

A TOWN WITH THE MOST PRECIOUS STONES IN THE WORLD

(Living with geology in İstanbul)



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*“Bu şehir-i İstanbul ki bî
mislü bahadır*

*Bir sengine yekpâre
Acem mülkü fedâdır”*

Nedim, in the “Tulip Era”, early 18th century

This city of İstanbul, which can by no-one ever be priced

Let, for a single stone of it, the entire Persian Land be sacrificed





Münster
(1488-
1552)

Die Stadt

Constantinopel

So vor zeitem Bizantium ge
nant/darnach ein haupt vnd sitz worden des orient
tischen Keyserthumbs/wie sy noch zu vnsern zeyten des Türckischen Key
sers wonung vnd oberste stat ist.



*From Sebastian Münster, the 'German
Strabo', Cosmographie, 1550, Basel*

No applied geology can be done without doing the basic geology of any area. The basic geology, i.e. stratigraphy, structure, petrography, palaeontology and geomorphology, also outlines the applied geology of any region.

Marx's statement that "philosophers have so far worked to understand Nature; what needs doing is to change it" represents a foolish recommendation. Since the beginning of the industrial revolution and rapid urban growth, we have come to appreciate that we must try to understand Nature as best we can and then try to live in it by imposing as little change on Her as is consistent with comfortable survival.



The oldest settlement in Istanbul: *The Yarimbürgaz Cave*.
Age of settlement c. 400 ka (medial Pleistocene)



From Berkay Dinçer:

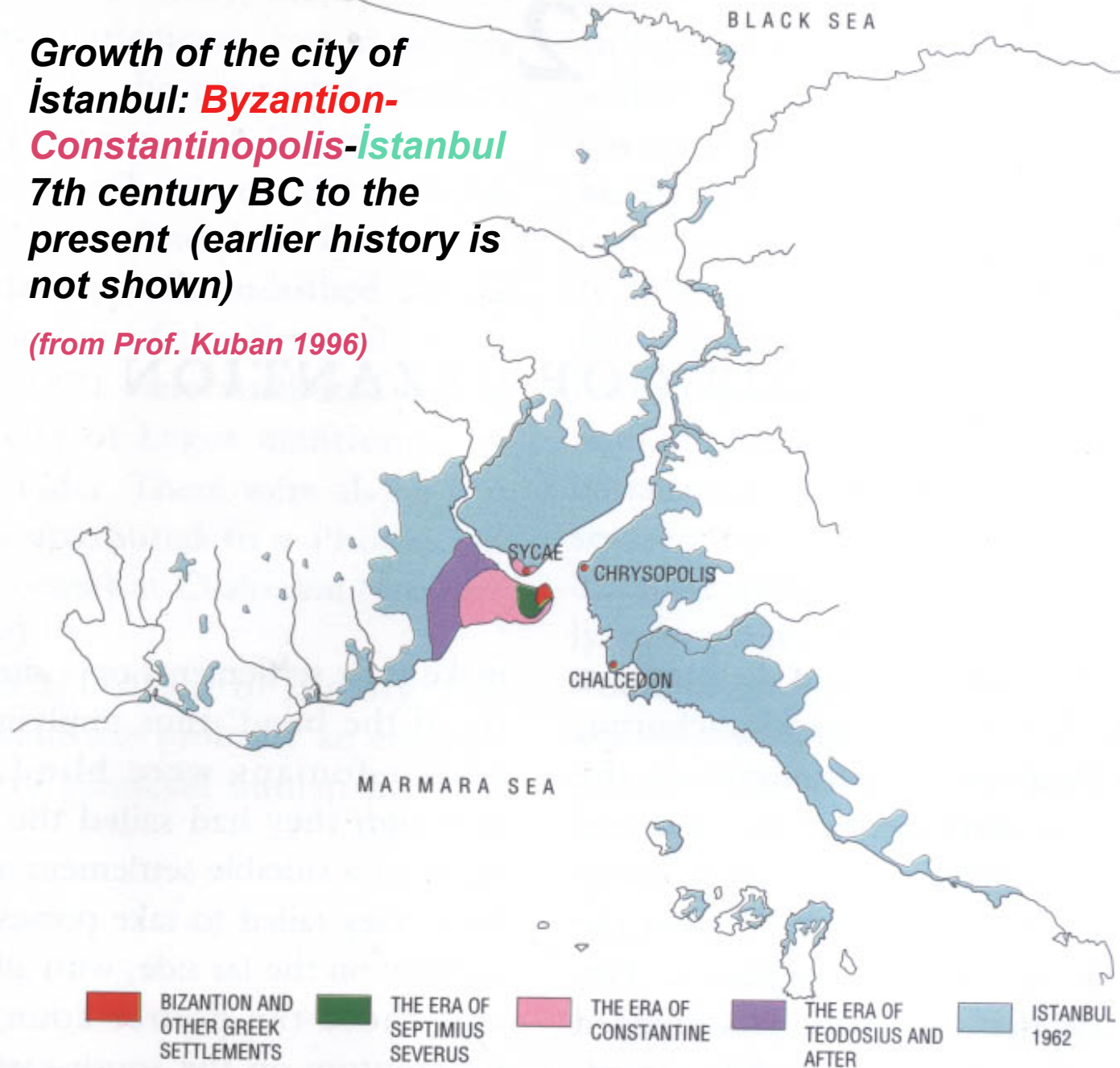
<http://paleoberkay.atspace.com/turkce/yatak3.html> viewed on 2 April '07



Prehistoric sites in and around the city of İstanbul (from Prof. Kuban, 1996)

**Growth of the city of
Istanbul: *Byzantion-
Constantinopolis-Istanbul*
7th century BC to the
present (earlier history is
not shown)**

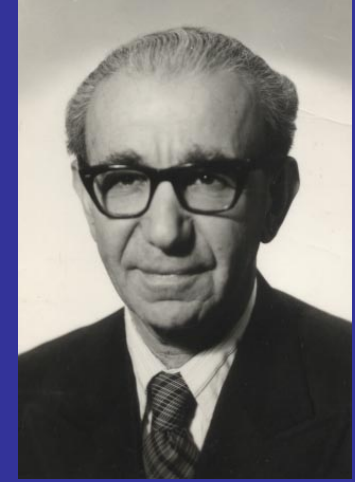
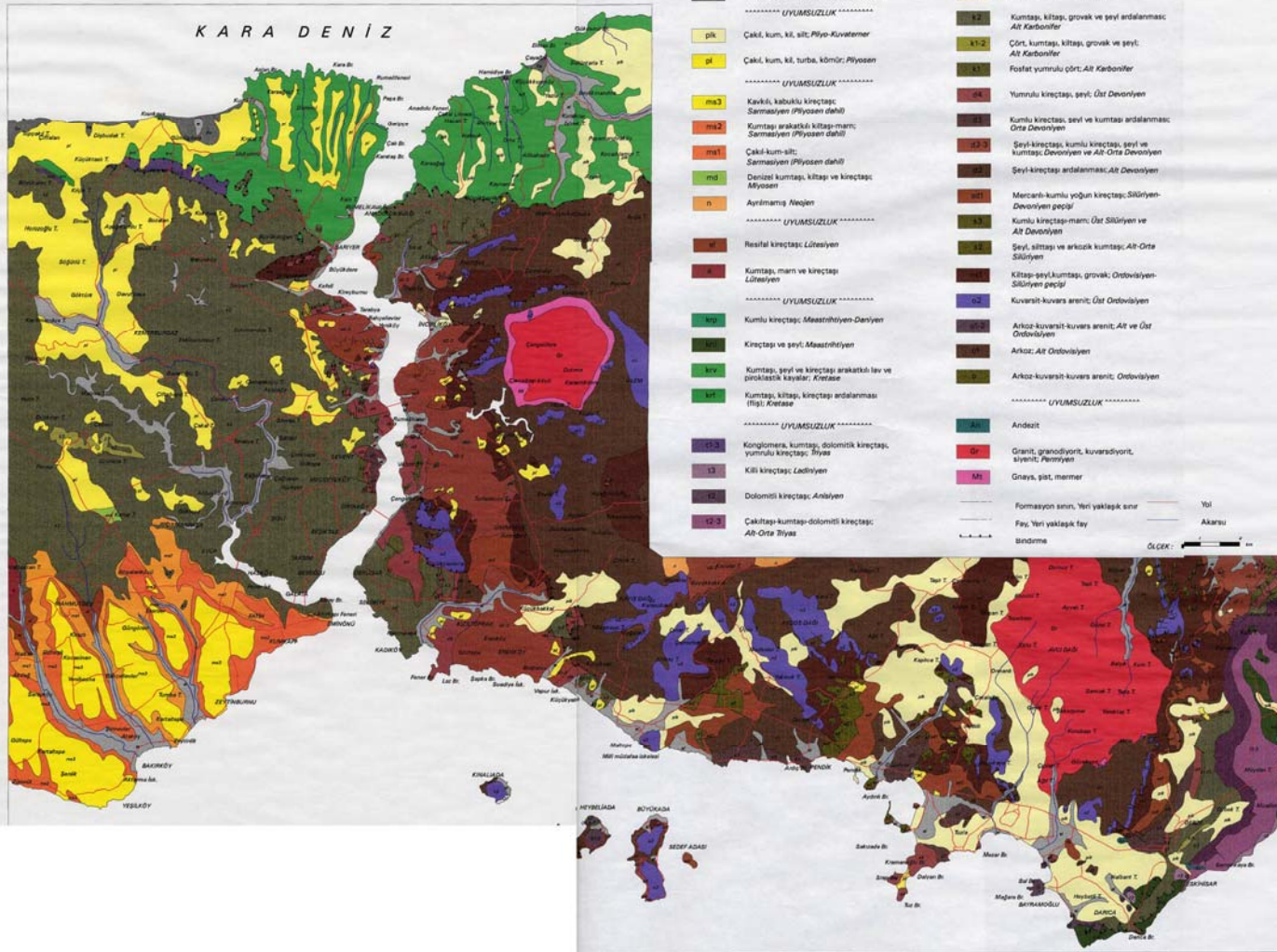
(from Prof. Kuban 1996)





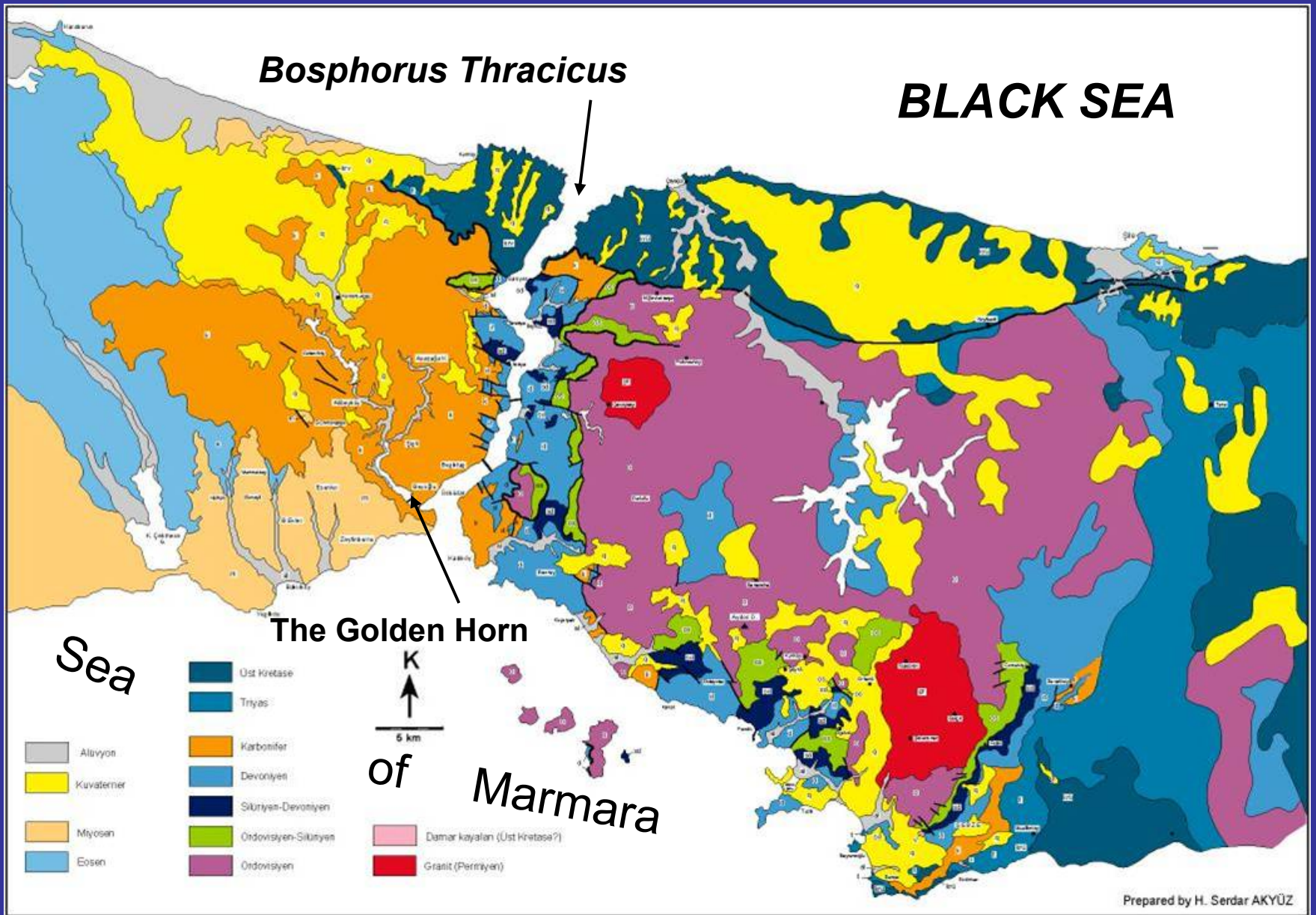
And today! With a population nearing 15 million and an area many times that of classical Constantinople, in the hands of incompetent and corrupt politicians, İstanbul is an urban disaster in the making

(1914 - 1995)



Professor İhsan Ketin (1914-1995)

The geological map of Istanbul by İhsan Ketin

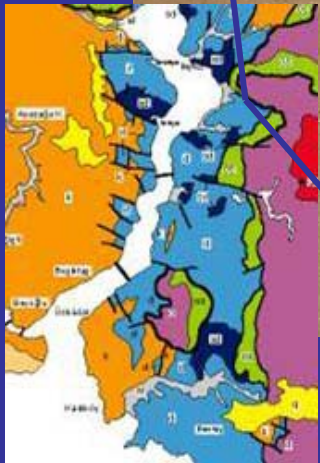


Geological map of Istanbul and its surroundings by Serdar Akyüz (2002, unpublished)



Alteration zone of
thrust

*Upper Ordovician (?) - Lower Silurian
arkoses in a S-vergent fold above a N-
dipping thrust fault N of Çekmeköy*

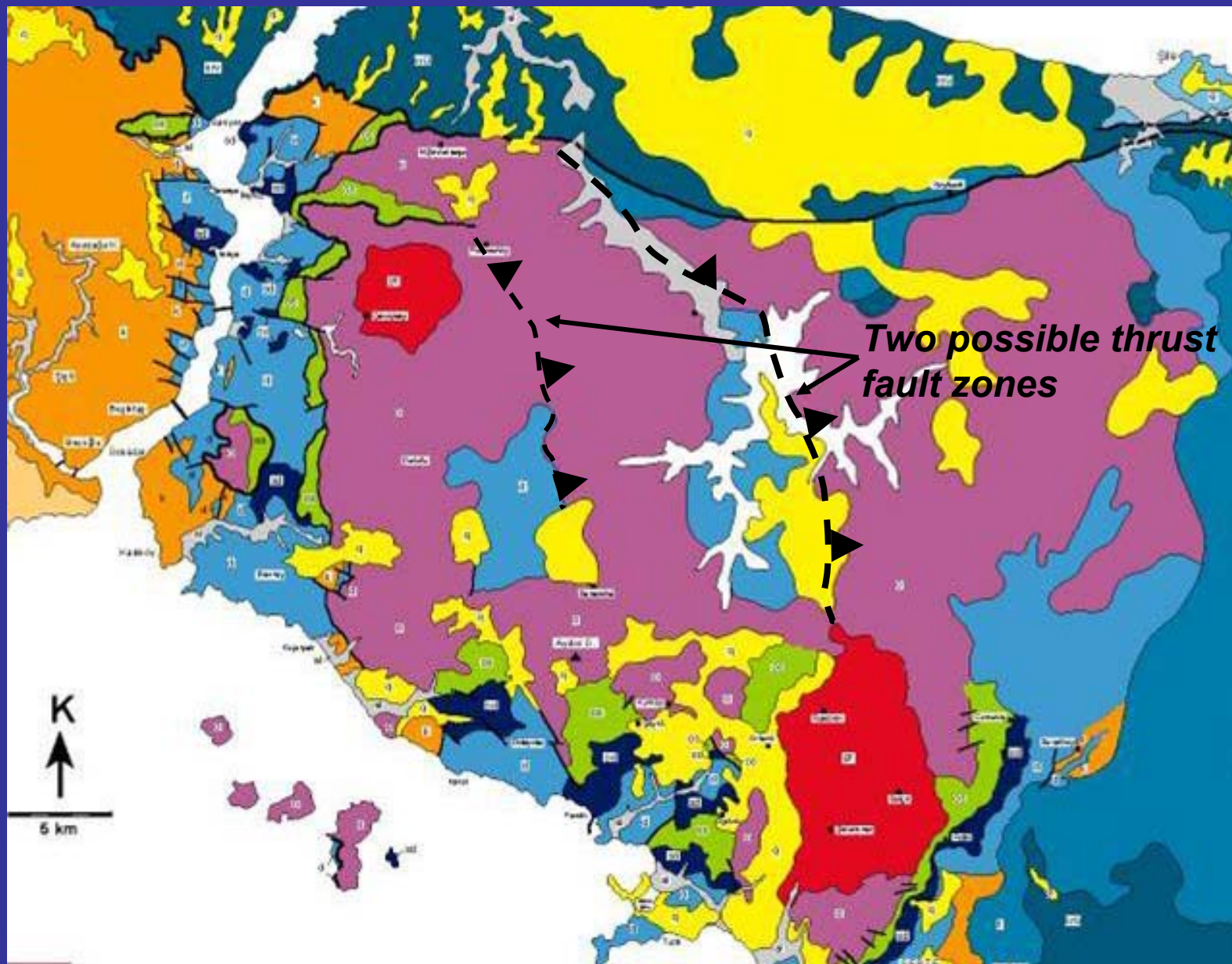




**Arkosic
sandstones
minimum 3
km thick,
basement not
exposed (rift
fill)**

Fanglomerate facies

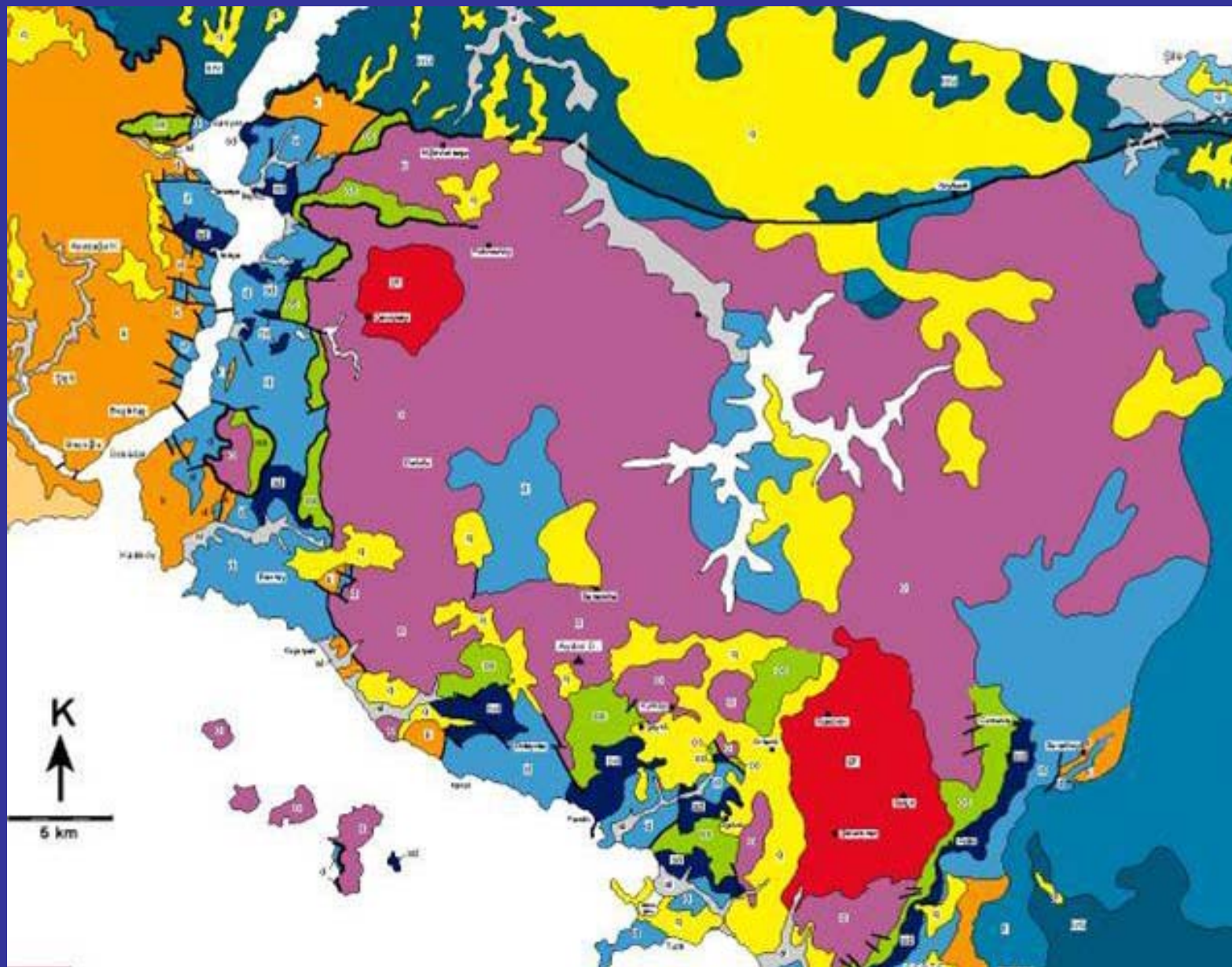




Distribution of the arkoses (purple: rift fill)



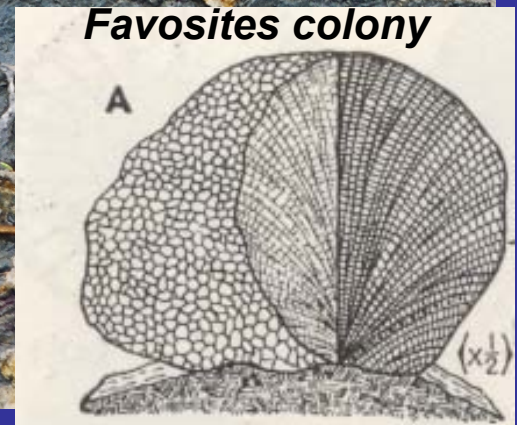
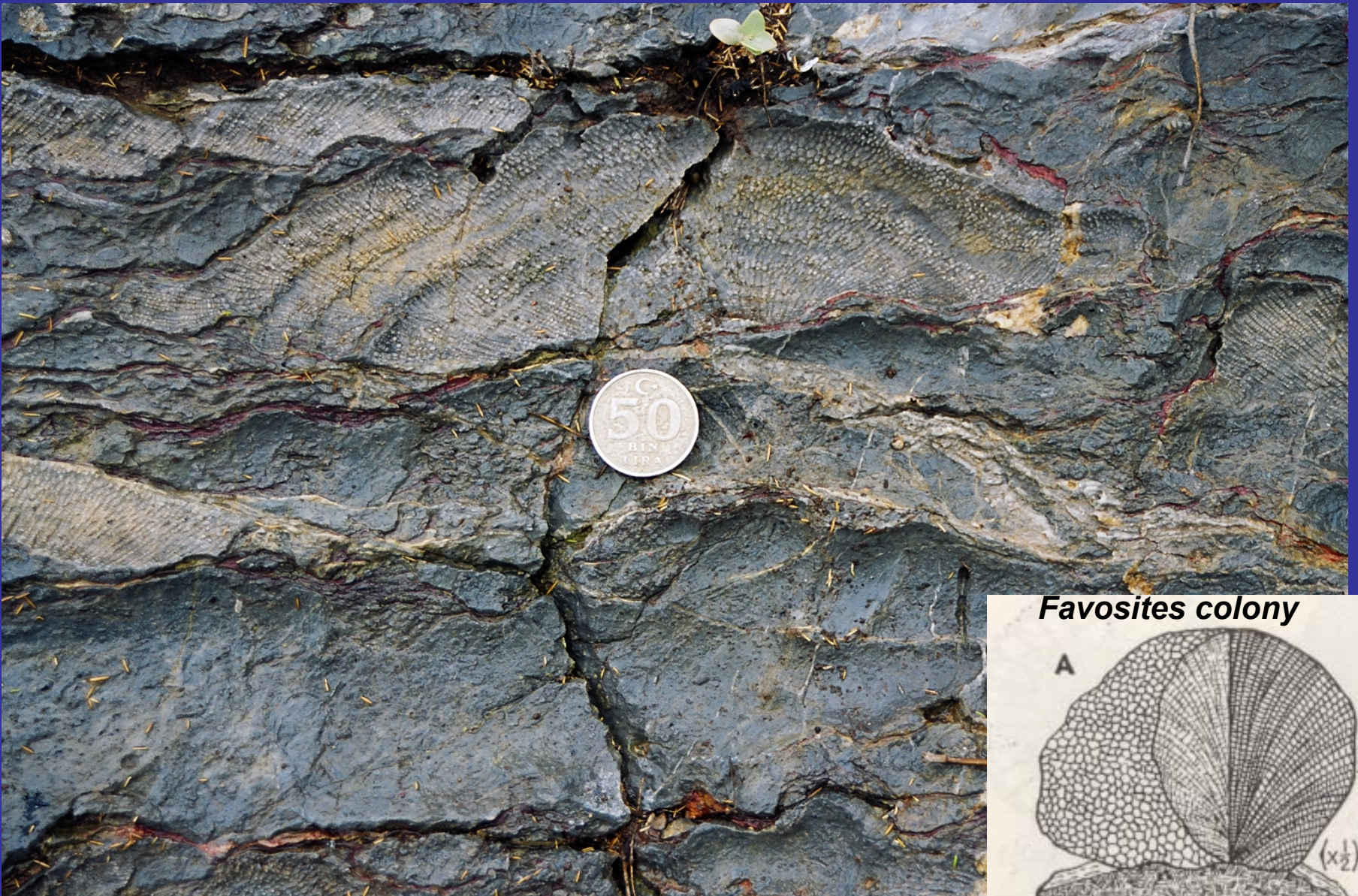
Orthoquartzites (beach facies): establishment of an Atlantic-type continental margin (E-facing)



Distribution of the quartzites (green: beach facies)



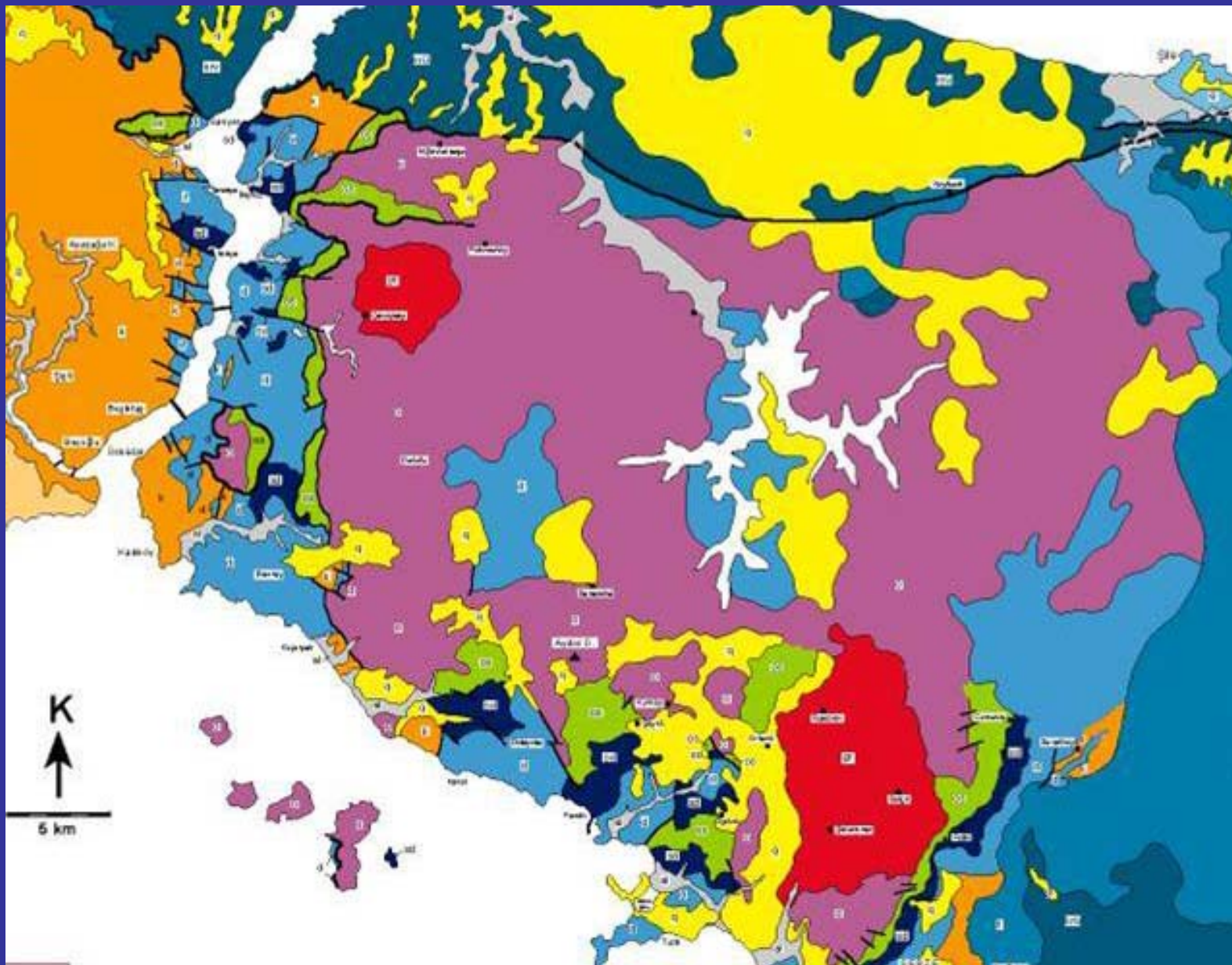
Reefal and laminated limestones (Upper Silurian-Lower Devonian) deposited on an open shelf: ***Establishment of an Atlantic-type continental margin***



Favosites-bearing reef limestones: Upper Silurian-Lower Devonian



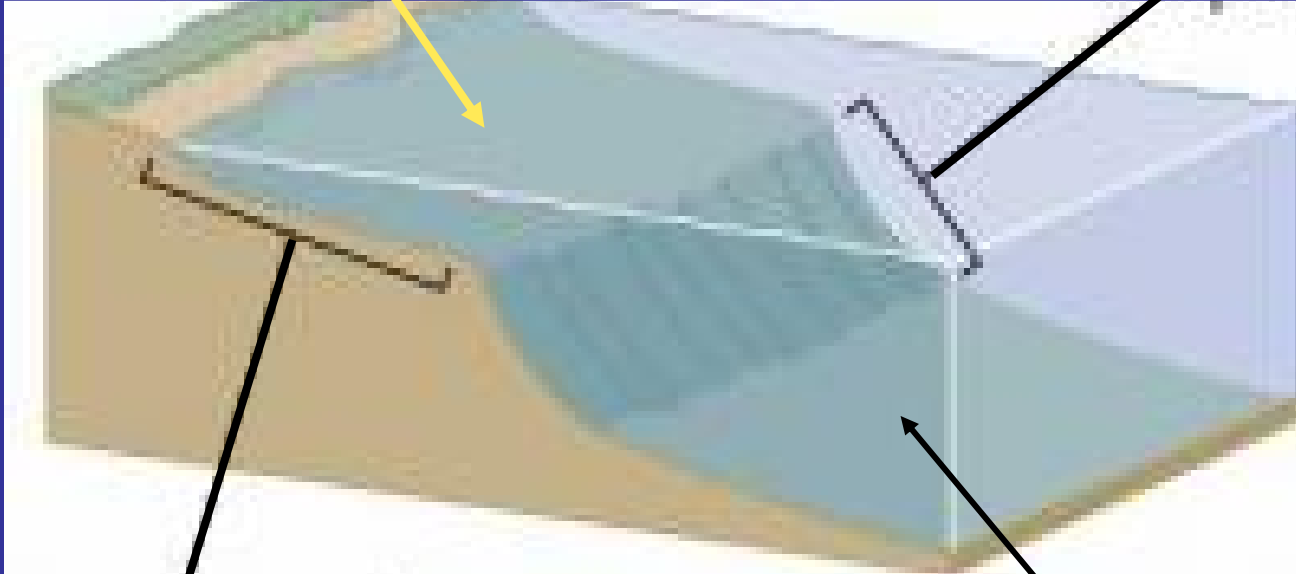
Laminated/nodular limestone (Upper Silurian-Lower Devonian). Nodules were structurally formed



Distribution of the Upper Silurian-Lower Devonian limestones
(dark navy blue: *initial shelf facies*)

*Istanbul latest Silurian-
Devonian sedimentation here*

WSW



Continental
slope

ENE

Continental shelf

Ocean floor



Shales with mica flakes of Middle Devonian above the Lower Devonian nodular limestones: Rhenic facies in a subsiding shelf



Dr. Abdullah Bey.
Membre de la Commission

Dr. Abdullah Bey (Karl Wilhelm Hammerschmidt: 1799-1874)

SÉANCE DU 6 MAI 1867

NOTE DE M. ABDULLAH BEY.

621

et aucune n'a de rapport, ni avec le calcaire pisolithique, ni avec la craie de Maëstricht.

M. Abdullah Bey fait la communication suivante :

Je me suis occupé depuis deux ans à faire des recherches sur les couches paléozoïques du terrain dévonien du Bosphore, à Constantinople.

La collection apportée à Paris pour l'Exposition universelle contient à peu près deux mille échantillons, mais l'espace restreint pour la section de la Turquie ne permet pas d'exposer convenablement la collection entière.

Sa Majesté Abdul-Azis, mon auguste Souverain, avait sanctionné la formation d'un Musée national à Constantinople, d'après ma proposition ; le but de mon voyage était entre autres aussi de déterminer ces pétrifications, et de me mettre en relation avec les divers musées et sociétés d'histoire naturelle pour des échanges futurs au profit du Musée à fonder à Constantinople.

Aujourd'hui je suis heureux de pouvoir offrir, comme hommage de ma part, les doubles de cette collection au musée paléontologique du Jardin des Plantes, si habilement dirigé par M. d'Archiac, où les amateurs pourront visiter ces recherches géologiques faites au Bosphore.

En même temps je prends la liberté de mettre sous les yeux de la Société les dessins que j'avais des pétrifications recueillies le long du Bosphore, dans les diverses localités sur la côte d'Europe, de Boiyoukdéré jusqu'à Arnautkoy, et sur la côte d'Asie, du mont Géant jusqu'à Kaulidja-Kartal et Pentek de la mer de Marmara. Cet ouvrage contient douze cents représentations ; il est exposé actuellement à l'Exposition universelle.

Séance du 20 mai 1867.

PRÉSIDENCE DE M. BELGRAND, vice-président.

M. Alf. Cailloux, secrétaire, donne lecture du procès-verbal de la dernière séance, dont la rédaction est adoptée.

Par suite des présentations faites dans la dernière séance, le Président proclame membres de la Société :

4. CRYPHEUS ABDULLAHI, de Verneuil.

Pl. xx, fig. 3.

CRYPHEUS ABDULLAHI, de Verneuil, *Compt. rend. de l'Acad. des sc.*, v. LXIV, p. 1219.





Werner Paeckelmann (1890-1952)

Beiträge zur Kenntnis des Devons am Bosporus, insbesondere in Bithynien

Von
Werner Paeckelmann
in Berlin

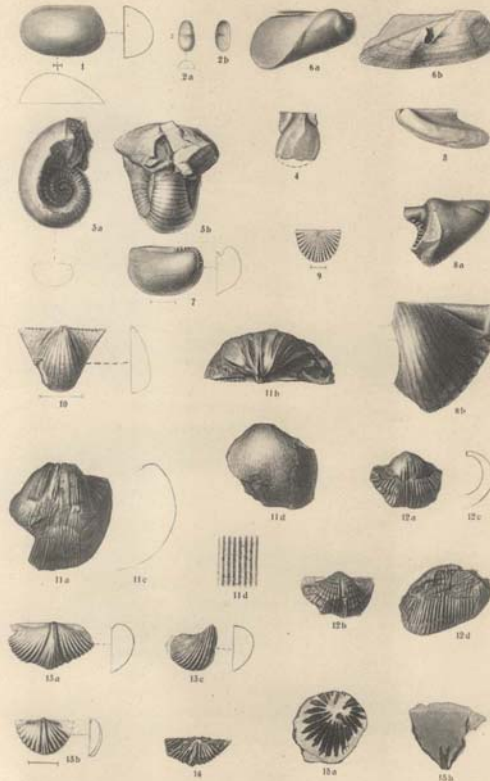
Mit 6 Tafeln und 5 Textfiguren

Herausgegeben
von der
Preußischen Geologischen Landesanstalt

BERLIN
Im Vertrieb bei der Preußischen Geologischen Landesanstalt
Berlin N 4, Invalidenstraße 44
1925

Abhandl. d. Preuß. Geol. Landesanstalt N. F. Heft 98

Tafel 5



gez. Alexander Schultz

Lithdruck Albert Fritsch, Berlin W 35

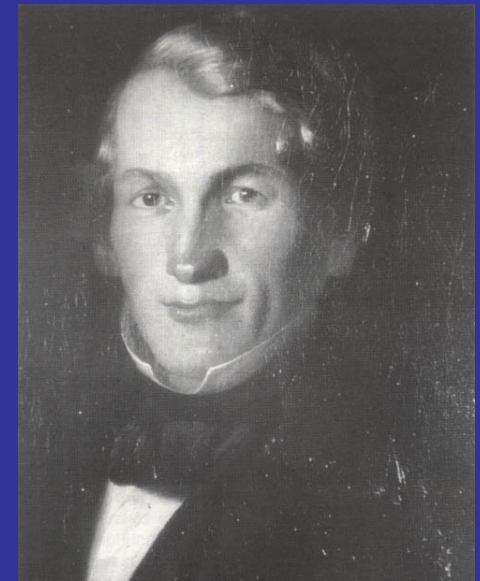


Phacops from the Middle Devonian Rhenic facies

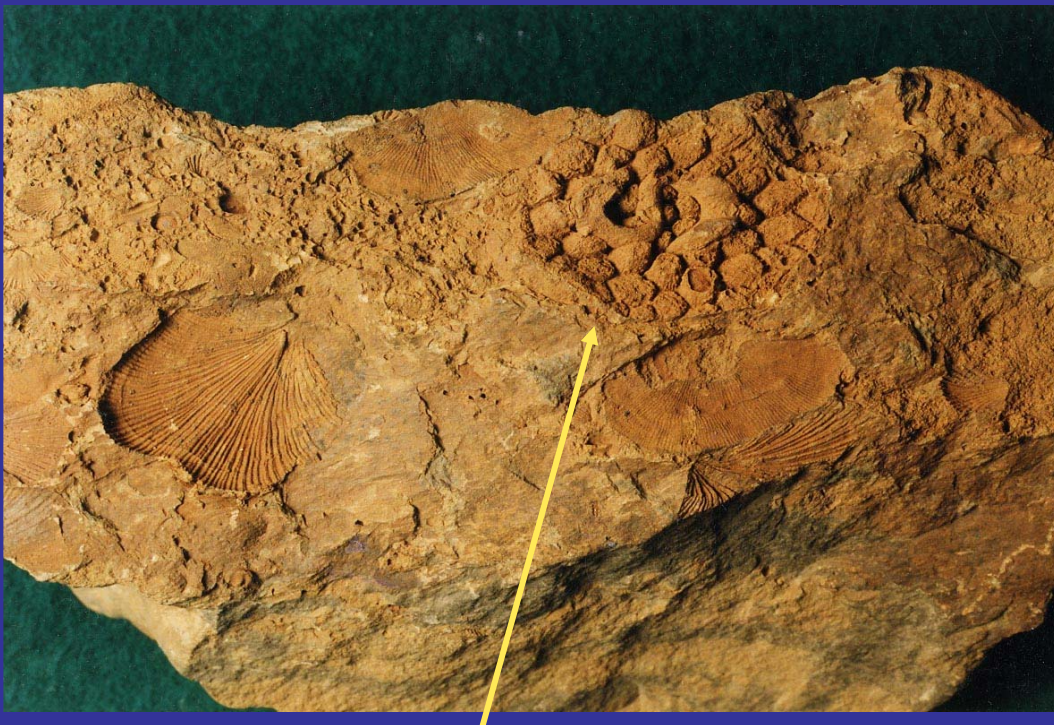


A new
tabular coral
from
Istanbul in
1863!

Pleurodyctium constantinopolitanum ROEMER, 1863



**Ferdinand
Roemer
(1818-1891)**

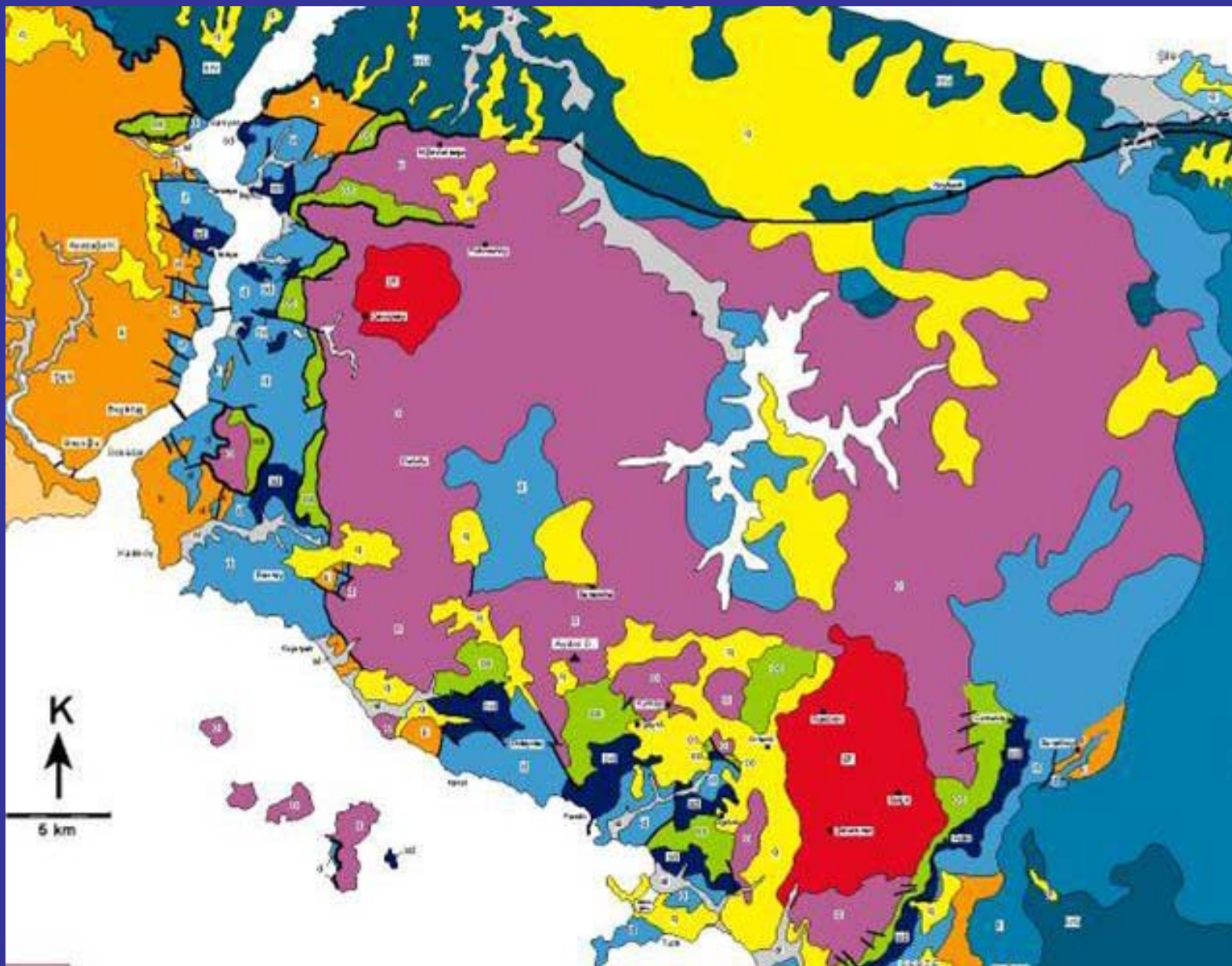


Pleurodyctium problematicum

Geognostische Bemerkungen auf
einer Reise nach Constantinopel
und im besonderen über die in
den Umgebungen von
Constantinopel verbreiteten
Devonschichten: *Neues Jahrbuch
der Mineralogie, Geologie und
Paläontologie*, 11, pp. 325-352
(1863)



Upper Devonian nodular limestone/shale rock: Denizliköyü Formation (Haas, 1968): starved, subsident shelf



Distribution of the Middle and Upper Devonian rocks (sky-blue: *subsident shelf*)



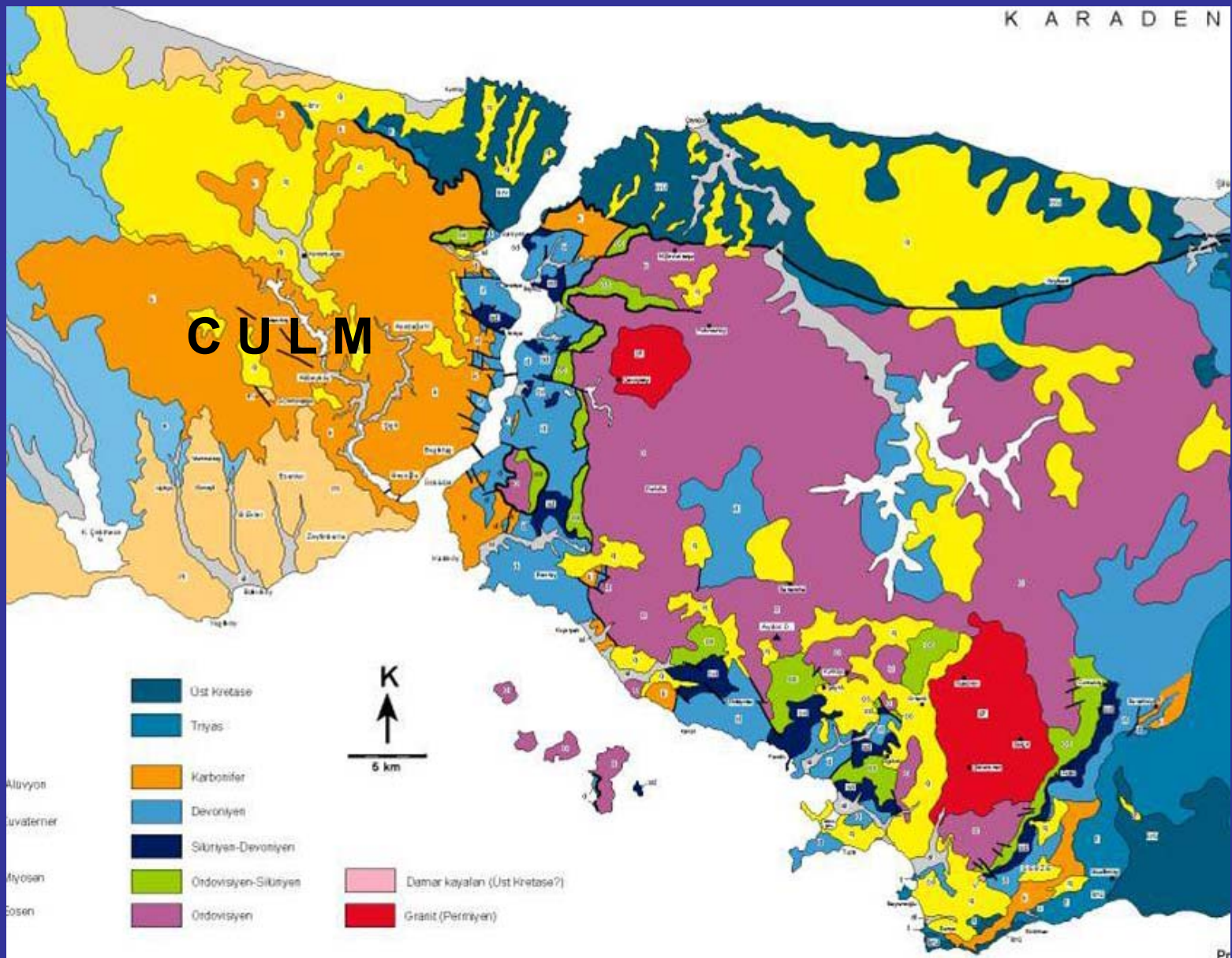
Lower Carboniferous (Visean) black cherts (\pm *Kulm Kiesel-schiefer*): deep restricted basin with little clastic input



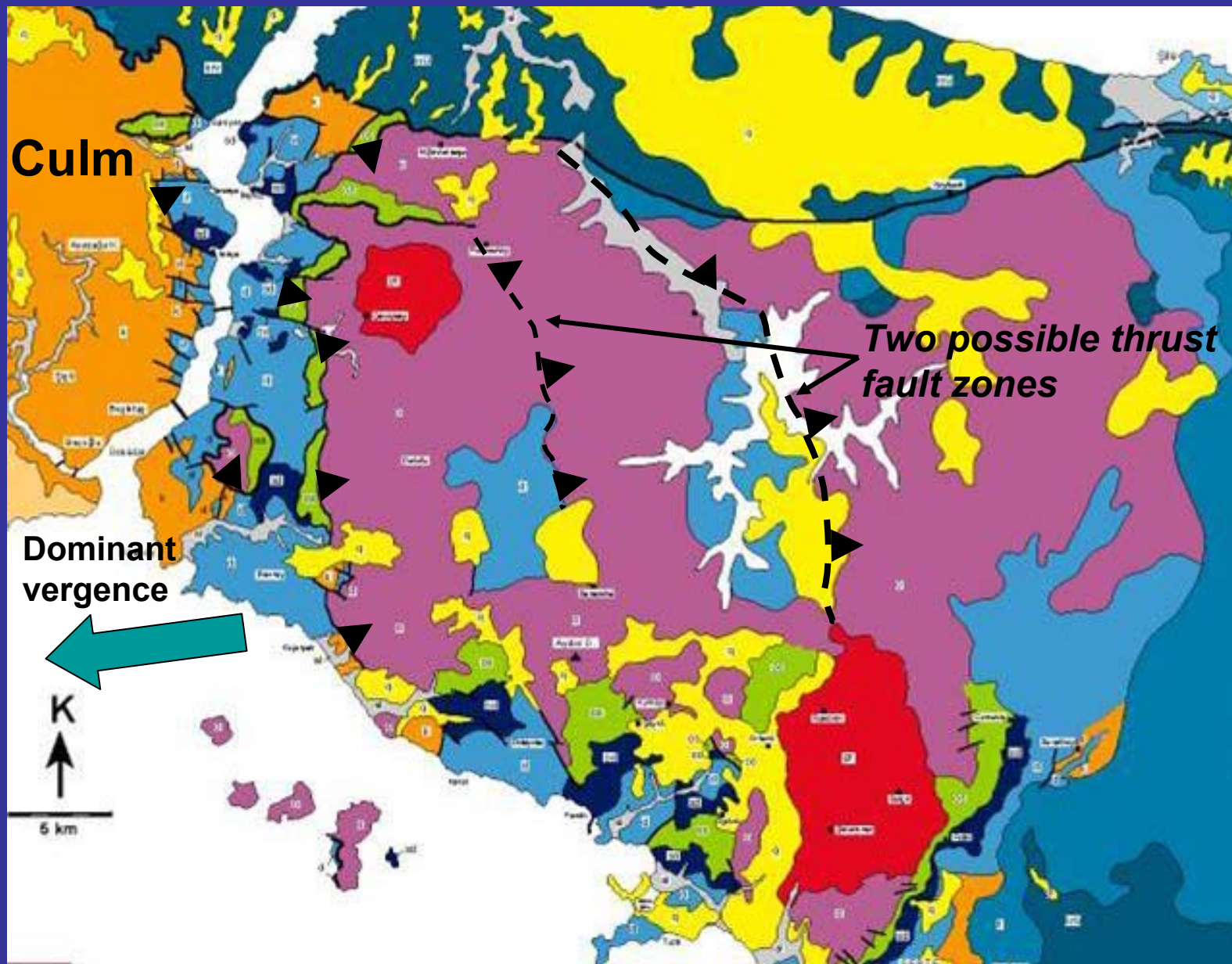
Lower Carboniferous flysch (=Kulm Ton- und Grauwackenschiefer): onset of Hercynian orogeny in Istanbul



Early Carboniferous flysch



The distribution of the Culm facies (orange) in and around İstanbul: notice its position in front of the thrusts in a marginal deep (fore- or hinterdeep)



The Hercynides in İstanbul are represented by a W-vergent foreland fold- and thrust belt



Folds showing top to W movement in the early Carboniferous flysch



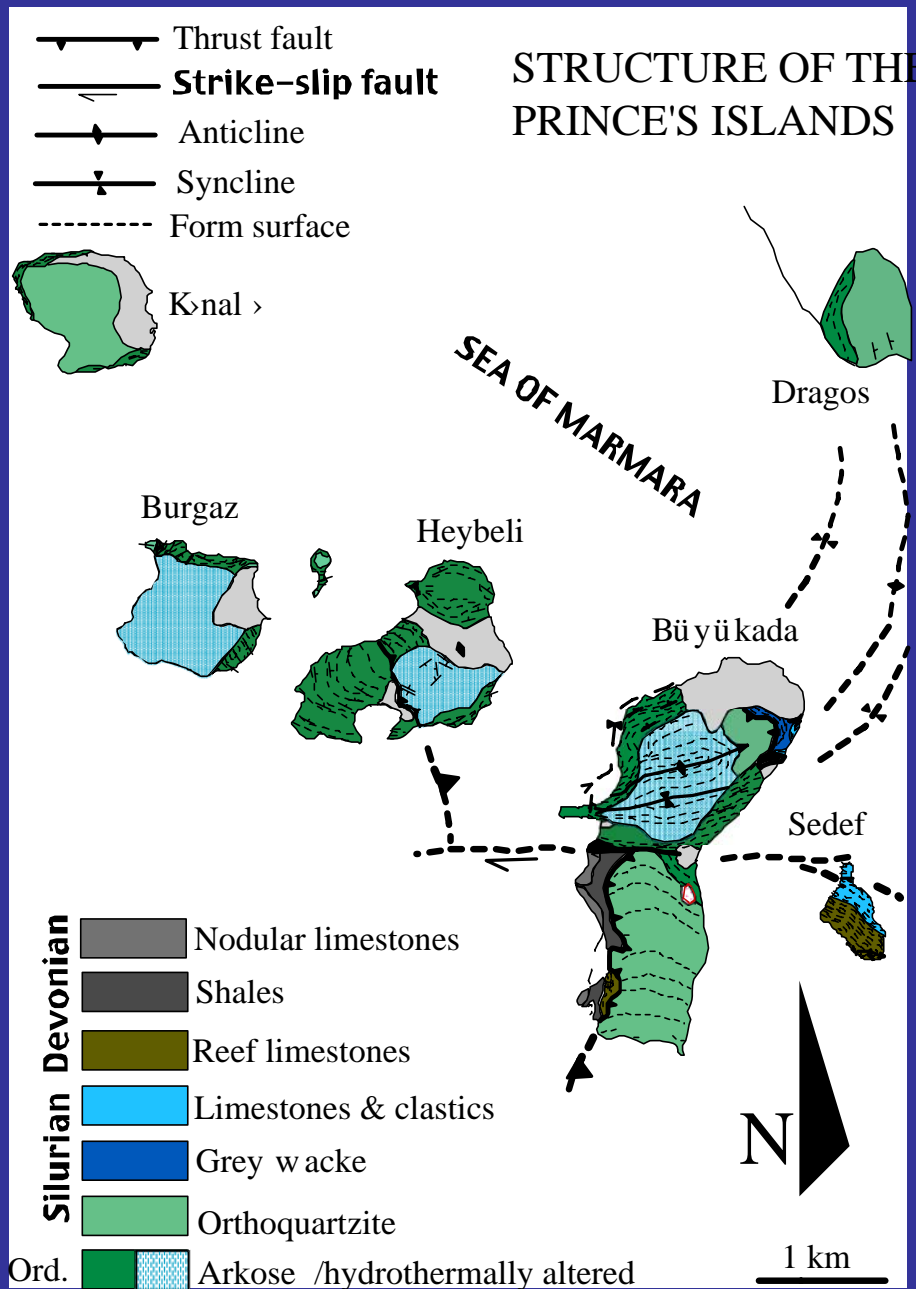
E-vergent asymmetric chevron folds in Middle Devonian shales



**W-vergent flexural slip fold in Upper Devonian limestones
in the Göksu Valley (= Sweet Waters of
Asia)**



W-vergent asymmetric folds and a thrust fault in the Upper Silurian-Lower Devonian limestones near Gebze (where Hannibal committed suicide)

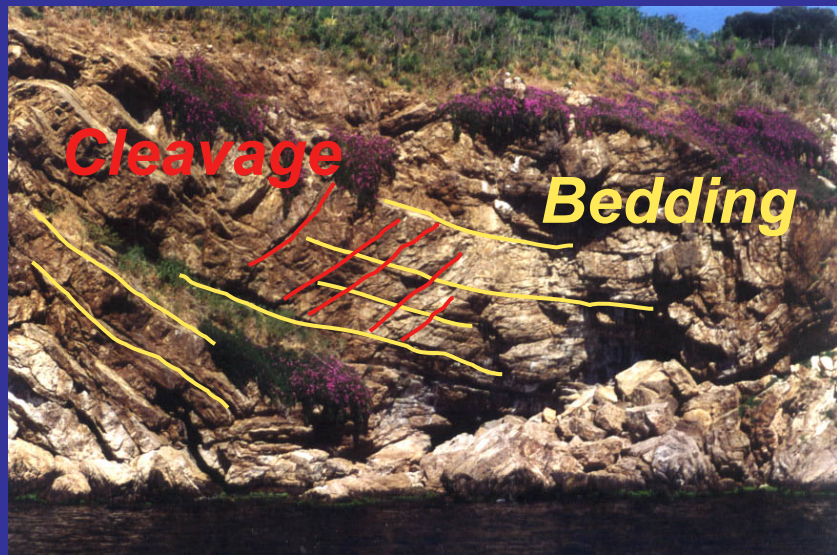
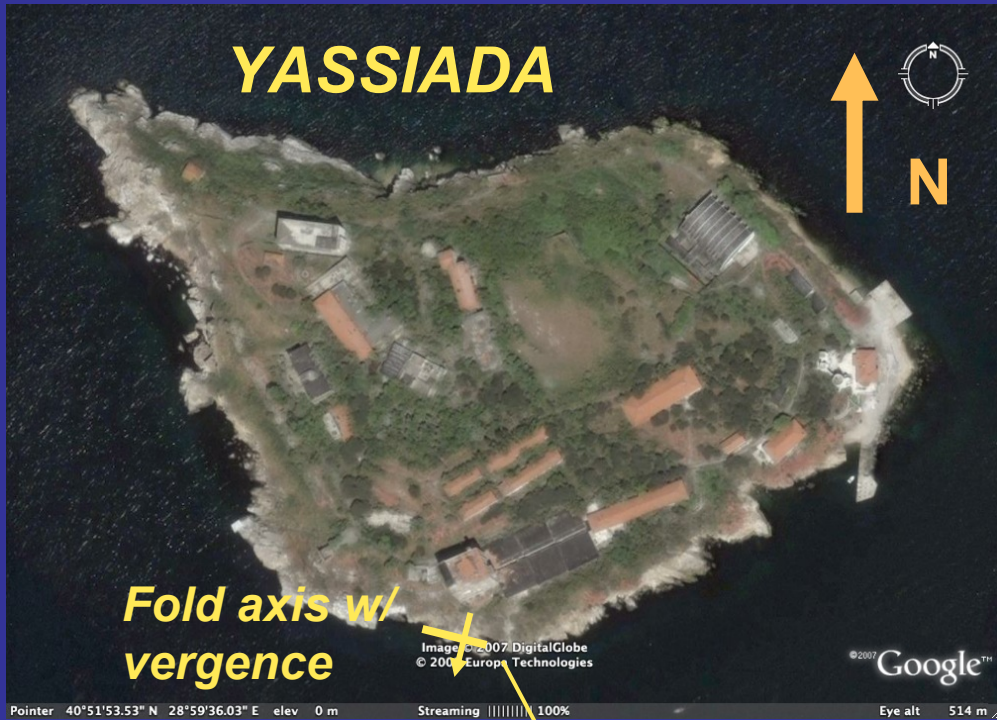


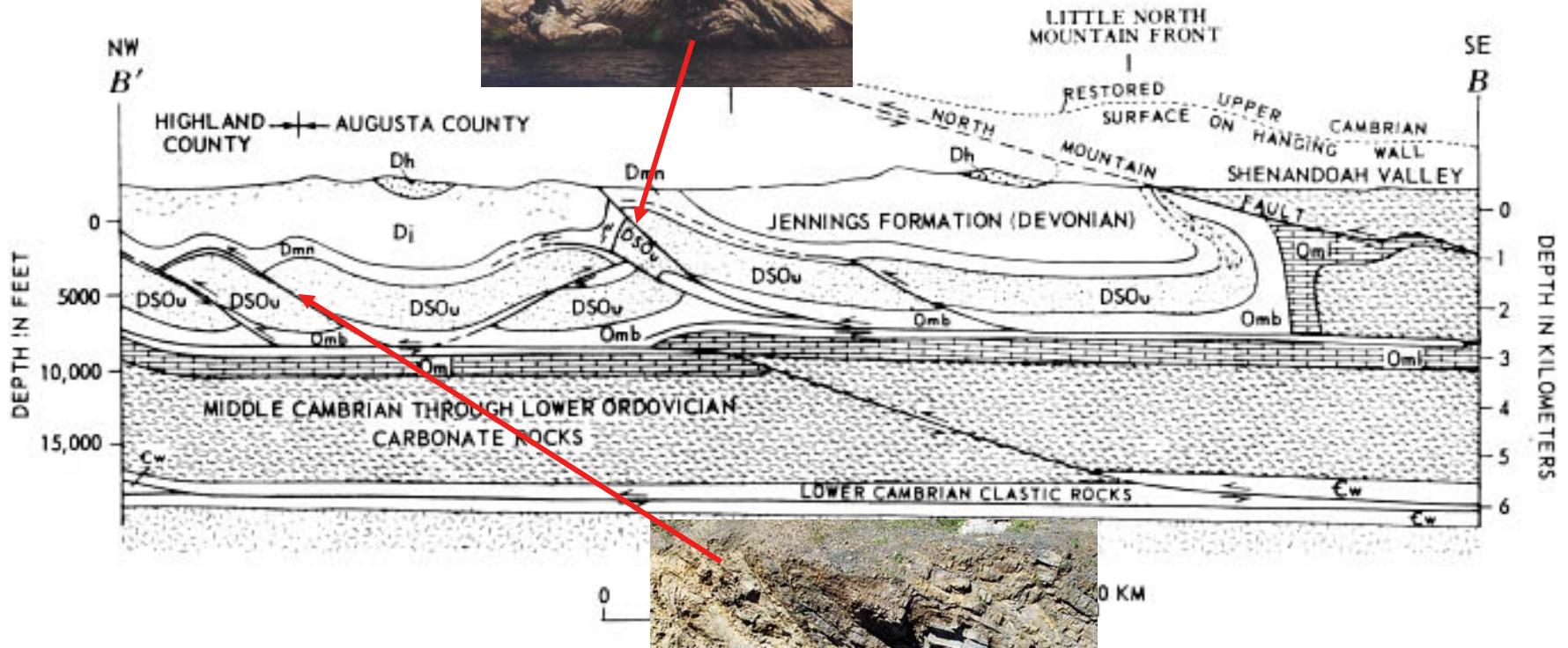
The structure of the *Prince's Islands* reinterpreted after Ketin (1953).

A clear west-vergent imbricated structure. Cleavage is only incipient and there is no metamorphism.

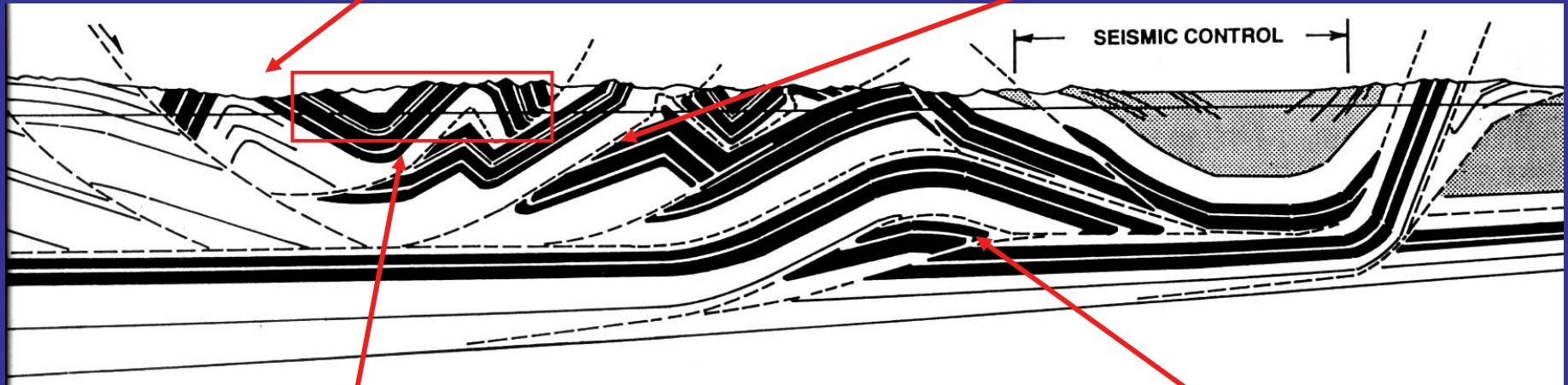
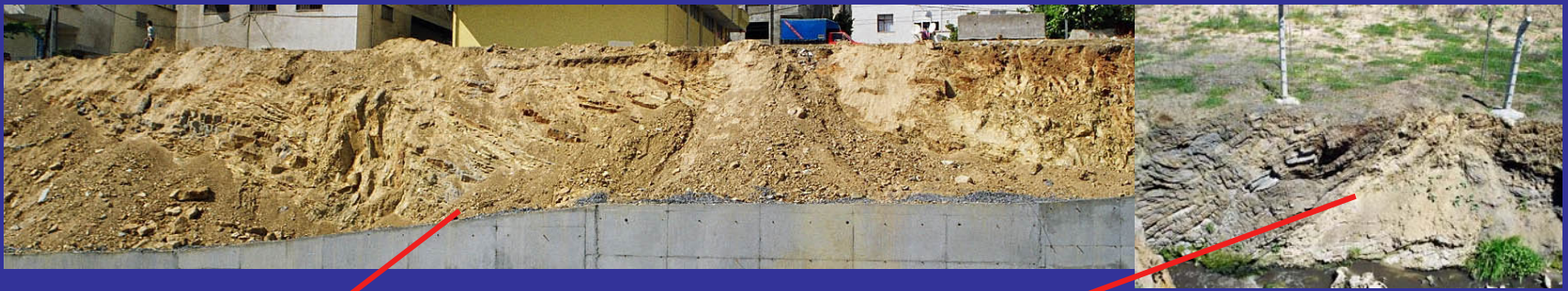


A doubly-overturned slump (?) fold S of the Island of Sedef
in early Devonian limestones



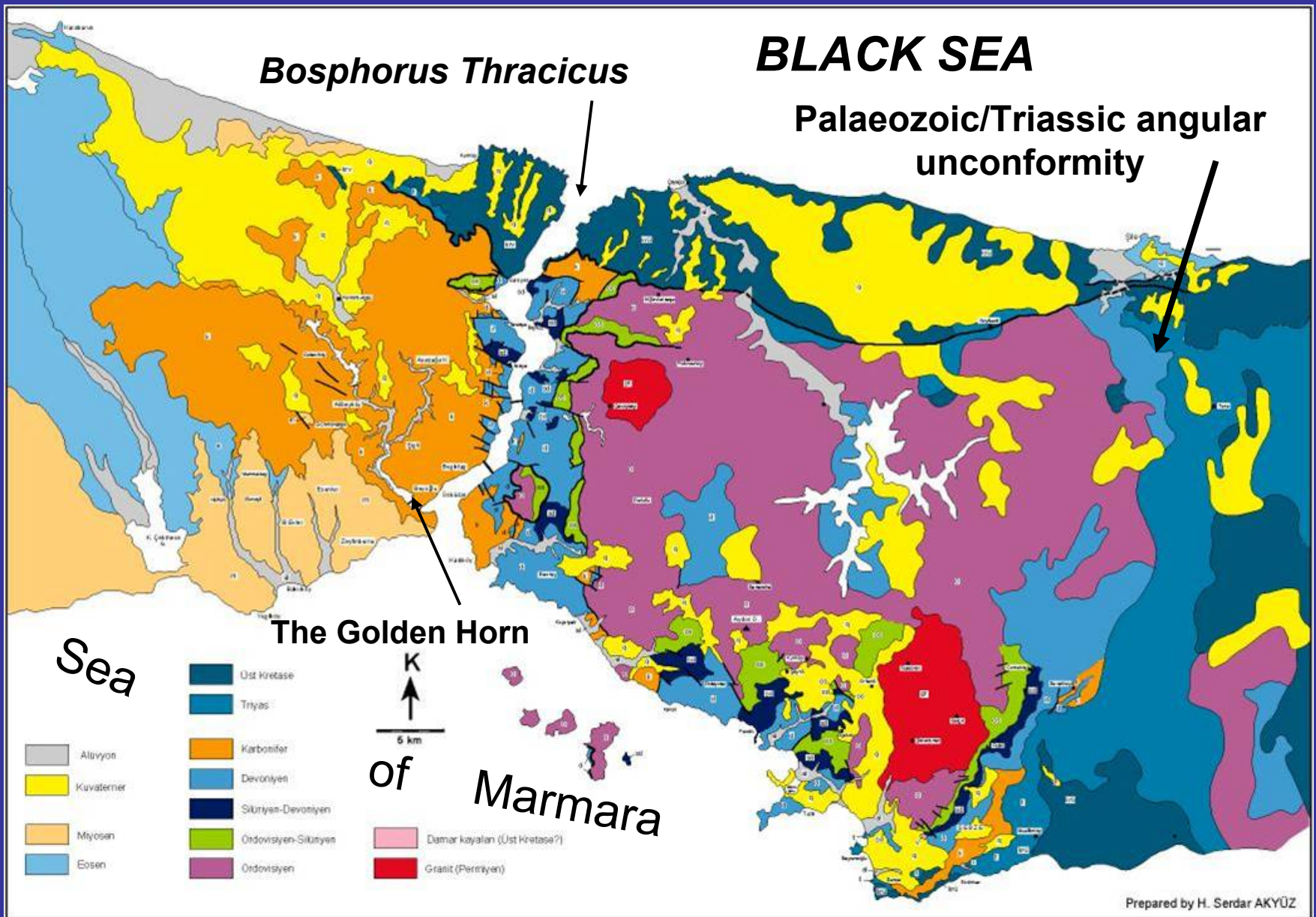


Comparative anatomy of fold and thrust belts



Comparative anatomy of fold and thrust belts

The Palaeozoic of İstanbul sits in a west-southwest-vergent fold and thrust belt. It is as yet not clear whether it is in a foreland or in a hinterland position.



The Triassic basaltic flow-bearing redbeds are the first unconformable deposits on the Palaeozoic of İstanbul



The basal conglomerate of the unconformable Triassic succession above the Palaeozoic of İstanbul

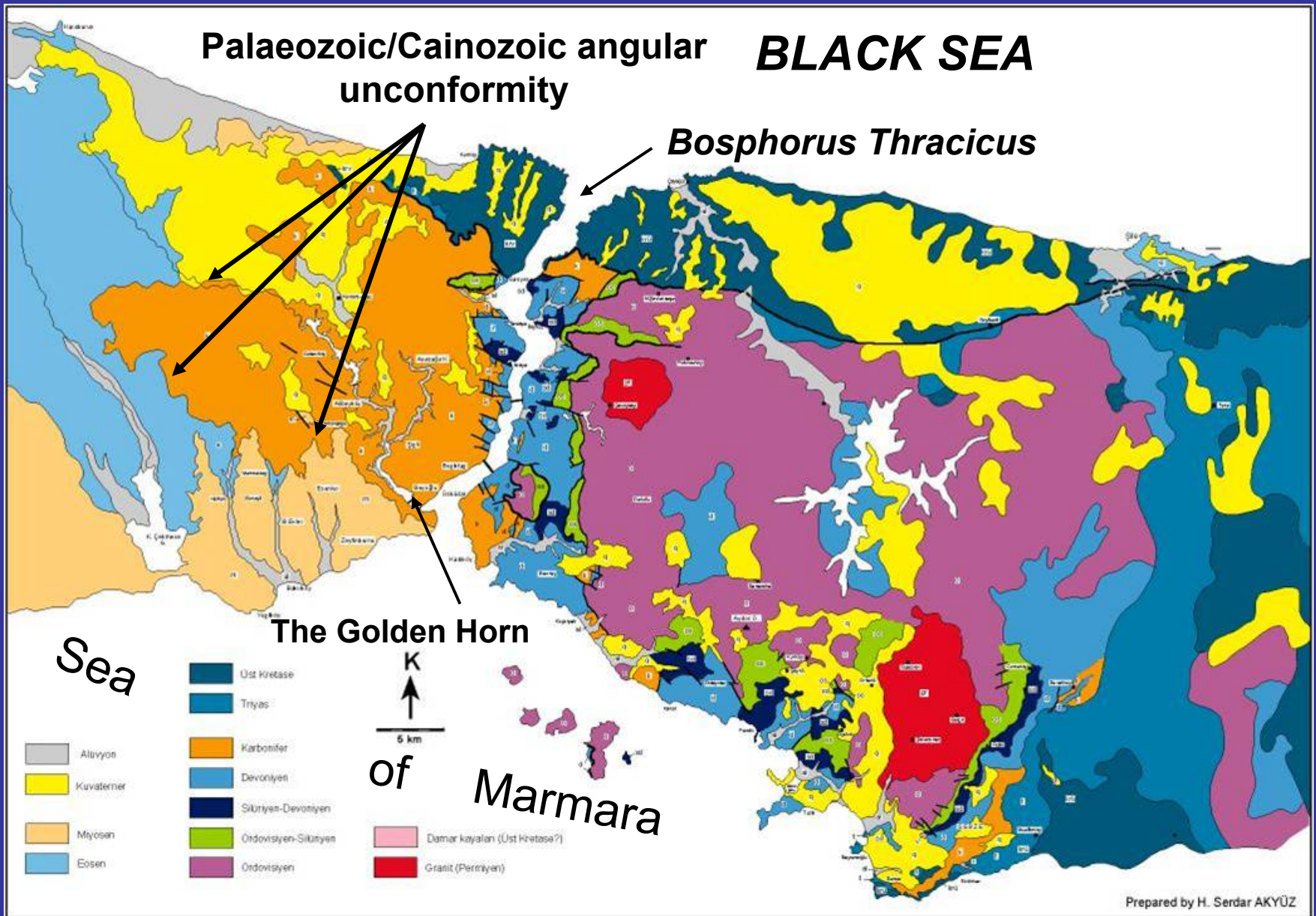


Rhyolitic tuffs and terrestrial sandstones of the basal Triassic above the Palaeozoic of Istanbul near Gebze

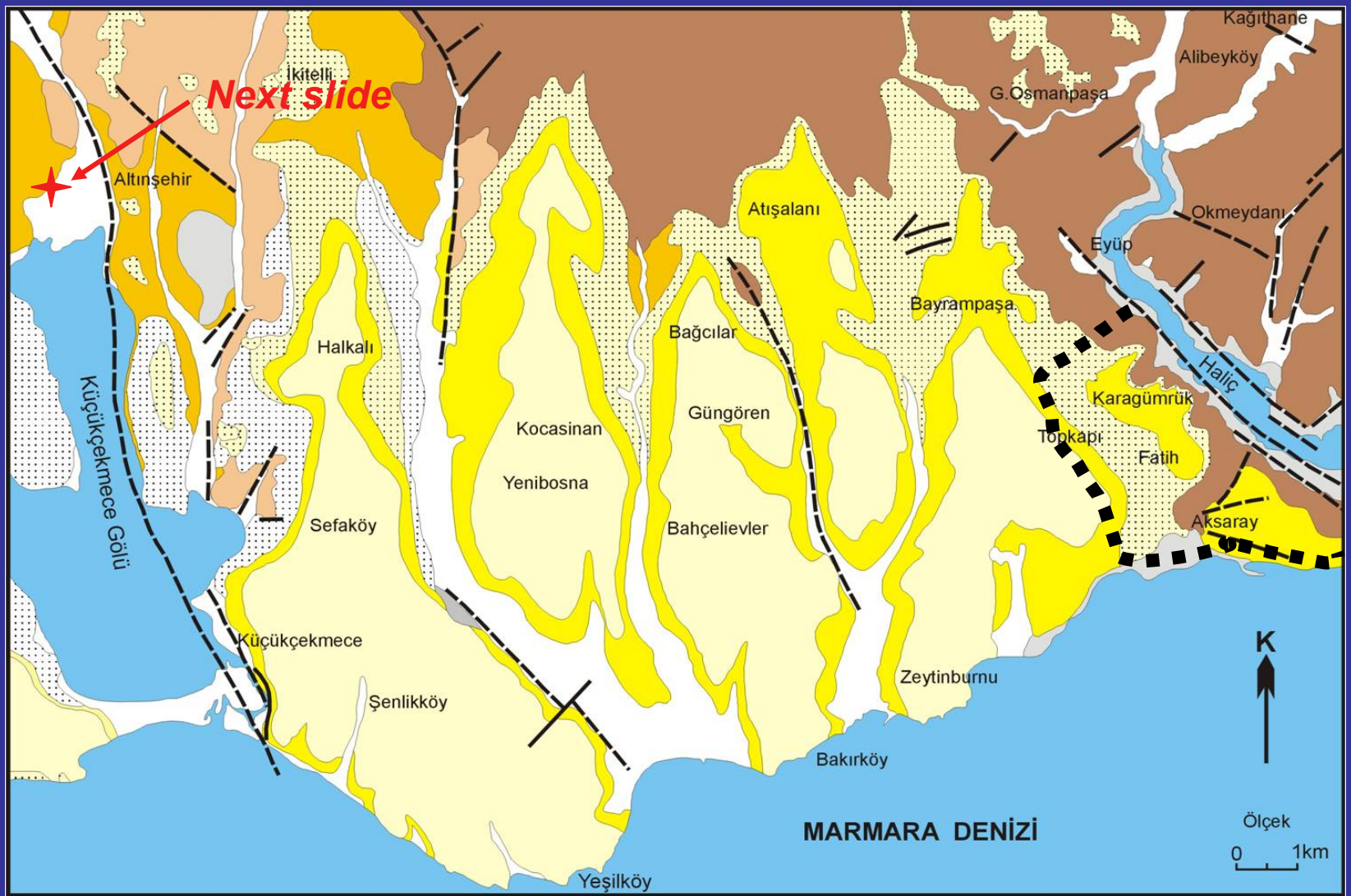
The Triassic around İstanbul is clearly an Alpine-type Triassic. It is thinner than the Triassic known from the Eastern and the Southern Alps and its ends with the Carnian under a sharp angular unconformity beneath the ?Coniacian (late Cretaceous) Hereke puddingstones, frequently used in İstanbul buildings as an ornamental stone.



Typical Hereke
Puddinstones from
İzmit, E of İstanbul



To the west, the Palaeozoic massif of Istanbul plunges beneath a Cainozoic cover



Trakva fm Carb.	İslambeyli fm Middle-Upper Eocene	Kırklareli kıt.	Gürpınar fm. Oligocene	Çukurçeşme fm. M-U Miocene	Güngören fm. Upper Miocene	Bakırköy fm.	Kuşdili Fm.-Alüvyon Quaternary	Yamaç molozu

Cainozoic deposits W of İstanbul



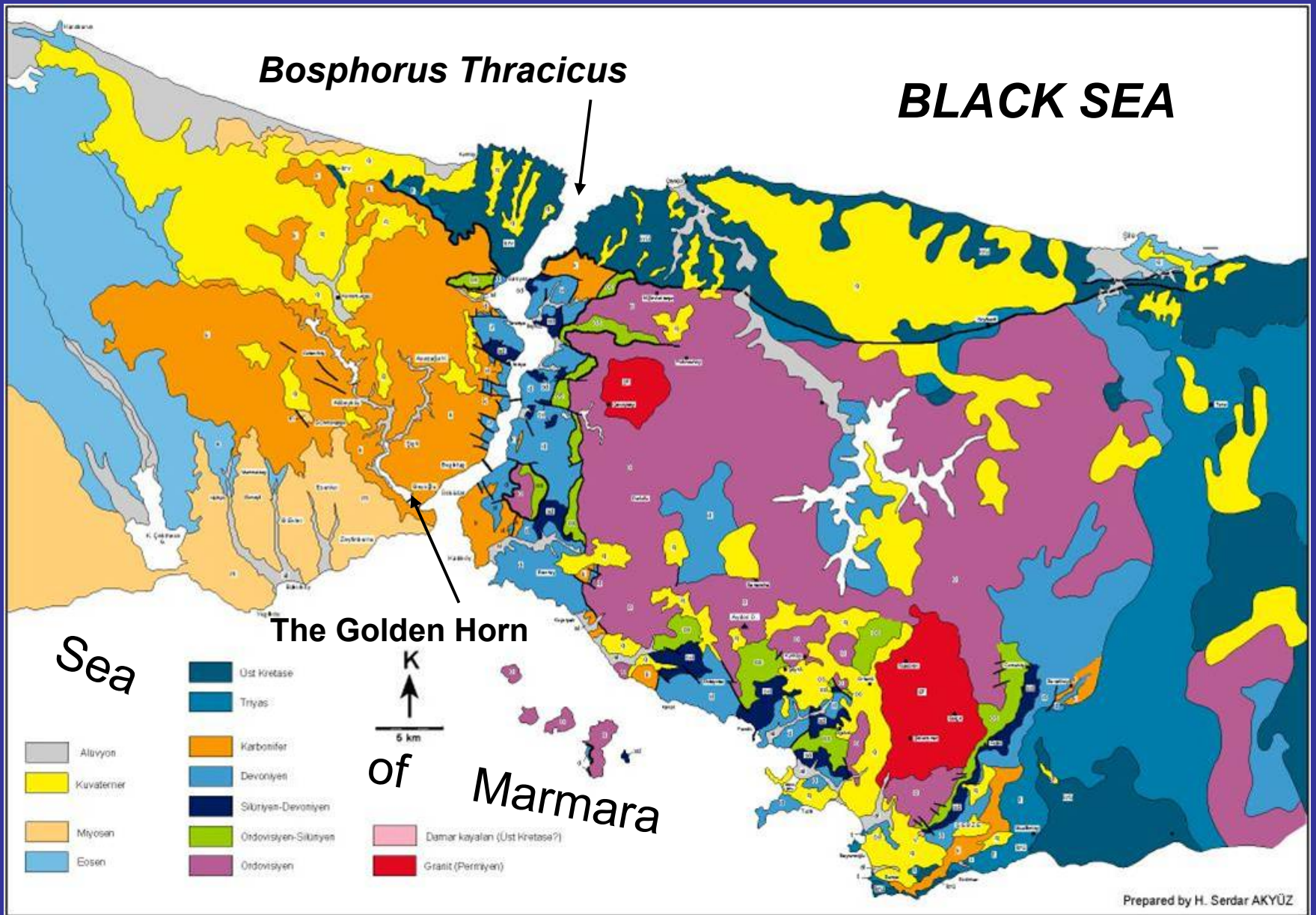
Eocene *in situ* reef core in Yarımburgaz, W of
İstanbul



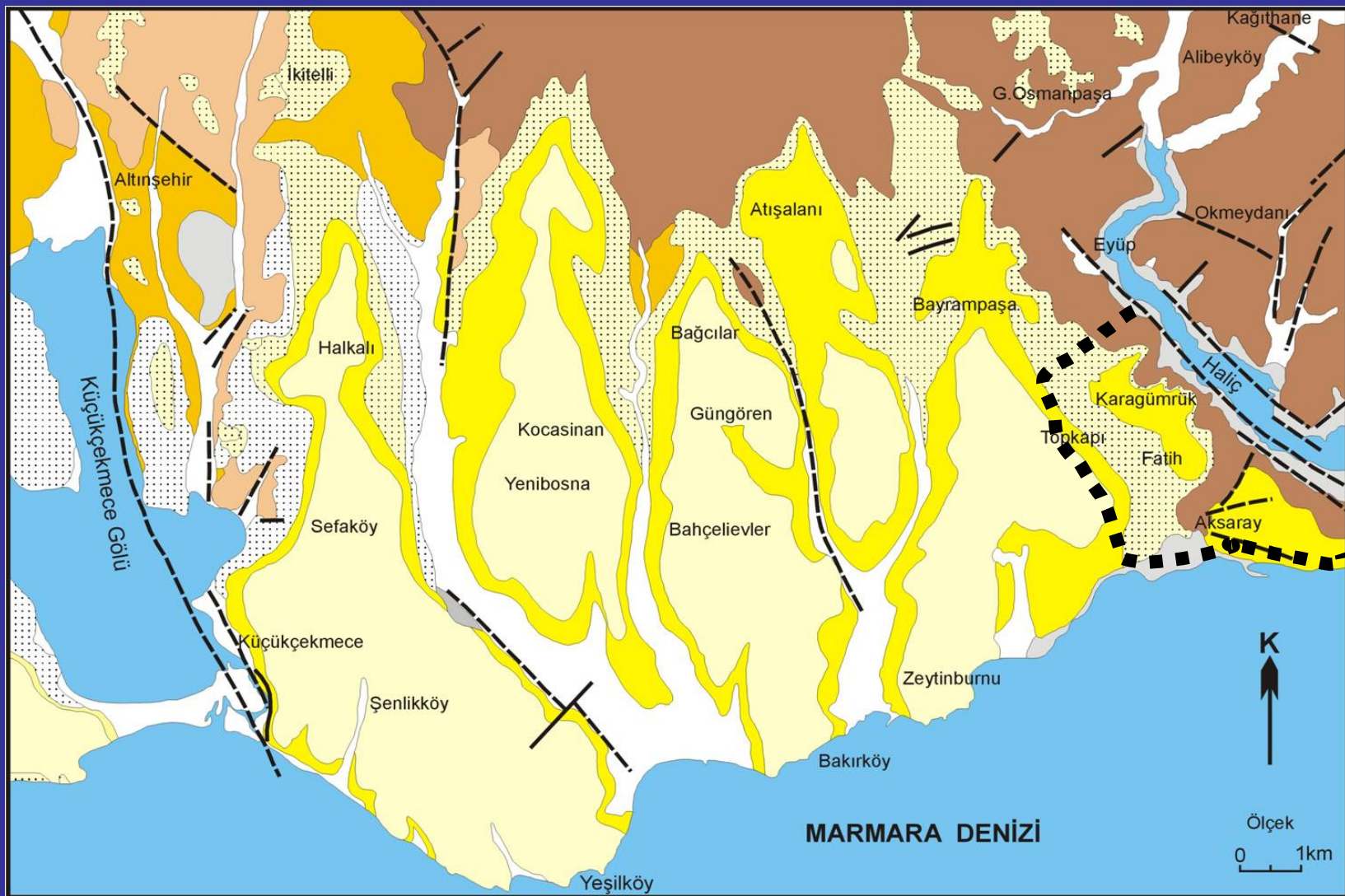
Corals in the Eocene reefs near Çatalca that are still *in situ*!



Nummulites gizehensis from the Priabonian (top Eocene) layers in the limestone quarries W of İstanbul. Diameter about 10 cm. (Also occurs in limestones used in building the Egyptian pyramids as first noted by Strabo)



The Miocene covers the Eocene disconformably in the western parts of the city

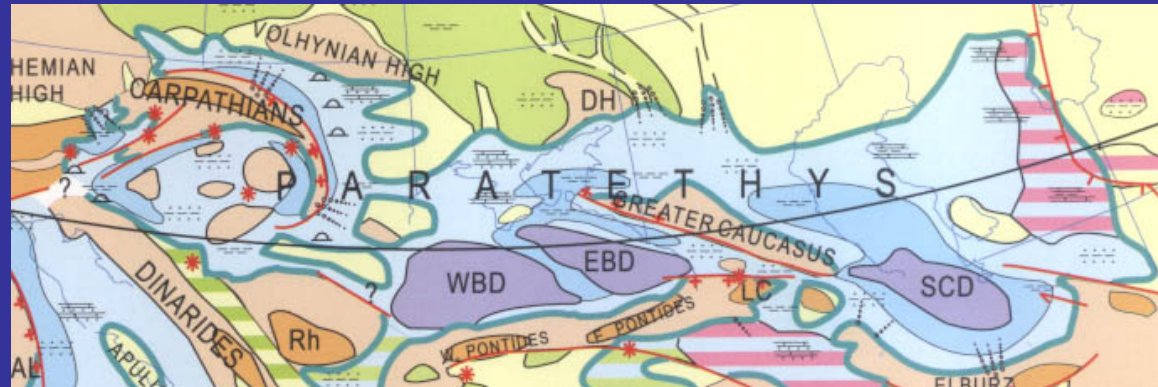


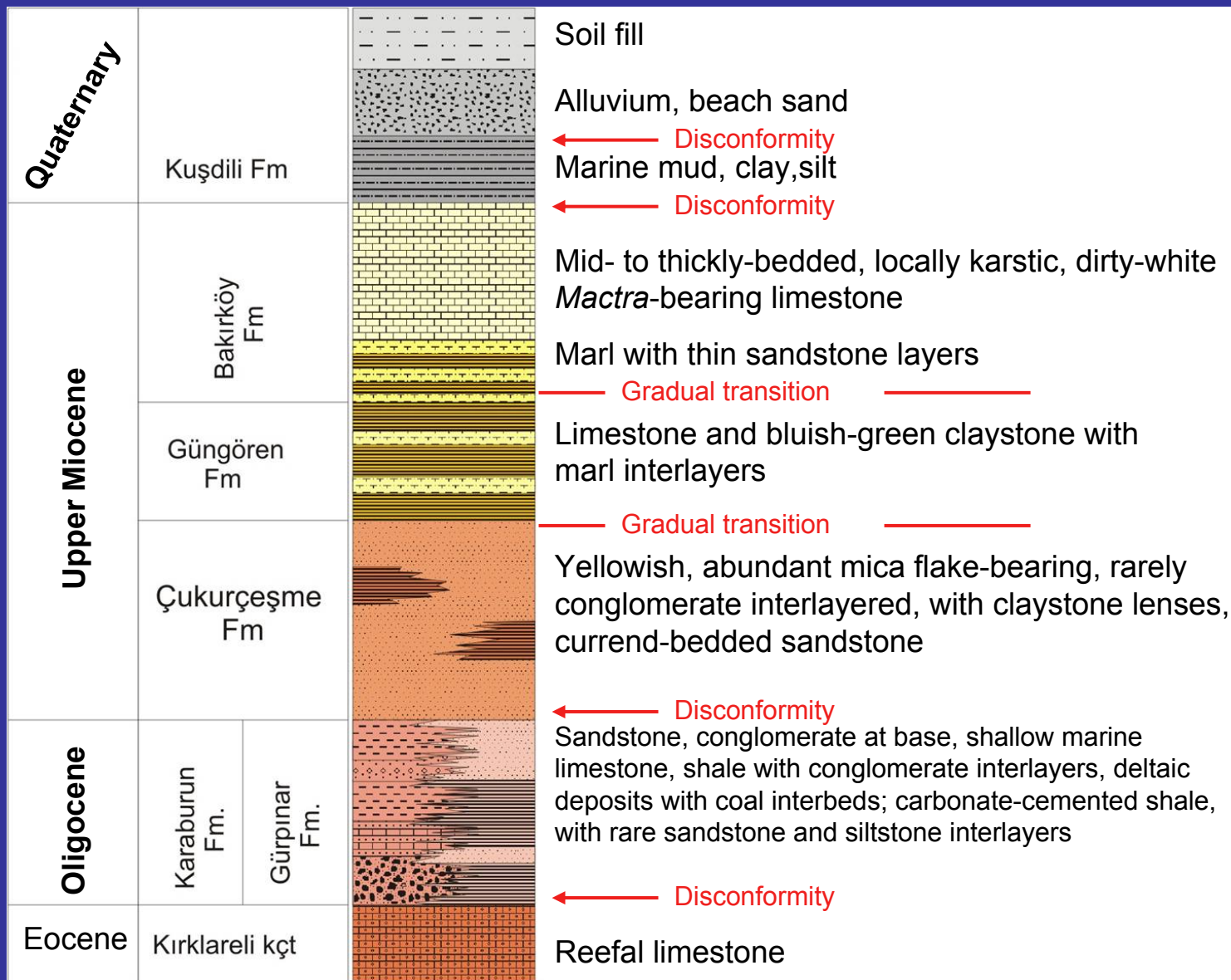
Distribution of the Miocene in the western suburbs of İstanbul

In the second chapter of this travel book, the *Seyahatname*, Evliya talks about the 'opening of the Black Sea': 'According to the true words of the historians familiar with astronomy, the Black Sea is a remnant of Noah's Flood. Its depth is 80 fathoms. It is a deep black sea. Before the Flood it did not mix with the Mediterranean and ended near the Black Sea strait near İstanbul. At that century, the fields of Salanta, Dobraçin, Keçkement, Kinkos and Pest and the valleys of Sirem Semendire in Hungary were entirely [parts of] the Black Sea. In the province of Dodushka near Venice, the places where the Black Sea used to mix with the waters of the Gulf of Venice are still visible. In fact, near Silistre the Fortress of Pravadi is a high burg reaching the skies. In that century, this fortress was at the sea shore. There are still iron rings to tie ships. Places on the rocks abraded by the rails of the bulwarks and the sterns of ships are still obvious. Another sign of the Black Sea is the Fortress of Menkub near Bahçesaray in the Crimea, which reaches the blue clouds. There too are ports to put the ships and columns to tie them. The Crimean island, the field of Heyhât, the Kipchak steppe and the entire land of Sakalibe were [parts of] the Black Sea., In fact a part of it reached the Caspian Sea, i.e., the Sea of Gilan and Demirkapı. In fact, this humble man [*i.e, the author*] found signs of marine creatures when, during the Moscow campaign in the era of İslâm Giray Khan, ... he was digging trenches in the field of Heyhât and in the places called Kerneli and Biym and Aşm for watering the horses. For instance, he dug out the shells of such insects [*sic*] as crabs, crawfish, mussels and oysters. From this it is understood that the valley of Heyhât was also [a part of] the Black sea.' (Evliya Çelebi Muhammed Zillî ibn Darviş 1314H {1896 AD}, pp. 37-38).



Evliya Çelebi
Muhammed Zillî ibn
Darvişl (1611-
?1682)





Cainozoic stratigraphy of the western tracts of İstanbul



Çukurçeşme current-bedded sands sitting unconformably on the deformed Palaeozoic



Çukurçeşme 'hooked' current bedding: definitive evidence for deposition in a stream



Mastra-bearing limestones, *Ostracode*-bearing shales and marls of the Upper Middle Miocene (Sarmatian)



Sarmatian limestone deposits with *Mactra* sp. (see inset) Paratethyan facies; almost identical to the Sarmatian in the Vienna Basin!

EXAMPLES FROM THE
KÜÇÜKÇEKMECE
VERTEBRATE ASSEMBLAGE
(Vallesian)

8.2 Ma *Dinotherium* molar
tooth



Aceratherium (similar to a
rhinoceros) molars
8.2 Ma







BLACK SEA

Bosphorus

SEA OF MARMARA

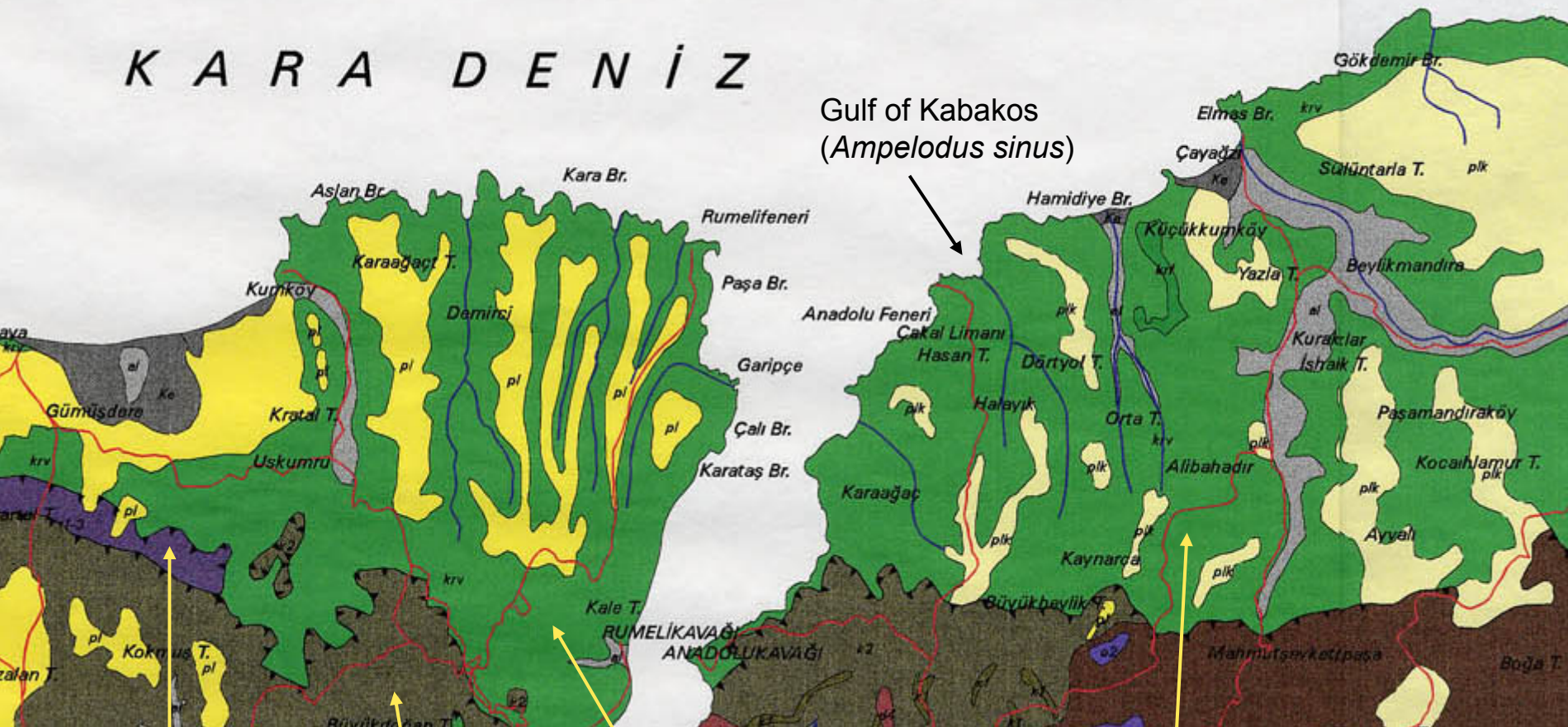
AEGEAN SEA

**Hellespont
(Dardanelles)**



**The
*Bosphorus
Thracicus***

K A R A D E N İ Z



Gulf of Kabakos
(*Ampelodus sinus*)

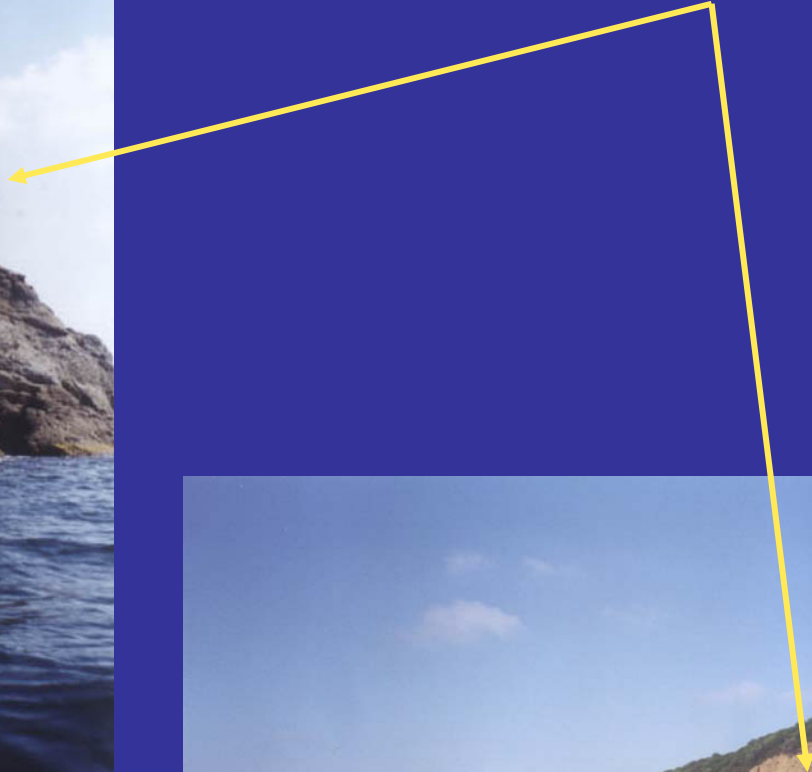
Triassic

Palaeozoic

Upper Cretaceous andesitic volcanics

NORTHERN EXIT OF THE BOSPHORUS

The Asiatic Symplegades or the “Clashing Rocks”





Massive flow with
columnar jointing

Agglomerates



Flow

Agglomerates



Face Occidentale d'Youn-Bournou, Cap à l'entrée de la Mer Noire, Côte d'Asie.

(a) Cirque Basaltique semblable à la Grotte de Fingal en Irlande.

Constantinople et le Bosphore de Thrace by Count Andreossy (1818)



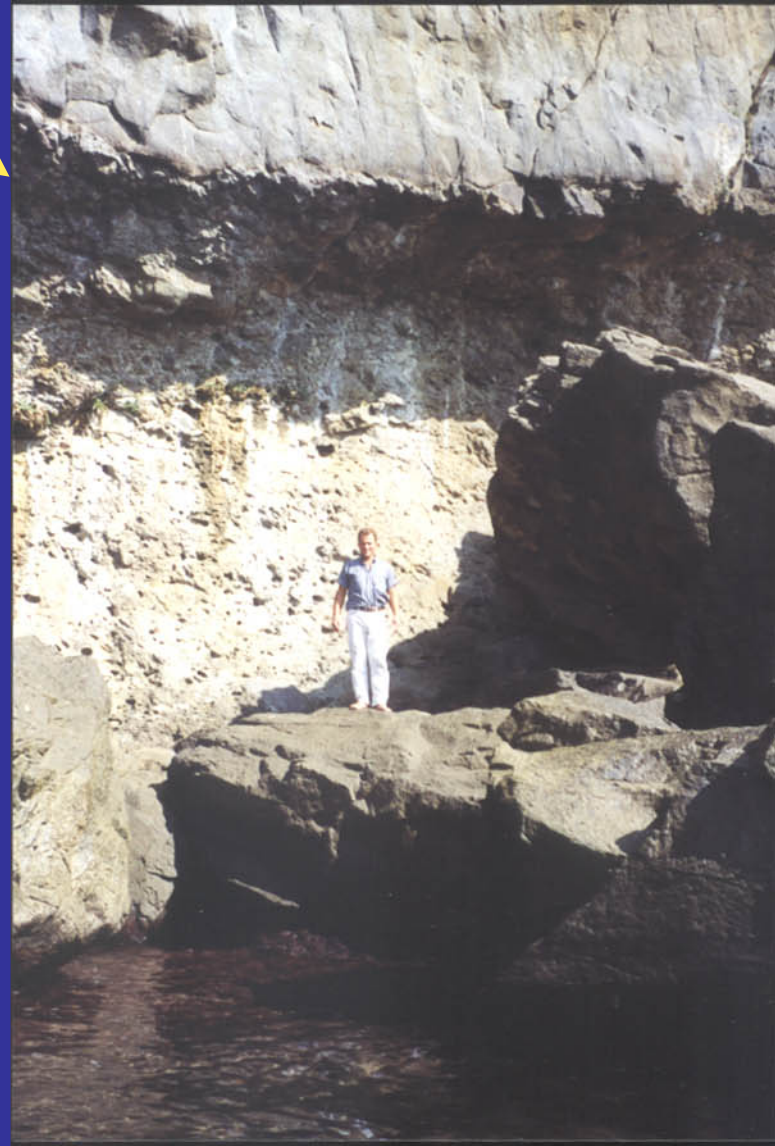
Fingal's Cave on Staffa, Scotland



Grotte de Fingal dans l'île de Staffa.

Explication de Playfair sur la Théorie de la Terre par Hutton (1815)

Flow/agglomerate contact



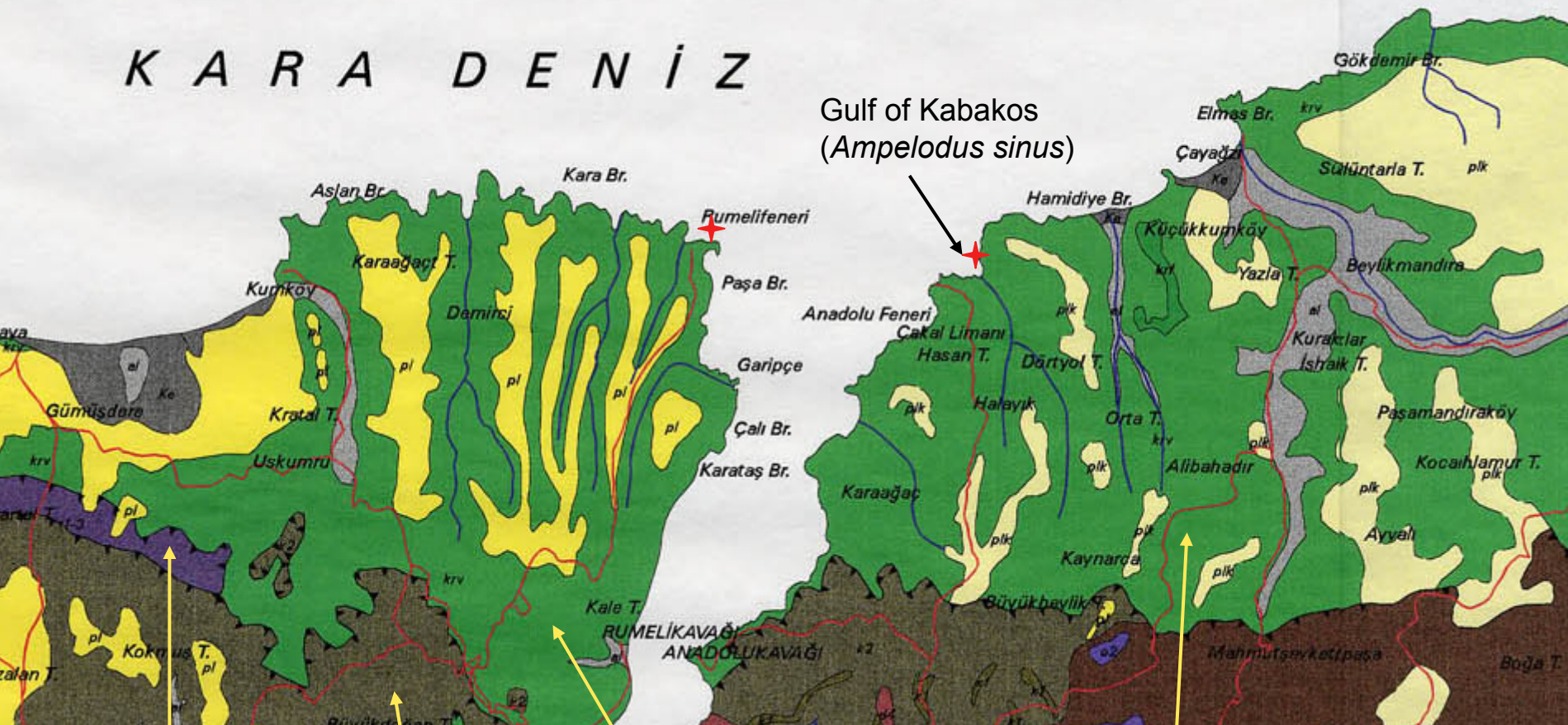
Agglomerates interlayered with andesitic flows in the Gulf of Kabakos, northern exit of the Bosphorus



Agglomerates in the south of the Gulf of Kabakos from the second edition of Count Andreossi's *Atlas* (1828)

K A R A D E N İ Z

Gulf of Kabakos
(*Ampelodus sinus*)



Triassic

Palaeozoic

Upper Cretaceous andesitic volcanics

NORTHERN EXIT OF THE BOSPHORUS

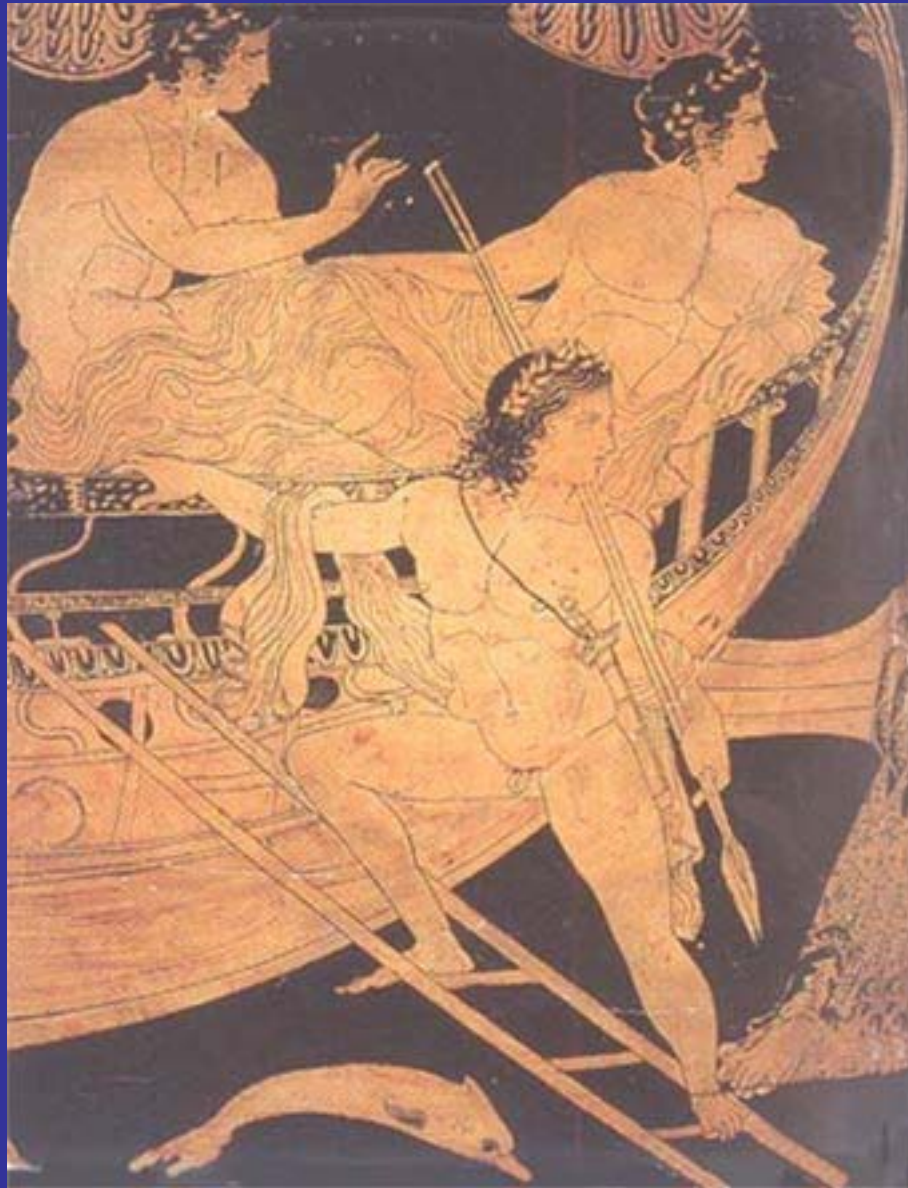
The European Symplegades (also agglomerates)



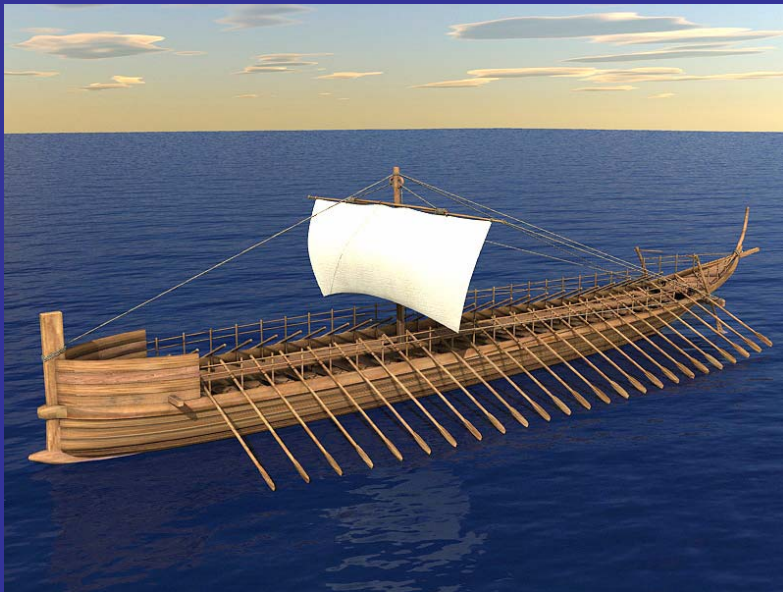
**Count Andreossy's sketch
(1818)**

The late Cretaceous (80 to 65 Ma on the basis of isotopic dating) to the north of İstanbul represents the andesitic volcanic rocks of a large stratovolcano sitting right at the northern exit of the Bosphorus and related to an ensialic island arc similar to that now seen in Japan. The Black Sea began opening by splitting this arc during the Aptian-Albian (125 to 99 Ma ago).

But, what is the origin of the myth of the clashing rocks, the Symplegades?



Argonauts on board the ship *Argo*



The route of the Argo after Malte-Brun (*Atlas de Géographie Universelle* 1837)

“First of all after leaving me, ye will see the twin
Cyanean rocks where the two seas meet. No
one, I ween, has won his escape between
them. For they are not firmly fixed with roots
beneath, but constantly clash against one
another to one point, and above a huge mass
of salt water rises in a crest, boiling up, and
loudly dashes upon the hard beach.”

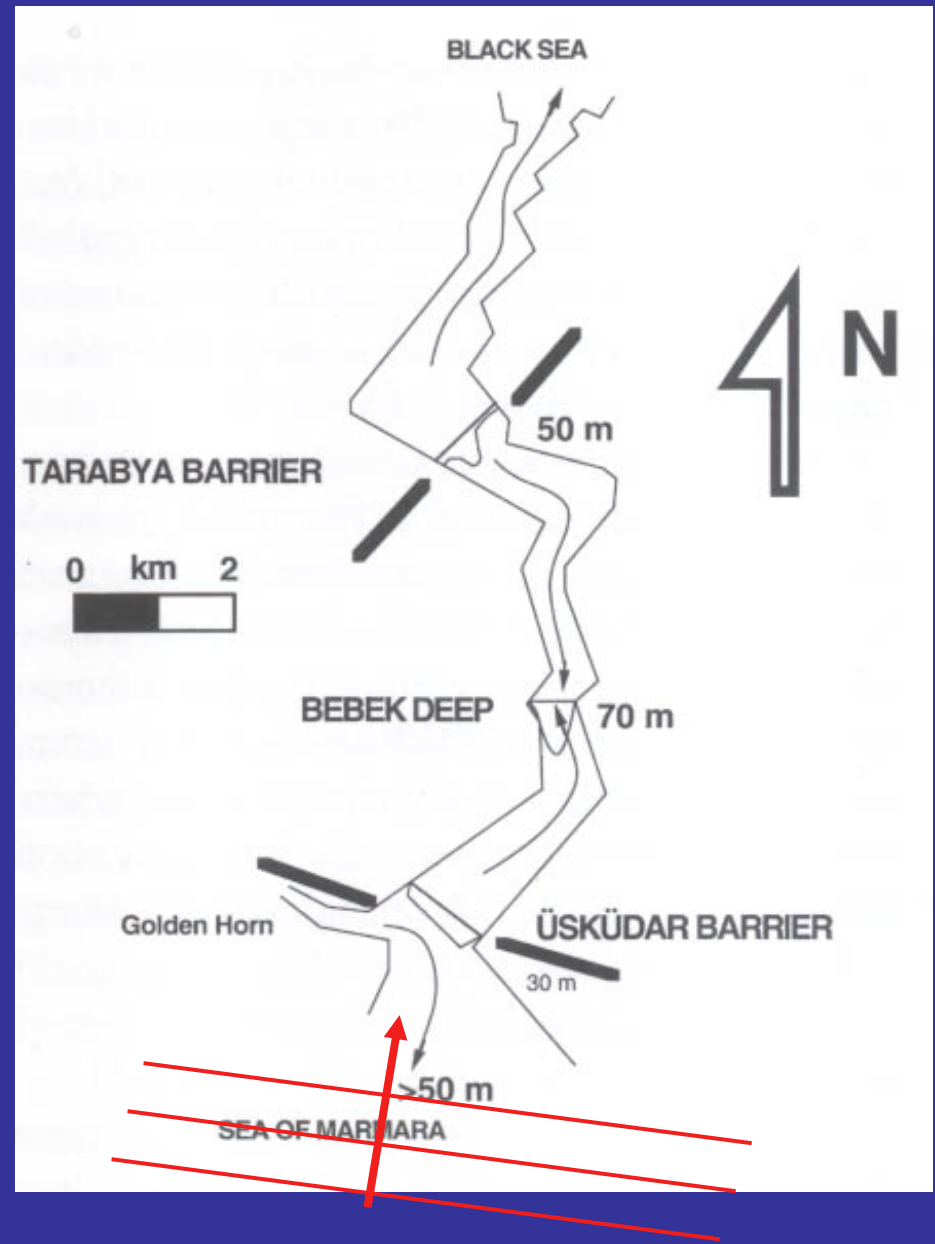
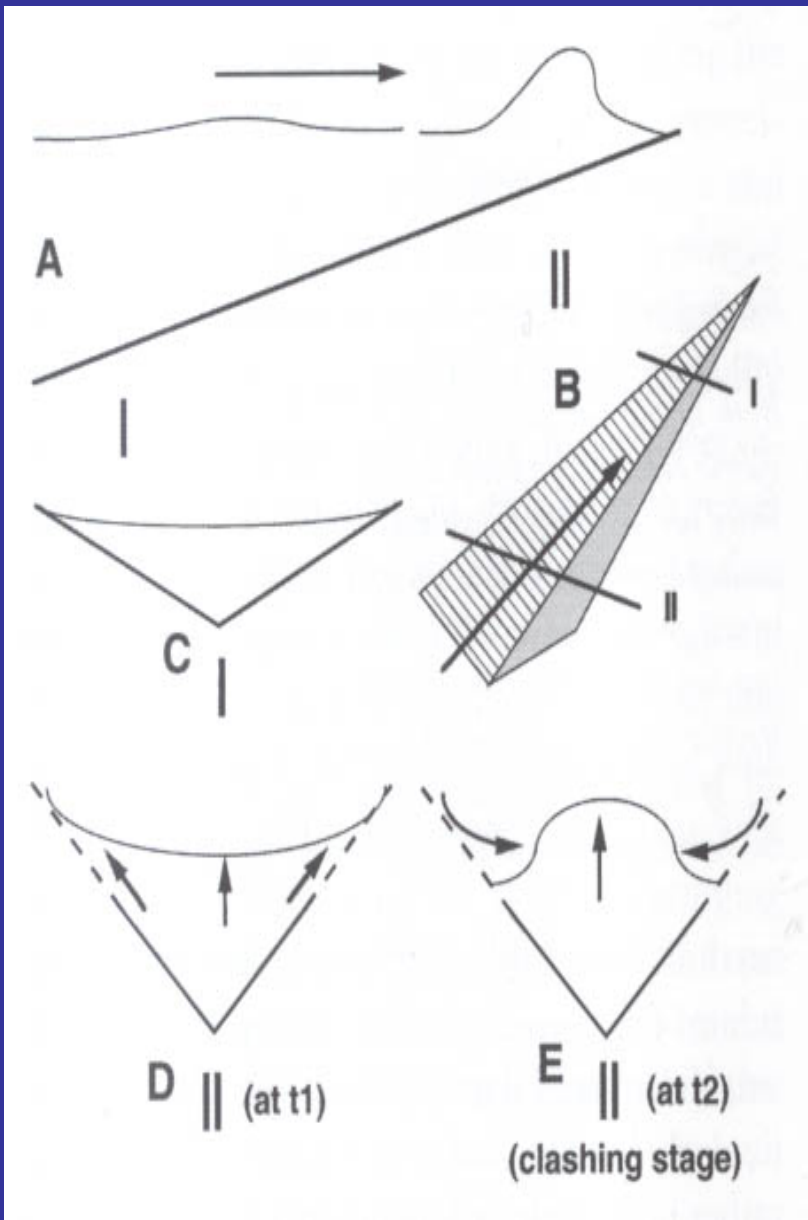
Apollonius Rhodius, *Argonautica*, II, 317-320

(English rendering by R. C. Seaton)

“From here your way lies north to the mouth of the Pontus in which the Cyanean rocks await that wander across the water, clashing in fury to crash their rocky cliffs together and falling apart again. No ship have they ever seen, for no one has dared to defy their violent motion that shakes the world’s very foundation: the ground shudders, and houses along the coast and even inland tremble and quake. But heaven, perhaps, will help you, for you will require help and wisdom, too, for your venture upon the uncharted sea from which even the birds keep away and the winds avoid. Neptune himself, uneasy about this part of his realm, guides the reins of his frightened steeds in other directions. What you must do is find a moment when these great rocks delay, and take advantage of that unusual chance to make your sudden dash. They separate and retreat and they reach the opposing shores, but then with a roar of water of enormous roiled waves they rush together again like mountains charging each other, and blue-green brine sluices down their oncoming flanks.”

Gaius Valerius Flaccus, *Argonautica*, IV, 924-930
(English rendering, 1999)

(David Slavin’s



Tsunami from the Sea of Marmara



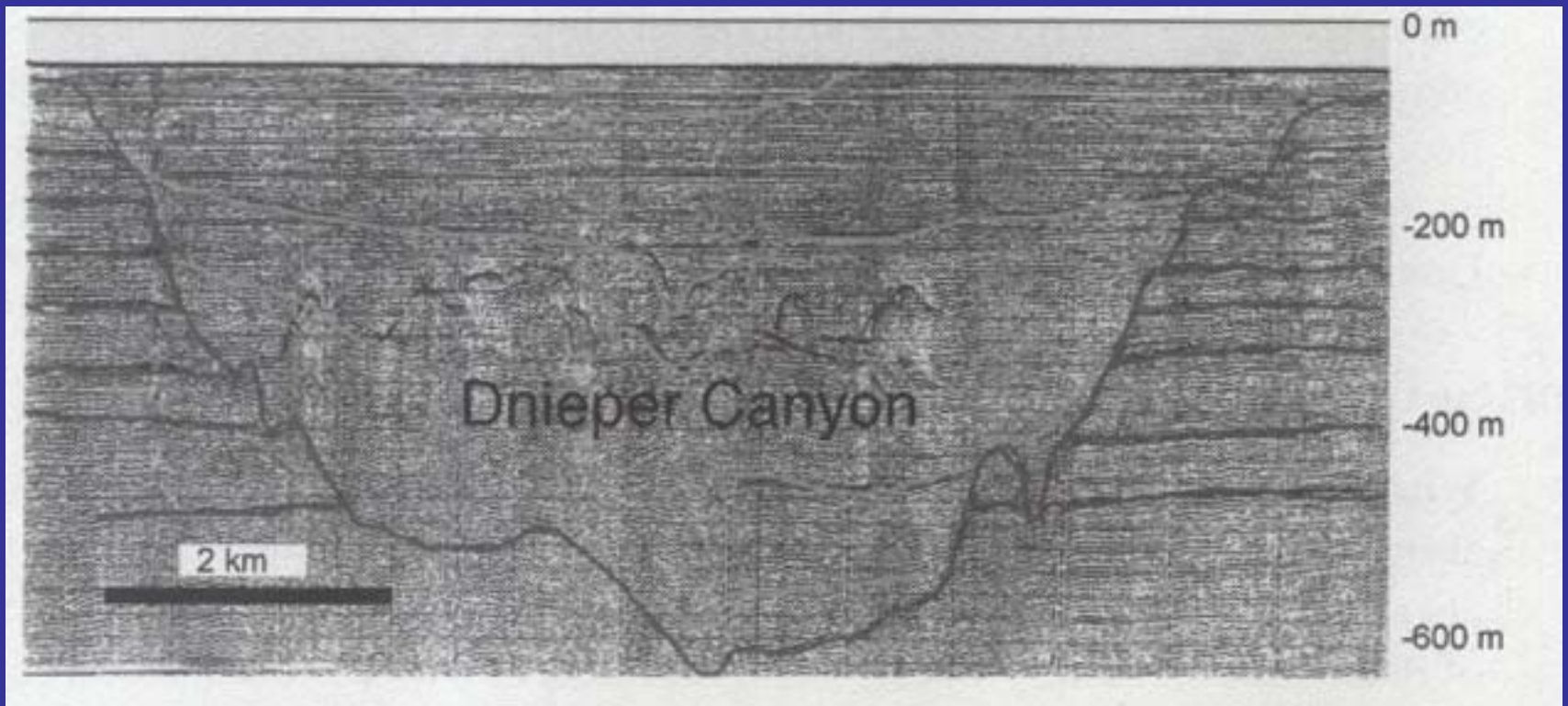
BLACK SEA

Bosphorus

SEA OF MARMARA

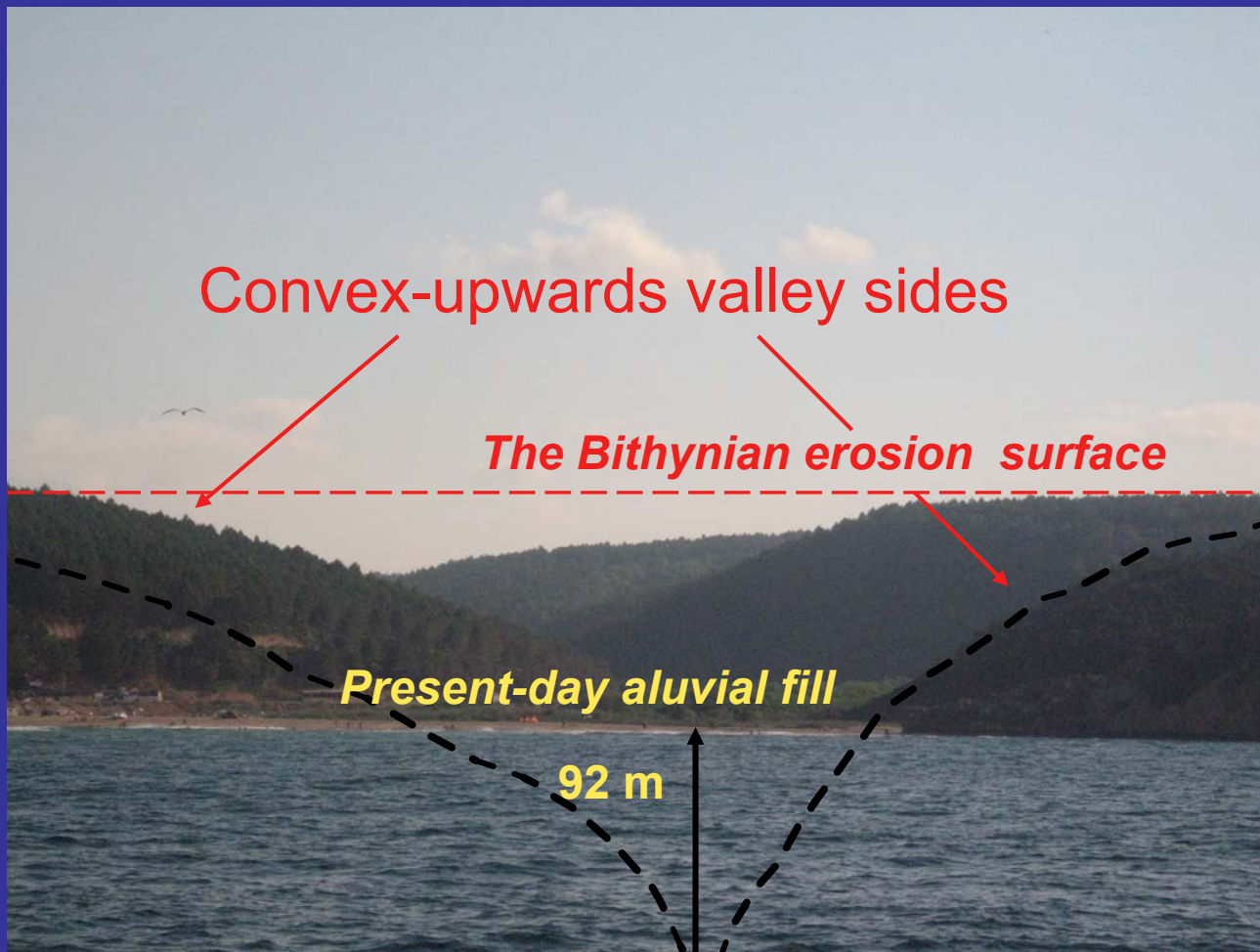
AEGEAN SEA

**Hellespont
(Dardanelles)**



Seismic profile across the Dnieper buried canyon
(From Ryan et al., 2003, fig. 3)





Convex-upwards valley sides

The Bithynian erosion surface

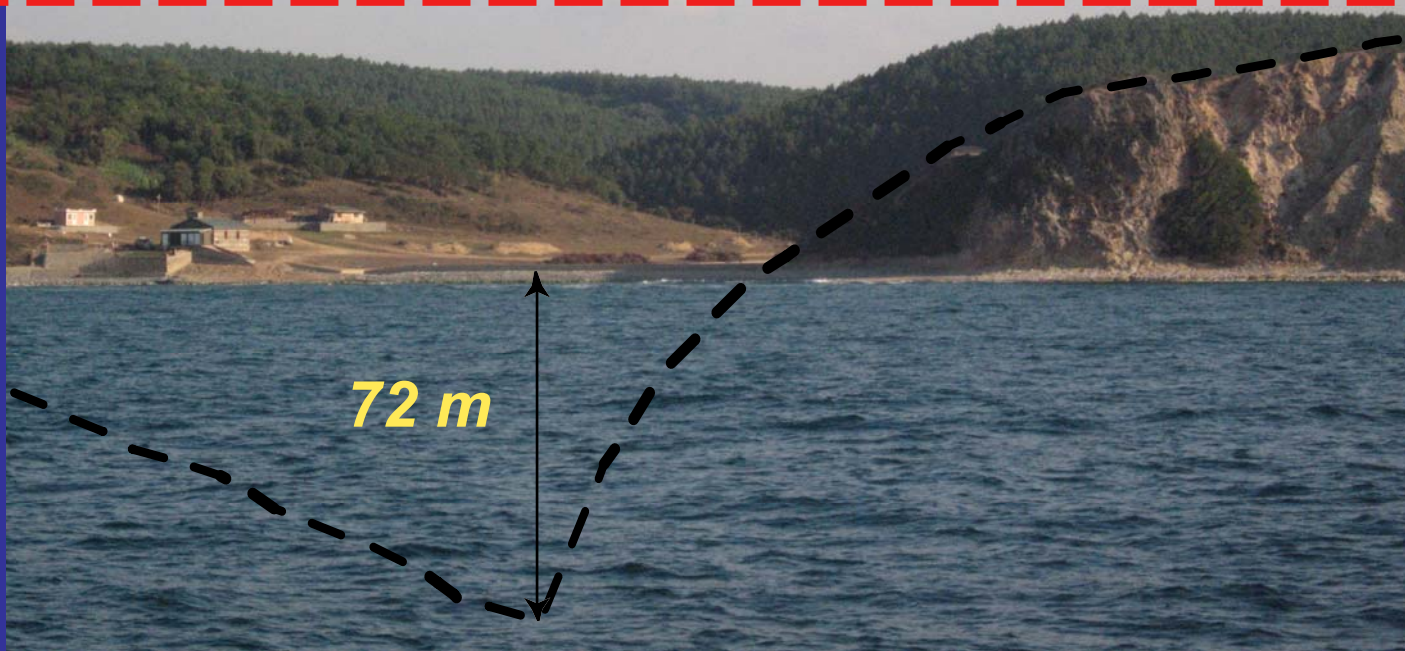
Present-day aluvial fill

92 m

***Probable depth excavated while the
Black Sea level was low***



Bithynian erosion surface



***Probable depth excavated while the
Black Sea level was low***



**A view of the
northern exit of the
Bosphorus on a
certain day c. 8000
years ago**



1509



1894



Earthquake in Istanbul



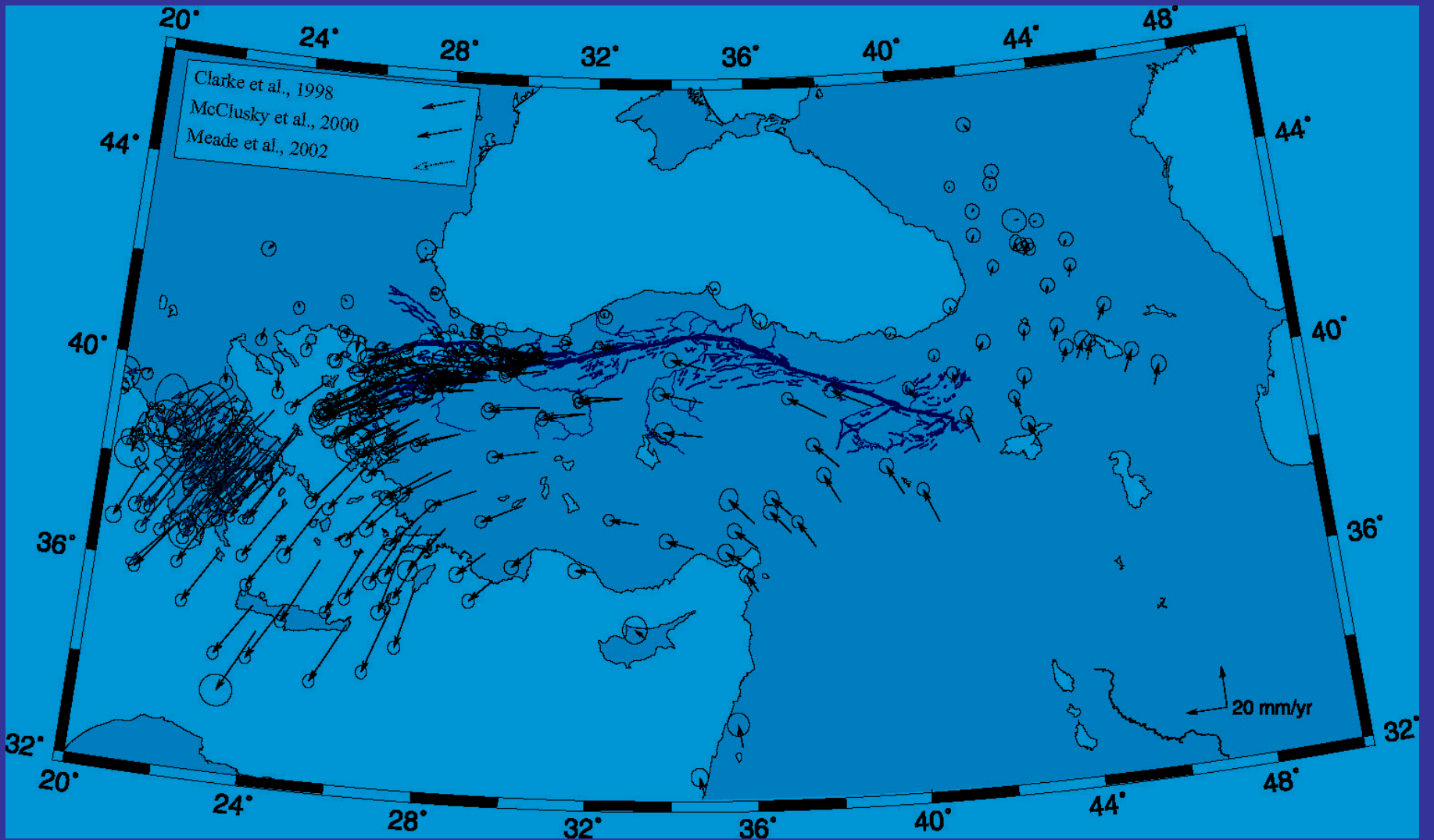
1894

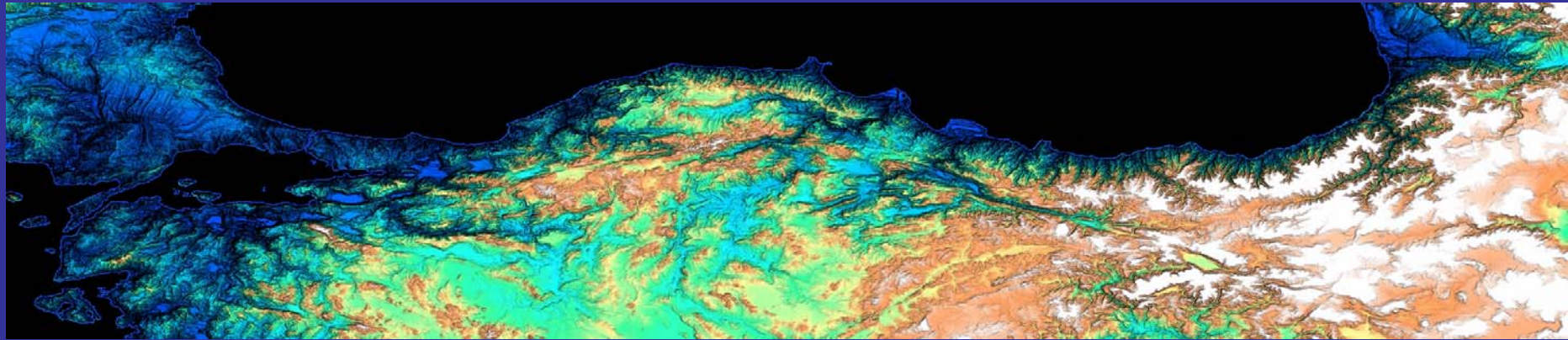


1556

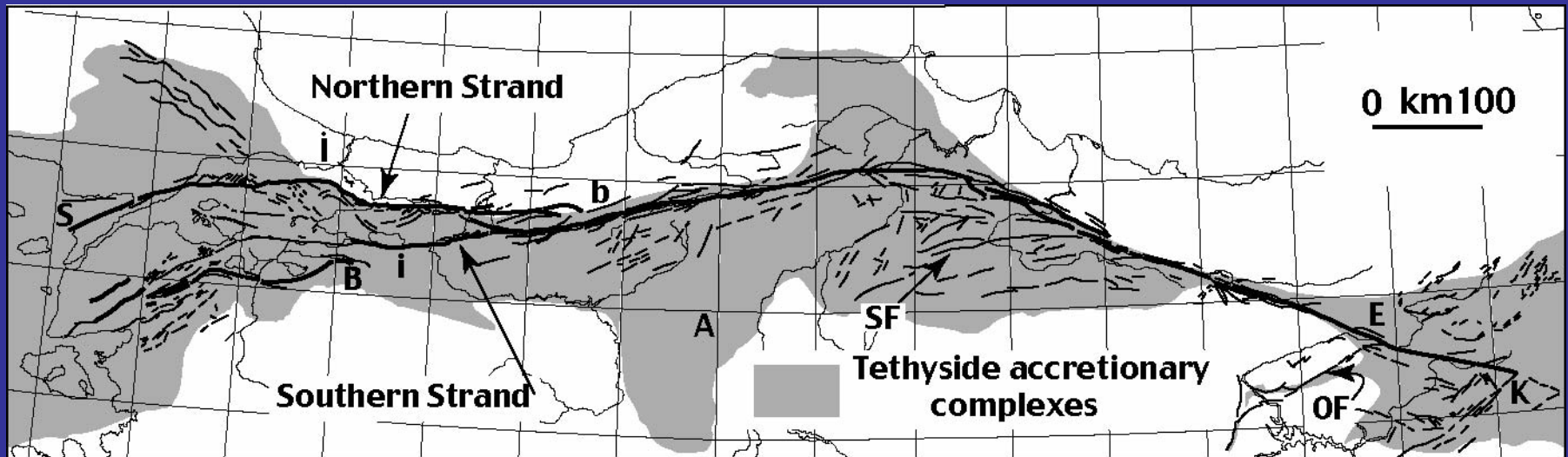


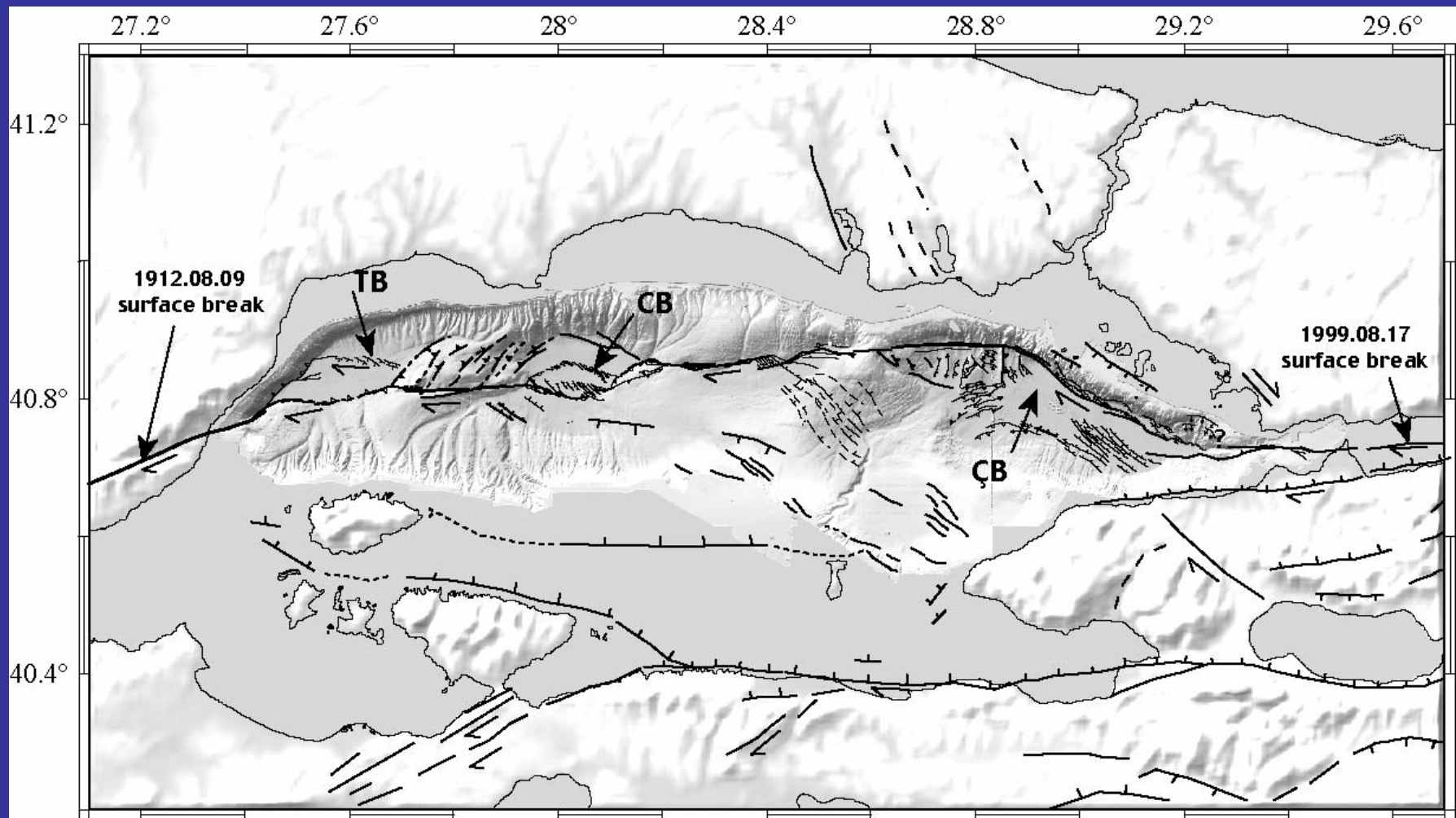
1999





The North Anatolian Fault





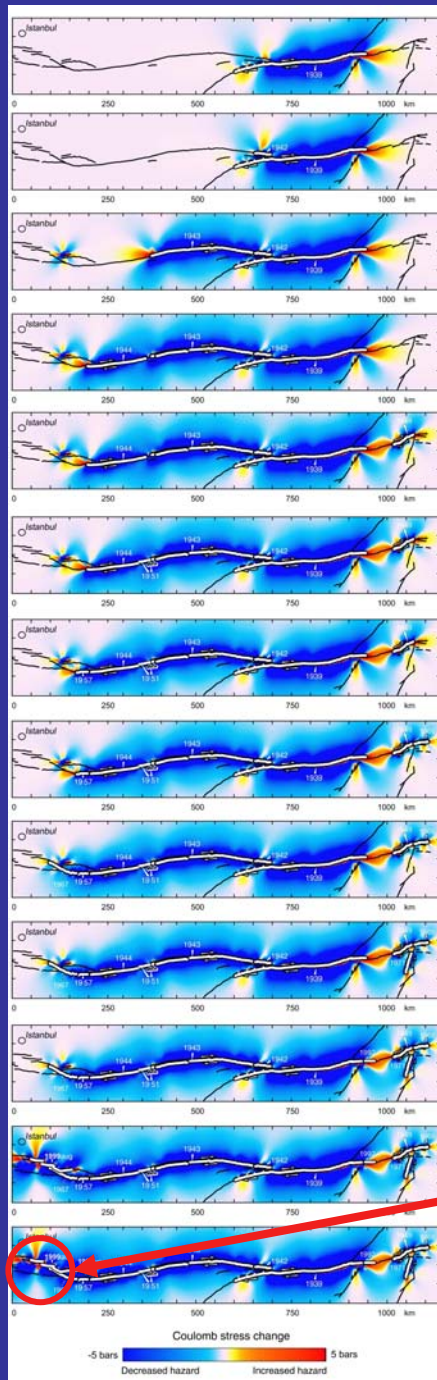
Branches of the North Anatolian Fault in and around the Sea of Marmara

Earthquake migration along the North Anatolian Fault during the 20th century

a Coulomb model

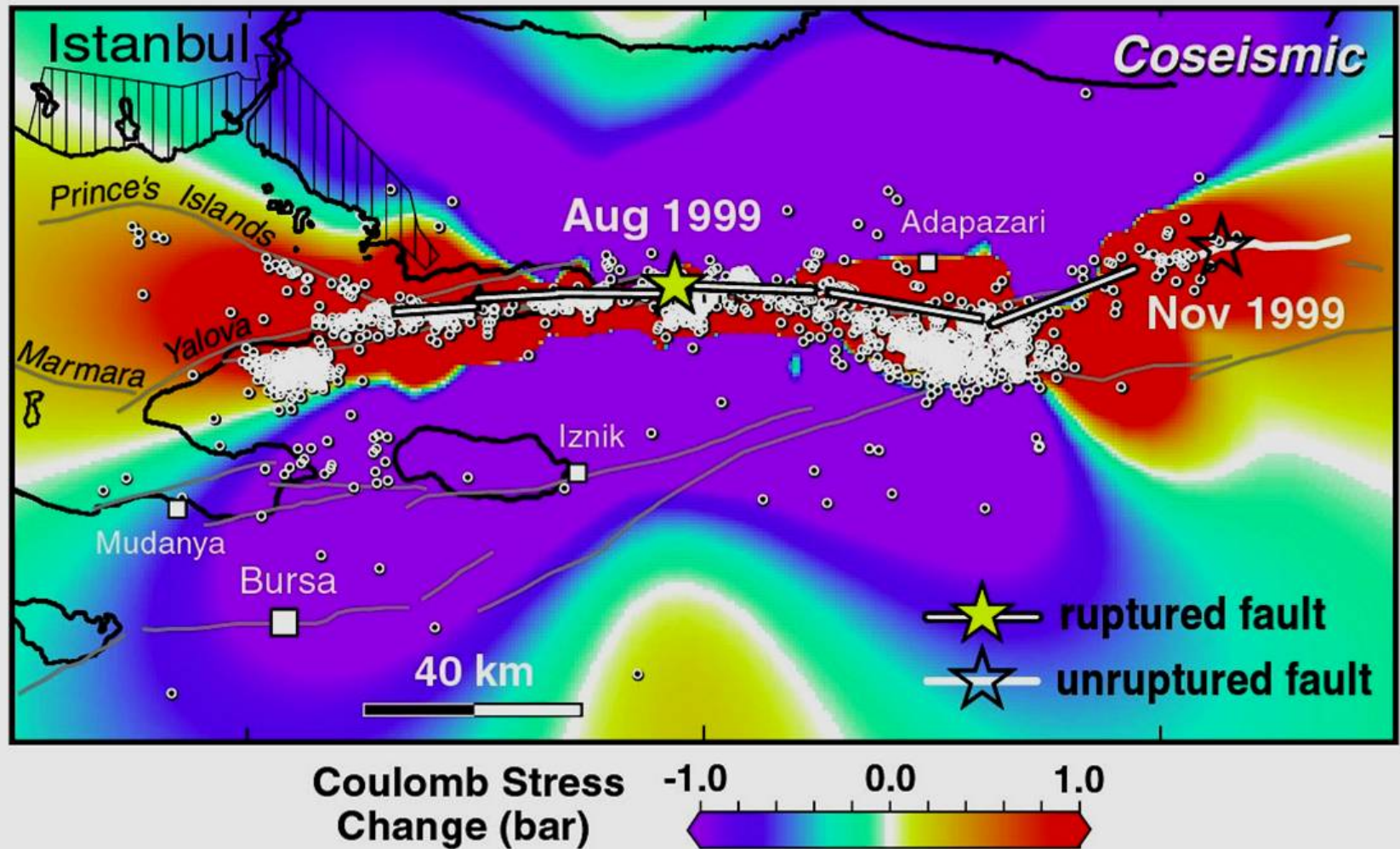
by

Bob Stern and Serhan Bozkurt



ALARM FOR ISTANBUL

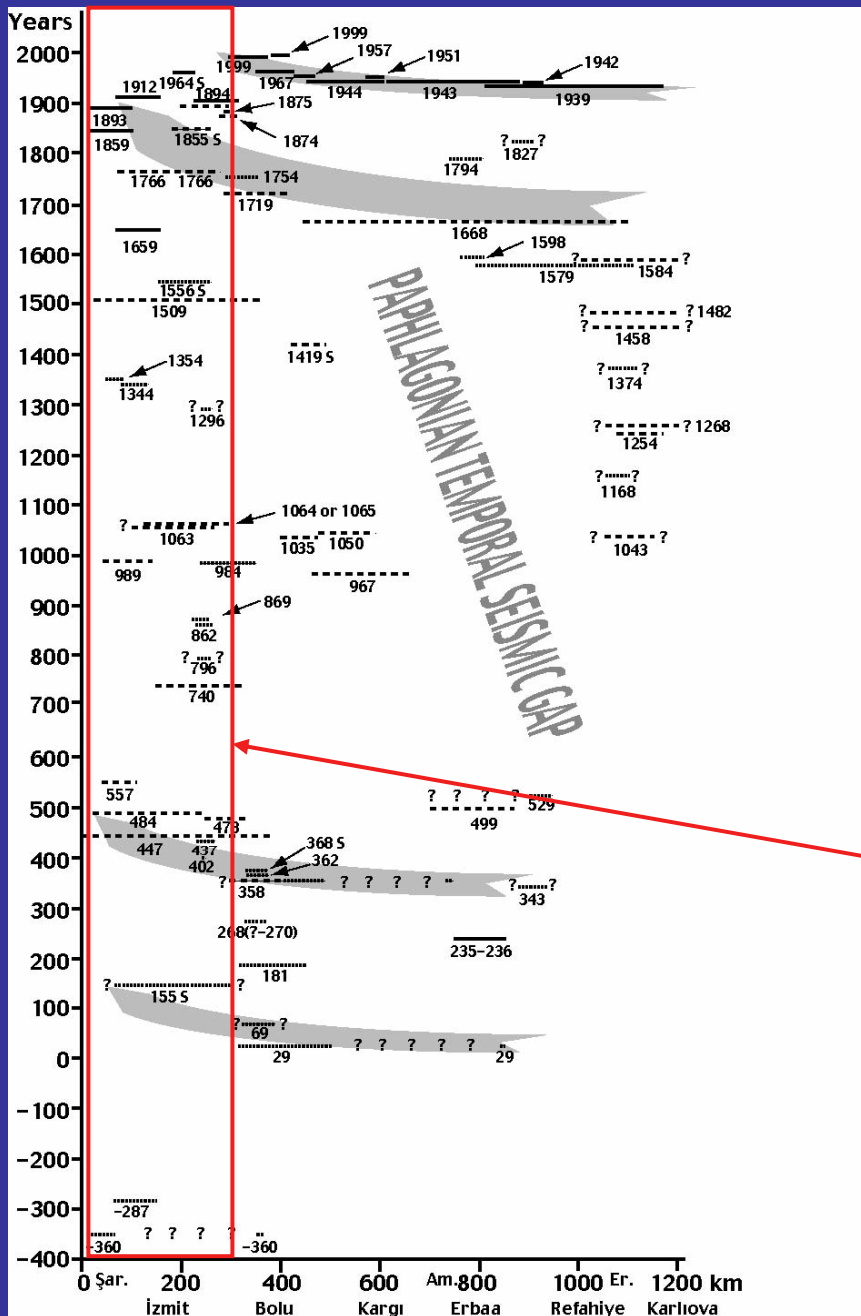
1999 Izmit shock increased stress and hazard on faults closer to Istanbul



Aftershocks and Nov 1999 Düzce shock struck where stress increased by Izmit shock

Historical seismicity of the North Anatolian Fault

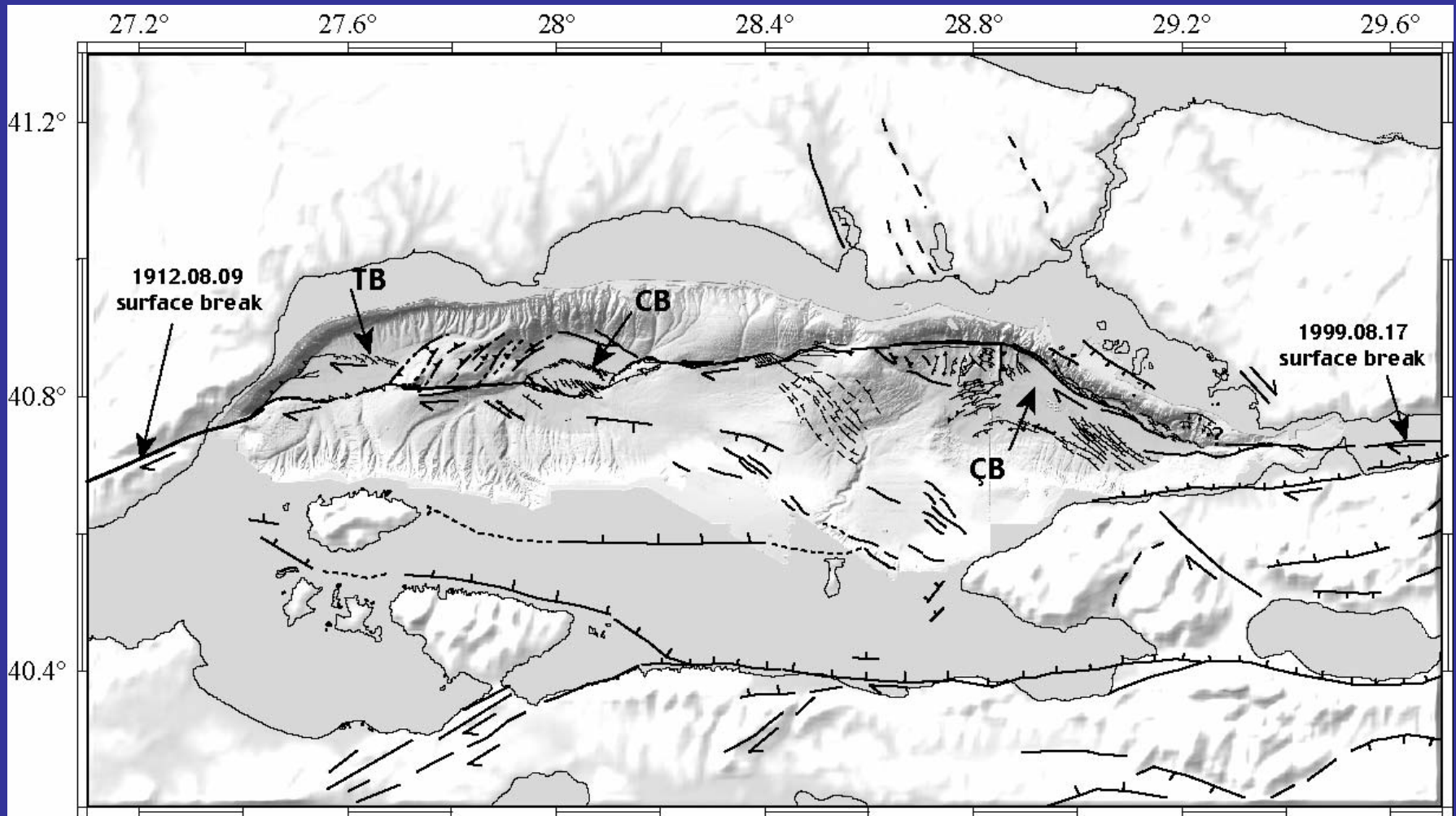
(from Şengör et al., 2005)



Earthquakes seriously affecting İstanbul



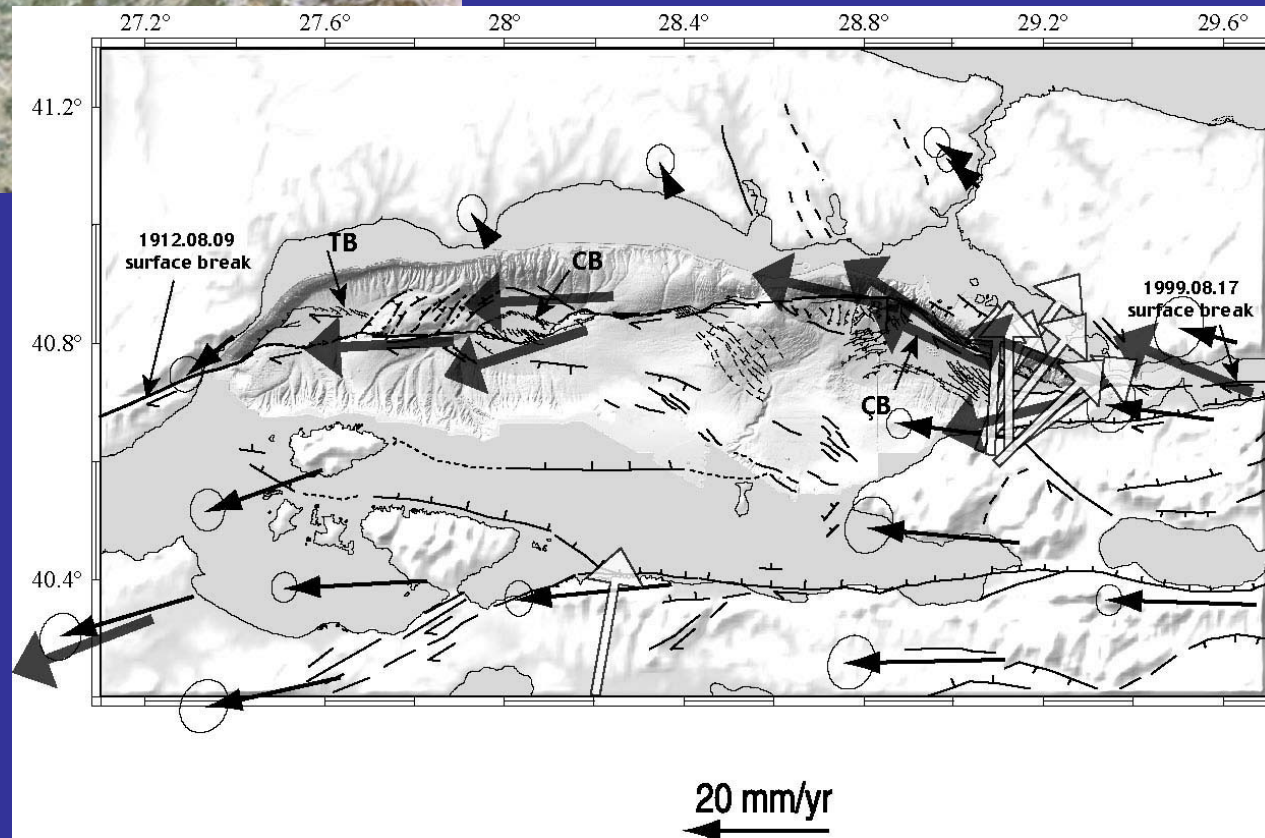
The earthquake of 10th May 1556 in Istanbul from the eyes of a European

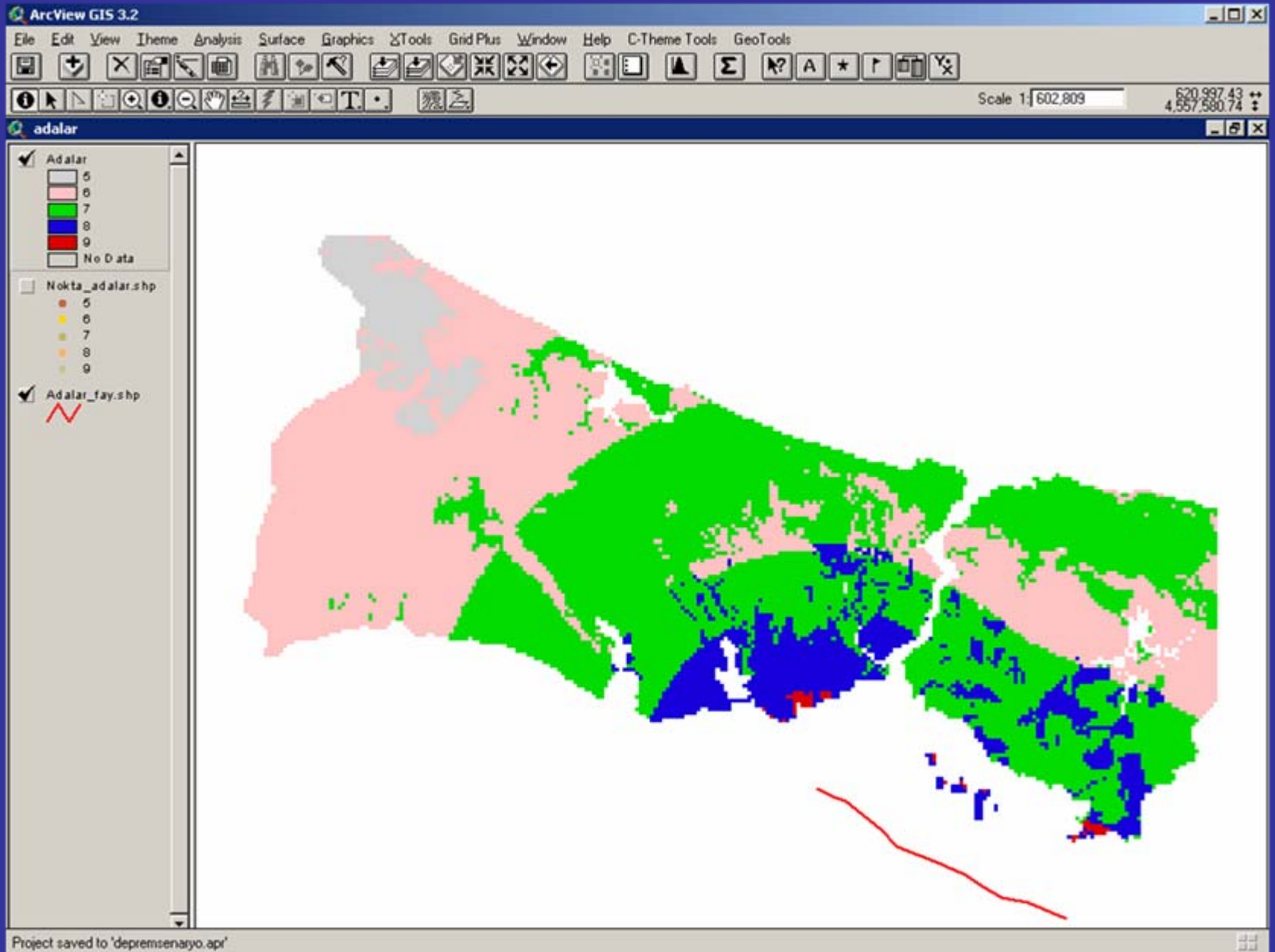


What will happen next???

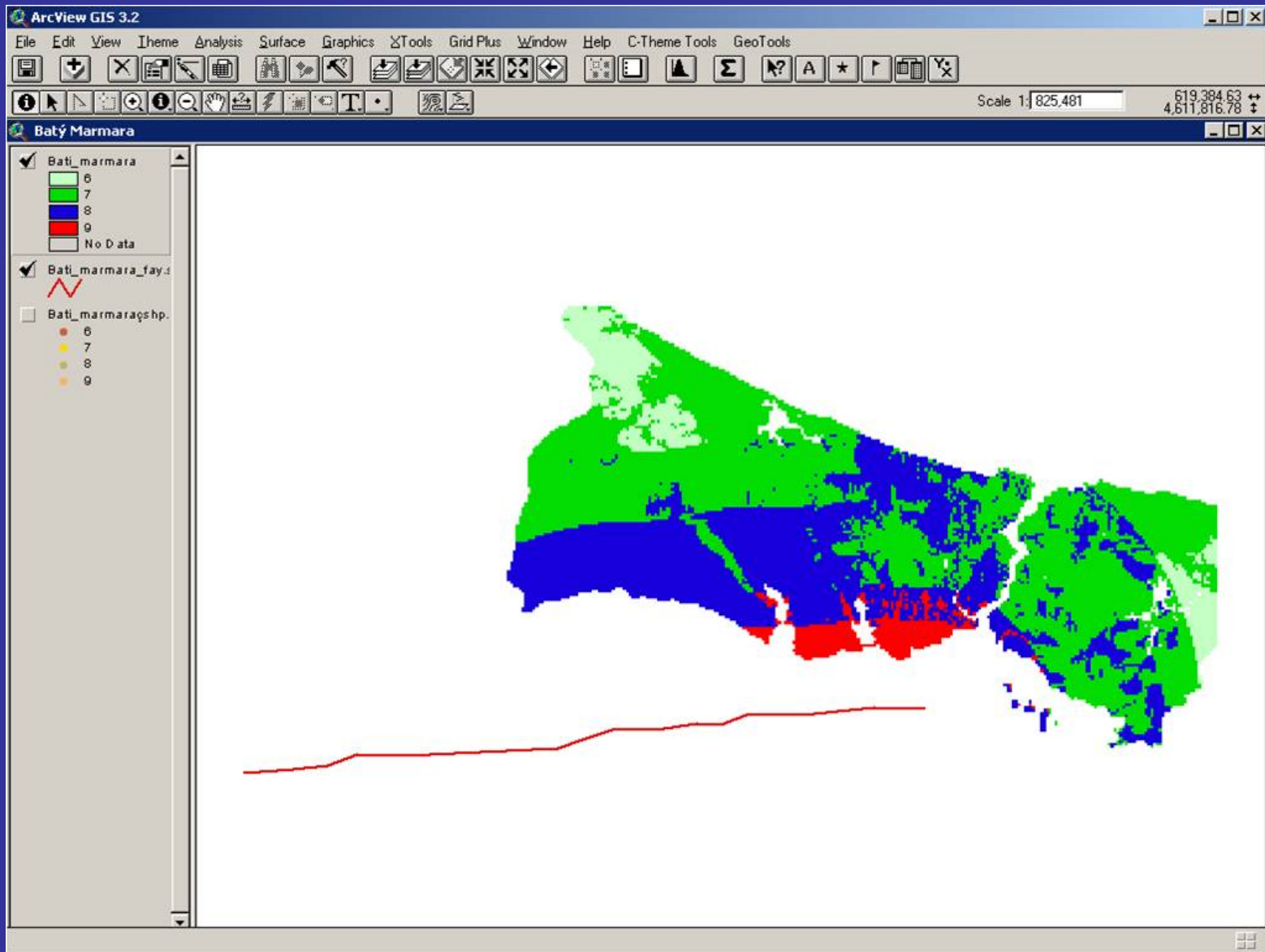


Current ground motion in and around the Sea of Marmara (from Şengör et al., 2005)

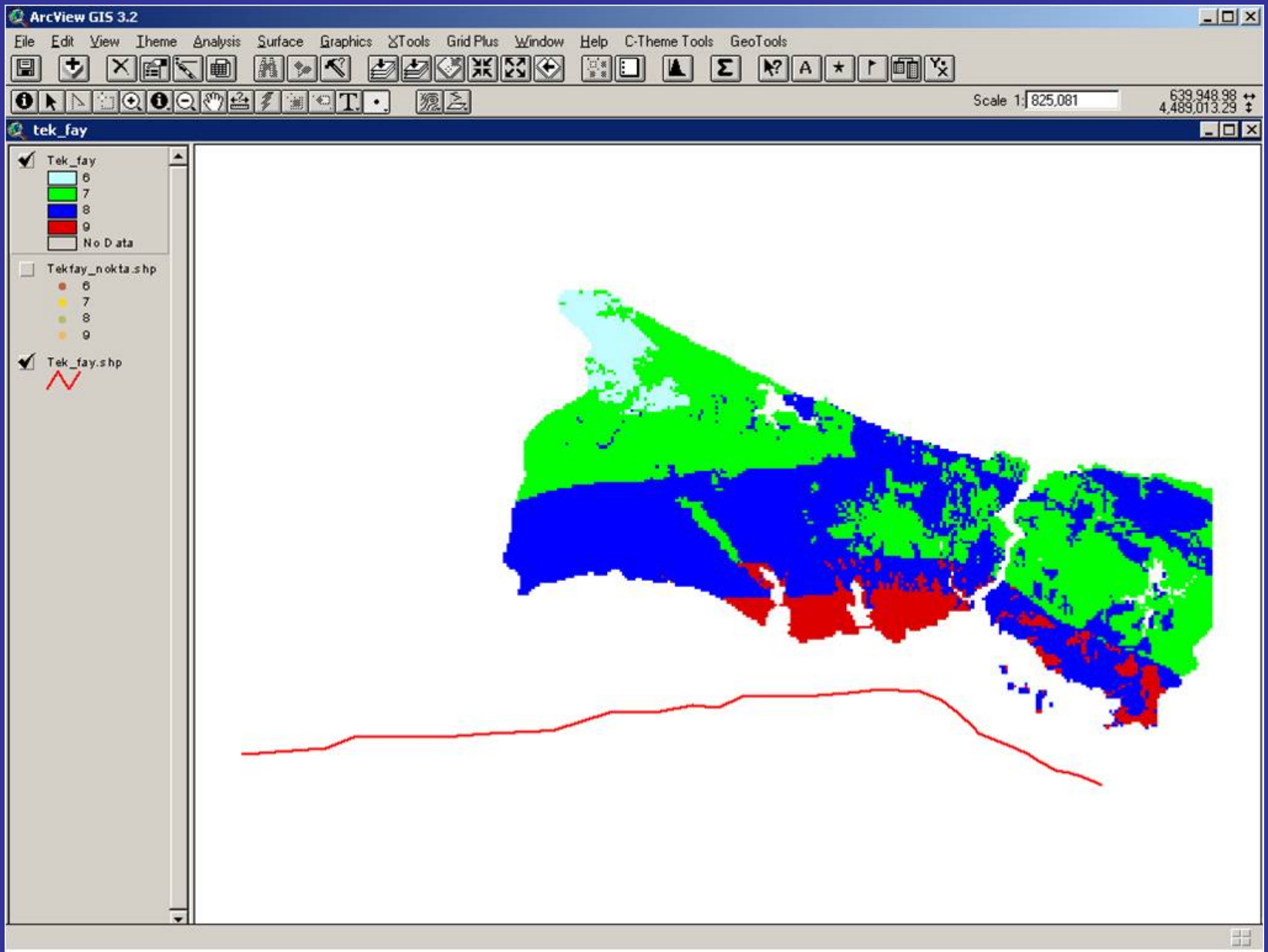




If only the eastern segment fails

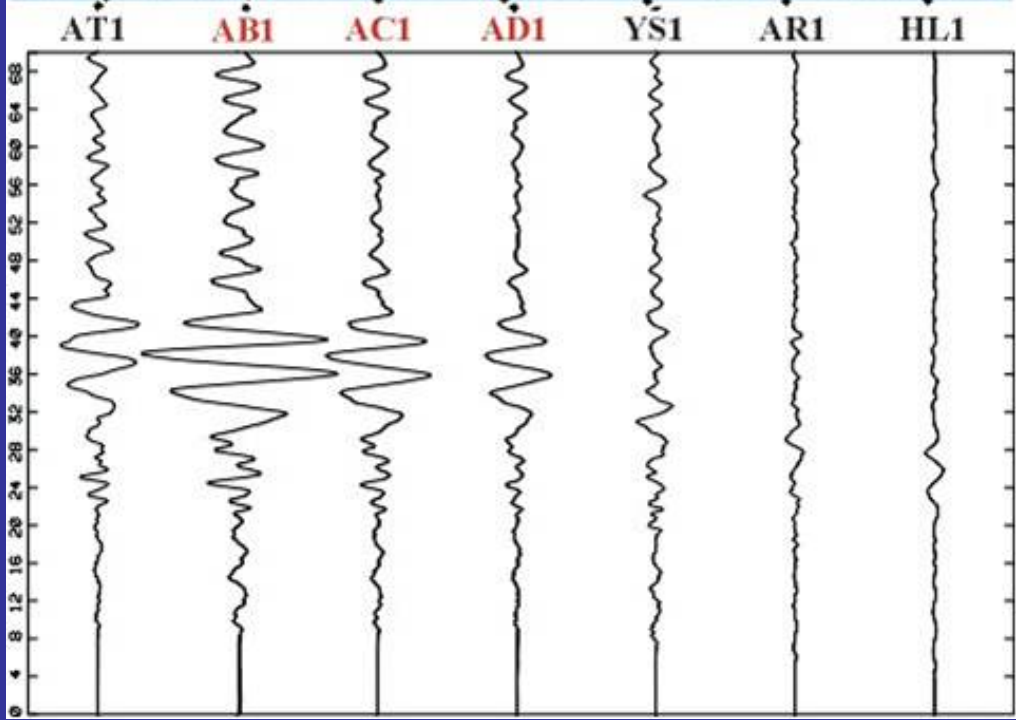
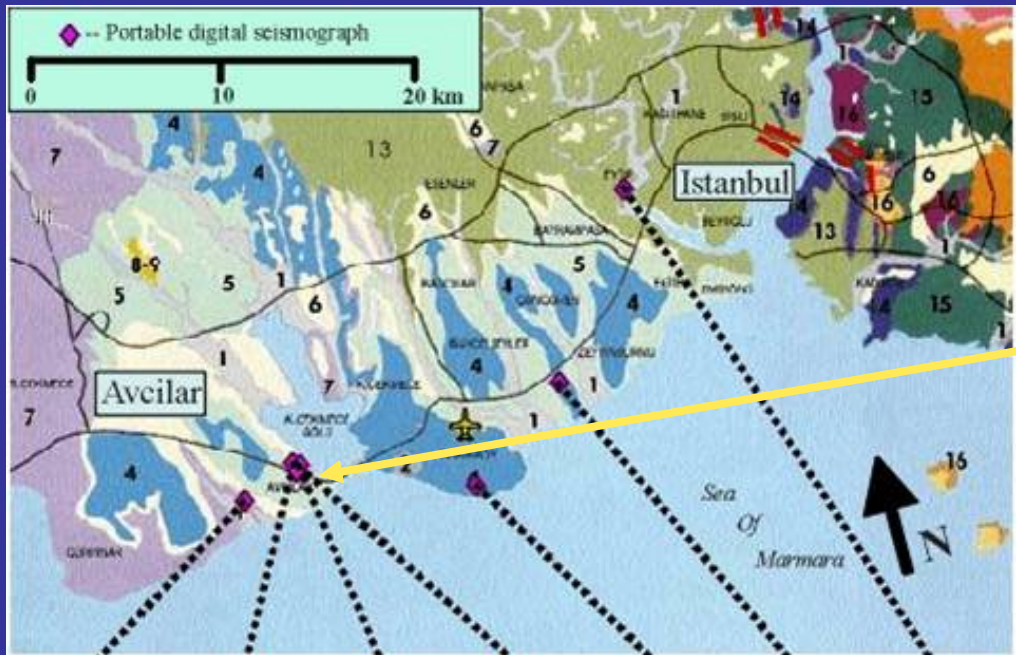


If only the western segment fails



***If the entire Marmara segment fails
likely scenario)***

(the most



Earthquake hazard was maximum in Avcilar, above the Güngören Shale Formation

Water in İstanbul

Where is the world's
first and still the longest
Hochquellenleitung?



The longest Roman Aquaduct was built in the 4th century AD to bring water to İstanbul! It is 245 km long and about 40 aquaducts have so far been found along its course

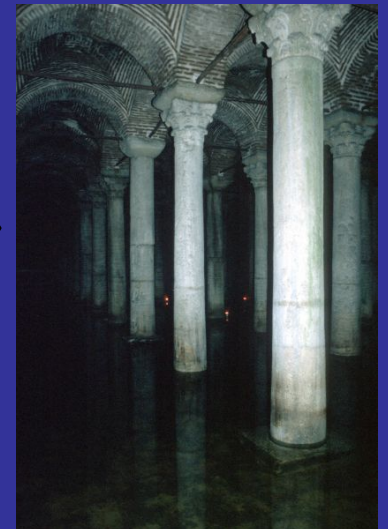


The Keçigerme Aquaduct System: one of the 40 along the way of the Strandja water supply system



The Valens Aquaduct: The terminus of the Strandja water supply system

The Basilica Cistern near the Hippodrome (Sultanahmet Square) →



Dankeschön!

Спасибо

Merci!

Thank you!

Çok teşekkürler!