Quantifying compensational stacking in deep water deposits. An example from the Lettergesh fm., Ireland.

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1. Compensational stacking

Compensational stacking describes the tendency of sediment transport systems to fill topographic lows, whilst avoid being deposited directly above older elements (Straub et al., 2009). This results in a sequence that maintains a more regular thickness while it grows (figure 1.1) than a system in which the same elements have unconstrained locations.

Compensation is a relatively common phenomenon. It can be observed in fluvial, delta, alluvial and deep water deposits. Although quantitative (Straub et al., 2009; figure 1.2) and qualitative (e.g. Prelat and Hogdson, 2013; figure 1.3) ways to characterize it have been suggested during the last decade, the geometrical frameworks and the behaviour of compensational stacking are not well known yet.

Compensation can have important implications in reservoir modelling since inter-element connectivity is in part controlled by the extent to which the elements are stacked compensationally. For this reason, studying this phenomenon and its geometry is critical. A better knowledge will advance our perception of these sequences, an will have practical implications in reservoir modelling.

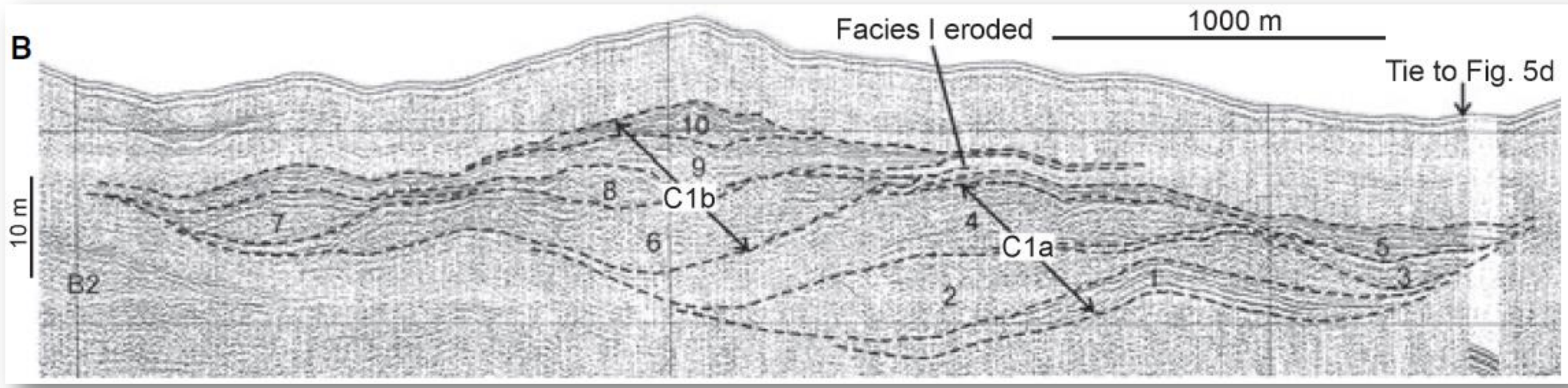

Figure 1.1. Compensational stacking in a deep water lobe natural system, by avulsion and erosion. From Deptuck et al., 2008.

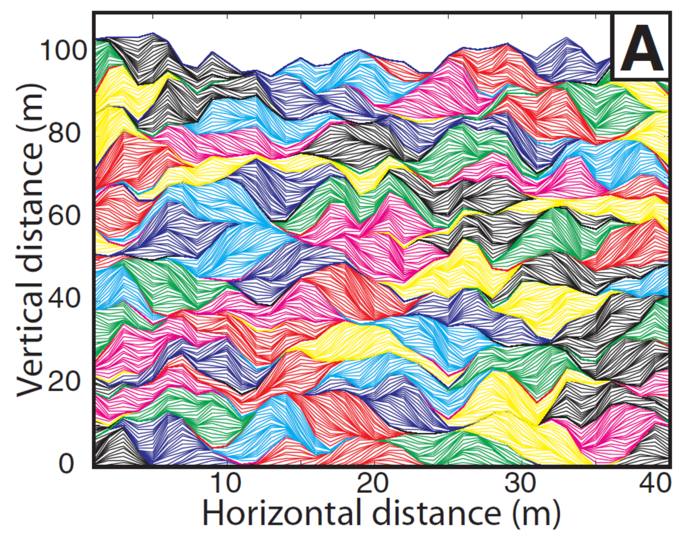

Figure 1.2. Compensationally stacked model generated with the algorithm of Straub et al. (2009). Each colour represents deposit between different avulsion events.

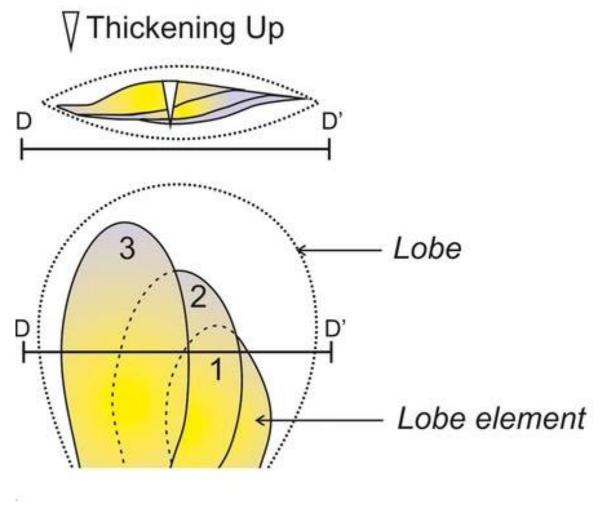

Figure 1.3. Idealized model of stacked lobes. Lobes are partially compensated (by lateral offset) while they prograde. This is explained in cross section by a thickening upwards trend. Prelat and Hogdson, 2013.

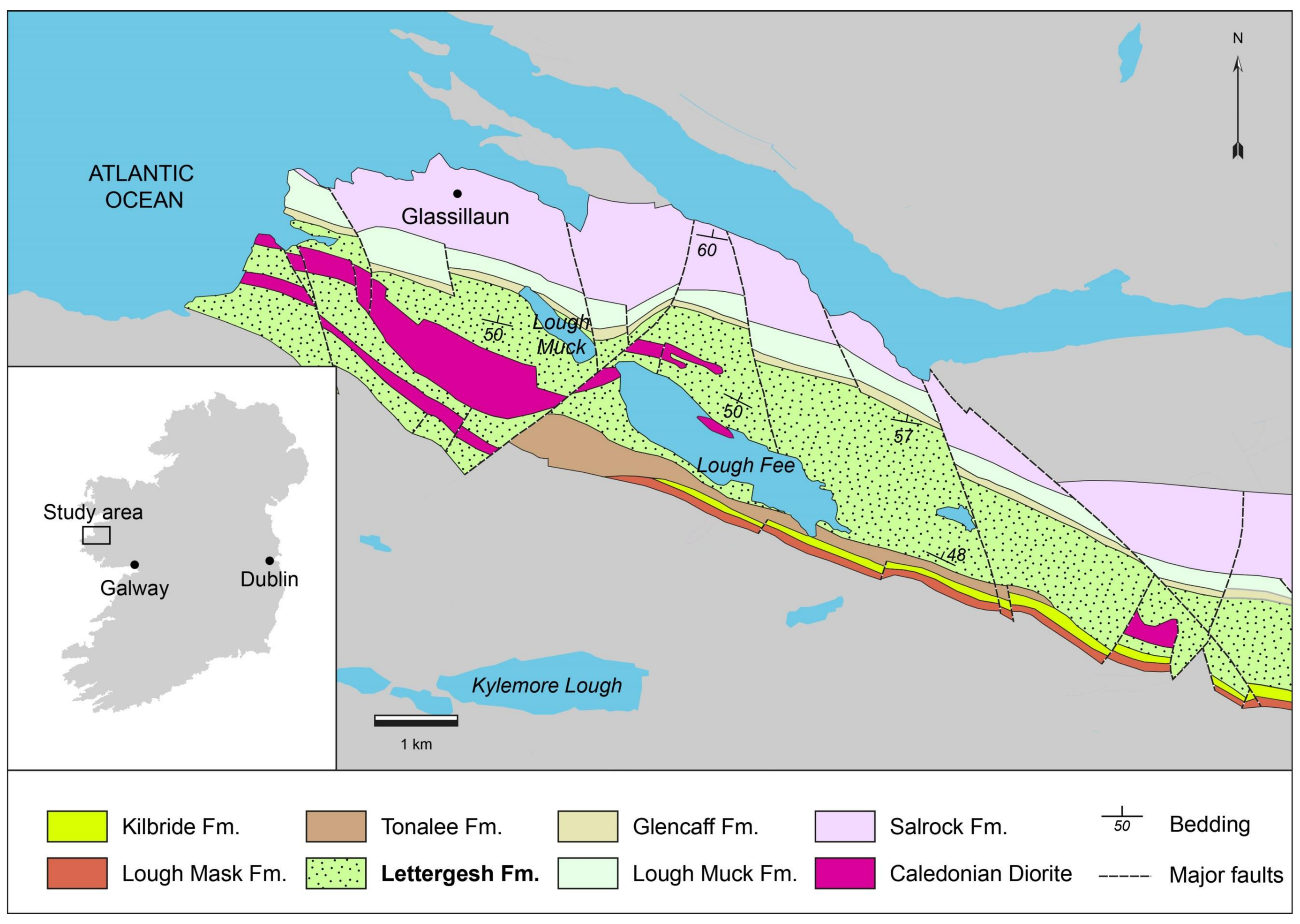

Figure 2. Geological map of the North Galway Silurian Succession. Modified from Geological Survey of Ireland.

2. Objectives and methods.

The aim of this study is to characterize the stacking of the Lettergesh Formation, West Ireland. Drone photogrammetry was performed; 22 hectares were mapped and modelled. Models allow big-scale structures to be seen, especially where access is problematic (i.e. cliffs) and support bed correlations: important horizons and beds (thicker than 20cm) were mapped. Facies analysis and logging was then complemented within the models.

3. The Lettergesh Formation

The Lettergesh Formation is part of the North Galway Silurian Succession (NGSS). The NGSS (figure 2) is constituted by a ~2700 meters thick volcanoclastic sequence deposited during the Upper Llandovery until the Middle Wenlock, for a period of time of ~5 Ma. It is characterized, from bottom to top, by clastic fluvial deposits, followed by a thick volcanoclastic turbidite sequence. On the top of the sequence, shallow-water and sub-aerial environments are characteristic. The sequence, therefore, shows a gradual transgression, followed by a strong regression. It is considered that these sediments where deposited in a small foreland basin, possibly with differential subsidence (Soper and Woodcock, 1990).

The Lettergesh formation is characterized by 1500 meters thick of poorly exposed deep-water turbidite lobes deposited in a basinal environment. Overall, the high lateral continuity, lack of lateral bed terminations and monotonous stratigraphy suggest that the beds are stacked vertically without compensation, consistent with deposition in a confined basin. It is supposed that the lobes where deposited one above each other, without occupying topographic lows.

4. Discussion

Photogrammetry models show different bed stacking styles. In figure 3.1, it is possible to recognize different packages, which are indicative of different deposition conditions. Quantitative analysis of compensation (compensation index, Straub et al., 2009) cannot be performed due to de poor exposure and the loss of information (resolution is limited to 20cm bed thickness).

Where the outcrops are accessible, facies analysis is conclusive: there are, at least, two distinctive dominant facies associations (figure 3.2), plus one more marginal association. The dominant associations intercalate each other recursively, and are clearly indicative of a change in the deposition style of the lobes. Like other lobe systems, these facies associations fit well with the descriptions given by Prelat et al., (2009) to describe lobe off-axis and lobe fringe environments.

From the tectonic point of view, the Lettergesh Fm. was deposited in a small foreland basin (Soper and Woodcock, 1990) and the lobes are characterized by the lack of lateral bed terminations. When the accommodation space is narrow relative to the lobe width (confined system), lobes will be stacked vertically, while showing forced progradation and retrogradation (figure 3.3). Photogrammetry and facies are consistent with this idea, they show progradation and retrogradation trends as thickening and thinning-upwards tendencies.

These preliminary results will improve our knowledge of the Lettergesh Fm., and future work in this and other deep-water formations (e.g. Ross Sandstone) will advance our perception of compensational stacking in different tectonic settings, as well as they will have practical implications in reservoir modelling.

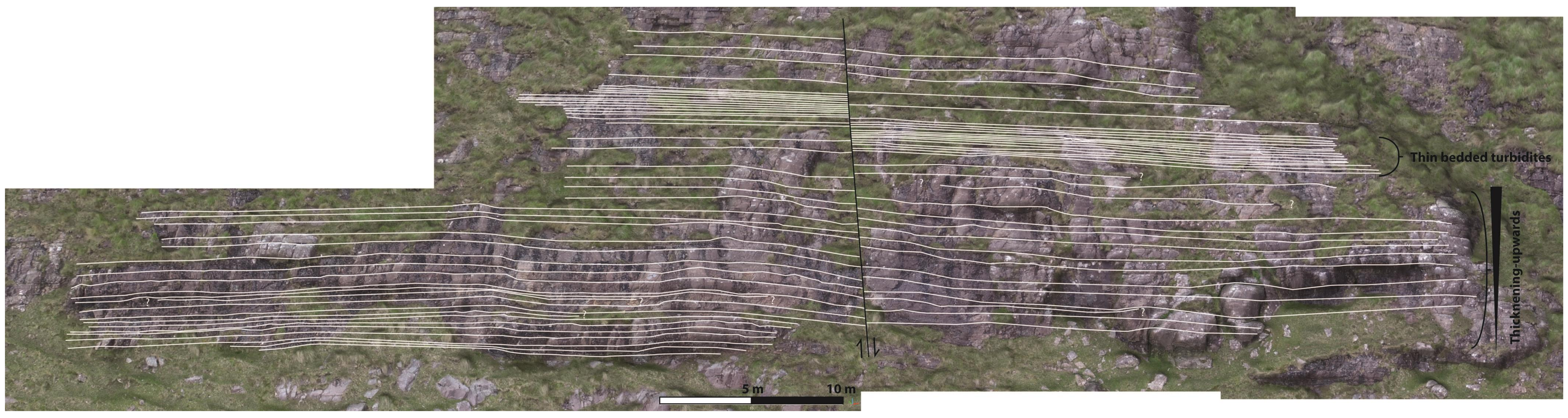

Figure 3.1. Photogrammetry model from a relatively well exposed and inaccessible outcrop. It is possible to recognize a thickening upwards sequence, followed by a well defined package of thin bedded turbidites. Some horizons are difficult to track, and some of them disappear, which could be indicative of amalgamation surfaces.

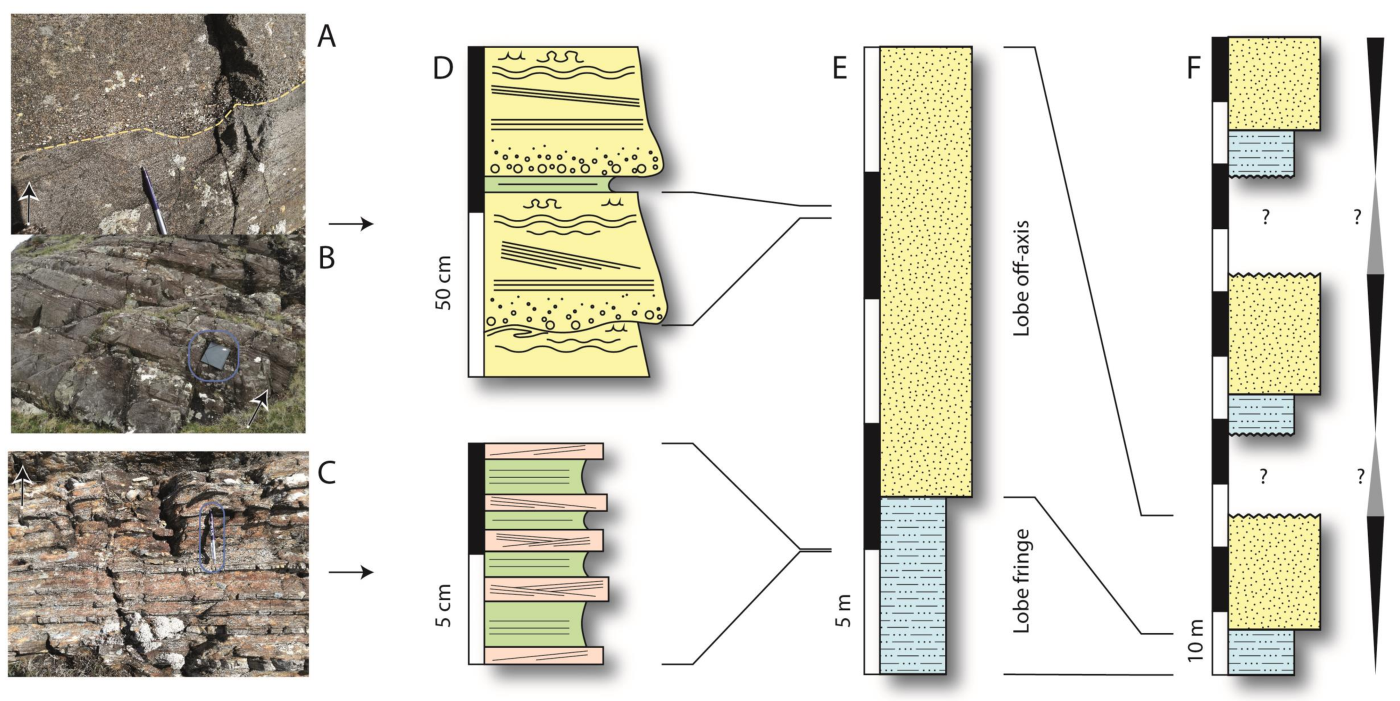

Figure 3.2. Hierarchical level and stacking. A) Amalgamation surface (pen is 14 cm). B) Typical outcrop where the Bouma sequence can be recognized (folder is 33 cm) C). Thin bedded turbidites, where flows in two directions were observed (pen is 14 cm). D) Bed-scale detail of turbidites (top) and thin bedded turbidites (bottom). E) Transition from thin bedded turbidites (lobe fringe) to medium bedded turbidites (lobe off-axis) is neat, and can be visible at the bed/lobe element scale. Column has been simplified. F) At the lobe scale, lobe off-axis prograde over lobe fringe deposits up to 3 times.

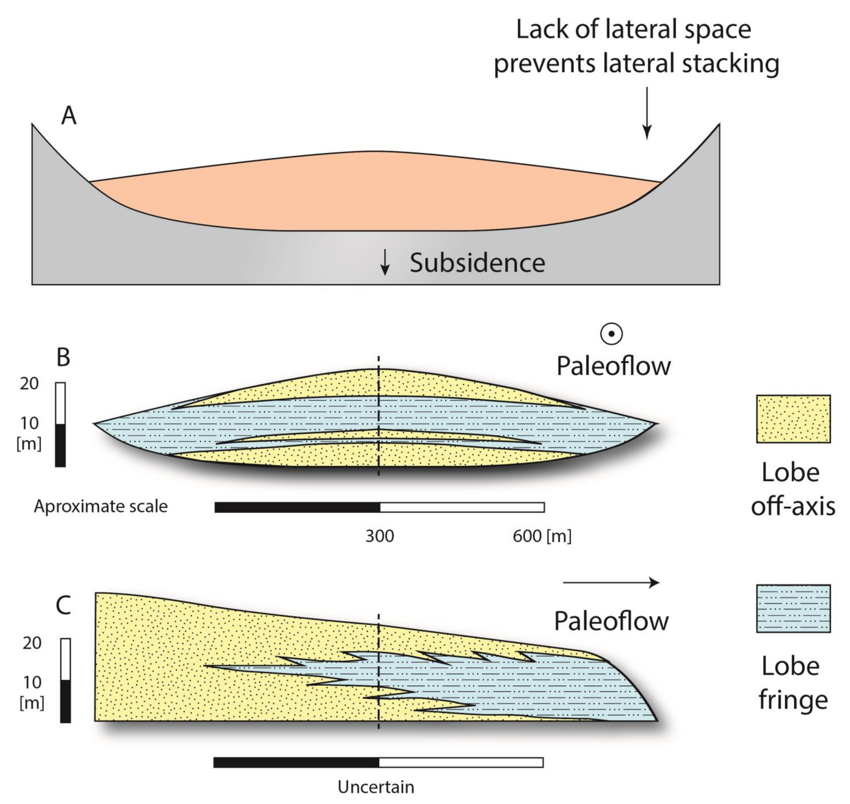

Figure 3.3. A) Conceptual model of the deposition a wide lobe in a narrow basin. There is not any space for any possible lateral offset. B) Transversal view of a idealized lobe according to the setting described in figure 3.2. Only forced progradation/retrogradation is possible. C) Longitudinal view of the idealized lobe described in B.

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FAULT ANALYSIS GROUP

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