Marine Geoscience Report 022

Shannon Estuary

Overview

The Shannon Estuary is located on the west coast of Ireland, where the River Shannon, Ireland's longest river, meets the Atlantic Ocean. It is joined by the Fergus River near Ennis and stretches approximately 100 km westward. As Ireland's only deepwater estuary of this scale, the Shannon Estuary acts as both a vital ecological corridor and a hub for industrial activity.

It is characterised by a geological setting that combines ancient tectonic structures with active sedimentary processes. The bedrock beneath the estuary dates to the Carboniferous Period and has been shaped by tectonic compression, glacial sculpting, and modern marine processes. Today, the estuary supports key infrastructure including ports and aquaculture zones, while also encompassing designated conservation areas due to its rich biodiversity.

Figure 1: Bathymetry of Shannon Estuary. Depths are referenced to Lowest Astronomical Tide (LAT).

Geological History

The Shannon Estuary’s geological history spans more than 400 million years and reflects a long sequence of tectonic collisions, basin evolution, sedimentation, and glacial reshaping.

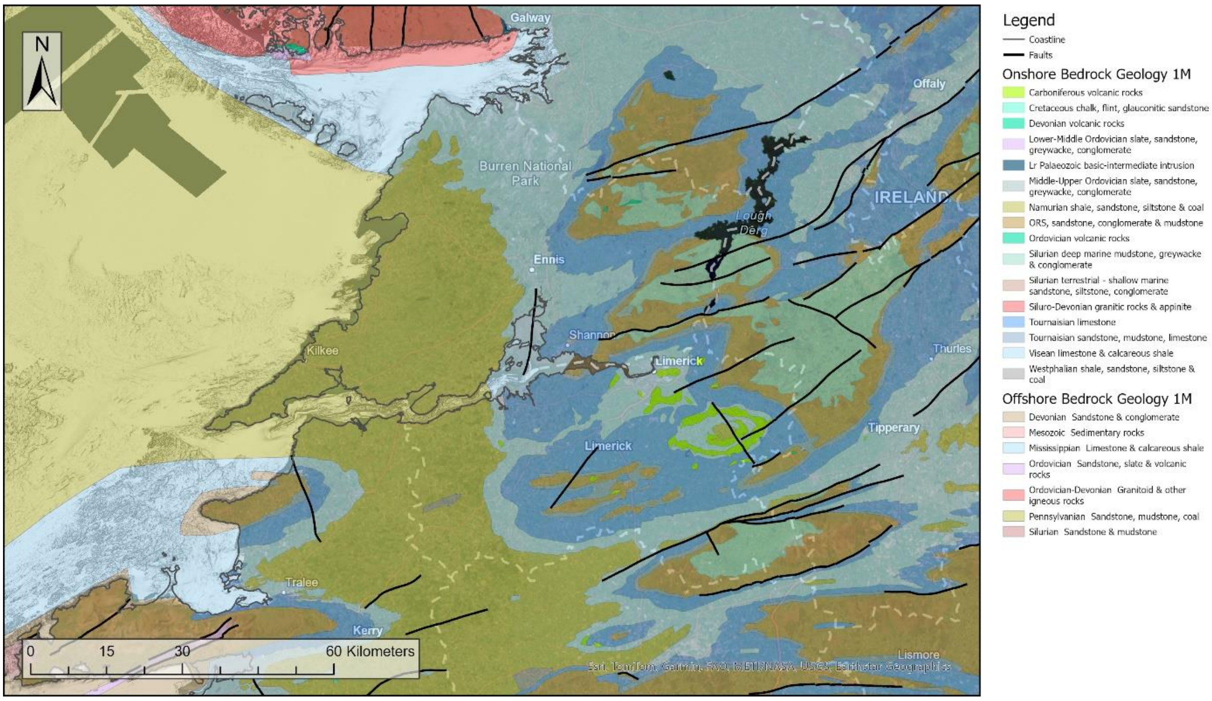

Figure 2: Geological overview of the region.

A defining feature is its alignment with the Iapetus Suture, a deep fault line marking the closure of the Iapetus Ocean during the Caledonian Orogeny, a continental collision and mountain building event which ended over 410 million years ago (Ma). This tectonic event, which joined the Laurentian and Avalonian crustal blocks, brought together the north-western and south-eastern parts of Ireland, shaping the foundations of the modern landscape (Geological Survey Ireland, n.d.). The Shannon Estuary lies along this ancient suture, which guided the development of the Shannon Basin.

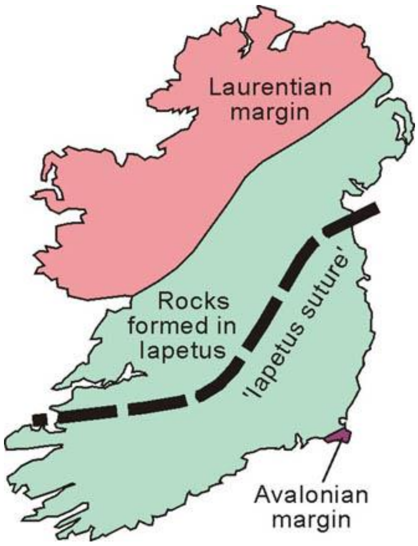

Figure 3: Diagram of Ireland showing the Iapetus Suture, the boundary between the Laurentian and Avalonian margins, from (Geological Survey Ireland, n.d.).

The collision created a deep marine basin in what is now western Ireland. This basin, known as the Shannon Basin or Clare Basin, developed during the Carboniferous Period (359-299 Ma). In the Early Carboniferous, tropical carbonate seas led to the formation of Waulsortian limestones. These were massive, largely unbedded lime-mud mounds that accumulated on the seafloor in quiet, below-wave-base settings (Meehan, et al., 2021). As the basin continued to subside, deeper water conditions developed, resulting in the deposition of thick sedimentary successions including the Clare Shales (anoxic mudstones), Ross Sandstone (turbidite fan systems), and the Gull Island and Tullig Sandstones (deltaic deposits) (Sleeman & Pracht, 1999). These transitions reflect changing environments: from deep marine to slope and eventually shallow deltaic systems (SEPM STRATA Society for Sedimentary Geology, 2019).

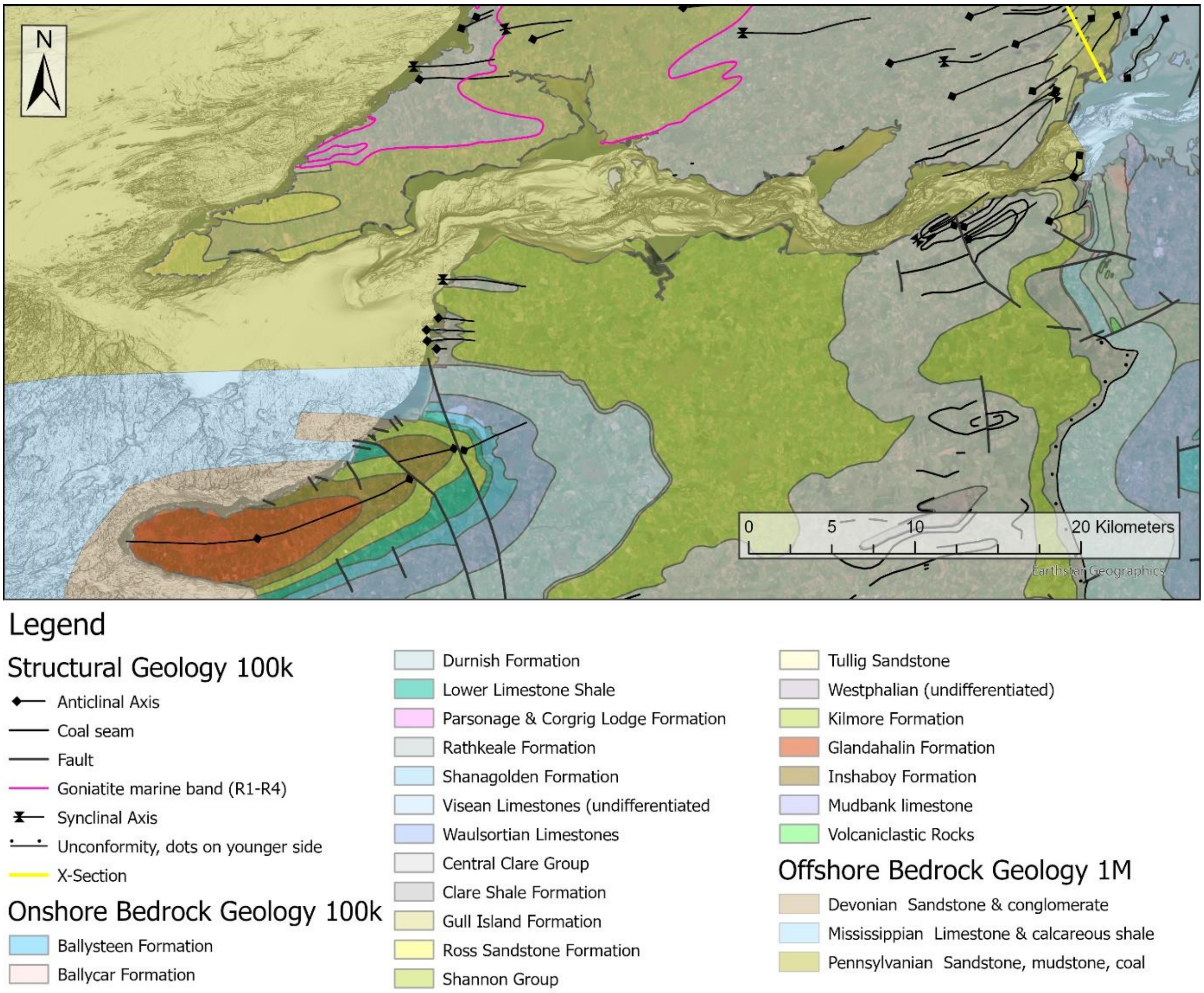

Figure 4: Detailed geology around the estuary.

By the end of the Carboniferous, the region experienced the Variscan Orogeny, a continental collision and mountain building event around 300 Ma, which folded and faulted the basin deposits under compressional forces from the south. Following the Variscan Orogeny, there is a significant gap in the geological record from the end of the Carboniferous Period until the Quaternary, around 2.58 Ma. This gap is largely due to prolonged uplift and erosion, which removed much of the deposited material from this time.

During the Quaternary, repeated glacial cycles affected the area. Ice sheets advanced across the region, overdeepening valleys and modifying the topography. After the last glacial maximum approximately 24 ka, rising sea levels flooded the overdeepened valley, giving rise to the estuary seen today (Ó Cofaigh, et al., 2012). Its persistence is due to a balance between tidal scouring and continuous sediment delivery from the River Shannon, which together prevent full infill (Sleeman & Pracht, 1999). The deepest part of the estuary channel reaches nearly 55 m, shaped by flow dynamics around submerged ridges and bends.

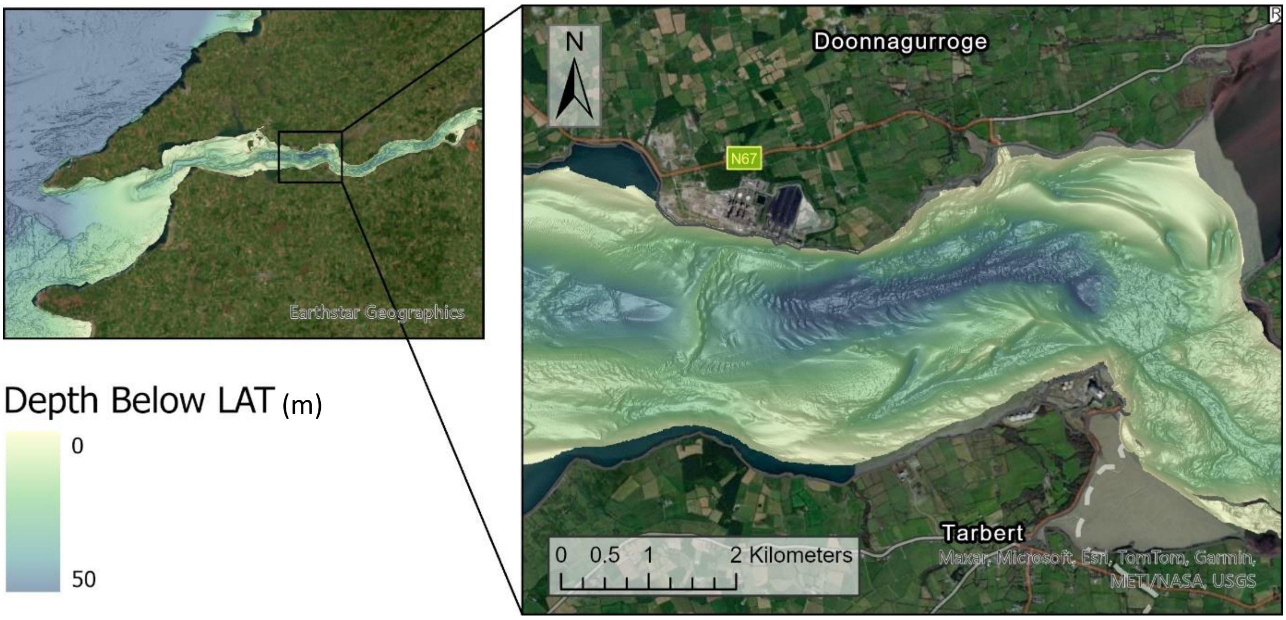

Figure 5: Bathymetric chart showing the deepest point in the estuary channel, reaching nearly 55 m water depth.

Elsewhere in the estuary, sediment deposition from both fluvial and marine sources has created extensive mudflats and saltmarshes, particularly in sheltered areas. These habitats are sustained by a high tidal range, which can exceed 5.5 m. Near the estuary mouth, wave action and post-glacial sea-level rise have resulted in thick accumulations of fine sediments, as shown in the sediment classification map below.

Figure 6: Sediment classification map of Shannon Estuary.

Seabed Features

The Shannon Estuary seabed contains a variety of geological and hydrodynamic features shaped by glacial, fluvial, and marine processes. These include ridges, sandwaves, mudflats, and evidence of both ancient glacial action and ongoing tidal currents.

The Bridge

One of the most striking features is *The Bridge*, a submerged ridge orientated north-north-east to south-south-west, located just south of the Moneypoint power station.

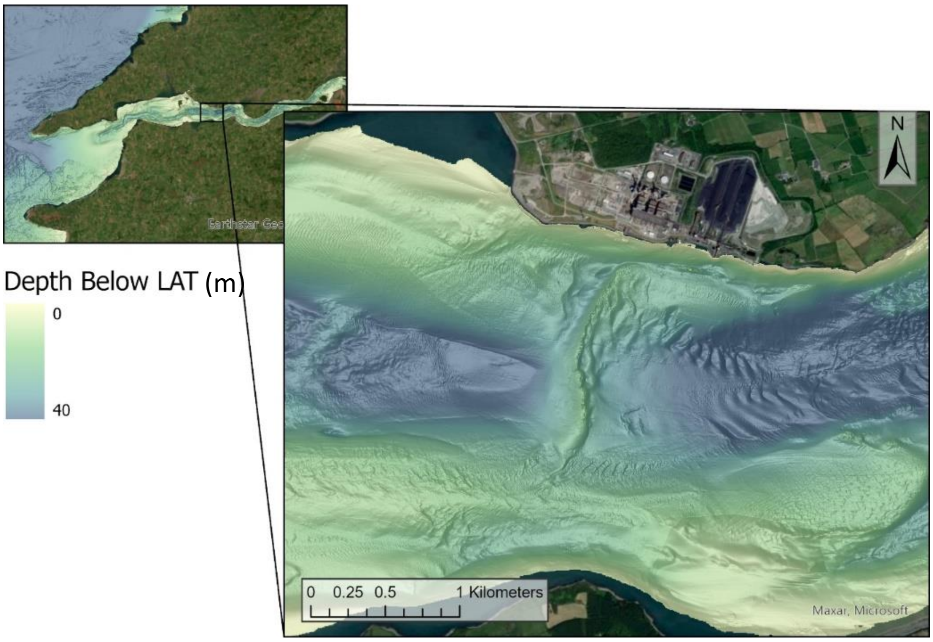

Figure 7: Bathymetric map of The Bridge ridge, south of Moneypoint power station.

Rising nearly 20 m above the surrounding seabed, it represents a significant elevation change in the estuary floor. Bathymetric profiles show steep sides and a shallow crest, which interact with tidal currents reaching up to 3 knots (Admiralty Chart 1548). Under strong westerly winds, this combination produces turbulent waters and overfalls, as noted on the Admiralty Chart.

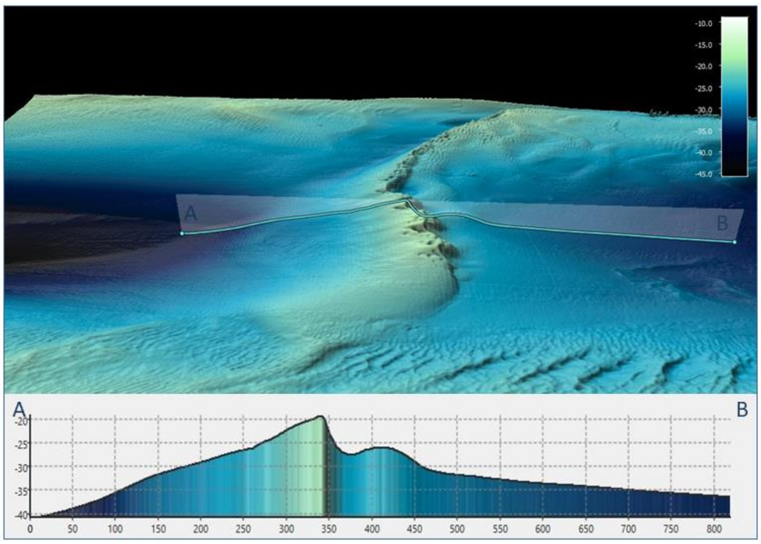

Figure 8: 3D Bathymetry with Elevation profile orientated from west (A) to east (B).

Geologically, *The Bridge* is best interpreted as an end moraine – a ridge formed at the stationary edge of a retreating ice sheet. Its planform orientation is transverse to reconstructed ice-flow, trending roughly perpendicular to onshore meltwater channels, drumlins, and glacially streamlined bedrock that indicate dominant north-east to south-west ice movement across the region. In map view (see figure below), the ridge lies across the direction of flow rather than parallel to it.

This interpretation is further supported by the presence of other morainic ridges mapped by the BRITICE project, which broadly align with the Bridge and sit on the same down-ice limit (Clark, et al., 2017). Taken together, the ridge geometry, its relationship to independently mapped flow indicators, and its correspondence with the BRITICE moraine belt make a moraine origin the most consistent explanation.

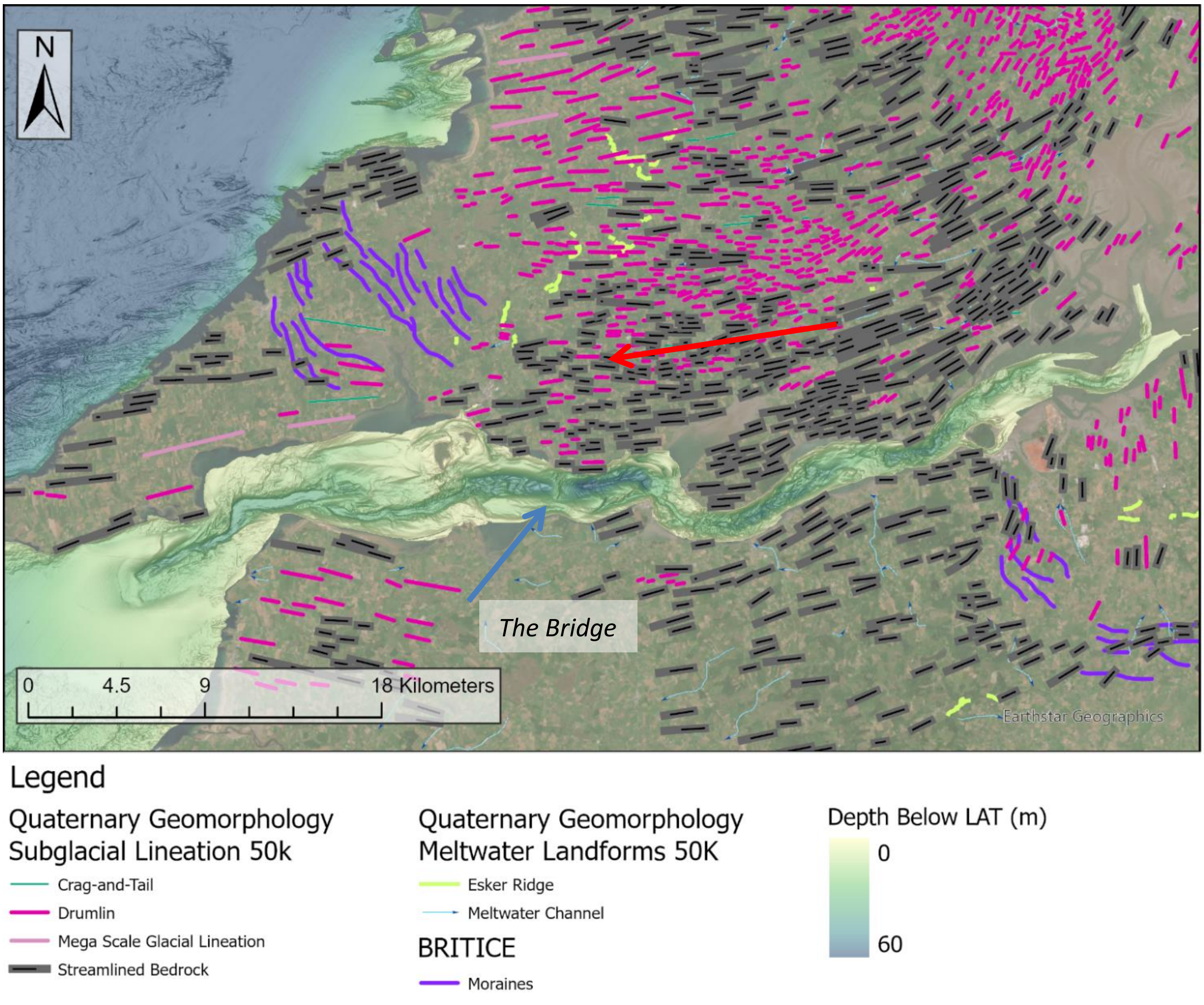

Figure 9: Glacial features, with inferred direction of glacier travel in red. Moraine data from (Clark, et al., 2017).

Shallow seismic geophysical data indicate that *The Bridge* is composed of layered sediment, while backscatter data show a relatively hard seabed, consistent with coarse or compacted sediment.

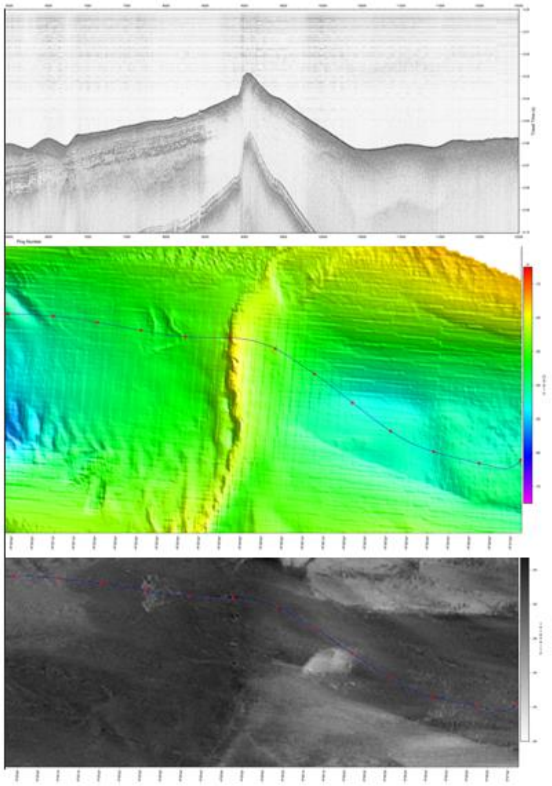

Figure 10: Sub bottom profile of the bridge (top), bathymetry (centre) and backscatter (bottom).

Sandwaves and Bedforms in Channels

Large sandwaves and smaller bedforms are present throughout the main channels of the estuary, particularly north of Foynes Island. These features, ripples and dunes formed by sediment transport, indicate active bedload movement driven by strong tidal and river currents.

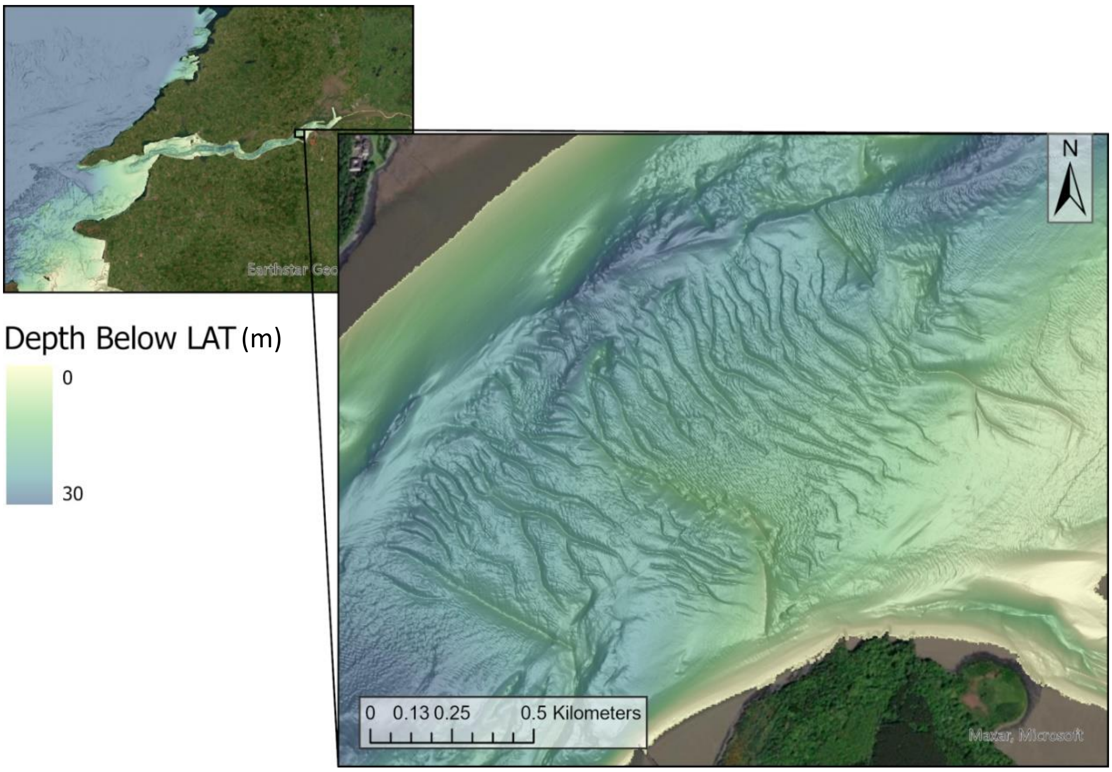

Figure 11: Sandwave field north of Foynes Island.

Sandwave crests range from a few centimetres to several metres in height and show both symmetrical and asymmetrical morphologies. This suggests a predominant net sediment transport direction superimposed on a bidirectional tidal flow, with local variations. Current acceleration around submerged features and bends in the estuary channels contributes to variation in wave shape and sediment deposition patterns (Ó Cofaigh, et al., 2012).

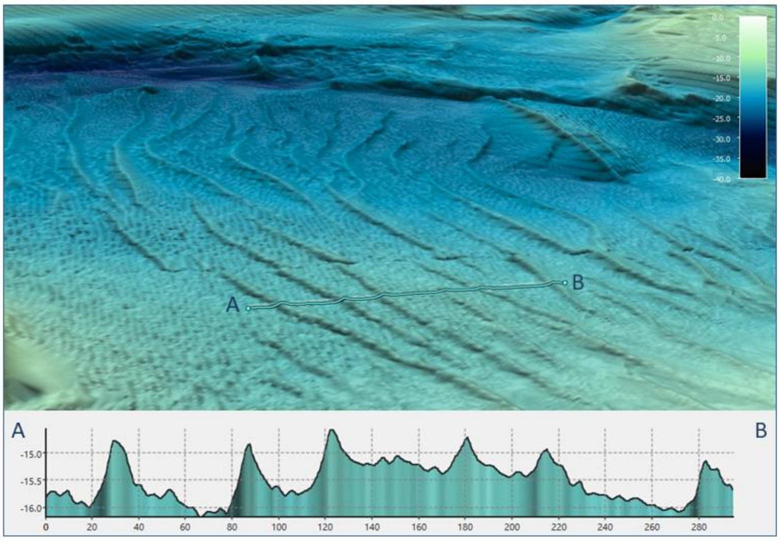

Figure 12: 3D Bathymetry with Elevation profile orientated from south-west (A) to north-east (B).

Comparative analysis of INFOMAR multibeam datasets shows that while the sandwave fields remain largely stable, some crestlines have migrated by up to 20 m between 2009 and 2013, both toward the north-east and south-west. This bidirectional migration is consistent with their development under a reversing tidal regime, where alternating flood and ebb currents drive sediment transport in opposite directions, and reflects fluctuations in current energy and sediment availability.

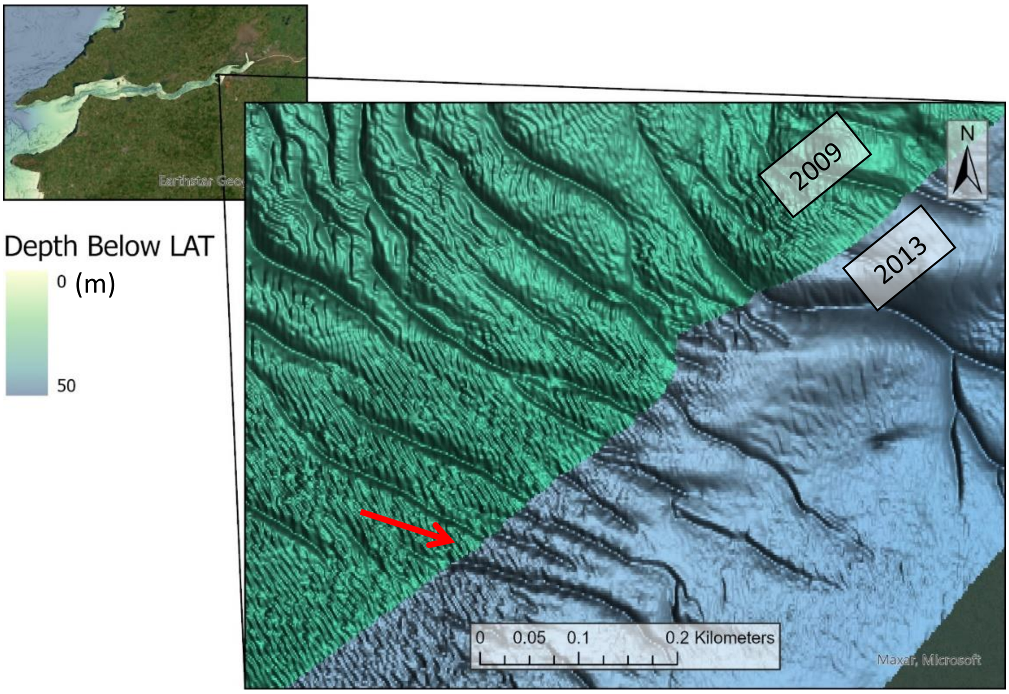

Figure 13: Displacement of sand waves between survey legs CV09_01 and KRY13_05 showing displacement, indicated by the red arrow.

Folded Rocks at Doon

Near the estuary's mouth, folded Carboniferous rocks are exposed both onshore and on the seabed at Doon Point. These east-west trending folds formed during the Variscan Orogeny, at the end of the Carboniferous. The folds reflect intense southerly compressional forces that deformed the Upper Carboniferous strata, producing large-scale structural features that remain visible in the bathymetry data.

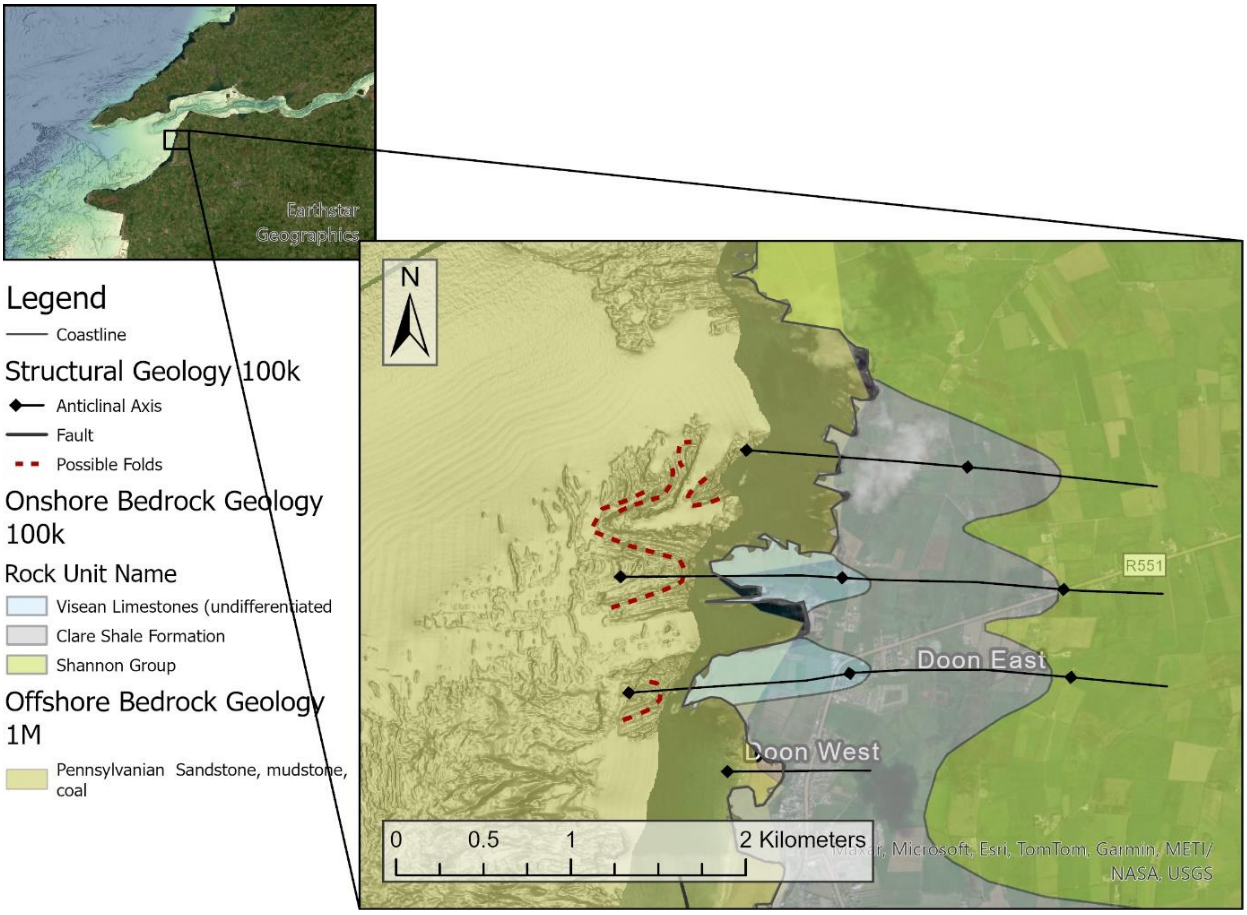

Figure 14: Structural geology of the folded outcrop at Doon.

Expression of Cables and Infrastructure

Multibeam data collected by INFOMAR have also identified linear seabed anomalies consistent with modern infrastructure, including submarine cables and pipelines. These features are most common in heavily trafficked areas near industrial ports, such as Foynes and Moneypoint, and are identifiable by their narrow width and linear geometry.

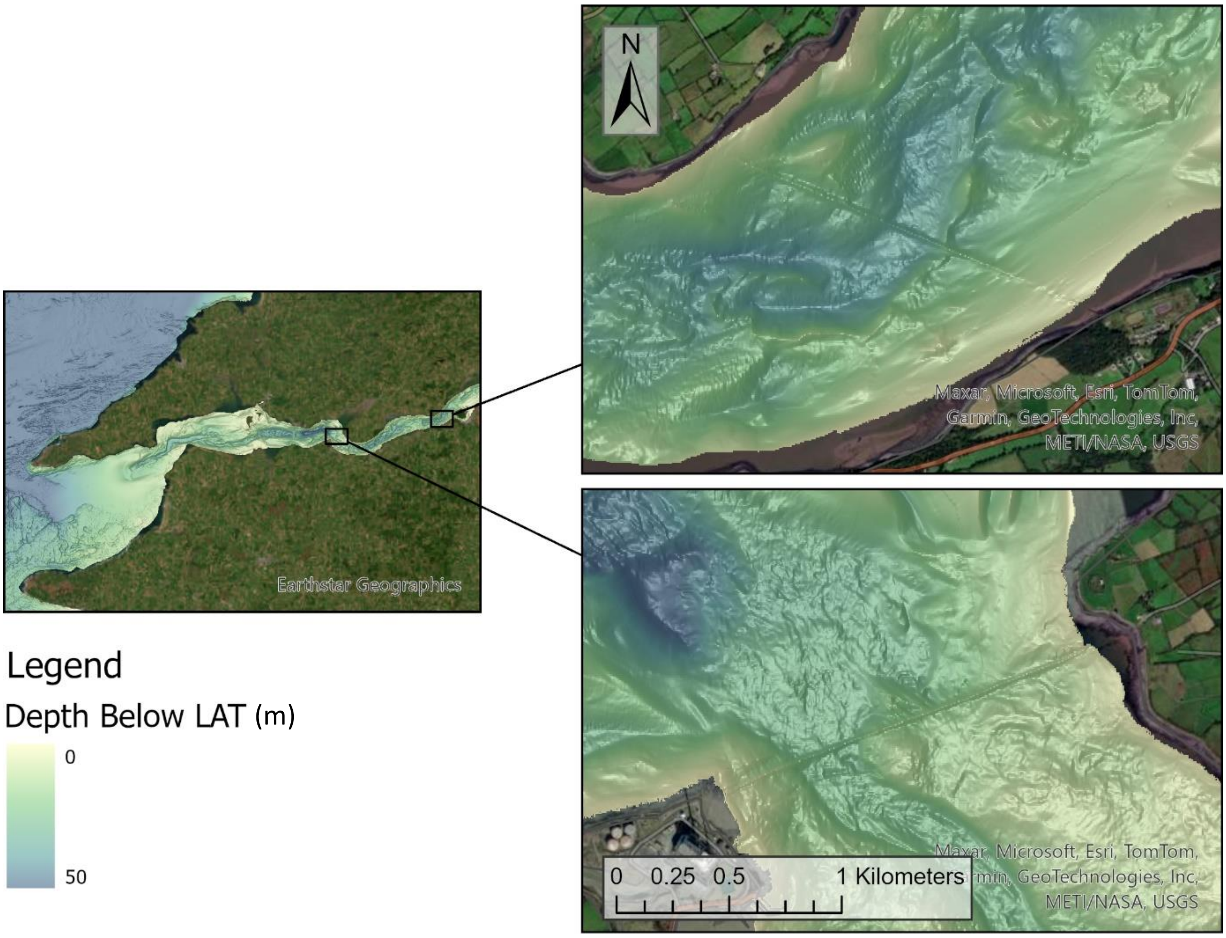

Figure 15: Cables/pipelines on the seabed near Foynes (top) and Talbert (bottom).

Biodiversity

The Lower River Shannon SAC is one of Ireland's largest and most ecologically significant conservation areas, stretching from Killaloe to Loop Head and Kerry Head. It protects a wide variety of Annex I habitats including large shallow inlets and bays, estuaries, mudflats and sandflats, sandbanks, alluvial forests, and reefs. It also safeguards populations of the Annex II species Bottlenose Dolphin, including Ireland's only known resident population of this species within an SAC boundary. Surveys have shown a relatively stable population of around 100 to 130 individuals (National Parks & Wildlife Service, 2013).

The site includes intertidal mudflats, sandflats, and saltmarshes, which support rich communities of invertebrates and act as critical feeding and nursery grounds for fish and birds. It also provides important roosting and foraging areas for wintering birds. The River Shannon and River Fergus Estuaries SPA, under the E.U. Birds Directive, overlaps the SAC and is of international importance, supporting over 50,000 wintering waterfowl including species such as dunlin, black-tailed godwit, light-bellied brent goose, and redshank (National Parks & Wildlife Service, 2015).

The estuary's diverse habitats, from estuarine mudflats to deep subtidal channels and reefs, provide conditions suitable for an extraordinary range of marine and bird life, making this area one of Ireland's richest estuarine ecosystems.

Conclusion

The Shannon Estuary records a long geological history, from the closure of the Iapetus Ocean and the development of the Carboniferous Shannon Basin, to later Variscan deformation, glacial modification and post-glacial sea-level rise. Its modern form reflects this inherited bedrock structure, together with ongoing tidal flow, sediment transport and river input.

The seabed remains active, with sand waves, ridges, mudflats and depositional zones shaped by strong tidal currents and sediment supply from both fluvial and marine sources. Features such as The Bridge, the sand-wave fields near Foynes and folded rocks near Doon show how glacial, sedimentary and structural controls continue to influence the estuary floor.

The estuary is also an important ecological area, supporting extensive intertidal habitats, internationally significant bird populations and Ireland's only known resident population of Bottlenose Dolphins. Its role as both a deepwater port and a protected natural area highlights the need for careful management based on good geological and environmental evidence.

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