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When The Earth Moves:

MEGA-EARTHQUAKES TO COME?

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When the Earth moves: Mega-earthquakes to come?

Executive summary

2010 has already proven to be a devastating year for earthquakes, with events in Haiti and Chile providing the world with a tragic reminder of the power and destructive capabilities of these natural perils. The Chile earthquake was particularly notable, as the seventh largest magnitude earthquake ever recorded. Most earthquakes of this kind are produced at subduction zones: this report considers some of the locations where such earthquakes may occur in the future and result in losses to the insurance industry.

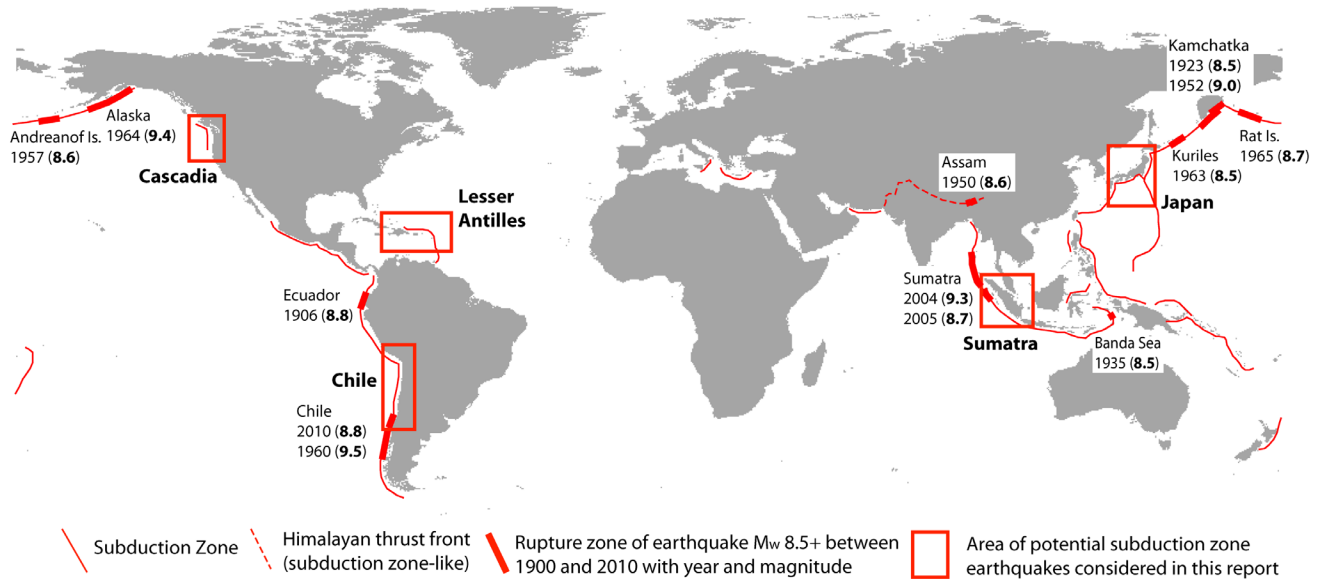
MEGA-EARTHQUAKES

The Maule earthquake that struck central Chile on 27 February 2010, of moment magnitude (M_w) 8.8, is the most recent example of a subduction zone mega-earthquake. Subduction zone earthquakes are produced at the interface where an oceanic plate slides beneath another plate, known as the upper plate, and the down-going plate descends into the interior of the Earth as a subducted slab. This type of earthquake includes almost all mega-earthquakes to affect the Earth. The term 'mega-earthquake' used in this report refers to events of moment magnitude greater than 8.

The 2010 earthquake was, however, a relatively small event in comparison to other previous, subduction zone earthquakes. It was only 5–10% of the size (in terms of moment magnitude) of the largest earthquake to have been recorded (Chile 1960; M_w 9.5) and also significantly smaller than the 2004 Sumatra earthquake of M_w 9.3.

FINDING FAULT: WHERE DO MEGA-EARTHQUAKES OCCUR?

Predicting the location of the next mega-earthquake is an inexact science but by examining the fault lines and historical precedence of earthquake activity in five of the world's most vulnerable regions, this report sets out to assess the current risk and improve our understanding of where and when the next mega-earthquake could hit. In addition to the scientific assessment, the report covers the (re)insurance sector's view and addresses the implications of a mega-earthquake for each region.



EVALUATING THE RISK

■ Caribbean (Lesser Antilles)

The absence of historical earthquakes on a large part of this subduction zone can be used to infer the occurrence of rare but very large earthquakes. The 2cm a year rate of plate convergence here is, in theory, enough to produce a mega-earthquake of M_w 9.0 once every 3000 years or so, although a more likely outcome is smaller but still large subduction zone earthquakes at intervals of as little as every 500–1000 years.

A major loss here would quickly use up available reinsurance capacity; a problem for an area overly reliant on a limited number of international reinsurance markets.

■ Chile

As the only segment of the Chile-Peru Subduction Zone not to have ruptured within the last 100 years, the north Chile segment is now considered to be a region at high risk from an earthquake similar to, or larger than, the 1877 Tarapaca or Iquique earthquake (M_w 8.3). Such an event could be comparable in size to the 2010 Maule earthquake with the possibility that coastal cities such as Iquique would experience felt seismic intensities, on the Modified Mercalli Scale (MMI) of VIII (destructive) or more, and that a large, regionally damaging tsunami could be produced—as also occurred in 1877.

Chile of course has had the most recent experience of a mega-earthquake. Reinsurance programs are now renewing with increases of 75% or more, with a trickledown effect likely on primary rates from loss activity and as insurers renew their reinsurance and try to pass on the higher cost of the cover.

■ **Indonesia (Sumatra)**

Padang is now regarded as being at high risk from a mega-earthquake comparable to that which occurred in 1797, with a magnitude of 8.5 or more. Such an event is likely to result in felt seismic intensities of MMI VIII (destructive) or greater, along 600km of the coast and on the Mentawai Islands offshore.

Recent losses have changed (re)insurance buying habits in Indonesia with more catastrophe cover being bought in the region than previously. In the event of a mega-earthquake, the reinsurance cover, which is largely being supplied by Singapore based international reinsurers, would undoubtedly increase in price following sizeable insured losses.

■ **Japan**

The South Japan Subduction Zone, also known as the Nankai Trough, has the longest historical earthquake record of any subduction zone. This reveals a complex pattern of large earthquakes distributed amongst three segments: sometimes the subduction zone experiences partial rupture, including pairs of earthquakes on the southwestern and northeastern segments, whilst on other occasions the whole subduction zone breaks in a mega-earthquake.

Depending on the location, a mega-earthquake in this region would most likely be a market-moving event. For reinsurers, Chile has been an earnings issue while a similar event in Japan would also likely hit their capital and most reinsurers see it as a peak peril.

■ **North America (Cascadia)**

The average recurrence interval for subduction zone earthquakes in Cascadia (Pacific North West) is 550 years but the range of intervals is between 300 and 1200 years. Recent work suggests clustering of earthquakes into series of up to five events occurring over 1500–2000 years, separated by quiet periods up to 1200 years long. There have been three earthquakes in the last 1000 years, which suggests that we are presently in the middle of an earthquake series.

The last mega-earthquake on the Cascadia Subduction Zone occurred 300 years ago, just before the start of historical records for the region. Whilst the short to medium term probability of a mega-earthquake may be low, there is potential for such an event in the future and insurers should not disregard the associated risks to the cities of the Pacific North West region.

OTHER EARTHQUAKE SOURCES

Although this report focuses on mega-earthquakes, these regions are also affected by other types of earthquake that contribute to the overall seismic hazard. In particular, upper plate earthquakes, produced by near-surface deformation in the plate above the subduction zone, can be locally very destructive when they occur near or even within coastal towns and cities. In addition, large earthquakes occurring at depths of 50km or more within the subducted oceanic plate, known as intraslab earthquakes, are characterized by anomalously high seismic energy release relative to their moment magnitude and can as a result be particularly destructive. Regions where upper plate and intraslab earthquakes are significant contributors to overall seismic risk are accordingly noted in this report.

STRESS TRANSFER

The phenomenon of stress transfer should be considered in the assessment of the probability of earthquake shaking from some of the subduction zones discussed in this report. This is when the occurrence of a mega-earthquake on one part of the subduction zone transfers stress onto adjacent segments, bringing them close to failure and producing a sharply increased conditional probability of earthquake rupture. This applies, at least, to the Sumatra-Andaman and Japan subduction zones and is an ongoing issue for research to address.

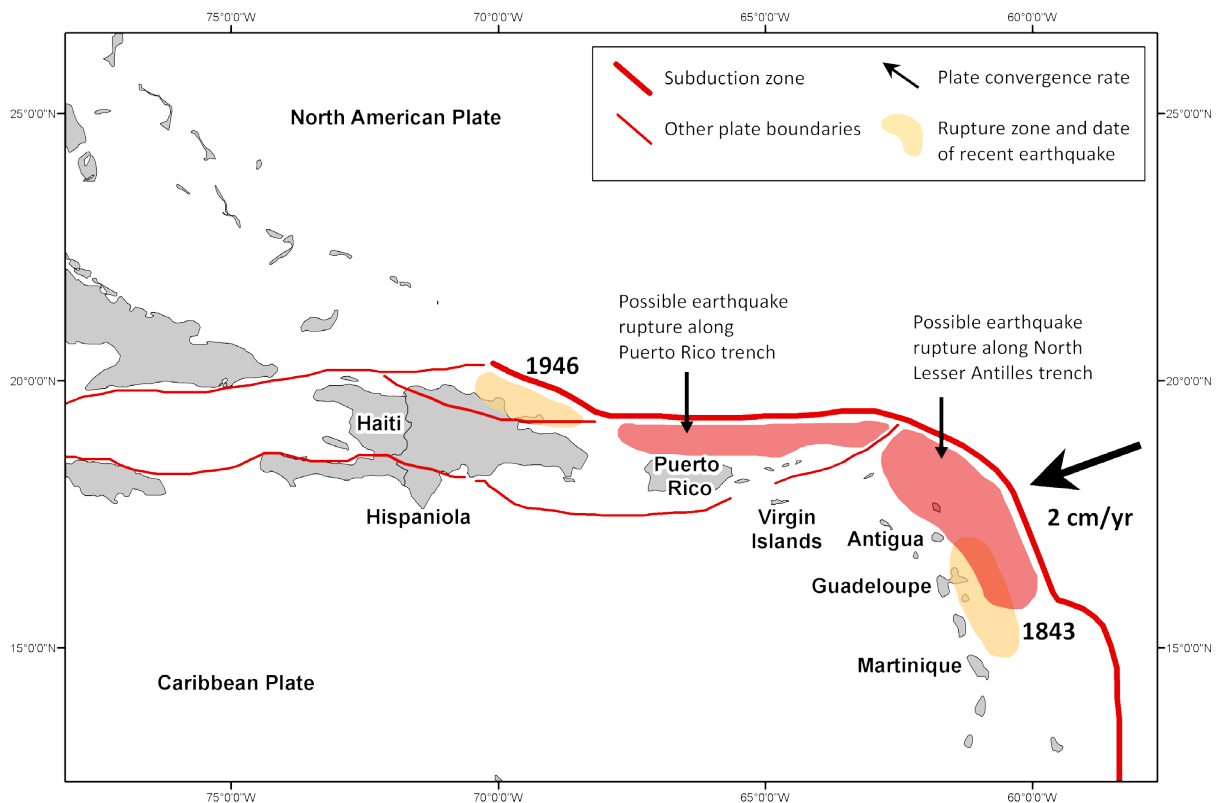
COMBINING EXPERTISE

The scientific views presented in this report are the work of Dr Simon Day at the Aon Benfield UCL Hazard Research Centre, based upon his interpretation of peer-reviewed literature. The report combines this academic research with the expertise of Aon Benfield's global Analytics and broking teams.

The goal is to deliver relevant research to insurers and reinsurers underwriting risks in some of the world's most earthquake prone areas and to create a more risk aware world so clients, governments and non-governmental groups are better able to protect and grow their organizations in the face of natural hazards and accompanying socio-economic risks.

Caribbean (Lesser Antilles)

The scientific view



THE FAULT

The North American Plate is being subducted westwards under the Caribbean Plate at a rate of about 2cm a year. The Lesser Antilles Subduction Zone extends north from Tobago and curves sharply west through the Puerto Rico trench, where subduction occurs at an angle that is highly oblique to northern Hispaniola.

THE HISTORY

Parts of the Lesser Antilles, most notably between the islands of Martinique and Guadeloupe in the south, and northern Hispaniola to the northwest, experience frequent medium-sized and damaging subduction zone earthquakes. Magnitudes reach 7.0 to 8.0 and previous events include the 1843 and 2007 Guadeloupe earthquakes and the 1946 M_w 8.0 Hispaniola earthquake. These frequent, less powerful earthquakes indicate that the subduction zone is strongly segmented at its northern and southern ends.

In contrast, the lack of historical earthquakes in the central part of the arc implies the occurrence of larger, less frequent earthquakes. Available evidence indicates that the plate boundary is not completely locked, so segments of the subduction zone have not been accumulating strain. Only about 30% of the convergence is being stored up to stress the plate boundary and generate earthquakes. Even so, the 2cm a year rate of plate convergence is in theory sufficient to produce a mega-earthquake of M_w 9.0, rupturing the whole sector from Hispaniola to Guadeloupe once every 3000 years or so.

It is, however, unlikely that the whole subduction zone would rupture at once, as the subducting North American Plate is sharply bent at the corner east of Puerto Rico and may in fact be split in two at that bend. Alternatively, there may be two segments—west and southeast of the Virgin Islands threatening Puerto Rico, and the northern Lesser Antilles—that rupture in smaller but still very large (M_w 8.5 or more) subduction zone earthquakes at intervals as short as every 500–1000 years.

THE RISK

Infrequent but potentially mega-earthquakes could affect the northern Lesser Antilles and Puerto Rico, implying a high level of risk and highlighting the need for research on prehistoric earthquakes in the region.

There is also evidence that the partly locked region of the subduction zone is relatively narrow and lies to the east and north of most of the islands (Barbuda, to the north of Antigua, may be an exception), so seismic shaking from a mega-earthquake would only be moderate. Shaking would, however, be long lasting and over a long period, so liquefaction of water saturated coastal sediment would be a significant secondary hazard.

Large earthquakes on the Lesser Antilles Subduction Zone have produced significant and damaging tsunamis, most recently as a result of the 1946 Hispaniola earthquake. A mega-earthquake on the subduction zone is likely to generate a major tsunami that would impact heavily upon developed coastal areas within 30 minutes of the earthquake occurring.

WHEN THE EARTH MOVES: MEGA-EARTHQUAKES TO COME?

Upper plate earthquakes constitute an additional significant hazard, especially along the north coast of Puerto Rico. Here the highly oblique angle of subduction beneath the island has led to intense deformation on many strike-slip faults, which display mainly lateral as opposed to vertical movement, within the upper plate.

The (re)insurance view

INSURANCE TAKE-UP

Insurance take-up throughout the Caribbean is quite high both on a commercial level and for private individuals, with a distinct economic division between those who live in extreme poverty where no insurance is bought, and those who are employed and will generally buy some cover such as motor or property. The tourist infrastructure which the islands rely upon for much of their income is, as expected, heavily insured.

Earthquake cover is wrapped up in standard property cover that generally includes catastrophe cover for wind and earthquake damage. There is the option to opt out of the catastrophe cover element which can reduce rates by as much as a half for the buyer but few take this option.

THE MARKET

Across the board, insurance rates in the region are falling and have been for the last two years with annual reductions of 5–10%. A particular feature of the Caribbean market is the high level of proportional reinsurance which creates a close correlation for rates on both the primary and reinsurance side. Therefore, if there is adequate capacity, as at present, reinsurance rates will also fall. If there is no major loss and prices continue to fall, there could be a reduction in reinsurance capacity as the attractiveness of writing Caribbean business declines.

IMPACT OF A MEGA-EARTHQUAKE

The Caribbean is viewed primarily in the light of windstorm peril; consequently the earthquake risk has been somewhat overlooked although Haiti and Chile have done much to remind the region of its vulnerability to earthquake activity. Any major earthquake loss would quickly reduce available reinsurance capacity as well as significantly firming-up rates; price rises would again be passed on very quickly to the primary side.

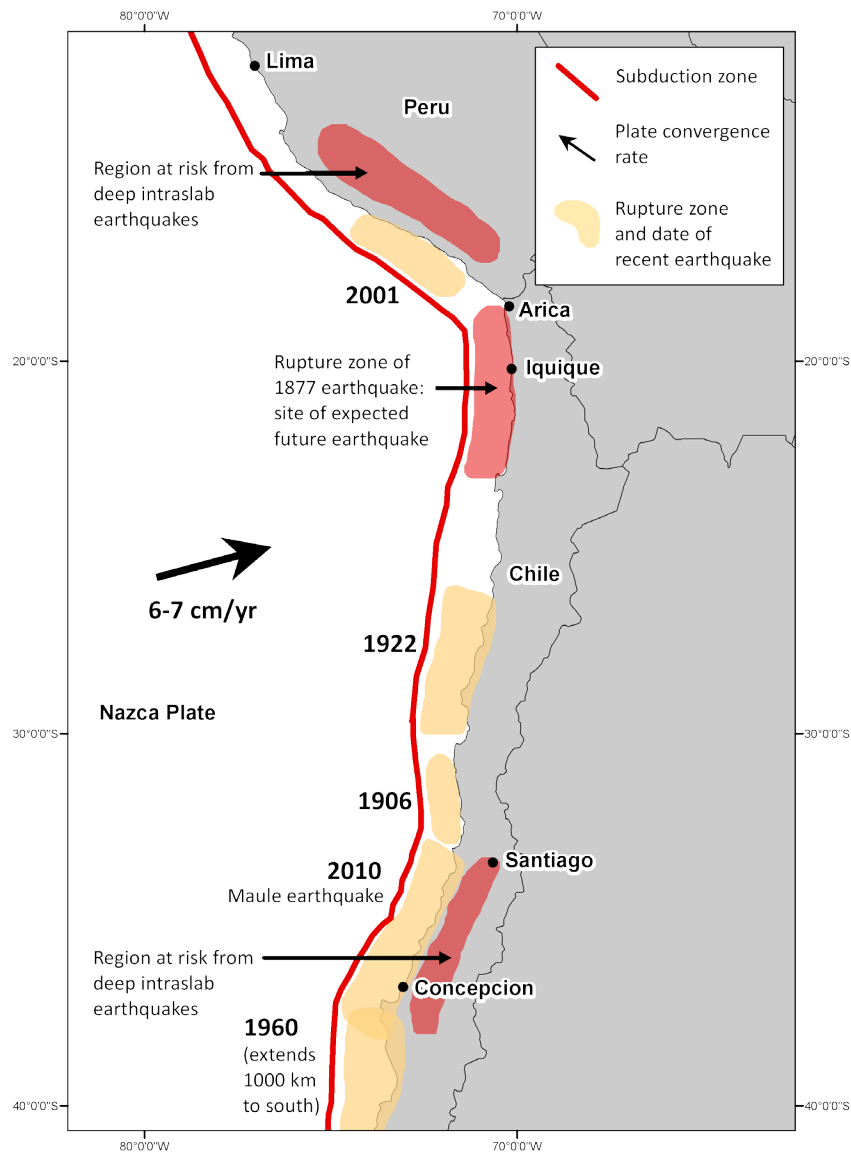
Less than 20 reinsurance markets provide the majority of capacity to the region which also makes it very vulnerable to a shortage of capacity if a number of those markets stop writing business there.

PREPARING FOR THE FUTURE

Recent events have also persuaded many insurers to reassess their levels of reinsurance protection with some looking for additional cover. These earthquakes provide useful loss data for calibration of the catastrophe models for this region, which remain a key tool for insurers who need to build in as much certainty as they can to understanding their exposures.

Chile

The scientific view



THE FAULT

The Nazca Plate is being subducted beneath Peru and northern Chile at a rate of 6–7cm a year, providing the potential for mega-earthquakes at a rate of about one every 100–200 years on any given fault segment.

THE HISTORY

Mega-earthquakes have occurred offshore from southern Peru in 1604, 1784, 1868 and 2001, resulting in high levels of damage in coastal cities and also significant tsunamis.

The sequence of known historical earthquakes for the subduction zone segment off northernmost Chile is much shorter because this is the area of the Atacama Desert: it has only become populated in the last 150 years. The last mega-earthquake in northern Chile was the 1877 M_w 8.3 earthquake, which ruptured a 500km long segment of the plate boundary, including the area offshore from the modern city of Iquique.

The M_w 8.8 Maule earthquake of 27 February 2010, which caused extensive damage between Concepcion and Valparaiso on the coast of central Chile, ruptured the only other segment of the Nazca Subduction Zone that has not broken since 1900. Other mega-earthquakes were in 1922 and in 1960 – the latter, the great southern Chile earthquake of May 1960, being the largest ever recorded.

THE RISK

The north Chile Subduction Zone segment is now considered to be a region at high risk from a repeat of the 1877 earthquake, or an even larger event comparable in size to the 2010 Maule earthquake. Such an earthquake would impact coastal cities such as Iquique with felt seismic intensities of MMI VIII (destructive) or more. It is also to be expected that a large, regionally damaging tsunami could be produced, as also occurred in 1877.

Peru and Chile also suffer from strong intraslab earthquakes (up to M_w 8.0) in the interior of the subducted plate. These occur at depths of around 50km and inland from the coast beneath the Central Valley of Chile and the coastal mountains of Peru. The largest intraslab earthquakes, such as those of 1939 in central Chile (25,000 deaths) and 1970 in southern Peru (66,000 deaths, including 25,000 killed by a landslide triggered by the earthquake) may, in fact, be more destructive and present a greater risk than the larger offshore earthquakes at the subduction zone plate boundary itself.

The (re)insurance view

INSURANCE TAKE-UP

Insurance take-up in this region is variable. In Chile, more than 75% of larger industrial and commercial operations buy fire and earthquake cover, while coverage is less comprehensive for small to medium sized companies with only 30% buying earthquake specific cover. On the residential side, the Chilean Insurance Association (AACH) states that only 24% of the country's homes have earthquake insurance. The figure is high for those with a mortgage (90%) while very few (10%) who do not have a mortgage against their home buy cover.

THE MARKET

With limited appetite amongst the domestic insurance market to hold onto earthquake risk, much of it is ceded to the international reinsurance market. This in turn means that reinsurance terms and conditions, and pricing, are a key driver for the primary pricing of earthquake cover in Chile. Before the Maule earthquake the market was softening for both insurance and reinsurance. For the last four to five years, rates have been declining at around 5-10% year-on-year for both commercial and residential properties and with little change in terms and conditions.

IMPACT OF A MEGA-EARTHQUAKE

The financial impact of the Maule earthquake of course is already being felt with USD8.0bn of gross losses, as of 31 March, reported to the Financial Equity Information by Chilean insurance companies. Despite the size of the loss however, Aon Benfield continues to predict that Maule will not affect global or regional earthquake rates outside of Chile.

Within Chile, reinsurance programs are renewing with increases of 75% or more. It is expected that specific changes to the Chilean insurance market will include a review of limits by insurers to ensure that they are meeting their exposure and learning lessons from the event. There will be a pricing differentiation according to the type of portfolio and geographical spread of business while areas under terms and conditions, such as a more precise event definition, are being considered.

A trickledown effect is also likely on primary rates due to loss activity, and as insurers renew their reinsurance and attempt to pass on the higher cost of the cover.

PREPARING FOR THE FUTURE

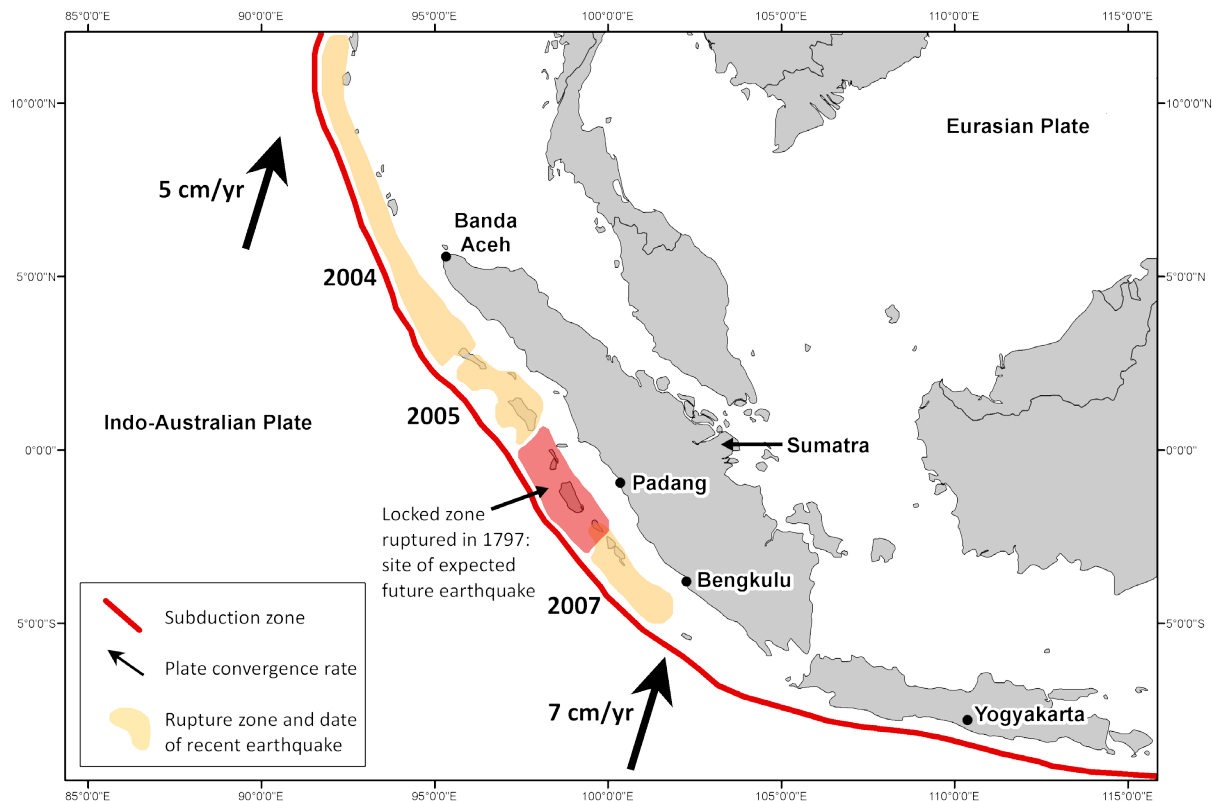
How Chile coped with the aftermath of the Maule earthquake throws up some positives. The seismic engineering code performed well considering the magnitude of the event and total building collapses were not widespread. Furthermore, fire following the event was not an issue and tsunami losses were confined to within 200 meters of the coast—accounting for less than 5% of overall losses.

For insurers, a focus on preparing for a catastrophe event in terms of efficiently dealing with the volume of claims and ensuring that the right procedures are in place is important.

There is also an opportunity to increase the size of the premium pot from those homeowners who did not buy earthquake cover because they did not have mortgages and were not obliged to. Selling the value of the product is critical here. It is also worth stressing that while reinsurers are differentiating on portfolios, insurers need to capture as much detailed information as they can on their own books in order to take advantage of any pricing differentiation.

Indonesia (Sumatra)

The scientific view



THE FAULT

The subduction zone west of Sumatra is the southern continuation of the Sumatra-Andaman Subduction Zone that ruptured in the M_w 9.3 earthquake of 26 December 2004. Here, the Indo-Australian Plate is being subducted in a northward direction beneath the Eurasian Plate, on which Sumatra is located, at a rate of about 7cm a year. A slice of western Sumatra between the two main plates is moving north relative to Asia, so there is also a major hazard from upper plate earthquakes within the crust beneath Sumatra.

THE HISTORY

Whilst the northern part of the Sumatra-Andaman Subduction Zone appears to rupture only in rare mega-earthquakes of M_w 9+, such as that in 2004, the section further south off the western coast of Sumatra ruptures in more frequent, slightly less powerful (M_w 8.2–9.0) earthquakes that are still highly destructive.

Historical mega-earthquakes have occurred in 1797, 1833, 2005 and 2007 arising from the rupture of different segments along the west coast of Sumatra. All, apart from the 2007 earthquake, have caused significantly destructive tsunamis, although not on the scale of the 2004 tsunami.

THE RISK

The region of the 1797 fault rupture, which lies offshore from the central Sumatran coastal city of Padang, is now the only segment of the subduction zone that has not ruptured in the sequence of earthquakes since 2004. Smaller earthquakes such as those of 1861, 1935 and 2009 either only broke small patches of the subduction zone plate boundary or occurred on intraplate faults above or below it, and did not relieve the stress that has accumulated on the 1797 rupture zone. Padang is therefore now regarded as being at high risk from a mega-earthquake, comparable to that of 1797, with M_w 8.5 or more. The future earthquake is predicted to produce felt seismic intensities of MMI VIII (destructive) or greater along 600km of the coast and on the Mentawai Islands offshore.

Broadly speaking, repeat earthquakes seem to occur along specific segments of the Sumatra-Andaman Subduction Zone, although the displacement in each and hence the size of the resulting earthquake does vary between successive events. Repeat intervals seem to be in the order of every 200–300 years, supporting the inference that a repeat of the 1797 earthquake could be likely in the near future.

The uplift and subsidence data also show that rupture zones extend down the subduction zone to the region between the Mentawai Islands and the mainland coast of Sumatra, so it is likely that Padang will be struck by a major tsunami when the next earthquake, comparable in size to that in 1797, affects the region.

The (re)insurance view

INSURANCE TAKE-UP

Insurance penetration in Sumatra and across Indonesia is limited at around 2-3% with specific earthquake protection even lower at less than 1%—not surprising in a country where the average daily wage is very low. Of those that do buy earthquake cover, the bulk is bought by the commercial and industrial sectors with only around 15% bought for residential protection.

THE MARKET

With strong competition for business on the direct side—there are around 100 insurers operating in Indonesia—rates have been softening with 10-20% discounts being offered year-on-year. This picture contrasts with the reinsurance side where rates have somewhat stabilised following the earthquake in Padang in 2009. However, the Padang losses, largely commercial in nature, hit many of the larger insurance companies which saw increases of 5-15% on their reinsurance programs. The relative abundance of reinsurance capacity has meant that the majority of those insurers less affected by the 2009 Padang event have been seeing reductions of 5-10%.

IMPACT OF A MEGA-EARTHQUAKE

Losses such as those arising from the 2009 Padang earthquake have changed buying habits with more catastrophe cover being bought than previously as cedants reconsider their exposures. In the event of a mega-earthquake, the reinsurance cover, which is largely being supplied by Singapore-based international reinsurers, would undoubtedly go up in price on the back of sizeable insured losses.

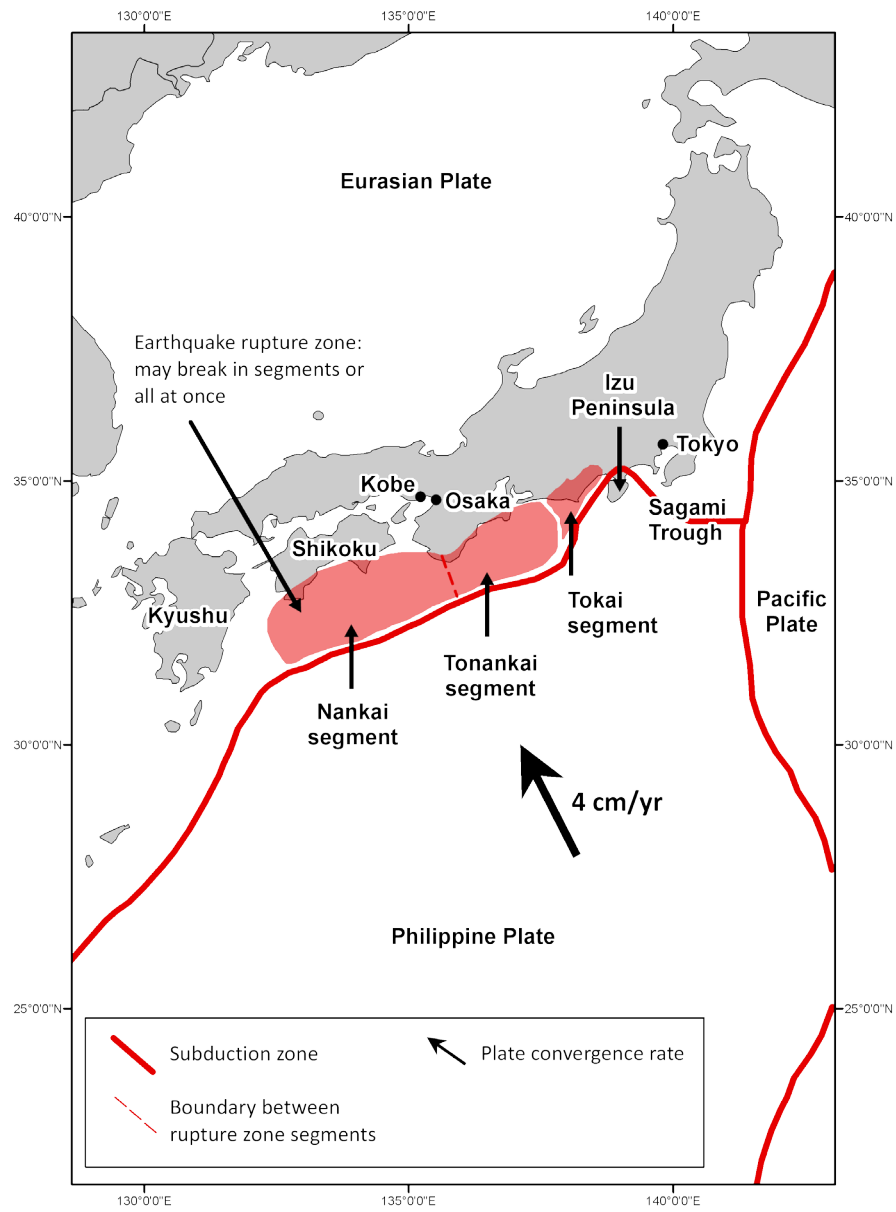
PREPARING FOR THE FUTURE

From an earthquake perspective, the region has good building codes in place but these are not enforced to a high enough standard. Poor quality control, for example, led to building damage during the 2007 Yogyakarta earthquake, which could have been avoided if the building codes had been followed properly and enforced.

A key lesson both from previous Indonesian catastrophes and from worldwide incidents such as Chile is that insurers need to understand what their exposures are and become more scientific in their purchasing of reinsurance with greater use of tools such as catastrophe models.

Japan

The scientific view



THE FAULT

The Philippine Plate is being subducted under southern Japan (which is located on the Eurasian Plate) at the Nankai Trough, at a rate of about 4cm a year. The subduction zone as a whole extends from south of Kyushu to the region of a triple plate junction southeast of Tokyo, where the Pacific Plate is being subducted beneath both the Philippine and the Eurasian Plates.

The easternmost section of the Philippine Sea Subduction Zone, where it comes onshore at the Izu Peninsula and continues east down the Sagami Trough, is the source of earthquakes that affect the Tokyo region, as in 1703 and the Great Kanto earthquake of 1923. This easternmost area also includes the Tokai segment of the subduction zone.

THE HISTORY

Japan has the world's longest historical record of subduction zone earthquakes with written records of earthquakes and associated tsunamis extending back to the Hakuho earthquake of 684 AD. Further evidence for these earthquakes is provided by coastal terraces along the Pacific coast of the country which are uplifted during earthquakes and subside between earthquakes.

Mega-earthquakes affect the Nankai Trough sections of the subduction zone between southwestern Shikoku and the Izu Peninsula, southwest of Tokyo. The Nankai Trough is divided into the Nankai (southwestern), Tonankai (northeastern) and Tokai segments. Although the historical records are ambiguous in some cases, it appears that the Nankai and Tonankai segments rupture either in pairs of earthquakes separated by hours (as in 1854) to a maximum of two to three years, or occasionally in a single mega-earthquake (as in 1707).

The boundary between the Nankai and Tonankai segments along the Nankai Trough lies under the Kii Peninsula to the south of Osaka. Many recent earthquake ruptures began in this area and propagated either to the southwest, to the northeast or in both directions.

Earthquakes rupturing one segment or the other have magnitudes of 7.8 to 8.4; the largest earthquakes rupturing along the whole subduction zone may have magnitudes up to 8.6.

THE RISK

Since 1360, intervals between mega-earthquakes along the Nankai Trough have varied between 90 years and 150 years. Greater intervals apparent earlier in the historic record may reflect incompleteness of the data. One of the notable features of the subduction zone is the strong correlation between ruptures of the Nankai and Tonankai segments. It is not clear if the Tokai segment ruptures in these earthquakes along the subduction zone further to the west or if it ruptures independently. Therefore, the behaviour of the Tokai segment is a key uncertainty in assessing the risks resulting from subduction zone earthquakes in South Japan.

Upper plate earthquakes to the north of the Nankai Trough, such as the 1995 Kobe event, are usually much smaller than the plate boundary earthquakes but have the potential to cause severe local damage.

The (re)insurance view

INSURANCE TAKE-UP

Given Japan's highly developed economy, earthquake insurance cover is perhaps not as widespread as expected. Take-up is modest for the industrial/commercial sector. Companies that do buy earthquake cover take it as an add-on and tend to buy on a first loss basis and not full value. Foreign companies operating in Japan however buy more comprehensive earthquake protection.

Earthquake coverage for domestic exposures is offered as an add-on to the property insurance policy by non life insurance companies. These earthquake exposures are pooled with the Japan Earthquake Reinsurance Company (JER), which provides coverage up to JPY5,500bn (USD58bn). Roughly 80% of this limit of liability is provided by the Japanese government.

There is also a highly developed mutual sector, not part of the JER Scheme, which accounts for a large percentage of Japanese earthquake exposure that reaches the international reinsurance market.

THE MARKET

Rates on both the direct and reinsurance side have been quite stable. Having just gone through the Japanese reinsurance season at 1 April, there has been evidence of a slight softening with plenty of capacity pushing rates down slightly by around 5%.

In relation to Japanese business there was no obvious reaction to the Chile earthquake. This may have been due partly to the earthquake occurring mid-way through the renewal season and there consequently being insufficient time to fully assess the impact. The insurance side has not reacted either and there is little sign of increased take-up amongst a population which has long been aware of the earthquake risk.

IMPACT OF A MEGA-EARTHQUAKE

A mega-earthquake in this region would most likely be a market-moving event. For reinsurers, Chile has been an earnings issue while a similar event in Japan would also likely hit their capital and most reinsurers view it as a peak peril.

With the current modest take-up of earthquake insurance in Japan, there would most likely be an increase in demand after a major loss. For example, this occurred following the Kobe earthquake loss in 1995.

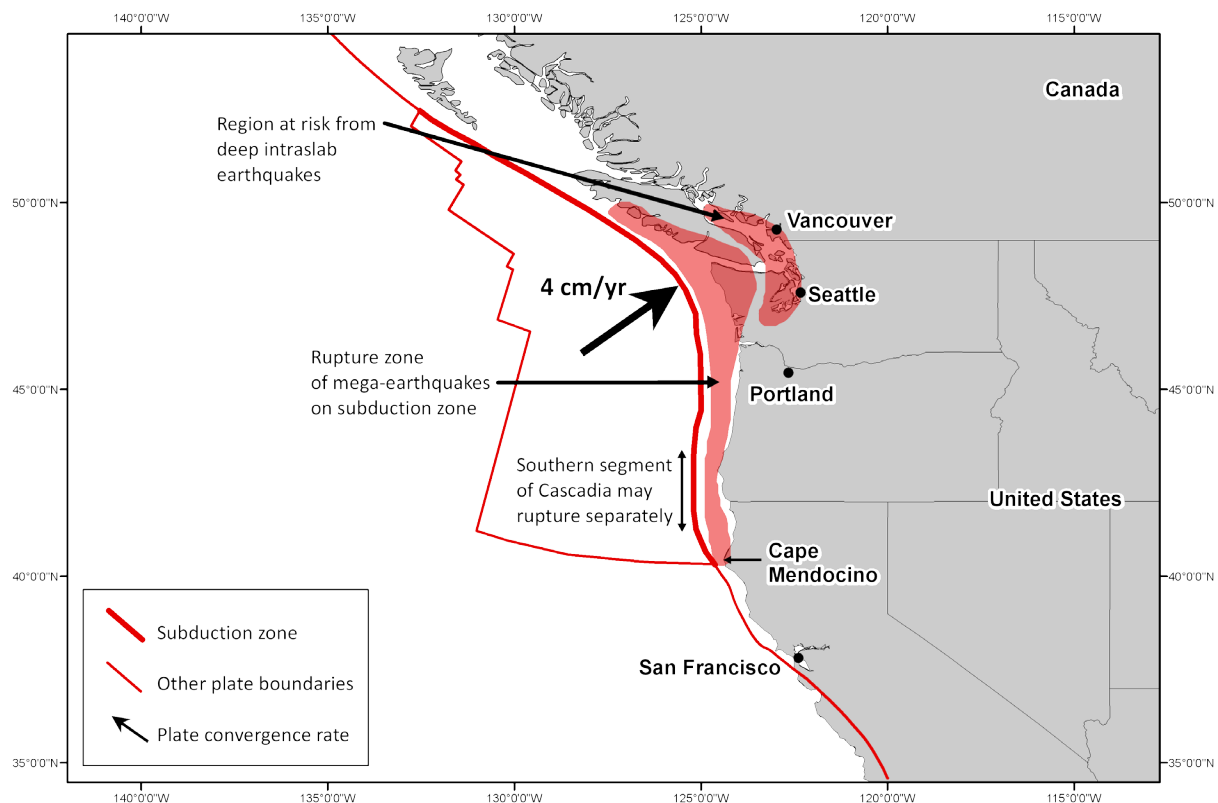
PREPARING FOR THE FUTURE

There have been few losses in recent times to help calibrate catastrophe models which, together with the varied nature of Japanese insurance policies, can make accurate assessment of the risk quite difficult. While understanding of their own portfolios is very good, what really drives the level of cover bought for most Japanese insurers are the regulatory requirements on solvency levels.

Japan's recent building codes are excellent and these are augmented by its relatively modern building stock. It is a country that has fewer old buildings and prefers to update more regularly; a factor that will work in its favor if it is struck by a mega-earthquake in the future.

North America (Cascadia)

The scientific view



THE FAULT

The Cascadia Subduction Zone is nearly 1000km long, extending from Cape Mendocino in Northern California (United States) to central Vancouver Island in British Columbia (Canada).

Cascadia has a narrow locked plate boundary, which is just 60–120km wide and defined by a pattern of ongoing ground deformation which, apart from the Olympic Peninsula area west of Seattle, is located mainly offshore. Any earthquake rupture will most likely occur beneath the sea, well to the west of the major cities of Portland, Seattle and Vancouver.

THE HISTORY

There has been no major earthquake on the subduction zone since European settlement. Studies of coastal subsidence, tsunami deposits and correlation with a tsunami observed in Japan, indicate that the last major earthquake occurred in January 1700 and was of approximate M_w 9.0.

Palaeoseismic and other geological studies indicate 14 similar earthquakes in the last 7700 years, almost all of which seem to have ruptured the entire length of the subduction zone; there is also some evidence for additional, smaller earthquakes that only rupture the southern quarter adjacent to southern Oregon and Northern California.

THE RISK

The average recurrence interval for subduction zone earthquakes in Cascadia is 550 years, but the range of intervals is between 300 and 1200 years. Recent work suggests clustering of earthquakes into series of up to five events over 1500–2000 years, separated by quiet periods up to 1200 years long. There have been three earthquakes in the last 1000 years, suggesting that we are presently in the middle of an earthquake series.

Only moderate levels of seismic shaking (MMI VI (strong) to VII (very strong)) are predicted in major cities, but these will be long lasting: liquefaction and building resonance effects will be important in determining the level of damage. Secondary hazards, such as landslides and local tsunamis, are likely to be significant in Puget Sound, west of Seattle, and Vancouver areas, owing to failures in thick sequences of post-glacial unconsolidated sediments.

Smaller communities on the Pacific coast are predicted to experience greater levels of shaking at MMI IX (ruinous) and also be highly vulnerable to effects of tsunamis. Deposits from past tsunamis associated with Cascadia earthquakes such as that in 1700 indicate that these would be highly destructive from Vancouver Island to California. Records indicate that the tsunami in January 1700 caused a moderate level of damage in Japan.

Other earthquake sources include frequent intraslab earthquakes at approximately 60km beneath Puget Sound and Strait of Georgia, west of Vancouver, and less frequent upper plate earthquakes near the surface, again in Puget Sound and Vancouver areas. These are capable of causing high levels of seismic shaking, but over smaller areas.

The (re)insurance view

INSURANCE TAKE-UP

Insurance penetration in terms of earthquake cover runs at around 30%, both for commercial and residential property in the Pacific North West. Pricing is competitive and earthquake cover is probably running at half the cost compared to peak earthquake zones such as California. One aspect of US residential earthquake cover worth emphasizing is that banks and mortgage lenders do not insist on insuring against this risk. The implications for insurers and reinsurers if this were to change would clearly be highly significant.

THE MARKET

Rates on both the primary and reinsurance side have been declining in the US. For commercial and residential property, insurance costs for earthquake cover have fallen by around 5% over the last two or three years. Reinsurers do not see the region as a particularly vulnerable area for earthquake-related losses and, as such, rates have softened with plenty of capacity around. Some companies do see it as a good area for diversifying their portfolio when balanced up against more volatile risks such as Florida windstorm.

IMPACT OF A MEGA-EARTHQUAKE

The Chile and Haiti earthquakes have had little effect on pricing of (re)insurance worldwide. It appears that catastrophe events need to be bigger and bigger to be market turning. It is hard to see what effect a mega-earthquake in Cascadia would have, if any, on rates throughout the wider North American region particularly given the lower population density of the Pacific North West area. Inevitably reinsurance pricing would respond on a local basis.

PREPARING FOR THE FUTURE

Whilst the short to medium term probability of such a Cascadia earthquake may be low—certainly in comparison to the situation in Sumatra—the detailed palaeoseismic investigations have clearly established the potential for such an event in the future and insurers should not disregard the associated risks to the cities of the Pacific North West region.

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Aon Benfield Research also brings together our academic relationships under one banner to deliver a wealth of relevant academic research material. We combine world class academic research with Aon Benfield's industry-leading catastrophe modeling, actuarial analysis and broking expertise to create a more risk aware world.



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