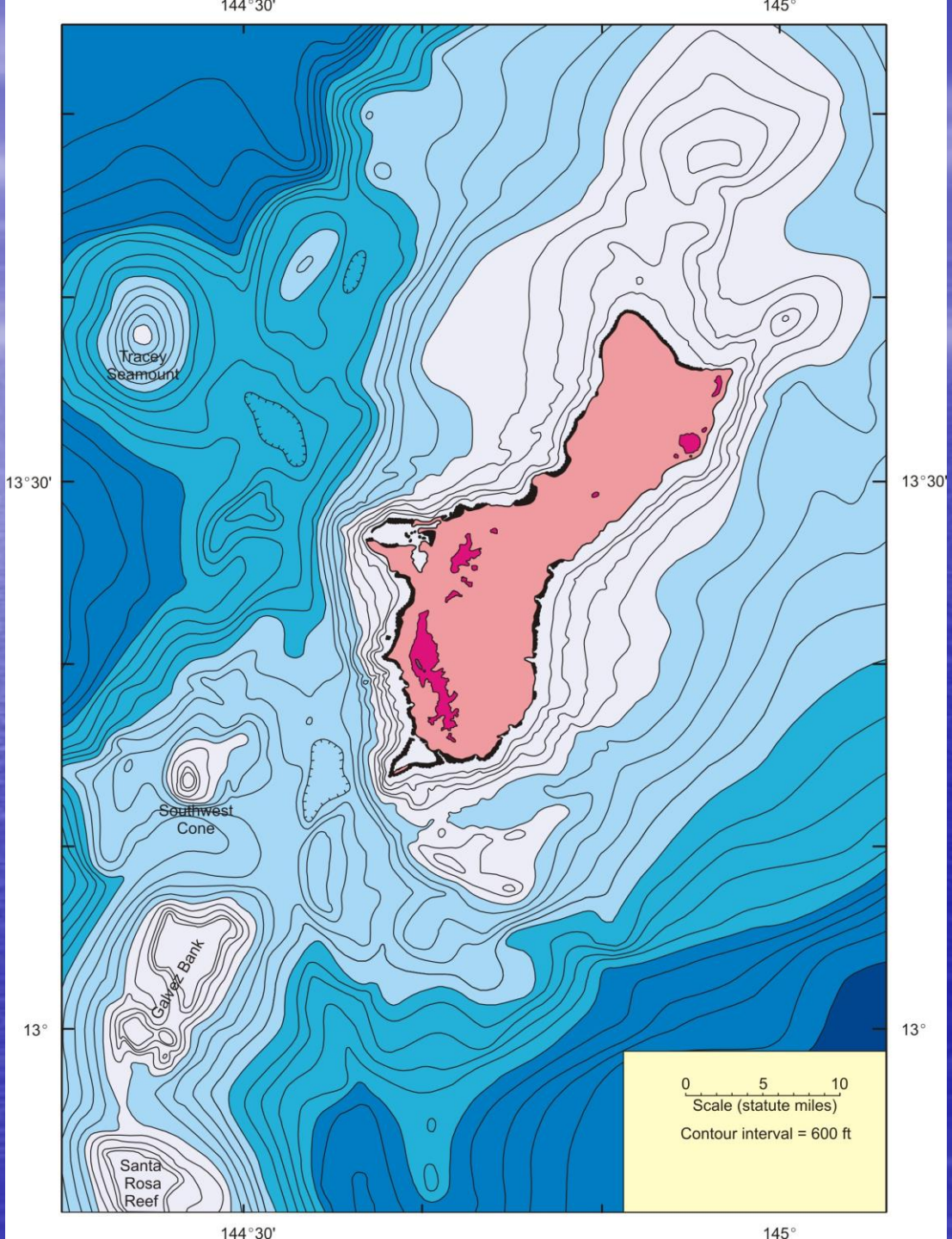
Marine Geology of Guam

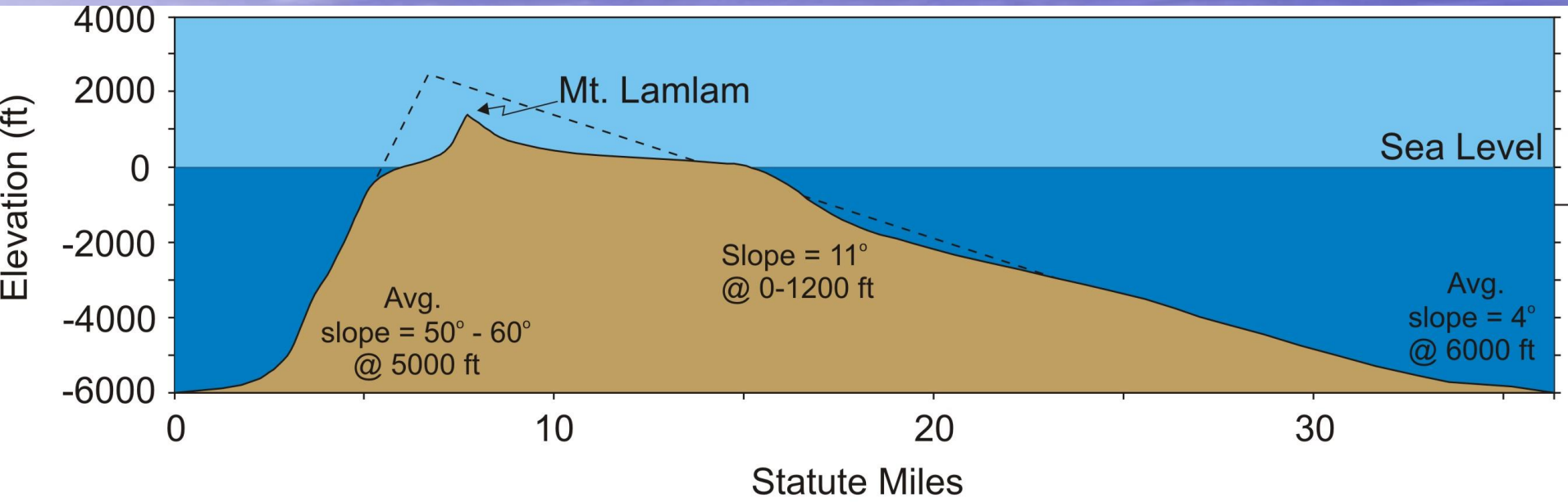
BI 201 Natural History of Guam

Class Presentation 18

- Bathymetry
  - Bathymetry is the measure of the depth of large bodies of water
  - Examination of a bathymetric map of Guam reveals differences in the seafloor to the east and west of the island

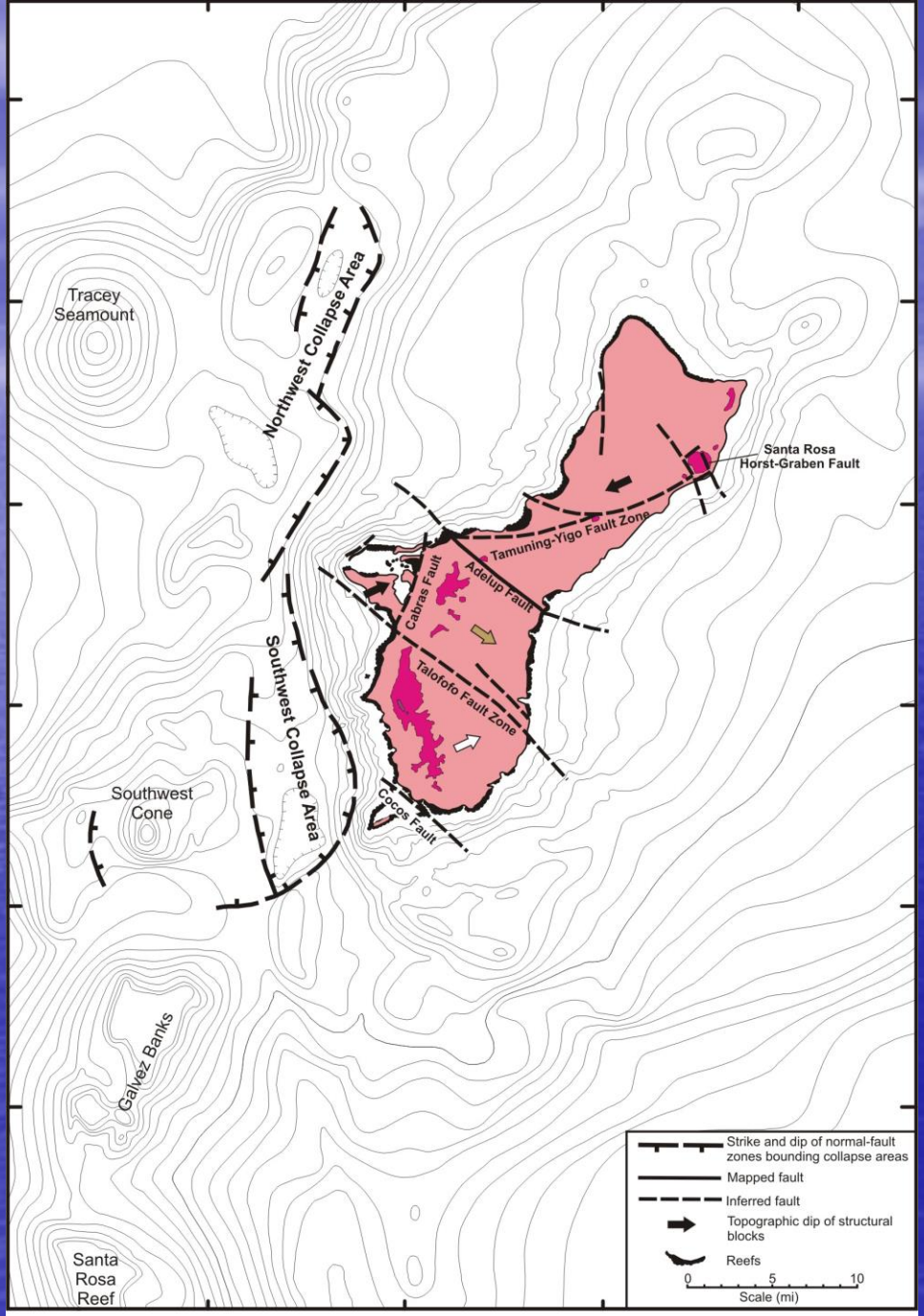

144°30'
145°
13°30'
13°
Tracey Seamount
Southwest Cone
Galvez Bank
Santa Rosa Reef
0 5 10
Scale (statute miles)
Contour interval = 600 ft

- East of Guam, the seafloor slopes down to the Mariana Trench zone in at a simple, smooth, gentle angle
- The average gradient is about 4° down to a depth of 6,000 ft
- The gradient is steeper near the island, averaging about 11° between the shoreline and the 1,200-ft isobath [probably because of reef sediment build-up]



East-west profile through Mount Lamlam. Lower profile has vertical exaggeration x5; upper one has identical vertical and horizontal scales. [Adapted from Emery, 1962].

- The seafloor west of Guam, in contrast, is complex
  - Off the Agat-Umatac-Merizo coastline, the gradient is 50 – 60° down to the 6,000-ft isobath, and it is up to 90° in some places
  - Much of this complexity is a result of the collapse of volcanic centers west of the island



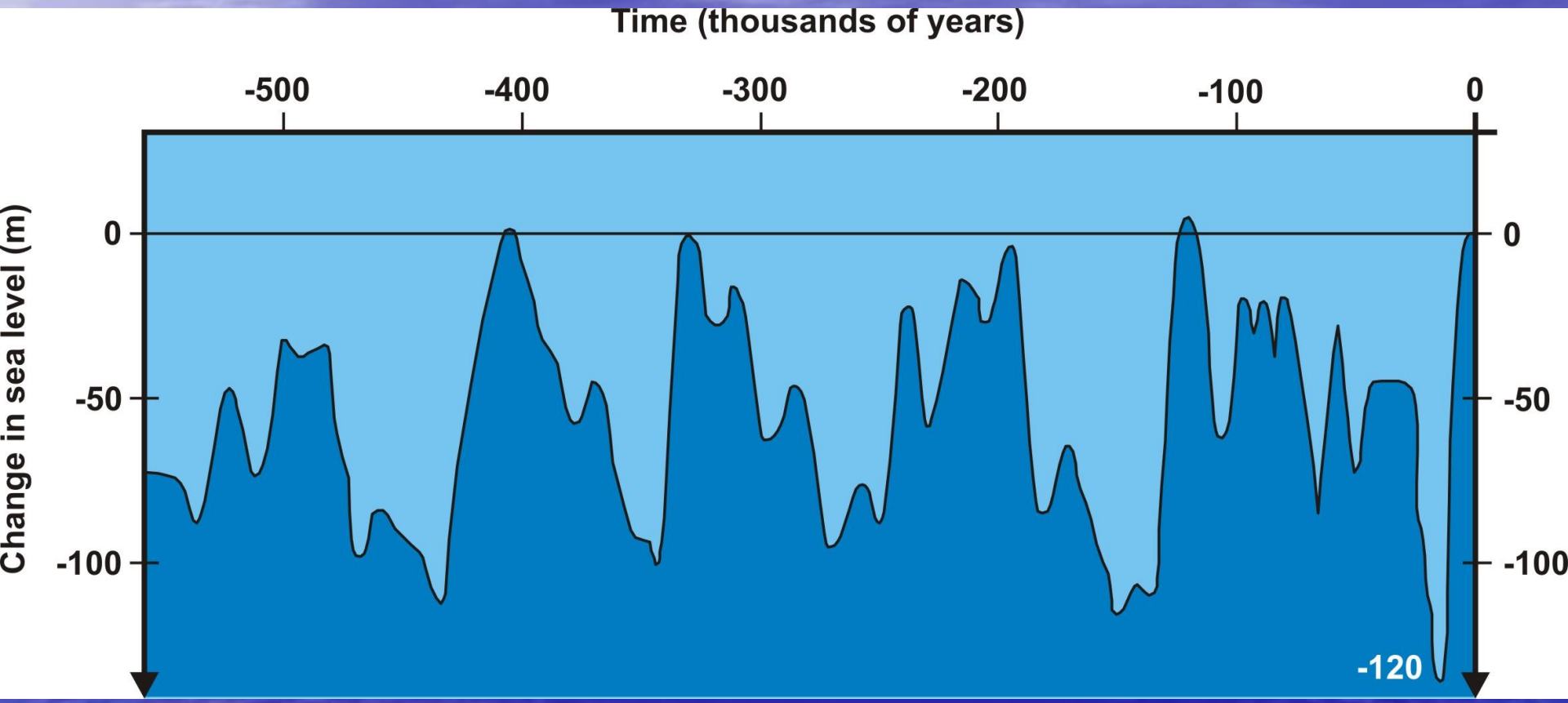
Submarine structural geology in the vicinity of Guam. [Adapted from Tracey et al., 1964].

- A series of 40 depth profiles of the upper portions of the submarine slopes of Guam were measured to determine the steepness and whether submarine **terraces** were present [a *terrace is* a nearly flat portion of the seafloor that is terminated by a steep scarp; the depth of a terrace is always measured at the outer edge, because sediments accumulate at the inner edge]

- Four terraces were found
  - The shallowest one, recognized in 20 profiles on all sides of the island, has a mean depth of 55 ft at its outer edge
    - This terrace was also found on Santa Rosa Reef
    - Three terraces are found at a similar depth at Bikini, Eniwetok and Rongelap Atolls in the Marshall Is., Espiritu Santo Is. in Vanuatu, Raroia in the Marquesas, and Oahu, Hawaii

- In 11 profiles, a terrace was found at 105 ft
  - This terrace is distributed mostly on the slopes west or north of the island
- The most common terrace of all, occurring in 25 profiles, has mean depth of 195 ft
  - This terrace is best developed on the East side of the island, but it also occurs on other sides
- The deepest terrace is at mean depth of 315 ft
  - This terrace was found in 16 profiles
  - It is commonly found worldwide, and it probably corresponds to the sea level drop during the last Pleistocene glaciation

- None of the 40 slope profiles contain all four of the main terraces, and only 6 profiles have 3 terraces
- There is also the possibility of another terrace at 1,200 ft, but its presence is uncertain
  - This terrace occurred in only 2 profiles
- Terraces represent old sea level stands
  - The sea level has alternately risen and fallen for about 2 million years in cycles of glaciation
  - Sea level falls during long a glacial epoch, and rises during brief, moderate interglacial spans
  - The last interglacial occurred 127,000 – 120,000 ybp during a much warmer global climate


Time (thousands of years)
-500
-400
-300
-200
-100
0
Change in sea level (m)
0
-50
-100
0
-50
-100
-120

- Sea level rose at a rate of about 1 cm/yr from 17,000 ybp to ca 6,000 ybp and then leveled off at the present level
- There may have been a higher-than-present sea level about 3,000 ybp on Guam, but it is difficult to determine here because of tectonic activity
- Terraces may be formed by constructional forces or erosional forces
  - Constructional forces include reef building
  - Erosional forces are wave action and bioerosion

- Sediments
  - Sediments are unconsolidated materials that settle to the bottom of a body of water
  - There are five major sources of marine sediments near Guam

1) terrestrial run-off

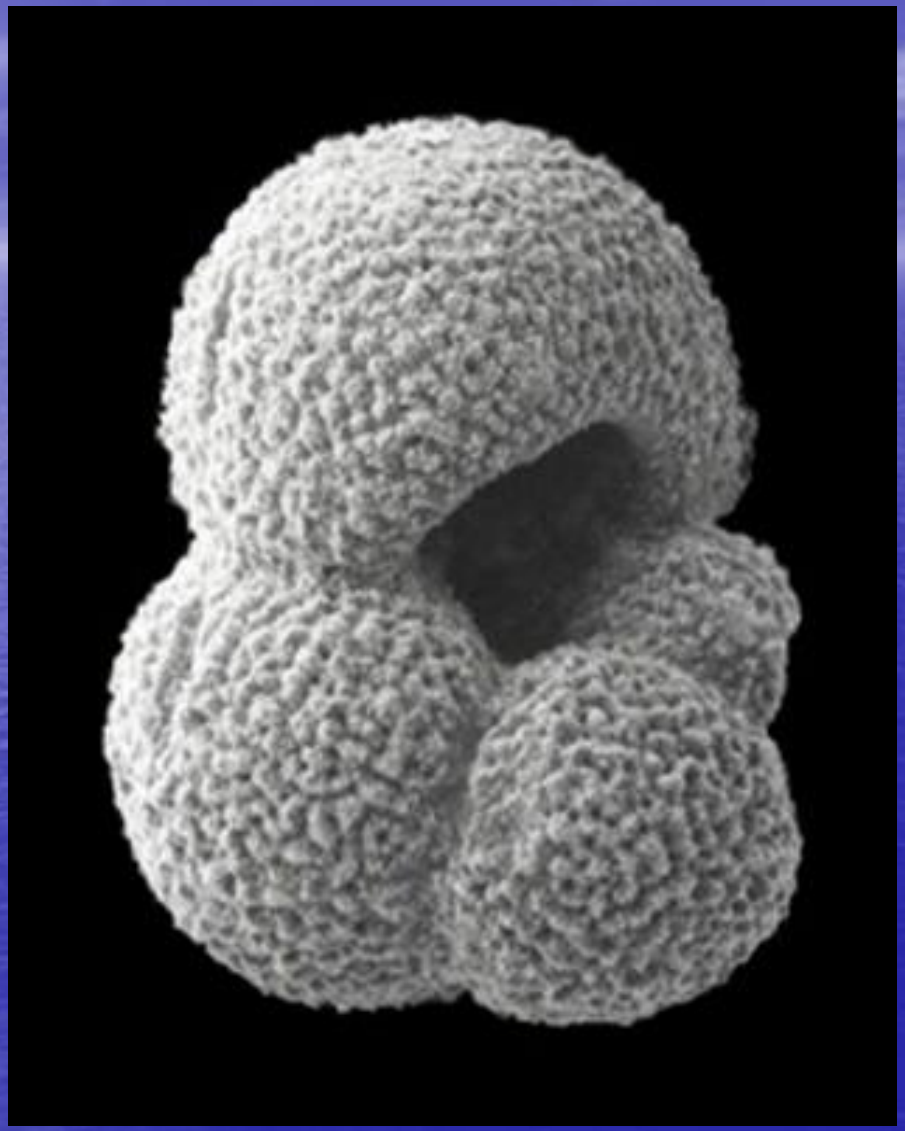
  - Erosional sediments are transported to shallow marine habitats, then re-suspended by storm waves and transported to deeper water offshore

2) Reef-building

- Calcium carbonate debris from skeletons of reef-building corals, calcareous algae, molluscs, and forams accumulates on the upper slopes of the island

3) Pelagic organisms

- Skeletons of pelagic organisms, especially the foram *Globigerina*, make up deeper sediments in the vicinity of Guam
- Forams produce a calcium carbonate test
  - They are kept afloat by gas bubbles when alive, but their tests form carbonate sediments when they die and sink



- Carbonate sediments are not found below the *carbonate compensation depth*
  - The carbonate compensation depth is the depth below which carbonates dissolve in seawater because of lower temperatures and higher pressures
  - In the Pacific, the compensation depth for aragonite is 200 – 400 m; for calcite, the compensation depth is 400 – 3500 m
  - Therefore, calcite and aragonite are not present in sediments below compensation depth, because the sinking calcium carbonate skeletons dissolve before they reach the seafloor

4) Volcanic activity

- Volcanic activity produces volcanic sediments primarily in the form of pyroclastic ash and dust size particles
- This pyroclastic debris dominates sediments down-current of the volcano

5) Siliceous ooze and red clay

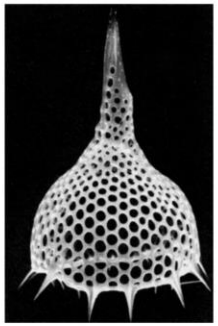
- There are two types of siliceous ooze
  a) radiolarian ooze, which contains the silica skeletons of Radiolaria
  b) diatomaceous ooze, which contains the silica frustules of diatoms
- Red clay sediments are composed of alumino-silicate debris eroded from the island

Minute Marine Organisms Found in Tropical Oceans

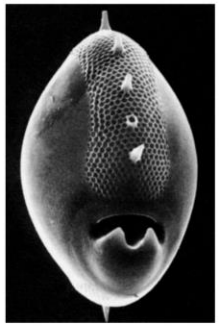
These Radiolarian Skeletons Are Made of Silica

Electron Micrscope Photographs
by Kozo Takahashi

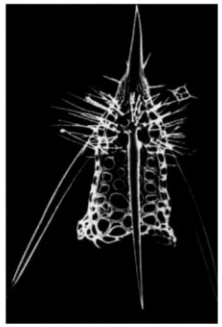
Euphysetta elegans, x280



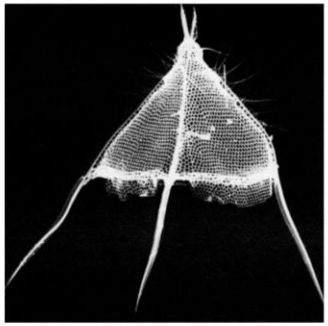
Anthocyrtidium ophirense, x230



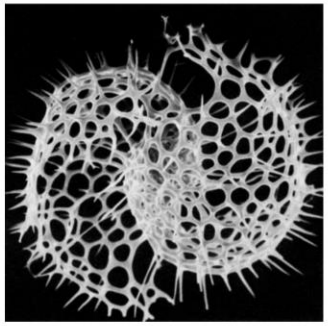
Challengerosium avicularia, x250



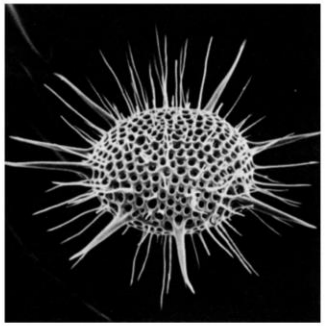
Dictyophimus crisiae, x190



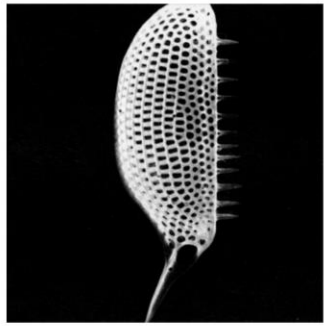
Dictycodon elegans, x120



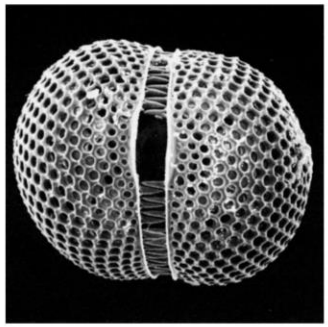
Larcospira quadrangula, x190



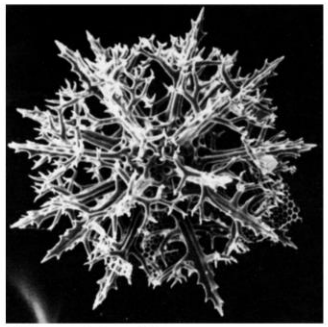
Heliodiscus asteriscus, x200



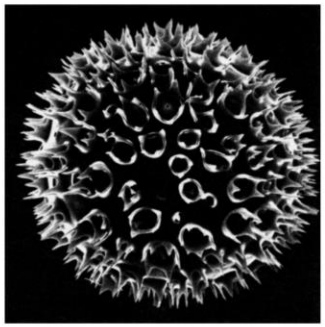
Conchidium caudatum, x170



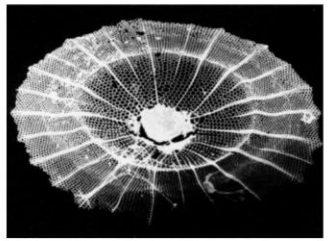
Conchellium capsula, x190



Elatomma pinetum, x140



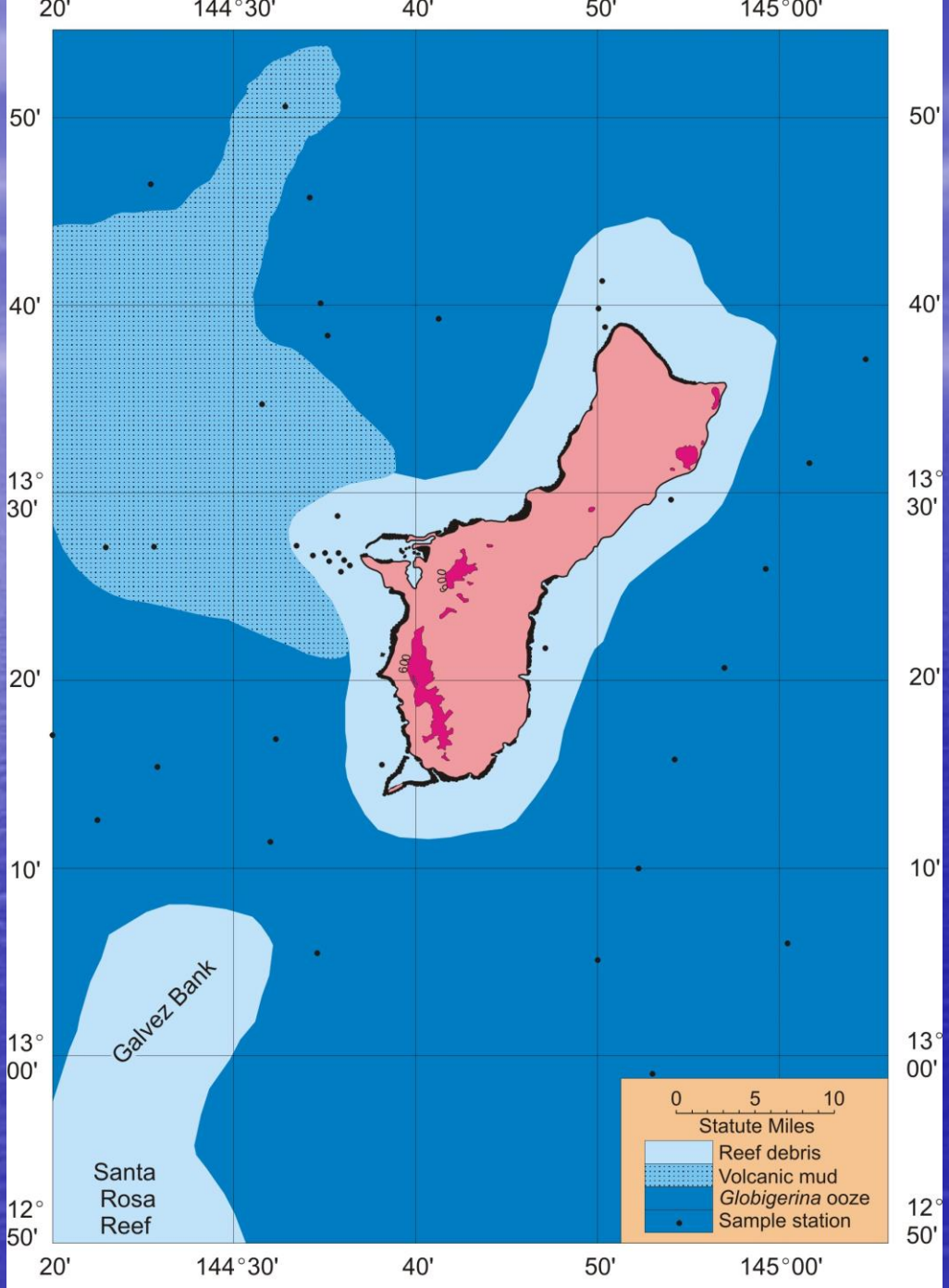
Acrosphaera murrayana, x290



Theophormis callipillium, x120

Source: Kozo Takahashi, 1981. Vertical Flux, Ecology and Dissolution of Radiolaria in Tropical Oceans: Implications for the Silica Cycle. Ph.D. Thesis. Massachusetts Institute of Technology/Woods Hole Oceanographic Institution WHOI-81-103.

- Distribution of sediments around Guam
  - On the East side of Guam, sediments are dominated to depth of about 3,000 ft by coral debris plus some terrestrial sediments from rivers
  - On the West side of the island, coral debris dominates sediments down to depth of about 6,000 ft



Distribution of deep-sea sediments near Guam. [Adapted from Emery (1962)].

– Comparison of deep sediments and shallow sediments in Guam

	N end of Guam (1170 ft depth)	S end of Guam (115 ft depth)
forams	40%	15%
mollusc shells	5%	10%
fine sand/silt	20%	10%
calcareous green algae	32%	18%
coralline red algae	2%	22%
coral	1%	25%

- Therefore, the distribution of nearshore sediments is determined by
  1) particle size
  2) reef production
  3) terrestrial input