Environmental and Exploration Geophysics II

Traps and Prospects

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Reflection seismology unveils the subsurface for our inspection and interpretation.
Essential ingredients needed to form hydrocarbon rich zones - source, reservoir, trap and seal
The explorationist at work
Sediments shed from the uplifted Sierra Madre Mountains pile up in coastal areas of the Rio Grande Embayment. The pull of gravity on this large mass of sediments caused faults to develop that accommodated gradual sliding or creep of large sediment laden blocks out into the Gulf of Mexico.
Deltas load the shelf with sediments and gravity takes over.

Sediments pile up in the embayment which slopes off into the Gulf of Mexico. Mass wasting of the shelf proceeded under the pull of gravity.
Faults rise to the surface in the landward direction as the sediments take a sled ride into the Gulf. These faults accommodate extension at a slow (creeping) but steady pace. Time is always available in excess for the geologist.
As extension faults develop, strata collapse back into the fault plane and additional sediments fill the resulting void and additional faults dipping toward and away from the direction of movement – the synthetic and antithetic faults, respectively.
From Seismic to reservoir image

http://www.gcmwenergy.com/seismic_line.htm
Seismic acquisition to subsurface imaging

http://www.gcmwenergy.com/seismic_survey.htm
Note the roll-over into the glide zone, synthetic and antithetic faults
Complex traps and cap rock
Significance to US carbon program:
Potential to upscale to impact US releases

Havorka, 2004, Texas Bureau of Economic Geology
Regional Geologic Setting – Cross Section

Pilot site

- Sandstone dominated units
- Mud-dominated units
- Carbonate dominated units

Base meteoric system
Major growth fault zone

Havorka, 2004, Texas Bureau of Economic Geology
Site Location

- 50-year-old oil field in the Yegua and Frio Formations
- Operator is a small independent
- Flank of a salt dome, steep dips, fault bounded compartments

Havorka, 2004, Texas Bureau of Economic Geology
• Injection interval: 24-m-thick, mineralogically complex Oligocene reworked fluvial sandstone, porosity 24%, Permeability 50 -300 md
• Seals – numerous thick shales, small fault block
• Depth 1,500 m
• Brine-rock system, no hydrocarbons
• 150 bar

Frio Brine Pilot

Havorka, 2004, Texas Bureau of Economic Geology
Model Area:
54 wells
19 wells with logs
Structural Cross Section

Well # 4

Well # 3

Bend in section

Havorka, 2004, Texas Bureau of Economic Geology
A quick look at the seismic around a salt dome
Stratigraphy

Well #3

MFS-40

MFS-43
MFS-434
MFS-44
MFS-444
MFS-45
MFS-46
MFS-47
MFS-48

Not shown: MFS-485, 49, 50

“A” Sand

“B” Sand

“C” Sand

Anahuac

Upper Frio Monitoring

Injection

Havorka, 2004, Texas Bureau of Economic Geology
Reservoir Model

Porosity

Fault planes

Monitoring well
Injection well

A sand
B sand
C sand

Havorka, 2004, Texas Bureau of Economic Geology
Typical Distribution of Porosity in “C”

Havorka, 2004, Texas Bureau of Economic Geology
Unexpected Results of Injection

Escape to groundwater, surface water, or air via long flowpath

Earthquake

Escape of CO$_2$ or brine to groundwater, surface water or air through flaws in the seal

Failure of well cement or casing resulting in leakage

Tom Wilson, Department of Geology and Geography

Havorka, 2004, Texas Bureau of Economic Geology
LONG-TERM FATE OF INJECTED CO₂
The low in the southeast is anomalous. Bring up crossline 140 and have a look. The travel time to the interpreted C38 reflection is much higher than that to the well pick. The denominator is large and we have a small average velocity.
In this case the travel time to the picked horizon is larger than the travel time to the location of the formation top. Since velocity usually increases with depth and travel time we get a higher velocity.
This depth converted map was constructed from the using the apparent velocity approach.
Isochron

- Create time grid for each horizon & include your polygon set (i.e. B46Time and C38Time grids)
- Convert them to depth using your favorite velocity models
- Associate polygon sets with your grids
- Tools > Calculators > Math on two maps
- fine tune parameters and select one or the other polygon set
Does it make sense?
Continue working with on your term projects!