



# How Do Scientists Conduct Research on Ancient Environments?

## Teacher's Slide Description

### ***JOIDES Resolution Expedition***

The *JOIDES Resolution* is the premier riser drill rig in the world. If you seek information about the seafloor, this ship has provided a wealth of samples that scientists have analyzed and documented. The drill ship is 143 meters long and has drilled over 2.1 km (1.3 miles) into the sea floor. The seafloor samples recovered include the remains of ancient living organisms, mineral-rich sediments, and rocks from the earth's crust.

### **Setting the Drill Location**

Once the drill ship arrives at its drilling location, a beacon is dropped to find the sea floor depth. The ship's crew sends the drill apparatus down to the seafloor, which then brings up core sections that are 9.6 meters long and 6 cm in diameter.

### **Bringing the Core on Deck**

The result of all the drilling for a core is a massive cylinder of sediments containing material that has been deposited over millions of years. The sediment may be rich in nitrogen, oxygen, carbon, and other elements that hold clues to many mysteries! Scientists who specialize in various scientific techniques will each take their turn sampling the core and analyzing the material.

The *JOIDES Resolution* can drill several thousand meters into the seafloor, depending on the scientific plan. For ease of use, the resulting core is cut into six 1.6 meter-long sections that will be used for research. These smaller sections are easier for scientists to carry and work with in the lab. These 6 cm diameter cores are split in half, leaving two core halves, each of which is shaped like a flat hot dog. One half, called an archive half, will be sent to a storage library of cores called a repository. The other half, called the working half, is sampled and researched right away, and later will also be sent to the repository for other scientists to use.

### **Observation (Data Collection): Qualitative**

The recovered cores can also be analyzed visually, resulting in qualitative data collection. The scientists have to look very closely at the core sections in the left image to notice any differences in color, texture, grain size or structure among the mostly gray, consistent layers of clay. However, the core shown on the right has many colors. This is the special core that our scientist Dr. Quan thinks will hold information about the most well-known mass extinction on Earth!

### **Observation (Data Collection): Quantitative**

Dr. Howie Scher collects seismic wave (p-wave) measurements in the physical properties lab during IODP Expedition 320. To simulate an earthquake, he sends p-waves through the core sample. This type of study is an example of quantitative data collection. Credit: Bill Crawford, IODP Imaging Specialist.

### **Core Sampling Process: Selecting and Sampling an Interval in the Core**

Each core is unique and can contain sediments that are millions of years old. After the core is analyzed by all non-invasive methods, samples can be taken from the core for specific research and projects. Styrofoam cylinders and cubes are used to fill in where core sample was removed in order to keep the core structure intact. The collected samples will most likely be destroyed in the research process, so scientists have to be very specific and choosy about what exact samples and at what depth intervals they would like.

### **Core Sampling Process: Labeling**

Deep sea core samples stored in these bags may hold clues to numerous scientific mysteries! Scientists have to carefully label every sample collected in order to identify each sample's location and depth. Some samples are analyzed during the expedition on the ship, some are analyzed back in the shipboard scientist's laboratories, and some are destined for other scientists' labs thousands of miles away.

### **Core Sampling Process: Recording the Sample**

Phil Rumford (Curator, IODP-USIO) explains how to take core samples and input the information into the repository database during IODP Expedition 311. The database is similar to a library catalog: scientists can search the database, locate samples they would like to use, then submit a request to have those samples sent to them for research.

### **Writing and Submitting a Sample Request**

Dr. Quan is double-checking her research proposal before she hits the 'submit' button! Scientists need to write large proposals in order to acquire and conduct research on the core sediment samples. Dr. Quan specifically chose various sampling sites and sections of the sea floor that would show her ancient life from 70-60 million years ago. Once the proposal is submitted, it is reviewed and hopefully funded. Dr. Quan can then request samples from the cores that will likely contain data useful for her investigation.

The IODP curator is in charge of sending samples to scientists so they can study ancient mysteries. The curator will email Dr. Quan and clarify any issues and confirm she is getting the right samples for the data she needs to support or refute her hypothesis. Since there are so many requests for samples, it takes a long time to get the samples needed for Dr. Quan's research.

### **Dr. Quan Receives Requested Core Samples!**

Within the box of deep sea core samples could be the answer to the mystery surrounding the death of the dinosaurs. It is a long process for Dr. Quan to get her materials; she wishes she could just grab some extra chemicals or rocks from the lab room!

The 66 million year old deep sea ocean core sediment is now ready to be examined by Dr. Quan. Everything is labeled and checks out. Once she opens the package, what will she have to do next?

### **Preparing Core Samples for Scientific Analysis: Grinding the Sample**

Dr. Quan uses a mortar and pestle to grind the sediments into a very fine powder. This is an example of an invasive testing technique. By grinding some of her sample she is breaking down the original evidence. For her analysis, she has to make sure there are no large pieces that would interfere with her instruments.

### **Preparing Core Samples for Scientific Analysis: Weighing the Sample**

Dr. Quan fills these tiny tin or silver containers with the ground-up samples. She needs to make sure to use a uniform amount for each sample to conduct her research. Why do you think she uses pure tin or silver for her samples? Each sample needs to be weighed on a very precise scale and recorded. Why do you think there is a glass box around the sample on this scale?

### **Preparing Core Samples for Scientific Analysis: Rolling the Sample for the Elemental Analyzer**

Dr. Quan needs to form the sample in its metal container into a uniform ball if she wants it to fit in the Elemental Analyzer's auto sampler and burn evenly. Sometimes she makes dozens of these small samples a day. When analyzing evidence to solve a mystery, exact measurements are necessary.

### **Preparing Core Samples for Scientific Analysis: Combusting the Sample**

Dr. Quan needs to double check that the rolled sample is small enough to fit correctly into the Elemental Analyzer. She uses various tools to be precise! The little metal balls go into the Elemental Analyzer which heats them to over 1000 degrees Fahrenheit! This is not your ordinary oven! It burns the tin or silver wrapped samples, combusting the 66 million year old organic solids into gas.

These gases are then sent to the \$300,000 mass spectrometer through small diameter metal gas tubing to be separated according to the masses of the various isotopes.

### **Isotope Ratio Mass Spectrometer Analysis**

This is an illustration of the inside of an Isotope Ratio Mass Spectrometer. This instrument can actually tell the molecular weight difference between Nitrogen gas ( $N_2$ ) molecules with molecular weight differences of 28, 29, and 30. Remember, the most common Nitrogen isotope is 14, and Nitrogen gas occurs as 2 Nitrogen atoms bonded together. In the mass spectrometer, each different molecular weight is directed towards a different detector by a very powerful magnet. The instrument records the molecular weight variations in the  $N_2$  gas from the sample being analyzed.

### **Data Display from Sample Analysis**

As the sample is measured by the mass spectrometer, the electronic signals from the instrument are shown in real-time on the attached computer. The computer also

allows Dr. Quan to check how the instrument is running, analyze standards, and program a sequence of samples to run continuously. This picture shows the results from an instrument test Dr. Quan runs in order to make sure the mass spectrometer is working well. Why is it important that the test is run before samples are analyzed?

### **Data Analysis**

Graduate student Mohamed Musa is learning how to look at the data generated by the Mass Spectrometer. He is trying to quickly recognize trends and anomalous data (data that doesn't fit or make sense), which will be important to his interpretation of the data. He will use this experience to learn how to eventually tackle other mysteries.

There is always a certain amount of uncertainty in the data obtained from real samples. Scientists need to check their work, take into account the limitations of the instruments, and identify errors caused by collecting samples and analysis methods. As long as the acceptable level of error is known and documented, you are conducting quality research.

### **Interpreting Results**

Once all of the data are checked and rechecked, Dr. Quan can begin to interpret the results. She makes spreadsheets and graphs of her data to do calculations and visualize trends. During her analysis she uses the data to make inferences about what the environmental conditions were like at the end of the Cretaceous Period, when the dinosaurs went extinct! The why and how of scientific research are the critical parts to answering questions. Dr. Quan's analysis and conclusions may take years and multiple research experiments to justify.

### **Publishing Findings**

It will take Dr. Quan many edits and revisions before her paper explaining all of her research is ready to be sent to a journal for review and publication. The reviewers are other scientists who are familiar with related areas of research. Once reviewed they will send her one of three responses: accepted, accepted with revisions needed, or rejected. Most of the time, the submitted papers need revisions. Dr. Quan revised the paper you see here 14 times before it was even submitted to the journal, but it was finally published in 2013. This part of the process can be very frustrating but it ensures that the research that is published is very accurate and well tested.

### **Presenting Findings**

Scientists often present their findings to fellow scientists at conferences. The scientist in the photograph is the co-chief of an expedition on the *JOIDES Resolution* who is presenting graphs of data to the ship-board research party. Perhaps Dr. Quan will get to present her nitrogen data soon!