Hidden beneath the seafloor throughout most of the world’s oceans lies a massive, dynamic plumbing system that is a central component of our planet’s inner workings. Heated and under pressure, seawater and other fluids flow and percolate up, down, and through myriad layers of subseafloor rock formations. At volcanically active mid-ocean ridges, where hot magma rises from the mantle to create new seafloor, this circulation vents heat from the earth’s hot interior. It plays an important role in regulating the chemical balance of the oceans and in forming huge ore deposits. At subduction zones, where old seafloor collides with an overriding tectonic plate and sinks back down to the mantle, fluid pressures within subseafloor formations are believed to be an important factor in triggering many of the world’s largest and most damaging earthquakes. Fluid flow beneath the seafloor also may help create the conditions that allow vast microbial communities to thrive in subseafloor formations. And it affects the migration of oil and gas and the formation of another common, potentially energy-producing hydrocarbon: gas hydrates. These are ice-like deposits of crystallized methane and water that form under higher pressures and frigid deep-sea temperatures.

Though we know that fluid flow beneath the ocean basins is fundamental and important, our ability to study conditions and processes that occur beneath the seafloor has been limited. To gain a window onto this relatively inac-
A new generation of Advanced CORKs will be deployed, starting in 2001. These will have inflatable packers that isolate separate zones in subseafloor formations so that different processes occurring within each zone may be identified.

They are collected in a recent workshop report available on the Internet site of the JOIDES Long-Term Observatories Program Planning Group (vertigo.rsmas.miami.edu/ltoppg.html). Among our more important findings, we have shown that:

- High fluid pressures can build up in the decollement, or plate boundary fault, at subduction zones (Hole 949C in the Barbados prism). This fluid pressure surely is a factor in the genesis of earthquakes that are so common in subduction zones.
- Fluids—driven by small pressure gradients—circulate laterally over many kilometers through the very highly permeable sediments of young oceanic crust in upper “basement” formations beneath the seafloor. This finding gives us a first glimpse of the mechanics of the subseafloor plumbing system, which, among other things, may prove important for studies of microbial ecosystems.
- Tides in the ocean exert periodic loads on the seafloor that propagate down into sediment and rock layers beneath the seafloor to varying degrees depending on the hydrological and elastic properties of the formations. This unexpected tidally driven flow in the subsurface may play an important role in regulating important subseafloor chemical interactions between fluids and rocks and in maintaining an environment to host microbial communities. It could also mean that subseafloor formations serve to dissipate a modest amount of tidal energy.

CORKs may represent the best option for in situ sampling of fluids below the seafloor, which has
proven very elusive to date. Five of the CORKs presently deployed include long-term self-contained fluid samplers suspended within the sealed holes to sample formation fluids (as opposed to the seawater used in the drilling process). Four were just recovered this past September using WHOI’s submersible Alvin and the wireline Control Vehicle of Scripps Institution of Oceanography’s Marine Physical Laboratory (MPL). With access to the sealed holes via a valve at the seafloor, our installations are also excellent for setting up long-term experiments to produce and sample subseafloor formation fluids. Our experience now allows us to predict in which settings sealed holes are likely to produce fluids naturally. In other cases we can take advantage of what we have learned about tidal effects on subseafloor fluid flow to produce subseafloor fluids at the valves.

We are gratified at the success of the CORK effort, and are particularly excited to be involving a widening circle of collaborators, ranging from physical oceanographers interested in our deep ocean tidal records to microbiologists interested in microbial systems hosted within the subseafloor formations that we access with the CORKs. However, we recognize that the 1991–1997 CORK design has a key scientific limitation: Until now, our design incorporated a single seal near the top of the hole, and thus our sensors integrate signals from the full range of formations that the hole penetrates beneath the seafloor. But in reality, subseafloor formations are not uniform. Our results and many other lines of evidence clearly indicate that permeability and fluid flow in various subseafloor formations varies because of intrinsic permeability differences in formations or because flow is channeled in discrete faults and fractures.

So we have proposed a new generation of “Advanced CORK” observatories starting with deployments planned for 2001. The next major advances in our understanding of subseafloor hydrology will come not only from expanding the range of in situ measurements and sampling devices incorporated in our sensor strings, but also and more importantly, from incorporating a capability to isolate many separate zones within the subseafloor formations and take measurements in each of them (see diagram, page 15).

Our funding agencies and JOIDES support this strategy, and we are simultaneously developing two technological approaches to implement this multi-sealing capability: a multi-packer instrumented casing system deployed by the ODP drill ship, and a wireline instrumented multi-packer system deployed by the MPL Control Vehicle. The first deployments of the former are scheduled for spring 2001 on ODP Leg 196 in two holes in the Nankai Trough subduction system off Shikoku Island, Japan (site of the Kobe earthquake). First deployments of the latter are scheduled for winter 2001 in a pair of existing young crustal holes in the Panama Basin (504B and 896A).