Development of River Terrace at the Releasing Bend of the Sumatran Fault Zone near Ranau Lake, Southern Sumatra

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Abstract

Strike-slip fault system of Sumatran Fault Zone related with the genesa of lakes which growth in some area along the fault. Ranau lake with its peculiar rectangular shape are controlled by the evolution of the ancient Ranau releasing stepover. The shape of the lake is elongated to the present trace of Sumatran Fault Zone. One of the common geomorphic markers at the strike-slip fault system is the releasing bend that indicate the thinning part of the landforms. We would like to reveal the mechanism in developing the river terraces. In this study we extracting the DEM-SRTM datasets with 30m resolution into profile that show the elevation changing of river terraces in Way Rekuk stream near the Ranau Lake. By using the profile of the landforms of the area, there are some information regarding the processes of the landforms which affected by the tectonic processes either the geomorphic erosion. The landform affected by the strike-slip fault system that initiate the vertical offset of the river terrace.

Keywords: strike-slip system, extensional, terrace, vertical offset, Ranau, Sumatran Fault Zone.

Introduction

Strike-slip faults commonly have extensional component in their system which show depression developed between or within principal displacement zone (PDZ). The topographic depression which is commonly called pull apart basin that form at the bends or stepovers in the strike-slip fault systems (Mann, 2007; Sylvester, 1988).

Bends and stepovers are typically different in origin of the pull apart basin (Figure 1). The bends commonly formed from one segment and the stepovers formed by two parallel strike slip fault (Bellier & Séebrer, 1994). However, fault stepovers may evolve into continuous fault bends and connected with the splays from the fault (McCay & Bonora, 2001). So, the terms could be used either as stepover or bends (Cunningham & Mann, 2007).

The releasing bends sometimes prospect for the mineralization and geothermal (Cunningham & Mann, 2007; Natawidjaja & Kesumadharma, 1993), the valley formed from the bends also provide fertile agricultural land (Cunningham & Mann, 2007). Bends also act as barriers to earthquake propagation (Barka & Kadinsky-Cade, 1988; King & Nabelek, 1985) and may be as the nucleation sites for major earthquakes (Shaw, 2006).

River terraces are commonly used as the geomorphic markers example for sloping geomorphic features. The development of river terraces define into two classes which are aggradational or constructional or fill and degradational or erosional or cut or strath (Burbank & Anderson, 2012).

In order to measure amount of deformation which occurred from tectonic processes, the geomorphic markers play an important role to identify the records of tectonic signal (Burbank & Anderson, 2012).

We would like to show the vertical deformation in the releasing bend within the active Sumatran Fault System. The releasing bend located near Ranau Lake in the southern part of Sumatran Fault System (Aribowo et. al., 2014).
Tectonic Setting

Ranau Lake located in Southern Part of Sumatra which is across by the right lateral strike-slip Sumatran Fault (Figure 2) which is called Kumering Segment (Sieh & Natawidjaja, 2000). The peculiar rectangular shape of Ranau Lake is believed to be formed by the stepovers evolution of the Sumatran Fault (Bellier & Sébrier, 1994, Primastuti et al., 1994). Thus, there are two major fault in Ranau Lake with NW-SE orientation, first is the ancient trace of Sumatran Fault at the southern part of the lake which is now inactive and the other one is the active Sumatran Fault trace (Bellier & Sébrier, 1994).

Bellier and Sebrier (1994) proposed the evolution of the southern part of The Sumatran Fault Zone (Figure 3). The first stage show that Ranaustepover and the normal faults bounding the future location of Ranau caldera. The second stage characterized by formation of a caldera in the northwestern of the stepover, and the third stage show that Ranaustepover is marked by the development of a new strike-slip fault across the pull apart basin, through the centre of the basin.

From the stages above Bellier and Sebrier (1994) conclude that Ranau caldera formed within releasing stepover, and the caldera were substituted by pull-apart basin boundary during last stage.

Data and Methods

We use SRTM30 datasets to be extracted into profile and also 3D view in order to show the releasing bend and the pull-apart basin near Ranau Lake. The imageries could be
downloaded from USGS website (earthexplorer.usgs.gov).

Field investigation on the site also has been conducted in order to see the geomorphology around Ranau Lake and identify the proof of vertical deformation in the strike-slip fault system. With the Garmin GPS handheld, we record the longitude, latitude and also the elevation from the stopsite and plot it into the map and also into the surface profile.

**Result and Discussion**

The hillshadearalysis of SRTM30 datasets show that there are pull-apart basin on the east side of Ranau Lake (Figure 4). This also showed by the greenish brown color simbology which define the depression and lake area.

The pull-apart basin located within the Kumering Segment strike-slip system. In the northwestern side of the basin, as the red dot in the figure located on the map is the location of river terrace outcrop.

Located on the southwest wall of the Way Rekuk stream, Sukau Region with elevation 620 m above sea level. The elevation of Way Rekuk stream is 580 m above sea level, it indicates approximately 40 m vertical deformation (Figure 5).

The river terrace laterally widespread northwest-southeast oriented, parallel with the Sumatran Fault. The river terraces deposits has grey to greyish black colored with very coarse to pebble grainsize. This deposits associated with soil and also tuff which is easily to be eroded (Figure 6).

The vertical deformation indicates that the river terraces near Ranau Lake is the degradational river terrace. This is also supported by the condition on the location which is very easily to be eroded and prone to landslide.

The vertical deformation also indicates that this area is the depression are within the strike-slip system. This condition also supported by hillshadearalysis that show peculiar shape of the pull-apart basin.
The river terrace vertical deformation is the product of transtensional site of the strike-slip fault system where there is normal slip sense within the system. This site probably seems on local scale compare to what proposed by Bellier&Sebrier (1994). But this site provide the geomorphic marker for Sumatran Fault.

Bellier and Sebrier (1994) mentioned that based on theoretical origin for pull-apart basin along strike-slip faults, the term releasing bend does not seem to occur along the Sumatran Fault. But we use this term base on the probability that fault stepovers may evolve into continuous fault bends and connected with the splays from the fault (Cunningham & Mann, 2007; McClay & Bonora, 2001). This is also supported by the term of active pull-apart basins which are easily recognize along active strike-slip fault and characterized by low topography, fault-bounded depression, inland lakes and closed topographic depression (Mann, 2007).

Sumatran fault associated with subducting plate which is the convergence is oblique, and this obliquity mechanically accommodated to strike-slip deformation (McCaffrey, 1992, 2009). The strike-slip models produced broadly similar elongate rhomboidal to sigmoidal basin with arcuate oblique-extensional sidewall faults (Aydin & Berryman, 2010; Mann, 2007; Wu et al., 2009).

The pull-apart models in 4D mentioned that the model of pull-apart basins contain two principle which are pure strike-slip and transtensional models (Figure 7) (Wu et al., 2009). Based on imageries interpretation, we interpret that the strike-slip system on the Kumering Segment is pure strike-slip model. This interpretation limited by the water area on Ranaulake, so we could not interpret the surface expression clearly. But the lineation from the west side of the Ranau Lake give fruitful guidance for the interpretation.

Figure 6. Photograph of river terrace and Way Rekuk stream

Figure 7. 3D visualisation of pull-apart basin reconstruction (Wu et al., 2009)
Sumatra, as we know with its Sumatran Fault and also volcanoes along the westernmost part of the island, so do the Ranau area, economically there are prospect for geothermal and mineralization. There are some geothermal manifestation surrounding Ranau Lake and for the mineralization, there are Seminung volcanic as the heat source. This is also supported by the existence of the low topographic area which is interpreted as the pull-apart basin. This pull-apart basin form depression containing significant sedimentary accumulations and may be zones of high heat flow and crustal dilation (Cunningham & Mann, 2007).

Contrary with the economical prospect, the releasing bend also act as barriers to earthquake propagation (Barka & Kadinsky-Cade, 1988; King & Nabelek, 1985) and may be as the nucleation sites for major earthquakes (Shaw, 2006). So, the mapping of releasing bends should be play an important role for mitigation concept.

Conclusions

Way Rekuk, Sukau Region is the example of the pull-apart basin on the Kumering Segment of Sumatran Fault. Based on hillshading analysis on the SRTM 30 datasets, it shows the low topographic expression which connected to Ranau Lake.

Based on field investigation, we found approximately 40 m vertical deformation as seen in the river terrace outcrop. This vertical deformation indicates the depression in the Sukau region. From field investigation, imageries interpretation and as we know that this area associated with strike-slip fault system, the development of river terraces included in degradational or erosional class.

The pull apart basin is purely strike-slip model based on the interpretation and based on comparing with models. This pull-apart basin economically prospect for the geothermal energy, as there are so many hot springs as the geothermal manifestation. This area also prone to the earthquake. Thus, the detail mapping of active fault and identify releasing bends will be as a fruitful contribution for mitigation concepts.

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References


