

Supplementary material for ‘The genesis of a giant mud canopy by catastrophic failure of a thick evaporite sealing layer’

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SEISMIC DATA

The 3D seismic data used in this study is pre-stack time migrated and processed to a zero phase wavelet. It is displayed with a polarity whereby acoustically hard reflections (increase in acoustic impedance downwards) appears as a positive amplitude. The bin spacing is 12.5 m, yielding a lateral resolution of 25 m. The dominant frequency is 50 Hz in the Pliocene to Recent Unit. The average p-wave velocity of the Pliocene to Recent unit is 1900 m/s, calculated from the TWT seismic data and depth data from the Kg45 and La52 wells. The vertical resolution, typically defined as a quarter wavelength (Brown, 2011) is 10 m. The average p-wave velocity through the mud canopy as recorded from the Kg45 well is 2250 m/s and was used for depth conversion of its upper and basal surface and volumetric computation. The areal extent and volume of the mud canopy is recorded here as >740 km² and c. 292 km³, however, these measurements are restricted by the marginal limits of the 3D seismic cube. The data and all key horizons were mapped using Schlumberger Petrel software.

DATING KEY STRATIGRAPHY

Foraminifera were examined from ditch cutting samples and partly seven Side Wall Cores from Kg 45-1B well. Calcareous nannofossil analysis was carried out on ditch cutting samples with a sample spacing varying from 5-10 m. The international Biostratigraphic scheme in Gradstein et al. (2012) was used for the biostratigraphic calibration. The below depth measurements are recorded as mbdf (meters below drill floor) with a DF-MSL (Drill floor – Mean Sea Level) of 38.35 m.

Calibration of the mud canopy and its overburden

The Late Miocene is dated at 3510 m by the occurrence of *Globorotalia menardii* and *Turborotalia acostaensis*, and at 3515 m by the occurrence of *Orbulina universa*, *Orbulina suturalis*, *Orbulina bilobata*, *Globigerinoides obliquus*, *Globigerinoides extremus*, *Globigerinoides trilobus*, *Globigerinoides sacculifer*. These planktonic foraminifera are diagnostic of biozone SN16 that correlates with the Tortonian.

The interval 3475 m – 3495 m is characterised by the first downhole appearance of the marker taxon *Triquetrorhabdulus rugosus* and *Helicosphaera pacifica*, which defines the top of subzone NN11b of the Late Miocene, lower Messinian. The interval 3505 m – 3525 m is characterised by the first downhole appearance of the marker taxon *Discoaster loeblichii*, which defined the top of subzone NN11a. The interval 3545 – 3610 m is characterised the first appearance of *Discoaster bollii*, which defines the top of biozone NN10. The zones of NN11a and NN10 are

diagnostic of sediments that are Late Miocene, Tortonian. The lithology of the mud canopy sampled at 3510 m is described in the well report as:

- Shale - medium grey, greenish grey, soft and very sticky, sub-blocky to blocky, moderately calcareous at top, locally slightly silty, rarely pyritic.

The unit directly overlying the mud canopy at the interval 3440-3460 m is characterised by the first downhill appearance of the marker taxon *Sphernolithus verensis*, which defines the top of zone NN13. The top occurrence of formaminifera including *Globorotalia margaritae* and *Globigerinoides obliquus* at 3355 m and *Globigerina nepenthes* at 3435 m define biozone SN20. These calcareous nannofossils and foraminifera define the sediments that buried the mud canopy as deposited during the lower Pliocene.

Calibration of the Messinian salt and its overburden

No Messinian salt was recovered in the Kg45 well. The La52 well in contrast encountered Messinian salt but TDs at 4565 m before encountering any nannofossils or foraminifera indicative of Tortonian sediments. The interval of 3770-4355 m is mostly barren to non-diagnostic. However, the first downhole appearance of the marker taxon *Triquetrorhabdulus rugosus* and *Reticulofenestra rotaria* define the top of subzone NN11b of the Late Miocene, Messinian age. The overlying interval 3630-3770 m is characterised by the top occurrence of *Globorotalia margaritae* and *Globigerinoides obliquus* at 3630m, *Globigerina nepenthes* at 3700 m and *Sphaeroidinellopsis* at 3740 m, which define the Early Pliocene biozones of SN19b,

SN19a and SN18 respectively. The first downhole appearance of the marker taxon *Sphenolithus verensis* in the interval 3600-3680 defines the top of zone NN13, also of the lower Pliocene.

SUPPLEMENTARY FIGURES AND CAPTIONS

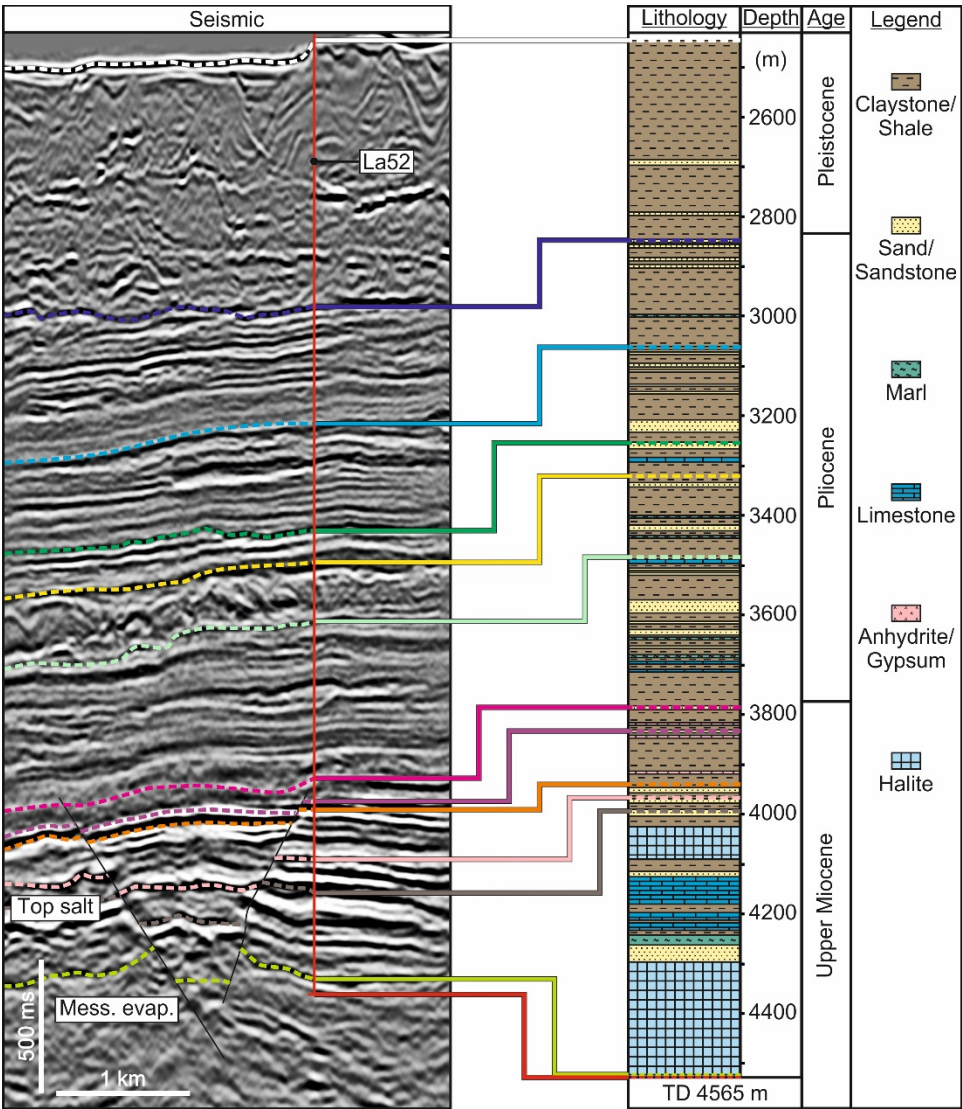


Figure S1. Well to seismic tie from La52 (see Fig. 1A for location) that TDs in the Messinian evaporites (Mess. Evap.). The well calibrates top salt (top of the halite dominated sequence) and the overlying Pliocene-recent succession in the study area. No Tortonian sediments were intersected.

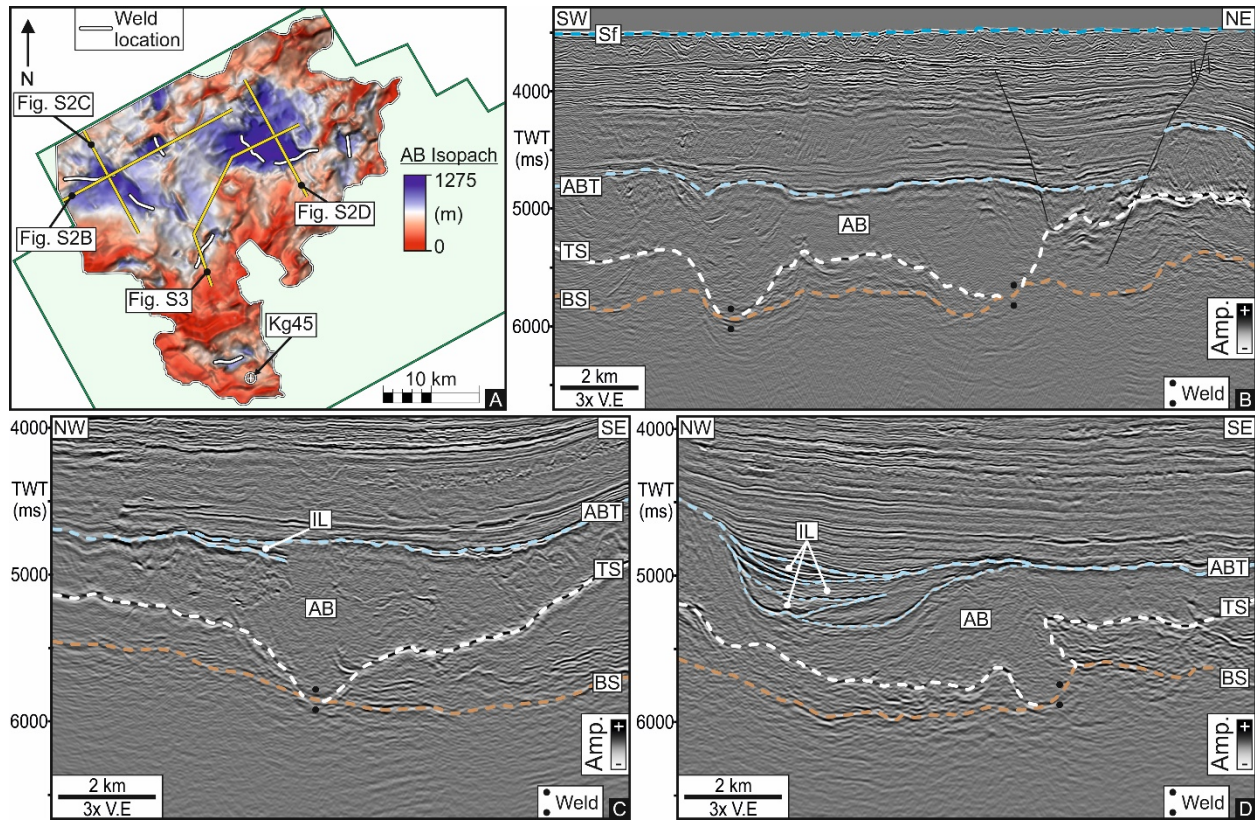


Figure S2. Welds and interdigitating lenses. A: An isopach map of the allochthonous body (modified from Fig. 2C), showing the location of welds, the Kg45 well and the lines of section for Figs. S2B-D. B: A seismic profile showing two welds (W) between the base of the allochthonous body (AB) at top salt (TS) and the base salt (BS). The thickness of the allochthonous body increases directly above each weld. Sf – Seafloor; ABT – Allochthonous body top. C: A seismic profile showing an increase in thickness of the AB and thinning of the Messinian evaporites toward a weld and an interdigitating lens (IL) at the ABT directly above the weld. D: A seismic profile showing a weld between the base of the allochthonous body and the base salt, as well as several interdigitating mud lenses overlying the ABT that formed during later extrusive episodes.

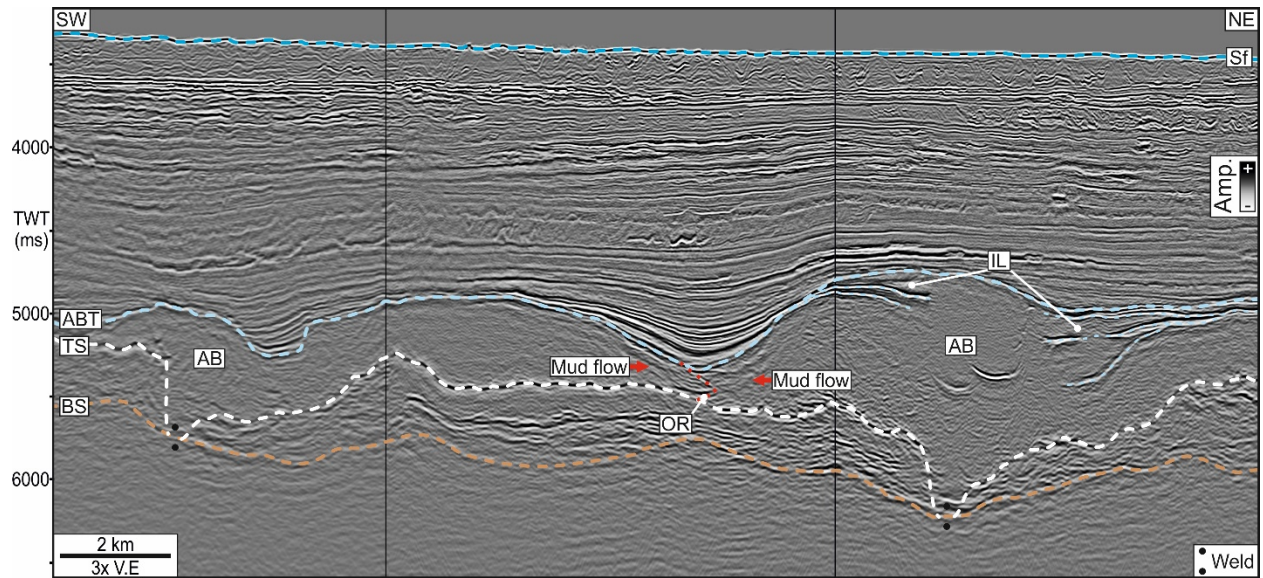


Figure S3. Coalescing flows. Two mud flows, each with a weld (W) where the base of the allochthonous body (AB) located at the top salt (TS) and the base salt (BS) are connected. The convergence of the two flows is highlighted by an oblique reflection (OR). Both mud flows thin towards the OR. IL – Interdigitating lenses.

REFERENCES

Brown, A. R., 2011, Interpretation of three-dimensional seismic data, Society of Exploration Geophysicists and American Association of Petroleum Geologists, 665 p.

Gradstein, F. M., Ogg, J. G., Schmitz, M., and Ogg, G., 2012, The geologic time scale 2012, elsevier.