Deformation mechanism and behavior of the Chegualin active fault in SW Taiwan

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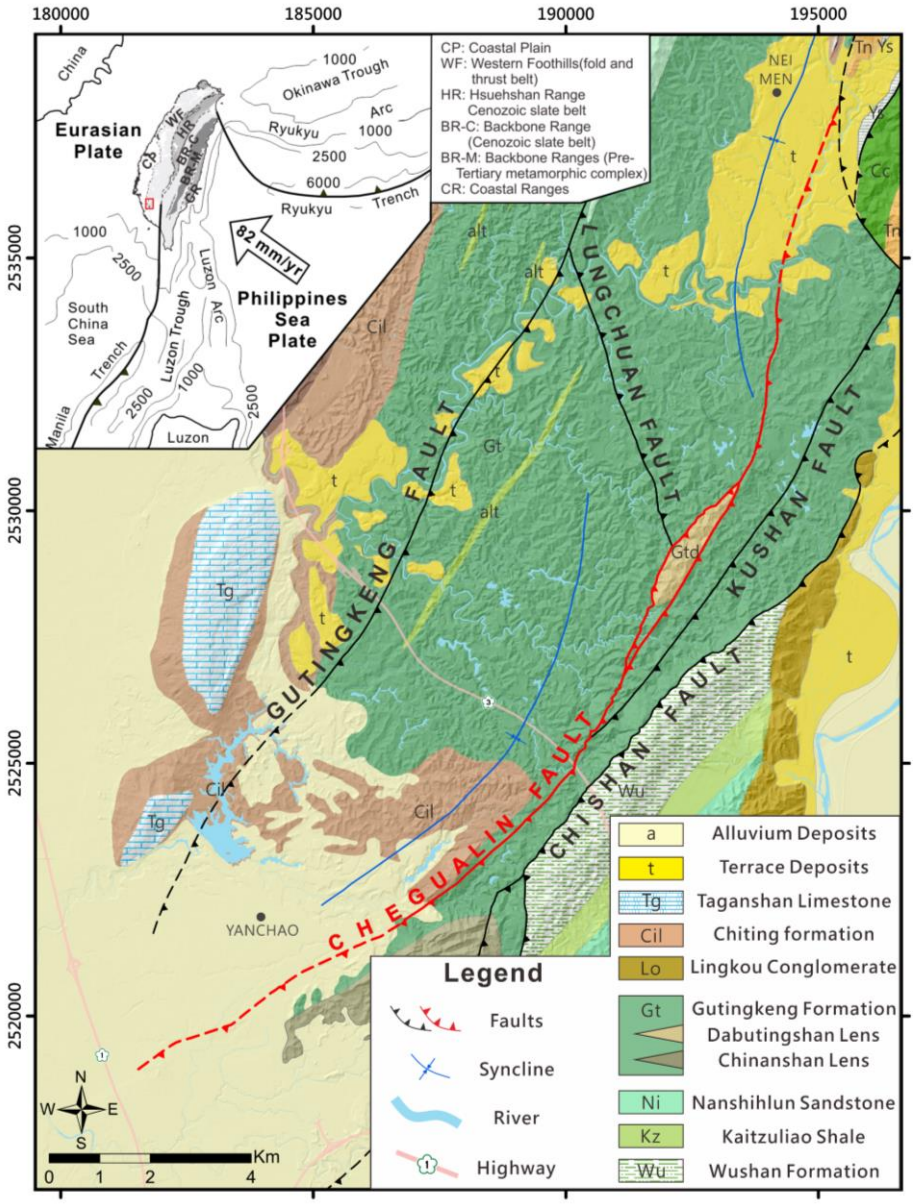
Advisor: Wen-Jeng Huang

Date:2022.10.28

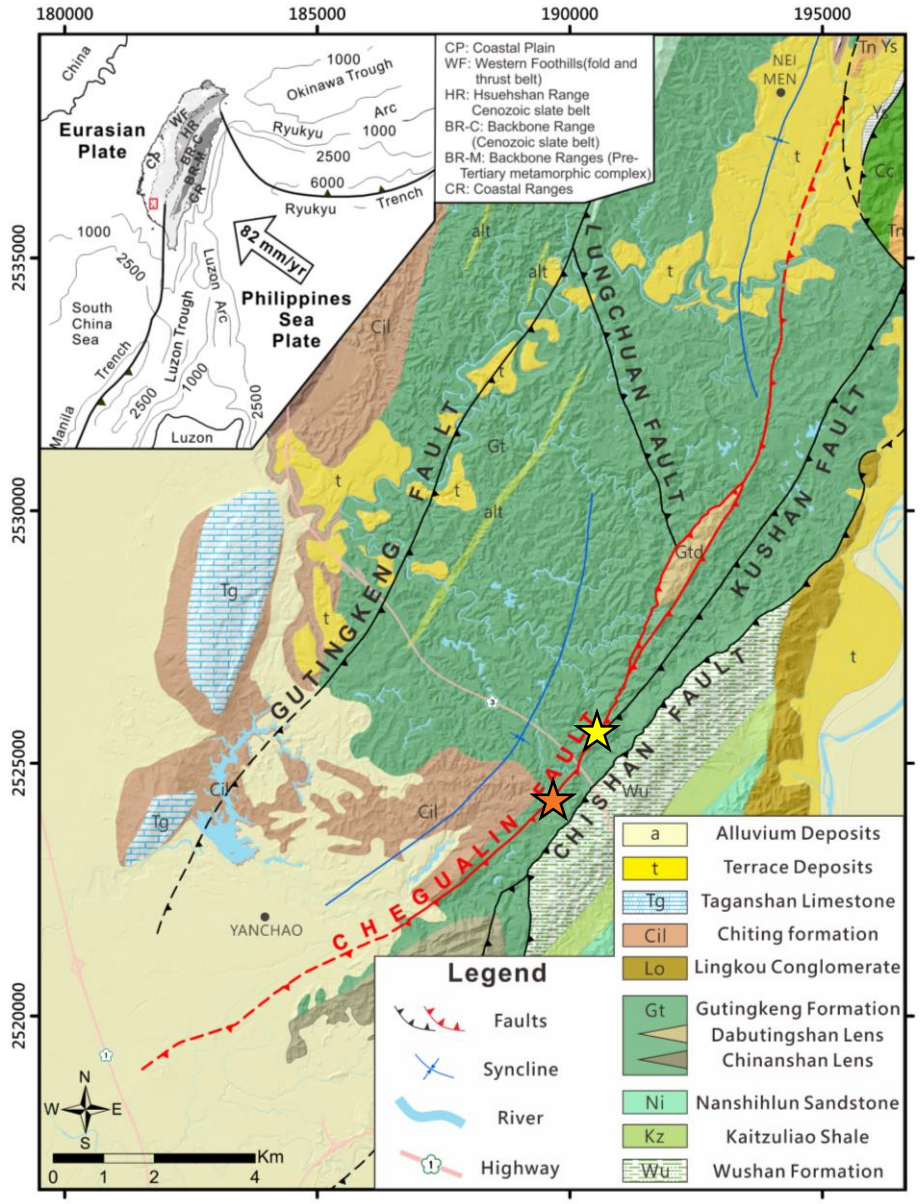
Introduction



(Modified after CGS, 2013; Lin et al., 2021)

- Chegualin fault is a thrust fault, striking NE-SW and dipping 30° to the east.
- Most of the fault trace is located within the Gutingkeng Formation.
- Gutingkeng formation is mainly composed of massive mudstone.

Research area and motivation



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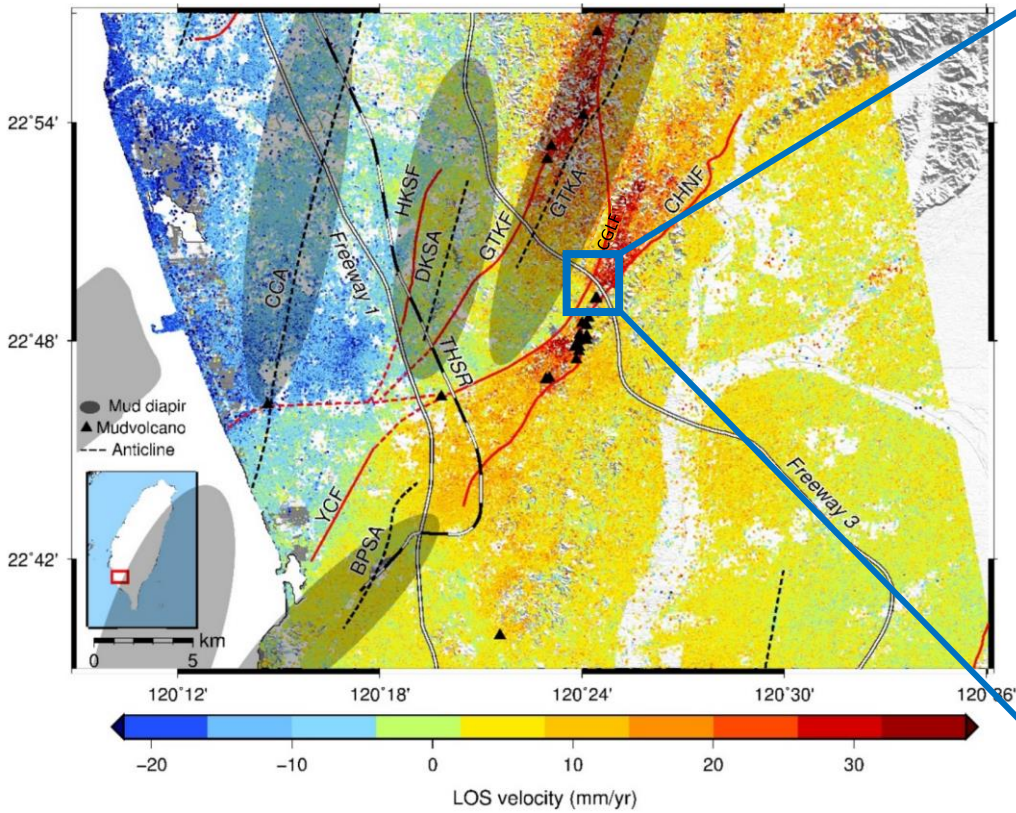
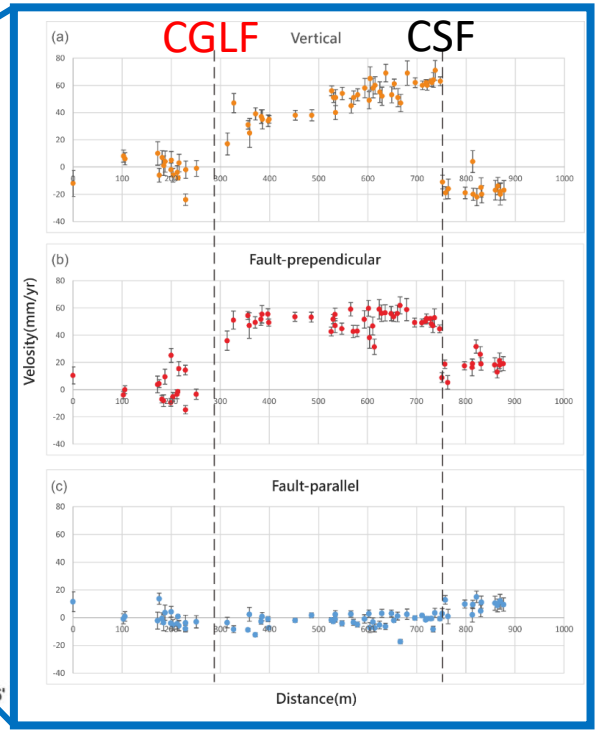


(Modified after Ching et al., 2017)



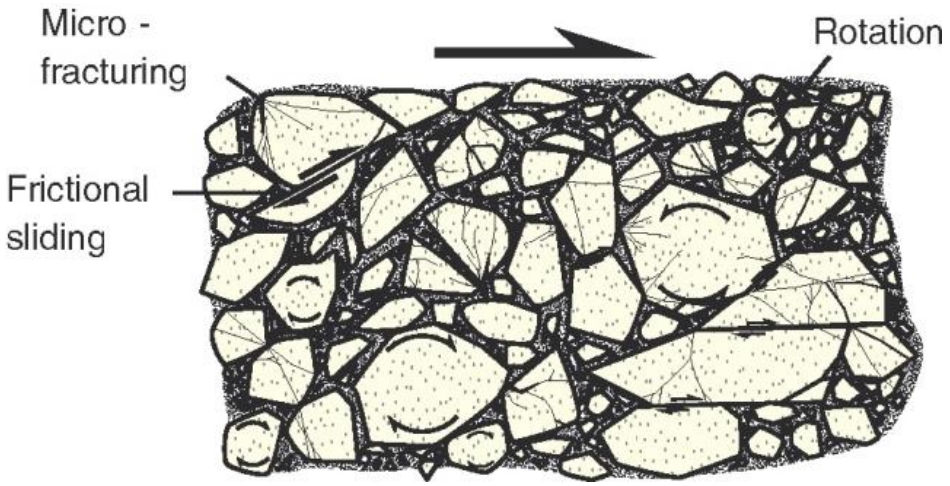
(Modified after Chun et al., 2014)

- The **creeping activity** of Chegualin can be observed through remote sensing.
- **Infrastructures** lying on the fault trace have **been damaged**.
- Further understanding about **deformation mechanism** and **fault behavior** is important for the seismic hazard assessment.

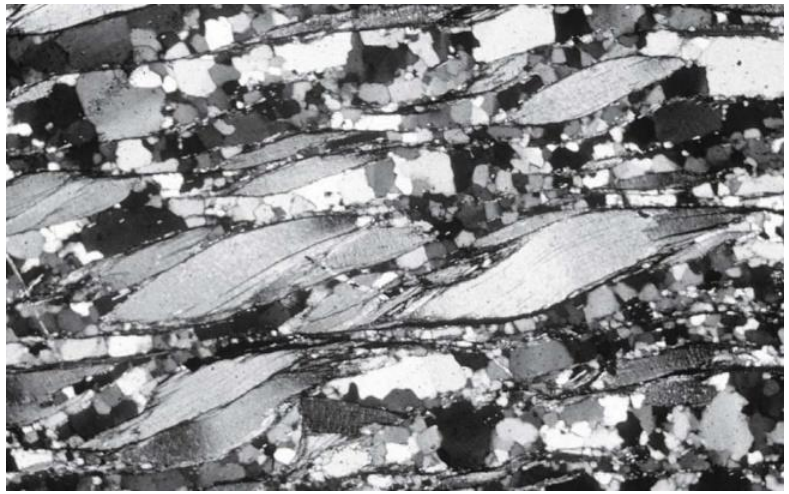
Research methods

- Optical microscope
  Samples were made into thin sections to observe microstructure.

- Scanning Electron Microscope
  Thin sections were coated with carbon for the detail microstructural study and the semiquantitative chemical composition.



- Brittle deformation

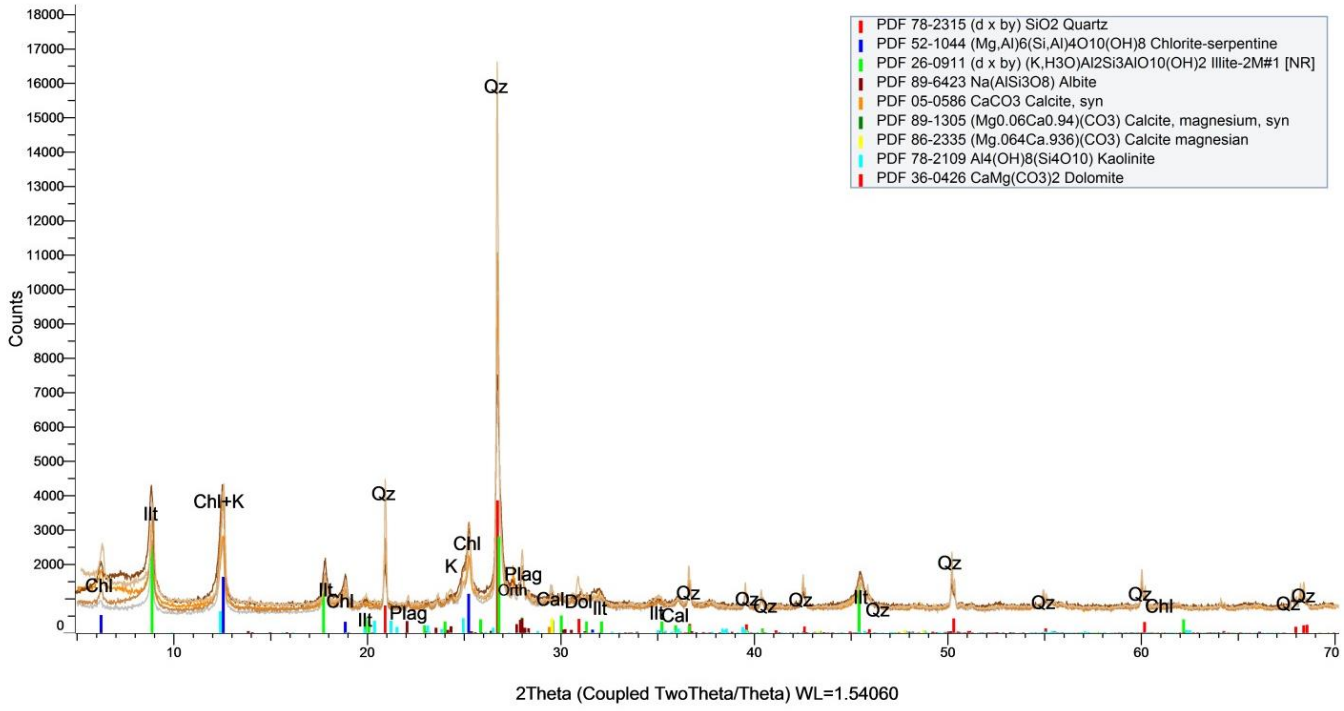


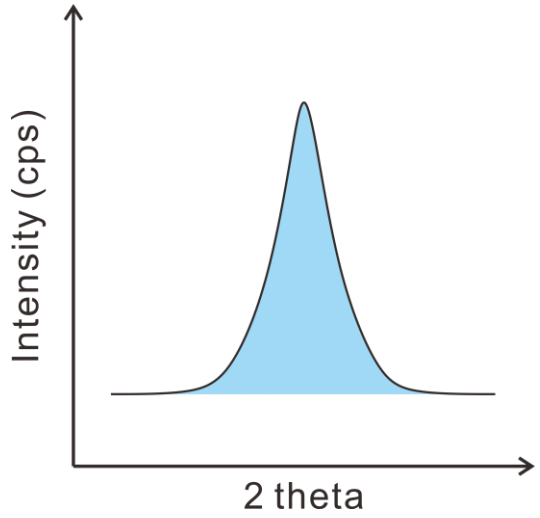
- Ductile deformation

Research methods

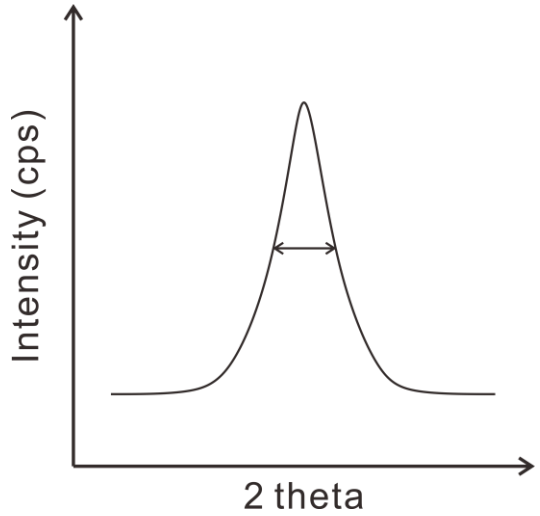
- X-Ray diffraction (XRD)

  Samples were pulverized to determine the mineral assemblages.





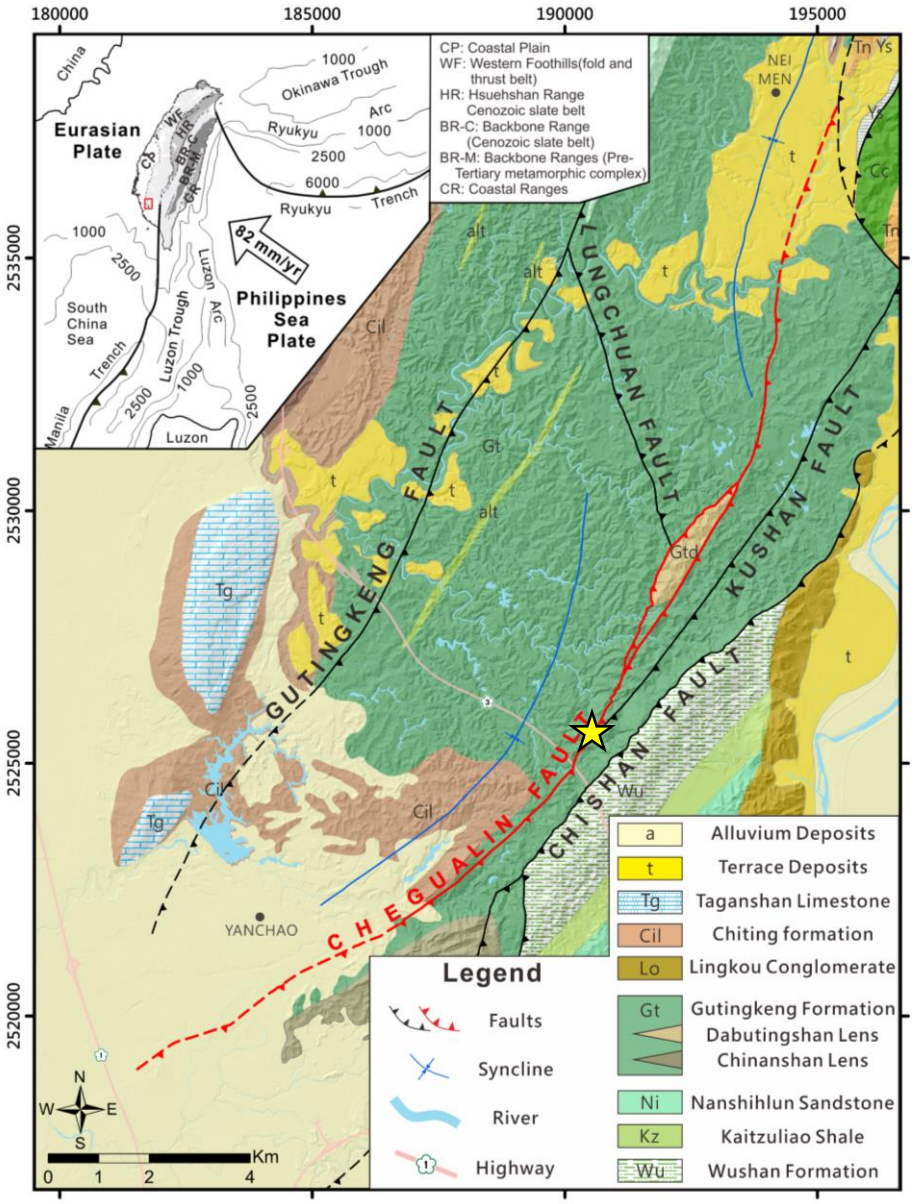
- Peak area



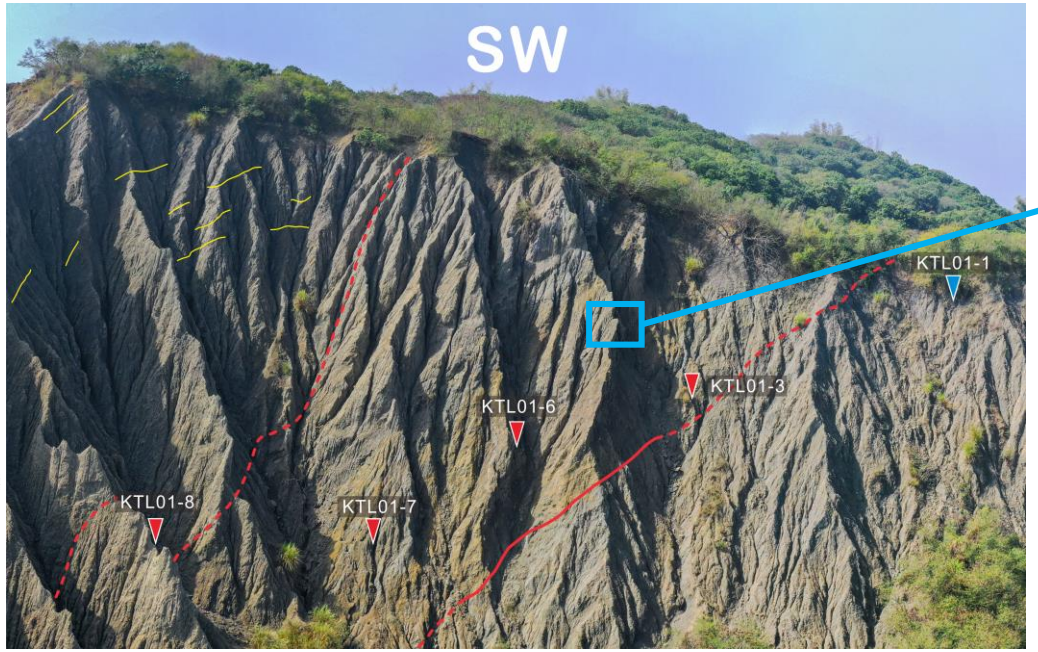
- Full Width Half Maximum

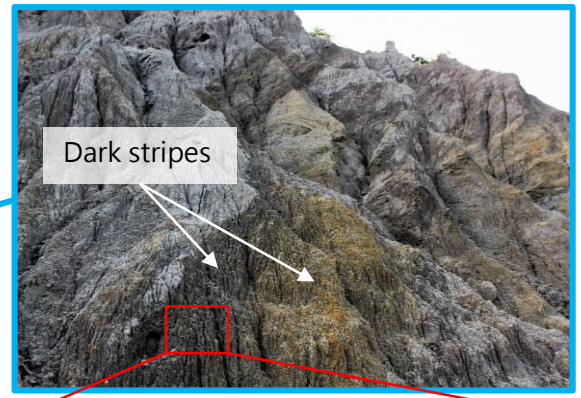
- Semi-quantification method follow Biscaye, 1965.
- Illite crystallinity based on KI index from Kübler, 1964.

Sampling sites-Outcrop



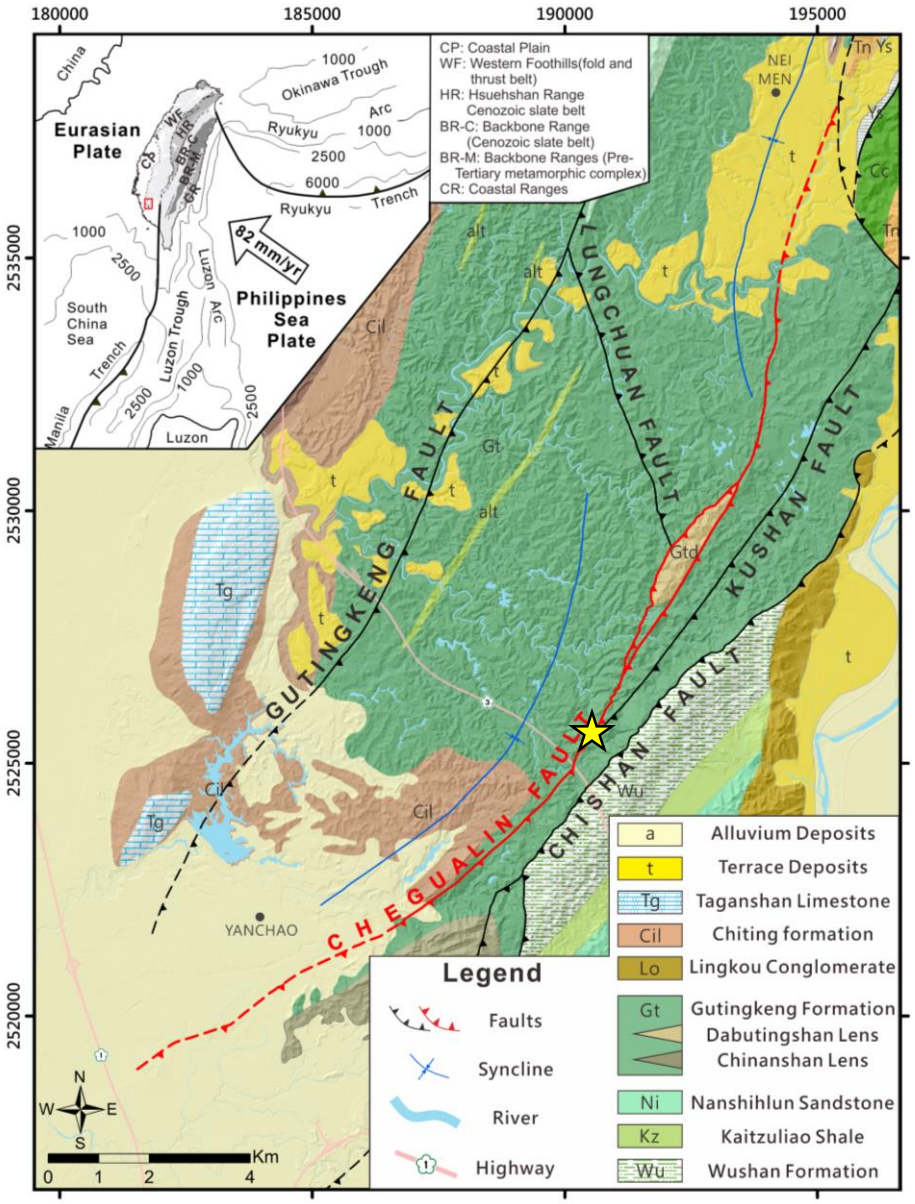
(Modified after CGS, 2013; Lin et al., 2021)





- Outcrop was divided into **four rock units** based on **fracturing intensity** and the **density of the black bands** of the rocks (Chen et al., 2021).
- Five samples were collected from the outcrop including **Light gray mudstone** from wall rock and **Gray mudstone**, **Yellowish mudstone** and **Black mudstone** from the fault zone of CGLF.

Sampling sites-Outcrop



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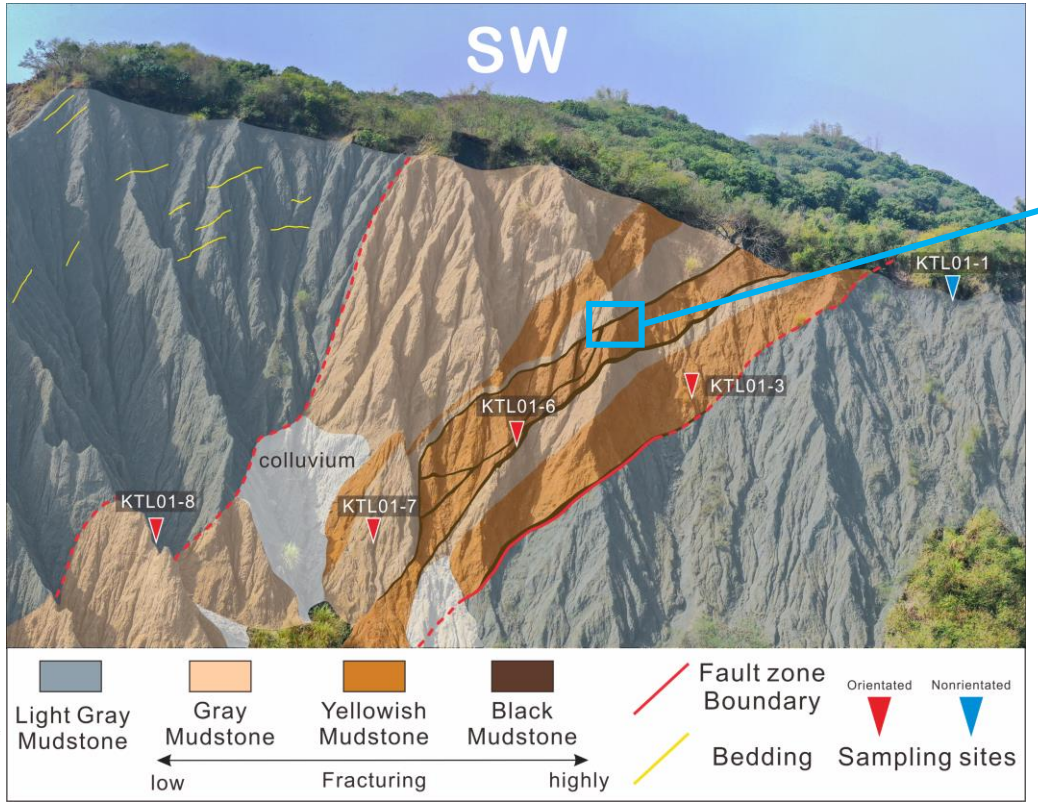

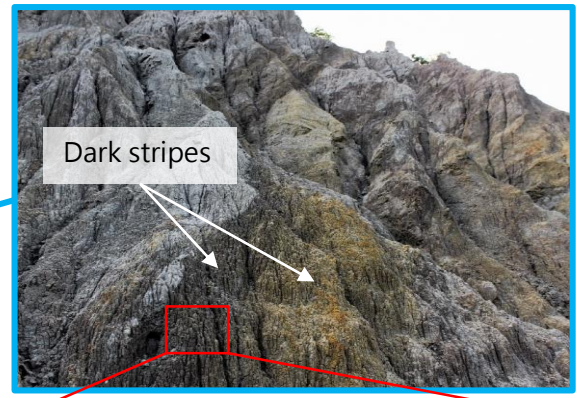

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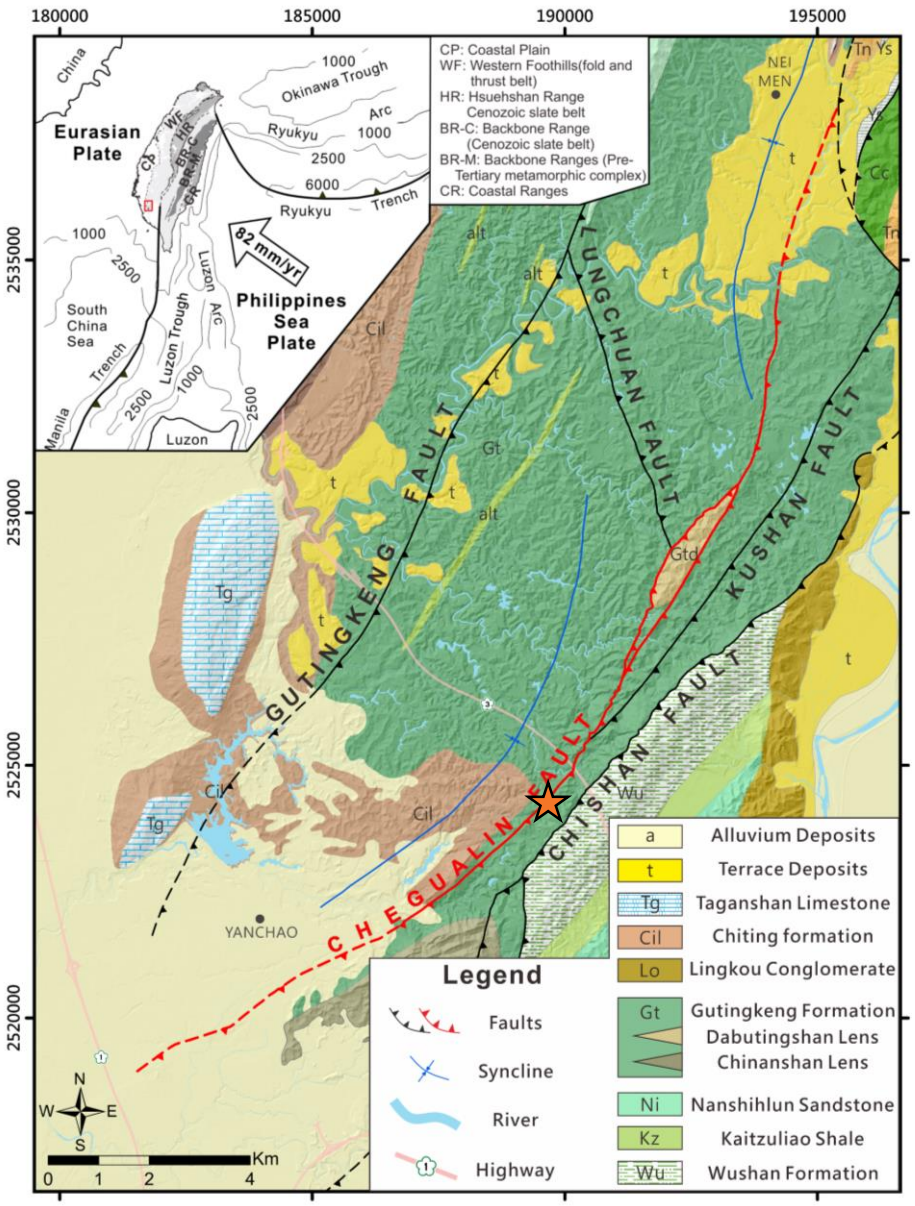
Sampling sites-Rock core



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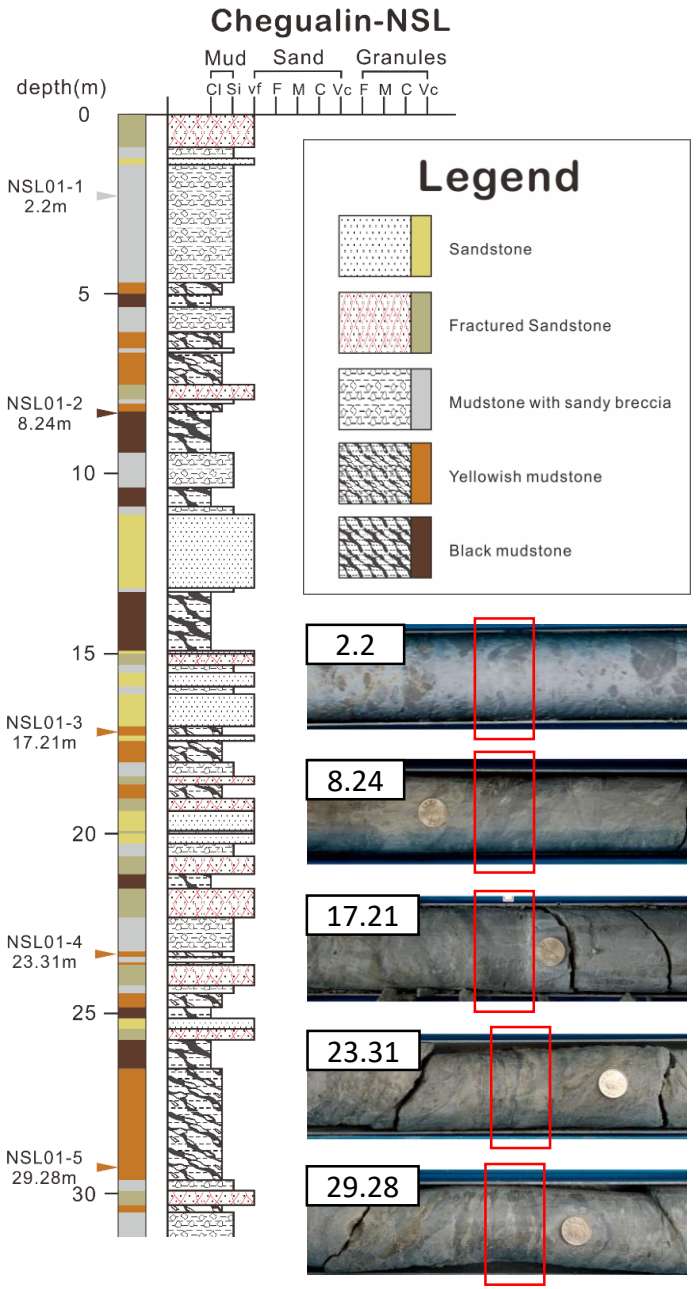
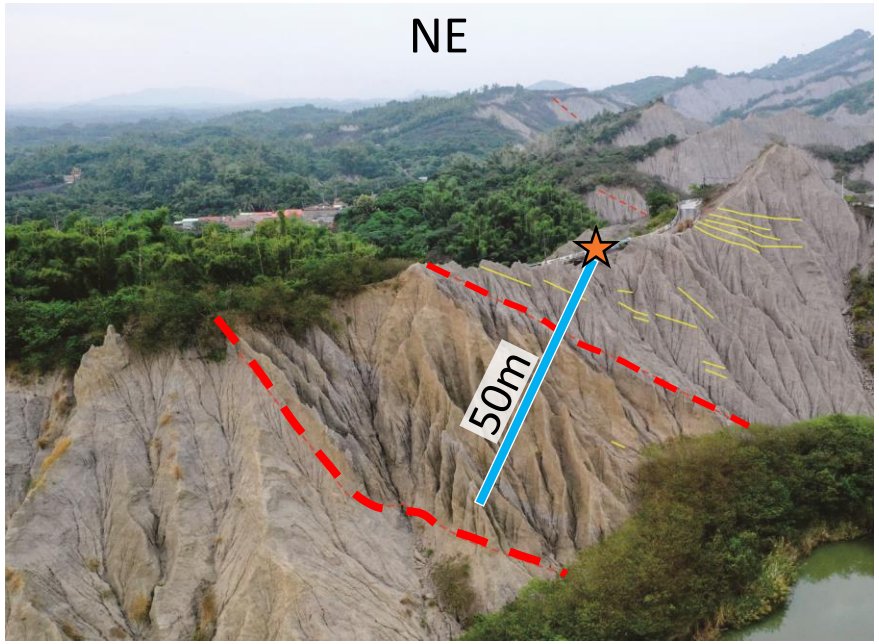
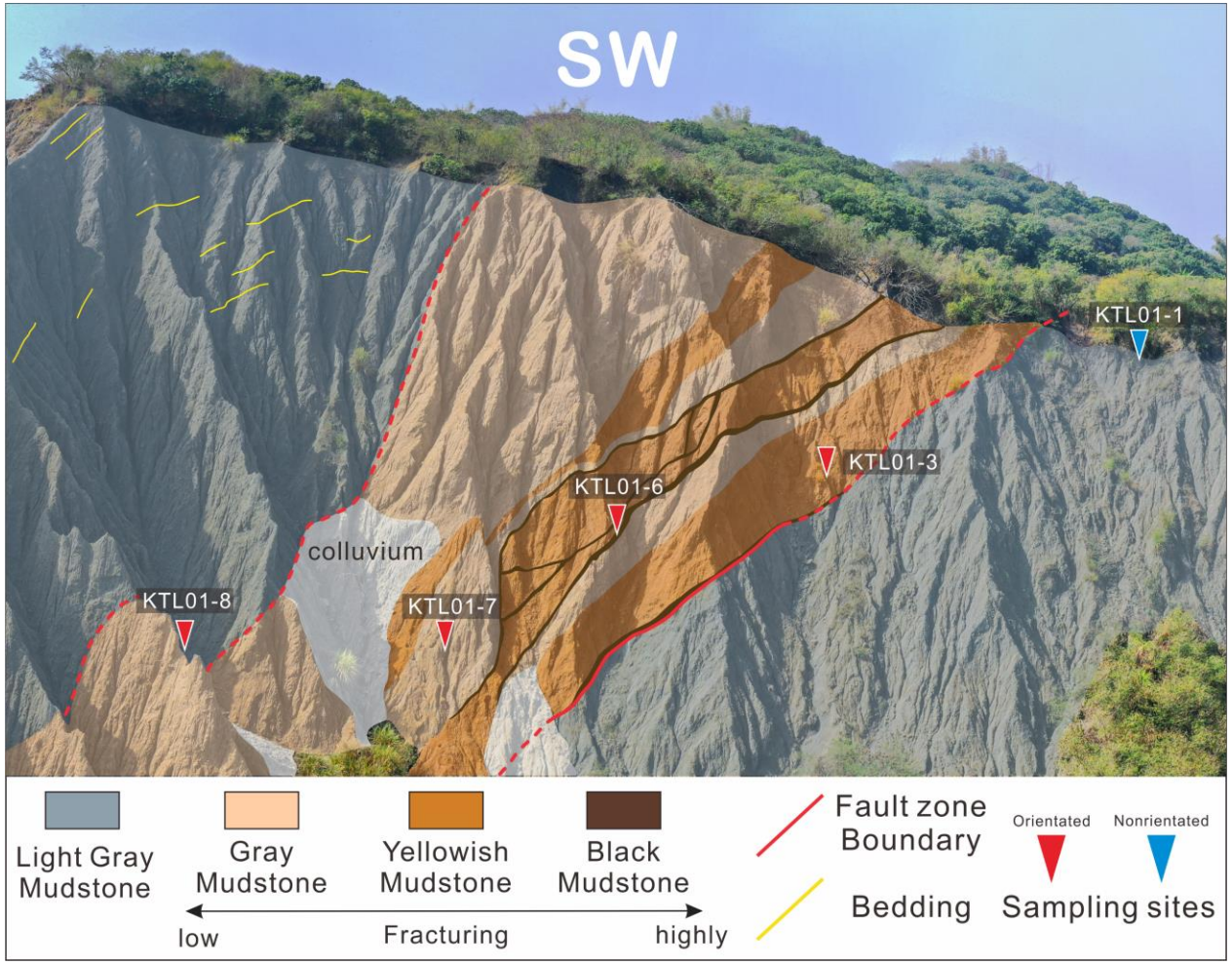


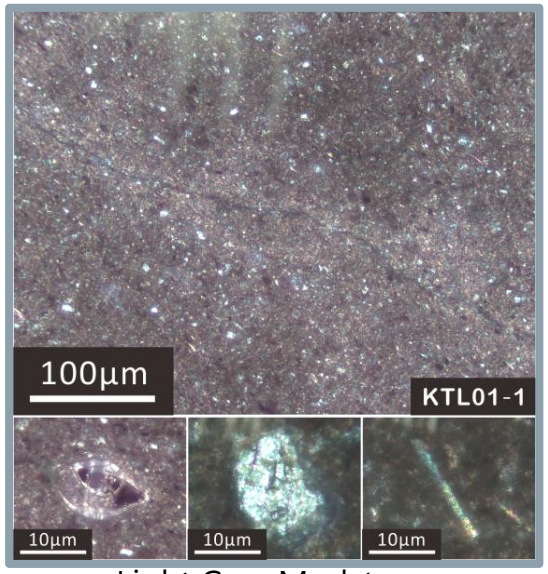


(Chen et al., 2021)

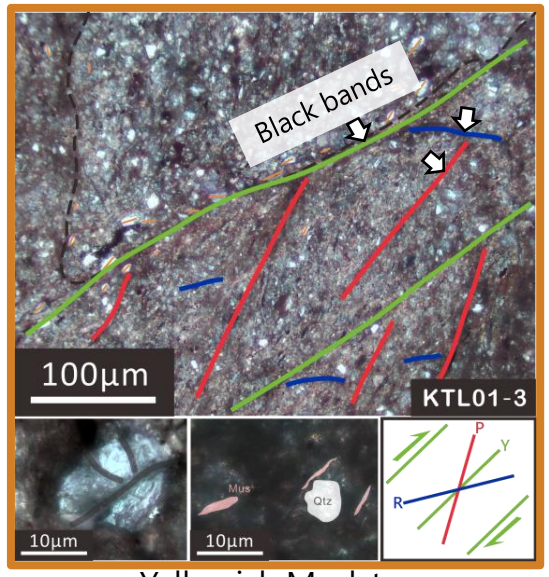
- The rock core was collected perpendicular to the fault zone and divided into different rock units based on the same standard applied to the outcrop.
- Five samples including **Light gray mudstone**, **Black mudstone** and **Yellowish mudstones** were collected.

Result- Optical microscope observations

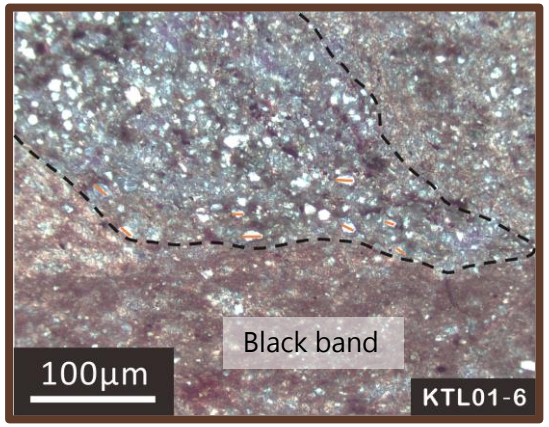




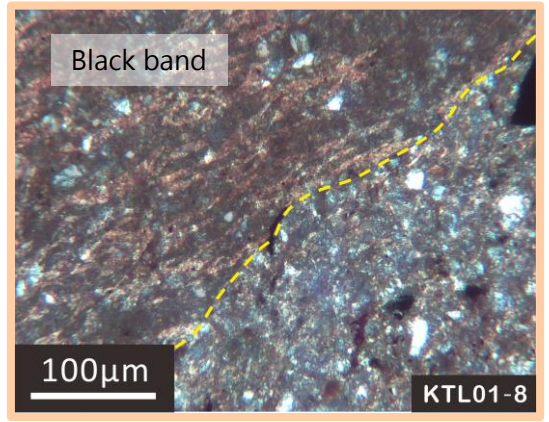
Light Gray Mudstone



Yellowish Mudstone



Black Mudstone

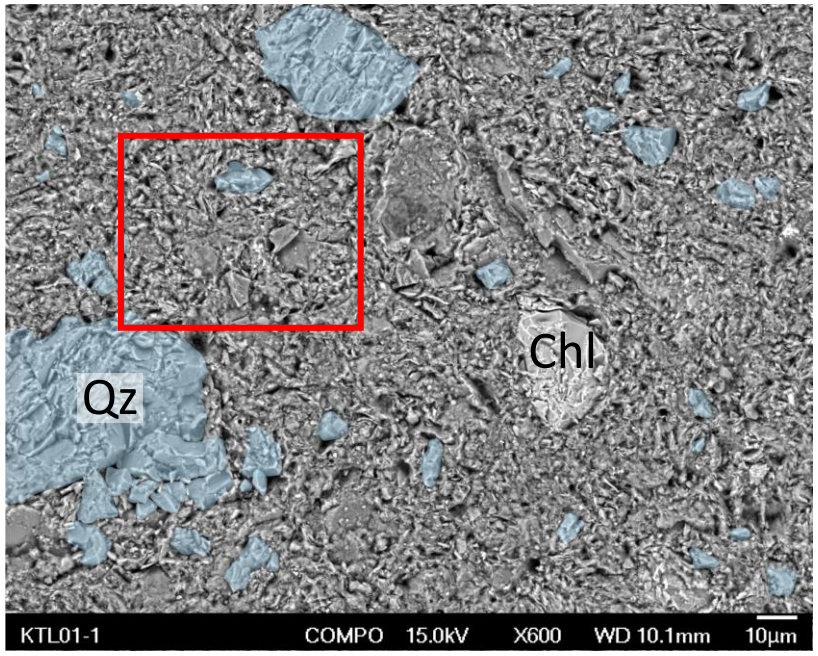


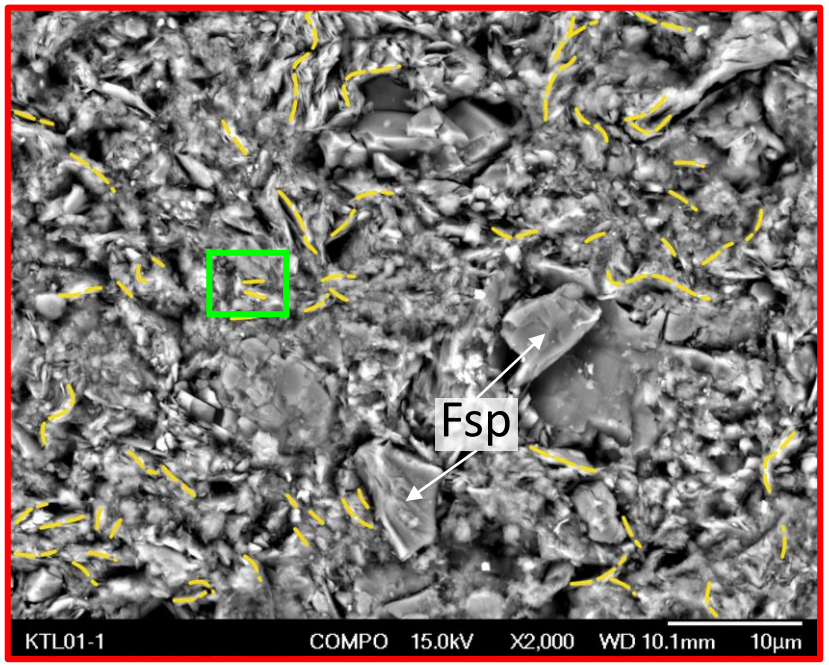
Gray Mudstone

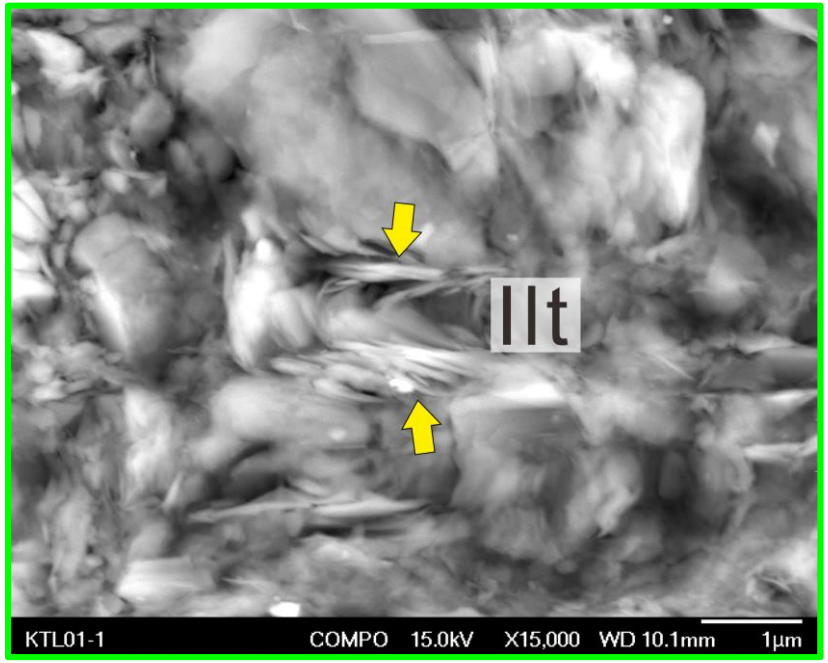
- In the wall rock, Light gray mudstone is composed of matrix with mineral grains distributed homogeneously.
- In the fault rocks, Black bands forming Riedel shear structure and deformed mineral grains are observed.

Result-SEM

Light gray Mudstone



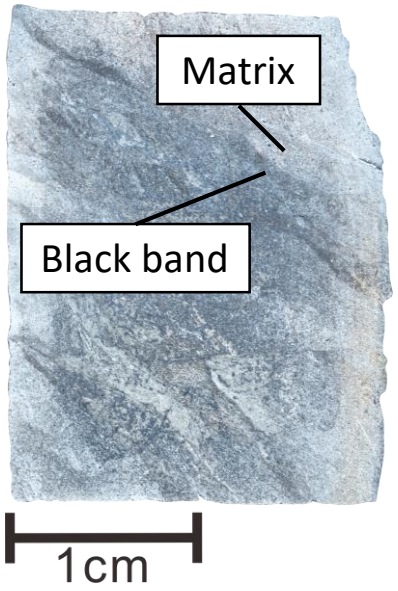


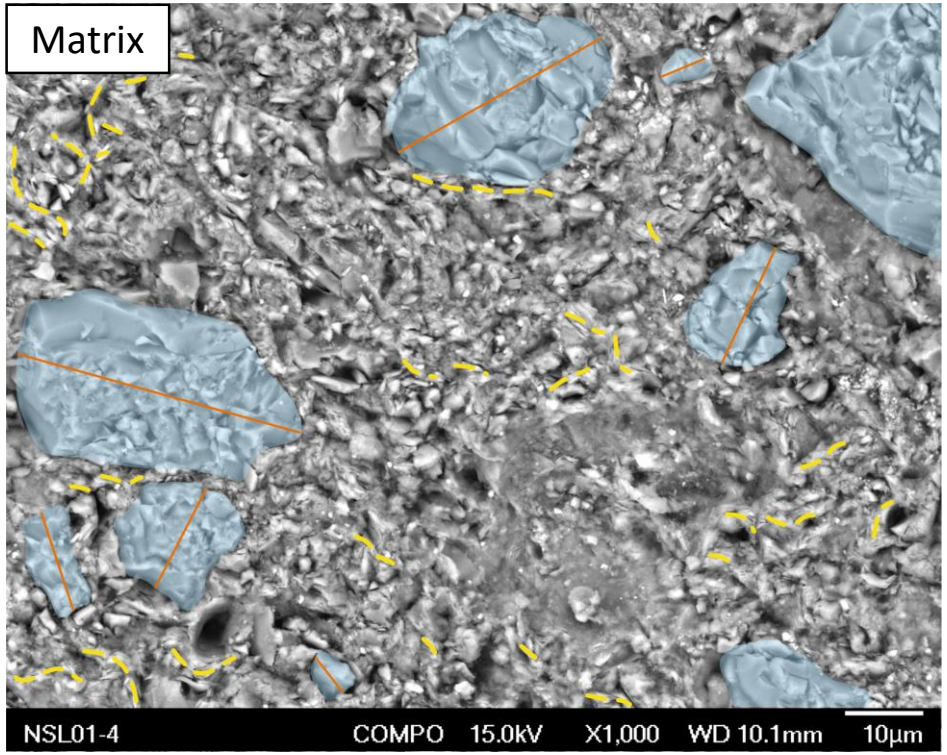


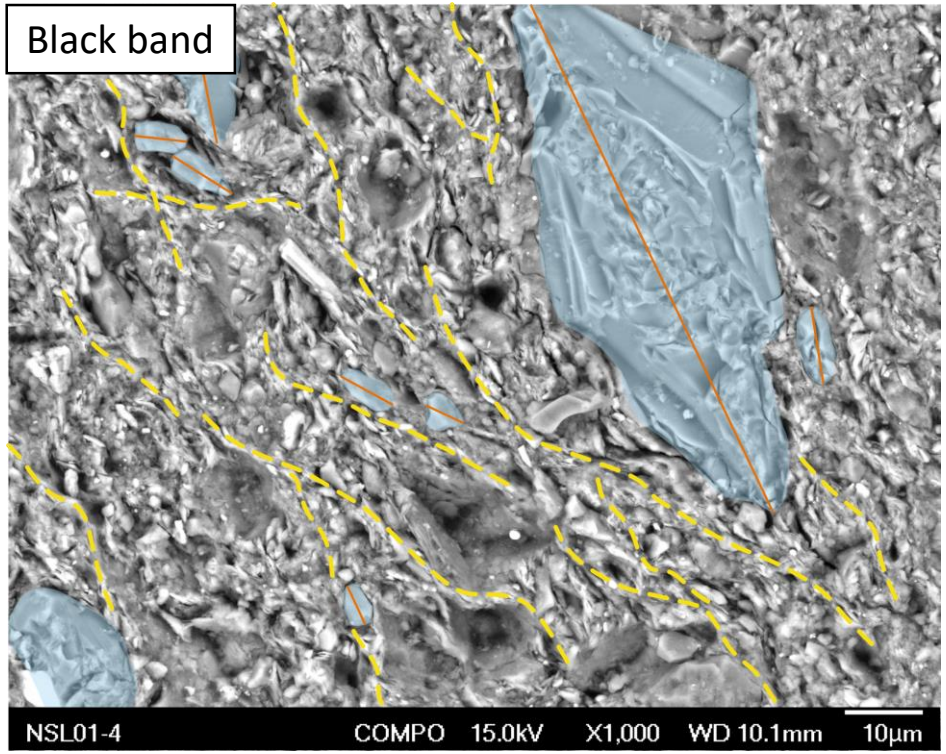
- The matrix is mainly composed of particles under 10 µm with some larger Quartz, Chlorite and Feldspar grains.
- Illite characterized by fabric-like occurrence can be found in the matrix with random alignment.

Result-SEM

Yellowish Mudstone

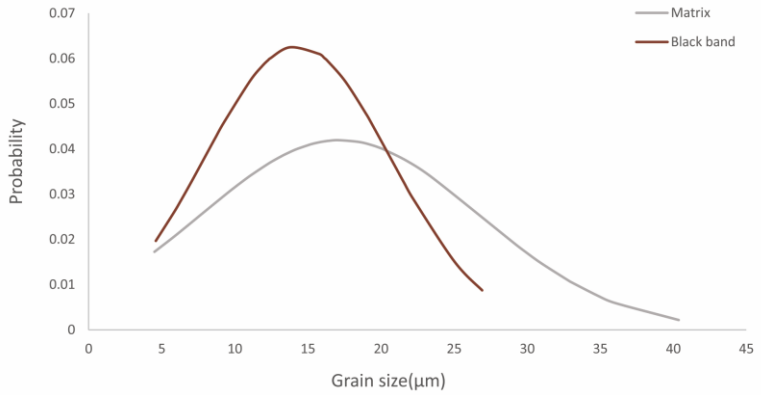






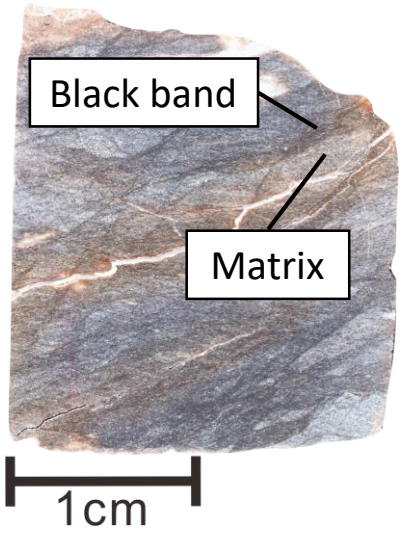
- The **quartz grains** in the black band showing **preferred-orientation** and the **alignment of illite** have **well continuity** and distribute **parallelly** with the black band direction.
- The **grain size** distribution of Quartz between matrix and black band indicates that the grain size **is smaller in the black band.**

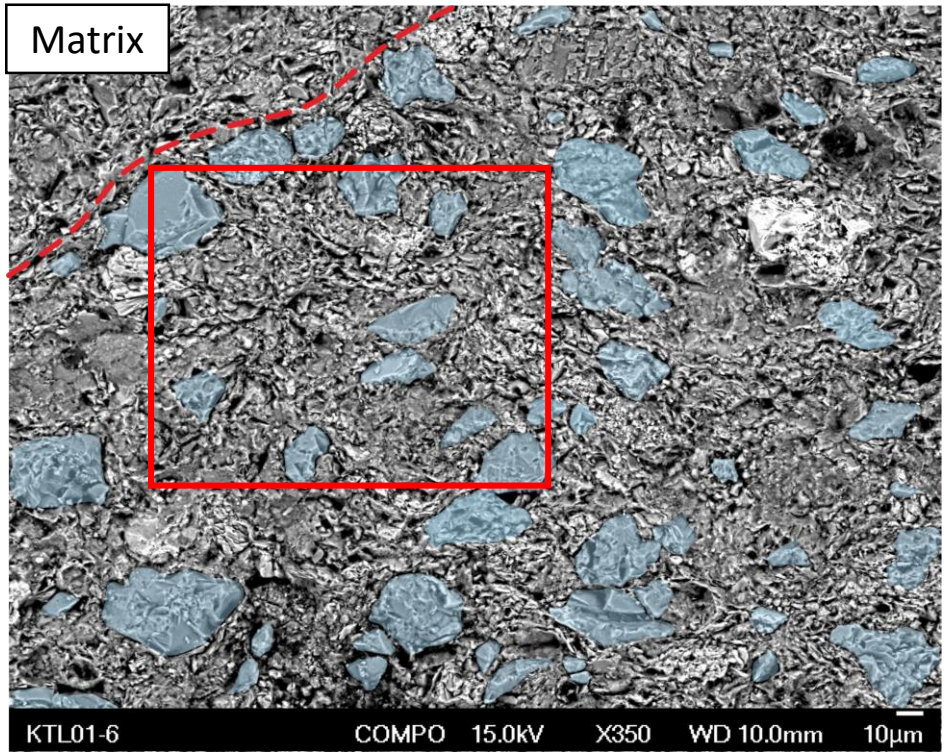
NSL01-4 Qz Grain size distribution

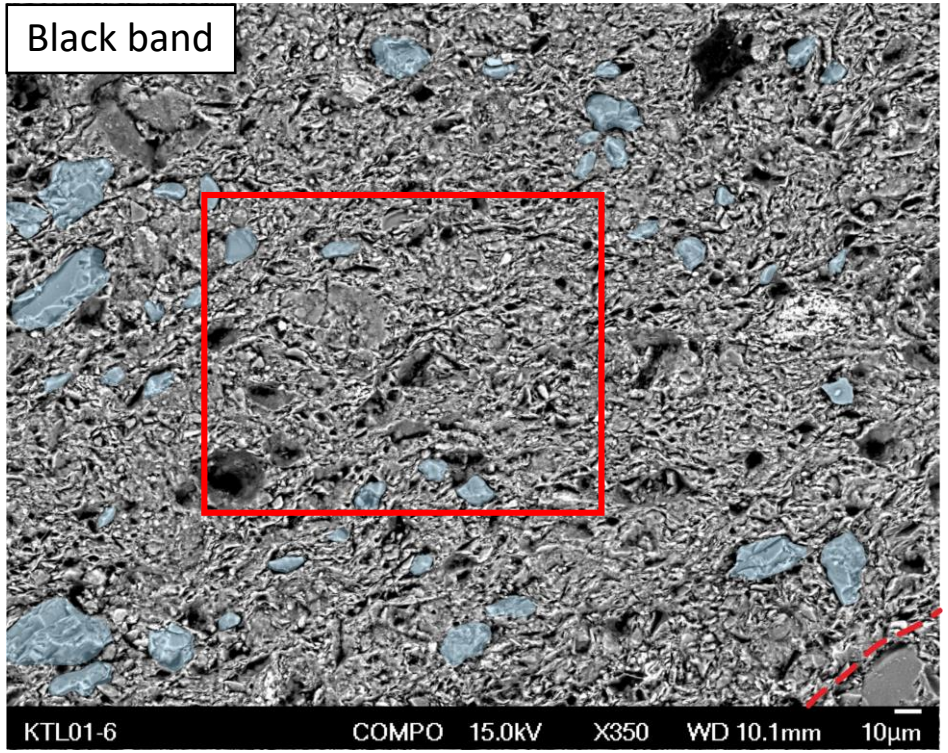


Result-SEM

Black Mudstone

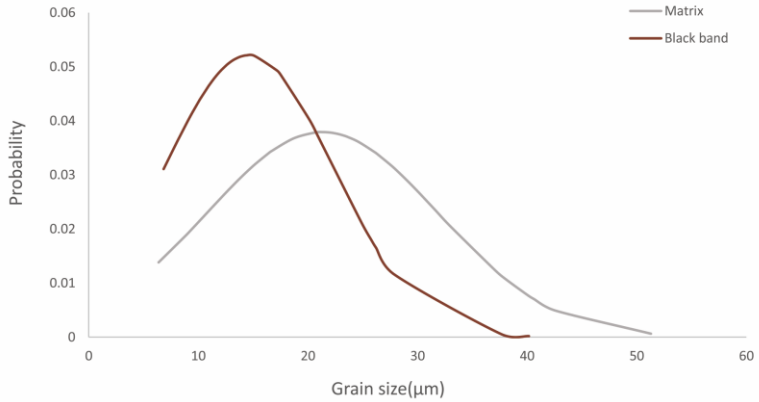






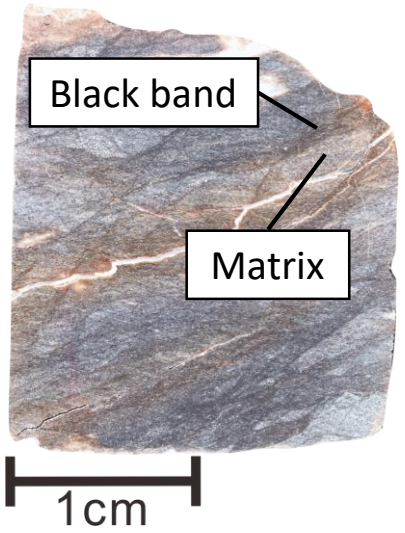
- Compared with matrix, grain size reduction of quart and the alignment of illite can be clearly observed in the black band.
- Combined with optical microscope observations the **mineral grains** are **rotated**, **fractured** and the **grain size becomes smaller** in the black band.

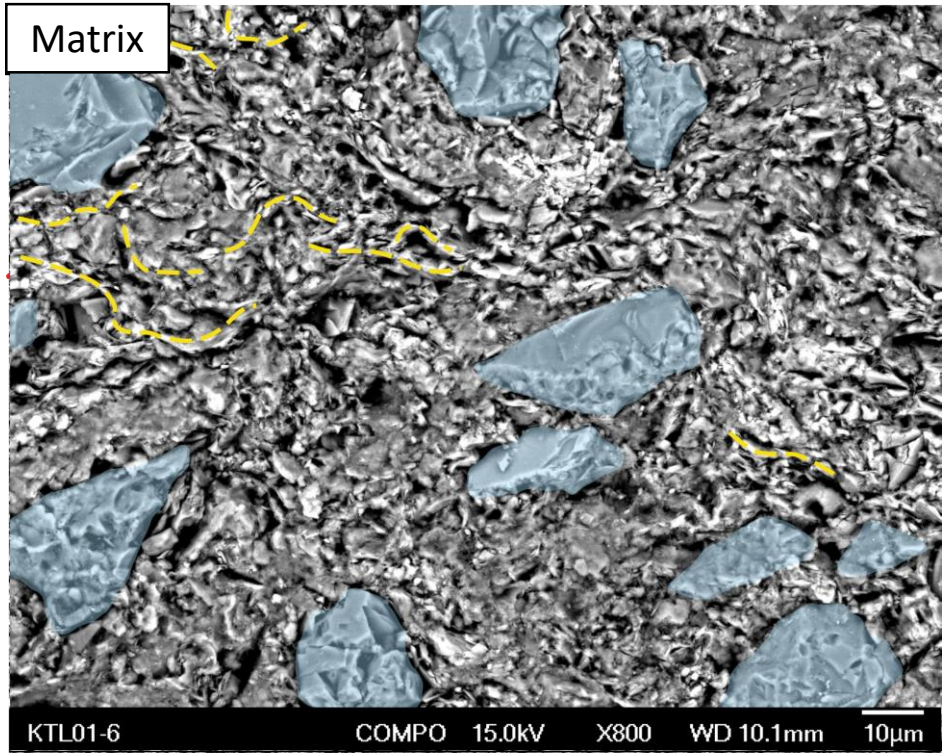
KTL01-6 Qz Grain size distribution

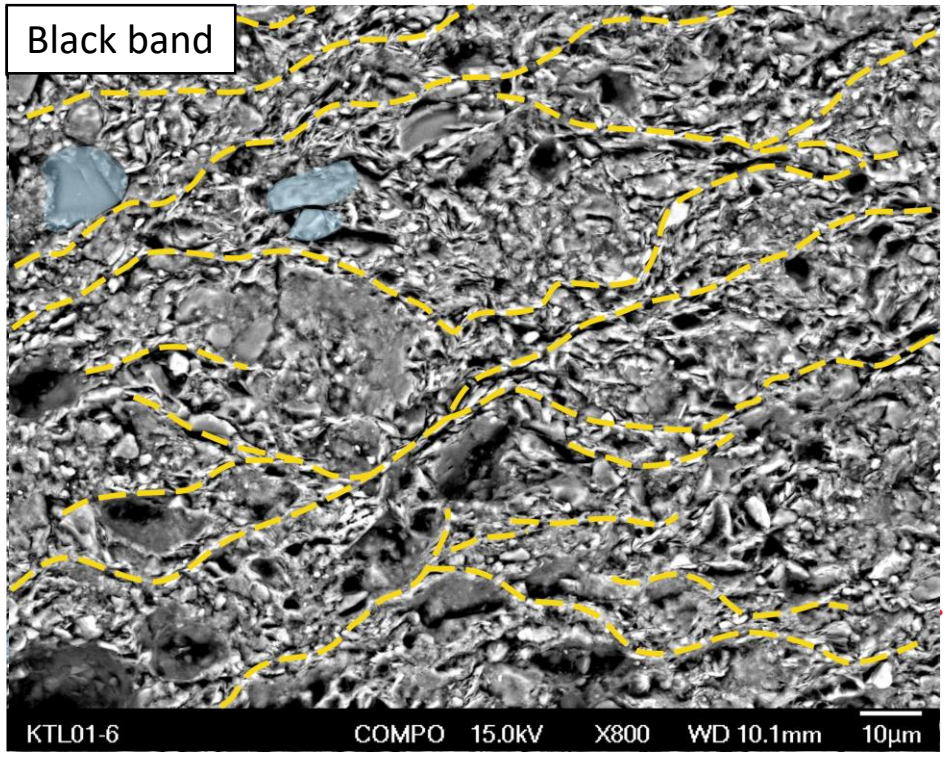


Result-SEM

Black Mudstone







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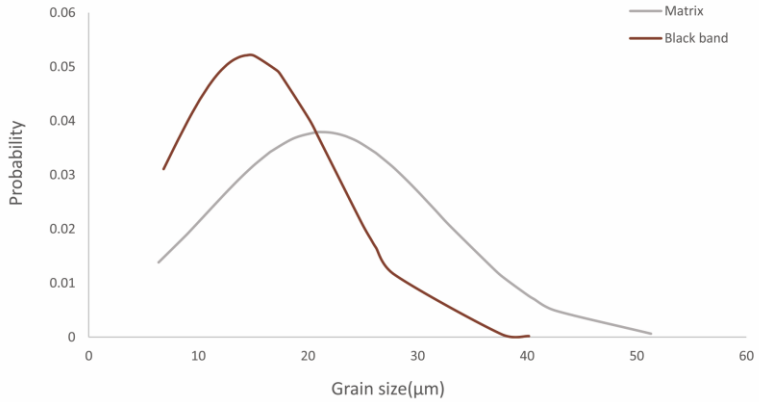
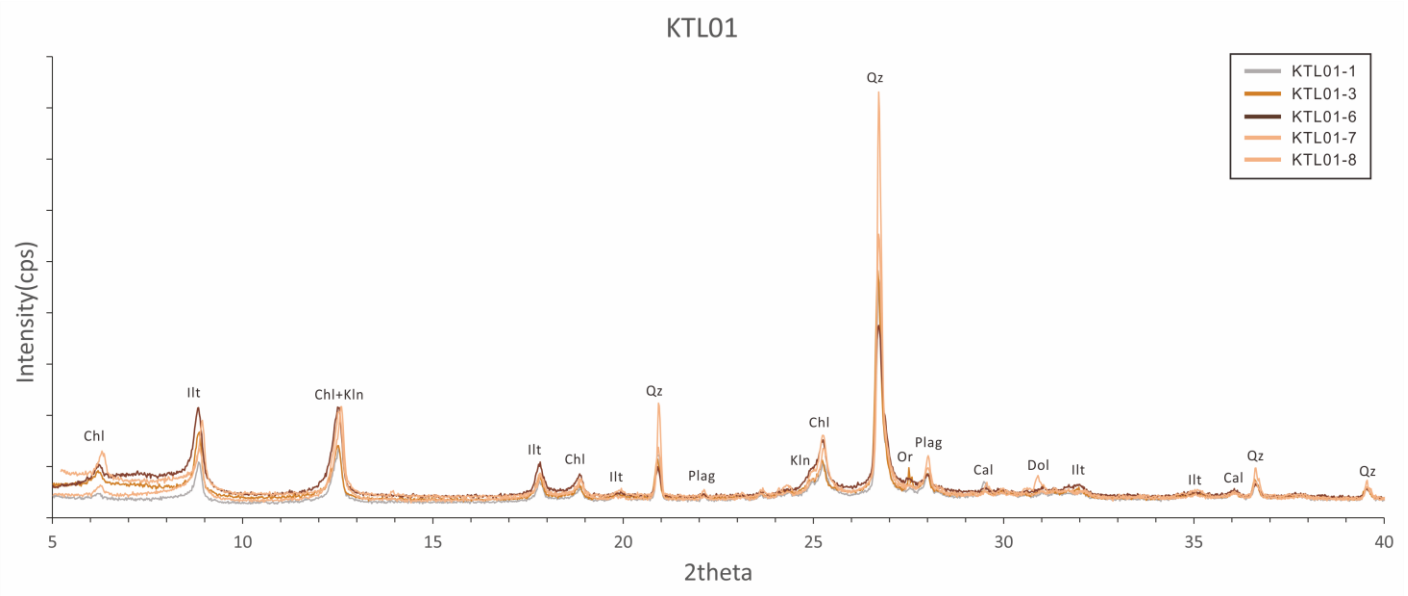
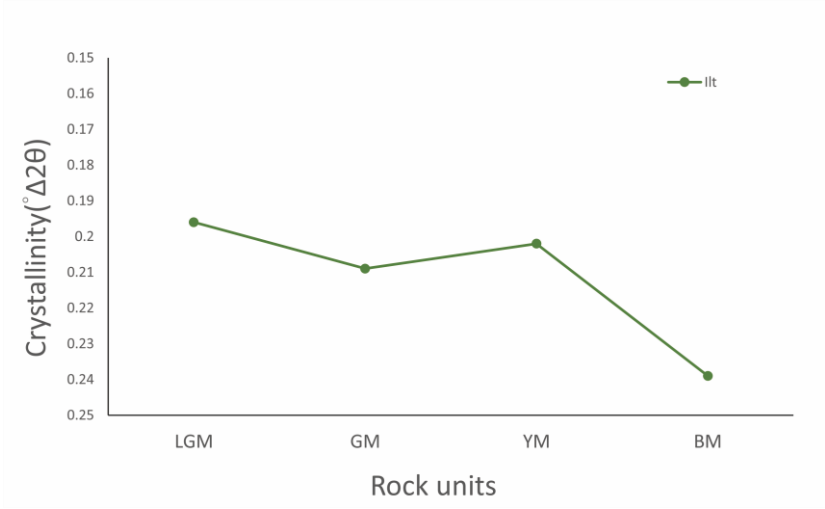
KTL01-6 Qz Grain size distribution

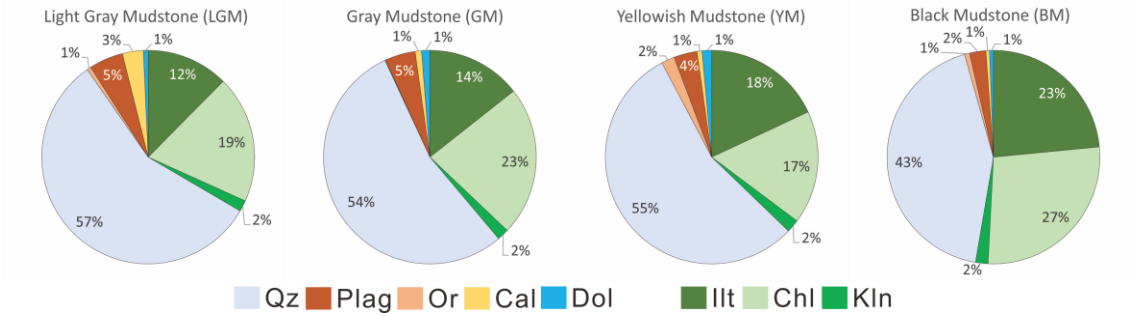


Result-XRD(X-ray Diffraction)

Whole rock samples – Outcrop



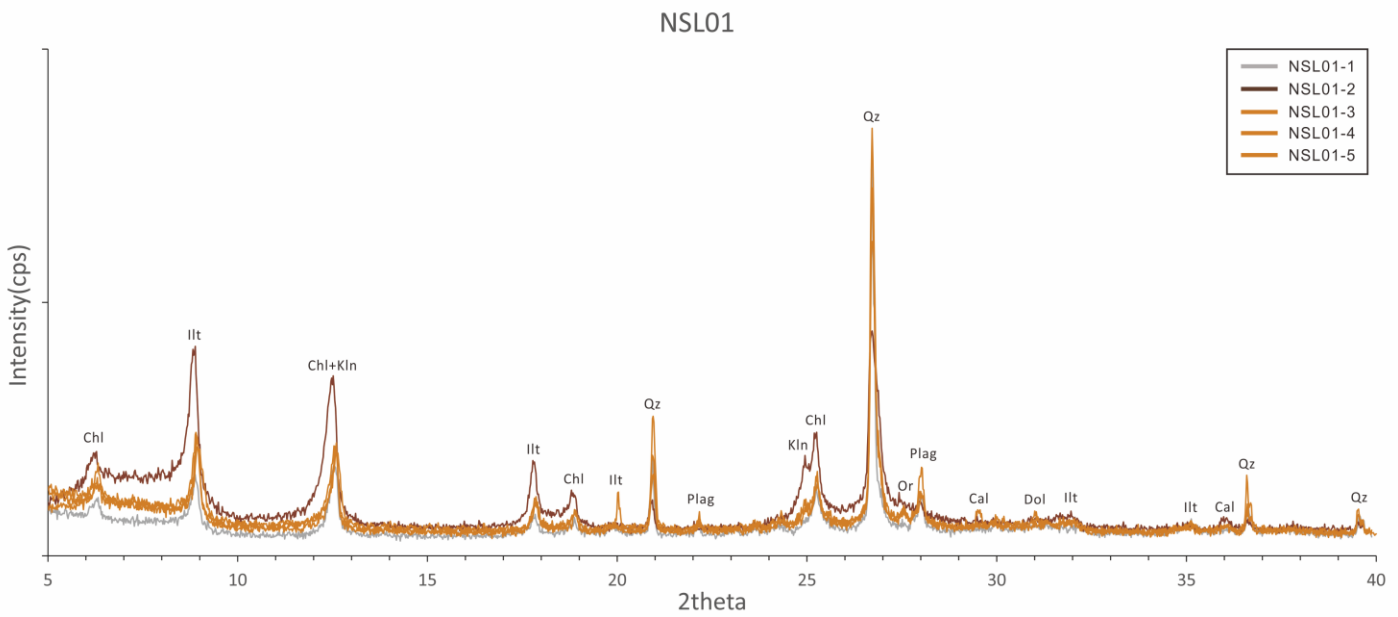


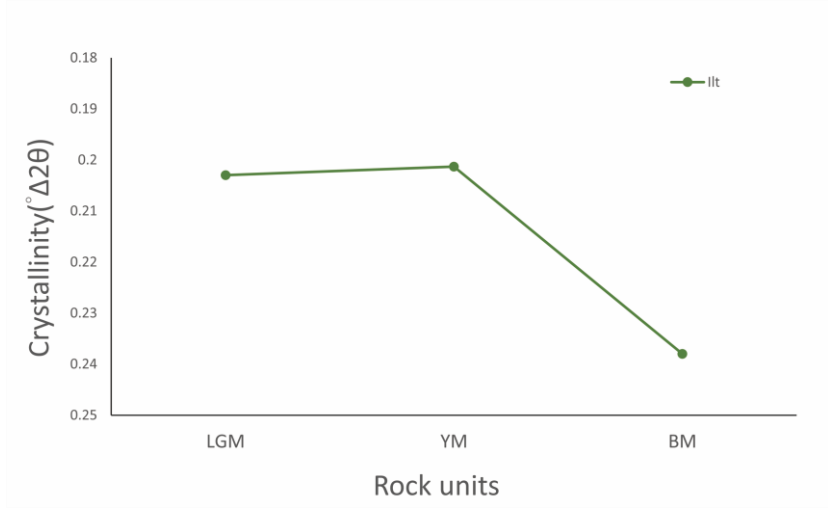


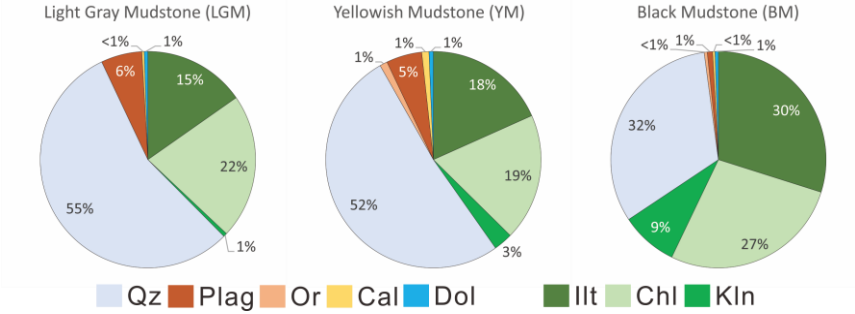
- The samples from the fault outcrop are composed of quartz, feldspar, calcite, dolomite, illite, chlorite and kaolinite.
- The **proportion of the clay minerals** is 34% in Light gray mudstone, 39% in Gray mudstone, 37% in Yellowish mudstone and **52% in Black mudstone.**
- The **crystallinity of the illite** shows a **decreasing trend** with increasing deformation intensity.

Result-XRD(X-ray Diffraction)

Whole rock samples – Rock core



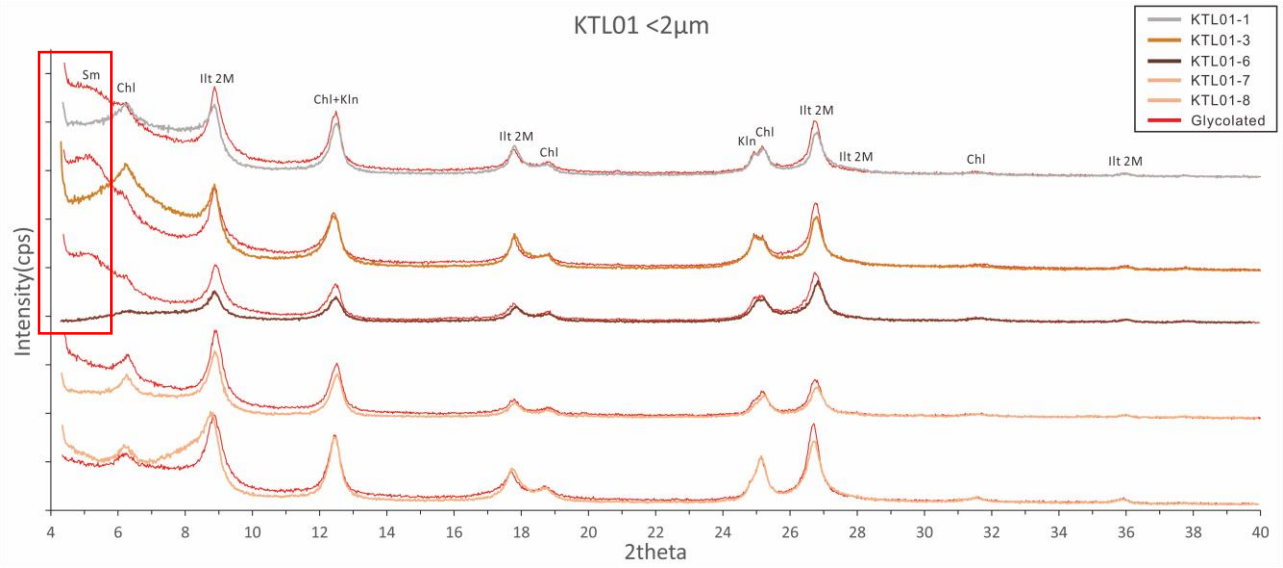


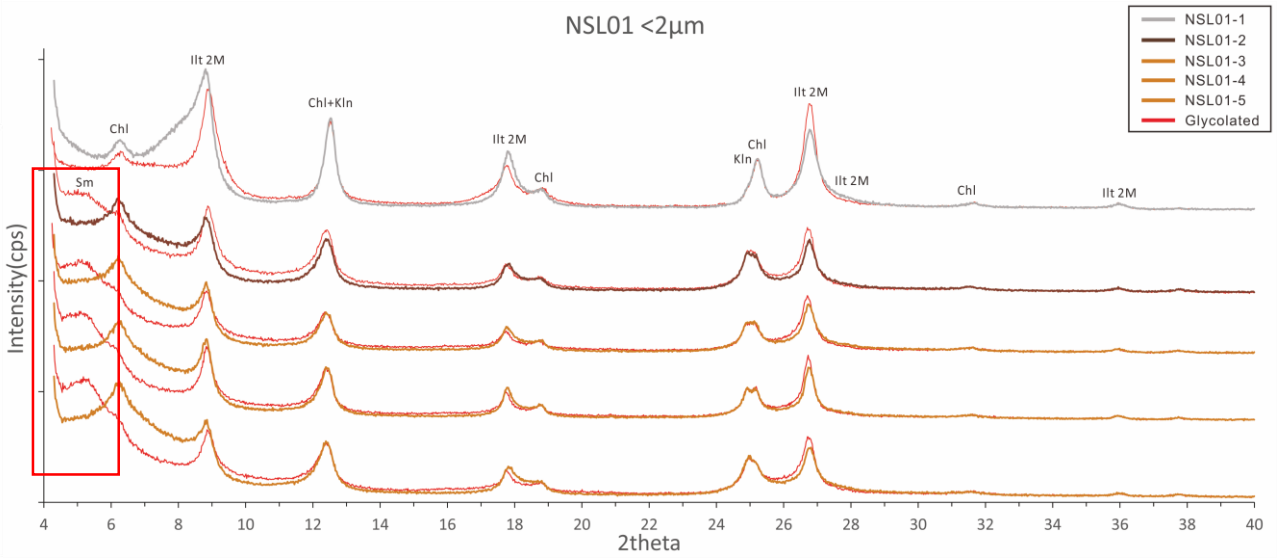


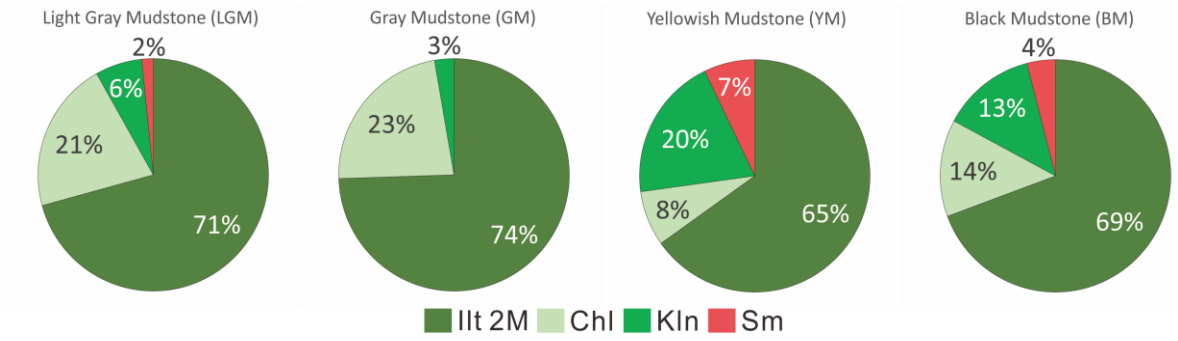
- The samples from the rock core are composed of quartz, feldspar, calcite, dolomite, illite, chlorite and kaolinite.
- The **proportion of the clay minerals** is 38% in Light gray mudstone, 40% in Yellowish mudstone and **66% in Black mudstone**.
- The **crystallinity of the illite** shows a **decreasing trend** with increasing deformation intensity.

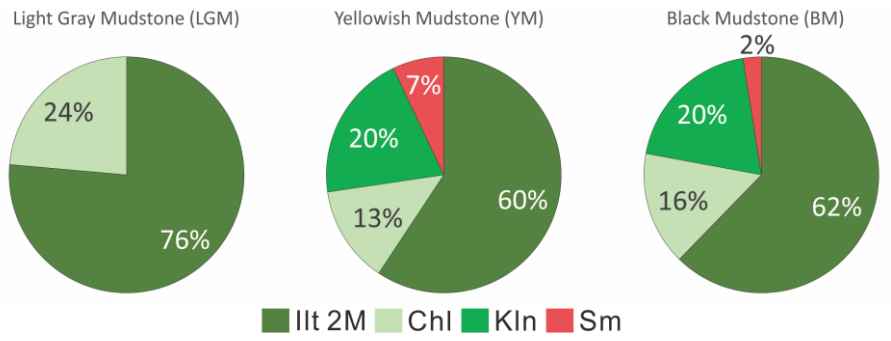
Result-XRD(X-ray Diffraction)

Clay minerals fraction samples





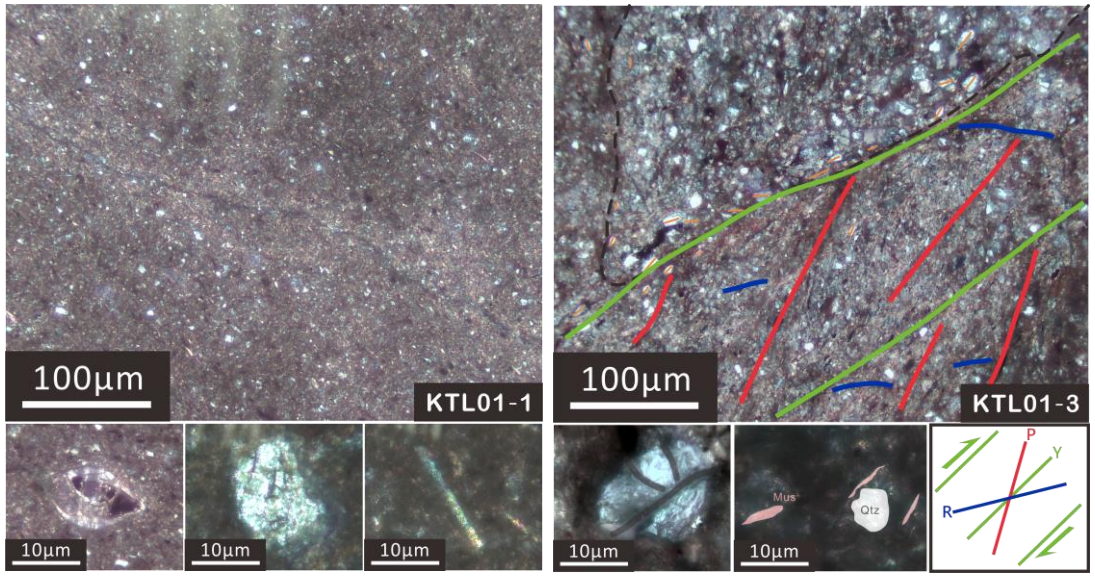




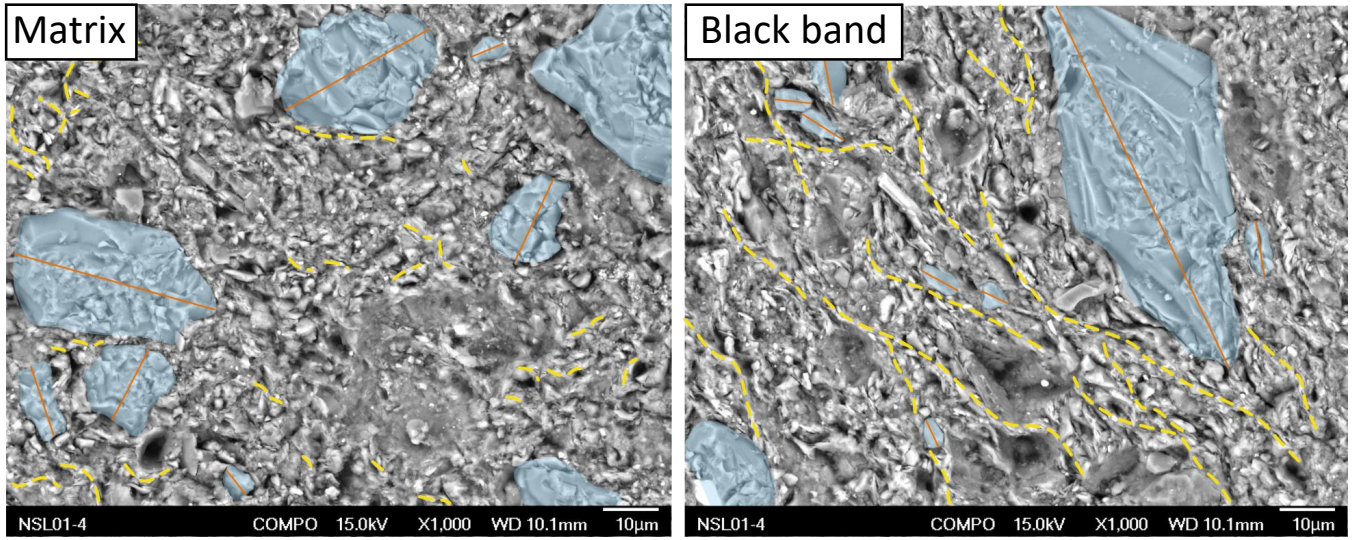
- The clay minerals are composed of illite, Kaolinite, chlorite and smectite.
- Smectite is found within the Light gray mudstone, Yellowish mudstone and Black mudstone.
- Compared with Yellowish Mudstone, Black mudstone has lower smectite but higher illite proportion.

Discussion

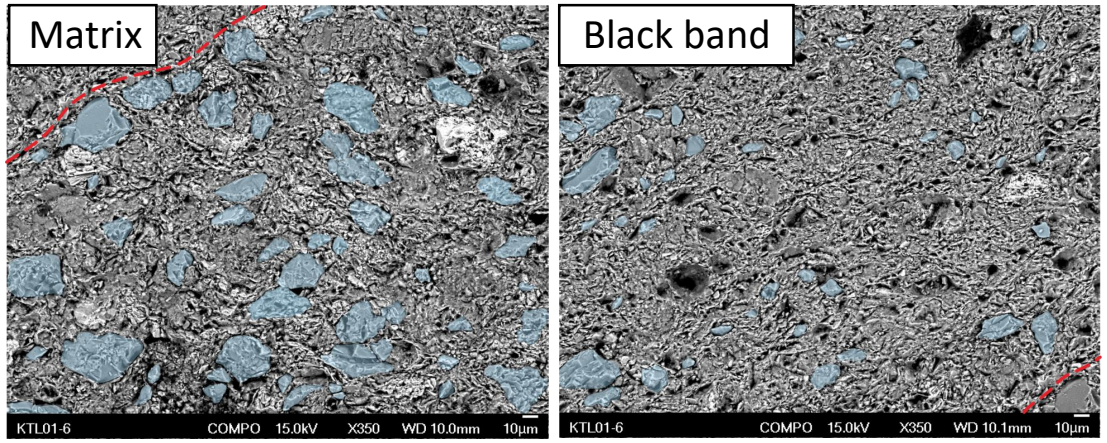
Deformation Mechanism of black bands – brittle or ductile?



Deformed mineral grains and Riedel shear



Minerals with preferred orientation.

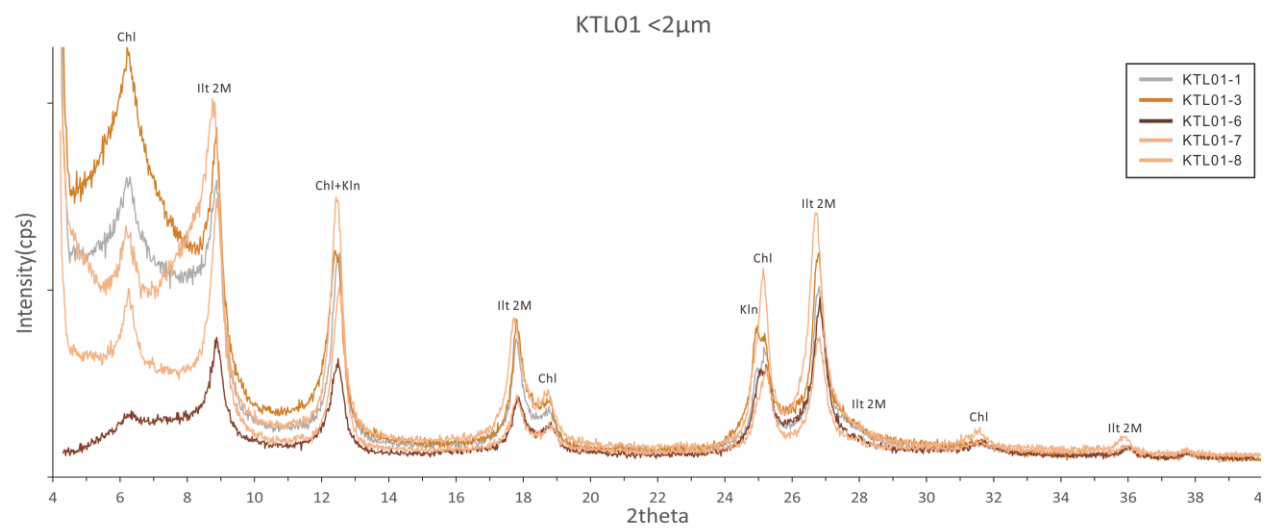


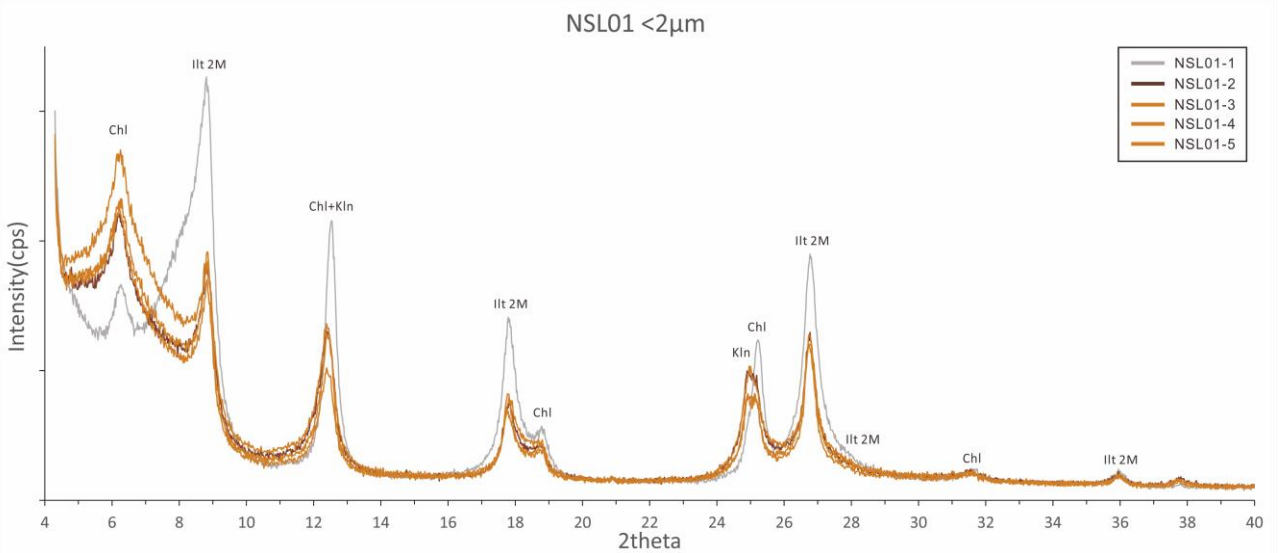
Grain size reduction

- Quartz grains were **fractured**, mica sheets were **bent** in the black bands.
- Order alignment of illite and quartz grains suggest that minerals were **reorganized and rotated** during shearing.
- Grain size reduction indicated that **comminution of grains** occurred during shearing.
- These evidence point out that the black bands were formed by **cataclasis**.

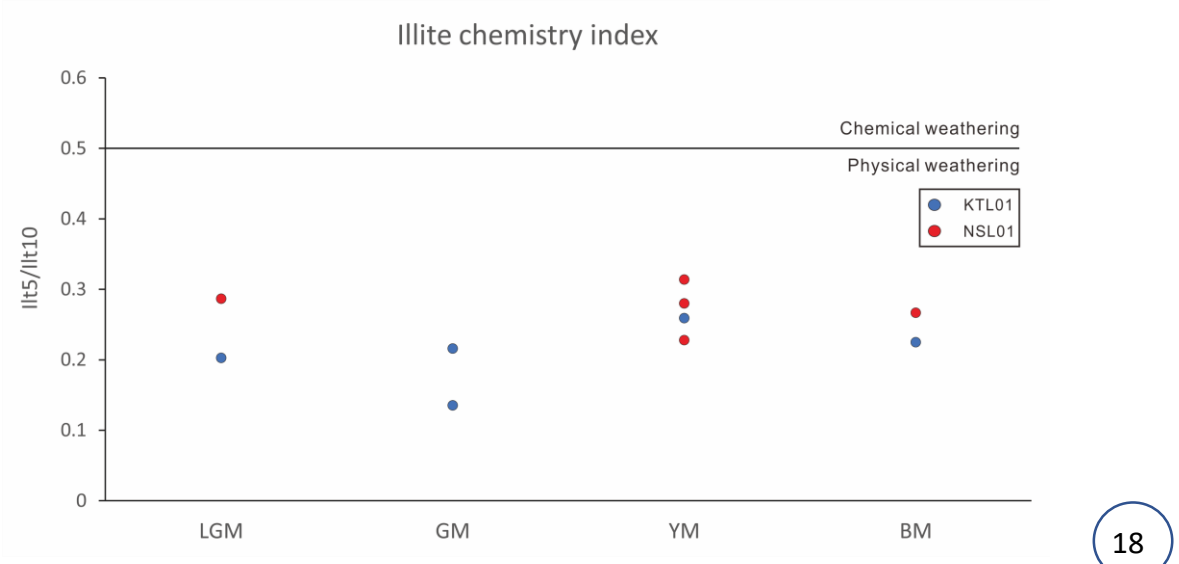
Discussion

Enrichment of clay minerals in fault rocks – Weathering or Faulting





- Illite is **detrital** in **origin** based on illite polytype quantification.
- **Weathering process is limited** since all of the values of illite chemistry index are under 0.5.
- **Poor crystallinity of illite** in rocks with higher deform intensity and the **occurrence of illite** suggest that the faulting causes the illite to be deformed within fault rocks.
- Based on these reasons we inferred that **the enrichment of clay** minerals were **dominated by the faulting**.



Discussion

Fault behavior implicated by clay mineral assemblage – Creeping or Creeping +Seismic slipping

Whole rock samples

Outcrop				
Rock units	LGM	GM	YM	BM
Clay minerals (%)	33	39	37	52
Illite (%)	12	14	18	23

Rock core			
Rock units	LGM	YM	BM
Clay minerals(%)	38	40	66
Illite (%)	15	18	30

- The proportion of the clay minerals increasing with the deform intensity.

Clay minerals fraction samples

Outcrop				
Rock units	LGM	GM	YM	BM
Illite (%)	71	74	65	69
Smectite (%)	2	0	7	4

Rock core			
Rock units	LGM	YM	BM
Illite (%)	76	60	62
Smectite (%)	0	7	2

- Proportion of Illite increase and Smectite decrease in Black mudstone.

- **Illite** within the fault zone is **formed by the seismic-slipping** and **smectite** is **formed by non-seismic slipping** based on previous research related to Illite-Smectite reaction induced by faulting.
- In our chase, both **Smectite and Illite are observed** forming in fault rocks.
- We interpret that during the fault creeping, **Gray mudstone** and **Smectite-rich Yellowish** mudstone **form first**. The accumulation of Smectite weakens the strength of the interface between Gray mudstone and Yellowish mudstone. Finally seismic-slipping occurred and formed the **illite-rich Black mudstone.**

Conclusions

- Based on the microstructural observations, we concluded that the black bands in the fault rock were formed through **cataclasis**. Which indicated that the deformation of Chegualin fault is **brittle deformation**.

- Through XRD analysis, enrichment of clays and presence of smectite were observed. Illite polytype and chemistry index point out that the **formation of illite through weathering is limited.** Illite crystallinity and microstructural observations suggest that the **enrichment of clays is mainly caused by the faulting.**

- The **variation of illite, smectite** between Smectite-rich Yellowish mudstone and illite-rich Black mudstone implies that the faulting behavior of Chegualin fault is not just a creeping fault.

Thank you for listening !