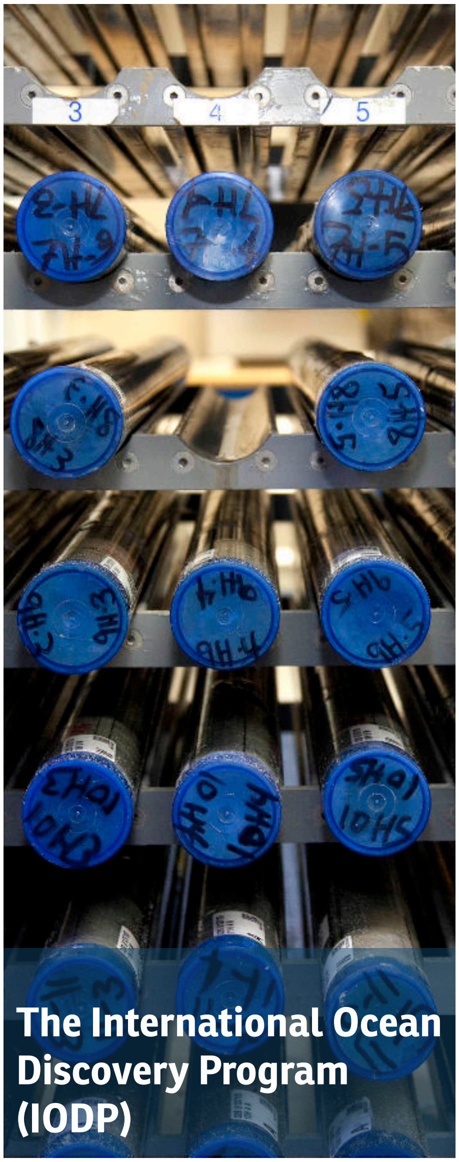
POP-UP DRILL DOWN

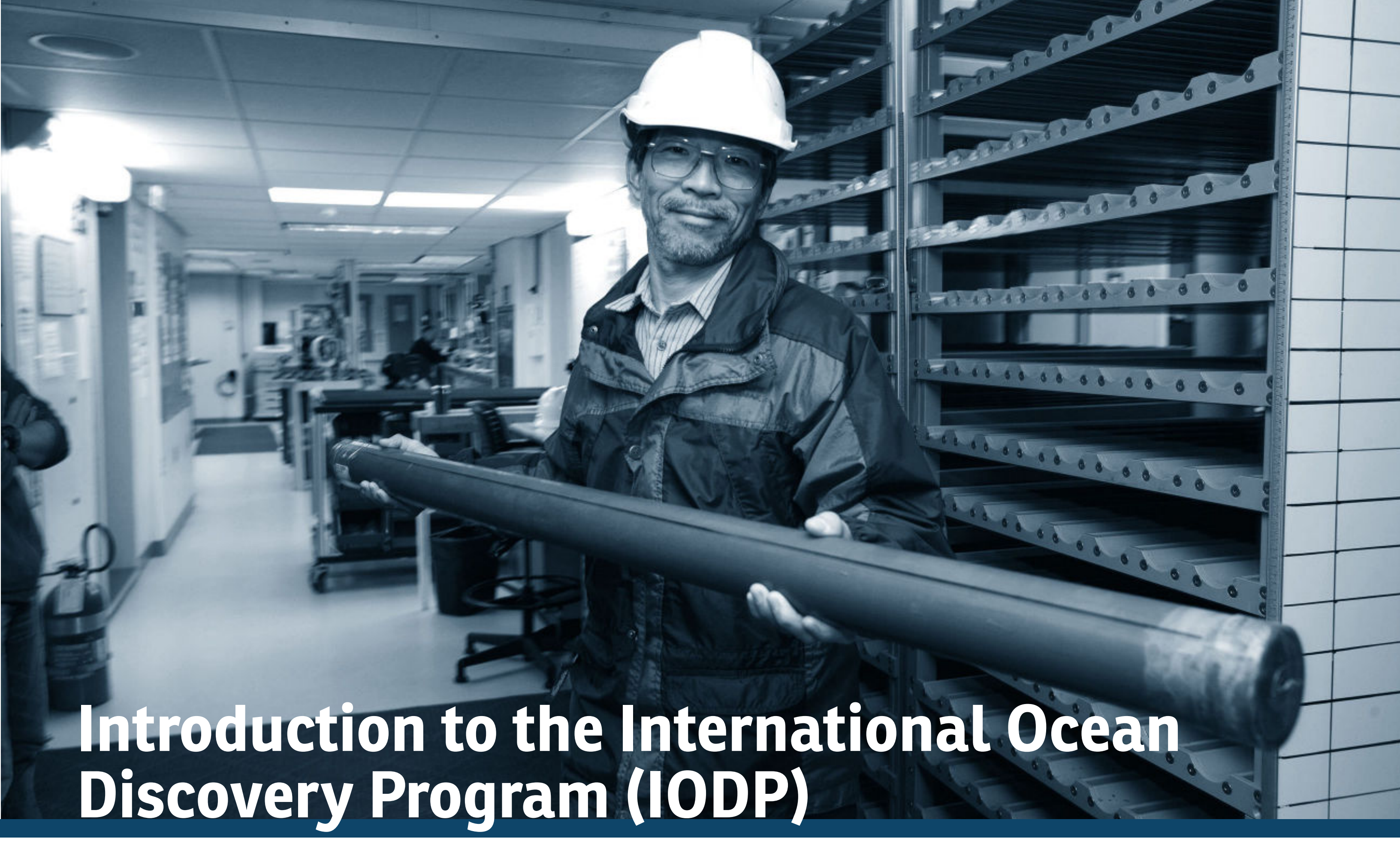
2017



The International Ocean Discovery Program (IODP)

Pop-Up/Drill Down Project

Kiosk Concepts



Introduction to the International Ocean Discovery Program (IODP)

The *JOIDES Resolution* is a seagoing research vessel that drills core samples and collects measurements from under the ocean floor, giving scientists a glimpse into Earth's development. Data from The JR's ocean drilling offer a scientific means of understanding climate and environmental change throughout a significant part of our planet's history—a research subject often termed Earth's paleoclimate. The JR's core samples are the "smoking gun" in evaluating many historical events related to paleoclimate, changes in the solid earth and more -- like the extinction of the dinosaurs and plate tectonics, for example.

Work aboard the research vessel never ceases; operations continue 24 hours a day. *JOIDES Resolution's* complement can consist of 50 scientists and technicians and 65 crew members. The crew consists of marine professionals and ocean drilling specialists, among others. The JR's science party is specific to each mission, with skills and science disciplines chosen especially to best achieve the mission's goals.

Sponsoring Agencies

The International Ocean Discovery Program (IODP) is an international research program that explores the history and structure of the earth as recorded in seafloor sediments and rocks. IODP builds upon the earlier successes of the Deep Sea Drilling Program (DSDP) and the Ocean Drilling Program (ODP), which revolutionized our view of Earth history and global processes through ocean basin exploration. IODP represents the latest generation of these highly successful scientific ocean-drilling initiatives and seeks to greatly expand the reach of the previous programs by forming a collaborative union among the United States, Japan, and the European Union, each of which is responsible for providing drilling platforms appropriate for achieving the scientific objectives outlined in the IODP Initial Science Plan.

Within the structure of IODP, the United States is responsible for operating the riserless drilling vessel *JOIDES Resolution*. Japan operates the riser drilling vessel *Chikyu*, and the European Union deploys mission-specific platforms capable of drilling in environments unsuitable for either riserless or riser vessels. The United States Science Support Program (USSSP) is operated by the Lamont-Doherty Earth Observatory of Columbia University. USSSP is responsible to NSF and IODP Management International (IODP-MI) for overall program leadership; technical, operational, and financial management; and delivery of services.

On board the *JOIDES Resolution*, scientists from all over the world participate in expeditions aimed at investigating the principal science themes for IODP: the deep biosphere and the sub-seafloor ocean; environmental change, processes and effects; and solid earth cycles and geodynamics.

Helpful Websites and Videos

Expedition Schedule: http://iodp.tamu.edu/scienceops/index.html
Education Portal: joidesresolution.org
U.S. Science Support Program: uscoeandiscovery.org

Introducing the International Ocean Discovery Program
Using Ocean Drilling to Investigate Earth's Volcanic History
A Brief History of Scientific Ocean Drilling
Why Ocean Drilling
Life On Board the JR
Aboard the JOIDES Resolution

Drilling to Understand Earth's Past, Present & Future

Scientific ocean drilling began in the late 1950s as Project Mohole – attempting to drill into the mantle, which 50 years later the program is still trying to do! Project Mohole attempted to drill through Earth's crust to the Mohorovic Discontinuity and retrieve a sample of the mantle. Although the mantle was never reached, Project Mohole showed that deep ocean drilling was a viable means of obtaining geological samples. The Deep Sea Drilling Program (DSDP) used the Glomar Challenger (1966-1983). During worldwide operations,
Glomar Challenger sailed 96 legs and drilled 624 sites. A few highlights: it verified the theory of plate tectonics, discovered that Antarctica has been ice-covered for 20 million years, and showed that the Mediterranean Sea completely dried up between 5 and 12 million years ago.

The Ocean Drilling Program (ODP: 1983-2003) was the first one to use the JR. It operated for 110 Legs and drilled 650 sites. Highlights include: defining the longest record of Earth's natural climate variability, collecting the first marine record of the K/T boundary, and successfully sampling gas hydrates.
The program became the Integrated Ocean Drilling Program in 2003. It was the most ambitious of these scientific drilling programs because it more fully integrated international partnerships, pulling together different drilling platforms from the US, Japan and Europe, working together under a structured scientific plan.

Topics that were addressed during IODP include: deep biosphere, gas hydrates, extreme climates, rapid climate change, continental breakup and sedimentary basin formation, large igneous provinces, 21st century Mohole, and seismogenic zones.

By 2013, there was some pushback to the word "drilling" in the public's mind, so when the first IODP ended, the name was changed to the International Ocean Discovery Program. The 10 year science plan (2013-2023) includes 14 challenge questions in the four areas of climate change, deep life, planetary dynamics, and geohazards. More detailed information about the science plan can be found here: http://iodp.org/about-iodp/iodp-science-plan-2013-2023.

The JR began working for the Ocean Drilling Program (ODP) in 1985. From 2006-2008, The JR was completely renovated with new scientific drilling equipment, new structural improvements and significant upgrades. It is almost a whole new ship! The JR returned as IODP's riserless drilling vessel in 2009, along with the riser vessel Chikyu operated by Japan, and mission-specific platforms operated by the European consortium ECORD. The *JOIDES Resolution* is owned by Overseas Drilling Limited, a subsidiary of Siem Offshore, and the ship is operated by the *JOIDES Resolution* Science Operator (JRSO at Texas A&M University) through funding from the U.S. National Science Foundation.

International Ocean Discovery Program (2013-2019)

Science themes include using records of past climate and ocean changes to inform the future, exploring deep life, and understanding deep Earth processes.

Integrated Ocean Drilling Program (2003-2013)

Most ambitious by involving:
- International Partnerships
- Multiple Drilling Platforms
- Sctructured, laid-out scientific goals.

Initiatives include:
deep biosphere, gas hydrates, extreme climates, rapid climate change, seismogenic zones, among others.

Ocean Drilling Program (1983-2003)

During the Ocean Drilling Program, the *JOIDES Resolution* sailed 100 Legs and drilled 650 sites.

Scientific Highlights:
Defined the longest record of Earth's natural climate variability.

Collected the first marine record of the K/T boundary.

Successfully sampled gas hydrates.

Deep Sea Drilling Program (1966-1983)

During worldwide operations, *Glomar Challenger* sailed 96 Legs and drilled 624 sites.

Scientific Highlights:
Verified the theory of plate tectonics; discovered that Antarctica has been ice-covered for 20 million years; showed that the Mediterranean Sea completely dried up between 5 and 12 million years ago.

Project Mohole (1958-1966)

Attempted to drill through Earth's crust to sample the mantle.

Project Mohole recovered first samples of oceanic crust and showed that deep ocean drilling was a viable means of obtaining geologic samples.

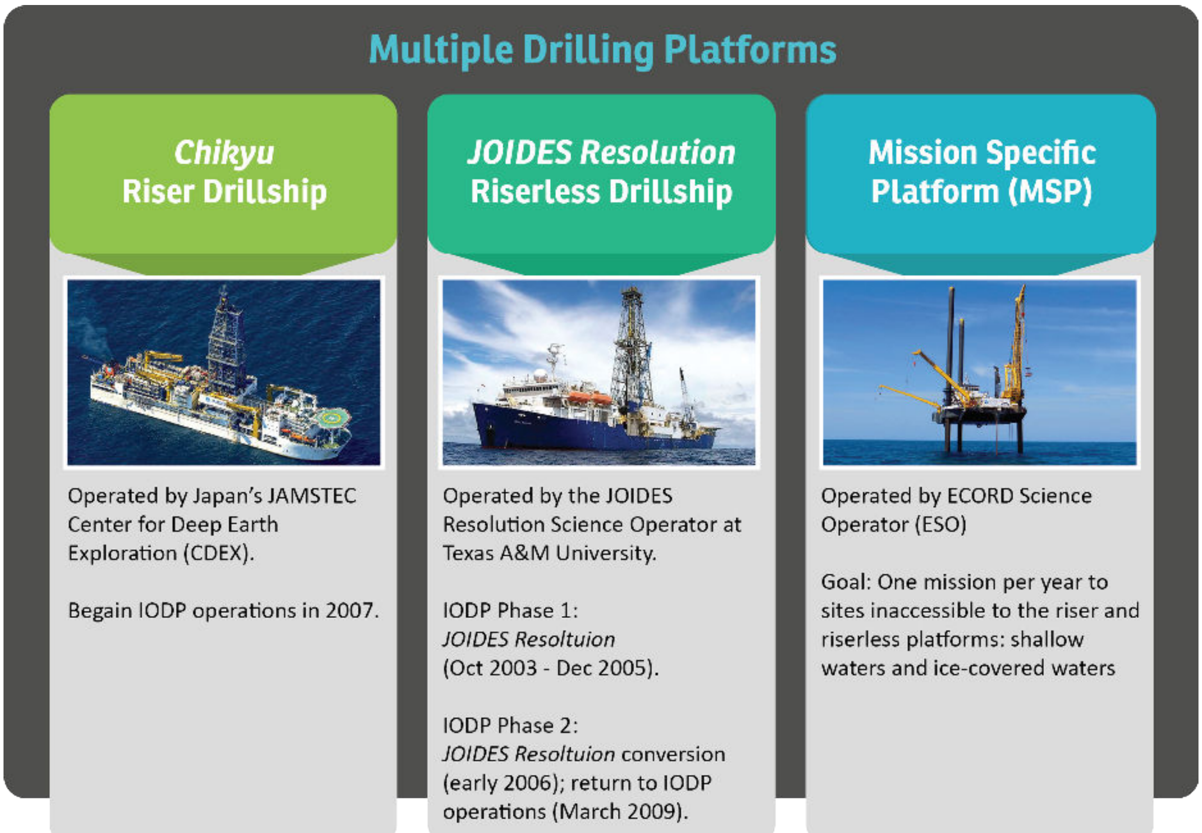
Drilling Platforms

The different drilling platforms involved in IODP operations include a riser-vessel which provides the ability to drill deepest into the Earth. Japan currently operates the Riser-vessel, Chikyu. The *JOIDES Resolution* is a riserless-vessel that enables drilling in the deepest water. Mission- specific platform allows drilling in areas which the other two platforms cannot. ECORD operates the mission-specific platforms, wherein they rent a specific platform for a specific expedition depending on the needs of that expedition. Together, these three operations enable IODP to conduct scientific ocean drilling almost anywhere in the world.

Chikyu: Riser Drillship operated by Japan's JAMSTEC Center for Deep Earth Exploration (CDEX). Began IODP operations in 2007.

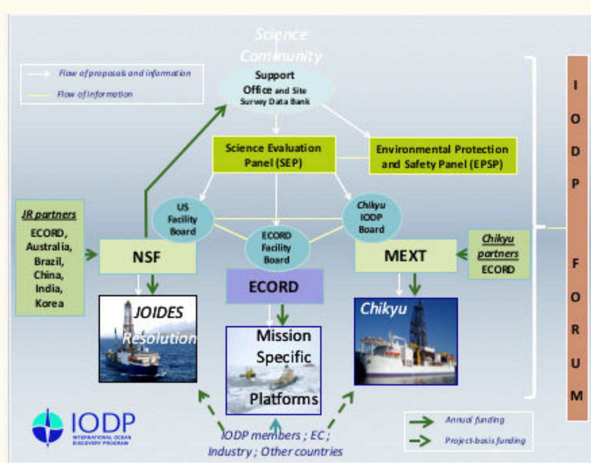
JOIDES Resolution: Riserless Drillship operated by the *JOIDES Resolution* Science Operator (JRSO) at Texas A&M University. IODP Phase 1: *JOIDES Resolution* (Oct. 2003 – Dec. 2005). IODP Phase 2: *JOIDES Resolution* conversion (early 2006); return to IODP operations (March 2009). Was completely renovated.

Mission specific platforms: not one single vessel. They rent a specific platform for a specific task. Operated by ECORD Science Operator (ESO). The goal of the program is one mission per year to sites inaccessible to the riser and riserless platforms. These include shallow waters and ice-covered waters.



Program Complexity

To give you an idea about the complexity of the program, take a look at this diagram. A lot of international partnerships and oversight committees to review and peer-review scientific plans and operations are going on all the time. Facility boards oversee each of the platforms. In the US, the National Science Foundation is the funder; it is important to note that the funds to support the US Education Officer come from NSF. In Europe they have the European Consortium for Ocean Research Drilling (ECORD). In Japan it's called MEXT. Science evaluation panels oversee expedition proposals. The Environmental Protection and Safety Panels (ESEP) look at the proposals to make sure they are environmentally sound and that they aren't going to cause any damage, (and won't cause an earthquake or explode the ship or anything like that!) Along those lines, it's important to know that the JR avoids areas with fossil fuels, because it is not equipped to handle the pressures that are involved in oil drilling. You may get this question from the public.



JOIDES Resolution Tour Guide

Your Two-Month "Home Away From Home"

The drillship was built in 1978 in Halifax, Nova Scotia, as a conventional oil drilling vessel. Then named Sedco/BP 471, she was refitted in Pascagoula, Mississippi during the fall of 1984 to accommodate the laboratory stack levels and other scientific facilities and equipment necessary for carrying out the program's objectives. When drilling operations began in January 1985, the ship was informally christened *JOIDES Resolution* after Captain James Cook's flagship of two centuries ago, HMS Resolution. She now officially carries the name *JOIDES Resolution*.

Measuring 144 meters (470 feet) long and 21 m (70 feet) wide, her ***derrick*** rises 66 m (215 feet) above the waterline and can support 1 million pounds of weight. The ship maintains location, even in heavy seas, by means of 12 computer-controlled thrusters, which are part of her dynamic-positioning system. She can drill in water depths to 8800 m (29,000 ft). In contrast to standard petroleum practice, drilling is done in riserless mode; therefore, extreme caution is exercised at all times in avoiding significant hydrocarbon accumulations.

Ship Lingo

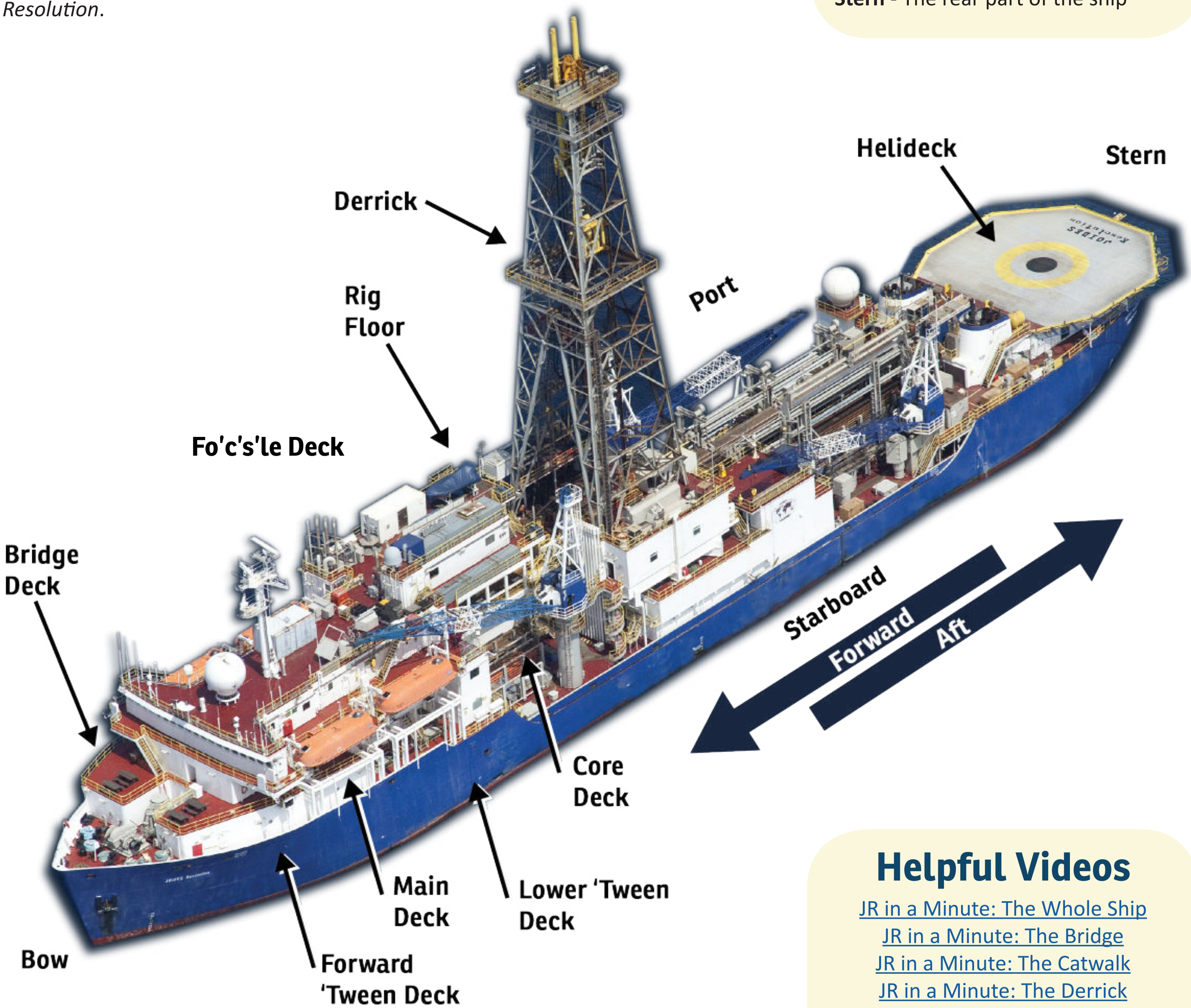
Aft - The portion of the vessel behind the middle area of the vessel; towards the stern

Bow - The front of the vessel

Port - The left side of the boat. Towards the left-hand side of the ship, facing forward.

Starboard - The right side of the boat. Towards the right-hand side of the ship facing forward.

Stern - The rear part of the ship



Helpful Videos

JR in a Minute: The Whole Ship
JR in a Minute: The Bridge
JR in a Minute: The Catwalk
JR in a Minute: The Derrick
JR in a Minute: Core Drilling
What is a CORK?
An Explanation of Deep Sea Coring

Drilling Operations

Rig Floor

The drilling process is controlled from the ***rig floor***. A ***pipe racker***, located aft of the rig floor, stores the pipes; one ***joint*** of drill pipe measures 9.5 meters and weighs about 874 kg (1925 lb). The crew makes a ***stand*** of drill pip by assembling three joints at a time. On the rig floor, a mechanical device called an ***iron roughneck*** makes up the ***drill string*** by connecting stands of pipe. The crew lowers the assembled drill pipe, with a drill bit attached, from the drill floor through the ***moonpool,*** a roughly 7 meter opening that extends through the bottom of the ship. (The process of lowering the drill string takes about 12 hours in 5500 m of water).

After the crew lowers the drill string to the seafloor, coring operations begin. The drill crew lowers ***core barrels*** through the drill pipe on a wireline. The entire drill string is rotated, cutting through the seafloor, and the core barrels retrieve and store the core material cut by the drill bit. The core barrels are then pulled up through the drill pipe to the rig floor, and technicians extract the long cylinder of sediment or rock. On average, the core barrel takes about 90 minutes to complete one round trip.

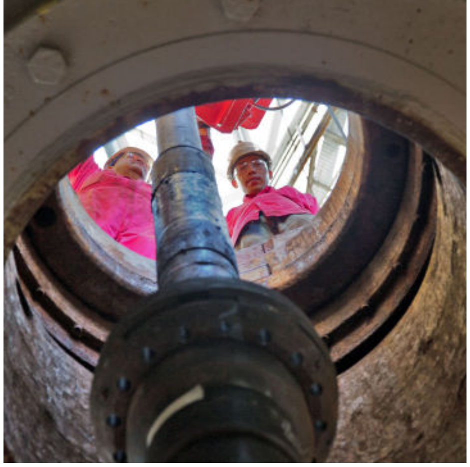
Deep holes often require several changes of ***drill bits***. Each change of drill bit requires that the entire drill string be brought up, stand by stand, until the bit at the bottom of the string can be changed on the rig floor.

With a new bit in place, the crew must reassemble the string before it reenters the hole. A ***reentry cone*** that is lowered through the moonpool and set on the seafloor enables the drill string to reenter the hole several times. A sophisticated system of scanning sonar equipment and an underwater television camera guide the drill string into the hole.

Catwalk

Each drill site is designated by a number, and an additional letter designation (A, B, C, D, etc.) is given to each hole at that site. Shipboard personnel hear an announcement from the rig floor saying “Core on deck” to indicate that the core is coming up. After each core is brought up from the seafloor, it is handed over to the laboratory technicians on the core receiving platform (also known as the ***catwalk***), a covered area outside the core lab. Since the core is ~10 meters long, it takes four to five technicians to carry it above their shoulders to the cutting station. Here, the core is cleaned, measured, and cut into ~1.5 meter sections. End caps are placed on the cut ends of the core - a clear end cap on the bottom of the core and a blue end cap on the top (blue for sky) and sealed with acetone. The hole number and section designation are written in permanent marker on each section of the core. This information is later engraved onto the core liner and included in a bar code sticker. A sample from each ***core catcher*** is taken from the end of sediment cores so that their age can be determined based on the microfossils present. In addition, samples may be taken for geochemical or microbiological analyses, and the cores may be scanned for temperature profiles.

Once cut, the core sections are brought into the core lab, where they are curated and prepared for processing.



Logging Operations

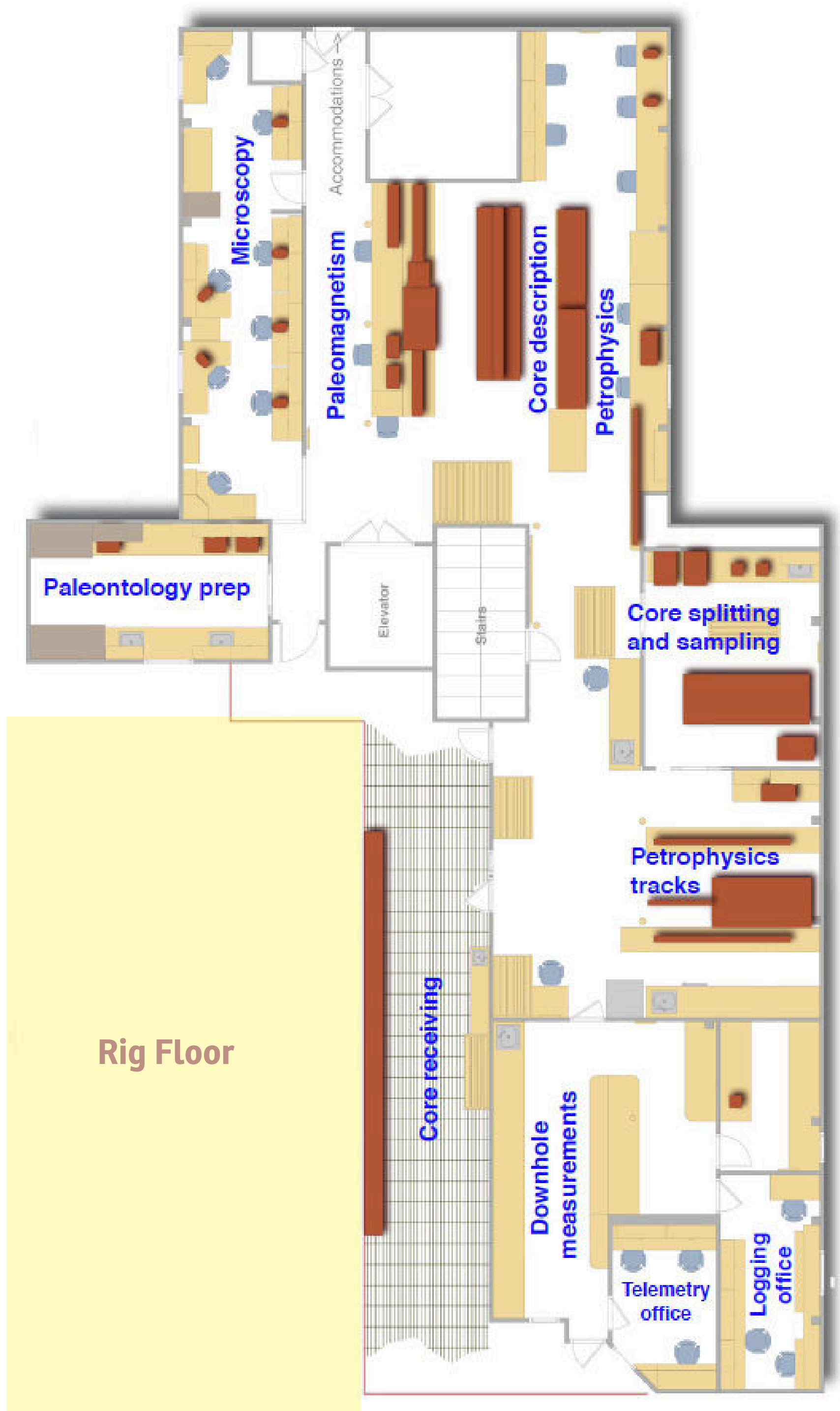
Logging operations begin once a hole has been cored. During logging, geophysical and geochemical measurements are acquired directly from the ***borehole wall*** - the hole itself becomes a sort of laboratory. Logging tools are attached to a wireline and lowered down the open hole, and the measurements are gathered as the tools are gradually pulled up. The data are transmitted to the surface through the wireline and analyzed in the downhole measurements laboratory. Many types of wireline logging tools are used by IODP to measure the physical, chemical, and structural properties of the borehole. The tools are typically combined in the tool strings; the two standard tool strings used by IODP are the ***triple combo*** and the ***FMS/sonic***. The triple combo measures the formation density, porosity, natural radioactivity, electrical resistivity, and size of the borehole. The FMS/sonic tool makes detailed resistivity measurements and provides sonic velocity data.

Logging-while-drilling (LWD) tools make measurements similar to those obtained by wireline tools; the difference is that LWD tools are not lowered into the hole after drilling, but are located above the drill bit and makes measurements as the hole is being drilled. (During most LWD operations, cores are not retrieved while drilling, so a separate coring hole is needed.) The main advantage of LWD is that the measurements are made right after the hole is drilled, when borehole conditions are optimal and the formations are less disturbed by the drilling process. LWD is not used routinely on the ship; most logging operations are conducted with wireline tools.

Heave Compensation

Most drilling problems are related to variations in the composition of sediment being drilled, and/or problems clearing out the hole. Add a rocking ship to the equation and the challenges can become even more complicated. To combat this, the JR employs heave compensation. There are heave compensation systems for both coring and logging. They help remove the impact of motion of the ship from either the drill string or the logging tools.

A passive heave motion compensator, which is suspended from the traveling blocks, is used for drilling. The top drive, which rotates the pipe and drill bit, is attached to the motion compensator. As the ship rises and falls with the waves and swell, pistons keep the bit on the bottom. During logging operations, compensation is provided by the wireline heave compensation (WHC) system, which is located near the Schlumberger winch cab.



Core Deck

Petrophysics Lab: Whole-Round Measurements

After cores equilibrate to ambient temperature, they are taken to the whole round multisensor track station and loaded onto a motorized core conveyor belt for the automatic measurement of ***resistivity*** (electrical resistivity of the sediment), ***magnetic susceptibility*** (indicates how much magnetic-bearing minerals are in the sediments), ***gamma ray attenuation*** (a proxy for the water content and porosity of the sediment), and ***P-wave velocity*** (how fast compressional waves travel through the sediment) at configurable intervals (typically at the cm scale). There is also a “fast track” that only measures magnetic susceptibility and gamma ray attenuation for rapid analyses when scientists want to get a quick look at the properties of a core.

The next step is the natural gamma radiation track. Here the gamma rays that are emitted during the decay of uranium, thorium and potassium isotopes are measured. These isotopes are found mainly in clay minerals within the core. The measurements are used for correlation among cores, holes and wireline log data.

At the thermal conductivity station, thin holes are drilled into soft sediment core liners and needle probes inserted through the holes into the whole cores. The probes contain a heating element and a thermistor that measure how fast the sediments or rocks warm up in response to the added heat. The thermal conductivities of hard rocks are performed in split cores with a disk that contains a “half-space” needle probe that is adhered to the surface of the rock. This probe operates using the same principles as the sediment needle probes. These measurements are used to determine heat flow, which can help with estimates of the age of ocean crust and the understanding of fluid circulation processes within the seafloor.

Core Splitting

The next step for the cores is the splitting room, where the cores are split longitudinally into halves. One half is imaged, described and archived. The other becomes the “working half.”

Sediment cores are placed on a grooved track on the cutting table. The track has a motor-controlled cutting tool that consists of two hooked razors that split the core liner, but are set at a depth to cause the least damage to the mud in the core. In addition to these razors, there is a thin wire that is held taught. As the cutting tool moves, the wire slices through the length of the core, much like a big cheese slicer. After the entire liner and end caps are cut, a good tap on the table next to the splitter usually separates the core cleanly into halves. Stickier sediments may cause the halves to cling together, but a small squirt of water (or even manually moving the parts with a spatula) will cause them to fall apart.

For more lithified sediments and rock cores, the blade and wire splitter is replaced by a water-cooled diamond saw assembly that splits the core and liner. For some hard rock cores, only the core liner is split first to allow access to the core. The pieces of core are cleaned of debris caused by the drilling. After the pieces are cleaned, they are compared to one another to find out if they are continuous but broken pieces, or if there are gaps. If there are gaps, plastic markers are glued in the casing to mark the gaps. Often

tool marks on the outside of the core can be matched up to help determine how the pieces were assembled. If pieces are present that might crumble or move during the cutting, a quick application of some plastic shrink wrap will hold them in place for the cutting.

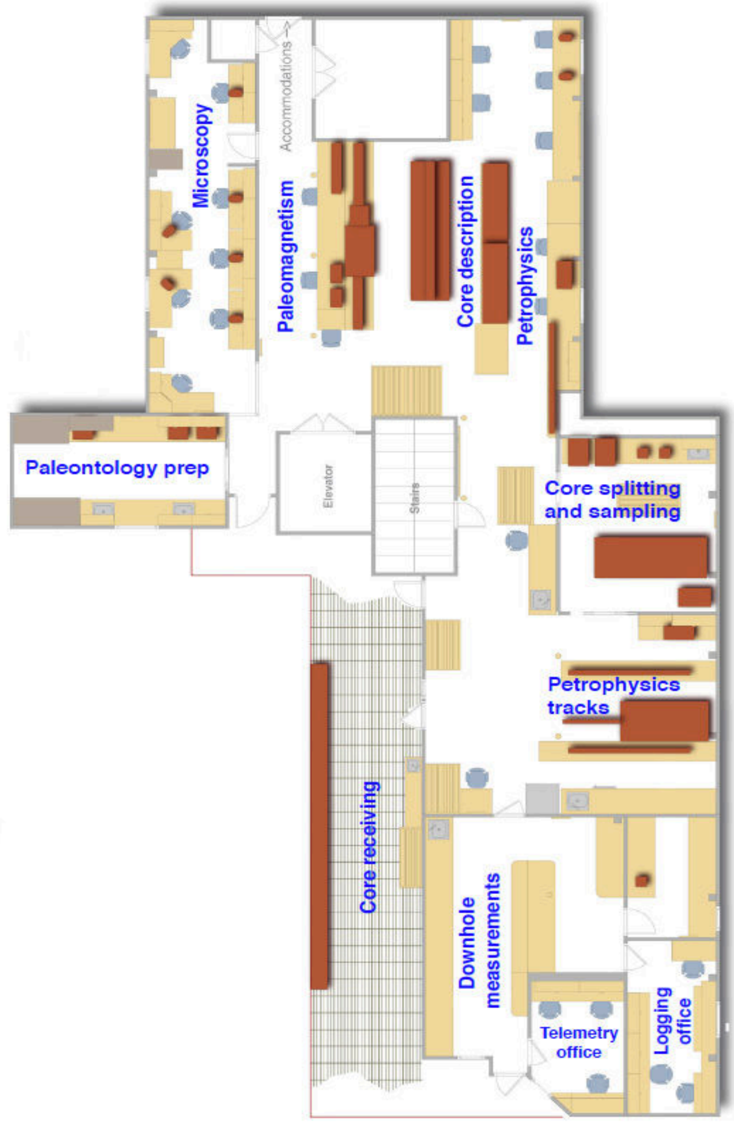
Next the reassembled core is placed in the same groove as the mud cores and split using the diamond cutting wheel assembly. The blade is slowly moved down the length of the core, slicing through the hard rock. Then the halves are carefully separated and cleaned to remove any dust created during the cutting. The core halves are then left to dry, and the various pieces are labeled with tags glued onto their surface.

Core Description

In the past, core description meant huddling over the archive half of the core, drawing in features and making notes on a "barrel sheet." While scientists still stand over the cores, discussing the features they see, they now have the ability to examine digital images of the cores as well as physical property track data.

After cutting, the surface of a sediment core is cleared of any material that may have been moved during the cutting process. The imaging station takes detailed high-resolution images of the cores. There is also a station that measures color spectral reflectance and point-source magnetic susceptibility of the core. These measurements can help with the correlation between holes and validate the susceptibility data collected by other methods. The revealed surfaces are visually described by sedimentologists. The high-resolution images can be displayed at the visual core description stations, which allow scientists to display the core images and physical property data over three monitors. They can zoom in on specific areas of interest and record descriptive and interpretive information into a database within a new, integrative framework and application.

Core Deck: Labs on the JR



Paleomagnetism Lab

The goal of paleomagnetism studies is to read magnetic field directions that are recorded in rocks and sediments. Periodically, the Earth's magnetic field undergoes major reversals from north to south. Because the orientation of the magnetic field is "locked into" all rocks as they've created, scientists can reach the changes like a bar code. They can see the pattern of the reversals in the core, match it to a template, and use that to help them determine the age of the sediment.

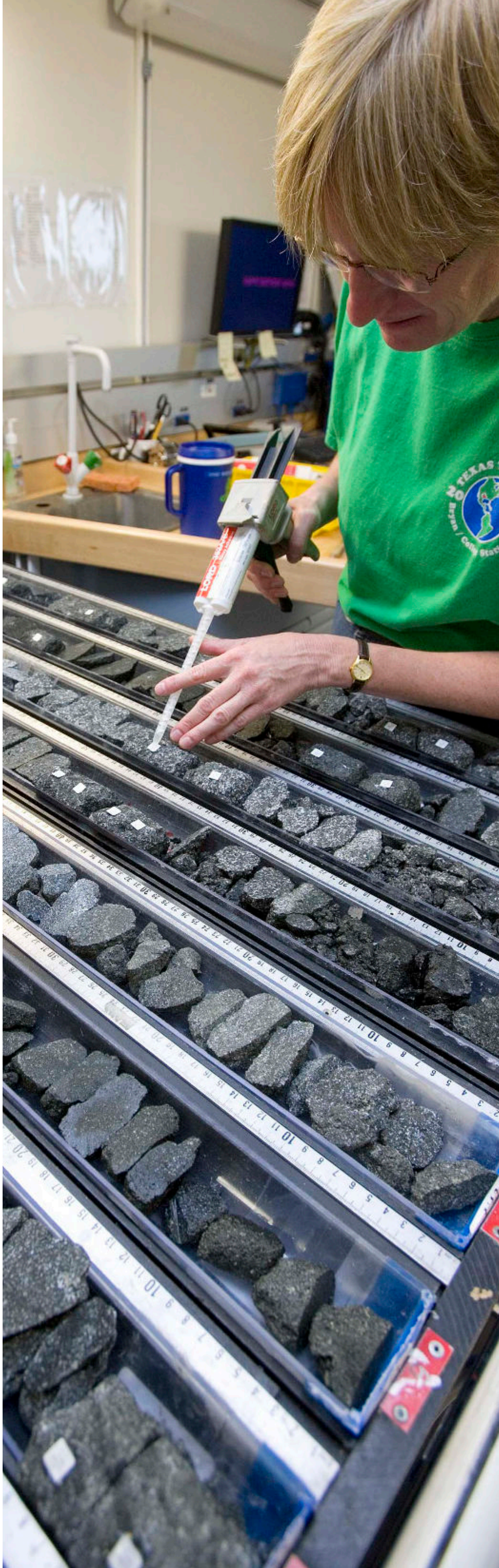
The workhorse of the paleomagnetics lab is a 2G Enterprises cryogenic magnetometer. As the archive half of the core is passed through the cryogenic magnetometer a high-resolution record is collected of its magnetic remanence (the permanent magnetic field properties of the sample). The magnetic shielding around the cryogenic magnetometer virtually eliminates the effects of the Earth's current magnetic field; this allows the instrument to measure the weak magnetic field that is preserved within the sediment. The cryogenic magnetometer may also be used to measure discrete samples, although these samples are taken from the working half of the core.

The paleomagnetism laboratory contains additional equipment, such as a Schonstedt alternating field demagnetizer for small samples of rock or sediment, and a Schonstedt thermal demagnetizer that is used on dry rock samples over a temperature range of 0 degrees Celsius to 800 degrees Celsius. Testing is performed on discrete samples from the working half of the core. These results can then be compared to the archive-half results to determine whether secondary magnetization components were adequately removed.

Microscopy Lab

Shipboard scientists use the microscopy laboratory for characterization of rocks and sediments, to investigate the nature of the subseafloor biosphere, and to study microfossils in order to determine the age of a sediment sequence. The microfossils can also be used to study the paleoenvironment through species assemblages, because different species prefer different temperatures and salinities. The primary task of shipboard petrographers (scientist who study rocks and minerals) is to observe and record the mineral content and textural relationships of components of the rock or sediment. These data are used to interpret the history of formation and evolution of Earth materials. Shipboard microbiologists use the microscope laboratory to examine the Earth materials recovered for cellular material and to make estimates of the level of possible contamination induced by the coring process. The main task for paleontologists is to date the sediment based on microfossils assemblages, because these data can be used by scientists to understand the rates and process of deposition, correlate sediment sequences from site to site, and put the sediment in the context of global climate and ocean events whose ages are already known. The dating is called "biostratigraphy" and is based on a comprehensive knowledge base of when new species appeared and old species died out.

Sediments are commonly examined under the microscope by preparing a "smear slide". A small amount of core material is scraped from the core with a toothpick and smeared on a glass specimen slide. Sedimentologists can then use optical properties to distinguish the various components of the sediment. In more competent sediments and igneous and metamorphic rocks, a thin section is prepared. A piece of the rock is sliced so thin (30 microns-standard copier paper is about 100 microns thick) that light



Age of the Core: How the Labs on the JR Work Together to Solve This Puzzle

Paleomagnetism Lab

Science Group: Paleomag

The Paleomag scienctists read magnetic field directions recorded in rocks & sediments. They observe the pattern of the reversals in the core, match it to a tempate & use that to help them determine the age of the sediment.

Miscrospy Lab

Science Group: Petrologists

Igneous and/or Metamorphic Petrologists observe the characterization of rocks and sediments, to investigate the nature of the subseafloor in order to determine the age of the sediment sequence.

Downhole Measurements Lab

Science Group: Loggers

Loggers analyze the downhole measurements which provide a continuous record of phyical and chemical properties of the sediments, rocks, and pore waters in the subsurface.

Petrophysics Lab

Science Group: Physical Properties

Phys. Props. scientists observe the indicators of the composition, formation, tectonic regime & environmetal conditions of the core samples.

Chemistry Lab

Science Group: Chemists

Chemists on the JR use the instruments to determine the amount, quality, source, and maturity of the organic matter preserved in sediments and test for nearly every element on the periodic table.

Microbiology Lab

Science Group: Microbiologists

Microbiologists investigate the deep biosphere where microbial life has been discovered. They measure the growth rate of bacteria recovered from deep beneath the seafloor.

can pass through the slice. The rock specimen is glued to a glass slide and polished until it reflects like a mirror. Under the microscope, petrographers can determine which minerals are currently present and can interpret what minerals were likely present when the rock formed. Scientists examine the crystallinity (proportions of glass and crystals), granularity (absolute and relative sizes of the components), shapes, and arrangement of the various materials that make up the rock. These studies can be used to interpret the physical conditions of formation and/or alteration the rock has experienced.

Microbiologists perform assays of organisms in sediments and rocks. Visualization and quantification of the total biological cell count is done using nucleic acid stains that bind to biological material. Estimates of the amount potential contamination from drilling disturbance are made by injecting fluorescent, micron-sized beads into the drilling fluid. The microbeads can be detected under the microscope and if present in a sample can indicate drilling fluid infiltrated the core.

Several major groups of microfossils are studied. Foraminifera (or forams) are single-celled animals that make carbonate shells. They can live near the sea surface (planktic) or near the sea bed (benthic). They are often big enough to be seen with the naked eye. Radiolarians are also single-celled animals that live near the sea surface, but they make their shells from silica rather than carbonate. They are common where there is upwelling of nutrient-rich waters, such as the Equatorial Pacific or offshore Antarctica. Calcareous nannofossils are very small carbonate plates and skeletal fragments produced by phytoplankton that live near the sea surface. They are found in marine deposits, often in vast numbers, sometimes making up the major component of a particular rock, such as the chalk of England. Diatoms are photosynthesizing algae that have a silica skeleton.

Downhole Measurements Lab

Sediment and rock cores recovered during IODP expeditions provide key data to interpret the geology and biology of the subseafloor environment. However, core recovery is not always complete. In addition, core samples brought to the surface are not at their original conditions of temperature and pressure. Downhole measurements complement core sample analyses and are vital for obtaining continuous and/or in situ records of ephemeral subseafloor formation properties. They provide a continuous record of physical and chemical properties of the sediments, rocks, and pore waters in the subsurface. Scientists use these data to develop a better understanding of a variety of characteristics of subsurface formations, such as lithology, porosity, permeability, alteration, and heat and fluid flow.

The Triple Combo tool string contains tools that measure the formation density, porosity, natural radioactivity, electrical resistivity, and size of the borehole. The logs that are generated from these tools are used to interpret the lithology and physical properties of the formations. The FMS/Sonic tool string consists of a Formation MicroScanner (FMS) and a sonic velocity tool. The FMS contains an array of sensors that make detailed resistivity measurements of the borehole wall. These measurements are combined to create a two-dimensional image of the borehole. The sound velocity data can be used in combination with density data from the Triple Combo to generate synthetic seismograms, which are used to relate formations in the borehole to seismic reflection data. IODP also has an array of specialty wireline tools used to obtain acoustic images of the hole, measure the magnetic properties of the formations, and create near-hole seismic profiles.

There is also a range of tools that make discrete measurements or collect samples at the bottom of a hole. Several probes are used to measure the formation temperature up to 1.1 meters below the bottom of the hole being drilled. The temperature probes penetrate the formation and are held in place for 10 to 15 minutes to record enough data to reliably extrapolate in situ sediment temperature.

In addition, there are several tools that can be used to measure the orientation of cores before they are removed from the formation. These tools record hole inclination, azimuth, and the orientation of the core relative to the hole. This information is used by paleomagnetists who study the magnetic signature recorded in sediments in order to carry out plate tectonics investigations.

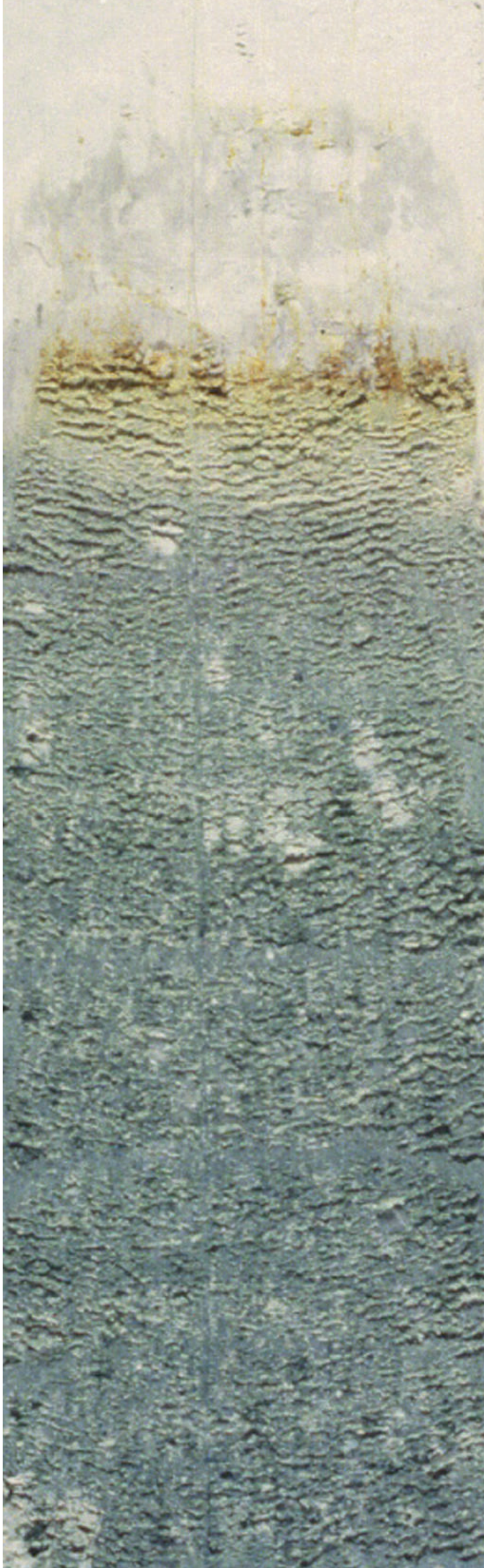
The downhole measurements laboratory also has tools that can be used by scientists to collect samples for later analysis. For example, a pressure core sampler (PCS) is used to collect core samples at downhole hydrostatic pressure. The PCS is of particular interest to scientists who study frozen gas hydrates, gases, or other pressure-sensitive materials that tend to decompose or escape during conventional core retrieval.

The facilities in this lab are sometimes used to coordinate the installation of long-term borehole observatories, which allow researchers to isolate boreholes from the ocean water above the seabed so that fluids cannot flow into or out of the drilled borehole. These observatories commonly contain sensors that hang in the borehole to monitor temperature, pressure, and chemical conditions as well as seismic responses in the hole for long periods of time.

Petrophysics Lab: Split-Section Measurements

The petrophysics lab is used to measure the physical properties of rocks and sediment. These properties are indicators of the composition, formation, tectonic regime and environmental conditions of the deposits. Because physical properties are usually well defined and quantitative, they help constrain the complex mineralogical and fluid systems in rocks and sediments. Data obtained in this lab are often correlated with similar measurements made in the downhole measurements lab. Physical properties and log data can also be correlated to seismic reflection records through the construction of synthetic seismograms. In addition, they can be used to study thermal and fluid flow models for oceanic sediment and basement formations.

After splitting, the working half of the core goes through the rest of the lab. The contact-based P-wave velocity instrument contains three sets of piezo-electric transducers that perform compressional velocity measurements in all three cartesian coordinates. Shear strength is measured with the automated vane shear (AVS). The AVS inserts a vane into the core and applies a rapid vane shear speed of 89° of torque per minute. At failure, when the core sample cracks, the angle of torque is converted to sediment strength. The moisture and density (MAD) station uses mass and volume measurements to provide an estimate of porosity and average density of the minerals in the sample. These data are used in combination with data collected from the gamma ray attenuation instrument and provide a direct link between density values and specific lithology within the cores. The porosity measurements provide insight into consolidation, composition, alteration and deformation of the seafloor sediments.



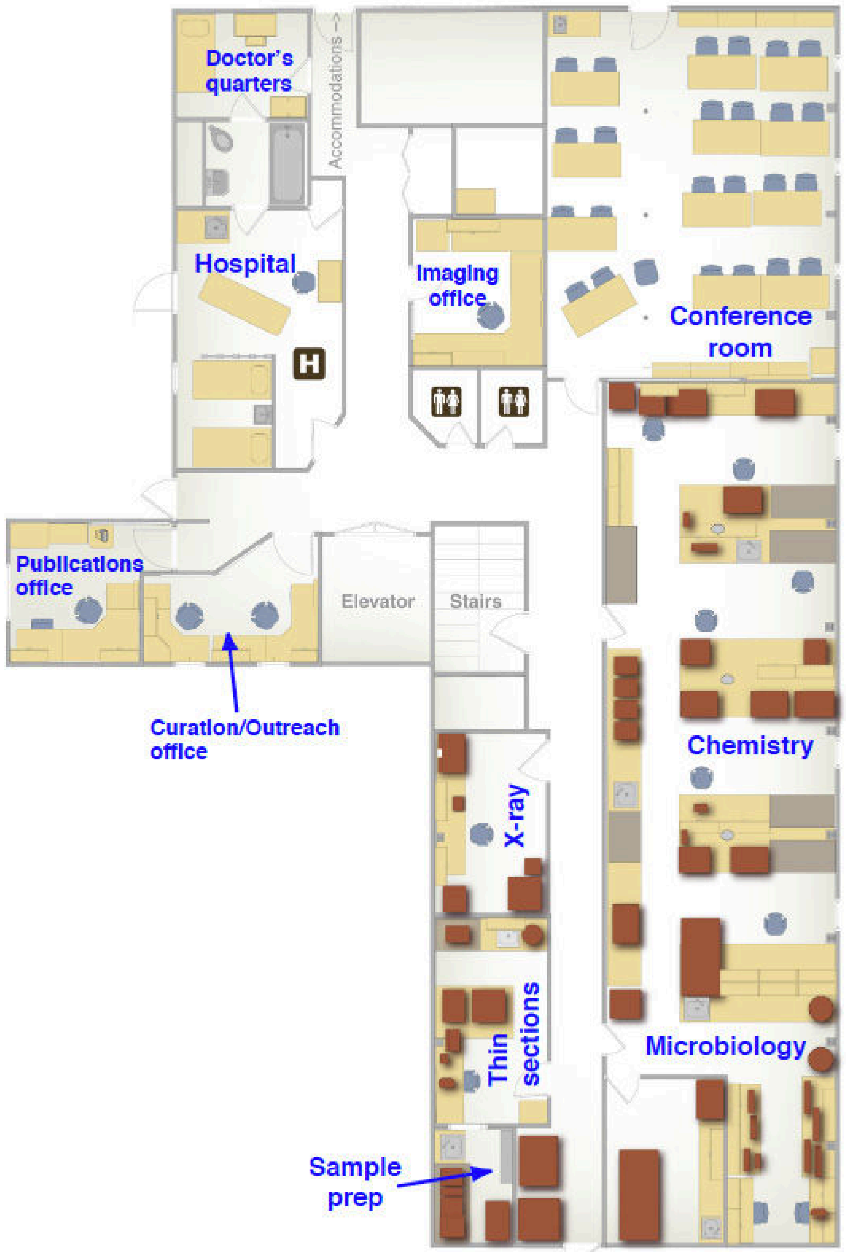
Fo'c's'le Deck

Chemistry Lab

The chemistry lab aboard the *JOIDES Resolution* provides an impressive capability for both organic and inorganic geochemical analyses. A vital responsibility of shipboard chemists is to provide data on hydrocarbons for safety and environmental concerns. Data on hydrocarbons are generally obtained from gases extracted from cores on the catwalk. The chemistry lab also has a variety of instruments that geochemists use to determine the amount, quality, source, and maturity of the organic matter preserved in sediments and to test for nearly every element on the periodic table. Geochemists employ these methods to determine the chemical composition of rocks and sediments, as well as to study the fluids that are contained within each.

Organic geochemists perform routine monitoring for hydrocarbons in sediment cores by heating one sample, approximately 5 cm^3 in volume, per core. Gases released during heating are analyzed for hydrocarbons such as methane, ethane, ethylene, propane, and propylene, using a gas chromatograph. A gas chromatograph can also be used to analyze non-hydrocarbon components, such as hydrogen sulfide, oxygen, nitrogen, carbon dioxide, carbon monoxide, and carbon disulfide.

Inorganic geochemists analyze pore water samples. Pore water samples require very



rapid handling because some constituents can be subject to chemical reactions. A change of the original pore water chemistry may be initiated when the samples are moved from a cold, pressurized environment at the bottom of the ocean to the much warmer and less pressurized atmosphere of a research vessel. To sample the pore water, whole round core sections are collected immediately after the core has arrived on deck. These go to the chemistry laboratory, where the pore water contained within is extracted using titanium squeezers and a hydraulic press that apply pressures up to 40,000 lb (about 4150 psi) to the sediment. For some investigations, it is essential to analyze pore water samples without delay. Other, more complicated investigations (e.g., isotopic studies) can be carried out on pore water samples only during post-cruise research in specialized shore-based laboratories.

Inorganic geochemists also analyze pore waters for the presence of a variety of chemicals. They test for salinity using a digital optical refractometer. Titration is used to measure the alkalinity and chloride, calcium, and magnesium concentrations of pore water. Ion chromatography is used to detect cations and anions of sulfate, calcium, magnesium, potassium, sodium, and more.

Analyses of a variety of nutrients and other pore water constituents (e.g., ammonium, silica, phosphate, bromide, and manganese) are conducted using colorimetric methods on the laboratory's spectrophotometer. The Inductively Coupled Plasma–Atomic Emission Spectrometer (ICP-AES) is used to detect and quantify a variety of major and trace elements, in pore water as well as in sediment and hard rock samples.

Microbiology Lab

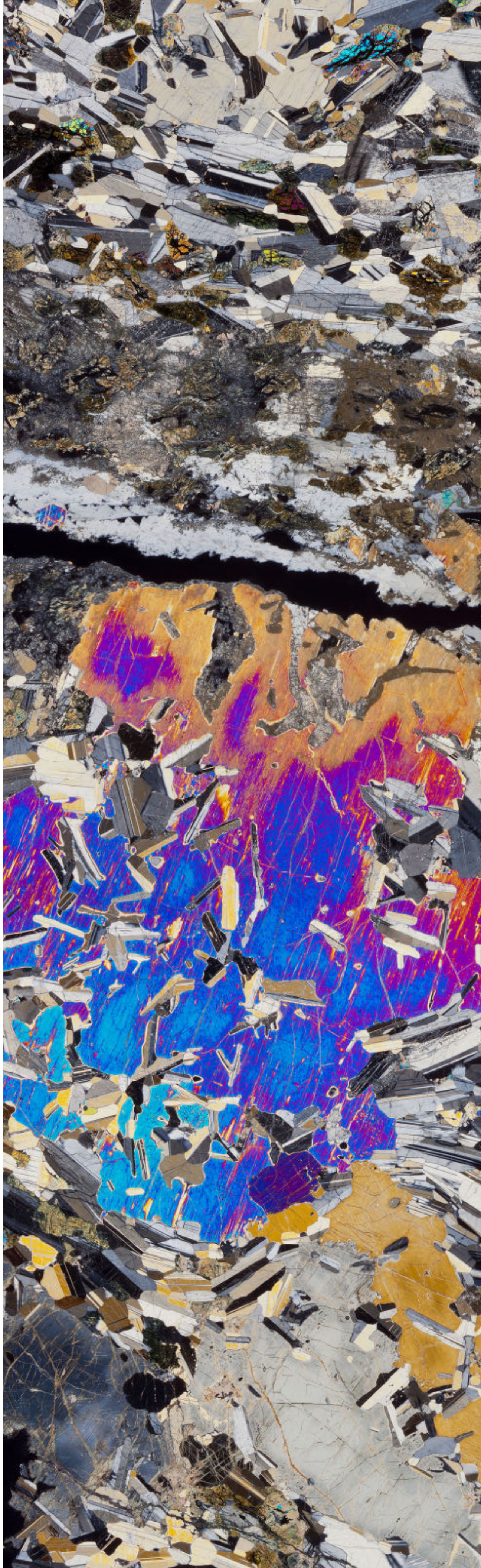
Microbial life has been discovered in cores recovered from as deep as 1 km below the seafloor. The microbiology laboratory enables scientists to investigate this deep biosphere. The laboratory contains an anaerobic chamber with rock-splitting and other sampling equipment for taking uncontaminated samples from the cores; a laminar flow hood for preparing uncontaminated samples for study; and facilities for incubating samples. The lab is also equipped with a cold room for processing samples for postcruise studies at 4°C. Pressure vessels and -86°C freezers allow 25 storage of samples under controlled conditions for future shore-based study. There is also an epifluorescence microscope available for performing cell counts. The ship also has facilities for conducting tracer experiments to quantify the extent of downhole contamination of the core by drilling fluid pumped down from the seafloor. Scientists can also measure the growth rates of bacteria recovered from deep beneath the seafloor.

X-Ray and Thin Section Labs

The X-ray lab is used to carry out powder diffraction analyses of minerals and rock powders. The thin section lab provides equipment for making thin sections of lithified and nonlithified materials.

Helpful Videos

Rock Visualization on the JR
Sedimentology on the JR
Structural Geology on the JR
Geochemistry on the JR
DownHole Logging on the JR



Main Deck and Forward 'Tween Deck Recreation

Main Deck

The galley, food storage areas, laundry room, and crew changing room are all located on the Main Deck. To get your laundry done, you just put the dirty clothes in a mesh bag and leave it outside the door. At the end of your shift or when you wake up, you'll find your clothes cleaned and folded. People tend to wear the same small sets of clothing day after day because ship life and ship laundry, geared toward getting industrially dirty clothes clean, is rough on clothing. Cabins are cleaned (including making the beds!) each day by the ship staff. A total of 15 people – seven galley crew, including the camp boss, and eight stewards – are responsible for feeding everyone, keeping the ship clean, and doing laundry. Meals are served in the galley from 11-1 and 5-7, both A.M. and P.M. At 9 and 3 A.M. and P.M. there is a cookie break. The 5 A.M. to 7 A.M. meal is a typical breakfast meal with eggs, bacon, pancakes, sausage, french toast, and oatmeal available in the serving window. The kitchen crew tries to have one entree that is more lunch/dinner–like at that meal, for those who are not just getting up. The other meals are all dinner-type meals, with a choice of several different entrees, one or two soups, a couple of cooked vegetables, rice, and some kind of potatoes. There is a salad bar, where the galley crew and stewards work hard to provide an interesting array of salad ingredients—even as the lettuce fades away and they can no longer rely on fresh produce. There is always bread of various types available, along with cereal, crackers, and cheese. On most Sundays (weather permitting) there are outdoor barbecues. There is a soft serve ice cream machine in the galley, so ice cream cones are a constant potential luxury. Special birthday cakes are prepared for anyone who celebrates a birthday while at sea. Diners can see the ocean from the galley and the moon pool is visible through one set of portholes.

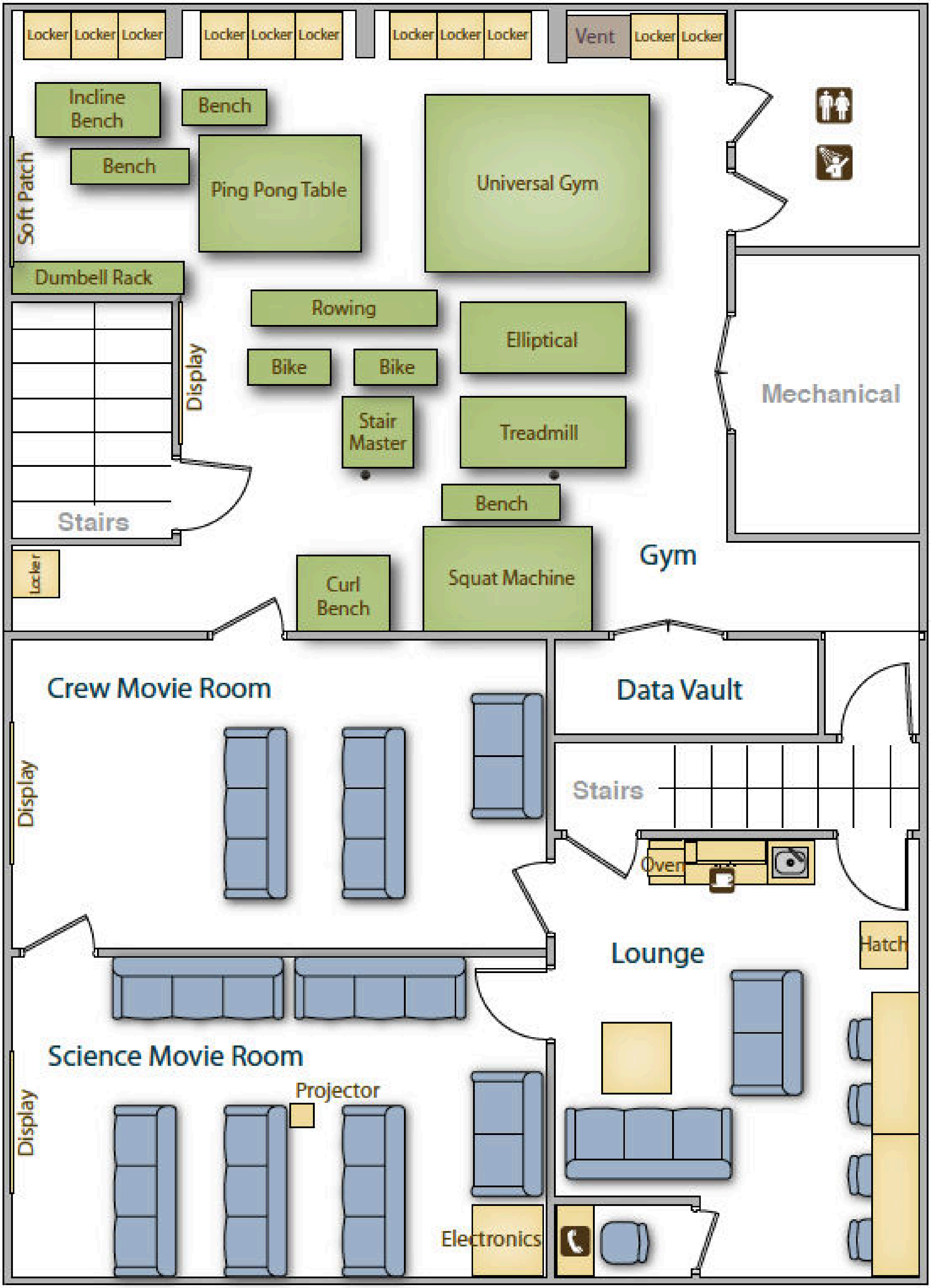
Accommodations

Sleeping quarters are distributed over several decks, with the scientific and technical staff usually occupying the Core through Main decks. The ship has 130 berths, 60 of which are reserved for the science party and technical support staff. (Always check with the person coordinating the tours to see if a cabin has been designated as a stop on the tour. Do not open any cabin that has not been identified as a tour stop, and remind visitors to please be quiet when entering this area.)

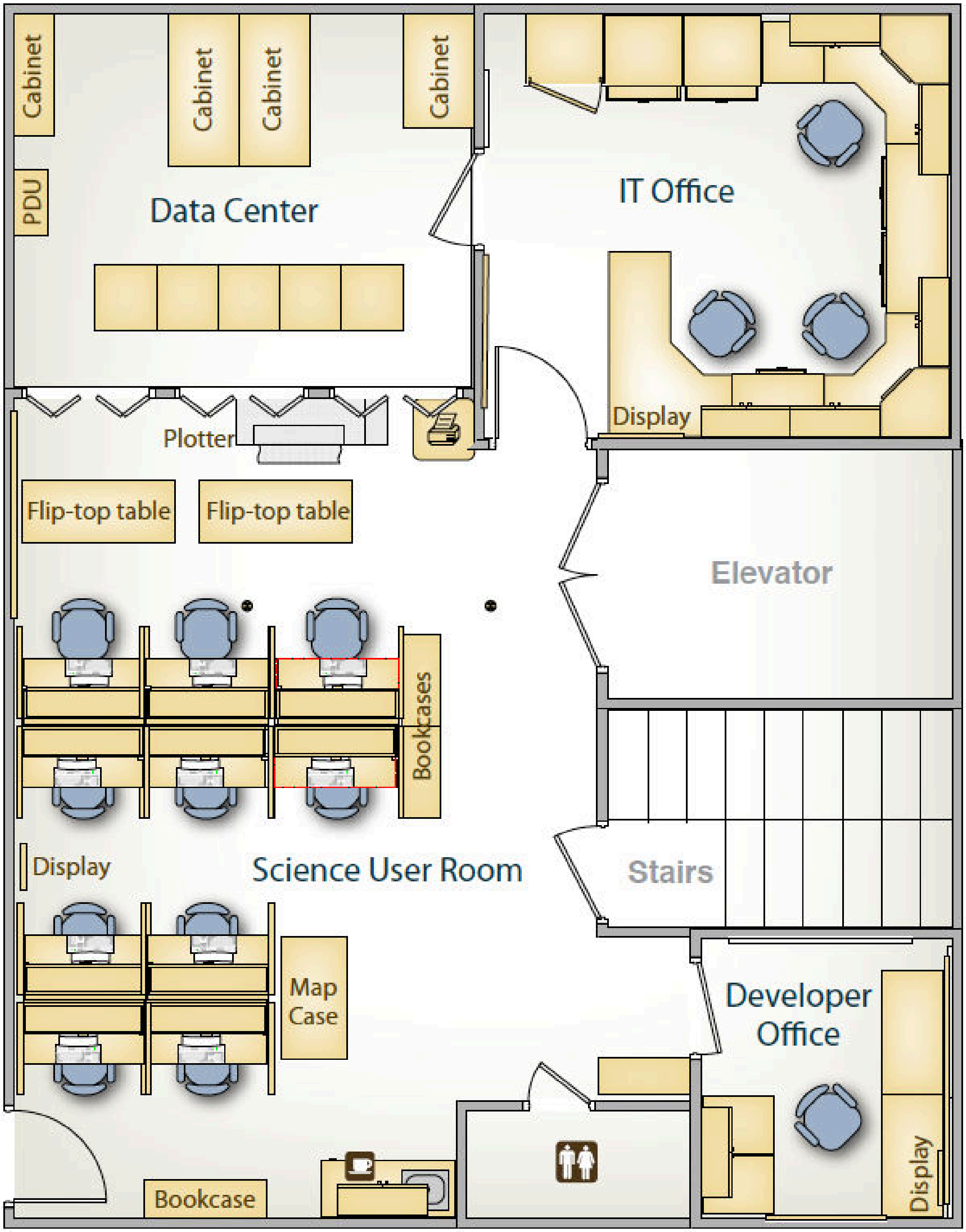
All staterooms are single or double occupancy. Each room has a locker, desk, emergency supplies (flashlight, breathing supplies in case of fire, etc.), a sink, and a medicine cabinet. Cabins with more than one bed have curtains around each bunk for added privacy and to keep out light. Staff members are usually assigned to room with someone who is on the opposite shift, so that each can have some solitude when off shift. Still, that is not always possible and occasionally two people on the same shift will have to share a room. Staff are asked not to go back to their cabins during their work shift as their roommates are likely trying to sleep. Most take a backpack or other bag with them so they will have everything they need once they leave the cabin for their work shift. In addition, everyone is expected to be quiet in the hallways of the accommodation area, as anyone can be trying to sleep at any hour.

The Forward 'Tween Deck houses the ship's recreation areas. It features a lounge for social gatherings, computers for internet use, a snack bar, a public telephone, a movie room with entertainment systems, and an air-conditioned gym. Movies are shown after every shift, with people taking turns making selections. There is a large library of available movies to choose from. To indicate a movie choice you write the name and time on the white board before the end of the shift. The gym contains benches, bikes, dumbbells, elliptical machine, rowing machine, stair-master, squat machine, treadmill, lockers, and a shower. There is also a large flat screen TV in the gym and stereo system so you can have music or video playing while you work out.

Forward 'Tween Deck Floor Plan



Lower 'Tween Deck - IT



The Lower 'Tween Deck houses the science user room, the information technology (IT) office, the application developer's office, and data storage. The science user room has Macintosh and PC computers available for use by the scientific and technical staff when they are not working in their labs. Programmers who are working to maintain and upgrade software packages during a cruise work out of the application developer's office.

The IT office is where the two Marine Computer Specialists ply their trade. They keep all of the various computer, data, and network systems working from day to day. In addition to the IT office, there is also the server room that houses the server computers, network hardware, and data storage systems used during a cruise. The networking hardware connects all computers on the ship, allowing them to share files and data. It also connects the ship to the Internet so that e-mail can be exchanged with shore and users can surf the web. Additionally, the network systems distribute video from cameras around the ship so that the science staff can keep track of what is happening on the rig floor. Since a single cruise can generate several terabytes of data, the server room houses 7 TB of storage space to hold it all.

Some data, such as log data, are transmitted to the shore electronically during the cruise. This allows shore-based specialists to provide advanced processing and quality control services. The processed data is then electronically returned to the ship for inclusion in the shipboard database. The rest of the data are transferred to the shore at the end of the cruise on hard drives and DVDs, making room for the data from the next cruise. All data and samples collected by the ship are under moratorium for one year. That means only scientists who sailed on the cruise have access for that period. After a year the information is released to the scientific community at large.

Computer & Internet Access

There are several ways to access the Internet and shipboard network. Once online, you will have access to most of the websites and services you can access from shore, with the exception of high-bandwidth sites that involve streaming video, like Skype and YouTube. These sites can be accessed for educational purposes with the assistance of the MCS.

Computer lab: there are several computers downstairs in the computer lab, including both Macs and PCs. These are all hooked up to both the Internet and to the shipboard network. They are widely used by the scientists onboard, so space may be limited and you may not always be able to nab one.

Lab computers: each lab has at least one computer hooked up to the Internet, and may have more that are connected to the shipboard network.

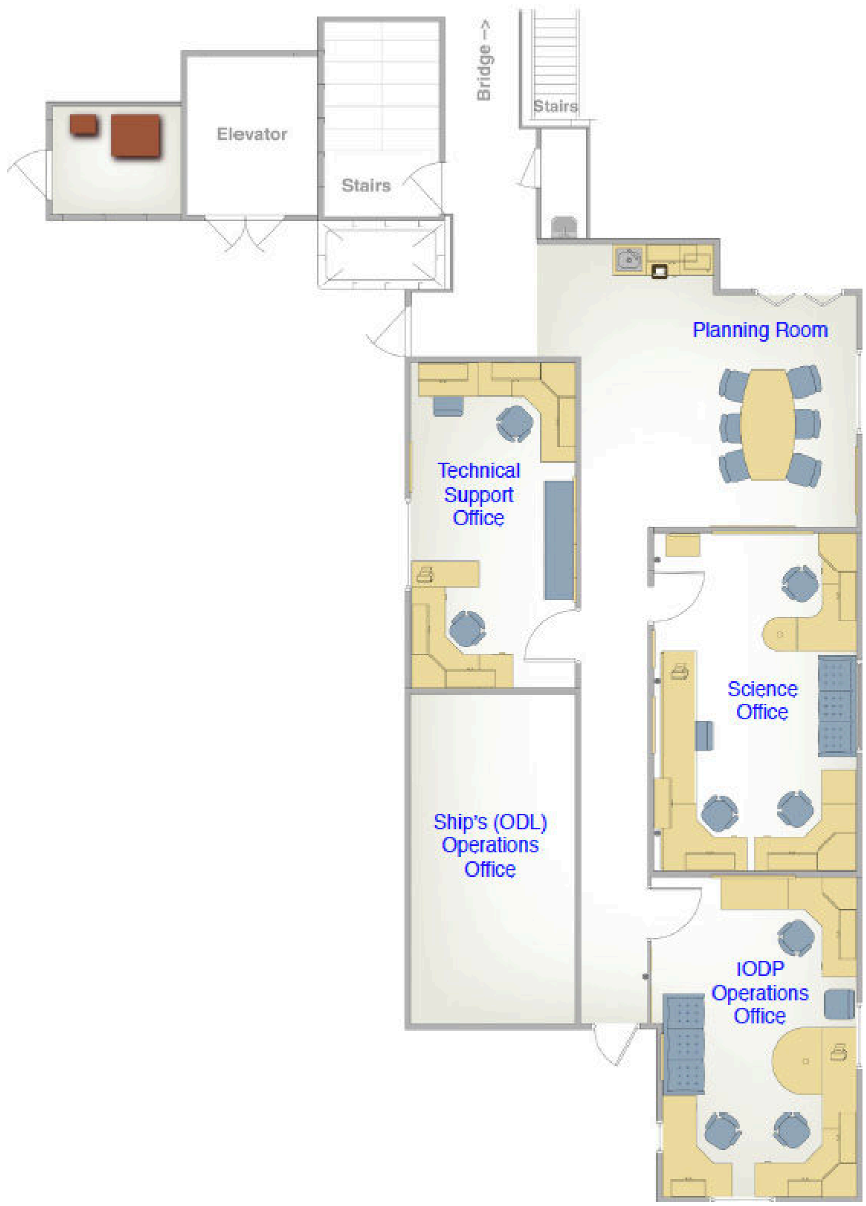
Personal laptops: Talk with the MCS about connecting your personal laptop to the shipboard network, so you can share and access files from your expedition. You will have to follow IODP guidelines regarding virus protection, and will have to install certain network software, but the process is easily completed during the first week of the expedition. As the Education Officer, you may be able to get Internet access on your personal laptop as well; talk to the MCS.

Education iPads: The education department has two iPads that are generally used for video broadcasts, and as a result, are set up with Internet and Zoom access. There is one wireless network onboard that can be used for Zoom and YouTube access; talk to the MCS about which computer/iPad you would like to use on this network. That will be the only one from which you can upload videos to the JR YouTube page. **Do not share these iPads with others for personal internet use!**

Bridge Deck

The ship's bridge, or navigating bridge to be more precise, holds a fantastic array of equipment, publications, reference books, and operating manuals. Not only is it used for navigation, but it is also the command center during any emergency situation.

The bridge on the JR has the very latest in technology, with GPS and automatic identification systems integrated into the electronic charts and radars. These modern navigational aids make it much easier and safer for the mariner to navigate. They allow the captain and crew to see the details of every other ship within about 24 miles. For emergency situations, the bridge has controls for the fire



pumps, ventilation and propulsion systems, fuel pumps, fixed fire fighting systems, and various internal and external communications systems. However, the tried and true methods which require no power to operate and which are free from outside interference—magnetic compass, sextant, paper charts, tide charts for coastal waters, and ocean environment charts—are also still available.

The ship's dynamic positioning system is integrated into the bridge. Dynamic positioning allows the ship to stay on location during drilling operations. It is important that the ship not move while the pipe is in the hole. To keep it on site, the ship has 12 thrusters positioned around the ship. The desired position is entered into the DP computers, and data from two GPS and one hydroacoustic beacon on the seafloor are fed into the DP computers to give a real time position. If the ship moves from the desired position, a force is applied by the thrusters and propellers to move the ship back to the desired location. A gyro-compass input ensures the ship's heading is maintained in the same way.

Safety

On the catwalk you are required to wear closed toed shoes and safety glasses. In order to enter the drill floor and other areas you need steel toed boots, safety glasses and a hard hat. While the ship is on site, anyone not directly connected with drilling operations is not allowed on the rig floor.

Boat Drills

The scientific work of the JR takes her to areas where immediate assistance is unavailable. Thus, it is necessary to rely on the knowledge and experience of the ship's crew to avoid potentially dangerous situations. Weekly boat drills are held to ensure that all shipboard personnel are prepared for possible emergencies. The ship has four new lifeboats, each of which is totally enclosed and is equipped with GPS.

Everyone on board is assigned a specific lifeboat. During boat drills, everyone reports to their assigned lifeboat with their life jacket and hard hat. On cold-weather expeditions, survival suits must be brought to the boat drill. The person in charge of each lifeboat will review emergency procedures. During some drills shipboard personnel will board the lifeboats. During other drills an empty boat might be lowered into the water.

Each lifeboat is motorized and can hold up to 70 people. They contain emergency rations and are equipped with beacons and signaling equipment to attract rescue authorities. UHF radios are also provided to communicate with rescuers and with the other lifeboats.

In addition, members of the ship's crew and technicians have been trained to handle emergencies such as fires. They periodically have special drills to practice those skills.

Project Rationale

Much like missions to outer space, the NSF-sponsored ship *JOIDES Resolution's* (JR's) deep ocean expeditions have the potential to ignite the imaginations of a whole generation of Americans—to engage thousands of people in the excitement of exploration, the process of science, and the people and tools required to get there. The JR is on a mission of scientific discovery into the unknown. What lies beneath all that water? What secrets about our planet's development and ancient history can be revealed by sediments and rocks below? How can these explorations shed light on topics of great societal relevance, like climate change, the huge biosphere beneath the seafloor, and geo-hazards like earthquakes and tsunamis? As with space exploration, this program requires extensive scientific collaboration and teams of engineers trying to reach highly inaccessible places in search of discoveries.

Unlike many of NASA's missions, the JR's adventures and achievements have largely flown under the radar. The JR is one of the largest research vessels in the world and is the flagship vessel for the International Ocean Discovery Program (IODP; www.iodp.org), an international research program dedicated to advancing scientific understanding of the Earth through drilling, coring, and monitoring the sub-seafloor. Unbeknown to most of the population, this country has invested more than $668 million in scientific ocean drilling over the past ten years alone and generated key evidence for major scientific theories, such as plate tectonics, extinction of the dinosaurs, and existence of life below the seafloor. Just this past year, the JR was instrumental in identifying the largest single volcano on Earth.
This project proposes to use the JR and her science to intrigue, engage, and inspire informal science audiences across the nation. The hypothesis of this project is that well-designed and facilitated Pop-Up exhibits and Drill Down opportunities at museums and libraries in carefully selected locations will provide an effective mechanism for increasing STEM learning access among under-served minorities, rural populations and girls – and create a broadly applicable model for doing so in other science fields.

The ultimate educational experience would be to bring large numbers of people to this ship. Its technological marvels have provided powerful inspiration for a lucky few. However, this is impractical. Instead, we will bring the ship to the people. In formal education, the educational arm of IODP has implemented teacher workshops – called the School of Rock (SOR) – to immerse K-16 and informal educators in science on the ship and at the Gulf Coast Repository (home to more than 100 km of cores, in College Station, TX), utilizing key sets of 50 years of authentic data and samples. Among the many outcomes of this program has been development of effective classroom activities and resources.

In 2011, NSF awarded an Informal Science Education Pathways grant, Ship to Shore Science (STSS; NSF Award #1114678) to the Consortium for Ocean Leadership (which manages IODP education programs) to develop and pilot innovative ways to bring the science of the JR to informal science audiences outside the classroom. We implemented four pilot projects, enabling the development of new tools and networks. Pop-Up/Drill Down Science will integrate and ramp up these small-scale projects, making deep earth/ocean science available to informal audiences at a whole new level. This project will be successful because it relies on a 10-year legacy of NSF-sponsored education materials and strategies, solid learning research, a fruitful and energizing 2-year Pathways grant, an innovative plan for new development and roll-out of programs and resources, and a fully integrated, experienced, energetic team.

Governing Thought / Mission

By offering the excitement and novelty of dynamic live kick-off events, our Pop-Up Blitz (PUB), along with the continuity of a longer term exhibit during the Drill Down program, the Pop-up/Drill Down Science Project aims to increase awareness and excitement about deep ocean drilling as a source of scientific understanding about our planet's ancient history, development and future.

Goals

The goal of Pop-Up/Drill Down Science is to learn more about how to increase access to and awareness of ocean/earth science and careers by exploring these key research questions:

- How do the Pop-Up Blitzes (PUBs) and Drill Down weeks create a sustainable model for STEM learning in informal environments (ranging from non-traditional venues like parks, parking lots, block parties, local festivals and malls to libraries and museums)?
- How does Pop-Up/Drill Down meet the needs of partner informal science education institutions and Girl Scouts to fulfill their own missions?
- What is the impact of short burst STEM programs for learning outcomes including a) increasing awareness and knowledge of ocean and earth science, technology, and the work of scientists/engineers and b) increasing interest in these activities among the general public (children, teens and adult participants) who attend the PUB and Drill Down events and activities?
- How does participation in the program's workshops and volunteer opportunities for Girl Scouts contribute -- particularly among girls from underrepresented minority and rural groups -- to awareness, interest, and understanding of STEM topics and related career fields?
- Does participation in the PUB and Drill Down events foster partnerships between educators and scientists and lead to broader dissemination of scientists' research and to the larger vision of NSF for broader impacts of its work?

Exhibition Big Ideas and Key Messages

Big Idea: From information recorded in the ocean floor, we can see and understand times on Earth both past and present, and even gain some insight into the future.

Key Messages:

- The ocean floor is geologically diverse, continuously changing, and largely unexplored.
- Information in ocean cores provide clues to the events of Earth's past and to Earth processes that impact people today.
- The *JOIDES Resolution* is an engineering marvel that uses cutting-edge technologies to drill and core the seafloor and discover its mysteries.

Main Exhibit Experience Areas

Main Experience Areas are:

- Family-oriented hands-on activities about earth science topics and technology illuminated or used by ocean drilling at 8 separate exhibit kiosks.
- A 1 to 5-minute immersive walk-through experience showcasing the history of earth as recorded in the sea floor.

Visitor Communication Goals

After experiencing the Pop-up/Drill Down Science Project visitors should:

KNOW

- That there is this big impressive ship that's going around the world drilling and bringing up sea floor sediments and studying them
- That scientists can learn a lot about earth's geology and history from ocean floor sediments
- There are always exciting new discoveries being made in this unexplored world (e.g., deep biosphere, giant volcanoes, clues about climate change, mass extinction events)

DO

- Take part in some bits of the processes by which scientists makes discoveries through ocean sediments
- Experience important parts of the scientific method: Observe/record, analyze, create theories/test theories, etc.
- Ask questions or try to learn more

FEEL

- Excited, intrigued, amazed, **curious to know more**, energized
- Pride/sense of accomplishment in learning a new skill or helping your kid learn a new skill.

1. The exciting discovery from studying the ocean floor
2. The role of science/JR in making this discovery and others like it
3. The importance of finds like this—why it matters and what we can gain from it in future.

Kiosk 1: The Geology Under the Sea

BIG IDEA The seafloor is geologically diverse, continuously changing, and largely unexplored.

Key Messages

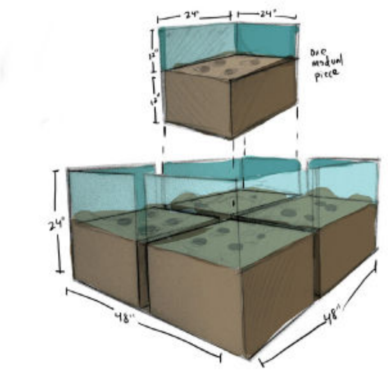
- The seafloor consists of plains, mountains, volcanoes, and trenches.
- The seafloor is not static. It is continuously in motion (though slow motion to our eyes) through seafloor spreading and subduction zones.
    - The movement of ocean plates can create earthquakes, volcanoes and tsunamis that impact us on land.
- The seafloor covers over 70% of the Earth and is mostly unexplored. There is an entire world within the oceanic crust. What would we want to know about the world beneath the seafloor?
    - There is much still to learn and discover in the seafloor.
    - The JR continues to allow us to explore the seafloor.

Visitor Attributes

Know: The seafloor covers most of the Earth, is active, and is largely unexplored.

Feel: Wonder at the size and scale of the seafloor; intrigued that so much is going on there; excitement that there is still a place on Earth that is largely unexplored.

Do: Interact with a model of the seafloor that shows the diverse geology and that can show how the seafloor spreads (Question to ask: Why isn't the Earth getting bigger?) and how volcanoes, earthquakes and tsunamis can result from this movement. We used a volcano activity as the main hook for this topic. Possibility to show how a fault breaks, or a tsunami forms?



Kiosk 2: The JR is a STEM Marvel!

BIG IDEA The *JOIDES Resolution* is an engineering marvel that uses a variety of technologies to drill and core the seafloor.

Key Messages

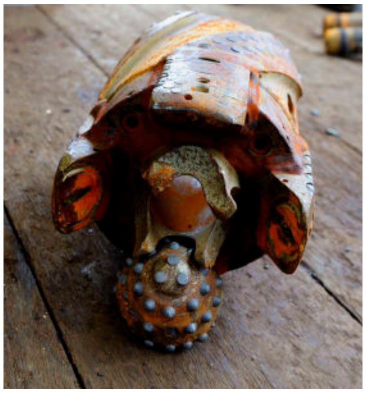
- The JR has the technology to drill down through waters as deep as 23,000 feet and then drill as deep as 6,500 feet deep into the seafloor.
- The JR has the ability to stay stable while drilling on the high seas, despite being constantly pushed around by waves and wind.
- The drill bits used have the ability to core a variety of seafloor substrates, from soft sediment to hard rock.
- The JR utilizes international and interdisciplinary crew and scientists, which is diverse in so many ways. You can be a part of it!

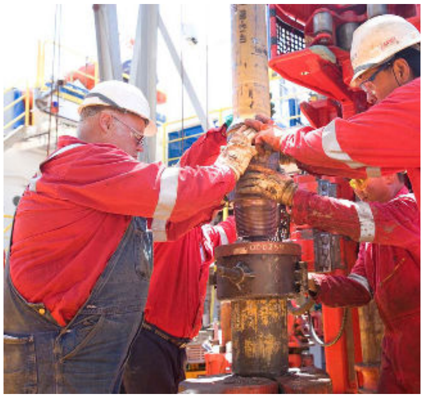
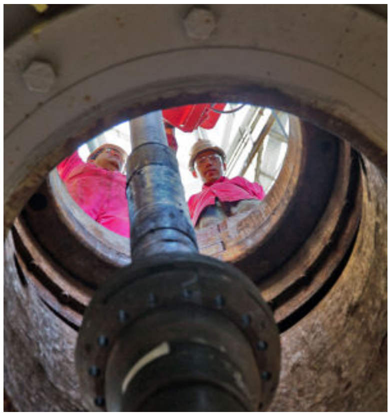
Visitor Attributes

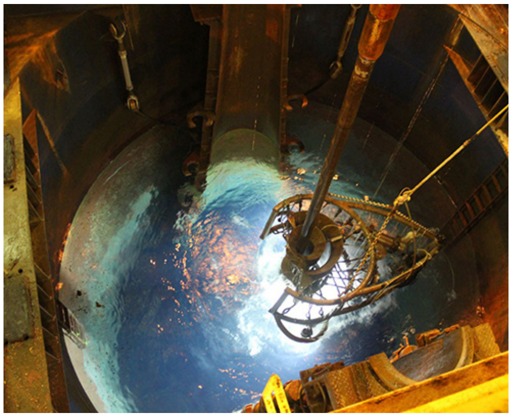
Know: The JR is an engineering marvel that uses a variety of technologies to drill and core the seafloor thousands of feet below the ship.

Feel: Wonder at the technology and engineering of deep sea drilling

Do: Interact with activities that allow visitors to try different drillbits on different substrates and/or simulates trying to hit a drill-site target while having the drillpipe/ship pushed around by wind and waves.




Kiosk 3: What is a Core?

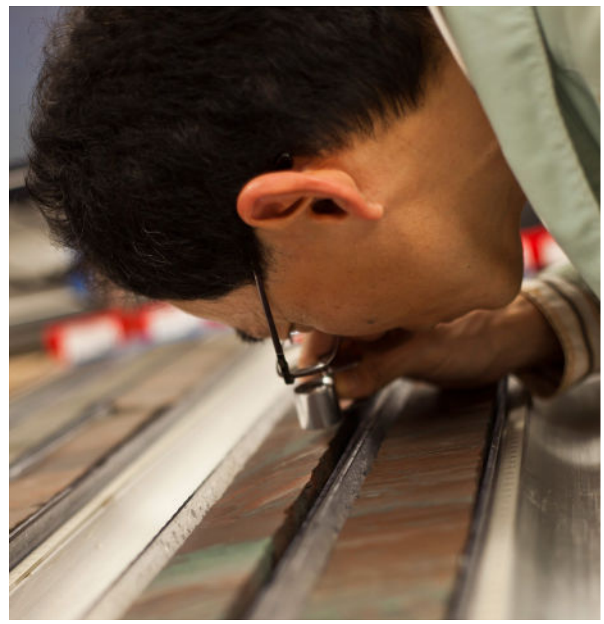
BIG IDEA Cores drilled by the JR provide clues to the events of Earth's past and to Earth processes that impact people today.

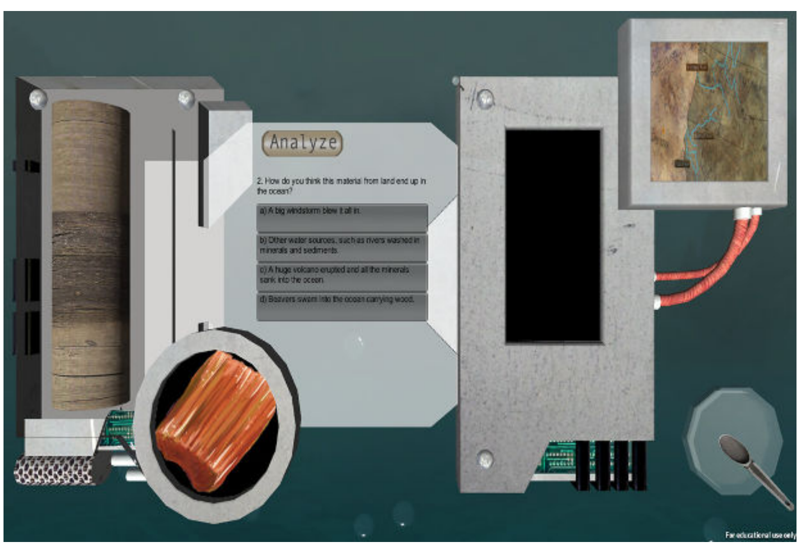
Key Messages

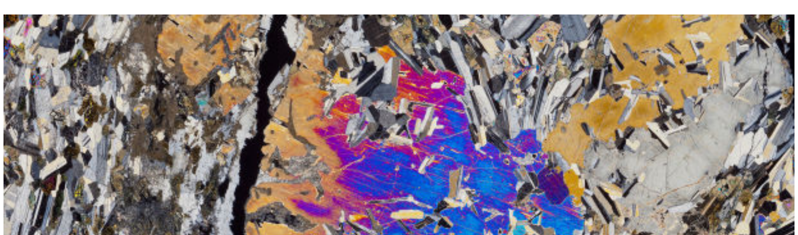
- The layers and content of the cores are clues that help scientists figure out the history of the Earth.
- Cores are like pages out of Earth's history book. We just have to learn how to read them.

Visitor Attributes

Know: Cores provide a way to read Earth's history that allow scientists to better understand how our planet works.
Feel: Awe at the beauty of some cores. Curiosity about how to "read" a core.
Do: Users view replicas of cores (either analog or images) and identify key features.







Kiosk 4: Paleomagnetism

BIG IDEA The Earth has magnetic poles, and these have flipped over Earth's history. These changes are recorded in the seafloor.

Key Messages

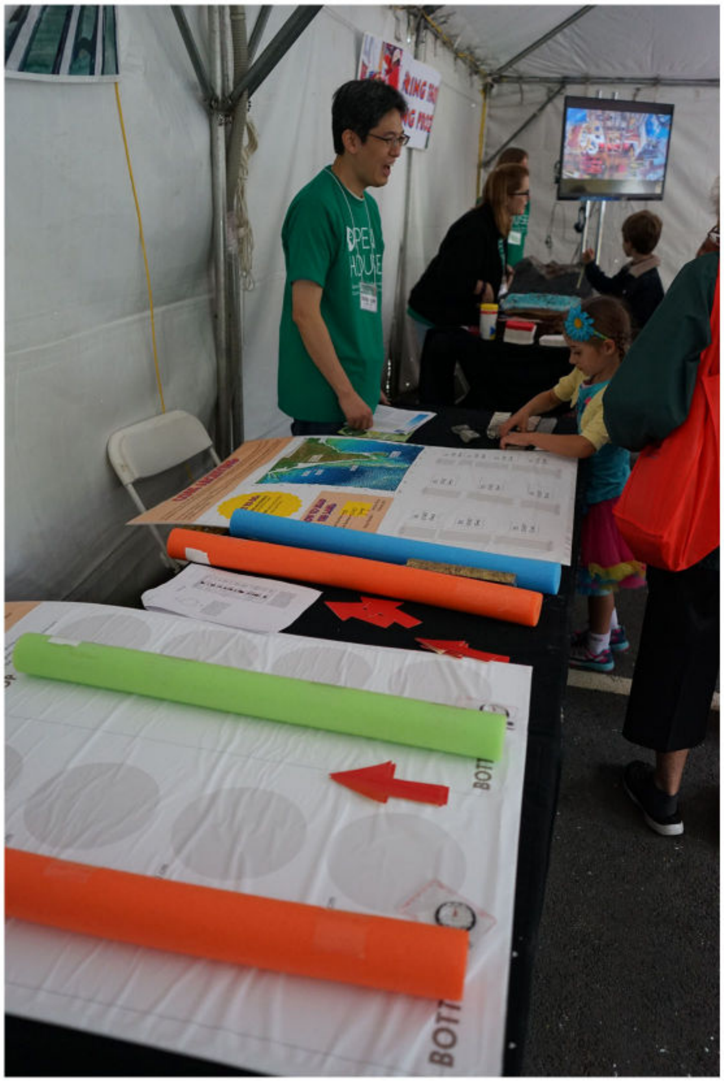
- The Earth's magnetic pole has shifted from the North Pole to the South Pole periodically over Earth's history.
- These changes are recorded in the rocks.
- Scientists on the JR use magnetometers to determine the magnetic orientation in seafloor core layers. They can use this information to determine the age of the rock, its location during formation, differing rates of seafloor spreading, and more.

Visitor Attributes

Know: What are the magnetic poles. Magnetic poles have changed over time. Iron particle orientations in seafloor rock preserve these reversals.

Feel: Wonder and curiosity at the magnetic properties of the Earth and the seafloor.

Do: Visitors use core models with embedded magnets and compasses to measure and record magnetic orientation in their cores. (Could have a model of Earth with a magnet inside that can switch the magnetic pole from North to South and watch iron filings outside of it change in orientation as the Earth's pole reverses.)



Kiosk 5: Climate Change and Microfossils: How We Know What We Know

BIG IDEA Fossils embedded in the seafloor record changes in climate through vast stretches of time.

Key Messages

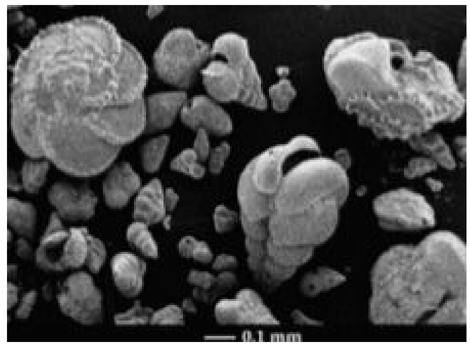
- Scientists have been able to determine changes in Earth's climate through Earth's past. One of the ways they do this is by looking at seafloor microfossils.
- Fossils are not all dinosaur-sized! Microfossils come from the hard, shell-like structures of microscopic plankton. These shell-like structures are so durable they will stay intact millions of years.
- Microfossil species live and have lived in many different ocean habitats throughout Earth's past. Each species has a distinct shell. Paleontologists look at each layer in a core to see what kind of microfossils they can find. If they find lots of microfossils from species that lived in cold water habitats, then they know the climate was cooler when those critters lived and died. The next core layer may have lots of fossils from species that lived in warm water habitats. That means the climate was warmer when those critters lived and eventually fell to the seafloor.

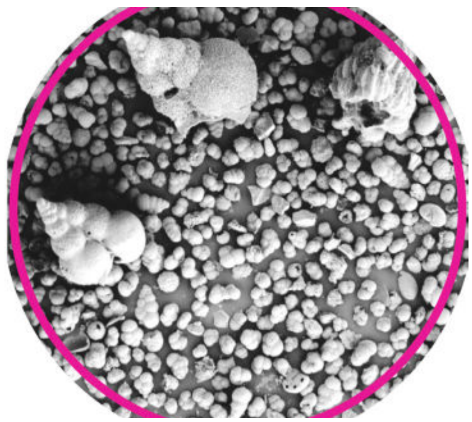
Visitor Attributes

Know: The seafloor is full of microfossils. Scientists study these microfossils to learn how climate has changed over Earth's past.

Feel: Wonder and amazement at the abundance and diversity of microfossils. Curiosity at how scientists can learn so many things from them.

Do: Visitors simulate scientists sieving a sediment sample for microfossils, identifying species, and determining past climate from them.





Kiosk 6: Dino Doomsday: Mass Extinction

BIG IDEA We learned about the extinction of the dinosaurs by studying the seafloor!

Key Messages

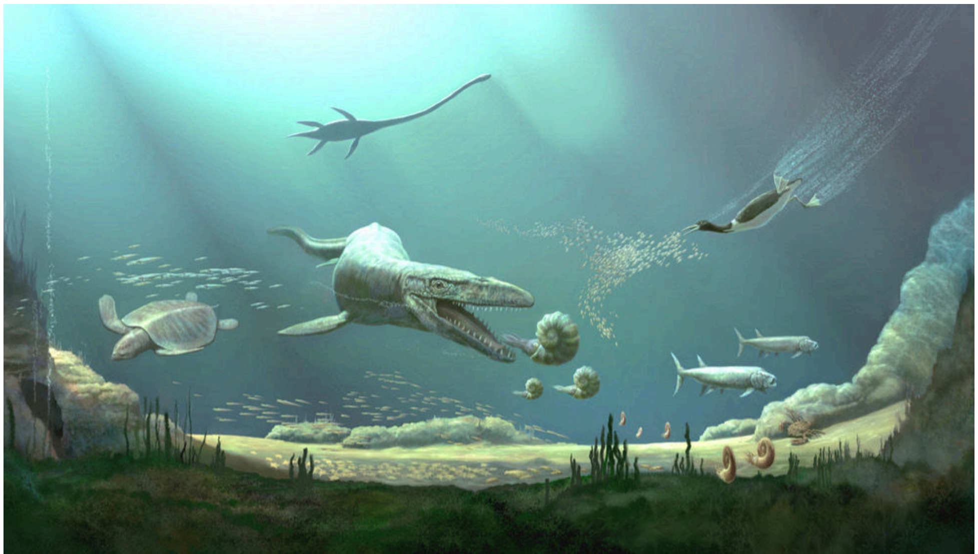
- Many deep-sea cores contain evidence that an asteroid impact 66 million years ago contributed significantly to the extinction of the dinosaurs.
- Along with most dinosaur species, it wiped out about 75% of all species.
- By looking at these cores, scientists have been able to figure out what the world was like before, during, and after the asteroid impact event.
- *66 million years ago an asteroid about 6 miles (10 km) across struck the Earth at what is now the Yucatan Peninsula in Mexico. It created a crater about 110 miles wide and set-off a series of events that devastated the entire world.*

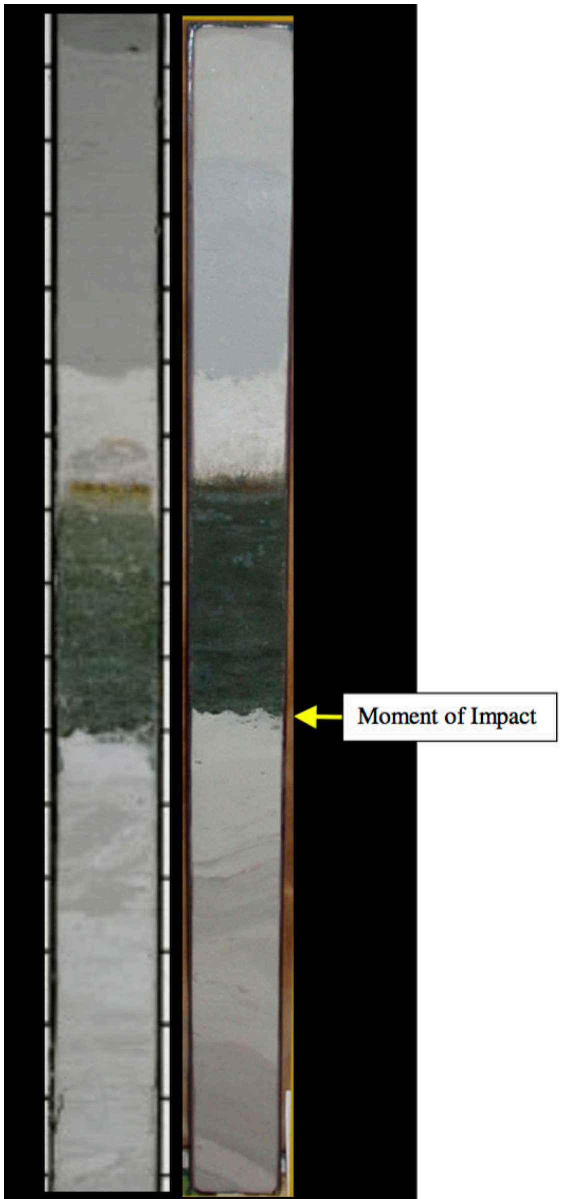
Visitor Attributes

Know: We know how the dinosaurs went extinct from studying ocean cores.

Feel: Wonder at the ability of scientists using seafloor cores to uncover the story of Earth's past. Enough concern about the destruction the asteroid caused to generate interest and excitement about an explosion, but not enough to freak people out.

Do: Look at evidence of the asteroid impact in cores. Enlarged Images/models of biodiversity before and after the impact, and other particles found in the cores. Way to model impact?





Kiosk 7: Life Below the Seafloor

BIG IDEA The majority of life on earth exists in the ocean floor, and depends on chemical energy rather than the sun's energy.

Key Messages

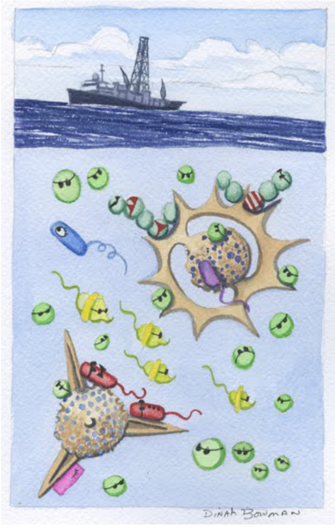
- In recent years, microbiologists have discovered microbes living deep in the seafloor. We have yet to discover the "limits to life" here in this extreme environment.
- Microbes are single celled-living organisms. Hardly any of them are actually germs.
- Seafloor microbes can do amazing thing like eat iron and poop rust or conduct electricity. Some of these abilities may help people in the future to do things like make clean energy or clean up pollution.
- These conditions might be similar to other planets in the solar system.
- Microbes can "eat" and "breath" rocks.

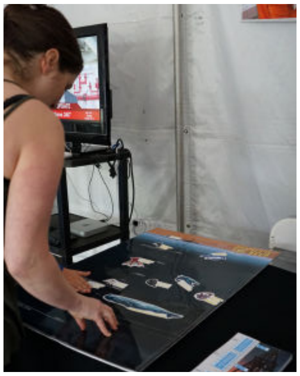
Visitor Attributes

Know: The seafloor is alive! Microbes live down there without light or oxygen.

Feel: Wonder at the adaptations of microbes living deep in the seafloor under extreme temperature and pressure conditions. These conditions might be similar to other planets in the solar system.. Excitement of the potential they have to help people in the future.

Do: Grow a nanowire. Have a model of a microbe try to touch another microbe so you can complete a circuit and let electrons flow through you. Play with a mudwatt battery. (Or what happens when microbes are in the wrong environment – iron vs sulfur rich? Or show how microbes eat or breathe rocks!)





Kiosk 8: Stories From the Core

BIG IDEA

What is it? In a single computer station, a choice of three brief interactive programs in which visitors explore the evidence contained in ocean sediments for dramatic geological and biological stories.

Cores are time machines, containing information that reveals stories about Earth's history.

Key Messages

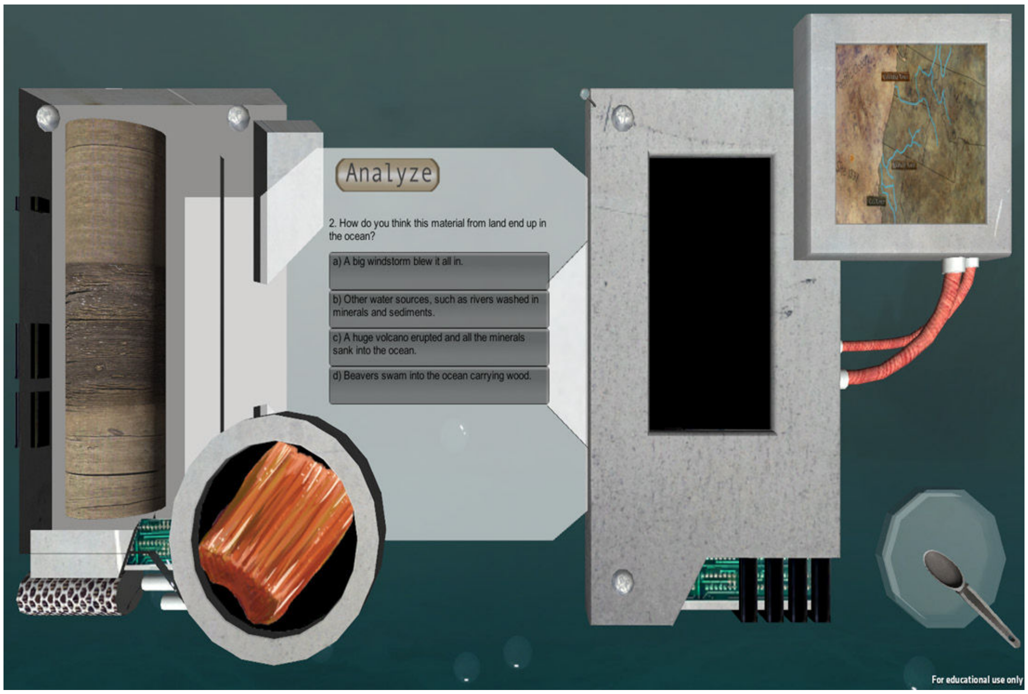
- Will vary depending on program

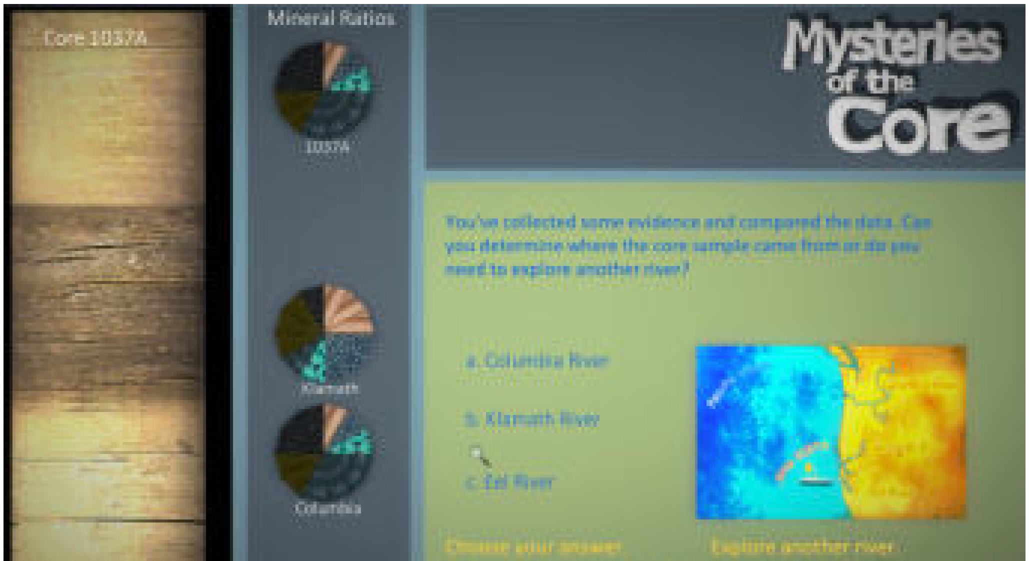
Visitor Attributes

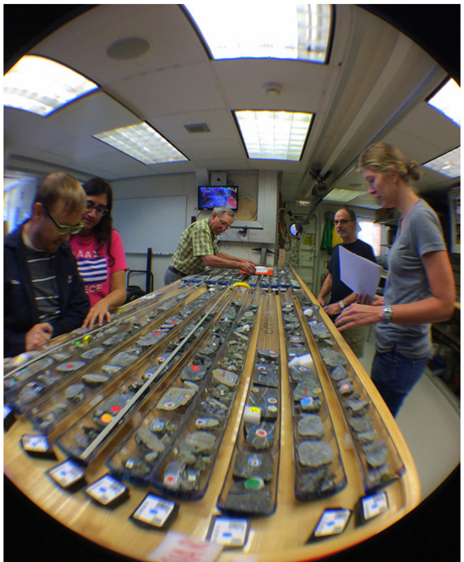
Know: Visitors will become aware of some key aspects of scientific ocean drilling and the kinds of evidence scientists can get from it. Visitors will find relevance in scientific ocean drilling and the stories it tells.

Feel: Visitors will have an engaging, enjoyable experience with the interactive (and will not be confused.)

Do: Visitors will learn and/or practice the skill of gathering evidence to answer a question.







PIE (Portable Immersive Experience) Description

BIG IDEA Science allows us to travel back in time and discover what happened in Earth's past. The JR is a time machine that brings us there.

Key Messages

- The seafloor covers over 70% of the Earth and is mostly unexplored.
- Seafloor science illuminates Earth's history and lets us travel back in time.
- The layers and content of the cores drilled by the JR are clues that help scientists figure out the story of the Earth.

Visitor Attributes

Know: We can learn about Earth's history by studying clues in the seafloor. Earth science is a time machine!

Feel: Wonder and awe at the scale of geological history, the diverse events that have happened over time, and the stories cores can reveal.

Do: Visitors will enter an immersive video experience which will give them a sense of the scale and depth of the ocean, geological time, the technology that allows the JR to drill the seafloor, what cores are, and how they provide us with a journey into Earth's past.