Illinois Basin Channel Fills and Point Bars: 3D Models from Legacy Mapping*

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Abstract

This research investigates conversion of 2D legacy subsurface mapping of Illinois Basin oil fields to 3D geometric models. The term legacy mapping refers to existing mapping showing the results of previous drilling and interpretation that is available only in hard-copy format. This research addressed three questions: First, what workflows support rapid and accurate legacy map conversion? Second, what geometry is typical of subsurface point bars and channel fills? Third, how can point bars and channel fills be accurately modeled?

Three Illinois Basin oil fields with available legacy mapping served as study areas. To examine conversion workflows, we digitized each field using a defined coordinate system and specific digitizing protocols. The protocols identified mistakes in data input and model calibration and located errors in digitizing. Project output was a standard suite of map and data products. This provided a consistent format and avoided time needed for unique map design.

To examine point bar and channel fill geometry, the 3D surface models developed in the standard mapping suite were manipulated to show each field with different tilts, rotations, and projections. Point bars were relatively easy to identify from their subsurface geometry and by comparison to surface analogs. Channel fills were more complex, perhaps due to deformation and compaction.

Accurate 3D modeling of point bars and channel fills required careful model manipulation. We initially used a default 45° rotation and 30° tilt, but changes generally were needed to clearly show subsurface shape. Use of draped structural contours or isopachs quantified size and slope, and map colors were selected to match strata.

We concluded that the conversion process employed facilitated rapid conversion and 3D visualization of legacy maps. Digitizing protocols ensured data quality, and standard map design decreased conversion time. Conversion efficiency depended heavily on understanding process workflows and on early identification of mistakes. Experience with the 3D models tilts, rotations, and projections provided the opportunity for personnel to develop a mental reference for the subsurface signature of point bars and channel fills. Finally, it was concluded that successful legacy map conversion requires not only sound graphics ability but an intimate understanding of geology, geophysics, and geomorphology if maximum benefit is to be taken from the effort.

Selected References

Barrows, M.H., and R.M. Cluff, 1984, New Albany Shale Group (Devonian-Mississippian) source rocks and hydrocarbon generation in the Illinois Basin, in G. Demaison and R.J. Murris (eds.), Petroleum Geochemistry and Basin Evaluation: AAPG Memoir, v. 35, p. 111-138.

Bethke, C.M., J.D. Reed, and D.F. Oltz, 1991, Long-range petroleum migration in the Illinois Basin: AAPG Bulletin, v. 75/5, p. 925-945.

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Swann, D.H., 1964, Late Mississippian rhythmic sediments of Mississippi Valley:-Bulletin of the American Association of Petroleum Geologists, v. 48/5, p. 637-658.

Pryor, W.A., and E.G. Sable, 1974, Carboniferous of the Eastern Interior Basin, *in* G. Briggs, (ed.), Carboniferous of the southeastern United States: GSA Special Paper, v. 148, p. 281-313.

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Eastern Section AAPG
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2012

Introduction

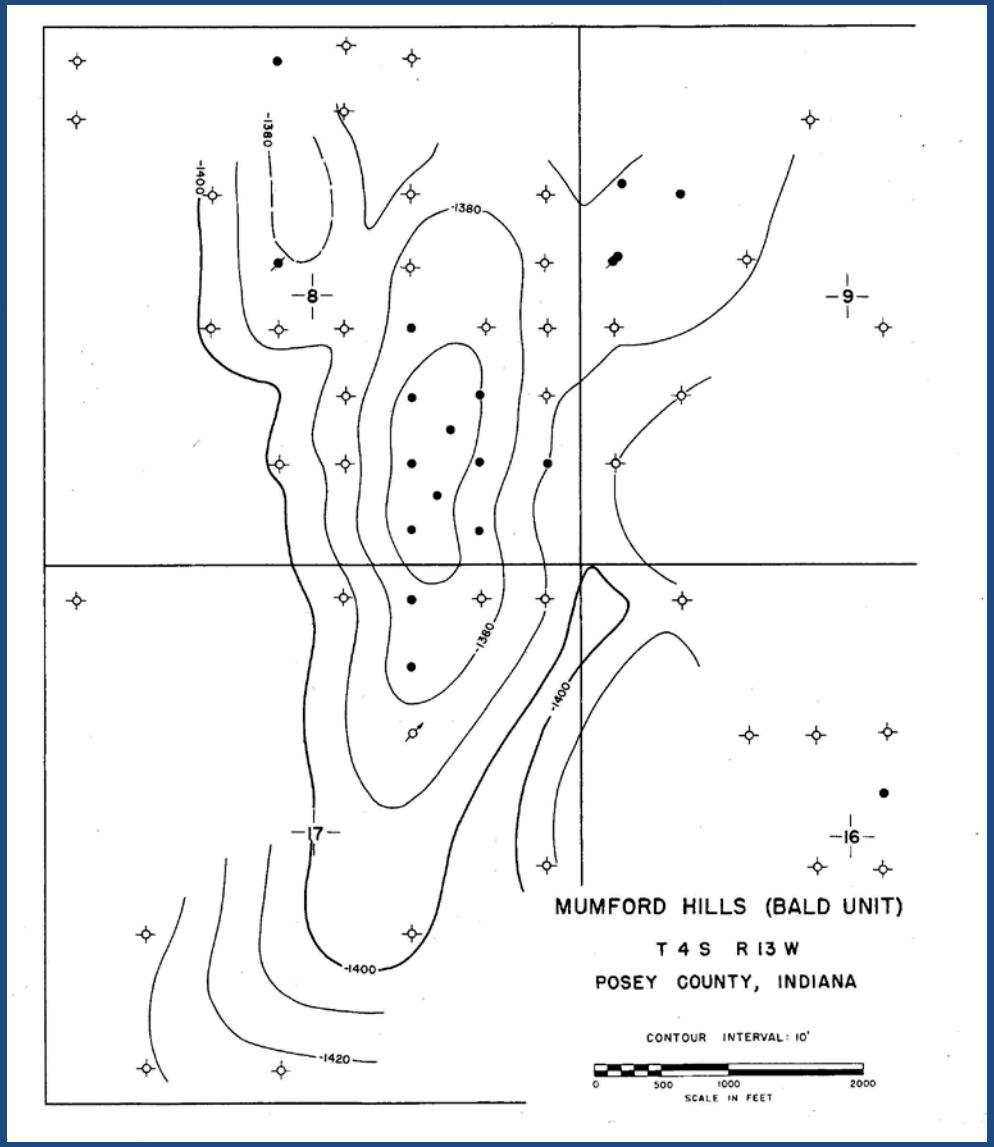
- Illinois Basin
  - 60,000 square miles
  - 3 states
  - 214,000,000 bbls of bypassed hydrocarbons

Introduction

- Active exploitation since 1900’s
- Intensive exploration 1940-1985
- Significant legacy mapping

Introduction

- Legacy mapping
  - Results of drilling
  - Geological interpretation
  - Hard-copy format

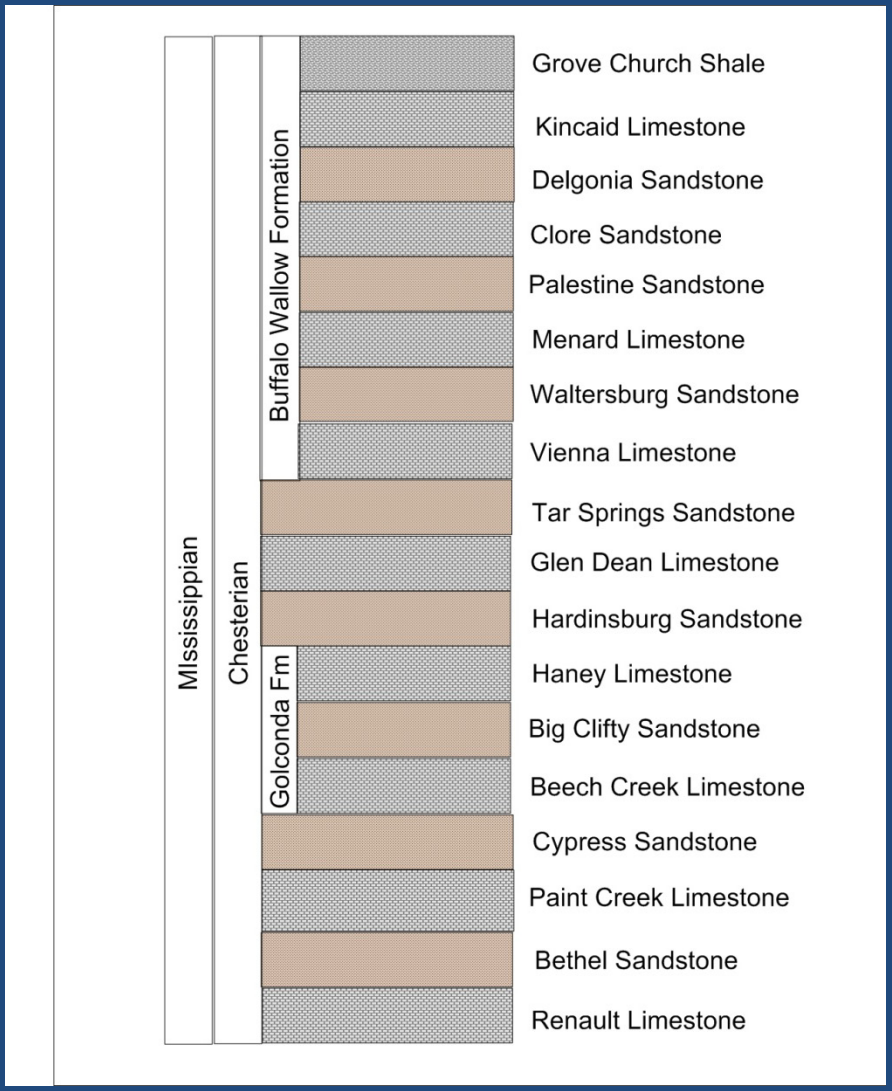


Objectives

- (1) What workflows support rapid and accurate legacy map conversion?
- (2) What geometry is typical of point bars and river channels in the subsurface? And
- (3) How can point bars and channel fills be accurately modeled in three dimensions?

Background--Geology

- Negative structural feature
- Pennsylvanian, Mississippian, Devonian rocks



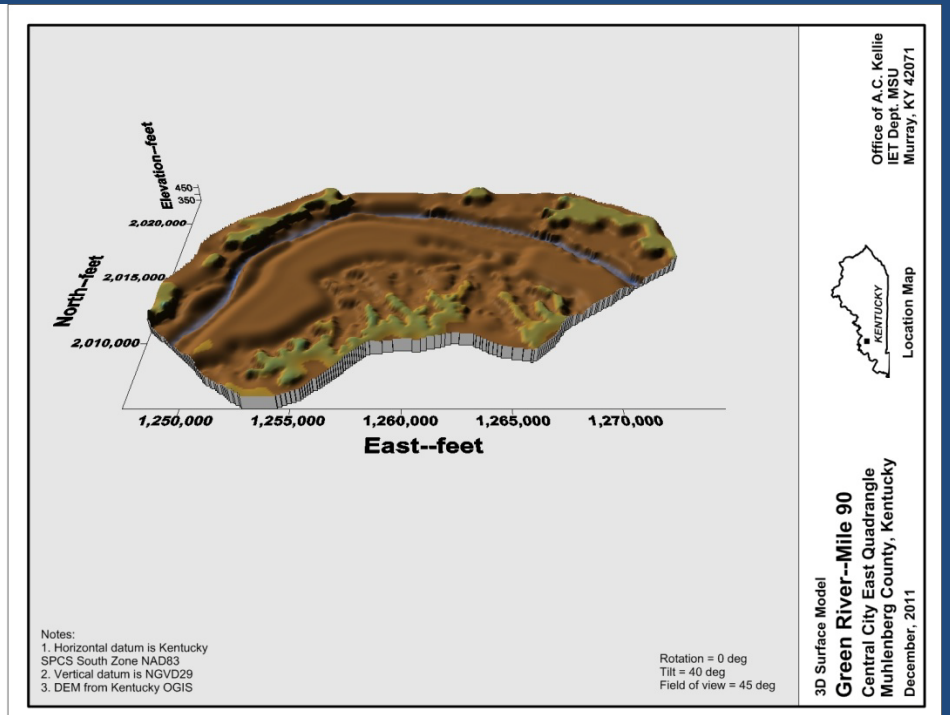
Background--Geology

- Significant work
  - Barrows and Cluff, (1984);
  - Bethke, Reed, and Oltz, (1991);
  - Bond, (1968); Freeman, 1941; Miller, (1968);
  - Sable and Dever (1990); Swann, (1964);
  - Pryor and Sable (1974); and Zuppann (1986)

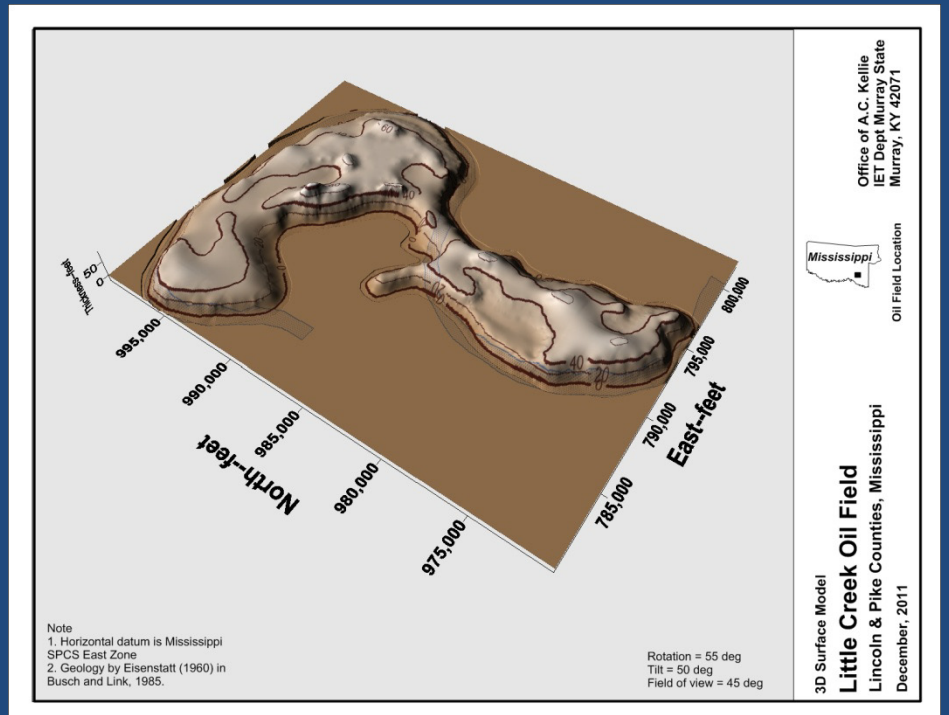
…and others!

Background--Morphology

Surface Analog
Central City Quad

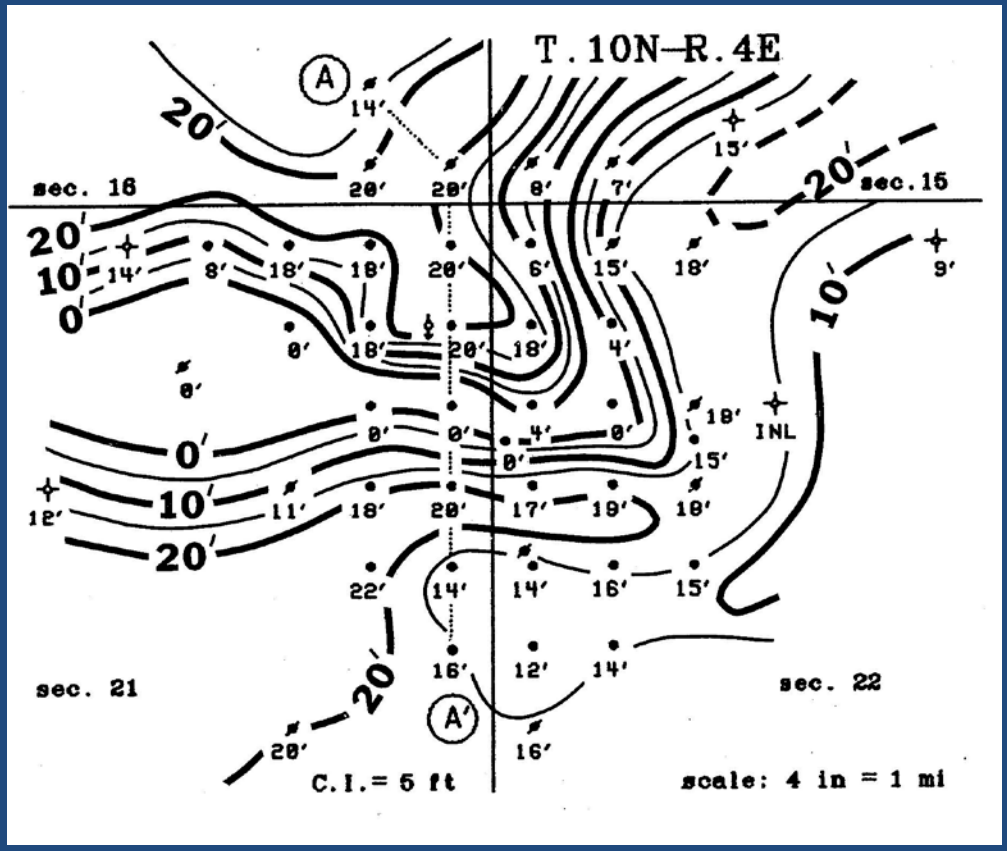


Subsurface Expression
Eisenstatt, 1985



Background—Legacy Maps

- Georeference
- Digitize by layer
- Validate
- Standard output

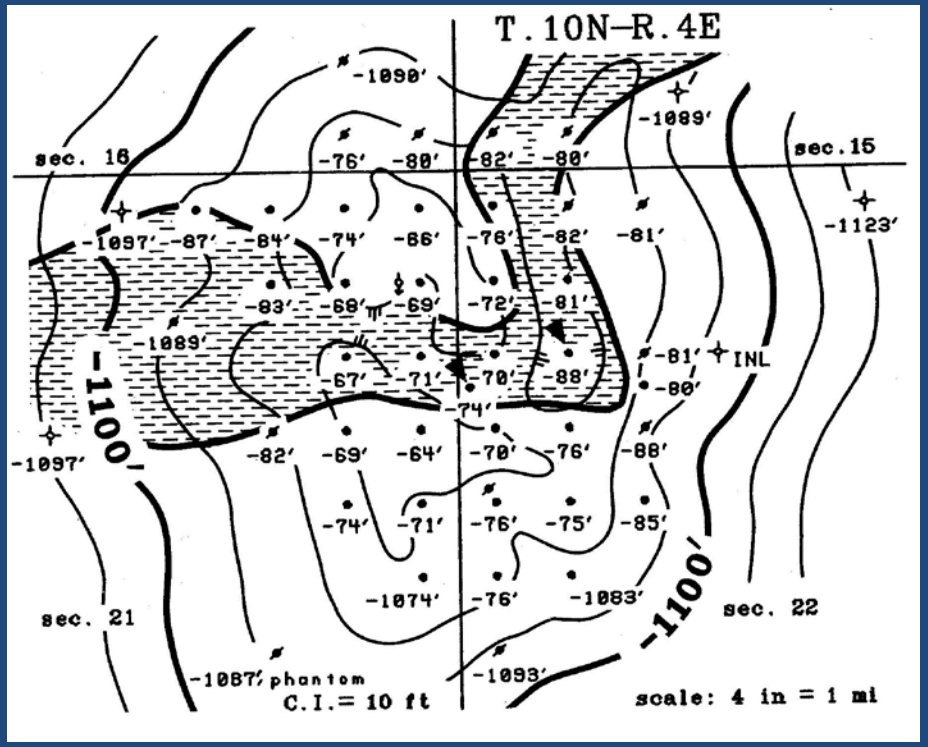


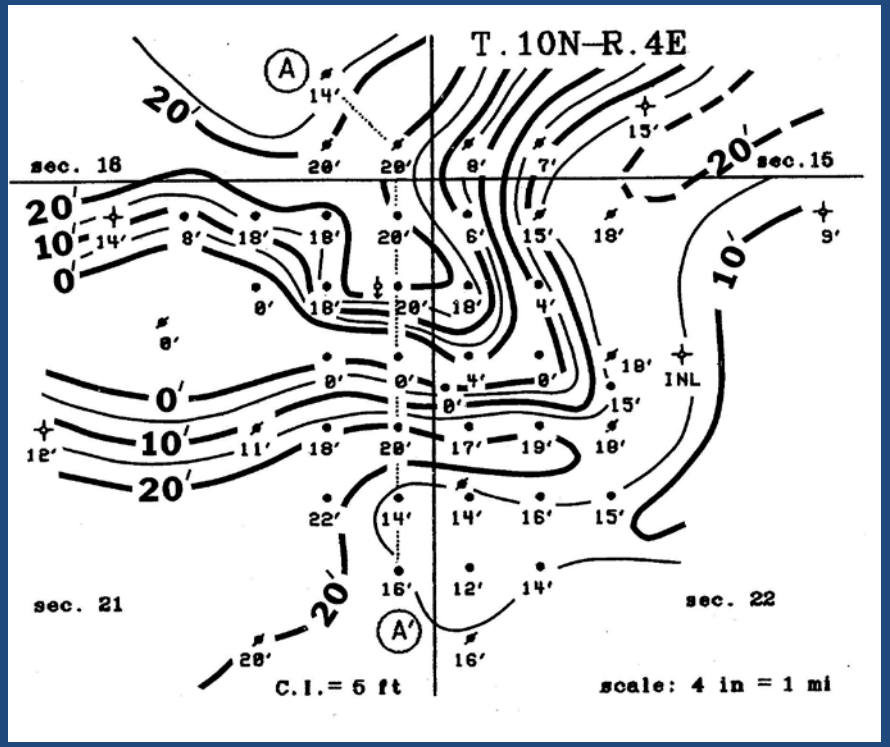
Study Areas

- Mode
- Midland
- Mumford Hills

- Legacy mapping
  - Structural contours
  - Isopachs

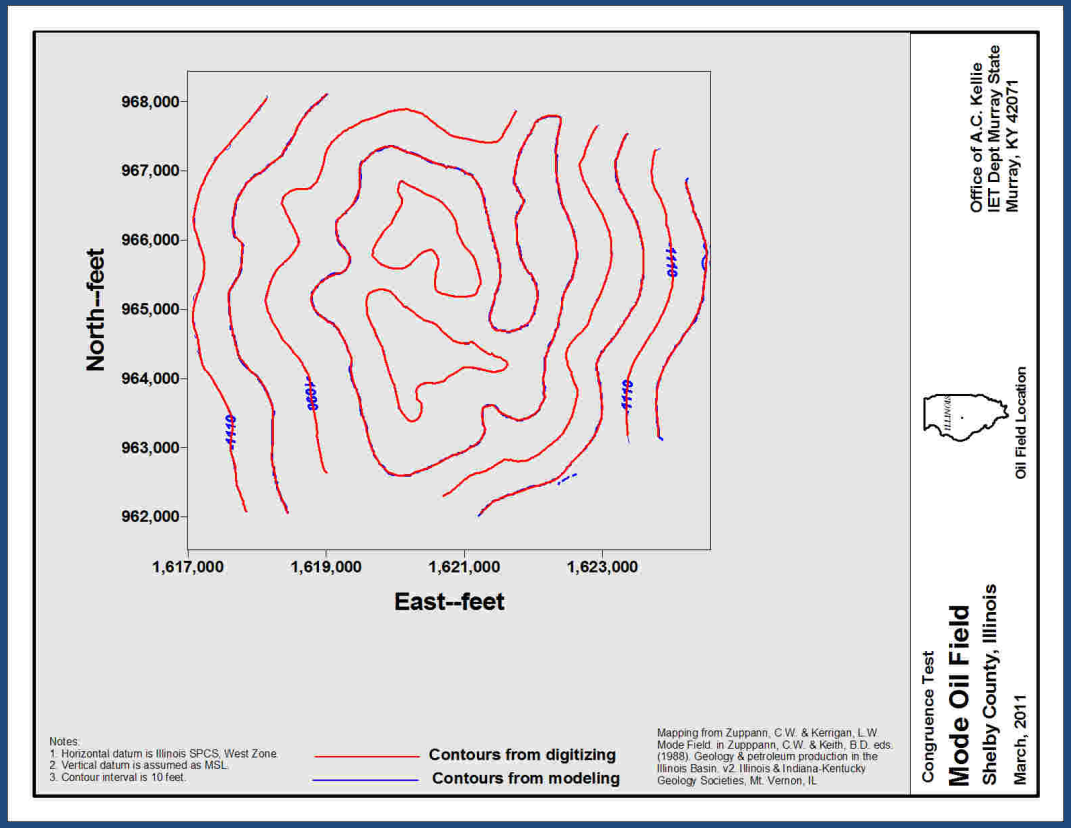
Legacy Mapping—Mode Field





Legacy Map Conversion Procedure

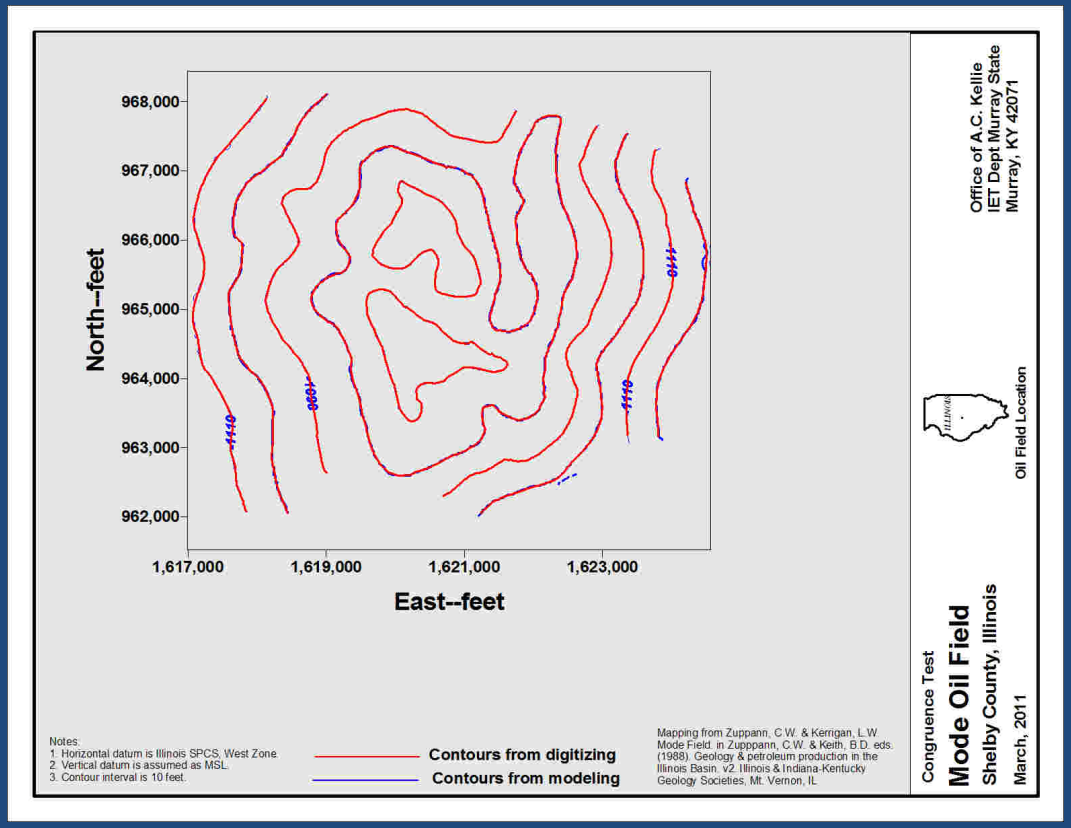
- Georeferenced
- Digitized
- Validated



Legacy Map Conversion Procedure

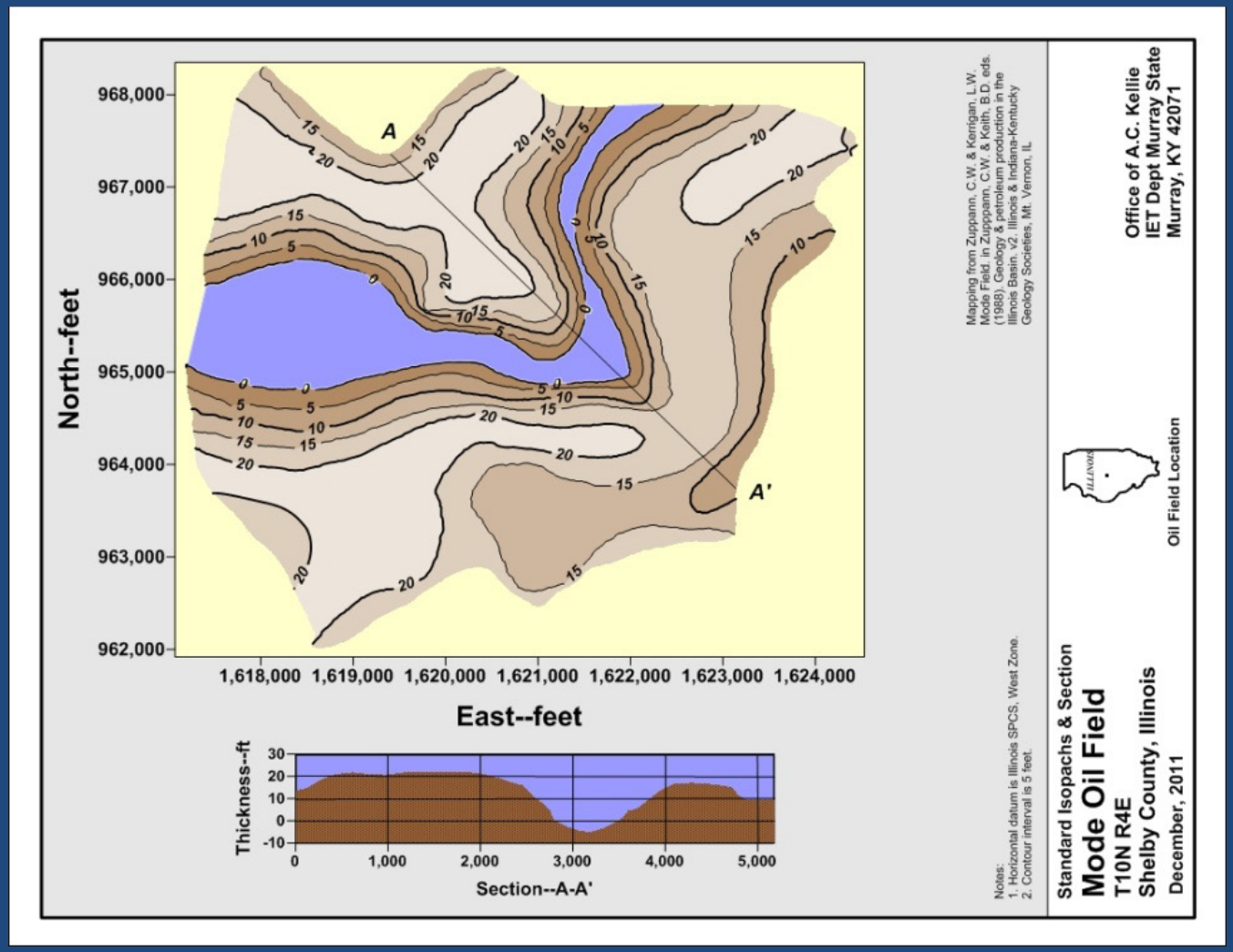
- Georeferenced
- Digitized
- Validated

- Standard format
- Map suite



Legacy Map Conversion Procedure

- Standard section
- 3D model
- Wireframe



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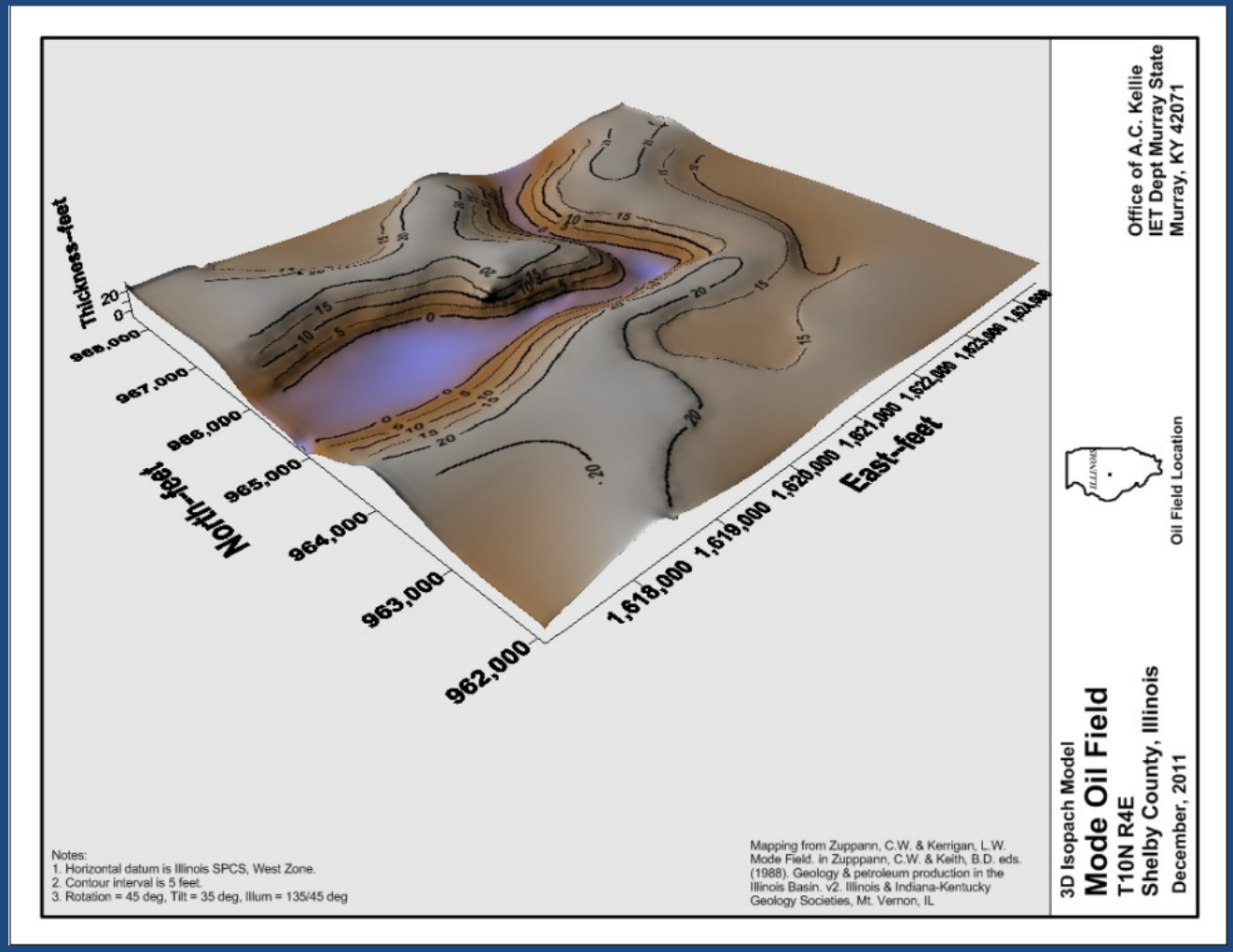

Legacy Map Conversion Procedure

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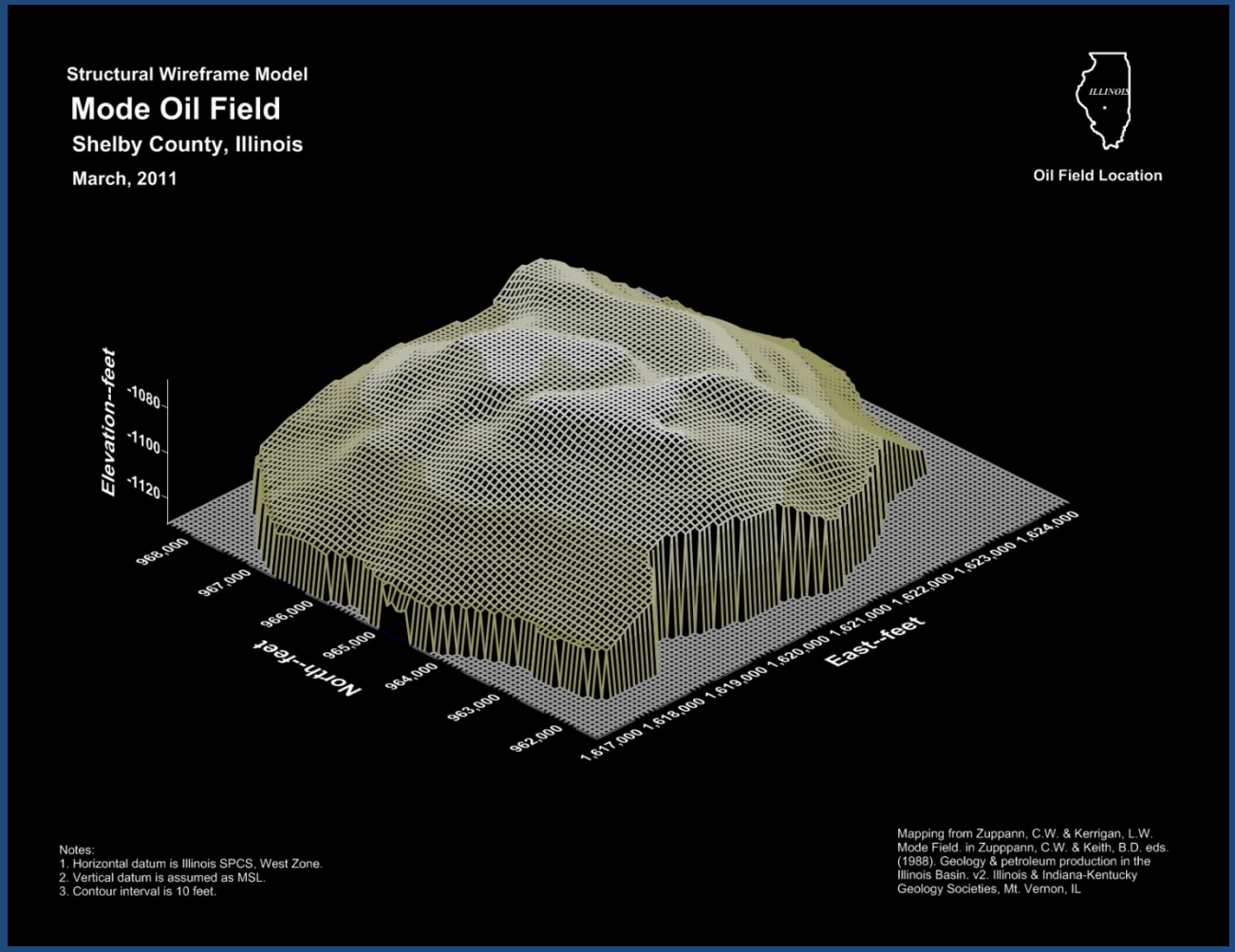
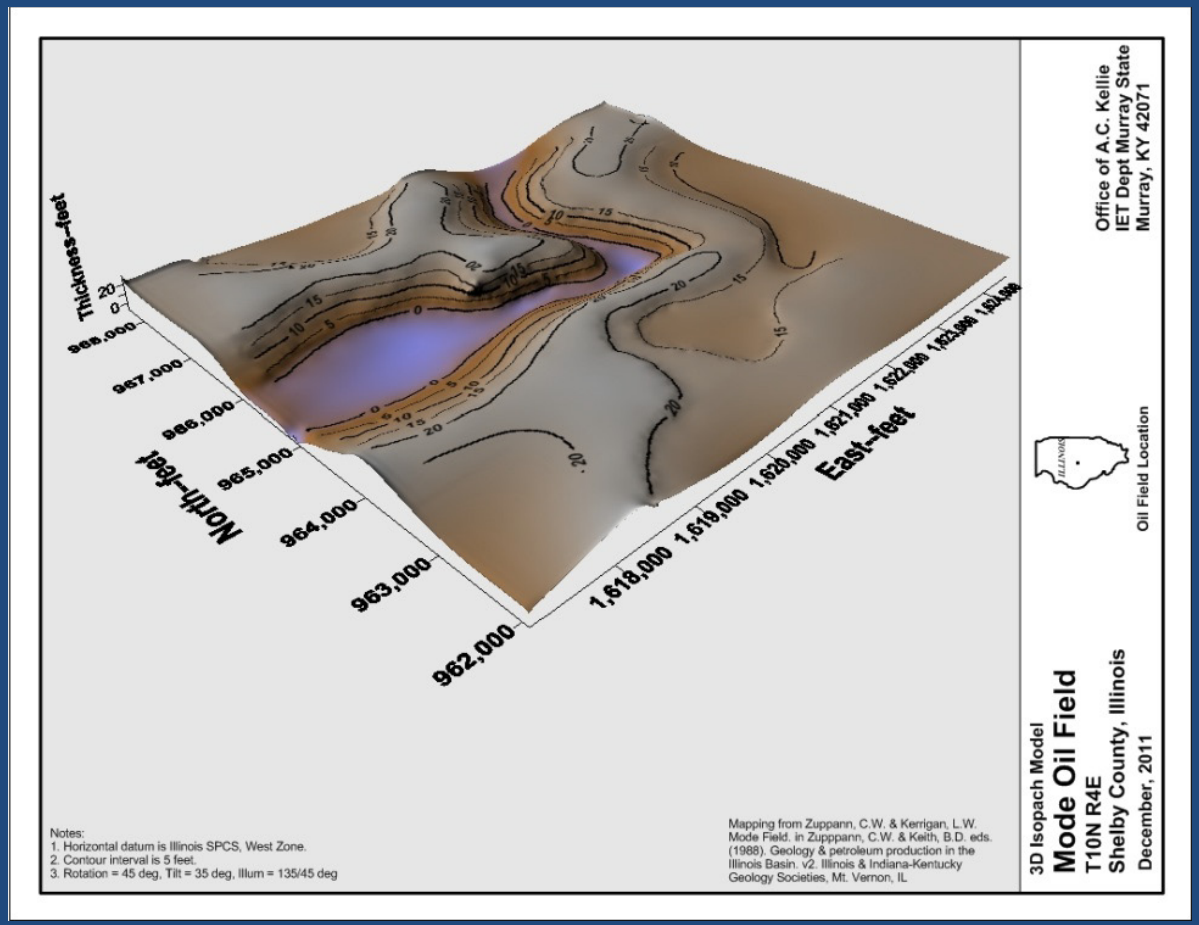


Legacy Map Conversion Procedure

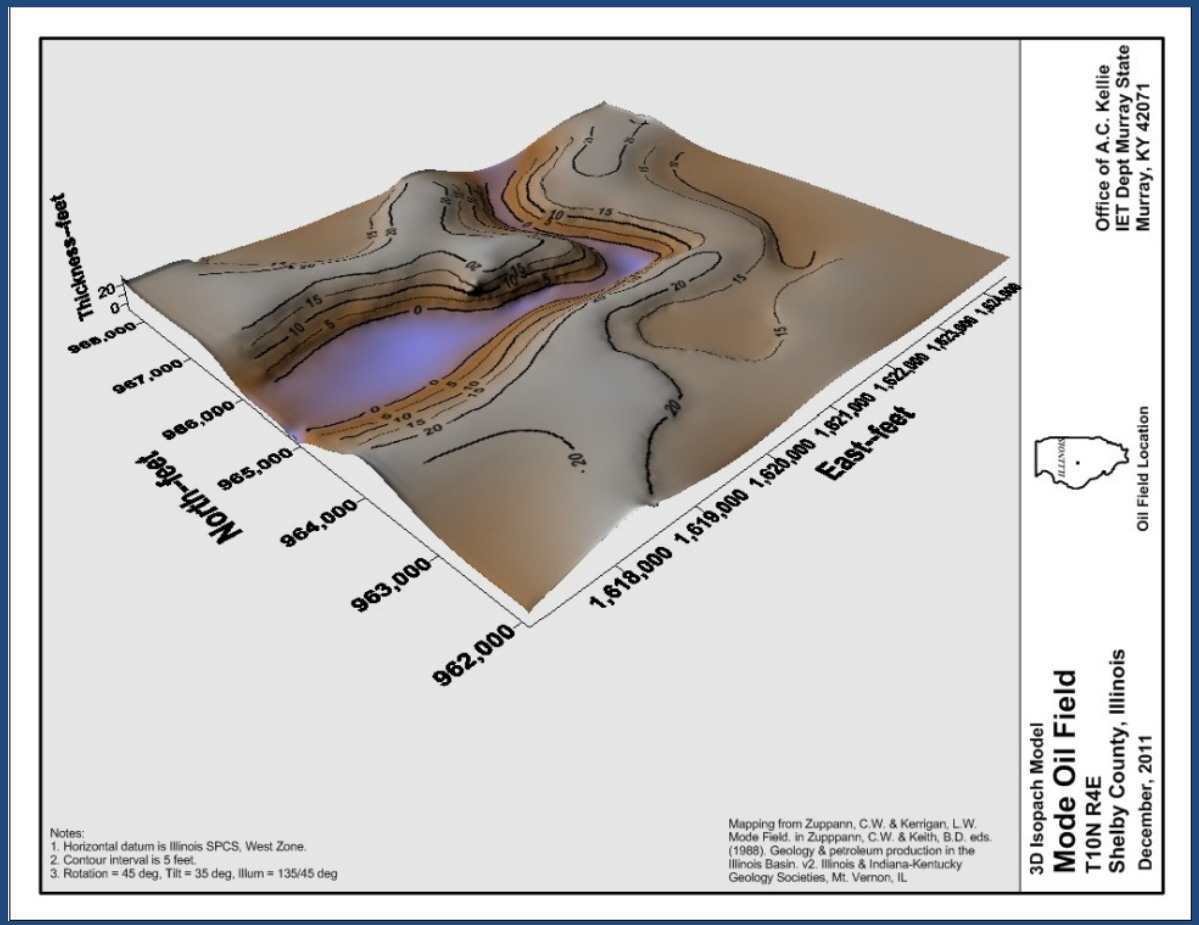
- Georeferenced & validated mathematical model
- Standard map suite
- Natural color to support interpretation

Mode Field—Subsurface Morphology



- Point bar
- Natural levees
- Meandering channel

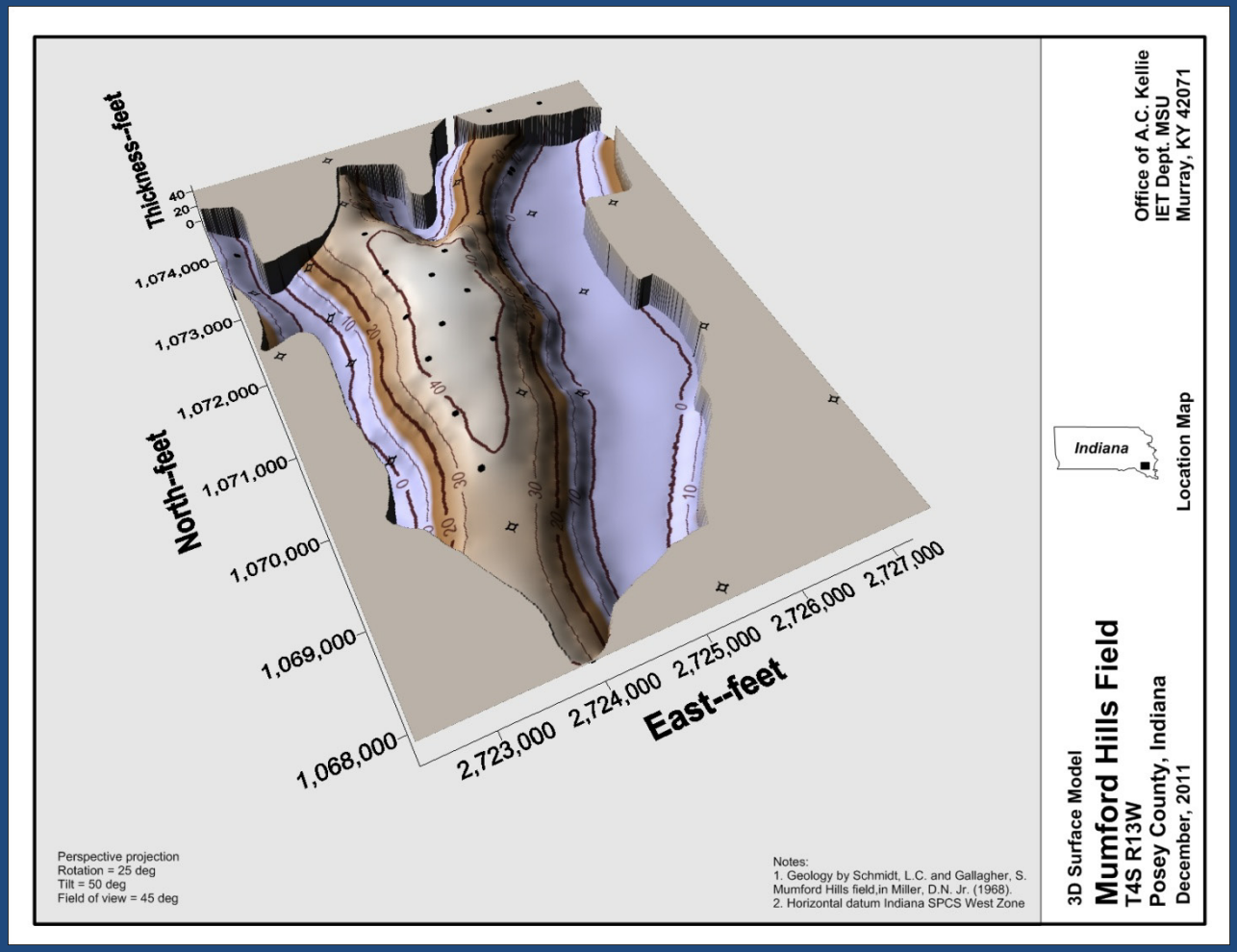
Mode Field—Subsurface Morphology



- Point bar
- Natural levees
- Meandering channel

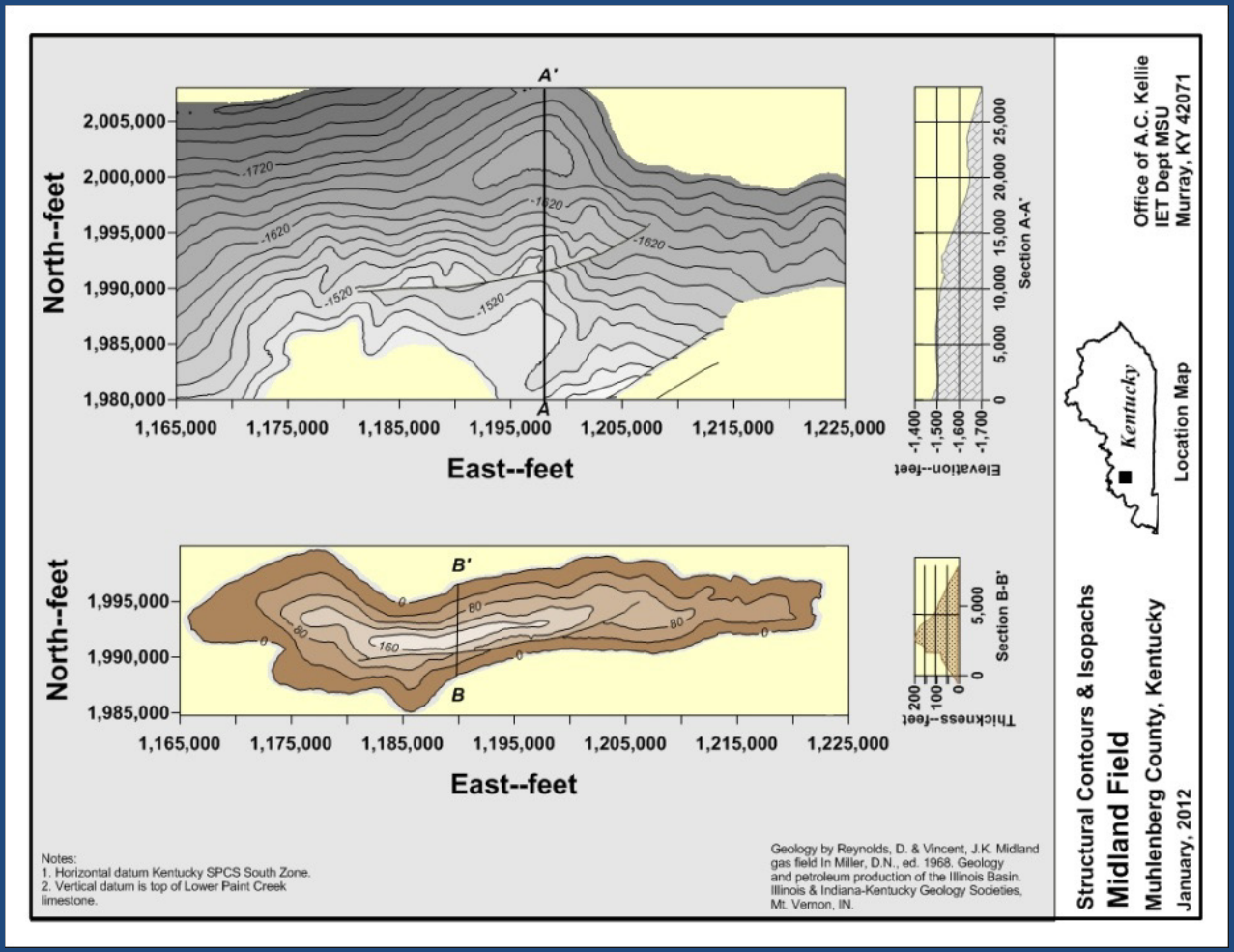
- Clay plug
- Negative space

Mumford Hills Field—Subsurface Morphology



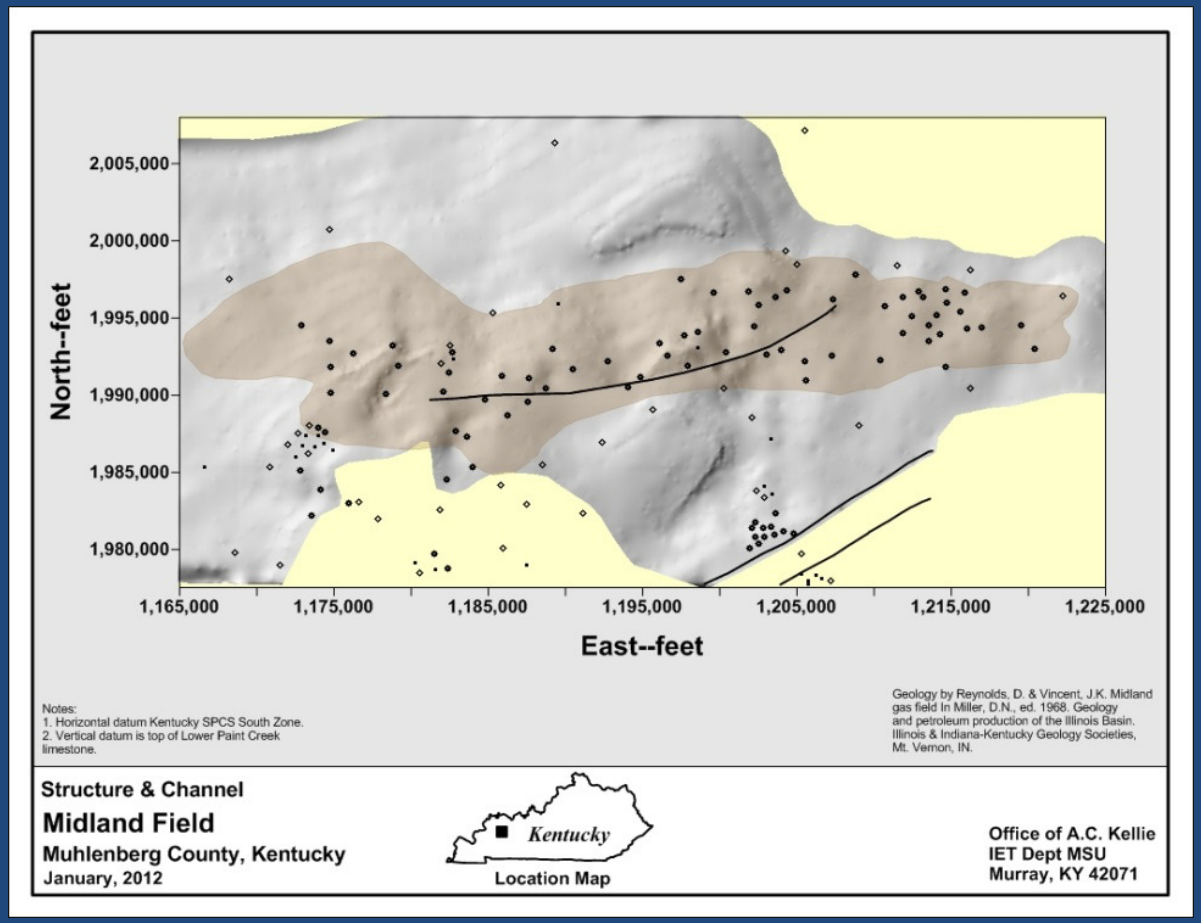
- Incised point bar
- Clay plug
- Similar to Mode Field

Midland Field—Subsurface Morphology



- Discontinuous mapping
- Faulted structure
- Reverse-image Ss channel

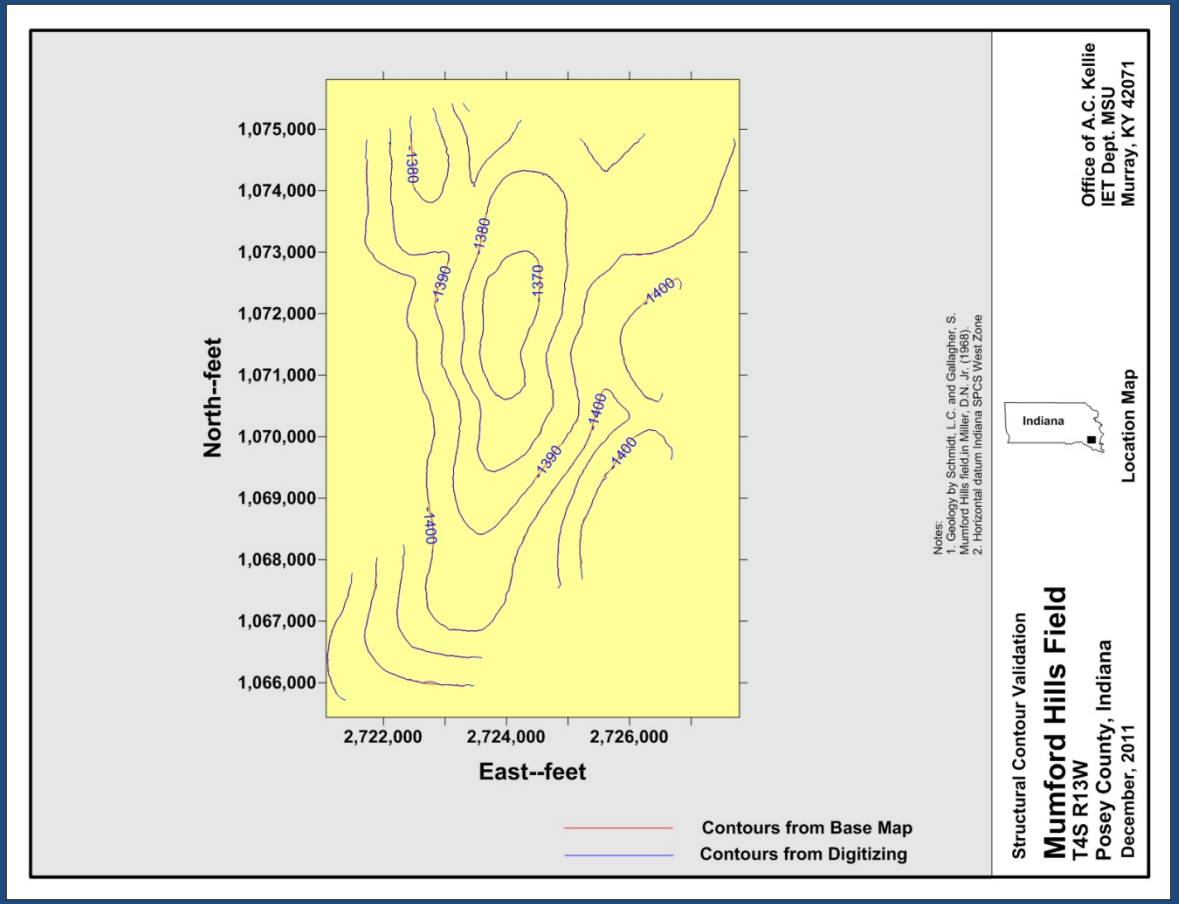
Midland Field—Subsurface Morphology



- Channel ss plotted on shaded image map
- Wells & dry holes added

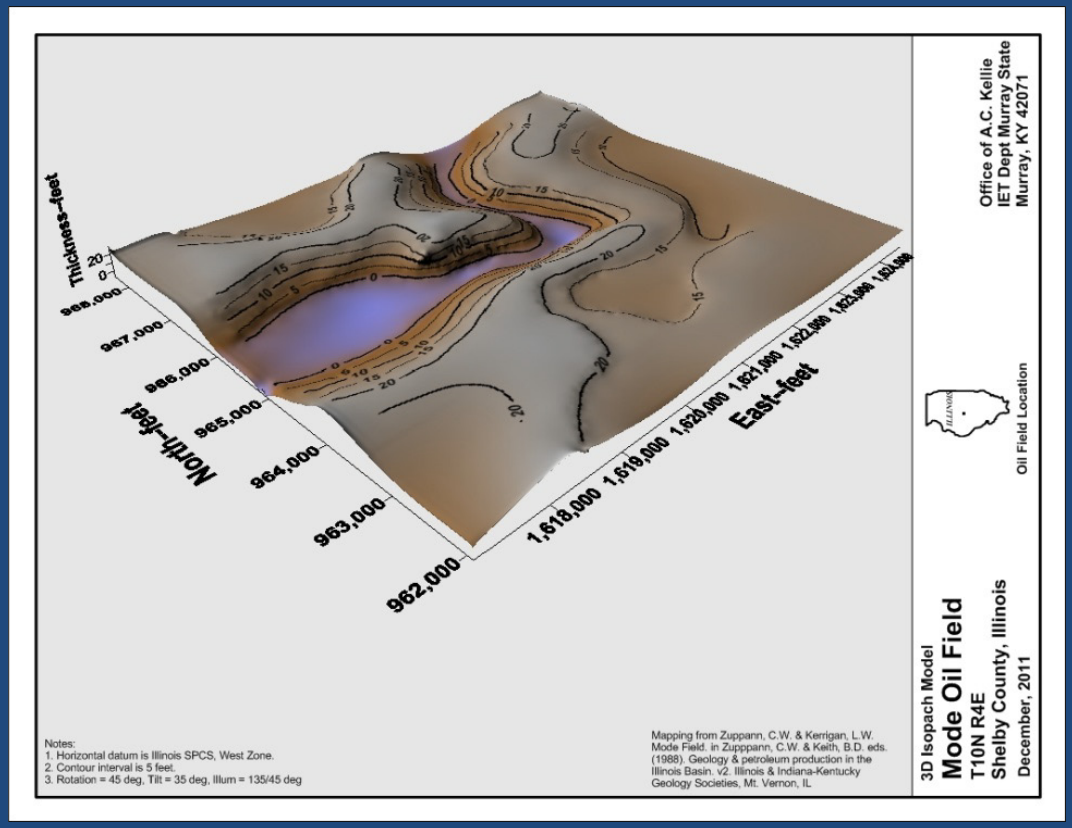
Results

- (1) What workflows support rapid and accurate legacy map conversion?
  - Digitizing protocols
  - Editing & validation
  - Defined product outputs



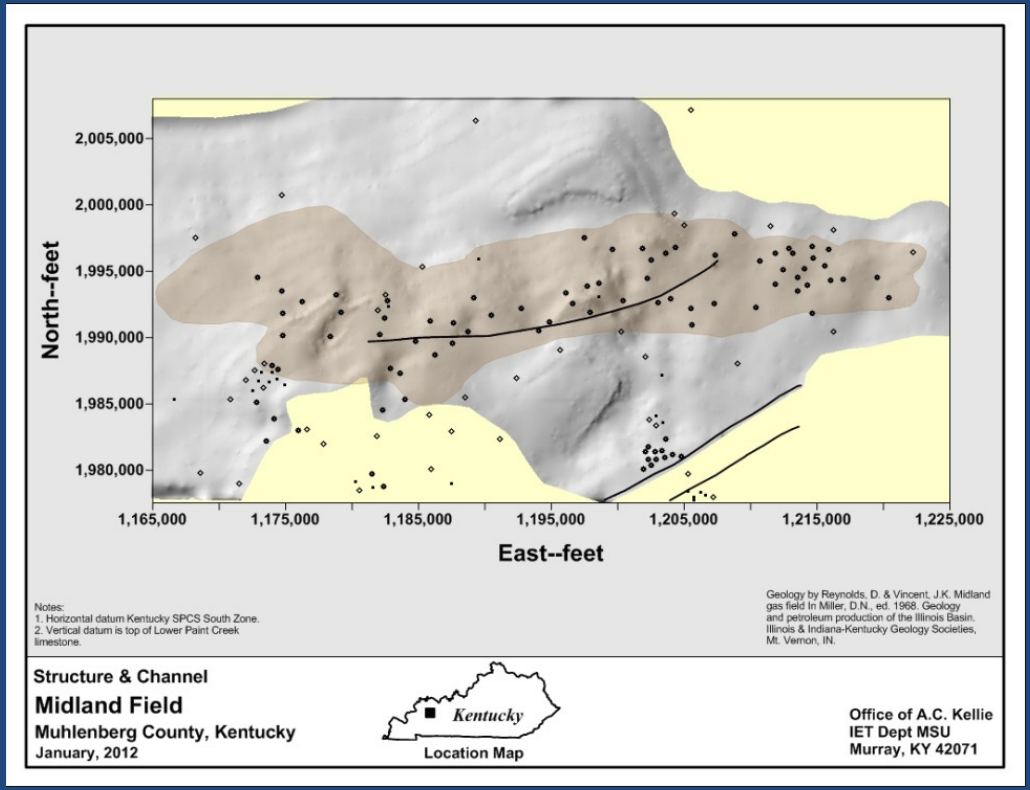
Results

- (2) What geometry is typical of point bars and river channels in the subsurface?
  - Characteristic surface shape
  - Presence of clay plug
  - “Reverse image” isopachs
  - Disected structures



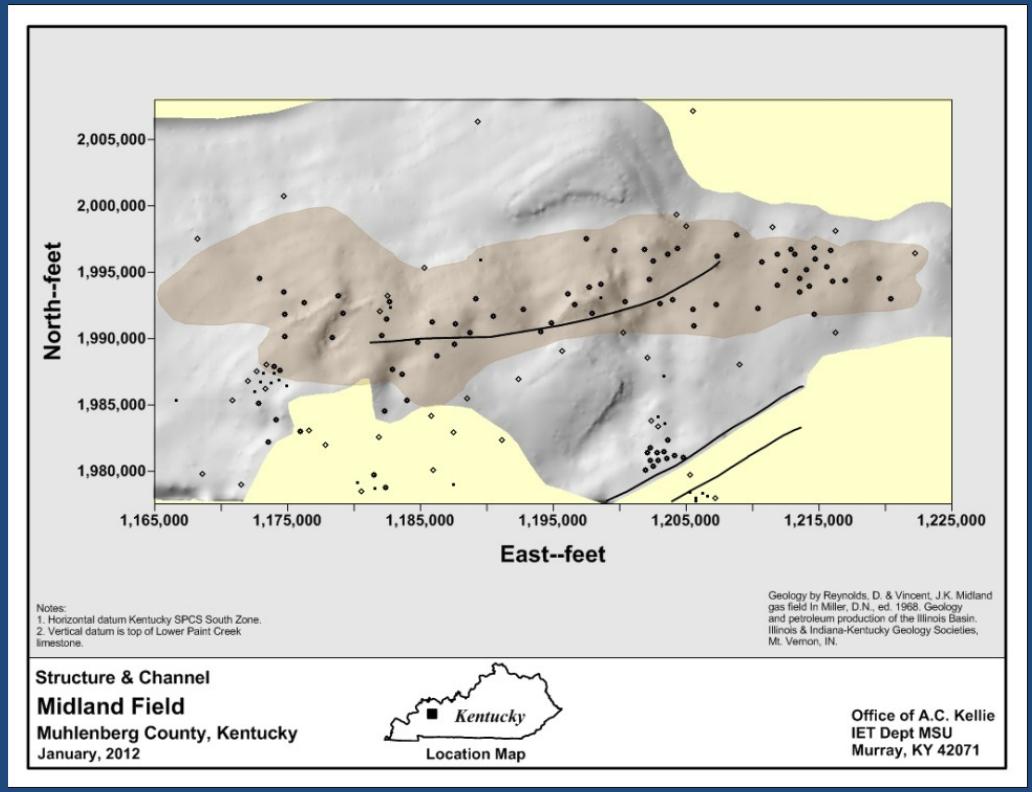
Results

- (3) How can point bars and channel fills be accurately modeled in three dimensions?
  - Natural colors
  - Tilted, rotated models
  - Superimpose fairway on shaded image map
  - Vary illumination & sun angle



Results

- (3) How can point bars and channel fills be accurately modeled in three dimension?
  - Natural colors
  - Tilted, rotated models
  - Superimpose fairway on shaded image map
  - Vary illumination & sun angle
  - NOT solely a question of geometry & graphics!



Thank you!

- Program committee for invitation to present
- Conference committee for arranging meeting
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