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## ODP/IODP "CORK" Long-Term Subseafloor Hydrogeological Observatories

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### Abstract

Since 1991, 22 reentry holes of the Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP) have been instrumented with long-term, sealed-hole, subseafloor hydrogeological observatories known as CORKs. This paper briefly reviews the scientific objectives of these installations and the evolution of the CORK designs, from the original single-seal CORK to several more recent models allowing isolation of multiple formation intervals in a single hole.

### Introduction

Since 1989, engineers of the Ocean Drilling Program (ODP, 1983-2003) and Integrated Ocean Drilling Program (IODP, 2003- ) have been working with ODP/IODP scientists to install long-term, sealed-hole, subseafloor hydrogeological observatories in selected reentry holes in hydrologically active areas on the deep ocean seafloor. The great majority of ODP/IODP holes are non-reenterable single-bit holes that are cored, logged, and simply abandoned. Roughly 1-3% of ODP/IODP holes are cased and equipped with reentry cones to allow deepening after bit changes and/or deployment of specialized instrumentation in the holes. Early experience indicated that, when such reentry holes were left open after penetrating hydrologically active formations, many of them acted as hydraulic shunts between the ocean bottom water and the formations. These holes were essentially long-term perturbation experiments that limited what could be learned about in-situ hydrogeological state and processes with any sort of measurements while the holes remained open. These limitations provided the motivation to develop the capability to seal the holes and allow simultaneous deployment of long-term monitoring instruments in the sealed holes, with data loggers and sampling ports accessible at the wellhead.

### Original Single-Seal CORKs

The earliest model included a plug at casing hangers in the throat of the reentry cone, much as a cork seals your favorite wine bottle (Fig. 1). That geometry provided an obvious name for the experiment, and the acronym "CORK" was coined; "CO" stands for circulation obviation because the plug shut off the perturbing circulation induced if the hole were left open, and "RK" stands for retrofit kit because the experiment could be retrofit to any existing reentry hole, whether drilled twenty years ago or the day before. The plug or "CORK body" incorporated a central bore, allowing for deployment of a sensor string down the drillstring into the sealed hole; the sensor string was suspended on a data logger that sealed into CORK body. Typical sensor strings have included pressure gauges above and below the seal, thermistor cables extending deep into the hole, and self-contained fluid samplers driven by osmotic pumps ("OsmoSamplers") suspended on the thermistor cables. Wellhead valves have also allowed submersible access to the sealed holes.

### Multi-Zone CORK Models

The scientific successes of the early CORKs also revealed an essential limitation: that the single-seal configuration averaged signals from the formation, and did not discriminate contributions from local hydrogeological structures and stratification. Thus, starting in 1998, three newer models were developed with multiple packer seals to separately isolate different hydrologically active zones in the subseafloor. The three models developed were: (1) the so-called Advanced CORK or ACORK, which incorporates within the primary casing system modular casing packers and external screens, as well as external umbilicals bringing pressures and fluid samples to data loggers and sampling valves on the wellhead; (2) the "Wireline CORK" or instrumented multi-packer string that can be installed in pre-existing reentry holes by wireline reentry from a conventional oceanographic research vessel; and (3) the "CORK-II," which incorporated smaller-diameter packers, screens, and umbilicals on a 4-1/2" diameter casing string suspended in a hole already cased with the ODP/IODP standard 16" to 10-3/4" casing strings.

### Scientific Objectives and Results

From 1991-2001, twelve holes were instrumented during ODP with this original CORK design; starting in 2001, ten more holes were instrumented by ODP and IODP with more sophisticated designs. Typical settings have been in