

Sample Selection:-

Core sampling has a significant influence on the success of core analysis laboratory measurements. A poorly conducted sampling program may limit the scope and result in ineffective experimental measurements. Sample selection must serve the needs in of different disciplines such as geology, petrophysics and reservoir engineering. Ideally, sampling should result in a statistically meaningful representation of the core material. Sample selection varies depending on the type of the test. As the requirements of basic core analysis and special core analysis differ significantly, samples selection should be done accordingly to meet the overall core analysis objectives.

Basic Core Analysis Sampling:-

Basic core analysis is usually done on every foot (~30 cm). If too many plugs fall in regions of poor quality core material, plugs may be taken at different positions (a few inches away from the predetermined locations). In general, emphasis should be paid to the cutting of plugs as close to the one foot spacing as possible without any regard for variations in lithology. Otherwise a bias towards apparently better formation properties may be unwittingly introduced, which can lead to improper log calibration. However, plugs which represent two different lithologies (on the border of different lithologies) should be avoided as the experimental data obtained on these core plugs can be significantly misleading. Core plugs can be cut both in parallel and in perpendicular orientations to the bedding. This would help to evaluate anisotropic reservoir parameters such as permeability.

Special Core Analysis Sampling:-

As the name suggests, some special precautions should be taken while sampling for special core analysis laboratory (SCAL) measurements. Unlike basic core analysis, samples are not taken at regular intervals for SCAL measurements. Most attention is often placed on rock type within the formation. The location and number of samples chosen for SCAL measurements should be representative of rock type under consideration. A core that first appears completely uniform may actually be highly heterogeneous with respect to petrophysical parameters. Therefore, while making the sample selection, use of a non-destructive imaging technique such as CT scanning is highly recommended. It is also recommended that twice as many samples to be taken for a given measurement for the purpose of maximizing representativeness of the samples, or repeat measurements may be needed. However, the number of SCAL samples is usually much smaller than that in basic core analysis.

Plug Preparation:-

Plug Drilling :-

While drilling plugs, various lubricants are used depending on the core material. Fresh water is used for clean sands and carbonates. Kerosene (or Blandol) is used for shale and halite bearing samples. Brine is used for cores containing clays or from high salinity environments. Unconsolidated cores are often kept as frozen and plugs are drilled using liquid nitrogen. Plugging usually takes 10-15 minutes per piece and plug dimensions are 2.5 cm (1 inch) in diameter and 5-7 cm (2-3 inches) in length for most conventional measurements. Plugs for special core analysis measurements are cut usually little larger (1.5 inch in diameter).

Fluid flow properties may vary with sample orientation. So, care needs to be taken in selecting the direction of the bedding. Horizontal plugs should be drilled parallel to the apparent bedding plane while vertical plugs are drilled perpendicular to the apparent bedding plane.

Plug cleaning:-

Before measuring porosity and permeability, the core samples must be cleaned of residual fluids and thoroughly dried. The cleaning process may also be apart of fluid saturation determination

Fluid saturation is defined as the ratio of the volume of fluid in a given core sample to the pore volume of the sample.

$$S_w = \frac{V_w}{V_p} \quad S_o = \frac{V_o}{V_p} \quad S_g = \frac{V_g}{V_p}$$

$$S_w + S_o + S_g = 1$$

where V_w , V_o , V_g and V_p are water, oil, gas and pore volumes respectively and S_w , S_o and S_g are water, oil and gas saturations. Note that fluid saturation may be reported either as a fraction of total porosity or as a fraction of effective porosity. Since fluid in pore spaces that are not interconnected can not be produced from a well, the saturations are more meaningful if expressed on the basis of effective porosity. The weight of water collected from the sample is calculated from the volume of water by the relationship.

$$W_w = \rho_w V_w$$

Where ρ_w is water density in g/cm³. The weight of oil removed from the core may be

computed as the weight of liquid less weight of water $W_o = W_L - W_w$

where W_L is the weight of liquids removed from the core sample in gram. Oil volume may then be calculated as W_o/ρ_o .

and oil and ,Pore volume V_p is determined by a porosity measurement water saturation.

Measurement Methods

Direct Injection of Solvent/ 1

The solvent is injected into the sample in a continuous process. The sample is held in a rubber sleeve thus forcing the flow to be uniaxial.

Centrifuge Flushing/ 2

A centrifuge which has been fitted with a special head sprays warm solvent onto the sample. The centrifugal force then moves the solvent through the sample. The used solvent can be collected and recycled.

Gas Driven Solvent Extraction/ 3

The sample is placed in a pressurized atmosphere of solvent containing dissolved gas. The solvent fills the pores of sample. When the pressure is decreased, the gas comes out of solution, expands, and drives fluids out of the rock pore space. This process can be repeated as many times as necessary.

Soxhlet Extraction/4

A Soxhlet extraction apparatus is the most common method for cleaning sample, and is routinely used by most laboratories. As shown in Figure 2.1a, toluene is brought to a slow boil in a Pyrex flask; its vapors move upwards and the core becomes engulfed in the

toluene vapors (at approximately 110°C). Eventually water within the core sample in the thimble will be vaporized. The toluene and water vapors enter the inner chamber of the condenser, the cold water circulating about the inner chamber condenses both vapors to immiscible liquids. Recondensed toluene together with liquid water falls from the base of

the condenser onto the core sample in the thimble; the toluene soaks the core sample and dissolves any oil with which it comes into contact. When the liquid level within the Soxhlet tube reaches the top of the siphon tube arrangement, the liquids within the Soxhlet tube are automatically emptied by a siphon effect and flow into the boiling flask.

The toluene is then ready to start another cycle.

A complete extraction may take several days to several weeks in the case of low API gravity crude or presence of heavy residual hydrocarbon deposit within the core. Low permeability rock may also require a long extraction time.

Dean-Stark Distillation-Extraction/5

The Dean-Stark distillation provides a direct determination of water content. The oil and water are extracted by dripping a solvent, usually toluene or a mixture of acetone and chloroform, over the plug samples. In this method, the water and solvent are vaporized

recondensed in a cooled tube in the top of the apparatus and the water is collected in a calibrated chamber. The solvent overflows and drips back over the samples.

The oil removed from the samples remains in solution in the solvent. Oil content is calculated by the difference between the weight of water recovered and the total weight loss after extraction and drying.

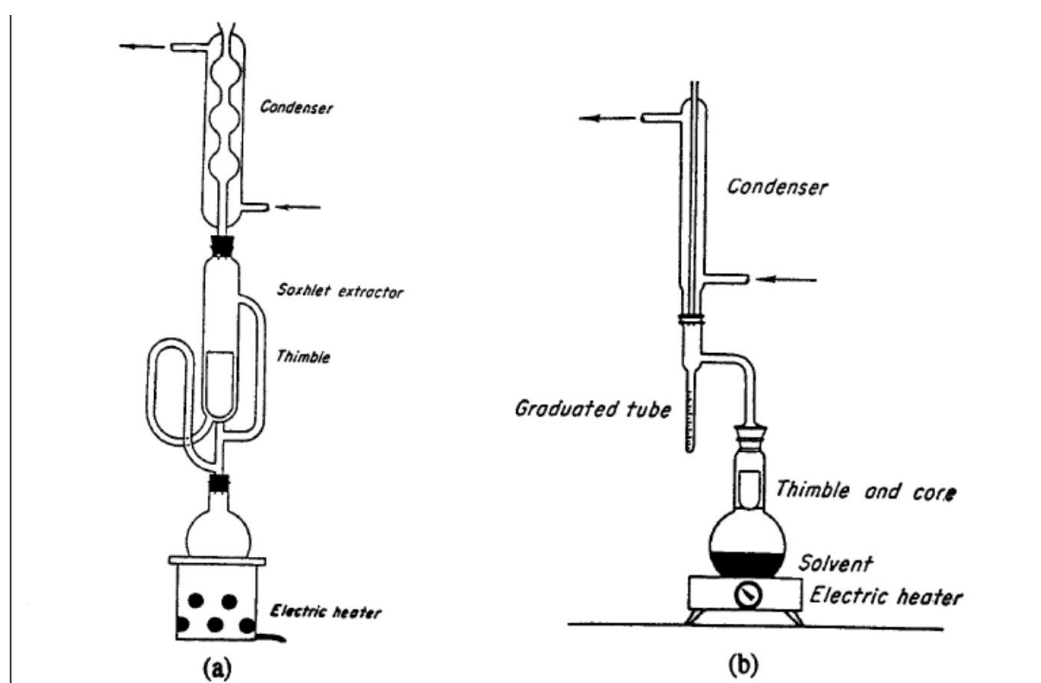
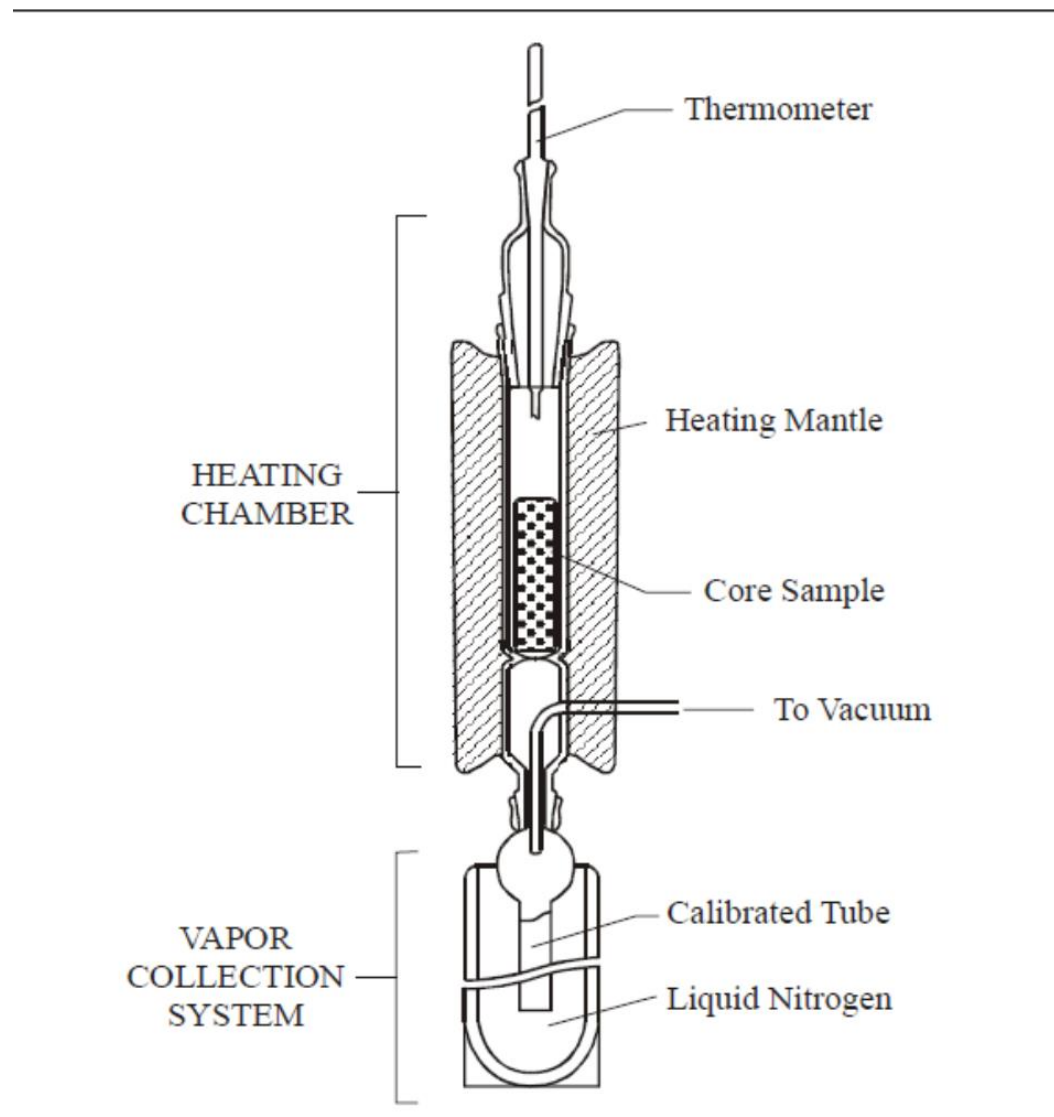


Fig. 2.1: Schematic diagram of Soxhlet (a) and Dean-Stark (b) apparatus.

Vacuum Distillation/6

The oil and water content of cores may be determined by this method. a sample is placed within a leakproof vacuum system and heated to a maximum temperature of 2300C. Liquids within the sample are vaporized and passed through a condensing column that is cooled by liquid nitrogen.



Drying :

After the saturation measurement is conducted and cleaning is performed, the core is dried. Prior to porosity and permeability measurements, all the remaining solvent and the salt must be removed. There are several drying techniques;

oven drying is the most common, inexpensive and the quickest one

Multiple core plugs can be simultaneously dried in a vacuum convection oven. The temperature is set at around 95 °C and each core sample should be dried until constant weight is obtained. When hydrated minerals such as clays are present, humidity ovens may be used to minimize sample alteration. Humidity ovens can be set at 60°C and 40% relative humidity. Because of the low temperature, drying may take several days. The resulting 'effective' porosity needs careful calibration to relate with either log-derived effective or total porosity.