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Detecting Active Faults Using Remote-Sensing Technique : A Case Study in the Sri Sawat Area, Western Thailand

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ABSTRACT: The result of remotely sensing data interpretation of the Sri Sawat Fault to the south of the Srinakarin Dam reveals that the major regional trend of lineaments is in the north to north-northwest direction mostly situated between two major northwest-trending faults, viz. the Mae Ping and the Three-Pagoda Faults. The studied fault eventually joins the Three-Pagoda Fault at its southern end. Space-borne image and aerial photographic interpretation together with ground truth survey also indicate three other minor faults in the northeast-southwest, north-south, and east-west directions. Several well-defined morphotectonic landforms in the study area including fault scarps, triangular facets, erosional benches, offset streams, shutter ridges and beheaded streams, are well recognized both from remotely-sensed data and in the field. These landforms, which are in most cases related to the studied fault, indicate the occurrence of both vertical and horizontal slip components in Quaternary sedimentary sequences. The thermoluminescence dating on fault-related sediments also confirmed the above active-faulting which generated the paleo-earthquake with a possible-magnitude of M6.3 on the Richter scle.

KEYWORDS: Sawat Faults, remote-sensing, active fault, earthquakes, Western Thailand.

INTRODUCTION

Earthquakes, as a part of environmental problem of human concern, can be regarded as natural disasters causing extreme and vigorous destruction. Major causes of earthquakes on land are attributed to fault movements. Several approaches have been applied for detecting fault activities, the most common and inexpensive approach for fault studies perhaps is a remote-sensing approach together with a ground-truth field survey[1]. This is because there are several, good supporting lines of evidence for explaining those earthquake activities within the landforms being produced by them.

In northern and western Thailand, the appearance of many earthquake activities were proved not only by historic but also instrumental records. Two major faults in western Thailand, viz., the Sri Sawat Fault (SSF) and the Three Pagoda Fault (TPF), are documented to be associated with earthquake activities[2,3,4,5,7]. Two major earthquakes were reported in western Thailand – one occurring on 21 March 1959 with the magnitude of 5.3 on the Ritcher scale[6] and the other on 22 April 1983 with the magnitude of 5.8 Mb.[8] These two earthquake events took place very close to the faults. So it is neccessary to investigate these faults in more detail. However, only few studies on earthquakes and related works have been done so far in Thailand and nearby countries. Hinthong[5] investigated the role of tectonic settings on earthquake activities in Thailand. He reported that the seismic source zone in Tenasserim range (Natalaya[6]) accounted for present-day earthquakes governed by the northwest-southeast right-lateral strike slip fault zones; i.e., the Moei-Uthai Thani Fault, the TPF, and the SSF. These three zones are believed to be responsible for historic earthquakes in western Thailand.

Several remote sensing techniques[4] have been applied for investigating geologic structures to geostructures related to earthquakes in Thailand and neighboring countries. The result is useful in determining the seismic-source zones to indicate the earthquake-prone areas. A new seismotectonic (or seismic-source) map is also proposed by Charusiri et al[4]. Kosuwan et al[9]investigated neotectonic evidence of Mae Chan Fault. Results from their interpretation of enhanced Landsat TM5 satellite images and aerial photographs indicate that the fractures on ground are mostly in the east-west trend. In addition, they found several pieces of geomorphic evidence that indicate the left - lateral fault movement. Won–in[10] grouped this segment as part of the Kanchanaburi segment of the TPF, using remote sensing and thermoluminesence (TL)-dating data. Charusiri et al.,[5] investigated the active faults along the SSF from satellite images and reported that the fault is a branch of the Mae-Ping Fault (MPF), orientating in the northwest-southeast direction. In addition, based on the K-Ar dating result, they found that the last movement of the SSF was 55 Ma. Nutthee et al.[11] studied faults on the southern part of the SSF segment based upon results from remote sensings, trench logging, and TL-dating data. They reported that

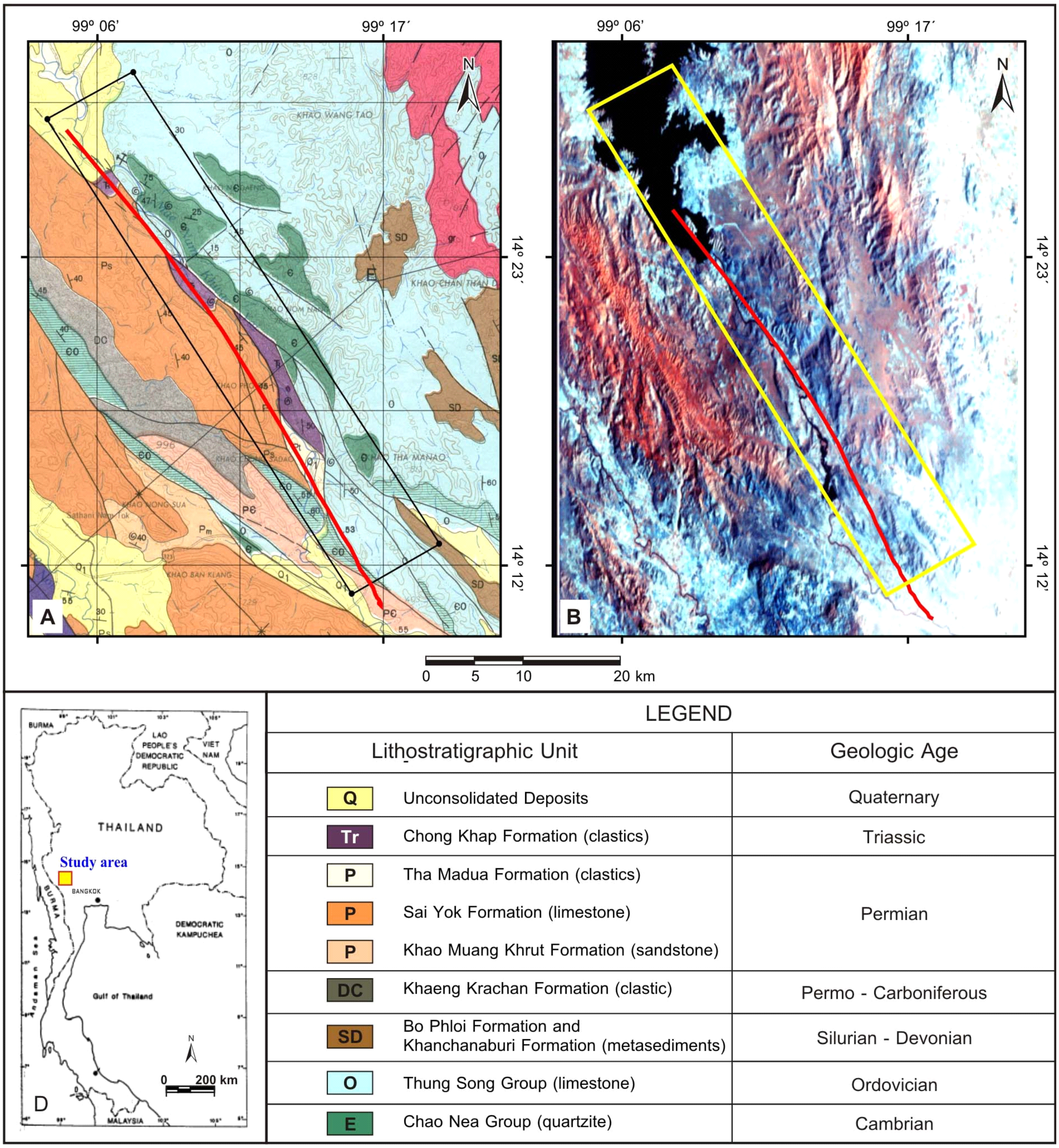


Fig 1. **A)** Fragment of geologic map based on Kemlek et al.[14] covering the study area (in box). Black dot indicates the epicenter of 22 April 1983 earthquake.

B) Enhance Landsat TM5 image (band 4,5,7 in red, green, blue, respectively) showing various rock types and the Srinagarin reservoir through which the major Sri Sawat Fault (solid line) passes.

the southern part of the SSF segment is the reverse fault with more than four movements in the past. The time of the last movement is about 4,900 to 5,000 years ago. It was noted that most studies involve more regional investigations, and not many are concerned about relatively detailed and local surveys.

The main aim of this study is to determine geomorphic evidence of Quaternary fault activities along the SSF using remote-sensing and field information. The result of the research can be applied to predict a probability of earthquakes occurring in this area. The SSF is located between the MPF and the TPF (Figure 1). Its length is about 380 km in total, and its major trend is in the northwest-southeast direction. With the applications of several geologic parameters, the SSF is assigned to be potentially active[4]

The study area of the southern SSF is located at southern part of the Srinagarin Dam near to Ban Tha Thung Na , Amphur Sri Sawat, Kanchanaburi Province. The study area covers about 200 sqkm and is bound by UTM Grid $^{5}07^{000m}$ E. – $^{5}30^{000m}$ E. and $^{15}72^{000m}$ N. – $^{15}100^{000m}$ N (or between lattitude 14° 04´ and 14° 18´, and longitude 99° 26´ and 99° 11´). The study area is shown in a 1:50,000 topographic map of Ban Kaeng Riang, Sheet no.4837IV, Series L7017. Routes to the study area (Srinagarin Dam) can be accessed all year by the Petchakasem Highway and the road no. 3199, passing through Nakorn Pathom Province and the city of Kanchanaburi.

Regional Setting and Structures

Geological Structures

The structures of the study area are quite intricate as dominated by folds and faults. The folds are recognized in several places both from field and satellite-borne image data. Results from the Landsat TM5 indicate that most fold axes are in the northwest-southeast trend, corresponding to those earlier reported by Bunopas[12], Siribhakdi et al.[13], and Kemlek et al.[14]. Fold structures can be visualized in several rocks, and many structures such as synclinal and anticlinal folds are discovered in the and Permian limestone[12] limestone in Khao Leam area[13] and the Ordovician. Our ground truth and remote-sensing surveys reveal that tight and recumbent folds are observed in Ordovician to Devonian strata, particularly in the western part of Kanchanaburi city and eventually join with the TPF.

Chuaviroj[15] recognized a few major faults in western Thailand, including the SSF and the TPF Zones. The north-south trending SSF displays the curvilinear pattern at the southern end with several minor fault sets. One of the SSF commences from Sri Sawat district and the northern part of Bo Ploi district, Kanchanaburi Province. This fault also passes the Khwae Yai River in the northwestern trend. To the north, the SSF deviates following the MPF by cutting many lithological units of the Paleozoic to Cenozoic ages. The Cenozoic units of faulted unconsolidated sediments are essential since they indicate that parts of SSF are quite young.

Geological Setting

The geology of the study and nearby areas has been studied extensively by several workers[12,14,16,17], the western area of Kanchanaburi comprises several faults of various directions, mostly trending in the northwest-southeast direction and cutting across several lithologics of different ages ranging from Cambrian to Quaternary (Figure 2).

The youngest unit includes long and narrow strips of Quaternary deposits filled by recent and old alluvial-fan, colluvial and flood-plain sediments of high and low terrace consisting of gravels, sands, silts and laterites. Lying unconformably under the Quaternary deposits are the Triassic rocks of the Chong Khab formation. This formation is composed mainly of shale with *Daonella* sp. and *Halobia* sp., and sandstone interbedded with limestone. The formation is underlain by the Permian Tha Madua sandstone including thickly bedded red sandstone and white quartz sandstone. Equivalent in age to the Tha Madua sandstone is the Sai Yok Limestone. This formation comprises massive and bedded limestones containing fusulinids, brachiopods, pelecypods and bryozoans indicating Permian age. The Sai Yok formation of Permian age is underlain by the Khaeng Krachan formation of the Permo-Carboniferous age. The formation consists of pebbly mudstone, gray sandstone, and dark gray shale, probably lying unconformably under the Permo-Carboniferous rocks are the Bo Ploi formation and Kanchanaburi formation of Silurian to Devonian age. The Group comprises mainly quartzite and phyllite with interbedded tuffaceous (meta)sandstone. Older than the rocks of the Silurian-Devonian age are those of the Thung Song Group, comprising banded argillaceous limestone, argillite and quartzite with Ordovician cephalopods. The oldest lithologic unit in the study region is the Tarutao (or Chao Nen Group) of Cambrian age. The Tarutao Group rocks are mainly metamorphosed siliciclastic rocks including massive to well-bedded quartzite and bedded green sandstone with alternated calcareous shale.

Regional Setting of the Sri Sawat Fault

Based on the enhanced Landsat TM5 data, it is visualized that the SSF mainly orients in the north to north-northwest trend in western Thailand (Figure 2B). Both ends of the SSF deviate their traces to the northwest-southeast direction and eventually join the MPF and TPF.

To the south, the SSF runs southeastward almost along the Khwae Yai River and passes Sri Sawat and Bo Ploi districts of Kanchanaburi. The fault cuts through the Paleozoic to Mesozoic rocks (Figure 2). Air-borne magnetic data[18] indicate that the SSF extends continuously southeastward to the central plain of the Chao Phraya basin and passes south of Bangkok (Figure 1). At present no work has been done so far for the southward extension of the SSF and TPF to discover whether it is active.

The southern segment of the SSF, where the study area is located, orientates in a similar trend to the main fault, which is dipping to the southwest direction. It covers the southern part of the Srinagarin Dam parallel with the Khwae Yai River along to the upper part of the central plain. The total length is about 25 km, and the fault cuts through the Permian limestone, the Triassic clastic rocks and the Quaternary deposits unconsolidated (Figure 1).

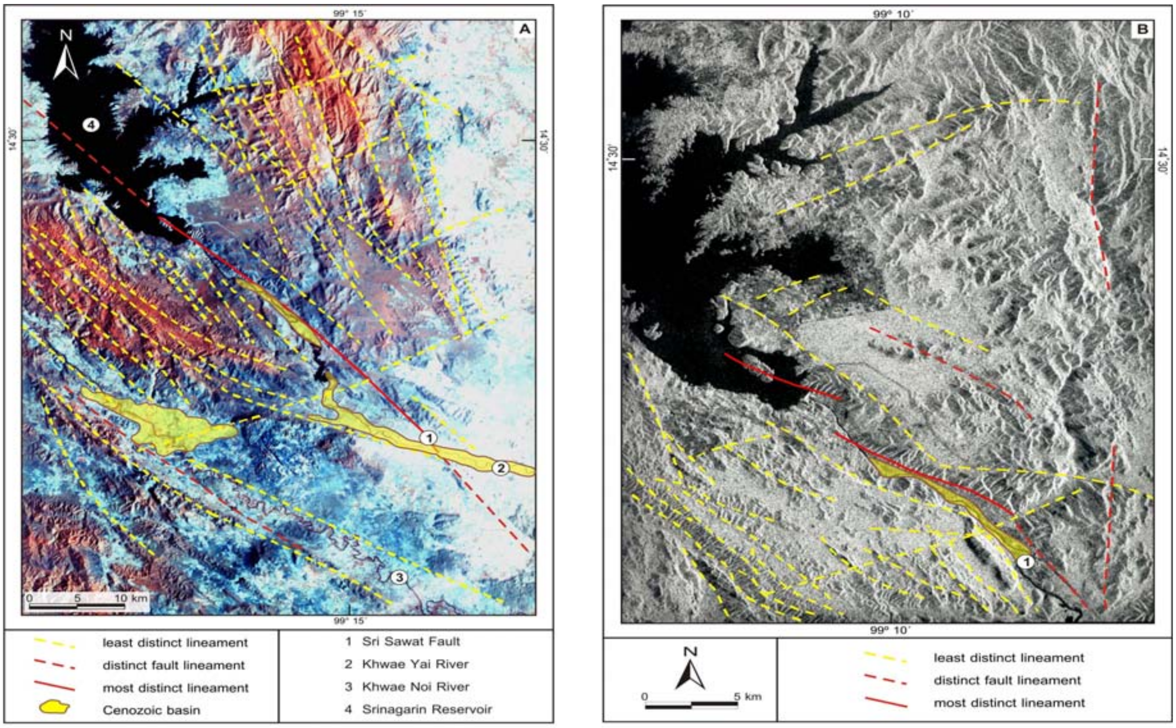
METHOD

Planning and Preparation

The first step involves mainly data and map preparation and compilation in order to comprehend current knowledge on remote-sensing interpretation from satellite images (JERS & Landsat TM5) and aerial photographs (Figures 3 and 5), to gain preliminary available information on the regional study area, and to arrange and rearrange relevant information for subsequent steps. Thus, seeking for previous works, acquiring the satellite images, aerial photographs, preparing topographic, geologic and related maps, constitutes the essential database for this step.

Data Acquisition, Data Interpretation and Analysis from Remote-sensing

The second step involves remote-sensing interpretation commencing on a small scale with satellite imagery and subsequent interpretation on a large scale with aerial photographs. Both enhanced Landsat TM5 and JERS satellite images (Figures 3A and B) form the basis for data interpretation. Landsat images at the scale of 1:250,000 were provided by National Research Council of Thailand (NRCT). The aerial photographs taken in 1994 at a scale of 1:50,000 were taken from Royal Military Survey Department. Lineaments are then interpreted for locating attitudes and orientations of the fault zones (Figures 2, 3, and 5). The more detailed investigation is undertaken including defining individual characteristic of lineaments and their continuity with the use of stereoscopic aerial photographs (Figure 4). All of geomorphologic evidence supporting fault movements is based on the works of Slemmon[1,1+] and



A B

Fig 2. **A)** Lineament map interpreted from Landsat TM5 showing orientation and kinds of lineaments of the southern Sri Sawat Fault, Kanchanaburi.
B) JERS image (18 June 1998) showing 3 categories of lineaments in the northeast, northwest, and north directions. Note that the northwest-trending lineaments are quite distinct, particularly that following Khwae Noi River (1).

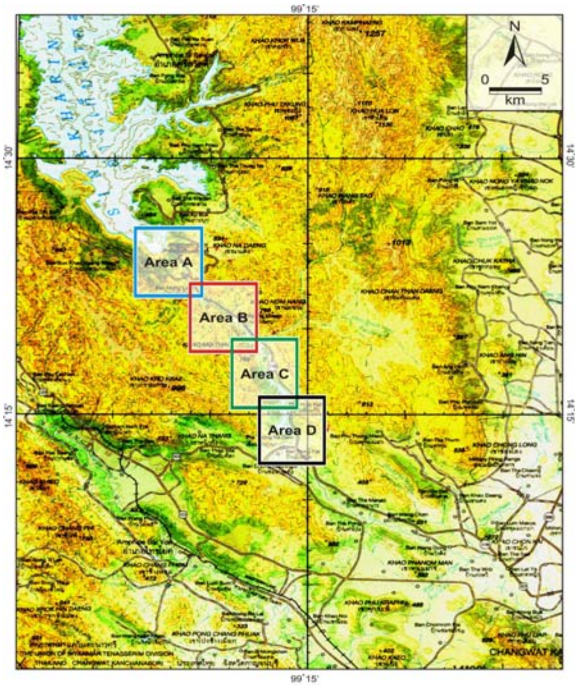


Fig 3. Part of a topographic map (sheet ND 47-7) showing the selected areas (A,B and C) for detailed morphologic analyses.

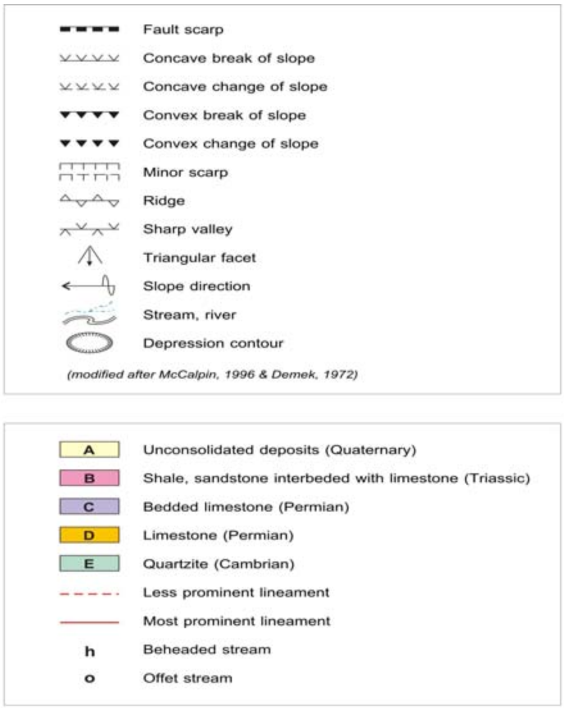
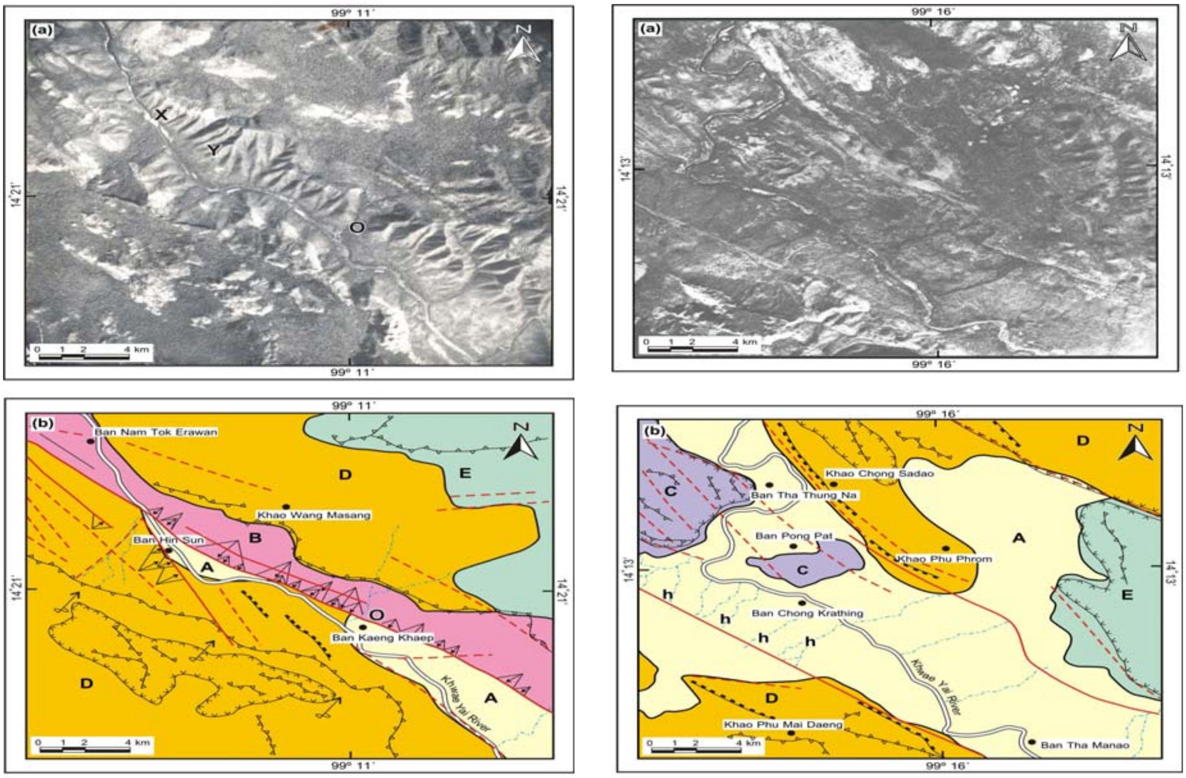


Fig 4. Symbols applied in the morphotectonic maps by aerial photographic interpretation.



A B

Fig 5.A) Area B selected for detailed morphologic analysis: a) Aerial photograph and b) Morphotectonic interpretation of Area B. Note that symbols are from Figure 4.

B) Area D selected for detailed morphologic analysis: a) Aerial photograph and b) Morphotectonic interpretation of Area D. Note that symbols are from 4.

McCalpin[20] (Figure 5A). Lineament maps shown in Figures 3A and B are the major output from this stage of research.

Field Investigation

Once the fault zones are defined, emphasis is placed on subsequent detailed geomorphic mapping in areas where Quaternary landforms and deposits are situated. Field checks were conducted on the outstanding geomorphic features, and morphotectonic landforms and styles were delineated at this step. In this study, geomorphic mapping related to neotectonic evidences aids in evaluating locations of active faults, nature of faulting, and identifying sequences of faulting in the focus areas.

Integration of Remote-sensing and Field Investigations

At this stage, all the results are integrated and interpreted together. Morphotectonic maps are the output and are made from all evidence from pre-fieldwork investigation and fieldwork study. Also, discussion is addressed in conjunction with previous works of Won-In[10] and Nuthee et al.[11], and paleoearthquake magnitude is estimated.

Results

Results from Satellite Image Interpretation

In this study, we applied digital enhanced Landsat TM5 and JERS (Figures 3A and B) images were used for data analysis. Practically, visual interpretation is regarded as the prime and most effective approach for identification of neotectonic features. For the Landsat images, the false colored composites, blue, green and red, are digitally added to the data image bands- 7, 5 and 4, respectively, following the work of Charusiri et al.[21]

The advent of image study and interpretation is to assist in delineating large-scale neotectonic features and to define the orientation and direction of the investigated fault segment. Our analysis indicates two types of neotectonic features (or landforms) in the study area, i.e. primary and secondary. The primary landforms include fault scarps and escarpments, facet spurs and range fronts, and the secondary landforms include offset streams, triangular facets, shutter ridges and beheaded streams.

Figure 3 shows that the southern SSF is continuous with a length of about 25 km. The main orientation of this segment (displayed in a solid line) is in the northwest-southeast direction, and lies very close to the Khwae Yai River. The fault exhibits a sharp contact boundary with the Cenozoic basin (or deposit). The larger dashed line indicates the less prominent feature (or lineament), extending from the main lineament. The smaller dashed line illustrates the least prominent lineaments which mostly pass the pre-Cenozoic rocks. They are generally small and discontinuous fault traces detected in satellite data.

The southernmost part terminates at the large alluvial plain of Kanchanaburi city. Several morphotectonic pieces of evidence can be recognized from enhanced remote-sensing and filed data. Among them, the most outstanding features are triangular facets and fault scarps.

Results from Aerial Photographic Interpretation

For more detailed investigation, four small areas were selected for aerial photographic investigation, which are mainly based on the results of lineament analysis on JERS-image data, shown in Figure 3. It is clear that geologic structures from the JERS image can be observed more clearly than those of the Landsat one.

Selected areas with an average area of approximately 25 km^2 (namely, areas A, B, C, and D in Figure 3) were investigated in order to trace facet and fracture configuration to clarify more morphological evidence on landforms.

Area A is located immediately at the southern part of the Srinagarin Dam. The direction of the main fault trace interpreted by aerial photographs is similar to that of the satellite image data; that is northwest-southeast. Along the fault a set of triangular facets (or facet spurs) was recognized in the Triassic clastic rocks. The base width of the triangular facet is estimated at about 400 m, and its height is about 250 m. The triangular facet faces in a southwest direction, with a steep dip angle.

Mostly the observed traceable fault scarps are in the Permian limestone, and they are steeper than the triangular facets. Therefore, it is believed that the fault scarps are older than the triangular facets. The main plane of the scarp strikes in a northwest-southeast direction, following the main fault. In some places, the fault planes dip very steeply to the southwest.

In area B (Figure 3), the most prominent lineament (or fault) trends in a northwest-southeast direction, and other small ones are in a roughly east-west direction, cutting through the Permian limestone and the Triassic clastic rocks.

Aerial photographic analysis reveals several pieces of morphotectonic evidences, such as the fault scarps, triangular facets, erosional benches, offset streams and shutter ridges.

Most fault scarps (Figures 5A and B) clearly observed in the Permian rocks are nearly vertical and rather continuous. The plane of this fault scarp strikes northwestward. A set of very sharp and clear triangular facets is found in Triassic clastic rocks along the traceable fault and dip in a southwest direction. The width of the facet base is about 200-400 m and its height is about 200 m. Main attitudes are similar to those of the scarps. The clear morphology of the triangular facets in clastic rocks indicates that these triangular facets should not be very old. This is because the clastic rock type is rather friable and easy to erode, so fault traces cutting through the clastics are relatively young. Two sets of triangular facets lead to the development of erosional benches, suggesting more than one time of fault movement.

The offset stream observed in this area (o in Figure 5A) has its intermittent streams flowing southwestward. When the drainage meets the fault trace, its course changes its direction to the northwest and flows back in the old direction. A shutter ridge (s in Figure 5) immediately observed at the drainage point is offset in response to the fault movement. Based on this evidence, it is believable that the offset most likely represents a right lateral movement, and the maximum offset was estimated at about 120 m.

From all the examined geomorphic evidences (with symbols shown in Figure 4), it can be summarized that the major fault trace is an oblique-right lateral fault with its dip-slip movement based upon the development of triangular facets and dextral movement as supported by the appearance of offset streams and shutter ridges.

In area C (Figure 3), investigation based on aerial photographs demonstrates that fault traces align in 3 directions, namely northwest-southeast, east-west and north-south. Fault scarps are recognized discontinuously only in the northwest direction. Small triangular facets are neither sharp nor clear. Mostly they pass through rocks of the Permian age, with a general dipping to the northeast. No offset stream is observed in the investigation area, and other geomorphic evidences are not distinct.

Area D (Figure 3) is located at the lower part of this segment. Information gathered from satellite image data depicts the major fault trace passing into the alluvial plain parallel to the Khwae Yai River. Aerial photographic study indicates that the fault trace examined aligns in a northwest-southeast direction, similar to those of the other northern areas.

Because the fault trace cuts through some plains, it causes difficulty in finding the paleoseismic evidence. However, in this area, beheaded streams (h in Figure 5B) are encountered as marked by changes in slopes of stream courses due to faulting. Fault scarps are also steeply dipping, and mostly trend to the northwest-southeast.

Offset streams of temporary (or ephemeral) drainage patterns with flowing direction from southwest to northeast are recognized in the Triassic rocks of area B. Some of the drainages flow from hills, and the others flow from minor scarps developed in the Permian rocks of area D. When the drainage meets fault traces, it expresses its flow direction from southwestward to northeastward. Then it suddenly changes its course to southeastward and after that it flows to the northeast. The result of the right-lateral movement caused the shift of the stream for about 30 m.

An outstandingly continuous fault scarp with the average height of 300 m, is also found in limestone terrains. The principle scarp trends in the northwest-southeast direction and dips very steeply southwestward. No triangular facet has been observed in this area.

In conclusion, the traceable faults in this area are likely to be obliquely lateral in nature. Their dip-slip component, although minor, is supported by beheaded streams and triangular facets, and the more prominent strike-slip component shows the right lateral style as displayed by offset streams.

Field Evidences

In order to better clarify and support the result from remote-sensing investigations, a short-period field or ground-truth survey (Figures 7 and 8) was conducted on geomorphology. A focus was made in the study area along the southern SSF, particularly those selected for aerial photographic investigation.

A ground-truth survey in area A indicates fault scarps and triangular facets (Figure 6A) trending in a northwest-southeast direction. Our result from the field investigation conforms very well with that of the aerial photographic interpretation. For the triangular facet features, the average base width is about 300 m and the average heigh 250 m.

Area B (Figure 3), almost parallel with the Khwae Yai River, is chiefly occupied by large limestone mountains with a dominant distinctive fault scarp. Evidence obtained from aerial photographic and field survey analyses indicates a set of a large well–preserved triangular facets occurring distinctively in the clastic rocks (Figure 5B) with an average base width of about 300 m and height of 200 m from the flat area. The attitude of facet spurs, being northwest-trending and southwest-dipping, can help to indicate the location of the main fault. Additionally, emotional benches (Figure 5B) are developed on this triangular facet. Field data observed at grid reference 198-862 reveal exposures of colluvial deposits, a small shutter ridge and the right - lateral offset stream.

The result from the aerial photographic interpretation on area C reveals that area C was influenced by several fault sets of different directions. However, field evidence suggests that due to strongly subdued weathering process, these faults are obviously old.

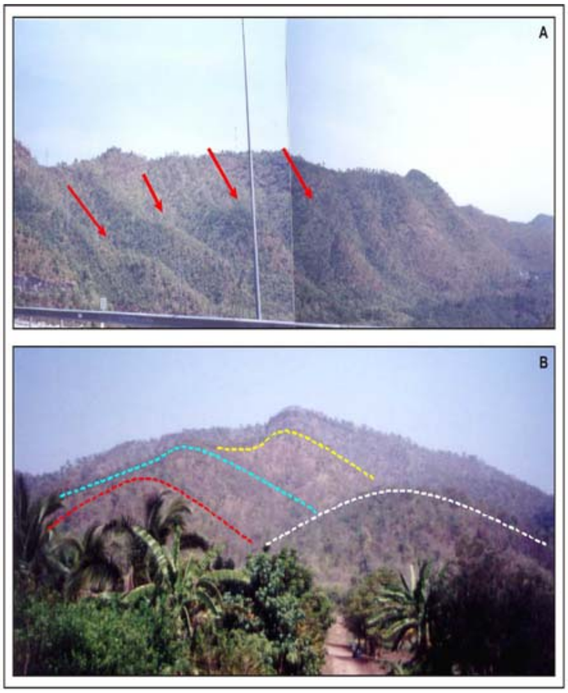


Fig 6. A) A panorama of set of the NW-SE trending triangular facet (arrows showing apexs o facet spurs) with the SW-dipping face in clastic Triassic rocks at Ban Hin Sun (grid reference 144-930). Photo taken to the east, at X in Figure 5A (a).
B) A set of erosional benches developed in clastic. Triassic rocks at Ban Hin Sun (grid reference 174-876). Photo to the northeast at Y in Figure 5A (a).

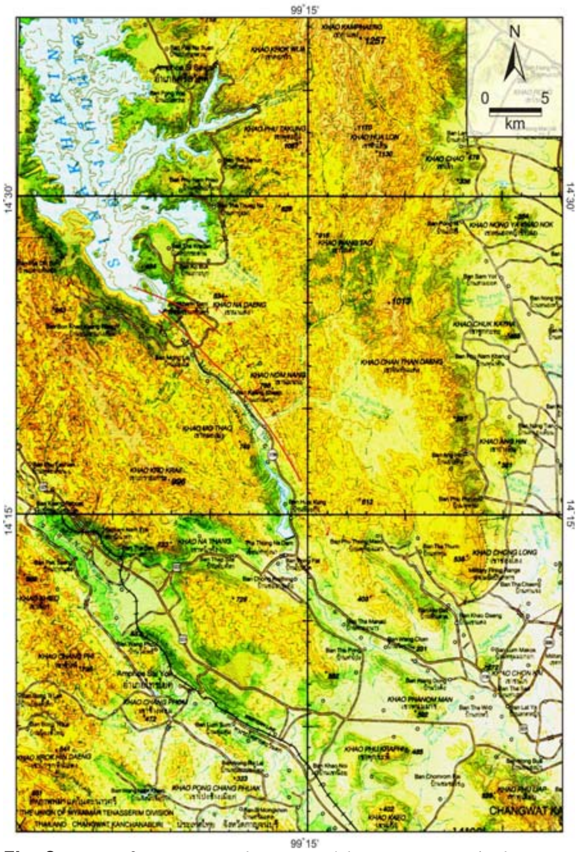


Fig 8. Part of a topographic map (sheet ND 47-7) showing locations and orientations of the study young faults (lines in red color).

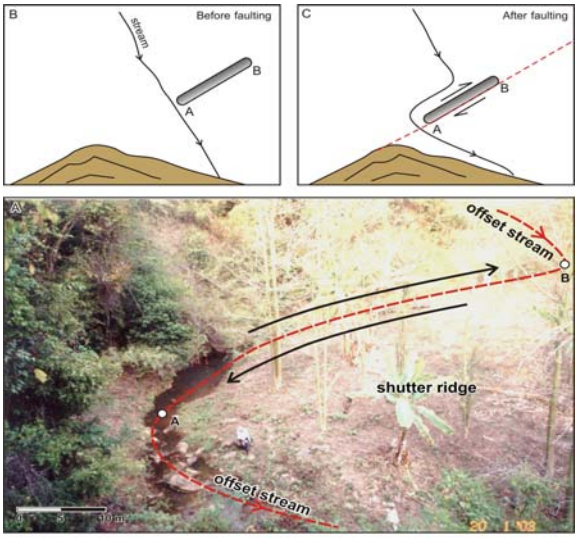


Fig 7. (A) Part of the smail, permanent stream flowing southwestward to the Khwae Noi River showing a right lateral offset and a shutter ridge, near Ban Kaeng Khacp (grid reference 199-186). Photo taken to the northeast at point to in Figure 5A (a), **(B)** and **(C)** show the interpreted scenario before and after fault movement, respectively.

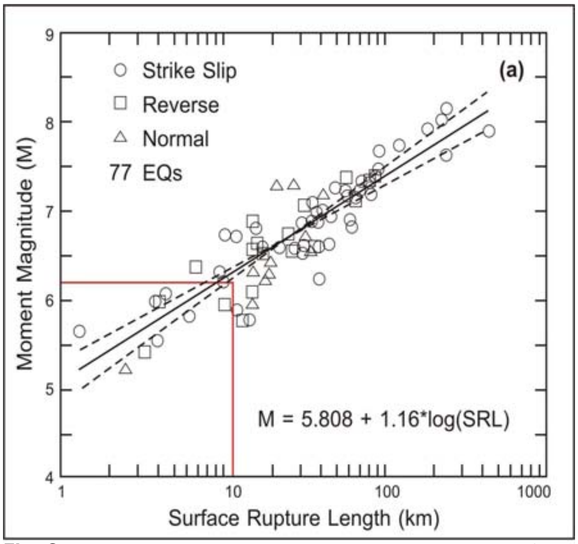


Fig 9. SRL graph showing the moment magnitude of the southern part of Sri Sawat Fault segment. Surface rupture length (SRL, in km) as a function of moment magnitude (M) for 77 earthquakes in the historical data set of Wells and Coppersmit.[22] Equation at bottom lists regression of M on log *SRL* for all fault types (from Wells and Coppersmith[22]).

Area D is chiefly occupied by large limestone towers with dominant fault scarps. A fault scarp as detected by aerial photographs runs following the northwest-trending Khwae Yai River which flows southeastward. Along the fault, there exist a few beheaded streams (or superimposed fault stream) developed in response to the sudden change in relief of the area surveyed.

Discussion

Discussion on the Nature and Characteristics of the Southern Part Sri Sawat Fault

Combined results on remote-sensing and field information from individual study areas indicate clearly that the southern SSF mostly follows the predated regional geological structures which mostly developed in the northwest-southeast trend prior to the Cenozoic times. The most prominent fault traces, as observed from field, space images and aerial photographs, are those orientated in the northwest-southeast trend. Others interesting lineament features, which in several cases are regarded as tectonic faults, are also observed in the north-south and northeast-southwest directions. However, they all are discontinuous and relatively short and may not be responsible for triggering large (paleo-) earthquakes.

For the whole part of the study area, we recognize both old and young faults. Remote-sensing information clearly indicates that the most probable old faults are those occurring in the northeast, north, and east directions, particularly where they cross – cut the Permian limestones and the Cambrian quartzites. As stated earlier, the northwest-trending faults, particularly those following and close to the Khwae Yai River are younger than faults of other direction in the study area. These northwest-trending faults, which are principally associated with the Cenozoic basins, exhibit both dip – slip and strike–slip movements with right-lateral motion.

From all of the results, it can be concluded that the southern SSF can be divided into 3 fault sets on the basis of direction, viz. northwest-southeast, north-south and northeast-southwest trends. The main and most prominent set of faults trends in the northwest-southeast direction almost following the course of the Khwae Yai River. It is of particular interest that these young faults are likely related to paleoearthquakes. There are 2 fault traces that show features of young movements with continuous length of 4.5 km and 10.7 km; one is near Ban Kaeng Khaep village and the other Ban Kaeng Riang village, respectively. Both fault traces are parallel and close to the Khwae Yai River. Their outstanding features at Ban Kaeng Khaep and Ban Kaeng Riang are very sharp and clear triangular facets, aligned continuously with dipping southwestward to the Khwae Yai River. These facets have an average base length of approximately 300-400 m and a plane height of approximately 400 m. An offset stream at Ban Kaeng Khaep village occurring in this fault trace performs a dextral offset of about 120 m.

From evidence of triangular facets, erosional benches, offset streams and shutter ridges, it is indicated that there are oblique strike–slip movements with both horizontal and vertical slip components along the studied faults. Therefore, they are regarded as oblique–lateral faults.

Two other fault traces with young fault movements are recognized. One fault trace cuts through the southern part of the Srinagarin Dam, with the length of 4.5 km. The other fault trace is parallel with the Khwae Yai River, extending from the southern part of Srinagarin Dam along the road to the Tha Thung Na Dam, with a total of length about 10.7 km (Figure 8).

Comparison with Previous Work

Won-in[10] investigated the TPF, northwest of Kanchanaburi, using results from remote-sensing interpretation and additional TL- dating. He grouped a southern part of the SSF as part of the Kanchanaburi segment of the TPF. However, he did not show any detailed description of how this current-studied fault becomes part of the TPF.

In this research, evidence from satellite images and aerial photographs clearly depicts that the studied fault segment extends continuously from the upper part of the SSF. Therefore, it can be stated that the studied fault belongs to the main SSF and does not belong to the TPF as proposed earlier by Won-in[10].

Our investigations using field and remote – sensing interpretation indicate that the studied southern SSF has a very high potential of being an active fault. This conforms with the result of Nuthee et al.[11] that his TL-dating data of fault-related colluviums at Ban Kaeng Khaep provides the last movement of this fault segment at 4,500 to 5,000 years ago, within Quaternary period. However, he concluded that the surveyed fault in the southern part shows its past movement in a reverse sense. This may be quite contrast to the result from this present study. A number of well-documented pieces of evidence support that the fault is normal, and not reverse as previously thought.

Estimation of Paleoearthquake Magnitude

The method of paleomagnitude estimation involves estimating the length of prehistoric surface rupture, and comparing its length to the surface rupture lengths (SRLs) of historic earthquakes of known magnitude. In this study, we apply the analyzed historic data set for of Wells and Coppersmith.[22] Similar plots are presented by Slemmons,[19] Bonilla et al.,[23] and Khromovskikh[24].

The historical data range from moment magnitude (M) 5.8 to 8.1. To estimate paleomagnitude from an inferred paleorupture length, we use a regression of M on SRL (length, measured as a straight–line distance between the rupture endpoints) from the equation M = 5.08+1.16xlog (SRL) as proposed by Wells and Coppersmith[22]

In this study, we applied the young fault trace from Ban Kaeng Riang to Ban Kaeng Khaep (Figure 8). The fault, which exhibits several well-defined, continuously and clearly traced morphotectonic features, is about 10.7 km in the total length. Based on the equation specified earlier. This SRL is equivalent to that triggered by the earthquake with the magnitude of 6.3 on the Richter scale. The location of this young fault movement is important for determining the exploration site for detailed ground geophysical investigation and trenching for paleoseismic studies (see also Danphaiboonphon).[25]

Conclusions

Based upon Landsat TM 5 and aerial photographic data interpretation together with field evidence and relevant previous data, conclusions can be drawn for the studied southern SSF as outlined below.

1. The studied fault segment is about 18 km long and orients in a northwest-southeast direction. It extends from the Srinagarin Dam along the road southeastward and passing Tha Thung Na Dam.

2. Lineaments belonging to the studied SSF segment are grouped into 3 sets based on their orientation, viz. the northwest-, north-, and northeast -trending lineaments. Among these the northwest- trending lineaments are the most distinct and more continuous than the others.

3. Several morphotectonic evidences are discovered along the studied SSF segment, particularly where bed rock connects with the roughly northwest-trending small and elongated Cenozoic basins, suggesting that the SSF segment is relatively young.

4. Tectonic morphology elucidates that the studied SSF segment is the normal and oblique strike-slip fault with major horizontal- and minor vertical- normal slip components.

5. The southern SSF segment is regarded as active in some parts, particularly the segment that extends from the southern part of the Srinagarin Dam to Tha Thung Na Dam, and is parallel and close to the Khwae Yai River and Cenozoic basins.

6. Estimation from the surface rupture length together with TL-age result reveals that there was an earthquake occurring between 4,500 - 5,000 years ago with the moment magnitude of 6.3 occurred along the studied SSF fault segment.

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