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Historical Evidence for Major Tsunamis in the Java Subduction Zone

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Historical Evidence for Major Tsunamis in the Java Subduction Zone[1]

Despite its role in the 'Ring of Fire, where the India-Australia plate subducts beneath the Eurasian plate, Java has been thought to be relatively aseismic. A landmark article by Newcomb and McCann (1987) drew attention to likely mega-events of 1833 and 1861 on the west coast of Sumatra (when historical observation was still rudimentary), and contrasted this with the absence of reports of such events in Java. They therefore predicted correctly that "great interplate earthquakes occur near Sumatra" but inferred that "a majority of slip on the plate interface near Java occurs aseismically". Their proposal to explain this difference had to do with the age of the subducting plates, thought to be as young as 42 million years in parts of Sumatra and as old as 142 million in parts of Java (Newcomb and McCann 1987: 421). The sequence of mega-events since 2004 in the Sumatra-Andaman zone in the past decade has more than justified the warning about Sumatra. The 9.2M earthquake and accompanying tsunami that killed about 230,000 people around the Indian Ocean in December, 2004, was followed by an 8.6M quake and tsunami that again devastated Nias in March, 2005, and tectonic shifts caused further 8.4M and 7.7M earthquakes on the Central section of the Sumatra subduction zone in September 2007 and October 2010 respectively, causing tsunami havoc chiefly in the Mentawei Islands. By contrast the Padang/Painan earthquake of "only" 7.6 Magnitude in September 2009 struck one of Sumatra's biggest cities and therefore caused heavy casualties, with over 1100 people killed and 180,000 buildings destroyed. Despite its traumatic effect on Padang's 800,000 people, geologists do not identify it as the necessary release of pressure on that section of the subduction zone, and worse events are therefore predicted in the near future (Sieh 2012: 11-14)

Since 2004, systematic research on antecedents for these traumatic events has yielded dramatic results. There is adequate physical evidence for a sequence of mega-earthquake and tsunami events of comparable magnitude to the events of 2004-10 affecting Sumatra and the exposed portion of the Malayan Peninsula in the 14th Century, and at intervals before that. In beach swayles of South Thailand and the west coast of Aceh (Sumatra), sand deposit layers have been found which demonstrate major past tsunamis, of which the most recent can be approximately carbon-dated (through associated organic material) to the period roughly 1300-1450 (Jankaew et al. 2008; Monecke et al. 2008; Bondevik 2008). Much more precise dates for the earthquakes which presumably triggered these tsunamis have been provided by analysis of coral uplift in islands off the West Coast of Sumatra. These showed a series of mega-earthquakes between 1347 and 1450 (Meltzner, Sieh et al. 2010; Sieh, Natawidjaja et al., 2008). Historical records do not stretch back so far, but there were lesser earthquakes and tsunamis in 1797 and 1833. All these occurred at a time when population was very sparse on Sumatra's west coast, so that casualties were only a fraction of what they would be today.

No comparable research has yet been conducted on Java's south coast, and the modern seismographs available since 1900 did not measure any 20th century earthquake there of more than magnitude 8. Two significant tsunamis hit Java subsequent to the 1987 article of Newcomb and McCann, but by comparison with the huge Sumatran events, they have not yet attracted serious and sustained research on the likely past and therefore likely future of Java. A tsunami in Java's

[1] I am particularly grateful to Brian Atwater (University of Washington), discussions with whom in Yogyakarta gave rise to this paper. Eko Yulianto, Merle Ricklefs, John Miksic, Kerry Sieh and Aron Meltzner were also very generous in sharing their essential expertise and insights into matters both historical and geological. They would not necessarily endorse the way I have worded our growing understanding of these matters, and I take full responsibility for the judgements expressed. This paper is published in this electronic format as part of ongoing discussions, and in the hope of stimulating further research.

southeast peninsula on June 3, 1994 reached a runup of 9m and penetrated up to 400 metres inland, killing 223 people in three coastal villages, with about 400 injured and over 1000 houses destroyed. This followed only a M 7.8 earthquake located very deep in the subduction trench, which caused no damage and was not felt strongly enough on land to wake more than 20% of the threatened coastal inhabitants (Synolakis et al 1995; USC 2011). In July 2006 another tsunami affected some settlements on the south coast of West Java, notably Pangandaran, where about 700 people were killed by a tsunami arising from a Magnitude 7.7 earthquake. Both these events are now understood as interpolate subduction events, though with a more complex pattern of aftershocks than the usual models predict (El Hariri and Bilek 2010). Earlier tsunamis on Java's relatively neglected South Coast are in the record only subsequent to the Dutch occupying Cilacap in 1839, and even then poorly documented. Very localised tsunamis were reported in 1840 and 1859, while a better documented one in 1921, after a 7.5 quake, affected about 275 km of the south coast, evidently with little damage (Newcomb & McCann, 1987: 429). The most destructive tsunami of modern times in Java was a result of the Krakatoa eruption in 1883, and therefore non-seismic. Given the high population density and indifferent construction controls and warning systems in Java, even a relatively modest quake such as the shallow 6.3 event which hit Yogyakarta in 2006 can cause massive suffering -- 5,700 were killed and 38,000 injured in that disaster. Overall, while the hypothesis that the Java subduction zone was aseismic is undermined by these events, there remains a danger that systematic research into past patterns will not begin until there is another horrendous disaster for which the population will have been poorly prepared. As in Sumatra, the Java (south) coast facing the subduction interface was very little populated until the Dutch built a major port and oil refinery at Cilacap in the twentieth century. The Cilacap coastal belt alone now has a population of over a million, and a major tsunami on the coast would now have consequences unthinkable in earlier centuries.

In looking for evidence of past events in Java before the seismograph, the scientific community has understandably been guided almost entirely by what was recorded through Dutch channels. There was a consistent Dutch presence in the ports of the north coast of Java from 1619, but Dutch officials of the 17th and 18th centuries were little inclined to report events in the interior or the south coast even if they knew of them, unless there was direct damage to Dutch economic interests. Boomgaard's trawling of Dutch sources for 17th century natural disasters found 13 volcanic eruptions and 22 earthquakes recorded for Maluku (the small 'spice islands' of eastern Indonesia), where Dutch economic interests were at the time concentrated in clove and nutmeg, but virtually none for Java (Boomgaard 2001: 212-3). Although even more geologically active than Maluku, at that stage Java's interior was marginal to Dutch interests. We do know that on 5 January 1699 the Dutch headquarters at Batavia (modern Jakarta) experienced "an earthquake so heavy and strong that nothing comparable had ever been known to have occurred here, the movement having lasted with severe shakes and shocks for about three quarters of an hour". There were aftershocks for several days, and the damage to Batavia itself included 28 killed and 49 stone buildings collapsed, with some damage to almost all houses (Coolhaas VI: 49-50). The magnitude of the disaster was confirmed by Chinese commercial reports (Ishii 1998: 237). From the further detail that all the waterways of the city were massively disrupted by uprooted trees that came down from the uplands and blocked the rivers, it seems likely that the centre of this earthquake was well to the south of Batavia itself, and therefore possibly seismic. But there was simply no reporting from closer to the epicentre.

The Javanese chroniclers had more reason to provide such information, at least on the Mataram kingdom which arose at the end of the 16th century in south central Java (modern Yogyakarta and Surakarta), though surviving chronicle texts do not pre-date the 18th century. This is the same region that had produced the first Hindu-Buddhist civilisation of Java in the 7th-10th centuries and gave the world the marvellous temples of Borobodur (Buddhist) and Prambanan (Hindu). It had fallen completely silent after the last inscription of 928, however, evidently because of some 10th century

disaster, usually assumed to be a volcanic eruption. The recently re-excavated Sambisari temple about 5km north of modern Yogyakarta was indeed wholly buried to a level of about 6 metres, while many other temples in the Prambanan area were not. Systematic geological research is in its infancy as regards the dating and intensity of volcanoes and earthquakes, as well as tsunamis, though something major surely happened. During the next six centuries we know almost nothing of the Mataram area (south-central Java) while the centre of civilization shifted to East Java and its north coast ports.

THE JAVANESE CHRONICLES

Unfortunately the Mataram chronicles that survived in 18th and 19th century manuscripts are notoriously opaque, but justify a careful re-reading. The most popular tradition of kingship is the Great Babad or *Babad Tanah Jawi*, first written down in the late 18th century, and filled with legendary elements designed to legitimate kings or explain their fall. Prominent in the discussion of successive Mataram kings is the story of their relationship with the magically powerful queen of the south seas (*Ratu Kidul* or *Nyai Roro Kidul*), who has her palace beneath the Indian Ocean near Parang Tritis, the small fishing port and closest outlet of the kingdom to the sea. She is still believed by many Javanese and Balinese to be the source of all the dangers associated with the southern ocean, carrying those who provoke her down to her watery palace. Oral and written traditions associate her with the founder of the Mataram dynasty, Senopati (thus perhaps around the 1580s), whom she encountered through a great storm and disturbance in the ocean which threw the fish onto the land (*Babad Tanah Jawa* V: 25; Ras 1987: 80-82,). But realising that it is Senopati's supernatural power that has done this, she promises him and his progeny a great kingdom. According to this tradition Mataram's and Java's most powerful ruler, Sultan Agung (reigned 1613-46), also obtained his supernatural power to rule by his mystic union with *Ratu Kidul* in her palace beneath the seas (Ras 1987: 145-6; de Graaf 1954: 76-7; Ricklefs 1998: 8-14). Stories of this Queen enhanced the popular fear of the southern ocean down to modern times, and probably played a useful part in discouraging settlement on the south coast. While the power of the myth suggests a memory of a tsunami on that coast, it does little to help us place it.

An older chronicle, however, apparently composed in 1738 and therefore the oldest known text of any chronicle, was seized by the British in Java in 1812, and rediscovered and given a modern edition only in the 1970s. This *Babad ing Sangkala* is a dated year-by-year brief summary of events in poetic form, though relatively free of the mythic elements of the other tradition. Its modern editor concluded after comparing it in detail with Dutch and other external evidence that "it is a remarkably accurate account of events in the period ca.1601-46," avoiding the attempts of the Great Babad tradition to fit events into a mythic pattern of repeated cycles (Ricklefs 1978: 172). This chronicle gives us the year dates in which numerous important events occurred, notably including the destruction of cities by war, fire or earthquake, the erection of buildings and arrival of envoys, and such key matters as the arrival of tobacco in Java (1600). Earthquakes (1584), volcanic eruptions (1634-5, 1641-2), epidemics (1625-6) and eclipses (1538-9, 1601-2) are noted by year. The dates are expressed in the form of poetic chronograms, whereby each digit of the date has a word equivalent which should match the meaning of the verse.

For the Indian-derived *Saka* year 1540, which ran from March 1618 to February 1619, an image of devastating flood occurs no less than three times, each expression of this disaster being in the form of a four-word chronogram equivalent to the date 1540. The Ricklefs translation of each chronogram is here given in italics (Ricklefs 1978: 32-3; stanzas 26 and 27).

> When *disappeared, turned into sea, was the earth* [*tasik buta iku bumi*] the people of Pajang were defeated; they left their land. Their Adipati sought refuge in Giri Liman. In Mataram, they moved [the court] to Karta, indeed, when *disappearing, all was turned into sea* [*tasik buta tunggal*], Pringgabaya fell in fear, when *disappeared the sea and the five lands* [*sagara ponca bumi kocap*].

Merle Ricklefs and the other historians who worked on these texts in the last century were looking not for tsunamis, but for the Babad's usefulness in dating political events. Other Javanese chronicles, written down considerably later than the *Babad ing Sangkala*, appear not to describe this disaster as such, but they may have mythologised it into the myth of *Ratu Kidul*. Several chronicles appear to confuse events of Senopati's and Sultan Agung's reigns, so that their transferring of a disaster that occurred at the outset of Sultan Agung's reign, in 1618, into the raging-sea event that provided the legitimation for the beginning of the dynasty forty years earlier is not out of character. *The Babad ing Sengkala* does now add greatly to the likelihood that a major tsunami occurred in 1618, and most likely in the central (Mataram) section of the south coast where the Ratu Kidul myth is centred. If so, Sultan Agung's supporters were able to convince themselves and their rivals that the flood was a sign of the ruler's supernatural power, not of his impotence before nature.

How can these suggestive findings be checked? Systematic scientific measurement of possible major events on the central part of Java's south coast has yet to begin. Following the 2006 tsunami in Pangandaran, an investigation was carried out in that area by an Indonesian team led by Eko Yulianto of LIPI. It found a layer of sand deposit 20 cm thick, substantially more than the 2006 layer, near the mouth of the Cikembulan river, above a layer of mangrove mud carbon-dated to approximately 400 years before the present (Yulianto et al. 2010: 5). While this finding might be consistent with a major tsunami affecting a large portion of the Java coast, it was not found at other sites where exploratory digs were carried out in the vicinity. There needs to be sustained research of the coastline of the Mataram area itself.

Dutch reportage is the usual resource of historians needing a check on the reliability of fancifully-written Javanese chronicles. But Dutch knowledge of Mataram affairs was minimal, especially before they established their permanent Asian base in Jakarta in 1619, renaming it Batavia. Until they began to interfere in Javanese affairs later in the century, Dutch interest in the interior was mainly in getting a supply of rice for their ships and troops from the Javanese heartland, usually through the central north coast port of Japara. This rice stopped coming early in 1618, and so Governor-General Reael despatched an envoy to try to reach the King of Mataram and ask for favourable access to rice supplies. The envoy, Cornelis van Maseyck, reached as far as the Surakarta area at the end of June 1618. There he learned that the older capital of Pajang, near Surakarta, had been conquered by Sultan Agung, and the population of all the surrounding villages had been taken away to build the new Mataram. The envoys could barely find enough food for their own survival. Van Maseyk was told that it was strictly prohibited to export rice, because even in the capital itself, rice was extremely expensive (van Maseyk 1618: 92). Another Dutch report claimed that rice was said to be so expensive in Mataram that "a great many people" were dying of hunger in its capital. The historian of this period, H.J. de Graaf, concluded from this that it must have been Sultan Agung's war with Pajang that caused the rice shortage, and so Pajang must have fallen earlier than the chronicle said, in 1617 rather than 1618 (de Graaf 1958: 46).

If however a major earthquake and tsunami in the Mataram area can be confirmed on the ground, Javanese history of the second and third decades of the 17th Century would have to be re-examined and rewritten. As it stands the established chronology of the period before Sultan Agung's regime is so uncertain that prominent Javanist C.C. Berg believed the chroniclers had simply invented the two predecessor reigns to legitimize Agung's. It would be consistent with the *Babad ing Sengkala* to

conclude that Sultan Agung attacked Pajang and carried away its men and its rice partly because he had lost much of both in the tsunami. We might then interpret Sultan Agung's unprecedented sequence of conquests as motivated in the first instance by a need to find a secure port outlet on the north coast, alternative rice supplies and manpower to build and populate his new capital at Karta. The decision to build this new capital cannot have been directly caused by a tsunami, since Kuta Gede (in the southeast of modern Yogyakarta) where the previous capital is understood to have been, lies about 20km from the south coast out of reach of any tsunami, while the new capital Karta and the sacred burial site of Imogiri are both further south, rather than retreating away from the coast.

If a 1618 tsunami wrought havoc on the Mataram area, it would have had to destroy significant economic and ritual assets on or near the south coast, subsequently lost to the historical record. In modern times this coast has had a fearsome reputation for danger, while the limestone cliffs that extend to the coast in the Gunung Kidul area provide no opportunity for agriculture. Yet even so where rivers meet the sea they can provide appropriate shelter for a fishing port to arise, as is the case today at Baron, in inhospitable Gunung Kidul about 20 km eastward along the coast from Parang Trites, as at other South Coast river-mouths. We know much too little about how the tectonic upheavals have changed the coastal geography over time to exclude the existence before 1618 of a significant port at the mouth of the Kali Praga or Kali Opak, the two major rivers of the Mataram rice-growing plain, both issuing out to the south coast near Parang Trites. At the time Mataram was beginning its rise in the late 16th century it did not have access to the north coast, and may well have depended on its own nearby south coast for fish, salt, and the import of some rice from more established agricultural areas in the Kedu plain. Although archeological evidence has not so far pointed to these river-mouths as centres of early Javanese commercial activity, there has not been sufficient interest in exploring the contemporary coast (let alone sites claimed by the sea) to rule it out. Similar possibilities exist for early Mataram (7th-10th century), which has left us five different models of sea-going boat types among the reliefs of the Borobudur. Why would this early civilization have built its capital and its temples on rivers leading to the south coast if all its outlets to the sea were very distant northern ones?

These possibilities will however remain speculative until there is sustained scientific work on the ground. To understand the likely future threats facing a heavily populated part of the ring of fire, it is essential that we know its past better.

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