

Breakup of the indo-australian tectonic plate essays examples

[Environment](#), [Disaster](#)



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Introduction

On 11 April 2012 two huge earthquakes occurred beneath the floor of the Indian Ocean, off the coast of North Sumatra. Registering a magnitude of 8.6, the first was followed by another of 8.2 magnitude, which scientists subsequently identified as an aftershock. Neither triggered a large scale tsunami, which scientists attribute to the movement being of the “strike-slip” type, rather than the “thrust” type. However, strike-slip earthquakes are normally of a much lesser magnitude. This one caused a relative lateral shift of part of the ocean floor of around 70 feet, compared with the previously largest recorded strike-slip earthquake, which was in San Francisco in 1906, and where the lateral movement was just 15 feet. Further, the location of this April’s earthquake was unusual – approximately 100 km from the boundary between the Indo-Australia plate and the Sunda plate (Bradbury, Apr. 2012). The Figure below shows the earthquake’s epicentre location (star shape) and the boundaries of the various major and minor tectonic plates in the vicinity.

Figure 1: Location of the April 2012 Earthquake

(Extracted from: “ Indonesian Quake Rattles Island Nation.” Real Science.)

This essay seeks to explain why many believe that the earthquake on April 11 2012 was part of “ the difficult process of breaking a tectonic plate” (Barras, Sep. 2012). According to Barras the aftershocks were felt “ the world over” and “ provided the best evidence yet that the vast Indo-Australian plate is being torn in two.”

Geological Environment and Processes Responsible

Barras reports that geologists have been seeking to determine why the earthquake occurred where it did – away from a plate boundary – and was of the strike-slip type, in which the rocks either side of the fault grind past each other in a lateral direction, as opposed to the more usual earthquakes at plate boundaries, in which one part of the Earth’s crust slides beneath another (a process known as subduction). Those are either “ normal” or “ thrust” types. In the latter case, the displaced rock moves upwards, which is what causes a tsunami when the location is beneath an ocean. The Figure below illustrates the movements involved in those three types of earthquake.

Figure 2: Types of Movements in Earthquakes

(Extracted from: “ Indonesian Quake Rattles Island Nation.”)

Barras refers to research by French scientists on earthquakes in the area, which found that 26 of those earthquakes between December 2004 and April 2011 were of the strike-slip type, which they believe suggests that “ the Indo-Australian plate is breaking up along a new plate boundary.” Further, those scientists suggest that even though India and Australia are located

over the same tectonic plate, Australia's movement is actually faster than that of India. The effect of that movement rate differential is to cause a central area of the Indo-Australian plate to begin to buckle, which may in turn be causing the plate to split. In more detail, though on a wider scale, the movement of the Indo-Australian plate is in a northerly direction, but its western half is being impeded by the Himalayas. That uneven pressure causes an area of compression in the plate's central area, which as a consequence may be causing the plate to crack. In the following Figure illustrating the process, the vertical dotted line represents the possible new plate boundary.

Figure 3: Uneven Indo-Australian Plate Movement

(Extracted from: "Earth cracking up under Indian Ocean.")

Although not everyone supports the views of those French scientists, Meng – at the University of California in Berkeley – believes that they may be right. He says: "I think it's a fair argument that the 11 April earthquakes may mark the birth of a plate boundary." A researcher at the US Geological Survey reported that he and his colleagues had observed that in the six days following the 11 April earthquake there were almost five times as many earthquakes around the world than normal – a phenomenon never previously seen (Barras).

More details of what seismologists believe actually occurred on April 11 2012 are provided in an ABC Science article entitled "Quake start of Indo-Australia plate split" (27 Sep. 2012). They believe there was what they call "A near simultaneous rupturing of at least four faults, stacked up and lying at right angles to one another." Data suggests they opened one at a time, but all

within a space of less than three minutes. As mentioned by others, they also note that it occurred well away from known plate boundaries, tearing a wide gash in the plate, “ confirming long-held suspicions that the plate is fragmenting.”

Geological and Topographical Features of the Plate Margin

The boundary or margin of the Indo-Australian plate in the area of Sumatra (the area nearest to where the stresses are believed to be associated with the breakup of the plate) is a subduction type boundary; i. e. where the oceanic plate descends beneath the Eurasian or Sunda plate, as shown in the Figure (“ Subduction zone beneath Sumatra, Indonesia”):

Figure 4: Indo-Australian Plate Boundary: Sumatra

(Extracted from: “ Subduction zone beneath Sumatra, Indonesia”).

As explained in the article, when the subducted Indo-Australian plate descends beyond 100km, the water within it lowers the melting point of the rock, creating magma, which – because it is hotter and less dense – migrates to the surface, generating the volcanic activity typical of Sumatra. The volcanoes there are in a chain running generally circa 300km away from a deep oceanic trench, which effectively forms the boundary between the two tectonic plates in this area.

Overall, the northern boundary of the Australian part of the Indo-Australian plate is complex in tectonic terms (Blewett, Kennett & Huston, 2012). In the area of New Guinea, the Australian and Pacific Plates are colliding, but further west the interaction is with the Eurasian Plate. In that section of the boundary, the boundary type is that of collision in the region known as the

Banda Arc, changing to subduction in the area of the Java and Sumatra trenches (Indonesia). The following Figure illustrates those boundaries (circled):

Figure 5: Australian Plate Boundaries

(Extracted from: “ Shaping a Nation: A Geology of Australia.”)

As noted by Blewett et al., the eastern and northern boundaries of the Australian Plate are part of the so-called “ Pacific Rim of Fire” – a region of the world which experiences a third of all the world’s earthquakes, and is the location of three quarters of the world’s volcanoes.

Human and Environmental Impacts

When the build up of stresses – usually at plate boundaries – cause earthquakes of the types that in turn trigger tsunamis, the immediate human impact can tragically be a considerable loss of lives. For example, a tsunami associated with a 7. 7 magnitude earthquake just off Sumatra in 2010 caused the loss of over 100 lives, while a volcanic eruption on Java, about 800 miles east, caused the deaths of more than 20 people (Belford, Oct. 2010). The same New York Times article notes that a 9. 1 magnitude earthquake centred on the same geological fault in 2004 triggered a tsunami that killed a massive 230, 000 or more people in the area of the Indian Ocean, with northern Sumatra being the worst hit.

There are two main factors that might mitigate the human impact in terms of loss of lives, in the event of future earthquakes associated with the breakup of the Indo-Australian Plate. Firstly, that if future earthquakes are also of the strike-slip variety (as was the April 2012 seismic event), it is possible that

there will not be associated major tsunamis. Secondly, if they occur in a similar area, i. e. at some distance from the plate boundary and away from land, the likelihood of collateral damage is reduced. There is of course no guarantee that they always will happen a long way from inhabited land masses, but the location of the suspected deformation and buckling of the Indo-Australian Plate makes that more likely.

Taking a more pessimistic view, Sharwood (27 Sep. 2012) reminds us that – notwithstanding the ultimate plate breakup will occur at a very long time in the Earth's geological future, there are 127 active volcanoes and 300 million people in Indonesia. In certain circumstances and at any time in the future, the human impact could be enormous.

An important factor affecting the degree of human impact of earthquakes is the global population growth coupled with increasing urbanization (often of poor quality construction) in earthquake-prone regions. This has been particularly so in recent history in the area of the Pacific Rim, where over 80 percent of the world's earthquakes have occurred (Doocy, Daniels, Packer, Dick and Kirsch, Apr. 2013). As their Public Library of Science article states, “The primary cause of earthquake-related mortality was building collapse, most frequently leading to soft tissue injuries, fractures and crush injuries/syndrome.”

As far as environmental impact in the immediate future is concerned, it is reasonable to take a pragmatic view; i. e. that earthquakes occurring as part of the progressive plate breakup and centred well away from the land, hence not triggering a tsunami, are likely to have little effect on the environment, unless they in turn trigger other earthquakes or seismic events such as

volcanic eruptions, for example.

In the longer term, due to the ongoing breakup of the plate – which experts believe has already been happening for around 15 million years (Spinks, Mar. 2013) – there will doubtless be many, many more earthquakes, as India and Australia move in approximately the same north to north-easterly direction, but with Australia moving faster than India. The Spinks article suggests that “ Over the next few tens of thousands of years” the most affected area southwest of Northern Sumatra is likely to suffer more earthquakes, but there could also be more earthquakes within continental Australia, even though it is thousands of kilometres distant from the area directly affected. The article further suggests that the breakup process has already created a new tectonic plate, known as the Capricorn Plate, although its existence is not yet proven. (Note: The Capricorn Plate location is depicted in the previous Figure).

In addition to tsunamis, other environmental impacts of earthquakes mentioned in the Spinks article include landslides, which can occur in hilly terrain, due the vibrations from earthquakes. Dependent on the precise locations, such landslides can of course cause loss of life and/or damage to property. Reassuringly, the article suggests there is little chance of the Australian mainland splitting in two. In contrast, it is evident from local earthquakes within the Australian continental landmass that Australia is instead subject to horizontal compression, squeezing opposite sides of faults together. That is likely to cause an uplift of the principal earthquake areas.

Discussion

It is interesting to note that a considerable amount of the media coverage of the April 11 2012 earthquake implies that it was the “beginning” of the process of the Indo-Australian Plate breaking up; yet other comment – sometimes in the same article – also notes that the process could have been in action for a very long time. One article suggests it has been happening for 15 million years so far, and is likely to continue for a similarly vast amount of time in the future.

In fact, according to Dr Christopher Scotese, a geologist at the University of Texas, it is possible that in 250 million years time the ever-continuing drift of the world’s tectonic plates will have resulted in the great majority of the Earth’s landmasses merging into a single “super-continent” which he calls “Pangea Ultima” (Scotese, last updated Apr. 2011). He admits that most of such prediction up to around 50 million years into the future is based on the continuation of current plate movements, but that beyond 50 million years guesswork plays a major part.

Whilst appreciation of these enormous timescales puts the process into a more realistic long-term perspective, it in no way diminishes the need to maintain short-term concern about the potential dangers from future earthquakes, volcanic eruptions and tsunamis. However, as far as the latter phenomenon is concerned, there are now increasingly efficient tsunami warning networks in place. These facilitate the issuing of a limited amount of early warning of the arrival of one of these rapidly-moving travelling waves that can cause severe damage and loss of life. The “Australian Tsunami Warning System” (2014) describes the system that is available to provide

Australian populations with between two and four hours warning, and which forms an integral part of the Indian Ocean Tsunami Warning and Mitigation System. From consideration of scientific opinion on the subject, it seems reasonable to expect that earthquakes associated with plate breakup are more likely to be of the strike-slip variety, and therefore less likely to trigger tsunamis. However, as was demonstrated by the April 11 2012 event, they can cause seismic disturbances including other earthquakes in locations at great distances from the initial event, so can still be a significant hazard. According to Spinks (2013) the elastic seismic waves initiated when an earthquake occurs travel at a great speed (between 4 and 10 kilometres per second), meaning that they could reach the opposite side of the planet (about 13, 000 kilometres) in less than 20 minutes.

Conclusions

There is little doubt that the Indo-Australian Plate is being subjected to uneven forces and stresses that may eventually cause it to split completely, and which almost certainly have already caused the creation of a new tectonic plate called the Capricorn Plate. Whilst those stresses have caused earthquakes, most notably on April 11 2012, a positive factor is that because they appear to be occurring well away from the northern boundary of the plate and therefore at some distance from inhabited landmasses, the human impact is not as severe as it might have otherwise been. Added to that, because the April 11 2012 earthquake was of the strike-slip type, there was no associated tsunami, further mitigating potential human and environmental impacts. It is to be hoped that future seismic events

associated with the continuation of this tectonic drift process will be of a similar nature; i. e. will not result in either serious losses of lives or major environmental damage. Regrettably, because earthquake prediction is by no means an exact science, only time will tell.

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