Three Decades of ODP/IODP CORK and LTBMS Borehole Observatories

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Since 1991, the Ocean Drilling Program, Integrated Ocean Drilling Program, and International Ocean Discovery Program have instrumented >30 subseafloor boreholes in sedimented young ocean crust or subduction settings with long-term sealed-hole observatories generally called CORKs (Circulation Obviation Retrofit Kits). Understanding subseafloor hydrology and its relationship to hydrothermal and tectonic processes have been prime objectives of scientific ocean drilling since the late 1970’s. However, early experience showed that holes that penetrated through marine sediments into underlying basement often allowed open exchange between formation and ocean, perturbing if not totally disturbing the in-situ hydrogeological state. This motivated the CORK approach to seal select holes with long-term sensor strings and data loggers, to record the recovery to the in-situ formation state, and to monitor natural hydrologic, tidal, and geodynamic signals. The original design included a single seal at the seafloor, and later designs have allowed for separately monitoring multiple zones sealed by packers in a single hole. Cased holes have also been retrofitted with (a) temporary “Smart Plugs”, enabling monitoring between drilling expeditions, and (b) “wireline CORK” or “CORK-Lite” installations deployed by remotely operated vehicles (ROVs). The sensor strings have always included pressure and temperature monitoring, and many have included self-contained fluid samplers driven by osmotic pumps (“OsmoSamplers”) customized for a variety of geochemical and microbiological sampling objectives. Typically, data and samplers have been recovered and/or exchanged at average intervals of 1-3 years using manned or unmanned research submersibles. Three CORKs in the northeast Pacific have been connected to the Oceans Network Canada cable network for power and real-time data, and one included a downhole seismometer and tiltmeter. Long-Term Borehole Monitoring Systems (LTBMS) deployed recently from D/V Chikyu and connected to the DONET cable network have included broadband seismometers, tiltmeters, and strainmeters. Results include documenting: (1) small pressure and temperature differentials associated with vigorous hydrothermal circulation in highly permeable young oceanic basement; (2) formation response to seafloor tidal loading; (3) formation pressure anomalies that reflect plate-scale strain in response to tectonic stresses and earthquakes; and (4) natural flow within young crust using hole-to-hole tracer injection and detection.

