# Lecture(7)

# Gamma ray logging

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**Definition:**

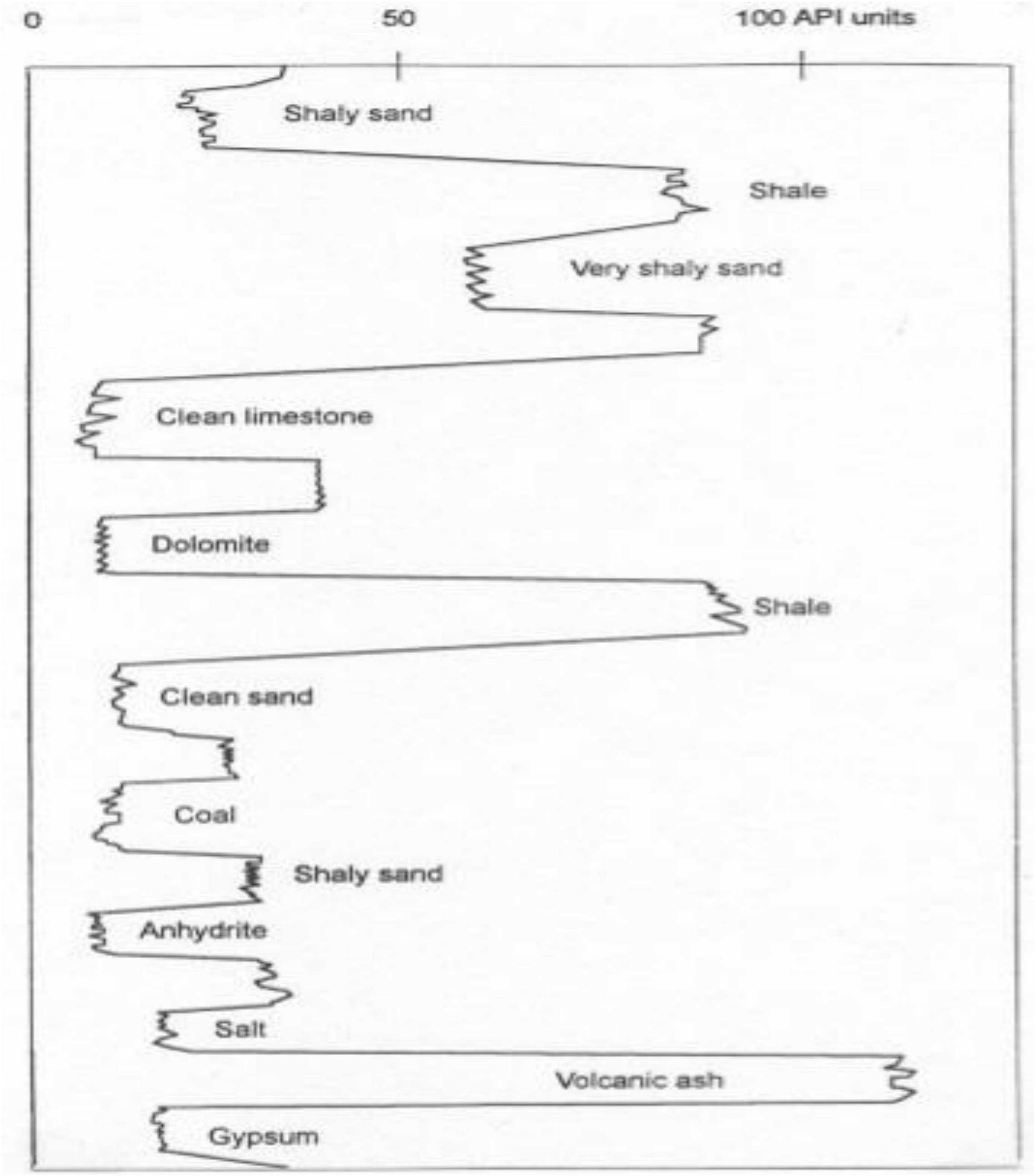
Gamma Ray

**Introduction:**

- The Gamma Ray log is a continuous measurement of the natural radioactivity emanating from geological formations.
- Principal isotopes emitting radiation are Potassium-40,Uranium, and Thorium (K40, U, Th) Isotopes.
- Isotopes concentrated in clays;thus higher radioactivity in shales than other formations.
- Sensitive detectors count the number of gamma rays per unit of time.* Gamma ray logging is a method of measuring naturally occurring gamma radiation to characterize the rock or sediment in a borehole or drill hole. It is a wireline logging method used in mining, mineral exploration, water-well drilling, for formation evaluation in oil and gas well drilling and for other related purposes. Different types of rock emit

different amounts and different spectra of natural gamma radiation.

- This difference in radioactivity between shales and sand stones/carbonate rocks allows the gamma tool to distinguish between shales and non-shales.




Fig(1):Distinguish between shale and Non-shale Rocks.

Shales often contain potassium as part of their clay content, and tend to absorb uranium and thorium as well. A common gamma-ray log records the total radiation and cannot distinguish between the radioactive elements, while a spectral gamma ray log (see above) can.

An advantage of the gamma log over some other types of well logs is that it works through the steel and cement walls of cased boreholes. Although concrete and steel absorb some of the gamma radiation, enough travels through the steel and cement to allow qualitative determinations.

sometimes non-shales also have elevated levels of gamma radiation. Sandstone can contain uranium mineralization, potassium feldspar, clay filling, or rock fragments that cause it to have higher-than usual gamma readings. Coal and dolomite may contain absorbed uranium. Evaporite deposits may contain potassium minerals such as carnallite. When this is the case, spectral gamma ray logging can be done to identify these anomalies.

**Applications:**

- Estimate bed boundaries, stratigraphic correlations
- Quantitative evaluation of shaliness
- Perforating depth control
- Identify mineral deposits of potash, uranium, and coal

- Monitor movement of injected radioactive material
- Correlation between wells and depth determination.

**Spectral GR logging:**

Some specialized gamma radiation logging distinguishes the three component decay chains (potassium, uranium, and thorium) by the wavelengths of their characteristic gamma emissions.

The characteristic gamma ray line that is associated with each component:

- Potassium : Gamma ray energy 1.46 MeV
- Thorium series: Gamma ray energy 2.61 MeV
- Uranium-Radium series: Gamma ray energy 1.76 MeV

Spectral gamma ray logs are used in mineral exploration (phosphats, Uranium and potassium salts) as well as to identify specific clay types, like Kaolinite or Illite. This can be used for environmental interpretation as Kaolinite forms from Feldspars in tropic soils by leaching of Potassium; and low Potassium readings may thus indicate paleosols. The identification of clay types is also useful for calculating the effective porosity of reservoir rock.

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# Uses of the Total Gamma Ray Log

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The gamma ray log is an extremely simple and useful log that is used in all petro physical interpretations, and is commonly run as part of almost every tool combination. Consequently, every well may have as many as 5 independent sets of gamma ray log data.

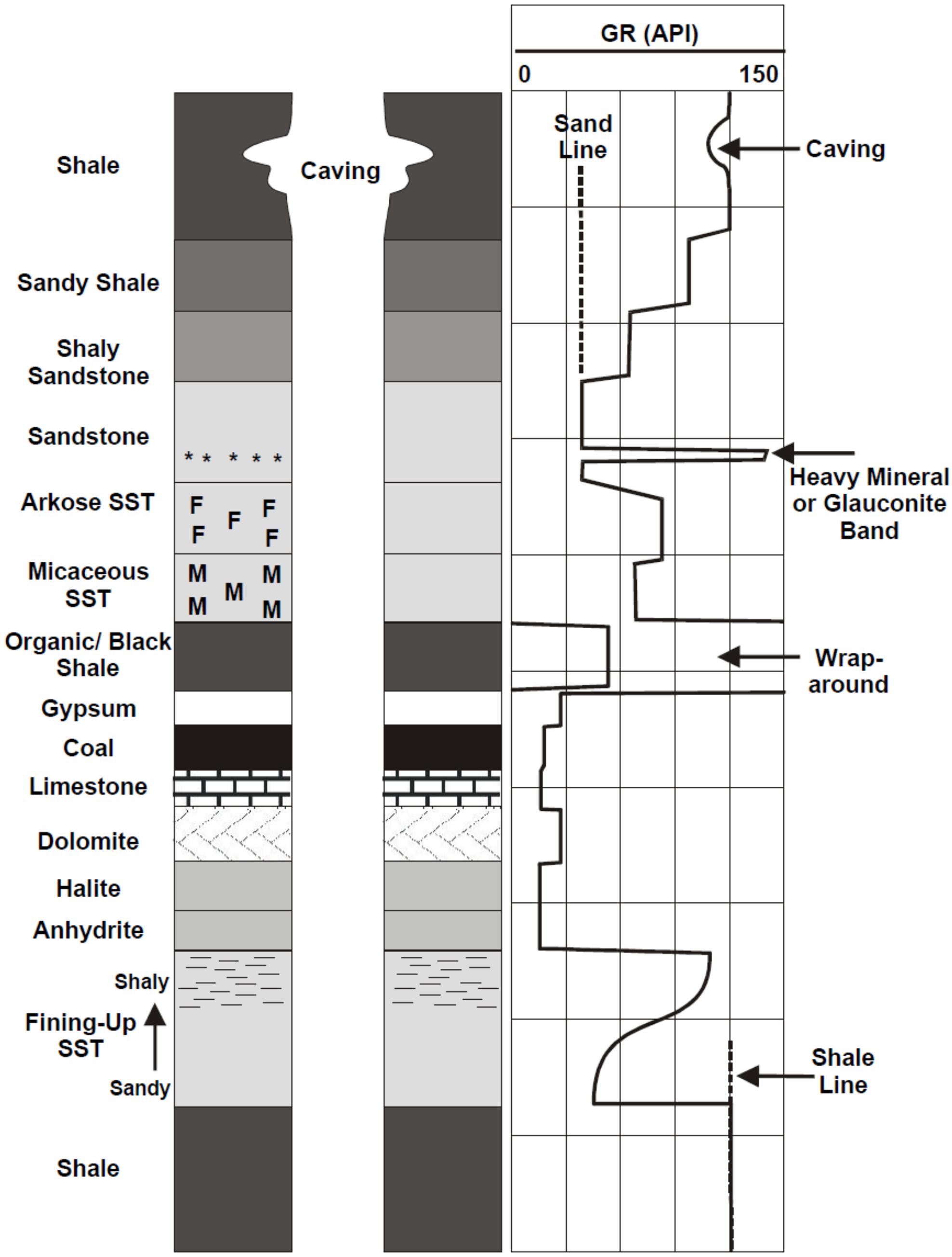
The high vertical resolution of the gamma ray log makes it extremely useful for depth matching and fine scale correlation. The main uses of the gamma ray log are outlined in the following sections. The first three applications are by farther most important.

## (1): Determination of Lithology:

The gamma ray log is an extremely useful tool for discrimination of different lithology's.

While it cannot uniquely define any lithology, the information it provides is invaluable when combined with information of other logs.(fig(2)).

Its main use is the discrimination of shales by their high radioactivity. Figure (2)shows how different lithology's affect the total gamma ray log. Note that shales, organic rich shales and volcanic ash show the highest gamma ray values, and halite, anhydrite, coal, clean sandstones, dolomite and limestone have low gamma ray values. Care must be taken not to generalize these rules too




.Fig(2):Effect of Different Lithologies on Gamma Ray.

much. us sandstones) or both For example aclean sandstone may contain feldspars (arkose sandstones), micas (micaceo (greywackes), or glauconite, or heavy minerals, any of which will give the sandstone higher gamma ray values then would be expected from aclean sandstone.

## (2)Determination of Shale Volume

In most lithology are simple being sandstone and , shales or carbonate and shale.

The gamma ray values can be used to calculate Shaliness ore Shale Volume($V_{sh}$ ) of the rock ,this is important to discriminate between reservoir and none reservoir rocks.

1st we must calculate Gamma ray index:

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

**..............(1)**

Where

$I_{GR}$=Gamma index.

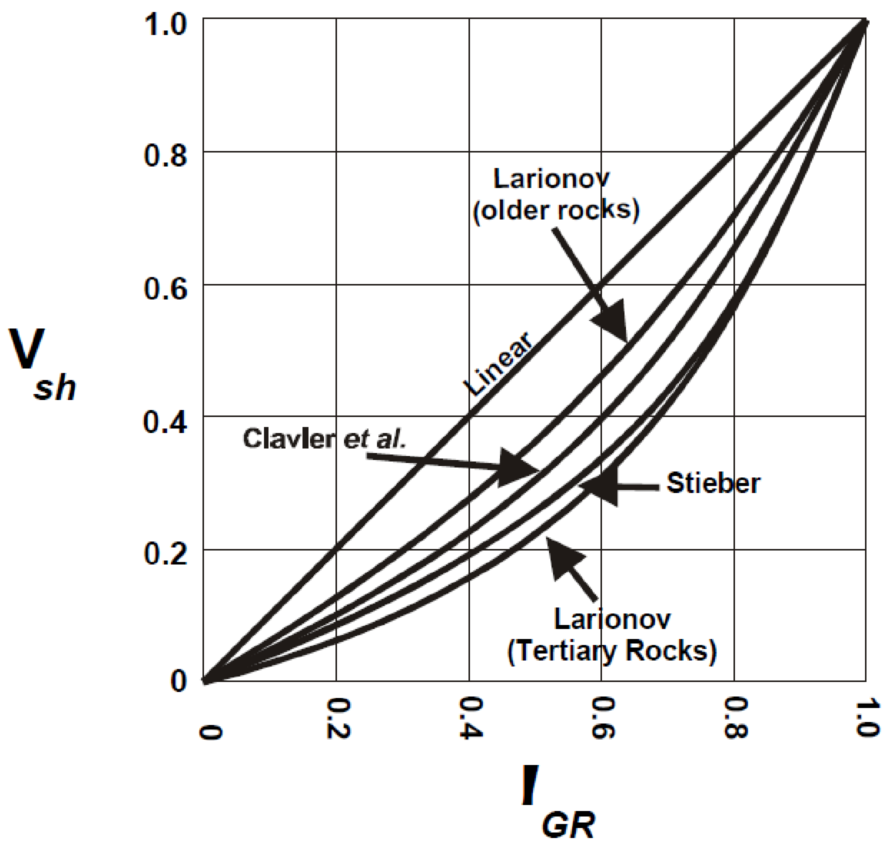
$GR_{log}$=The gamma ray reading at the depth of interest.

$GR_{min}$= the minimum gamma ray reading( usually the mean value in clean sand ore carbonate)

$GR_{max}$=Maximum gamma ray reading( usually mean maximum through shale or clay formation.

Many Petro
physicists assume $I_{GR}=V_{sh}$

To Correct the Value of $I_{GR}$ Should be entered to chart below, Fig(2).




Fig(3):Calculation of Shale Volume.

**(3):Depth Matching:**

**It has high ratability and we can match even in cased hole, most relies on matching the pattern of gamma ray.**

**(4): Cased hole correlations:**

**We used it especially in perforate the correct depth.**

**(5):Recognition of Radio active mineral deposits.**

**Most important are the potass deposites and uranium deposits.**

**Potassium -40 emit gamma ray with a single energy =1.46 Mev. Ther is linear shipe between account of potassume and Gamma ray count, after holke correction , 15API unit per1%wt.$K_2o$.**

**There is no simple relationships between Gamma ray index and abundance of uranium because energy spectrum also includes radiation from another elements in the uranium –radium series.**

**(6): Recognition of None-Radioactive mineral deposits:**

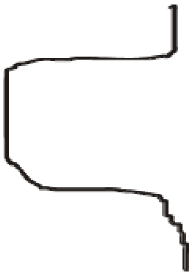
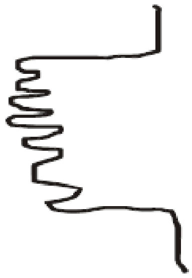
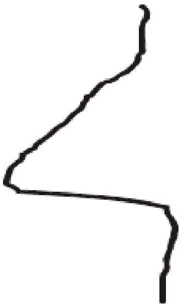
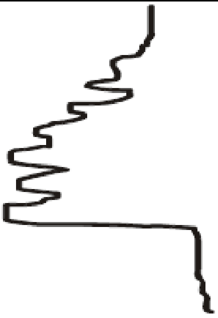
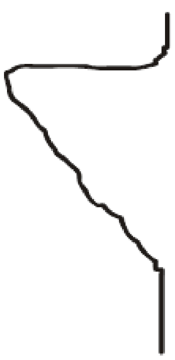
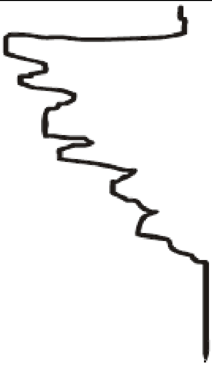
**Like salt, anhydriye, Gypsume and Coal beds. Reorganization by reading table because some evaporates having Pot assume.**

## (7) Radio Isotopes Tracer operation :

**To finde the location of Pipe leakes,Thiefe zones and Chanelling behind the casing,So gamma ray used as detectore.**

## (8):Facies and depositional environment.

**The gradual changes are indicator of litho-faciesand depostional –environment of the rocks and associated with change in grain size and sorting which associated with sedimentary environment as well ase with shaliness of the rocks.Fig(4).**

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

**Fig(4): The gamma ray log and depositional environment.**