Slope failure features and their distribution in the forearc off northwestern Sumatra

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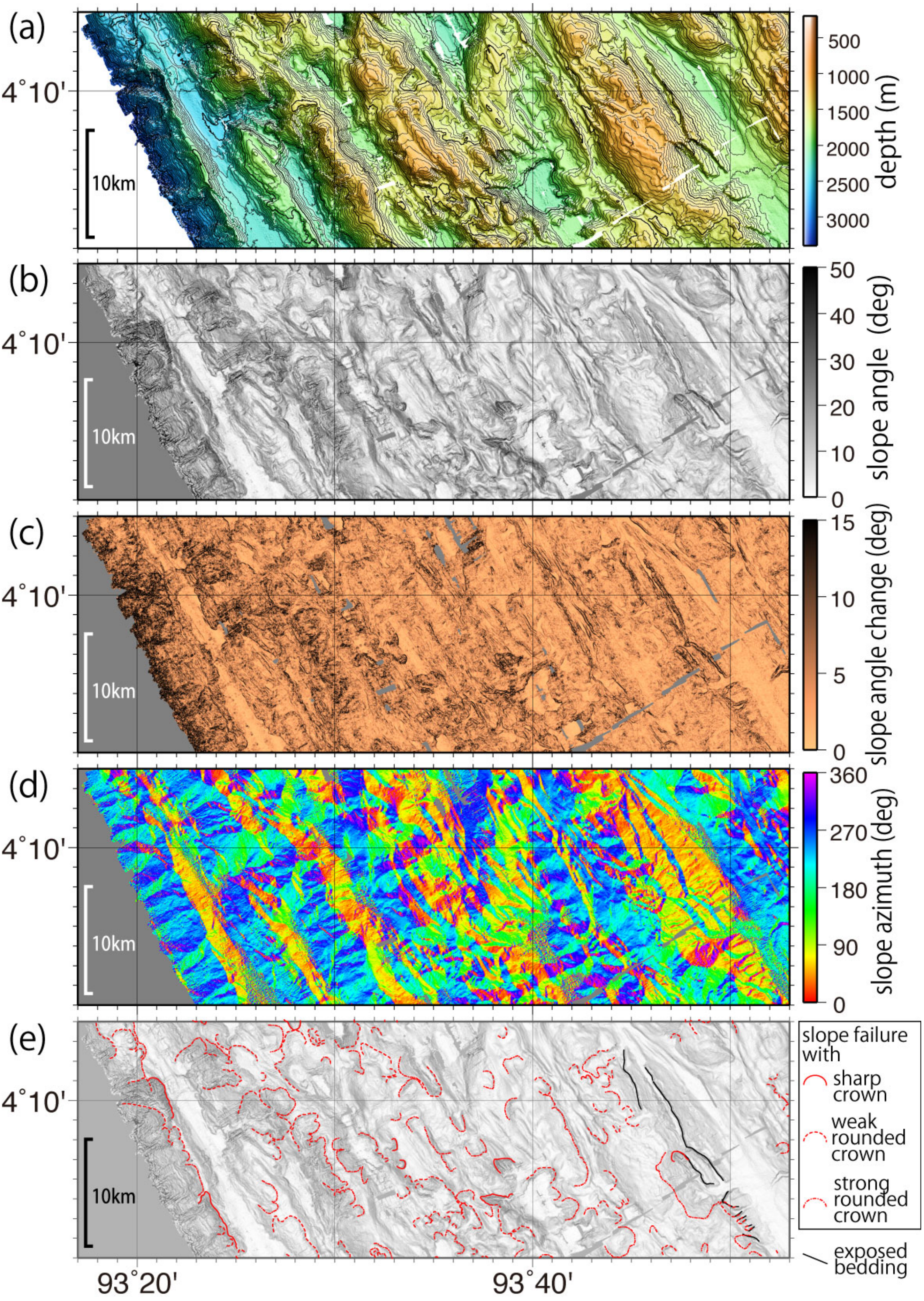
In Feb. 2005 and Oct. 2009, we conducted multi-narrow beam bathymetric (MNB) surveys during NT05-02 cruise with R/V Natsushima (NT05-02 scientific party, scientific party,http://www.jamstec.go.jp/jamstec-e/sumatra/ natsushima/bm/contents.html)and KY09-09 cruise with R/V KAIYO (Hirata et al.,2012, JAMSTEC report), respectively. Apporox. 1 degree angular intervals of multi narrow beams with both the R/Vs makes us possible to retrieve detailed bathymetry with high resolution of ˜35 meters in azimuthal direction for seafloor of ˜2000 meters in water depth beneath ship tracks. Hirata et al. integrated these multi-narrow beam bathymetric data to construct detailed bathymetric data (grid data of ˜37 meters interval for the surveyed area with ˜50 km x ˜100 km, surrounded by latitudes 3°50’ N and 5°00’ N, and longitudes 93°10’ E and 94°10’ E). In this study, we identify slope failure features in the forearc region off the northwestern Sumatra, and discuss its spatial distribution in terms of the geological processes.

To identify bathymetric features clearly, we make four kinds of maps as follows; slope angle map, slope angle change map, slope (direction) azimuth map, as well as plain bathymetric map. Slope angle is defined by arctangent of dz/ds, where z is the water depth and s is unit distance vector projected the steepest descending direction on horizontal plain. Slope angle change is defined by arctangent of second derivative of a unit distance vector s. Slope (direction) azimuth is defined by arctangent of dx/dy, where x and y are due east and due north components, respectively, of unit distance vector projected the steepest descending direction on horizontal plain. As a sample, we show figures consisting of slope angle map ((b) in Fig), slope angle change map (c), slope (direction) azimuth map (d) as well as plain bathymetric map (a) for a small rectangular region in the forearc off northwest Sumatra. We finally interpret such kinds of maps to identify slope failure features, etc (e).

We can identify the upper portion of slope failure structures with an elevation difference of about 1 km which bounded the western edge of the outer arc high, although we cannot retrieve bathymetry of the Sumatra Trench at ˜ 4500 meters water depth because the multi-narrow beam survey systems can sounding up to less than 3000 meters. The slope failure structures are created by several to more than ten of successive landslides in the region shown in Fig. The landslide features show uneroded and sharp crowns, implying that the landslide features nearby the Sumatra Trench are created “recently” in geological time scale. Slope failure features with weak to strong rounded crowns come to appear as our sample point migrates landward. This can be explained from the formation process of the outer arc high off northwestern Sumatra ; thick, upper sedimentary layers in the top of subducting Indo-Australia plate that are stripped off at the toe of the forearc obduct onto the outer arc high so that accretional process proceeds (Mosher et al.,2008, Mar.Geol.; Misawa et al., 2014, EPSL).This means that landward (eastward) of the outer arc high is accreted older than its seaward (westward).

On the one hand, there are exceptions to such a geological rule; we can find several slope failure features with uneroded, sharp crowns in a landward region where many slope failure features with weak and strong rounded crowns exist (e.g., two slope failure structures with a width of ~ 1 km around a location of4°06’N, 93°39’E). These relatively fresh failure structures existing landward of the outer arc high possibly relate to recent activation of major thrusts proposed in the outer arc high off northwest Sumatra (Hirata et al., 2010, AGU).

Keywords: Sumatra, forearc, outer arc high, slope failure, submarine landslide


(a)
4°10'
10km
500
1000
1500
2000
2500
3000
depth (m)
(b)
4°10'
10km
50
40
30
20
10
0
slope angle (deg)
(c)
4°10'
10km
15
10
5
0
slope angle change (deg)
(d)
4°10'
10km
360
270
180
90
0
slope azimuth (deg)
(e)
4°10'
10km
slope failure with
sharp crown
weak rounded crown
strong rounded crown
exposed bedding
93°20'
93°40'