

# A comparison of legacy and recently acquired multichannel seismic data on 95 Ma Pacific oceanic crust south of the Hawaiian Islands

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# The aim

Determine the character of the oceanic crust and Moho North and South of the Hawaiian Islands...

...Where the Pacific plate is flexed downwards and upwards, partly by volcanic loading, and partly by the dynamics of the Hawaiian hotspot...

...To examine the implications for volcano loading, plate flexure and mantle rheology, and the possibility of magmatic underplating beneath the flexed oceanic crust.

# How?... Two multichannel seismic expeditions

**1982 – RC2308**

*R/V Robert D. Conrad + R/V Kana Keoki*



**2018 – MGL1806**

*R/V Marcus G. Langseth*



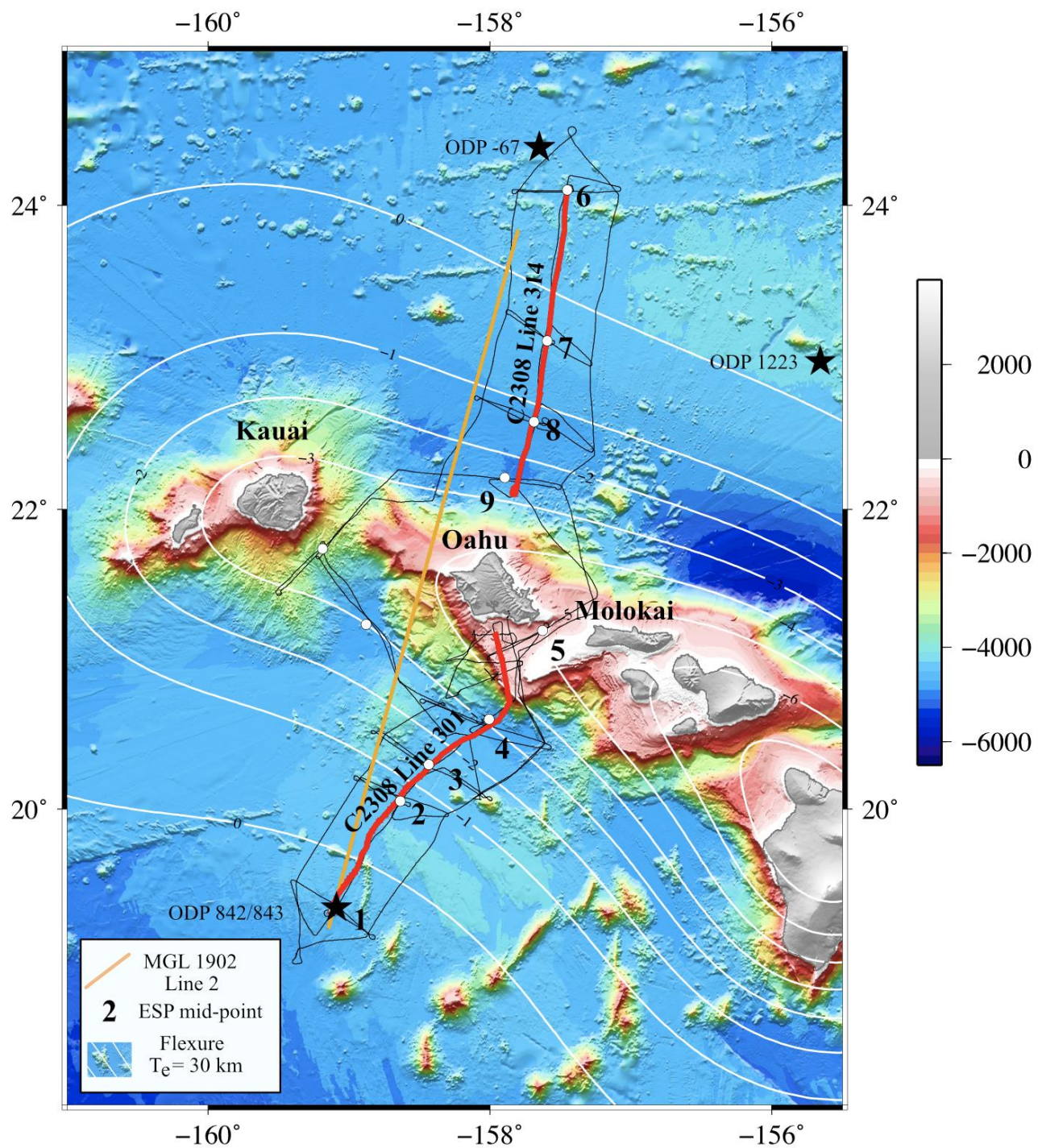
Image credits:

*R/V Robert D. Conrad* – Henry Chezar

*R/V Kana Keoki* – Scripps Institution of Oceanography Photographs

*R/V Marcus G. Langseth* - Lamont-Doherty Earth Observatory





***R/V Robert D. Conrad + R/V Kana Keoki  
(RC2308 - 1982)***

- Conrad and Kana Keoki shooting,  
Conrad receiving
- Conrad shooting and receiving
- 1,2,3,...** Expanding spread profile  
(velocity analysis) locations

***R/V Marcus G. Langseth  
(MGL1806 - 2018)***

- *One line of 8 in total*

## 1982 - RC2308

*R/V Robert D. Conrad + R/V Kana Keoki*

Two ships steam, one behind the other

Both ships shooting alternately

Shot spacing: 30 seconds + random dither

48 receivers on single streamer behind *Conrad*

Streamer length of 3.6 km

**BUT effective offset from two ships' shots: 7.2 km**

***Some lines with an effective offset of 16km!***

## 2018 – MGL1806

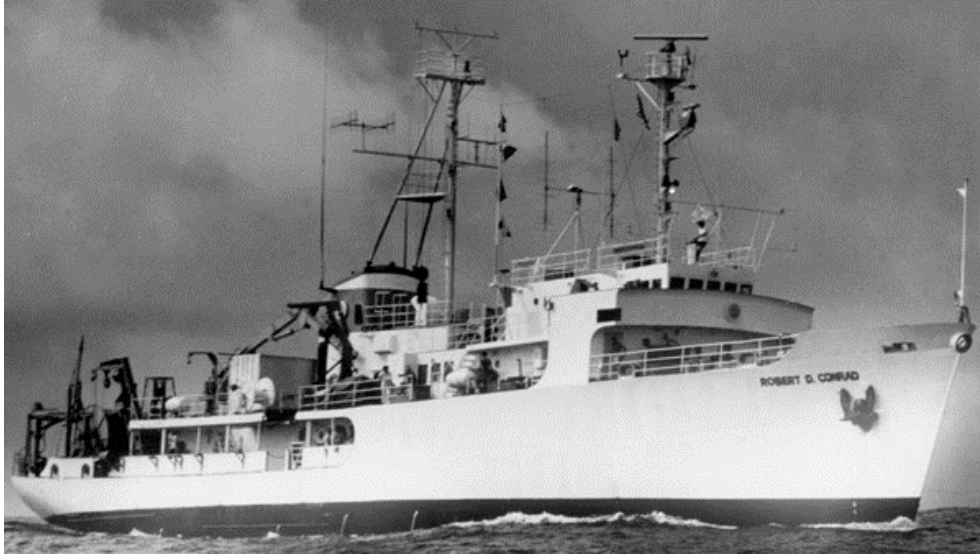
*R/V Marcus G. Langseth*

Single, 15 km long streamer

~28 second shot spacing

Ocean bottom seismometer (OBS) data collected

OBS spacing 10-15 km



The 1982 expedition data has been used in ocean island structure and plate flexure studies for *+35 years!*...

(e.g. *Watts et al. 1985; Bellas et al. 2020*)



But can we get even more out of these legacy data?....

And what can these data bring to contemporary seismic geophysics?

## **To breathe new life into old seismic, we...**

Read and digitised original field tapes, and deblended shots from two ships (*Provided by LDEO – see Acknowledgements*)

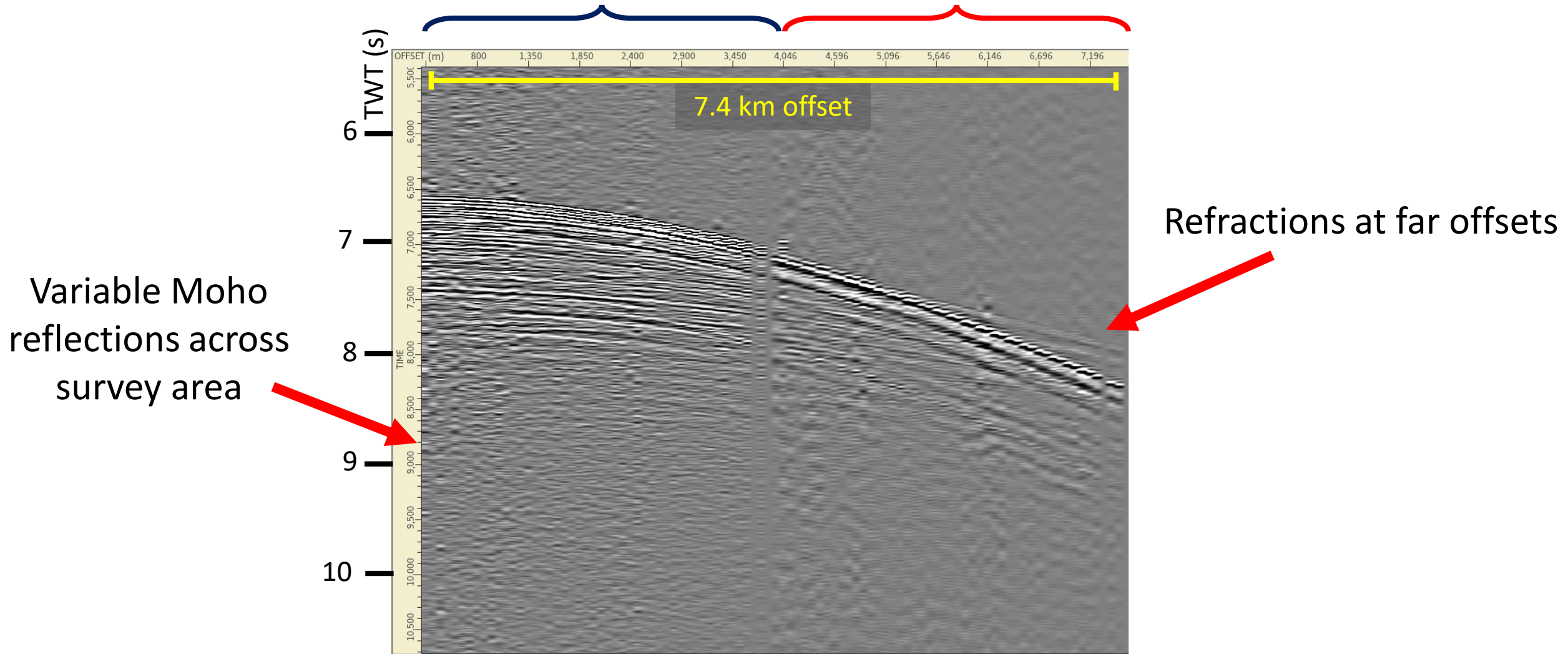
Used the original paper seismic sections and ship navigation data to build acquisition geometry headers for digitised seismic traces

Merged two ships' shot gathers to form digital 7.2km offset, 96 channel composite gathers with complete SEG-Y headers.



*Conrad shooting into Conrad's streamer*

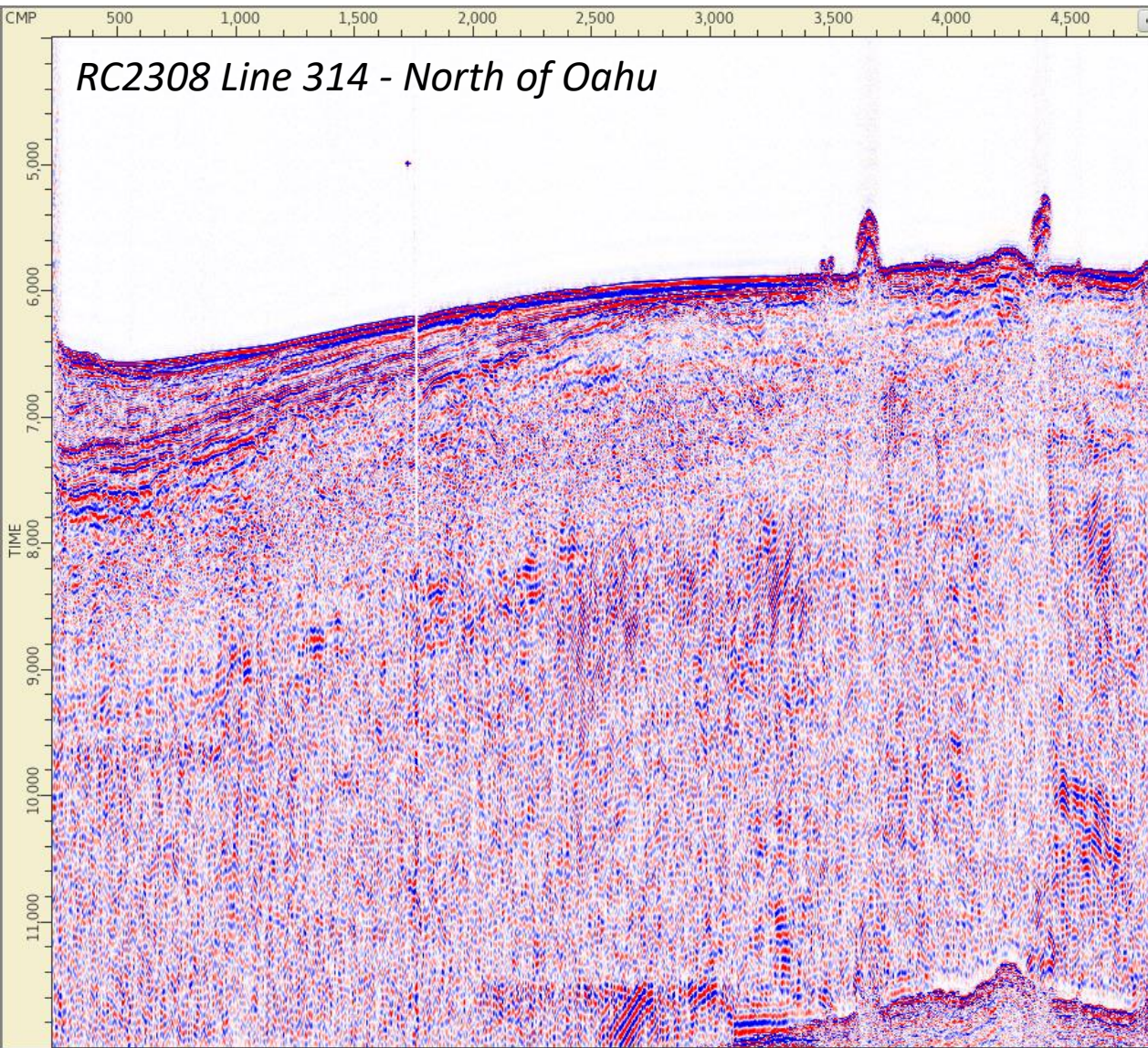
*Kana Keoki shooting into Conrad's streamer*



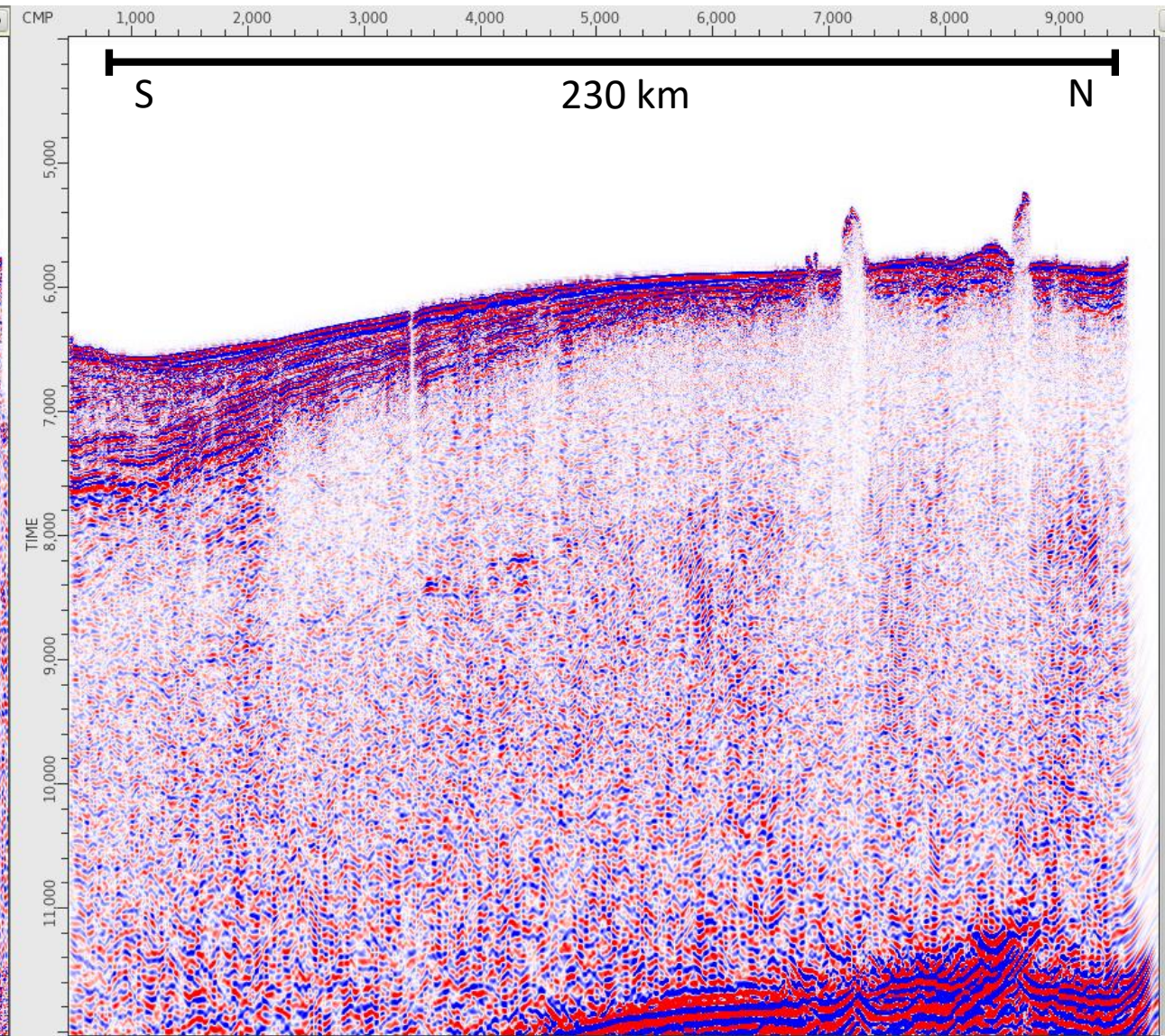
*Sample 2-ship composite shot gather from legacy data  
RC2308 Line 314 - North of Oahu*



*And with some preliminary reprocessing...*



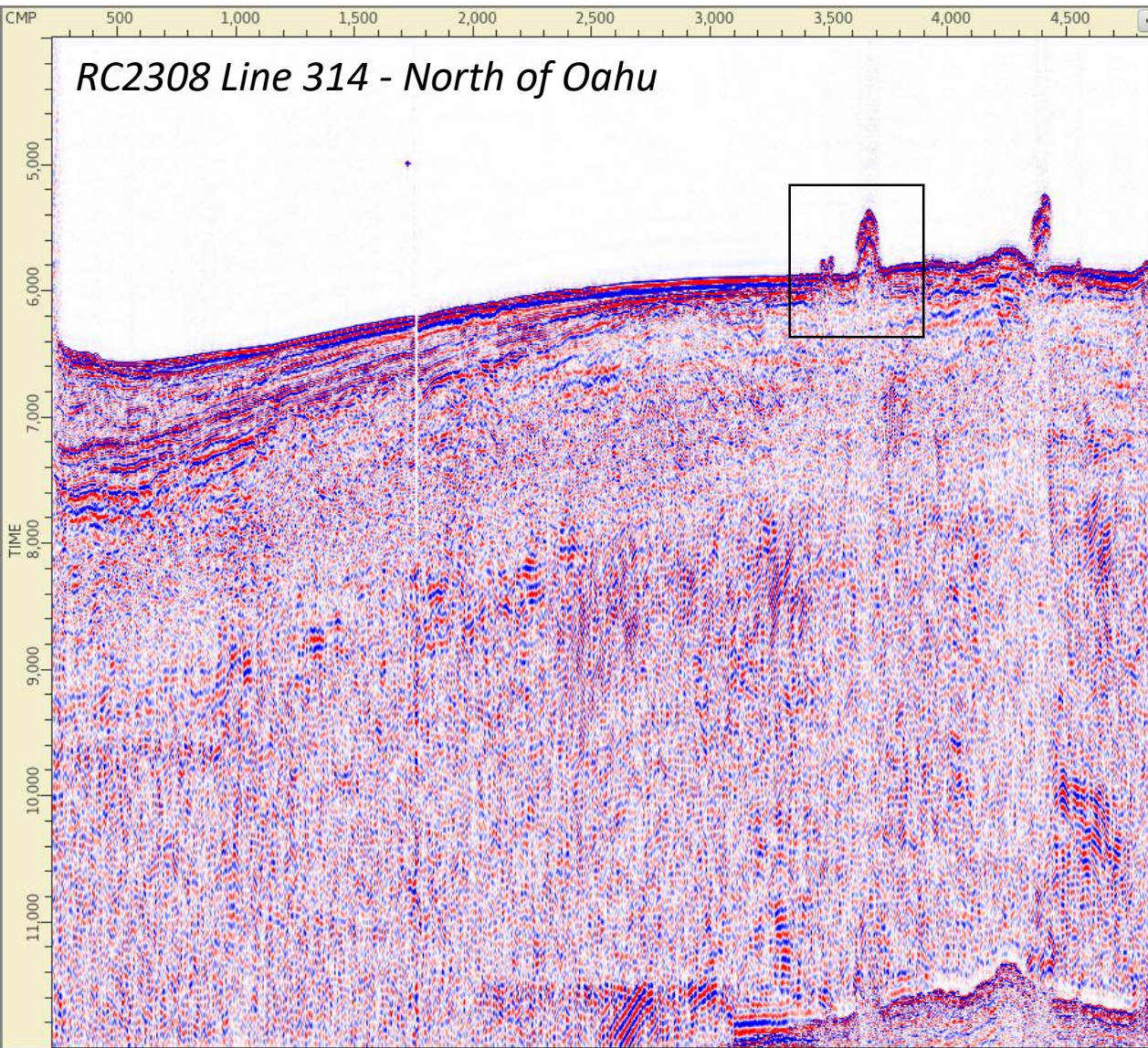
*Legacy stack (provided by LDEO to ASP\_UTIG)*



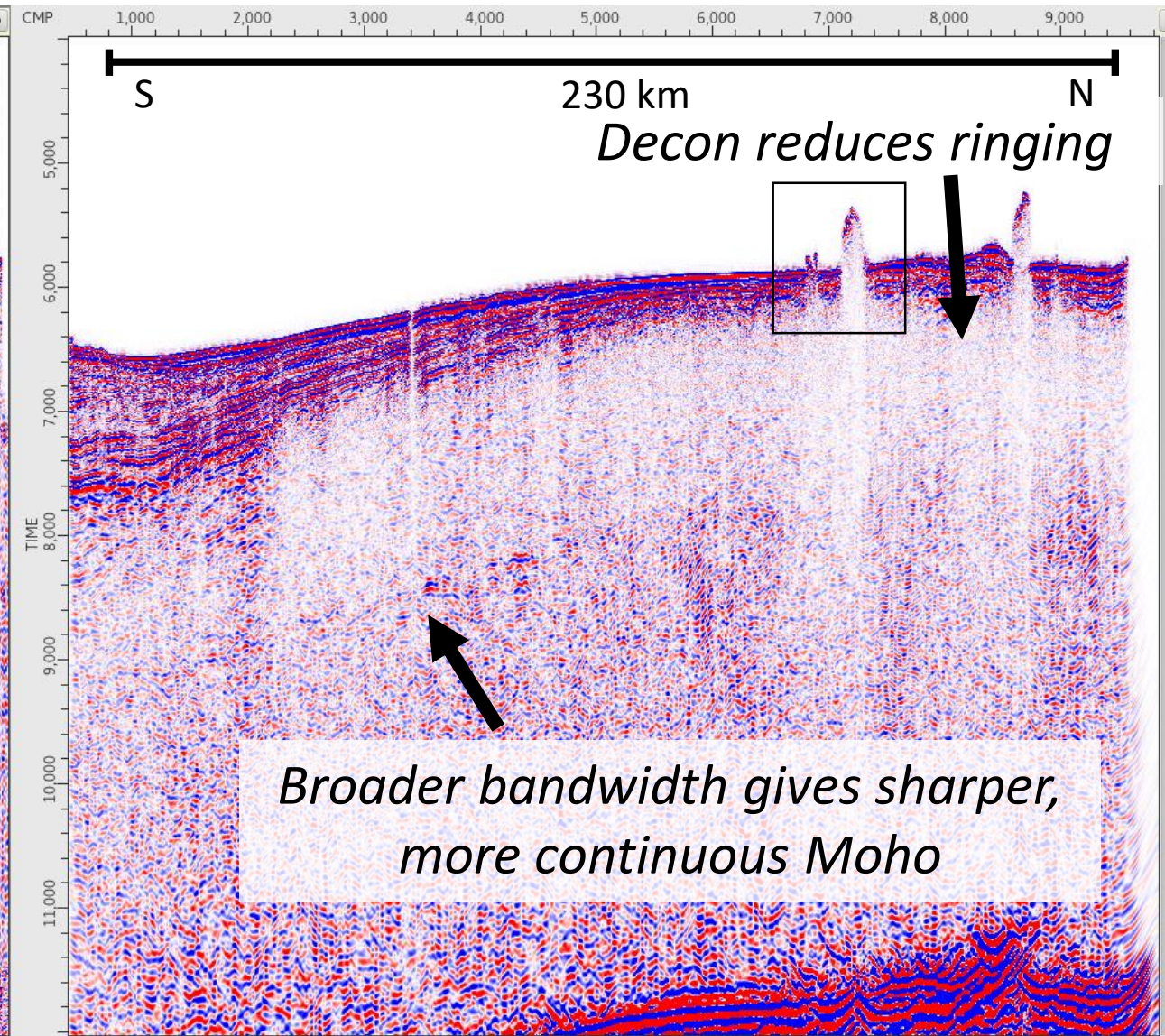
*Preliminary reprocessed and PreSTM*



*And with some preliminary reprocessing...*



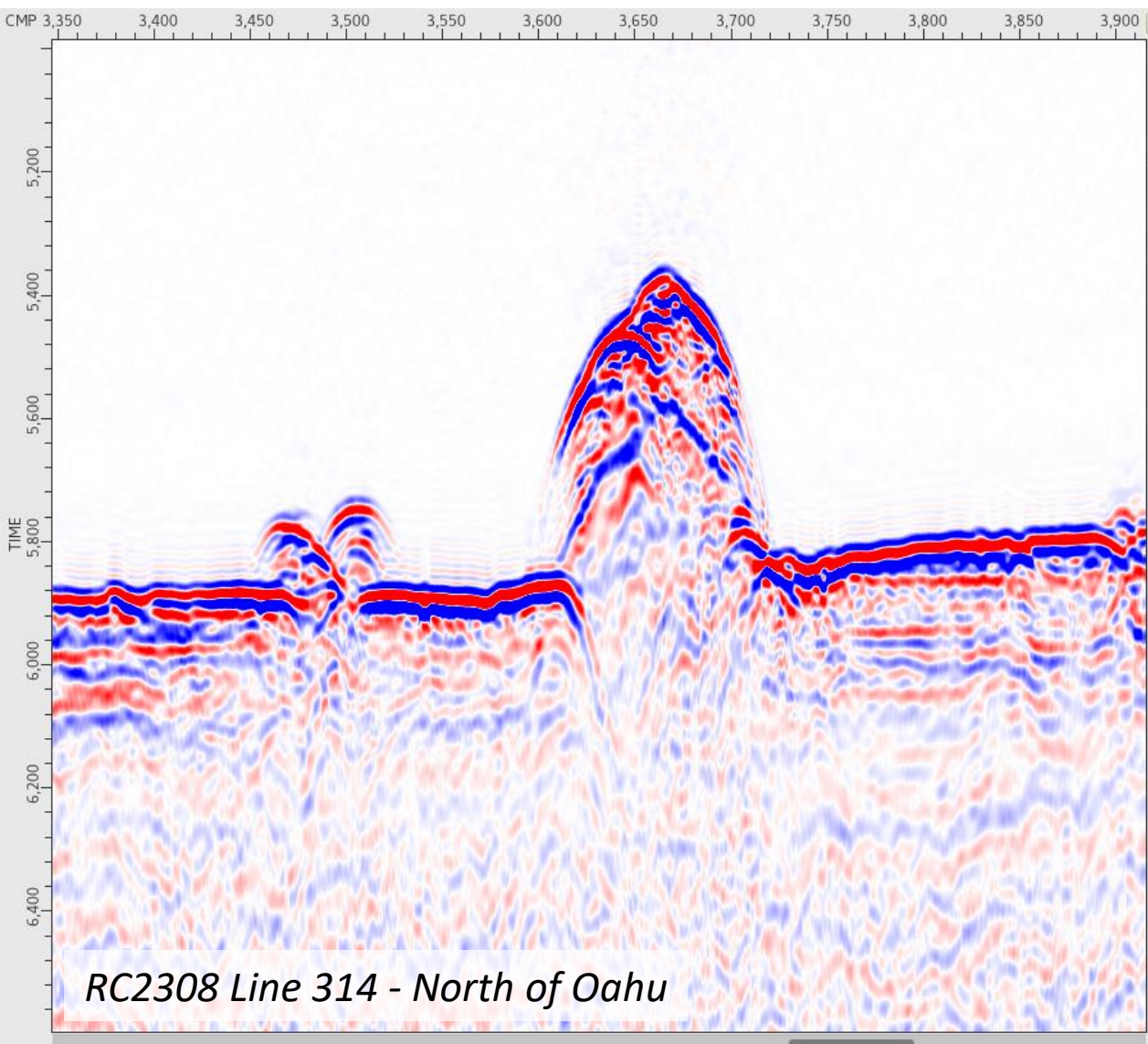
*Legacy stack (provided by LDEO to ASP\_UTIG)*



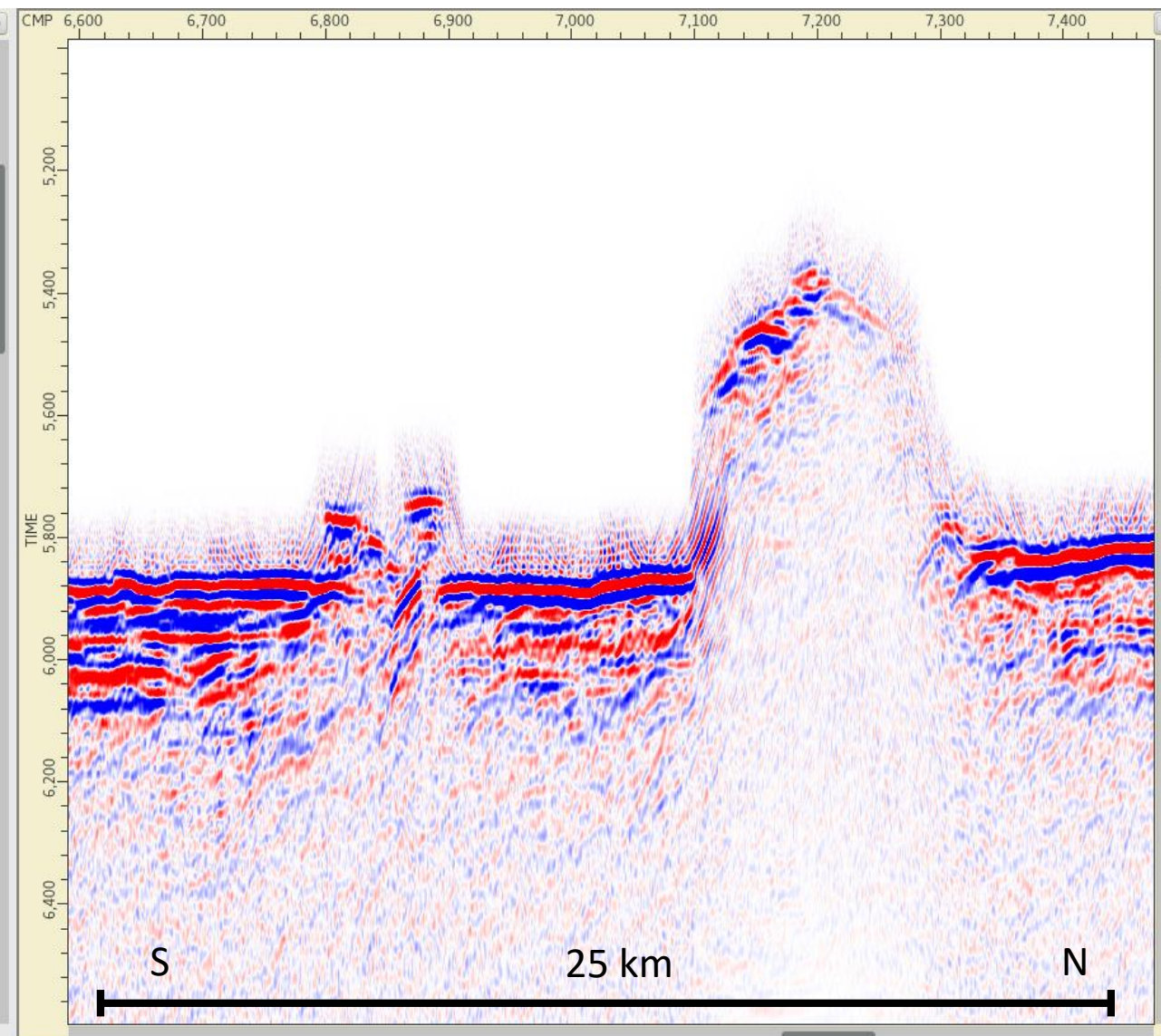
*Preliminary reprocessed and PreSTM*



*And with some preliminary reprocessing...*



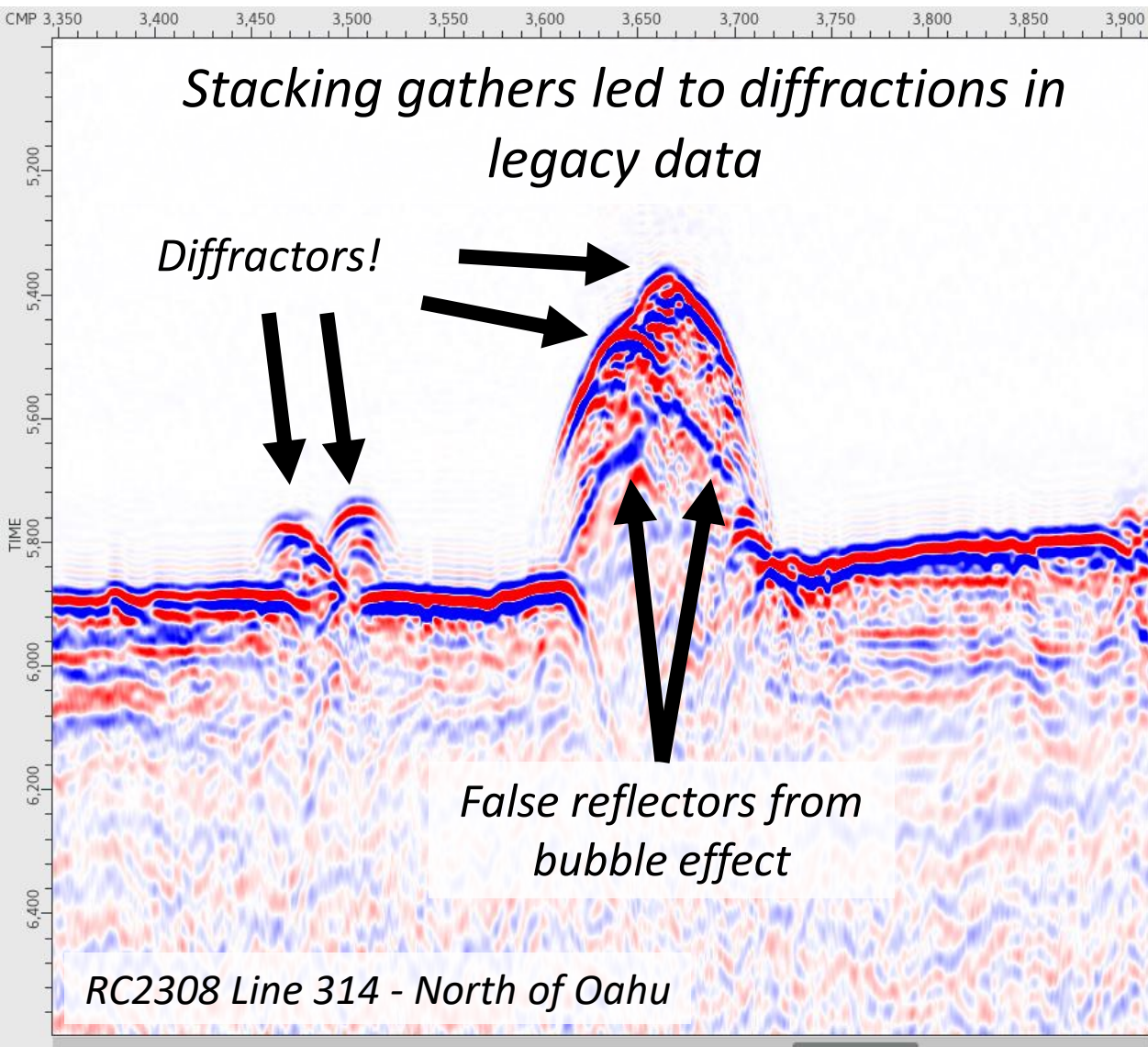
*Legacy stack (provided by LDEO to ASP\_UTIG)*



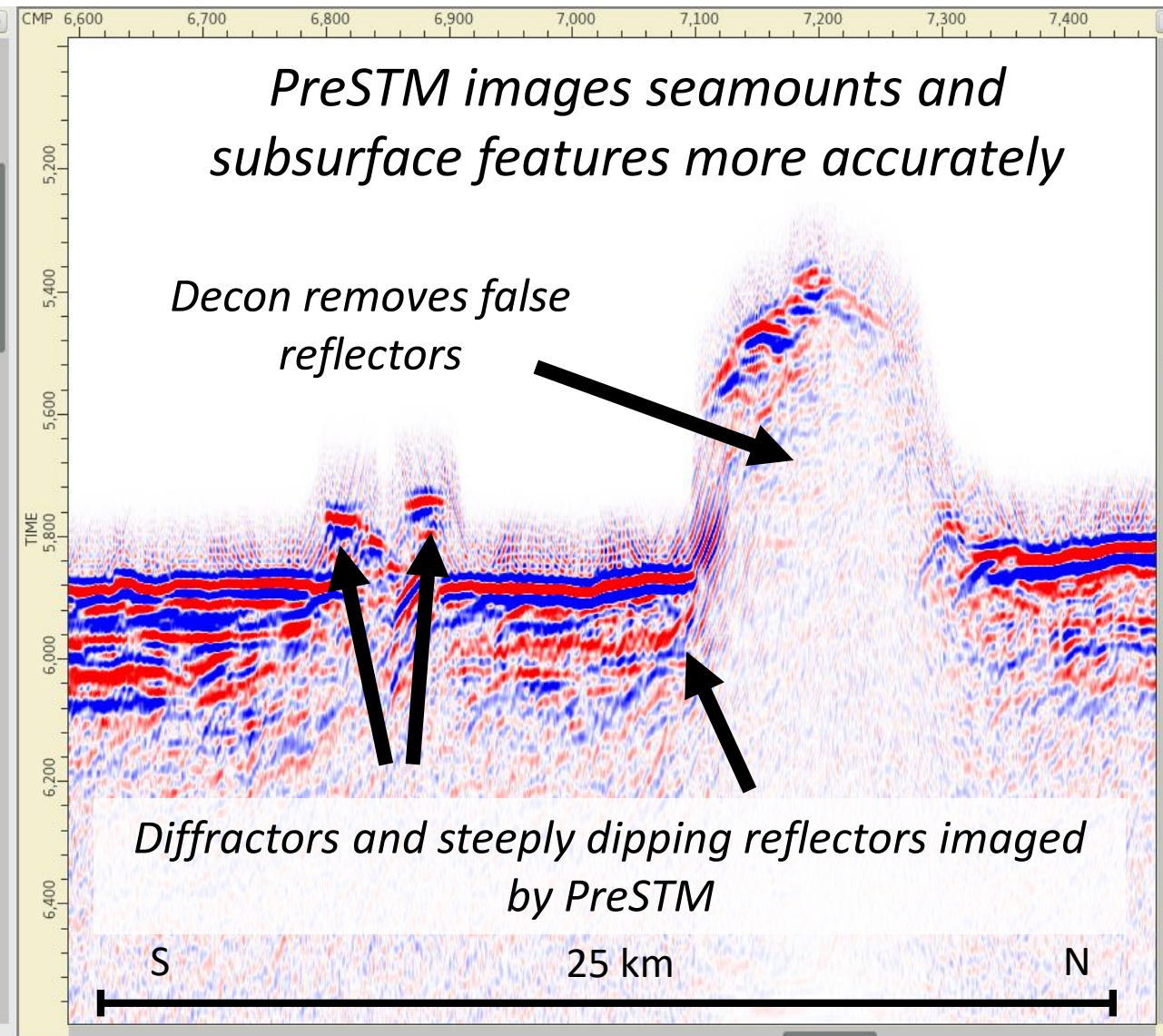
*Preliminary reprocessed and PreSTM*



*And with some preliminary reprocessing...*

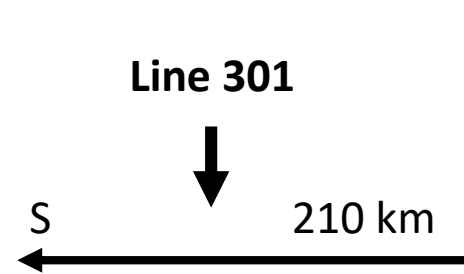
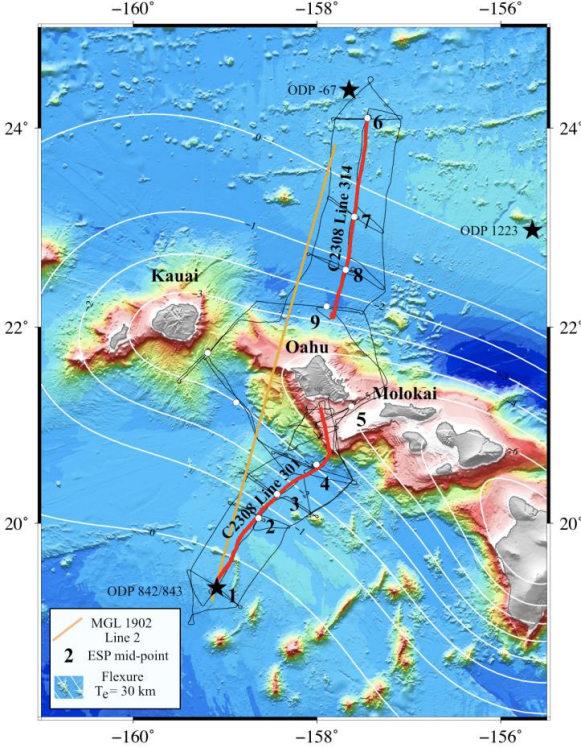


*Legacy stack (provided by LDEO to ASP\_UTIG)*



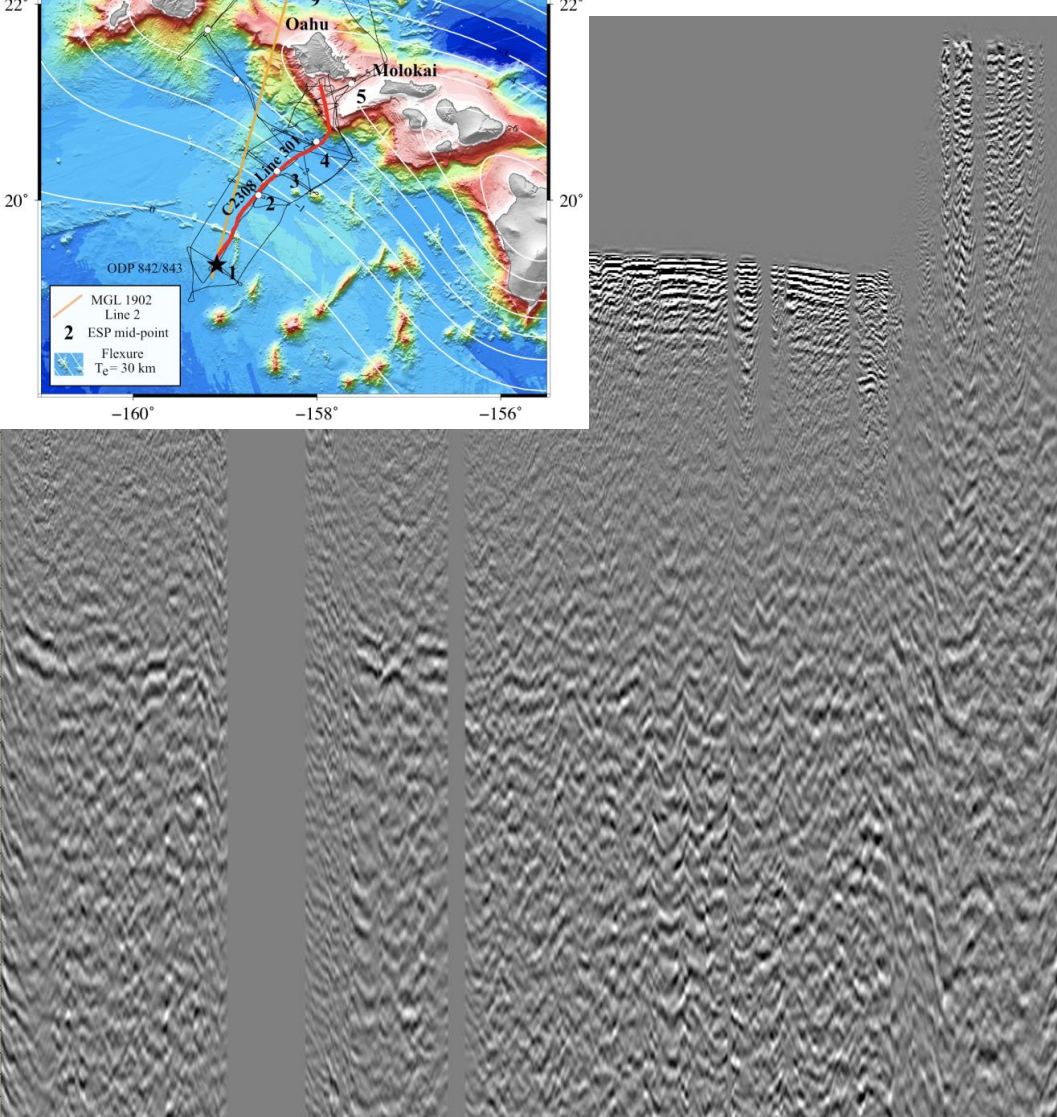
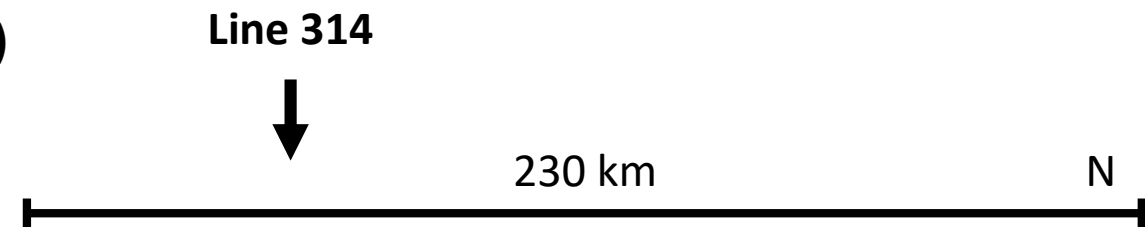
*Preliminary reprocessed and PreSTM*





**Edifice  
(Oahu/Molokai)**

↓



**Depth subsea**

— 2 km —

— 4 km —

— 6 km —

— 8 km —

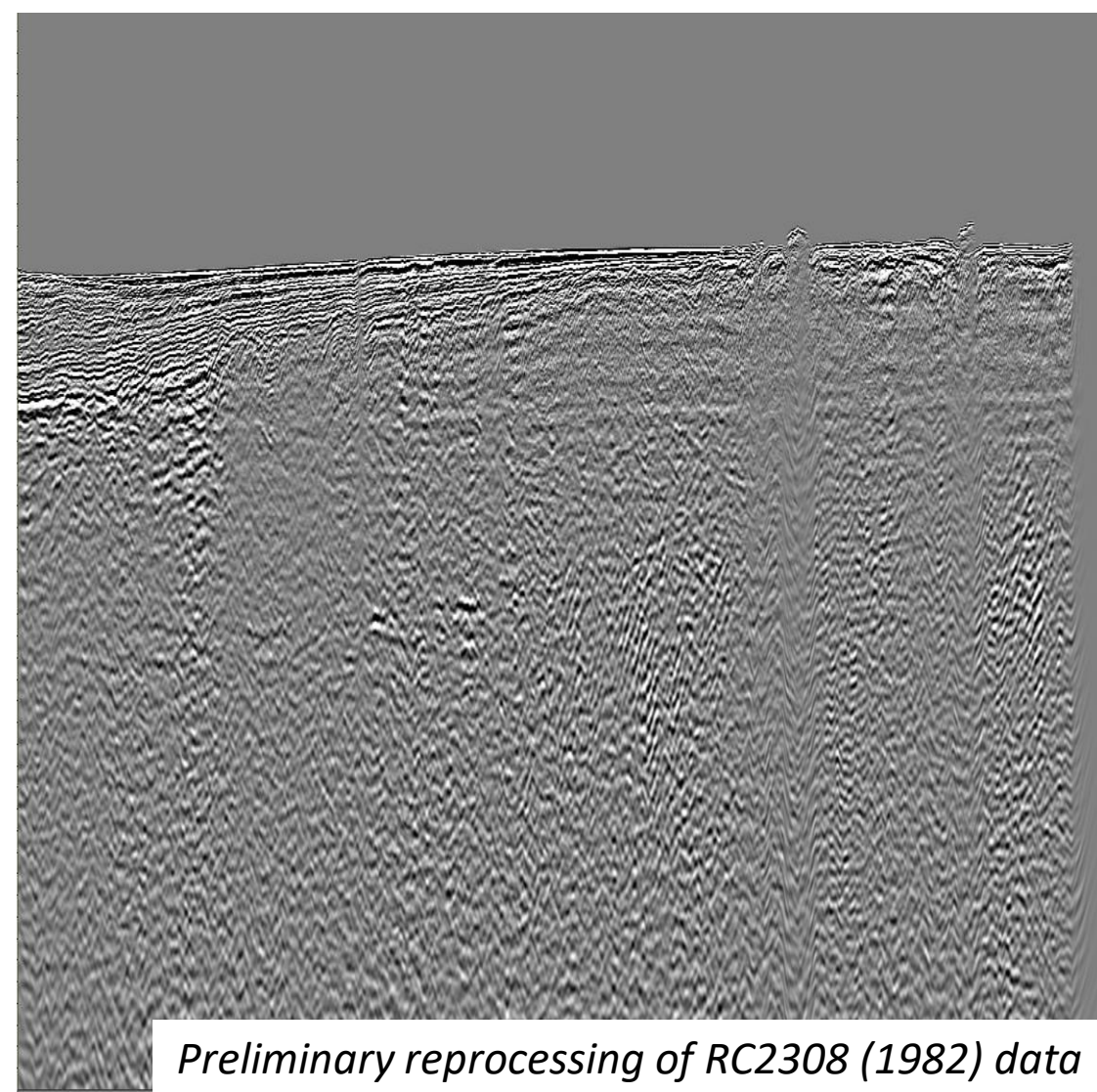
— 10 km —

— 12 km —

— 14 km —

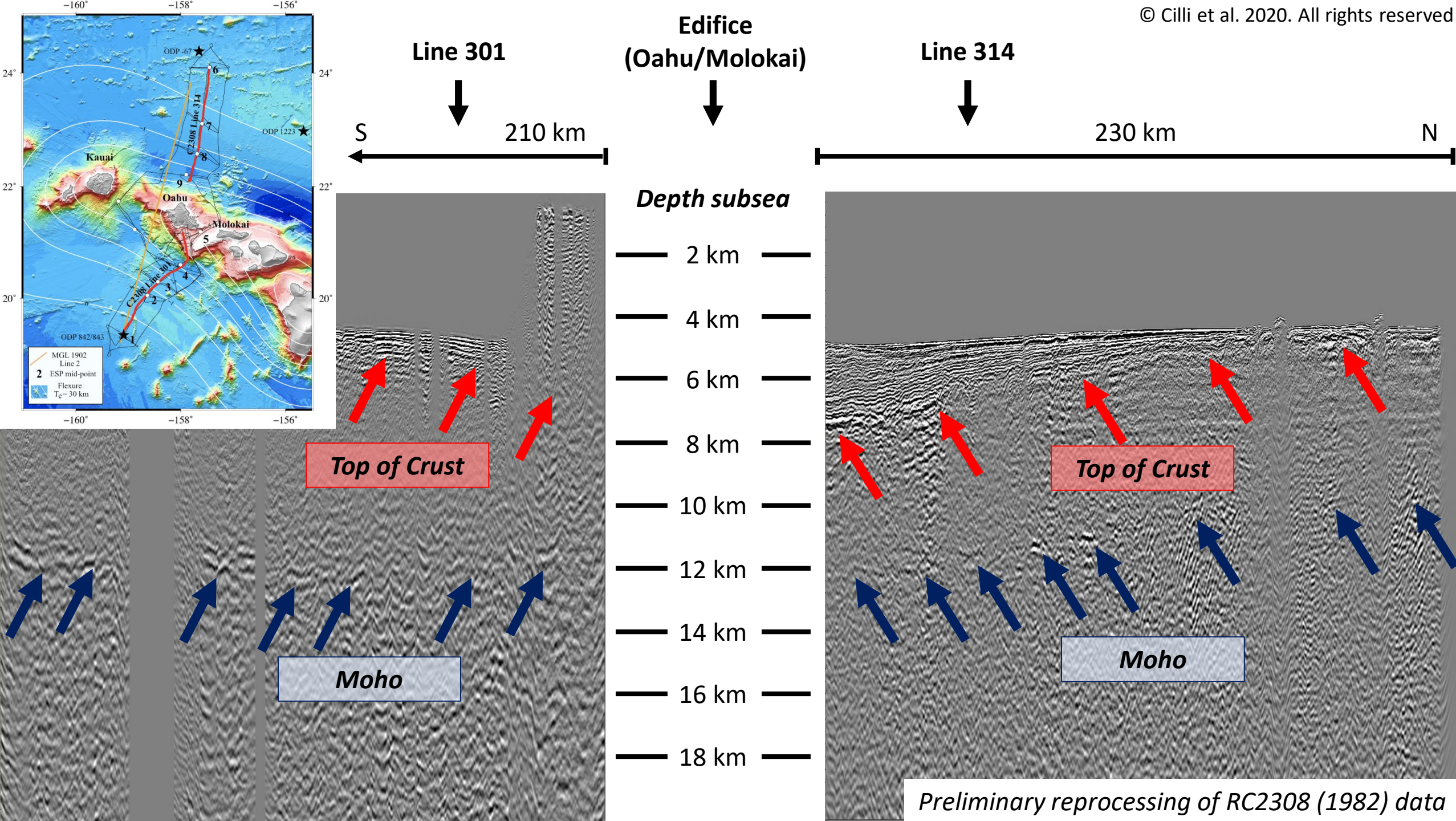
— 16 km —

— 18 km —

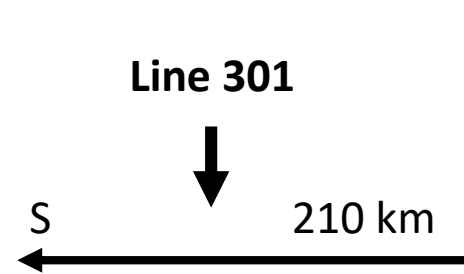
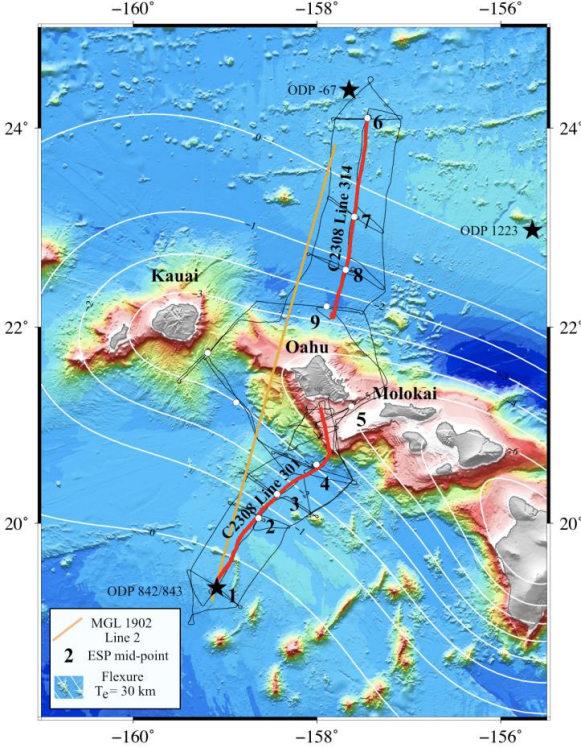


*Preliminary reprocessing of RC2308 (1982) data*

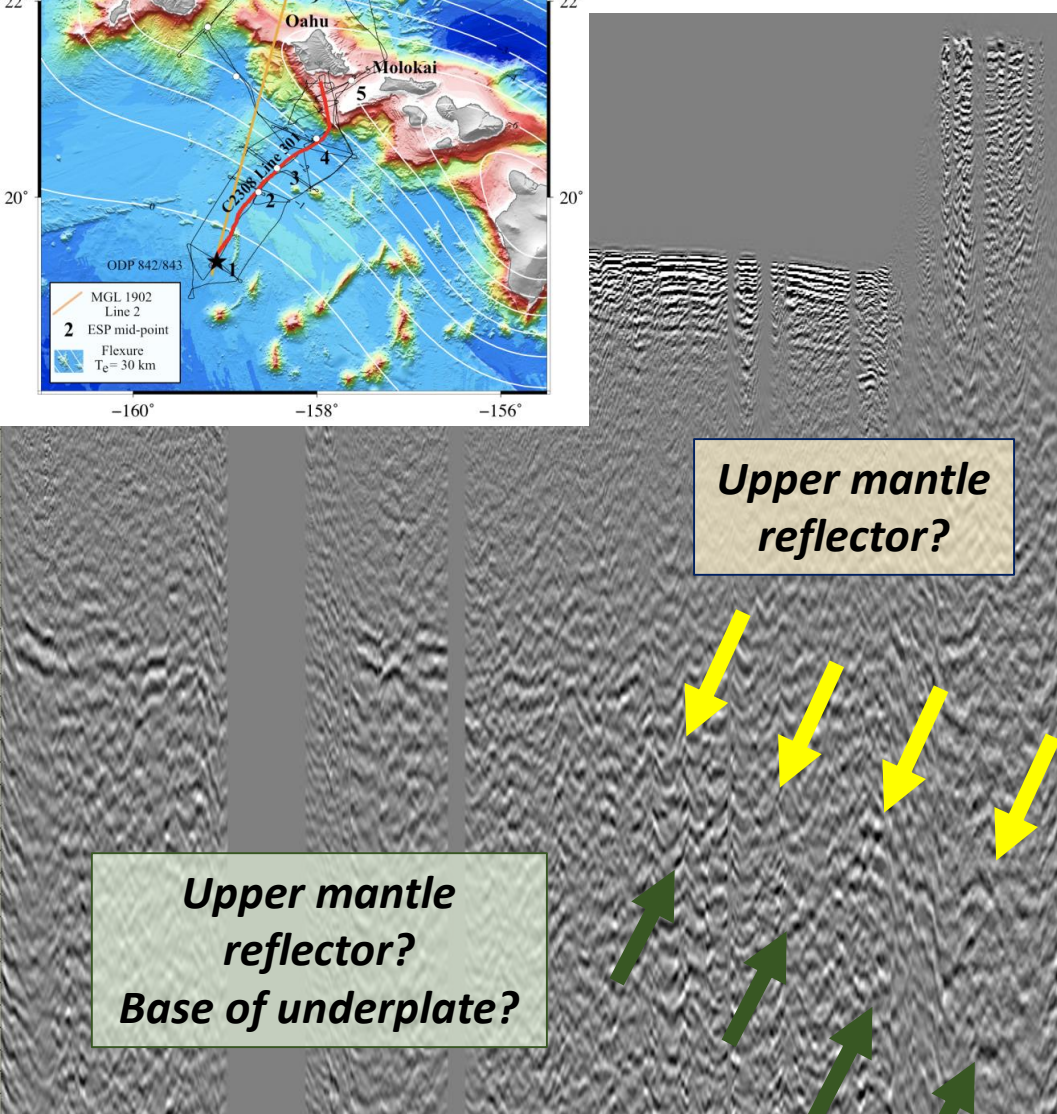
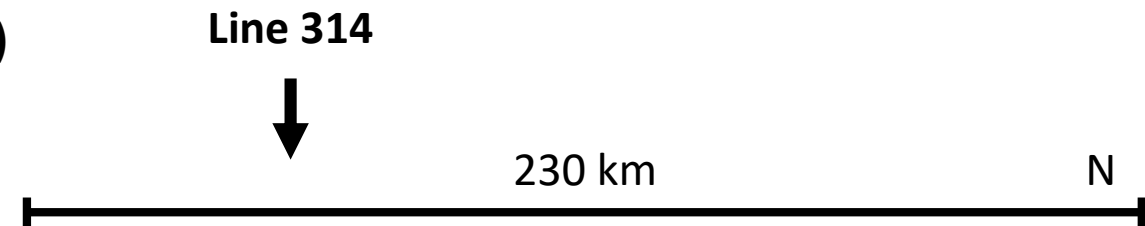








**Edifice  
(Oahu/Molokai)**



*Depth subsea*

2 km

4 km

6 km

8 km

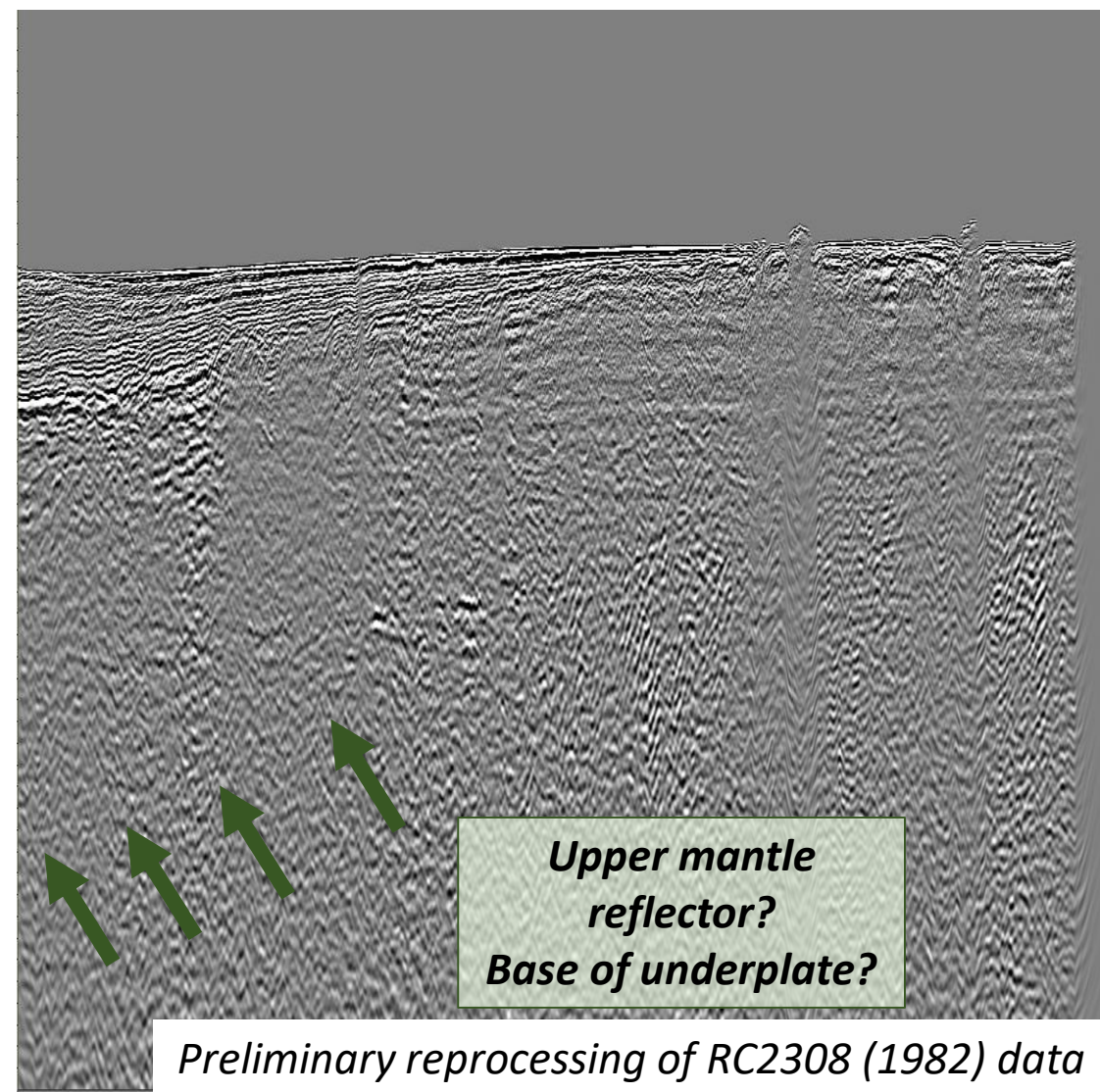
10 km

12 km

14 km

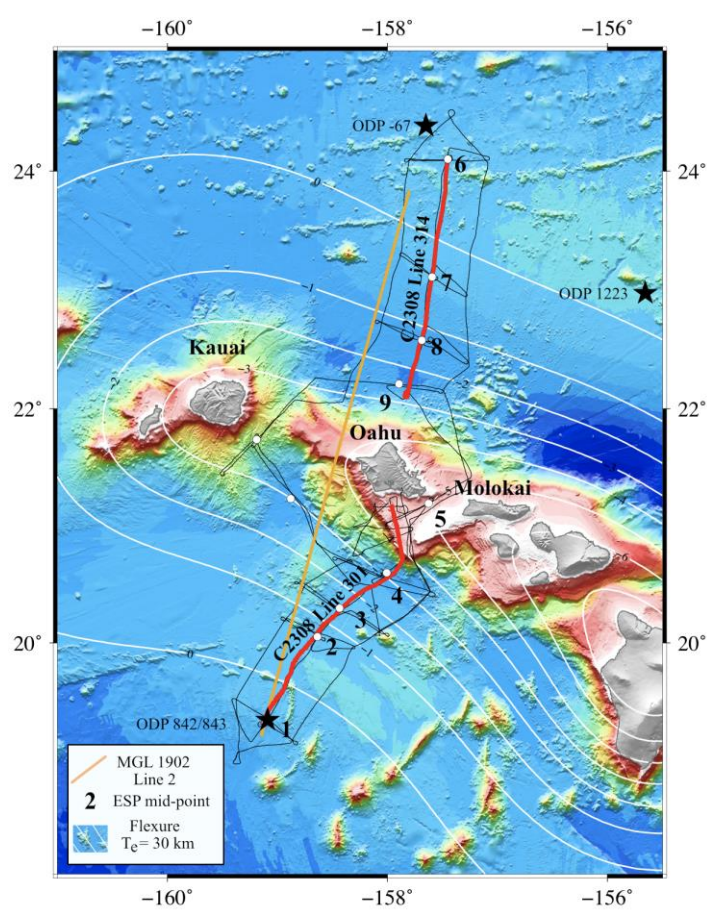
16 km

18 km

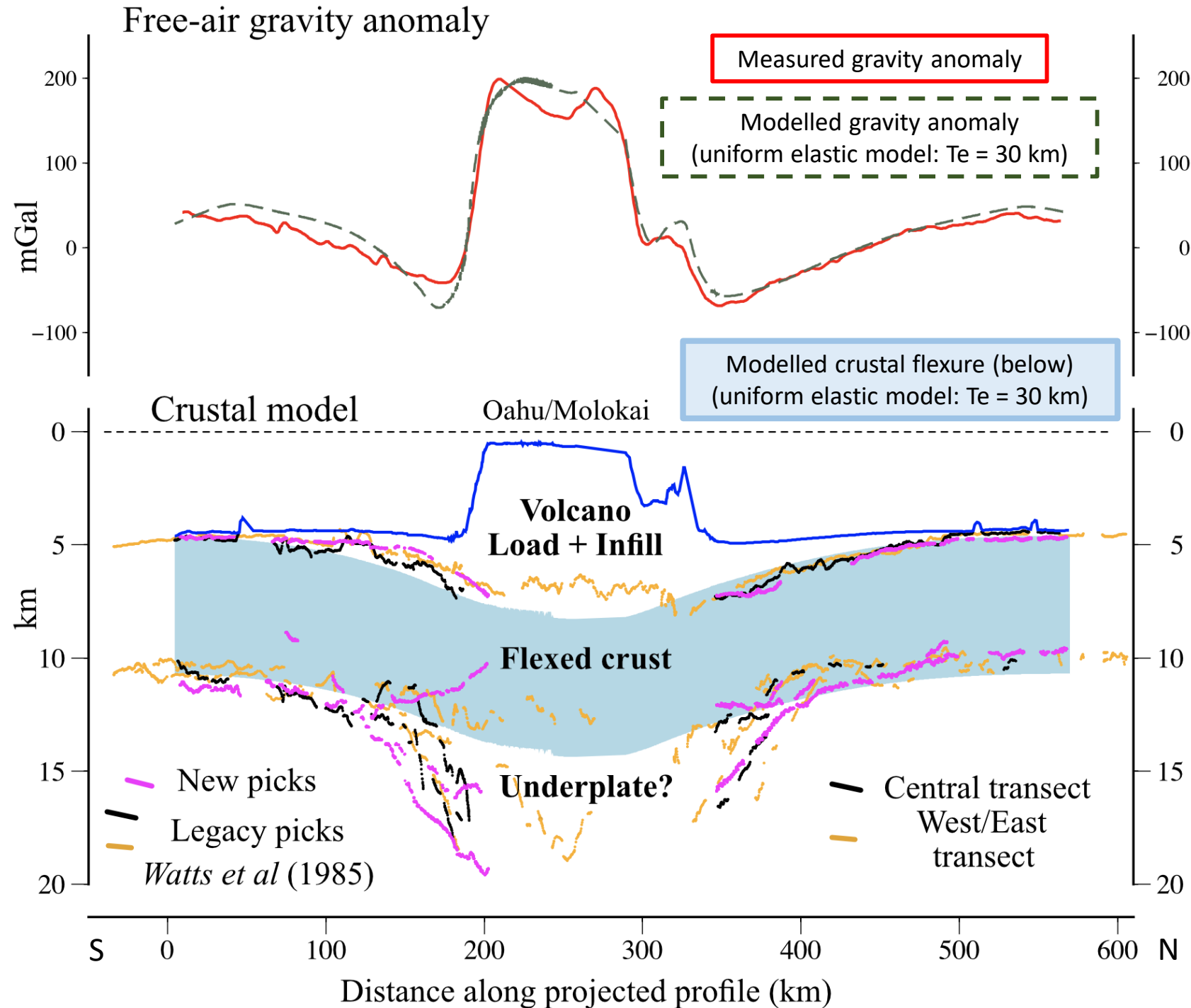


*Preliminary reprocessing of RC2308 (1982) data*





*Picking key reflectors on reprocessed data (magenta) brings new insights compared to legacy picks (black and orange)*

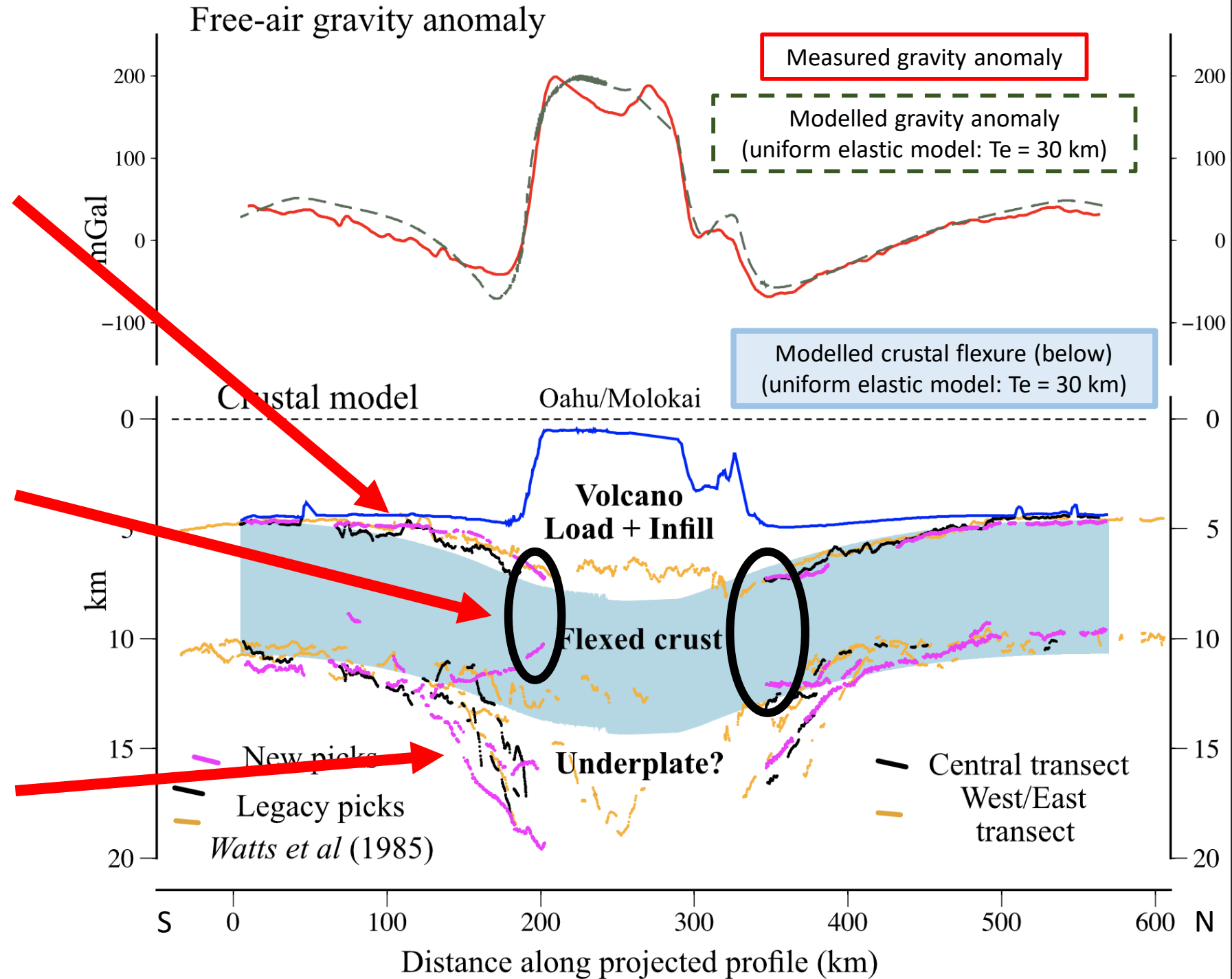


# Free-air gravity anomaly

*Smoother, more continuous reflectors*

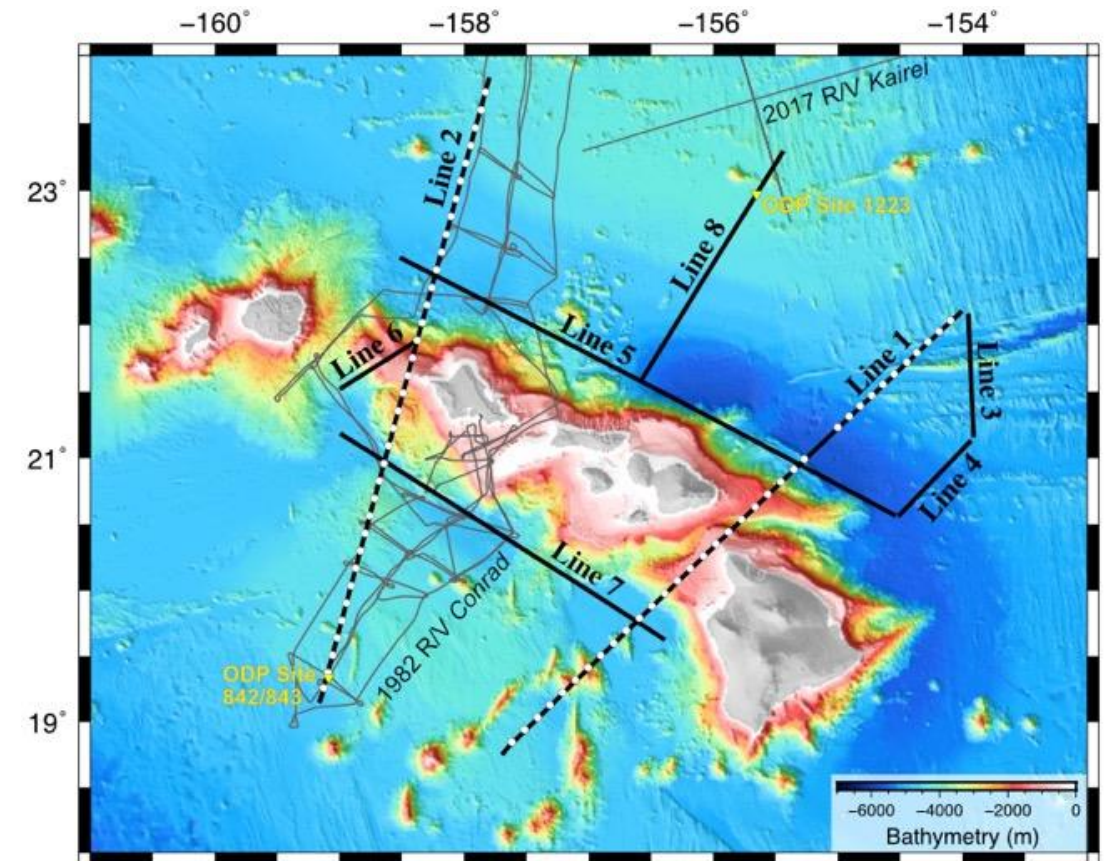
*Crustal thinning towards the edifice*

*Cannot rule out underplating*



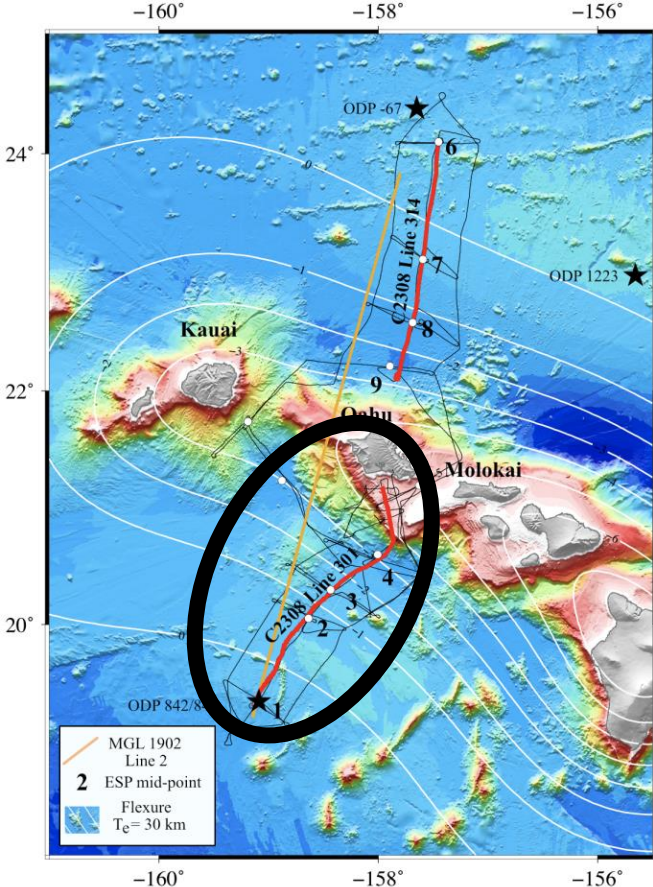


And how does this seismic reprocessing relate to the 2018 seismic survey MGL1806 on R/V *Marcus G. Langseth*?...



MGL1806 (2018) survey geometry

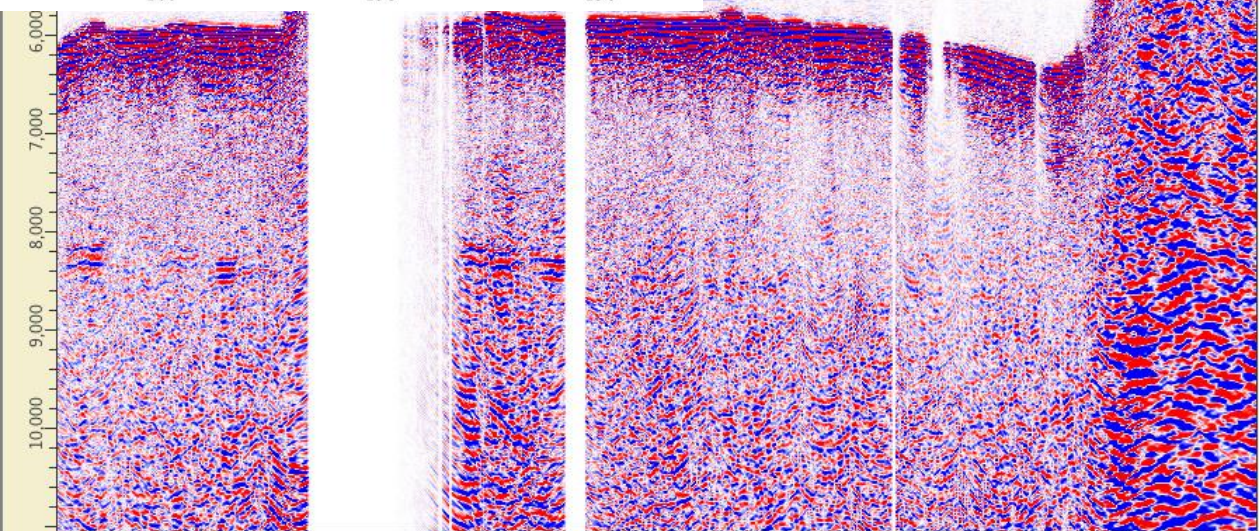




RC2308 (1982)

S 210 km N

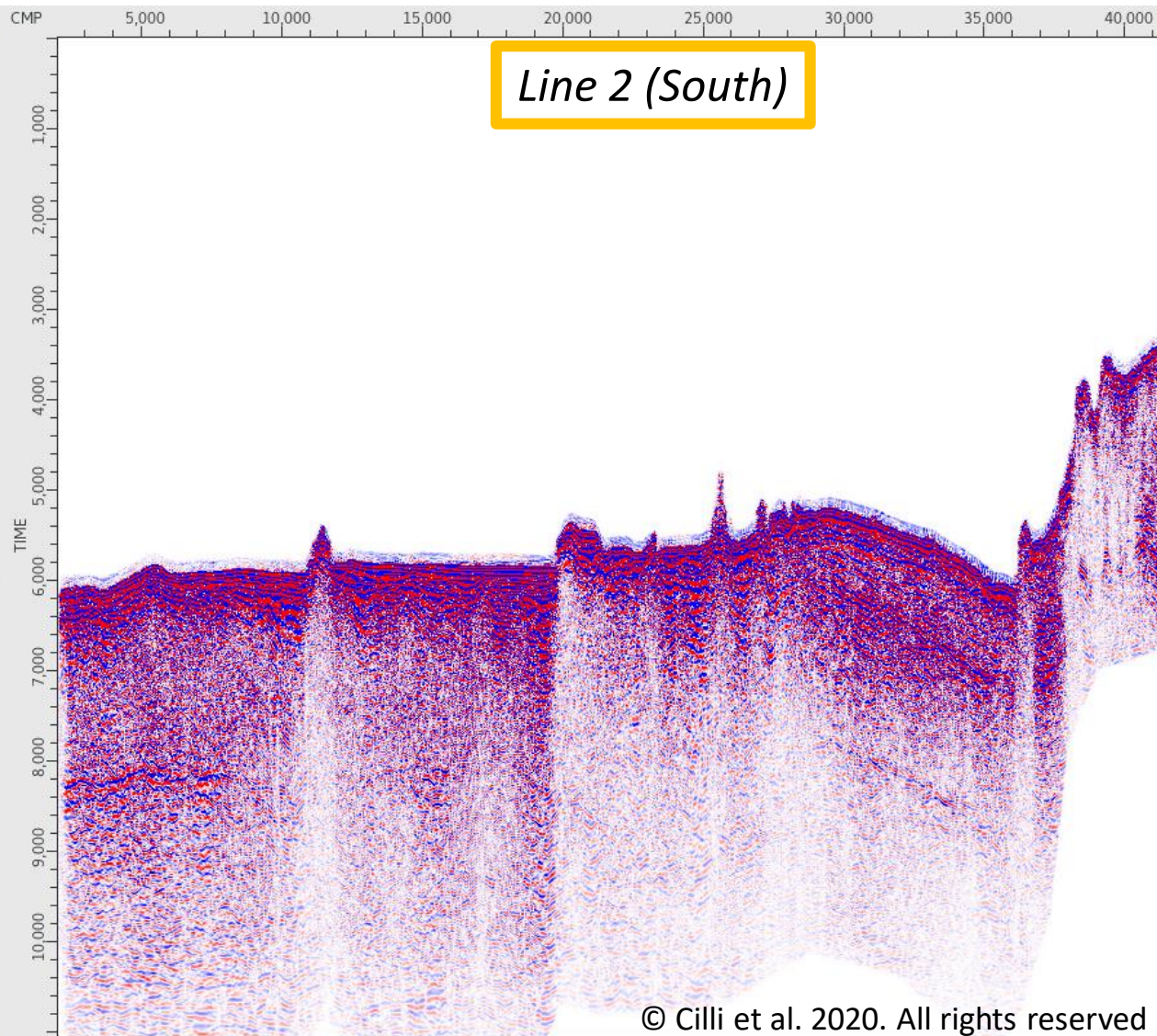
Line 301



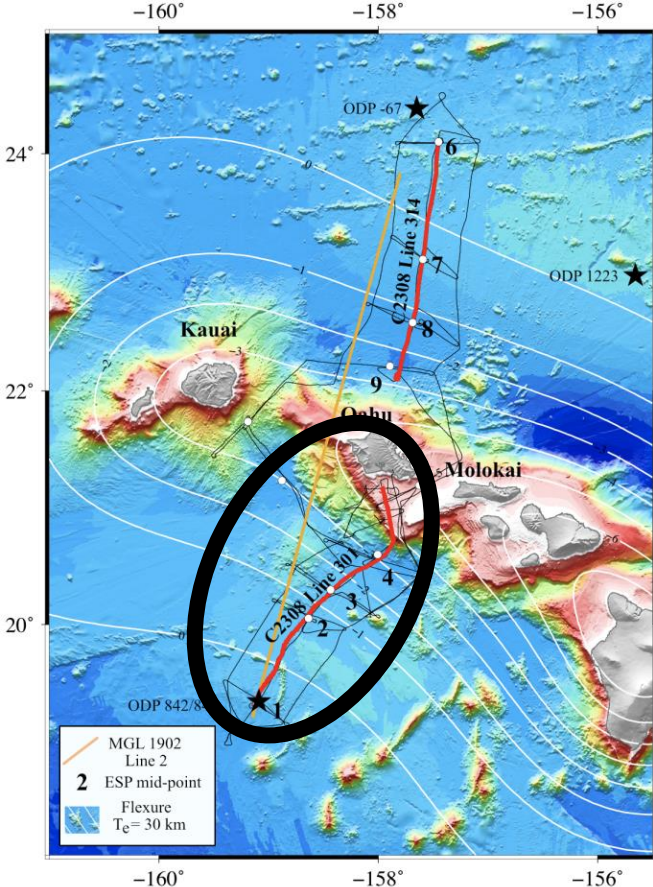
MGL1806 (2018)

S 280 km N

Line 2 (South)



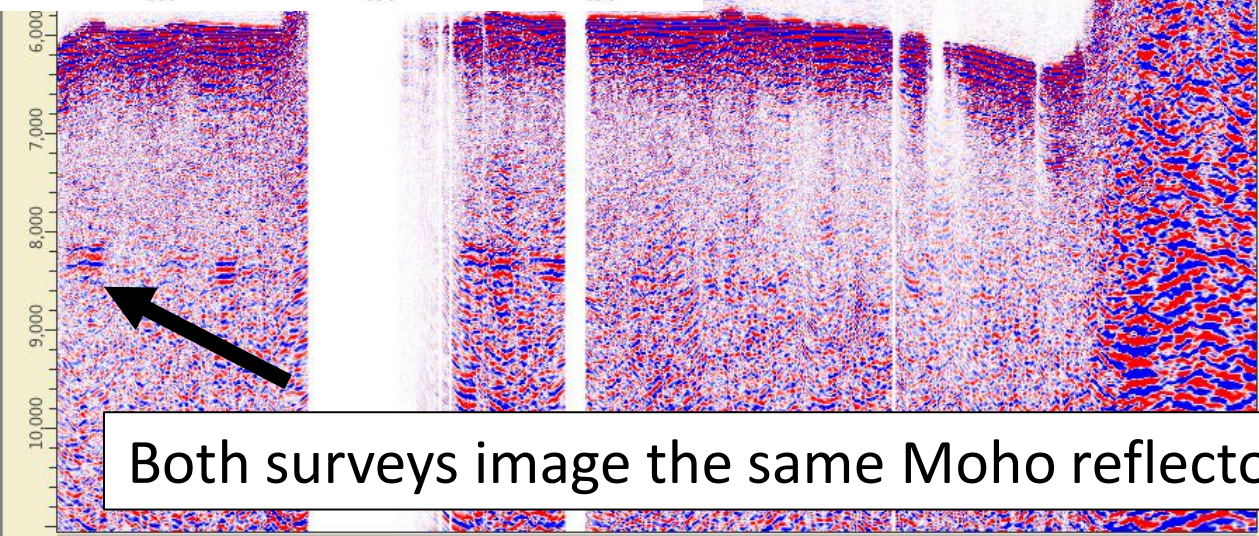




RC2308 (1982)

S 210 km N

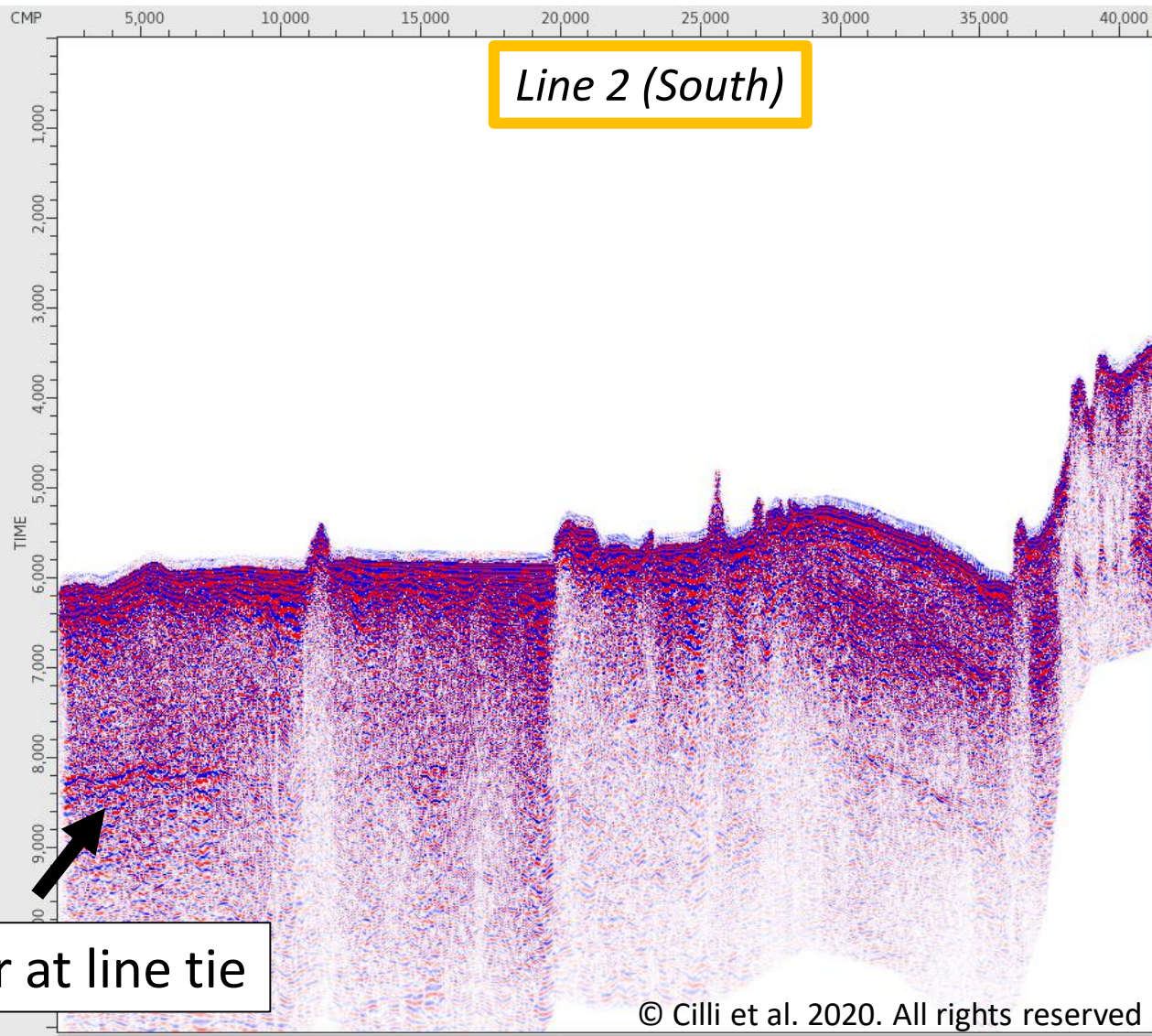
Line 301



MGL1806 (2018)

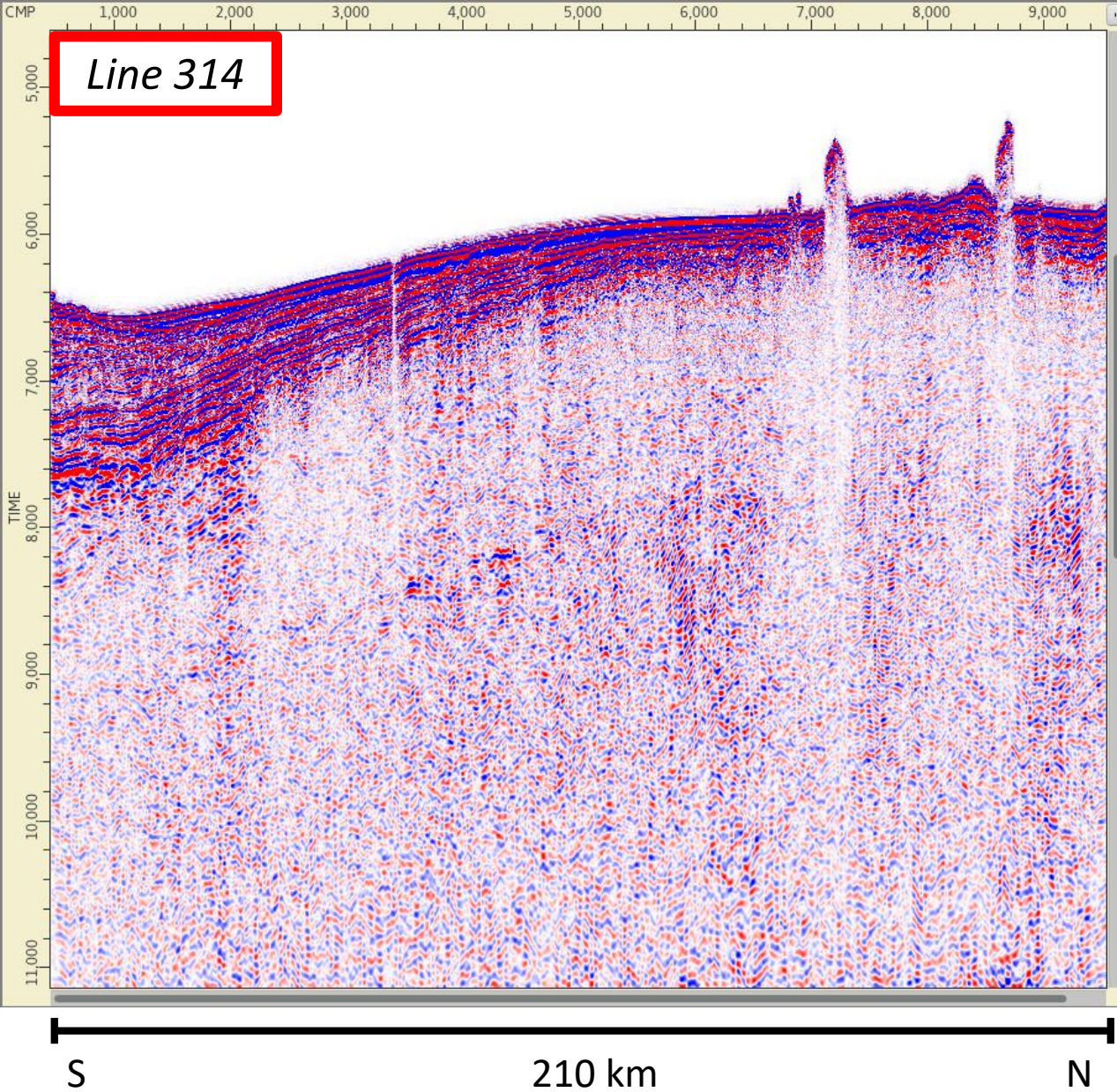
S 280 km N

Line 2 (South)

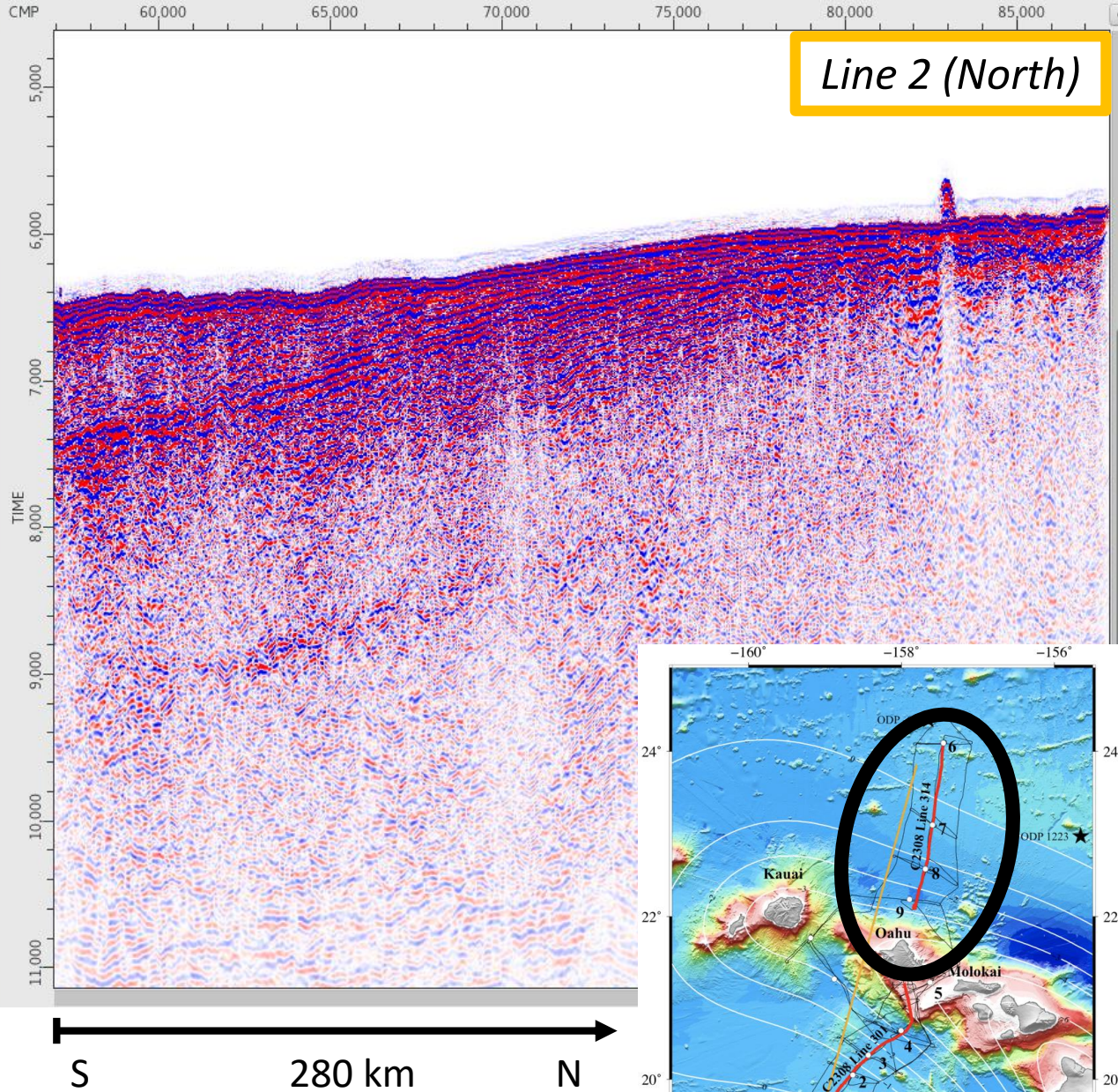


Both surveys image the same Moho reflector at line tie

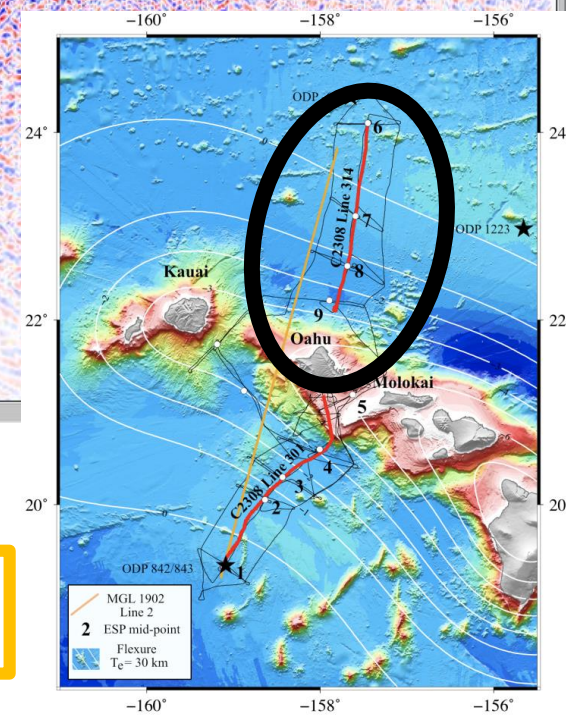




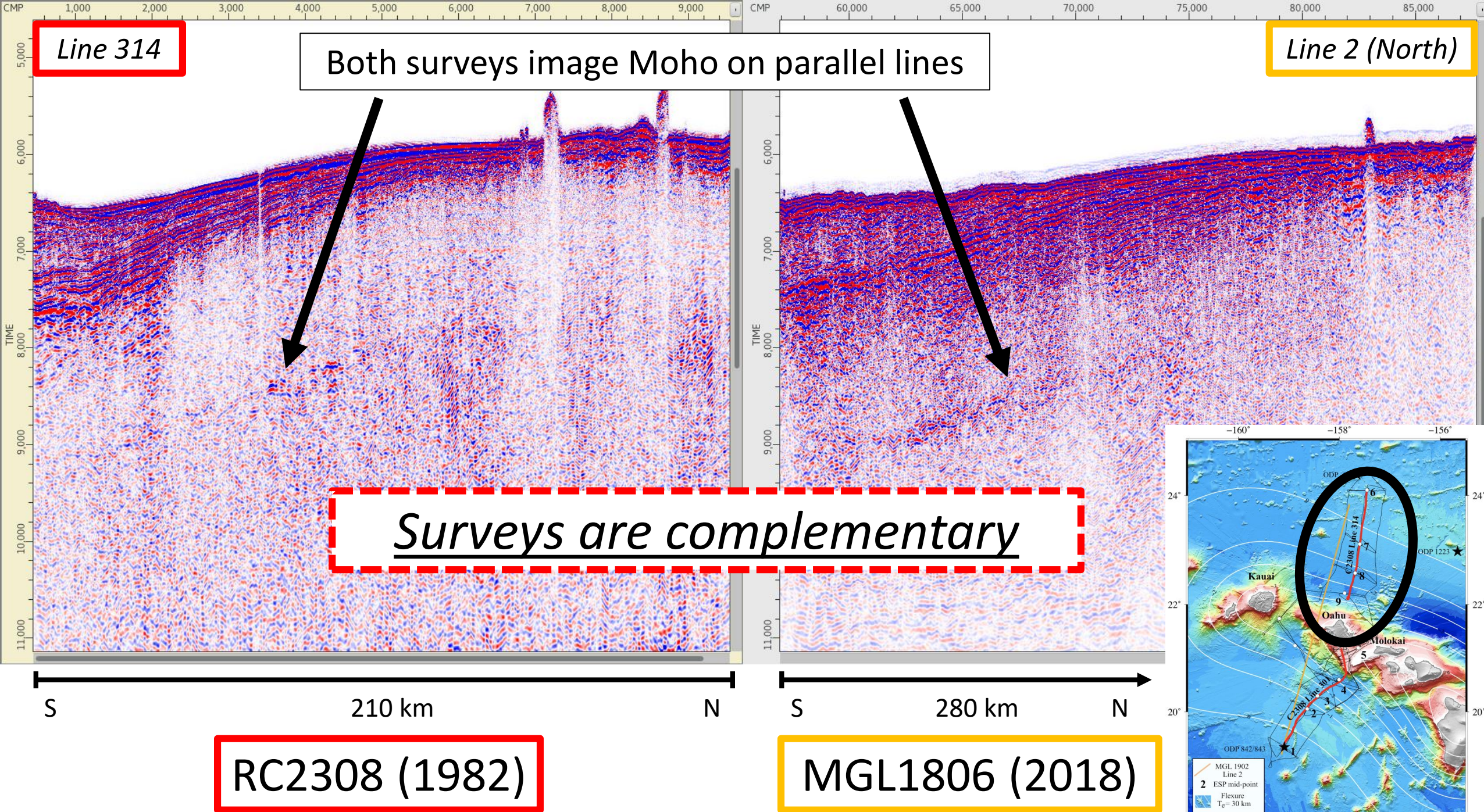
**RC2308 (1982)**



**MGL1806 (2018)**

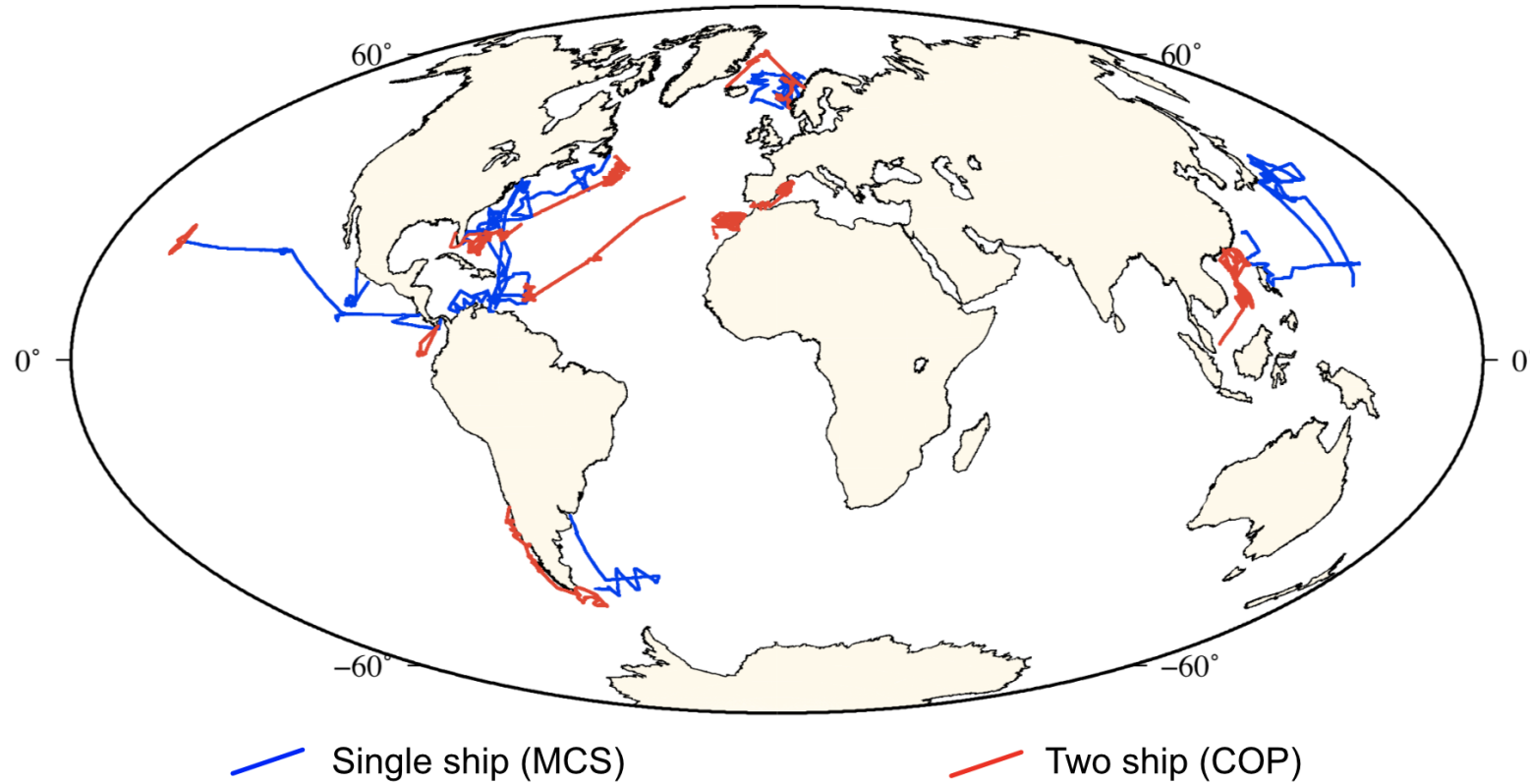








## *R/V Robert D. Conrad*



There were over 30 multichannel seismic research cruises by *R/V Robert D. Conrad*, with seismic data that we believe are still stored on original field tapes.

*Could digitising and reprocessing lead to a new trove of marine geophysical data?!...*



# Conclusions

**By reprocessing R/V *Robert D. Conrad* RC2308 (1982) seismic data, we:**

- Create digital, long-offset, 96 channel MCS field data for the first time
  - Improve imaging compared to legacy data
- Gain new geological insights with higher confidence through reprocessed data
  - E.g., crustal thinning beneath the Oahu/Molokai edifice
- Complement the state-of-the-art seismic survey, MGL1806 (2018)
- Show the benefits and value of reprocessing legacy seismic data for the marine geoscience community



# Acknowledgements

- NERC
- NSF-MGG
- Joyce Alsop, Rose Anne Weissel, Suzanne Carbotte of the Lamont-Doherty Earth Observatory of Columbia University for legacy data access
- Shearwater GeoServices for providing *REVEAL* software for seismic processing