Chapter 3 CEMENTING Why running cement?Marly limestones are overlain by siltstones and clays with interbedded quartz sands.The ideal wellbore for cementing has the following characteristics: A stabilized wellbore (e.g., no sloughing, thin and impermeable mud filter cake, and no losses or inflow) A uniform wellbore geometry (e.g., in gauge and as uniform as possible, no excessive doglegs or wash!outs) Conditioned mud (e.g.; minimum viscosity, yield point, gel strength and density; degassed) Accurate wellbore data (e.g., bottomhole static tem!perature [BHST], bottomhole circulating tempera!ture [BHCT], pore pressures, fracture gradients, hole caliper, well trajectory, etc.) A centered casing with a 1.5–in.A successful primary cement job: Meets the chemical and physical requirements of slurry performance and displacement mechanics Performs the job design, which has practical proce!dures for field execution (e.g., availability and ca!pacity of equipment, composition of cement and mud removal systems, etc.) Confirms cement systems by testing with the cement and water to be used on the actual job Implements all special instructions or procedures determined during the job design.Figure 2.3: Tectonic elements and geologic provinces of Sirte basin 2.3.1 The pre rifting sediments (Cambro – Ordovician): The Cambro–Ordovician sediments were represented by Gargaf Formation which consisted of continental sandstone, conglomerate and shale beds.2.3.3 The Post Rifting Sediments: This stage represents the Oligocene – Miocene sediments (Arida sandstone Formation), which was mainly shallow marine (Tidalto supra tidal environment) as result of regional lowering in the sea level (Regression).Mud Additive Effect on Cement Barite Increase density reduces compressive strength Caustic calcium compounds Acts as an accelerator Diesel oil Decreases density Thinners Act as retarders The mixture of mud and cement causes a sharp increase in viscosity.It is located in the northern margin of the African plate, with approximate coordinates (14o00' – 20o00'E) and (28o00' – 31o00'N).The northern margin of the African plate was effected by a series of tectonic activities due to interaction of the African and Eurasian plates that formed the structural features of the Sirte basin (Elakkari, 2005). 2.4).The primary reservoirs of Sirte basin within concessions included the Cambro– Ordovician to Cretaceous Gargaf formation, the Upper Cretaceous sand and carbonates, the Paleocene carbonates, the Eocene carbonate and Oligocene sandstone.These sediments were mainly marine of different depositional environments as result of fluctuation in sea level either raising (Transgression) or lowering (Regression), controlled by NW–SE oriented horst and graben structures.The consequences of an unsuccessful cement job can be: Casing corrosion occurs when the casing is exposed to formation brines, H2S or CO2 Excess lateral loads result in the ovaling, buckling or complete collapse of the casing, especially where plastic salts are cased off.PfPHP fracture After Cementing Job: To ensure a good cement bond, There are two types of acoustic logs namely: the cement bond log (CBL) and the variable density log (VDL) and they are usually done together.The Tertiary sediments represented Hagfa Shale Formation which acted as source rock for Tertiary reservoirs in the Sirt Basin.The Hagfa Formation overlain by succession of carbonate, shale, and dolomite and evaporate.Properties of Cement: The main properties required of cement slurry are summarized as follows: Compressive strength: To support the casing string with compressive strength of 500 psi, it is generally thought to be adequate (includes a certain safety factor).Most units are capable of mixing and displacing 50–70 cubic feet of slurry per minute, In order to minimize contamination by the mud in the annulus a pre–flush or spacer fluid is pumped ahead of the

cement slurry.The amount of water loss that can be tolerated depends on the type of cement job, for example:- Squeeze cementing requires a low water loss since the cement must be squeezed before the filter cake builds up and blocks the perforations; Primary cementing is not so critically dependent on fluid loss.Lightweight additives (extenders): These are used to reduce slurry density for jobs where the hydrostatic head of the cement may exceed the fracture strength of certain formations.Cement Equipment: Some equipment is used in cementing operation, as follows: Down hole cementing equipment: In order to carry out a conventional primary cement job, some special equipment must be installed in the casing string as it is run: Guide shoe: A guide shoe is used to guide the casing through the hole, avoiding jamming the casing in washed-out zones, or in deviated wells.Figure 2.1: showing basins of Libya oil field 2.2 Geological Setting and Tectonic Elements: The Sirte basin is one of the youngest sedimentary basins in Libya and covers an area of approximately 600.000 km2 (Fig.The final structure stage developed the traps and migration of hydrocarbon from source rocks and accumulated in the different reservoirs during Early Oligocene and Pleistocene Epoch (www.scihub.org).Figure 2.2: A stratigraphic cross section of the Sirte basin showing source rocks and hydrocarbon accumulations (Schlumberger, 2006) 2.3 Stratigraphy: The sediments of Sirte basin could be divided into: o The Pre Rifting Sediments (Cambro – Ordovician).Functions of cement and cementing can be summarized as follows: Cementing is the process by which cement slurry is placed in the annulus, bonding the casing to the formation.Other types of cement not covered by the API specification include:- Pozmix cement: Formed by mixing Portland cement with Pozzolan (ground volcanic ash) and 2% bentonite.Under standard laboratory conditions (1000 psi filter pressure, with 325 mesh) a slurry for a squeeze job should give a fluid loss of 50-200 cc. For a primary cement job 250-400 cc is adequate.Seawater Retarders: In deep wells the higher temperatures will reduce the thickening time of the cement slurry and the cement becomes fewer pumps able.This is necessary because the cement slurry in the annulus is denser than the displacing fluid in the casing, thereby creating a U-tube effect.Surface cementing equipment: The following surface equipments are used in cementing: Mixing and pumping facilities: In the most rigs, cement materials are handled in bulk, which are blended and mixed much easier.The post Cretaceous faulting system was generated by sinistral and dextral strike slip movement of Sahara platform west ward long the Mediterranean Sea (Tethys).2.4.2 Gattar formation: The mid to late Eocene Gattar Formation consists of chalky limestones, marly in parts, with occasional shale interbeds.The axis of thicker deposits between the two fields reflects up to 100 ft of subsidence during the deposition of Gattar Limestones.More commonly, job objectives are: Achieve the desired cement tops to protect the cas!ing from corrosion.Classes D, E and F: These are known as retarded cements due to a coarser grind, or the inclusion of organic retarders (lingo sulphonates).The slurry should have sufficient thickening time to allow for mixing, pumping and displacement before the cement sets and hardens in the annulus.Slurry density: Standard slurry densities may have to be altered to meet specific requirements (e.g., a low strength formation may not be able to support the hydrostatic pressure of cement whose density is around 15 ppg).It is recommended that the cement slurry is displaced under turbulent conditions, except in areas where this may cause the fracturing of weak formations or washouts, in which case plug flow conditions should be used.(A pressure of 1000-1500 psi is applied to allow the dart to shear the retaining

pins and move the sleeve down to uncover the ports).Total time of cementing job = displacement time + mixing time + release time Total time of cementing job =(displacement volume)/(displacement rate)+mixing time + release time Hydrostatic pressure of cement slurry: Hydrostatic pressure must be less than fracture pressure of the formation and greater than formation pressure.Formation pressure = hydrostatic pressure of drilling fluid – ?Psafe Fracture pressure = fracture gradient x TVD PH = 0.052 x ?It shares its borders with Tunisia and Algeria on the west, Egypt on the east, Niger and Chad on the south, Sudan on the south east, while in the north is located on the Mediterranean cost.The formation of NWSE faulting system of horst and graben patterns started in Early Cretaceous and culminated during the Tertiary.Throughout the Late Cretaceous, the sea continued to advance south wards and by the end of Maastrichtian age only a few scattered crests remained above the sea level as isolated island.The Gargaf Formation bounded by unconformable boundaries and overlain by Bahi Formation and underlain by Basement igneous rocks.These sediments represented Bahi sandstone, Waha, Sirte Shale and Kalash Formations.Figure 2.4: Stratigraphic section of Sirte basin 2.4 The main formations in the study area In this section local variations in the sequence above the Facha reservoir are described and the implications discussed.The top Hon surface generally follows the form of the reservoir (Facha) top, with two highs axially aligned northwest–southeast.If the top of the evaporites are non–erosional and assumed to have been horizontal at the time of deposition, then the isopach map indicates the form of the underlying Facha reservoir at this time.Planning the Cement Job: Each cement job must be carefully planned to ensure that the correct cement and additives are being used, and that a suitable placement technique is being employed for that particular application:– The cement can be placed correctly using the equipment available.These tests will help to assess the effect of different amounts of additives on certain cement properties (e.g. thickening time, compressive strength development etc.) [3].Costly and time–consuming remedial cementing is required to correct the primary cement job or to repair the damage resulting from the poor primary cement job; well production is stopped during this operation.Corrosion resistance: Formation water contains certain corrosive elements, which may cause deterioration of the cement.Common types of additive used include:– Barite (barium Sulphate) – This can be used to attain slurry densities of up to 18 ppg.Mud contaminants: As well as the compounds deliberately added to the slurry on surface to improve the slurry properties, there will also be the effect of the mud down hole which comes into contact with the cement in the casing or in the annulus.To prevent mud contamination of the cement a spacer fluid is pumped the annulus is that it forms channels which are not easily displaced.The mixer consists of a funnel shaped hopper, a mixing bowl, a water supply line and an outlet for the slurry.The height of this cemented part of the annulus will depend on the fracture gradient of the formation (a height of 3000'–4000' is common), Figure (3.7) illustrate the steps of the first stage of cementing.When the wiper plug reaches the float collar the rubber diaphragm is ruptured, allowing the cement slurry to flow through the plug.(A wiper plug is sometimes not used if the casing is badly scaled, to avoid bridging) When the solid shut–off plug reaches, the float collar lands on the plug and stops the displacement.To ensure that the cementing job in the safe side, there are two factors must be considered: Total Time of Cementing Job: The time that required for cement slurry movement from the surface inside the casing and return back through the annulus to the surface.The

period from Maastrichtian to Upper Eocene was characterized by macro basin subsidence and continued transgression with minor regression.The Pre-rift and Post-rift sediments were dominated by clastic, whereas the Syn-rift sediments were dominated by carbonate (Fig.Wireline logs through the Hon evaporites show excellent correlation across the area and a detailed comparison allows identification of missing section which is interpreted as fault cuts.2.4.3 Bu M'ras formation: The Bu M'ras Formation is late Eocene in age and consists of shales with limestone interbeds.Stimulation treatments or secondary/tertiary recov!ery cannot be confined to the zone of interest.(See Table 3.1) To properly design a cement job, accurate system properties obtained through laboratory testing of field batch samples and mix water are imperative.Effects of reducing amount of mix water: They can be summarized as follows: Slurry density, compressive strength, and viscosity will increase.Permeability: After the cement has hardened the permeability will be very low (< 0.1 mille-Darcy).This is much lower than most producing formations.Major Cement Additives: Some additives should be used to improve the casing function, as follows: Accelerators: These are added to shorten the time taken for the cement to set.In reducing the slurry density the compressive strength is also reduced and the thickening time increases.Common types of lightweight additives used include:- Bentonite (2-16%) - This is by far the commonest type of additive used to lower slurry density.Diatomaceous earth (10 - 40%) - The large surface area allows more water absorption, and produces low density slurries (Down to 11 ppg).Friction reducing additives (dispersants): These are added to improve the flow properties of the slurry.In particular they will lower the viscosity so that turbulence will occur at a lower circulating pressure, thereby reducing the risk of breaking down formations.On offshore rigs the cement is transferred pneumatically from supply boats to the storage bins, Fig. 3.6) provides the connection between the discharge line from the cement unit and the top of the casing designed to hold the cement plugs used in the conventional primary cement job.Cementing Stages: In cementing conductor and surface casing strings the cement should completely fill the annulus back to surface:- Long pumping times.For these reasons an alternative cement operation is carried out in two stages:- First stage: The procedure is as described earlier except that a smaller volume of slurry is used, so that only the lower part of the annulus is cemented.Throughout the cement job the mud returns from the annulus should be monitored to ensure that the formation has not been broken down.The Bahi, Waha and Arshad were the principal reservoirs while the Sirt Shale Formation was the source rock.The conventional method of doing this is to pump cement down the casing and displace it around the casing shoe into the annulus.To assist the engineer in designing the cement slurry, pilot tests are carried out in the laboratory before the job goes ahead.annular gap, which prevents slurry dehydration and bridging.Primary cementing is one of the most critical stages during the drilling and completion phases of a well, and it has only one chance for success.Gas or fluid annular migration occurs as a result of poor zonal isolation.The differences between the cements lie in the distribution of the five basic compounds, which are used to make cement: C3S, C2S, C3A, C4AF, and CaSo4; (See table 3).Classes A and B: These cement classes are generally cheaper than other classes of cement and can only be used at shallow depths where there are no special requirements.Gypsum cement: Formed by mixing Portland cement with gypsum, giving a high early strength and can be used for remedial work.Consequently they are often used to seal off water

producing zones where they absorb and set to form dense, hard cement.The casing shoe should not be drilled out until this strength has been attained – referred to as 'waiting on cement' (or WOC).Thickening times ('pump ability'): This is the time during which the cement slurry can be pumped and displaced into the annulus (i.e., the slurry is pumped during this time).Generally 2–3 hours thickening time is enough, including a safety factor to allow for delays and interruptions in the cementing operation.If water is lost from the cement slurry before it reaches its intended position its 'pump ability' will decrease and water sensitive formations may be adversely affected.Lowering the C3A content of the cement increases the Sulphate resistance.Common types of accelerator used include: Calcium chloride (CaCl2) 1.5 – 2.0% Sodium chloride (NaCl) 2.0 – 2.5%.Retarders are used to prolong the thickening time and avoid the risk of the cement setting in the casing prematurely.The use of these additives allows more mix water to be added, and hence increases the yield of the slurry.Hematite (Fe2O3) – The high specific gravity of hematite can be used to raise slurry densities to 22 ppg.Fluid loss additives: It is used to prevent dehydration of the cement slurry and premature setting.Carboxyl methyl hydroxyethyl cellulose (CMHEC) 0.3 – 1.0% (CMHEC will also act as a retarder).Commonly used additives include:– Polymers 0.3–0.5 lb/sac of cement.A float shoe prevents cement from flowing back into the casing, once the cement is displaced behind the casing.(3.1) The float collar contains also a non–return valve so that the cement slurry cannot flow back up the casing.(Sometimes the guide shoe also has a non–return valve as an extra precaution) It is essential that the non–return valves are effective in holding back the cement slurry.This filling up process increases the running in time and can be avoided by the use of automatic or differential fill up devices fitted to the float collar or shoe.The proper use of centralizers will help to: Improve displacement efficiency (i.e., place cement around the casing).Each centralizer is hinged so that it can be easily clamped onto the outside of the casing and secured by a retaining pin.The spacing of centralizers will vary depending on the requirements of each cement job.Wipers / Scratchers: These are devices run on the outside of the casing to remove mud cake and break up gelled mud, Fig.The unit normally has twin pumps (triplex, positive displacement) which may be diesel powered or driven by electric motors.The volume is based on the need to provide sufficient separation of mud and cement in the annulus (20–50 bbl.When the pre–determined volume has almost completely pumped, the pumps should be slowed down to avoid excessive pressure when the plug is bumped.After the first stage is complete a special dart is released from the surface, which opens the ports in the stage collar allowing direct communication between casing and annulus.Most of its production is from oil fields which are distributed in the major sedimentary basins in Libya (Fig.The formation of the Sirte basin was associated with series of subsidence events which caused number of troughs (Fig.In the beginning of the Late Cretaceous (Cenomanian), the sea entered the basin and only the major horsts in Sirte basin were emergent (Fig.2.3.2 The syn rifting sediments (late cretaceous–late Eocene): This stage represented the Late Cretaceous– Late Eocene sediments (basin fill stage).The Cretaceous sediments unconformable over lay the Gargaf quartzite Formation.However, in South Hakim the Hon surface crest is offset to the southeast, indicating the later focus of structural activity.The structural low between the two fields is still apparent but of reduced relief, suggesting any faulting penetrating the Hon surface is minor.North Hakim shows little change, but the crest of the South Hakim structure was originally further northwest, only

displaced to the present position by later movement.This confirms the focus of residual movement and/or compactional drape over deeper structures.2.4.4 Post Bu M'ras section: The post Bu M'ras section consists of undifferentiated Oligocene sediments.After a hole is drilled, the well casing is then inserted and the gap between this casing and the wall of the hole is cemented.More casings are then run down in a smaller hole, cemented, and repeated until proper depth is achieved.The cement will isolate zones and support the casing throughout the life of the well.Execution: In addition to the effects of accurate well data on de!sign, cement–job success depends on the job being executed in compliance with the job design.Provide adequate casing sup!port, to maintain well control during the cement placement and setting.Class B has a higher resistance to Sulphate than Class A. Class C: This cement has a high C3S content and so produces a high early strength.Their increased cost must be justified by their ability to work in deep wells at higher temperatures and pressures.Class H has a coarser grind than Class G and gives better retarding properties in deeper wells.If the amount of mix water is increased significantly above the recommended values, some bentonite should be added to absorb the free water.Two commonly found compounds are sodium and magnesium sulphate.However if the cement is disturbed during setting (e.g. gas intrusion) higher permeability may occur (5–10 Darcy).Additives may be in granular or liquid form and may be blended with the bulk cement or added to the mix water.The amount of additive used is usually given in terms of a percentage by weight of the cement (based on each sack of cement weighing 94 lb).The WOC time is usually based on the time taken for the cement to attain a compressive strength of 500 psi.Common types of retarders used include: Calcium lingospulphonate (sometimes with organic acids) 0.1 – 1.5%.The result is a slight decrease in compressive strength, and increase Sulphate resistance.Sand – graded sand (40–60 mesh) gives a 2 ppg increase in slurry density.Calcium lingo sulphonate 0.5–1.5 lb/sac.The major effect of a highly viscous fluid in preventing a good all round cement bond is around the casing.When a guide shoe contains a valve element, it is described as a float shoe.It acts as a seat for the cement plugs used in the pumping and displacement of the cement slurry.At the end of the cement job there will be some cement left in the casing between the float collar and the guide shoe which must be drilled out, Fig.This creates a buoyancy effect, which can be reduced by filling up the casing from the surface at regular intervals while the casing is being run (every 5–20 joint).The ports through which the fluid enters are blocked off before the cement job begins.The use of a differential fill–up device also reduces the effect of surge pressures on the formation.Centralizers: These are hinged metal ribs, illustrated in Fig.Centralizers are especially useful in deviated wells where the casing tends to lie on the lower side of the hole.The centralizer is prevented from moving up and down the casing by positioning the centralizer across a casing coupling or stop collar.For large volume cement jobs several bulk storage bins may be required on the rig.For any cement job, it must be sufficient water available to mix the slurry at the desired water/cement ratio.Automatic devices (den so–meters) can also be used to measure the slurry density.For water based muds the spacer fluid is often just water, but specially designed fluids are available.Cement jobs are often unsuccessful because the cement plugs are installed incorrectly or not released properly.There are ports in the stage collar, which are initially closed by an inner sleeve, held by retaining pins.Circulation is established through the stage collar before the second stage slurry is

pumped, Fig.If necessary, more than one stage collar can be run on the casing so that various sections of the annulus can be cemented.One disadvantage of stage cementing is that the casing cannot be moved after the first stage cement has set in the lower part of the annulus.Condition the mud to ensure good flow properties (low PV, low YP) so that it can be easily displaced.o The Syn Rifting Sediments (Late Cretaceous–Late Eocene).The Kalash Formation was widespread in concessions and acted as a cap rock in some places of central Sirt basin.2.4.1 Gir formation (Hon Member): The Hon Member of the Gir Formation is dominated by a thick sequence of anhydrite.Thin dolomite interbeds occur throughout, with interbeds of massive salt in the latter part.A good cement job is essential to allow further drilling and production operations to proceed.Prevent the movement of fluids from one formation to another through the annulus.Protect the casing from corrosive fluids in the formations.The cement will achieve adequate compressive strength as soon as it is placed.Successful primary cementing: The wellbore conditions can affect the success of a primary cement job.Designs of cement job: The cement job is designed for turbulent–flow dis!placement whenever possible.Casing centralization must be part of the cementing recommendation.Evaluation: Job evaluation is the comparison of job results versus the job objectives and, if different, the determination of the reason.Classification of Cement: There are several classes of cement approved by the API.Diesel oil cement: A mixture of one of the basic cement classes (A, B, G, and H) with diesel oil or kerosene.Lower volume of slurry is obtained from each sack of cement.If the amount of mix water must be increased above the recommended values, some bentonite should be added to absorb the free water.The obtained cement compressive strength is a function of several variables:– Temperature.Most slurry densities vary between 11–18.5 ppg.These will react with lime and C3S to form large crystals of calcium sulphoaluminate.These crystals expand and cause cracks in the cement structure.For high Sulphate resistant cement the C3A content should be 0–3%.Accelerators are especially important in shallow wells where temperatures are low.In deeper wells the higher temperatures promote the setting process, and accelerators may not be necessary.It will also however reduce compressive strength and Sulphate resistance.The increased yield due to the bentonite added may be seen in cement tables.Pozzolan – This may be used in a 50% / 50% mixes with the Portland cements.\ Heavy additives: These are used when cementing through over pressured zones.Common additives used include: Organic polymers (cellulose) 0.5 –1.5%.It can be a simple guide or may contain a ball valve or flapper valve, Fig.Shoes have either inner parts made of aluminum or cement; both being easily drillable, with the advantage that cement is more resistant to impact.These devices allow a controlled amount of fluid to enter the casing at the bottom of the string.Cement Plugs: The main functions of cement plug which shown in Fig.Wipe the casing from mud before cement is pumped and then wipe casing from the cement film after the complete volume of cement is pumped.Their function is to keep the casing away from the borehole so that there is some annular clearance on all sides.In critical zones they are closely spaced, while on other parts of the casing string they may not be necessary at all.The density of the slurry should be regularly checked during the cement job.These units can operate at high pressures (up to 20,000 psi) and at variable flow rates.The cement pumps or the rig pumps may be used for the displacement.Excessive hydrostatic pressure from the cement column.The casing is the circulated clean before the cement operation begins (at least one casing volume should be circulated).It

is essential that the cement plugs be correctly placed in the cement head.The first plug (wiper plug) is pumped down ahead of the cement to wipe the inside of the casing clean.The second plug (shut–off plug) is pumped down after the cement and is followed by the displacing fluid.The plug should be 'bumped' to pressure up to 1000 psi (do not exceed burst pressure of casing).The pressure is then bled off slowly to ensure the float valves are holding.The volume of displacing fluid necessary to land the plug should be calculated before the job begins.Fracture gradient = 0.9 psi/ft (given).TVD = true vertical depth.Pressure.(3.1).3.3.(3.4).(3.4).(3.10).?2.3).