

DEVELOPMENT OF ACTIVE FAULT MAPPING METHOD USING GEOELECTRIC AND GEOGRAPHICAL INFORMATION SYSTEM

Yurni Suasti¹, *Dipo Caesario¹, Wikan Jaya Prihantarto², Bigharta Bektu Susetyo¹, Paus Iskarni¹

¹ Department of Geography, Universitas Negeri Padang, Indonesia;

² Remote Sensing and Geographic Information System, Universitas Negeri Padang, Indonesia

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ABSTRACT: On February 25th, 2022, an earthquake with a magnitude of 6.2 in Nagari Kajai, Talamau District, West Pasaman Regency, resulted in considerable structural damage because it originated from a shallow earthquake with a hypocenter depth of 12.6 km and is a manifestation of the strike-slip faulting system linked to the Sumatra Fault System (SFS), which is adjacent to the Angkola segment, Barumon Segment, Sumpur Segment, and Sianok Segment is a newly-found active fault in this area. All of Nagari Kajai (Kajai Village) Sub-district is covered in volcanic deposits, whether they are new (quaternary deposits) or a combination of old (tertiary deposits) and young (quaternary deposits) as a product from the Talamau Mountain and the Maninjau Mountain. These geological activities will provide a good impression of the topography and geomorphology of a newly found active fault, The Kajai Fault. The geomorphological analysis is used to get new characteristic features for this new fault line continuation using Landsat 8 imagery and supported by aerial photography using Unmanned Aerial Vehicles (UAV). A 2D subsurface image was obtained from the Wenner-Schlumberger geoelectric survey configuration to get an excellent subsurface interpretation of lithology in this area. From this interpretation, the Kajai Fault is present in a valley filled with volcanic products and a narrow diversion of the Batang Talu River. The geoelectrical survey images show a double juxtaposition from two interpreted faults, namely F1 and F2, which run through The Kajai village and are suspected to be one of the shallow earthquake sources.

Keywords: Fault Mapping, Geoelectric, Geographical Information System, Kajai

1. INTRODUCTION

The West Pasaman (Pasaman Barat) Regency is one of the districts within the province of West Sumatra, located on the island's western side. The folding and faulting elements that make up the geological structure of the West Sumatra area are frequently controlled by subduction characteristics [1]. One of the tectonic structures close to the research region is the Semangko Fault, often known as the Great Sumatra Fault Zone [2]. This area is located in an active fault zone where earthquakes are more likely to occur. An active fault is related to tectonic geomorphology, which determines the activity of tectonics that brings catastrophes [3]. The increasing frequency of catastrophes caused by nature is tightly linked to human behavior concerning the natural environment [4]. Devastating earthquakes might come from this fault, which could be a source of earthquakes in this region. Therefore, it would be intriguing to study given the region's geological characteristics.

The largest and most prominent geological feature in the West Pasaman Regency is the Great Sumatra Fault Zone, which is composed of normal faults, folds, shear faults, and other geological formations. Geomechanics analysis from several wells in Sumatra's central and southern districts indicates that the regionally defined S_H adjacent to the active Great Sumatran strike-slip fault is oriented at a high angle

(70°–80°) to the fault [5]. The Great Sumatra fault zone is a member of a group of trench-parallel strike-slip fault systems that cooperate with subduction zones to support obliquely convergent plate movements [6]. One of the most significant earthquakes in this area was the earthquake that occurred on March 8th, 1977; this Pasaman earthquake had an epicenter at 0.5°N -100.04°E, a magnitude of 6.1, and a depth of 19.5 Km. In Sinurat Sub-district, the earthquake severely damaged 737 homes, a market, seven schools, eight mosques, and three offices. In Talu Sub-district, the earthquake severely damaged 245 homes, three schools, and eight mosques [7].

The research area is a protected forest area of the Talamau Mountains, located about 25 km east of Simpang Empat Village, also known as Nagari Kajai (Kajai Sub-district), a part of Talamau District. Geographically, the boundaries of the study area are 0°09'39.6" North Latitude and 99°55'44.3" East Longitude, with an area of around 37 km². Administratively, the research area is in Kajai Village, West Pasaman Regency, West Sumatra Province. The research area can be reached in about 8 hours from Padang City by land transportation.

On February 25th, 2022, at 8:39 (local time), a 6.1-magnitude earthquake that struck West Pasaman Regency in West Sumatra, Indonesia, sparked significant alarm among decision-makers at all national and regional levels and scholars. At a depth

of 10 kilometers, the epicenter was situated on the landward slopes of Talamau Mountain. In the Talamau segment, which has not previously been mapped on geological maps or other thematic maps, an active Semangko fault caused this shallow crustal earthquake. According to the Meteorology, Climatology, and Geophysics Agency of Indonesia or Badan Meteorologi, Klimatologi, dan Geofisika (BMKG), the Great Sumatran Fault zone's right-lateral strike-slip faults served as the source mechanism for the February 25th, 2022, West Pasaman earthquake. It is possible that the movement of the Talamau Fault, which connects to the Sianok Fault, was the cause of the earthquake in West Pasaman on February 25th, 2022, based on distribution damage to buildings concentrated on the northwest side of Talamau Mountain and on the east side of Talamau Mountain, the distribution of landslide or soil movements on the northern slope of Talamau Mountain forms a northwest-southeast pattern. There were no known segments along which the Mw 6.1 Pasaman earthquake occurred. To determine whether a previously unknown segment of the Great Sumatran Fault ruptured or whether a different but equally unknown fault was to blame [8].

The goal of this study is to analyze any surface indication to get a better view of the fault that may have been caused in 2022 (magnitude of 6.1), the Pasaman earthquake and its associated sequences through the regional geology and geomorphological aspect, detailed image interpretation (slope trend, direction of slope, drainage straightness, straightness and shaded relief, and curvature) and subsurface rupture imaging through a pseudo-cross-section of the subsurface layer of the earth using geoelectrical resistivity method for detecting near-surface ground rupture zones. Then, a new Geomorphological Model is built in 3D to obtain a better active fault trace view and understanding. The deposits associated with quaternary volcanoes are another obstacle in this study since they obscure several tectonic and geomorphological characteristics, making it more challenging to trace the fault's existence.

2. MATERIAL AND METHODS

Quick mapping is the process of gathering, processing, and displaying geographic data rapidly to meet an event's information demands under the relevant standards [9]. It is possible to utilize the data produced by The Rapid Mapping operations as a framework to support disaster management (initial disaster management) policies at all phases, including pre-disaster, during the catastrophe, and post-disaster [10]. The research strategy (Fig. 1) involved decoding satellite images and aerial photography, which involved a band combination technique for brightening the images. The brightness value of the same surface material caused by topographic

conditions, shadows, and sunlight intensity is seen using this band combination method to more clearly observe the distribution of land cover [11]. Field validation exercises are then conducted on the ground using near-surface geoelectric tools using a Naniura model NRD 22S resistivity-meter and then plotting the field measurement results on the study area's geological map allows for additional interpretation regarding the active fault to get a better geomorphological analysis [12].

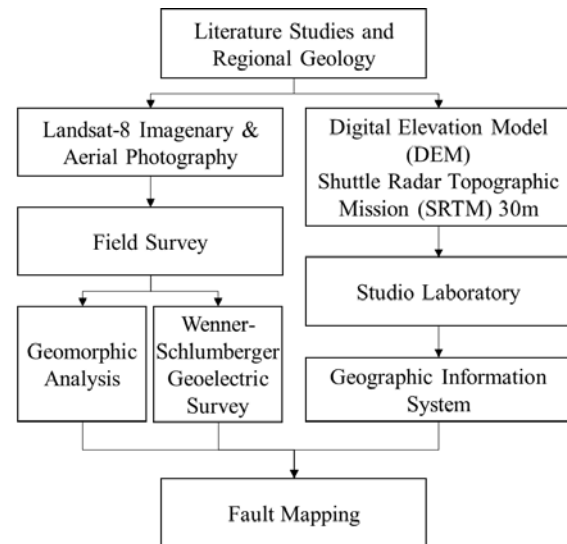


Fig. 1 Research stages and methodology.



Fig. 2 One of the heavily damaged homes owned by inhabitants of Nagari Kajai (0°09'48.0"N & 99°55'50.1"E).

Landsat 8 imagery in the 2013 version and Landsat 9 imagery are used in this study. The Shaded Relief model DEM SRTM (Digital Elevation Model-Shuttle Radar Topographic Mission) data are then placed onto this picture. The ITC (International

Institute for Aerospace Survey and Earth Sciences) system, which comprises analytical, synthetic, and pragmatic surveys, provides the foundation for the interpretation [13]. The trend of ridges, valleys' straightness, and other aspects of the landscape that may be seen in the field are used to divide the units in the geomorphological study. Field observations (Fig.2) and fault mapping are first created at the stage of creating a 2D geoelectric cross-section profile, which is followed by the interpretation of slope and valley alignment patterns from high-resolution aerial photography using Unmanned Aerial Vehicle (UAV) and DEM SRTM (Digital Elevation Model- Shuttle Radar Topographic Mission) using the ArcGIS program. To get a better cross-section, the ResIPy program is used for forward modeling of geoelectric data [15]. The fault zone's general location, geometry, internal structure, and affected lithologies can be determined by forward modeling, which accurately replicates the crucial components of the observed electrical resistivity data [16]. Measured data began

with a Digital Elevation Model (DEM) and remote sensing techniques to find traces of possibly active faults and possible sites for field investigations to locate active faults in the Kajai Village and its surroundings precisely [17]. Furthermore, overlaying these two data to create a realistic appearance and alignment of the Kajai Fault using a matching analysis method between the findings of the fault alignment using the most reasonable model that caused or potentially generated earthquake hazard that is carried out in detail on a large [18].

3. RESEARCH SIGNIFICANCE

This study proposed to be one part of a rapid mapping that offers a solution to answer the urgency of an effective and comprehensive research method, as well as to describe the micro zonation of earthquake hazard-prone areas post-earthquake damage to buildings in Kajai Sub-district or "Nagari

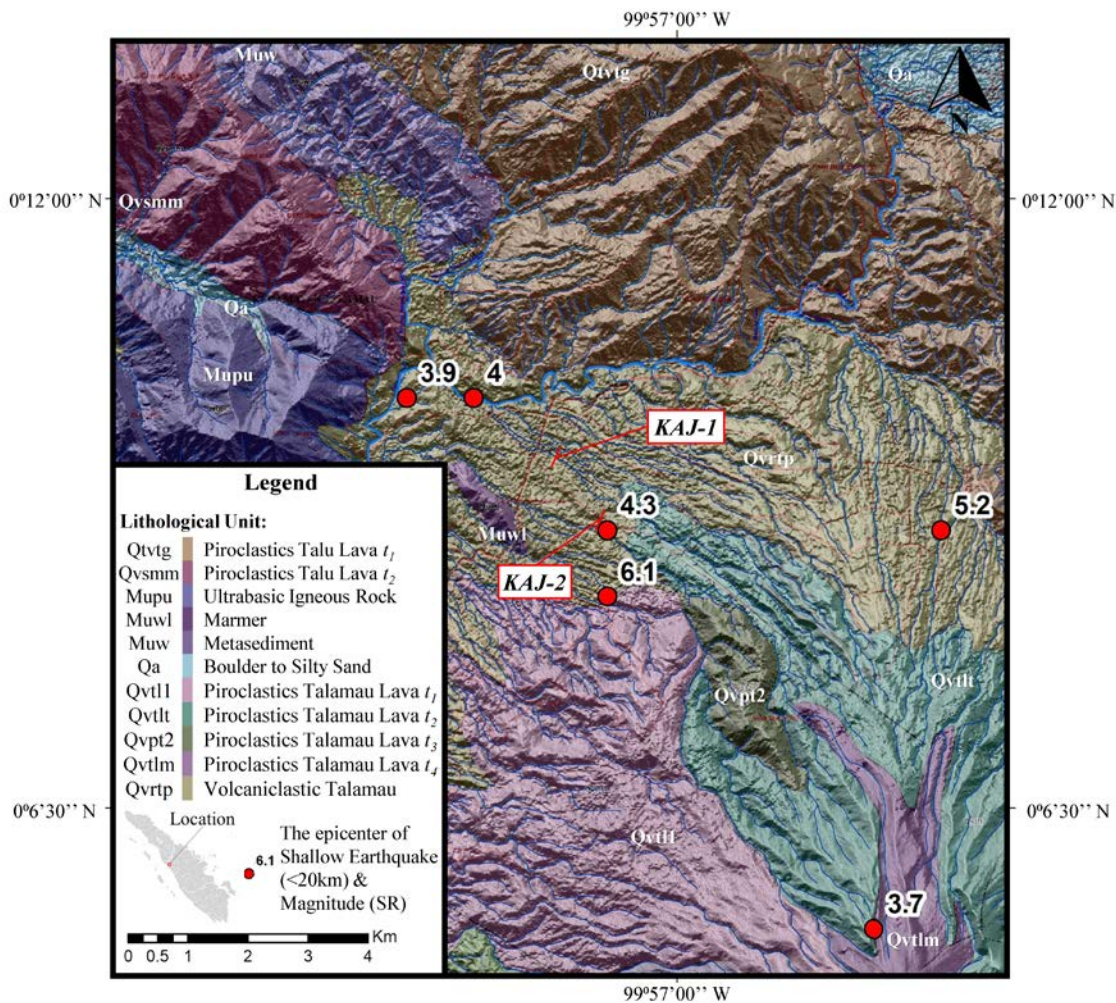


Fig. 3 The geological map of Kajai Sub-district and its surrounding areas, as elucidated through the interpretation of remote sensing data [14] overlay with the epicenter of shallow earthquake (<20km) represented by a prominently discernible red dot and the two-dimensional line of the shallow electrical profile (KAJ-1 and KAJ-2) illustrated by the red line.

Kajai” West Pasaman Regency. On the other hand, making a fault mapping of The Kajai Fault that caused a lot of building damage can be used as a development innovation related to mapping an area affected by a natural disaster to complement research related to mapping research areas, Kajai Sub-district, Talamau District, West Pasaman Regency.

4. RESULTS

4.1. Regional Geology

Sumatra is not a homogeneous segment of Gondwana-derived continental blocks, but probably the island consists of two different segments, namely arc and continental segments [19]. The Pretercier to Holocene-aged rocks that make up this region are varied and include sedimentary rocks, metasediments, young volcanic rocks, and intrusive rocks [7]. The pre-tertiary rock group exposed as bedrock in the eastern part of Bukit Barisan is the Tapanuli group (Tapanuli Group), which is of Early

Carbon to Early Perm age consisting of the Kuantan Formation which has lithology characteristics of greenschist metamorphic rocks, amphibolites and meta conglomerates [20]. Chronological conformable above it, The Peusangan Group, which is Late Permian to Late Triassic in age, consisting of tuffaceous limestone lithology, both of which have tectonic contact with the Woyla Group, which is Late Jurassic to Early Cretaceous in age, which is dominated by associated rocks with ophiolite which is very difficult to identify [21]. Several sedimentary and volcanoclastic rock groups cover this bedrock group, which is penetrated by some intrusion rocks, and this sedimentary rock separates Tertiary sedimentary rocks into three Super Groups: Super Tertiary Groups I, II, and III. In the study area, the Pre-Tertiary rock group is covered by Tertiary sedimentary rocks consisting of quartz sandstone, shale, siltstone, and claystone (Sihapas Formation), in contrast, volcanic rocks are products of old Talu, Amas, and Saligoro volcanoes which form indistinguishable volcanic rocks (Talu) and are

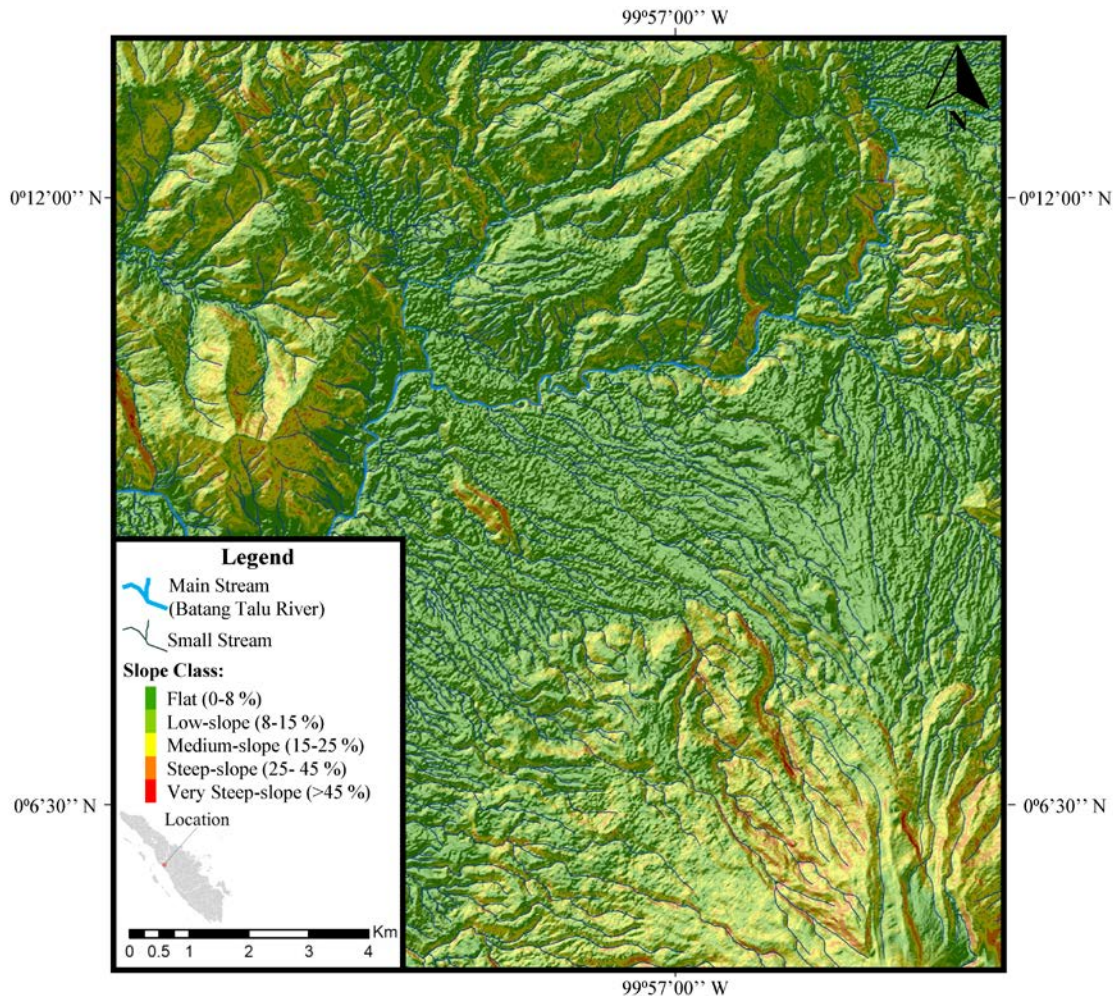


Fig. 4 Slope map Kajai of Sub-district and surrounding area. The low-slope class dominates the area around Kajai village. However, some steep to extremely step-slope features are to the north and south of the village indicating the presence of very different geological and geomorphological features.

composed of porphyritic andesite lava and breccias (Saligoro) and tuffaceous sandstones, tuffs, and lava from the Amas volcano.

Quaternary sedimentary rock groups that overlap Pre-tarsier and Tertiary rocks unconformably consist of sand, gravel, silt, and silt (Minas Formation) and debris rock in the form of fan deposits and river deposits consisting of conglomerate, coarse sand, sand, silt, and mud. Quaternary volcanic rocks result from the activities of the old Pasaman volcano, Gajah Mountain, and Talamau volcanoes. The products of the old Pasaman volcano consist of andesite-basaltic lava, volcanic lava, and volcanic clastics. In contrast, the products of Gajah Mountain are andesitic and vesicular dacite lava and andesite-porphyrific basalt. The youngest volcanic deposits originating from the Talamau volcano are acid-base lava, tuff sandstone, and silt [22]. The Talamau District area, Nagari Kajai, is filled with volcanic deposits, either in the form of young volcanic (quaternary deposits) or a mixture of old volcanic (tertiary deposits) and quaternary

deposits (Fig. 3). Sequentially from the highest score (the least compact rock) to the lowest (more compact rock), are rocks in the Talamau District area, Nagari Kajai, sediments resulting from volcanic activity/sediments pyroclastic, sandstone, limestone, metasediments and ultramafic rocks.

4.2. The Slope Trend and The Direction of The Slope

Slope trends are obtained from DEM (Digital Elevation Model) data, which is a map of the slope and the direction of the slope. The slope and direction of the slope will significantly assist in interpreting the geological structure. Significant changes in the value of the slope and the direction of facing the slope can be indicated as the presence of a linear structure. The slope is calculated in degrees ($^{\circ}$), which are then grouped into five classes, namely: flat (0° - 8°), gentle (8.01° - 15°), slightly steep (15.01° - 25°), steep (25.01° - 40°), and very steep ($>40^{\circ}$). The research location appears to be dominated by a rather steep

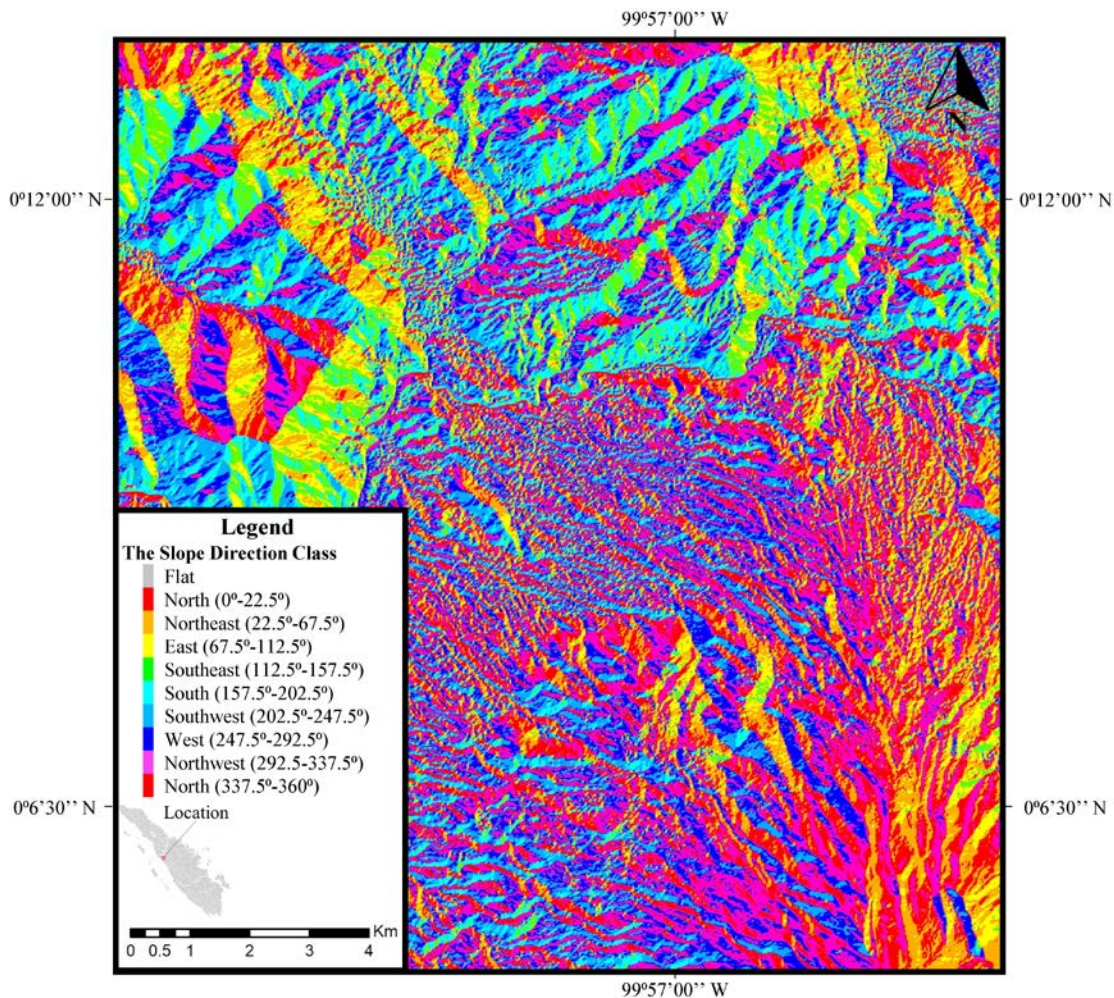


Fig. 5 The Slope direction of the Sub-district and surrounding area shows a different impression between the areas in the north of the study and those in the south, demonstrating an existence of extremely diverse geological and geomorphological characteristics. between these two areas.

slopes (Fig. 4). By default, the direction of facing the slope will be mapped to eight cardinal directions (north, northeast, east, southeast, south, southwest, west, and northwest) and one class as flat (Fig. 5). The direction facing the slope will describe the pattern of topographical formations due to the structure, which is very beneficial in the analysis. The straightness of the valley and the ridge will be more visible on the slope direction map. Both will be associated with changes or confluence of two different slope-facing directions. Two distinct texture groups are visible on these maps, one associated with the Talamau volcanic relief in the south and the other with the more denudated hills relief in the north, separated by the Batang Talu river, which runs from the northeast to the southwest.

4.3. Drainage Straightness And Shaded Relief

The flow pattern of the river in the study area is divided into three types, namely dendritic, parallel,

and pinnate patterns (Fig. 6). At Kajai village, there is a predominant parallel river pattern that is influenced by the alignments created by the geological structure. In the northern part, the river pattern is still dominated by relatively rigid rock types, as shown by the dendritic river pattern. On the other hand, in the southern part, a pinnate river pattern reflects the effect of volcanic morphology. The river flow pattern is an important clue to determine the type of rock and structure control in an area. The flow patterns in igneous rocks are denser than those in sedimentary rocks due to lower infiltration [23]. In addition, the dominant morphology of igneous rocks is higher than sedimentary rocks because igneous rocks are more resistant to weathering and erosion.

4.4. Straightness And Shaded Relief

Lineament is a geological feature that includes faults, fractures, joints, and lithological boundaries. These structures can predominantly be determined

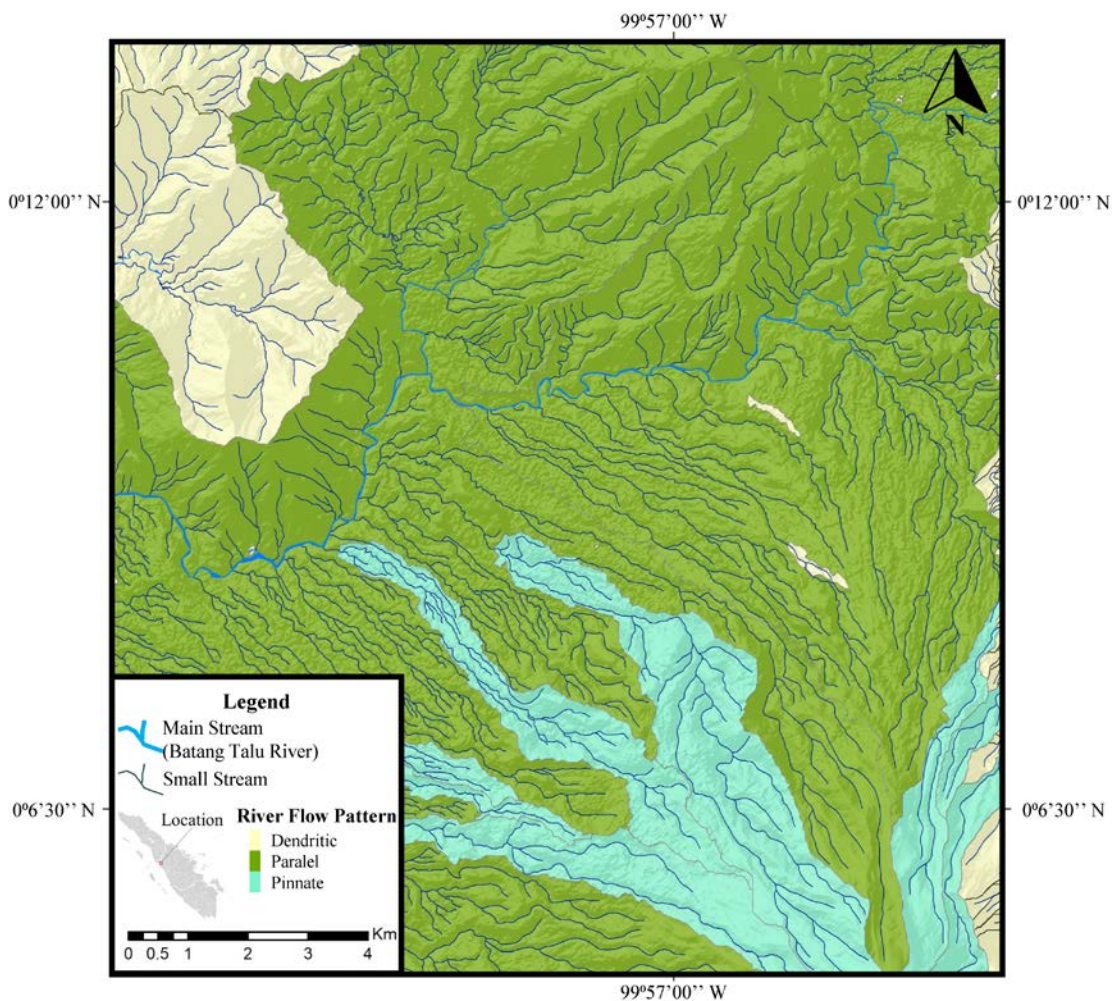


Fig. 6 The river flow pattern map of The Kajai Sub-district and surrounding area illustrates a distinct direction shifting in the pinnate class from N-S (North-South) to NW-SE (Northwest-Southeast), showing the presence of incredibly controlling geological features making a rapid shift in the course and flow patterns of the rivers in the research region.

from diverse remote sensing data sources and techniques [24]. The straightness of the structure is the straightness that is controlled by the geological structure, which produces topographic lineaments such as ridges and valleys, depressions, or escarpments, and most of the alignment is a manifestation of the joint direction, faults, folds, dikes, and contact rock layers [25]. A lineament is any linear structure on the Earth's surface that is too exact to have formed by coincidence, and faults are more or less straight lineaments formed by tectonic activity [26]. Lineament mapping has been substantially aided by aerial photography and remotely sensed imagery. The quest for lineaments verges on numerology at times, and their apparent importance can take on almost supernatural aspects [27]. Straightness is one of the characteristics that indicate subsurface elements or weak structures such as faults [28]. That straightness is a geological structure related to the valley's straightness, a weak zone, usually a tectonic alignment [29]. Shaded relief aims to increase the contrast of intensity variations in smooth images,

over-contouring, or pseudo-color representation [30] for better geomorphological unit interpretation for better geomorphological unit interpretation results. The light direction of 315°, 0°, 45°, and 90° azimuth are used in creating shaded reliefs. There are two elevation angles of the sun used. Namely, 45° and 75°, and the best one will be selected for the following interpretation steps. The four shaded relief results with the selected sun angle are then averaged by weighted sum with the raster calculator tool to become one integration shaded unit relief map.

The straightness of the valleys and ridges analysis indicates two primary patterns, mainly N-S (North-South) and NW-SE (Northwest-Southeast), which shift around Kajai village. Apart from that, variations in the Aspect Trend Southeast's class (green area), indicate at least +/- 1 Kilometers of displacement (Fig. 7) along the alignment near Kajai Village, which changed the direction of The Batang Talu River, which initially flowed from NE-SW (Northeast-Southwest) subsequently undergoing a notable shift to NW-SE (Northwest-Southeast).

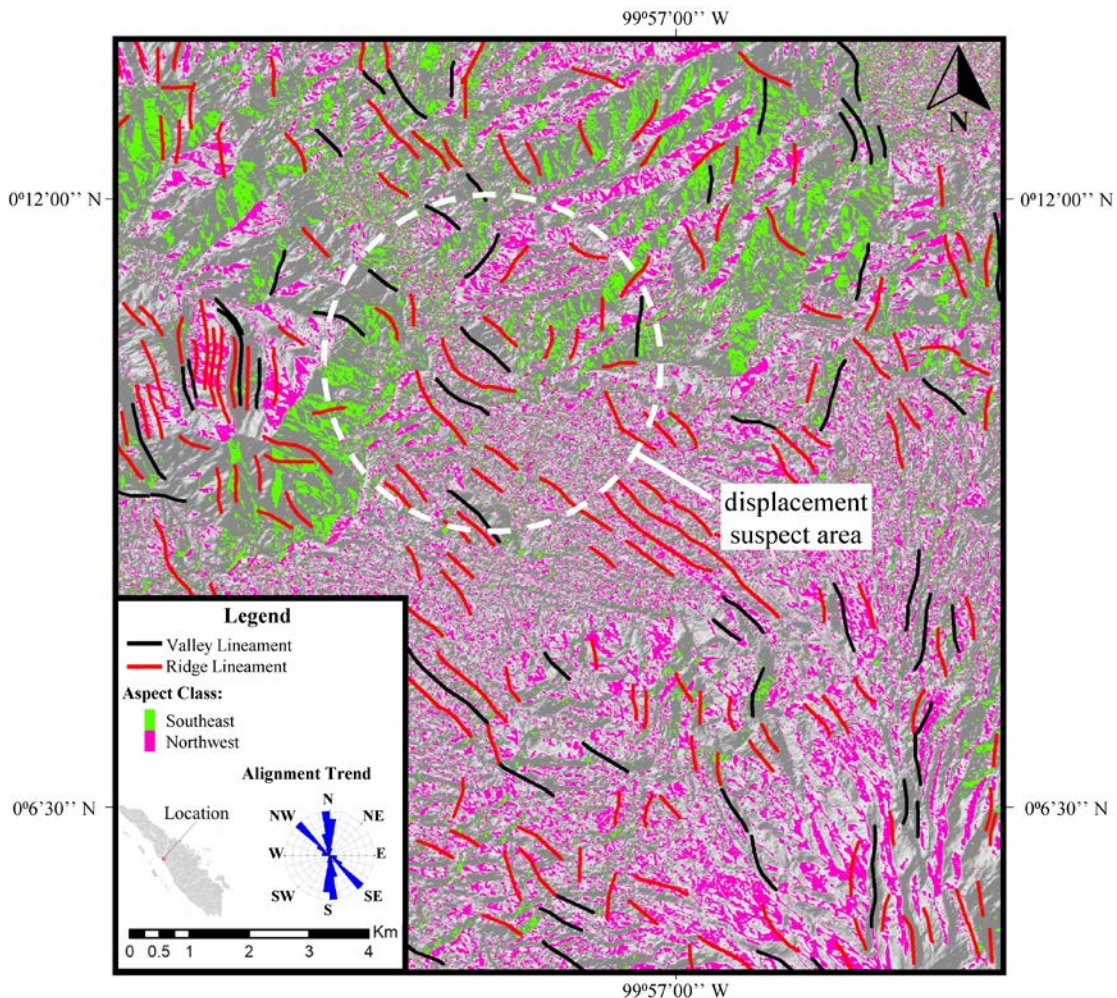


Fig. 7 Overlapping straightness of the ridge and straightness of the valley on the slope direction map of Kajai Sub-district and surrounding area. The white circle dash area indicates a displacement (lateral juxtaposition), corresponding to the change in direction of the Batang Talu River.

4.5. Curvature

Curvature is defined as the second derivative of a surface or slope of slope. Curvature is very useful in identifying an area that has significant changes and variations in slope and slope direction [31]. In ArcGIS Spatial Analyst, curvature tools generate the curvature itself and will produce two other valuable data, namely profile curvature and planform curvature (Fig. 8). The curvature file is parallel to the direction of the maximum slope. Planform curvature, or what is commonly called plan curvature, is the direction perpendicular to the maximum slope of the slope. Overlays between curvature, profile curvature, and plan curvature with shaded relief and DEM (Digital Elevation Model) can further accentuate morphological aspects. These overlay steps will facilitate the interpretation and delineation of the straightness of the linear structure. The straightness of the valley, which indicates the presence of geological structures [29], will be associated with low digital values on the curvature map.

This straightness shows the geological structure will be present at dark pixels on the curvature map. In contrast to the curvature profile, the geological structure will be associated with high pixel values or the bright hue of the curvature profile. On the plan curvature map, the geological structure will be associated with low values so that it will be in a dark hue.

4.6. 2D Geoelectric Cross-Section Profile

Throughout an earthquake cycle, fault zone resistivity structure may vary temporally [32]. From the appearance of the surface topography, the KAJ-1 site shows flatter landforms than the KAJ-2 site, but both locations show the presence of a moderately flowing river body nearby. Geoelectric measurements were carried out in a 200-meter stretch perpendicular to the direction of the slope, which has relatively significant changes in height and is an area affected by quite severe earthquakes.

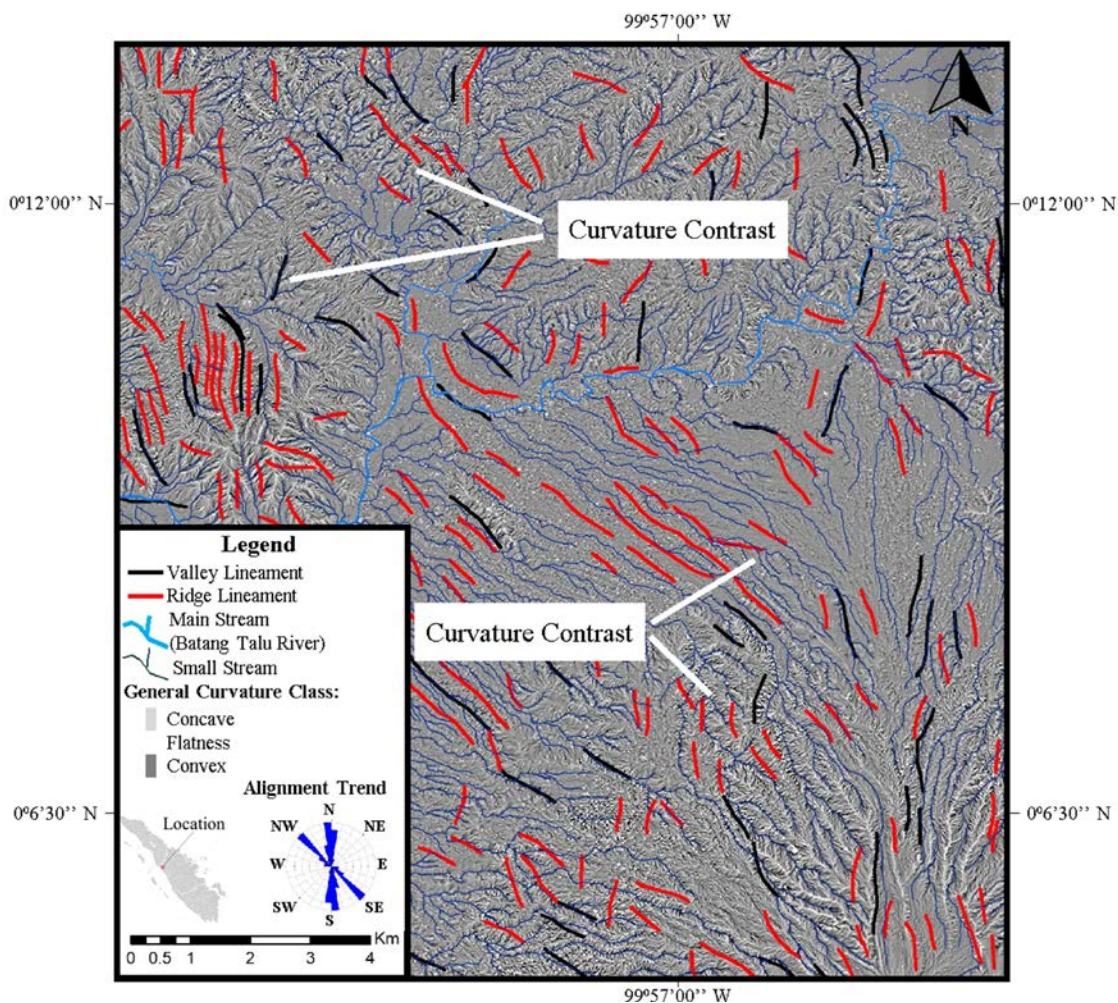


Fig. 8 Profile curvature of Kajai Sub-district and surrounding area changes in different characteristics that relate to the NW-SE (Northwest-Southeast) alignment around Kajai village. There are several different contrast curvatures in the northern and southern parts of the study area.

Line KAJ-1 was measured at the northernmost part of the fault, which is located at the Talamau Volcano's lower slopes, while Line KAJ-2 is placed at the slope that is closest to the fault. According to surface land use, both site measurements are primarily covered in agricultural land with tick soil, occasionally displaying a recently formed volcanic rock boulder (Fig. 9a and Fig. 9b). To interpret the continuity and trend of the Kajai fault zone (Fig. 9c), a 2D-line Geoelectric Cross-Section Profile was surveyed using a 2D Schlumberger-Werner configuration, then using forward modeling using ResIPy Software to get an actual resistivity for each layer of rock.

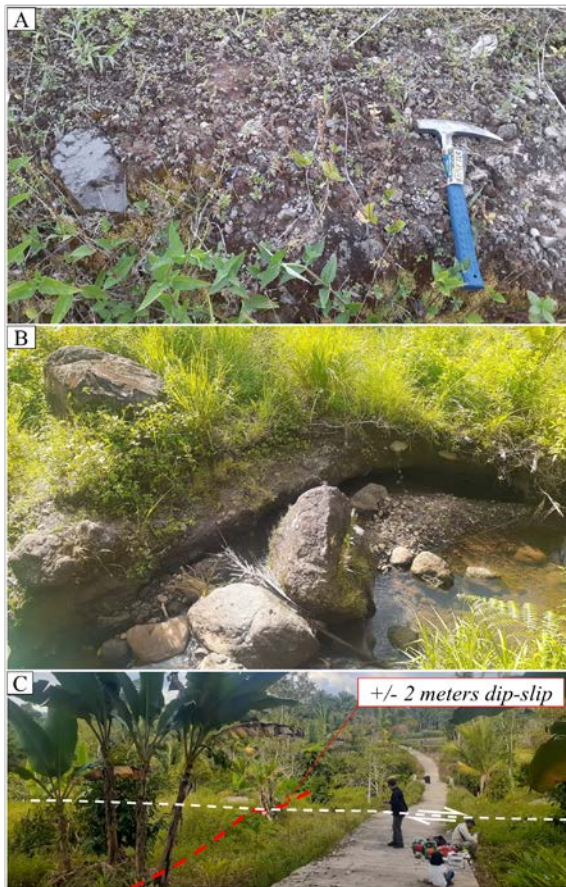


Fig. 9 (a). Volcanic breccia from site KAJ-1 shows a fresh volcanic breccia showing a cobble size andesitic rock fragment. (b). A boulder-sized andesitic rock fragment from KAJ-2. (c). Interpreted alignment showing an undulating topography.

Two samples of the thin sections are obtained to get a better lithology interpretation from the resistivity value. The volcanic rock incision of volcanic breccia has a porphyritic andesite texture. The composition consists of phenocryst (up to 2.0 mm), pyroxene, hornblende, and opaque minerals embedded in a very fine groundmass. The bedmass is formed by plagioclase cryptolite and secondary

minerals of iron oxide and clay minerals. These rocks show the presence of vesicles (cavities). The total amount of phenocrysts present is about 35-40%.

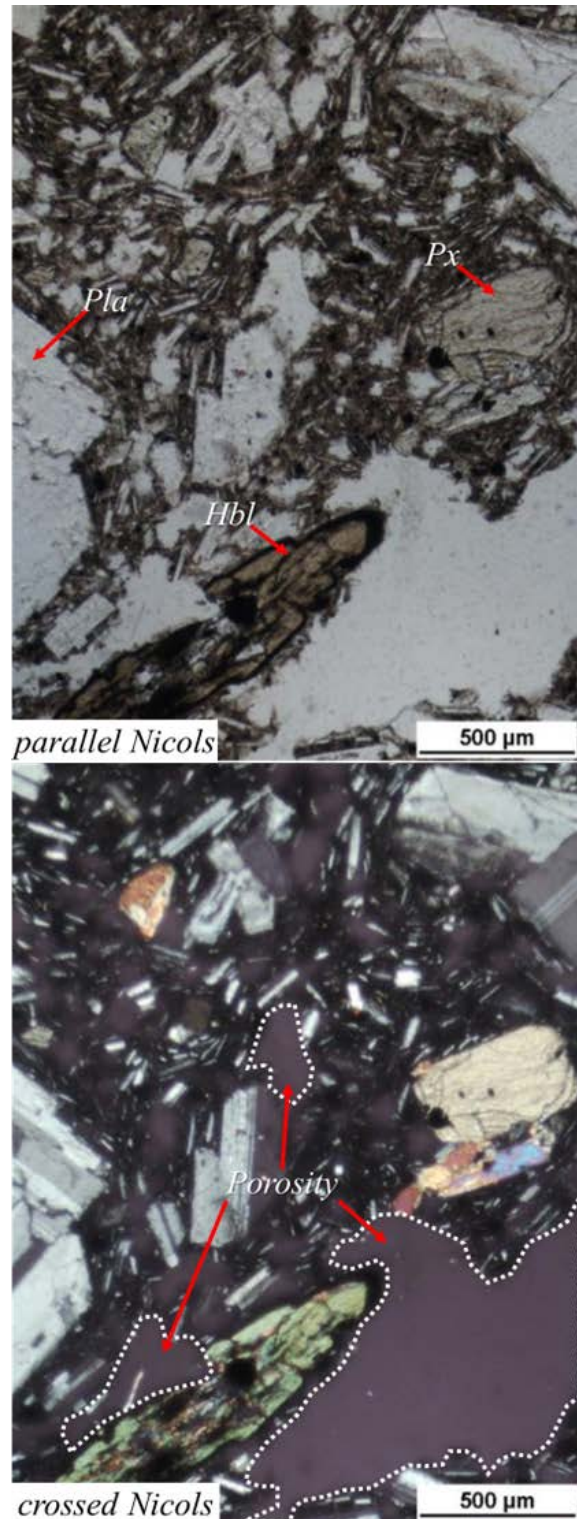


Fig. 10 Parallel and Crossed Nicols on thin section samples of a fresh phenocryst from Volcanic Breccia (Rock Unit 1) namely pyroxene-hornblende andesite with coarse phenocryst showing a good porosity as primary vesicular porosity.

Porphyritic textured andesitic volcanic rock incisions. It consists of phenocryst (up to 4mm) plagioclase, pyroxene, and hornblende, as well as opaque minerals embedded in the groundmass showing flow texture. The orientation of the plagioclase microliths indicates the flow texture; the other minerals in the groundmass are a slightly beige/yellowish brown glassy mass, as well as opaque minerals (Fig. 10). This rock-rich layer is a good aquifer layer due to the presence of low-resistivity minerals (opaque minerals) and secondary porosity [33]. From these features, it is interpreted that three layers of quarter sedimentary rock can be separated (Table 1), including Fine Tuff, Coarse Tuff, and Volcanic Breccia.

Table 1. The range of electrical resistivity is used for the identification of the geological units.

No	Color Code	Actual Electrical Resistivity	Geological Unit
1	Red to Dark Brown	320 - 10,000 Ωm	Volcanic Breccia (Fragment: Andesite & Matrix: Coarse Tuff)
2	Light Brown	80 - 320 Ωm	Coarse Tuff
3	Yellow	2 - 80 Ωm	Fine Tuff

Source: Data analysis 2022.

According to the KAJ-1 line (Fig. 11), there are only two rock units, fine tuff, and coarse tuff, which are distinguished by the presence of a groundwater level that corresponds to the difference in porosity between the two units. The Kajai Fault trace on this track has a reasonably upright slope with a 50-degree angle with the direction of the fault plane towards the Southwest, as indicated by a change in resistivity value, which was subsequently recognized as a fault that ran through this location and given the name F1.

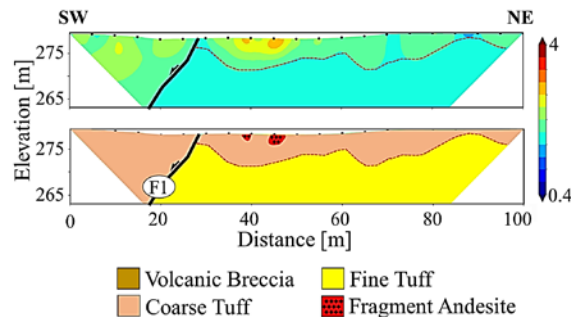


Fig. 11 Interpretation of lithology profile results from geoelectric surveys on KAJ-1.

The KAJ-2's line (Fig. 12) has more complex lithological units compared to the KAJ-1's line,

including the appearance of volcanic breccia, coarse tuff, and fine tuff rock units. In addition to that, the KAJ-2 track provides a more rigid lateral resistivity value threshold, commonly referred to as F2, to make the interpretation of this fault more straightforward. F2 has an almost vertical angle, precisely 75 degrees, but a plane direction towards the NE (Northeast).

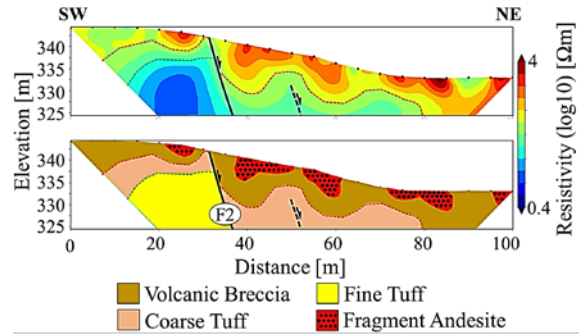


Fig. 12 Interpretation of lithology profile results from geoelectric surveys on KAJ-2.

4.7. Interpretation of Geomorphology And Kajai Fault Zone

The landscape in the surrounding area of the Kajai Sub-district, a part of the Talamau district, may be categorized into eight groups based on genetics and terrain texture, which are Ancient Crater Plain of Talu, Upper Volcano Slopes, Middle Volcano Slopes, Lower Volcano Slopes, Denuded Volcano Hill, Denudacial Hill, Isolated Hill and Barely Lifted Plain. Hill-shading methods are used to get better relief and roughness of the landscape around the Kajai Sub-district. In general, the study area can be divided into three parts; in the northern part, there is the remnant of the Talu Volcano, which is reflected by a rough texture and a lot of denudated circular escarpment Figs. A flat crater landscape is quite broad, stretching to the Northeast, which is one of the settlement areas, namely the Talu Sub-district. This section divides the geomorphological unit into 2: (1) An ancient Crater Plain and (2) Denuded Volcano Hill. In the western part, a denudated hill landscape fills 25% of the study area. An active Talamau volcano formed the morphology of the upper, middle, and lower volcano slopes, with a prominent and circular escarpment. A recent volcanic deposit reflected in a nearly north-south trending discontinuous escarpment covers the traces of the continuation of the Kajai fault, which has a long NW-SE alignment cut through the Kajai village, with a slight slump texture that fills toward a Small Barely Lifted Plain Unit. Almost similar methods have been discussed by previous studies in determining the alignment of an active fault, especially the South Mashhad Fault Zone in Iran [18] or the San Andreas Fault Zone in the United States of America (USA) [32]. Even though they have a similar

method unique findings in each methodology and special approach, lie in the scale of the studies and emphasis on geomorphological features supported by pseudo-cross-section images from better and more extensive data. However, on the active Kajai fault, although it was on a smaller scale, it could be categorized as a big challenge because there are young volcanic deposits covering the continuation of this active fault, and the level of damage in Kajai Village caused by these fault movements. Therefore a 3D model was built using GIS (Drainage network, Straightness, Curvature, Slope Trend, and Direction) and Geoelectrical methods to interpret the continuity of the Kajai fault with the assistance of geomorphological analysis using remote sensing. Then, the fault plane was interpolated (Fig. 13) from the 25th February 2022 earthquake data towards the epicenter point, forming a branching fault feature in the shape of a horsetail splay with a negative flower structure regime [34]. This is consistent because the presence of Kajai village in the form of plains indicates that an active depression zone exists beneath

this village. The continuation of the F1 and F2 fault directions continues (Fig. 14) taking into account the shape of the geomorphological unit boundaries that have been created previously.

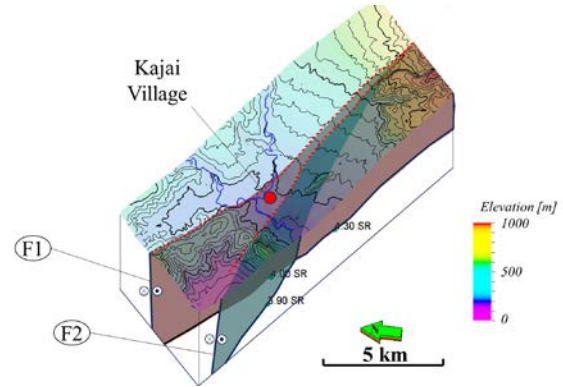


Fig. 13 F1 and F2 as a part of the Kajai Active Fault zone near, interpreted by using flower structures in a dextral divergent-wrench fault zone model.

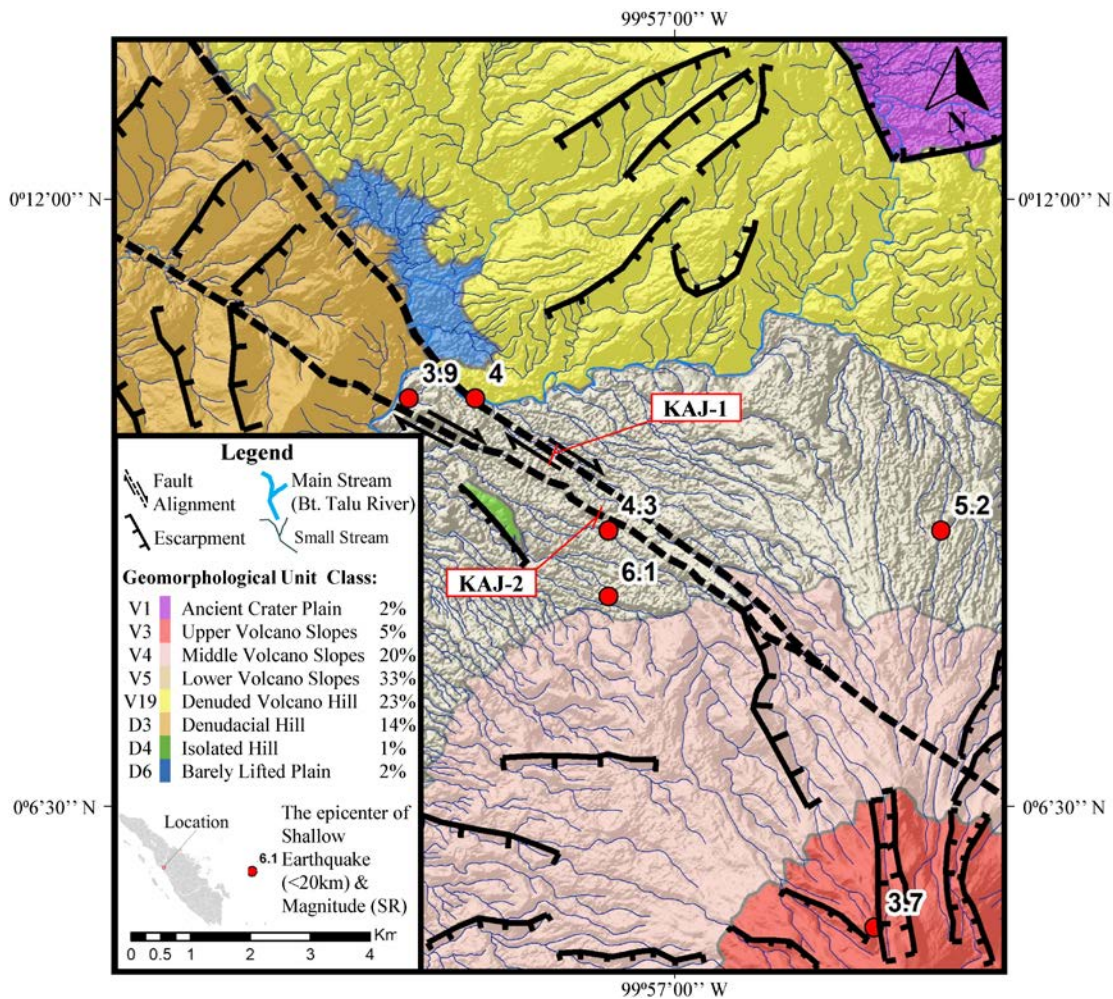


Fig. 14 Simplified Geomorphological Unit map of Kajai Sub-district and surrounding area overlay with a new fault interpretation F1 and F2. The juxtaposition of geomorphological units is visible in V4 and V5 (Middle Volcano Slopes and Lower Volcano Slopes).

5. CONCLUSIONS

This study demonstrates how the two subparallel segments of the F1 and F2 Kajai Fault systems result in the formation of a Quaternary-Volcanic deposit and the fall of bedrock, which is an ultrabasic igneous rock, followed by the covering of the valley by younger volcanic deposits. In terms of geomorphological aspects, the Kajai fault system's alignment involves the tearing off of a few denudation hills morphology resulting in a short shifting of The Batang Talu River pathway, creating a plain morphology that eventually became the village of Kajai. Geoelectrical sections located in the interface of quaternary deposits on both faults identify F1 and F2. The F1 fault, as an active fault, is crucial to the assessment of the seismic risk to Kajai Village and the surrounding area.

6. ACKNOWLEDGMENTS

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