THE KRAKATAU VOLCANO 125 YEARS AFTER THE CATASTROPHIC ERUPTION (AUGUST 27, 1883)

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The Krakatau volcano (latitude 6.10°S, longitude 105.42°E; often misstated as Krakatoa) is situated in the Sunda Strait between Sumatra and Java (Figs. 1 and 2). Its 1883 eruption, the second largest in Indonesia during historical time (*Venzke et al., 2002*), belongs to the most often commemorated natural events in the history of mankind. The eruption was not the only documented manifestation of eruptive potential of the Krakatau volcano in the past. The first historically documented strong explosion occurred in 416 A.D. (*Venzke, 2002*). More than a century later, the year 535 A.D. marks the worst climactic conditions of the last 1600 years - a finding based on tree-ring and ice-core data (*Wohletz, 2000*). Proposed causes of this climactic downturn include a catastrophic eruption of Krakatau volcano (*Keys, 1999*) or a bolide impact near the same location. The event is supposed to be responsible for subsequent climate destabilization all over the world, lasting years or perhaps several decades. Another destroying event occurred in the region of the nowadays Sunda Strait in 1115 (*Boscowitz, 1890*). Then, a disastrous earthquake allegedly destroyed an isthmus connecting Sumatra and Java by that time. Later, strong eruptions of Krakatau occurred in 1680 and 1684 (*Venzke et al., 2002*).

The 1883 Krakatau eruption ejected more than 25 cubic kilometers of rock, ash and pumice, generated the loudest sound historically reported, heard as far away as 5 000 km, and destroyed two-thirds of the island of Krakatau (Fig. 3). Number of casualties in the Sunda Strait and in its vicinity was assessed between 35 and 70 thousand. Giant sea waves reached height of up to 40 meters and propagated through the Indian Ocean and the South Atlantic Ocean, as plotted in the map by *Hermann Berghaus (1888)*, the part of which is reproduced in Fig. 4. Already this map, published 116 years before the damaging tsunami following the 2004 Sumatra-Andaman earthquake, pointed to a deadly potential of tsunami generated in Indonesia to the coast of the Bay of Bengal and Indian Ocean. An eye-witness on board of a vessel with refugees trying to escape from the endangered town of Telong Betong on the Sumatran side of the Sunda Strait described his experience with the following words: *"We saw a gigantic wave of prodigious height suddenly advancing upon us at great speed from the direction of the open sea. Immediately, the captain brought his vessel round so as to meet the wave stem foremost. After a moment of poignant anxiety, we found ourselves lifted up with terrific speed; our vessel bounded upward, and then we felt ourselves again plunged into the abyss. But the wave had passed us, and we were out of all danger. Like a high mountain, the gigantic wave sped furiously towards the shore while, immediately after, three other great waves followed it. Thus we had before our eyes the terrible spectacle of the waters rushing in and destroying the town, sweeping away first the lighthouse, which fell in like a pack of cards, then all the buildings beyond. In a few moments all was over, and where once Telok-Betong stood there was soon nothing but water"* (*Boscowitz, 1890*).

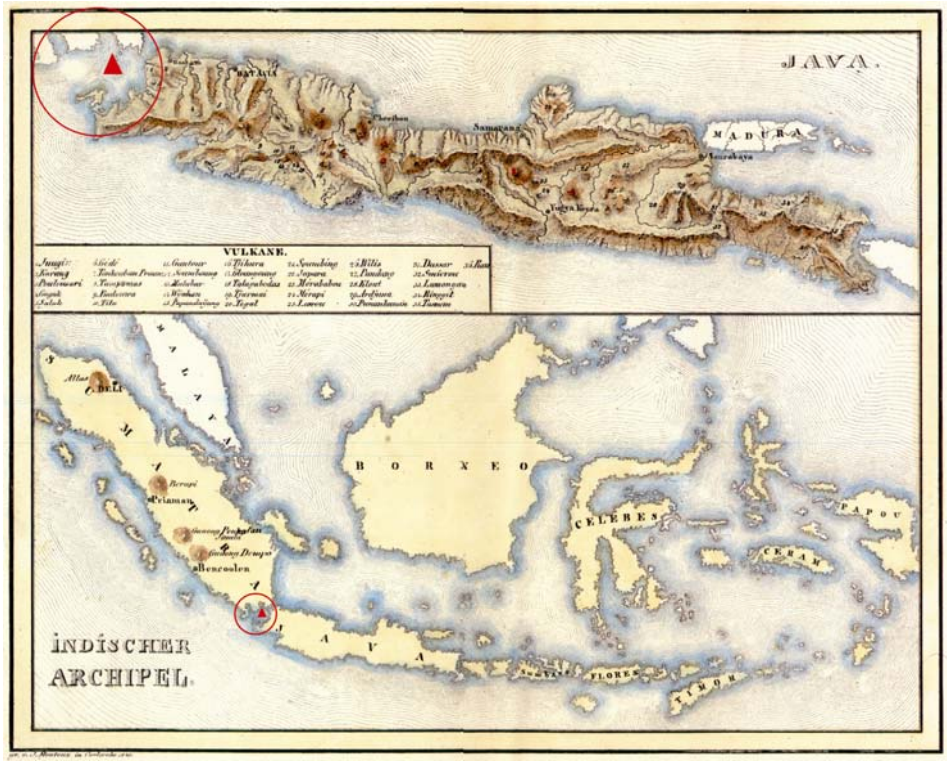

Fig. 1. Regional geographical maps of Java and Indonesia (*Leonhard, 1844*); position of the Sunda Strait denoted by circle, the Krakatau volcano by triangle.

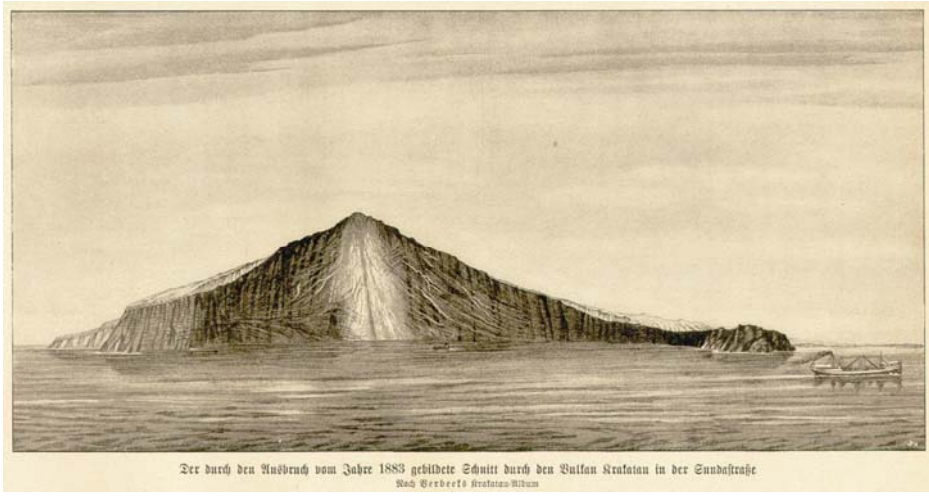

Fig. 2. Krakatau volcano after the 1883 catastrophic eruption (*Kraemer, 1902–1904* after *Verbeek, 1986*).

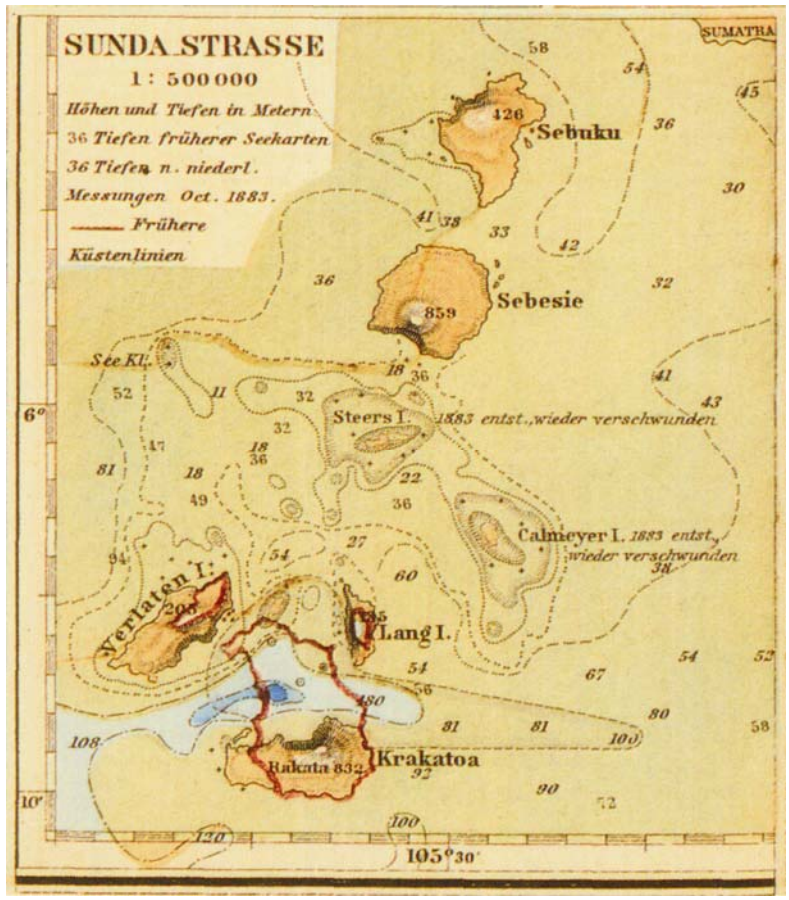

Fig. 3. Map of islands in the Sunda Strait after the 1883 eruption (*Berghaus, 1888*). Coastline before the 1883 eruption denoted by the red line.

In 1927, the post-collapse cone of Anak Krakatau (Child of Krakatau) emerged from the sea within the 1883 caldera. Since then, the volcanic activity of Krakatau is almost permanent, but mostly mild, enabling numerous tourists to admire the volcano closely. Only eruptions in 1932 and 1938 were stronger (*VEI* 3).

Since 2005, the Sunda Strait and the Krakatau volcano dynamics has been monitored by the KrakMon (Krakatau Monitoring) project, a joint initiative of the Indonesian Centre of Volcanology and Geological Hazard Mitigation (CVGHM) and the German Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) (*http://krakmon.vsi.esdm.go.id/*).

In 2002, the paper by *Špičák et al. (2002)* was published on numerous occurrences of strong (m_b between 4 and 6), teleseismically recorded earthquakes beneath the volcano during the last 40 years (1964–2005), reaching depths from shallow down to 100 km

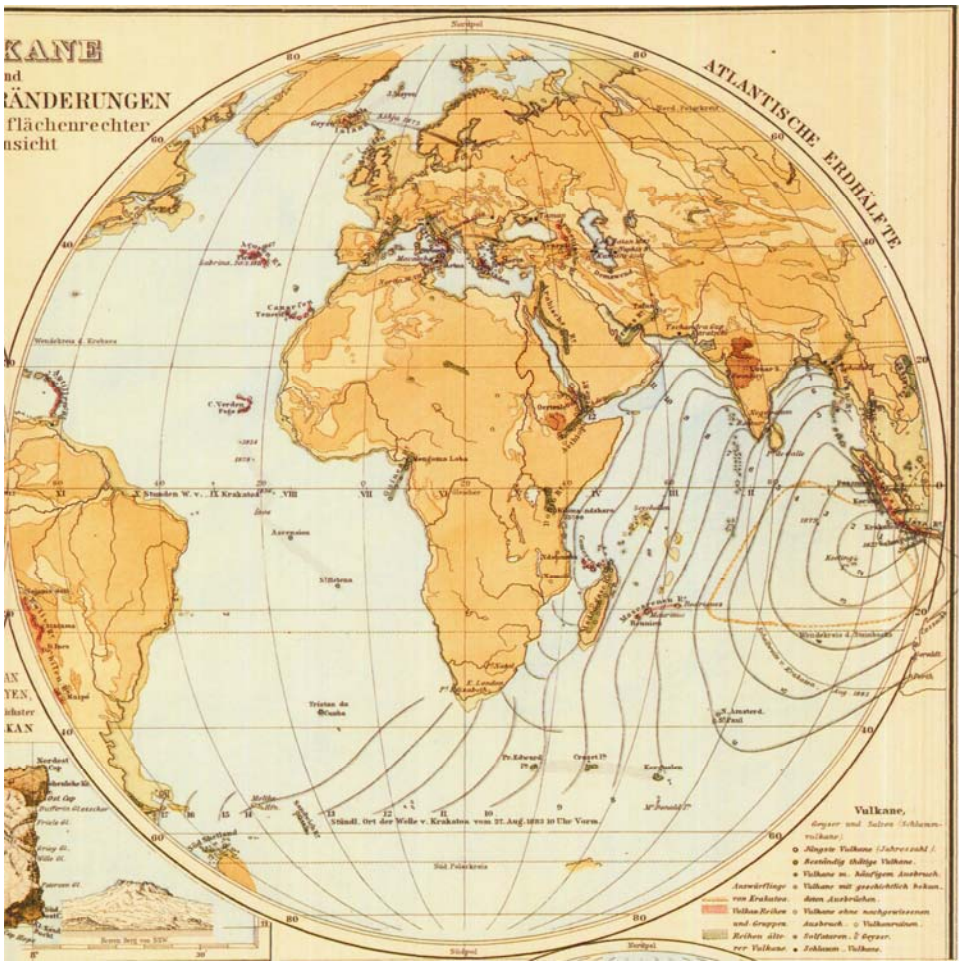

Fig. 4. Isolines expressing propagation velocity of tsunami generated by the 1883 Krakatau eruption in the Indian Ocean and South Atlantic Ocean (*Berghaus, 1888*). The time interval between two neighbouring isolines is 1 hour. Coast of India was reached by tsunami in 6 hours, coast of Madagaskar in 9 hours and eastern coast of southernmost South America in 17 hours.

(Fig. 5). Such earthquakes probably express recent dynamics of the plumbing system of the Krakatau volcano. The continuous occurrence of the earthquakes in time (instead of episodic swarms and/or aftershock sequences) seems to reflect a steady magma transport to the Earth's surface. Focal depths of earthquakes constrain the location of the primary magma generation to greater depths, to the subducting slab of the Indo-Australian plate. Recent strong earthquake occurrence beneath the Krakatau volcano is unique among the subduction-related volcanoes.

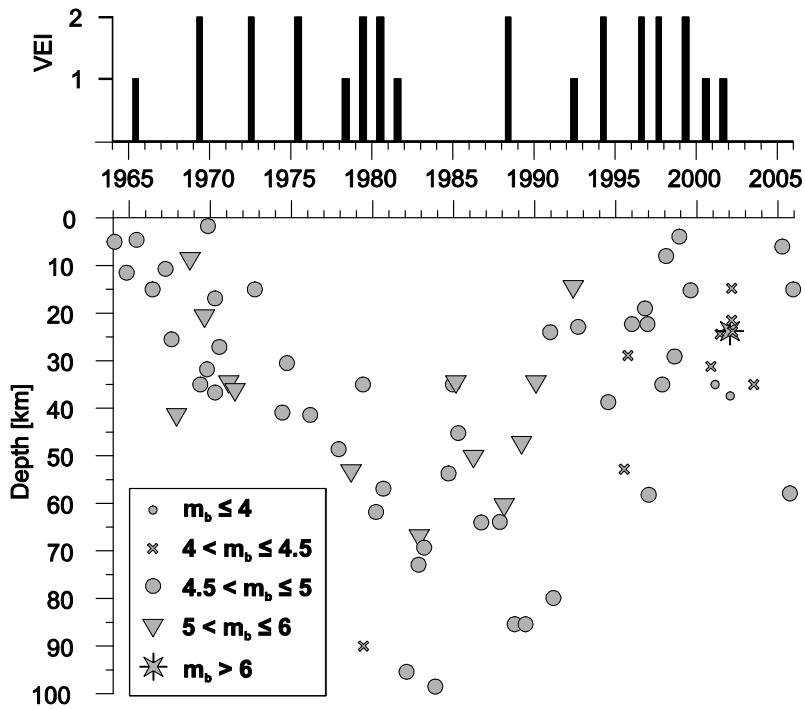

Fig. 5. Time plot of strong earthquake occurrences beneath the Krakatau volcano (73 earthquakes are denoted according to their body wave magnitude, mb) and its eruptive history (expressed by the volcanic explosivity index, *VEI**) in the modern period 1964–2005. Eruptive history taken from *Venzke et al. (2002)*, earthquake hypocentre parameters from *Engdahl et al., (1998)*.

* *VEI* - Volcanic Explosivity Index, a measure of the magnitude and energy of volcanic eruptions based on several basic parameters - eruption duration and style, volume of eruptive products, and the eruption column height. The scale is open-ended with the largest volcanoes in history given magnitude 8. Each interval on the scale represents a tenfold increase in observed eruption. *VEI* 1 - Stromboli; *VEI* 4 - Sufrière Hills, Montserat, 1995, ejecta volume > 0.1 km^3; *VEI* 5 - St. Helens, USA, 1980, ejecta volume > 1 km^3; *VEI* 6 - Krakatau, Indonesia, 1883, ejecta volume > 10 km^3; *VEI* 7 - Tambora, Indonesia, 1815, ejecta volume > 100 km^3; *VEI* 8 - Toba, Sumatra, Indonesia, 73 000 B.P., ejecta volume > 1 000 km^3 (*Sigurdsson, 2000*).

Acknowledgements: The authors are grateful to our colleague M. Švamberková for technical help in preparation of this paper.

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