Neotectonic Implications between Kaotai and Peinanshan

Abstract

Longitudinal Valley was the suture zone between the Philippine Sea plate and the Eurasia plate. Peinanshan was the southest segment of the Coastal Range Fault, and the fault was divided into two here. We can find out the position of fault scarp roughly by DEM or aerial photos, and then cooperate with field observing and GPS result to infer the appearance of subsurface structure. We utilize 3 - D topography characteristic from the north segment to the south segment, and depict subsurface structure section. We find that the subsurface structure from the north segment to the south segment was a little different. It was more intact that front thrust seems to be development in the north segment, and the Longitudinal Valley was also collided from north to south. Compare with the GPS data, we thought the Lichi fault in the east side of Peinanshan should be the high angle thrust with left-slide component, and the Luyeh fault in the west side of Peinanshan should be the front thrust of the Coastal Range Fault.

Introduction

Motivation

Taiwan was located at the boundary between the Eurasia plate and the Philippine Sea plate. This plate-boundary setting brings dense and frequent earthquake activities to the island, hence they bring up a lot of calamities. In order to lower the level of the earthquake disaster, we should know the location of the active fault and its pattern of motion first. In recent years, progress of the digit topography technology combined with the geomorphology make active fault and analysis of tectonic topography progress. As the Chi-Chi Earthquake, by detailed analysis of structure topography and field observation, we find most surface rupture happens on active fault system which has obvious topography characteristic. Active fault repeats the activity in the same position, and let the special structure characteristic on topography. By the method to tectonic geomorphology, we can learn the location of active fault to lower the effect of damage, and we hope to help us understanding the active property of active fault. Moreover, by the chance of studying active fault in Longitudinal Valley , we can compare with active fault system in suture zone of other areas in the world to understand development, fault behavior and neotectonic implications of active fault system in suture zone more.

Geology in Study Area

Longitudinal Valley was a suture zone between the Philippine Sea plate and the Eurasia plate. West side of the Longitudinal Valley was the Pre-Tertiary Metamorphic Complex and the Miocene Series Slate; Longitudinal Valley was the suture zone, and the surface was covered by sediment of current river; East side of the Longitudinal Valley was Coastal Range, and compose by the Miocene Series igenous rock and Tertiary turbidite of front-arc basin. The geology of the study area include Lichi mélange (Lc) and Peinanshan Conglomerate (Pn). Lichi mélange was produced from the suture zone of the plate collision. The foundation was mudstone, and mixed with a lot of foreign rock, such as sandstone and ophiolite. Because it was produced in the process of the plate collision, the mudstone was very weak and easy to erode and deform. Peinanshan Conglomerate was a thick conglomerate layer with sandstone and mudstone. There were schist, slate, limestone, metasandstone, metabasite, and less sandstone in conglomerate; It mainly came from schist in the Central Range and some part from the Coastal Range Racks, the environment was from shelf facies to river facies.

The tectonic system in the Longitudinal Valley was very complicated, and Dr. Biq(Biq,1965) proposed Longitudinal Valley was formed by two high angle active thrust fault that sloped against at first. There were two high angle thrust fault which were face to face on Longitudinal Valley both sides to make rift valley in the middle area. The west one was called Central Range Fault. From topography, that present a series of intermittently roughly linear scarp along the west side of Longitudinal Valley and the east side of the Central Range. In the paper(Shyu et al., 2002), the WuHe Tableland was the product of the Central Range Fault, because the Central Range Fault made a turn here and produced thrust component to build the WuHe tableland. According to the analysis of the gravity data, there was obvious discontinuity in the west side of the Longitudinal Valley , so we thought there should be a fault. The east one was called Coastal Range Fault (Longitudinal Valley Fault), and it distributed the boundary between the Longitudinal Valley and the Coastal Range. The north part of fault entered to the sea at the Hualianxi, and the south part was divided into two fault; the east one was the strike-slip fault (Lichi Fault), and the west one was the thrust fault(Luyeh Fault). The faults wound around Peinanshan and entered the sea near Peinanxi and Taitung City. In paper(Hsu , 1962), the Coastal Range Fault was a active fault at first, and this fault was the plate boundary which separated the Coastal Range of the Philippine Sea plate and the Central Range of the Eurasia plate.

Methods

There were observation of aerial photos, digital elevation model, geodesic survey, and field work in this research.

Aerial photos :

We use the stereoscope that make two pair aerial photos produce the three-dimensional image. We can recognize topography characteristic by rise and fall, for example: difference of rocks, change of bedding, range of terrace, landslides, and collapse etc.. In this research, we mainly apply to recognize topography of active structure. About recognization topography of active structure, we mainly utilize fault in the process of activity left topography characteristic on the surface. Main topography characteristic have linerment, tectonic scarp, tectonic depression, tectonic bulge and laterally offset landform. We utilize topography characteristic to understand the kind of the fault. There were strike-slip fault and thrust fault as the principa in this study area. Strike-slip fault on topography produced offset stream, fault slice ridge, shutter ridge, and pressure ridge etc.. Thrust fault was hard to recognize on aerial photos, but it still produced fault scarp on topography. Normal fault easy produced fault scarp and triangular facets etc.. Besides fault system, the fold system , collapse , range of destroying also can be recognized. The aerial photos we used were from 1978 to 1983 collected by the Department of Geosciences, NTU.

Digital elevation model

Digital Terrain Model (DTM) or Digital Elevation Model (DEM) is a kind of elevation data which can store, read and analysis by computer. The best benefit of using DEM(or DTM) is that we can map on the computer directly, and it is more difficult to make eyes tired than using aerial photos. Besides, aerial photos sometimes have bad quality or cloud covers. That will not happen in DEM(or DTM). In addition the software of GIS was developed fast, and offered a lot of complementary functions, like contour , change of slope, absolute coordinate, cross-section, 3-D image etc.. It also can offer comprehensive topography information quickly to conveniently recognize topography. We used Taiwan 40 meter DEM and Longitudinal Valley 5 meter DEM in this research.

Field work

The investigation in the field is the best method to test the analysis in lab. Although we can get the active structure from reaction on topography in the bigger scale by aerial photos and DEM(or DTM), it is difficult to find the tiny phenomenon. Field work means we can check surface characteristic which was suspected to be active fault or just caused by other strength (as rivier erosion).

Analysis

Mapping of DEM and aerial photos

After mapping on 40m and 5m DEM, we can depict terrace and structure by topography characteristic. There were two main faults here. One was on the west side of Peinanshan, and the other one was on the east side of Peinanshan. The fault on the west side which was called Luyeh Fault on the geologic map was a thrust fault. The geological characteristic was the contact of Peinanshan Conglomerate and slate. It was died out in the south segment of Peinanshan and in the north segment of Kaotai, and the structure on the contact with Central Range was not very clear. There were normal fault phenomenon on the top of of anticline which was produced by Luyeh Fault. The fault on the east side which was called Lichi fault, and the geological characteristic was the Lichi mélange thrusted on the Peinanshan Conglomerate by high angle. We just can find the fault scarp on the Funky blob, the northeast part of Peinanshan and a lilttle on the Coastal Range from DEM and aerial photos, so we need to investigate in the field to supplement what we can't get from DEM and aerial photos.

Field observation

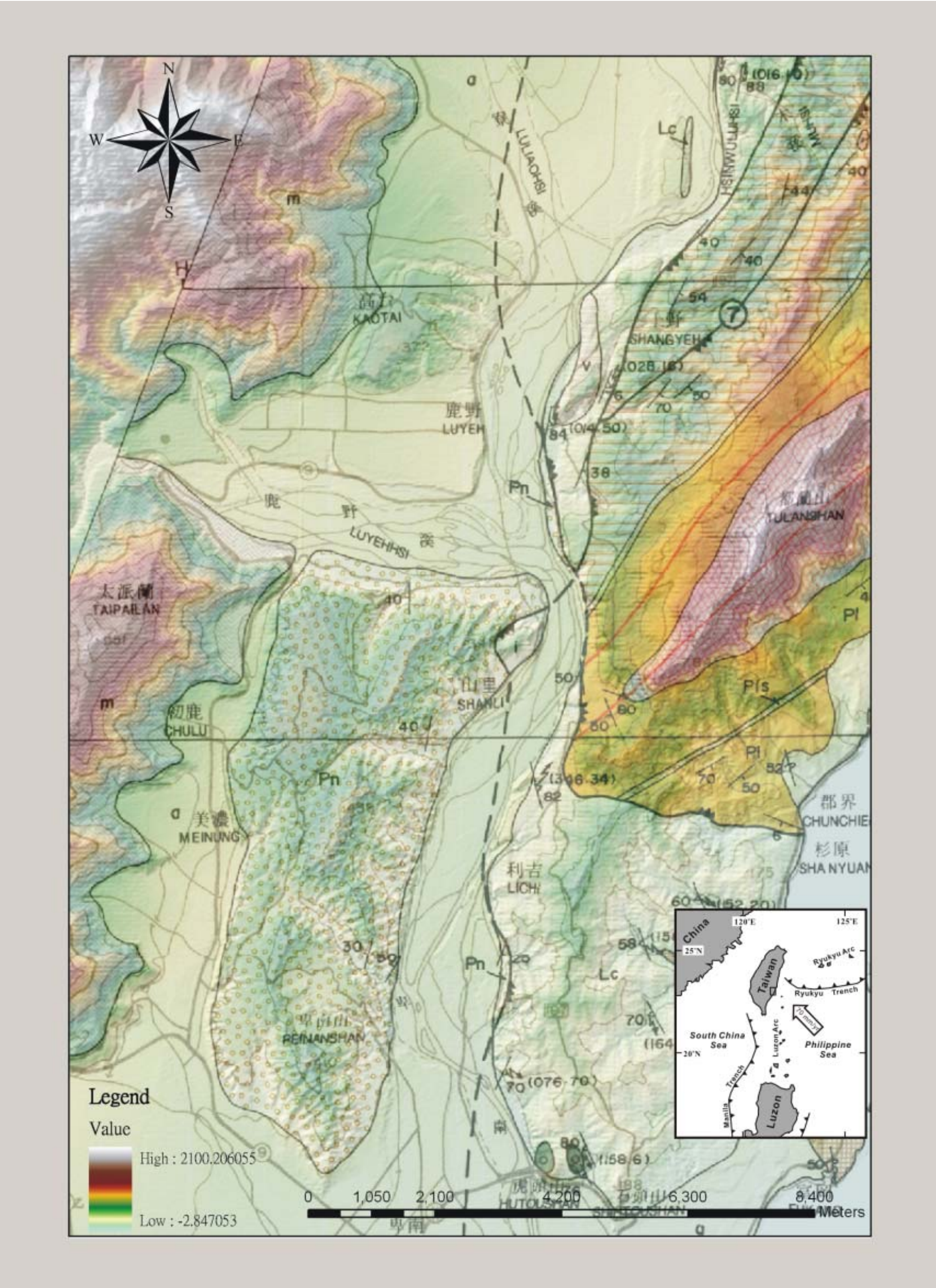

Fig.1 Index map of study area. Geology map a stack of DEM. It show geological fault relation with lithology and topography.

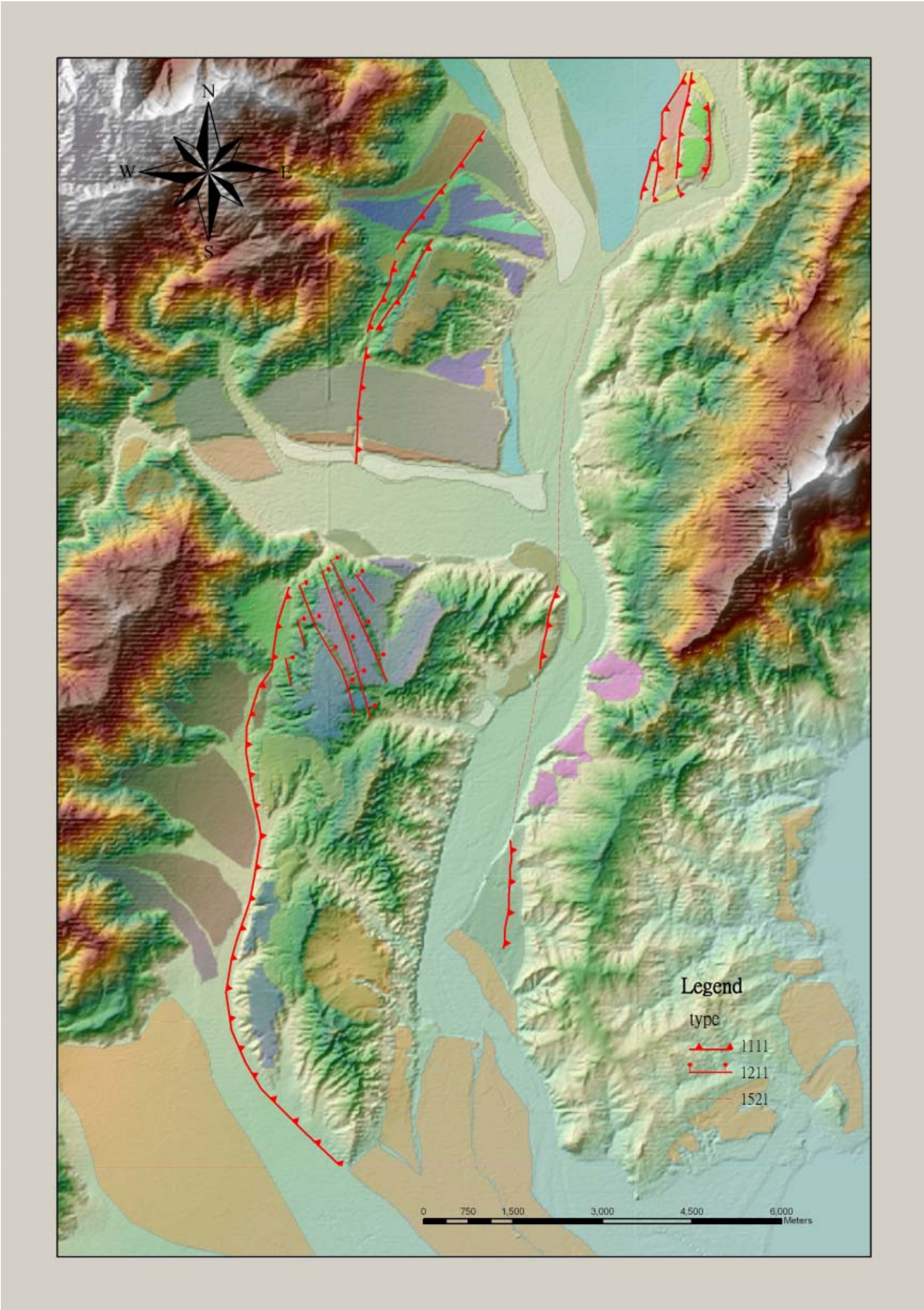

Fig.2 Map terraces and structures on DEM, and we utilized the phenomenon by structure effect at the same period terraces to determine the pattern of structures.

Fig.3 In order to trace the contact of Peinanshan Conglomerate and slate. Because of too much vegetation, and perhaps a lot of colluvium, it is difficult to find the exact contact location. But we find some shear zone, the fault should pass here.

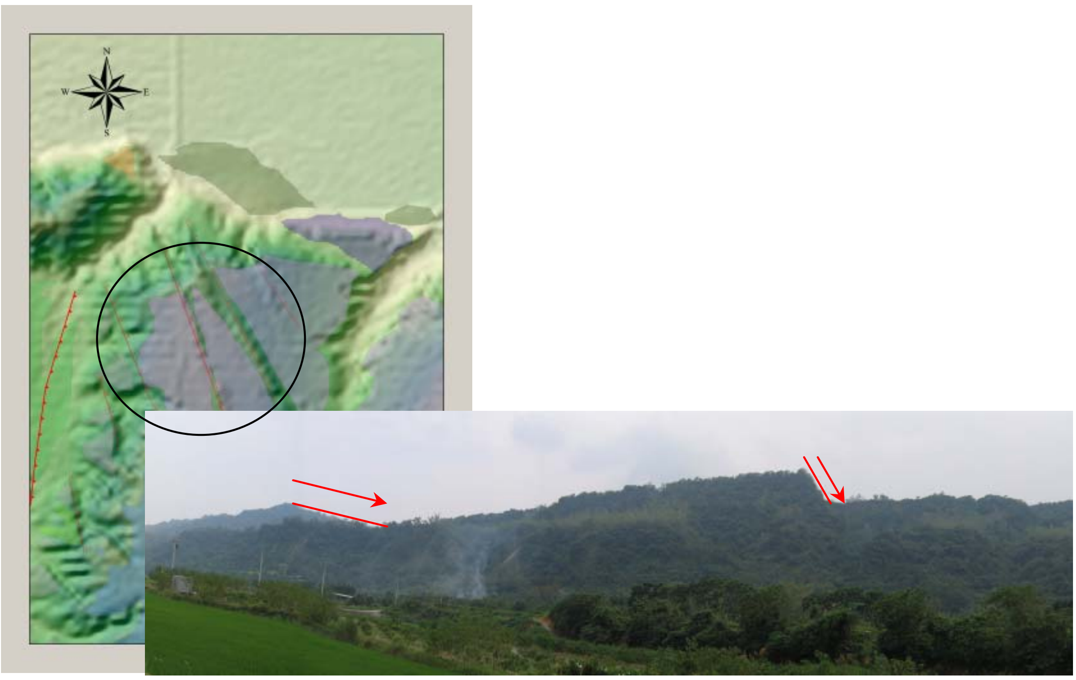

Fig.4 By field observation, we can find out the linear of the normal fault. It is the same with what we map on the DEM.

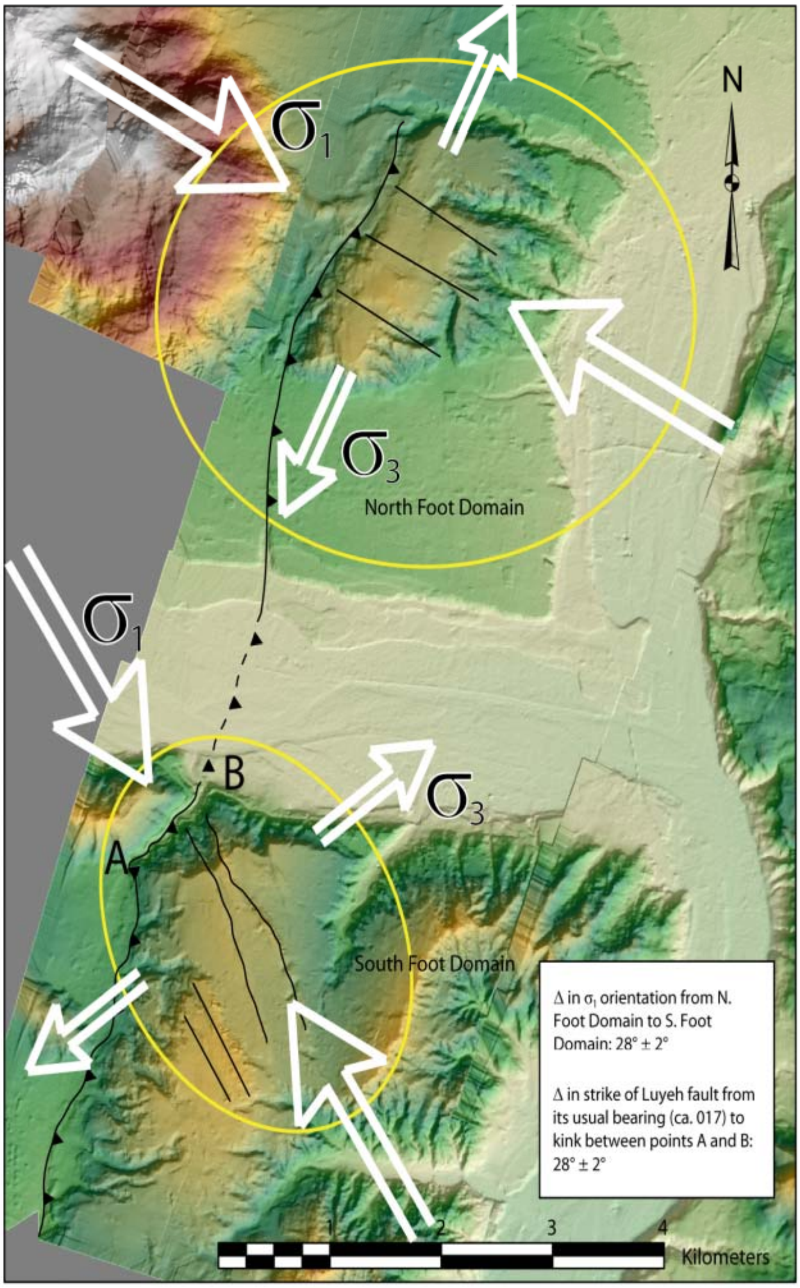

Fig.5 It shows a relation with σ1 and σ3 in the Kaotai area and the north segment of
Peinanshan.

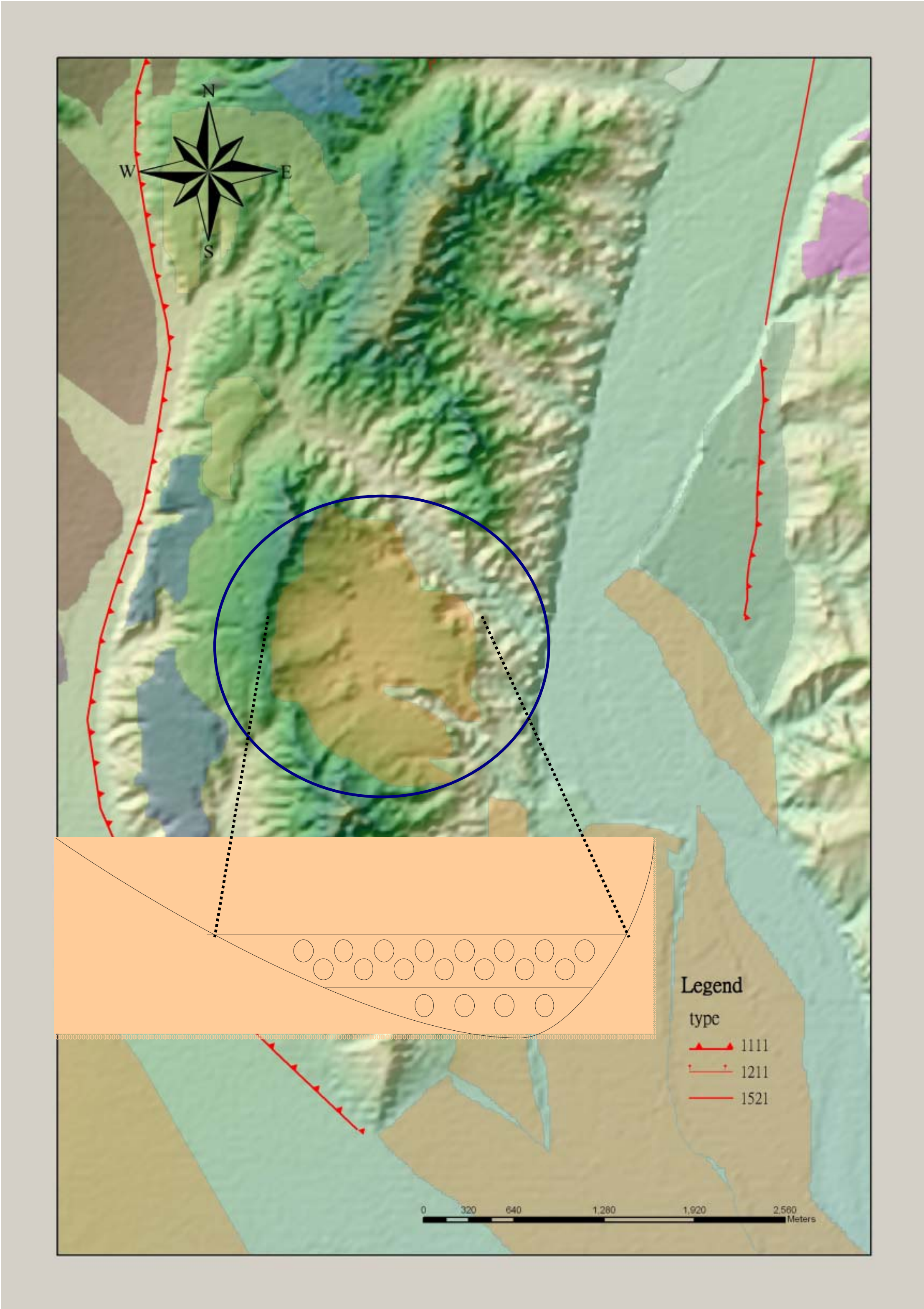

Fig.6 The two dip in the distance less than 20 meter were horizontal to vertical, but we didn't find any phenomenon of active structure. There were landslide characteristic on topography, so we supposed it may be landslide on the axis of syncline to let the dip change big in two very close region.

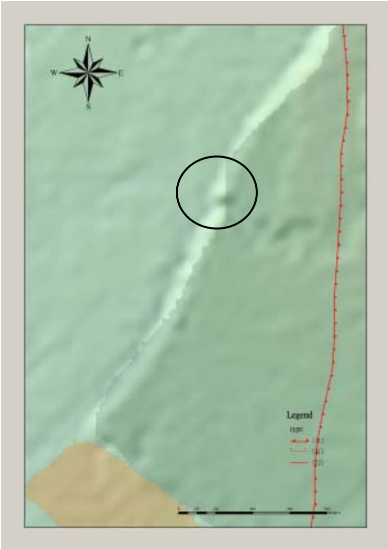

Fig.7 We can find out the obvious contact here, the upper one should be terrace conglomerate, the below one should be Lichi mélange, but the mineral included in right side and left side were different. It may cause such difference because of shear zone.

Summary

By observation of DEM, aerial photos and field observe etc., we infered the pattern of subsurface structure. We utilize 3 - D topography characteristic from the north segment to the south segment, and depict subsurface structure section. We find that the subsurface structure from the north segment to the south segment was a little different. It was more intact that front thrust seems to be development in the north segment, and the Longitudinal Valley was also collided from north to south. Compare with the GPS data, we thought the Lichi fault in the east side of Peinanshan should be the high angle thrust with left-slide component, and the Luyeh fault in the west side of Peinanshan should be the front thrust of the Coastal Range Fault.

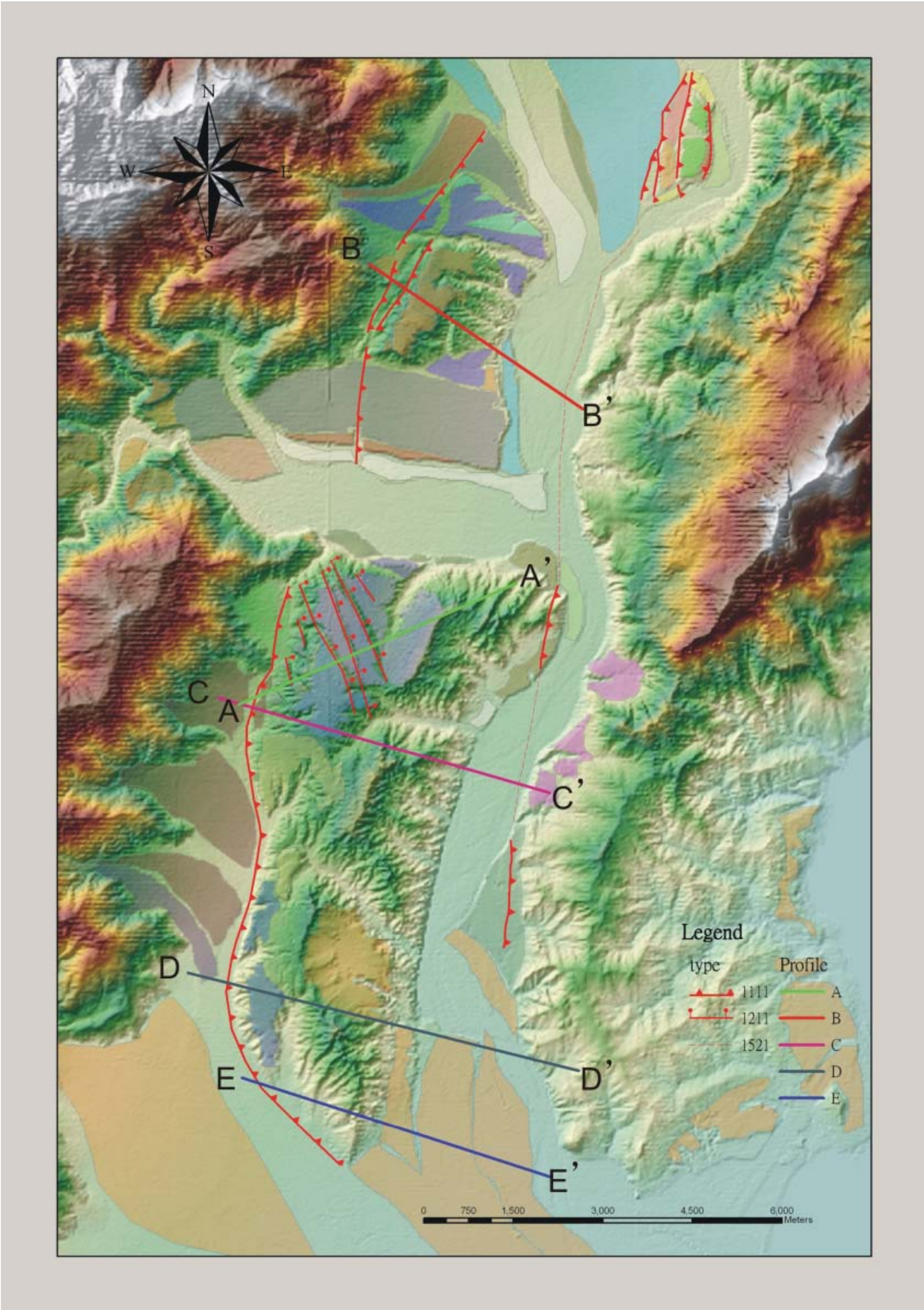

Fig.8 ProfileA , B, C, D, E was label on the surface topography image with sunlight shade.

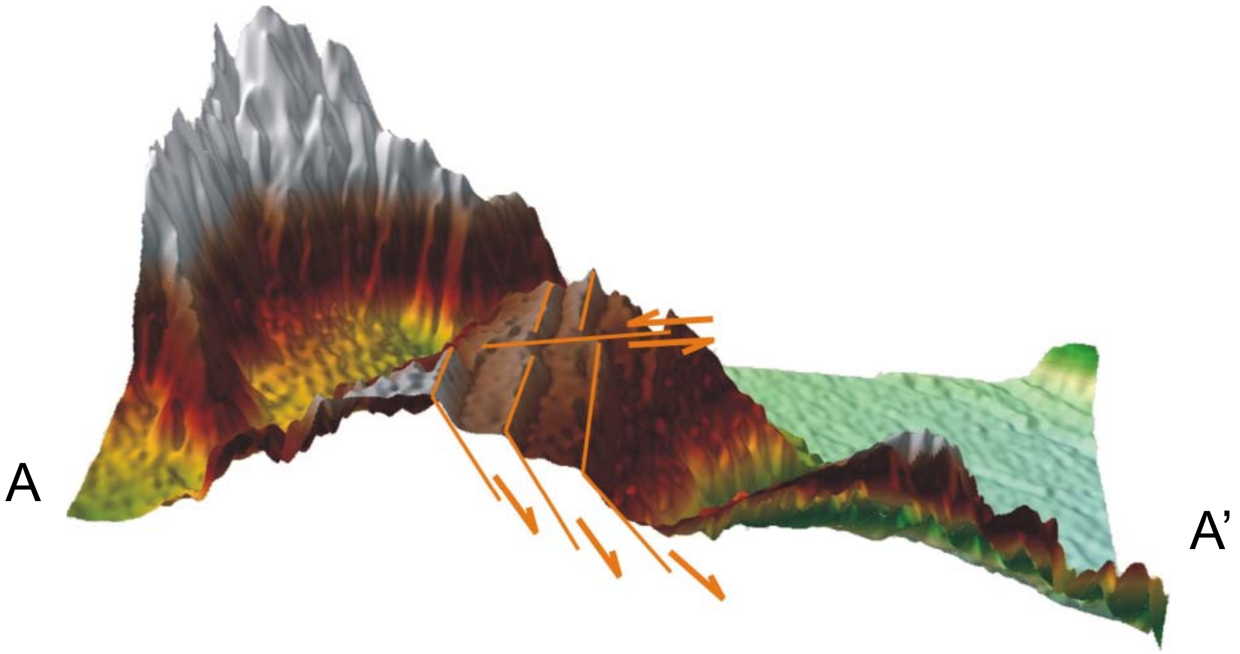

Fig.9 Profile A: 3- D model and subsurface structure sketch map.

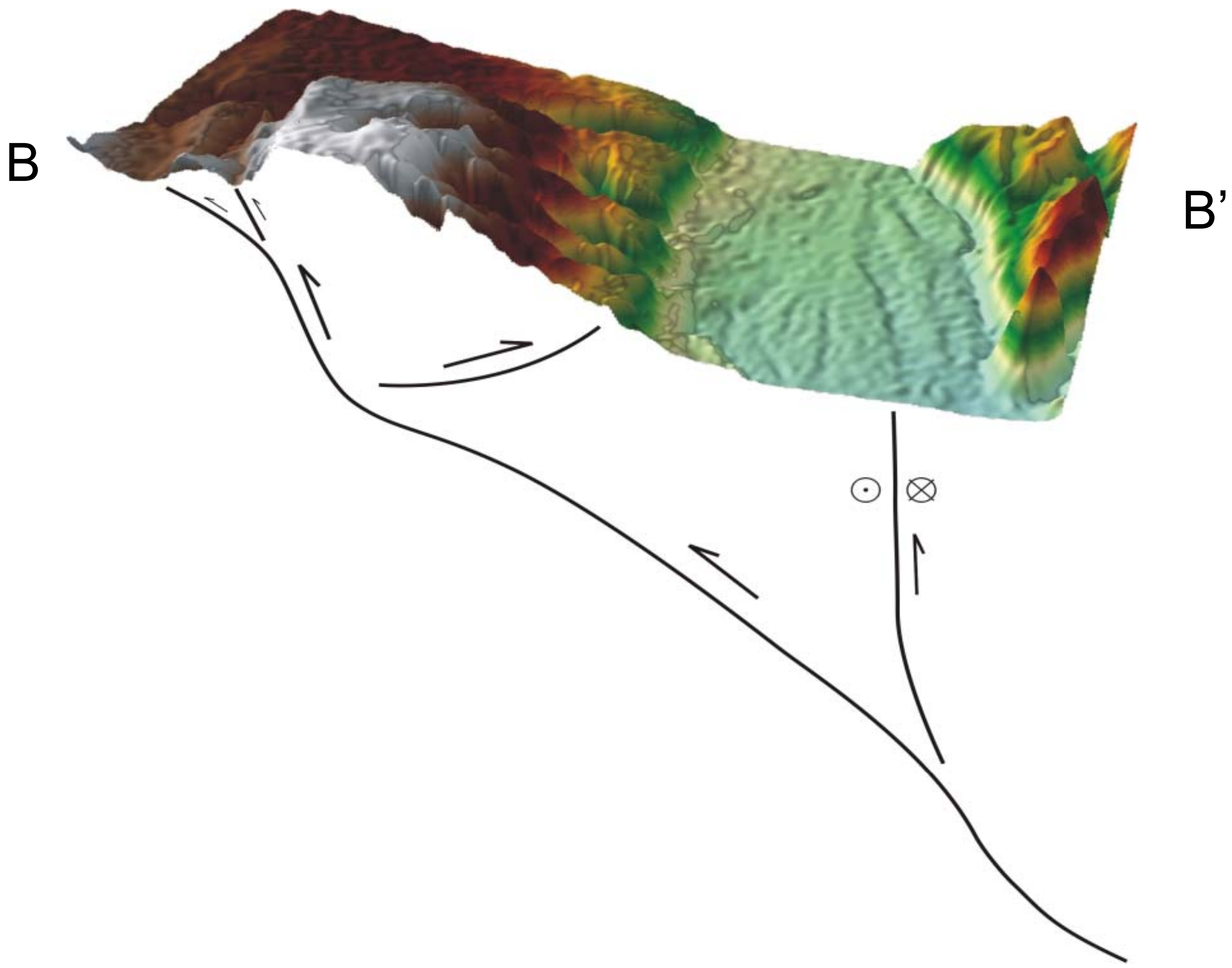

Fig.10 Profile B: 3- D model and subsurface structure sketch map.

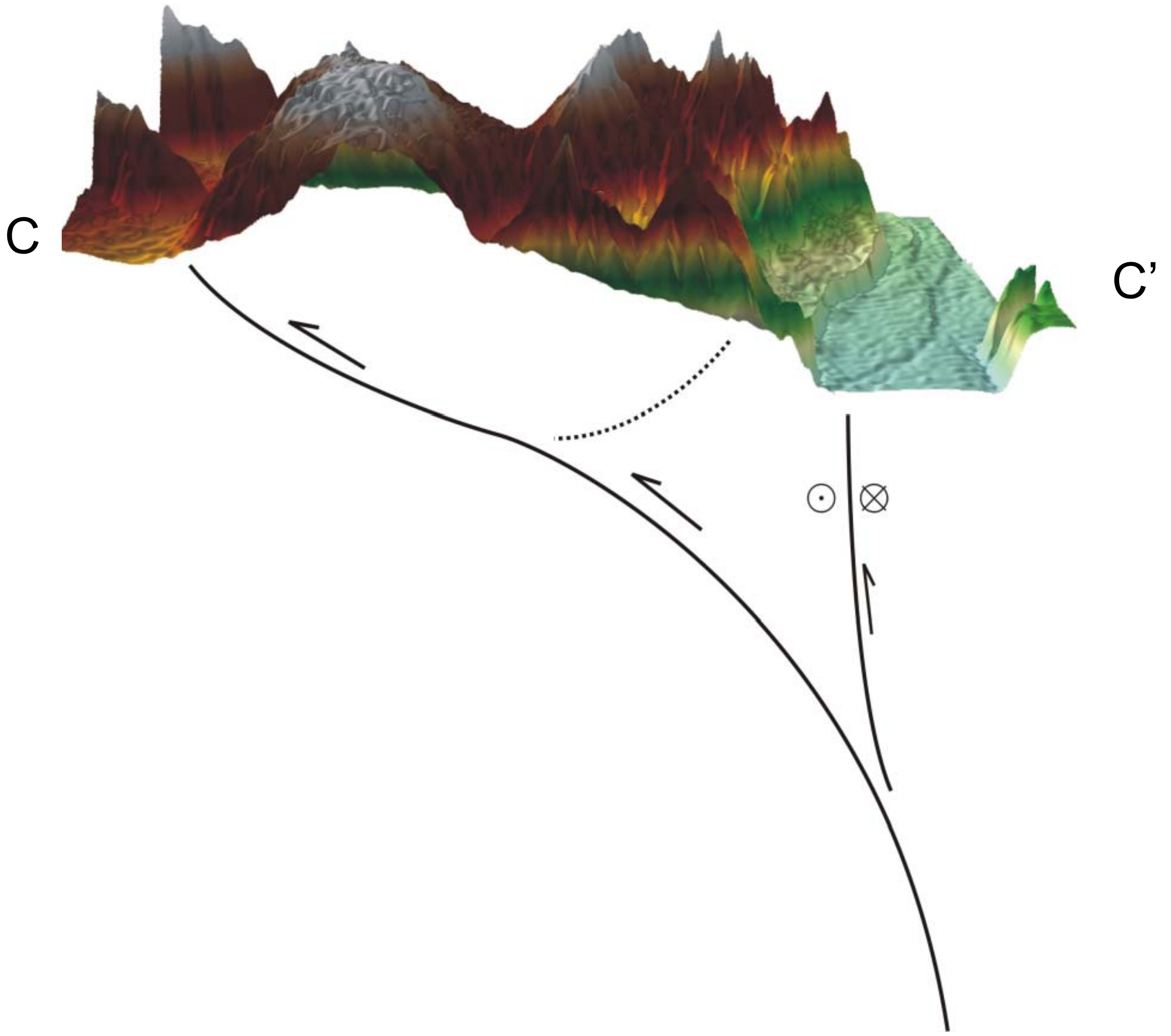

Fig.11 Profile C: 3- D model and subsurface structure sketch map.

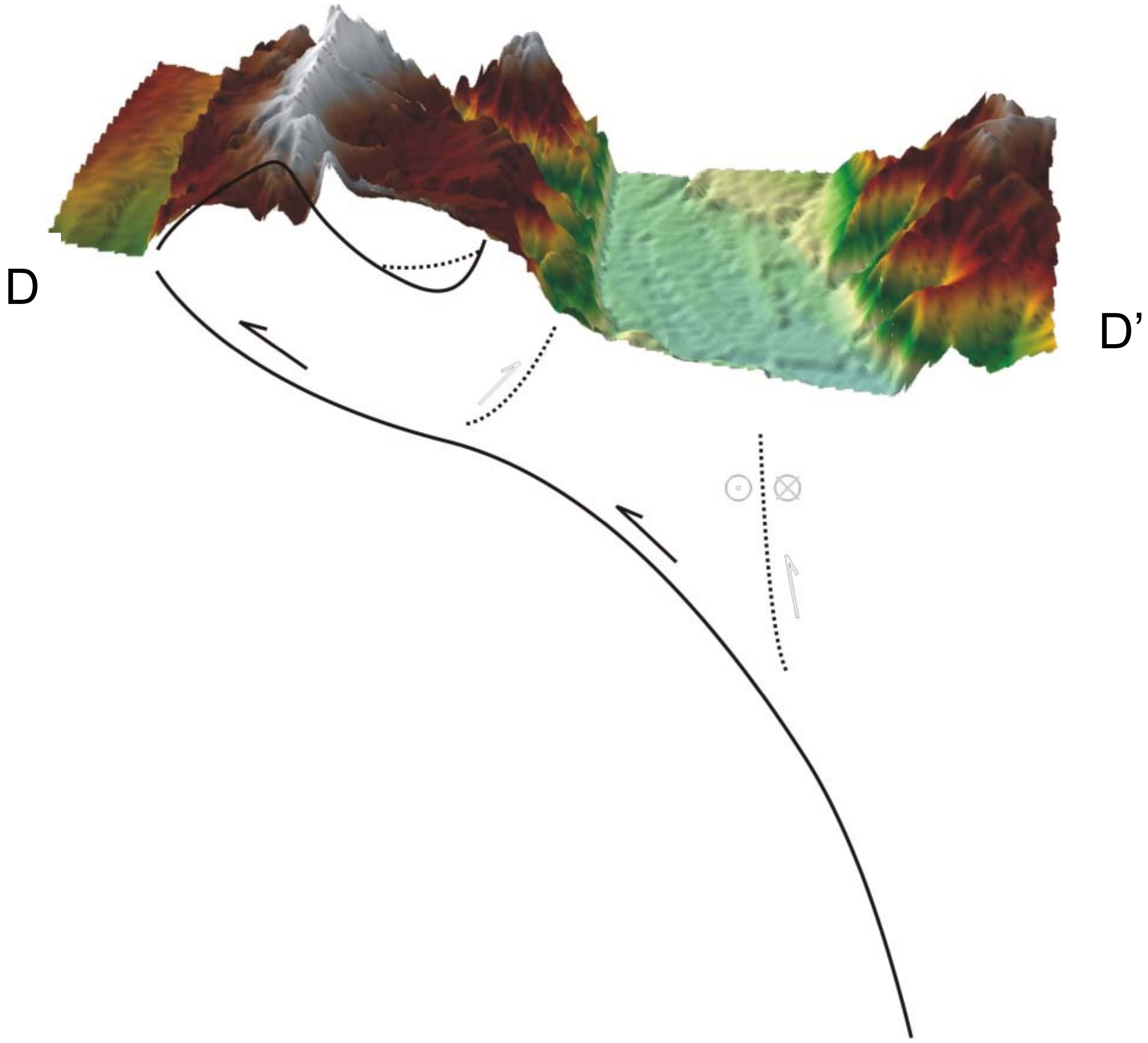

Fig.12 Profile D: 3- D model and subsurface structure sketch map.

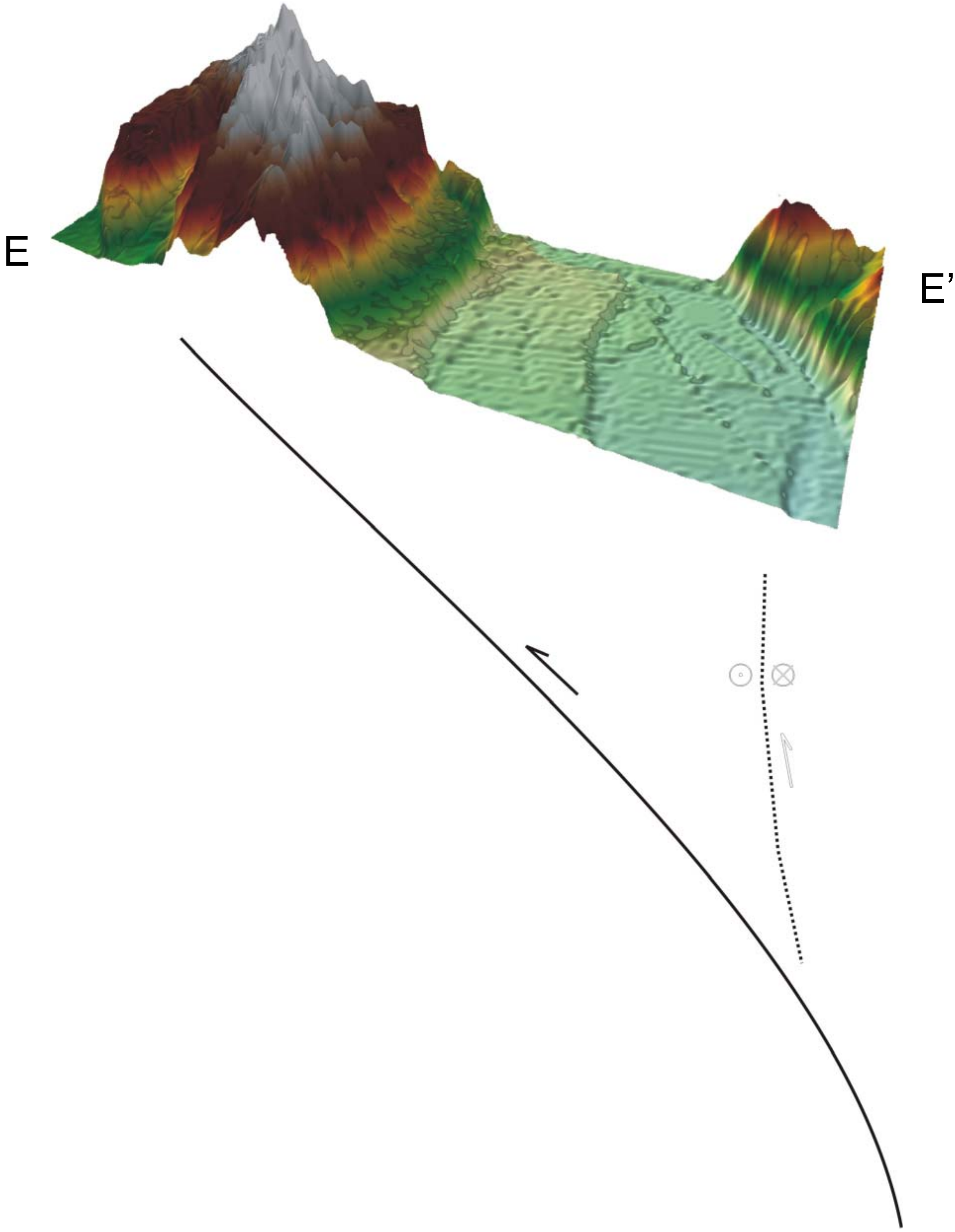

Fig.13 Profile E: 3- D model and subsurface structure sketch map.