

EVIDENCES OF SHALLOW GAS AND SEEPAGE IN SHALLOW WATER DEPTHS (<100M)

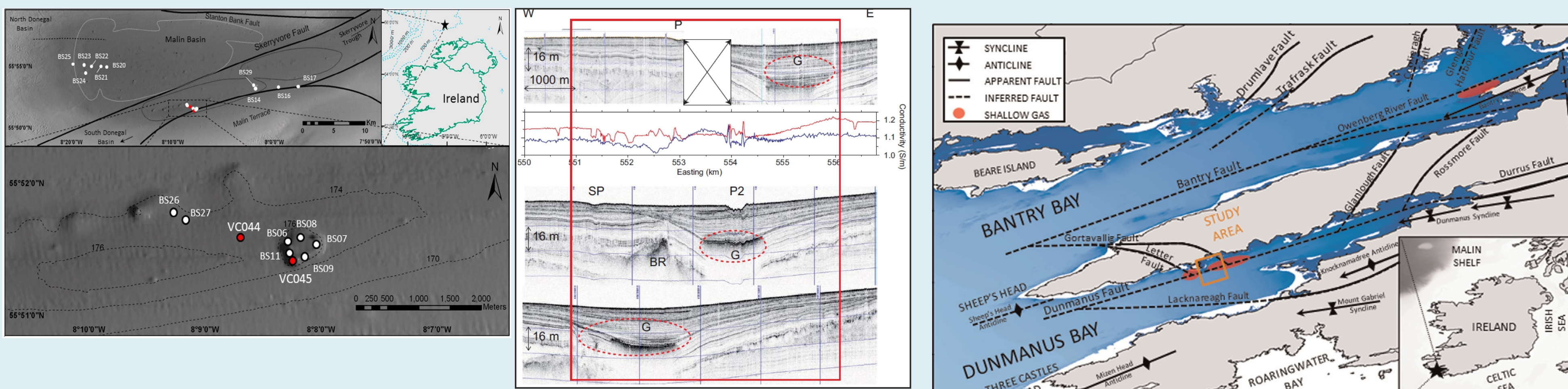


Figure 1A (TOP): Pockmark clusters in the Malin Deep micro basin. Skerryvore Fault; black dotted line (Szpak et al., 2012).

Figure 1B (TOP-RIGHT): Gas anomalies in the central part of the Malin basin shown in the electromagnetic data (EM) and 3 parallel shallow seismic lines (Garcia et al., 2014). Gas accumulation facies (G) are present in the three parallel lines and coincide with the edges of the EM gassy region (C). SP is a small pockmark. The bright reflector (BR) is interpreted as a magmatic intrusion.

Figure 2A (TOP-RIGHT): Bathymetry of Dunmanus and Bantry Bays with major structural features and shallow gas locations. A major fault in this area, the Dunmanus Fault, crosses just north of the pockmark field with the smaller Gortavall Fault branching out just 250m north-west of the pockmark field.

Figure 2B (BOTTOM-RIGHT): Bathymetry illustrating pockmark clusters D to F and individual MBES lines (right panel) with acoustic-signals ascribed to ascending bubbles in the vicinity of the encircled pockmark features.

FLUID MIGRATION AND SEEPAGE IN DEEPER WATER DEPTHS (>500M)

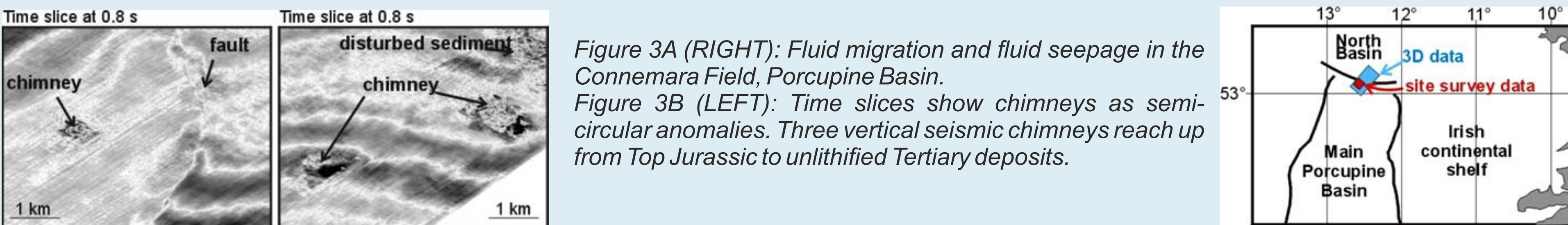


Figure 3A (RIGHT): Fluid migration and fluid seepage in the Connemara Field, Porcupine Basin. Figure 3B (LEFT): Time slices show chimneys as semi-circular anomalies. Three vertical seismic chimneys reach up from Top Jurassic to unlifted Tertiary deposits.

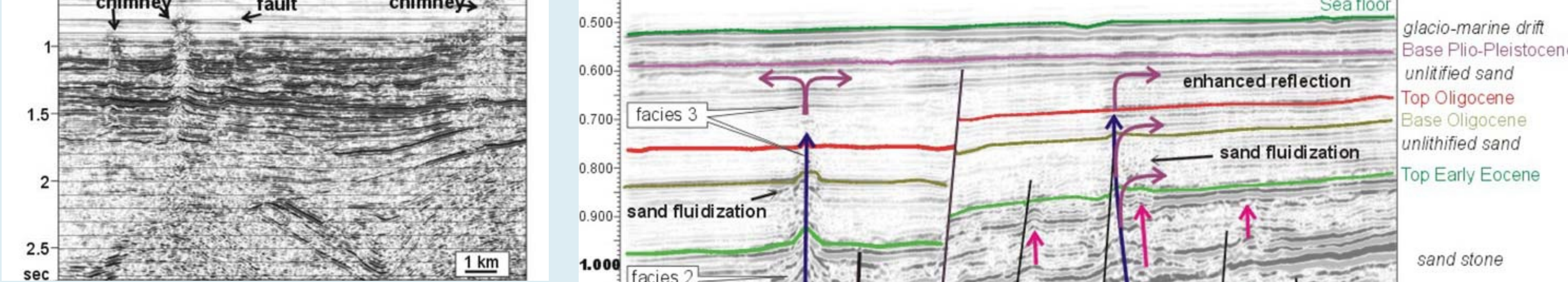


Figure 4 (RIGHT): Interpreted fluid migration pathways based on seismic and well log interpretation. Deep-rooted vertical chimneys appear to be main conduits for vertical fluid migration from Jurassic reservoirs. Where chimneys cross permeable layers (Early Eocene), lateral fluid migration occurs particularly in up-dip strata. Secondary chimneys root in Early Eocene. In younger unlifted sands, fluid injection causes wide-spread deformation—interpreted as fluidization—and pockets of gas charged sediment.

DATA AND METHODS FOR EXPLORING NATURAL GAS HYDRATES IN IRISH OFFSHORE

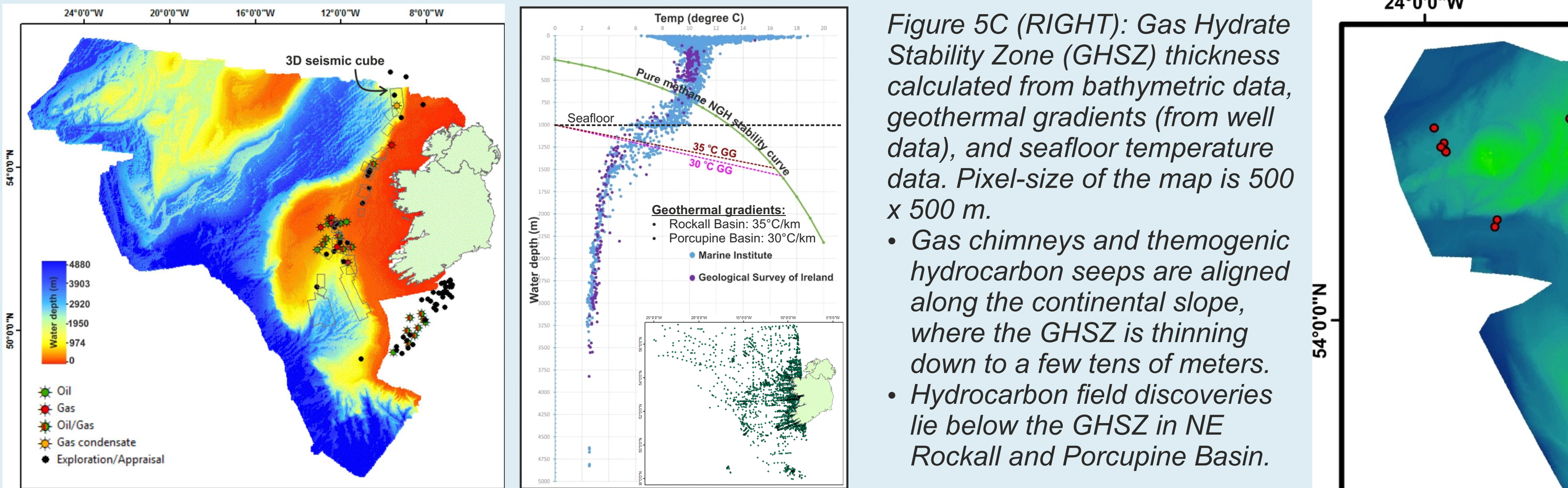


Figure 5A: 3D seismic cubes and wells overlain on bathymetric data. Oil and gas finds in Irish offshore shown in green and red dots.

Figure 5B: Seafloor temperature from 4760 CTD casts. Geothermal gradients from well data.

Figure 5C (RIGHT): Gas Hydrate Stability Zone (GHSZ) thickness calculated from bathymetric data, geothermal gradients (from well data), and seafloor temperature data. Pixel-size of the map is 500 x 500 m.

Figure 5D (LEFT): Source rock distribution in Porcupine and Rockall basins generally coincident with the GHSZ extent.

Figure 5E (RIGHT): Essential elements required for formation of oceanic NGH.

MARINE GAS HYDRATE STABILITY ZONE IN IRELAND AND EUROPE

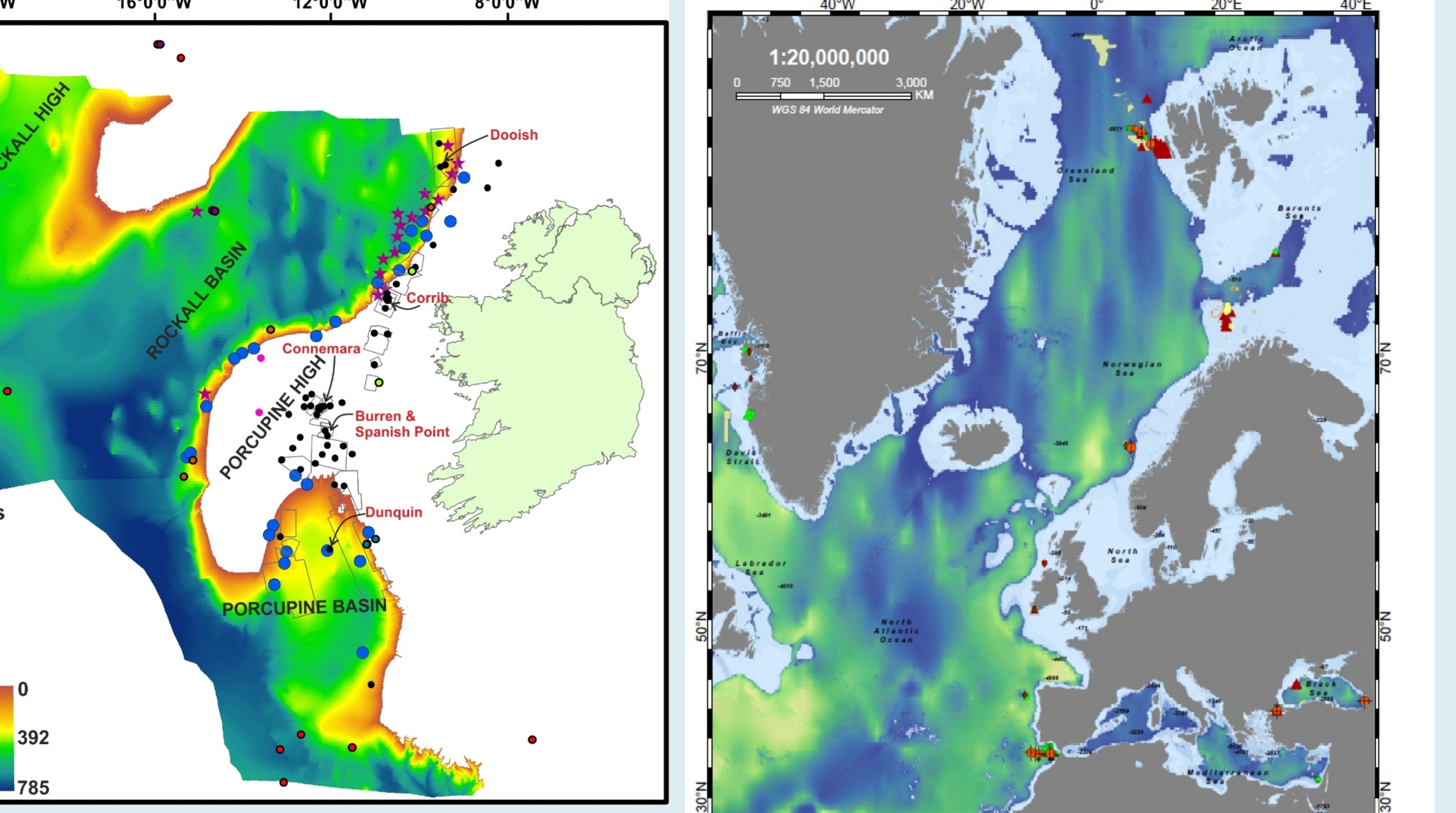


Figure 5F (RIGHT): This map was produced as part of the COST-MIGRATE project "Marine gas hydrate - an indigenous resource of natural gas for Europe". The offshore area of Ireland is the latest addition to the European Marine Gas Hydrate thickness map.

POTENTIAL NATURAL GAS HYDRATE RESERVOIRS IN IRISH OFFSHORE

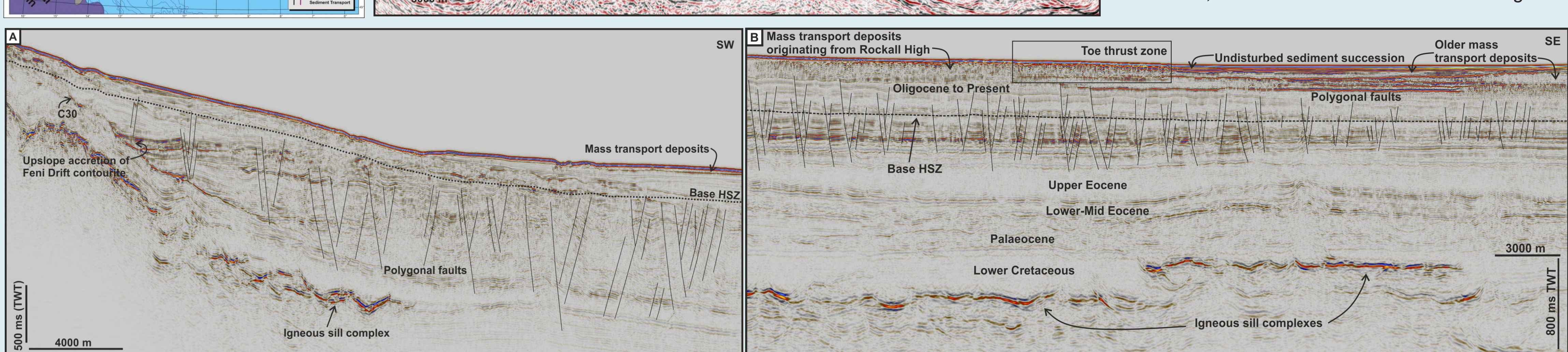
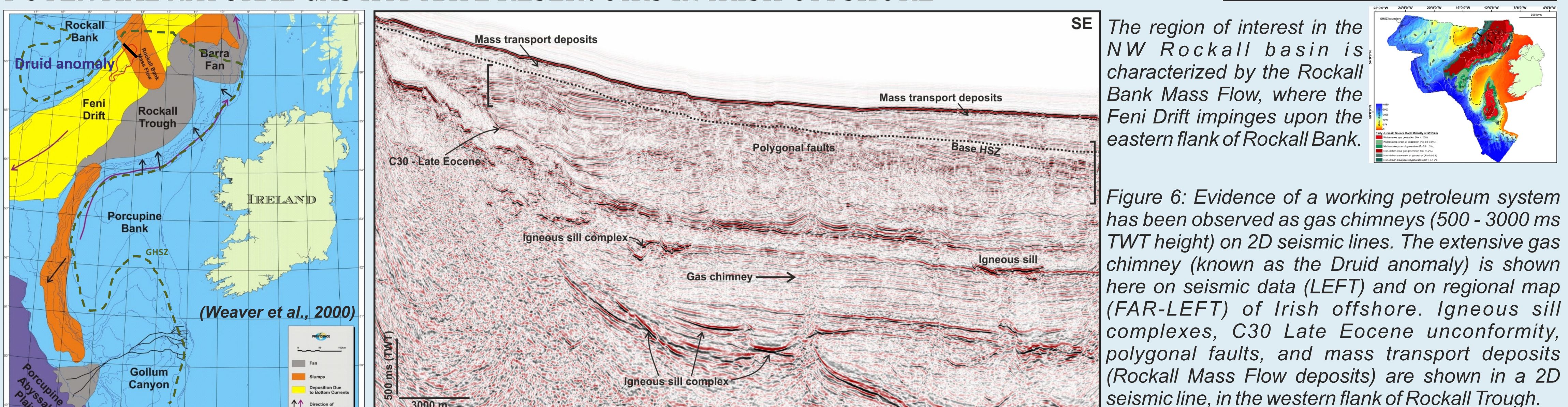


Figure 7: (A) Interpretation of polygonal faults on 2D seismic line along the western flank of the Rockall Trough. The Late Eocene C30 angular unconformity has also been marked along with the Fenit Drift contourite, and mass transport deposits. (B) Further SE of the same 2D seismic line, interpretation of mass transport deposits (of older and present times), associated toe thrust zone of the debris lobe, polygonal faults, and igneous sill complexes are shown. Location of 2D seismic data is shown in the top right corner map of Irish offshore.

CONCLUSIONS

- A high - resolution GHSZ thickness map has been calculated for Irish basins, which extends up to 785m below sea-floor. The aerial distribution of GHSZ is largely coincident with the potential source rock distribution in Irish basins.
- Prospective NGH reservoirs and migration pathways overlying proven source rocks have been identified in NW Rockall and Porcupine basins. Isolated sand bodies, mass transport deposits, and contourite deposits could be potential targets for oceanic NGH exploration.
- Multiple episodes of fluid seepage have been observed in the Slyne Basin, possibly linked with re-activation of faults.
- Vp and resistivity values were measured in the laboratory following controlled formation of methane gas hydrate in core-samples collected from an area which is within the calculated GHSZ in Irish offshore.

ACKNOWLEDGEMENTS:

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1. Northwest Rockall Basin

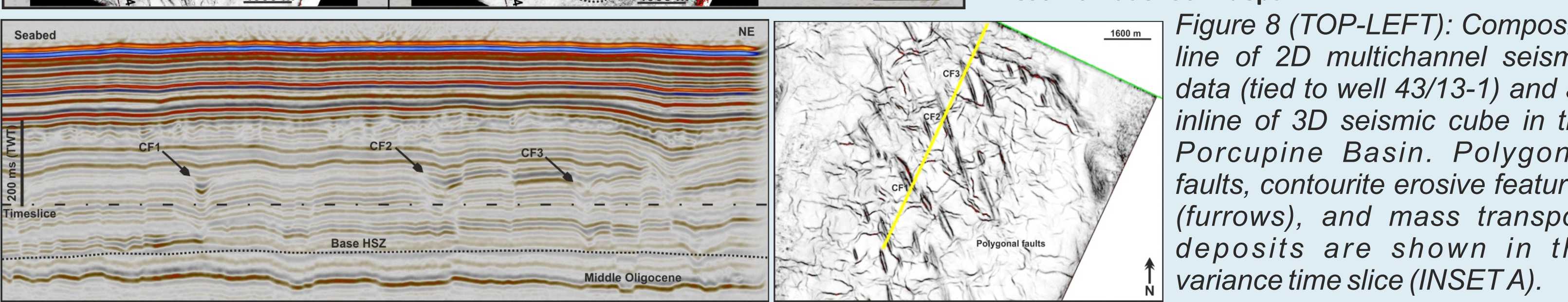
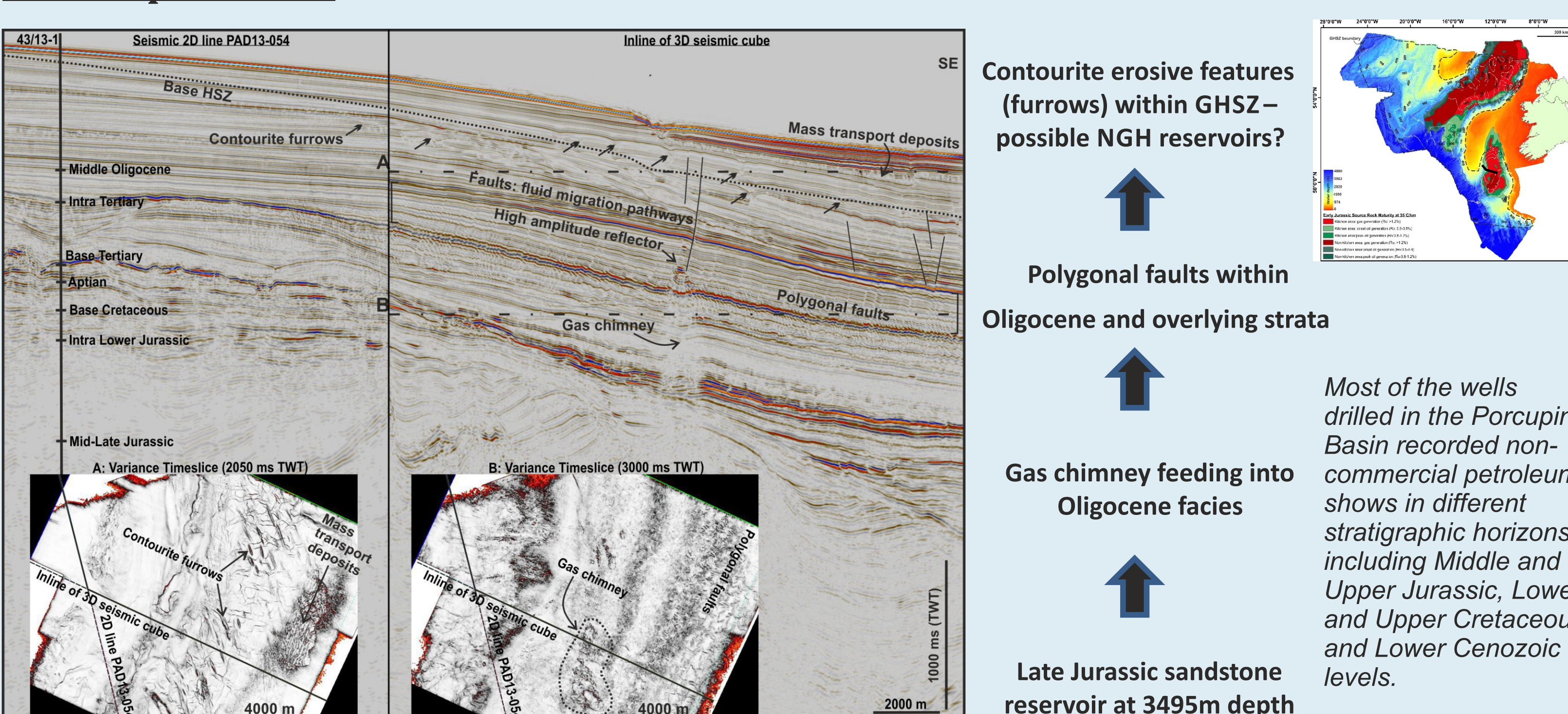


Figure 8: (TOP-LEFT) A large gas chimney is also shown on the seismic cross-section, whose extent is outlined in the variance time slice (INSET B). The location of the time slices are shown by dashed lines in the seismic cross-section.

Figure 9: (BOTTOM-LEFT): Close-up look at the contourite furrow features within the GHSZ. (BOTTOM-RIGHT) Spatial distribution of the contourite furrow features and polygonal faulting shown on variance time slice (location shown by dashed line in the seismic cross-section. In a given area of 10x10 km2, 35 of these contourite features are separated by less than 1 km.

Table 1: (LEFT) Volumetric calculations of NGH in an average contourite furrow.

	LOW CASE	MEDIUM CASE	HIGH CASE
Area (km ²)	0.352	0.45	0.66
Net HSZ (km)	0.05	0.08	0.1
Gross Rock Vol (km ³)	0.0176	0.036	0.066
Porosity	0.25	0.3	0.35
Hyd Saturation	0.1	0.15	0.2
FVF	160	160	160
GIIP (m ³)	72160000	265680000	757680000
GIIP (bcf)	2.54	9.38	26.75

Figure 12: (LEFT) Location of the 83/20-sb01 stratigraphic borehole site on the eastern Rockall margin, showing the main structural elements in the region. CB, Cillian Basin; EB, Eris Basin; EH, Eris High; SB, Slyne Basin; NBB, North Brona Basin; SBB, South Brona Basin; MB, Macdara Basin.

Figure 13: (LEFT) Interpreted seismic reflection profile (line 11 sparker, unmigrated) across borehole site 83/20-sb01 on the eastern margin of the North Brona Basin. (RIGHT) Description of the cored section in shallow borehole 83/20-sb01.

BURIED POCKMARKS, TURBIDITE CHANNEL SYSTEMS AND FAULTS IN THE SLYNE BASIN

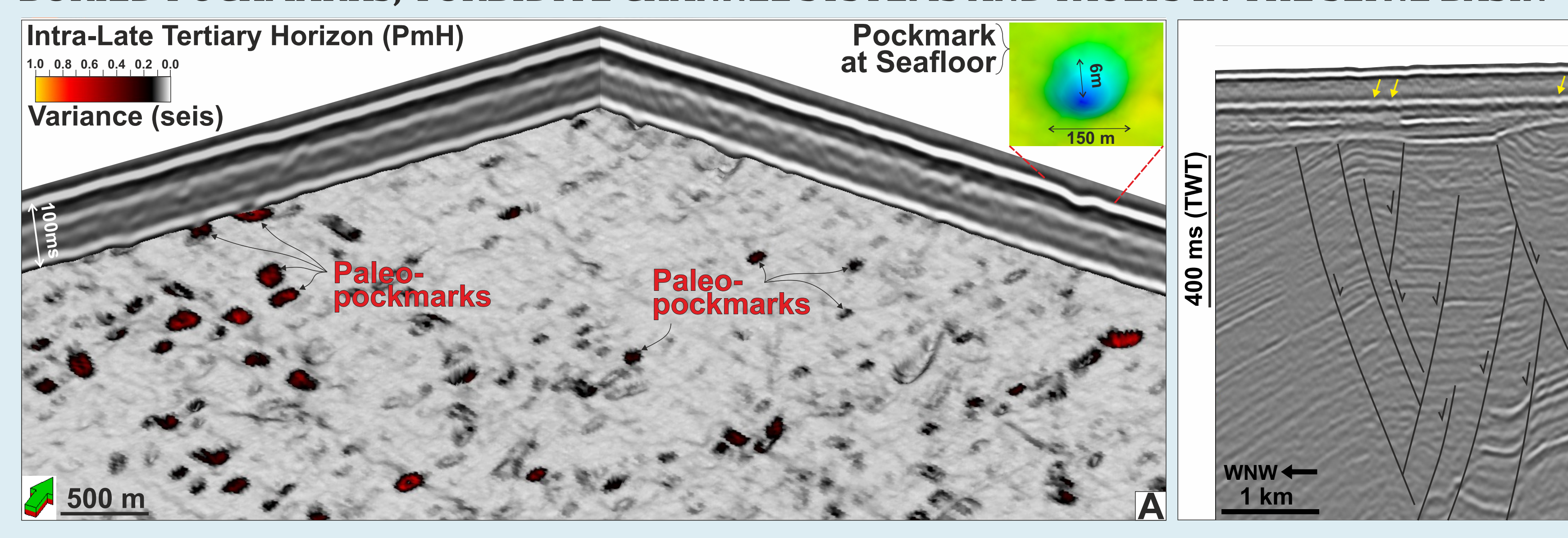


Figure 10: (A) Pockmarks on the seafloor and the Intra-Late Tertiary horizon (PmH). Variance attribute extracted along PmH surface highlights the presence of abundant paleo-pockmarks. Inset box shows morphology and dimension of a seafloor pockmark. (B) Mesozoic strata and normal faults truncate at the Late Tertiary Unconformity (U/C). Paleopockmark depressions shown at the PmH. Well data was tied with the 3D seismic data for age determination of geological unconformities in the Slyne Basin. (Roy et al., in preparation)

PETROPHYSICAL INVESTIGATION ON HYDRATE-BEARING SEDIMENTS IN LABORATORY

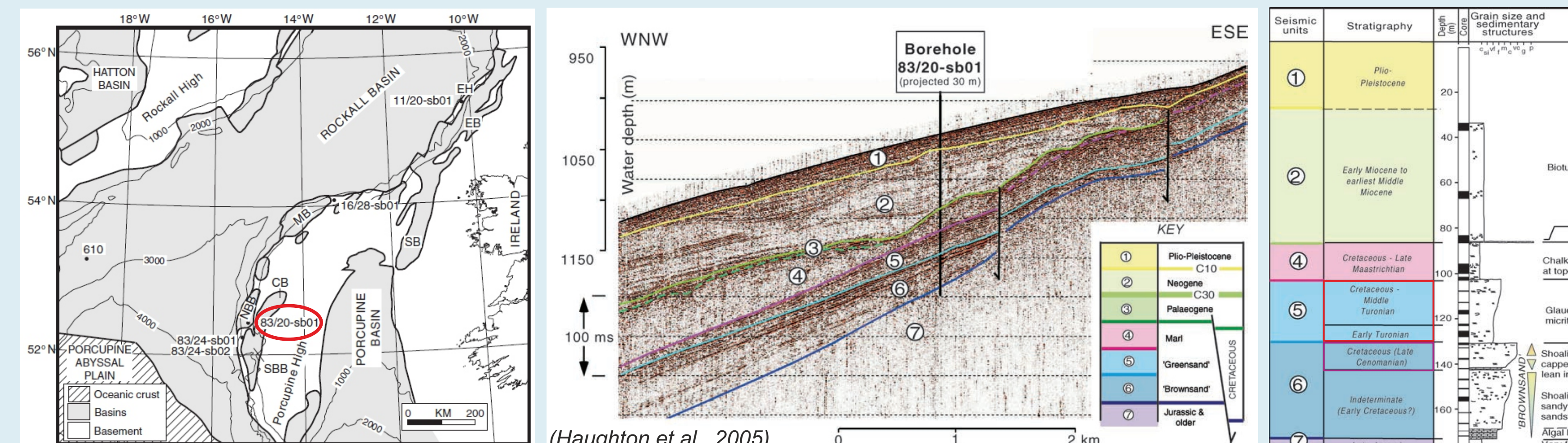


Figure 11: (LEFT) Schematic diagram of the experimental set-up. (TOP & BOTTOM) Sonic velocities (Vp) and 2-electrode resistivity values were measured at various ice saturation levels. 0% KCl solution was used for the whole extent of the experiment. We observe an increase in the Vp at 22% ice saturation (as well as resistivity value), while methane was injected in the sample. The injected methane pressure (40 Bars) was above the hydrate stability, which might have led to the formation of cementing hydrate with the bound water in the core plug.

A combination of sedimentological and fault-related architectures and properties are responsible for the formation of pockmarks in Slyne Basin.

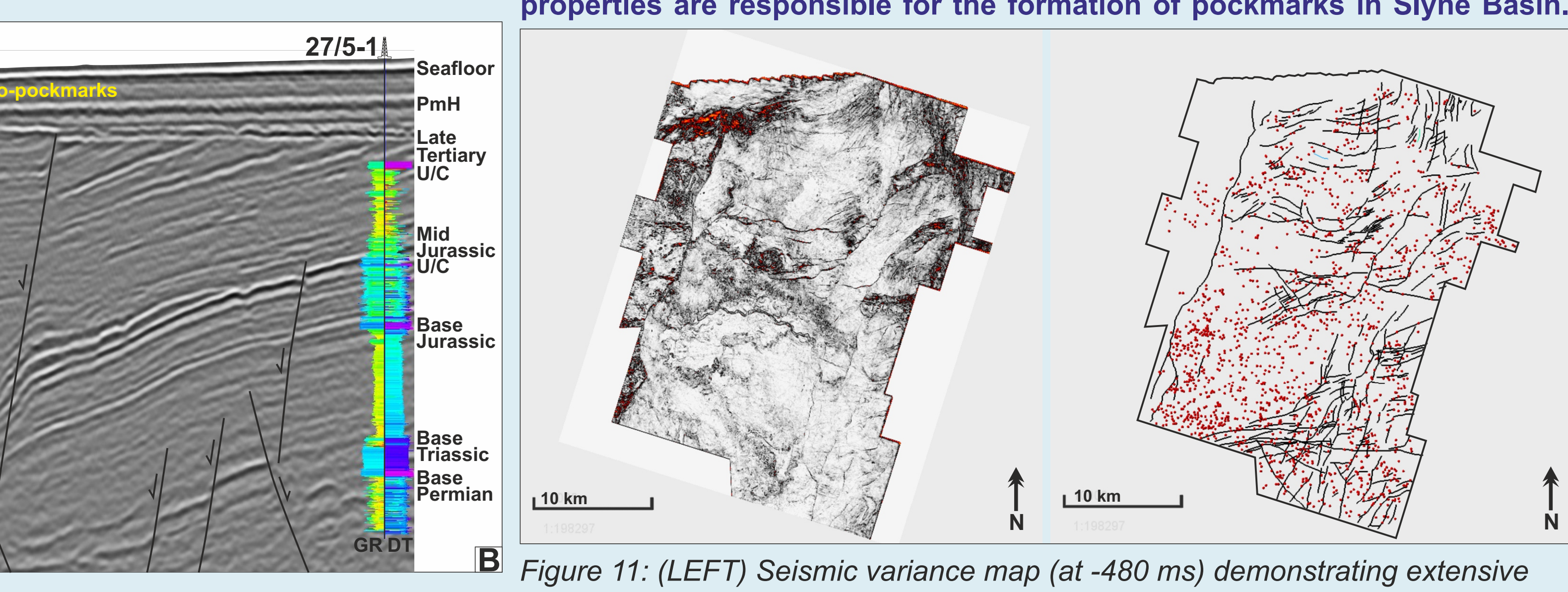


Figure 11: (LEFT) Seismic variance map (at -480 ms) demonstrating extensive turbidite channel systems and faults. (RIGHT) Spatial distribution of fault traces (black lines - interpreted using RMS amplitude and Variance attribute maps) along with buried pockmarks (red dots). See Figure 7B for stratigraphic levels of buried pockmarks, channels, and faults.