— University of Mosul —
College of Petroleum & Mining Engineering

Well Logging Engineering

Lecture Nine

Assist. Prof. Dr. Muneef Mahjoob Mohammed

Petroleum and Refining Engineering Department

Email: m.m.mohammed@uomosul.edu.iq

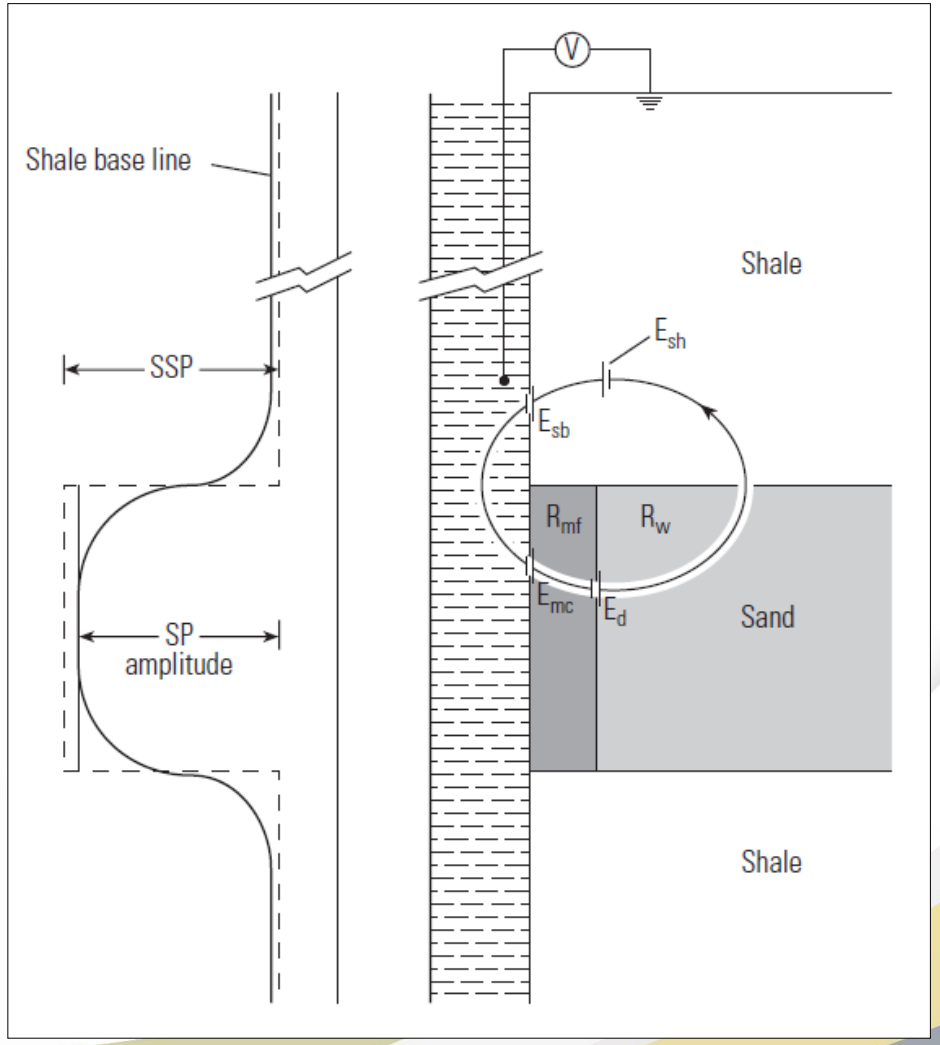
LECTURE CONTENTS

- Principle of Spontaneous potential (SP) log
- Measurements Tools
- Log presentation
- The amplitude of the SP deflection
- Uses of the SP log

- **1- Principle:**
- The spontaneous potential log (SP) measures the natural or spontaneous potential difference (sometimes called self-potential) that exists between the borehole and the surface in the absence of any artificially applied current. The log is very simple that requires only an electrode in the borehole and a reference electrode at the surface. These spontaneous potentials arise from the different access that different formations provide for charge carriers in the borehole and formation fluids, which lead to a spontaneous current flow, and hence to spontaneous potential difference, (Fig. 1).

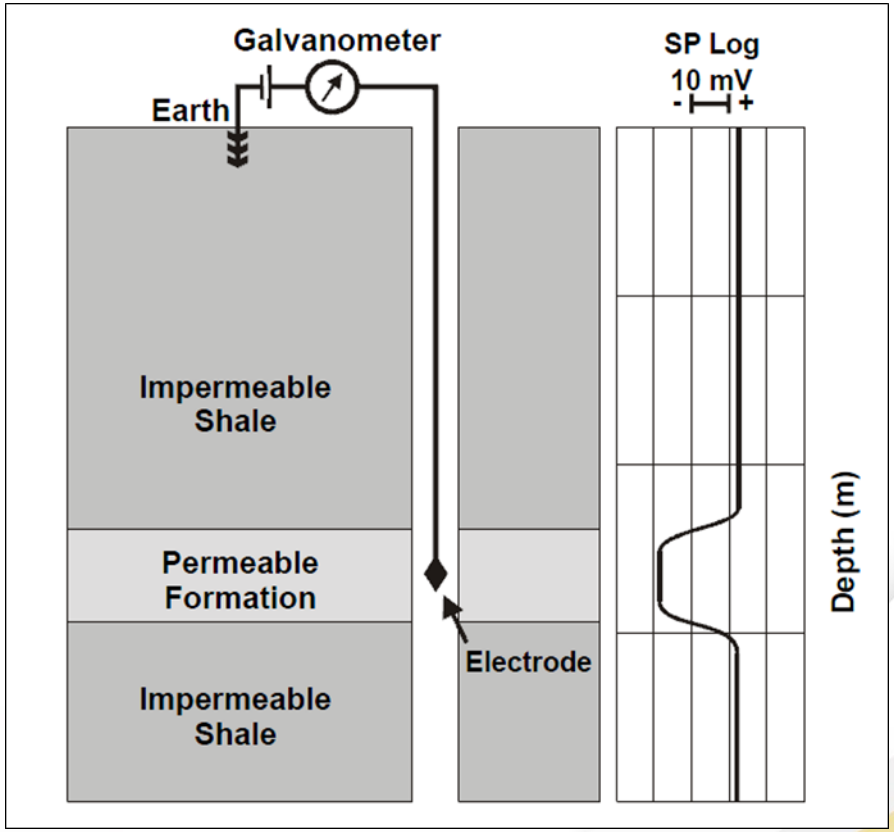
- There are three factors are necessary for the existence of an SP current:
- a- A conductive fluid in the borehole (i.e. a water-based mud).
- b- A porous and permeable bed between low porosity and impermeable formations.
- c- A difference in salinity between the borehole fluid and the formation fluid, which are the mud filtrate and the formation fluid in most cases.

- **1- Principle:**
- Electric currents arising from electrochemical factors within the borehole create the SP log response. These electrochemical factors are brought by differences in salinities between mud filtrate (Rmf) and formation water resistivity (Rw) within permeable beds (Fig. 1). Because a conductive fluid is needed in the borehole for the SP log to operate, it cannot be used in non-conductive (i.e. oil-based drilling muds).

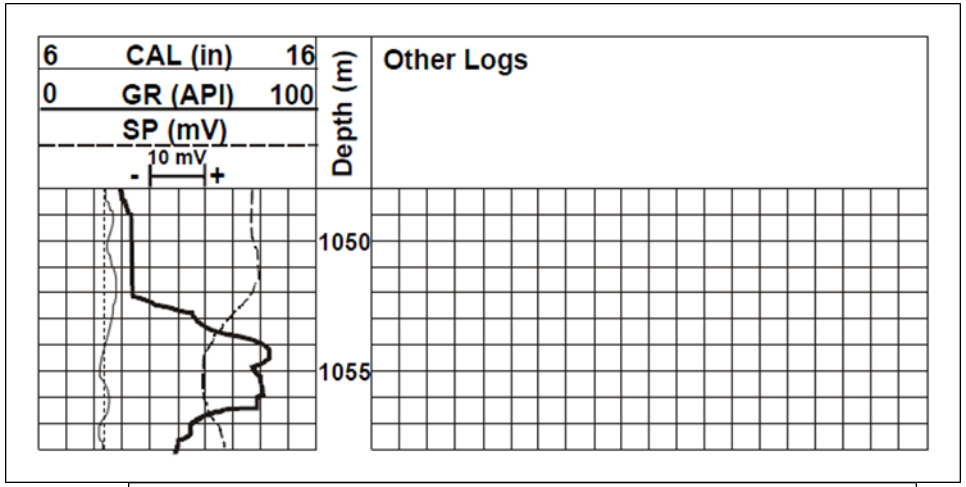


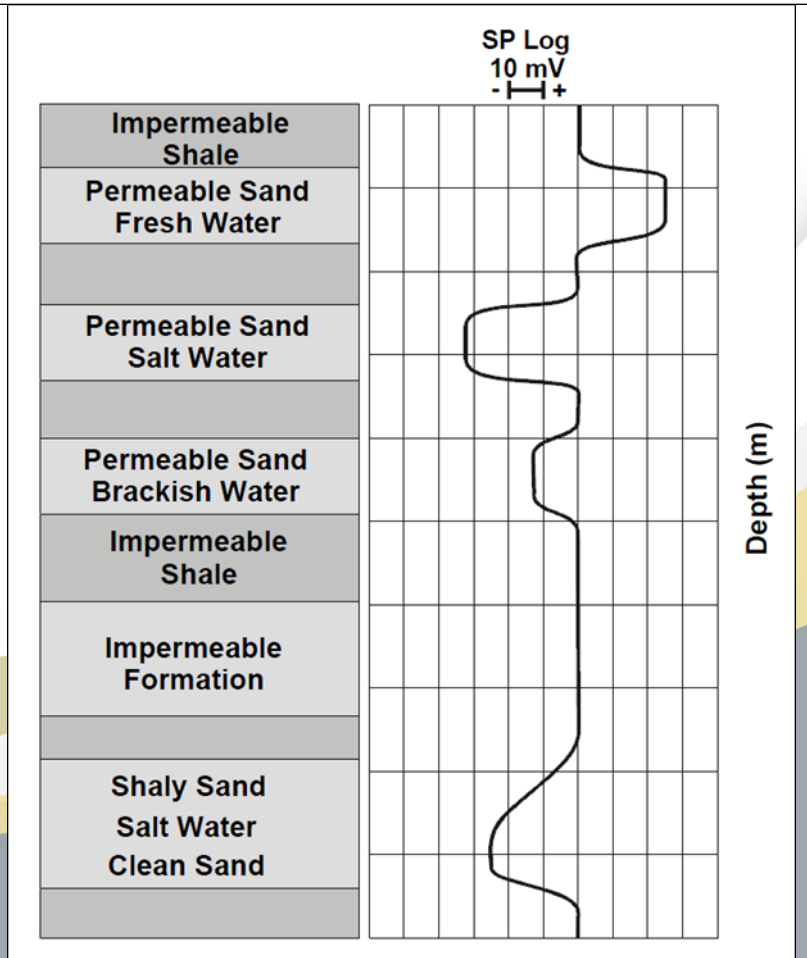
- **2- Measurements Tools:**
- The tool is extremely simple, consisting of a single electrode that is connected to a good surface earthing point via a galvanometer for the measurement of DC potential (Fig. 2). A small 1.5 V battery is also included commonly to ensure that the overall signal is measured on the correct scale.
- The spontaneous potential log is a record of direct current (DC) voltage differences between the naturally occurring potential of a moveable electrode in the well bore, and the potential of a fixed electrode located at the surface (Fig. 2). It is measured in millivolts.
- Only relative changes in potential are measured because the absolute value of SP is meaningless. Changes of the order of 50 mV are typical. For the log to be good, a good earth is necessary, which is often a metal spike driven 1 m into the ground.

- **2- Measurements Tools:**
- The log has a low vertical resolution, is rarely useful in offshore environments, and is always recorded in the leftmost track of the log suite, together with the GR log.
- It is very important to recognize that this log has no absolute scale, relative changes in the SP log are important. This is reflected in the design of the log header, which shows only a bar that represents a change of 10 mV.
- The SP log is difficult to run offshore because:
- a- A good earth is difficult to find.
- b- The amount of electrical noise on board a rig often causes problems in accurately measuring signals that commonly change by less than a millivolt.



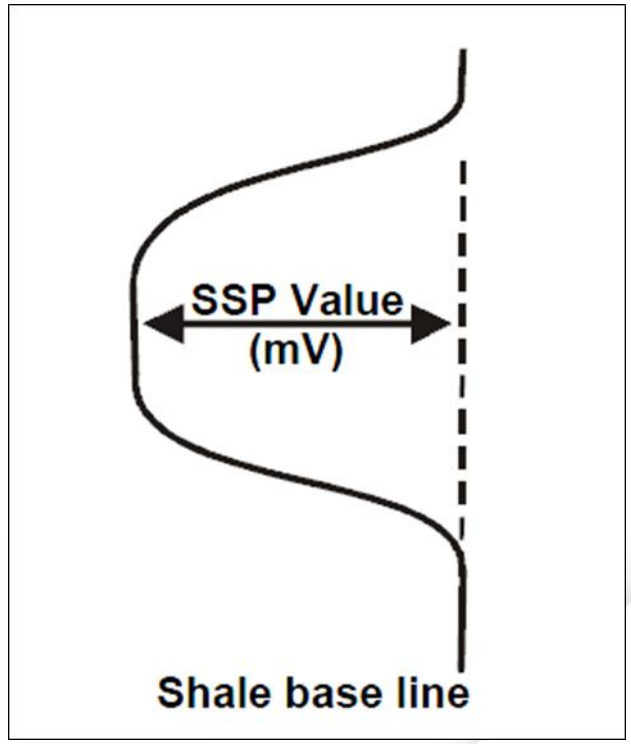
- **4- Log presentation:**
- SP is shown in millivolts, and is recorded on the left-hand track of the log in track #1, with negative deflections to the left and positive ones to the right (Fig. 3).
- Figure 4 shows a schematic diagram of typical SP log responses.
- In reading the SP log, it is best to first define a shale baseline. This is the typical SP level for shales and can be found by comparing the SP log with the GR log response. Permeable formations will then have excursions of variable intensity to the left or right of this line, depending upon the relative salinities of the formation water and the mud filtrate. It is useful to know the salinity or resistivity of the mud filtrate from the log header, if available, as this will indicate whether the formation water is likely to fall at a higher or lower salinity.





- **5- The amplitude of the SP deflection:**
- Several factors govern the amplitude of the SP deflection opposite a permeable bed. This is because the size of the deflection and the change in the SP curve between beds depends upon the distribution of the current flux and the potential drops taking place in each part of the formation. The following parameters are important:
- a- The thickness of the permeable bed, h.
- b- The true resistivity of the permeable bed, Rt.
- c- The diameter of the invaded zone, di.
- d- The resistivity of the invaded zone, Rxo.
- e- The resistivity of the bounding formations.
- f- The resistivity of the mud, Rm.
- g- The diameter of the borehole, dh.
- h- The relative salinities of the mud filtrate and the formation fluids.

- **5- The amplitude of the SP deflection:**
- The recorded SP log represents the potential drop in the borehole, only. To use the SP curve quantitatively, a value for the total potential drop around the circuit must be derived. This is called the static spontaneous potential (SSP). This value may be derived from correction charts. However, a direct reading of the SSP may be obtained directly from the SP log opposite thick, clean, shale-free, 100% water-bearing formations. The SSP is the value in millivolts of the difference between the SP log at the shale baseline and that in the center of the thick clean formation, as shown in Figure 5.



- **5- The amplitude of the SP deflection:**
- The SP deflection obtained for homogeneous shaly formations or thin shaly beds after correction for bed thickness is called the pseudo-static spontaneous potential (PSP). The SSP is the value in millivolts of the difference between the SP log at the shale baseline and that in the center of the thick homogeneous shaly formation, or a thinner bed if a bed thickness correction has been carried out.
- If there is a proportion of shale in the permeable bed, the SP deflection is reduced from what it would be if the bed was clean and contained the same fluids. Hydrocarbon saturation also decreases SP deflections.

- **6- Uses of the SP log:**
- The SP log has four main uses:
- a- The detection of permeable beds.
- b- The determination of the resistivity of formation water (Rw).
- c- The indication of the shaliness of formation.
- d- Correlation.

Thank You