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EGU26 GENERAL ASSEMBLY

Inherited lithospheric weakness enabled rapid stress transmission across the Tibetan Plateau

Zhaotong Sun[1,2], Giulio Viola[2], Jing Liu-Zeng[1], Leonardo Del Sole[2,3], Yong Zheng[4], Xuwen Shen[1]

Corresponding: sunzhaotong2021@outlook.com

[1] School of Earth System Science, Institute of Surface-Earth System Science, Tianjin University, Tianjin 300072, China. [2] Dipartimento di Scienze Biologiche, Geologiche ed Ambientali-BiGeA, Università di Bologna, Bologna 40126, Italy.
[3] Istituto Nazionale di Geofisica e Vulcanologia, Roma 00143, Italy. [4] Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China.

ALMA MATER STUDIORUM UNIVERSITA' DI BOLOGNA

a Motivation

The Issue How did the rigid Asian lithosphere respond to the initial India-Asia hard collision (~65-50 Ma)?

1. Progressive outward and northward growth (Tibetan Plateau growth > 30 Myr).
2. Rapid lithospheric stress transmission (< 5 Myr).

Why the Altyn Tagh Fault? The Altyn Tagh Fault (ATF) is a >1600 km long lithospheric fault zone and an ideal recorder of far-field stress.

The Challenge Reliable deformation ages are necessary to pinpoint the timing of localization along the edges of the plateau. Age constraints rely on indirect methods (thermochronology, stratigraphy) that can't distinguish climatic erosion / fluid circulation from actual tectonic slip.

Direct dating of frictional fault slip is a viable approach.

b Tectonics Setting

Sampling localities Eastern Altyn Tagh Fault, Aksay Bend.

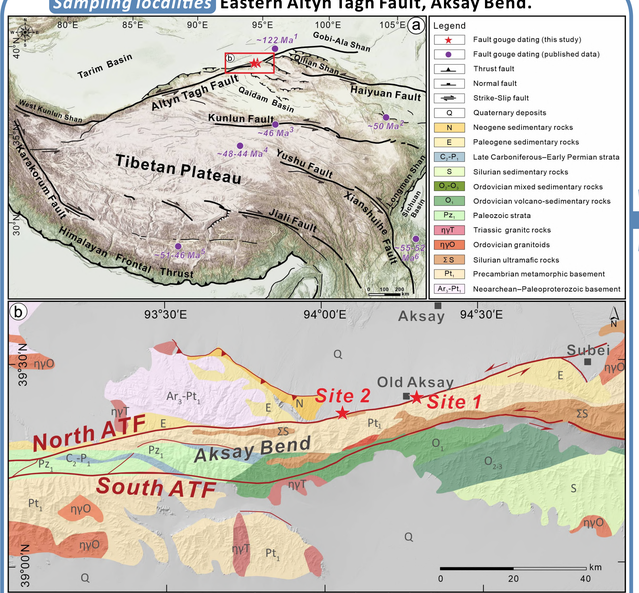

Fig. 1. Regional tectonic setting and sampling localities.
a, Simplified active fault map of the Tibetan Plateau. Red stars indicate our sampling sites (Sites 1 and 2). Purple dots mark previously dated fault-gouge localities across the plateau: 1, Nanjieshan Fault; 2, West Qinling Fault; 3, Xidatan Fault; 4, Fenghuoshan Fault; 5, Zhongba-Gyangze fault; 6, Leibo Fault.
b, Geological map of the eastern ATF near Old Aksay showing the main fault branches.

c Workflow

How we directly dated brittle fault

- Identify "Brittle Structural Facies"(BSFs) at the outcrop by detailed structural investigations.
- Separate authigenic illite from carefully selected fault rock samples.
- K-Ar dating + Illite Age Analysis.
- X-ray diffraction + microstructural analysis.

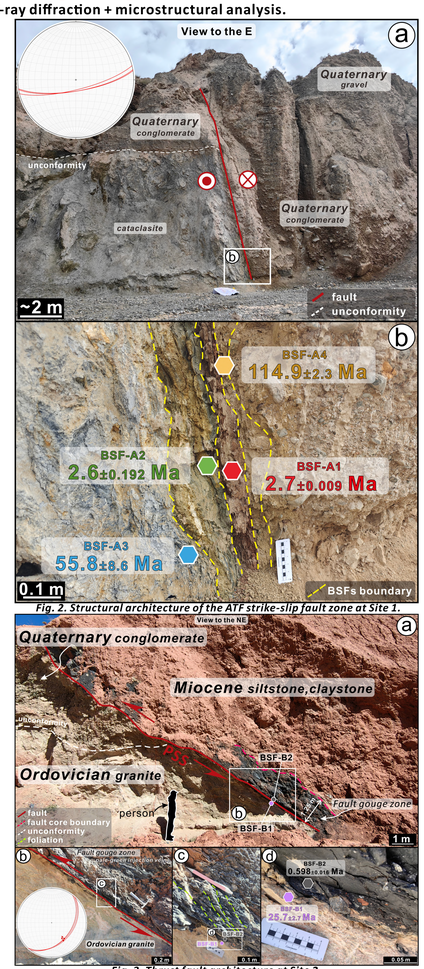

Fig. 2. Structural architecture of the ATF strike-slip fault zone at Site 1.

Fig. 3. Thrust fault architecture at Site 2.

d Episodic faulting

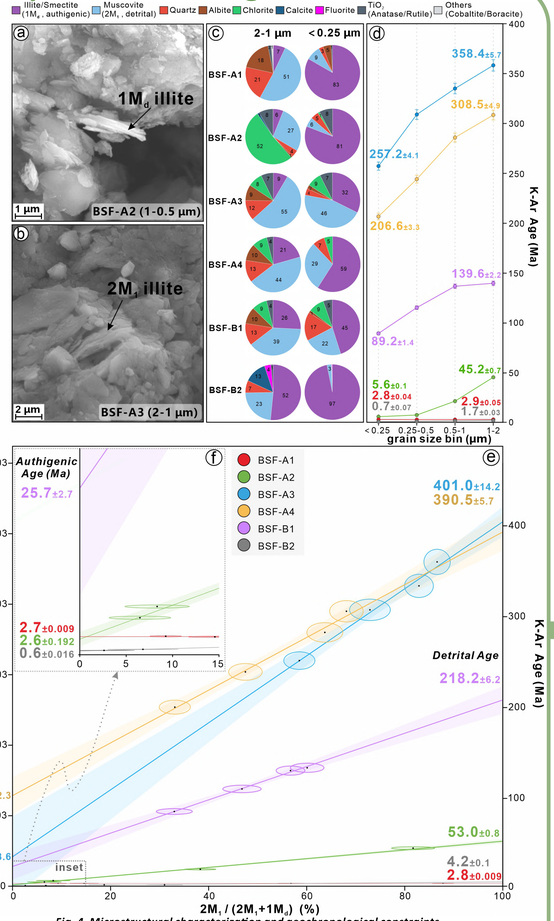

Fig. 4. Microstructural characterization and geochronological constraints.

- **~115 Ma** The presence of a lithospheric-scale zone of weakness.
- **~56 Ma** The first direct geochronological evidence that brittle deformation along the ATF initiated within <10 Myr of collision onset.
- **~26 Ma ~2.7 Ma,~0.6 Ma** Progressive localization of deformation and multiple reactivation to present times.

e Tectonic Evolution Model

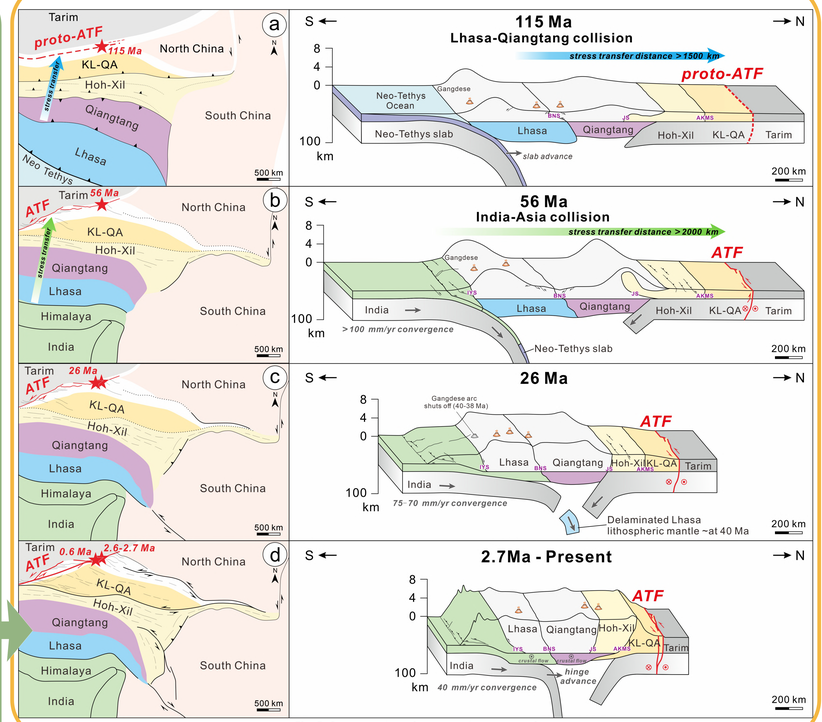

Fig. 5. Conceptual spatiotemporal reconstruction.

f Take-home Messages

- ***Lithospheric Preconditioning*** The ATF is not merely a Cenozoic structure. A proto-ATF fault active at ~115 Ma established a long-lived lithospheric weakness that preconditioned Asia for later collision-driven deformation.
- ***Rapid Far-field Stress Transmission*** Reactivation at ~56 Ma indicates that India-Asia hard collision stresses transmitted across >1500–2000 km of continental lithosphere within <10 Myr, triggering near-synchronous brittle faulting along inherited weaknesses at the northernmost boundary of the present-day Tibetan Plateau.
- ***Faults as Deep-Time Stress Gouges*** The 115–0.6 Ma record shows repeated deformation localization on major lithospheric faults. Efficient deformation along inherited weaknesses is a persistent mode of continental tectonics, as also shown by present-day geodesy.