Tectonics Term Definitions
Lec- 1

By : Dr. Maher M Mahdi // Asst. lecturer Hawraa Al-Sahalni

Continental margin:

Zone that consists of the *continental shelf, *continental slope, and *continental rise. It extends from the shoreline to the deep-ocean floor at a depth of 2000 m. The zone is underlain by *continental crust.

Continental margins have been divided into *active margins or *passive margins depending on their coincidence, or otherwise, with *plate margins.

Continental shelf:

Gently seaward-sloping surface that extends between the shoreline and the top of the *continental slope at about 150 m depth. The average gradient of the shelf is between 1 : 500 and 1 : 1000 and, although it varies greatly, the average width is approximately 70 km.

Five major types of shelves may be recognized: (*a*) those dominated by tidal action; (*b*) those dominated by wave and storm action; (*c*) those dominated by carbonate deposition; (*d*) those subject to modern glaciation in polar areas; and (*e*) those floored by *relict sediments which constitute up to 50% of the total shelf area.

Carbonate platform:

A structure that forms in shallow water where there is extensive deposition of carbonate that is not mixed with siliclastic sediments.

Types of Carbonate platforms

A number of different morphologies of carbonate platform are recognized, the most widely documented being **rimmed carbonate shelves** **or** **carbonate ramps** .

Rimmed carbonate shelves which are flat-topped platforms bordered by a rim formed by a reef or carbonate sand shoal. In some places *oolitic sand has accumulated to form *barrier islands. In others reef-building organisms have built reefs along the rim (e.g. the Great Barrier Reef).

Carbonate ramp (**Non-rimmed carbonate shelves)** has a gently sloping surface extending seaward from the coastline, with no sharp break between shallow and deep water.

Tectonic Influence

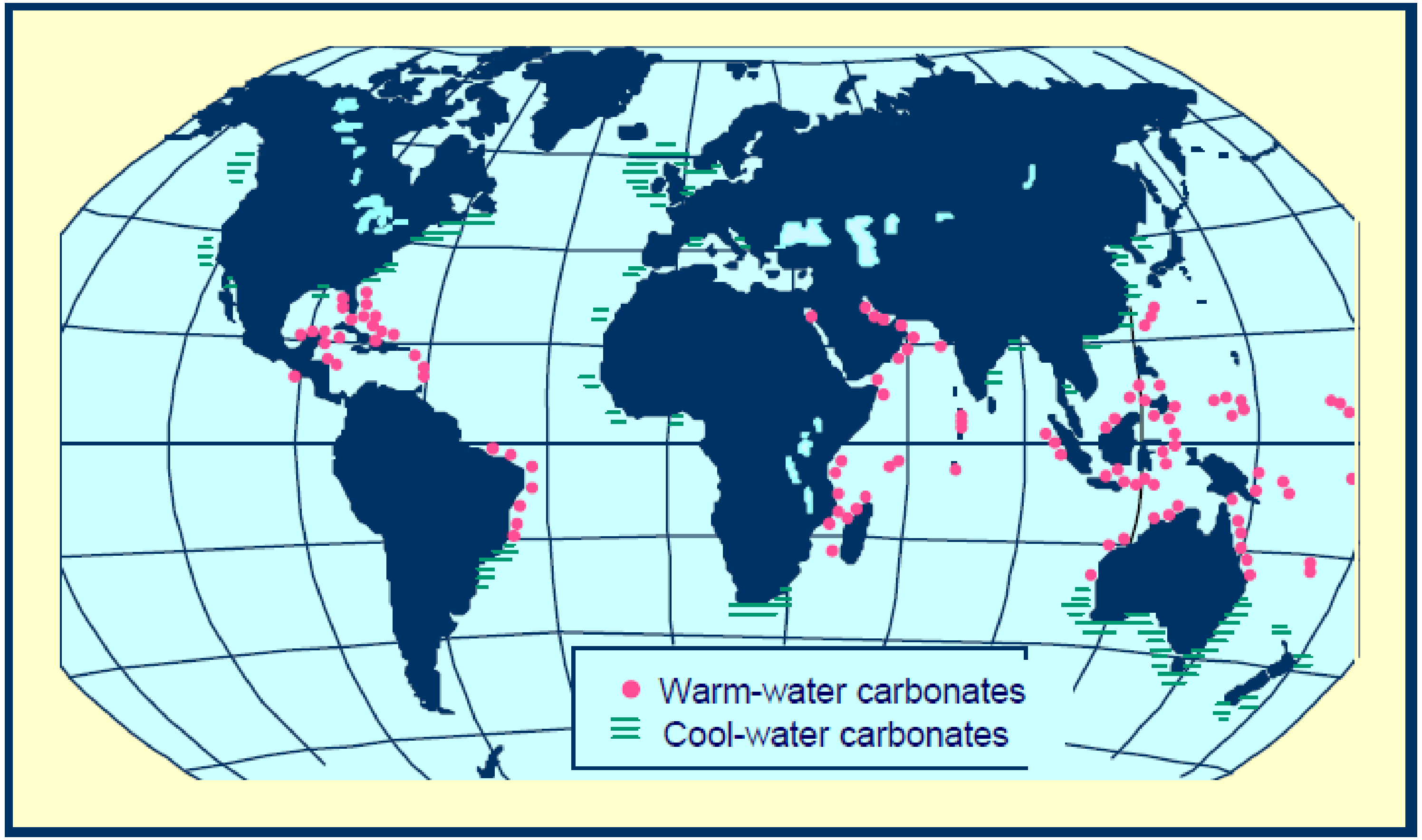
The tectonic setting Influences the characteristics of carbonate platforms, with the largest occurring on **passive continental margins** while smaller platforms form on localized submarine highs such as **fault blocks** in extensional settings and on **salt diapirs**.

Great Barrier Reef

barrier islands

Distribution of Recent Carbonate Sediments

Carbonate Sedimentary Environment



Carbonate Platforms

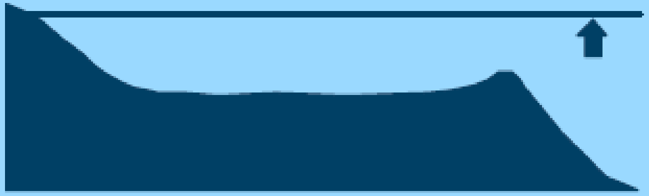
Rimmed shelf

Carbonate ramp

Epeiric platform

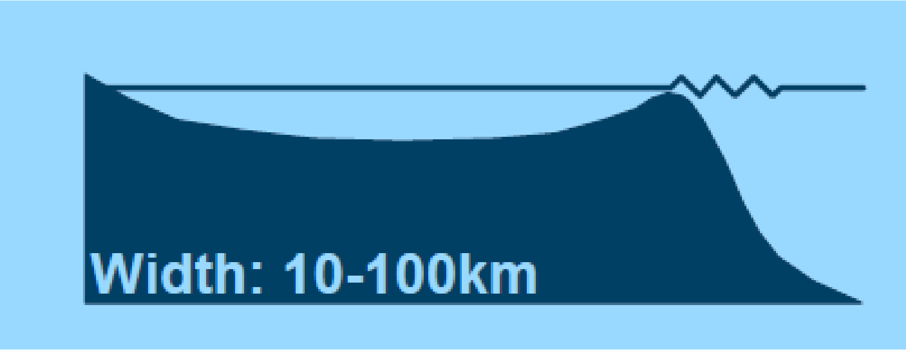
Isolated platform

Drowned platform



Rimmed shelf

Features



Marked topographic change at shelf edge

Shelf edge → reef/sand body

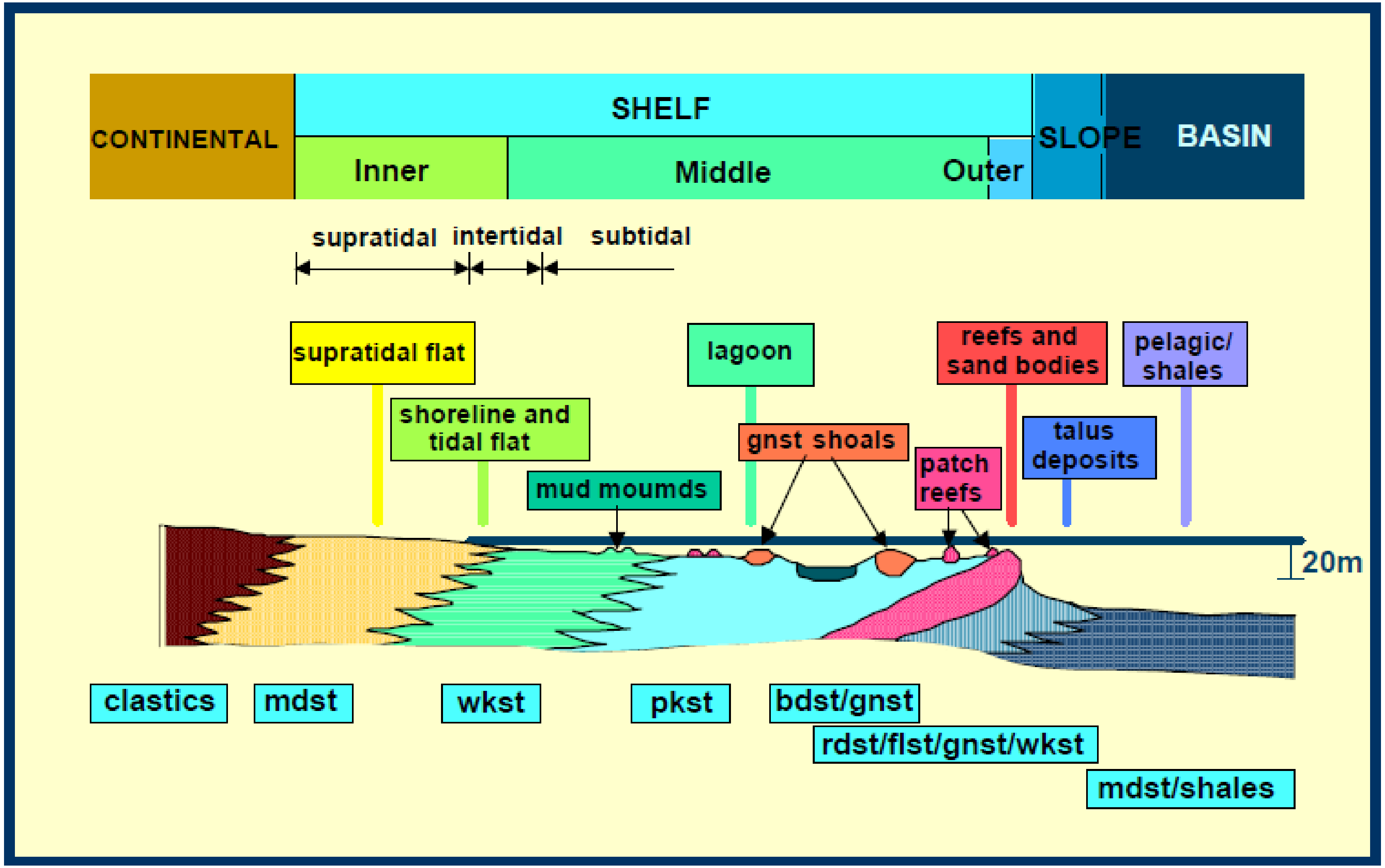
behind Barrier → development of lagoon

Shoreline → tidal flat/beach-barrier system

Examples: off South Florida, Belize, off Queensland

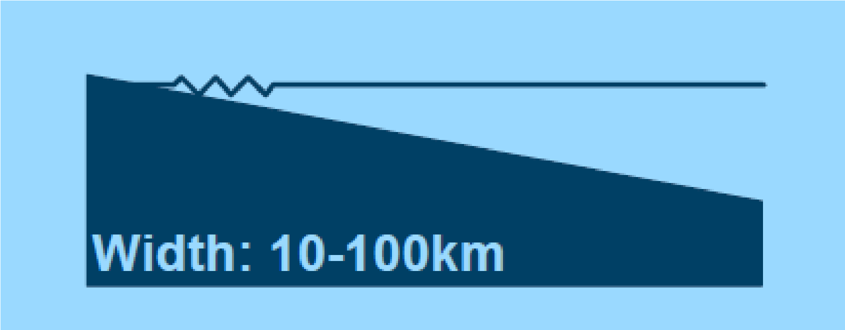
Depositional Model for Rimmed Shelf

Carbonate Sedimentary Environment



Carbonate Ramp

Features



> Shelf with gentle slope
→ similarity to clastic-dominated shelf

> Influence of storms periodically

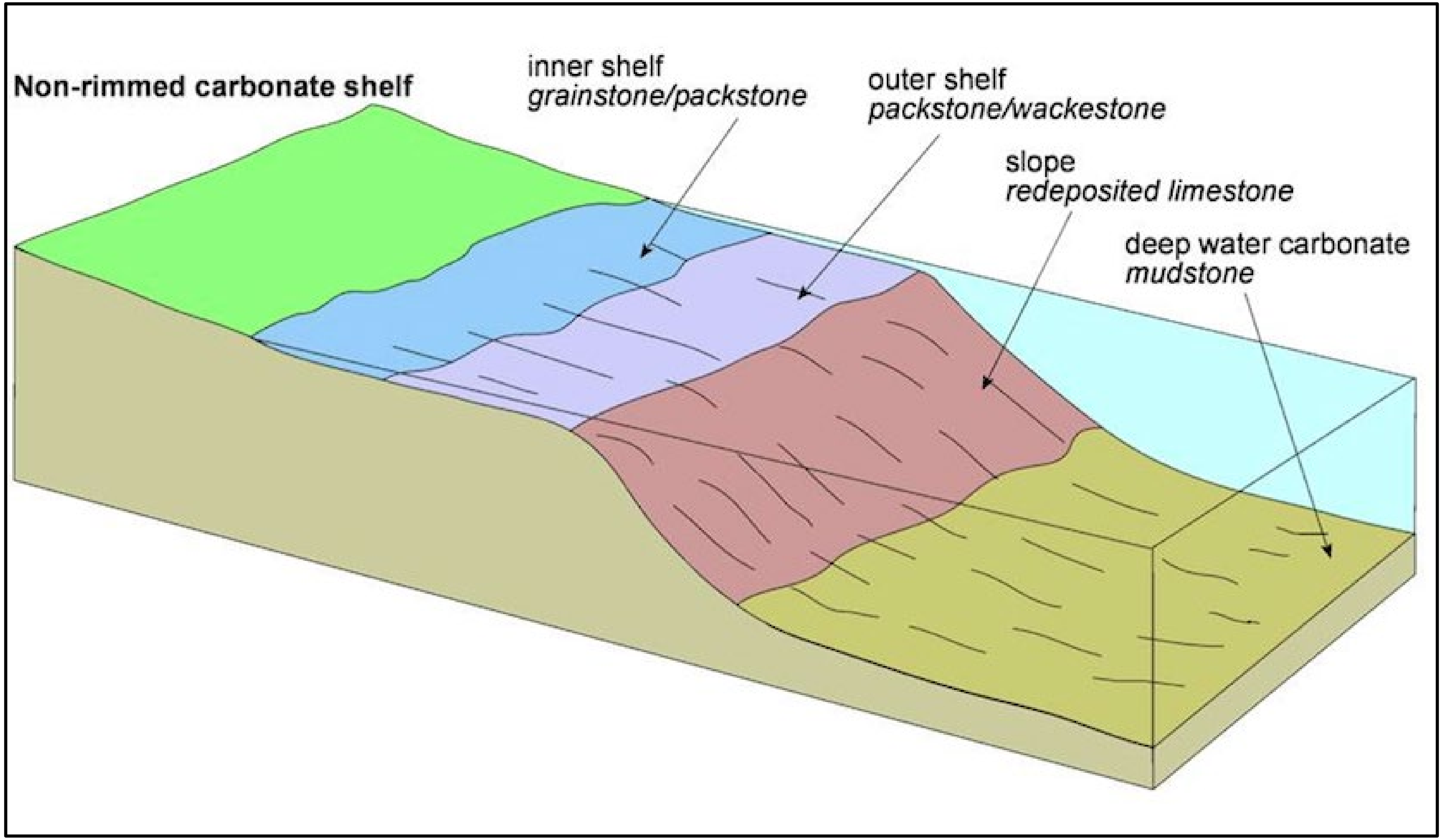
> Absence of a large scale of reefs

Inner ramp → High energy environment
→ small-scaled patch reef

Outer ramp → Low energy environment
→ pinnacle reef/mud mound

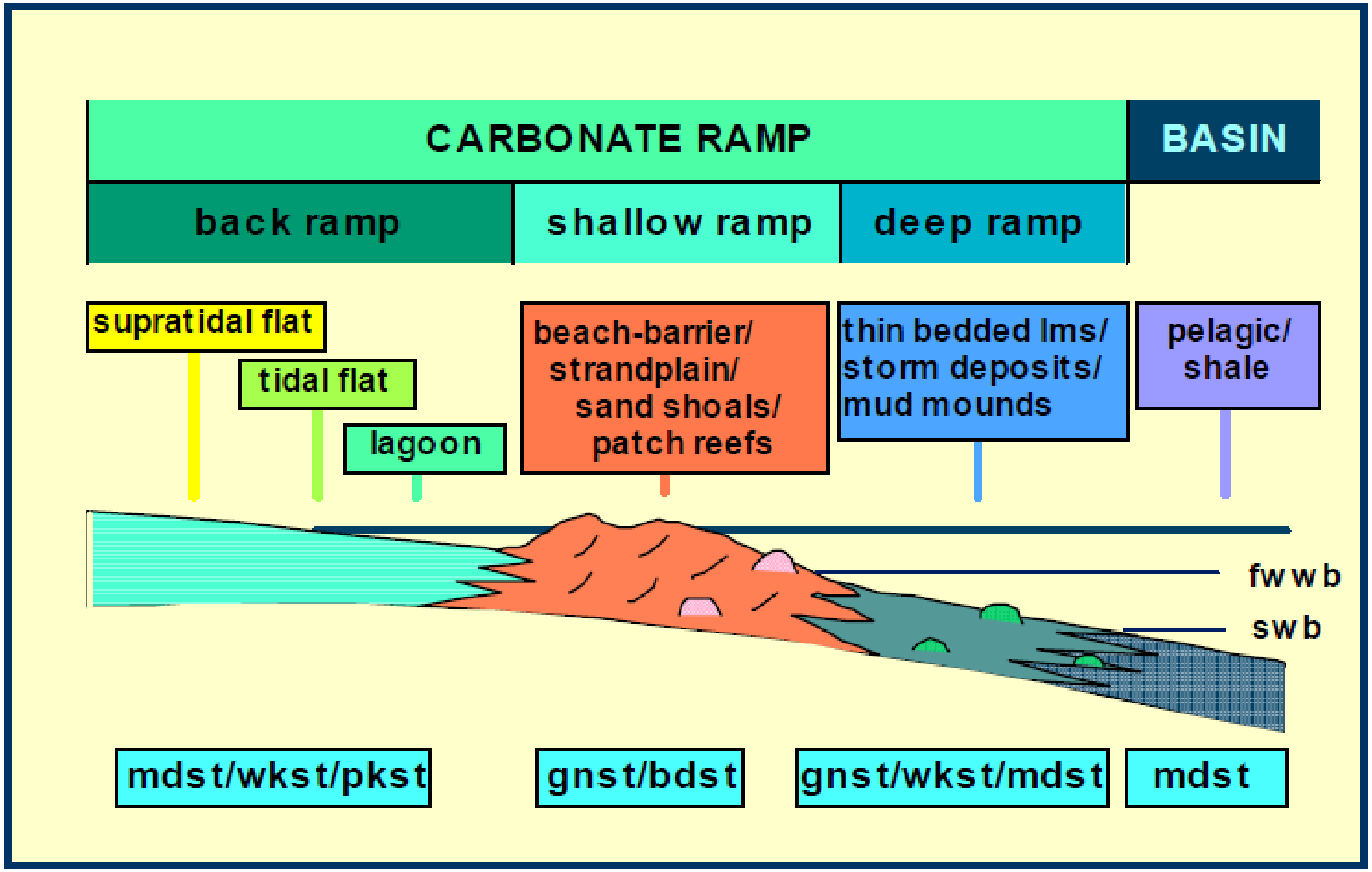
Shoreline → Beach-barrier system/tidal flat/ tidal delta/lagoon/strand plain

Examples: off Yucatan Pen., Persian Gulf, Shark Bay



Carbonate Ramp Depositional

Depositional Model for Carbonate Ramp

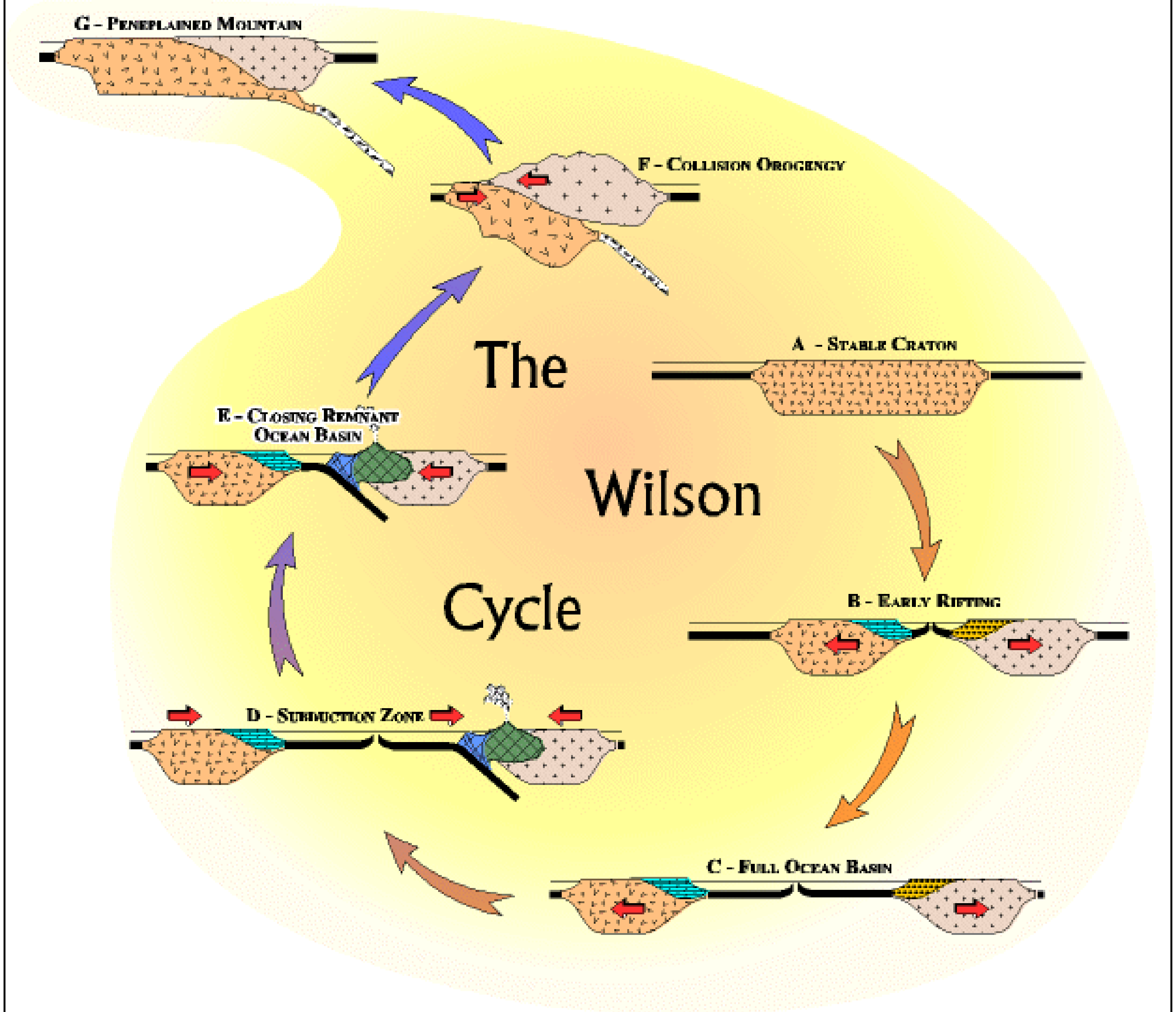


Tectonic History Of Iraq
Lec- 2

By : Dr. Maher M Mahdi // Asst. lecturer Hawraa Al-Sahlani

Tectonic History Of Iraq

- **Preface**
- tectonic history of Iraq during the (Phanerozoic Eon) a period of 600 million years ago to the current time.
- The history of Iraq connected directly with the History of Arabian plate
- Depending on Wilson cycle and plate tectonic theory ,Numan, 1997 put this scenario to interpret the tectonic history, as well as Goff and jassim ,2006.



http://geollab.jmu.edu/Fichter/Wilson/wilsoncircl.html

Iraqi tectonic phases

- **Iraq divided tectonically into three phases depending on Wilson Cycle**
  1. **(Intra-plate Phase)**
  2. **(Open Phase)**
  3. **(Close Phase)**
- **Every phase has sub-phases**

First : Intra-plate Phase (600-250 MY) (Infracambrian and Paleozoic)

- In this stage, Iraq within African plate
- Iraq occupied the Intra-plate basins in this stage
- Consist of two tectonic stages

A- (Stage of Pull apart Basins)

B- (Stage of Pan Basins)

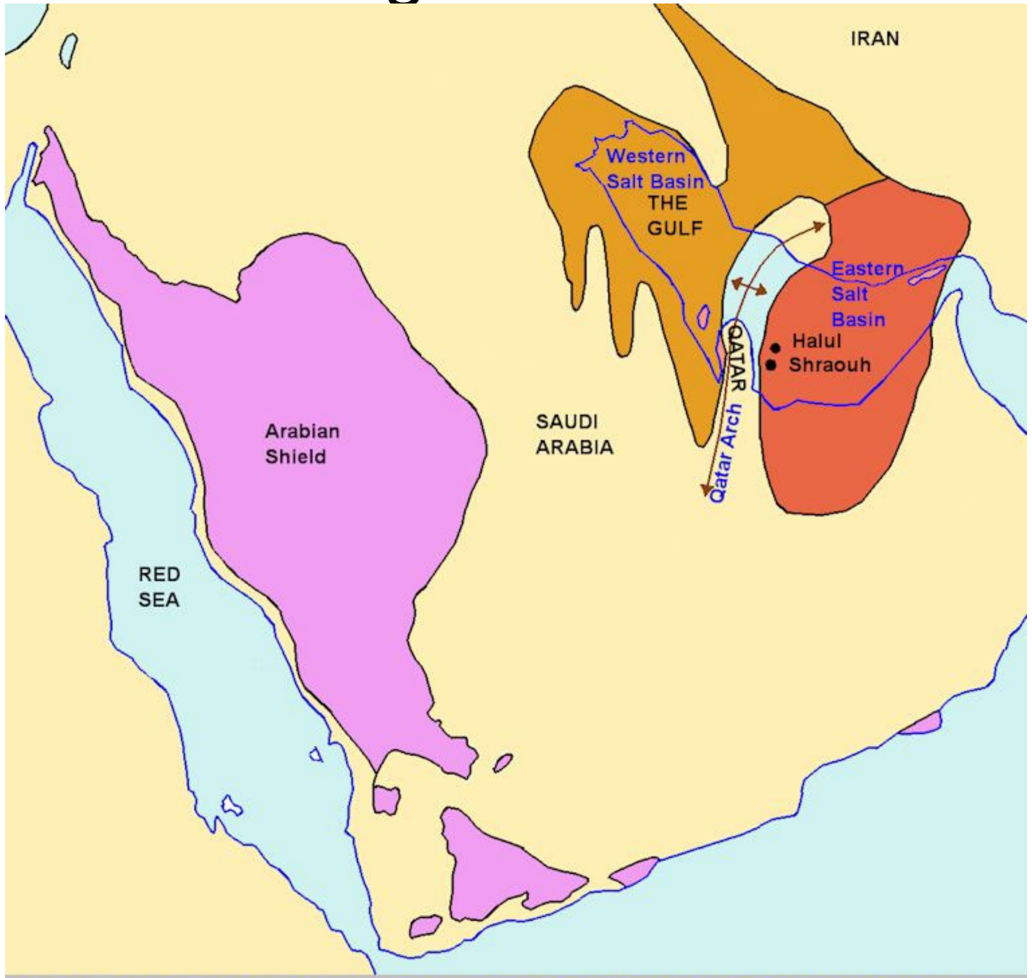
A-Stage of Pull apart Basins (600MY)

Najd Orogeny caused to be pull apart basins during infrcamberian

- The result of this basin is

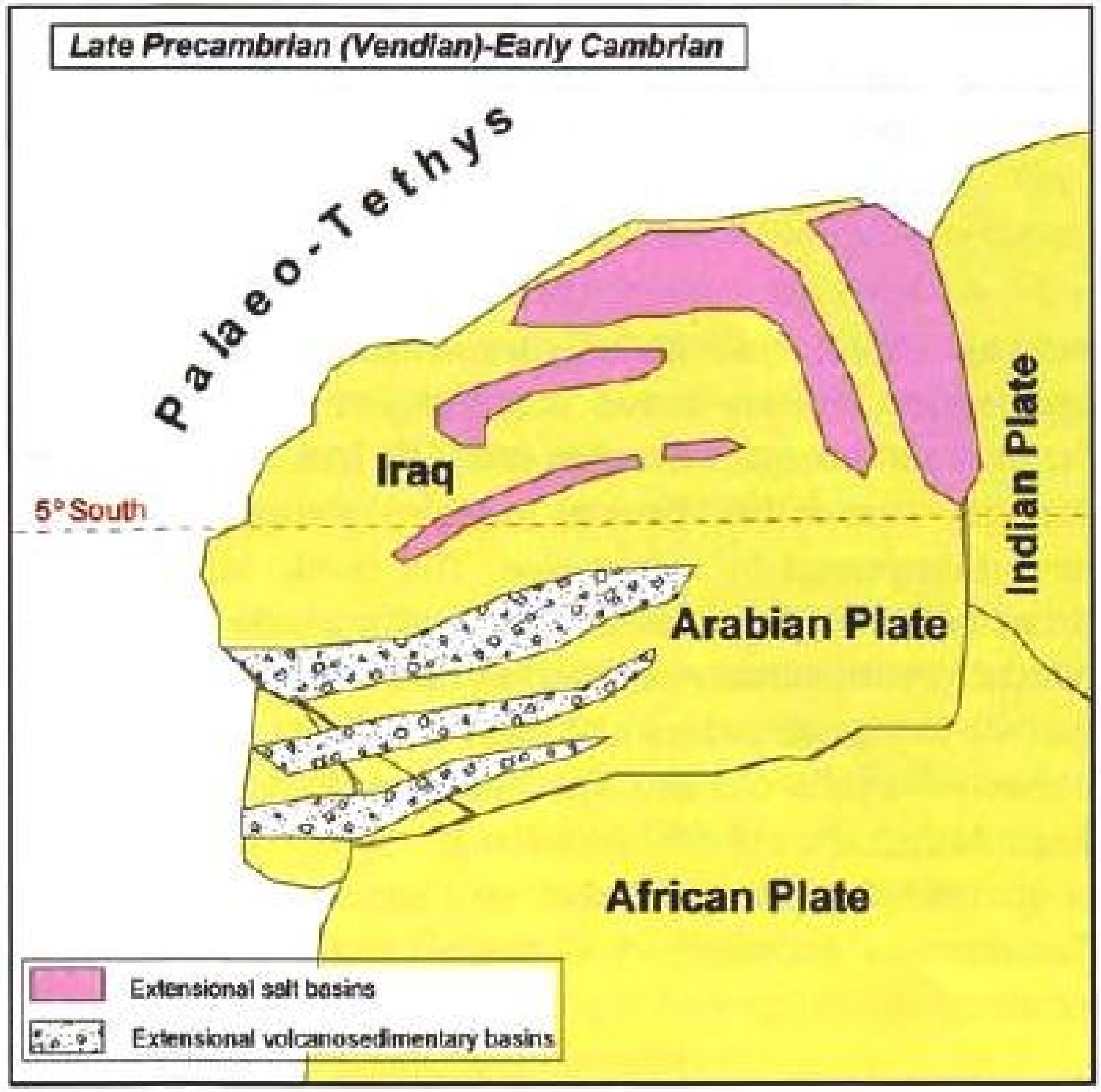
Hormuz Formation (570 MY)

with dykes within salts



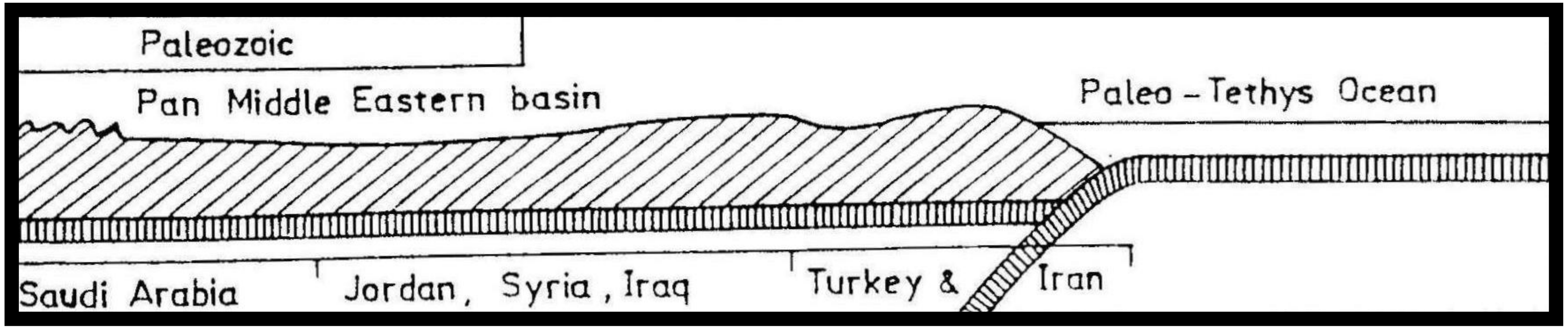
THE SETTING OF THE INFRA-CAMBRIAN, HORMUZ SALT BASINS OF THE ARABIAN GULF.

Pull apart Basins



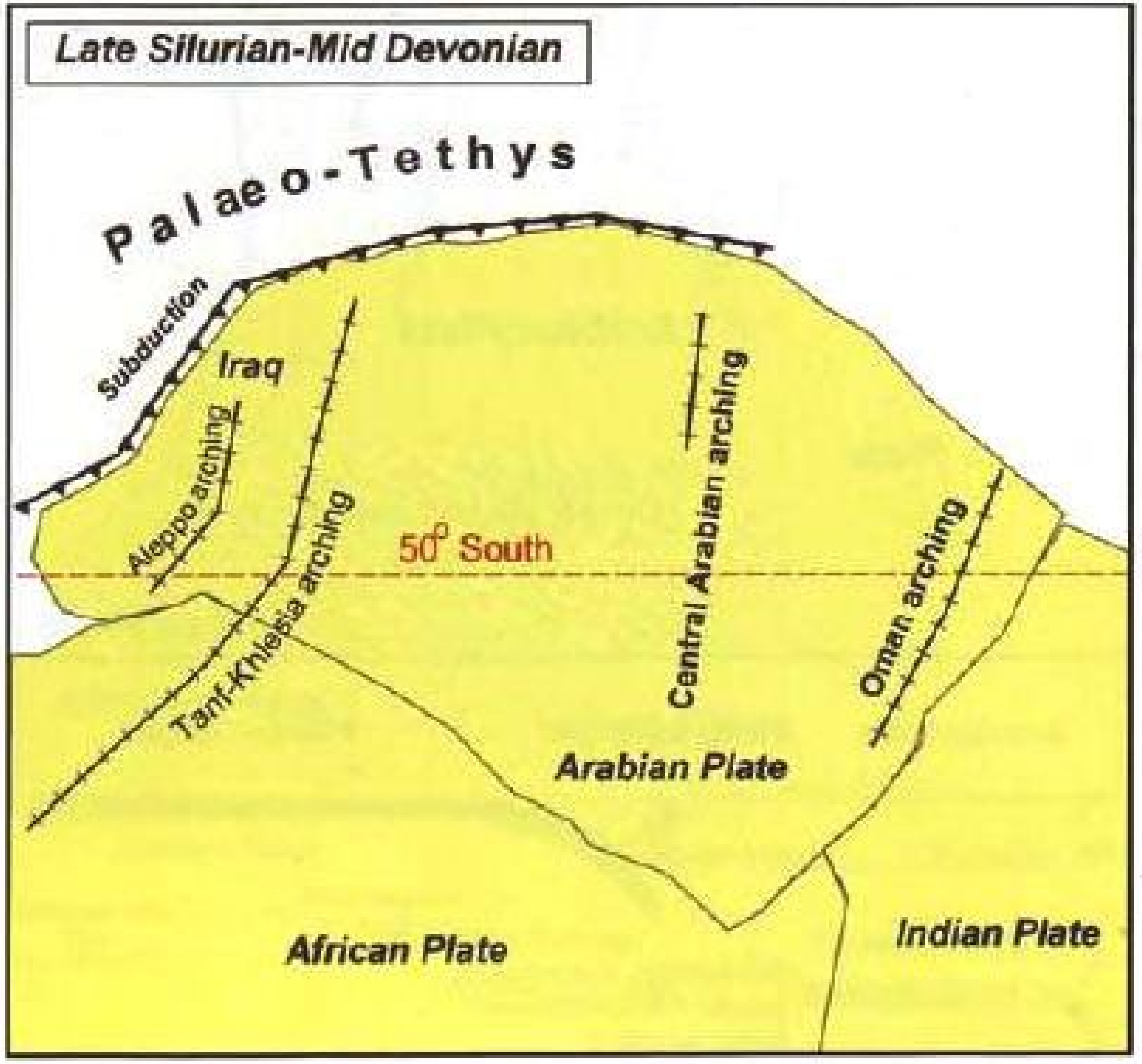
B- (Stage of Pan Basins) (550-250 MY)
Paleozoic era

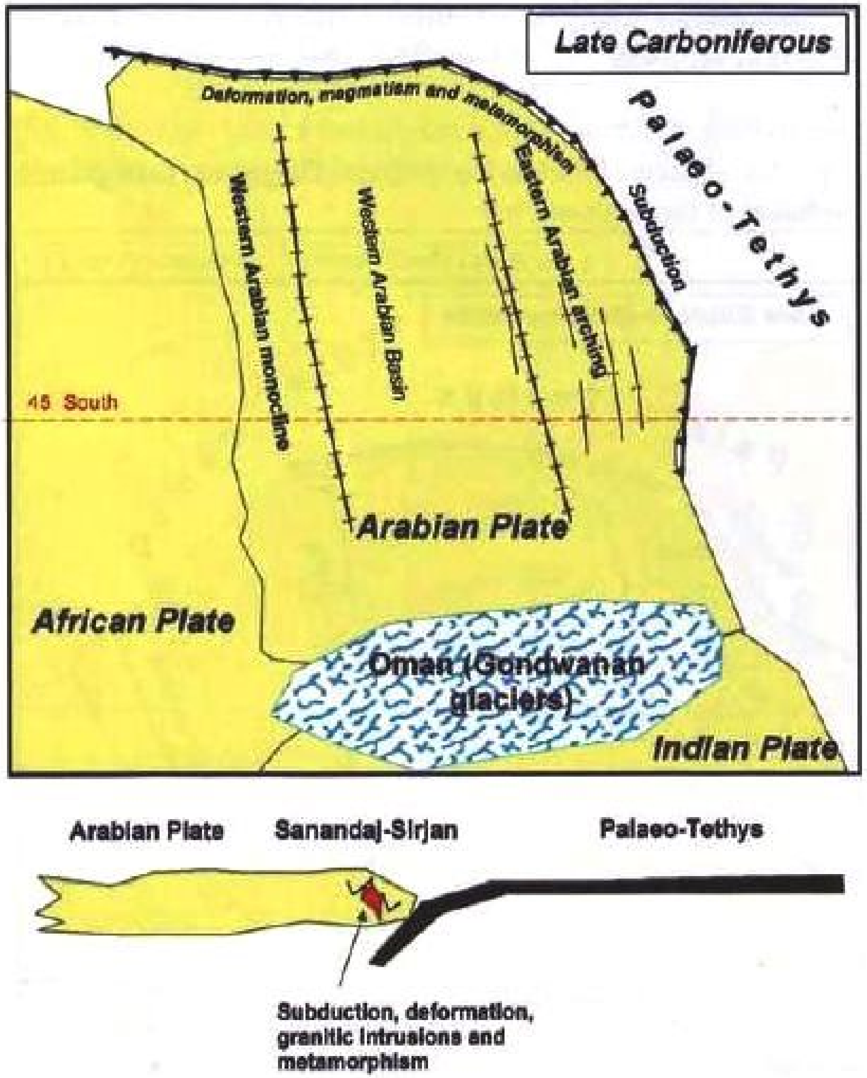
- wide basin inter the Arabian plate called (Pan Basins), reach to 4 km thickness



- subduction of oceanic crust to the (Paleo-Tethys)under the south eastern part of Arabian, Turkish and Iranian plate (Gondwana)
- Hercynian Orogeny was happened in Paleozoic

Paleozoic events in Arabian plate





Second : Open Phase

Triassic –L. Jurassic periods (250-200M.Y)

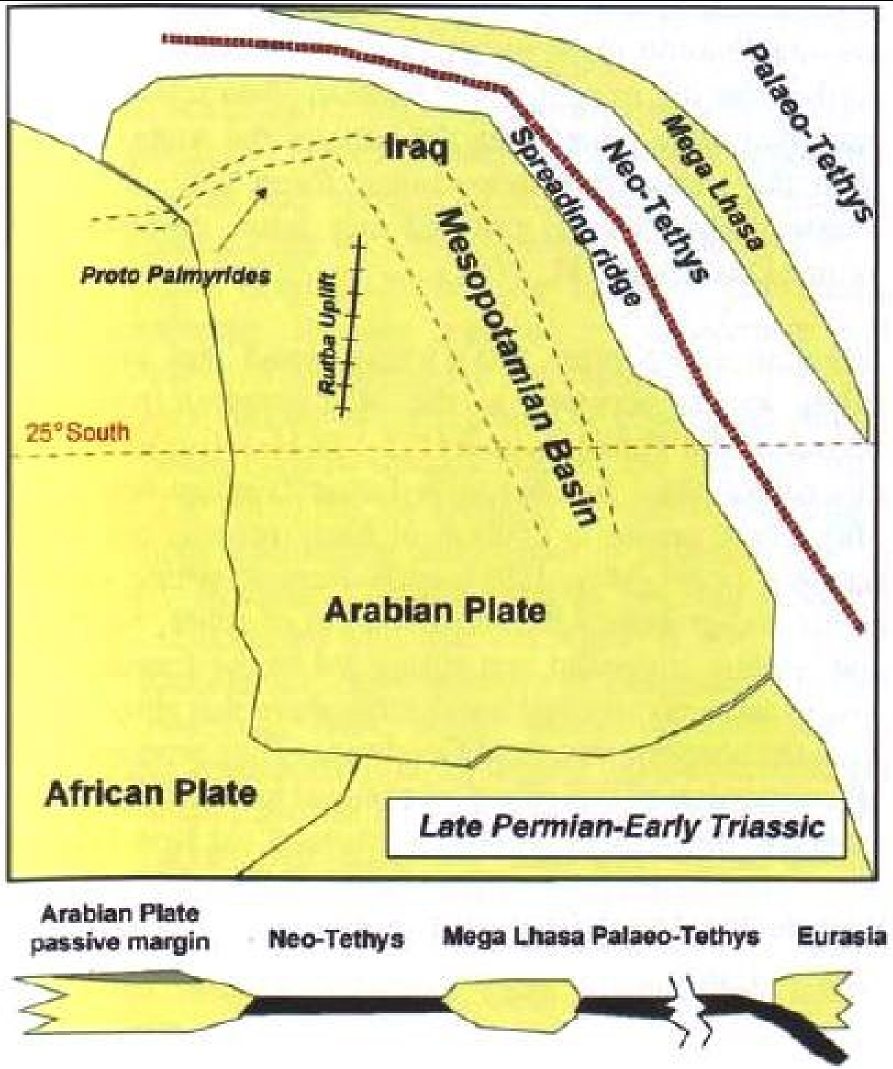
- Represents the process of opening the first phase of the Wilson tectonic cycle.
- This phase began separation plates Iranian and Turkish plates from Arabic plate, which has remained part of the African plate
- Neo-Tethys was created
- During this stage the mid oceanic ridges has been created under the Neo-Tethys
- It divided into :
- 1- (Early Rifting Stage)

  2- (Stage of Passive Margins)

A-Early Rifting Stage
E.Triassic (250 M.Y)

- Began as a result of the presence of convection currents down the north-eastern part of the African plate
- The rift basins represent the thinning regions in the lithosphere
- In this stage the evaporation deposits have been accumulated such as (Najma and Gotnia Formations).

Early Rifting Stage

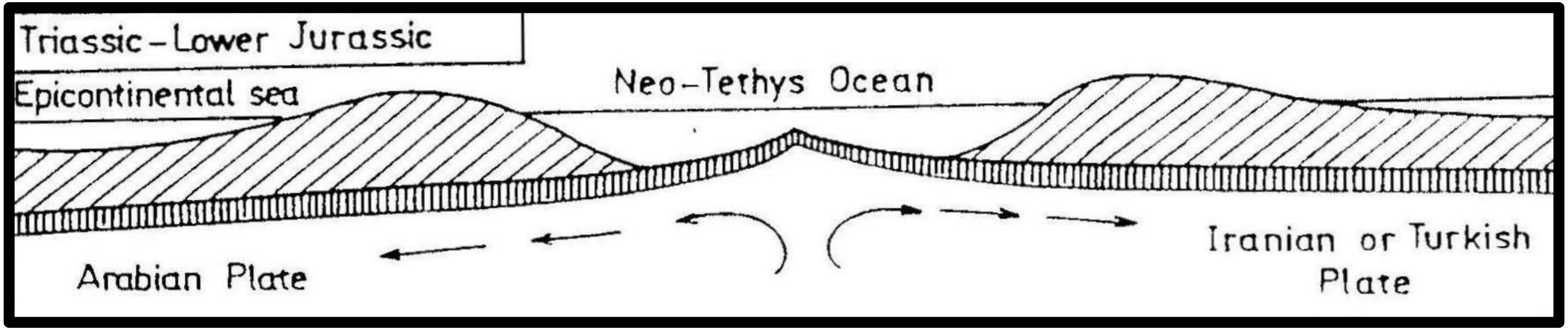


B-Stage of Passive Margins

- Lower-plate passive margin in the Turkish and Iranian plates while Upper-plate passive margin to the Arabian plate

- The huge Subsidence happened in the Arabian plate cause of Thermal Decay , this operation led to high thickness of deposits

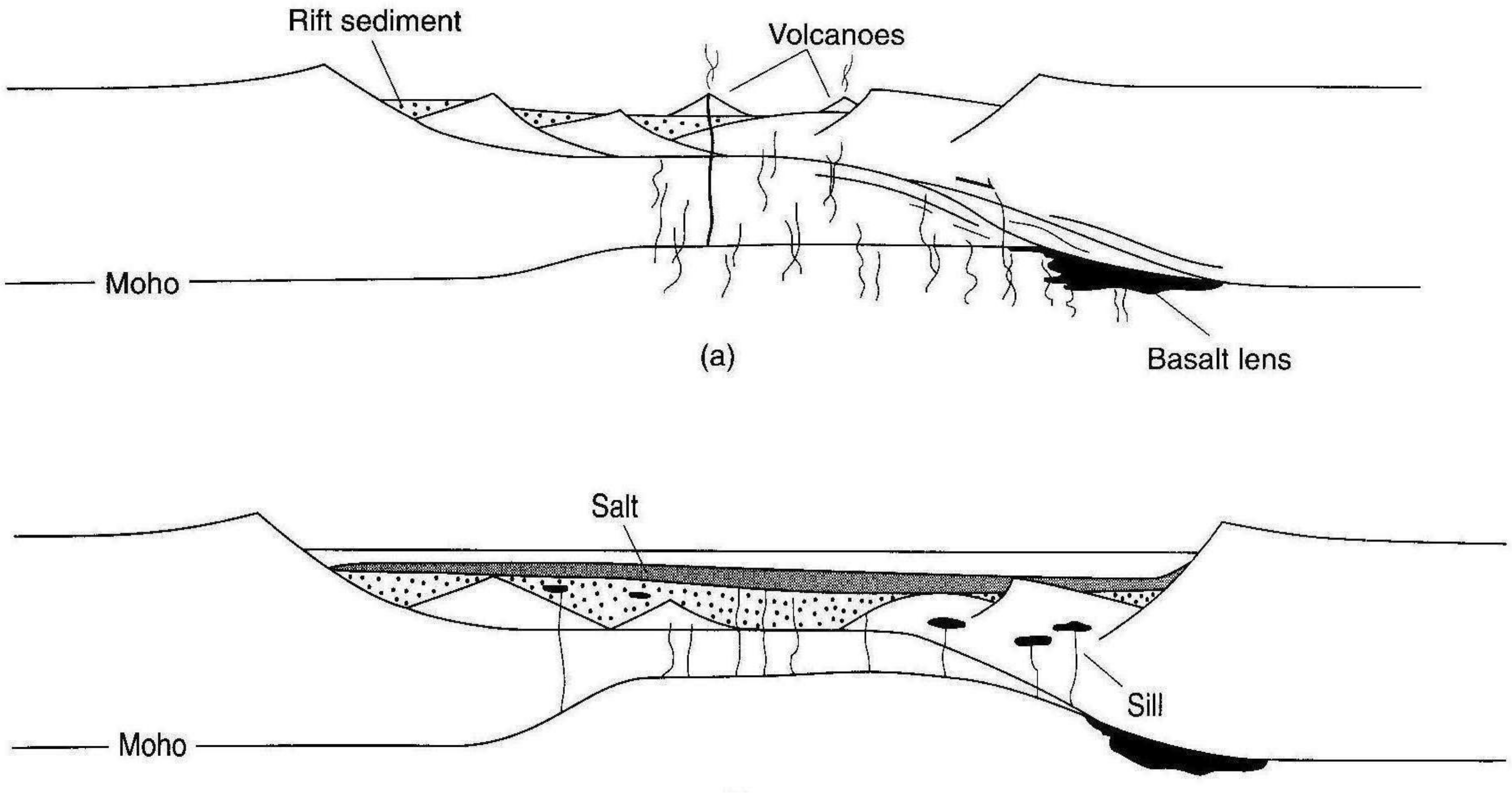
Tectonic position of Iraq during the opening phase



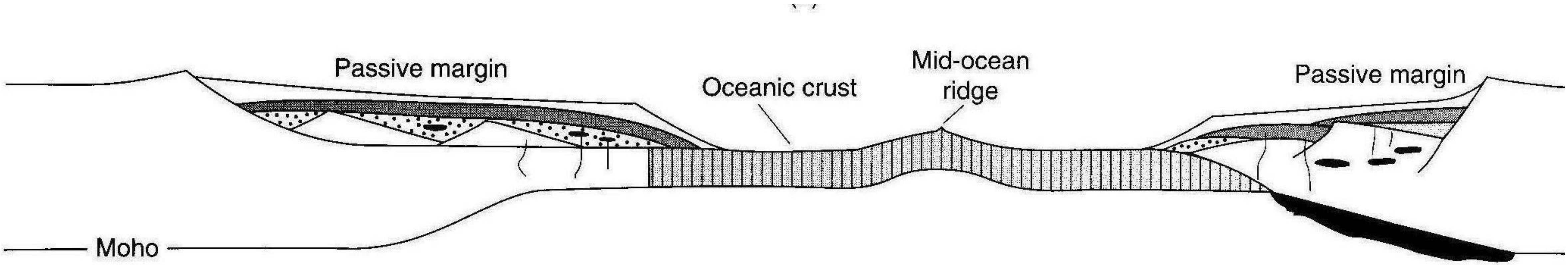
- **Important events**
- 1- separation of Iranian and Turkish plates from Arabian plate
- 2- Neo- Tethys formation
- 3-creation of Mid oceanic ridge
- 4- accumulative of salts deposit

Brief :

Early Rifting Stage



B-Stage of Passive Margins



(c)

Third : closing phase –U.Jurassic to recent (200 -0 M.Y)

- In this phase happened a geodynamic inversion in the tectonic forces of the region where the Extensional Forces turned that prevailed in the process of opening up to the forces of compression led to the convergence of plates

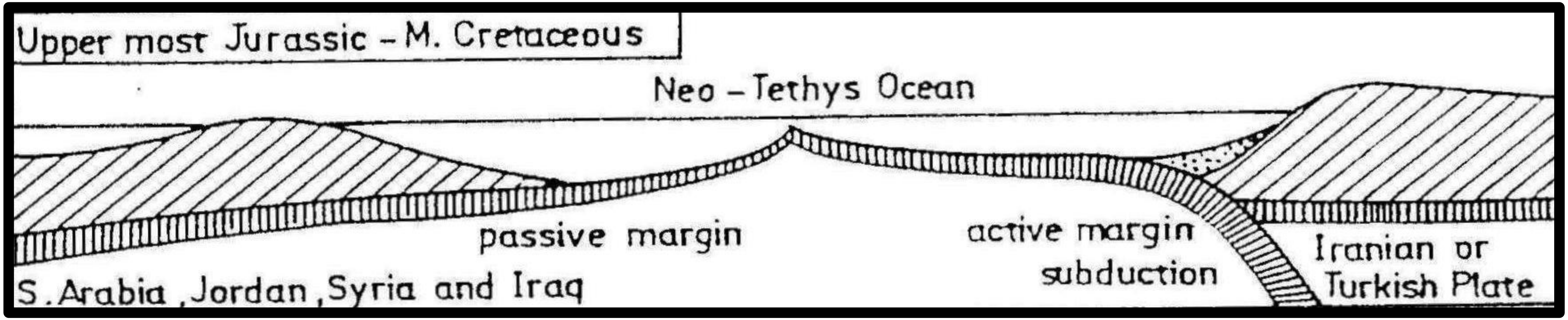
- Two stages in this phase :

1. Subduction stage
2. Collision stage

Subduction stage (200 – 40 M.Y)ago

- This phase began in the upper Jurassic and lasted until the end of the Tertiary
- During this phase, subduction Event of the oceanic crust of the neo Tethys down Iranian and Turkish plates (active margin) while the Arabian plate still passive margin
- Demolishes who was representing the Mesopotamian basin subjected to strong pressure led to a reversal of the usual movement on faults and converts it to reverse faults and thus turning graben structures to horst
- Continued convergence between the plates during this phase, which saw a number of movements tectonics (Nevadan and Laramaid movements).

Subduction stage



Collision stage (24- 0)M.Y ago

- This phase began from the end of tertiary (Miocene) and continues to the present time .

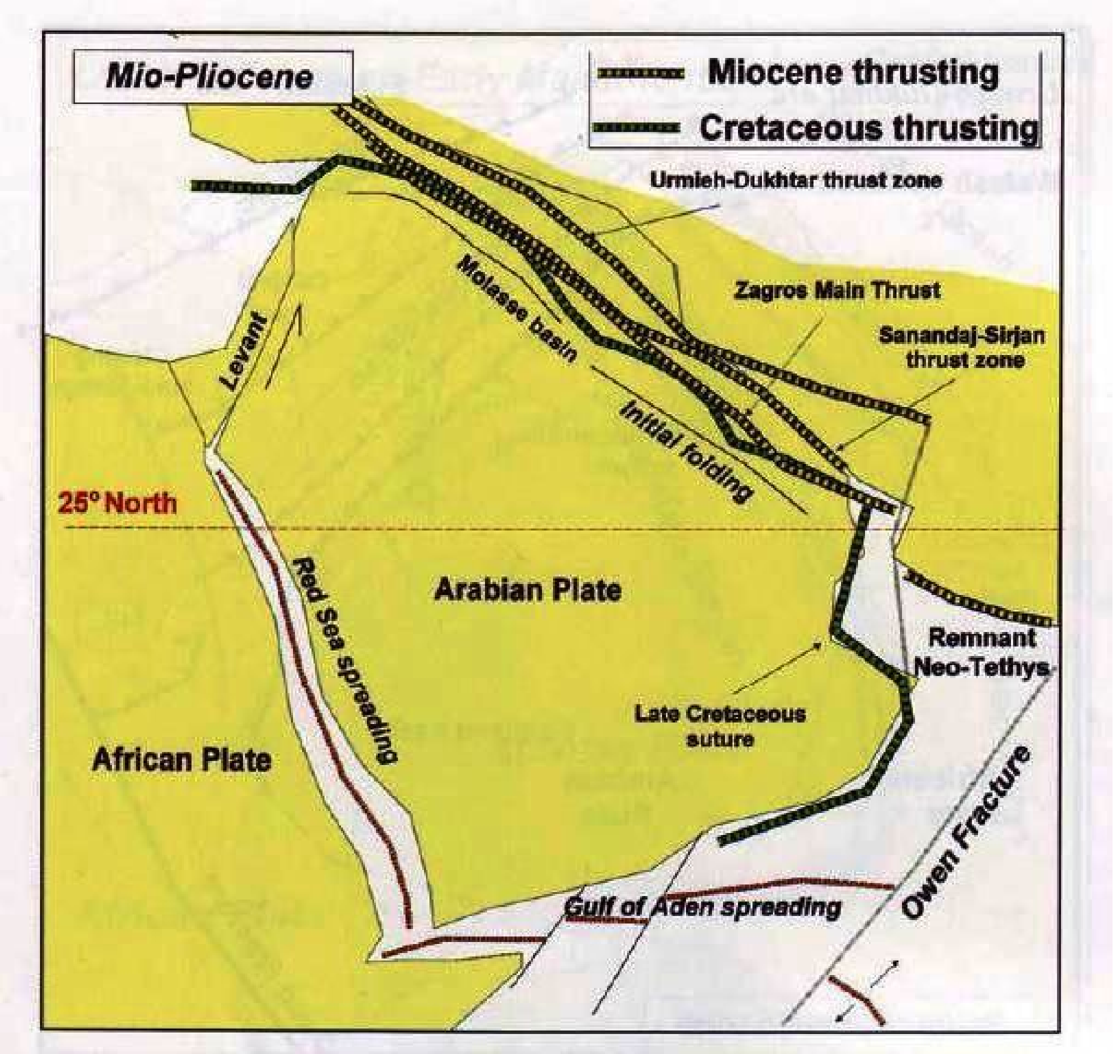
During this phase occurred collision of the Arabian, Iranian and Turkish plates, which led to a Alpine Orogeny

- A result of the collision between the Arabian and Iranian plates, created the **Zagros** mountain range **And** **Torus** mountain range between Arabian and Turkish plates.

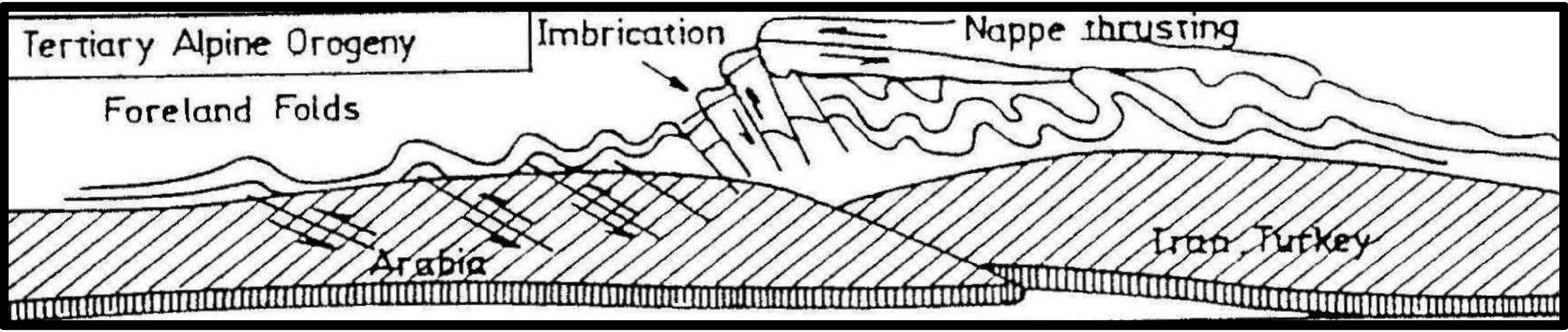
- Of the most important characteristic of this phase is to **be foreland basins.**

- Fatha and Injana formations are the important formations that indicated of the end of Fordland basin

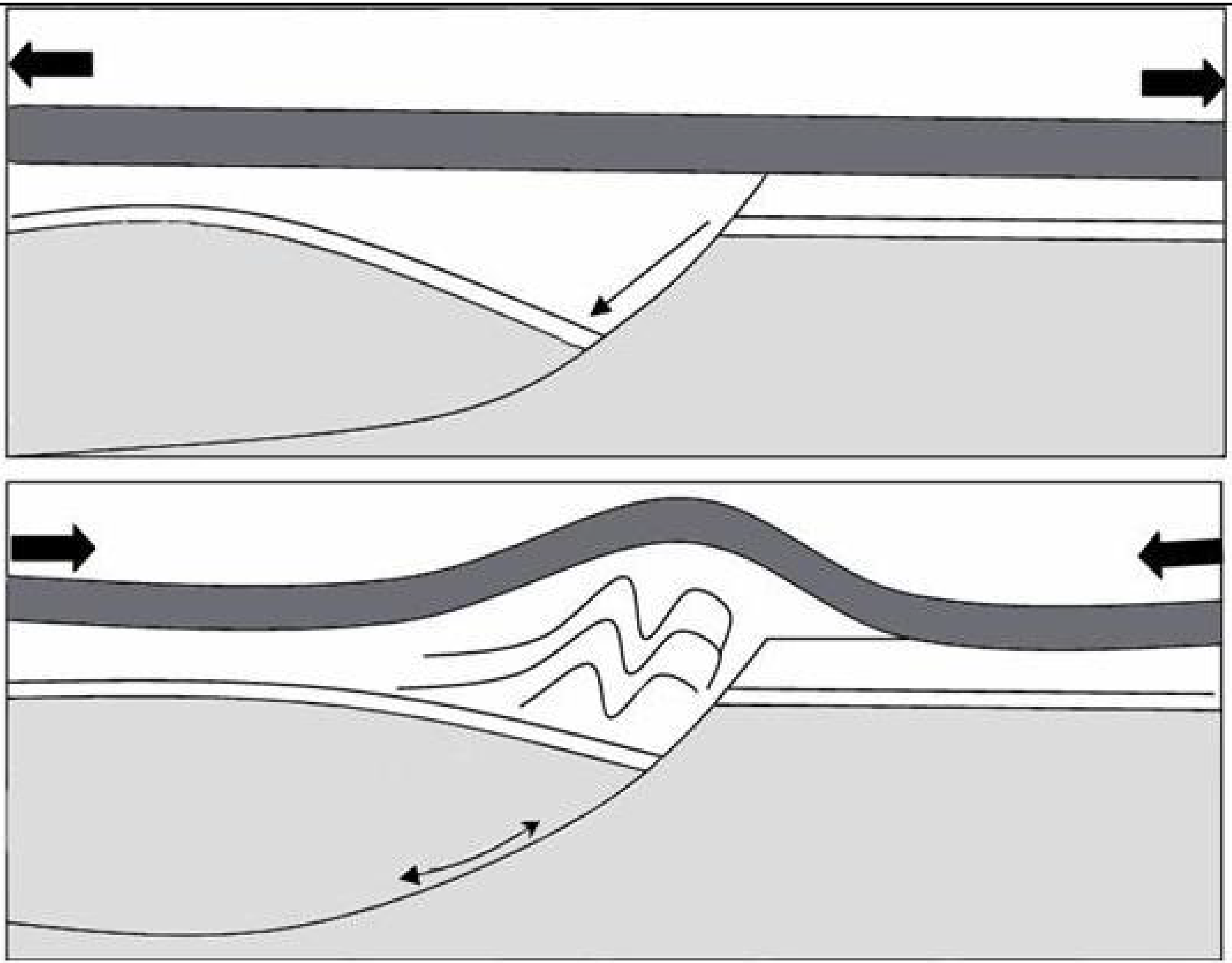
Collision stage



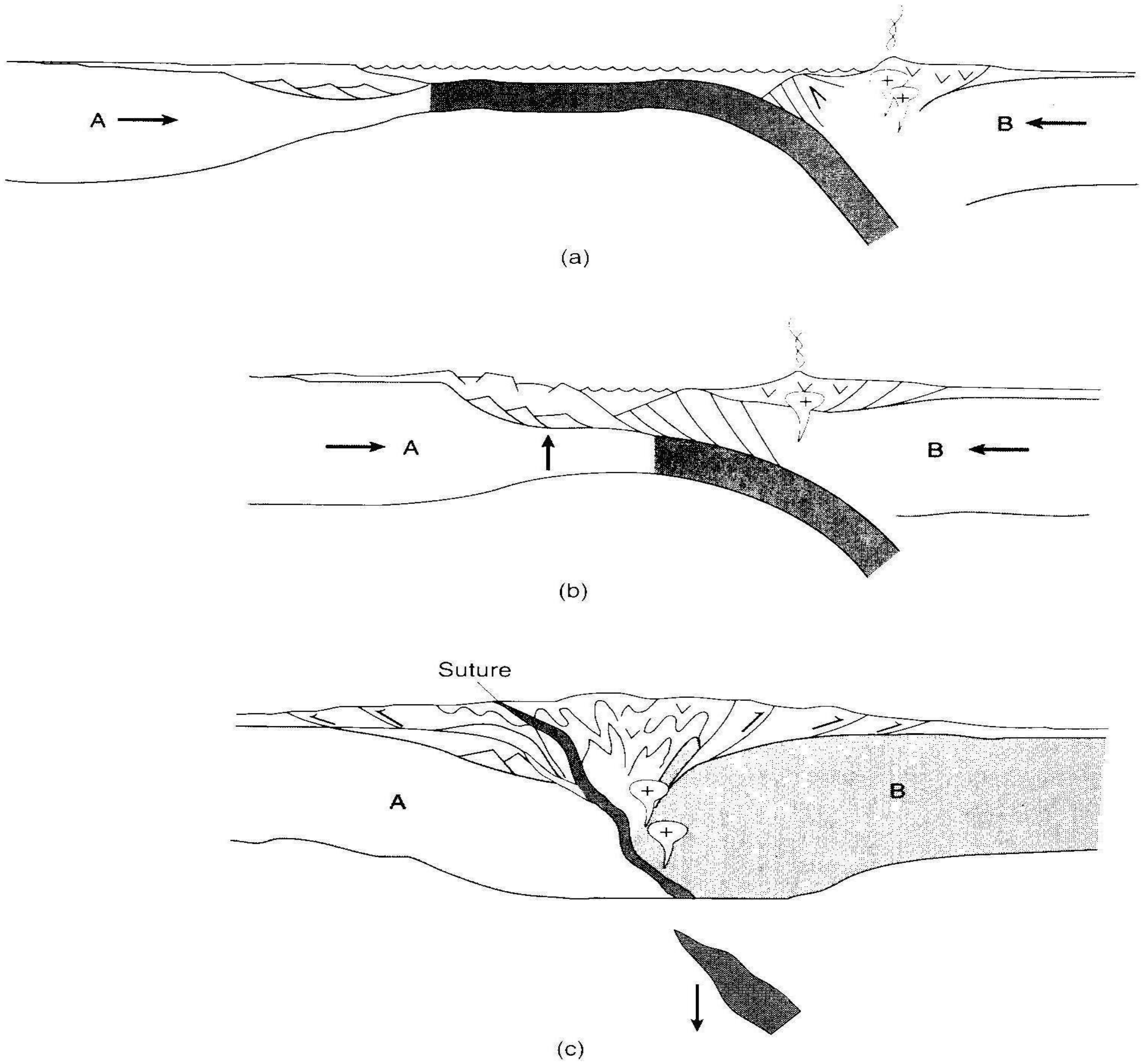
Collision stage

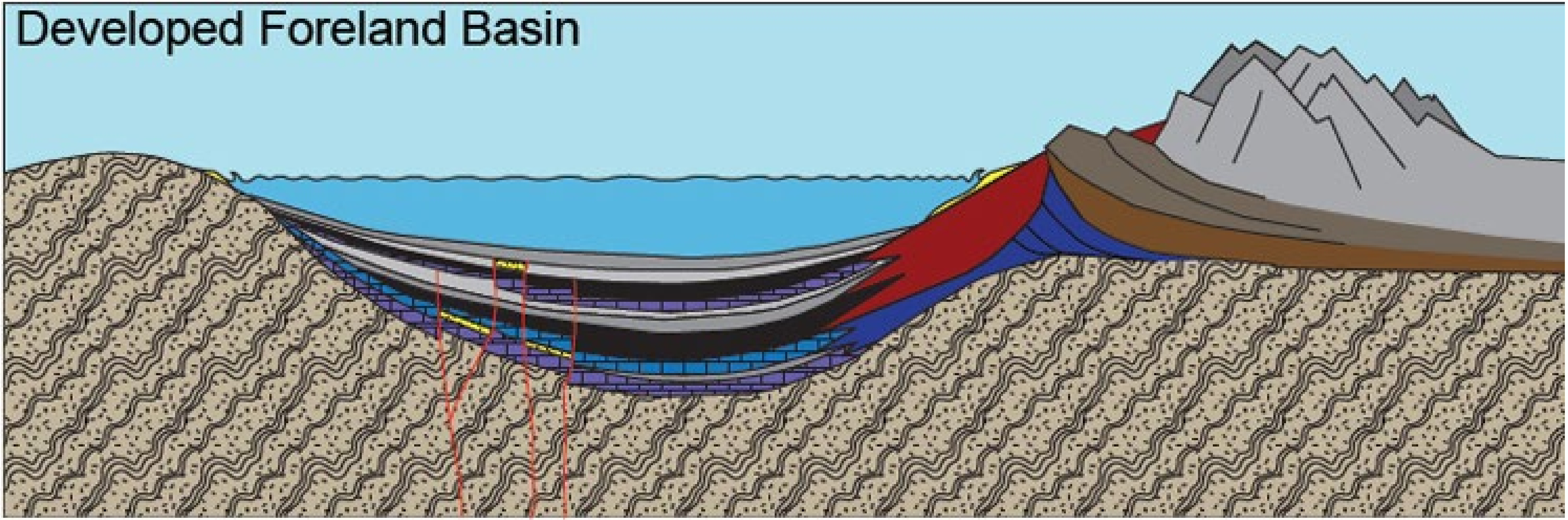


Mechanism of the folding in Foreland



Closing phase




Developed Foreland Basin

Numan,1997,2000,2001

1 subductional tectonic facies of the Zagros Thrust.

2 Zone of imbrication of the foreland basin.

3 Highly folded Zone of the foreland basin.

2+3 Foreland basin.

4 Suspended basin, foothill zone of the quasiplatform foreland.

5 Sagged basin of the Mesopotamian zone of the quasiplatform foreland.

4+5 Quasiplatform foreland.

2+3+4+5 Foreland Belt of the Arabian Plate.

6 Salman zone.

7 Rutba-Jezira zone.

6+7 Stable platform deposition.

Buday and Jassim,1987

1 Eugeosynclinal

2 Miogeosynclinal

1+2 Gosynclinal

3 High Folded Zone

4 Foothill Zone

5 Mesopotamian Zone

3+4+5 Unstable Shelf

6 Salman Zone

7 Rutba-Jezira Zone

6+7 Stable Shelf

Jabal Sanam

شكل (١-١) التقسيم التكتوني للعراق محور عن (Buday and Jassim,1987)

و(Numan,1997,2000, 2001) وموقع منطقة الدراسة

Jassim & Goff, 2006 divided Iraq tectonically to three zones

1-Stable shelf

A-Rutba subzone B- Jezira subzone C- Salman zone

D- Mesopotamian zone

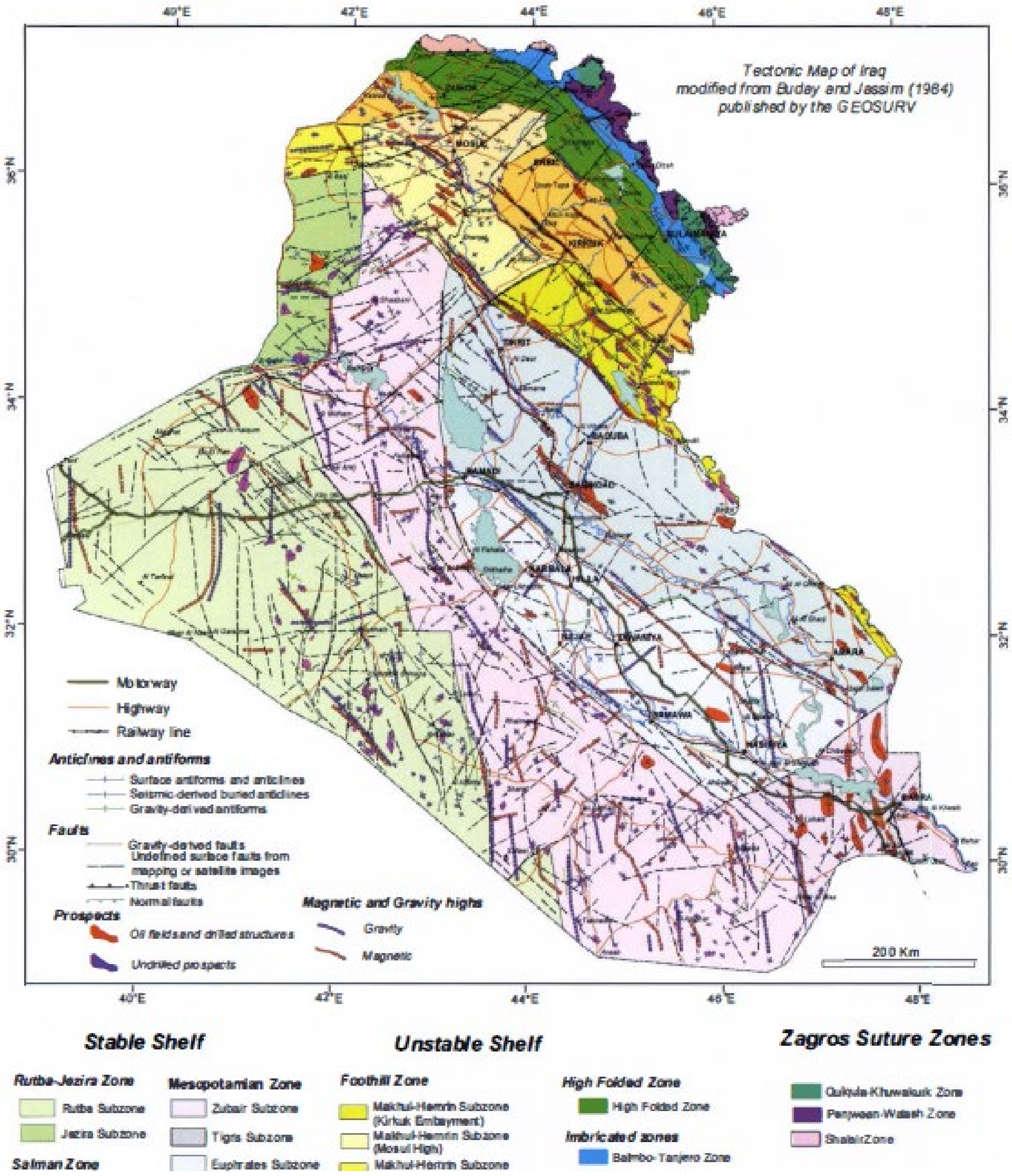
- Zubair subzone
- Tigris subzone
- Euphrates subzone

2- Unstable shelf

A- Foothill zone B- High folded zone

3-Zagros suture zone

Qulqula - khuwkurk zone B- Penjween – wlash zone C- Shalair zone



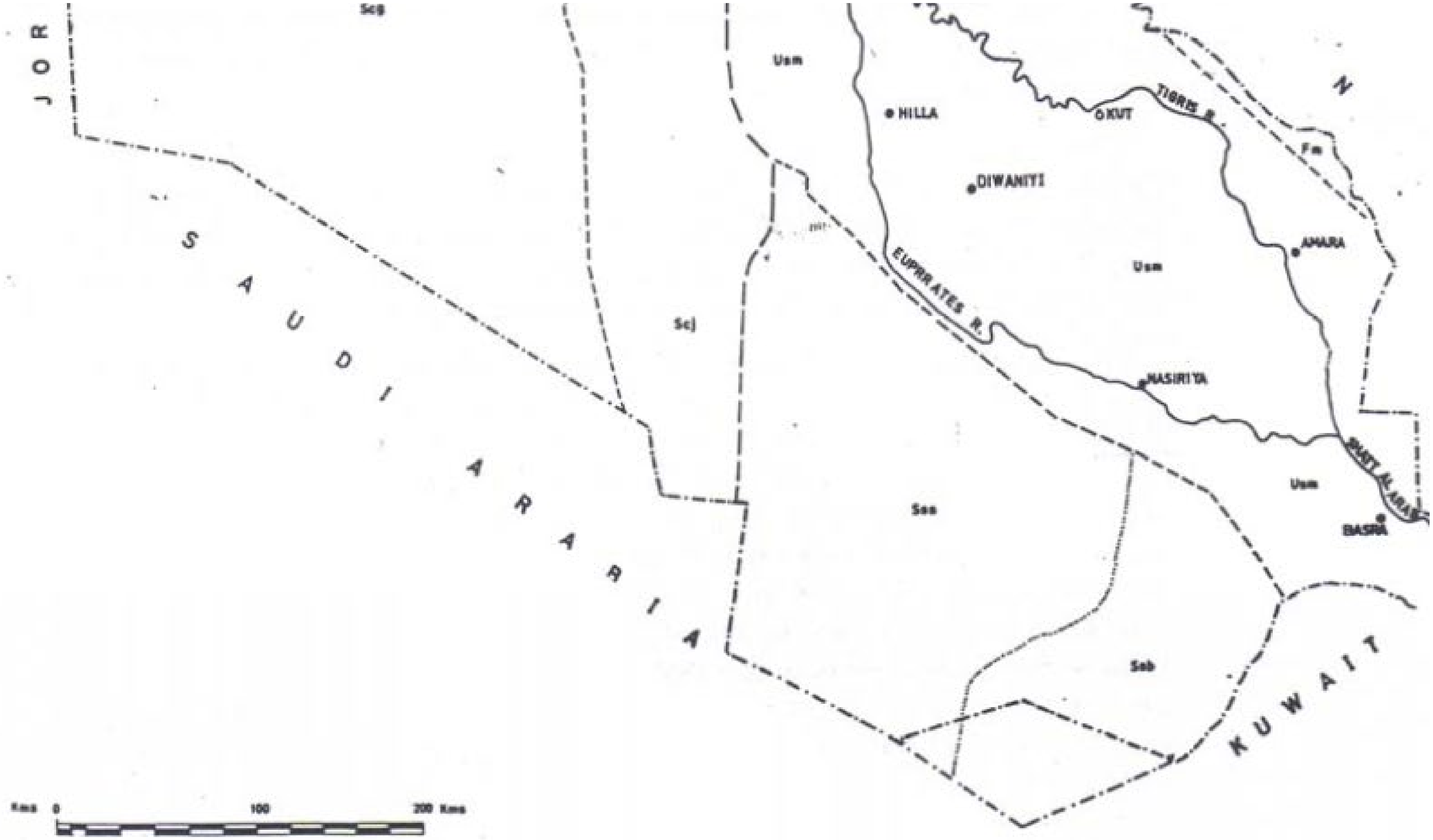
Tectonic Map of Iraq
modified from Buday and Jassim (1984)
published by the GEOSURV
40°E
42°E
44°E
46°E
48°E
36°N
34°N
32°N
30°N
MOSUL
KIRKUK
SULAIMANIYA
BAGHDAD
BAQUBA
RAMADI
KARBALA
HILLA
DIWANIYA
SAMAWA
NASIRIYA
AMARA
BASRA
Motorway
Highway
Railway line
Anticlines and antiforms
Surface antiforms and anticlines
Seismic-derived buried anticlines
Gravity-derived antiforms
Faults
Gravity-derived faults
Undefined surface faults from mapping or satellite images
Thrust faults
Normal faults
Prospects
Oil fields and drilled structures
Undrilled prospects
Magnetic and Gravity highs
Gravity
Magnetic
200 Km
Stable Shelf
Unstable Shelf
Zagros Suture Zones
Rutba-Jezira Zone
Rutba Subzone
Jezira Subzone
Salman Zone
Mesopotamian Zone
Zubair Subzone
Tigris Subzone
Euphrates Subzone
Foothill Zone
Makhul-Hemrin Subzone (Kirkuk Embayment)
Makhul-Hemrin Subzone (Mosul High)
Makhul-Hemrin Subzone
High Folded Zone
High Folded Zone
Imbricated zones
Balambo-Tanjero Zone
Qulqula-Khuwakurk Zone
Penjwean-Walash Zone
Shalair Zone

Tectonic Divisions of Iraq
Lec- 3

By : Dr. Maher M Mahdi // Asst. lecturer Hawraa Al-Sahlani

Buday, 1980

TURKEY
SYRIA
IRAN
JORDAN
ZAKHO
TT
AMADIYA
Hfn
Fqg
Fch
Fm
MOSUL
GR. ZAB
Fqm
ARBIL
Hfr
Fk
RAWANDOZ
Tz
Zr
LESSER ZAB
Scr
KIRKUK
SULAIMANIYA
Ib
BAIJI
TIGRIS R.
Scj
EUPHRATES R.
ANAH
Sca
Uam
DIYALA
KHANAQIN
BAQUBA
BAGHDAD
RAMADI
RUTBA



JOR
SAUDI ARABIA
KUWAIT
N
Scg
Scj
Usm
See
Seb
Fm
HILLA
KUT
TIGRIS R.
DIWANITI
AMARA
EUPHRATES R.
NASIRIYA
SHATT AL ARAB
BASRA
Kms 0
100
200 Kms

Scr	Abu Rassain Block (With Sinjar Block)	Western Subzone	Block Faulted Zone	Stable Shelf	Nubio-Arabian Craton
Sca	Anah Block				
Scj	Abu Jiu Subzone				
Sss	Salman Block	Shabicha Subzone			
Ssb	Busaya Block				
Usm	Mesopotamian Zone			Unstable Shelf	
Fm	Makhul Subzone		Foothill Zone		
Fgm	Qalian Subzone - Mosul Block				
Fqg	Qalian Subzone - Gussir Block				
Fk	Kirkuk Subzone				
Fch	Chemchemal Subzone				
Hfr	Qamchuqa - Ranya Subzone	High Folded Zone			
Hfa	Amadiya Shaqlawa Subzone				
Ir	Outer (Rowanduz) Subzone	Imbricated Zone		Mio-Geosyncline	Geosycline
Ib	Inner (Marginal Belt) Subzone				
TT	Northern Thrust Zone				
Tz	Zagroz Thrust Zone		Eugeosyncilne		

- **The platform part of the Iraqi territory is divided into two basic units**

1. **The Stable Shelf**

- The Stable Shelf is characterized by reduced thickness of the sedimentary cover and by the lack of folding.

2. **The Unstable Shelf**

- The Unstable Shelf has a thick and folded sedimentary cover; the intensity of the folding increasing in northeastern-direction.

- **The Stable Shelf or Syrian-Iraqi Zone is divided into three sub zones**

- **The first one** is the Western Sub zone with the highest and most stable **Ga'ara Block**, the relatively mobile **Anah Block** and the moderately , mobile **Abu Rassain Block** with the **Khleisia Uplift**.

- **The Second Unit** is the, North-South trending **Abu Jir Subzone** forming during the development of the country' - often a very important paleogeographical and structural boundary.

- **The Last Unit** of the Shelf is the **Shbicha** Subzone forming together with the **Anah**, **Abu Rassain** and partly **Abu Jir** units a transition to the mobile parts of the platform.

  - **The Shbicha Subzone** is divided into the northwestern **Salman Block** and southeastern **Busaya Block**.

- **The Unstable Shelf is divided into Three Units, the outer, central and innermost units.**

- **The outer (westernmost) unit** of the Unstable Shelf is the **Mesopotamian Zone**

Characterized by great subsidence since at least Mesozoic times culminating in the late Cenozoic and by slight folding of the sedimentary covers.

- It is divided into the southwestern Euphrates Subzone and northeastern Tigris Subzone.

- The Mesopotamian Zone roughly corresponds to the late Neogene foredeep.

- **The central unit of the Unstable Shelf is the Foothill Zone.**
- It is characterized by thick sedimentary cover and by well marked folding.
- The folds are 'arranged in narrow long anticlines and broad flat synclines.

- **The Foothill Zone** is divided according to the peculiarities of its stratigraphy and partly structure into **several minor** units:

  - **Makhul Subzone in the southwest**
  - **Kirkuk and Qalian Subzone in the central part of the zone**
  - **Chemchemal Subzone in the northeast.**

- **The innermost unit is the High Folded Zone**
- which is characterized by **intense folding** and **orogenic uplift**, with closely packed narrow anticlines and synclines.
- Only a narrow stripe of the **Alpine** geosynclinal area falls within Iraq.
- It belongs to the southern branches of the Asian Alpines and the Iraqi units are parts of **the Toros** (in the north) and **Zagros** (in the northeast) Mountains.

➢ The Imbricated Zone

Marked by Thrust-Folded Structures and by several **thrust or thrust over blocks of eugeosynclinal** sediments or magmatic.

- **The Imbricated Zone** is composed of the
  - **Outer-Rawanduz Subzone** wit mostly Mesozoic sediments
  - **The Inner-marginal belt Subzone**, which is essentially-an intro-montane Tertiary basin.

- **The second zone** is the **Northern Thrust Zone**, which according to Buday (1973b) is composed of sediments of the miogeosynclinal ridge thrust over the miogeosynclinal trough of northern Iraq.

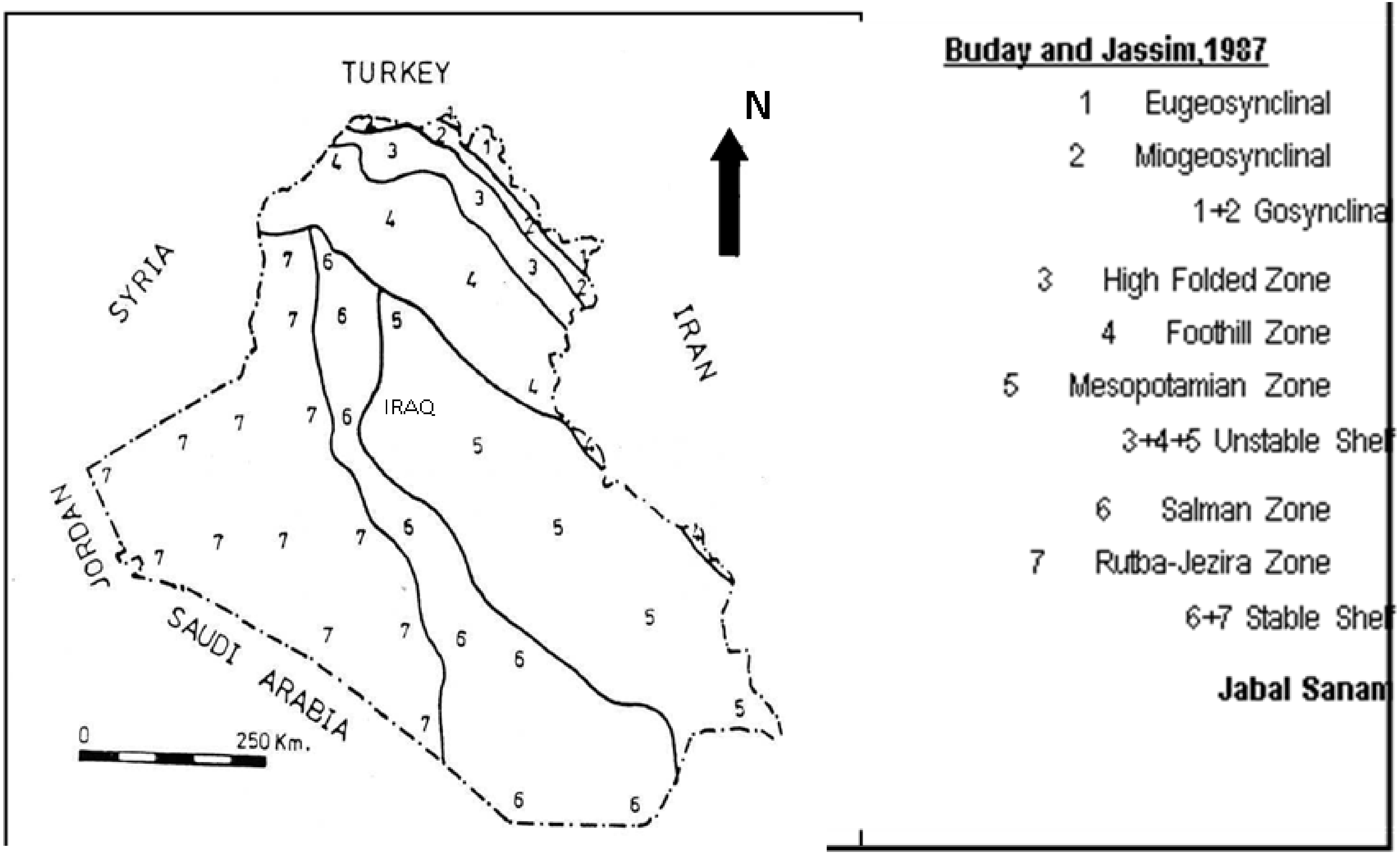
➢ The Zagros Thrust Zone

Is composed essentially of two main parts.

These are the **structurally lower and outer Tertiary units** composed of the mostly **sedimentary** **lower naopurdan unit** and the **higher volcanic – sedimentary walash unit**,

the **structurally** higher formerly' designated as **Qandil unit**, has a very complex structure and stratigraphy, which is still subject of investigations and discussions.

It is clear that the bulk of its sediments and magmatics is Cretaceous or older however the later has not been proved.


TURKEY
SYRIA
IRAN
IRAQ
JORDAN
SAUDI ARABIA
N
0
250 Km.
Buday and Jassim,1987
1 Eugeosynclinal
2 Miogeosynclinal
1+2 Gosynclina
3 High Folded Zone
4 Foothill Zone
5 Mesopotamian Zone
3+4+5 Unstable Shelf
6 Salman Zone
7 Rutba-Jezira Zone
6+7 Stable Shelf
Jabal Sanam

TECTONIC AND STRUCTURAL EVOLUTION OF THE MESOPOTAMIA FOREDEEP, IRAQ

Lec-4

By : Dr. Maher M Mahdi // Asst. lecturer Hawraa Al-Sahlani

Tectonic Divisions of Iraq

The first comprehensive tectonic division of Iraq was introduced by Buday (1980), then by Buday and Jassim (1987). In their work, the Iraqi territory was divided into:

Stable Shelf (to the southwest) and **Unstable Shelf** (to the northeast).

Unstable Shelf into Mesopotamian, Foothill, High Folded and Geosynclinal Zones.

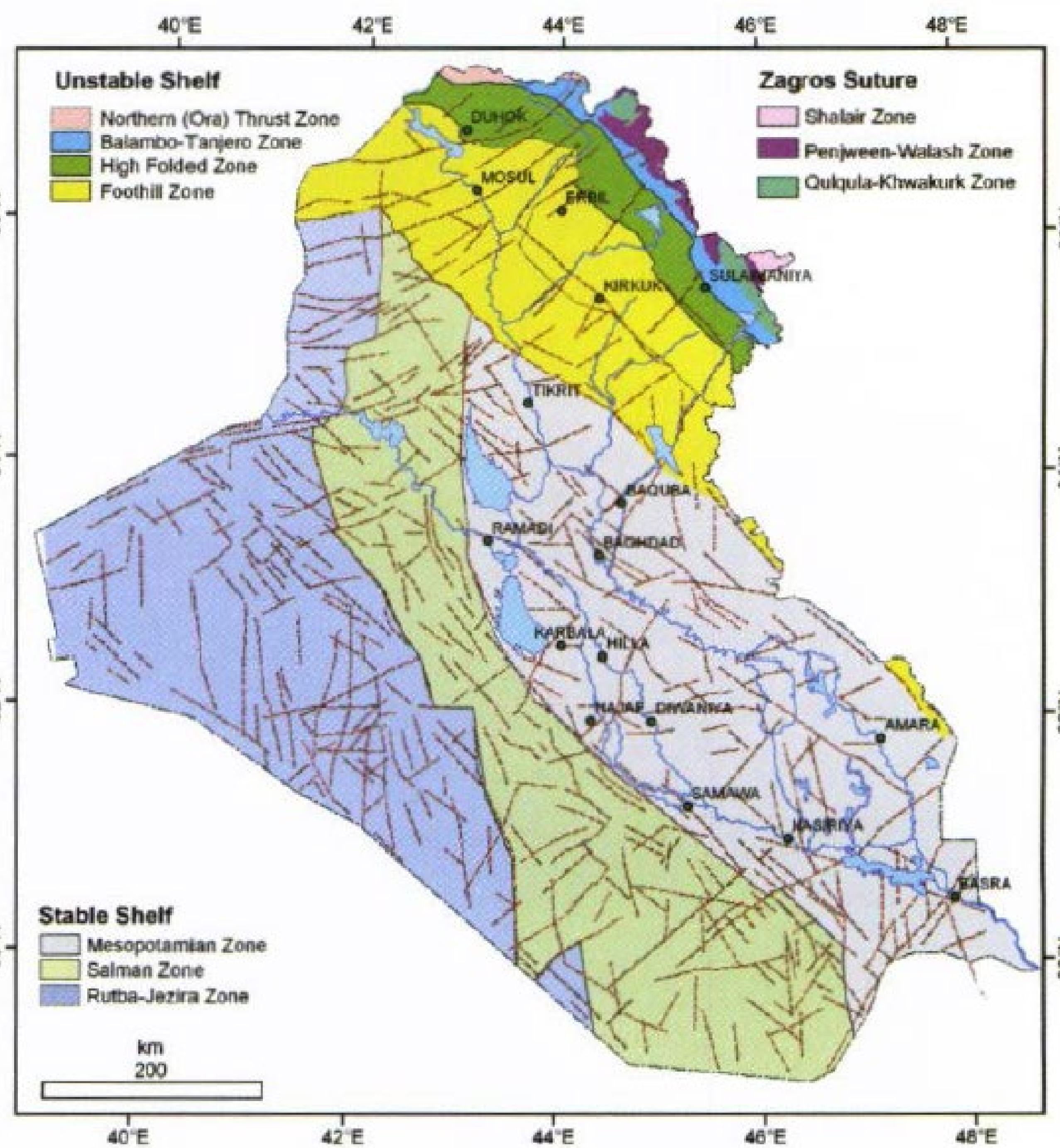
According to this division, **the Mesopotamian Zone** as a part of the Unstable Shelf, is bordered from the northeast by "the first superficially and morphologically prominent anticlines starting with Makhul, continuing southeastward with Himreen, Badra and Buzurgan". major zone.

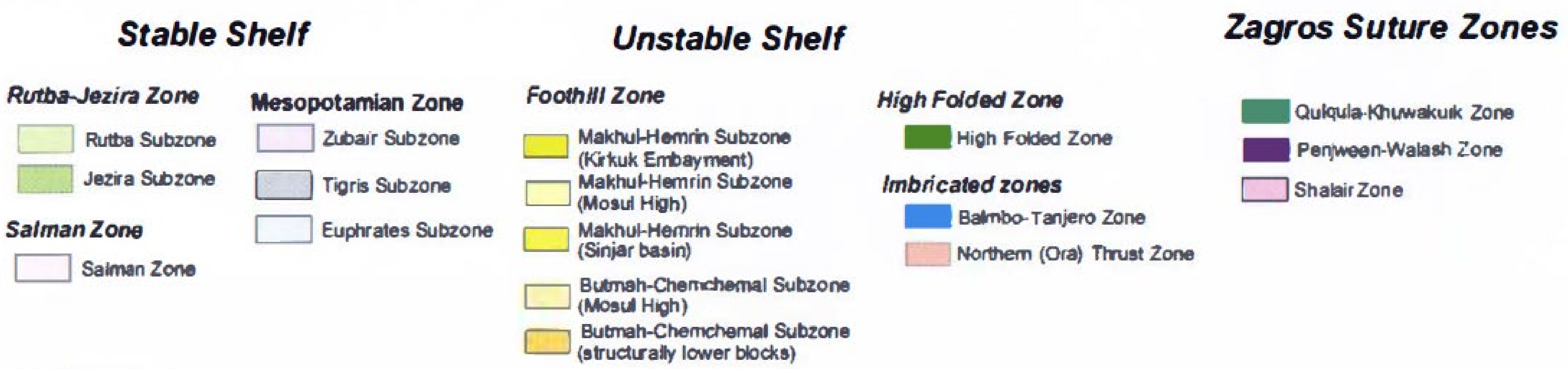
The southwestern boundary of the zone coincides with the Euphrates Fault, extending in a NW direction to Al-Ramadi, then swings sharply in a NS direction to follow the Tharthar valley, and then terminates against Makhul Range near Al Hatra .

Furthermore, they have subdivided the Mesopotamian Zone into a minor eastern (Tigris), western (Euphrates), and southern (Zubair) Subzones.

Jassim and Goff (2006) made a crucial modification to the tectonic divisions by considering the Mesopotamian Zone as a part of the Stable Shelf.

Goff and Jassim 2006




Stable Shelf
Rutba-Jezira Zone
Rutba Subzone
Jezira Subzone
Salman Zone
Salman Zone
Mesopotamian Zone
Zubair Subzone
Tigris Subzone
Euphrates Subzone
Unstable Shelf
Foothill Zone
Makhul-Hemrin Subzone (Kirkuk Embayment)
Makhul-Hemrin Subzone (Mosul High)
Makhul-Hemrin Subzone (Sinjar basin)
Butmah-Chemchemal Subzone (Mosul High)
Butmah-Chemchemal Subzone (structurally lower blocks)
High Folded Zone
High Folded Zone
Imbricated zones
Balambo-Tanjero Zone
Northern (Ora) Thrust Zone
Zagros Suture Zones
Qulqula-Khuwakurk Zone
Penjween-Walash Zone
Shalair Zone

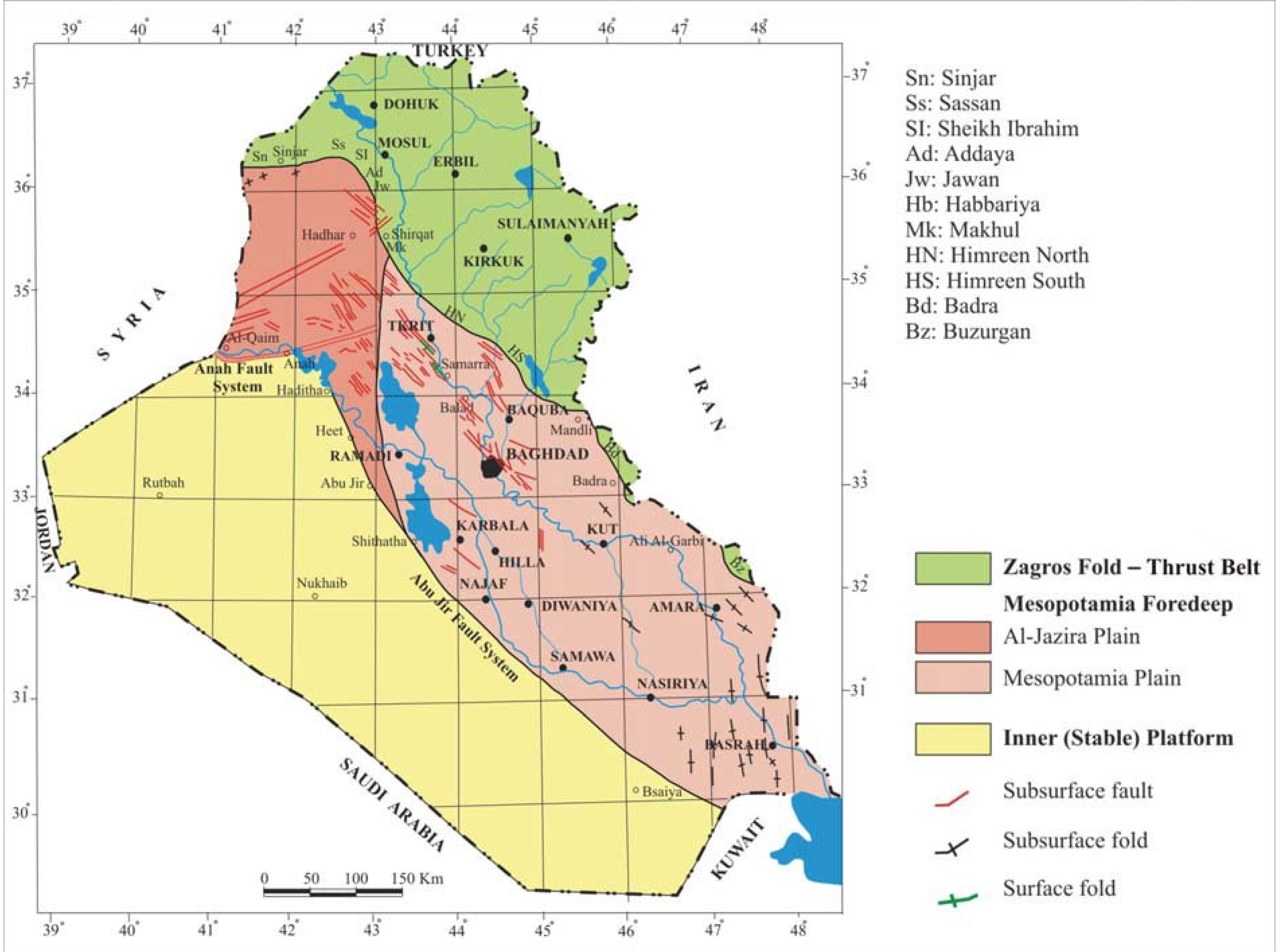
Depending on Fouad

It is critically important to mention that almost all of the mentioned tectonic divisions of Iraq, have had considered the present day "Mesopotamian Flood Plain" as the entire Mesopotamian basin (or zone).

This consideration has caused a lot of confusion and uncertainties to the true structural nature of the basin. Actually, the Mesopotamia Basin is much larger and areally extensive, than that of the Mesopotamian Zone (or Flood Plain),which consists only a part of it.

The present day Mesopotamia Basin extends from northeast Syria to the Straits of Hormuz. It consists of two domains, the first is a terrestrial one that covers parts of northeast Syria, Iraq, and parts of Kuwait and the coastal plains of Iran, and the second is a marine, represented by the Arabian Gulf Basin.

The term "**Mesopotamia Foredeep"** will be used instead of the Mesopotamia Zone, because of its comprehensive dynamic and tectonic implications.
Moreover, the Mesopotamia Foredeep will be redefined as well as its geological setting and boundaries, to fit the modern tectonic and structural concepts.



TURKEY
SYRIA
IRAN
JORDAN
SAUDI ARABIA
KUWAIT
DOHUK
MOSUL
ERBIL
SULAIMANYAH
KIRKUK
TIKRIT
Samarra
Balad
BAQUBA
Mandli
BAGHDAD
Badra
RAMADI
Heet
Haditha
Anah
Al-Qaim
Anah Fault System
Hadhar
Shirqat
Sinjar
Rutbah
Abu Jir
Shithatha
Nukhaib
KARBALA
HILLA
NAJAF
DIWANIYA
KUT
Ali Al Garbi
AMARA
SAMAWA
NASIRIYA
BASRAH
Bsaiya
Abu Jir Fault System
0 50 100 150 Km
Sn: Sinjar
Ss: Sassan
SI: Sheikh Ibrahim
Ad: Addaya
Jw: Jawan
Hb: Habbariya
Mk: Makhul
HN: Himreen North
HS: Himreen South
Bd: Badra
Bz: Buzurgan
Zagros Fold – Thrust Belt
Mesopotamia Foredeep
Al-Jazira Plain
Mesopotamia Plain
Inner (Stable) Platform
Subsurface fault
Subsurface fold
Surface fold

TECTONIC AND STRUCTURAL EVOLUTION OF THE MESOPOTAMIA FOREDEEP, IRAQ

The Mesopotamia Foredeep contains a thick sedimentary pile that thickens northeastwards. On the surface, it is covered mainly by different types of Quaternary deposits that thicken southeastwards.

Magnetic and gravity data are the only source of information about the basement.

According to the CGG (1974), the basement is 8 Km deep in the western part of the foredeep, and sloping eastwards to 14 Km deep, near the Iraqi Iranian borders.

Sequence Stratigraphy of the Mesopotamia Foredeep

- **Paleozoic sequence**

The full thickness of the Paleozoic sequence is not penetrated in any borehole in Iraq. Only few deep exploration wells in central and southern Iraq reached the uppermost part of the Paleozoic sequence. Nevertheless, at the northwestern part of the foredeep, the deep Khleissia-1 exploration well penetrated **2098 m** of the Paleozoic sequence.

The penetrated sequence is assigned to the Ordovician Khabour, Pirispiki, Carboniferous Ora and Harur formations.

The Paleozoic sequence, as it is the case in most Arabia, is dominated by **siliciclastic** sediments deposited in a shallow epicontinental sea. The sediments reflect a considerable uniformity around the Paleo-Tethys passive margin.

- **Mesozoic sequence**

The Mesozoic sequence within the foredeep consists of an almost complete sedimentary succession without significant breaks.
The thickness of the sequence progressively increases from the west to the east to be around 5 Km.

The sequence often begins with Triassic evaporites, shales and carbonates of neretic to lagoonal nature, passes upwards into an open and shallow marine carbonates with subordinate evaporites of Jurassic age, then to an alternation of carbonates and sandstones, followed by an open marine carbonates of Cretaceous age.

The Mesozoic sediments are the main source rock and reservoir forming sequence in central and south Iraq.

• Cenozoic succession

The Cenozoic succession usually consists of Paleogene open marine carbonates that grades up into a Neogene lagoonal and restricted marine evaporitic facies, followed by molasse type deltaic and continental clastics.

The Quaternary deposits exhibit an exceptional development within the foredeep, incomparison to that in other places in the Iraqi territory. These deposits, which cover three quarters of the basin, progressively thicken from northwest to southeast.
The maximum recorded thickness is about **300 m** near Basra city.

Depending on their location, Quaternary deposits show variable stratigraphic relationship to the underlying pre-Quaternary sediments, ranging from conformable gradational, unconformable erosional, and unconformable angular.

Tectonics:
Foreland Basins
Lec- 5

By : Dr. Maher M Mahdi // Asst. lecturer Hawraa Al-Sahlani

Foreland Basins

- Although mountain belts tend to be associated with the uplift of rock material to several kilometers in height, they are bordered by regions of subsidence called ***foreland sedimentary basins***. These basins are "wedge-shaped" in cross-section with a depth that gradually decreases from the mountain belt towards the adjacent craton.

- The term **foreland basin** was introduced by Dickinson (1974), who proposed two broad categories:

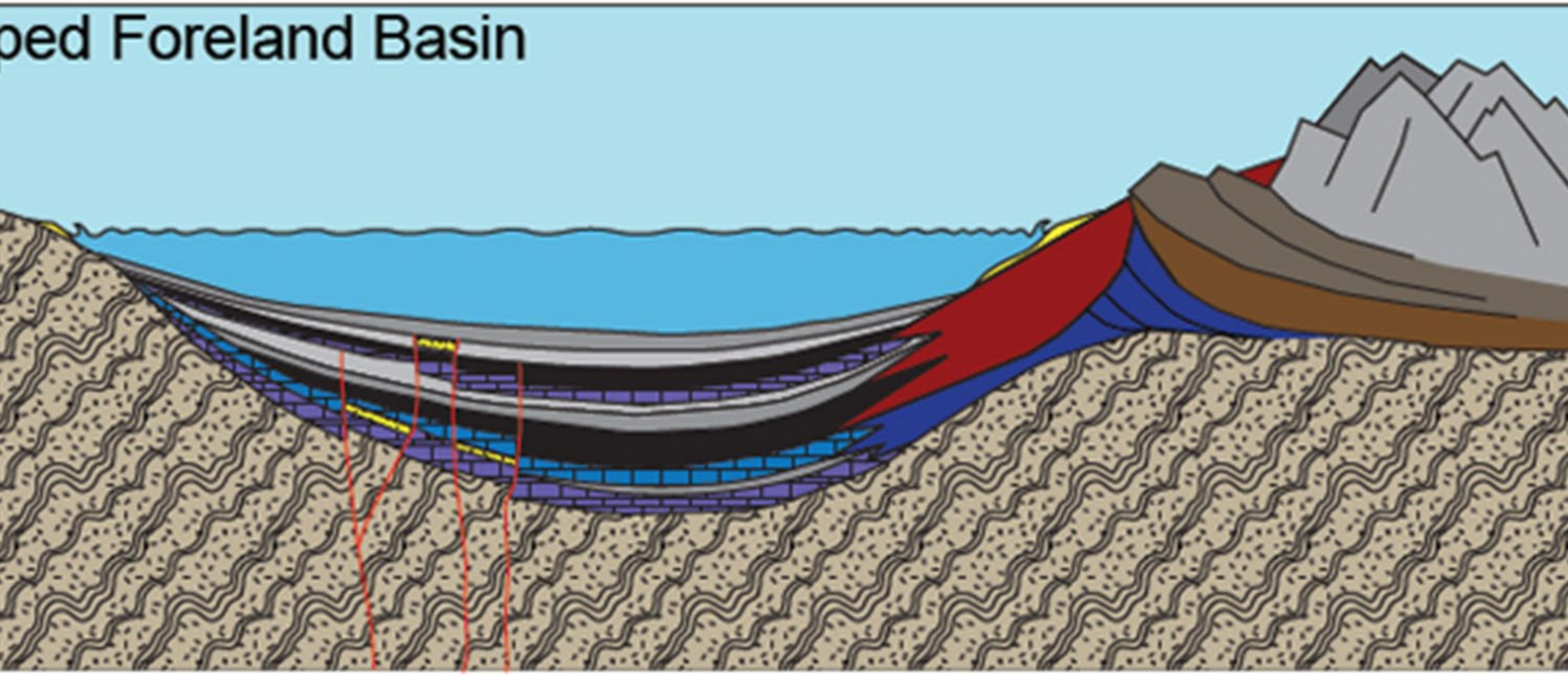
- **Peripheral foreland basins** - related to continent-continent collision (e.g. the Indo-Ganges basin and the North Alpine basin)

- **Retro-arc foreland basins** - related to the subduction of oceanic lithosphere (e.g. the Late Mesozoic-Cenozoic Rocky Mountain basins)

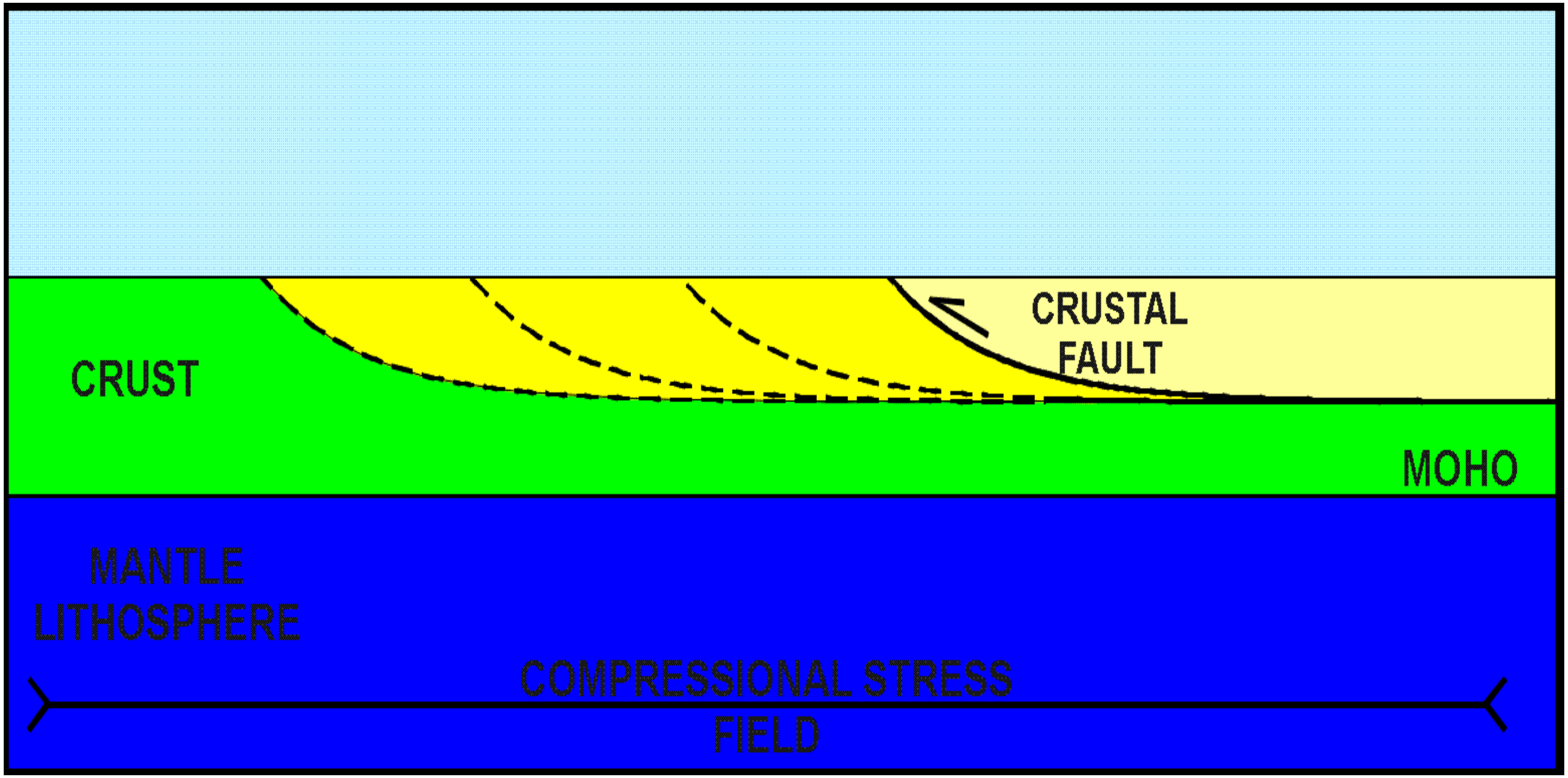
How do foreland basins form and evolve?

Foreland basins are associated with regions of compressional tectonics. They are formed primarily as a result of the downward flexing of the lithosphere in response to the weight of the adjacent mountain belt, though many geological and geodynamic processes combine to control their subsequent evolution.

The following sections provide a schematic explanation of the formation and evolution of a foreland basin:

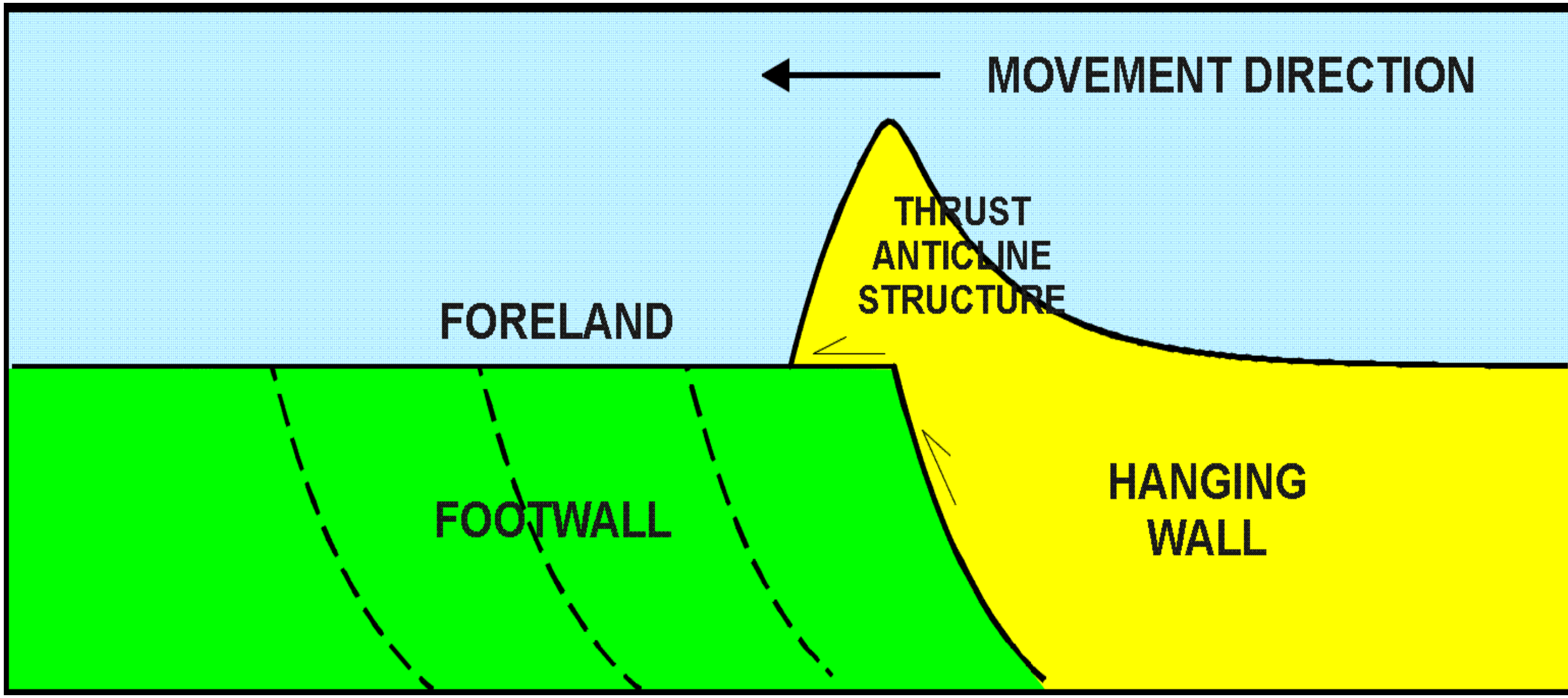

ped Foreland Basin

- Submit Compressional stresses generated at lithosphere plate boundaries may be sufficient to cause reverse movement along pre-existing and newly generated crustal faults.



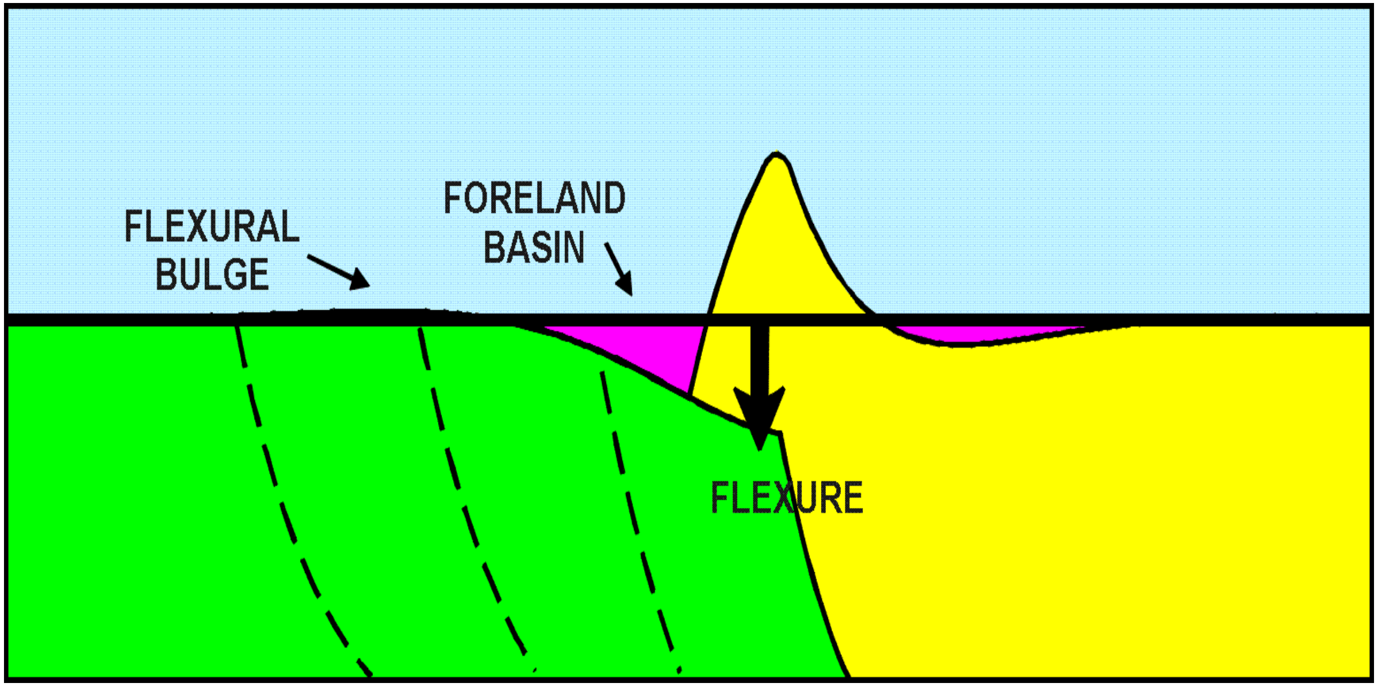
Compressional stresses cause reverse movement along major fault structures.

- Submit Reverse movement along a crustal or basement fault causes the hanging wall of the fault to be displaced over the footwall. An uplift structure is generated which is commonly referred to as a thrust anticline. This process of displacing hanging wall material onto that of footwall generates a mountain belt and also represents thickening of the crust.



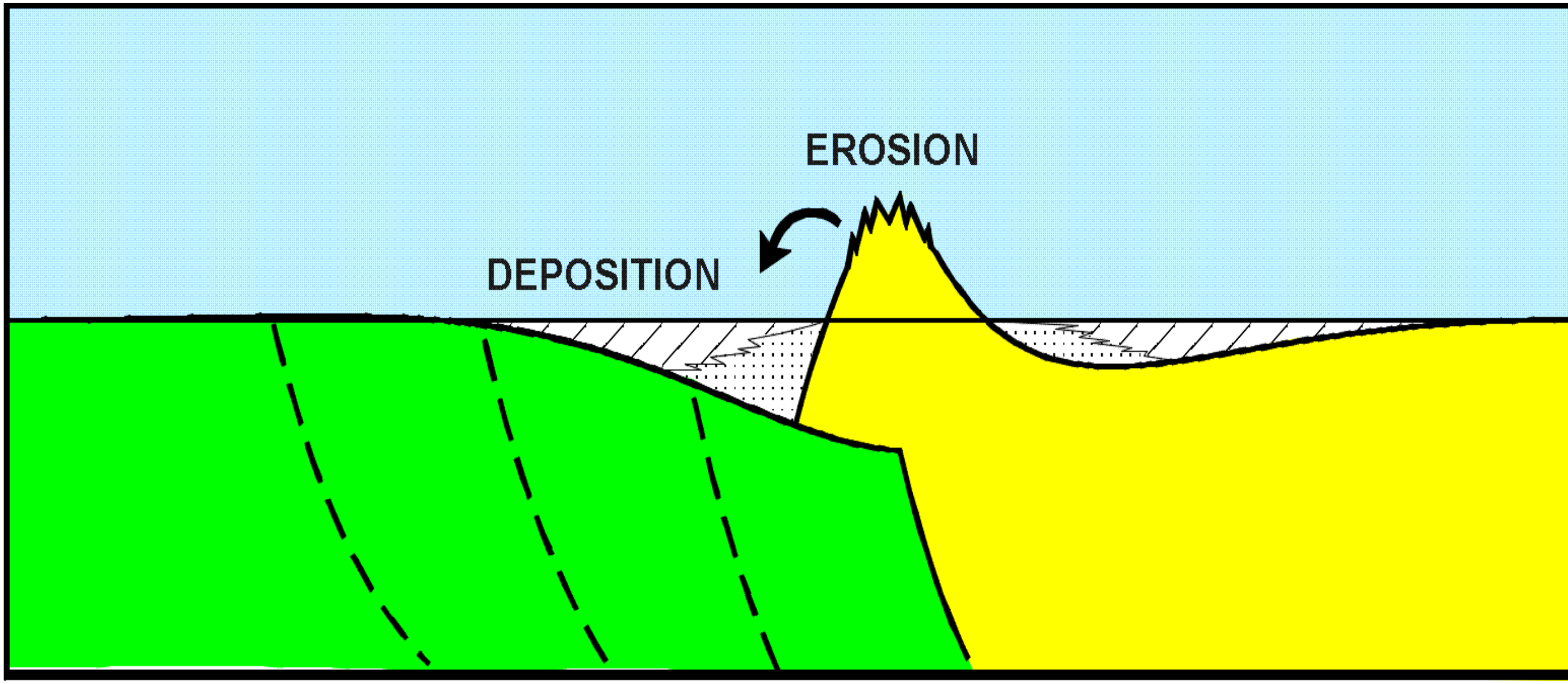
Development of a thrust anticline structure in response to reverse fault movement

- The formation of the mountain belt (i.e. thickening of the crust) imposes a load upon the lithosphere, which responds by flexing.
- As a consequence a **foreland basin** is generated ahead of the mountain belt.
- The depth of the basin is a maximum immediately adjacent to the mountain belt, but gradually decreases with increasing distance onto the foreland until eventually uplift occurs in the form of a structure commonly referred to as ***a flexural or foreland bulge***



The lithosphere flexes in response to loading from the thrust belt and a foreland basin is generated

- The magnitude of mountain belt, foreland basin and flexural bulge are controlled by the complex interaction of several geological and geodynamic processes.
- For example, the mountain belt will be eroded with time and, therefore, decreased in size.
- The material eroded, however, is mostly deposited into the foreland basin generating further loading and enhancing the depth of the basin.



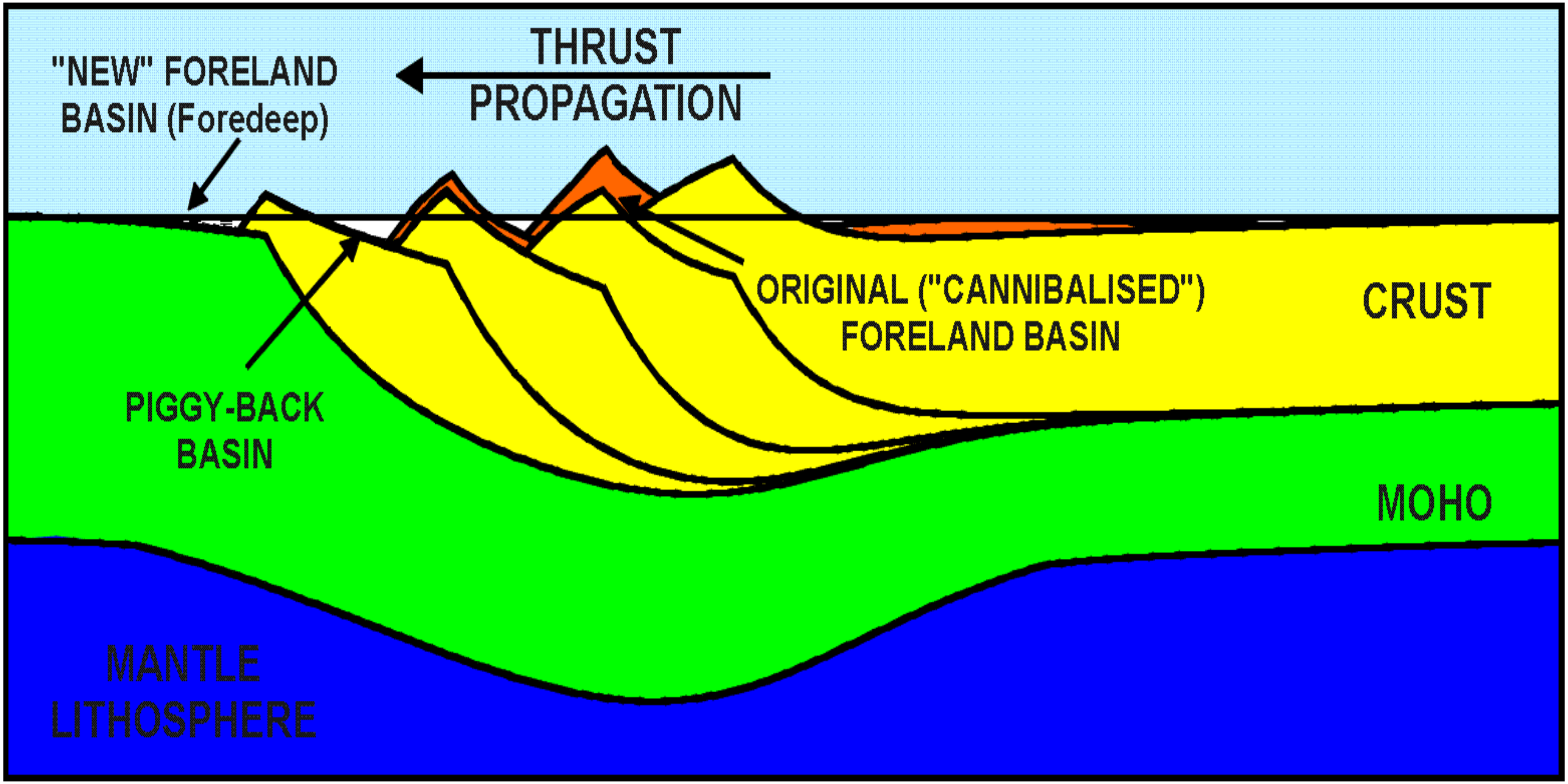
Thrust belt erosion and foreland basin infill

The Structure and Stratigraphy of Foreland Basins

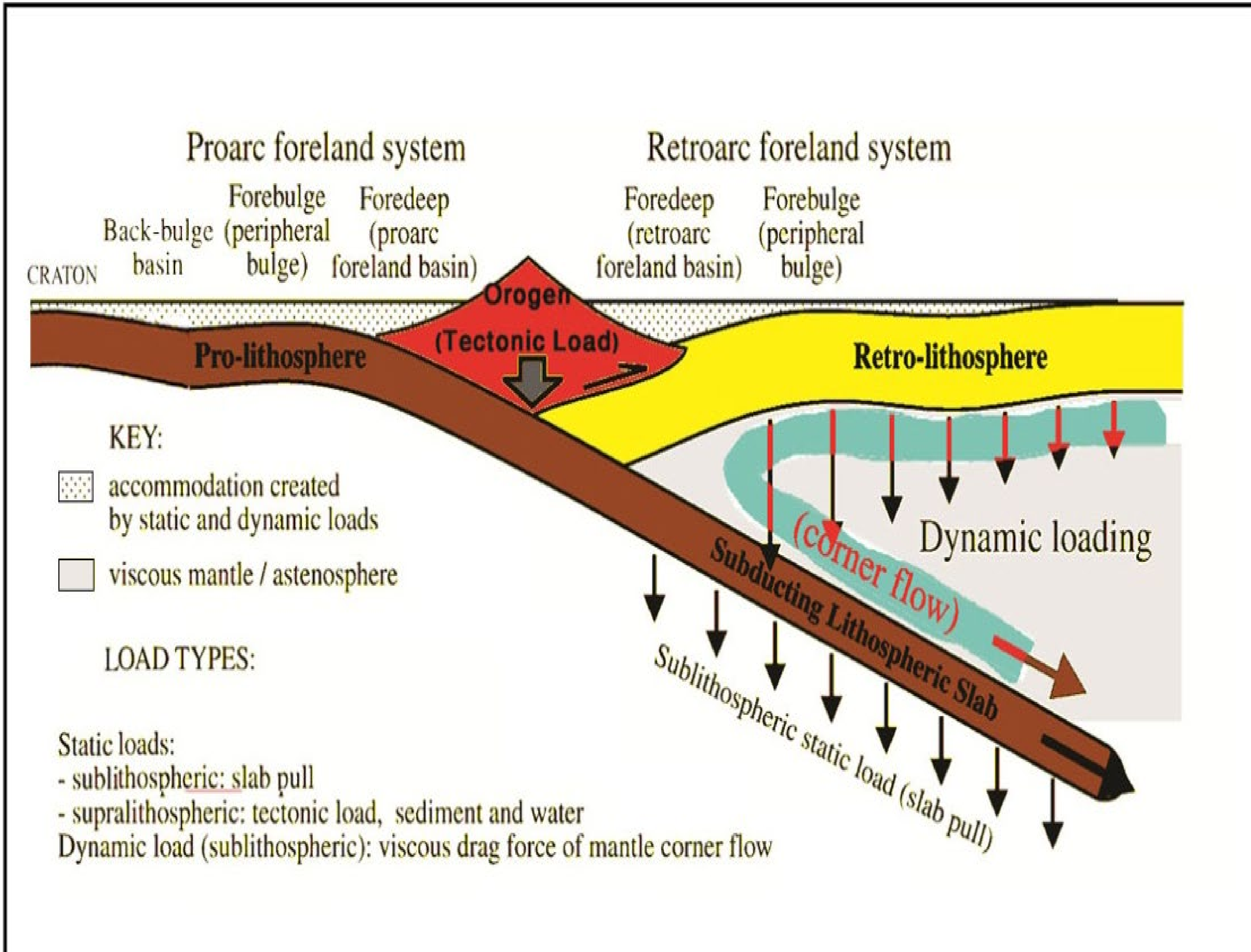
- In structural terminology, basins associated with compressional tectonics are either categorized as ***fore deep* (or *toe-trough*) or *piggy-back* basins.**
- The ***fore deep* (or *toe-trough*)** can be applied to the basin depocentre forming ahead of the active thrust system.
- The ***piggy-back basins*** refer to depocentres forming on top of the moving thrust sheets.

Many thrust belts in the geological record show a codominance of these two types of basin structures.

- For example, the Apennines and Southern Pyrenees exhibit a sort of coupling between the different basin structures such that as the thrust belt gradually migrated to the craton there was deposition in both foredeep and piggy-back basins.
- In contrast, basin formation in the Alps was dominantly taking place ahead of the thrust belt.



Thrust belt - foreland basin evolution


Proarc foreland system
Retroarc foreland system
CRATON
Back-bulge basin
Forebulge (peripheral bulge)
Foredeep (proarc foreland basin)
Orogen (Tectonic Load)
Foredeep (retroarc foreland basin)
Forebulge (peripheral bulge)
Pro-lithosphere
Retro-lithosphere
KEY:
accommodation created by static and dynamic loads
viscous mantle / astenosphere
LOAD TYPES:
(corner flow)
Dynamic loading
Subducting Lithospheric Slab
Sublithospheric static load (slab pull)
Static loads:
- sublithospheric: slab pull
- supralithospheric: tectonic load, sediment and water
Dynamic load (sublithospheric): viscous drag force of mantle corner flow

Foreland basin system:

It consists of four discrete depozones, referred to as the *wedge-top*, *foredeep*, *forebulge* and *back-bulge* depozones

1. The wedge-top deposes :

Is the mass of sediment that accumulates on top of the frontal part of the orogenic wedge. Wedge-top sediment tapers toward the hinterland and is characterized by extreme coarseness, numerous tectonic unconformities and progressive deformation. Wedge-top depozones accumulate under the competing influences of uplift due to forward propagation of the orogenic wedge and regional flexural subsidence under the load of the orogenic wedge and/or subsurface loads.

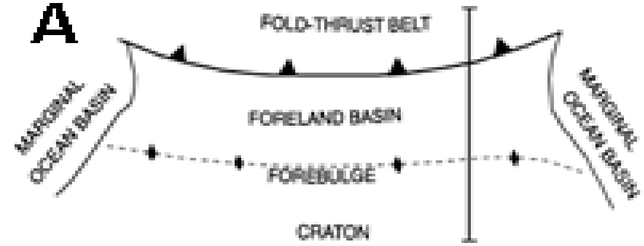
2-The foredeep depozone :

Consists of the sediment deposited between the structural front of the thrust belt and the proximal flank of the forebulge. This sediment typically thickens rapidly toward the front of the thrust belt, where it joins the distal end of the wedge-top depozone. Whereas most of the sediment accommodation in the foredeep depozone is a result of flexural subsidence due to topographic, sediment and subduction loads

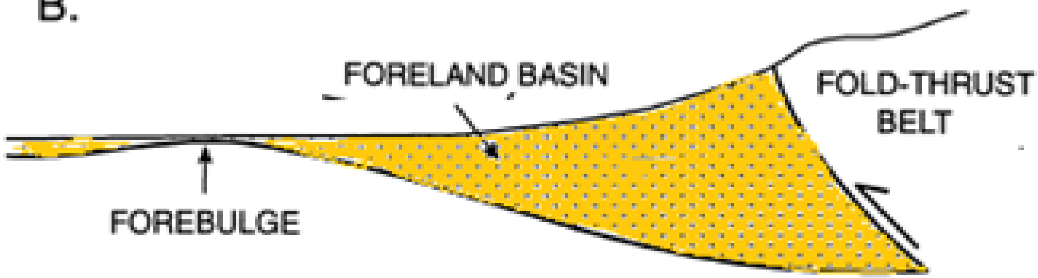
3. The forebulge depozone: Is the broad region of potential flexural uplift between the foredeep and the back-bulge depozones. Fore bulge depozones are commonly sites of unconformity development, condensation and stratal thinning, local fault-controlled depocentres,and, in marine systems, carbonate platform growth.

4. The back-bulge depozone: Is the mass of sediment that accumulates in the shallow but broad zone of potential flexural subsidence craton ward of the forebulge. Sediment accommodation in back-bulge depozones may result mainly from aggradation up to an equilibrium drainage profile (in subaerial systems) or base level (in flooded systems).

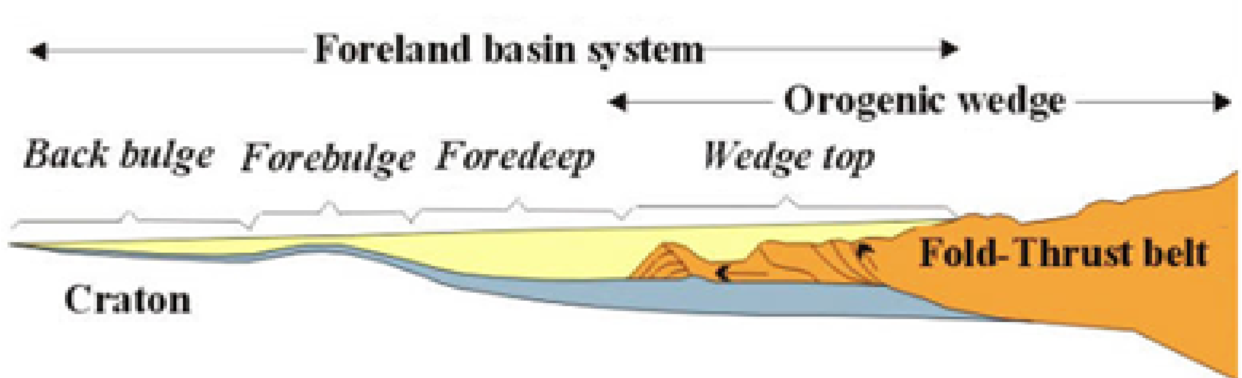
A


FOLD-THRUST BELT
MARGINAL OCEAN BASIN
FORELAND BASIN
MARGINAL OCEAN BASIN
FOREBULGE
CRATON

B.


FORELAND BASIN
FOLD-THRUST BELT
FOREBULGE

C.


Foreland basin system
Orogenic wedge
Back bulge
Forebulge
Foredeep
Wedge top
Fold-Thrust belt
Craton

Depending on the fullness in deposits:

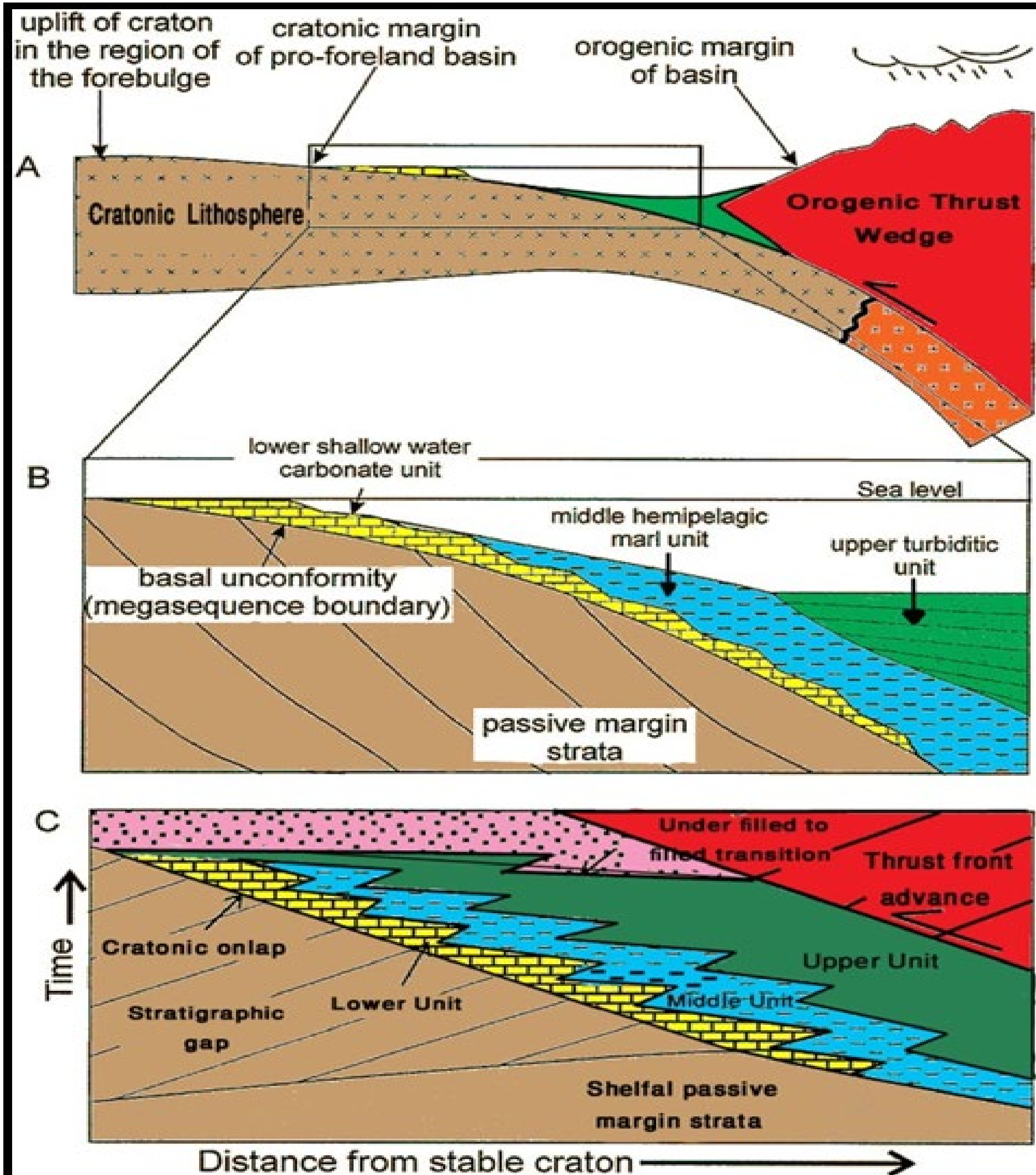
- the **foreland basins** are classified into three phases: Under-filled (Trinity), Filled and Overfilled (Tankared, 1986).

- **The under-filled trinity** can be summarized as follows depending on Sinclair (1997):

- (a) Lower unit that may or may not be underlain by a basal unconformity and that comprises a variable thickness (0–2500 m, average 550 m) of shallow marine limestones and sandstones.

- (b) Middle unit composed of 50–4000 m (average 830 m) of mudstones rich in pelagic microfauna.

- (c) Upper unit comprising 45–4000 m (average 2000 m) of sandstones dominated by turbidites and classically termed "flysch".



uplift of craton in the region of the forebulge
cratonic margin of pro-foreland basin
orogenic margin of basin
A
Cratonic Lithosphere
Orogenic Thrust Wedge
B
lower shallow water carbonate unit
Sea level
middle hemipelagic marl unit
upper turbiditic unit
basal unconformity (megasequence boundary)
passive margin strata
C
Under filled to filled transition
Thrust front advance
Time
Cratonic onlap
Upper Unit
Middle Unit
Lower Unit
Stratigraphic gap
Shelfal passive margin strata
Distance from stable craton