Random Genetic Simulation of Lobes: Internal Architecture Construction and Gridding*

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Abstract

In geostatistical facies models, the sedimentary genetic processes are often neglected. As a consequence, the realizations are not very realistic in terms heterogeneity patterns. In this paper, following the methodology initiated by Hu and al. in 1994, a random genetic simulation process is developed for modelling lobe sand bodies (deep water lobe sediments for instance). This technique is used to produce a realistic facies model of lobes internal architecture and to fill in the space between horizons of deposition. This methodology is encouraging to produce realistic images of lobes that can be good candidates for multiple point geostatistics but also to obtain reservoir gridding of such geological objects in conformity with the depositional scheme. Some improvements of the modelling procedure are also discussed such as turbiditic channels incorporation and lobe complex building.

Random genetic simulation of lobes:
internal architecture construction and gridding

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Presentation outlines

- Introduction
- Description of the methodology
- Presentation of sensitivity tests
- Presentation of case study results
- Suggestions for further works
- Conclusions

Introduction

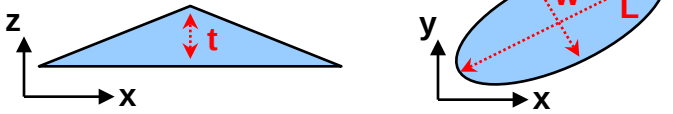
- Goals:
  - random simulation of internal architecture of lobes
  - mimic sedimentary process of lobes in object based simulation

- Previous works:
  - “random genetic simulation of the internal geometry of deltaic sand bodies”, 1994, Hu L.Y., Joseph Ph., Dubrule O., in SPE Formation Evaluation
  - “stochastic surface-based modeling of turbidite lobes”, 2005, Pyrcz J., Catuneanu O., Deutsch C., in AAPG Bulletin

- Contribution:
  - generalization of Hu and al. technique

Description of the method (1): recall

- Individual objects are bedsets

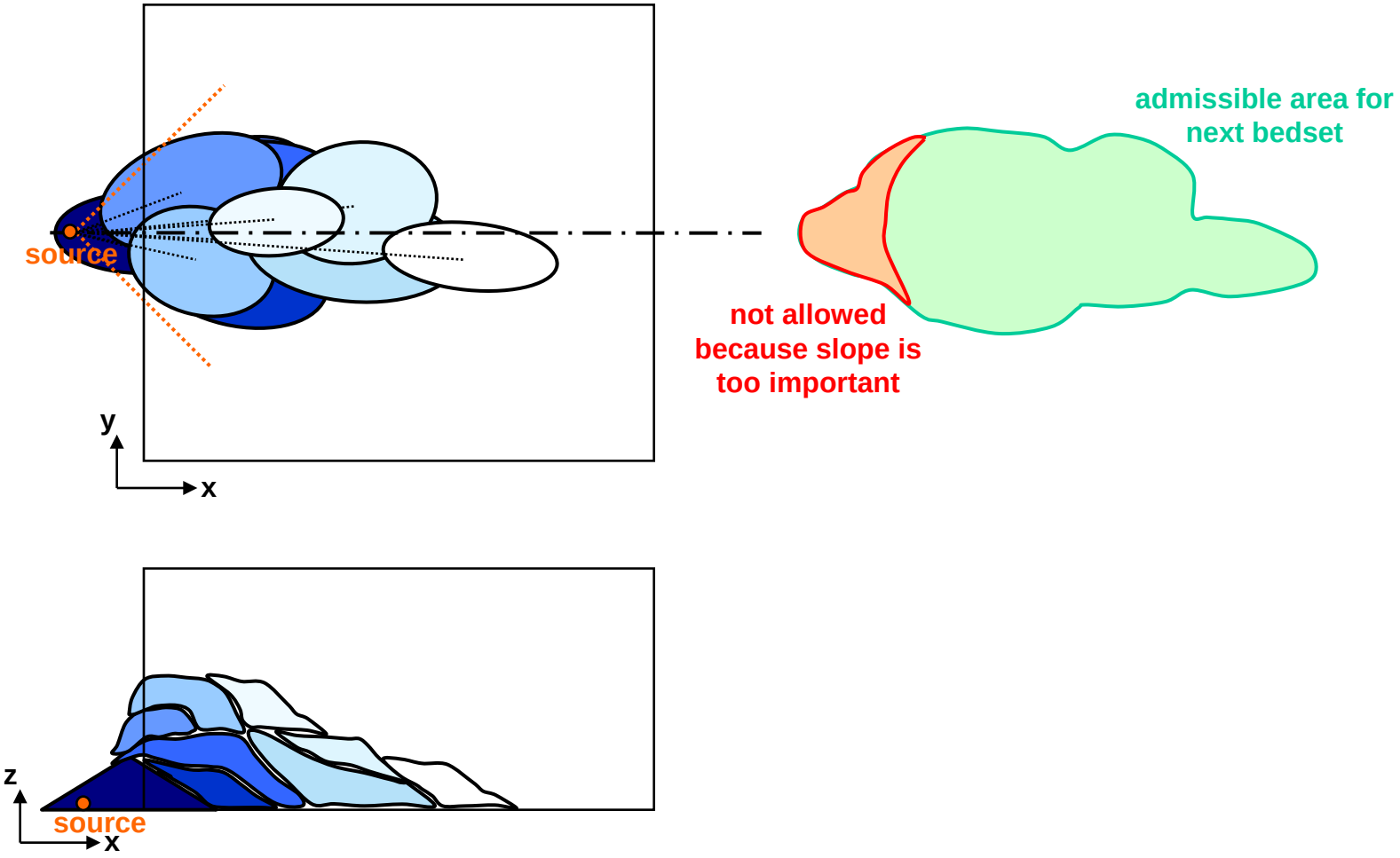


- A source of sediments and a simulation domain are provided

- Bedsets are not located with a boolean process but according to the source and previous simulated bedsets:
  - bedsets have to be in contact with the previous simulated bedsets
  - bedsets are deformed so that no matrix remains between them
  - a distribution of dimensions is provided
  - a distribution of directions is given for the line from source to bedset center
  - a distribution of distances from the source is given on the selected direction

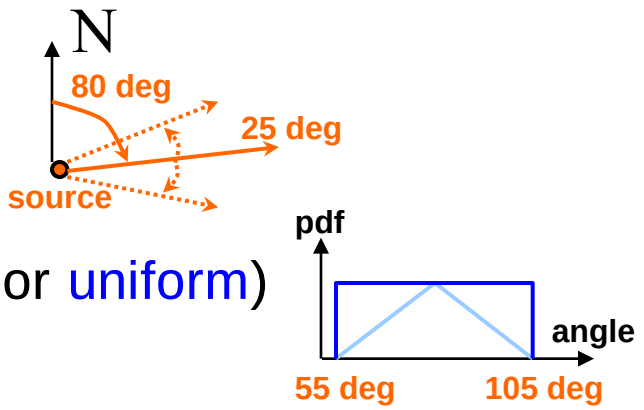
- Simulation is stopped according to one of the following criteria:
  - the volume of the lobe is reached
  - a maximum elevation is reached

Description of the method (2): recall cont.

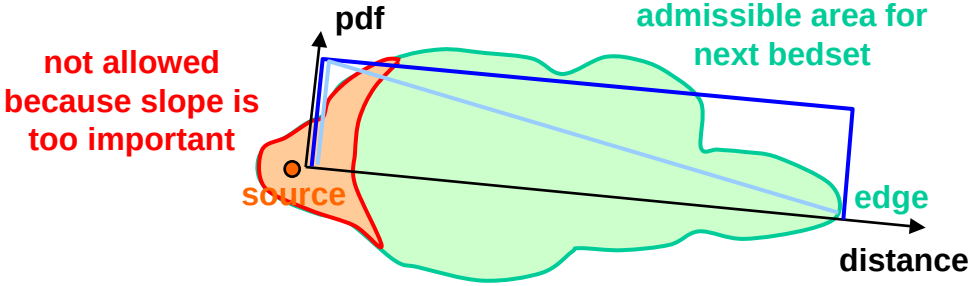


Description of the method (3): options

- **Choice of directions** distribution:
  - select main direction of deposition
  - select uncertainty on the direction
  - select distribution shape (triangular or uniform)

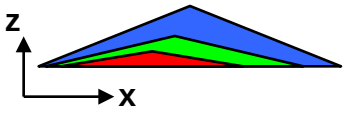


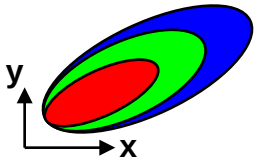
- **Choice of distances** distribution:
  - between source and edge of admissible area in selected direction
  - select distribution shape (triangular or uniform)

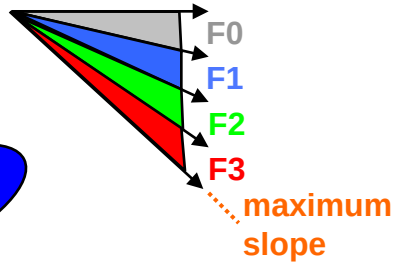


Description of the method (4): options cont.

- Select a surface of deposition
  - constant elevation
  - surface (built from conditioning data ?)
- Select a maximum elevation for accommodation
  - constant elevation
  - surface (built from conditioning data ?)
- Select a maximum slope for bedset stability
- Define facies attribution
  - slope domain for the center point of the bedset
  - heterogeneous bedset

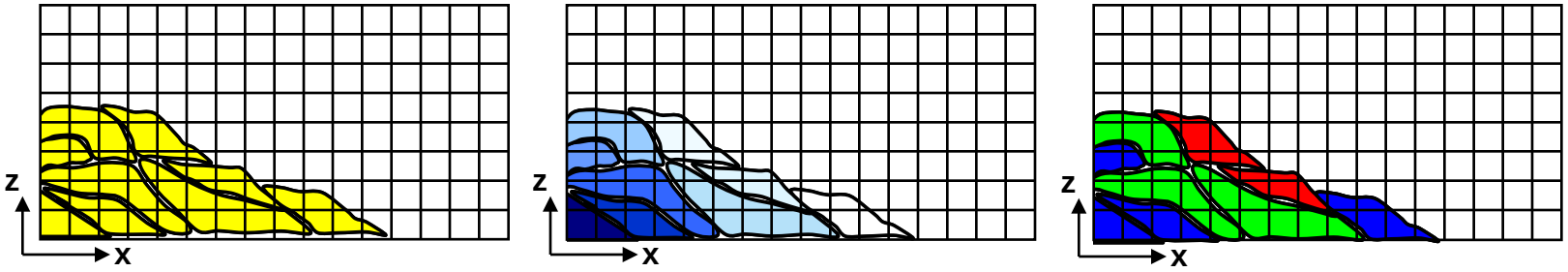




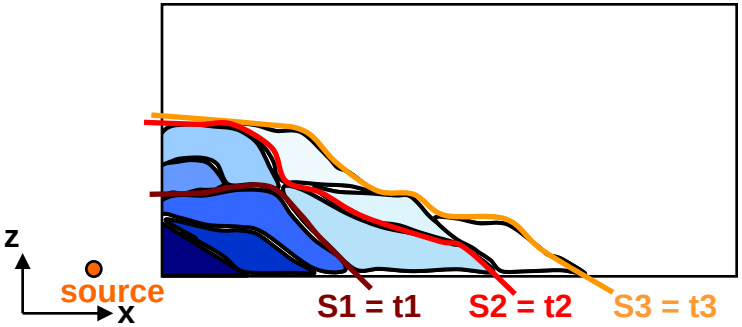


Description of the method (5): outputs

- **Properties on a regular grid**:
  - lobe number, bedset number, facies number

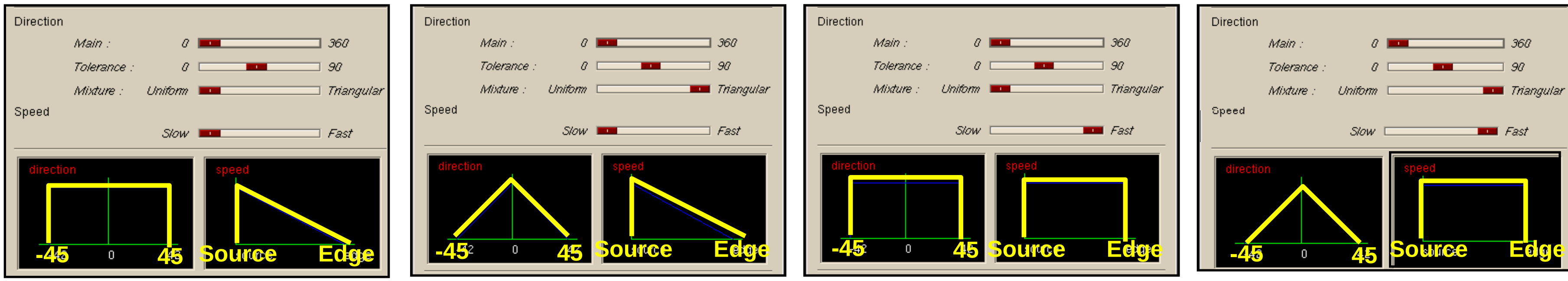


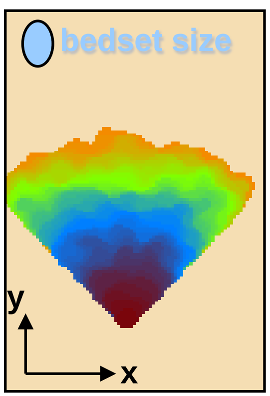
- **Intermediate surfaces of deposition**:
  - corresponding to different volumes of bedsets
  - with properties (lobe, bedset, facies, slope)



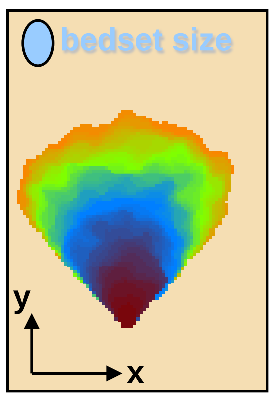
Sensitivity tests (1):
influence of directions and distances distributions

- Sensitivity to direction and distances distribution shape, all other parameters unchanged

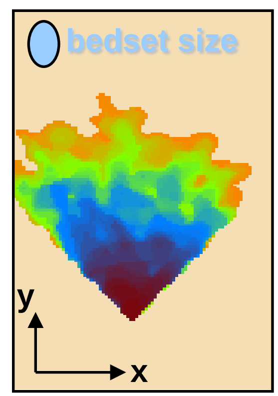




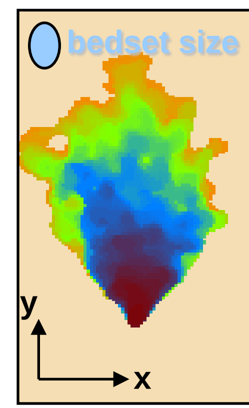
directions: uniform
distances: triangular



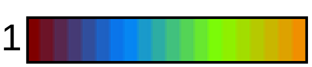
directions: triangular
distances: triangular



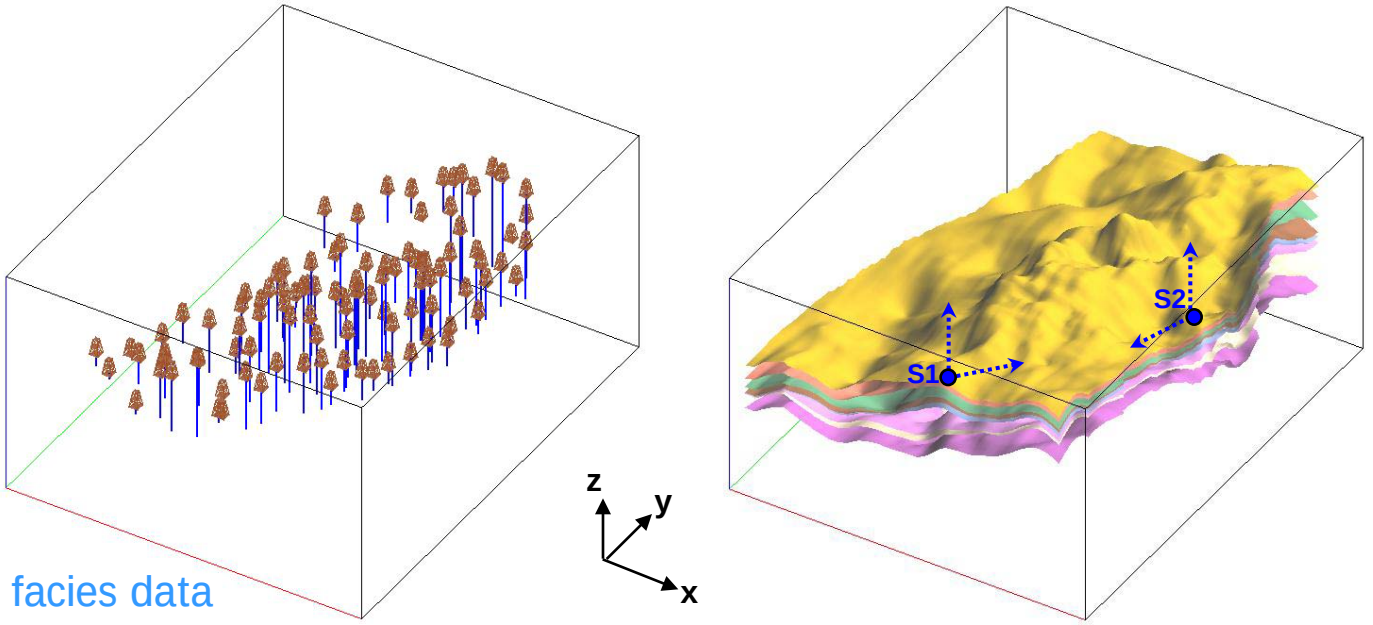
directions: uniform
distances: uniform



directions: triangular
distances: uniform

bedset number: 1  150

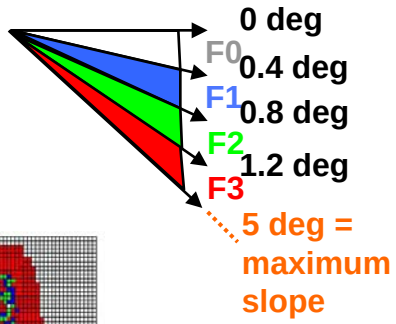
Case study (1): data set

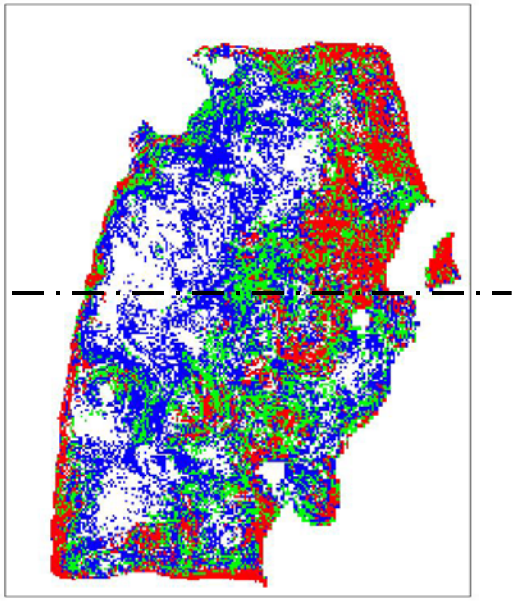


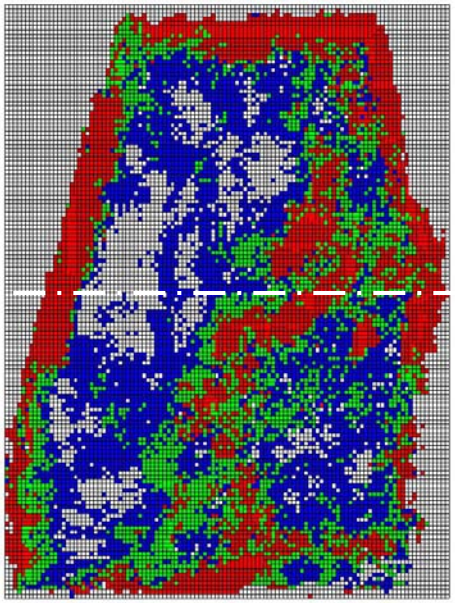
- Application:
  - 110 wells, no facies data
  - 7 geological units observed at wells (markers), interpreted as lobes
  - kriging interpolation of markers between wells → depositional and accommodation surfaces for each lobe
  - source placed at location corresponding to maximum thickness of the lobe
  - bedsets size from variography of thickness maps
  - facies is assigned with bedset slope classification
  - grid building with intermediate surfaces of deposition

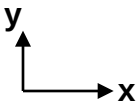
Case study (3): results cont.

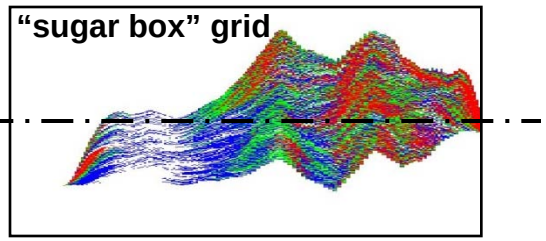
- Lobes facies results
  - Slope classification is clearly observed
  - Need details inside bedsets?

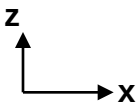


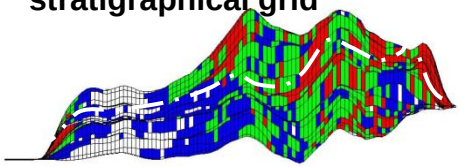






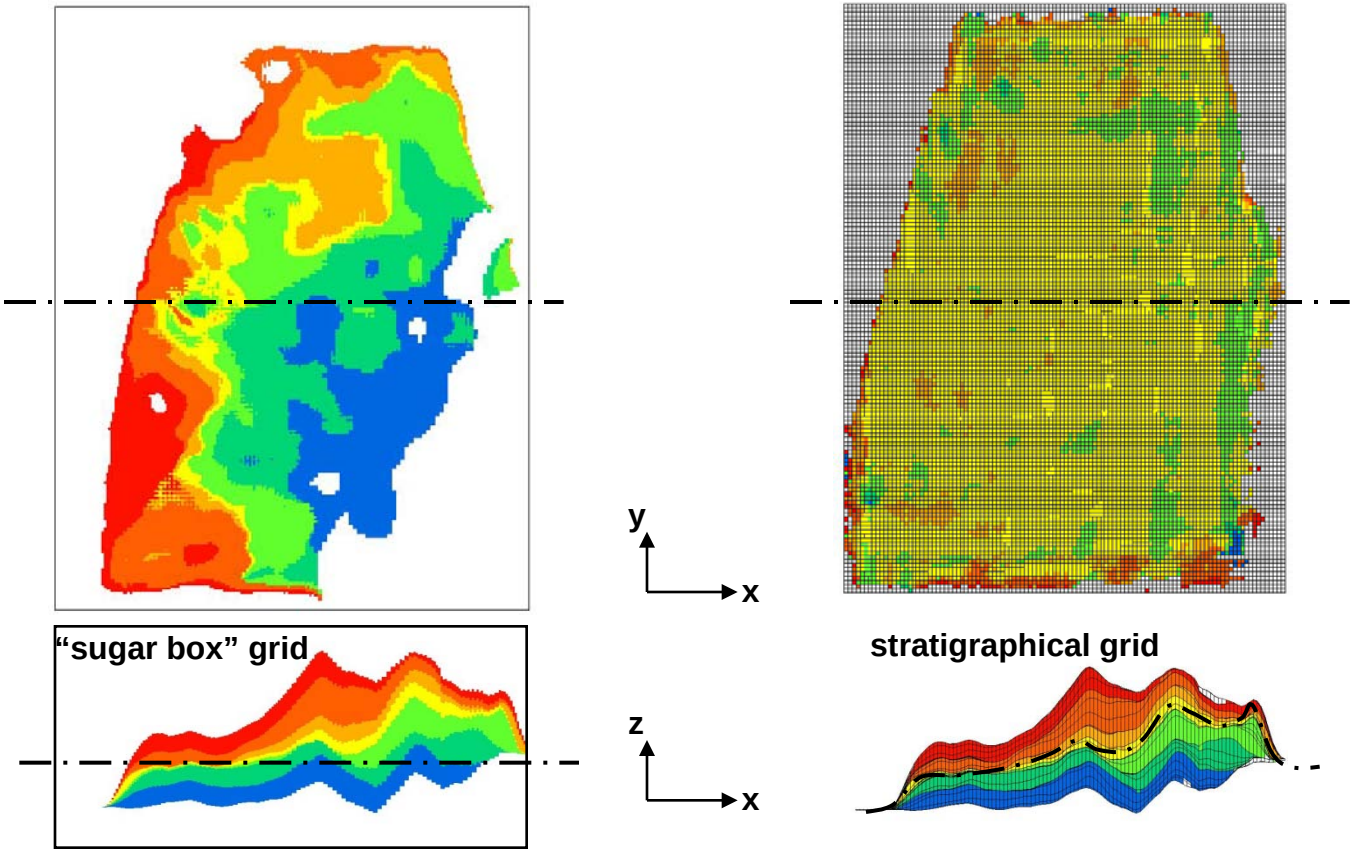






Case study (2): results

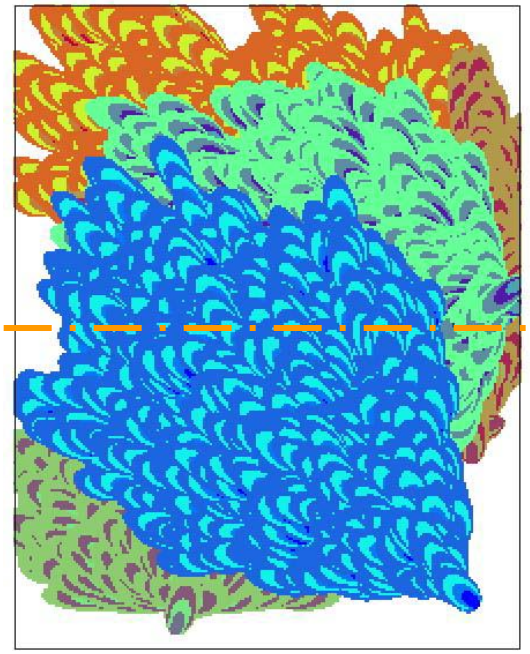
- Lobes reconstruction results
  - limiting surfaces of lobes are honored
  - use intermediate surfaces to build the grid



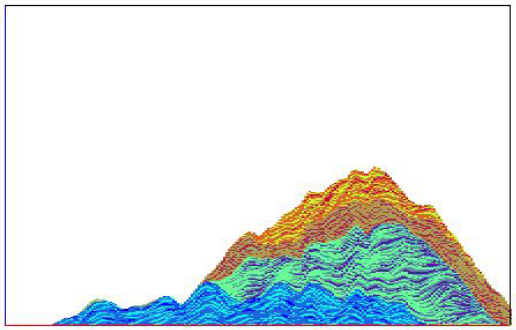
Case study (3): results end

facies assignment alternative

- Use of heterogeneous bedsets to assign facies



x-y bottom view



x-z cross section flattened view

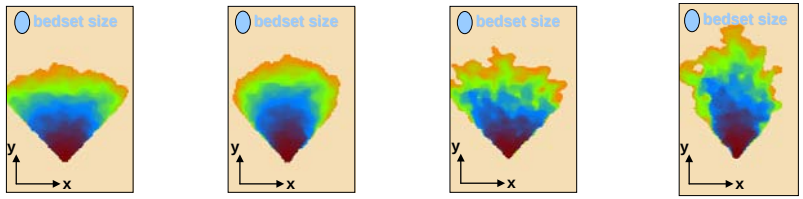
Further works (1):
conditioning

- In case study, markers data but no internal facies data
- Is facies assignment relevant for petrophysics ?
- Is it possible to improve mechanism for internal facies data conditioning ?

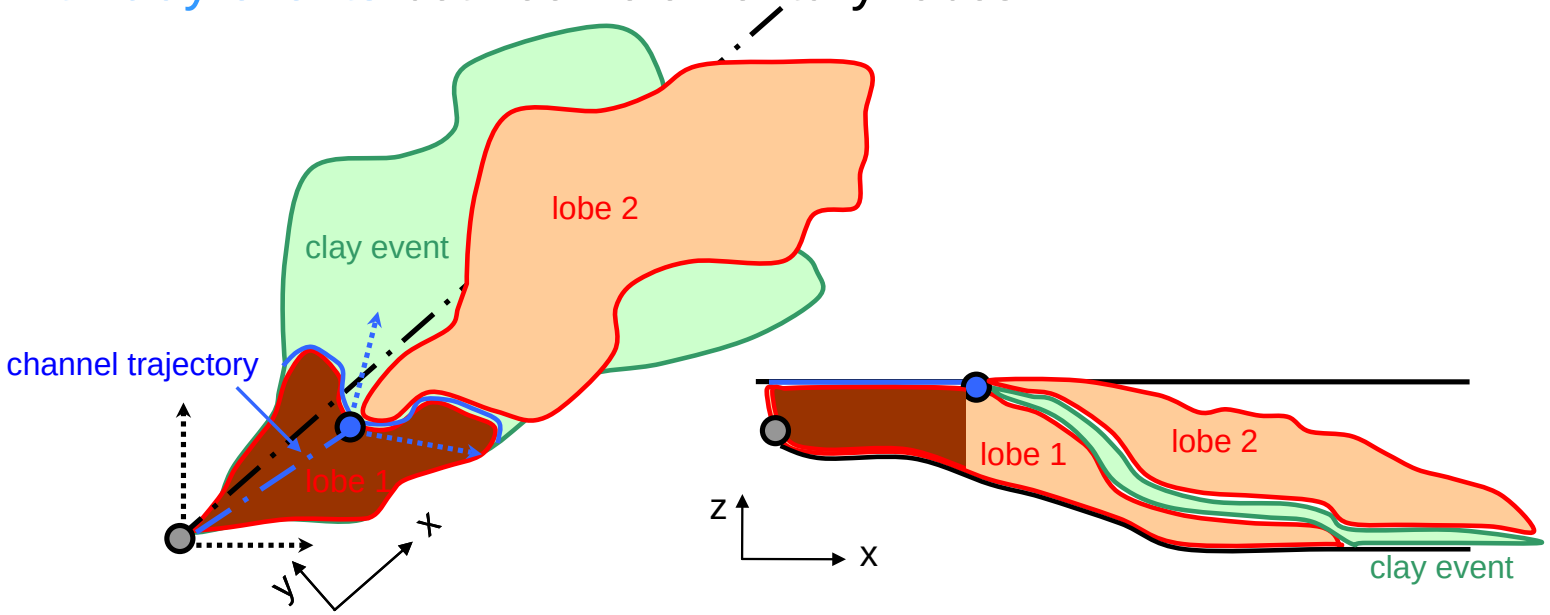
Further works (2):

improvements for lobes

- Build lobe complex:
  - with elementary lobes



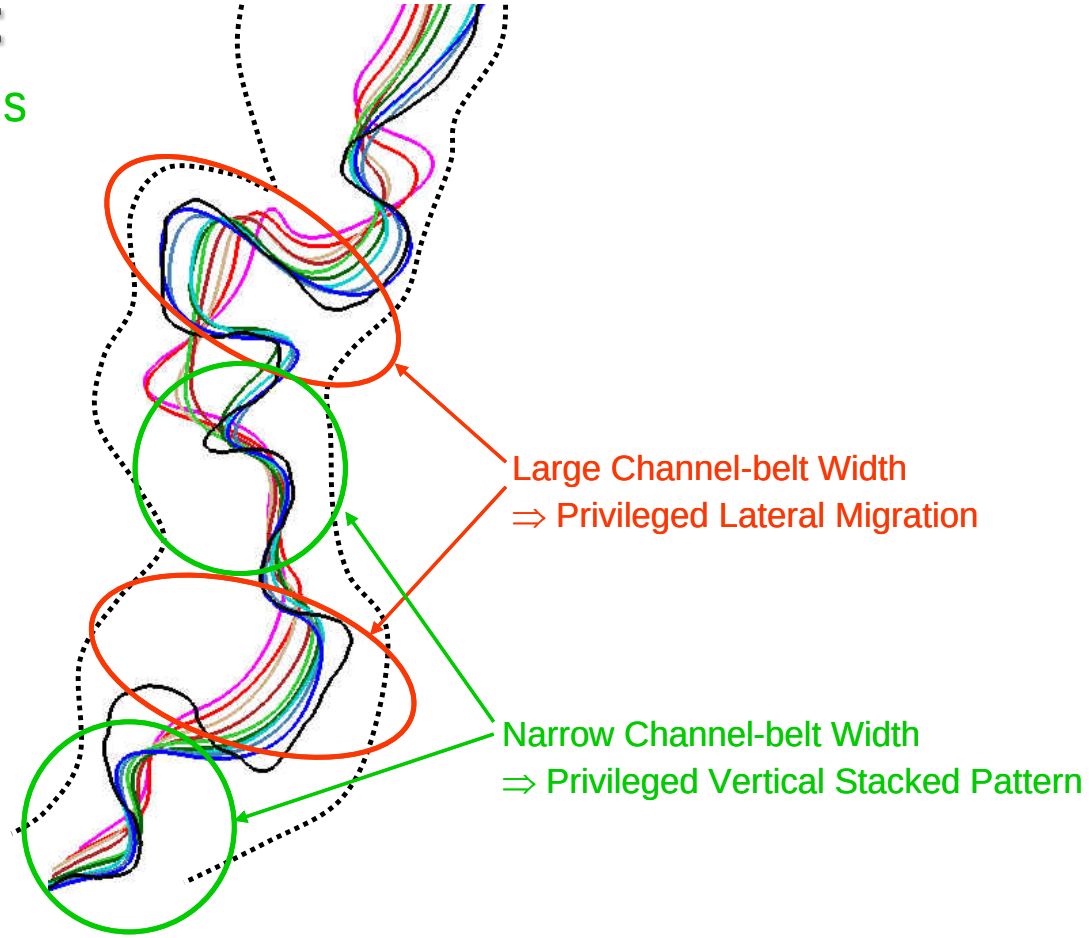
  - with source migration to the admissible zone (accomodation space)
  - with channels on the trajectory of the source
  - with clay events between elementary lobes



Further works (3):

other depositional environments

- **Turbiditic channels**:
  - vertical aggradations
  - lateral migrations



Conclusions

- Lobe model useful for:
  - facies attribution from depositional context
  - building grids compatible with depositional context
  - building training images for multiple point statistics
- Conditioning:
  - Possible for geological unit markers
  - Difficult to impossible for internal geometry facies data
- Lobe model can be extended:
  - Source migration
  - Lobe complex building
- Other environments can be addressed:
  - Turbiditic channels

References

Hu, L.Y., P. Joseph, and O. Dubrule, 1994, Random genetic simulation of the internal geometry of deltaic sand bodies: SPE Formation Evaluation, v. 9/4, p. 245-250.

Pyrcz, M.J., O. Catuneaun, and C.V. Deutsch, 2005, Stochastic surface-based modeling of turbidite lobes: AAPG Bulletin, v. 89/2, p. 177-191.