An Overview of Well Logging

1.1 INTRODUCTION

The French translation of the term well logging is carottage électrique,* literally “electrical coring,” a fairly exact description of this geophysical prospecting technique when it was invented in 1927 [1, 2]. A less literal translation might be “a record of characteristics of rock formations traversed by a measurement device in the well bore.” However, well logging means different things to different people. For a geologist, it is primarily a mapping technique for exploring the subsurface. For a petrophysicist, it is a means to evaluate the hydrocarbon production potential of a reservoir. For a geophysicist, it is a source of complementary data for surface seismic analysis. For a reservoir engineer, it may simply supply values for use in a simulator.

The initial uses of well logging were for correlating similar patterns of electrical conductivity from one well to another, sometimes over large distances. As the measuring techniques improved and multiplied, applications began to be directed to the quantitative evaluation of hydrocarbon-bearing formations. Much of the following text is directed toward the understanding of the measurement devices and interpretation techniques developed for this type of formation evaluation.

Although well logging grew from the specific need of the petroleum industry to evaluate hydrocarbon accumulations, it is relevant to a number of other areas of interest to earth scientists. New measurements useful for subsurface mapping have evolved which have applications for structural mapping, reservoir description, and

---

*The French definition is mentioned for two reasons: as an acknowledgment of the national origin of well logging and as one of the rare cases in which Anglo-Saxon compactness is outdone by the French.
sedimentological identification. The measurements can be used to identify fractures or provide the formation mineralogy. A detailed analysis of the measurement principles precedes the discussion of these applications. In this process, well logging is seen to require the synthesis of a number of diverse physical sciences: physics, chemistry, electrochemistry, geochemistry, acoustics, and geology.

The goal of this first chapter is to discuss well logging in terms of its traditional application to formation hydrocarbon evaluation and to describe the wide variety of physical measurements which address the relevant petrophysical parameters. We begin with a description of the logging process, to provide an idea of the experimental environment in which the measurements must be made.

1.2 WHAT IS LOGGING?

The birth of logging can be dated to the first recorded event [1] at Pechelbronn on September 5, 1927 where H. Doll and the Schlumberger brothers (and a few others) made a semicontinuous resistivity measurement in that tired old field in Alsace. The operation was performed with a rudimentary device (a sonde) consisting of a bakelite cylinder with a couple of metallic electrodes on its exterior. Connecting the device to the surface was a cable/wire, thus providing us with the term wireline logging. Wireline refers to the armored cable by which the measuring devices are lowered and retrieved from the well and, by a number of shielded insulated wires in the interior of the cable, provide for the electrical power of the device and a means for the transmission of data to the surface. More recently, the devices have been encapsulated in a drill collar, and the transmission effected through the mud column. This procedure is known as logging while drilling (LWD).

1.2.1 What is Wireline Logging?

The process of logging involves a number of elements, which are schematically illustrated in Fig. 1.1. Our primary interest is the measurement device, or sonde. Currently, over fifty different types of these logging tools exist in order to meet various information needs and functions. Some of them are passive measurement devices; others exert some influence on the formation being traversed. Their measurements are transmitted to the surface by means of the wire line.

Much of what follows in succeeding chapters is devoted to the basic principles exploited by the measurement sondes, without much regard to details of the actual devices. It is worthwhile to mention a few general points regarding the construction of the measurement sondes. Superficially, they all resemble one another. They are generally cylindrical devices with an outside diameter on the order of 4 in. or less; this is to accommodate operation in boreholes as small as 6 in. in diameter. Their length varies depending on the sensor array used and the complexity of associated electronics required. It is possible to connect a number of devices concurrently, forming tool strings as long as 100 ft.