

CORKS in the Crust: Part 1

Interpreting Pressure Measurements at the Seafloor and in the Earth's Crust on the Juan de Fuca Plate

Summary

Students use CORK data to investigate the causes, effects, and relationships between fluid pressure measurements at the seafloor and the oceanic crust below.

Learning Objectives

Students will be able to:

- Interpret a graph of fluid pressure measurements
- Make calculations based on this data

National Science Education Standards

Standard A: Science as Inquiry

Standard D: Earth and Space Sciences

Ocean Literacy Essential Principles

2. The ocean and life in the ocean shape the features of Earth.
7. The ocean is largely unexplored.

Target Age: Grades 11-12, undergraduate

Time: One class period

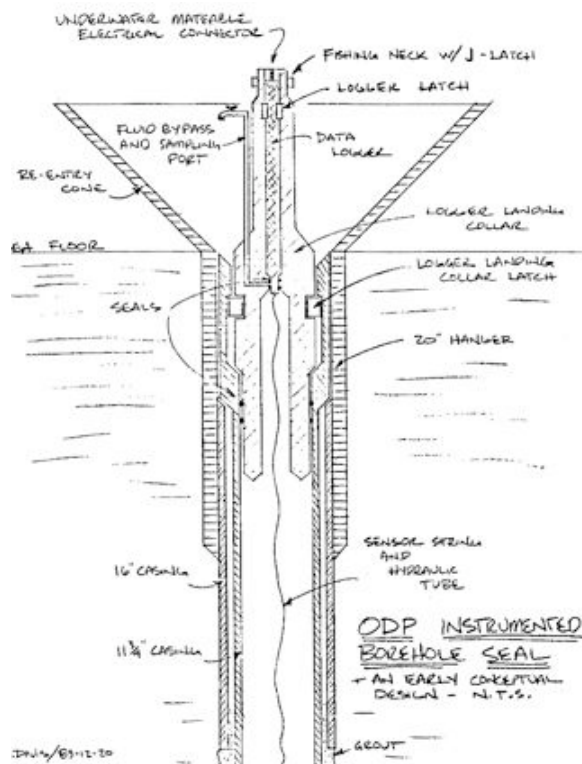
Materials

- Chart of the northeast Pacific
- Pen or pencil
- Ruler
- Physics or oceanography texts

Background

Since 1968, the scientific ocean drilling programs (DSDP, ODP, and IODP) have studied Earth's history by sampling and analyzing rock and sediment cores from thousands of sites on the ocean floor. Scientists have also been able to measure a host of properties like pressure, temperature, and water chemistry in the boreholes after the cores are collected by lowering special sensors down on a wire-line. By 1989, however, a group of scientists including Keir Becker, Earl Davis, and Robb Carson began to envision an "instrumented borehole seal" that could measure the properties and processes of water in the crust after the effects of drilling had subsided.

It was as we sailed for Middle Valley that the acronym "CORK," or "Circulation Obviation Retrofit Kit," was coined by ODP Operations Superintendent Glen Foss. The configuration of the original design bears an obvious resemblance to a cork in a bottle; "CO" referred to stopping the fluid exchange between formation and ocean bottom water that was to be expected if holes into hydrologically active



The vision for the "CORK" or "Circulation Obviation Retrofit Kit" was first sketched out on a dinner napkin (above) during a 1989 cruise to the Middle Valley spreading center in the northeast Pacific (seaward of Victoria, Canada).

formations were left unsealed; “RK” referred to the fact that the experiment could be installed in any reentry hole, whether drilled the day before or 20 years earlier.... the ODP CORK effort succeeded far beyond the vision we originally sketched out on a dinner napkin in 1989! —K. Becker and E.E. Davis in CORK design review in *Proceedings IODP/ Volume 301*

Several sites on the Juan de Fuca Ridge axis and flanks have now been drilled and sealed by CORKS equipped with long-term pressure and other data collecting instruments. In September 2007, a party of about a dozen scientists, graduate students, and teachers from the United States and Canada traveled aboard *RV Atlantis* to the sites where they recovered long-term data, installed new equipment, and serviced CORK observatories. Alison LaBonte descended to the seafloor in *DSV Alvin* to download pressure data directly from the instruments at Site 1027C.

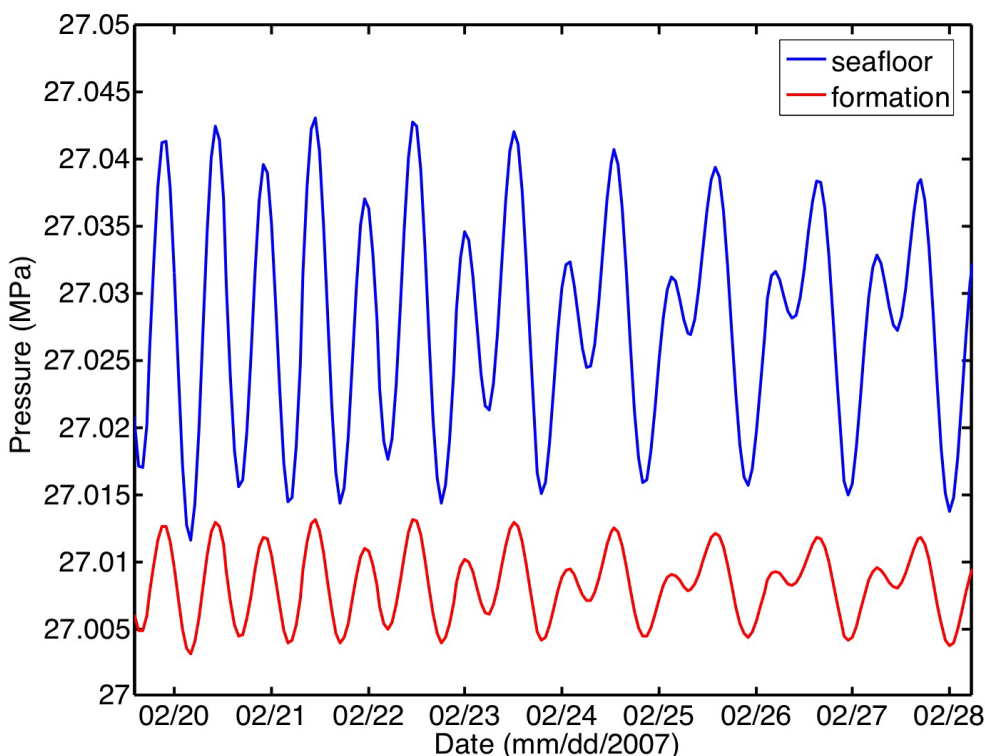
What To Do

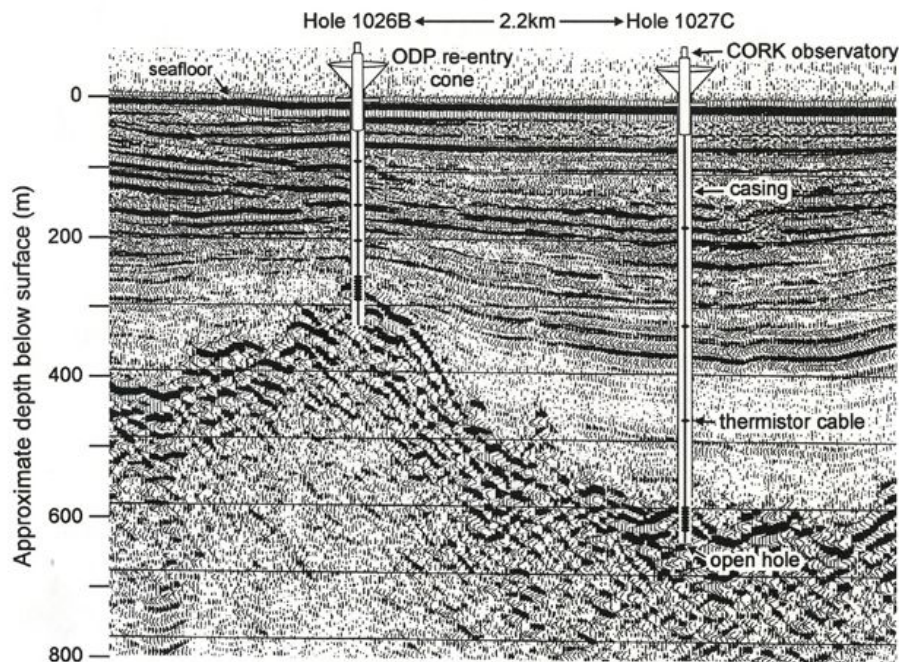
Use Alison’s data to investigate the causes, effects, and relationships between recent fluid pressure measurements at the seafloor and the oceanic crust below, and to draw inferences about the properties and processes of the Earth’s crust. Record your answers on a separate piece of paper and be prepared for a class discussion. *Hint: The answers are easier than they may first appear.* (Data and questions provided by Alison LaBonte.)

1. The graph depicts pressure measurements recorded at the seafloor (blue line). What is the period of the signal?
2. Circle the largest or maximum oscillation. What is the maximum change in pressure in pascals (Pa)? Knowing 10,000 Pa is equal to 1 meter of water height, what is the maximum change in water height above the seafloor pressure gauge?
3. Using your answers to questions 1 and 2, what do you think is causing this oscillation, or periodic pressure signal, observed at the seafloor?
4. The oceanic crust, like a saturated sponge, has pores filled with water and is compressible. When the crust is squeezed, the volume of these pore spaces is reduced. How will this “volumetric strain” affect the pressure in the crustal formation?
5. Imagine trying to squeeze a porous block of metal (ceramic) that is stiff and relatively incom-



Drs. Earl Davis and Alison LaBonte work on CORK hardware on board the *RV Atlantis*. (Photo: Beth Orcutt)





Seismic section showing Holes 1026B and 1027C.

- pressible compared to the sponge by applying the same pressure you applied to the sponge. The corresponding pressure change in the pore spaces of the stiff block will be (choose one) **greater/less** than the pressure change in the sponge's pore spaces. Think about and describe the relative volumetric strain that resulted from your attempts to squeeze the two different materials. Grab a sponge and a metallic block if you need to.
- The pressure due to the column of water above the seafloor acts to load and unload the crustal formation. Measure the formation (red) and seafloor (blue) amplitudes of any single pressure oscillation. Calculate the ratio of change in formation pressure to change in seafloor pressure. This ratio is called the loading efficiency. What is the relationship between loading efficiency and compressibility?
 - Compare your answer with the loading efficiency your classmates calculated using different oscillations. Are your results the same or different? What does this say about the compressibility of the crust over the time scale of the measurements?
 - This instantaneous change in pressure due to the applied load is called the "elastic response." The elastic response is followed by a "diffusive response." Diffusion is the subsequent drainage of water from a region of high pressure to a region of low pressure. In the case where the crust was squeezed, water will drain (choose one) **into/out** of the crust.
 - The rate of this drainage, or diffusive flow of water, depends on the pressure differential and the permeability of the material. At CORK Site 1027C the fluids in the ocean basement formation are trapped by the overlying marine sediments, which are effectively impermeable. Therefore the response of the formation to the periodic loading is likely purely (choose one) **elastic/diffusive**.



Earl and Ali work with CORK data on board the RV Atlantis.