

A decorative border surrounds the text, consisting of various mathematical symbols in black and cyan. The symbols include circles (some filled, some hollow), crosses (both black and cyan), and plus signs (both black and cyan). The symbols are scattered around the perimeter of the page.

# Active Structures at the Toe of the West Foothills in Southwestern Taiwan, Tainan

Presenter: Chang-Chih Chen 陳長志

Advisor: Prof. Maryline Le Beon

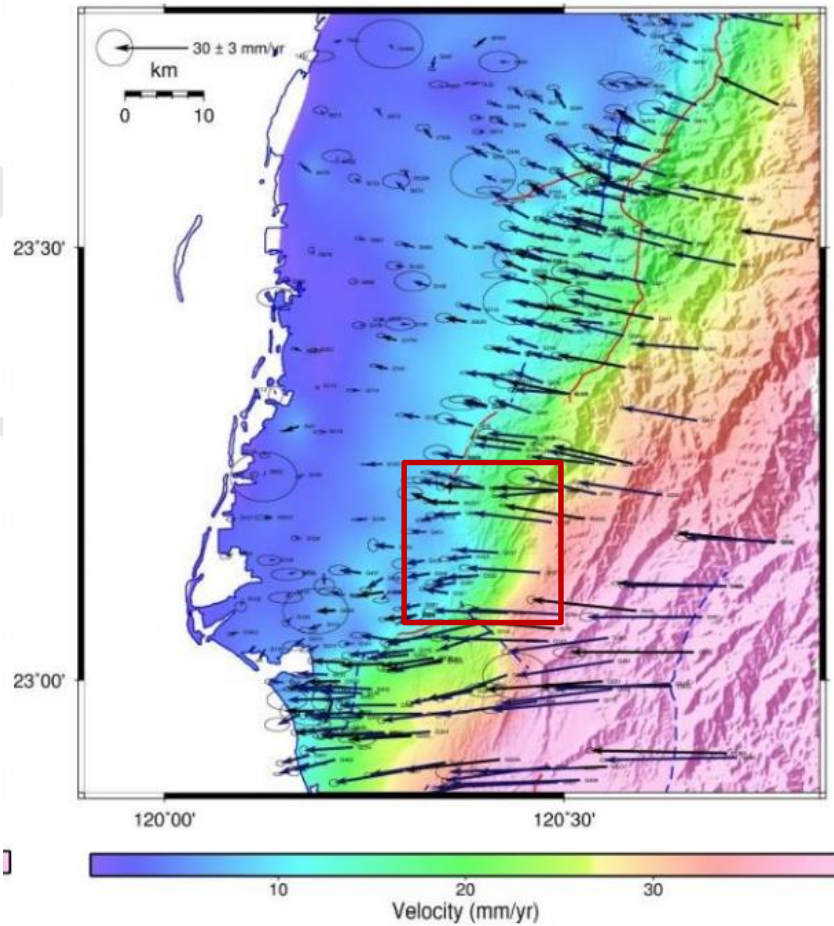
Date: 03/18



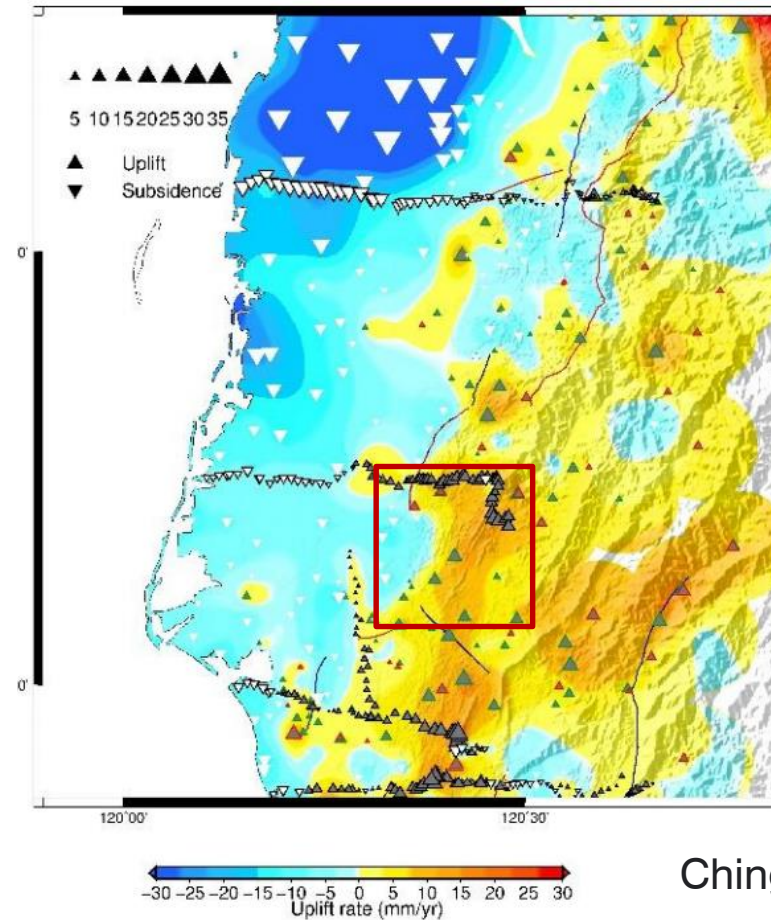
# Introduction

# GPS Velocity

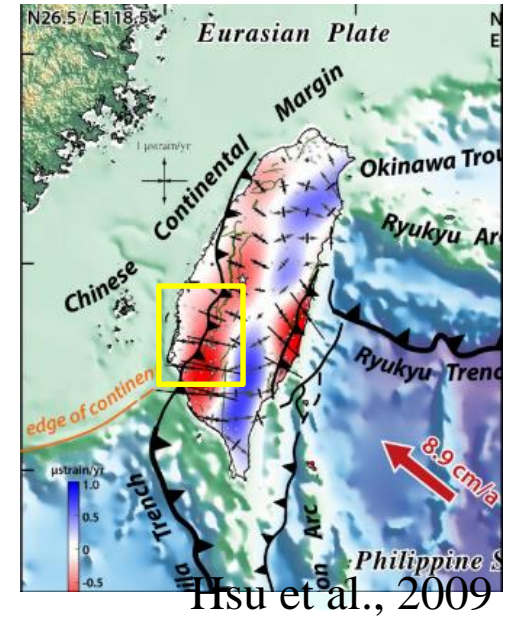
+ Horizontal



+ Vertical



Ching et al., 2018

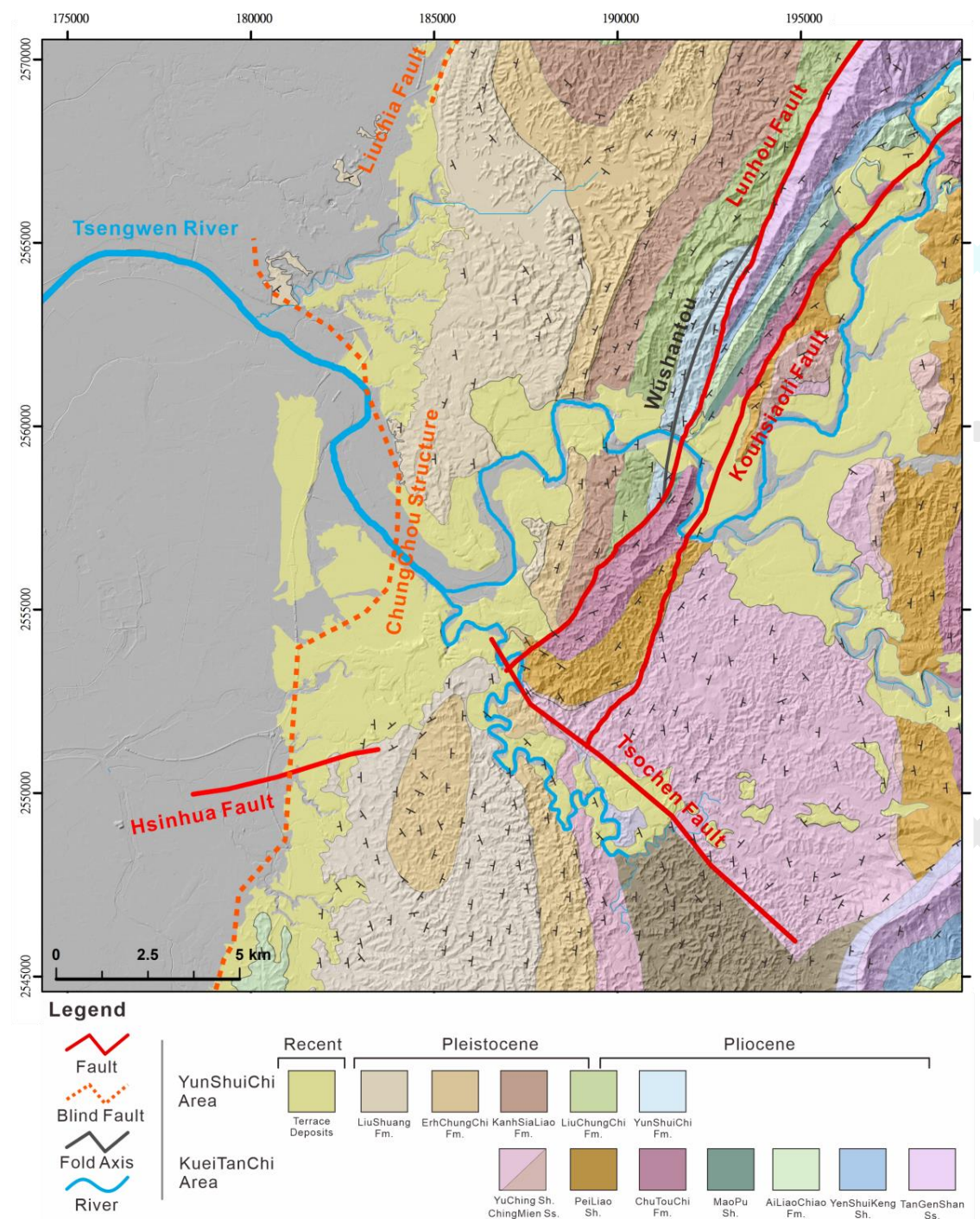


Hsu et al., 2009



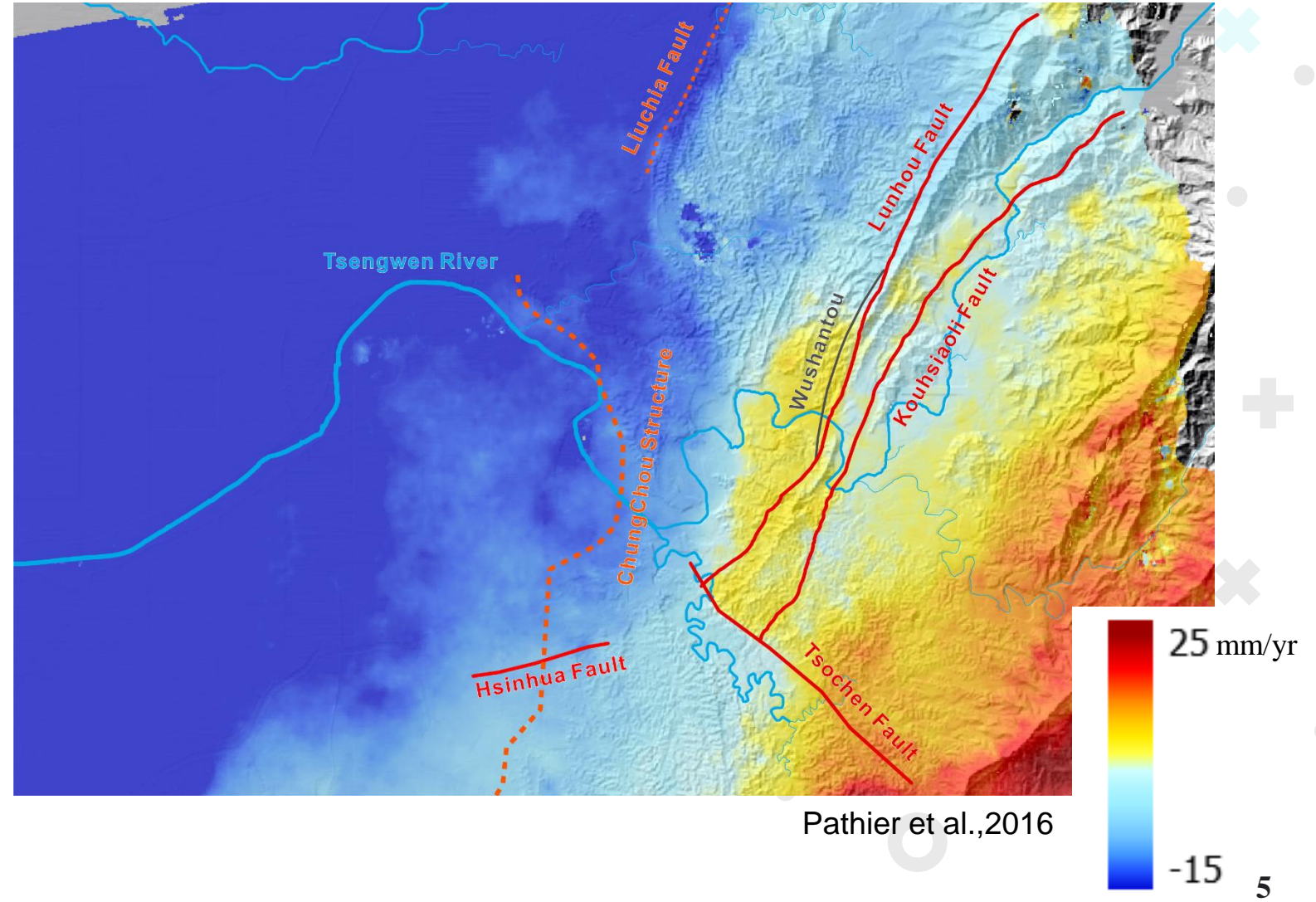
# Geological Setting

- + From West of Wushantou Anticline, the age of the formations change from Pliocene to Pleistocene.
- + The dip angle from West of Wushantou Anticline to East becomes gentle .
- + According to previous studies, there would be blind structures at the toe of the foothills.



# Current Deformation in Southwestern Taiwan

- + The deformation in southwestern Taiwan extends beneath the populous plain.
- + It is important to understand them well for seismic hazard assessment.
- + We are interested in geometry of the structures and their shortening rate.



Pathier et al., 2016

# Aims of the Study

## + Structural Geology

- + Deep Boreholes
- + Seismic Reflection Line
- + Biostratigraphy
- + Surface Geology

+ We want to determine the **geometry**, **shortening rate** of these structure.

## + Geological Cross-sections

## + Holocene Deposits

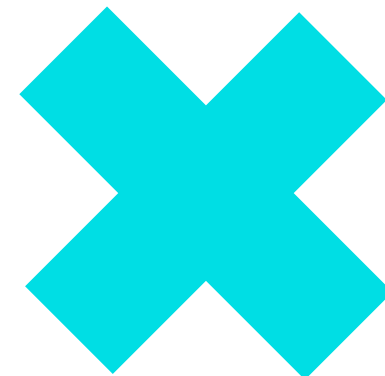
- + River Terraces
- + Shallow Boreholes

## + History of the Deformation





# Methods



# Seismic Reflection Lines

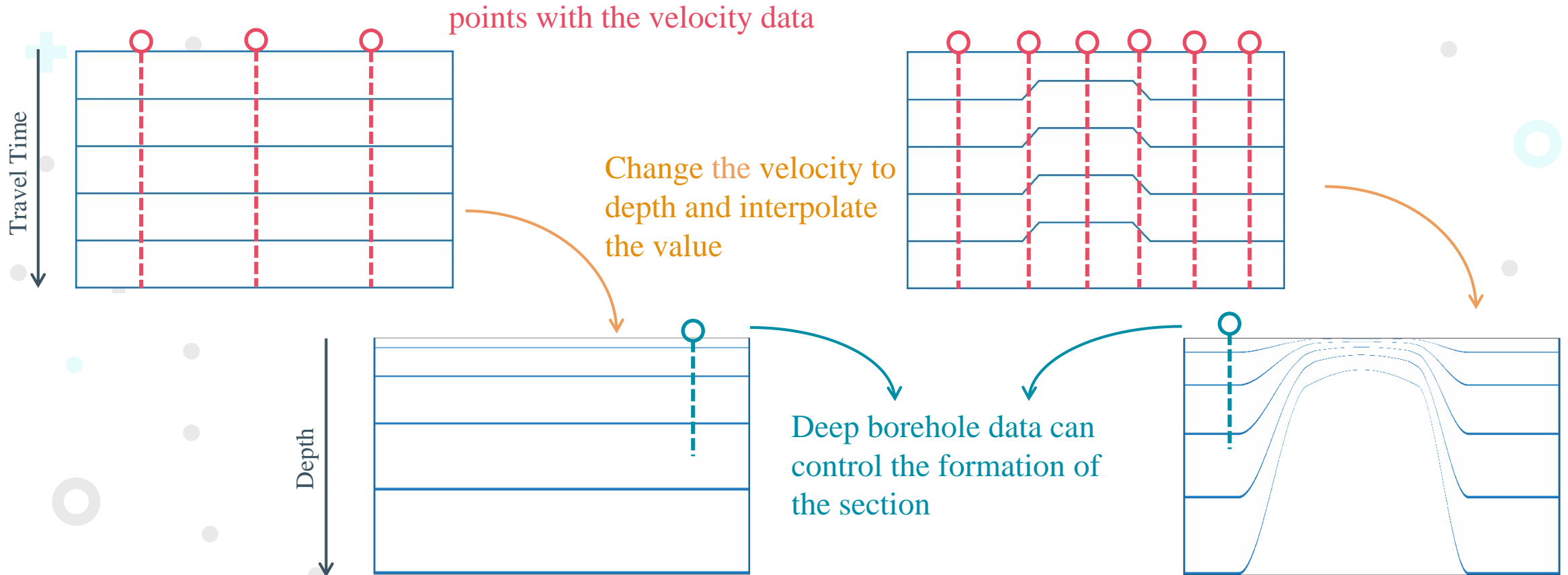
- + The original seismic reflection lines data format is **travel time**. We need to transform it from time to **depth**
- + Using the Matlab code (Burgi et al., 2021) to solve this problem

```
Editor - E:\Study\BurgiMatlab\twt2depth.m
twt2depth.m x +
73 % Originally written by Dana Peterson and Peter Polivka, modified by Paula
74 % Bøgi, April 26, 2016
75
76 %% Parameterize Image
77
78     timeImJPG      = imread( timeIm );
79     [Npix,Mpix,Cdepth] = size( timeImJPG );
80     load(DataFits); %structure named DataFits
81
82 %Determine which velocity curve(s) to use for image
83
84     if exist( sprintf( 'VelModelInputs/vel_imnum_%s.mat', timeIm(1:end-4) ) ) == 0
85
86         imshow( timeImJPG );
87         [xcol,ycol] = ginputc;
88         vel_imloc   = [ round(xcol) round(ycol) ];
89         filler      = input( ' ');
90         velnum      = input( 'Which velocity curve(s) from DataFits?: ' );
91         save( sprintf( 'VelModelInputs/vel_imloc_%s', timeIm(1:end-4) ), 'vel_imloc' );
92         save( sprintf( 'VelModelInputs/vel_imnum_%s', timeIm(1:end-4) ), 'velnum' );
93
94         close
95
96     else
97
98         load( sprintf( 'VelModelInputs/vel_imloc_%s', timeIm(1:end-4) ) );
99         load( sprintf( 'VelModelInputs/vel_imnum_%s', timeIm(1:end-4) ) );
100
101     end
102
103 % Relate velocity curve(s) to image
104
105     nVelCurve      = length( velnum ); % number of assigned velocity curves
106     pixLocVC       = vel_imloc(:,1); % column index for each assigned velocity curve
107     nVelPts        = nan( 1,nVelCurve ); % number of points used from each chosen vel curve
108     pix            = []; % row index for TWTT from velmodels, stacked
109     vels           = []; % velocity for each TWTT from velmodels, stacked
110
111     for i=1:nVelCurve
```



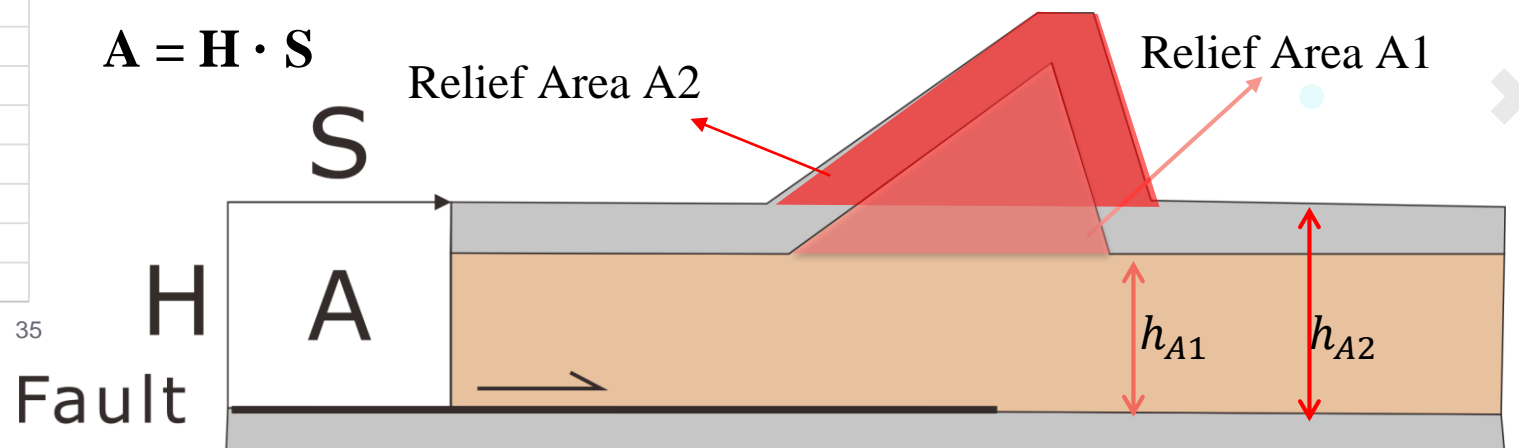
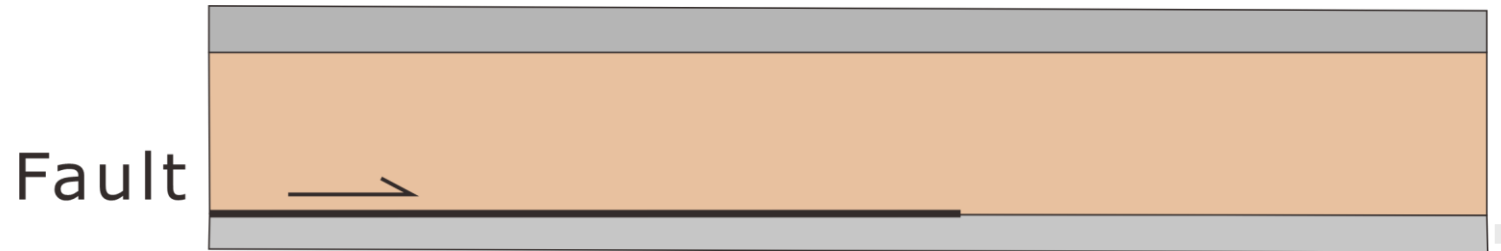
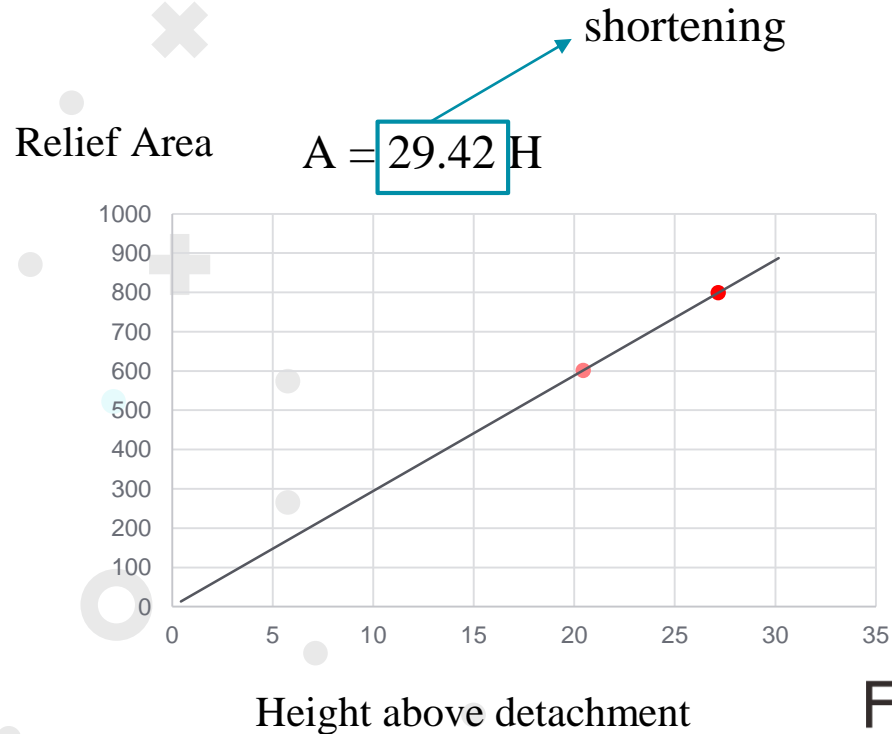
# Seismic Reflection Lines

+ Using the velocity curve to transform the seismic line from travel time to depth



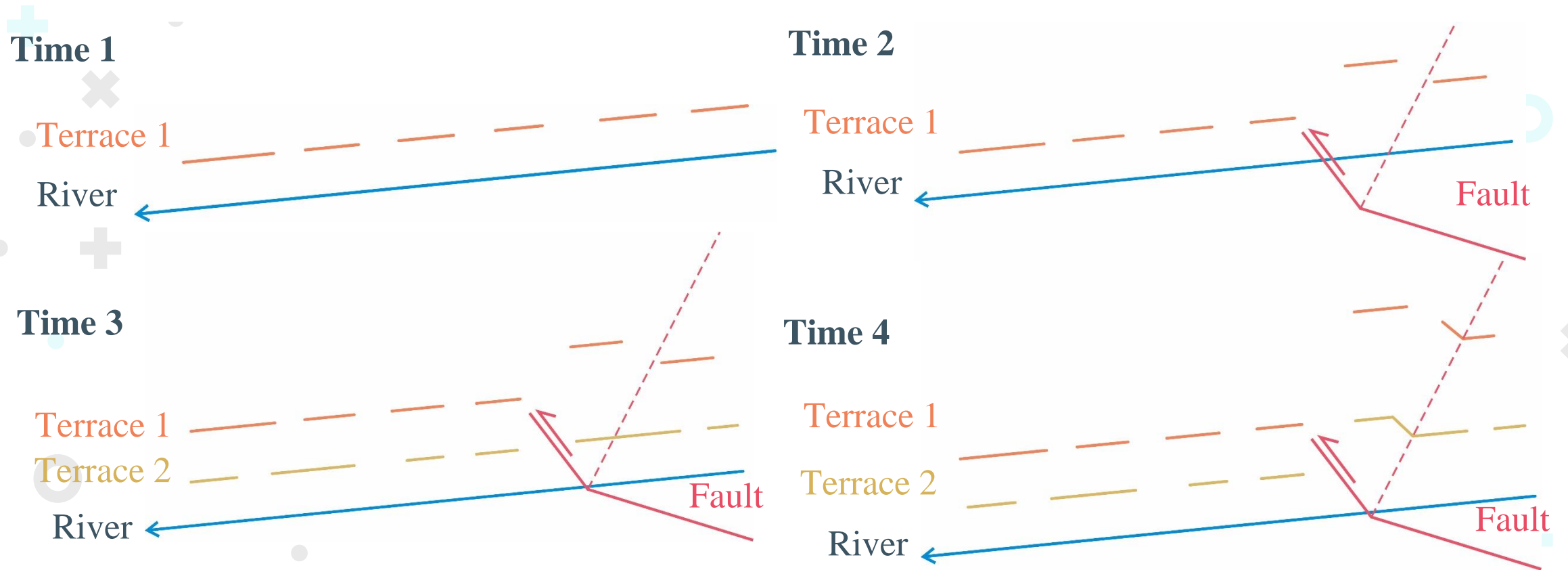
# Relief Area Analysis

- + We can find the deformed layers from the seismic lines and use the relief area of different layers to calculate the shortening.



# River Terraces

+ Using the terraces for which we have **dating data** and comparing their **height above the river bed** allows us to quantify the deformation.



# River Terraces

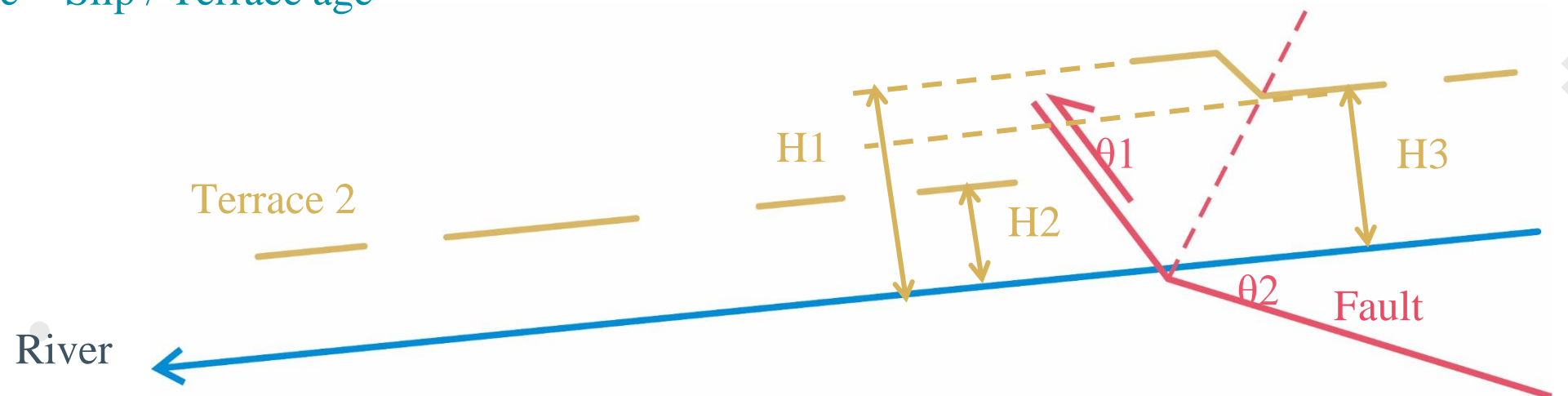
- + Based on the dating data and the height of the terraces, we can calculate the **uplift** .
- + If we have the orientation of the fault, we can also calculate the **shortening** .

✕  $H1 - H2 = \text{Uplift}$

$\text{Uplift} = \text{Slip} \times \sin \theta$

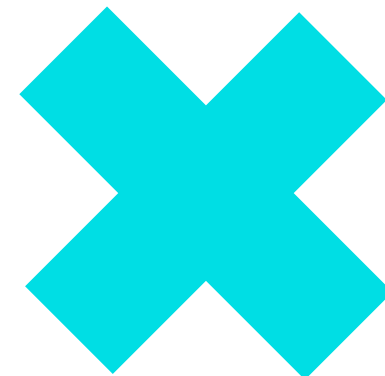
✕  $\text{Slip Rate} = \text{Slip} / \text{Terrace age}$

$$\begin{aligned} \text{Slip} &= (H1 - H2) / \sin \theta_1 \\ &= (H3 - H1) / \sin \theta_2 \end{aligned}$$



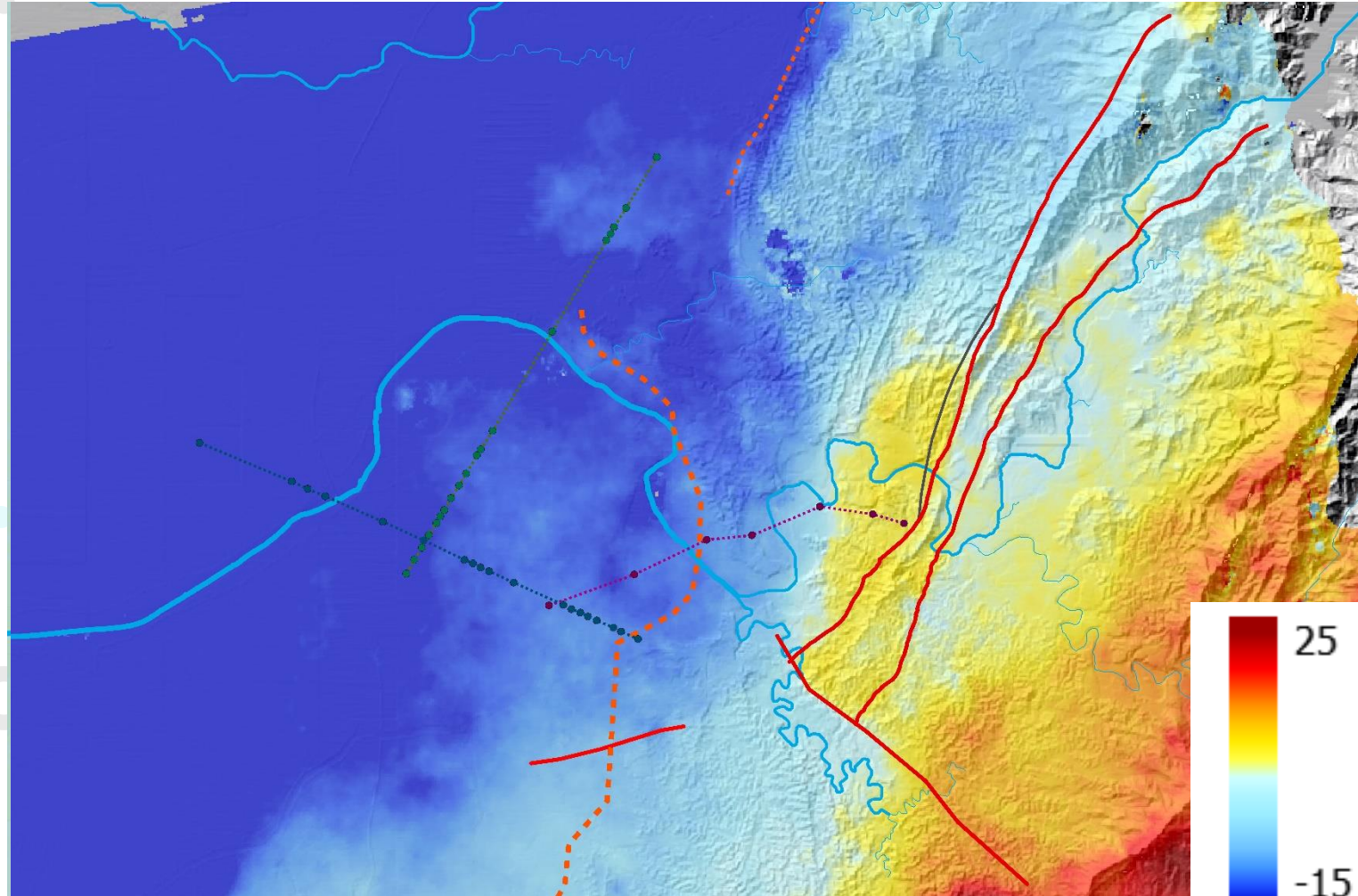


# Results



# CPC Seismic Reflection Lines

+ We get three seismic reflection lines at our study area.



80-LTSH-D3



80-KM-V1



81-LTHS-DB



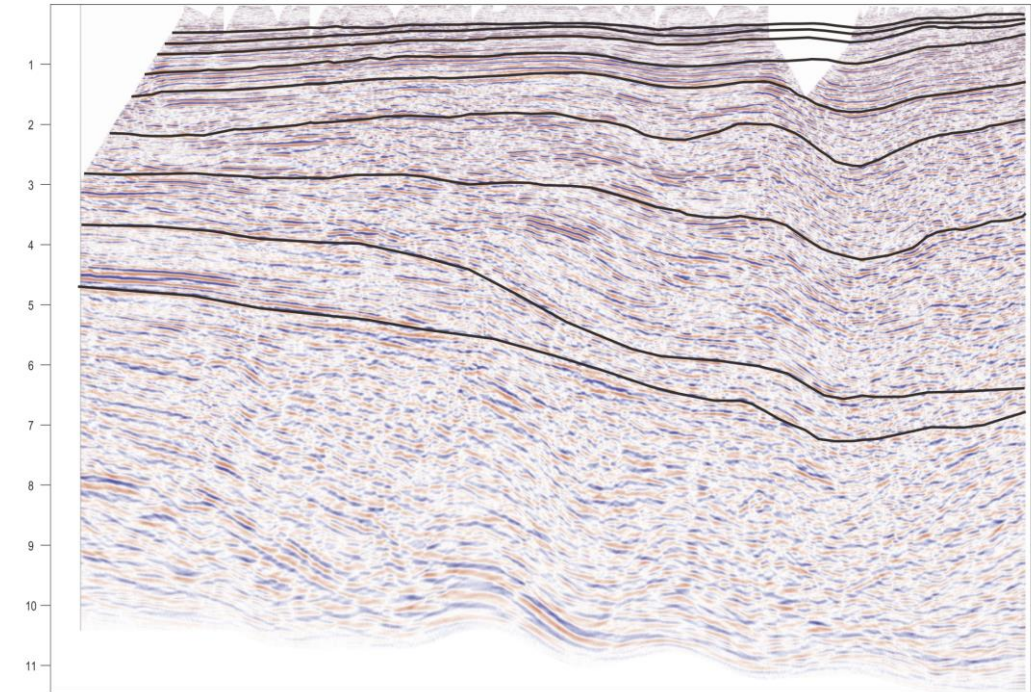
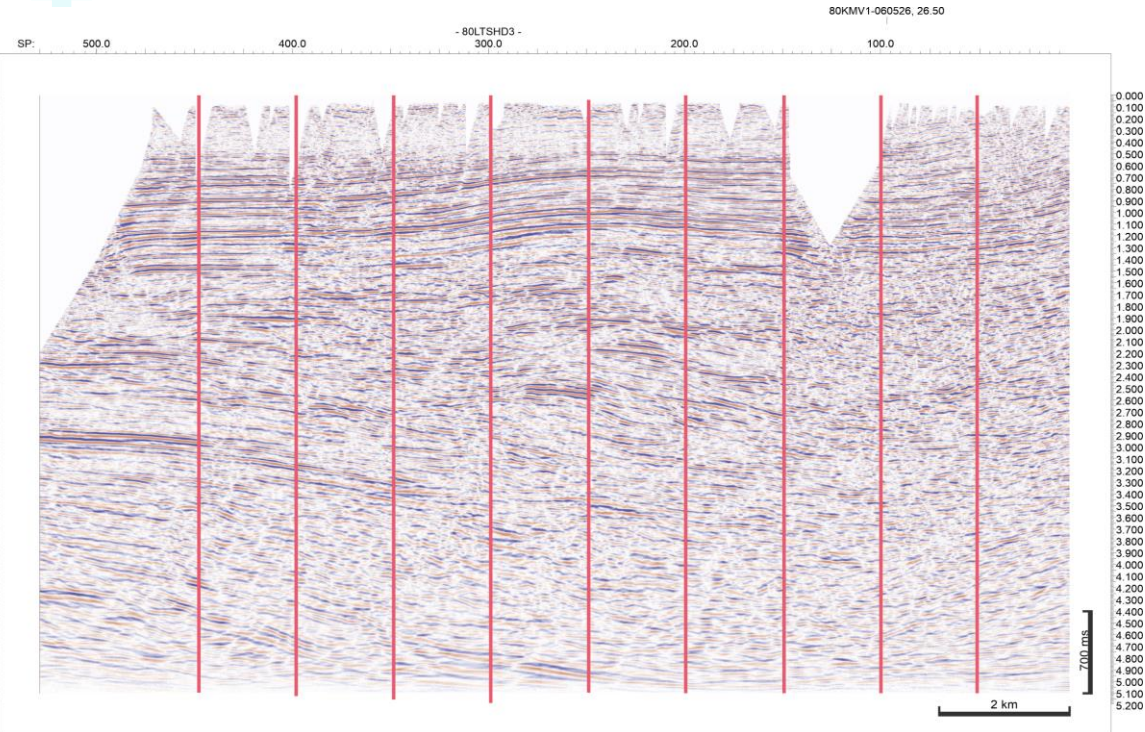
# CPC Seismic Reflection Lines

+ Transformed travel time to depth and tried to draw the layer to quantify the deformation

+ **Travel Time**

Points with velocity data

+ **Depth**



80-LTSH-D3

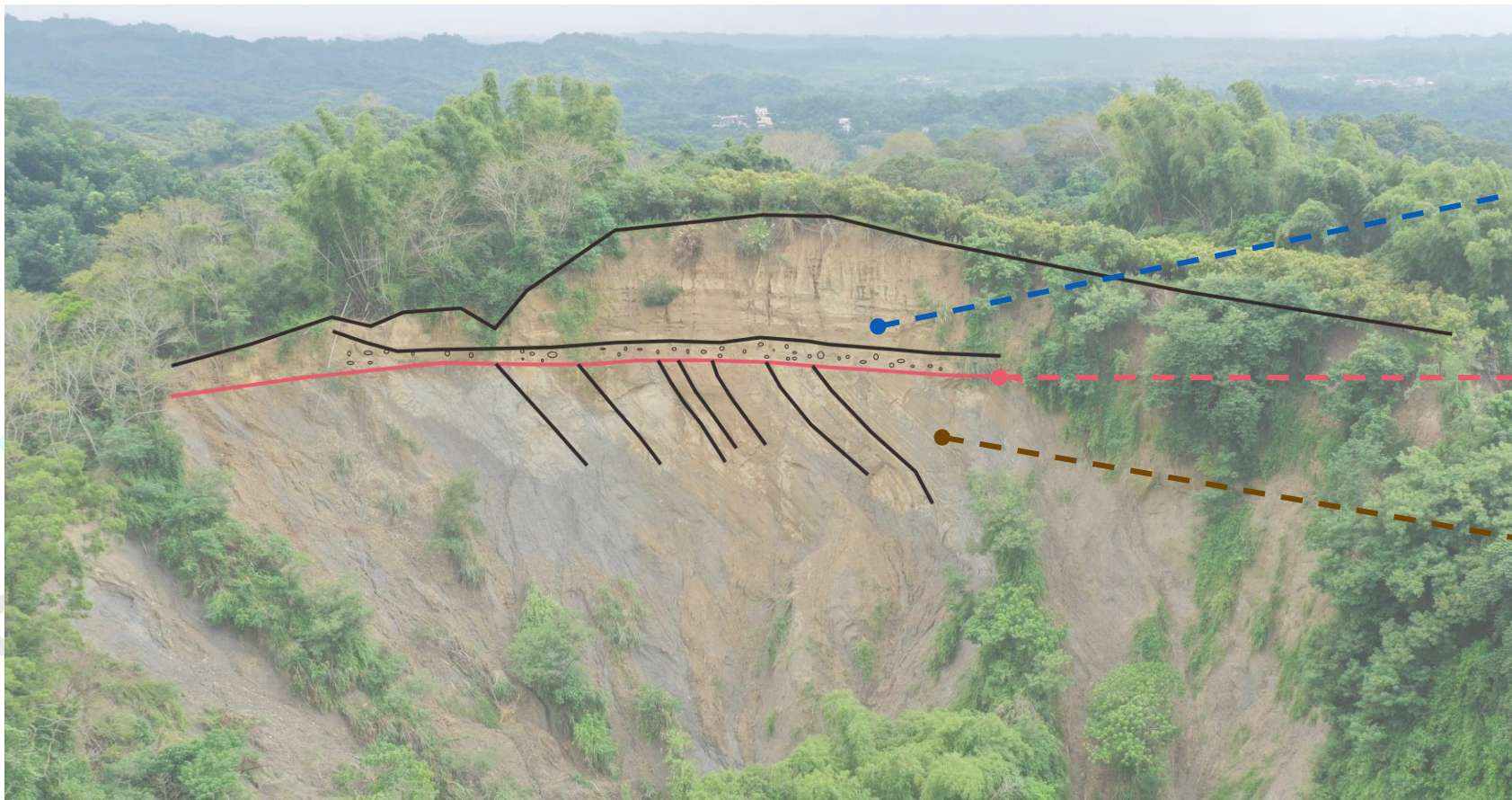


# Tsengwen River Terraces

Charcoal  
C-14 dating



+ Finding the strath and collecting the dating samples in the river deposit.



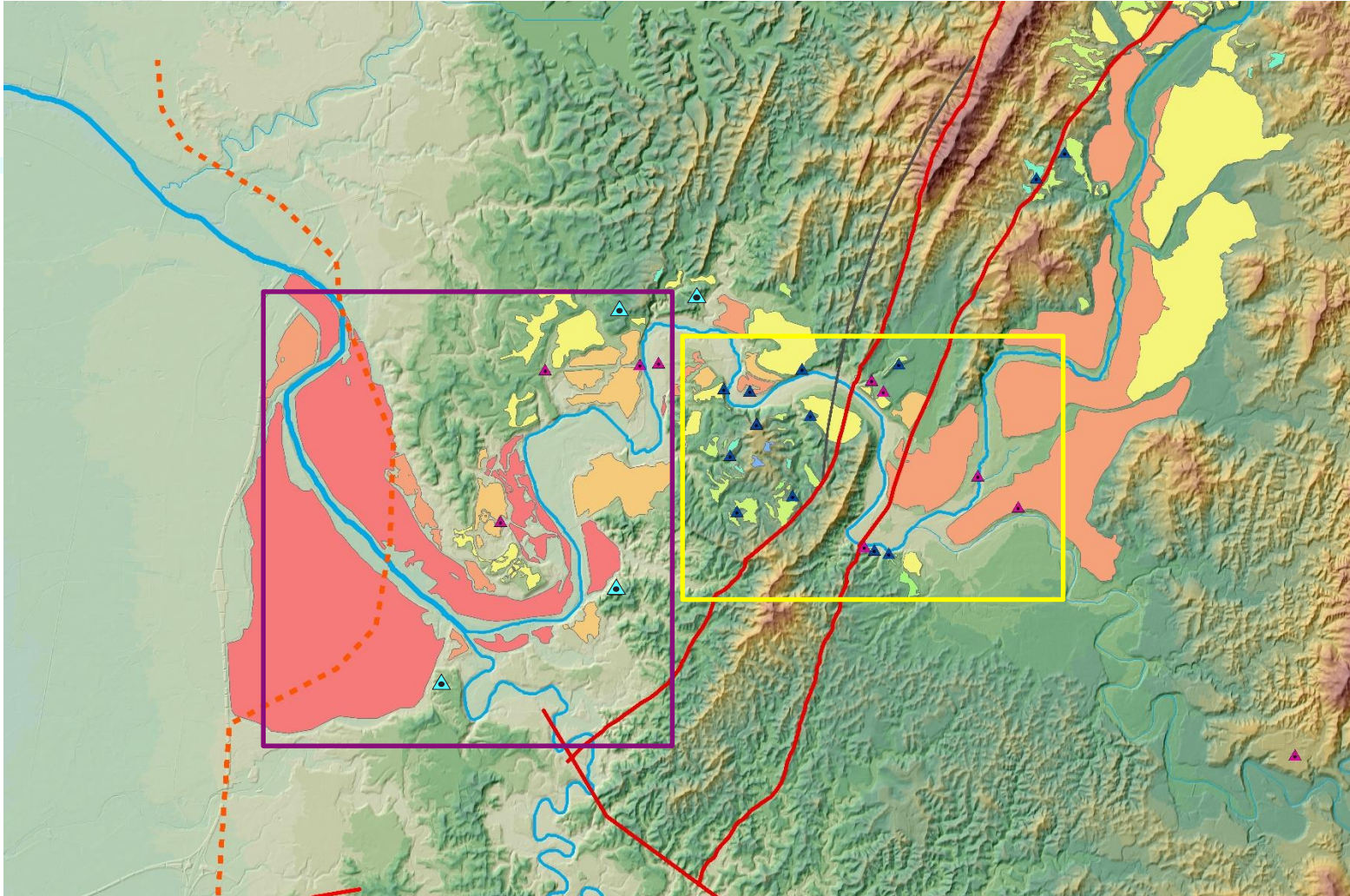
River Deposit

Strath

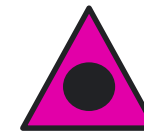
Bedrock



# Tsengwen River Terraces



+ We classified different terraces and collected the dating samples at different terraces



Dating points from ML Hsieh



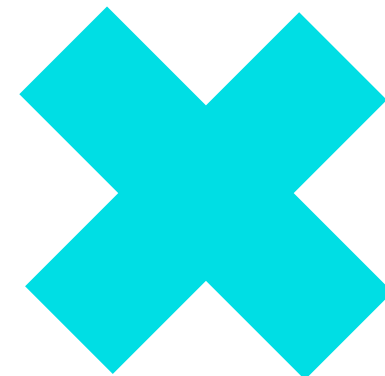
Dating points from JW Shih



Dating points from my study

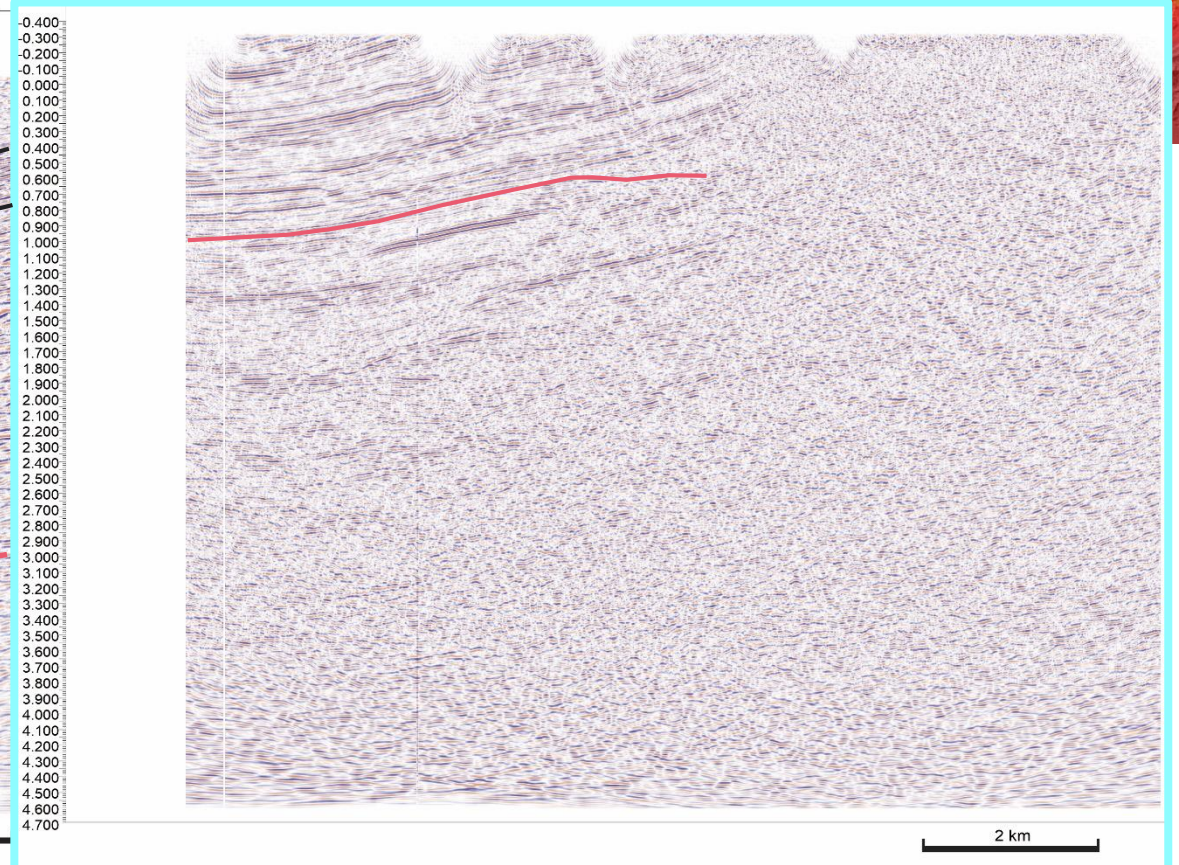
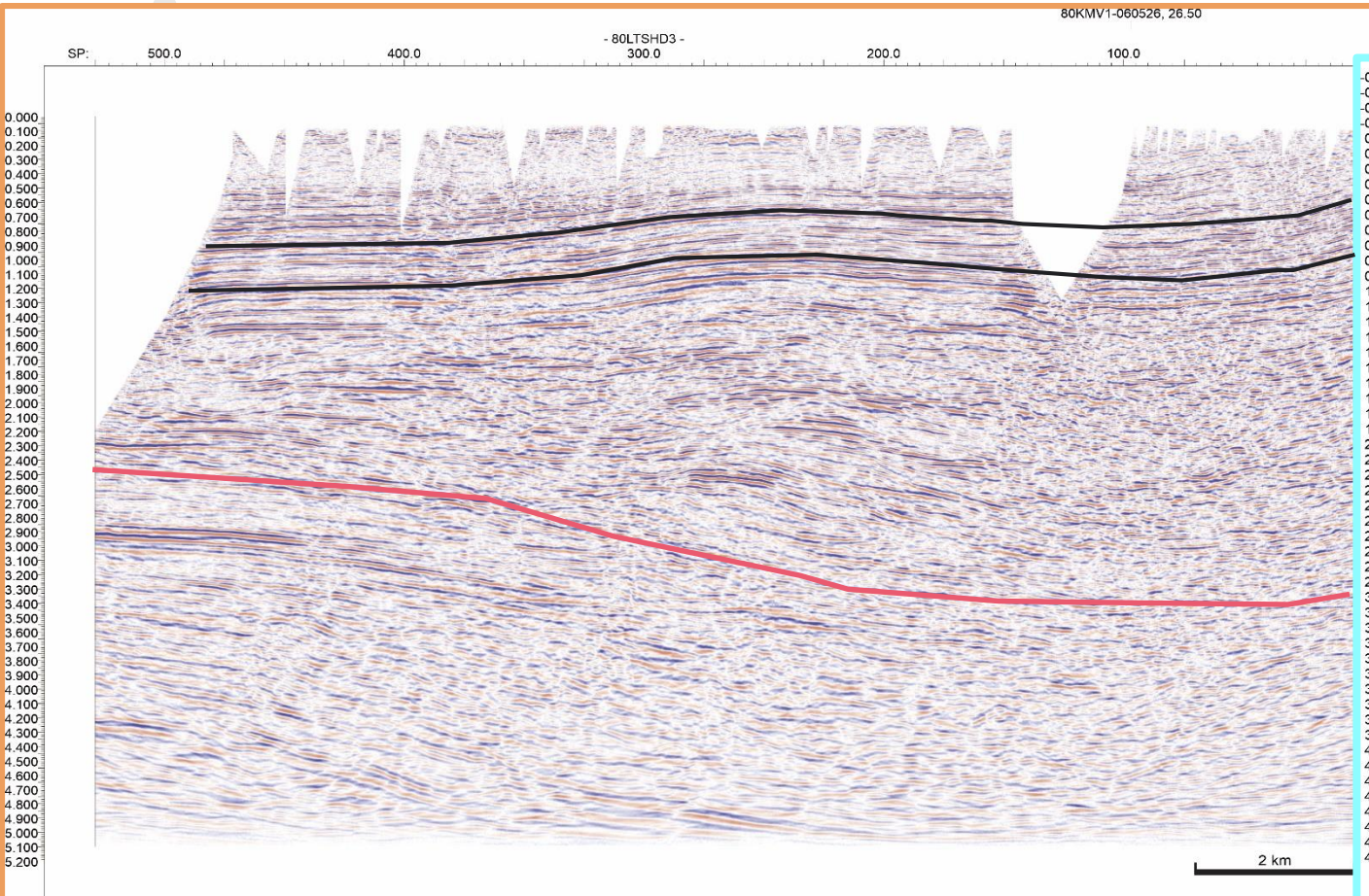
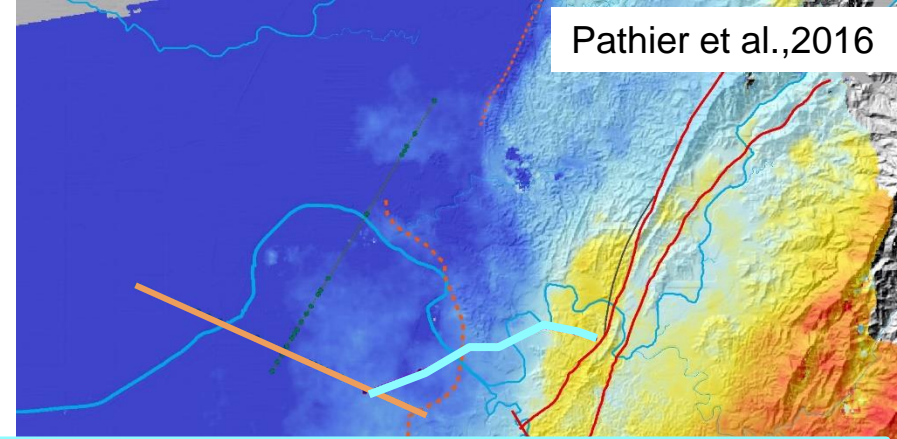


# Discussion





# Deformation at the Plain

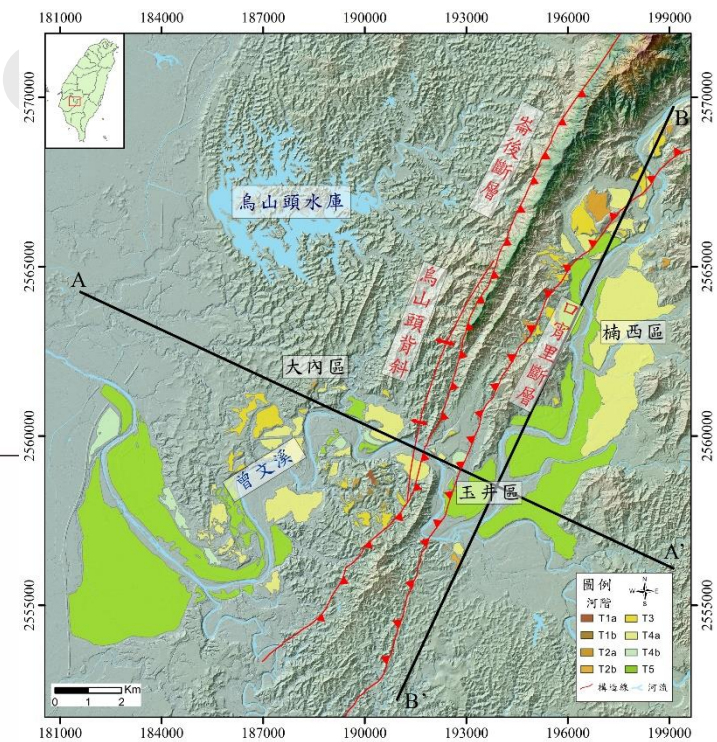
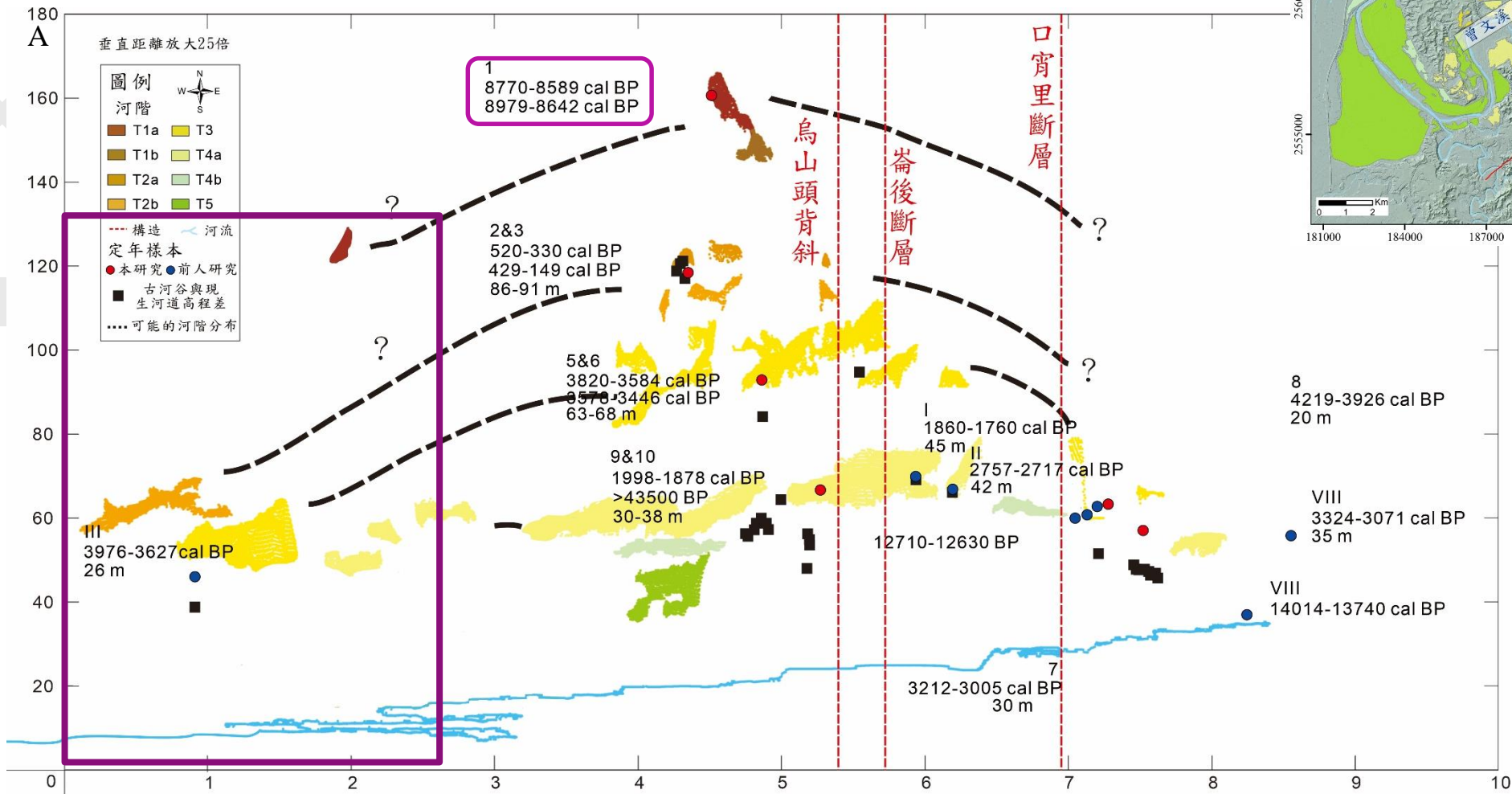


+ The seismic data can see the fold and it matches well with the InSAR data



# Terraces Projection

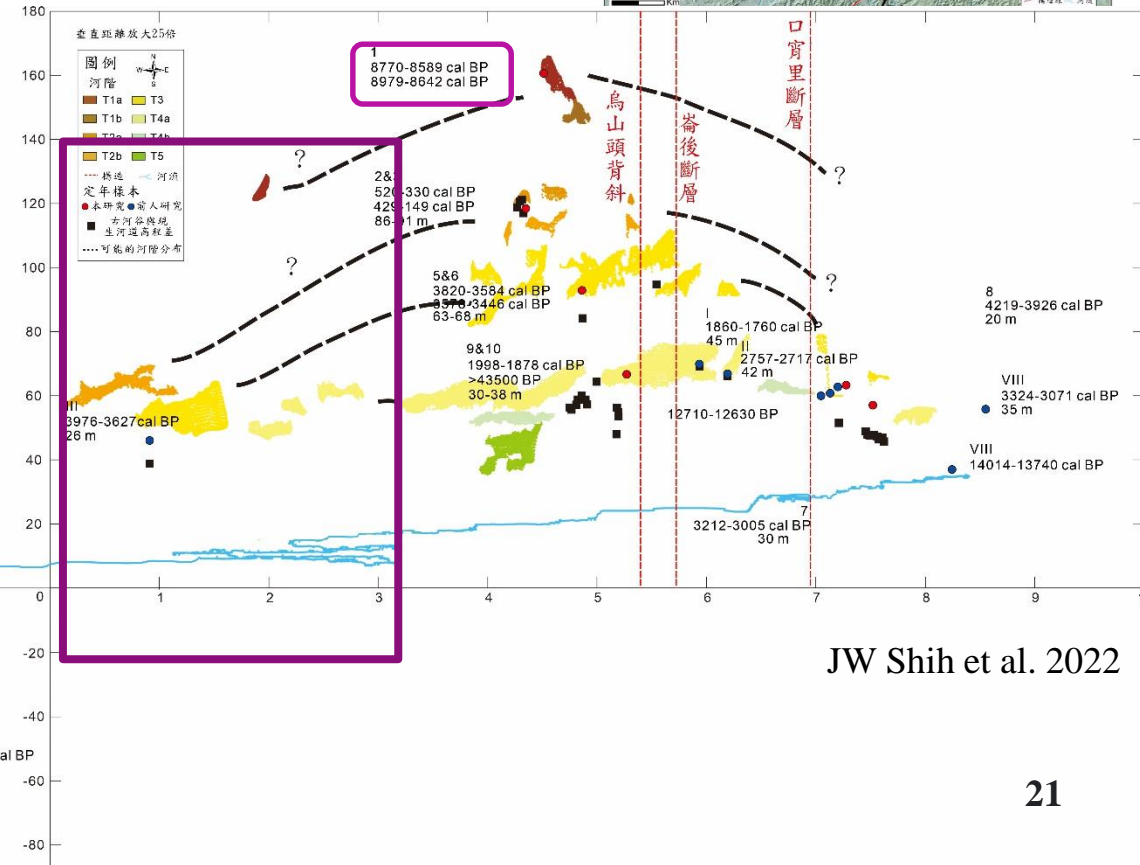
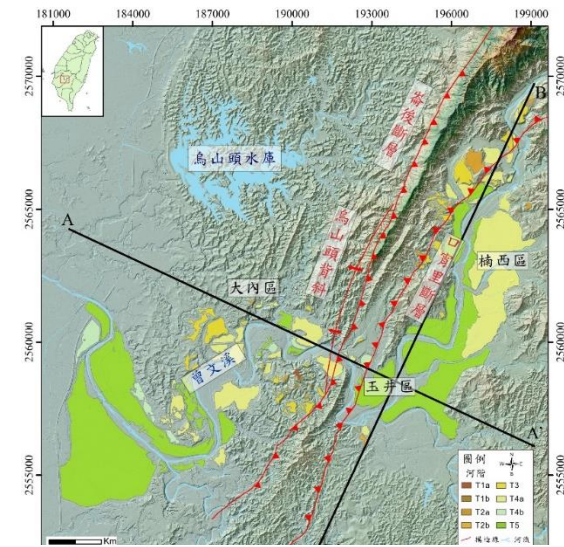
+ From previous studies we can find out the terraces can show the deformation of the structure.





# Terraces Projection

- + We correlate the shallow boreholes dating results and the terraces ages and find out that they have more than 100m different.
- + And we can find out that the downstream still active compare to the coastal plain.
- + We need to get more samples at the downstream to understand how the deformation change from hill to coastal plain.



JW Shih et al. 2022

# Conclusions

- + Based on the Seismic Reflection Lines we can see that the **geometry of the fold** fits well with the InSAR data.
- + ChungChou Structure maybe is a **detachment**, but not a reverse fault.
- + Tsengwen River terraces and shallow boreholes in the coastal plain can show the **deformation** of the structures, but we need more dataing data at the downstream to **correlate the terraces** from upstream to downstream.

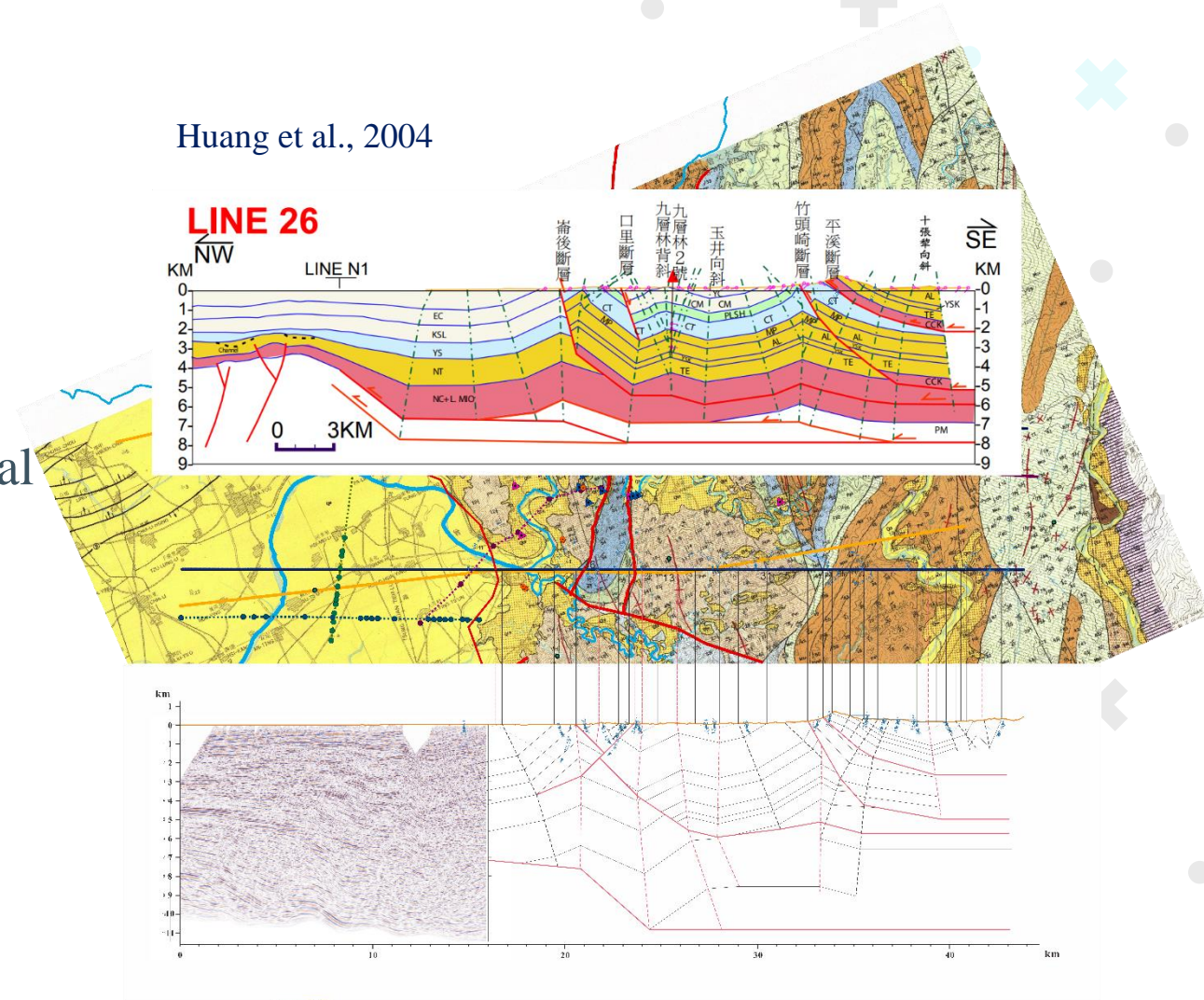


# Future Works

# Future Works

- + Go to field to get the more precise elevation of the strath by RTK and total station
- + Finish drawing the seismic lines
- + Combine all the data to draw the geological cross-sections and quantify the shortening

Huang et al., 2004





**Thank You For Listening**