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## **Large-Scale Sand Injectites in the North Sea: Seismic and Event Stratigraphy and Implications for Hydrocarbon Exploration\***

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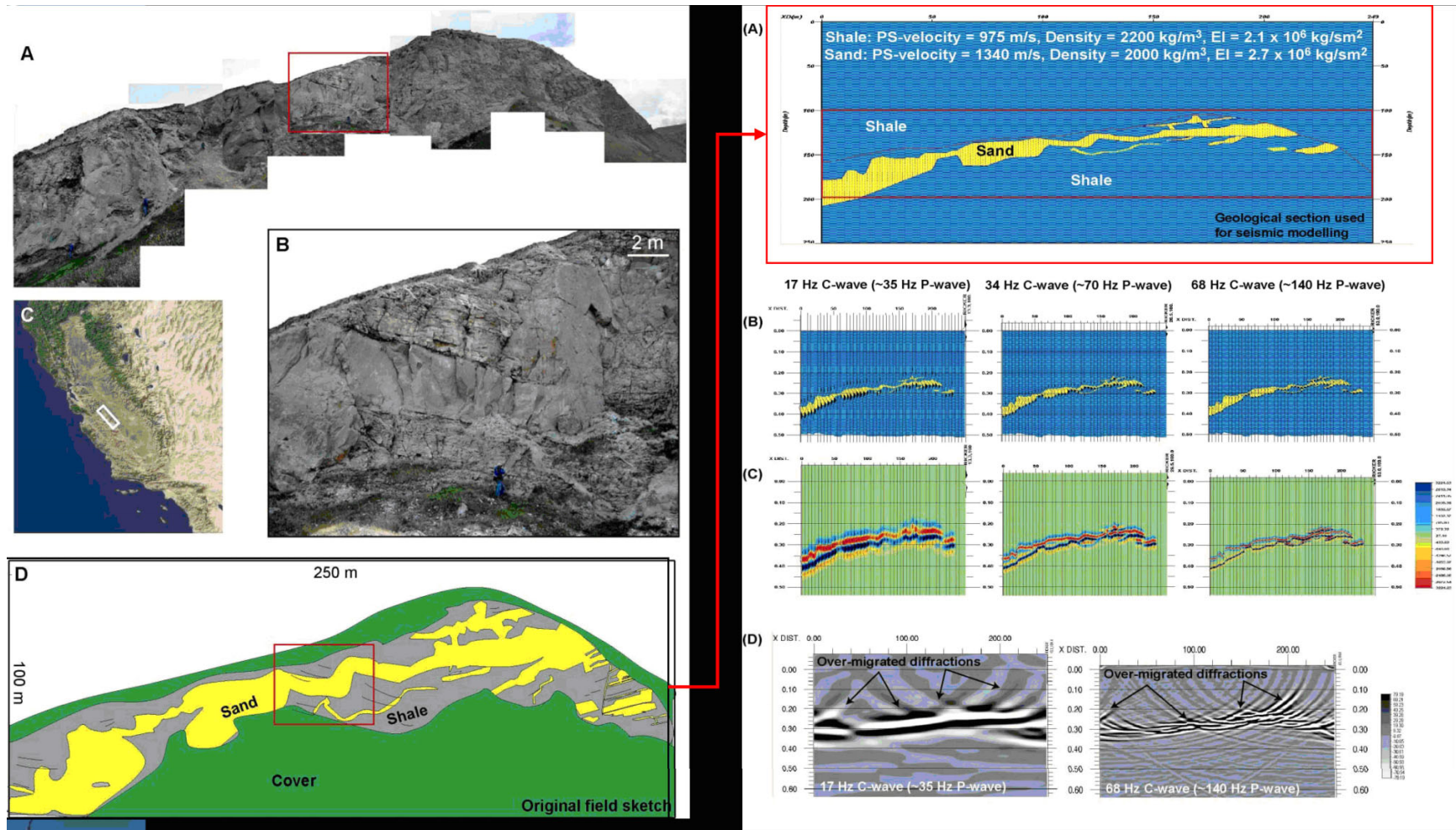
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### **Abstract**

Large-scale sandstone intrusions are common in deepwater depositional systems, with excellent outcrop examples in California, Patagonia, France, Antarctica, Sakhalin, and Greenland. The largest subsurface examples constitute entire oil fields, particularly common in the Paleogene of the central and northern North Sea. Recent studies have documented their occurrence in the North Sea from the Upper Cretaceous to the Neogene, from the Norwegian-Danish Basin through the northern Central Graben, the Outer Moray Firth, the South Viking Graben, to the North Viking Graben, and in the Faroe-Shetland Basin.

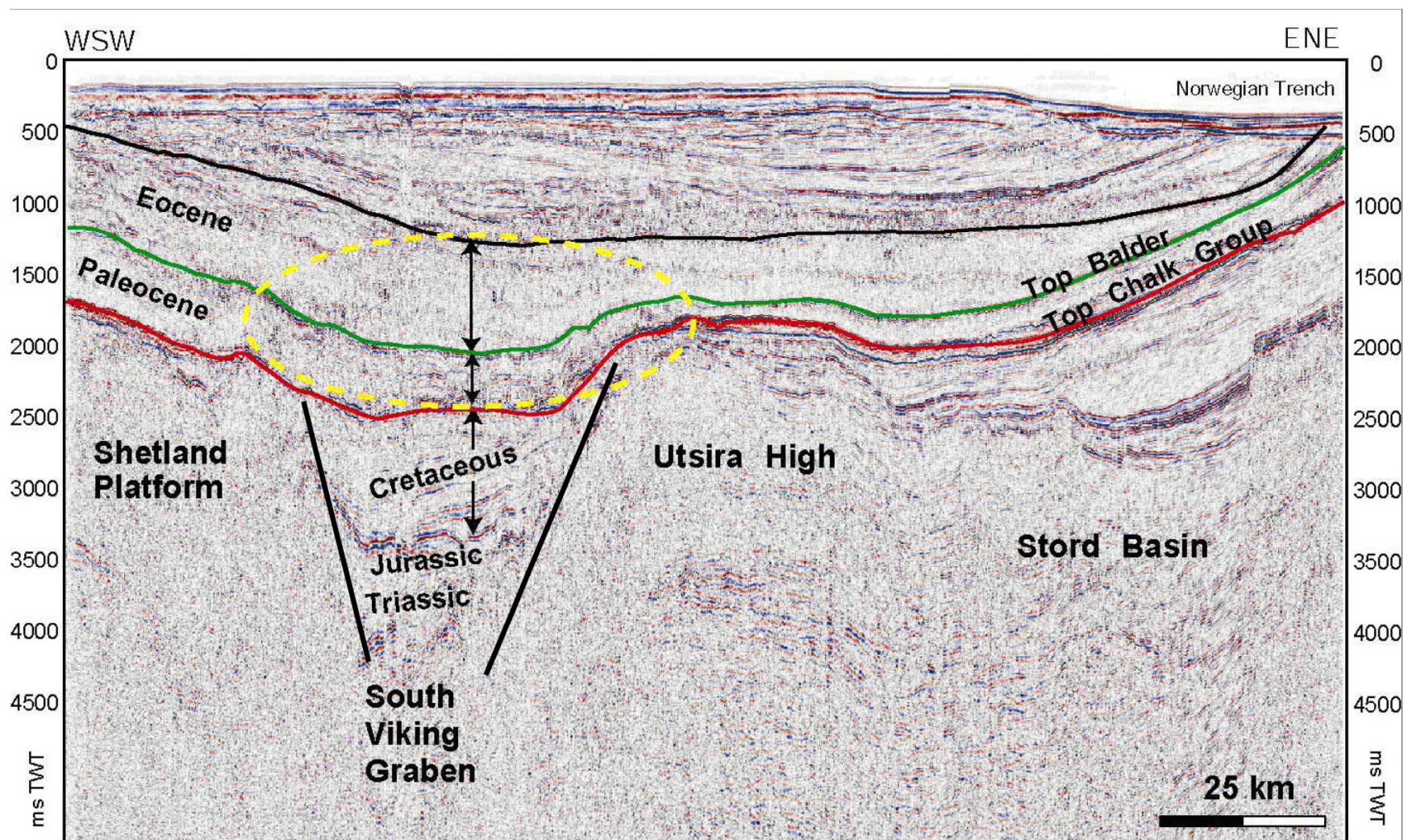
This paper article reviews the tectono-stratigraphy of large-scale sandstone intrusions and their implications for hydrocarbon systems in the North Sea. The origin of the intrusions in the North Sea and in many basins worldwide remains largely unconstrained. In particular, the 1) timing, 2) sand and fluid source, 3) source of overpressure, 4) role of hydrocarbons, and 5) triggering mechanisms remain unresolved. Proposed mechanisms and drivers include liquefaction by earthquakes or meteorite impacts, diagenetic and hydrocarbon fluids, disequilibrium compaction, lateral transfer of pressure. In terms of hydrocarbon exploration, large-scale intrusions are important reservoirs with intricate geometries usually characterised by excellent intra- and inter-reservoir connectivity. Some intrusions may act as long-term fluid conduits and may thus be implicated in hydrocarbon migration and act as long-term fluid conduits (valves), increasing cross-stratal fluid flow over hundreds of metres of section, assisting pressure bleed off and compaction.

In other areas, sandstone intrusions may act as fluid sinks when penetrated during drilling. Sandstone intrusions may connect isolated reservoir bodies over tens of kilometres laterally and over several hundreds of metres vertically. The sizes of individual completely injected sandbodies range up to 0.5-1.0 km<sup>3</sup> in volume. Only a few such large-scale intrusions have been targeted deliberately, but several have been drilled before their true origin were realized, causing much confusion in the initial appraisal and production of oil in these bodies. Intrusions associated with in-situ remobilized sandbodies are extremely common in the North Sea Paleogene and currently constitute important infill drilling targets on the Gryphon and Alba Fields and several smaller oil fields in the North Sea, whereas frontier examples include deepwater West Africa.



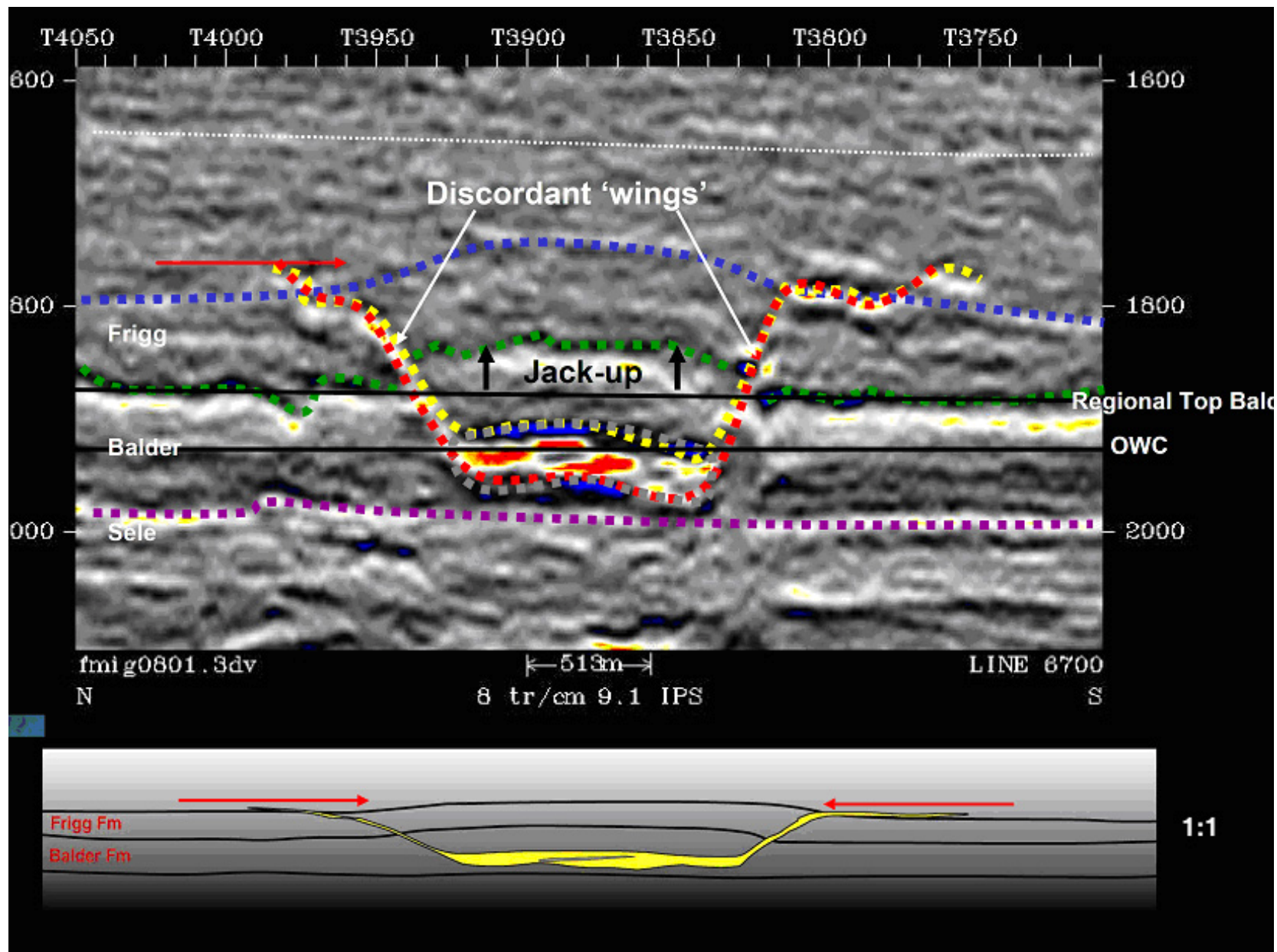
Outcrop analogue and seismic modelling of large-scale (wing-like?) sand injectite in the Eocene of the San Joaquin Valley, California (from Huuse et al., 2007).



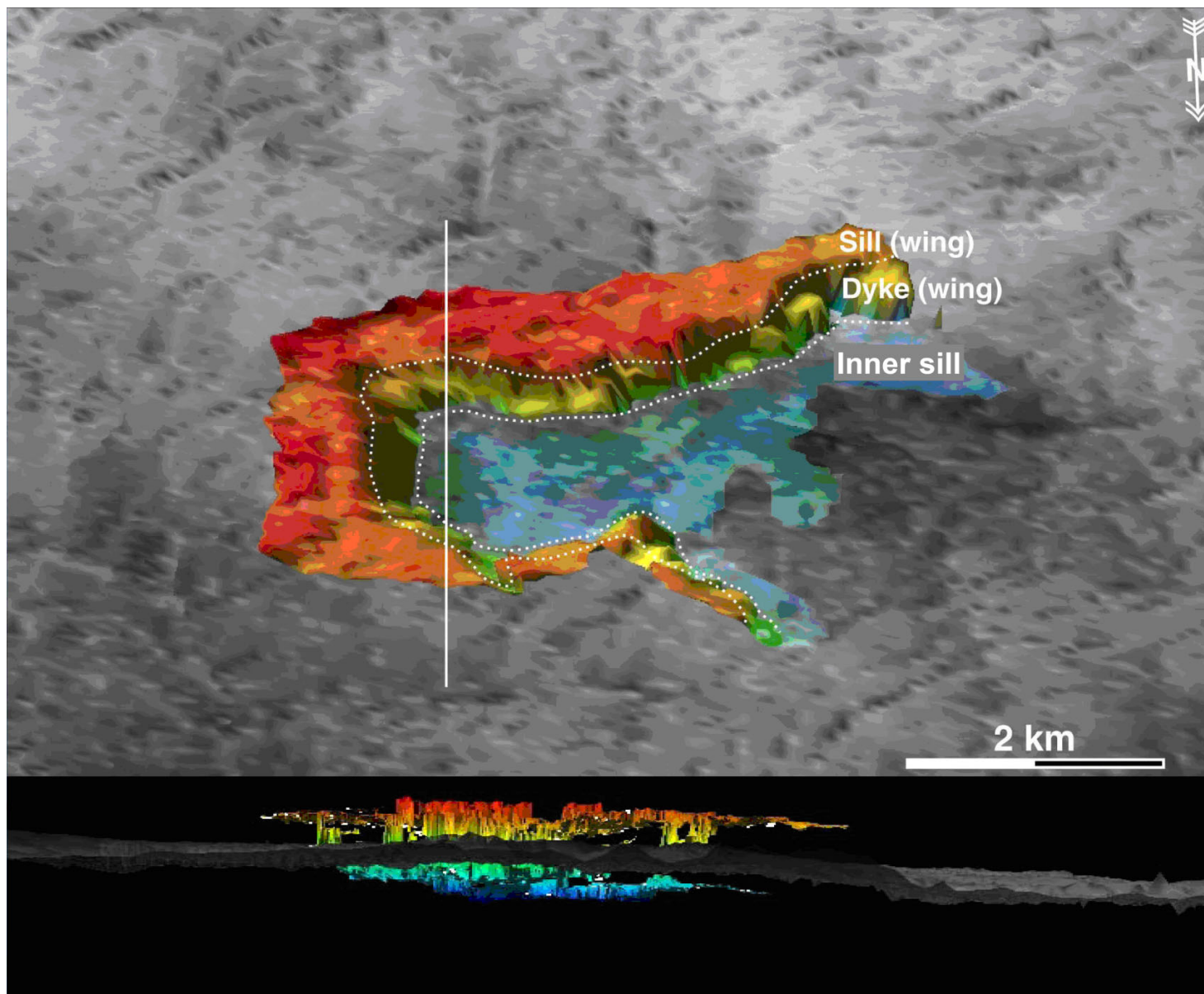


Structural-stratigraphic setting of large-scale sand injectites in the South Viking Graben, North Sea (within yellow-dash outline).





Volund Field, South Viking Graben: Balder sand with marginal 'wings.'



Volund Field: 3D morphology.

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