2008.05.12

中國四川汶川地震概要

- 地震震源特性

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886-2-6630-0570

地震震源特性

- 地體構造與震源機制
- 災情推測
- 地震有感範圍

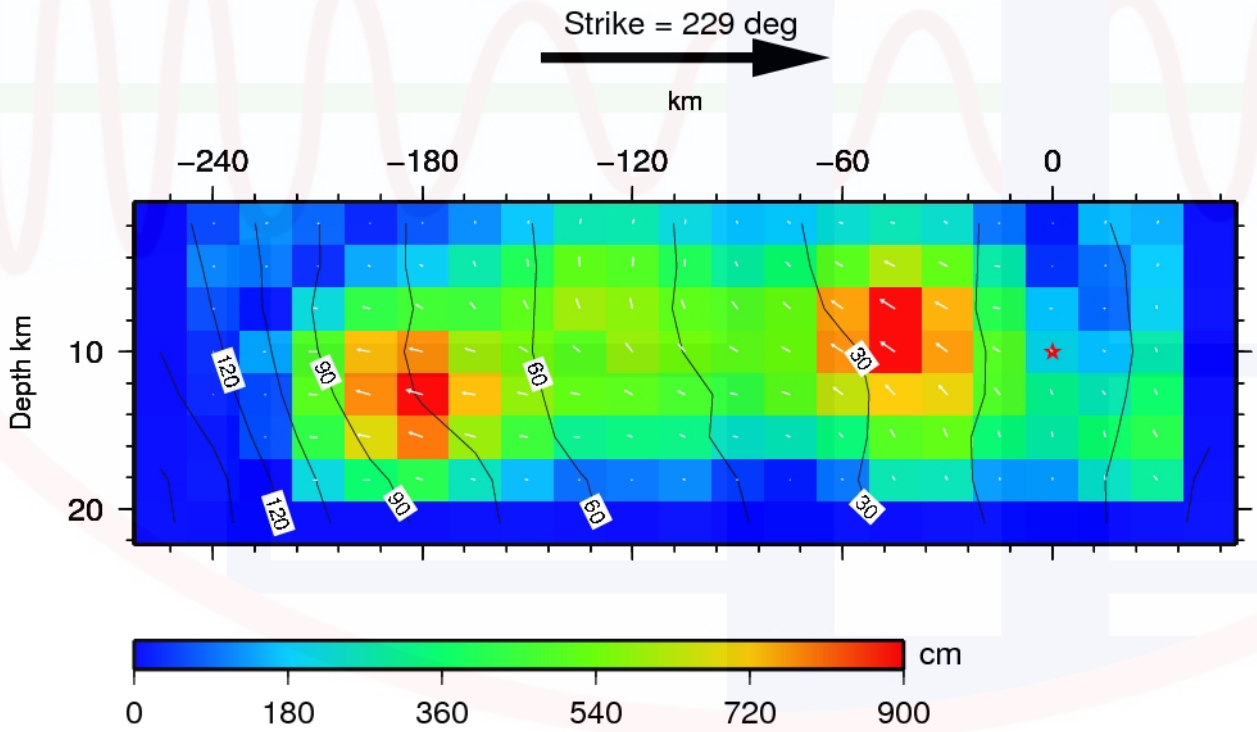
美國地質調查所USGS公布之地震參數

2008/05/12 14:28:00 31.021°N, 103.367°E, 深度10 km

At least 8,500 people killed. Felt widely in China. Also felt in parts of Thailand and Taiwan.

Longmenshan fault or a tectonically related fault.

The magnitude 7.5 earthquake of August 25, 1933, killed more than 9,300 people.

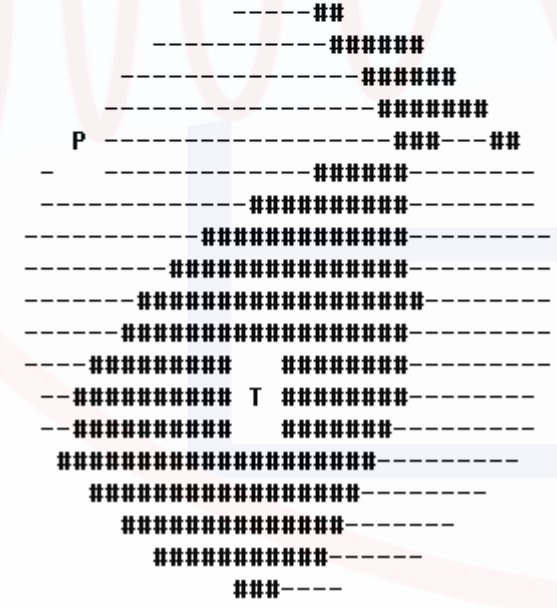


震源機制

USGS

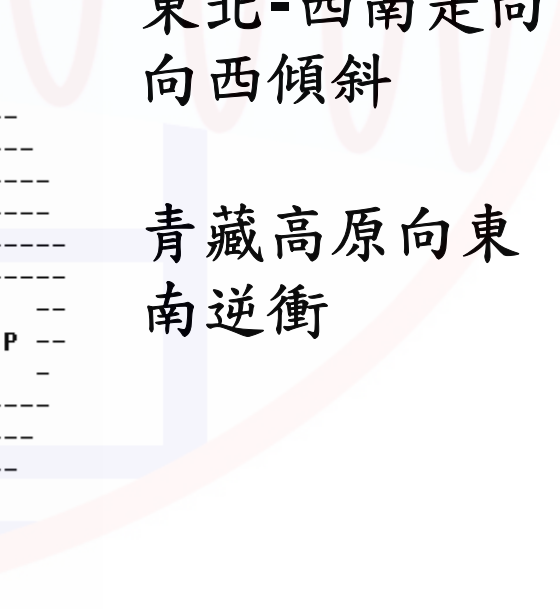
```
USGS CENTROID MOMENT TENSOR
08/05/12 06:28:49.29
Centroid:   31.969  104.231
Depth  16          No. of sta:155
Moment Tensor;   Scale 10**20 Nm
  Mrr= 5.47        Mtt=-0.57
  Mpp=-4.90        Mrt=-4.34
  Mrp= 1.10        Mtp=-3.48
 Principal axes:
  T  Val=  8.27  Plg=57  Azm=202
  N       -1.31      31       36
  P       -6.96       6      302

Best Double Couple:Mo=7.6*10**20
 NP1:Strike=  2 Dip=47 Slip=  45
 NP2:       238     59       128
```



HARVARD

```
CENTROID-MOMENT-TENSOR  SOLUTION
GCMT EVENT:     M200805120628A
DATA: II IU CU G  IC GE
MANTLE WAVES:   99S, 238C, T=150
TIMESTAMP:      Q-20080512075125
CENTROID LOCATION:
ORIGIN TIME:      06:28:41.4 0.1
LAT:31.49N 0.01;LON:104.11E 0.01
DEP: 12.0  FIX;TRIANG HDUR: 22.2
MOMENT TENSOR: SCALE 10**28 D-CM
RR= 0.563 0.003; TT= 0.026 0.002
PP=-0.589 0.002; RT=-0.285 0.030
RP= 0.620 0.023; TP=-0.313 0.002
PRINCIPAL AXES:
1.(T) VAL=  0.991;PLG=57;AZM=227
2.(N)      -0.096;    25;      2
3.(P)      -0.895;    20;    103
BEST DBLE.COUPLE:M0= 9.43*10**27
NP1: STRIKE=229;DIP=33;SLIP= 141
NP2: STRIKE=352;DIP=70;SLIP=  63
```

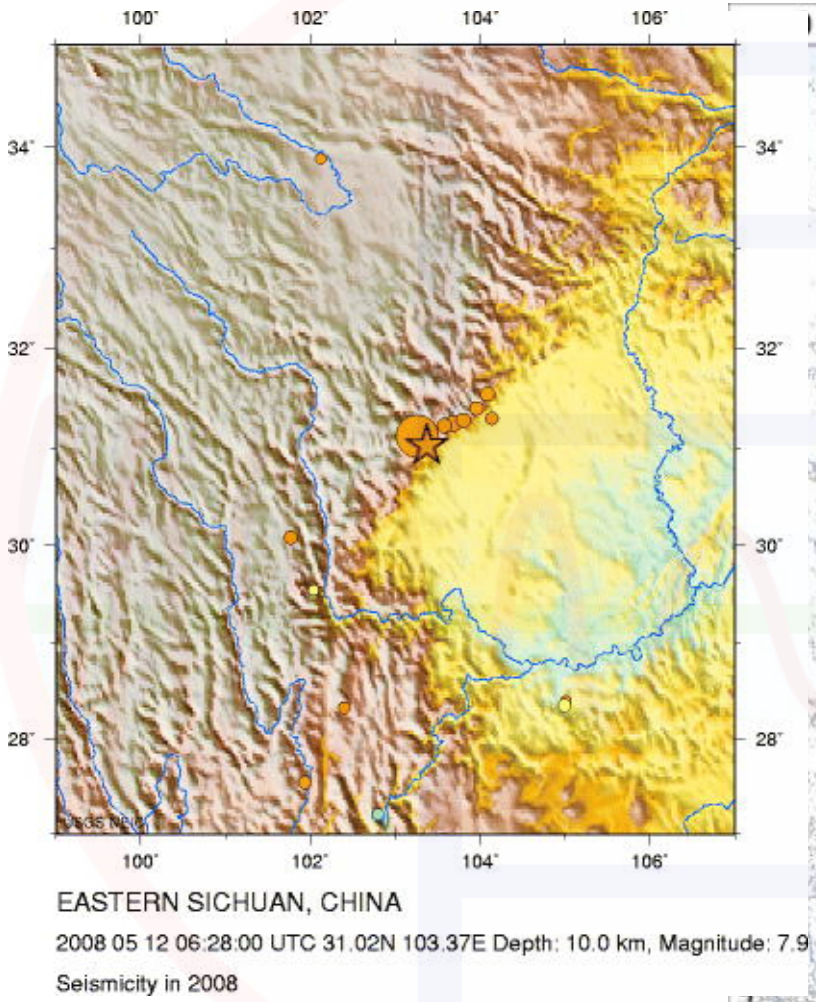


特性：
逆衝斷層

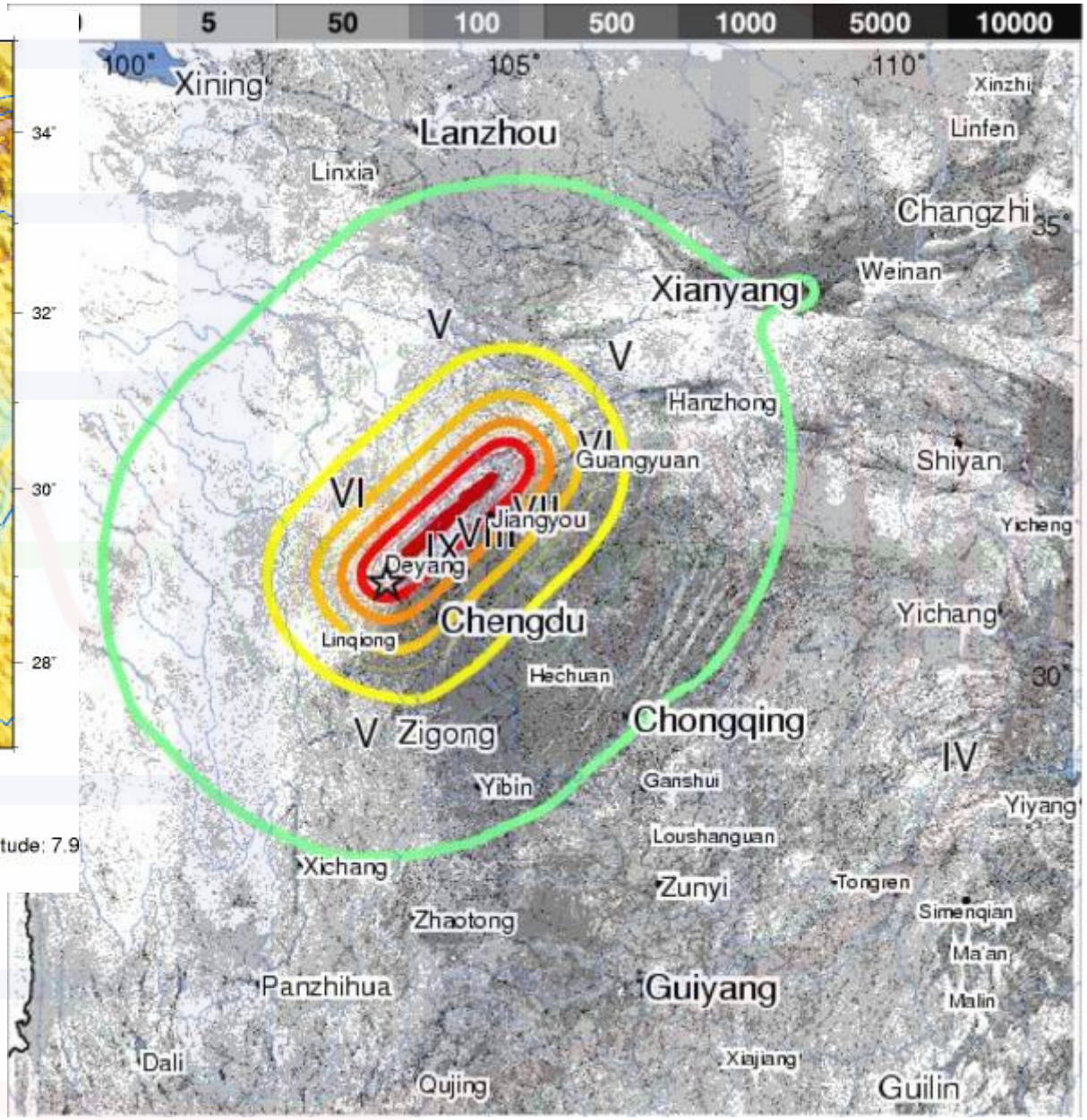
比對地形、構造運動後主破裂面為東北-西南走向向西傾斜

青藏高原向東南逆衝

餘震



USGS估計的震度分佈圖



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世界各種地震震度分級比較表

震度分級		我國現用 震度階 2000 年	日本氣象廳 震度階 1996 年	M. S. K. 震度階 1964 年	新 MERCALLI 震度階 1956 年	CANCANI 震度階 1903 年	DE ROSSIFOREL 震度階 1833 年
0	無感	0.8gal 以下	0	Ⅰ無感	Ⅰ0.5gal 以下	Ⅰ0.25gal 以下	Ⅰ
						Ⅱ0.25～0.5gal	
					Ⅰ0.5～1.0gal	Ⅲ0.5～1.0gal	
1	微震	0.8～2.5gal	1	Ⅱ極輕	Ⅱ1.0～2.1gal	Ⅳ1.0～2.5gal	Ⅱ
					Ⅲ2.1～5.0gal		
2	輕震	2.5～8.0gal	2	Ⅲ弱		Ⅴ2.5～5.0gal	Ⅲ
					Ⅳ5～10gal	Ⅵ5～10gal	
3	弱震	8～25gal	3	Ⅳ大部份人有感			Ⅳ
					Ⅴ10～21gal	Ⅶ10～25gal	
				Ⅴ12～25gal			Ⅴ
					Ⅵ21～44gal		
4	中震	25～80gal	4	Ⅵ25～50gal		Ⅷ25～50gal	Ⅵ
					Ⅶ44～94gal		
				Ⅶ50～100gal		Ⅸ50～100gal	
5	強震	80～250gal	5 弱				Ⅶ
				Ⅷ100～200gal	Ⅷ94～202gal		
			5 強			Ⅹ100～250gal	
							Ⅷ
				Ⅸ200～400gal			Ⅸ
6	烈震	250～400gal	6 弱		Ⅸ202～432gal		
			6 強			Ⅺ250～500gal	
7	劇震	400gal 以上	7	Ⅹ400～800gal			Ⅹ
					Ⅹ432gal 以上		
					Ⅺ	Ⅻ500～1000gal	
				Ⅺ,Ⅻ800gal 以上	Ⅻ		

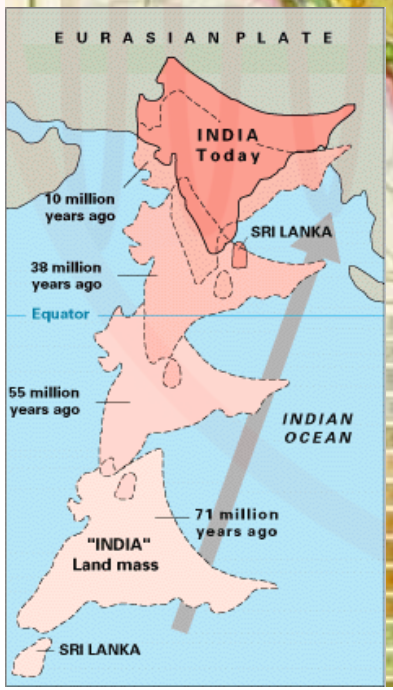
備註：日本震度階僅爲示意圖，實際日本震度階是由加速度值與地震動持續時間經計算而得，無法僅由加速度值得知。

中央氣象局
地震百問

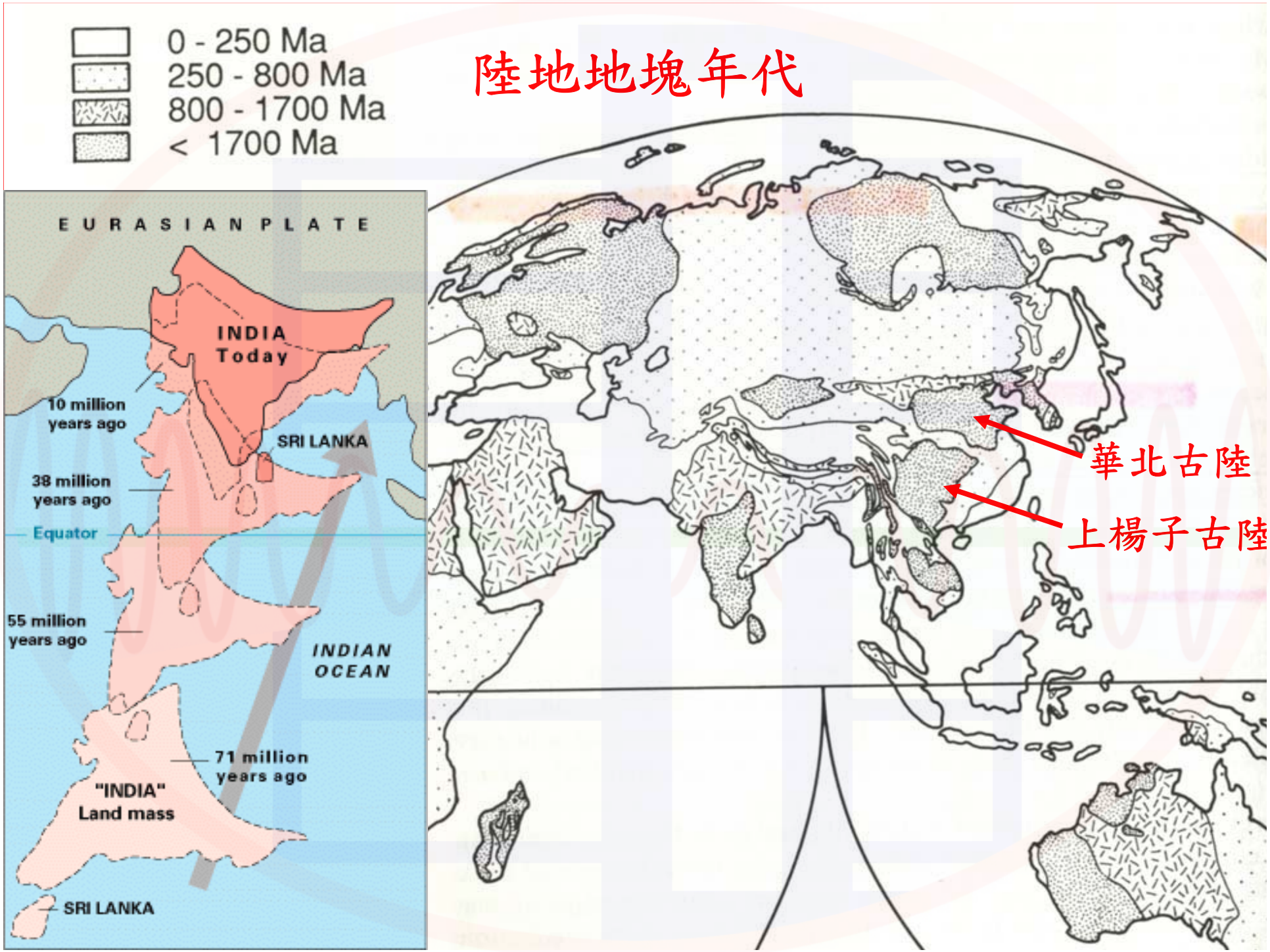
NCREE

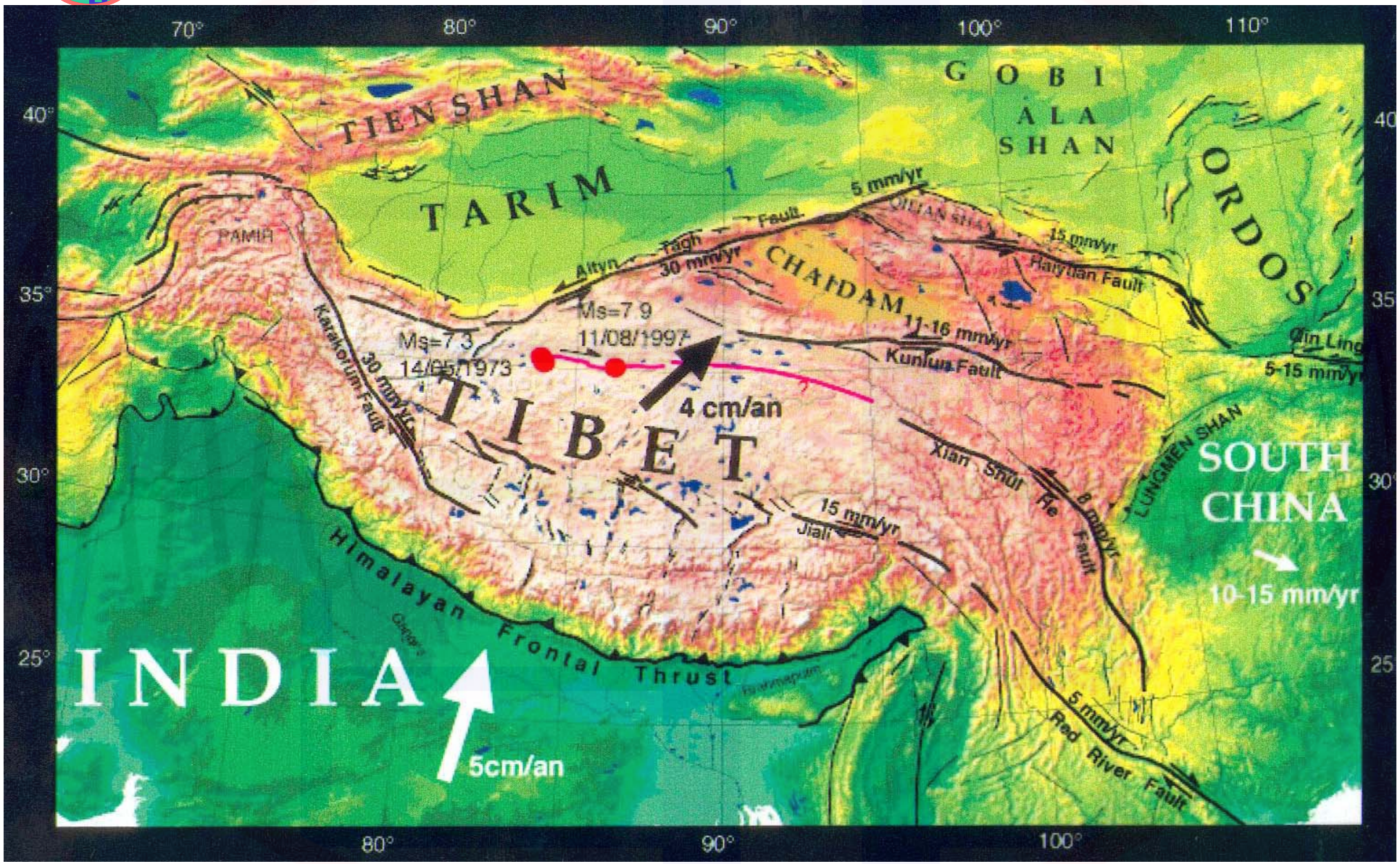
震源機制與地體構造

中國地質圖

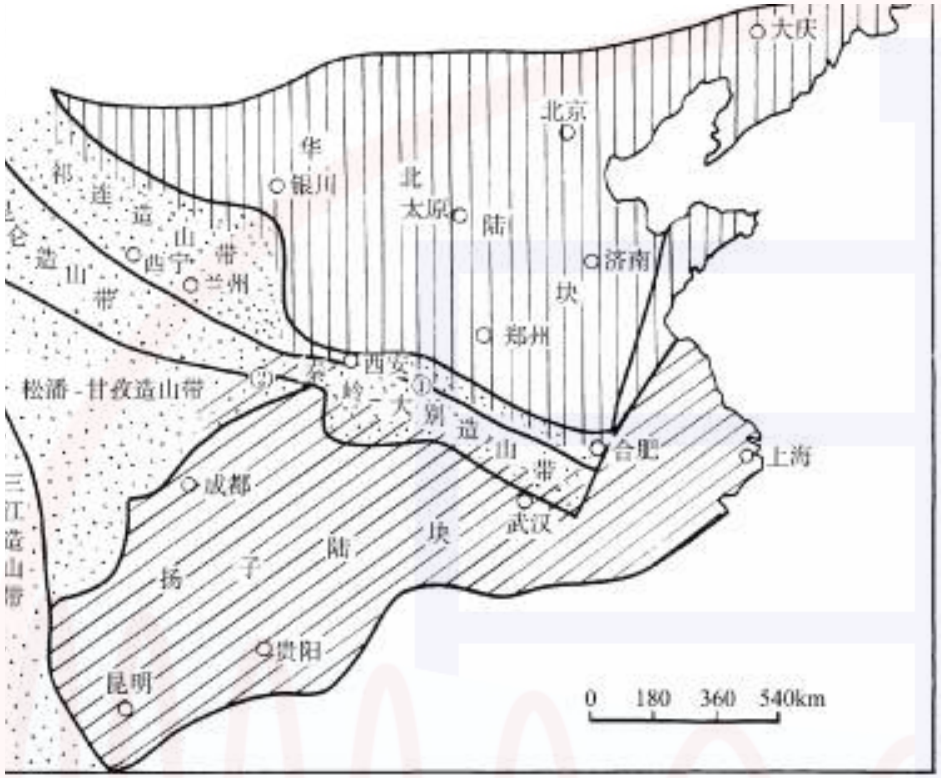

EURASIAN PLATE
INDIA
Today
10 million
years ago
SRI LANKA
38 million
years ago
Equator
55 million
years ago
INDIAN
OCEAN
71 million
years ago
"INDIA"
Land mass
SRI LANKA

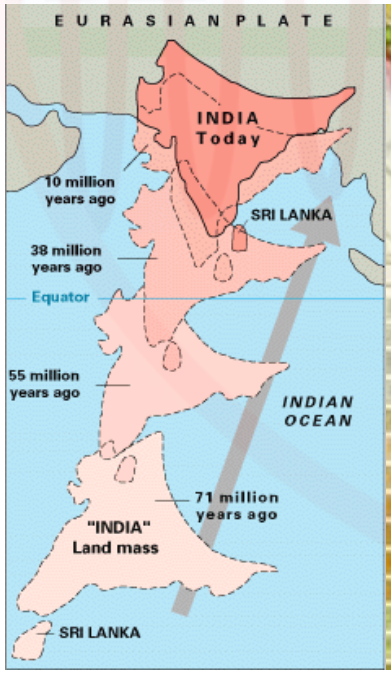
陸地地塊年代


0 - 250 Ma
250 - 800 Ma
800 - 1700 Ma
< 1700 Ma
EURASIAN PLATE
INDIA
Today
10 million
years ago
SRI LANKA
38 million
years ago
Equator
55 million
years ago
INDIAN
OCEAN
71 million
years ago
"INDIA"
Land mass
SRI LANKA
華北古陸
上楊子古陸


70°
80°
90°
100°
110°
40°
35°
30°
25°
TIEN SHAN
TARIM
GOBI
ALA
SHAN
ORDOS
PAMIR
5 mm/yr
Altyn Tagh Fault
30 mm/yr
CHAIDAM
15 mm/yr
Haiyuan Fault
Ms=7.9
11/08/1997
Ms=7.3
14/05/1973
11-16 mm/yr
Kunlun Fault
Qin Ling
5-15 mm/yr
Karakorum Fault
30 mm/yr
TIBET
4 cm/an
Xian Shui He Fault
8 mm/yr
LUNGMEN SHAN
SOUTH
CHINA
15 mm/yr
Jiali
10-15 mm/yr
Himalayan Frontal Thrust
INDIA
5cm/an
5 mm/yr
Red River Fault

中國地質圖


大庆
北京
华
北
陆
块
银川
太原
济南
郑州
西安
合肥
上海
成都
武汉
贵阳
昆明
西宁
兰州
祁连造山带
松潘-甘孜造山带
秦岭-大别造山带
扬子陆块
0 180 360 540km


EURASIAN PLATE
INDIA
Today
10 million
years ago
SRI LANKA
38 million
years ago
Equator
55 million
years ago
INDIAN
OCEAN
71 million
years ago
"INDIA"
Land mass
SRI LANKA

怒江
瀾滄江
金沙江

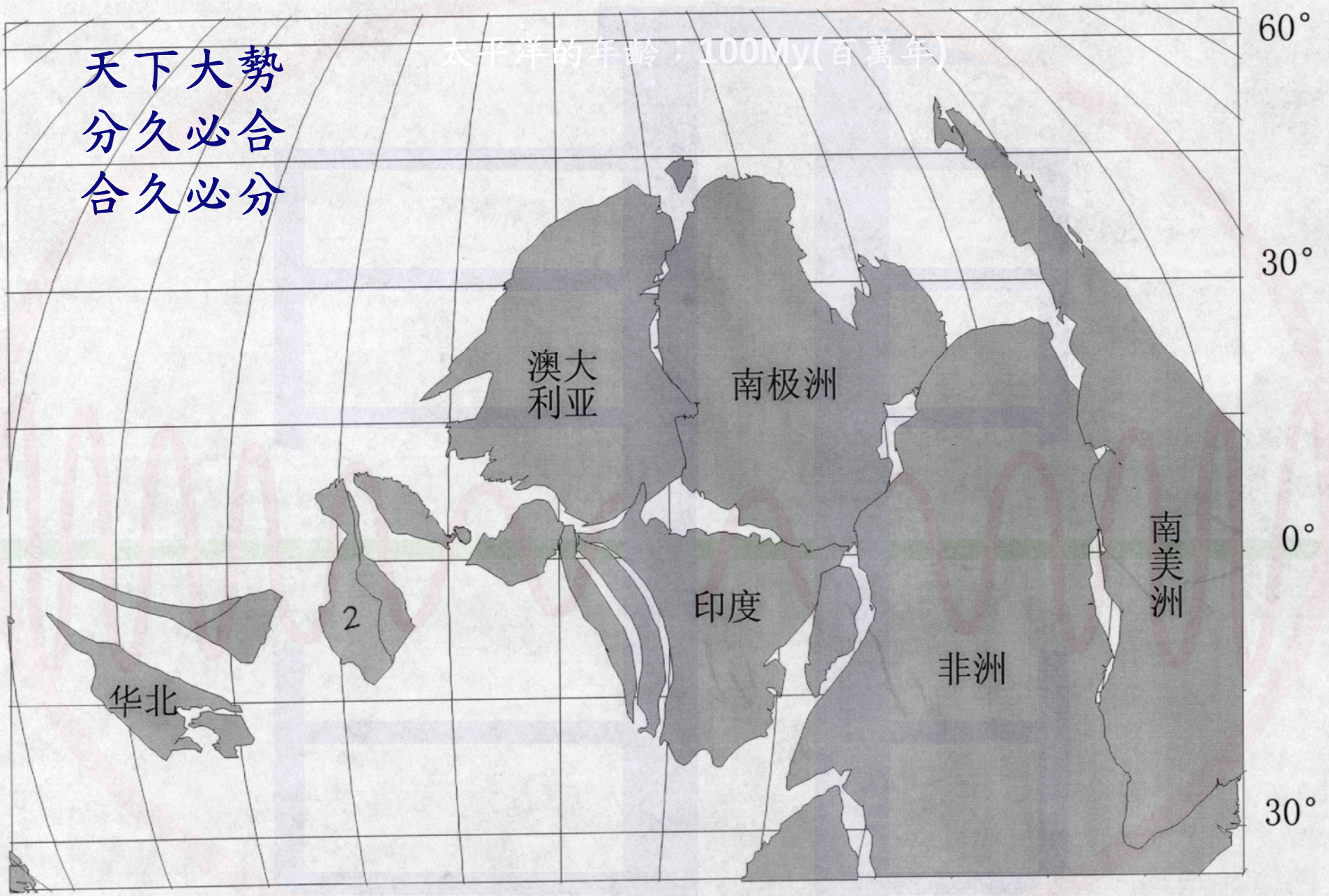


图 2、寒武纪时期（550Ma）古板块位置复原图

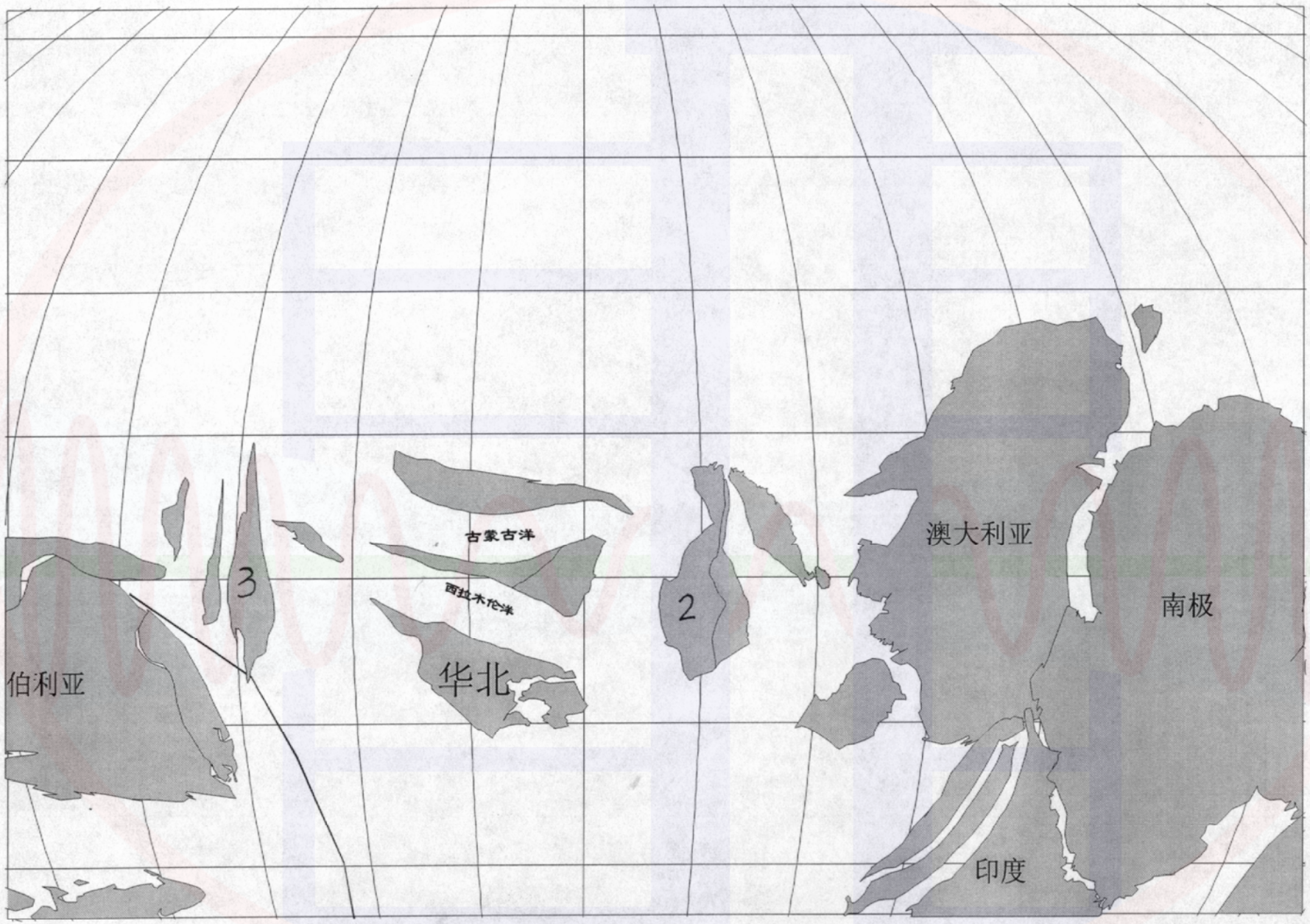


图 3、中、晚奥陶纪时期（460Ma）古板块位置复原图

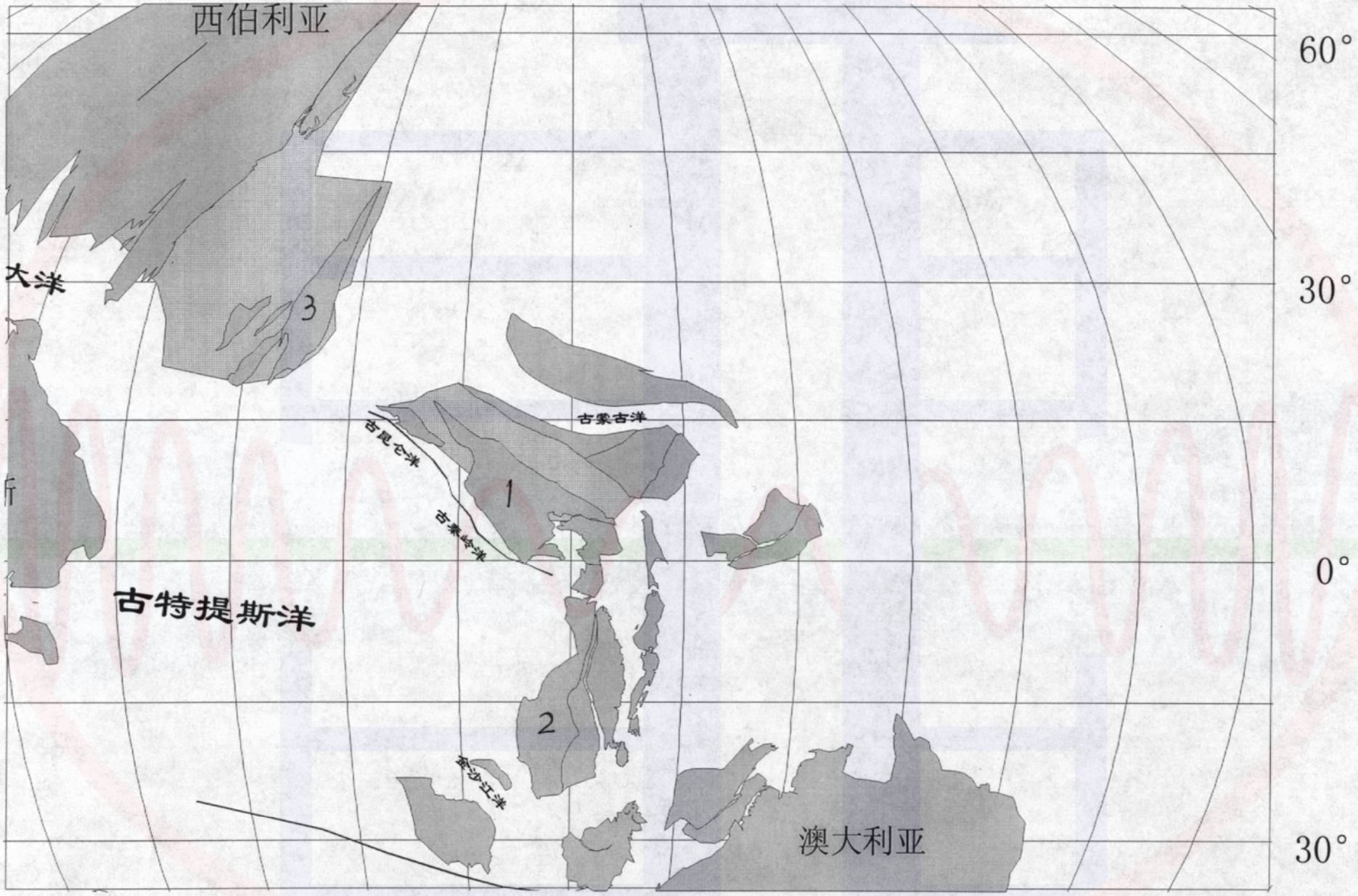


图 4、中、晚奥陶世时期（340Ma）古板块位置复原图

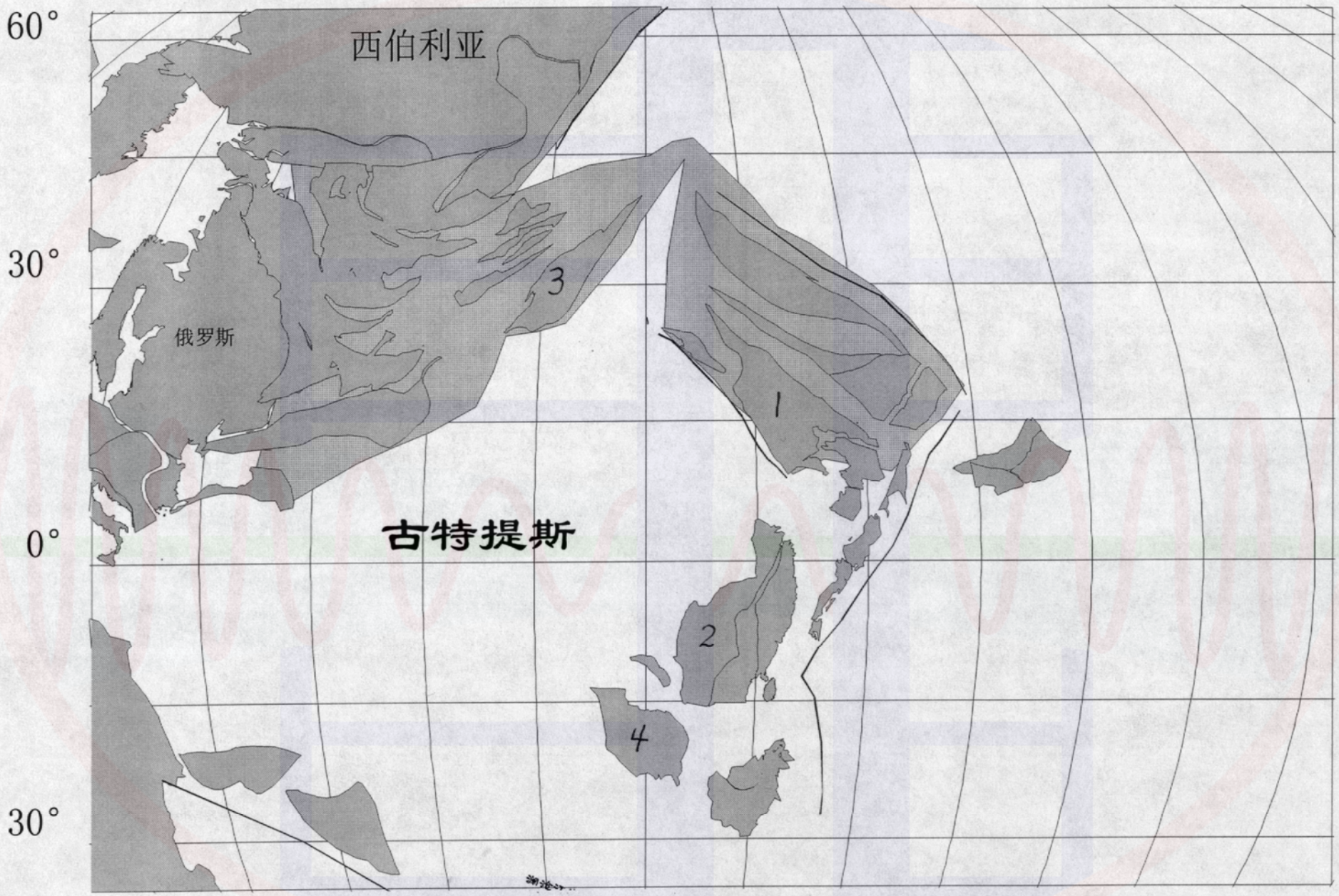


图 5、早二叠世时期（270Ma）古板块位置复原图

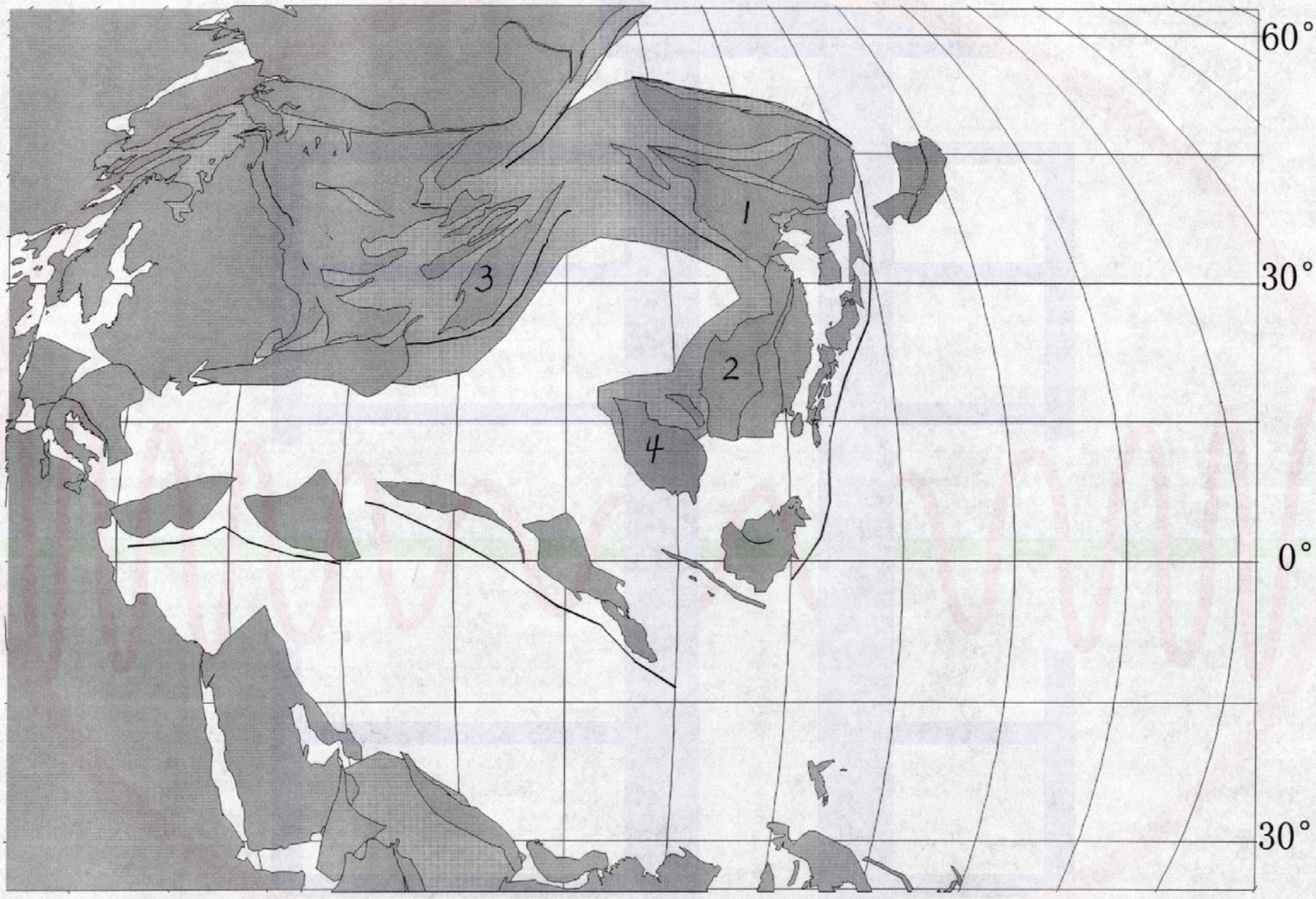


图 6、晚三叠世时期（220Ma）古板块位置复原图

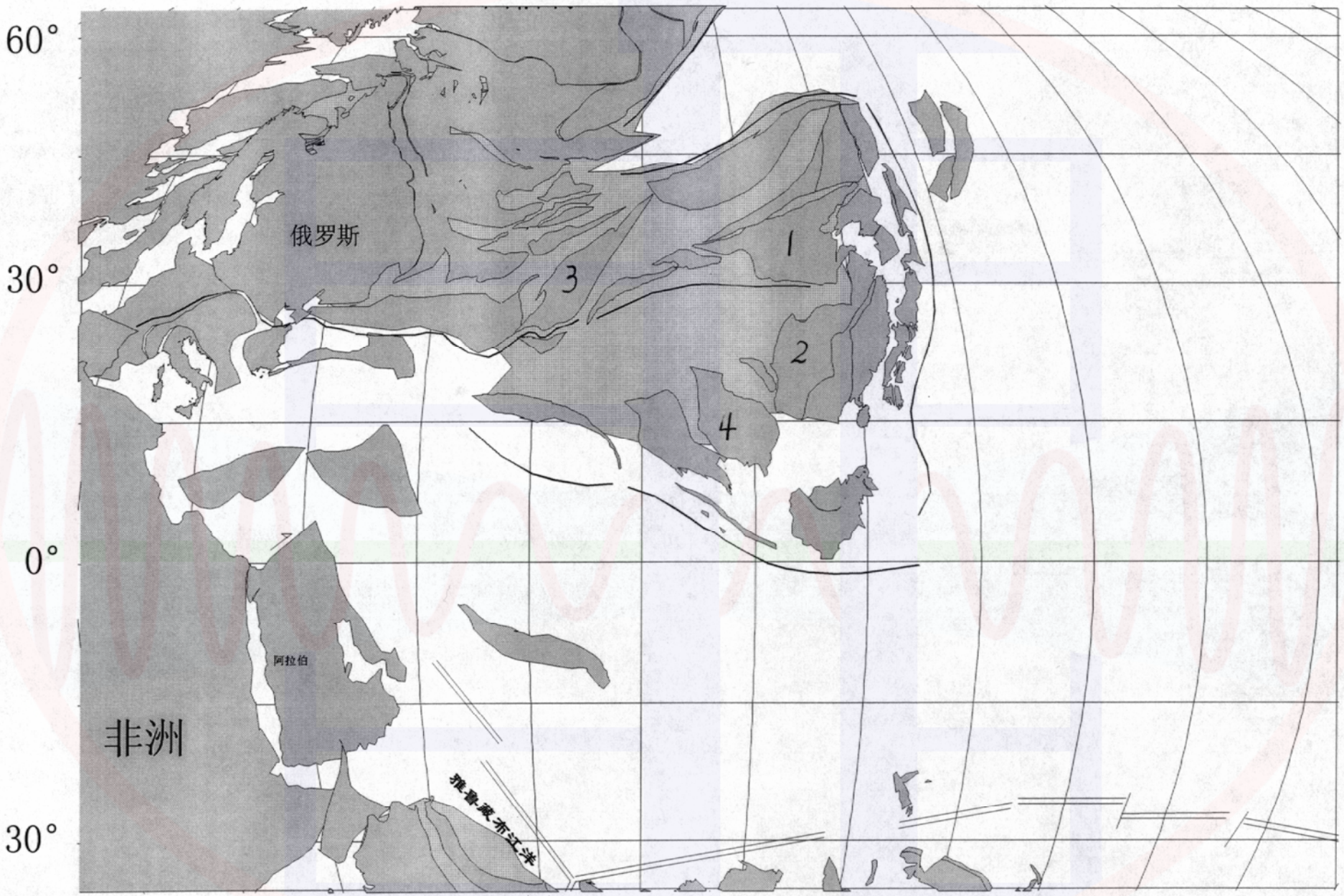


图 7、早、中侏罗世时期（185Ma）古板块位置复原图

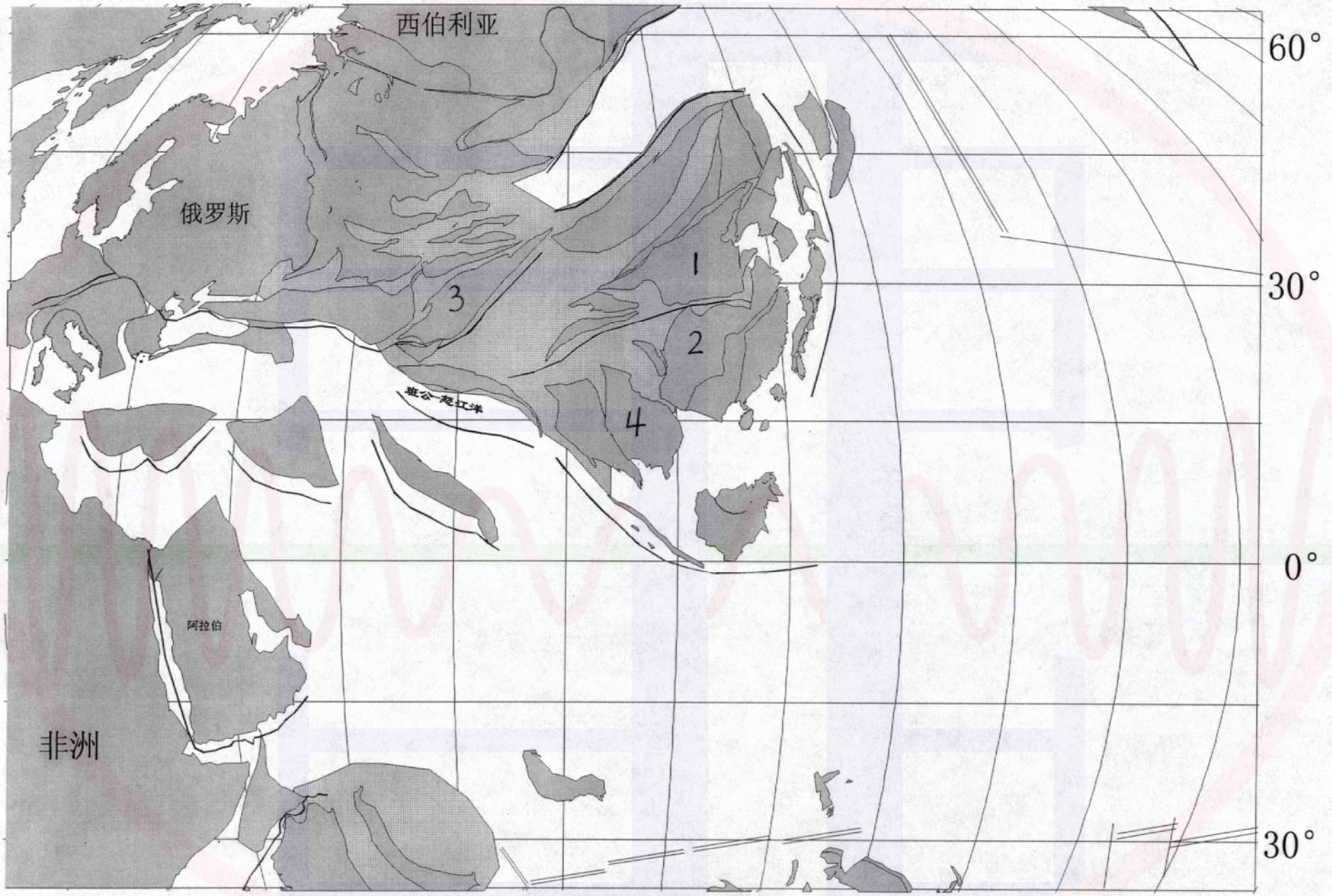


图 8、晚侏罗世时期（150Ma）古板块位置复原图

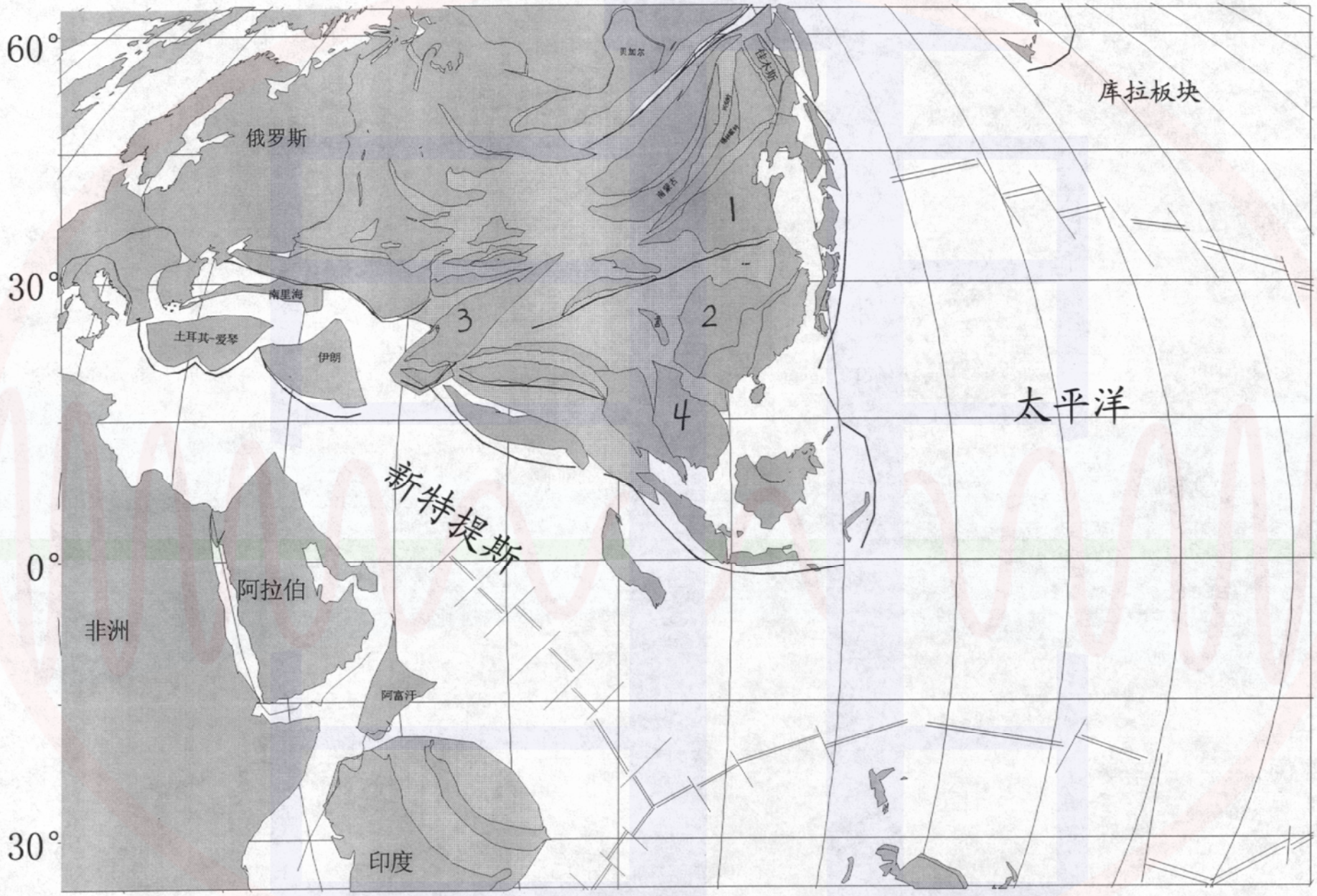


图 9、白垩纪世时期（100Ma）古板块位置复原图

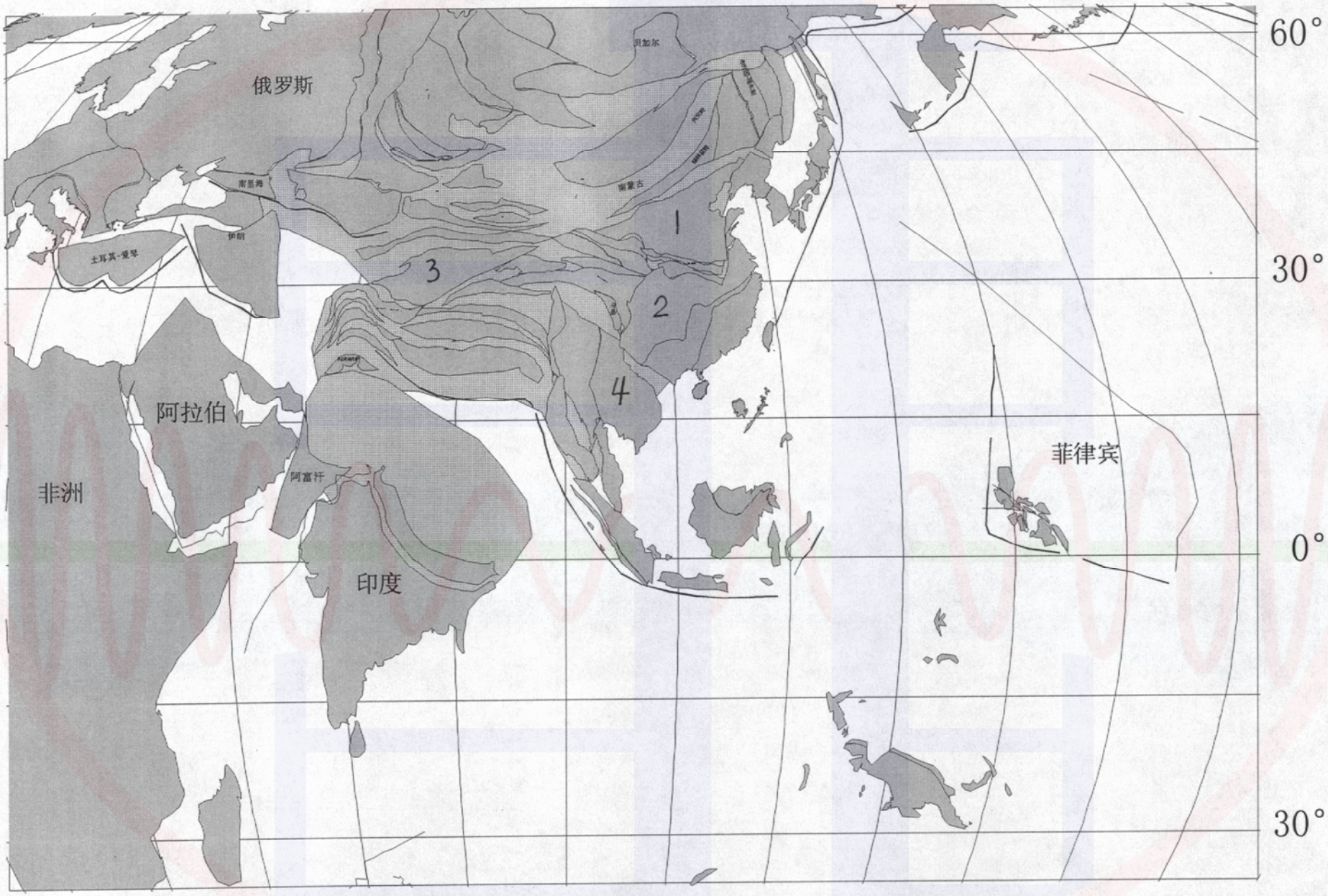
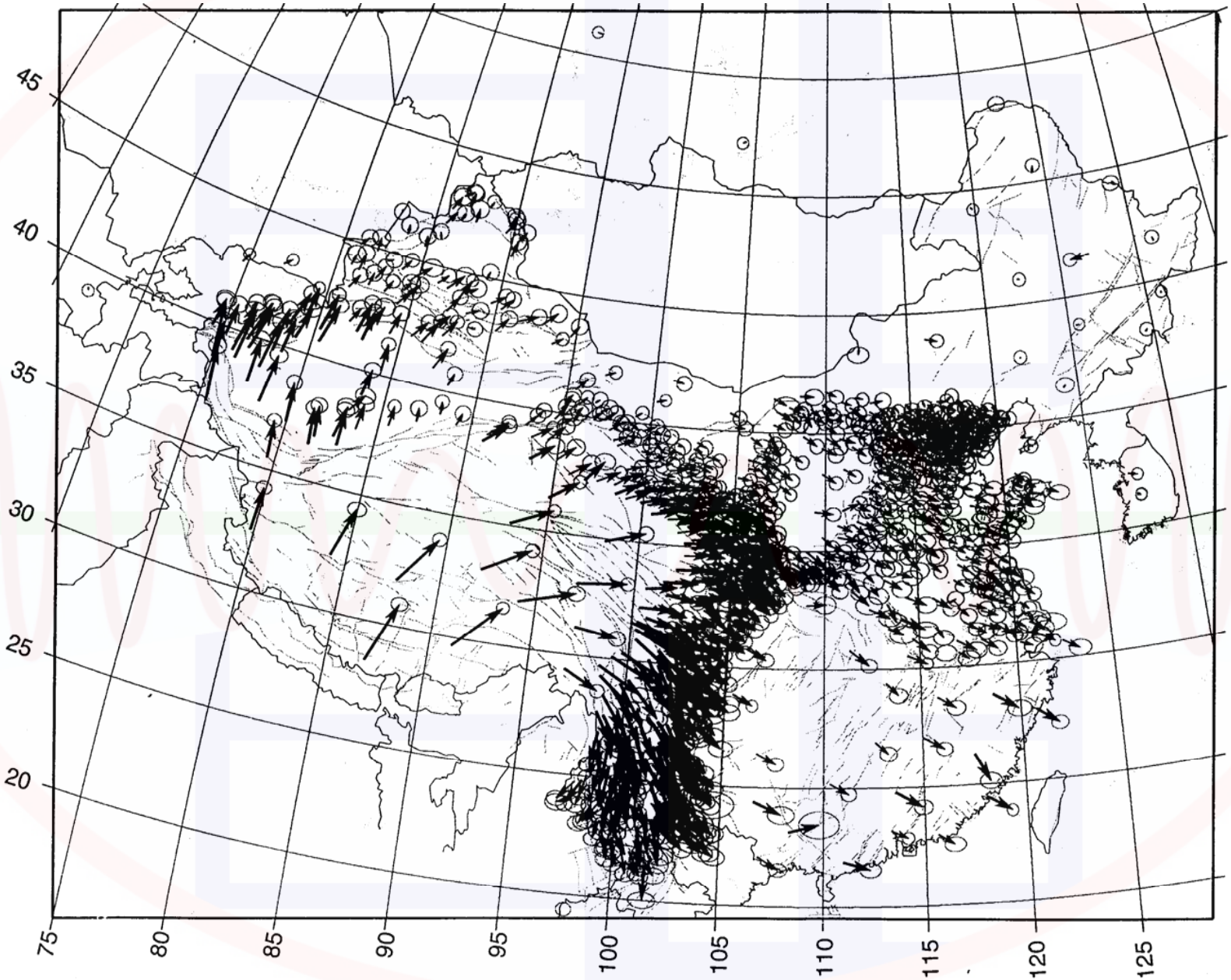
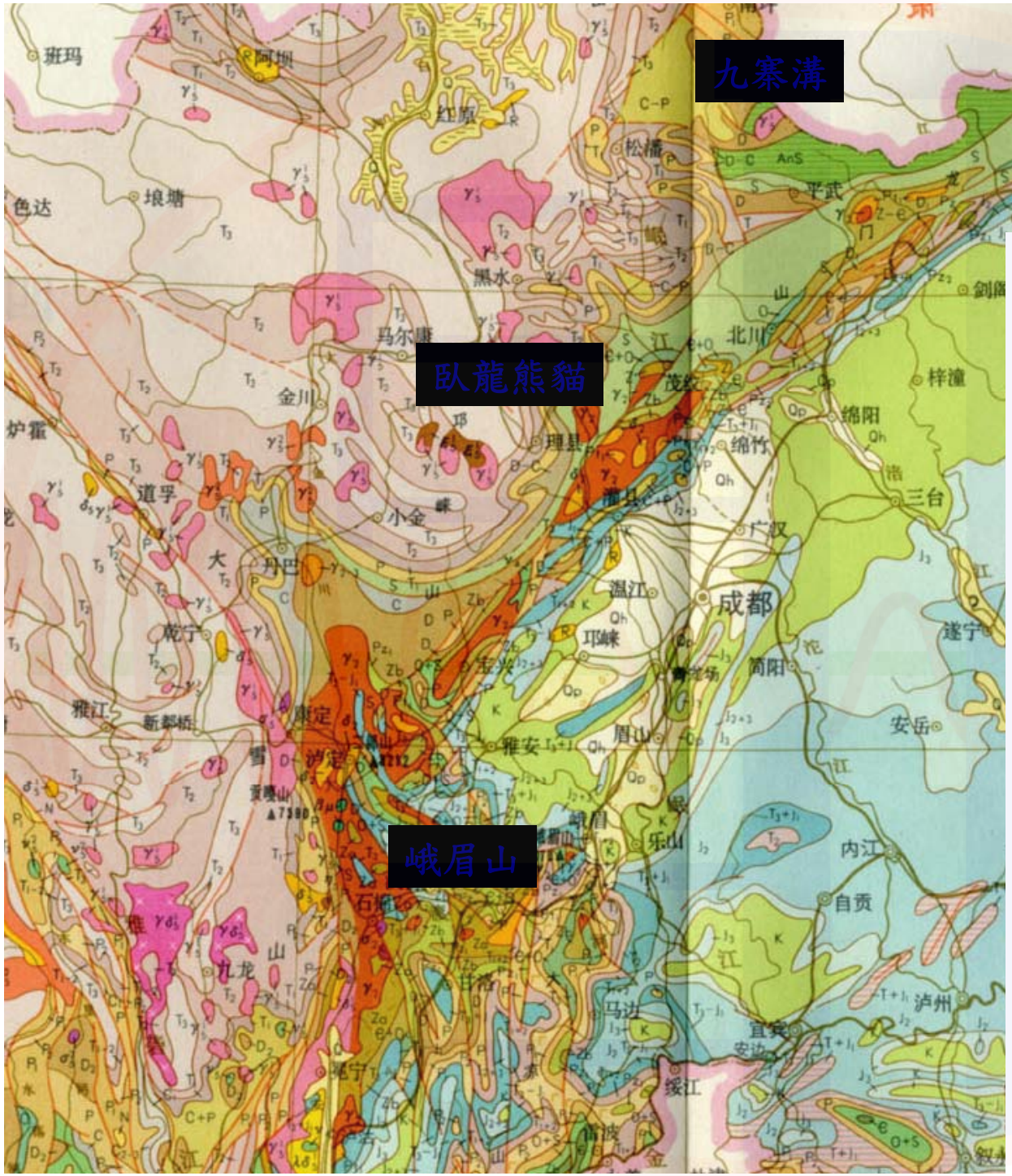
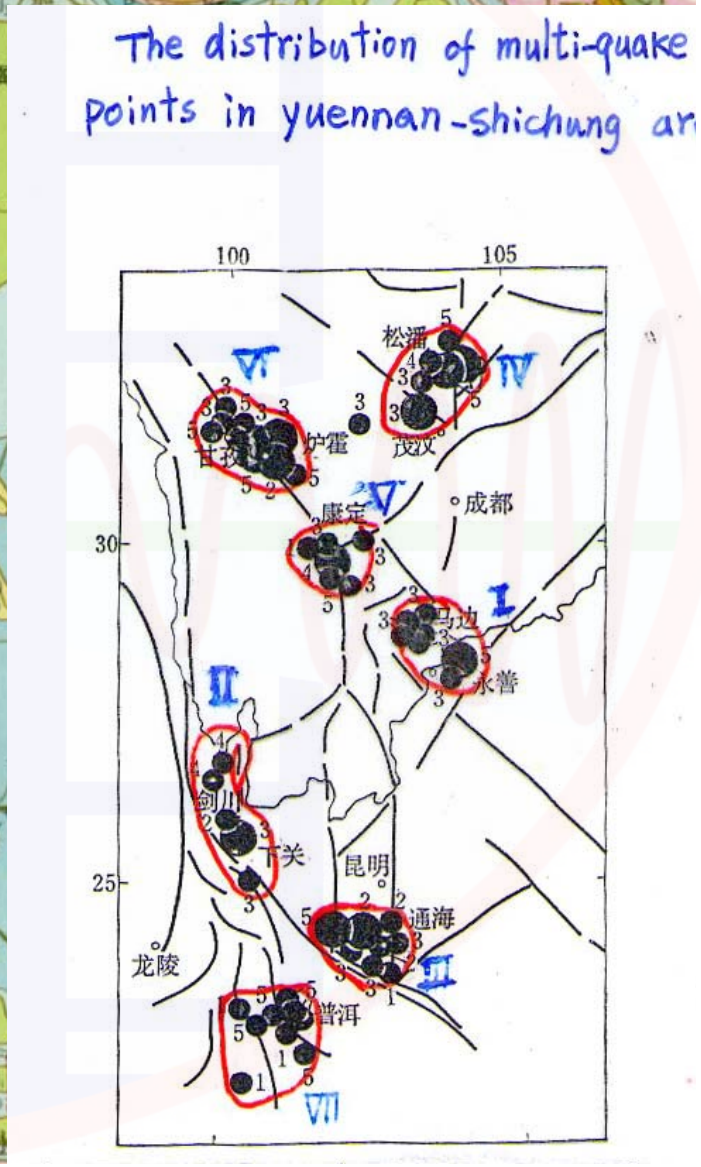


图 11、早第三纪时期（50Ma）古板块位置复原图

GPS量測板塊運動速度




九寨溝
蜀道難，難於上青天
臥龍熊貓
峨眉山
班玛
阿坝
红原
松潘
平武
汉中
西乡
石泉
宁强
色达
埂塘
黑水
马尔康
金川
理县
茂县
北川
绵阳
梓潼
三台
绵竹
广汉
成都
温江
邛崃
简阳
道孚
小金
丹巴
泸定
康定
雅安
眉山
乐山
内江
自贡
泸州
宜宾
安岳
遂宁
九龙
雅江
新都桥
炉霍
甘孜

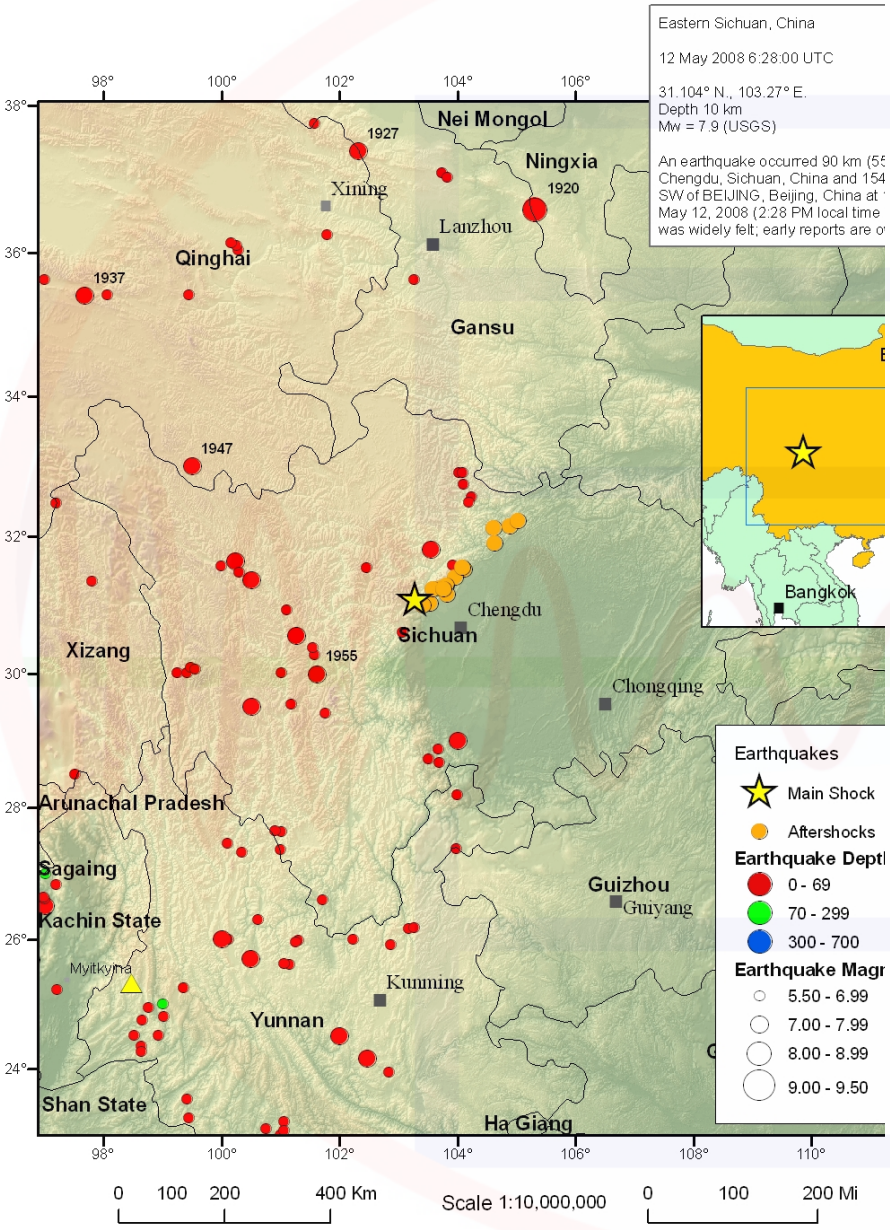

The distribution of multi-quake
points in yuennan-shichung ar
100
105
30
25
松潘
炉霍
甘孜
茂汶
康定
成都
马边
永善
剑川
下关
昆明
通海
龙陵
普洱
Ⅰ
Ⅱ
Ⅲ
Ⅳ
Ⅴ
Ⅵ
Ⅶ

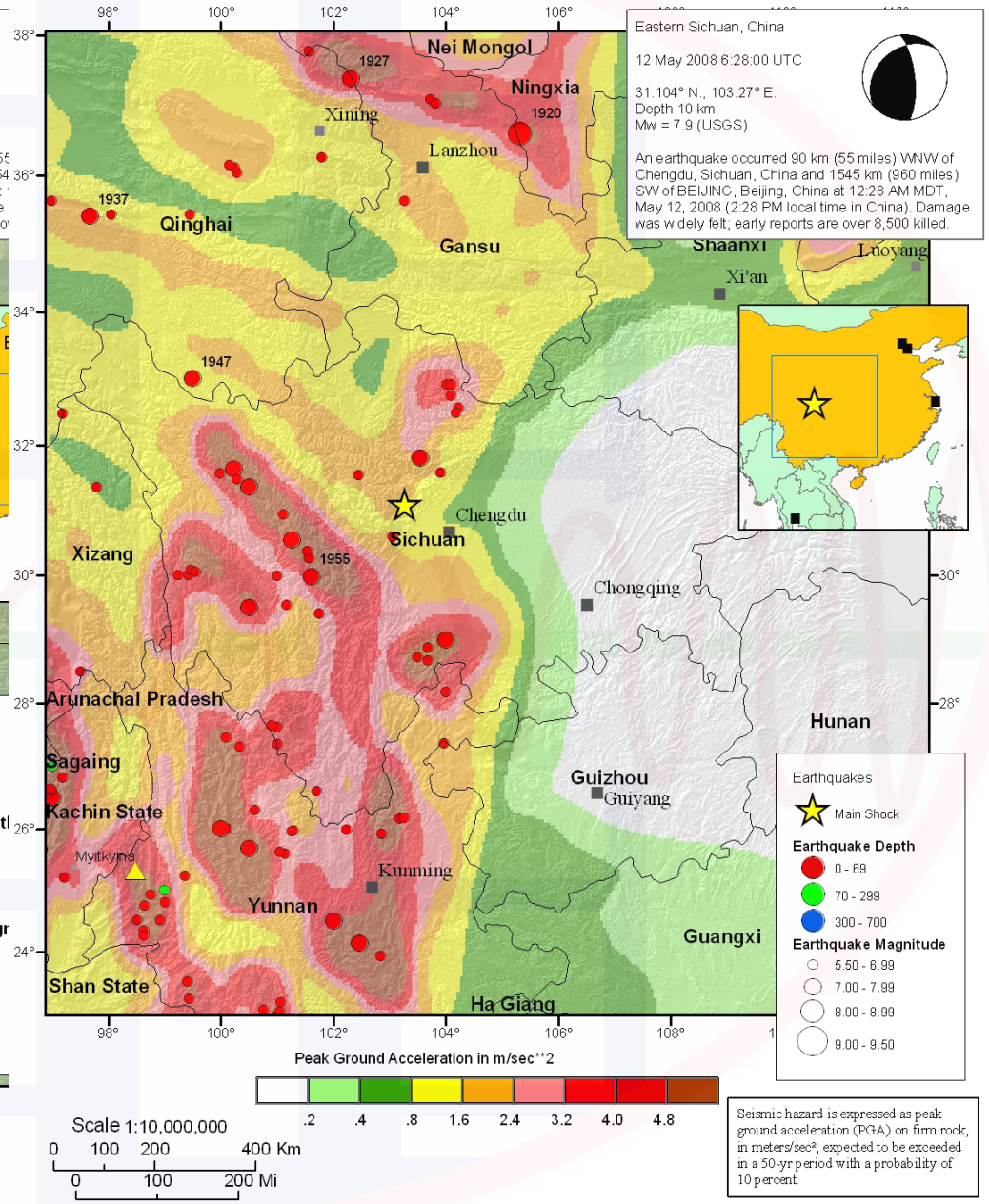
四川爐霍地震

1973年2月6日，爐霍縣雅德發生7.6級地震。地震損失嚴重，死亡2175人，受傷2756人，絕戶88戶，孤兒43人；房屋倒塌1.57萬幢，破壞2867幢，損失牲畜40427頭、糧食201萬公斤。極震區內房屋倒塌几乎百分之百。從爐霍縣的俄米到則兒位，藏房全部倒平。“笨殼房”及全木結構房屋也遭到嚴重破壞或傾斜。縣城的5600幢房屋，全倒4600幢，嚴重破壞880幢，出現裂縫90幢。川藏公路有17處遭嚴重破壞。滑坡、地裂、山石滾落普遍。地震還造成一些公路橋梁破壞和電訊線路破壞，使通訊中斷。

USGS HAZARD MAP

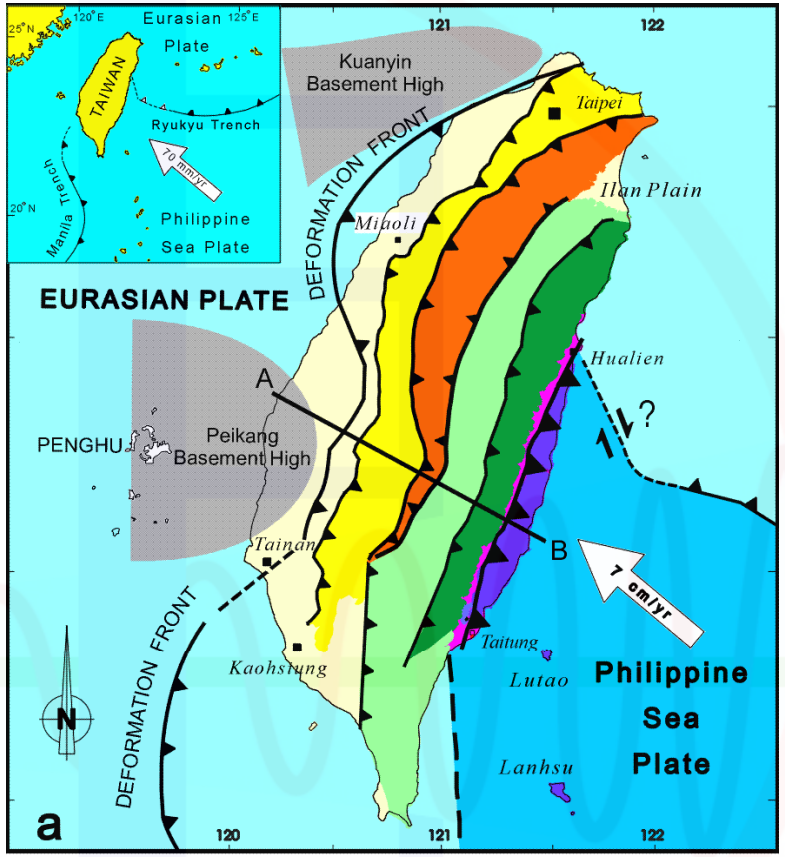
7.9 Eastern Sichuan, China, Earthquake of 12 May 2008

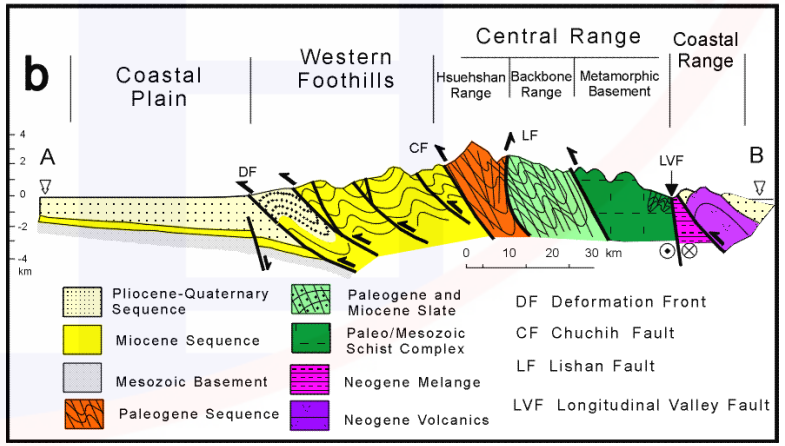


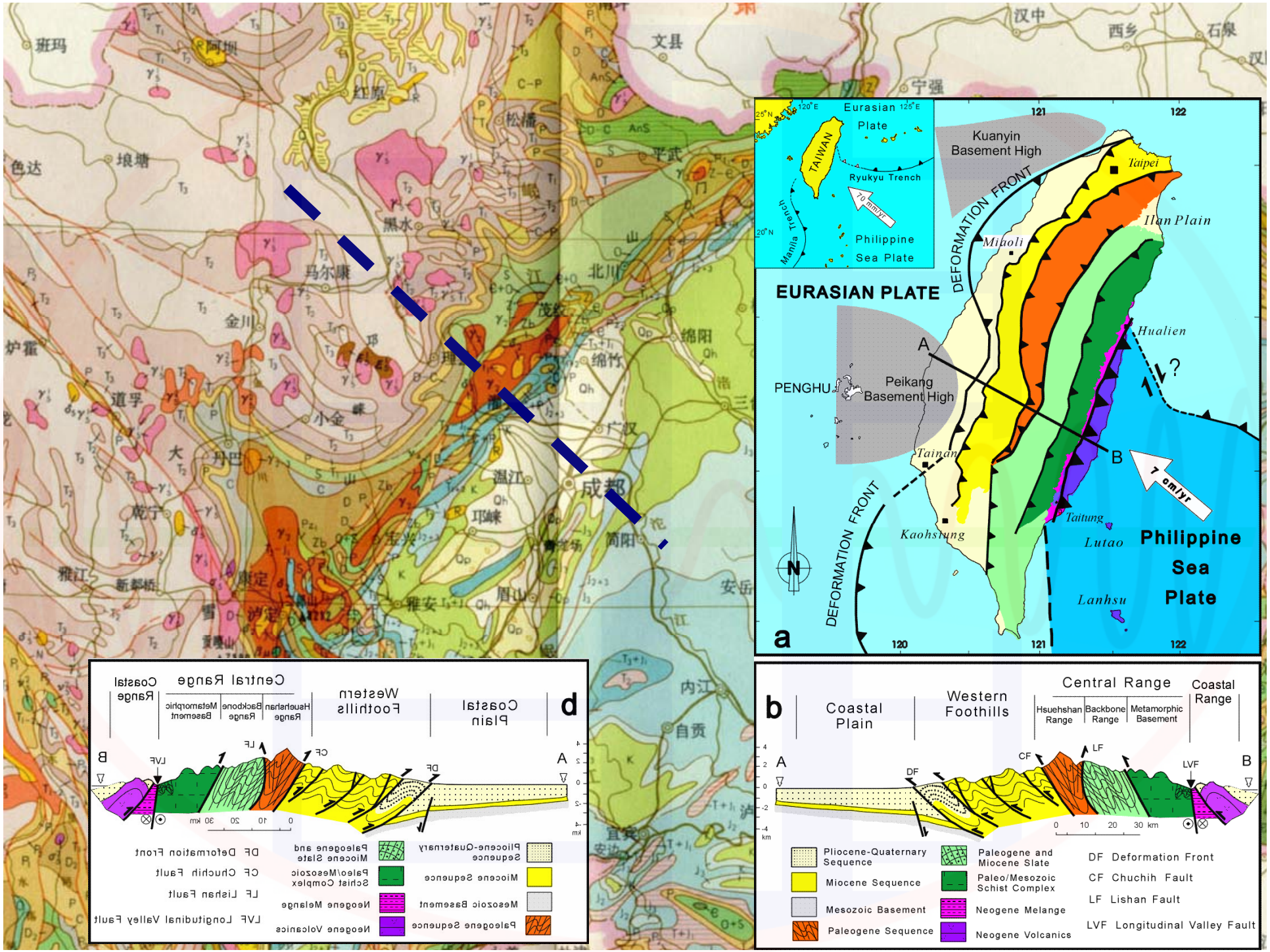


Seismic hazard is expressed as peak ground acceleration (PGA) on firm rock, in meters/sec², expected to be exceeded in a 50-yr period with a probability of 10 percent.

台灣造山帶—薄皮逆衝理論



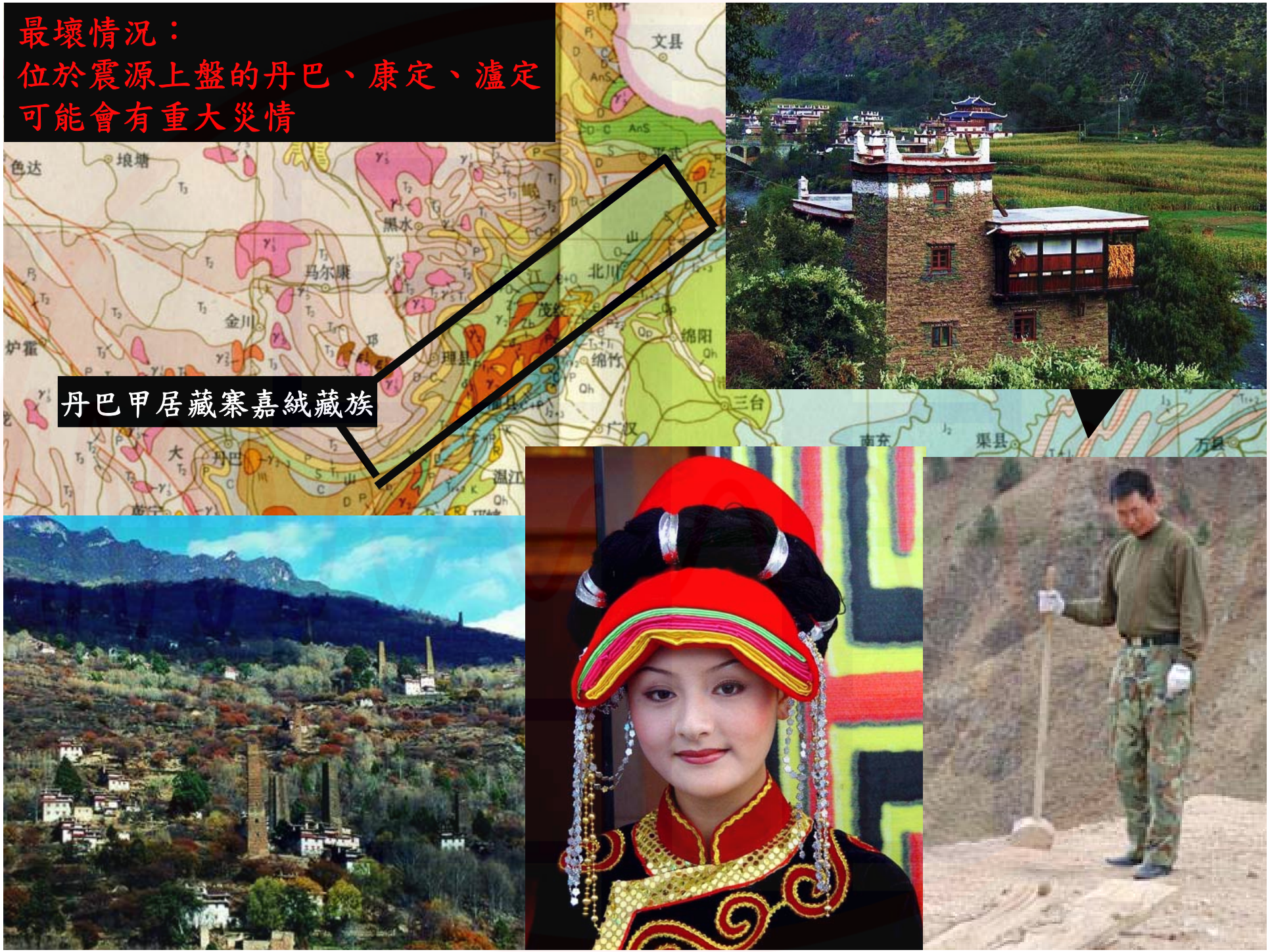


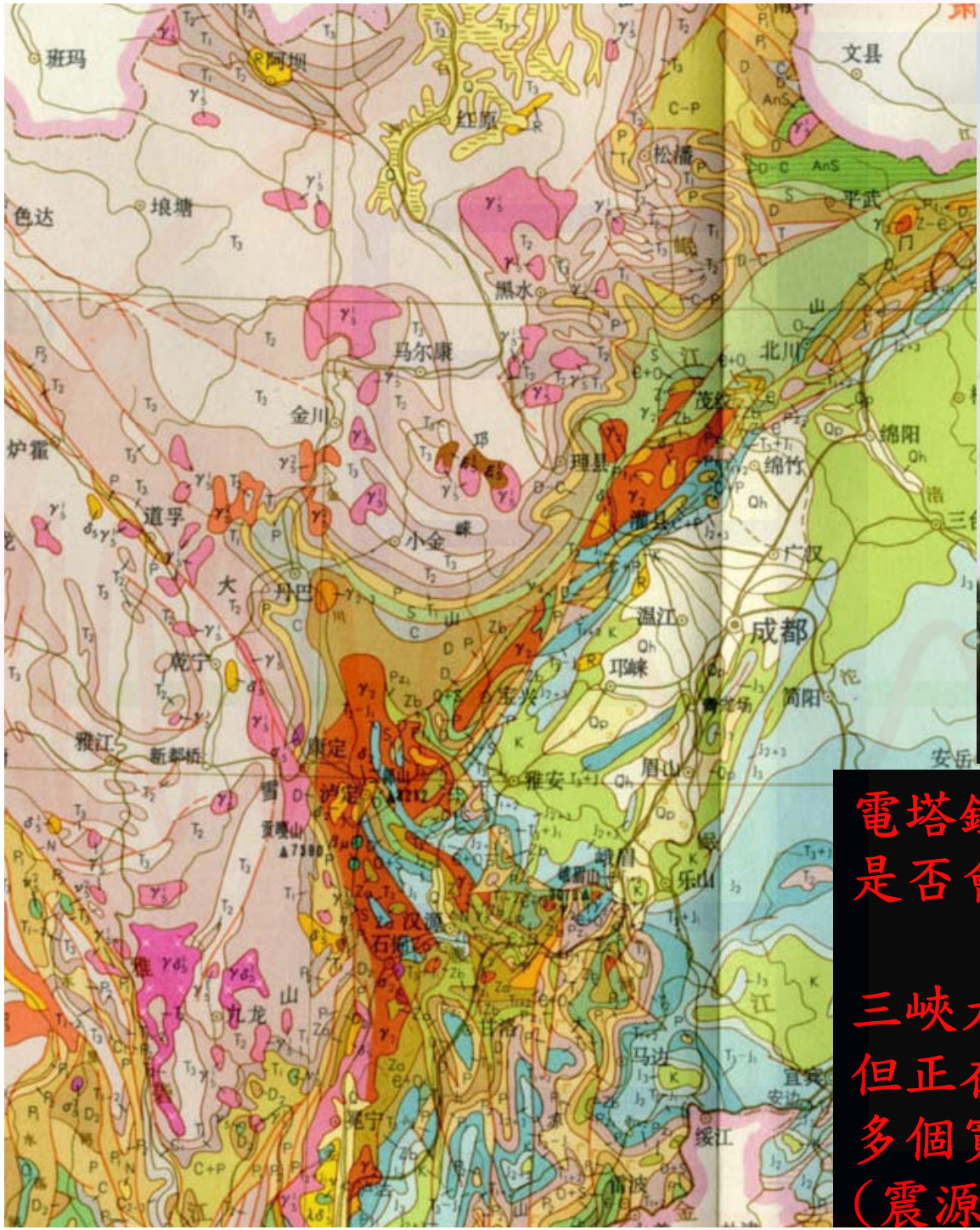

Eurasian Plate
TAIWAN
Ryukyu Trench
70 mm/yr
Philippine Sea Plate
Manila Trench
EURASIAN PLATE
Kuanyin Basement High
DEFORMATION FRONT
Taipei
Ilan Plain
Miaoli
Hualien
PENGHU
Peikang Basement High
A
B
Tainan
Kaohsiung
7 cm/yr
Taitung
Lutao
Lanhsu
Philippine Sea Plate
a
b
Coastal Plain
Western Foothills
Central Range
Coastal Range
Hsuehshan Range
Backbone Range
Metamorphic Basement
DF
CF
LF
LVF
Pliocene-Quaternary Sequence
Miocene Sequence
Mesozoic Basement
Paleogene Sequence
Paleogene and Miocene Slate
Paleo/Mesozoic Schist Complex
Neogene Melange
Neogene Volcanics
DF Deformation Front
CF Chuchih Fault
LF Lishan Fault
LVF Longitudinal Valley Fault
d

NCREE

災情 -- 最壞的消息還未出現

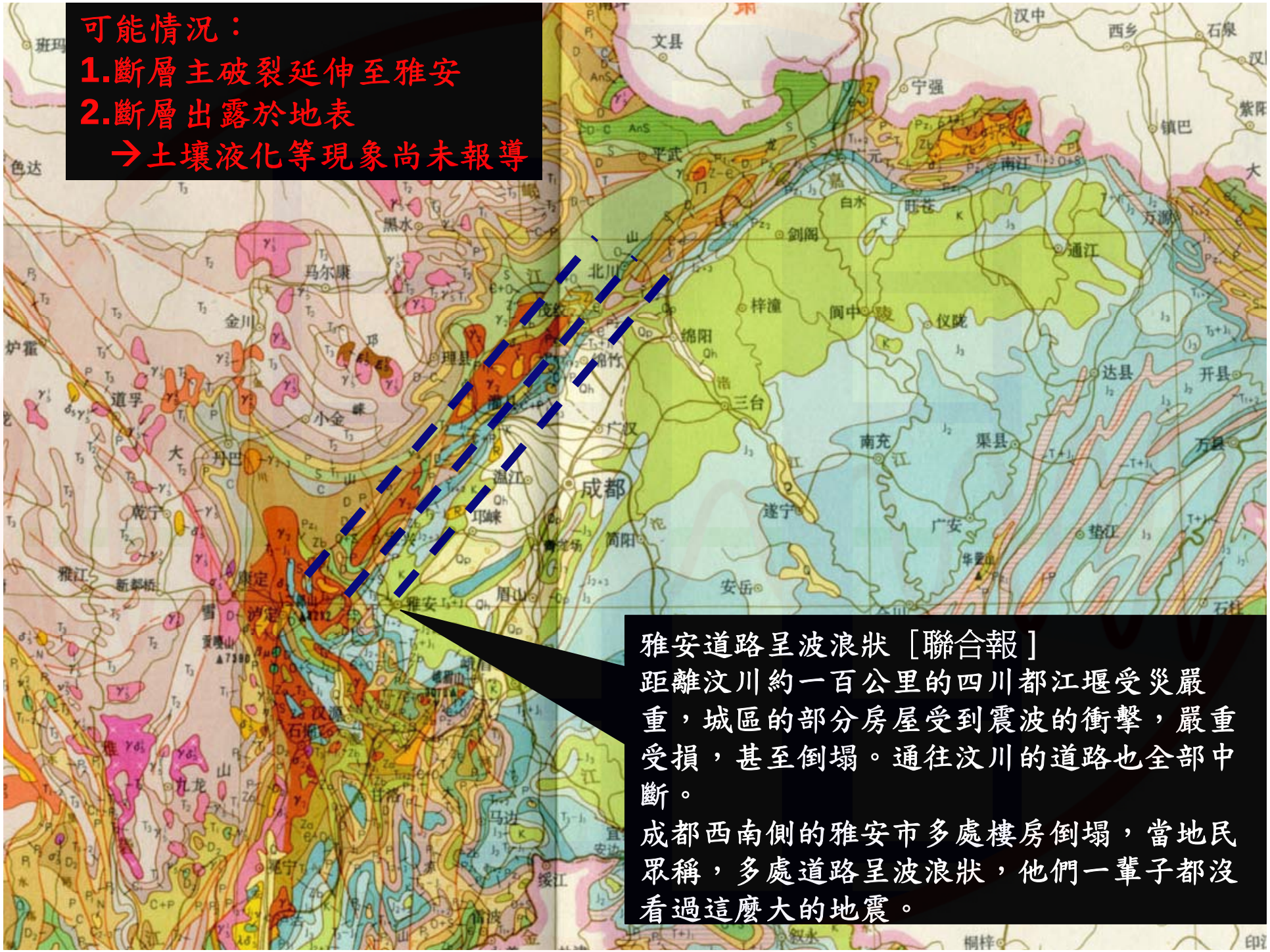
最壞情況：
位於震源上盤的丹巴、康定、瀘定
可能會有重大災情





電塔鐵柱尺寸比台灣細很多
是否會有大規模受損災情？

三峽大霸未受損
但正在大小金川施工中的水電站
多個寬約200~300公尺水壩
(震源上盤)是否會受損？


可能情況：
1.斷層主破裂延伸至雅安
2.斷層出露於地表
→土壤液化等現象尚未報導
雅安道路呈波浪狀［聯合報］
距離汶川約一百公里的四川都江堰受災嚴重，城區的部分房屋受到震波的衝擊，嚴重受損，甚至倒塌。通往汶川的道路也全部中斷。
成都西南側的雅安市多處樓房倒塌，當地民眾稱，多處道路呈波浪狀，他們一輩子都沒看過這麼大的地震。
文县
汉中
西乡
石泉
宁强
镇巴
平武
南江
白水
旺苍
剑阁
通江
梓潼
阆中
仪陇
绵阳
三台
南充
渠县
达县
开县
成都
简阳
遂宁
广安
垫江
安岳
金川
马尔康
理县
小金
丹巴
道孚
炉霍
色达
雅安
眉山
邛崃
温江
广汉
康定
泸定
石棉
汉源
九龙
冕宁
缓江
桐梓

為什麼有感範圍這麼大？

- 四川強震／搖到台灣來！**101**大樓民眾：「我要逃生嗎？」
- 地震的威力遠及北京、上海甚至泰國曼谷、越南河內和台灣都感受得到。路透報導，曼谷的高樓搖晃了約**7**分鐘之久。

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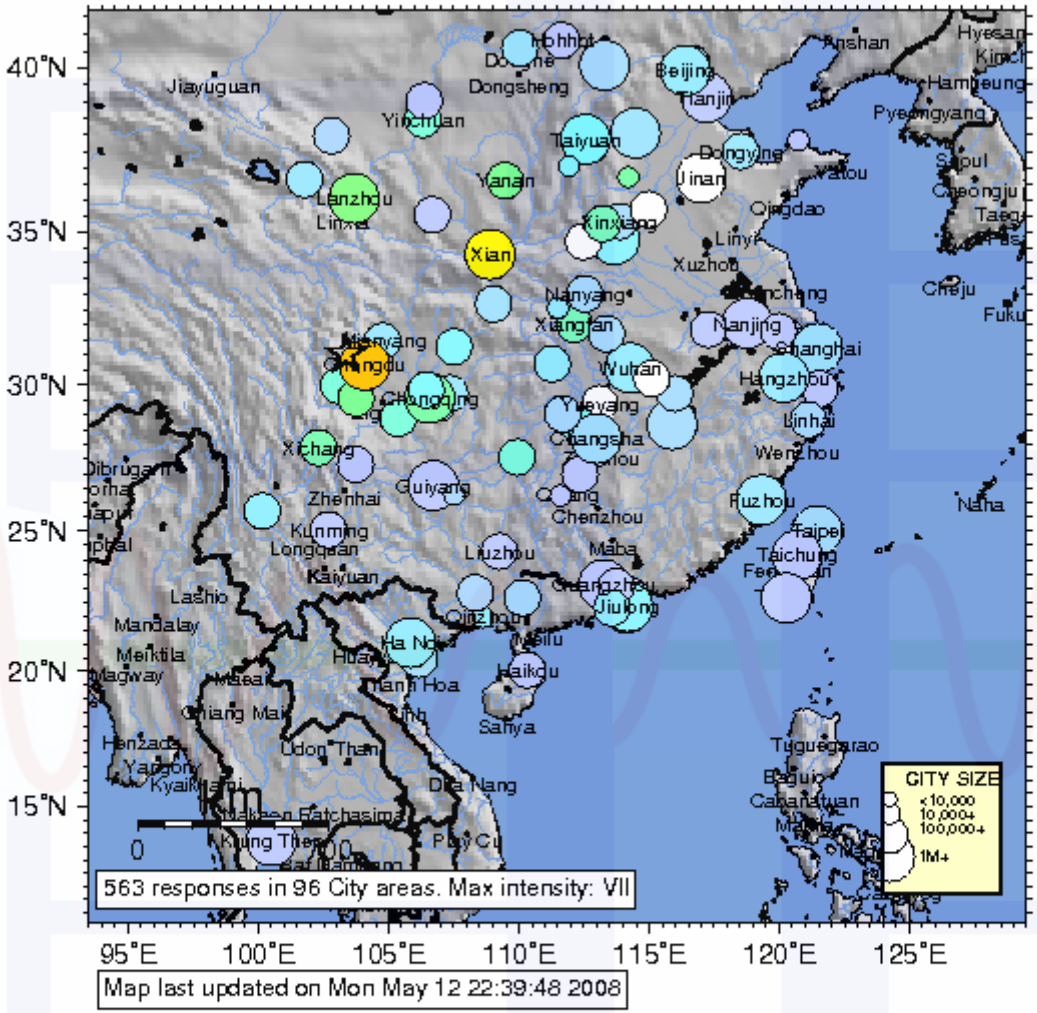
USGS Community Internet Intensity Map (52 miles WNW of Chengdu, China)

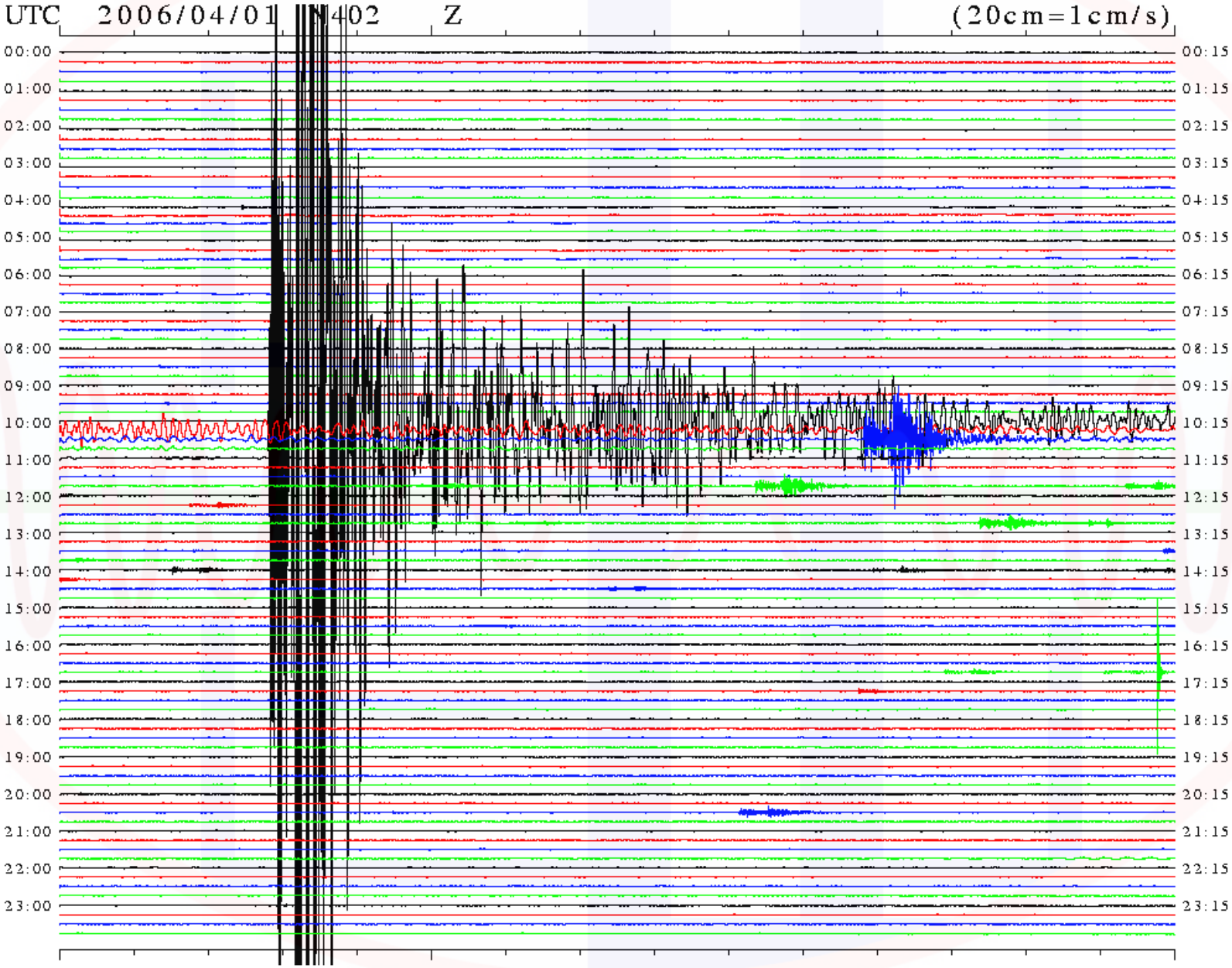
ID:2008ryan 06:28:00 GMT MAY 12 2008 Mag=7.9 Latitude=N31.02 Longitude=E103.37



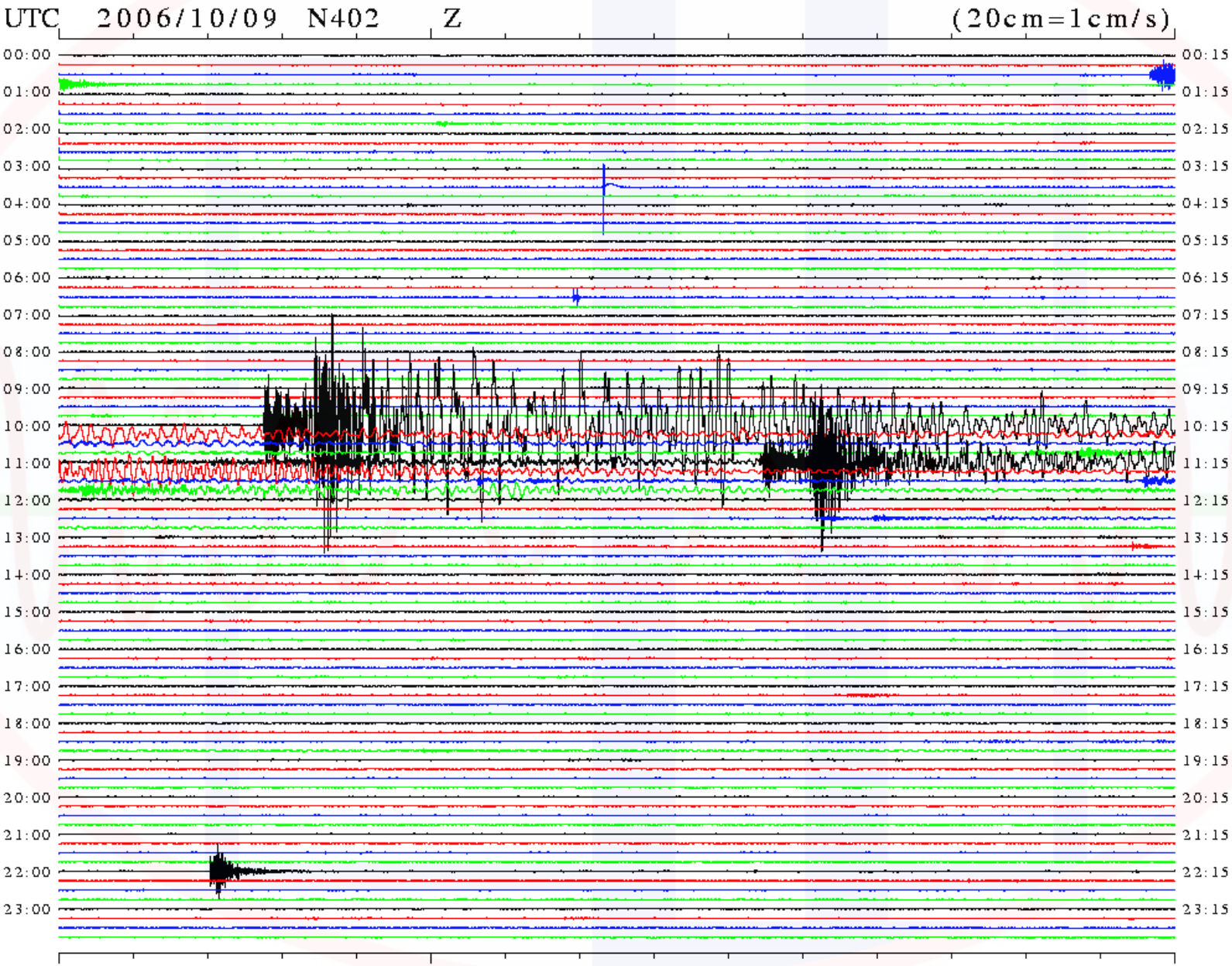
Map last updated on Mon May 12 22:39:48 2008

INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy

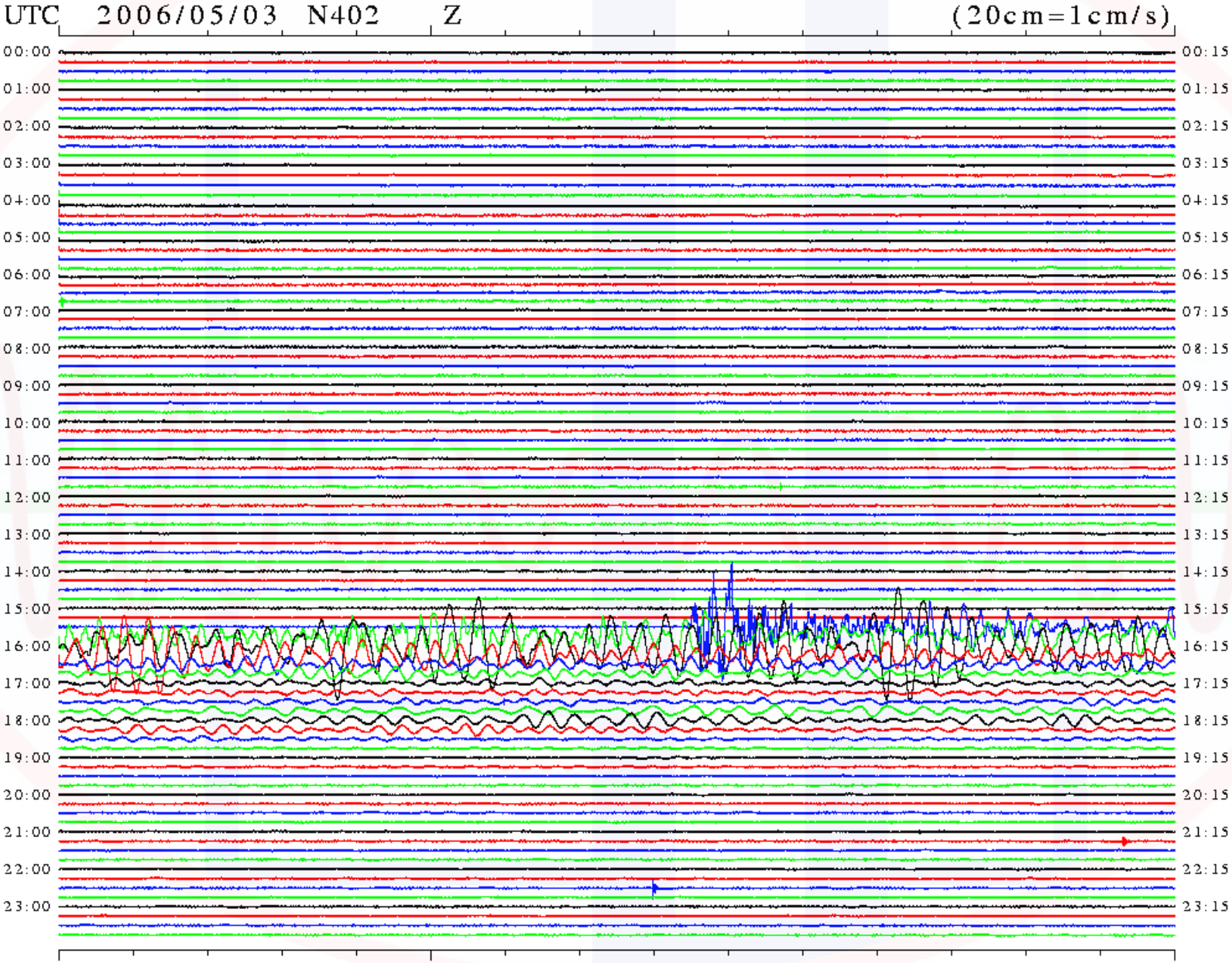
台東卑南　ML6.2　DIST~160km



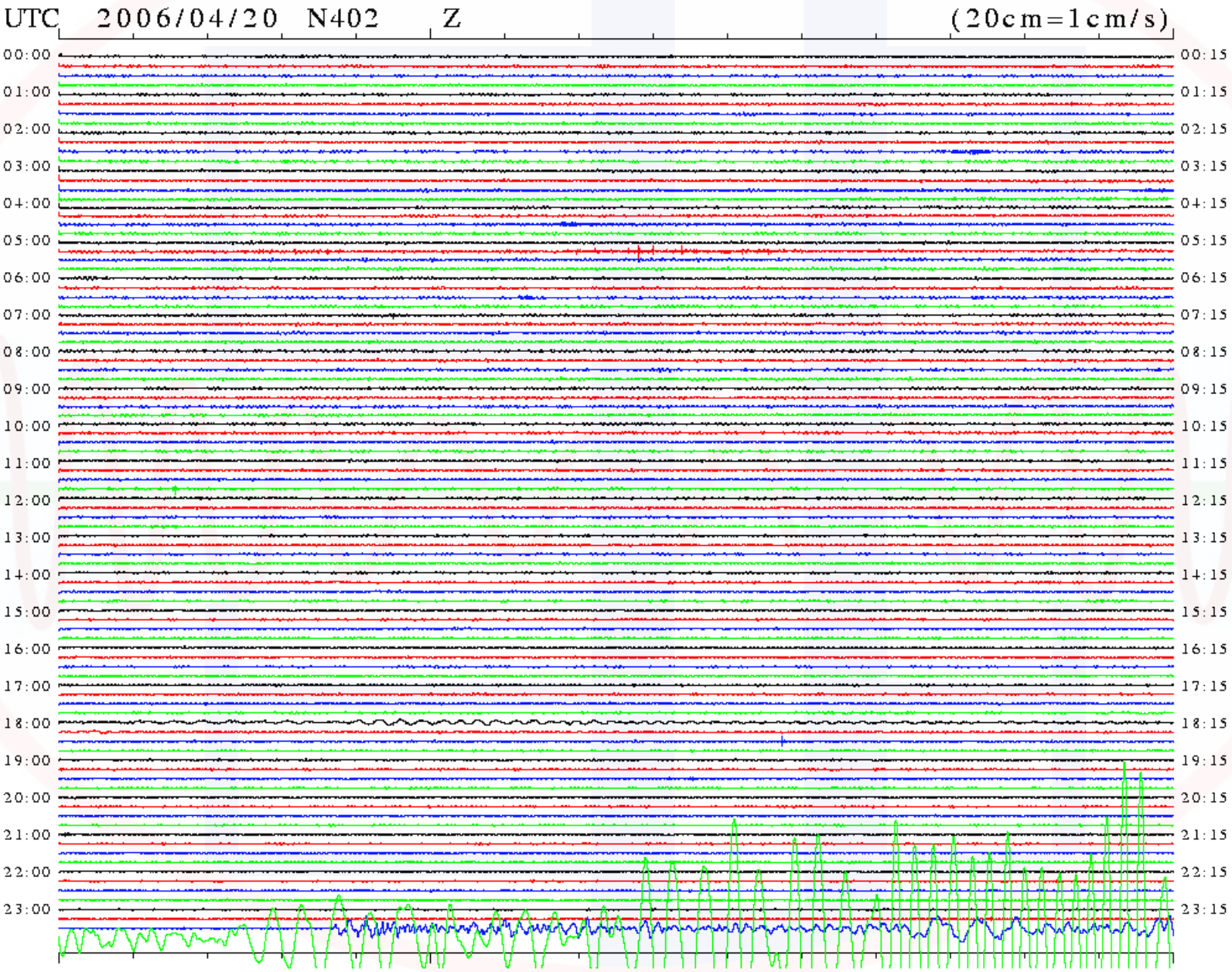
菲律賓　Mw6.3 DIST~400km



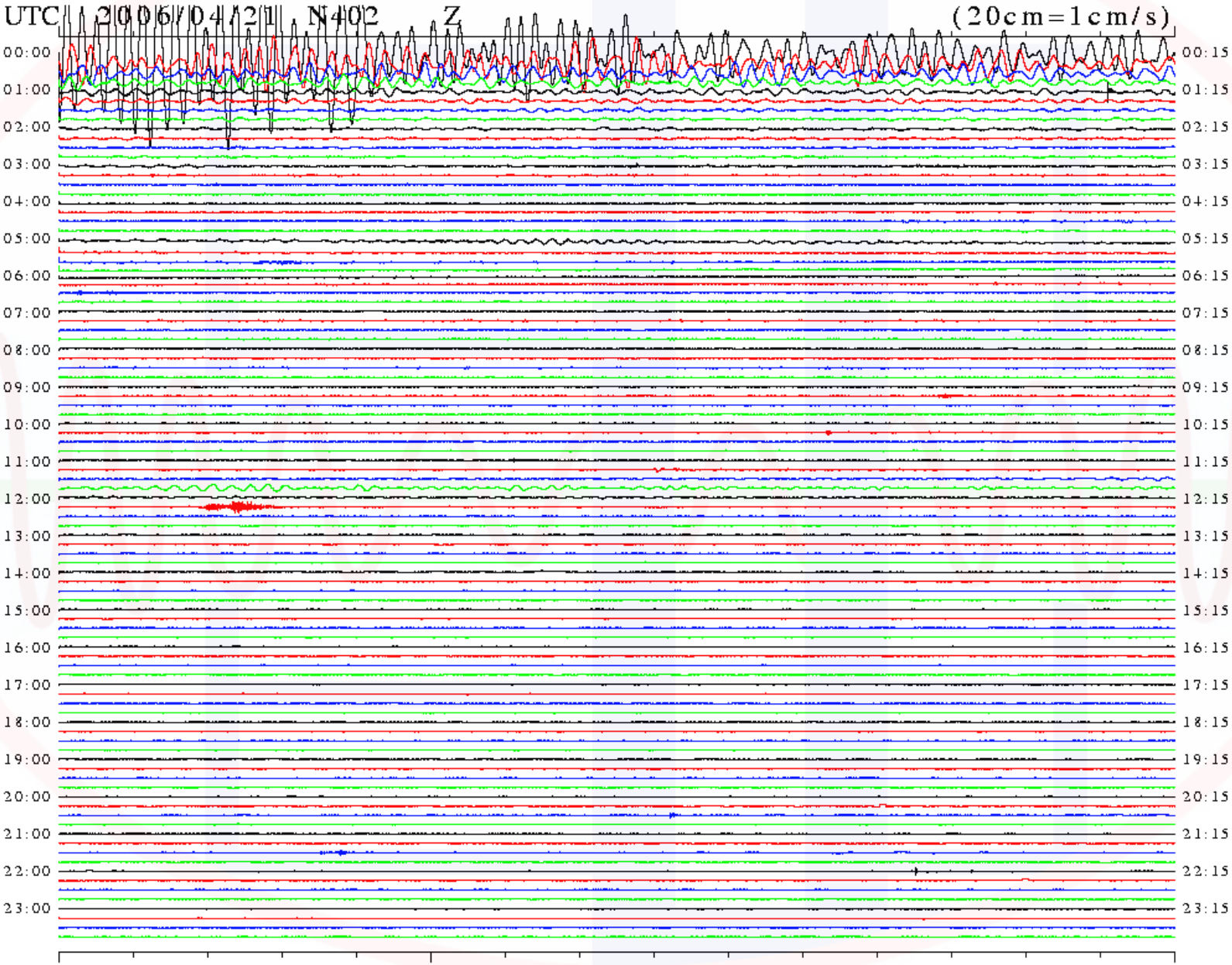
TONGA　Mw8.0　DIST~7660km 經太平洋、菲律賓海傳至台灣

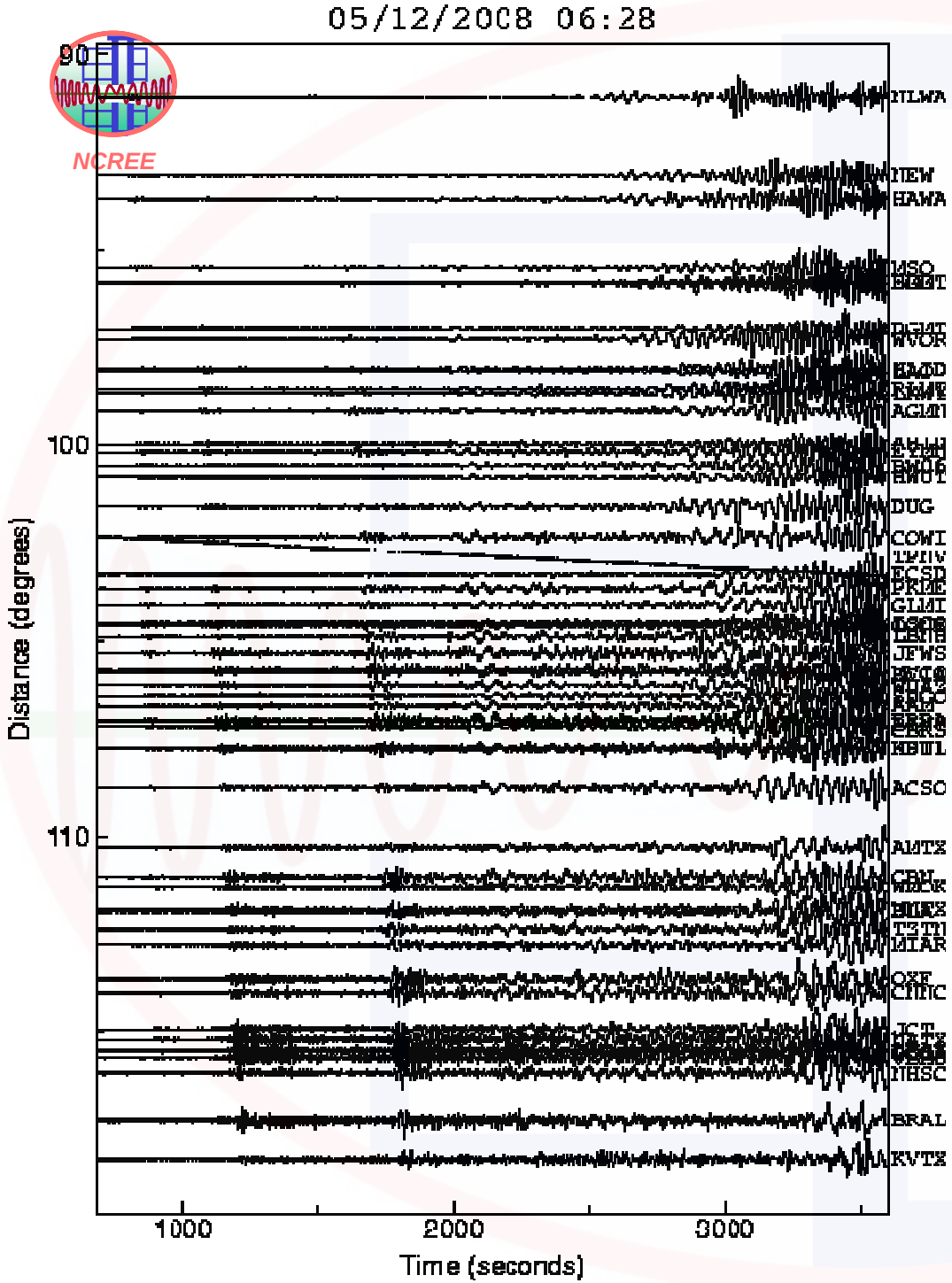


俄羅斯　堪察加半島北方　Mw7.7 DIST~6000km　沿大陸棚傳至台灣



俄羅斯　堪察加半島北方　Mw7.7　DIST~6000km　沿大陸棚傳至台灣



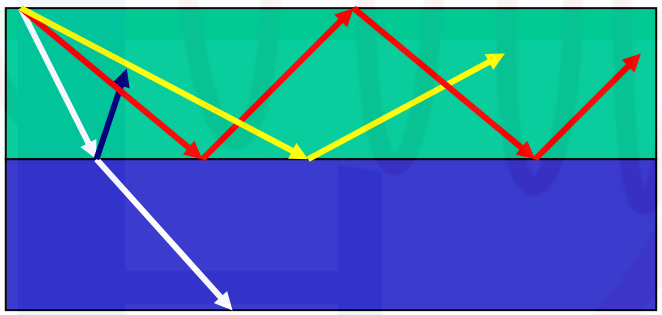


當地震波傳播到500km之外表面波就發育完成，慢慢變成整個波列中振幅最大的波相，周期約5~20秒。

因此在台北、上海、曼谷等坐落在厚土層上的超高建築就會搖晃比較劇烈。

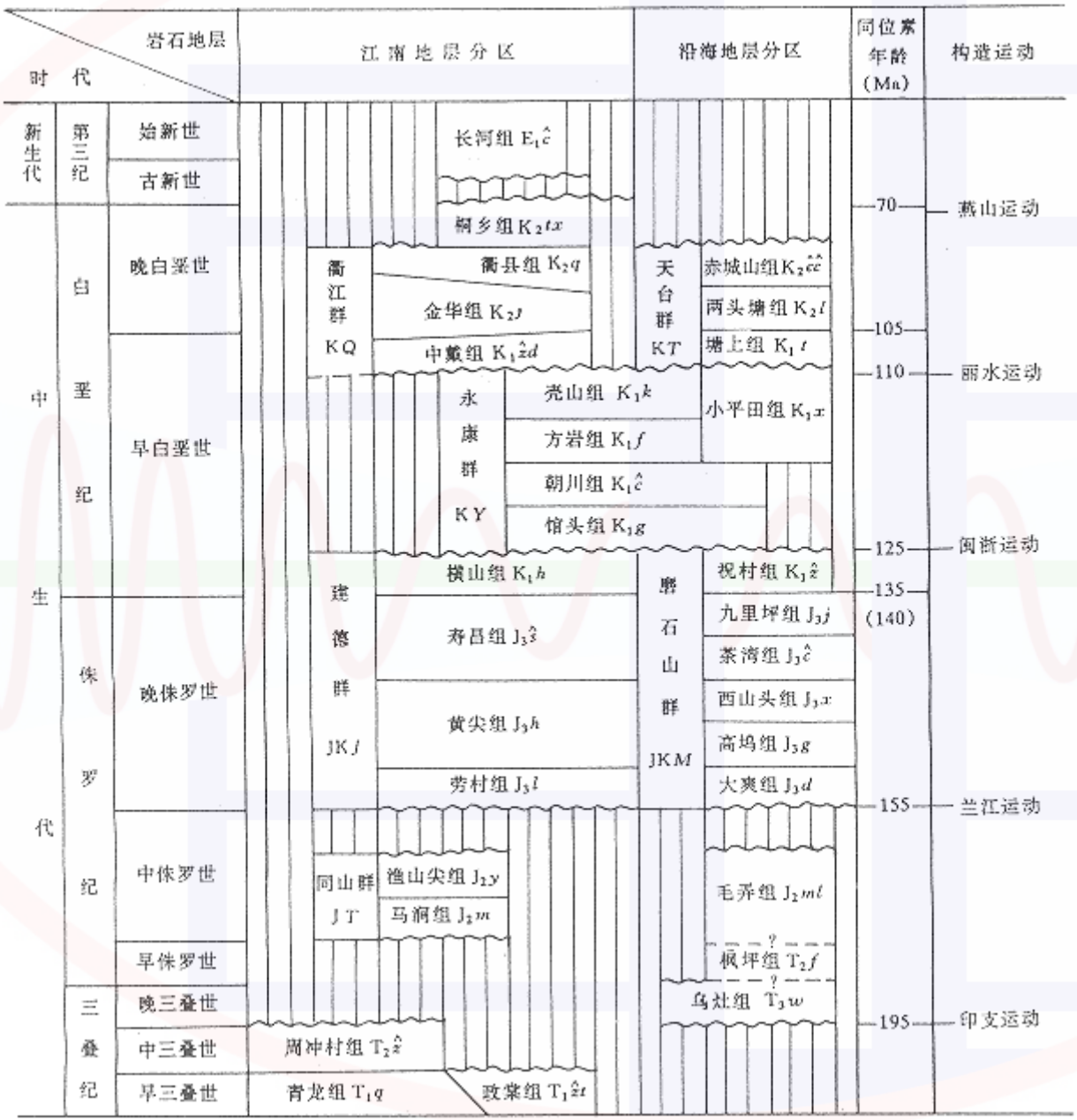
SNELL's LAW

SURFACE WAVE
振幅隨 r^{-1}衰減



BODY WAVE
振幅隨 r^{-2}衰減

破壞條件：
地殼厚度突然變化：陸海交界
經過高衰減年輕地殼



大陸地體構造運動
大致在70百萬年前
完成

-> 大陸地殼非常老

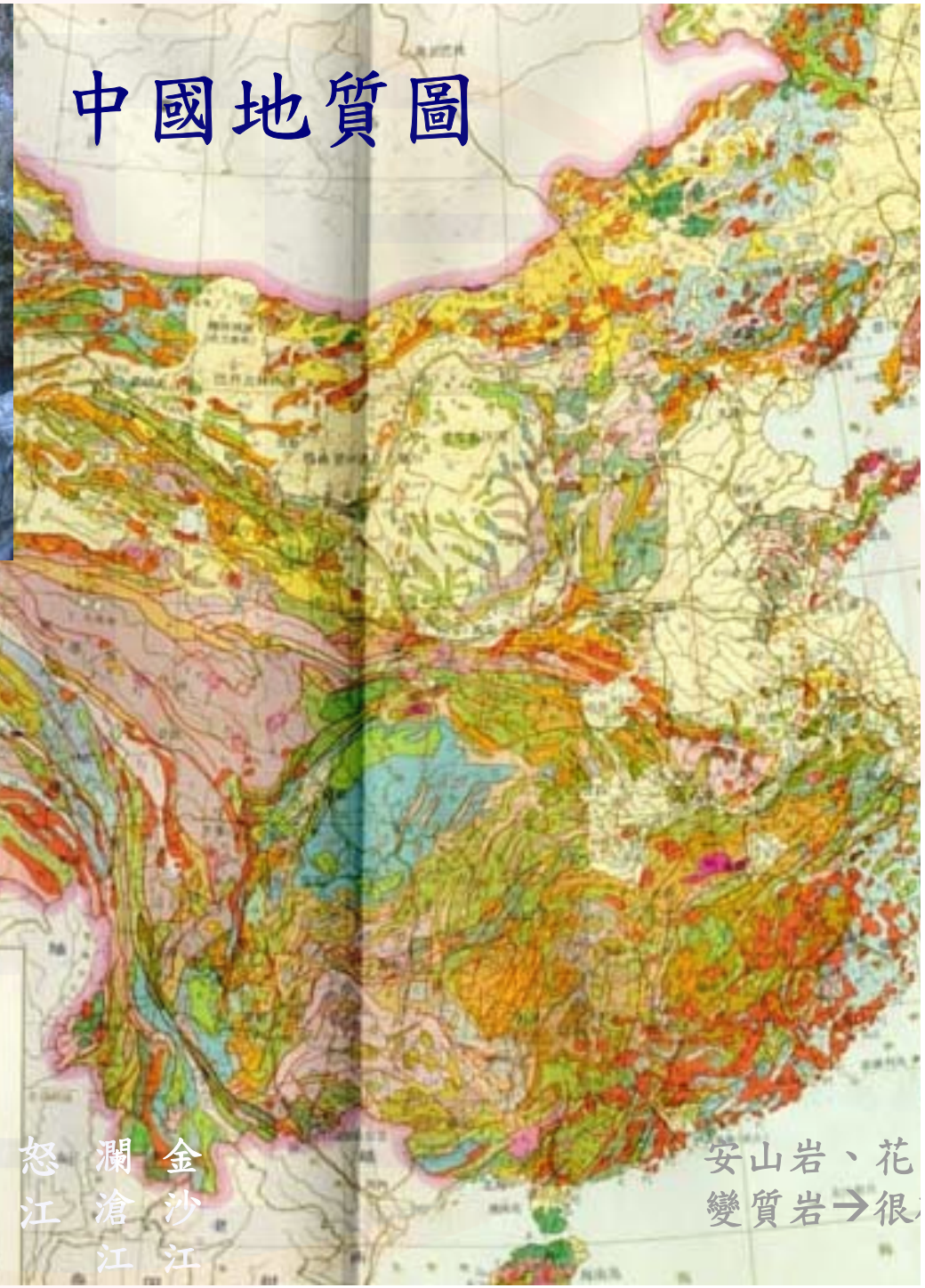
台灣蓬萊造山運動
自10百萬年前開始
在2~4My達顛峰
大屯火山
基隆火山

埔里運動　24My

太平運動　65My

太魯閣九曲洞

中國地質圖



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簡報完畢