— University of Mosul —
College of Petroleum & Mining Engineering

Well Logging Engineering

Lecture Seven

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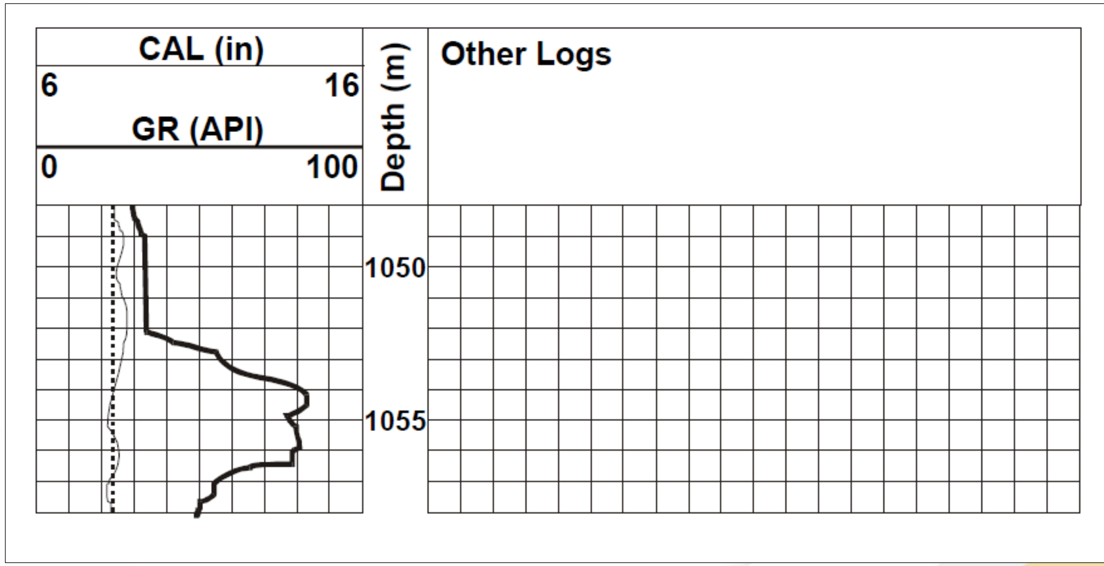
LECTURE CONTENTS

- Principle of Gamma Ray Log
- Log Presentation
- Borehole Quality
- Uses of Gamma Ray Log
- Uninvaded Zone

- **1- Principle:**
- The gamma ray log measures the natural gamma radiation emanating from the formations. This gamma radiation originates from potassium-40, and the isotopes of the Uranium-Radium and Thorium series. Since many gamma rays can pass through steel casing, the log can be run in both open and cased holes.
- Once the gamma rays are emitted from an isotope in the formation, the energy of the rays is reduced as a result of collisions with other atoms in the rock (Compton scattering). This scattering will continue until the energy of the gamma rays is completely absorbed by the formation.
- The gamma-ray intensity is a function of:
- a- The initial intensity of gamma ray emission, which is a property of the elemental composition of the rock.
- b- The amount of compton scattering that the gamma rays encounter, which is related to the distance between the gamma emission and the detector and the density of the intervening material.
- Therefore, the tool has a limited depth of investigation.

- **1- Principle:**
- The gamma ray log normally reflects the shale content in the sedimentary formations, because the radioactive elements tend to concentrate in the shales and clays, and these elements are more radioactive than sand or carbonate.
- Therefore, shale-free sandstone and carbonates have low concentrations of radioactive materials and give low gamma ray readings.
- As shale content increases, the gamma ray log response increases because of the concentration of radioactive materials in shale

- **2- Log presentation:**
- The gamma ray log is recorded in track #1usually with the calliper log and is scaled in API units. The API scale, which is used in log presentation, normally ranges from 0 to 100 API and 0 to 150 API. When gamma ray logging is carried out through the cement casing, a scale of 0 to 50 API is most often used, as a result of the lower values measured due to the attenuation of the gamma rays by the casing. Tracks #2 and #3 often contain either a porosity log or a resistivity log (Fig. 1).



- **3- Borehole quality:**
- The gamma ray log usually runs centred in the borehole. If the borehole suffers from caving, the gamma ray log can be badly affected. In intervals that suffer from caving, there is more drilling mud between the formation and the gamma ray detector to attenuate the gamma rays produced by the formation (Fig. 2).
- Note that the denser the mud used, the greater the underestimation will be, because of increased Compton scattering in the drilling mud. The measured overestimation may usually be corrected if the calliper log for the well is known.

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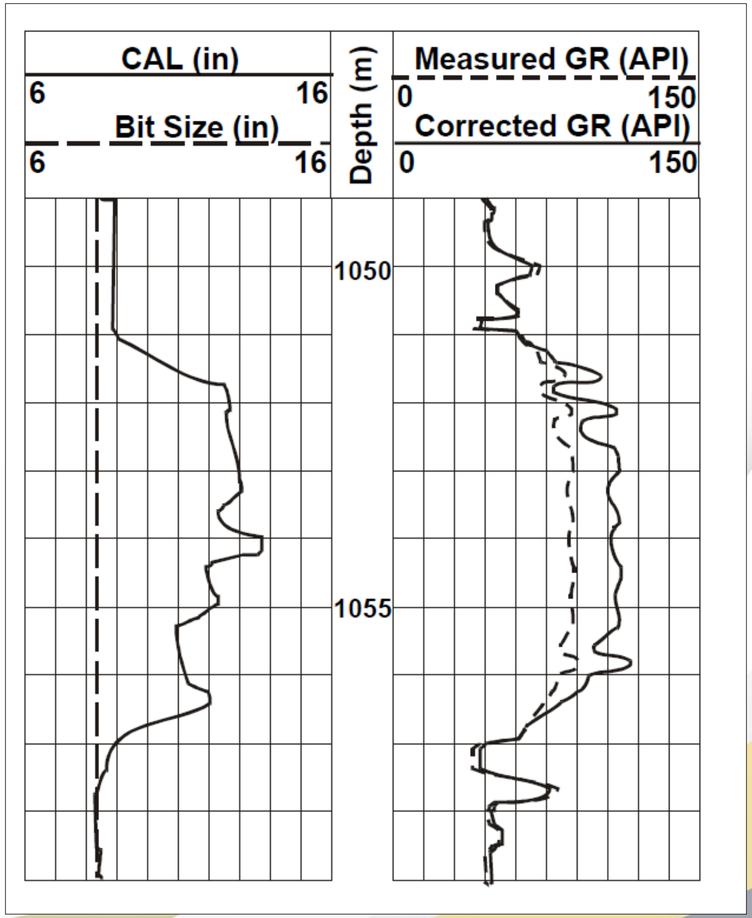


- **4- Uses of gamma ray log:**
- The main uses of gamma ray log are:
- a- Determination of lithology:
- The gamma ray log is extremely useful tool for discrimination of different lithologies. Its main use is the discrimination of shales by their high radioactivity. Shale-free sandstone and carbonates have give low radioactivity because they have low concentration of radioactive materials.

- # b- Determination of shale content:

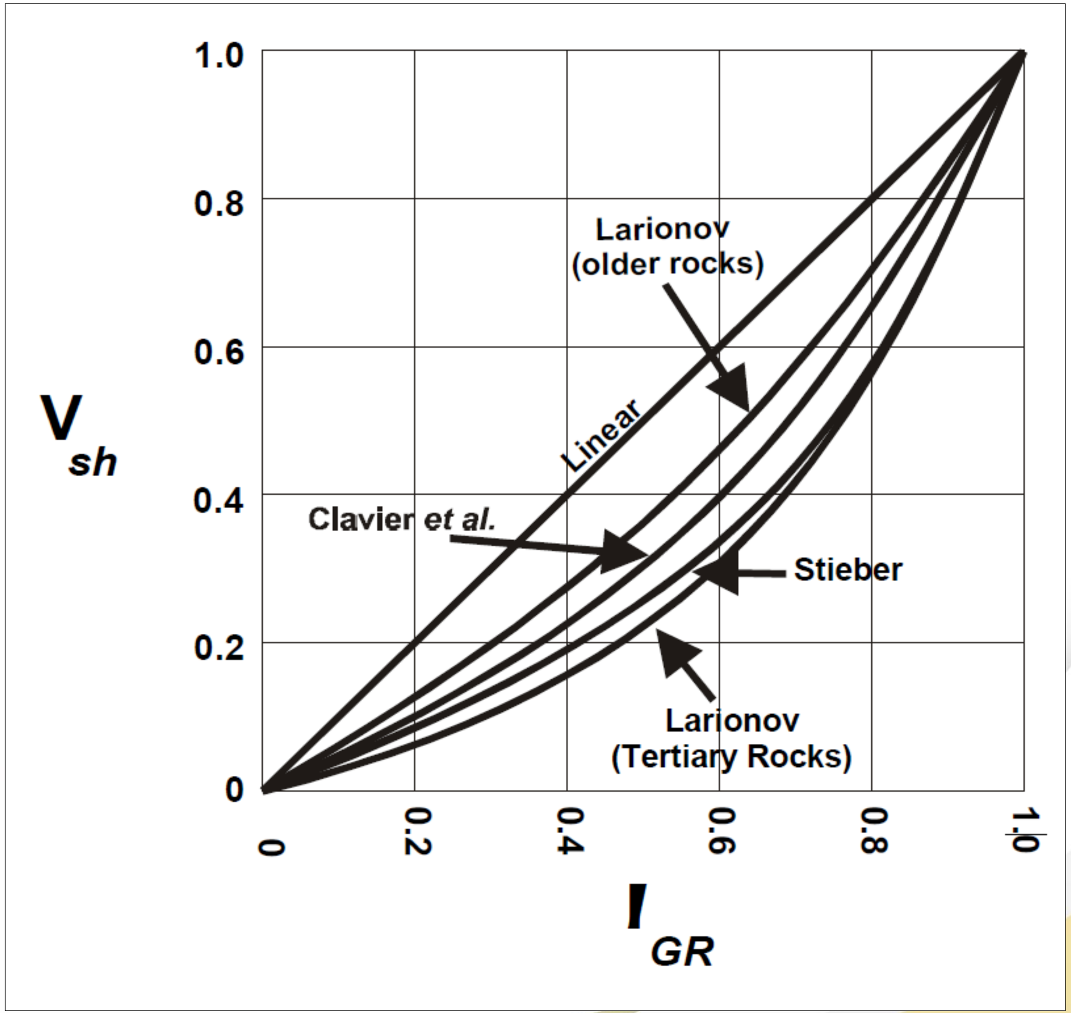
- Because shale is more radioactive than sand or carbonate, gamma ray logs can be used to calculate volume of shale in porous reservoirs. Once the main lithologies have been identified, the gamma ray log values can be used to calculate the shaliness or shale volume Vsh of the rock. This is important because the value of the shale volume is used to discriminate between reservoir and non-reservoir rocks.
- The first step to determine the volume of shale from a gamma ray log is by calculation of the gamma ray index. This index is calculated by the following formula:

$$I_{GR} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}$$

- Where:
- IGR: gamma ray index.
- GRlog: gamma ray reading of formation.
- GRmin: minimum gamma ray (clean sand or carbonate).
- GRmax: maximum gamma ray (shale).

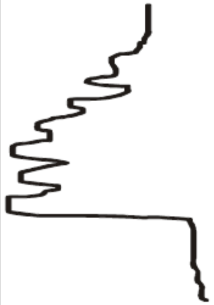
- Many petrophysicists then assume that Vsh = IGR. However, the value of the IGR can be corrected by entered it into the chart shown in Fig. 3, from which the corresponding value of Vsh may be read.

- Figure 3: Calculation of shale volume.



- **c- Facies and depositional environment analysis:**
- The gamma ray log is used to measure the shaliness of a formation. The shaliness does not change suddenly, but occurs gradually with depth.
- Such gradual changes are indicative of the litho-facies and the depositional environment of the rock, and are associated with changes in grain size and sorting that are controlled by facies and depositional environment as well as being associated with the shaliness of the rock.
- Figure 4 shows the shape of gamma ray log response for various depositional environments.

Figure 4: The gamma ray log and depositional environments.

Shape	Smooth	Environments	Serrated	Environments
Cylinder Represents uniform deposition.		Aeolian dunes Tidal sands Fluvial Channels		Deltaic distributaries Turbidite channels Proximal deep-sea fans
Bell Shape Fining upwards sequences.		Tidal sands Alluvial sands Braided streams Fluvial channels Point bars		Lacustrine sands Deltaic distributaries Turbidite channels Proximal deep-sea fans
Funnel Shape Coarsening upward sequences.		Barrier bars Beaches Crevasse splays		Distributary mouth bars Delta marine fringe Distal deep-sea fans

Thank You