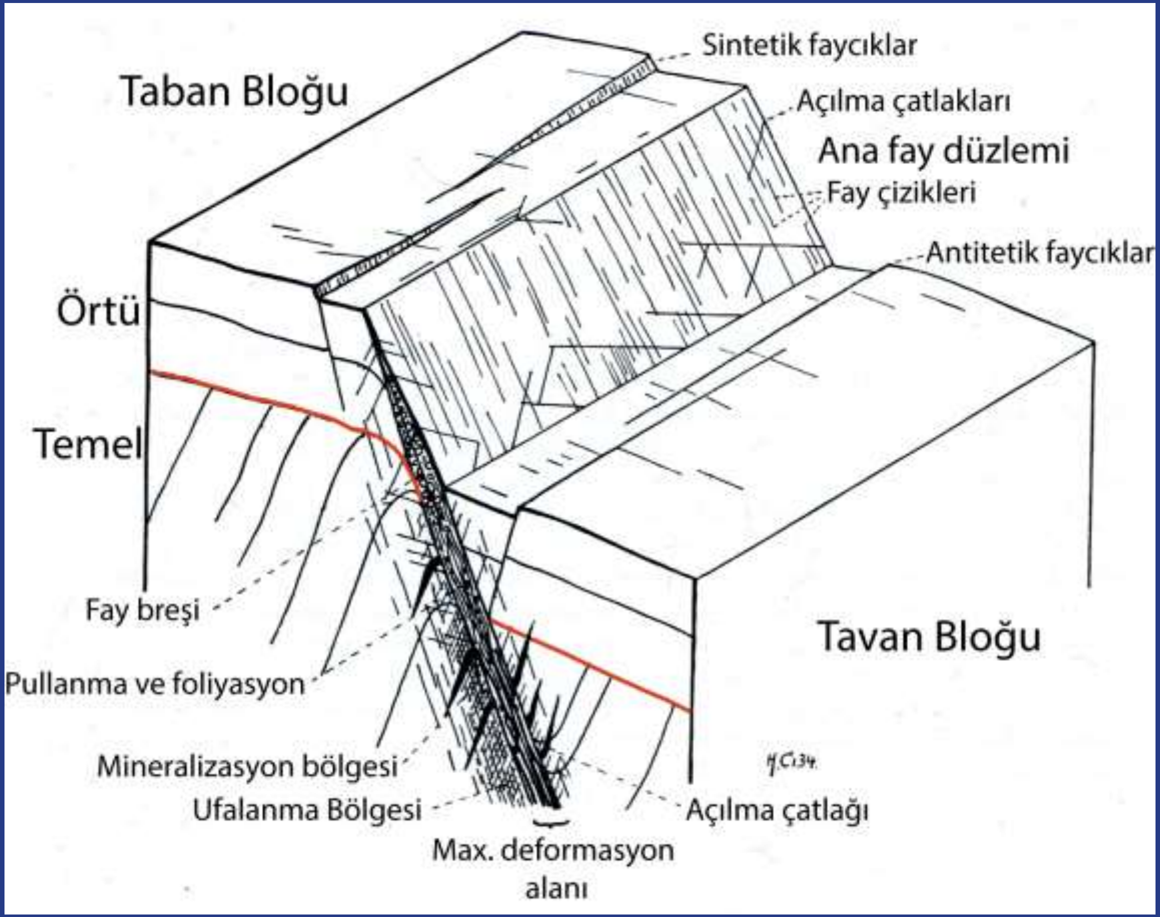
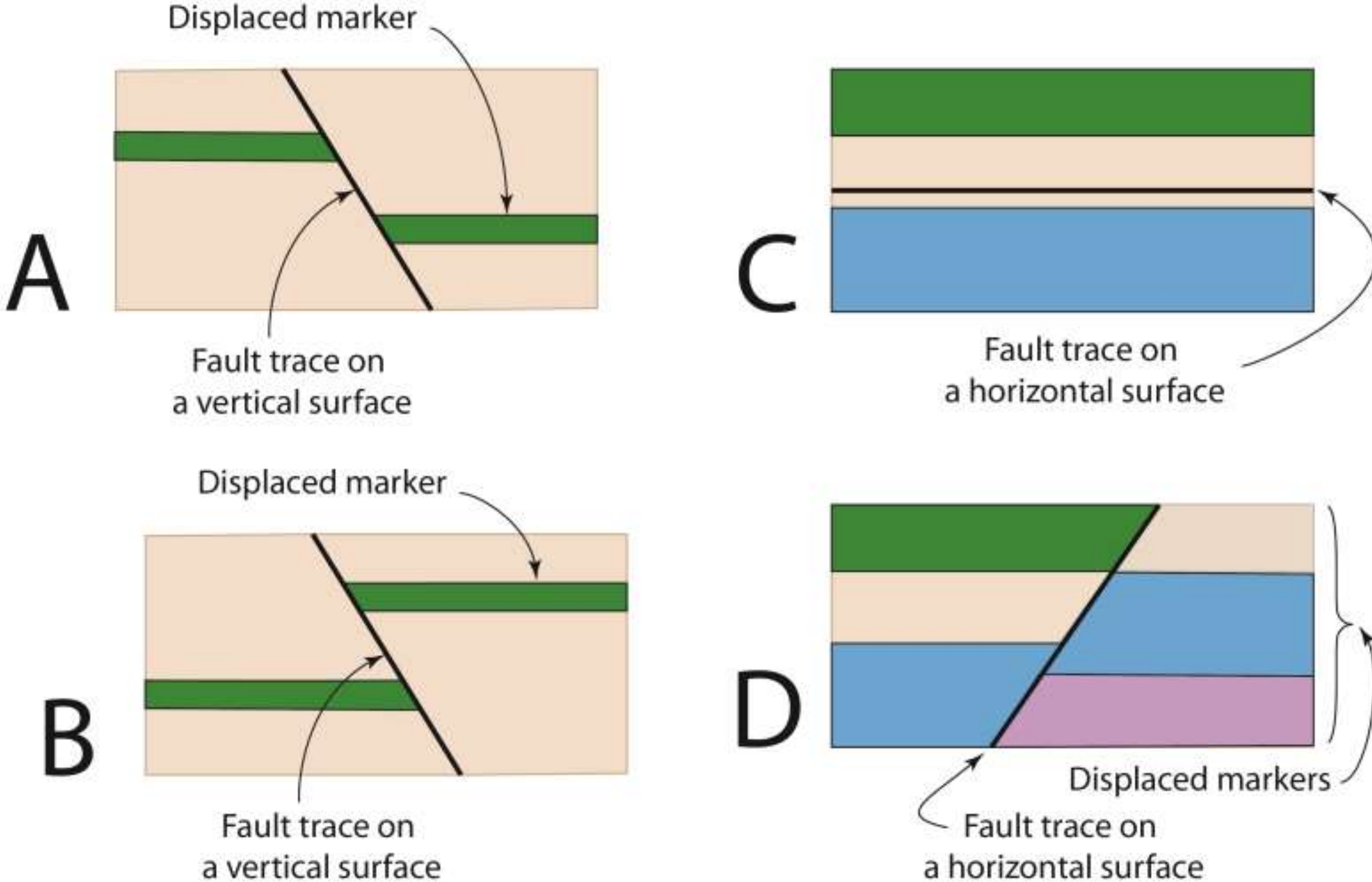
EĞİM ATIMLI NORMAL FAYLAR (ÇEKİM FAYLARI)

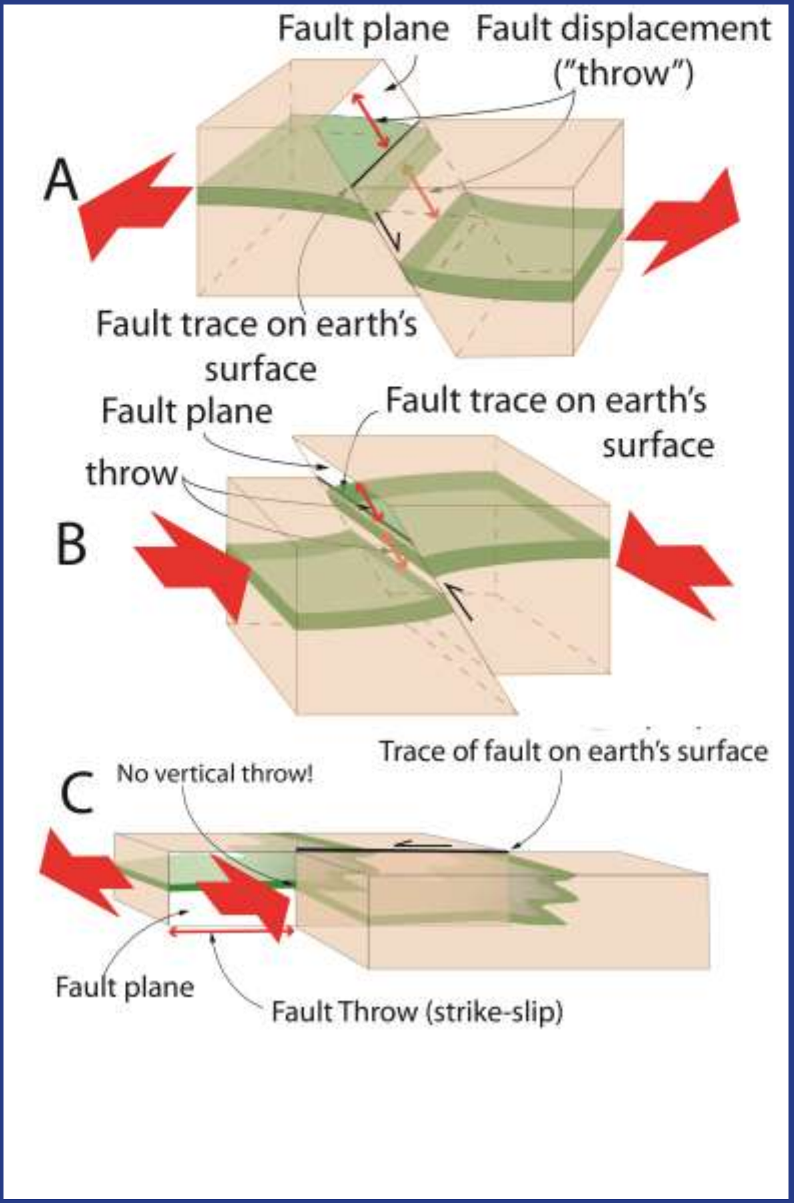


Tüm kayaçlar, uzama yaratan gerilme altında daralma yaratan sıkışma altındakine nazaran daha zayıftırlar. Onun için doğada en çok görülen fay çeşidi eğim atımlı normal faylardır. Bu nedenle de tâ 16. yüzyıldan beri madenciler, maden galerilerinde karşılaştıkları bu tür faylara “normal fay” demişlerdir.

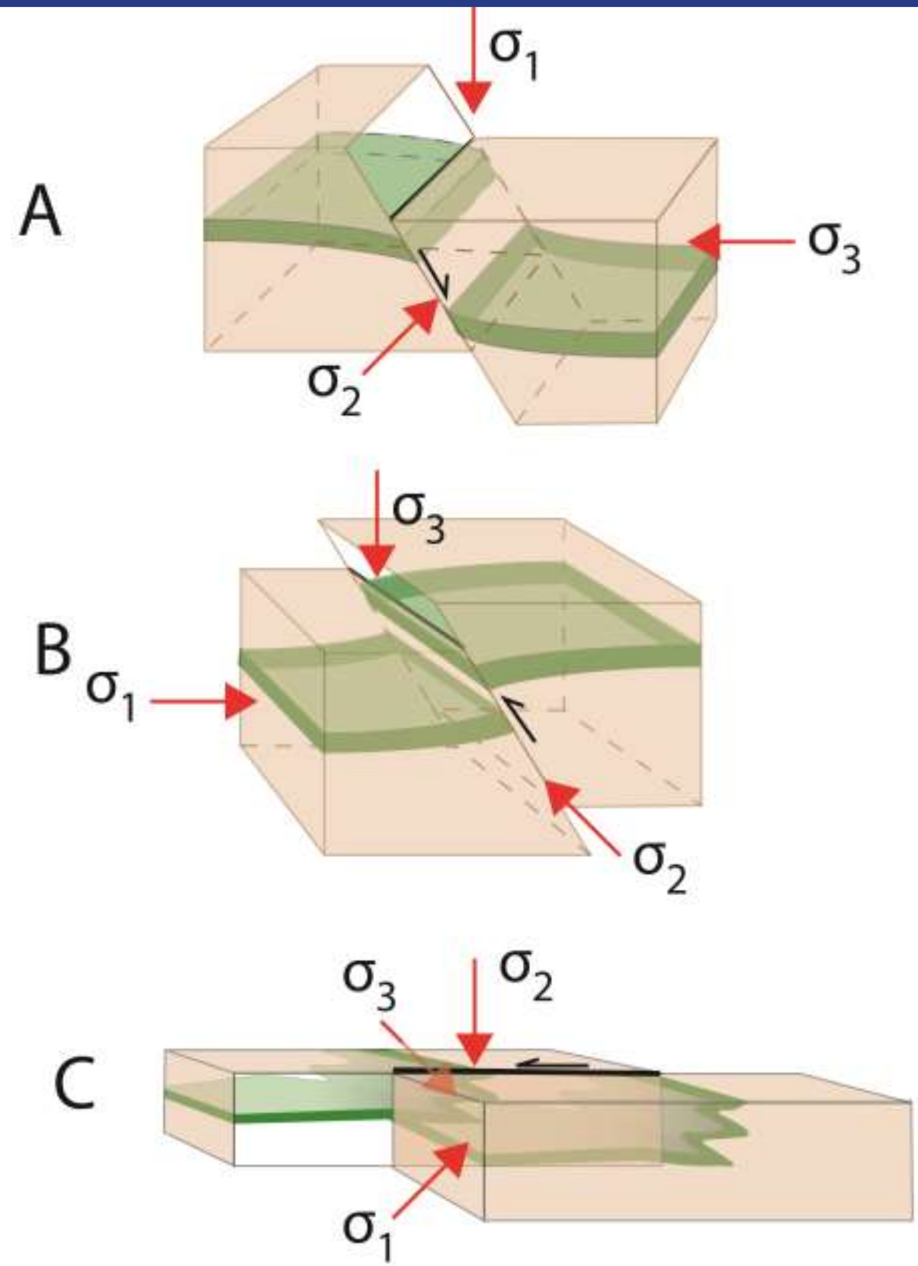
Balthasar Rössler’in meşhur Ayna (*Speculum*) adlı eserinden fay türleri (1700)



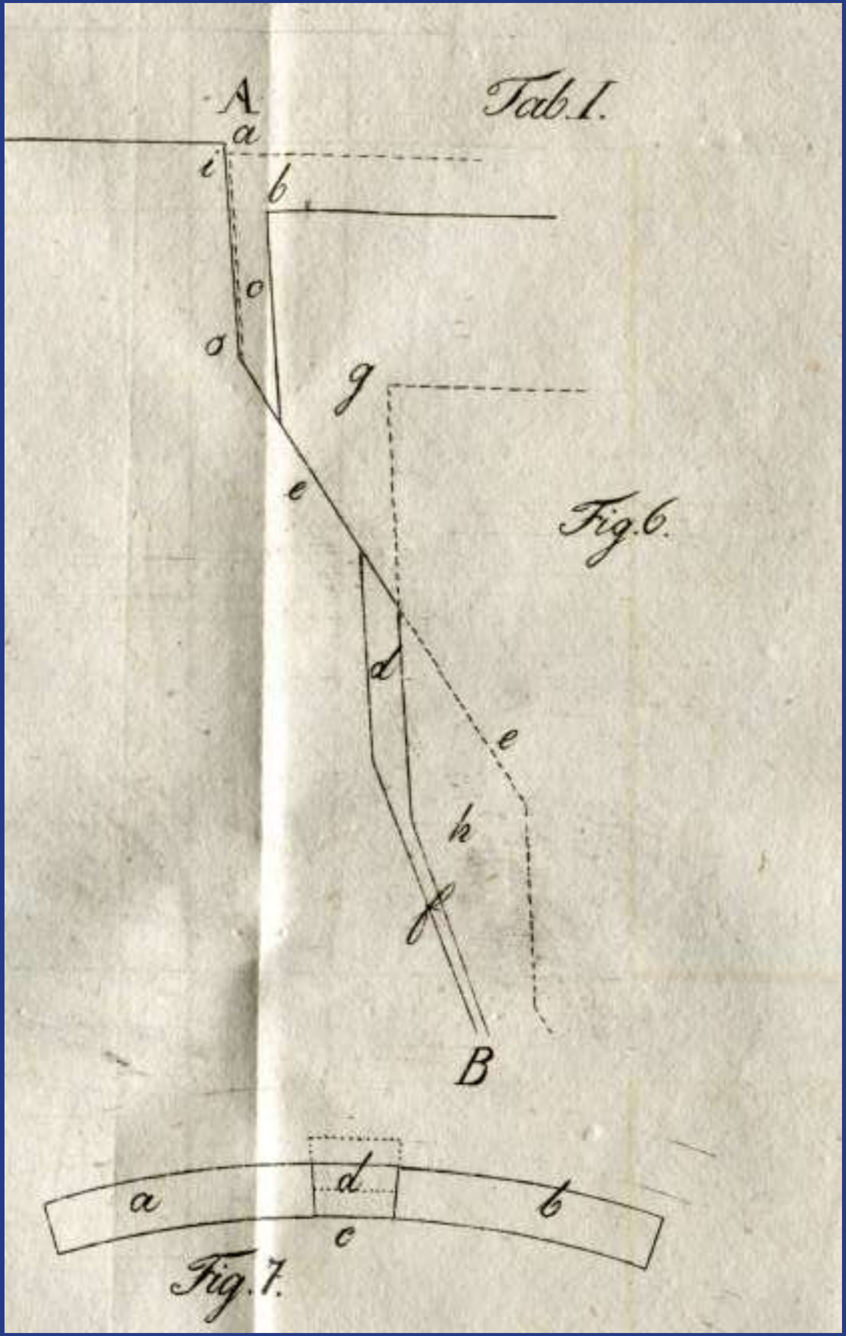
Geometrik fay sınıflaması



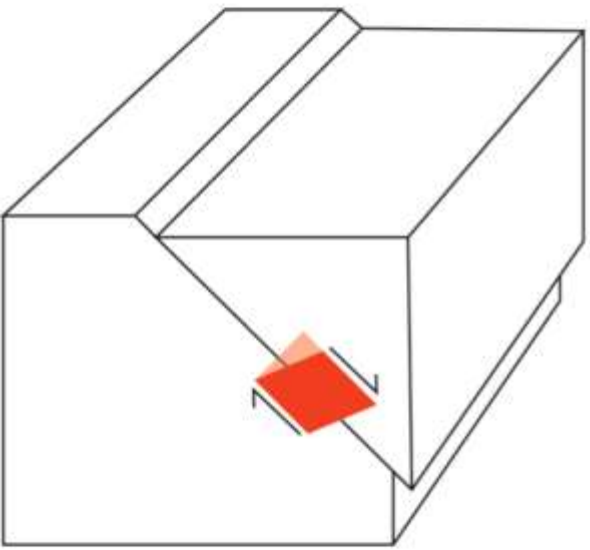
Kinematik fay sınıflaması

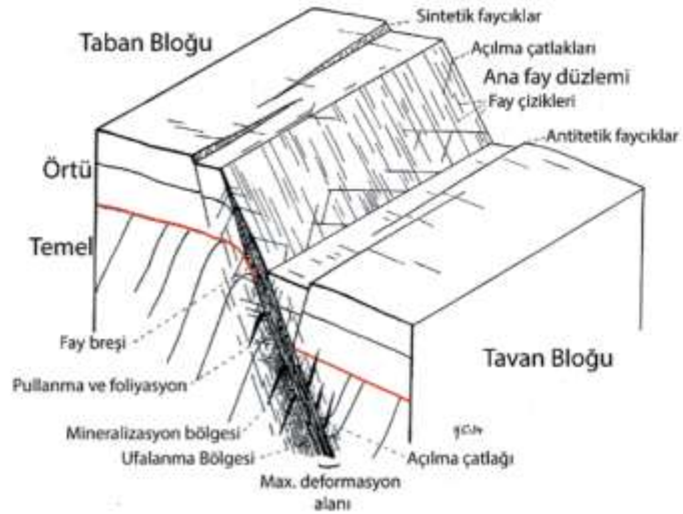


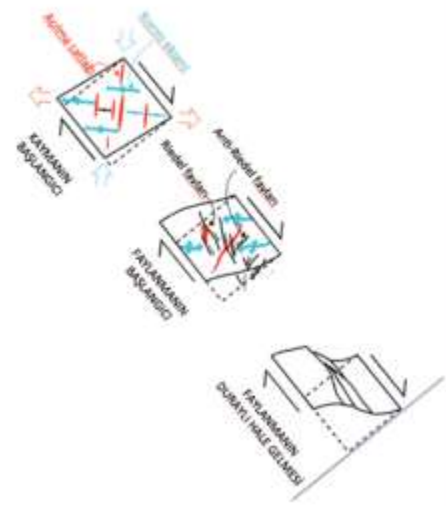
Dinamik fay sınıflaması



Normal faylar üzerinde düşey ve yatay hareket bileşenleri (Schmidt 1824)

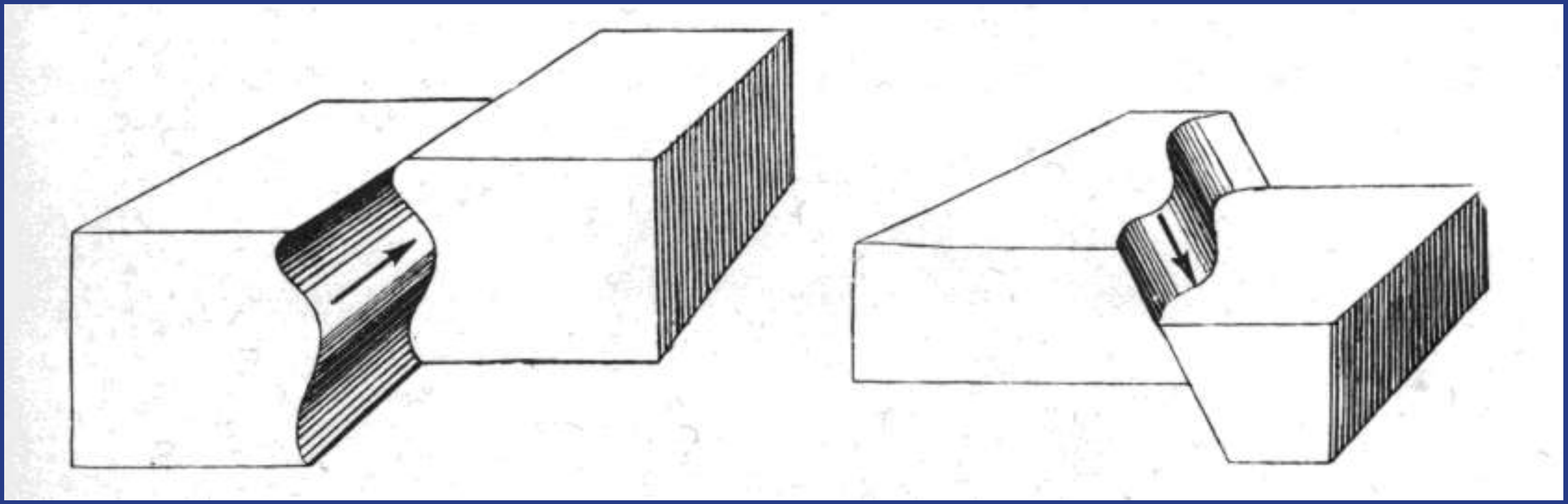






Normal eğim atımlı faylar üzerinde gelişen yapılar.

Fay atımını atılan kayaçları deneştirerek doğrudan göremediğimiz yerlerde bu yapılar bize atımın yönü hakkında bilgi verirler.

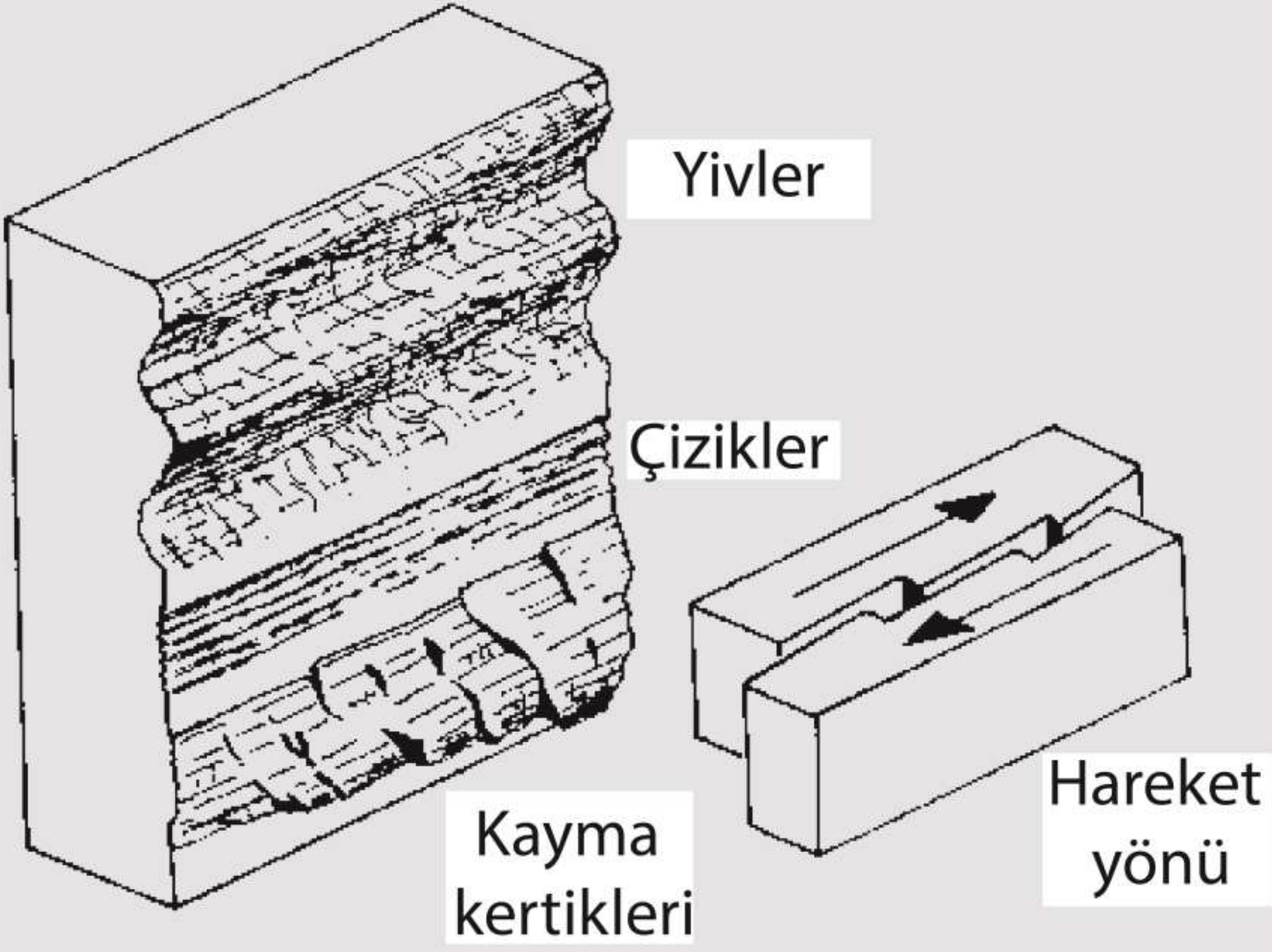


Bir fay üzerinde yiv (=*cannelure*) yapıları. Bu yapılar cm’den metrelere varabilen genişlikte olabilirler ve fayın hareket doğrultusu hakkında en güvenilir bilgileri verirler.

Yivli bir normal fay aynası (Salton Sea, Kaliforniya, ABD)

Efes eğim atımlı normal fayı üzerinde yivler

Yivli bir yanal atım fay aynası (Kenya, Afrika)

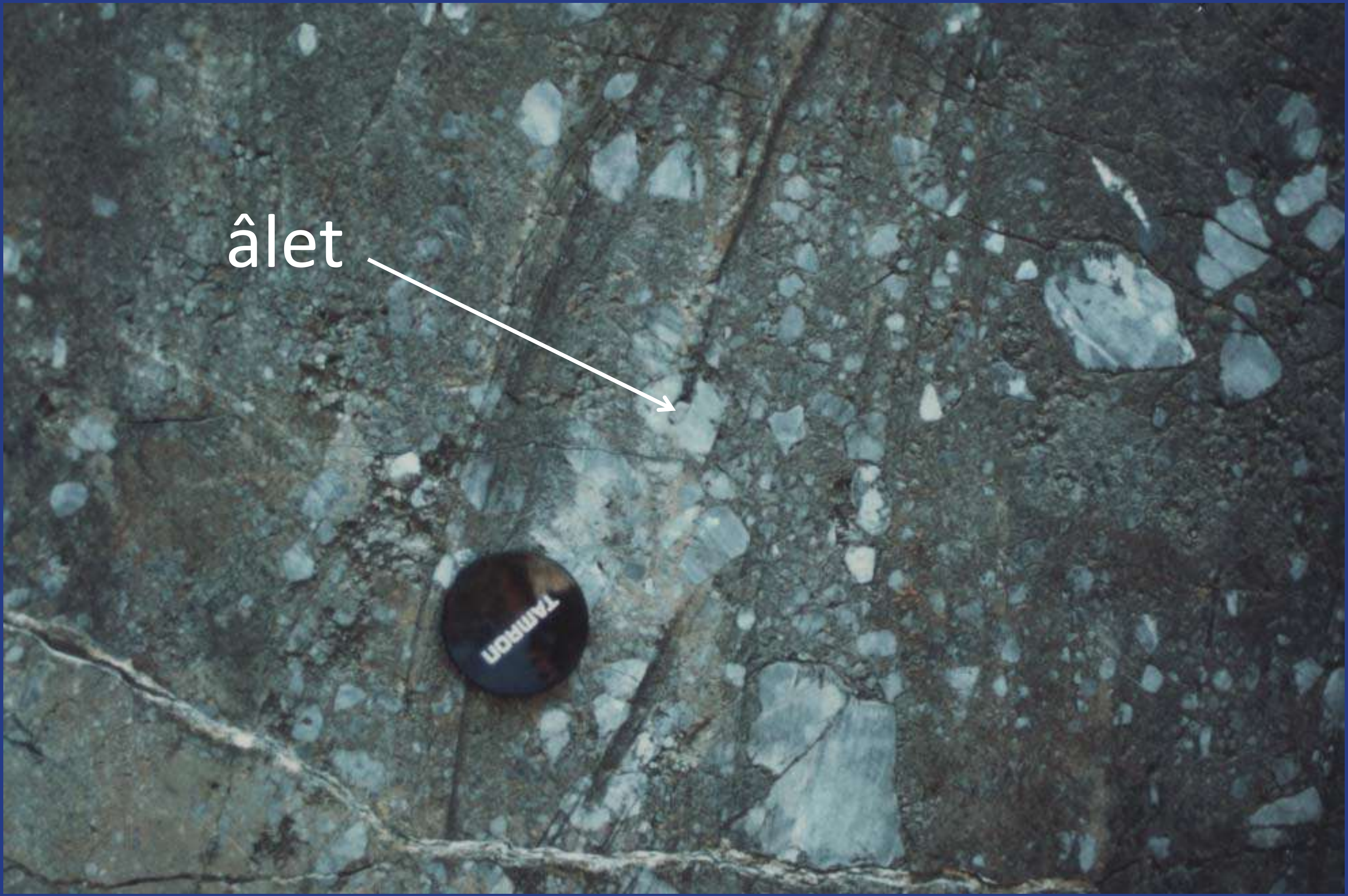


Bir fay yüzeyinde (fay aynası) görülen yapılar

Bir fay aynası üzerinde fay çizikleri ve fay kertikleri

Efes eğim atımlı normal fay aynası üzerinde fay çizikleri

Kuşadası'nda Alatlı fay çiziği.

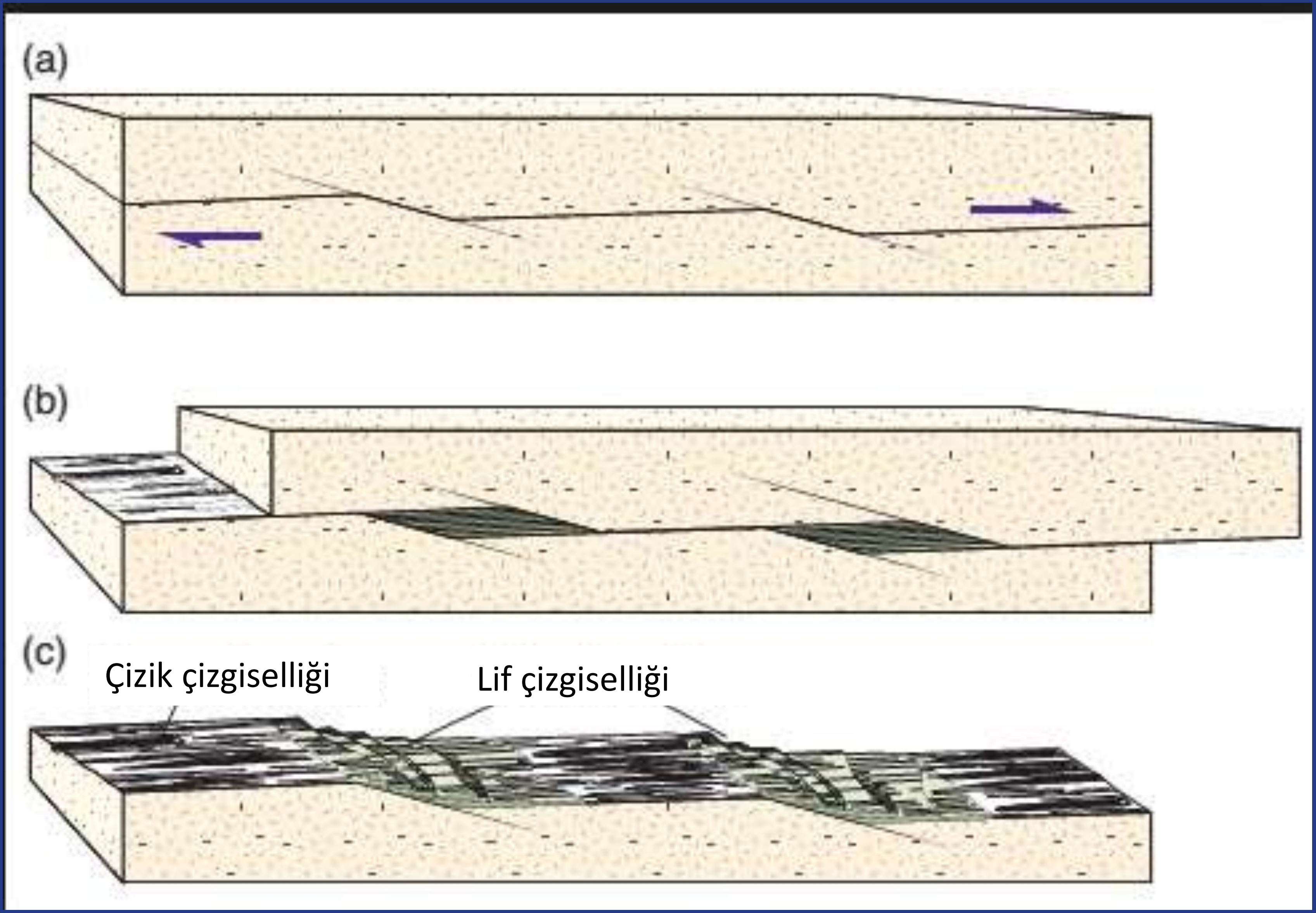


Fay çiziğinin içinde onu oluşturan “âlet”. Çizik içerisinde âletin bulunması fayın hareket yönü hakkında bilgi verir

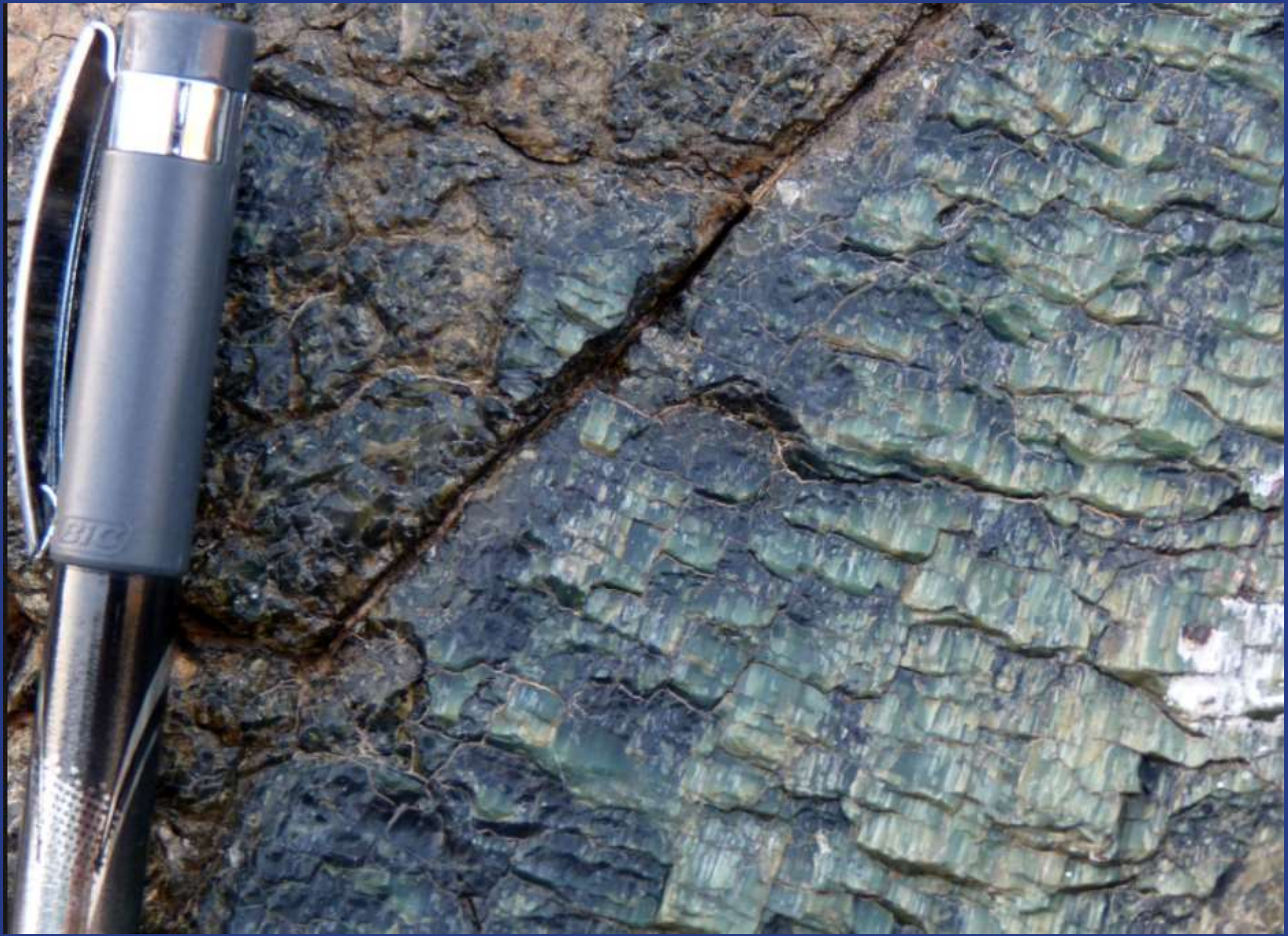
Bir fay aynası üzerinde çizikler ve kayma kertikleri.
Bu fay düzleminin üzerindeki blok sağa doğru hareket etmiştir.

Bir fay düzleminde fay kertikleri

Kalsit dolguları. Bunlar kayma kertikleriyle karıştırılmamalıdır. Bunlar da faylarda hareket yönünü gösterirler.



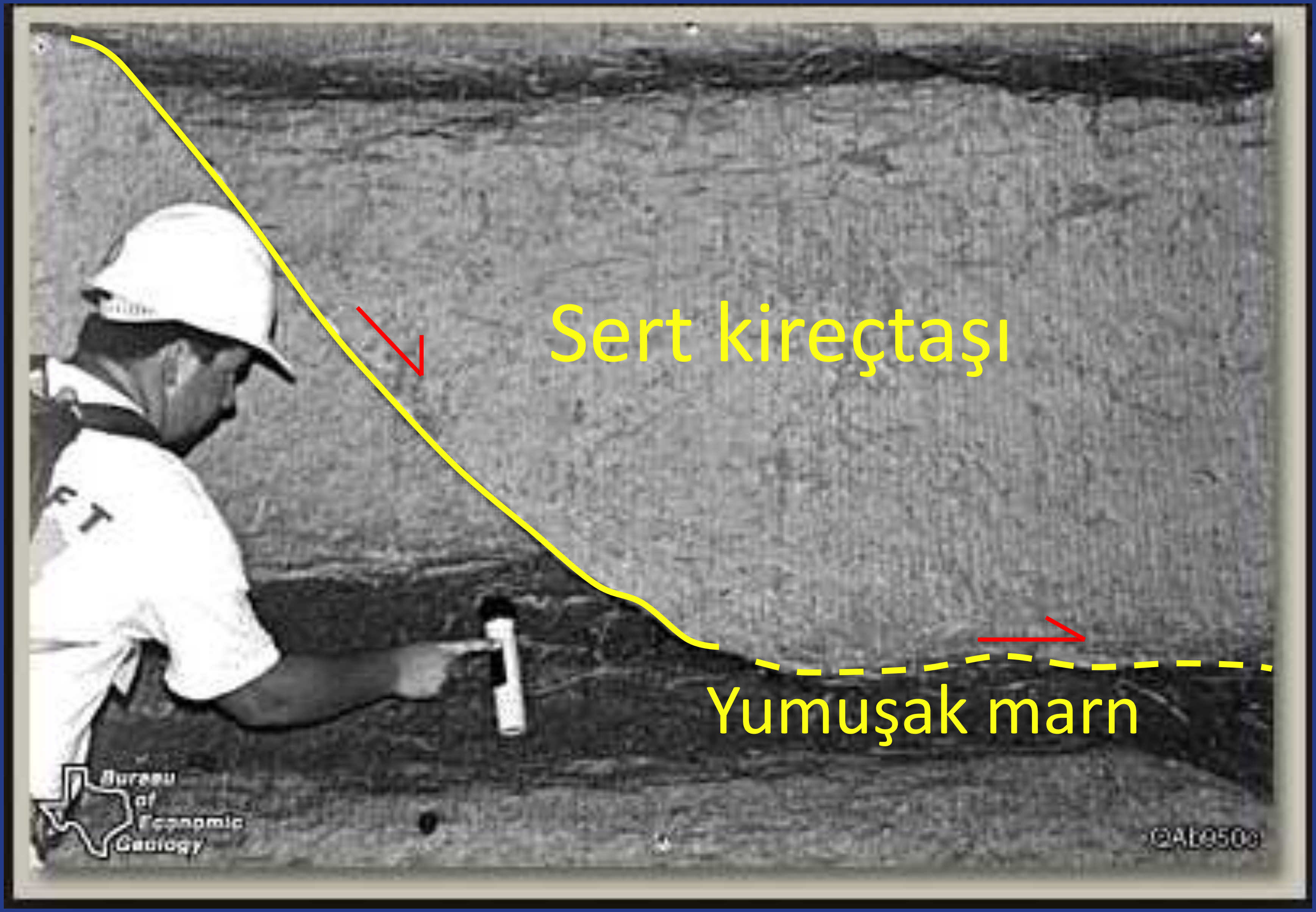
Bir fay düzlemi üzerinde kalsit dokularının kertiklerin yarattığı boşluklarda oluşması



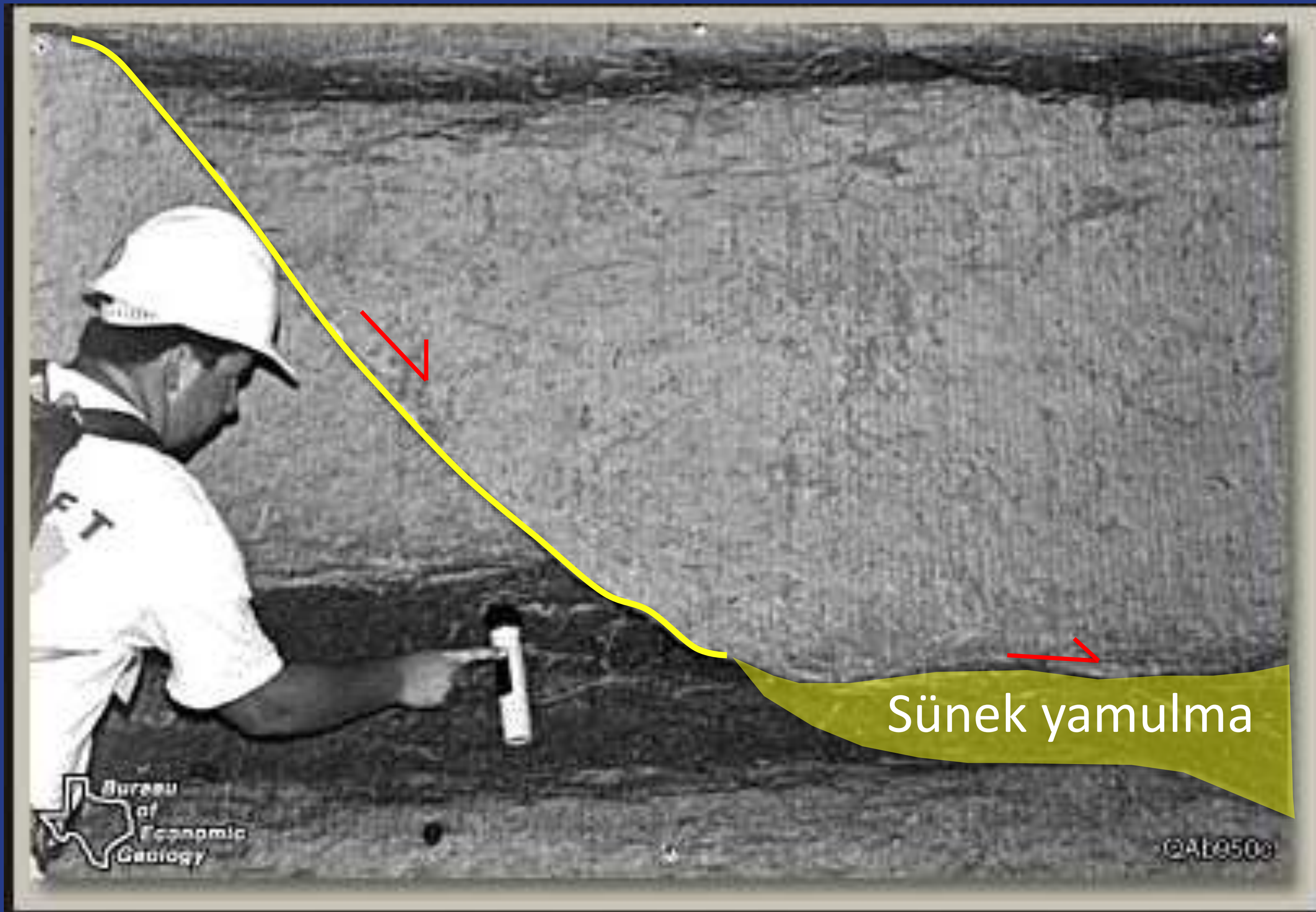
Serpantin içerisinde fay kertikleri. Kertikler önünde serpantin mineralleri büyümüştür. Görülen çizgisellikler serpantin lifleridir. Umman.

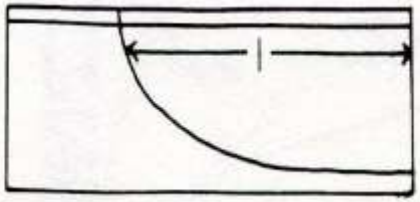
Burhaniye güneyinde listrik normal faylarla sınırlanmış bir horst

Austin Tebeşir Formsyonunun alt kesiminde listrik bir normal fay

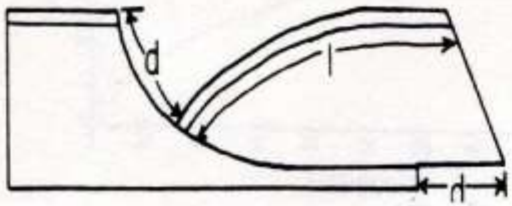


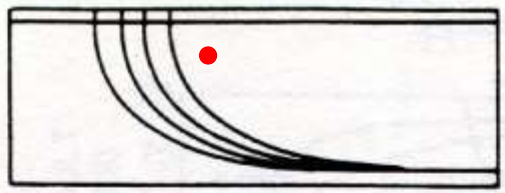
Sert kireçtaşı
Yumuşak marn
Bureau of Economic Geology


Sünek yamulma
Bureau of Economic Geology

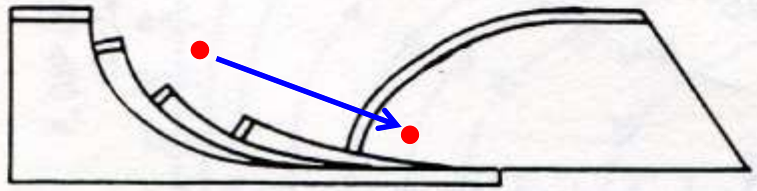


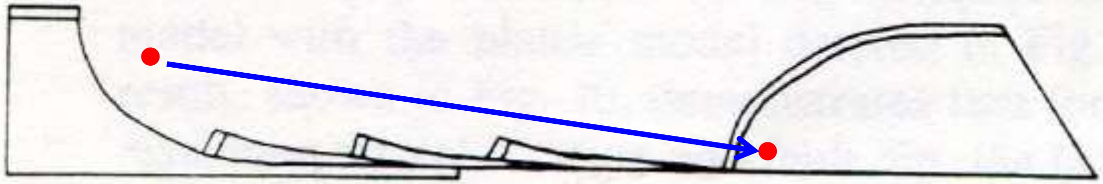
Tek listrik eğim atımlı normal fay





Bir takım listrik eğim atımlı normal fay

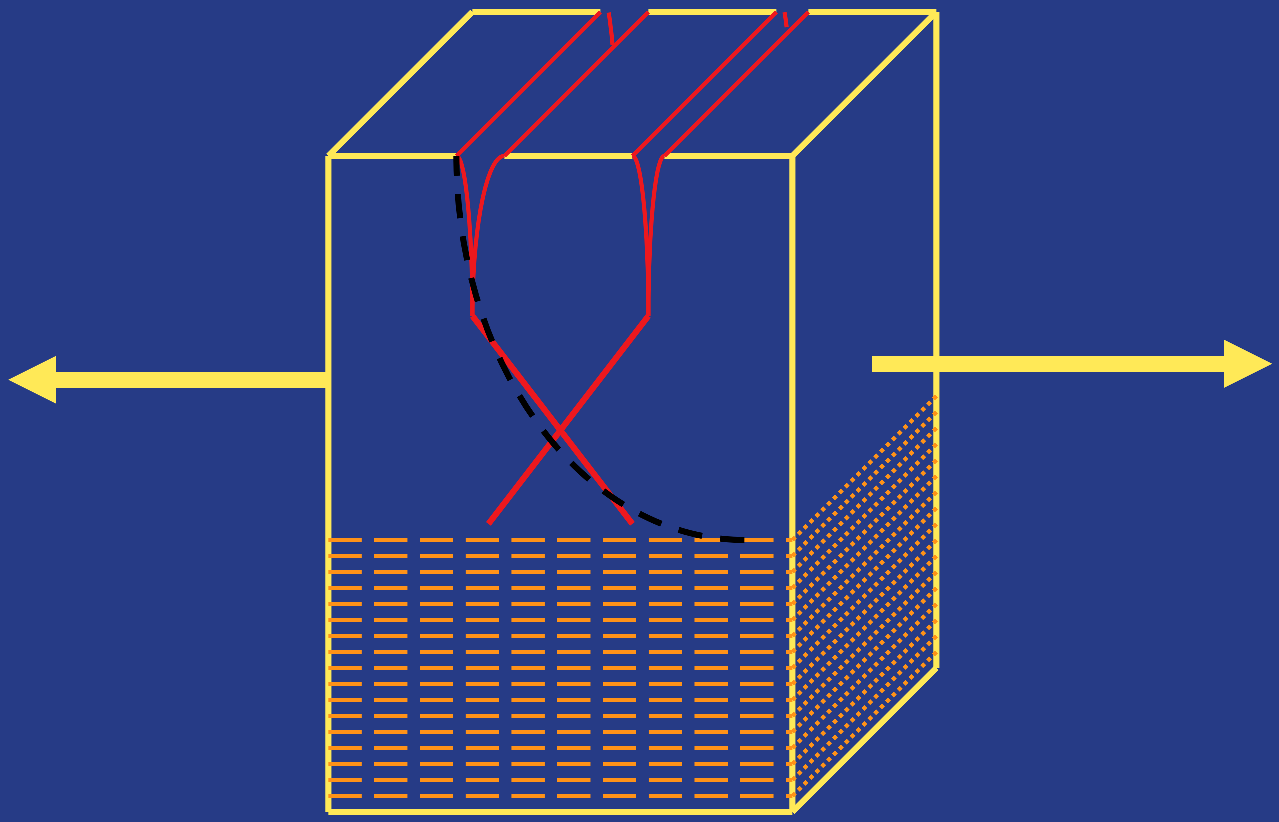




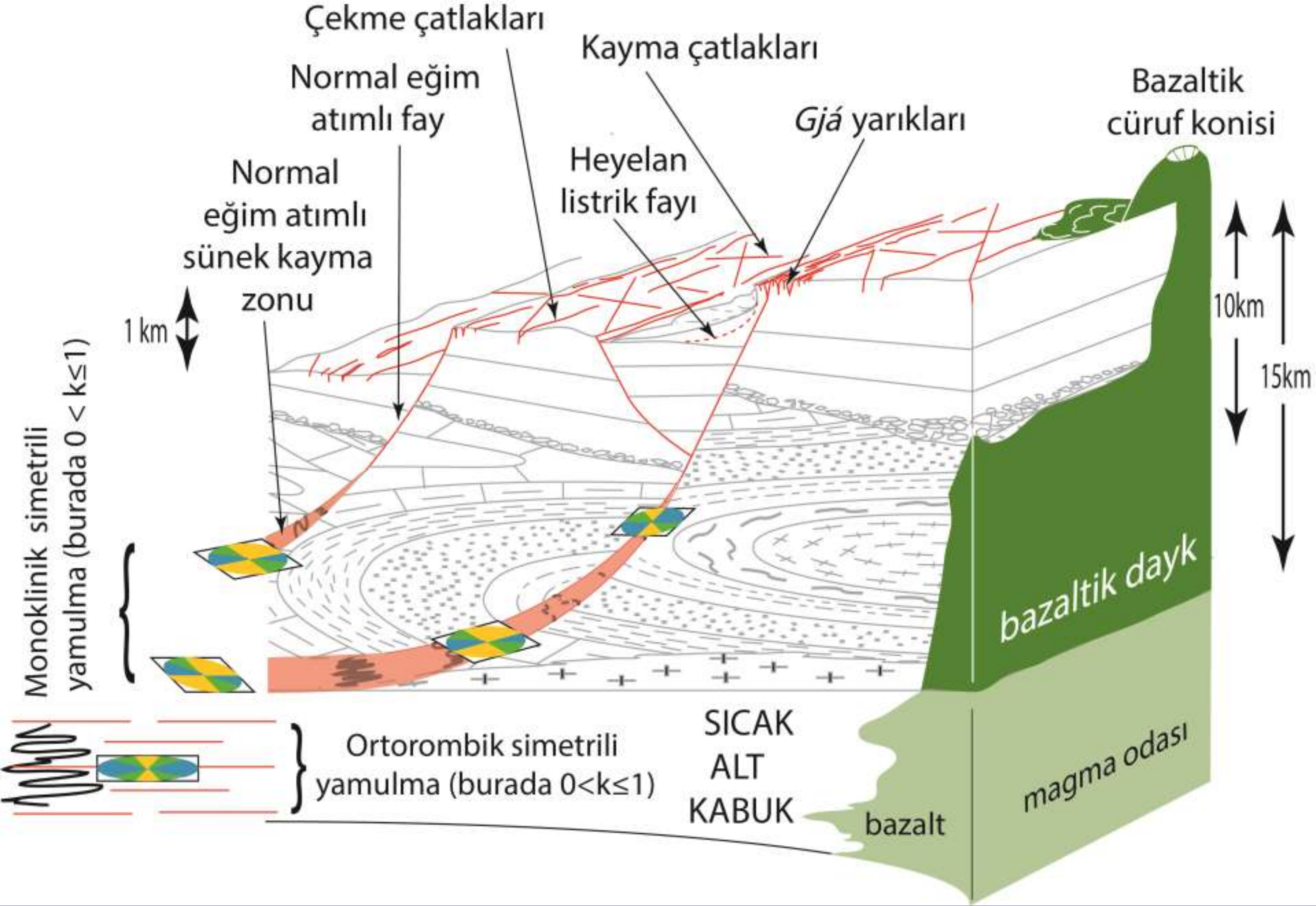
Listrik faylar, eğimleri eğim yönünde azalan faylardır. Bunlar normal eğim atımlı veya ters eğim atımlı olabilir; hattâ bazı yanal atımlı faylar bile belli bir listrisite (yani listrik olma özelliği) gösterebilirler.

Listrik fay terimi ilk defa 1909'da Eduard Suess tarafından, meşhur eseri *Das Antlitz der Erde*'nin (Arz'ın Çehresi) 4. cildinde jeolojiye sokulmuştur.

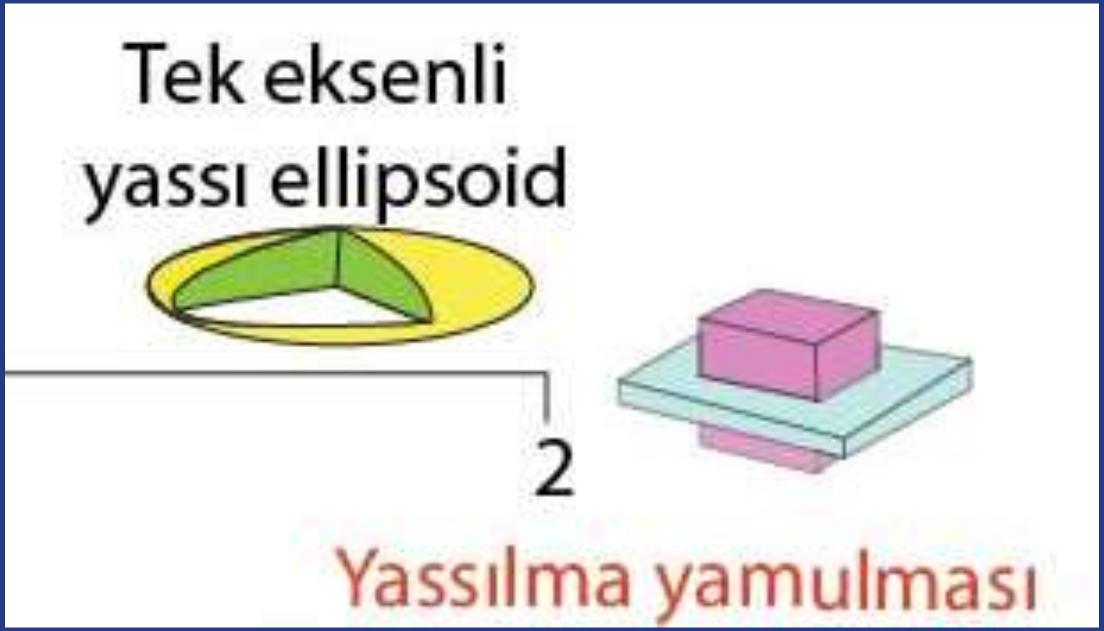
Listrik terimi, Eski Yunanca λίστρον (listron) = kürek kelimesinden türetilmiştir "kürek şekilli" anlamına gelir.

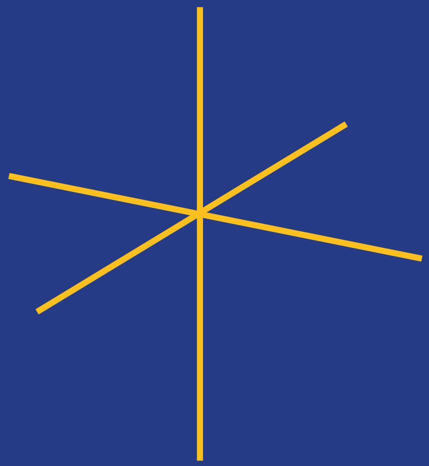


Listrik normal faylar niçin olmak zorundadırlar?



Büyük bir listrik eğim atımlı normal fay sistemi





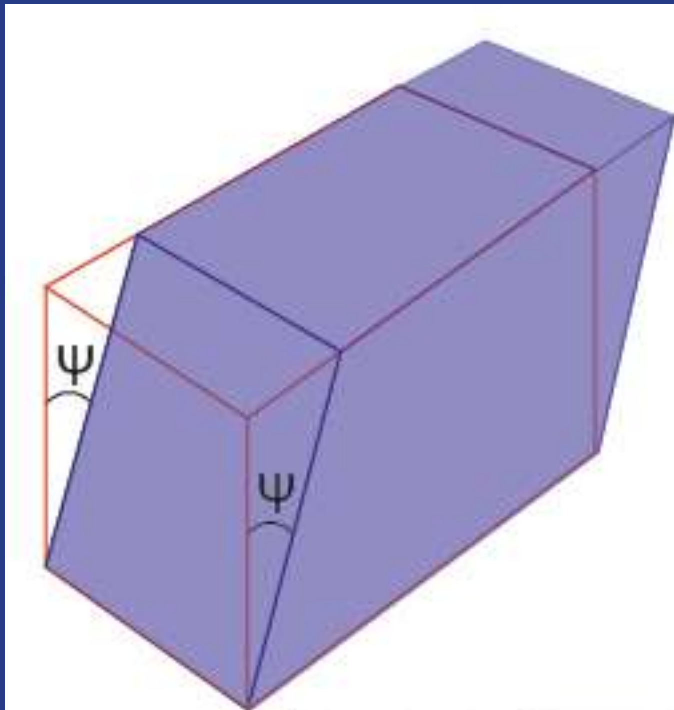
Bütün eksenler
birbirine dik

Ortorombik simetrili yamulma (saf kayma yamulması)

ῥόμβος (rombos) = dönen şey

Geometride romb her kenarı
birbirine eşit dörtgen anlamına gelir

όρθιος (ortios) = dik, düz, doğru

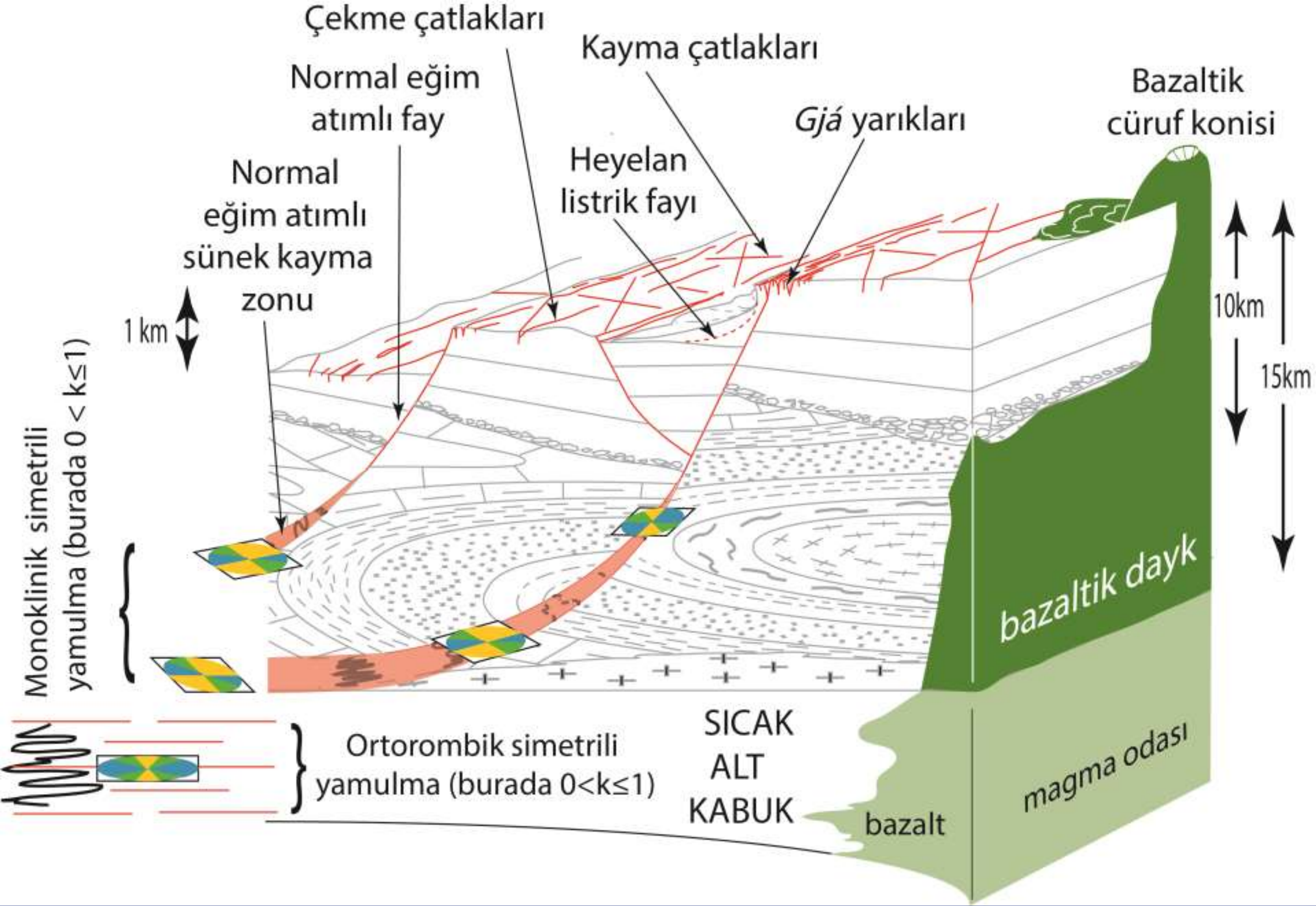


İki eksen birbirine dik, geri kalan eksen onların oluşturduğu düzleme eğimli

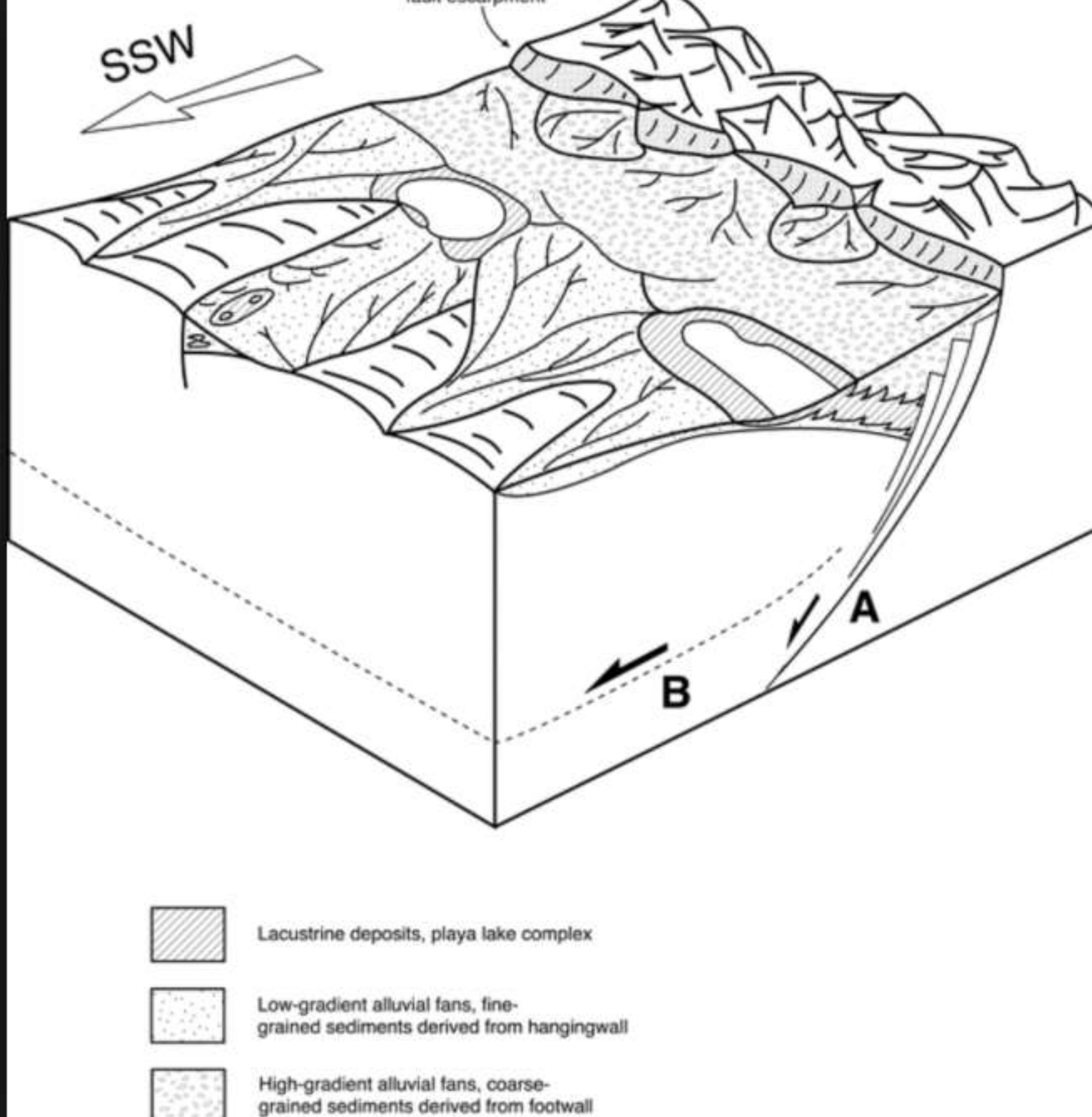
Monoklinik simetrili yamulma (basit kayma yamulması)

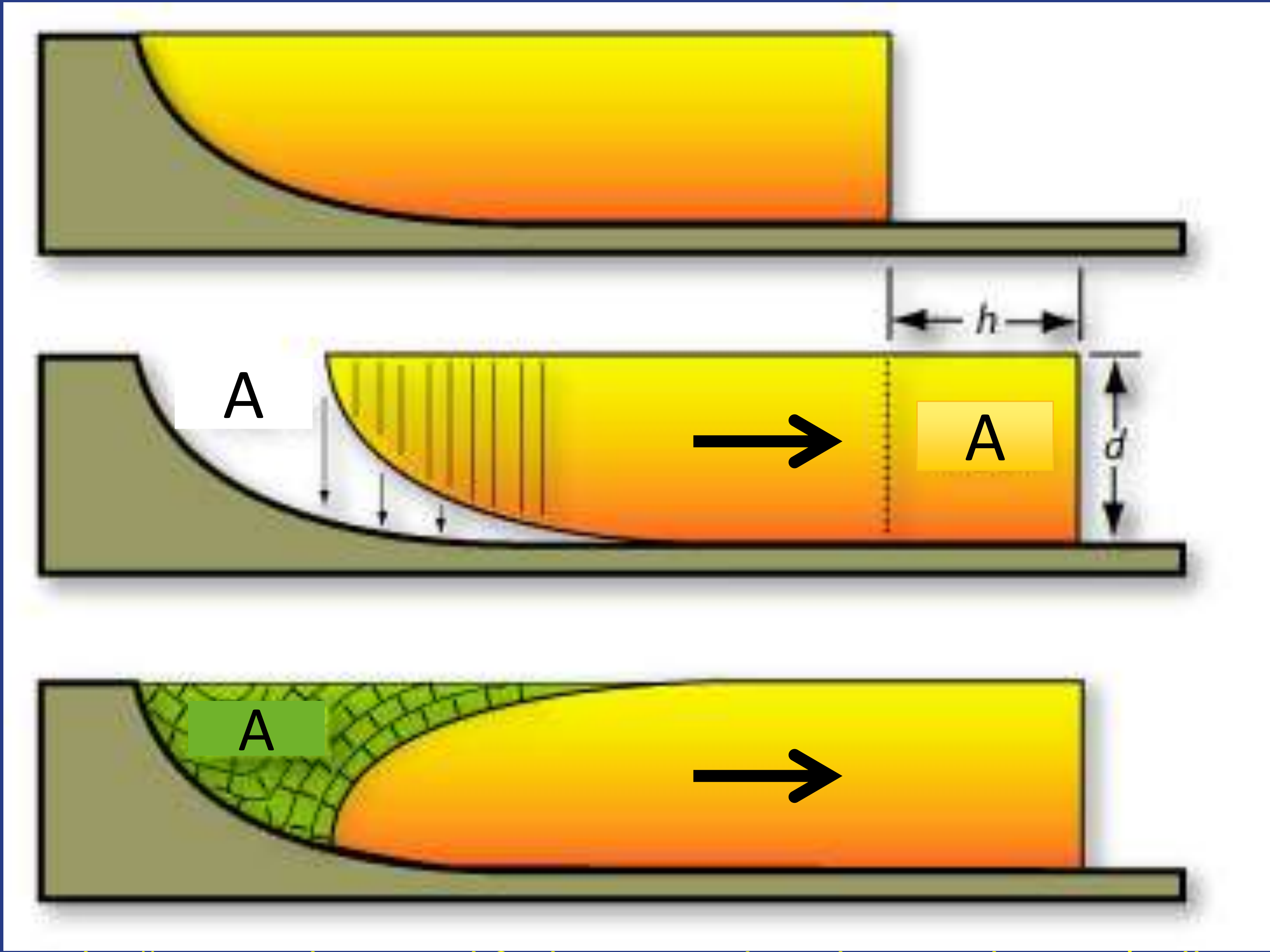
μονό (mono) = tek

κλίνω (klino) = eğim



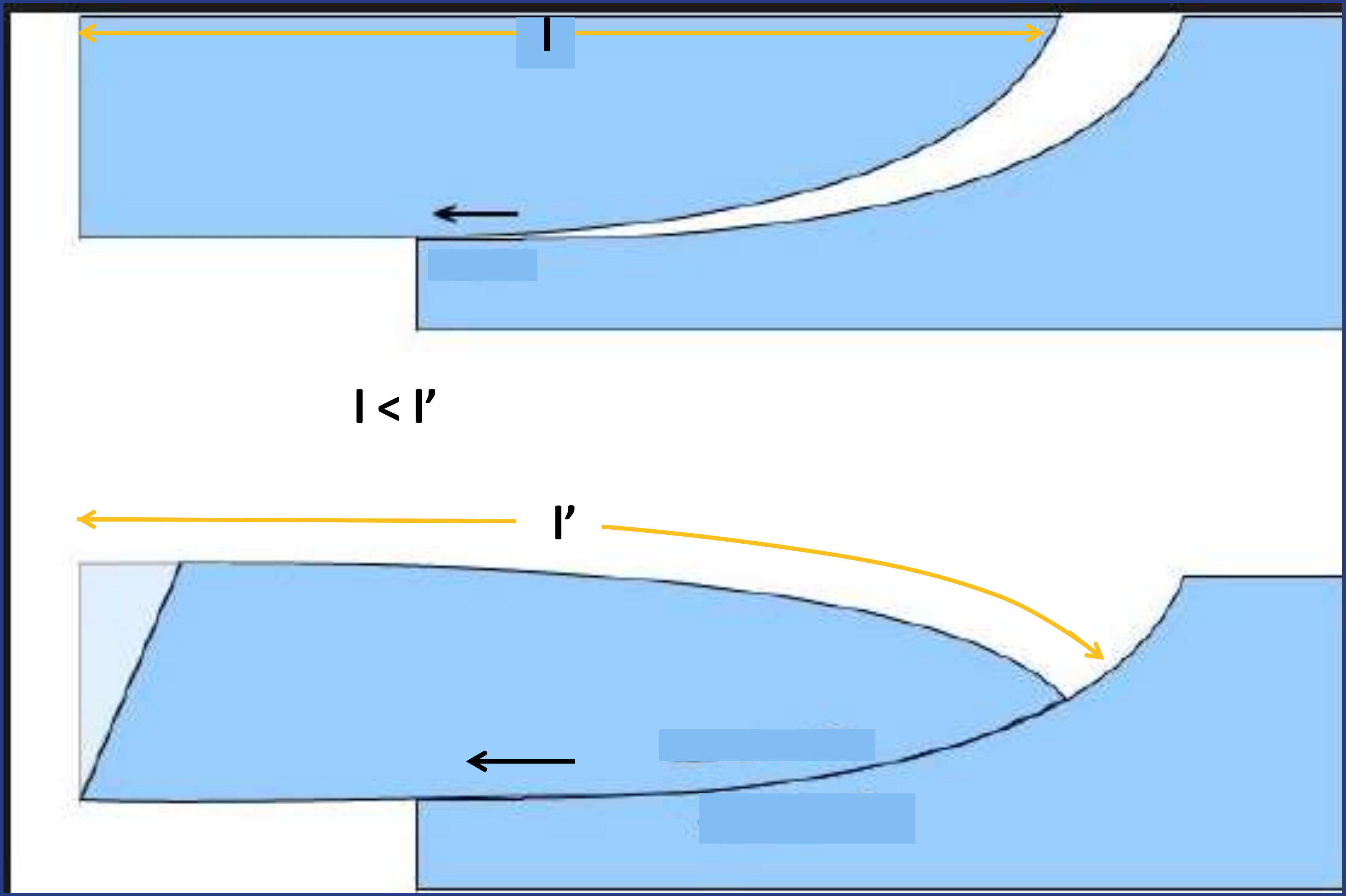
Büyük bir listrik eğim atımlı normal fay sistemi


SSW
A
B
Lacustrine deposits, playa lake complex
Low-gradient alluvial fans, fine-grained sediments derived from hangingwall
High-gradient alluvial fans, coarse-grained sediments derived from footwall

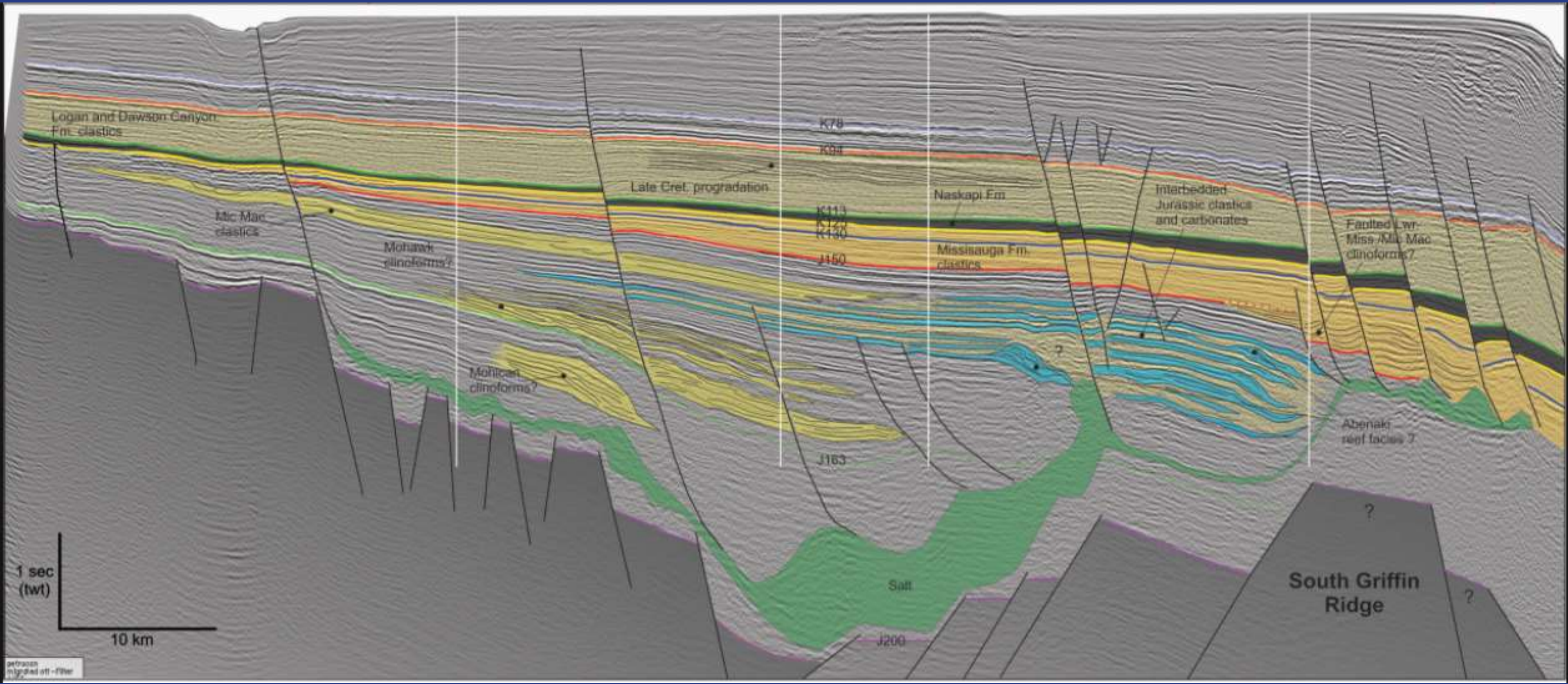


Listrik eğim atımlı normal faylanma nedeniyle yuvarlanma (*rollover*) antiklinalinin ve onunla ilgili senklinalinin oluşumu.

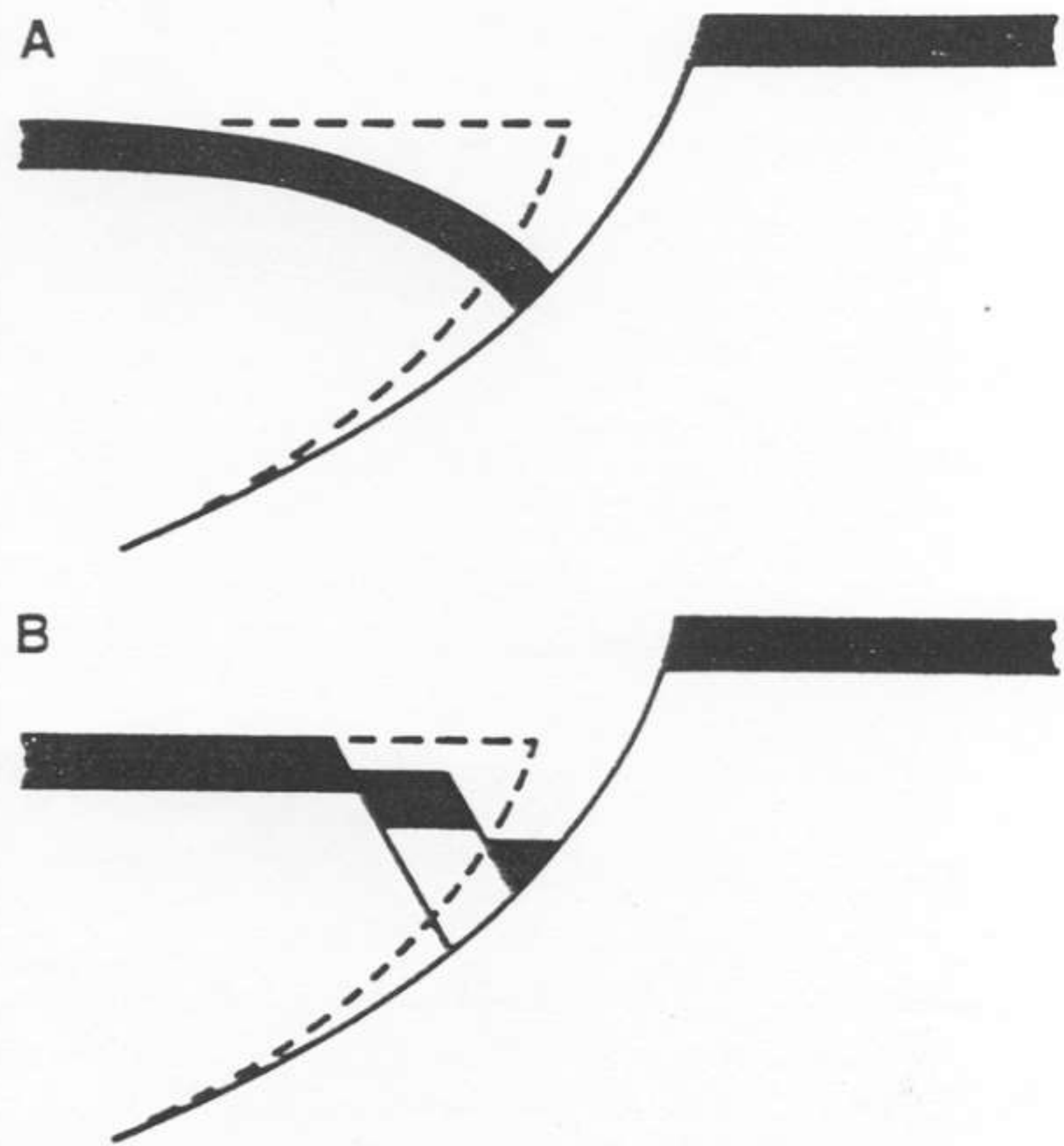
Bir eğim atımlı normal listrik fay üzerinde gelişen bir yuvarlanma antiklinalinin bir kısmı.

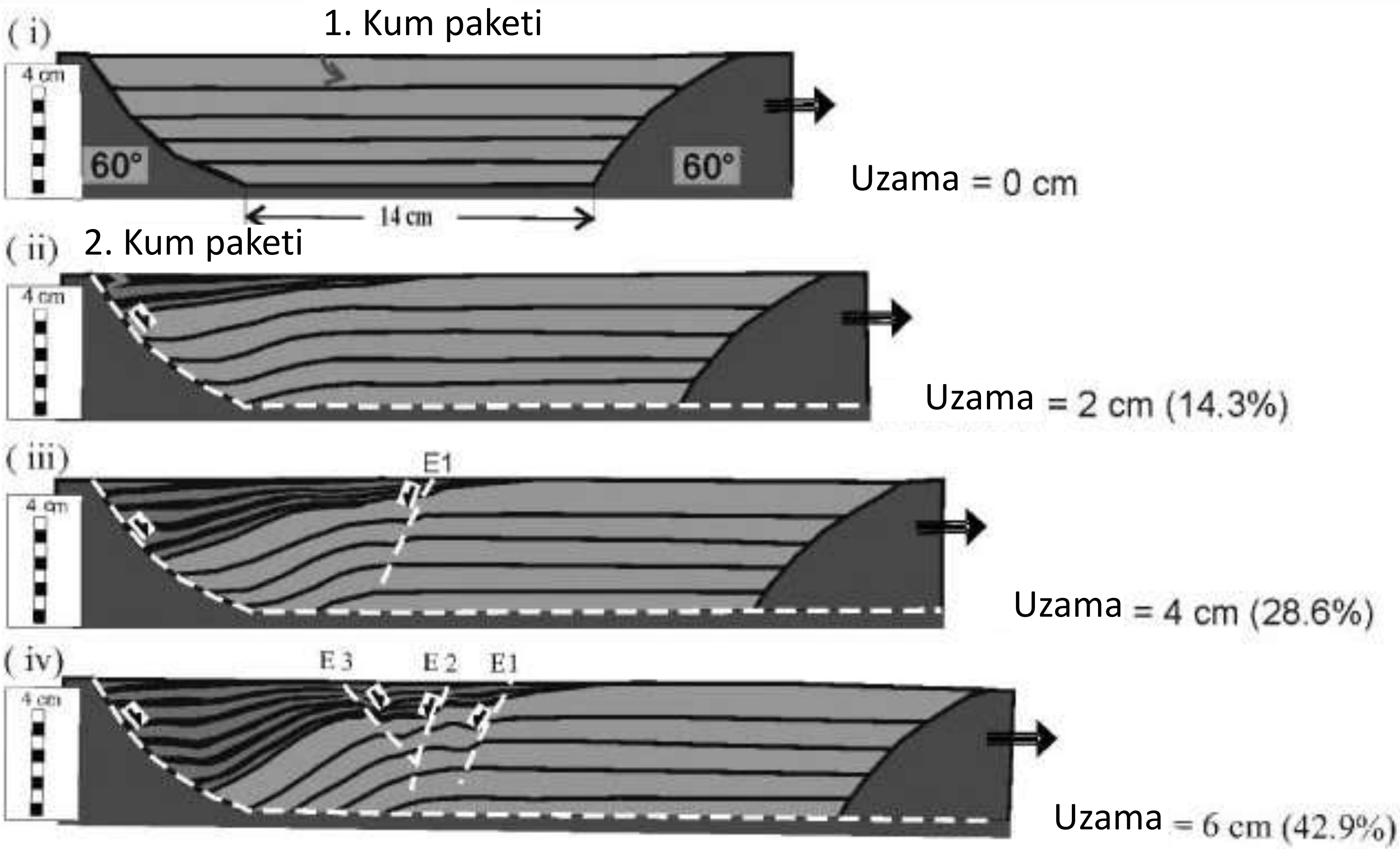


Eğim atımlı normal listrik faylarla ilişkili yuvarlanma antiklinalleri, tavan bloku üzerinde uzamaya neden olurlar

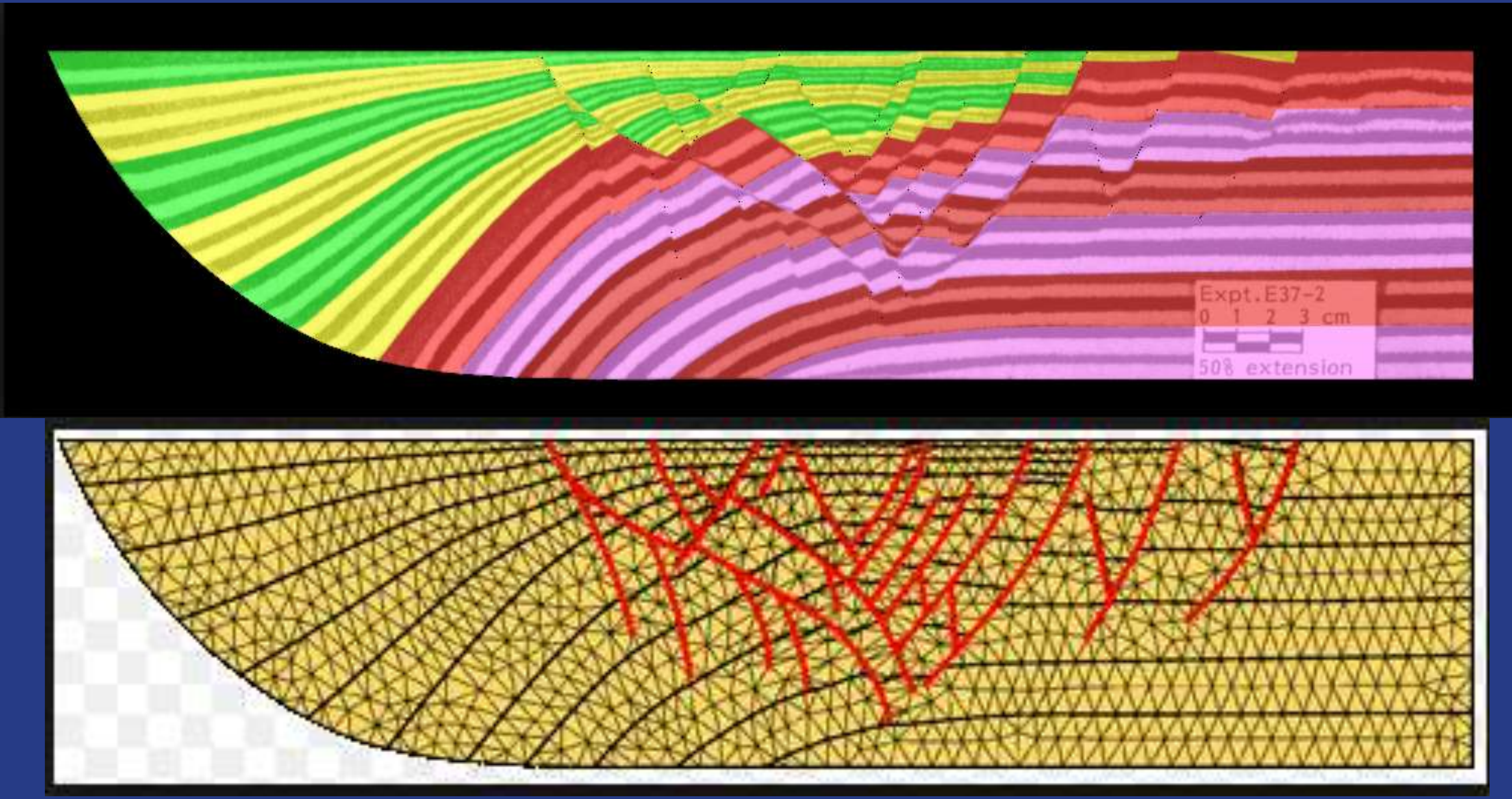


Kanada’da Atlantik Okyanusu kıt’a kenarında gelişmiş bir yuvarlanma antiklinalinin üst kesimi. Burada “antiklinalin” yuvarlanırken nasıl faylarla parçalandığına dikkat ediniz.

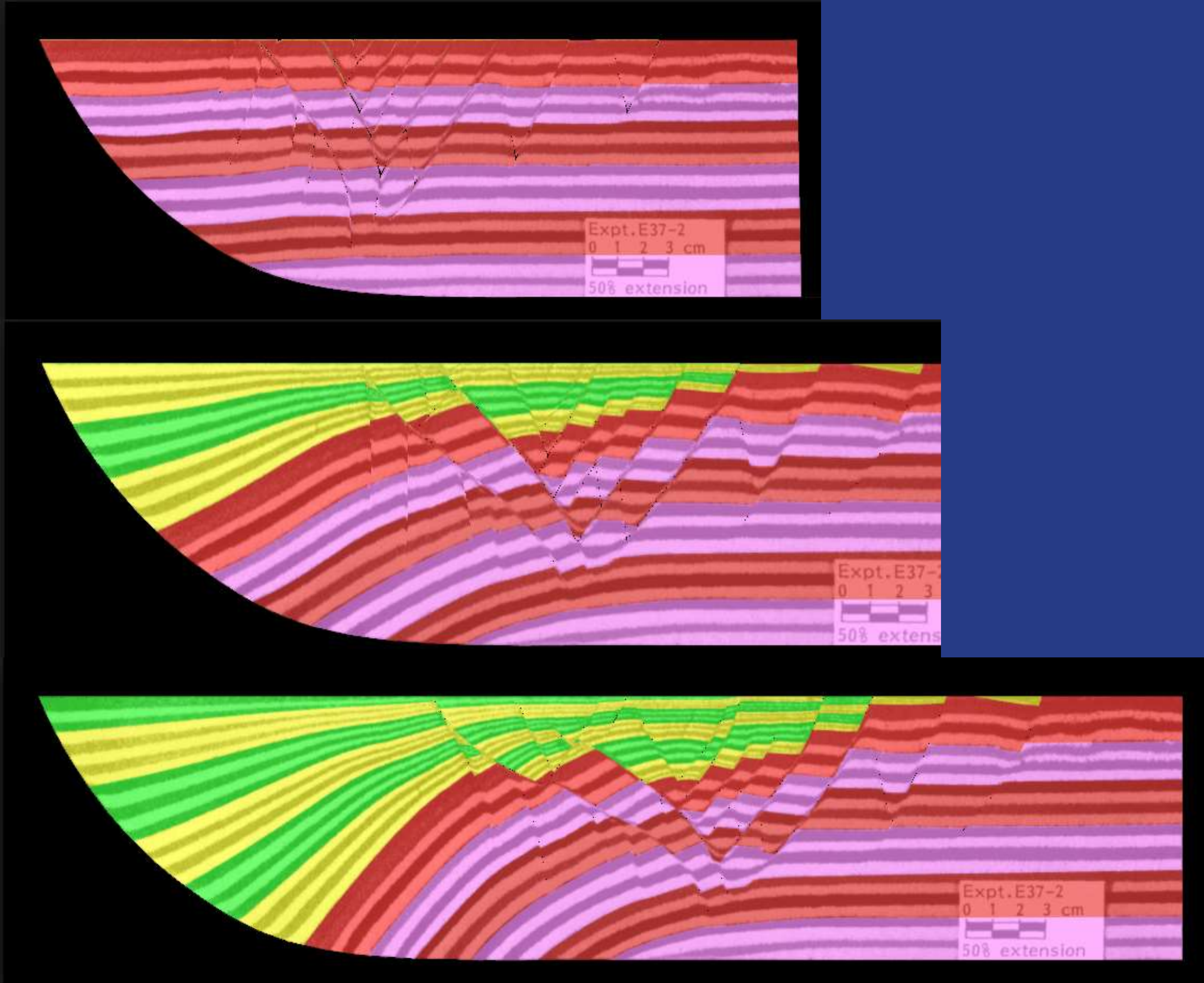

A
B



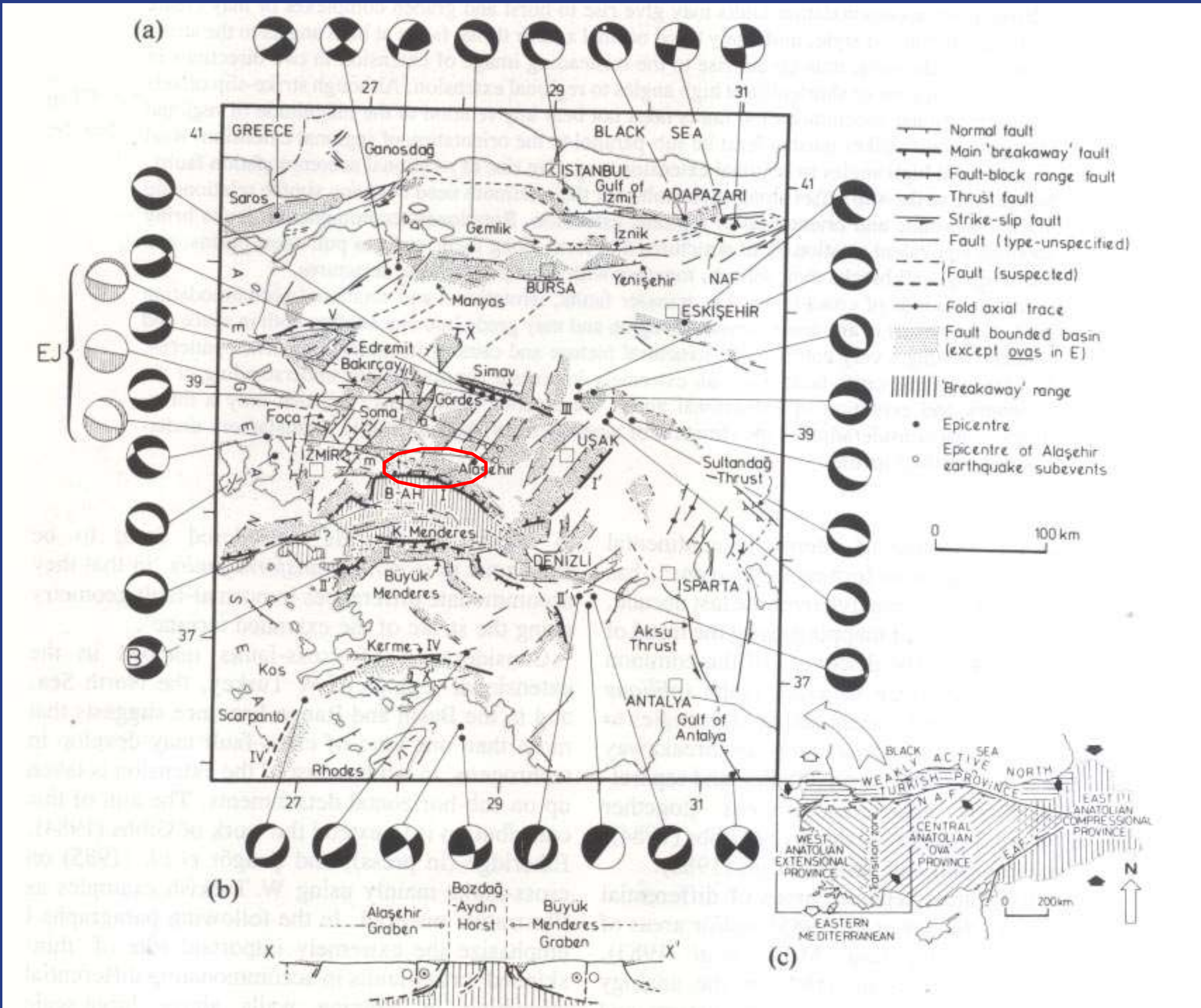
Listrik eğim atımlı normal fay üzerinde gelişmiş bir yuvarlanma antiklinali üzerinde meydana gelen faylanmanın deneysel olarak gösterilmesi. Deneyler kum paketleriyle yapılmıştır.



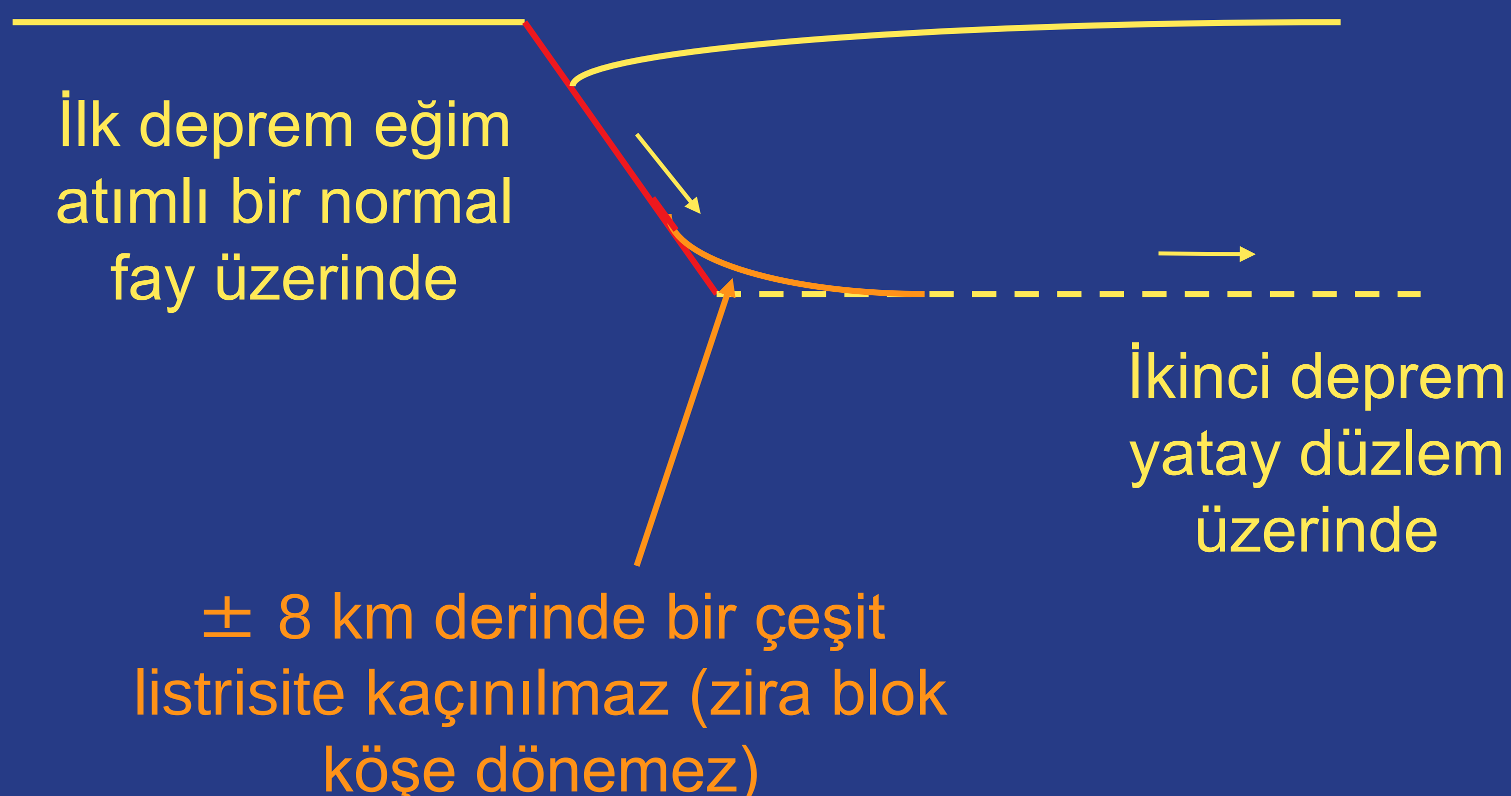
Bir ana listrik eğim atımlı normal fay üzerinde gelişen ikincil normal faylar

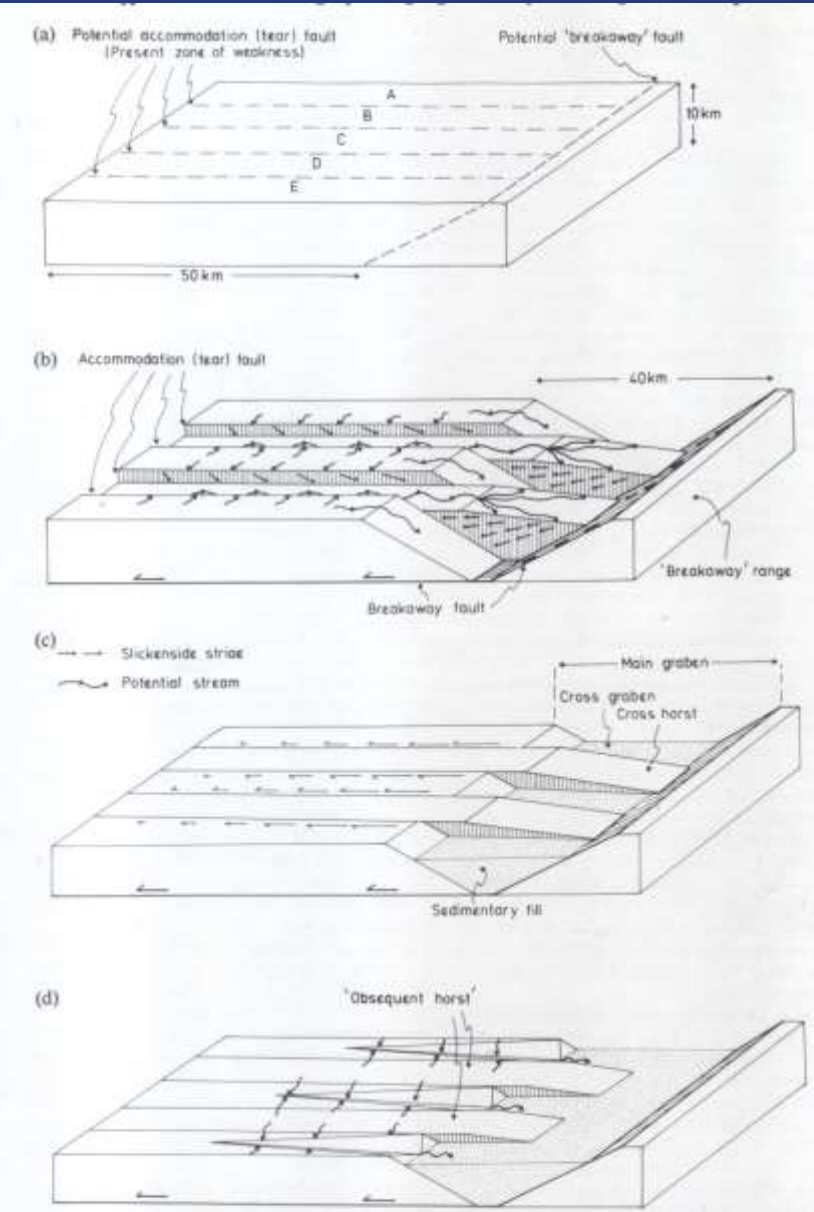

Expt.E37-2
0 1 2 3 cm
50% extension
Expt.E37-2
0 1 2 3 cm
50% extension

Kum kutusu deneyleri için gereken araçlar: Bunlar herkesin evde bile yapabileceği türden şeylerdir.

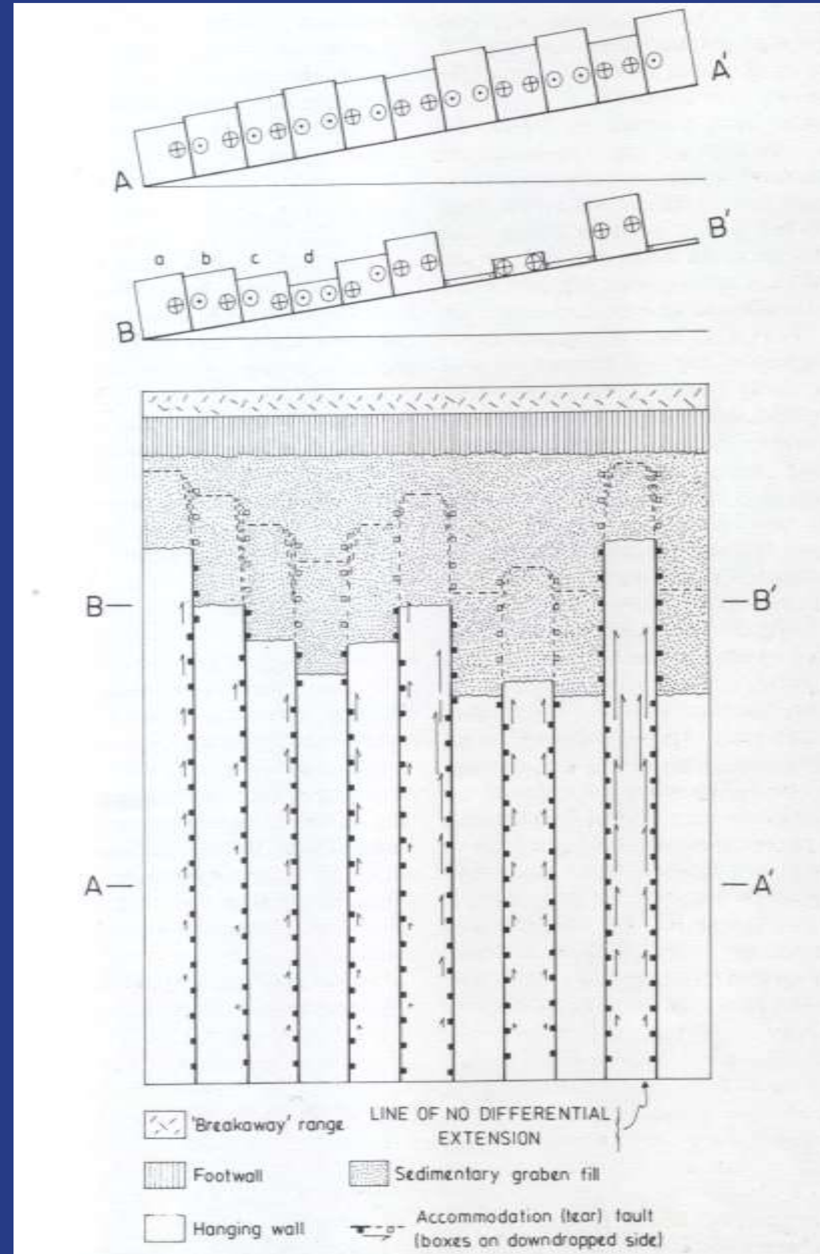

(a)
(b)
(c)
GREECE
BLACK SEA
Ganosdağ
Saros
ISTANBUL
Gulf of Izmit
ADAPAZARI
Gemlik
İznik
BURSA
Yenişehir
NAF
ESKİŞEHİR
Manyas
Edremit
Bakırçay
Simav
Gordes
Soma
Foça
İZMİR
Alaşehir
B-AH
UŞAK
Sultandağ Thrust
K. Menderes
DENİZLİ
Büyük Menderes
ISPARTA
Aksu Thrust
Kerme
Kos
ANTALYA
Gulf of Antalya
Scarpanto
Rhodes
EJ
Normal fault
Main 'breakaway' fault
Fault-block range fault
Thrust fault
Strike-slip fault
Fault (type-unspecified)
Fault (suspected)
Fold axial trace
Fault bounded basin (except ovas in E)
'Breakaway' range
Epicentre
Epicentre of Alaşehir earthquake subevents
0 100 km
Alaşehir Graben
Bozdağ-Aydın Horst
Büyük Menderes Graben
X
X'
BLACK SEA
WEAKLY ACTIVE NORTH TURKISH PROVINCE
N.A.F.
WEST ANATOLIAN EXTENSIONAL PROVINCE
Transition zone
CENTRAL ANATOLIAN 'OVA' PROVINCE
EAST ANATOLIAN COMPRESSIONAL PROVINCE
E.A.F.
EASTERN MEDITERRANEAN
0 200km
N

28 Mart 1969 Alaşehir depremi

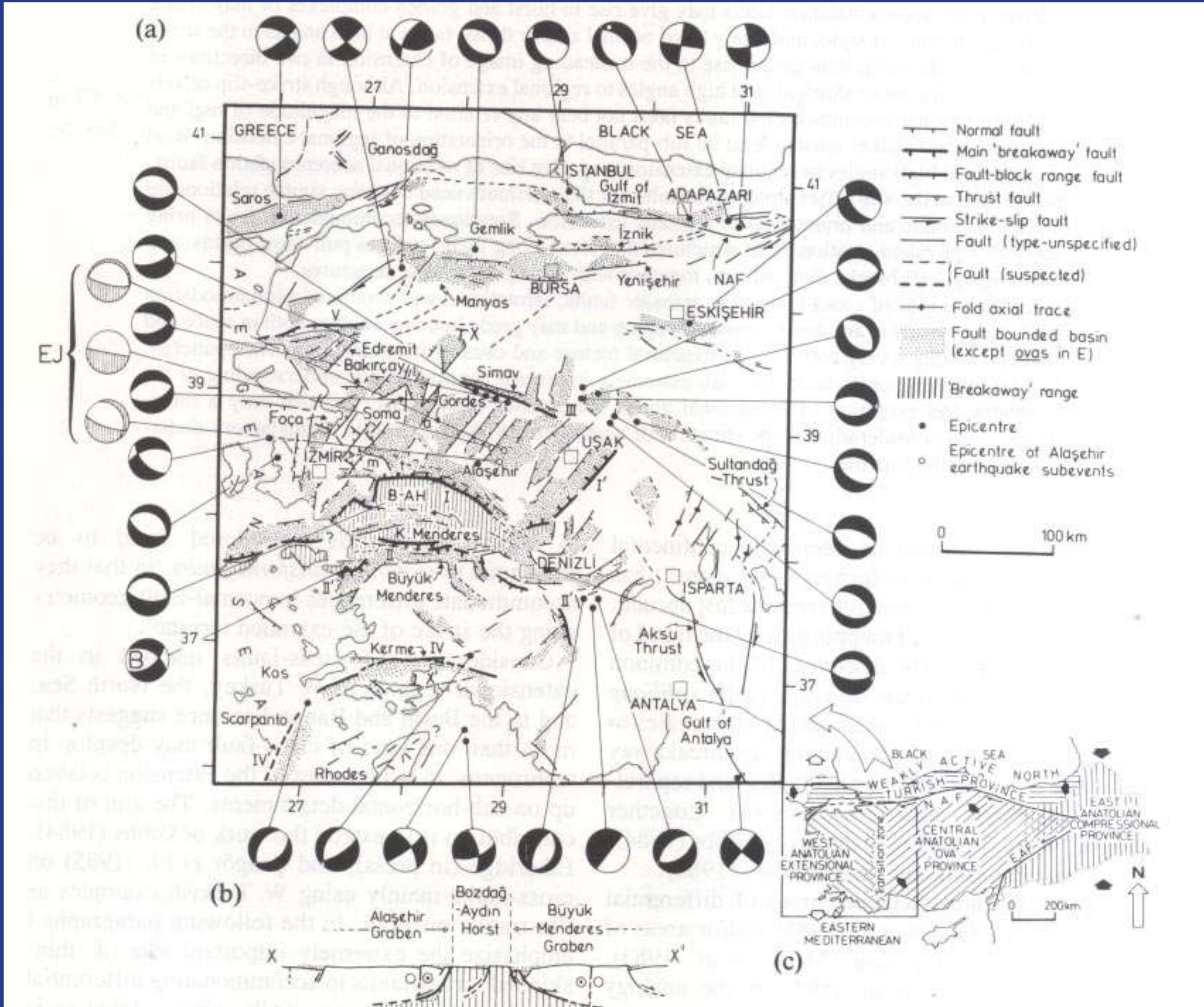




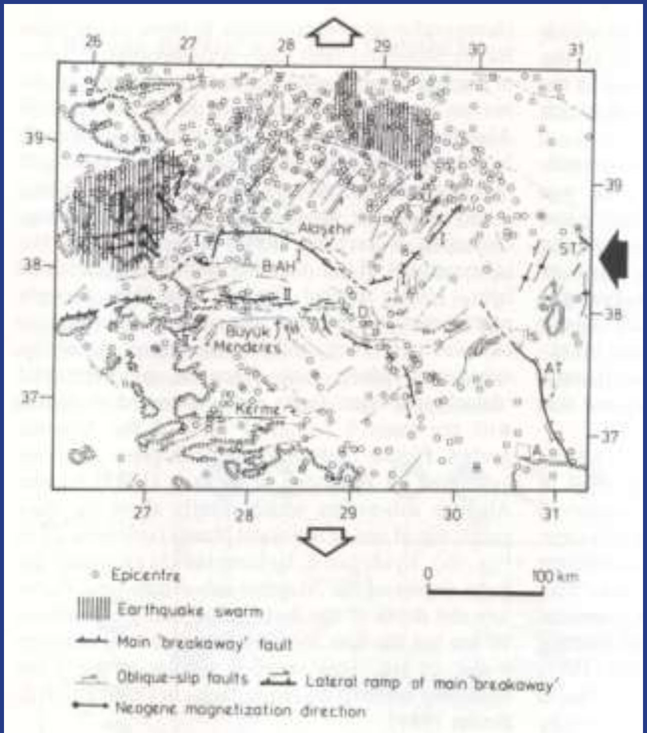
(a) Potential accommodation (tear) fault
(Present zone of weakness)
Potential 'breakaway' fault
A
B
C
D
E
10km
50km
(b) Accommodation (tear) fault
40km
'Breakaway' range
Breakaway fault
(c) Slickenside striae
Potential stream
Main graben
Cross graben
Cross horst
Sedimentary fill
(d)
'Obsequent horst'

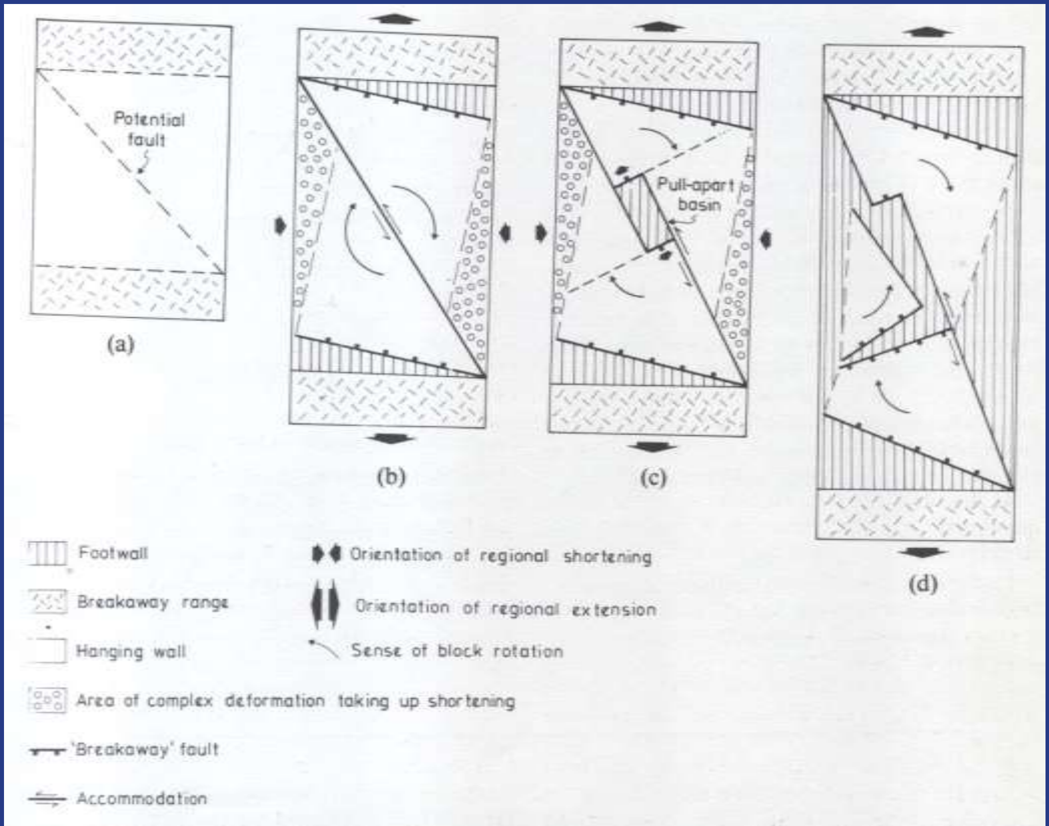


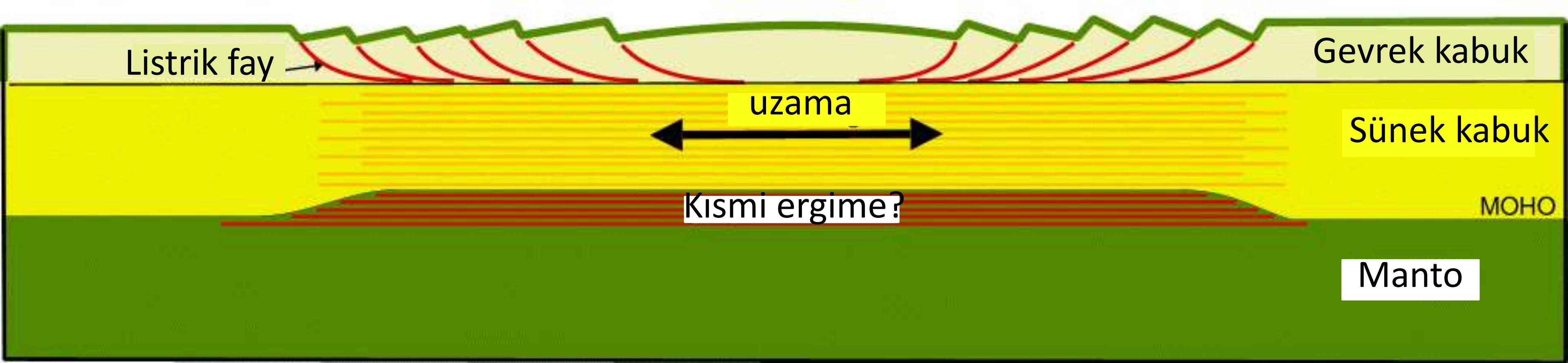
A
A′
B
B′
a
b
c
d
B—
—B′
A—
—A′
'Breakaway' range
LINE OF NO DIFFERENTIAL EXTENSION
Footwall
Sedimentary graben fill
Hanging wall
Accommodation (tear) fault
(boxes on downdropped side)

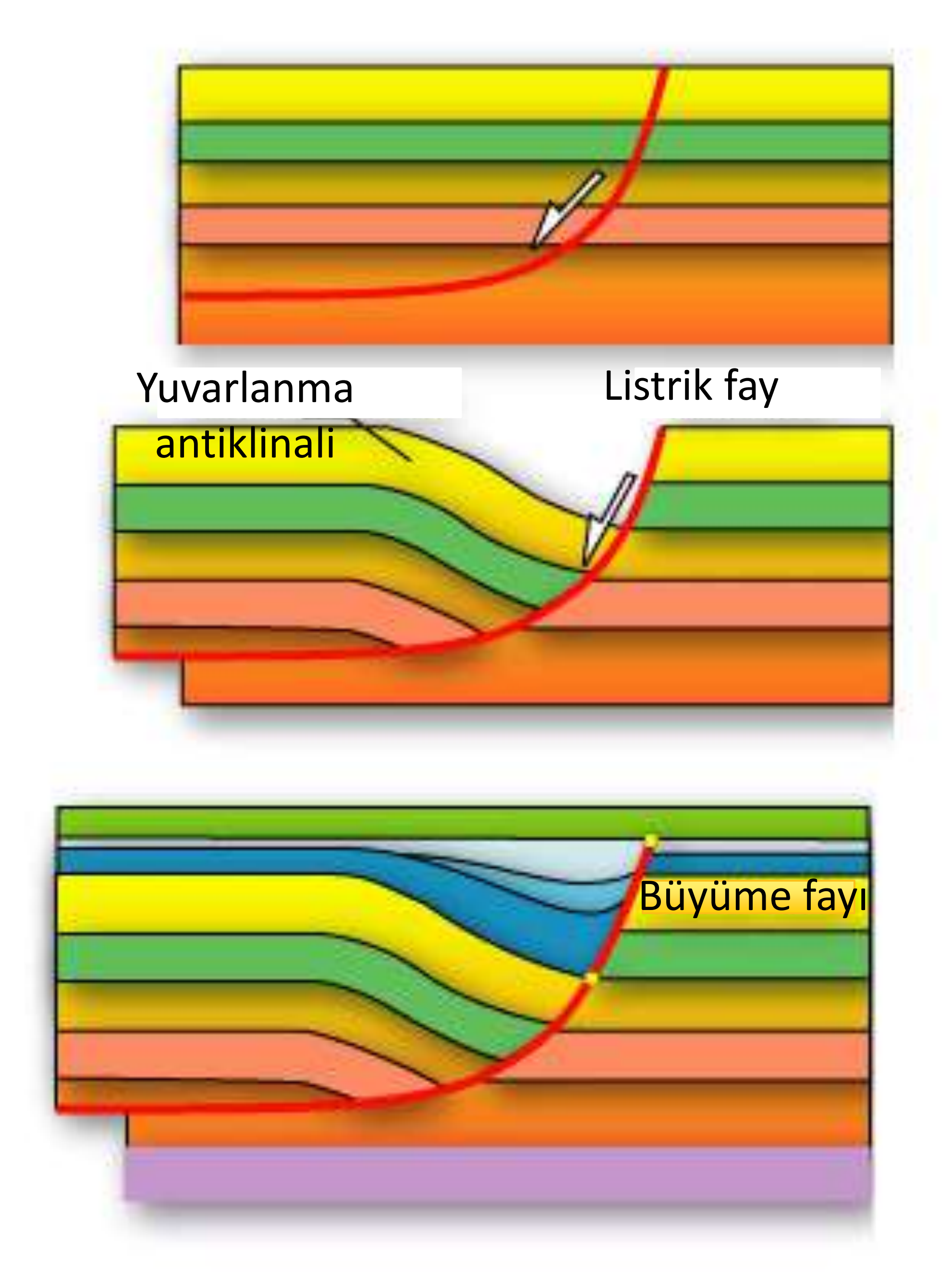


(a)
(b)
(c)
GREECE
BLACK SEA
ISTANBUL
Gulf of İzmit
ADAPAZARI
Ganosdağ
Saros
Gemlik
İznik
BURSA
Yenişehir
NAF
Manyas
ESKİŞEHİR
Edremit
Bakırçay
Simav
Gordes
Soma
Foça
İZMİR
Alaşehir
UŞAK
Sultandağ Thrust
B-AH
K. Menderes
Büyük Menderes
DENİZLİ
ISPARTA
Aksu Thrust
Kerme
Kos
Scarpanto
Rhodes
ANTALYA
Gulf of Antalya
EJ
Normal fault
Main 'breakaway' fault
Fault-block range fault
Thrust fault
Strike-slip fault
Fault (type-unspecified)
Fault (suspected)
Fold axial trace
Fault bounded basin (except ovas in E)
'Breakaway' range
Epicentre
Epicentre of Alaşehir earthquake subevents
0 100 km
Alaşehir Graben
Bozdağ Aydın Horst
Büyük Menderes Graben
X
X'
WEAKLY ACTIVE TURKISH PROVINCE
NORTH
NAF
EAST
EAST ANATOLIAN COMPRESSIONAL PROVINCE
WEST ANATOLIAN EXTENSIONAL PROVINCE
Transition zone
CENTRAL ANATOLIAN 'OVA' PROVINCE
EAF
EASTERN MEDITERRANEAN
N
0 200km


Alaşehir
B.AH
Büyük Menderes
Kerme
Epicentre
Earthquake swarm
Main 'breakaway' fault
Oblique-slip faults
Lateral ramp of main breakaway'
Neogene magnetization direction
0
100 km

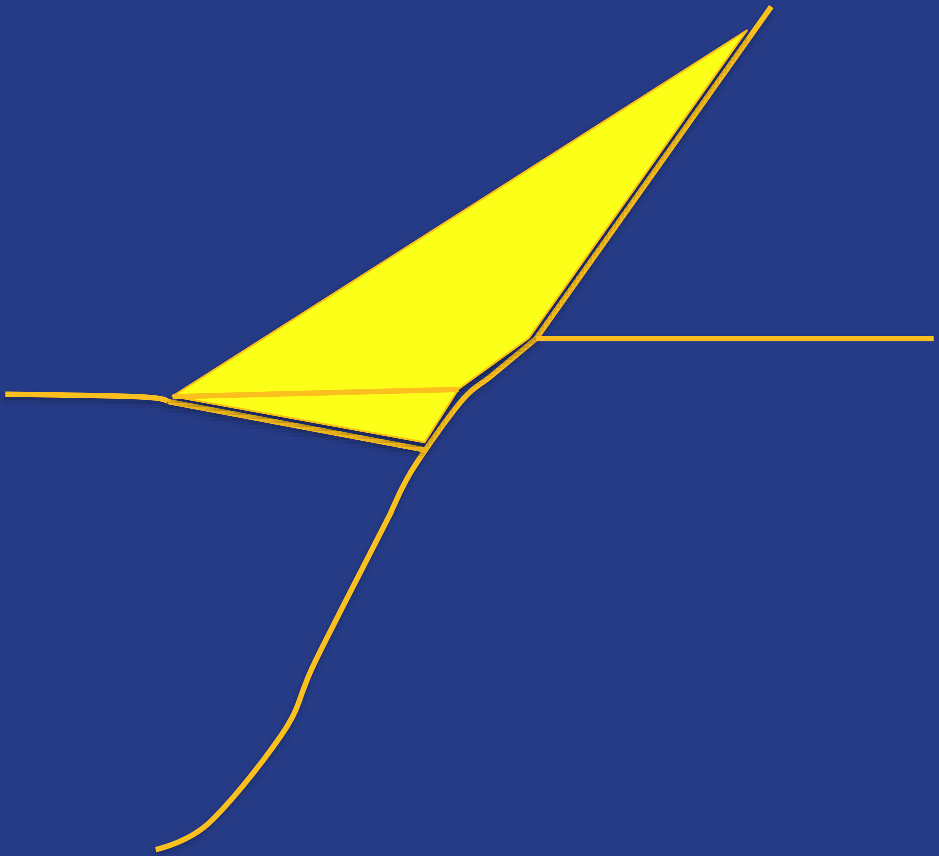

Potential fault
Pull-apart basin
(a)
(b)
(c)
(d)
Footwall
Breakaway range
Hanging wall
Area of complex deformation taking up shortening
'Breakaway' fault
Accommodation
Orientation of regional shortening
Orientation of regional extension
Sense of block rotation


Listrik fay
Gevrek kabuk
uzama
Sünek kabuk
Kısmi ergime?
MOHO
Manto

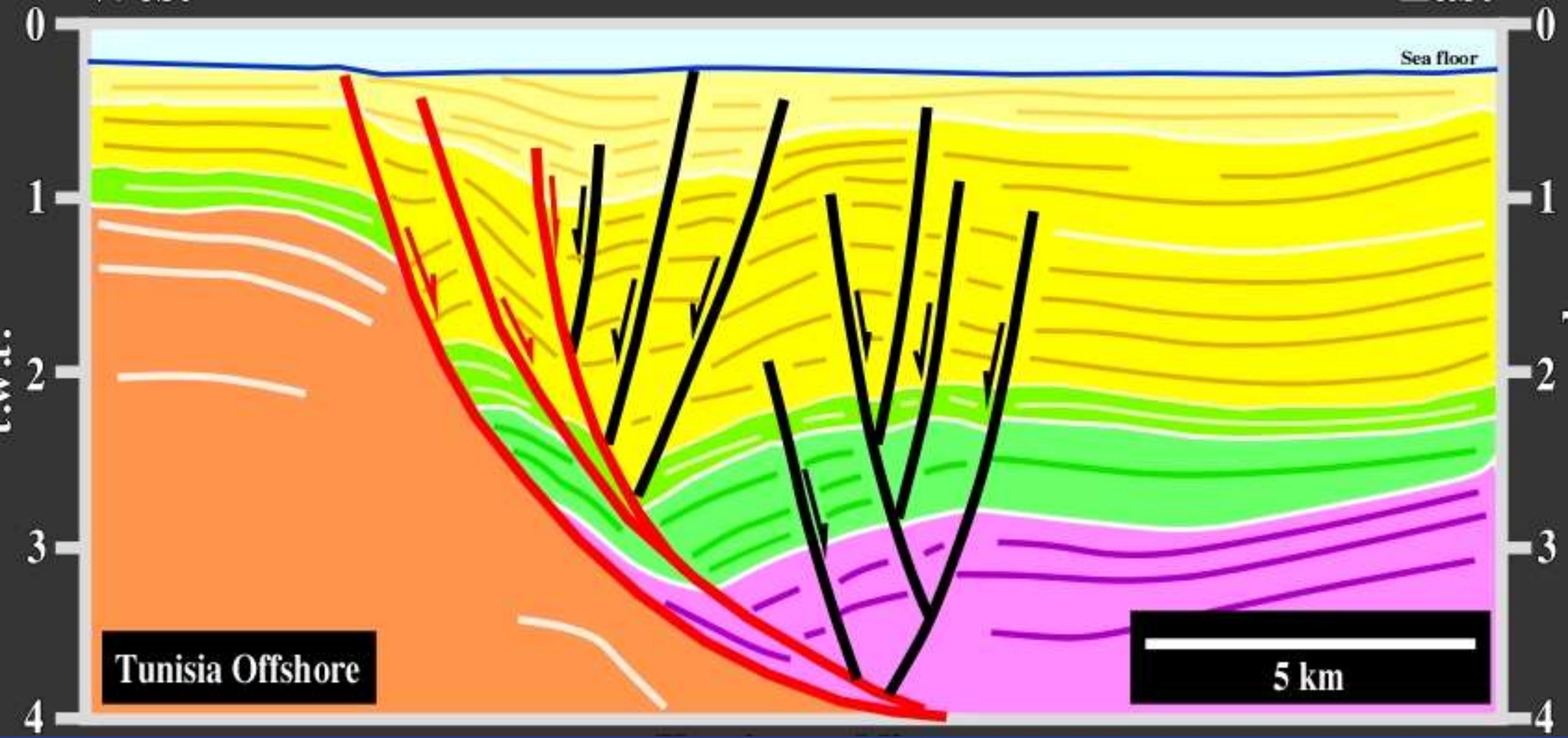


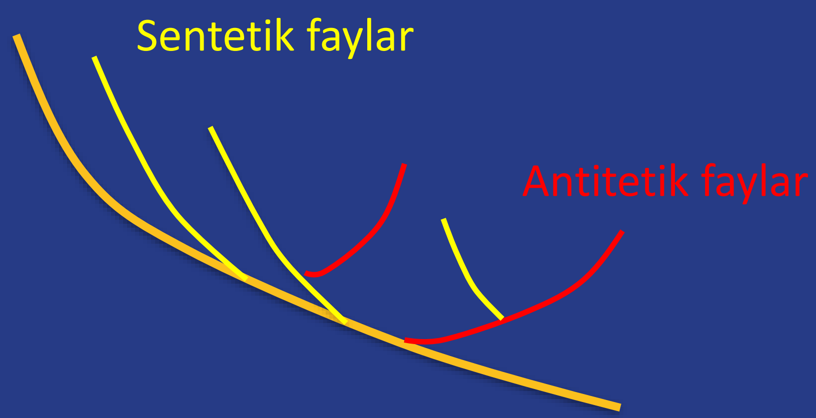
Listrik eğim atımlı normal faylanma esnasında büyüme fayları (“growth faults”) oluşursa, bu görüldüğü şekilde olur.

Yani çökelme (=sedimentasyon) faylanma esnasında sürer.

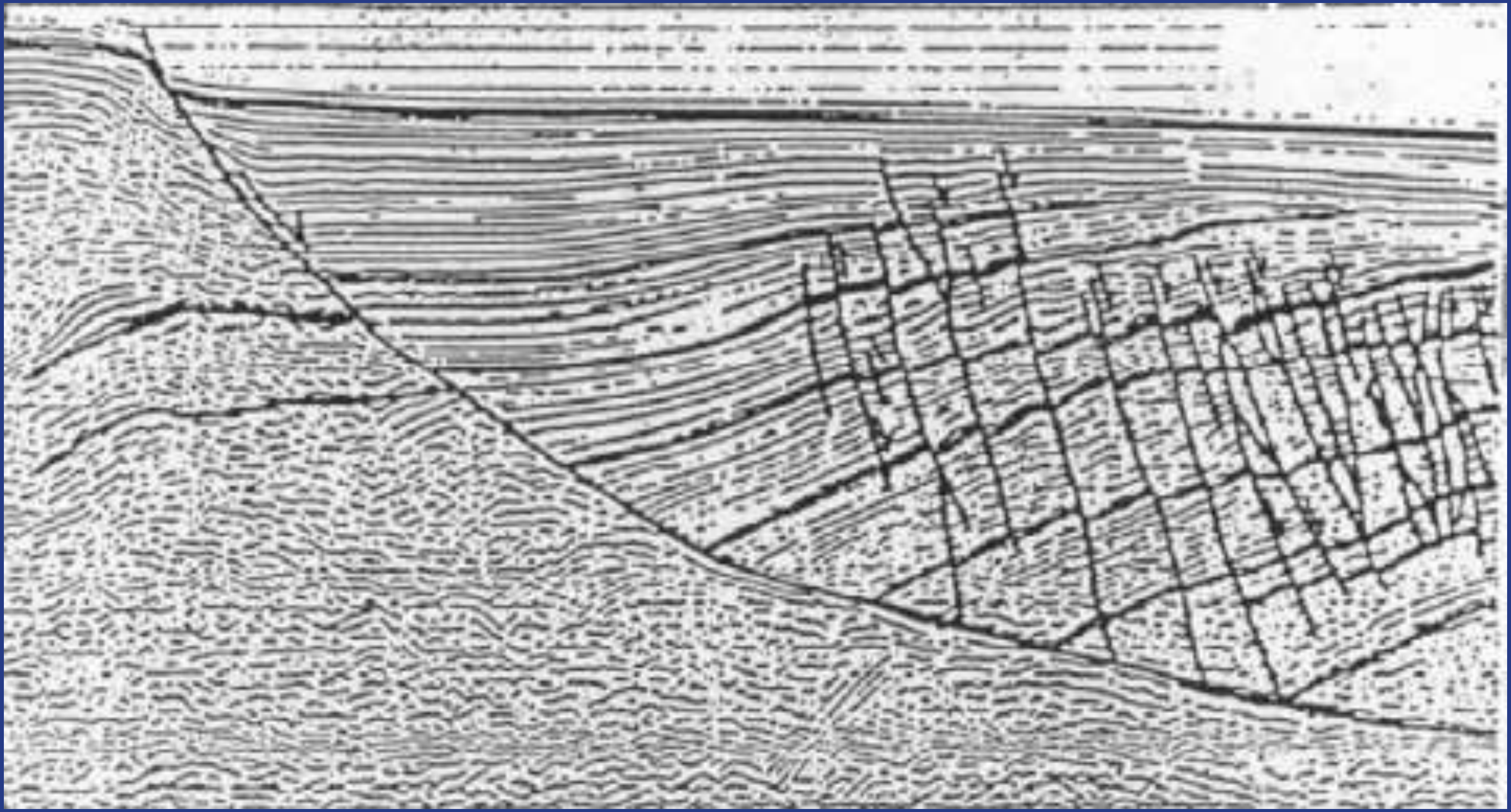


Küçük boyutlu bir büyüme fayı (normal fay):
Austin Tebeşir Formasyonu, Texas, ABD

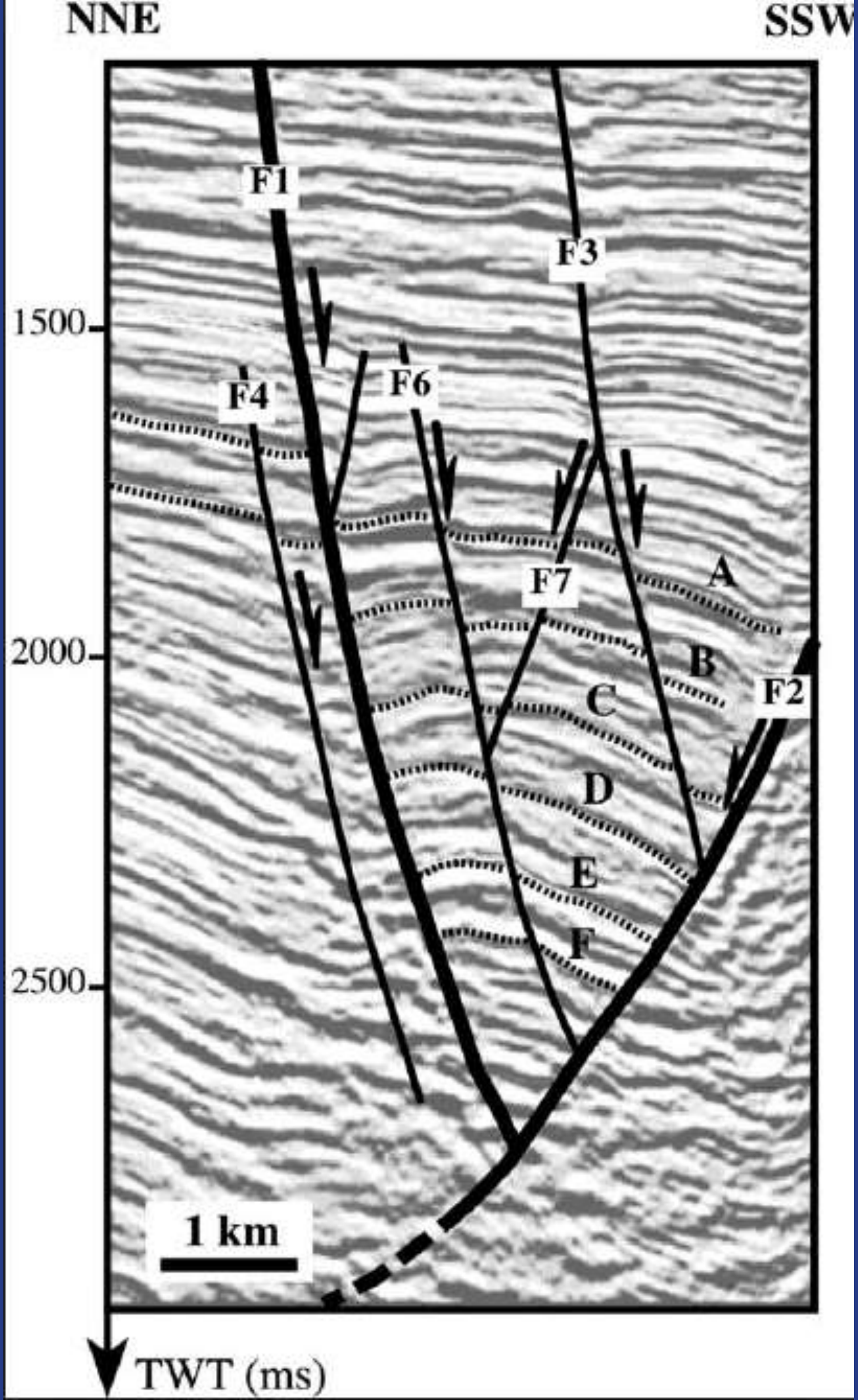




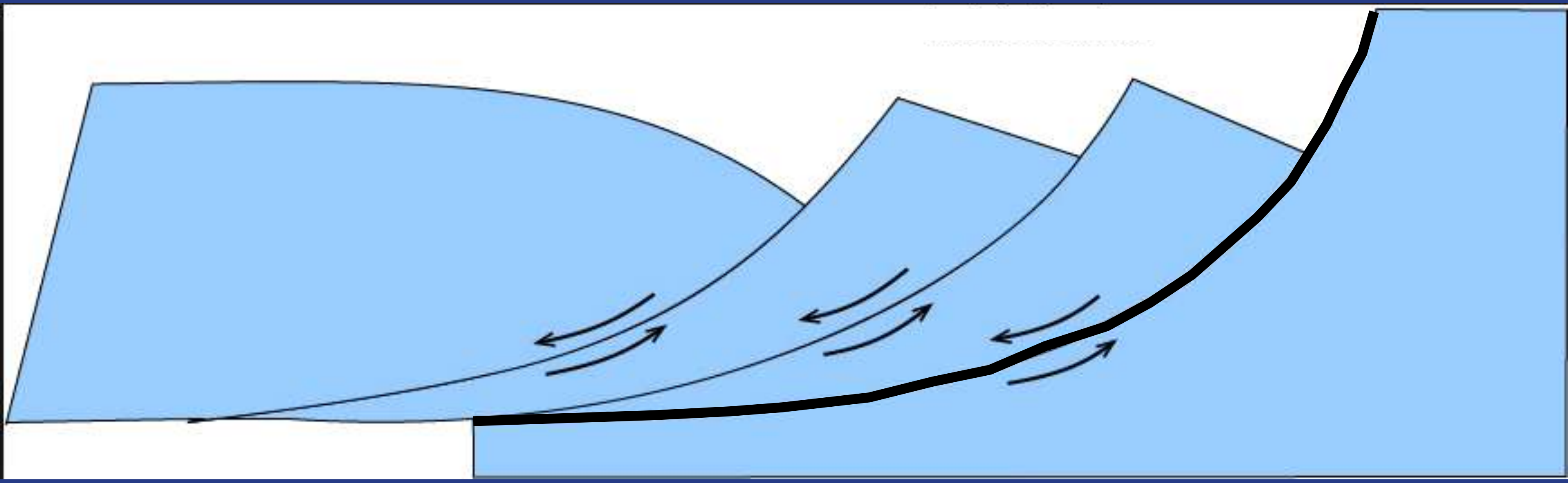
Sentetik ve antitetik faylar



Listrik bir eğim atımlı normal fayın tavan blokunda gelişmiş sentetik düzlemsel normal fay takımı

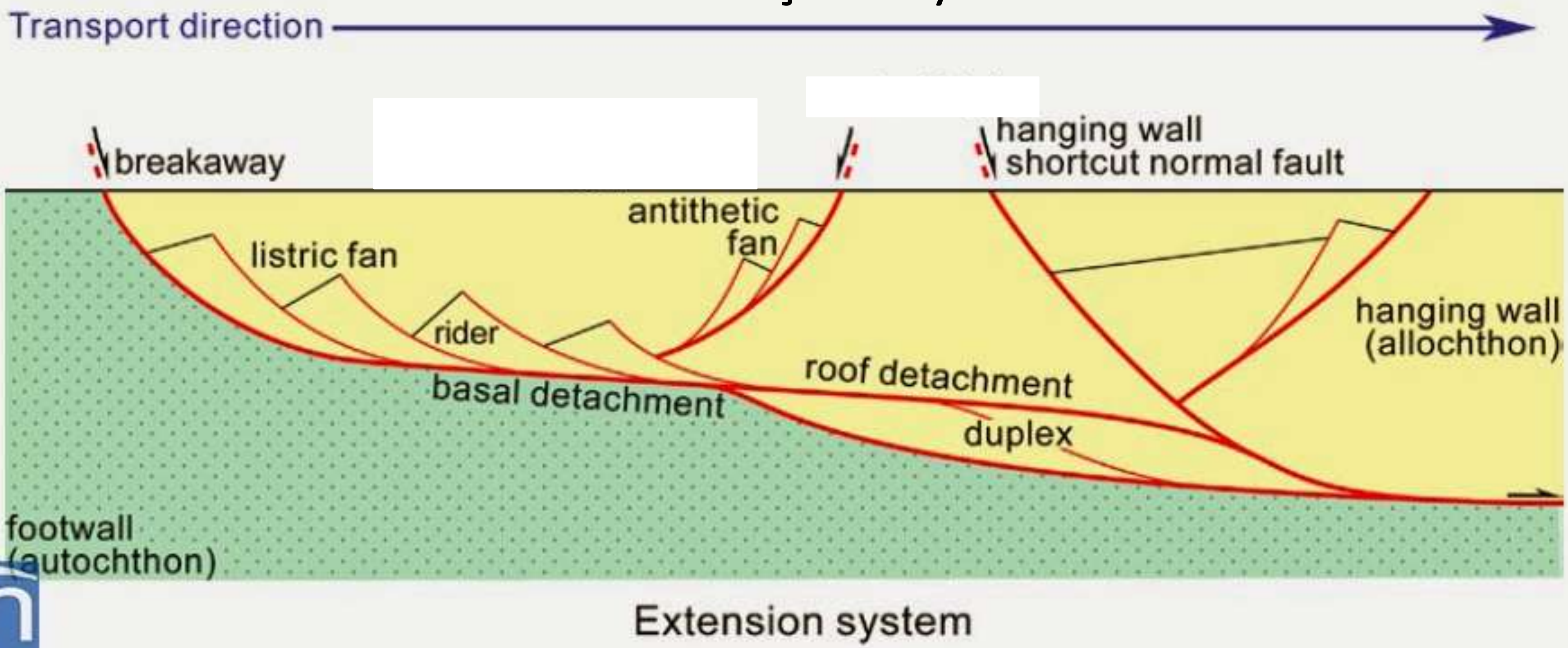


F2 ana fayı üzerinde gelişmiş sentetik ve antitetik normal fay takımları

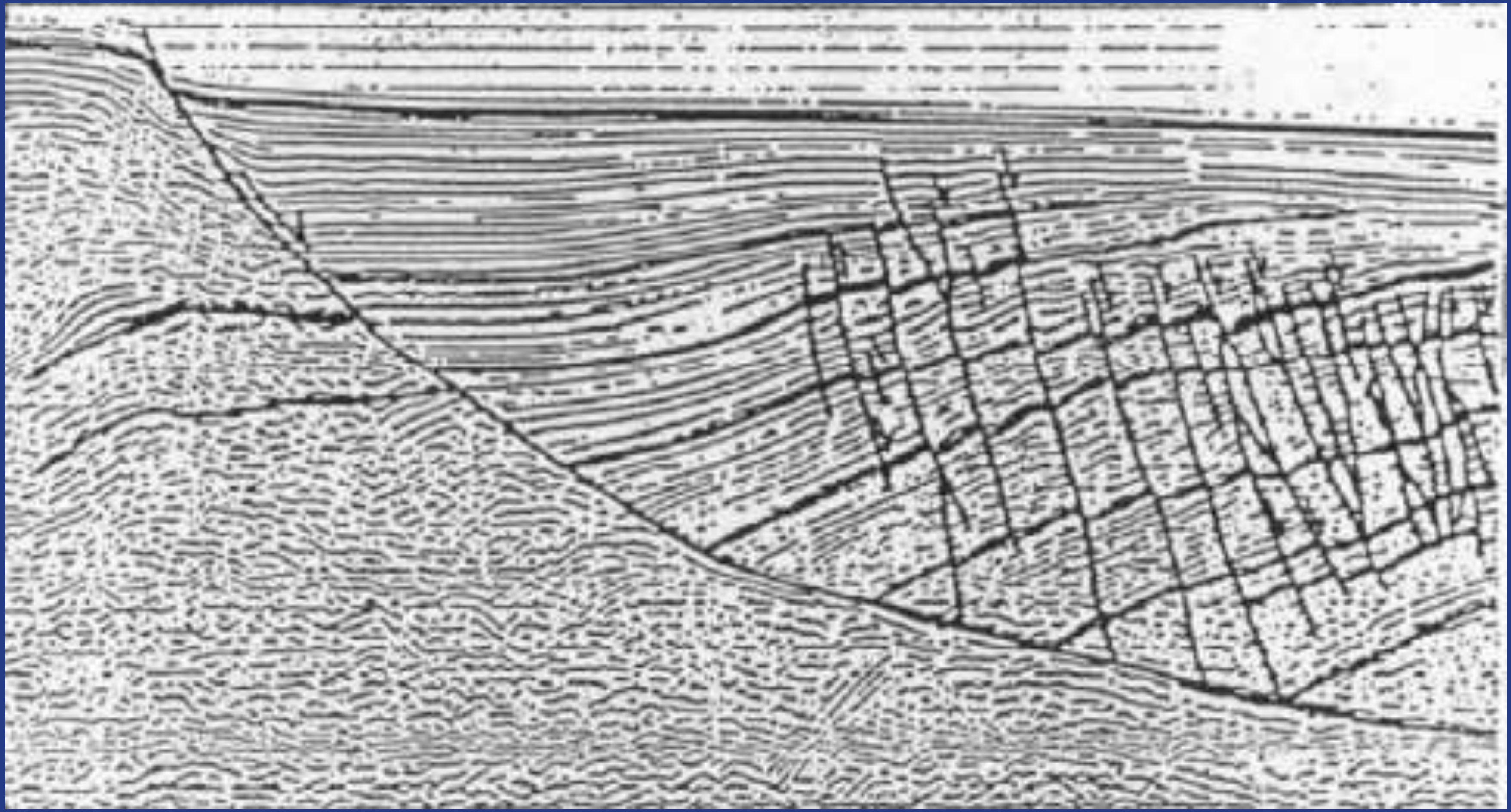


Bir ana ve iki sentetik listrik normal faydan oluşan bir fay yelpazesi

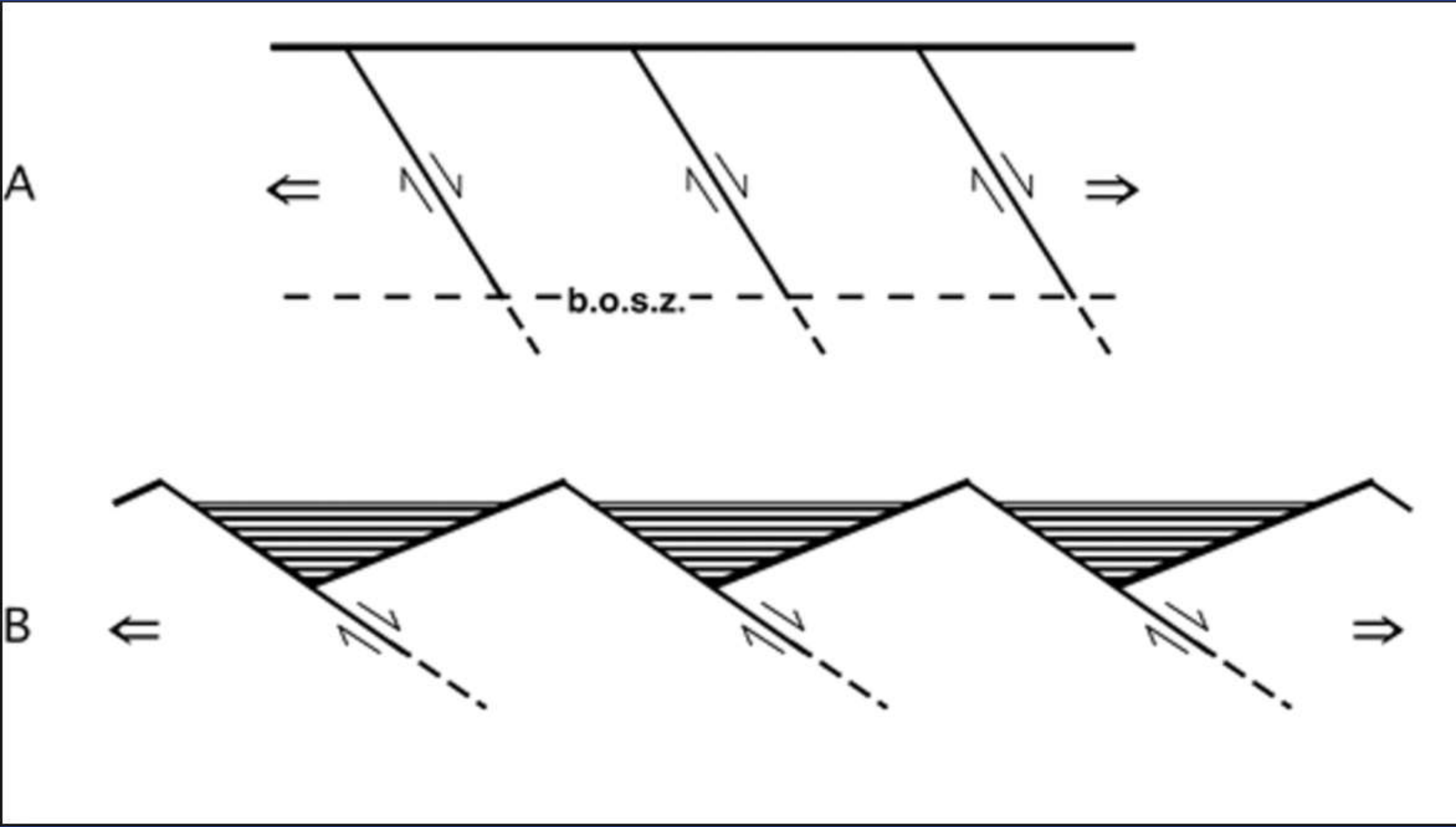
Tektonik taşınma yönü



Breakaway: Kopma
Listric fan: Listrik yelpaze (burada sentetik yelpaze olarak)
Rider: Binici
Basal detachment: Taban kurtulma fayı
Roof detachment: Tavan kurtulma fayı
Duplex: Dubleks
Antithetic fan: Antitetik yelpaze
Footwall: Taban bloku (otokton)
Hanging wall: Tavan bloku (allokton)

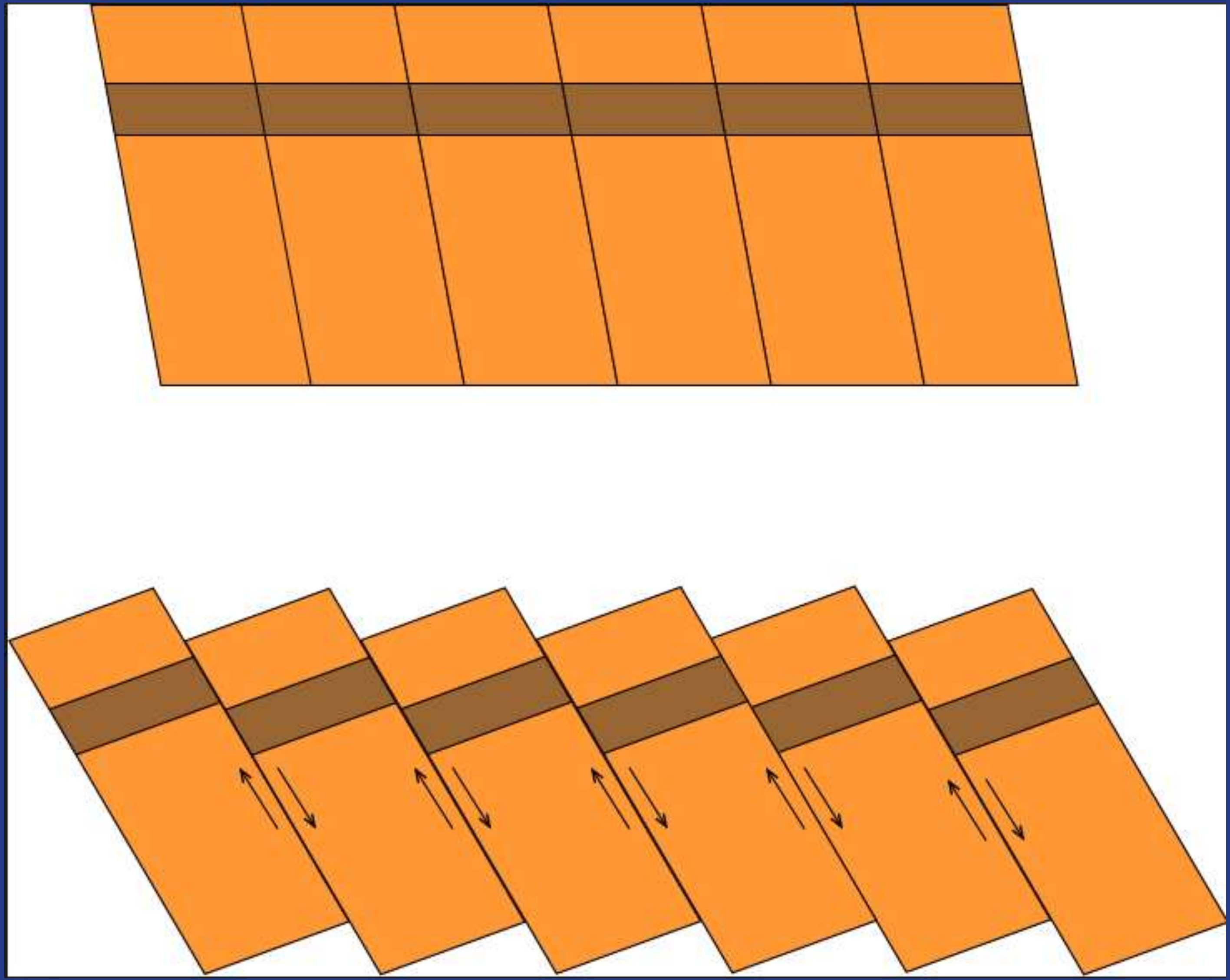


Düzlemsel sentetik fay takımı. Bunlar tektonik uzama esnasında nasıl davranırlar?

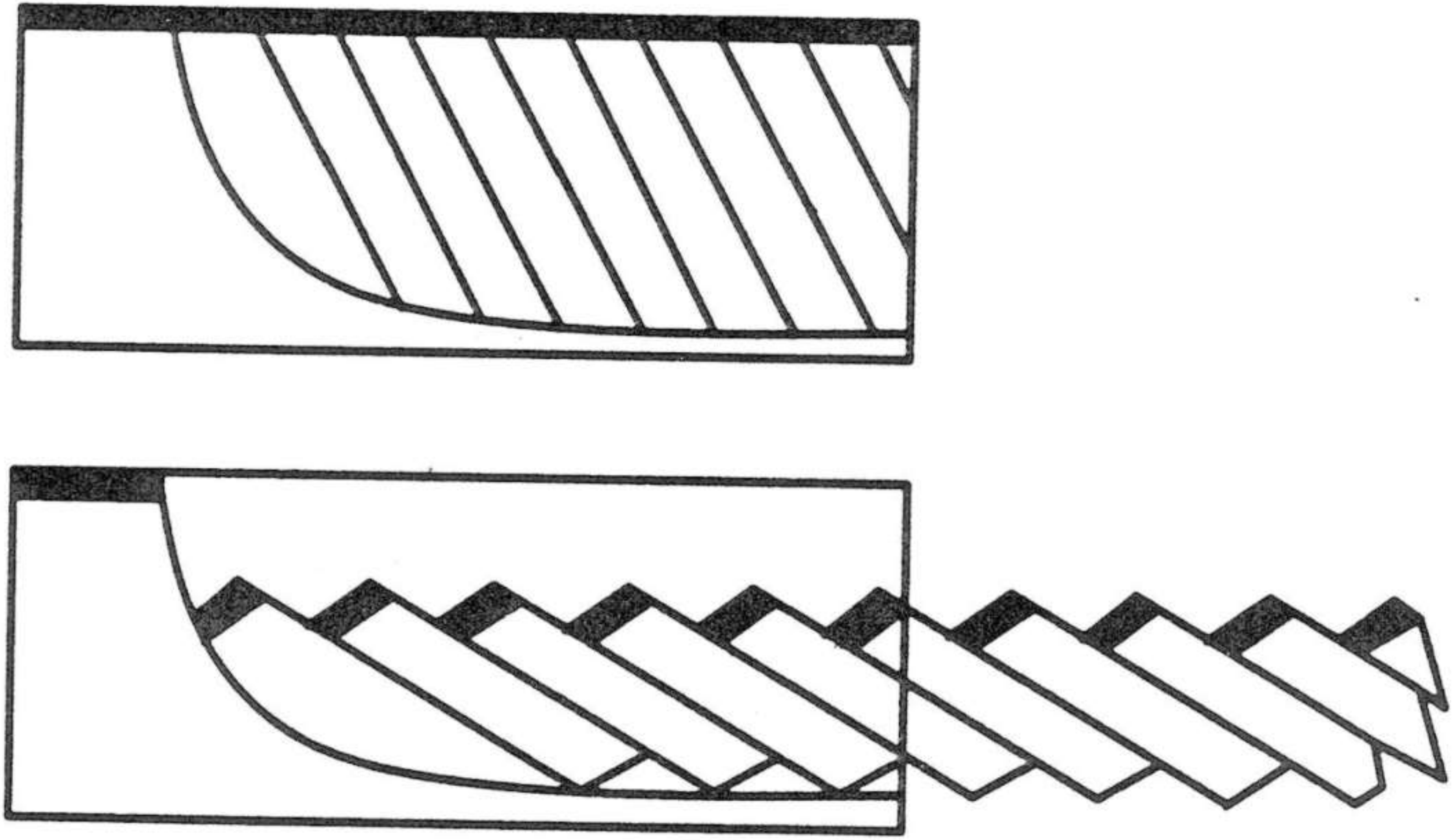


Genellikle sahada tesbit edilebilen normal fay parametreleri

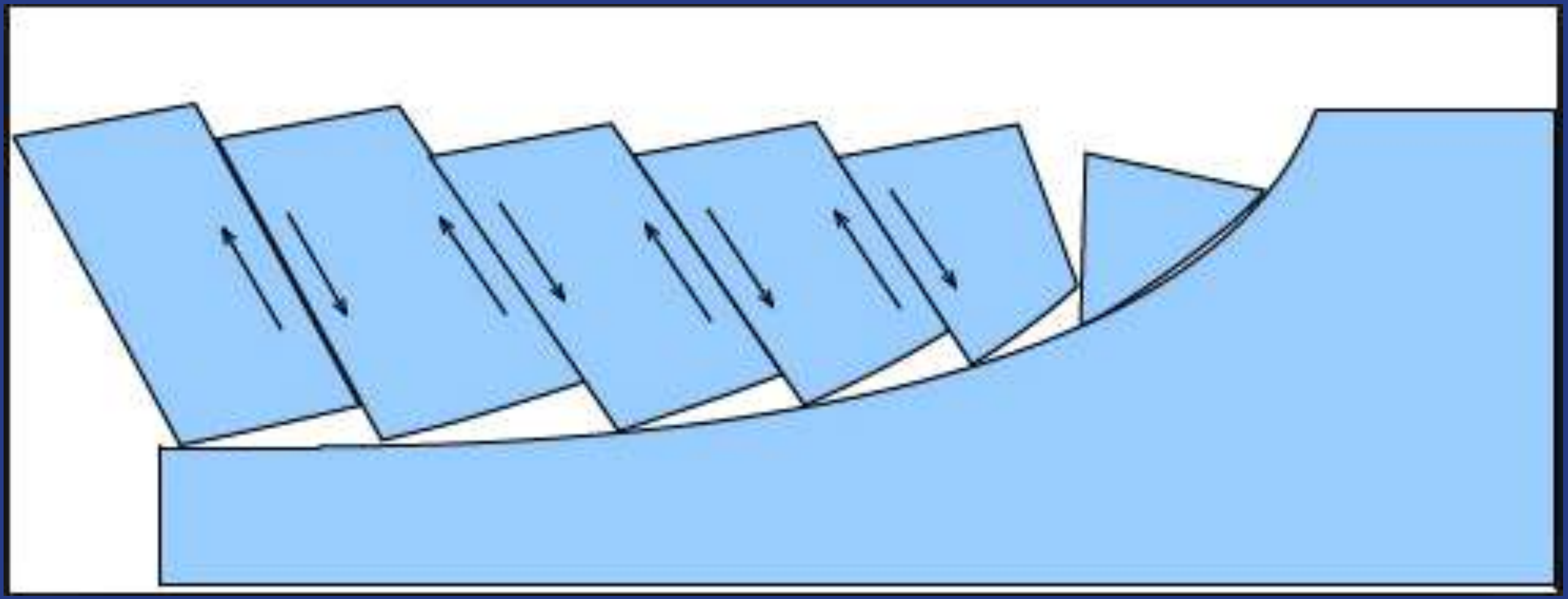
Dominolar gibi yatmış, normal fay blokları: Tempe, Arizona, ABD



Düzlemsel, eğim atımlı normal faylar. Bunların bölgesel ölçekte olanları takım halinde çalıştıkları zaman, hem faylar, hem de onları sınıırlayan bloklar, yatay eksenler etrafında dönmek zorundadırlar.

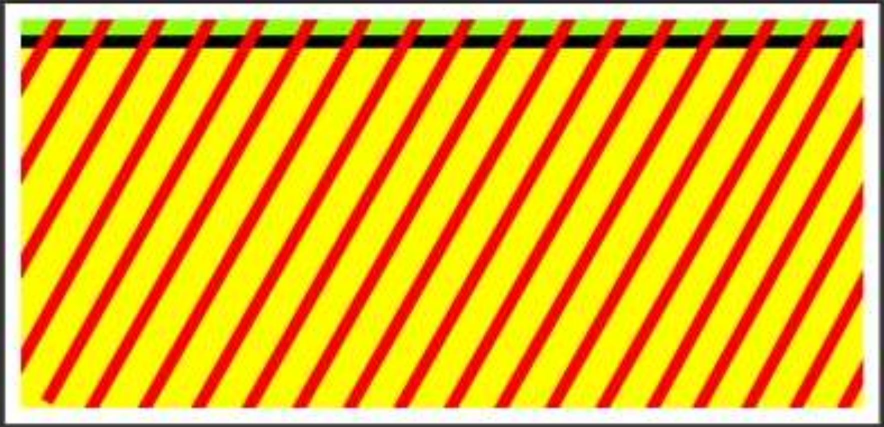


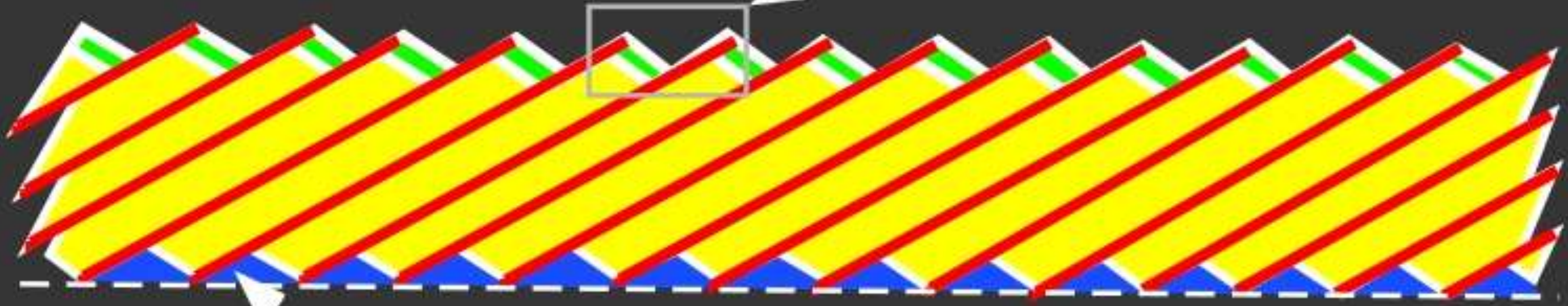
Domino-tipi normal fay sistemlerinin çalışabilmesi
için en az bir listrik normal faya ihtiyaç vardır



Bir listrik normal fay üzerinde gelişen domino tipi normal fay sistemi

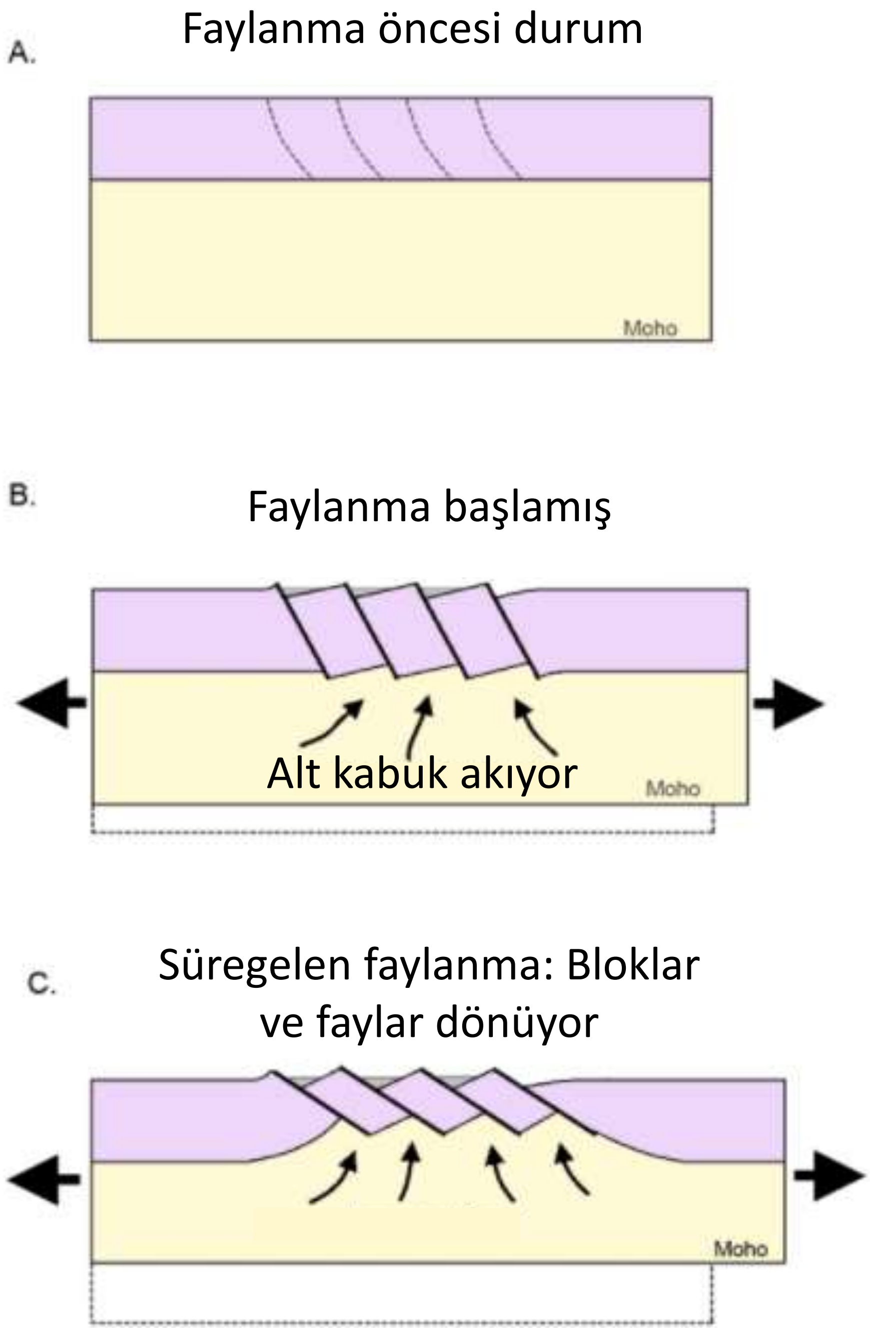
Düzlemsel eğim atımlı normal fay takımı (domino tipi faylanma)





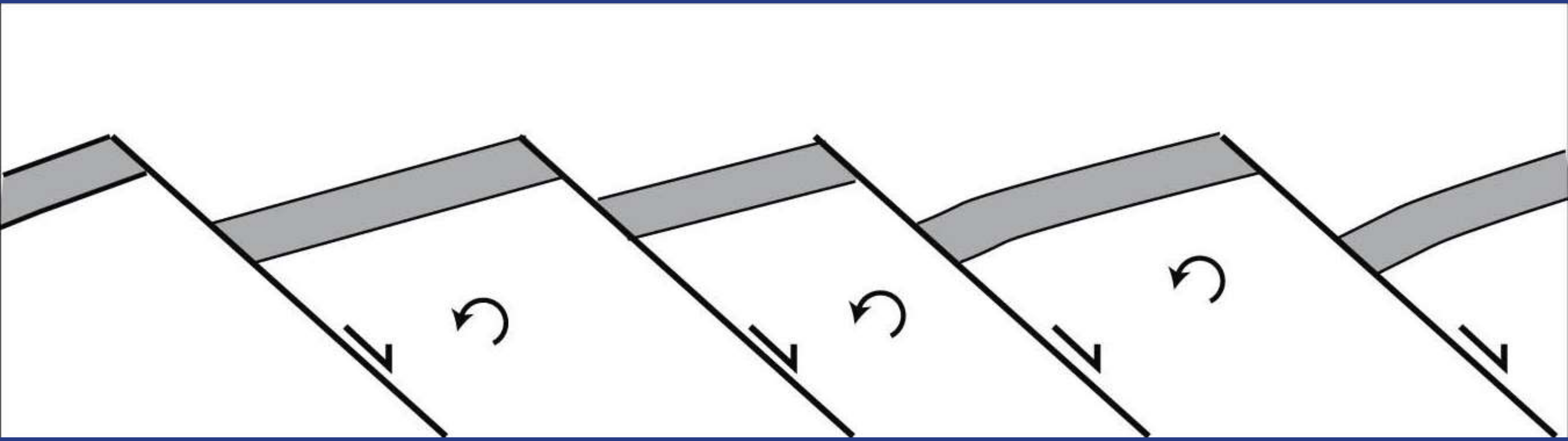
Wernicke 1982

Fayları teker teker aşağıya doğru izleyelim: Boşluk sorunu iki şekilde çözülmüş: 1. Fay aşağı doğru listrikleşmiş 2. Fay üzerindeki atım kayaç içinde minik kayma zoncuklarına dağıtılarak karşılanmış.

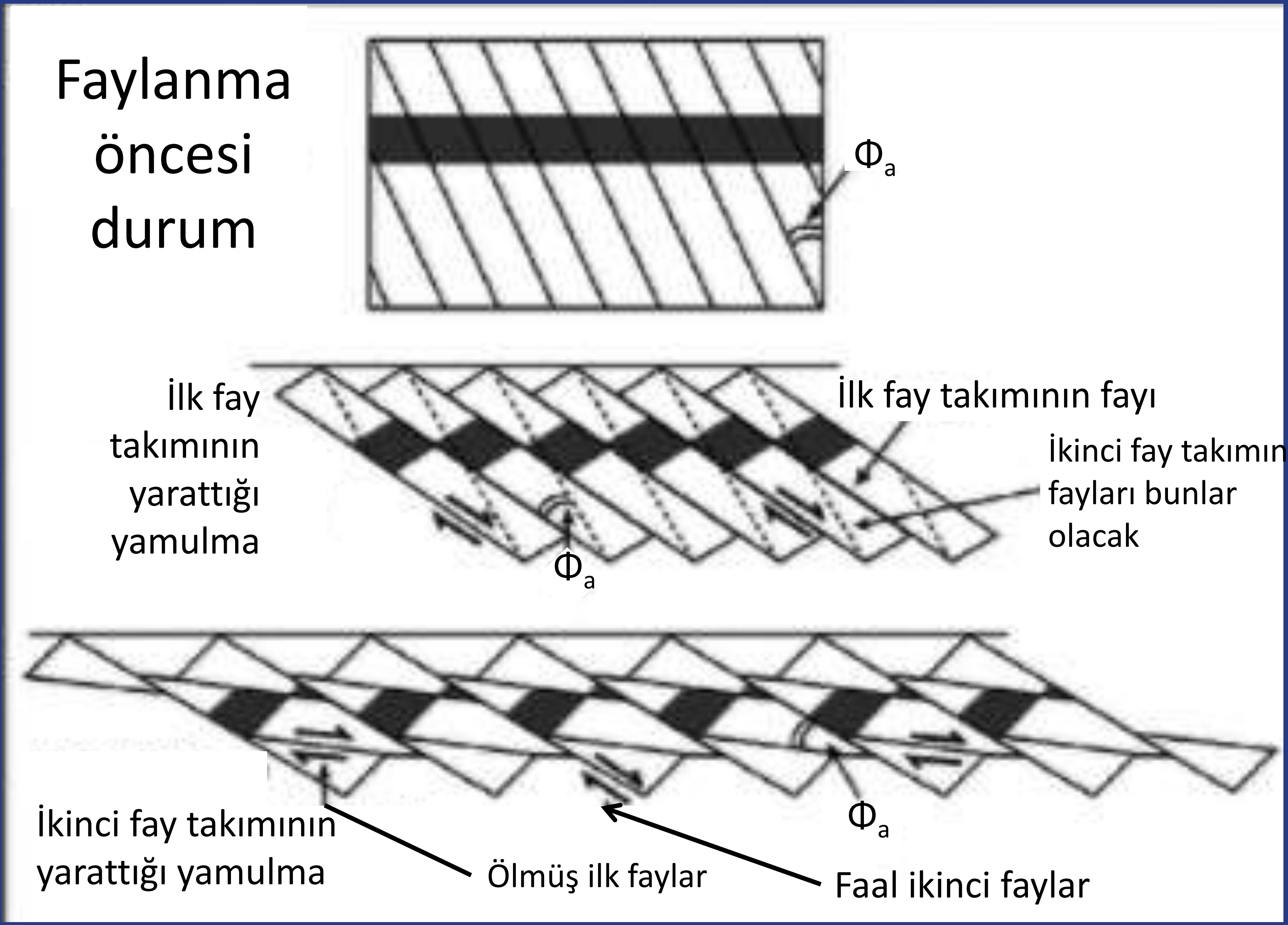


Burada dönen blokların alt uçlarında ortaya çıkan boşluk sorunu alt kabuğun akarak boşlukları doldurması sonucu çözülmüş.

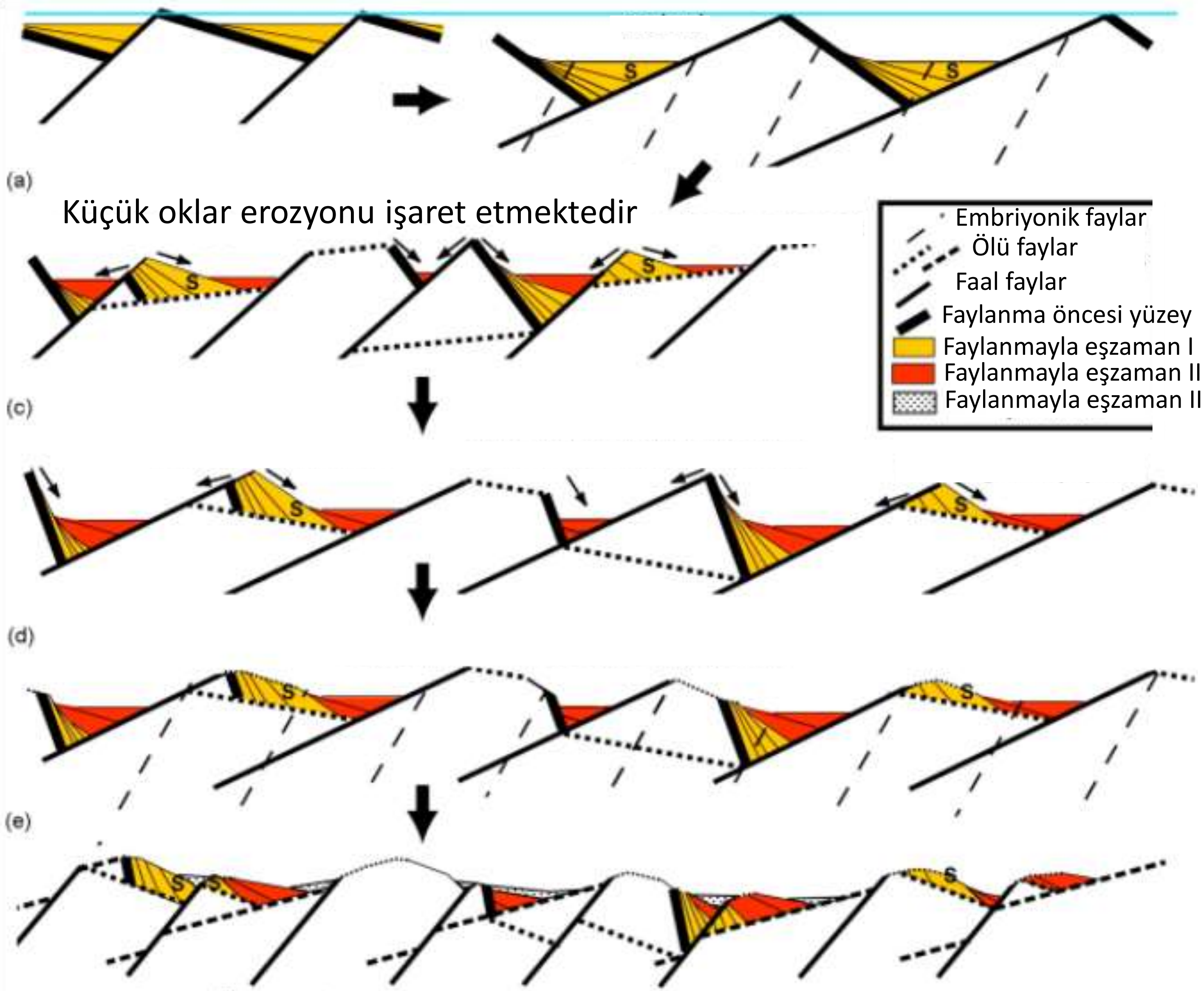
Bu tür bir geometri Doğu Afrika Rift vadilerinin en güney ucundaki Malawi (eski adıyla Nyassa) Gölü çevresinde gözlenen 30 km derinlikteki depremlerle belgelenebilmiştir.



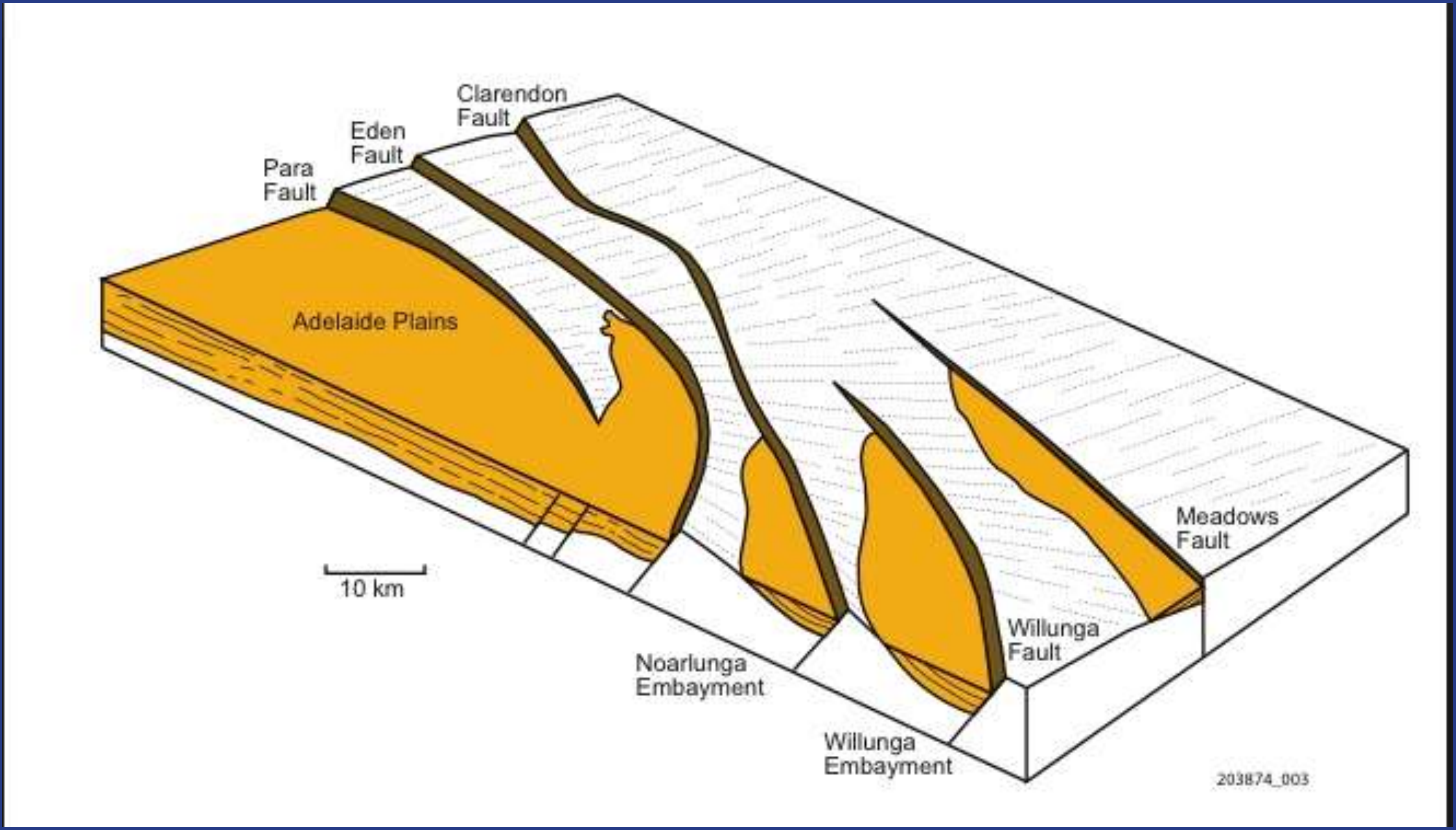
Domino stili faylanmada hem blokların hem de fayların dönmek zorunda olduklarına bilhassa dikkat ediniz!



Sürekli uzama altında oluşan ilk faylar dönerek uzamanın gerektirdiği atımları karşılayamaz hale gelince ikinci bir fay takımı meydana gelir ve yeni bloklar oluşturur. Bu bloklar da aynı ilk oluşanlar gibi dönerler.



Yandaki şekil, takla atan fayların tanınamamasından kaynaklanan yanlış bir restorasyonu göstermektedir. Burada elde edilen uzama %10’dur. Halbuki gerçek uzama % 330’dur!



Domino stilinde oluşan düzlemsel eğim atımlı normal faylar haritada genellikle düzlemsel değillerdir. Burada Güney Avustralya’daki Adelaide fay sisteminin bir blok diyagramı görülmektedir.

Domino stili faylanmayla çarpılmış bloklar: Triyas-Jura Blomidon Formasyonu, Nova Scotia, Kanada.

Domino-stili çarpılmış normal fay blokları: Mısır

Kapaklı kuzeyinde domino-stili faylanmayla çarpılmış normal fay blokları, batı Türkiye

Ankara kuzeyinde domino stili çarpılmış normal fay blokları

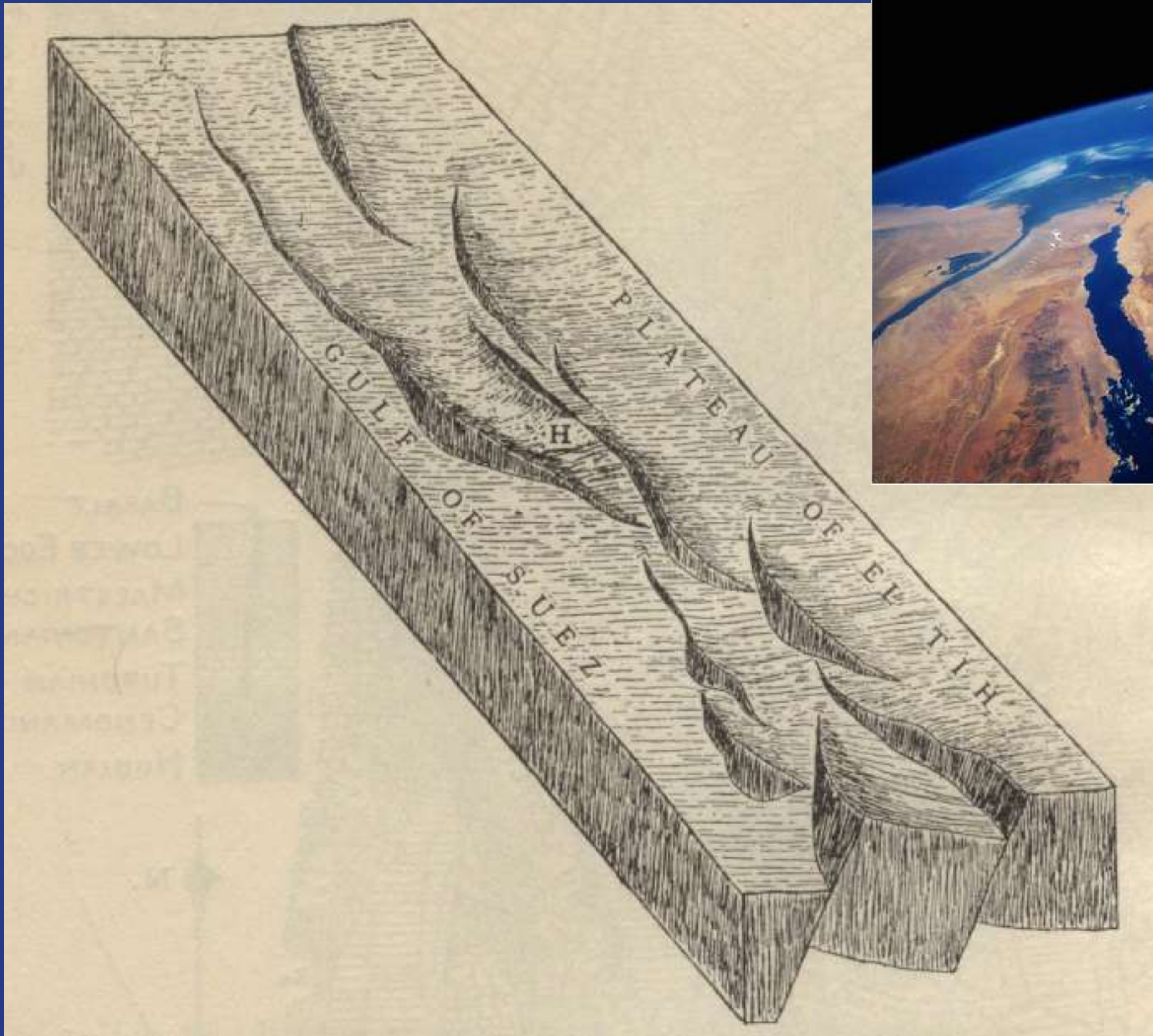
Ankara kuzeyinde volkanitler içerisinde domino stili faylanmış bloklar


TAHRİP ALANI

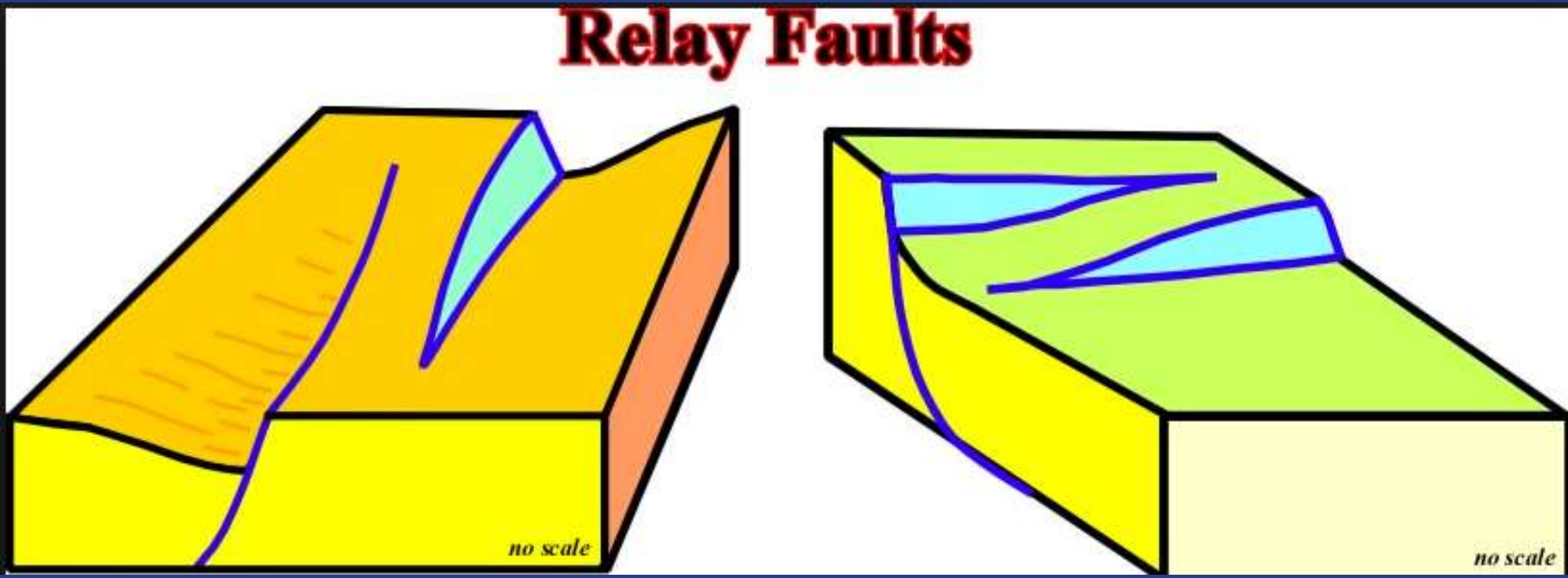
Faylanmayla dönmüş ve baştan faylanmış volkanitler. Ankara kuzeyi

Ankara kuzeyindeki normal faylanmış volkanitler içinde gelişmiş çok geniş bir tahrip alanı

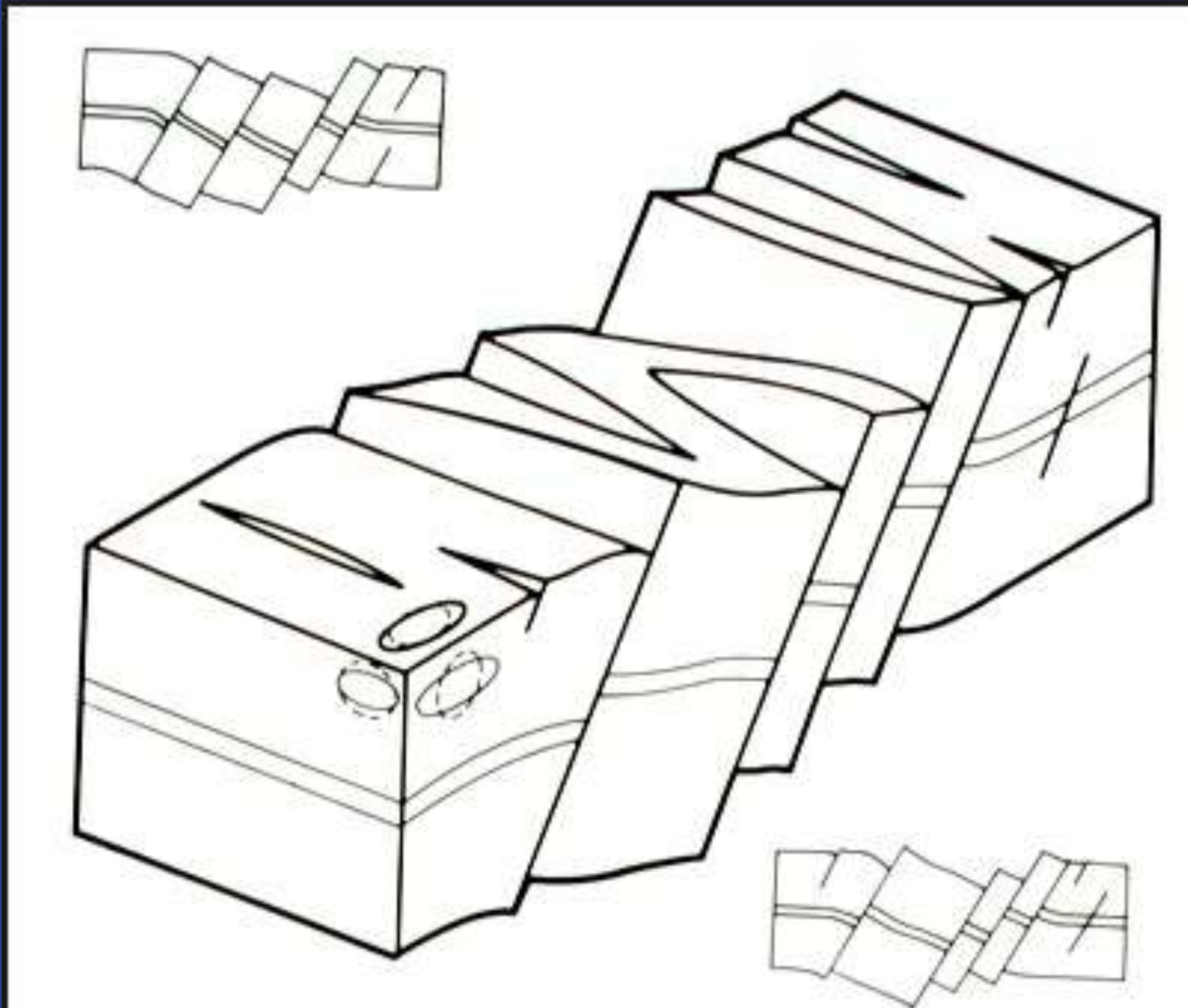
Ankara kuzeyinde normal faylar: detay

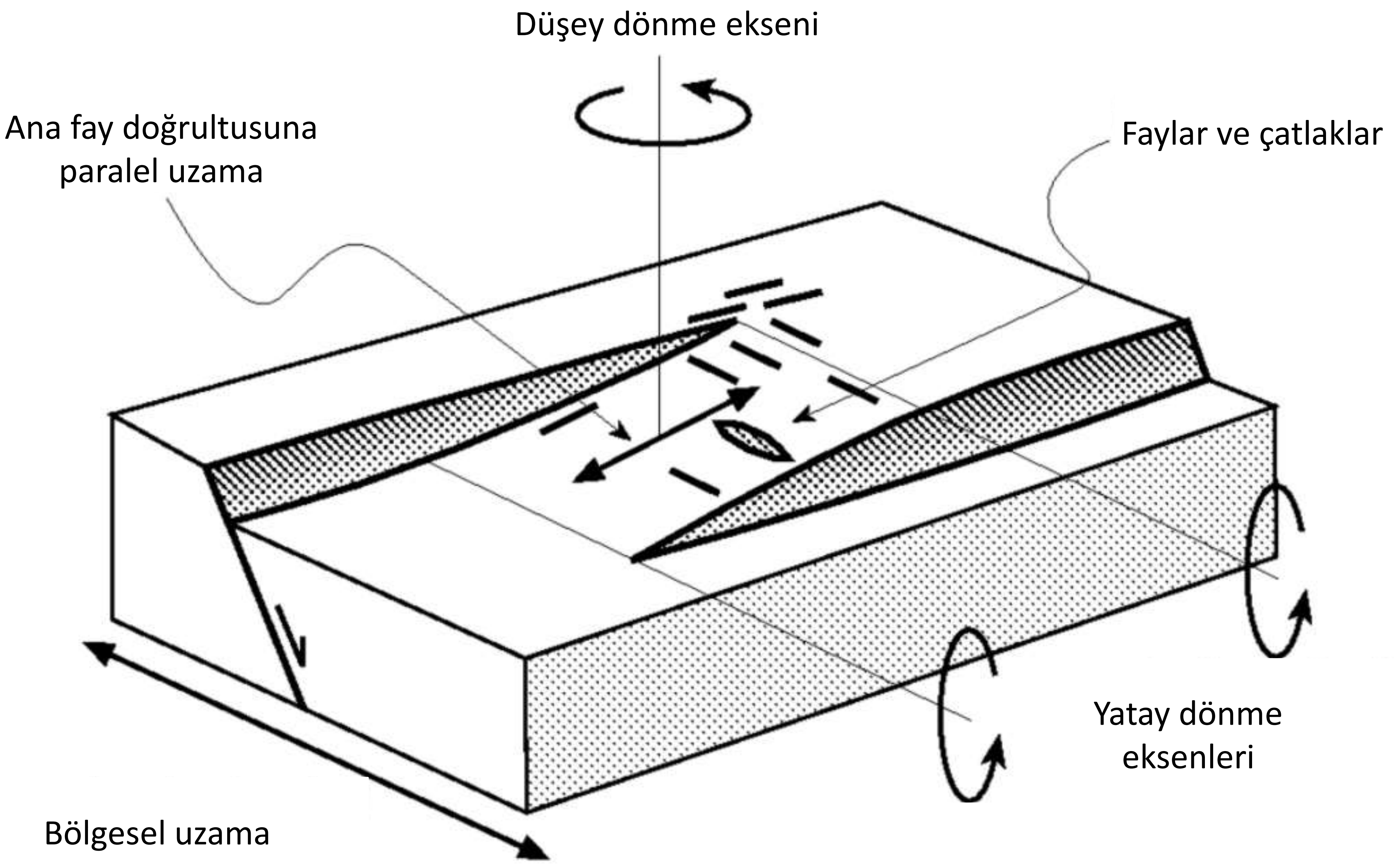


Süveş Körfezinin KD kenarında Normal Faylar

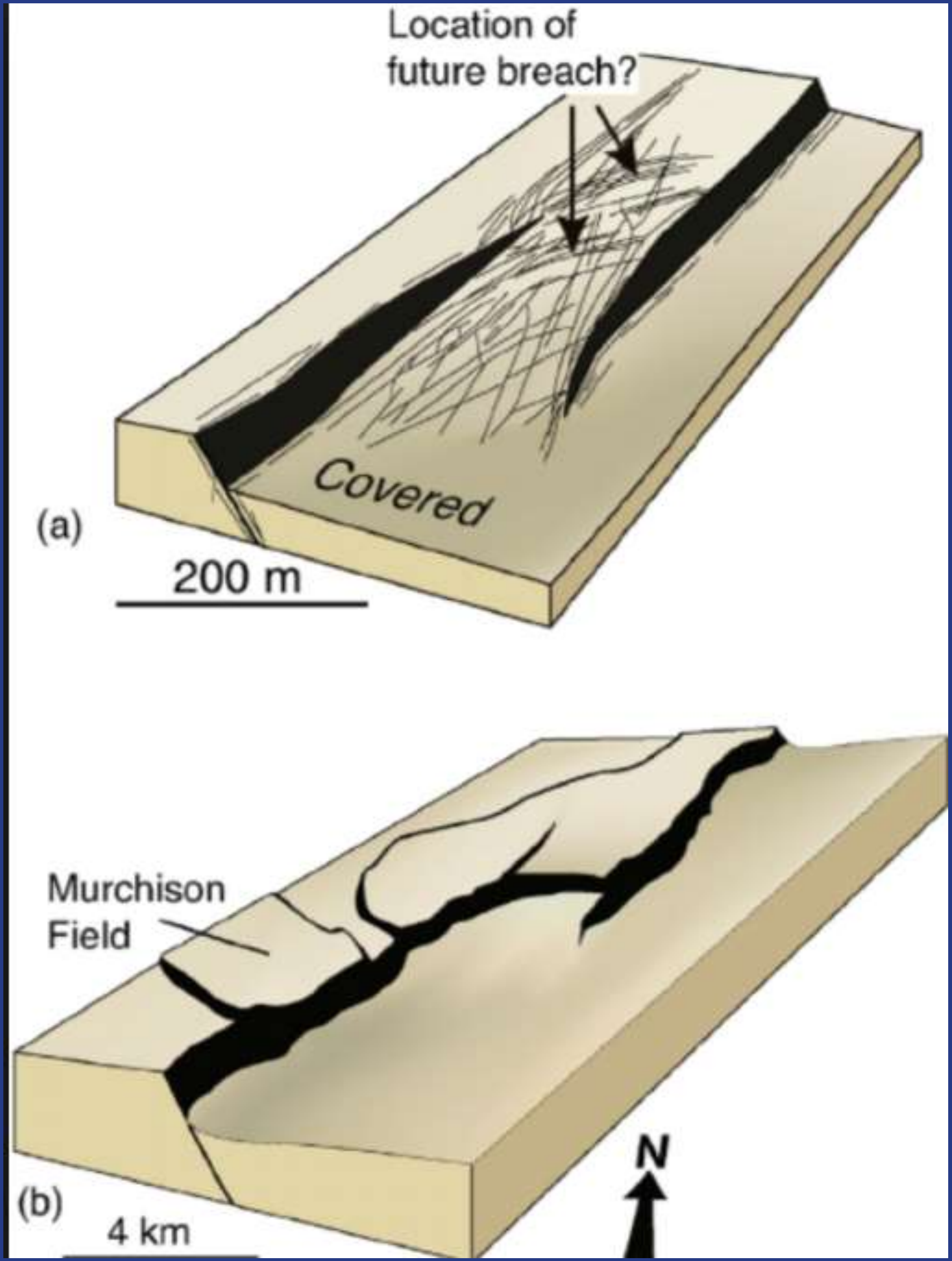


Relay faylarına Türkçe “nakil fayları” denebilir, çünkü bunlar hareketi birinden diğerine nakleden faylardır.



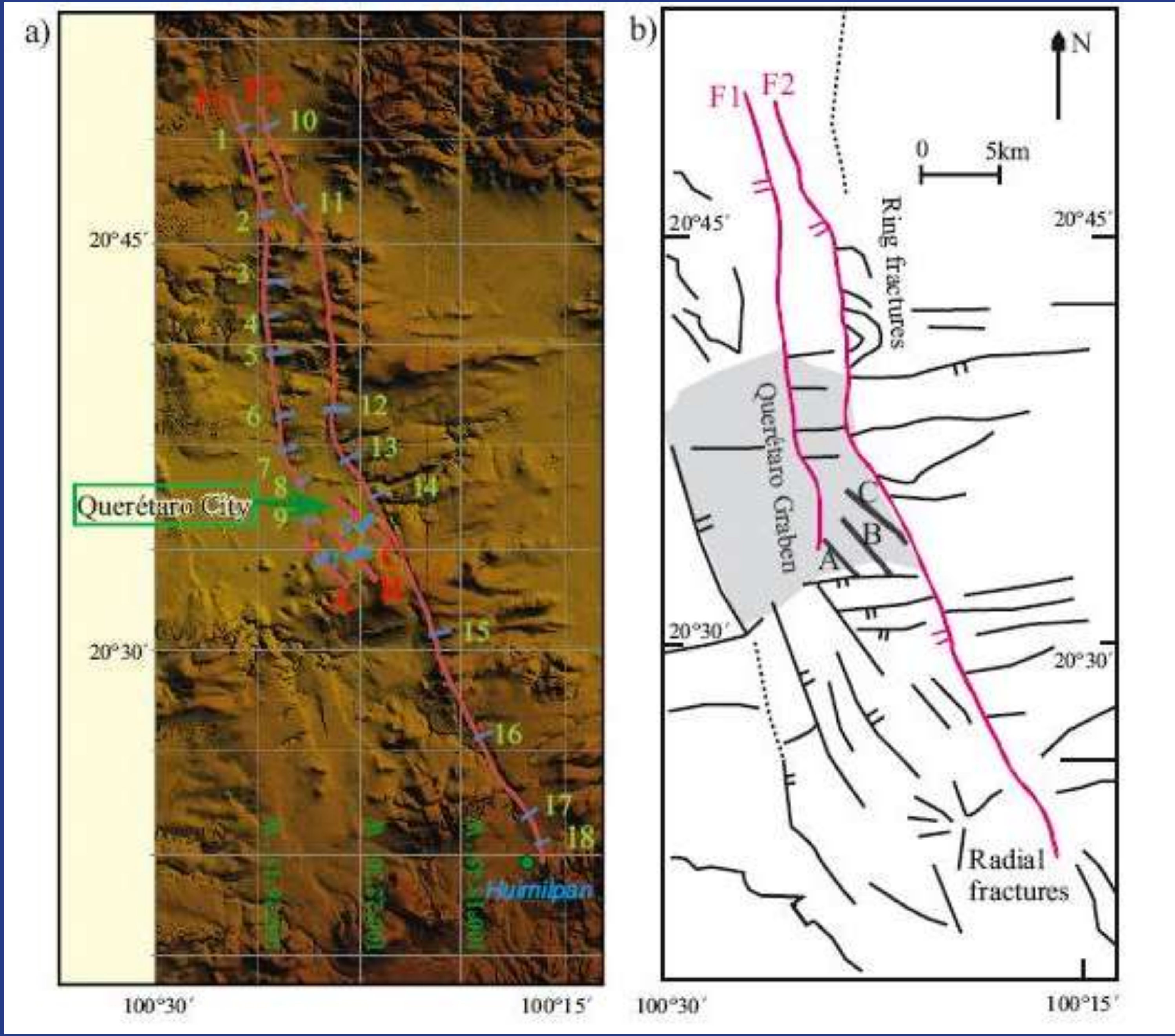


Uzama tektoniğinin egemen olduğu bir alanda normal faylar arası nakil alanının yapısal jeolojisi

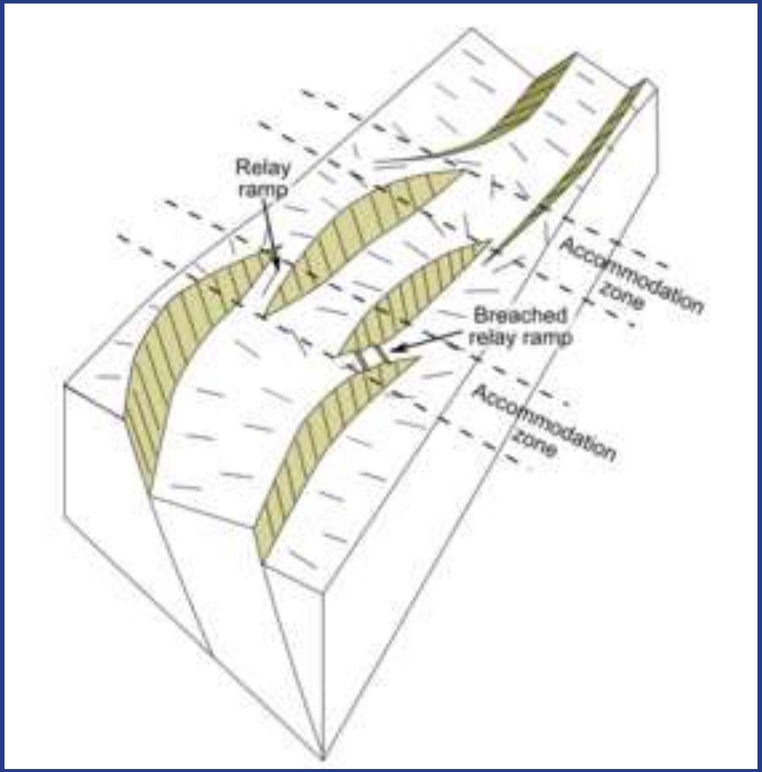


Fossen, H. ve Rotevatn, A., 2016, Fault linkage and relay structures in extensional settings – a review: *Earth-Science Reviews*, c. 154, ss. 14-28

Yandaki şekil bu makaleden alınmıştır. Relay yapıları hakkındaki en faydalı kaynak bu makaledir. Pek çok arazi örneğinin tartışıldığı bu makalenin okunması hararetle önerilir.

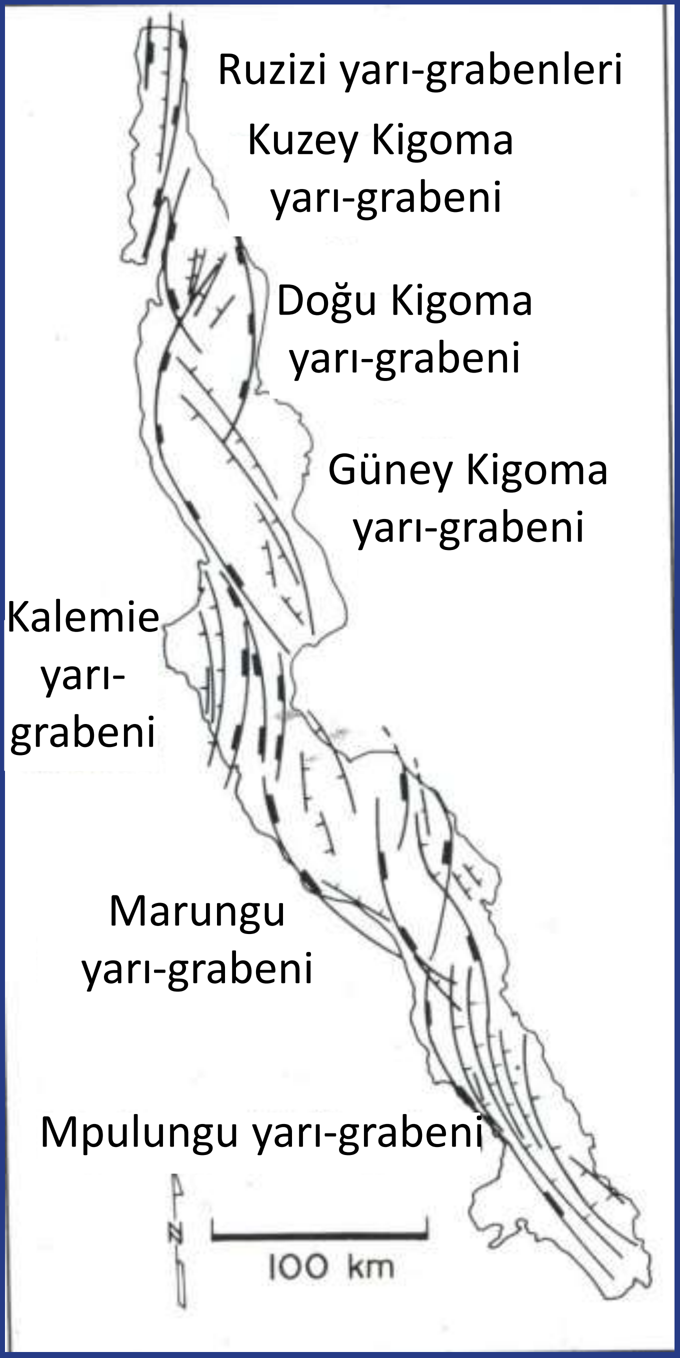


Querétaro grabeni içinde bir relay fay alanı, Meksika

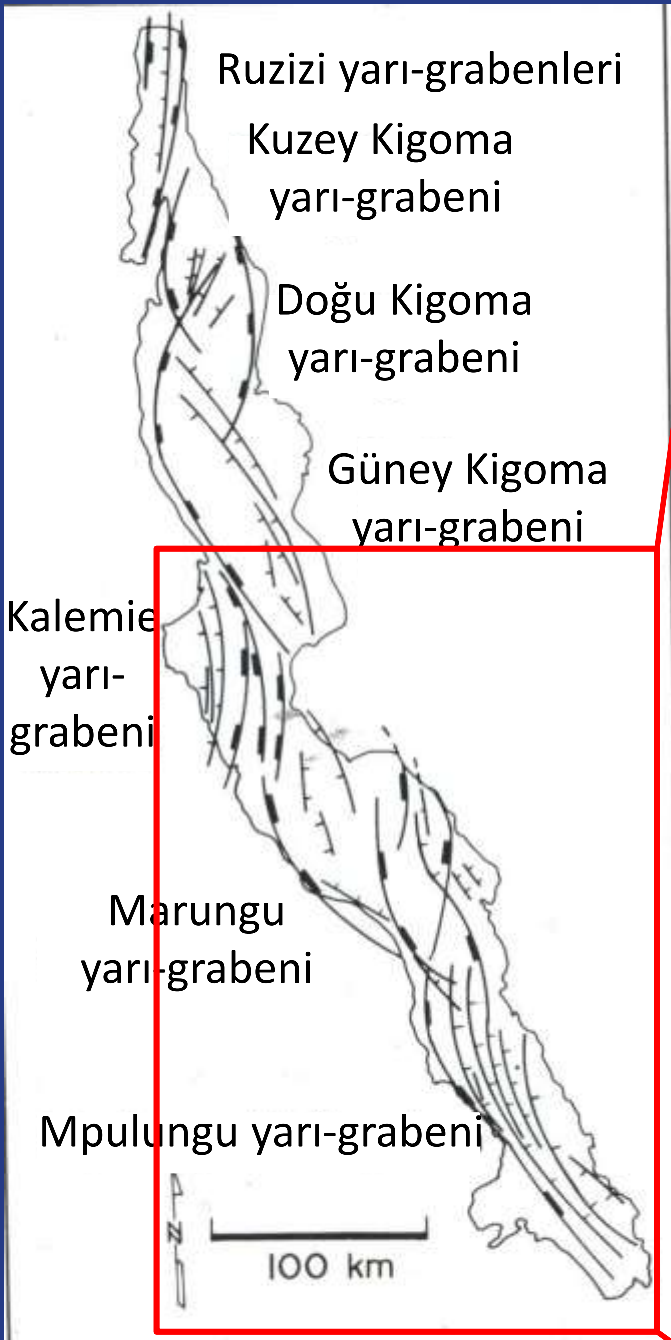


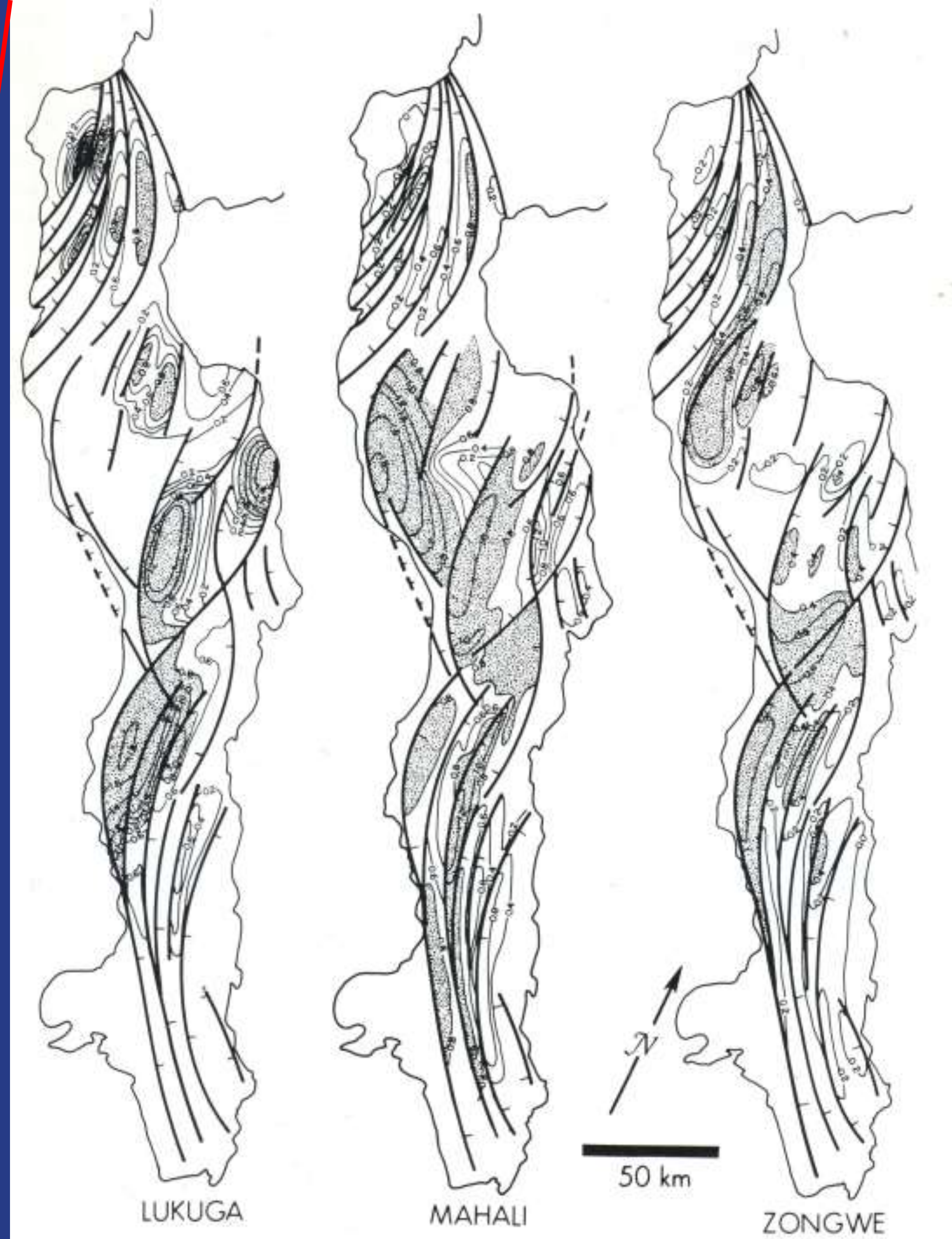
Relay (=nakil) alanlarının İngilizce terminolojisi

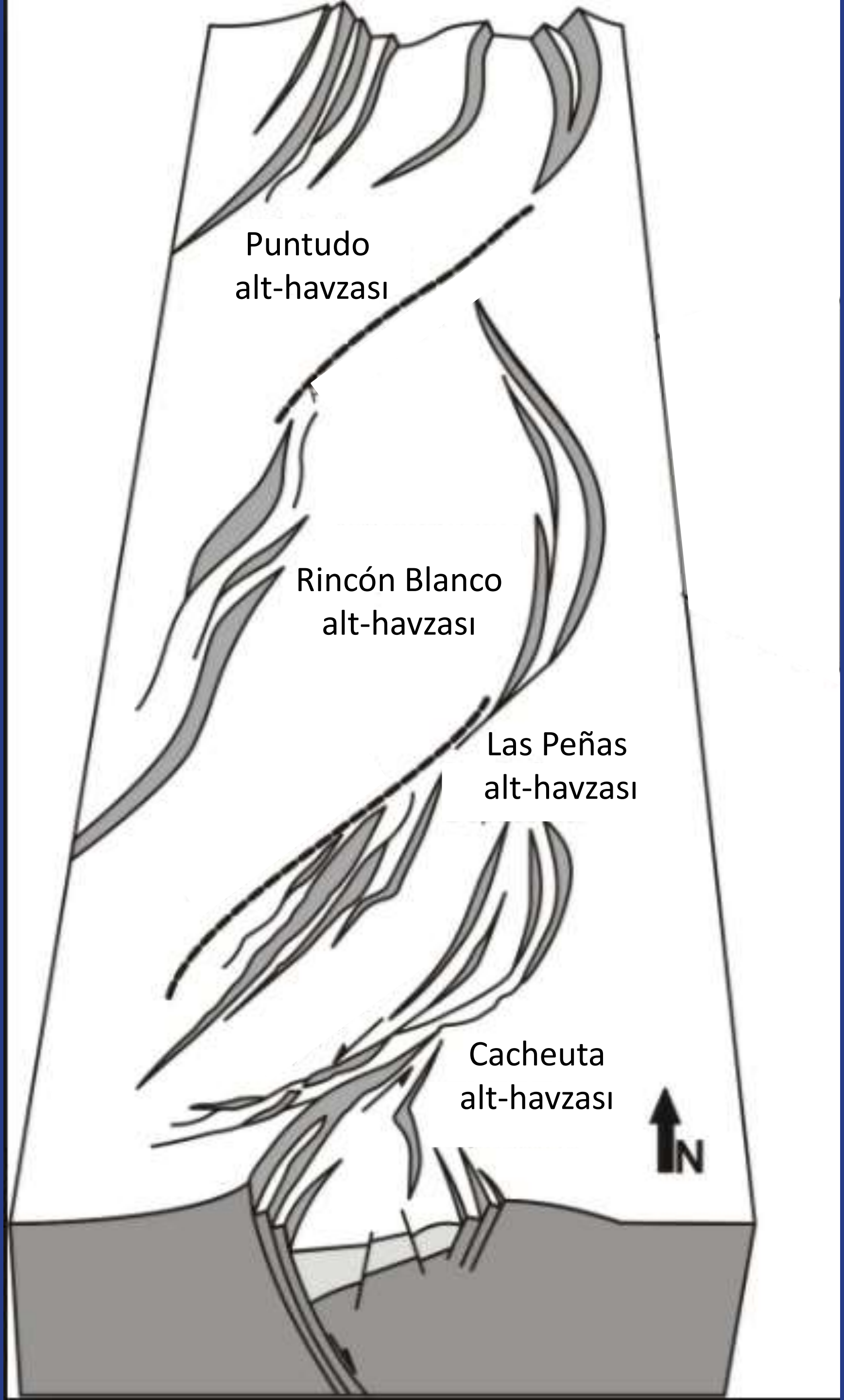
SUDAN
ETHIOPIA
Main Ethiopian Rift
20 Ma
SOUTH SUDAN
21-25 Ma
DEMOCRATIC REPUBLIC OF CONGO
Albert >14 Ma
Lokichar 30 Ma
SOMALIA
UGANDA
KENYA
Kivu
W. Anza
Tanganyika
TANZANIA
Manyara
25 Ma
Karimbas
Malawi
ZAMBIA
MOZAMBIQUE
Lacerda <5 Ma
MADAGASCAR
ZIMBABWE
BOTSWANA
0 250 500 KM



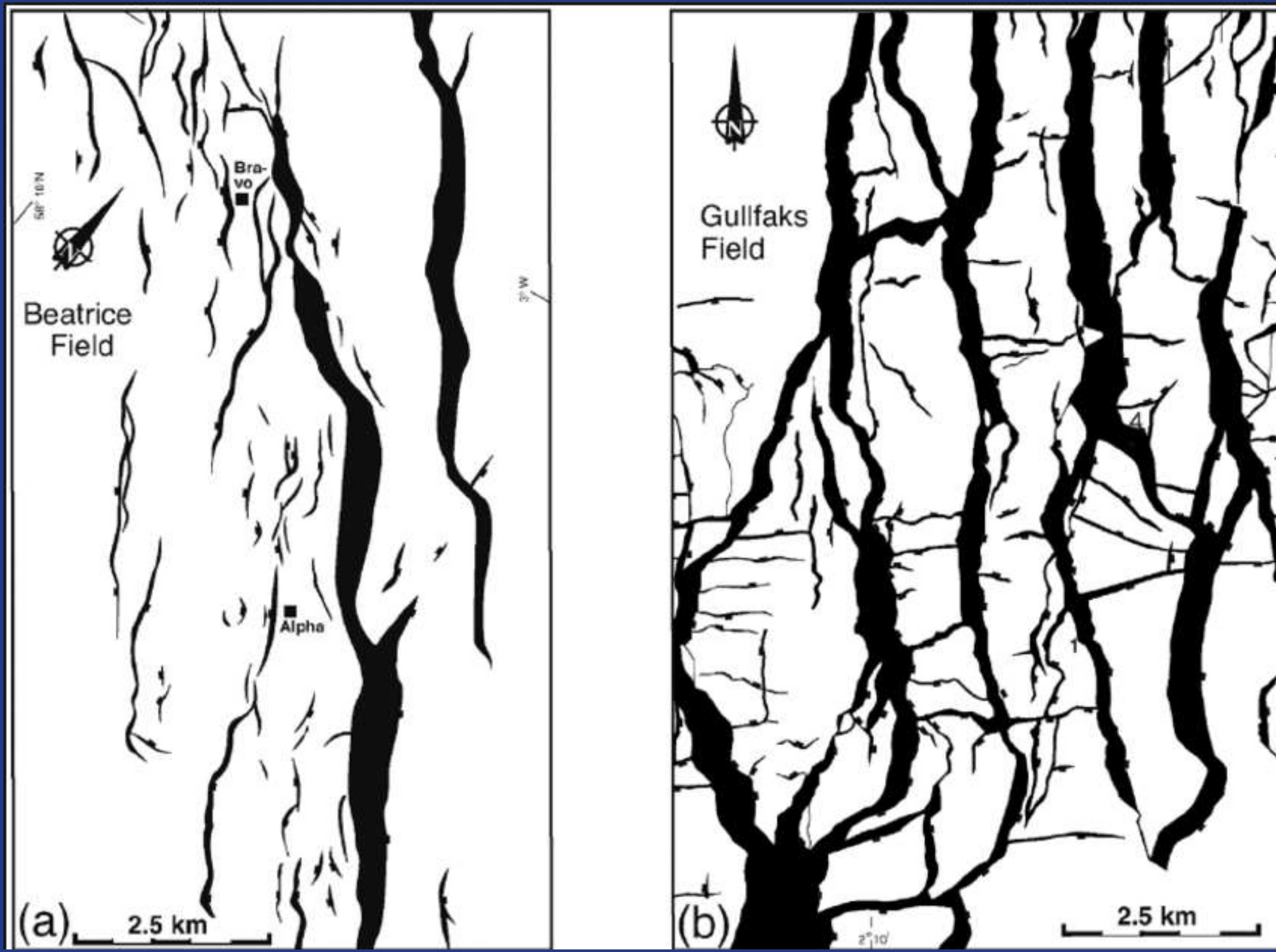
Doğu Afrika Rift Sistemi içerisindeki Tanganyika Riftinin içindeki listrik eğim atımlı normal faylarla sınırlanmış yarı-grabenler


Ruzizi yarı-grabenleri
Kuzey Kigoma yarı-grabeni
Doğu Kigoma yarı-grabeni
Güney Kigoma yarı-grabeni
Kalemie yarı-grabeni
Marungu yarı-grabeni
Mpulungu yarı-grabeni
N
100 km


N
50 km
LUKUGA
MAHALI
ZONGWE

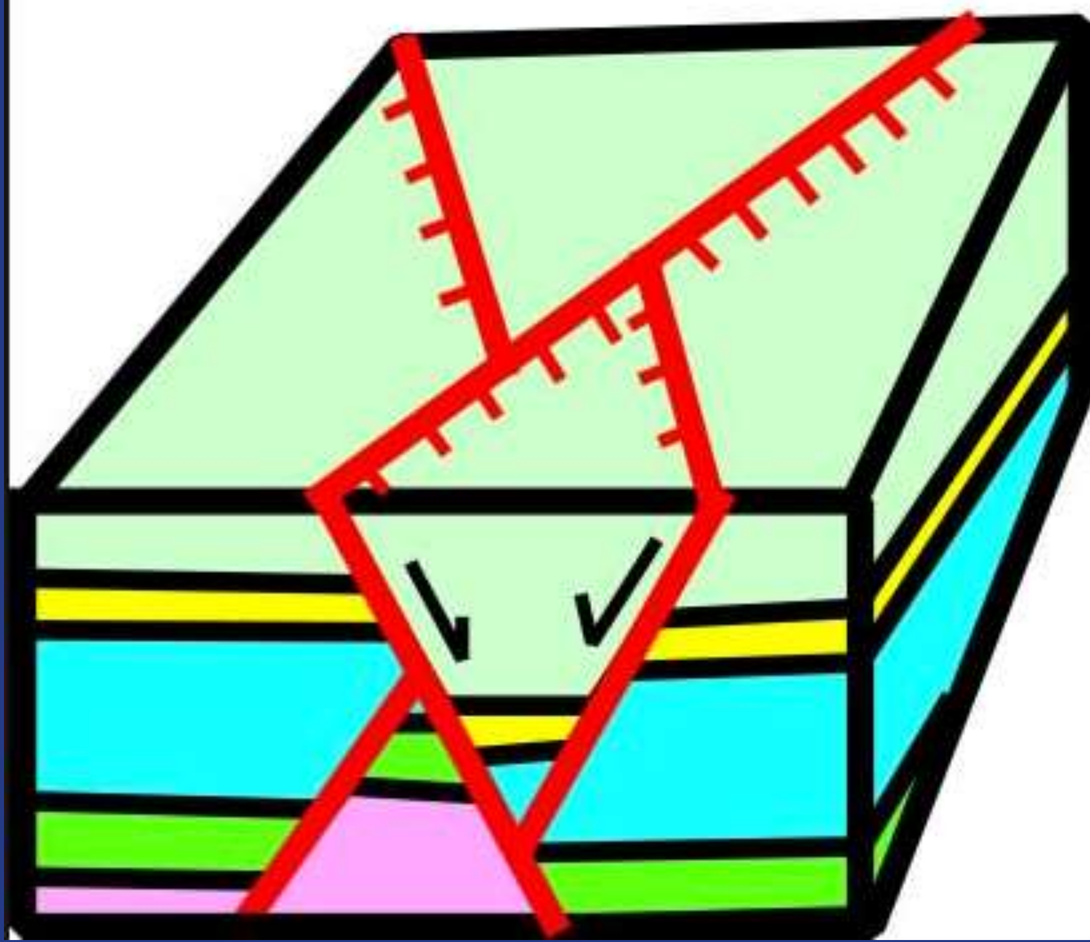


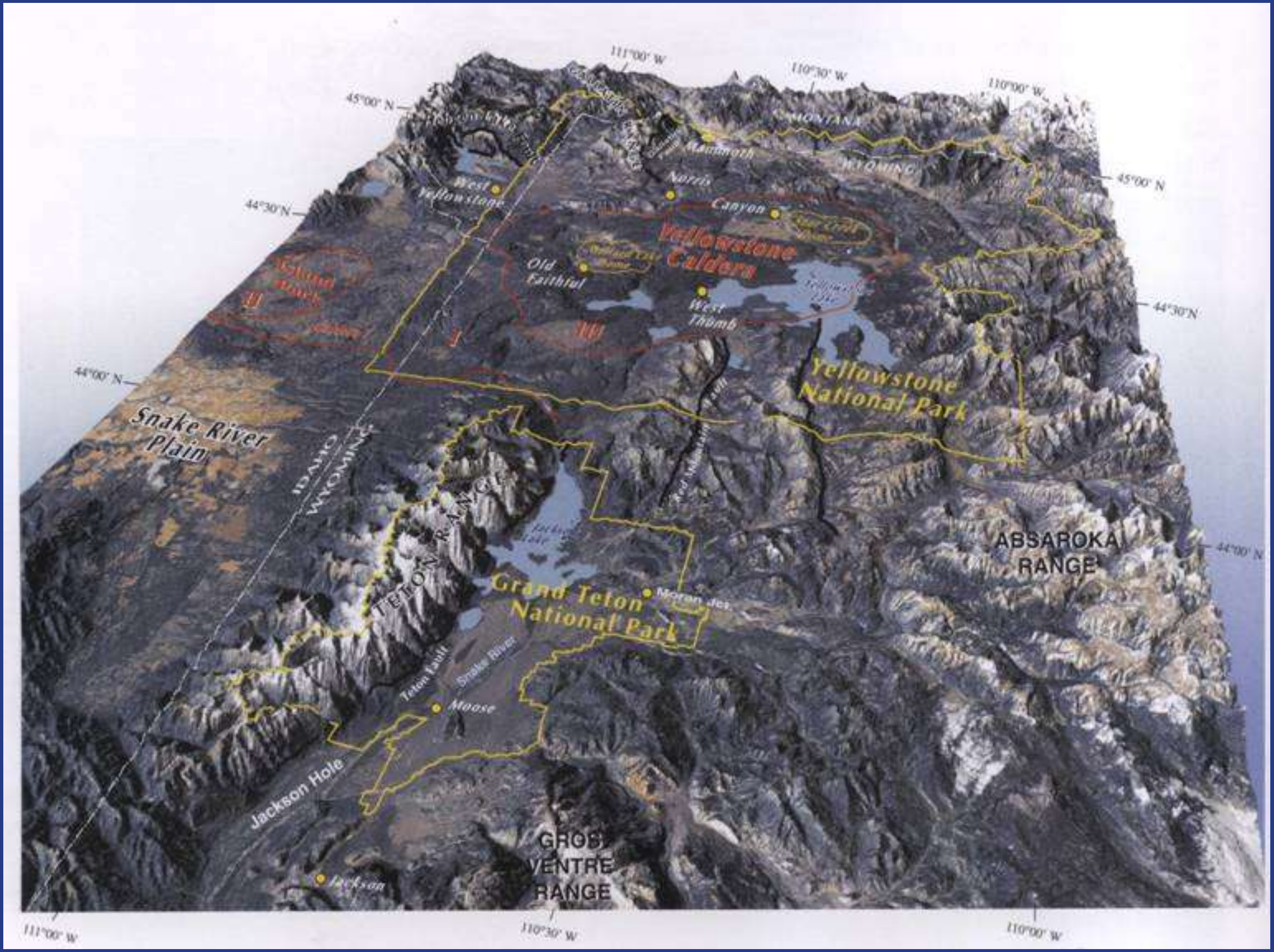
Cuyana Havzası, Arjantin



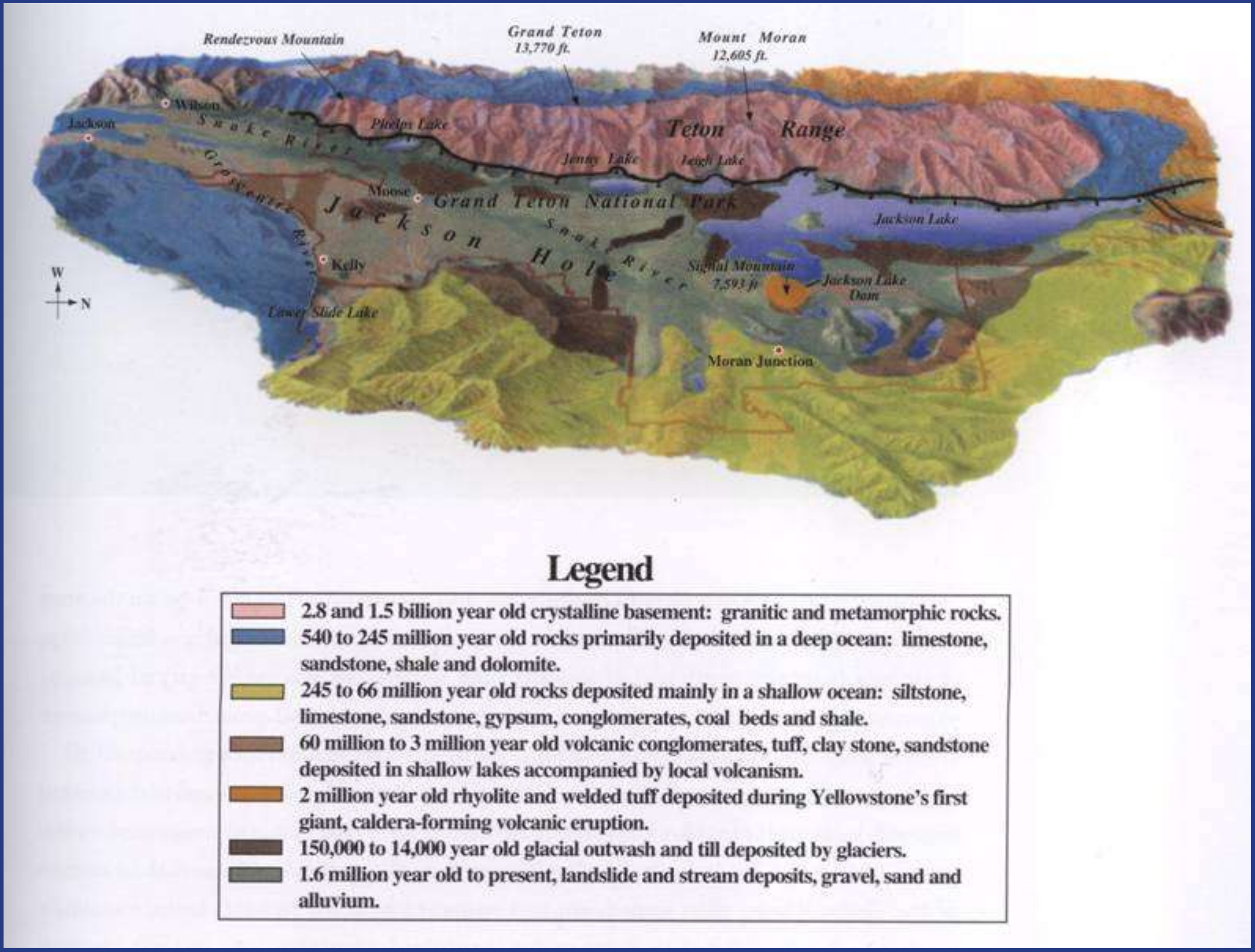
Beatrice ve Gullfaks petrol sahaları, Kuzey Denizi,
Norveç karasuları

X-fayları: harita ve kesit görünümleri

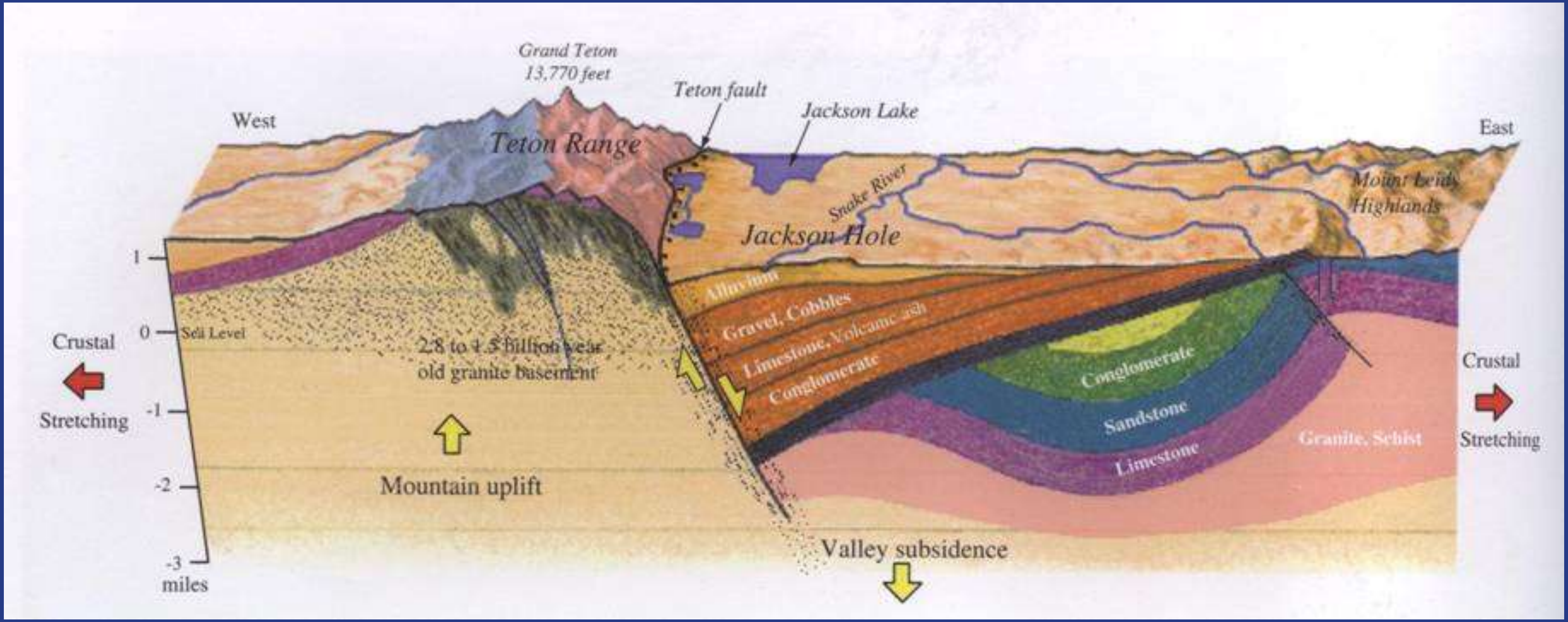




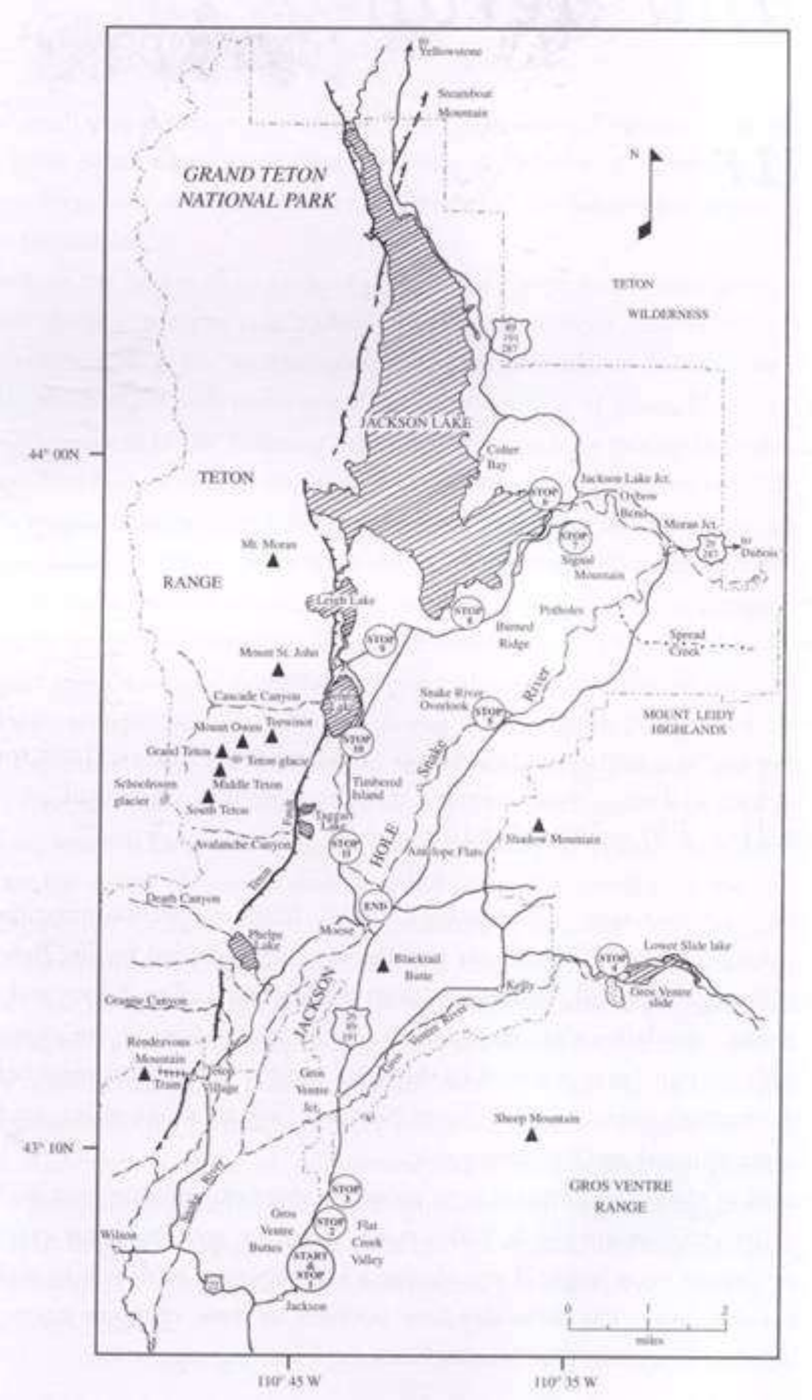
Grand Teton ve Yellowstone oblik topoğrafya haritası



Grand Teton jeolojik blok diyagramı



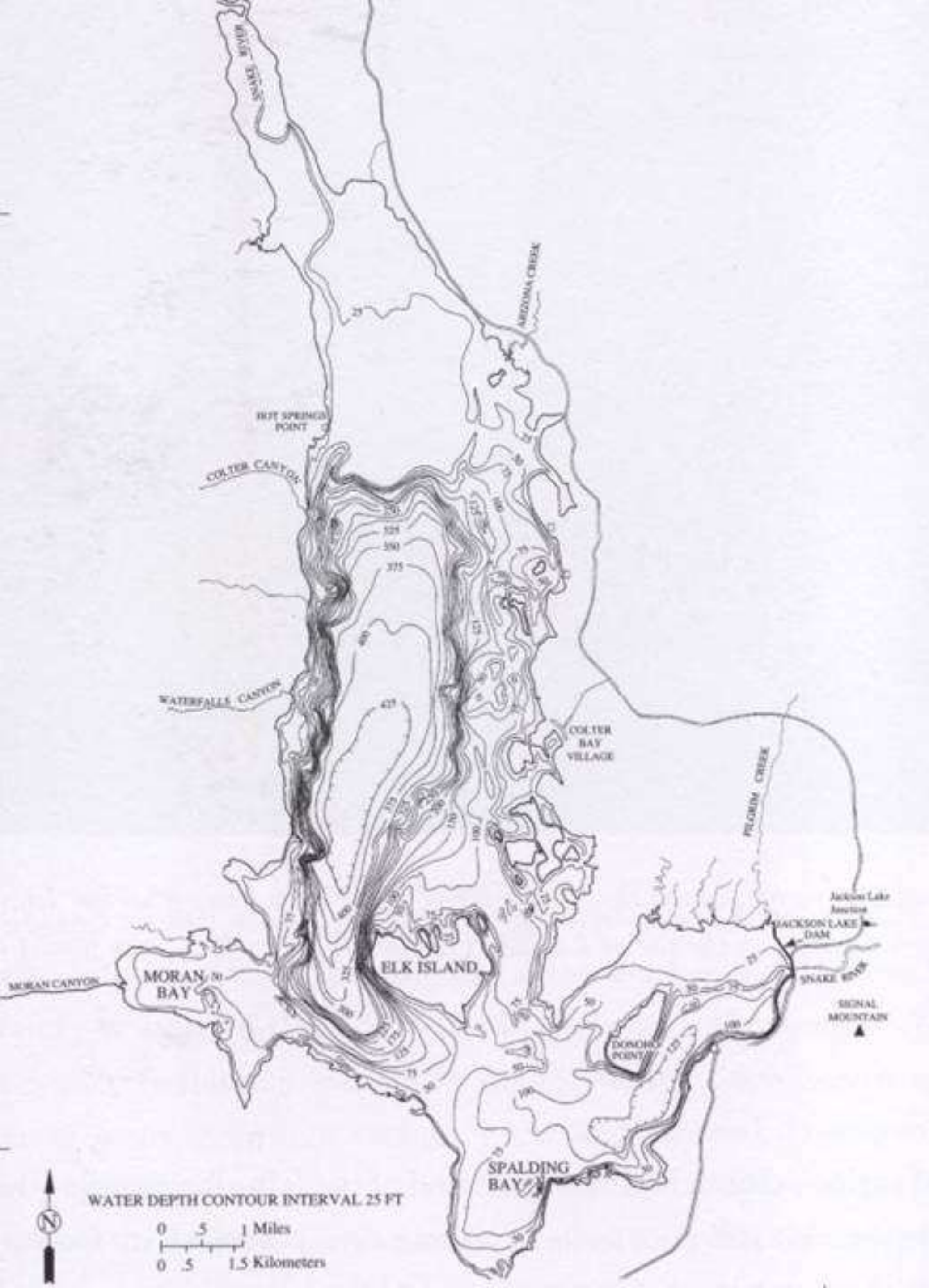
Grand Teton blok diyagramı ve kesiti



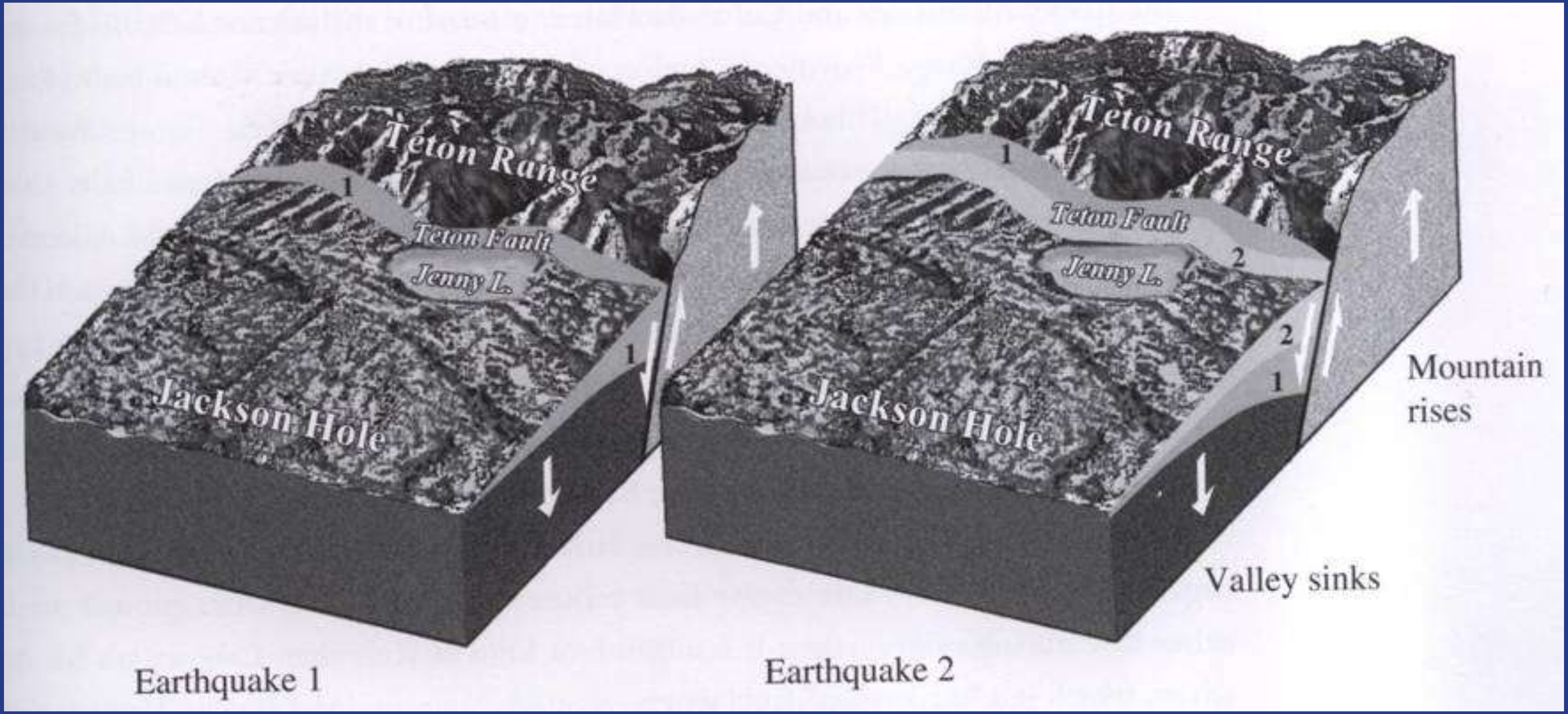
Grand Teton faal tektonik haritası

Jackson Gölü ve Grand Teton silsilesi

- Jackson Gölü ve Grand Teton silsilesi güney ucu



Jackon Gölü derinlik haritası



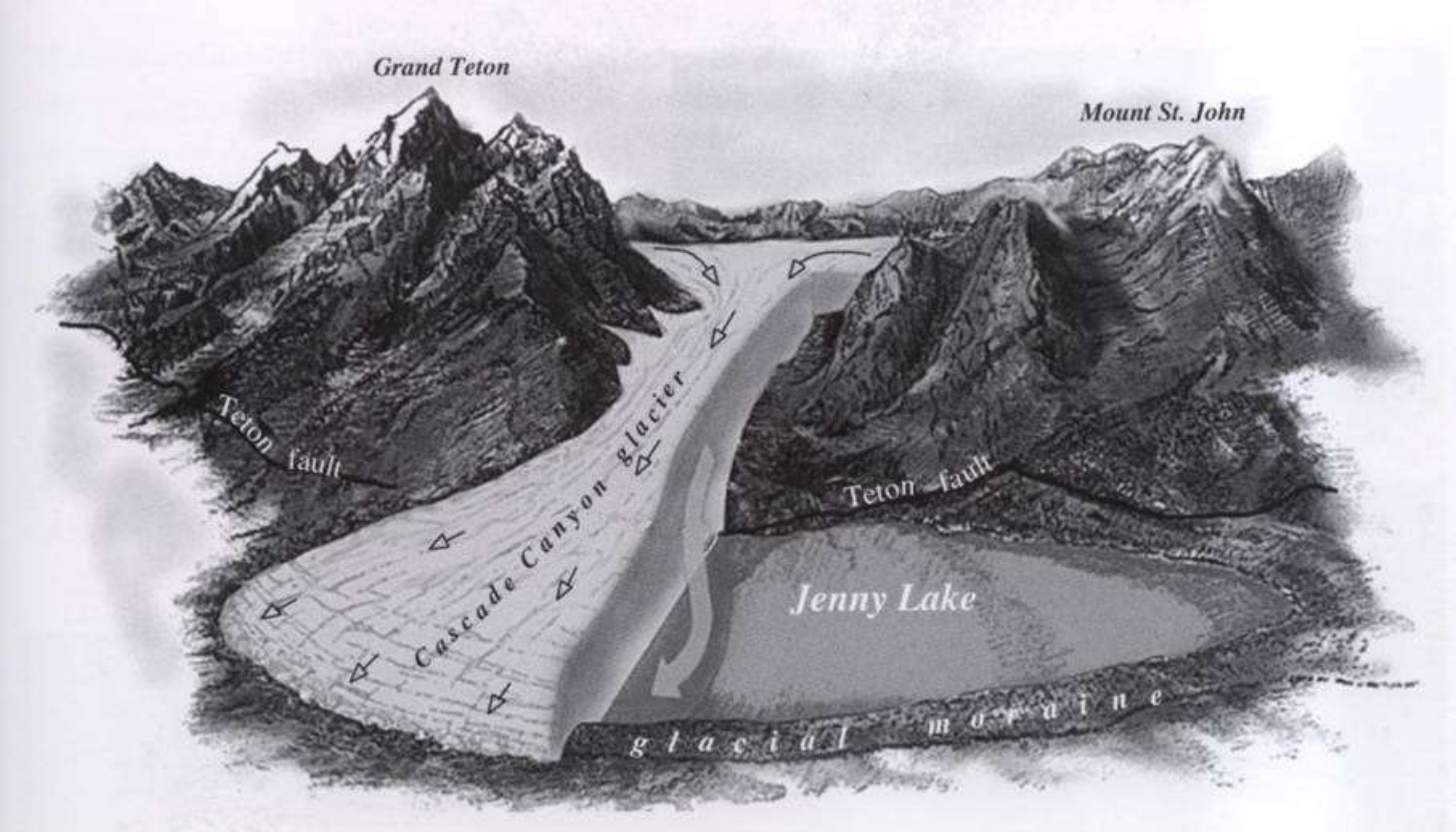
Teton Range’ in nasıl oluştuğunu gösteren blok diyagram

Teton Range eteğinde Mg: 7’ lik fay dikliği

Teton silsilesi

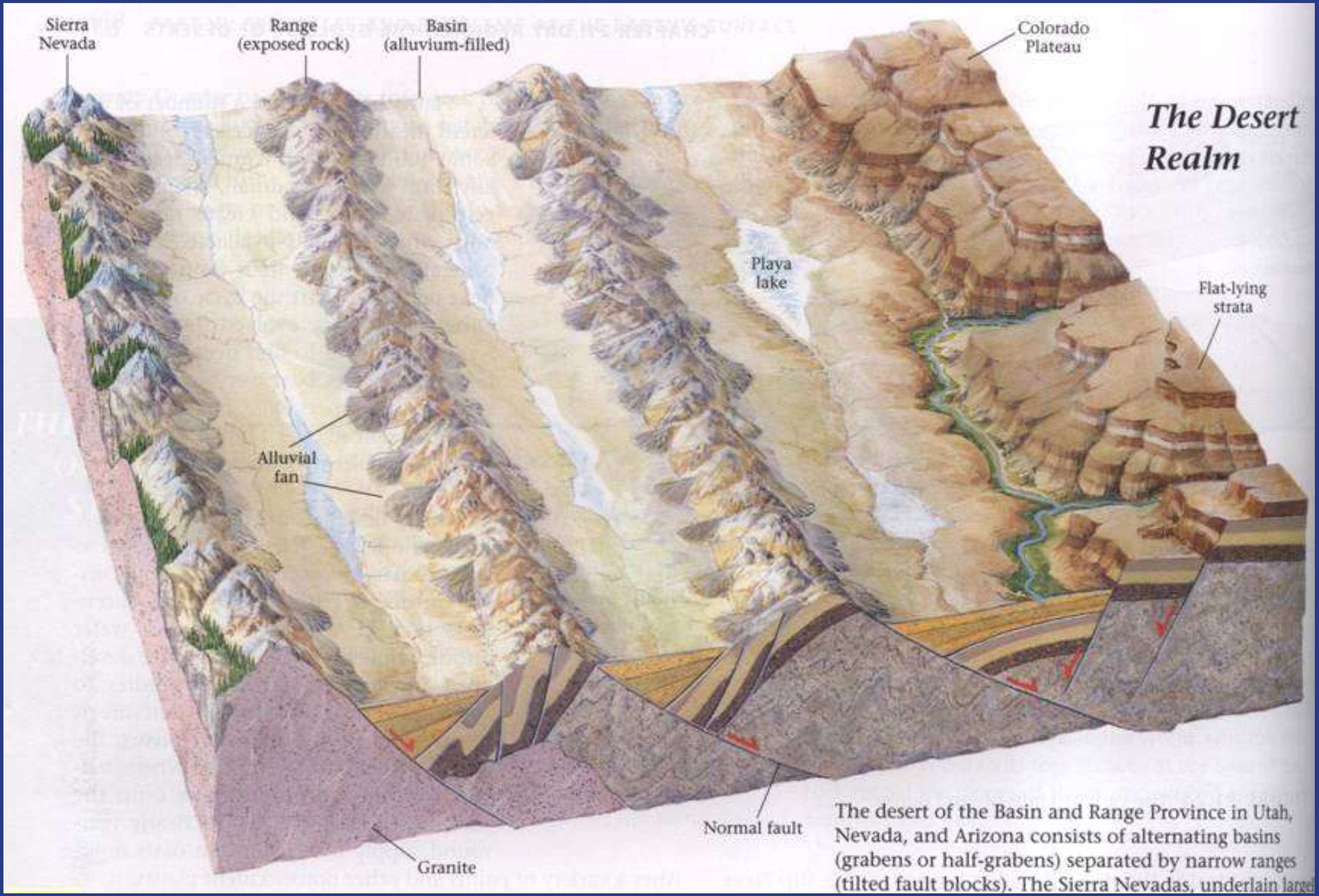
Teton silsilesi önünde gözlenen morenler ve fay diklikleri

Buzul çağında Teton’un görünüşü

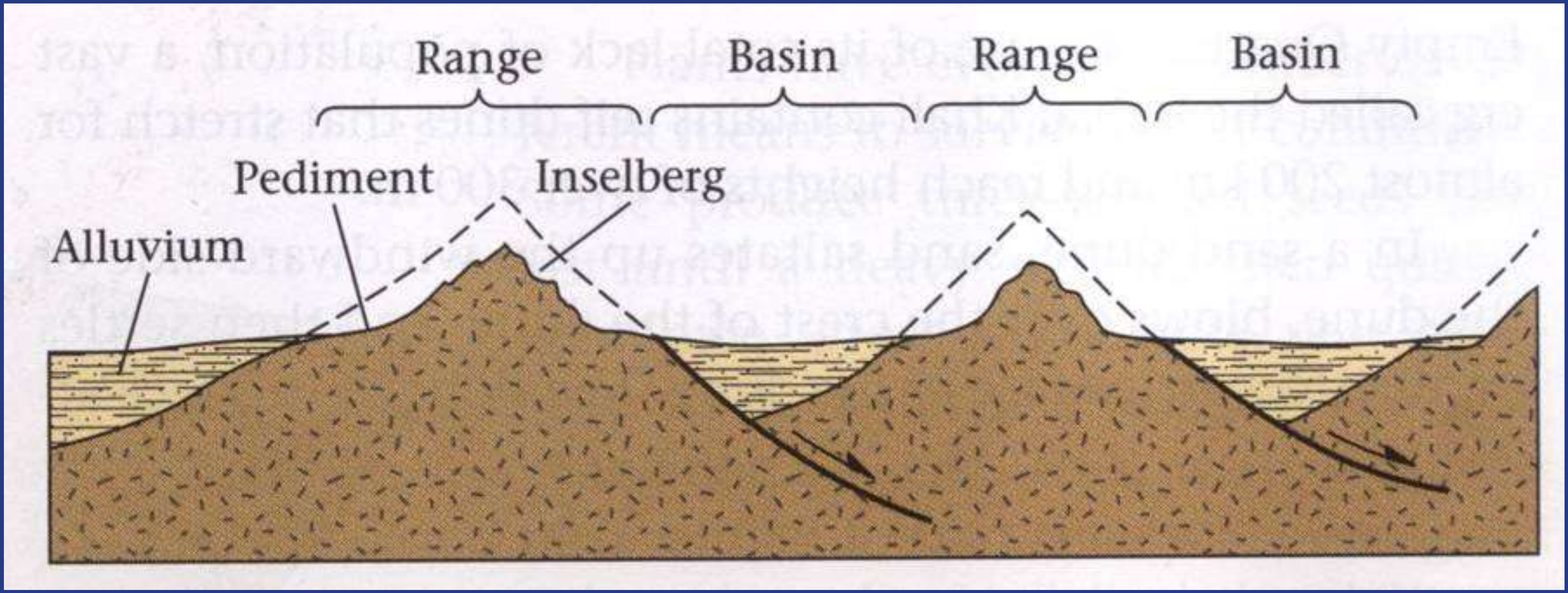


Jenny lake’in oluşumu. Bir normal fay ve morenler ile sınırlandırılmış

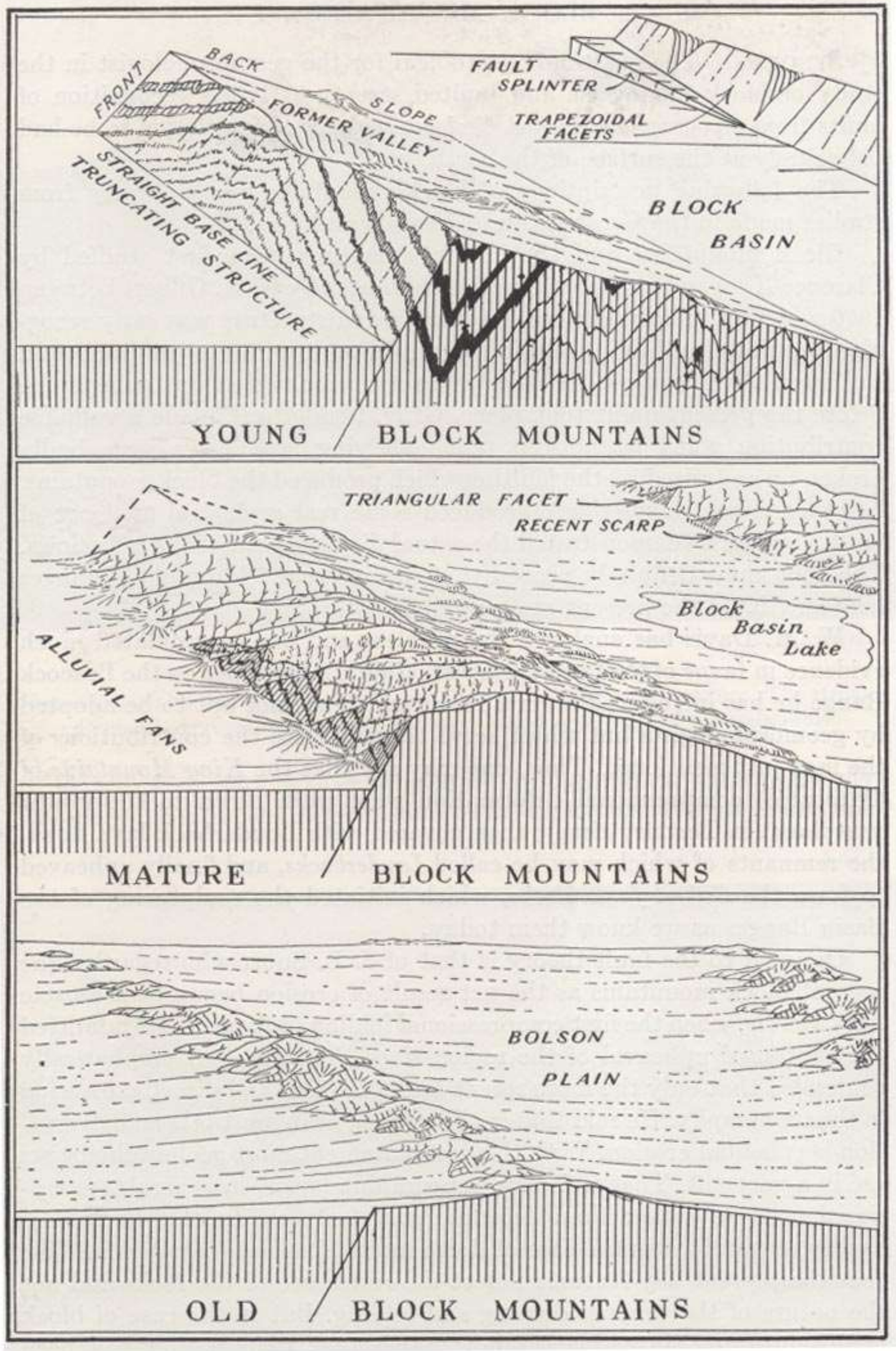
Jenny Gölü



Tipik 'Basin and Range' topoğrafyası

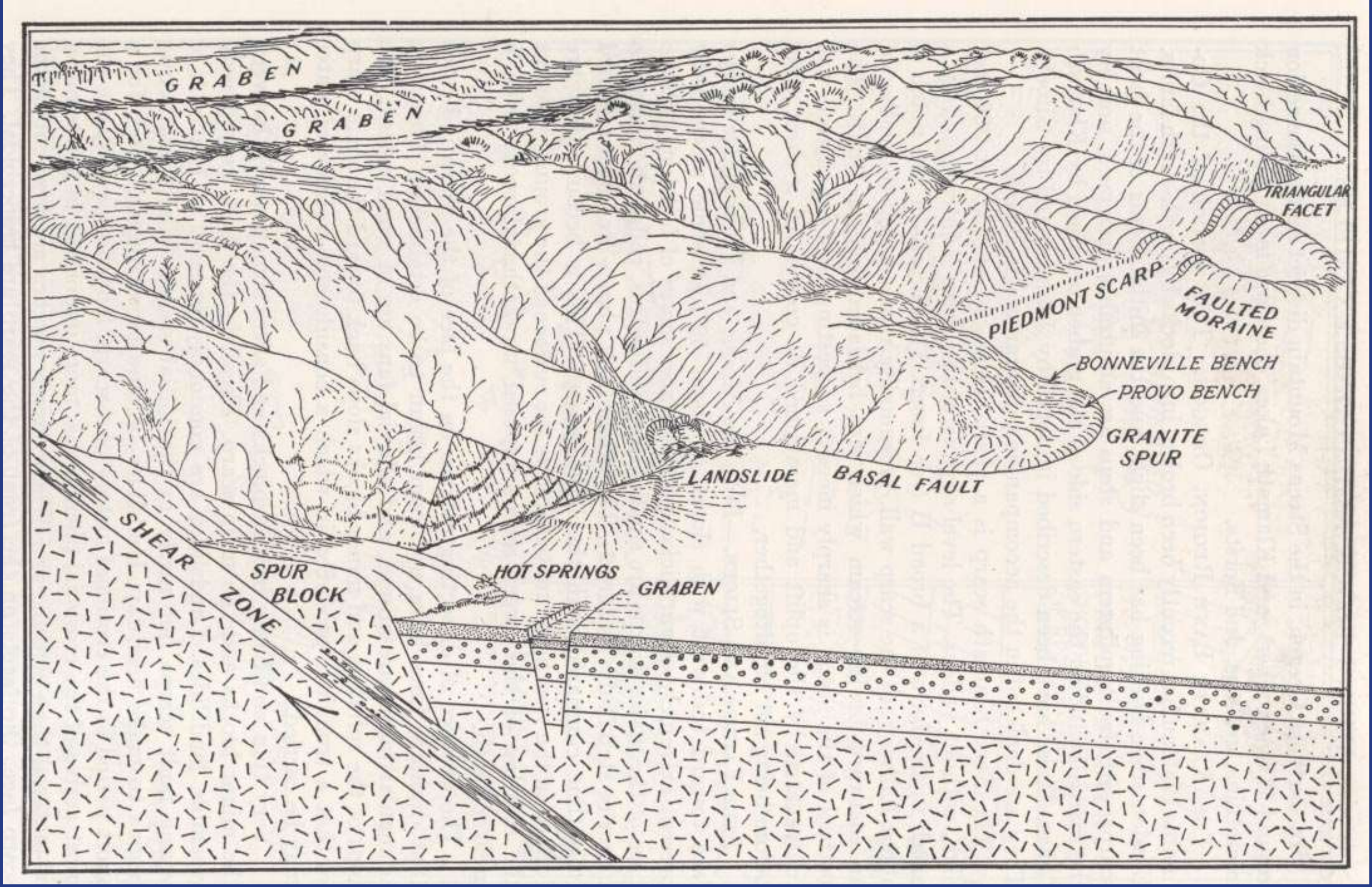


‘Basin and Range’ ‘de morfolojik gelişmeler

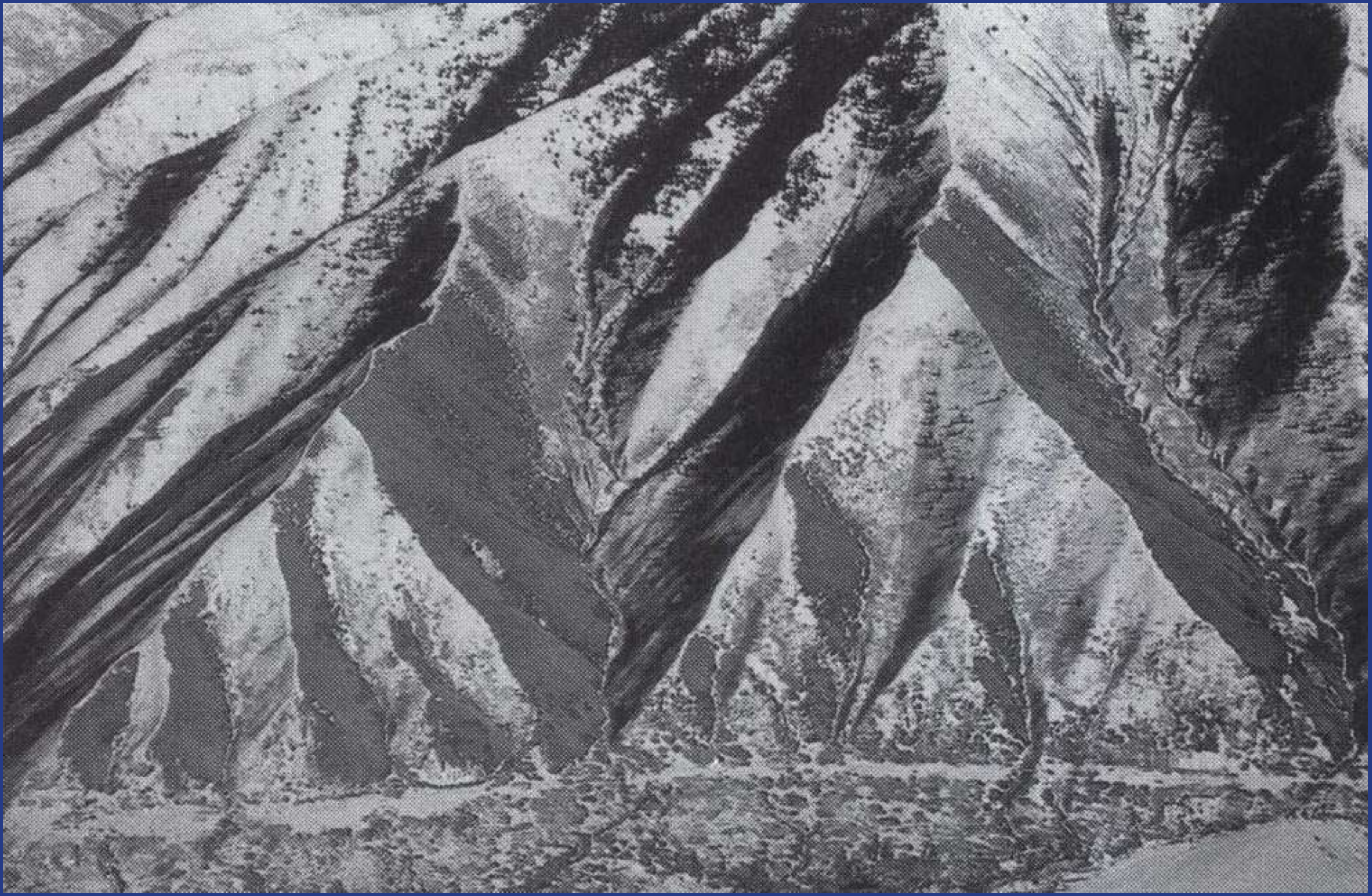


'Basin and Range' morfolojik evrimi

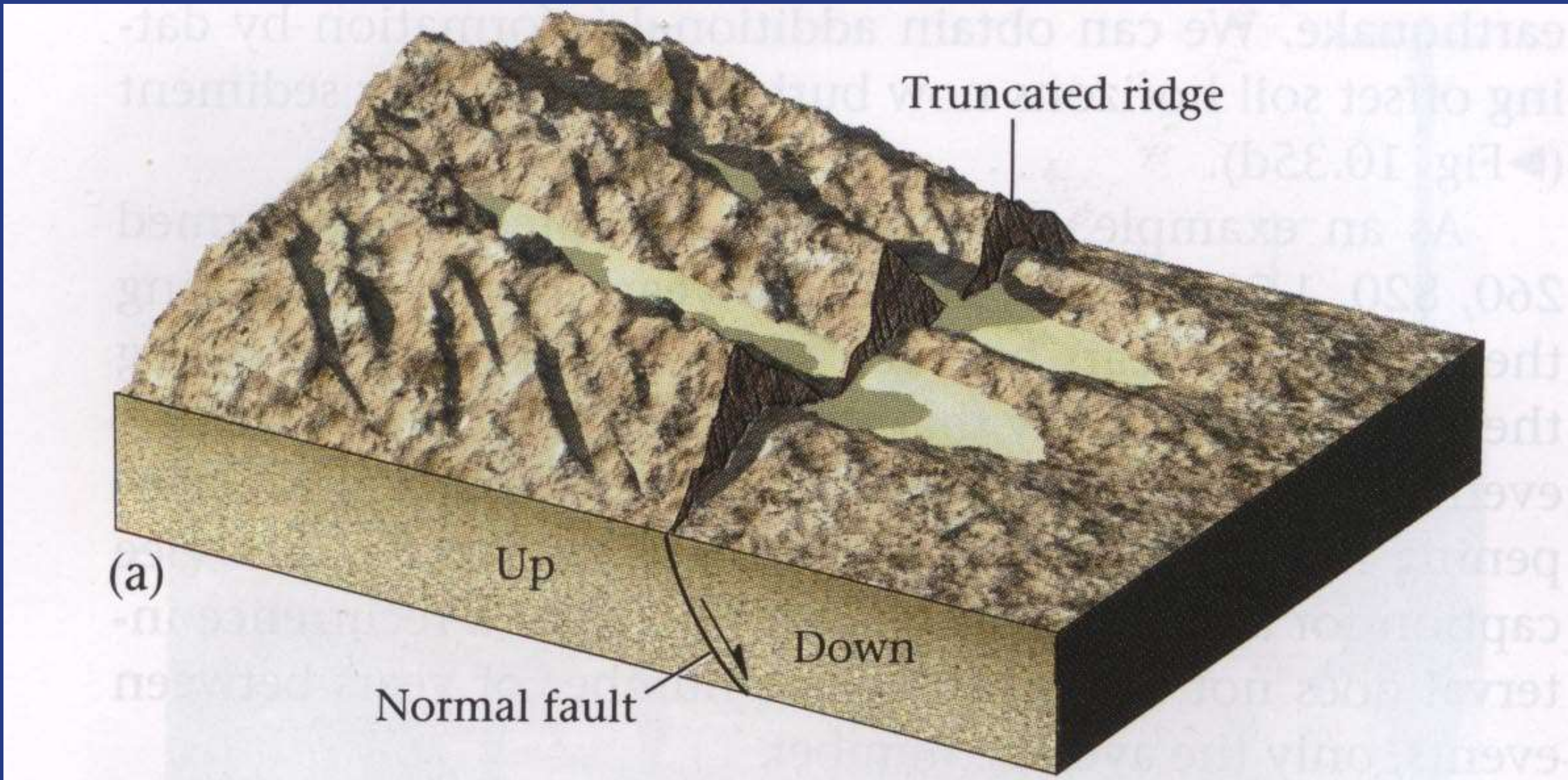
Wasatch cephesi



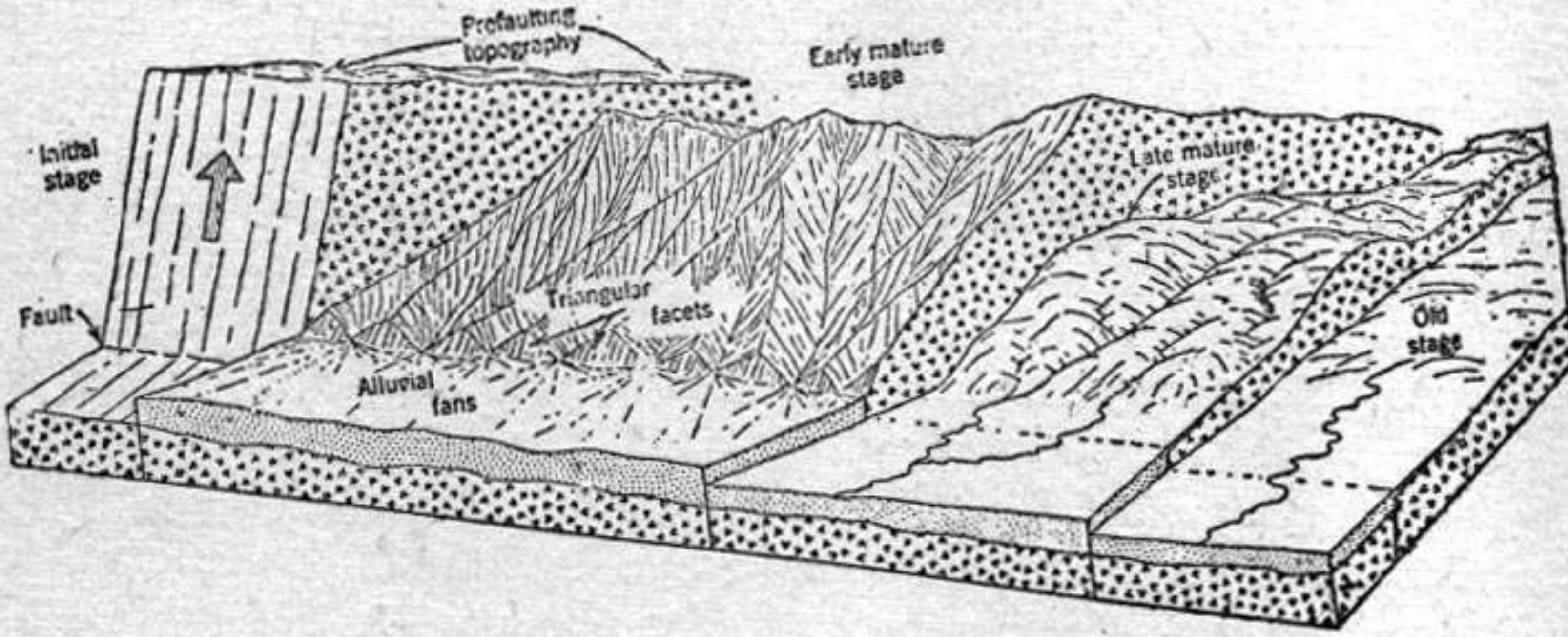
Wasatch cephesi diyagramı



Wasatch cephesinde üçgen façetalar

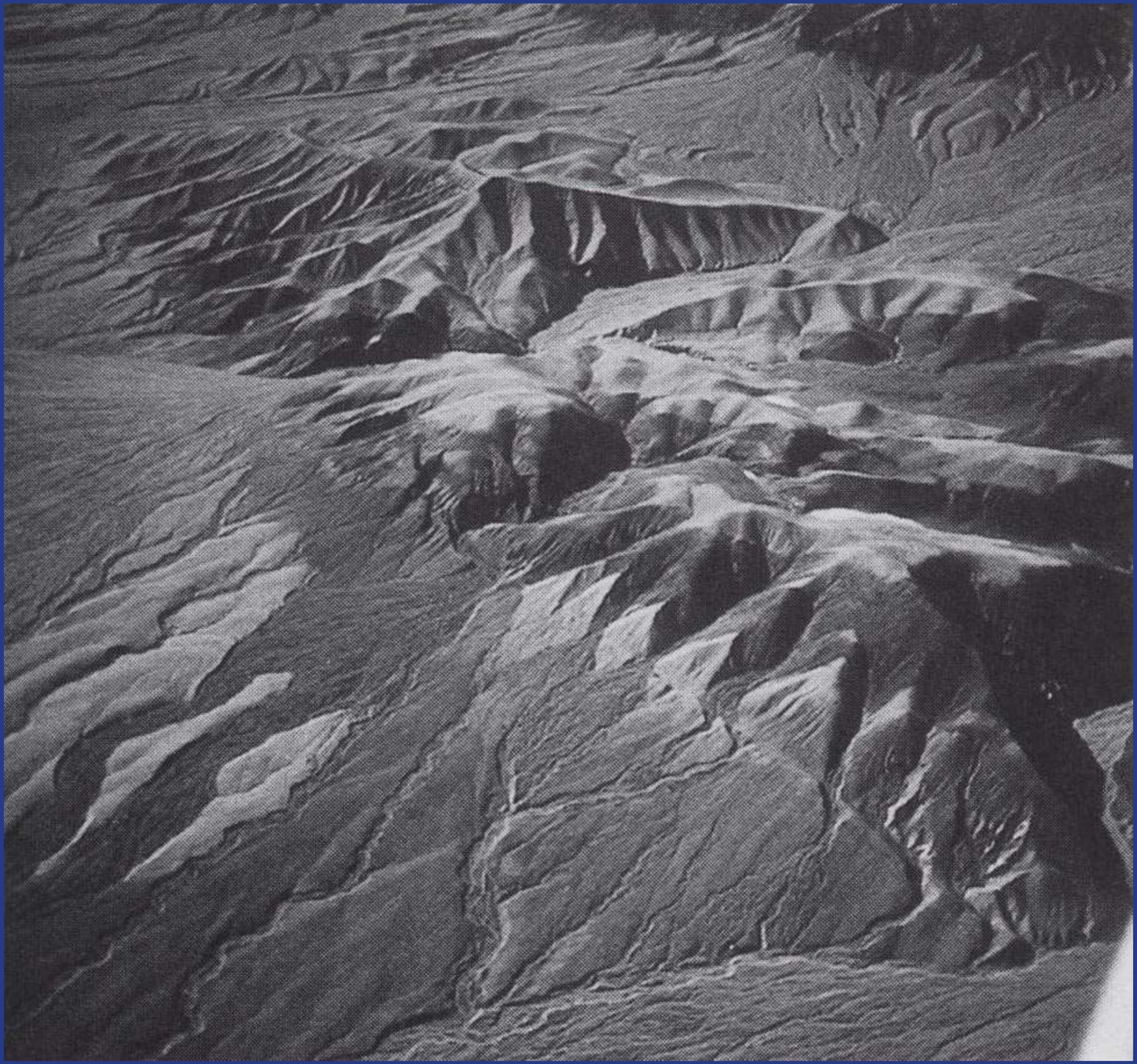


Üçgen façetaların oluşumu

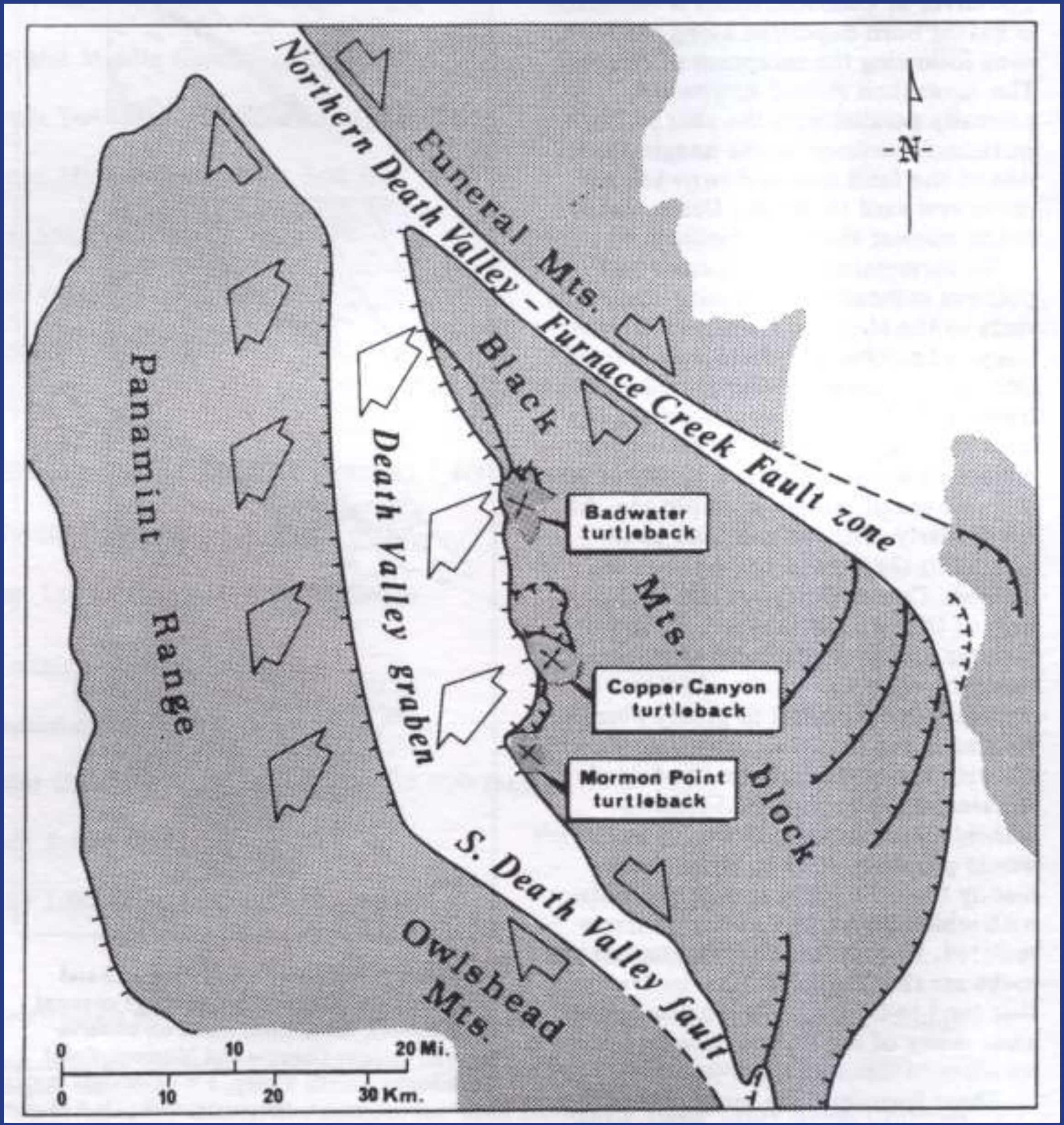


Şek. 172 — Fay dikliklerinin tekâmülü (*Davis*'e göre *Strahler*'den). Soldan sağa doğru: 1 — Başlangıç safhası ve fay dikliği. 2 — Olgunluk safhası başlarında durum. Yarılma, fay façetaları ve birikinti konileri. 3 — Olgunluk safhası sonlarında durum. 4 — İhtiyarlık safhasında durum.

Fay dikliğinin morfolojik evrimi

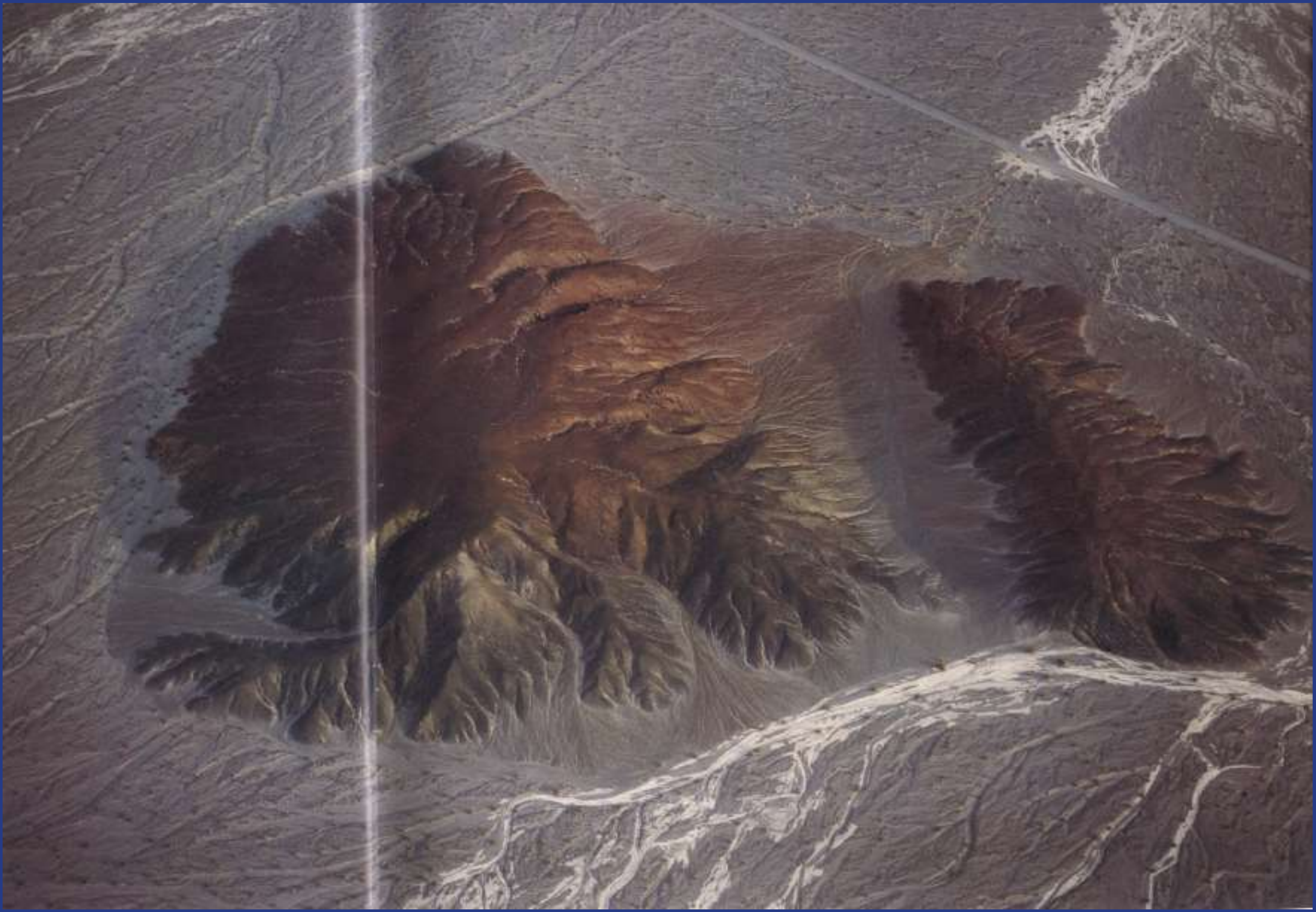


Oblik fay üzerinde üçgen façetaların gelişimi



Death Valley basitleştirilmiş tektonik haritası

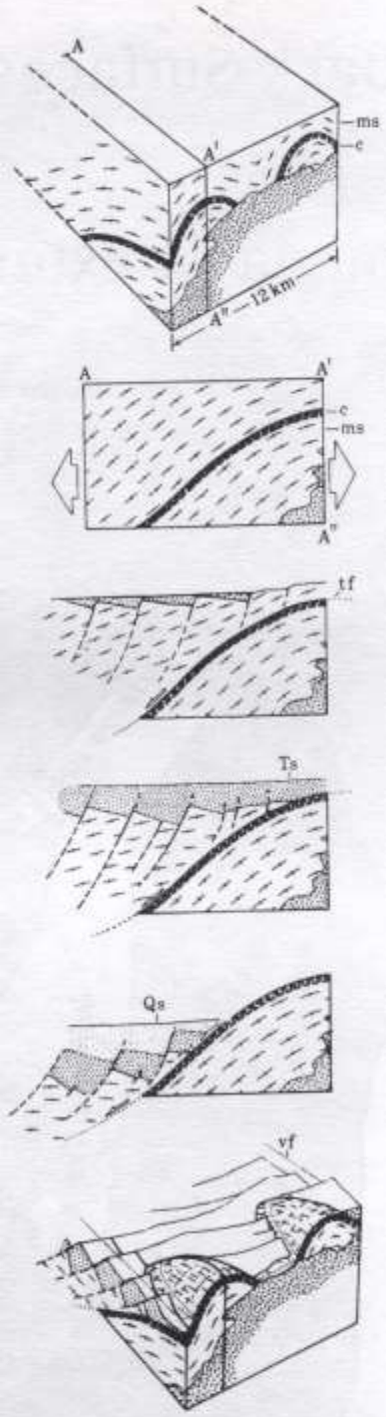
Death Valley yalancı renklendirilmiş uygu görüntüsü



Death Valley ortasında ki volkanitler üzerine yanal atım

Black Mountains ‘de bir kaplumbağa sırtı fayı

Death Valley’de düşük açılı normal Fay



Kaplumbağa sırtı ve düşük açılı normal faylarınoluşumu

Kaplumbağa sırtı faylarını kesen normal faylar (Death Valley, Black Mountains)

Black Mountains ‘ de bir Normal fay

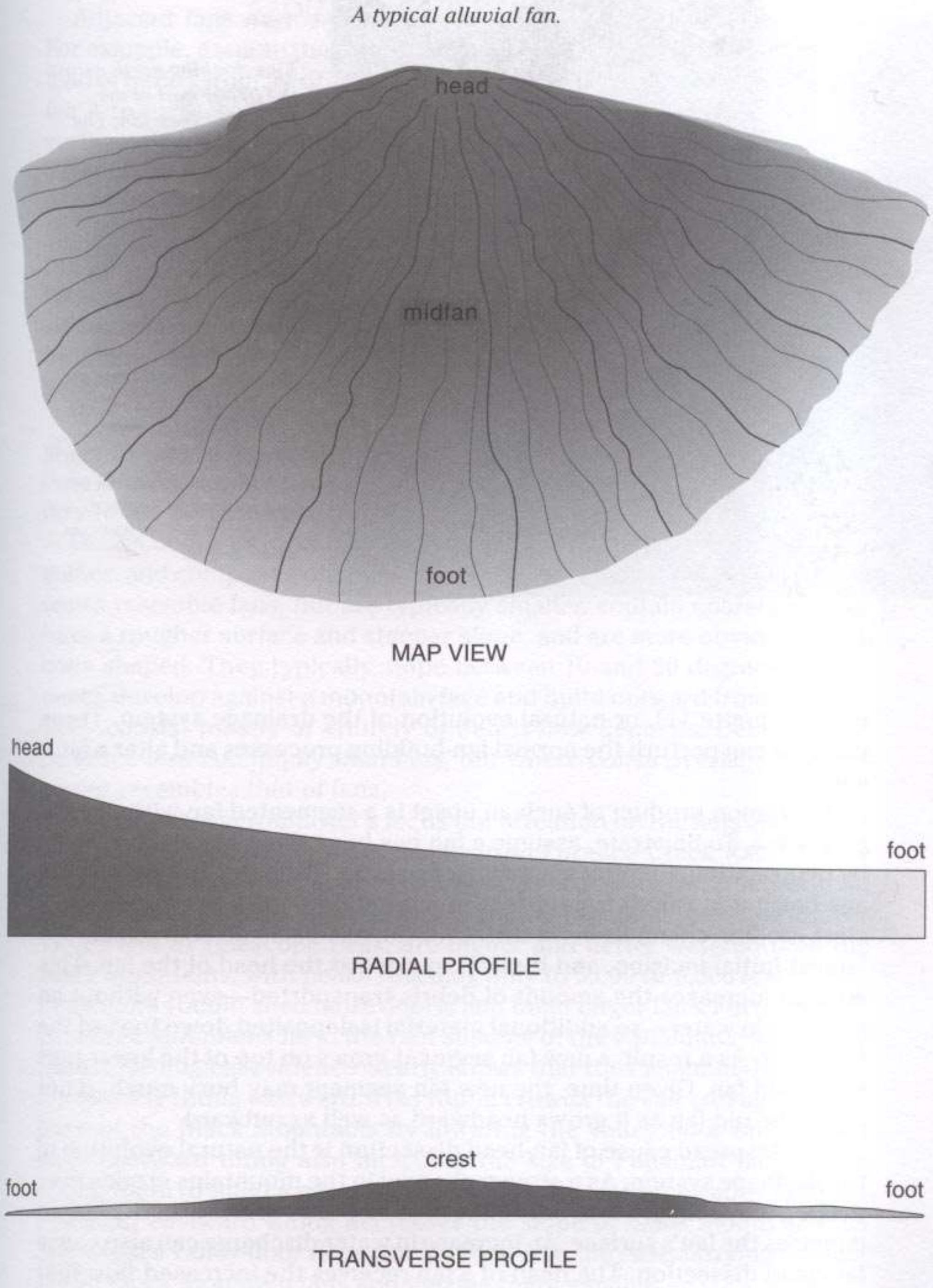
Normal bir fayın
fay aynası

(Black Mountains)

Black Mountains ‘ de depremle oluşmuş bir fay basamağı

Fernes Creek Depremi fayı

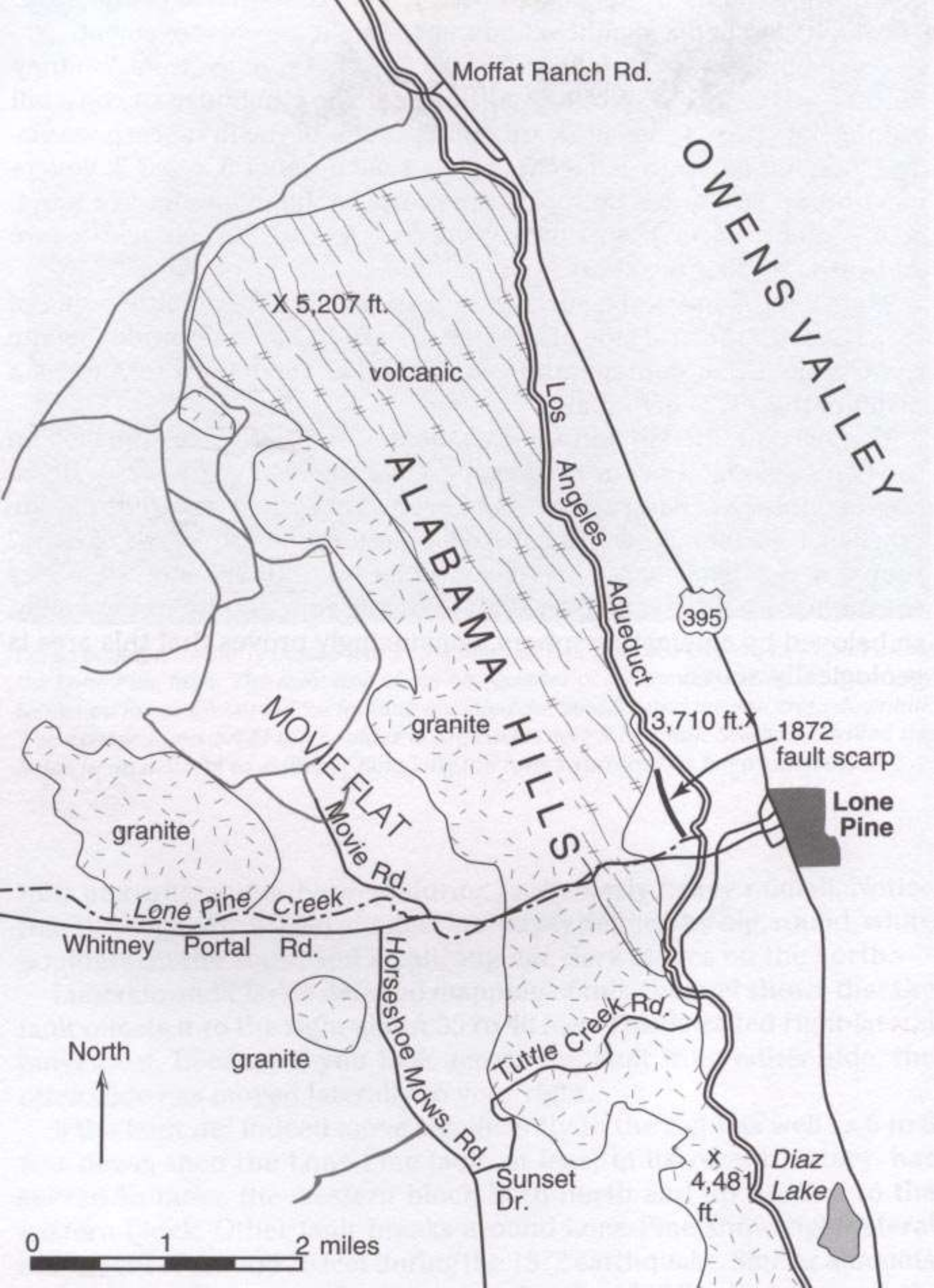
Death Valley’de bir alüvyal yelpaze



Bir alüvyal yelpazenin morfolojisi

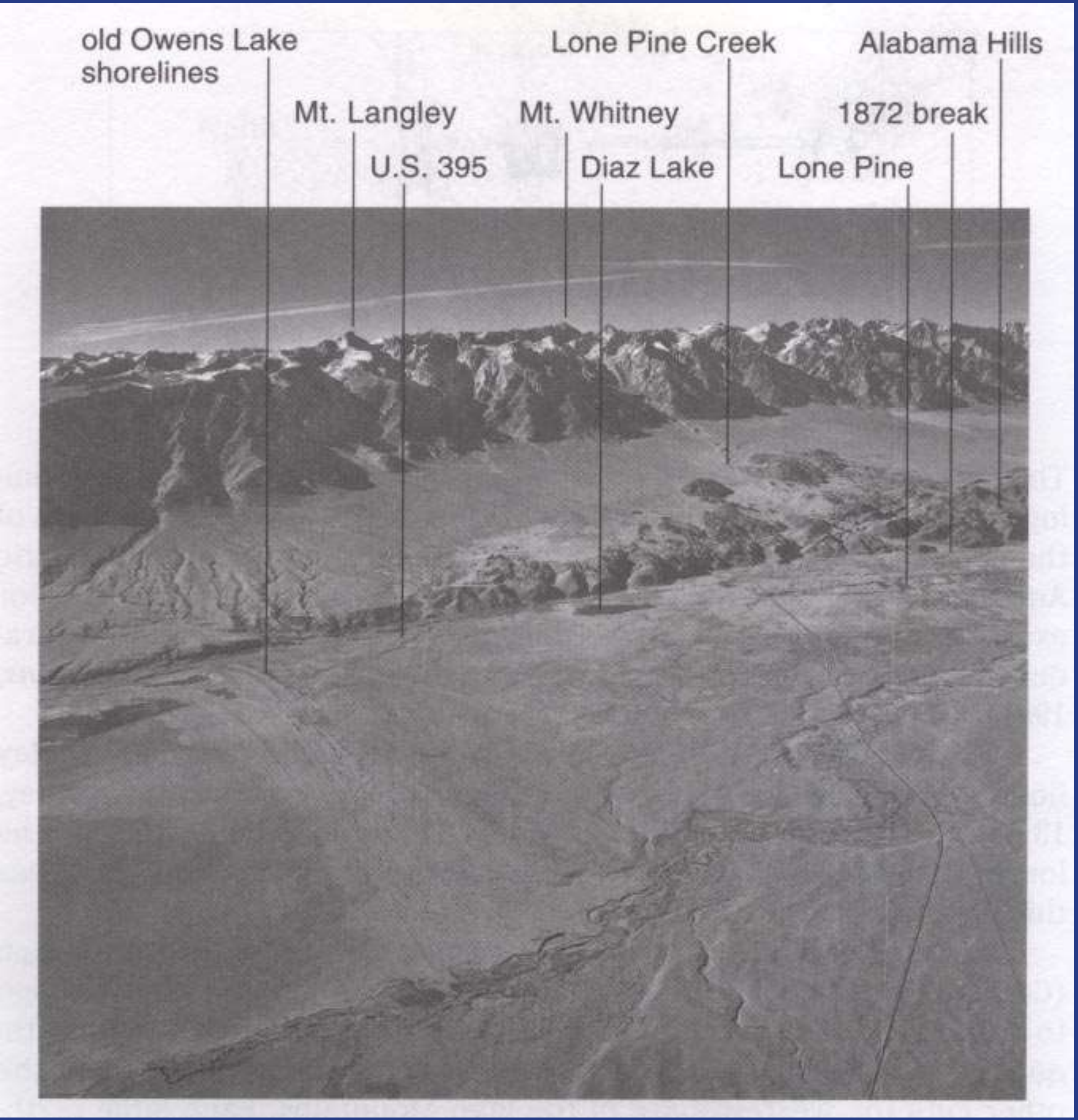
Death Valley ‘de bir deprem fayı basamağı ile kesilmiş alüvyal yelpaze

Death Valley ‘de bir deprem fayı basamağı ile kesilmiş alüvyal yelpaze

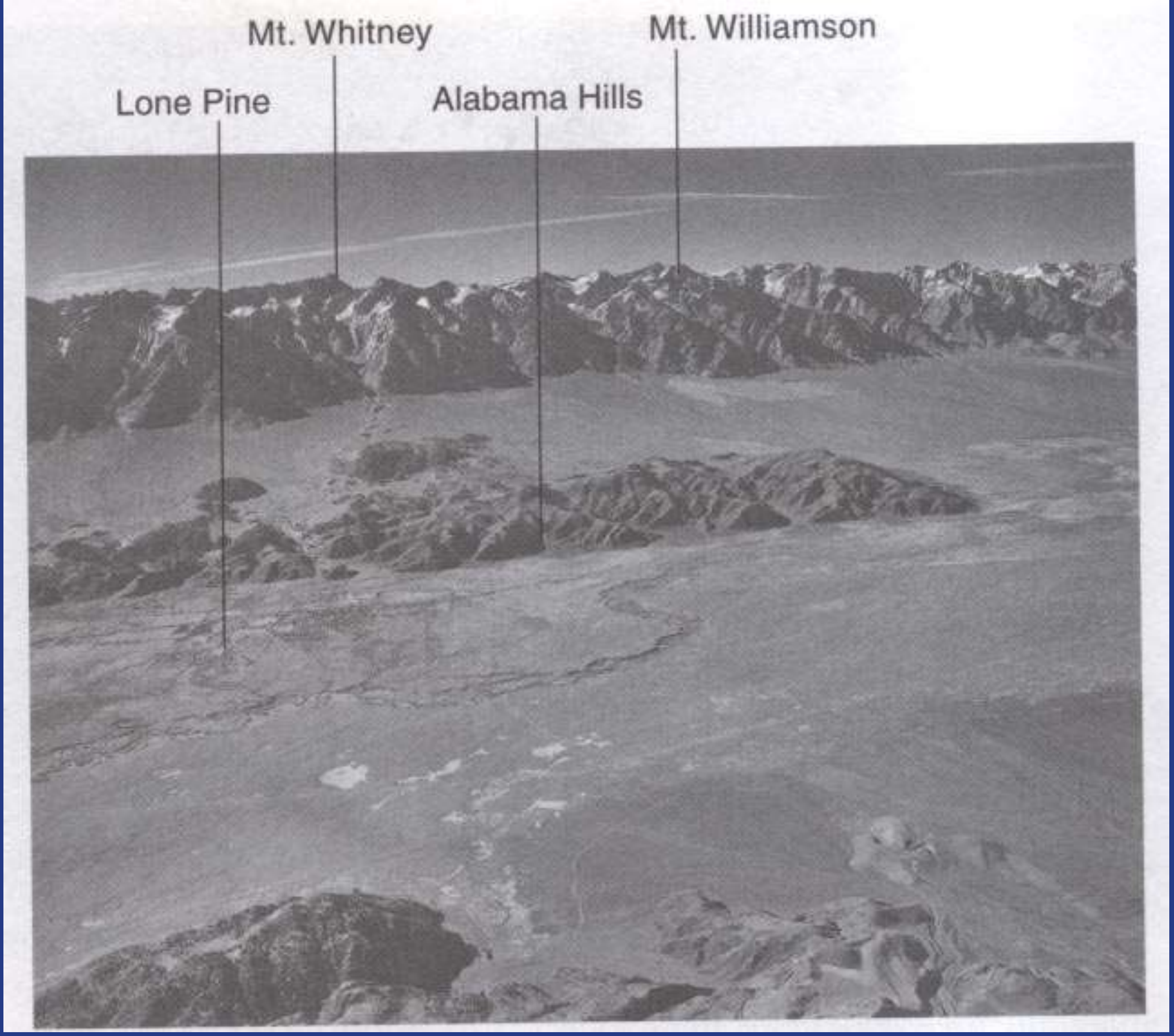


Owens Valley Batısı tektonik haritası

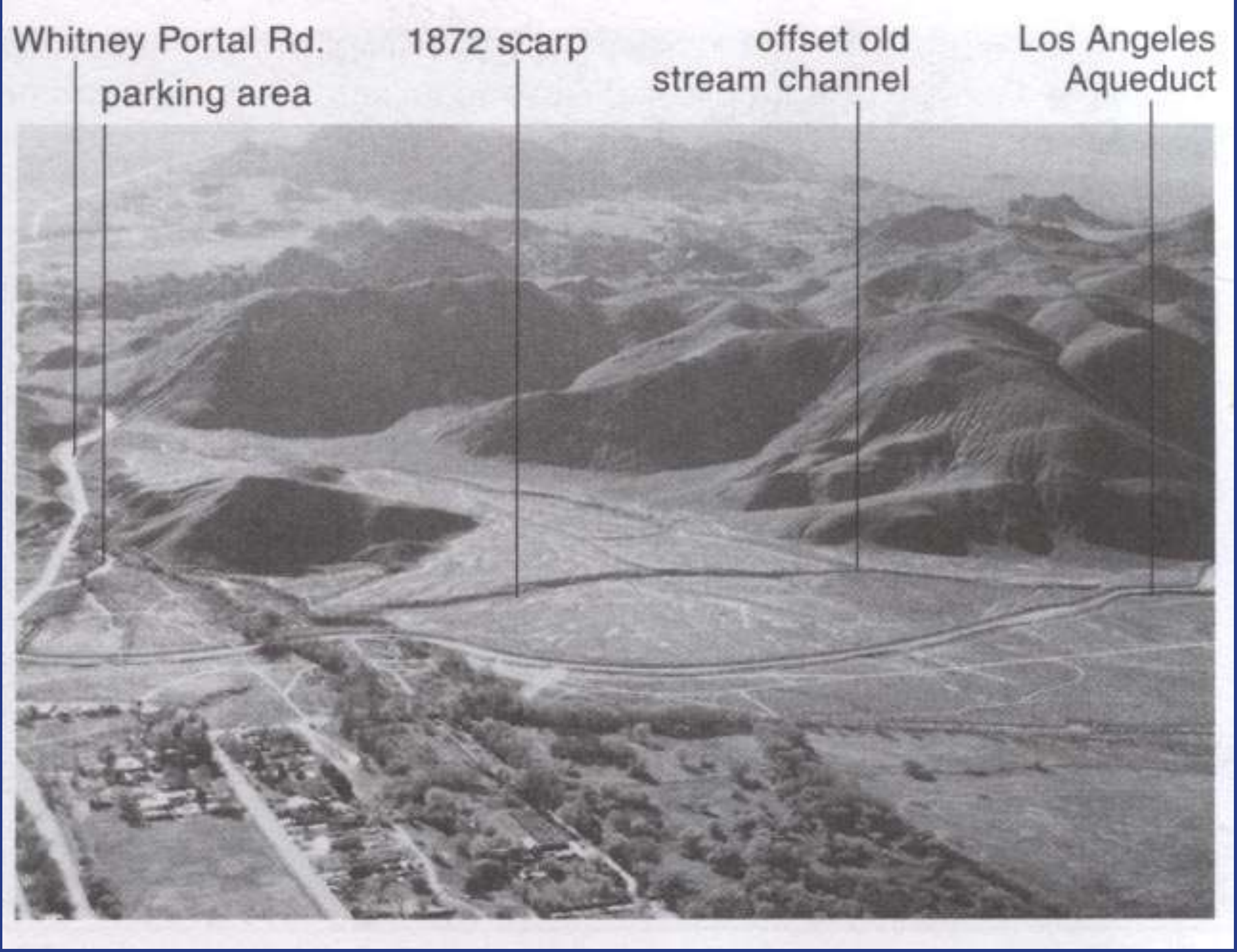
Owens Valley Sierra Nevada ‘nın görünüşü



Fay basamağı (Owens Valley)



Fay basamağı (Owens Valley)



Owens Valley 1872 kırığı

Hilton Creek Fayı

Hilton Creek Fayı

Hilton Creek Fayı

Owens valley 1872 kırığı

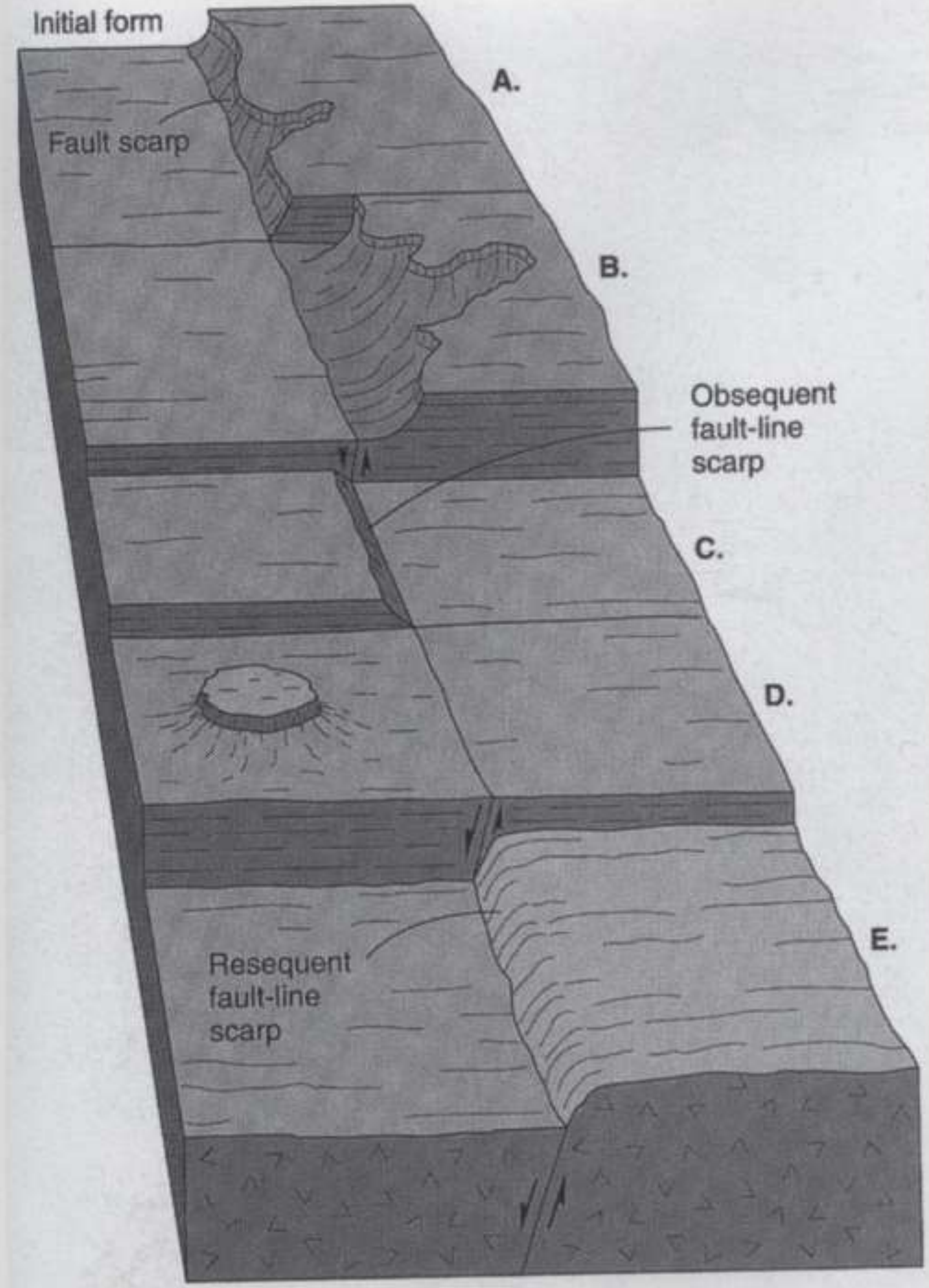
Doğu Afrika Rift Vadisi
Uydu Görüntüsü

Tanzanya’da Doğu Afrika Rift Vadisi omuzları

İzlanda’da Atlantik ortası riftlerinden çeşitli manzaralar

İzlanda’da Atlantik ortası riftlerinden çeşitli manzaralar

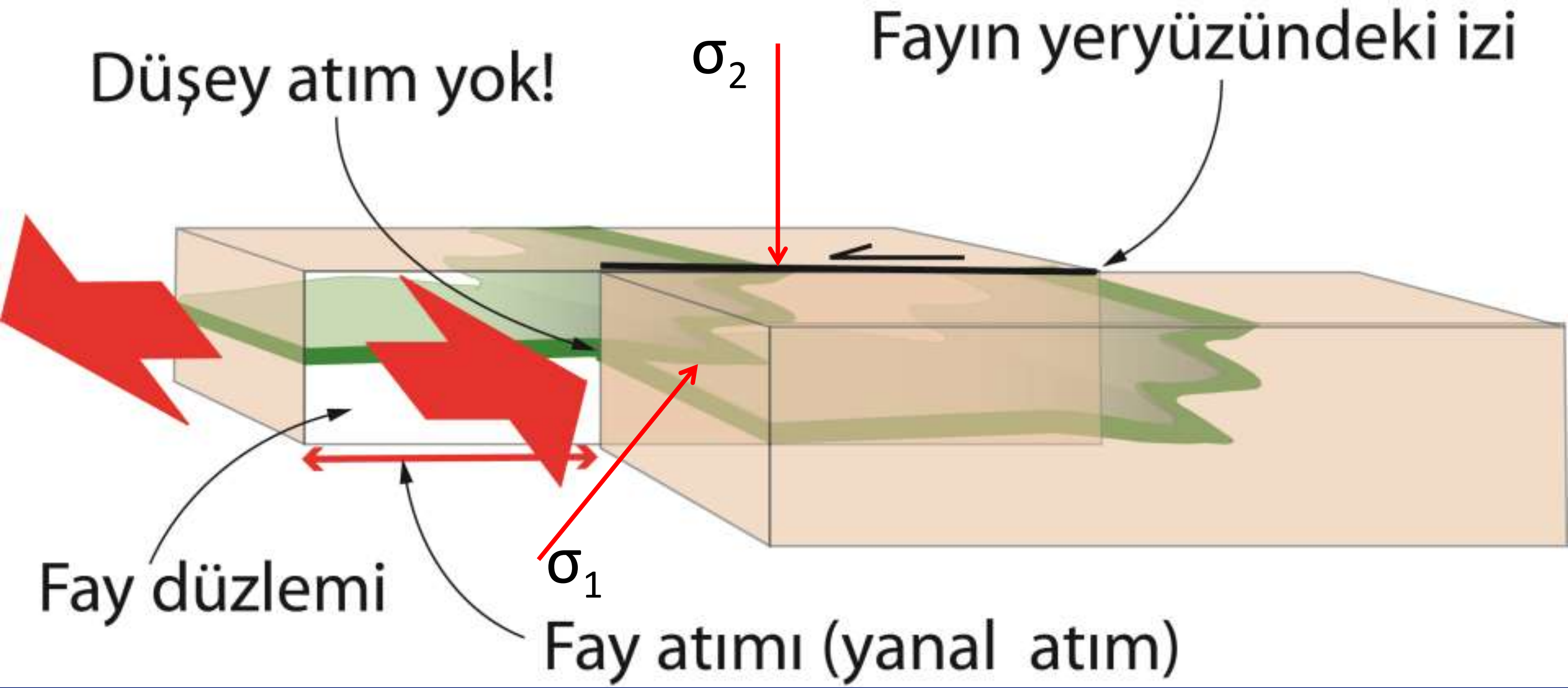
İzlanda’da Atlantik ortası riftlerinden çeşitli manzaralar



Fay dikliğinden obsekant ve resekant fay dikliklerinin oluşması

YANAL ATIMLI FAYLAR

A. M. Celâl Şengör



Yatay makaslama gerilmesi fayları

(Burada da fayı yaratan gerilme sistemi bellidir)

Bugün bütün dünyada arazide kullanılan terminoloji burada gösterilen disiplinli adlamaya uymaz. Bunun çok acı sonuçları görülmüştür. Kesitte gördüğü bir ters fayı gerçekten bindirme sanan veya kesitte gördüğü bir normal fayı gerçekten faya dik bir uzam ürünü zanneden sayısız jeolog çok ciddî yanlışlar yapmışlardır.

Hâlâ pek çok ders kitabında ters fayın (reverse fault) 45°'den büyük eğimi olan daralmalı faylar için, bindirmenin (thrust fault) için ise daha düşük açılı faylar için kullanıldığı gibi zırva iddialar vardır. Halbuki bu iki terim iki değişik adlama grubunun terimleridir ve fayın değişik özelliklerini dile getirirler. Bunlardan kaçınmamız gerekmektedir. Yoksa iki insandan bahsederken birine meselâ erkek diğerine ise uzun boylu demek gibi birbiriyle karşılaştırılması imkânsız terimler kullanmş oluruz.

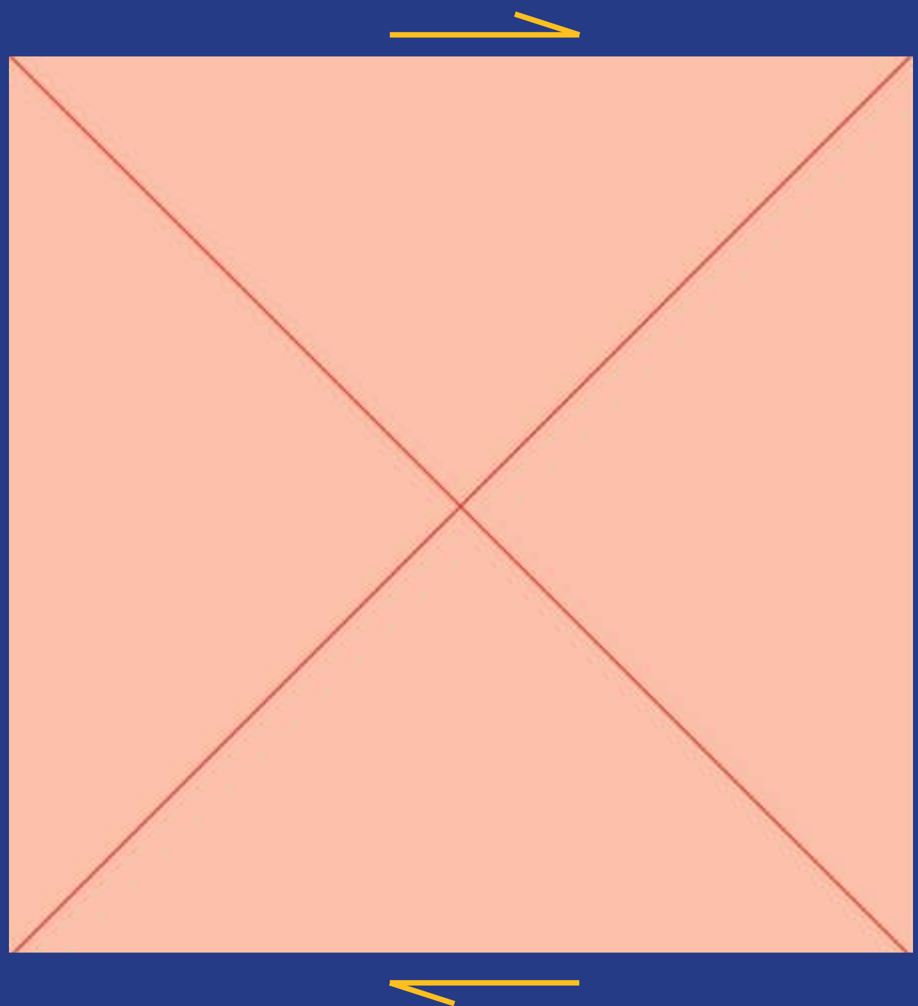
Ancak bütün dünyadan ayrı bir terminoloji kullanmak da başkaları tarafından anlaşılmamızı imkânsız kılar. Onun için, ben size yayınlarımda kullandığım terminolojiyi önereceğim:

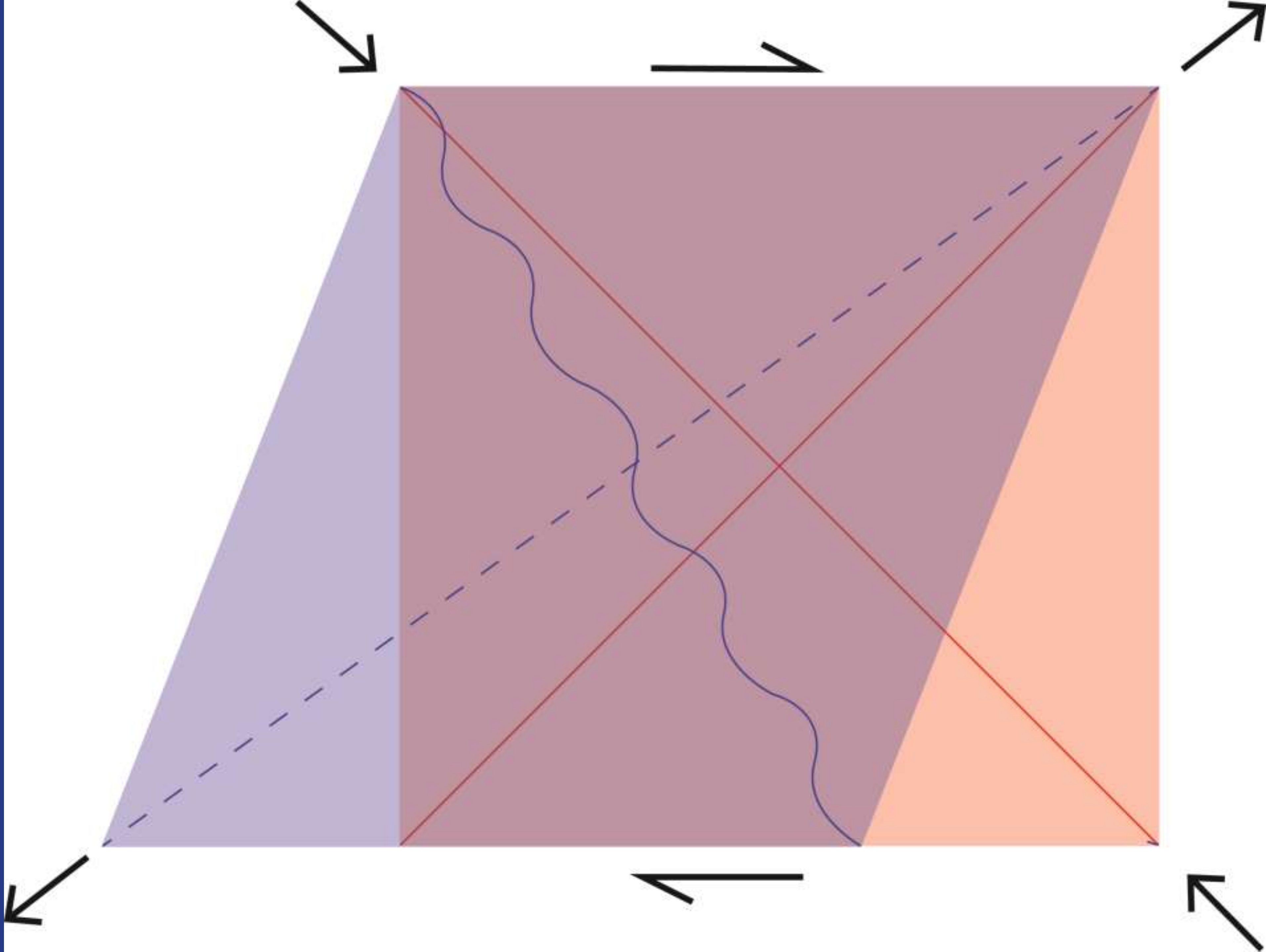
1 Eğim atımlı normal fay için sadece normal fay.

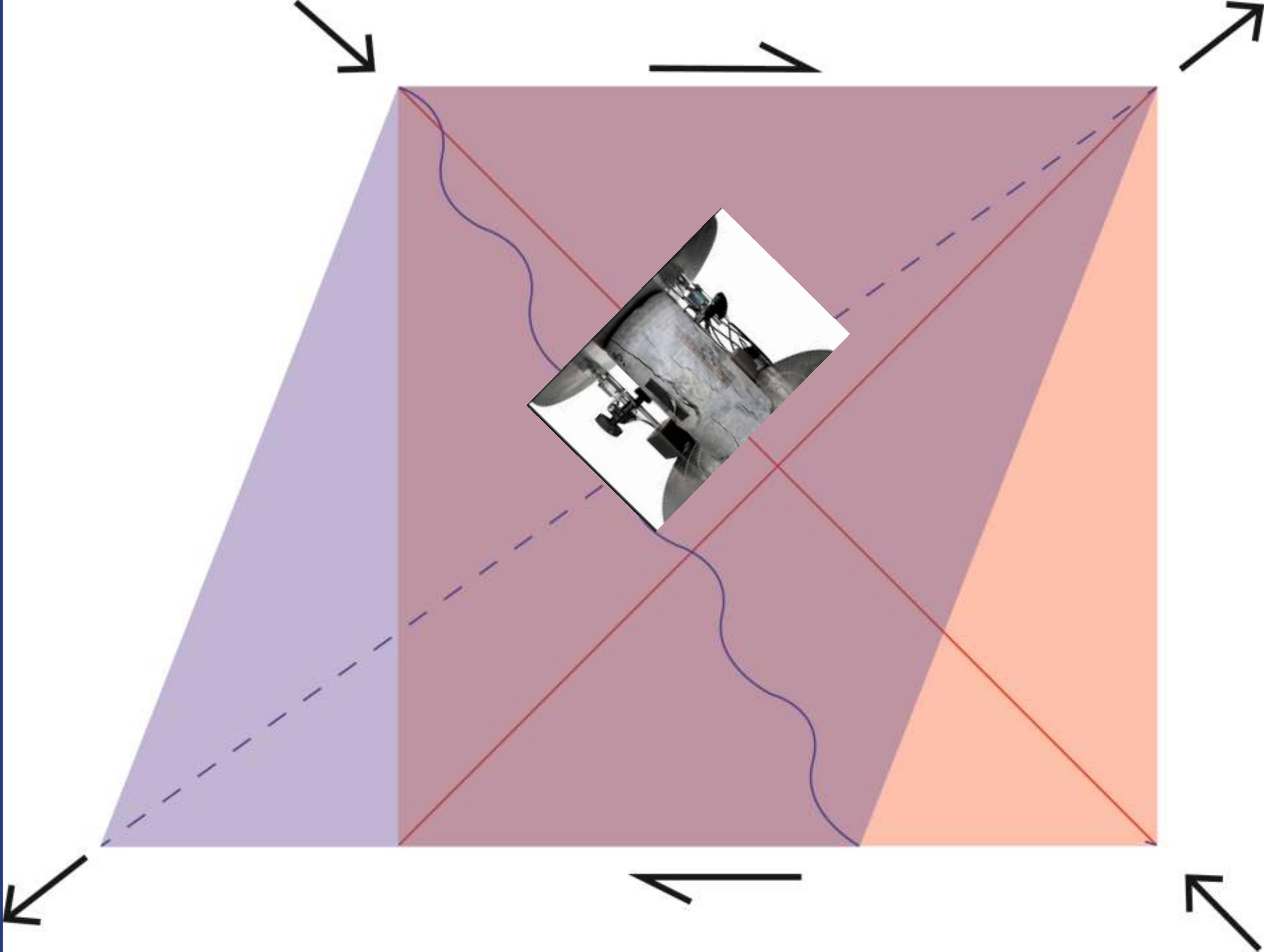
2 Eğim atımlı ters fay için bindirme (bunun yüksek veya düşük açılı bir bindirme olup olmadığını bildirmenizde yarar vardır).

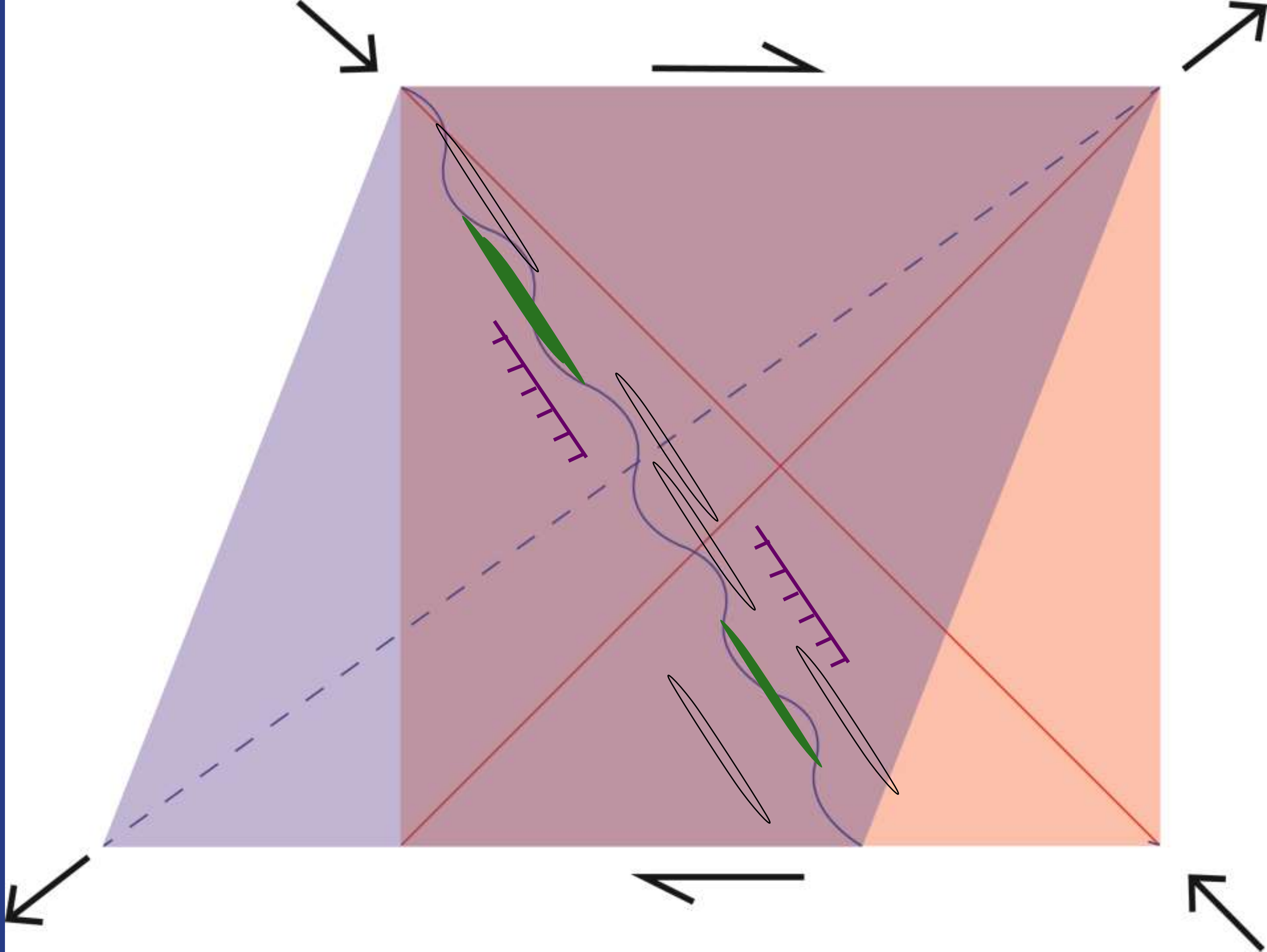
3 Yanal atımlı fay için sadece yanal atımlı fay.

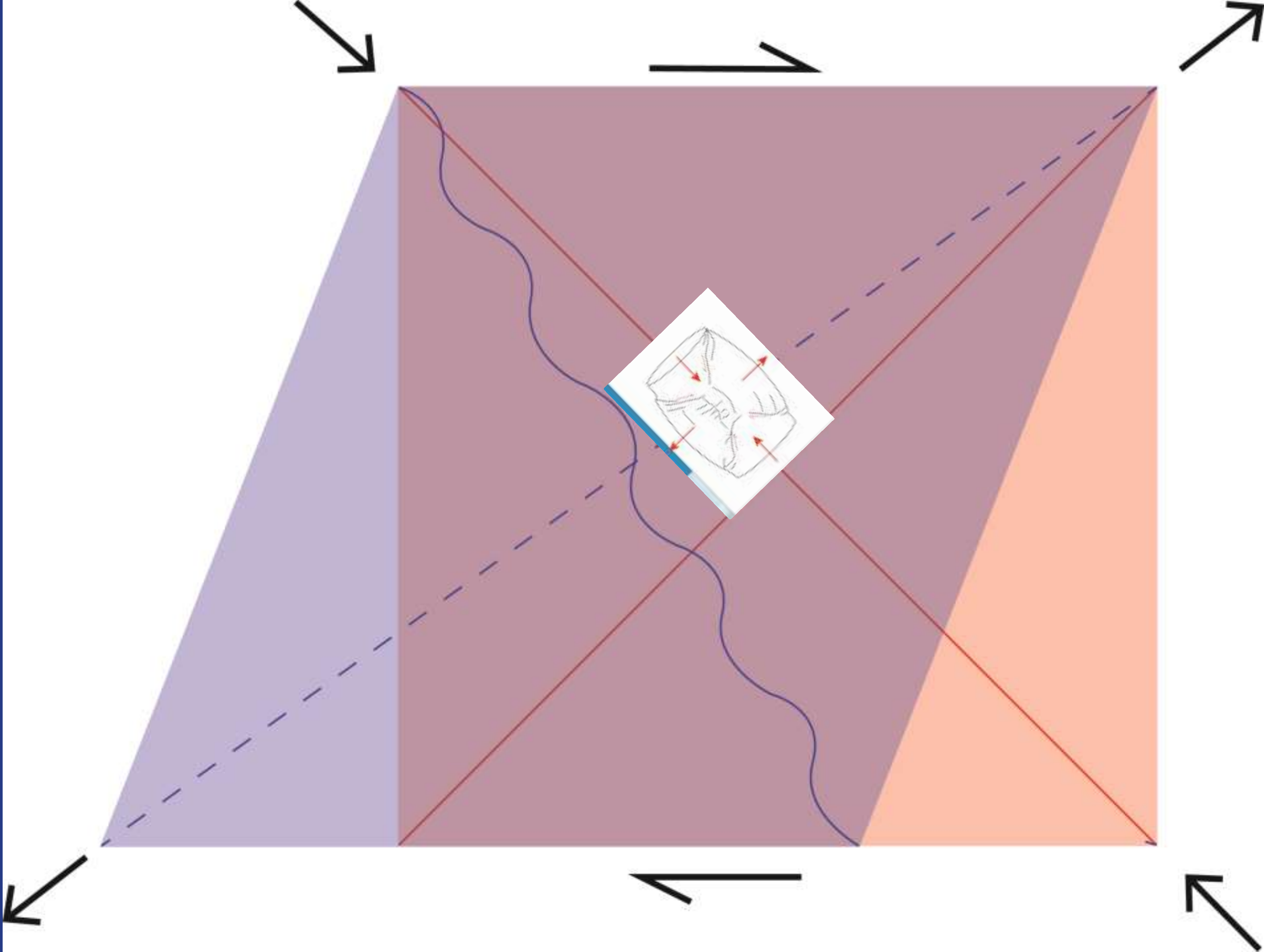
Şimdi kısaca faylanma esnasında gelişen yapılara bakalım.

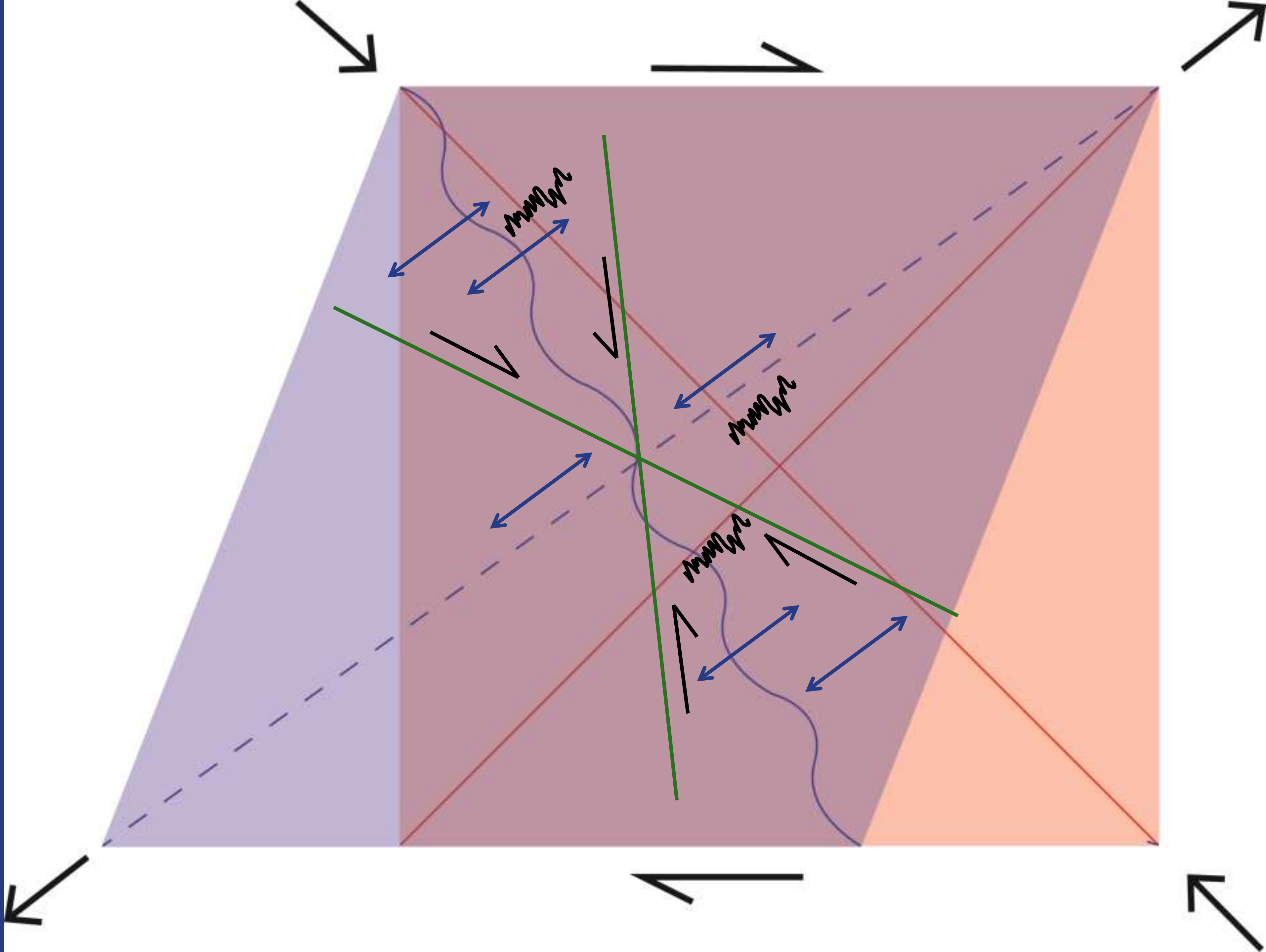


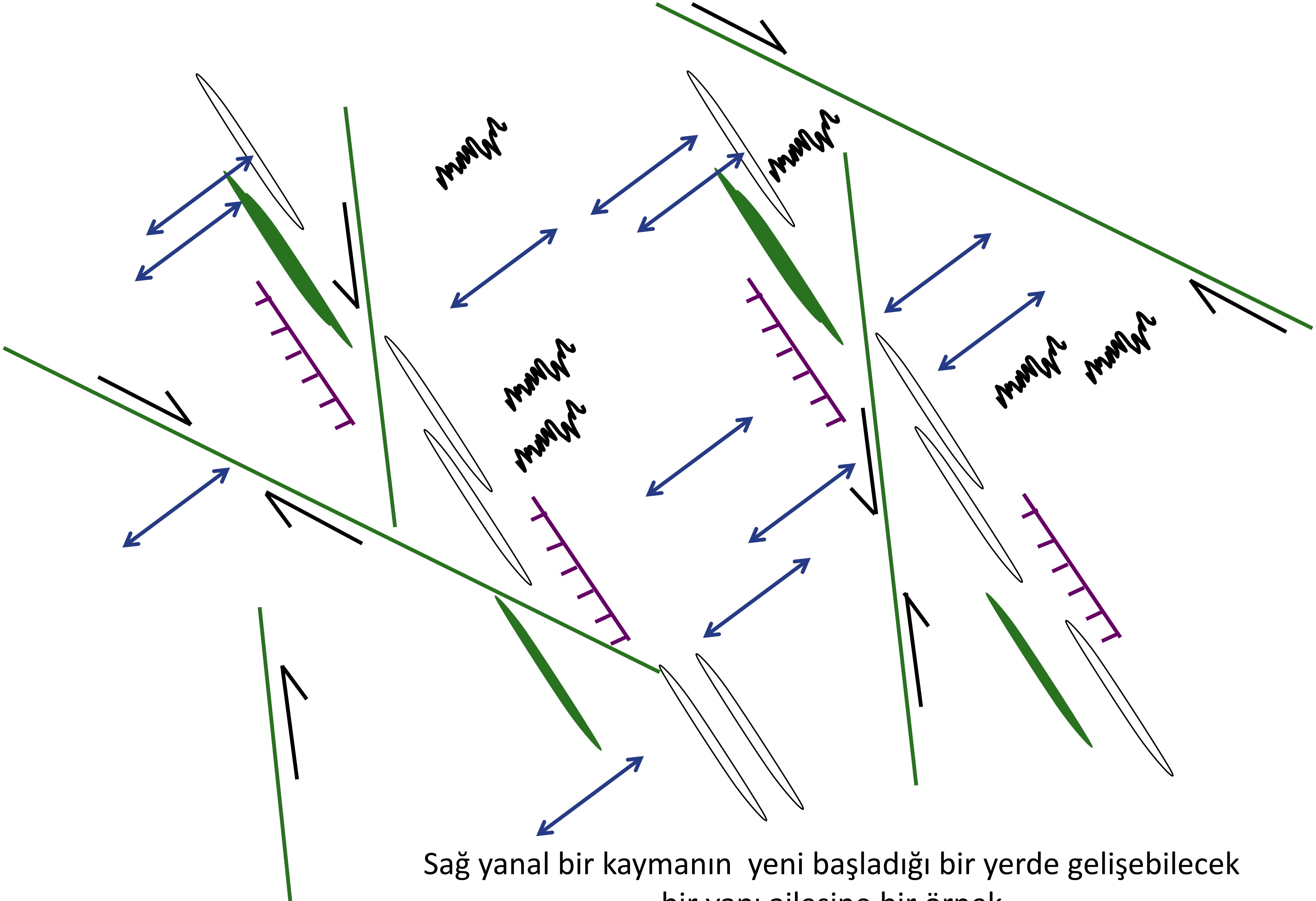




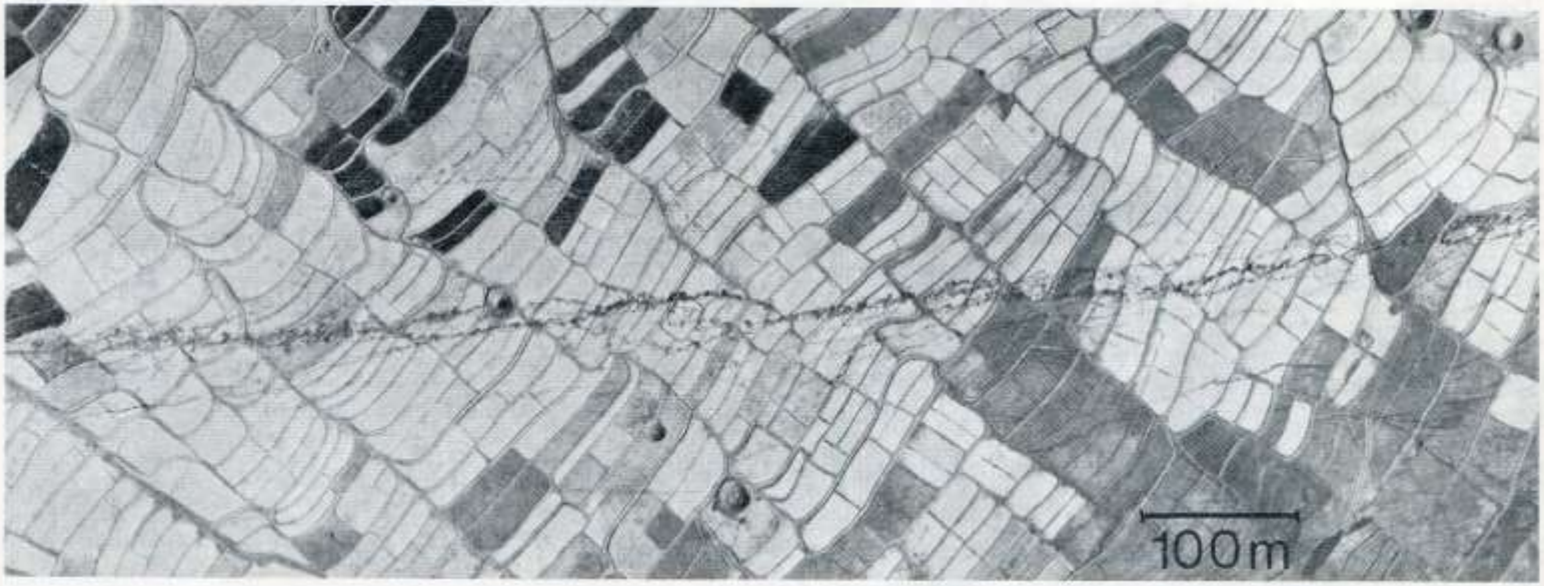




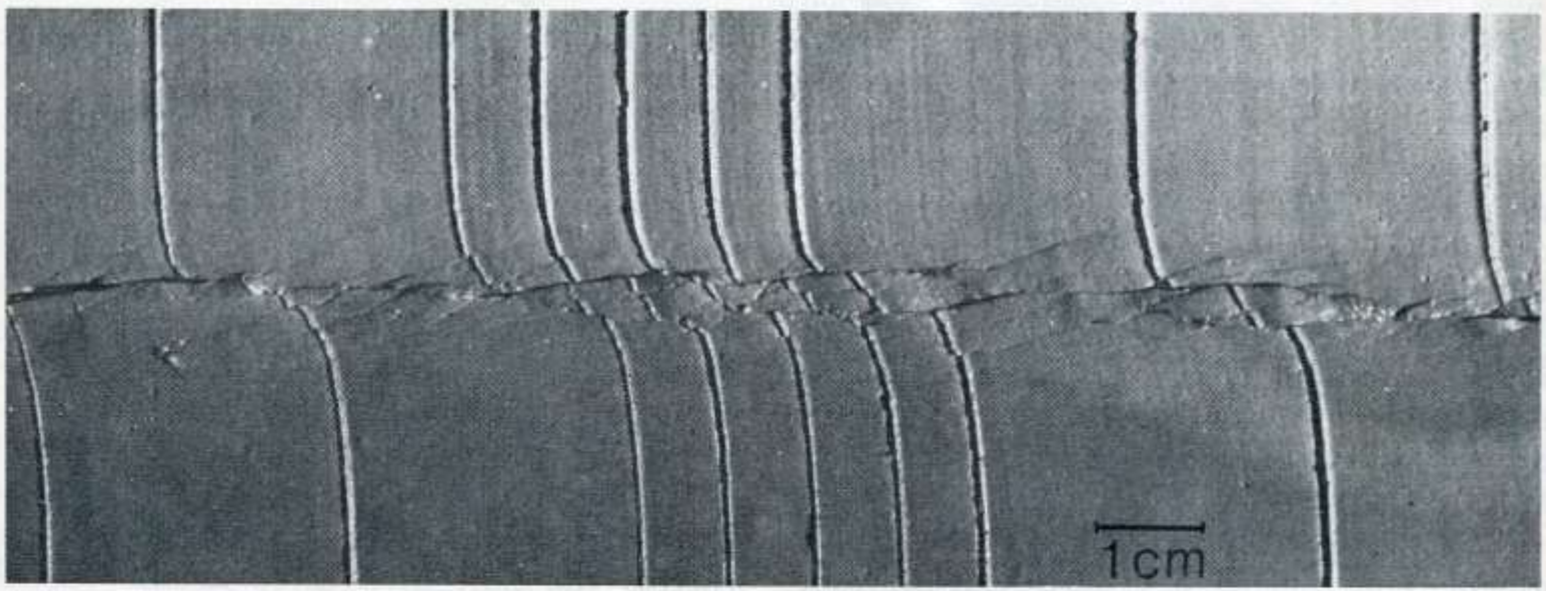




Sağ yanal bir kaymanın yeni başladığı bir yerde gelişebilecek
bir yapı ailesine bir örnek

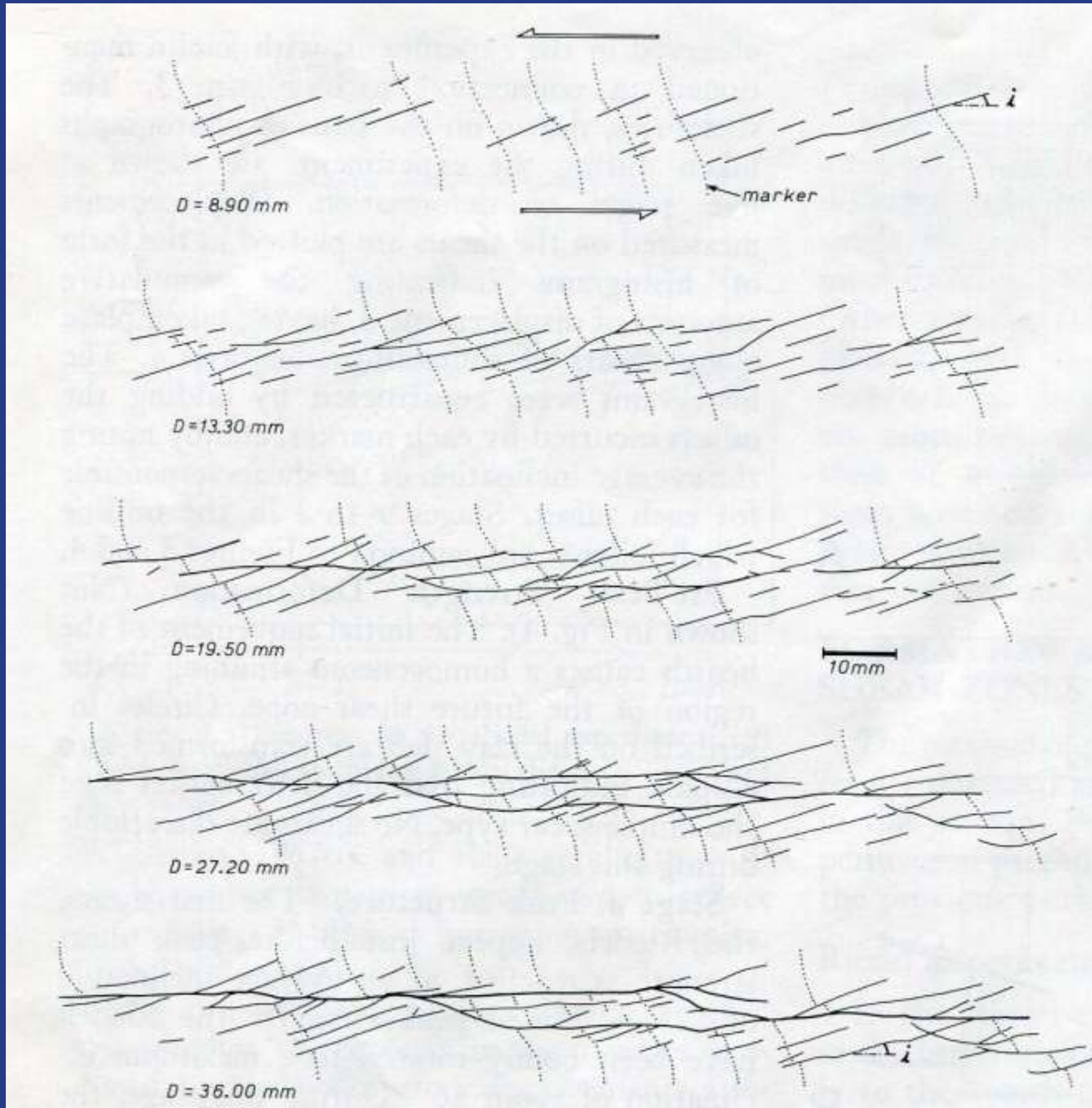


A Yukarıda: Dasht-i Bayaz depremi kırıkları, İran; aşağıda deneysel kırıklar

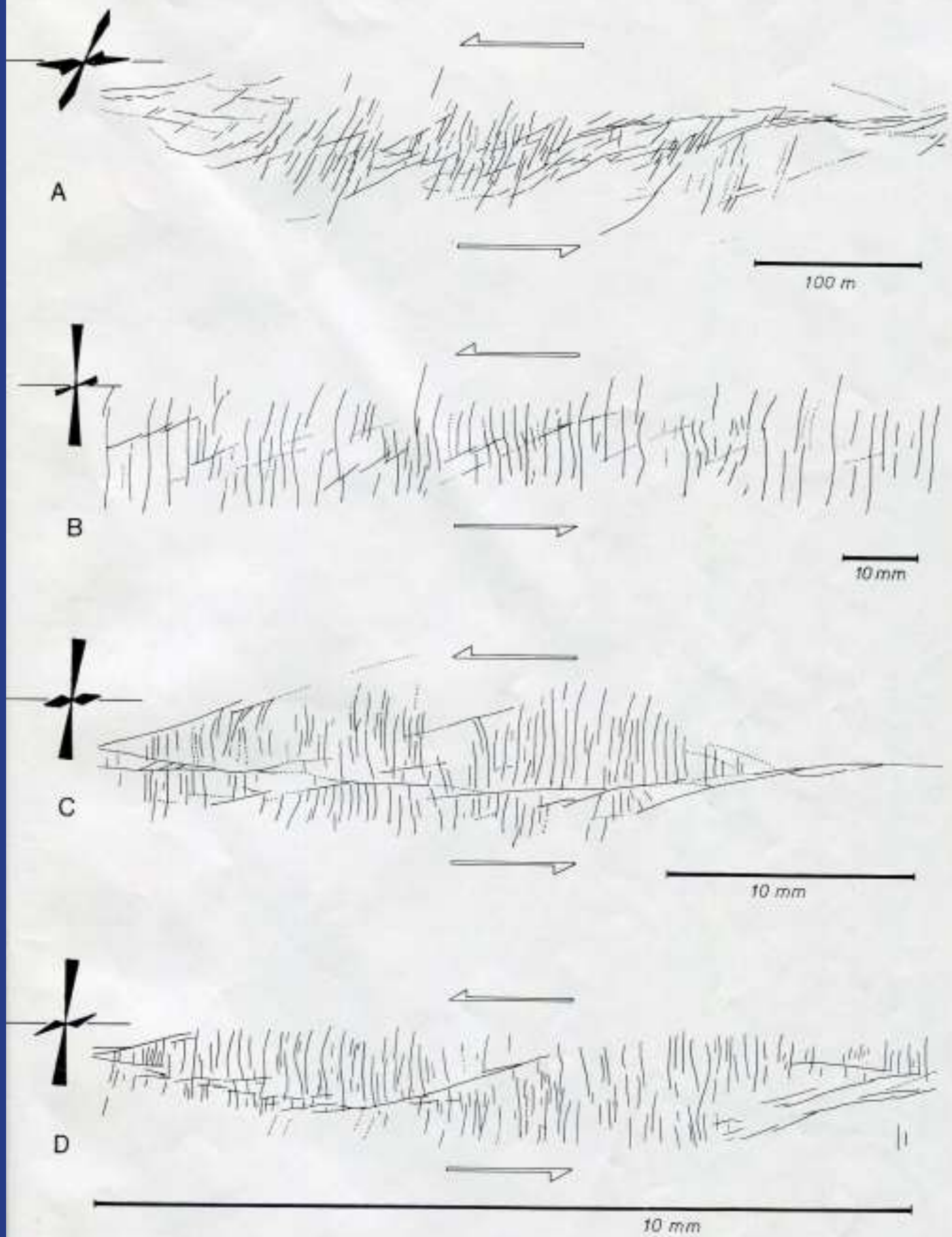


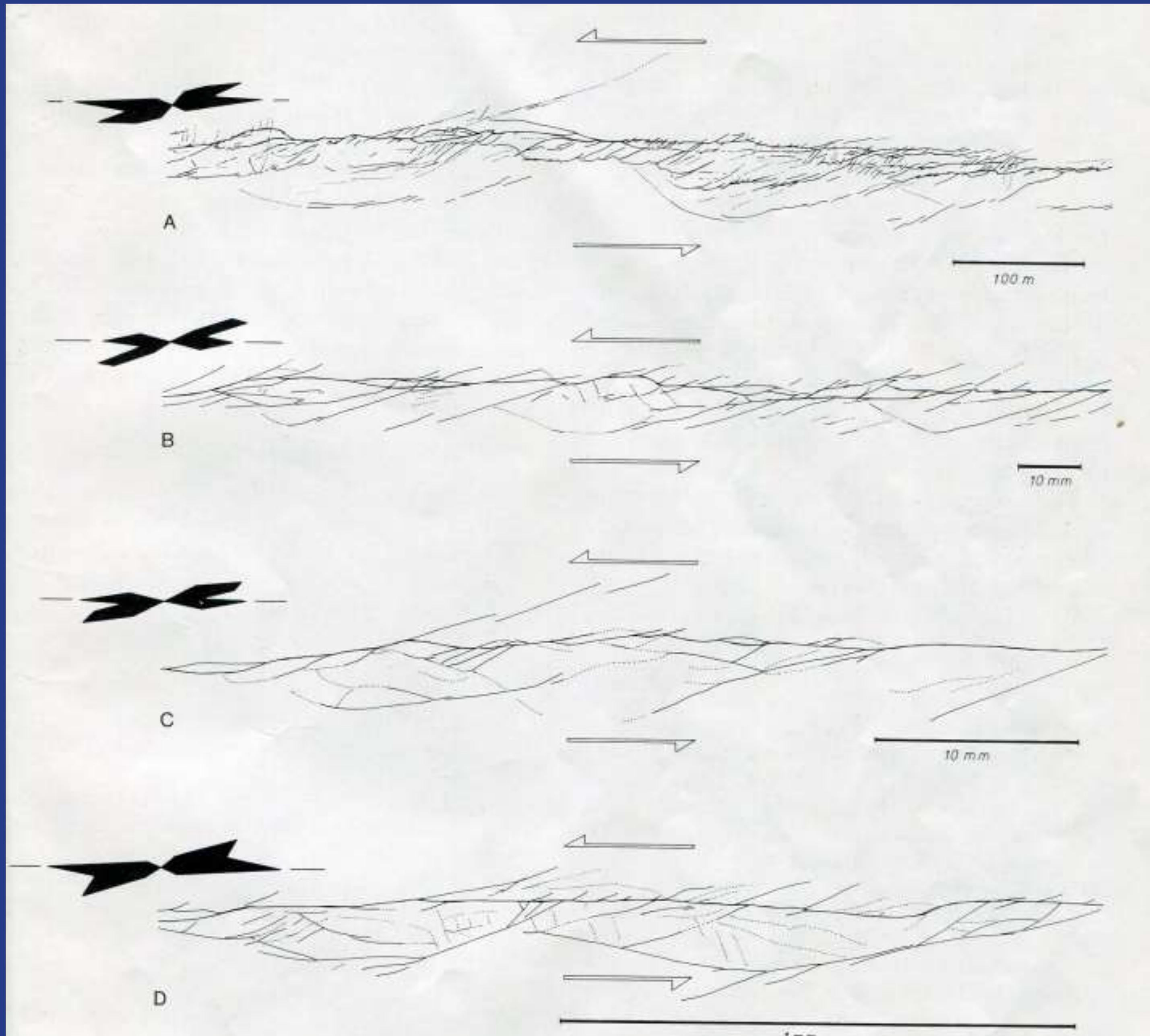
Tchalenko, J. S. 1970 Geological society of America Bulletin, cilt 81, ss. 1625-1640.

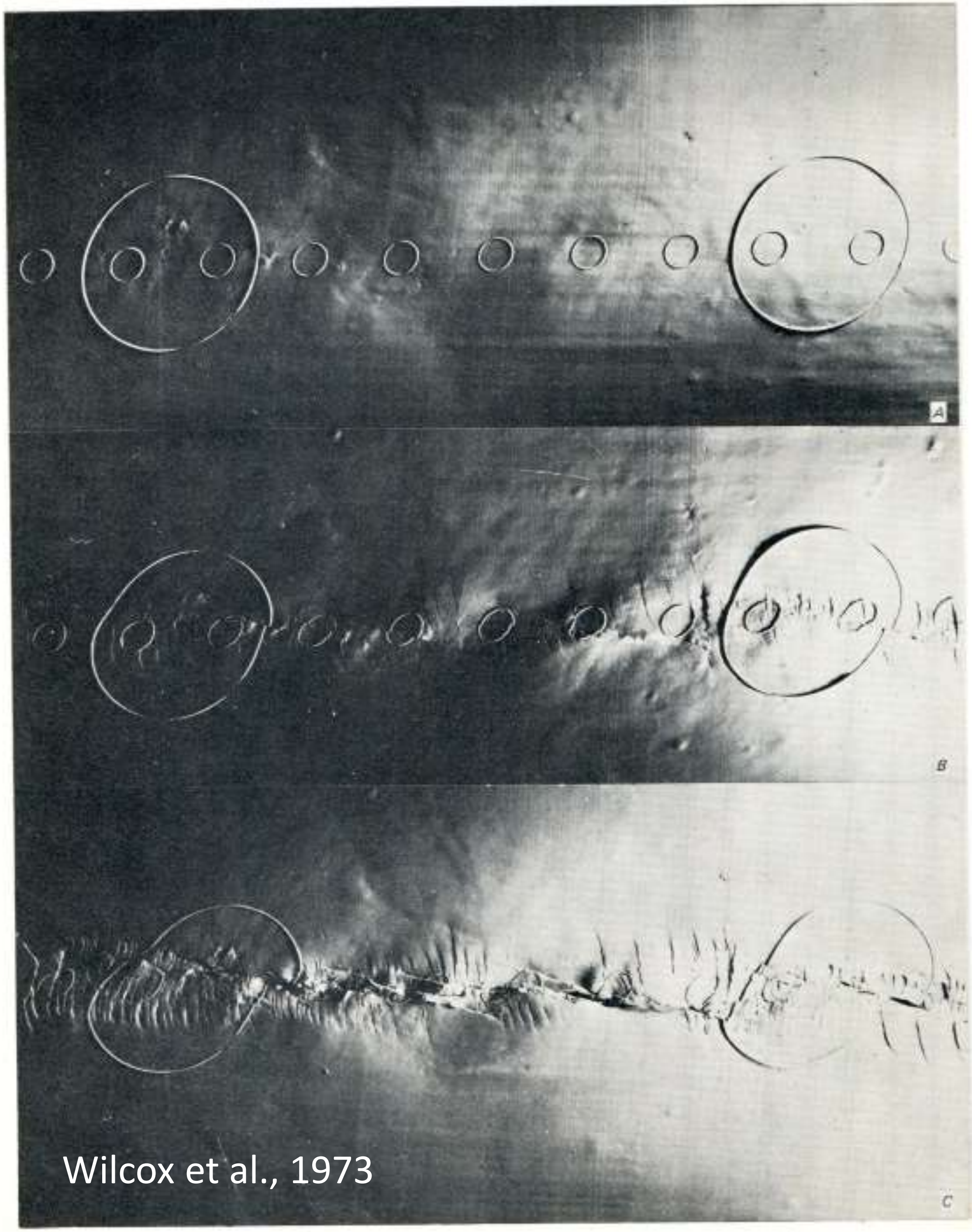
Kayma yamulması esnasında oluşan yapılar ölçekten bağımsızdır. Onun için deneysel olarak da taklid edilebilirler.



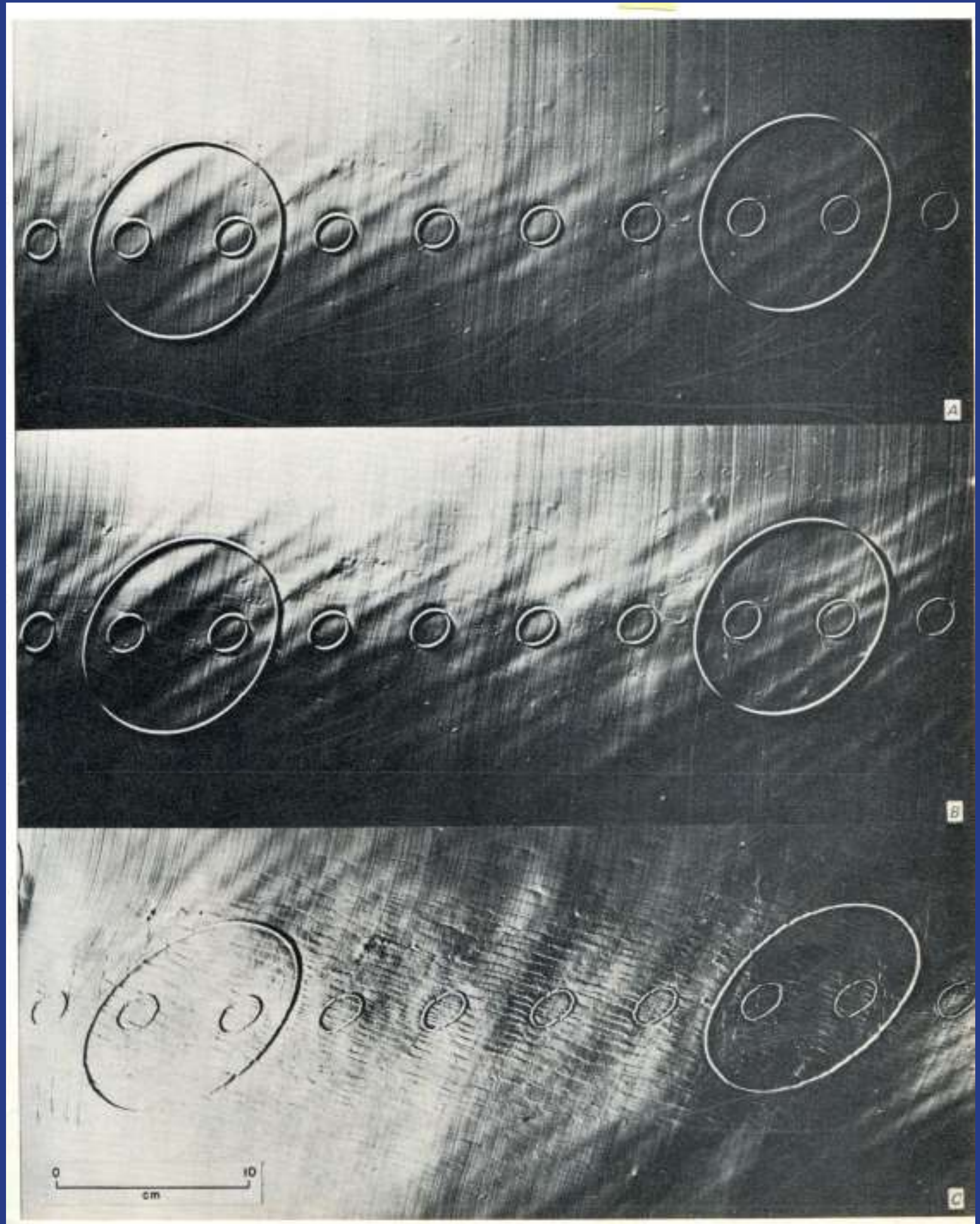
i
marker
D = 8.90 mm
D = 13.30 mm
D = 19.50 mm
10mm
D = 27.20 mm
i
D = 36.00 mm

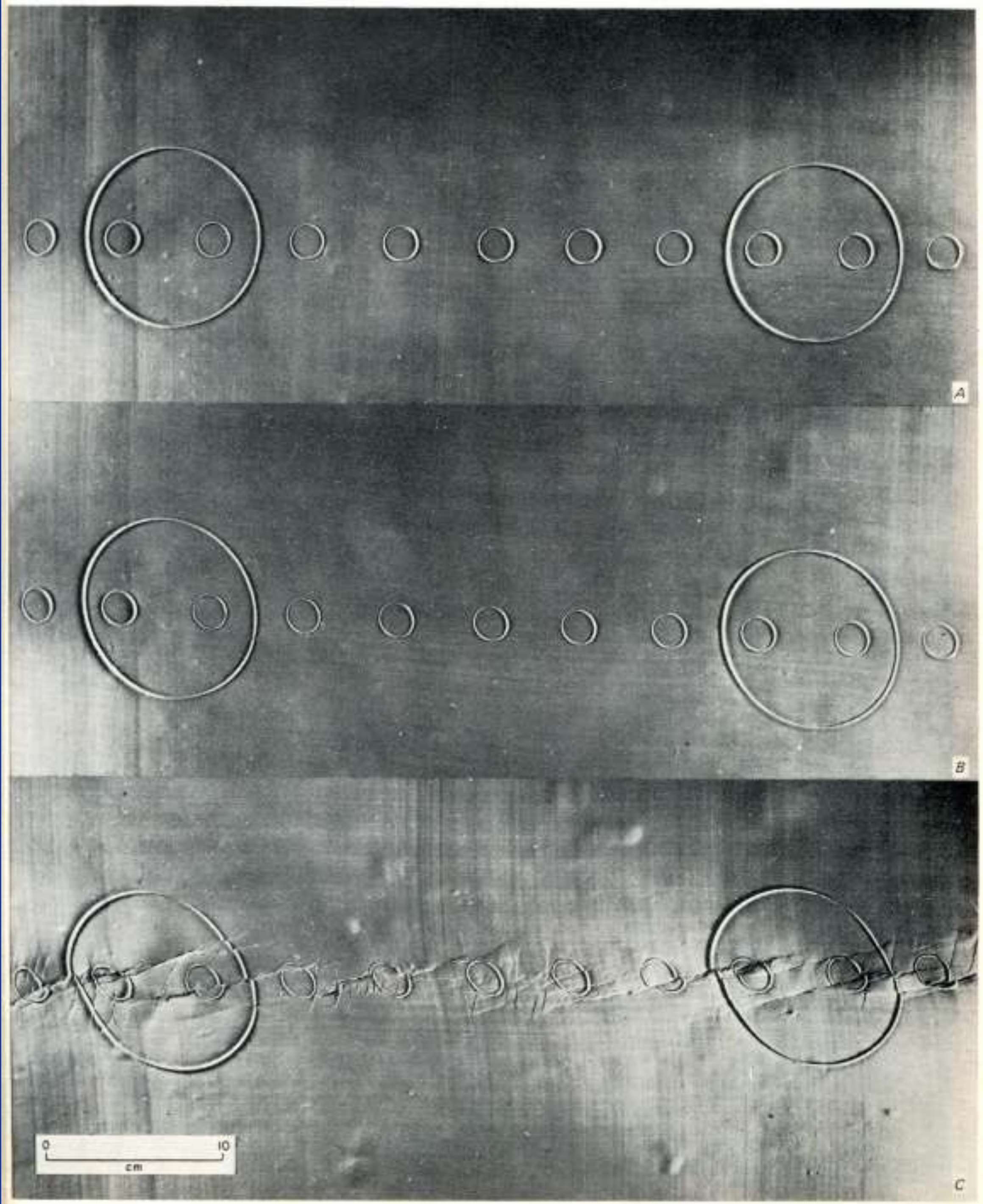

A
100 m
B
10 mm
C
10 mm
D
10 mm

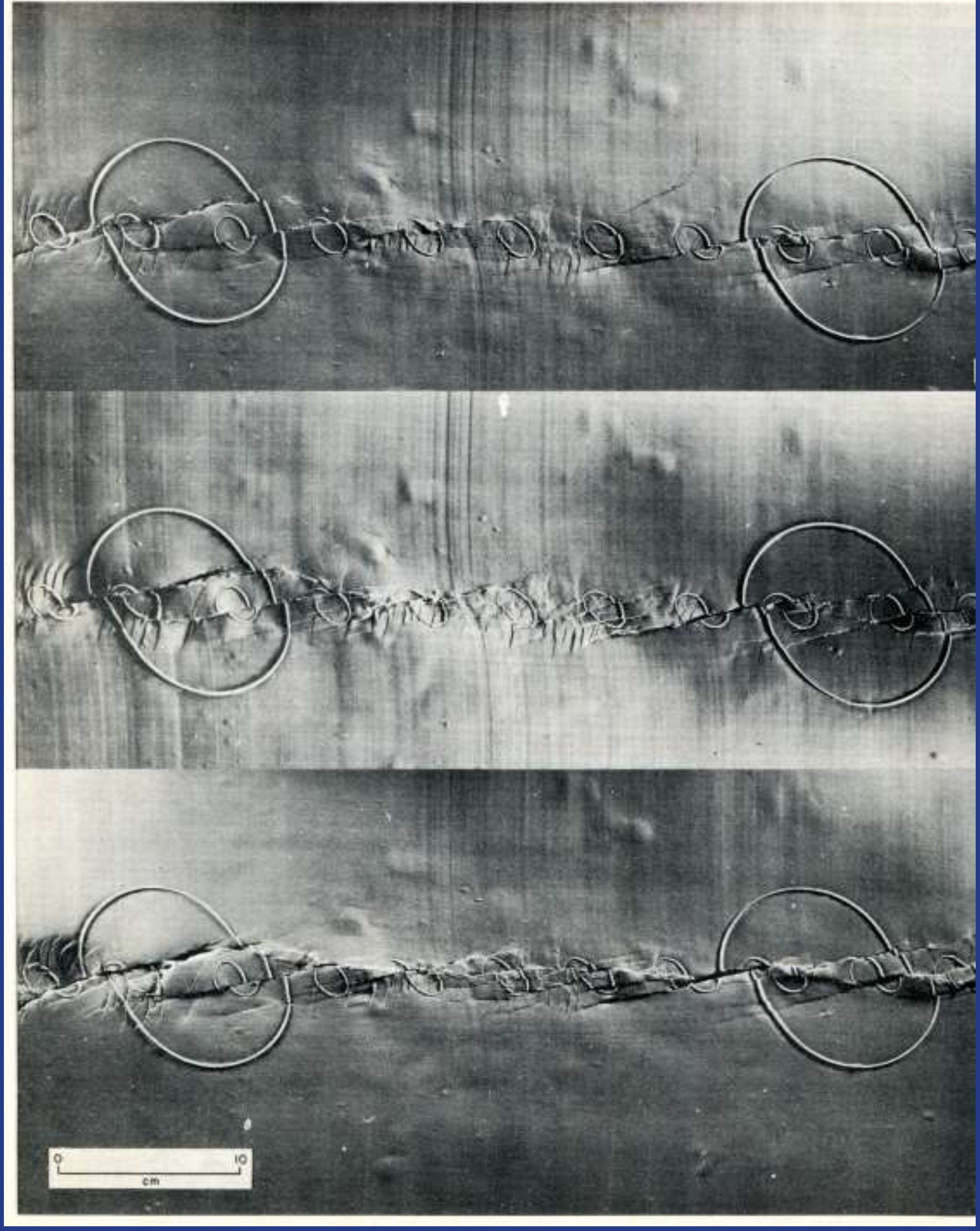

A
100 m
B
10 mm
C
10 mm
D
1 mm



Wilcox et al., 1973

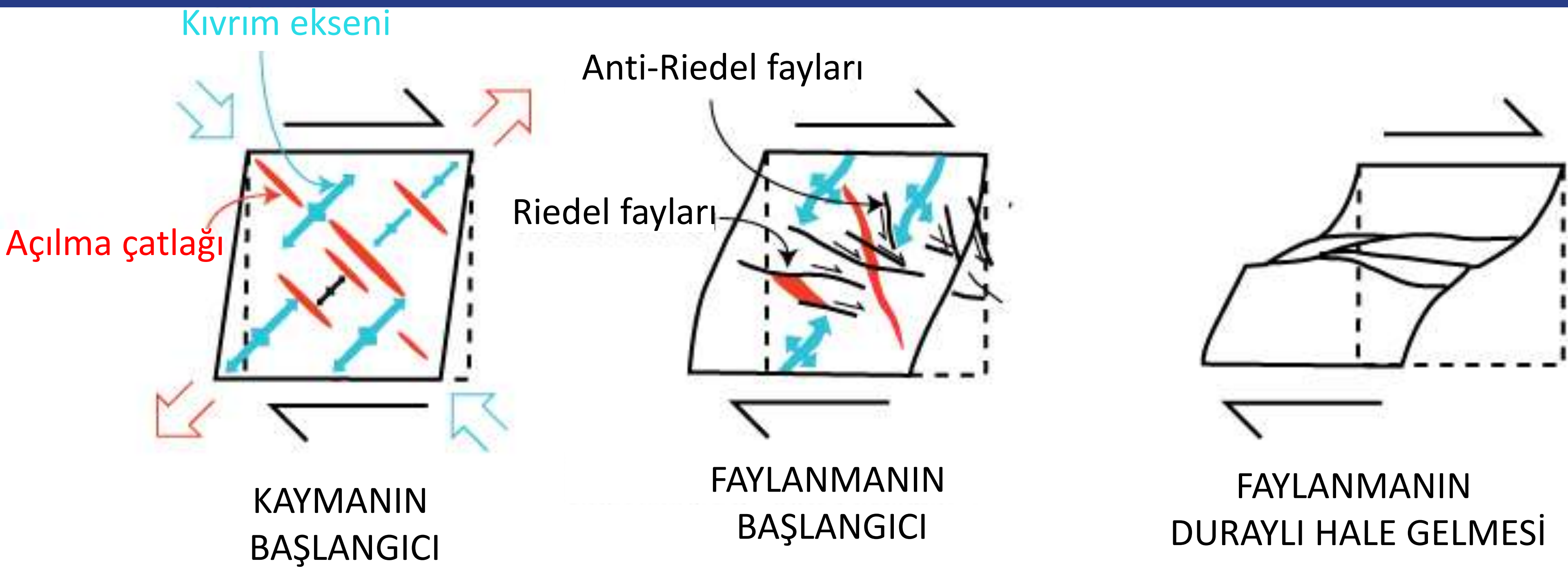

A
B
C
0
10
cm


A
B
C
0
10
cm

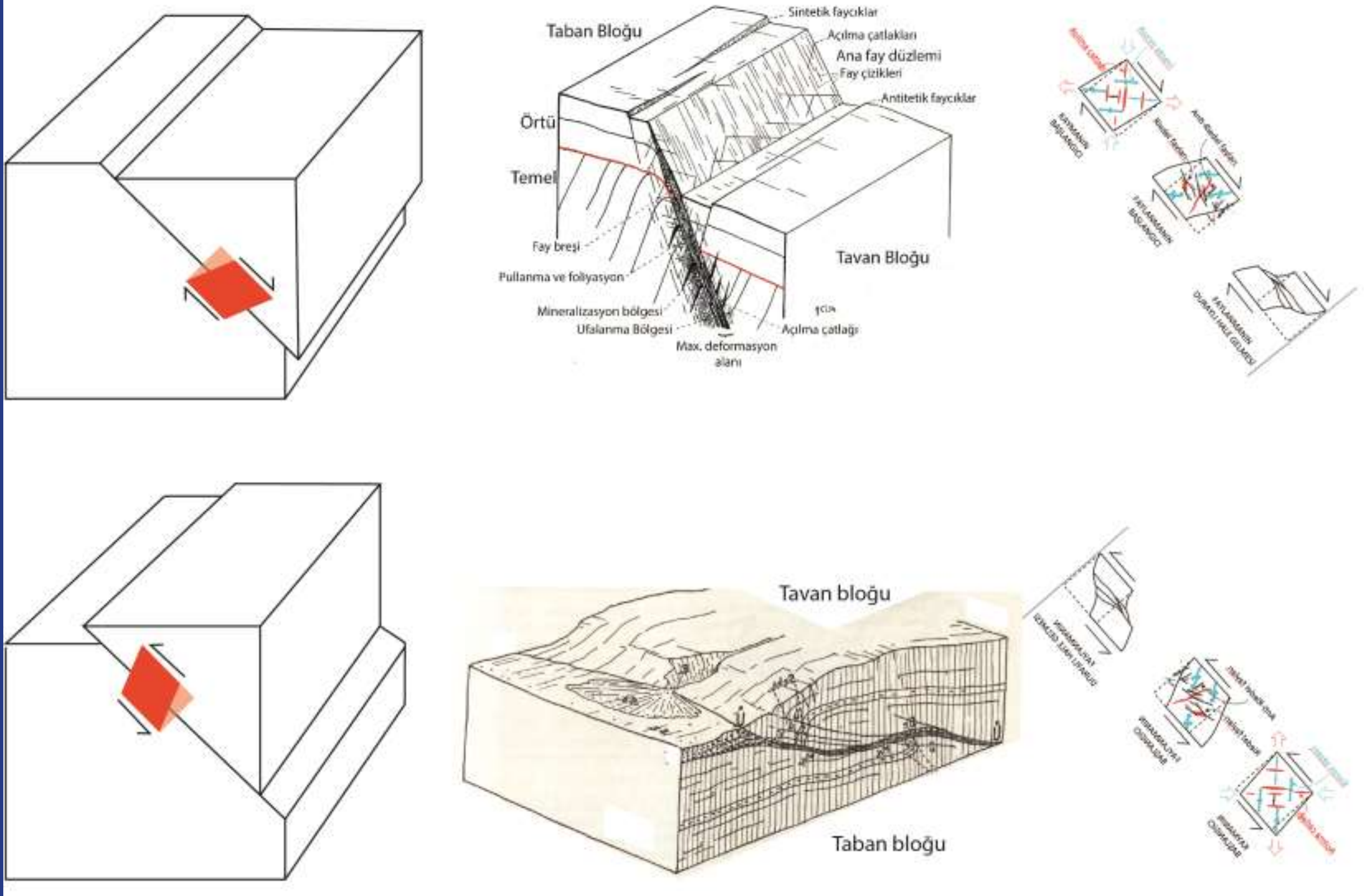

0
10
cm

Küçük bir sol-yanal kayma hattı üzerinde gelişen yapıcıklar

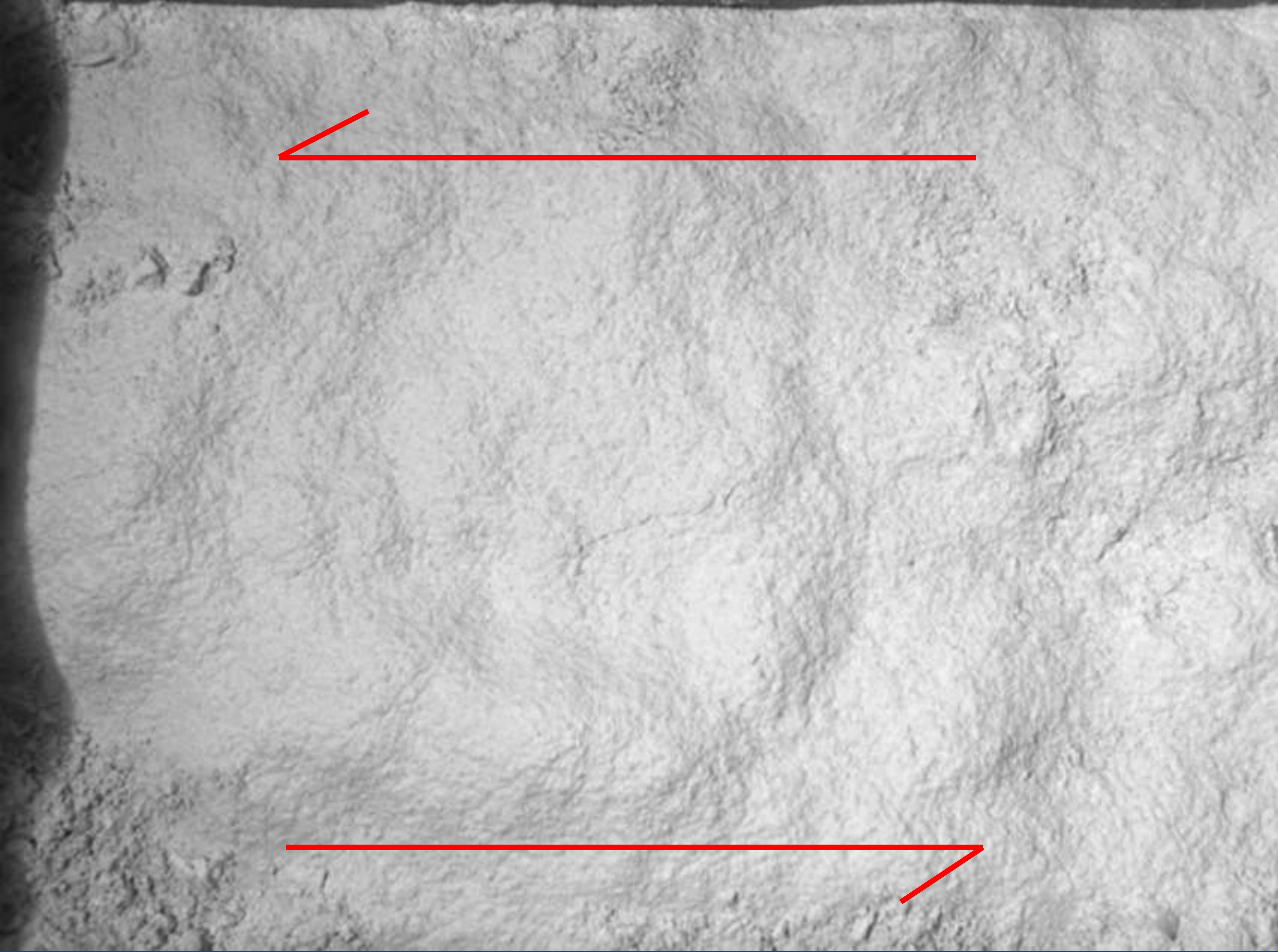
Bir önceki resmin detayı

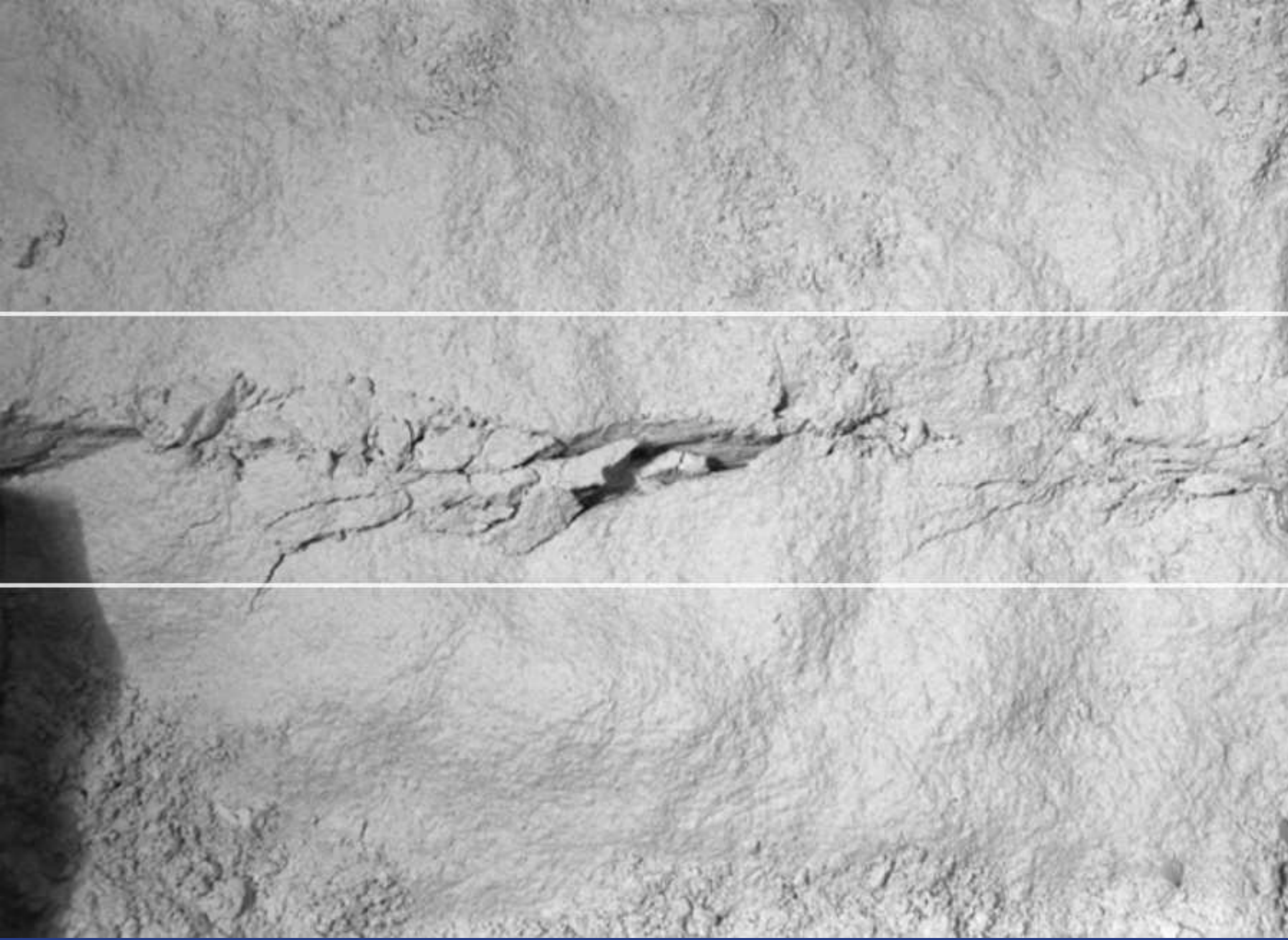


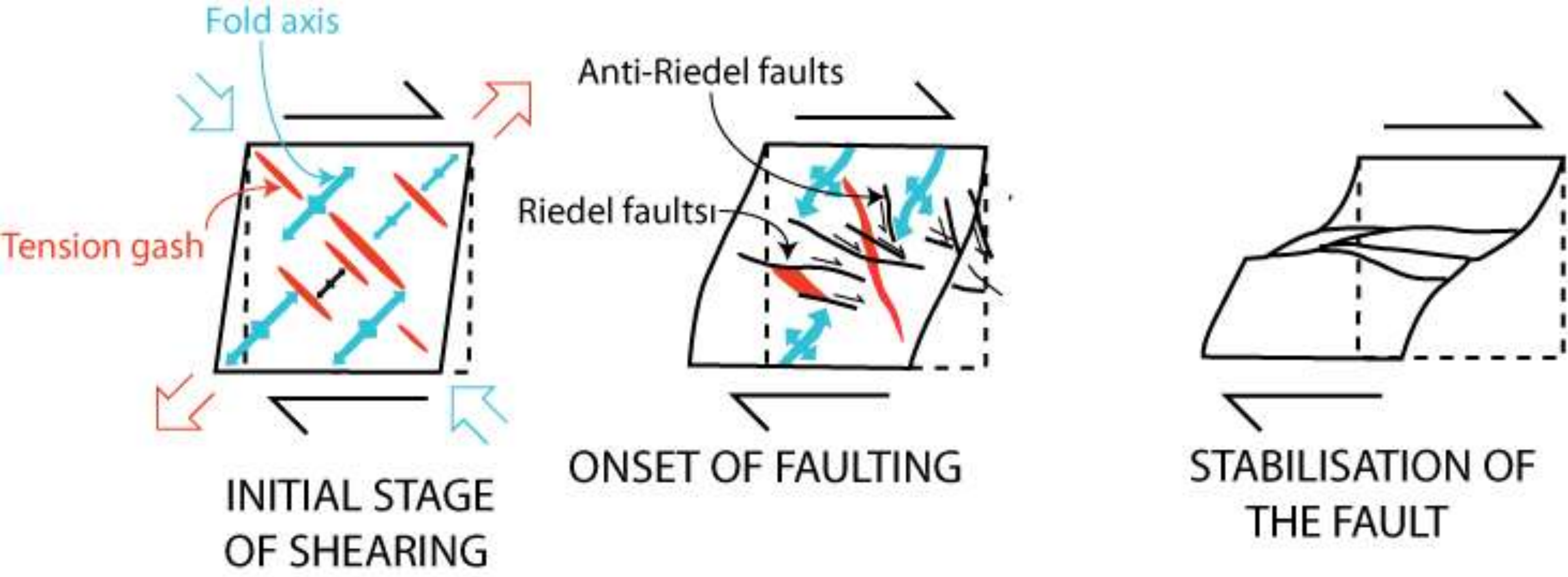
Riedel, Tchalenko ve Wilcox ve diğerlerinin yaptıkları deneylerin özeti



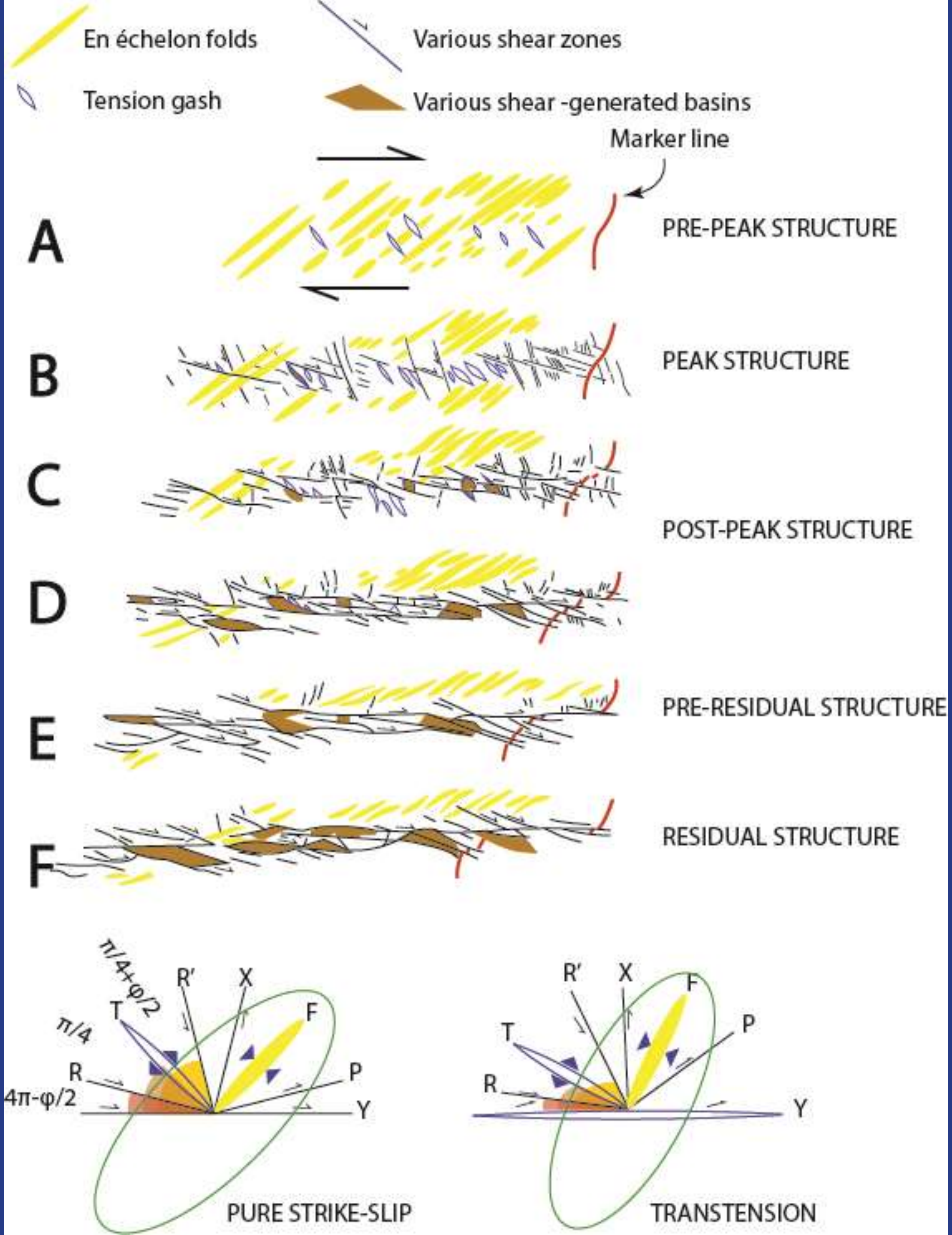
Faylanma esnasında gelişen yapılan ilkede her yerde aynıdır. Fay türüne göre farketmez. Onun için genelde faylanmanın evrimini bir kere öğrenmek yeter.



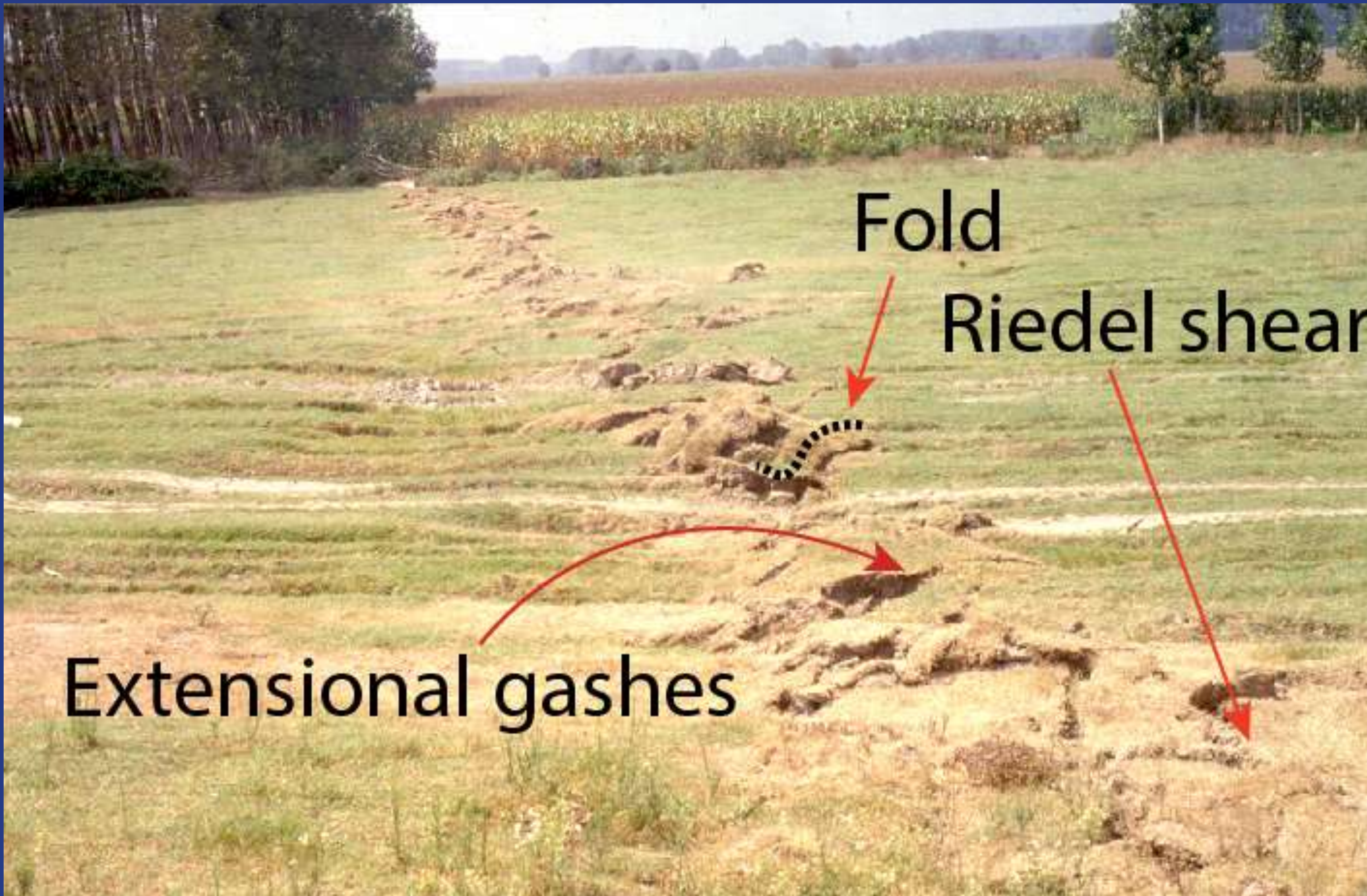


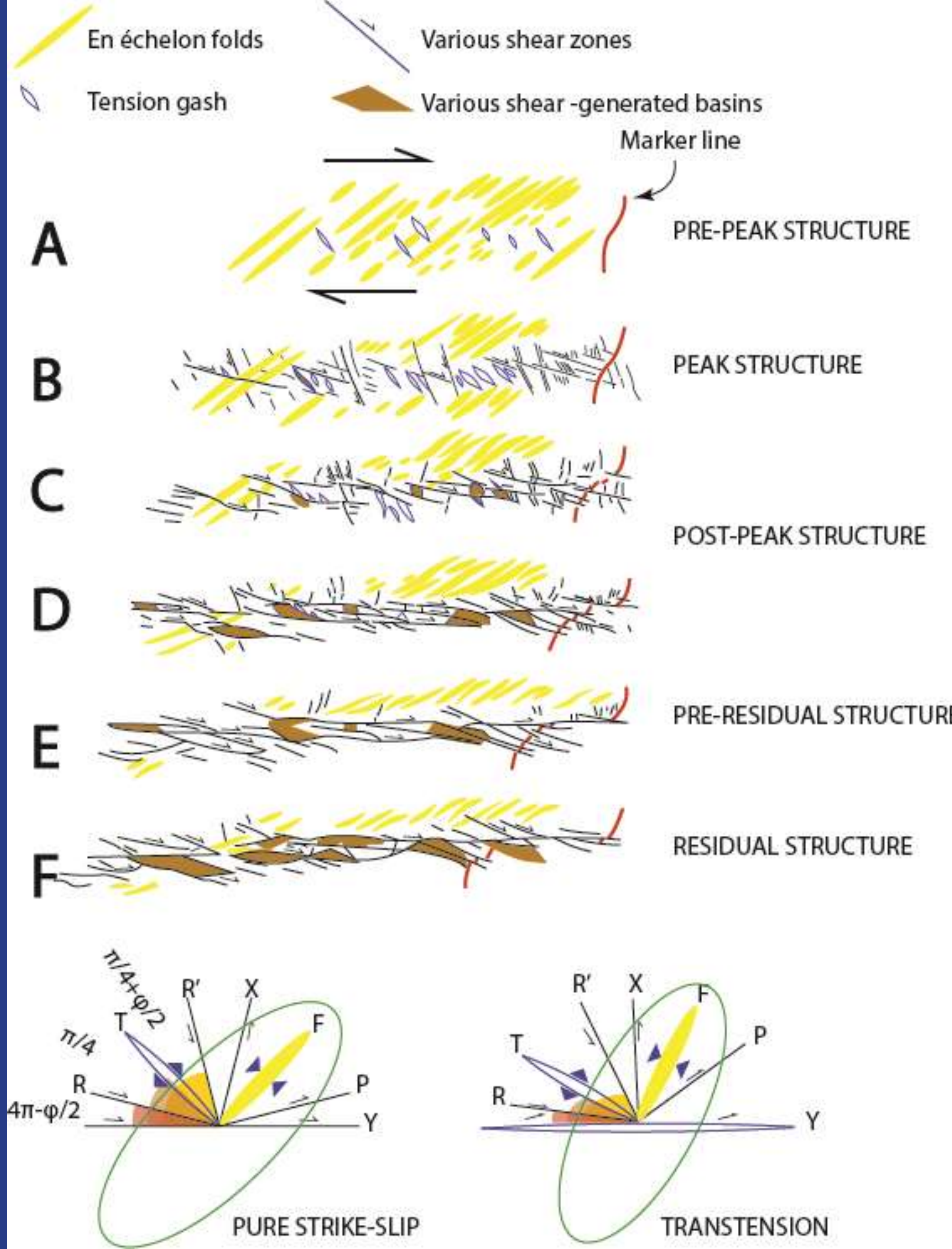


Strike-slip fault systems do not pop into existence whole. They undergo stages of evolution before a through-going fault materialises. During this process the shear zone narrows.

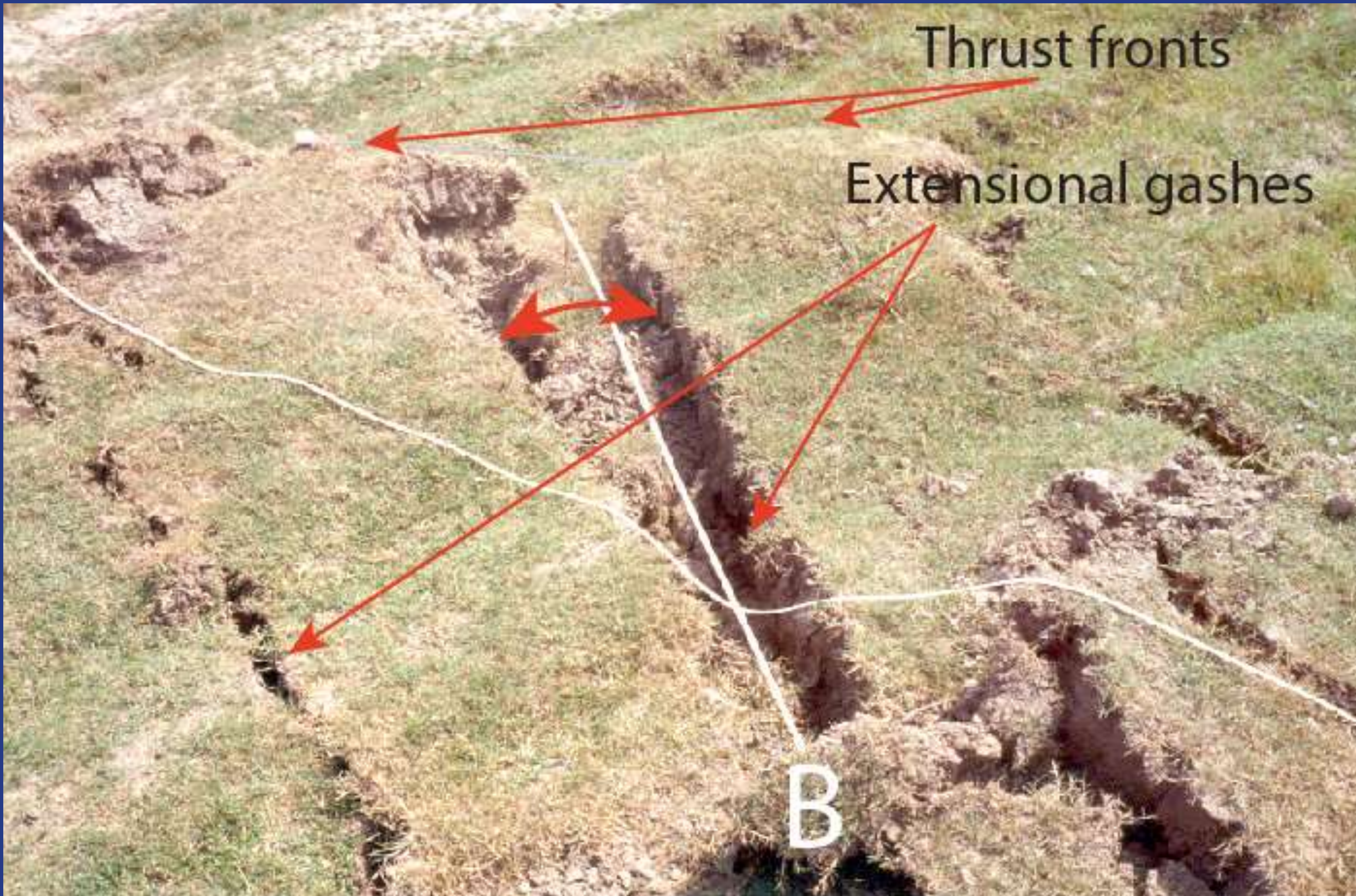


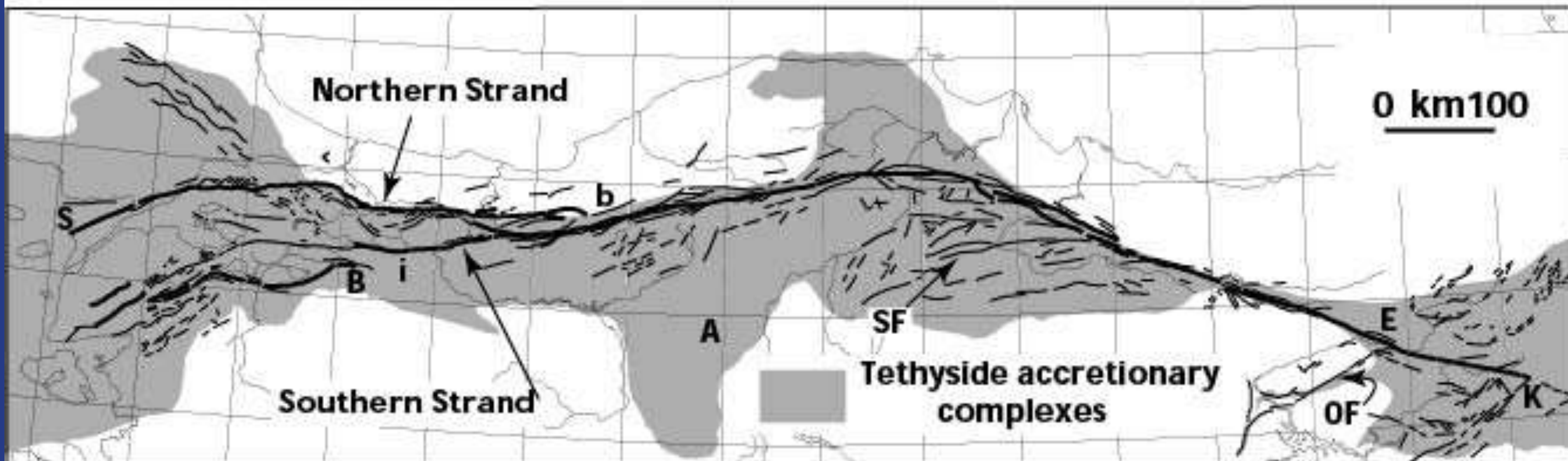
En échelon folds
Various shear zones
Tension gash
Various shear -generated basins
Marker line
A
PRE-PEAK STRUCTURE
B
PEAK STRUCTURE
C
POST-PEAK STRUCTURE
D
E
PRE-RESIDUAL STRUCTURE
F
RESIDUAL STRUCTURE
π/4+φ/2
π/4
4π-φ/2
T
R
R′
X
F
P
Y
PURE STRIKE-SLIP
TRANSTENSION

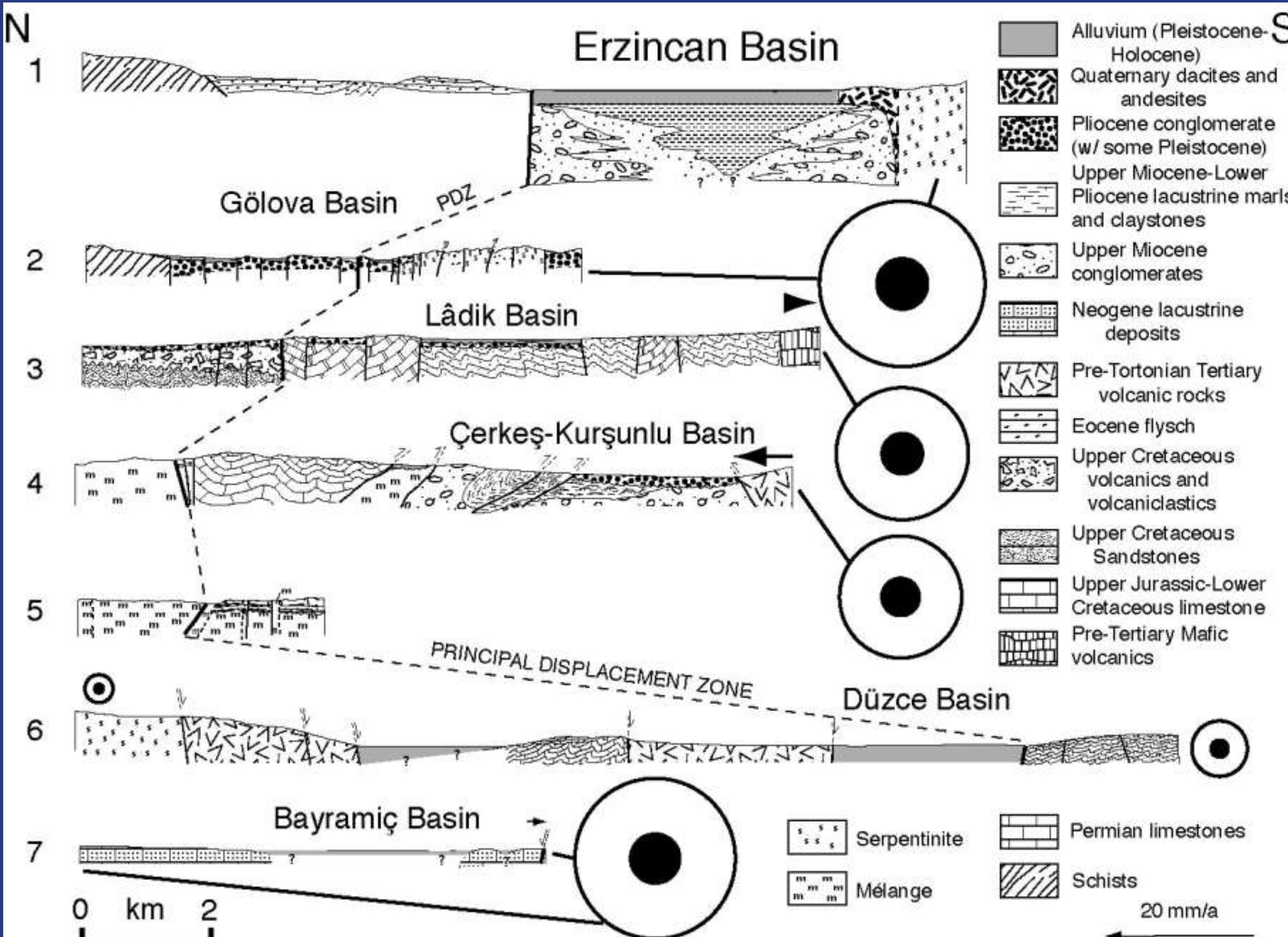

Fold
Riedel shear
Extensional gashes



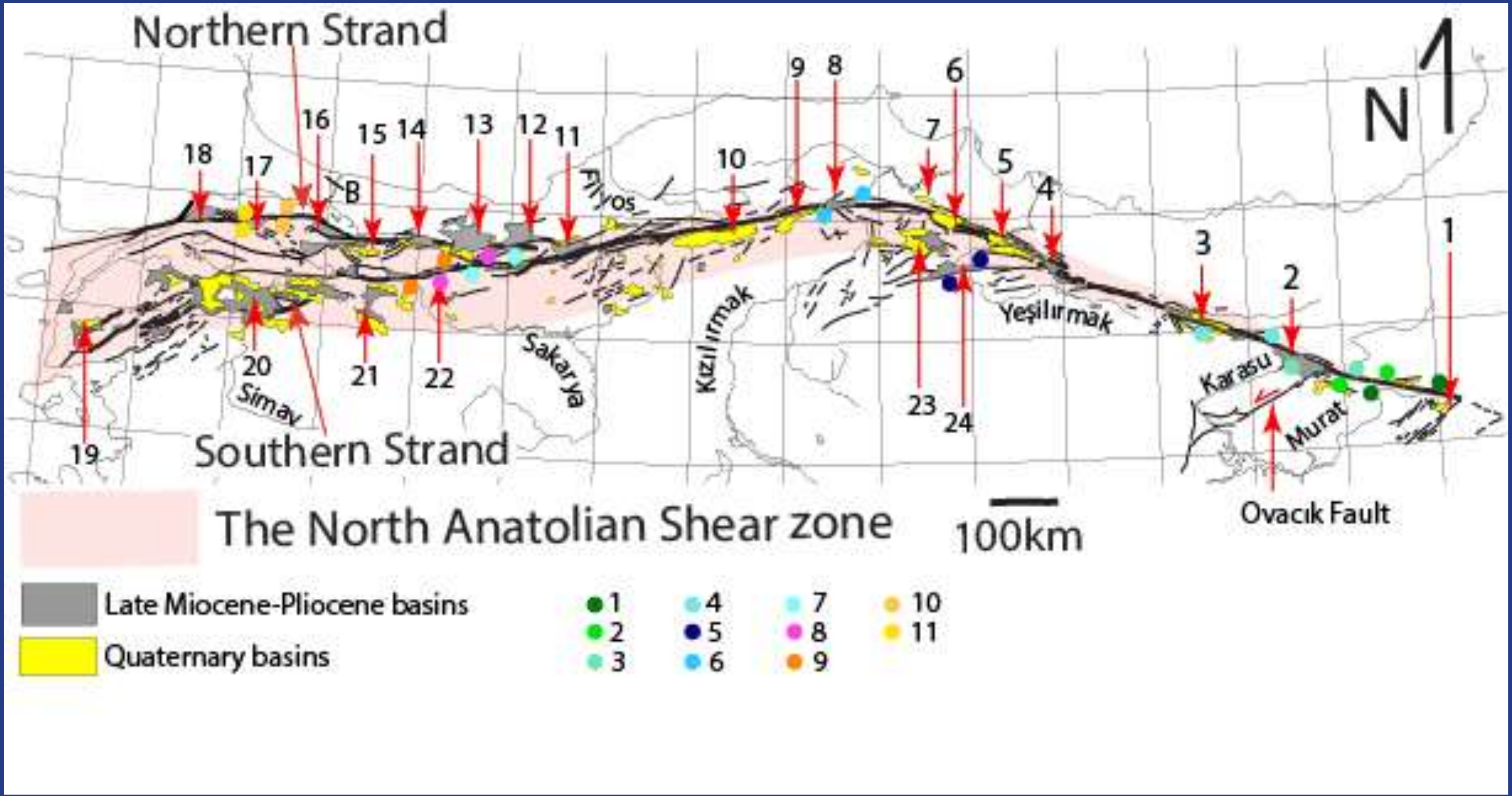
En échelon folds
Various shear zones
Tension gash
Various shear -generated basins
Marker line
A
PRE-PEAK STRUCTURE
B
PEAK STRUCTURE
C
POST-PEAK STRUCTURE
D
E
PRE-RESIDUAL STRUCTURE
F
RESIDUAL STRUCTURE
π/4+φ/2
π/4
4π-φ/2
T
R
R′
X
F
P
Y
PURE STRIKE-SLIP
TRANSTENSION


Thrust fronts
Extensional gashes
B

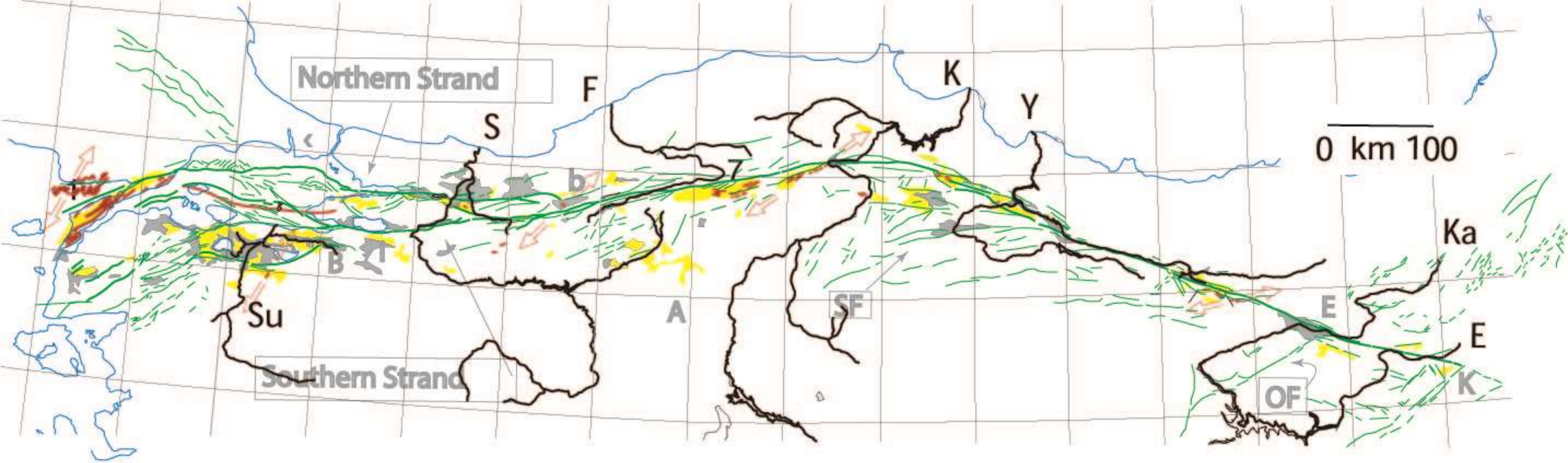

Northern Strand
0 km100
S
b
B
i
A
SF
E
K
OF
Southern Strand
Tethyside accretionary complexes

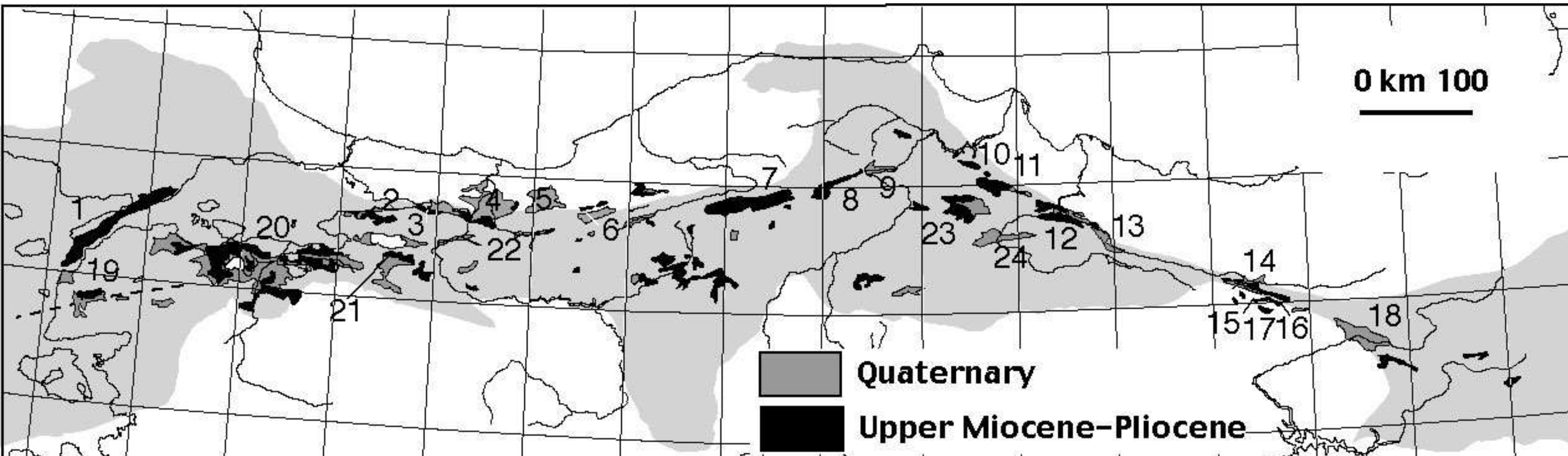


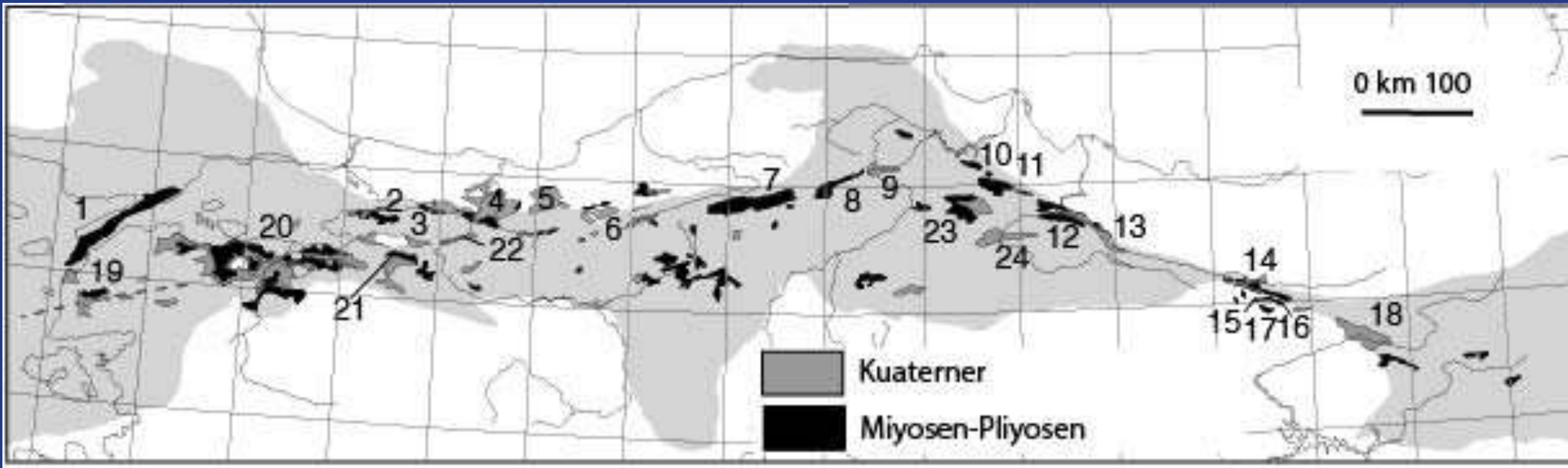
N
S
Erzincan Basin
Gölova Basin
PDZ
Lâdik Basin
Çerkeş-Kurşunlu Basin
PRINCIPAL DISPLACEMENT ZONE
Düzce Basin
Bayramiç Basin
1
2
3
4
5
6
7
0 km 2
Alluvium (Pleistocene-Holocene)
Quaternary dacites and andesites
Pliocene conglomerate (w/ some Pleistocene)
Upper Miocene-Lower Pliocene lacustrine marls and claystones
Upper Miocene conglomerates
Neogene lacustrine deposits
Pre-Tortonian Tertiary volcanic rocks
Eocene flysch
Upper Cretaceous volcanics and volcaniclastics
Upper Cretaceous Sandstones
Upper Jurassic-Lower Cretaceous limestone
Pre-Tertiary Mafic volcanics
Serpentinite
Mélange
Permian limestones
Schists
20 mm/a



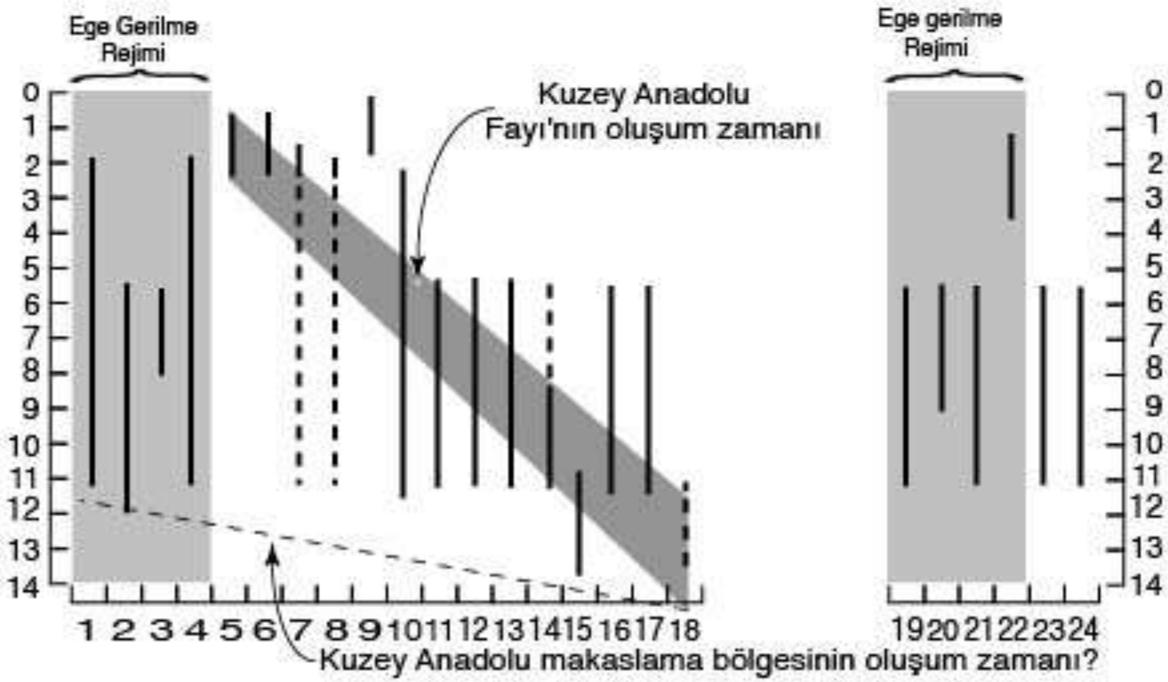
Northern Strand
Southern Strand
N
Filyos
Sakarya
Kızılırmak
Yeşilırmak
Karasu
Murat
Simav
Ovacık Fault
B
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
The North Anatolian Shear zone
100km
Late Miocene-Pliocene basins
Quaternary basins
1
2
3
4
5
6
7
8
9
10
11


Northern Strand
F
S
K
Y
0 km 100
b
Ka
B
Su
A
SF
E
E
OF
K
Southern Strand


0 km 100
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Quaternary
Upper Miocene-Pliocene

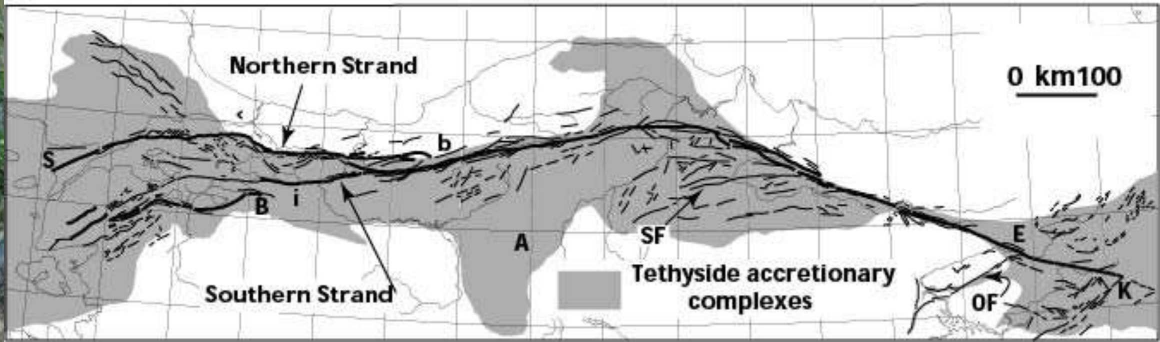


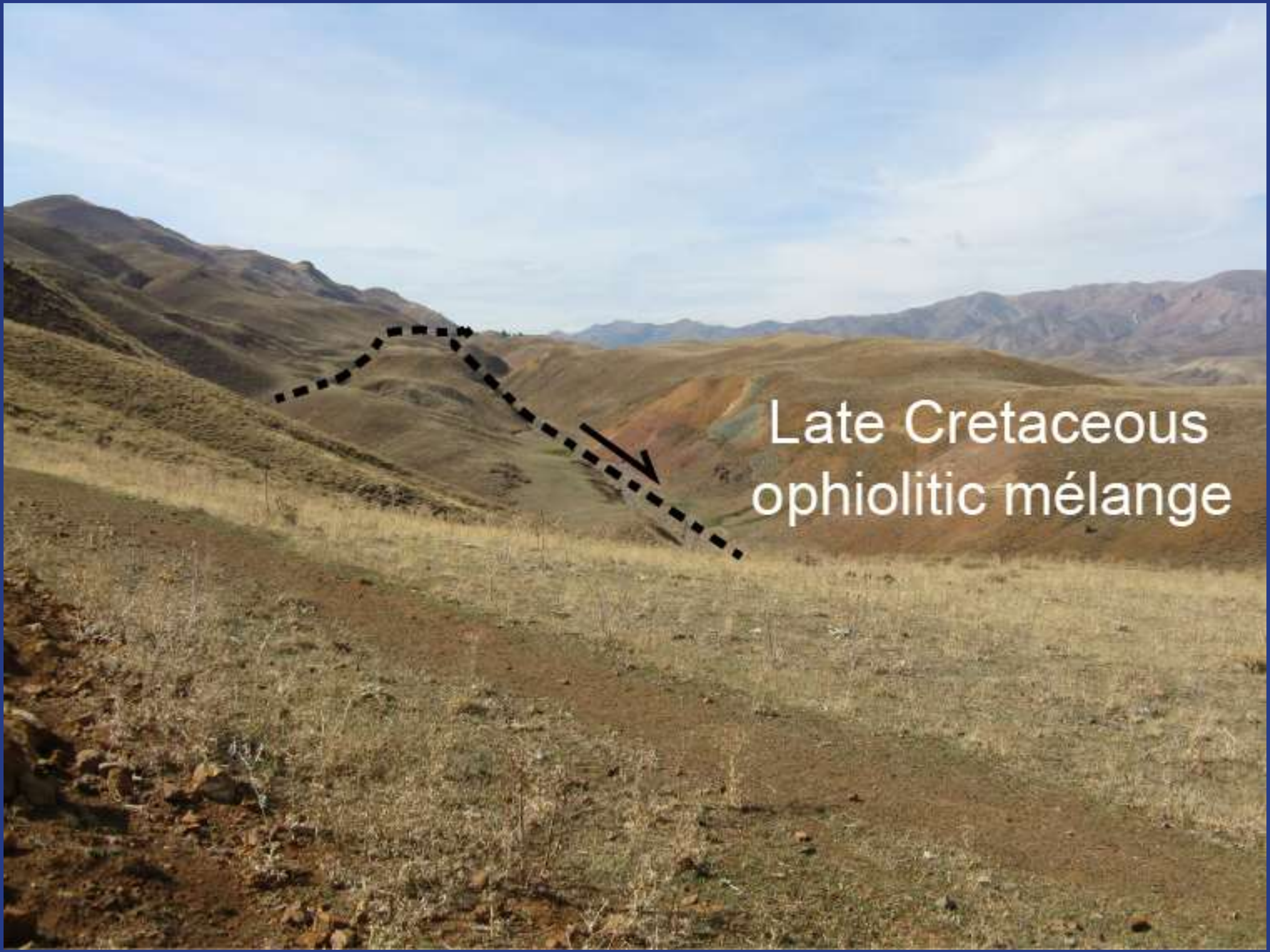
0 km 100
Kuaterner
Miyosen-Pliyosen
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

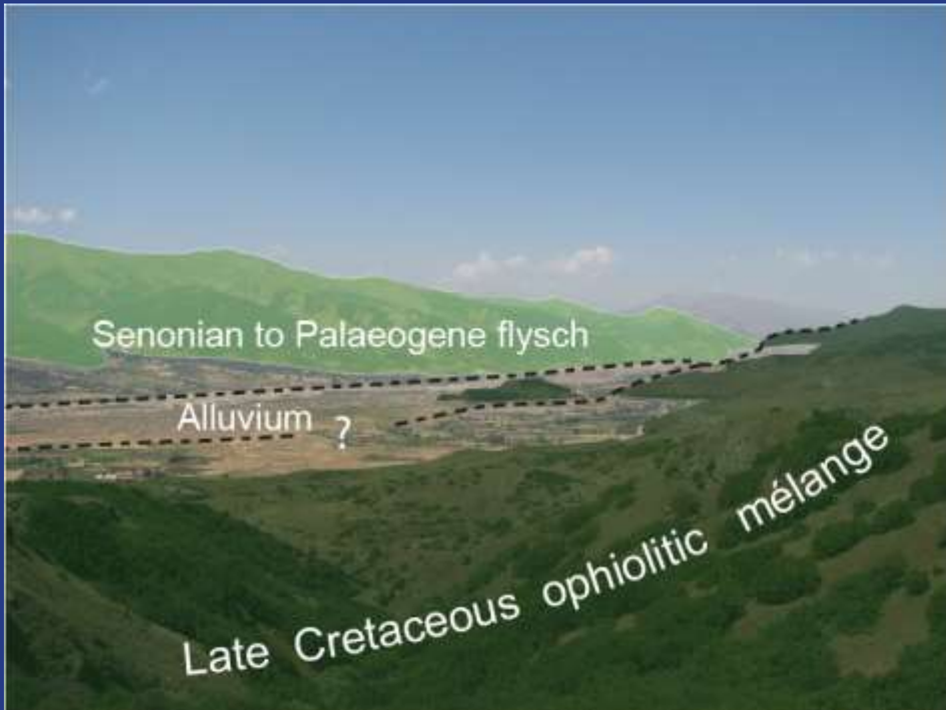


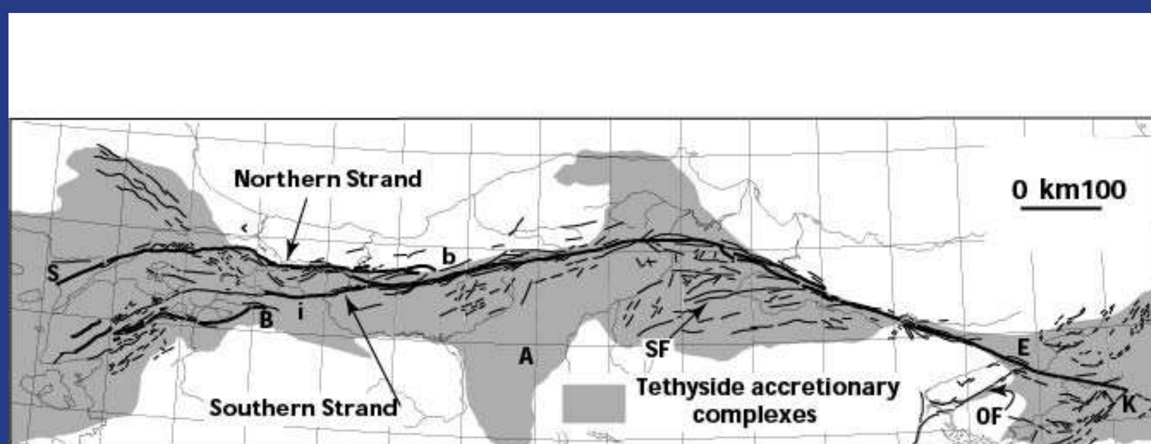
Ege Gerilme Rejimi
Kuzey Anadolu Fayı'nın oluşum zamanı
Ege gerilme Rejimi
Kuzey Anadolu makaslama bölgesinin oluşum zamanı?
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
19 20 21 22 23 24


sezerler

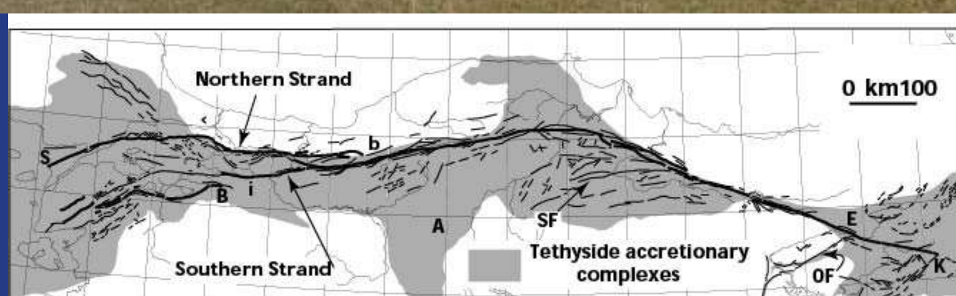

Northern Strand
0 km100
b
S
B
i
A
SF
E
Tethyside accretionary complexes
Southern Strand
OF
K


Late Cretaceous
ophiolitic mélange

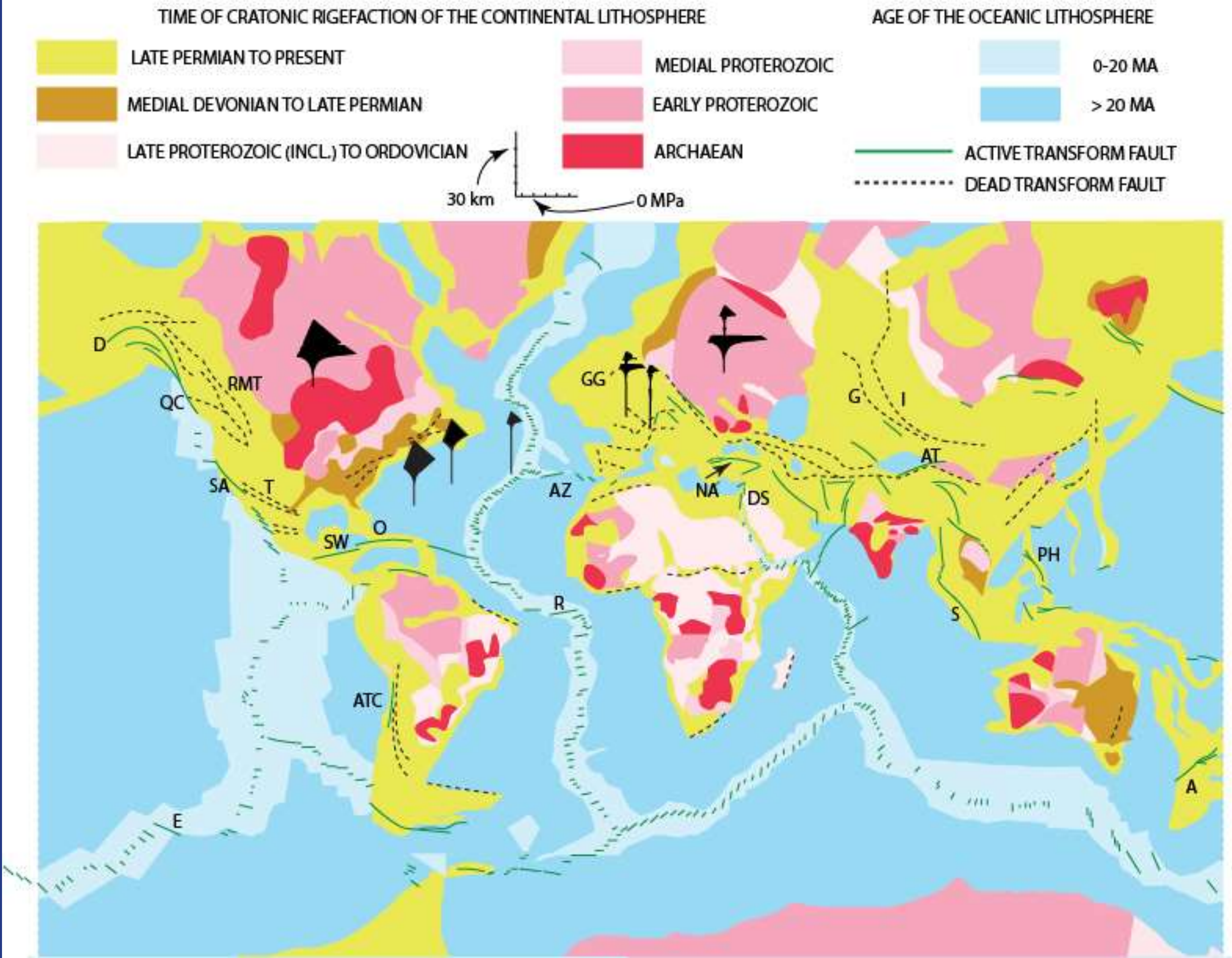

Senonian to Palaeogene flysch
Alluvium ?
Late Cretaceous ophiolitic mélange

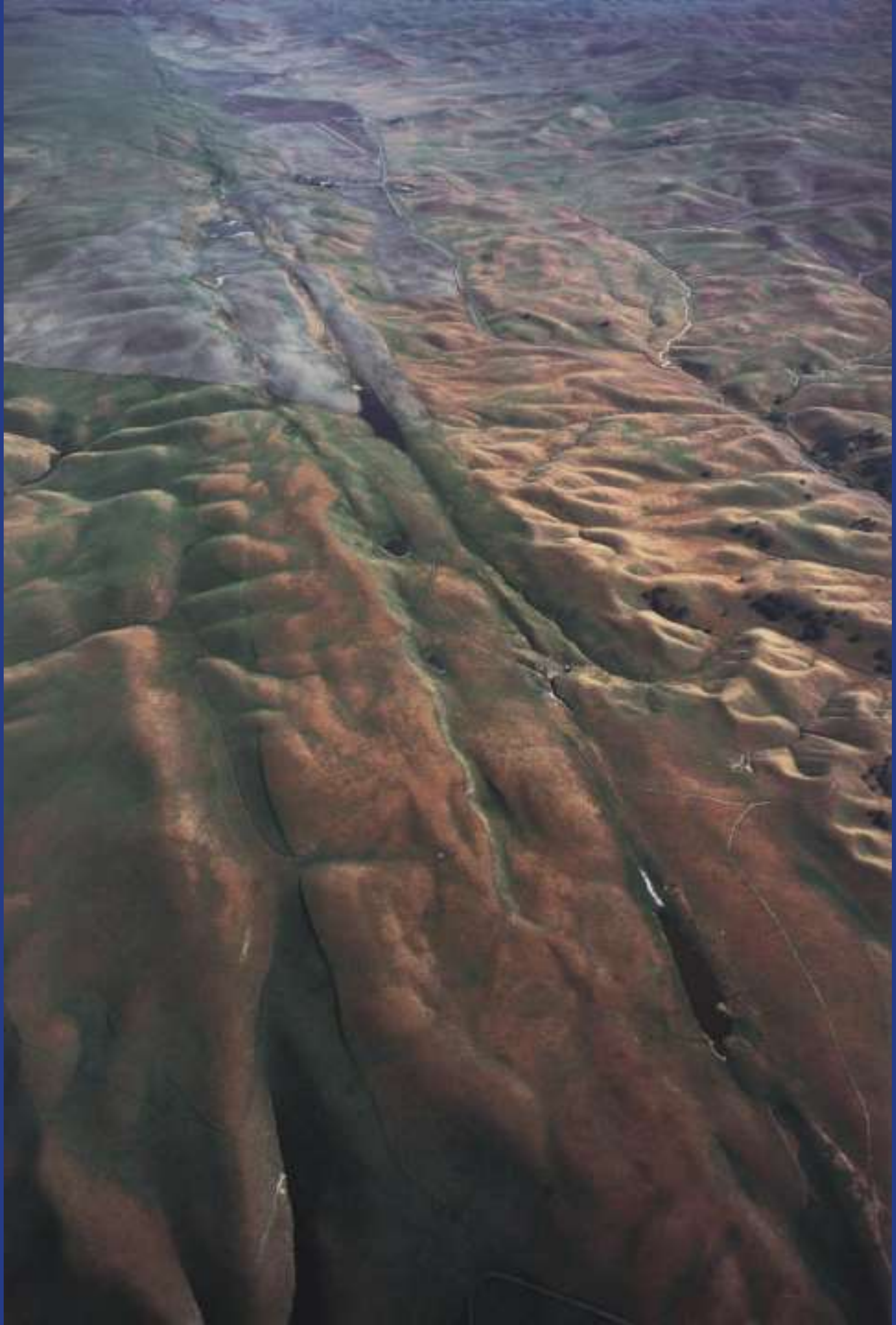

Northern Strand
0 km100
S
b
B
i
A
SF
E
K
OF
Southern Strand
Tethyside accretionary complexes

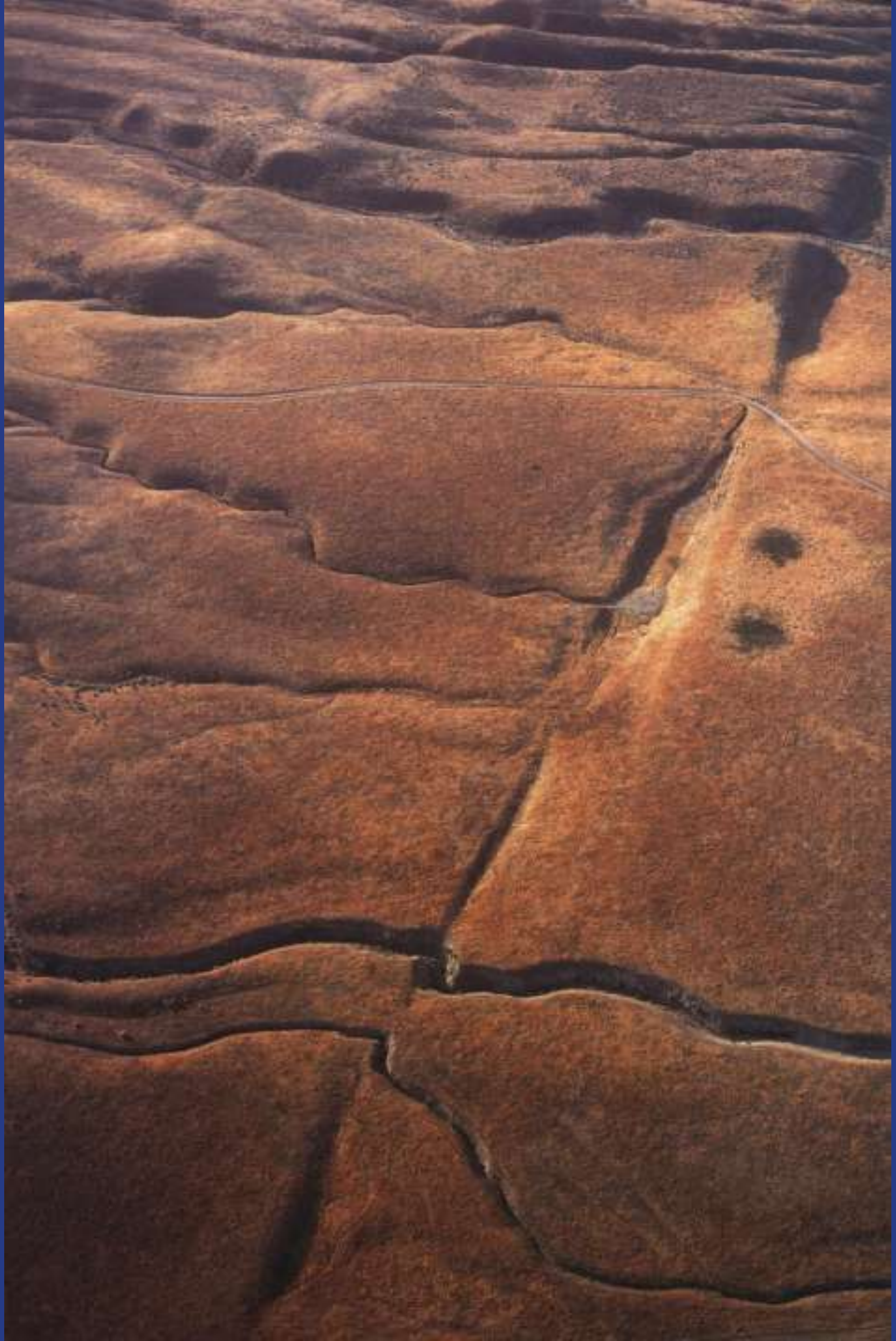
Upper Eocene andesites,
basalts and trachytes
SAG POND
Lacustrine clays in the sag pond overlying
Pliocene fluvial conglomerats and sandstones

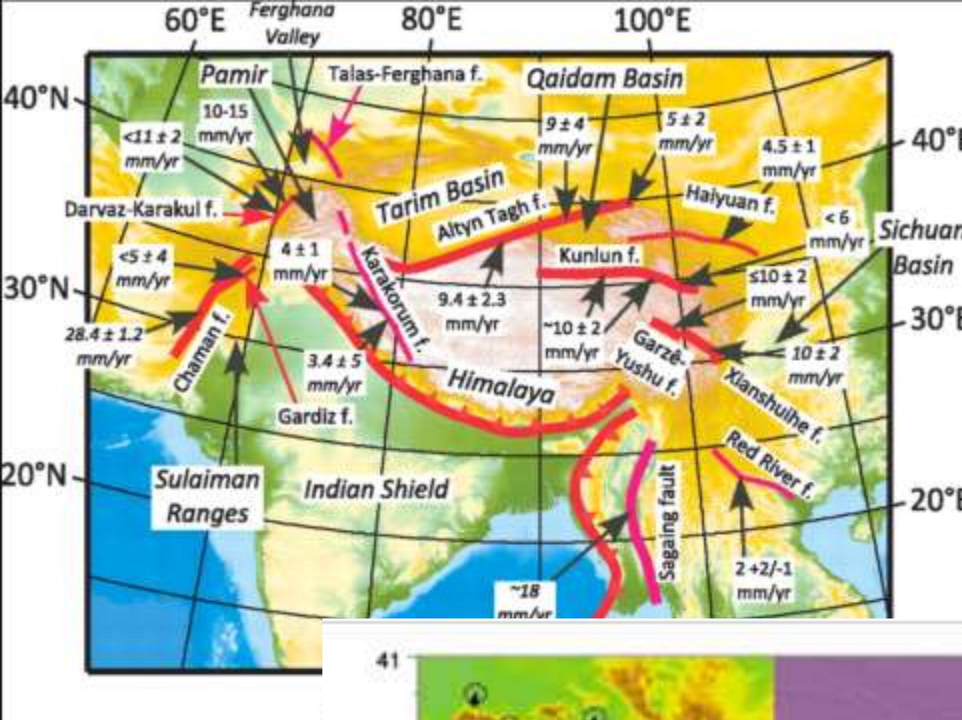


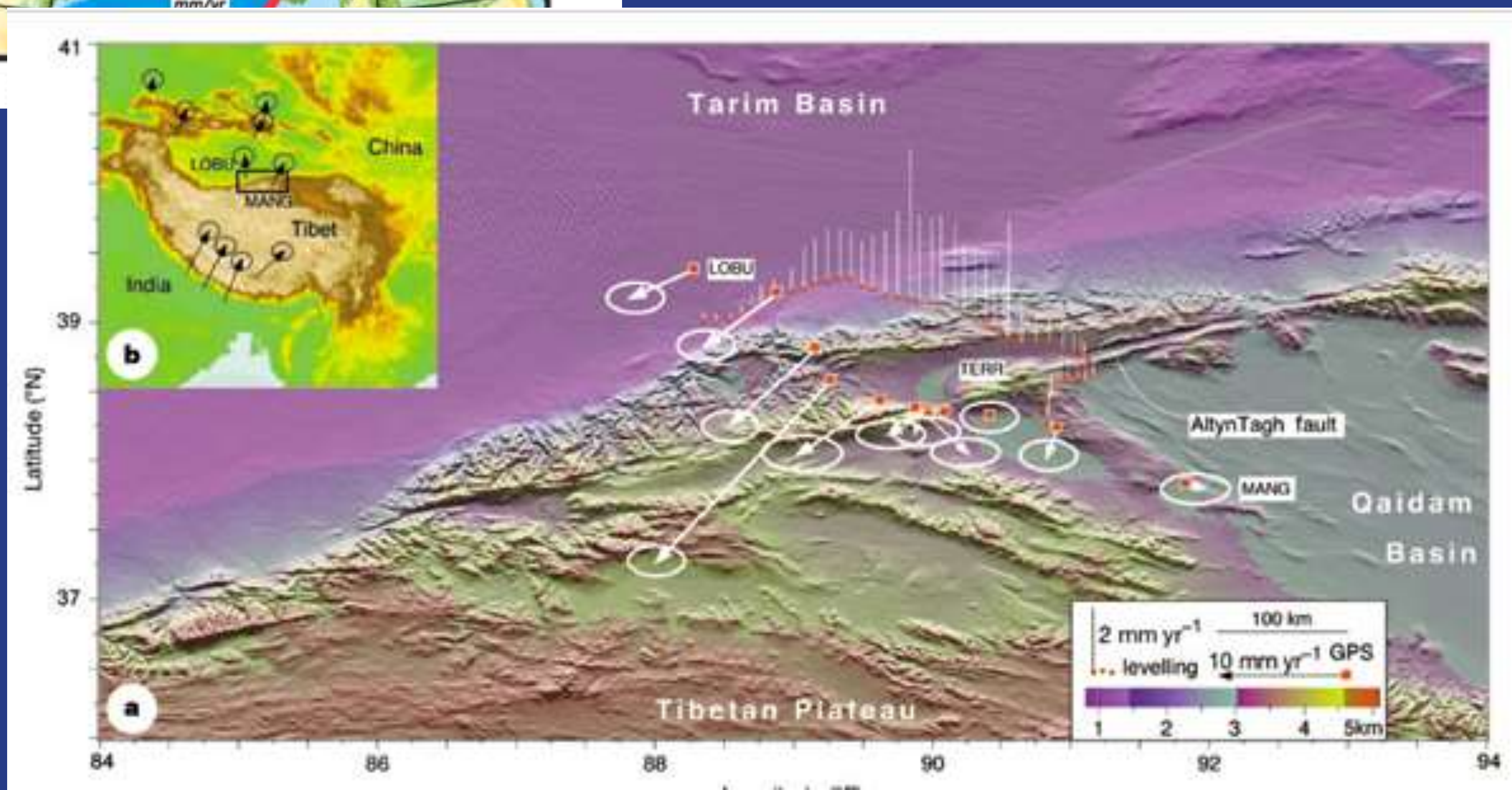
Northern Strand
0 km100
S
b
B
i
A
SF
E
Tethyside accretionary
complexes
Southern Strand
OF
K

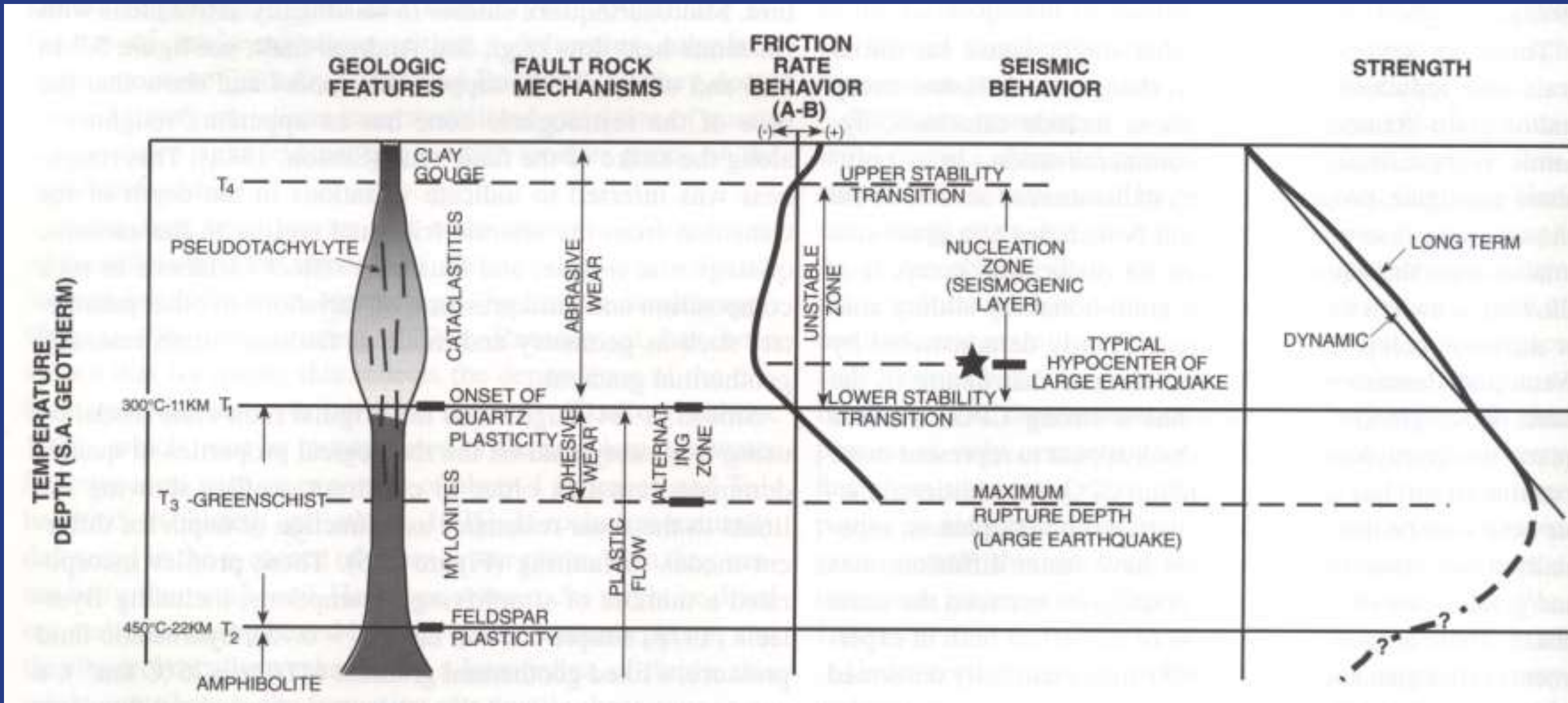

TIME OF CRATONIC RIGEFACTION OF THE CONTINENTAL LITHOSPHERE
LATE PERMIAN TO PRESENT
MEDIAL DEVONIAN TO LATE PERMIAN
LATE PROTEROZOIC (INCL.) TO ORDOVICIAN
MEDIAL PROTEROZOIC
EARLY PROTEROZOIC
ARCHAEAN
30 km
0 MPa
AGE OF THE OCEANIC LITHOSPHERE
0-20 MA
> 20 MA
ACTIVE TRANSFORM FAULT
DEAD TRANSFORM FAULT
D
RMT
QC
SA
T
SW
O
ATC
E
R
AZ
GG
NA
DS
G
I
AT
PH
S
A

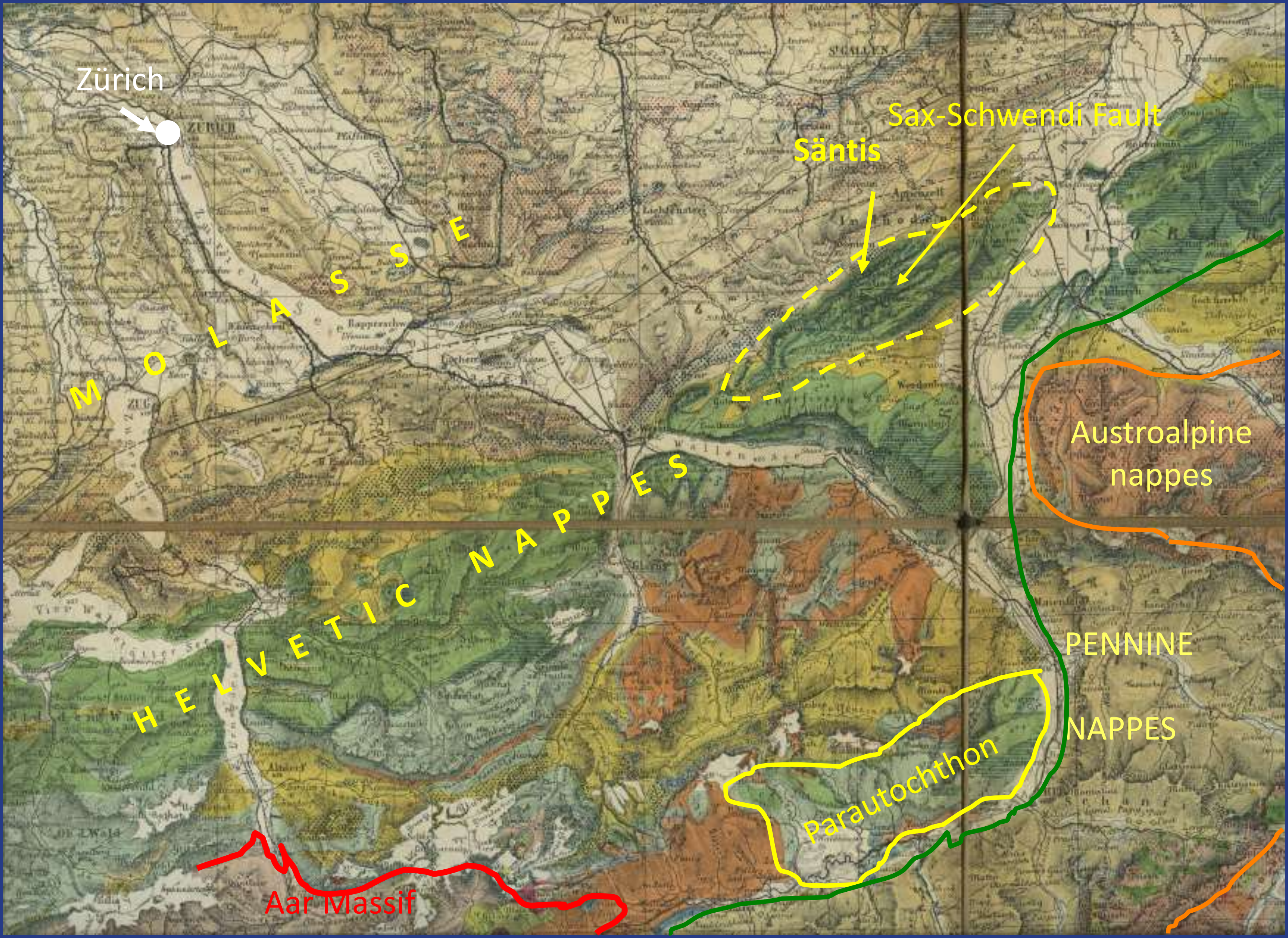




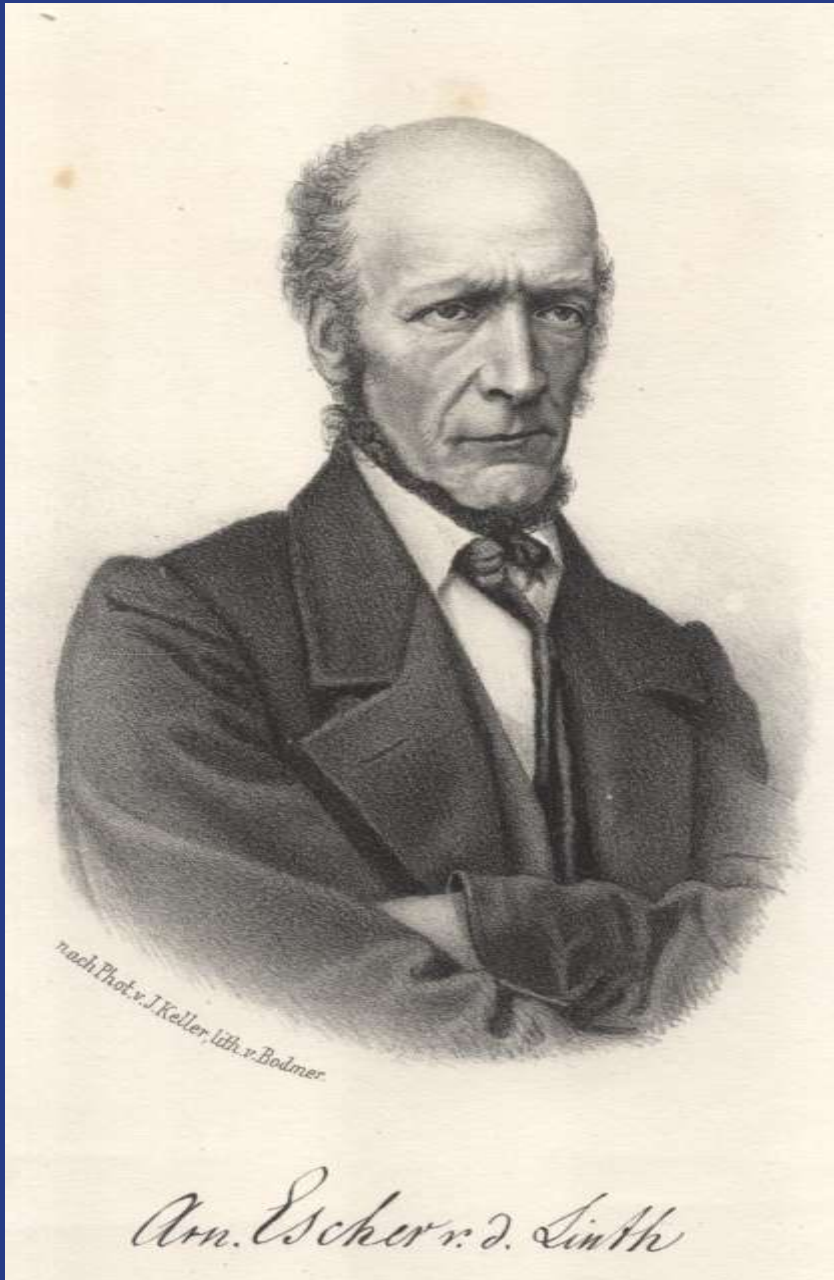

60°E
Ferghana Valley
80°E
100°E
Pamir
Talas-Ferghana f.
Qaidam Basin
40°N
10-15 mm/yr
<11 ± 2 mm/yr
9 ± 4 mm/yr
5 ± 2 mm/yr
4.5 ± 1 mm/yr
40°E
Tarim Basin
Darvaz-Karakul f.
Altyn Tagh f.
Haiyuan f.
< 6 mm/yr
Sichuan Basin
<5 ± 4 mm/yr
4 ± 1 mm/yr
Karakorum f.
Kunlun f.
≤10 ± 2 mm/yr
30°N
9.4 ± 2.3 mm/yr
~10 ± 2 mm/yr
30°E
28.4 ± 1.2 mm/yr
Chaman f.
3.4 ± 5 mm/yr
Garzê-Yushu f.
10 ± 2 mm/yr
Himalaya
Xianshuihe f.
Gardiz f.
Red River f.
20°N
Sulaiman Ranges
Indian Shield
Sagaing fault
20°E
2 +2/-1 mm/yr
~18 mm/yr


41
39
37
Latitude (°N)
84
86
88
90
92
94
Tarim Basin
LOBU
TERR
AltynTagh fault
MANG
Qaidam Basin
Tibetan Plateau
China
Tibet
India
b
a
2 mm yr⁻¹
100 km
levelling
10 mm yr⁻¹ GPS
1
2
3
4
5km

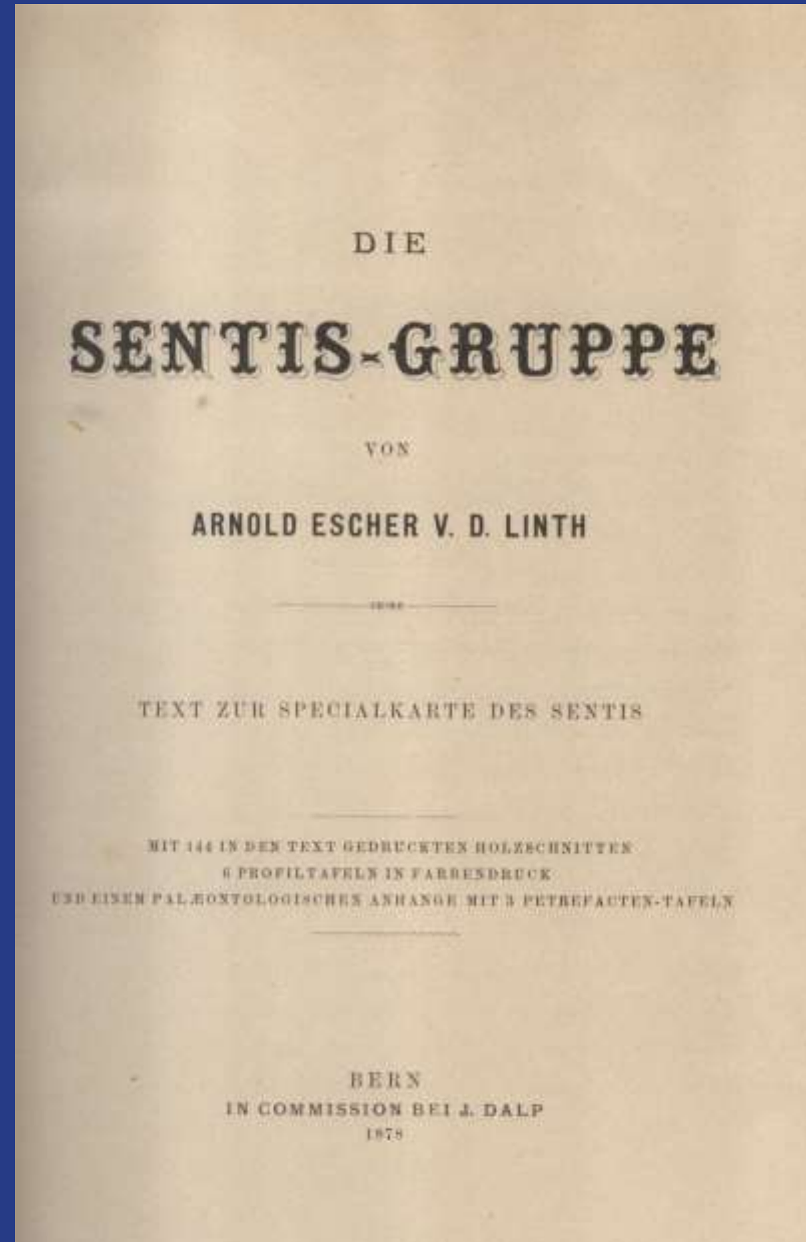

GEOLOGIC FEATURES
FAULT ROCK MECHANISMS
FRICTION RATE BEHAVIOR (A-B)
(-) (+)
SEISMIC BEHAVIOR
STRENGTH
TEMPERATURE DEPTH (S.A. GEOTHERM)
CLAY GOUGE
T_4
UPPER STABILITY TRANSITION
PSEUDOTACHYLYTE
CATACLASTITES
ABRASIVE WEAR
UNSTABLE ZONE
NUCLEATION ZONE (SEISMOGENIC LAYER)
LONG TERM
DYNAMIC
TYPICAL HYPOCENTER OF LARGE EARTHQUAKE
300°C-11KM T_1
ONSET OF QUARTZ PLASTICITY
ADHESIVE WEAR
ALTERNATING ZONE
LOWER STABILITY TRANSITION
T_3 -GREENSCHIST
MYLONITES
PLASTIC FLOW
MAXIMUM RUPTURE DEPTH (LARGE EARTHQUAKE)
450°C-22KM T_2
FELDSPAR PLASTICITY
AMPHIBOLITE
?



Geological map of Switzerland by Arnold Escher von der Linth and Bernhard Studer (2nd edition, 1869)



Arnold Escher von der Linth (1819-1882)



DIE

SENTIS-GRUPPE

VON

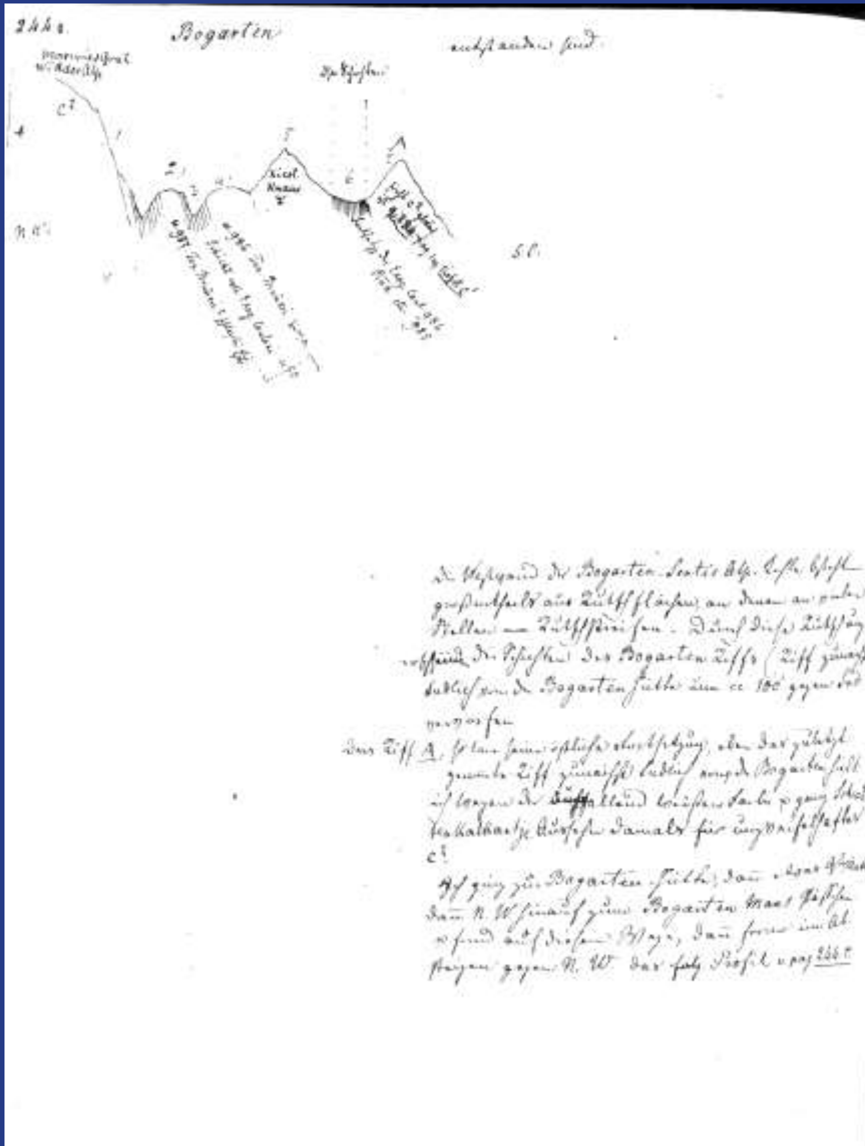
ARNOLD ESCHER V. D. LINTH

TEXT ZUR SPECIALKARTE DES SENTIS

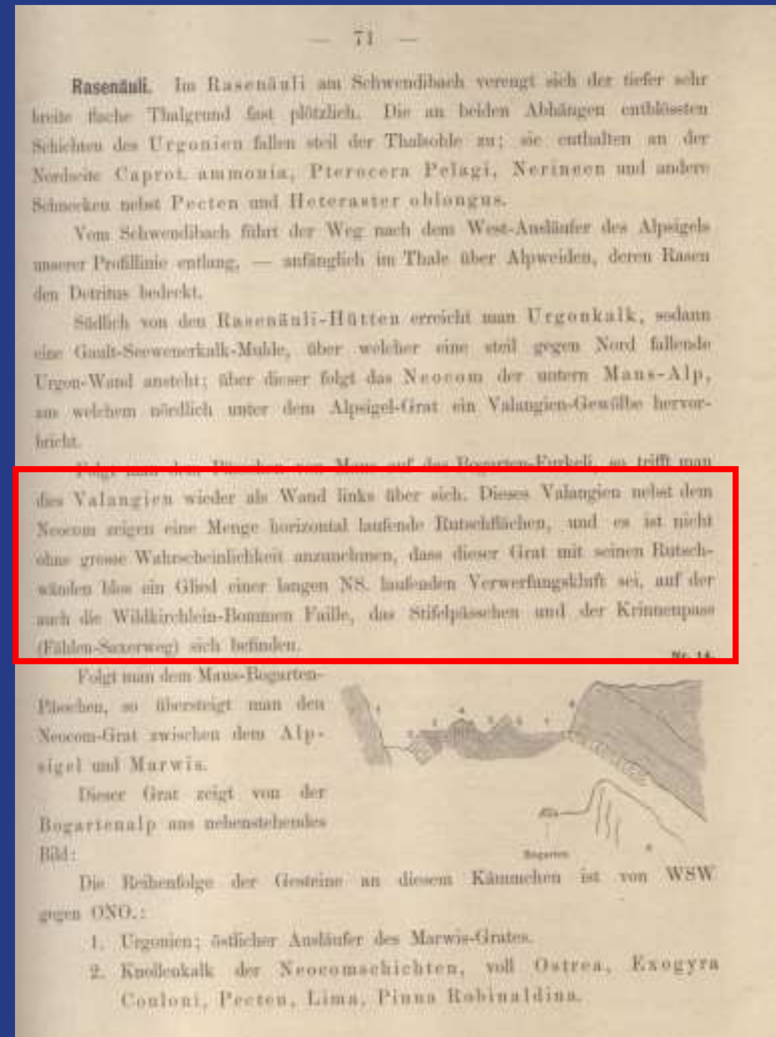
MIT 144 IN DEN TEXT GEDRUCKTEN HOLZSCHNITTEN
6 PROFILTAFELN IN FARBENDRUCK
UND EINEM PALÆONTOLOGISCHEN ANHANGE MIT 3 PETREFACTEN-TAFELN

BERN
IN COMMISSION BEI J. DALP
1878

Escher (1878)



Field notes by Escher: September 1854



Rasenäuli. Im Rasenäuli am Schwendibach verengt sich der tiefer sehr breite flache Thalgrund fast plötzlich. Die an beiden Abhängen entblössten Schichten des Urgonien fallen steil der Thalsohle zu; sie enthalten an der Nordseite Caprot. ammonia, Pterocera Pelagi, Nerineen und andere Schnecken nebst Pecten und Heteraster oblongus.

Vom Schwendibach führt der Weg nach dem West-Ausläufer des Alpsigels unserer Profillinie entlang, — anfänglich im Thale über Alpweiden, deren Rasen den Detritus bedeckt.

Südlich von den Rasenäuli-Hütten erreicht man Urgonkalk, sodann eine Gault-Seewenerkalk-Mulde, über welcher eine steil gegen Nord fallende Urgon-Wand ansteht; über dieser folgt das Neocom der untern Mans-Alp, aus welchem nördlich unter dem Alpsigel-Grat ein Valangien-Gewölbe hervorbricht.

Folgt man dem Pfädchen von Mans auf das Bogarten-Furkeli, so trifft man das Valangien wieder als Wand links über sich. Dieses Valangien nebst dem Neocom zeigen eine Menge horizontal laufende Rutschflächen, und es ist nicht ohne grosse Wahrscheinlichkeit anzunehmen, dass dieser Grat mit seinen Rutschwänden blos ein Glied einer langen NS. laufenden Verwerfungskluft sei, auf der auch die Wildkirchlein-Bommen Faille, das Stifelpässchen und der Krinnenpass (Fählen-Saxerweg) sich befinden.

Fig. 14.

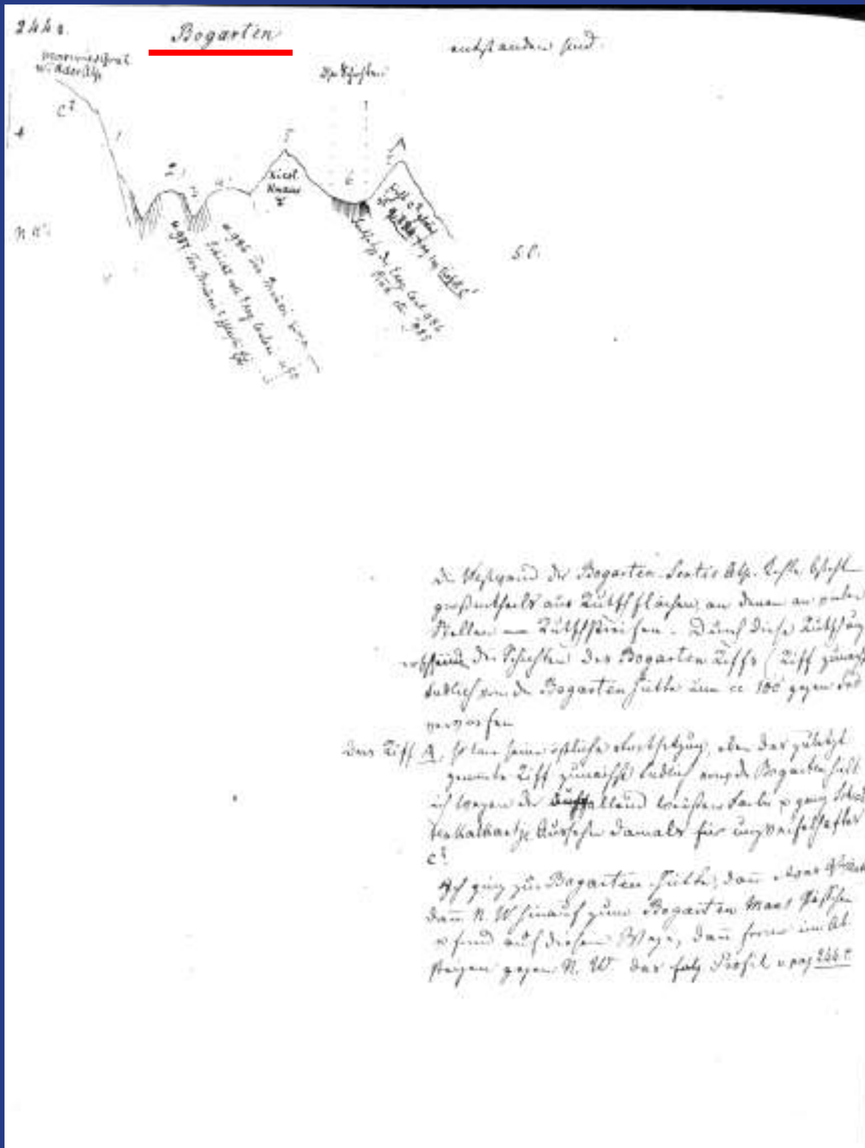
Folgt man dem Maus-Bogarten-Pässchen, so übersteigt man den Neocom-Grat zwischen dem Alpsigel und Marwis.

Dieser Grat zeigt von der Bogartenalp aus nebenstehendes Bild:

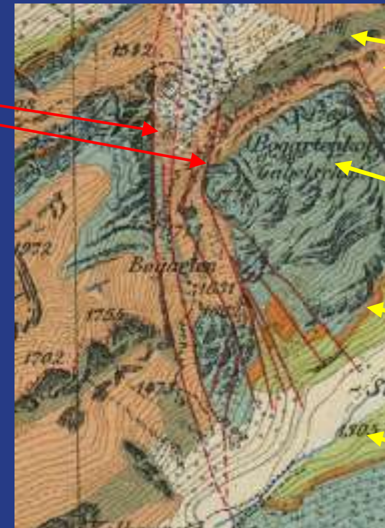
Die Reihenfolge der Gesteine an diesem Kämmchen ist von WSW gegen ONO.:

1. Urgonien; östlicher Ausläufer des Marwis-Grates.
2. Knollenkalk der Neocomschichten, voll Ostrea, Exogyra Couloni, Pecten, Lima, Pinna Robinaldina.

Published version edited by Casimir Moesch (1878): “Whetever that is good in it is from Escher, whatever wrong is from Moesch” (Heim, 1919)



Sax-Schwendi fault at Bogarten



Lower Cretaceous

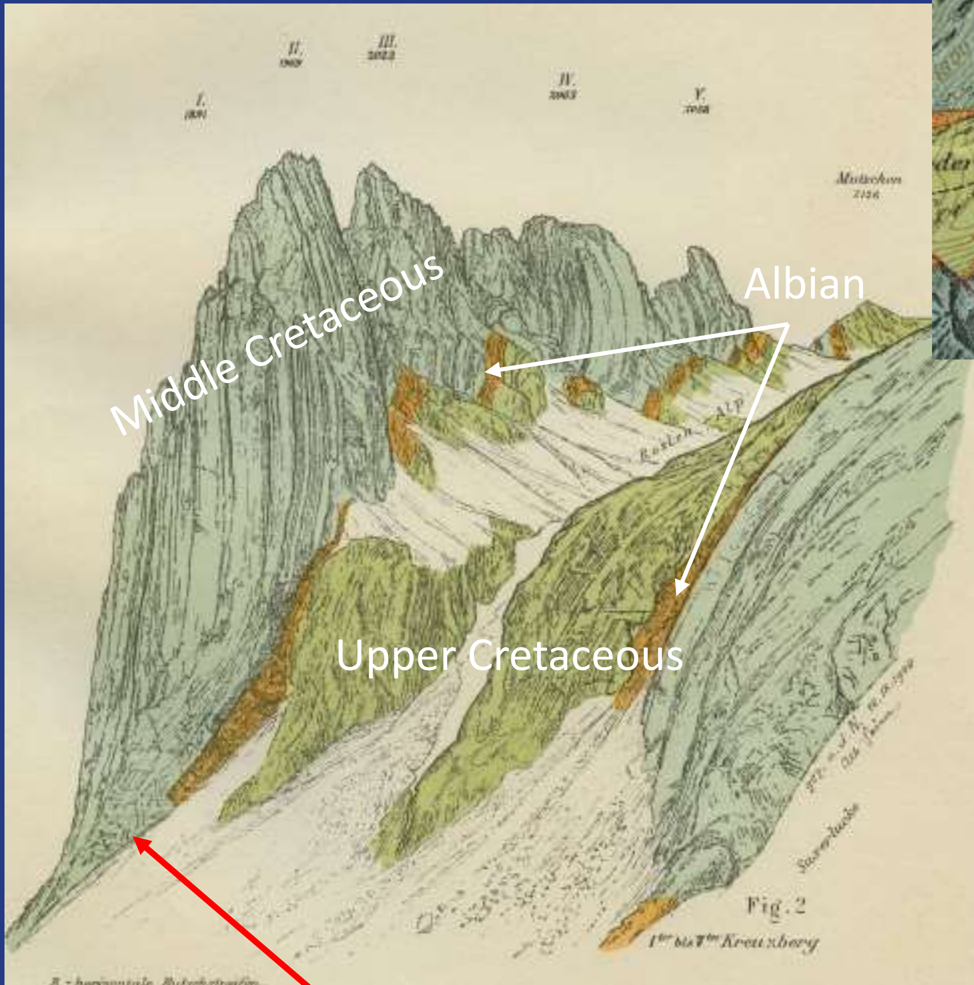
Middle Cretaceous

Albian

Upper Cretaceous

Sax-Schwendi Fault in the field:

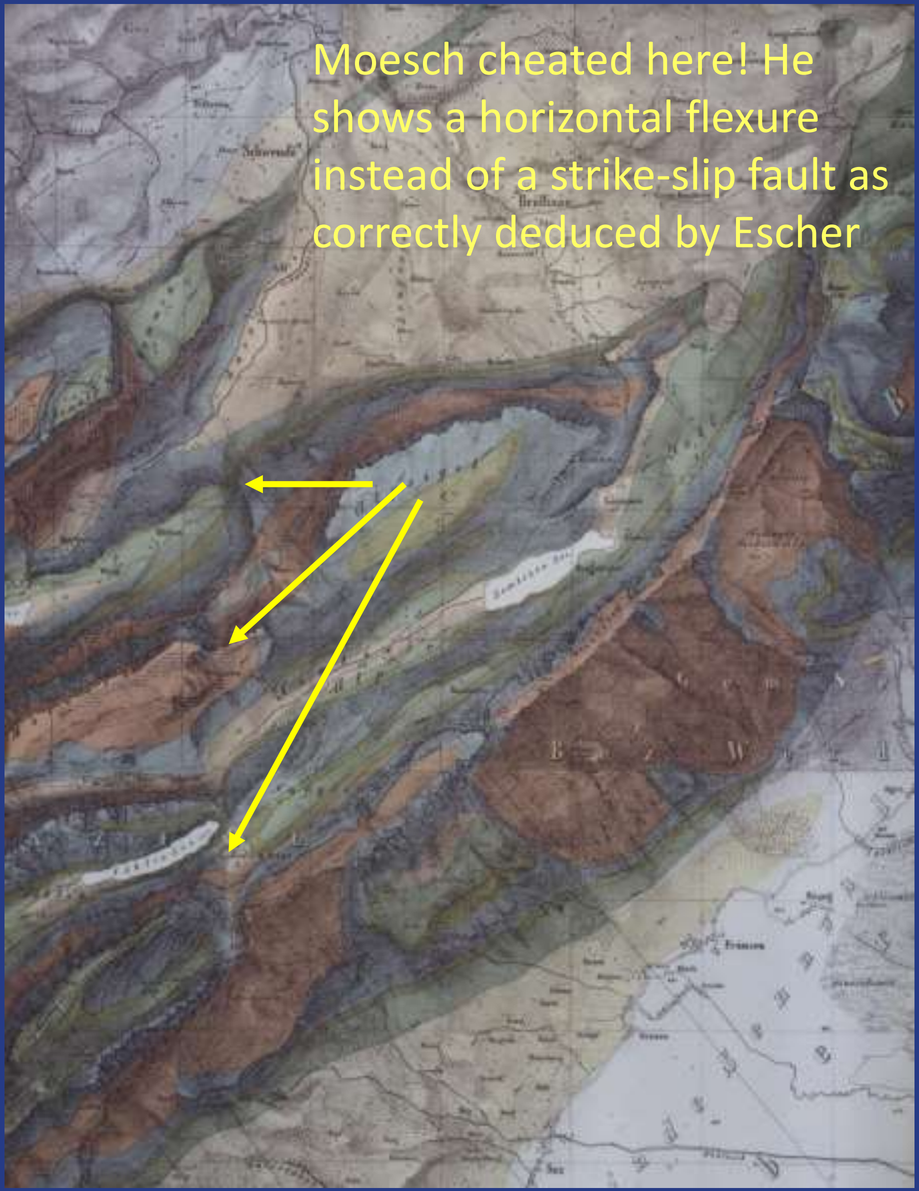
Bogarten-Lücke



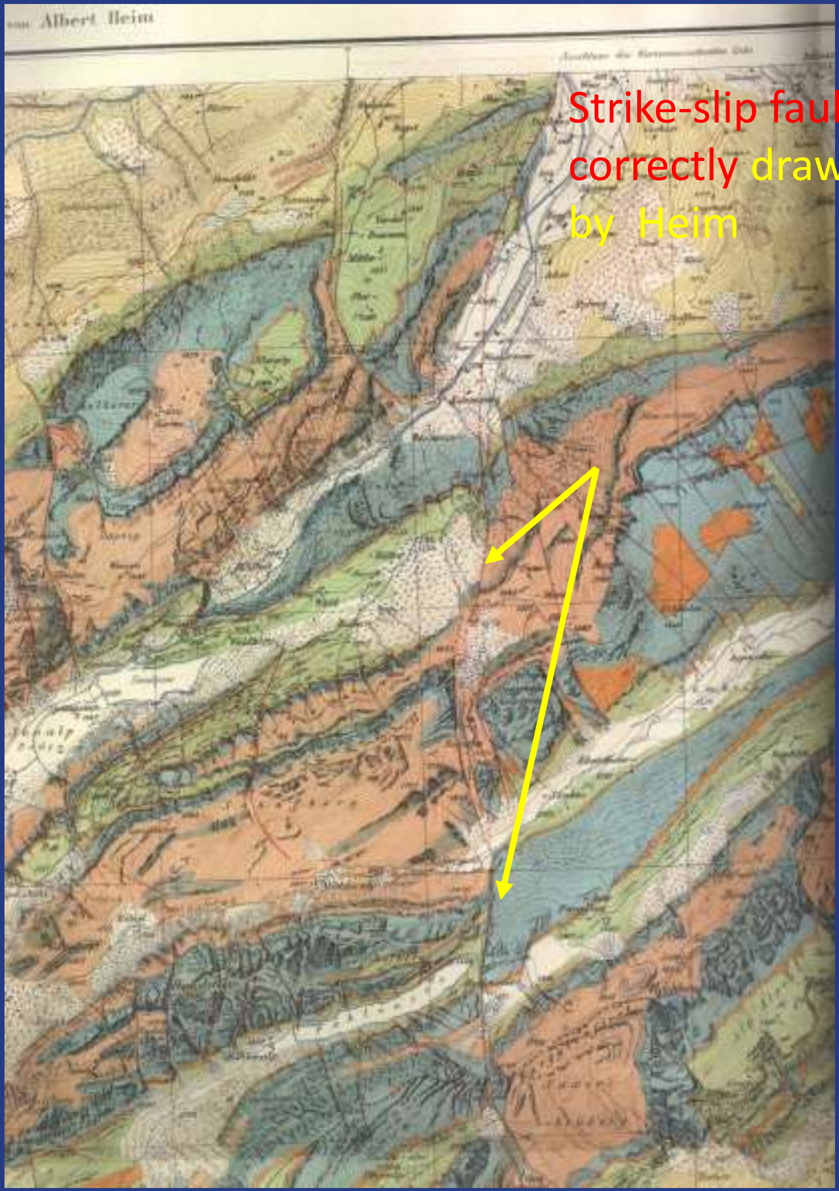
Horizontal striae on slickenside

From Heim (1905)

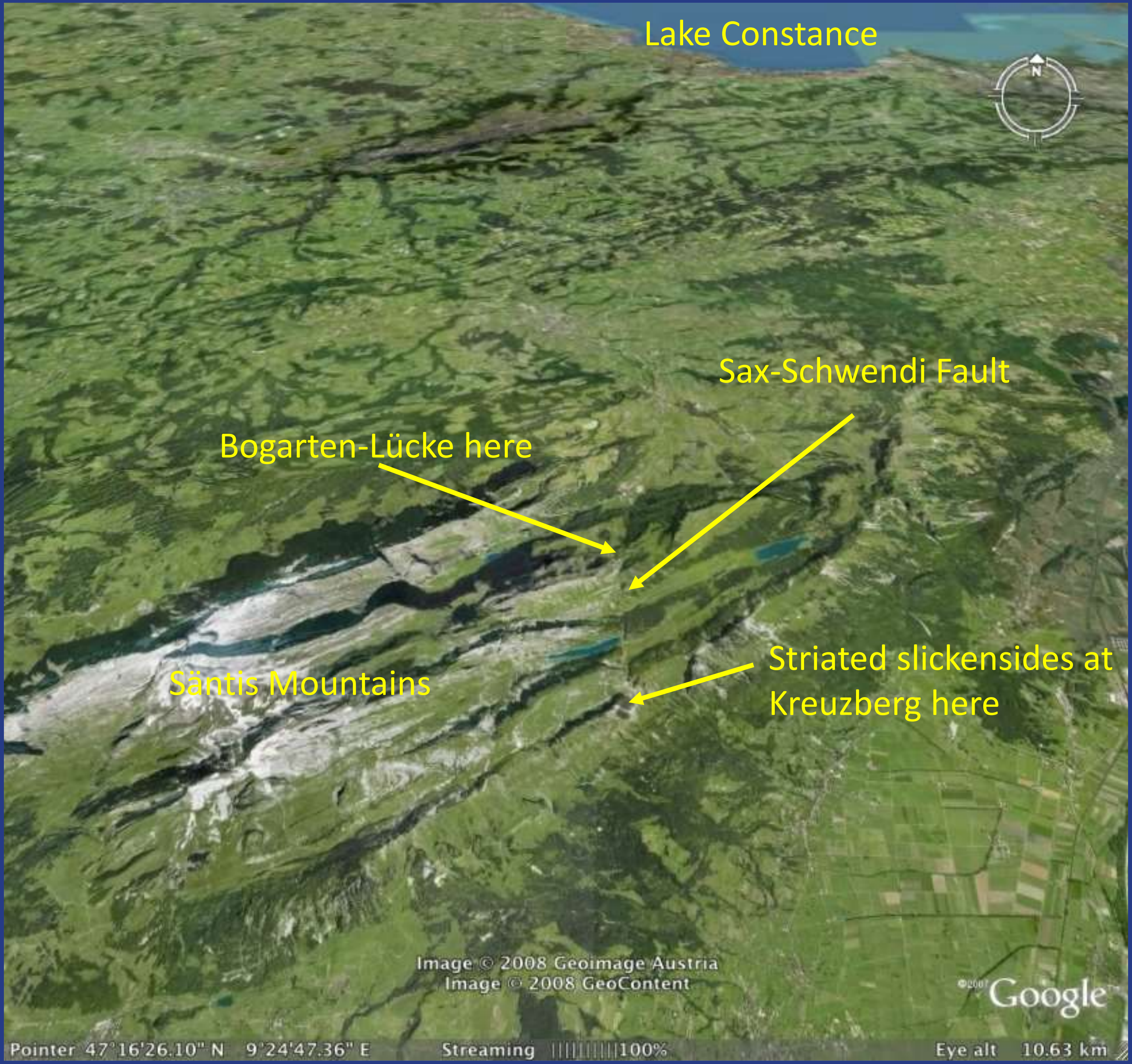
Kreuzberg (=Cross mountain)



Escher («corrected» and published by C. Moesch 1878)



Albert Heim (1905) The Sax-Schwendi Fault properly recognised


Lake Constance
Sax-Schwendi Fault
Bogarten-Lücke here
Säntis Mountains
Striated slickensides at
Kreuzberg here
Image © 2008 Geoimage Austria
Image © 2008 GeoContent
Google
Pointer 47°16'26.10" N 9°24'47.36" E
Streaming 100%
Eye alt 10.63 km

Sax-Schwendi Fault in the field

(Google Earth)

Suess: *Das Antlitz der Erde*, v. 1a (1883);

English edition 1904: *The Face of the Earth*

on one side of the dividing plane are more crowded together, and show a greater tendency to form overfolds than those on the other.

These surfaces of separation have a most important bearing on the origin of folded mountain chains.

Escher, of noble and undying memory, when explaining to me in 1854 the folded structure of the Säntis, pointed with particular emphasis to a little face of rock in the neighbourhood of Wildkirchli, which appeared to form part of a fissure cutting transversely across the folds. When in 1857 he described the six folds of the Säntis before the Helvetian Society of Natural Sciences at Trogen he said: 'Whereas in the longitudinal direction of this chain no faults occur, on the other hand fissures transverse to it may be observed, which often traverse the whole mountain chain, as for instance that from Wildkirchlein to the valley of the Rhine. In these transverse clefts the polishing of the fractured surfaces, as well as their dislocation, may be observed.'

Escher also made the following entry in his notebook when visiting the Rasenäuli: 'The Valangien (near the Bogarten-Furkeli), as well as the Neocomian, presents a number of horizontal glide-surfaces; and it is extremely probable that this ridge, with its slickensides, is merely a part of a long fault running north and south, on the course of which the Wildkirchlein-Bommer fault, the little Stifelpass, and the Krinnenpass (Fählen-Saxerweg) also lie [1].'

Let us emphasize the following points in this first example: the strike towards the north (slightly to the west), at right angles to the direction of all the folds, the great length of the line and the horizontal striation of the slickensides; these are the three fundamental characters of all surfaces of this kind.

Jaccard's works on the Jura of the Vaud and Neuchâtel reveal the presence of a much more important transverse line in this region. From the southern border of the chain, passing close to the north-eastern end of the Lac de Joux and thence northwards through Hôpitaux nearly as far as Pontarlier, a disturbance is visible in the course of the folds of the Jura; this is most violent in the south, and seems to disappear towards the north. It is characterized in the south by the occurrence of short chains running north and south: Jaccard, in 1869, was uncertain whether these were to be regarded as independent chains, or merely as the deflected extremities of the folds lying to the west of the disturbance. Further observation has established the latter view as correct; on this great line of dislocation, therefore, which runs north and south, the inner folds of the Jura have been *dragged along at right angles to the strike.*

[1] A. Escher v. d. Linth, Geologische Beschreibung d. Sentis-Gruppe (edited by Moesch); Beitr. zur geol. Karte der Schweiz, 1878, XIII, pp. 71, 231.

Eduard Suess (1831-1914)

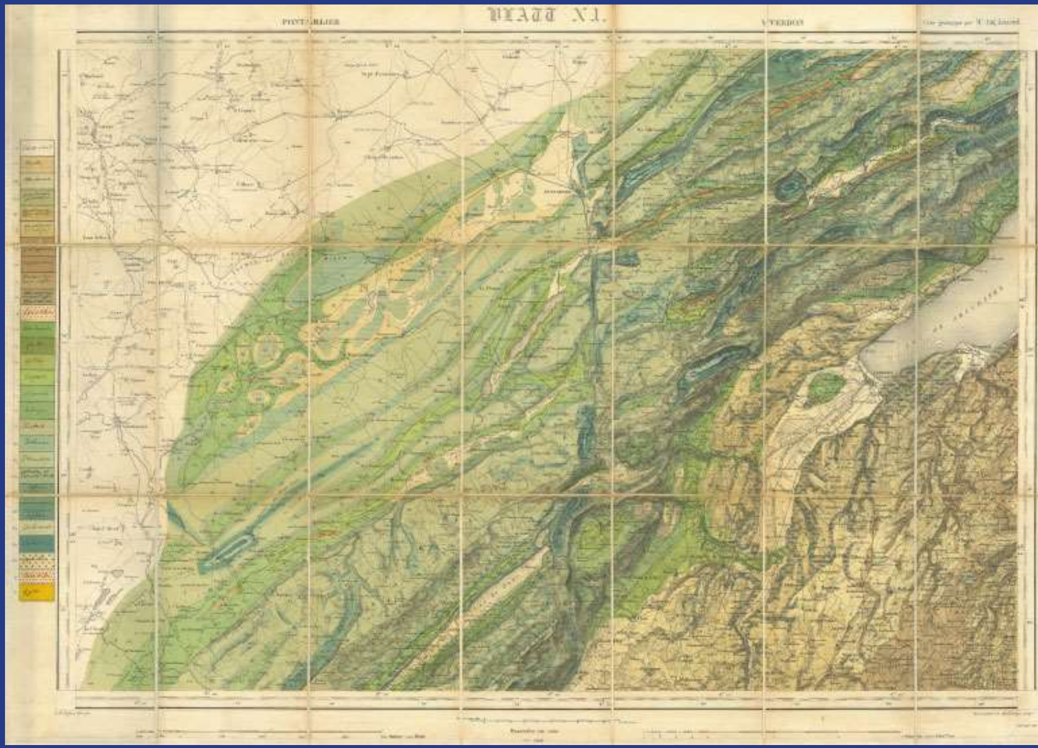

Eduard Sueß

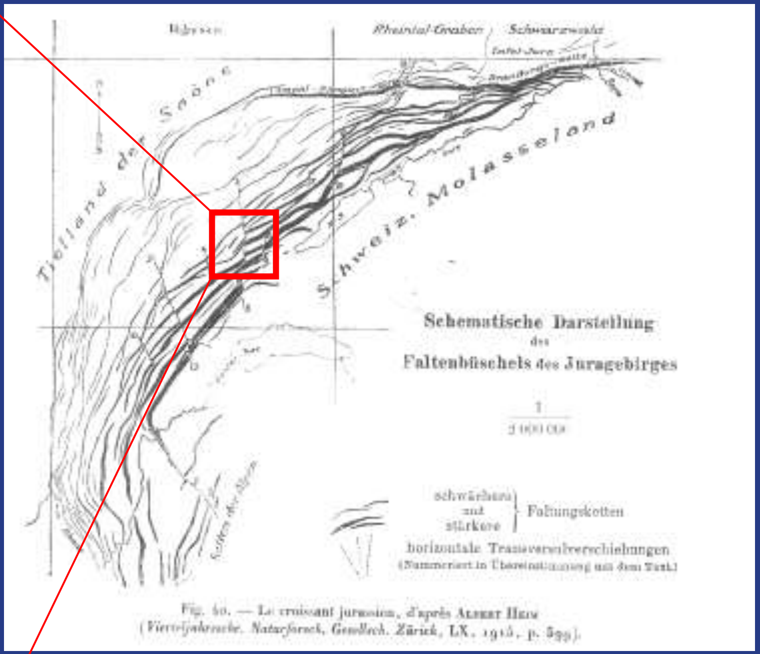
Erinnerungen

Mit 2 Bildnissen und 4 Textabbildungen

Verlag von S. Hirzel / Leipzig 1916

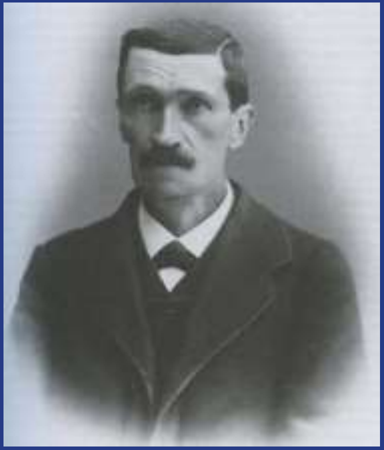
Suess: *Memoirs* 1916





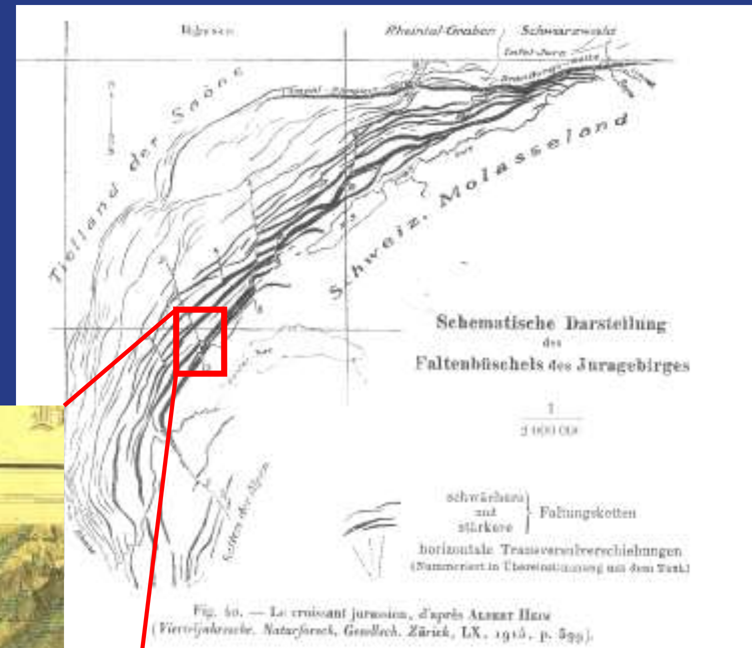
Structure of the Jura Mts after Heim (1915)

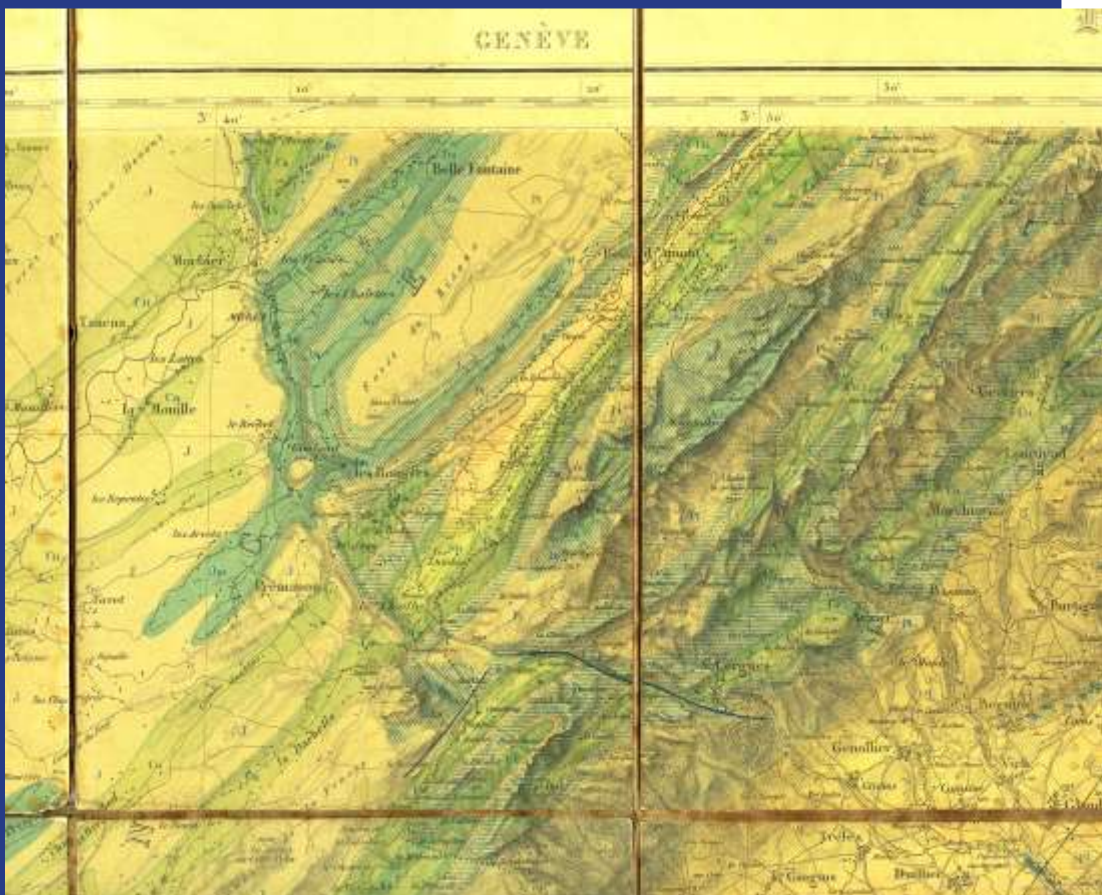
The Pontarlier strike-slip fault as mapped by Samuel Auguste Jaccard (1833-1895), published in 1838 and referred to by Suess in 1883 as a *strike-slip fault*.



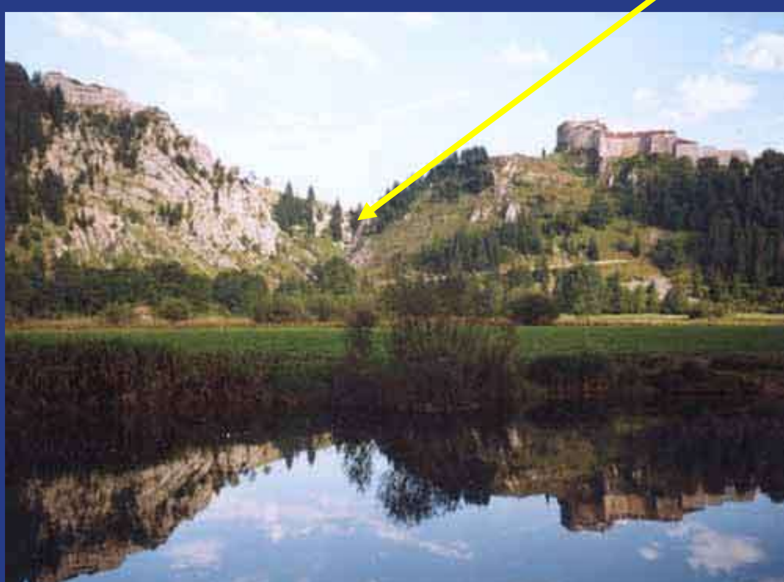
JACCARD

Another sheet of Jaccard’s map (1868) showing a part of the Jura with the Champagnole strike-slip fault.





Mt Larmont
anticline



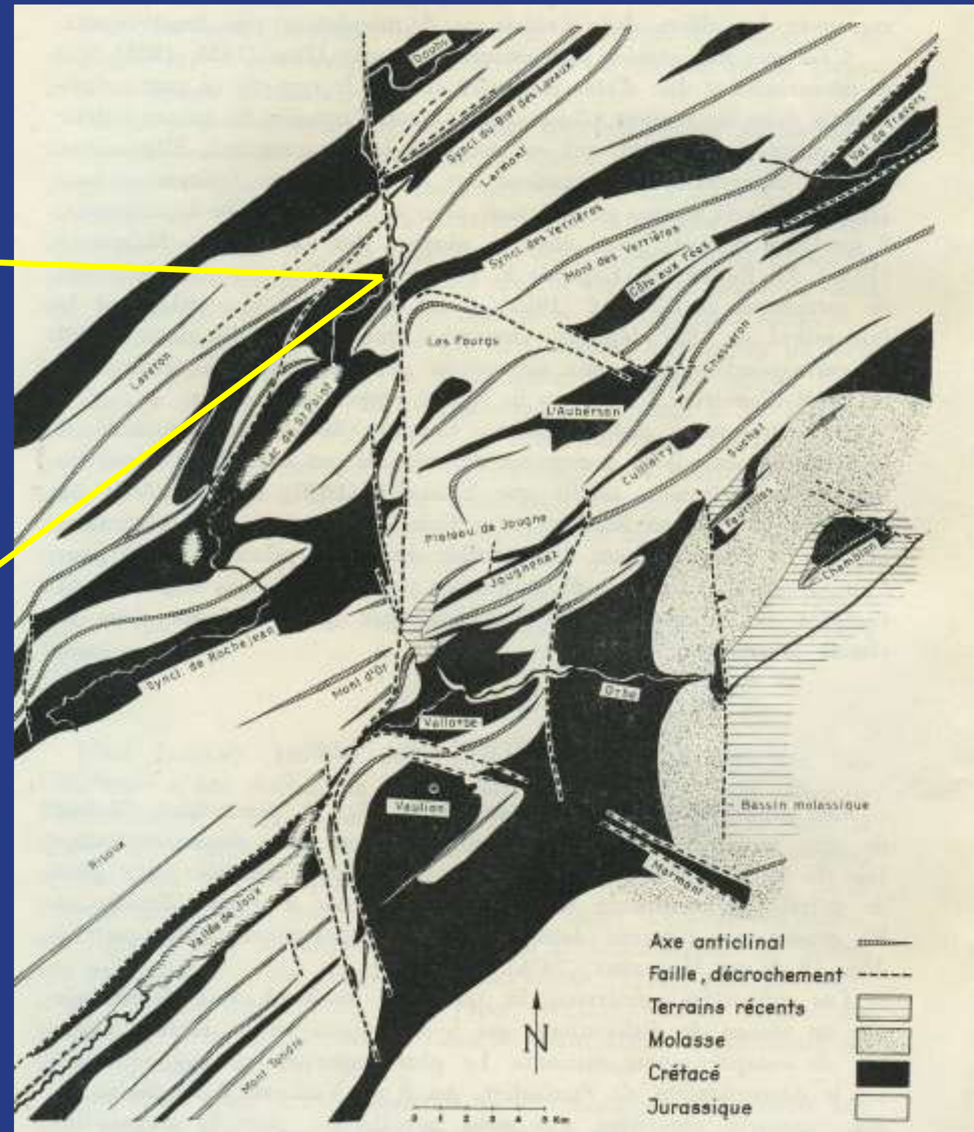
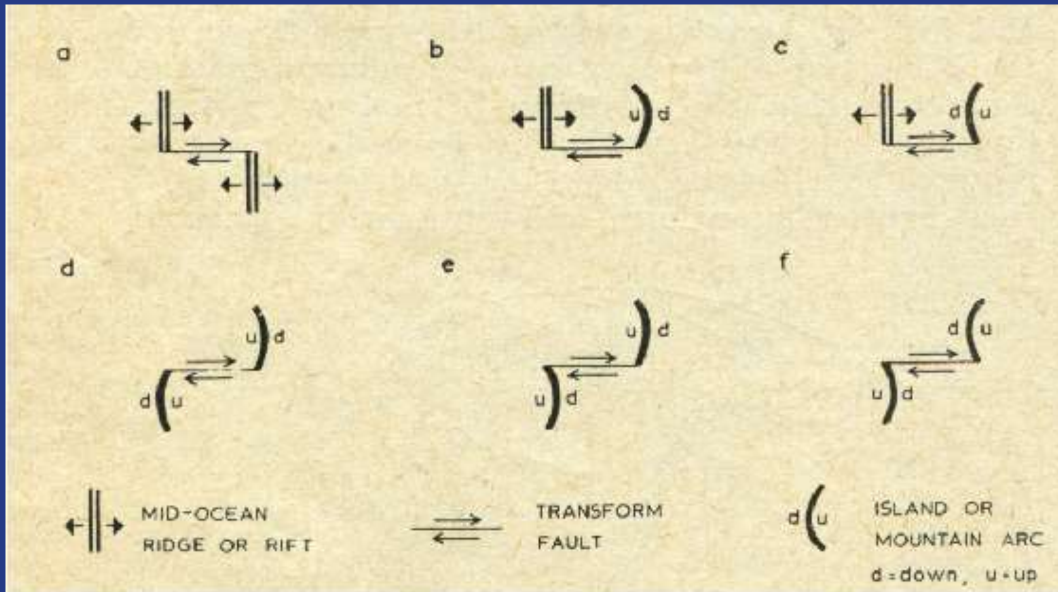
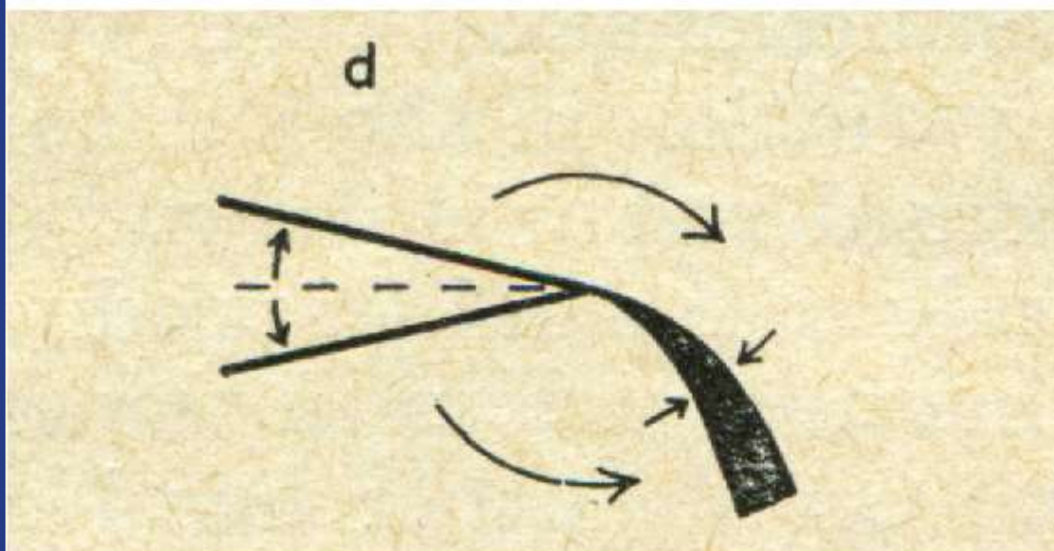


FIG. 1. — Esquisse tectonique régionale.

The watergap (*la Cuse*) of Pontarlier located on the strike-slip fault (Aubert's map,1959)



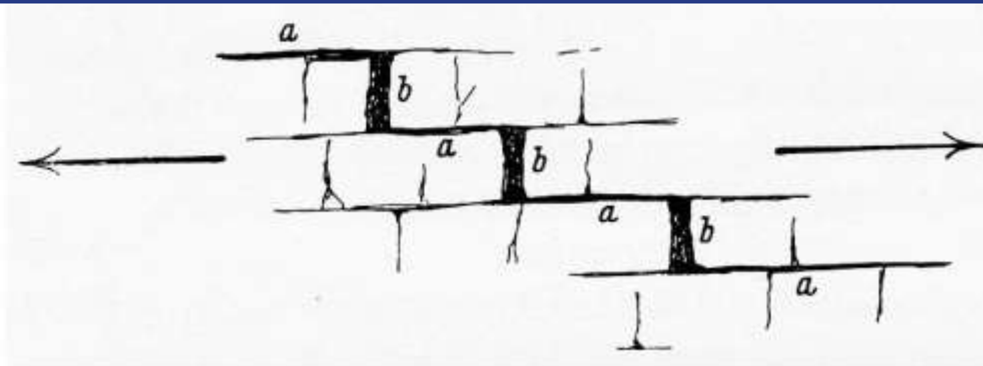
a



b

Wilson, J. T., 1965, A new class of faults and their bearing on continental drift: *Nature*, cilt. 207, ss. 343-347.

A



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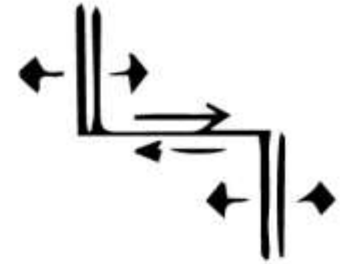

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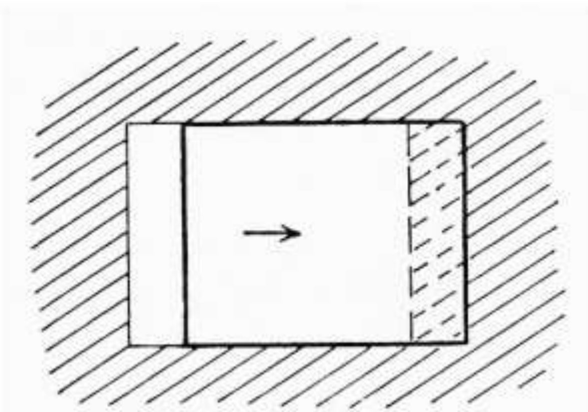

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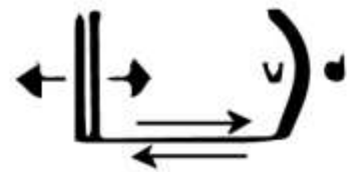

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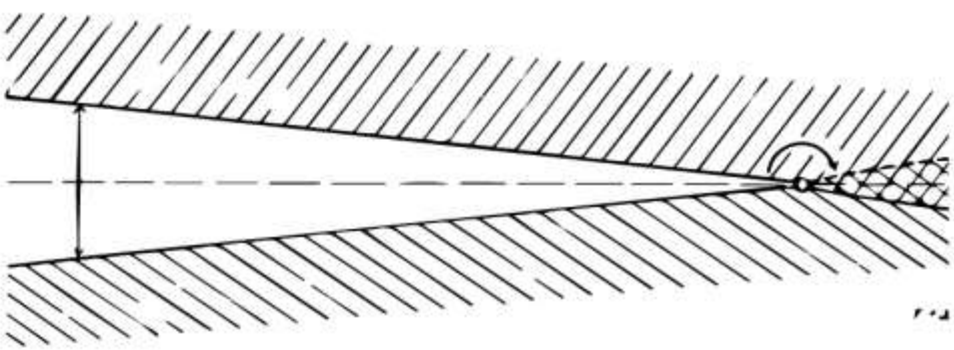
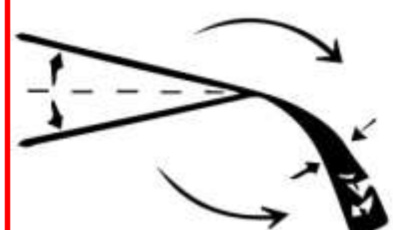
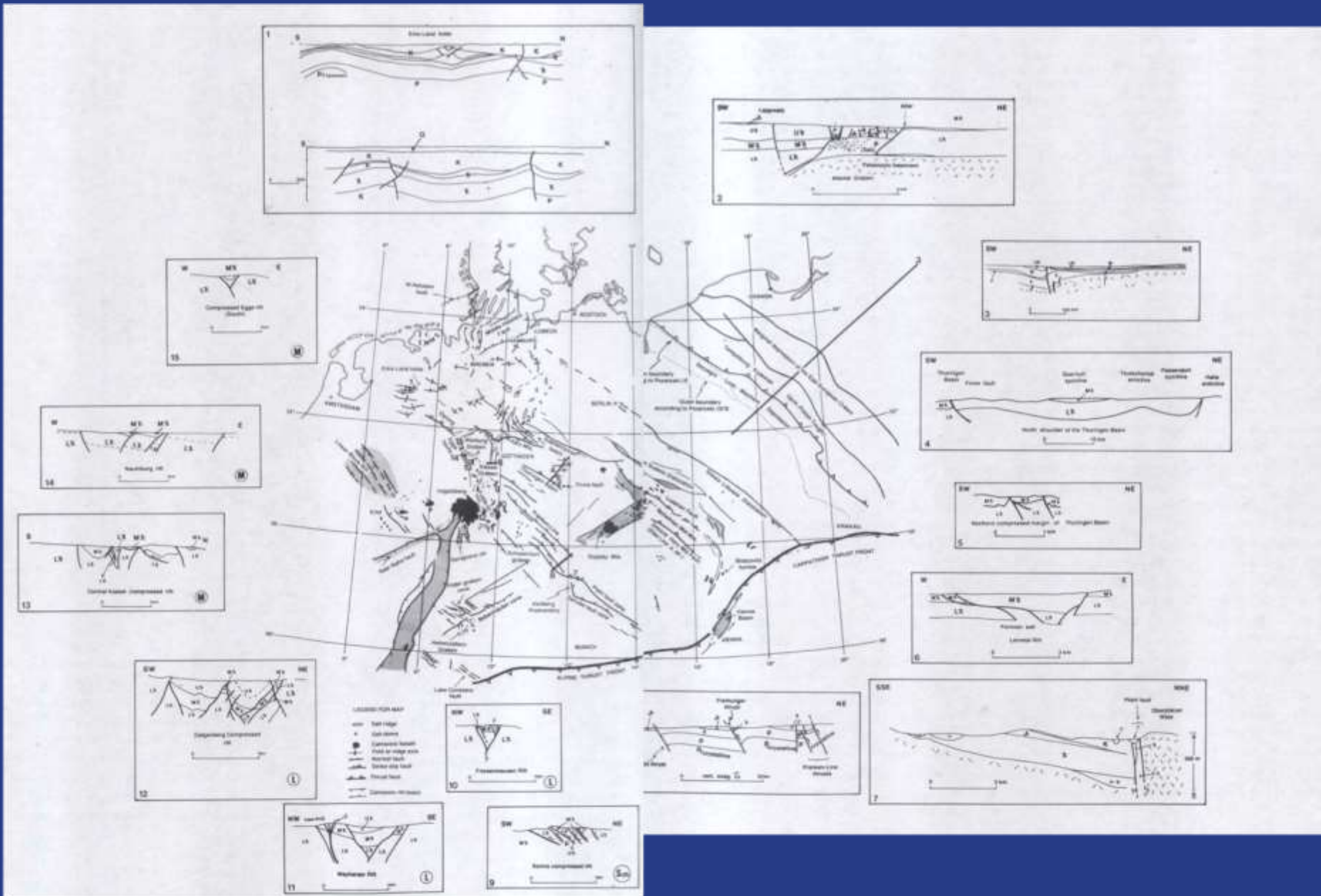


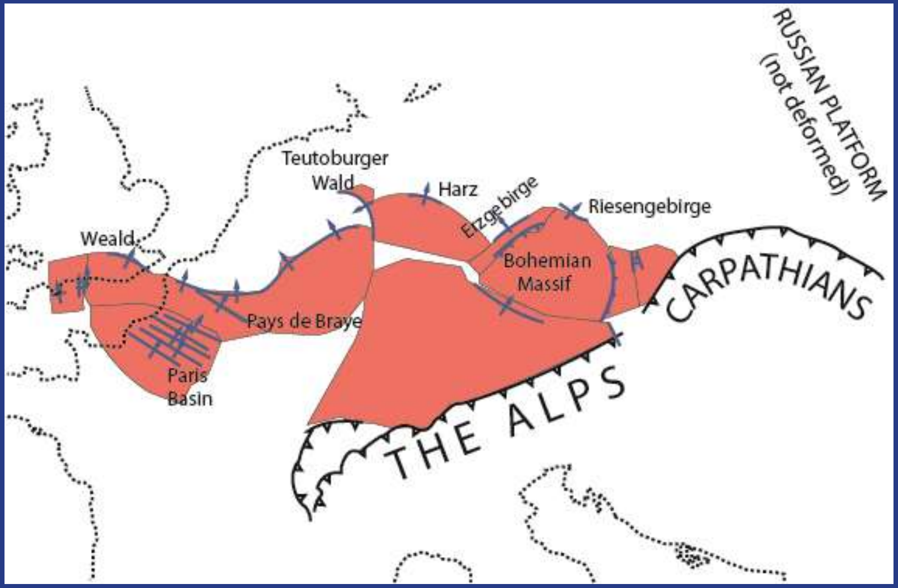
F

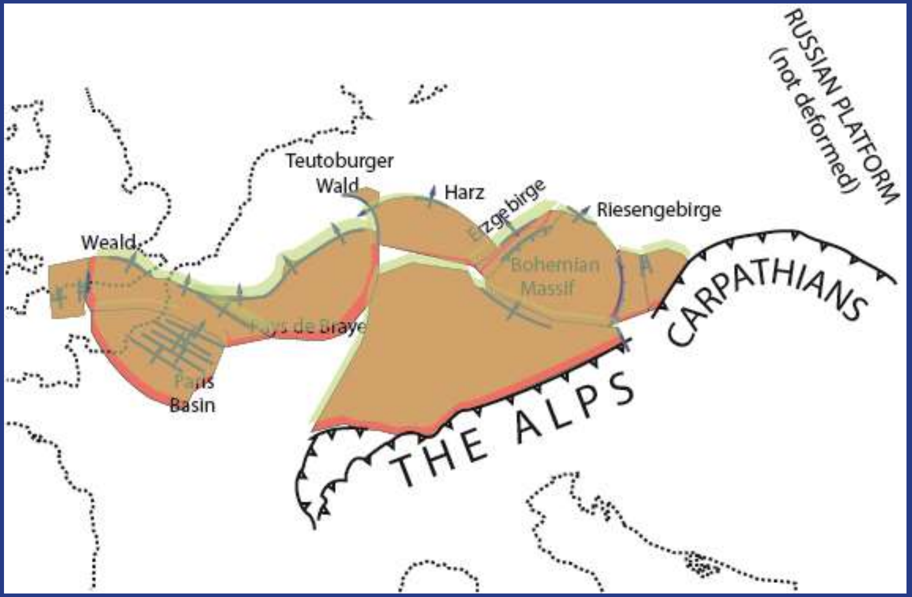


Lotze, F., 1937, Zur Methodik der Forschungen über saxonische Tektonik: *Geotektonische Forschungen*, v. 1, pp. 6-27.

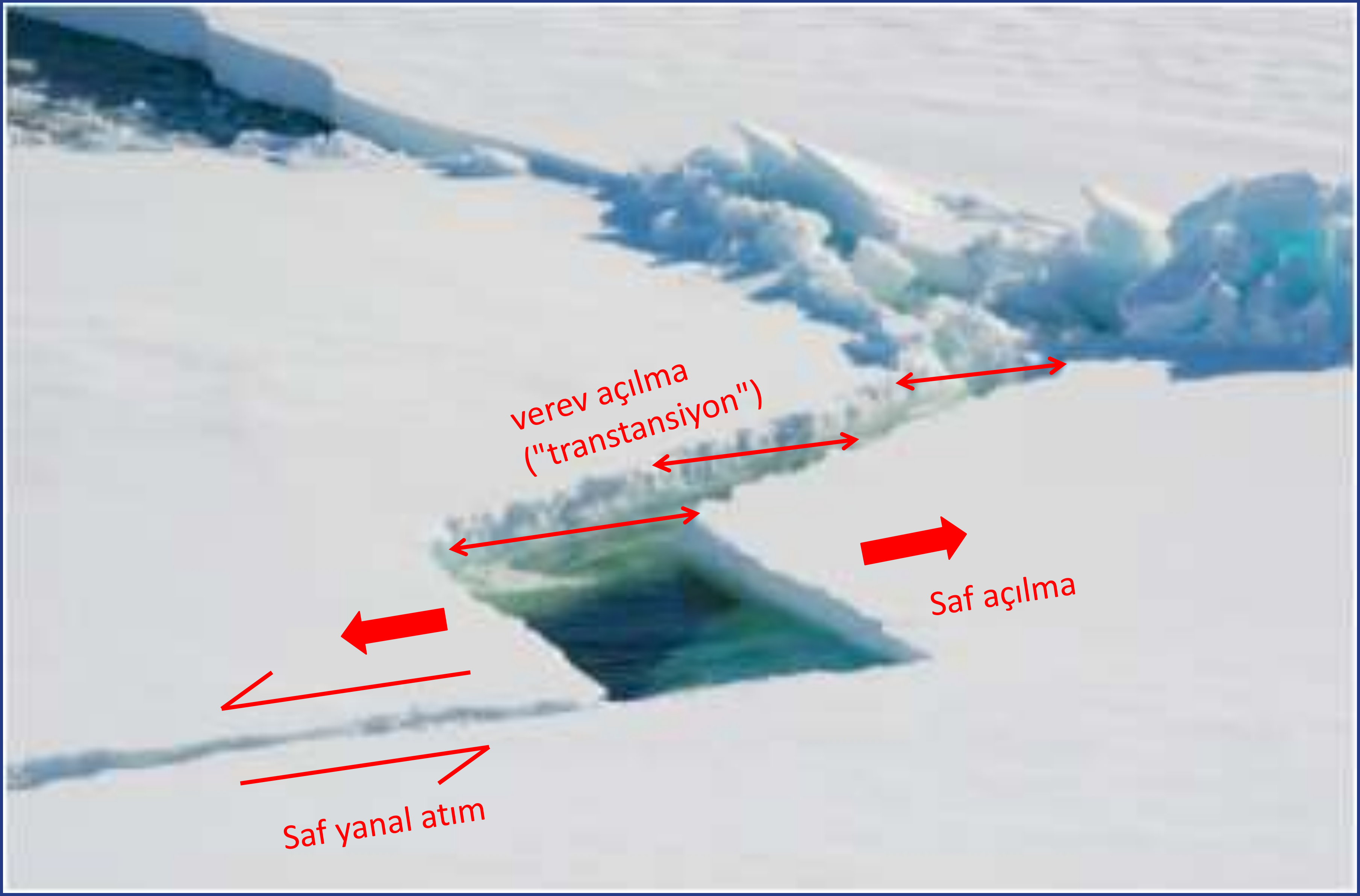
Wilson, 1965







Suess, E., 1875, *Die Entstehung der Alpen*, Braumüller,
Wien, 168 ss.


verev açılma
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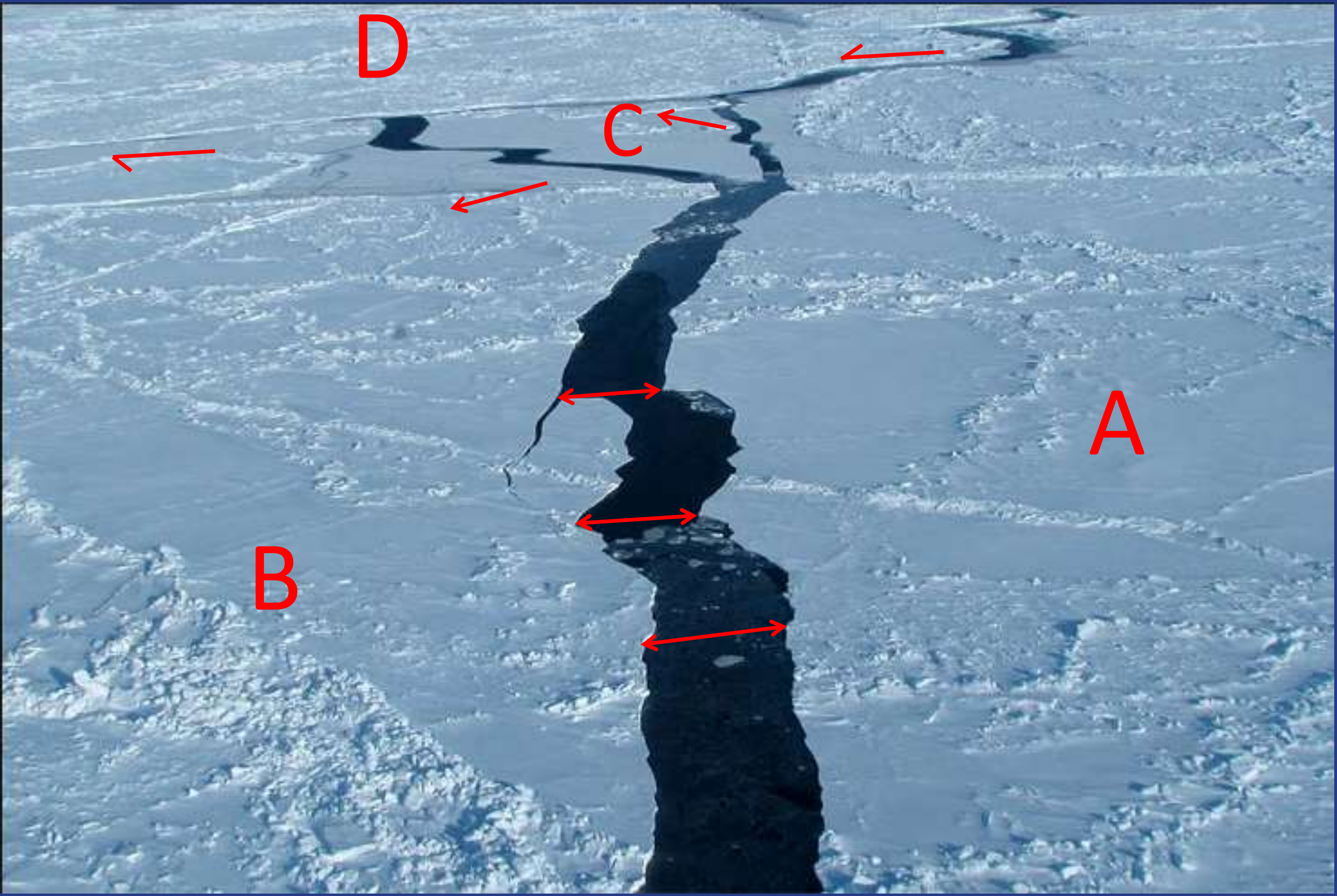
D
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B

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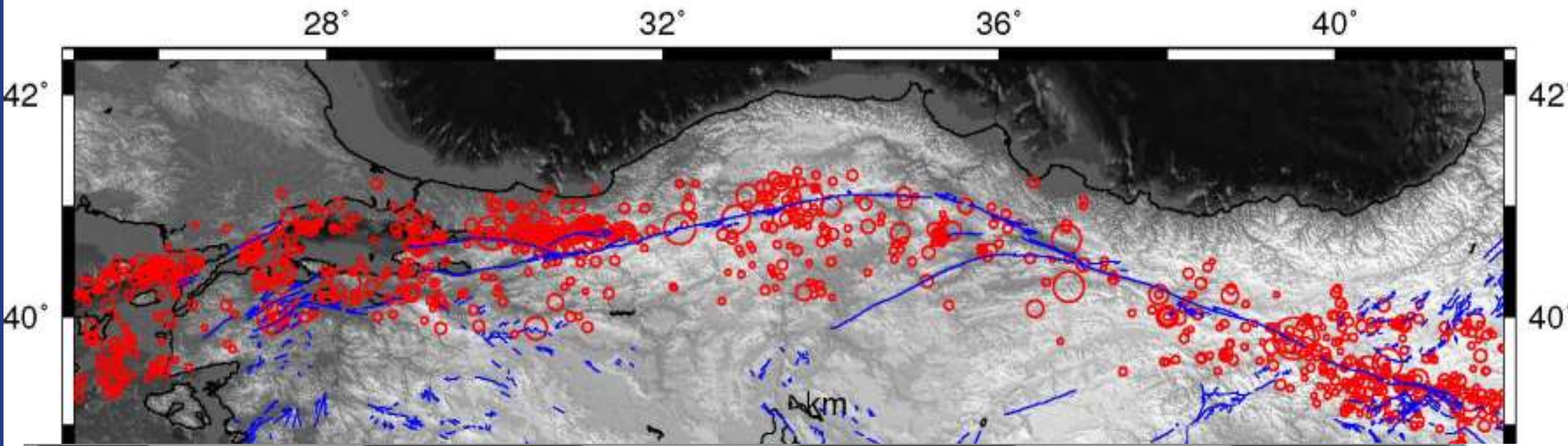

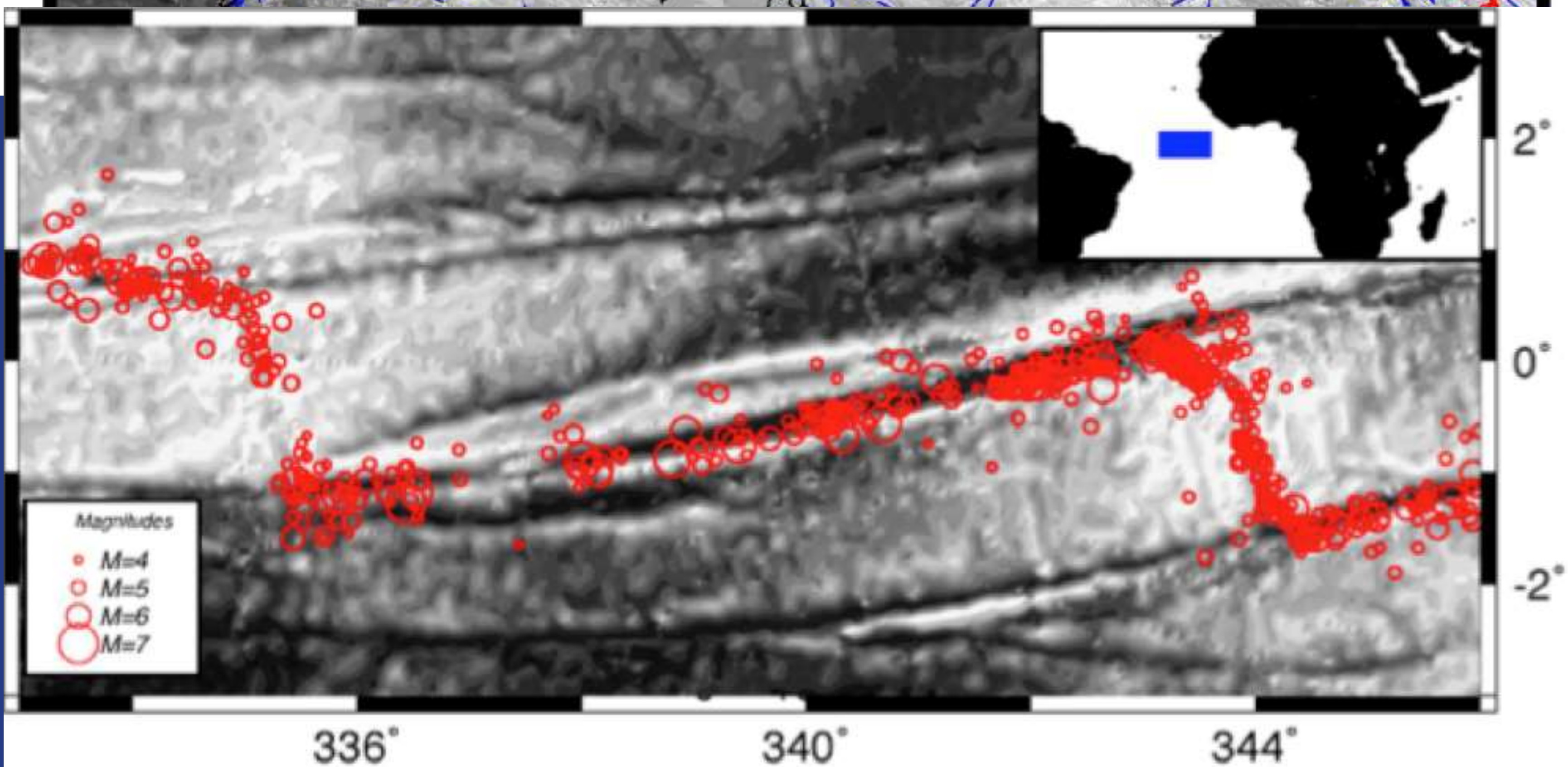

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