BUILDING THE SEG/EAEG OVERTHRUST VELOCITY MACRO MODEL

JEAN-CLAUDE LECOMTE[1], EWAN CAMPBELL[2] and JEAN LETOUZEY[1]
[1] *Institut Français du Pétrole, PO Box 311, 92506 Rueil-Malmaison Cedex, France*
[2] *TNO Institute of Applied Geoscience*

Introduction

Thrust zones are areas in the crust that give extreme imaging and interpretation problems to reflection seismologists. This article presents the development of a 3D overthrust model that will be used by geophysicists to construct synthetic seismograms in order to test and improve the validity of the seismic imaging processes.

The overthrust model depicts a complex thrusted stratigraphy unconformably overlying an earlier extensional and rift sequence. An initial, 3D surface, model was constructed from a series of 2D cross sections. This model was then modified and used to generate a gridded 3D velocity macro model.

The Model

The total model area was 20 x 20 x 4 km to allow for a zone of maximum seismic coverage of 12 x 12 x 4 km. The model contained an extensional, fault block system at the basement level, with a zone of sediment cover on the basement blocks. Above this, there was an erosional truncation. A thrusted stratigraphic succession with a salt layer at the base was then deposited on the unconformity. The salt acted as a detachment level for the thrusts. Layer thickness was kept constant and layer geometry in the anticlinal structure was kept parallel.

The geometry introduced into the model was designed to test a number of geophysical imaging problems:

- 3 zones; a monoclinal zone, a thrust anticline and a flat zone.
- The convergence of two, irregular, thrust planes.
- An extensional basement structure below the salt horizon with structural trends perpendicular to the thrust strike.
- A footwall bulge that died out laterally, under the thrust package.
- Wave propagation in areas with complex shallow subsurfaces.

The idea behind this geometry was to introduce large lateral velocity contrasts into the model. Velocities varied from 2500 m/s at the surface to 6000 m/s in the basement. The convergence of the faults would test the resolving power of the seismic tool in areas of strong, velocity contrasts. There was a large velocity contrast at the base of the salt décollement level to provide a reference level during processing. The footwall bulge was introduced to test whether anticlinal features observed on seismic sections were the result of real structure or velocity pull-ups as a result of steep fold limbs. In order to test static effects velocity contrasts in the form of a buried topography were introduced, the shape of which is a function of the lithologies. At this time there is no known algorithm to cope efficiently with a surface topography in finite difference modelling schemes. In addition, channels and crevasse splay lenses were introduced into various layers throughout the model. The main features of the model are as follows:

- 3 thrusts; 2 converging, 1 blind and dying out laterally.
- Thrust anticlines.
- Thrust ramps and flats.
- Swing in strike of thrusts.
- 17 layers
- Parallel bedded, kink folding, no reverse limbs.
- Channels and crevasse splays in the upper sandstone layers.
- Buried topography of an upper weathering layer.

It was necessary to add an extra fault in order to induce a swing in the strike of the emergant fault planes. A blind fault was added to take up theis extra deformation. The resulting thrust geometriesare similar to those observed in McClay (1992), Dalstrom, (1970) and in sandbox experiments at IFP.

The stratigraphy and lithologies chosen are those typical of an extensional zone and of a mixed marine / terrigenous succession deposited upon evaporites. The thickness of the layers conform to those observed in reality while the depth of each lithology was chosen to correspond with the mechanical requirements of the fault geometry. Flats in the thrust planes were restricted to incompetent layers.

Building The Model

The model was constructed in 3D from 11 parallel 2D cross sections using GOCAD®. The cross sections were constructed using Thrustpack®. Thrustpack® is a structural forward modelling program which was used to deform a 3.5 km thick sedimentary succession. Deformation in a layer is taken up by kink folding. Using

Thrustpack® to design the model, resulted in a model with "built-in" 2D geometrical validation of the geology. The percentage shortening of each of the 3 faults could be varied in order to induce variations in the strike of the faults. The fold geometry generated by Thrustpack® is controlled by the deformation rules of Suppe (1983). 3D validation of the thrust plane geometry was carried out by the Fault Analysis Group of the University of Liverpool. The Fault Analysis Group also validated and designed the fault and rift sequence geometry of the basement.

GOCAD® was then used to construct a series of 3D surfaces that represented the horizons and faults of the model. constructed in GOCAD® used these faults and horizons to construct a 3D grid. The horizons were used as barriers in the interpolation of velocity values within the 3D space of the model. The horizon model then became a series of different 3D domains each with a different index value. The layers represented by different domains in the grid were then assigned a velocity value. Velocities for each of the lithologies were derived from those observed for similar lithologies at similar depths in the Rocky Mountains.

A subset of the model, containing the central portion of the velocity grid (see Figure), was then used to generate synthetic shot records in order to test aquisition parameters and modelling algorithms.

Conclusions

The overthrust model is a complex 3D structure both geologically and geophysically. With such a model, wave propagation will be difficult to understand and good seismic imaging is a challenge.

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References

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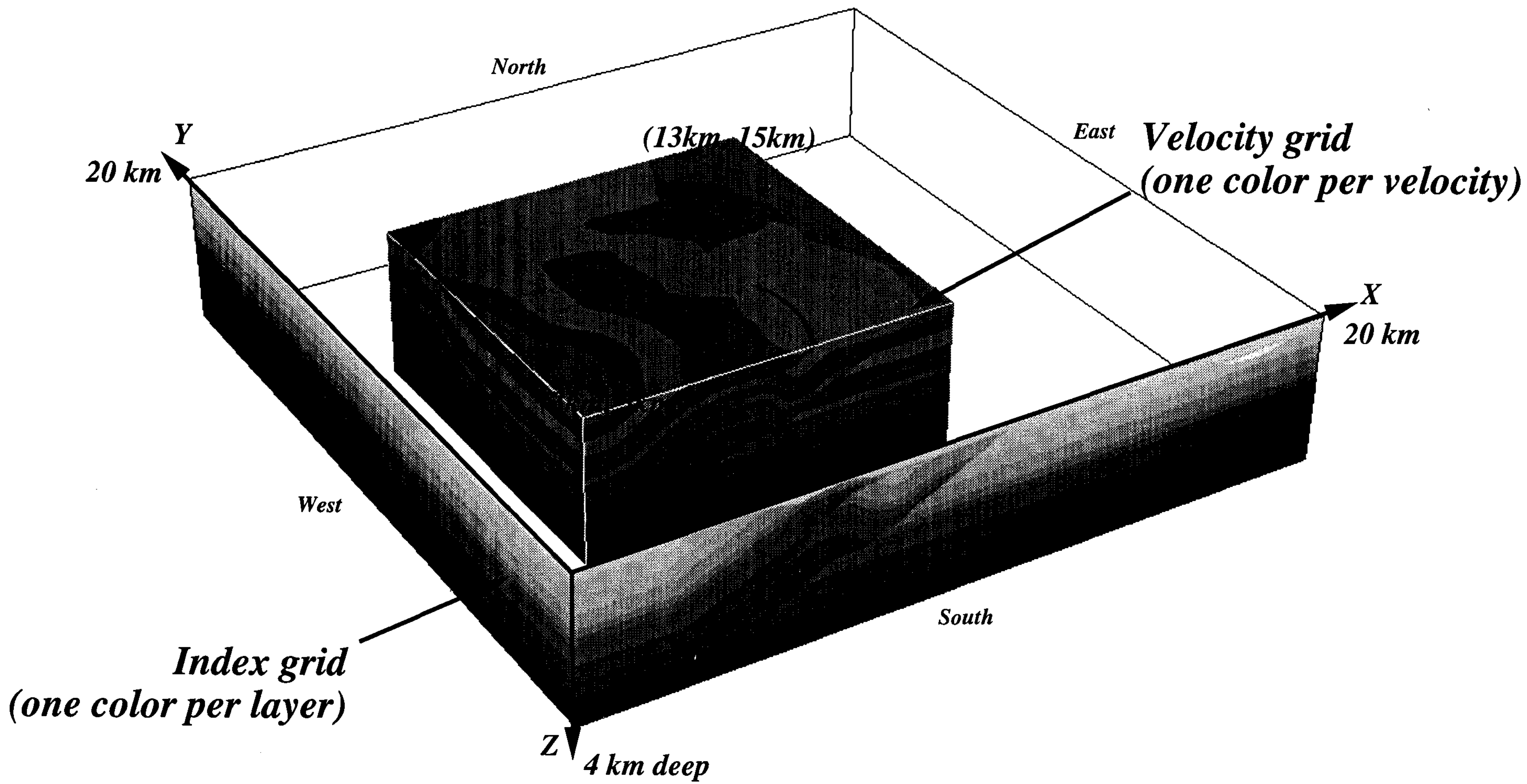
Grid Models



Realization in IFP with the help of GOCAD software