Effect of Volcanic Bodies on Hydrocarbon Reservoirs in the North-Eastern Part of Chicontepec Foredeep, Mexico*

Supratik Sarkar[1], Kurt Marfurt[1] and Roger Slatt[1]

Search and Discovery Article #50279 (2010)
Posted July 19, 2010

* Adapted from an oral presentation at AAPG Annual Convention and Exhibition, New Orleans, Louisiana, USA, April 11-14, 2010

[1]ConocoPhillips School of Geology and Geophysics, University of Oklahoma, Norman, OK. (supratik.sarkar@ou.edu)

Abstract

Foredeep basin turbidite systems develop in elongated highly subsiding troughs in front of fold-thrust belts associated with plate convergence or collision. Deep water sedimentation in the Chicontepec foredeep is an example of such a turbidite system in front of the Sierra Madre Oriental fold thrust belt. The reservoirs here are primarily formed by submarine fans although large portions of the systems are dominated by mass transport complexes (MTCs). These MTCs along with poor grain sorting, grain maturity, diagenesis, and tectonic effects make the reservoirs highly complex and compartmentalized. Intrusive and extrusive volcanic events in this convergent tectonic margin add to the complexity of the reservoir.

Previous studies indicate that the majority of the volcanism in this region took place from pre-Oligocene to Quaternary. Age of the turbidite reservoirs at Chicontepec is predominantly Paleocene-Eocene. As part of a comprehensive reservoir characterization process, our goal is to identify the effects of the large-scale volcanic intrusive and extrusive bodies on the reservoir. The eastern part of the Amatitlan 3D seismic survey includes four separate oil fields. Spectral decomposition and other attribute stratal slices indicate that the main reservoir interval in all the four oil fields is part of a large submarine fan system. A large volcanic body and several smaller intrusive and extrusive volcanic features predominantly overlay the ‘Coyotes’ field, which is one of the four fields. Ant tracking and most positive curvature attributes indicate the presence of natural fractures in the reservoir interval with a greater concentration in ‘Coyotes’. Furthermore, the permeability and net-to-gross ratio in ‘Coyotes’ is higher than that in the adjacent fields where the volcanic features are less obvious or nonexistent. One hypothesis is that the intrusive volcanic bodies created fractures or secondary

porosity in its close proximity and it was emplaced before the migration of hydrocarbons into the reservoir. We are currently conducting outcrop studies and rock physics based studies to validate our seismic amplitude and attribute based hypothesis. Well logs from only a few wells encountered the volcanic interval, which show spikes of low gamma ray, high resistivity, variable density and low velocity at the volcanic layers. The velocity anomaly might be indicative of fractures within the volcanic bodies.

References

Cantagrel, J.M. and C. Robin, 1978, Strontium isotope geochemical studies in the typical series of East Mexican volcanoes: Bulletin de la Societe Geologique de France, v. 20/6, p. 935-939.

DeCelles, P.G. and K.A. Giles, 1996, Foreland basin systems: Basin Research, v. 8/2, p. 105-123.

Delpino, D.H. and A.M. Bermudez, 2009, Petroleum systems including unconventional reservoirs in intrusive igneous rocks (sills and laccoliths): The Leading Edge, v. 28/7, p. 804-811. DOI: 10.1190/1.3167782

Pena, V., S. Chavez-Perez, M. Vazquez-Garcia, and K.J. Marfurt, 2009, Impact of shallow volcanics on seismic data quality in Chicontepec Basin, Mexico: The Leading Edge, v. 28/6, p. 674-679. DOI: 10.1190/1.3148407

Salvador, A., editor, 1991, The Gulf of Mexico Basin, *in* The Decade of North American Geology: The Geology of North America, Geological Society of America, v. J, 568 p.

EFFECT OF VOLCANIC BODIES ON HYDROCARBON RESERVOIRS IN THE NORTH-EASTERN PART OF CHICONTEPEC FOREDEEP, MEXICO

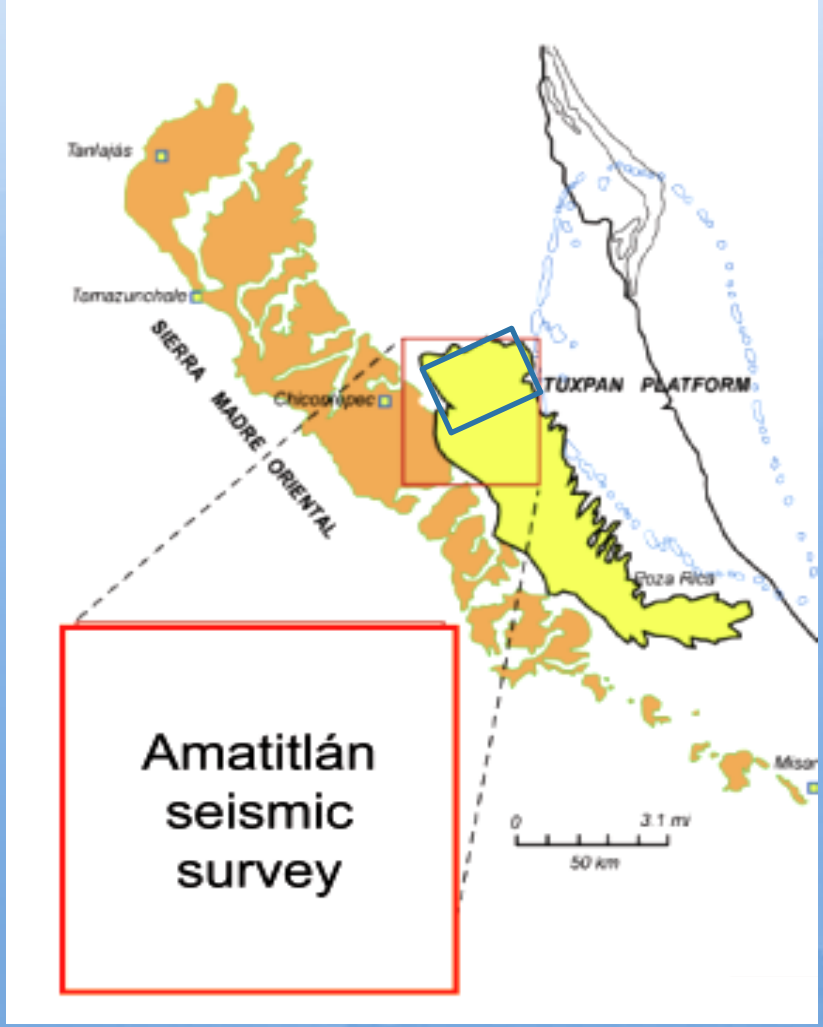
Supratik Sarkar, Kurt J. Marfurt, Roger M. Slatt.

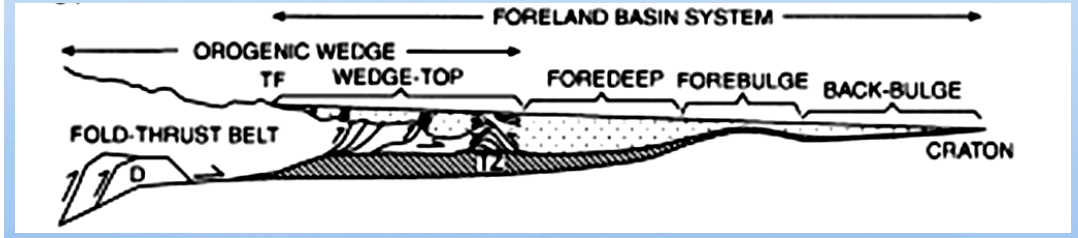
ConocoPhillips School of Geology and Geophysics,
University of Oklahoma.

OUTLINE

- INTRODUCTION
- IGNEOUS PETROLEUM SYSTEMS
- VOLCANICS IN CHICONTEPEC FOREDEEP
- SEISMIC BASED STUDIES
- CONCLUSIONS

INTRODUCTION





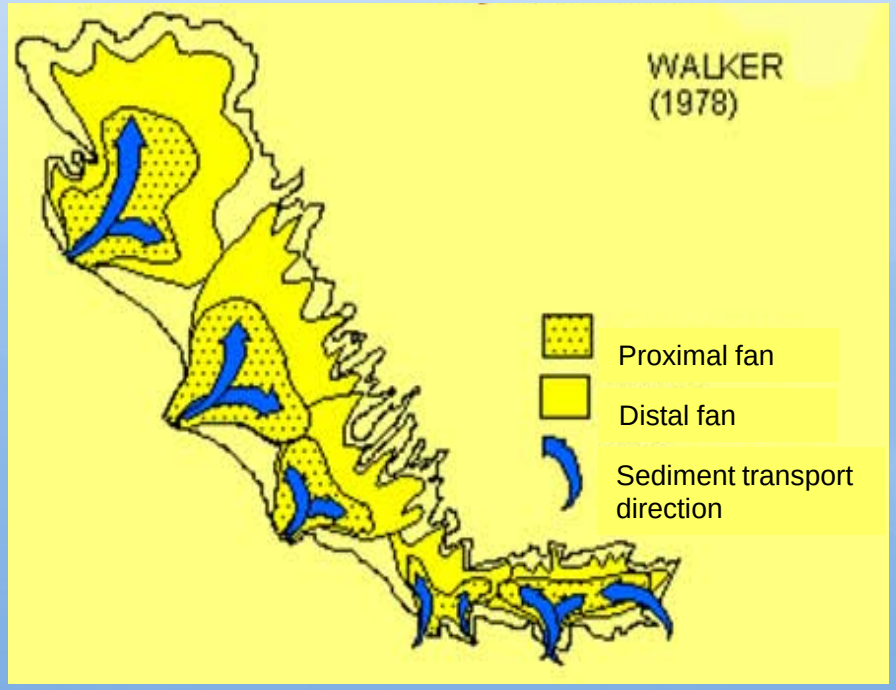
DeCelles and Giles (1996)

Chicontepec is Mexico's 2nd most important field.

The Chicontepec play lies in a foredeep basin, west of the Tuxpan Platform; east of the Sierra Madre Oriental fold thrust belt.

INTRODUCTION

Salvador, 1991



Generalized depositional system

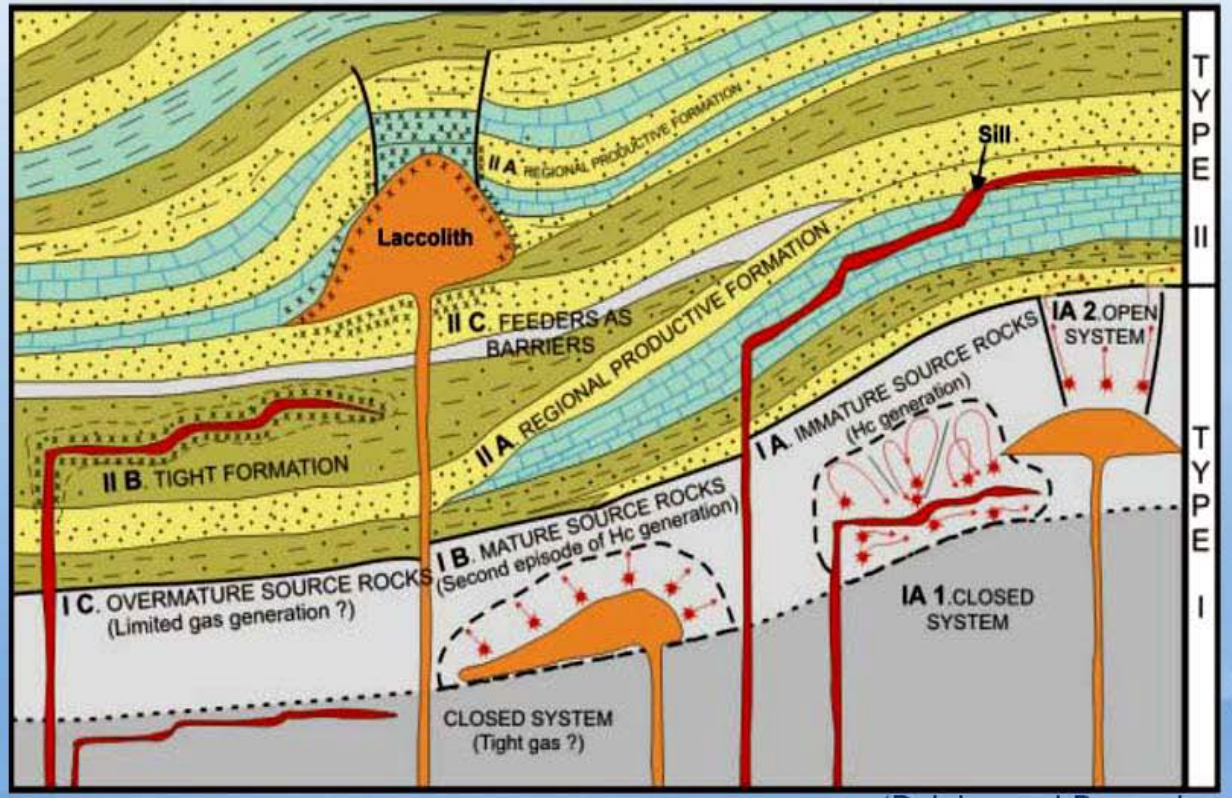
OUTLINE

- INTRODUCTION
- IGNEOUS PETROLEUM SYSTEMS
- VOLCANICS IN CHICONTEPEC FOREDEEP
- SEISMIC BASED STUDIES
- CONCLUSIONS

IGNEOUS PETROLEUM SYSTEMS

Type I: igneous rock is intruded into a potential source rock

Type II: igneous rock has been emplaced in another type of sedimentary rock



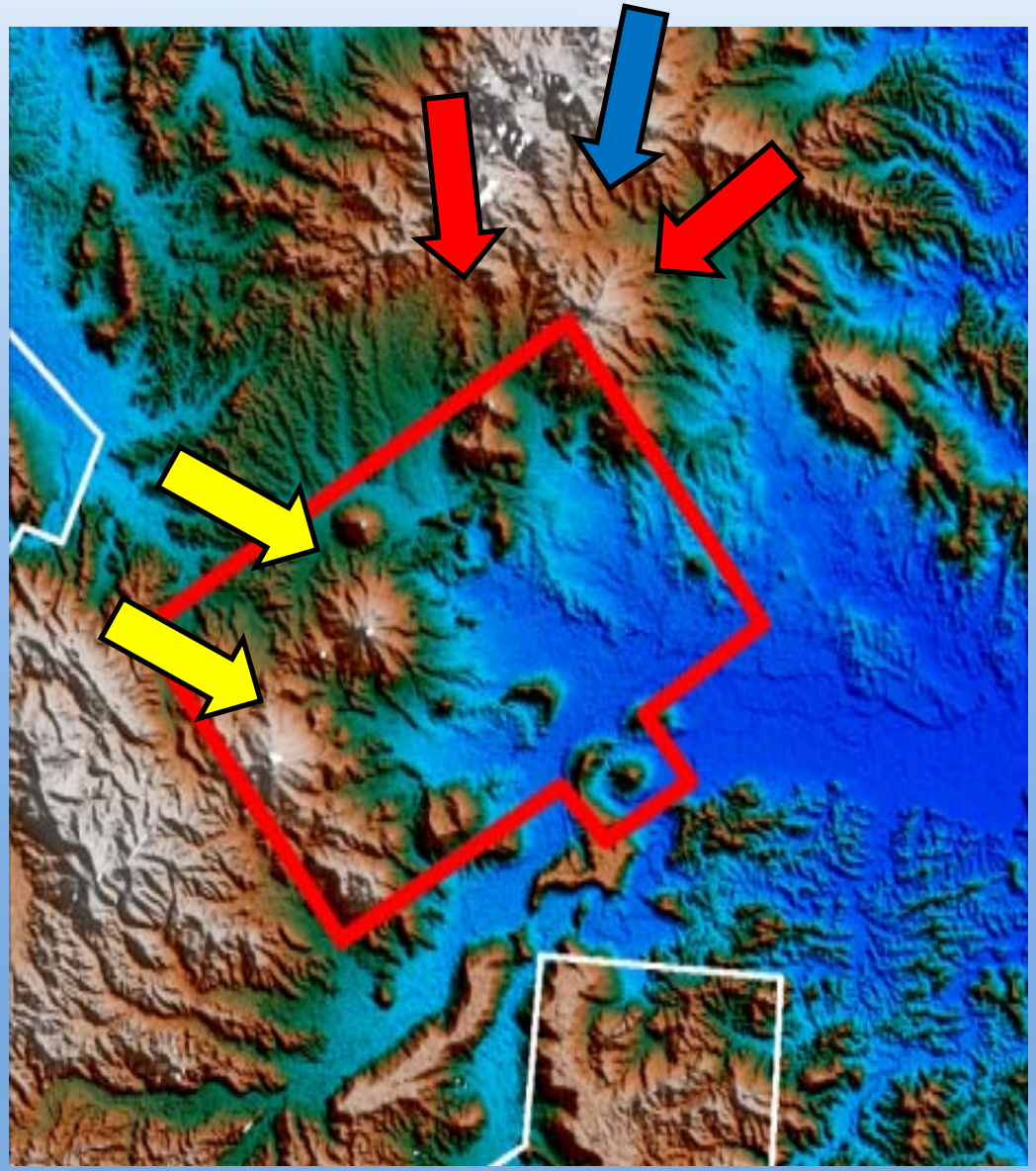
(Delpino and Bermudez, 2009)

Notes by Presenter: Different types of igneous petroleum systems related to sills and laccoliths. Type I, when the igneous rock is intruded into a potential source rock, and (b) Type II, if the igneous rock has been emplaced in another type of sedimentary rock. (After Delpino and Bermudez, 2009).

OUTLINE

- INTRODUCTION
- IGNEOUS PETROLEUM SYSTEMS
- **VOLCANICS IN CHICONTEPEC FOREDEEP**
- SEISMIC BASED STUDIES
- CONCLUSIONS

VOLCANICS IN CHICONTEPEC FOREDEEP



5 km

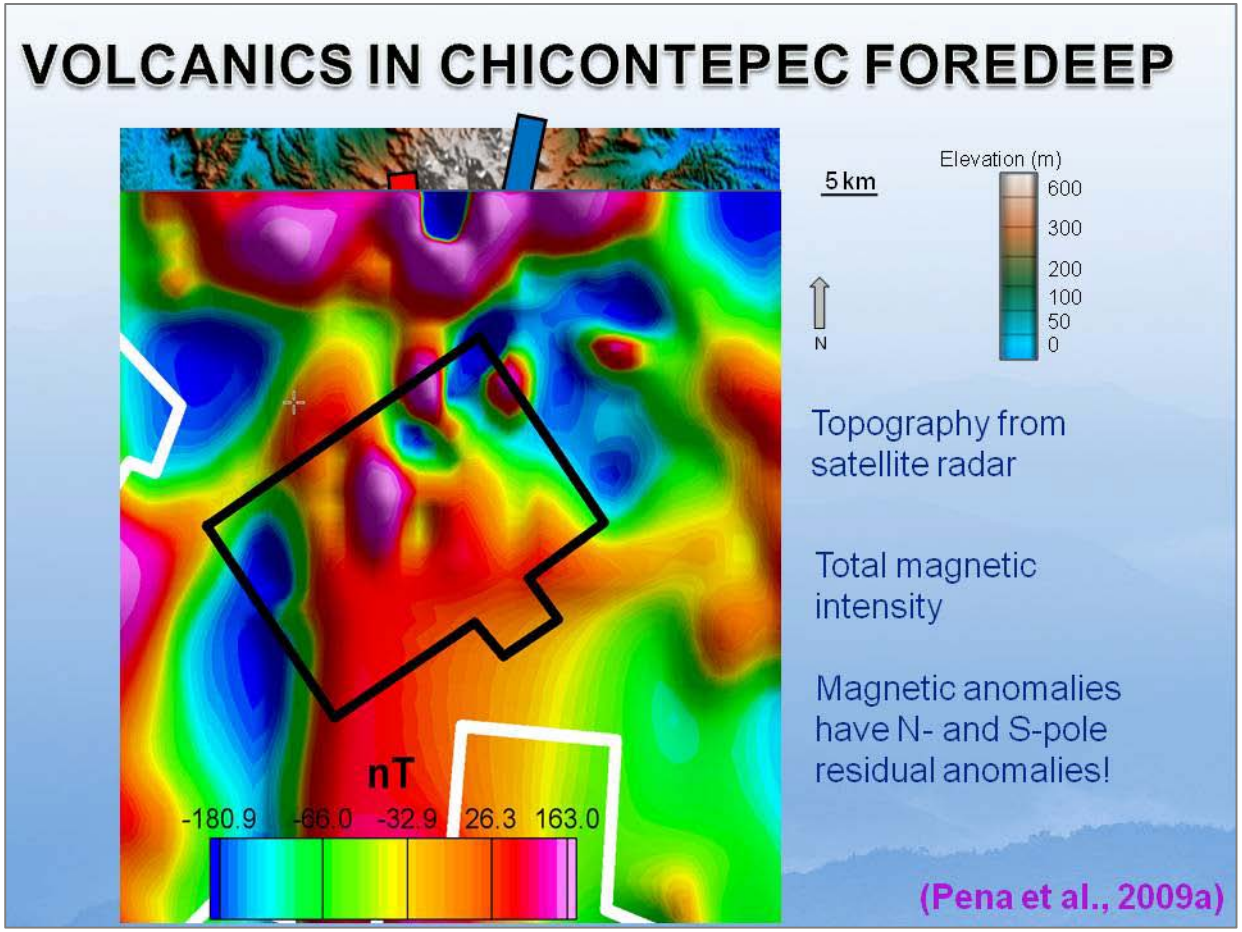
N

Elevation (m)

600
300
200
100
50
0

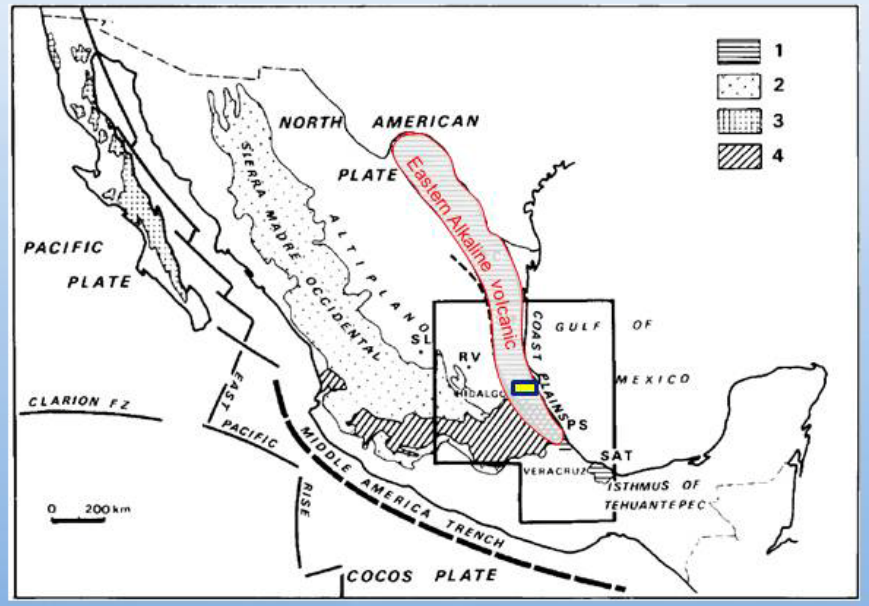
Topography from satellite radar

(Pena et al., 2009a)



Notes by Presenter:
(a) Topographic map with the Amatilán seismic survey outlined in red. Arrows indicate volcanoes and a possible dike. White outlines indicate limits of municipalities.
(b) Total magnetic intensity (TMI) map of the same area filtered to enhance shallow magnetic anomalies (survey outlined in black). The blue arrow indicate a negative and the red arrows positive magnetic anomalies. The signature of the volcanoes indicated by yellow arrows is more complex, suggesting buried magnetic sources. (Topography data from http://seamless.usgs.gov/website/seamless/viewer.htm) . TMI data from ftp://ftpext.usgs.gov/pub/cr/co/denver/musette/pub/open-file-reports/ofr-02-0414) (After Pena et al., 2009b).

VOLCANICS IN CHICONTEPEC FOREDEEP

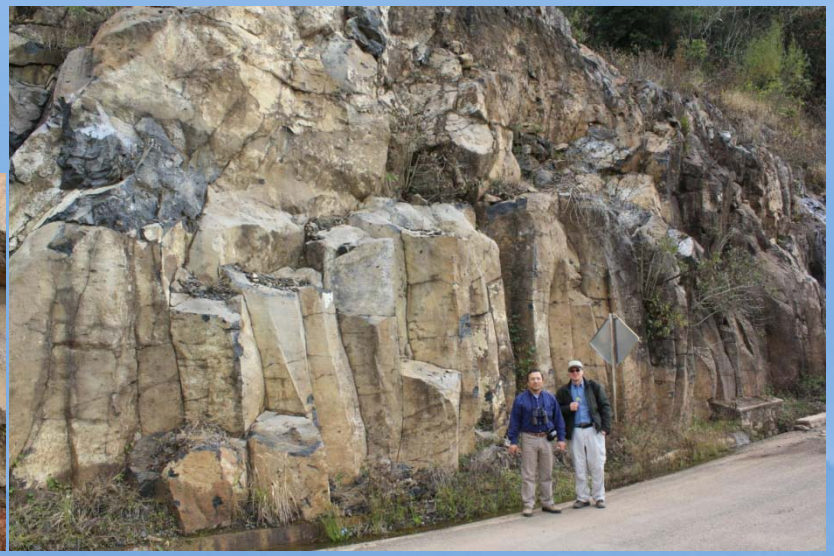


Eastern alkaline volcanic province: Late Oligocene to recent in various phases

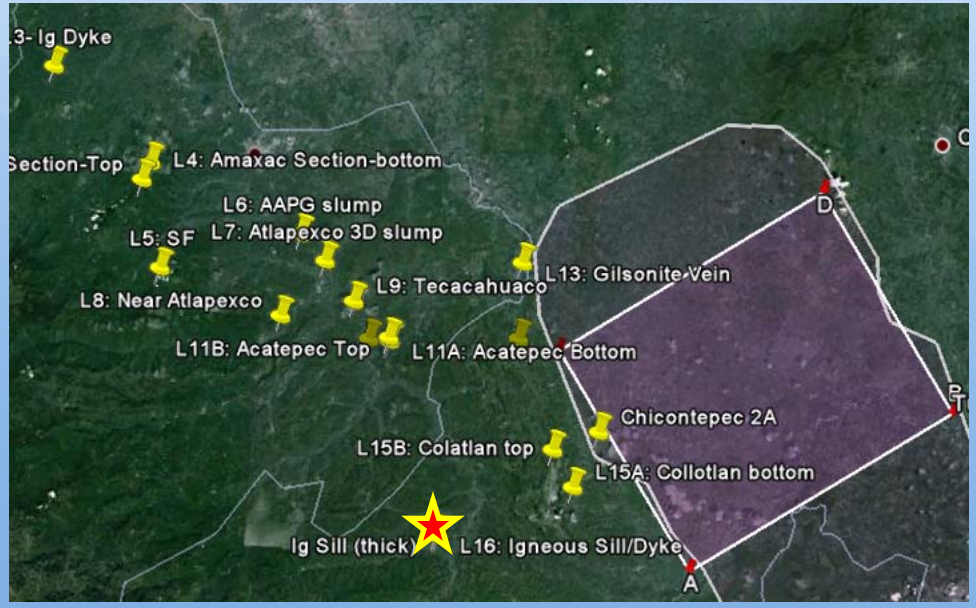
Major pulses in Chicontepec: Late Oligocene- Early Miocene. (Cantagrel and Robin; 1978)

Notes by Presenter: The four volcanic provinces in Mexico(according to Demant and Robin, 1975, modified). 1= eastern alkaline province; 2= andesitic- ignimbritic province of the Sierra Madre Occidental; 3= Californian province; 4= andesitic trans- Mexican belt. SC= Sierra de San Carlos, ST= Sierra de Tamaulipas, PS= Palma Sola massif, SA= San Andreas Tuxtla massif, RV and SL = Rio Varde and San Luis Cities.

VOLCANICS IN CHICONTEPEC FOREDEEP



VOLCANICS IN CHICONTEPEC FOREDEEP



VOLCANICS IN CHICONTEPEC FOREDEEP

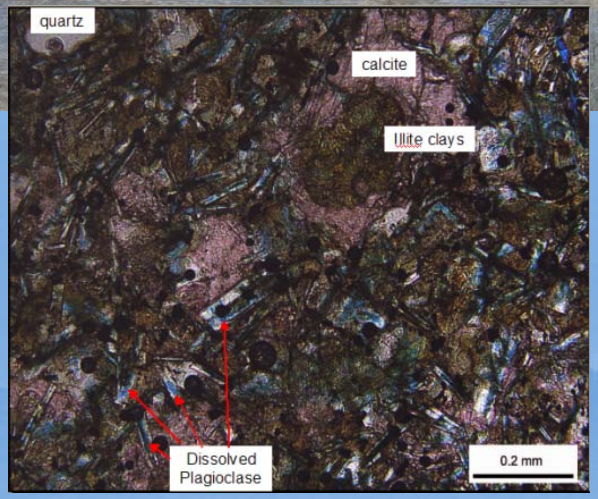
sandstone

sill

sandstone

sill

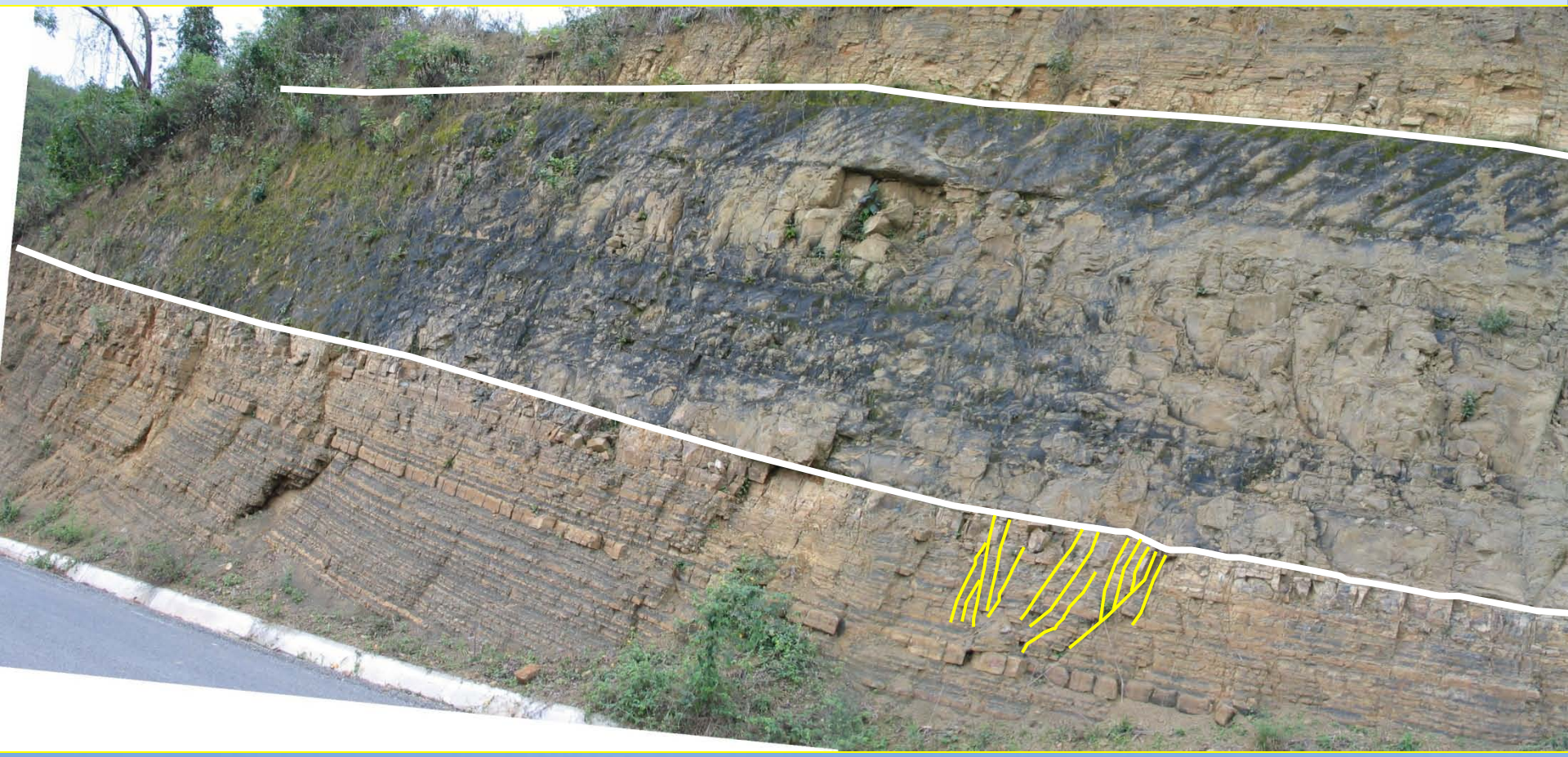
sill



VOLCANICS IN CHICONTEPEC FOREDEEP

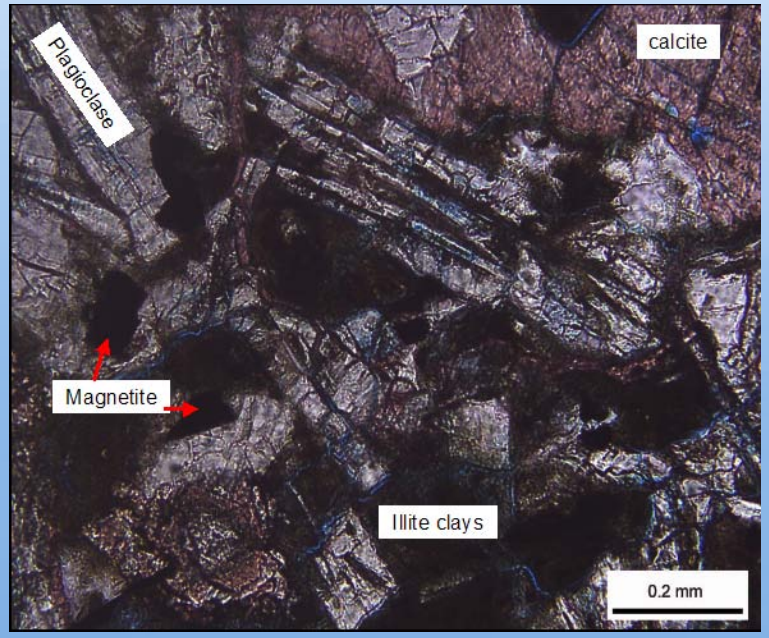
VOLCANICS IN CHICONTEPEC FOREDEEP

VOLCANICS IN CHICONTEPEC FOREDEEP

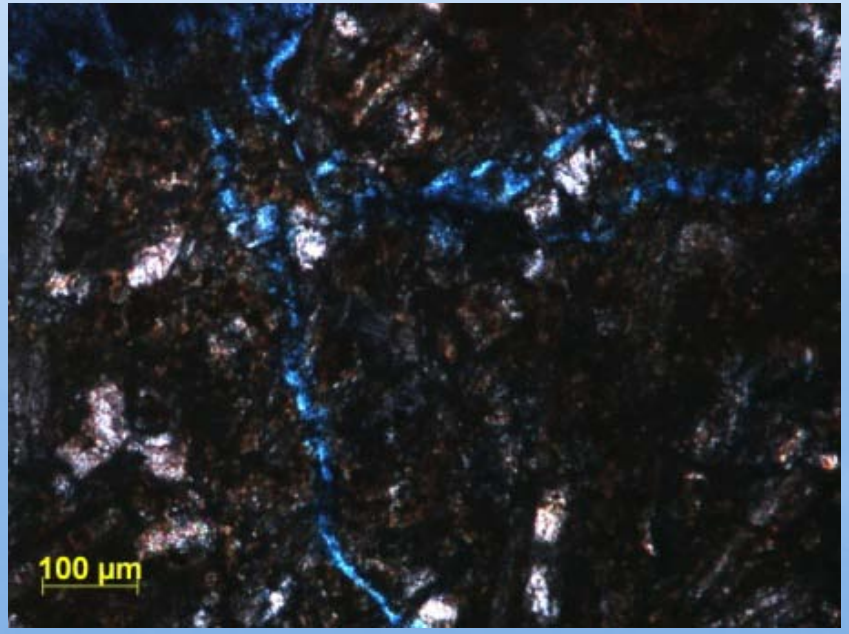


VOLCANICS IN CHICONTEPEC FOREDEEP

Photomicrographs



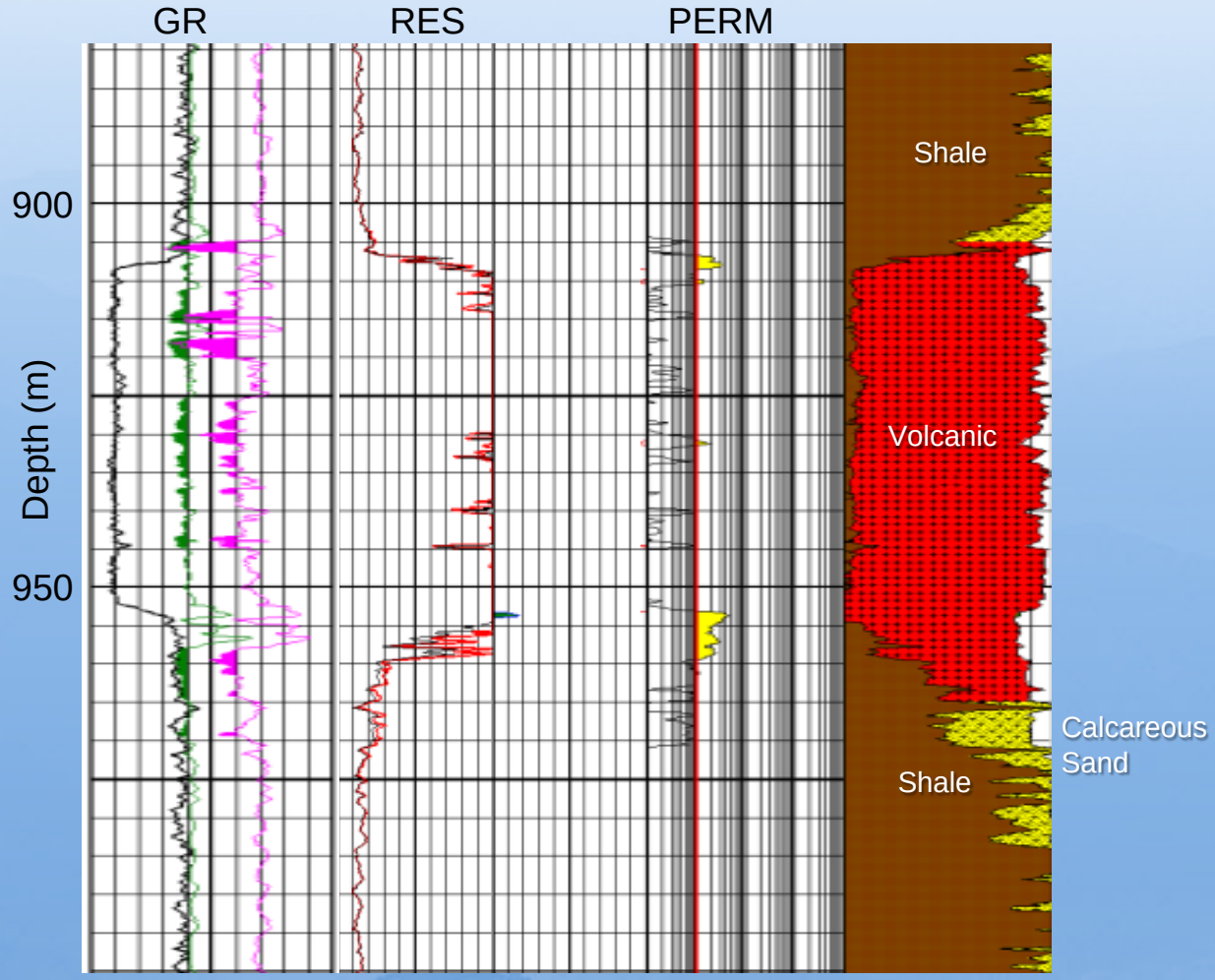
Volcanics



Contact zone

Courtesy Steve Cossey/ M Bitter

VOLCANICS IN CHICONTEPEC FOREDEEP

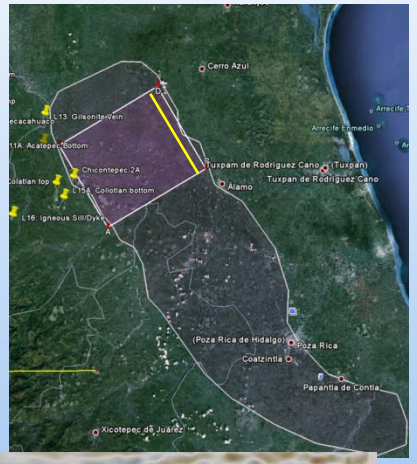


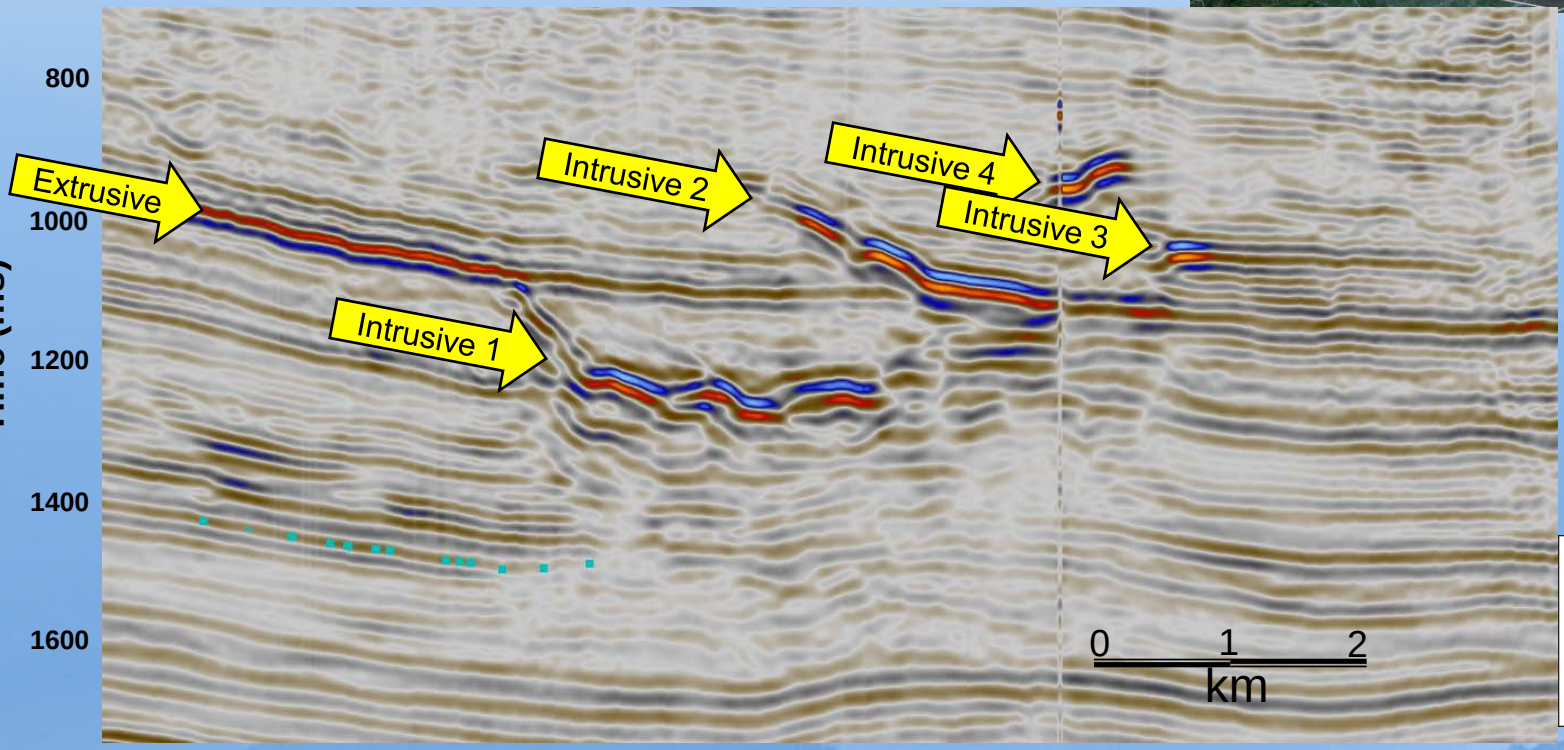
Typical well log response of a sub volcanic intrusive at Chicontepec

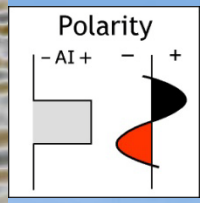
OUTLINE

- INTRODUCTION
- IGNEOUS PETROLEUM SYSTEMS
- VOLCANICS IN CHICONTEPEC FOREDEEP
- **SEISMIC BASED STUDIES**
- CONCLUSIONS

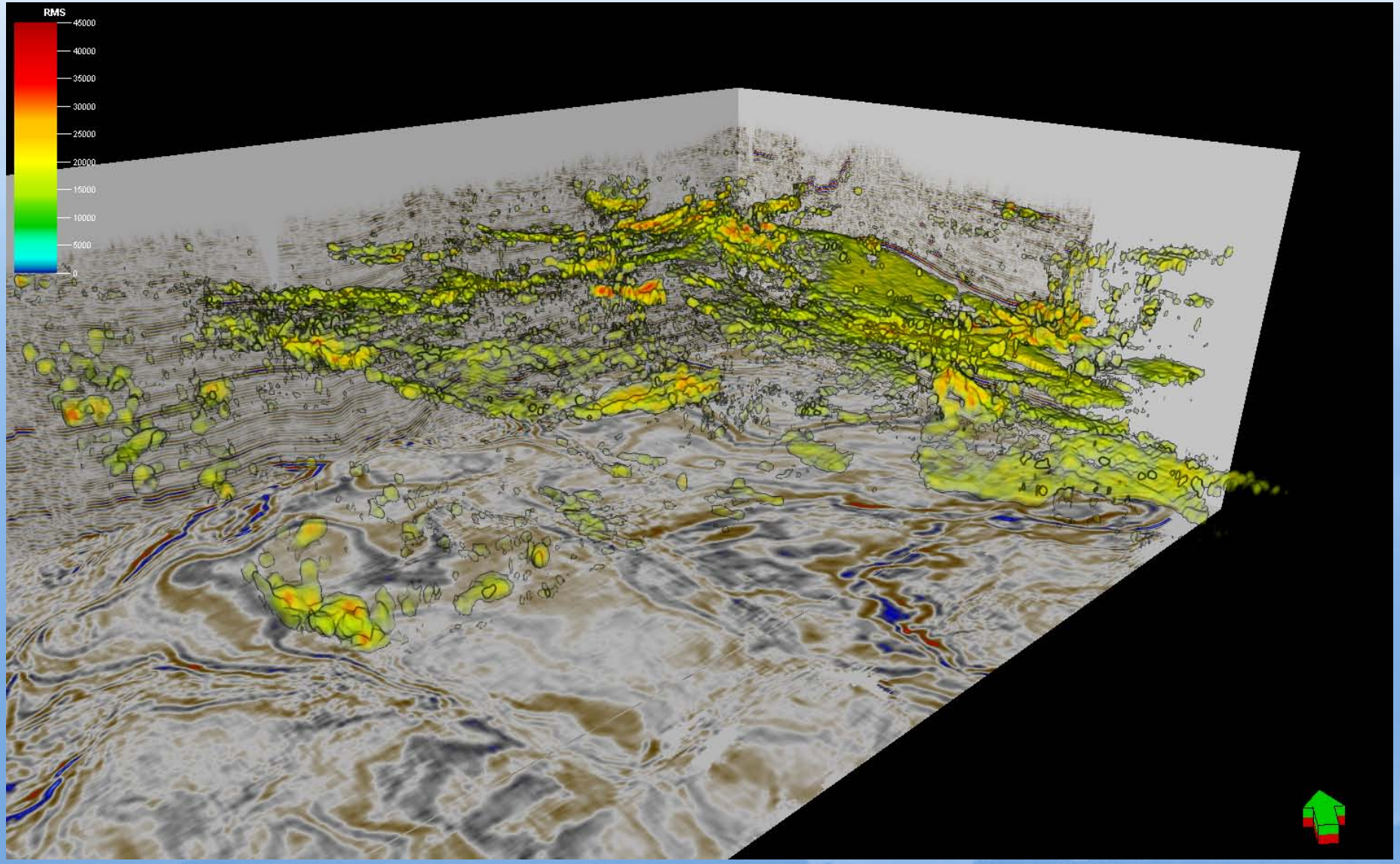
SEISMIC BASED STUDIES





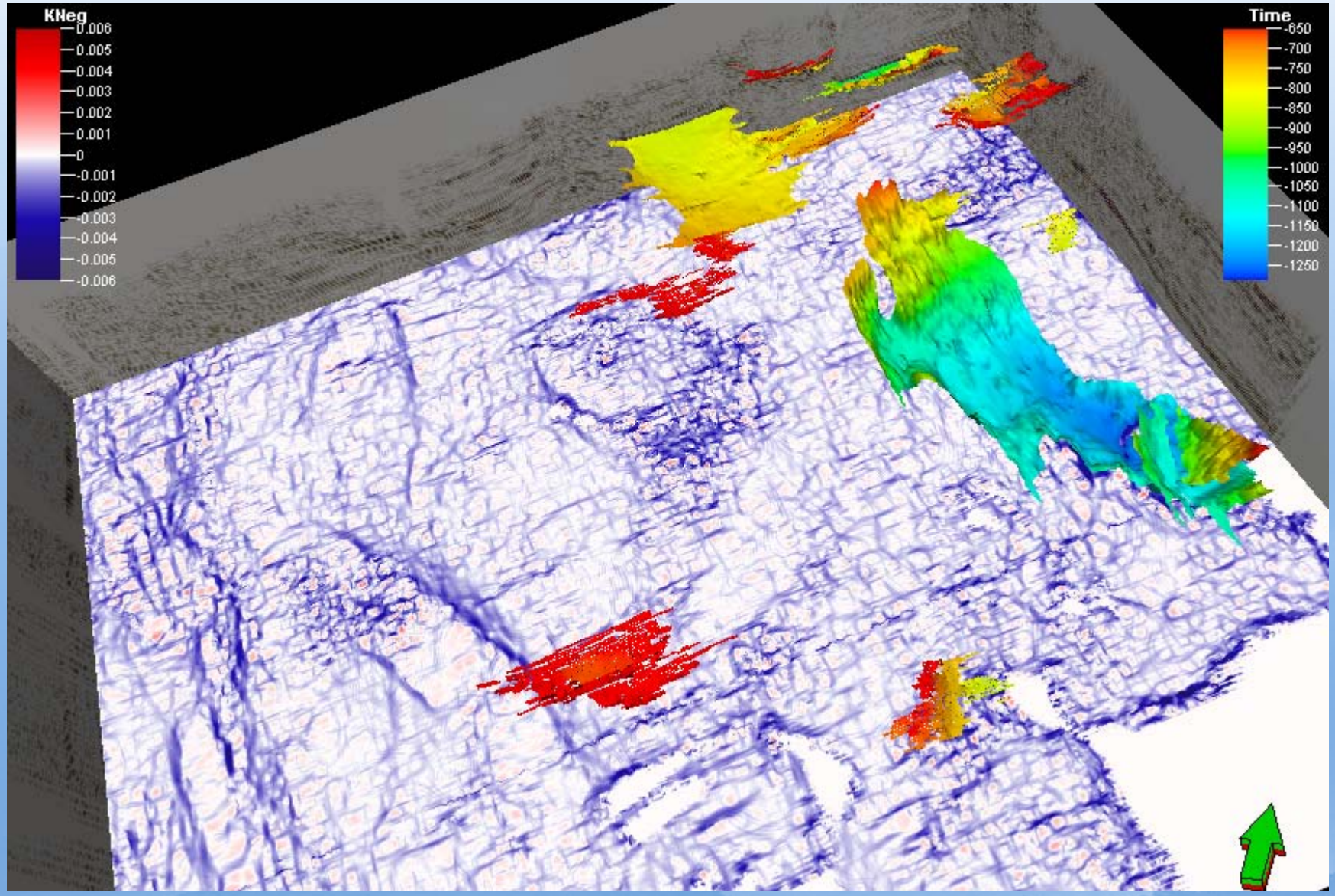


SEISMIC BASED STUDIES



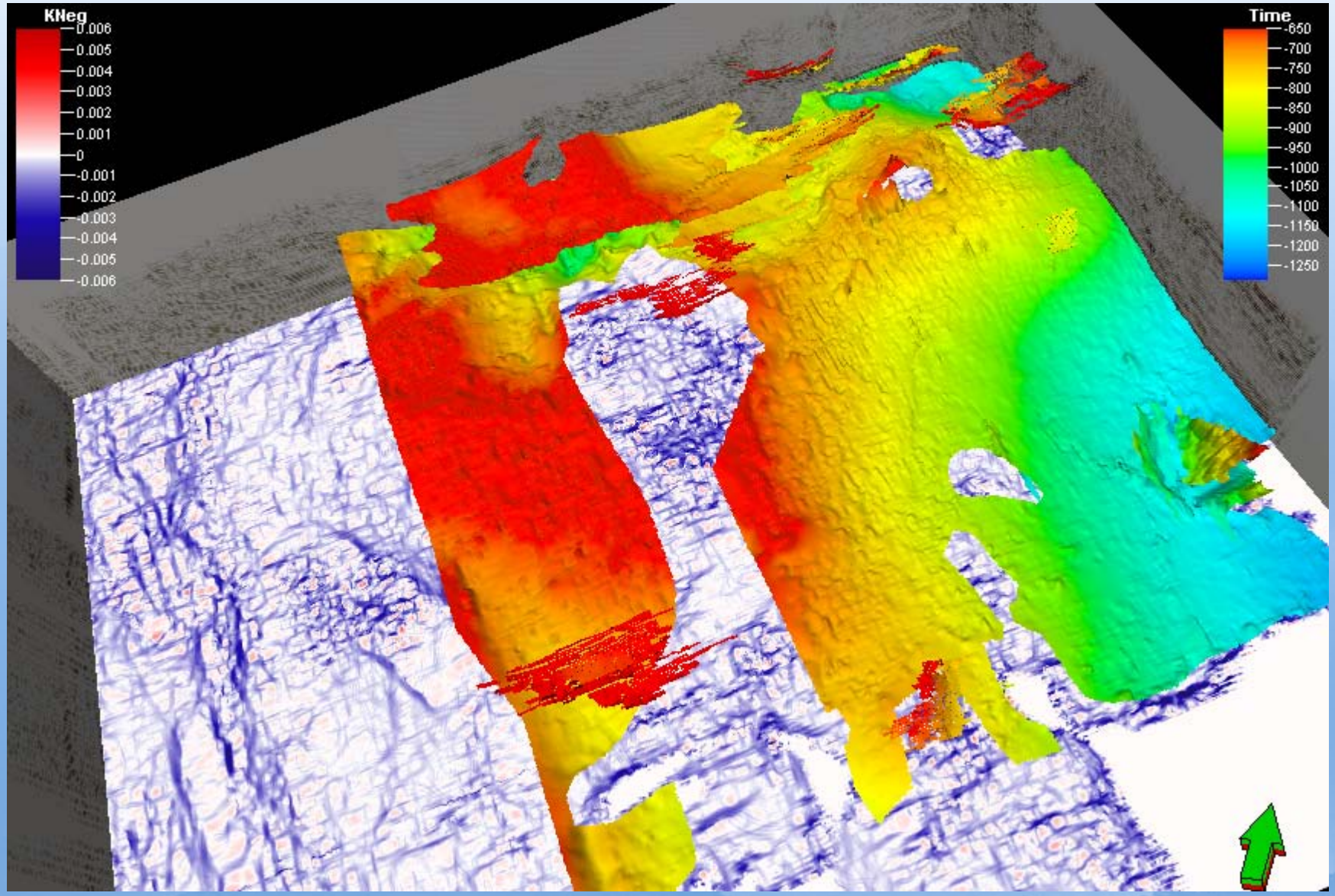
RMS amplitude within igneous geobodies

SEISMIC BASED STUDIES



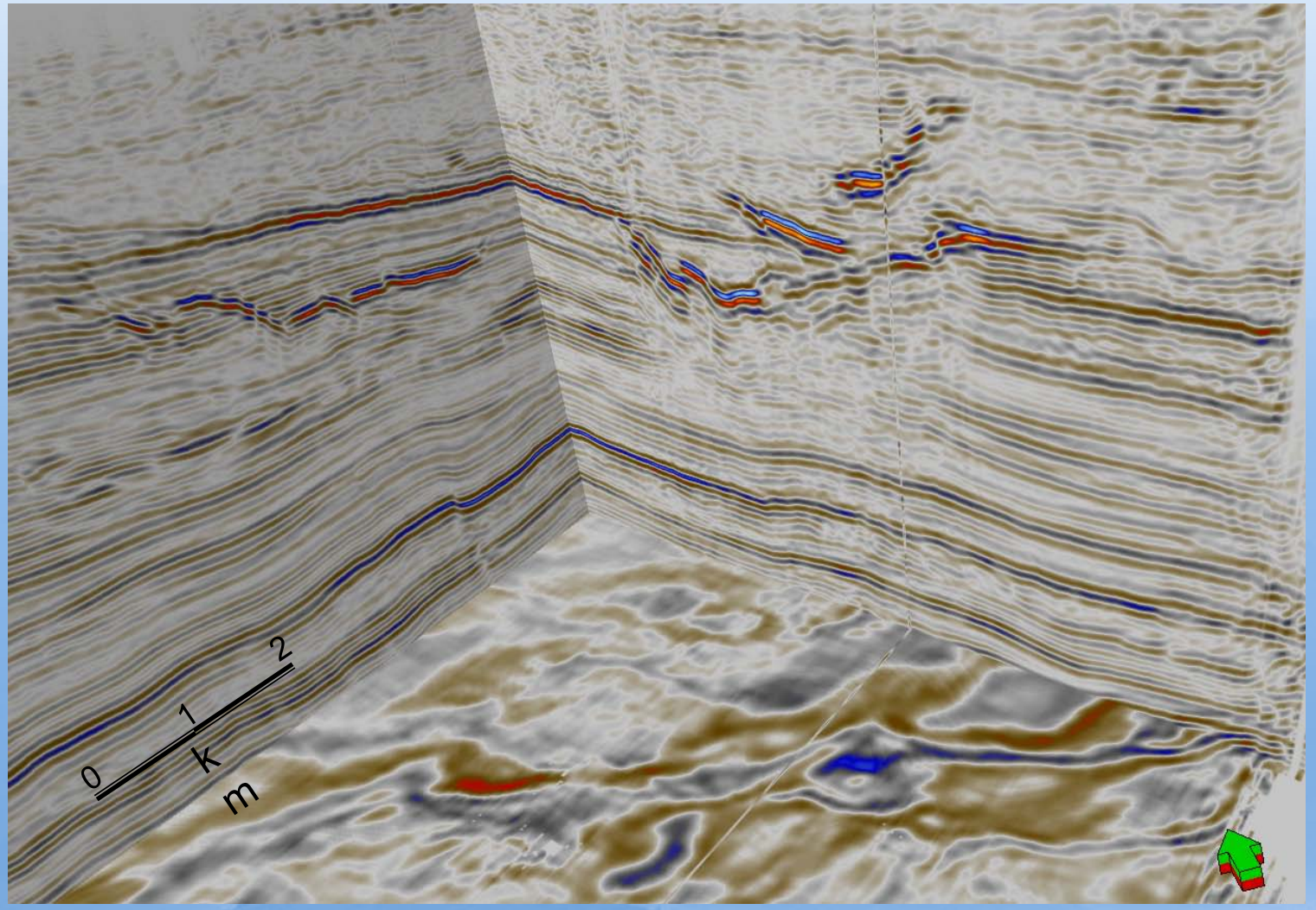
Map of volcanic intrusives; time slice from most negative curvature volume through underlying Chicontepec Formation

SEISMIC BASED STUDIES

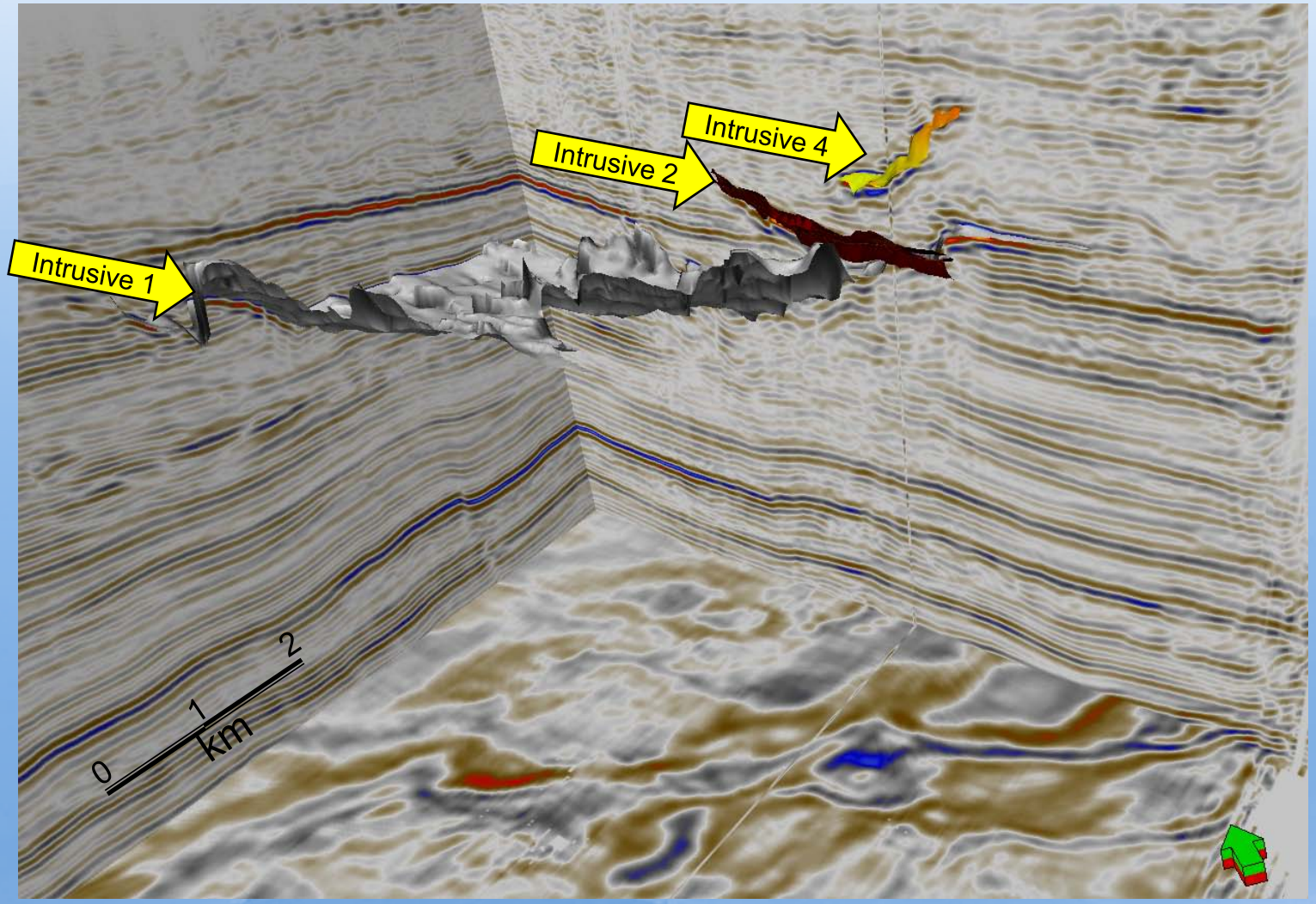


Map of volcanic intrusives and extrusives; time slice from most negative curvature volume through underlying Chicontepec Formation

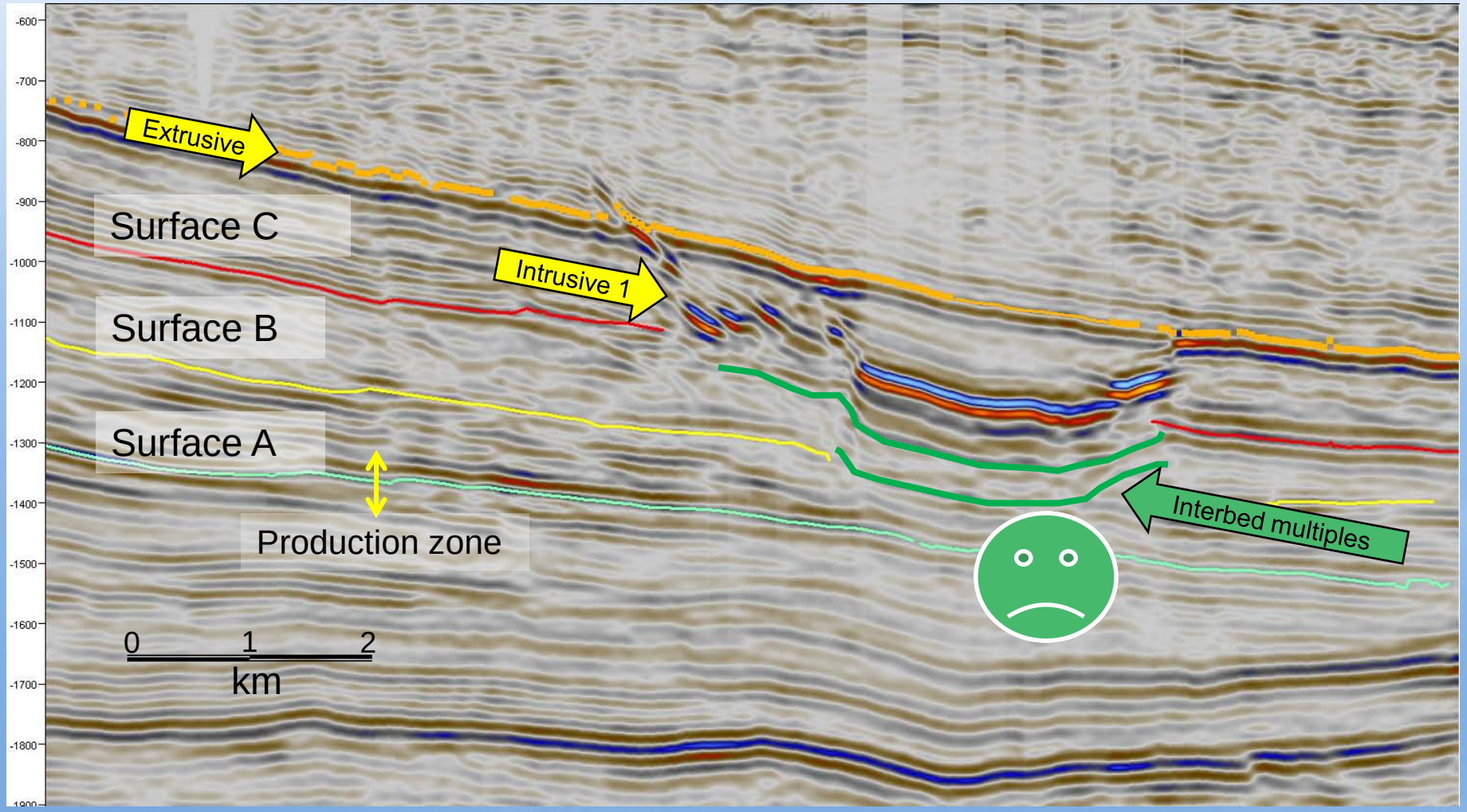
SEISMIC BASED STUDIES



SEISMIC BASED STUDIES

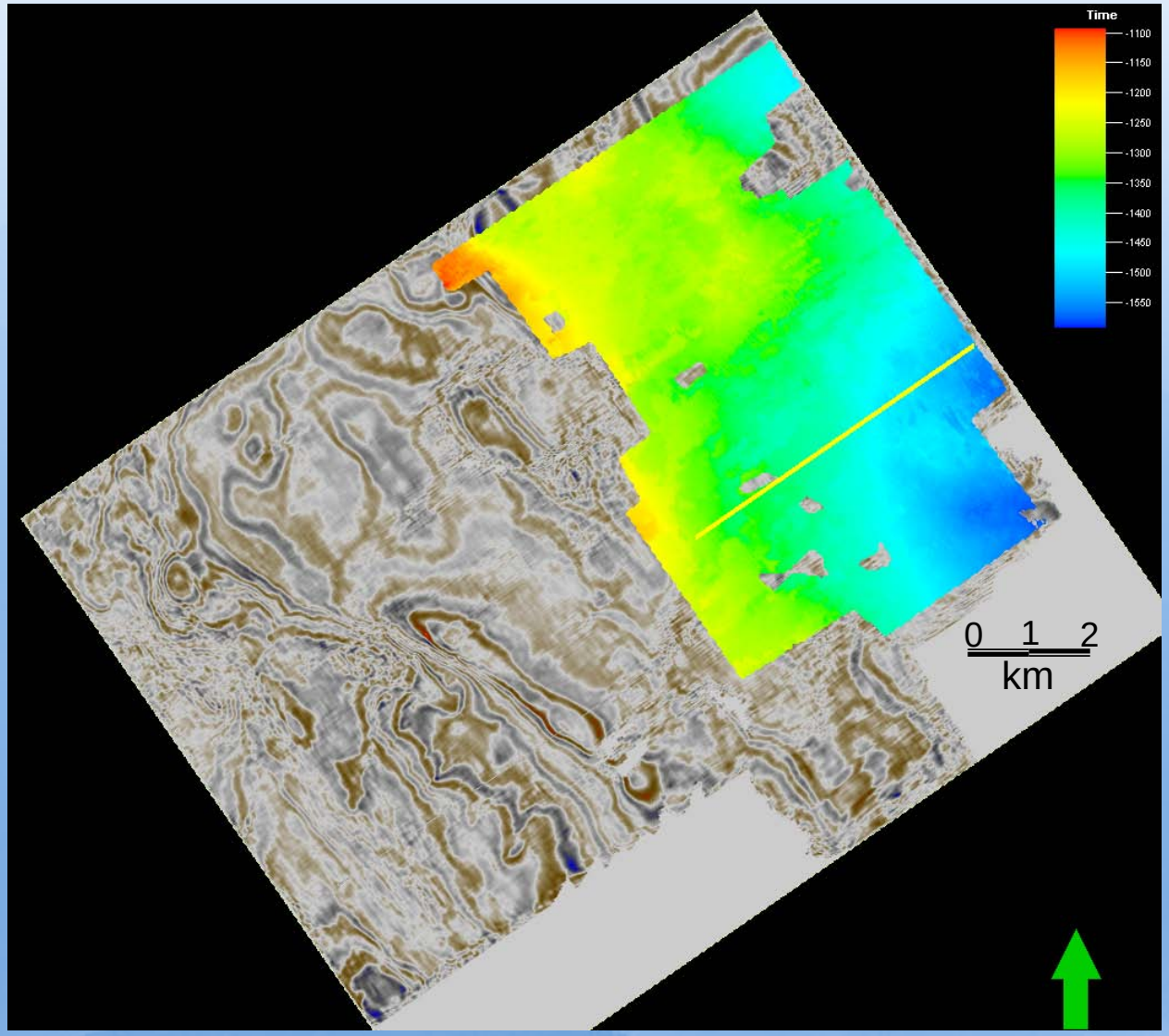


SEISMIC BASED STUDIES



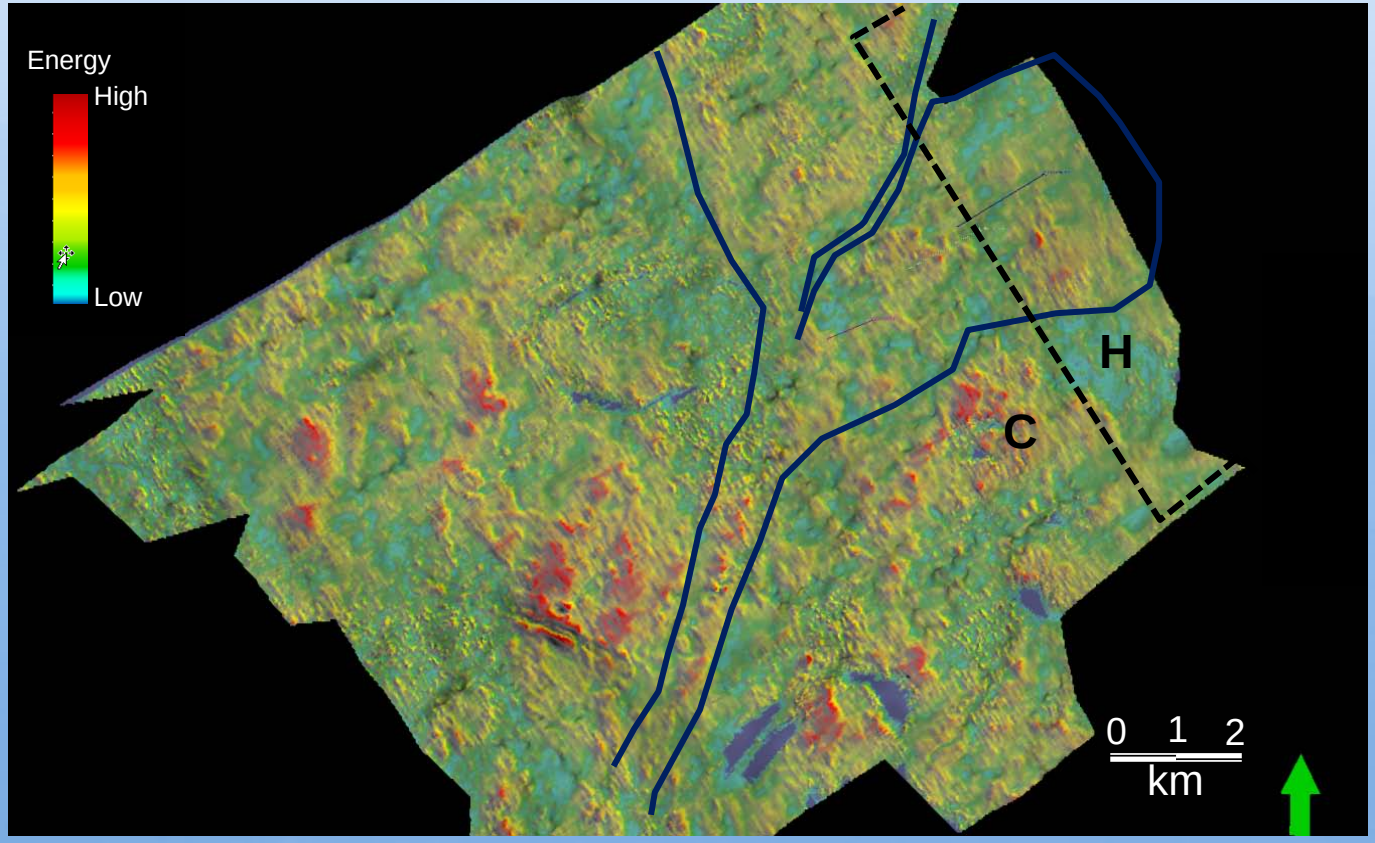
Marked surfaces below volcanics

SEISMIC BASED STUDIES



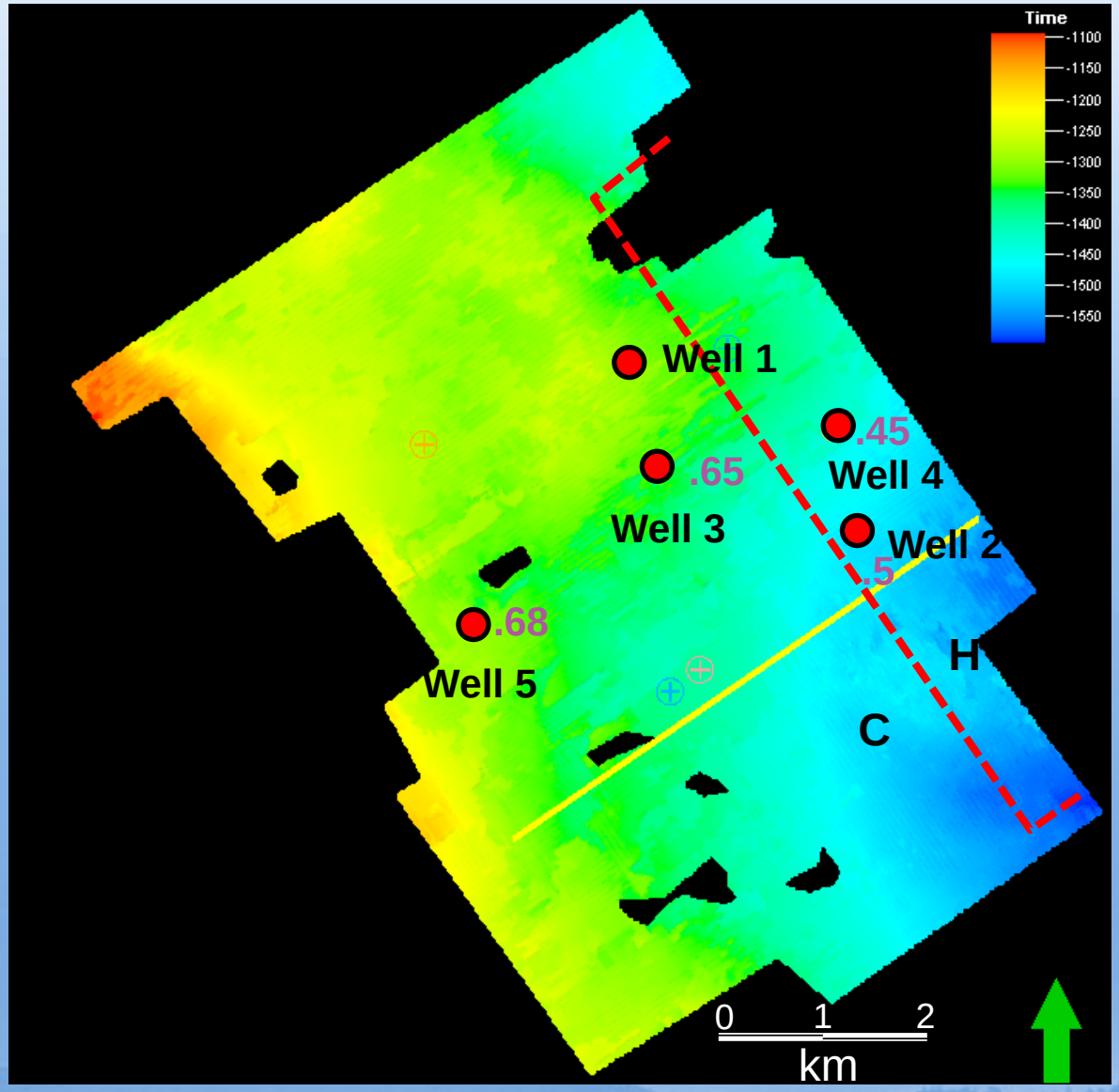
Time Structure map of Surface A

SEISMIC BASED STUDIES



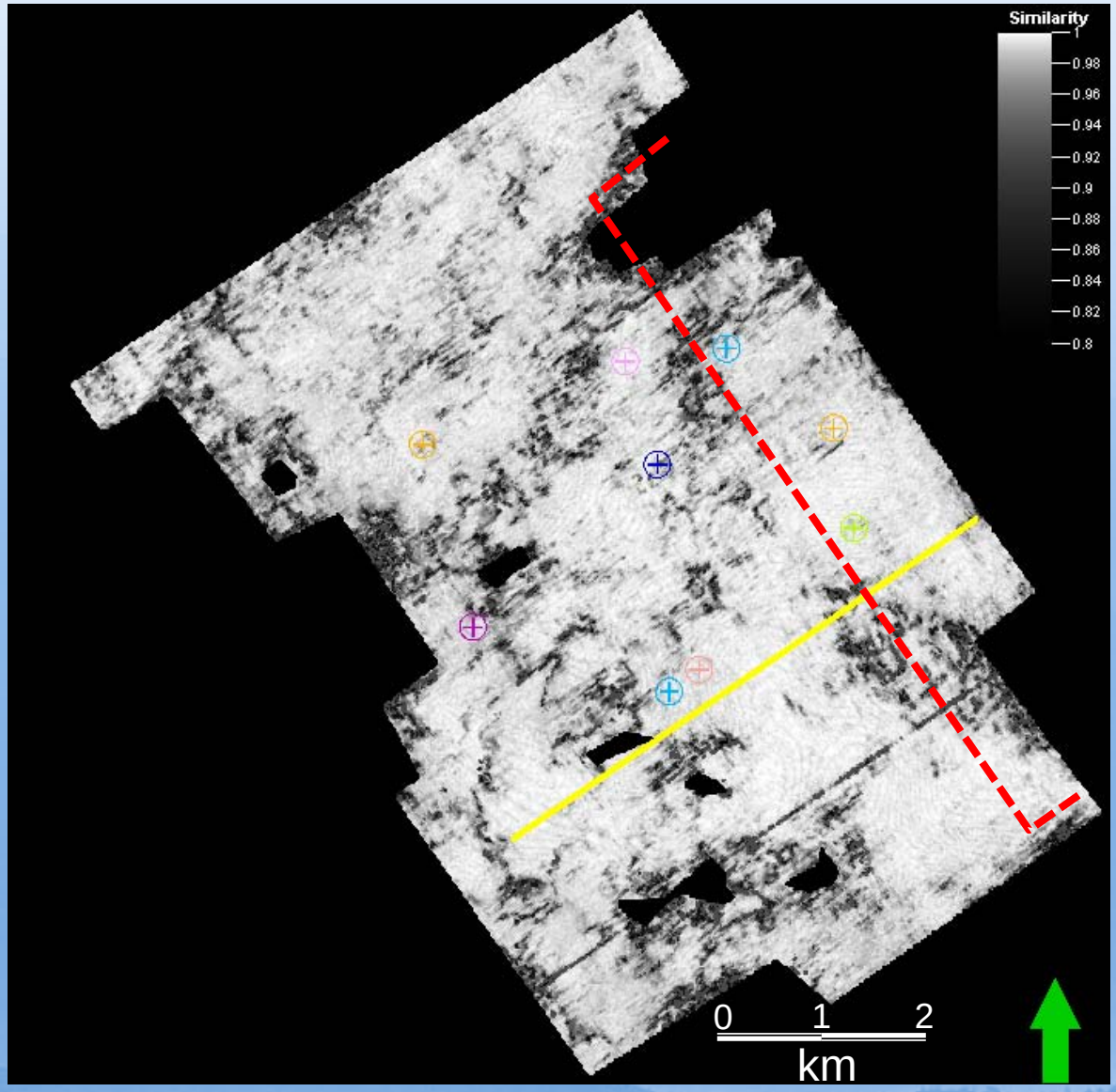
Coherent energy and coherent energy gradient
near top Paleocene

SEISMIC BASED STUDIES



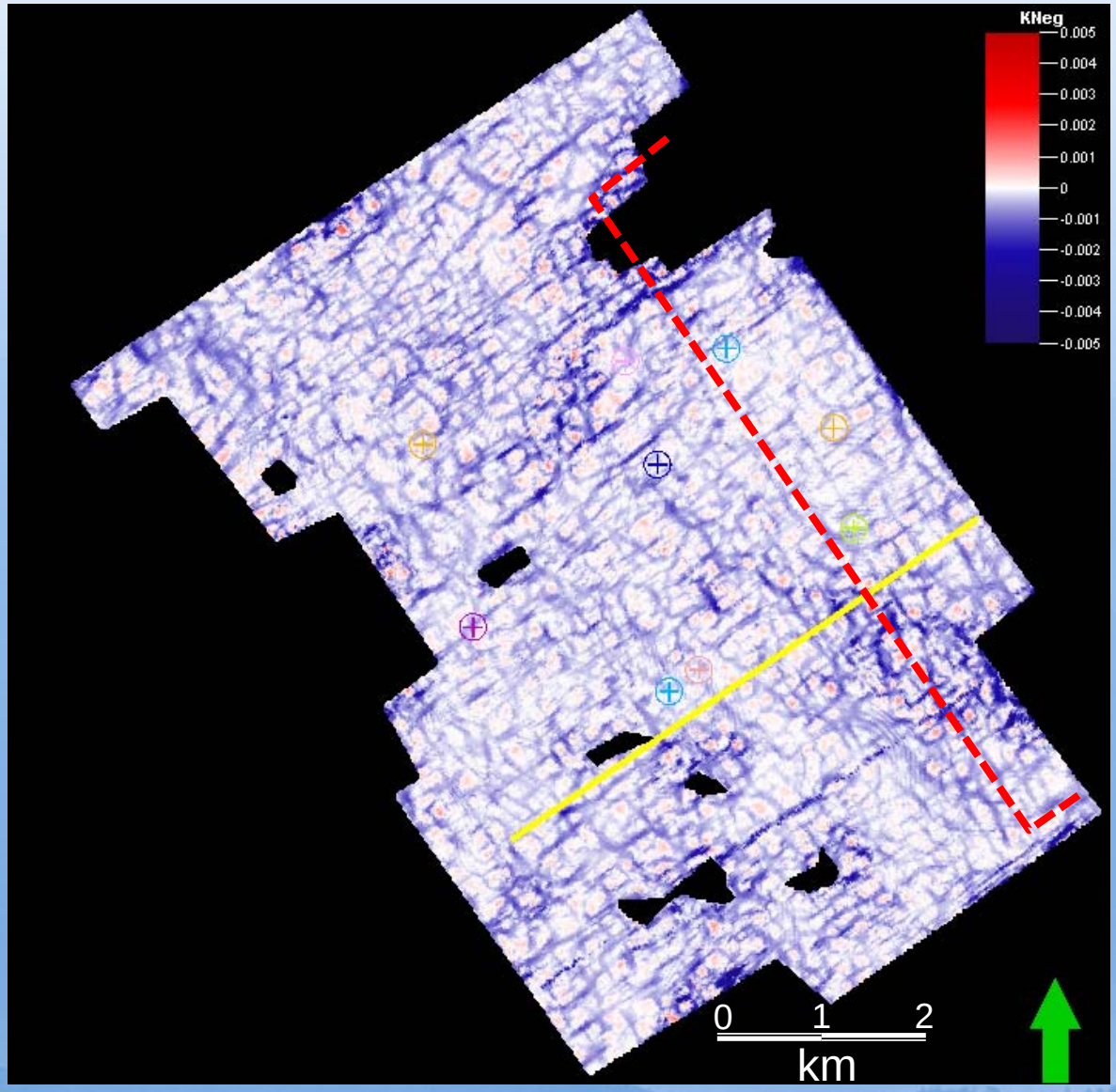
Net/ gross values from some wells

SEISMIC BASED STUDIES



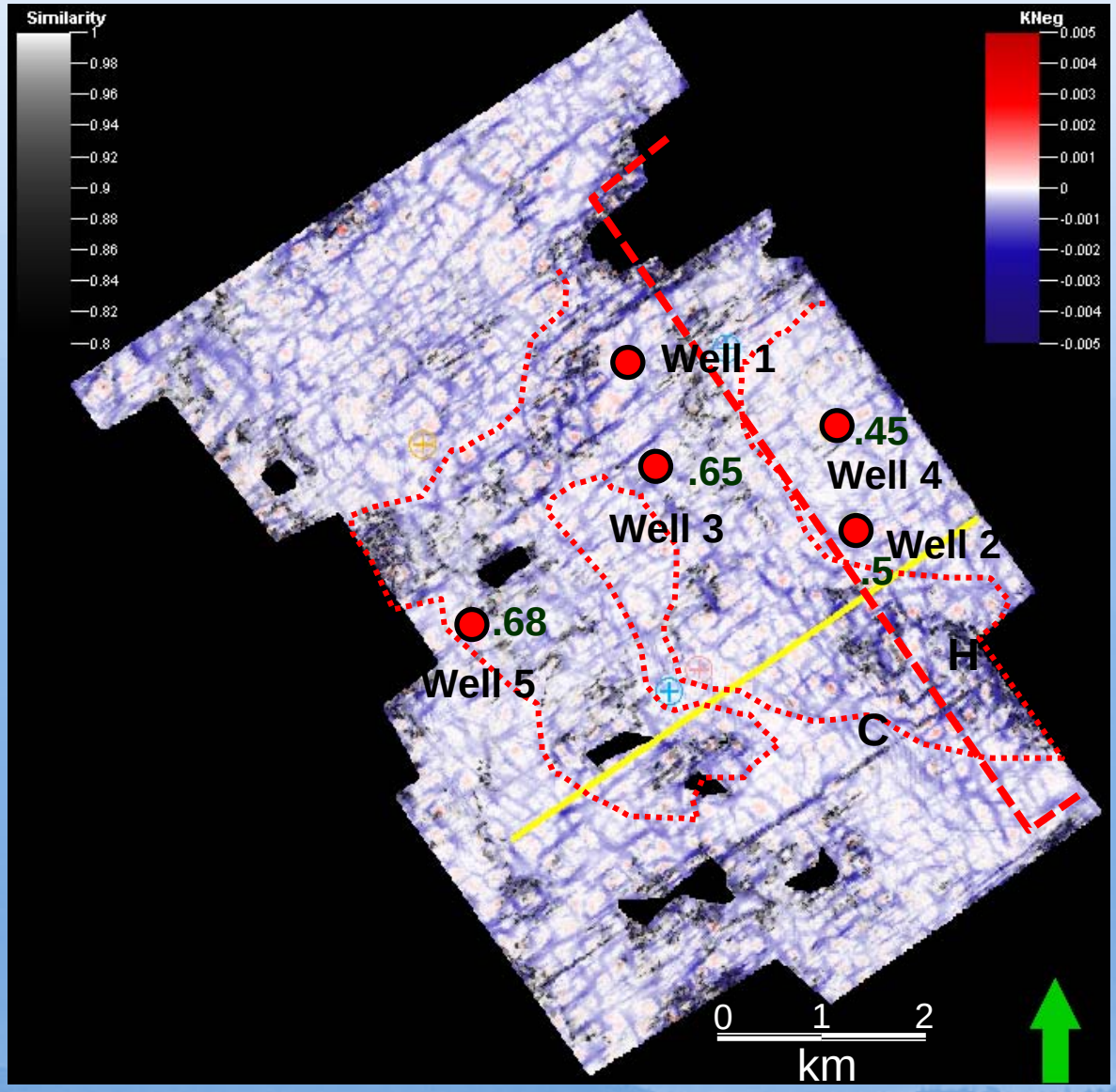
Energy ratio similarity extracted on Surface A

SEISMIC BASED STUDIES



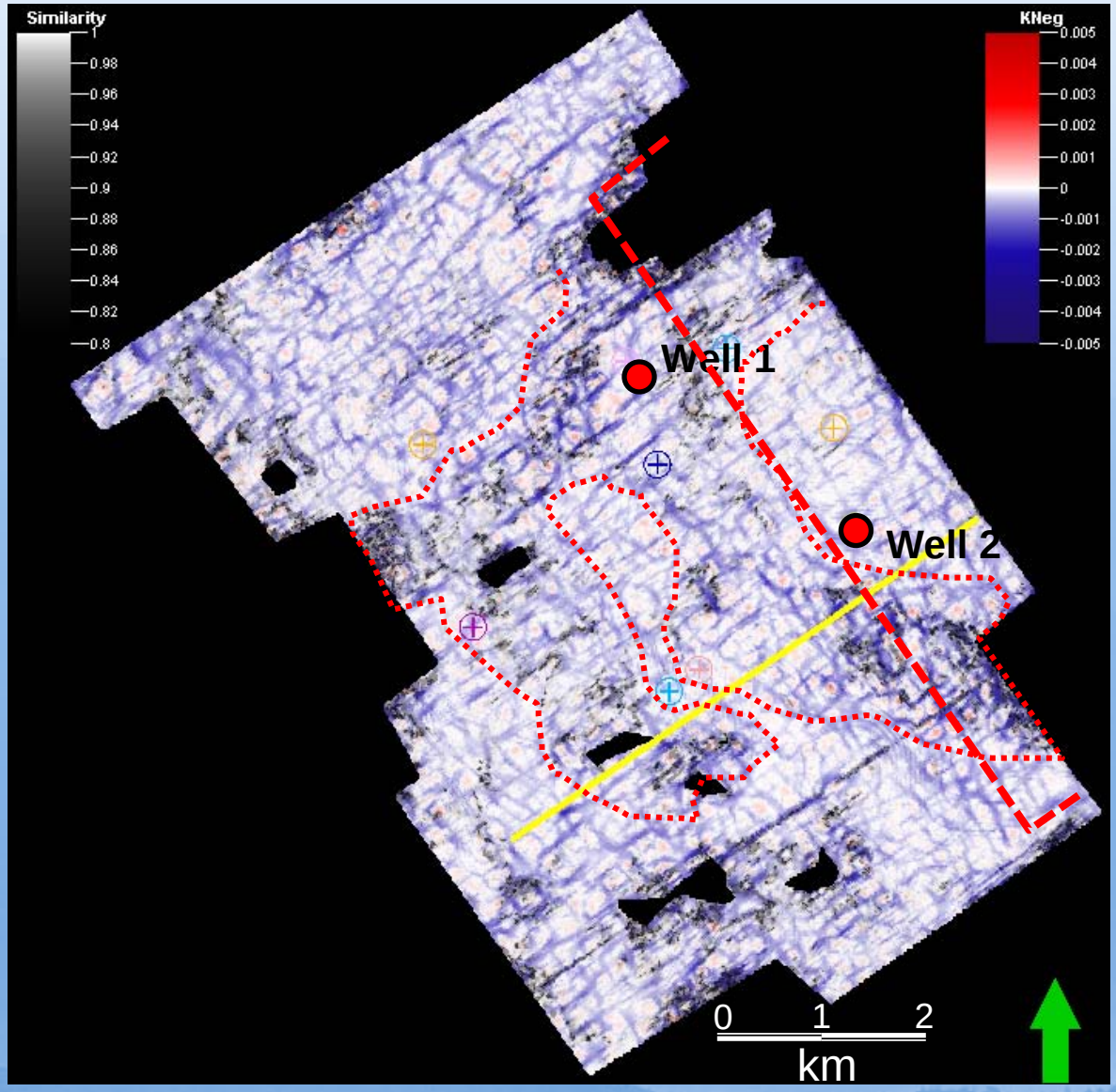
Most negative curvature extracted on Surface A

SEISMIC BASED STUDIES



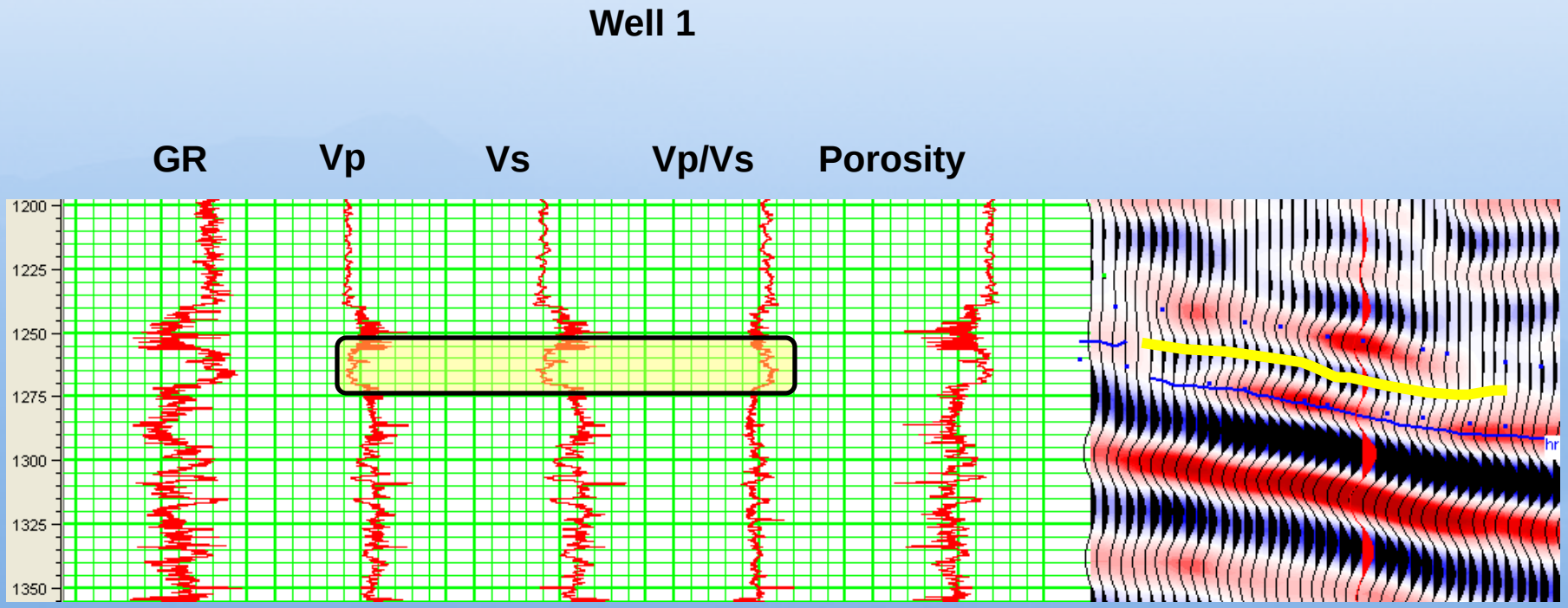
Energy ratio similarity and most negative curvature on Surface A

SEISMIC BASED STUDIES

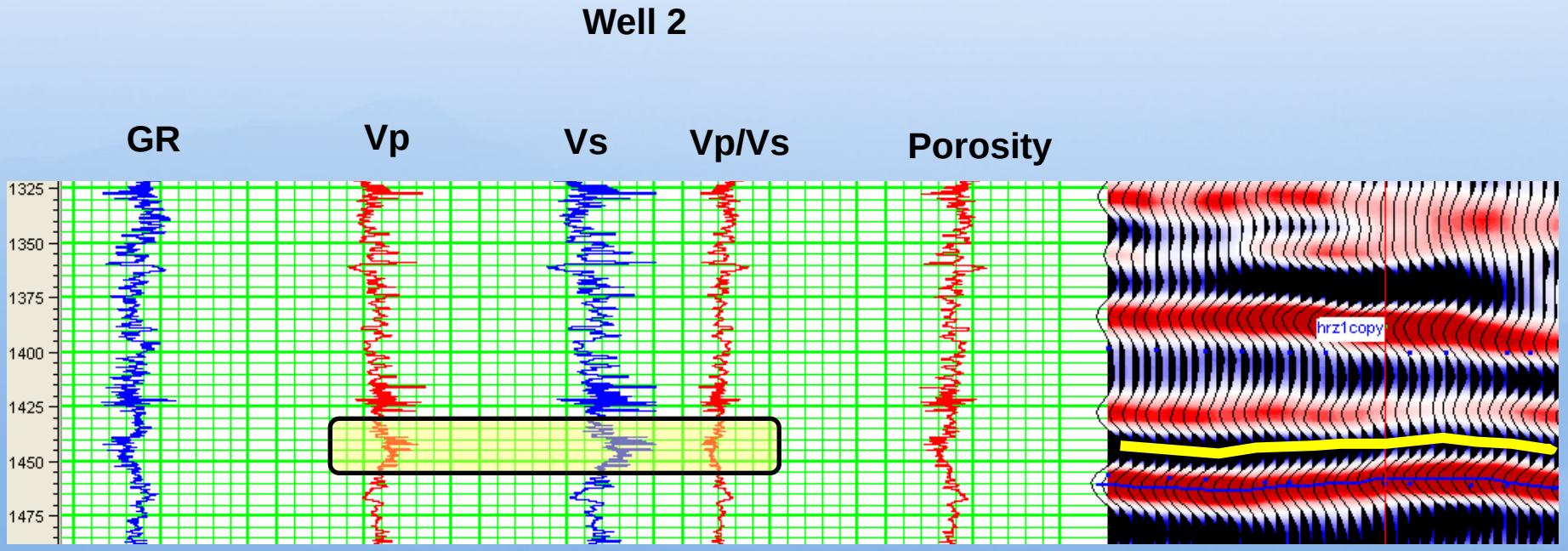


Energy ratio similarity and most negative curvature on Surface A

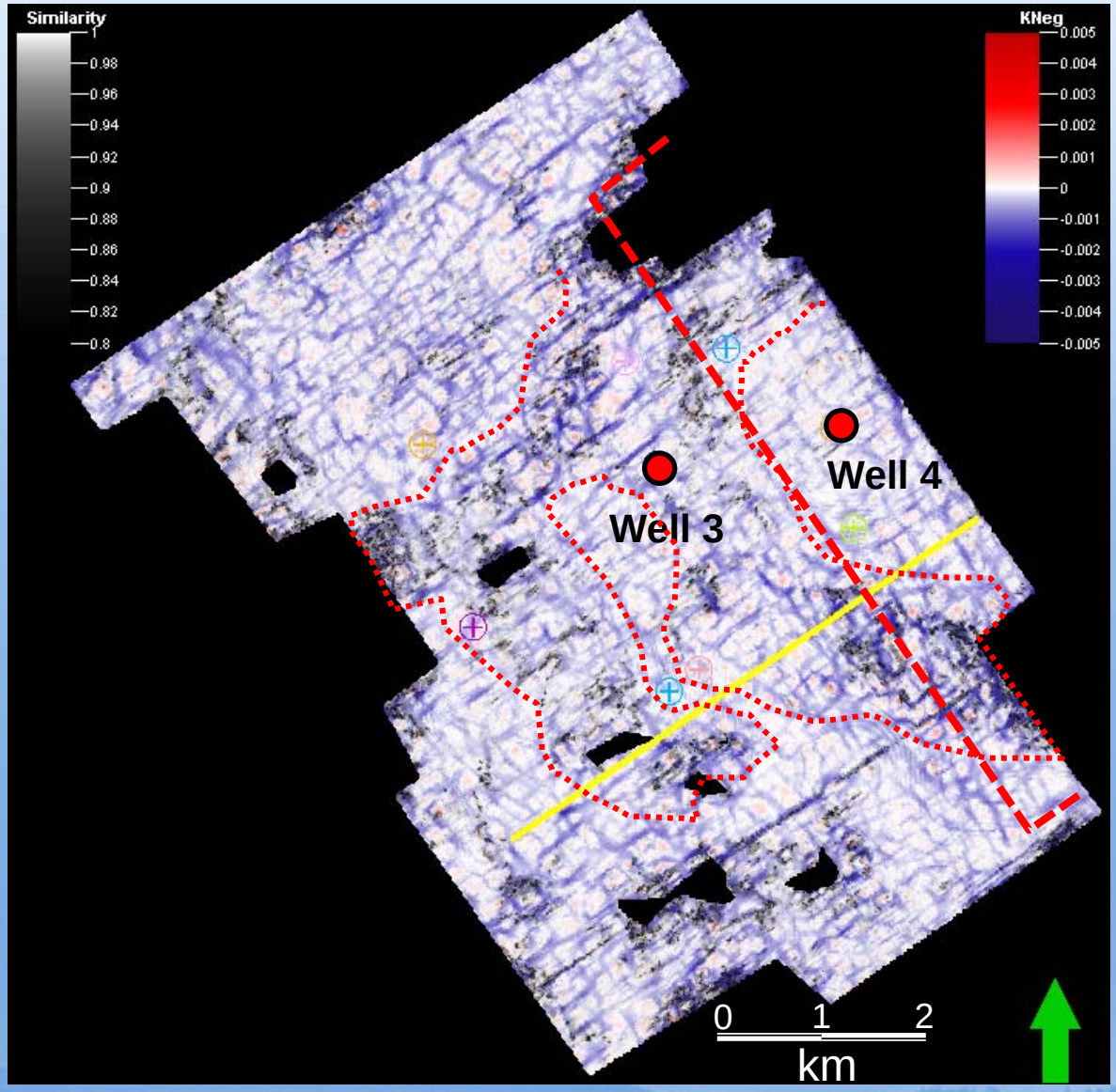
SEISMIC BASED STUDIES



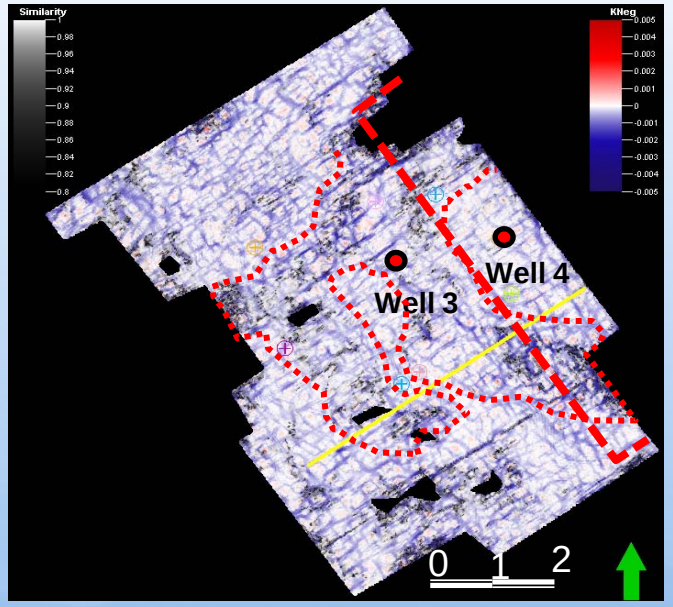
SEISMIC BASED STUDIES

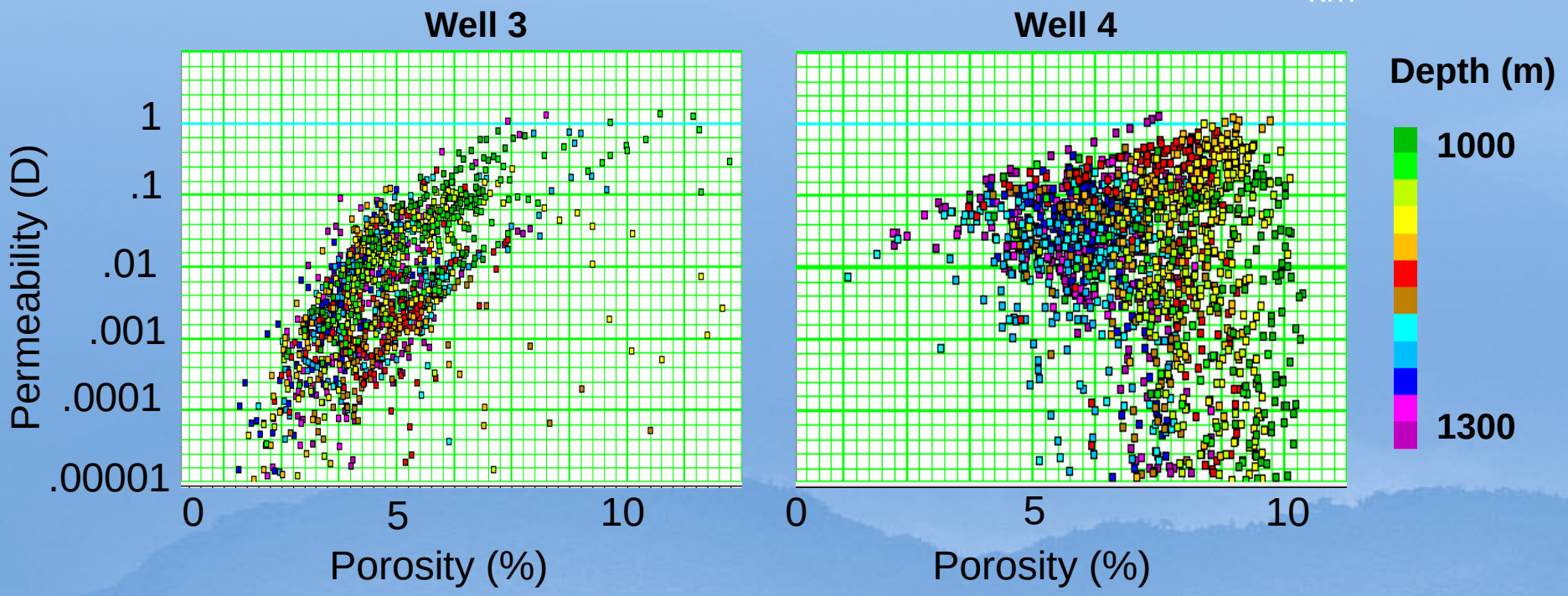


SEISMIC BASED STUDIES



SEISMIC BASED STUDIES





CONCLUSIONS

- Sub volcanic intrusive bodies modify the reservoir quality in its surroundings by several processes.

- Edge detecting attributes provide us clue about areas of increasing fracture density.

- Simple rock physics relationships provide deterministic control for detecting the zones.

- Volcanic bodies and the areas affected by volcanic bodies should be looked at with importance: have the potential of becoming reservoir.

ACKNOWLEDGEMENT

- Dr. Sergio Chavez Perez.
- Dr. Juan Berlanga and his business group at Pemex.
- Industrial sponsors at AASPI consortium.
- Cossey and Associates.