

Dinantian carbonates

Exploring for synergy between E&P and geothermal

Introduction

The Lower Carboniferous Dinantian carbonates have recently become the target for exploration of both hydrocarbons and hot water in the Netherlands. Evaluation of recent E&P and geothermal wells in Belgium and the Netherlands, combined with seismic mapping (e.g. Hoornveld, 2013 and Boots, 2014) has resulted in a new distribution map of Dinantian carbonates (see Fig 1) and has led to a better insight in the mechanisms and conditions leading to favourable reservoir quality.

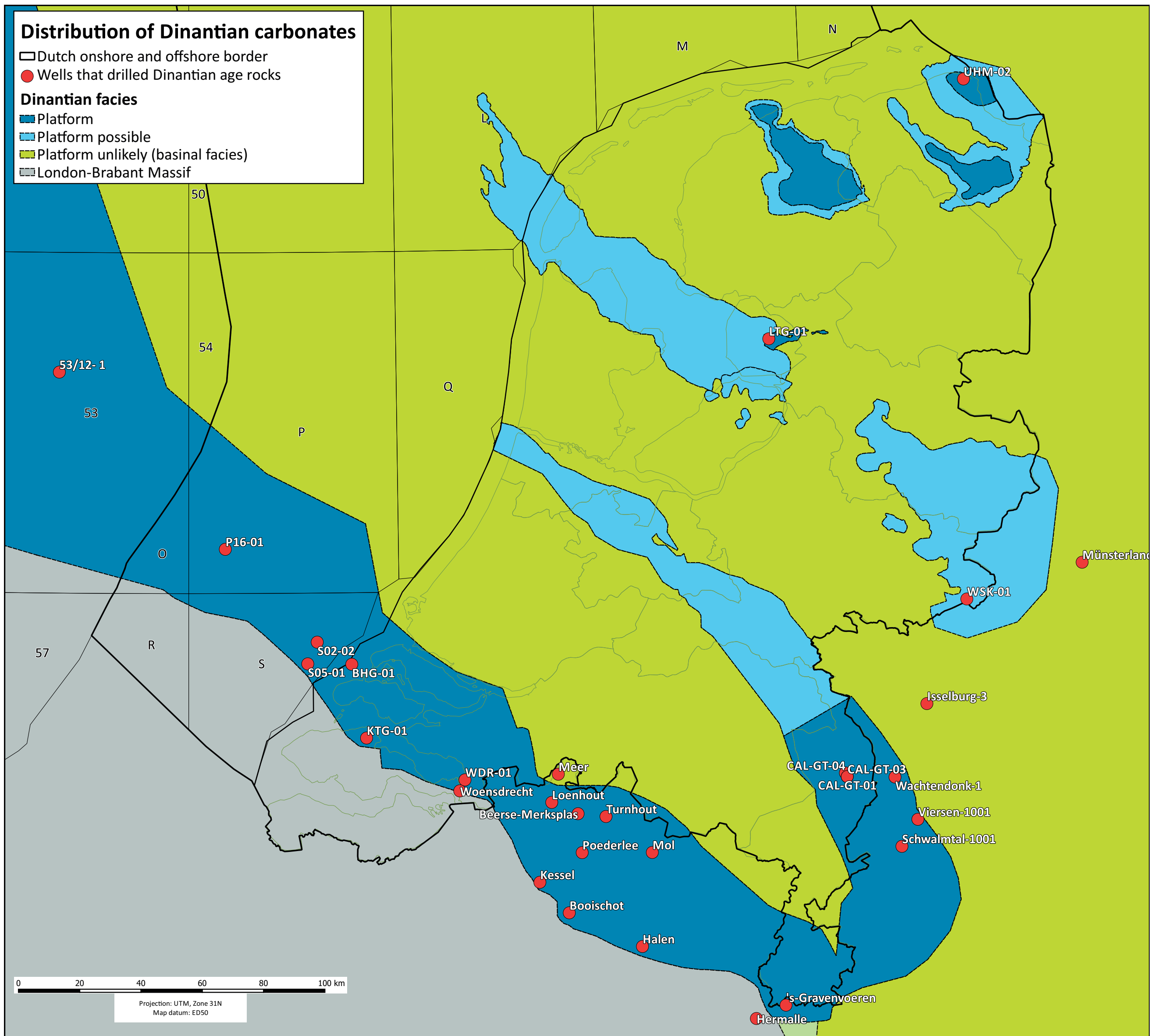


Fig. 1:
Distribution map of the Dinantian carbonates. The dark blue indicates the locations where a carbonate platform is proven by a well and/or where the seismic has clear indications for platform structures. Light blue indicates locations without direct proof of platform facies, but where a local high in the early Carboniferous is expected. (Modified from a TNO report on ultra-deep geothermal energy, Boxem et al, 2016).

Changing views on reservoir quality: From tombstone to cave

The main reason why Dinantian carbonates were under-explored was the misconception that these rocks are always tight. Numerous wells and seismic data, however, show the potential for fractured and karstified (producing) reservoir. UGS wells in Belgium and recent geothermal wells in the Netherlands found highly permeable reservoir (Fig 2).



Fig. 2:
Core with karstified Dinantian carbonate rock from Belgian UGS well.

Prospective targets

- The conceptual diagram in Fig 3 shows the different scenarios for karstification and/or fracturing of Dinantian carbonate reservoir – to be explored for.
- The prospective structures indicated in Fig 3 can be recognized on seismic data (see Figs. 4 & 5).

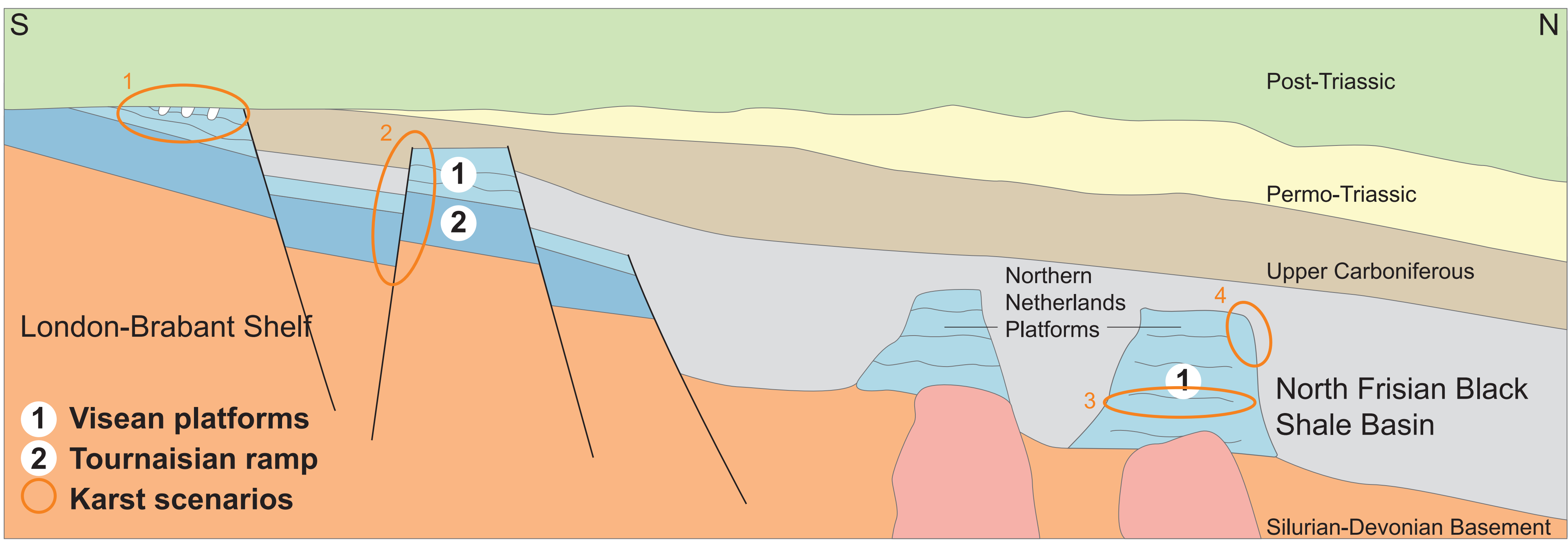


Fig. 3: Locations with a higher chance of karstification are indicated by orange ellipsoids. 1 Meteoric karstification takes place when the rocks are exposed at surface and fresh water flows through faults and fractures. 2 Hydrothermal karstification takes place when hot fluids flow upwards through deep-seated faults. These fault zones will be fractured as well. 3 Intra-platform karstification takes place during sea level low stands in between periods of carbonate platform development. Indications for these 3 scenarios have been found in wells and seismic data in recent studies. 4 Mixed coastal-zone karstification can occur when a carbonate platform is exposed to a mix of fresh and salt water. The edges of the platform will also be more prone to fractures as a result of instability.

Dual target exploration

- In the Dutch offshore P-Quad acreage has been awarded in 2016 to explore for HC's in the Dinantian carbonates.
- There is geothermal potential in onshore Netherlands, as proven by the Californie geothermal projects.
- The exploration for hydrocarbons and geothermal exploration both require reservoir quality carbonates; combining both targets could mitigate the risks; a "dry" E&P well may be operated as a geothermal well in case of sufficient permeability.

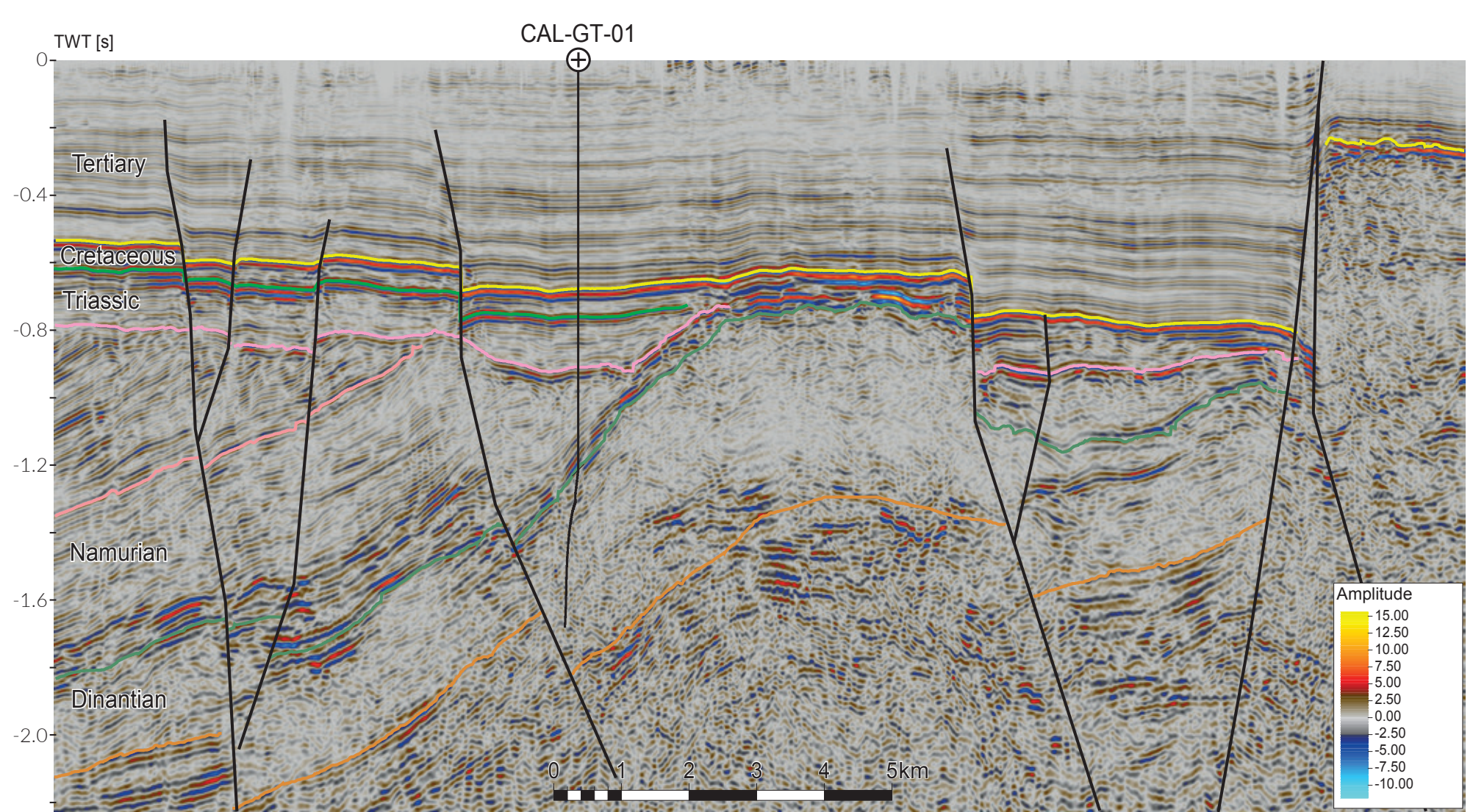


Fig. 4: Seismic line through geothermal well CAL-GT-01. This well encountered a cavity larger than 30 m and produced 240 m3/hr. The seismic shows that the well was drilled into a fault zone. Evaluation of samples indicates that the karstification and dolomitisation were caused by hydrothermal diagenesis (Poty, 2014).

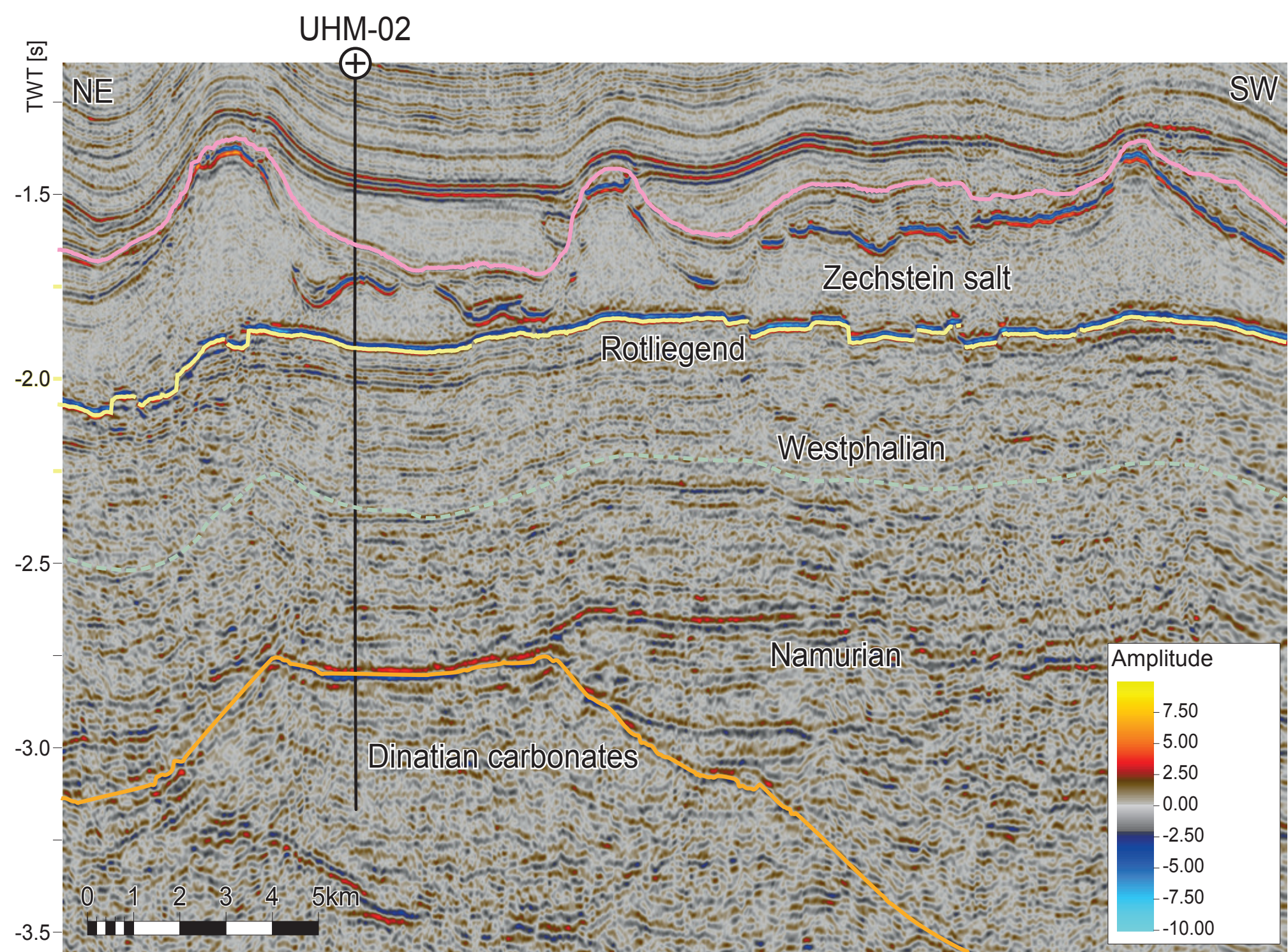


Fig. 5: Example of a Dinantian carbonate platform visible on seismic. The well UHM-02, plotted on the seismic line, was drilled in the middle of the platform encountering a few, thin, karstified zones. More fractured and karstified, hence more permeable, carbonate rock may be found near the edges of the platform.