Marine Magnetotellurics (MMT)

Stewart K. Sandberg
WesternGeco EM

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WesternGeco

Seafloor Environment

Seawater is a conductor

Acts as a low-pass filter for fluctuating EM fields generated above it in the ionosphere and magnetosphere. Little power is present at the seafloor at frequencies above a fraction of a hertz in water greater than a few hundred meters.

Contamination of signal by man-made or cultural sources is substantially reduced by the seawater layer.

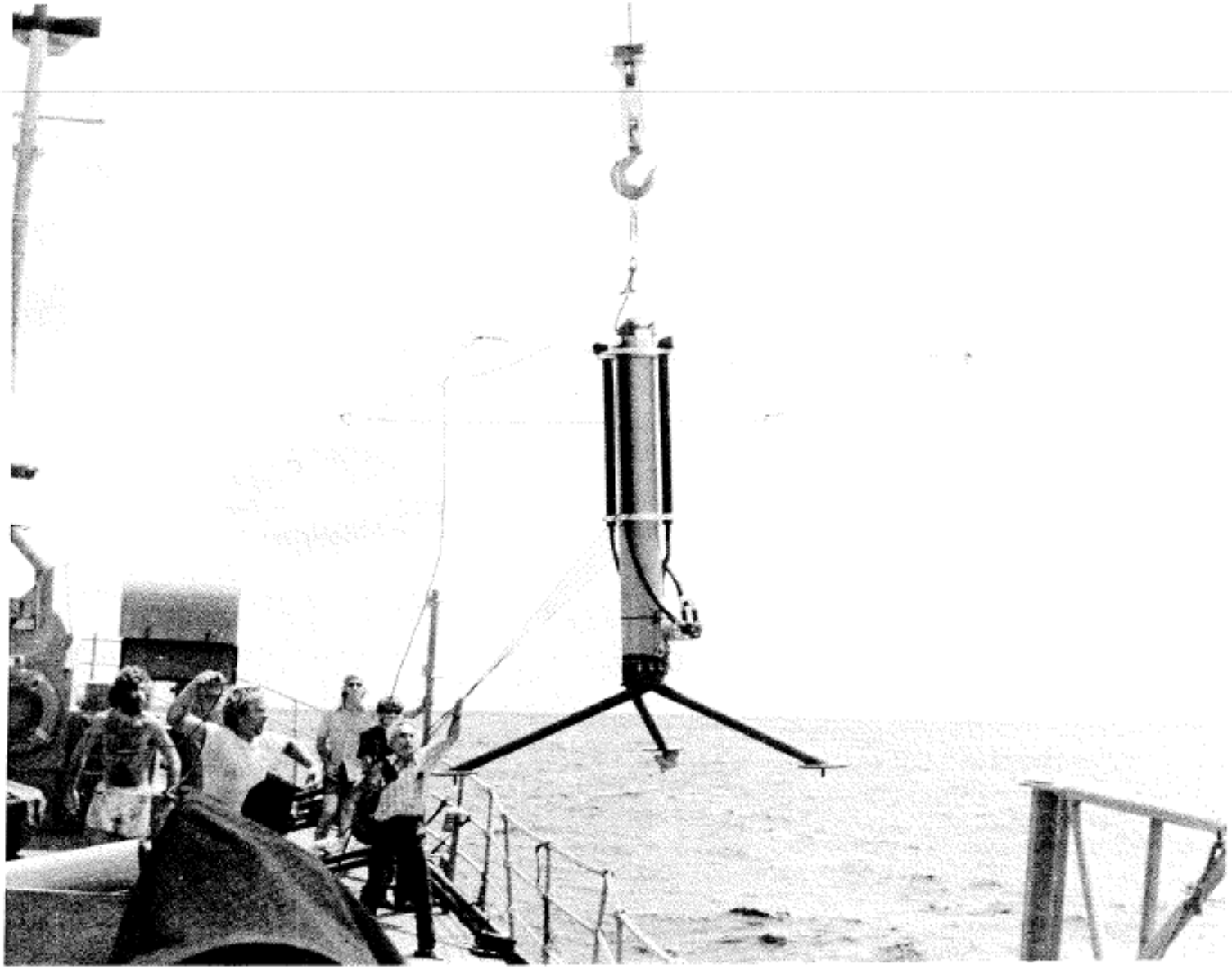
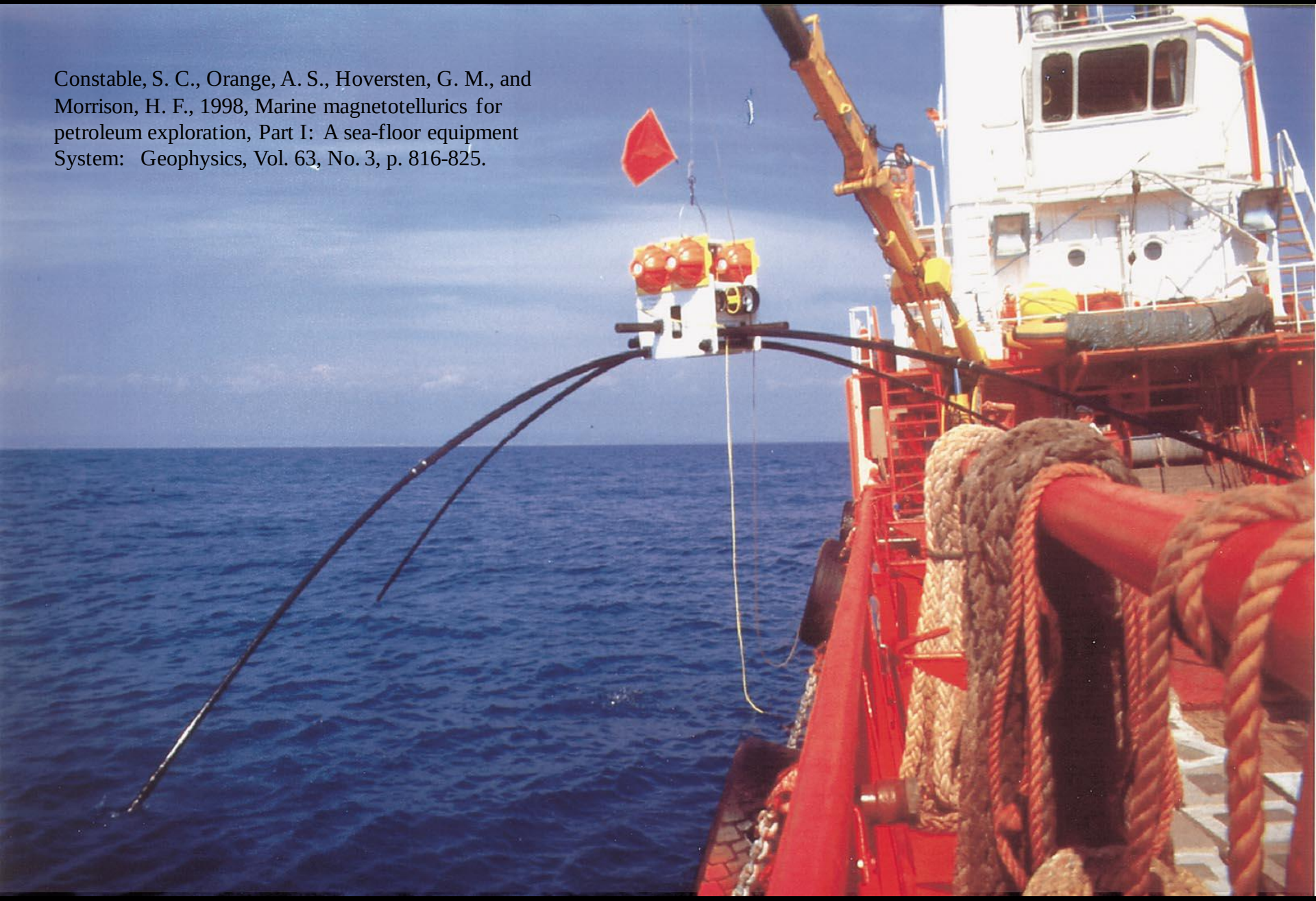


Fig. 3. A short span electric field instrument being deployed from the *R/V Alexander Agassiz* in 1976. The aluminum pressure case houses the recording electronics, while the four horizontal arms are salt bridges that connect Ag-AgCl electrodes, located on the water chopper near the base of the pressure case, to the ocean. The tripod anchor is released under timer control, and the remainder of the instrument returns to the surface under slight positive buoyancy.

“It is unlikely that MT sounding will ever be useful for marine geophysical exploration purposes, except possibly for delineating regional (as opposed to small-scale) geological structure on the continental shelves.”

Chave, A. D., Constable, S. C., and Edwards, R. N., **1991**, Electrical methods for the seafloor: in Nabighian, M. N., Ed., Electromagnetic methods in applied geophysics, Vol. 2, Soc. Expl. Geophys., p. 938.



Constable, S. C., Orange, A. S., Hoversten, G. M., and Morrison, H. F., 1998, Marine magnetotellurics for petroleum exploration, Part I: A sea-floor equipment System: Geophysics, Vol. 63, No. 3, p. 816-825.

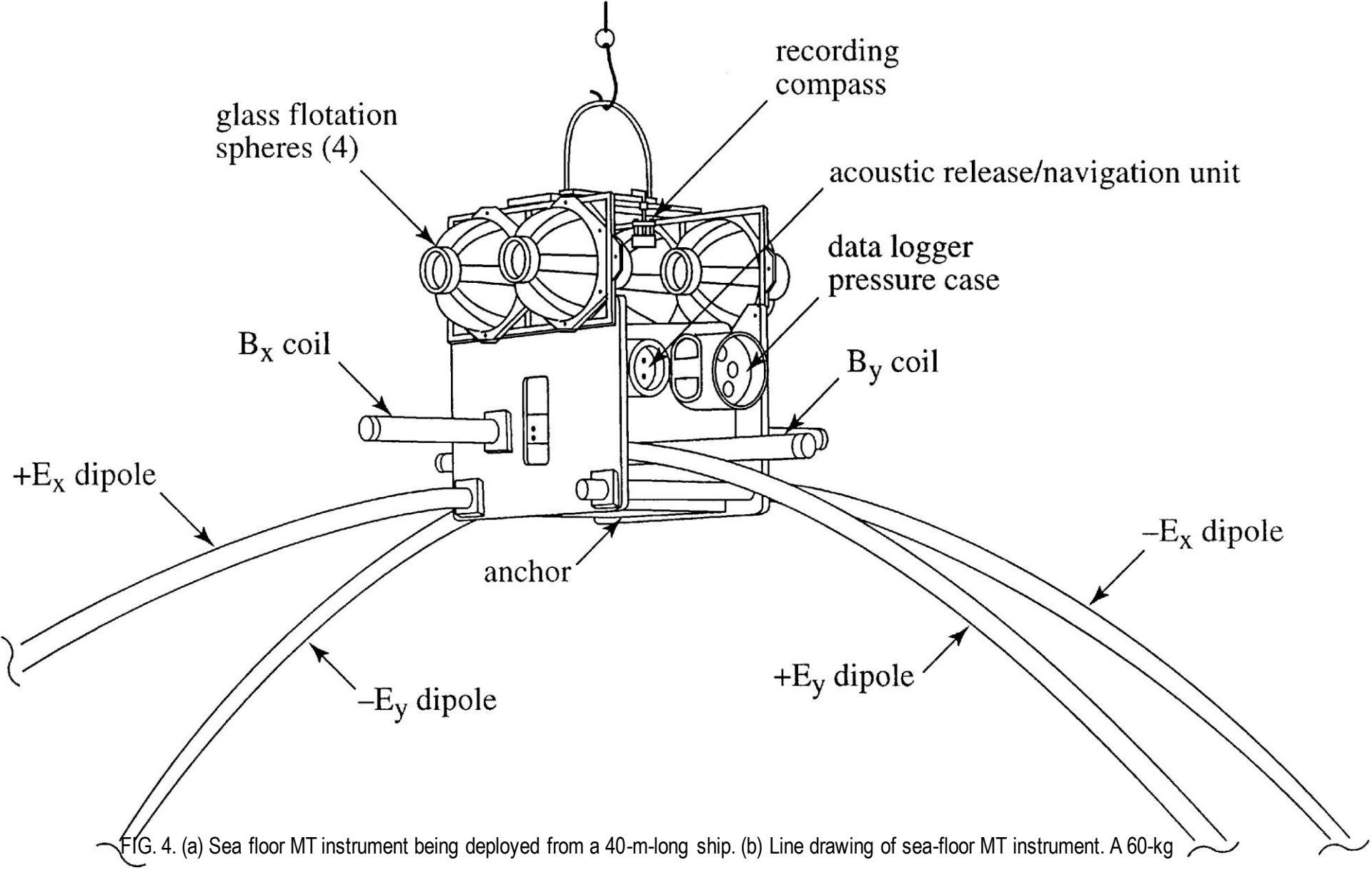
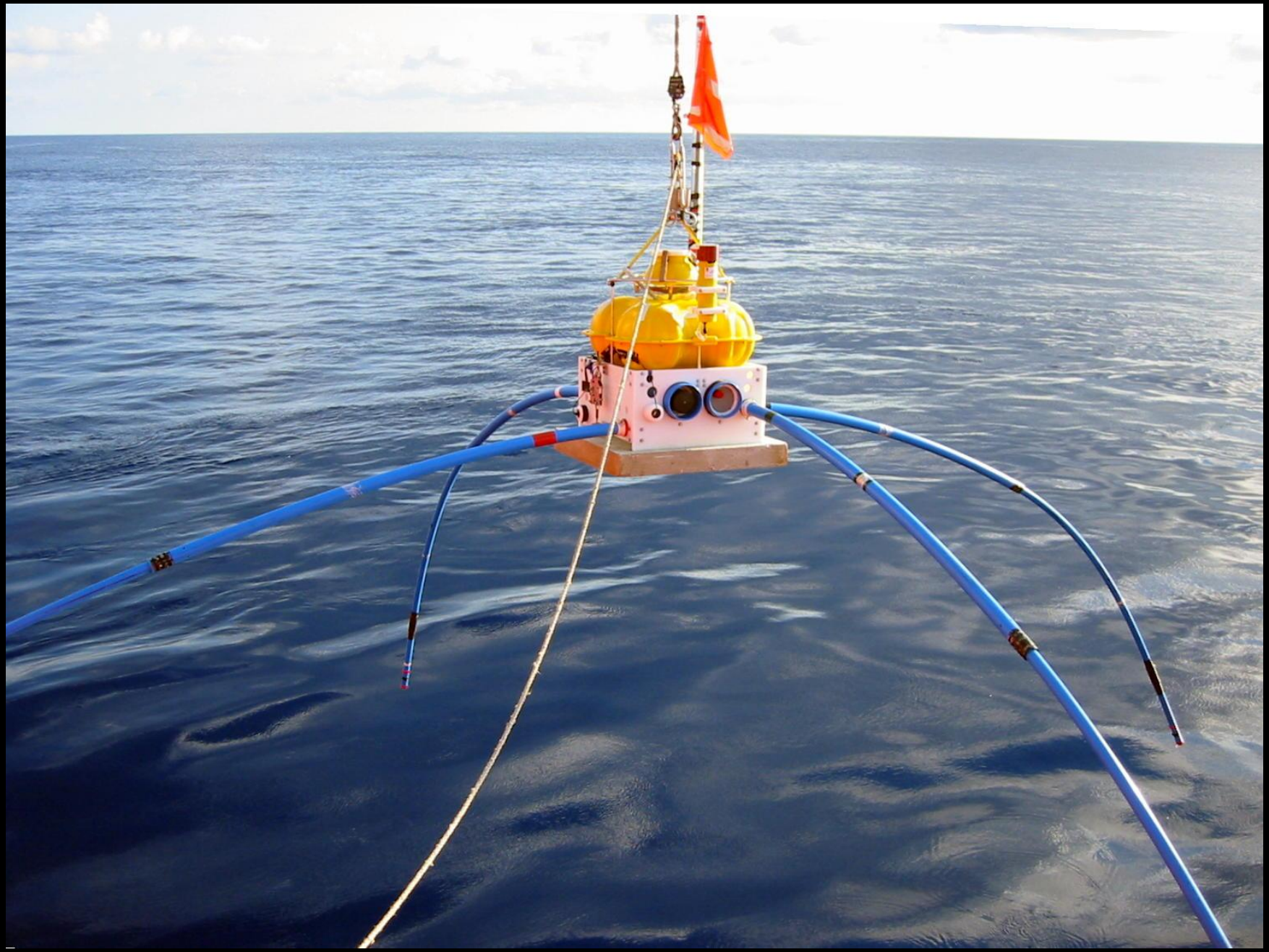
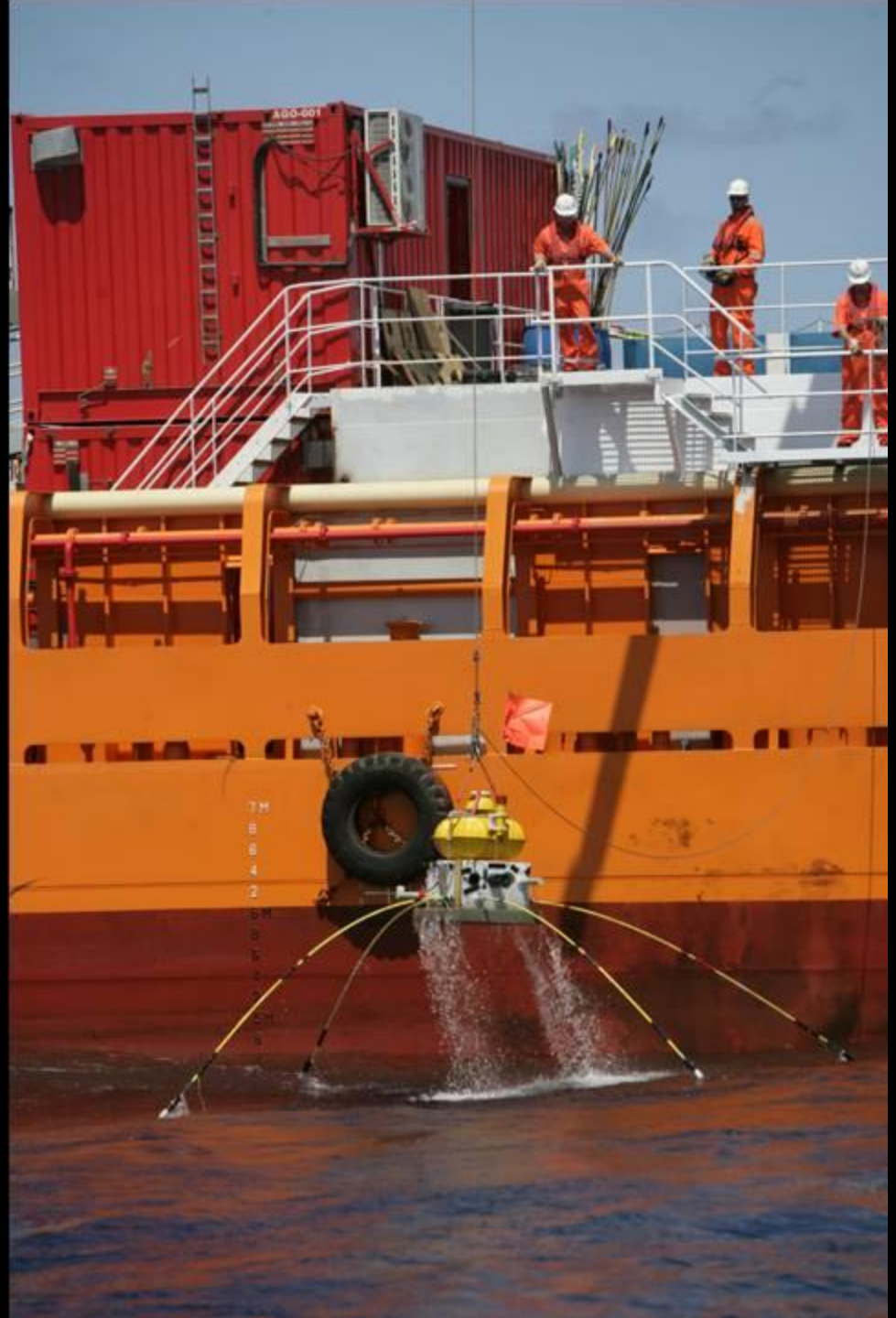


FIG. 4. (a) Sea floor MT instrument being deployed from a 40-m-long ship. (b) Line drawing of sea-floor MT instrument. A 60-kg concrete anchor held beneath the center of the package sinks the device to the sea floor. The anchor is released by the acoustic unit on receipt of a command code, and the device rises to the surface with the help of the glass flotation spheres. The electric dipole arms are 5-m lengths of 5-cm-diameter polypropylene pipes terminated with silver–silver chloride electrodes. Dipole cables run along the insides of the tubing.

MMT Receiver
Offshore Faeroe
Islands





Receiver-Handling Operations

ABAS

IT SWL 13M-10M

MMT Hydrocarbon Exploration Applications

Sub-salt exploration

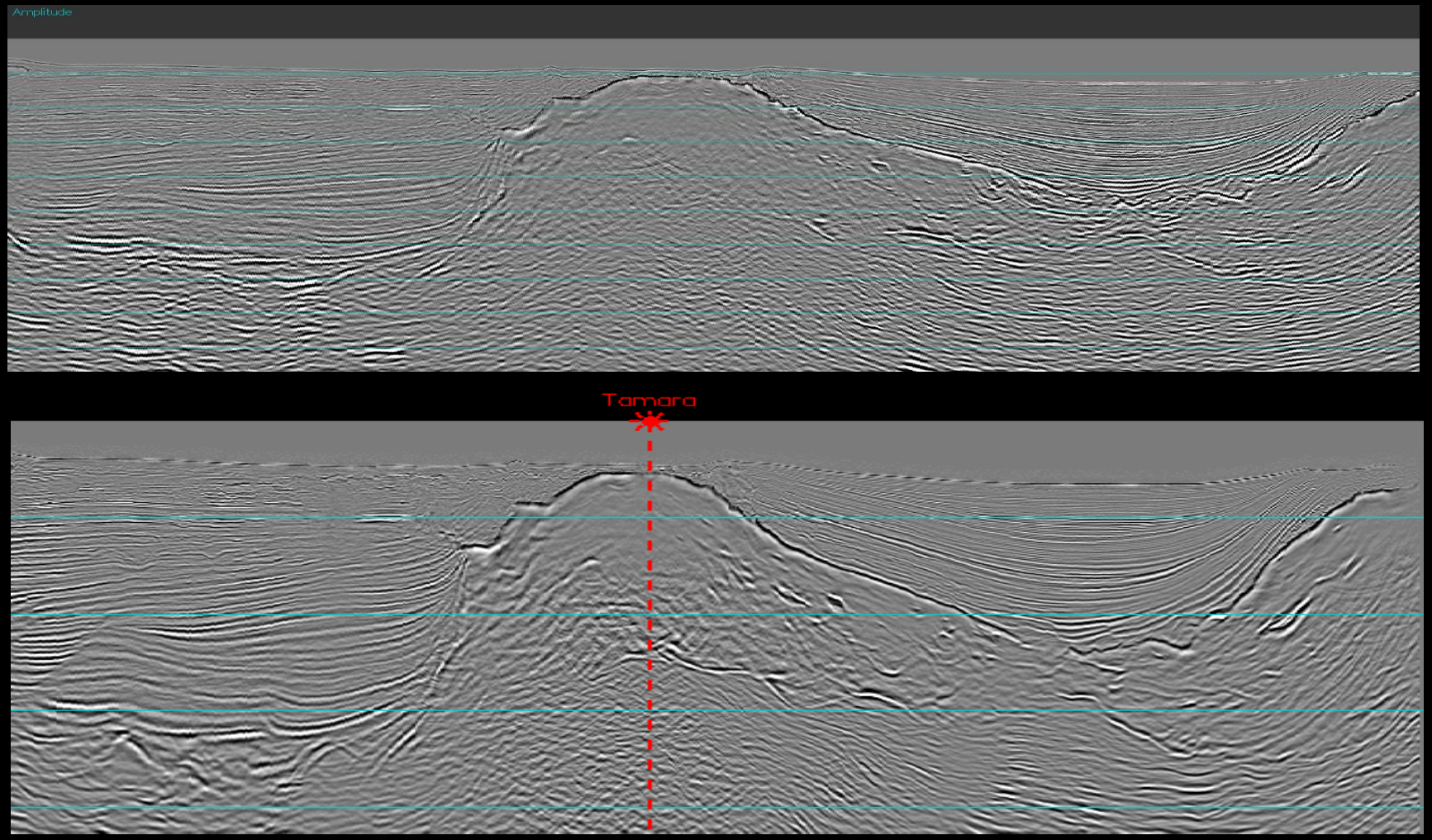
Mapping thickness and extent of volcanics

Mapping thickness of carbonates

Case Study:

Subsalt Imaging – Gulf of Mexico MMCI

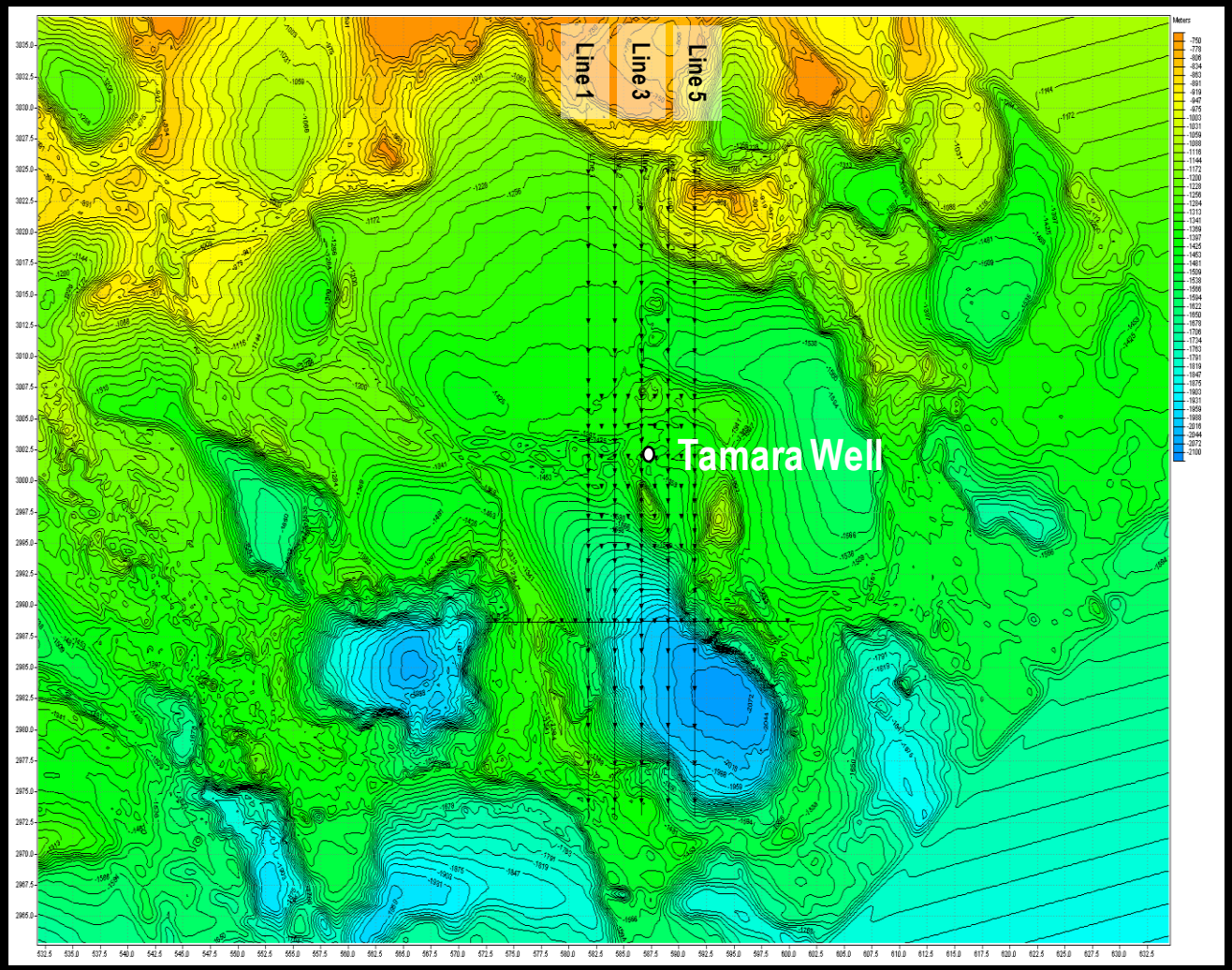
Original Motivation



Bathymetry Map with MMT Stations and Lines

171 Sites

Q4 2006 Acquisition



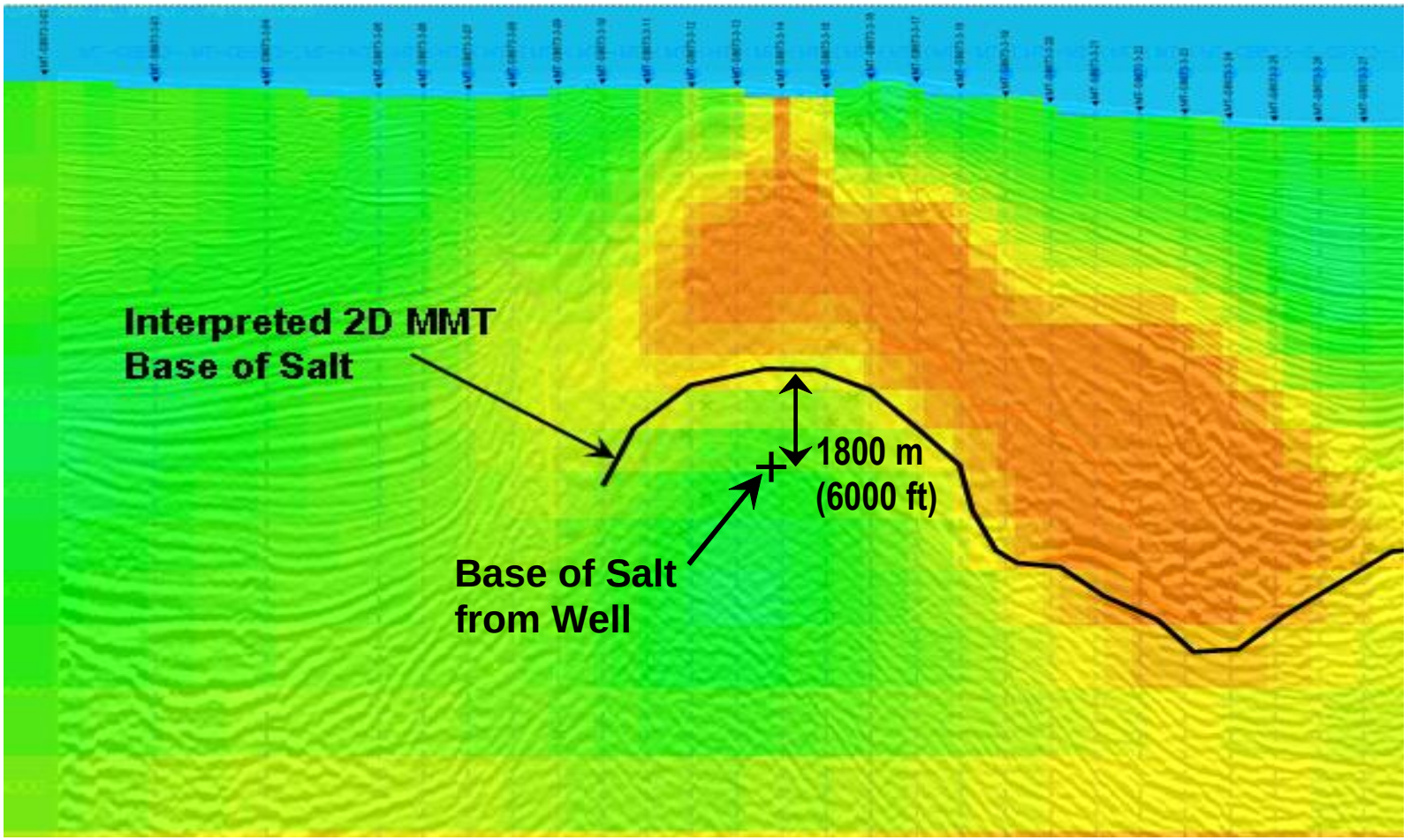
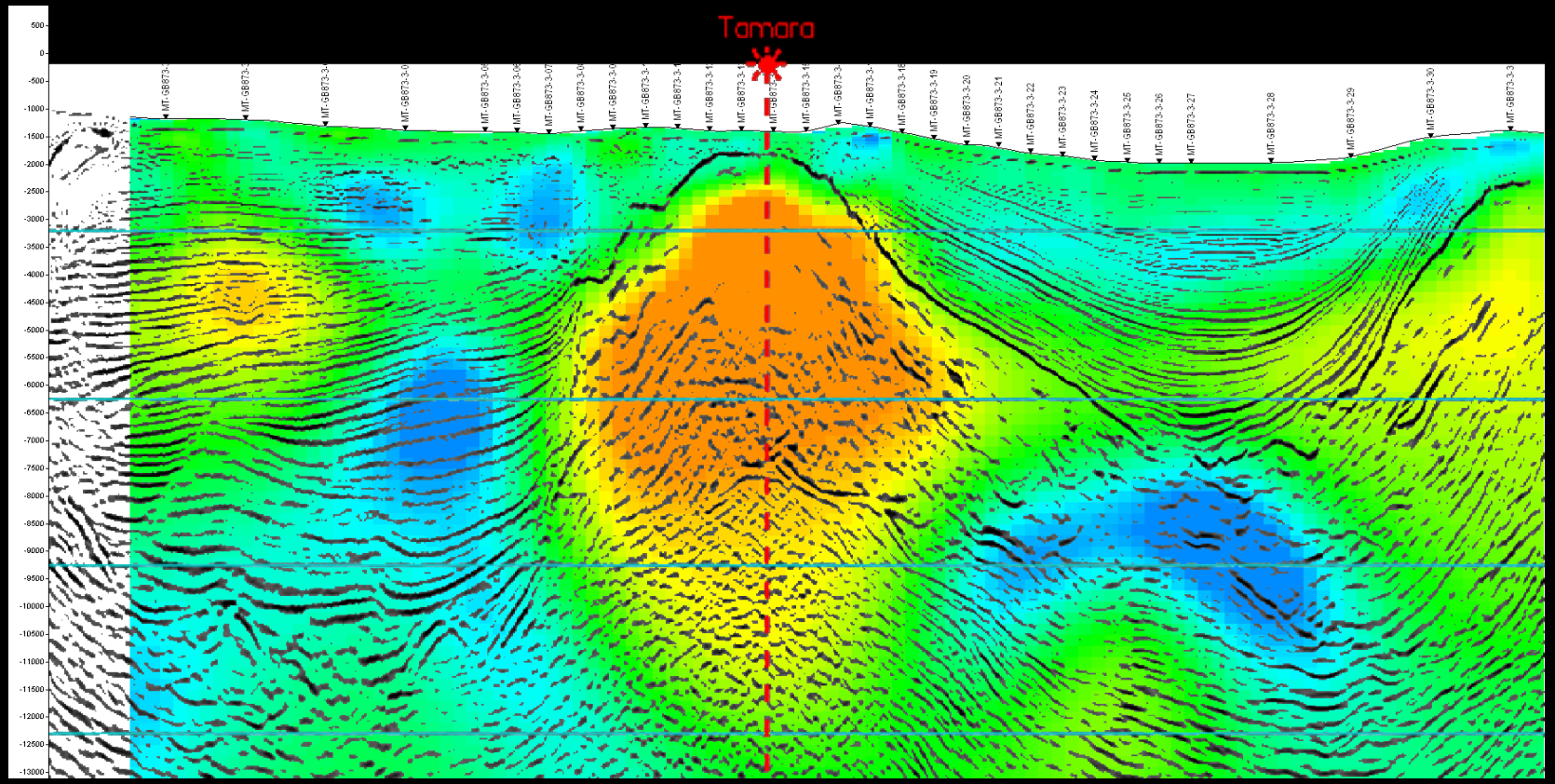
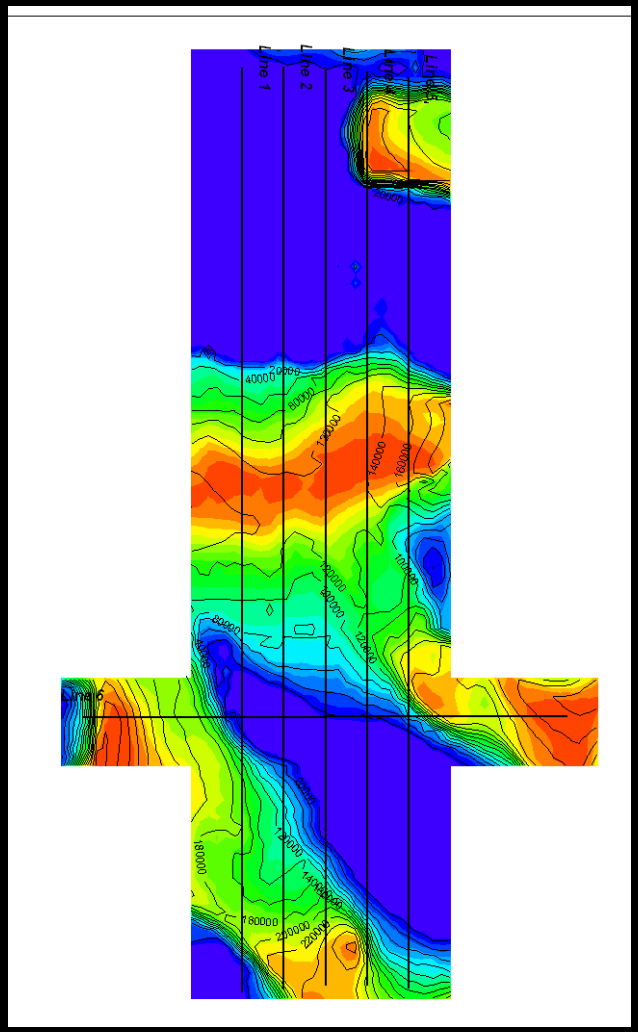


Figure 3. The 2D smooth (pixel-based) inversion result for Line 3 TM mode data. Initial guess was 5 ohm-m salt body based upon seismic interpretation. NRMS = 1.41, color scale treats model values > 5 ohm-m as dark orange, and interpreted base of salt is based on 5 ohm-m isoresistivity. Background is conventional seismic image.

Line 3 – MMT and WAZ Seismic



Transverse Resistance – 16000 feet depth



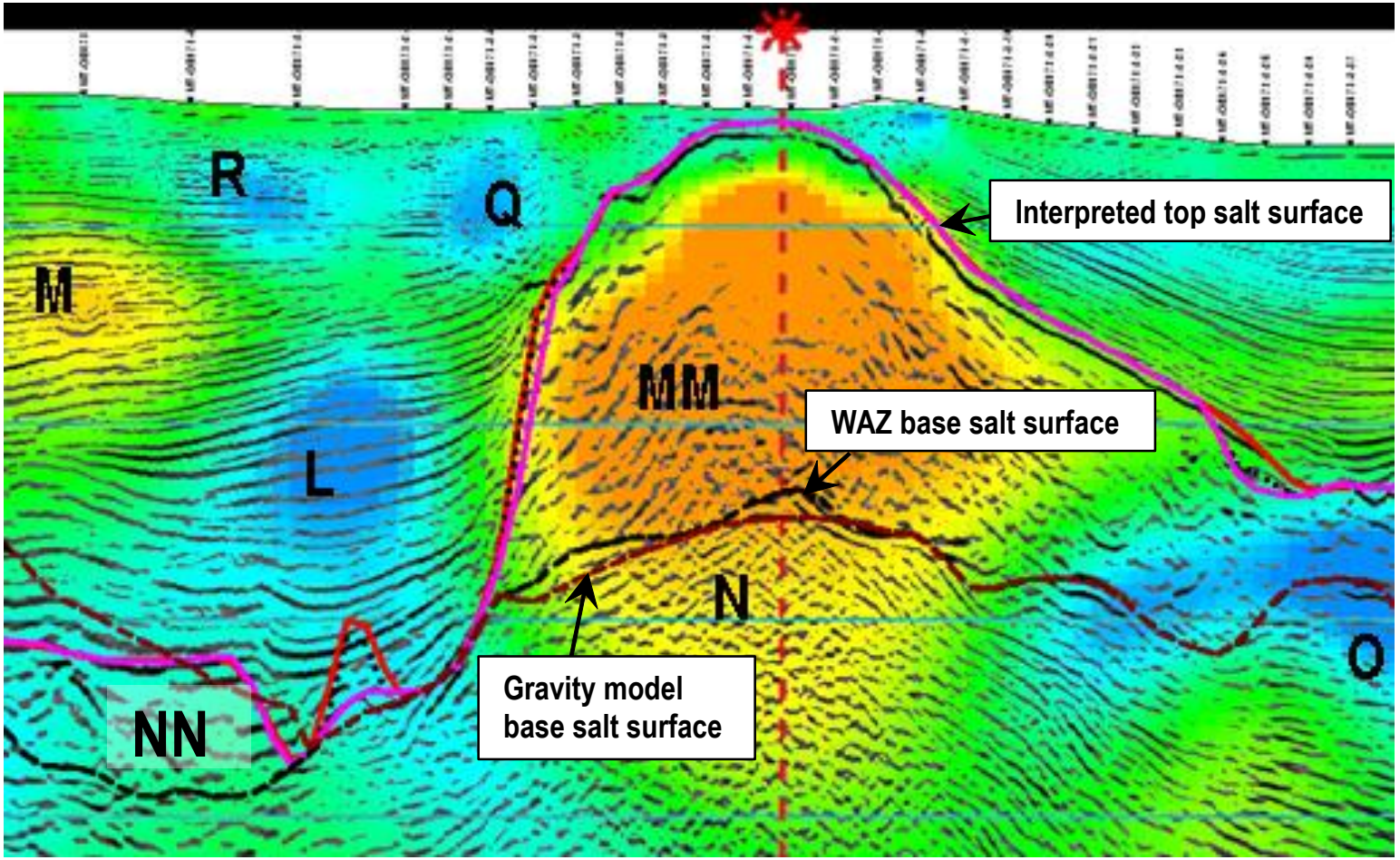
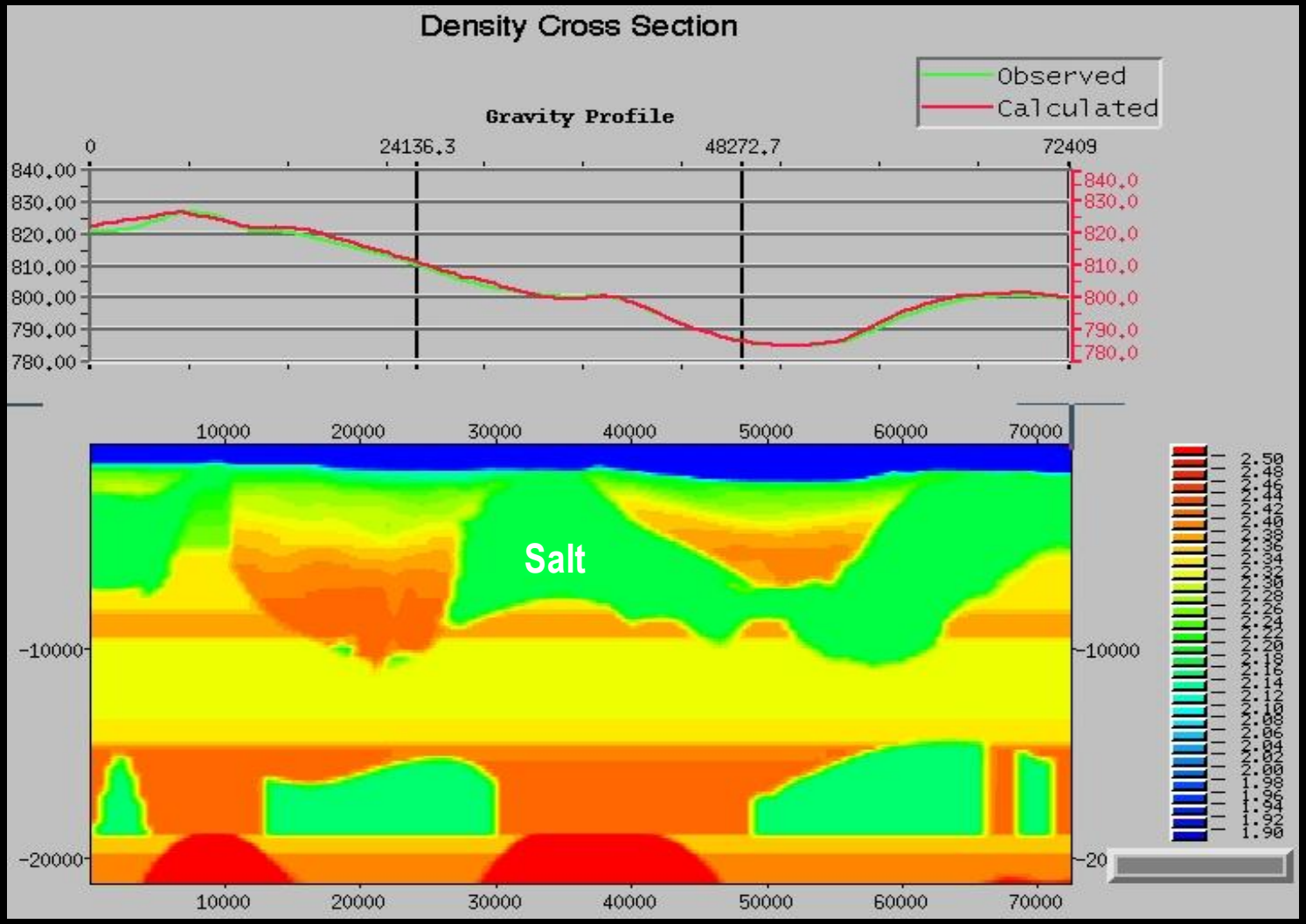
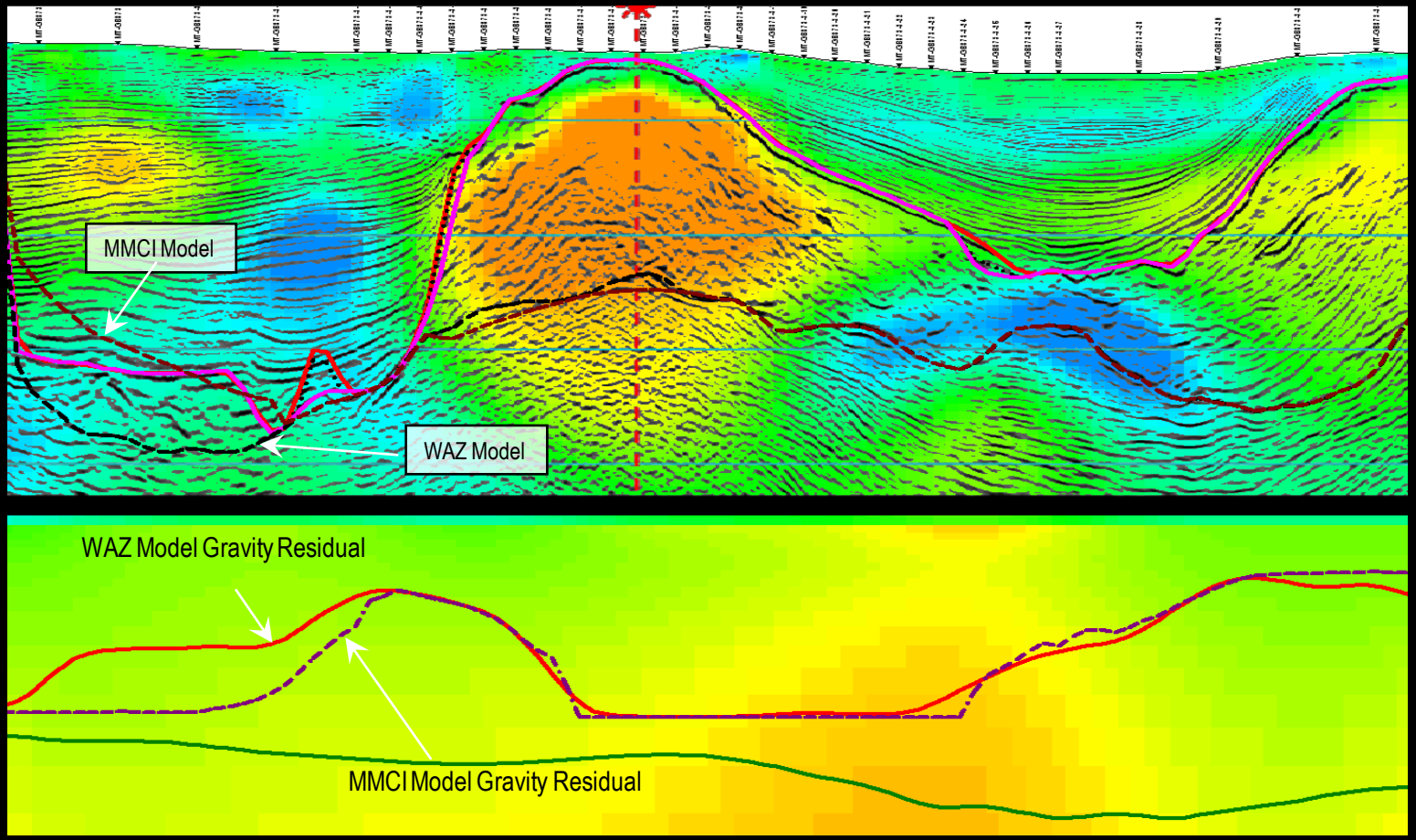


Figure 5. The 3D smooth (pixel-based) inversion model cut along Line 3. Initial guess was a 1.2 ohm-m half-space. Color scale treats model values >23 ohm-m as dark orange, light blue is 1 ohm-m and dark blue is less than 0.5 ohm-m. Interpreted interfaces are labeled. Background is WAZ seismic image.

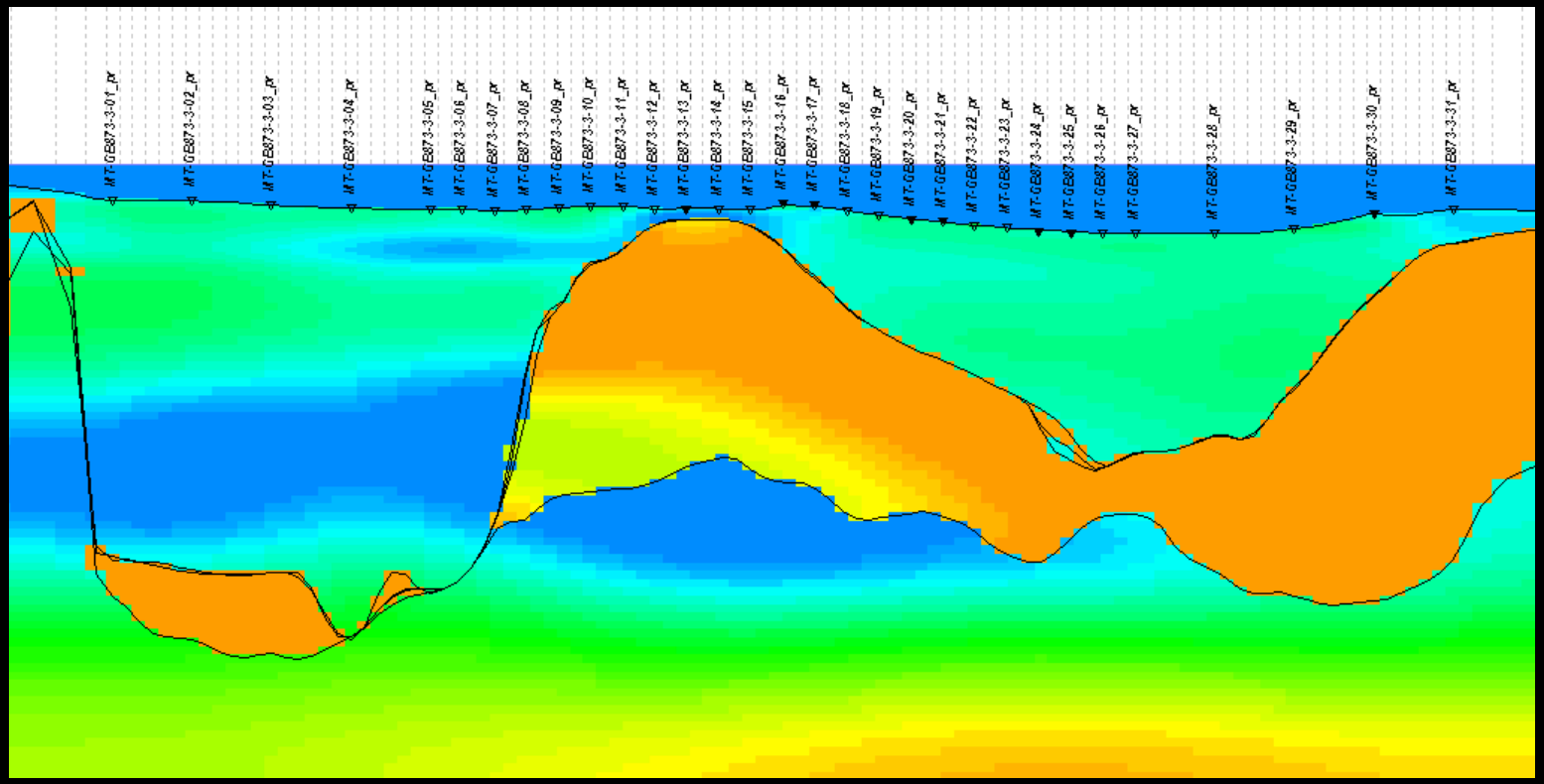
Line 3 – Gravity Model



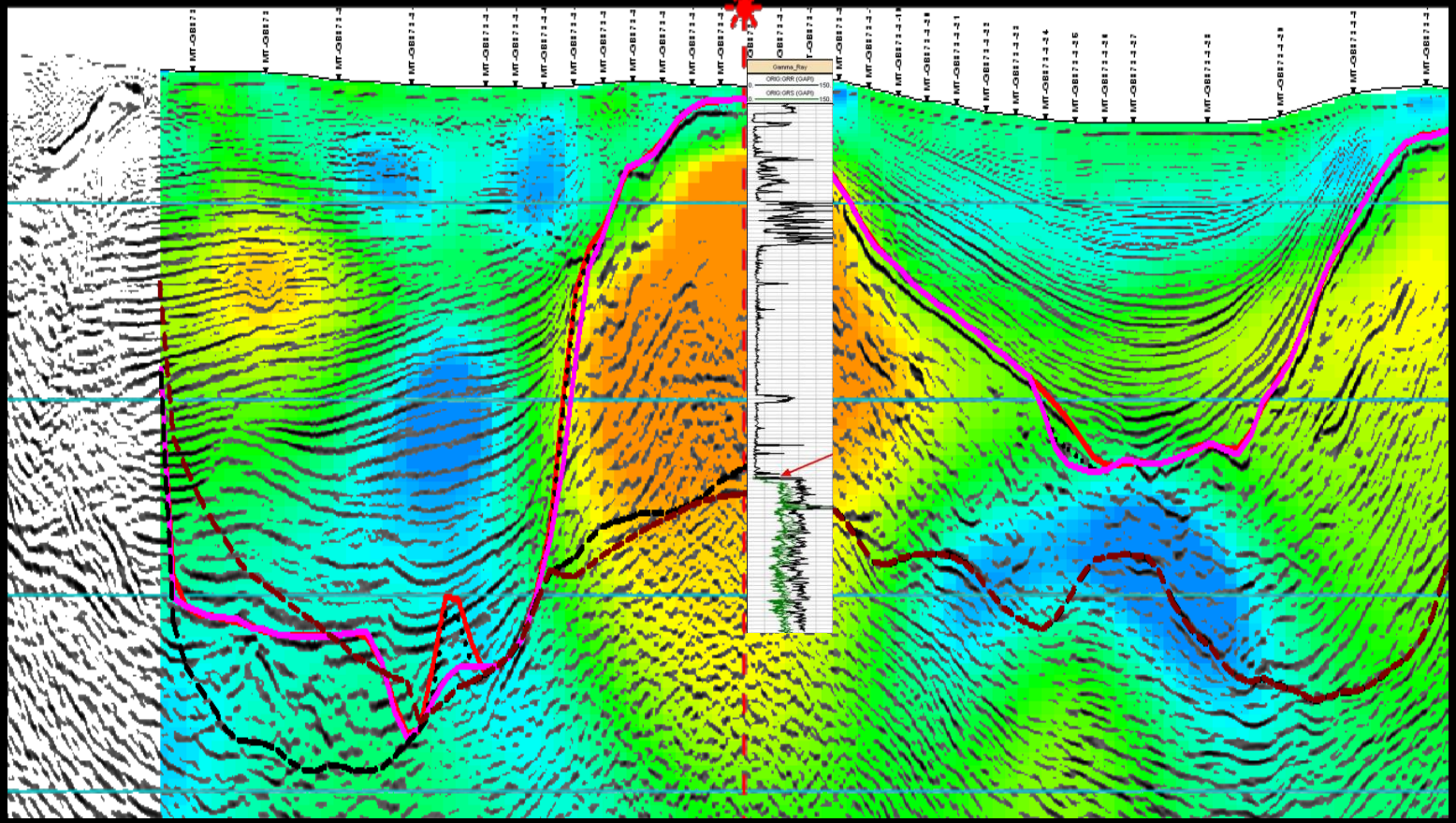
Line 3 – MMT and Gravity on WAZ Seismic



Line 3 – A Priori Inversion with WAZ Interfaces

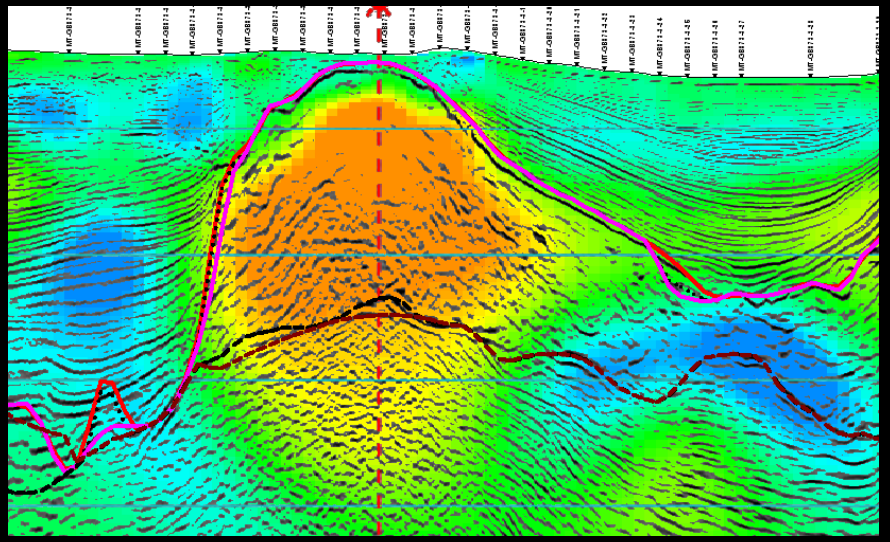


Line 3 – Summary of Interpretation

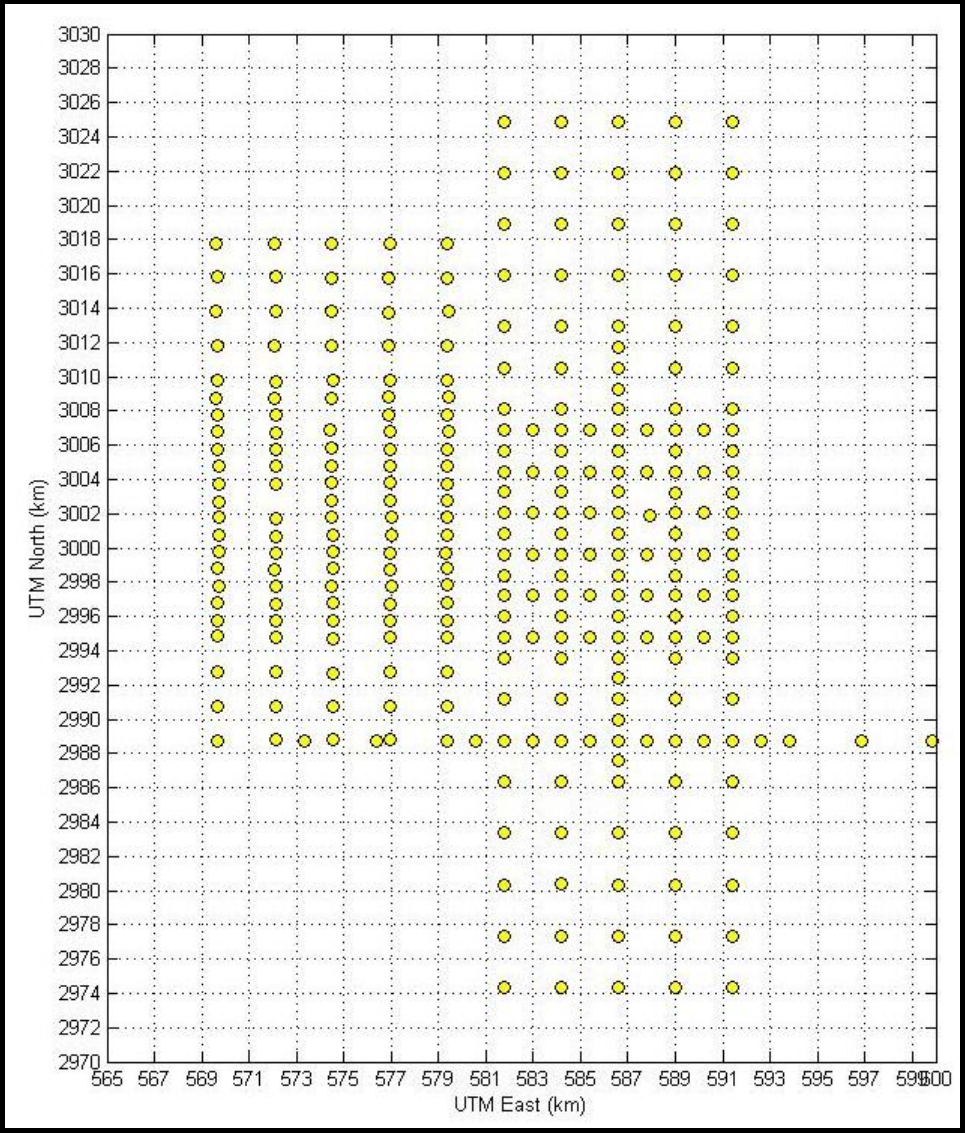


Line 3 – Summary

- All three measurements agree; there is a high degree of confidence in the WAZ salt geometry over the main salt body
- MMCI suggests overpressure/low velocity zones that may effect the velocity model outside the salt



MMT sites of Phase 1B



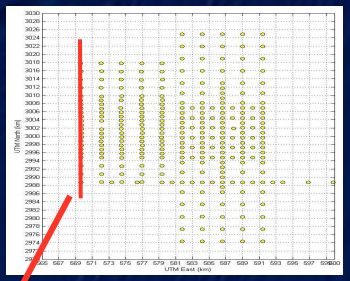
Inversion Parameters:

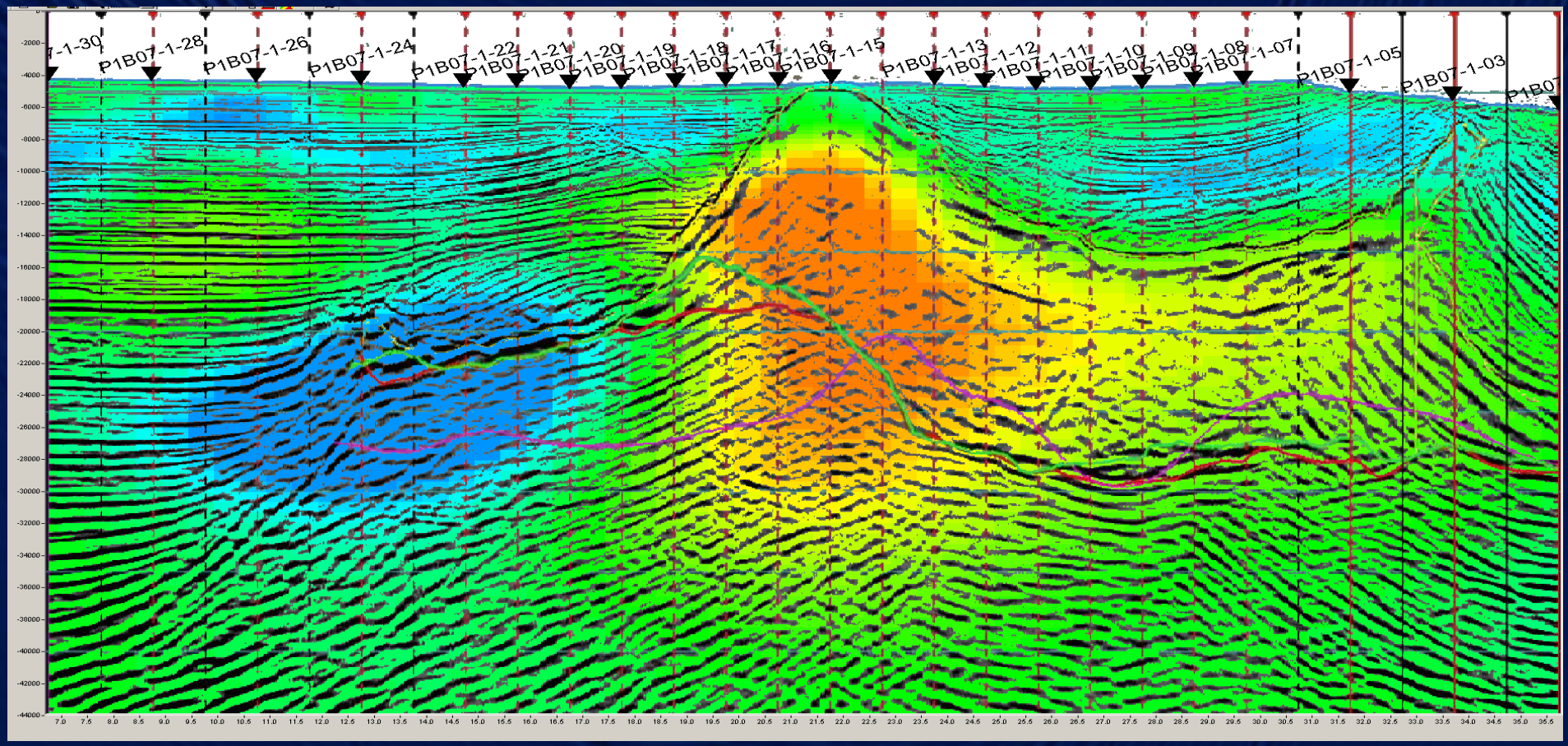
-Model mesh: 80*119*135

-Starting model: 2.0 Ωm background resistivity

-Free inversion: no parameters constrained

P1B Line 1

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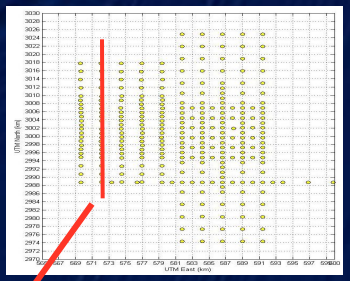
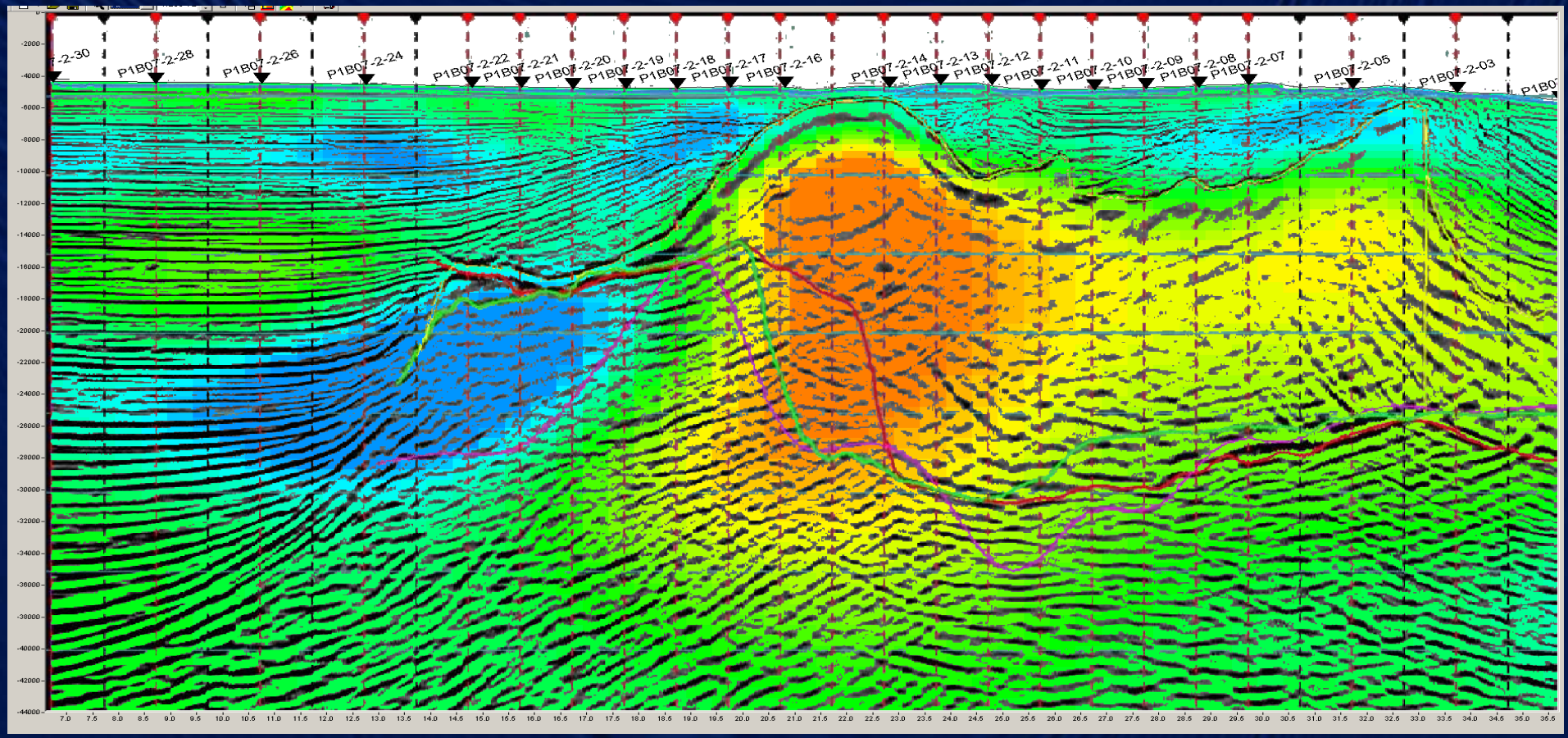
P1B07-1-19
P1B07-1-18
P1B07-1-17
P1B07-1-16
P1B07-1-15
P1B07-1-13
P1B07-1-12
P1B07-1-11
P1B07-1-10
P1B07-1-09
P1B07-1-08
P1B07-1-07
P1B07-1-05
P1B07-1-03

P1B Line 2

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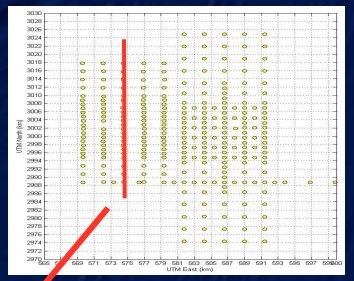
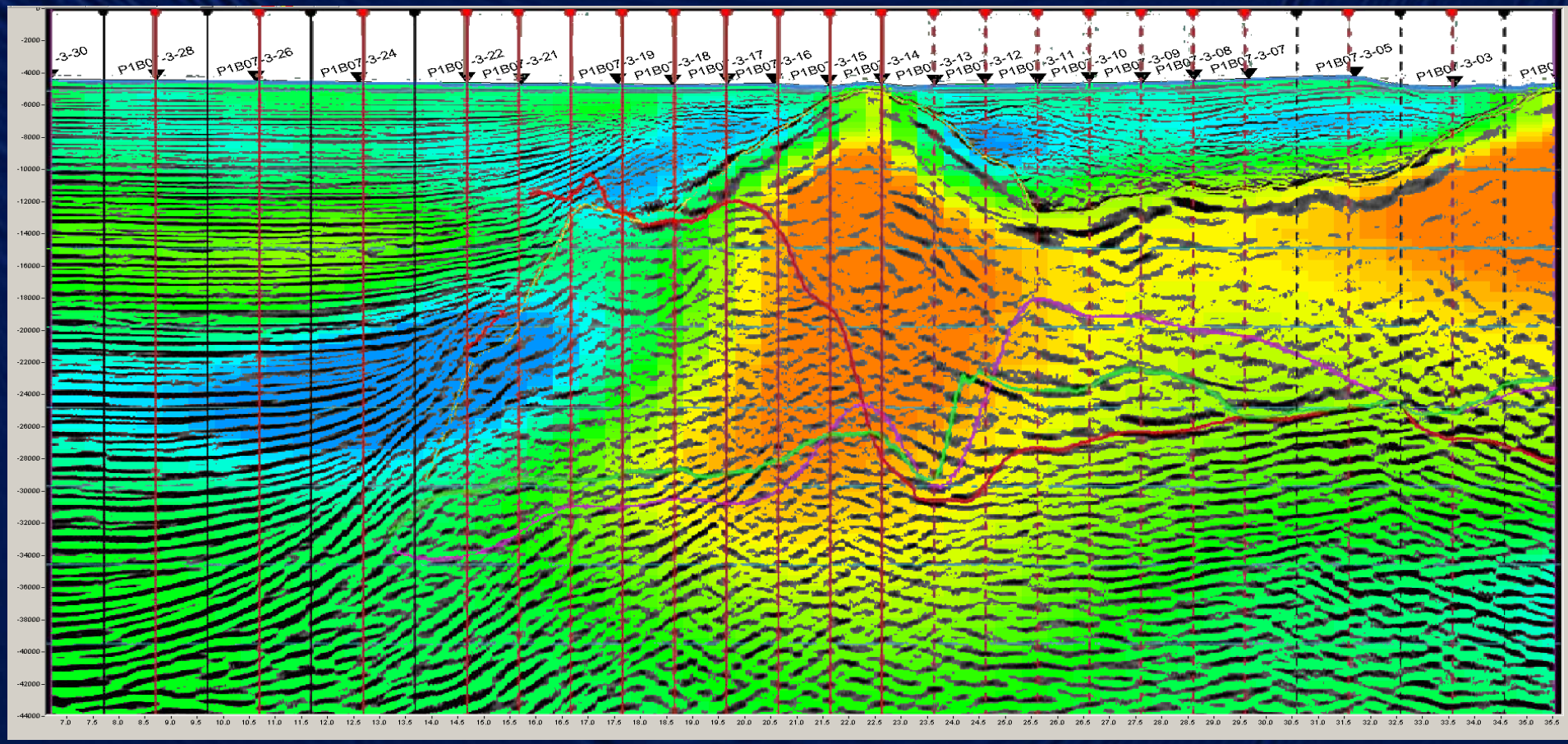
P1B07-2-03

P1B Line 3

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