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A Virtual Ride through a Fractured Carbonate Reservoir Analog: 3D Digital Reservoir Model of a Microbialite Reef in the Neoproterozoic Nama Group in Namibia*

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Abstract

In this study, we describe and interpret a reservoir model constructed from a Neoproterozoic fractured thrombolite-stromatolite reef system. Due to the increasing significance of these systems as possible hydrocarbon reservoirs, a better understanding of their internal structure is required.

A new frontier in approaching this problem is the development of digital outcrop models (DOMs). These are highly valued datasets in petroleum geoscience because they allow all elements of a petroleum system to be imaged in detail. Light detection and ranging (LiDAR) is a technique that has come to the forefront of creating DOMs in the last decade. This laser-based measurement system allows the rapid acquisition of detailed point data describing an outcrop in 3D with high precision of a few centimeters. In conjunction with traditional mapping methods, these 3D photorealistic DOMs are used for the development of static and dynamic reservoir models. Field geologists can bring the outcrop virtually to the office.

As a potential reservoir analogue, outcrops of the Omkyk Member in the Neoproterozoic Nama Basin of Namibia were chosen for the development of a DOM. The exceptional quality of the outcrops provides an excellent opportunity to study a microbial dominated reef system as a potential reservoir. This reef complex developed in a wave-dominated inner carbonate-ramp setting and it is characterized by the evolution of individual thrombolite-stromatolite build-ups. Previous studies have shown that the spatial distribution of the reefal build-ups is the major constraint on the reservoir quality and connectivity. However, these studies have not investigated the fracture and fault network, which has a major impact on the connectivity between the individual build-ups and consequently on the reservoir quality. We scanned and digitized an area of approximately 3 km² and evaluated the contribution of the fracture patterns to the enhancement of the reservoir quality. We developed a reservoir model with the modeling software JewelSuite™ to simulate the interplay between vertical and lateral facies changes and fracture sets. In this paper, we show how LiDAR based mapping and the quantitative acquisition of fracture and fault patterns improve our understanding of fractured carbonate reservoirs.

Furthermore, this reservoir model can be used as a base model for microbialite reservoirs, such as the reservoirs in the recent giant discoveries in the Cretaceous pre-salt, offshore Brazil.

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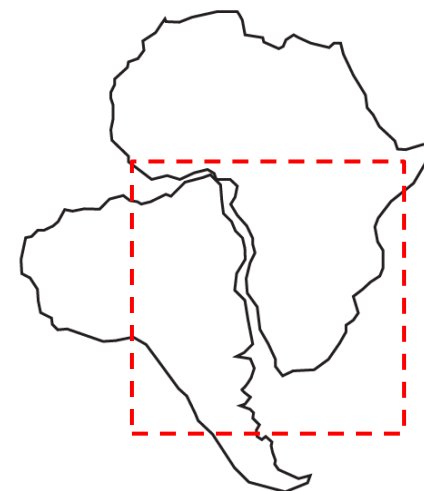
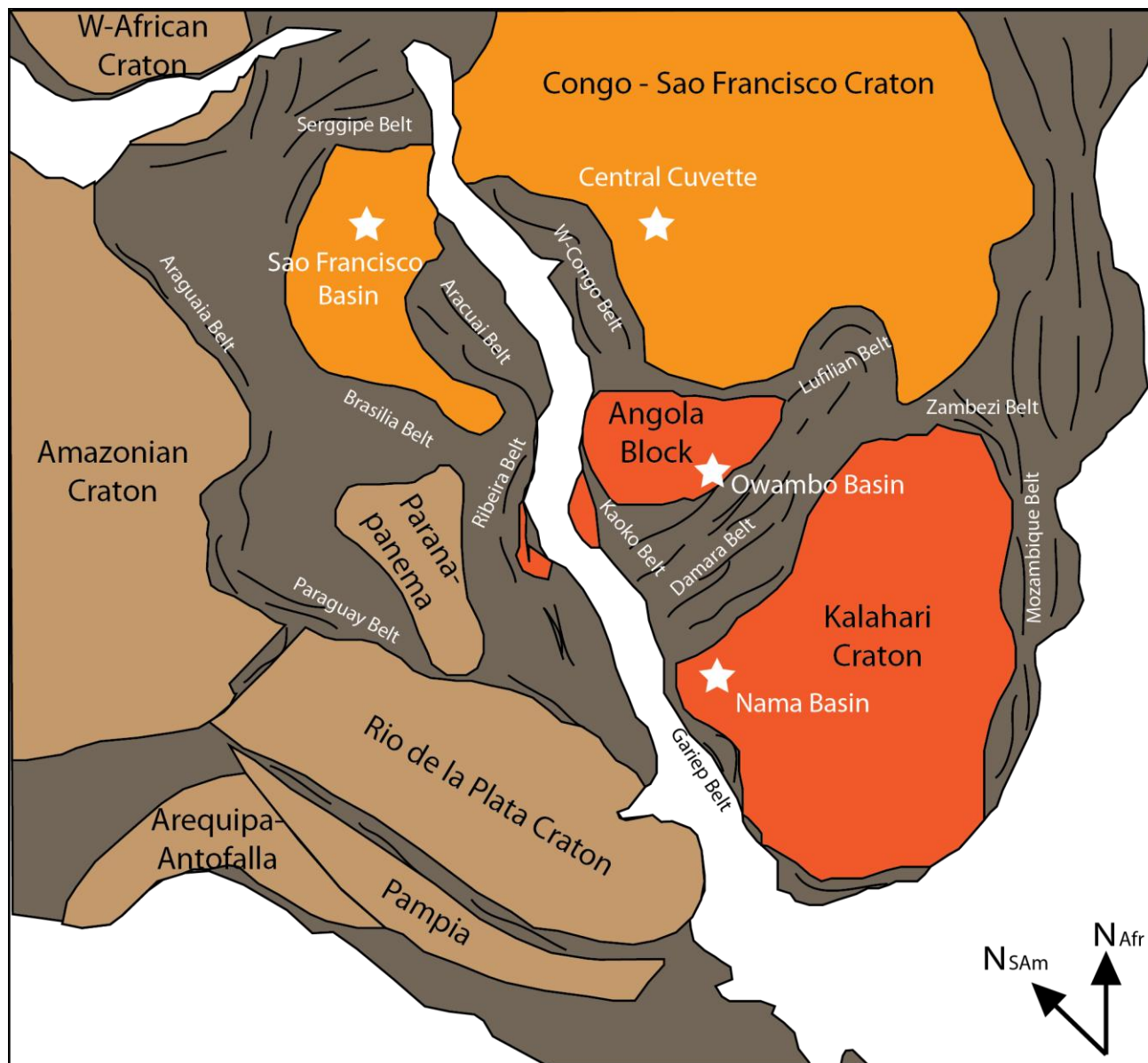
A Virtual Ride through a Fractured Carbonate Reservoir Analog

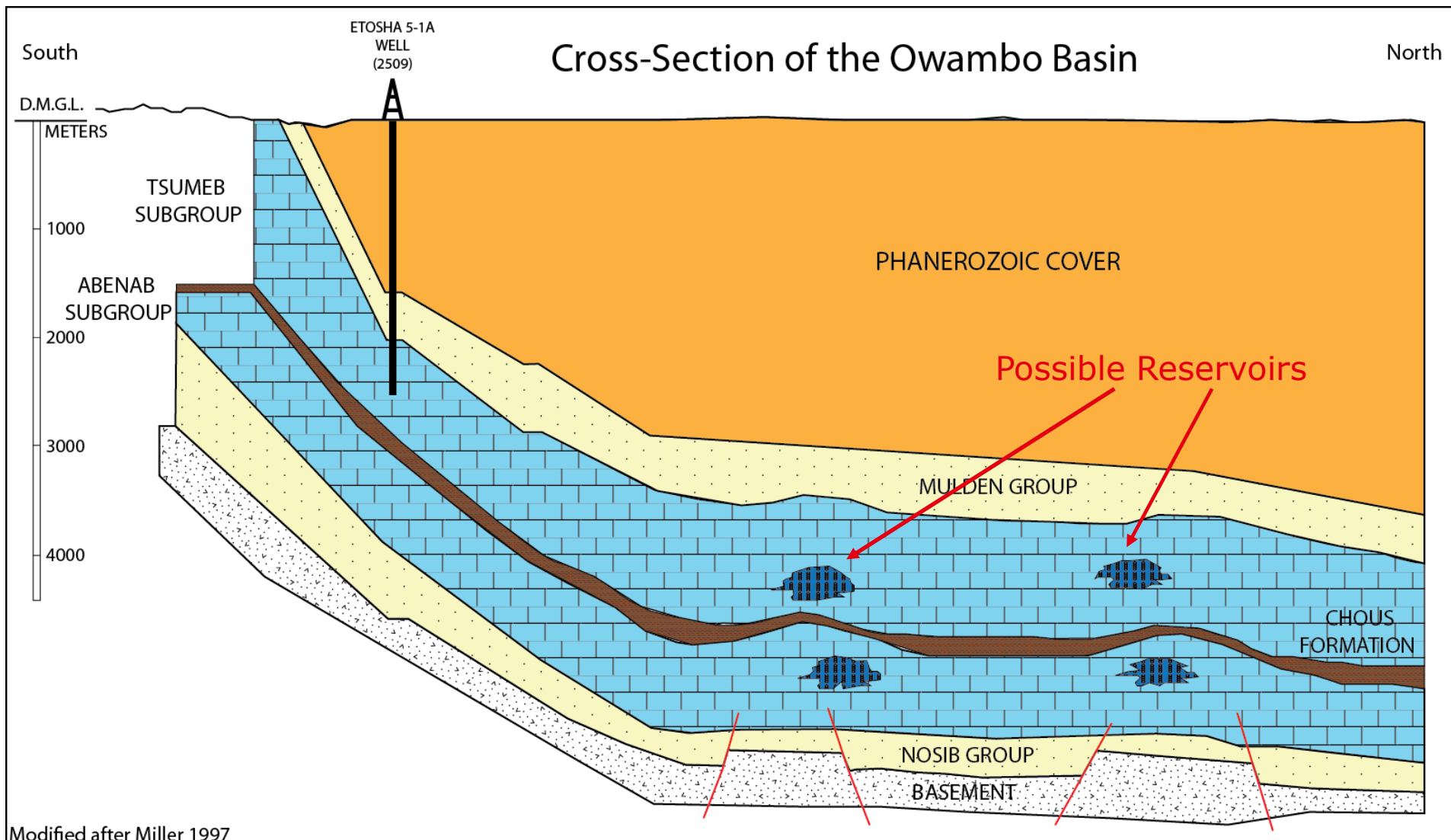
3D Digital Reservoir Model of a Microbialite Reef
in the Neoproterozoic Nama Group in Namibia

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- Introduction of the Neoproterozoic Research Programme
- LiDAR-based fieldwork
- Facies and fracture modeling
- Development of a hydrocarbon reservoir model
- Preliminary insights

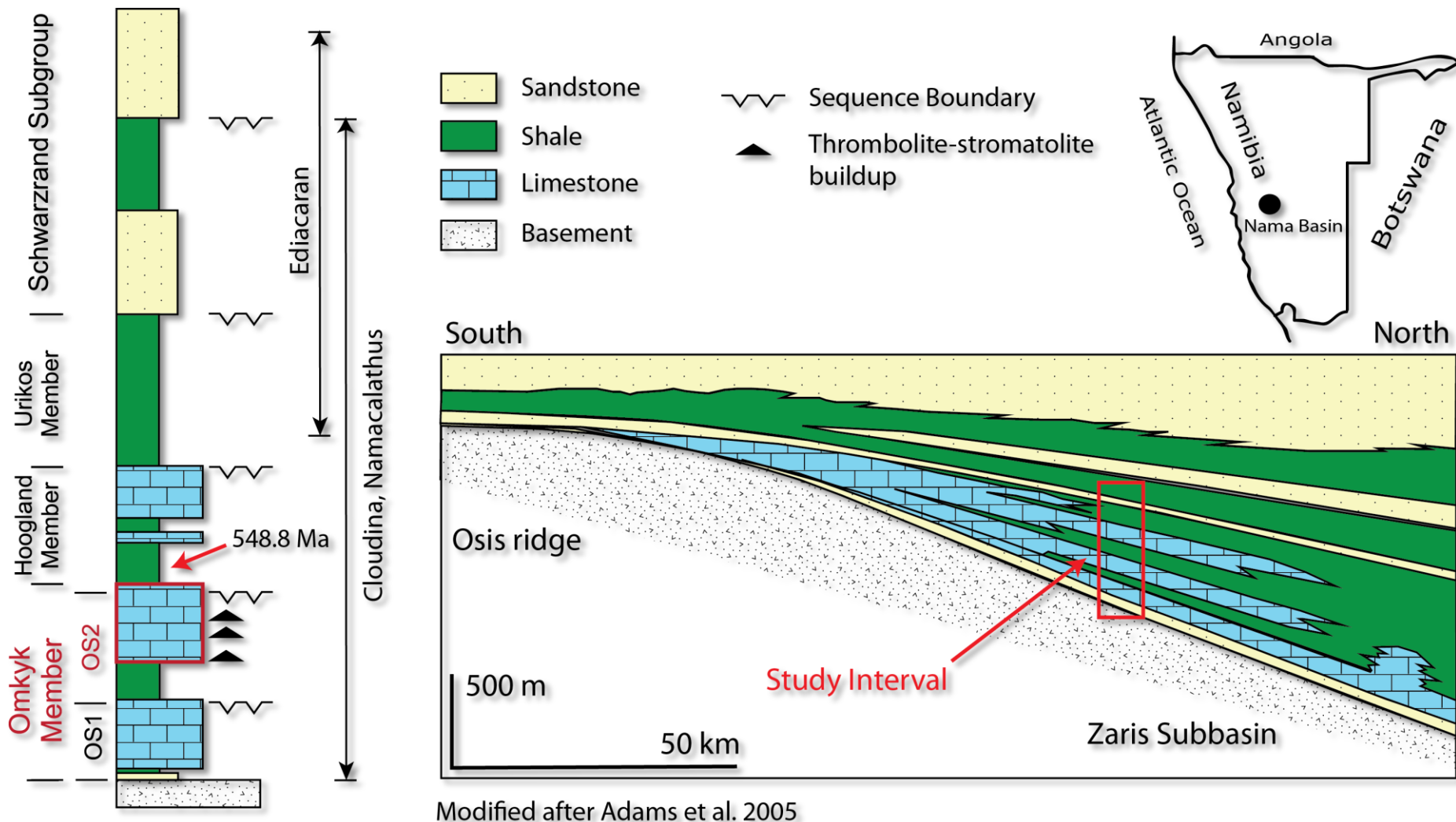




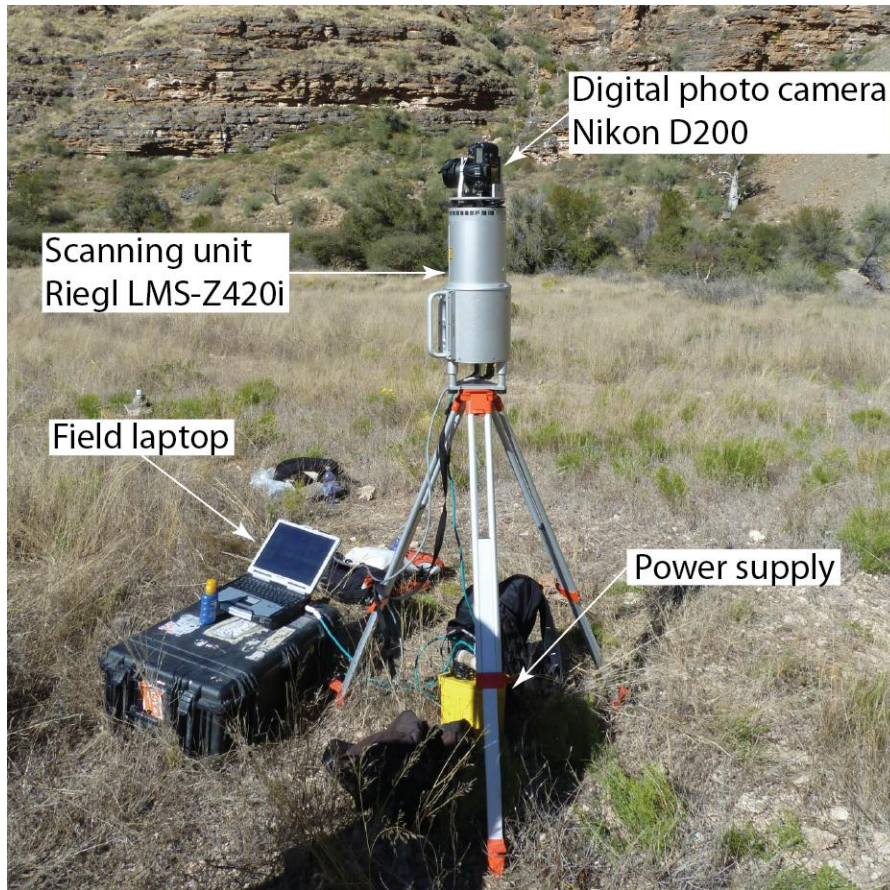
Modified after Miller 1997



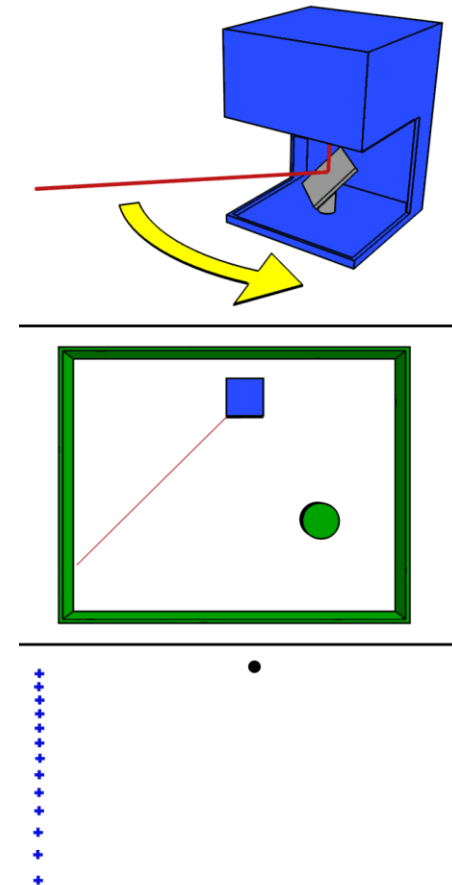
Kuibis Carbonate Ramp

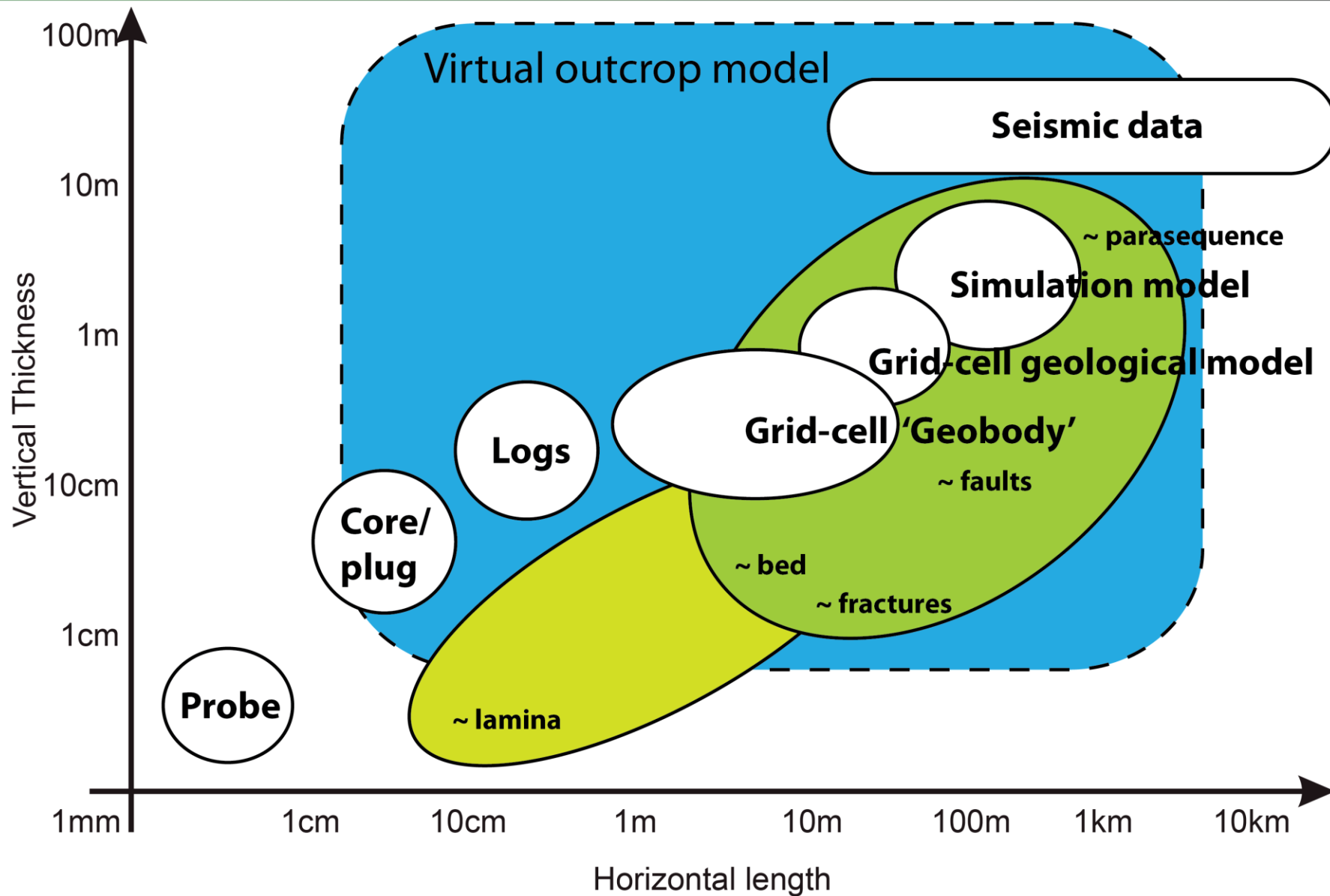


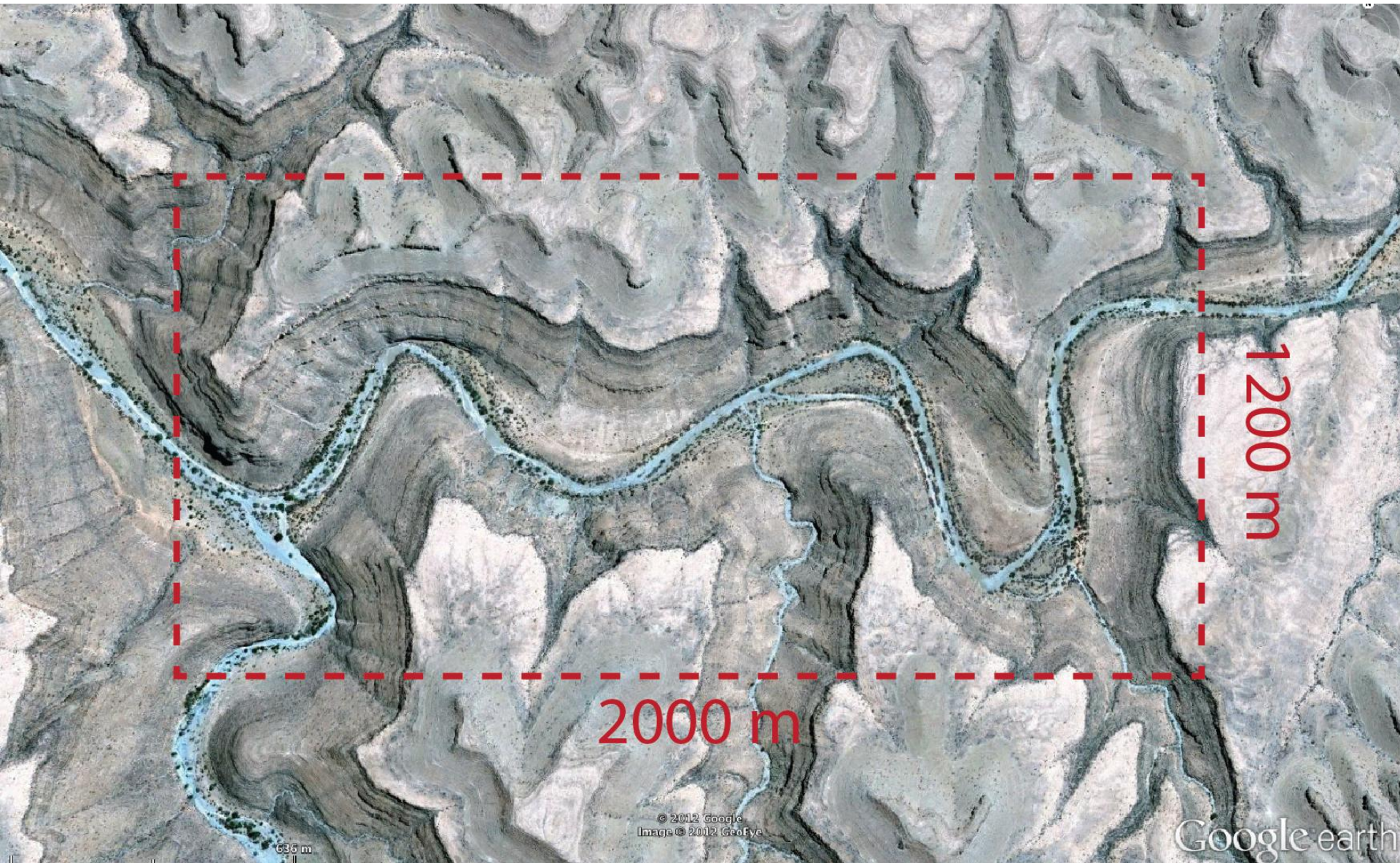
LiDAR: Light Detection And Ranging

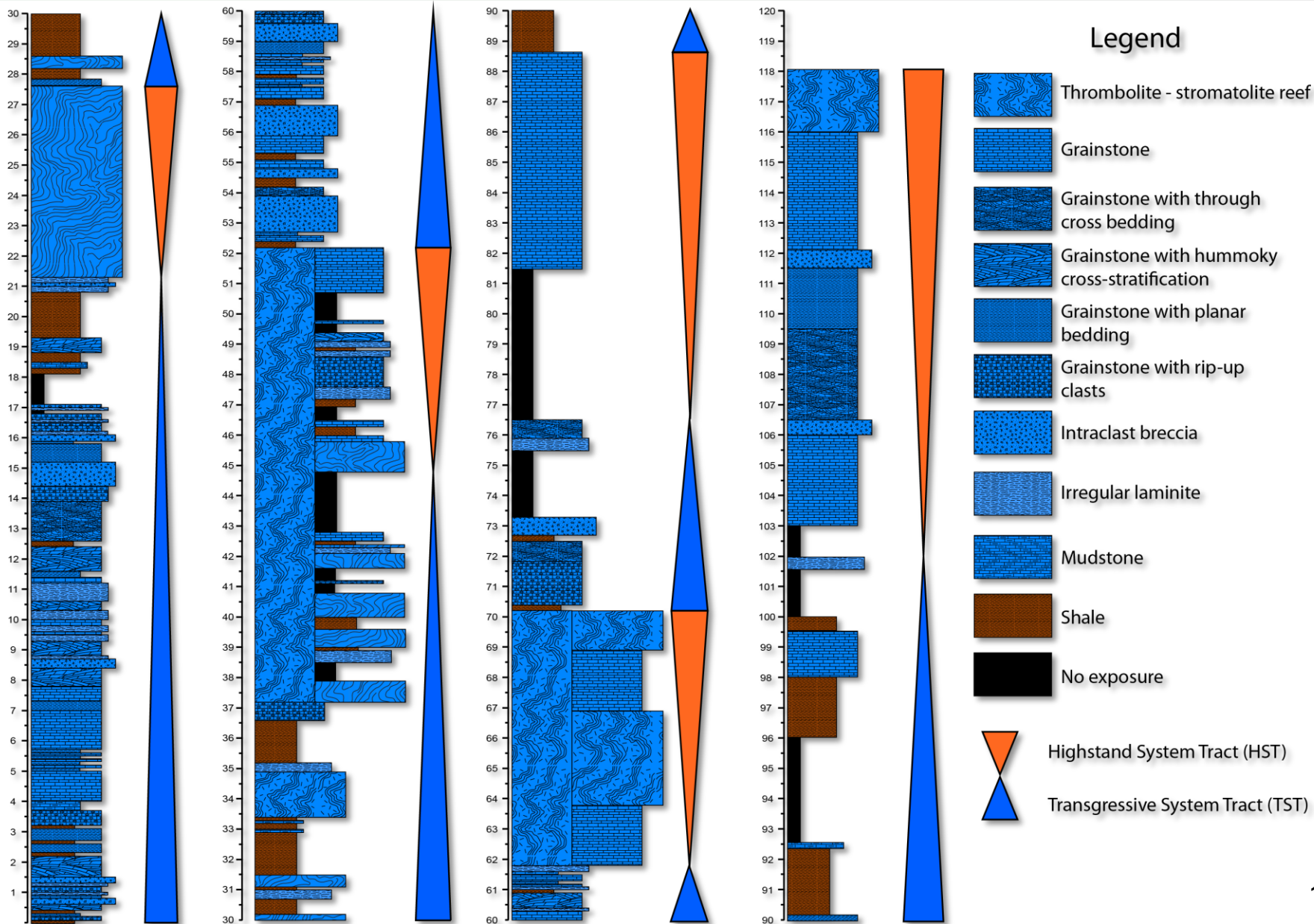


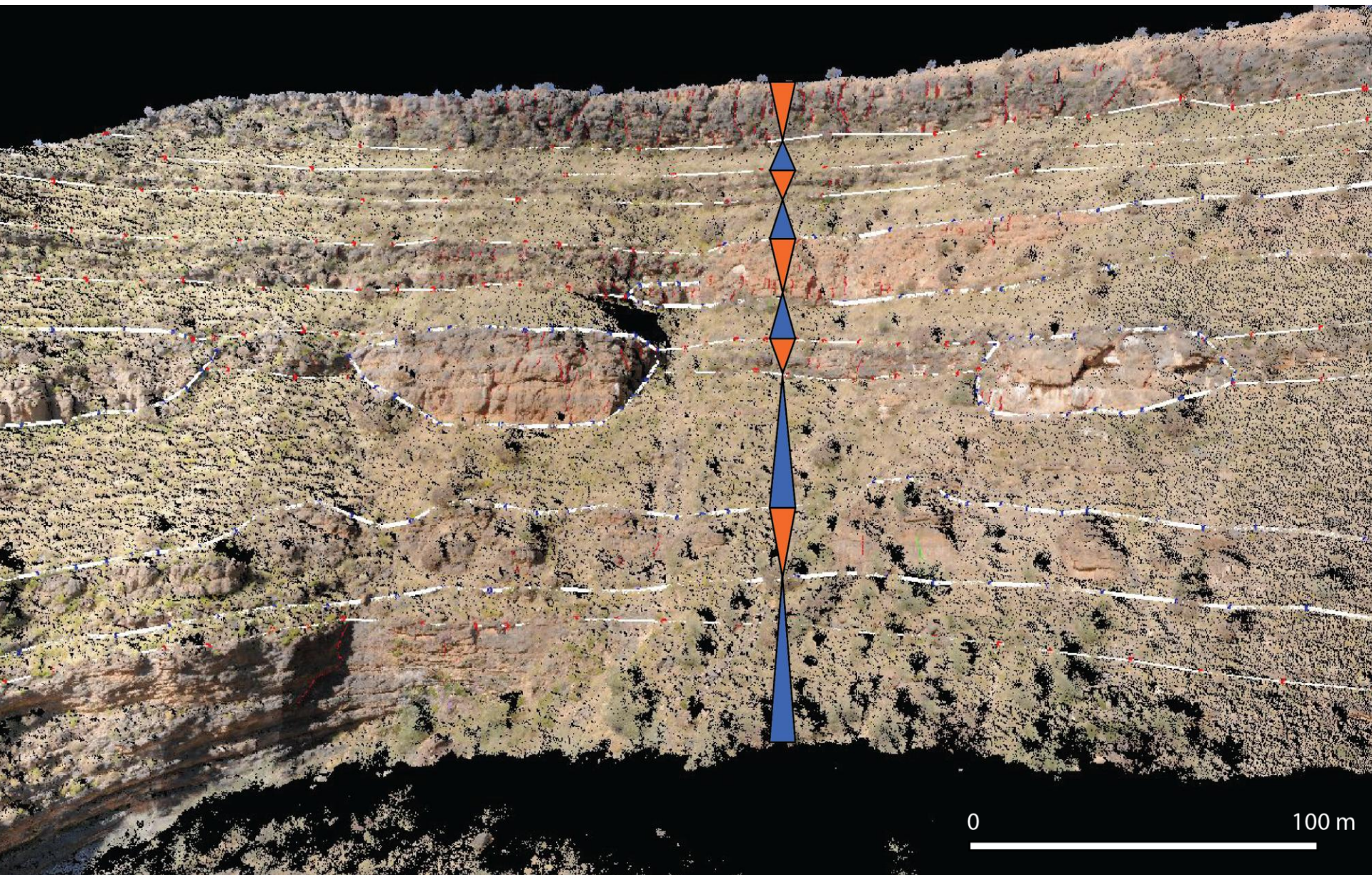
Riegl LiDAR scanner









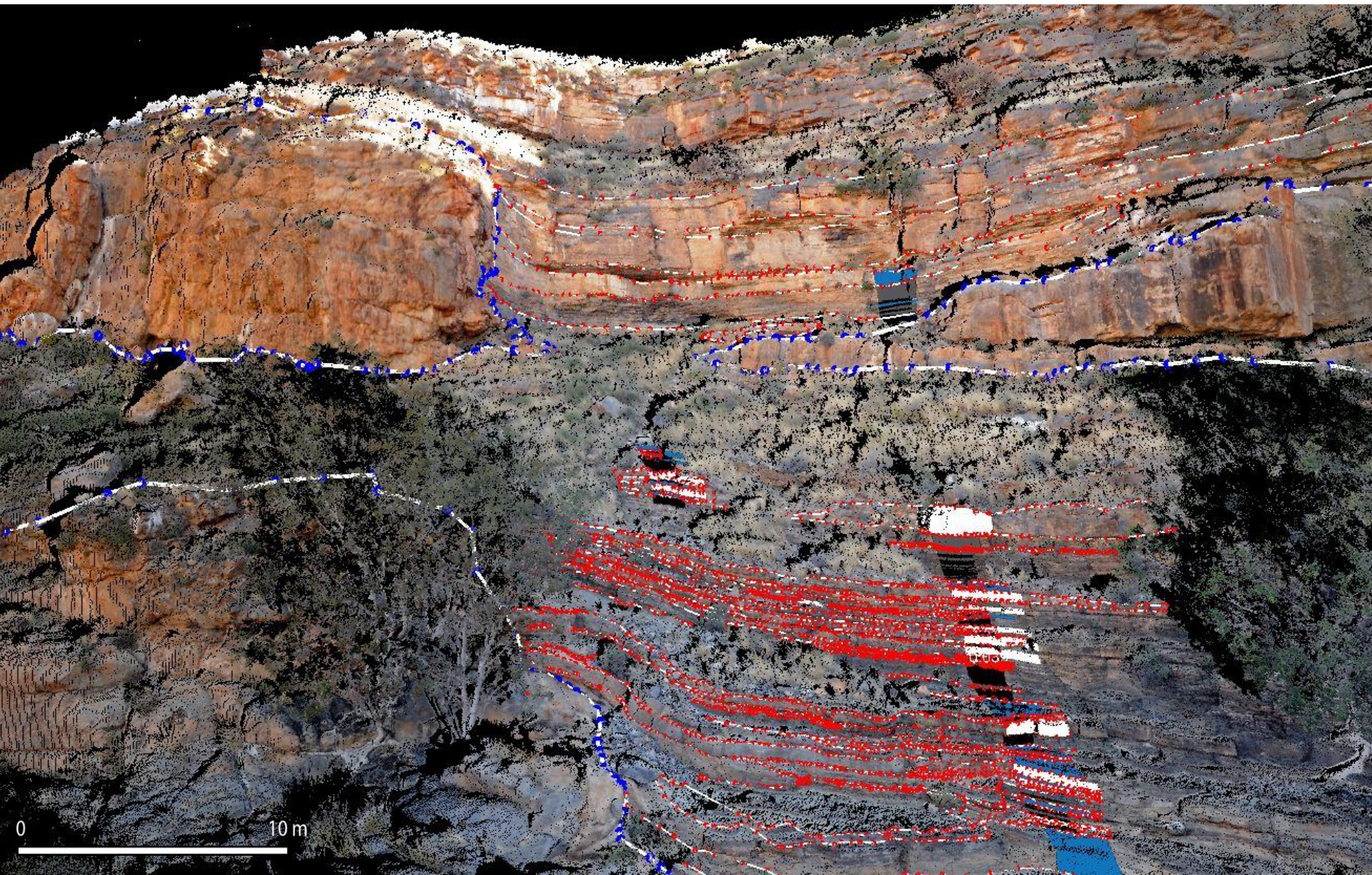


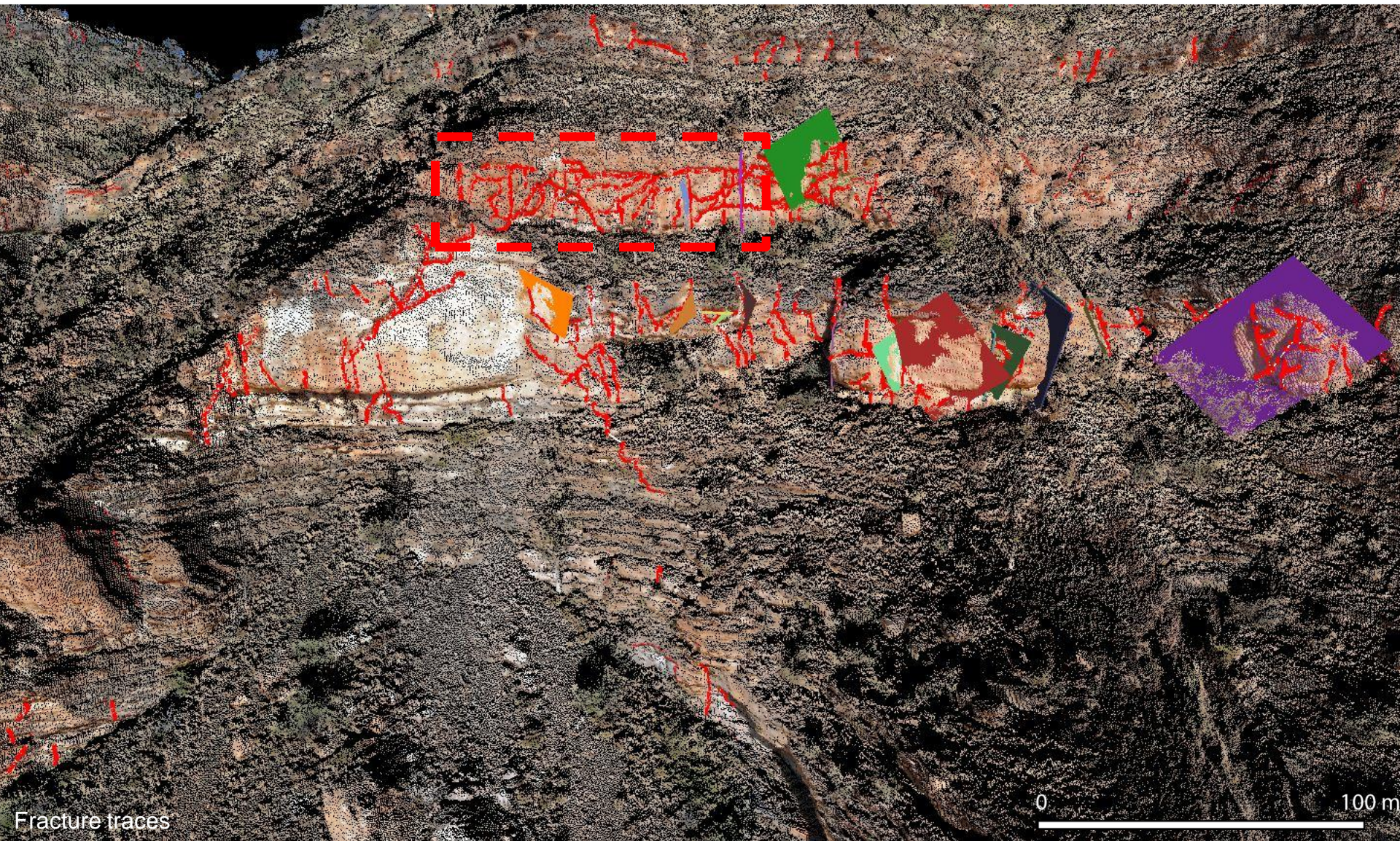
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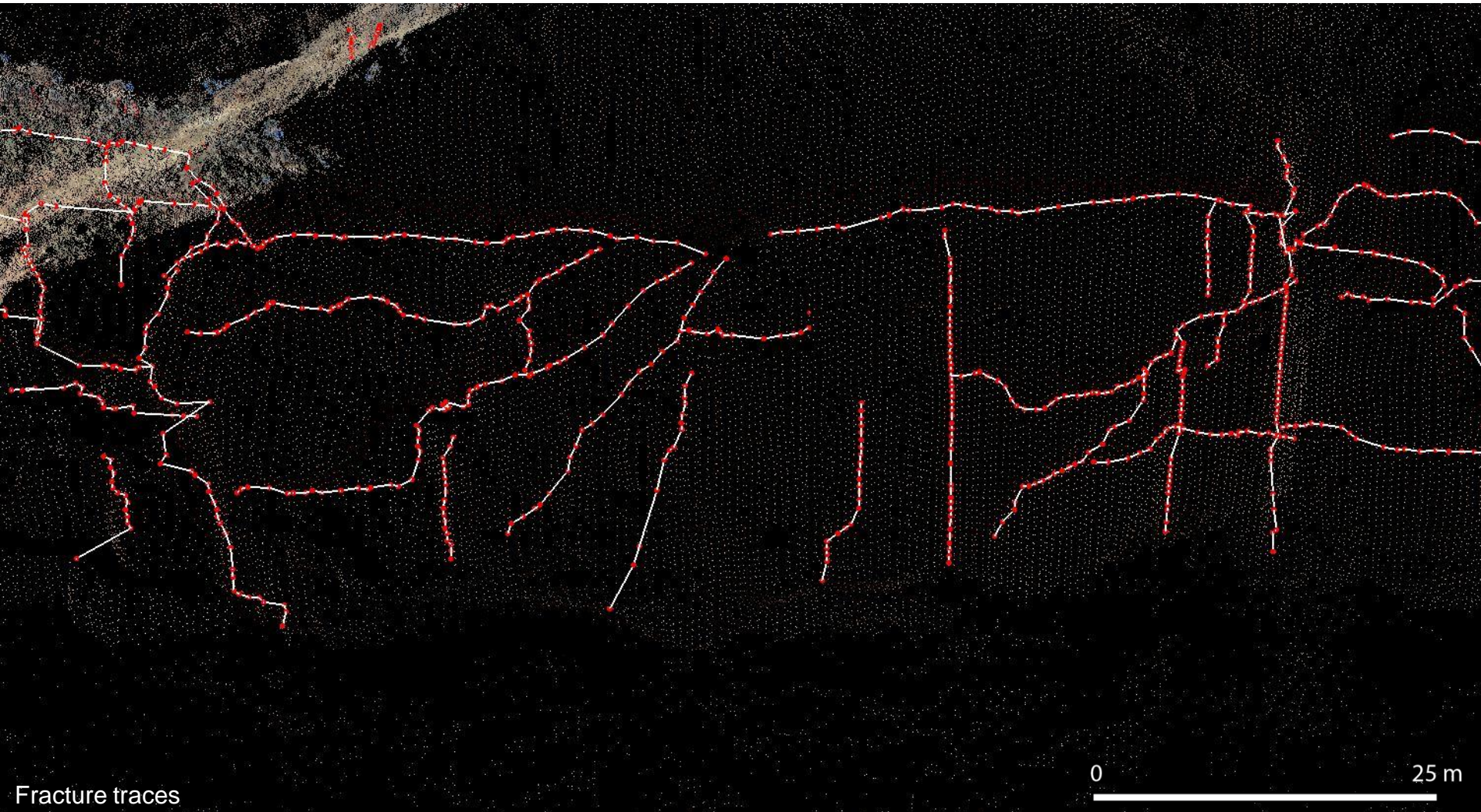
- Reservoir characteristics
 - Evolution of the microbial build-ups
 - Horizontal and vertical facies variations
 - Fracture modeling
- Development of a geocellular reservoir model
 - for reservoir simulation
 - to optimize well planning
 - and drilling operation

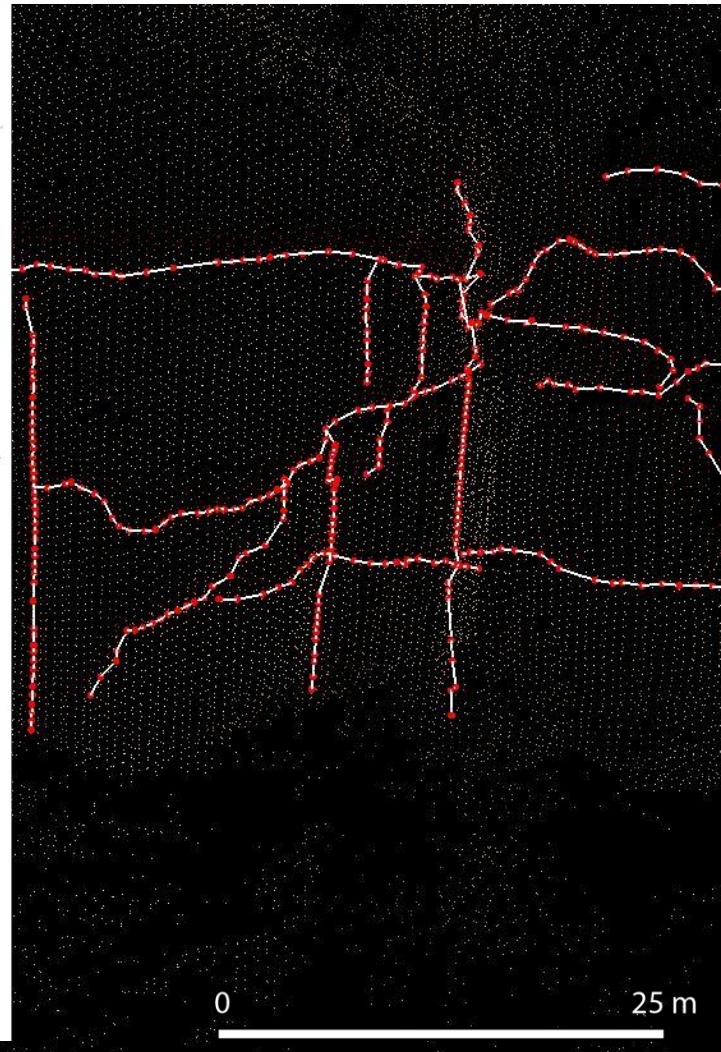
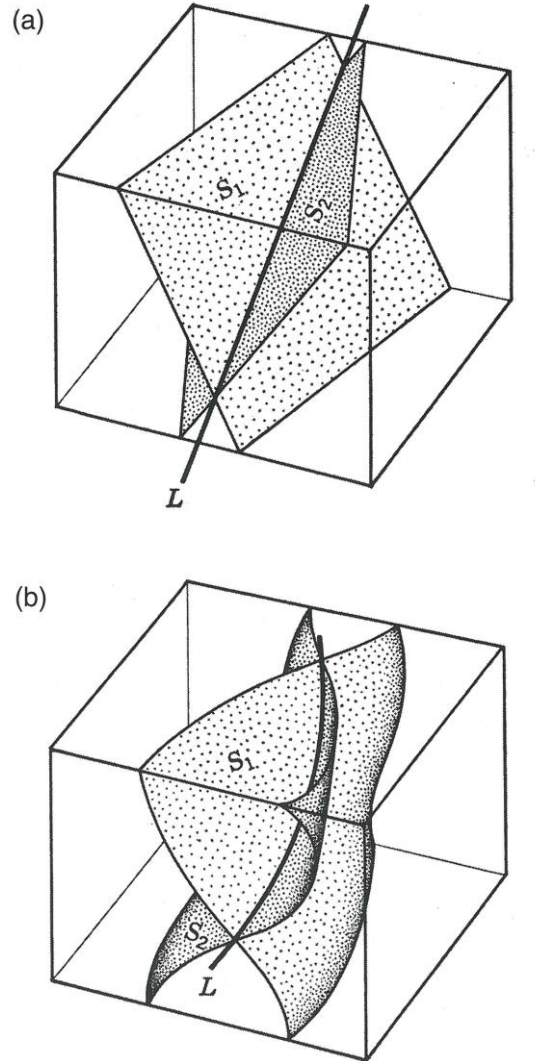
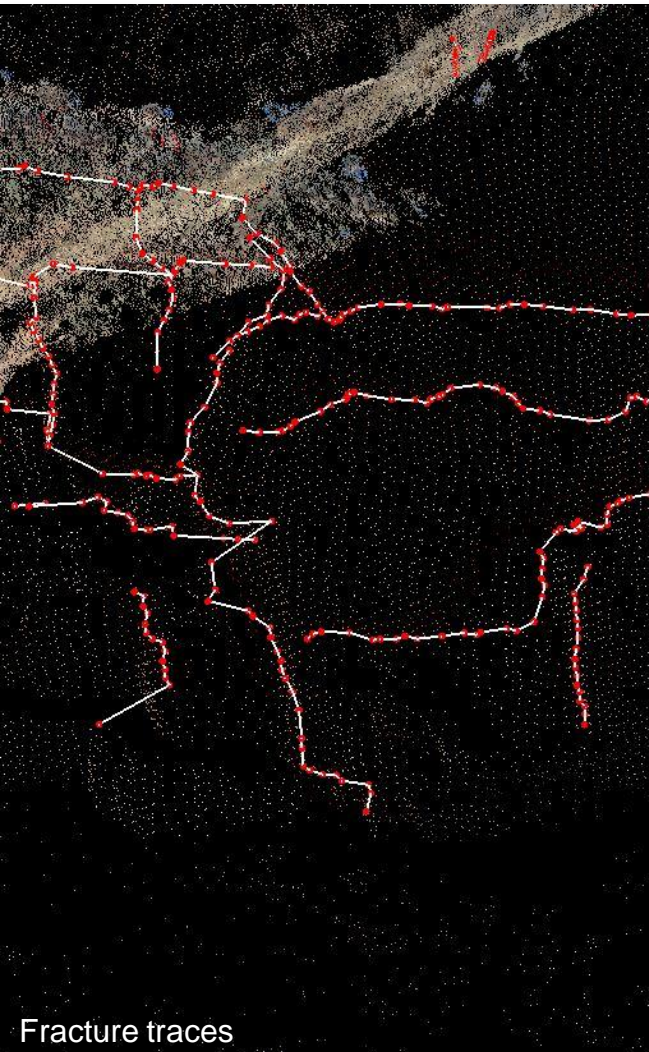


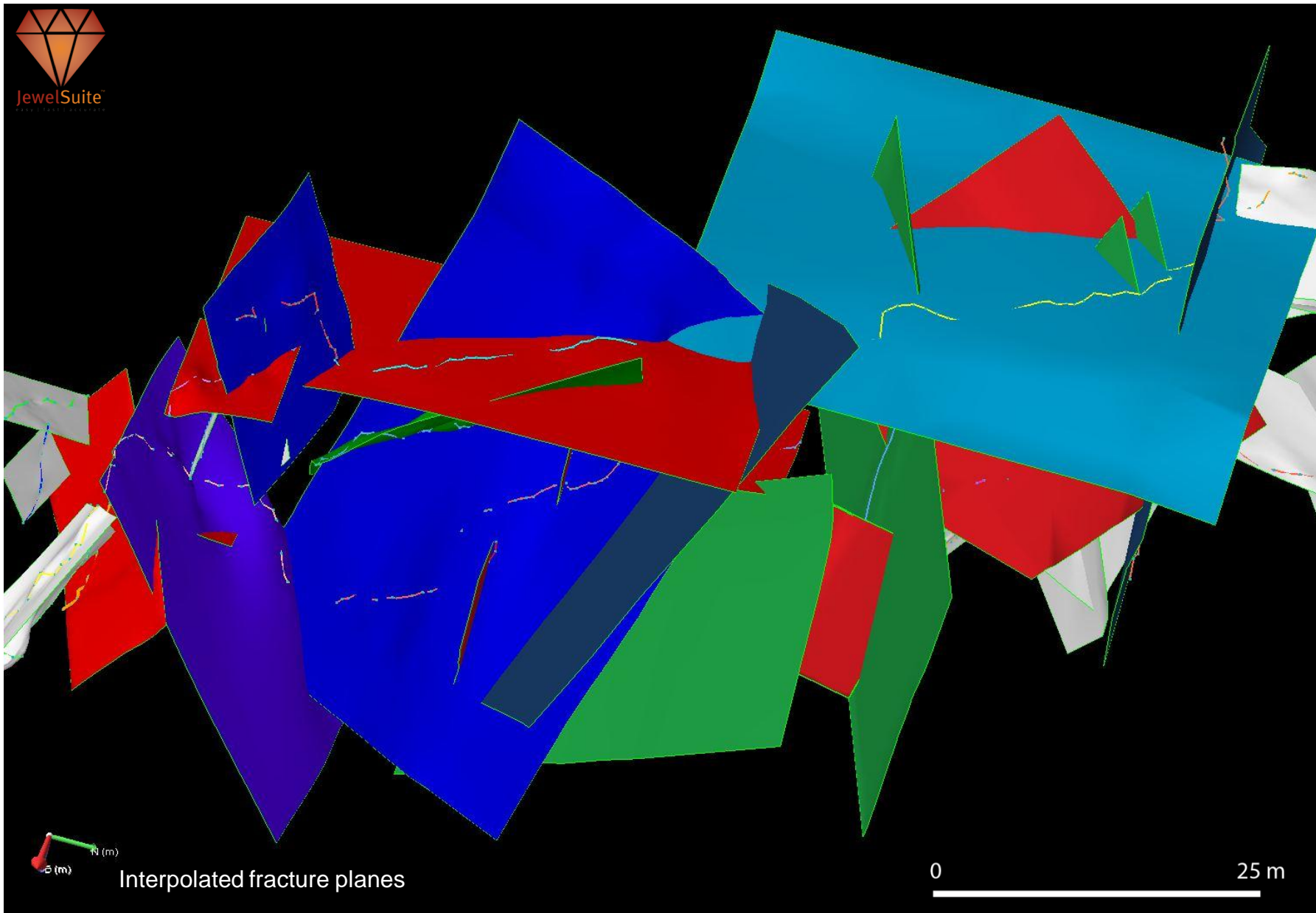


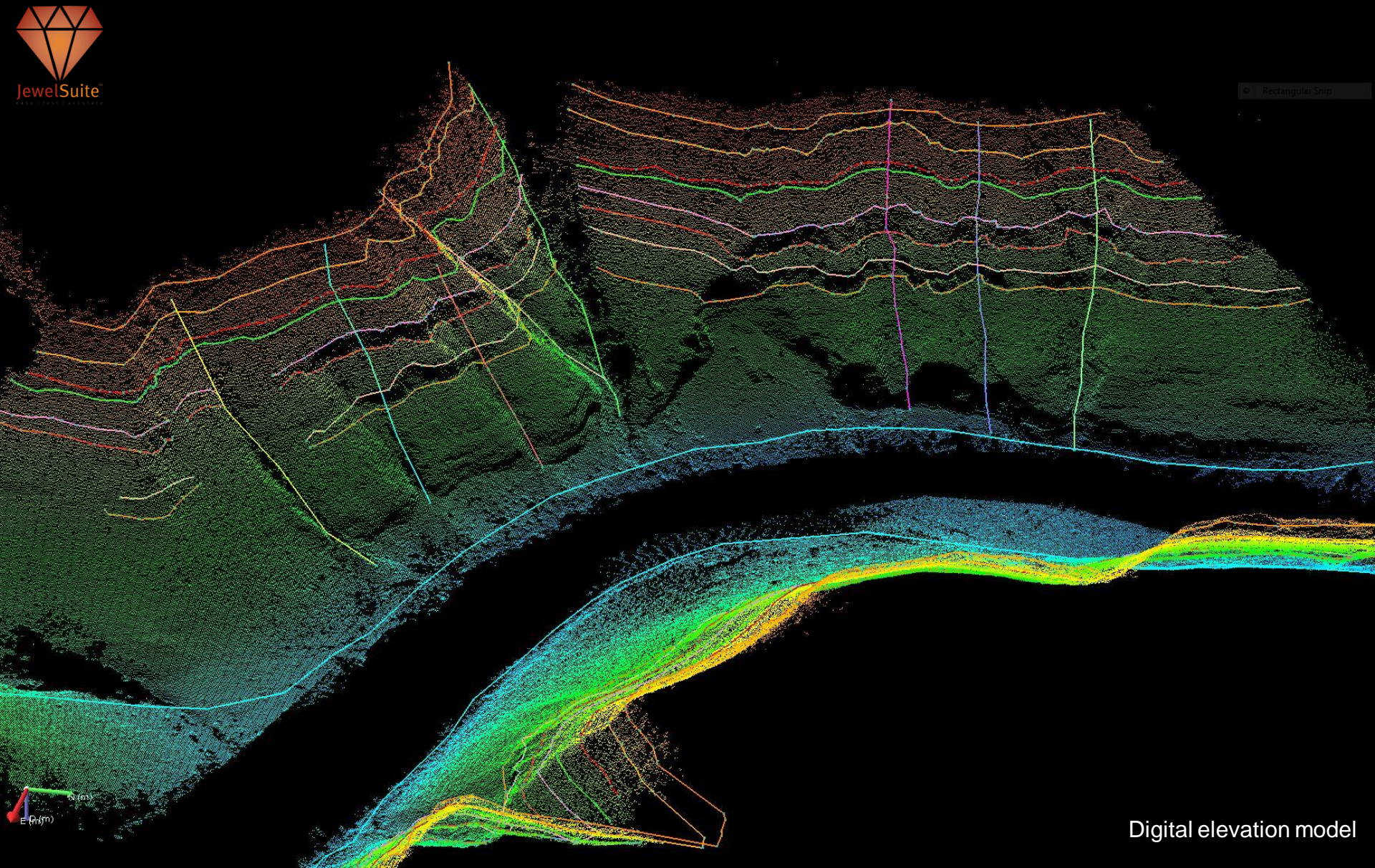


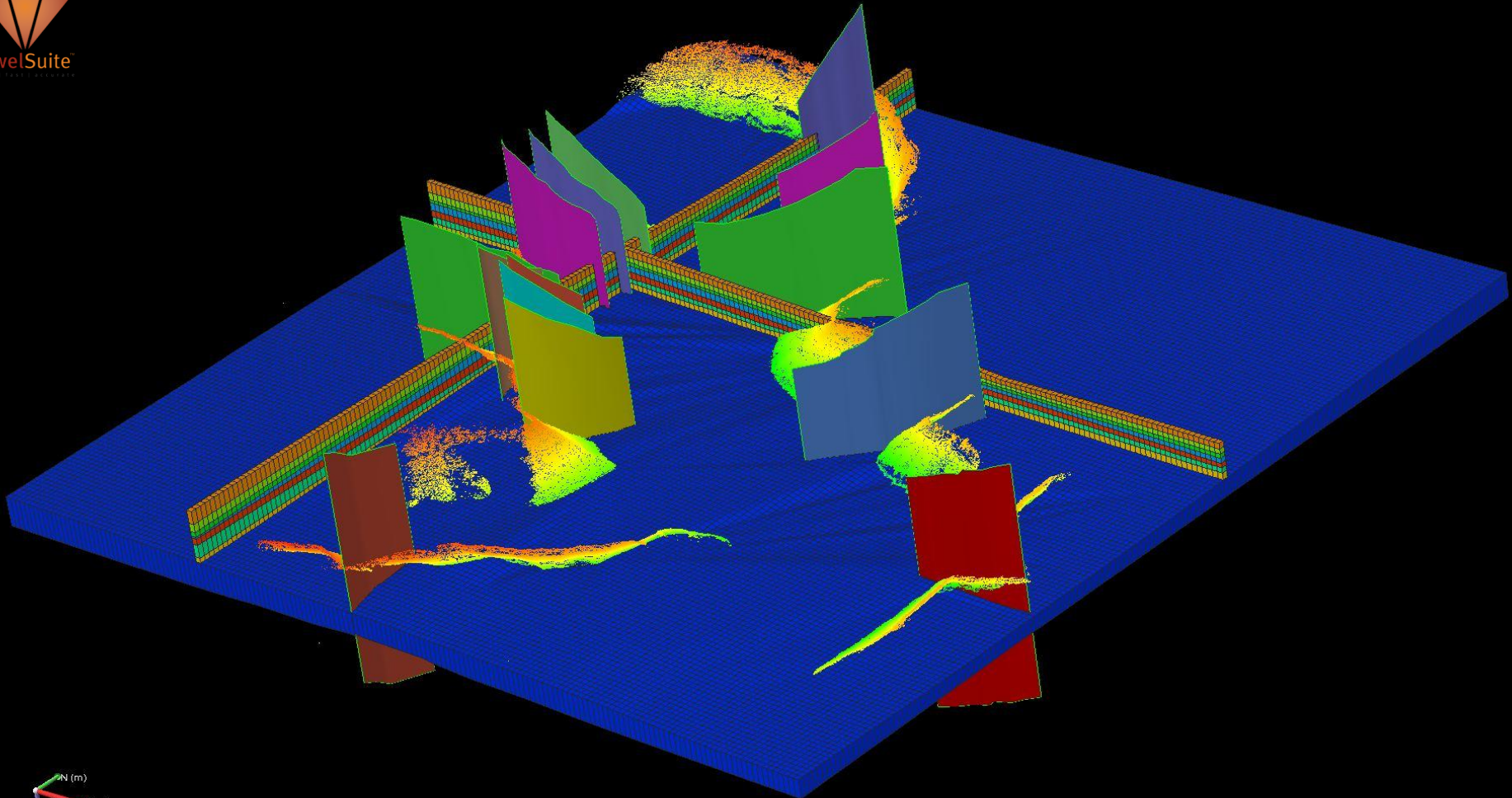
Fracture traces



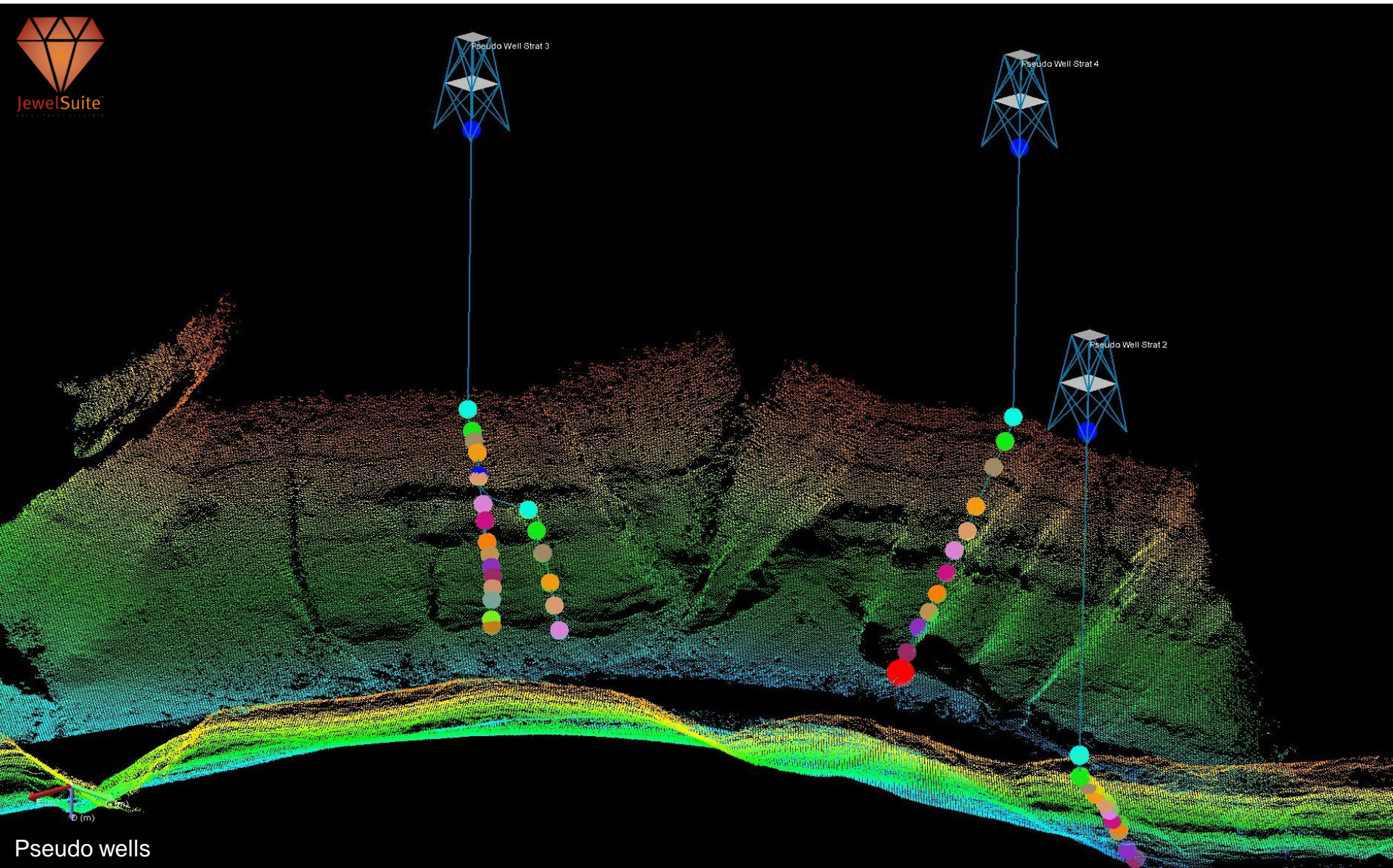




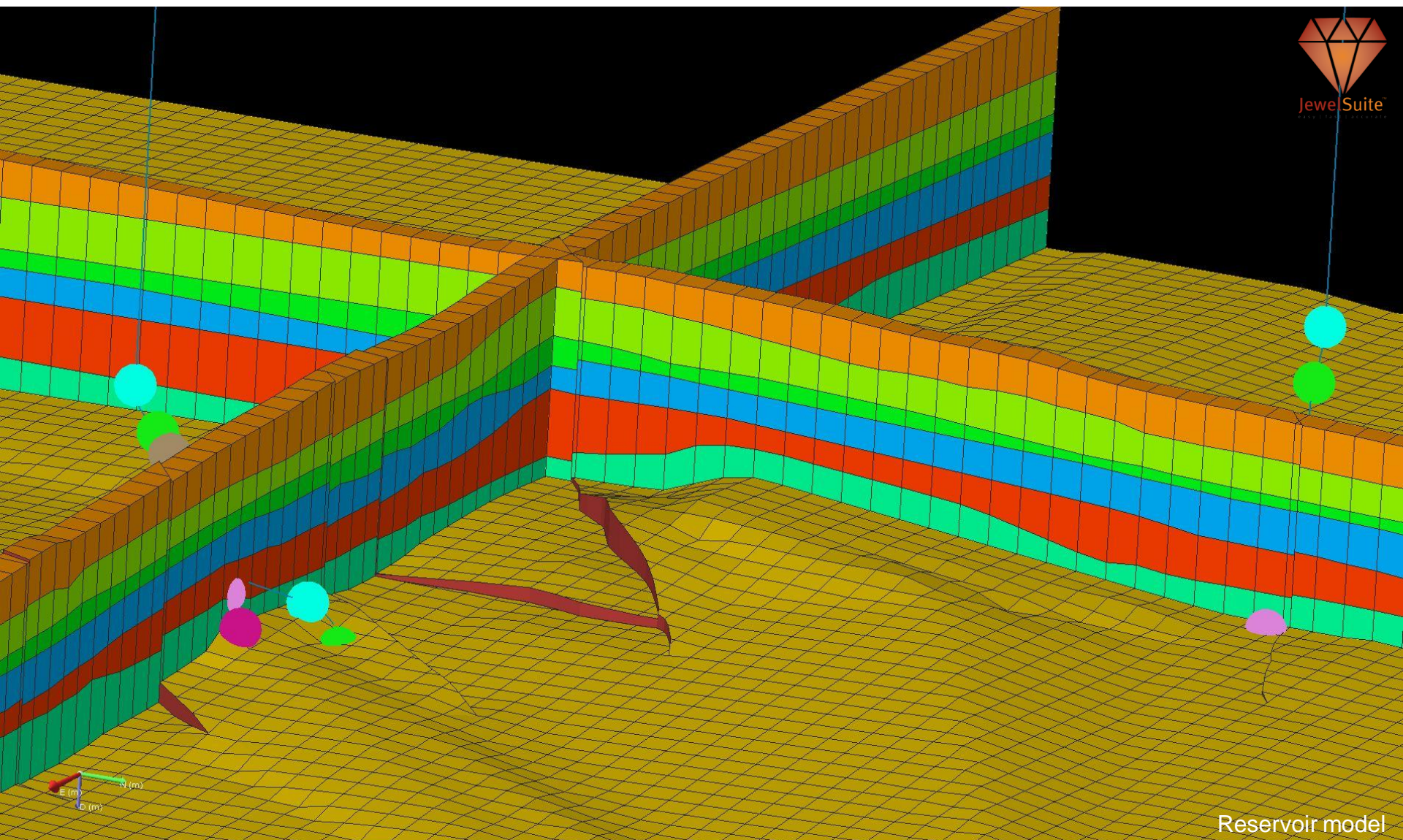


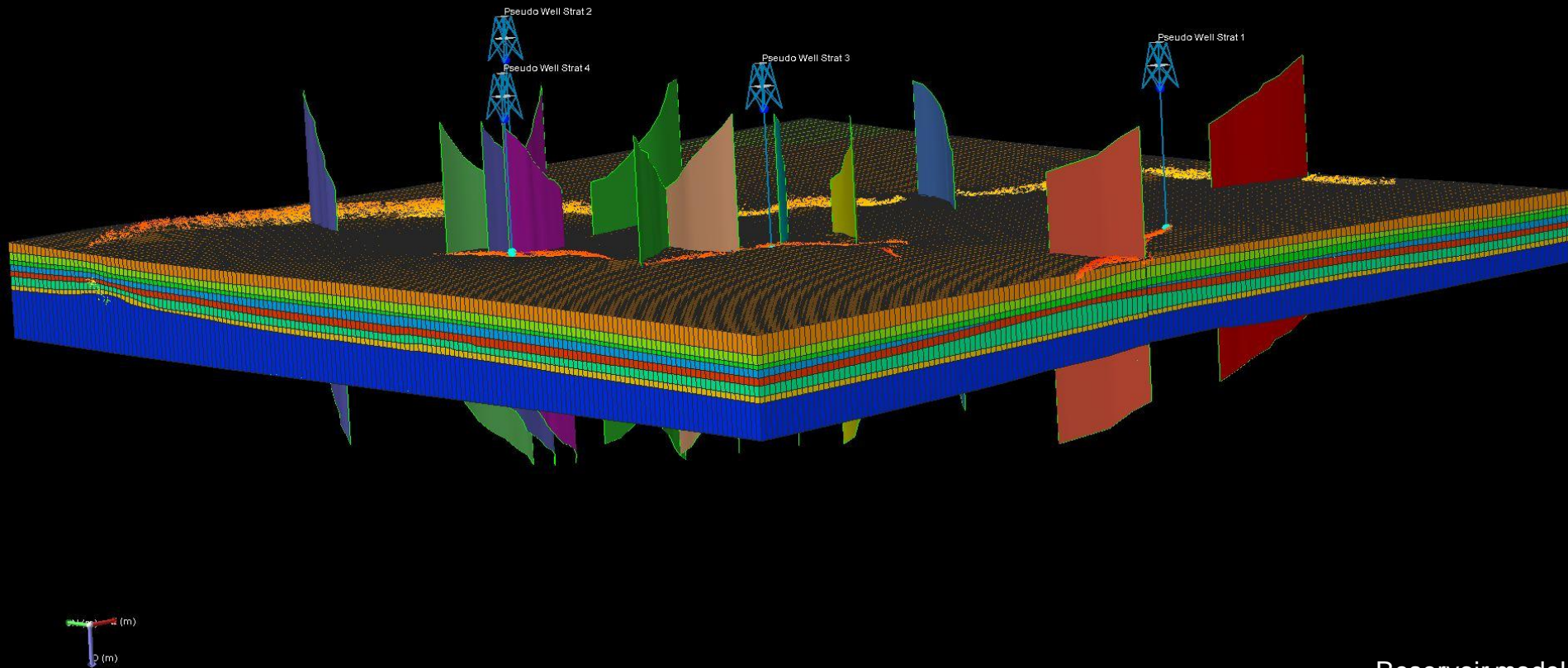


Reservoir model



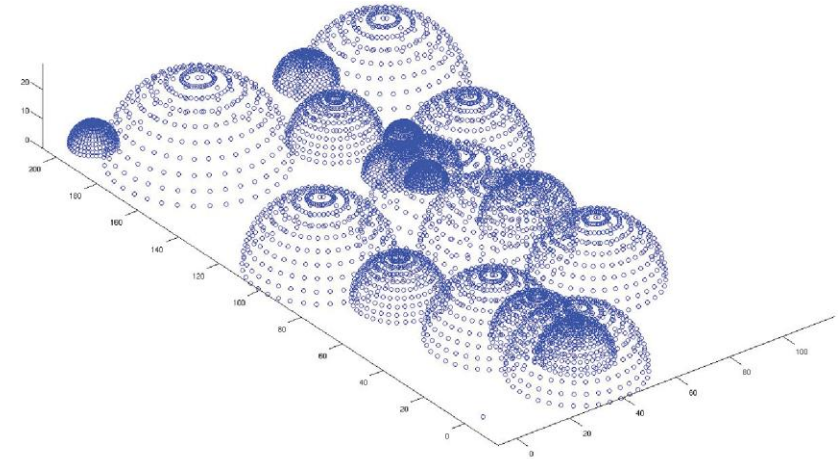
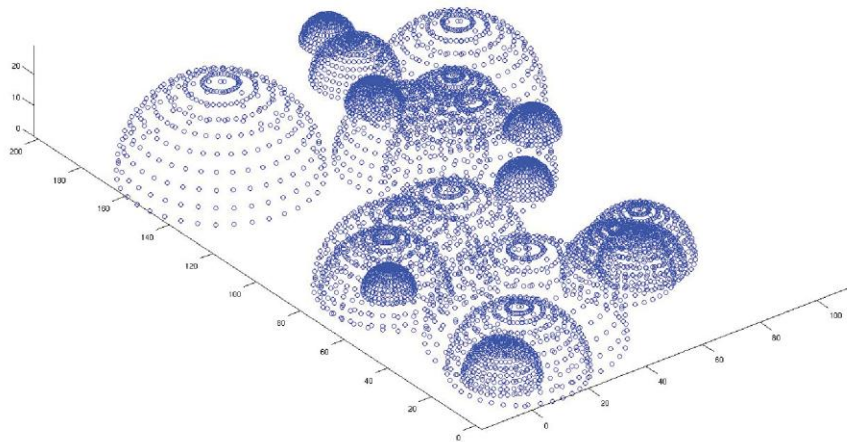
Pseudo wells



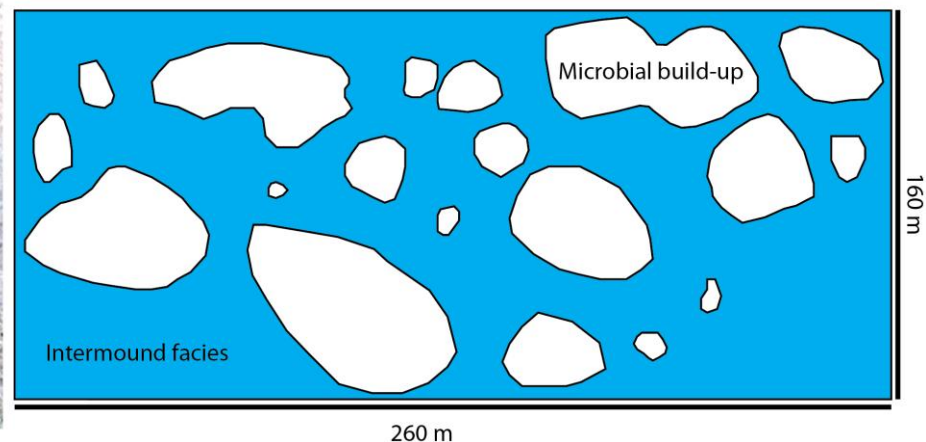
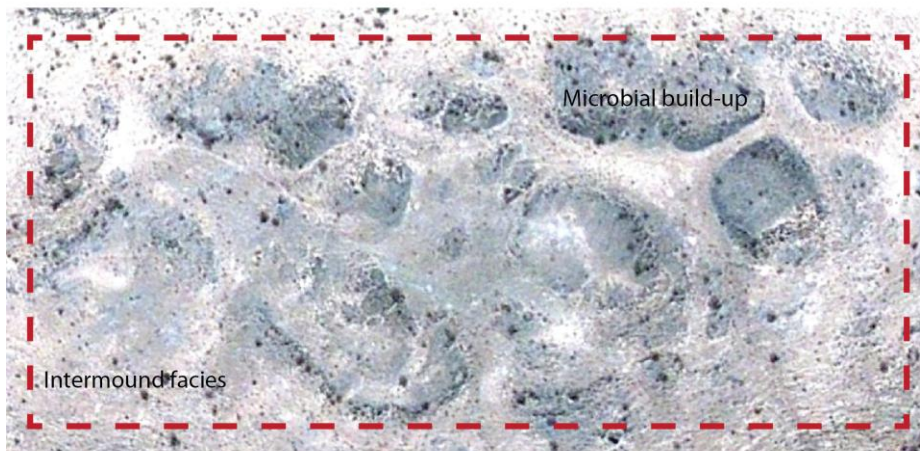


Reservoir model

Matlab based numerical forward modeling



Multiple-point geostatistics



- LiDAR is an excellent method to acquire data for static reservoir modeling. The implementation into JewelSuite reservoir modeling software is a straightforward process.
- Characterization of the vertical and horizontal facies variations in the microbial reef system.
- Fracture network characterization and modeling.
- This approach has direct implication to optimize drilling and completion.
- Not only implications for the Neoproterozoic potential reservoirs but also for the Pre-salt reservoirs offshore Brazil.