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An effective method for 3D geological modeling with multi-source data integration

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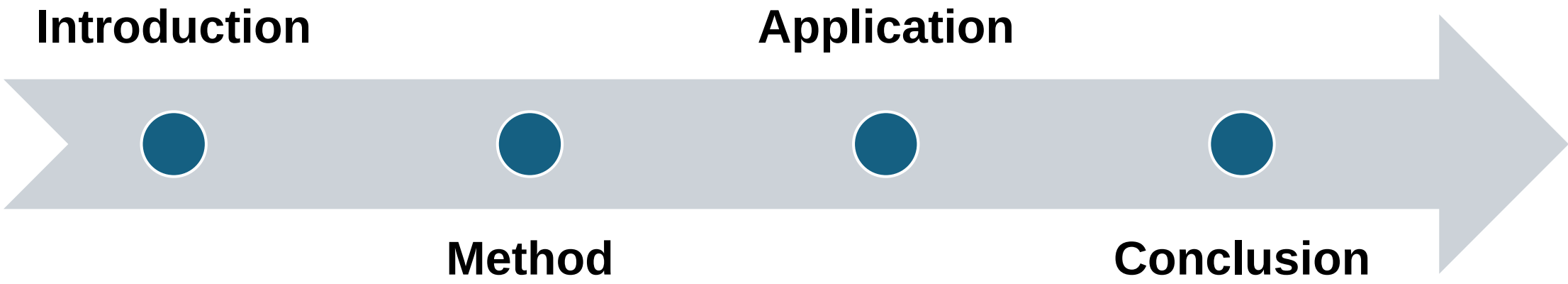
Outline



Introduction

What data sources do we use to build a 3D geological model?

Existing method	V.S.	Method in this paper	
Borehole		Borehole	Geological maps
Cross-section data		Cross-section data	Topographic maps
		Property data	Structural geology maps
		Seismic reflection data	Satellite image, etc.
Sparse Undersampled		Various Sufficient	

Introduction

A stepwise refinement method with multi-source data integration in the Subsurface Visualization System (SVS).

- A specific 3D geological modeling system to implement this method
- Developed in Visual C++ 6.0 using the OpenGL
- Runs on PC platforms

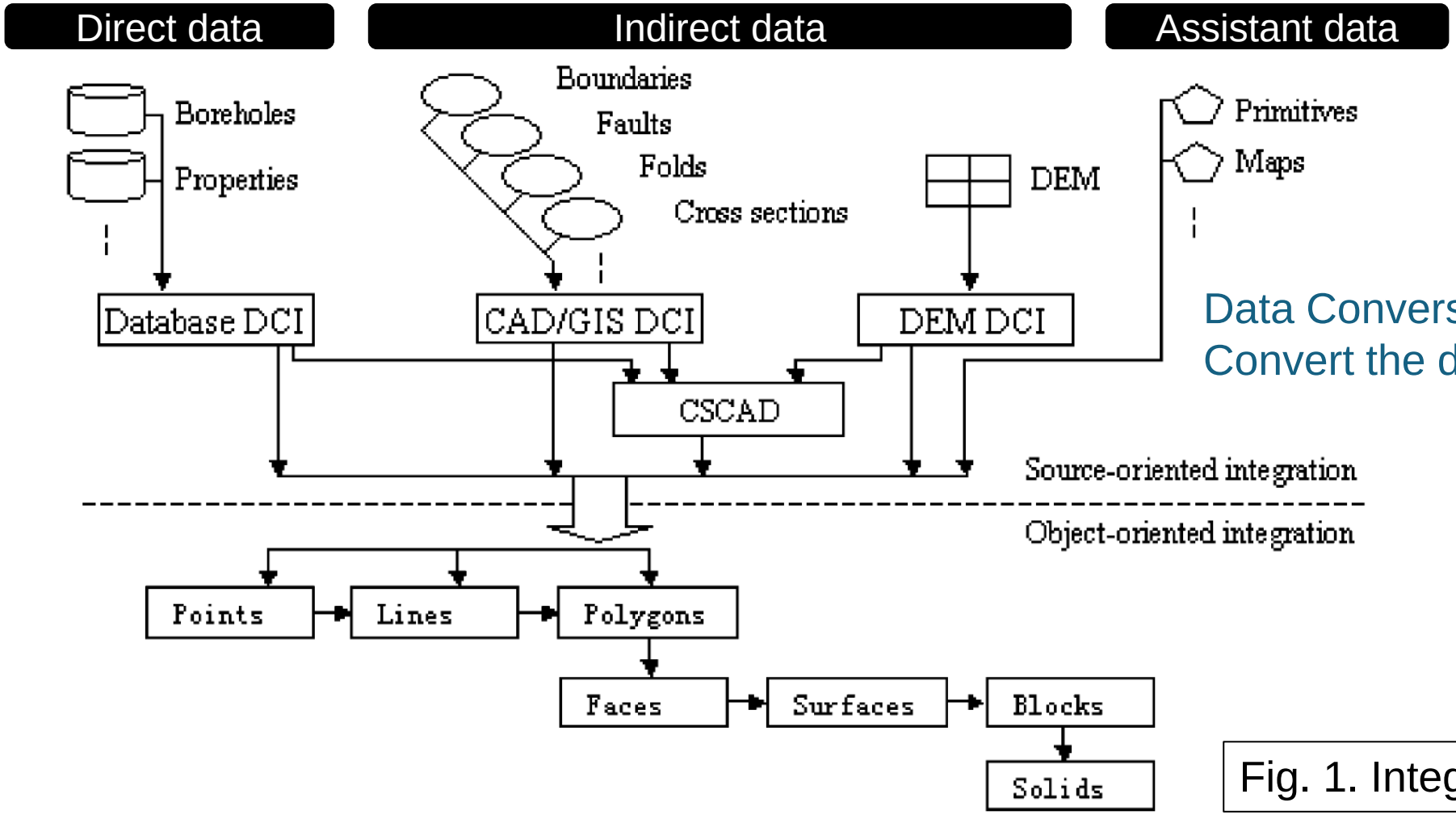
→ Can simulate geological structures whether the available geological data is sufficient or not

→ Can increase the accuracy of 3D modeling

Method

1. Integration of 2D/2.5D data
2. Supplement of cross-sections
3. Simulation of faults
4. Definition of a template
5. Construction of horizons
6. Representation of solids

1. Integration of 2D/2.5D data

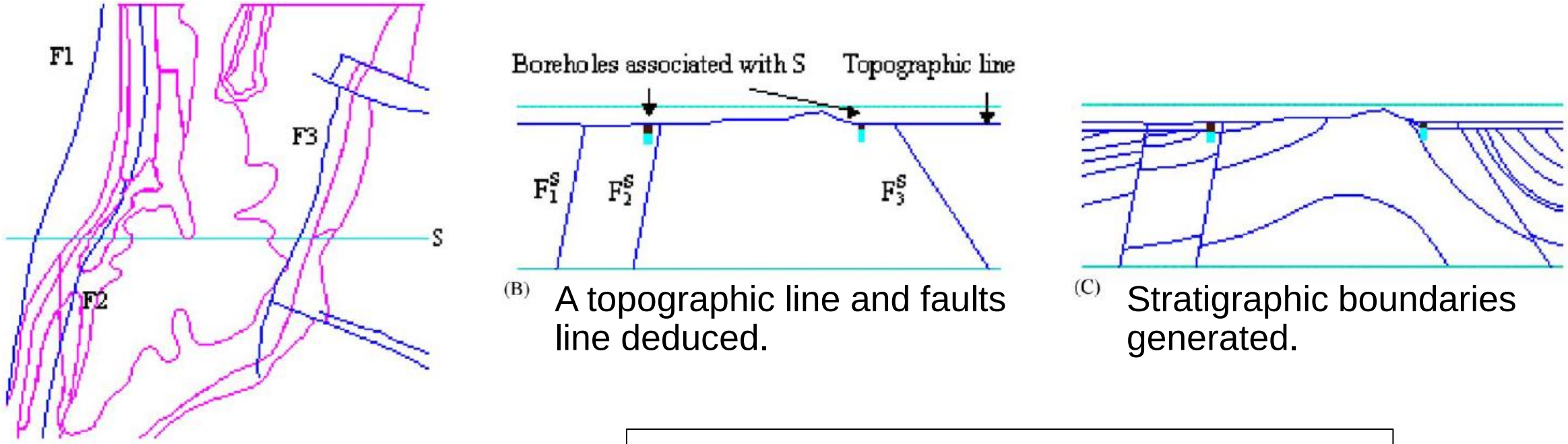


Data Conversion Interface (DCI):
Convert the digitized data to SVS

Fig. 1. Integration architecture.

2. Supplement of cross-sections

CSCAD tool allows users to semi-automatically define a cross-section based on digitized geological data.



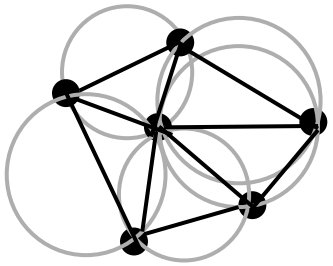
(A) Digitized geological data.

(B) A topographic line and faults line deduced.

(C) Stratigraphic boundaries generated.

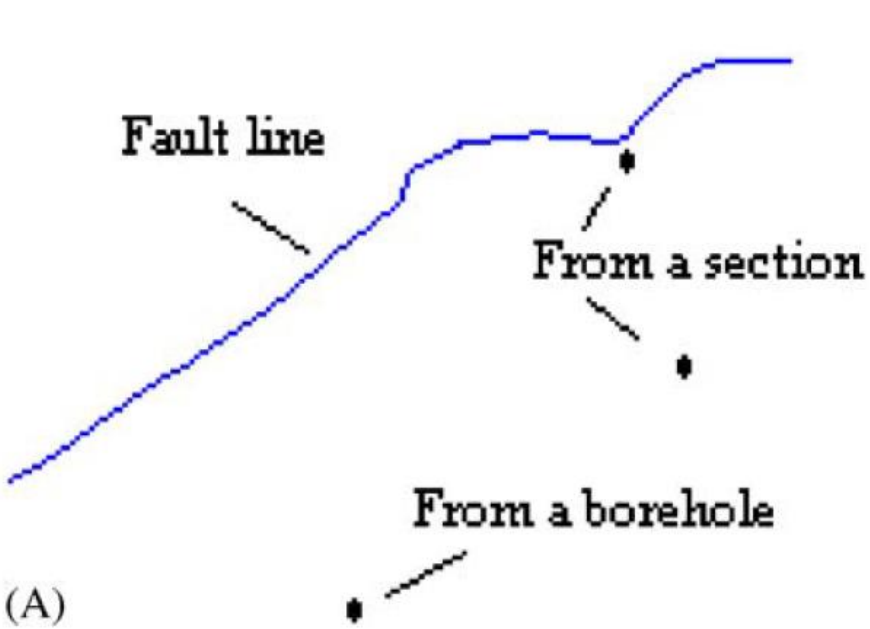
Fig. 2. Defining a cross-section using CSCAD.

3. Simulation of faults

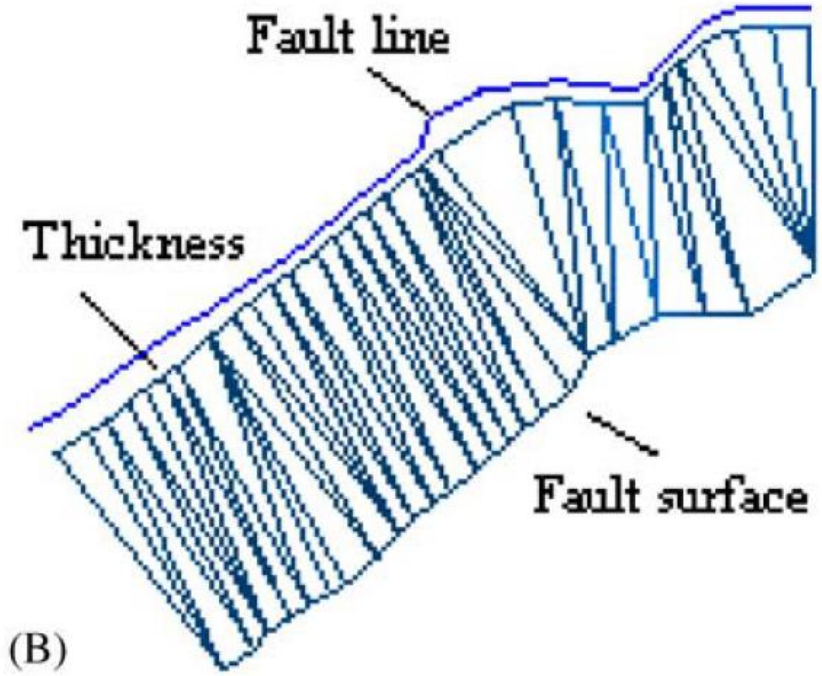


The fault points are connected by constrained Delaunay triangulation to generate a Triangular Irregular Network (TIN) model.

Fig. 3. Fault simulation.



3 fault points and 1 fault line.



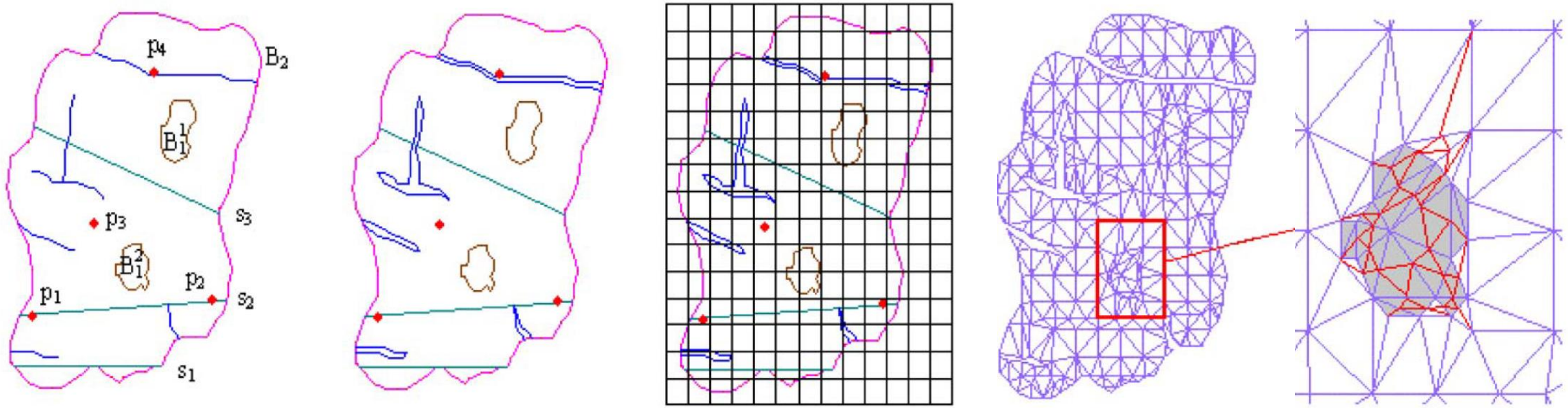
A TIN model of deduced fault.

4. Definition of a template

A template is a data reference format used to guide the construction of horizon models in the 3D geological modeling process.

5. Construction of horizons

Horizon refers to the modeled surface of a geological layer (strata boundary).



(A) Geological data.

(B) Fault data deduced.

(C) Regular points assigned.

(D) TIN mesh.

(E) Recursive Subdivision.

Fig. 5. Horizon modeling.

6. Representation of solids

Horizon-to-solid methods:

1. Calculating the intersection points between two horizons and horizons and faults.
2. Reconstructing the Triangular Irregular Network (TIN) models.
3. Establishing a boundary representation solid model by the topological relationship between faults and each horizon surface.

Modeling in Huai Bei, China

Regional geological condition

- Rocks are folded several times
- 136 faults
- Numerous valuable deposits (e.g. anthracite coal)

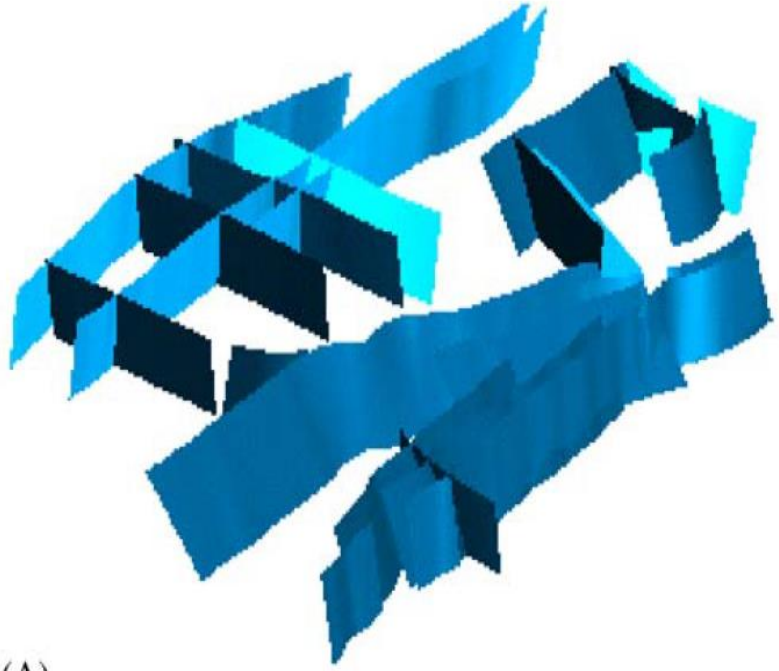
Available geological data

- Geological maps
- Topographic maps
- Structural geology maps
- 179 borehole data
- 9 cross-sections

Modeling in Huai Bei, China

Steps:

1. Integrate the digitized source data to the subsurface visualization system (SVS) modeling format through DCI.
2. Construct 29 supplementary cross-sections in the CSCAD environment.
3. Simulate 79 faults following the basic properties of faults.



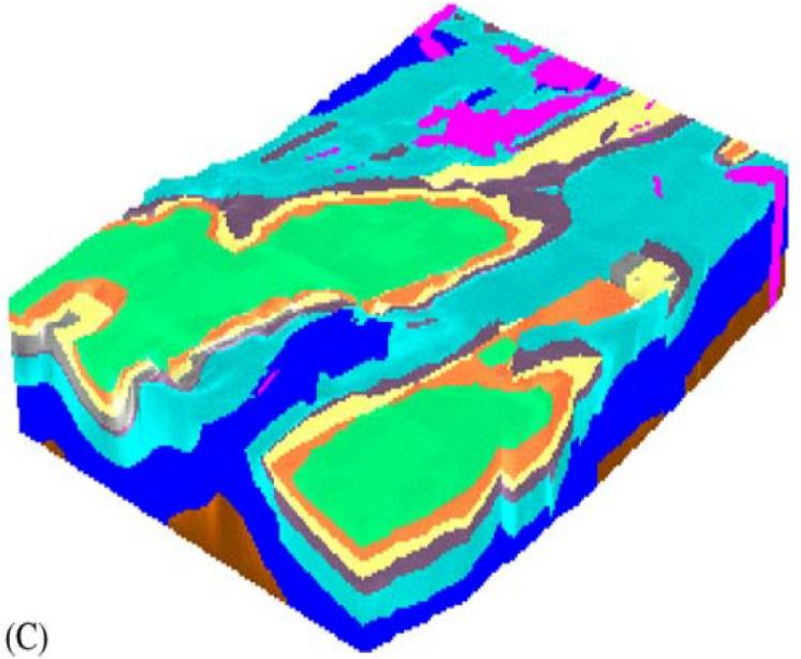
(A) Fault models.

Modeling in Huai Bei, China

Steps:

4. Define a template as data reference format.
5. Generate each horizons from top to bottom.
6. Create solid models of stratigraphy from horizon models.

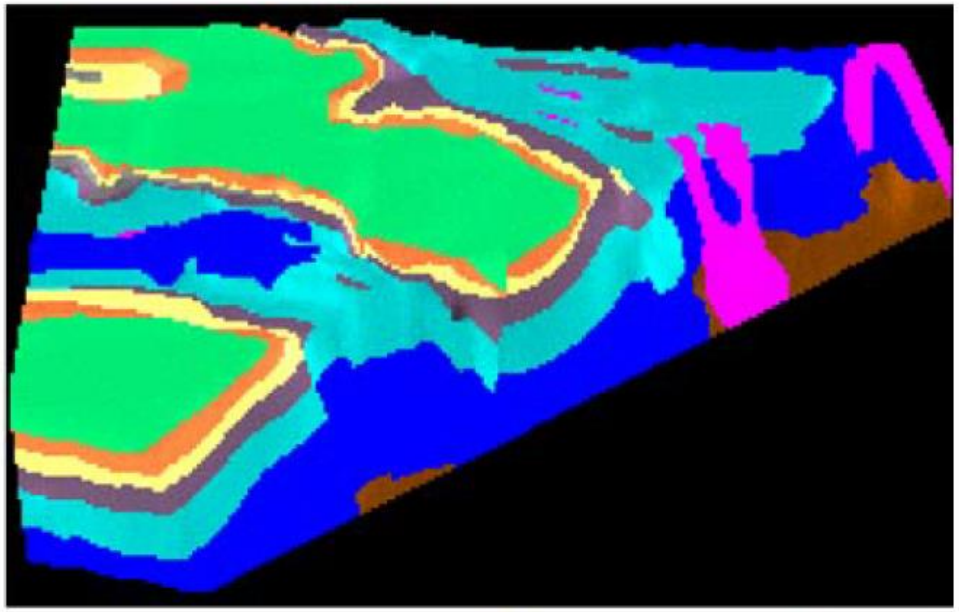
(B) Horizon models.



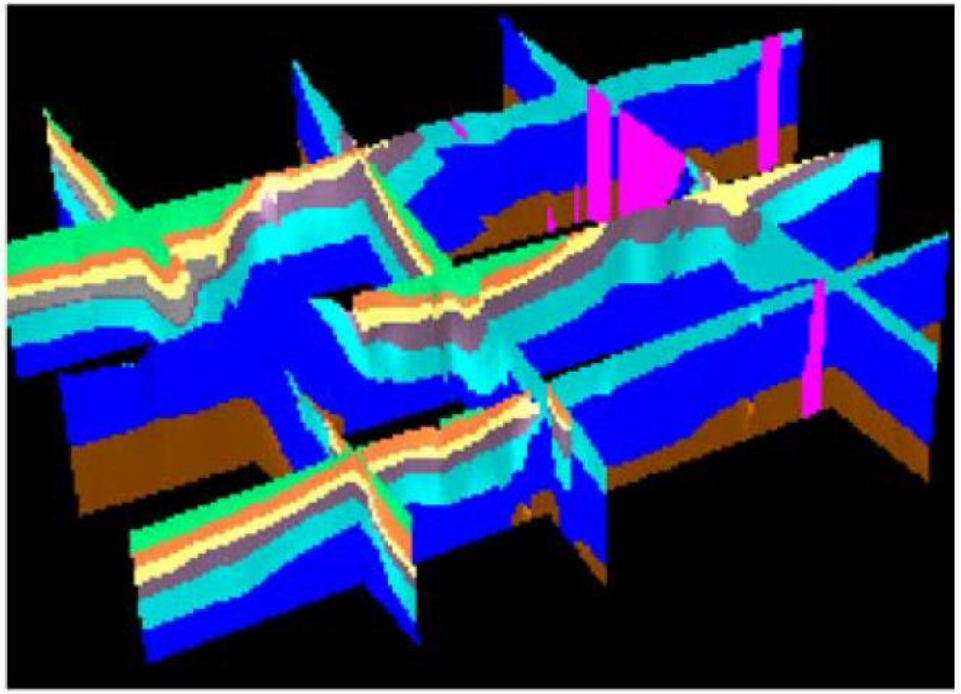
(C) Solid models.

Fig. 6. Example of 3D modeling in Huai Bei, China

Modeling in Huai Bei, China



A 3D section.



Fence diagrams created from solids.

Conclusion

- The stepwise refinement method with multi-source data integration significantly improves 3D geological modeling.
- Strata boundaries can be precisely controlled through multi-source data integration, which enhances the overall accuracy of the 3D model.

Thank you for your attention