PS Compound Seismic Forward Modeling of the Atiart Submarine Canyon Outcrop, Spain: Application to the Submarine Canyon on the Subsurface Loppa High, Barents Sea*

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Abstract

The inability to resolve geological details can lead to erroneous seismic interpretation and create higher risk during the prospect evaluation and assessment. Seismic forward modeling of outcrop analogue can provide an important link between the architectural geometries and facies composition observed in the outcrop and in seismic data. The aim of this work is to produce a realistic model that can potentially bridge the critical gap in resolution between two different geological datasets and provide improved insight to the interpretation of petroleum targets. This study utilized traditional geological mapping and digital outcrop modeling techniques of the Atiart outcrop in Ainsa, Spain, and was coupled with morphometric analysis of the subsurface canyon systems from the Loppa High, Barents Sea to produce 3-D geometry and facies model. Rock properties have been taken from the subsurface Loppa High canyon system with facies comparison to the Atiart sedimentary logs. These kinds of integrated outcrop studies were used to create the realistic properties model (gamma, density, shear- and compressional-waves, and velocity). Ray-based convolution method has been performed to produce normal polarity, zero-phase, pre-stack depth migrated seismic model. In addition, gamma model was used to predict net-to-gross for the different facies in the canyon system. Three realizations at 20 Hz, 30 Hz, and 40 Hz have been performed to find the specific frequency that matches the interpreted seismic data in the Loppa High (subsurface). The 40 Hz model shows important results that detailed architecture of the canyon system is successfully captured: 1) Single seismic trace indicated stack of several heterogeneous sedimentary layers. 2) Canyon surface not only identified by truncation reflection terminations, but also identified by relatively low amplitude within single seismic trace. 3) Syncline reflector on the canyon-fill might be refer to differential compaction or a seismic artefact. 4) Lateral degradation of the amplitude strength indicates lateral variation on the lithofacies. Our work shows an important result on how to reduce the uncertainty in seismic interpretation of canyon systems. This research also contributes to better constraints on lithology predictions, pit-falls detection, architectural elements, and geometry distribution of canyon systems.

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Integrated Outcrop Studies

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SEPM sesion on the Deepwater Depositional Environments

1.0 Background

The inability to resolve geological details can lead to erroneous seismic interpretation.

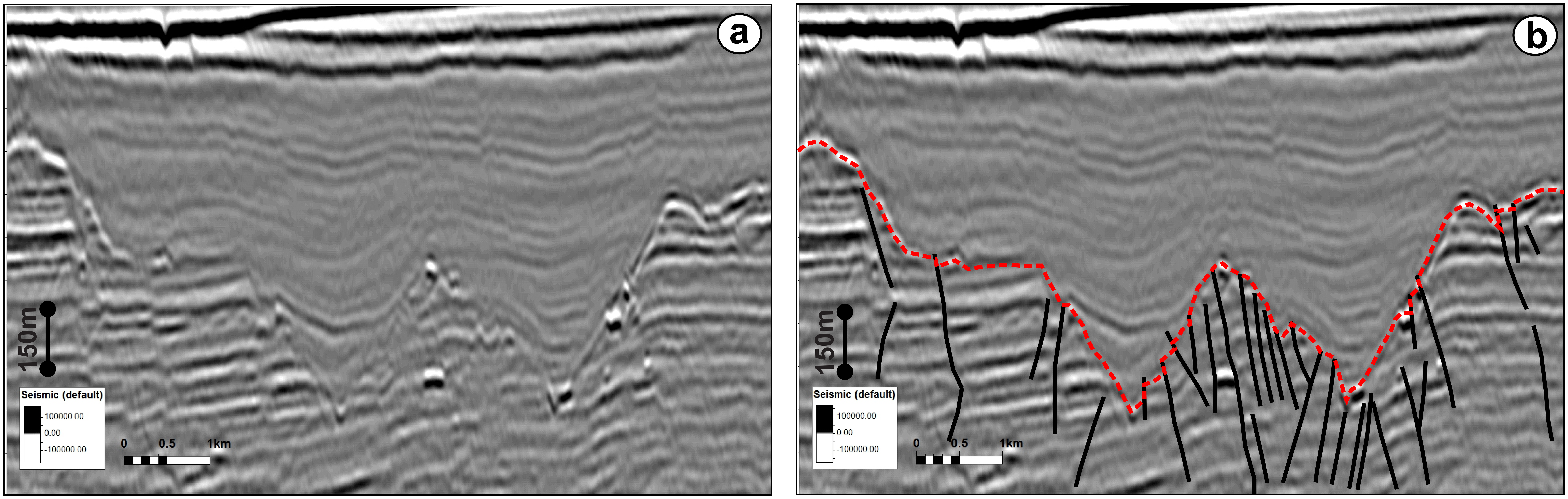

Figure 1. Seismic section (a) and interpreted section (b) of the submarine canyon system, Barents Sea (Harishidayat et al., 2018)

2.0 Data

This study utilized outcrop (Ainsa - Spain) and subsurface (Barents Sea - Norway) data that have similiarity in term of submarine canyon environment.

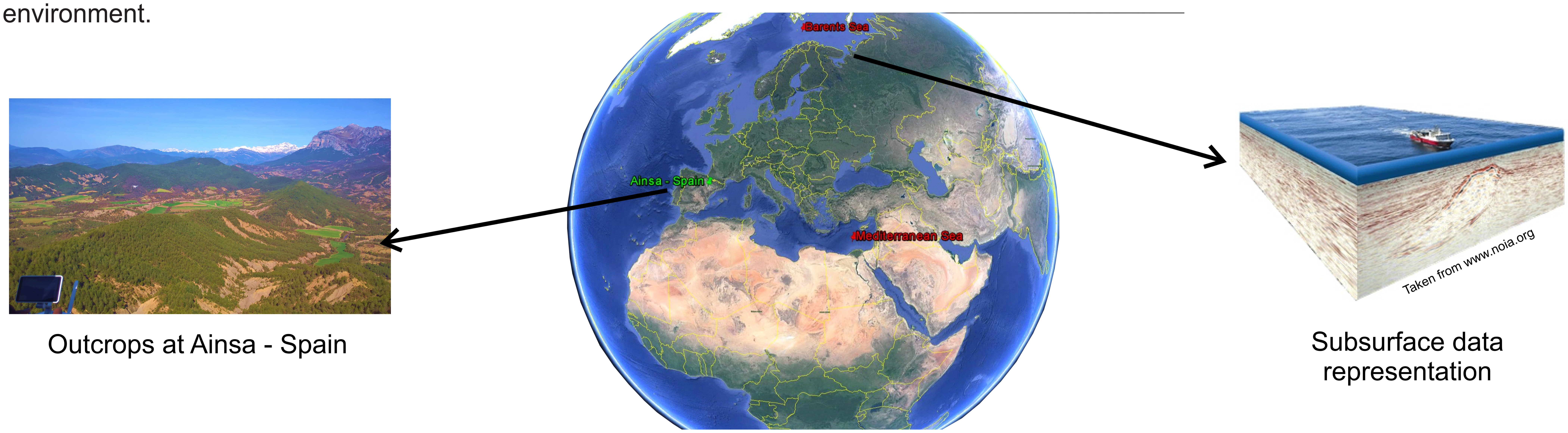

Figure 2. Localities and types of data that used in this study

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3.0 Methodology

We have implemented ''Integrated Outcrop Studies'' method by Johansen et al., 1994 where coupling between outcrop and subsurface are necessary to produce seismic forward model that can calibrated subsurface seismic interpretation.

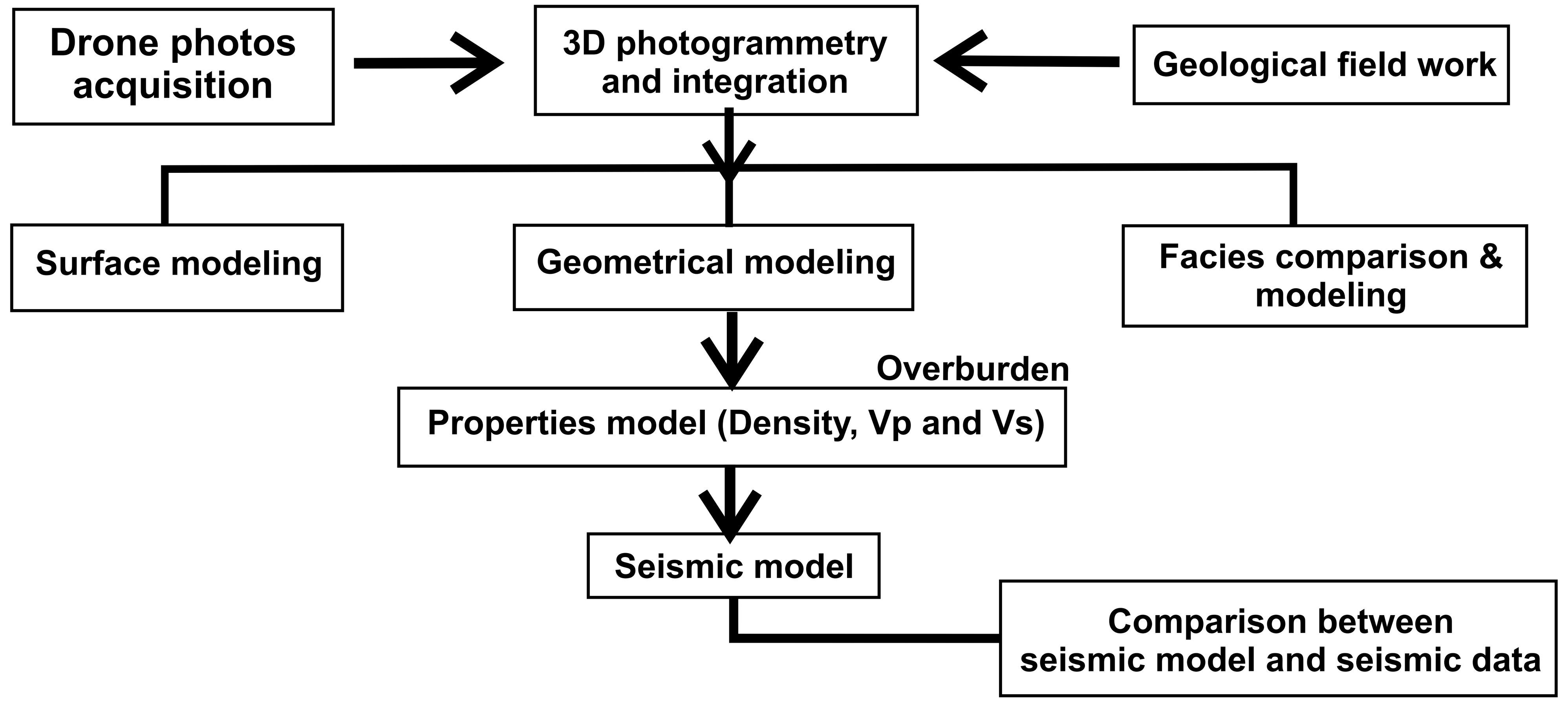

Figure 3. Workflow used in this study

4.0 Results

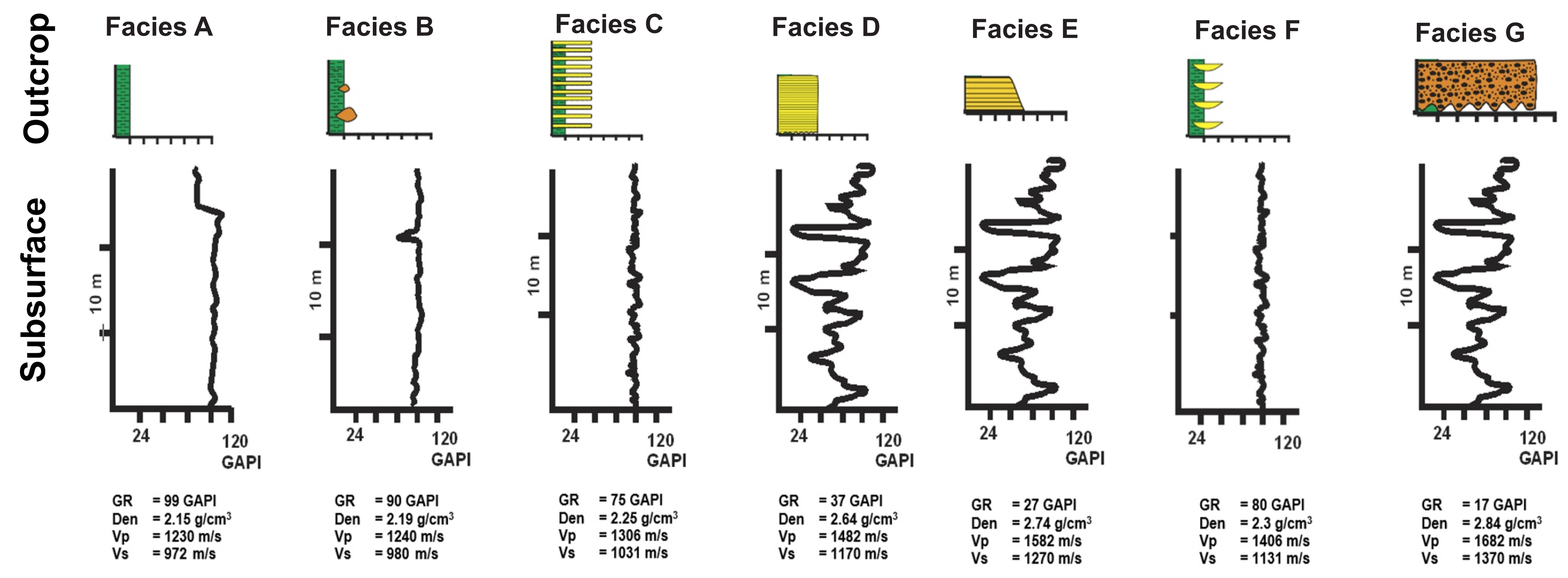

Figure 4. Sedimentary facies comparison

We have implemented ''Integrated Outcrop Studies'' method by Johansen et al., 1994 where coupling between outcrop and subsurface are necessary to produce seismic forward model that can calibrated subsurface seismic interpretation.

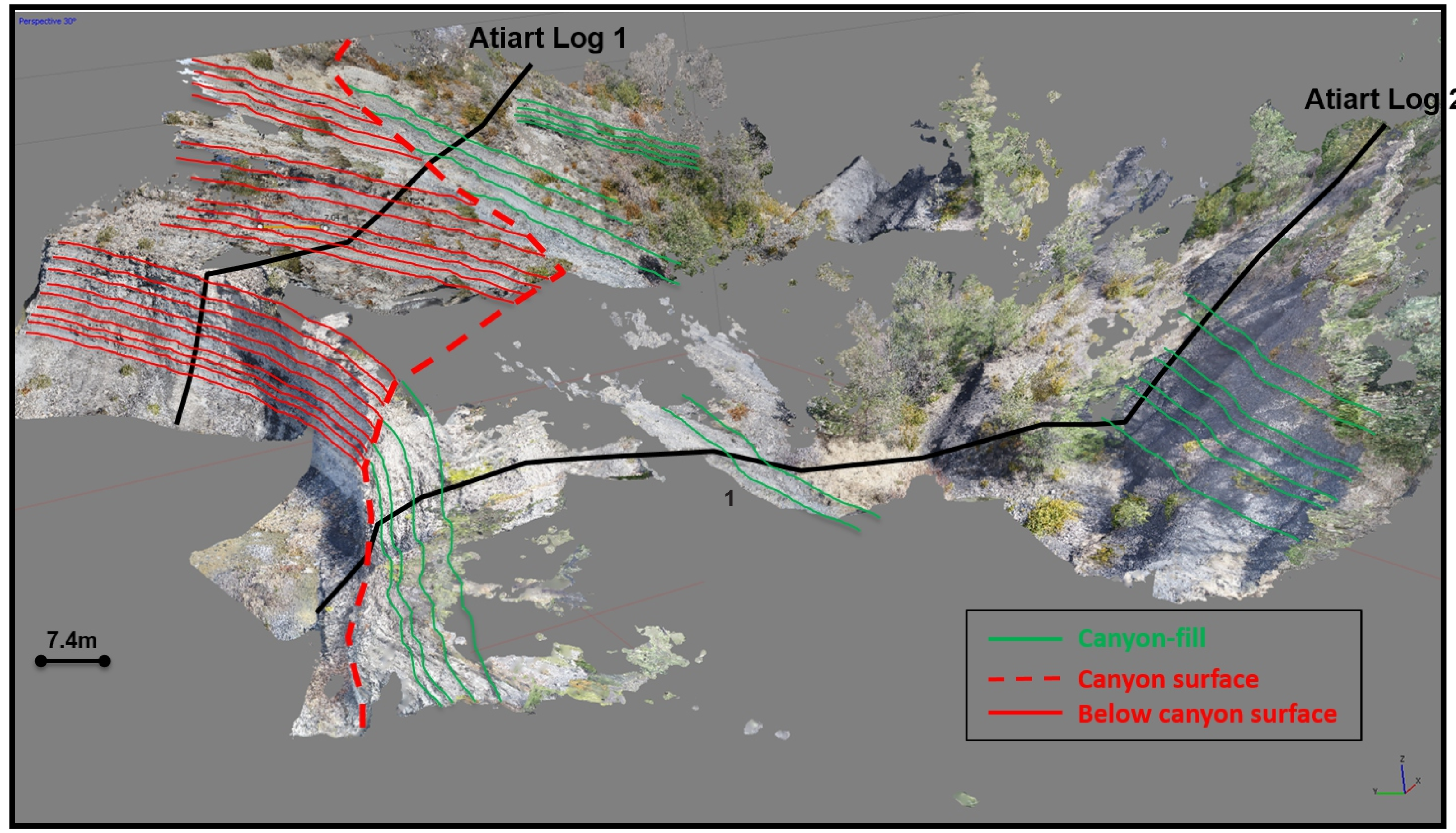

Figure 5. 3D Photogrammetry and integration

Overburden factor has included on the properties model to make seismic modeling more reliable

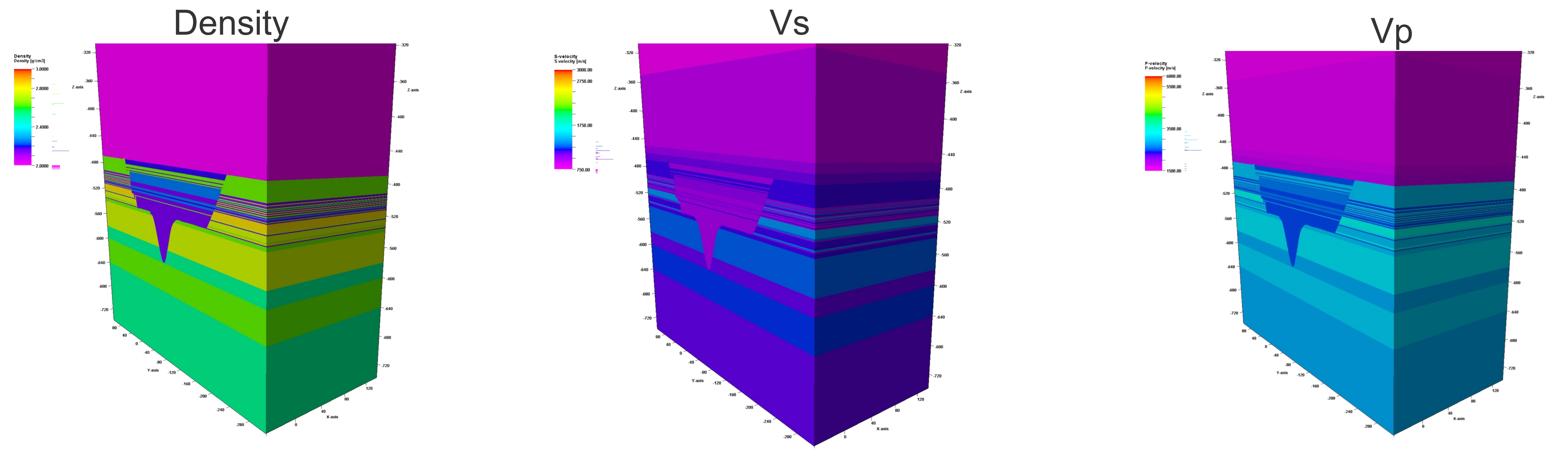

Figure 6. 3D properties model

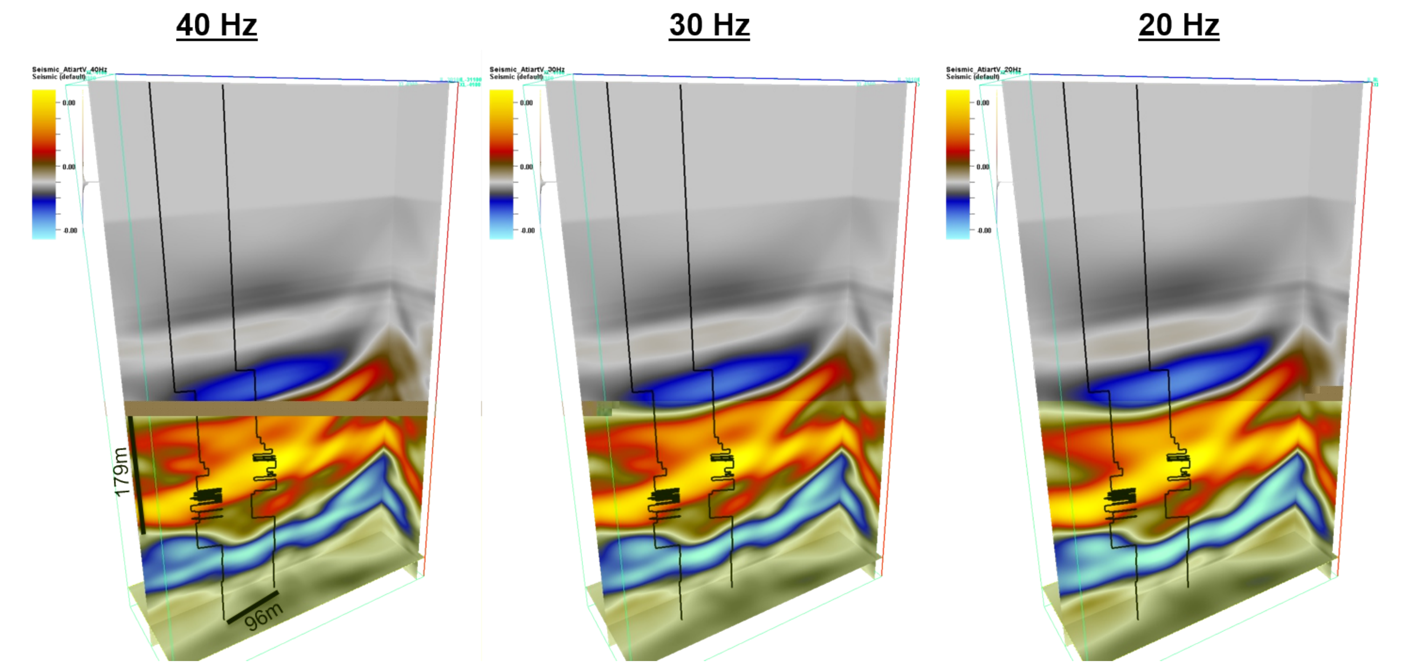

Figure 7. Seismic model from three different frequencies overlay with synthetic GR logs from sedimentary logs

Three different frequencies were used in the study and the 40Hz revealed most of the details.

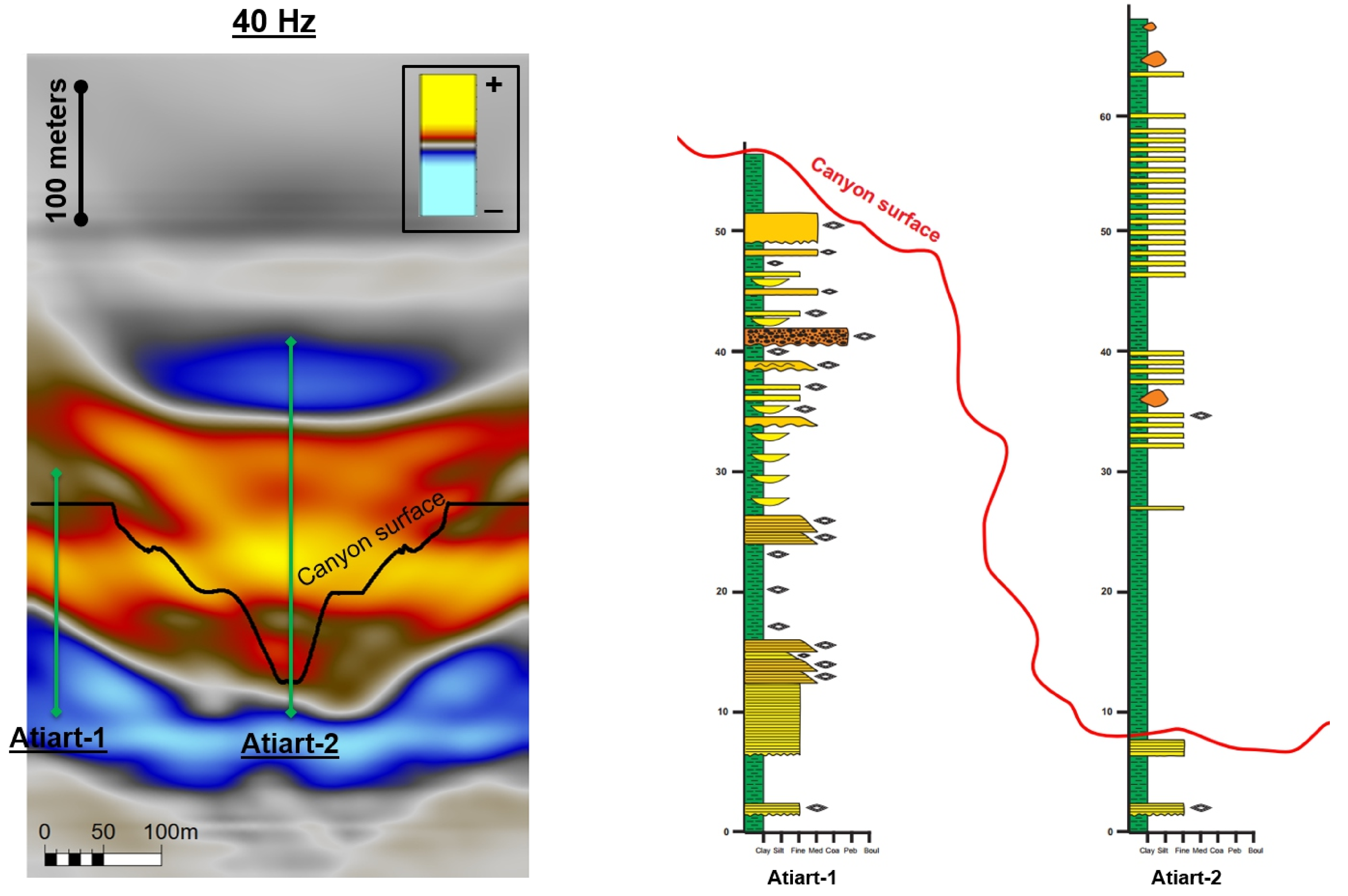

Figure 8. Seismic model with control of sedimentary logs

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Integrated Outcrop Studies

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Comparison between seismic model and real seismic data revealed several important informations:

- Single seismic trace: stack of sedimentary layers.
- Canyon surface: low amplitude within single seismic trace.
- “Syncline” reflector on the canyon-fill: differential compaction or a seismic artefact.
- Amplitude lateral degradation: lateral variation on the lithofacies.
- Sedimentary processes: high energy of erosive surface and low energy of shale suspension.

*Note that CRE: Conformable Reflection Element, while HARE: High Amplitude Reflection Element (Harishidayat et al., 2018)

Outcrops (Ainsa - Spain) **Subsurface (Barents Sea - Norway)**

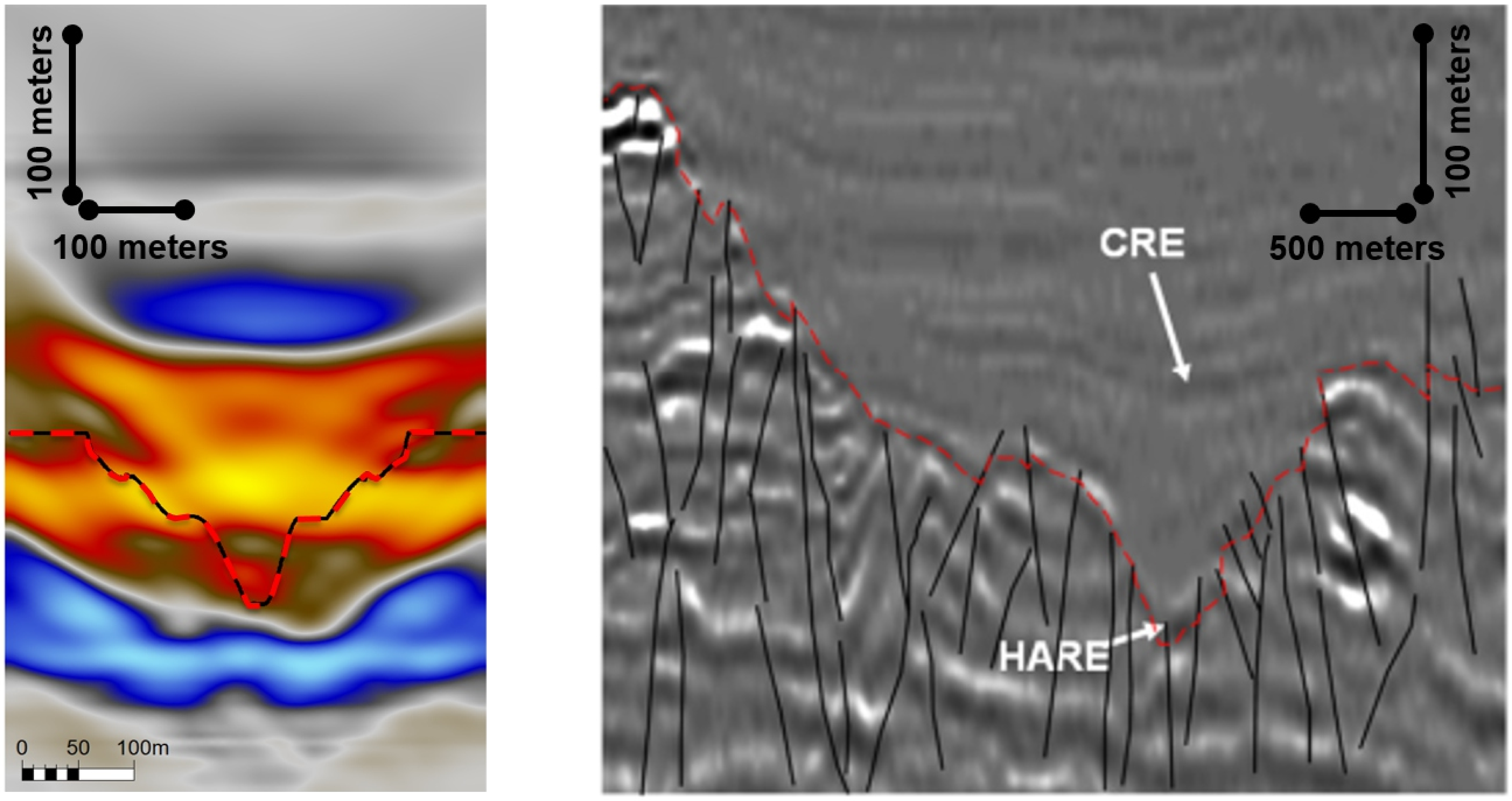

Figure 9. Seismic comparison*

5.0 Conclusion & Way Forwards

- Integrated Outcrop Studies (Johansen et al., 1994. Johansen et al., 2007 and Johansen et al., 2013) is a powerful tool to correlated seismic data and outcrop data from the same geological setting.
- The correlation is needed to compare all the geology and geophysical characteristics
- Comparison will reduce the uncertainty of seismic interpretation
- The next step is to use outcrop rock properties for seismic modeling
- The next step is to add stratigraphic forward modeling into the workflow to guide the lateral distribution of the rock properties

6.0 References

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