

# Seismic interpretation of the Canterbury Plains, New Zealand

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## I. ABSTRACT

The 2010-2011 Canterbury earthquake sequence on the South Island of New Zealand occurred in a region where hidden faults systems were unknown, but were suspected. Following the 2011 Christchurch earthquake, 2D seismic reflection data was acquired in the Canterbury region. The seismic data, along with a regional tectonic and geologic overview, is used to image, interpret, and identify faults extending to basement structure beneath the Canterbury Plains.

Hidden fault structures have been suspected in the Canterbury Plains (Pettinga et al., 2001); however the region has been largely unstudied with very little well control and a lack of seismic data. This research contributes to constraining seismic hazard and risk assessment by identifying the presence of faults beneath the central Canterbury plains and within the city of Christchurch in newly acquired 2D seismic profiles.

## II. STUDY AREA

The study area is focused on the South Island of New Zealand (Figure 1). The Canterbury Plains are bound by the foothills of the Southern Alps to the west, and Banks Peninsula and the Pacific Ocean to the east (Figure 1b). The Northern Canterbury Plains border basin and range topography, whereas flat alluvial outwash plains are represented by the central area (Forsyth et al., 2008).

Two areas are of interest for this research. The first location is on the east coast of the Canterbury Region in the city of Christchurch, and the second area of interest is located in the central Canterbury Plains.

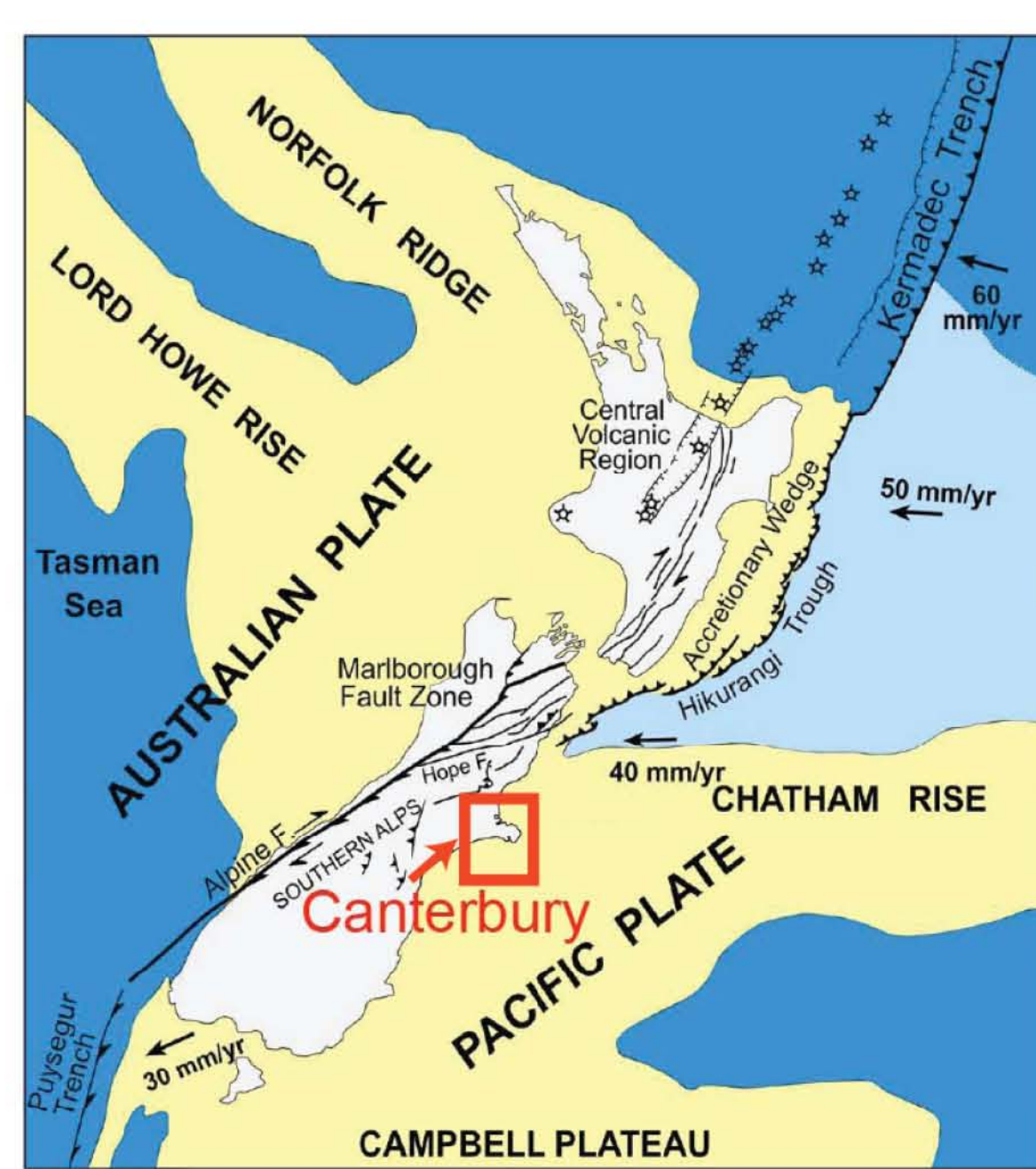


Fig 1a. New Zealand

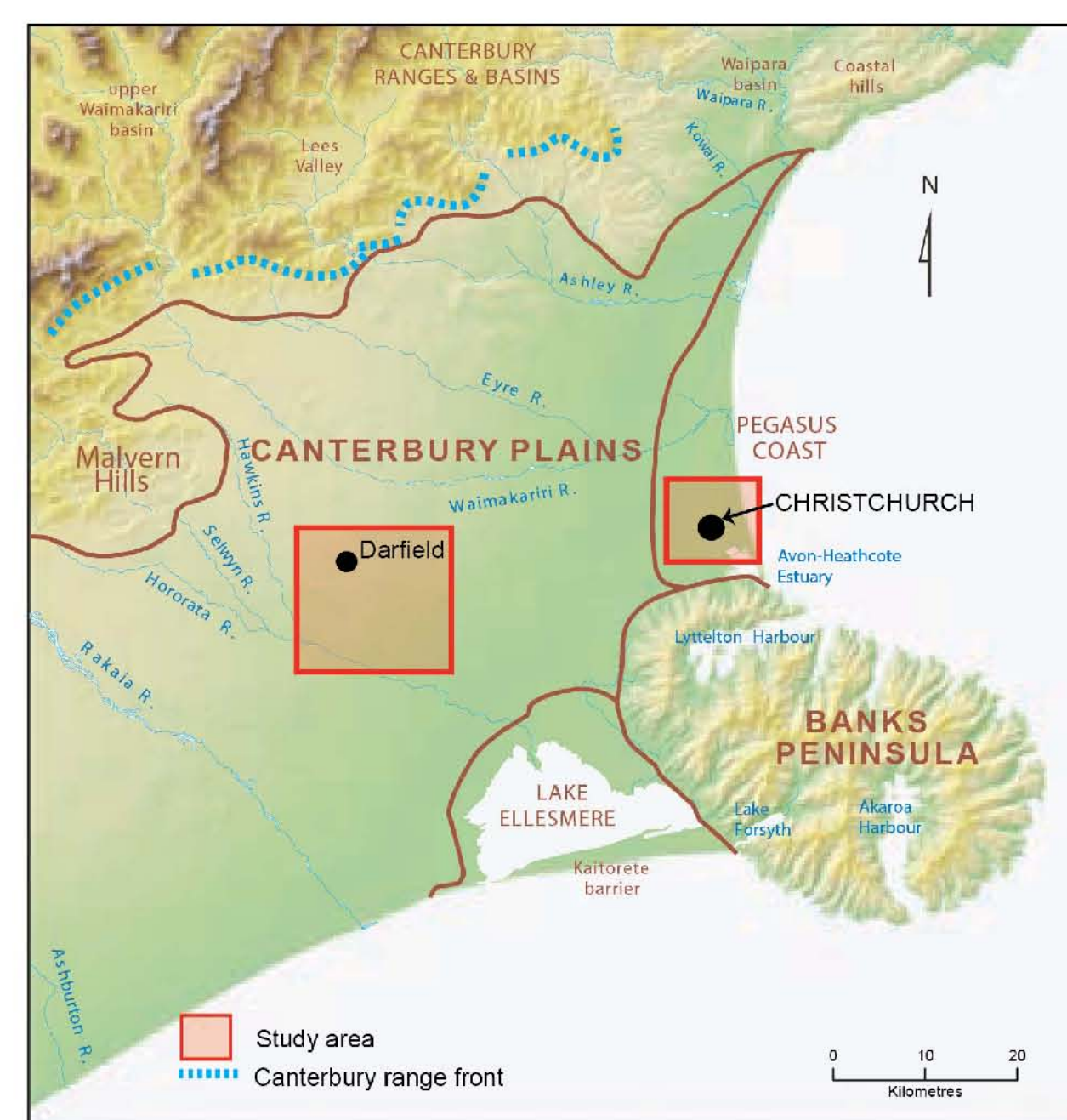


Fig 1b. Canterbury Plains, South Island with two study areas indicated.

## REFERENCES

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- Pettinga, J., M.D. Yetton, R.J. Van Dissen, and D. Downes, 2001, Earthquake source identification and characterization for the Canterbury Region, South Island, New Zealand, Bulletin for the New Zealand society for earthquake engineering, 34, 4, 282-317.

## III. THE 2010-2011 CANTERBURY EARTHQUAKE SEQUENCE

The Canterbury earthquake sequence includes the 4 September 2010 Darfield earthquake with an epicenter approximately 40 km west of Christchurch, the 22 February 2011 Christchurch earthquake, the 6 June 2011 aftershock, and the 23 December 2011 New Brighton aftershock sequence. The focus of this research is on the Darfield and Christchurch events.



Fig 2a. Map showing fault trace of the Greendale Fault (in red) which ruptured the surface on 4 September 2011 during the Darfield earthquake. The Port Hills Fault (in dashed yellow) is the surface projected fault location based on GPS and DInSAR data from Beaven et al. (2012). Event epicentres are green stars



Fig 2b. Aerial photograph of the E-W trending Greendale Fault. A drainage canal is displaced by shear fractures along the fault surface. Image taken by Richard Jongens of GNS science.

## IV. DATA ACQUISITION

A collaborative effort between the University of Calgary CREWES research group and the University of Canterbury resulted in a 2D reflection seismic data program in April 2011. Seismic data was acquired in the city of Christchurch and the Canterbury area with the goal of mapping blind faults, and interpreting the structure of the Greendale Fault. The geologic interpretations of this research were based on comprehension of the geologic history of the Canterbury Plains, previous geophysical seismic interpretations both offshore and on land, and the 433 m deep Bexley wellbore.



Fig 3a. Seismic data acquisition in the city of Christchurch, New Zealand. Line 1 (orange) is 8km along New Brighton Beach, and Line 2 (yellow) is along Barbadoes Street. Google earth V 7.0.3.8542. (25 April 2012) Christchurch, New Zealand.



Fig 3b. Highfield Road seismic line (in yellow). Started on south end at station 306 and ended north at station 641. The Greendale Fault ruptures the surface in an E-W orientation. Google earth V 7.0.3.8542. (28 January 2013) Highfield Road, New Zealand.

## V. SEISMIC INTERPRETATION

The interpreted New Brighton Beach 2D seismic line with 3x vertical exaggeration is shown in Fig 4. The green horizon represents the Wainoni gravels, the yellow horizon represents the Early Pleistocene Top of Kowai Formation, and the red horizon represents the Miocene Volcaniclastics. The Port Hills Fault is interpreted 400 ms below stations 500-520. An additional projected fault shown in black dashed line towards the north end of the seismic line just intersects the Miocene Volcaniclastics.

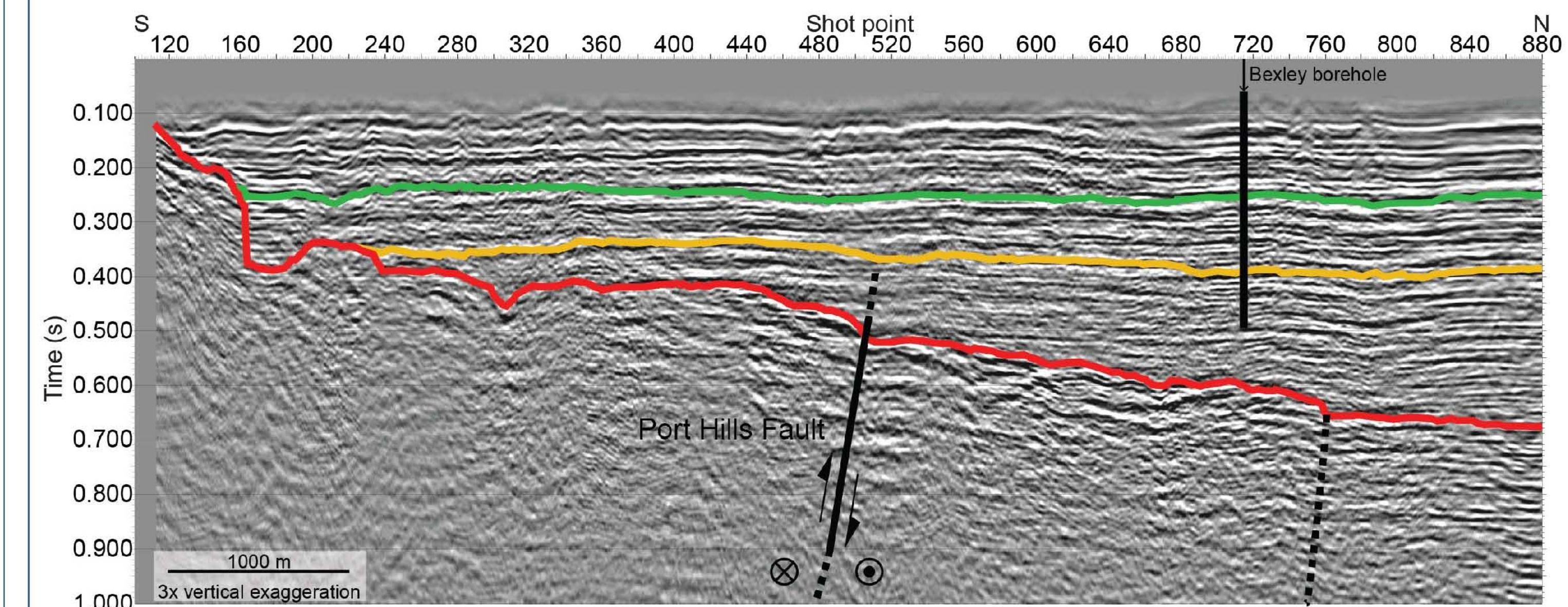
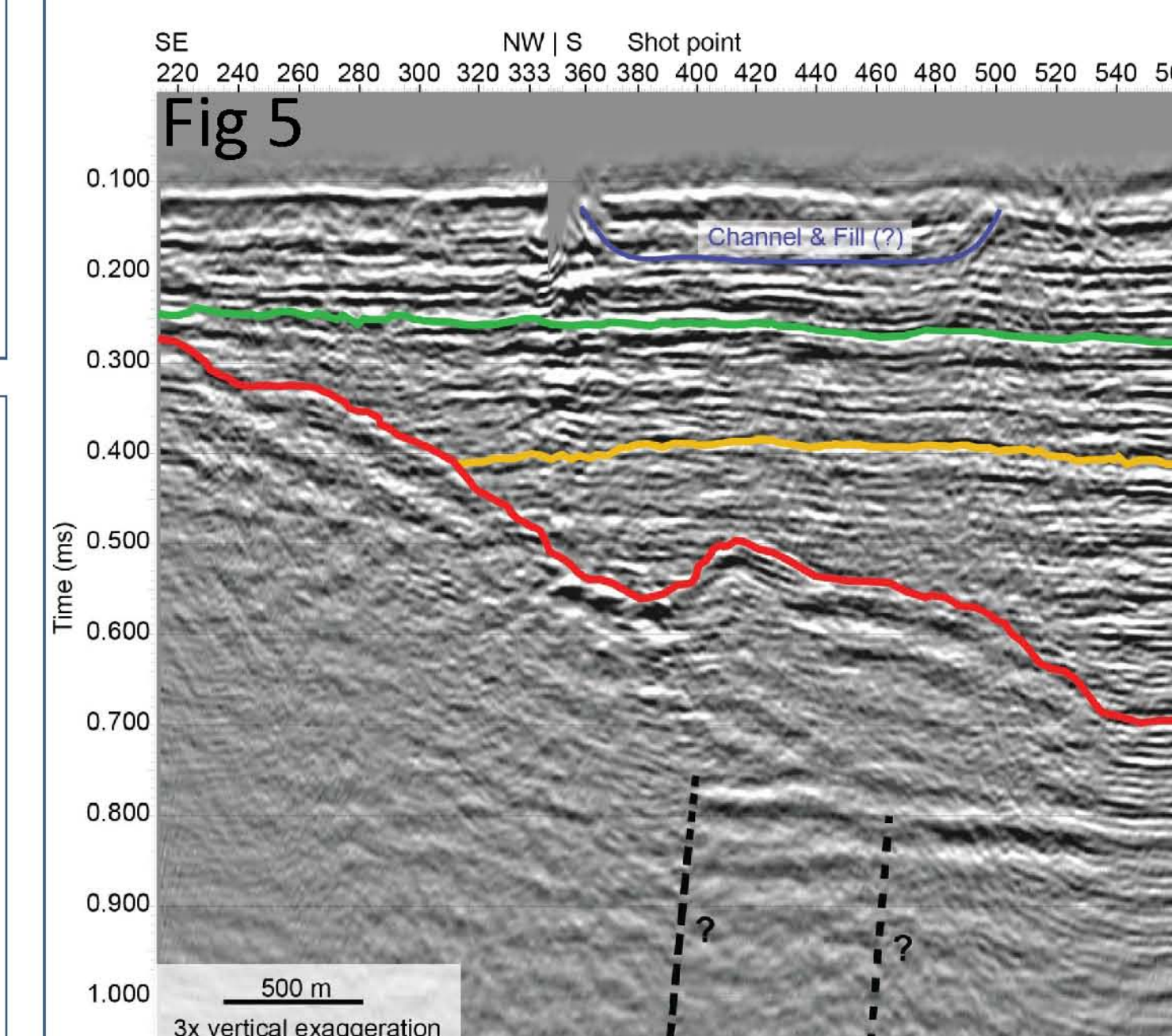
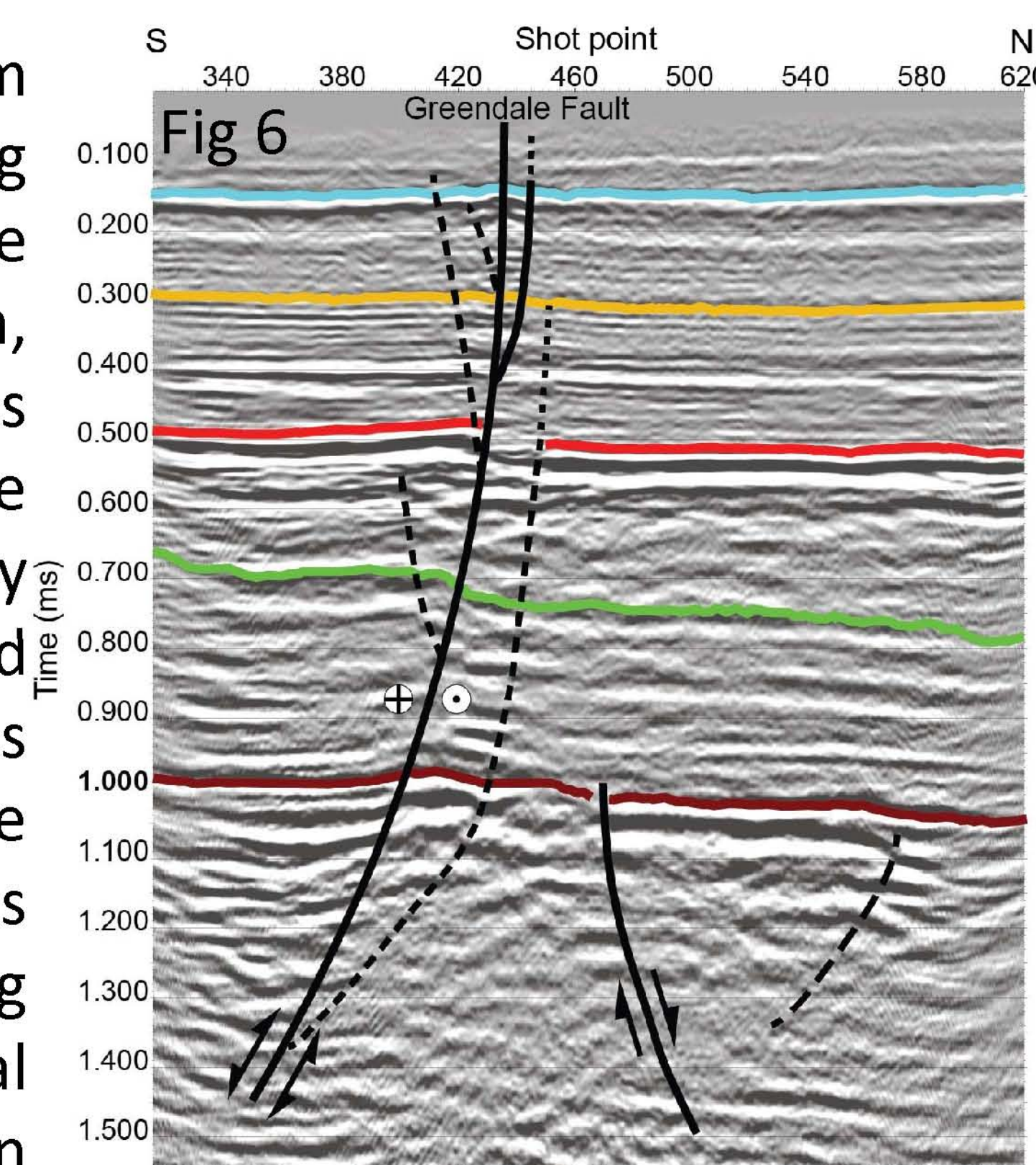


Fig 4. Seismic interpretation of New Brighton Beach. The Port Hills Fault ruptured during the 22 February 2011 6.2 Mw earthquake and projects approximately 350 m below surface.



The Barbadoes Street seismic profile interpretation is shown in Fig 5. The change in line direction occurs at station 360. The green horizon represents the Wainoni gravels, the yellow horizon represents the Early Pleistocene Top of Kowai Formation, and the red horizon represents the Miocene Volcaniclastics. Possible projected south dipping faults are indicated in dashed black lines. Also interpreted is a channel and fill zone.

The Highfield Road seismic line 35 km west of Christchurch is interpreted in Fig 6. The 125,000 year gravels are represented by the light blue horizon, the Top of the Kowai formation is represented by the yellow horizon, the Miocene volcaniclastics/Mid-Tertiary limestone is represented by the red horizon, the Top of the Paleogene (?) is represented in green, and the undifferentiated Mesozoic basement is picked in brown. The E-W trending Greendale fault is primarily dextral strike slip and is illustrated below station 440, where the fault ruptured the surface.



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