

1. Aims and Introduction

In actively extending areas there is a strong coupling between tectonic deformation and factors that control sediment transport and accumulation (Fig 1.1.). There have been a number of studies that have investigated the link between tectonics and sedimentation, resulting in general links between basin fill character and rift asymmetry, surface tilting, fault displacement and the history of fault linkage (e.g. Gawthorpe and Leeder, 2000; Fig 1.2.)

The issue still remains if these relationships can be: A) tested and more effectively linked to the fault system evolution and B) better tuned to the setting of Irish rift basins.

Triassic and Upper Jurassic rift basin plays in the Irish offshore are relatively poorly imaged by seismic datasets(Fig 1.3.). Seismic attributes provide only limited constraints on depositional architecture and potential reservoir distribution. The fault systems active during rifting are better imaged and better preserved.

This project aims to investigate the extent to which fault geometries and inferred fault system evolution can provide insights into stratigraphic architecture and reservoir presence. This will impact on identifying and risking prospects at syn-rift level in the Irish basins.

Figure 1.1. The challenge in linking rift evolution and stratigraphic architecture is to take into account the above factors. Forward stratigraphic modelling is an approach that can be used to explore competing controls on deposition and address the implications for stratigraphy.

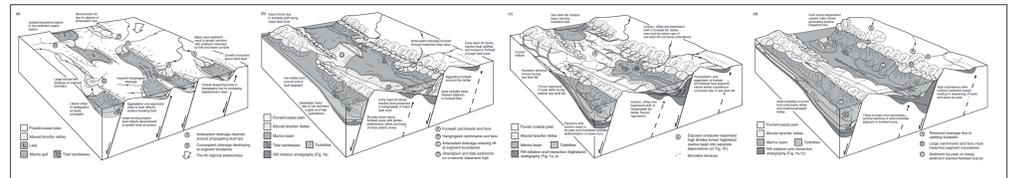
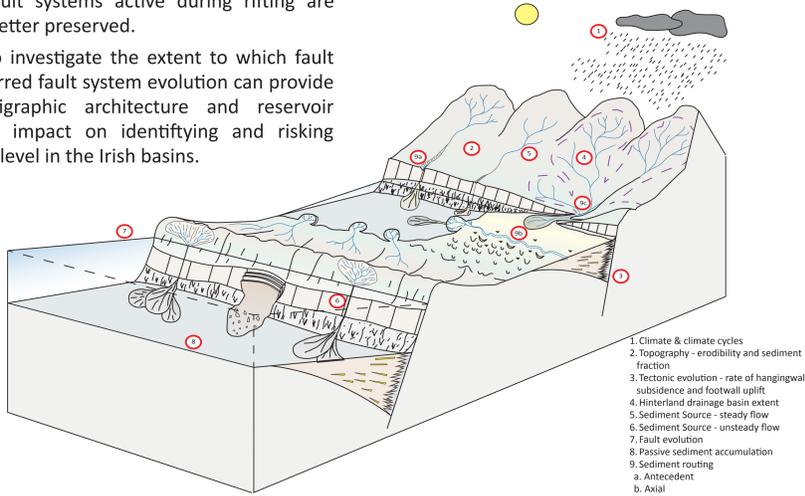


Figure 1.2. Tectono-sedimentary evolution of a normal fault array (coastal/marine environment, (a) from fault initiation to (b) interaction and linkage at sea level highstand and (c) sea level lowstand and (d) through going fault stage. From Gawthorpe and Leeder, 2000.

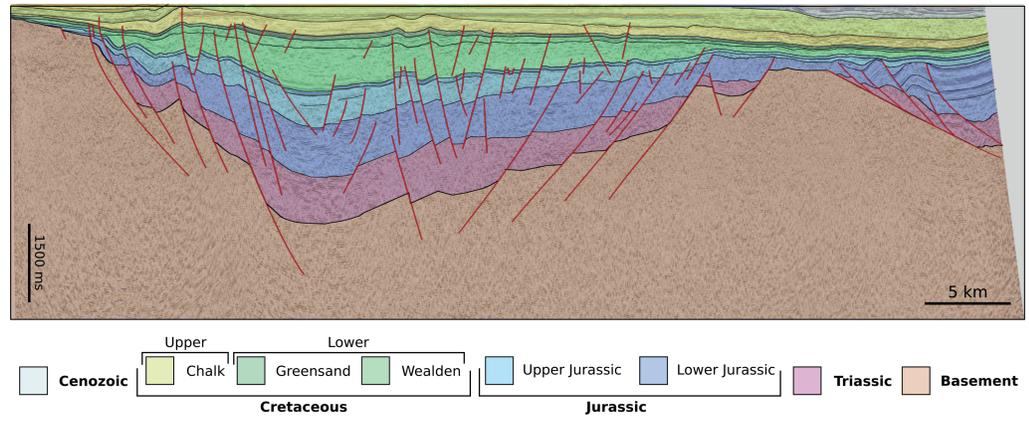


Figure 1.3. Cross section from the Celtic Sea Basin. Seismic courtesy of the Petroleum Affairs Division and cross section provided by Rodriguez Salgado, P. (PhD HCA.2PhD8)

2. Forward Stratigraphic Modelling

Forward stratigraphic modelling is a method that can be used for exploration purposes to understand the key factors that control the stratigraphic geometries and architecture of a basin. The methodology is increasingly used in hydrocarbon exploration workflows to help predict source rock distribution, reservoir presence and the likelihood of seal in cases where these cannot be constrained by other means (Shafie & Madon, 2008). Forward stratigraphic modelling is a powerful tool in analysing and exploring the various competing controls on syn-rift depositional architecture. The inputs as part of the forward modelling workflow are highlighted in Figure 2.1. Forward modelling demands careful weighing up of input parameters and a significant part of the project involves definition and justification of appropriate sediment supply relationships, water discharge values, diffusion coefficients, basin morphometrics, palaeogeography and timeframe and amplitude of external forcing.

Two forward stratigraphic modelling softwares have been used thus far: SEDSIM; and Geological Process Modelling (GPM) from Schlumberger(Figure 2.2.). SEDSIM makes use of a variation of the Navier-Stokes equation which describes fluid flow in three dimensions. SEDSIM numerically models the physical processes that influence the way sediment is distributed in many sedimentary systems (Shafie & Madon (2008) (Figure 2.3.i). Geological Process modelling (GPM) is a plugin to Petrel by Schlumberger. The basic mode of sediment movement in GPM is by diffusion which simulates dispersion of sediment by erosion and transportation processes driven by gravity (Figure 2.3.ii). There are two parameters that control dispersion: the diffusion coefficient that controls the strength of the diffusion; and a diffusion curve that acts as a unitless multiplier.

Numerous conceptual models have been created to investigate the input parameters. The conceptual models aim to highlight the effect of a certain parameter while all other parameters remain constant (Figure 2.4). Following on from the initial set of models testing the basic input parameters and software capabilities a group of experiments were run in order to replicate the conceptual models of Gawthorpe and Leeder (2000) which investigate the potential tectono-sedimentary evolution of a normal fault array (Figure 2.5.).

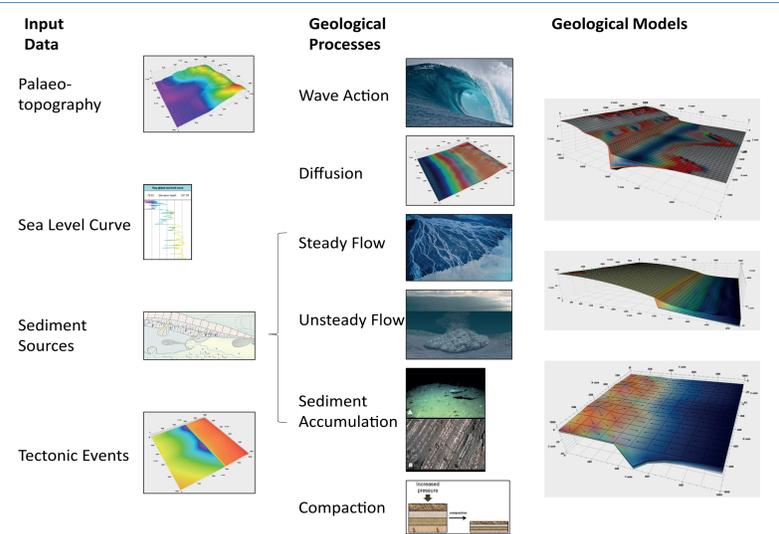


Figure 2.1. Workflow for creating forward stratigraphic models in Geological Process Modeling.

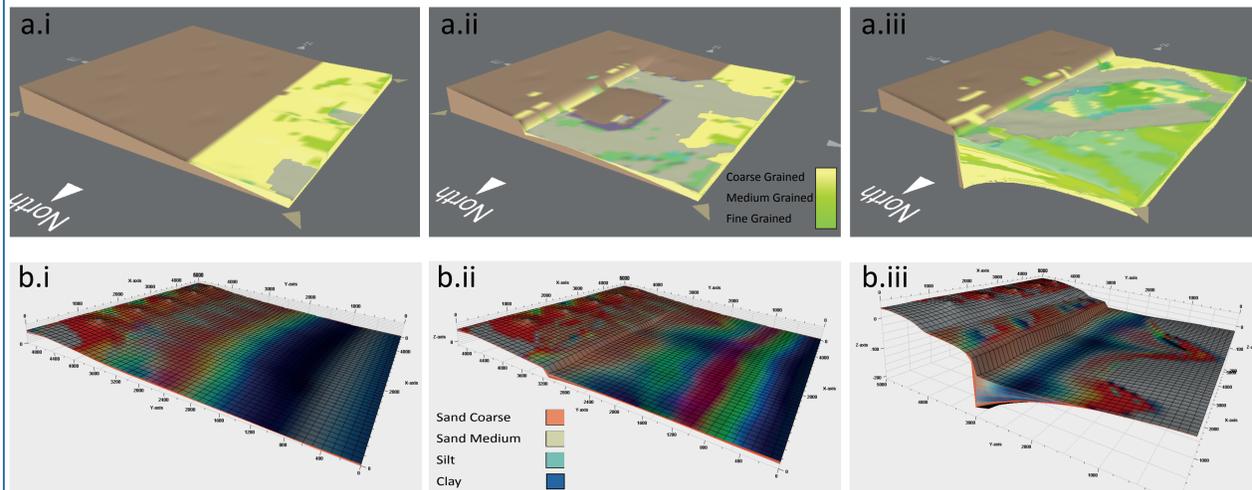


Figure 2.2. Forward stratigraphic models produced using SEDSIM (a) and GPM (b) of rifting from (i) rift initiation to (ii) fault propagation and linkage and (iii) rift climax.

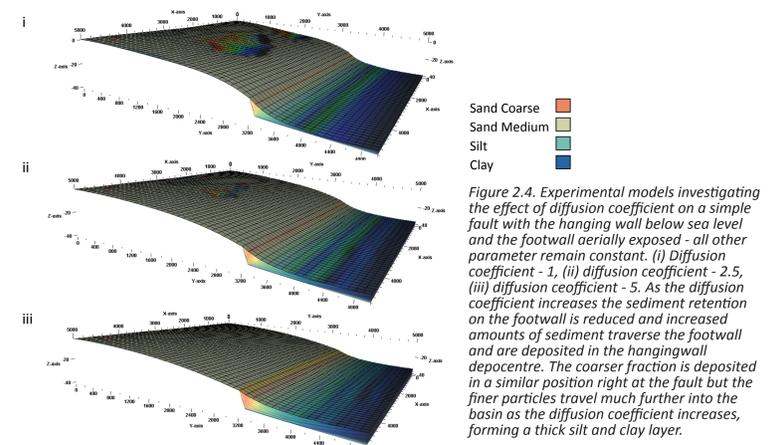


Figure 2.4. Experimental models investigating the effect of diffusion coefficient on a simple fault with the hanging wall below sea level and the footwall aurally exposed - all other parameter remain constant. (i) Diffusion coefficient - 1, (ii) diffusion coefficient - 2.5, (iii) diffusion coefficient - 5. As the diffusion coefficient increases the sediment retention on the footwall is reduced and increased amounts of sediment traverse the footwall and are deposited in the hangingwall depocentre. The coarser fraction is deposited in a similar position right at the fault but the finer particles travel much further into the basin as the diffusion coefficient increases, forming a thick silt and clay layer.

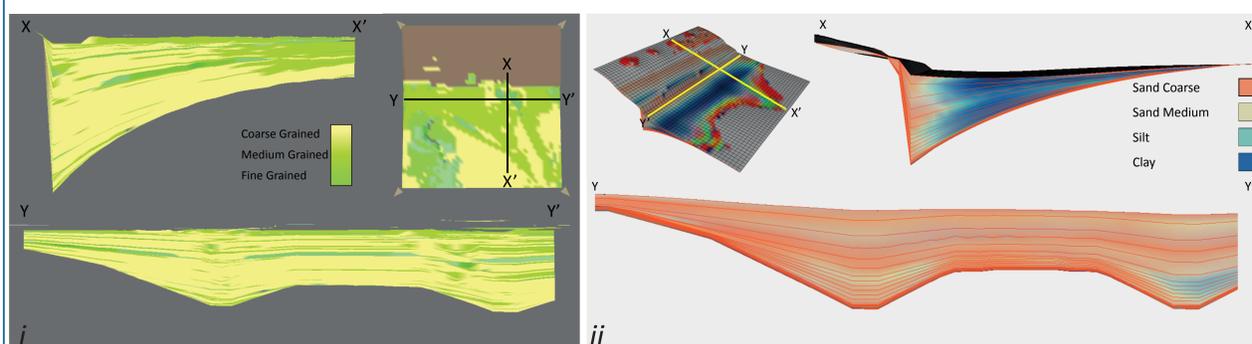


Figure 2.3. Cross Sections from models shown in figure 2.2. displaying modelled depositional response during rifting with a variable sea level in (i) SEDSIM and (ii) GPM. Both models re-create fanning of sediment into the fault with increased accommodation as well as the fining of sediment basinward.

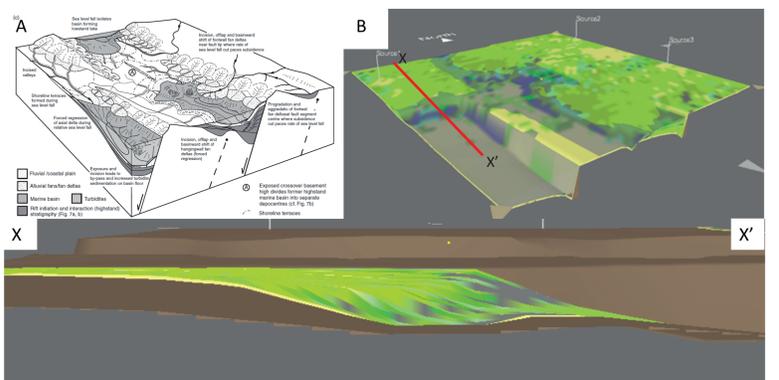


Figure 2.5. Mature rift stage in a continental environment. A – Model from Gawthorpe and Leeder (2000), B – SEDSIM model equivalent. Cross section shows recreation of an axial fan in the subsiding hangingwall

3. Further Work

- To increase the complexity of the forward stratigraphic models to include the parameters not yet explored.
- To investigate the effects of relay ramps on fluvial networks during rifting - are the sources seen to divert and preferentially flow down relay ramps.
- How does the hydrodynamic setup of a fluvial source determine the likelihood to divert along relay ramps, divert away from uplifting footwalls or flow transversely.

References

Gawthorpe, R. L., and M. R. Leeder. "Tectono-Sedimentary Evolution Of Active Extensional Basins". Basin Research 12.3-4 (2000): 195-218.
Shafie, K. and Madon, M. (2008). A review of stratigraphic simulation techniques and their applications in sequence stratigraphy and basin analysis. Bulletin of the Geological Society of Malaysia, 54, pp.81-89.