

Regional Geology of the Western Pacific

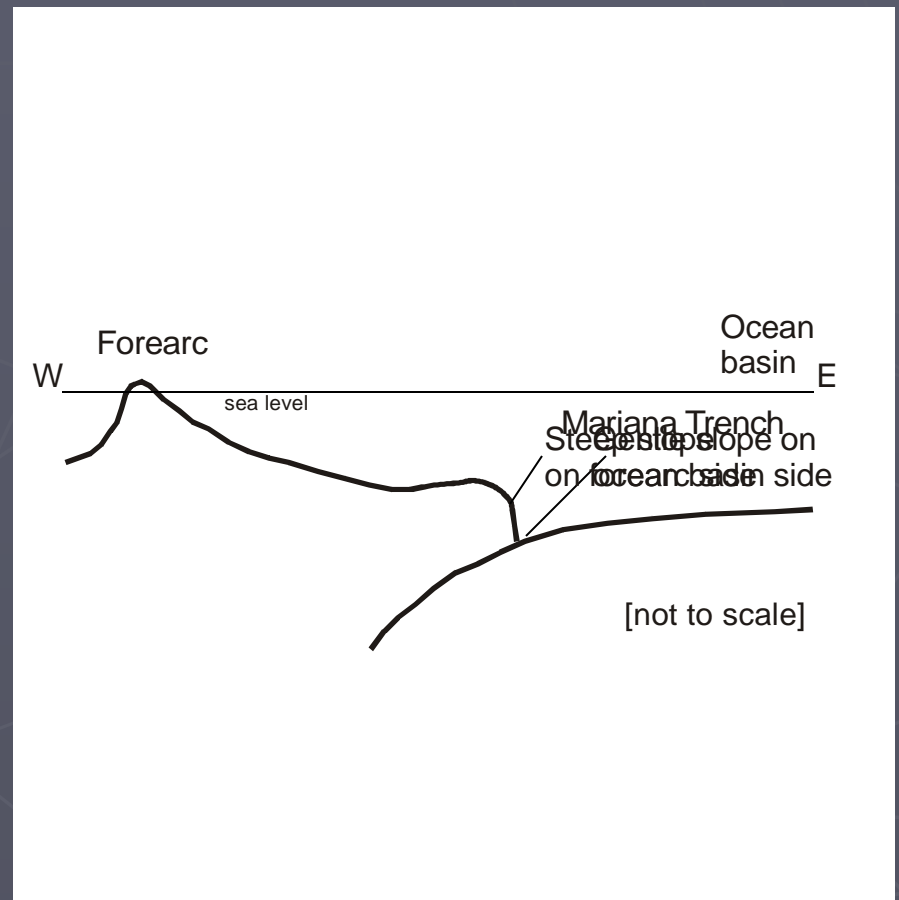
BI 201 Natural History of Guam
Class Presentation 04

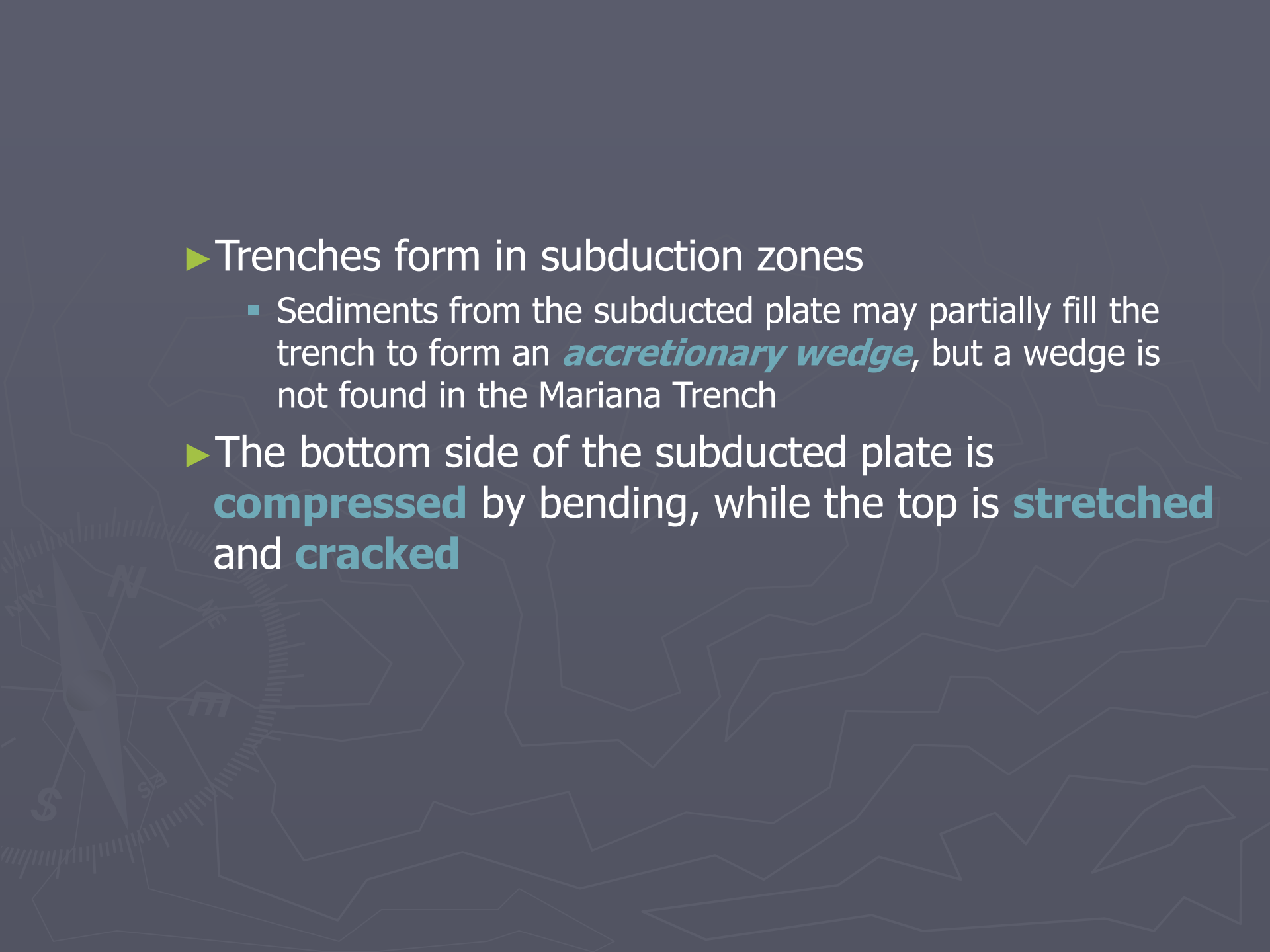
▶ General characteristics of geographic features

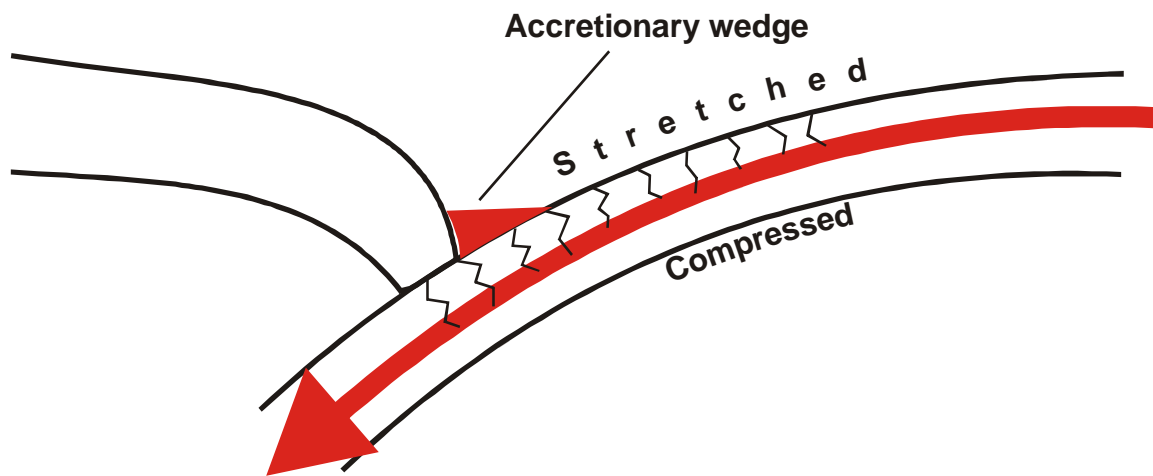
A. Submarine trenches

- ▶ Trenches may be curved or linear
 - They are usually curved because of the nature of compression on a spherical object
- ▶ Trenches are associated with forearc ridges
 - They are always parallel to a ridge system and located on the ocean side of ridge (as opposed to the continental side)
- ▶ Trenches are much deeper than their associated basinal areas, i.e., general oceanic basins

- ▶ Trenches are not very wide, averaging 50-100 km in width
- ▶ Trenches are always asymmetrical in cross section
 - steep on the side facing the forearc ridge
 - sloping on the side facing the ocean basin



- 
- ▶ Trenches form in subduction zones
 - Sediments from the subducted plate may partially fill the trench to form an *accretionary wedge*, but a wedge is not found in the Mariana Trench
 - ▶ The bottom side of the subducted plate is **compressed** by bending, while the top is **stretched** and **cracked**



B. Submarine ridge systems

- Ridge systems are often complex
- They are almost always associated with trenches (i.e., subduction zones), at least at some time during their development

- Types of ridges:

- a) Forearc ridges

- A forearc ridge is always associated with a trench, and therefore is always associated with subduction
 - ▶ e.g., the Mariana Ridge, Bonin Ridge, Ryukyu Ridge

- b) Backarc ridges

- Backarc ridges always lie behind forearc ridges
 - Therefore, they are always associated with the forearc
 - Backarc ridges are not associated with active subduction
 - ▶ e.g., the West Mariana Ridge

c) Backarc spreading ridge

1) Active backarc spreading ridge

- An active backarc spreading ridge is an area where the seafloor is spreading
- This type of spreading zone is also called a rift zone
- e.g., Mariana Trough (a.k.a., Mariana Backarc Spreading Ridge)

2) Inactive backarc spreading ridge

- ▶ This type of ridge is also called a fossil spreading ridge
- ▶ e.g., the Yap ridge North of Yap Trench

▶ Submarine Basins

- Basins essentially are relatively low-relief areas of seafloor between ridges
- They are not just smooth, flat zones, but most areas are characterized by jagged ridges and swales
 - ▶ Topographic relief may be up to 500 to 600 m
 - ▶ Ridges extend parallel to backarc and forearc ridges
 - ▶ Swales may be secondarily filled by sediments in areas near volcanism
 - e.g., Parece Vela Basin [Pår•î' •sî Vé'lå]
 - ▶ The area between the Palau-Kyushu Ridge and the West Mariana Ridge
 - e.g., Mariana Basin
 - ▶ Geologically young and very small; only the Bonin Basin is smaller

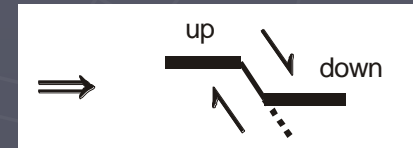
► Mariana Trench

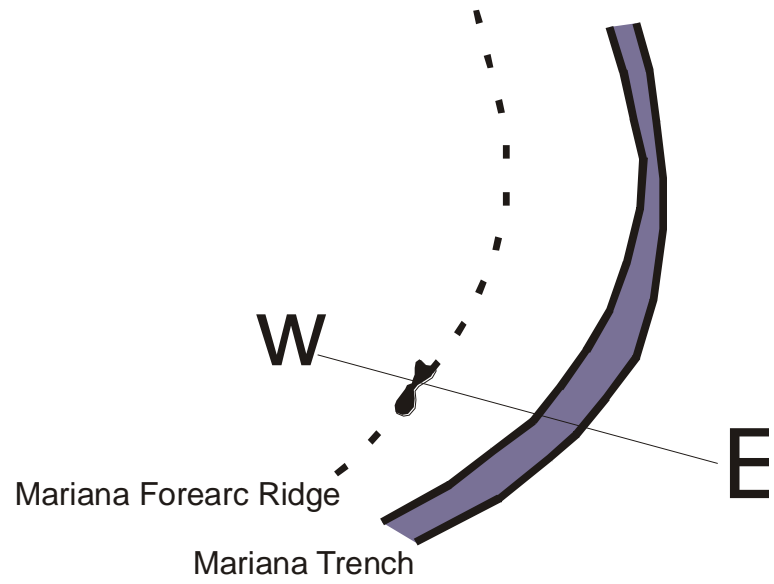
- The depth of the Mariana Trench is mostly 8,000 – 10,000 m (26,400 – 33,000 ft) deep and 75 – 100 km (ca. 47 – 62.5 mi) wide
- The ocean floor E of the trench has a general depth of almost 6,000 m (~20,000 ft) and is dotted with seamounts (i.e., Magellan Seamounts)

- Shallow parts of the trench occur in places where seamounts or groups of seamounts lie close to the E side of the Mariana Ridge (e.g., near lat 16° , 20° , & 26°)
 - ▶ Presumably at these places, seamounts are colliding with the forearc as subduction proceeds, and perhaps they will be scraped off the down-sliding plate and added to the forearc
 - ▶ Much of the material of the Mariana Ridge may represent past additions of seamounts
- The closest point of the Mariana Trench to Guam is ca. 75 mi to the East

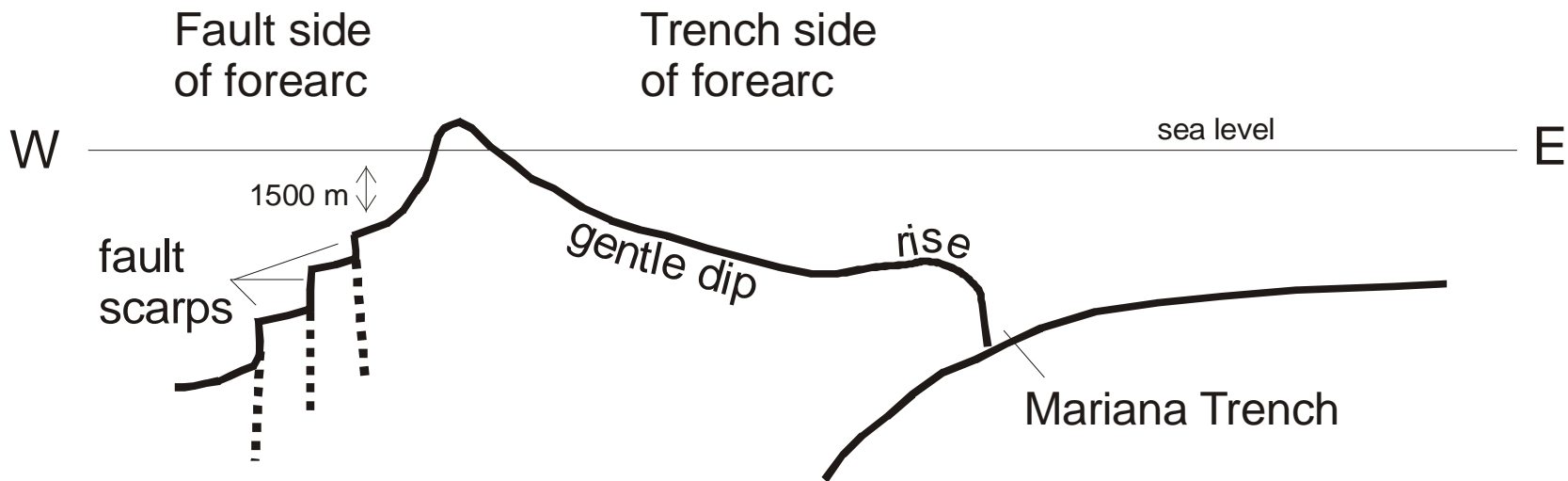
▶ Mariana Forearc Ridge

- The Mariana Forearc Ridge is mostly submergent, with scattered emergent islands
- The East side of the ridge slopes gently towards the trench, with a slight rise before plunging into the trench
 - ▶ This slope is mostly covered with sediments
- The West side of the ridge is characterized by a series of 5 to 6 fault scarps
 - ▶ These are normal faults (a.k.a. high angle fault)
 - ▶ The first step at Guam is at a depth of 5,000 to 7000 ft
 - ▶ At Saipan, the step is shallow and supports Tanapag Barrier Reef





Mariana Forearc Ridge



[not to scale]

- ▶ Forearc ridges always have this topography
- ▶ They are always associated with subduction, at least within relatively recent geological time
- ▶ Forearc ridges are commonly capped with emergent reef deposits
- ▶ With the Mariana Forearc, there is active volcanism that always occurs on continental side, or fault side

► The Mariana Basin

- The Mariana Basin is semi-enclosed, with the opening at the southern end
- The Mariana Basin is 250 km (147+ mi) wide
- Its maximum depth is 5,000+ m, and its average depth is 4,000 m [i.e., ca. 2,000 m less than Pacific Ocean floor E of Mariana Trench
- Its floor is covered by sediments

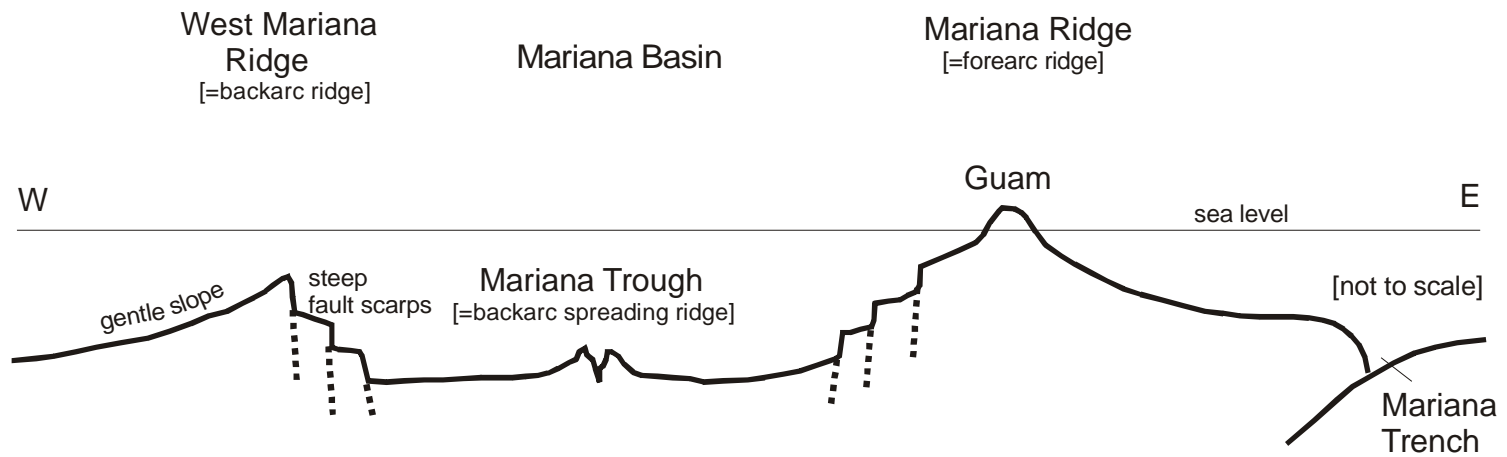
► The Mariana Trough

- The Mariana Trough is the active rift zone
- The rift is spreading at 6 cm/yr (Circum-Pacific Council for Energy and Mineral Resources, 1981) [3.3 cm/yr according to Hessler & Lonsdale, 1991]
- The depth of the active rift is at 3,500 – 4,000 m at crest
 - This is ca. 1,000 m deeper than comparable mid-ocean ridges
- The crest of the Mariana Trough lies ca. 75 mi W of Guam

► West Mariana Ridge

- The West Mariana ridge is a backarc ridge that is also described as a **remnant arc ridge**, because it rifted from the forearc ridge
- It is completely submergent, and lies about 150 mi West of Guam
- It has prominent fault scarps on the East and a gently sloping West side
 - Therefore, it is like a mirror image of the Mariana Ridge, except it is covered with greater quantities of sediments
- The ridge is mostly narrow, but locally broad

- The West Mariana Ridge is not associated with active subduction, and therefore it is not associated with a submarine trench
- The ridge crest occurs at a depth of 1,500 m
- The average depth is $>1,000$ m
- The West Mariana Ridge is commonly capped with shallow, forereef reef deposits
 - ▶ Therefore, it has been shallower in its geological past
- It is not volcanically active



► Yap Ridge

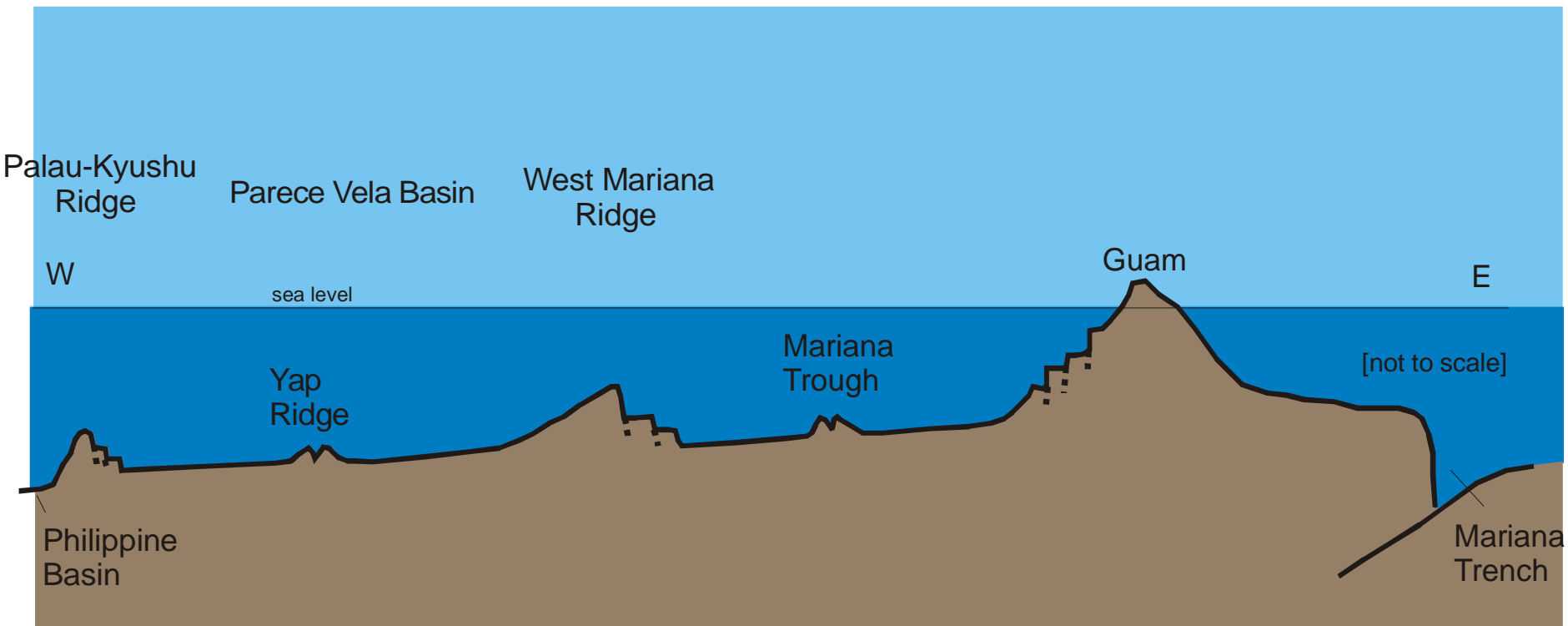
- The Yap Ridge is a **fossil spreading ridge** or **inactive backarc spreading ridge**
 - There is no magma and no seafloor spreading
- The depth of the crest is 1400–1500 m
- The crest lies ca. 375 mi West of Guam

► Parece Vela Basin

- The Parece Vela Basin extends west of the West Mariana Ridge
- The depth ranges from 4,700 – 5,800 m
 - Therefore, it is relatively deeper than the Mariana Basin and shallower than the Philippine Basin
- The Parece Vela Basin is ca. 800 km wide at its broadest sector
- The basin broken by high-relief ridges and swales in the central part and covered by fine sediments as thick as 90 m

► Palau-Kyushu Ridge

- The Palau-Kyushu Ridge is relatively deeper than the West Mariana Ridge
- The average depth of this ridge is 2700 m
- The Palau-Kyushu Ridge lies ca. 681 mi West of Guam



► Philippine Basin

- The Philippine Basin lies to the West of the Palau-Kyushu Ridge
- The age of the Philippine Basin is older than Guam, while all to the geological features East of the Palau-Kyushu Ridge are younger or the same age as Guam
- The depth of the Philippine Basin is 5,800–6,500 m
- The Mindinao Trench is still older, and it is associated with construction of the Philippine Islands