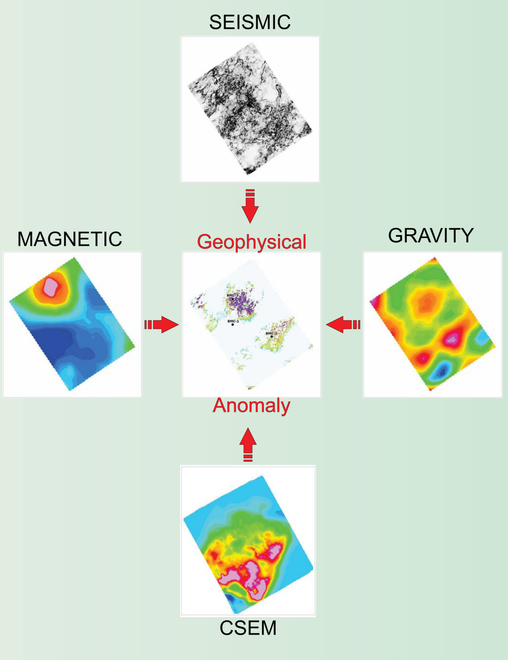

Time lapse EM challenges

4D CSEM technology still in its infancy.

Modeling studies and applications are exceedingly rare.

Feasibility studies too simplistic leading to poorly understood:

- Potential
- Where and when
- Value and how
- Key factors in success