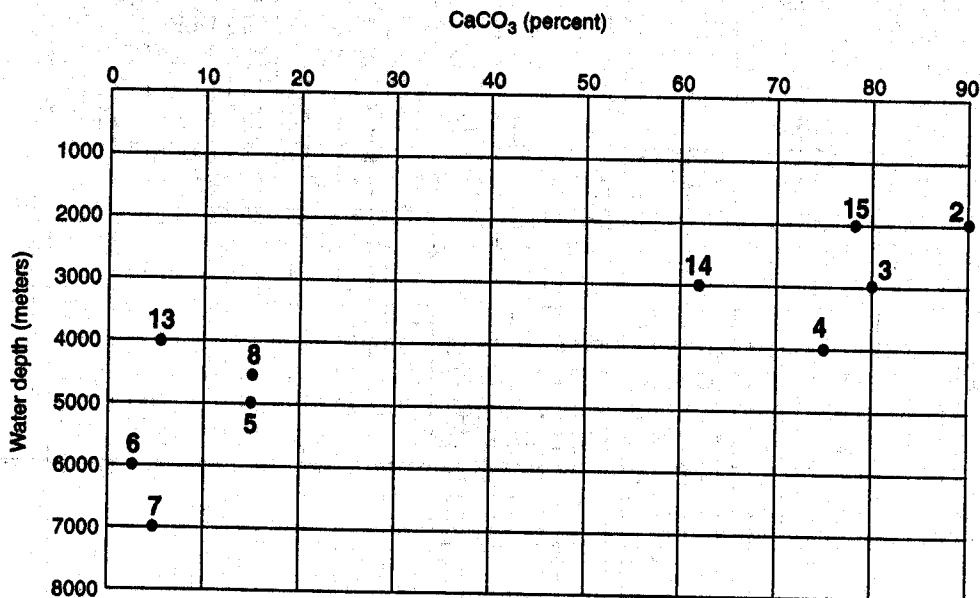


Exercise 5. Materials of the Sea Floor

The intent of this exercise is to give an overview of the origin and distribution of sediments present on the ocean floor. Student should appreciate that the major sediment types defined herein are based on the major composition of the bulk sediment. For example, an ooze may well contain some minor proportion of red clay sediment, terrigenous sediments may well contain some minor carbonate and red clay material, etc. A number of questions relate to the carbonate compensation depth; the complexity of the answers will depend on the depth of discussion of this dynamic physicochemical phenomenon.

In addition to plotting sediment data and studying map distribution, it is helpful to have sediment samples that can be viewed under high magnification. At this point, it is also useful to acquaint the students with basalt and granite inasmuch as this distinction between oceans and continents is emphasized in the lecture. Most scientific supply houses, such as Ward's, stock various types of seafloor sediment, as well as mounted slides of diatoms, radiolaria, and foraminifera.

1. a. See completed graph below. Students may want to know why some samples in shallower depths on the margin, or on fans or rises, have less carbonate than deep-sea oozes at similar or greater depths. On the continental margins, much sediment comes from erosion of terrigenous materials and is delivered to oceans at much faster rates than those of carbonate. Relative carbonate percentages result from a combination of factors, including rates of biological production, carbonate dissolution, and dilution by non-biological sediment. Nearshore dilution by high input of terrigenous material is a major factor.

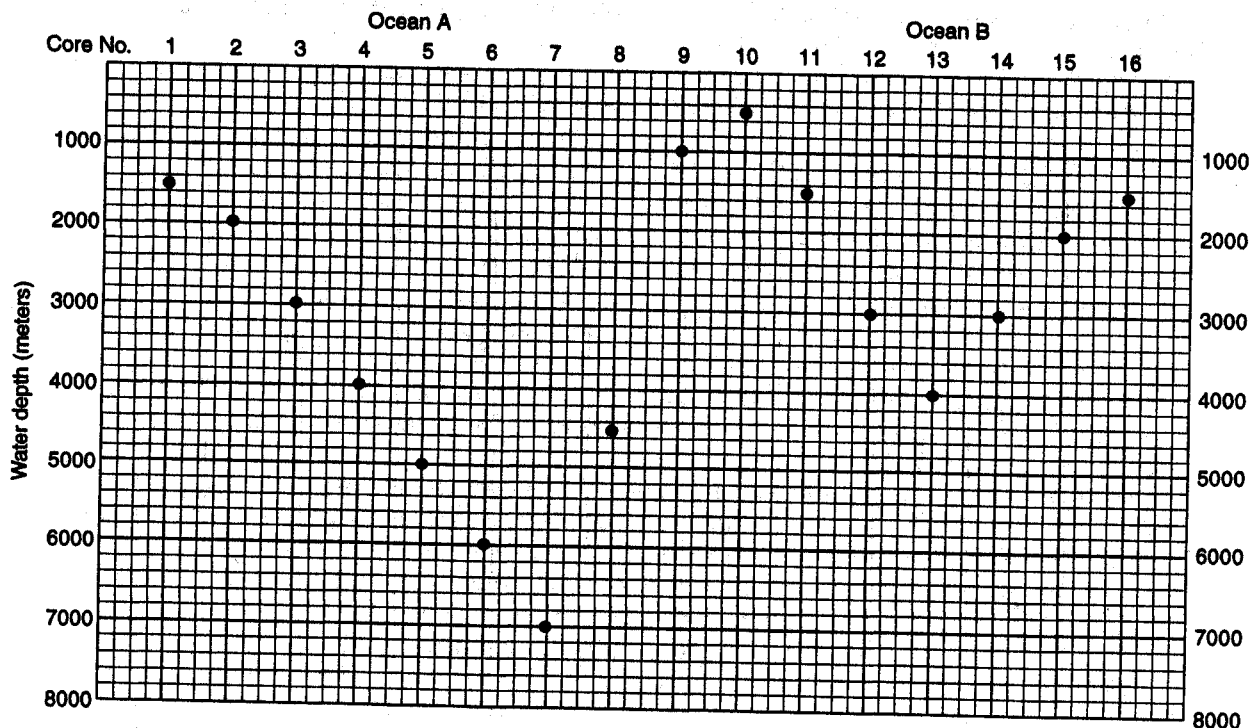


- b. The decreased carbonate content of oceanic sediments at depths greater than 4,000 meters is due to increased carbonate dissolution. Carbonate dissolution results from the corrosiveness of seawater, which increases as temperature decreases, pressure increases, carbonate-ion content decreases, and dissolved carbon dioxide increases (through respiration of organic matter). In general, these changes correspond with increasing depth. In addition, bottom-waters increase in their carbon dioxide content over time through benthic respiration, producing "older" bottom-water that is more corrosive than "newer" bottom-water.

Based on these dissolution dynamics, the depth below which preservation of carbonate is negligible is termed the carbonate compensation depth or CCD. The CCD represents a dynamic chemical balance between supply rate and dissolution rate of carbonate. Regions of high surface production of carbonate compared to organic material (e.g., equatorial Pacific) generally have a deeper CCD because of high carbonate sedimentation and rapid carbonate burial, whereas regions with low carbonate production compared to organic material (e.g., near-shore, high nutrient regions) generally have a shallower CCD. In terms of the role of bottom-water conditions, the Pacific generally has a shallower CCD than the Atlantic or Indian Oceans because of its greater age and carbon dioxide content.

- c. The sharp reduction in carbonate content in Ocean A occurs between Cores 4 and 5 (4,000–5,000 meters), whereas the reduction in Ocean B occurs between Cores 13 and 14 (3,000–4,000 meters). Both are reasonable depths compared to the real-world CCD. The difference in depth of sharp carbonate content between the two oceans may be related to the tectonic and sedimentary processes which dominate the two basins. Ocean B has a great deal of sediment influx from major rivers which may dilute the calcium carbonate percentage within Core 13. In contrast, Ocean A has a sediment-trapping trench so its overall sediment composition is not as affected by terrigenous influx. Also, the CCD in Ocean B may be shallower if bottom-waters are older than those in Ocean A (see 1b above).

2. See completed graph below.



3. Closer to the continents, the supply of continental (terrigenous) sediment increases and dilutes the oceanic contributions. The relatively steep gradients of the continental margin cause sediments to slide/slump to greater depths in turbidity currents. In the shelf regions, strong currents and wave action move sediments to the shelf edge and ultimately to greater depths.

4. The absence of red clay sediments in Ocean B is the result of the input of large amounts of terrigenous sediments to the deep ocean. If a trench is present at the base of the continental slope (e.g., Ocean A), then the trench traps sediment coming from the land and thereby prevents "dilution" of the oceanic sediments. Students should appreciate that there is probably as much red clay material in Ocean A as in Ocean B, but it is simply diluted beyond easy recognition as a predominant sediment type.
5. These cores are from nearshore areas where terrigenous sedimentation is high. The fans and submarine canyons are the main pathways for land-derived sediments moving to the deep ocean floor. Therefore, the pelagic grains are highly diluted by high terrigenous grain input.
6. The most parsimonious explanation is that the ocean crust has moved away from the spreading ridge, and therefore into deeper waters, over time. Early in Core 5's history, depths were relatively shallow, far from land, and above the CCD. Therefore, carbonate ooze was the predominant sediment type. The transition to red clays marks the time when the Core 5 area sank below the CCD, which precluded significant carbonate accumulation and thereby only accumulation of red clays. Additional explanations would involve changing compensation depths, productivity, etc., but the cooling-driven subsidence should be included regardless.
7. In Ocean A, the trench traps sands from the land sources. In Ocean B, the smooth slope from shelf to deep sea permits turbidity currents and sediment mass movements to reach the deep ocean floor.
8.
 - a. One inch equals approximately 25 mm. If red clay accumulates at 1 mm/1,000 years, then one inch would be 25 times that amount or 25,000 years of time at the given rate (amount divided by rate equals time).
 - b. Five meters is 5,000 mm. For red clay accumulation, that would then be equal to 5,000 mm divided by 1 mm/1000 years, or 5,000,000 years of time. If we assume that oozes accumulate 10 times faster than red clay deposits, then the rate would be 10 mm/1,000 years. The amount would be 5,000 mm divided by 10 mm/1,000 years, or 500,000 years. Total time would then be the sum of the two time intervals or 5,500,000 years of sedimentation.
9. The basins act as a series of sediment traps. The inner trap catches the most sediment from the land sources; the outer basin catches the remnant material after losses to the inner and middle basins. This is an example of the effect of sediment trapping by depressions and trenches. Thus, the rates tell us the relative effectiveness of the traps and also show that the main source of sediment must be from the continent.