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Artificial Sandstone Cores Production with a Wide Range of Petrophysical Properties

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Abstract. In petroleum engineering, to investigate the effect of a certain factors on rock permeability, it is more convenient to use homogenous rock samples with nearly constant initial permeability. Obtaining a sandstone rock samples with a constant initial permeability is very difficult. Also the difficulties in getting (or lack) the natural field cores let many researchers to look for a permanent source of rock samples. Adding to these circumstances, the permanent need for continuos supply of rock cores for teaching purposes encourages to look for an alternative source of rock samples.

The purpose of this paper is to simulate natural sandstone rock and come-up with a homogeneous compacted rock with known properties. Many scholars investigated the effect of some sedimentation and compaction factors on rock properties, but few attempts to manufacture an artificial sandstone matrix with wide ranges of rock properties were made. In this study the main rock lithification factors were defined and their effect on rock properties were evaluated. These factors are grain size, cementing material concentration, compaction (confining) pressure, and dehydration temperature. Five groups of a grain size ranged between 45 and 300 µm were used. The cementing material was added 4 to 8 % by weight of sand grains, and a 11350 to 23500 psi compaction pressure was applied to shape the sandstone cores. By varying these factors, a wide range of rock samples with different properties were produced. The stability of these samples and their properties were evaluated. A homogeneous artificial sandstone cores samples with a permeability of 15 to 5000 md and a porosity of 20 to 33 % were obtained. The mean pore size of these core samples was between 11 and 50 µm. The results of this study were presented as graphs of simulated lithification factors versus rock properties. With the help of these graphs, a sandstone core with a certain initial permeability and mean pore size can be produced.

Introduction

Sand can be defined as an unconsolidated sedimentary deposit of clastic particles that vary in size between 1/16 mm and 2 mm and are derived from a source rock through mechanical means and/or as a result of chemical weathering. A sandstone is the consolidated or cemented sand grains which have an average specific gravity of 2.65 [1].

With progressive sedimentation the imposed loads on the deposited sand grains could range from zero psi up to the weight of several miles of superposed sediments (overburden stresses of 14000 – 36000 psi). During the initial stages of sedimentation, the pressure is probably hydrostatic. As sedimentation progresses, the pressure becomes triaxial. Finally, as the overburden load becomes large enough, the pressures are probably become uniaxial [2].

The sedimentation environment of the sandstone affects the fluid flow through the rock. The main environmental deposition factors that resulted in the formation of sandstone are the lithification factors. These factors include: size and shape of sand grains, cementing material, compaction pressure, and dehydration temperature of the cemented sand

Factors Affecting Rock Properties

(1) Grain size and shape

Particle shape and roundness are two very significant factors in the mechanical compaction of sands. These two factors affect both bridging (the ability of grains to resist deformation by sliding and rearrangement) and porosity [1]. Roundness is a measure of the sharpness of the particle edges, regardless of shape. Large diameter sand grains are usually more rounded than the smaller ones. Sphericity is a measure of the degree the shape of the particle approaches that of a sphere [2].

The porosity and the permeability of the assemblage of grains change with the change in the ratio of large to small grains and with the relative proportion of large and small grains [3]. Also porosity diminishes as the grains deviate from uniform size distribution, because: (a) the finer grains fill the voids between the large grains and (b) the coarsest grains reduce the porosity by occupying a volume that would otherwise be occupied by the finer, porous material [3].

The porosity of the fine sands is on the average greater than that of the coarse sands, as small grains has a bad sphericity and consequent poorer packing. Where all sand grains are perfect spheres, porosity is independent of absolute grain size. Permeability decreases as the average grain size decreases [3].

(2) Cementing material

Cementation processes in coarse-grained sediments have a pronounced tendency to cement the mass around the points of particle contacts. Thus, there is only a relatively small effect on the total porosity or the volume of large pores, but a substantial effect on the fine pore, with ultimate blocking of the natural constrictions in the flow path and great reduction in permeability [1]. Calcite-cemented grains are more loosely packed than silicate-cemented grains [3]. Thus, sodium silicate was used to cement and bond the sand grains at the contact points.

A good adhesive requires silicates generally with $SiO_2:Na_2O$ ratios from 2.5 to 3.8. For maximum adhesive strength the lower ratio types are used because they can be obtained with a higher concentration of solids. For more water resistance bonds, the higher ratios are needed [4].

The surface tension of the silicate solution will draw the silicate solids into the region of the grain to grain contact. When dehydrated, the silicate solids efficiently contribute to the strength of the sand body. The greater volume of dilute silicate solution allows for more efficient wetting of the sand as well as buildup of solid silicate at grain to grain junctions and a more efficient bond is formed. Up to 5% cement may be present before cementation starts to affect the porosity. Permeability and porosity decrease with increasing cement content, as would be expected [3].

(3) Compaction pressure

There will be some gain in density without major deformation as particles flow past each other into voids. But sticky, rough or irregularly shaped particles will inhibit this tendency. Change of relative positions may involve particle deformation (particle edges breaking or particle shattering) to pass through a small gap [6].

Sand grains are compacted by grain re-arrangement and shattering of sharp grain points. Compacted, well-rounded, smaller-sized grains have a high break (shattering) point pressure than lesser compacted, angular, large grains [1].

Densification by compaction is accompanied by removal of the largest voids, which resulted in a considerable restriction of flow or permeability reduction. Combined effect of cementation and compaction would result in much more rapid reduction of porosity in highly angular sands (fine sands tend to be more angular) [1].

The compaction of the sand plus sodium silicate mixture (to form sandstone body) can be done by using a steel cell and a punch. The mixture is poured into the cell and pressed by the punch (connected to hydraulic arm) to shape the resulted sandstone. The force on the punch is transmitted both to the wall and to the bed of the sand grains. The pressure exerted on the powder near the wall decrease exponentially with distance from the moving punch owing to the die wall friction. The high shear stresses at the outer edge of the cell give rise to a dense region, and the low pressure near the middle of the cell account for the drop in the density in this region [6].

(4) Dehydration temperature of the cemented compacted sand

The hardening of a binder can produce solid bridges of high strength between particles. When water or some other liquid is present in the mixture, drying of the compact and crystallization of a dissolved substance may form solid connections between particles [6]. High dehydration temperature is needed to insure a stable crystallized cementing material with a strong attachment to the sand grain surface.

Basic Rock Properties

(1) Pore size distribution

Pore size distribution represents the shape of the pore structure of the rock. It is partially function of rock permeability. In this distribution the cumulative percentage of pores are plotted versus pore size, which gives a clear idea about the width of flow channels. Also the homogeneity of the internal structure of the rock matrix can be detected from this distribution. Pore size distribution can be measured using mercury injection capillary pressure apparatus. Non-wetting fluid is injected into the rock sample at a pressure overcomed the capillary forces at the pore throat. The pore radius can be calculated by knowing the surface tension and the contact angle of the injected non-wetting fluid.

For mercury injection: pore radius (μm) = 88.38/injection pressure (psi)

Then the cumulative pore size distribution can be obtained by plotting saturation versus pore diameter.

(2) Porosity

Total porosity is defined as the ratio of void space to bulk volume of the rock sample. Pores may be interconnected or not, but for the flow of a fluid to be possible at least part of the pore space must be interconnected. The ratio of the interconnected pore volume to the bulk volume is defined as the effective porosity. Effective porosity can be determined by the saturation method.

(3) Permeability

The ability of a rock to transmit fluids under differential pressure. Permeability can be calculated by measuring pressure differential and by applying Darcy's law.

Experimental Design

In this work grain size, cementing material percent, and compaction pressure were varied to produce cores with different properties.

Sand grains

The used sand was brought from Kharje area 80 Km south to Riyadh. It is a red to brown colored uniformly sorted sand with only 2% of the grains are smaller than 75μm and 15% larger than 500 μm.

After sieving, only five groups of the sieved sand were used in this study.
These groups are classified according to the grain size as:
Group (1) is 300 – 250 μm (average grain size 275), group (2) is 250 – 212 μm (average grain size 231), group (3) is 212 – 150 μm (average grain size 181), group (4) is 150 – 106 μm (average grain size 128), and group (5) is 106 – 75 μm (average grain size 90) In this study, sandstone cores were produced each time by using only one group of sand grains.

The large grains group shows rounded to well-rounded grains with a 0.9 sphericity. In the small sand grains group, the grains were sub-rounded to rounded with a 0.8 sphericity.

Cementing material

Sodium silicate solution with a specific gravity of 1.4 (manufactured by ADWAN chemicals) was used. The SiO_2 : Na_2O ratio was 3.2:1 [7].

The solution was tested for dehydration and weight loss as a function of the temperature. Also, the resulted solid sodium silicate was tested for stability when was mixed with water (hydrated) then the stable solid sodium silicate was tested for the acid dissolution.

When the solution was put at 100 °C for several hours, the loss in the weight was nearly 40%. When water was added to the resulted solid material, it was completely dissolved within less than one day. Then the dehydration temperature was increased to 200 °C, and weight loss was found to be 58% and there was a great resistance to dissolution in water. Thus, a 300°C was chosen as the solidification temperature that to be used in core production. At this temperature the weight loss was 60% and there was no sign of dissolution even after leaving the sample for several days in water.

Sodium silicate was used as a cementing material in three different concentrations at 4, 6, and 8 %. This weight percent represents the weight percent of sodium silicate in the sandstone core after solidification at 300° C.

Compaction pressure

A stainless steel cell was used to compact the sand-sodium silicate mixture (Fig.1). The cell consists of a cylinder with a 3.8 cm inside diameter and two rods with 3.75 cm outside diameter. Compaction was carried out using a hydraulic compression machine. Three compaction loads were used in this study:

20000 Ib (11300 psi), 30000 Ib (17000 psi), and 40000 Ib (22600 psi)

Compaction pressure can cause fragmentation of some sand grains, which causes grain size reduction. Thus, a crushing test was carried out to investigate the amount of size reduction.

Dry Crushing Test

A three dry 150 gm sand samples were taken from each group and crushed under the three chosen compaction loads, using the compaction cell. The crushed samples were sieved and the weight percent of the under-size grains were measured. As expected, most of the fragmentation took place at the cylinder wall and near to the compaction rods face. Dry crushing tests and sieving analysis showed that:

Group one sand grains had the higher size reduction percentage.

At 11300 psi compaction pressure, 9.3 to 15% of the sand suffered size reduction, with 2.3 to 1.8% was crushed to fine grains (less than 45 μm).

At 17000 psi compaction pressure, 11 to 21% of the sand suffered size reduction, with 3.8 to 2.4% was crushed to fine grains.

At 22600 psi compaction pressure, 16 to 30% of the sand suffered size reduction, with 6 to 3.9% was crushed to fine grains.

Increasing sand grain size or compaction pressure resulted in more size reduction

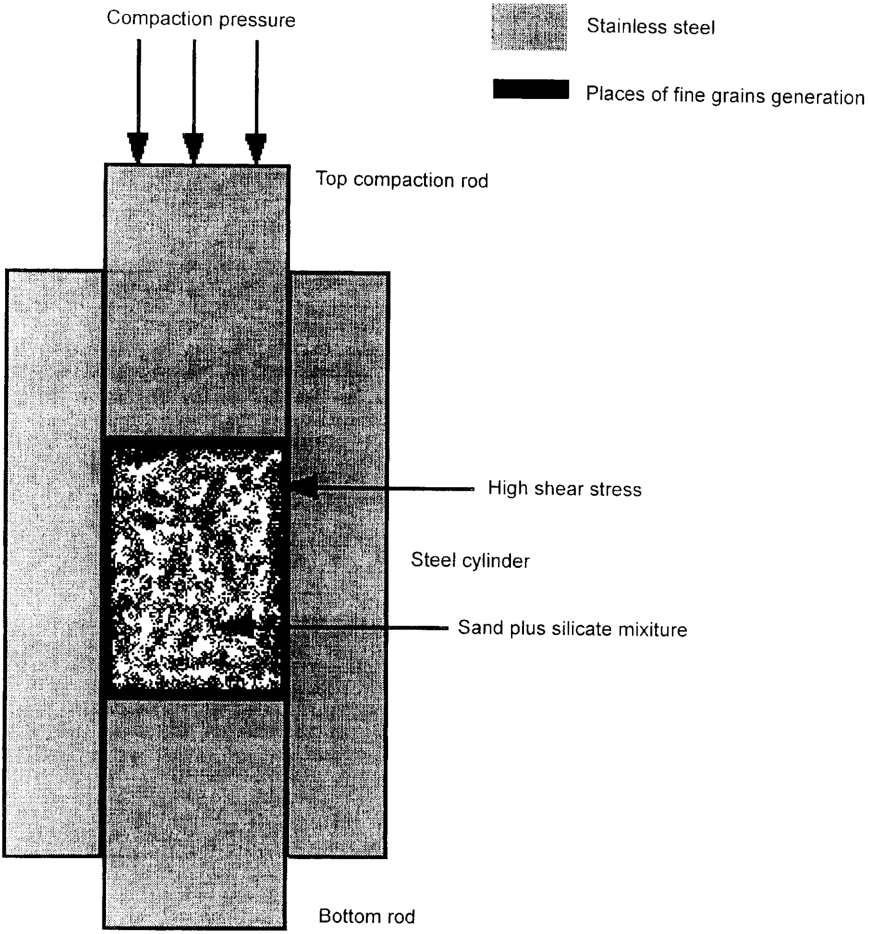

Fig. 1. Compaction cell.

In the actual core production process, the compacted sand is not dry, but it was mixed with sodium silicate solution. The presence of this solution wets the sand grains surface and acts as a lubricant, which reduces the friction between sand grains and hence, reduces fragmentation effect as compaction pressure was applied. Also the compaction cylinder wall was wetted with hydraulic oil to reduce high shear stress at that location, and hence reduces fragmentation effect at the cylinder wall.

These two factors would reduce size reduction effect and fine grains generation to a value less than what was noticed in dry crushing tests. Furthermore, the presence of the generated fine grains at the two core ends was reduced by cutting off the two circular faces of the produced cores.

Core Production Procedures

A 150 gm sand sample of certain size group is mixed with sodium silicate solution with the needed percentage. The mixing was done manually to ensure that sodium silicate covers most of the grains surfaces. The mixing should be continuos until the mixture losses its humidity. The mixing efficiency can be enhanced by adding few water droplets to the mixture. By doing this, the mixture will take longer time to loss its humidity, and hence providing longer mixing time and better coverage of grains surfaces.

The compaction cylinder wall was wetted by hydraulic oil to reduce friction between sand grains and the cylinder wall and to ease the ejection of the compacted core from the compaction cell. Then the mixture was poured into the compaction cell and the compaction pressure was applied gradually to allow the sand grains to rearrange its positions and slid past each other to fill the voids.

The ejected core was heated gradually to 100°C and left at this temperature for nearly one day, then the temperature was raised gradually to 300°C at a rate of 25°C per hour. This step by step temperature raising resulted in a gradual dehydration and the crystallization of sodium silicate into a more stable material. The produced cores were 3.8 cm in diameter and 6 cm in length.

Compressive Strength Test

It was important to test the compressive strength of the produced cores. A core was prepared for this test which consists of sand grains smaller than 300 μm and larger than 75 μm mixed with 6% sodium silicates. The mixture was compacted at 17000 psi, then it was dehydrated gradually to 300 °C. The compressive strength of this core was compared with the compressive strength of Bera sand stone core having the same dimensions and flow properties. The results of a uniaxial loading test show that the produced core had higher yield strength. The yield strength of the produced core was 5700 psi and the yield strength of the Bera sandstone core was 5000 psi.

Results and Discussion

(1) Effect of core production factors on porosity

Figure 2 shows the effect of the compaction pressure and cementing material concentration on the core porosity against varying average grain size. In this figure, several curves represented the percentage of sodium silicate for all the applied compaction pressure.

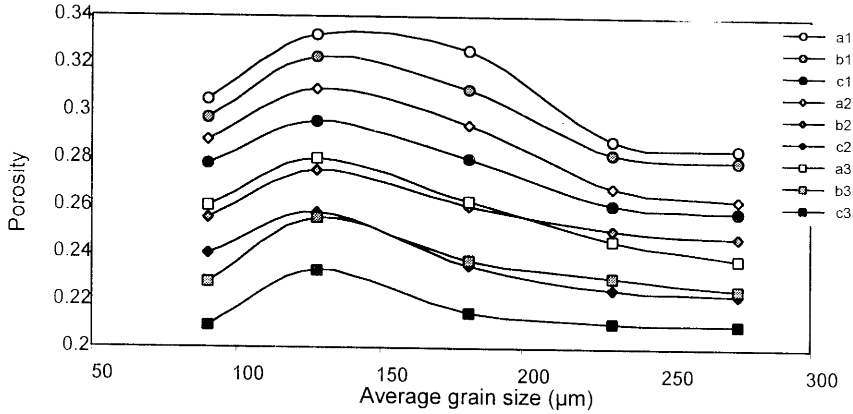

Fig. 2. Core porosity versus average grain size (a, b, c refer to 4, 6, 8 % sodium silicate and 1, 2, 3 refer to 11300, 17000, 22600 compaction pressures).

At a constant cementing concentration of 4% and a low compaction pressure, decreasing the average grain size from 275 to 231μm resulted in a small increase in the porosity. Further reduction of the grain size gave a higher porosity. Using an average grain size less than 128μm resulted in a reduction in the porosity, as the cementing material had a greater effect in plugging small pores than it dose in large ones.

As the compaction pressure increases, the porosity becomes more leveled, and the compaction pressure becomes the control factor instead of the grain size which was the control factor at the low compaction pressure. At a low compaction pressure, increasing the cementing material concentration from 4 to 6% had a minimal effect on the porosity as compared with the concentration of 8%.

(2) Effect of core production factors on permeability

Figures 3 and 4 show the effect of the compaction pressure on the core permeability at a constant cementing concentration and varying grains size. At a constant cementing concentration of 4% and low compaction pressure (Fig. 3), decreasing the average grain size from 275 to 231μm resulted in a sharp reduction in the permeability. This can be explained by the fact that the large grains suffers higher grain fragmentation and fine generation, which resulted in sharp reduction in permeability as these fines can plug some of the fluid flow paths. Further reduction in the grain size resulted in a gentile reduction of the permeability then a sharp reduction for grain size less than 128μm. This last sharp reduction in permeability is caused by the narrowing of the already small pores caused by cementing material. Increasing the compaction pressure resulted in a smoother reduction of the permeability. When the compaction pressure increases the effect of grain size becomes less, as the high compaction pressure becomes the control factor instead of the grain size. But for a grain size less than 128 μm, the effect of the grain size variation was still the main factor. At a constant cementing concentration of 8% (Fig. 4), the curve of the medium compaction pressure becomes closer to the high compaction pressure curve, as the effect of cementing concentration factor becomes higher.

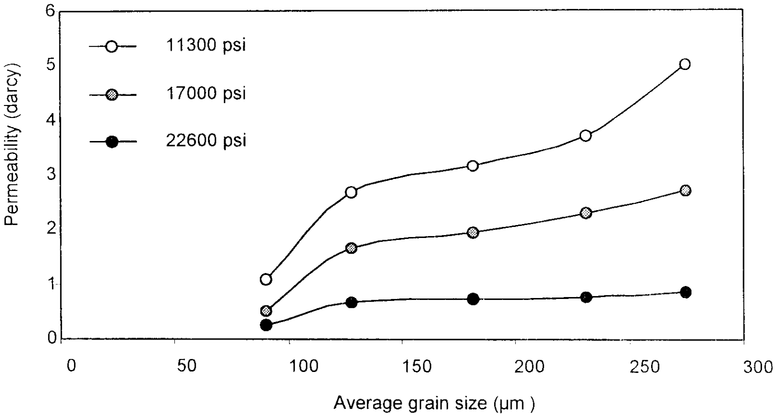

Fig. 3. Core permeability versus average grain size (4% cementing material) at different compaction pressures.

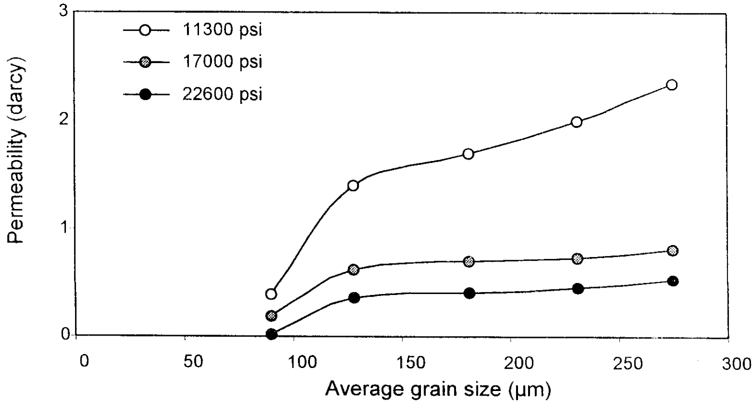

Fig. 4. Core permeability versus average grain size (8% cementing material) at different compaction pressures.

Figures 5 and 6 show the effect of cementing material concentration on the core permeability at a constant compaction pressure and a varying grains size.

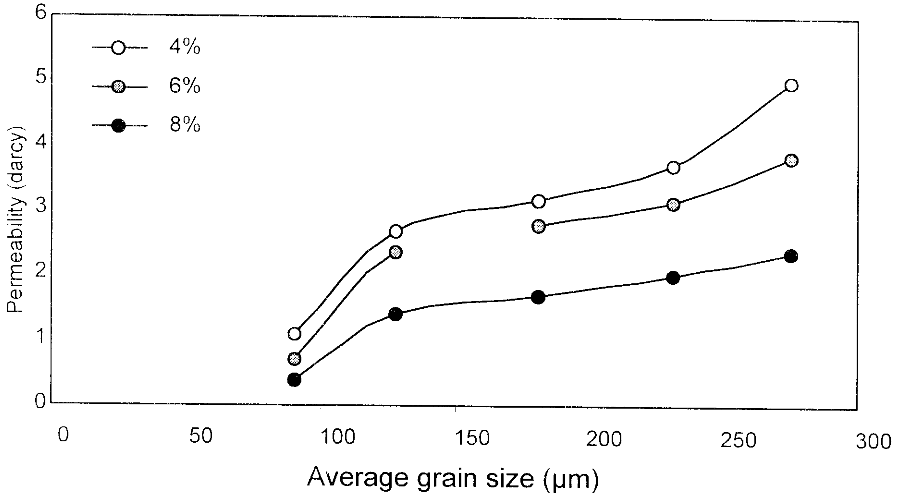

Fig. 5. **Core permeability versus average grain size at 11300 psi compaction pressure and different cementing material percentages.**

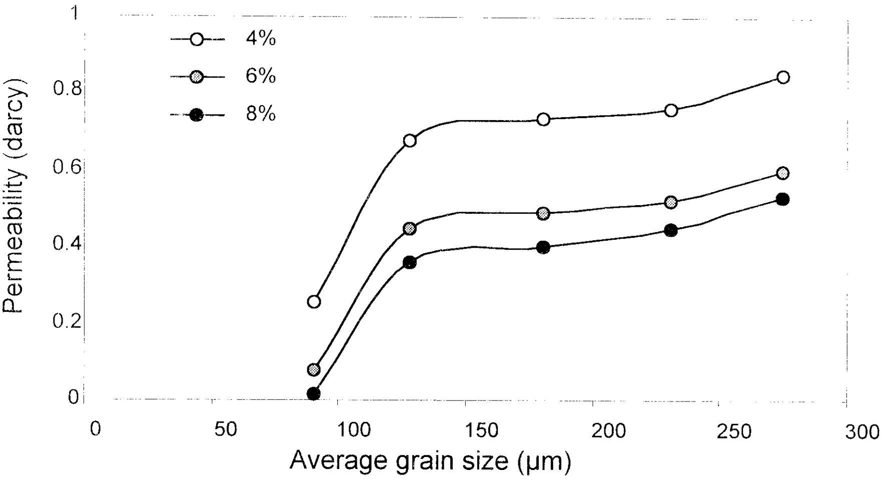

Fig. 6. **Core permeability versus average grain size at 22600 psi compaction pressure and different cementing material percentages.**

The effect of cementing material concentration on the permeability reduction trend is similar to that of the compaction pressure with few exceptions. The first one is that at low compaction pressure (Fig. 5), the high cementing material concentration had a less capability in leveling the effect of grain size factor than what compaction pressure had. The second exception is that at low compaction pressure, the medium cementing material concentration curve was closer to that of low concentration curve. Whereas at high compaction pressure (Fig. 6), the medium concentration curve becomes closer to the high concentration curve. This observation shows clearly the superiority effect of compaction pressure factor over cementing material concentration factor.

(3) Effect of core production factors on pore size distribution

Figures 7 to 9 represent the cumulative pore size distribution of the produced cores under different production factors. In these figures the pore size is plotted versus mercury saturation. Saturation represents the volume percent of the pores occupied by the mercury at a certain injection pressure. As pore size decreases, injection pressure needed for the mercury to inter that pore increases.

Figure 7 shows the cumulative pore size distributions of the produced cores at 22600 psi compaction pressure and 6% cementing material concentration. Each produced core had a narrow pore size distribution, which is an important advantage of the produced cores. There is a sharp reduction in mean pore size (toward smaller pores) when grain size was decreased to 90 µm (group five grains). For the grain of groups one through four, the mean pore size was between 20 and 24 µm. When group five was used, the mean pore size decreases sharply to 11 µm.

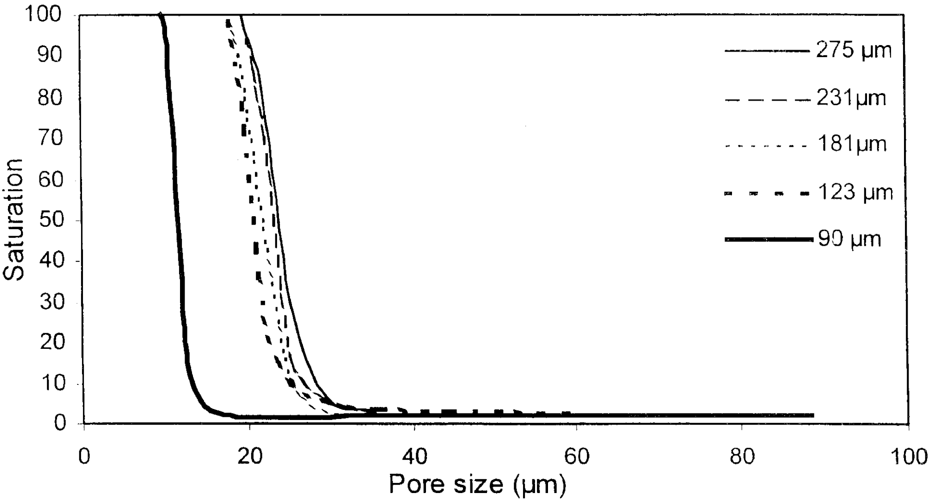

Fig. 7. Pore size distribution for a core produced at 22600 psi compaction pressure with 6% cementing material.

Figure 8 shows the cumulative pore size distributions of the produced cores at 22600 psi compaction pressure and 8% cementing material concentration. As grain size decreases, the pores size becomes smaller. But the reduction rate in pore size was less as grain size decreases. This is true for a grain size larger than or equal 128μm compacted at high pressure. For the grains of group one, the mean pore size was 24 μm. This mean pore size was reduced by 12.5% when group two grains were used, then by 11% when group three grains were used, then by 5.3% when group four grains were used.

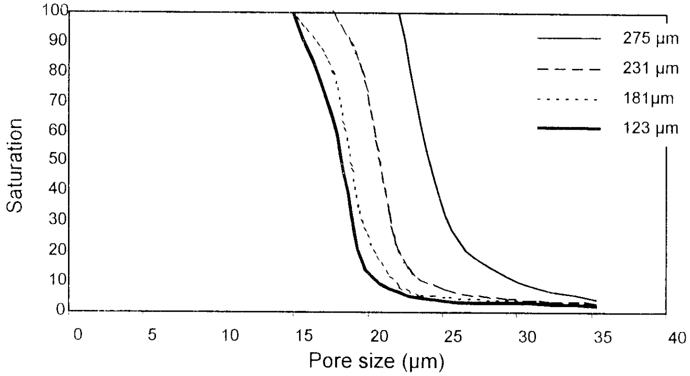

Fig. 8. Pore size distribution for a core produced at 22600 psi compaction pressure with 8% cementing material.

Figure 9 shows the cumulative pore size distributions of the produced cores at 11300 psi compaction pressure and 8% cementing material concentration. In this figure as grain size decreases, pores size distribution becomes narrower. For grain size of 90 μm (smallest grains used in this study), pore size distribution becomes nearly vertical which means that the pores have almost the same size.

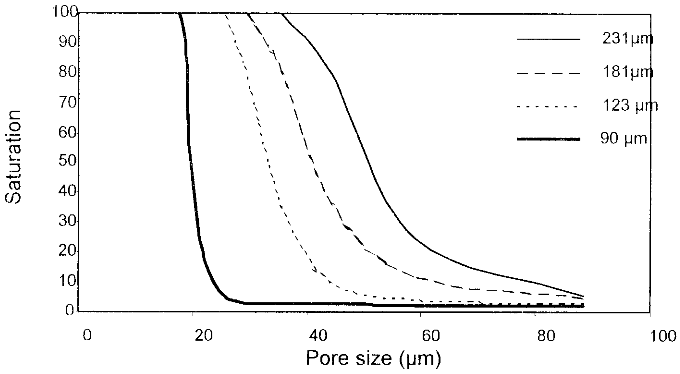

Fig. 9. Pore size distribution for a core produced at 11300 psi compaction pressure with 8% cementing material.

Figure 10 shows the change in mean pore size of the produced cores as the sand grain size varies at different compaction pressures and cementing concentration. For a grain size smaller than 128 μm, for all groups, there is a sharp reduction in the mean pore size.

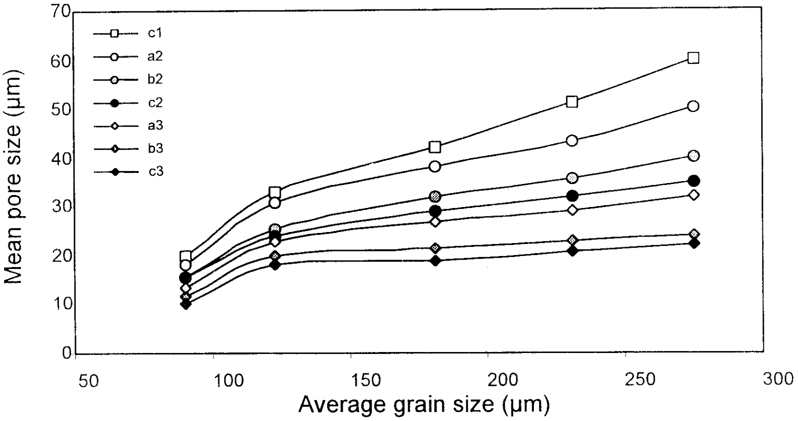

Fig. 10. Core mean pore size versus average grain size (a, b, c refer to 4, 6, 8 % sodium silicate and 1, 2, 3 refer to 11300, 17000, 22600 psi compaction pressure).

Applications

To produce a core with a certain permeability and a specific average grain size, the most suitable cementing material concentration and the applied compaction pressure to produce such core must be chosen first. With the help of Figs. 11 through 16, this can be achieved. These figures give permeability as a function of the compaction pressure and the cementing material concentration for different sand grain sizes. Other core properties (porosity and mean pore size) can be obtained from Figs. 17 through 28.

For example, say we need to produce a core with a permeability of 100 md:

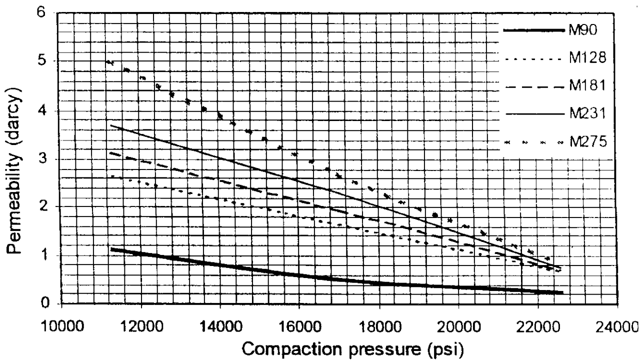

Fig. 11. Core permeability versus compaction pressure (at 4% cementing material) for the five sand grain size groups.

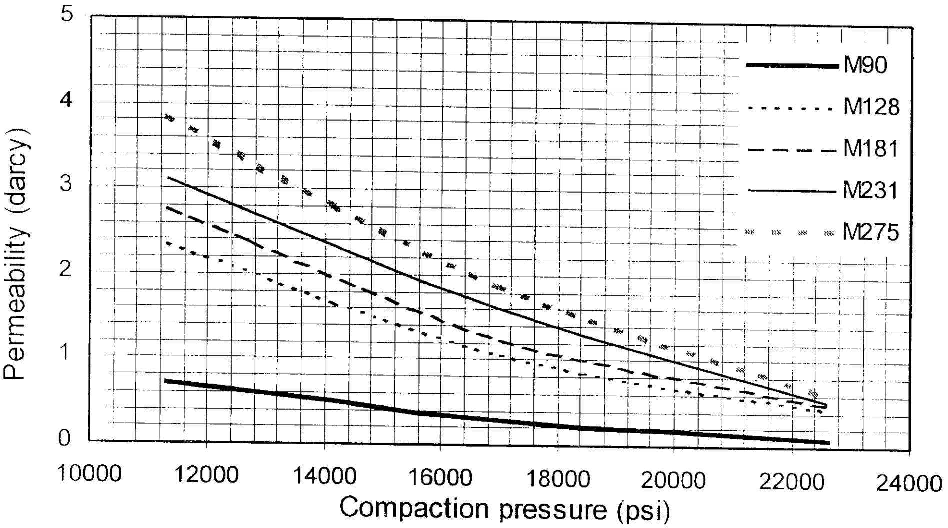

Fig. 12. Core permeability versus compaction pressure (at 6% cementing material) for the five sand grain size groups.

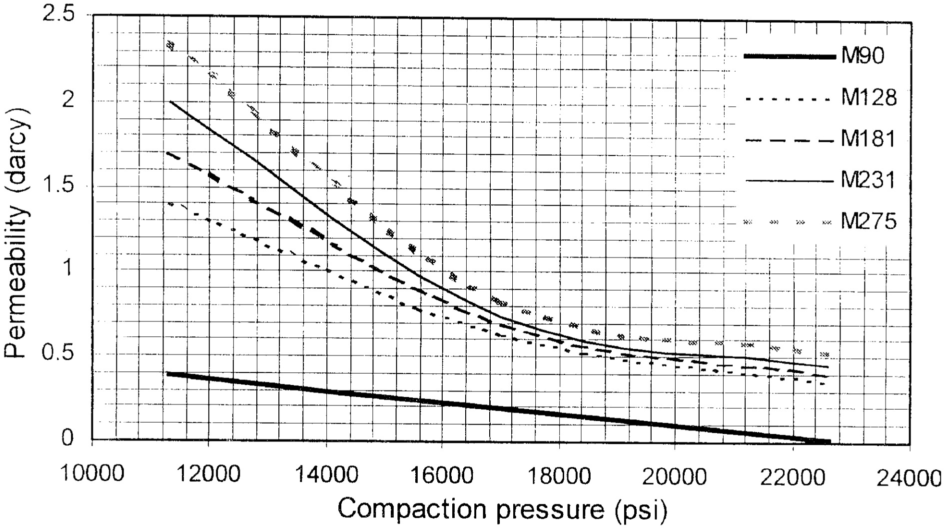

Fig. 13. Core permeability versus compaction pressure (at 8% cementing material) for the five sand grain size groups.

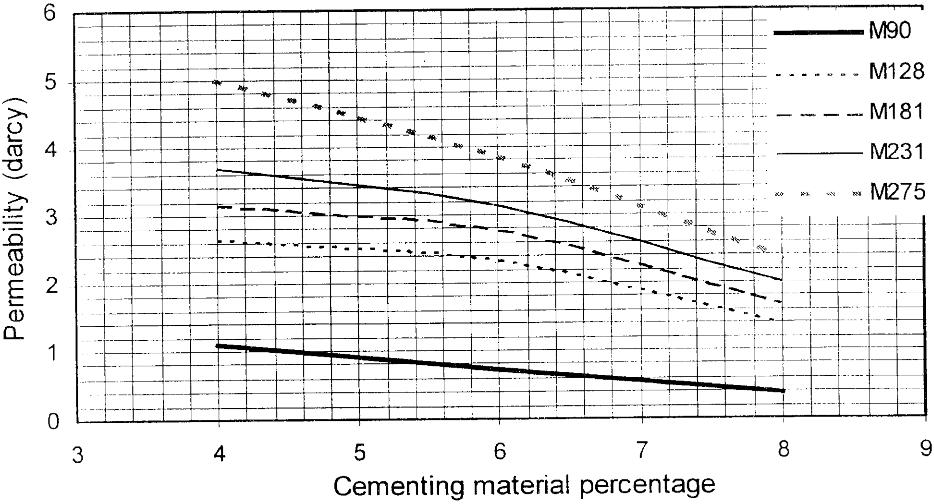

Fig. 14. **Core permeability versus cementing material percentage (at 11300 psi compaction pressure) for the five sand grain size groups.**

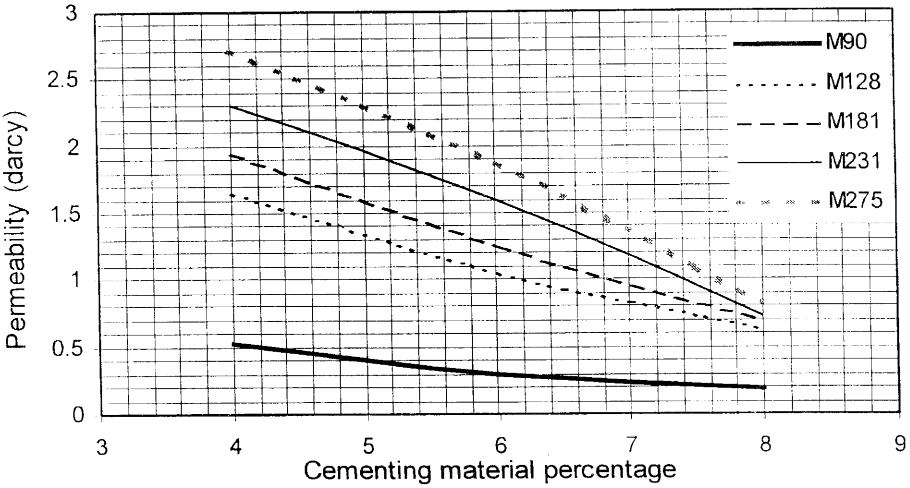

Fig. 15. Core permeability versus cementing material percentage (at 17000 psi compaction pressure) for the five sand grain size groups.

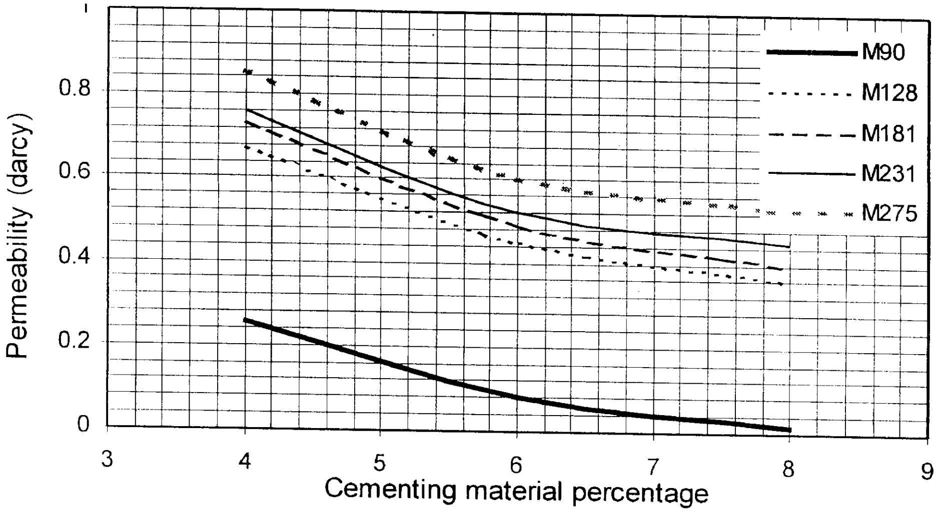

Fig. 16. Core permeability versus cementing material percentage (at 22600 psi compaction pressure) for the five sand grain size groups.

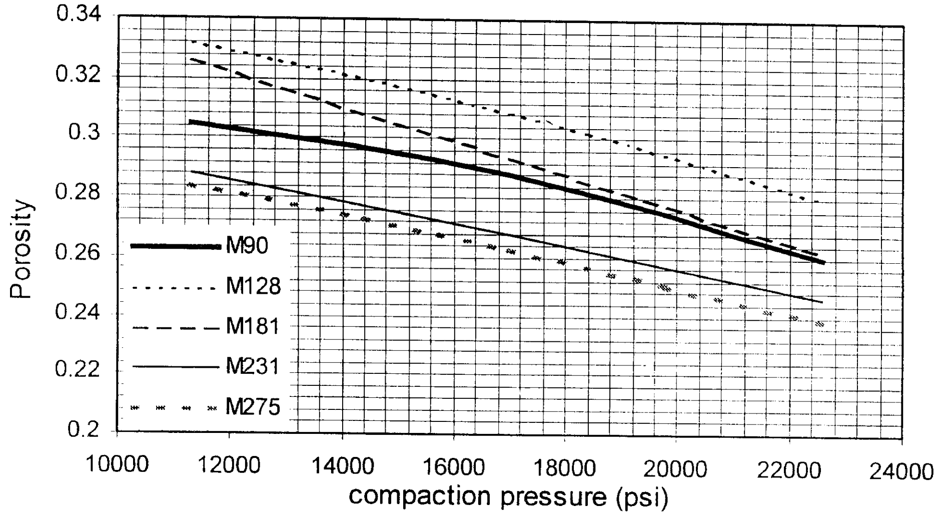

Fig. 17. Core porosity versus compaction pressure (at 4% cementing material) for the five sand grain size groups.

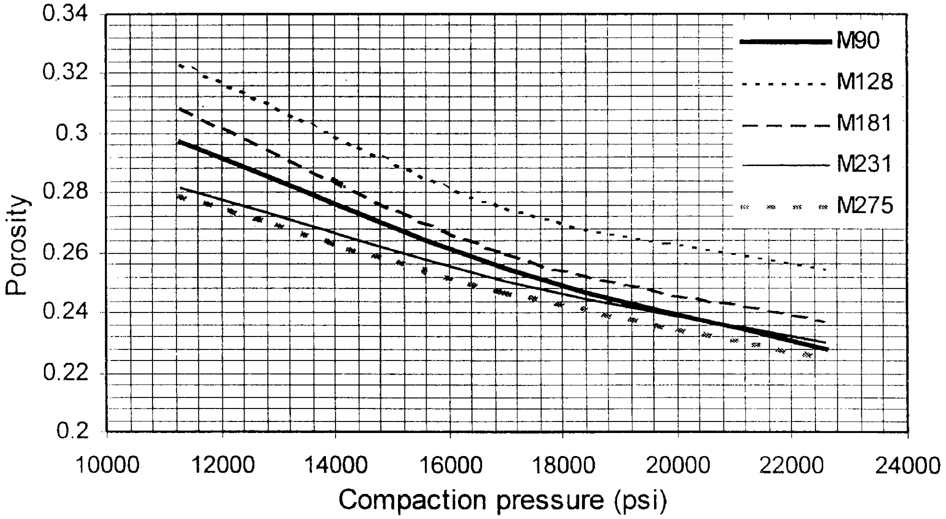

Fig. 18. Core porosity versus compaction pressure (at 6% cementing material) for the five sand grain size groups.

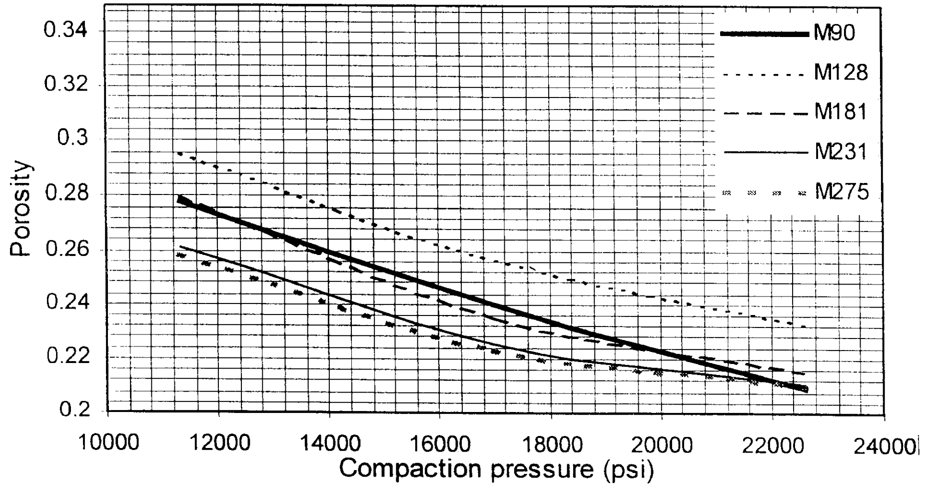

Fig. 19. Core porosity versus compaction pressure (at 8% cementing material) for the five sand grain size groups.

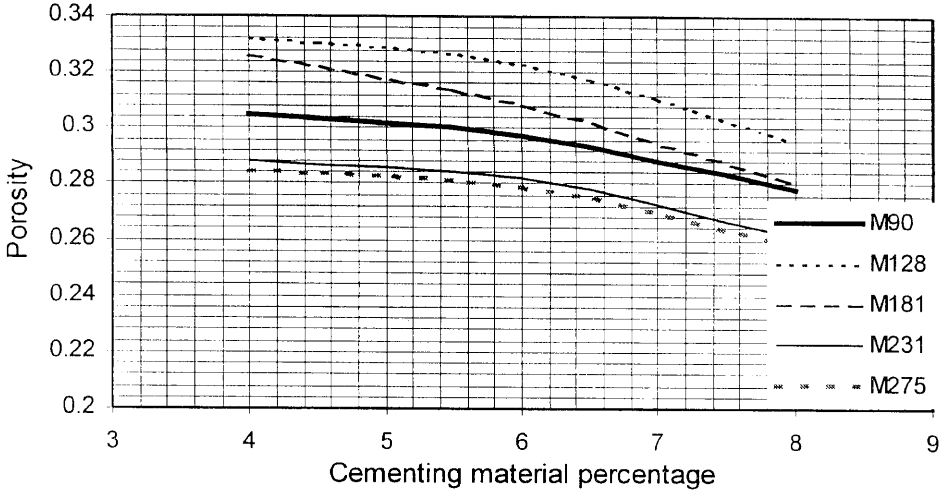

Fig. 20. Core porosity versus cementing material percentage (at 11300 psi compaction pressure) for the five sand grain size groups.

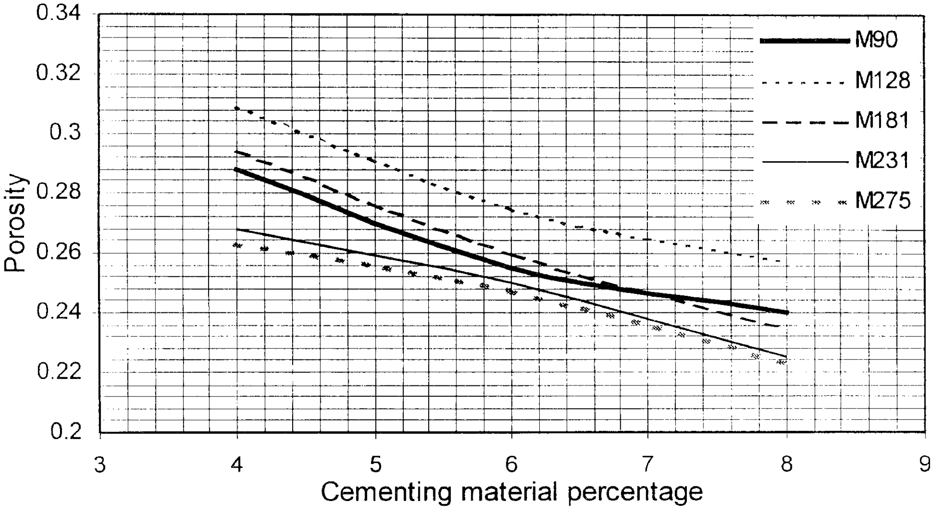

Fig. 21. Core porosity versus cementing material percentage (at 17000 psi compaction pressure) for the five sand grain size groups.

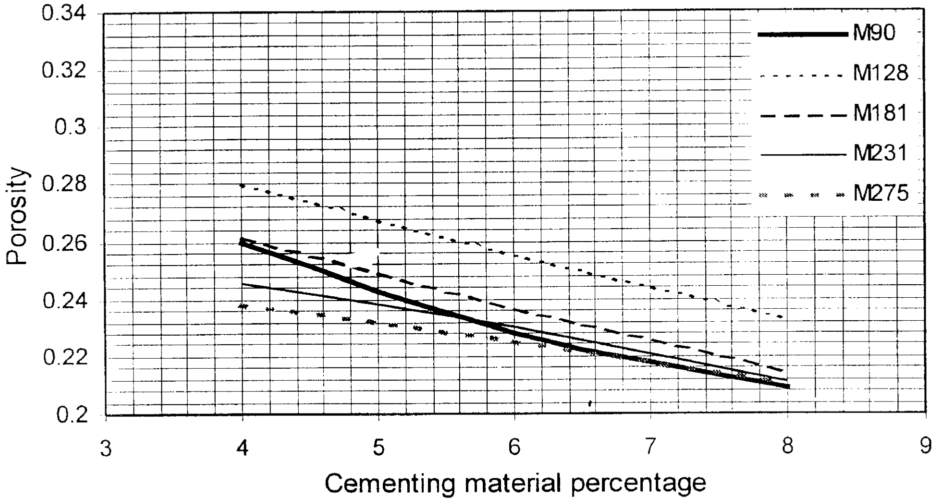

Fig. 22. **Core porosity versus cementing material percentage (at 22600 psi compaction pressure) for the five sand grain size groups.**

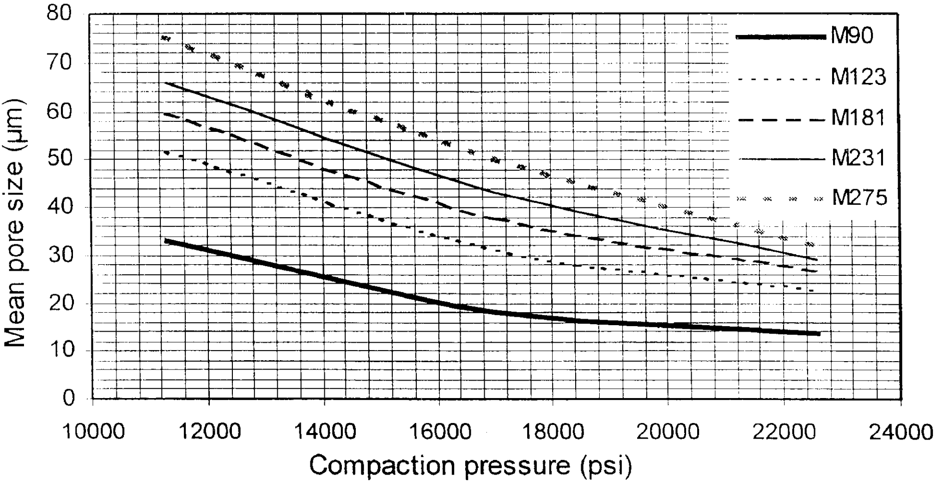

Fig. 23. **Core mean pore size versus compaction pressure (at 4% cementing material)for the five sand grain size groups.**

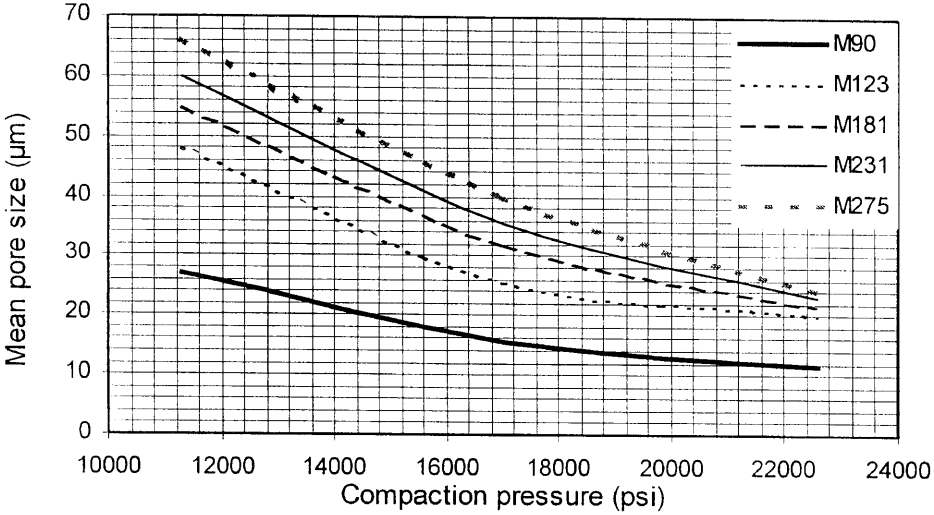

Fig. 24. Core mean pore size versus compaction pressure (at 6% cementing material) for the five sand grain size groups.

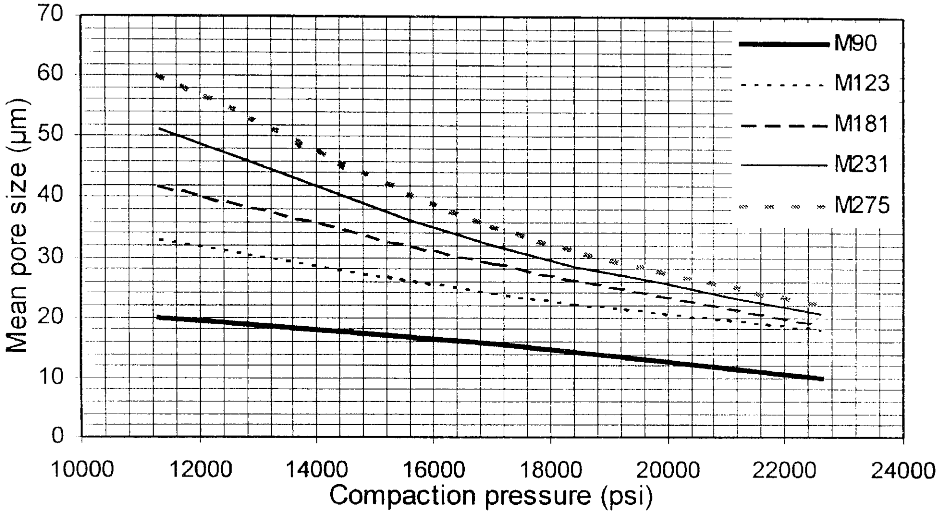

Fig. 25. Core mean pore size versus compaction pressure (at 8% cementing material)for the five sand grain size groups.

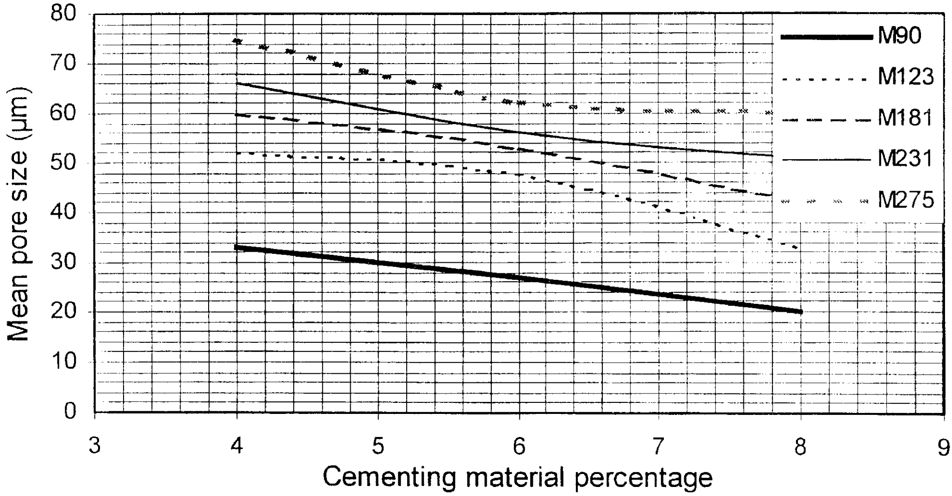

Fig. 26. Core mean pore size versus cementing material percentage (at 11300 psi compaction pressure) for the five sand grain size groups.

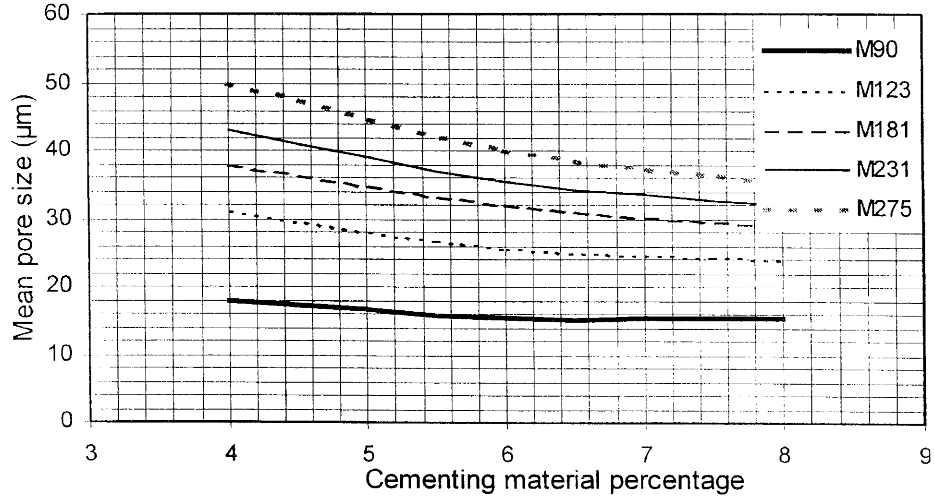

Fig. 27. Core mean pore size versus cementing material percentage (at 17000 psi compaction pressure) for the five sand grain size groups.

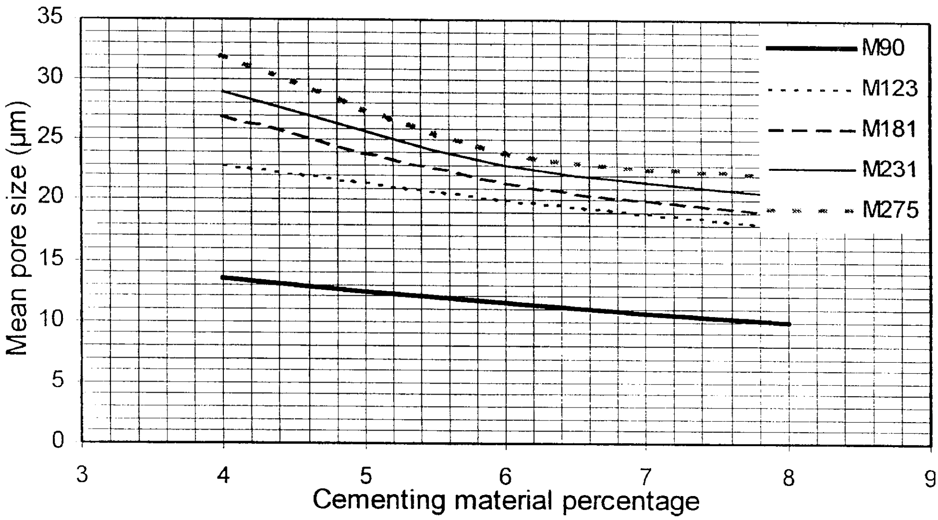

Fig. 28. **Core mean pore size versus cementing material percentage (at 22600 psi compaction pressure) for the five sand grain size groups.**

By a quick look to figures 11 through 16, this can be done by using an average grain size of 90 μm (the fifth sand grain group) with:

6% weight percent cementing material and 21600 psi compaction pressure (Fig. 12).

Or 8% weight percent cementing material and 19600 psi compaction pressure (Fig. 13).

Or 5.7% weight percent cementing material and 22600 psi compaction pressure (Fig. 16).

The second choice is the preferable where the applied compaction pressure is the lowest, which will result in less fine grains generation.

From Figs. 17 to 28, the second choice would result in a core with 13 μm mean pore size (Fig. 25) and 22.4% porosity (Fig. 19).

Conclusions

(1) A complete and a detailed procedure for artificial cores production with a wide range of properties and a good yield strength was presented in this study.

(2) Decreasing the average grain size from 275 to 231μm resulted in a small increase in the porosity. Further reduction of the grain size gave a higher porosity until a critical size was reached. Using an average grain size less than the critical grain size (128μm) resulted in a reduction in the porosity. As the compaction pressure increases, the porosity versus average grain size plot becomes more leveled. The cementing material concentration factor becomes more effective in reducing the porosity, when it increases from 4% to 8% (at low compaction pressure).

(3) Permeability versus grain size variation results show clearly the predominant of the effect of the compaction pressure factor over the cementing material concentration factor. For a grain size higher than 128μm, the effect of the grain size variation factor was less as the compaction pressure increased (or as core density increased). Whereas for a grain size less than 128 μm, the effect of the grain size factor on the permeability was the main factor at all conditions even at high compaction pressure. There was a very sharp reduction in the permeability as the average grain size was reduced to 90 μm.

(4) Produced cores had a very narrow cumulative pore size distribution. At high compaction pressure, there was a very sharp reduction in the mean pore size when the average grain size was decreased to 90 μm. As the grain size decreases, the cumulative pore size distribution becomes narrower.

References

[1] Chilingarian, G.V. and Wolf, K.H. "Compaction of Coarse-grained Sediments I." *Development in Sedimentology,* 18A, Elsevier Scientific Publishing Company, 1975.

[2] Chilingarian, G.V. and Rieke, H.H. "Compaction of Argillaceous Sediments." *Development in Sedimentology,* 16, Elsevier Scientific Publishing Company, 1974.

[3] Chilingarian, G.V. and Wolf, K H. "Compaction of Coarse-grained Sediments II." *Development in Sedimentology,* 18B, Elsevier Scientific Publishing Company. 1976.

[4] Iler, R.K. *The Chemistry of Silica.* John Wiley & Sons, 1979.

[5] Falcone, J. S. "Soluble Silicates." *ACS Symposium Series* 194, pp 251- 270, American Chemical Society, Washington, D.C., 1982.

[6] Stanley. N.G. *Enlargement and Compaction of Particulate Solids.* Butterworths Monographs in Chemical Engineering, Butterworth & Co. Ltd., 1983.

[7] Adwan Chemical Industries Co. Ltd, Industrial City, Riyadh.

إنتاج عيّنات صخرية ذات نطاق واسع من الخواص البتروفيزيائية

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ملخص البحث. في مجال هندسة البترول، عند دراسة تأثير عامل معين على نفاذية الصخر، من الأنسب استعمال عيّنات صخرية متجانسة ذات نفاذية ابتدائية ثابتة. إن صعوبة إيجاد صخر بهذه الخاصية وصعوبة الحصول على عيّنات صخرية من مواقع الإنتاج البترولي إضافة إلى الحاجة المستمرة لعيّنات صخرية لاستعمالها في مجال التعليم، جعلت البحث عن مصادر بديلة للعيّنات الصخرية حاجة ملحة.

إن الهدف الرئيسي من هذه الورقة هو تمثيل العوامل المتعلقة بتكوين الصخر الرملي الطبيعي ومحاولة محاكاة هذه العوامل لإنتاج صخر رملي مماثل للصخر الطبيعي. من أهم هذه العوامل حجم حبيبات الرمل وشكلها، المادة اللاحمة، والضغط الناتج عن وزن المترسبات.

تم استخدام خمس مجموعات من الرمل وثلاث تركيزات من المواد اللاحمة وكذلك ثلاثة مستويات من الضغط لتشكيل الصخر. بتغير هذه العوامل تم إنتاج عيّنات صخرية بخواص متعددة وتم قياس هذه الخواص وتصنيفها في أشكال بيانية لتسهيل استعمالها.

تم إنتاج عيّنات صخرية بنفاذية أولية تتراوح بين ٠,١٥ و ٥ دارسي ومسامية تتراوح بين ٢٠ و ٣٣٪. بالاستعانة بالأشكال البيانية المنتجة يمكن إنتاج صخور رملية بنفاذية ومسامية معيّنة وذلك باختيار العوامل المكوّنة للصخر.