# 西藏野外工作甘苦談
# Field work in Tibet

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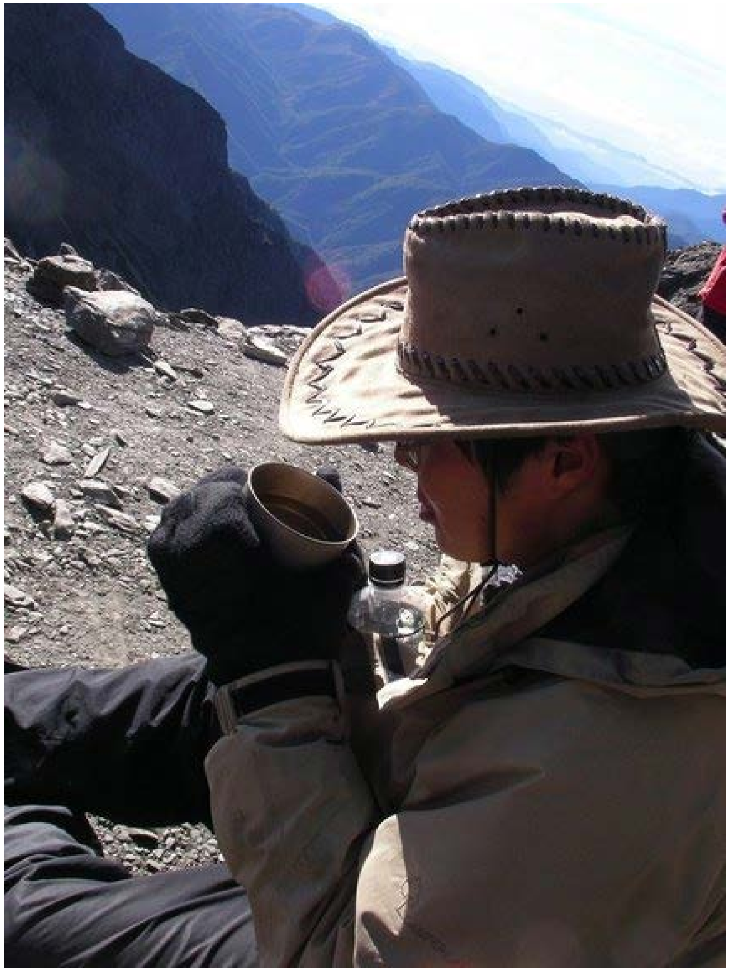
# 個人簡歷 CV

- 流浪時間：21年(1996-)
- 美國國家公園:35+座
- 台灣百岳攻略：13枚
- 離島攻略：澎湖、蘭嶼、綠島、小琉球、基隆嶼
- 奇特旅遊地點：西藏7次、青藏鐵路1次、越南奠邊府、墨西哥沙漠、大峽谷底部、黑海、紐西蘭。



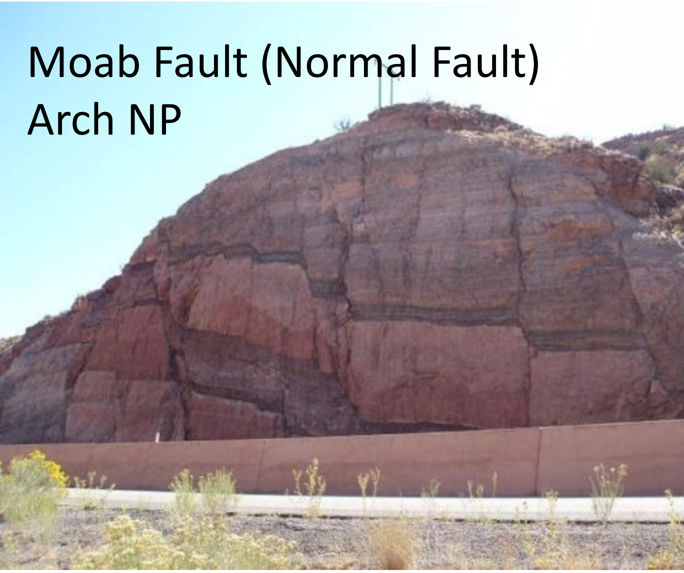
# 禮拜一開始在這裡工作





# 一切的起源921集集地震




Moab Fault (Normal Fault)
Arch NP


2013 薄荷島地震


2010墨西哥地震

# 參與國外地震調查


1951崩錯地震
西藏


2008
汶川地震


2016熊本地震

# 野外工作(Field work)

- **野外地質學**就是專門


叫做**地質調查**

# 地質學家的密技
## Extra-skill of geologist



543Lab at Tibet

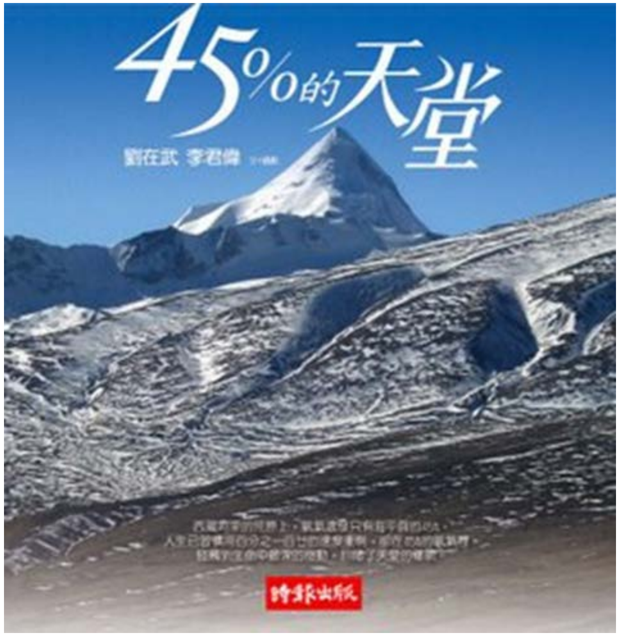
Great thanks to my friends in China



# 在西藏做研究(旅遊?)的優缺點

## Why Tibet？

世界屋脊，高度4500公尺以上，有第三極之稱。




優點：

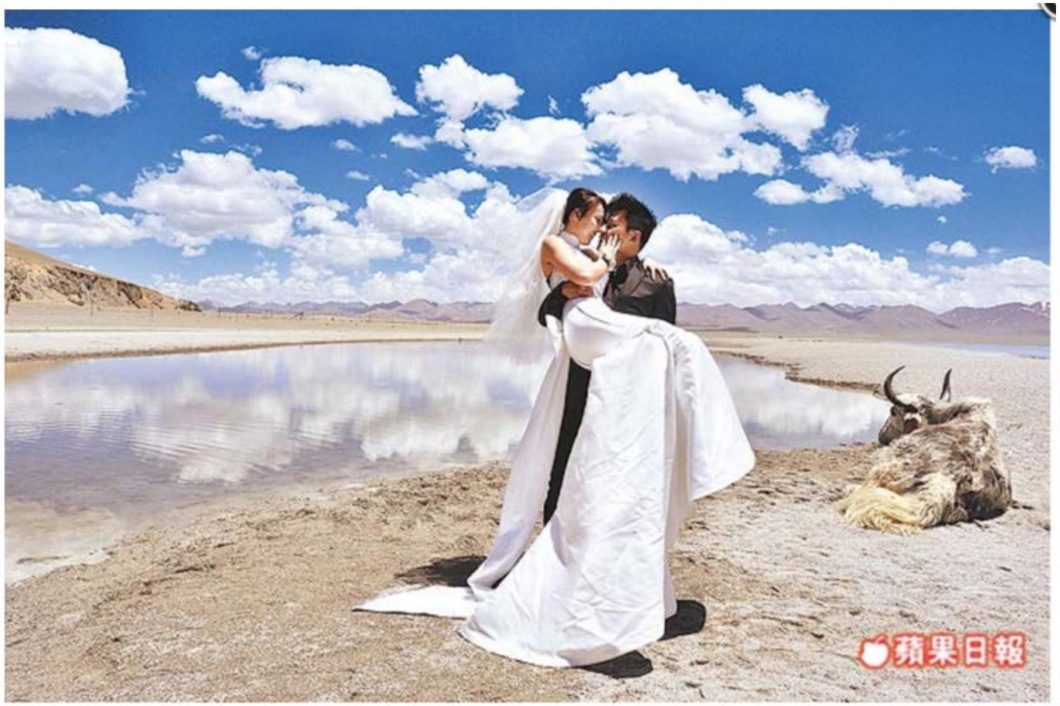
- 氧氣稀薄，照片怎麼拍怎麼漂亮
- 適合做天文研究。

缺點：

- 氧氣稀薄，容易有高山症與身體不適。
- 洗澡問題。

# 好瘋 海拔5200米 攀珠峰拍婚紗 (蘋果日報)

【劉嘉韻／台北報導】為留下一生一次的回憶，很多新人選擇特殊景點拍婚紗照。台北市一對準新人，上月扛著白紗禮服跑到西藏自拍婚紗照，不但得克服高山症，新娘還穿著高跟鞋與露肩婚紗，在海拔五千二百公尺的珠峰（聖母峰）登山口拍照，新娘說：「我應是史上在地球表面最高處穿婚紗的新娘，很有意義。」




郝亦為抱起賀楚芬，在海拔4700公尺、風景壯闊的納木錯湖畔拍照。郝亦為提供


郝亦為、賀楚芬在珠峰登山口自拍婚紗照。

http://www.appledaily.com.tw/appledaily/article/headline/20120710/34357614/

# 羊卓雍錯

Elv.4441m



http://www.wed8848.com/2015/xizangkp_0618/264.html

# 那木錯

Elv. 4718m西藏第二大的湖泊，也是中國第一大的鹹水湖



http://www.wed8848.com/2015/xizangkp_0704/268.html

# 在西藏做研究(旅遊?)的優缺點
# Why Tibet?

缺點：大量經費，路途遙遠。(20天2-4人約25-30萬)
優點：幅員遼闊，豐富礦產，研究完成度不高，比較容易有新成果出現


趕路趕到晚上9:24的天色

# 路途遙遠,所以車很重要


**Land cruiser 4500**


**Hilux**

[Toyota成恐怖分子最愛座駕]

# 除了車很重要,路況也很重要

# 在西藏做研究(旅遊?)的優缺點
# Why Tibet?

缺點：

- 每年適合研究（旅遊）的時間只有5-6與8-10月。
- 手續麻煩（入藏函1-3月）。


四月某一天的氣候變化

# 寒冷的具體表現
# Frozen condiction

# 在西藏做研究(旅遊?)的優缺點
# Why Tibet?

優點：

- 研究主題（旅遊）很熱門，藏文化很特別。


http://www.wed8848.com/2015/xizangkp_0822/278.html

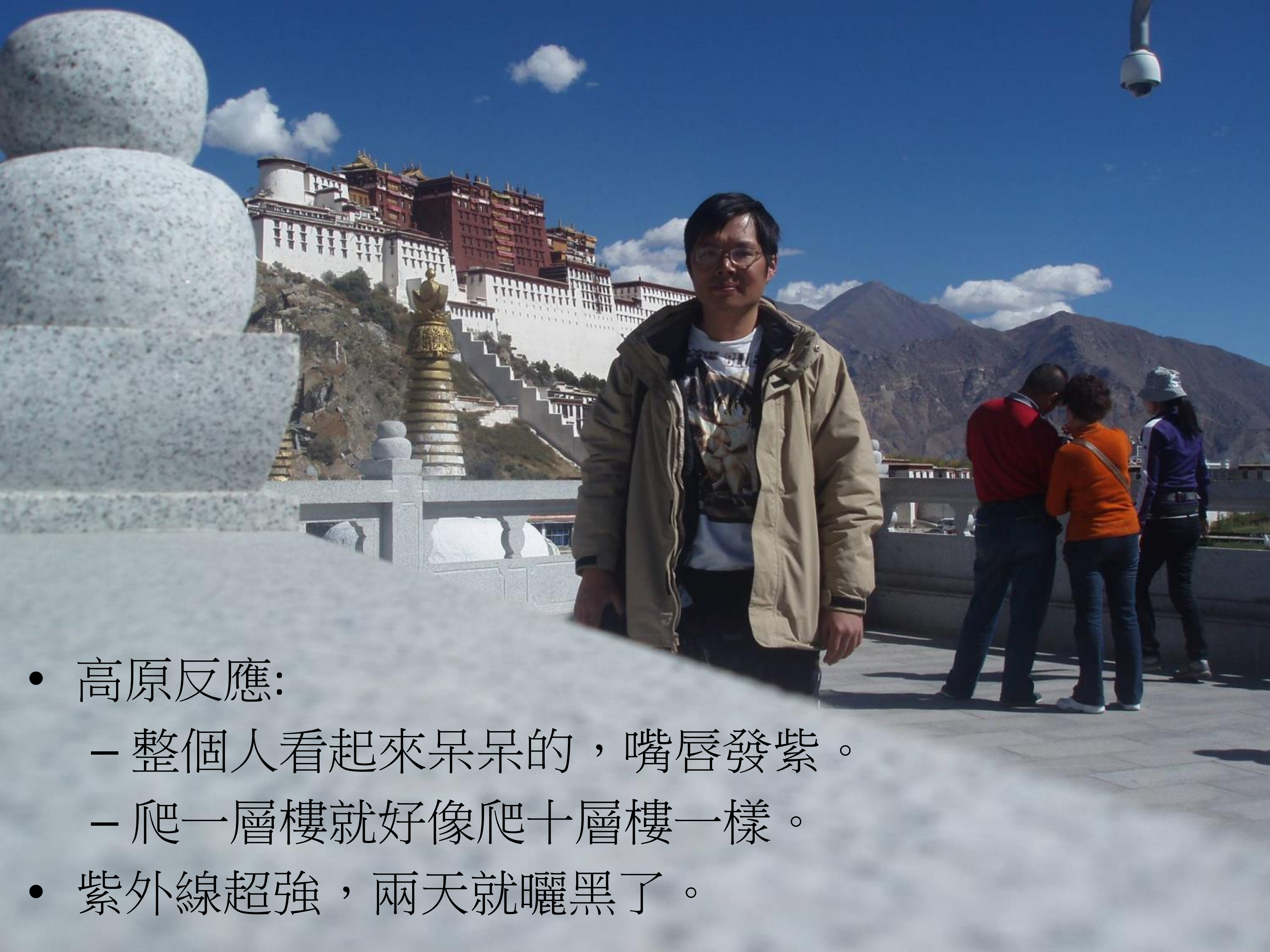
# 布達拉宮


實際情況


http://www.wed8848.com/2015/xizangkp_0907/283.html#6d


http://www.wed8848.com/2015/xizangkp_0506/248.html


http://www.wed8848.com/2015/xizangkp_0610/261.html



- 高原反應:
  - 整個人看起來呆呆的，嘴唇發紫。
  - 爬一層樓就好像爬十層樓一樣。
- 紫外線超強，兩天就曬黑了。

# 2011年 西藏解放60周年

# 大昭寺&八廓街



http://www.wed8848.com/2015/xizangkp_0822/278.html

http://www.wed8848.com/2015/xizangkp_0506/248.html

# 在西藏做研究的優缺點:住
# Why Tibet?


缺點：外國人與台港澳居民相同(只能住涉外旅館)。

# 在西藏做研究的優缺點:食
# Why Tibet?

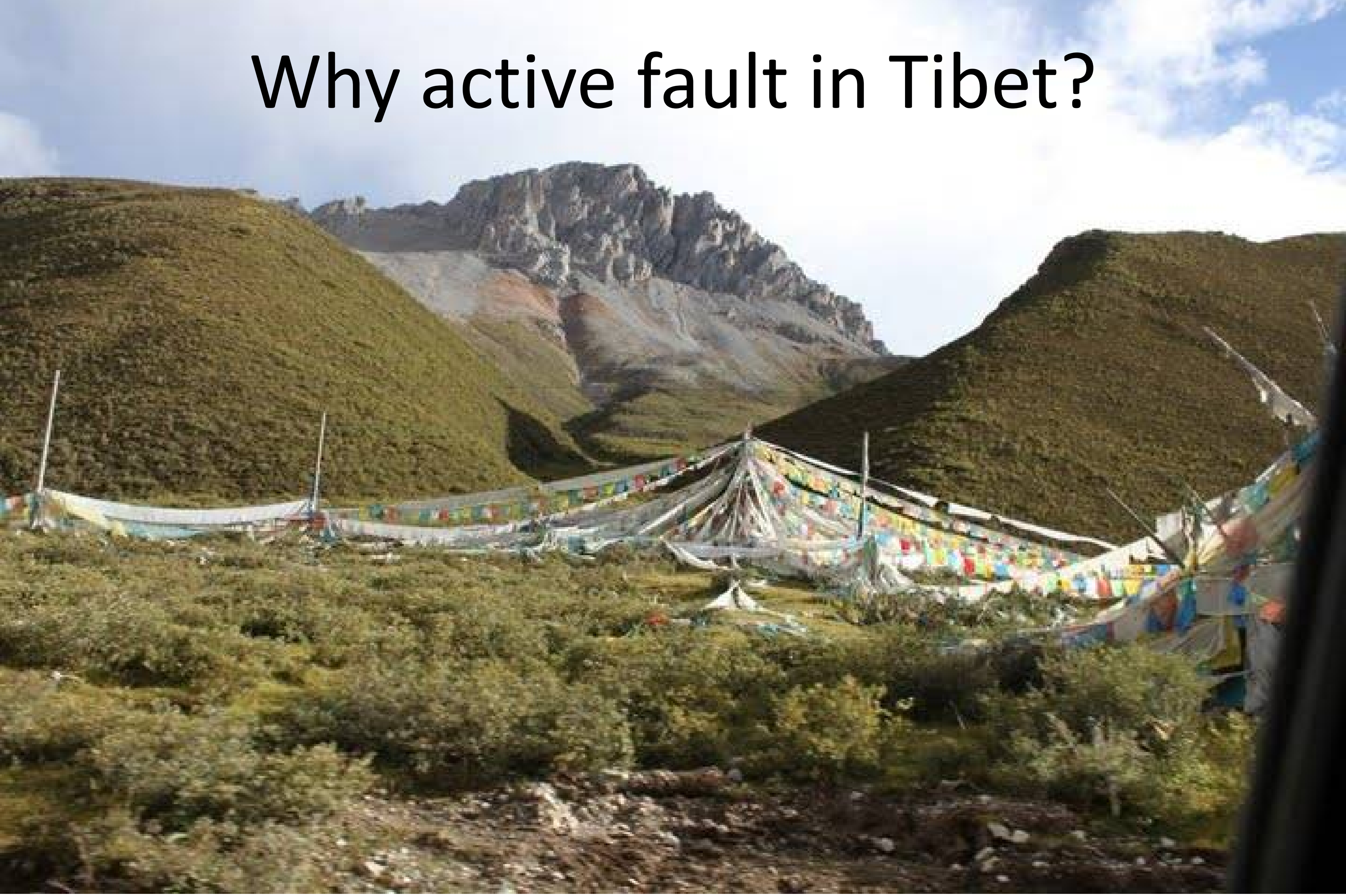
優點：

- 體驗不同的人生
- 訓練自己(or同伴)的脾氣

缺點：

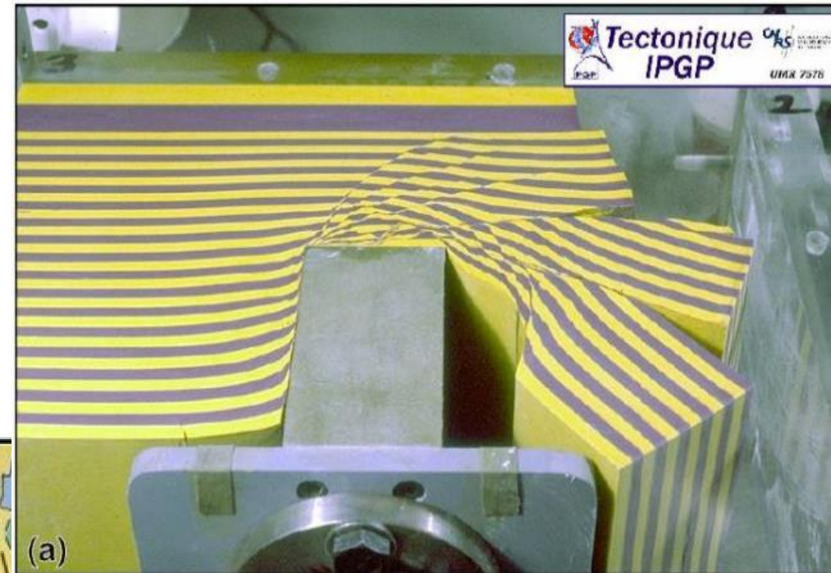
- 川菜（麻辣）、藏菜（難吃）
- 廁所問題(90%乾式)

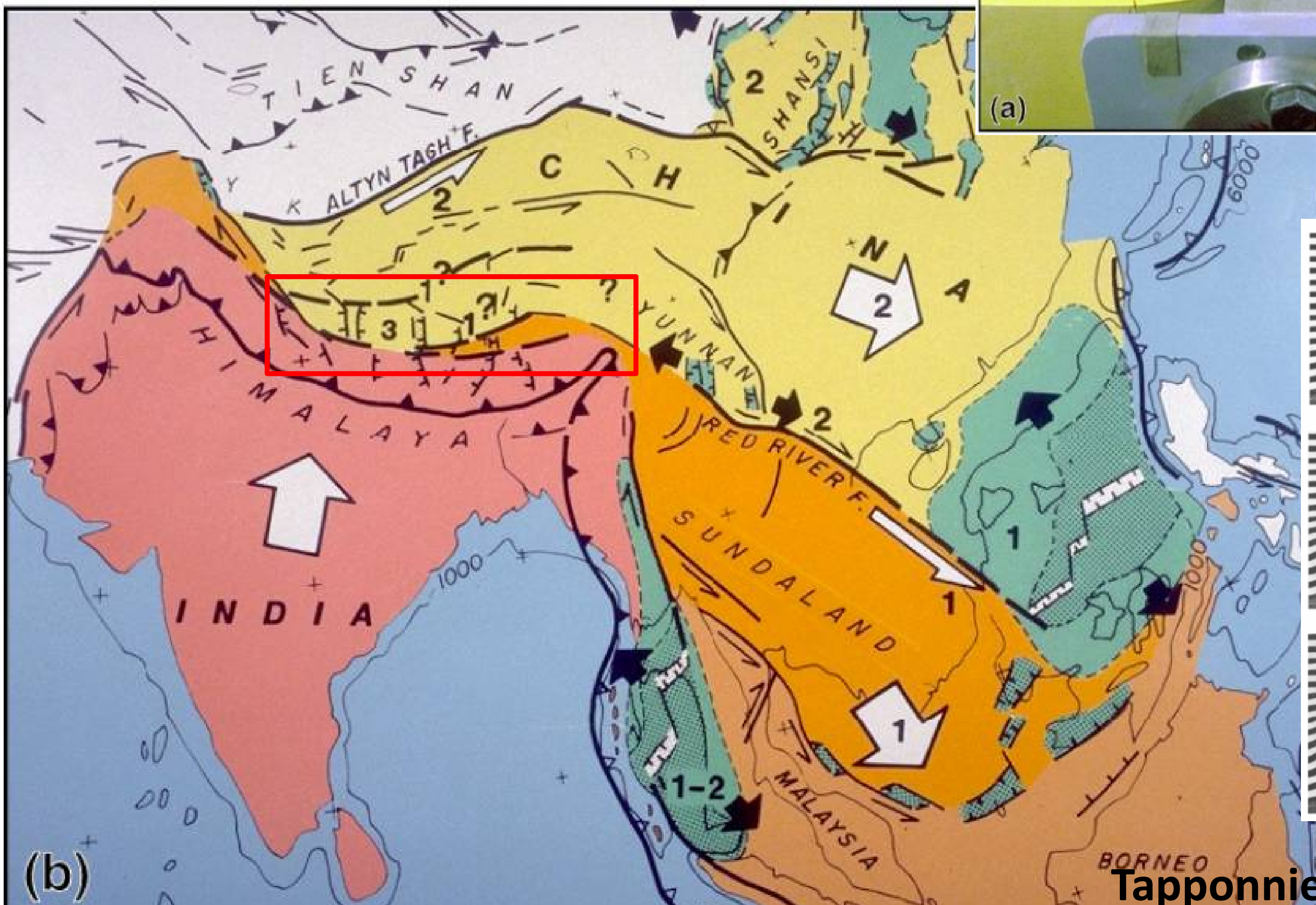
# Why active fault in Tibet?

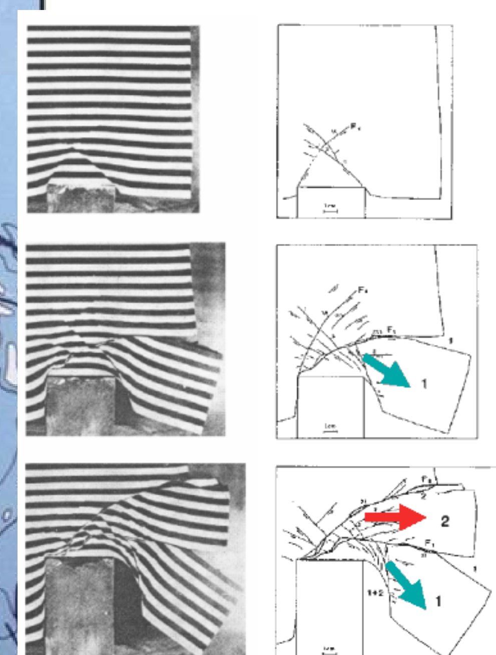


1999 Chi-chi earthquake in Taiwan

# Block model

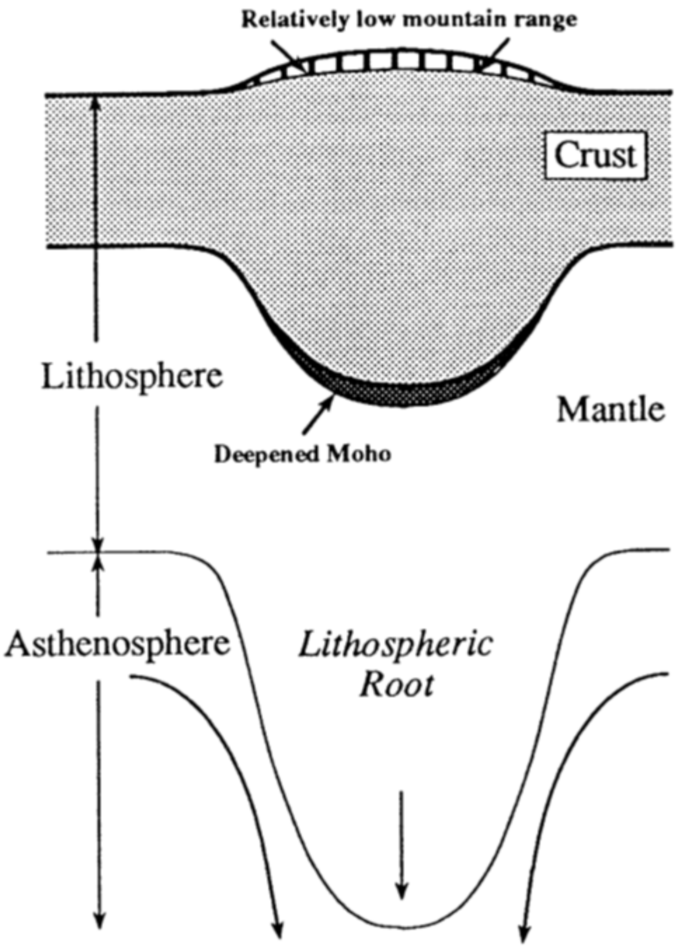


Tapponnier et al., 1982

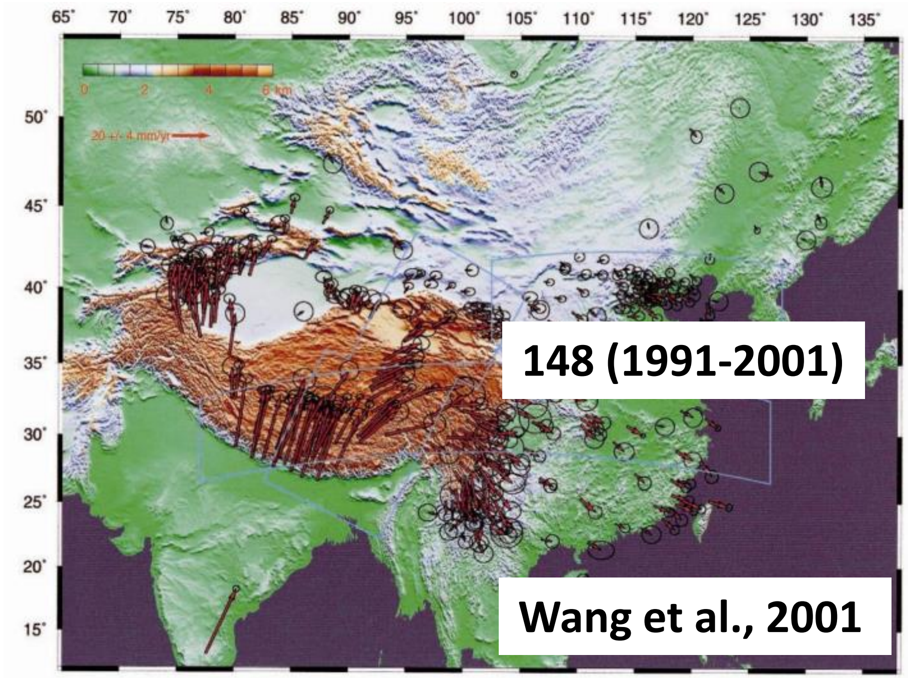
# Continuum model




**~85%** of India's convergence could potentially have been absorbed by crustal or lithospheric thickening. Only c. **10–20%** of the India–Asia convergence taken up by lateral extrusion.

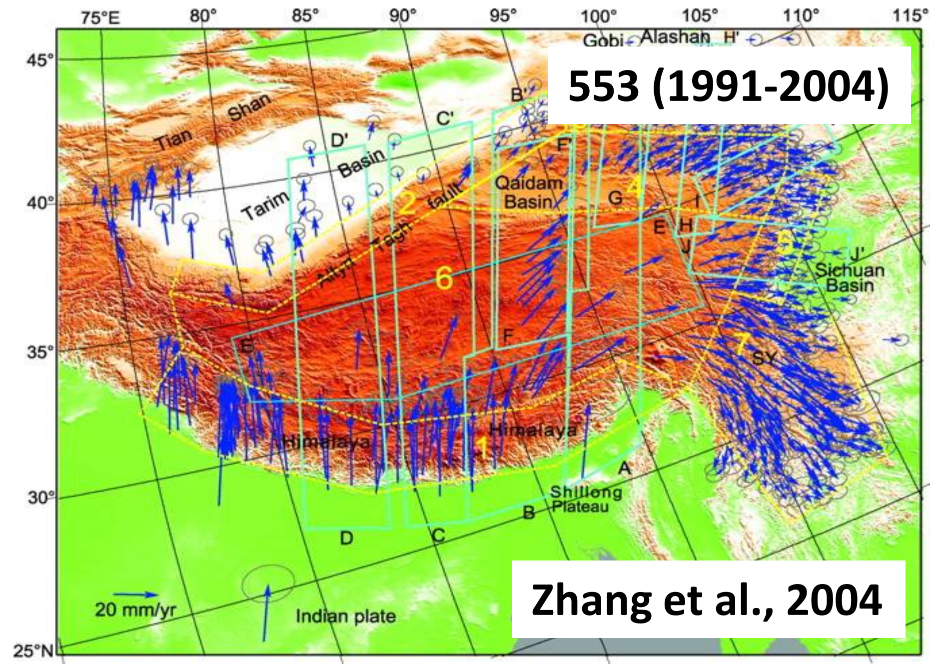
England and Molnar, 1997; 2005

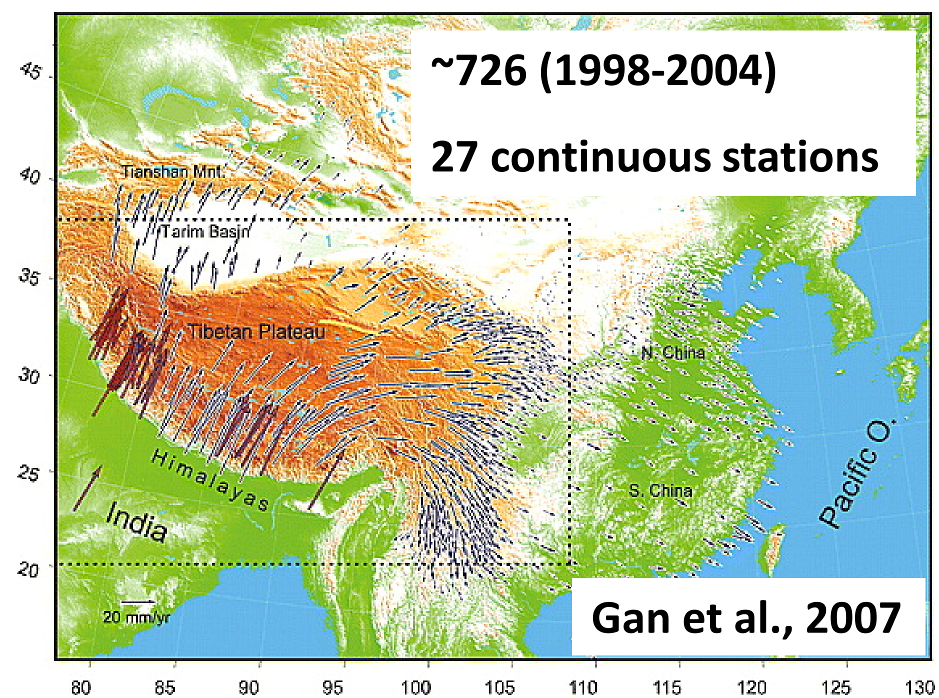
# GPS result



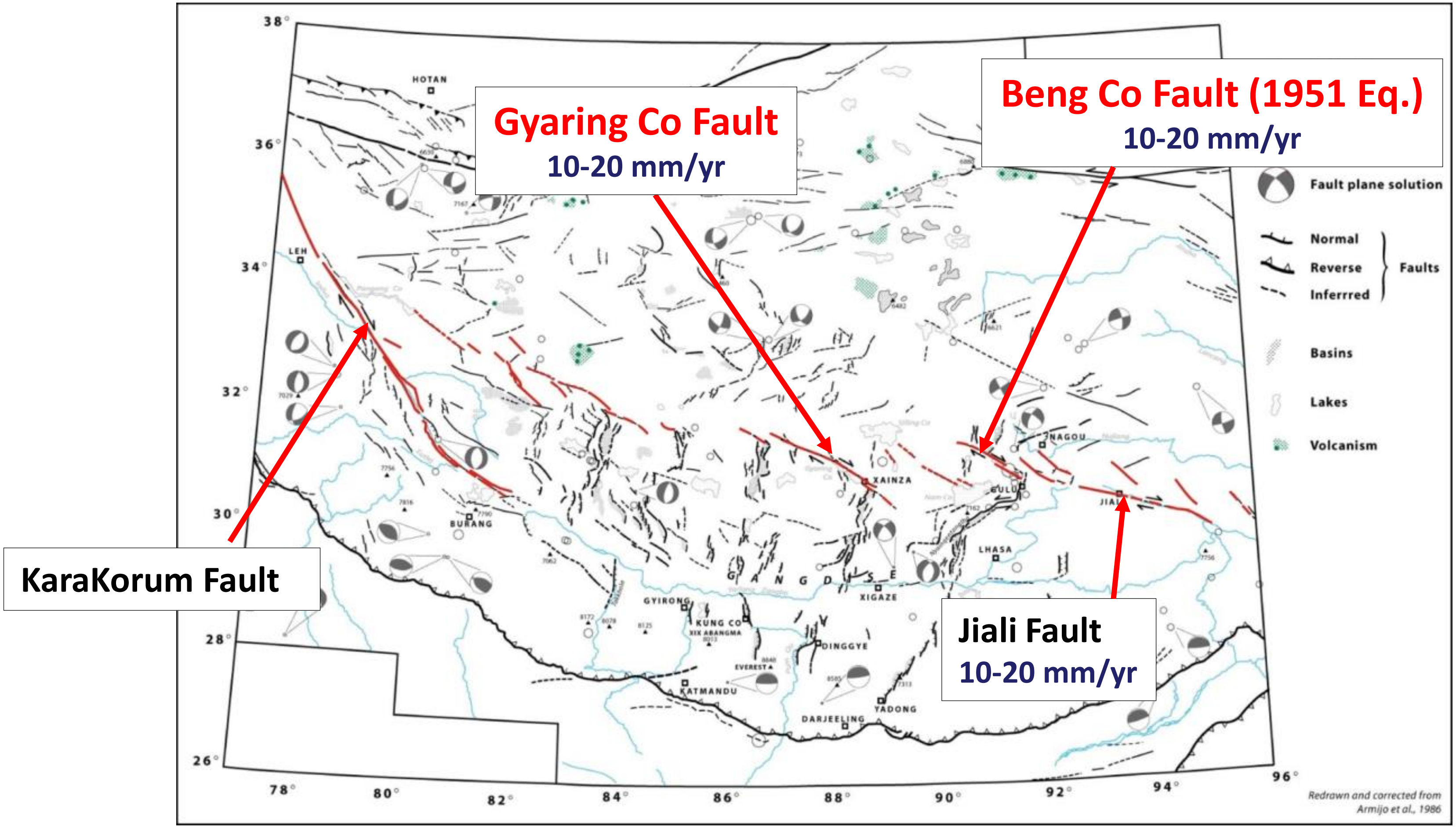

35.9 ± 1.0 mm/yr

GPS in Taiwan
141 (1993-1999; Yu, 1997)
~310 continuous stations
(1995-2005; Ching et al., 2011)



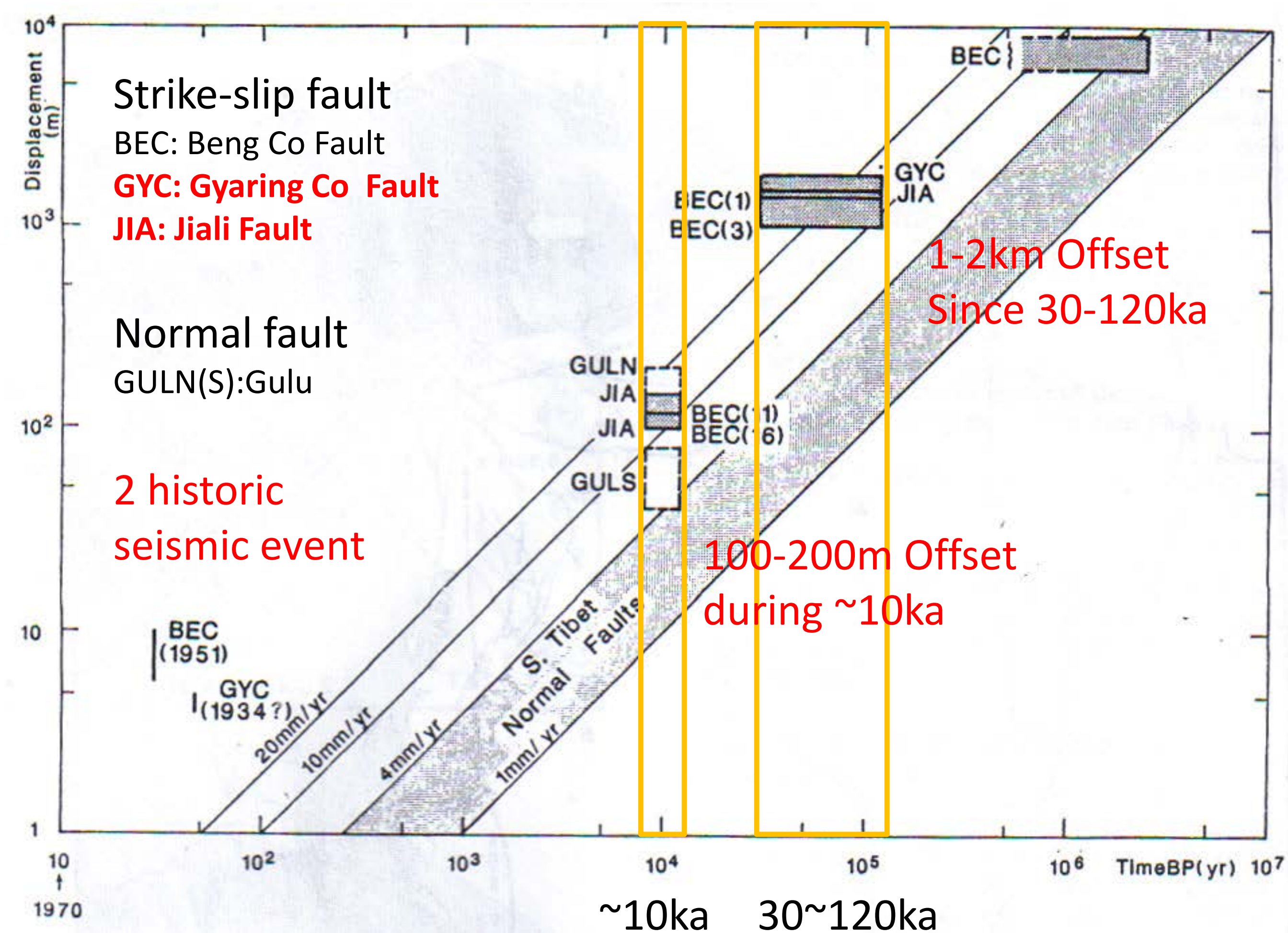



# The Karakoram-Jiali fault zone (KJFZ)



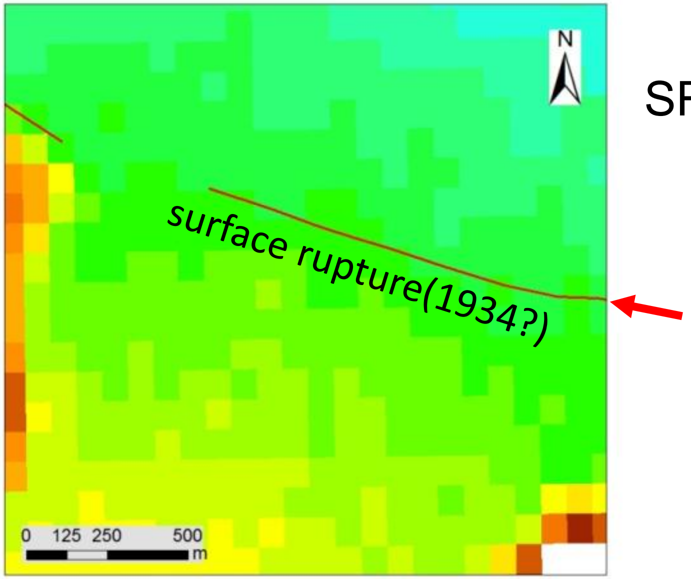

Modified from Aromjo et al., 1989

# The Slip rate of the active fault in the central Tibet

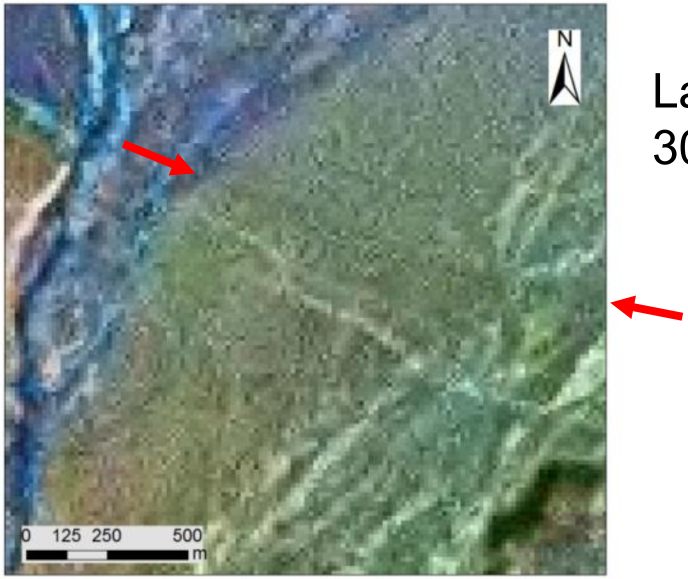



**Armijo et al., 1989**

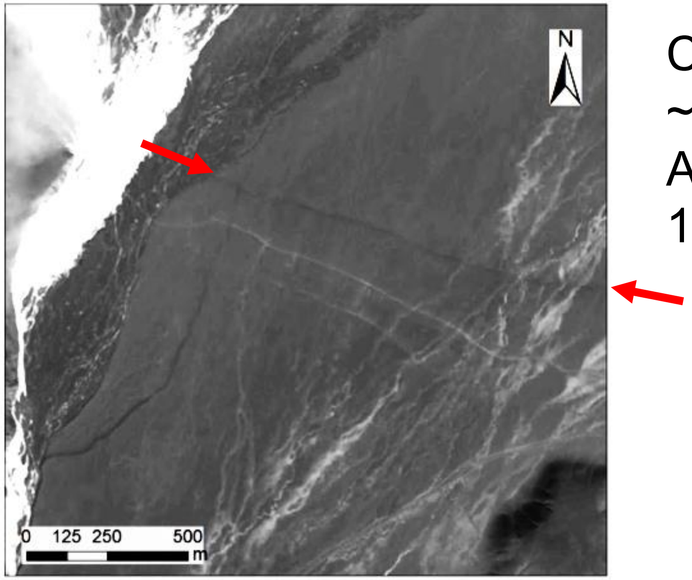
# The resolution of Satellite image and SRTM



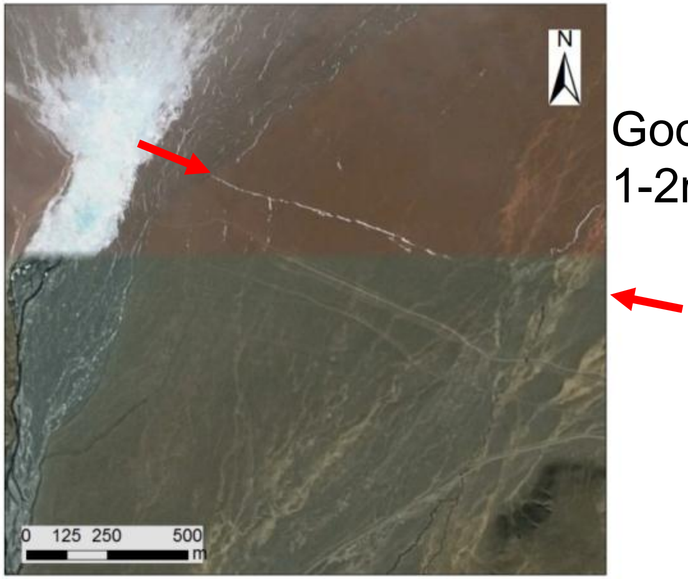

SRTM 90m




Landsat7
30m



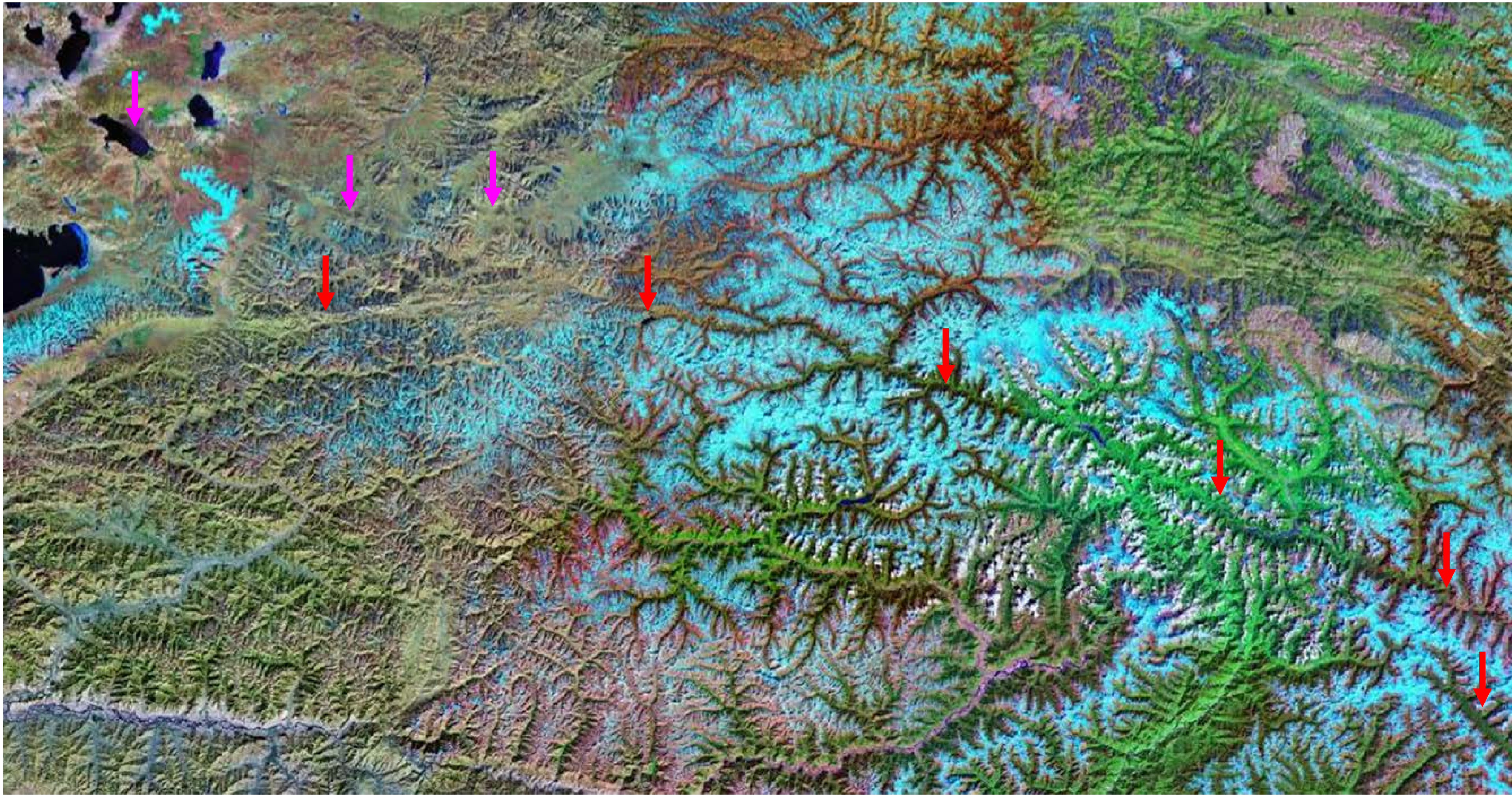

CBESR1
~15m
Aster
15m

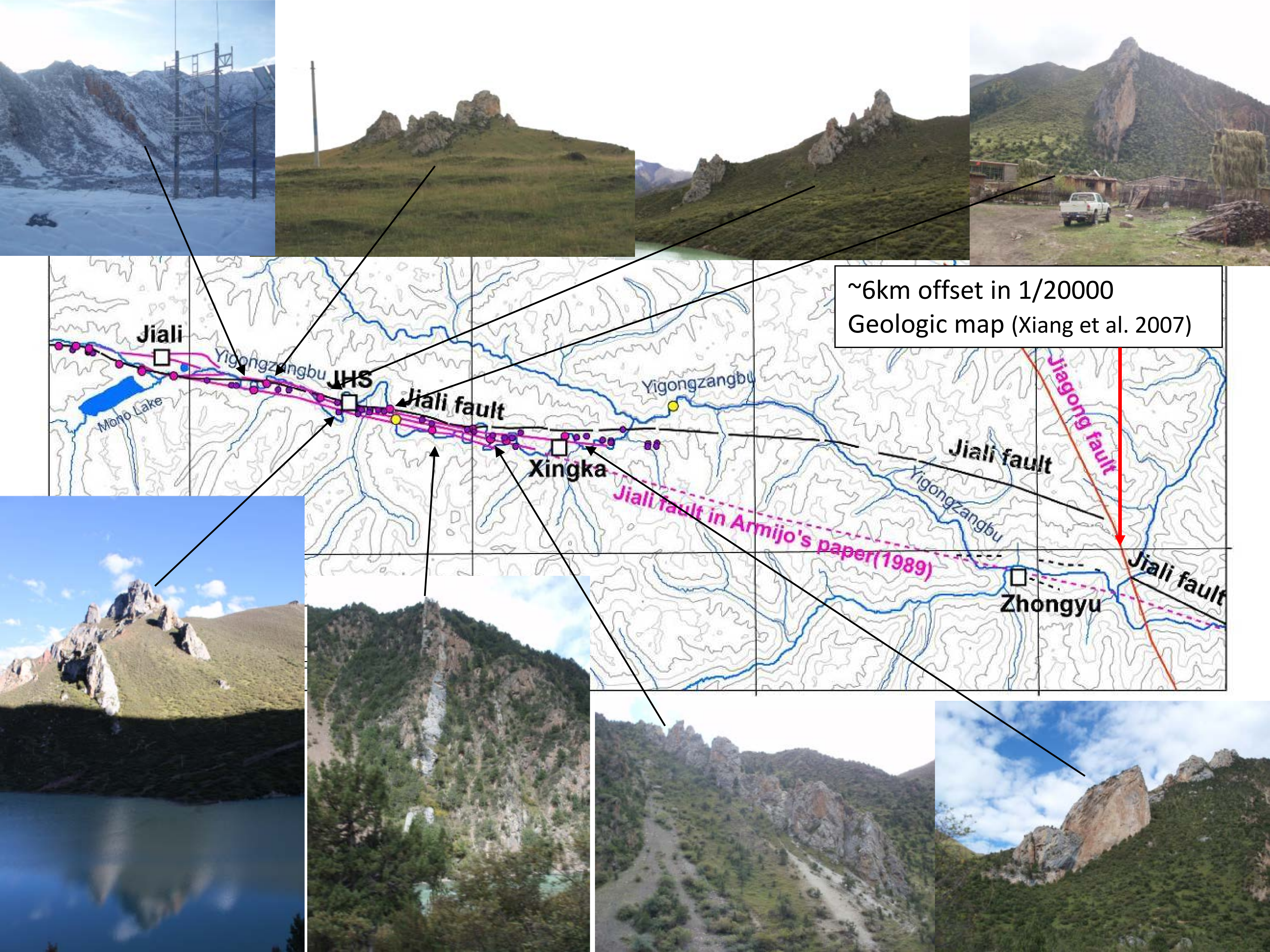



Google earth
1-2m

# Jiali fault (嘉黎斷層)
# 第三次入藏 2009/10(博四)

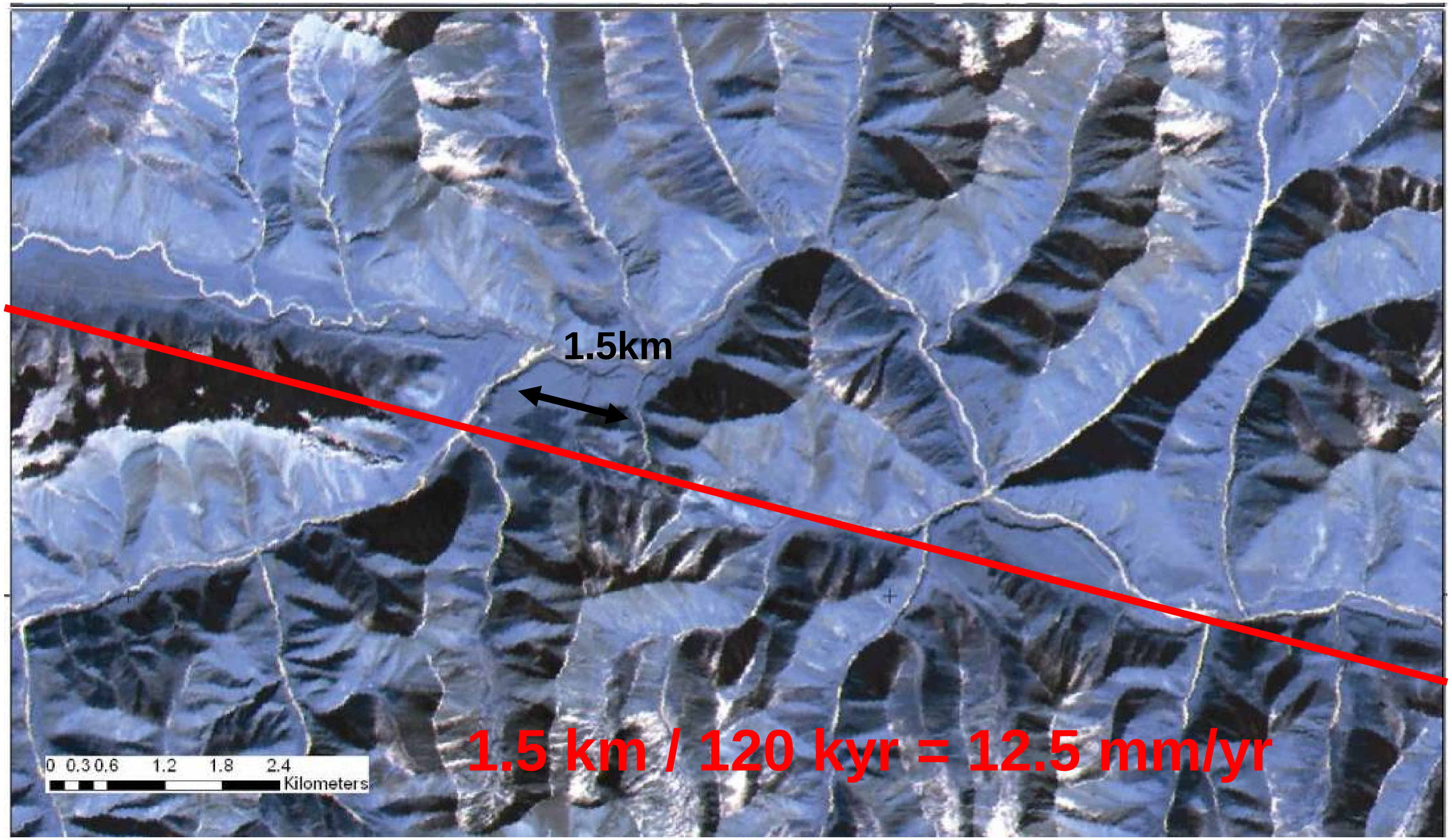
# Jiali fault on Landsat7 image




~6km offset in 1/20000
Geologic map (Xiang et al. 2007)
Jiali
Yigongzangbu
JHS
Jiali fault
Mono Lake
Yigongzangbu
Xingka
Jiali fault
Jiagong fault
Yigongzangbu
Jiali fault in Armijo's paper(1989)
Zhongyu
Jiali fault

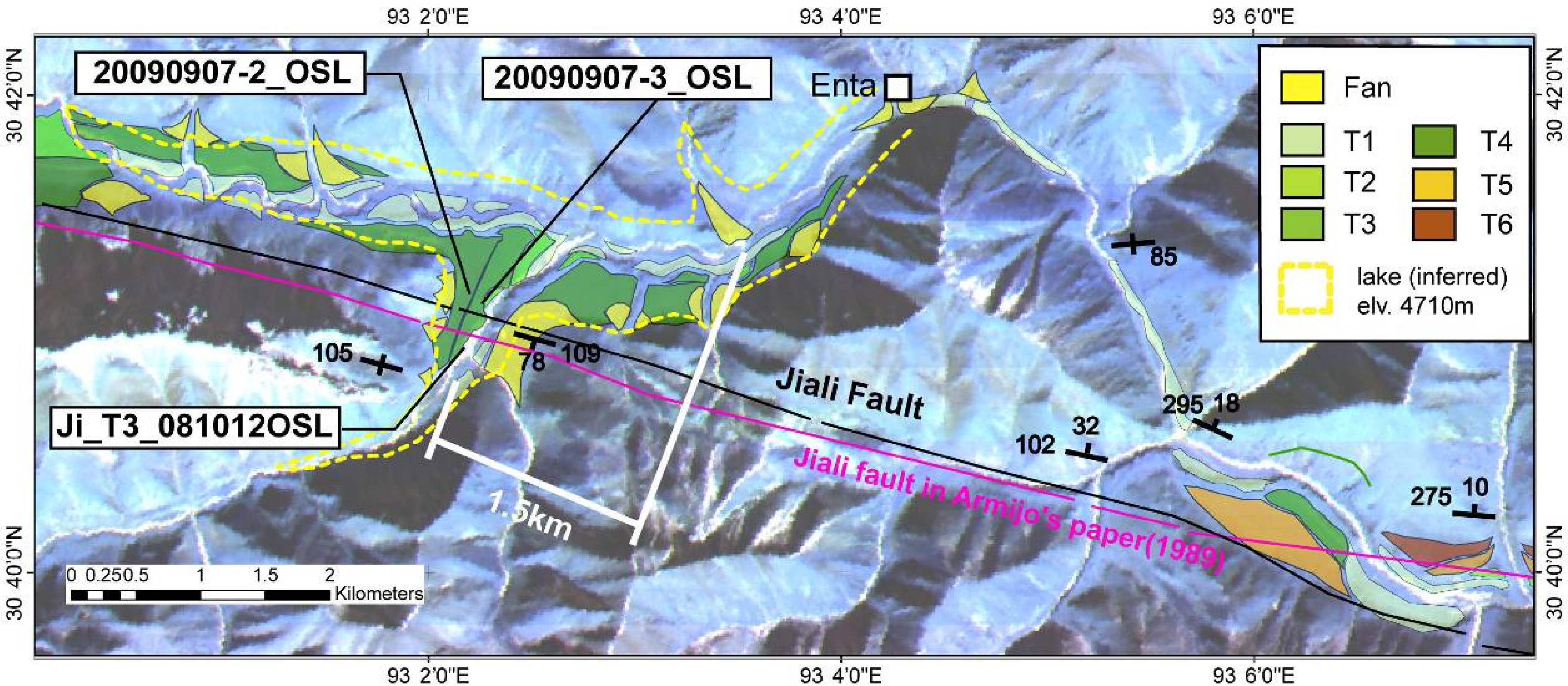
# The evidence of the active(?) Jiali Fault

Spot B in Armijo et al., 1989



# The evidence of the inactive Jiali Fault

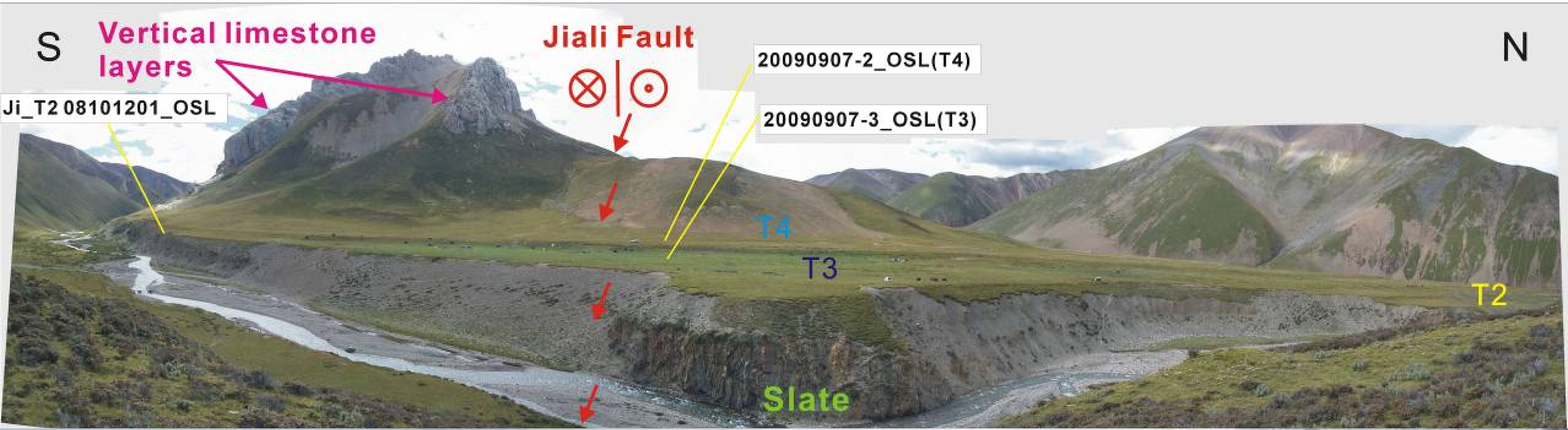
**1.5 km / 120 kyr = 12.5 mm/yr** Spot B in Armijo et al., 1989




The T3 age is 4.5 ± 0.3ka (OSL), and The T4 age is ~5 ka.

If Armijo is right, the fault offset should be ~75m.

# The evidence of the inactive Jiali Fault

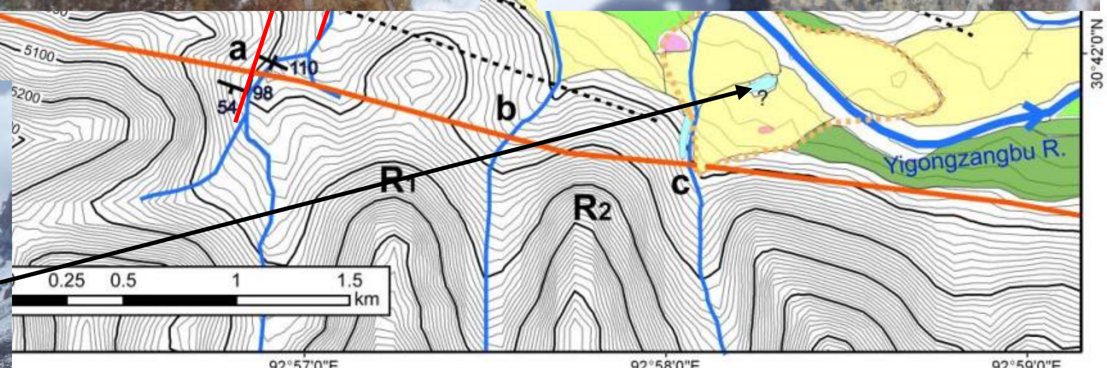


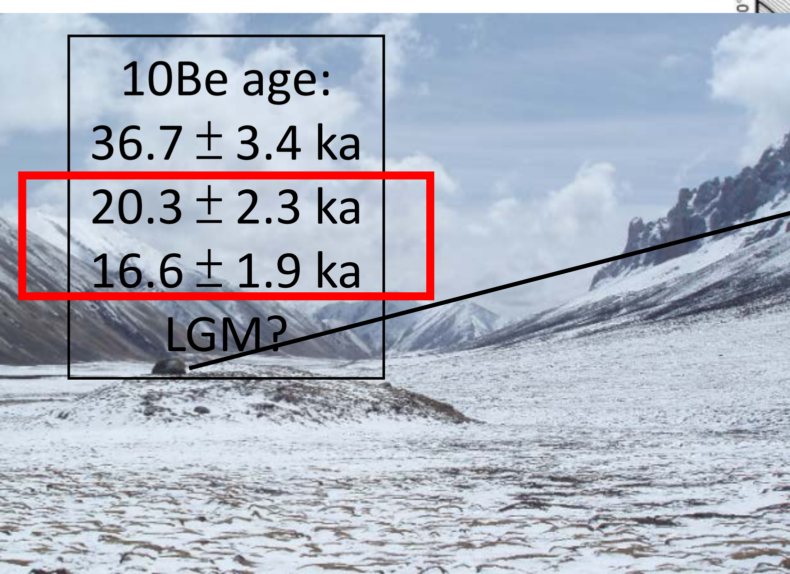


The Jiali fault is no longer active after 5 ka at least !!!

# The evidence of the active(?) Jiali Fault

Spot A in Armijo et al., 1989




**100-150 m / 10000 yr = 10 – 15 mm/yr**
**(Armijo et al.,1989)**

# *in-situ* Cosmogenic Exposure Dating

$^{10}Be$ 5.1 ± 0.3 atoms/g/yr
*at sea level , high latitude*

***$^{10}$Be production pathways in rocks***

$^{16}_{8}O(n,x)^{10}_{4}Be$

$^{28}_{14}Si(n,x)^{10}_{4}Be$

$^{16}_{8}O(\mu^{-},x)^{10}_{4}Be$

$^{28}_{14}Si(\mu^{-},x)^{10}_{4}Be$

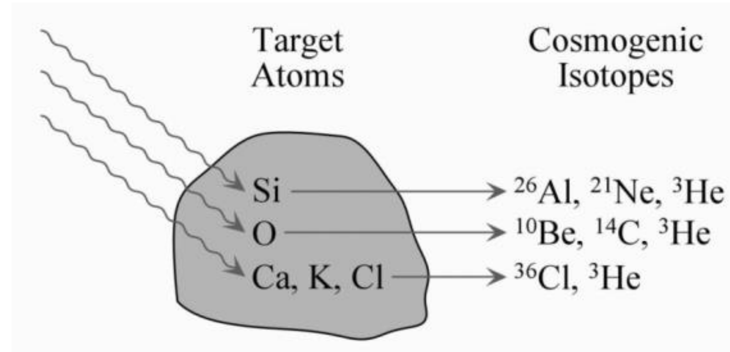
$^{7}_{3}Li(\alpha,p)^{10}_{4}Be$

$^{9}_{4}Be(n,\gamma)^{10}_{4}Be$

$^{10}_{5}B(n,p)^{10}_{4}Be$

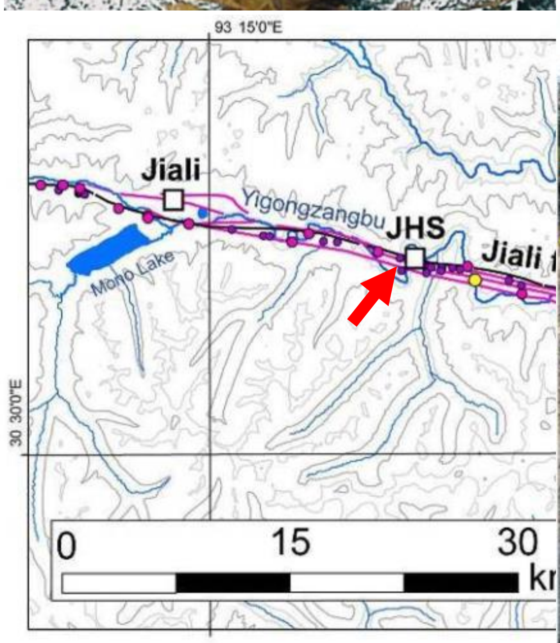
$^{13}_{6}C(n,\alpha)^{10}_{4}Be$

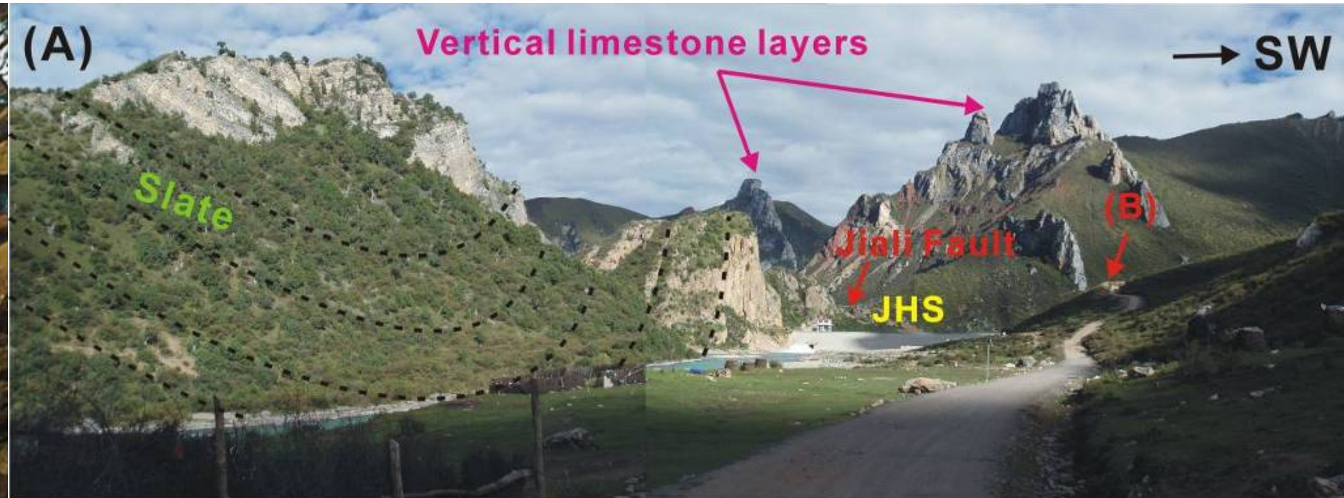
*neutrons(n)*
*antimuons(μ-)*



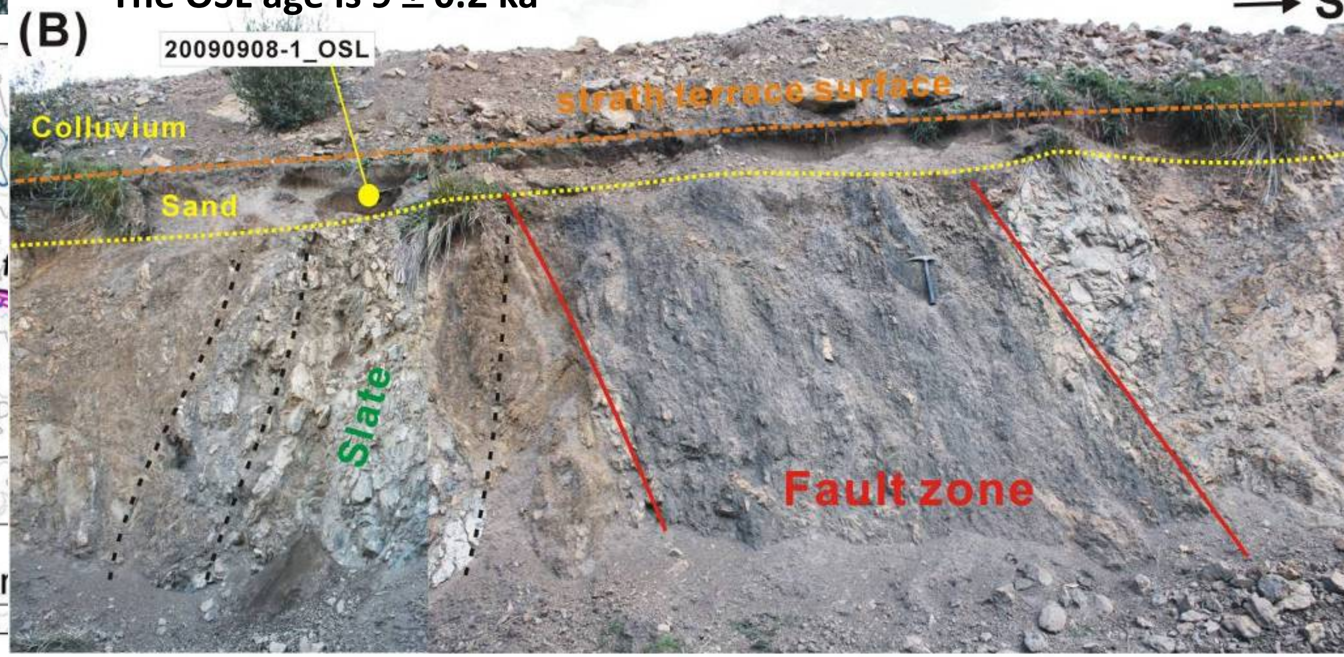

$$^{10}Be\ age = \frac{^{10}Be\ concentration\ of\ rock}{Production\ rate\ of\ ^{10}Be}$$

# The evidence of the inactive Jiali Fault




The OSL age is 9 ± 0.2 ka



2010-2012

研究頓時像陷入泥沼之中.....

# 只好休息一下.....喝杯酥油茶....

## Tea Time

# Normal Fault: 1952 Surface rupture

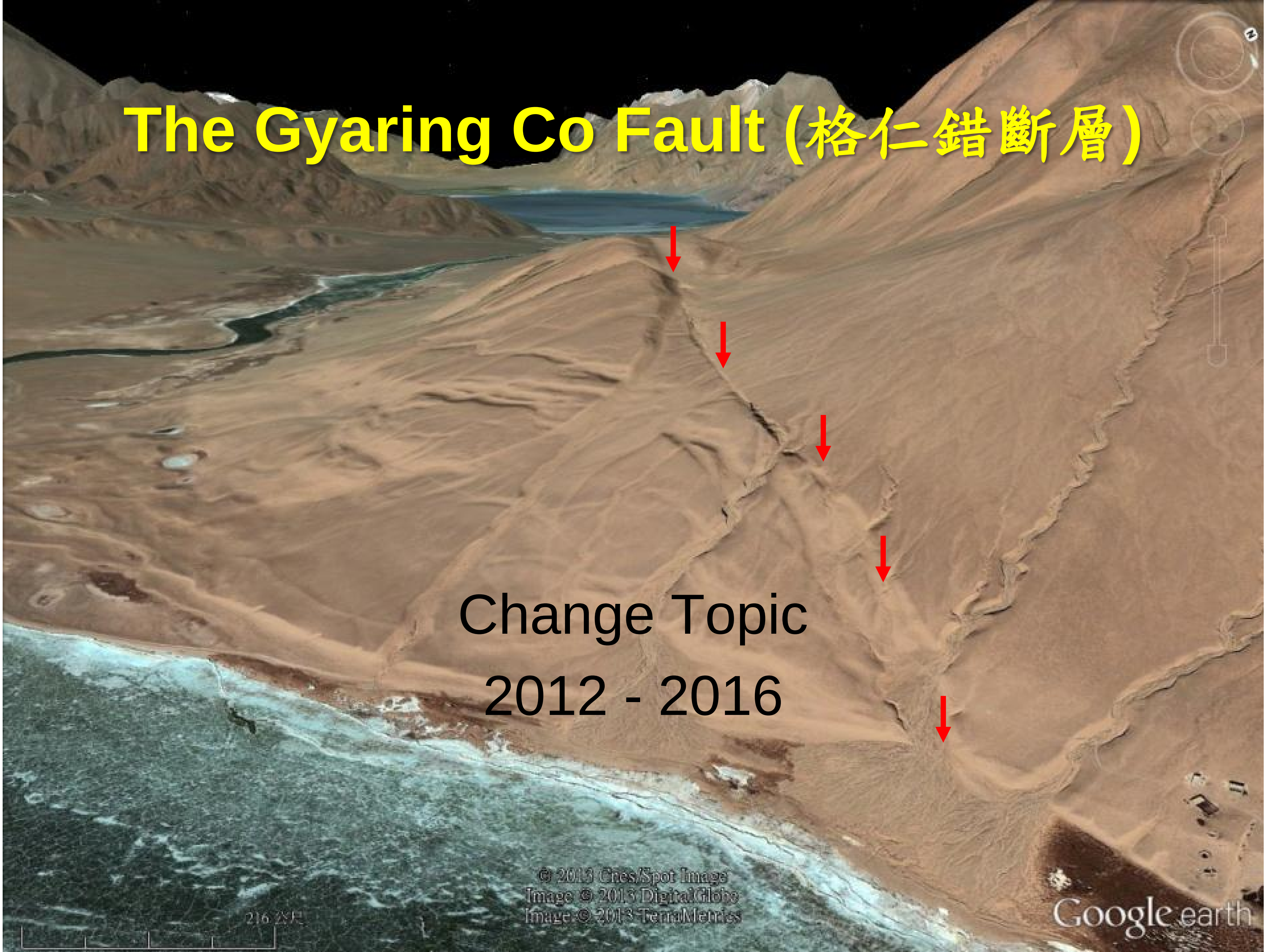
**The same feature in Fig. 23a in Armijo et al.,1986**

看看其他著名的斷層露頭

# 1952 Surface rupture

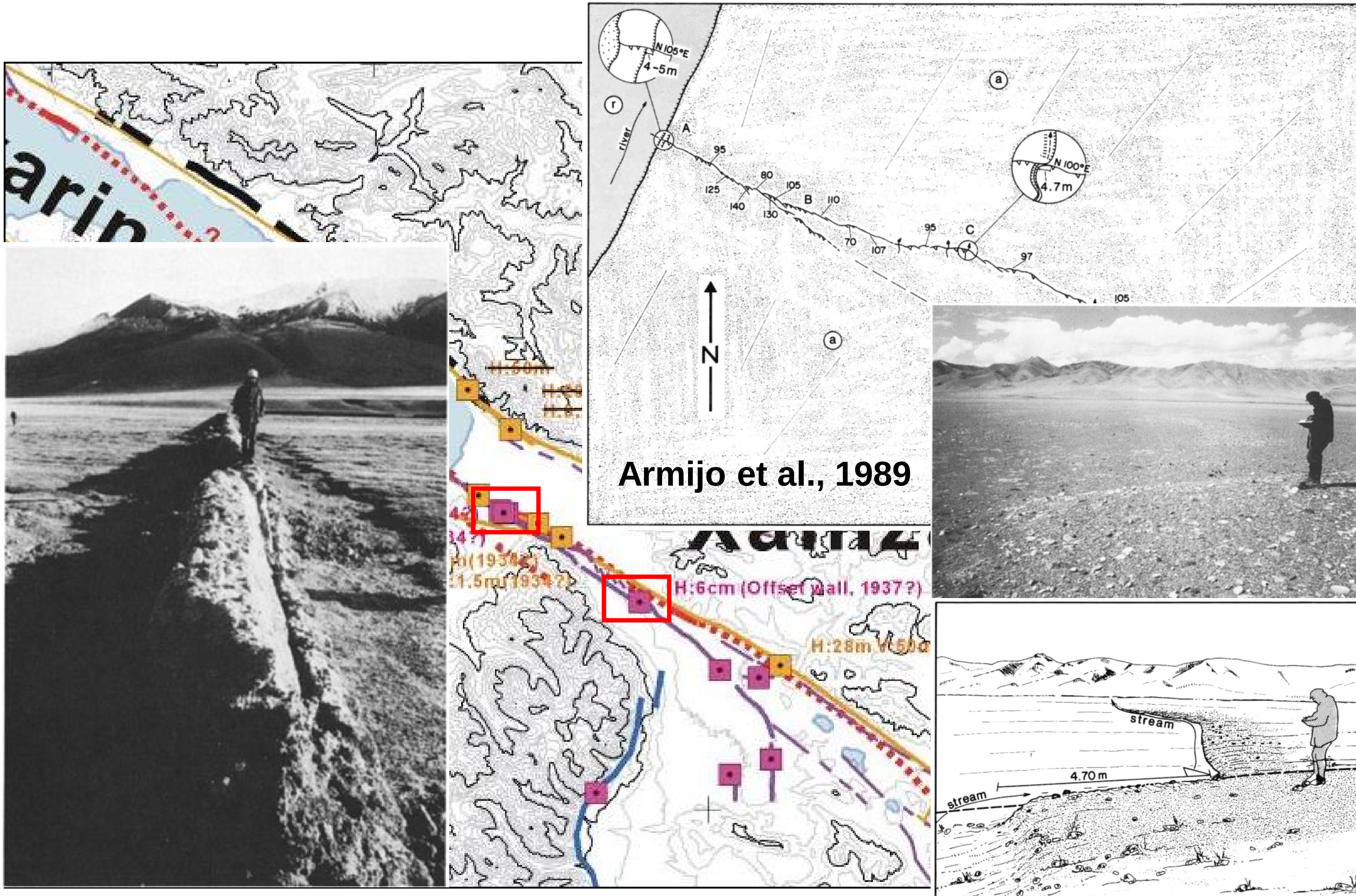
**The same feature in Fig. 24c and 25c in Armijo et al.,1986**

# Normal Fault-1411 Surface rupture

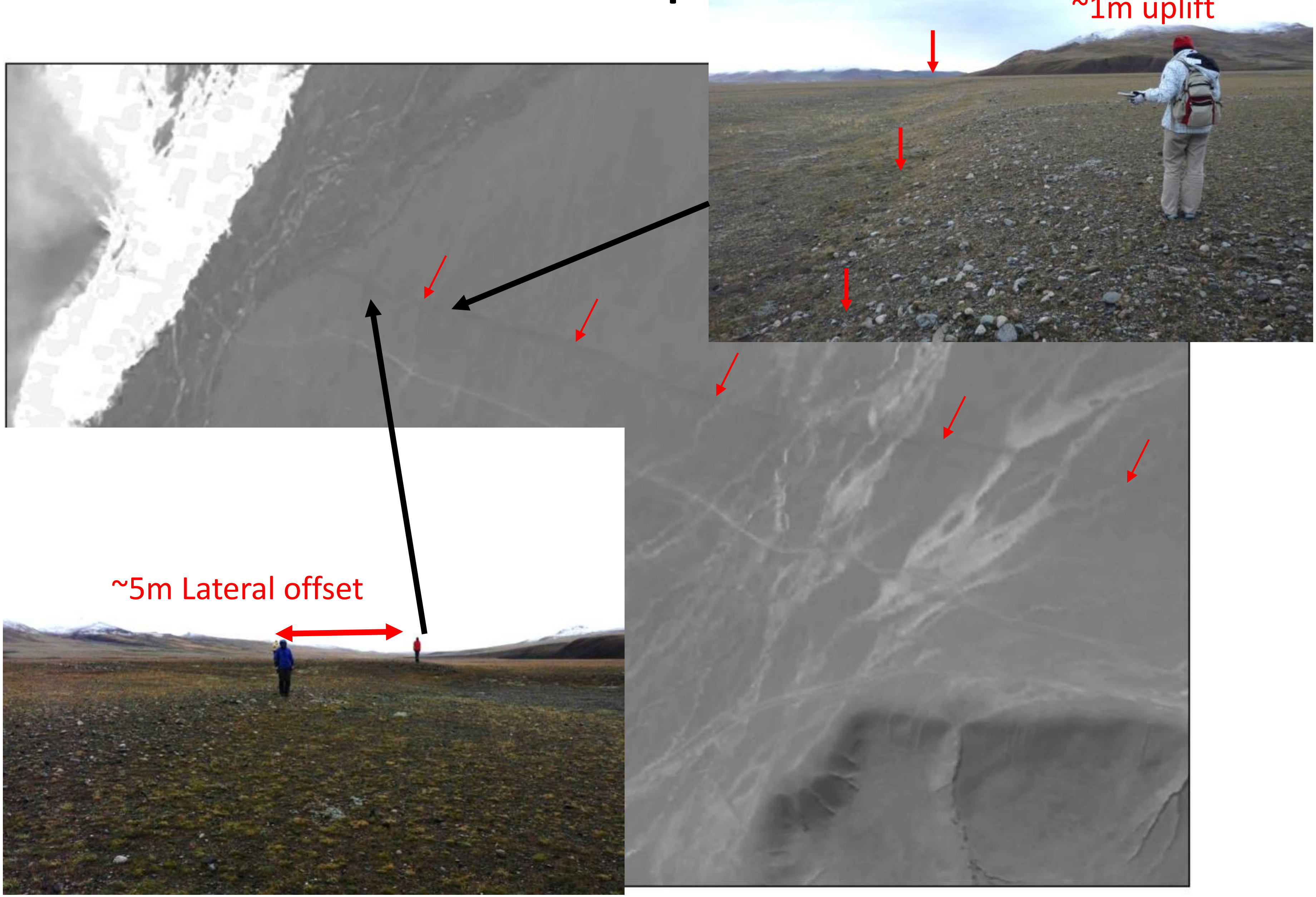

The Gyaring Co Fault (格仁錯斷層)
Change Topic
2012 - 2016
© 2013 Cnes/Spot Image
Image © 2013 DigitalGlobe
Image © 2013 TerraMetrics
Google earth

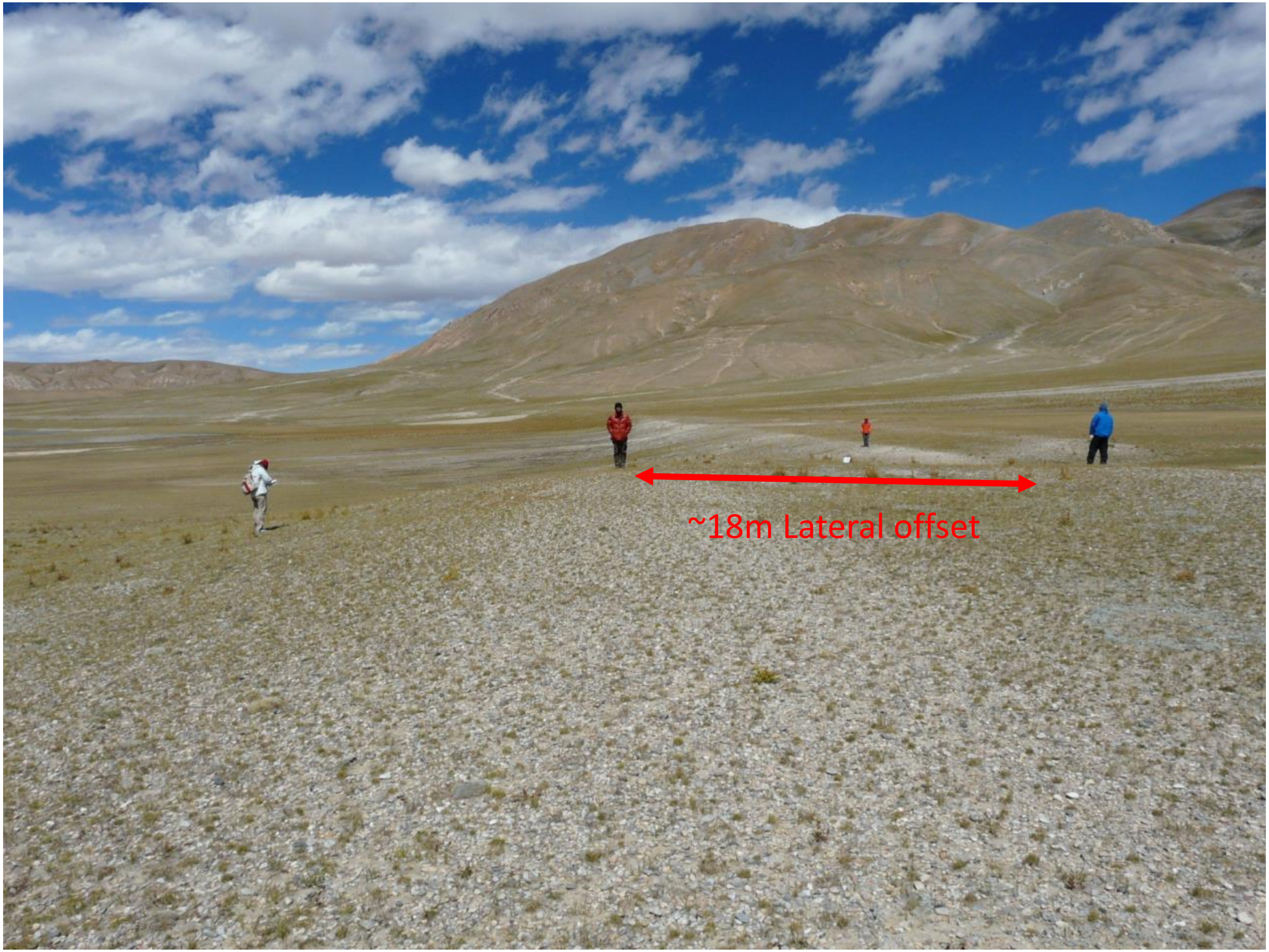
# The Gyaring Fault (1934? event)

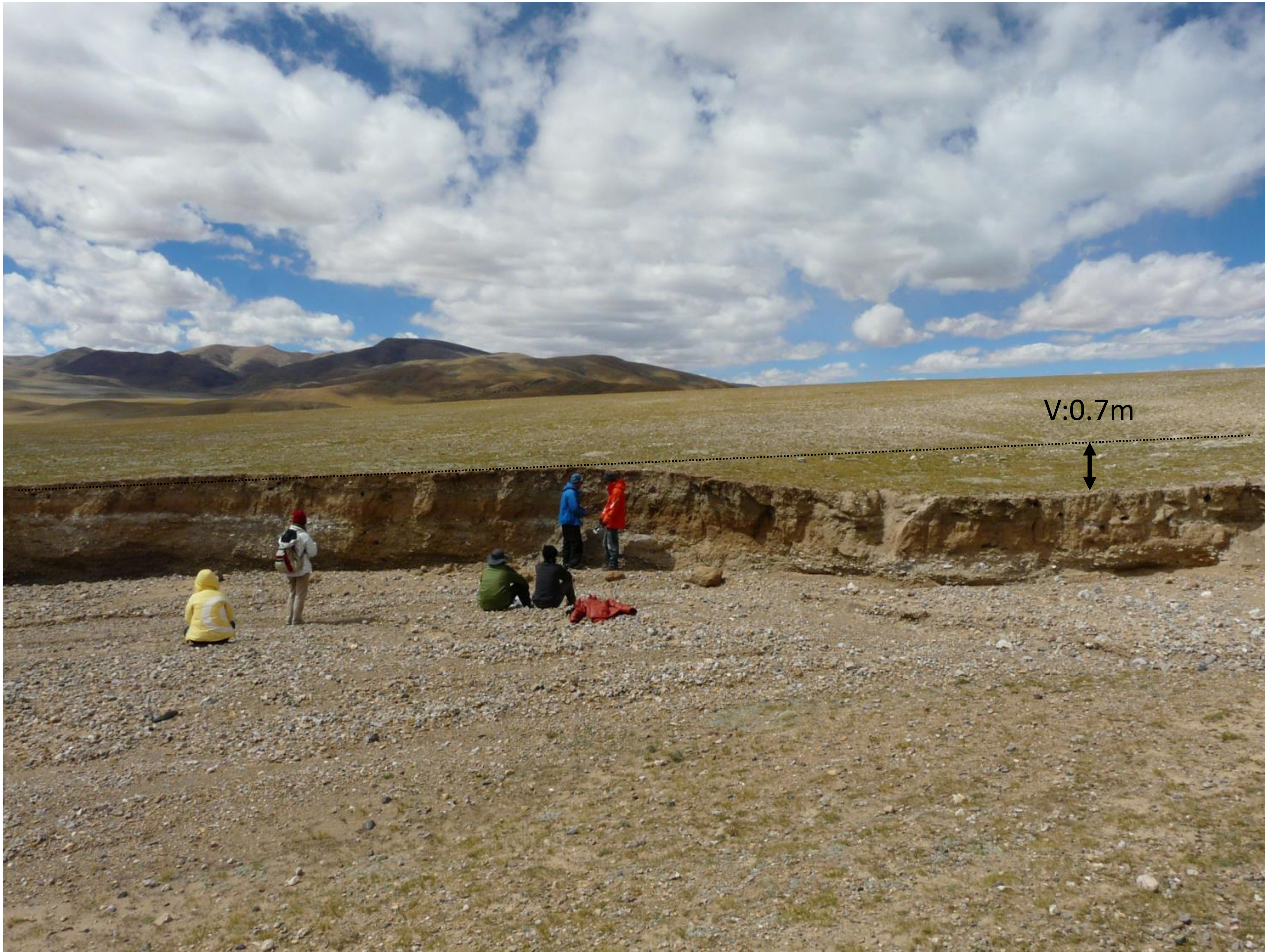
# The southern part of Gyaring Co Fault

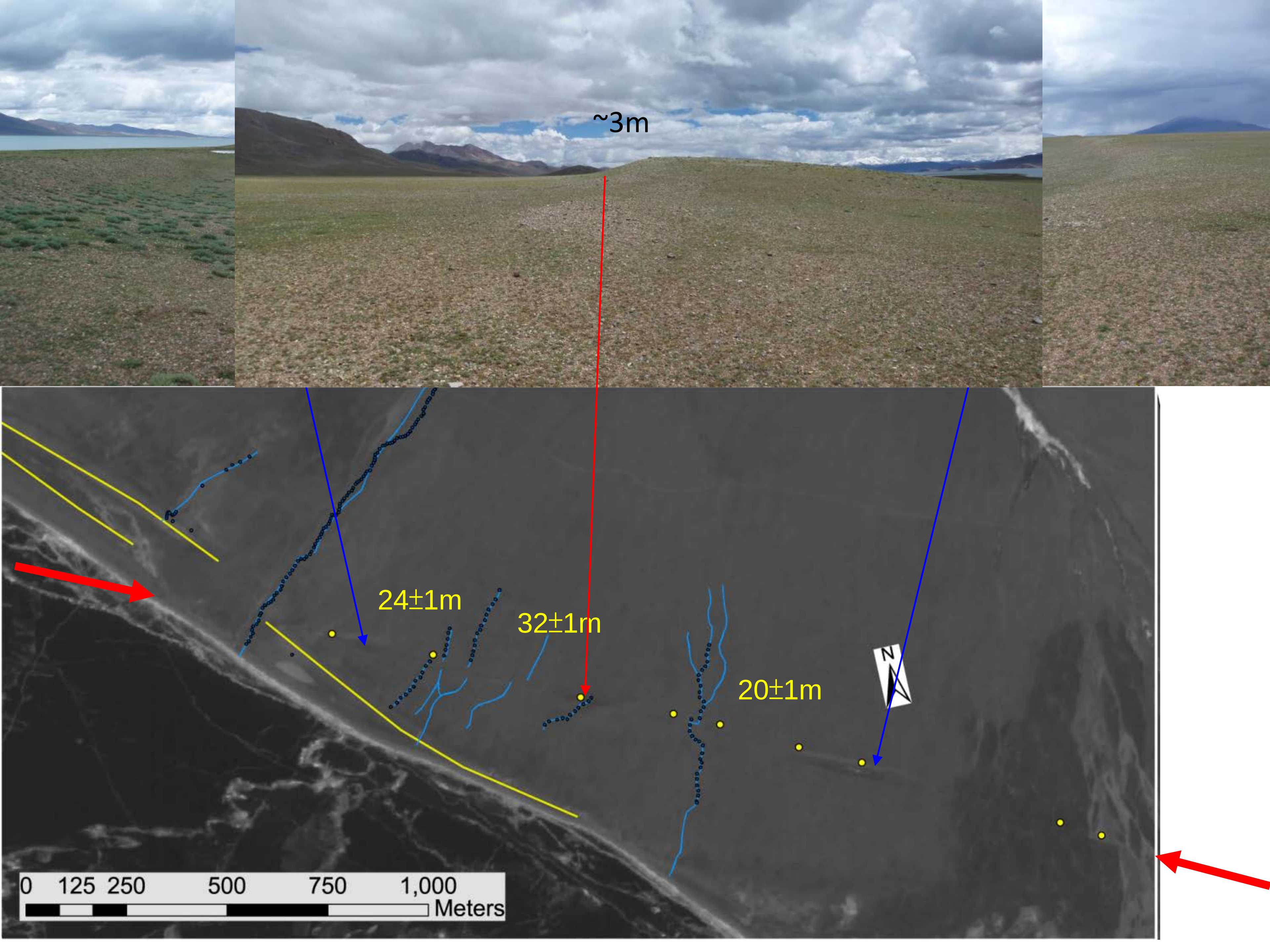


# 1934 surface rup




~18m Lateral offset

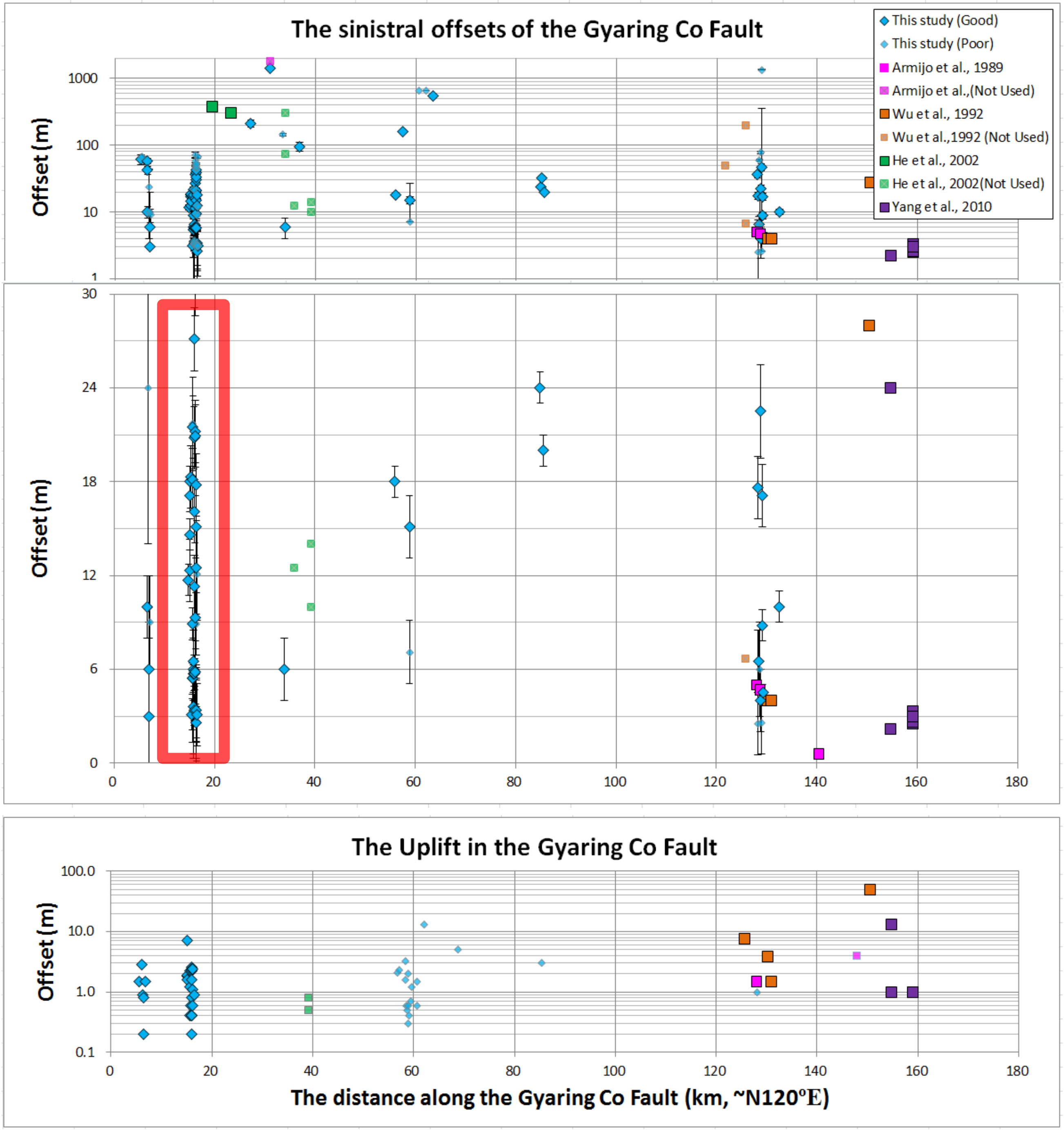

V:0.7m



~3m
24±1m
32±1m
20±1m
N
0 125 250 500 750 1,000
Meters

# 研究終於露出一線曙光
# 格仁錯湖的日落 2012/10

# All Offset data




**129 Dextral Offset**

99 (this study)

5 (Armijo et al., 1989)

7 (Wu et al., 1992)

8 (Ho et al., 2002)

10(Yang et al., 2010)

**68 Vertical offsets**

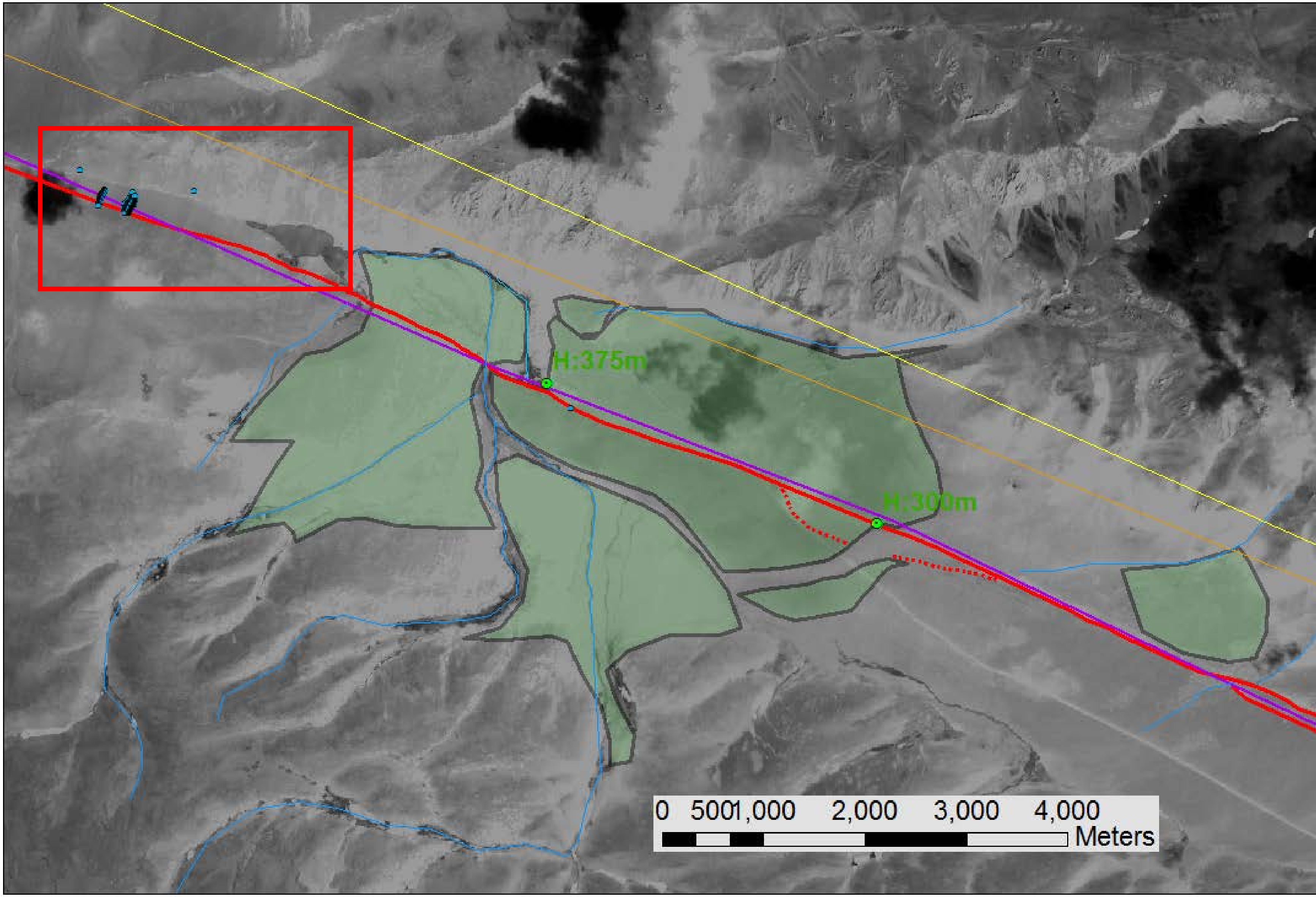
58 (this study)

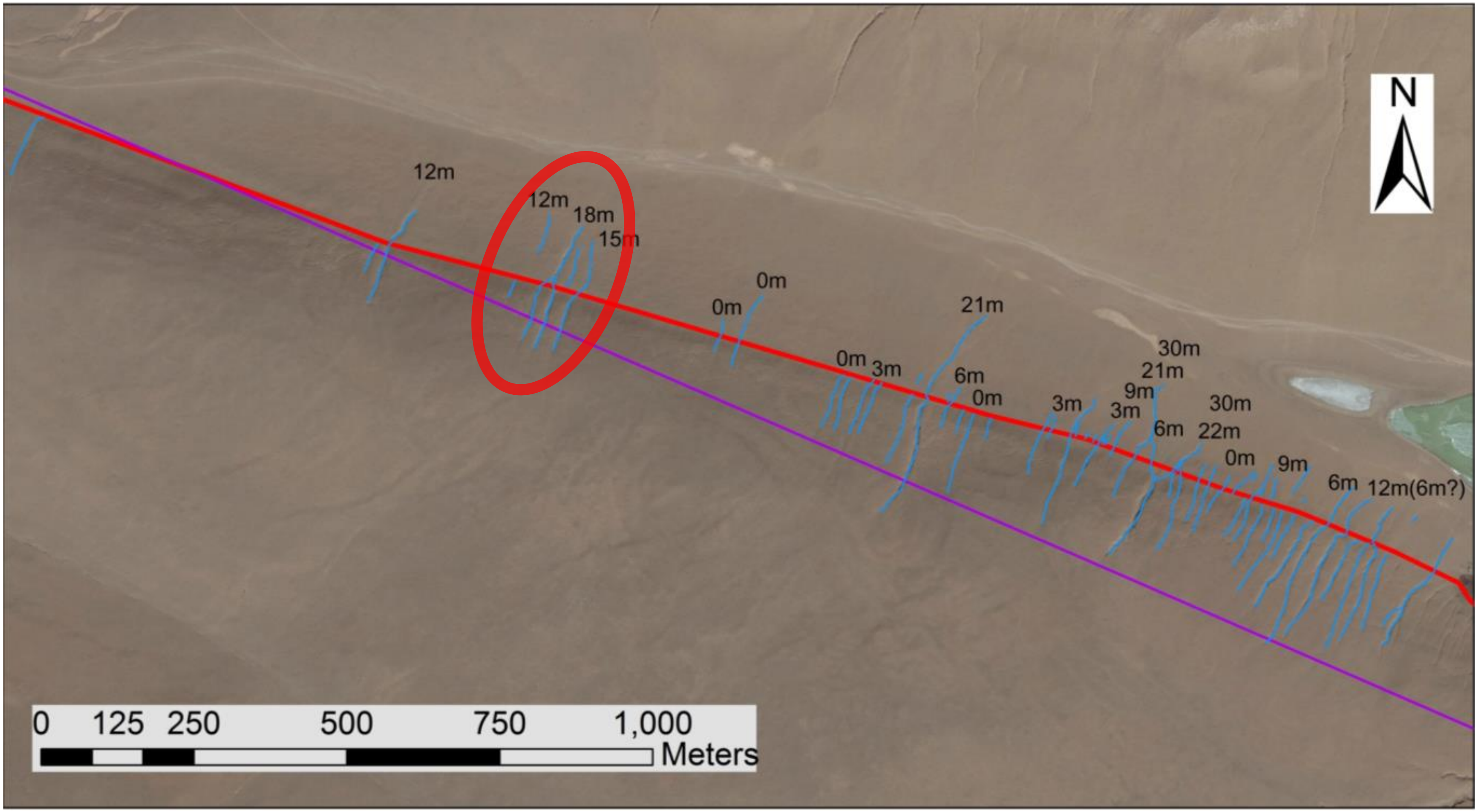
1 (Armijo et al., 1989)

4 (Wu et al., 1992)

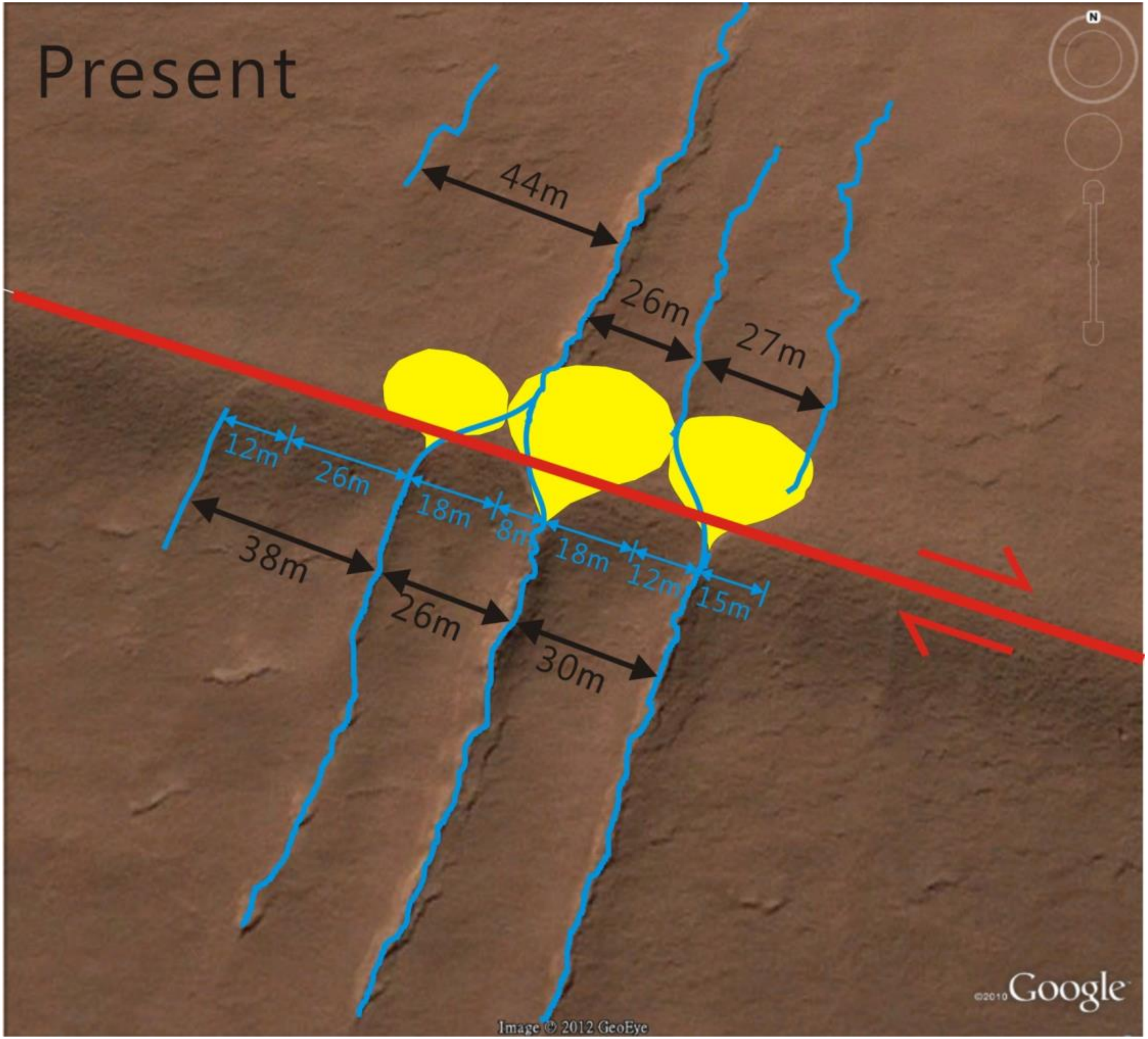
2 (Ho et al., 2002)

3(Yang et al., 2010)

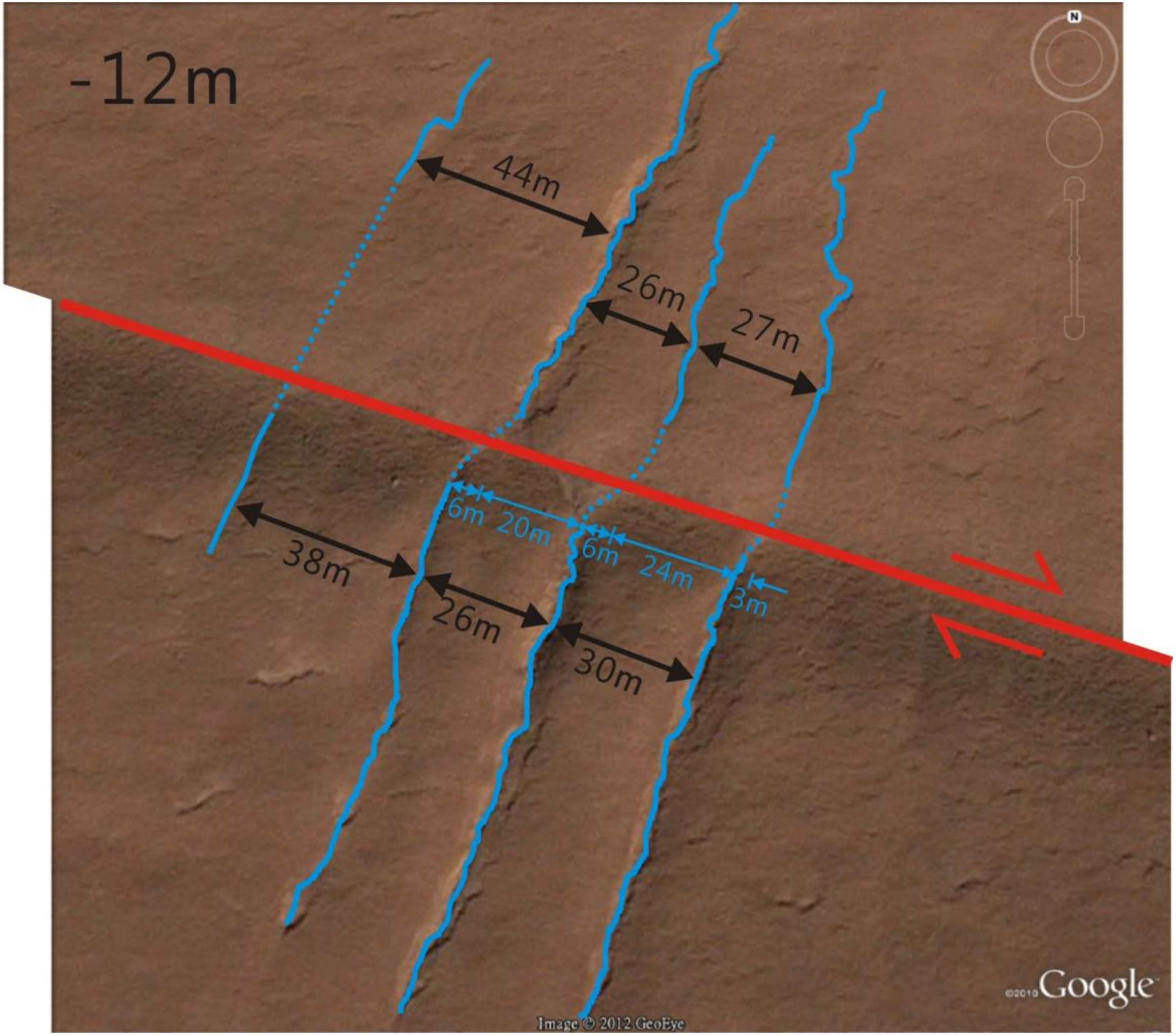

H:375m
H:300m
0 5001,000 2,000 3,000 4,000
Meters


N
12m
12m
18m
15m
0m
0m
21m
0m
3m
6m
0m
30m
21m
9m
3m
3m
30m
6m
22m
0m
9m
6m
12m(6m?)
0 125 250 500 750 1,000
Meters

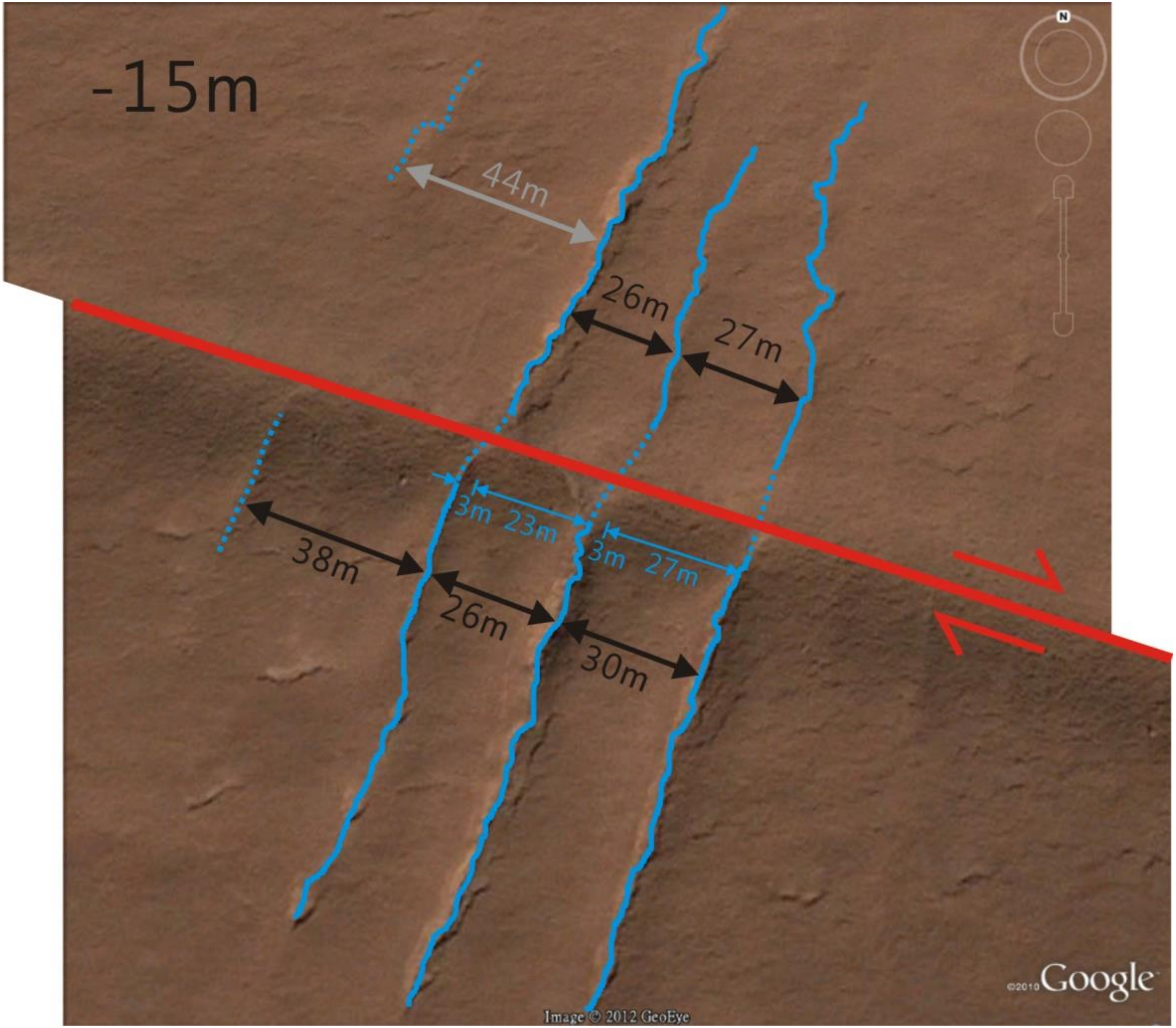
N
Image © 2012 GeoEye
©2010 Google



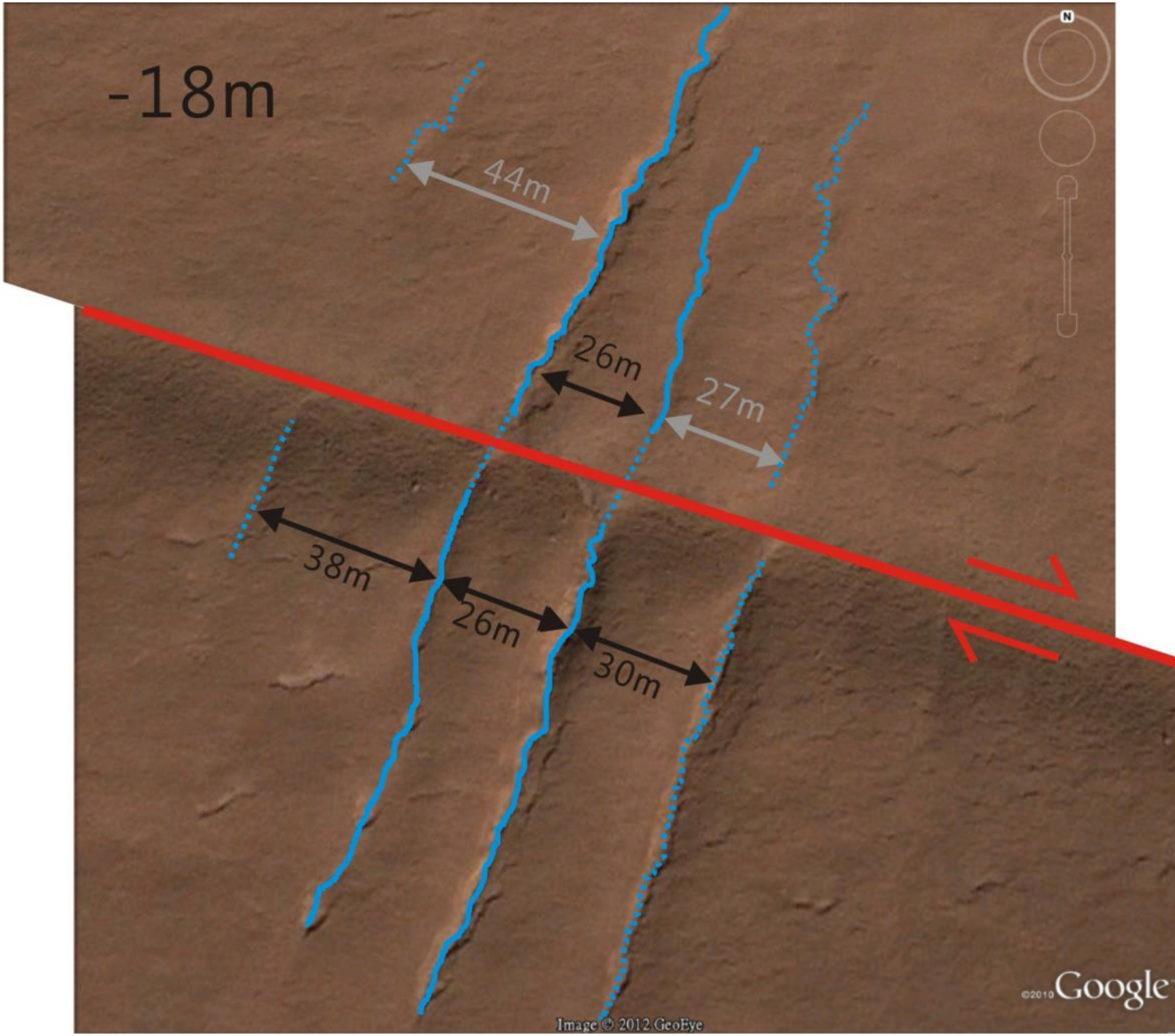
Present
44m
26m
27m
12m
26m
18m
8m
18m
12m
15m
38m
26m
30m
Image © 2012 GeoEye
©2010 Google



-12m
44m
26m
27m
6m
20m
6m
24m
3m
38m
26m
30m
Image © 2012 GeoEye
©2010 Google

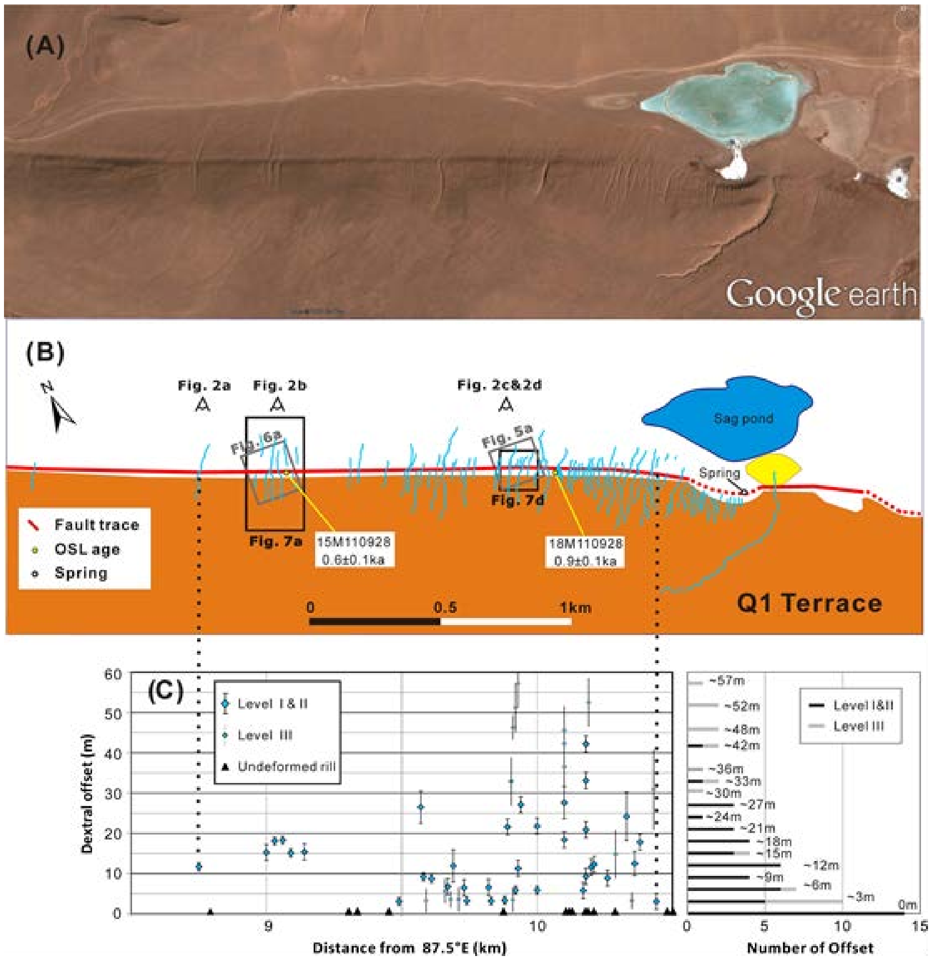


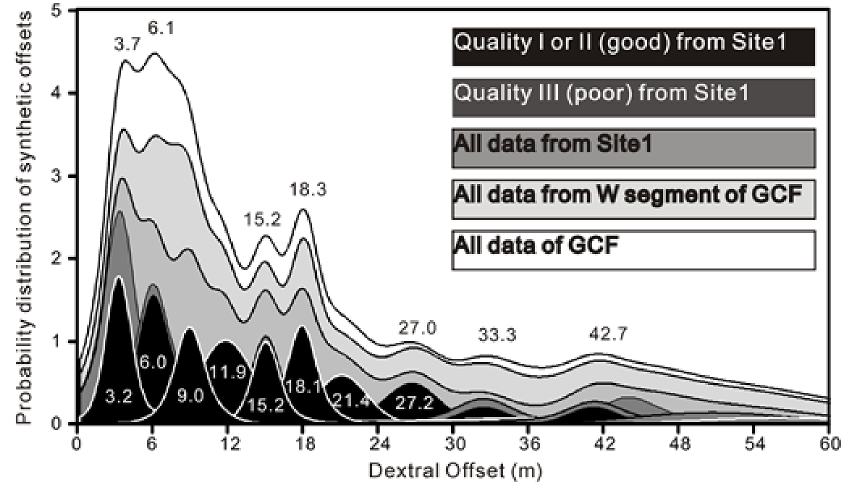
-15m
44m
26m
27m
3m
23m
3m
27m
38m
26m
30m
N
©2010 Google
Image © 2012 GeoEye

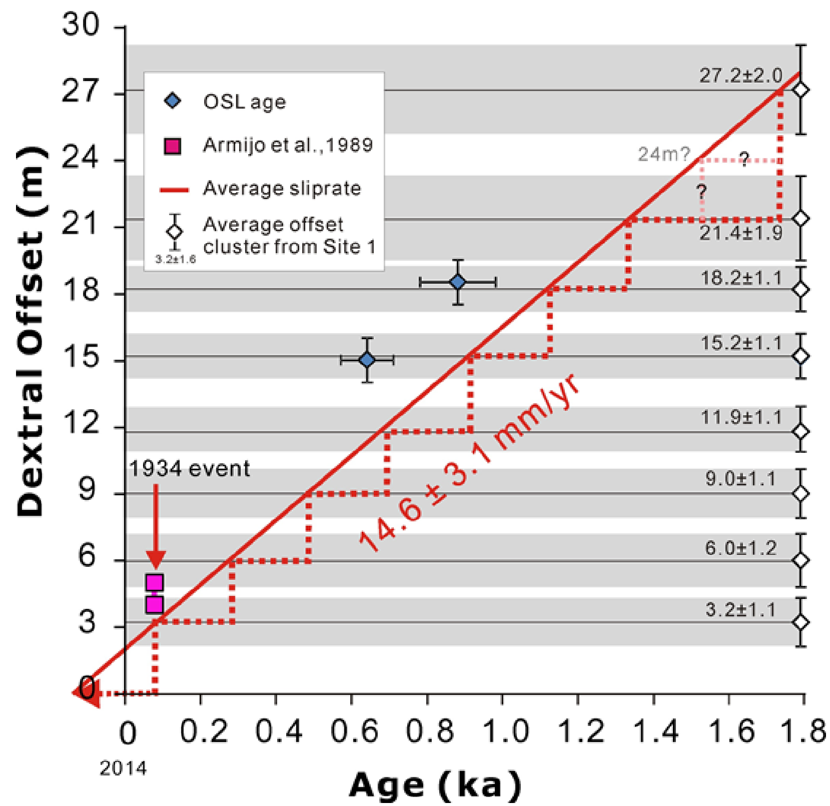


-18m
44m
26m
27m
38m
26m
30m
Google
Image © 2012 GeoEye

# Characteristic slip?

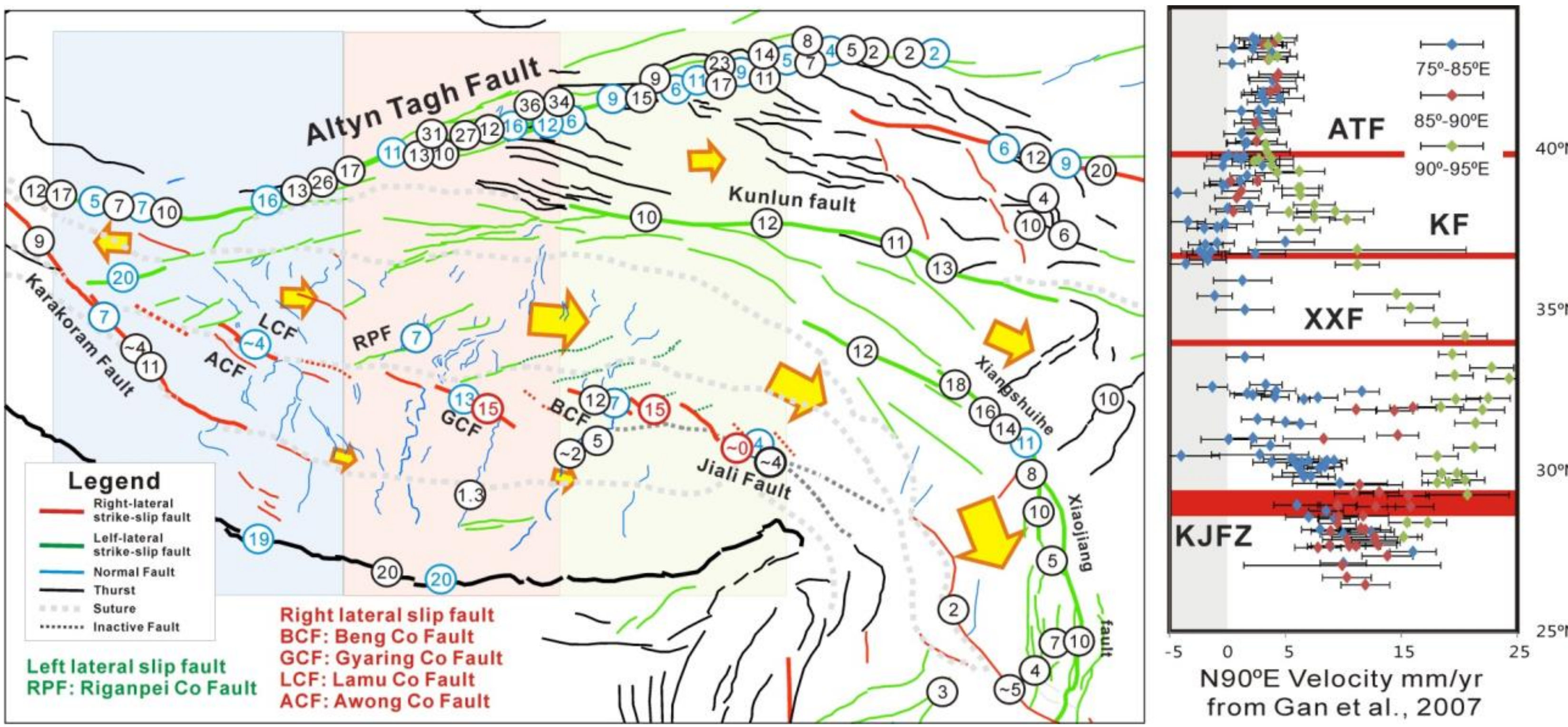



What can we improve the
Kinematics of Tibetan plateau?

# Results & Discussion I

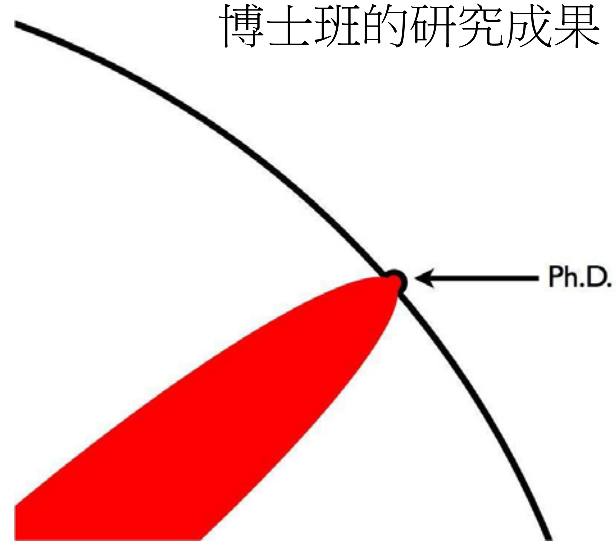


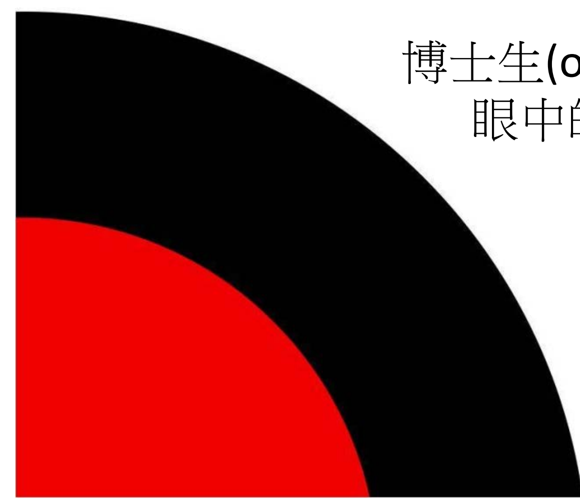

Active faults map modified from Taylor et al., 2003 & 2009; Tapponnier et al., 2001
726 GPS vectors during 1998-2004, Gan et al., 2007
Slip rate from Chen et al., 2004; Searle et al., 2011; Song et al., 2011; Taylor & Peltzer, 2006; Van der Woerd et al., 2002; Xu & Deng, 1996 (**Red**: this study; **Black**: Quaternary slip; **Blue**: geodetic data).

# 【教育專輯】 博士班是什麼？可以吃嗎？

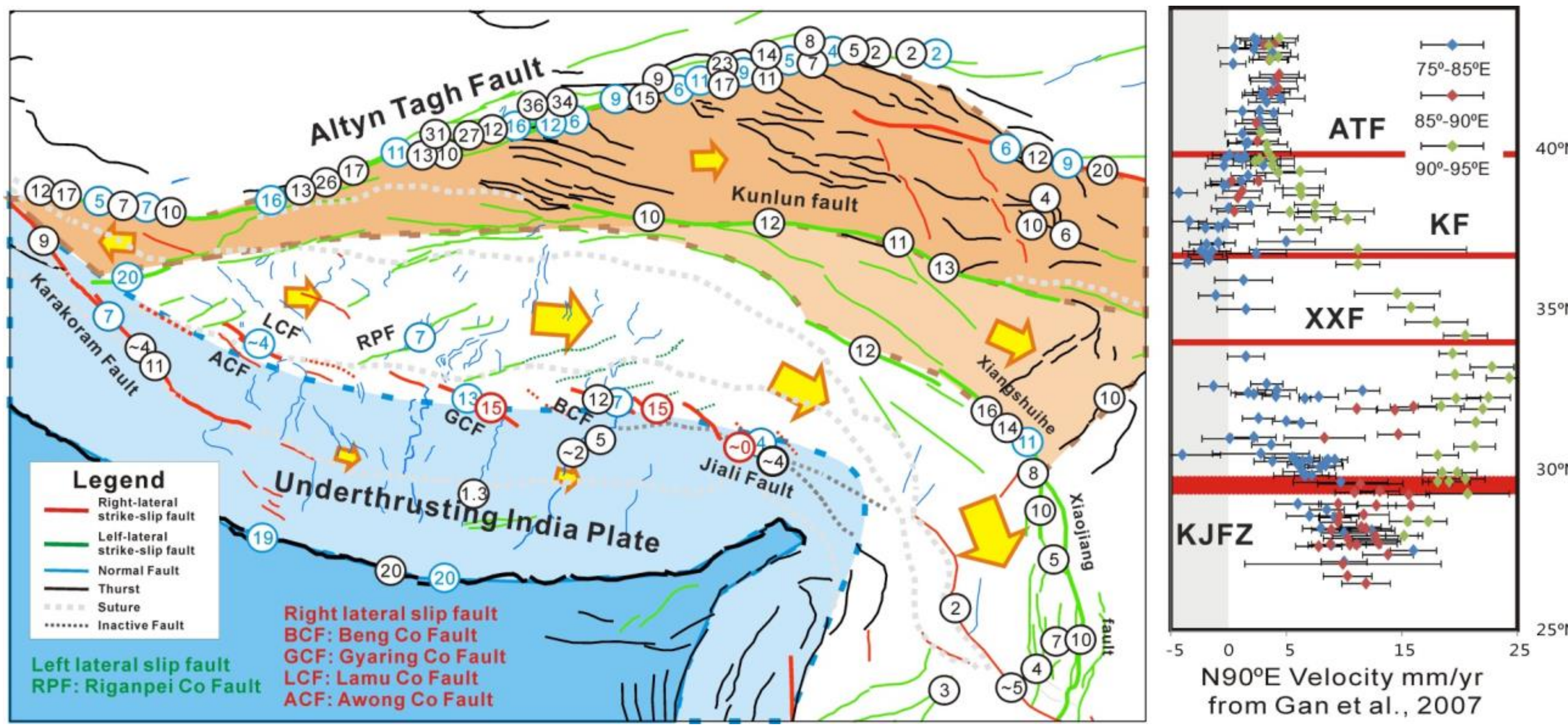
(資料來源:泛科學網頁 )


博士班的研究成果



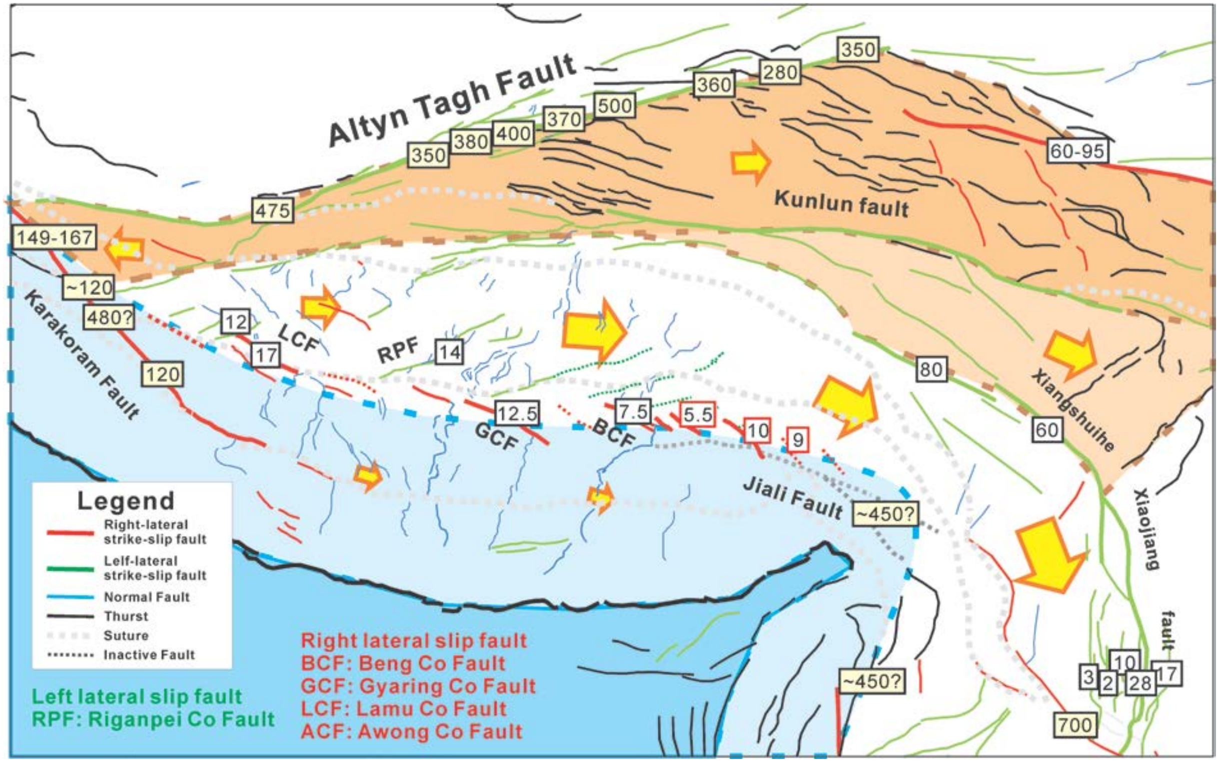



# Underthusting model
# 瞎子摸象???




Modified from Argand,1924; Copley et al., 2011

# Results & Discussion II



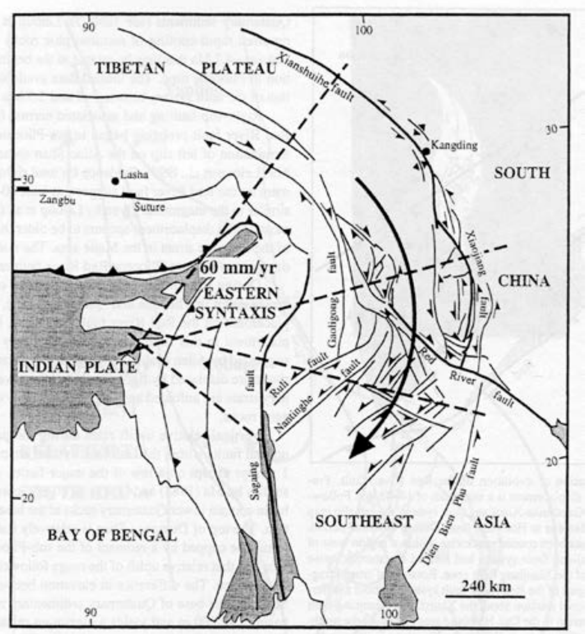
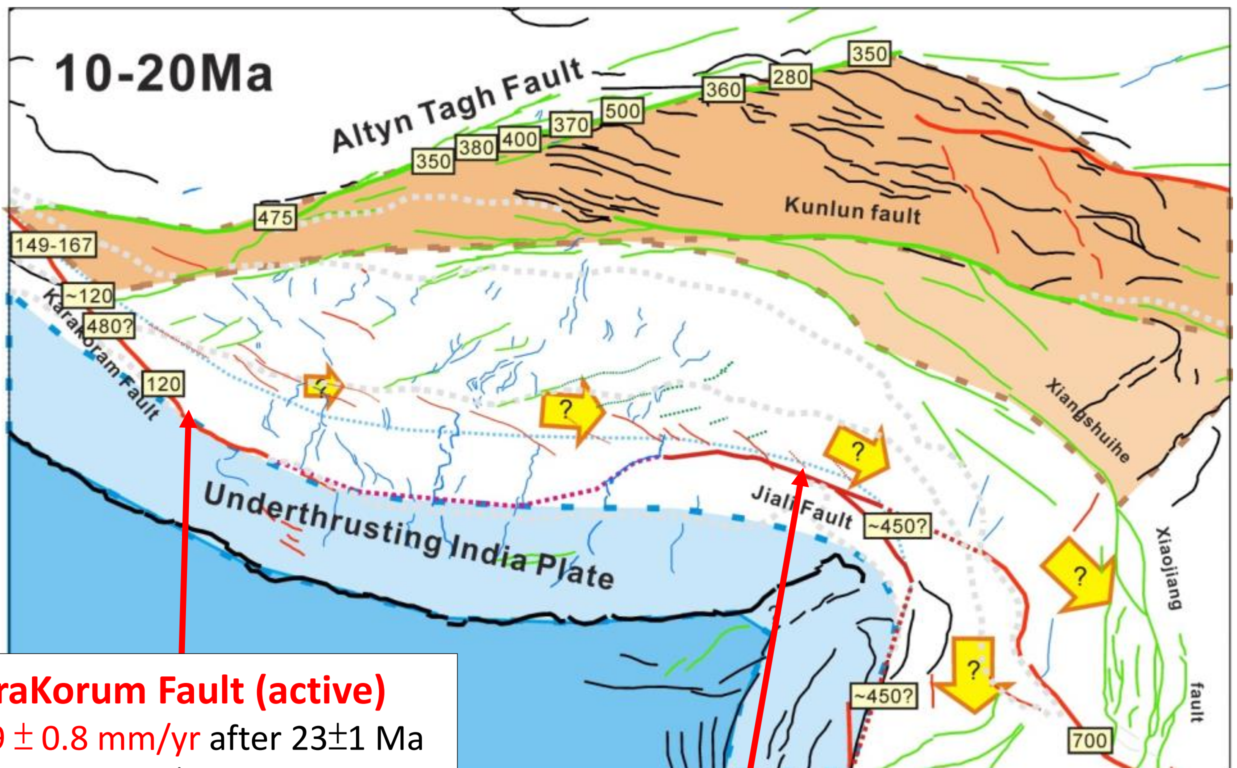




Figure 50. Generalized tectonic model relating displacement along the Xianshuihe-Xiaojiang fault system to rotation of crustal material around a poorly defined point south of the eastern Himalayan syntaxis. The crustal material does not rotate as a rigid body but is strongly internally deformed. The rotation affects the active Sagaing fault and the Indo-Burman ranges.

Wang, 1998

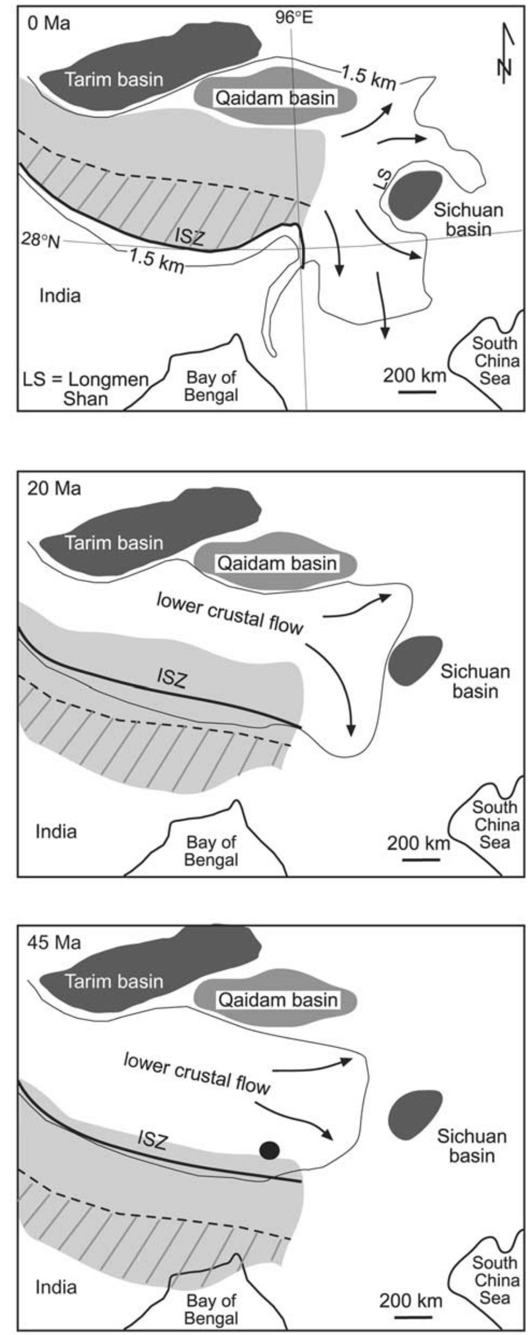
Total displacement data from this study (red), Armijo et al., 1989;Leloup et al.,1995; Searle et al., 2011; Taylor et al. 2003; Wang, 1998 (black).

# Underthusting model




**KaraKorum Fault (active)**
6. 9 ± 0.8 mm/yr after 23±1 Ma
(Robinson, 2009a)

**Jiali Fault (active)**
active during 12~18Ma (Lee et al.,2003; Lin, et al., 2009)

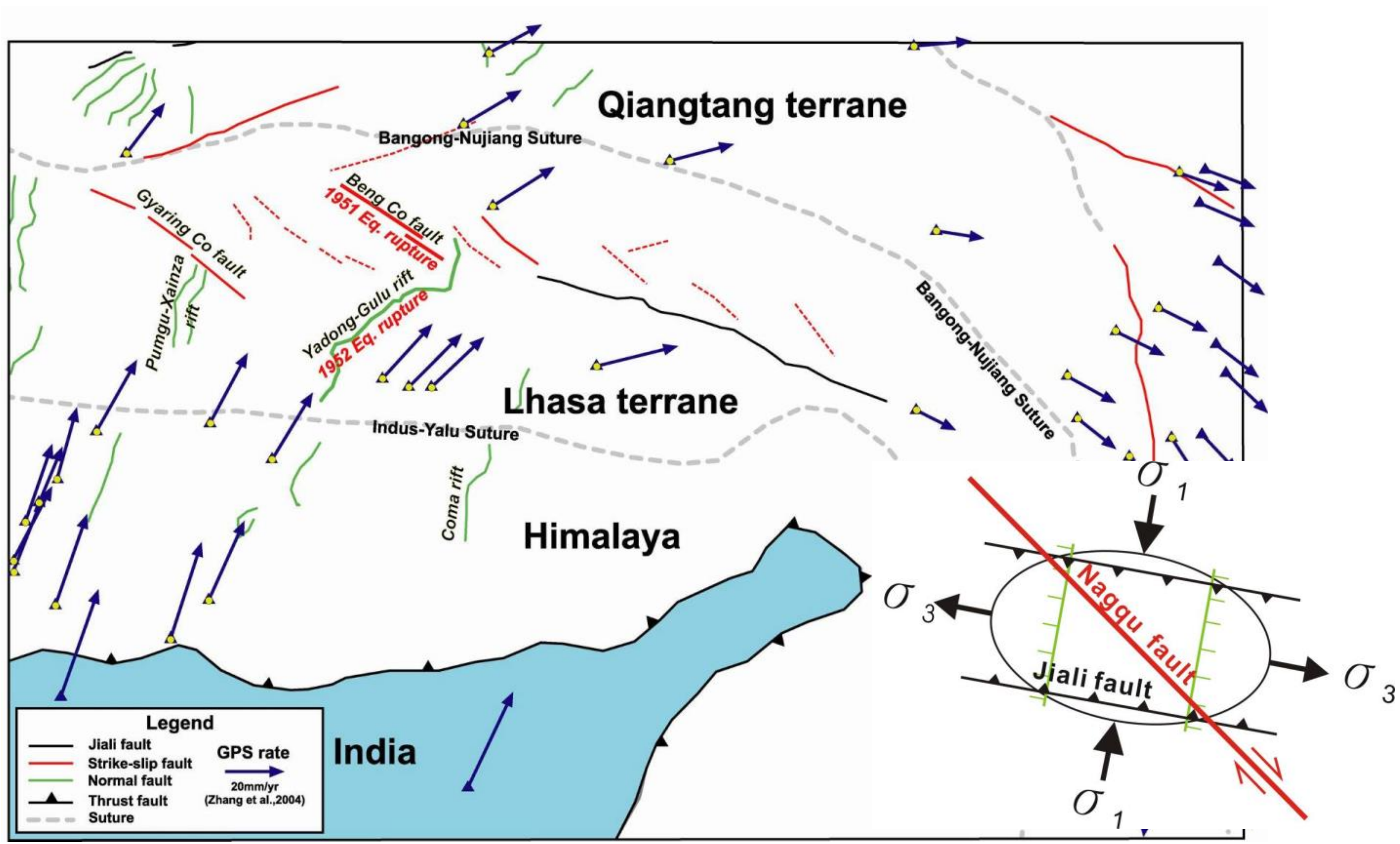


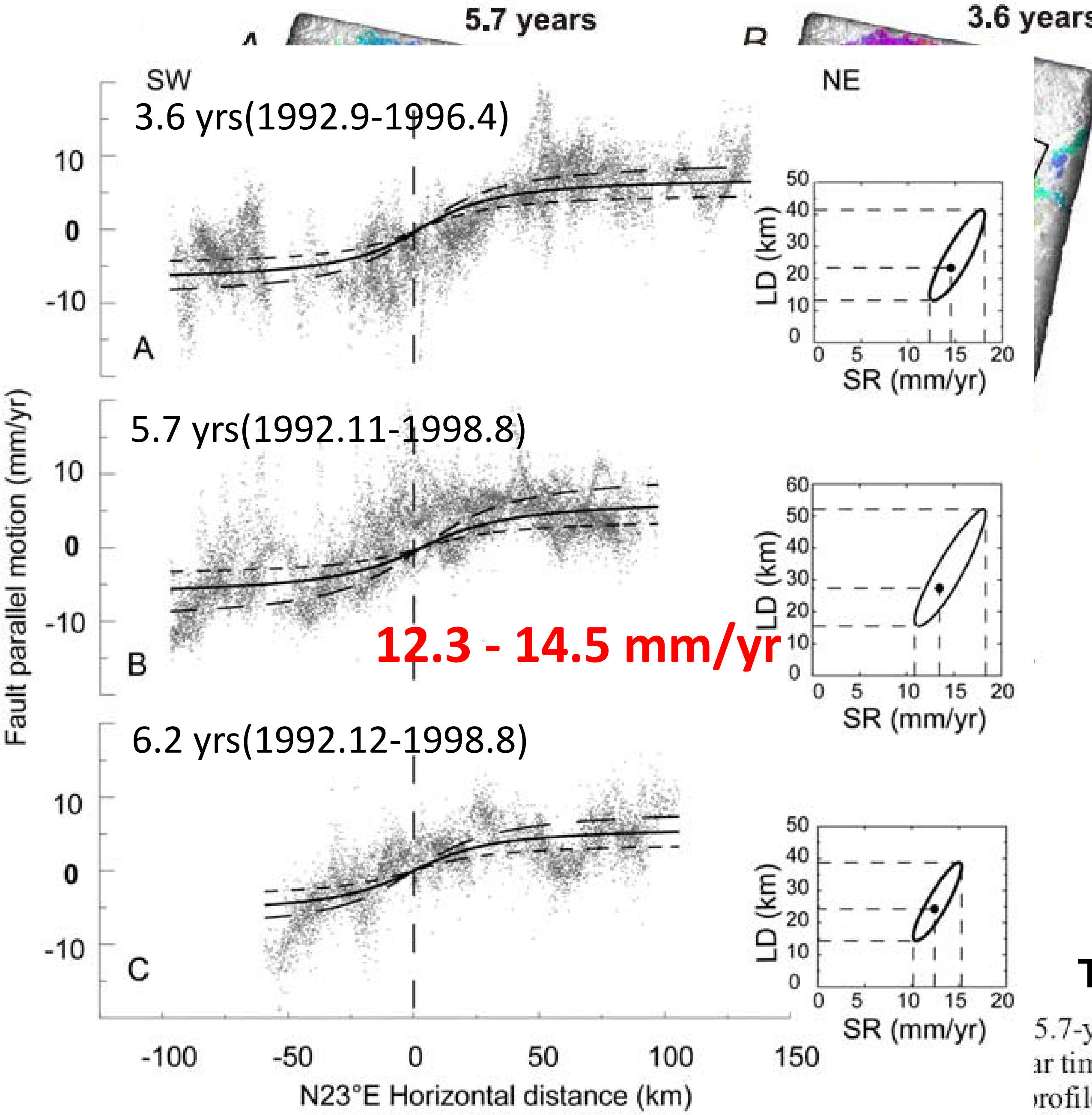

DeCelles et al., 2002

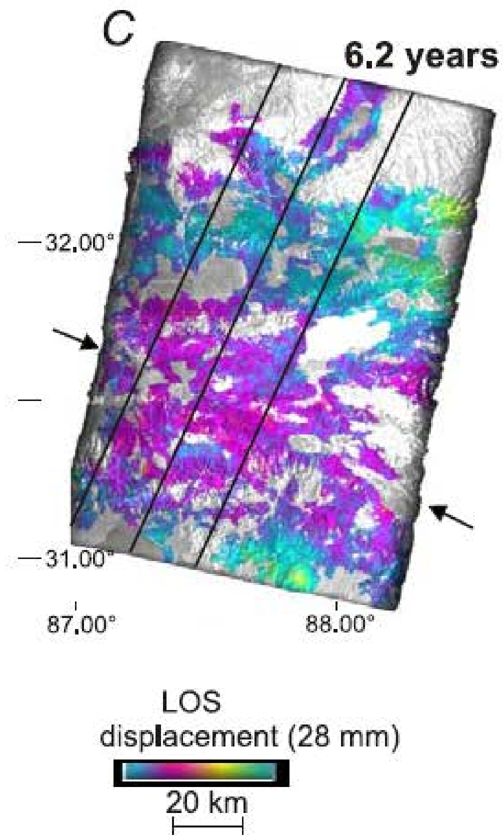
# Thanks for your attention


Tashi de-leh (扎西德勒)

# Active faults in E-Tibet





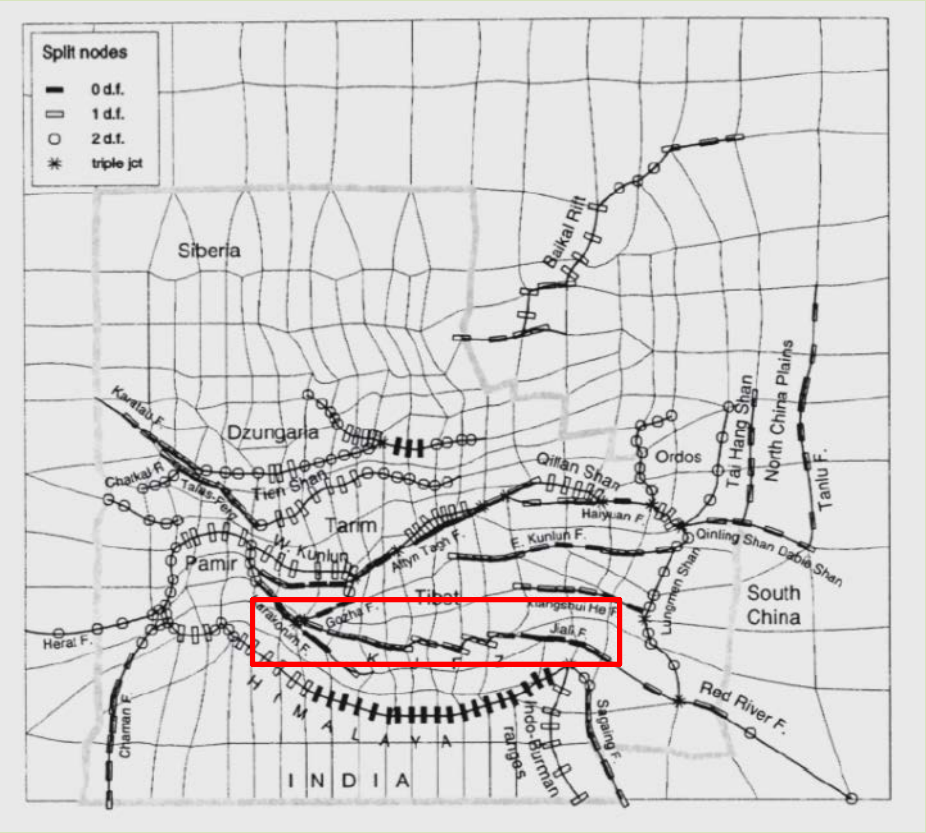



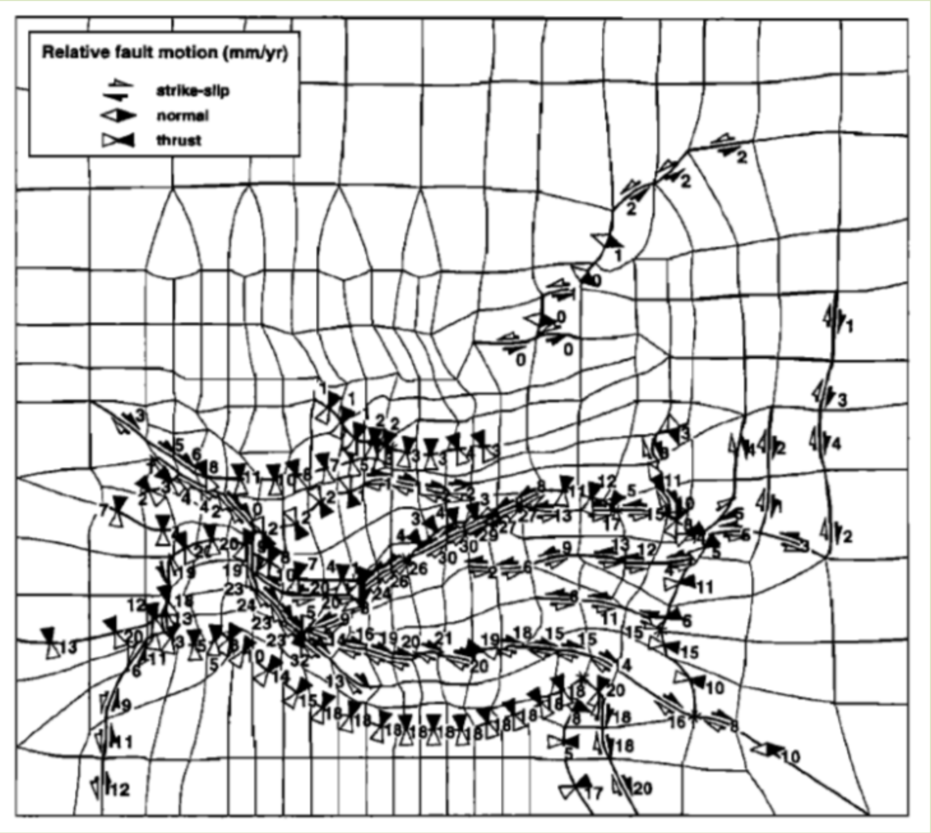

**Taylor and Peltzer, 2006**

See Figure 2 for location.

5.7-year time period (orbits 6920–
ar time period (orbits 7421–20657).
rofiles shown in Figures 10 and 11.

# Present-day kinematics of Asia derived from geologic fault rates



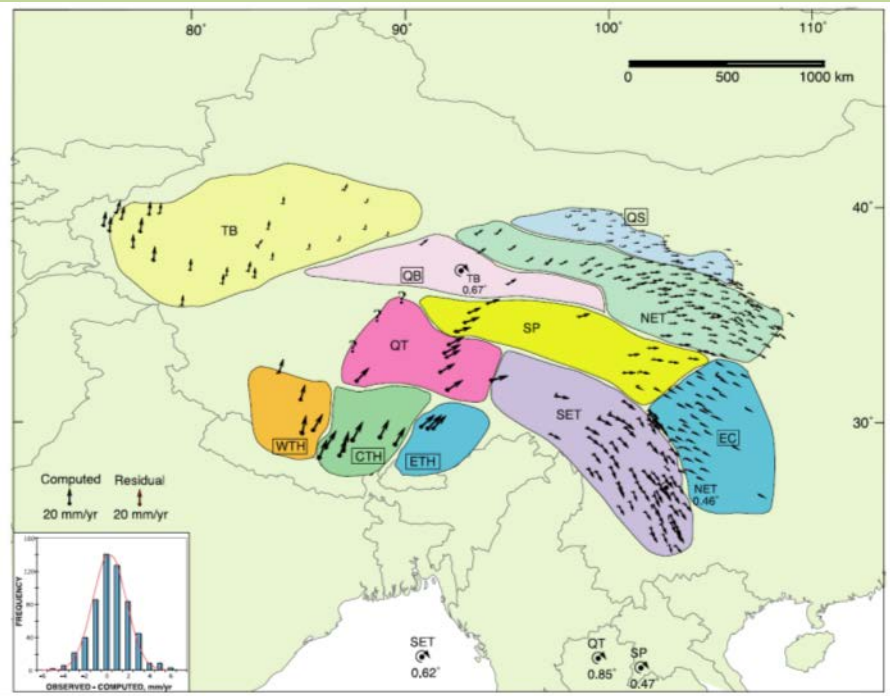



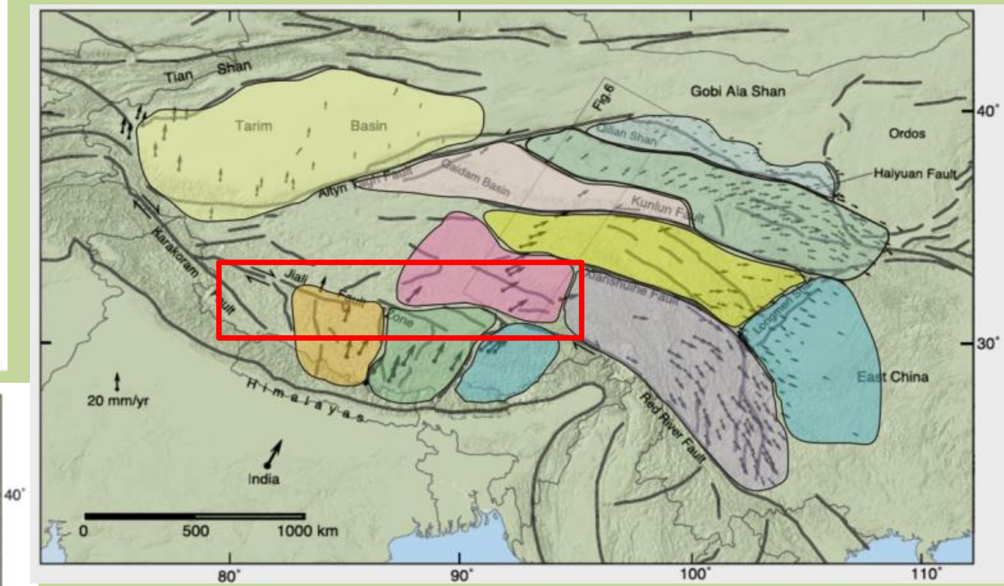

1.Fault motion accounts for more than **80%** of the deformation, allowing us to describe our velocity model in terms of quasi-rigid block rotations on the sphere.

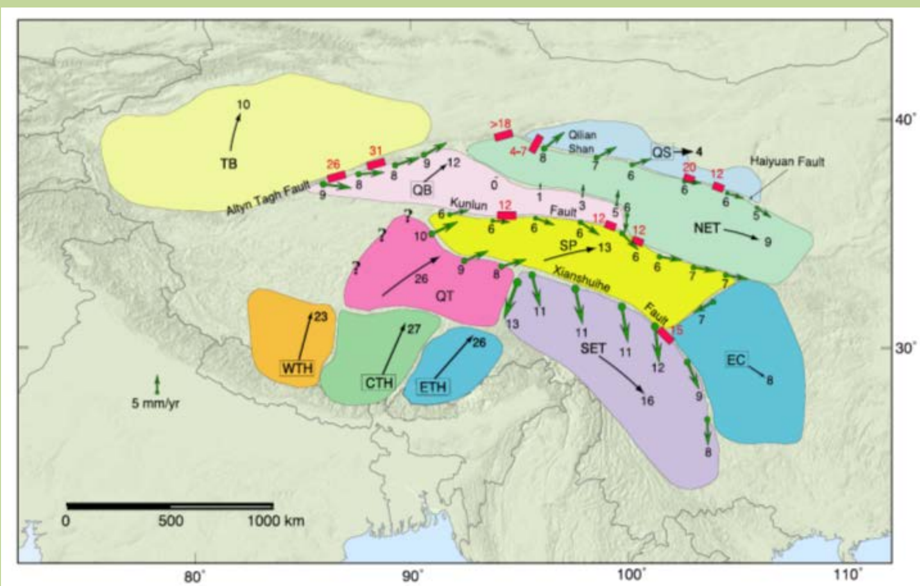
2.Over the last 10,000 years, **73±4%** of the north-south shortening between India and Asia has been absorbed by thickening of the lithosphere, and **27%** has been accommodated by lateral extrusion of continental blocks.

Peltzer and Saucier, 1996

# Microplate model for the present-day deformation of Tibet



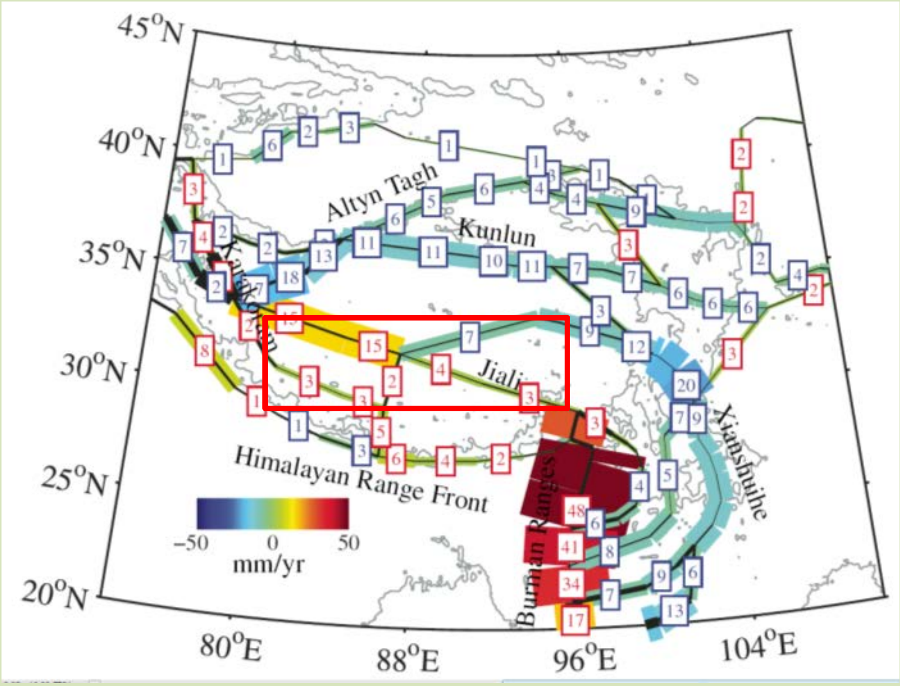

Predicted interblock velocities (thicker green arrows)
Average block velocities relative to Eurasia (**thinner black arrows**)
Geologically estimated slip rates (red).

Thatcher, 2007

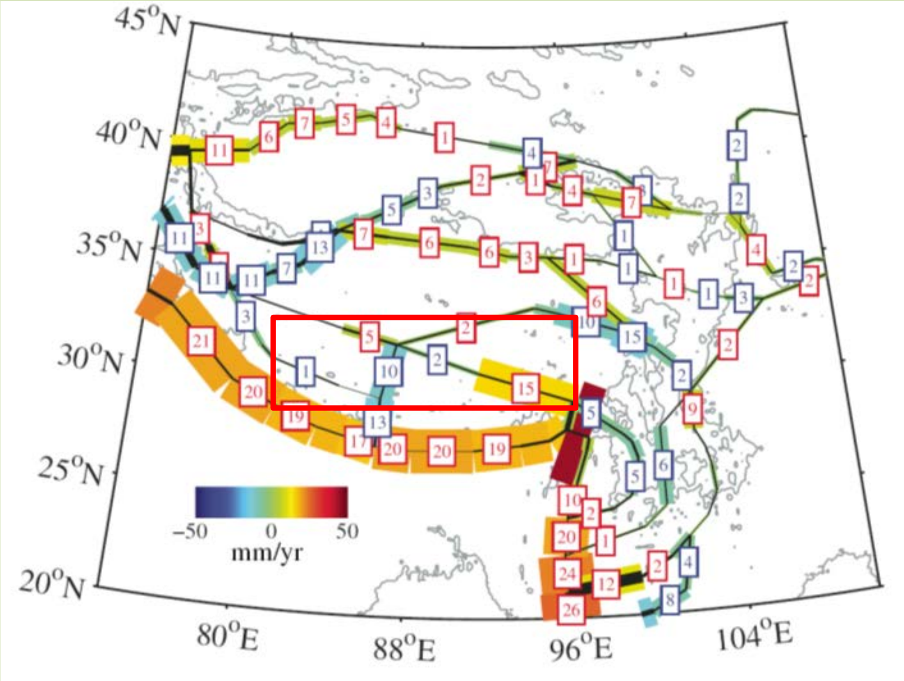
# Present-day kinematics at the India-Asia collision zone

The block model geometry is based on published fault maps (Kapp and Guynn, 2004; Peltzer and Saucier, 1996; Tapponnier et al., 2001)

**Model strike-slip rates**

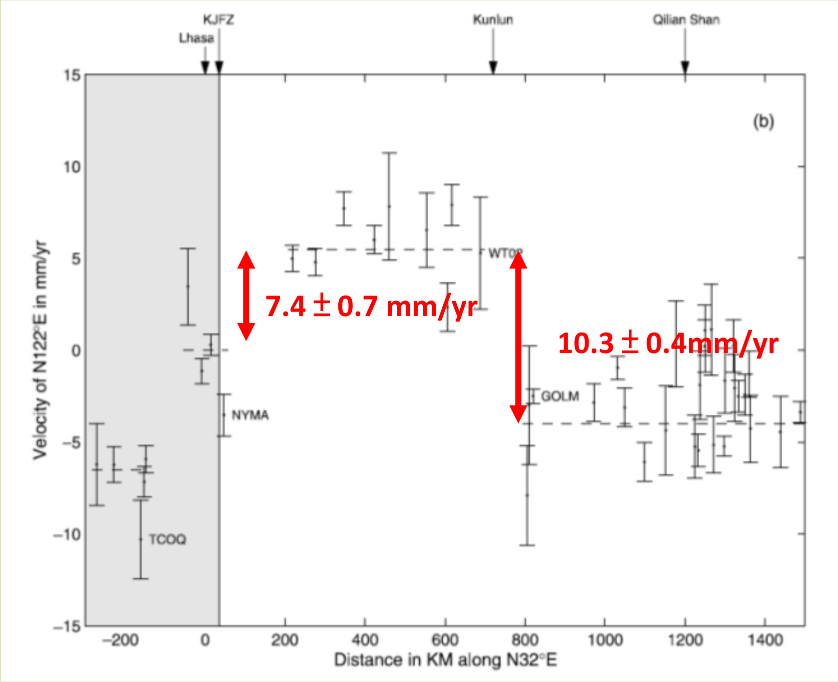


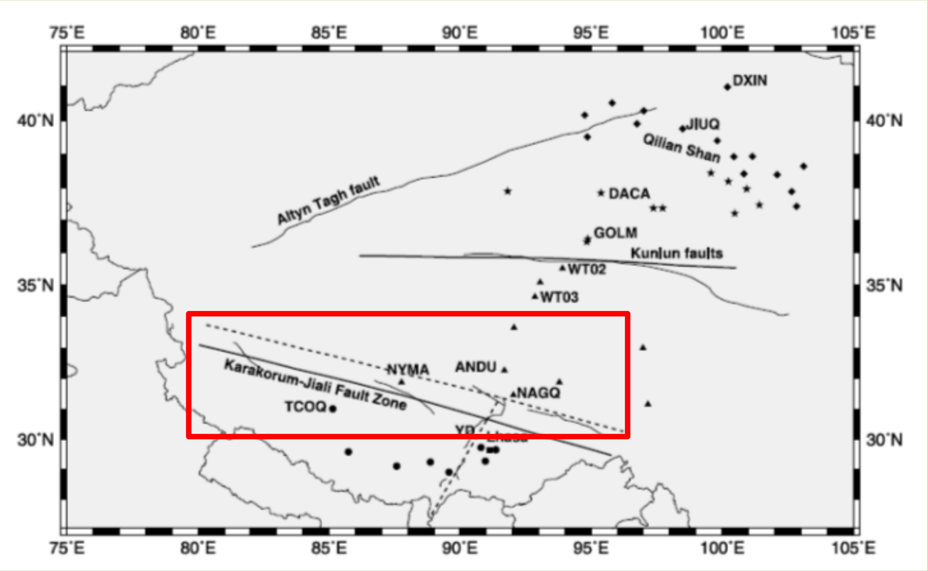

**Model tensile and dip-slip rates**




Meade, 2007

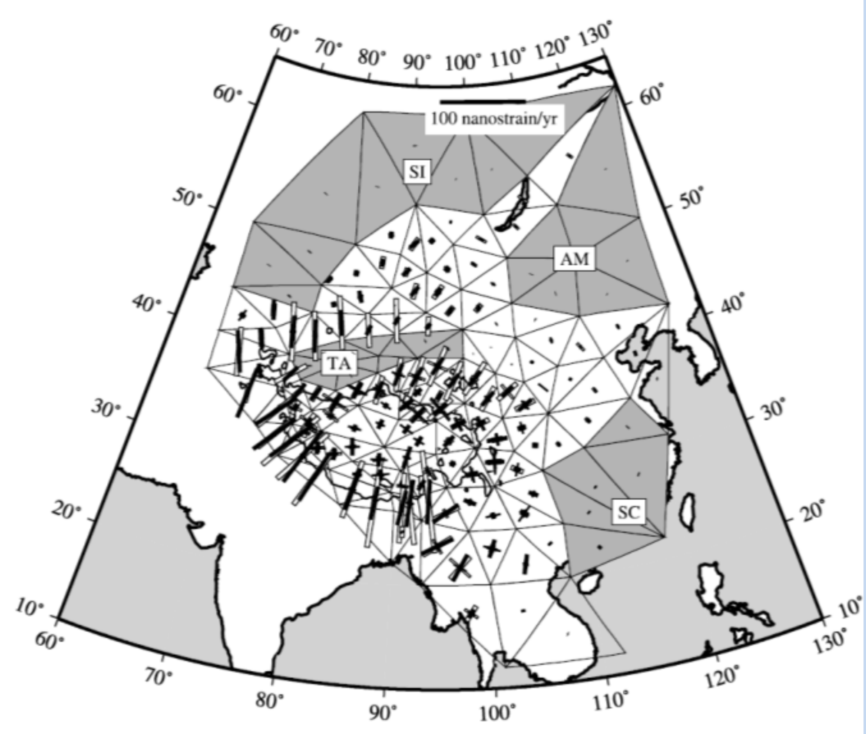
# A deforming block model for the present-day tectonics of Tibet

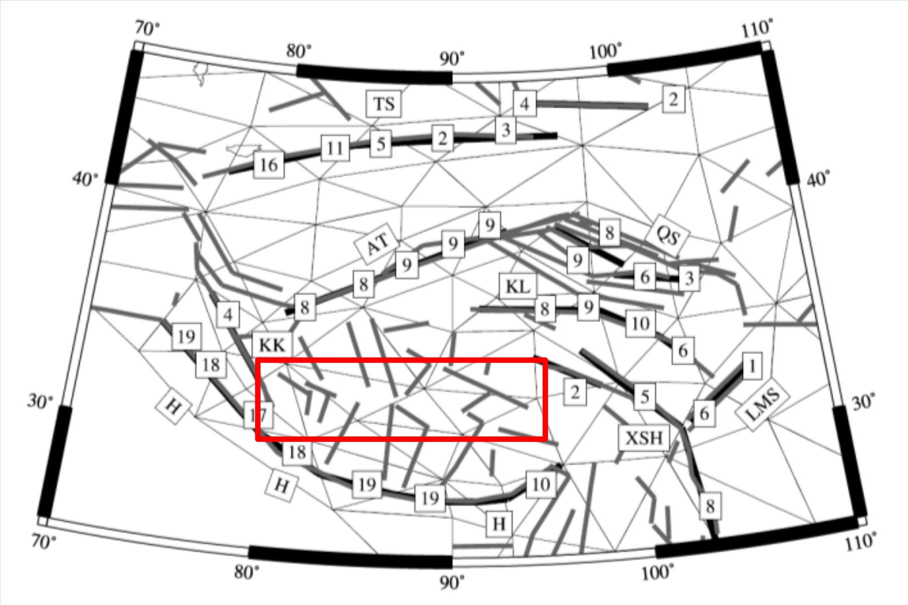



We find **7.4 ± 0.7 mm/yr** of right-lateral slip on the Karakorum-Jiali fault zone, significantly slower than that previously estimated from offset geologic features.
Chen et al., 2004

# Late Quaternary to decadal velocity fields in Asia

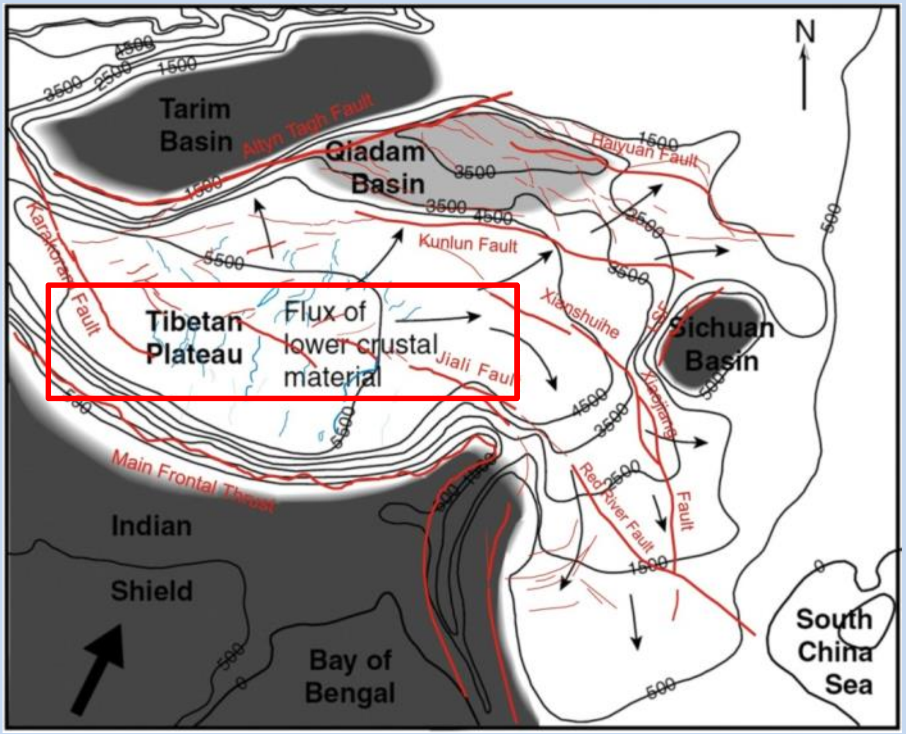


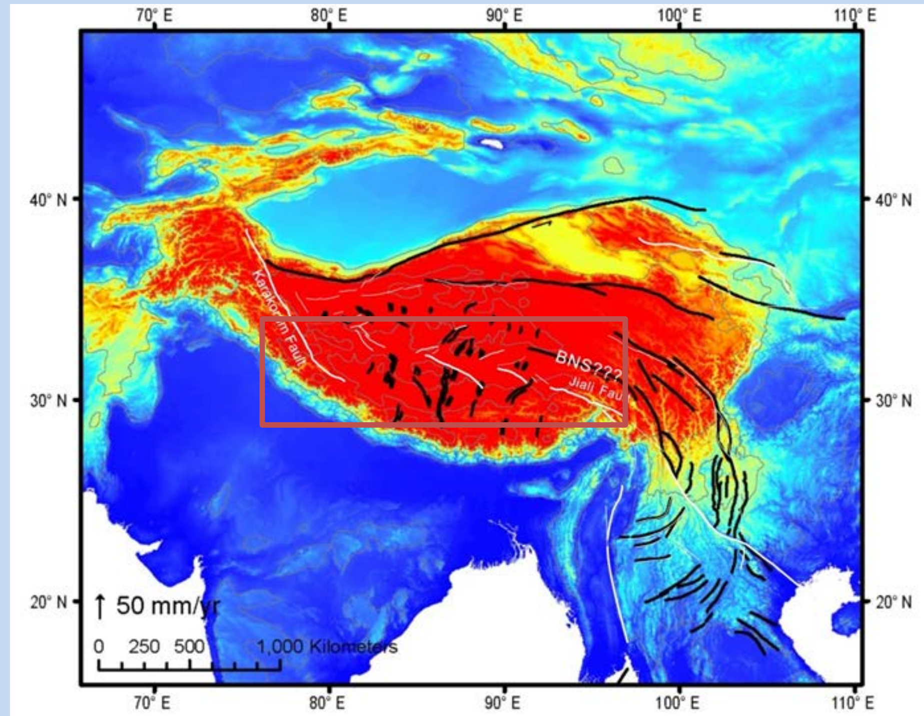




The combined solution for velocities shows plate- or block-like motion within deforming Asia only in Tarim, south China, and the Amurian region; elsewhere the kinematics of rigid blocks does not provide a useful description of the motion.

England and Molnar, 1997; 2005

# Lower crust flow



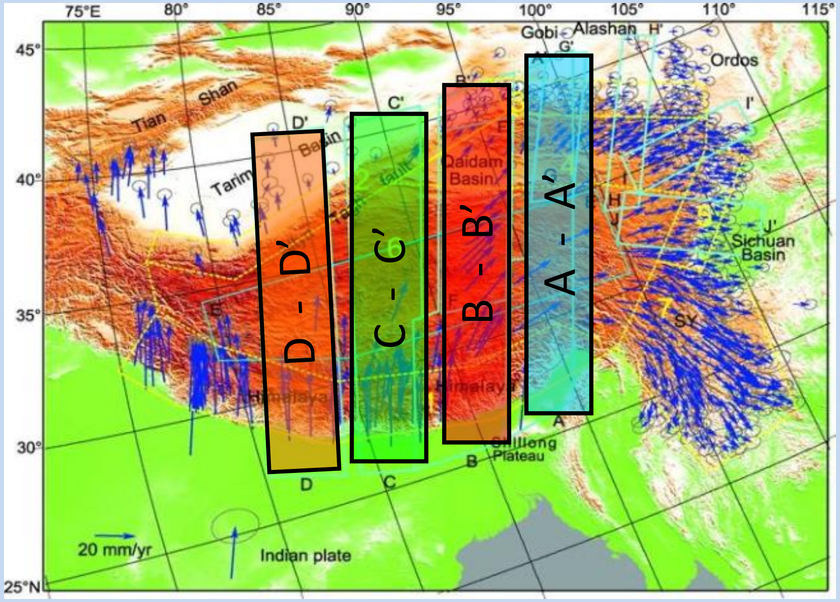



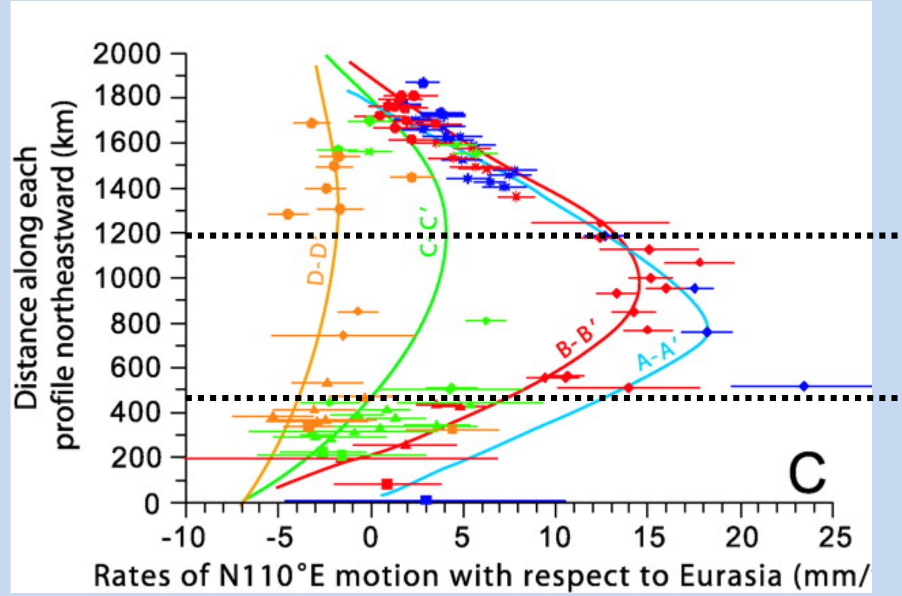

Modified from Clark & Royden ,2000

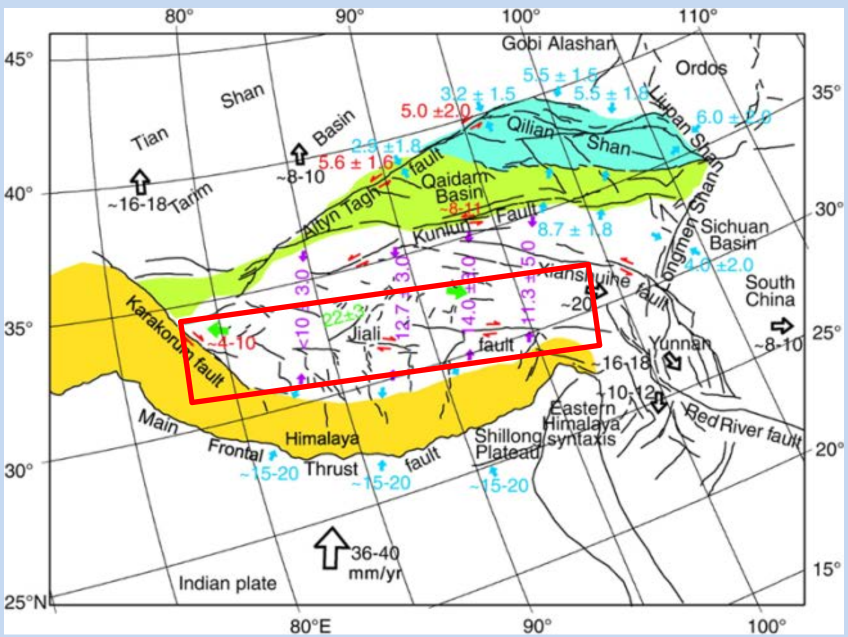
(active faults : Taylor et al., 2003)

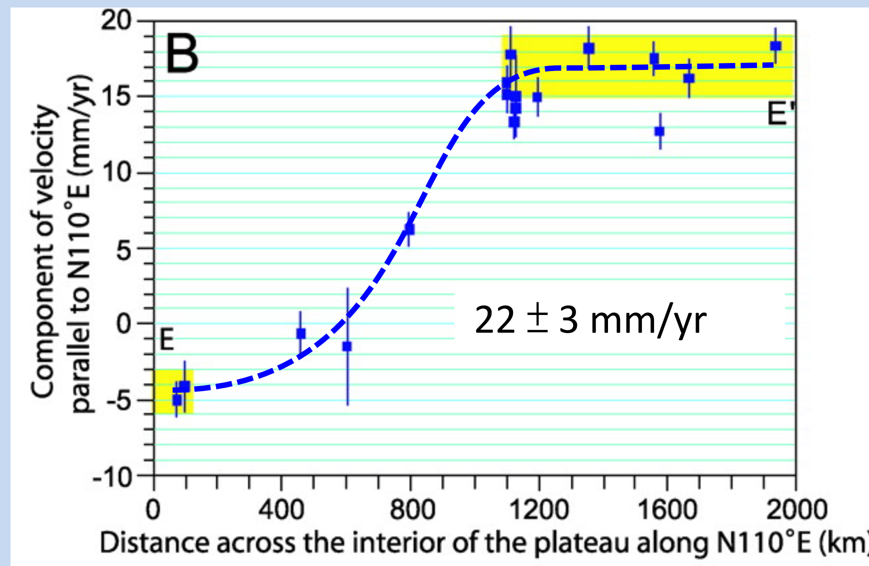
Modified from Clark & Royden ,2008

(active faults : Taylor et al., 2003)




**Zhang et al., 2004**

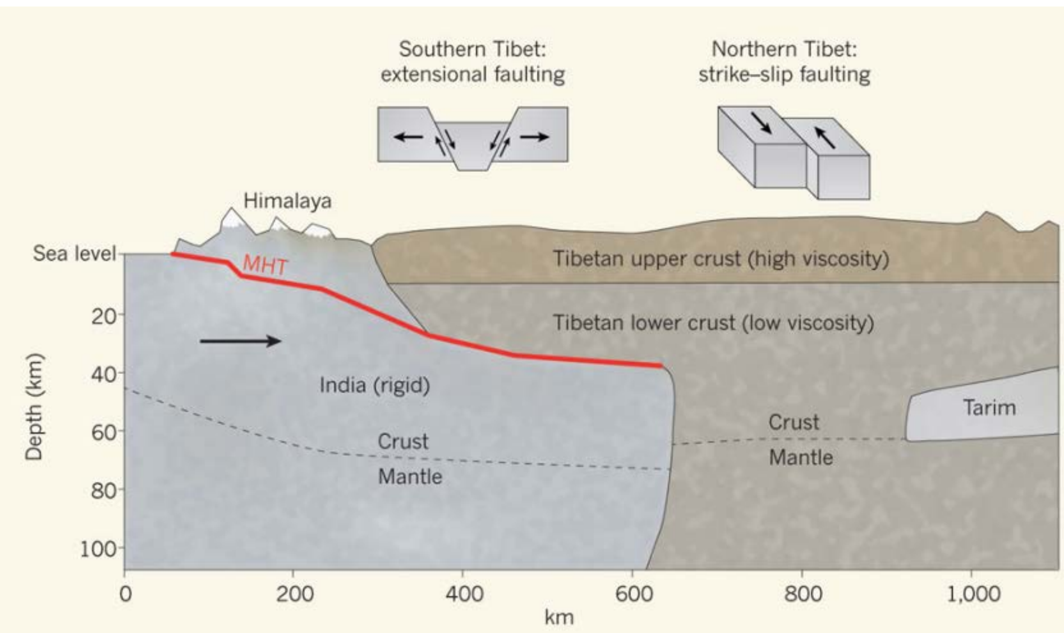
# New mechanical model for Tibet

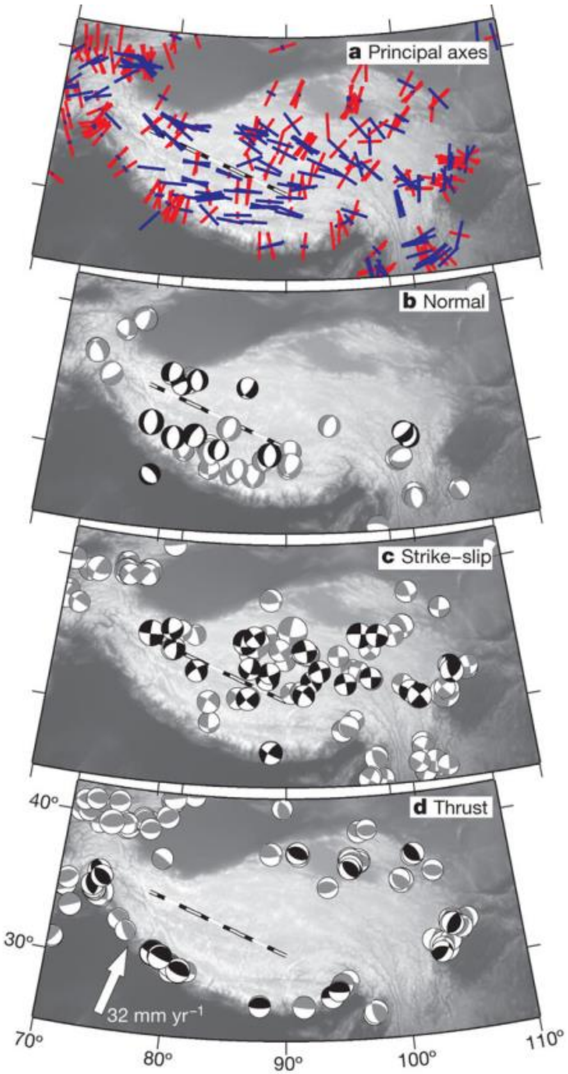
LETTER

doi:10.1038/nature09926

## Evidence for mechanical coupling and strong Indian lower crust beneath southern Tibet

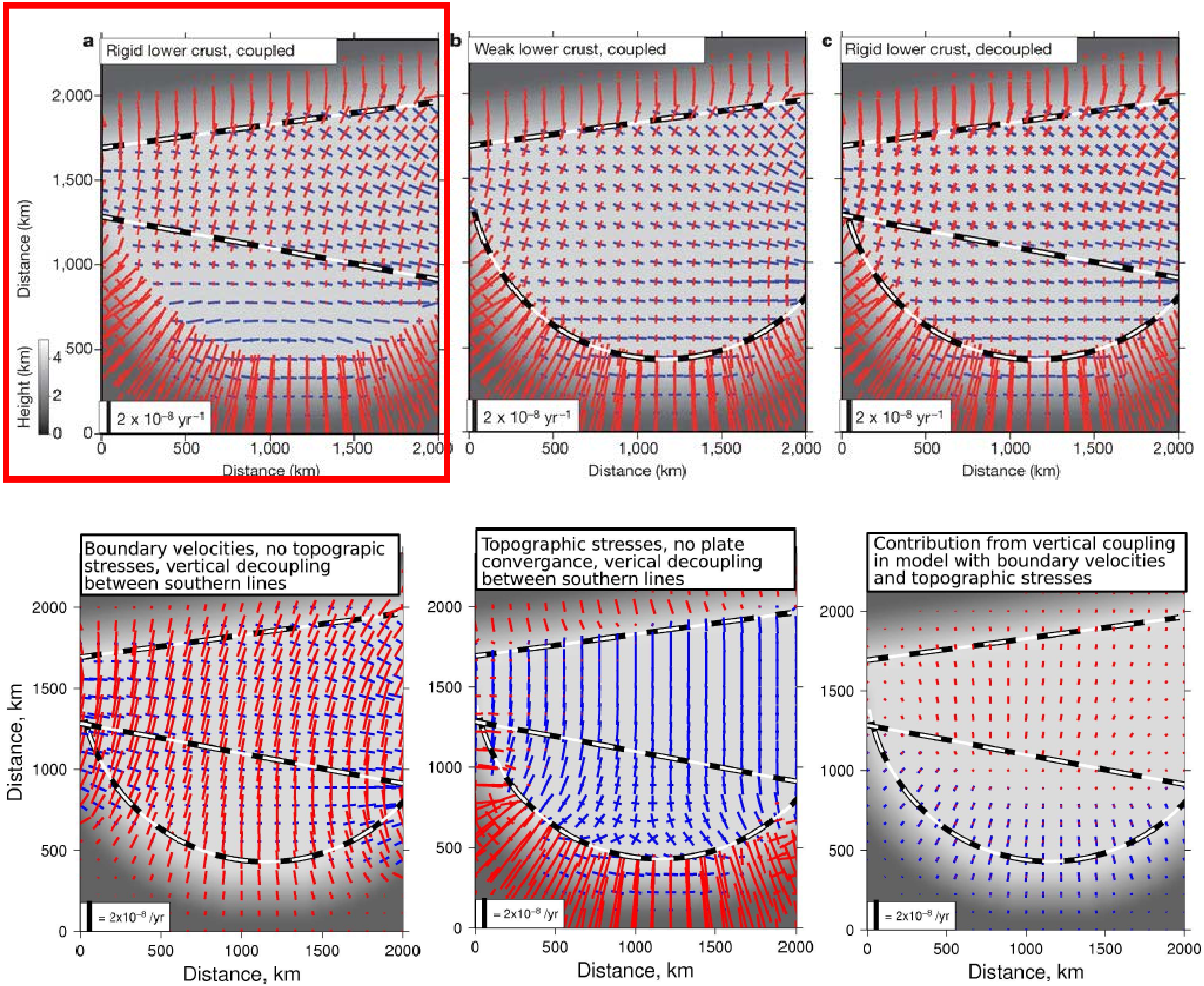
Alex Copley[1]†, Jean-Philippe Avouac[1] & Brian P. Wernicke[1]



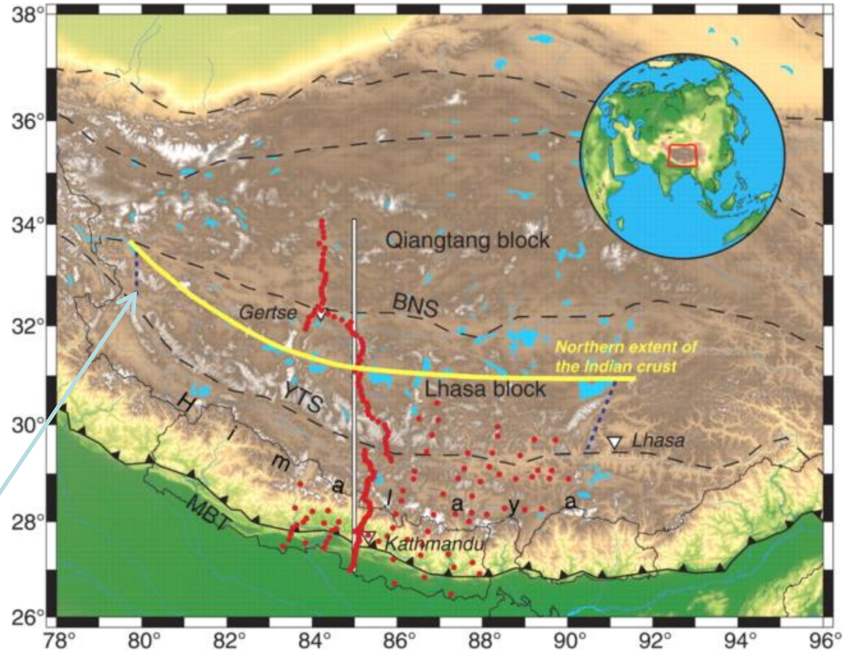

Freymueller, 2011 Nature

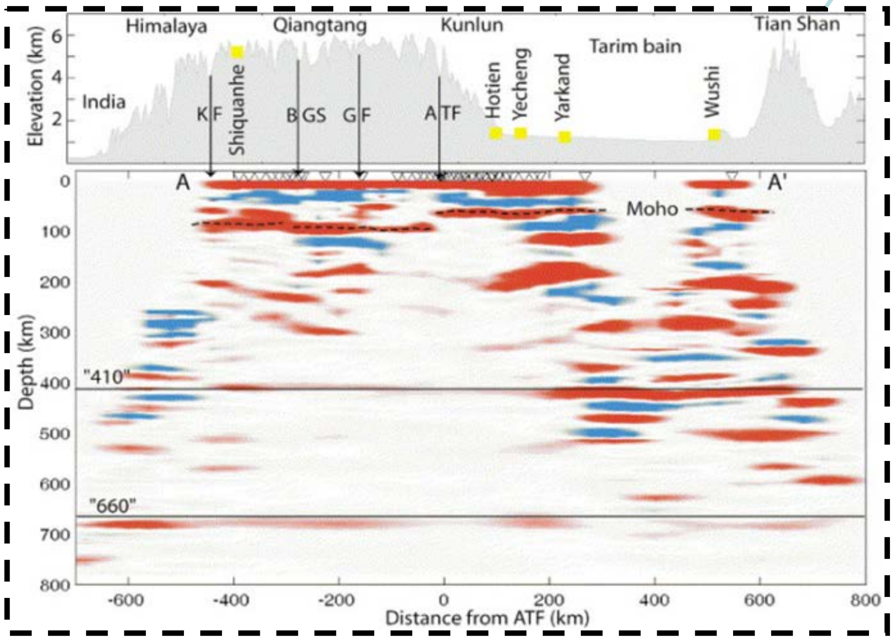
Copley et al., 2011 Nature



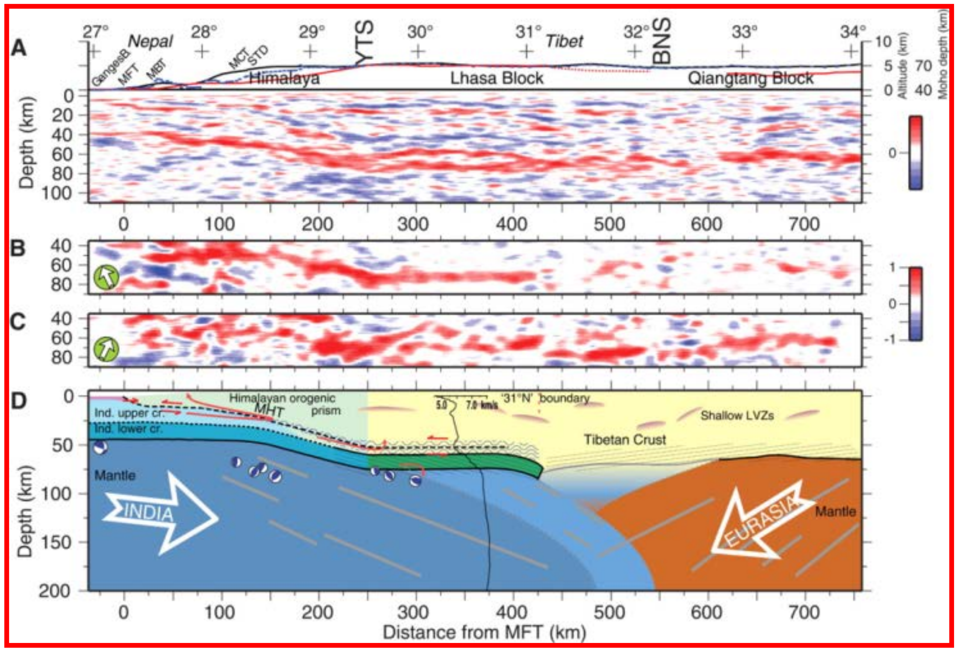

Copley et al., 2011 Nature

# Underplating in the Himalaya-Tibet Collision Zone Revealed by the Hi-CLIMB Experiment



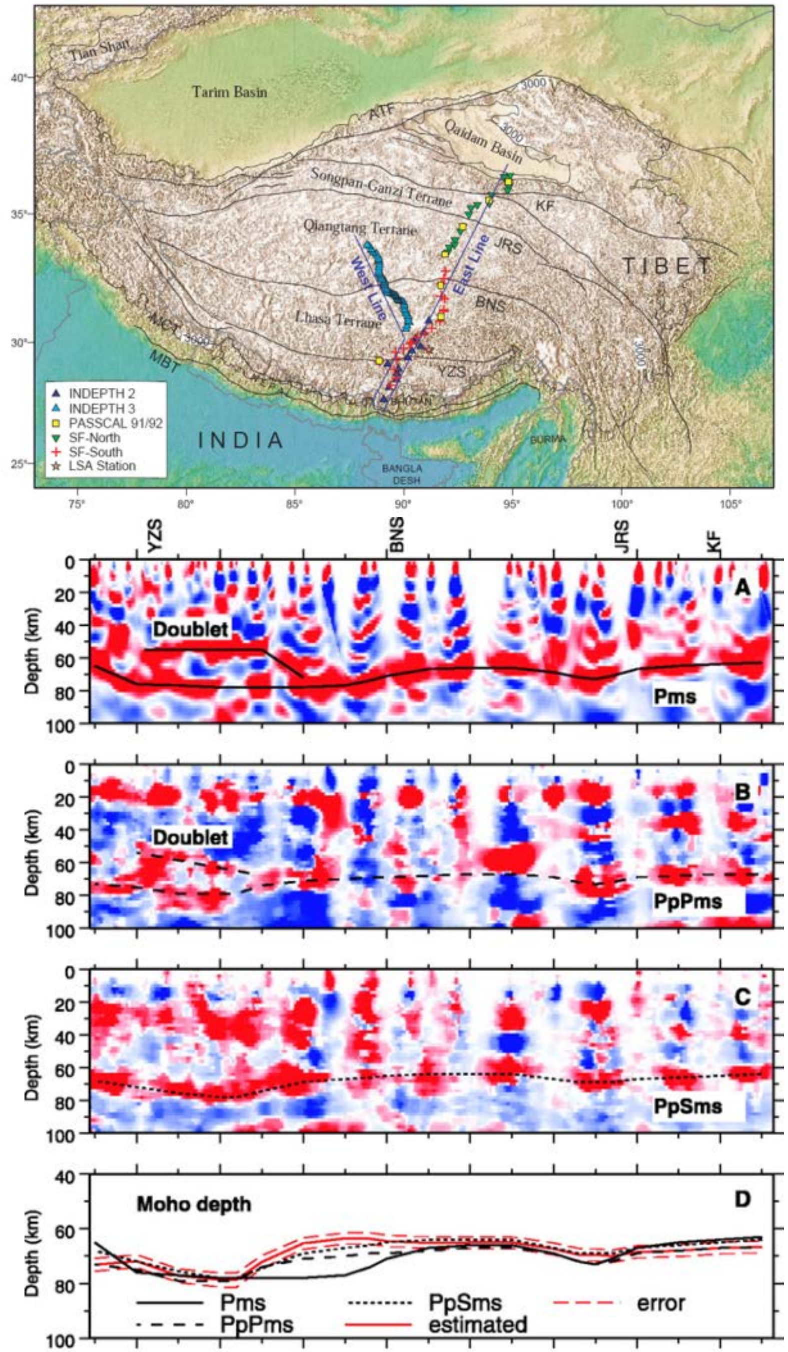



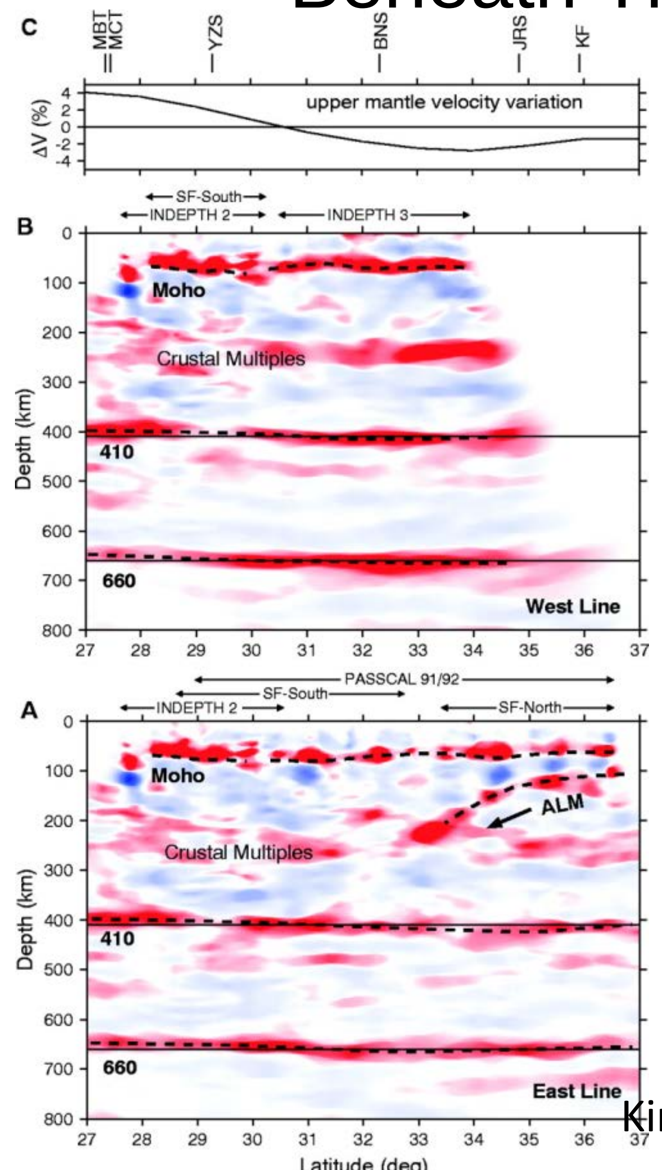

Wittlinger et al., 2004



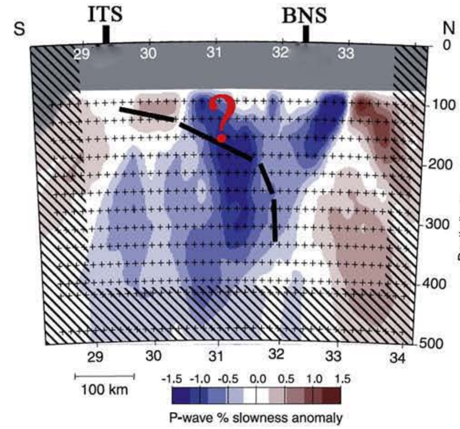

Nábělek et al 2009 Science

# Seismic Images of Crust and Upper Mantle Beneath Tibet

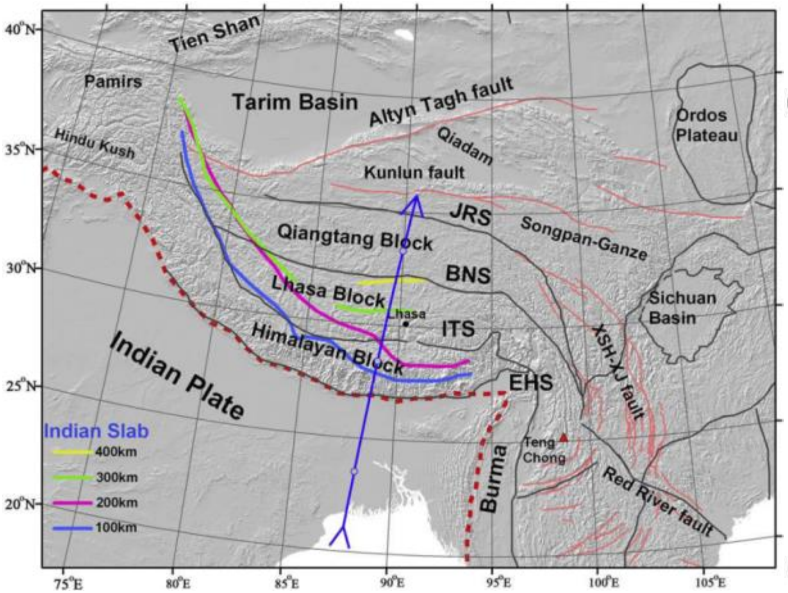


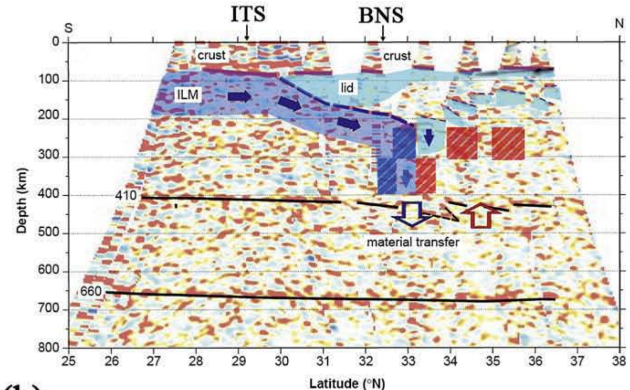

Kind et al., 2002




Teleseismic tomography based on theINDEPTH II and III data (Tilmann et al., 2003)

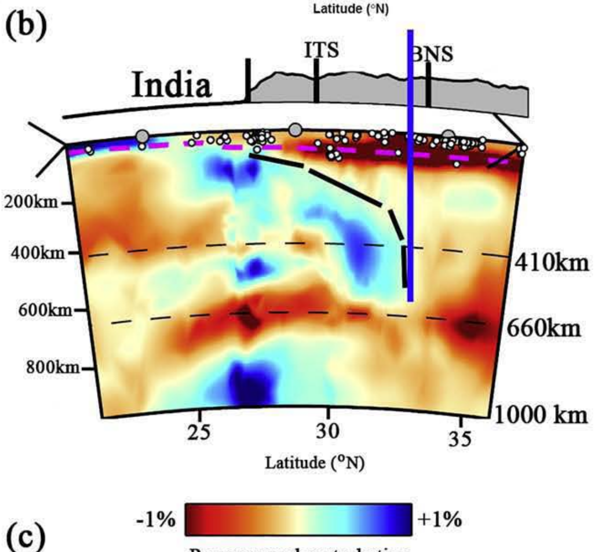



(a)



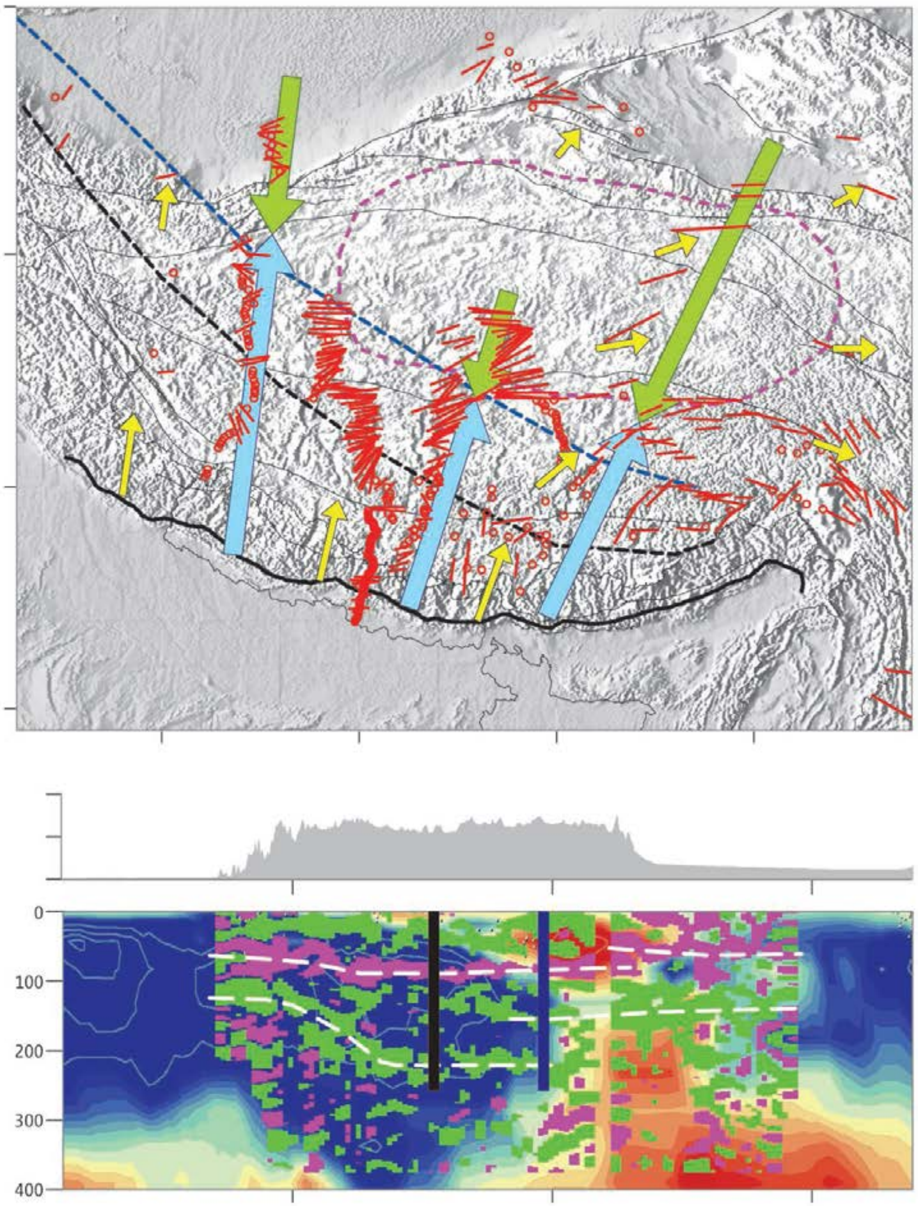

Teleseismic receiver function image from the INDEPTH II and Sino-American PASSCAL experiments (Kosarev et al., 1999)

(b)




(c)

Li et al., 2008




Kind and Yuan, 2010 Science