Reservoir Modelling of a Bioclastic Calcarenite Complex on Favignana, Southern Italy: The Application of Multi-point Statistics*

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Abstract

The island of Favignana provides an exceptional three-dimensional insight of the internal architecture of a Lower Pleistocene complex bioclastic calcarenitic wedge. Field data indicate that these calcarenites consist of foramol association, originated during cool to temperate water conditions in a high-energy, storm dominated, open shelf environment. Predominant sedimentary structures vary from small-scale trough cross bedding, large foresets to large scours filled by structureless massive bioclastic material. Overall a main transport direction to the SE indicates the prograding nature of these deposits. Based on the sedimentological characteristics and reservoir properties, this sedimentary complex is believed to be a relevant analogue for several important hydrocarbon fields worldwide such as the Perla Field in Venezuela.

A detailed reconstruction of facies distribution and description of sedimentary body dimensions and relative position have been carried out in order to model the reservoir heterogeneity and flow properties of a similar buried sedimentary complex. The rock properties could in fact change significantly during burial, as sedimentary bodies consisting of different primary textural and compositional characteristics could be subject to different type of diagenetic modifications.

The internal architecture of the Favignana calcarenite was thus reconstructed on a 3D geo-cellular model using a multi-point statistics (MPS) approach. For this, the following main types of input data were used:

1) pseudo-well data with stratigraphic and compositional information;
2) probability maps of each facies, created from field data and conceptual model;

3) training images.

The latter in particular are unique for the MPS approach and allowed us to create an arbitrary three-dimensional image which represents the distribution in space of the different sedimentary facies. Because the large availability of exposures due to both natural outcrops and extensive quarries this case study provide a unique opportunity to test and validate the reliability of the MPS modeling approach on a field scale area (2x3 km).

Overall the results obtained are well representing the overall architecture as described by the conceptual geological model generated from outcrop data. The use of MPS, compared to other geostatistical facies modelling approaches, is therefore preferable for situation where a solid conceptual geological model, validated by hard data, is available.

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Reservoir Modelling of a Bioclastic Calcarenite Complex on Favignana (southern Italy): the application of Multipoint Statistics

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Introduction

- Outcrop modelling is often considered the ultimate test for geo-modelling softwares
  - *"If you cannot draw it , you cannot model it"*
- Multi Point Statistic is a 'fashionable' approach and seems to be the one allowing to capture better the 'nature' of reservoirs
- Geo-modelling teaching tool

Project Outline

- **Where**: Favignana Island (West of Sicily, Italy)
- **What**: Lower Pleistocene bioclastic wedge complex exposed along the coast of the island as well as in several quarries, providing a unique opportunity for data collection and 3D geometry reconstruction.
- **How**: standard field work access from land and sea, coupled with reservoir rock characterization lab analysis and 3D modeling.
- **Who**: Delft University of Technology/University of Geneva + University of Utrecht (Arnoud Slootman)

Objectives

- **'Quick Modelling Approach'**
  - Large data set and well distributed.
  - 'Good' understanding of geology and 3D architecture.
  - Set Expectations.
  - Ability to validate model in the field.

    - Test different modelling approaches available on Petrel 2010

Study Area

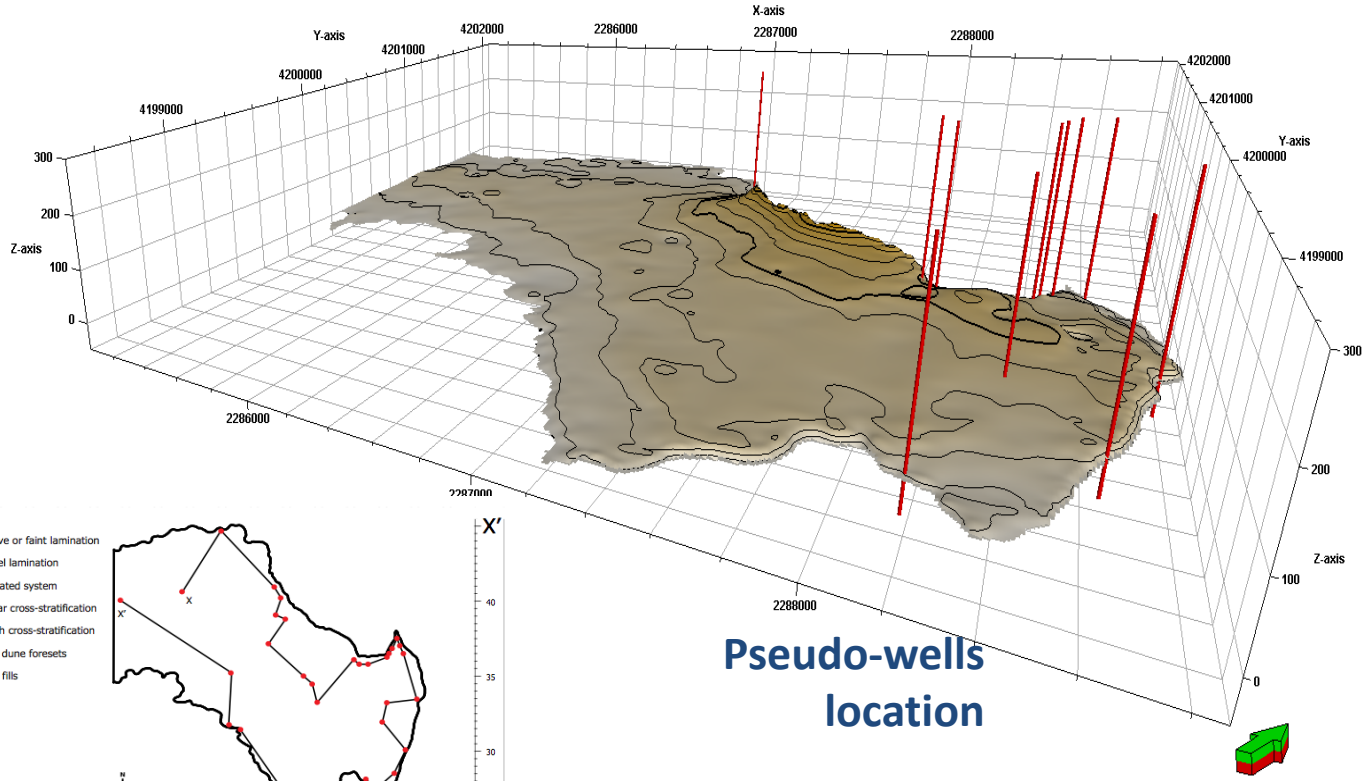
Egadi
Archipelagos

Arrows indicate main outcrops along the coast

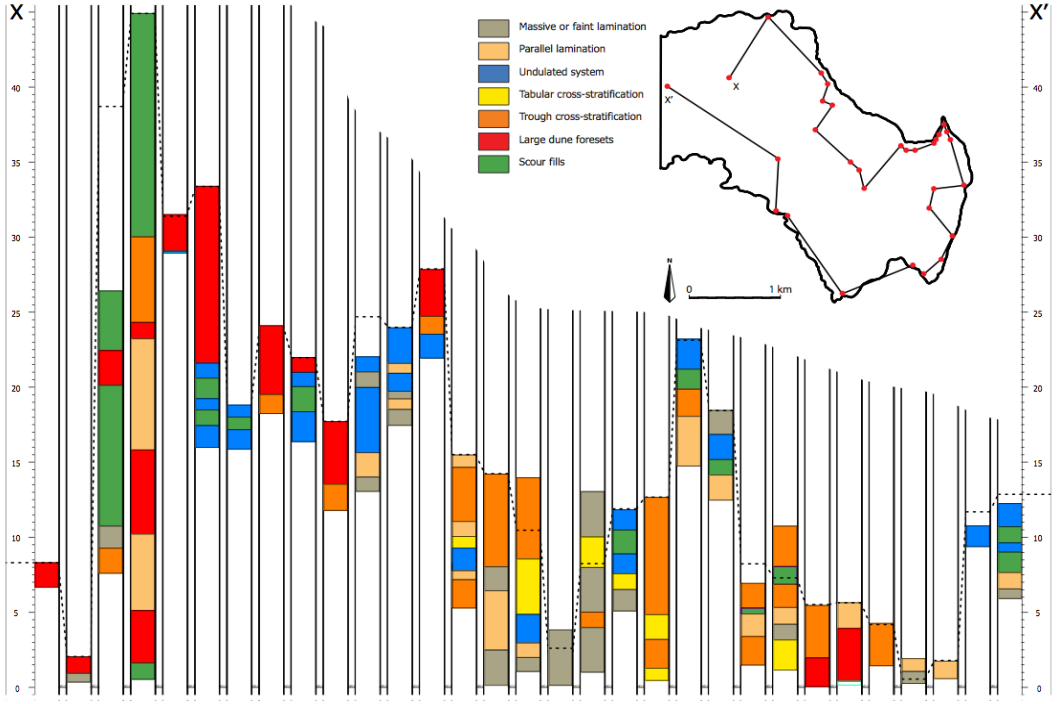
Favignana Island

Continue exposures along the coast,
together with large number of active and ancient quarries makes this area a good case study to reconstruct the 3D sedimentary architecture.

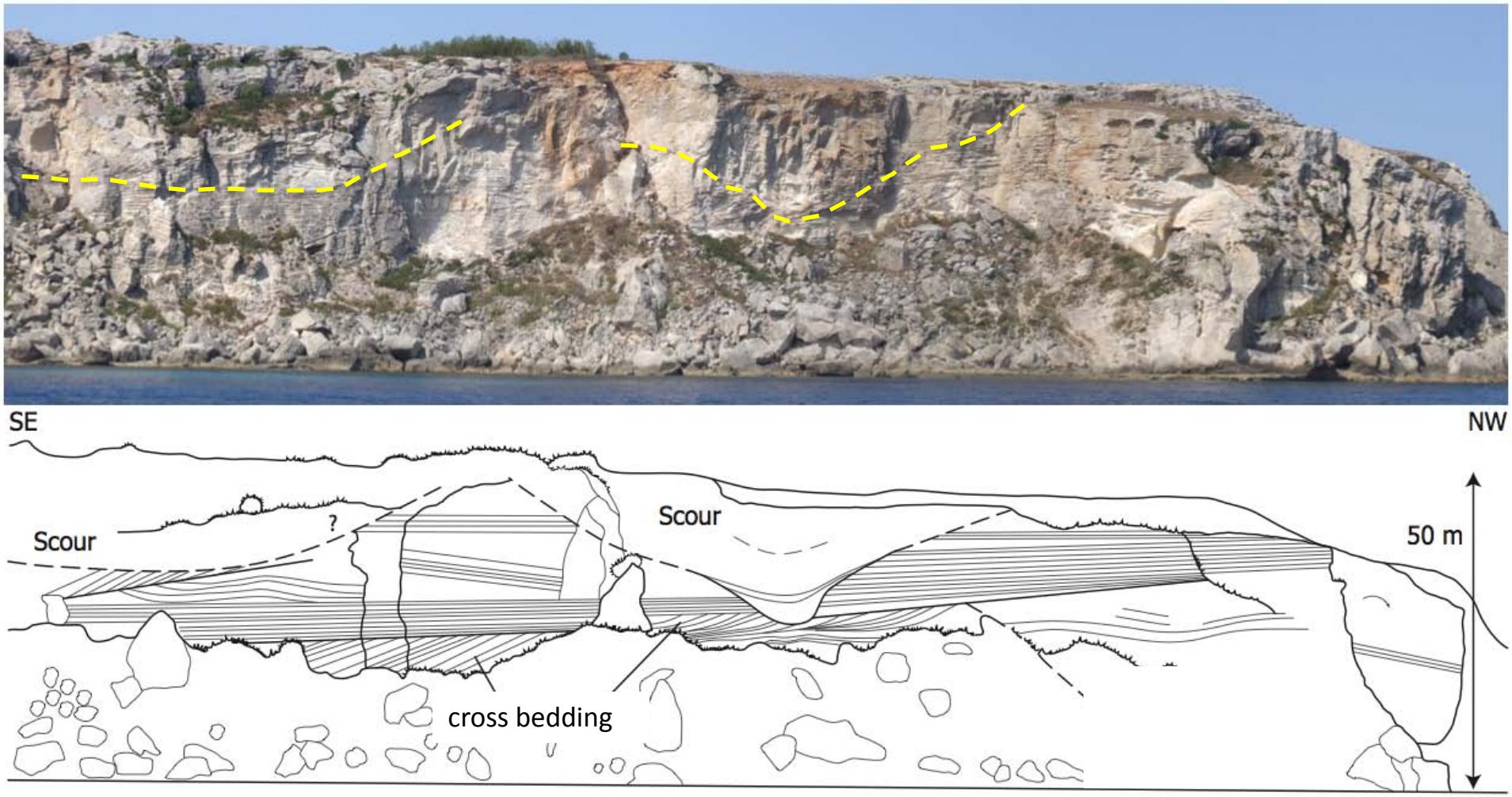
Favignana Biocalcarenites Stratigraphy

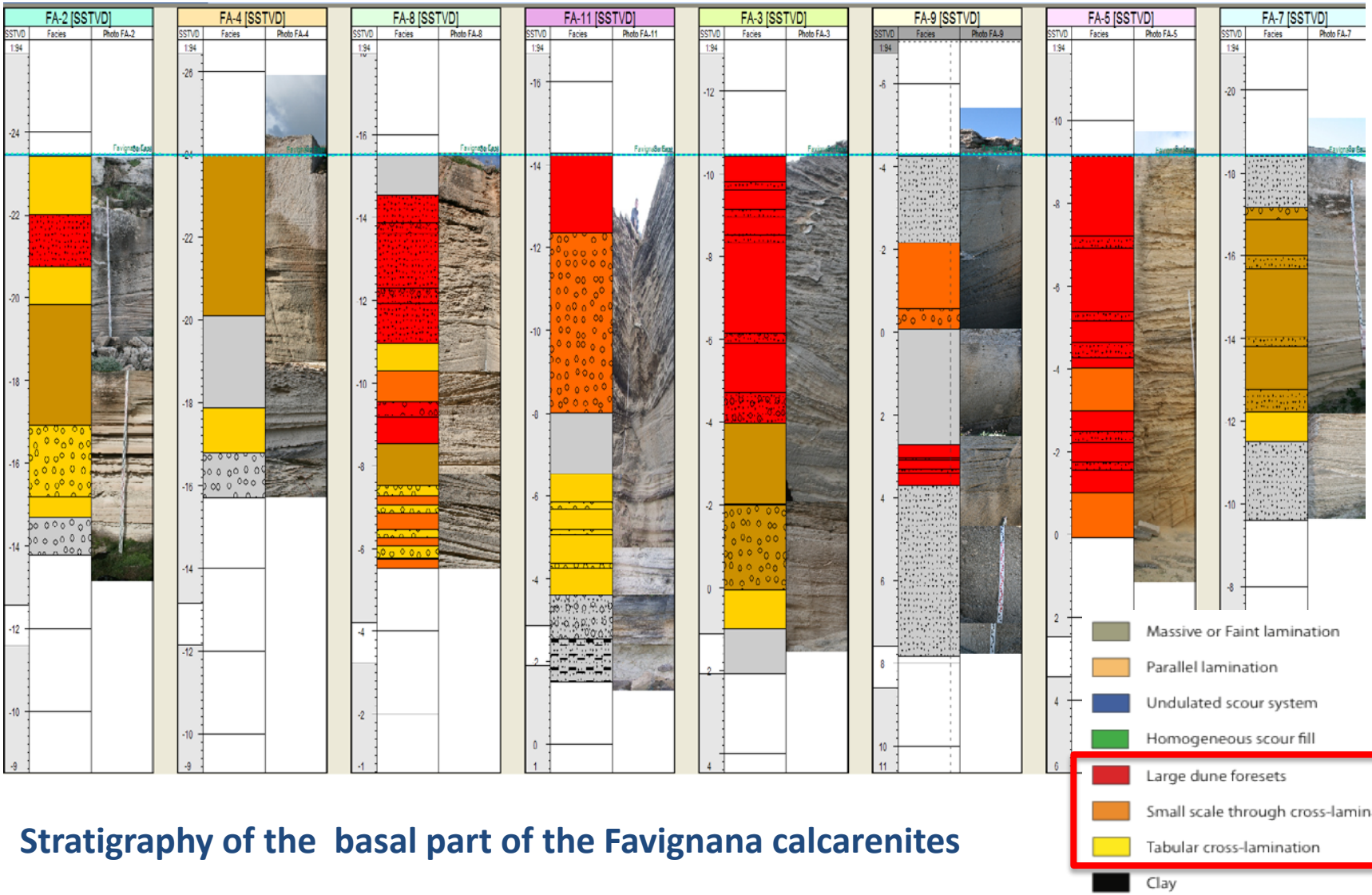


Pseudo-wells location

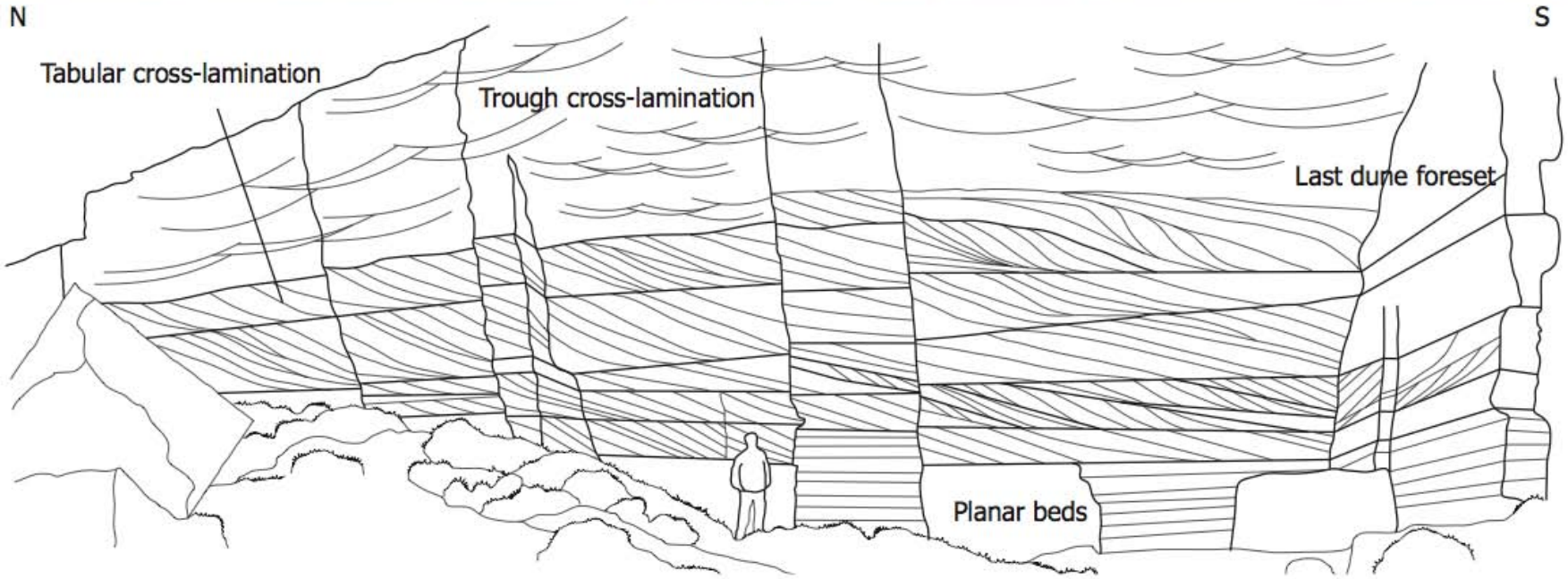


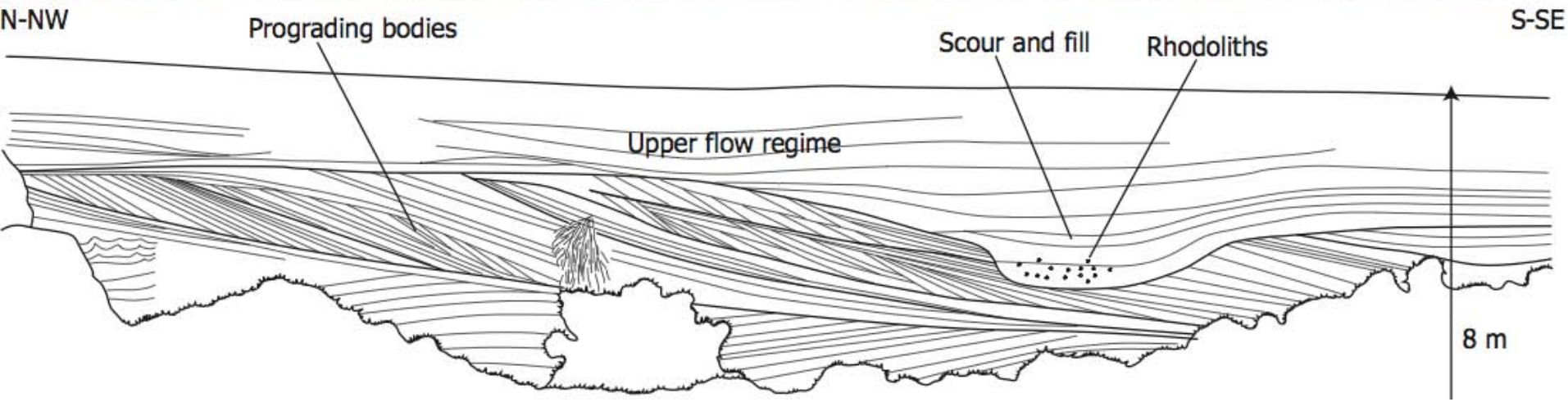
Pseudo-wells correlation


SE
NW
Scour
?
Scour
50 m
cross bedding

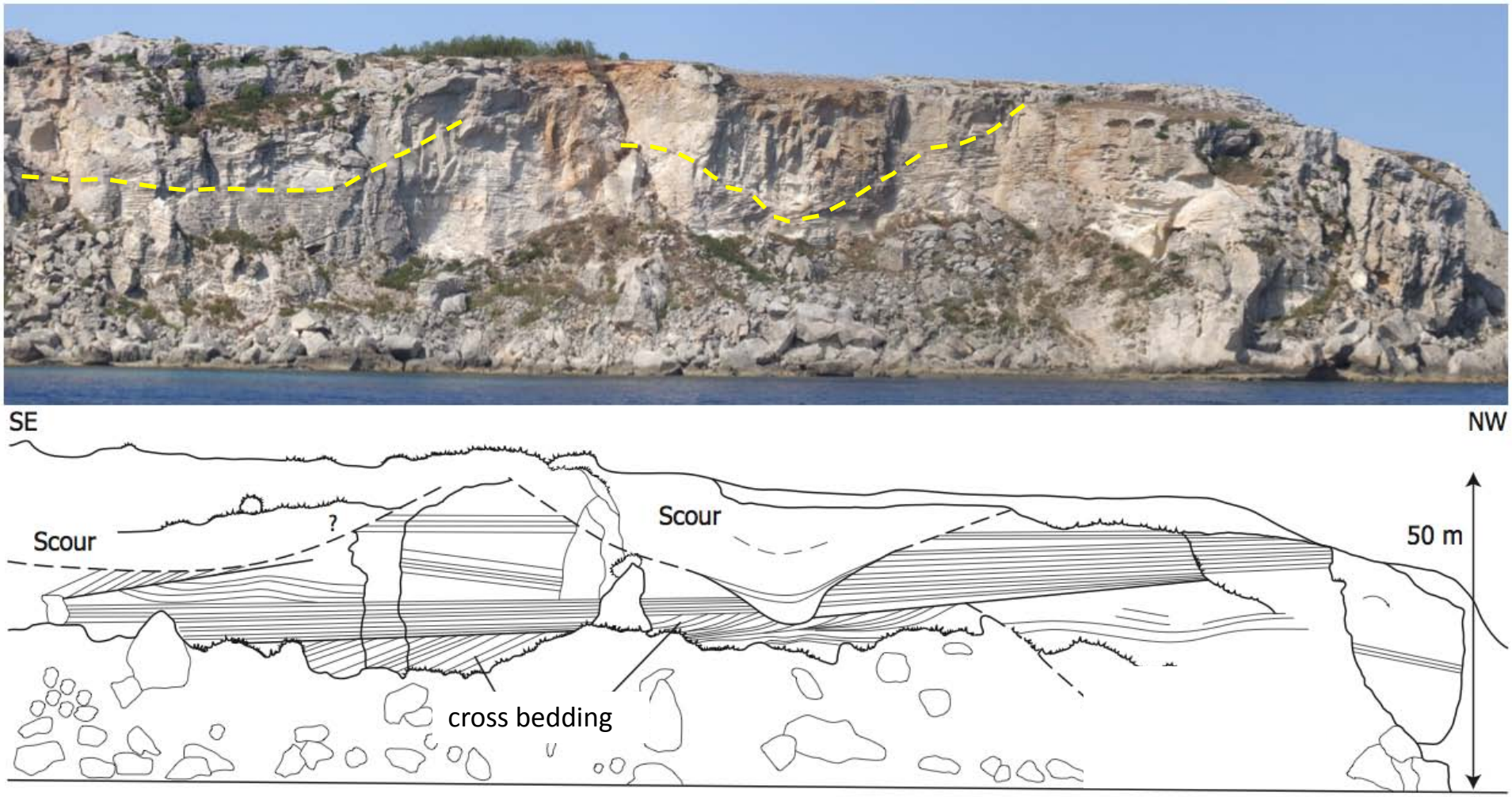


Stratigraphy of the basal part of the Favignana calcarenites


N
S
Tabular cross-lamination
Trough cross-lamination
Last dune foreset
Planar beds



Elongated transversal scours: well sorted and homogenous biocalcarenites


SE
NW
Scour
?
Scour
50 m
cross bedding

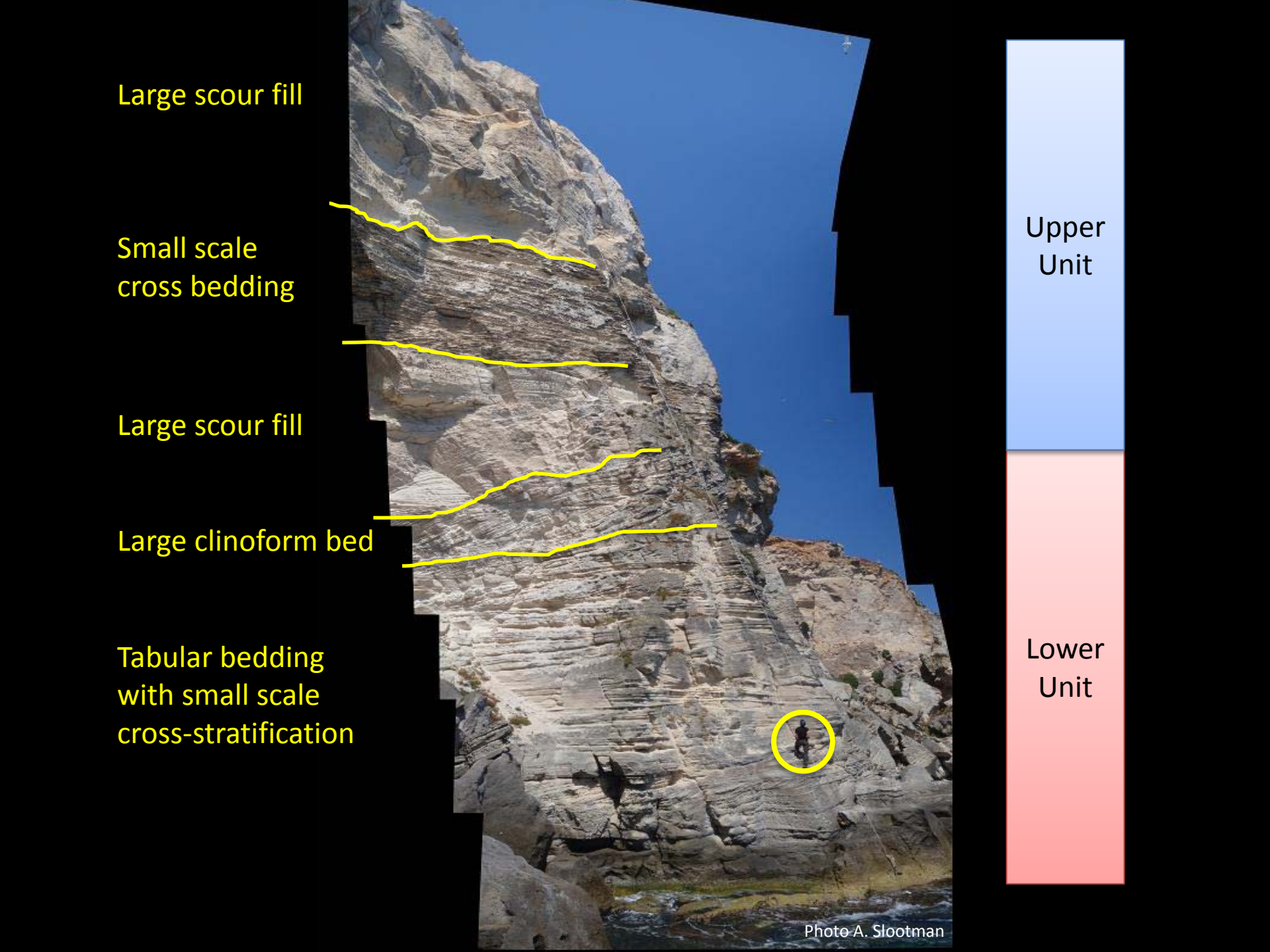
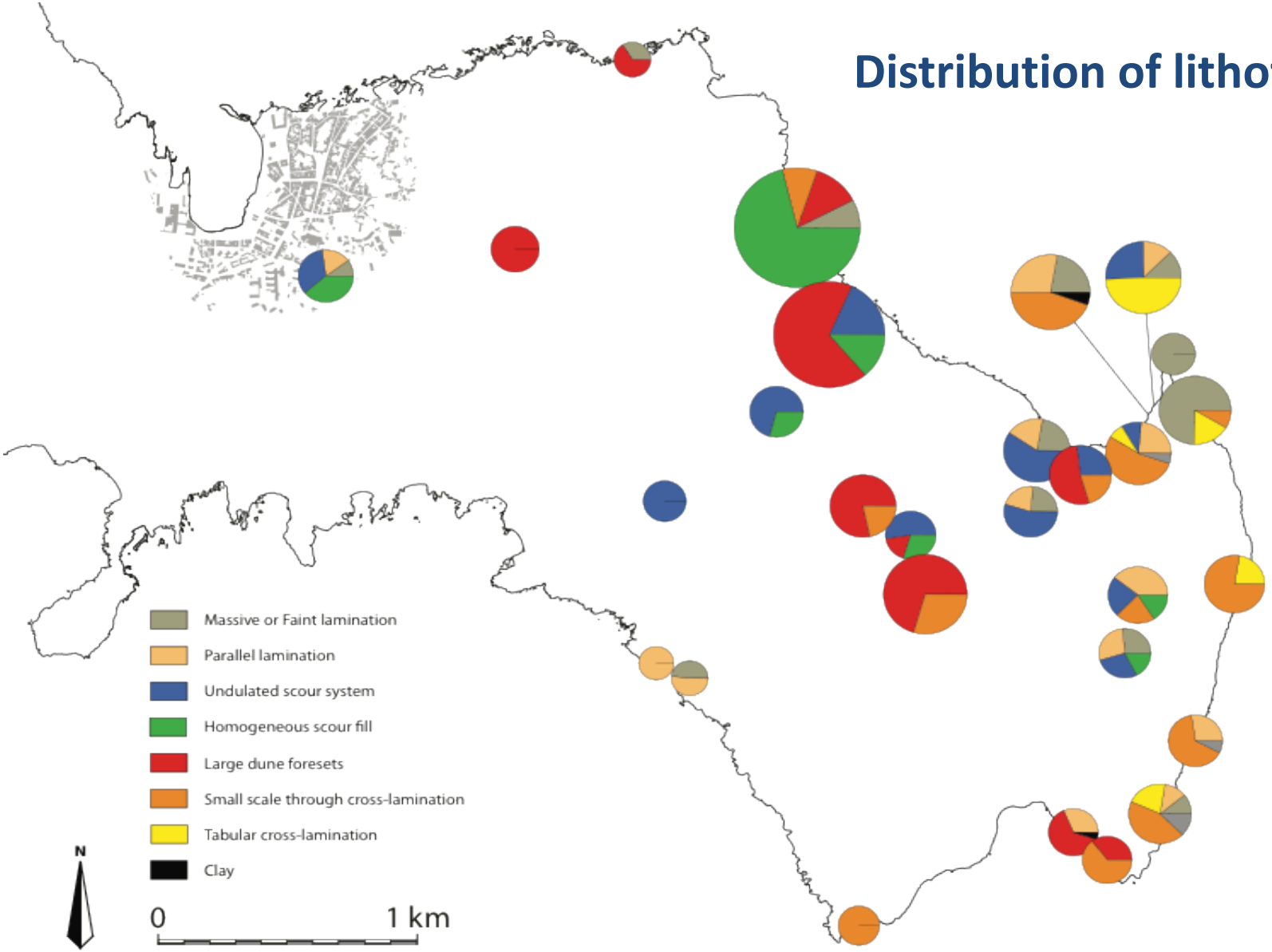
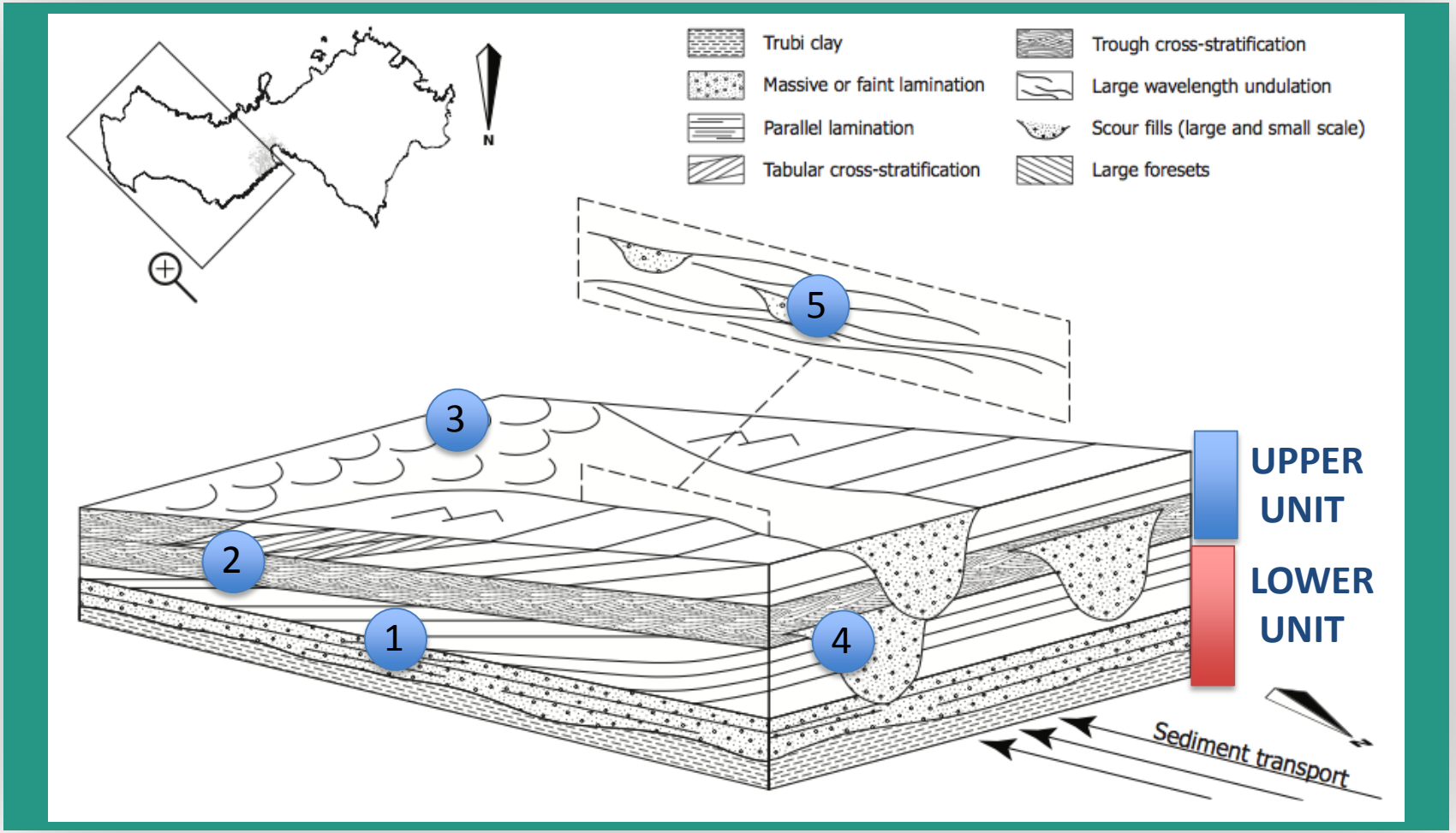

Large scour fill
Small scale cross bedding
Large scour fill
Large clinoform bed
Tabular bedding with small scale cross-stratification
Upper Unit
Lower Unit
Photo A. Slootman

Photo A. Slootman

Photo A. Slootman

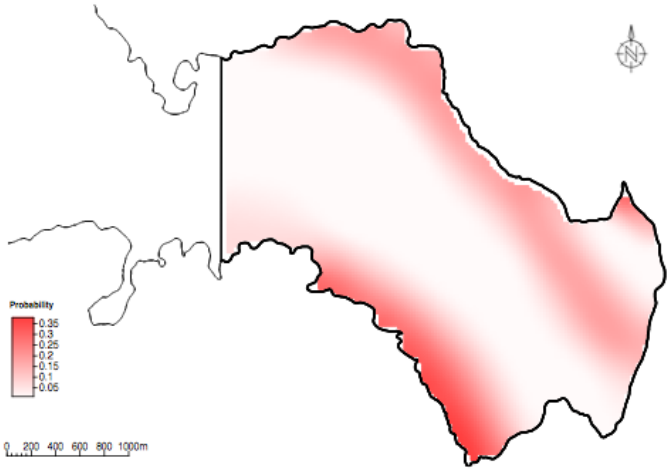
Distribution of lithofacies



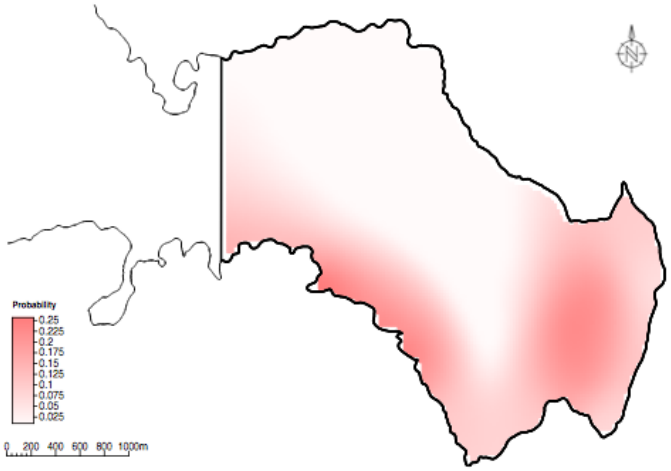


Conceptual Geological Model
Architectural elements

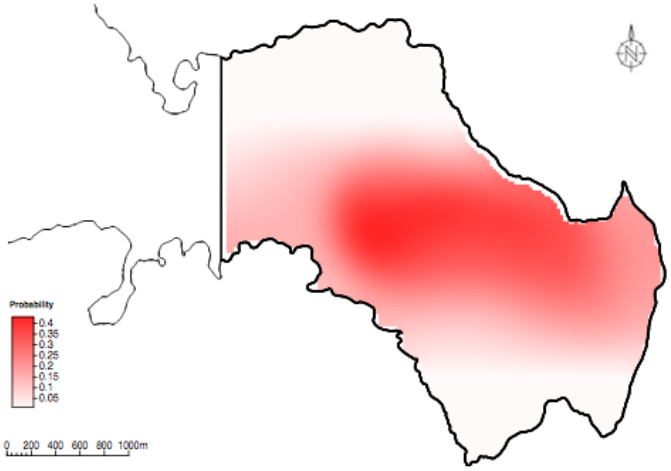
1. Horizontal to low angle tabular beds
2. SW Dipping tabular beds
3. Wedge shaped beds
4. Large scours NW-SE oriented
5. Small scours SW-NE oriented



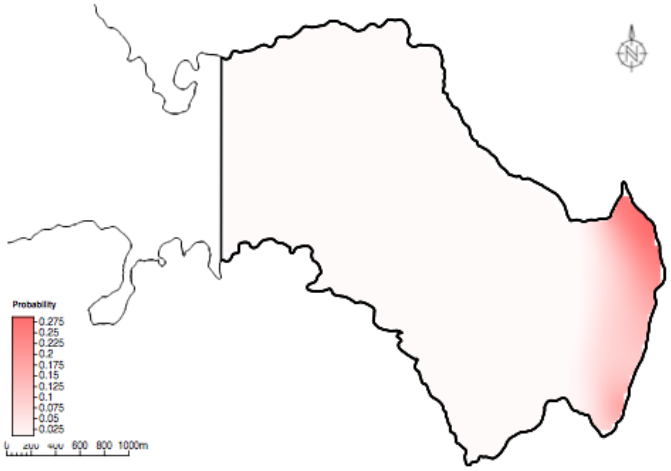
(a) Massive or faint lamination



(b) Parallel lamination



(c) Undulated scours



(d) Tabular cross-lamination

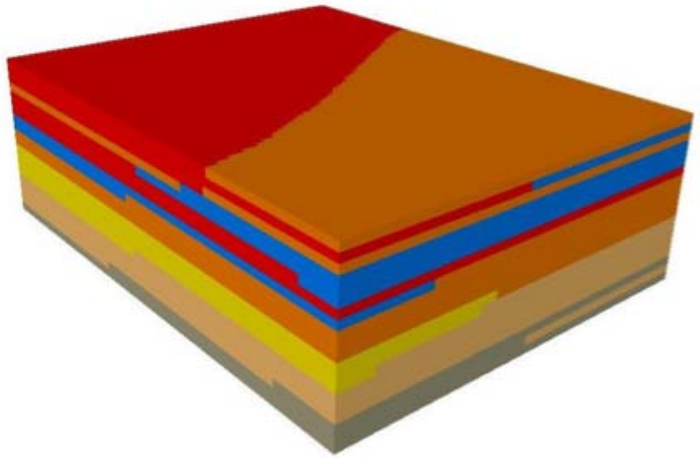
Probability maps for individual lithofacies used as input in the modelling process.

(a) k = 2 of 20 (b) k = 4 of 20 (c) k = 6 of 20

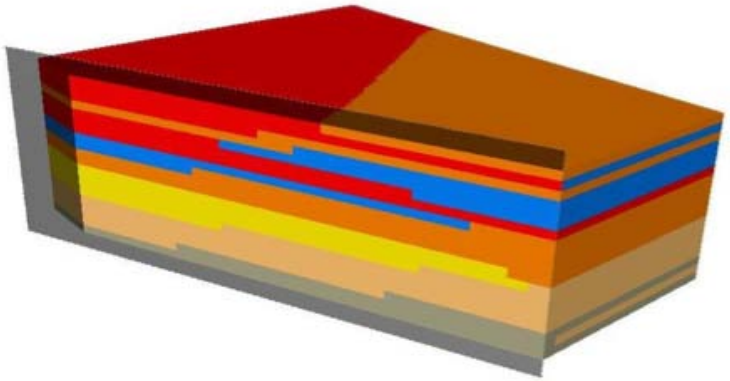
(d) k = 9 of 20 (e) k = 14 of 20 (f) k = 18 of 20

- Massive or Faint lamination
- Parallel lamination
- Undulated scour system
- Homogeneous scour fill
- Large dune foresets
- Small scale through cross-lamination
- Tabular cross-lamination
- Clay

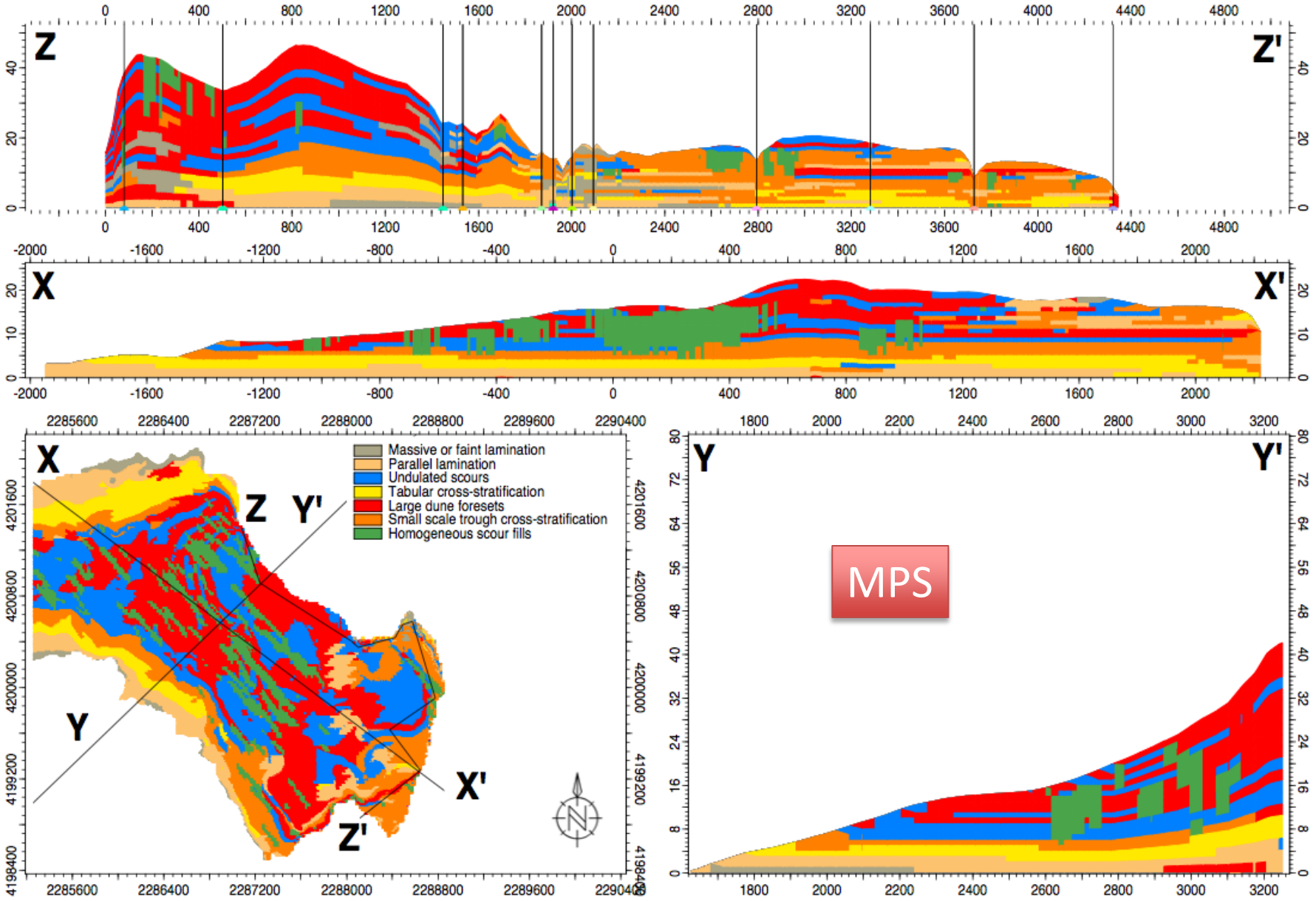
Training images grids used for MPS modelling

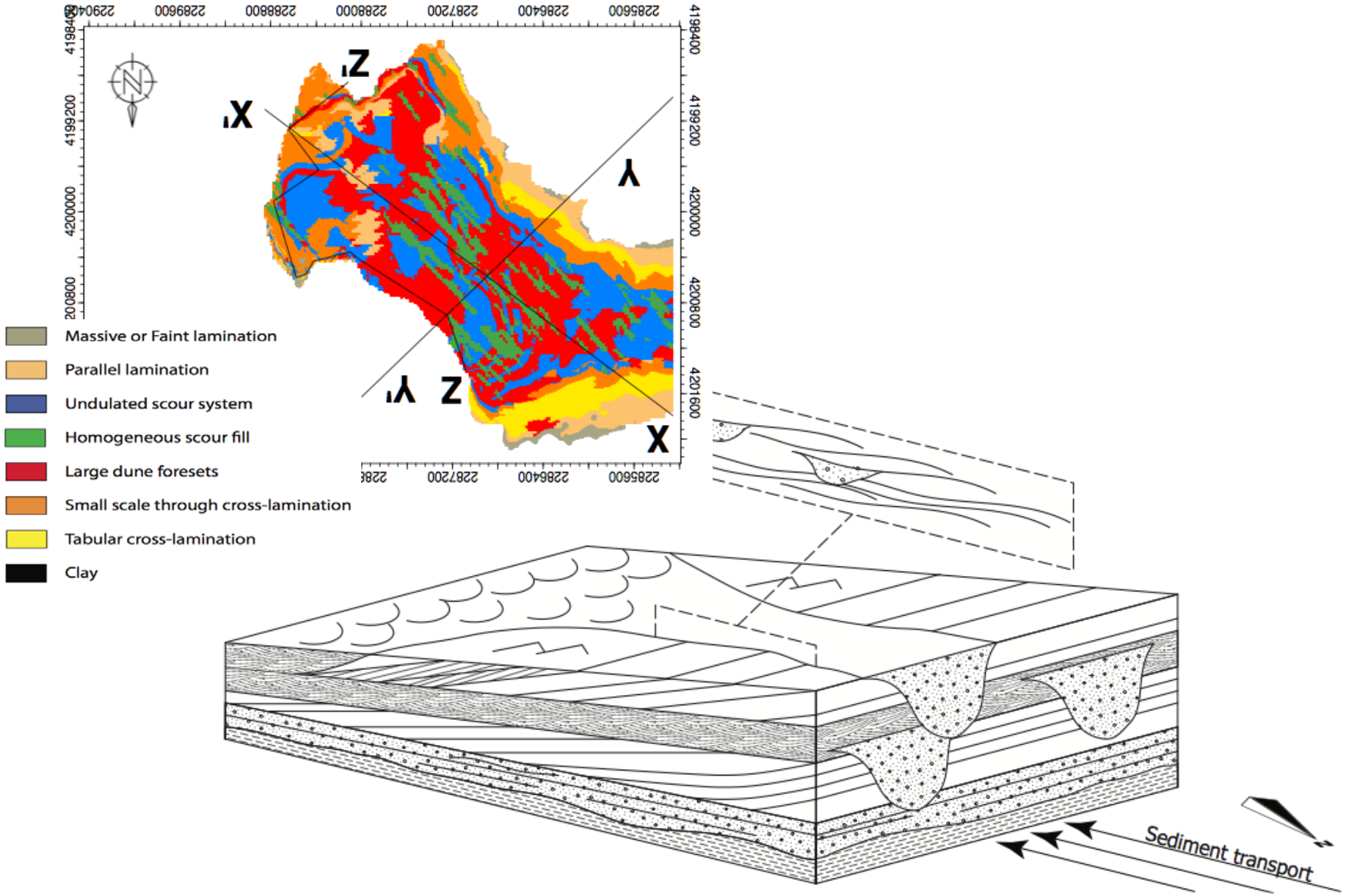


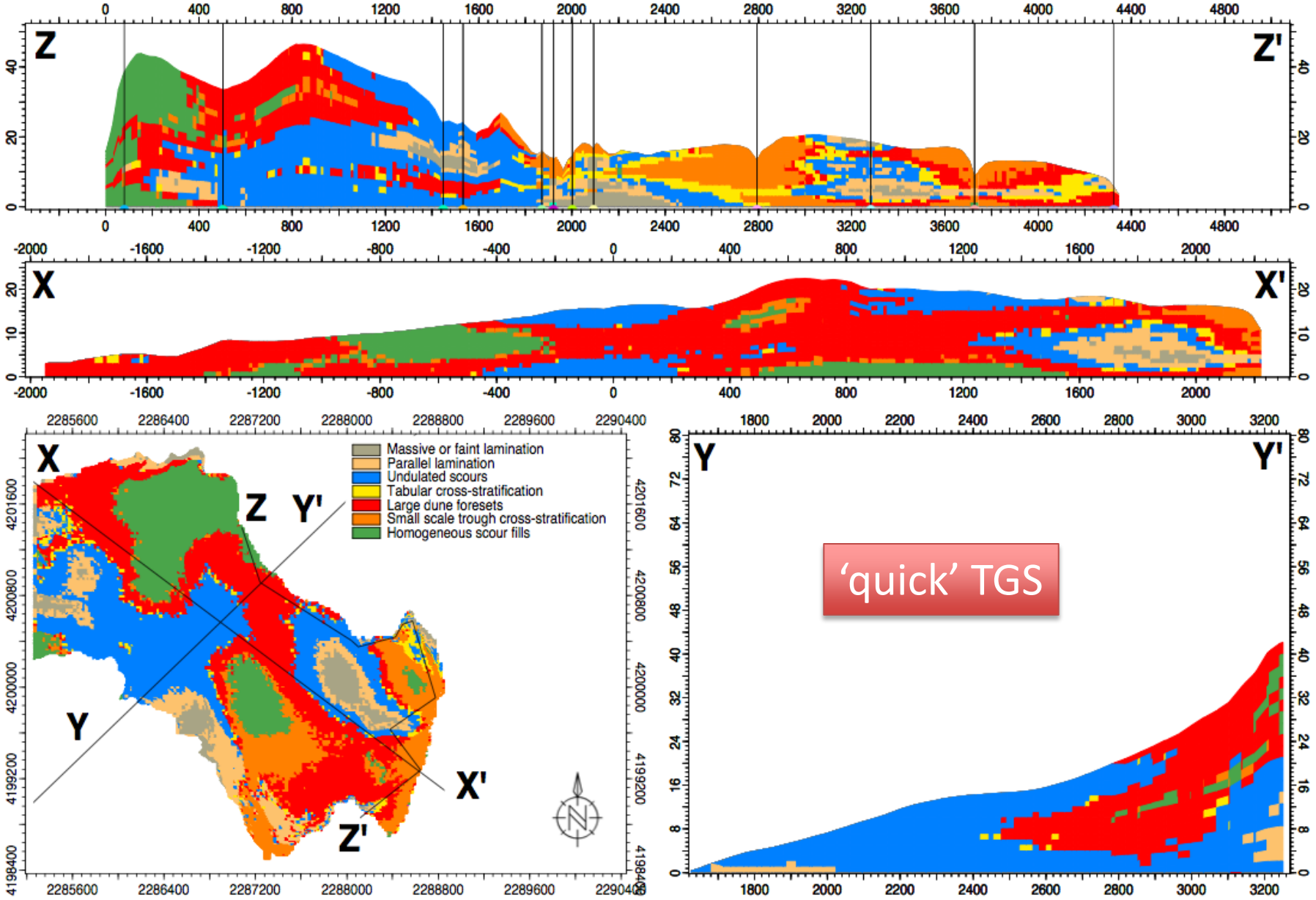
(a) Training image used in the MPS algorithm.

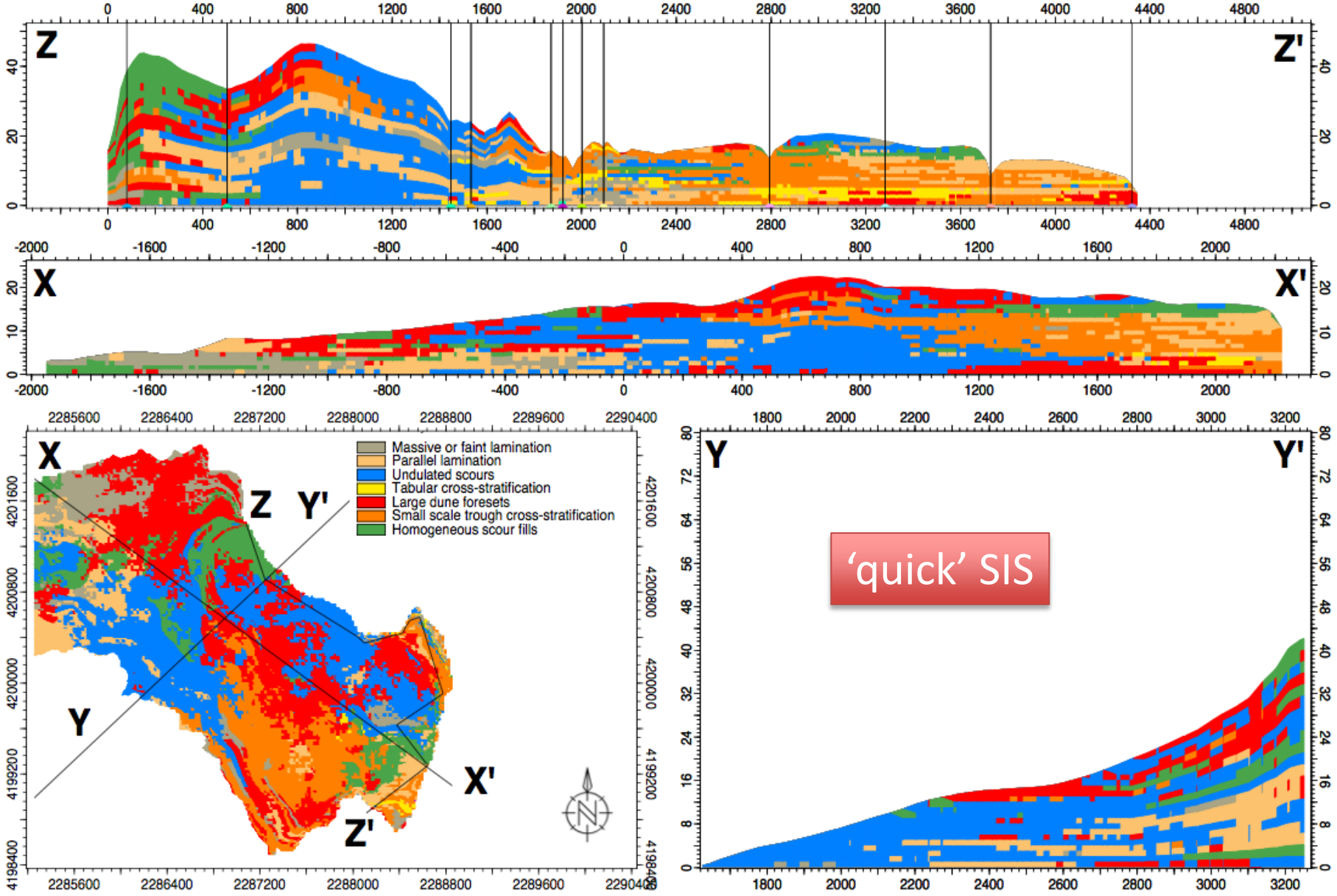


(b) Intersected training image in order to illustrate internal architecture.


Z
Z'
X
X'
Y
Y'
Massive or faint lamination
Parallel lamination
Undulated scours
Tabular cross-stratification
Large dune foresets
Small scale trough cross-stratification
Homogeneous scour fills
MPS

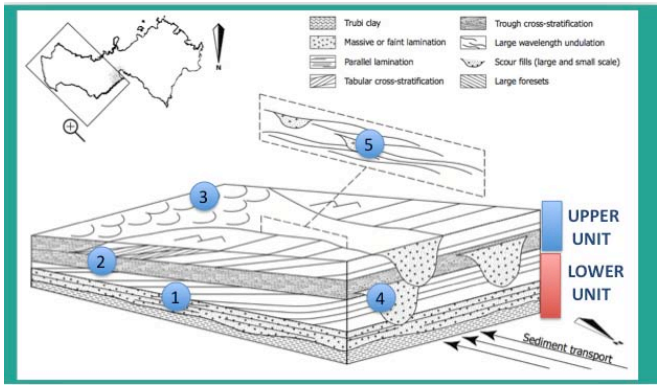

Z'
X'
Y
Y'
Z
X
Massive or Faint lamination
Parallel lamination
Undulated scour system
Homogeneous scour fill
Large dune foresets
Small scale through cross-lamination
Tabular cross-lamination
Clay
Sediment transport


Z
Z'
X
X'
Y
Y'
Massive or faint lamination
Parallel lamination
Undulated scours
Tabular cross-stratification
Large dune foresets
Small scale trough cross-stratification
Homogeneous scour fills
'quick' TGS


Z
Z'
X
X'
Y
Y'
Massive or faint lamination
Parallel lamination
Undulated scours
Tabular cross-stratification
Large dune foresets
Small scale trough cross-stratification
Homogeneous scour fills
'quick' SIS

From concept to geo-cellular model: Which one fits better ?

CGM



SIS

TGS

MPS

The ‘skyscraper’: an isolated 4x4x30 m high rocks, spared from quarry exploitation. Just one grid block ?

Conclusions

- Any geo-cellular modelling approach requires a solid “conceptual geological model”
- MPS approach ‘requires’ a detailed analysis of distribution and shape of architectural elements (quick button push is not possible).
- Overall stratigraphy is captured but not the finest details of reservoir heterogeneity.
- For this specific case study, even when done quickly, MPS seems to yield more geological meaningful results than SIS and TGS.
- More to be done…


Thank you