Hierarchical characterisation of submarine channels: Insights from 3D seismic data from the Taranaki Basin, offshore New Zealand

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1. INTRODUCTION

Submarine channels can host large hydrocarbon accumulations but are challenging from a reservoir modelling perspective. In strongly to weakly confined systems, a hierarchical classification scheme, shown conceptually in Fig 1.1, can be used to characterise them. A hierarchical modelling scheme (Figs. 1.2) requires as input geometrically and stacking characteristics at each hierarchical level.

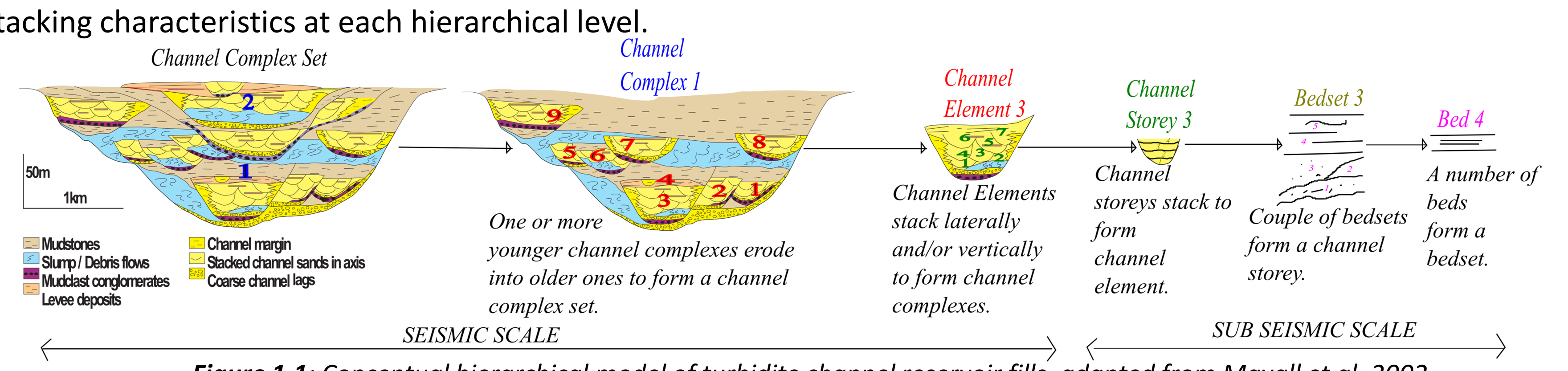


Figure 1.1: *Conceptual hierarchical model of turbidite channel reservoir fills, adapted from Mayall et al. 2002.*

Geometrical characteristics include the size of the channel object (thickness, width and length) as a fraction of the size of the object in which it is contained. Stacking characteristics include the fractional volume of the container occupied by the smaller object, and the extent to which the objects are interconnected. These are shown for the idealized channel complex in Fig 1.3a and 1.3b.

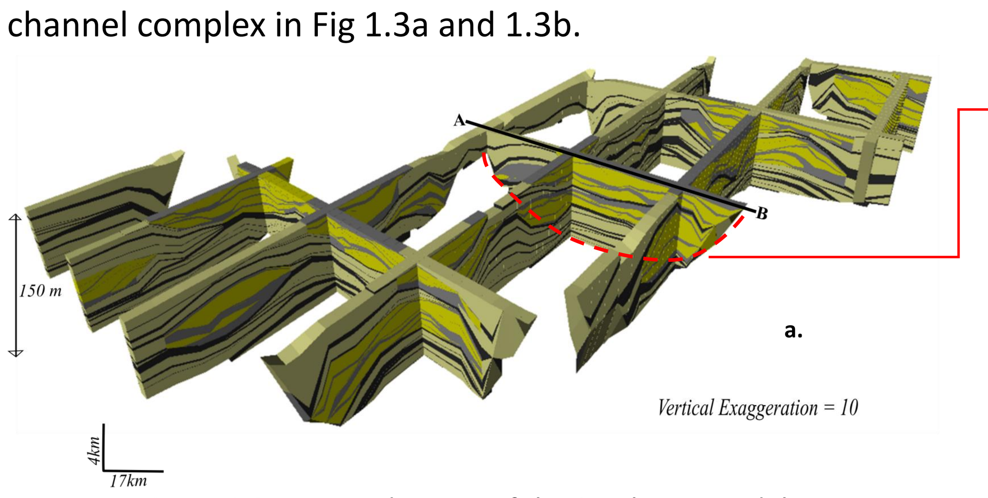


Figure 1.2a: Fence diagram of the 3D vbFIFT model.

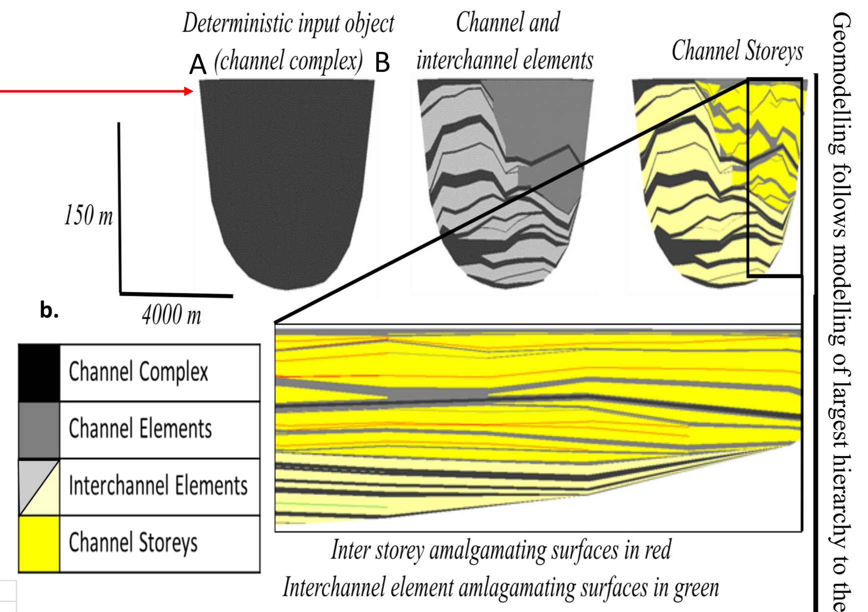


Figure 1.2b: Cross-section A-B through the initial 3D vbFIFT model, showing the hierarchical arrangement of net and non-net facies.

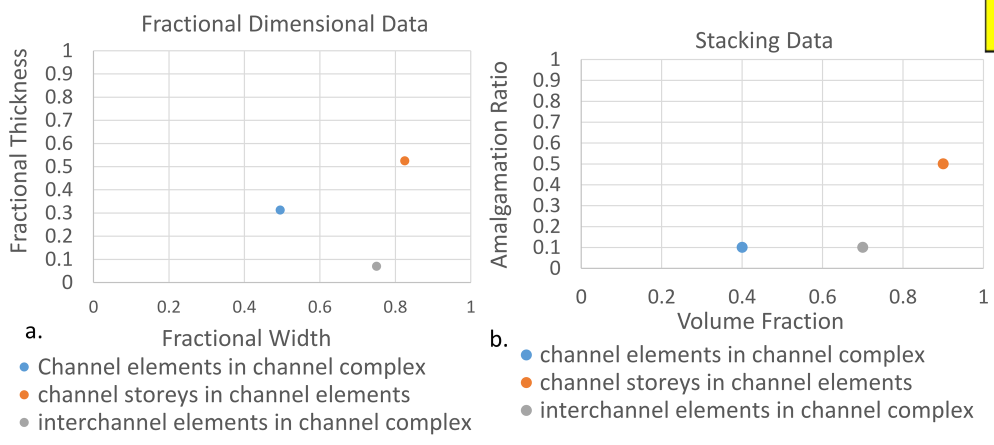
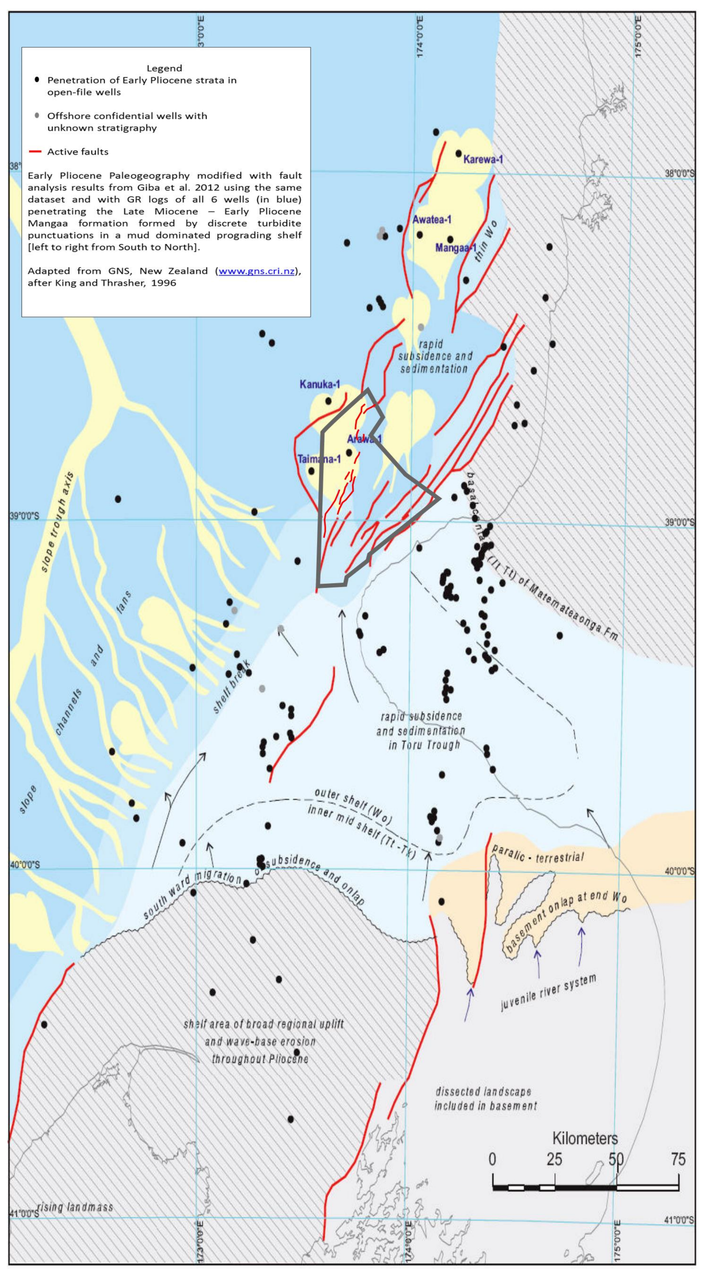


Figure 1.3: Dimensional (a) and stacking data (b) for initial vbFIFT model.

On this poster, two systems are analysed and dimensional and stacking data are collected. Further quantification of the hierarchical structure of submarine channels from different geological settings are required to constrain input for hierarchical reservoir modelling.

2. Dataset 1: Parihaka Channel Complex Set, Offshore West New Zealand



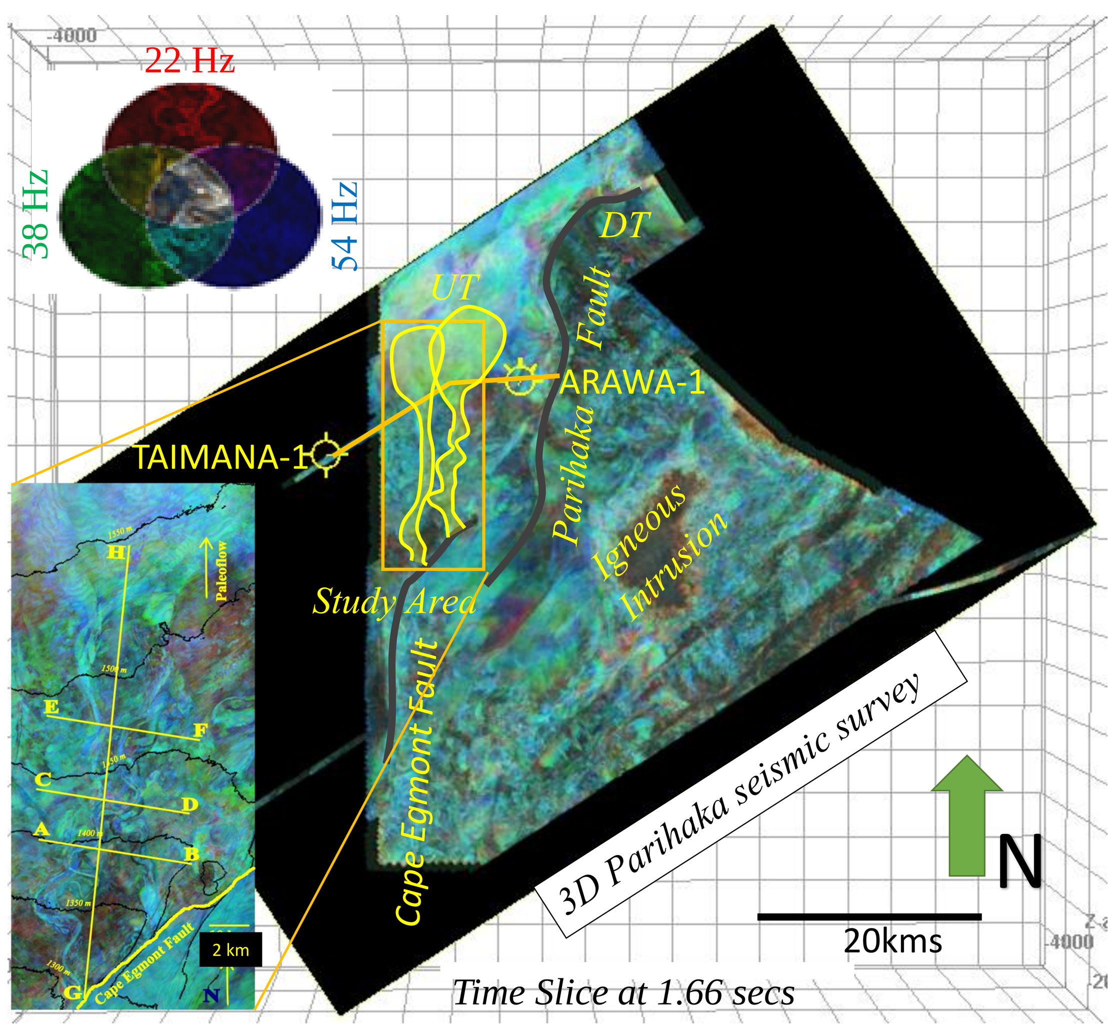
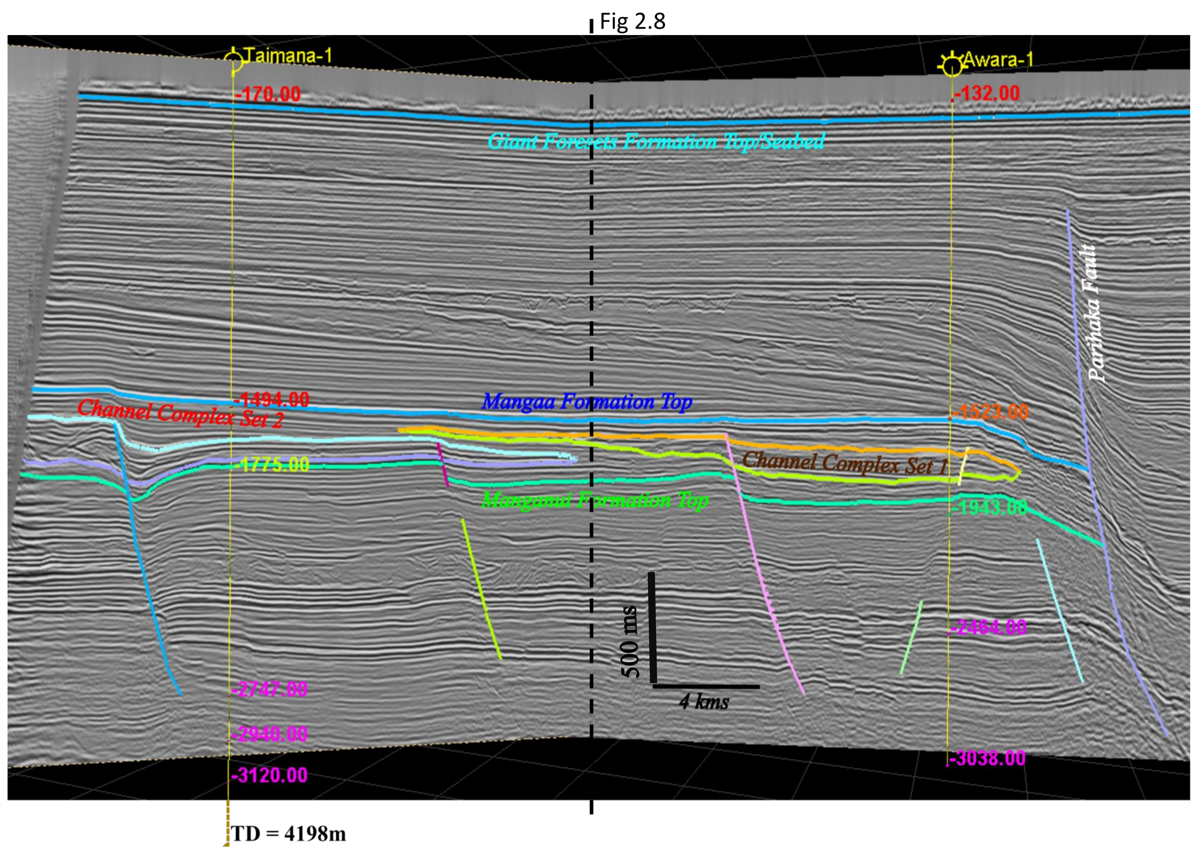


Figure 2.1: *Channel complexes within channel complex set 1. The complexes are bounded by faults in the East, South and West (beyond data outline). RGB render of three dominant frequencies of the data, Slope contour Interval=50 m.*

Figure 2.2: *Early Pliocene paleogeographic map showing direction of sediment transport in conjugation with major discontinuities at basin scale.*

The late Miocene-early Pliocene Mangaa formation was deposited between the major Late Cretaceous to Early Eocene and Plio-Pleistocene rift events (Fig 2.2). The 3D seismic clearly shows three hierarchical levels of channelized deposits. Two channel complex sets are identifiable between the two wells (Fig 2.3), and this study focuses in detail on Channel Complex Set 1, which is well-imaged within the 3D seismic area (Fig 2.1). In the main study area, deposition was partially confined system in the East by the footwall of the Parihaka Fault, and the channel deposits give way to lobes in the North of the study area (Fig 2.1).



Channel complex set 1 is composed of two channel complexes, each of which contain a number of smaller channel elements (Figs 2.5 – 2.8). Stacking and fractional dimensional parameters have been measured, and are shown in the results section (Fig 4.1, 4.2). Similar scales of object are evident in the interpretation of Arawa-1 well Gamma ray log (Fig 2.4).

Figure 2.3: *Composite cross section between two wells penetrating Mangaa formation, see Fig 2.1 for location.*

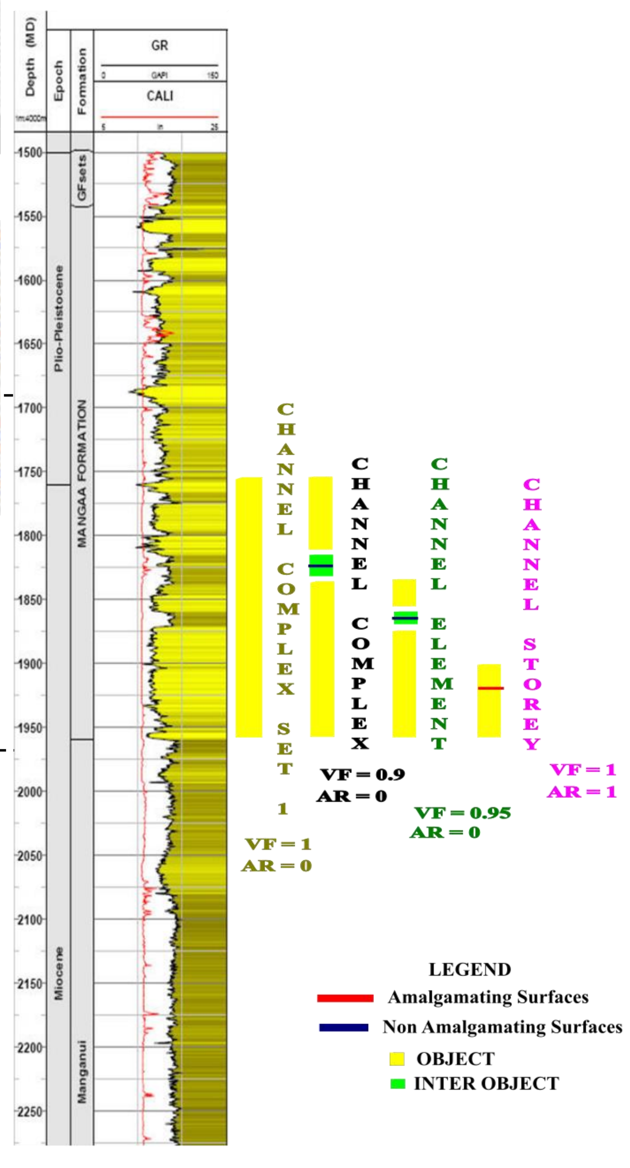


Figure 2.4: *GR log of Arawa-1 well.*

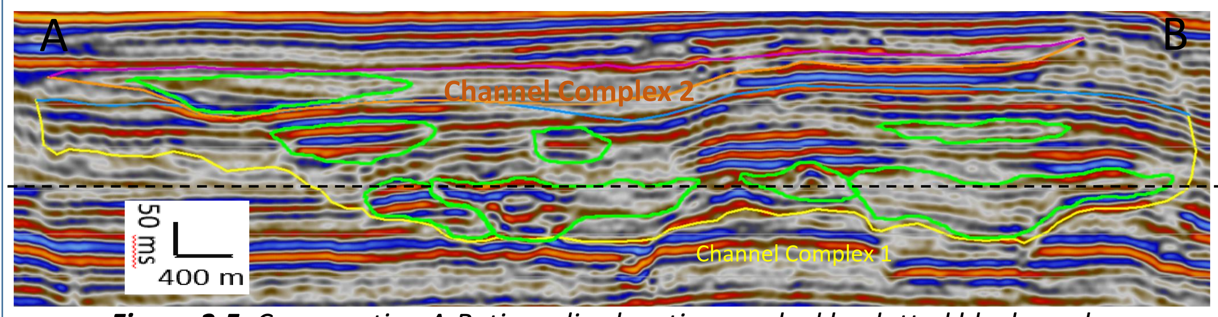


Figure 2.5: *Cross section A-B, time slice location marked by dotted black marker.*

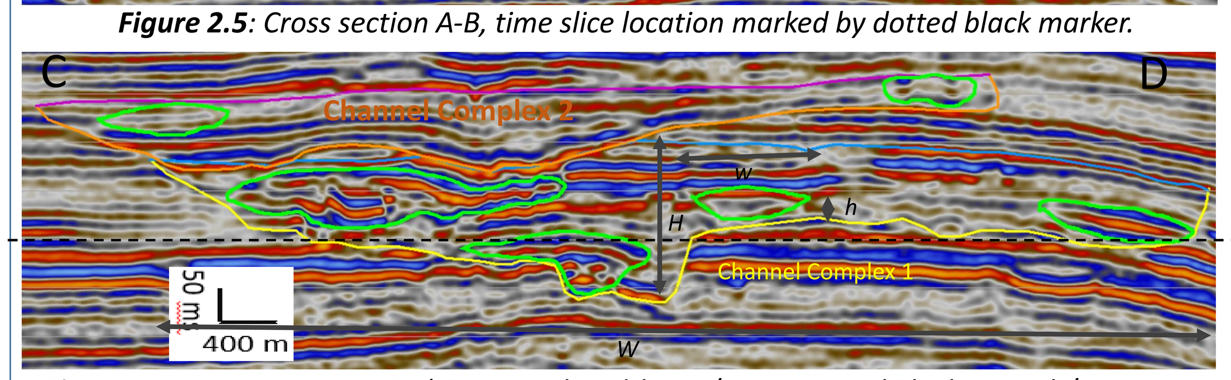


Figure 2.6: *Cross section C-D. * Fractional Width = w/W, Fractional Thickness = h/H*

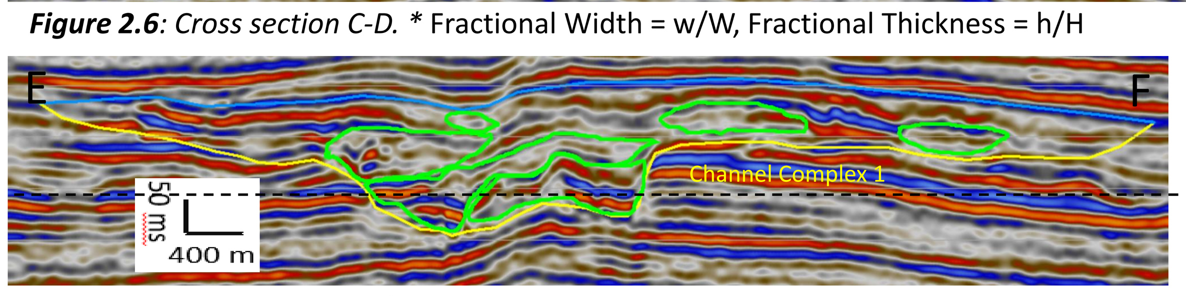


Figure 2.7: *Cross section E-F.*

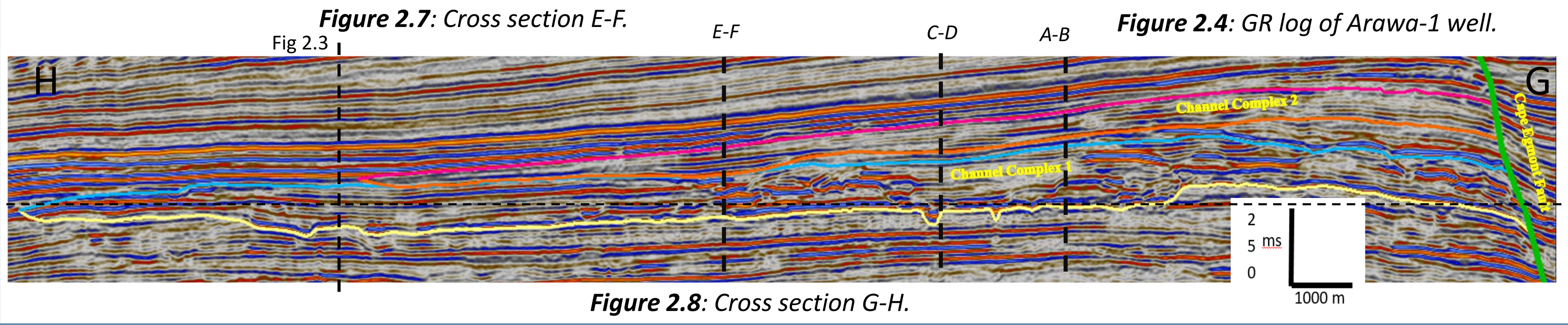


Figure 2.8: *Cross section G-H.*

3. Dataset 2: Beacon Channel Complex, Brushy Canyon, U.S.A.

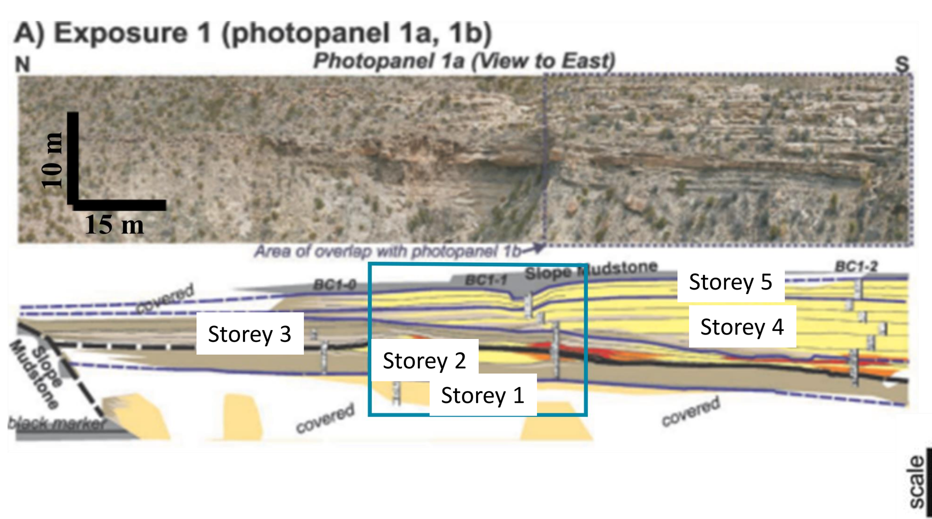


Figure 3.1: *A well exposed outcrop of the channel complex used for estimation of volume fraction, amalgamation ratio and fractional dimensional data, inset location of BC1-1 stratigraphic column.*

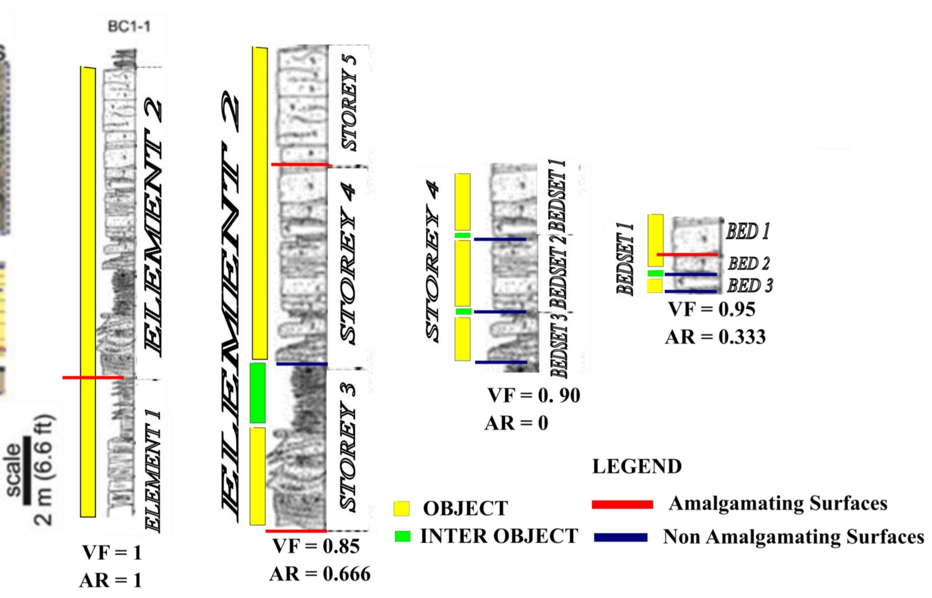


Figure 3.2: *Schematic of log BC1-1 classified hierarchically to estimate Volume Fractions (VF) and Amalgamation Ratio (AR).*

Sixteen sedimentological logs have been interpreted hierarchically to obtain stacking information of the system (e.g. Fig 3.2). Seven annotated outcrop panels have been analysed to obtain dimensional data (e.g. Fig 3.1). Results are shown in the results section (Fig 4.1, 4.2).

For the Stacking data, hierarchical volume fraction is defined as the fraction of the object volume that is occupied by objects one hierarchical level smaller. Hierarchical amalgamation ratio is defined as the number of object bases that erode into underlying objects (at same hierarchical level) as a proportion of all object bases.

For the dimensional data, fractional width and fractional thickness are defined as dimensions of the object as a proportion of the dimensions of the object one hierarchical level larger that they are contained within.

4. Results

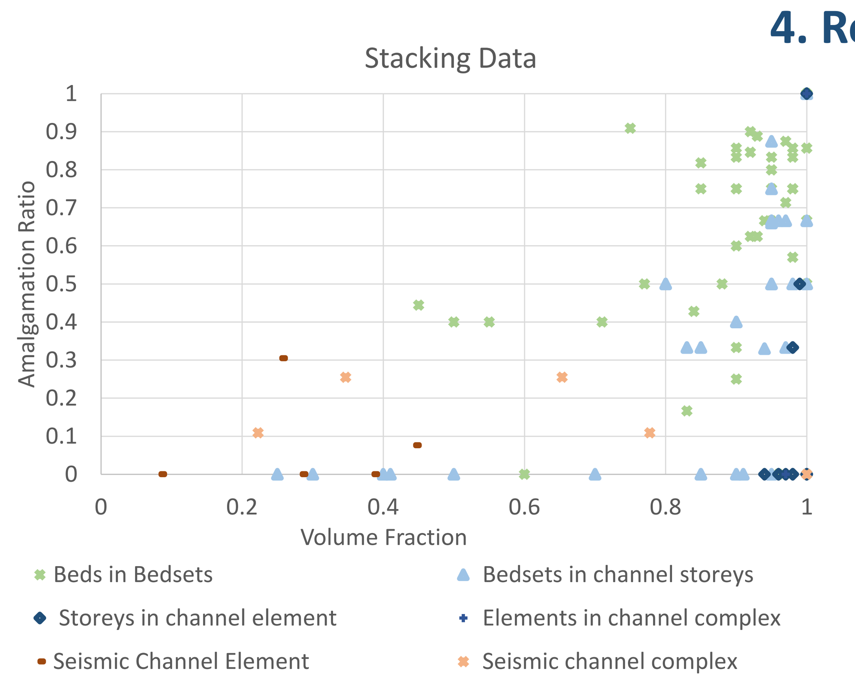


Figure 4.1: *Plot of Volume Fraction and Amalgamation Ratio for two hierarchies observed in dataset 1 and four in dataset2.*

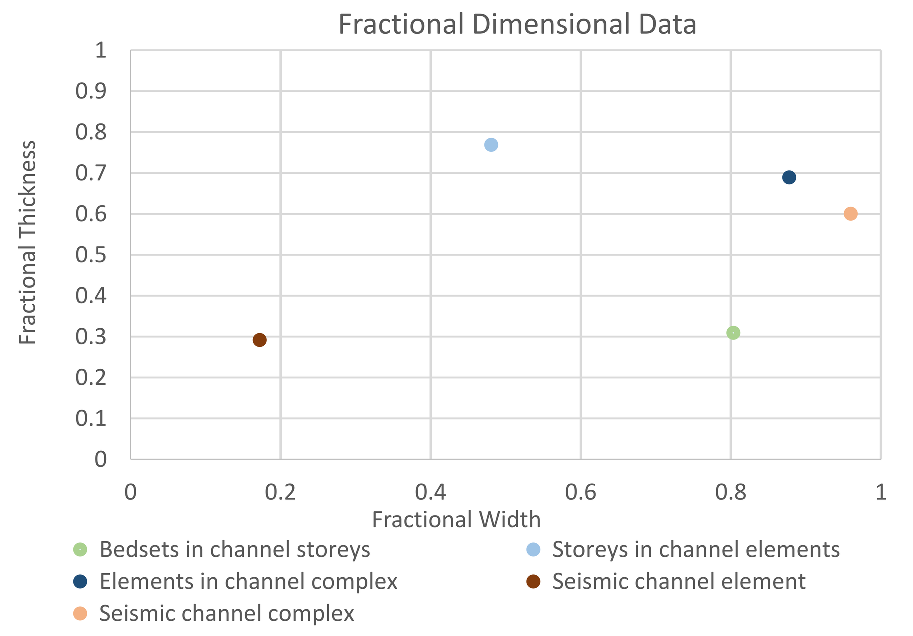


Figure 4.2: *Plot of average fractional width and average fractional thickness for two hierarchies observed in dataset 1 and three in dataset 2.*

A consistent trend of increasing amalgamation at smaller hierarchical levels is observed in the Brushy Canyon dataset (Fig 4.1). However, no trend is evident in the fractional dimensional data (Fig 4.2).

In general, the larger-scale channel objects in Parihaka system appear better connected (given their low volume fractions) than the small-scale Brushy Canyon system.

Further work is required to better constrain the trends in these datasets, and to obtain more data from different datasets.

5. Conclusions and the future work

The geomodelling workflow discussed in the poster allows for creation of reservoir scale but bed-resolution 3D geomodels. Seismic interpretation assists in qualitative improvements such as confinement, top and base structure, interaction with faults and other discontinuities etc. while extensive literature quantification provides a database of useful parameters required for generating them. Such models will be used in future for flow simulation to analyse the role of multiple scales of geological heterogeneity and object connectivity on oil production, reservoir pressure, sweep of reservoir fluid by the injected fluid and other production characteristics.

6. Acknowledgement

We thank GNS Science, New Zealand for providing the seismic data and all related information on New Zealand basins on their website and reports.

7. References:-

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