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8000-year quake record improves understanding of Alpine Fault

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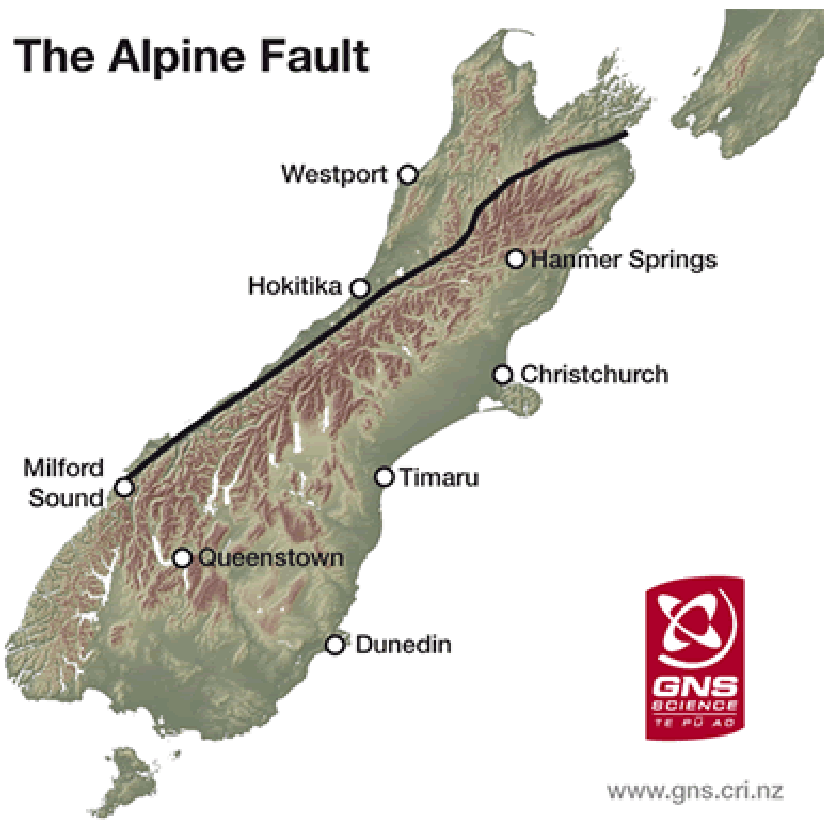


(Phys.org) -- A geological study of the southern section of the New Zealand's Alpine Fault spanning the past 8000 years has given scientists an improved understanding of the behaviour of this major plate boundary fault.

The investigation, which was centred on a remote river terrace near Lake McKerrow about 35km northeast of Milford Sound, and supplemented with information from the Haast area, found evidence of 24 surface ruptures of the Alpine Fault dating back to 6000BC.

Scientists used a range of investigation techniques, including radiocarbon dating of seeds, leaves, and reeds contained in swampy sediments, to determine the ages of the ruptures.

The dating measurements were made at GNS Science's Rafter Radiocarbon Laboratory in Lower Hutt.

The findings dramatically improve the known earthquake history of the Alpine Fault. Previously scientists had determined the ages for only the last four earthquakes dating back to about 1000AD.

The project has produced one of the longest continuous earthquake records of any on-land plate boundary fault in the world. Knowing the ages of so many major earthquakes enables a better understanding of the fault's behaviour.

The investigation found the mean interval between large earthquakes on the fault is 330 years and two thirds of the intervals were between 260 and 400 years. As with many natural systems, there was a spread of intervals with the longest being about 510 years and the shortest about 140 years.

The Alpine Fault extends about 600km along the spine of the South Island between Milford Sound and Marlborough. When it ruptures, it produces an earthquake of about magnitude 8.0.

The study, published in *Science* this week, focuses on alternating peat and silt layers left as a signature from each of the surface ruptures of the fault. The scientists looked specifically at the timing of past earthquakes at the Lake McKerrow site and did not determine the length of surface rupture for these earthquakes.

The four-year research project was led by GNS Science and funded by the Marsden Fund, which is administered by the Royal Society of New Zealand. Other participants were from Victoria University of Wellington, as well as scientists from Italy, Israel, and the United States.

Recent studies have suggested that fault rupture occurs randomly or in clusters in response to a range of factors including interactions with other nearby faults. However, this study has shown that for faults similar to the Alpine Fault, a fairly regularly repeating earthquake cycle is a realistic foundation on which to base earthquake hazard estimates.

Based on this research, scientists have estimated there is a 30% probability of a large earthquake on the Alpine Fault in the next 50 years. This is at the higher end of existing estimates, which were based on only the last four large quakes on the fault. Scientists have more confidence in this new estimate as it is based on a much longer earthquake record.

“There is considerable interest in these new results given that earthquakes on the Alpine Fault pose a threat to large parts of the South Island,” said project co-leader Kelvin Berryman of GNS Science.

“On a national scale, we can now base our modelling on knowledge of the timing of 24 earthquakes compared to the four that were known prior to this investigation. This will greatly improve the reliability of earthquake hazard modelling,” Dr Berryman said.

“This research has particular significance to Canterbury where the findings are being incorporated in liquefaction and earthquake shaking mitigation measures as part of the rebuilding process."

For project co-leader Ursula Cochran, also of GNS Science, the long earthquake record they uncovered highlighted the inevitability of a major earthquake occurring on the southern section of the Alpine Fault in the future.

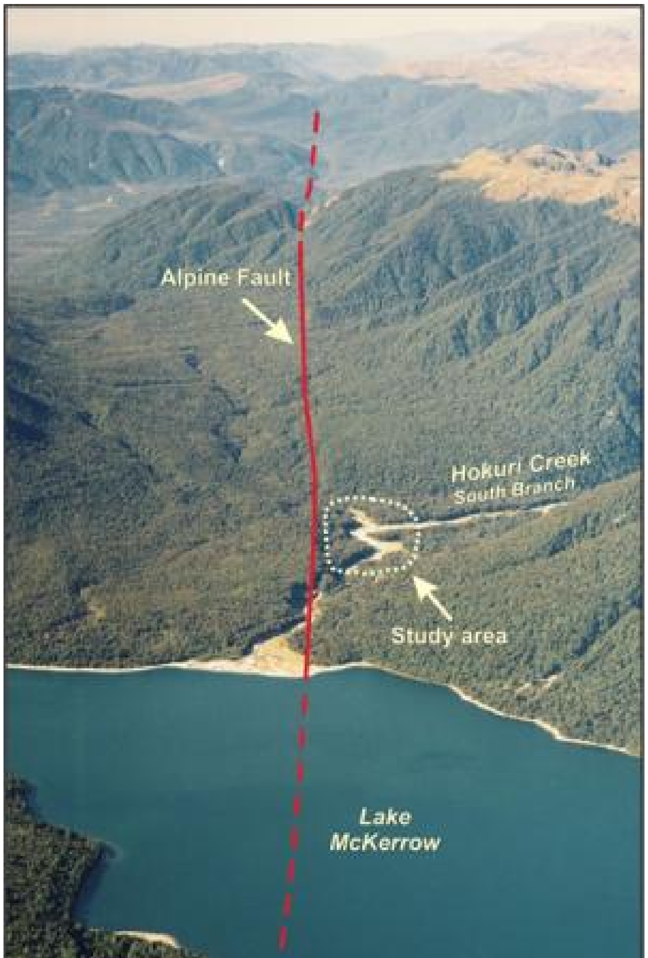
"The last earthquake occurred about 295 years ago, so there is no better time than the present to prepare for the next one," Dr Cochran said.

At the household level, these measures include emergency kits, anchoring furniture, removal of old-style chimneys, and family communication plans. At the local community level, measures could include planning for the care of the elderly and young if the community is isolated, and identifying skills and equipment helpful in a disaster.

At the local and regional government level, hazard mitigation policies in land use planning, strengthening earthquake-prone buildings and infrastructure, will reduce loss of lives and incomes.

“The more thorough the preparation, the lower the eventual impact will be,” Dr Cochran said.

Alpine Fault Q&A



An aerial view of the Alpine Fault looking northeast from Lake McKerrow, 35 km northeast of Milford Sound. Photo: Lloyd Homer, GNS Science

1. What was the problem the scientists were trying to resolve with this project, and how did they go about it?

The biggest unknown at the start of this project, and for similar projects on many major faults worldwide, was the pattern of major earthquake recurrence. Do the major earthquakes occur randomly, regularly, or in clusters? The goal of this project was to determine the ages of as many past major earthquakes as possible. The scientists obtained a large number of high-resolution radiocarbon ages (about four per rupture) in an attempt to accurately date the past earthquakes preserved as abrupt changes in sediment layers at the study site. This is a high number of radiocarbon ages compared to other active fault investigations in New Zealand.

2. How does radiocarbon dating work in helping scientists understand the rupture behaviour of a major fault?

Scientists were able to radiocarbon date leaves and seeds that were buried by silt each time there was a major earthquake. The silt layers were deposited at the time of earthquakes when fault movement temporarily dammed Hokuri Creek and silt from river sediment was deposited on top of peaty sediment. The scientists could see striking alternations between peat and silt in the banks of Hokuri Creek and these sedimentary signatures of earthquakes extended back in time for 8000 years. They represented more than 20 fault movements and accompanying major earthquakes.

Ages of these major alternations show that the fault has ruptured regularly in the past - not like clockwork but not randomly or in clusters as is observed on some other faults. The shortest interval between quakes was about 140 years. The longest interval was about 510 years, with an average of 330 years.

3. Are these findings entirely new?

These findings are entirely new for the Alpine Fault. Prior to this project, the ages of only the last four Alpine Fault earthquakes were well known. Long records with more than 20 earthquakes have been obtained from other faults around the world such as the San Andreas Fault in California, but they are very rare. The Alpine fault is perhaps only the fifth such long record and it has revealed the most regular rupture behaviour yet reported.

4. What is the take-home message from this investigation?

Scientists have found a fault that responds to the steady motion of tectonic plates by rupturing at reasonably regular intervals. This illustrates that at least some plate boundary faults can be "well-behaved" when they are have high rates of movement and are not influenced by activity on other nearby faults. Based on this research, scientists have estimated there is a 30% probability of a large earthquake on the Alpine Fault in the next 50 years. This is at the higher end of existing estimates, which are based on only the last four large quakes on the fault. Scientists have more confidence in this new estimate as it is based on a much longer earthquake record.

5. Does 'well behaved' mean that scientists can predict the year, or decade, when the next rupture will occur?

No, unfortunately not. It simply means the Alpine Fault exhibits a fairly regular cycle of stress accumulation and rupture. It does not have long periods of more than 1000 years of inactivity. Equally, it does not have clusters of big earthquakes occurring at short intervals.

6. What are the wider implications of this work?

The research has important earthquake hazard implications nationally by providing a much longer record and therefore a more reliable forecast of when the next major earthquake will occur on the southern section of the Alpine Fault. The last major earthquake on the Alpine Fault occurred 295 years ago. As we are approaching the average time between ruptures - 330 years - there is no better time to get serious with mitigation and preparedness.

7. How might authorities use these findings in disaster planning?

Scientists have been communicating results of Alpine Fault research to authorities in New Zealand for many years. The current research results add confidence to the forecast of average repeat intervals of major earthquakes, the elapsed time since the last earthquake, and most-importantly the relatively regular repeat time. The important things for authorities are to encourage personal and household preparedness, to address earthquake-prone building occupancy in areas near to the fault, and to encourage preparedness actions among emergency services and responding agencies.

8. Is there a concern that the public might misinterpret these research findings?

The public might misinterpret these findings as a prediction – it is not. There is also a possibility of misinterpreting the results as the earthquake being imminent, which it may not be. The mean recurrence interval between the 24 earthquakes is about 330 years. So with an elapsed time of about 295 years since the last big quake, a major earthquake in the near future would not be a surprise. Equally it could be up to 100 years away. The bottom line is – if not in our lifetimes then it is increasingly likely in our children's or our grandchildren's. Therefore a precautionary approach is certainly warranted.

9. How do scientists account for the variability in rupture intervals - from 140 years to 510 years?

There are numerous factors that cause a fault to rupture that can change through time including rock strength, frictional properties of the fault plane, and transfer of stress from other nearby faults. Therefore, there will always be some natural variability in the timing of earthquakes. The results of this study show some of the most regular behaviour for faults worldwide indicating that there are few factors changing dramatically through time for this section of the Alpine Fault.

10. How representative is the southern section of the Alpine Fault (where this study was conducted) of the entire Alpine Fault?

Previous studies on the Alpine Fault indicate that some earthquakes have only ruptured northern parts of the fault, while others appear to have ruptured almost the entire length of the fault. This study did not investigate rupture length, so although scientists consider the earthquakes at Hokuri Creek were large enough to rupture much of the southern and central parts of the fault, they will not be certain of this until they can correlate with earthquake records at other sites. Work currently being done by NIWA on the offshore part of the fault, south of Milford Sound, may help to determine how far south such earthquake ruptures extended.

11. This research seems to reach a somewhat different conclusion to recent studies by other research teams. Why do scientists studying the same fault come to different conclusions?

Prior to this study, all estimates of the mean recurrence interval for the Alpine Fault were based on three or four past earthquakes. Estimating a mean from 24 ruptures is more reliable than previous studies. The dates of the four most recent earthquakes haven't changed, but this study has shown that the variability in recurrence in recent times is not representative of the variability over an 8000 year time frame.

12. Where might research go from here and what challenges do scientists face?

Scientists are keen to refine the timing of past earthquakes by further dating of the sediments. This would be followed by robust statistical analysis on the expanded collection of dates. However, there is no funding for this at present. Secondly, it is important to find other sites along the fault so that the results from a single site can be validated by results from other locations. It is a challenge to find appropriate sites where there are long records of past fault movements, and where it is possible to date sediments. The physical environment along the Alpine Fault is very challenging with annual rainfall of 5-8 metres and steep slopes that are prone to landsliding, which obscures the fault in many locations. There is also thick rainforest that makes access difficult and fast-flowing rivers carrying coarse gravel that is difficult to date.

13. Is this research peer-reviewed?

The research underwent exhaustive international peer review. *Science* is a highly reputable international journal and it publishes fewer than 10% of research papers it receives.

More information: Science 29 June 2012: Vol. 336 no. 6089 pp. 1690-1693 DOI: 10.1126/science.1218959

Provided by GNS Science

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