Facies Modelling in Irap RMS: Turbidites

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Introduction

Turbidite reservoirs are very heterogeneous by nature and combined with their deepwater environment and hence high development costs, it is important that accurate geological models are built. Irap RMS enables realistic modelling of the facies architecture and thus greater understanding of the internal flow units of the reservoir.

What are Turbidites?

Turbidites are gravity driven mass flows that transport sands from shallow water to deep-water depositional environments. They have a lensoid geometry normal to the main flow direction and tend to form in a stacked pattern with a common sediment source point.

Turbidites possess characteristic changes in facies, commonly having coarser layers towards the bottom of the deposit and finer laminations at the top of the sequence. This results from differing settling velocities of the different particle sizes present. This upward fining is known as a Bouma sequence. Turbidite bodies also display a proximal-to-distal and an axial-to-margin fining in grain size. The flow direction of turbidites is controlled by variations of the local sea floor topography. Consequently, paleotopographic features are reflected in the geometry and orientation of the sand bodies.

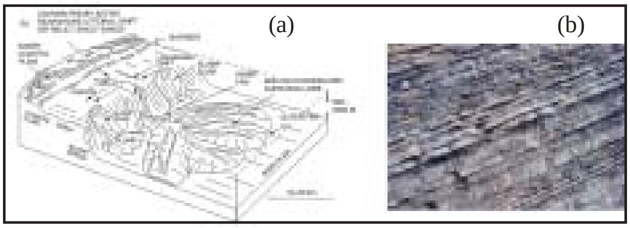

Fig.1a: Schematic diagram of a turbidite depositional environment from Emery, D. & Myres, K. J. (1996) Sequence Stratigraphy. Blackwell Scientific Publications, Oxford.
Fig.1b : Field example of a turbidite outcrop. Taken from the Thrace Basin of North West Turkey.

Turbidite modelling in Irap RMS

Object based facies modelling is successfully used to model objects such as channels, reefs and bars. However, turbidites have a much more detailed geometry and possess complex variations in orientation and local reservoir connectivity.

FaciesComposite, an object based modelling technique in Irap RMS, has introduced objects with a flexible shape that is built around a piecewise linear centreline called the backbone. This allows the definition of sand body geometry so that the user can define the architecture desired. To incorporate the topographic features of the turbidite bodies, it is possible to condition the backbone geometry to a vector field.

Within the stochastic petrophysical modelling tool of Irap RMS, it is possible to define porosity/permeability values for each individual turbidite sand body. The variations observed in grain size and hence reservoir quality can also be incorporated into the reservoir model.

Defining the Geometry

The geometry of the turbidite body is easily defined using the preset backbone geometry. The aerial shape of the body and the thickness variations along and across the axis of the body can be interactively defined to best match the desired architecture.

The dimensions of the sandbody are provided by the user as is volume fraction (the percentage of sand expected in the model). Irap RMS will use such constraints when building the model so that all criteria are honoured.

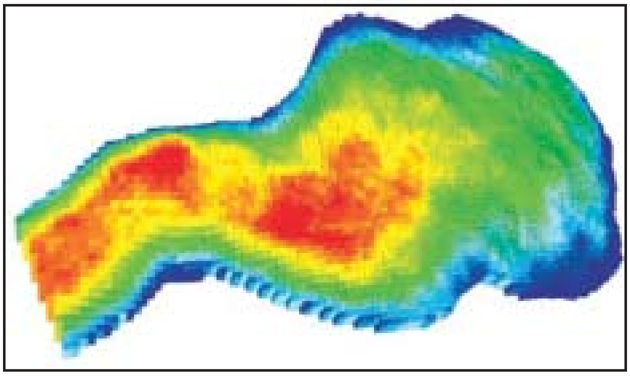

Fig. 2 : Illustration showing a modelled turbidite lobe. The reds and yellows represent the greatest thickness (proximal and axial locations) and the blues and purples the lowest thickness (turbidite margins).

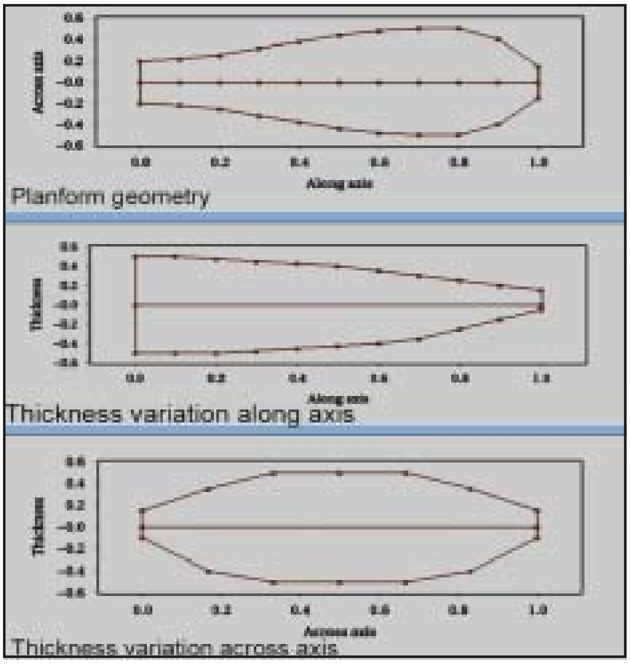

Fig. 3 : Above: The three geometric profiles available for defining the turbidite shape. In aerial view the shape is more confined and narrow at the proximal end and gradually widens along its length before narrowing at its distal termination. Thickness gradually decreases along the axis of the turbidite body and is greater towards the centre of the body, thinning towards its margins.

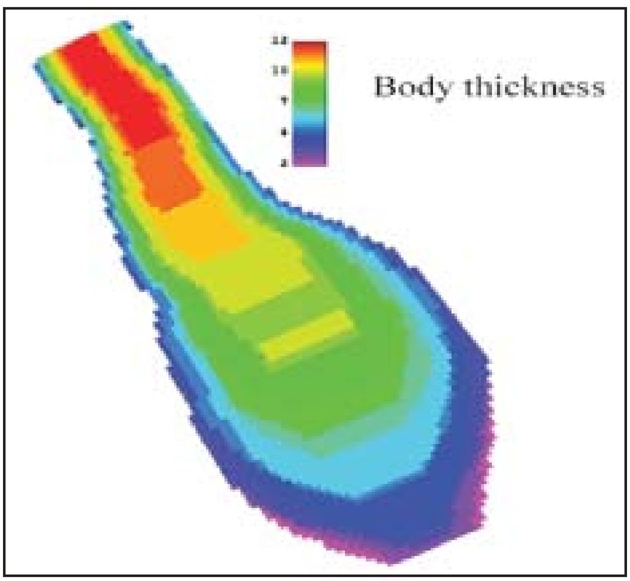

Fig. 4 : Illustration showing a modelled turbidite lobe. The reds and yellows represent the greatest thickness (proximal and axial locations) and the blues and purples the lowest thickness (turbidite margins).

Turbidite Orientation

As geometry and orientation of the turbidite bodies are strongly controlled by local topography, it is possible to condition the local orientation of the turbidite bodies to a vector field, which describes the local depositional direction. This is created using a structural interpretation of the reservoir, isochore maps or seismic data. These are used as a guide to digitise 'flow lines', which can then be used to generate the 2D or 3D vector fields. Fig.-5 shows an isochore map has been used to digitise flow lines to generate a vector field. The turbidite bodies are conditioned on this vector field so they will follow the same pattern.

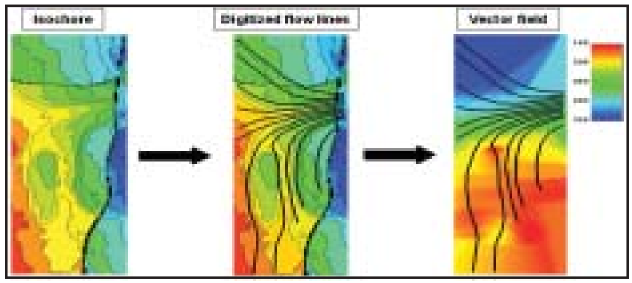

Fig. 5

Focused entry point Turbidite distribution

Geological interpretation of the reservoir area will give the user an idea of the sediment entry/source point, which can then be reflected in the model. For example, an isochore map can be used to create a high intensity region which is then used to 'seed' the locations of the turbidite sandbodies. Each object has a reference point at a given location which governs the placement of the object within

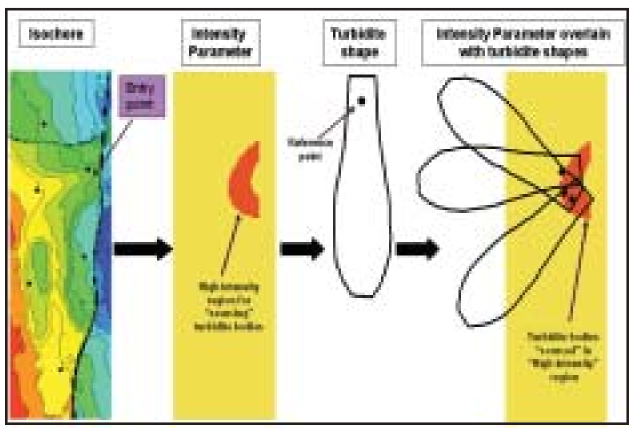

Fig. 6: Above an intensity parameter is created from an isochore map. The reference point of the tubidite shape controls the placement of these bodies within the facies model to generate a focused point sediment source.

the model. The location of the reference point is proportional to the intensity at that location, thus by placing this reference point towards the proximal end of the sand body object and by using the intensity parameter created, each turbidite body will be sourced through a focused entry point centred over the proximal end of the sand body.

Turbidite Distribution

The distribution and stacking effects of the sand bodies are controlled by pointwise repulsion. The repulsion is applied to the reference points on the sand body objects and the user can then define the maximum repulsion distances of these reference points in the x, y and z directions. An angular influence and interaction function can also be applied.

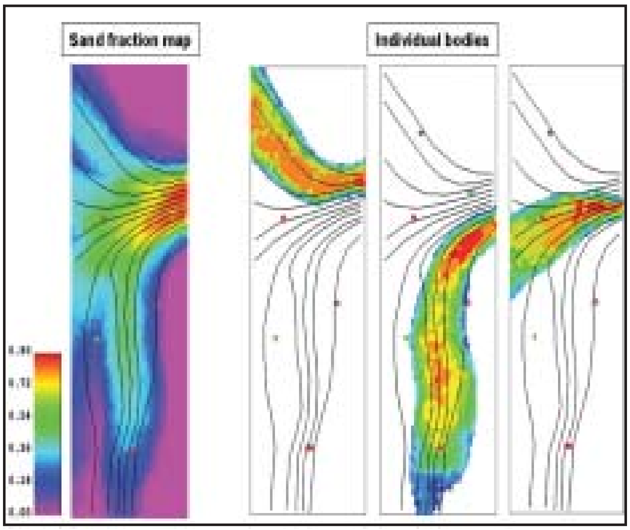

Fig. 7 : Below shows how individual sand bodies have been modelled. Their distribution has been guided using repulsion controls and has also been conditioned to the vector field.

Simulated model

Using the constraints outlined above, a facies model and a petrophysical model can be simulated. The facies model uses all user defined input, including the sediment entry point, the object repulsion and the vector field. The model created follows all of these constraints as shown in the illustrations.

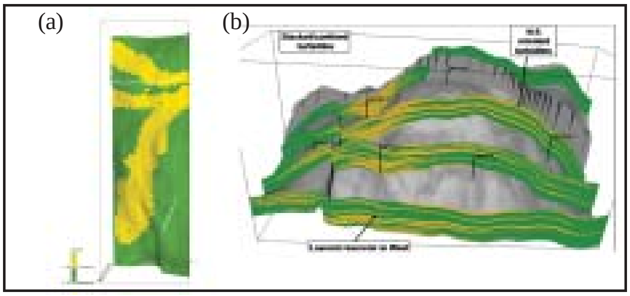

Fig. 8 (a) : Layer view of facies model, showing affect of defined geometry, vector field, sediment entry point and repulsion.

Fig. 8 (b) : Final facies model. Remember it has been constrained to all user defined input, including geometry, object dimensions, volume fraction, sediment entry point, object repulsion and the vector field. This model can now be used to populate the grid with petrophysical data.

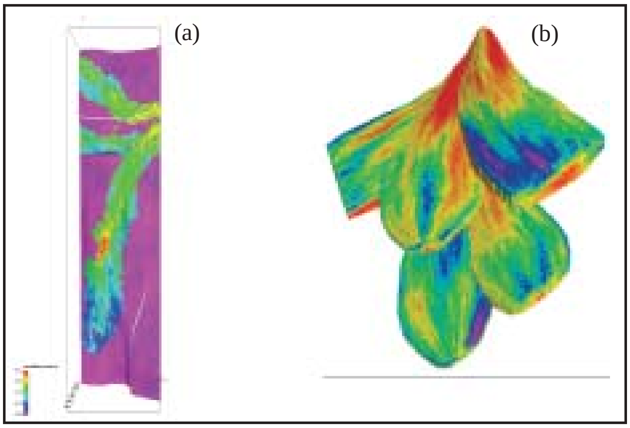

Fig. 9 (a) : Layer view of porosity model, showing same layer as illustrated in facies model. The porosity model clearly honours the facies model. The porosity variations also following local body orientation.

Fig. 9 (b) : Porosity distribution in stacked turbidite lobes. The highest porosity (reds and yellows) are at the more proximal end and in the more axial part of the turbidite body with lower porosity values (blues and purples) along the margins of the body.

The petrophysical model can then be conditioned on the facies model so that the porosity/permeability output will honour the facies model. The varying distribution of grain size within a turbidite body produces spatial trends that directly influence petrophysical properties. Trap RMS allows the user to estimate and model proximal-to-distal, axial-to-margin and vertical trends and then incorporate these into the petrophysical model.