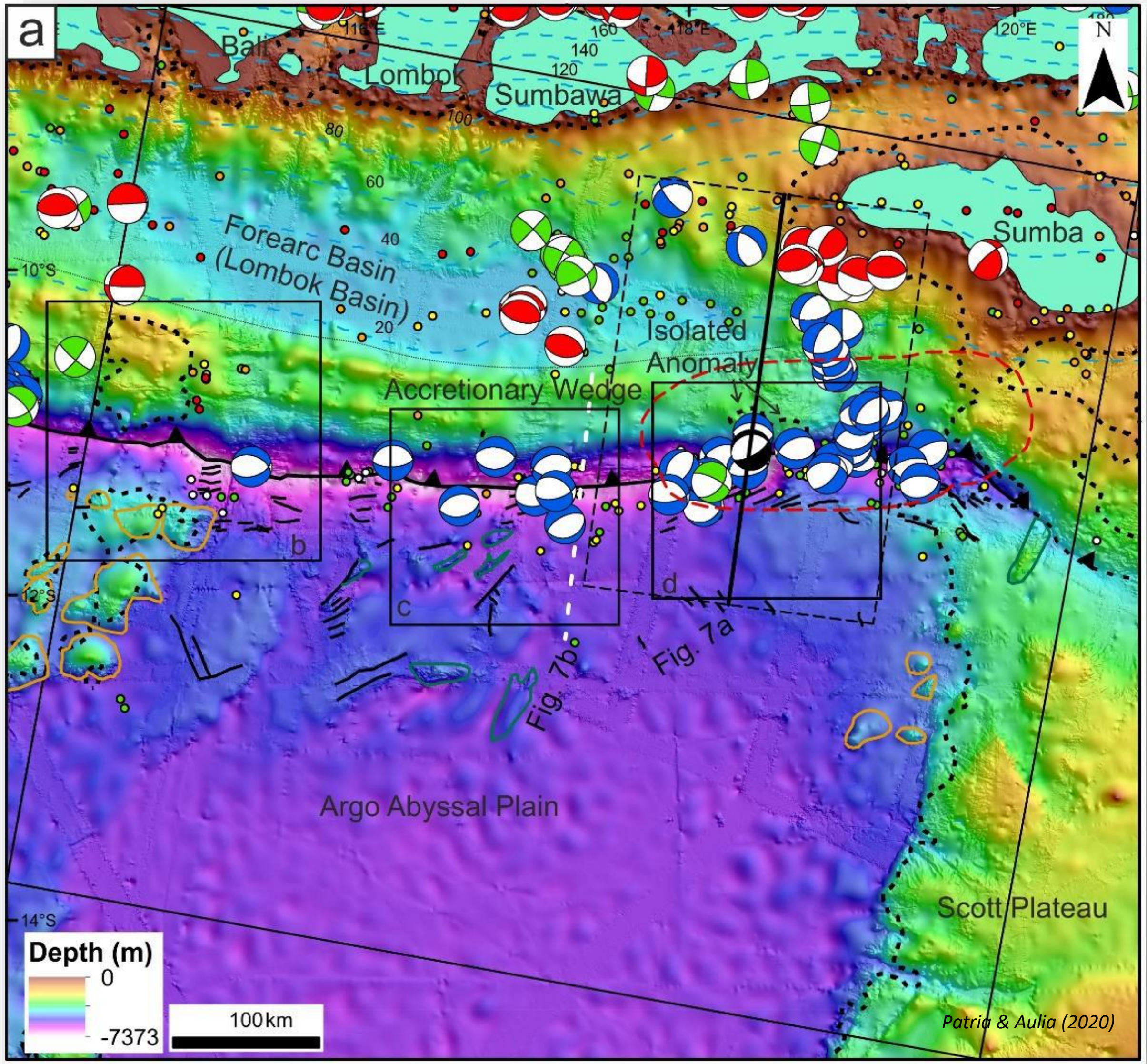
TEKNIK GEOFISIKA ITS & MASYARAKAT GEOLOGI TATA LINGKUNGAN INDONESIA

Webinar - 21 Mei 2021



Memahami Gempa "Outer-Rise" Busur Sunda dari Sumatra sampai Sumba

Awang Harun Satyana

Geolog Independen

Diskusi

1. Histori, Identifikasi, Karakterisasi Gempa "Outer-Rise"
2. Tektonik Subduksi Busur Sunda
3. Gempa "Outer-Rise" Sumatra-Jawa
4. Gempa "Outer-Rise" SW Sumba Mw 8.3 (1977) dan Tsunami
5. Pemodelan Gempa "Outer-Rise"

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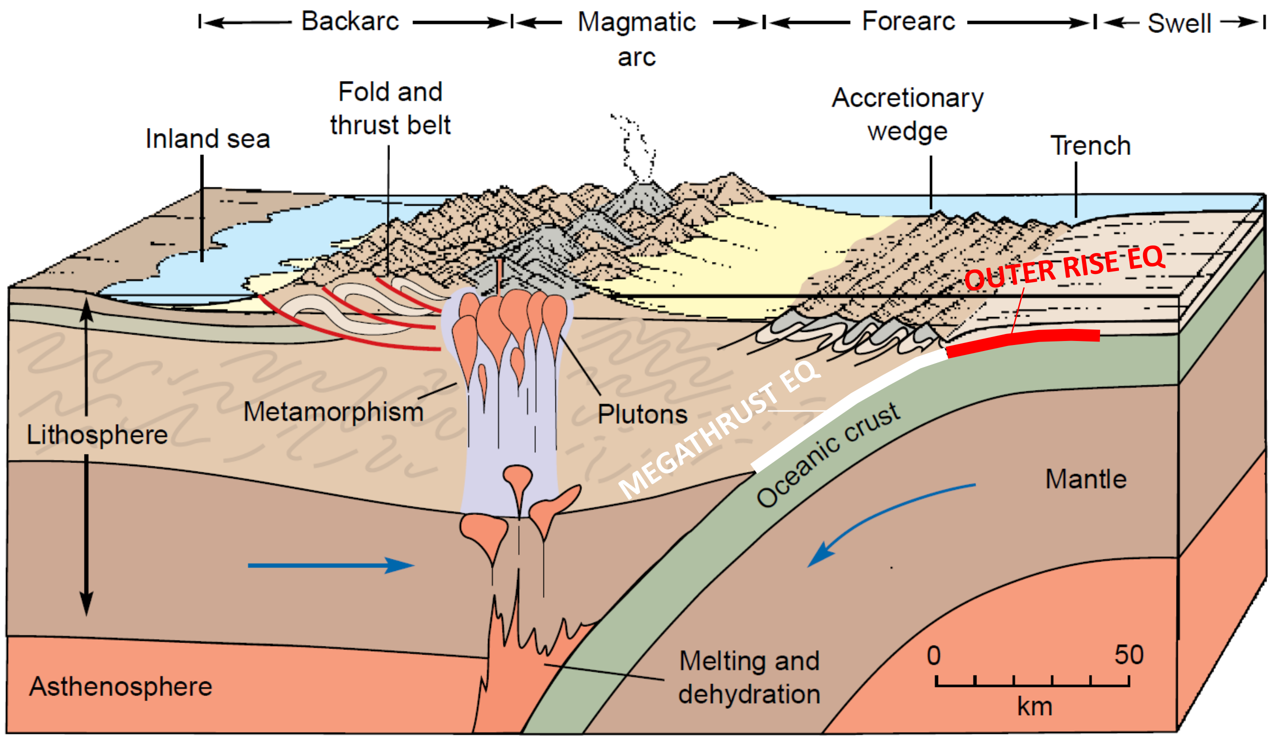
5. Pemodelan Gempa “Outer-Rise”

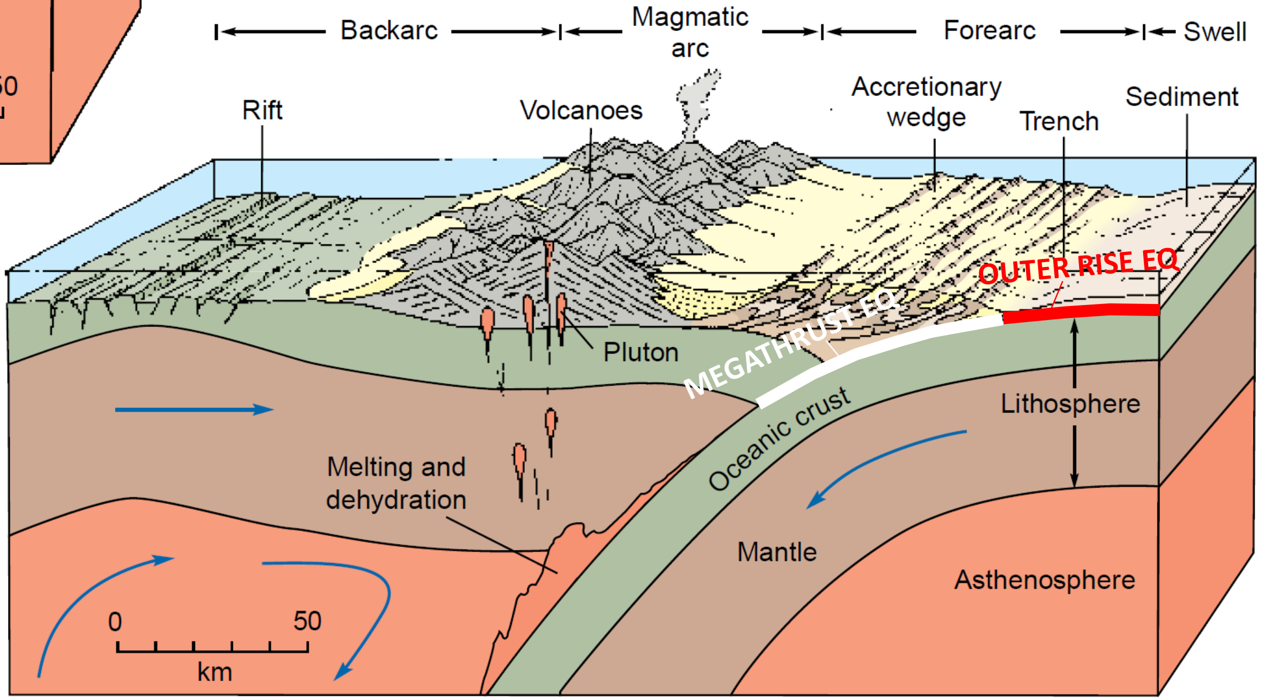
ocean-continent convergence



Outer Rise Earthquakes

"outer-rise event" refers to any earthquake which occurs within the oceanic plate in the vicinity of the trench axis (Christensen & Ruff, 1983).

ocean-ocean convergence



Several important structural and topographic features form at many subduction zones. ***A broad rise or bulge in the downgoing plate, known as an outer swell, commonly develops where the plate bends to dive down into the mantle.***

Hamblin and Christiansen (2009)

Classical paper on outer rise earthquakes

JOURNAL OF GEOPHYSICAL RESEARCH VOL. 73, No. 24, DECEMBER 15, 1968

Tensional Character of Earthquake Foci beneath the Aleutian Trench with Relation to Sea-Floor Spreading

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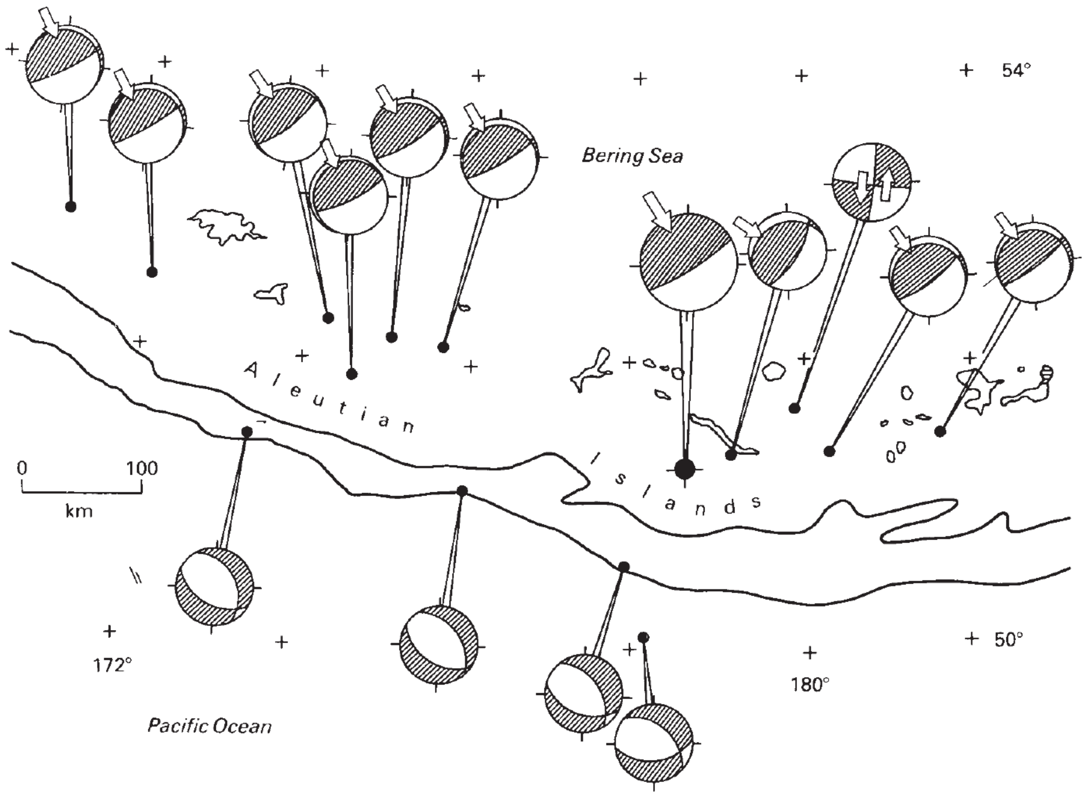
The relation between the hypothesis of sea-floor spreading and features noted in previous studies of the Alaska earthquakes of 1964 and the Rat Islands earthquake of 1965 has prompted a further investigation of the larger earthquakes of the entire Aleutian chain. Sixty-six earthquakes which occurred in the decade 1957–1966 are examined. The hypocenters of these shocks are found to be separated spatially into two distinct groups. Twelve earthquakes occurred along a narrow line immediately below the axis of the Aleutian trench or under the seaward slope of the trench. The remaining hypocenters were distributed over a broader tabular region beginning midway between the trench and the islands proper and extending under the islands. Foci of the first group are uniformly extensional in character with axes of tension aligned normal to the local axis of the trench. Foci of the second group are conformable to an underthrust of the island arc, and the direction of underthrust at the individual foci is in agreement with a rotation of the oceanic plate about a pole located at 85°W, 50°N. Certain foci represent related effects such as an arc–arc transform fault, or a strike-slip shear at the eastern extremity of the arc. All features could be predicted by the hypothesis of sea-floor spreading and are presented as evidence in support of island arcs as the locale of a sink mechanism required by the hypothesis.

INTRODUCTION

In a paper of much current interest, *Isacks et al.* [1968] have related the observations of seismology to what is termed the 'new global tectonics,' which is founded on the hypothesis of sea-floor spreading and the motion of rigid lithospheric plates over the surface of the earth. A key element of the new tectonics is the underthrusting of the lithosphere at island arcs. *Isacks and Sykes* [1968] have proposed a focal mechanism of shallow and deep focus earthquakes in the Tonga and Kermadec islands that supports this hypothesis. The discussion by the author [*Stauder and Bollinger*, 1966a] of the shock, located at the eastern extremity of the active area and occurring near the close of the aftershock sequence, has the character of an arc–arc transform fault, one of the types of transform faults postulated by *Wilson* [1965]. Finally, foci under the trench or under the outer edge of the trench are tensional in character. This observation is in keeping with an effect proposed by *Isacks et al.* [1968] as likely to occur in the upper portion of the plate near the axis of flexure as the plate begins to bend and to descend under the arc.

In view of the importance of such evidence in support of the hypothesis of sea-floor spreading



Classical paper on outer rise earthquakes

Journal of

GEOPHYSICAL RESEARCH

VOLUME 75 | JULY 10, 1970 | NO. 20

Flexural Rigidity, Thickness, and Viscosity of the Lithosphere[1]

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Gravity Division, Earth Physics Branch, Department of Energy, Mines, and Resources, Ottawa, Canada

The earth's lithosphere and asthenosphere are modeled as a thin elastic sheet and a fluid substratum, respectively; the physical principles involved are briefly described. The flexural rigidity of the lithosphere is deduced from observations of the wavelength and amplitude of bending in the vicinity of supercrustal loads. Data from Lake Bonneville given by M. D. Crittenden, Jr., are reinterpreted to give a value for the flexural rigidity of the lithosphere in the Basin and Range province of the western United States of 5×10^{22} Newton meters. Observations of loading in Canada give values for the flexural rigidity of greater than 3×10^{23} N m for the Caribou Mountains in Northern Alberta; about 4×10^{23} N m for the topography over the Interior Plains; about 10^{23} N m for the Boothia uplift in arctic Canada; and about 10^{25} N m for the bending of the beaches of Pleistocene Lakes Agassiz and Algonquin. The flexure of the lithosphere at Hawaii and the bending of the oceanic lithosphere near island arcs give values of about 2×10^{23} N m. For short-term loads (10^3–10^4 years) the flexural rigidity of the continental lithosphere is almost two orders of magnitude larger than for long-term loads, indicating nonelastic behavior of the lithosphere with a viscous (about 10^{23} N sec m^{-2}) as well as an elastic response to stress. From the values of the flexural rigidity, the thickness of the continental lithosphere is inferred to be about 110 km and that of the oceanic lithosphere about 75 km or more. The anomalously low flexural rigidity of the lithosphere of the Basin and Range province may be due to a very thin lithosphere, only about 20 km thick, with hot, lower crustal material acting as an asthenosphere.

In three recent papers I described a number of examples of crustal bending in the vicinity of such supercrustal loads as Pleistocene ice sheets, volcanic islands, or topography [*Walcott*, 1970 *a*, *b*, *c*] that were interpreted as flexure of the lithosphere beneath the load. This model of flexure is a simple one, involving mechanical equilibrium of a strong, elastic lithosphere floating on a fluid asthenosphere, and is remarkably useful in providing a coherent picture of the diverse observations of crustal bending. The earlier papers were principally concerned with providing an explanation for local earth structure, but an important outcome in each case was an estimate of the local value of the flexural rigidity of the lithosphere. In this paper I combine these values with those from new interpretations and data and interpret the variability of the flexural rigidity in terms of earth structure.

The geological and physical evidence for the existence of a strong outer crust overlying a weaker layer in the earth was summarized by *Barrell* [1914 *a*, *b*] when he first introduced the words lithosphere and asthenosphere, respectively, for the two layers. He argued that the earth appeared to be very strong when measured by the support necessary for the surface loads of the major deltas and topography or for

[1] Earth Physics Branch Contribution 311.

Isacks et al. [1968] suggest that the lithospheric plates are bent down under the island arcs along the dipping plane of earthquake foci, and a number of suggestions have been made as to why this should be so. Accordingly we should find an **upward flexure or rise** along some parts of island arcs similar to that of the Hawaiian arch. Such a flexure is evident in many island arcs (Figure 2), and a maximum amplitude of about 700 meters is similar to that of the Hawaiian structure.

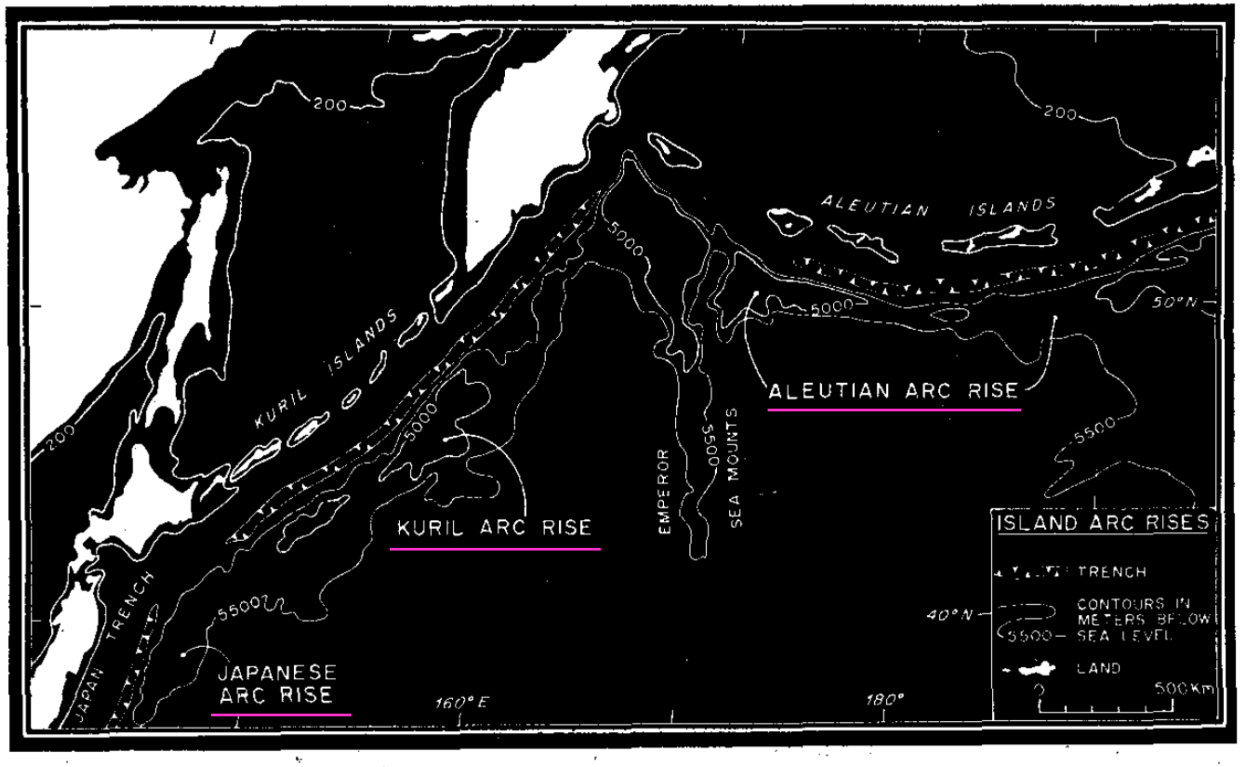

Fig. 2. Island-arc rises on the ocean side of the Aleutian, Kuril, and Japanese arcs. The rises have a wavelength of about 500 km and a maximum amplitude of 700 meters. They are interpreted as the complementary flexure produced by the bending of the oceanic lithosphere as it plunges down beneath the island arcs.

Geophys. J. R. astr. Soc. (1971) **23**, 173–189.

The Kuril Trench - Hokkaido Rise System: Large Shallow Earthquakes and Simple Models of Deformation

Thomas C. Hanks

(Received 1971 January 21)*

Summary

Large shallow earthquakes of the Kuril Trench are distinct from those of the adjacent Aleutian Trench in two important ways: in the case of the Kuril events, (1) the rate of occurrence of events near or oceanward of the trench axis with tensional focal mechanisms is markedly lower and (2) the average apparent stress of 14 shallow events is almost an order of magnitude higher. An explanation of these observations is that the oceanic lithosphere forming the Kuril Trench–Hokkaido Rise system is acted upon by a horizontal compressive stress of several kilobars in a direction normal to the Kuril Trench axis.

Calculations based on simple models of elastic deformation support

VOL. 84, NO. B12 JOURNAL OF GEOPHYSICAL RESEARCH NOVEMBER 10, 1979

Earthquakes and Bending of Plates at Trenches

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The mechanisms, distribution, and total moment of earthquakes within the bending oceanic plate seaward of trenches constrain possible mechanical models of the lithosphere. The average annual horizontal slip in normal fault earthquakes, as estimated from the cumulative seismic moment, exceeds the total extension predicted by an elastic plate model. Thus bending is not predominantly an elastic process but must include a large amount of permanent deformation. Normal-faulting earthquakes are associated with every major trench system in the Pacific and Indian oceans, but events indicating horizontal compression are rare. The predominance of normal faults over thrust faults, normal events as deep as 25 km within the lithosphere (well constrained by *pP*), and the existence of large ($M_s > 7.5$) normal fault earthquakes suggest that the average oceanic lithosphere is not under regional horizontal compressive stress which is a large fraction of the bending stresses. The location of thrust fault events as deep as 40–50 km within the bending plate requires the lithosphere to have significant strength at least as deep as 50 km. A two-layer plate model with elastic–perfectly plastic rheology can satisfy these seismological constraints and fit the observed shape of the trench and outer rise. Large regional stresses are not required, and vari-

GEOPHYSICAL RESEARCH LETTERS, VOL. 10, NO. 8, PAGES 697-700, AUGUST 1983

OUTER-RISE EARTHQUAKES AND SEISMIC COUPLING

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Abstract. Outer-rise earthquakes can be separated into two basic categories based on focal mechanism: compressional and tensional events reflecting compressional and tensional outer-rise stress regimes. We propose a model that connects the stress regime in the outer-rise to the behavior of large subduction earthquakes and explains the focal mechanisms and both the temporal and spatial occurrence of the subduction zone leads to a tensional regime at the top of the plate, grading into a compressional regime at the bottom.

We offer an alternative model to explain the occurrence and focal mechanisms of outer-rise events. In our model, the stress regime in the outer-rise varies both temporally and spatially due to the cyclic influence of the large underthrusting earthquakes. In this way the occur-

Classical papers on outer rise earthquakes

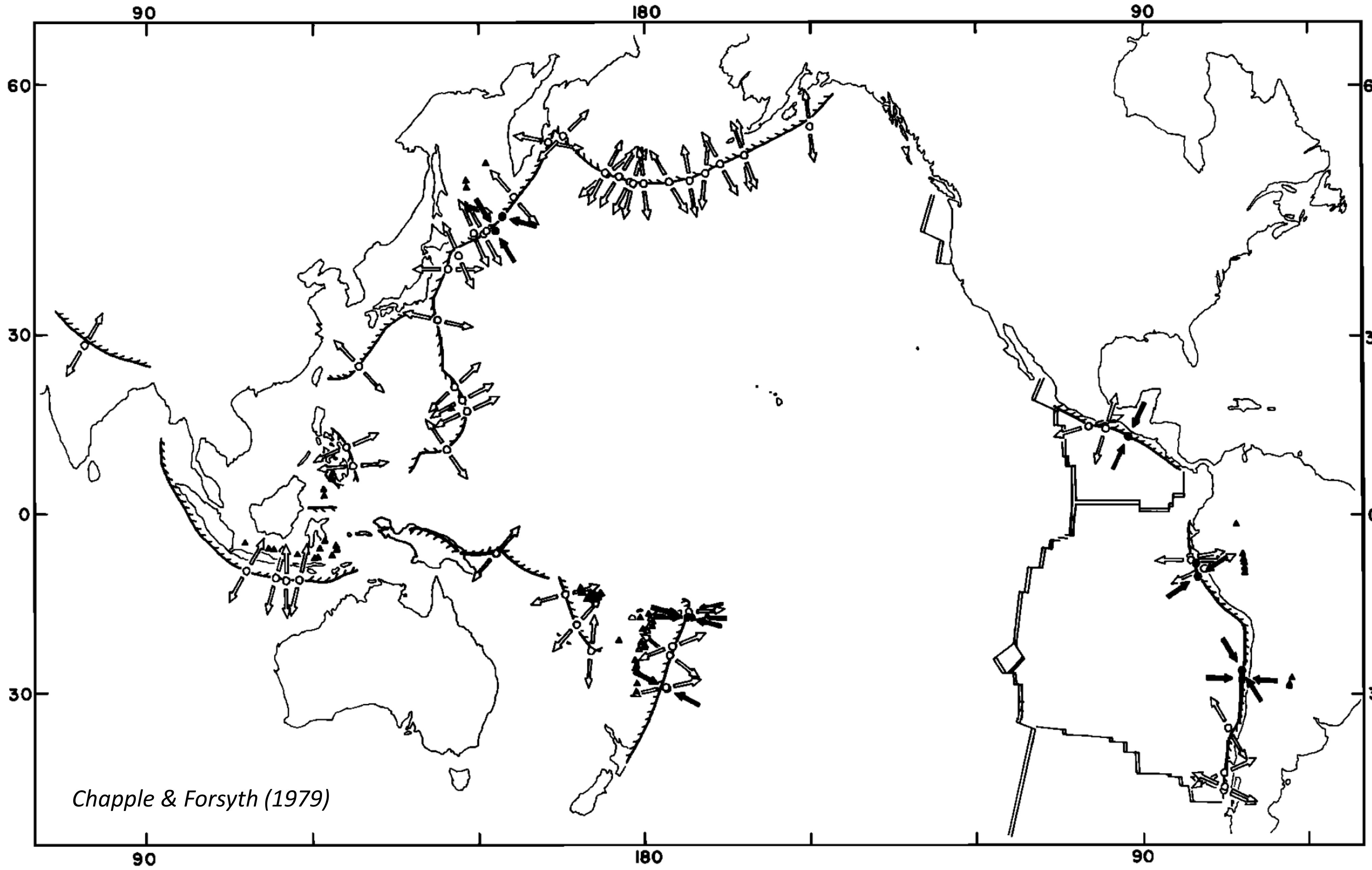
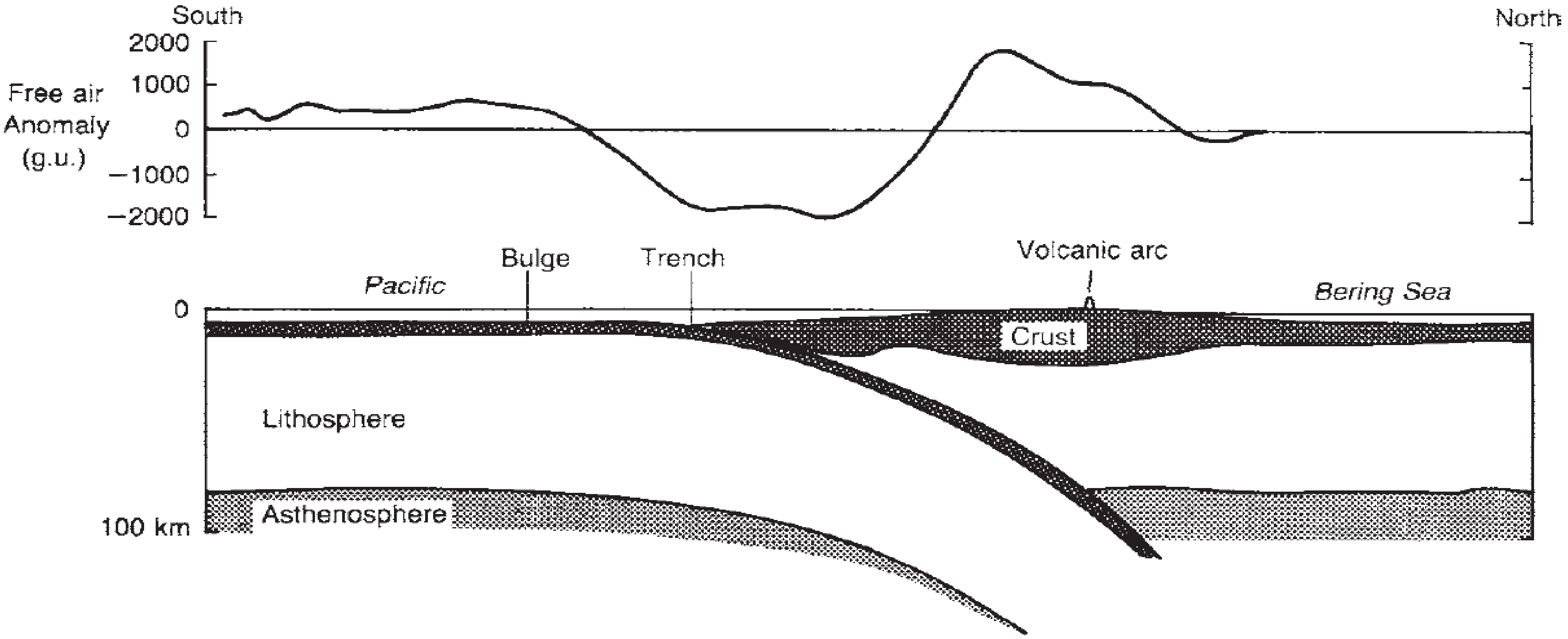


Fig. 1. Earthquakes associated with bending of the oceanic plate before subduction. Open symbols are tensional events; closed symbols compressional events. Arrows indicate direction of tension or compression axes. Triangles represent epicenters of earthquakes deeper than 600 km during the period 1963–1974.



Gravity anomalies of an oceanic subduction zone (Grow, 1973)

The flexural bulge of the downgoing lithosphere to seaward of the trench is marked by a positive gravity anomaly of about 500 g.u. (Talwani & Watts, 1974).

Flexural bending of the lithosphere also gives rise to the topographic bulge present in the subducting plate on the oceanward side of the island arc. This regional rise of sea bed topography is located between 100– 200 km from the trench axis and has an amplitude of several hundred meters.

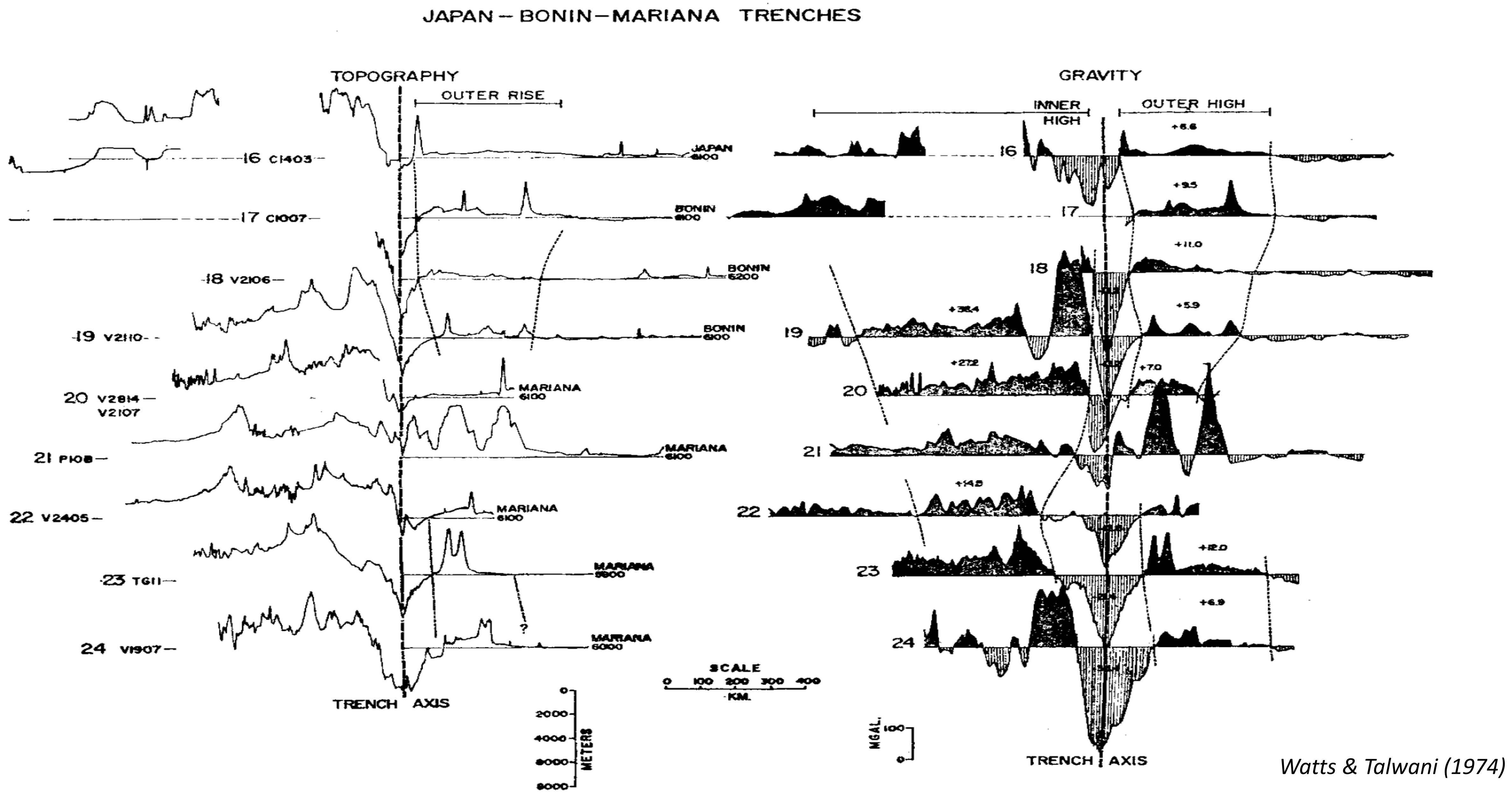
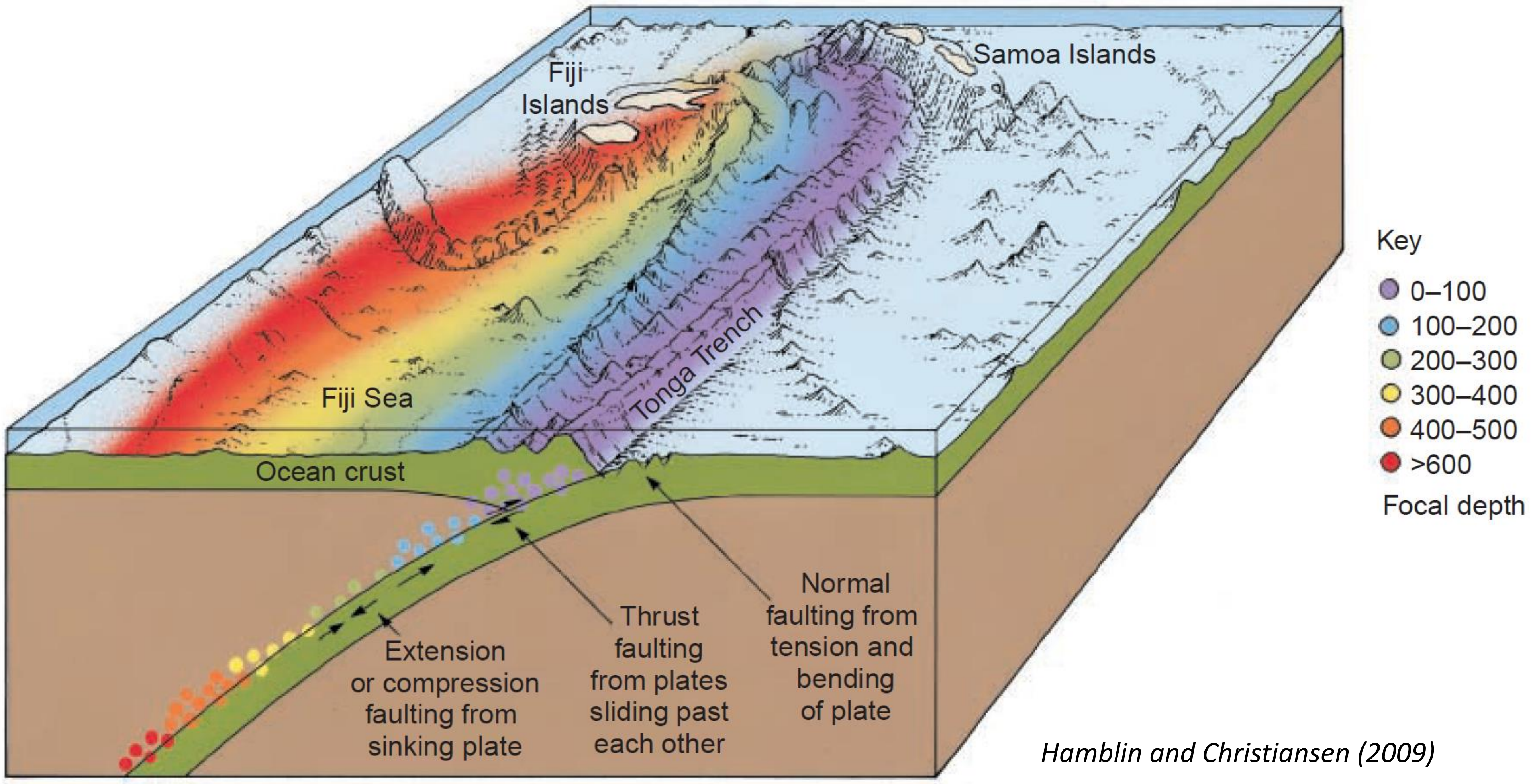


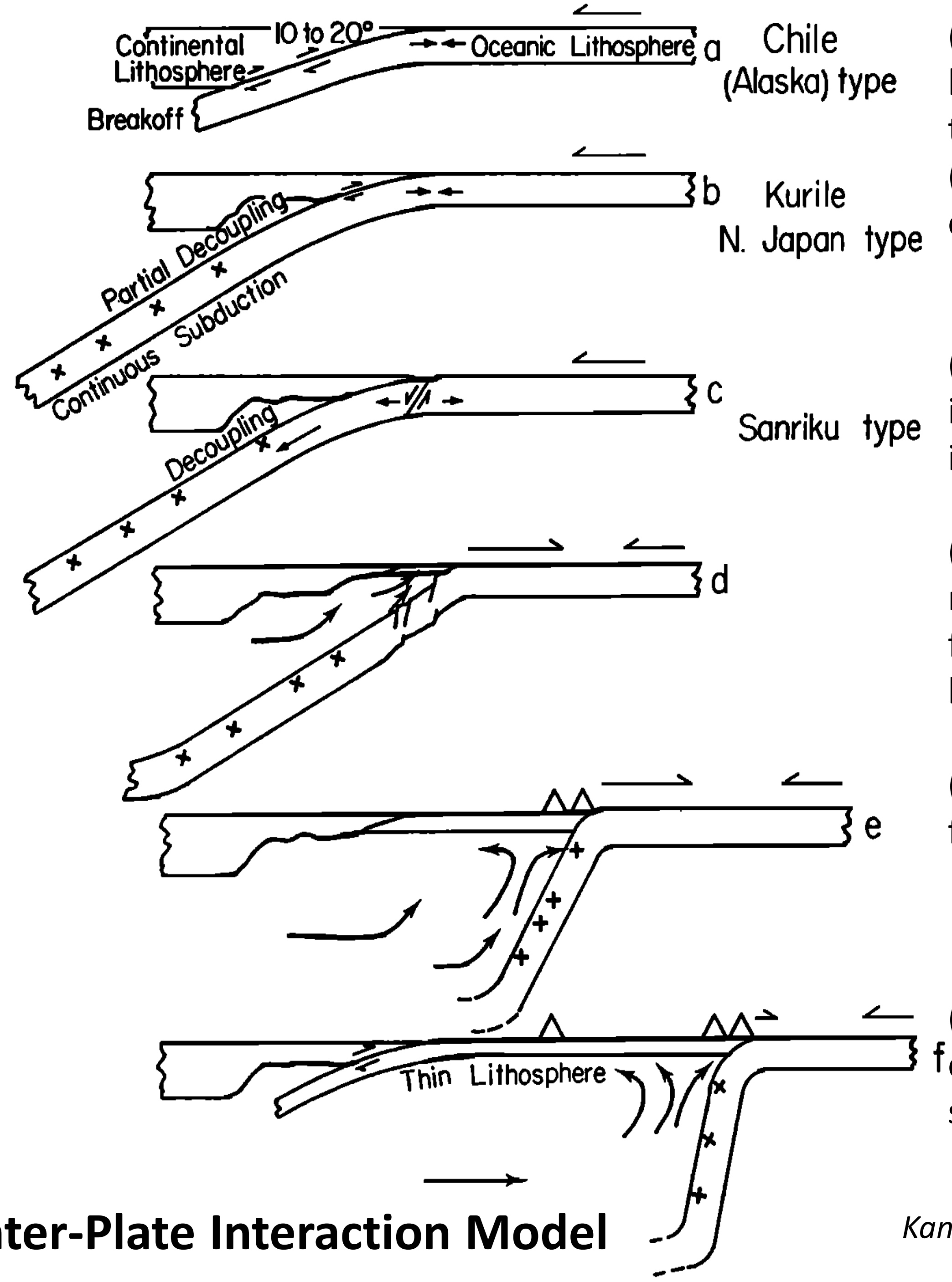
FIG. 4. Topography and gravity anomaly profiles 16–24 (Fig. 1) of the Japan, Bonin and Mariana Trenches. Note the relatively steep seaward wall of the trench and the outer rise in topography for profiles 16–18. In comparison, the seaward wall is shallower and the outer rise in topography reduced in amplitude for profiles 19–24. The significance of these observations is discussed in the text.



Hamblin and Christiansen (2009)

Earthquake foci in the Tongan region in the South Pacific occur in a zone inclined from the Tonga Trench toward the Fiji Islands. The top of the diagram shows the distribution of earthquake epicenters, with focal depths represented by different-colored bands. The cross section on the front of the diagram shows how the seismic zone is inclined from the trench. The colored dots represent different focal depths. This seismic zone accurately marks the boundary of the descending plate in the subduction zone.

Inter-Plate Interaction Model



Kanamori (1977)

(a) Strong coupling between the oceanic and continental lithospheres results in great earthquakes and break off of the subduction lithosphere at shallow depths.

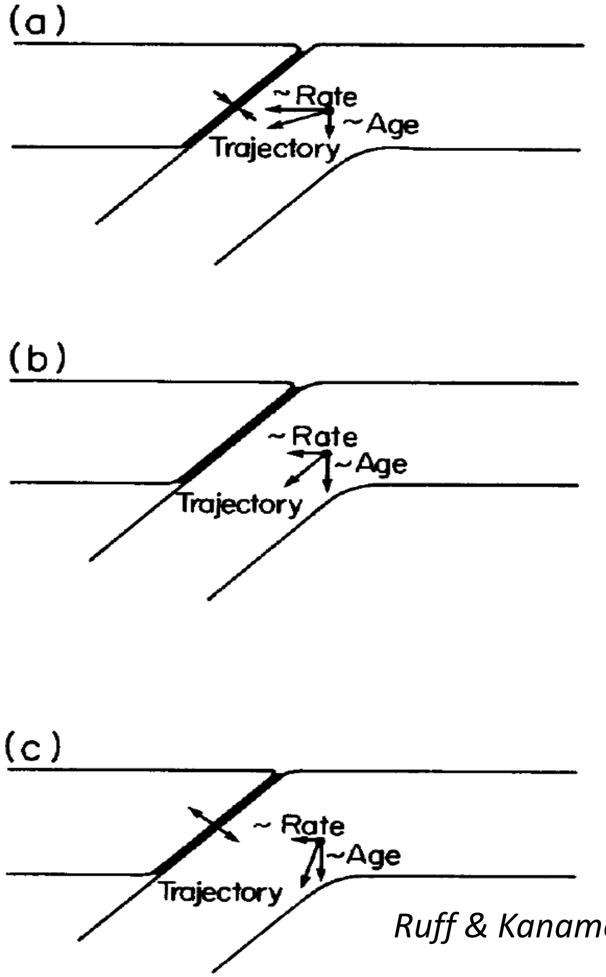
(b) Partial decoupling results in smaller earthquakes and continuous subduction.

(c) Further decoupling results in aseismic events and intraplate tensional events.

(d) Sinking plate results in retreating subduction and formation of a new thin lithosphere.

(e) Episodic retreat and formation of ridges.

(f) Decelerated retreat and commencement of new subduction



Ruff & Kanamori (1980)

Fig. 6. Schematic representation of how particular combinations of lithospheric ages and convergence rates might cause subducting slabs to have preferred trajectories, thereby affecting Benioff zone geometry. The preferred instantaneous trajectory of a slab is most certaintly affected by other influences, such as the global mantle flow.

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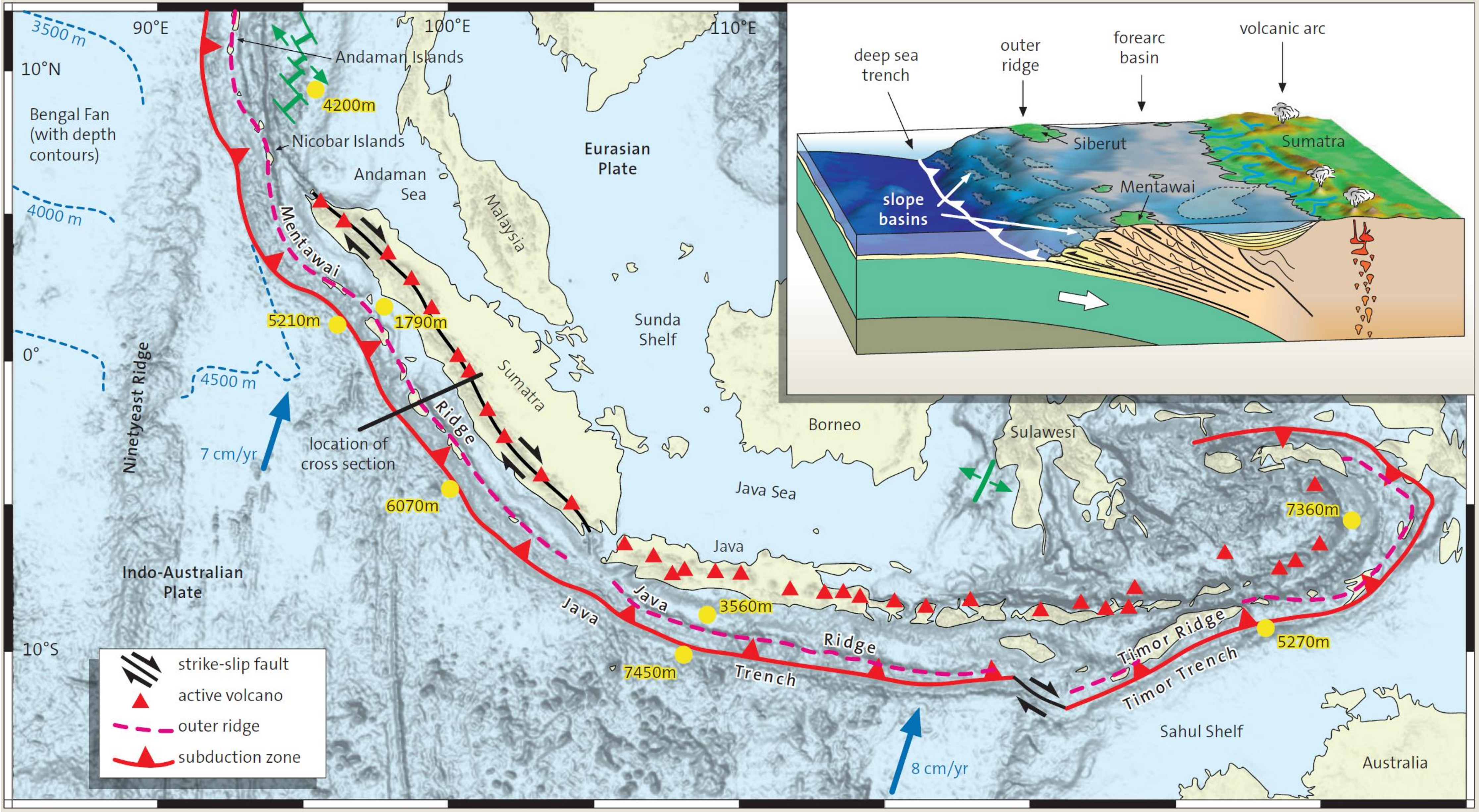
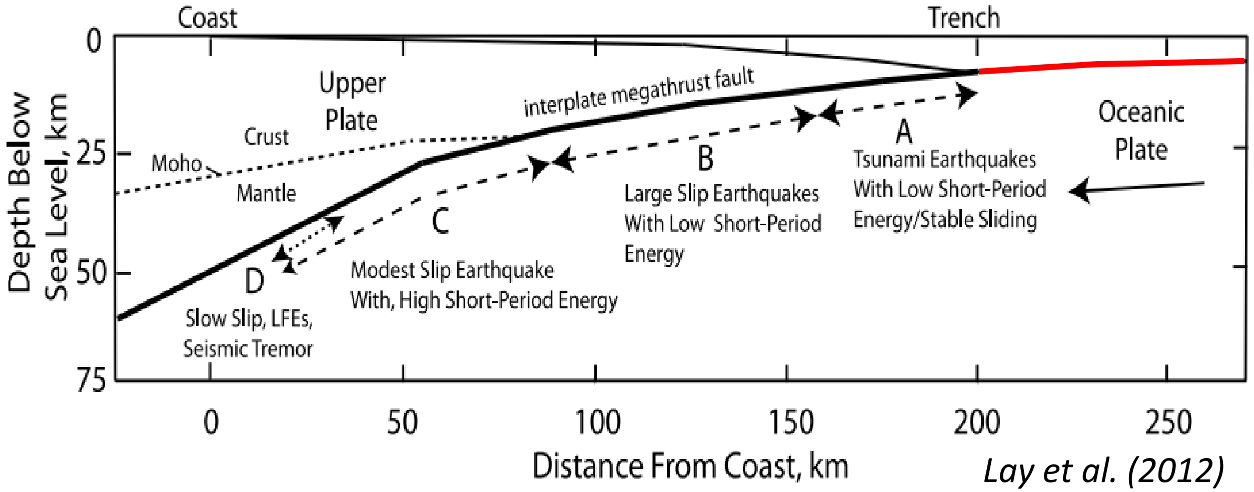


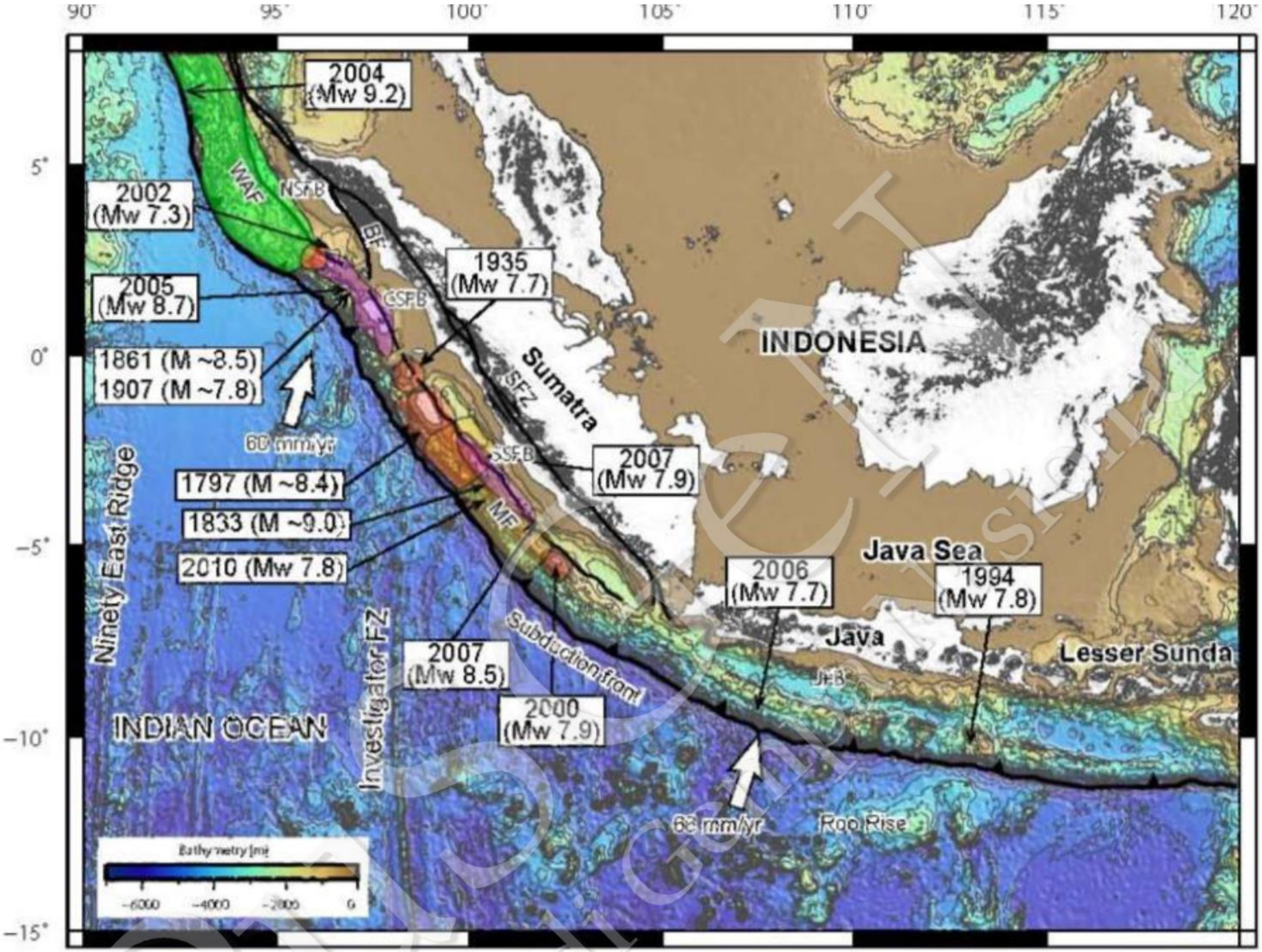
Map showing contrasting plate-tectonic conditions along the Sunda Arc. In front of Sumatra, sediment of the thick Bengal fan are scraped-off and incorporated into the accretionary wedge. This causes the outer ridge to emerge from the sea at this location (Mentawai Ridge – see insert). In front of Java, the deep sea trench and the outer ridge are significantly deeper. In front of Australia, the continental crust of the Sahul shelf is being subducted beneath the Sunda Arc; this causes a particularly strong uplift of the outer ridge (Timor Ridge) and marks the initial stage of orogenesis.

Frisch et al. (2011)

Newsweek (December, 2005)



Lay et al. (2012)



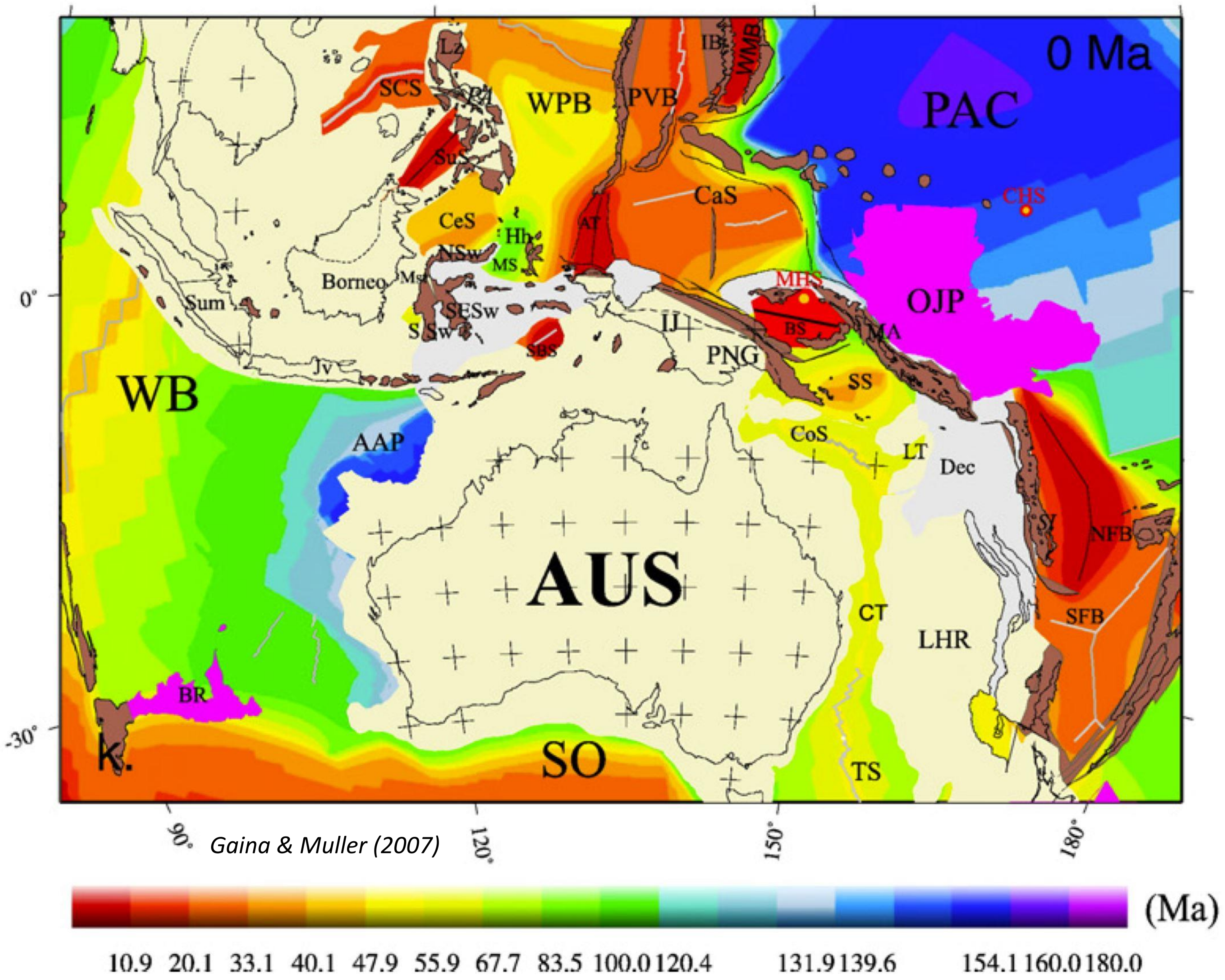
Peta regional struktur yang berkembang di Sumatra (Diament dkk., 1992; Malod and Kemal, 1996; Samuel and Harbury, 1996), dan daerah rupture gempa besar (Abercrombie dkk., 2001; Ammon dkk., 2006; Briggs dkk., 2006), serta fitur struktur utama di kerak Samudra.

Pusgen (2017)

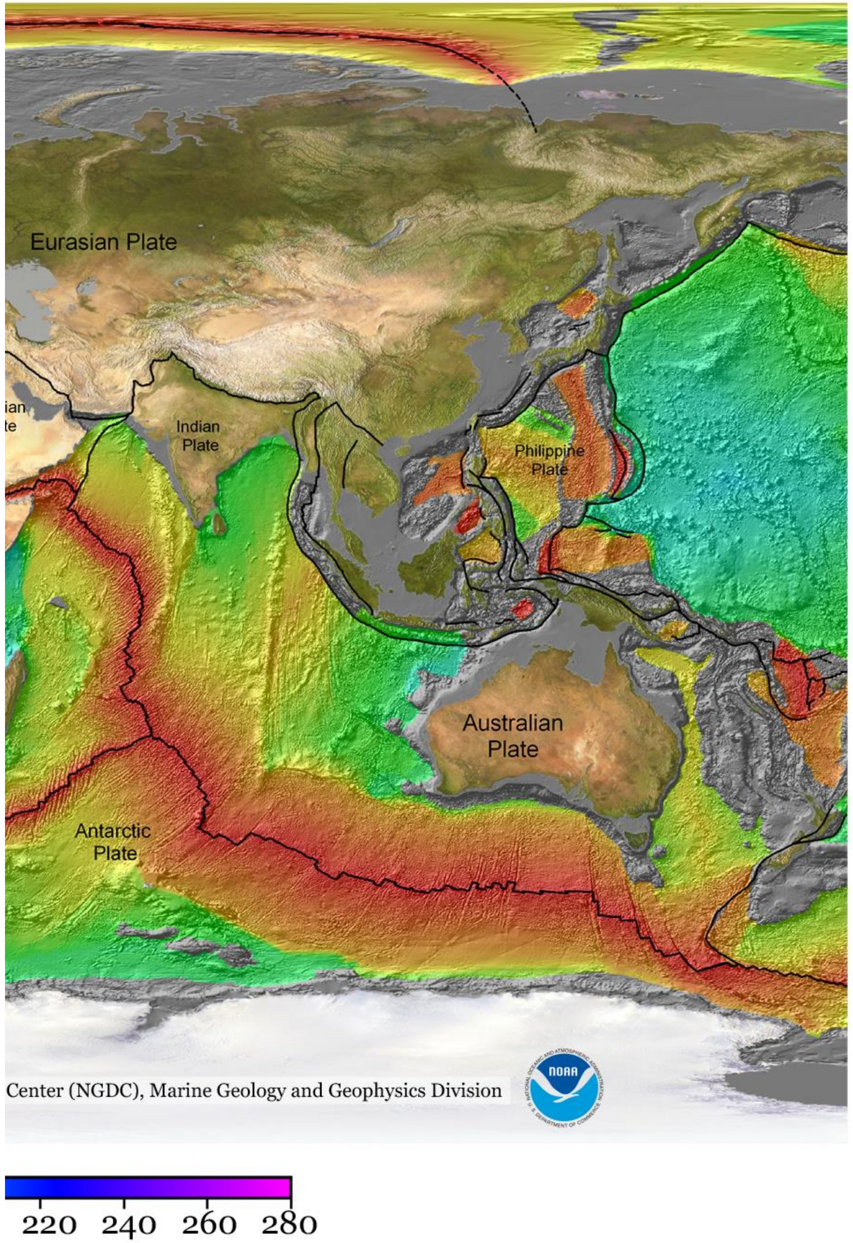
Age of Oceanic Lithosphere (m.y.)

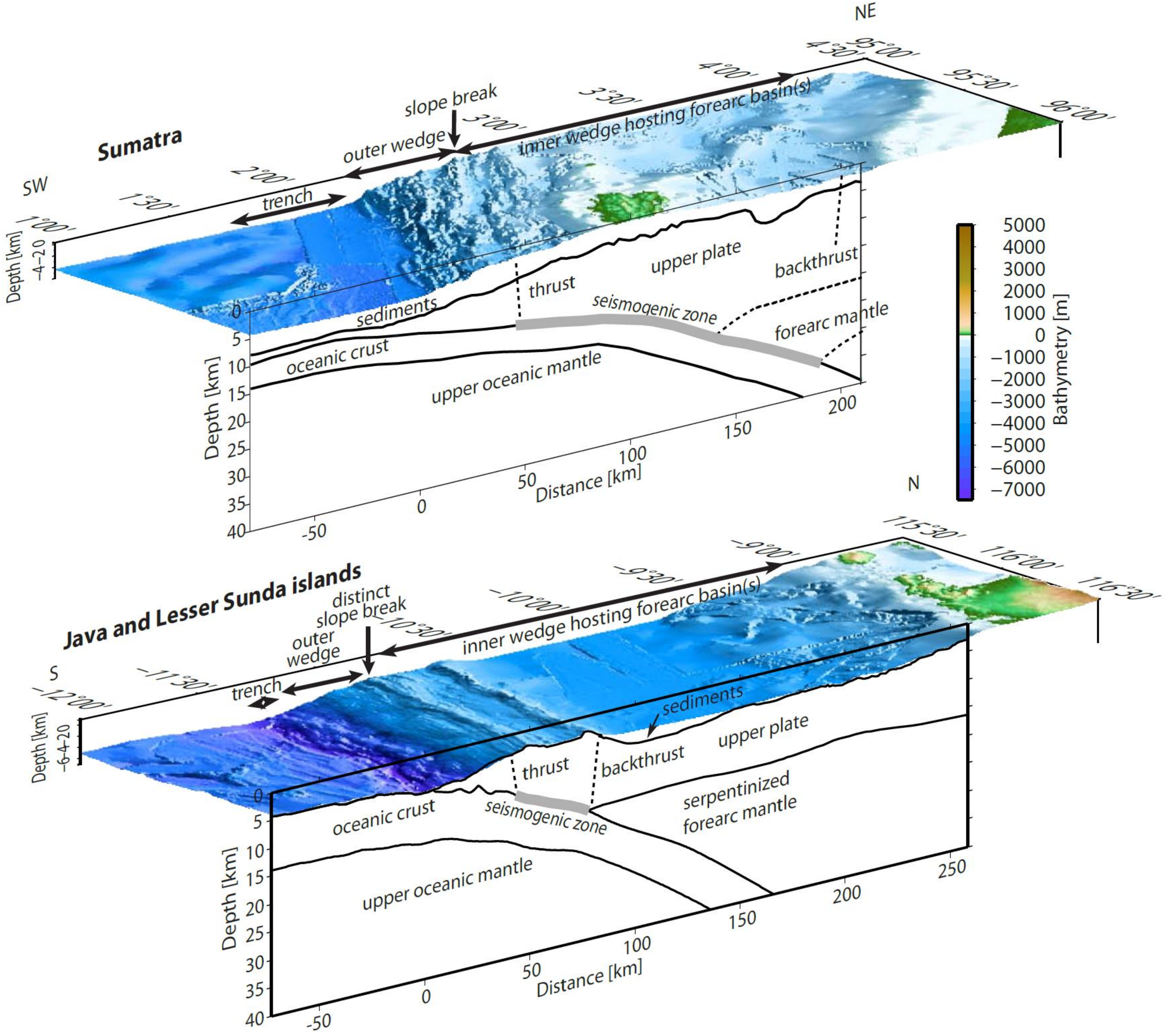
Data source:

Muller, R.D., M. Sdrolias, C. Gaina, and W.R. Roest 2008. Age, spreading rates and spreading symmetry of the world's ocean crust,Geochem. Geophys. Geosyst., 9, Q04006, doi:10.1029/2007GC001743.



Gaina & Muller (2007)





Sketches of typical trench-perpendicular cross sections implemented in sections of bathymetrical charts for Sumatra (top) and Java and the Lesser Sunda islands (bottom) to highlight differences in subduction setting affecting the earthquake hazard across the Indonesian margin. SZ are thick solid grey lines along the subduction fault.

Krabbenhoeft et al. (2010)

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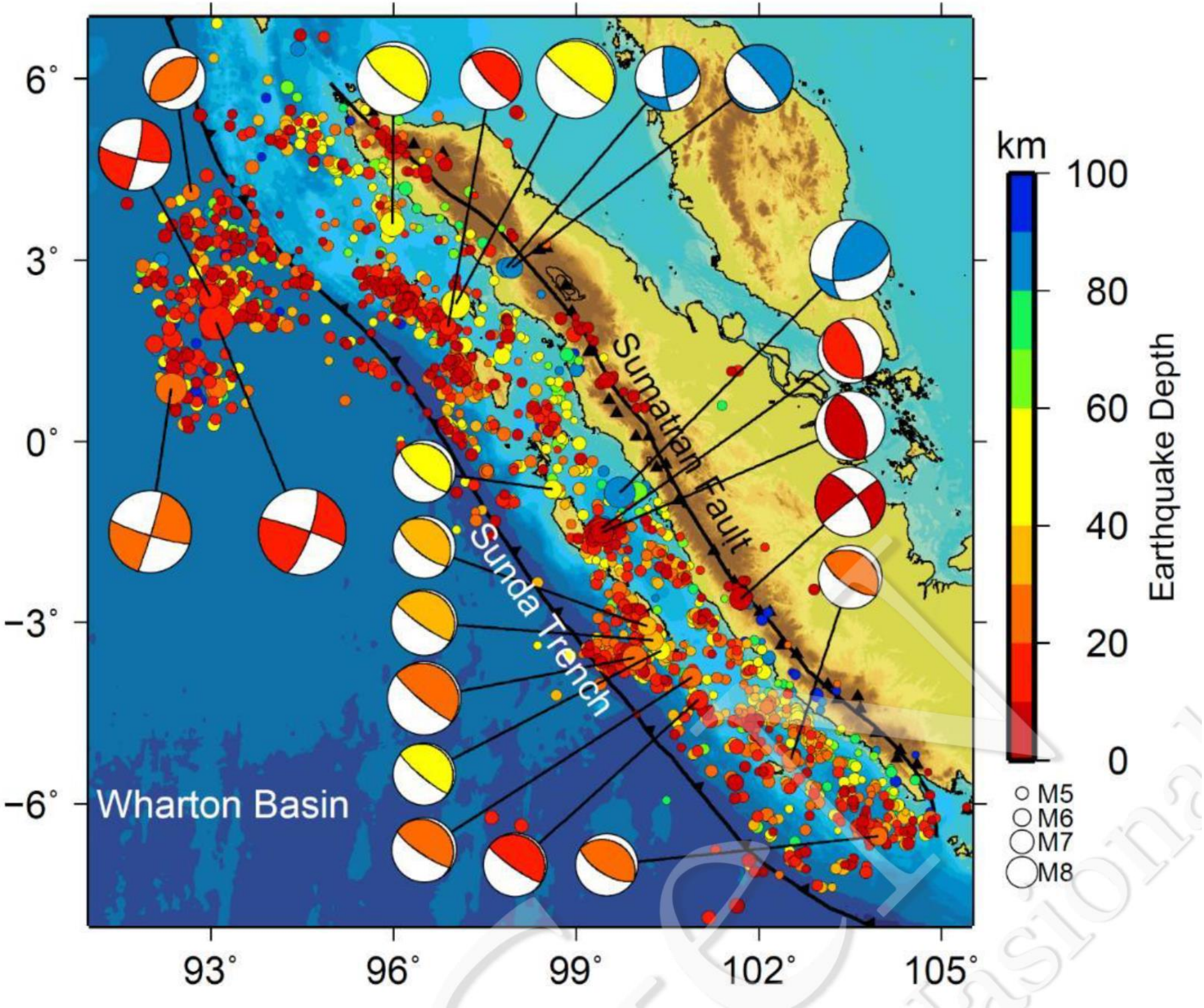
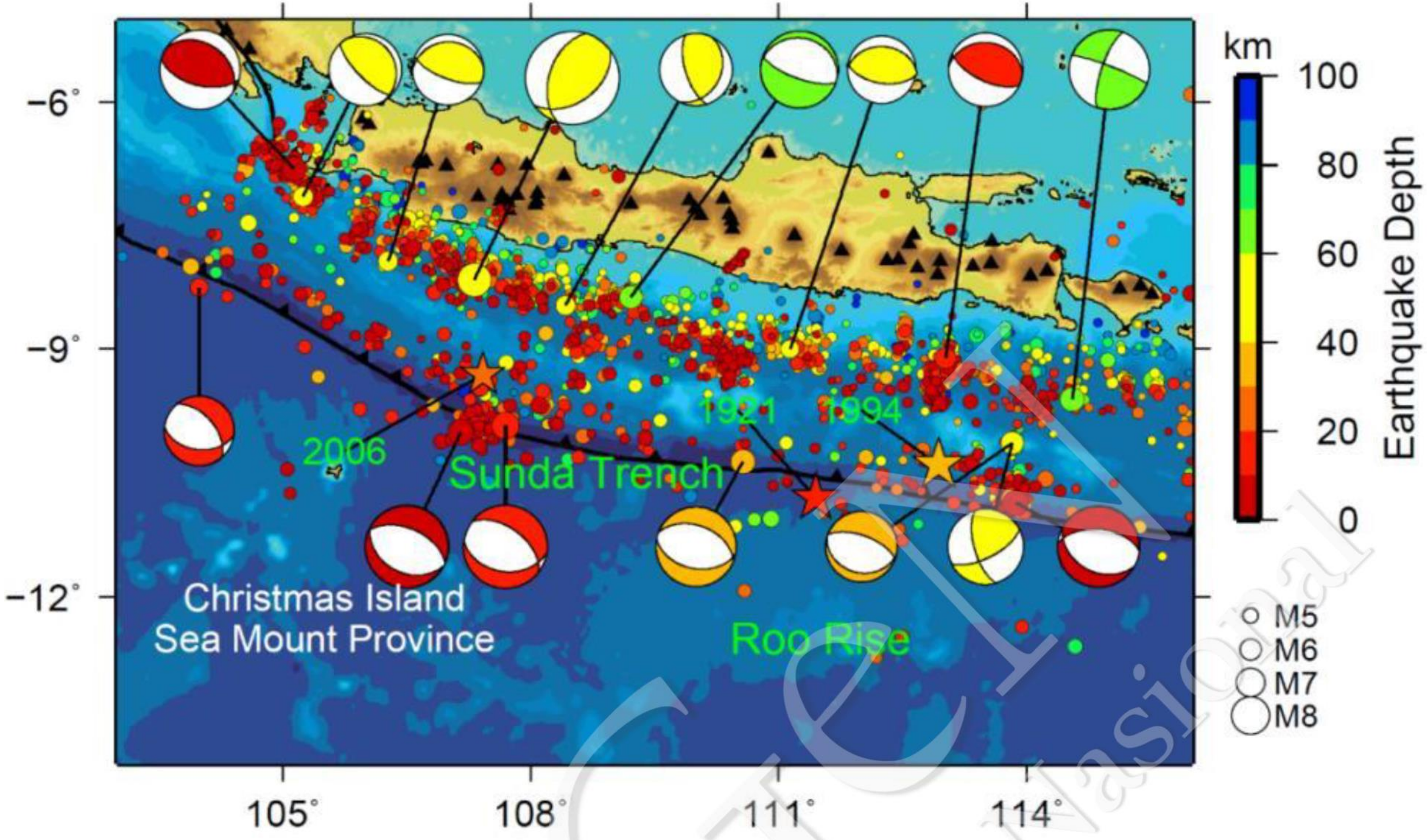


Seismisitas hasil relokasi gempa-gempa Sumatera dengan magnitudo ≥ 4,0. Mekanisme fokus diambil dari *Global Centroid Moment Tensor* (GCMT) (Dziewonski dkk., 1981; Ekström dkk., 2012) untuk gempa dengan magnitudo ≥ 6,0 (Shiddiqi, 2015)

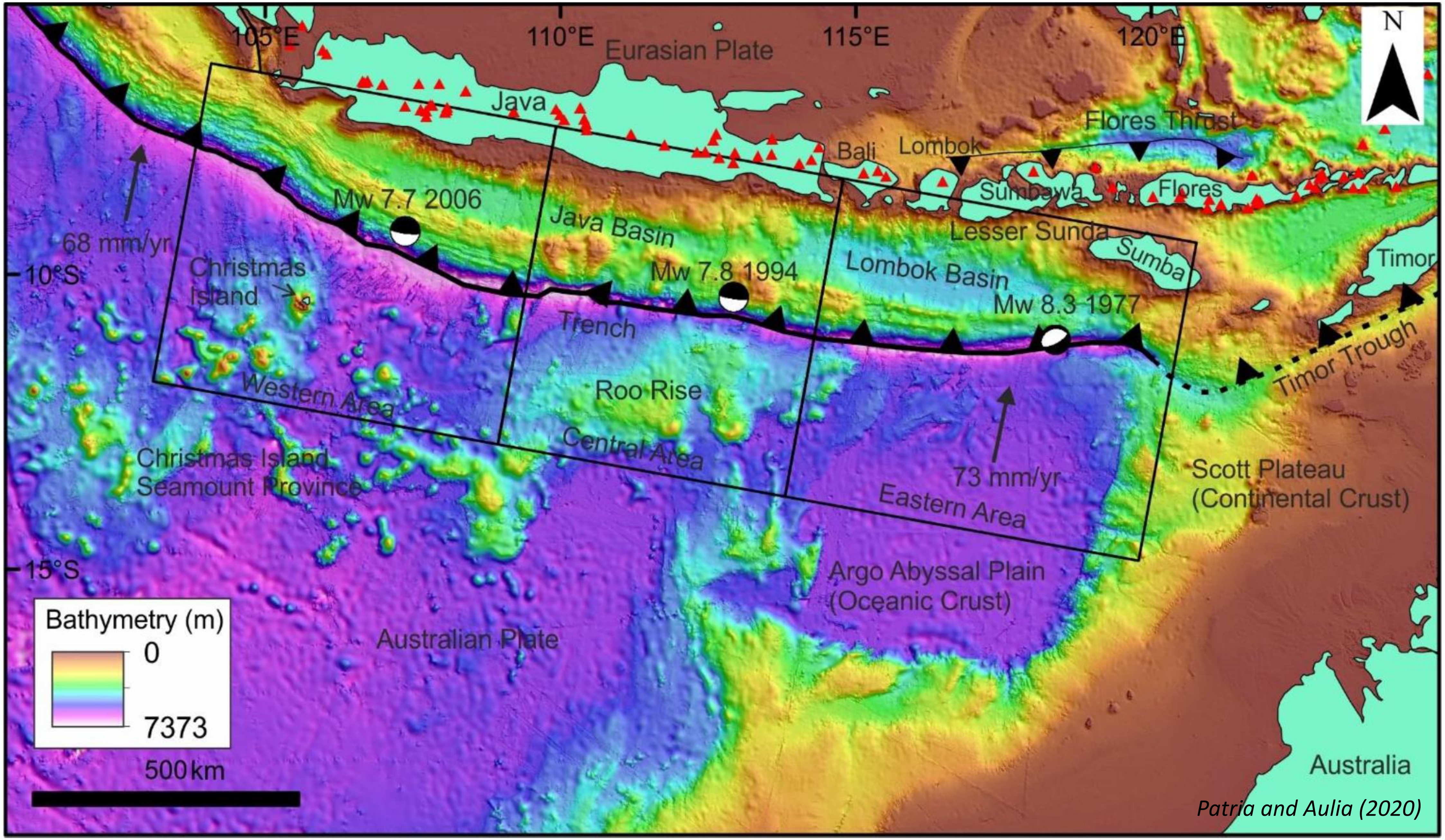
Pusgen (2017)



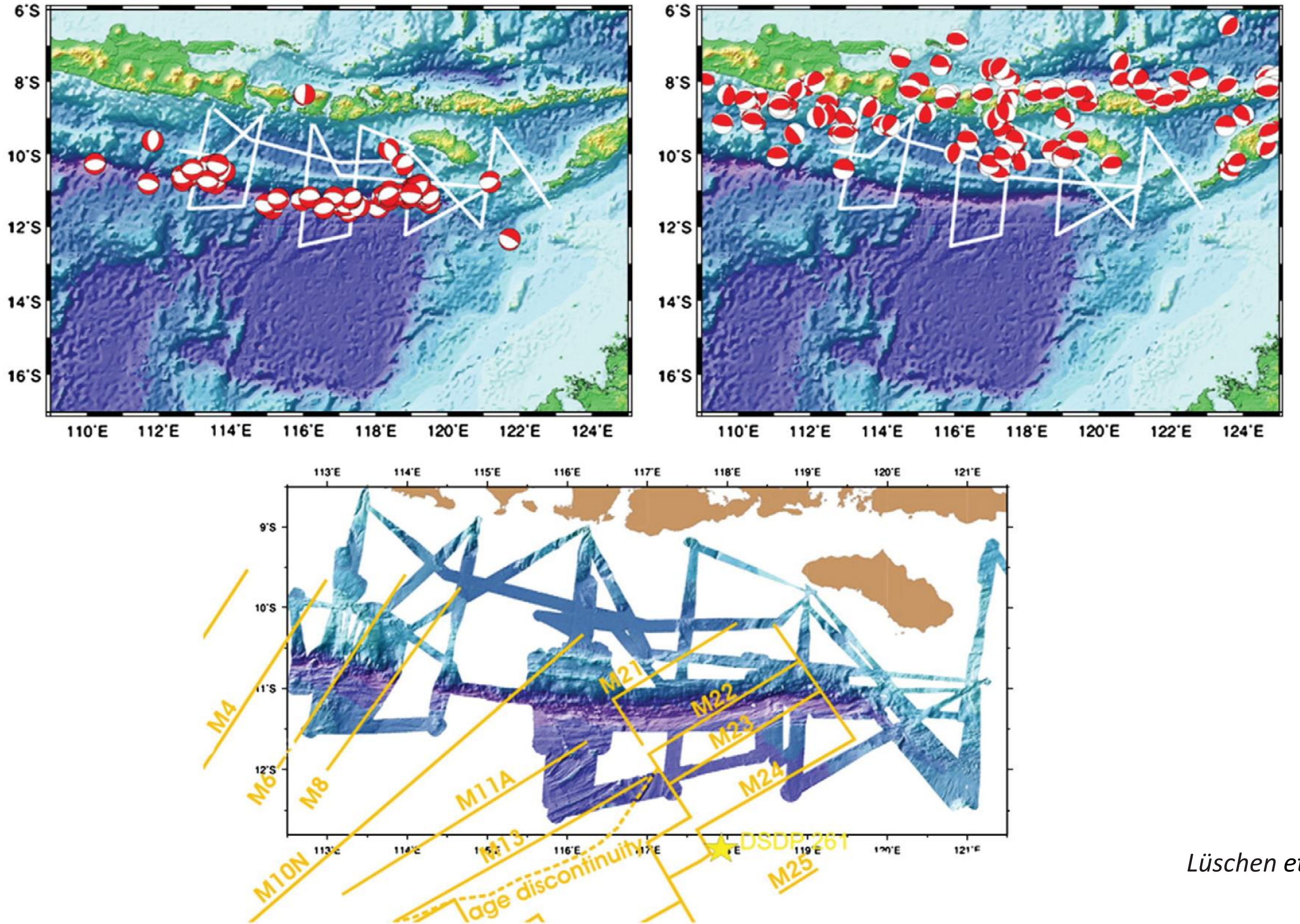
Episenter gempa hasil relokasi di Pulau Jawa dan sekitarnya untuk *event* dengan kedalaman ≤ 100 km dan magnitudo ≥ 4. Mekanisme fokus merupakan solusi dari GCMT untuk gempa dengan magnitudo ≥ 6 (Shiddiqi, 2015)

Pusgen (2017)

Tectonic elements and main morphological features of Java Subduction Zone

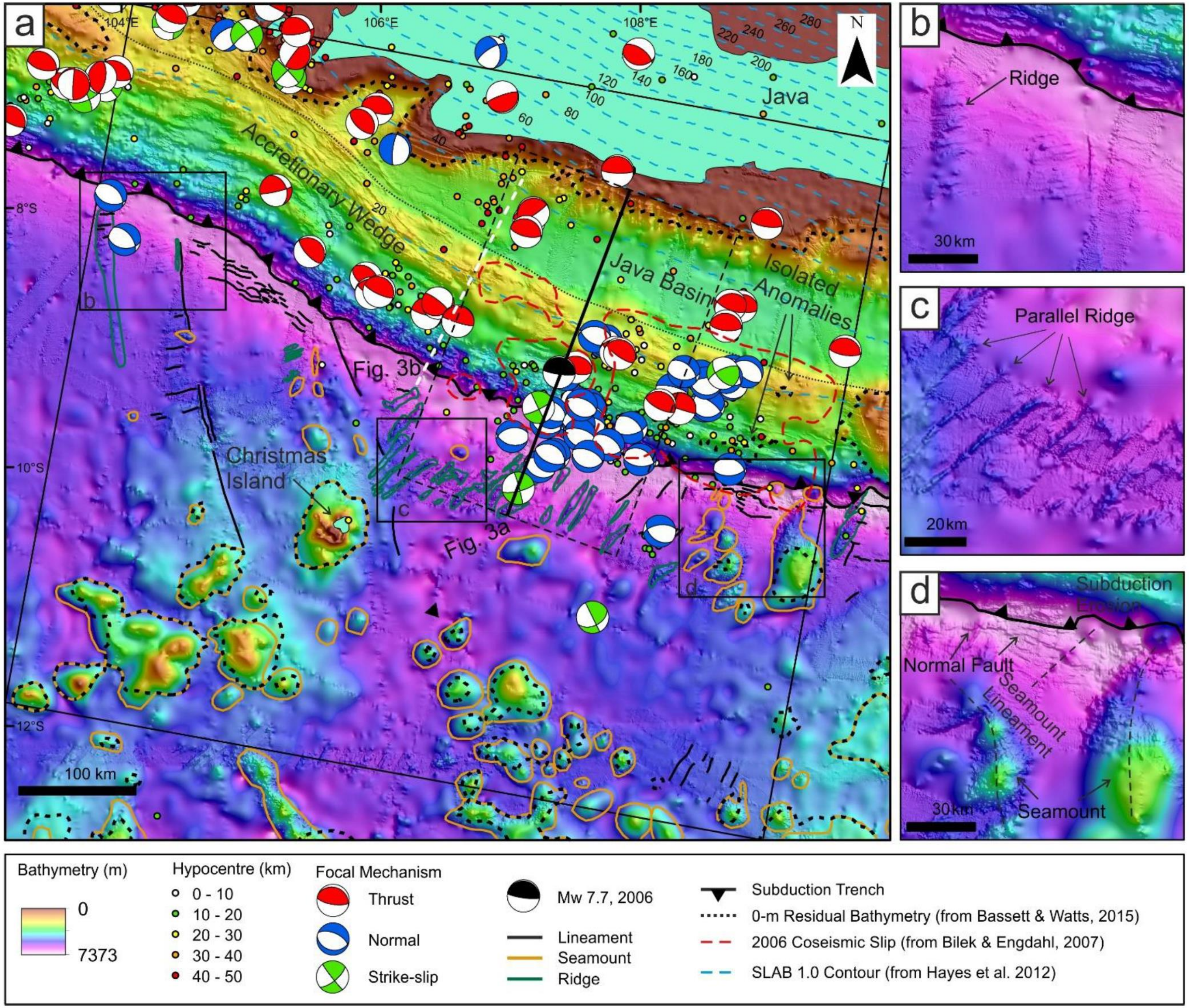


Patria and Aulia (2020)



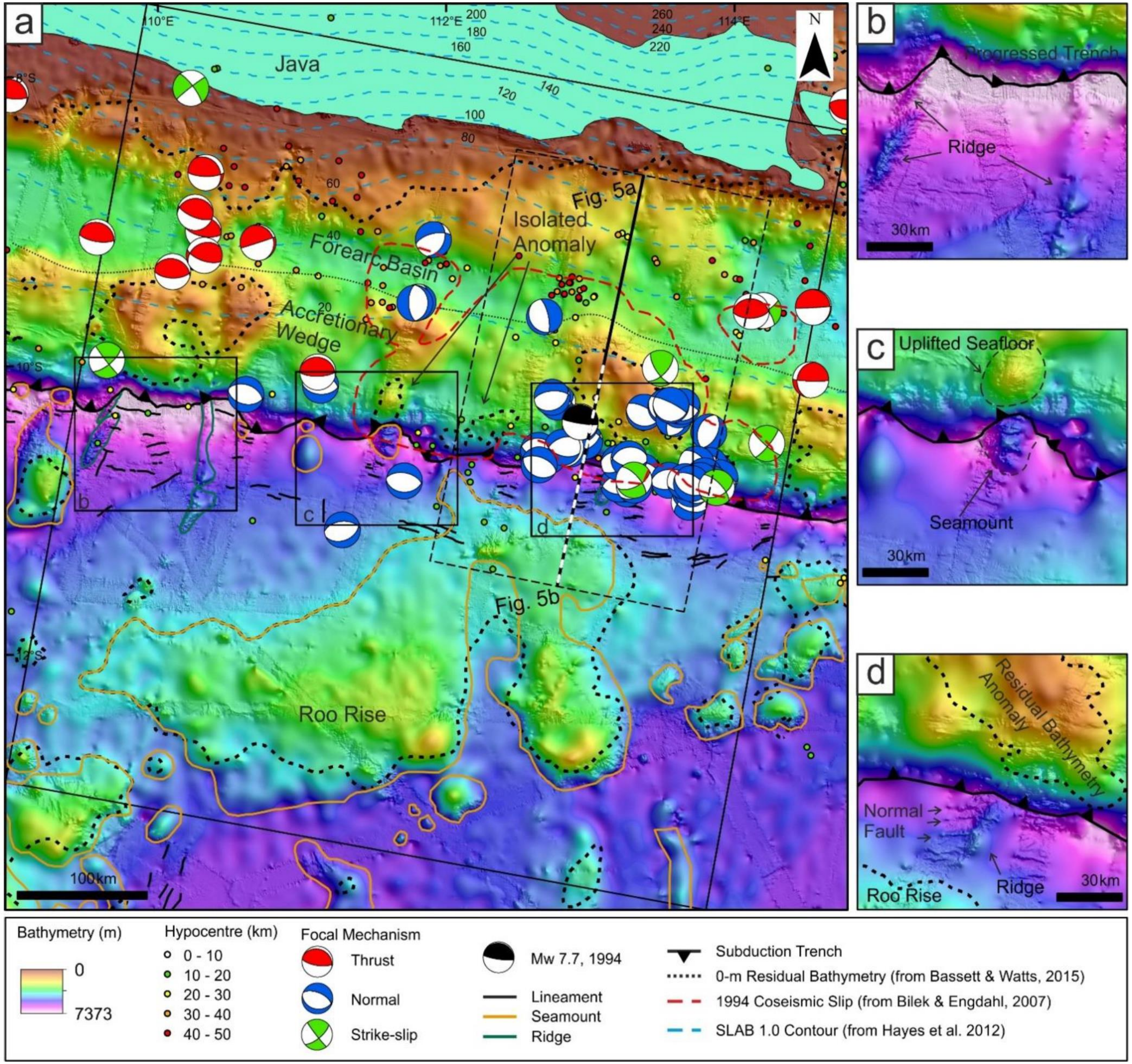
Lüschen et al. (2011)

Fig. 9. Focal mechanism of shallow earthquakes (Engdahl, pers. comm., 2008; Engdahl et al., 2007) selected for focal depth lower than 30 km (10 km depth resolution) of normal faulting type (upper left) and all earthquakes (10 km depth resolution) of thrust type (upper right) in the study area. Normal faulting southward of the trench is characterized by an extensional regime (upper left). Compressional mechanism (upper right) may correspond to the seismogenic zone beneath the forearc basins and the volcanic arc. Note that beneath the outer arc high there is no earthquake activity. Bathymetry and interpreted magnetic lineations are shown at bottom. Plate convergence is in North–South direction. Age of subducting oceanic plate increases from West to East from Cretaceous (Roo Rise) to Jurassic (Argo Abyssal Plain).



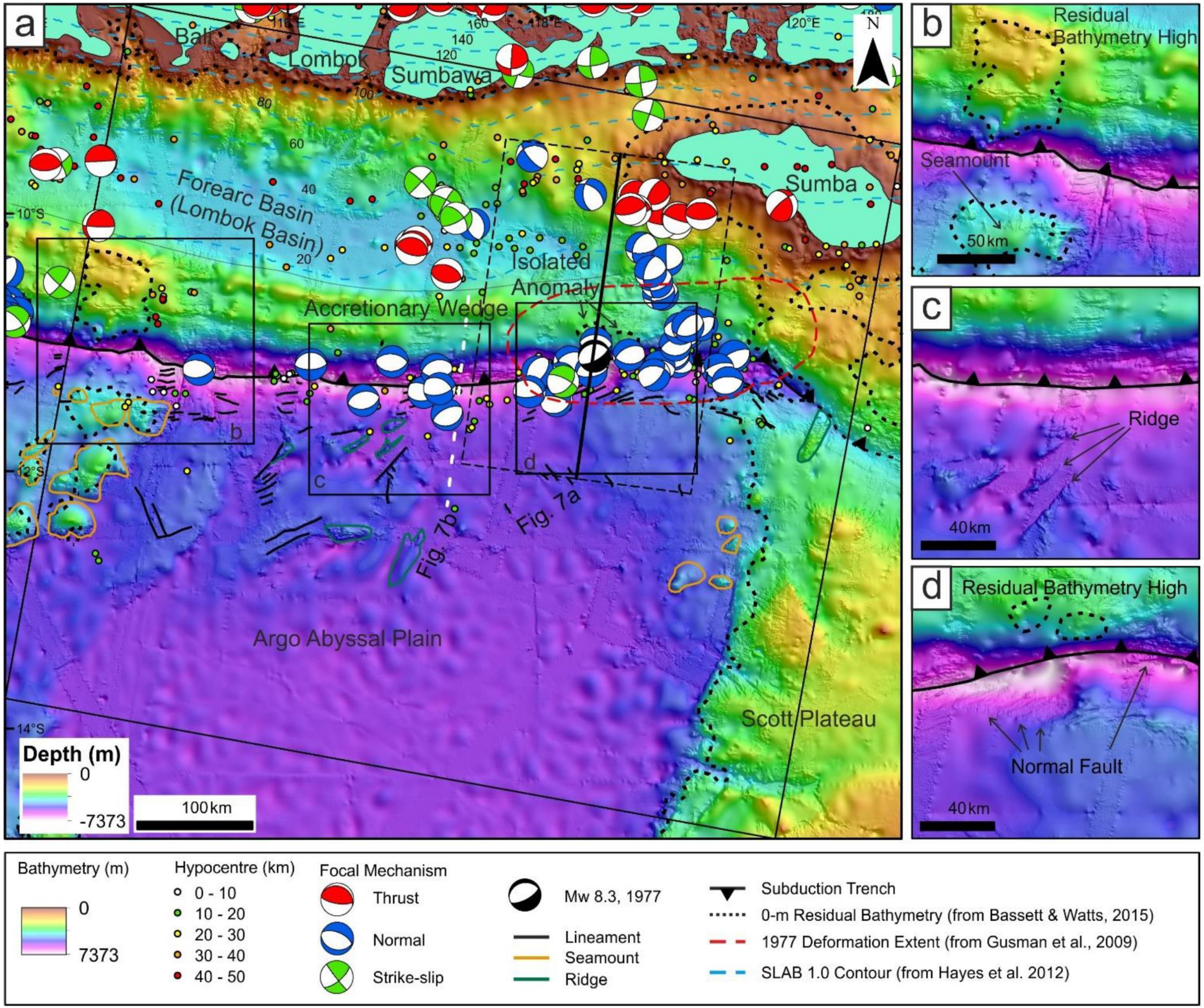
a) Bathymetric map of the western area with structural interpretation, compiled with seismicity and extent of coseismic slip of Mw 7.7 2006 Earthquake. b) N-S oriented ridge near subduction trench. c) Series of parallel ridges on oceanic crust. d). Seamounts which associated with the landward progression of the trench.

Patria and Aulia (2020)



Bathymetric map of the Central Area with structural interpretation, compiled with seismicity and extent of coseismic slip of Mw 7.8 1994 Earthquake. b) NNE-SSW oriented ridge near subduction trench, associated with the landward progression of the trench. c) Seamount is in contact with the trench and uplifted seafloor in front of the seamount. d). Uplifted zone with high residual bathymetry is in further landward from Roo Rise.

Patria and Aulia (2020)



a) Bathymetric map of the Eastern Area with structural interpretation, compiled with seismicity and extent of coseismic slip of Mw 8.3 1977 Earthquake. b) Comparable residual bathymetry highs on both oceanic crust and accretionary wedge. c) Ridge on Oceanic crust. d). Isolated residual bathymetry anomalies in accretionary wedge and normal faults in the near trench zone.

Patria and Aulia (2020)

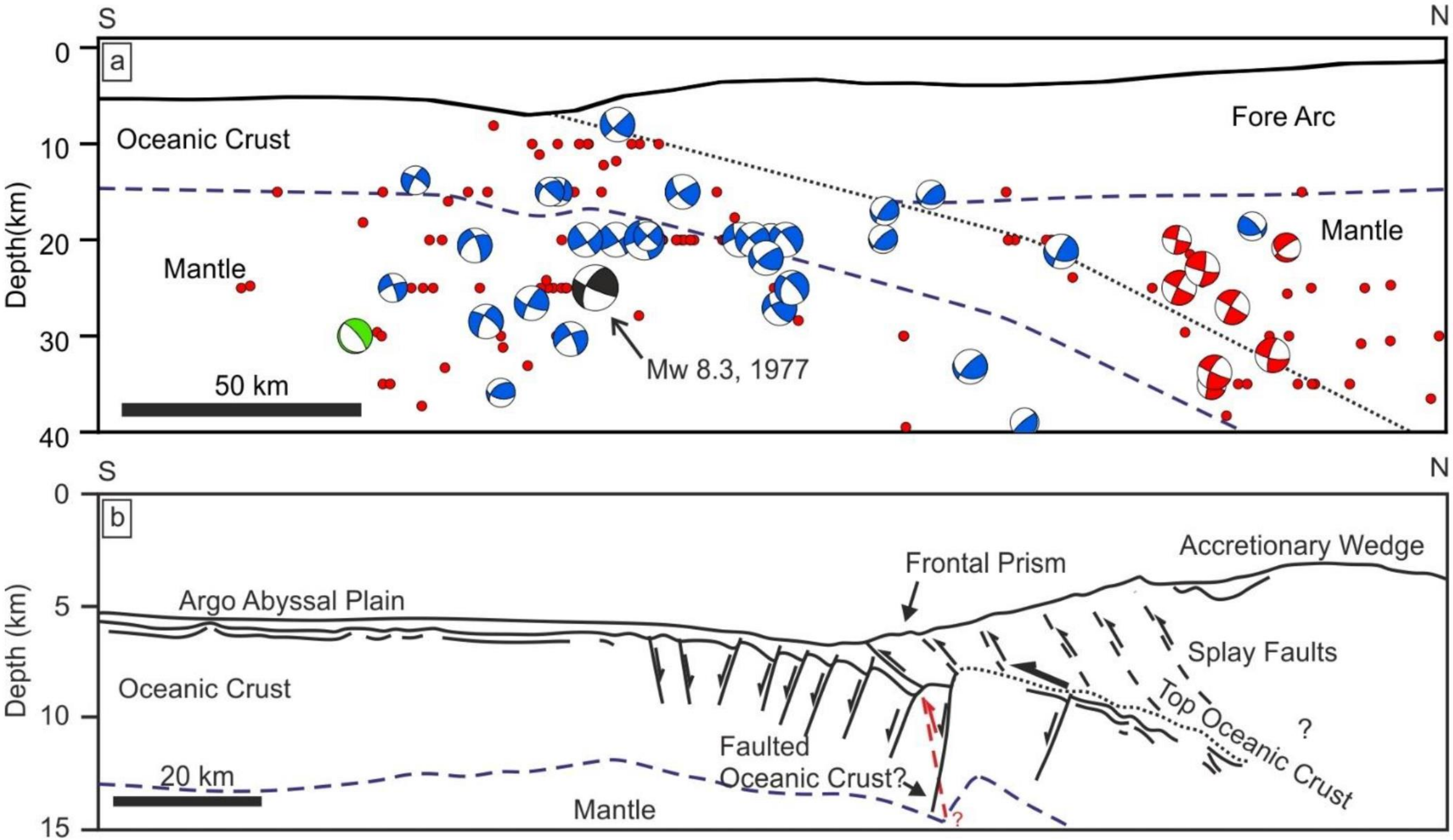


Figure 7. a) Cross-section showing seismicity and focal mechanism within a zone of 100 km width from the centerline in the Eastern Area. Mantle-crust boundary is adapted from Luschen 2009. Top of subducting geometry based on SLAB 1.0 (Hayes et al. 2012). b) Seismic Interpretation Profile BGR06-311 (modified after Lüschen et al. 2011).

Patria and Aulia (2020)

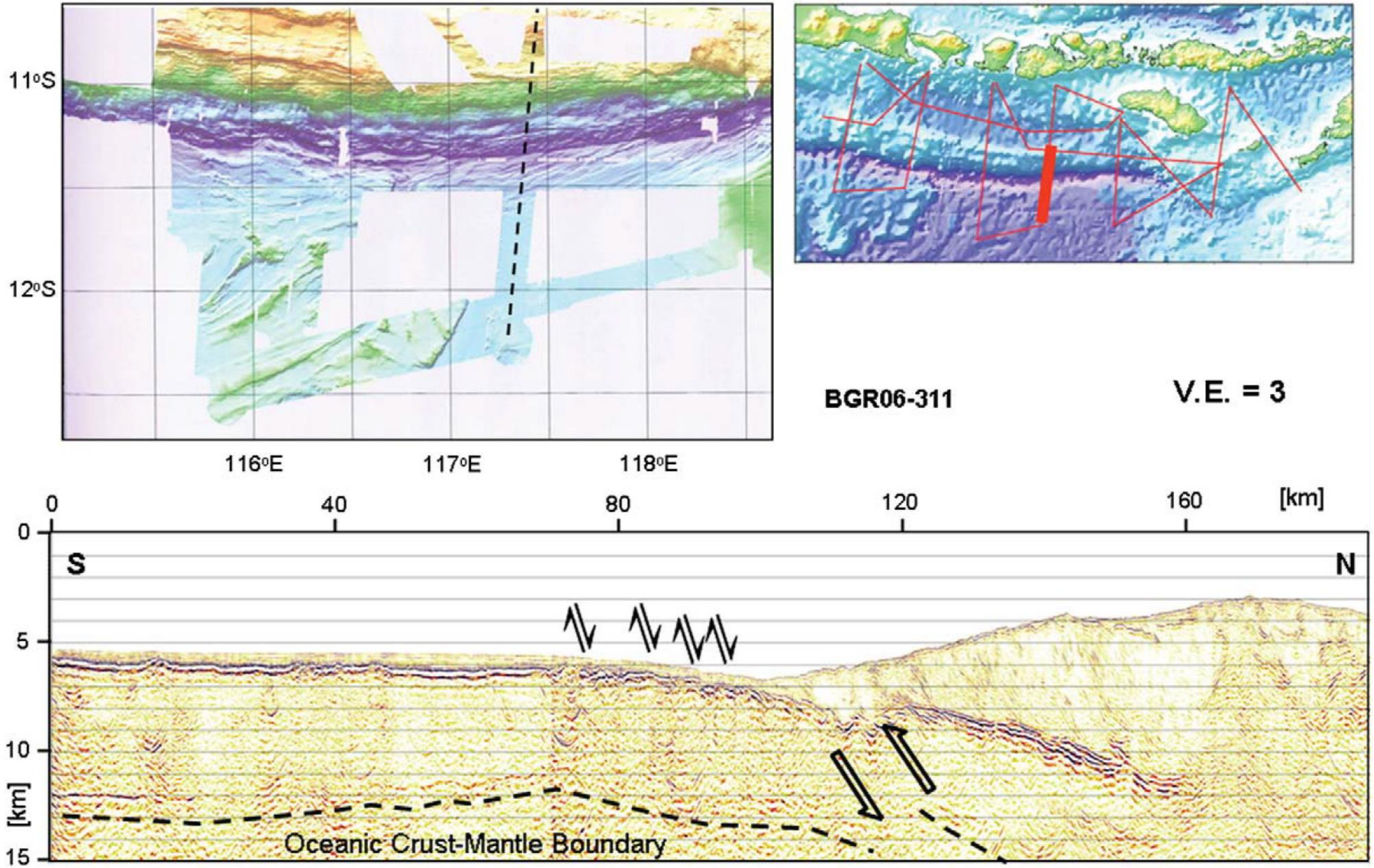


Fig. 8. Details of profile BGR06-311 (PreSDM) in the Argo Abyssal Plain area. Arrows mark relative movements with normal faulting in the outer trench slope. The upper/lower plate interface beneath the outer arc high is relatively smooth, in contrast to other profiles. However, beneath the toe of the accretionary wedge a prominent break is visible, which is mirrored also at the base of the oceanic crust (Moho). Large arrows indicate interpreted thrust movements affecting the entire oceanic crust. Note that the dashed line indicating the oceanic crust–mantle boundary has been shifted a little to greater depth in order to not obscure the boundary. Bathymetry (upper left) shows rippled seafloor south of the trench,

Lüschen et al. (2011)

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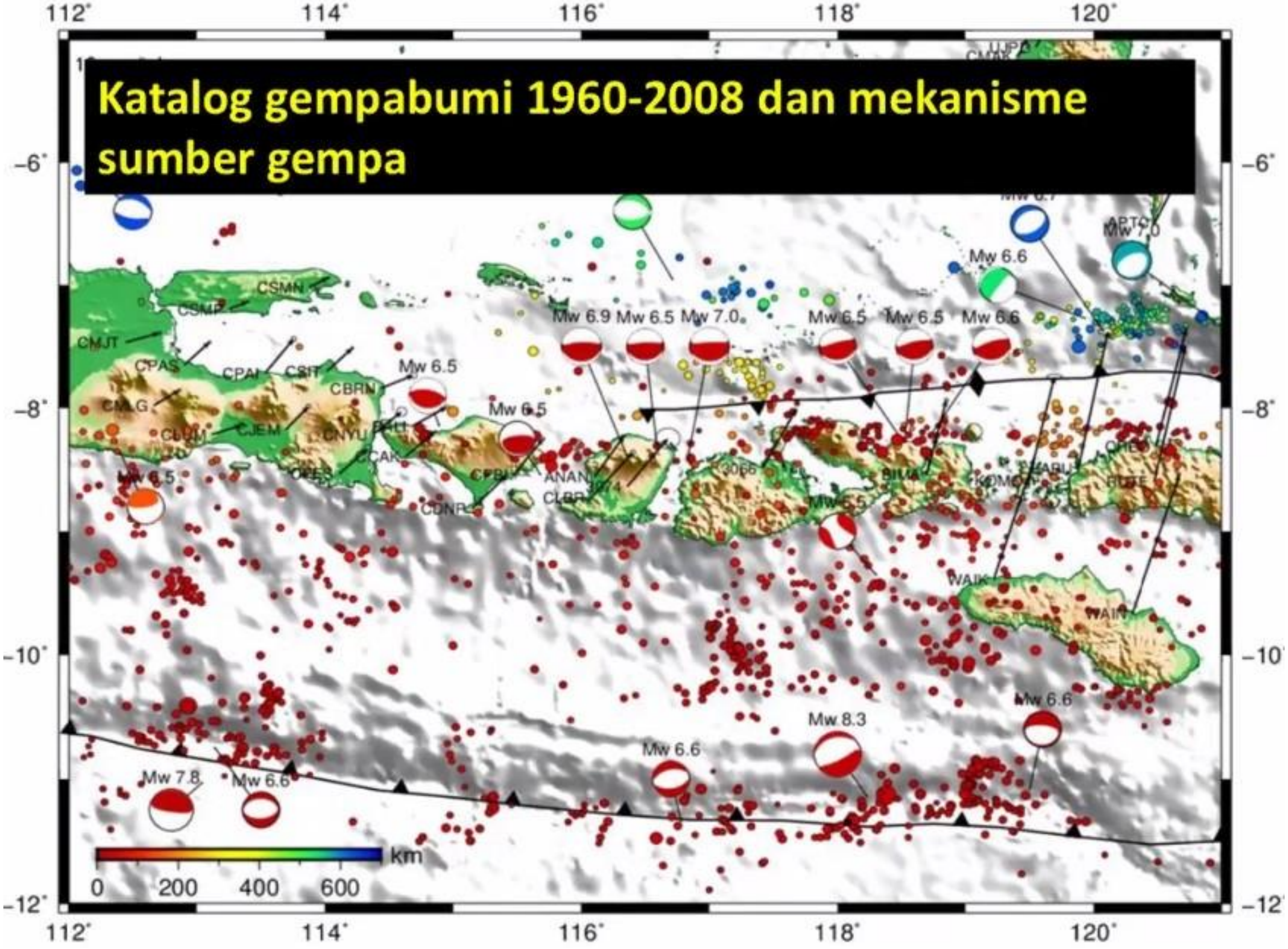
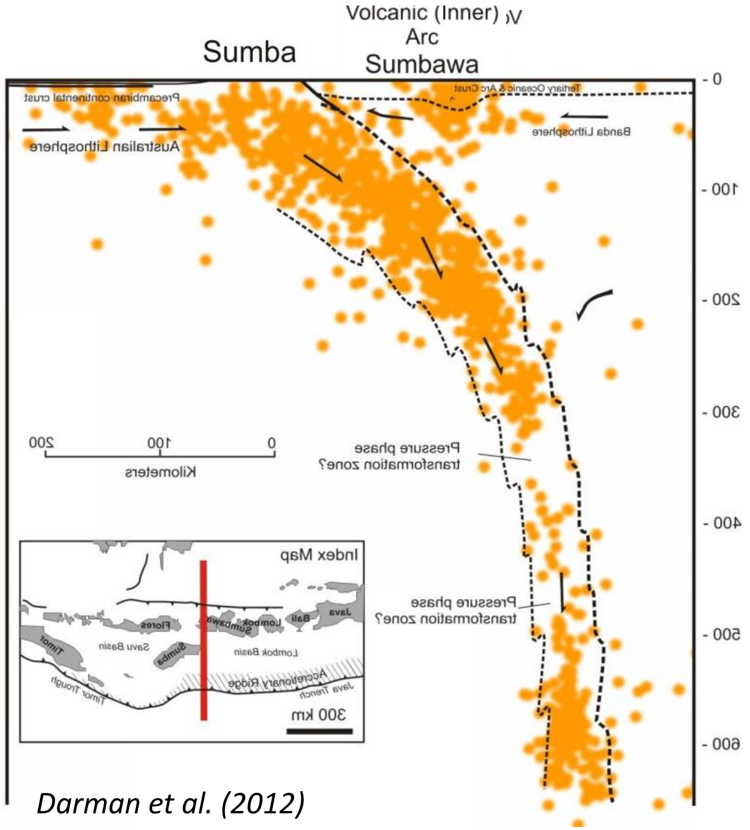
Katalog gempabumi 1960-2008 dan mekanisme sumber gempa



Daryono (2020)

SW Sumba Outer-Rise Earthquake

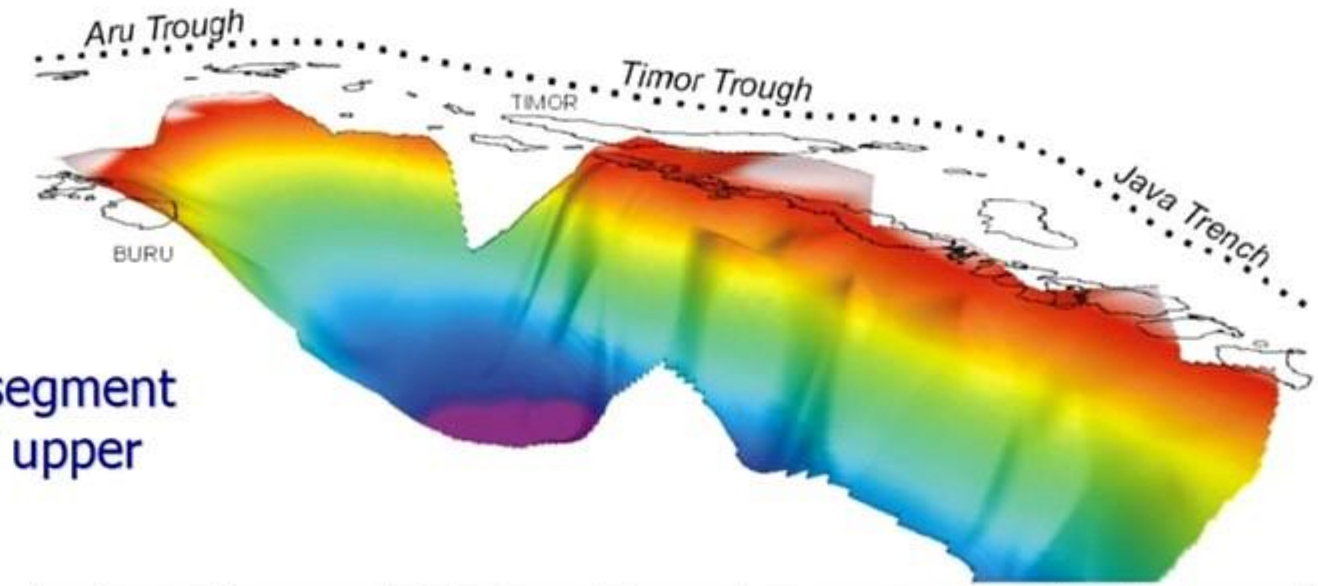
1. The great outer-rise earthquake (Mw 8.3) occurred near the Sunda trench, Indonesia, on 19 August 1977. The earthquake has been previously studied using seismological data. The earthquake generated a large tsunami that caused severe damage in Sumbawa and Sumba Islands in Indonesia. The tsunami was also observed at tide gauges in Australia.
2. The largest normal fault earthquake with a magnitude of 8.3 is possibly caused by a crustal scale-fault that breaks the entire oceanic crust. According to Lynnes and Lay (1988), the ruptured zone of Mw 8.3 1977 Earthquake has extended to about 30-50 km depth. Thus it is considered that this earthquake may slip along the crustal-scale normal fault (Patria and Aulia, 2020).
3. The great 1977 Sumba earthquake is the biggest outer-rise earthquake in Indonesia ever recorded. The mechanism of outer-rise events is generally a normal fault type with the tension axis perpendicular to the trench, and the focal depths are quite shallow. These aspects are basically consistent with the bending lithosphere interpretation. Ruff (1996) shows that the largest outer-rise events have tensional focal mechanisms, and they tend to occur in uncoupled subduction zones, for example, the 2 March 1933 Sanriku (Mw 8.4) and 19 August 1977 Sumba (Mw 8.3) events.



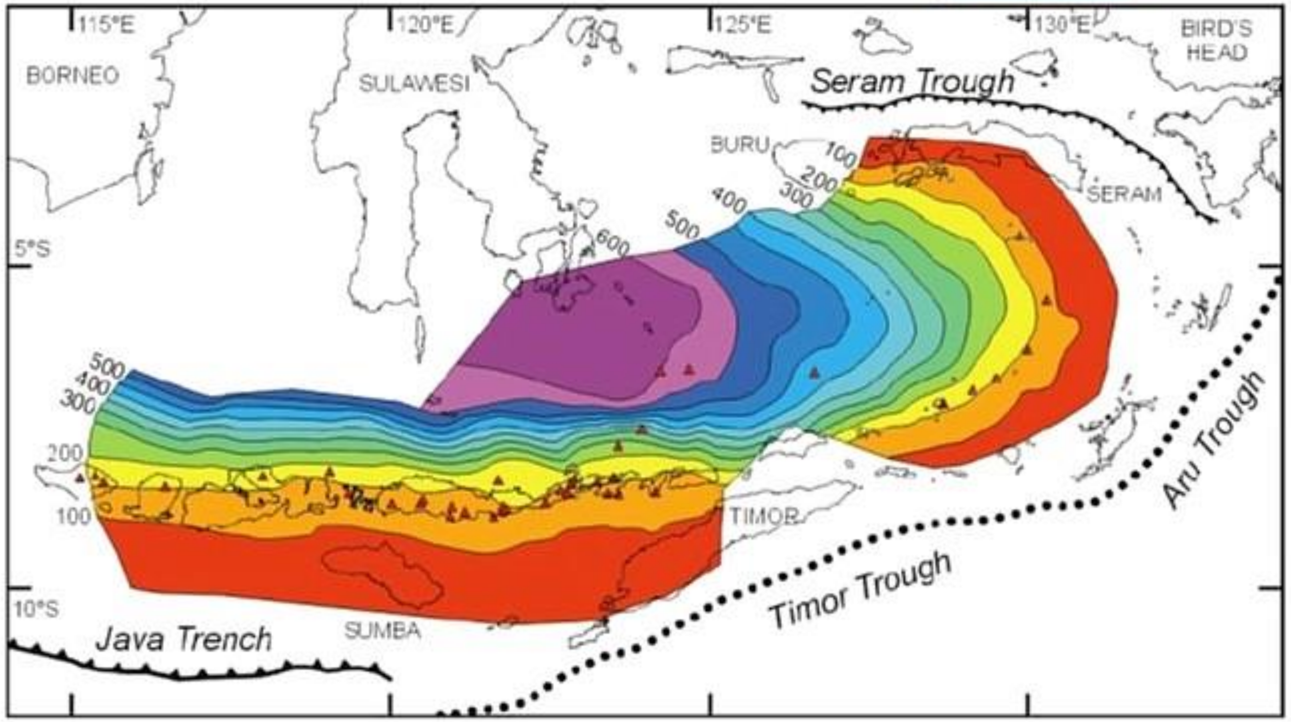
Darman et al. (2012)

In the Sunda Arc, the width of the plate interface, as measured from the trench axis to the 100-km depth contour, indicates a more broad zone of contact at Sumatra, where great interplate earthquakes occur, and a relatively narrower zone at Java, where shallow portions of the Benioff zone dip more steeply (Figure 2). The width of the zone of contact between adjoining plates has been related to the characteristic earthquake size of Pacific subduction zones [Kelleher et al., 1974]. Extremely long rupture zones (> 400 km), and hence great earthquakes, were found to occur at margins with shallowly dipping slabs and wide zones of contact, while moderately large rupture zones (> 150 km) occur in regions that dip more abruptly. These observations are consistent with the concepts of coupling in that younger lithosphere being subducted at a higher convergence rate has a more shallow dip, a greater area of contact, and greater shear traction applied to the plate boundary

Newcomb & Cann (1987)

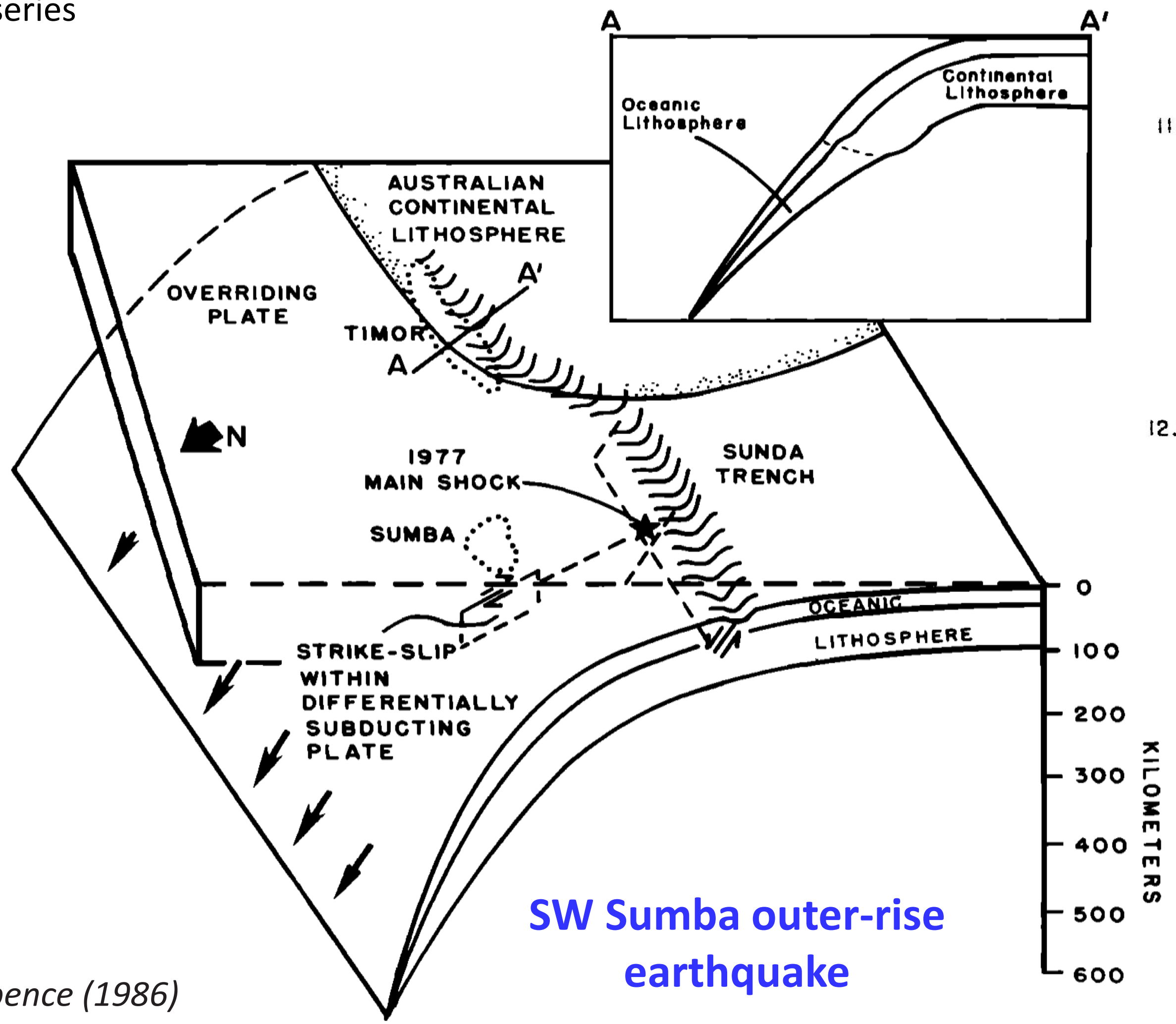


Note flat segment at base of upper mantle



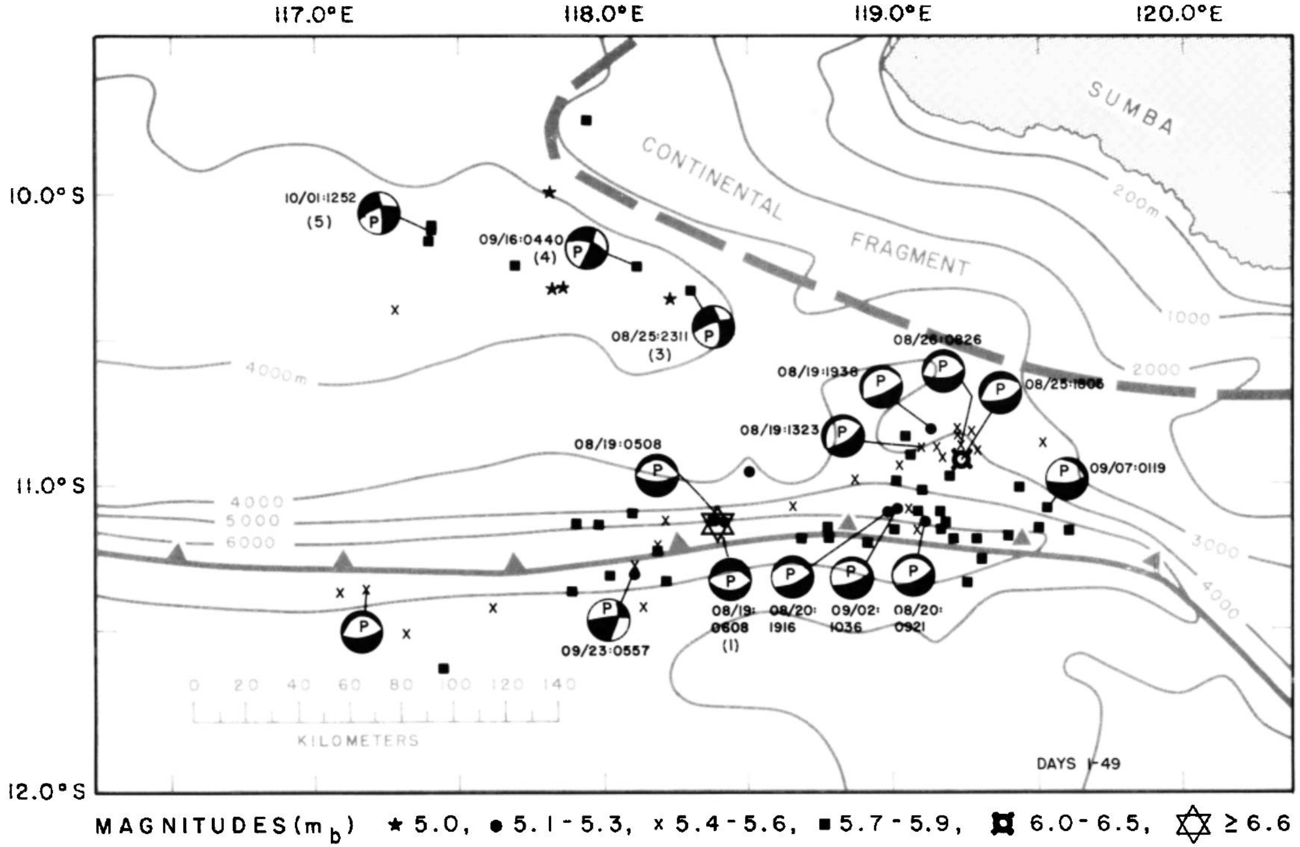
Hall (2014)

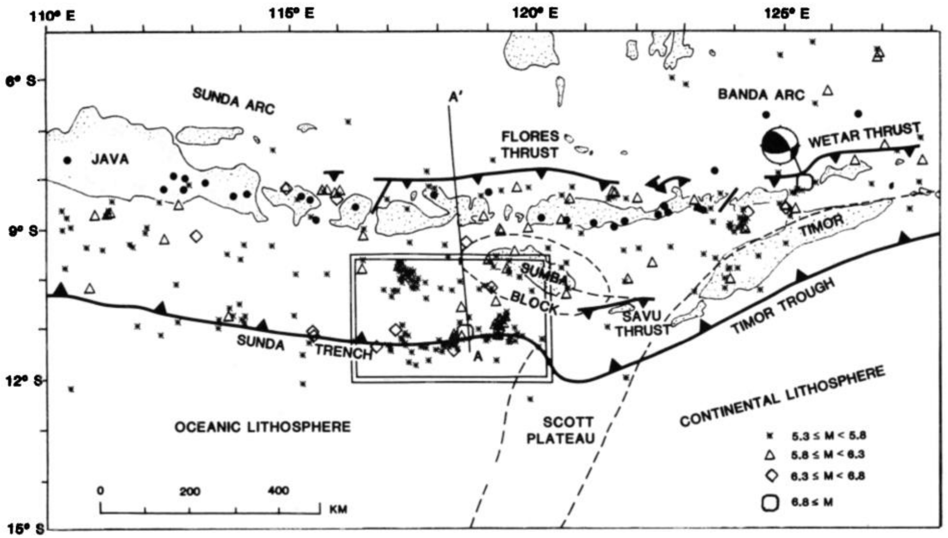
Plate's negative buoyancy causes very large slab pull forces. Great interface thrust earthquakes are absent at the Sumba region, and slab pull forces are inferred to have partially decoupled the subducted plate from the overriding plate. This decoupling permits slab pull stresses to be guided updip to the region of the Sumba main shock. Such shallow-acting slab pull provides a bending moment at the trench and explains the deformation and timing observed for the entire Sumba earthquake series

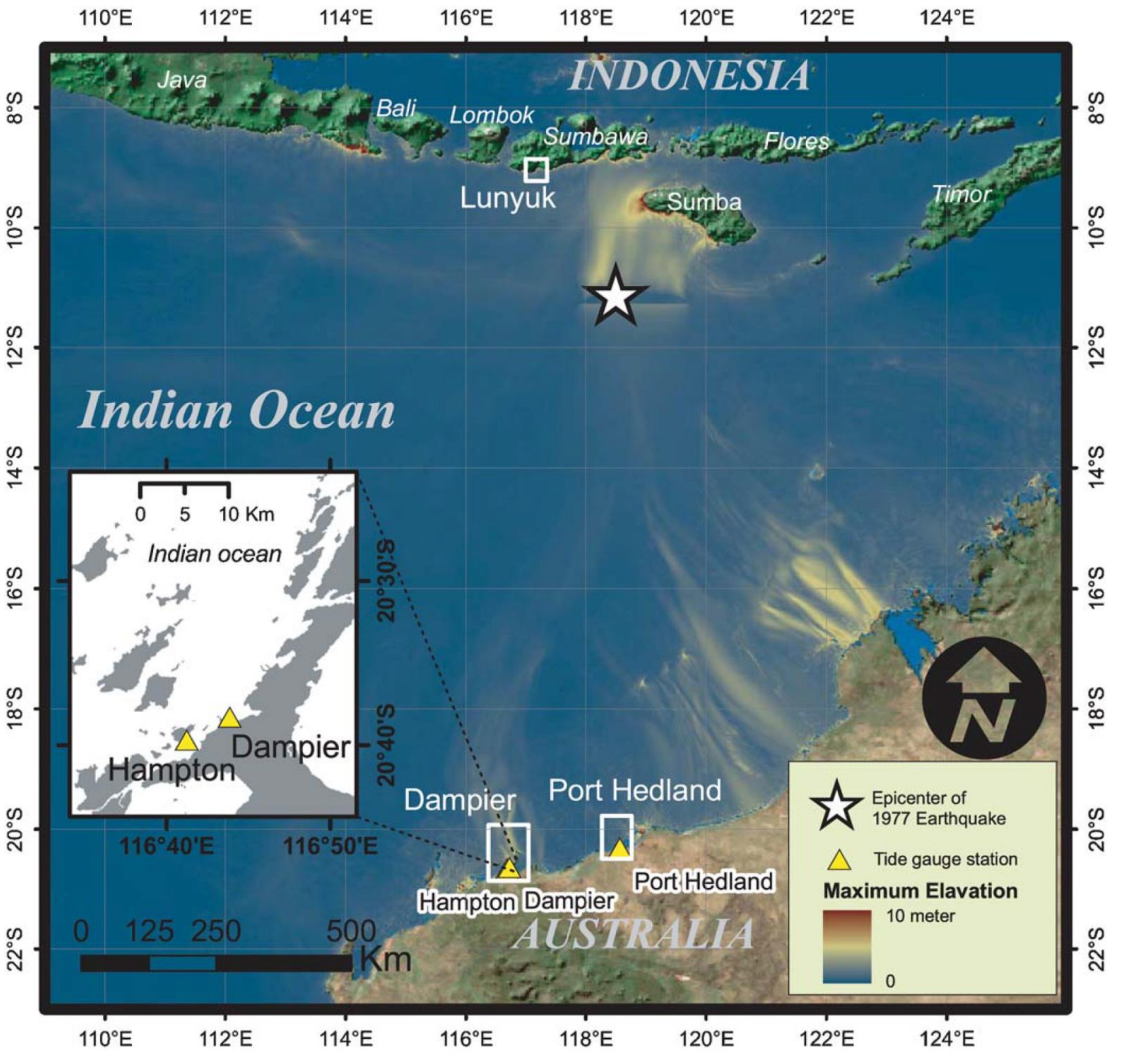


SW Sumba outer-rise earthquake

Spence (1986)

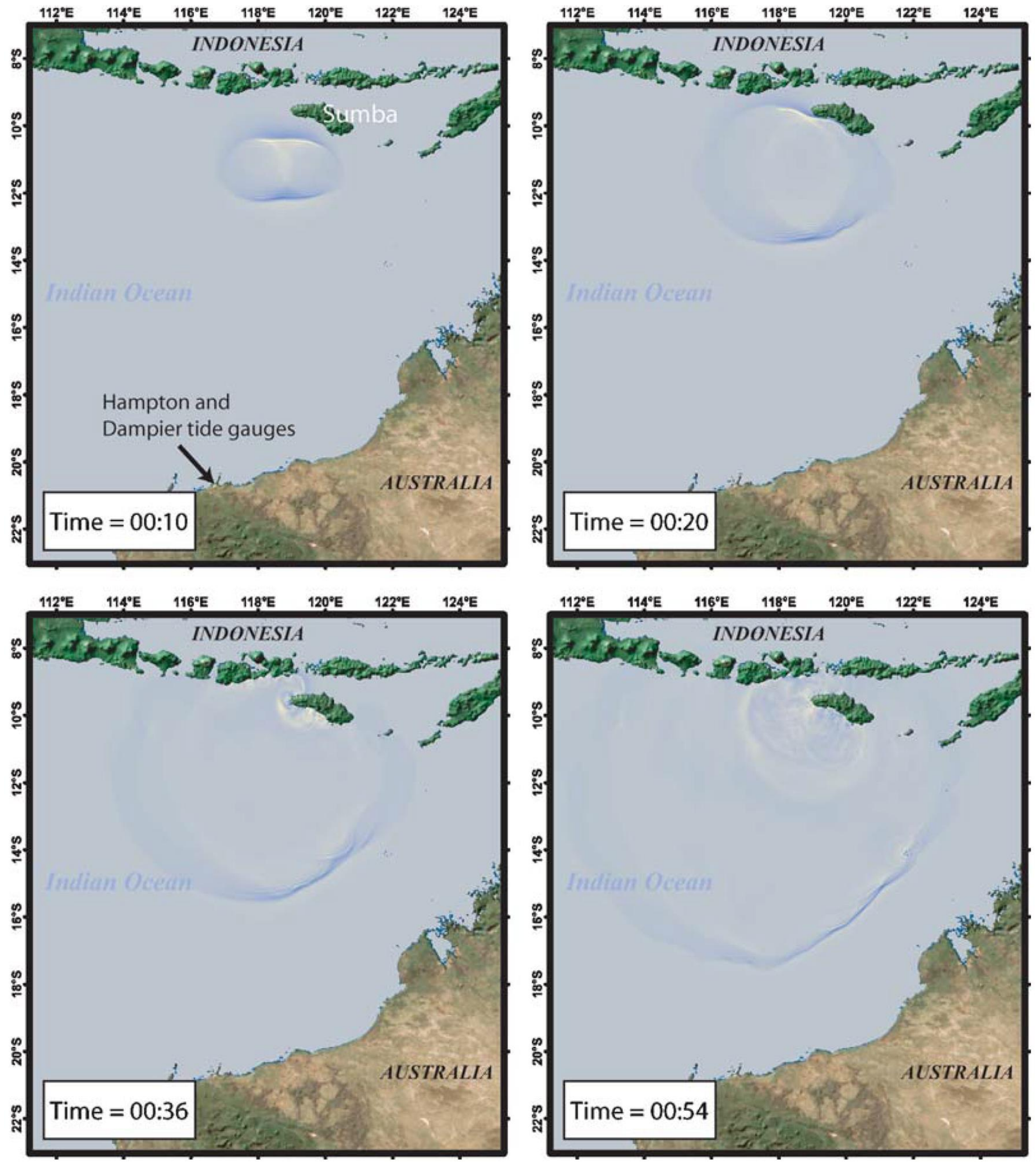






Maximum tsunami elevation
calculated from the far-field tsunami simulation. The white rectangles are the computation domains for small grid systems. The tsunami was recorded by three tide gauges located in Australia. Those tide gauges are indicated by yellow triangles. The inset map shows a closer look at the Dampier region where two tide gauges are located.

Gusman et al. (2009)



Snapshots of **tsunami propagation** at time 10, 20, 36, and 54 min.

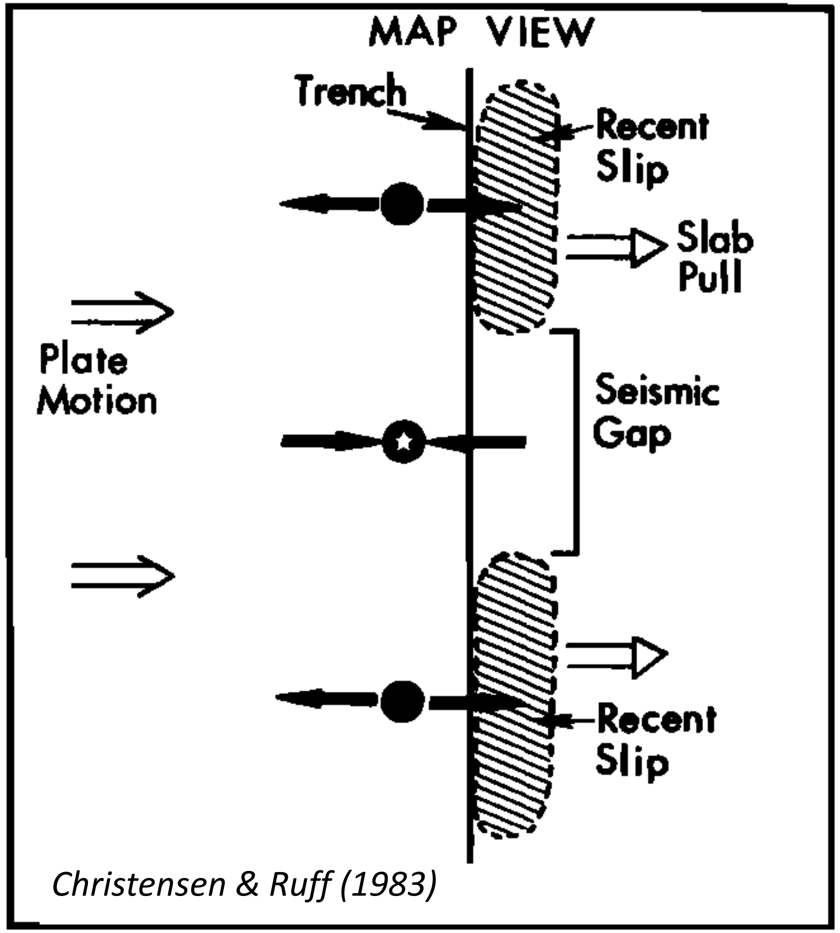
Gusman et al. (2009)

Diskusi

1. Histori, Identifikasi, Karakterisasi Gempa "Outer-Rise"
2. Tektonik Subduksi Busur Sunda
3. Gempa "Outer-Rise" Sumatra-Jawa
4. Gempa "Outer-Rise" SW Sumba Mw 8.3 (1977) dan Tsunami
5. **Pemodelan Gempa "Outer-Rise"**

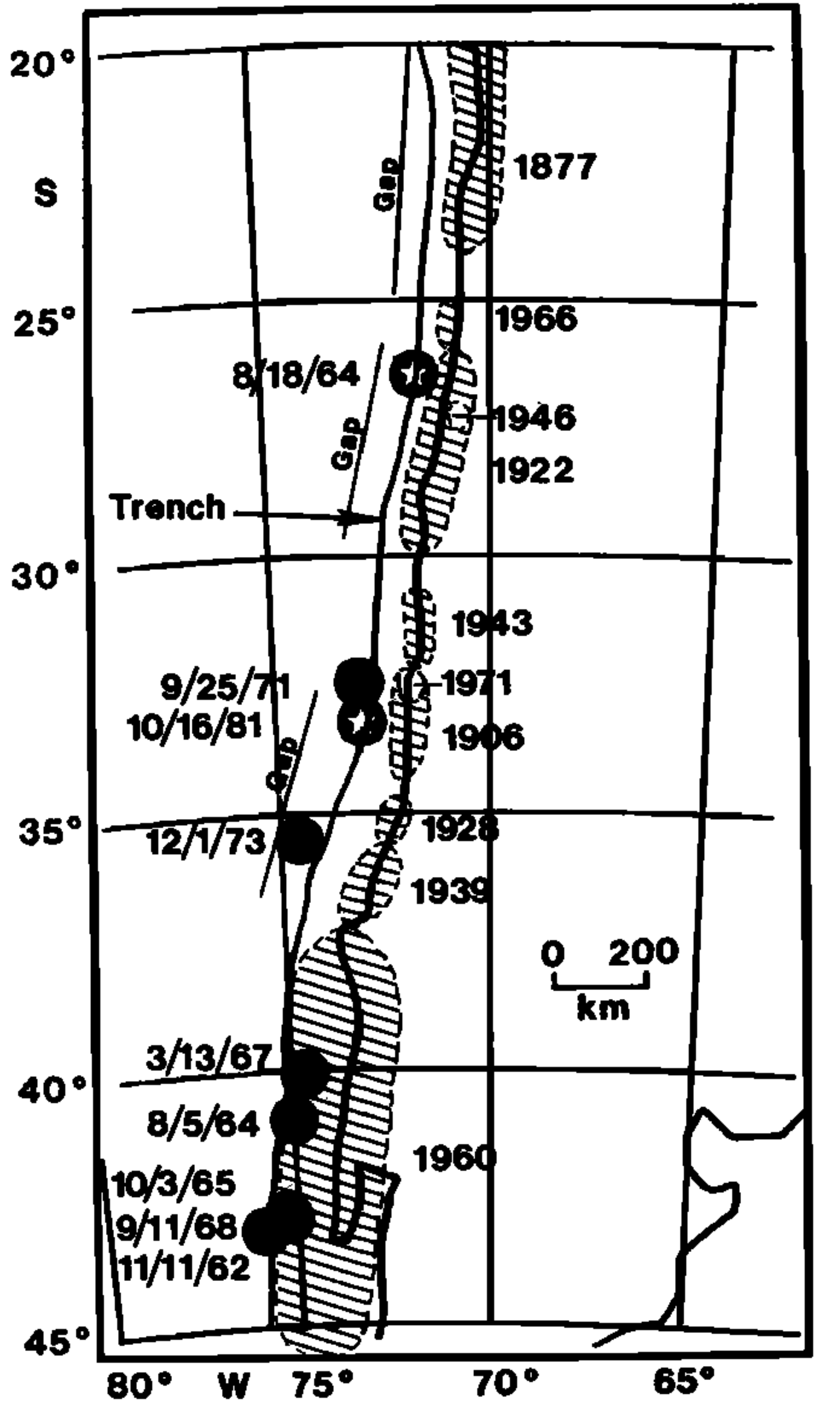
Model of Outer-Rise Earthquakes

1. **Christensen & Ruff (1983)** proposed a model that relates the occurrence of outer-rise events to the coupled and uncoupled nature of subduction zones.
2. In subduction zones that are inherently uncoupled and constantly in tension from slab pull, only tensional outer-rise events occur. These events can occur at any time and are not necessarily related to seismic activity along the plate interface.
3. In coupled subduction zones both tensional and compressional outer-rise events occur.
   a. Tensional outer-rise events occur after large subduction events when tensional stress from slab pull is transmitted to the outer-rise.
   b. Compressional outer-rise events occur in regions that are strongly coupled and have accumulated compressional stress in the outer-rise through movements in adjacent regions; many such regions would be recognized as seismic gaps.
4. Tensional outer-rise events are more numerous and widespread than compressional outer-rise events. Perhaps the more characteristic behavior of the outer-rise is to deform under tensional stresses due to slab pull.
5. Compressional outer-rise events may occur on the relatively rare occasion when the compressional stress in the outer-rise reaches some critical level prior to a large subduction type event.

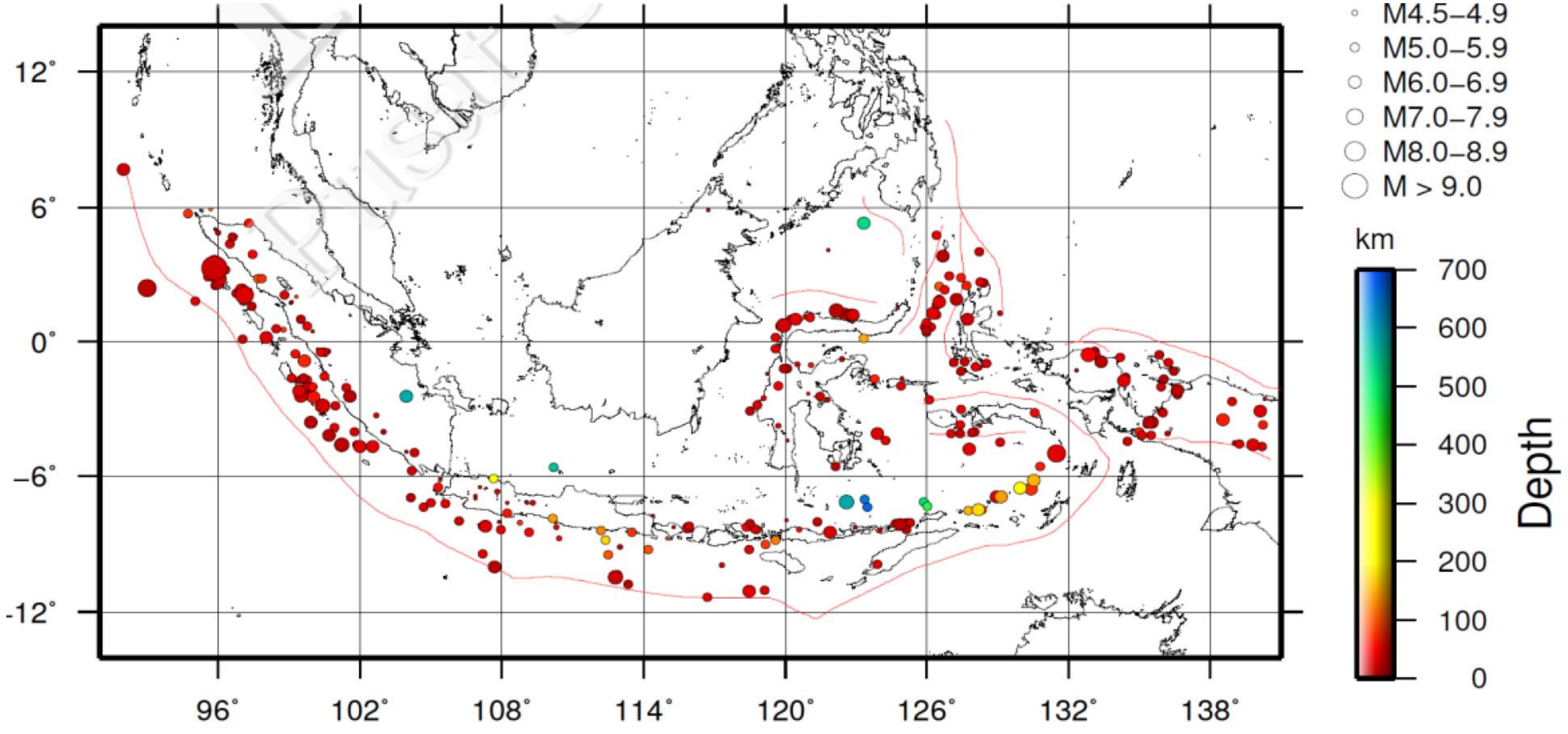


Schematic representation of proposed model for coupled subduction zones. Map view of idealized subduction zone with subduction occurring from left to right. Recent large shallow underthrusting earthquakes are represented by shaded regions. Compressional outer-rise events are shown as open symbols and tensional as closed symbols with arrows depicting major stress axes orientation.

a. *Tensional outer-rise events occur after large subduction events when tensional stress from slab pull is transmitted to the outer-rise.*
b. *Compressional outer-rise events occur in regions that are strongly coupled and have accumulated compressional stress in the outer-rise through movements in adjacent regions; many such regions would be recognized as seismic gaps.*



Outer-rise events off the coast of Chile. Tensional outer-rise events are shown as solid symbols, compressional as open symbols. Rupture zones of large underthrusting earthquakes are shown as shaded regions (after Kelleher, 1972).



Peta episenter gempa merusak pada periode tahun 1938-2014 (Masturyono dkk., 2015)

Pusgen (2017)

PETA SUMBER GEMPABUMI DI INDONESIA

Perlu memasukkan potensi gempa dari wilayah "outer-rise".

Sumber : Pusgen, 2017)

Sebaran sumber gempabumi di Indonesia :

- ✓ Zona penunjaman terletak di laut.
- ✓ Zona Benioff/ Interplate bisa di darat.
- ✓ Sesar aktif dominan di darat dan ada beberapa di laut

Faizal –Pusgen (2020)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