OPTIC IMAGES, DEM AND RADAR INTERFEROMETRY FOR THE STUDY OF DIEN BIEN ACTIVE FAULT

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ABSTRACT

Dien bien active fault is one of major active fault in Vietnam. This fault zone is situated at the region of highest seismic potential in Vietnam. In this paper, we use LANDSAT/TM, SPOT, RADAR ERS1-ERS2 and aerial photo to determine active fault length, fault characteristics related to state of stress. Thematic observation from LANDSAT, SPOT combined with digital elevation modelling (DEM) from topographics map and RADAR interferometry can detect fault segment. GPS measurement help to correct geometry of LANDSAT and RADAR image for feeting to topographical map. Clear evidence of the active strike-slip movement is also found on the conjugate Dien Bien fault. Left lateral strike-slip offsets of these faults are determined by analysing tributaries, stream channels, Quaternary alluvial fans, river valley from LANDSAT, SPOT images, detail topographical maps and field observations. Measured left-lateral offsets of river rang between 270 and 790 m. For mapping in detail the fault scarp, We have to use in same time satellite images LANDSAT, SPOT , aerial photo and DEM.

1. INTRODUCTION

Remote sensing application is at young state but its results in geological sciences are quite considerable. We demonstrate in this paper that if analyses of optic images and radar interferometry are combined with Global Positioning System GPS and geomorphologic observations, it will prove a powerful tool for the study of active tectonics and reduction of seismic hazard. For long time, geologists have used satellite images to identify rocks and geological structures. The progresses of advanced techniques allows one to study not only global geological processes but also the mechanisms of geological phenomena in detail. The high spatial resolution and stereo capacities provide quantitative measurement of surface or near surface regions. Progresses in stereoscopic satellite images, radar and infrared images can be applied in the investigation of geological hazards. Information regarding active faults, recent

tectonic movements and earthquake hazards can be derived from satellite image analysis (Winter et al., 1994, Phan Trong Trinh, 2001). Important progresses in the application of remote sensing have been achieved in the observation of crust displacement. We note here two main approaches in using satellite images for the determination of tectonic movements. The first approach involves the outstanding results in the application of radar interferometry in the observation of earthquake deformation in Landers, California. Synthetic Aperture Radar (SAR) interferometry is used to determine changes in the ground surface resulting from an earthquake at a very high precision of 3 cm (Massonnet *et al*., 1993). An interferogram was constructed by combining to topographic information with SAR images obtained by the ERS-1 satellite before and after the earthquake. The co-seismic displacement of active faults associated with the Landers earthquake agrees well with the slip measurement made in the field and with the results of an elastic haft space dislocation model. Compared with geodetic surveying techniques, the SAR interferogram provides a denser spatial sampling and higher precision. It does not require the installation of ground stations before an earthquake. The second approach is the thematic study of panchromatic and multispectral satellite images that allows precise mapping of fault traces and estimates of fault displacements. The offset of landforms such as river and drainage patterns, moraines, glacial valleys, alluvial fans and terraces can be observed and measured from satellite images such as LANDSAT and SPOT. If the age of landforms is reasonably estimated, a fault slip rate can be calculated. The satellite images is combined with field study and other measurements such as classic geodesy, Global Positioning System (GPS) and analysis of earthquake focal mechanisms. Our study in this paper is mixing these two approaches. In this study, radar interferometry is not used to determine co-seismic displacement but only for making the Digital Elevation Modelling. We make DEM also from digital topographical map of 50.000 scale.

2. RESULT

The continental extrusion that pushed Indochina Southeastwards along the Red River shear zone was a major event in South East Asia. In North Vietnam, various structures associated with strike-slip motion occurred in the first phase of extrusion (Leloup et al., 1995, Findlay et al. 1997). More recently (late Cenozoic) the sense of movement on this fault has changed. Paleostress analysis indicates that since the Miocene two main tectonic phases affected (Lacassin et al., 1994). Several active faults associated with the phase 2 are clear in North Vietnam. Amongst these, two main zones seem to be relatively fast movement: the Red River fault zone and Dien Bien Phu fault. In North Vietnam, right lateral Red River fault zone splays into two major active fault branches. The Red River branch that limits to the SW the metamorphic massif of Day Nui Con Voi follows the Red River valley (Phan Trong Trinh, 1995). Clear evidence of the active strike-slip movement is also found on the conjugate Dien Bien fault. Left lateral strike-slip offsets of these faults are determined by analysing tributaries, stream channels, Quaternary alluvial fans, river valley from LANDSAT, SPOT images, detail topographical maps and field observations. Measured left-lateral offsets of river rang between 270 and 790 m. For mapping in detail the fault scarp, We have to use in same time satellite images LANDSAT, SPOT, aerial photo and DEM. We try to make DEM by various ways: from digital topographical map of 50.000 scale, from stereo aerial photo and radar interferometry. Two scenes in descending mode over the Lai Chau - Son La districts were used to test the technique of SAR Interferometry for

Digital Elevation Model (DEM) The two scenes used are the ERS-1 image from 23 March 1996 and the equivalent from ERS-2 from 24 march 1996. Two radar images have been registered, the

Figure1: Dien bien fault determined from LANDSAT image

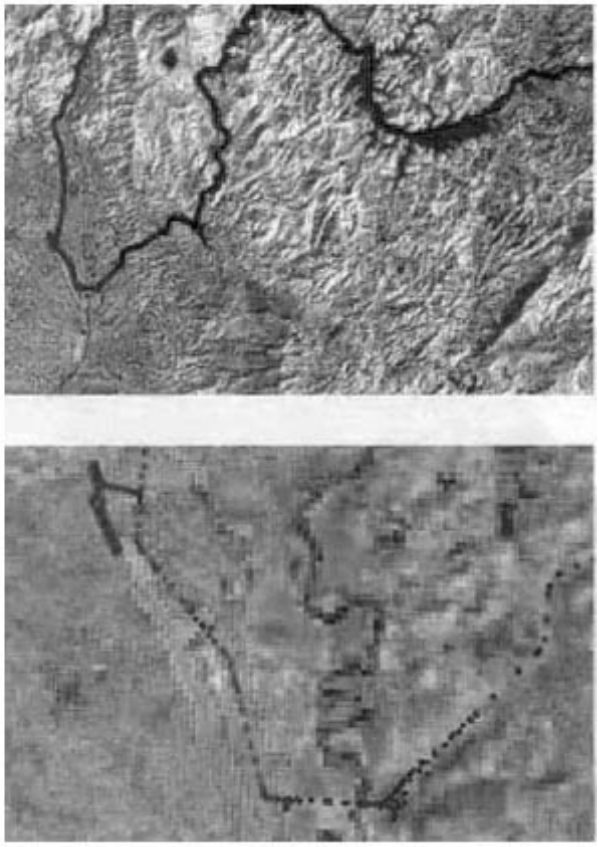

Figure2: GPS tracs for the correction of images

phase difference image or interferogram was produced. In the interferogram, there were areas devoid of fringes due to the returned signals are not coherent from lakes and rivers since it is constantly moving. The coherence is useful parameter in the process of phase unwrapping. In the coherence image the values range from 0 (black) to 1 (white). Areas of high coherence are located in alluvial plains such as de Dien Bien Phu one or the Black River. Most of the areas area however in dark because of the woody slopes and the steep of those it slopes. Using average length of offset channels and a minimum rate of 100mm/yr for river propagation, slip rates of

Dien bien fault is estimated to be 6.2 +- 4.0 mm/yr. Vietnam is considered as a region of low seismic activities. This remark seems to be the contradiction with the observation of intensive

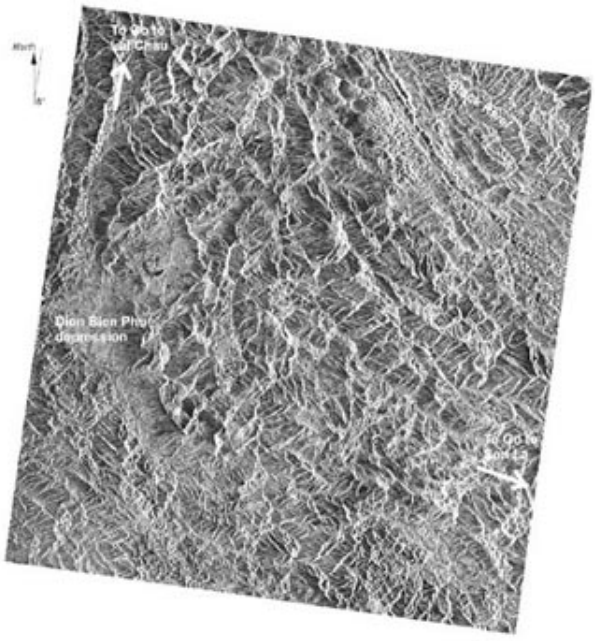

Figure 3 : ERS-1 Intensity image - 9 July 1996

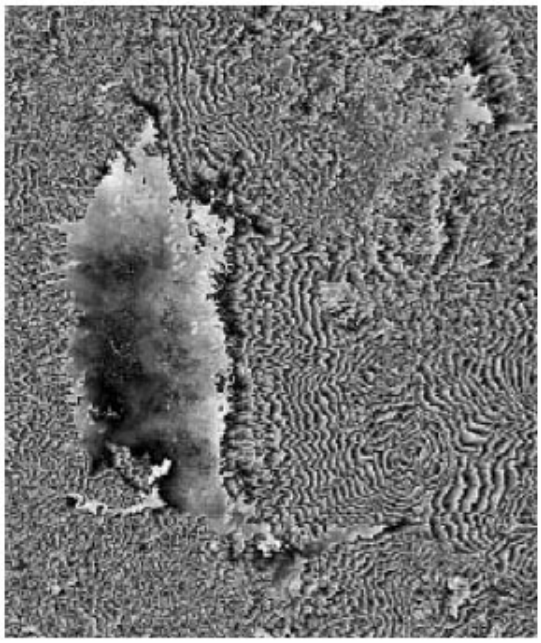

Figure 4: subset of the full scene centered over de Dien Bien Phu depression. The perpendicular baseline is 154 meters. The altitude of ambiguity is thus 67 meters. In the mountainous areas, this means that a lot of fringes appear.

Active faulting in NorthWest Vietnam. Seismic hazards were studied by some workers. One approach is probabilistic evaluation from earthquake data (Nguyen Hong Phuong, 1991). One other one is the estimation of seismic risk from active faults (Phan Trong Trinh et al., 1999)The evaluation of seismic risk in Vietnam is carried out in following successive stages: A seismic hazard assessment affected through the combinations, at various scales, of the structural geology with seismicity. The estimate of the seismogenic capability of the active faults identified through satellite image, topographic and geological map, field survey and earthquake catalogue. A seismic risk assessment of the regional seismic hazards on the site corresponding to the occurrence of design earthquake magnitude such as: maximum credible earthquake (MCE), maximum design earthquake (MDE) and operating basis earthquake (OBE). Maximum credible Earthquake is estimated from combination of various methods: fault segments, fault surface, seismic moment and seismic moment rate. Slip rate is an important parameter for evaluation of

maximum Earthquake. It is determined from geomorphologic analysis or from geodesic measurement.

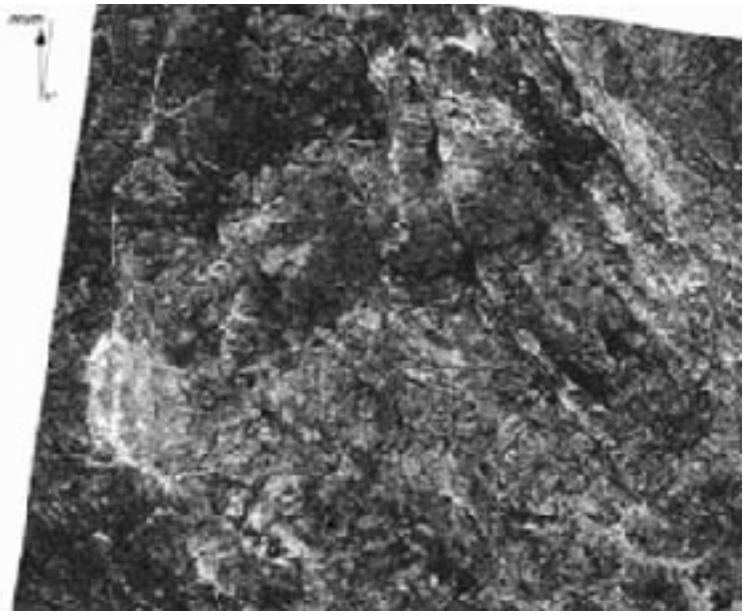

Figure 5: Coherence Image.

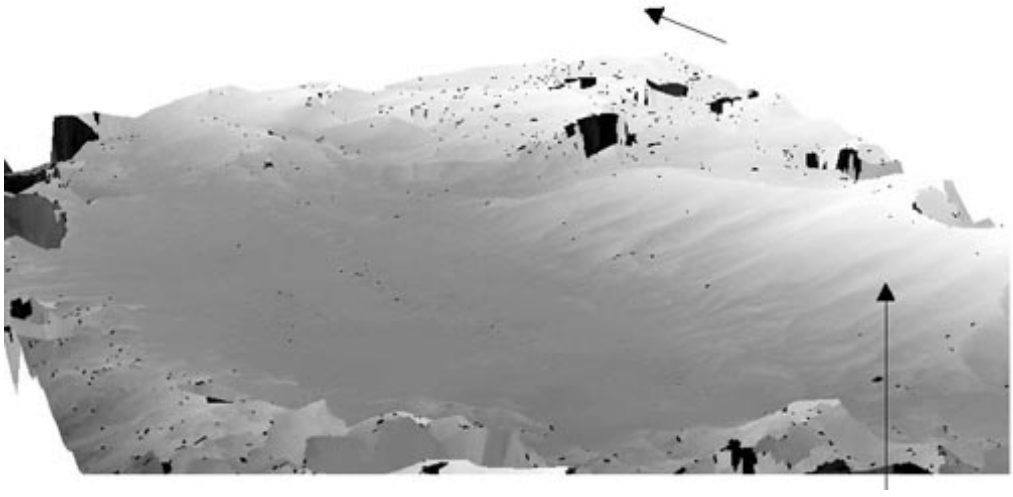

Figure 6: View to the North of the Dien Bien Phu depression made from RADAR interferometry

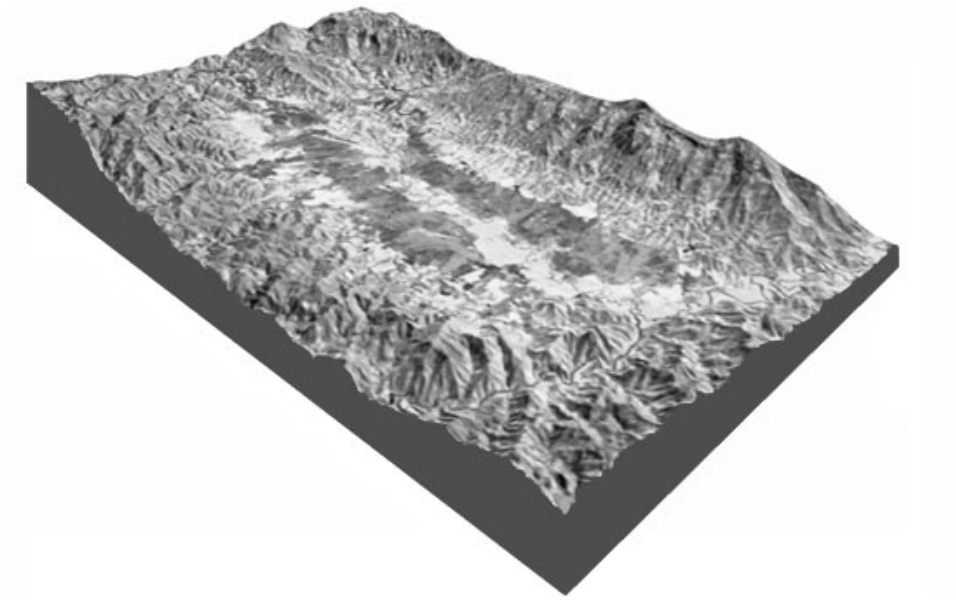

Figure 7: DEM made from topographic map 1/50.000 and LANDSAT image

3. CONCLUSION

In this paper, we present the DEM made from topographic map and from RADAR interferometry. This result help for the study of active fault and seismic assessment of Dien bien fault . If the remote sensing combine with GPS, Geological and geomorphologic observation, it is a power tool for mapping active fault and evaluation of seismic hazards.

4. ACKNOWLEDGMENTS

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