FAYLAR

TÜRKİYE'DEKİ FAY SİSTEMLERİ

TÜRKİYE'NİN DEPRESELLİĞİ

Prof.Dr. Sabah YILMAZ ŞAHİN

Mayıs-2011

Fay nedir?

Yerkabuğundaki deformasyon enerjisinin artması sonucunda, kayaç kütlelerinin bir kırılma düzlemi boyunca yerlerinden kayması ile ortaya çıkan kırıktır.

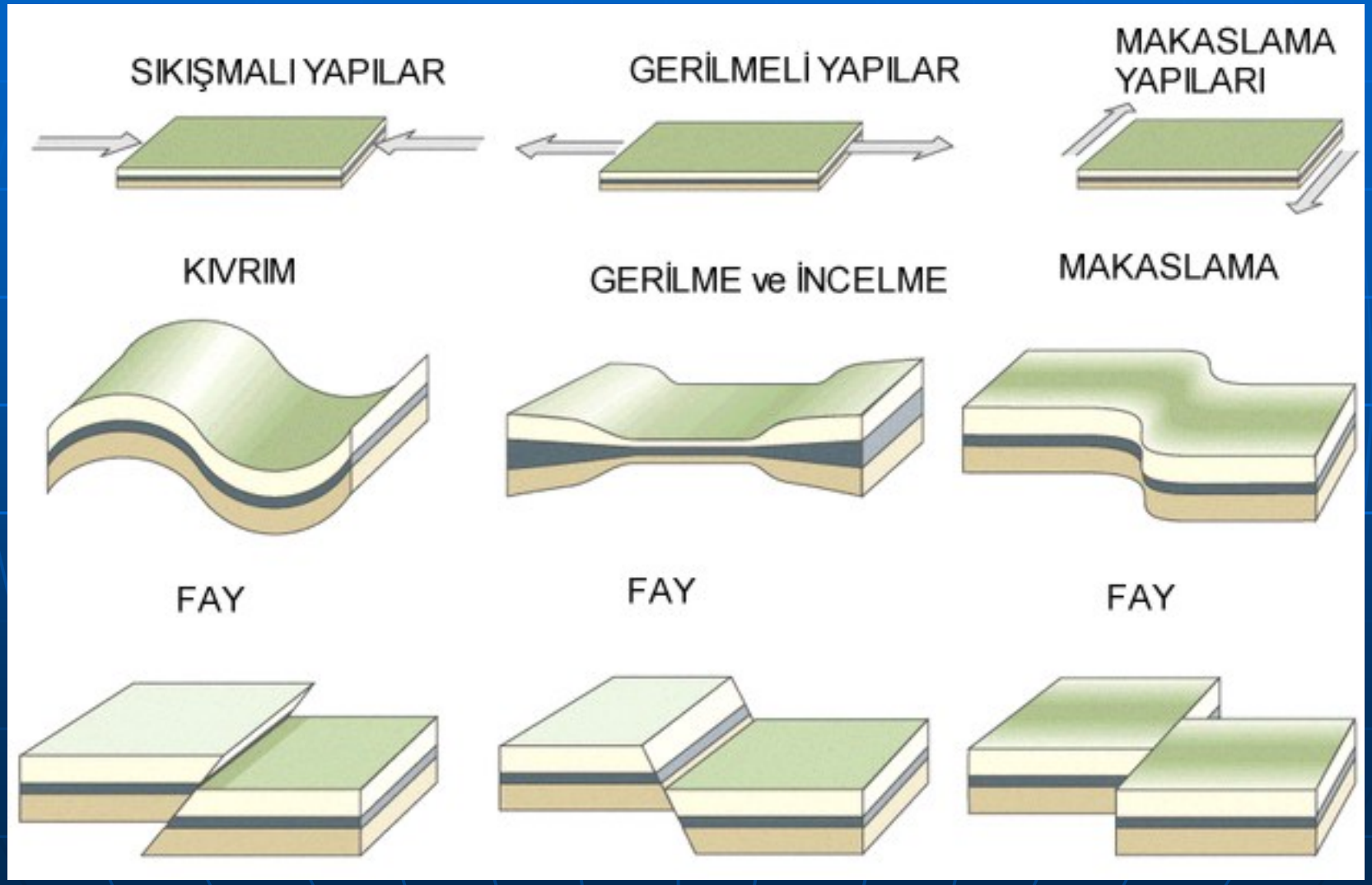
Veya,

Yerkabuğunu oluşturan kayaçların bir yüzey boyunca kırılması ve oluşan iki parçanın birbirine göre göreceli olarak yer değiştirmesidir.

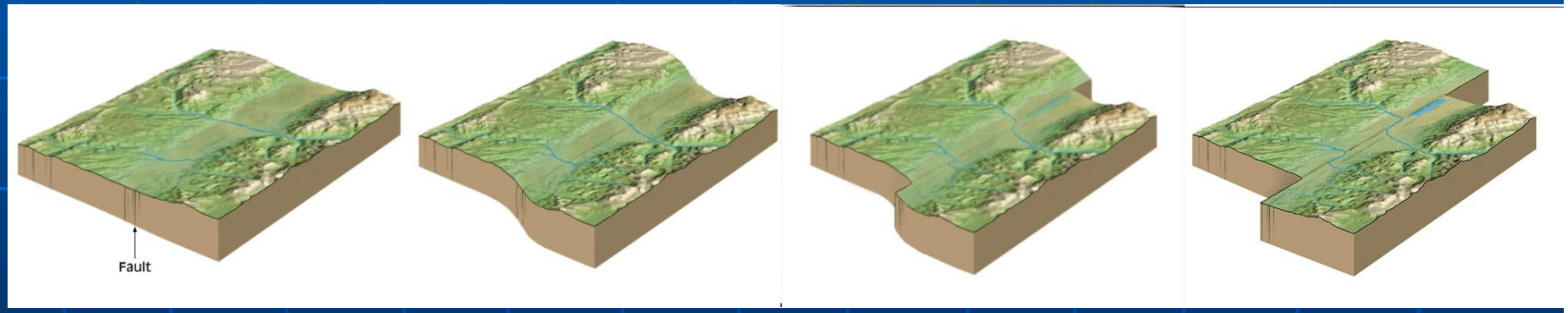
•Eğer bir kırığın iki tarafındaki kayalar birbirlerine göre gözle görülür miktarda hareket etmişlerse (atım gelişmiş ise) bu kırığa ***fay*** adı verilir.

• **Fayların boyutları** birkaç cm'den birkaçyüz hatta bin km'ye, atım miktarları ise birkaç cm'den onlarca hatta bazen yüzlerce km 'ye kadar değişmektedir.
• Fayların boyu depremin büyüklüğü ile logaritmik olarak oranlıdır.
• Büyük ve sığ depremlerde yeryüzünde gözlenen fayın boyu yüzlerce km'ye erişebilmektedir. Örneğin 1939 Erzincan depreminde oluşan fayın boyu 360 km olup üzerindeki en büyük yer değiştirme (atım) ise 750 cm'dir.
• Faylar **segmentler** (birbirinin devamı şeklindeki fay parçaları) şeklinde olabilirler.

Faylanmaya neden olan hareketler



•Bir fayın oluşumundan önce bölgede bir gerilme gelişir, bölge deforme olur. Gerilme kayaların kaldıramayacağı seviyeye gelince kayalar kırılır.



FAYLAR

Atım Yönlerine Göre:

- Eğim atımlı fay (normal ve ters)
- Doğrultu atımlı fay (sağ ve sol yönlü)
- Yan atımlı fay (normal ve ters)

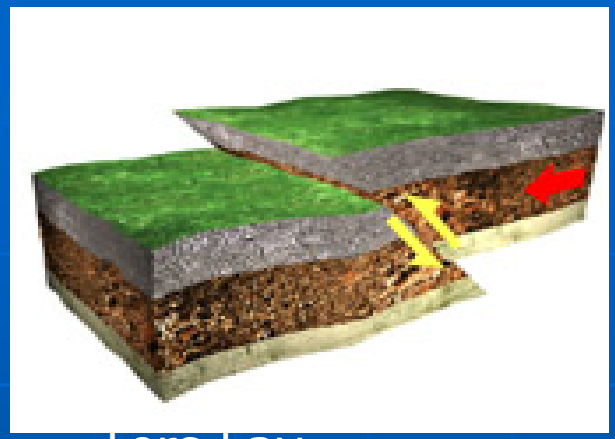
Jeolojik Yapılar ile İlişkilerine Göre:

- Enine fay
- Boyuna fay
- Diyagonal fay
- Doğrultu fayı
- Eğim fayı

Mekanik Özelliklerine Göre:

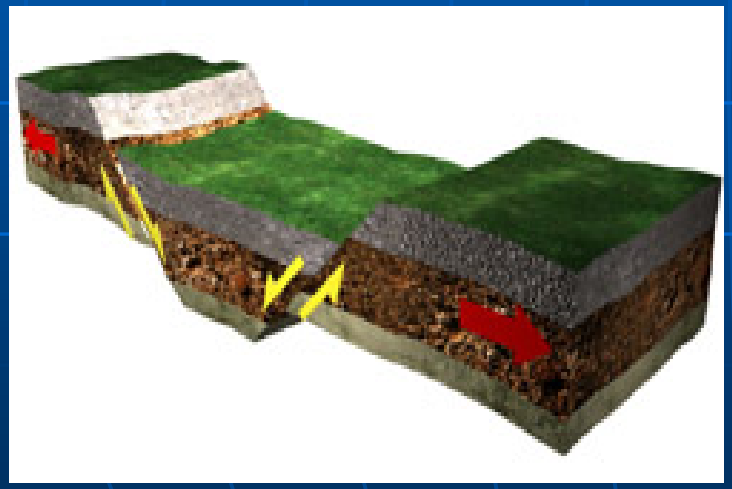
- Gravite fayı (= normal fay)
- Bindirme fayı (= ters fay)
- Yırtılma fayı (= doğrultu atımlı fay)

Normal Fay

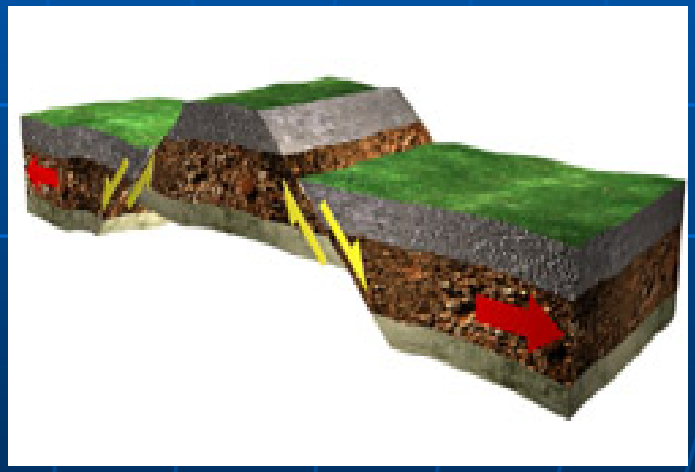


Ters Fay

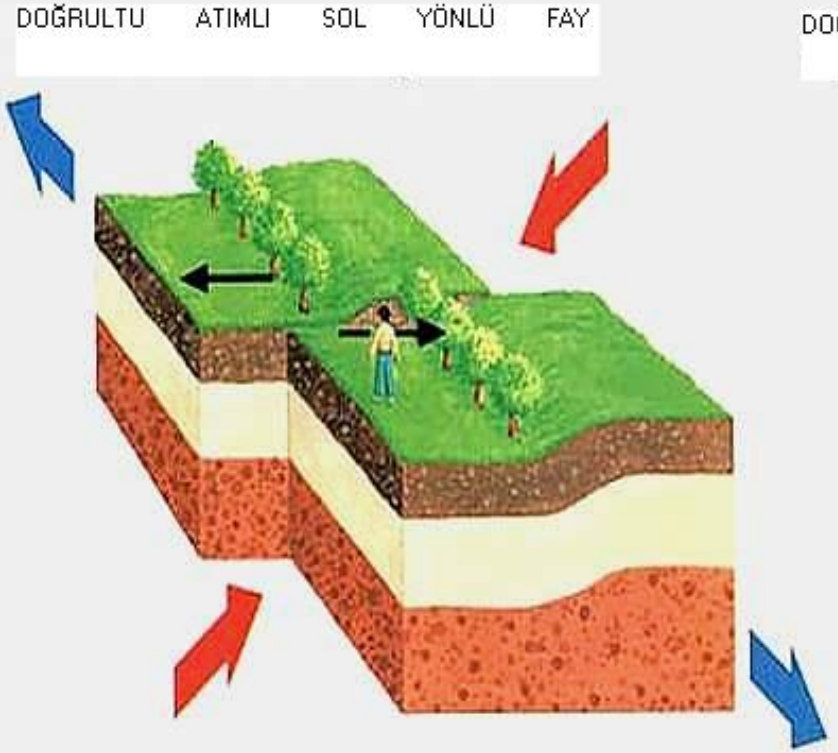
Doğrultu Atımlı Faylar

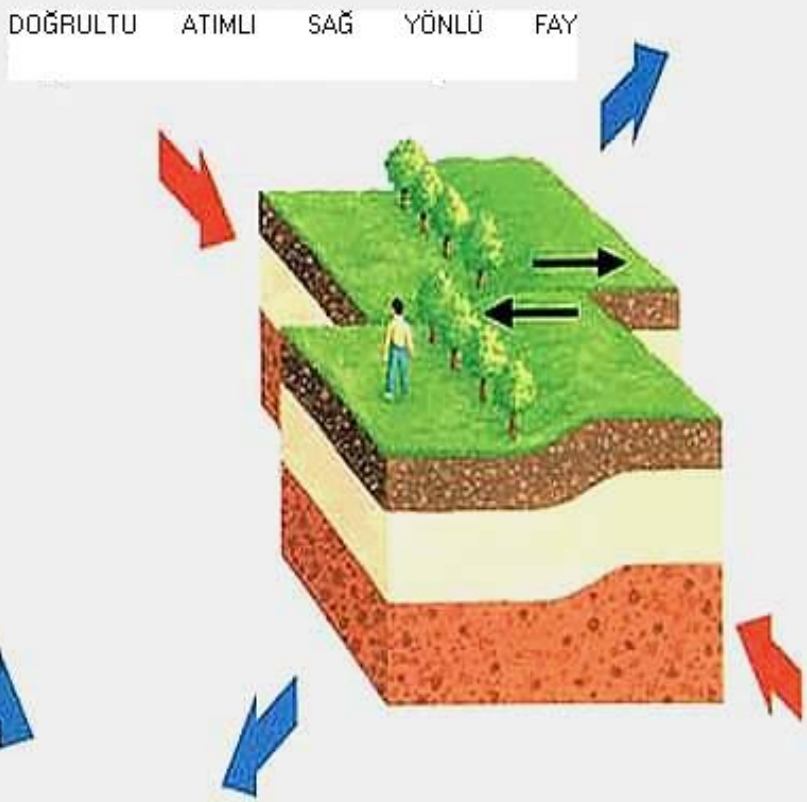


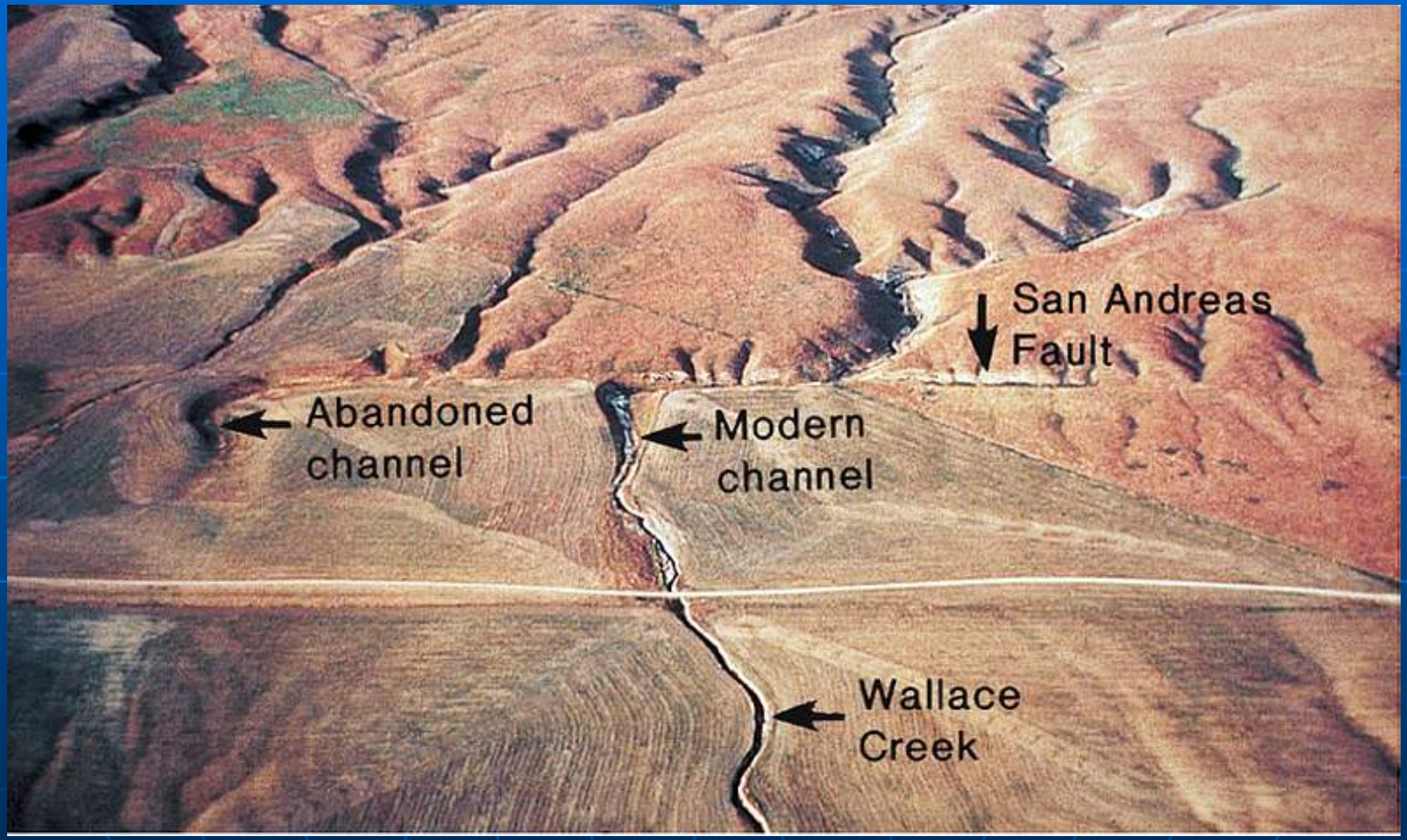
Çöküntü (Graben)

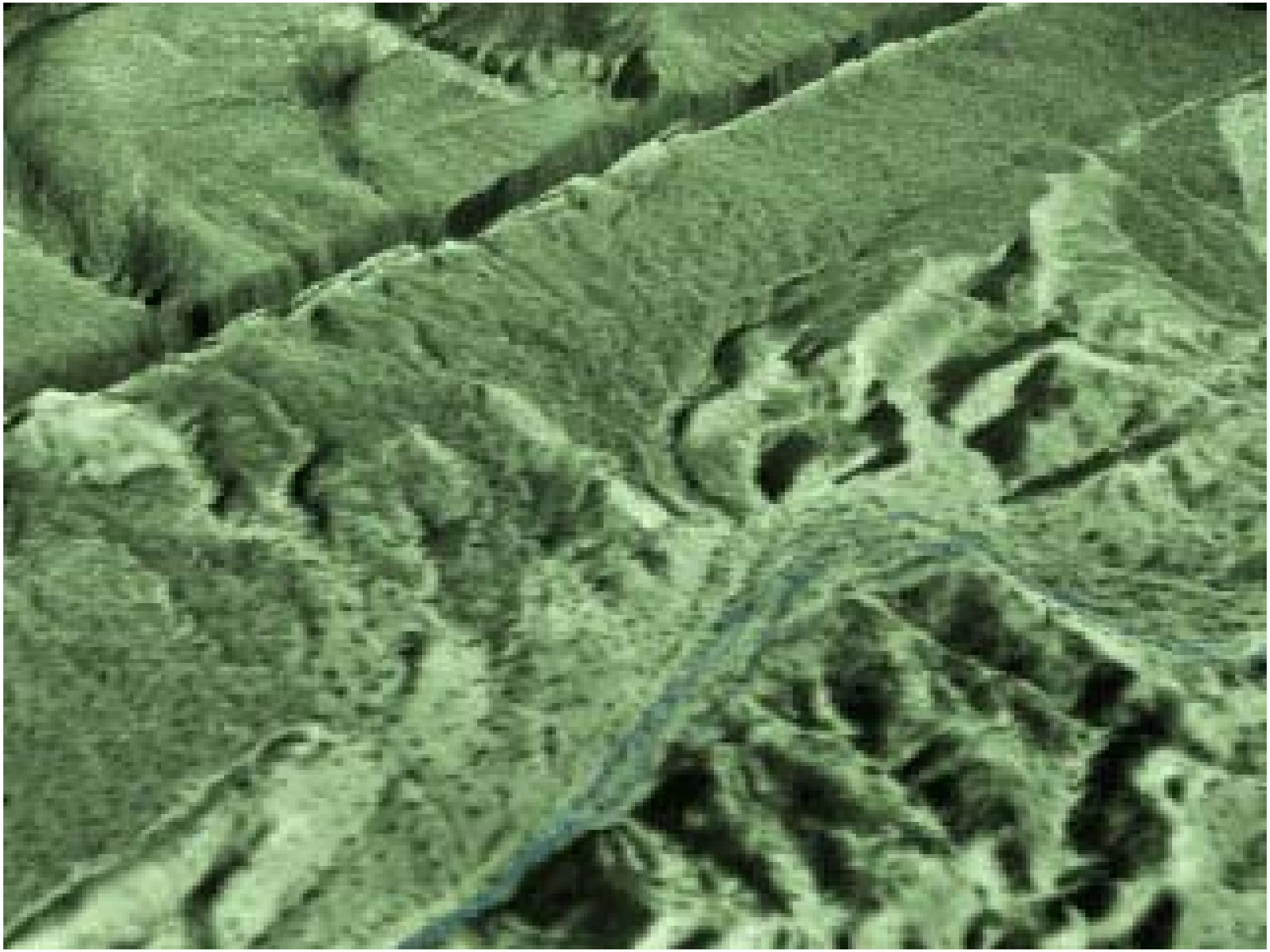


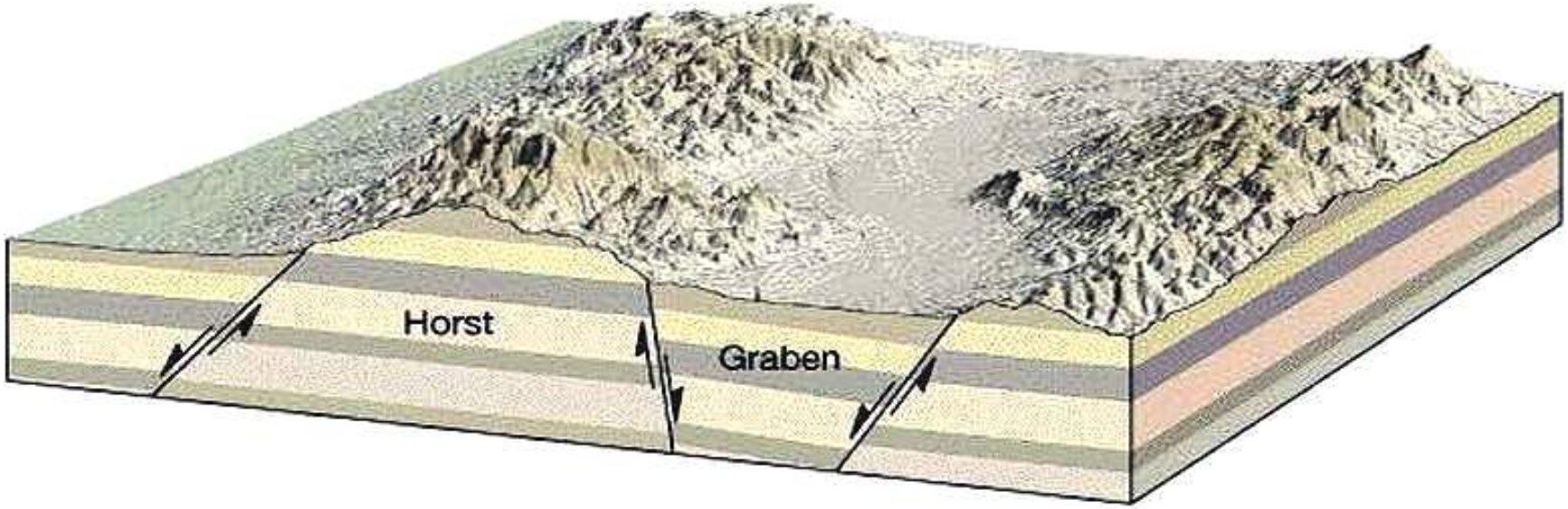
Yükselti (Horst)

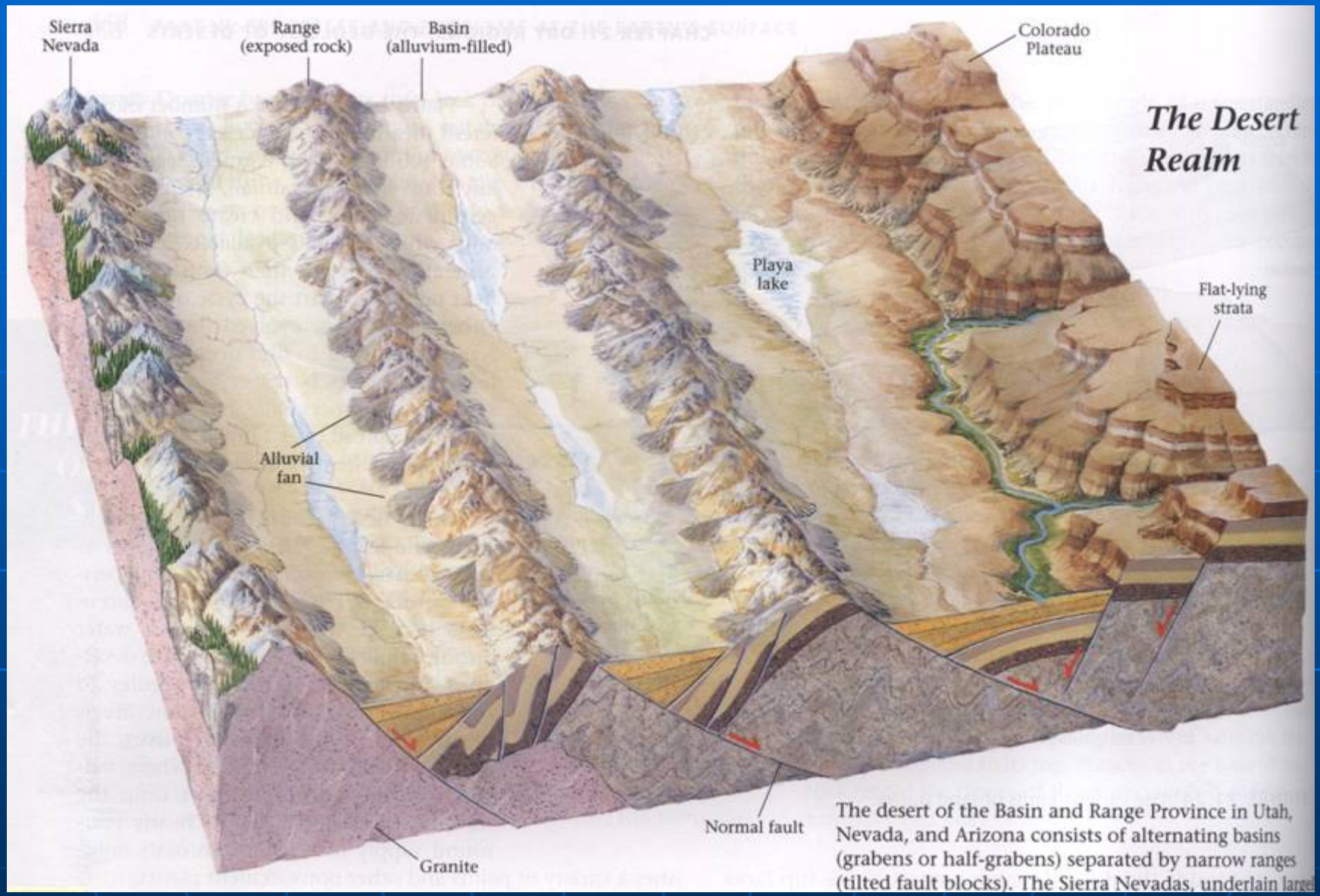

DOĞRULTU ATIMLI SOL YÖNLÜ FAY


DOĞRULTU ATIMLI SAĞ YÖNLÜ FAY


San Andreas
Fault
Abandoned
channel
Modern
channel
Wallace
Creek



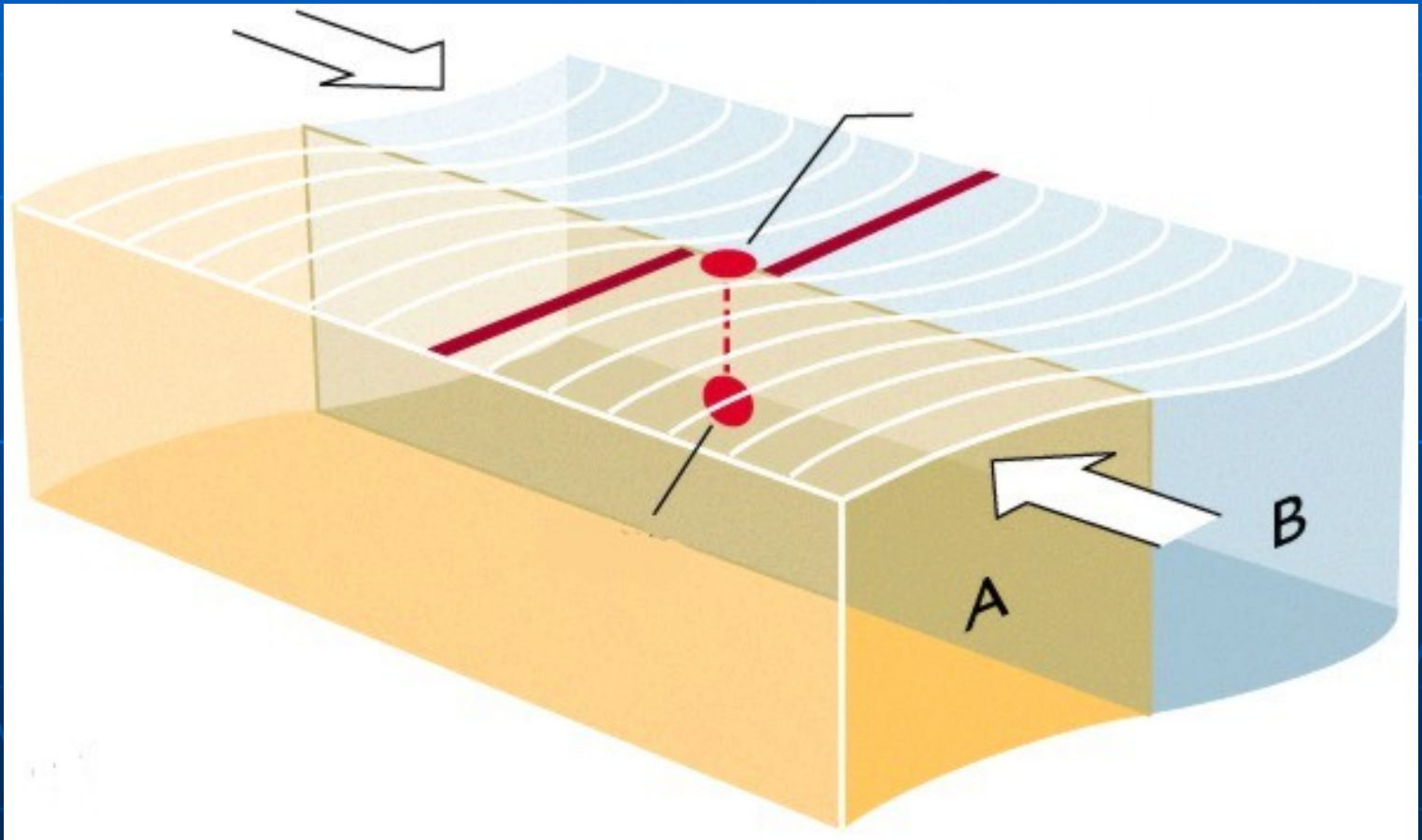

Horst
Graben



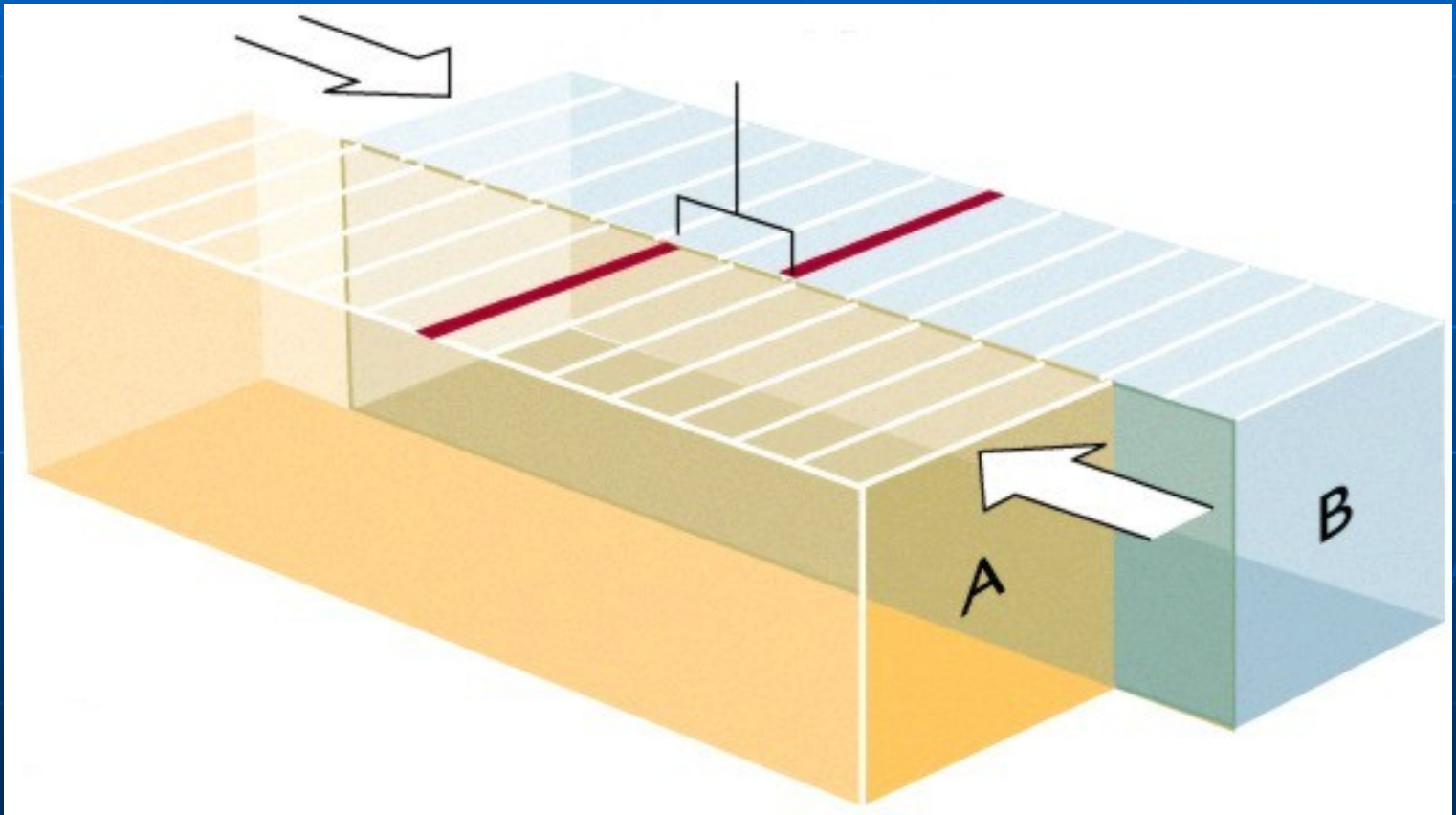
The desert of the Basin and Range Province in Utah, Nevada, and Arizona consists of alternating basins (grabens or half-grabens) separated by narrow ranges (tilted fault blocks). The Sierra Nevadas, underlain large

Tipik 'Basin and Range' topoğrafyası

Kırılan fay üzerinde o zamana kadar biriken enerji boşalır. Deprem gerçekleşir. Bloklar duruluncaya kadar artçı depremler oluşur. Bunlar daima ana şoktan küçüktür.



Bölgenin kırılması ile ve fayın iki tarafı birbirine göre belli bir miktar atılır. 17 Ağustos depreminde bu atım 5 metreye yakındır.



TÜRKİYE'DEKİ FAY SİSTEMLERİ

- Doğrultu Atımlı Faylar
- Eğim Atımlı Faylar
- Bindirmeler
- Grabenler
- Diri Faylar ve bunlara bağlı Depremsellik

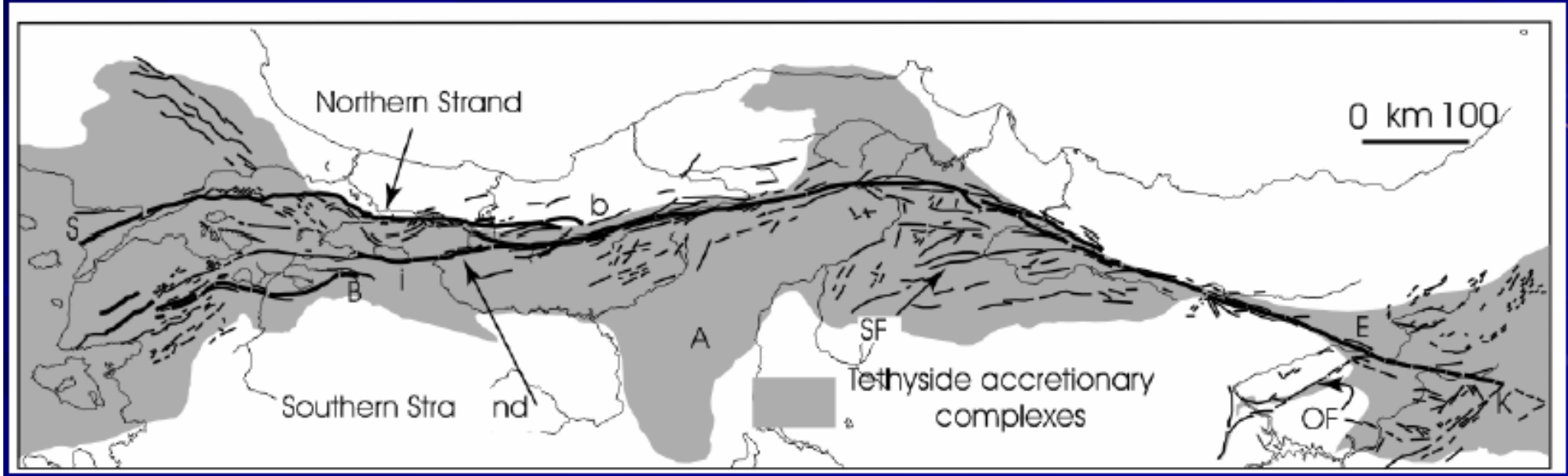
TÜRKİYE'DEKİ FAY SİSTEMLERİ

- Kuzey Anadolu Fayı
- Kuzey Doğu Anadolu Fay Zonu
- Doğu Anadolu Fayı
- Ecemiş Fayı
- Ege Graben sistemi
- Doğu Anadolu sıkışma bölgesi
- Ölü Deniz Fayı

TÜRKİYE DİRİ FAY HARİTASI/ACTIVE FAULT MAP OF TURKEY

North Anatolian Fault Zone

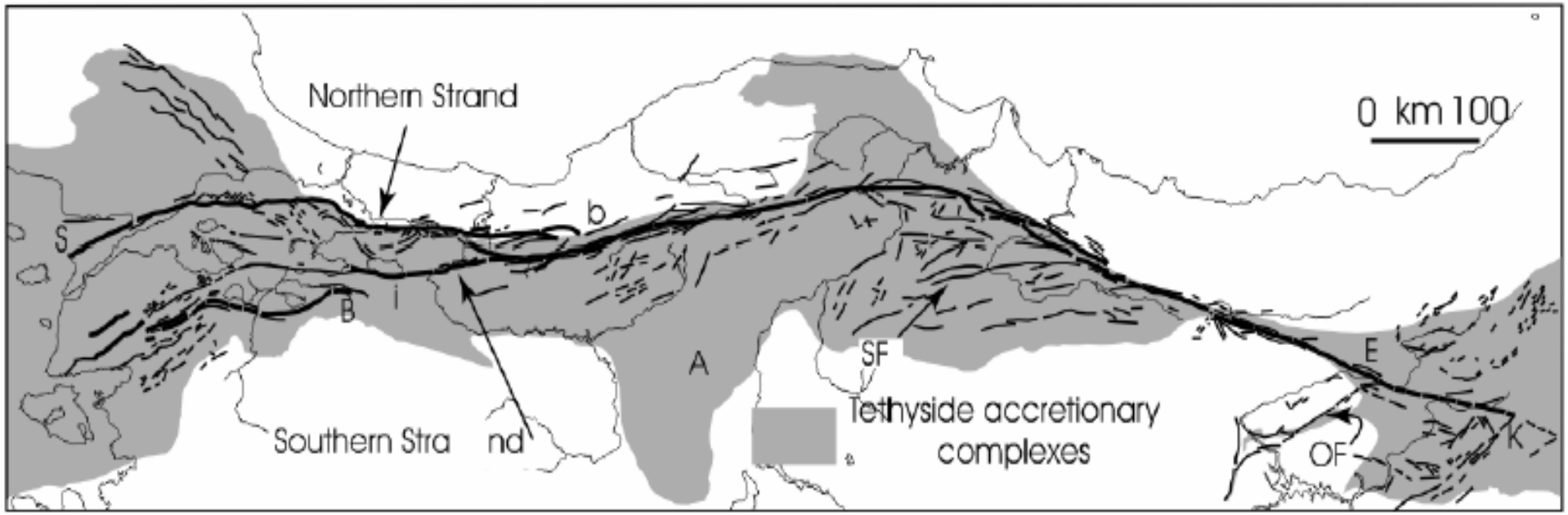
- 1200 km-long, broad arc-shaped, dextral strike-slip fault system
- Extends from Karlıova in the east to Greece in the west.
- Forms the boundary between the Eurasian and Anatolian Plates
- The North Anatolian Fault is only a member of a much larger right-lateral shear zone consisting of a large number of dextral shear-related structures.
- This shear zone extends along mostly a bimaterial interface juxtaposing subduction-accretion material of the Tethysides and older and stiffer continental basements to its north



Şengör et al, 2005

The NAF splays into two major strands in the east of the Sea of Marmara around Dokurcun,

- The northern strand is more active
- The southern strand bounds the southern margin of Sea of Marmara, then bends southward and runs into the Aegean Sea



Şengör et al, 2005

- Kuzey Anadolu Fay'ının Yaşı Orta-Üst Miyosen (11 MY) olup, en genç hareketi Pleistosen'den (1.6 MY) daha gençtir.

- KAF batıya doğru gençleşmekte ve bu bölgede oluşan basenlerle birlik oluşturmaktadır.

- KAF 11 MY önce doğuda Erzincan civarında oluşmaya başlamış ve batıya doğru hareketi 11 cm/yıl olup, batıya doğru daha da artarak devam etmiştir.

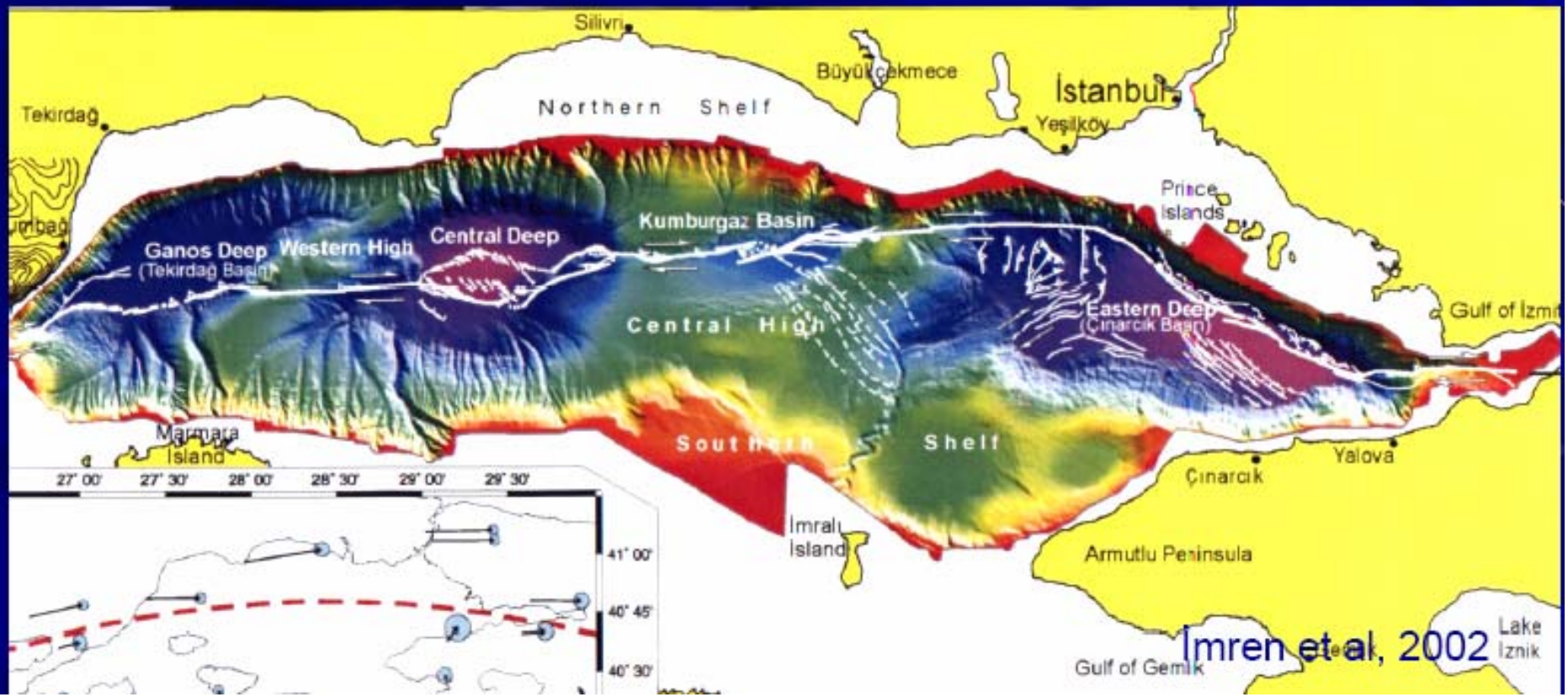
- KAF batıda Marmara denizi içine doğru ulaşabilmektedir.

- Jeolojik veriler, KAF'daki toplam atımın 20-25 km den 85 km'ye kadar değiştiğini ileri sürmerktedirler.

KAF-Köprübaşı
Image © 2006 TerraMetrics
© 2006 Europa Technologies

Sea of Marmara

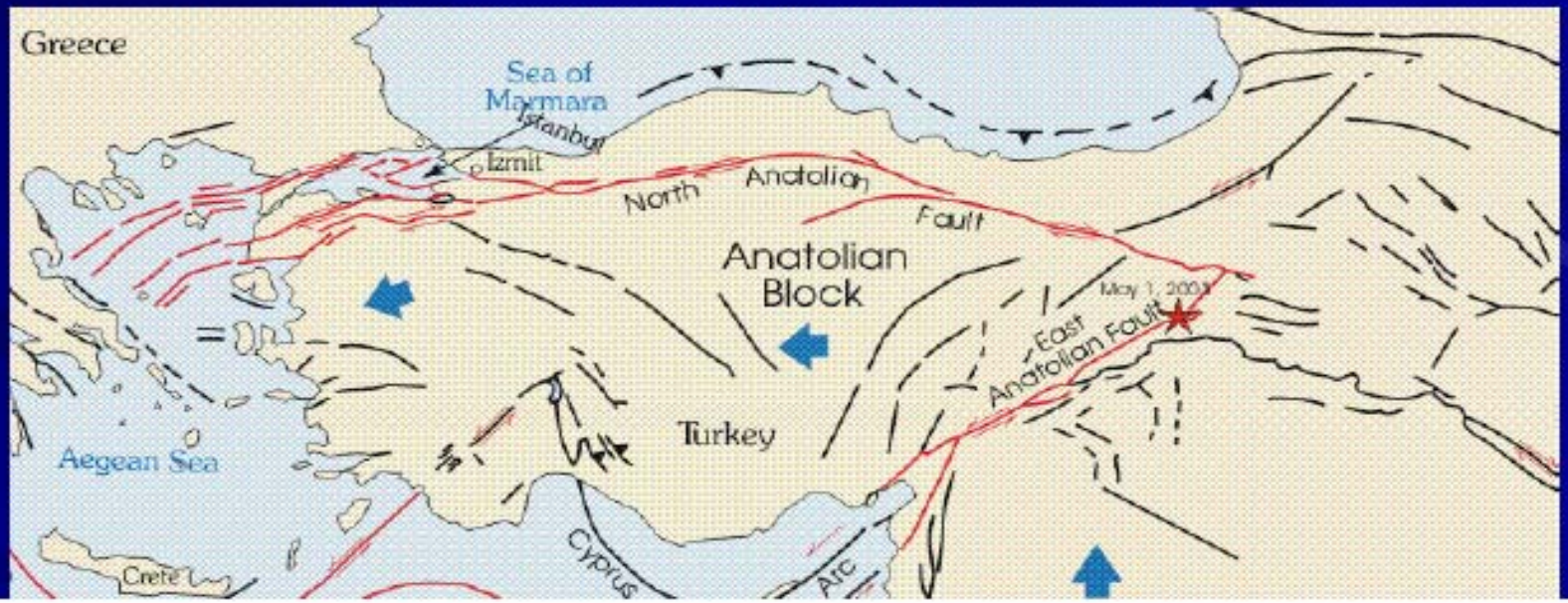
- The Marmara region forms a transition zone between the area of pure strike-slip deformation and Aegean Extensional region
- Deep marine asymmetric strike-slip basins (Çınarcık, Central Marmara, Tekirdağ)
- The basins consist of Plio-Quaternary sediments reaching over 3 km.



İmren et al, 2002

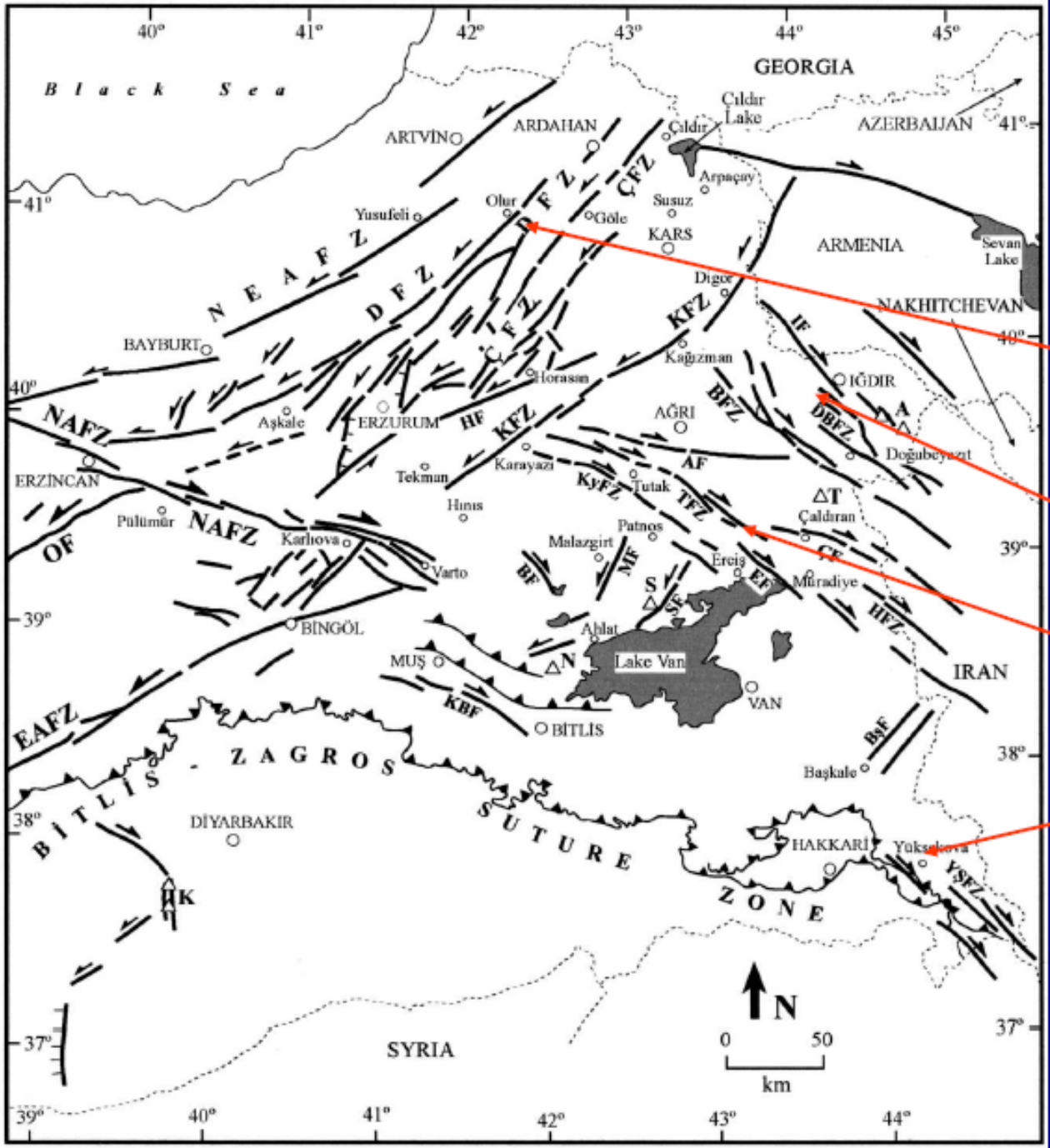
East Anatolian Fault Zone

- 600 km-long,
- Sinistral
- Accomodates to the westward extrusion of Anatolia.
- Forms the boundary between the Anatolian Arabian plates.



Doğu Anadolu Fayının Yaşı, Atım Miktarı (Okay and Tüysüz, 2005)

- Jeolojik veriler kullanılarak, DAFZ'da sol yanal yer değiştirmenin 3.5-15 km ile 15-27 km olduğu,
- GPS verilerine göre atımın 11±2 mm/yıl olduğu ileri sürülmektedir.
- DAF için farklı yaşların önerildiği;
- Üst Pliyosen (yaklaşık 3 MY)
- Üst Pliyosen (yaklaşık 1.8 MY)

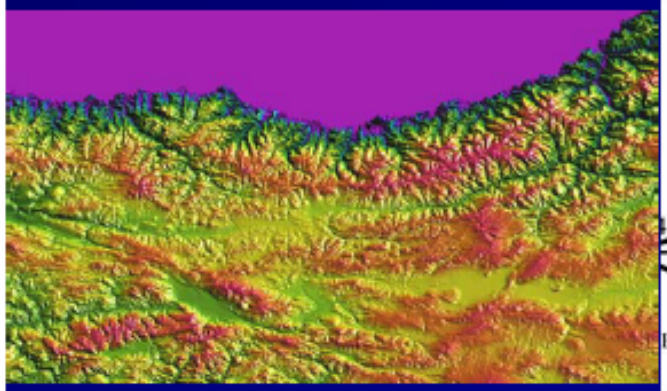


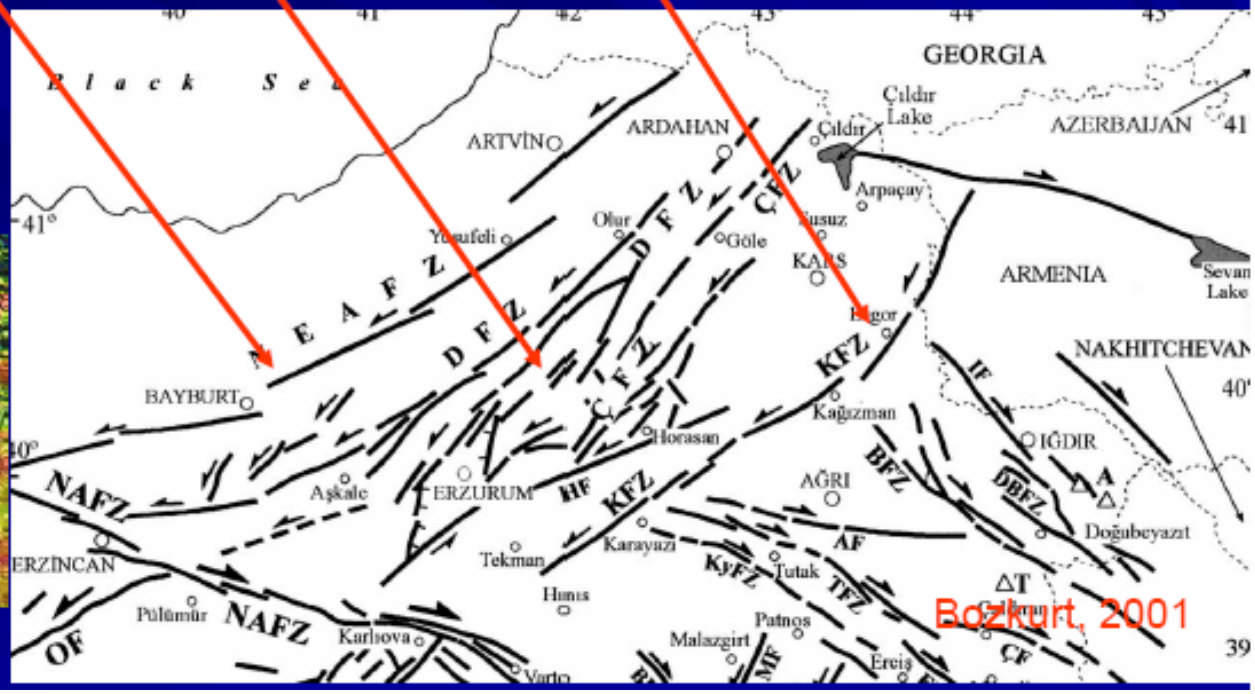
IMPORTANT ACTIVE FAULTS

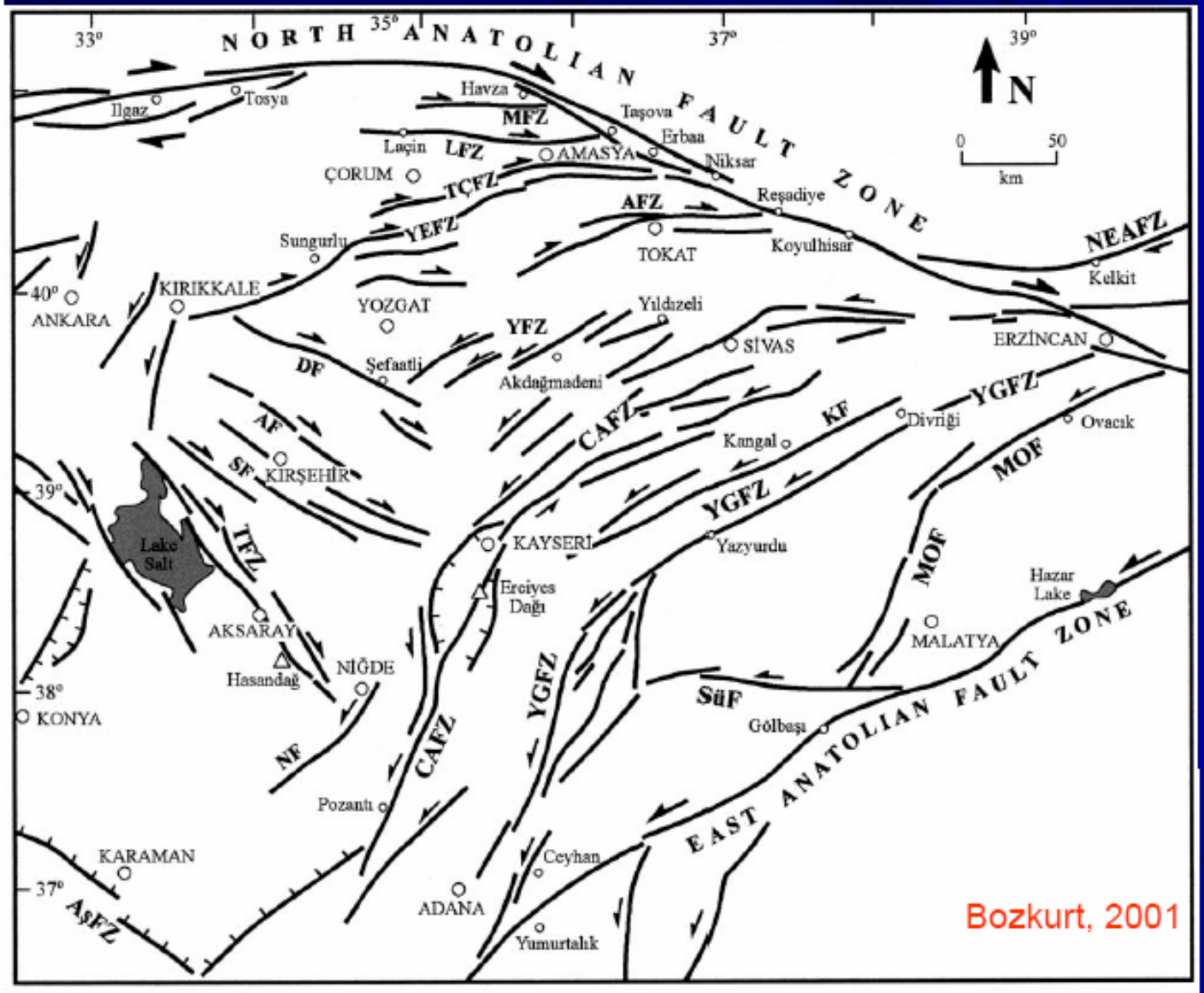
- Northeastern Anatolian Fault
- Iğdır, Balıkgölü and Doğubayazıt
- Ağrı,Karayazı, Çaldıran, Horasan and Erciş
- Yüksekova–Şemdinli

Northeastern Anatolian Fault Zone

- Left-lateral
- 350 km-long
- Slip rates of 8 ±5 mm/y according to GPS measurements
- Average 18–25 mm/y according to geological data
- Consists of Kelkit, Dumlu-Çobandede and Kağızman Fault Zones







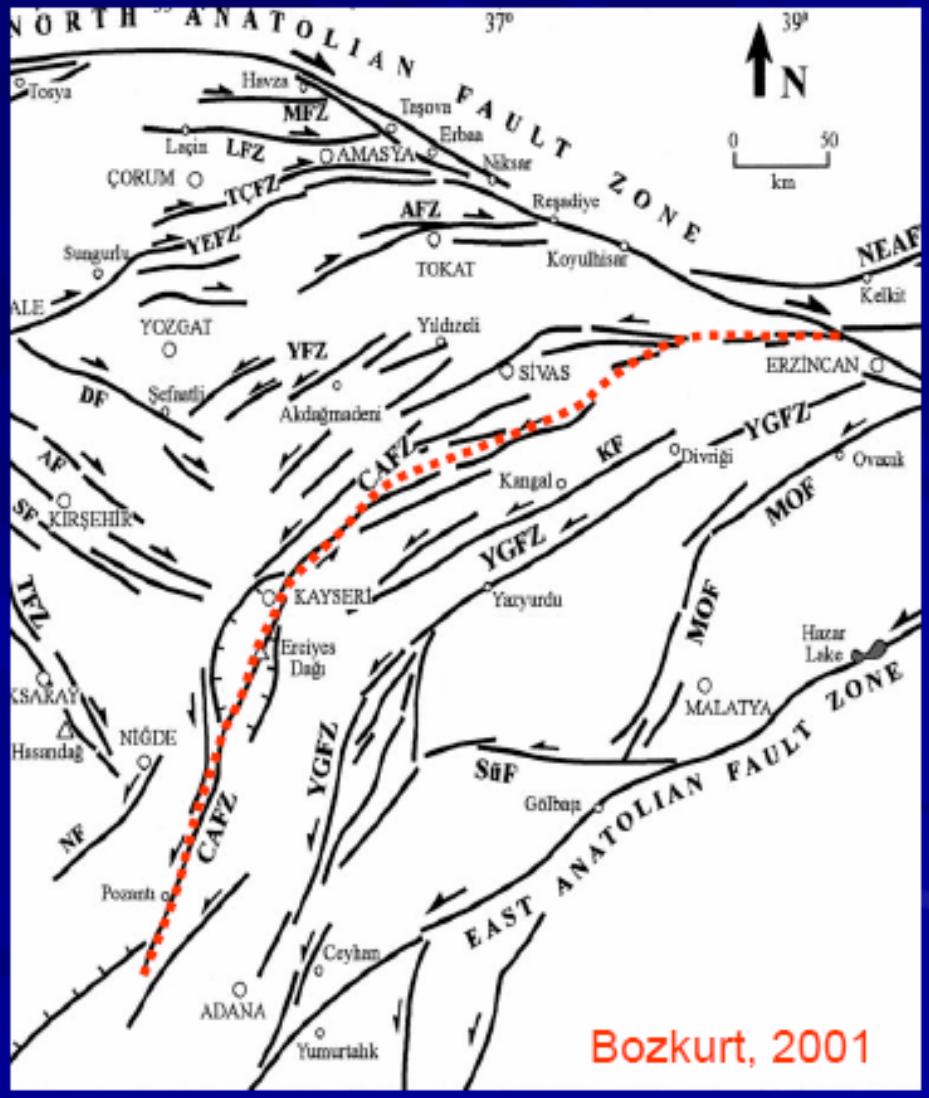
Bozkurt, 2001

IMPORTANT ACTIVE FAULTS

- Ecemiş
- Ovacık-Malatya
- Yakapınar-Göksun and Kangal
- Ezinepazar-Sungurlu
- Laçin-Merzifon
- Kırşehir
- Almus
- Tuzgölü

The Ecemiş Fault Zone

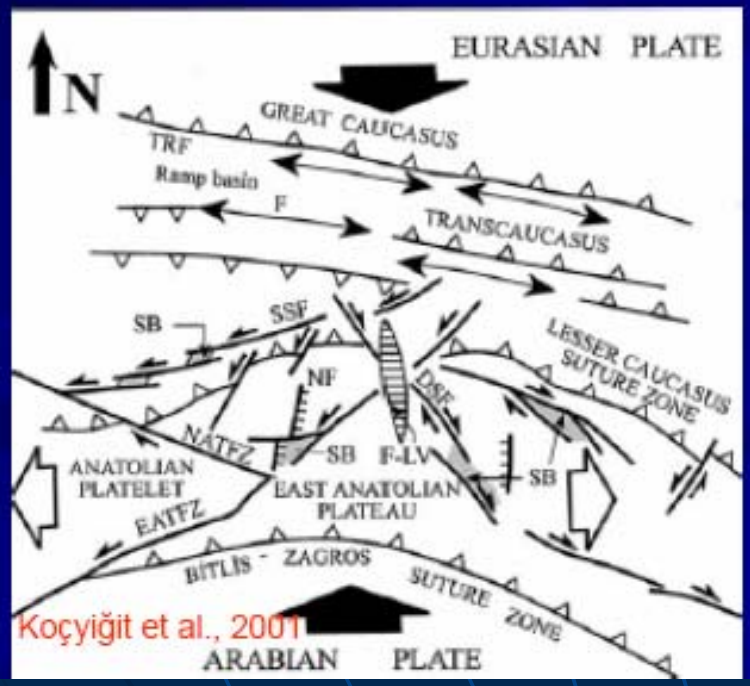
- Sinistral
- 700 km long
- Formed by the reactivation of a palaeotectonic structure in the Plio-Quaternary.
- Seismically less active
- Total displacements during the palaeotectonic and neotectonic periods are 70 km and 24 km, respectively.
- Some pull-apart basins (Erciyes, Tuzla, Sultansazlığı)



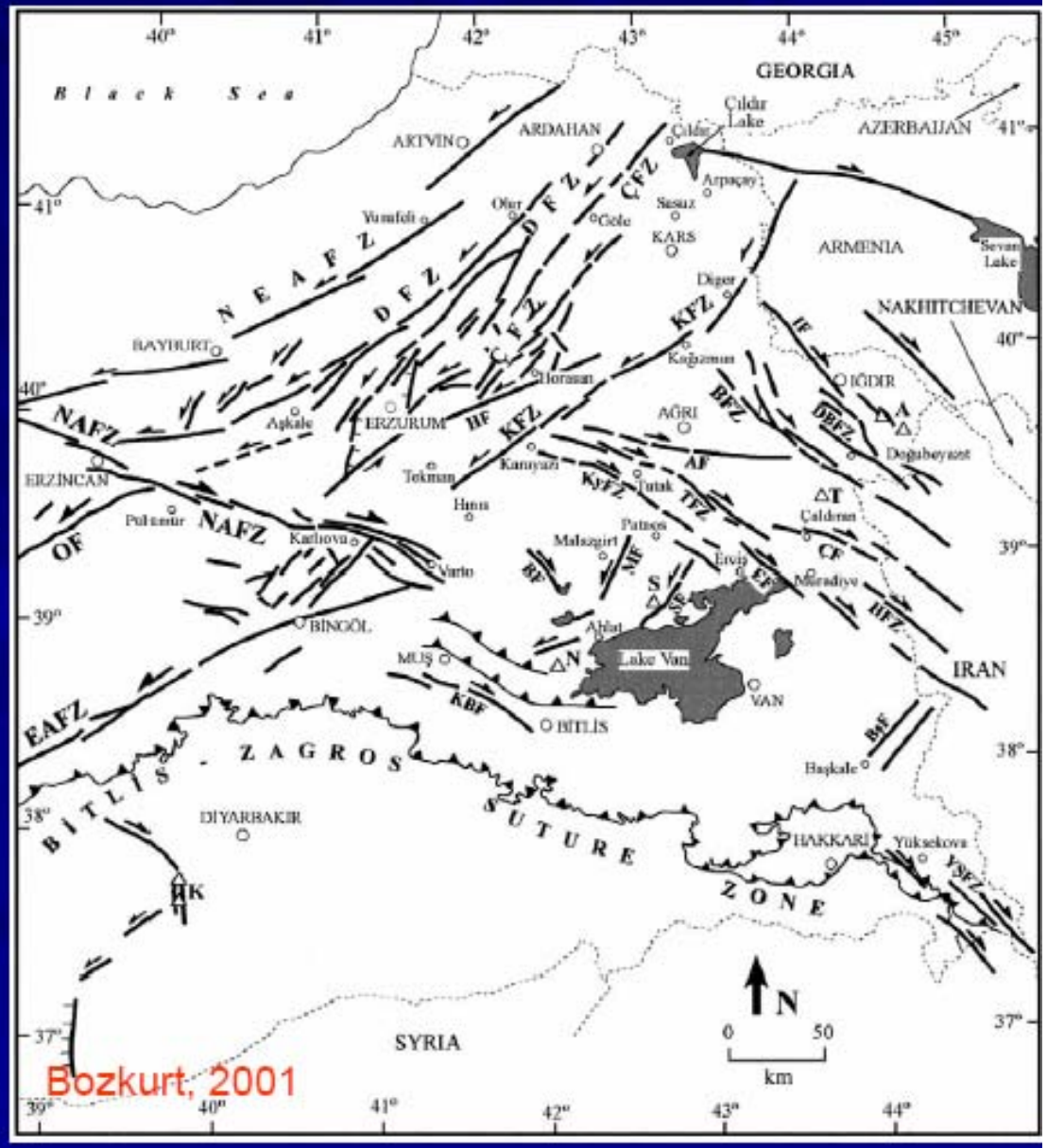
Bozkurt, 2001

East Anatolian Contractional Province

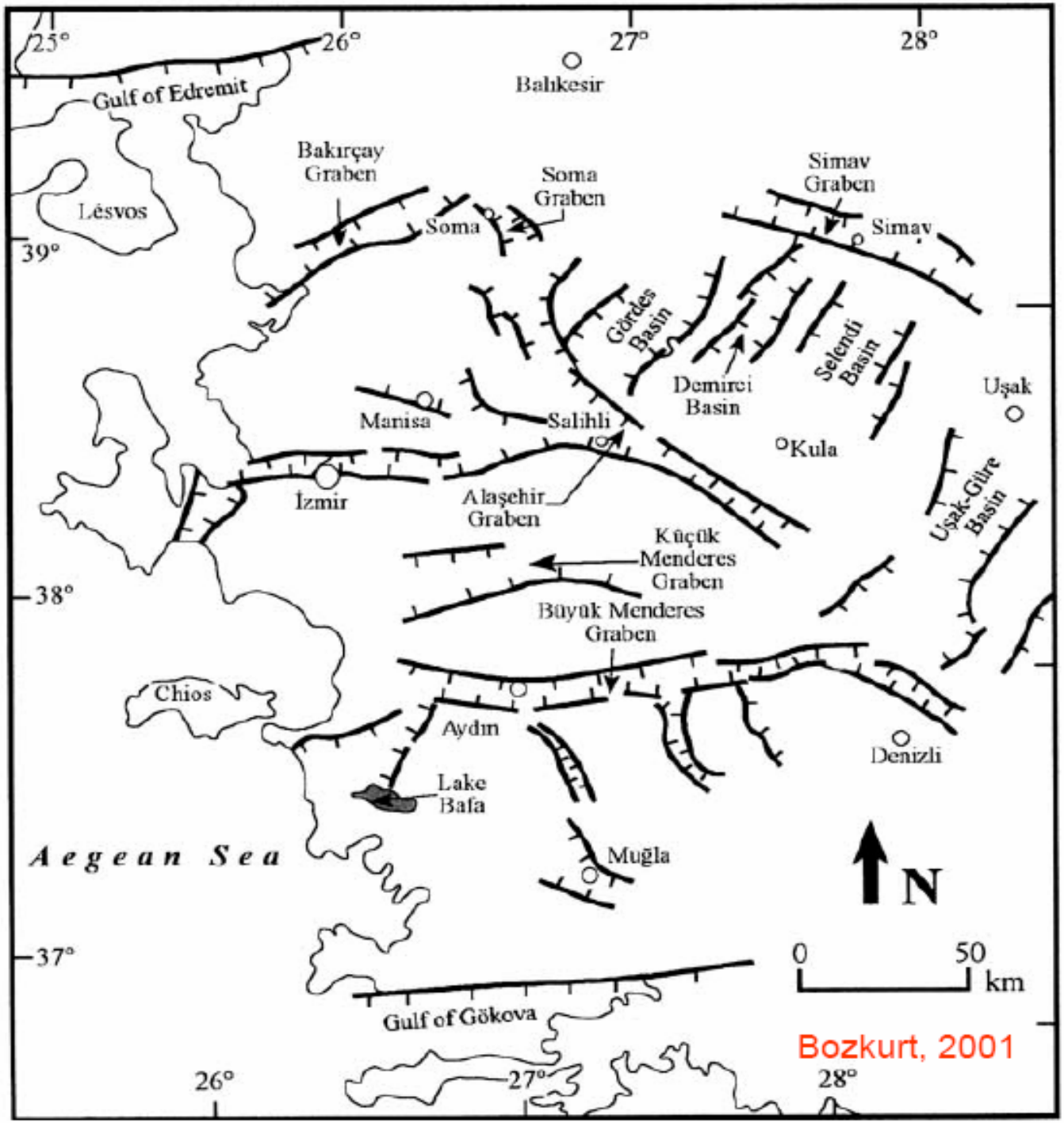
- NE- and NW-trending conjugate strike-slip faults
- Pull-apart basins (Erzurum and Ağrı basins) along the strike-slip faults
- E–W trending compressional ramp basins (Muş, Van and Pasinler)
- N-S trending tensional cracks



Koçyiğit et al., 2001



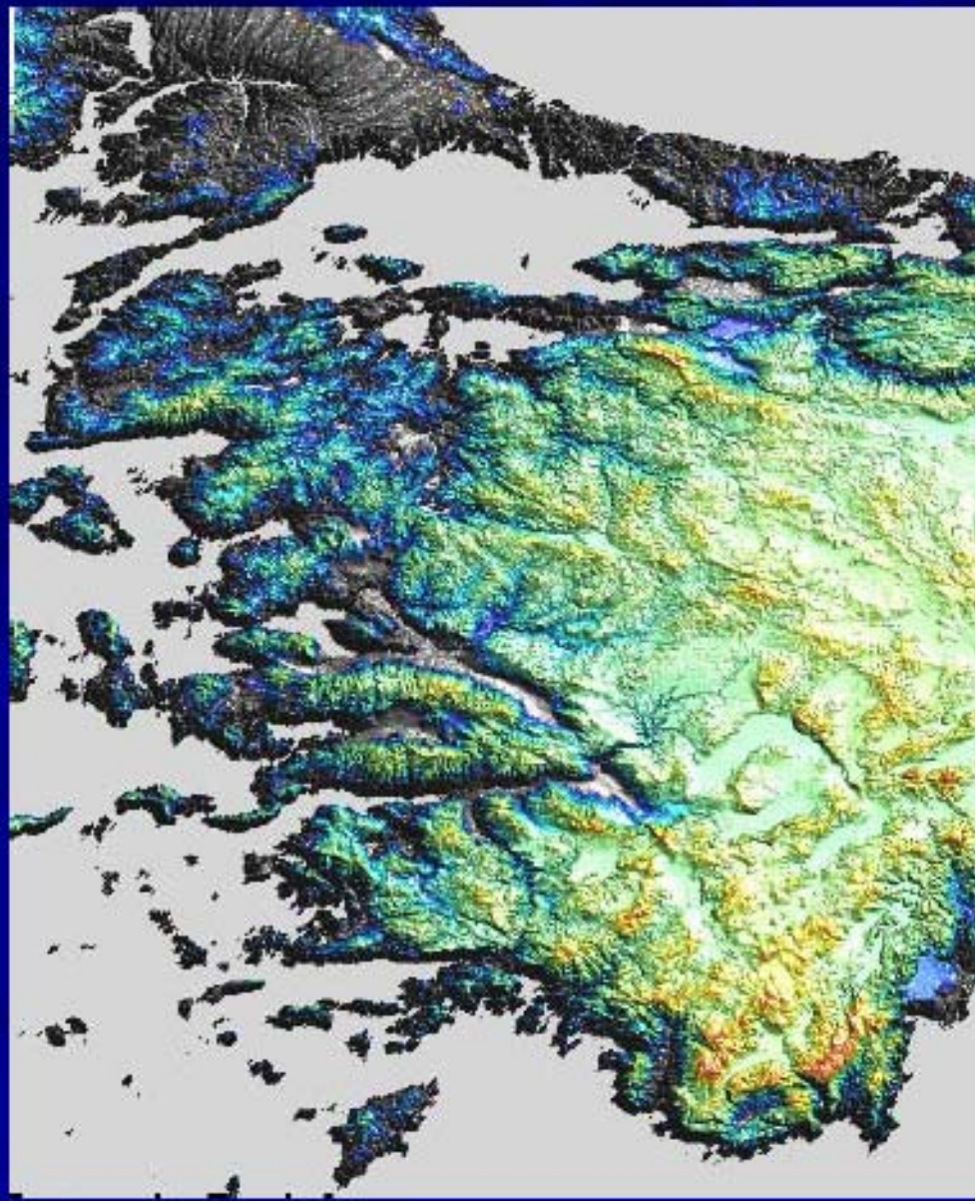
Bozkurt, 2001



Ege Graben sistemi

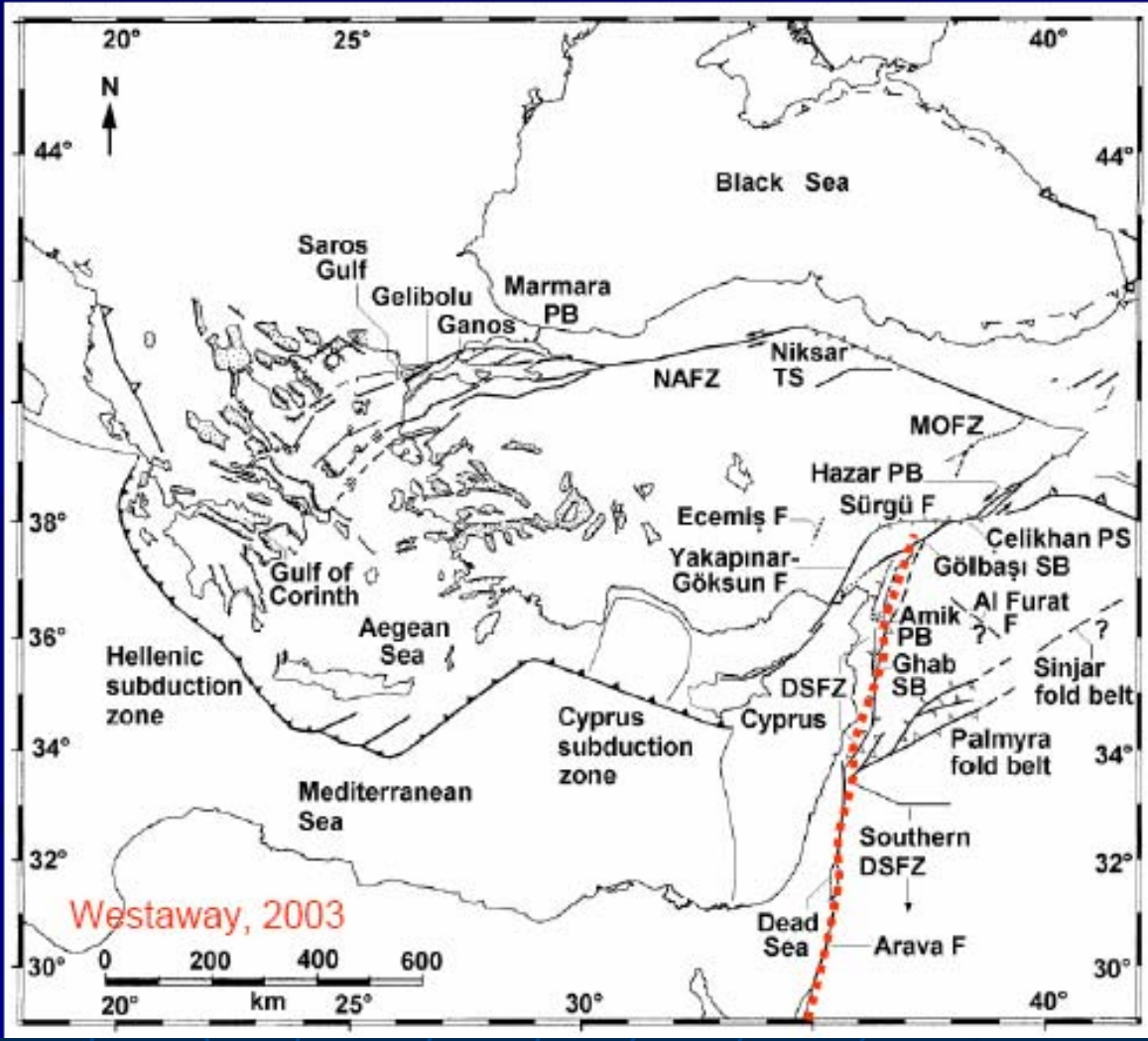
Western Anatolia

- One of the most seismically active and rapidly extending regions of the world (>30 mm/y).
- E–W trending grabens (Edremit, Bakırçay, Kütahya, Simav, Gediz, Küçük Menderes, Büyük Menderes, and Gökova).
- NNE-and NNW- trending grabens (Uşak, Selendi, Demirci, Gördes, Soma)



Dead Sea Fault Zone

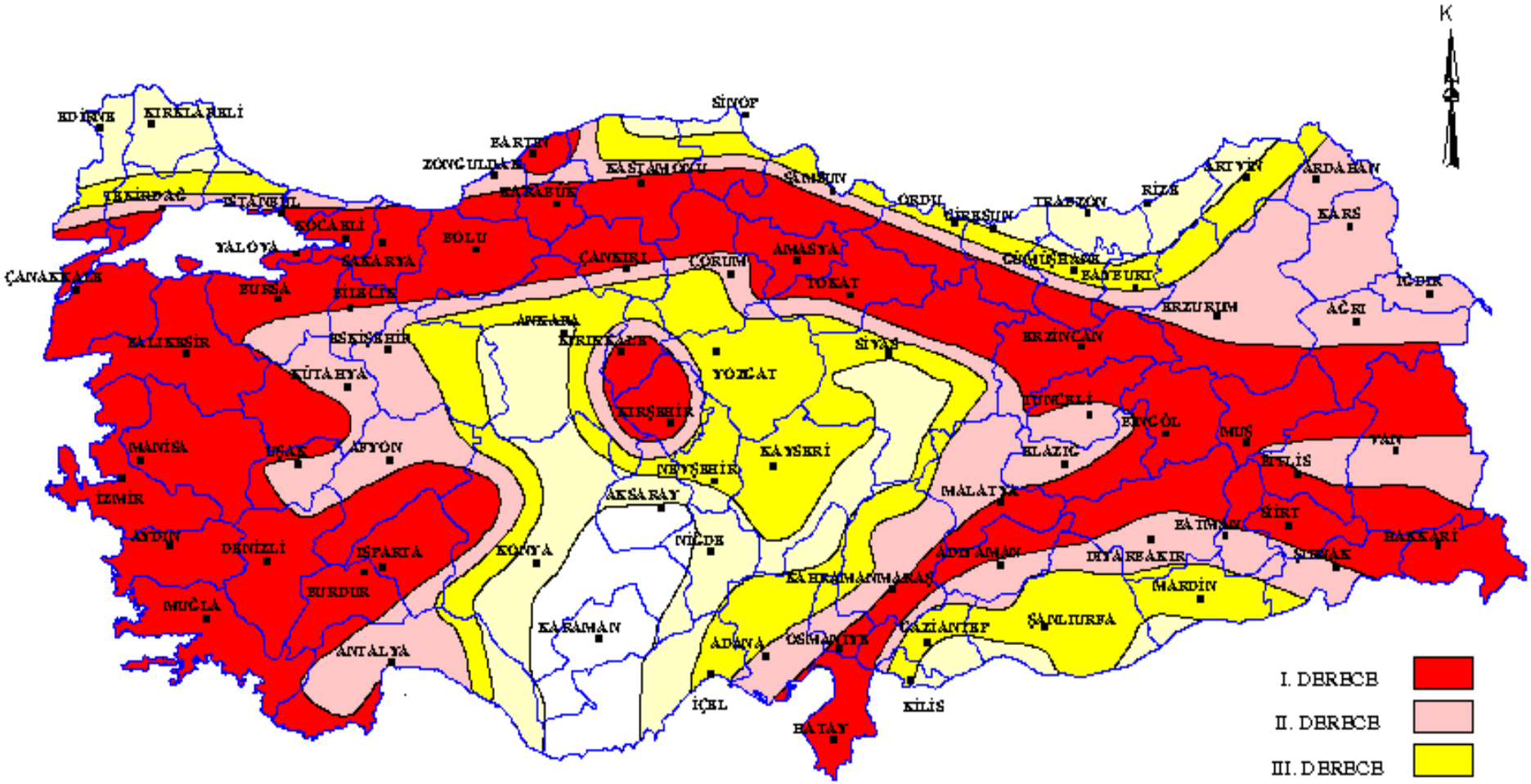
- 1000 km-long,
- Sinistral
- Plate boundary of transform type
- Separates the African and Arabian plates
- Different views about its age ranging 10 to 20 Ma



OFFSET of the DSFZ

- Estimates ranges 110 km for the southern section and 70–80 km for the northern section.
- Recent studies indicate 10–20 km of total slip.
- Some argued movement in two separate stages:
  - 60–65 km offset during 25–14 Ma
  - 40–45 km offset during the last 4.5 Ma.

Türkiye’nin depremselliği (Sismotektoniği)

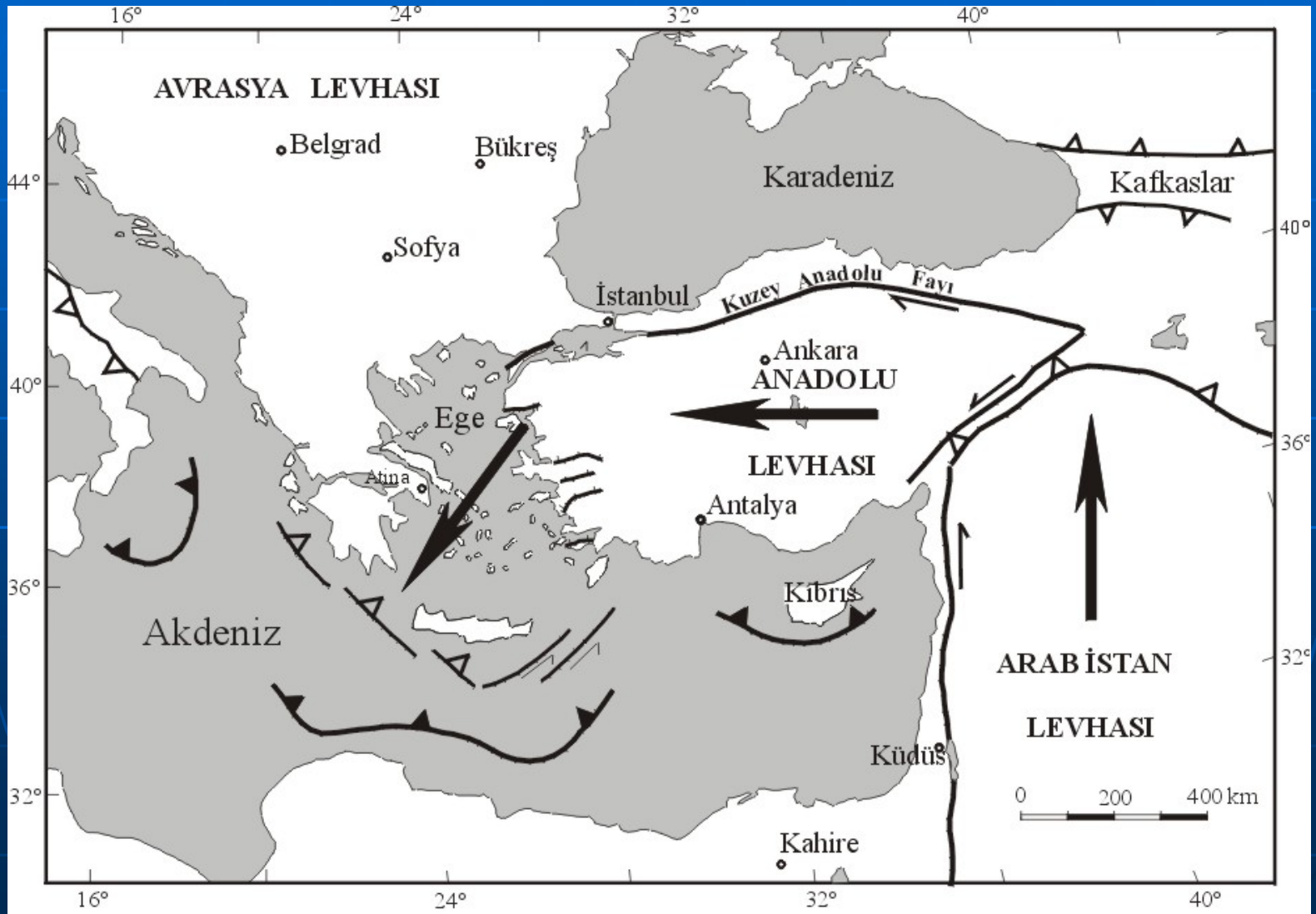


* T.C Bayındırlık ve İskan Bakanlığı, 1996

B.Özmen, M.Nurlu ve H.Güler'in 1997 yılında hazırladıkları,
"Coğrafi Bilgi Sistemi ile Deprem Bölgelerinin İncelenmesi" kitabından alınmıştır.

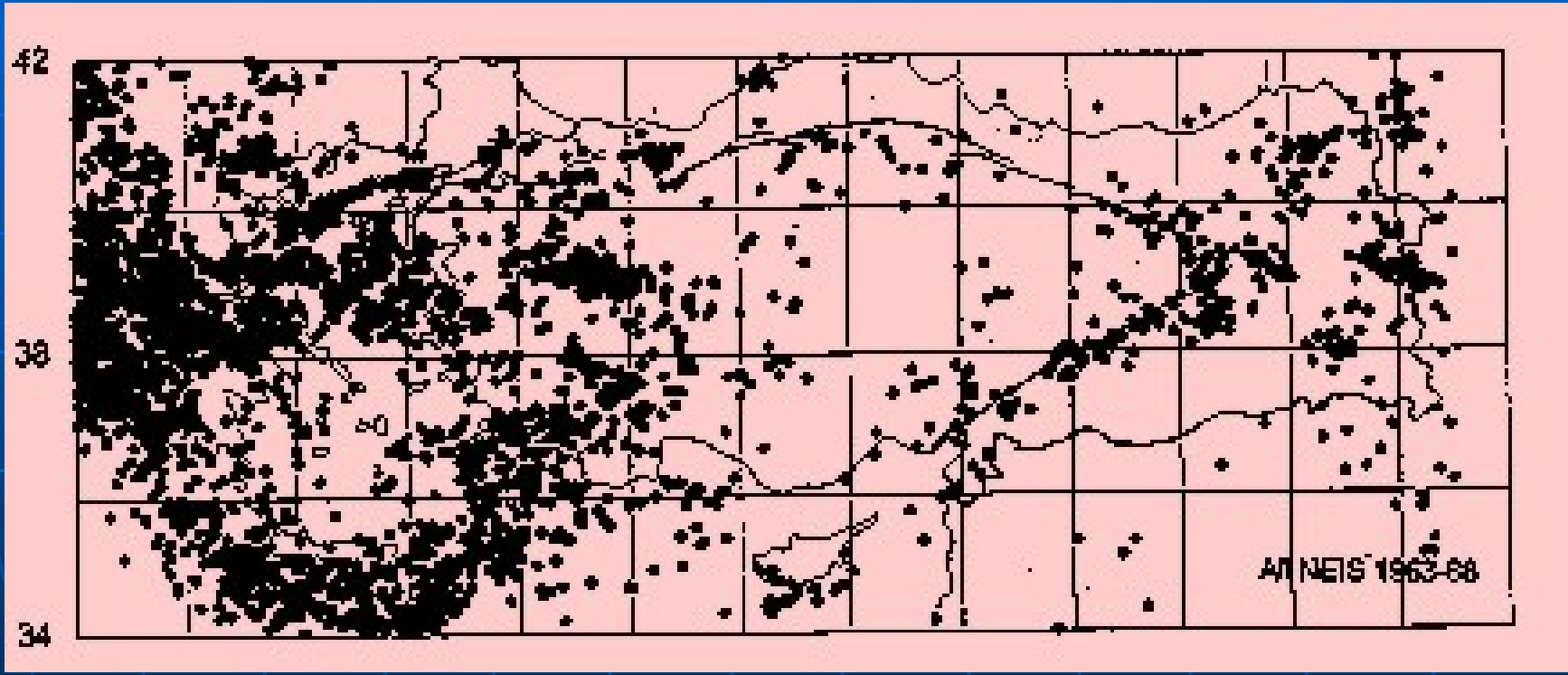
AFET İŞLERİ GENEL MÜDÜRLÜĞÜ
DEPREM ARAŞTIRMA DAİRESİ
ANKARA-TÜRKİYE

TÜRKİYE TEKTONİK AÇIDAN DÜNYANIN EN AKTİF BÖLGELERİNDEN BİRİDİR

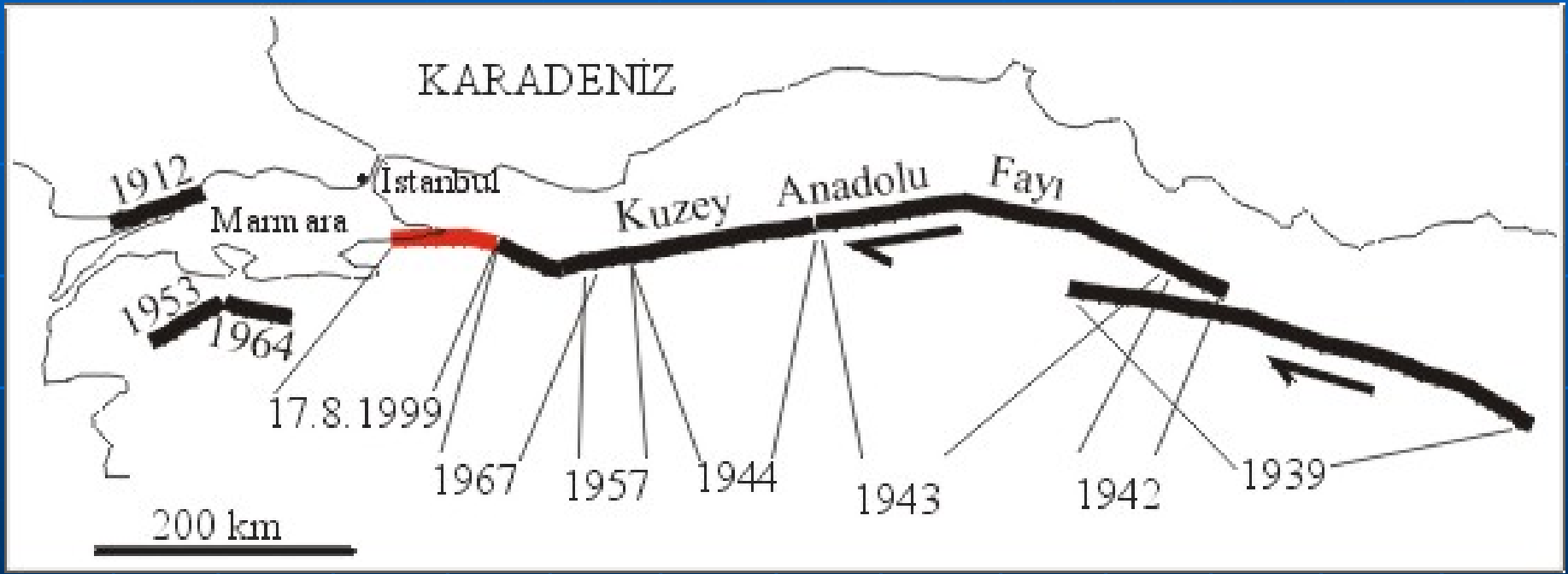


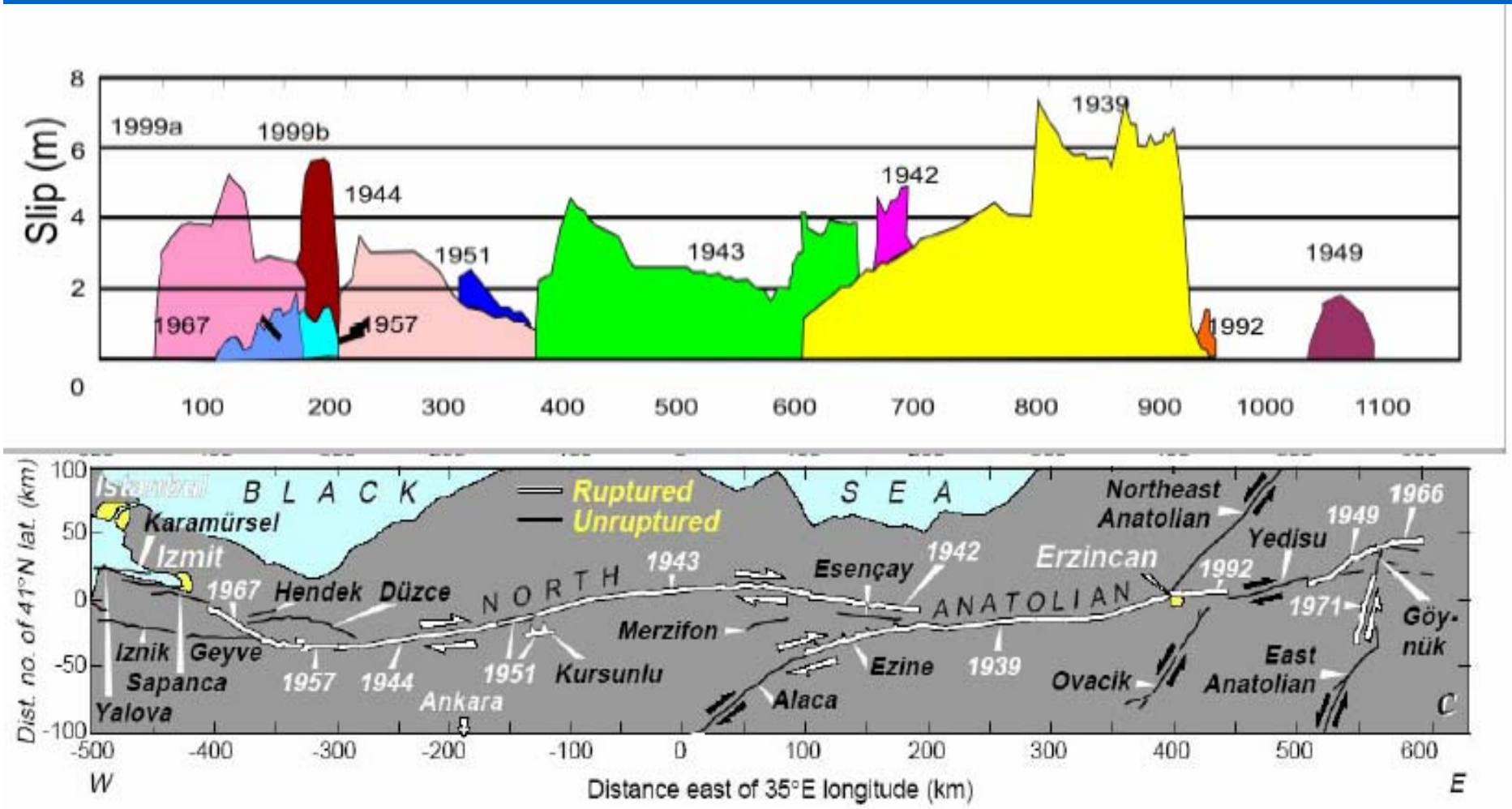
Şek. 1

1963-1988 DEPREM ODAKLARININ DAĞILIMI



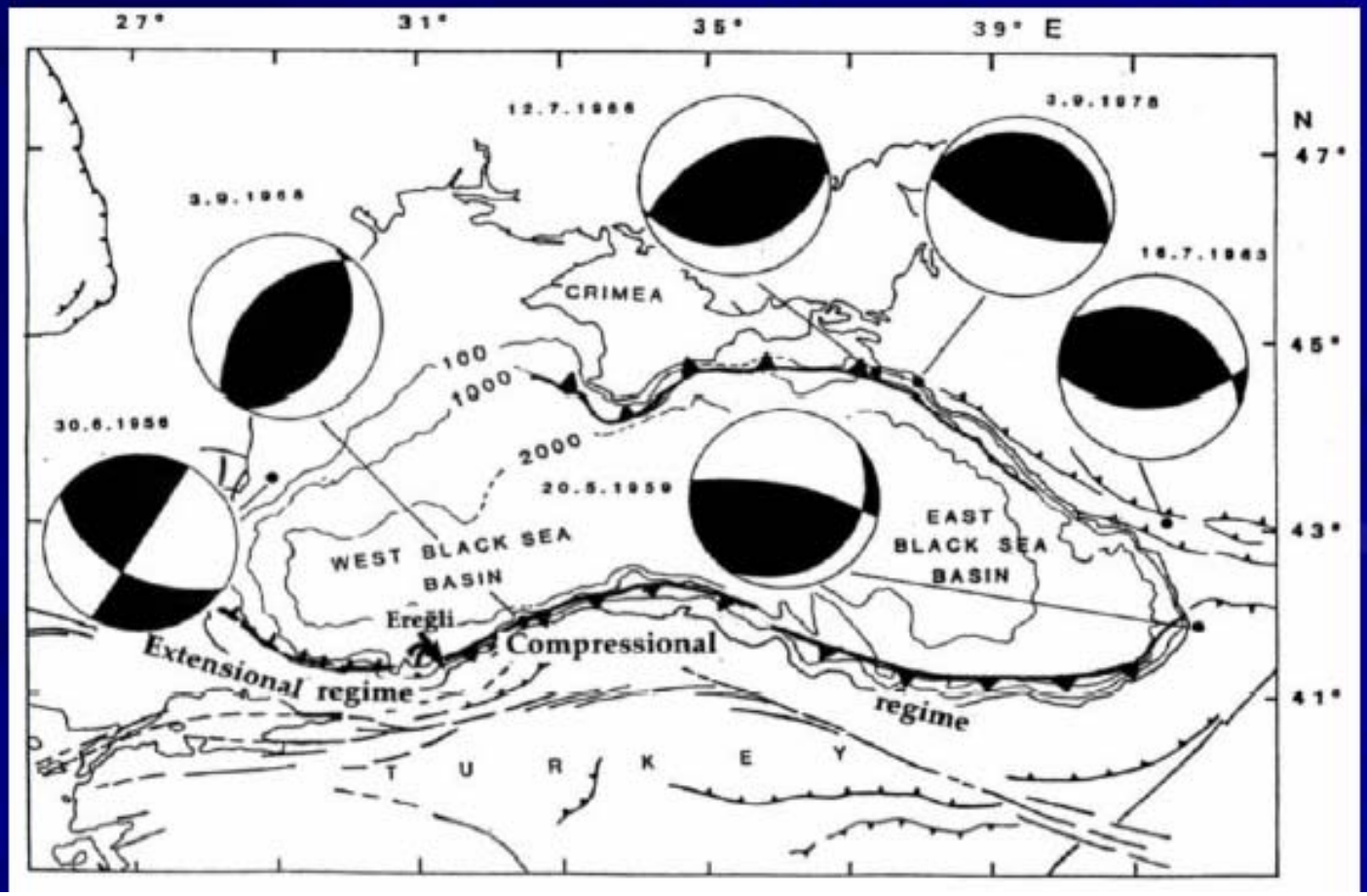
KUZEY ANADOLU FAYI ÜZERİNDE 1939 DA BAŞLAYAN ve BATIYA GÖÇEN BİR DEPREMLER DİZİSİ OLUŞMAKTADIR




Slip (m)
1999a
1999b
1944
1951
1943
1942
1939
1949
1967
1957
1992
Ruptured
Unruptured
BLACK SEA
Istanbul
Karamürsel
Izmit
Hendek
Düzce
NORTH ANATOLIAN
Esençay
Erzincan
Northeast Anatolian
Yedisu
1966
Merzifon
Iznik
Geyve
Sapanca
Yalova
Kursunlu
Ankara
Ezine
Alaca
Ovacik
East Anatolian
Göynük
Dist. no. of 41°N lat. (km)
Distance east of 35°E longitude (km)
W
E

North Anatolian Province

- Delimited by NAF and NEAF
- E-W trending fold and thrust belt.
- The slip rates are less than 5 mm/y
- 3 September 1968 Bartın earthquake (M = 6.8)



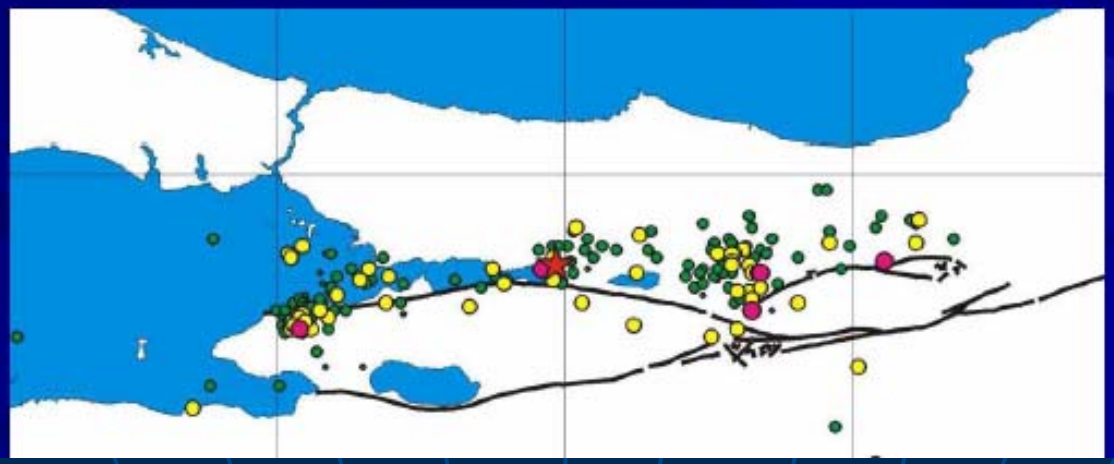
Tarı et al., 2000

- Beginning with 1939 Erzincan earthquake, the NA ruptured by 8 earthquakes (M >6.7) propagating sequentially in a westward progression
  - 26 December 1939 Erzincan (M = 7.9)
  - 20 December 1942 Erbaa-Niksar (M = 7.1)
  - 26 November 1943 Tosya (M = 7.6)
  - 1 February 1944 Bolu–Gerede (M = 7.3)
  - 26 May 1957 Abant (M = 7.0)
  - 22 July 1967 Mudurnu (M = 7.1)
  - 17 August 1999 Kocaeli (M = 7.4),
  - 12 November 1999 Düzce (M =7.2)
- This westward propagation has been interpreted i terms of a Coulomb failure model, whereby every earthquake concentrates the shear stress at the western tip of the broken segments leading to westward migration of the large earthquakes.

17 August and 12 November 1999 Earthquakes

17 August (M= 7.4) and 12 November (M=7.2) 1999 events killed moer than 20.000 people and ruptured about 160 km of the northern branch of the NAF.

These earthquakes have also loaded the Marmara segment(s?) of the fault and a major, M≤7.6 event is expected in the next half century with an about 50% probability on this segment.

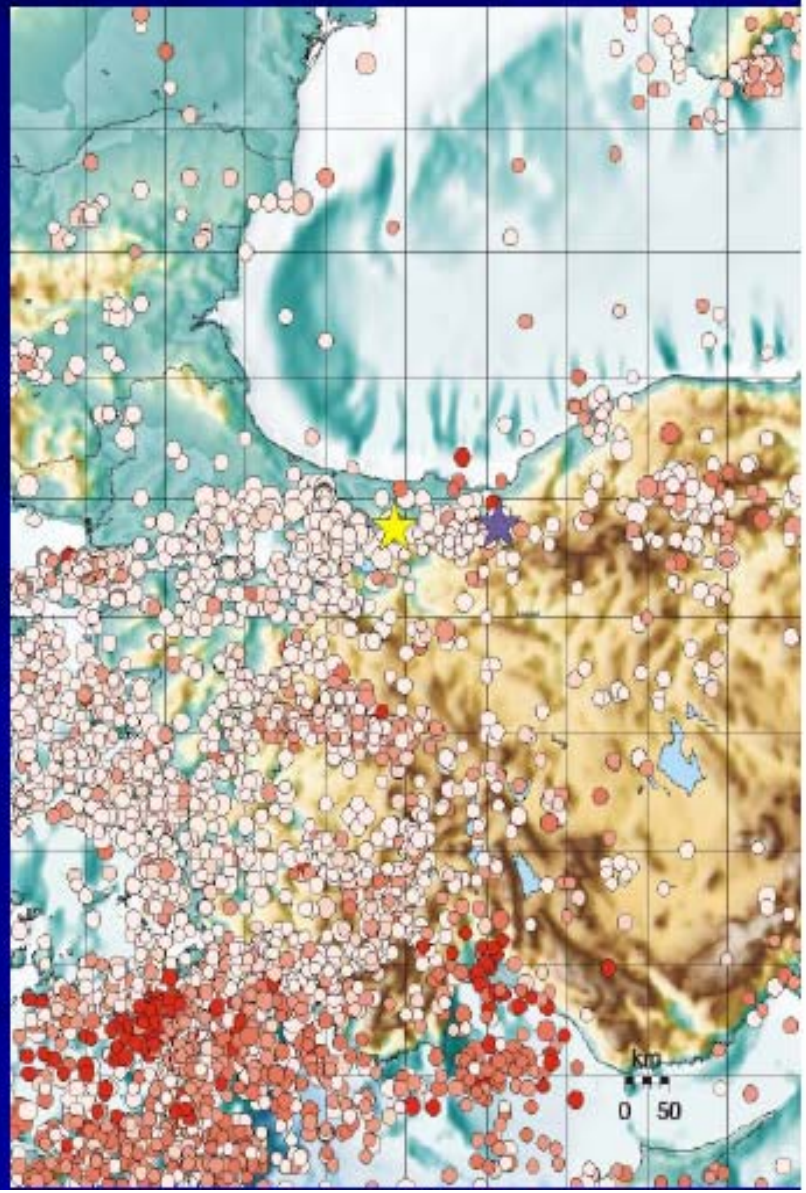


Seismicity of the eastern part of the Central Anatolian Province

- 1717 and 1835 Ecemiş
- 9 March 1902 Çankırı (Ms=5.5)
- May 1914 Gemerek (M = 5.6)
- 1938 Kırşehir (M = 6.8)
- 21 February 1940 Erciyes (M = 5.1)
- 13 April 1940 Yozgat-Kayseri (M =5.3)
- 4 August 1996 Mecitözü–Çorum (M = 5.6)

Biggest earthquakes of Western Anatolia

- 20 September 1899 Menderes
- 19 January 1909 Foça (M= 6.0)
- 18 November 1919 Soma (M = 6.9)
- 31 March 1928 Torbalı (M = 6.3)
- 2 May 1928 Emet (M = 6.2)
- 23 April 1933 Gökova (M = 6.5)
- 19 July 1933 Denizli (M = 5.8)
- 22 September 1939 Dikili-Bergama (M = 6.5)
- 23 May (M = 6.2) and 13 December 1941 Muğla (M = 6.0)
- 6 October 1942 Edremit Körfezi–Ayvacık (M = 6.8)
- 24 June 1944 Gediz (M = 6.0)
- 21 December 1945 (M = 6.0?)
- 16 July 1956 Söke–Balat (M = 7.1)
- 25 April 1959 Köyceğiz (M = 6.3)
- 11 March 1963 Denizli (M = 5.5)
- 2 March 1965 Salihli (M = 5.8)
- 13 June 1965 Honaz (M = 5.3)
- 25 March 1969 Demirci (M = 5.9)
- 28 March 1969 Alaşehir –Sarıgöl (M = 6.5)
- 28 March 1970 Gediz (M = 7.2)
- 11 October 1986 Çubukdağ (M = 5.5)



Major earthquakes in the East Anatolian Contractional Province during the 20th Century

- 12 July 1900 Kağızman (M= 5.9)
- 8 November 1901 Erzurum (M=6.1)
- 28 April 1903 Patnos (M=6.3)
- 28 May 1903 Ardahan (M= 5.7)
- 4 December 1905 Malatya (M= 6.8)
- 13 September 1924 Horasan (M = 6.8)
- 1 May 1935 Digor (M= 5.8)
- 10 September 1941 Erciş (M= 5.9)
- 6 September 1975 Lice (M = 6.6)
- 24 November 1976 Çaldıran (M = 7.3)
- 30 October 1983 Horasan–Narman (M = 6.8)

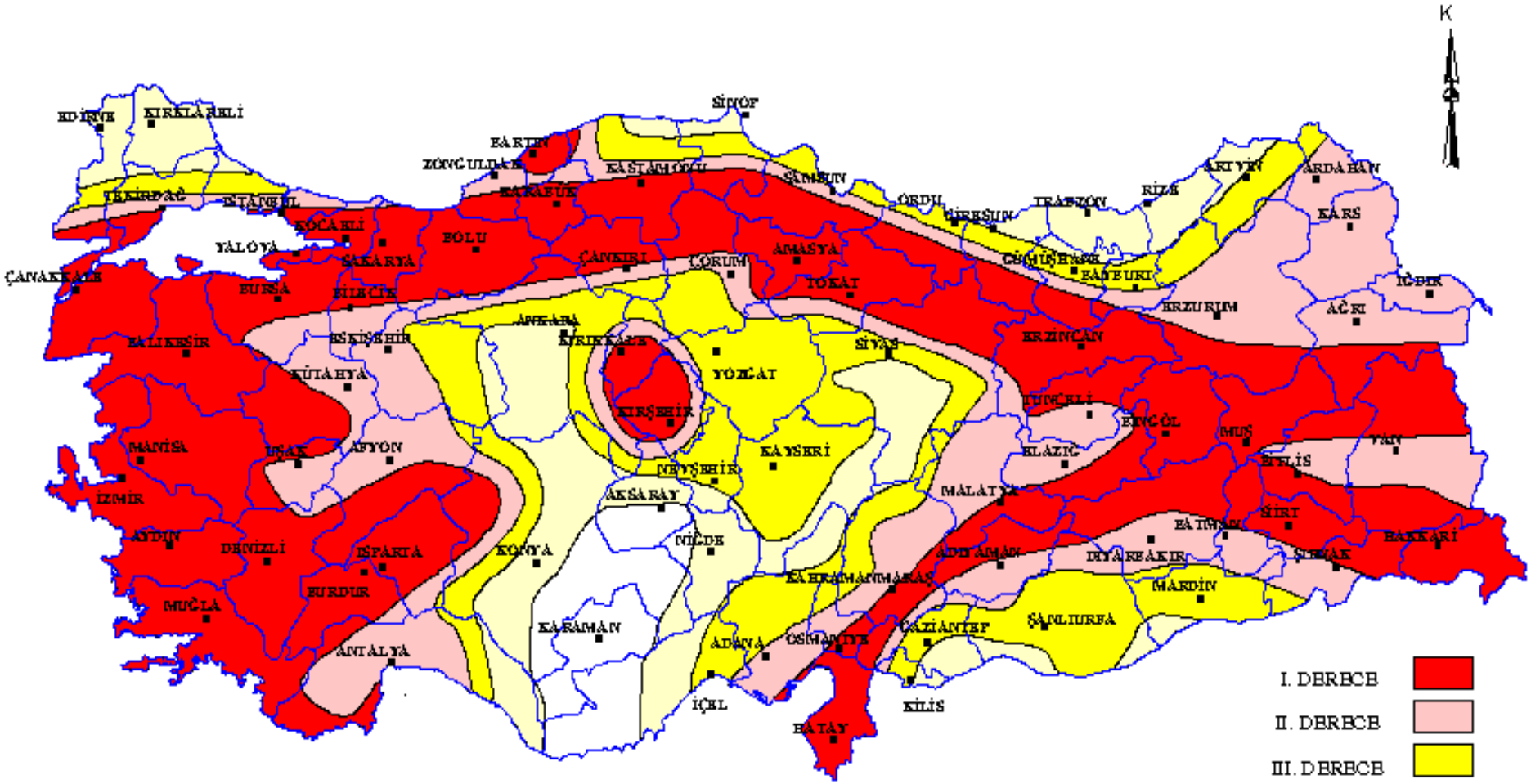
3.85m

4.65m

LPG
4.95m

4.90m

4.80m



* T.C Bayındırlık ve İskan Bakanlığı, 1996

B.Özmen, M.Nurlu ve H.Güler'in 1997 yılında hazırladıkları,
"Coğrafi Bilgi Sistemi ile Deprem Bölgelerinin İncelenmesi" kitabından alınmıştır.

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