Deep Earth Academy
CONSORTIUM FOR OCEAN LEADERSHIP

Site Selection for ODP Leg 198, Shatsky Rise-Northwest Pacific Ocean

Why Did They Drill There?

Introduction

While the map of holes drilled in the seafloor by scientific ocean drilling expeditions may look like a dartboard (Figure 1), the location of every site is precisely and carefully planned. Every scientific ocean drilling expedition has a story that begins with a scientific goal (and a proposal, of course), and each expedition targets a region of the seafloor that will provide a means of attaining the scientific goal. That goal may be to obtain a better idea of the structure and composition of oceanic crust, or to improve our understanding of how water circulates through the crust, or to recover sediments that record the paleoceanographic history of a particular time and place, just to name a few examples.

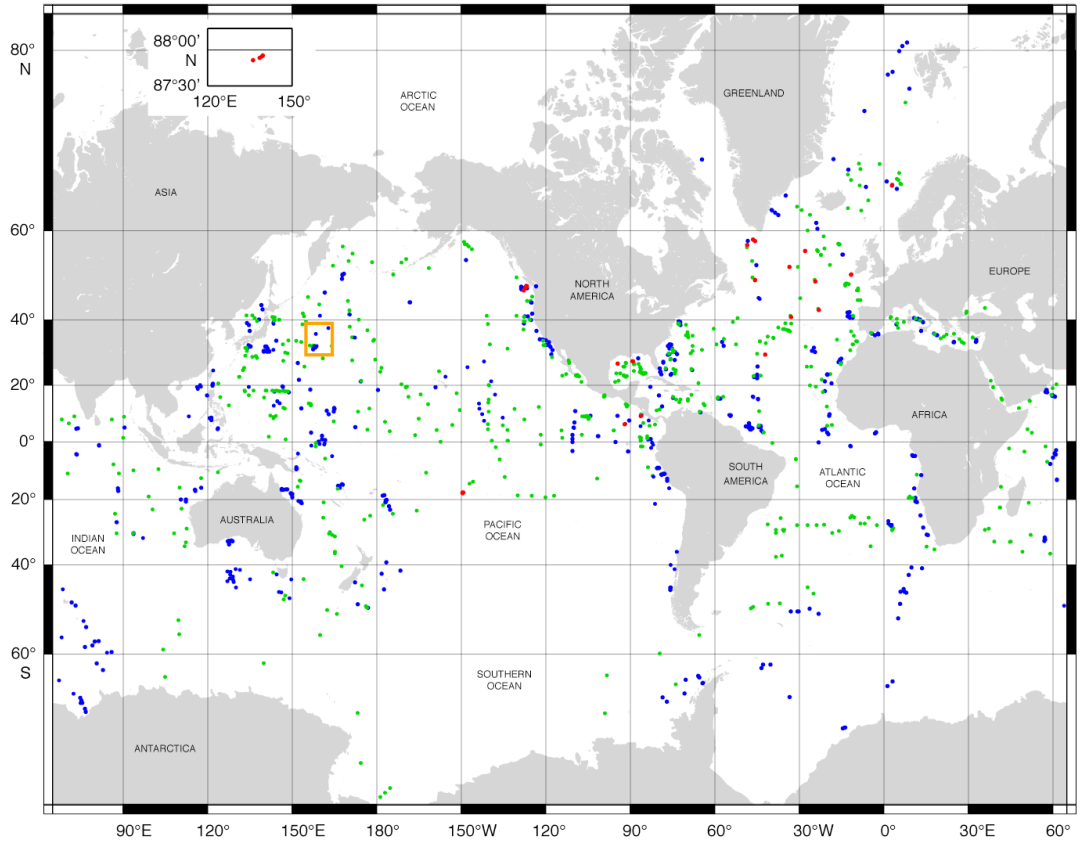

Figure 1. Map of all the sites drilled by the DSDP, ODP, and IODP. The orange box indicates the modern location of the Shatsky Rise Leg 198 sites.

Background

ODP Leg 198 was entitled, "Extreme Warmth in the Cretaceous and Paleogene: a Depth Transect on Shatsky Rise, Central Pacific." The goals of this leg are nicely summarized in the abstract of the Leg Summary in the Initial Reports volume (Chapter 1, Proceedings of the Ocean Drilling Program, Initial Reports Volume 208; http://www-odp.tamu.edu/publications/198_IR/198ir.htm).

"The mid-Cretaceous (~125-85 Ma) and early Paleogene (~65-34 Ma) were characterized by some of the most equable climates of the Phanerozoic and are among the best known ancient "greenhouse" climate intervals. In addition, these intervals contain some of the most abrupt and transient climatic changes in the geologic record, including the Paleocene-Eocene Thermal Maximum (PETM), the mid-Maastrichtian deepwater event (MME), and the early Aptian Oceanic Anoxic Event (OAE1a). These critical transitions involved dramatically modified oceanic circulation patterns, profound changes in geochemical cycling, and abrupt turnover in marine biotas. Recent ocean drilling efforts have led to profound advances in our understanding of the ocean and climate dynamics of a warm Earth; however, we have yet to gain a firm knowledge of how atmospheric or deep-ocean circulation operates in the apparent absence of substantial thermal gradients, how rapid removal of important elements such as nutrients in some of these events is maintained for a long period of time, and exactly how environmental changes cause extinction and speciation of marine biotas.

Ocean Drilling Program (ODP) Leg 198 on Shatsky Rise was designed to address the causes and consequences of Cretaceous and Paleogene global warmth. The objectives were to address the origin of the long-term climatic transition into and out of "greenhouse" climate as well as abrupt climatic events."

Paleoceanography is the study of the ancient ocean-climate system. Paleoceanographers use a variety of proxies to reconstruct the past, including the composition of the sediments, geochemistry of microfossil shells and organic matter, analysis of ancient plankton communities, and evidence of cyclicity in the sedimentary record, to mention a few of the broad areas of inquiry. Stable isotopes of oxygen and carbon (∂18O, ∂13C) are among the most commonly used proxies in paleoceanography. The calcite hard parts of calcareous nannofossils and foraminifers can be studied isotopically by dissolving the calcite in acid to liberate CO2 gas and then measuring the isotopic composition of that gas on a mass spectrometer. The bulk sediment can be analyzed, or individual shells of foraminifera (i.e., individual species or genera of planktonic and/or benthic foraminifera) can be picked from the sample and analyzed isotopically. However, diagenesis, or alteration of the original calcite due to dissolution or etching of the calcite shells, and reprecipitation of secondary calcite on foraminifera shells is particularly problematic. Diagenesis typically increases with increasing depth in a drill hole; in other words, the more deeply buried, the more diagenesis the calcareous microfossils are likely to have experienced.

Activity written by: Debbie Thomas, Texas A&M University, 2007

Where would you drill?

1. The primary objective of ODP Leg 198 was to recover a depth transect of Paleogene and Cretaceous age sediments (~23-130 Ma). This was a paleoceanographic leg, so continuous core recovery of well-preserved biogenic sediment was of highest priority. If you were tasked with the responsibility to pick the drill sites, what criteria would you use to guide your selections?

2. Why would a paleoceanographic leg target sediments deposited on an oceanic plateau that is "elevated" relative to the surrounding seafloor (a bathymetric high)?

3. Examine the seismic profile for your group's site. What is the water depth of the proposed site?

4. Are there prominent features evident in the seismic reflection profile? Can you identify the transition between sediment layers and basalt? Are there features within the sediment pile that might indicate prominent changes in sediment composition or accumulation? At what depth below seafloor do these changes occur?

5. Now let's go into the core lab. How do the features that you have identified in the seismic reflection profiles compare with the actual recovered sediments? Are these changes related to sediment composition or changes in sediment accumulation (e.g., "condensed" intervals)? Does your estimate of the depth below seafloor from the seismic profile match with the depth of the recovered sediment?

6. Finally, what was the paleogeographic location of Shatsky Rise during the Cretaceous? How might you explain the occurrence of chert throughout much of the Cretaceous-age sediments in the Leg 198 Sites? Why is there no chert in the Paleogene and younger-age sediments?

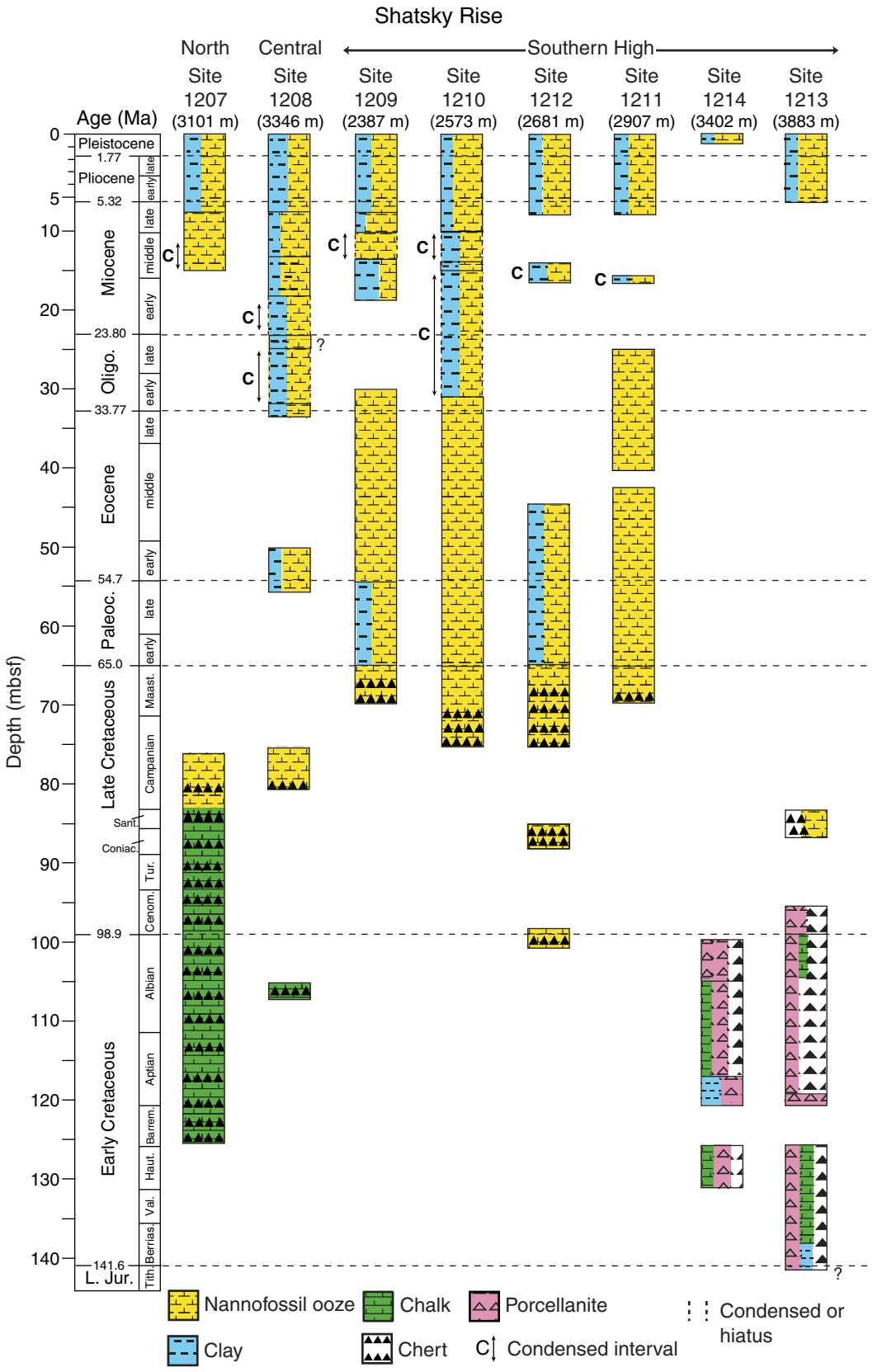

Figure 2. Summary of stratigraphy and lithologic succession from Sites 1207 to 1214. Lithology is plotted against time to show duration of periods of deposition and location of unconformities. Southern High Sites 1211 through 1214 are ordered by present-day water depth. (Figure F21 from the 198 Initial Reports Leg Summary).