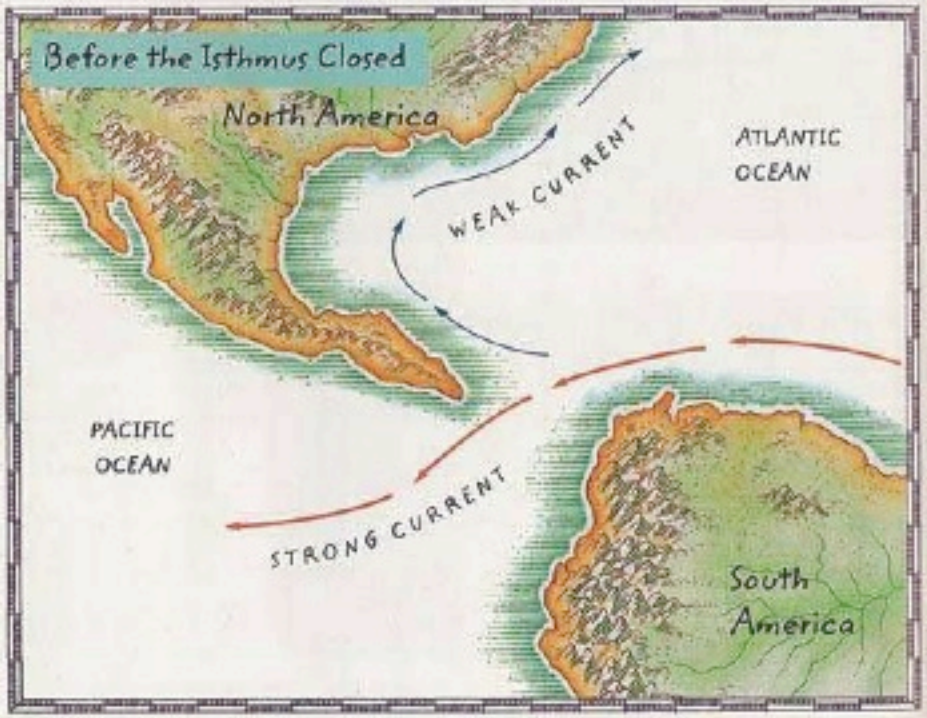
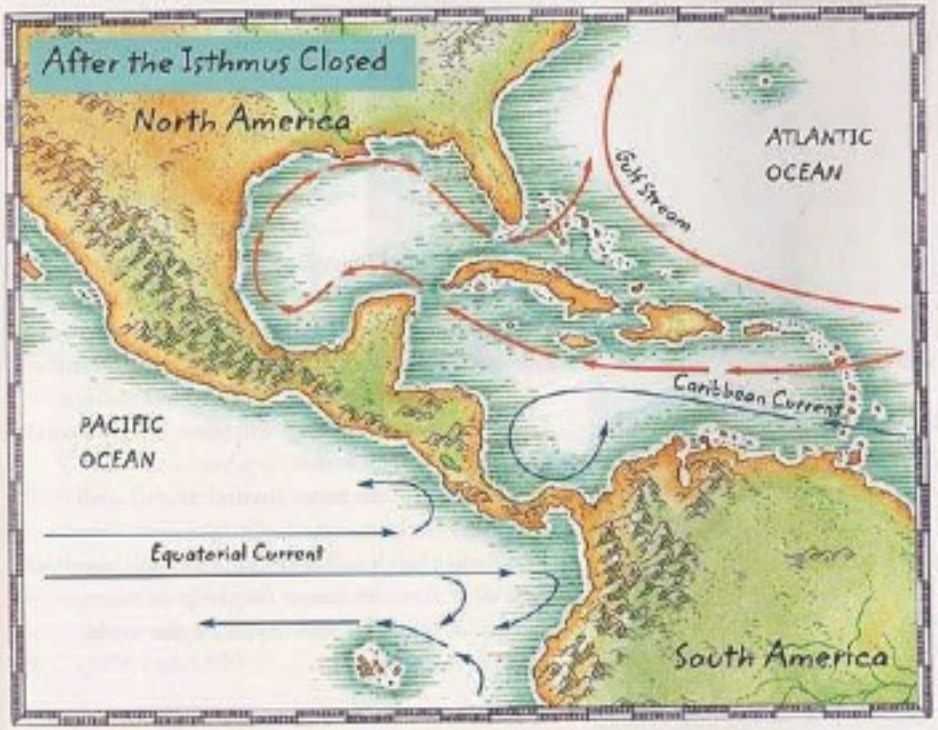
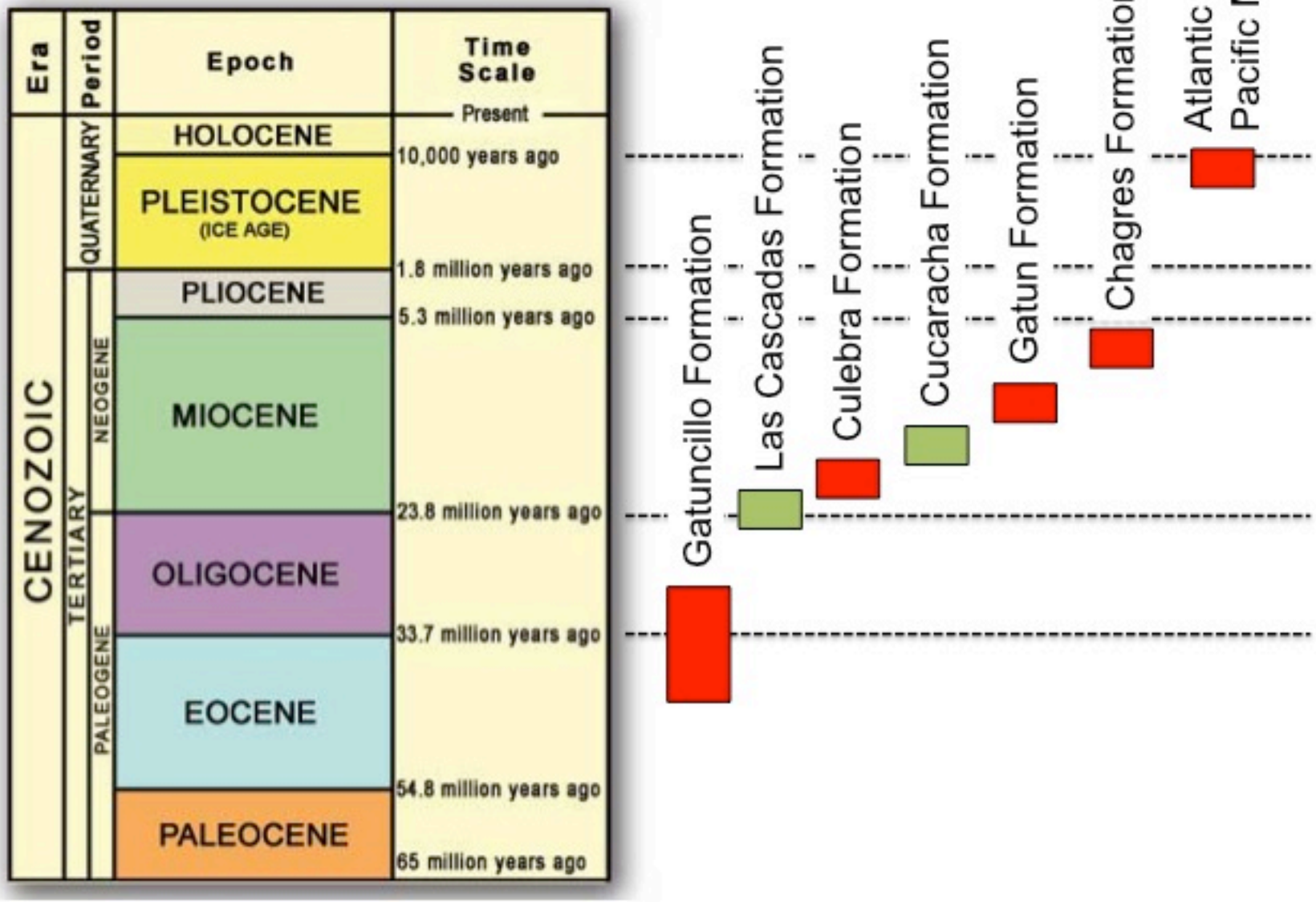
Invertebrate fossils of Panama:

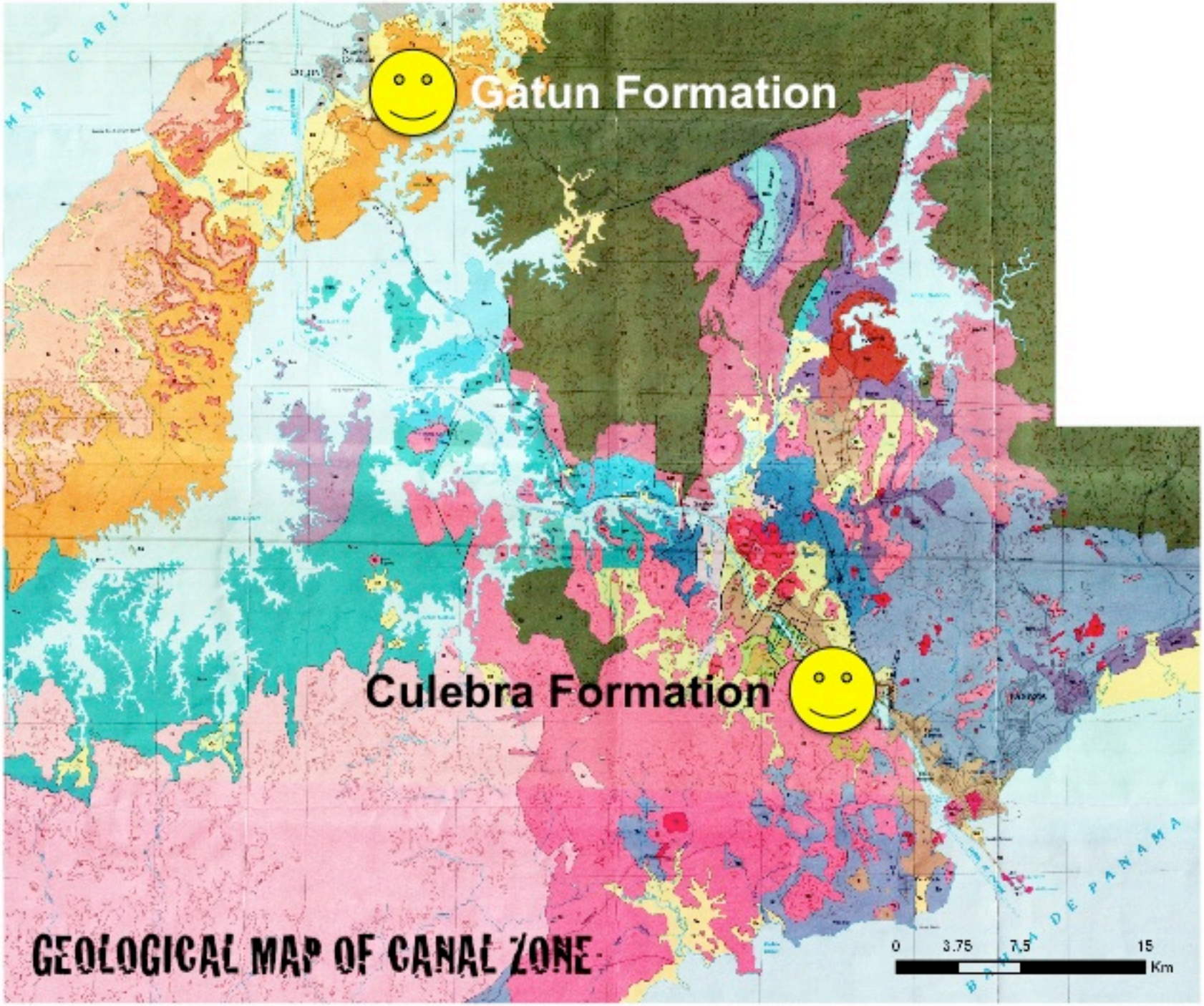
A 40 million year history of an ocean gateway





GEOLOGICAL TIME SCALE AND PANAMA FOSSIL RECORD




Gatun Formation
Culebra Formation
GEOLOGICAL MAP OF CANAL ZONE
0 3.75 7.5 15
Km


LATE EOCENE-LATE OLIGOCENE
- 25-40 million years ago


EARLY MIOCENE - 19-21 million years ago


LATE MIOCENE (Colon)
- 12-9 million year ago


LATE MIOCENE-PLEISTOCENE (Bocas)
- 8-1 million years ago


PLEISTOCENE CRABS


EOCENE ECHINODERMS

MIOCENE SEA STAR

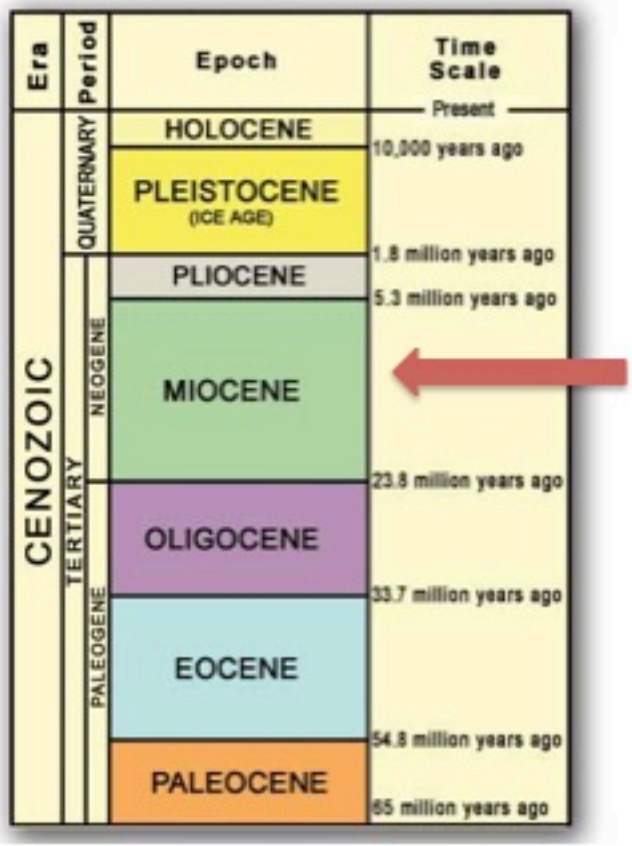
OLIGOCENE AND MIOCENE BRACHIOPODS

MIOCENE NAUTILUS

MIOCENE BIVALVES AND GASTROPODS

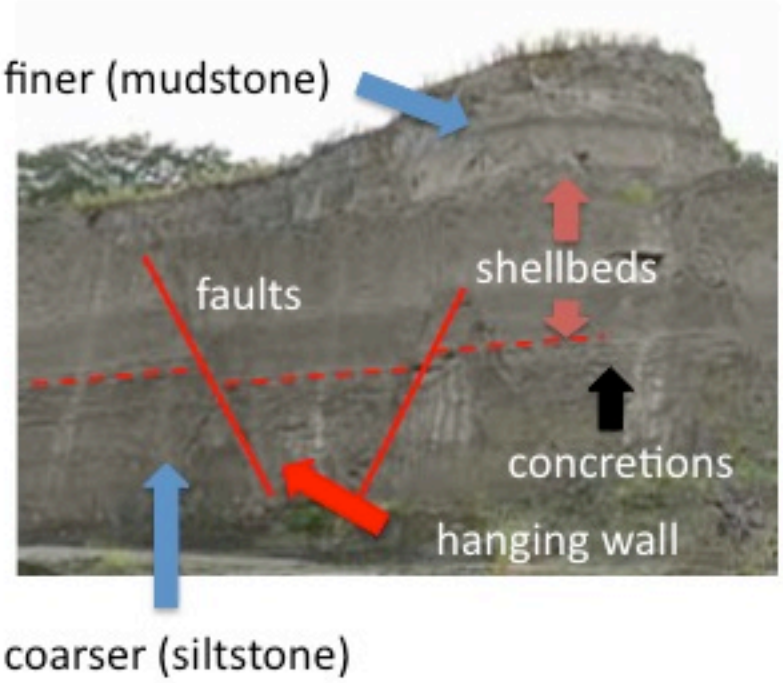
THE GATUN FORMATION - GEOLOGY

- The Gatun Formation accumulated during the Late Miocene (11.8-5.2 million years ago).
- The fossils at Residencia San Judas are approximately 11 million years old.
- The formation was deposited during a phase of tectonic subsidence (the sedimentary basin was sinking).
- It rests upon Oligocene rocks with an unconformable contact (meaning time is missing). It is overlain unconformably by later Miocene rocks (Chagres Formation)



THE GATUN FORMATION - GEOLOGY

- The sequence of sediments at Residencia San Judas likely accumulated over tens to hundreds of thousands of years, and represent a number of fluctuations in sea-level.
  - The fine sediments at the very top of the section likely accumulated in deepest water.
  - Cemented (hardened) shell-beds near the base of the section, and the concretions (hard round blocks of sediment) probably accumulated when sea level was lowest.
- Numerous normal faults (where the hanging wall has moved downward) can be observed, and indicate that the basin experienced extension (stretching) after accumulation of the Gatun Formation.



THE GATUN FORMATION – PALEOENVIRONMENTS

- The Gatun Formation at Residencia San Judas was deposited in shallow offshore (10-50 m) marine environments, proximal to the coastline, although in relatively low wave and current energy. The sediments are typically siltstone (fine-grained, but gritty to touch), and burrows are not easily observed.

- Characteristic taxa of these paleoenvironments include: *Anadara dariensis*, *Panchione mactropsis*, *Turritella altilira*, *Cymatophos veatchi*, and many *Conus*.

THE GATUN FORMATION – PALEOECOLOGY

- Fossil invertebrate species of the Gatun Formation occupied a variety of ecological niches (ways of life).

- Many species are filter-feeders (or suspension-feeders), meaning that they derive their nutrition by filtering particulate organic material from water.
  - Some of these live above the sediment-water interface (known as an *epifaunal* life-habit). Being epifaunal allows an organism to be free of sediment that may bury or choke them, and to be exposed to currents that carry organic particles.
  - Other filter-feeding taxa live below the sediment-water interface (referred to as an *infaunal* life-habit).

Epifaunal bivalve (scallop)

Infaunal bivalves (clams)

THE GATUN FORMATION – PALEOECOLOGY

- Some species are deposit-feeders (or detritivores) that obtain nutrients by consuming detritus (decomposing organic matter). These are typically infaunal, but are more common in deeper environments.

Traces made by deposit-feeding bivalves

- The last common group of species are carnivores (predators or scavengers). Predators will actively seek out living prey and in most cases drill (boreholes) or chip the enclosing shell of the prey to access tissue.

Traces made by naticid-predator (upper center)

THE GATUN FORMATION – PALEOECOLOGY

Infaunal suspension feeders:

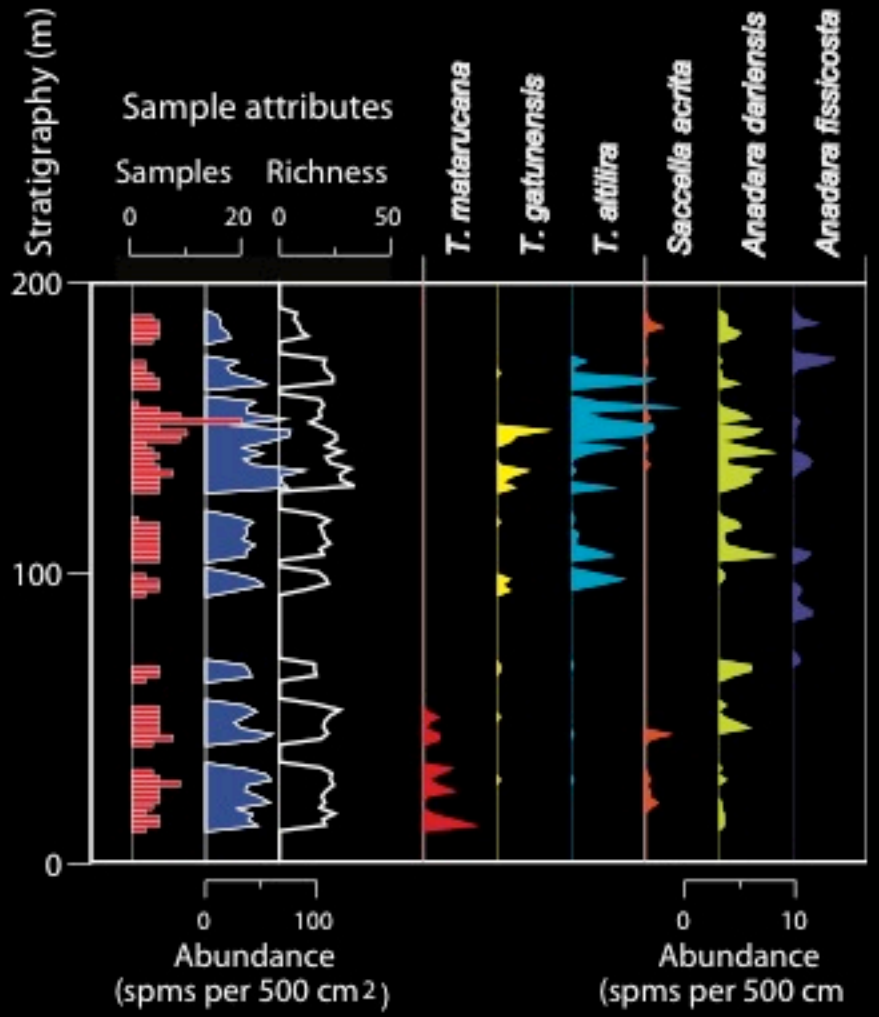
Semi-infaunal suspension feeders:

Infaunal deposit feeders:

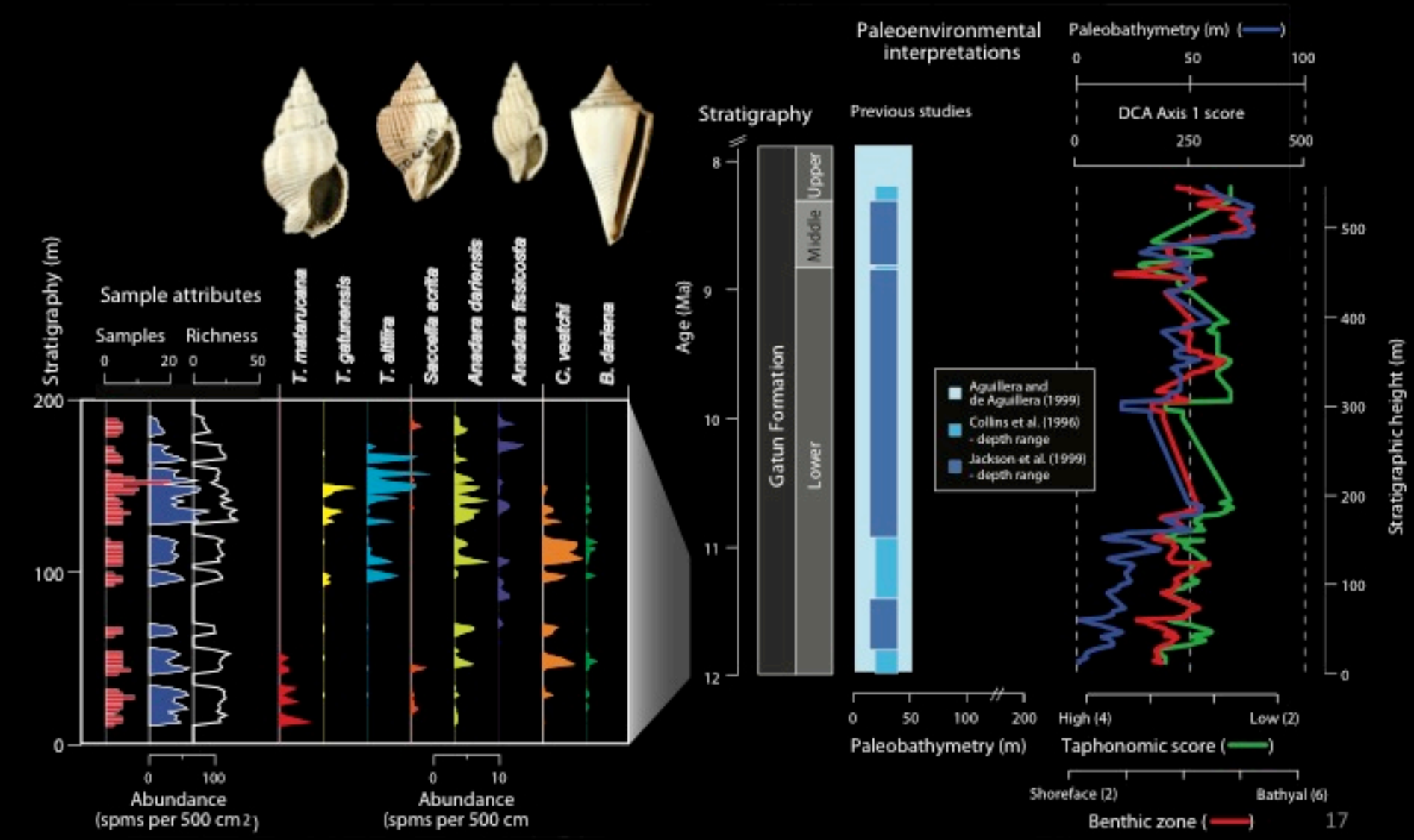
Epifaunal suspension feeders:

Predators/scavengers:

THE GATUN FORMATION – PALEOECOLOGY



THE GATUN FORMATION - PALEOECOLOGY

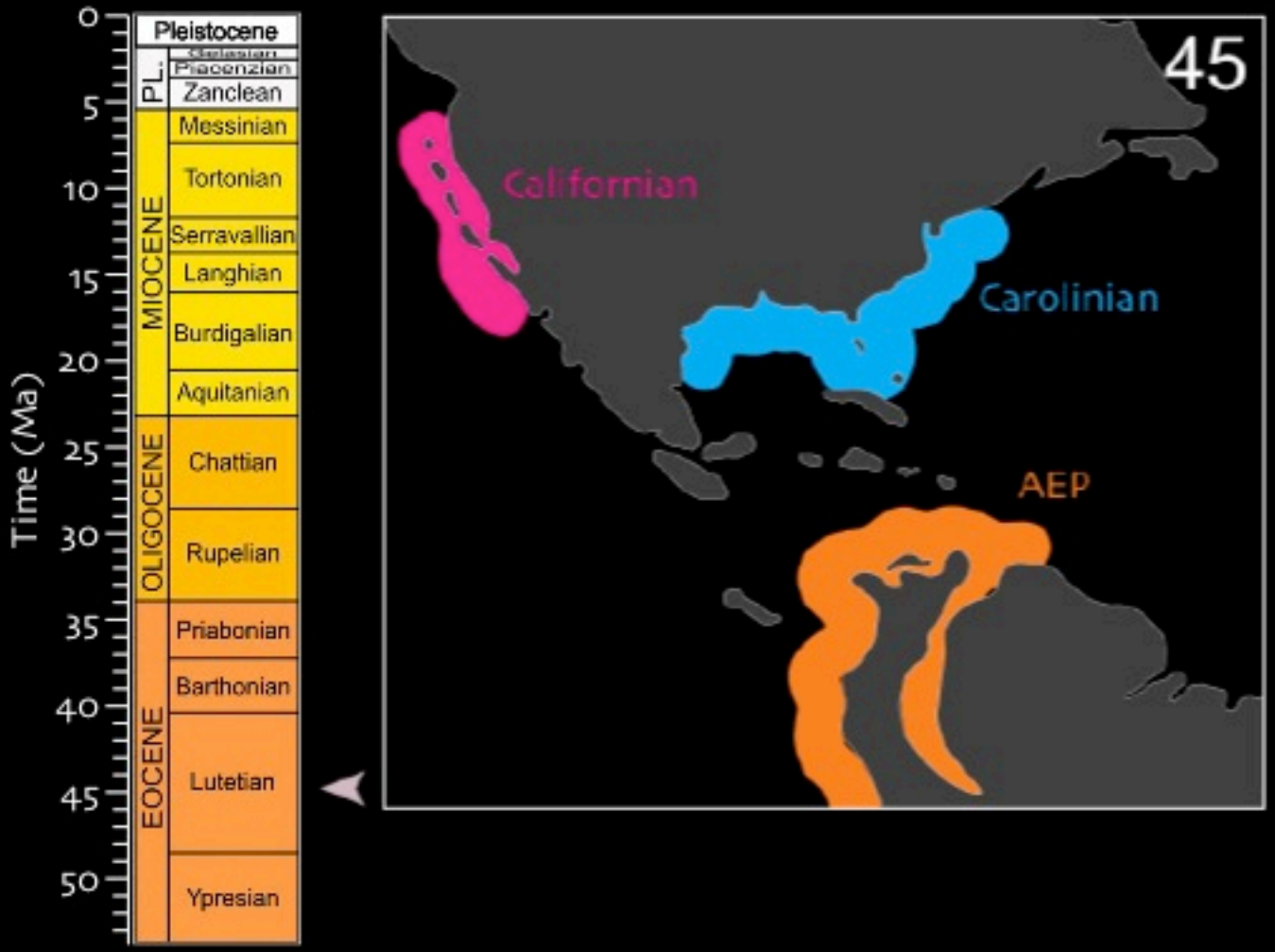


THE GATUN FORMATION - BIOGEOGRAPHY

THE GATUN FORMATION – BIOGEOGRAPHY

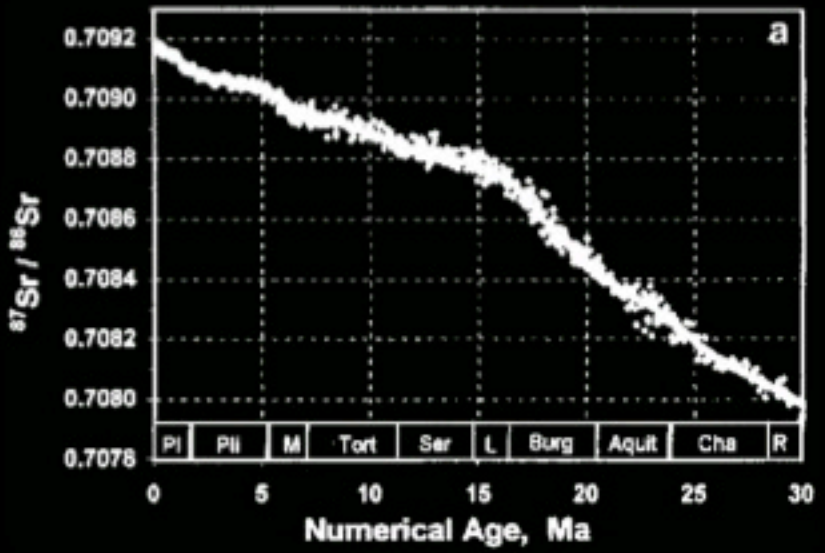
- Statistical comparison of the taxonomic composition of faunal assemblages.
- Assemblages that are similar to one another are defined as biogeographic provinces.
- The distribution of biogeographic provinces are then plotted on paleogeographic maps.

THE GATUN FORMATION - BIOGEOGRAPHY



THE GATUN FORMATION – AGE

- Absolute dating methods
  - Strontium isotope ($^{87}Sr/^{86}Sr$) dating (11.5-9.1 Ma)
  - Uranium-lead ($^{238}U/^{206}Pb$) dating of igneous (volcanic) rocks (8.24 ±0.15 Ma)
  - Argon-Argon ($^{40}Ar/^{39}Ar$) dating of igneous (volcanic) rocks (9-9.8 Ma)
- Relative dating methods:
  - macrofossil biostratigraphy (early late Miocene, 12-8 Ma)
  - microfossil biostratigraphy (NN8-NN10 = 11.0-8.6 Ma)



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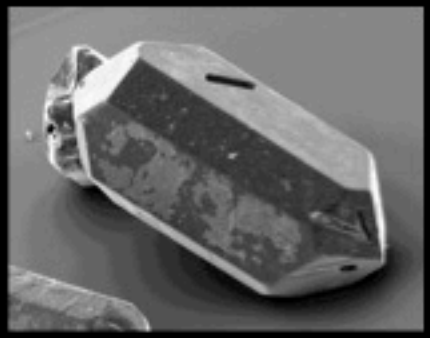

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