



Effects of the in situ stress on the mechanical anisotropy in the Longmaxi gas shale

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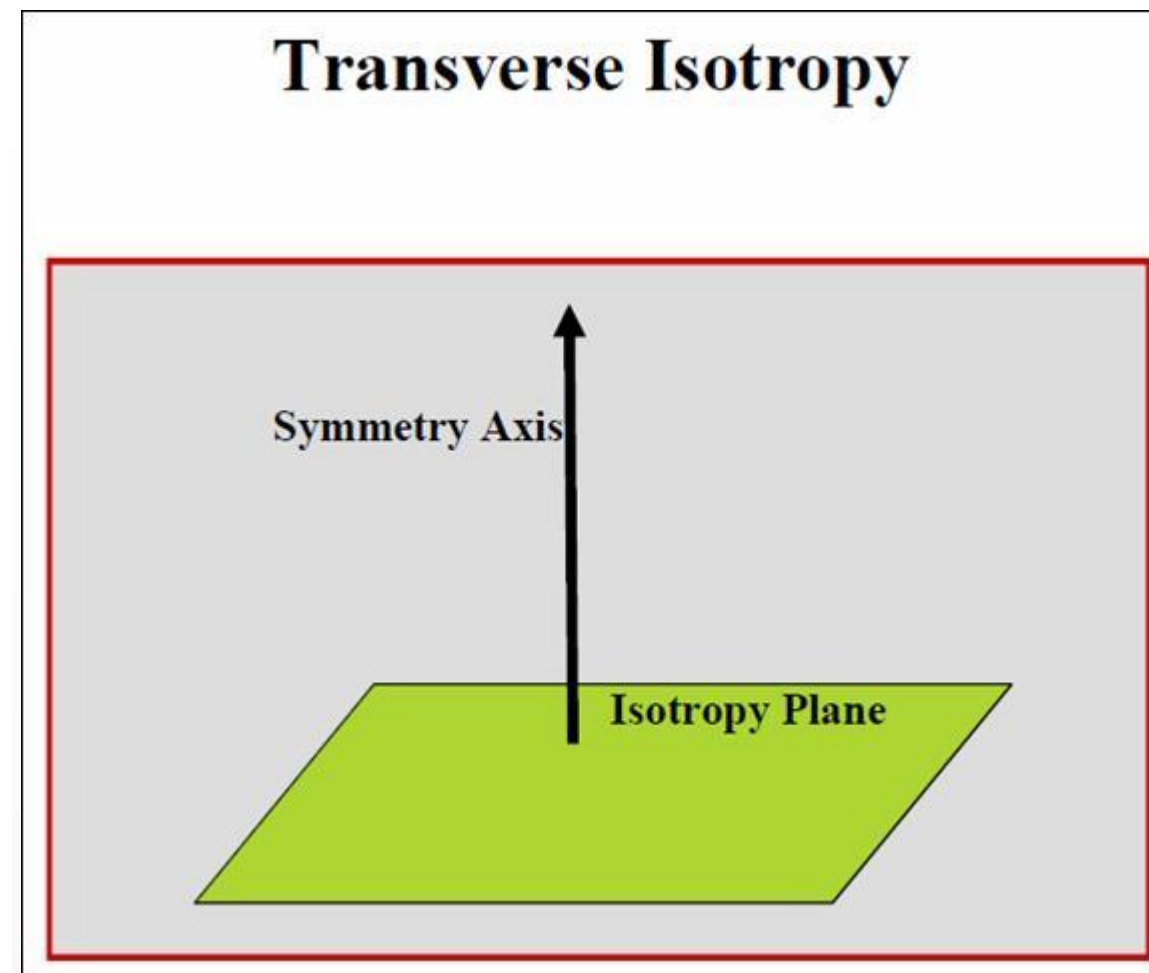
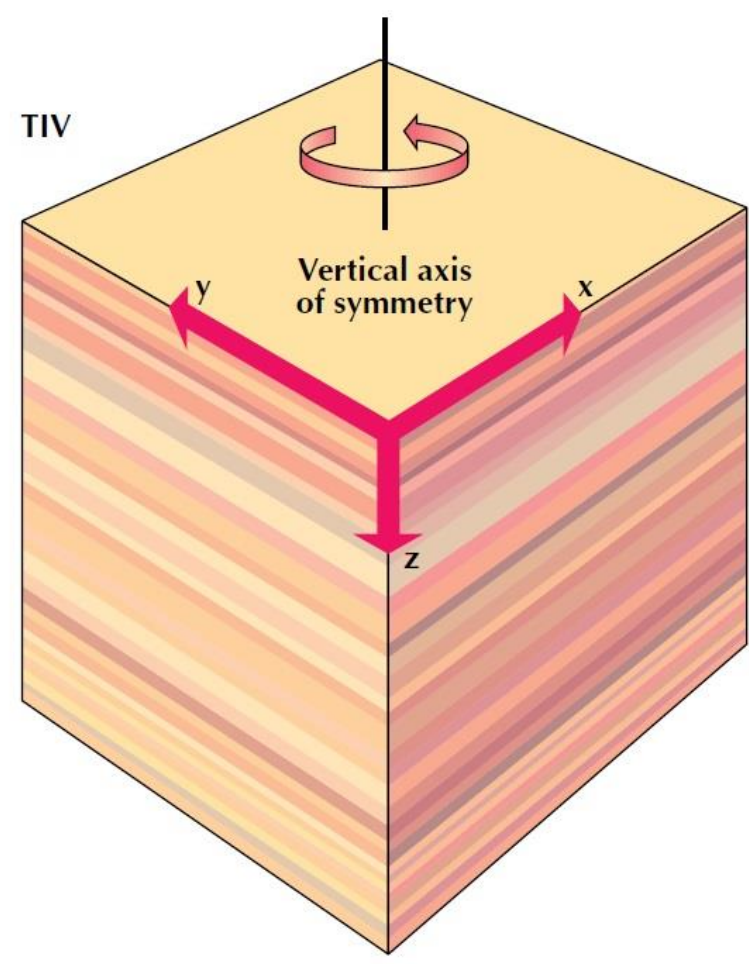
INTRODUCTION

Transverse isotropy theory has long history

- First reported by [Chenevert and Gatlin, 1965]
- Symmetry of Poisson's ratio and similar Young's modulus within the bedding plane were found [Chenevert and Gatlin, 1965]

Transverse isotropy model has limitations

- Complex crack patterns observed in the experiments cannot completely be accounted by transversely isotropic models [Na *et al.*, 2017].
- Different people put forward different methods to increase accuracy.



- Transverse Isotropy: properties are **uniform** horizontally within a layer, but vary vertically and from layer to layer(Schlumberger definition).

Transverse isotropy or 3D anisotropy?

- Is bedding plane the only factor affects the properties ?
- Do X and Y **always** have the same properties?

Can stress anisotropy cause anisotropy?

- In situ stress is anisotropic.
- Relation between velocity and mechanical properties has been found[Holt *et al.*, 2012].
- Velocity difference is greatly influenced by stress anisotropy in triaxial compression tests[Anon, 2011].
- In situ stress may be another factor affect mechanical properties in shale.

METHODS

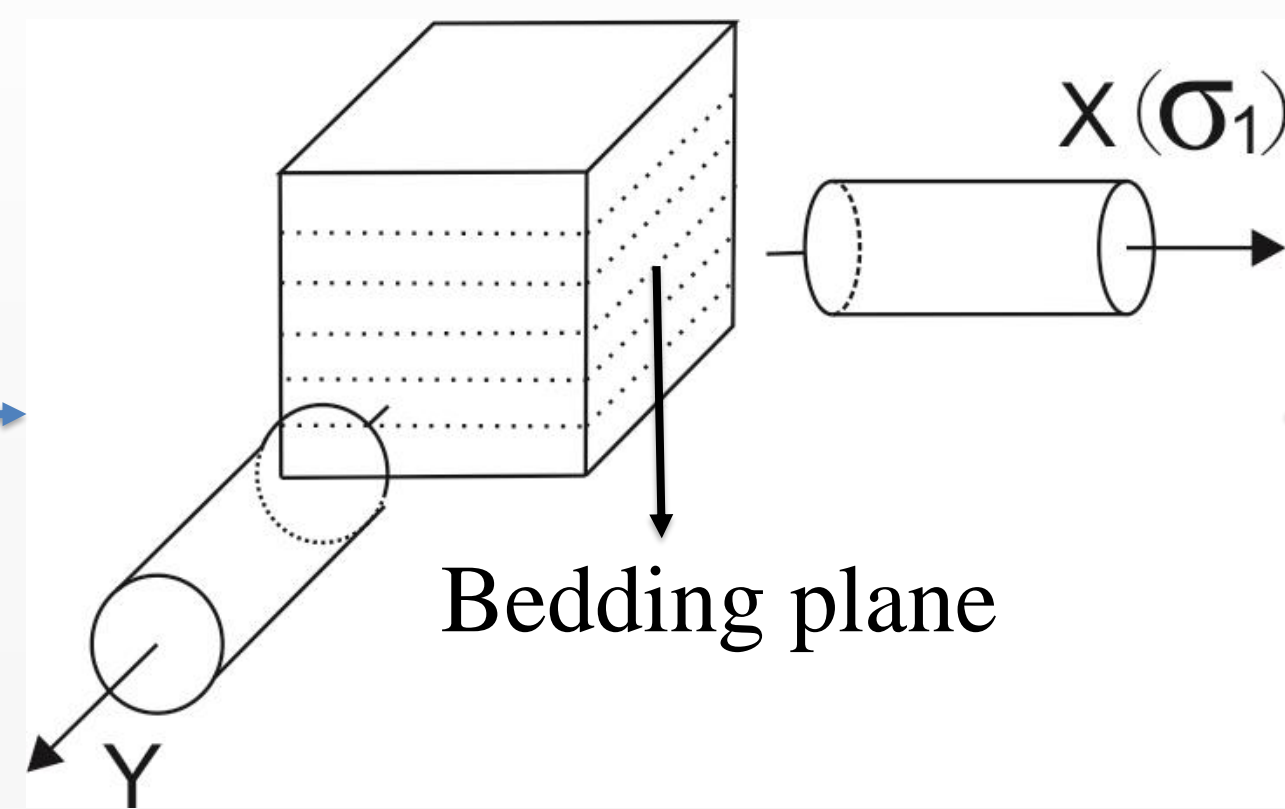
Sample Location

- N29° 52'47.8", E108° 17'06.6"
- Shizhu County, Chongqing, China
- Longmaxi formation (shale): NW330° ∠35°



Sample Orientation

- Same bedding plane
- **X: major principle stress**
- Y: perpendicular to X



Experiment Overview

- Sample size: Φ50mm×100mm
- Experiment apparatus: TAW 1000
- Location: China University of Petroleum



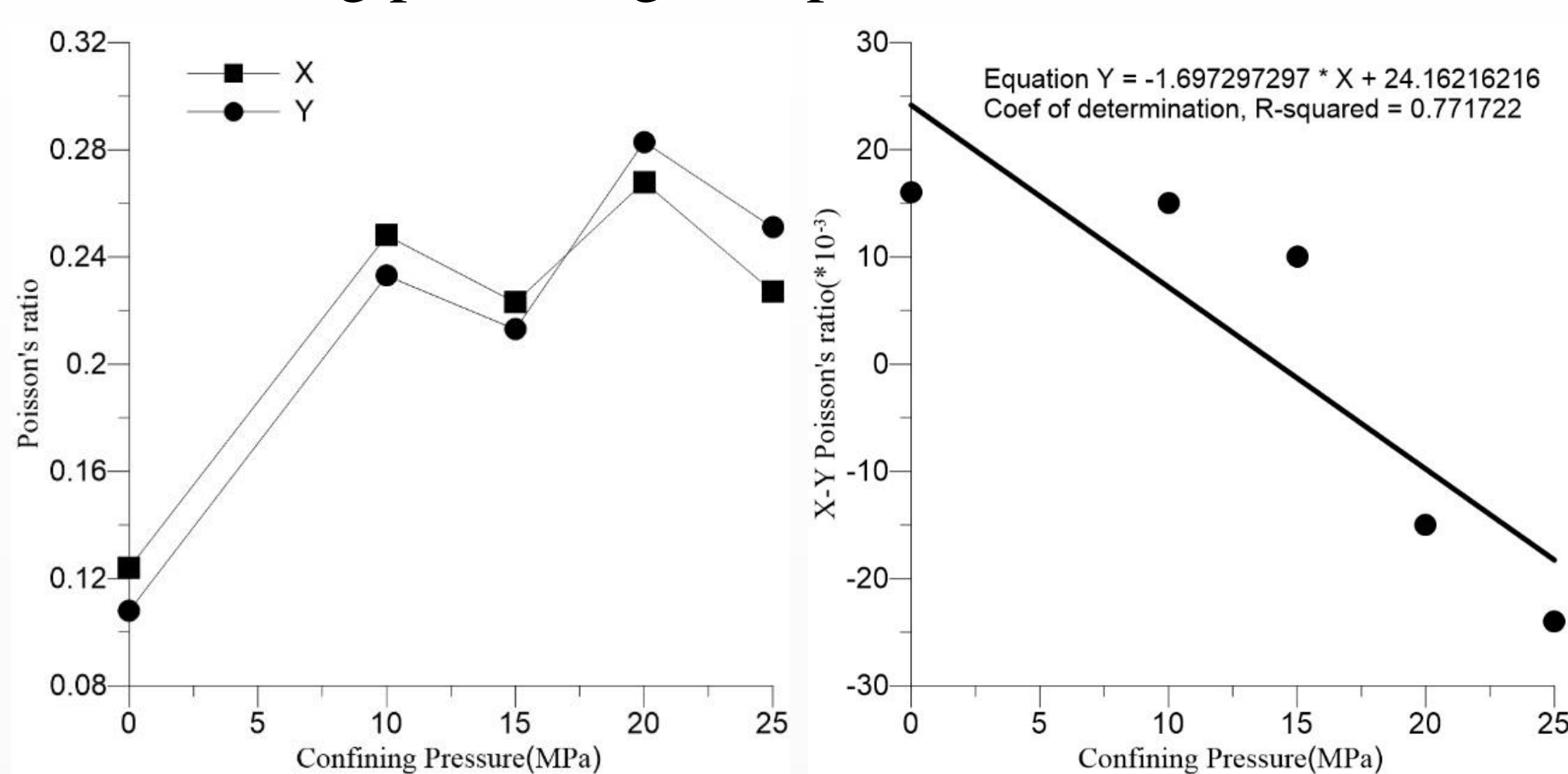
Experiment Design

- Confining pressure(MPa):
0 10 15 20 25
- Experiment target:
Young's modulus
Poisson's ratio
Peak strength
- Compare experimental results from X and Y group
- Analyze friction angle and cohesion according to the sample direction

RESULTS AND DISCUSSIONS

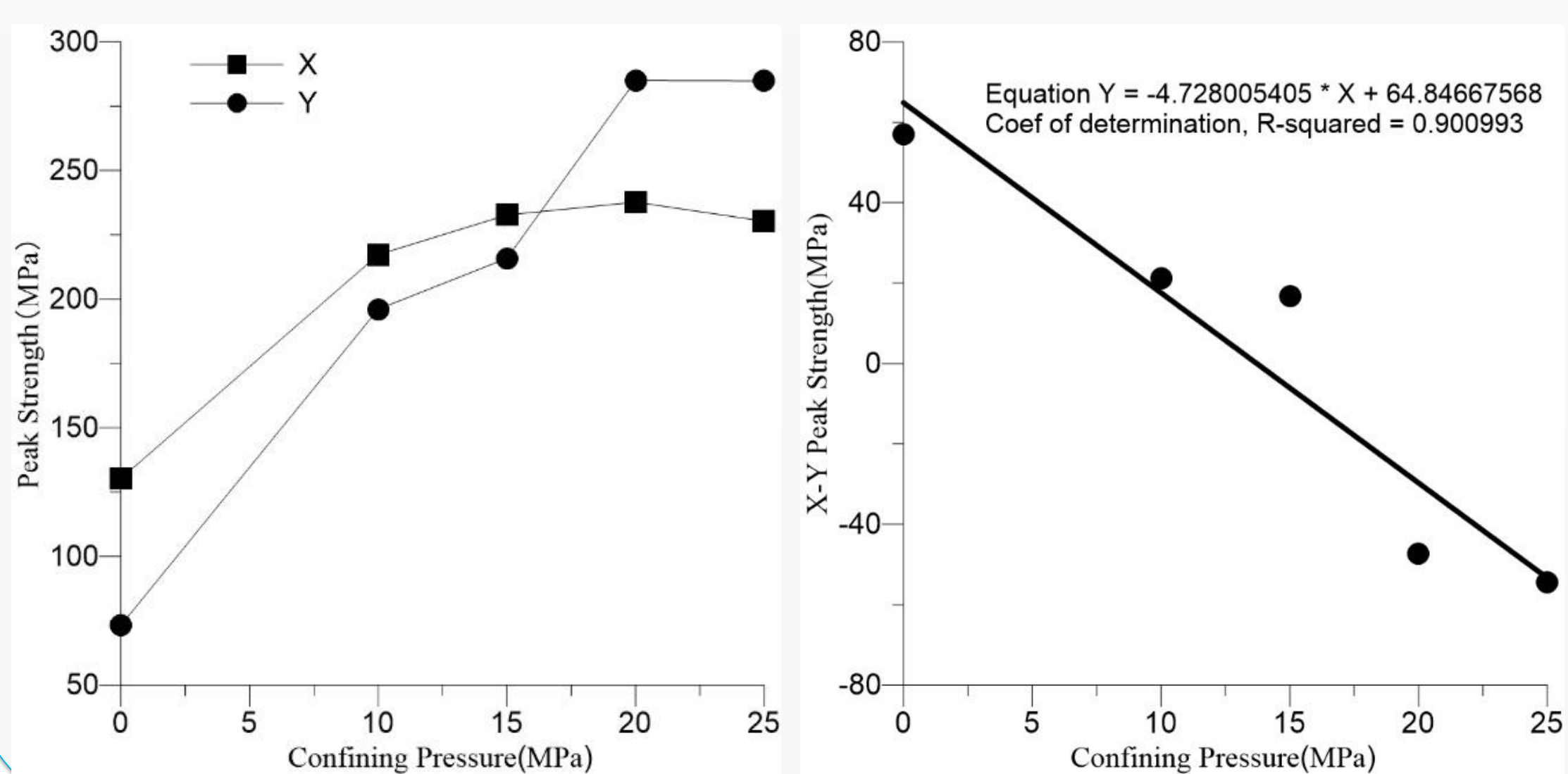
Poisson's ratio differs in two directions

- A **intersection point** exists between the confining pressure of 15MPa and 20MPa.
- Values in X group are bigger than Y group before the intersection point.
- Difference between X group and Y group rises as confining pressure goes up.



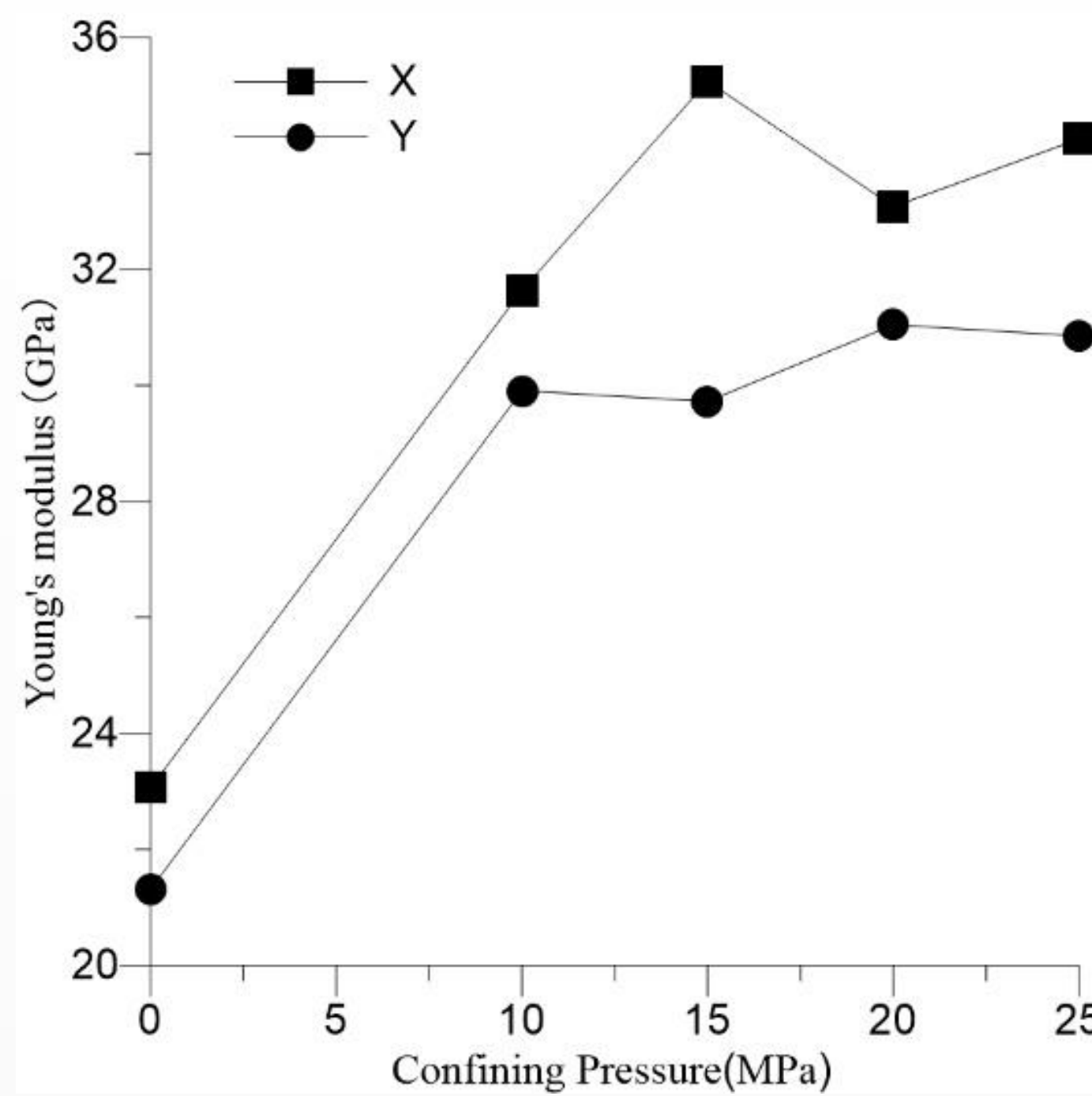
Peak strength differs in two directions

- A **intersection point** exists between the confining pressure of 15MPa and 20MPa.
- Similar results to Poisson's ratio



Young's modulus differs two direction

- Young's moduli in X group are **always** bigger than those in Y group.
- Difference between two directions shows no regularity.



Different cohesion and friction angle in two directions

- X direction has higher cohesion but lower friction angle compared with Y direction.
- If data from X and Y groups are analyzed together, the results are different from the results in single group.

	Cohesion(MPa)	Friction Angle(°)
X	29.305	43.34
Y	14.713	53.16
X and Y	19.091	50.03

CONCLUSIONS

Regular difference of peak strength and Poisson's ratio

Young's modulus in X group>Young's modulus in Y group

Different cohesion and friction angle in two groups

Different mechanical properties in X and Y directions

In situ stress has impact on the anisotropy

Not transverse isotropy but anisotropy in three dimensions

More proof in our latest research:

- ◆ X plane has 1.32 million microfractures.
- ◆ Y plane has 0.71 million microfractures.

Open question:

- ◆ Why peak strength and Poisson's ratio has similar intersection point while Young's modulus not?
- ◆ The meaning of the intersection point in the Poisson's ratio and peak strength diagrams?

References

- Anon (2011), Stress anisotropy and velocity anisotropy in low porosity shale, *Tectonophysics*, 503(1–2), 34–44, doi:10.1016/J.TECTO.2010.09.023.
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