CHAPTER 4.2

Drilling Operations and Engineering

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Drilling operations are highly professional tasks requiring special expertise and skills. Therefore, Principal Investigators (PIs) usually contract service companies to plan and execute scientific drilling. Accordingly, the PIs have the duty to oversee all operations as well as to control schedules and budget. In several projects supported by ICDP, these PIs´ tasks have been either entrusted to independent drilling consultants or to the OSG engineers. They performed as technical and managerial advisors or 'company men' at the drilling site and were supported by additional external experts when needed. This system allows PIs to focus on oversight issues and information to stakeholders and scientific community. In order to describe the operational and engineering tasks, this chapter summarizes some key aspects of drilling engineering and operations execution.

Basics of drilling

In the majority of drilling operations for scientific goals either rotary drilling or diamond wireline coring techniques have been used. In both cases a bit is mounted on a rotating steel pipe and lowered into the ground by a drilling derrick (Fig. 4.2.1). For deep drilling operations, bottom hole assemblies made up of a bit, stabilizers, reamers, drill collars and heavy weight drill pipe are needed. The drill string is propelled by a rotary table, or a top-drive, and consists of connected pipe elements through which a drilling fluid is pumped down the well. The drill mud, usually water with clay minerals and some other minor additives to adjust density, viscosity and lubrication, cools the bit and carries cuttings of the destroyed volume of rock to the surface through the annulus between the borehole wall and the drill-string. Modern oilfield type drilling uses downhole motors that are propelled by the drill mud. The circulating drilling fluid is treated at surface to remove the solids and control the 'mud' properties. The drilling progress (rate of penetration, ROP) is controlled by rotary speed, weight-on-bit (WOP), and mud hydraulics. Once a drill pipe length is completely drilled down, an additional pipe is connected to extend the drill string.

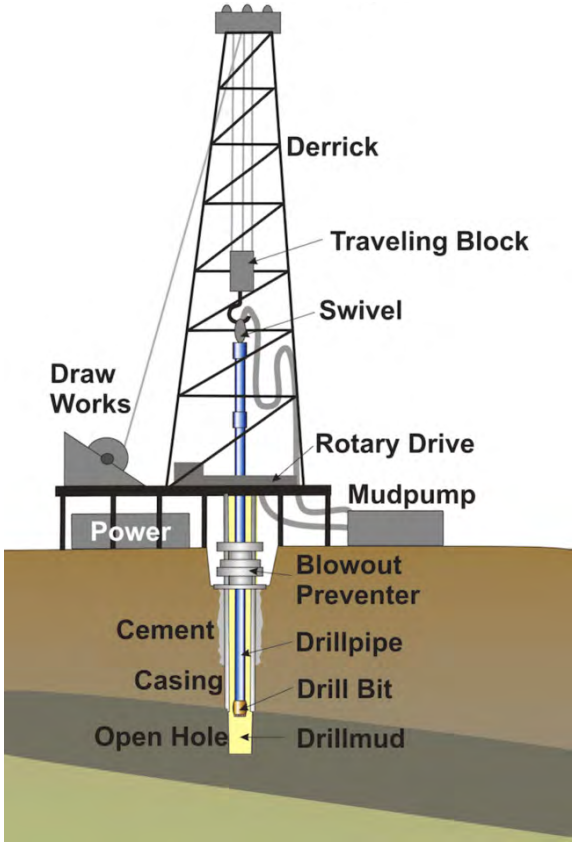

Fig. 4.2.1: Key components of rotary drilling

When drilling from a ship or floating platform, the borehole remains open to the sea/lake floor, so mud and cuttings do not return to the drill rig. In this set-up drilling must be performed with water in place of drilling mud allowing cuttings spilling out on sea or lake bottom around the well. However, if pressure control and mud return is required, an outer second pipe, a so-called riser, is put in place so the mud and cuttings can be pumped back to the deck.

Coring is performed with a hollow core bit that leaves a central column of rock. This core slides into a pipe barrel while drilling progresses. In the oilfield rotary coring technique, after coring the length of the core barrel, the whole assembly has to be pulled back out of the hole (pipe trip out) to get the core to the surface. In many scientific drilling projects, by contrast, continuous coring by wireline coring technique is utilized to avoid time-consuming round trips. The core barrel is retrieved through the drill string by sinking a wireline catching device that connects to the retrievable inner coring assembly with the drilled-out rock column inside. Once latched into the coring assembly's head, the core barrel is winched up to surface and replaced by an empty core barrel for the next round.

The actual formation-cutting method varies depending on the type of rock or sediment present along depth. Typically, thin-kerf diamond core bits with high-rotation speed are used for hard rock drilling, roller cone abrasion bits are used for softer sedimentary rock, and non-rotating sharp edged hollow metal pistons of several meters length are hydraulically shot (forced) into soft sea/lake-floor sediments to collect cores and thus advance the borehole.

Instable borehole conditions as well as saline or over-pressured formations often require that casing or liner pipes have to be installed. To hold casing in place and avoid formation fluid migration to surface, the casing must be cemented in place after being run in hole. Usually, wells are drilled following a telescopic configuration, starting with largest hole diameter at surface and ending up in the smallest diameter at bottom hole. Exceptions are so-called monobore configurations with static diameter from surface to end depth. Health, safety and environmental regulations or critical downhole conditions often require additional procedures to ensure safe drilling operations and to minimize environmental impact. This includes borehole stability control through mud density variation, biodegradable drilling fluid additives and blowout-preventers (BOP) devices.