

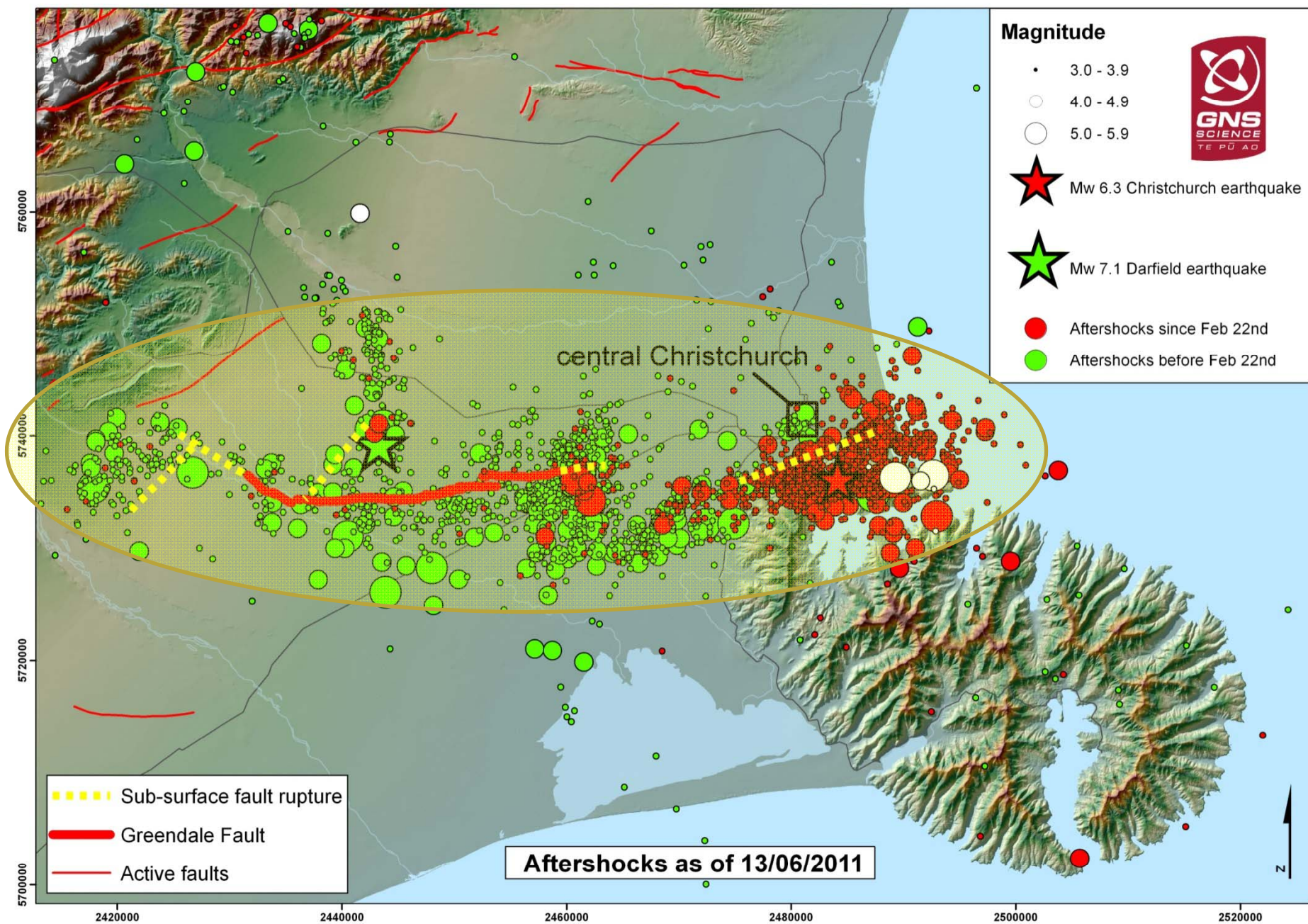
# **Progress in understanding the Canterbury Earthquakes**

**Kelvin Berryman**  
**Manager, Natural Hazards Research Platform**

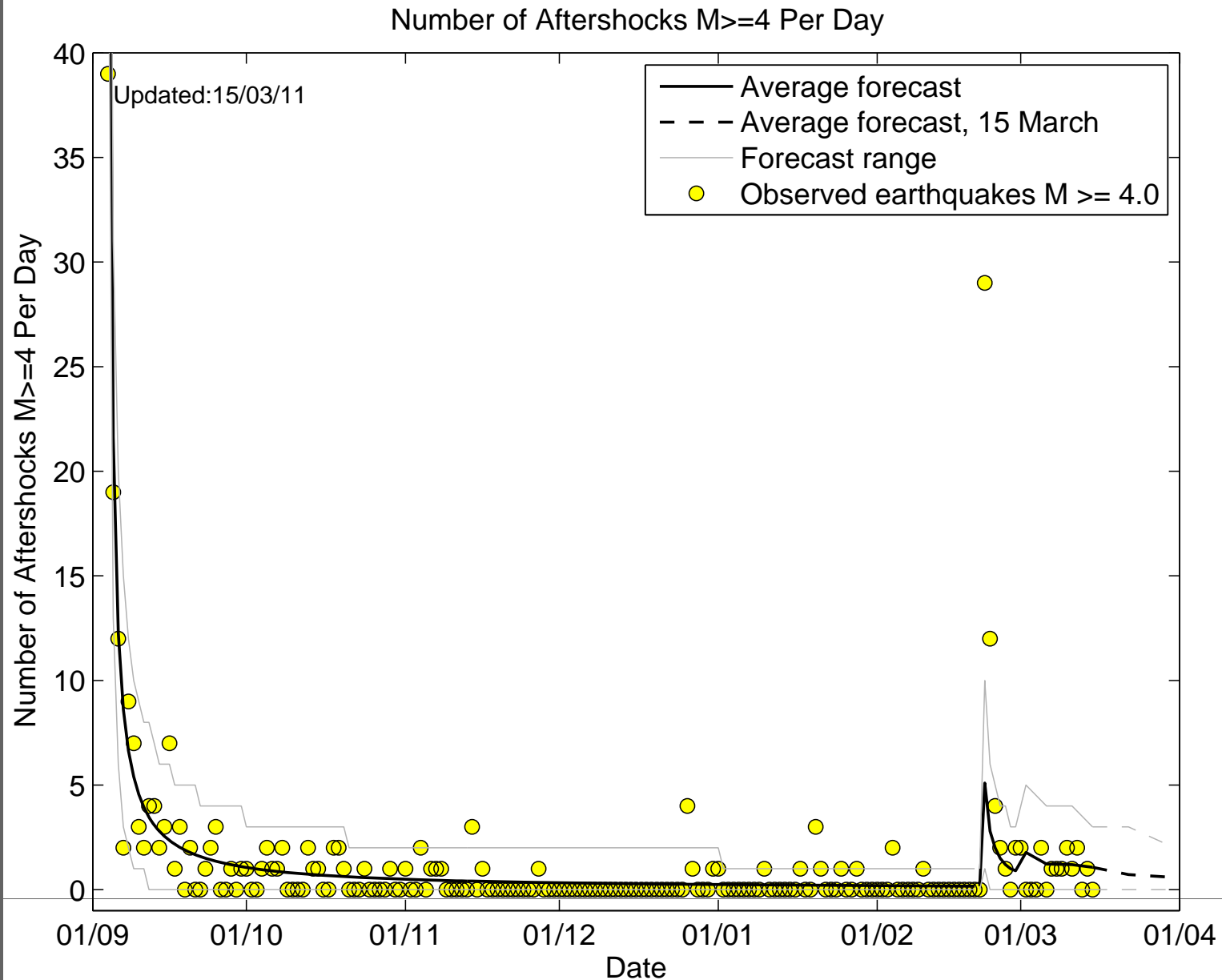
**Dr. Matt Gerstenberger – GNS Science**

**Dr Philip Barnes – NIWA**

**Prof Jarg Pettinga – University of Canterbury**



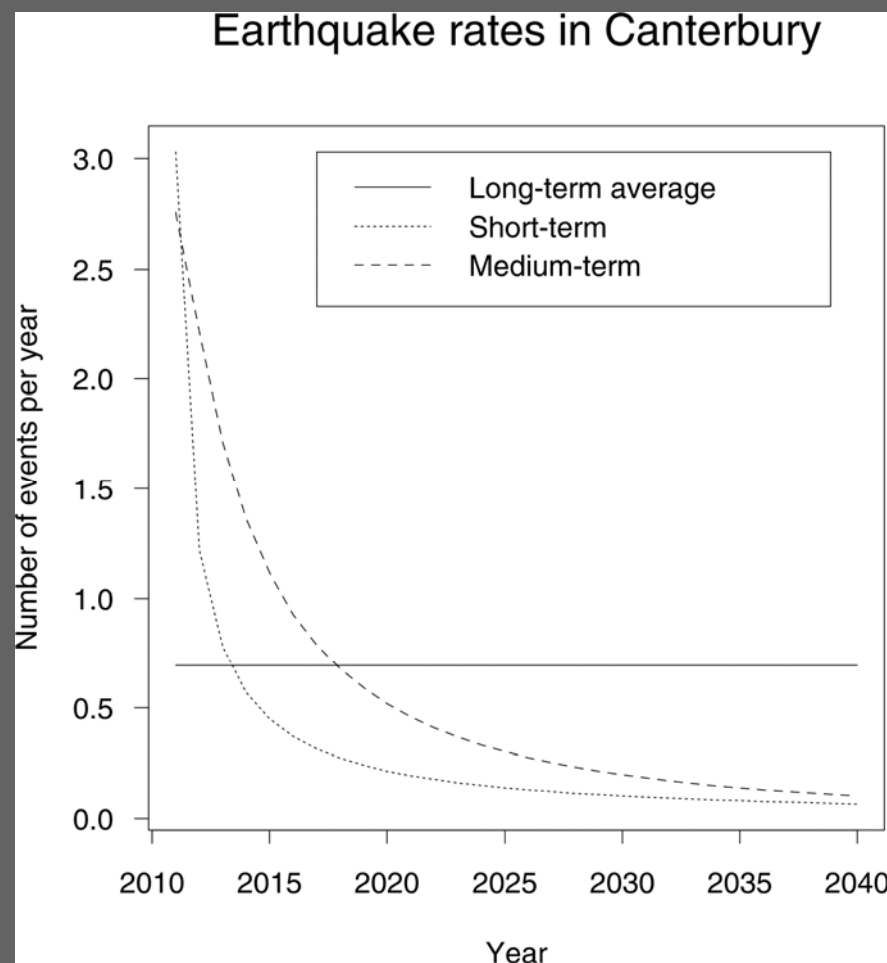
# Aftershock Decay Rate



# Long-term (50yr) Earthquake Rate Forecast

- Used to inform update of building codes
- Accounts for different earthquake clustering scales
- Combines four different models
- Used to estimate probabilities of ground shaking

- Increasing time scale ↓
- **Short-term clustering model**
    - *Days to Year(s)*
  - **Medium-term clustering model**
    - *Years to decades*
  - **Long-term average model**
    - *Average earthquake rate since 1960*
  - **NSHM fault model**
    - *Longest-term mostly time-independent*



Yearly number of earthquakes greater than magnitude 5 from three models



## Extended probabilities of aftershocks and larger events for Canterbury following the 2010 Darfield earthquake from short-term model

Start Date		+1 Year			+1 Month			+7 Days		
	Mag Range	Avg. expectation	Poisson conf. bounds	Prob.	Avg. expectation	Poisson conf. bounds	Prob	Avg. expectation	Poisson Conf. bounds	Prob
15/6/11	5.0-5.9	4.1	[1 8]	98%	1.85	[0 5]	84%	1.0	[0 3]	63%
	6.0-7.9	0.42	[0 2]	34%	0.7	[0 1]	16%	0.09	[0 1]	9%
15/7/11	5.0-5.9	2.5	[0 6]	92%	0.45	[0 2]	36%	0.14	[0 1]	13%
	6.0-7.9	0.3	[0 2]	26%	0.05	[0 1]	5%	0.01	[0 1]	1%
15/8/11	5.0-5.9	2.2	[0 5]	89%	0.34	[0 2]	29%	0.09	[0 1]	9%
	6.0-7.9	0.2	[0 1]	18%	0.04	[0 1]	4%	0.009	[0 1]	<1%

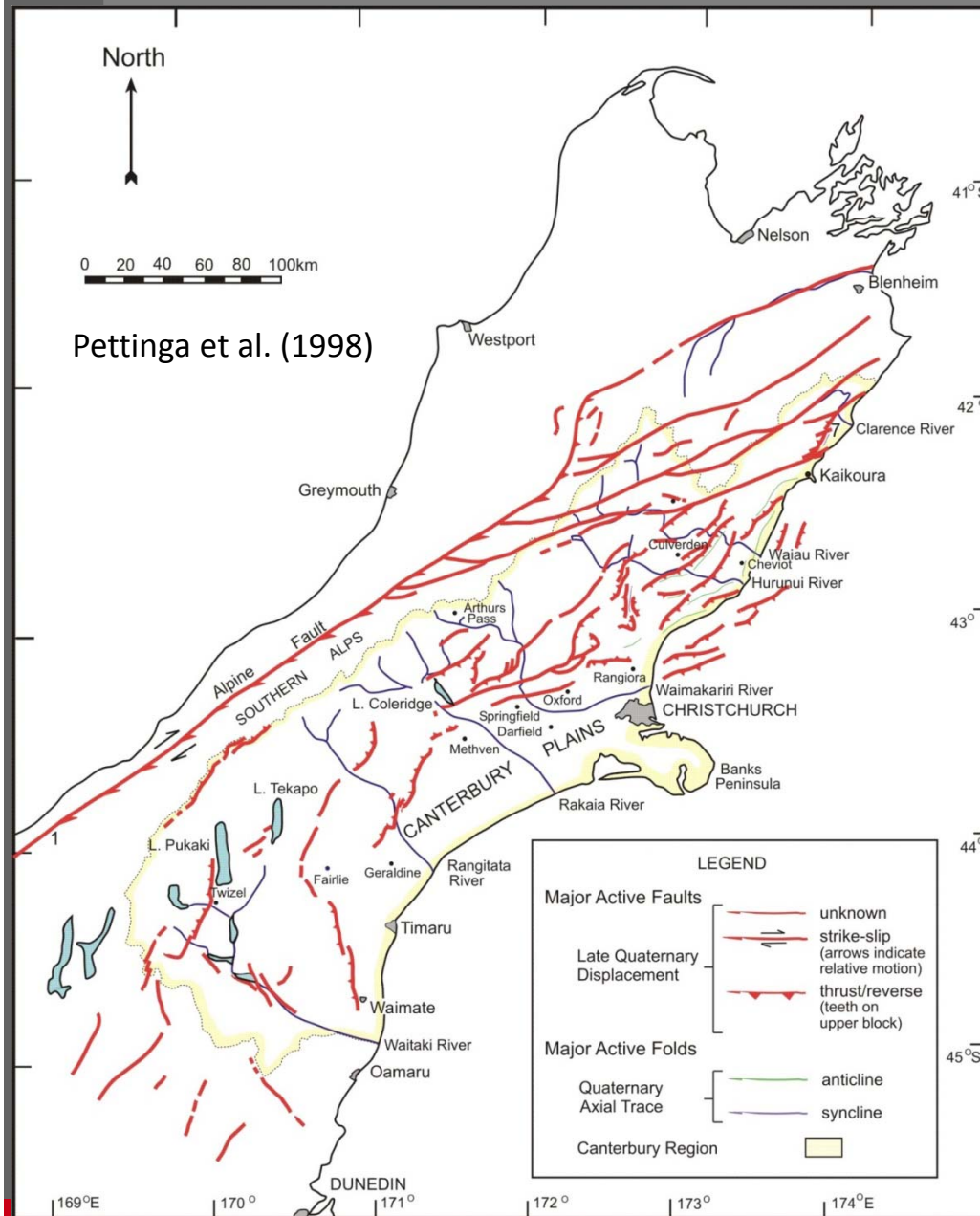
All earthquakes up to June 14, 2011 were used for these calculations. These forecasts are anticipated to change as the sequence continues to develop.

- The occurrence of large events on Monday 13<sup>th</sup> have increased the probabilities
- Extended “quiet times” may cause a decrease in the probabilities
- Each day a larger event does not occur, the probabilities decrease
- Probability of a M6.0 is approximately 10 times that of a 6.9

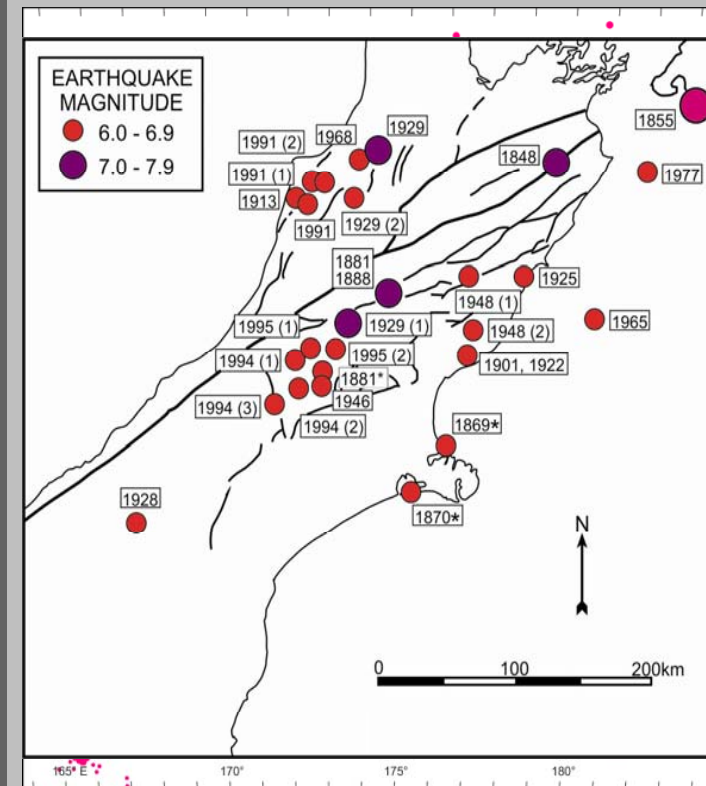
**So, if there are going to be further large aftershocks or triggered events, where might they occur.....**

- this is why we have turned to geophysical surveys to investigate where bedrock faults occur with any evidence of recent movement**

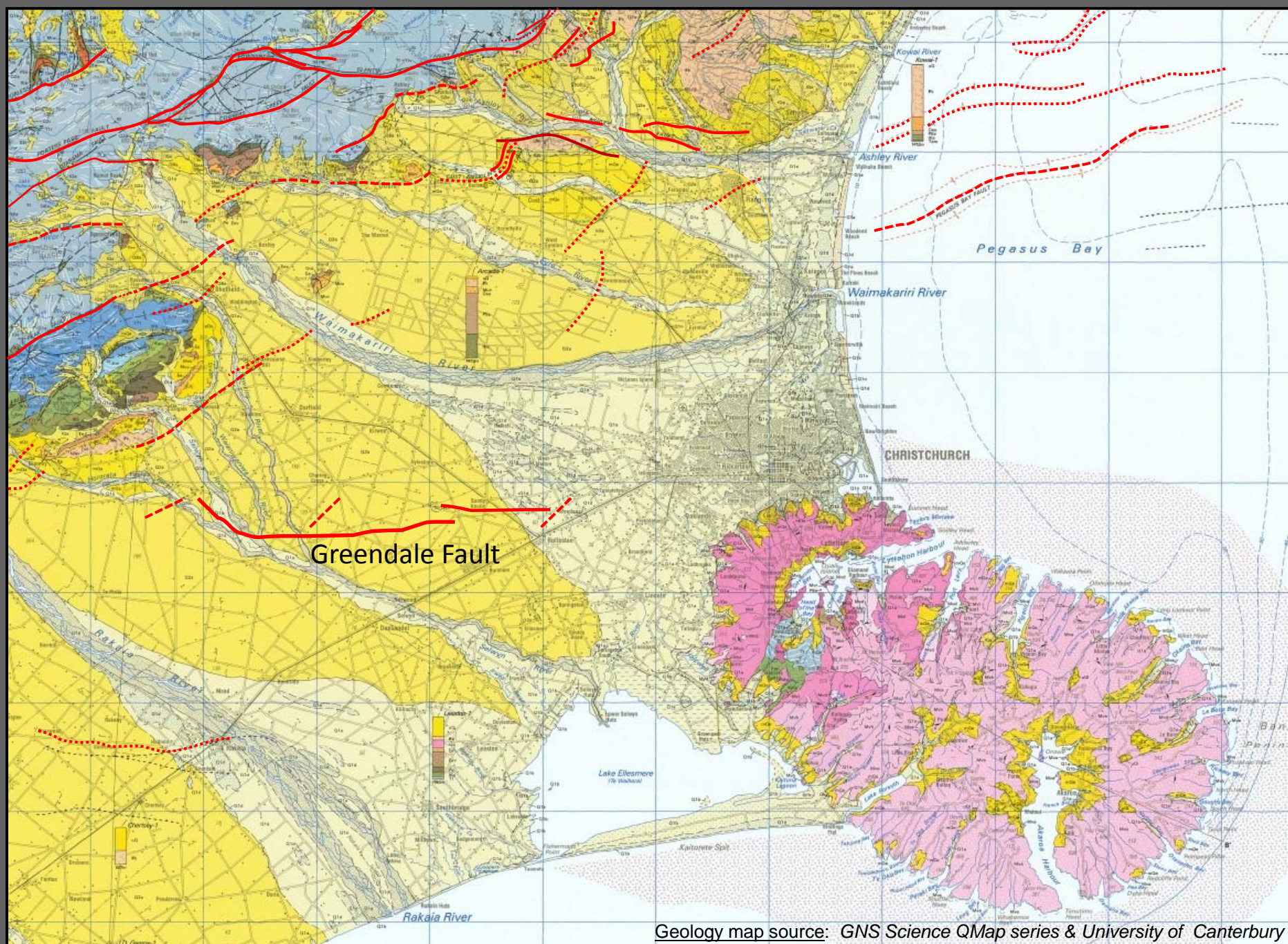
# Faulting ..... and the Earthquake-driven Landscape



Canterbury has many active faults that contribute to the earthquake hazard

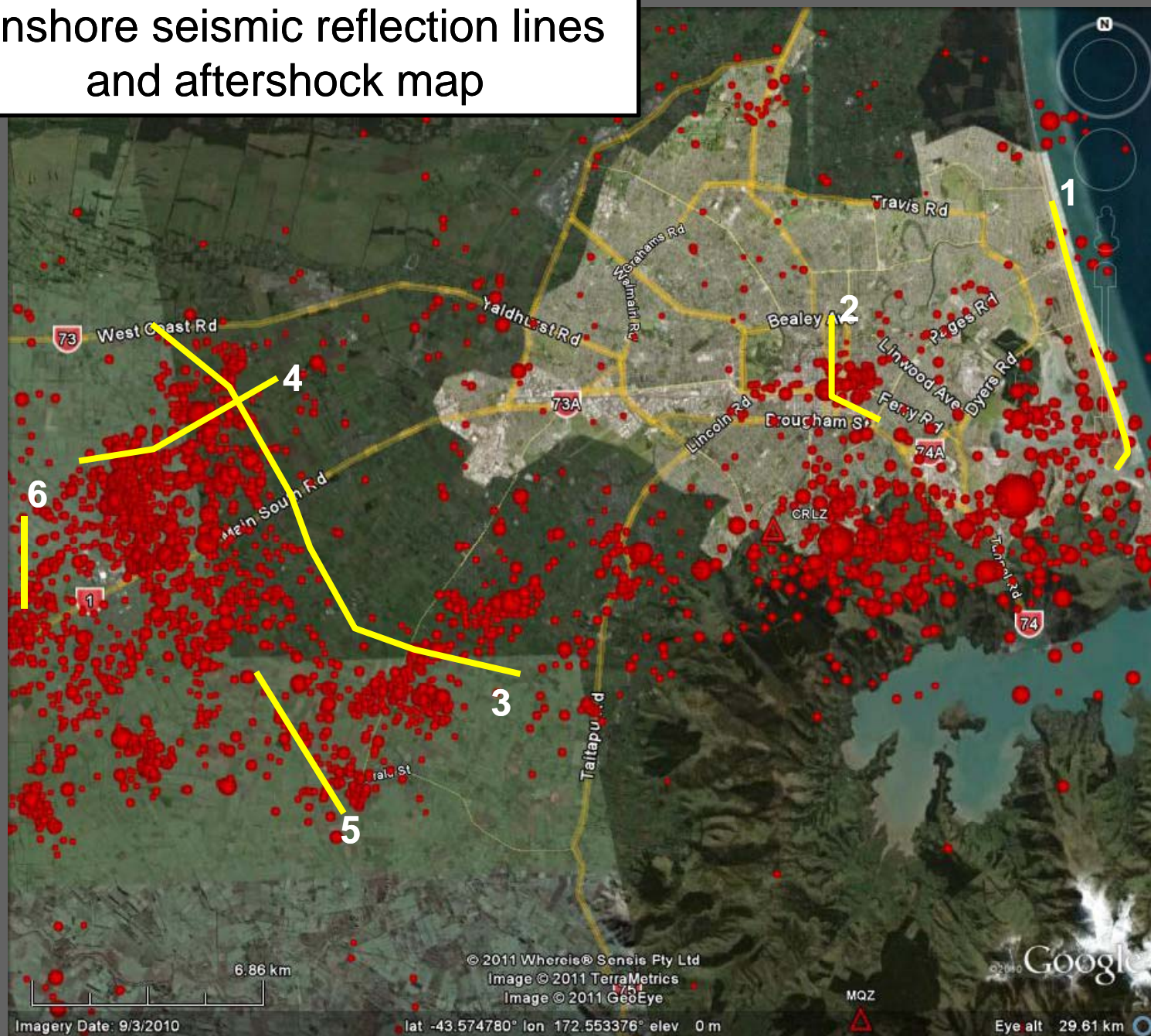






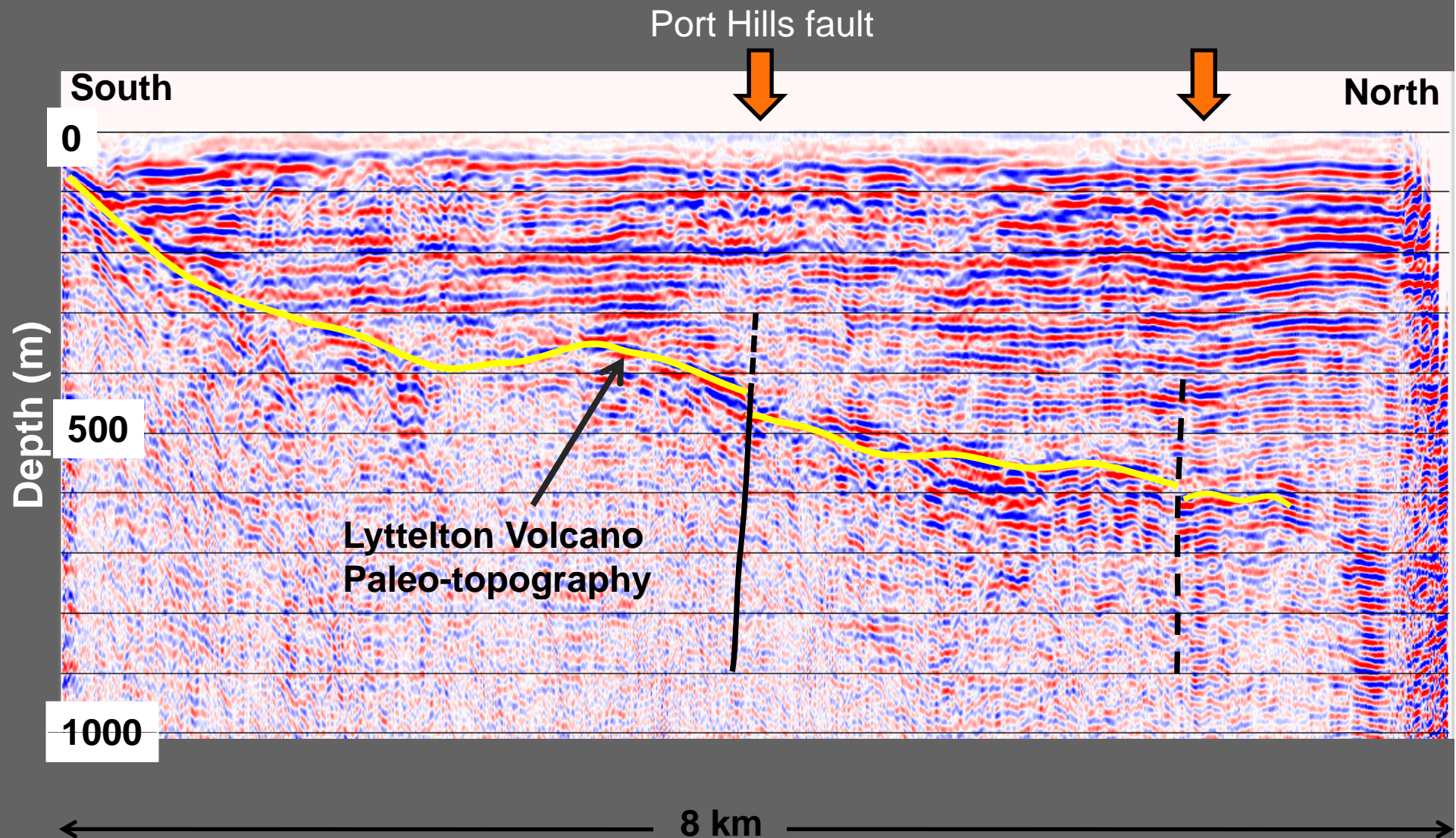


## Onshore seismic reflection lines and aftershock map





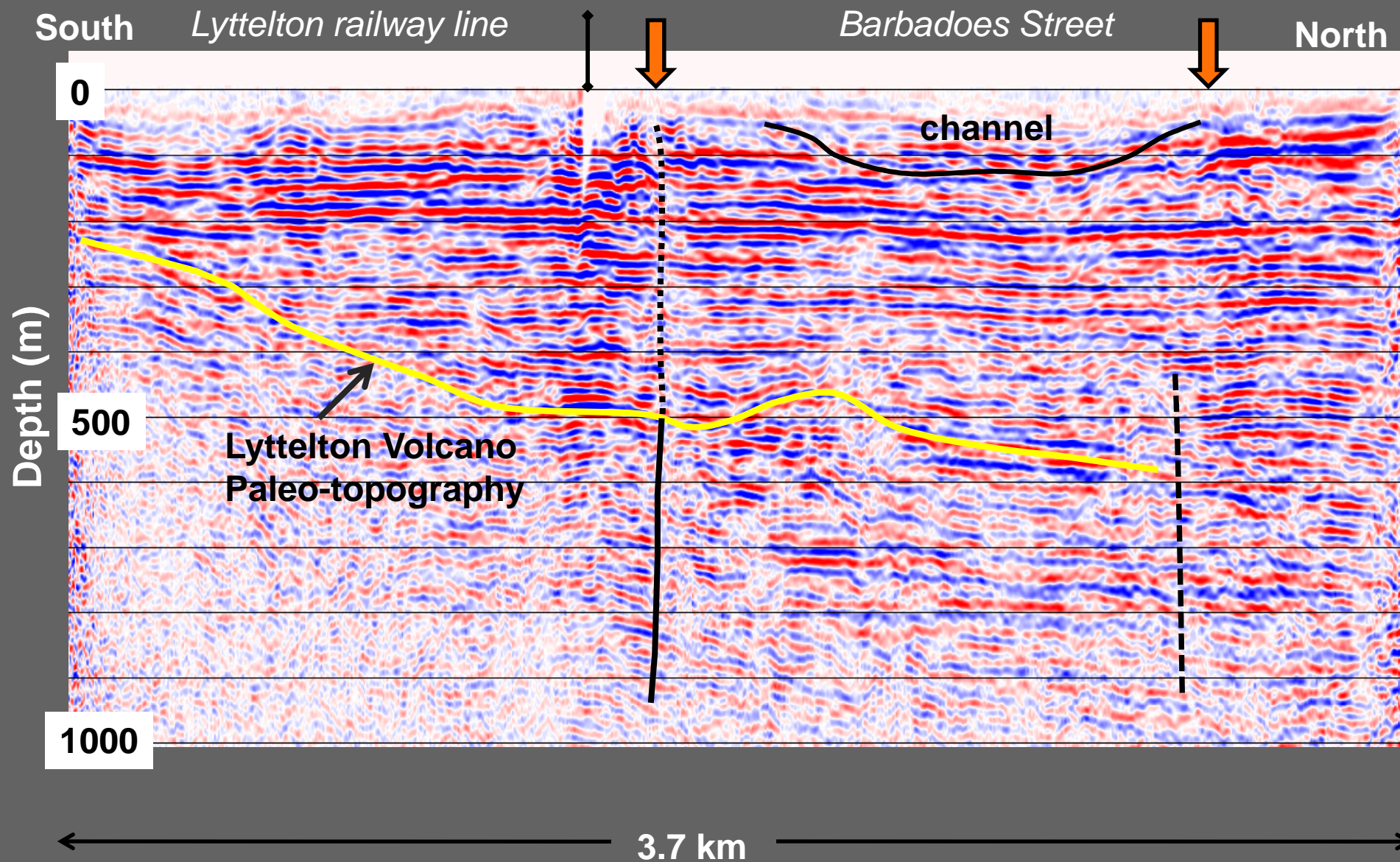
# Line 1 - New Brighton Beach



Note: based on preliminary processing and analysis, may be subject to further revision

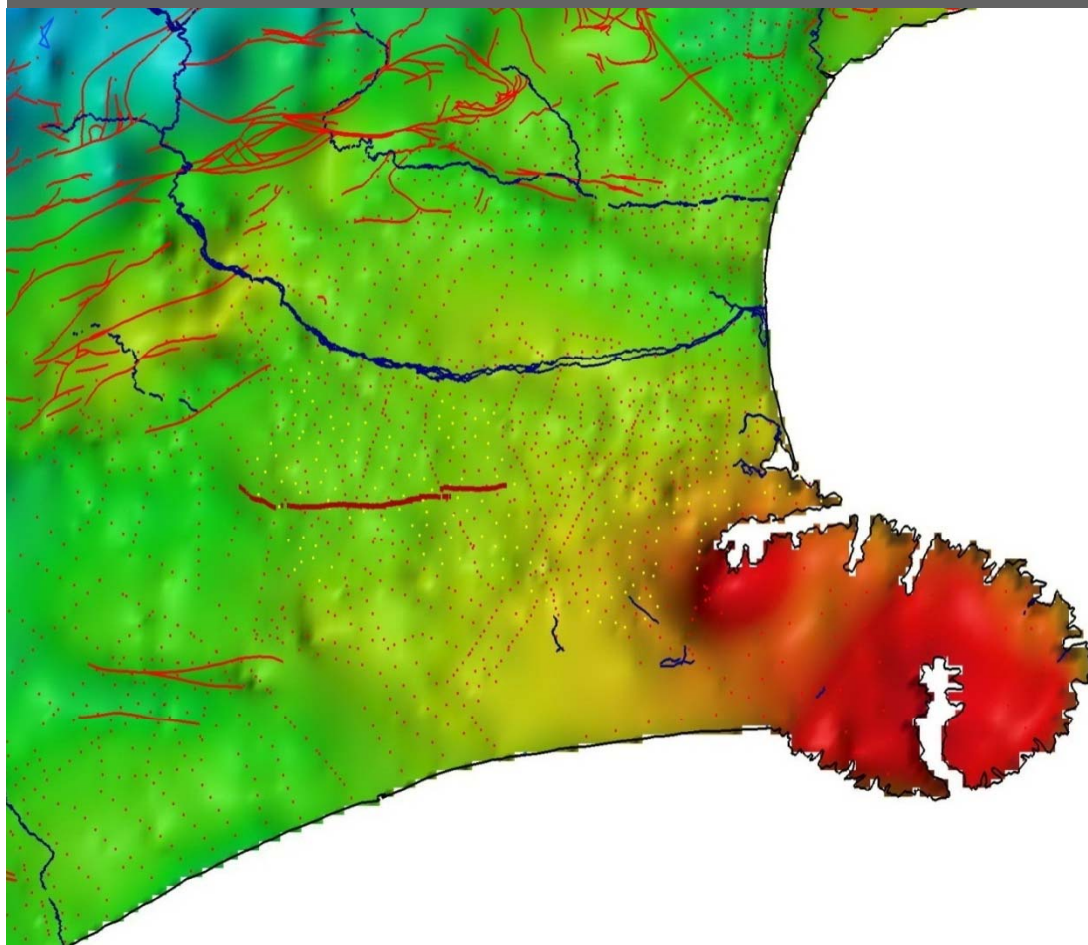


## Line 2 - Barbadoes Street



Note: based on preliminary processing and analysis, may be subject to further revision





## Investigating Canterbury subsurface structure

Magnetic signature of rocks

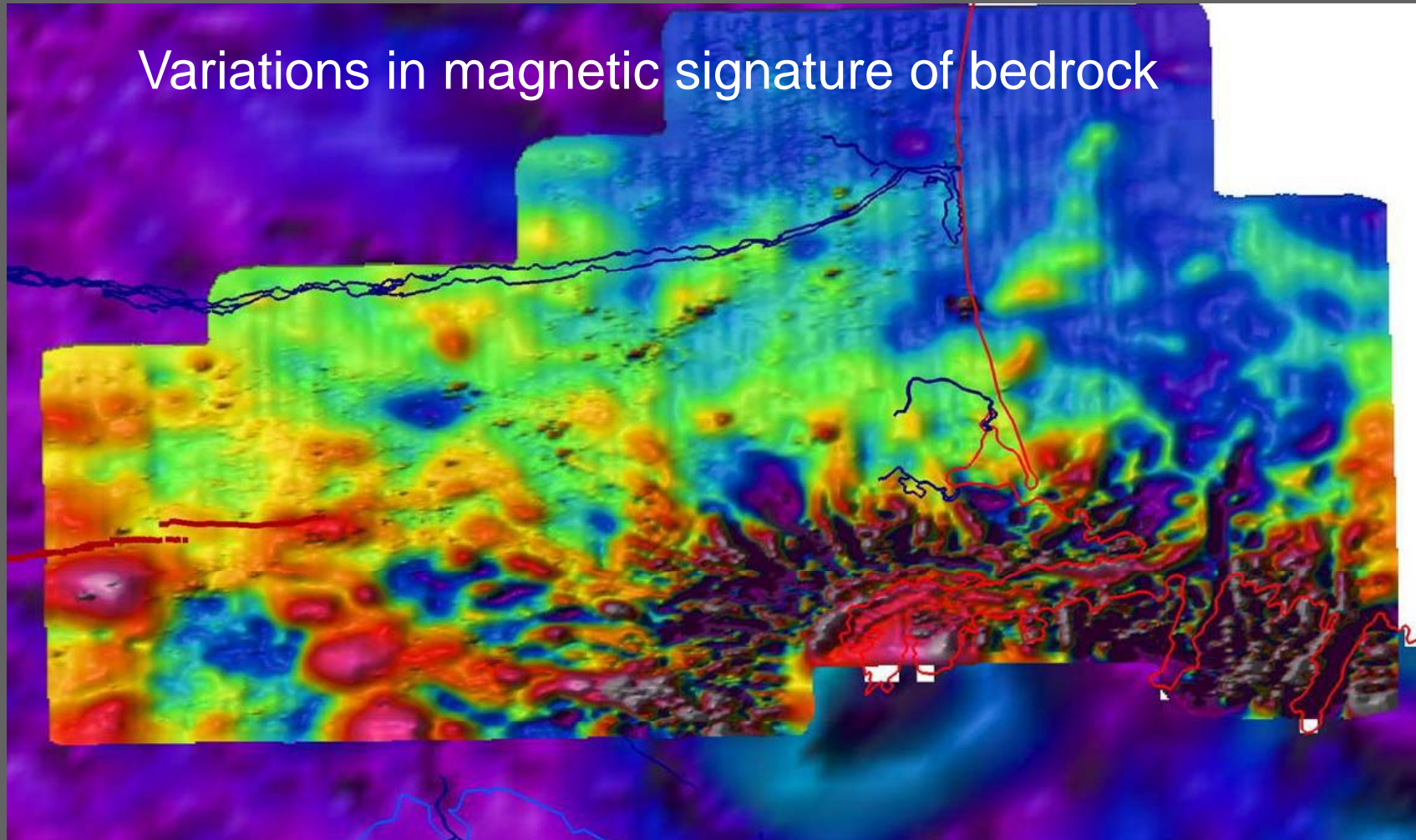
Near surface variations in rock density

- Red lines are known surface active faults
- Dots are gravity measurement locations

Note: based on preliminary processing and analysis, may be subject to further revision



## Variations in magnetic signature of bedrock

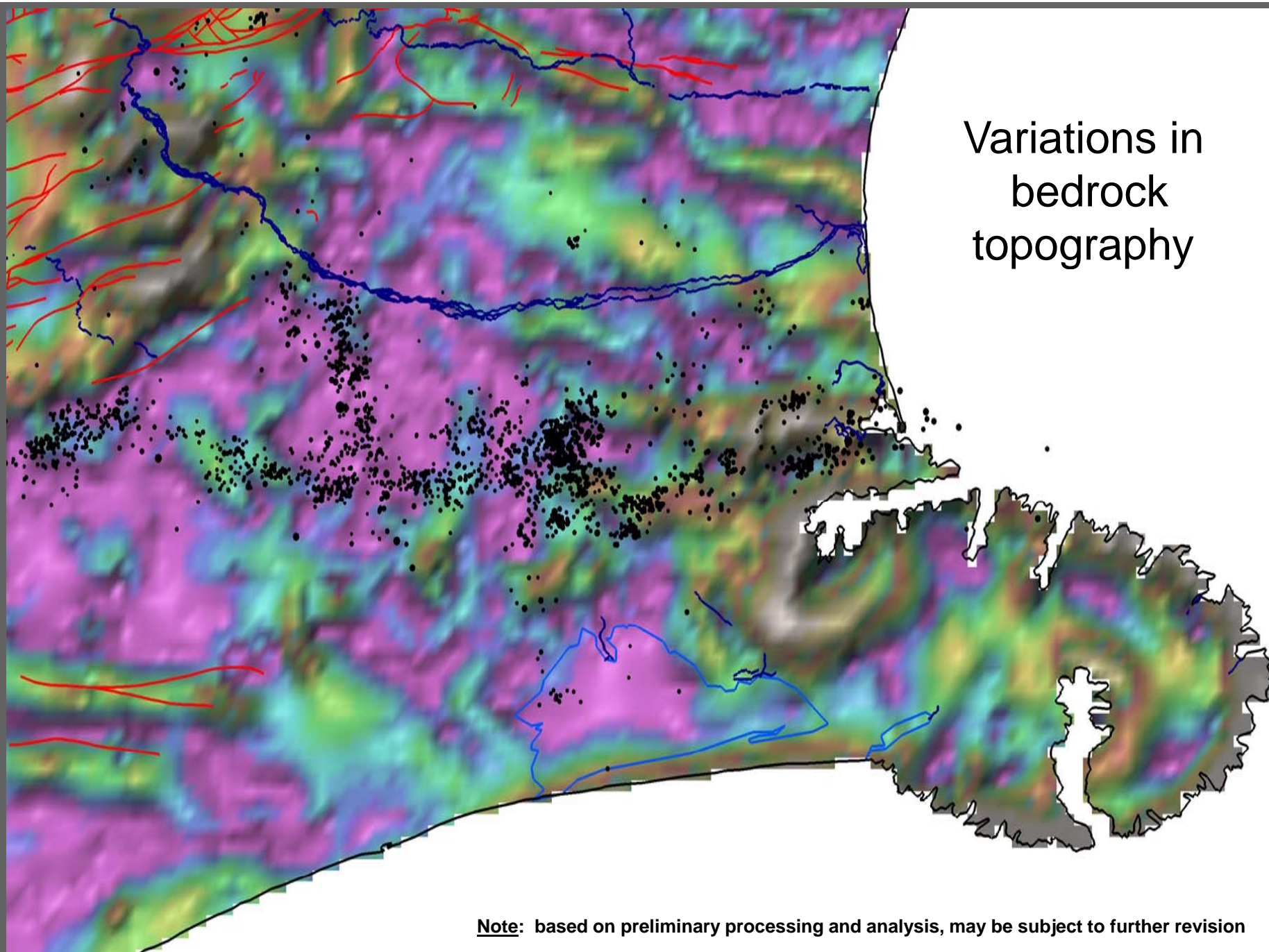


- Collection finished last week.
- Variations are dominantly due to volcanism (12-6 Ma Banks Peninsula)
- Buildings and other man-made features need to be identified

Note: based on preliminary processing and analysis, may be subject to further revision



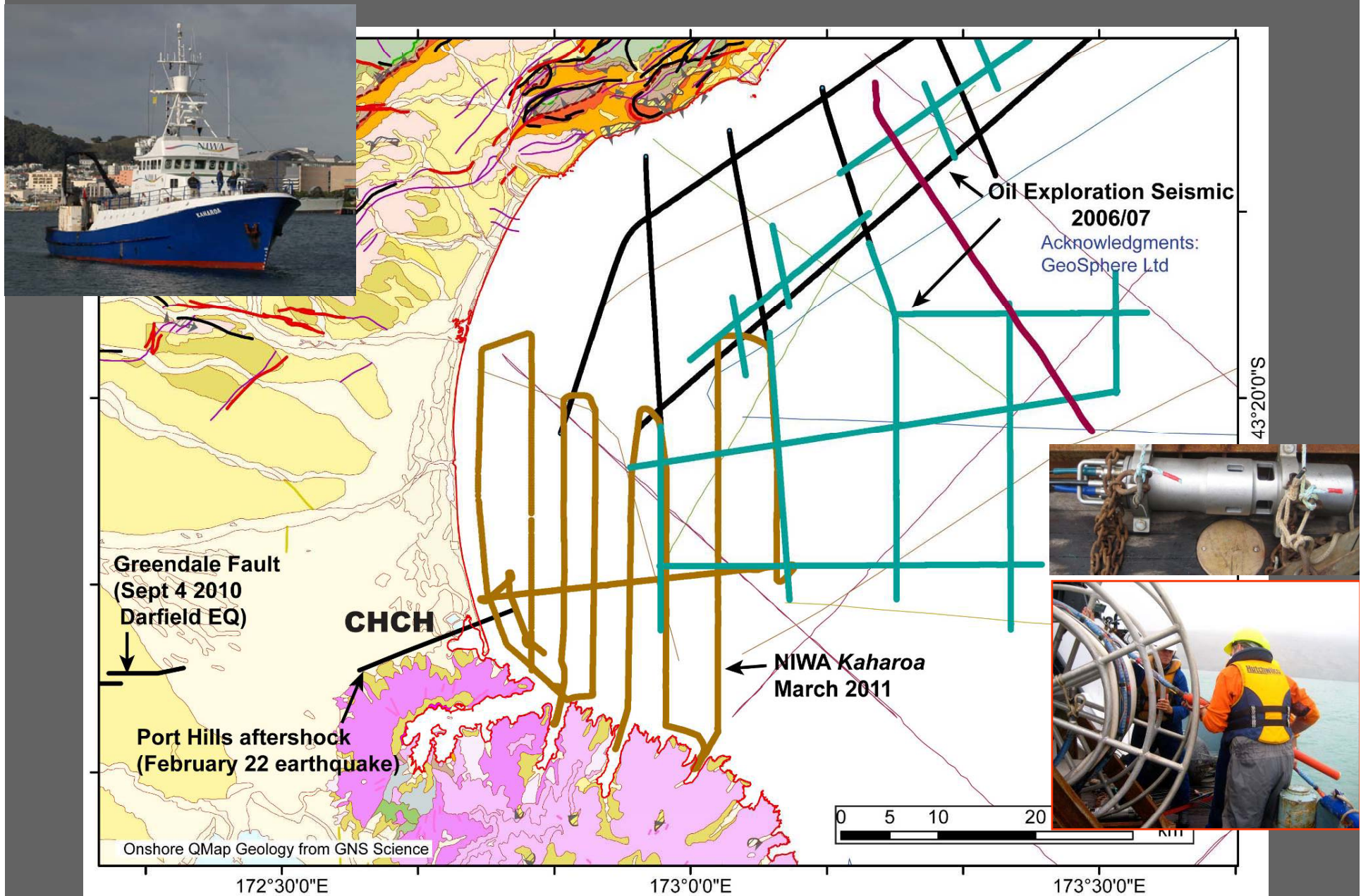
## Variations in bedrock topography



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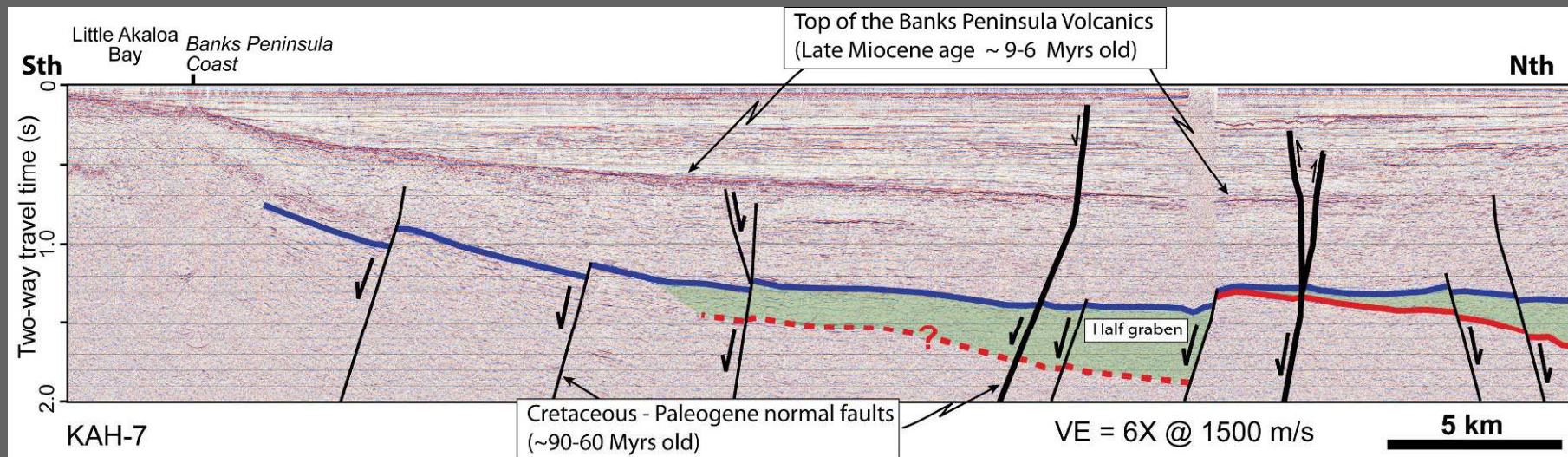
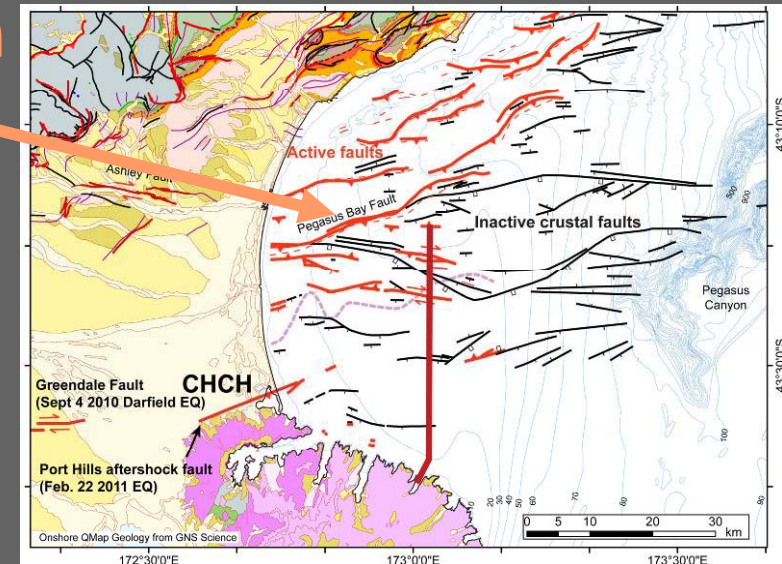
# Multichannel Seismic Reflection data





# Is there active faulting south of the Pegasus Bay Fault?

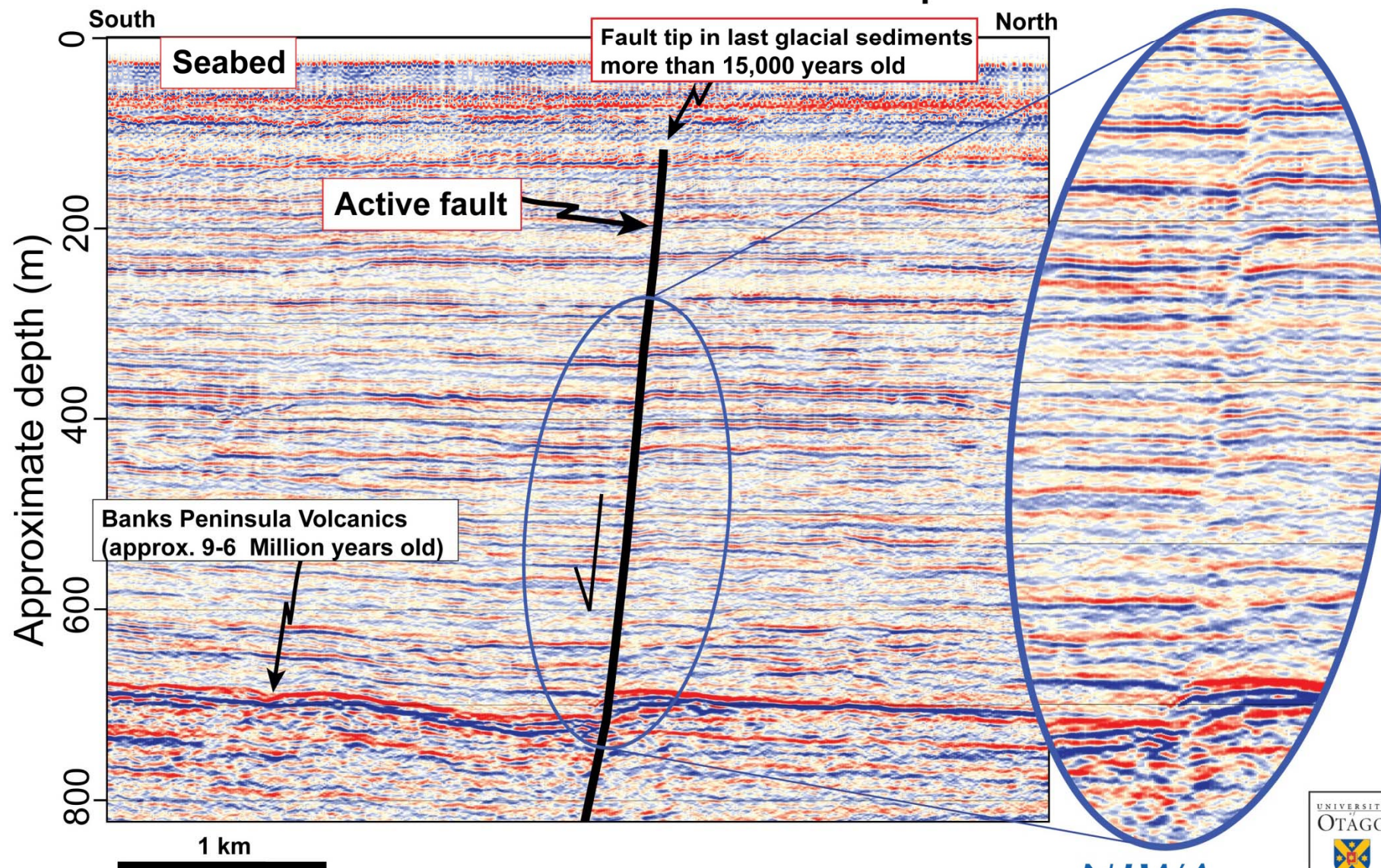
**Note:** based on preliminary processing and analysis, may be subject to further revision



**YES, but the faults must have very low vertical slip rates**



# Seismic Profile of Active Fault East of Kaiapoi



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**NIWA**  
Taihoro Nukurangi

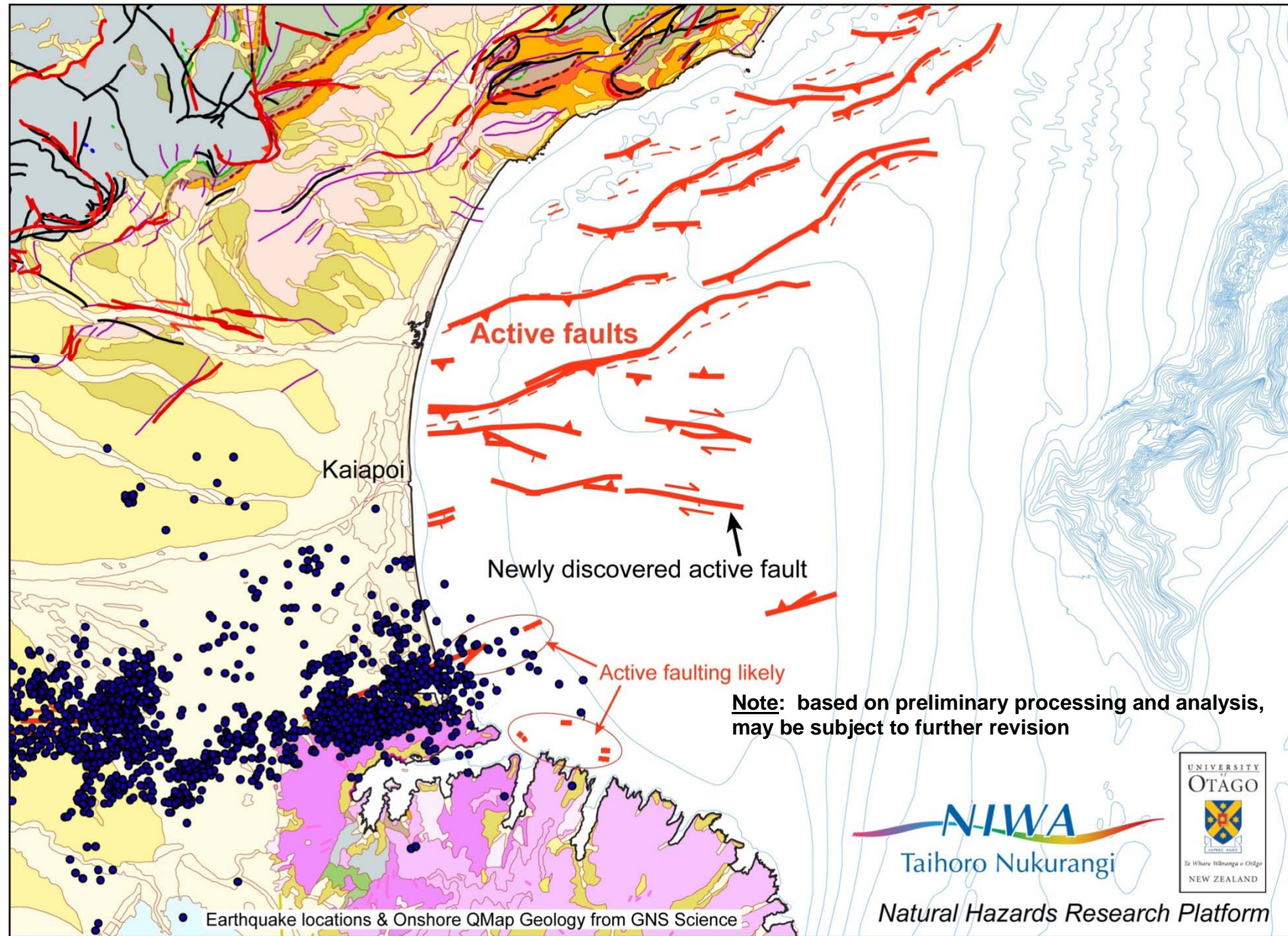


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## Active Submarine Faults Beneath Pegasus Bay



## In Summary

1. Faults imaged appear to have extremely low movement rates consistent with very long intervals between major earthquakes
2. There is no evidence of aftershocks stepping onto further offshore faults
3. Further results relating to the seismic profiling southwest and west of the city will become available in a month or so
4. Evidence for low rates of fault movement across the region derived from the subsurface geophysical studies is consistent with assessment that the September and February earthquakes are rare occurrences in Canterbury
5. Forecasts for earthquake activity in the future (1-50 years) has been incorporated into a revision of the building code for the rebuild programme in Canterbury
6. The research teams will be focusing on the integration of the various datasets to provide more confident assessment of earthquake likelihood