Seismic reprocessing of EW9601, Puysegur Margin, South Island, New Zealand

Introduction

The EW9601 voyage was part of the NSF-funded SIGHT program (see AGU Geophysical Monograph 175 and many papers, e.g. Davey et al. 1998. Tectonophysics 288, 221-235), but the southern leg of EW9601 (transit around South Island) was funded by GNS Science and so neither the field or processed geophysical data were lodged in an open repository.

The full navigation of EW9601, including the transit south of South Island, is lodged in the MGDS system (Cruise DOI: 10.7284/901302). Several papers have arisen from this transit (e.g. Wood et al. 2000 NZJGG 43: 289-302. Mortimer et al. 2002 NZJGG 45, 349-363). The original field data appear to have been lost at GNS Science, though we hope they may still be located at a later date. Our work is restricted to the profile that crosses Solander Basin, for which we were able to locate some of the original files from project work done in the late 1990s.

Citation of processed data

The original data acquisition and processing should be cited whenever line EW9601 across Solander Basin is used:

Melhuish, A., Sutherland, R., Davey, F.J. and Lamarche, G., 1999. Crustal structure and neotectonics of the Puysegur oblique subduction zone, New Zealand. Tectonophysics, 313(4), pp.335-362. https://doi.org/10.1016/S0040-1951(99)00212-7

The EW9601 field data were recovered by Jenny Black at GNS Science from the original processing project done by Anne Melhuish and Rupert Sutherland. Jiten Patel then organized the navigation and cleaned shot gathers during MSc thesis work at Victoria University of Wellington, NZ, before the SISIE voyage of 2018 (Gurnis et al. 2019, EPSL 520: 212-219). The data were reprocessed as a group effort (with guidance from Steffen Saustrup) during the SISIE voyage. The primary citation for the recovered and processed version of the EW9601 data is:

Patel, J., Sutherland, R., Gurnis, M., Van Avendonk, H., Gulick, S.P., Shuck, B., Stock, J. and Hightower, E., 2021. Stratigraphic architecture of Solander Basin records Southern Ocean currents and subduction initiation beneath southwest New Zealand. *Basin Research*, *33*(1), pp.403-426. https://doi.org/10.1111/bre.12473

Final reprocessing of the data was completed by Brandon Shuck during PhD thesis work at UTIG, Austin, Texas and can be cited as:

Shuck, B.D., Van Avendonk, H.J.A., Gulick, S.P.S., Gurnis, M., Sutherland, R., Stock, J., Patel, J., Hightower, E., Saustrup, S. and Hess, T., 2021. Strike-slip enables subduction initiation beneath a failed rift: New seismic constraints from Puysegur Margin, New Zealand. *Tectonics*, *40(5)*, e2020TC006436. https://doi.org/10.1029/2020TC006436

Cruise information

Original raw field data and processed versions of seismic data from the EW9601 cruise are available from the Academic Seismic Portal at the Marine Geoscience Data System (https://www.marine-geo.org/tools/search/entry.php?id=EW9601). Details of the data acquisition can be found in the cruise report in the Documents section of the MGDS page and accessed via the following link:

https://www.marine-geo.org/tools/search/Document_Accept.php?client=DataLink&doc_uid=3685&entry_id=EW9601

Files in this archive

Navigation files

EW9601_nav_II_nztm.txt --> navigation file from ship.

Columns are: shot, longitude, latitude (WGS84), NZTM northing, NZTM easting, distance (m)

EW9601_CDPnav.csv --> reference for CDP locations.

Columns: shot, cdp, shot_x (m), cdp_x (m), longitude, latitude

Note: columns 3 and 4 represent inline distance of CDP with origin at the location of first shot used for EW9601 line and corresponding CDP = 2. Every shot is listed and hence only ever fourth CDP location.

EW9601_CDPnav_interp.csv --> reference for every CDP location.

Columns: shot, cdp, cdp_x (m), latitude, longitude

Note: columns 1 represents pseudo shotpoints for every CDP along the profile.

Data

EW9601_p1_shots.sgy --> shot gathers, minimally cleaned

EW9601_edited_shots.sgy --> processed shot gathers

EW9601_radon_cdps.sgy --> processed cdp gathers

EW9601_PSTM.sgy --> Final Kirchhoff Prestack Time Migration stack

Velocity model

Exported every 100 CMPs, at 40 ms increments

EW9601_intervels_updated.txt --> interval velocity model in time.

Columns are: CMP, time (ms), velocity (m/s)

Screenshots

EW9601_shots_edited.png --> before/after processing shot gathers

EW9601_radoncdps.png --> before/after processing cdp gathers

EW9601_PSTM.png --> comparison between final Shipboard image and new PSTM image

EW9601_velmodel.png --> interval velocity model derived from stacking velocities (smoothed 125 CMP's, max velocity = 6000 m/s)

Reprocessing sequence

Final sequence used by Brandon Shuck

EW9601_edited_shots.segy

1. Read shots into Paradigm
2. Trace editing (omit noisy channels)
3. Assign geometry (50 m shot spacing)
4. Resample to 4 ms
5. Noise suppression
    - 0-6 Hz low-frequency wave noise suppression
6. Butterworth filter 3-100 Hz
7. Interpolation for edited traces in shot domain
8. Spherical divergence gain correction
9. Predictive gap deconvolution

EW9601_radon_cdps.segy

10. Sort to CDP gathers
11. NMO overcorrection applied to separate primary and multiple energy
12. Parabolic radon multiple attenuation
13. Trace mixing on NMO-flattened gathers (3 traces, equal weights)
14. Time-varying butterworth filter
    - 0-4000 ms; 6-65 Hz
    - 4000-6000 ms; 6-65 Hz
    - 6000-6500 ms; 6-45 Hz
    - 6500-10000 ms; 6-25 Hz
    - 10000-16000 ms; 6-15 Hz

EW9601_PSTM.segy

15. Stacking velocity analysis every 250 CDPs
16. Kirchhoff 2D Prestack Time Migration
    - Travel-time fitting algorithm
    - RMS velocity function (derived from smoothed stacking velocities)
    - 2000-CDP-wide aperture at 10000 ms
17. Time-varying filter
18. Trace mixing (3 traces, equal weights)
19. Inside (multiple attenuation) and outside (wavelet stretching) mutes applied
20. Stack