Refining fault zone mapping approaches and examples – 20220322 additions

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Heuristics by demonstration: examples of fault maps
Let’s see how other groups have solved these problems
This is not exhaustive

Let’s look for

- Morphologic features
- GIR
- Surficial Geologic mapping
- Primary vs. secondary
- How well are the mapped features supported by the data?

Heuristics by demonstration: examples of fault maps: Geological Survey of Japan

中央構造線活断層系(四国地域)ストリップマップ

STRIP MAP OF THE MEDIAN TECTONIC LINE ACTIVE FAULT SYSTEM IN SHIKOKU

1:25,000

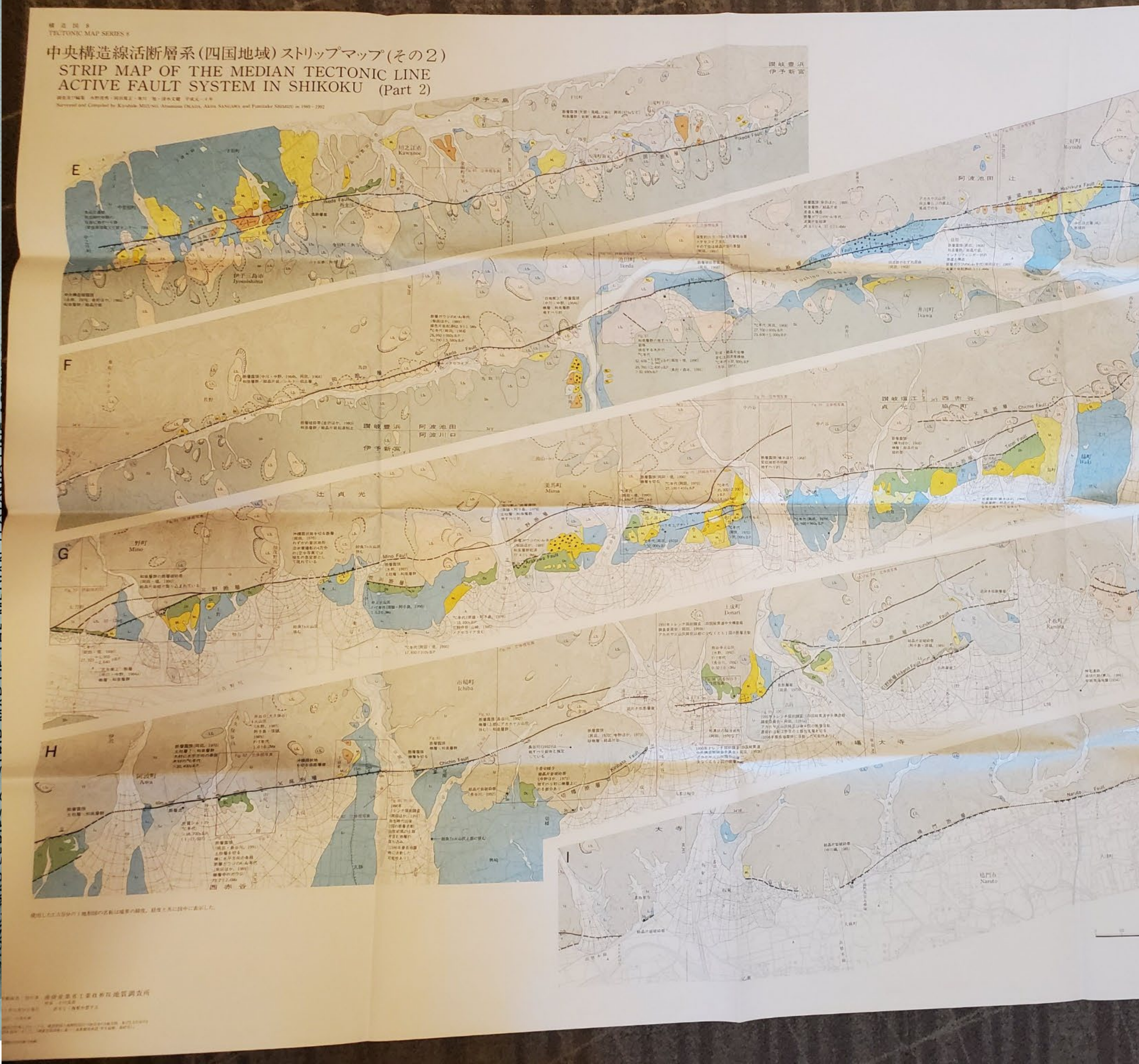
地 質 図	2
凡　　例	1
説 明 書	1

地　質　調　査　所

GEOLOGICAL SURVEY OF JAPAN

1-3, Higashi 1-chōme, Tsukuba-shi, Ibaraki-ken, 305 Japan

1993



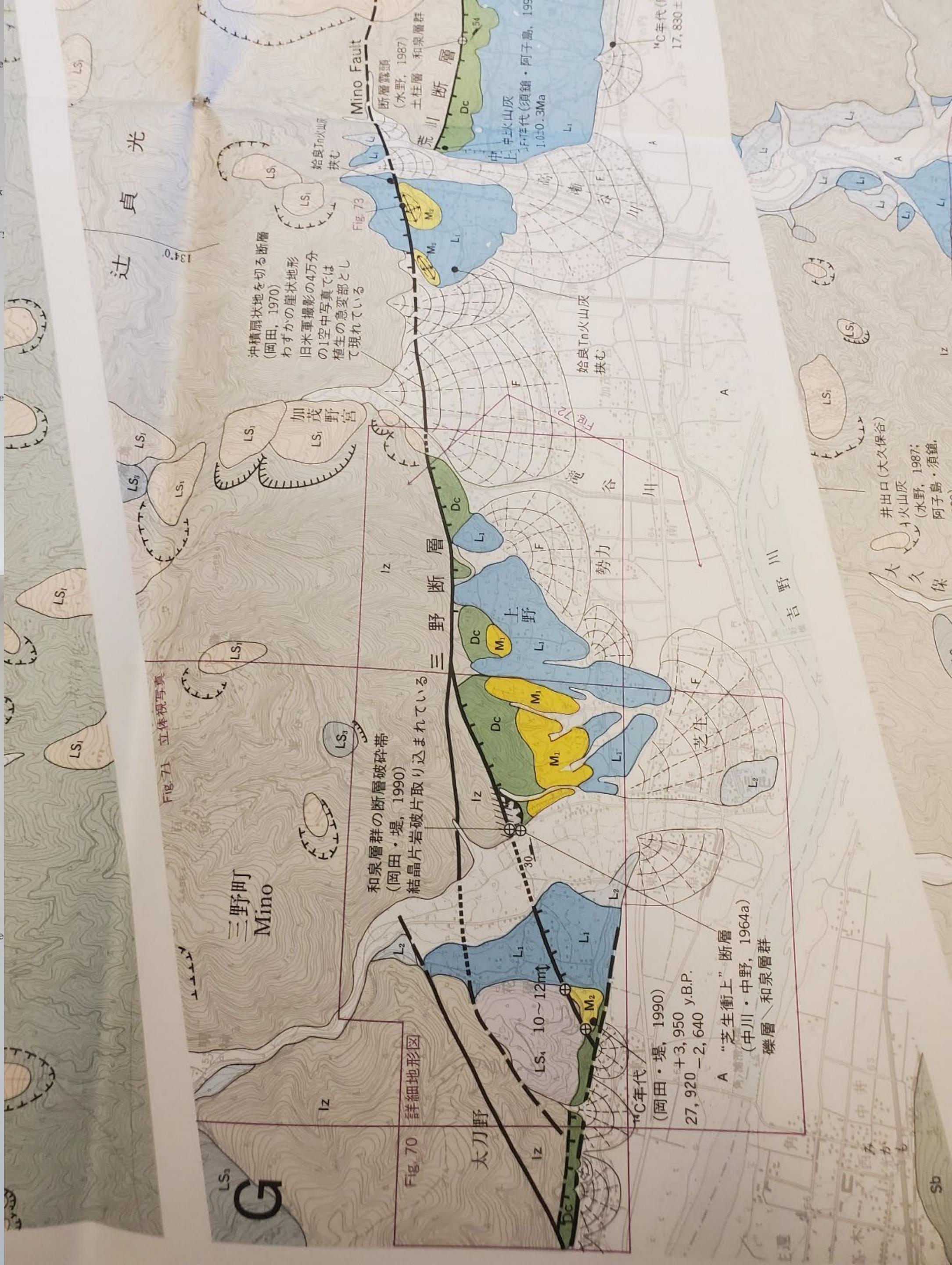
完新世 Holocene

完新世 Holocene	埋立地 Reclaimed land	R	
	沖積層 Alluvium	A	礫，砂及びシルト Gravel, sand and silt
	沖積扇状地堆積物 Alluvial fan deposits	F	礫及び砂 Gravel and sand
後期更新世 Late Pleistocene	低位段丘 2 堆積物 Lower terrace 2 deposits	L_2	礫及び砂 Gravel and sand
	低位段丘 1 堆積物 Lower terrace 1 deposits	L_1	礫及び砂，部分的にシルト，姶良Tn火山灰(21,000-25,000y.B.P.)を挟む Gravel and sand, partly silt, intercalated with Aira-Tn ash (21,000-25,000y.B.P.)
	中位段丘 2 堆積物 Middle terrace 2 deposits	M_2	礫及び砂，部分的にシルト Gravel and sand, partly silt
	中位段丘 1 堆積物 Middle terrace 1 deposits	M_1	礫，砂及びシルト Gravel, sand and silt
中期更新世後期 Late Middle Pleistocene	高位段丘堆積物 Higher terrace deposits	H	礫及び砂，部分的にシルト Gravel and sand, partly silt
鮮新世－中期更新世前期 Pliocene to Early Middle Pleistocene	郡中層 Gunchu Formation	Gu	礫，砂及びシルト，火山灰，亜炭層を挟む Gravel, sand and silt, intercalated with volcanic ash and peat
	八倉層 Yakura Formation	Yk	礫及び砂，部分的にシルト Gravel and sand, partly silt
	鳥ノ子層 Torinoko Formation	Tr	礫及び砂，部分的にシルト Gravel and sand, partly silt
	岡村層及びその相当層 Okamura Formation and its equivalents	Ok	礫，砂及びシルト，火山灰を挟む Gravel, sand and silt, intercalated with volcanic ash
	土柱層及びその相当層 Dochu Formation and its equivalents	Dc	礫，砂及びシルト，火山灰を挟む Gravel, sand and silt, intercalated with volcanic ash
	岩屑流堆積物 Debris flow deposits		岩塊及び礫 Rock block and gravel
中期中新世 Middle Miocene	石鎚層群及び貫入岩類 Ishizuchi Group and Intrusive rocks	An	安山岩類 Andesites
始新世 Eocene	久万層群 Kuma Group	Ku	角礫岩 Breccia
後期白亜紀 Late Cretaceous	和泉層群 Izumi Group	Iz	礫岩，砂岩及び泥岩 Conglomerate, sandstone and mudstone
前期－後期白亜紀 Early to Late Cretaceous	三波川変成岩類 Sambagawa metamorphic rocks	Sb	結晶片岩類 Crystalline schists

地すべり地形 Landslide configuration

- 開析されていない，あるいはほとんど開析されていない滑落崖 Main or lateral scarp of which crown is fresh or not dissected
- やや開析された滑落崖 Main or lateral scarp of which crown is partially dissected
- LS_1 滑落崖を伴い，輪郭が明瞭な移動体 Landslide mass with definite margins and main scarp
- LS_2 移動体が残っていない可能性のある地すべり地形 Landform morphology suggestive of a highly eroded landslide
- LS_3 緩慢な滑りあるいはクリープが最近生じた斜面 Unstable slope or incipient landslide mass
- LS_4 滑落崖が不明な移動体または断層運動に伴って分離した岩体 Landslide mass of which main scarp can not be identified or dislodged fault block
- 破線は境界の不明瞭な部分 Broken line shows questionable part of margin

- 活断層（後期更新世－完新世に活動的） Active fault (active during Late Pleistocene to Holocene)
- 推定活断層 Inferred active fault
- 伏在活断層 Concealed active fault
- 古期第四系を変位させるが変位地形の不明瞭な断層 Fault which cut older Quaternary deposits but has weak
- 狭義の中央構造線（和泉層群と三波川帯の境界） Median Tectonic Line in a narrow sense as the boundary
- 断層の落下側 Downthrown side of fault
- 断層の横ずれセンス（右ずれ） Strike-slip sense of fault (right-lateral)
- 強い断層破砕帯 Fault fracture zone
- 押しかぶせ断層または断層活動に関連した地すべりの面 Plane of overthrust or landslide related to fault moveme
- 撓曲崖 Flexure scarp
- 10m 低断層崖の比高 Relative height of fault scarplet
- 50m 河川の屈曲とその変位量 Offset stream and its amount
- 段丘面の傾動 Direction of tilted terrace surface
- 背斜軸 Anticlinal axis
- 向斜軸 Synclinal axis
- 膨らみまたは圧縮尾根 Mound or pressure ridge
- 断層鞍部 Fault saddle
- 風隙 Wind gap
- トレンチ掘削地点 Location of trench excavation survey
- 断層露頭 Fault exposure
- その他の露頭及び試料採取地点 Other exposure or sampling location
- Fig. 5 Fig. 18 説明書に説明されている露頭，地域の範囲と図の番号 Extent and figure number of outcrop and area describe
- 崖地形（同一区分の段丘面間にみられる段丘崖） Scarplet (terrace scarp)
- ボーリング地点 Boring site
- 60 断層面の走向及び傾斜 Strike and dip of fault plane
- 20 地層の走向及び傾斜 Strike and dip of strata
- 80 逆転層の走向及び傾斜 Strike and dip of overturned strata
- 植物化石の産出 Occurrence of plant fossil



Japanese active fault map (from Okada and Ooi field trip guide, 2006)

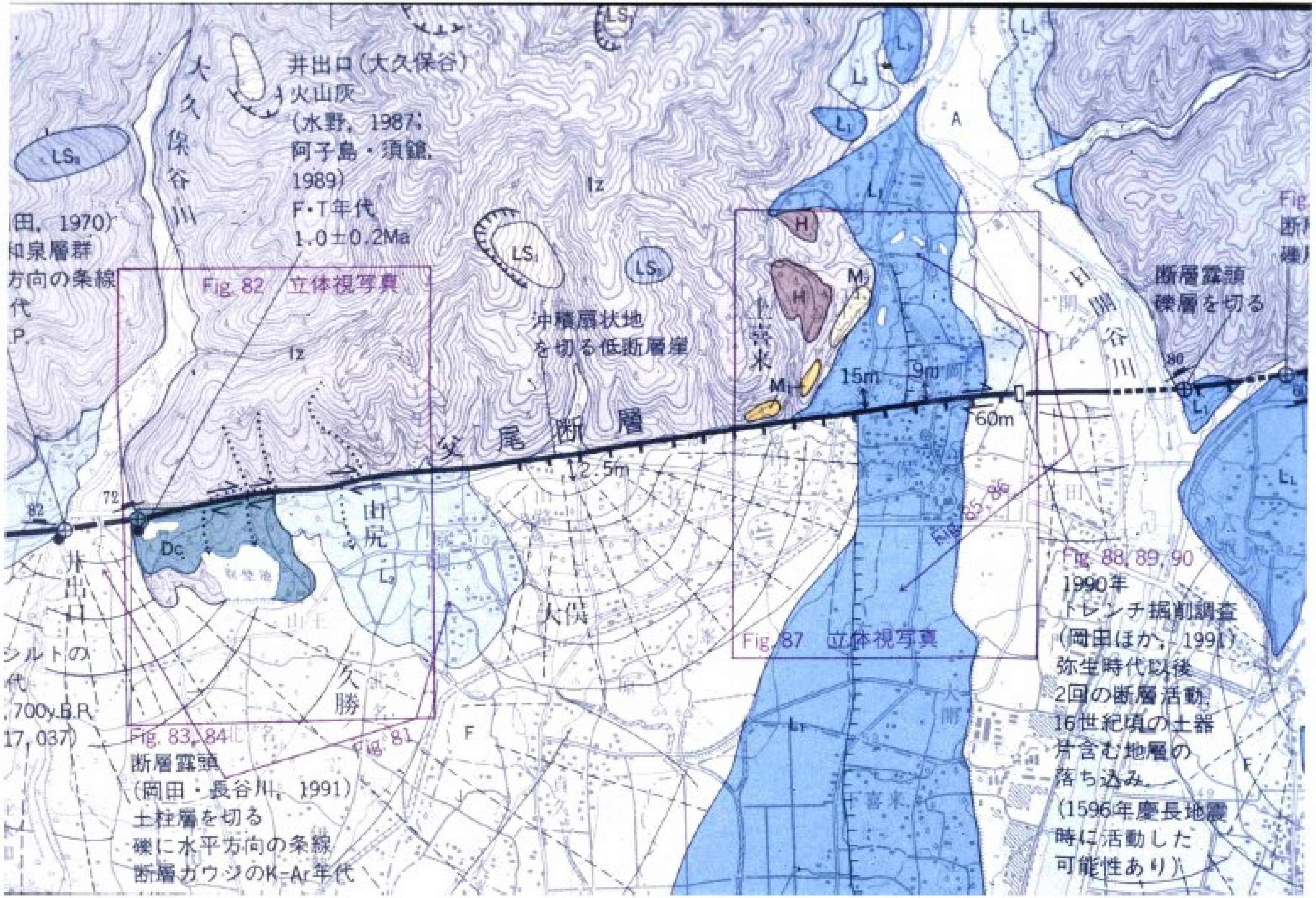
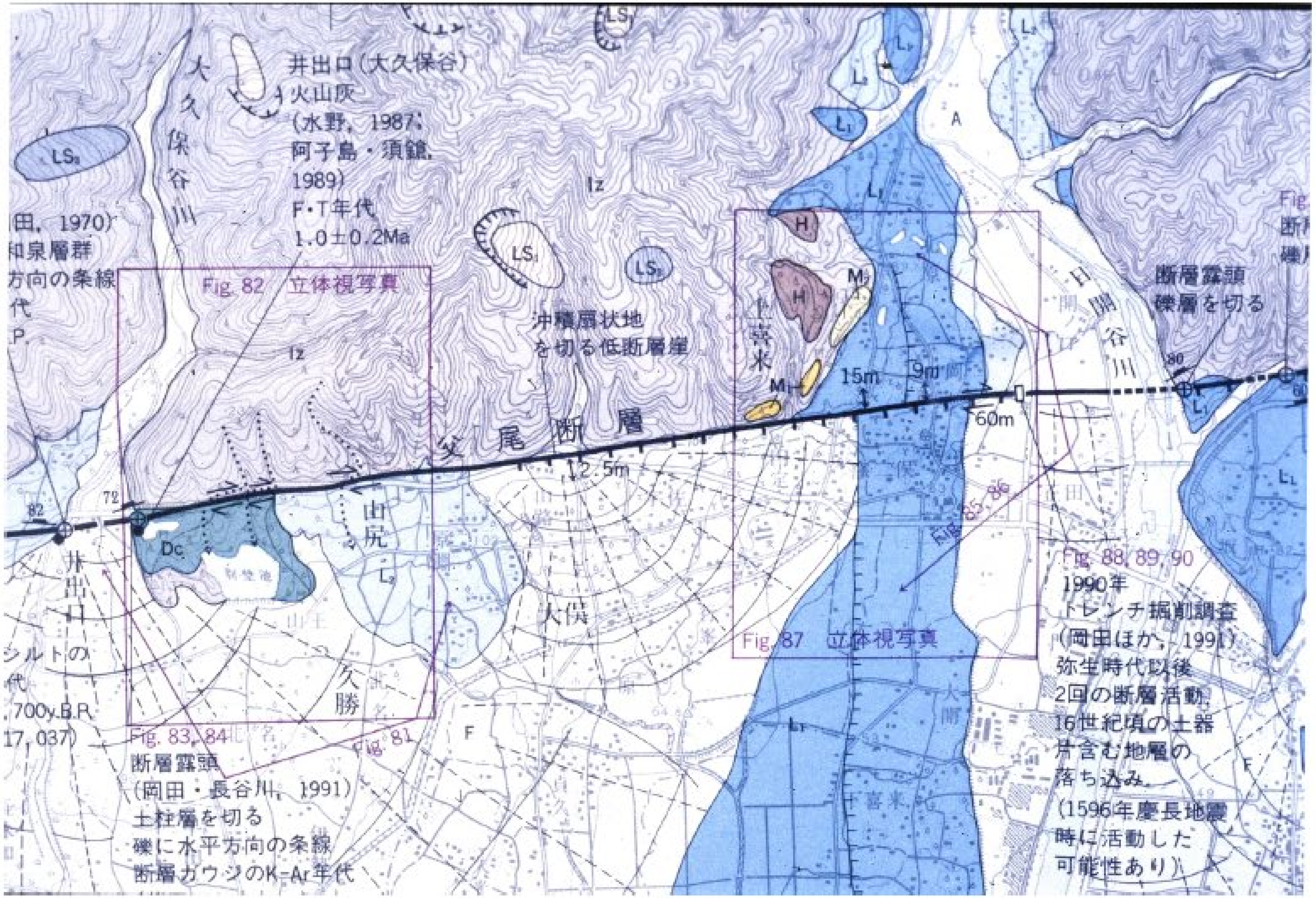


Fig. 5-2 Part of fault strip map (Mizuno and others, 1993), showing the location of Ideguchi to Kamigirai, Ichiba Town, Awa City, along the Chichio fault.

Japanese active fault map overview for prior slide (from Okada and Ooi field trip guide, 2006)

Fig.5-3 Oblique aerial photograph of fault scarp and fault outcrop along the Chichio fault, Awa City. View is to the northeast. Photo taken by A.Okada.



Japanese active fault map (from Okada and Ooi field trip guide, 2006)

Fig. 5-2 Part of fault strip map (Mizuno and others, 1993), showing the location of Ideguchi to Kamigirai, Ichiba Town, Awa City, along the Chichio fault.

Japanese active fault map stereopair for prior slide (from Okada and Ooi field trip guide, 2006)

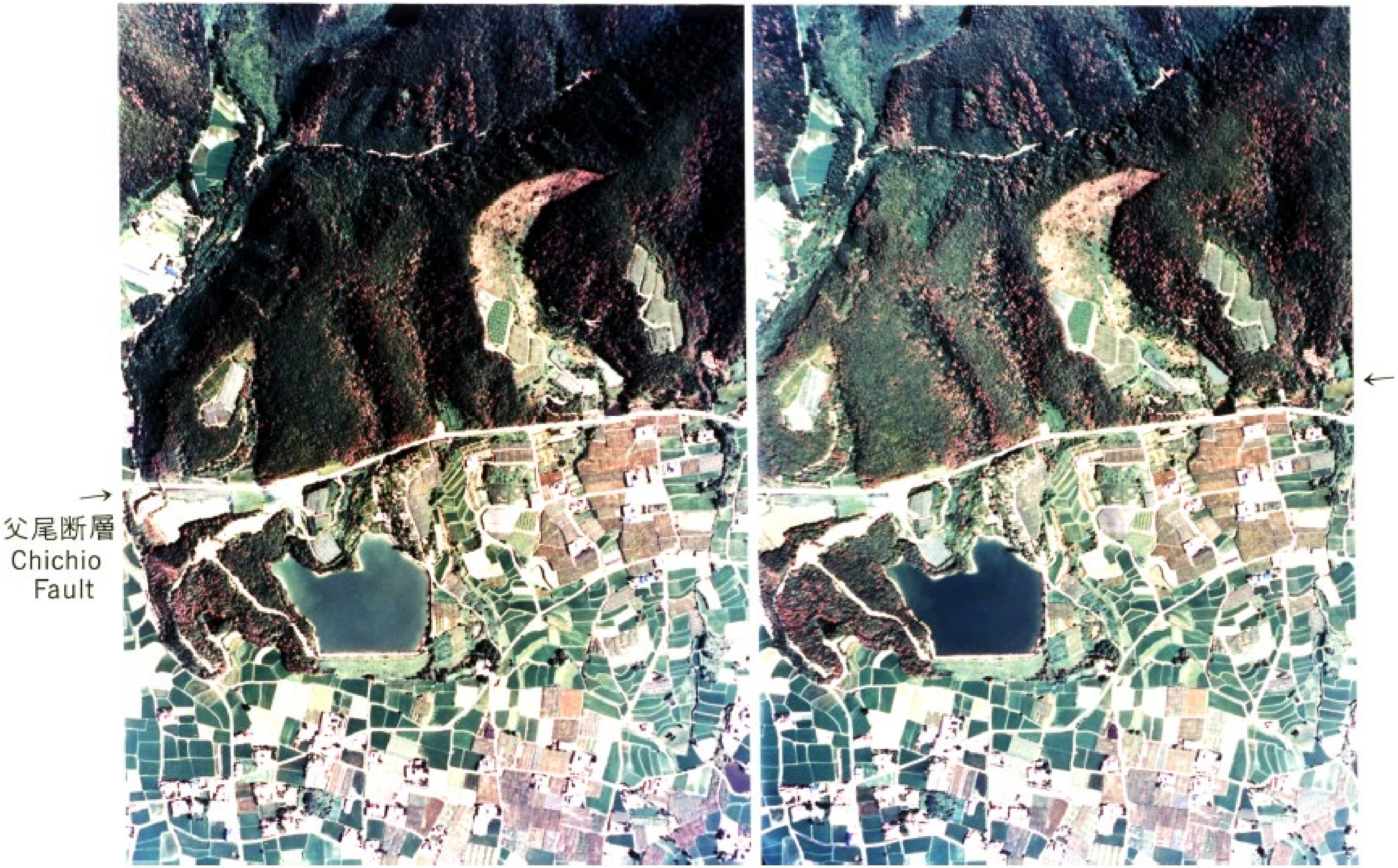
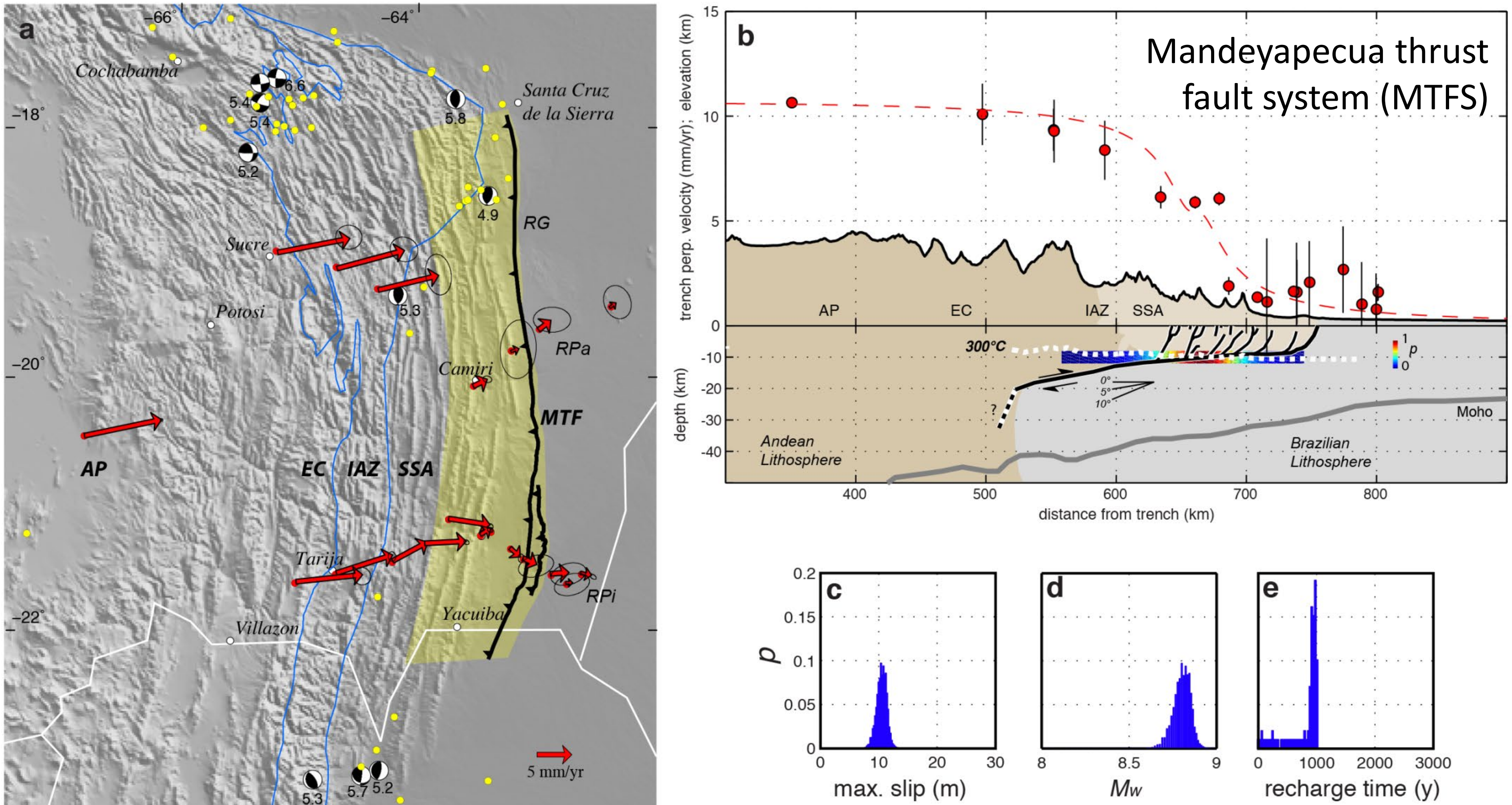
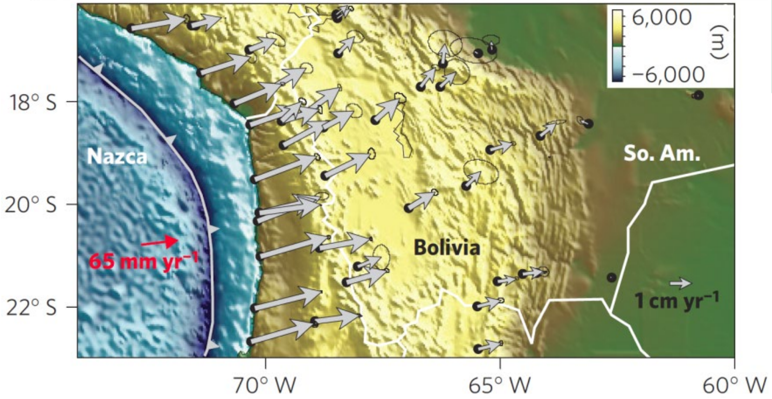


Fig.5-4 Right-laterally offset streams and fault notches at Ideguchi, Awa City, Tokushima Prefecture. Stereo-pair of aerial photographs by Geographical Survey Institute.

Heuristics by demonstration: examples of fault maps: Bolivia eastern Andean foreland thrust fault





nature geoscience

LETTERS

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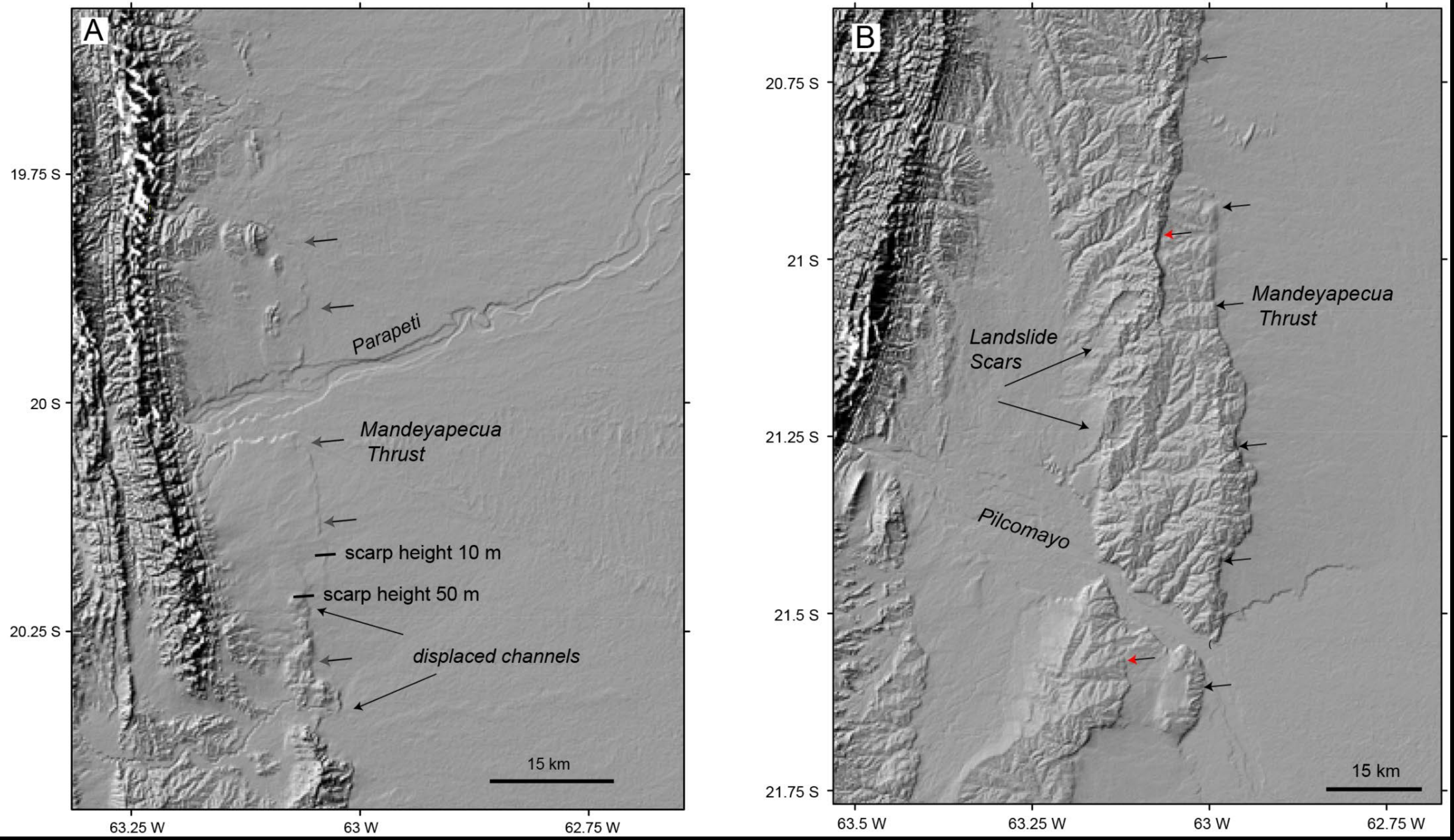
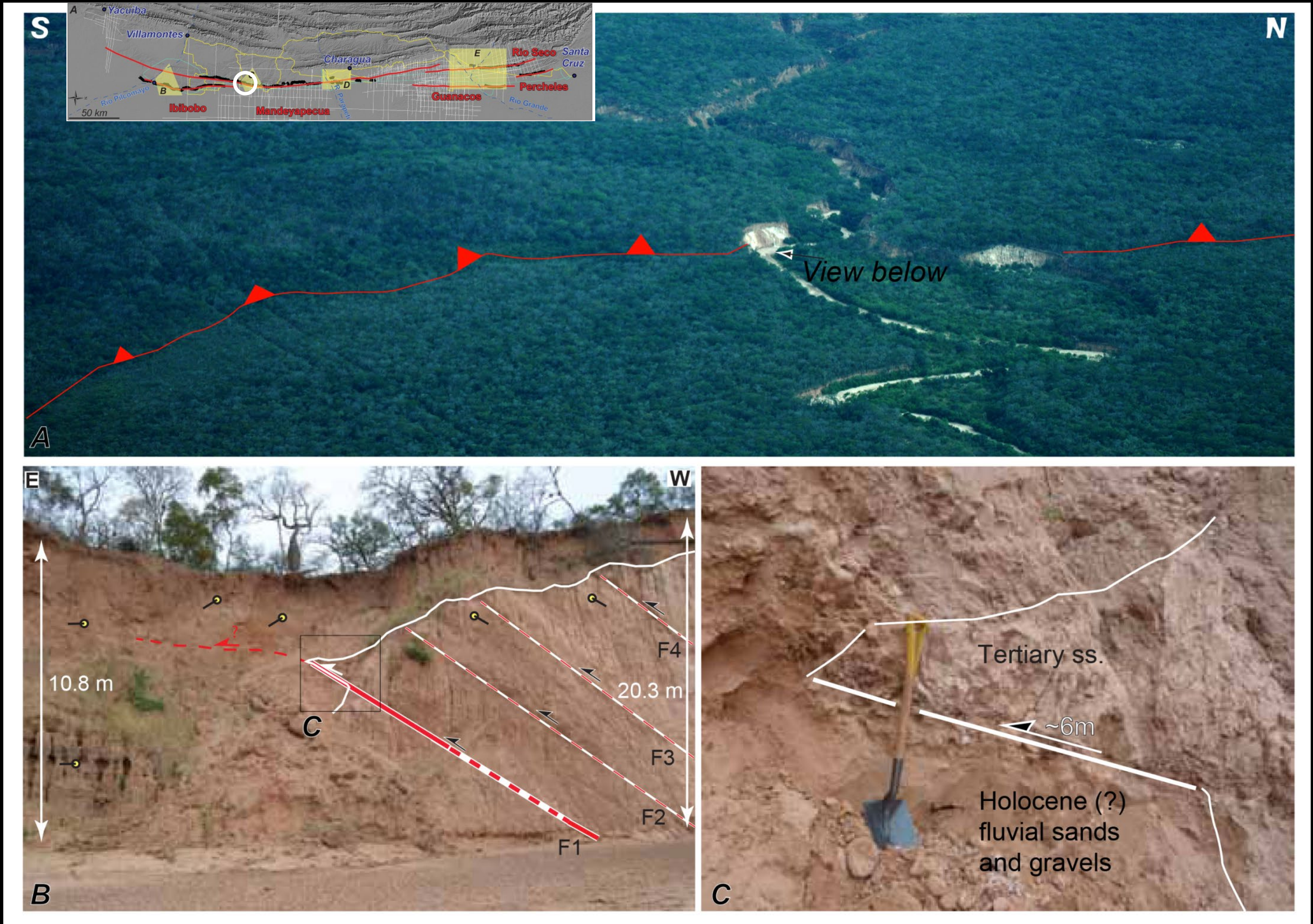
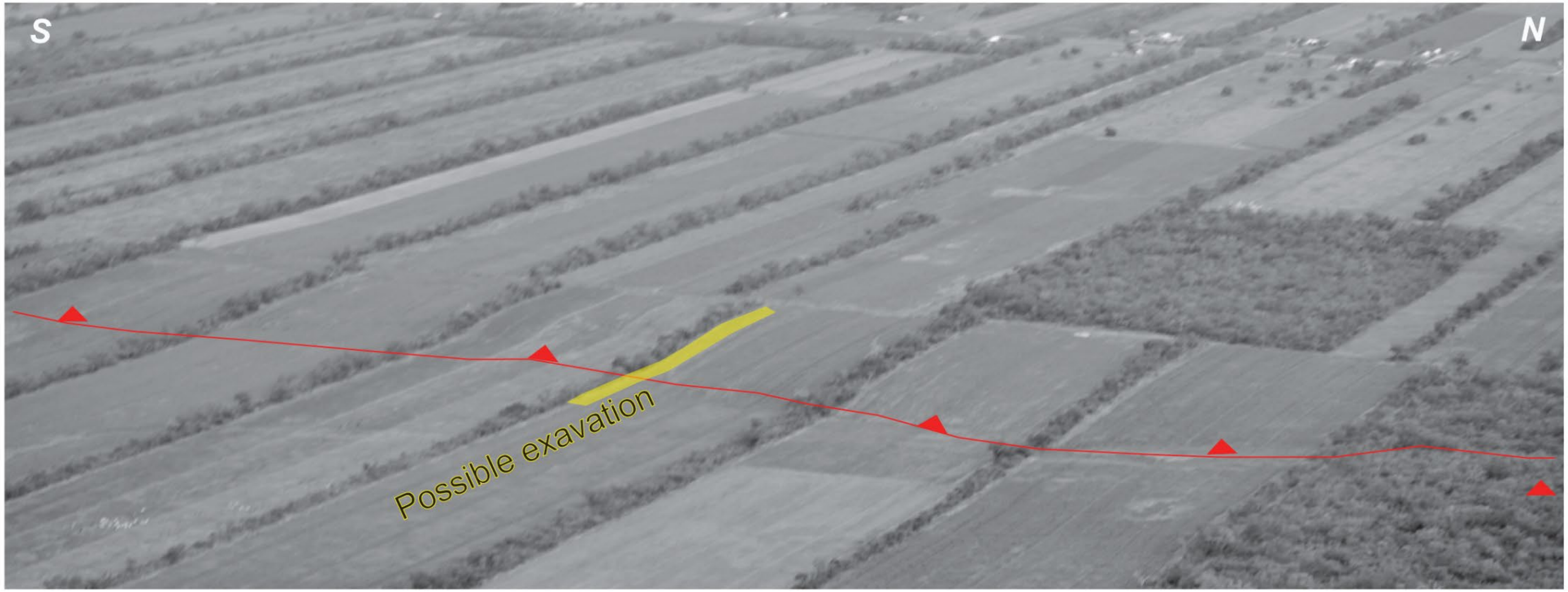
Orogenic-wedge deformation and potential for great earthquakes in the central Andean backarc

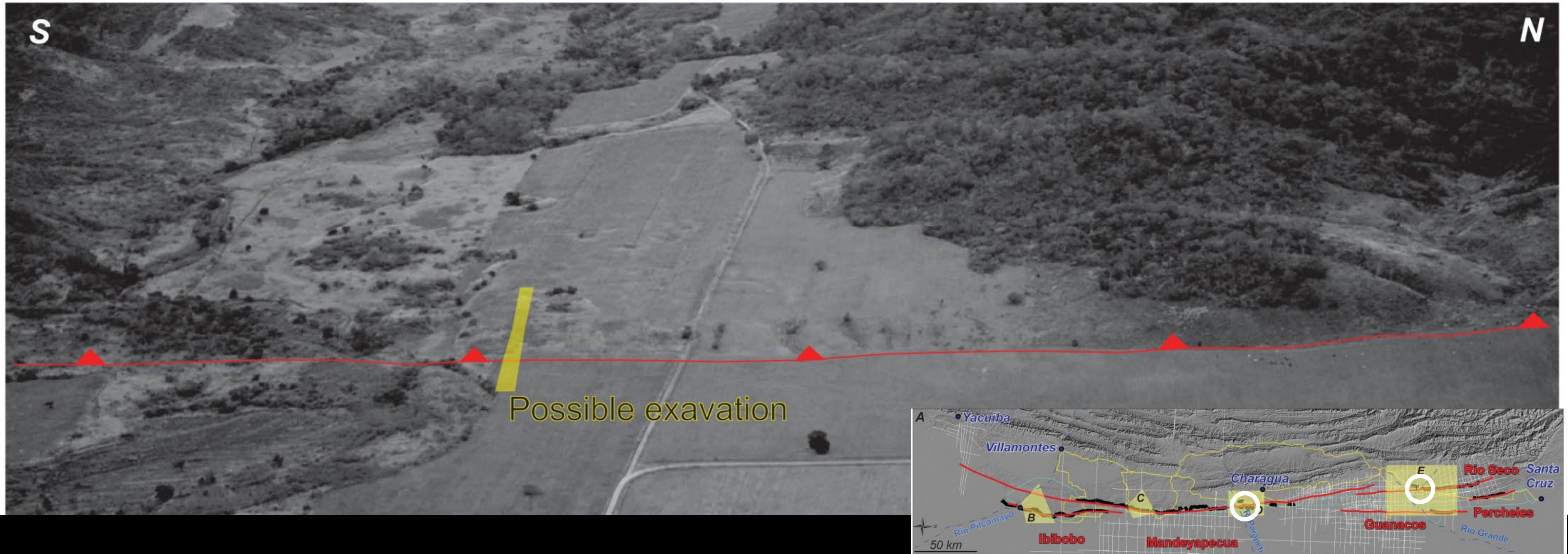
Benjamin A. Brooks[1]★, Michael Bevis[2], Kelin Whipple[3], J Ramon Arrowsmith[3], James Foster[1], Tomas Zapata[4], Eric Kendrick[2], Estella Minaya[5], Arturo Echalar[6], Mauro Blanco[7], Pablo Euillades[7], Mario Sandoval[6] and Robert J. Smalley Jr[8]



Big fault scarps in SRTM 90 m DEM!


S
N
A
Yacuiba
Villamontes
Charagua
Santa Cruz
Rio Seco
Percheles
Guanacos
Ibibobo
Mandeyapecua
Rio Pilcomayo
Rio Grande
B
D
E
50 km
View below
A
E
W
10.8 m
20.3 m
F1
F2
F3
F4
C
B
Tertiary ss.
~6m
Holocene (?) fluvial sands and gravels
C


S
N
Possible exavation


S
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Possible exavation
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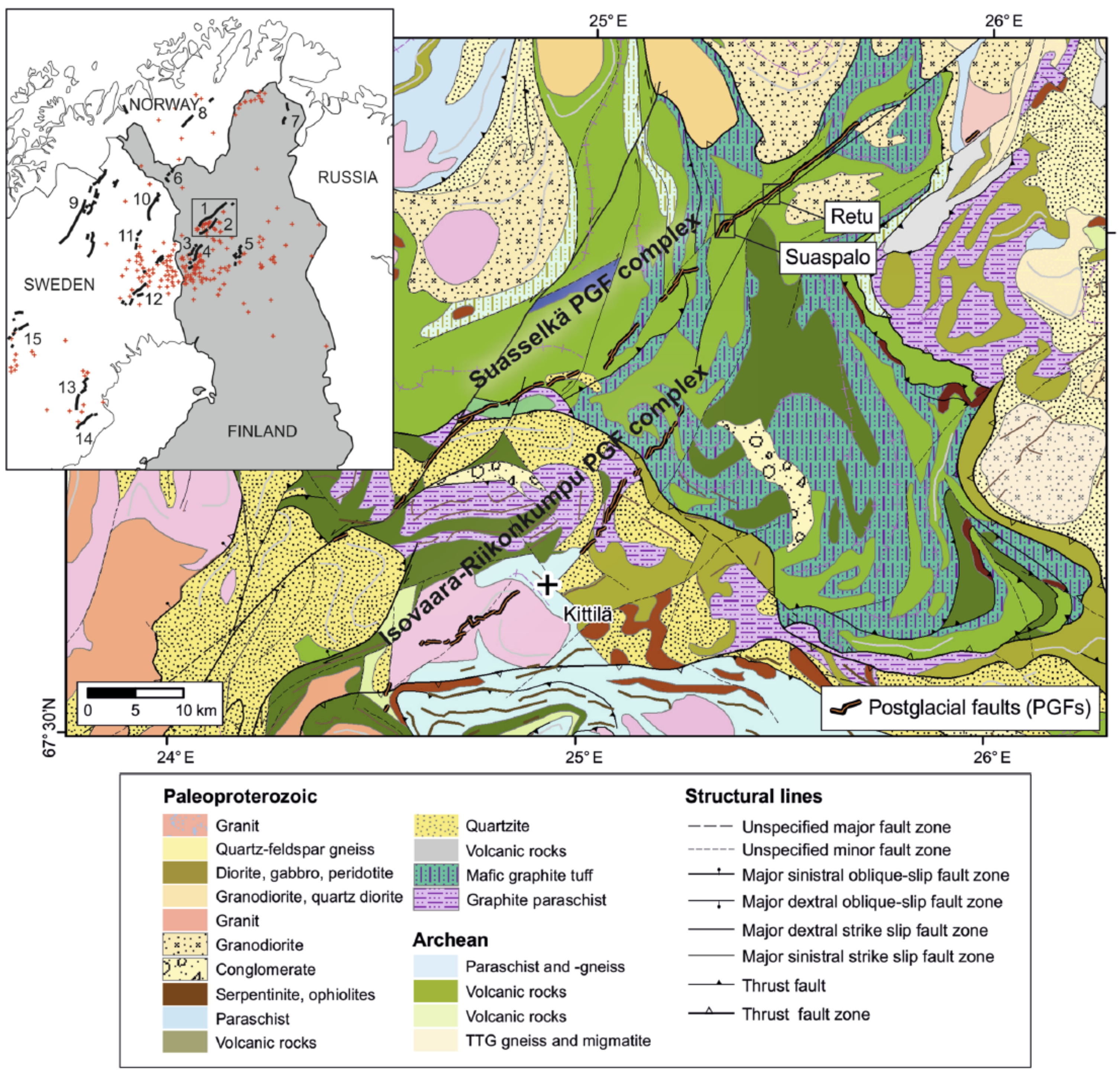
Yacuiba
Villamontes
Charagua
Santa Cruz
Rio Seco
Percheles
Guanacos
Ibibobo
Mandeyapecua
Rio Pilcomayo
Rio Parapeti
Rio Grande
B
C
E
50 km

Heuristics by demonstration: examples of fault maps: Fennoscandian post glacial faulting

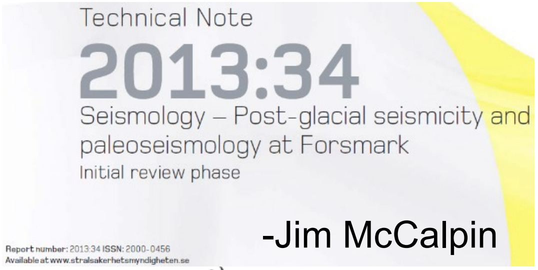


International Journal of Earth Sciences (2019) 108:1049–1065
https://doi.org/10.1007/s00531-019-01695-w

ORIGINAL PAPER

Postglacial reactivation of the Suasselkä PGF complex in SW Finnish Lapland

Antti E. K. Ojala[1] · Jussi Mattila[1] · Timo Ruskeeniemi[1] · Jukka-Pekka Palmu[1] · Nicklas Nordbäck[1] · Jukka Kuva[1] · Raimo Sutinen[2]


Technical Note
2013:34
Seismology – Post-glacial seismicity and paleoseismology at Forsmark
Initial review phase
Report number: 2013:34 ISSN: 2000-0456
Available at www.stralsakerhetsmyndigheten.se
-Jim McCalpin

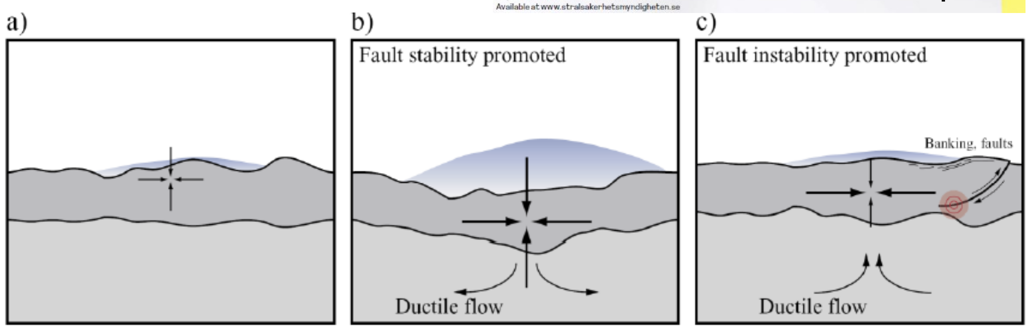
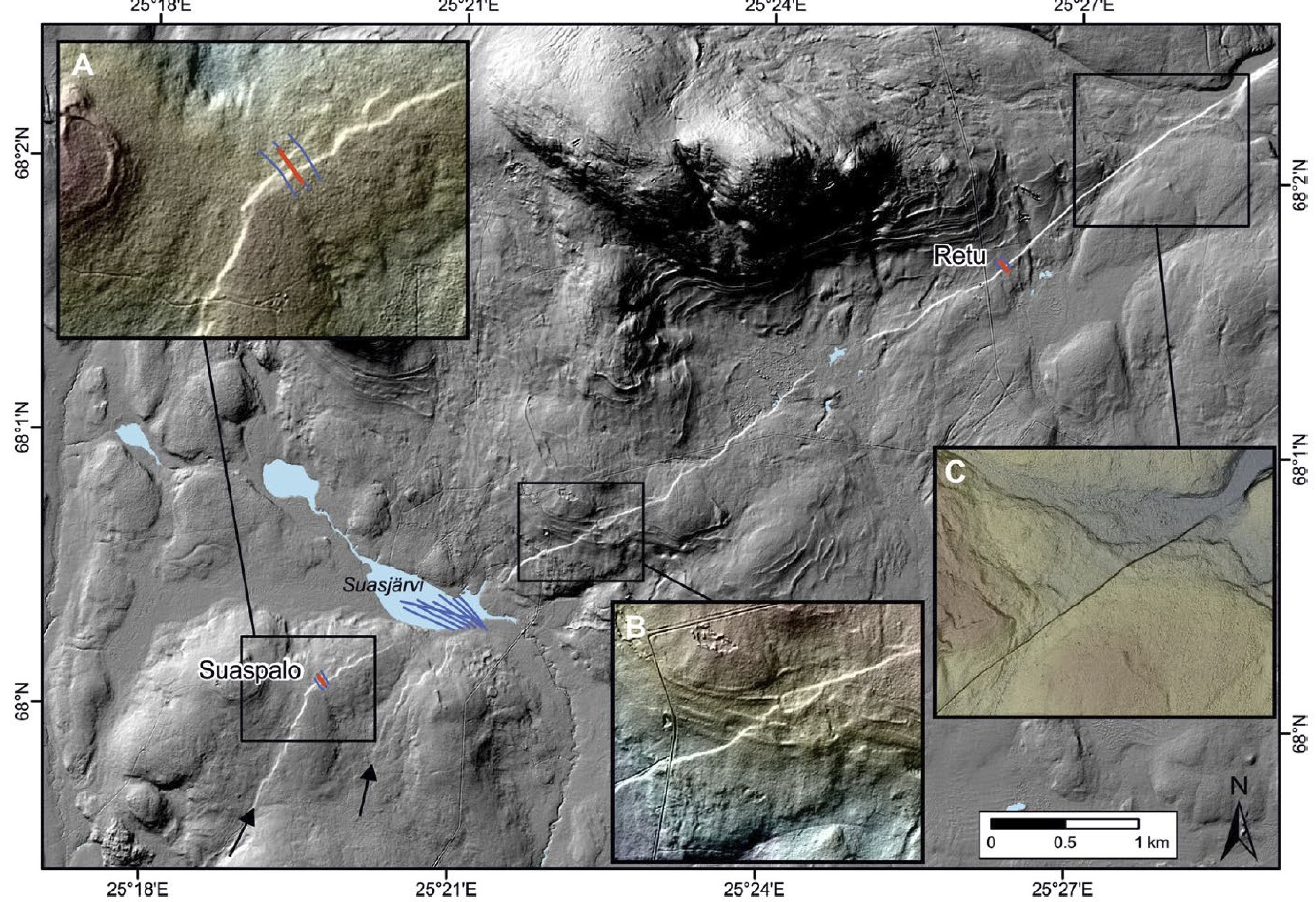


Fig. 5. Schematic cartoon illustrating how the stress field changes during the pre (a) syn (b) and c) post glacial times. During the growth of the glacier, horizontal tectonic stresses accumulate while differential compressibility promotes fault stability. Mantle material flows, relatively slowly, from beneath the glacier. When the glacier retreats, differential stresses promotes fault instability, in particular on gently dipping faults oriented perpendicular to σ1. Mantle material flows back, and the crust is slowly regaining its state of equilibrium. (From Munier and Fenton, 2004, p. 197)


955


25°18'E
25°21'E
25°24'E
25°27'E
68°2'N
68°1'N
68°N
A
B
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Retu
Suaspalo
Suasjärvi
N
0
0.5
1 km

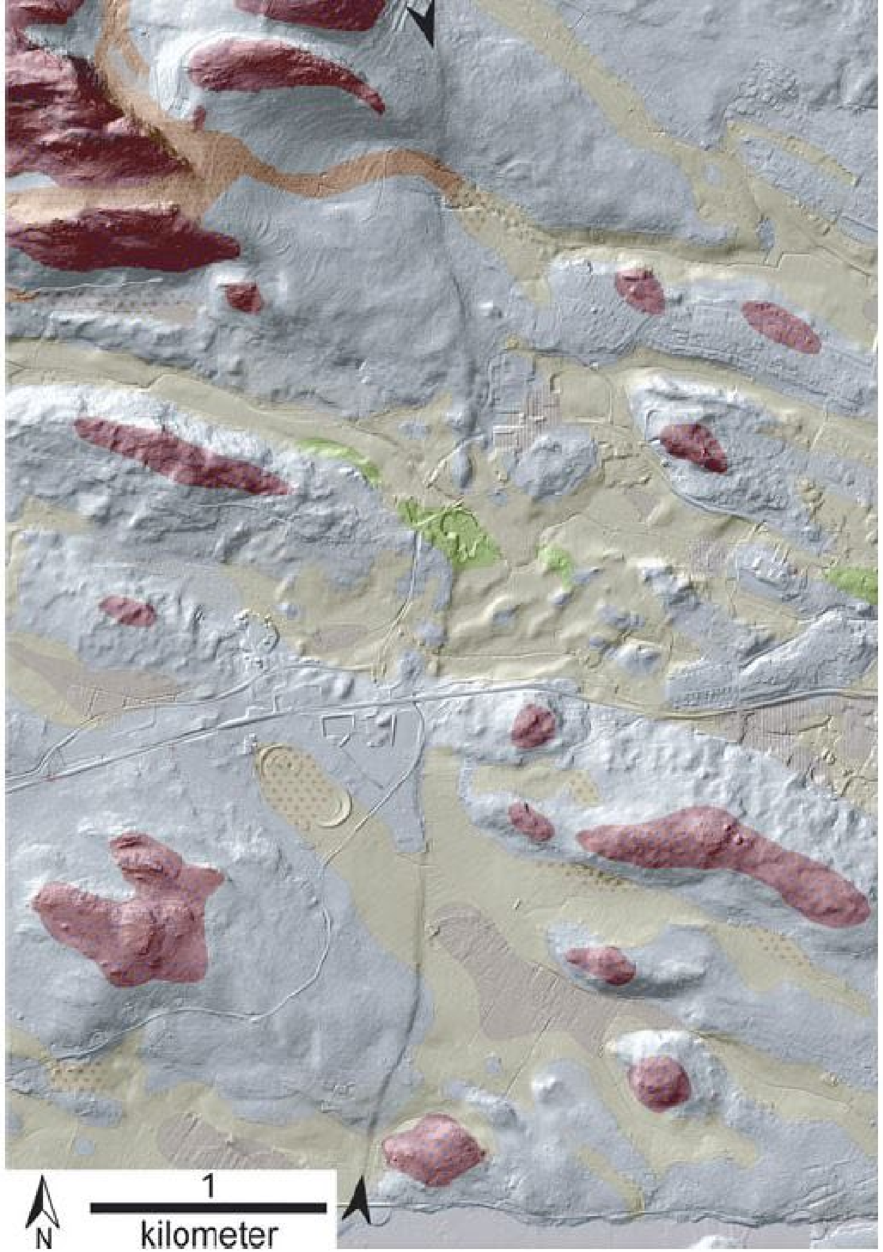


Fig. 3. A surficial geologic map (Mikko et al. 2011) laid over the LiDAR-derived DEM of the Bollnäs area. The scarp, marked by the arrows, cuts multiple units of glacial sediment. Bedrock is red, till is blue, glaciofluvial sediment is green, clay/silt is light tan and organic sediment is dark tan.

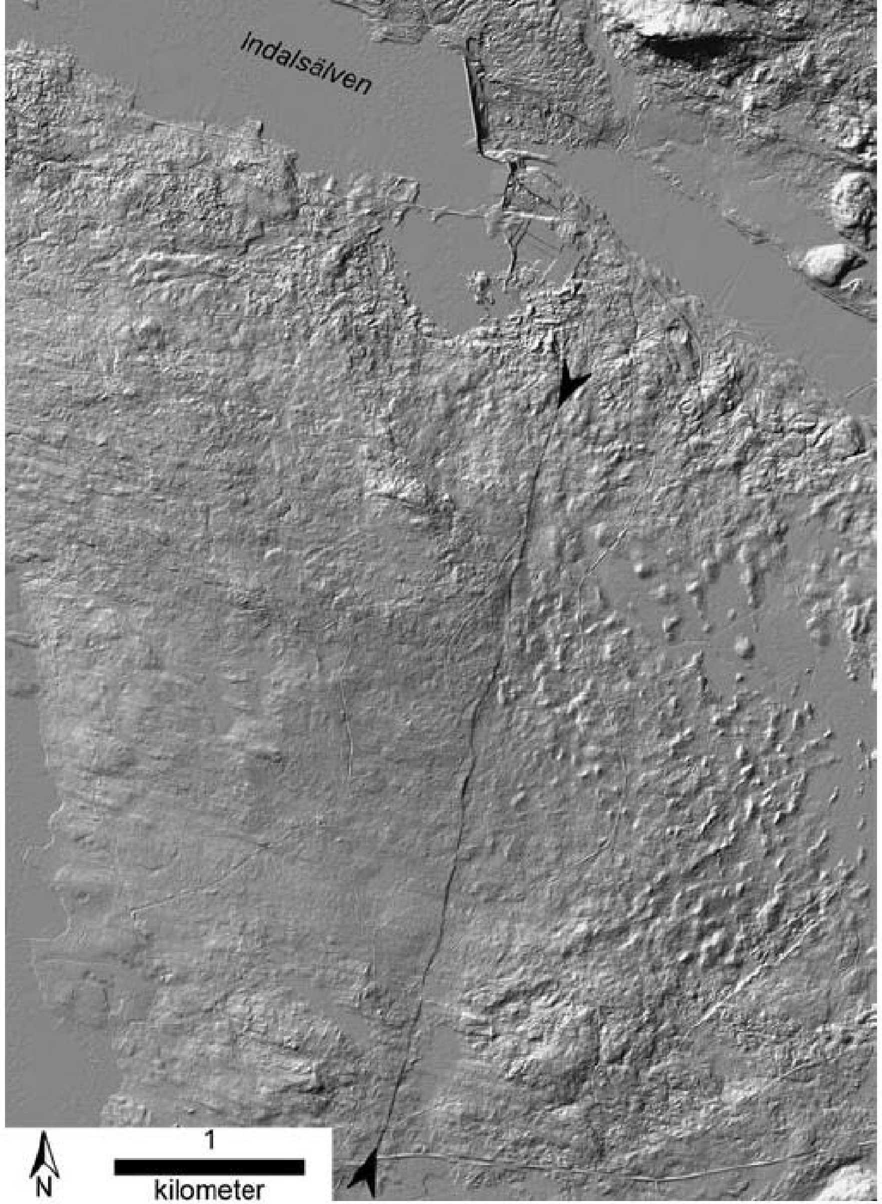


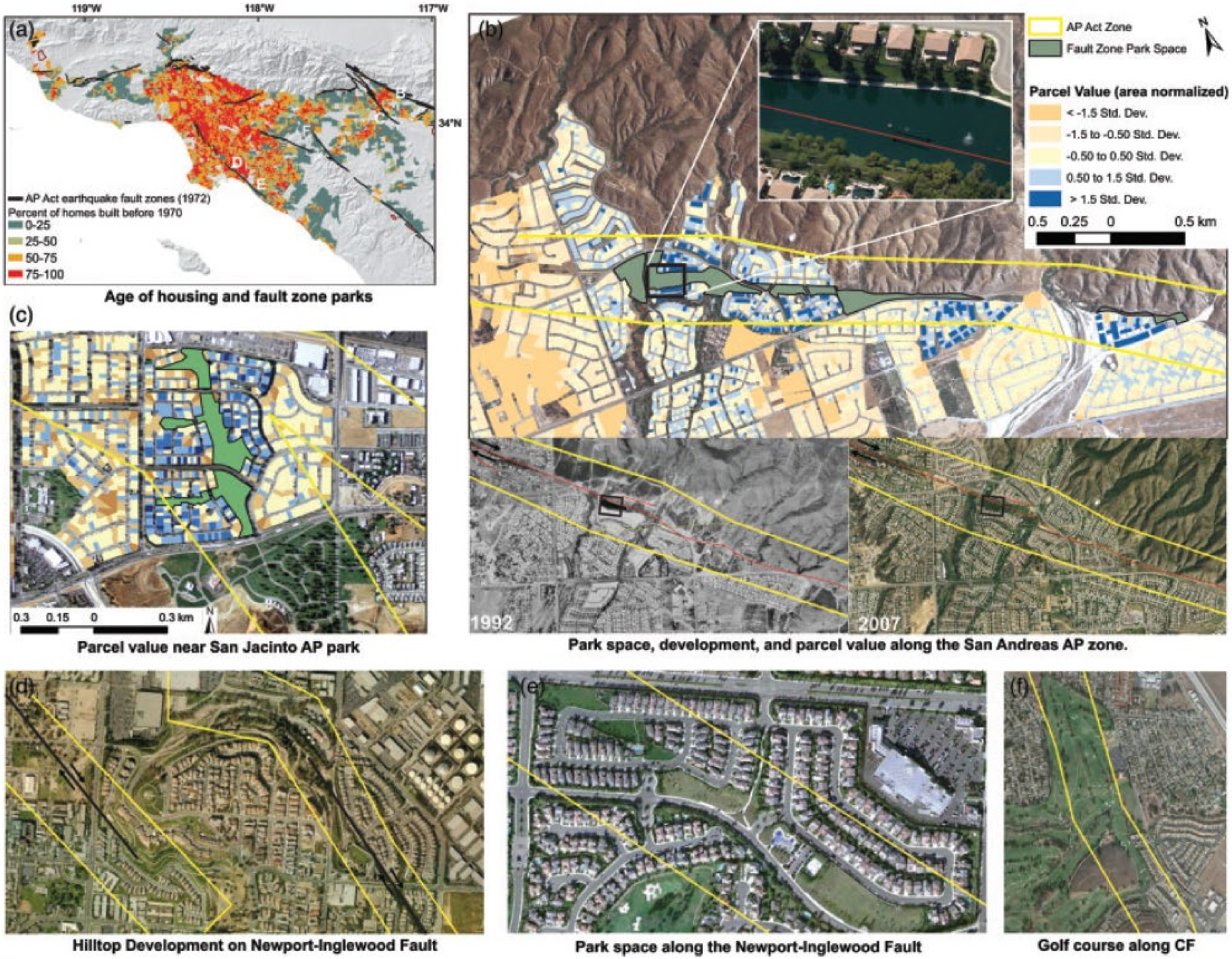
Fig. 4. LiDAR-derived DEM showing the Lillsjöhögen scarp in Jämtland. The feature crosscuts streamlined glacial landforms that were created by westward flowing ice.

Henrik Mikko, Colby A. Smith, Björn Lund, Maria V.S. Ask & Raymond Munier (2015) LiDAR-derived inventory of post-glacial fault scarps in Sweden, GFF, 137:4, 334-338, DOI: 10.1080/11035897.2015.1036360

Unexpected consequences of fault zone delineation and regulation

Toke, N. A., Boone, C. G., Arrowsmith, J R., Fault Zone Regulation, Seismic Hazard, and Social Vulnerability in Los Angeles, California: Hazard or Urban Amenity? Earth's Future, Volume 2, Issue 9, Pages: 440-457, DOI: 10.1002/2014EF000241, 2014.

"Despite hazard disclosures, social vulnerability is lowest within AP regulatory zones and vulnerability increases with distance from them. Because the AP Act requires building setbacks from active faults, newer developments in these zones are bisected by parks. Parcel-level analysis demonstrates that homes adjacent to these fault zo ne parks are the most valuable in their neighborhoods."



Mapping and image interpretation

Basic considerations for interpretation

- Shape: general form, configuration, outline of individual objects.
- Size: consider in context of image scale
- Pattern: spatial arrangement of objects (e.g., orchard)
- Tone: relative brightness or color of objects on an image
- Texture: frequency of tonal change (smoothness or coarseness)
- Shadows: gives profile view of object and implies relative heights
- Site: refers to geographic or topographic location; what do you expect to be there?
- Association: occurrence of certain features in relation to others
- Resolution: what is the finest thing you can see?
- Targets: identify main features you want to emphasize on your map

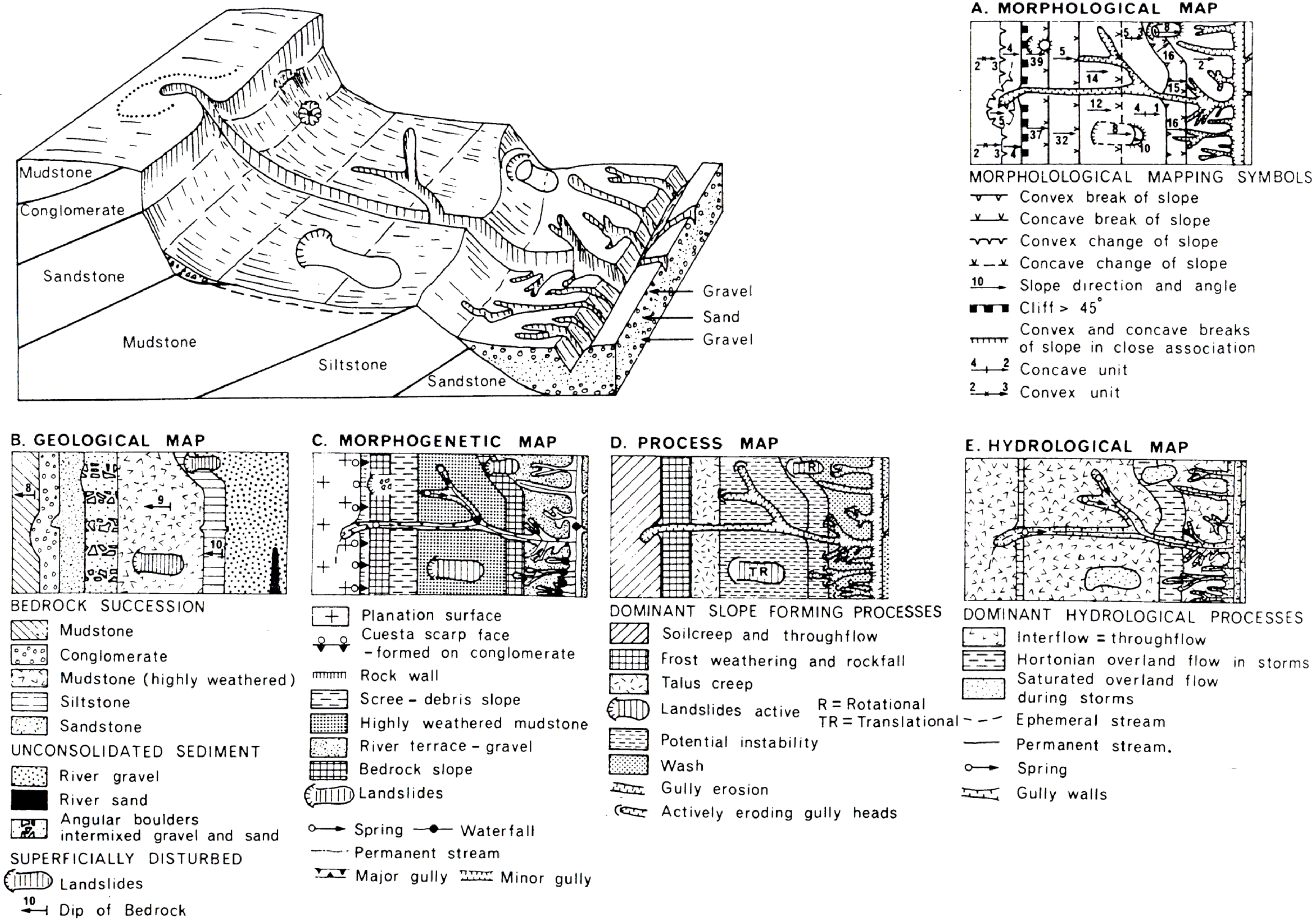


FIG. 10.3. Maps are some of the most common landscape models. These maps show various features and interpretations of one landscape represented in a block diagram. Such maps are very useful for recording field observations. (Modified and extended from Brunsden *et al.* 1975.)