GEOSOUND

Geosound, 2025, 61, 39-50 ISSN: 1019-1003
Geosound (Yerbilimleri) Dergisi

Araştırma Makalesi/Research Article

Investigation of Quartz Sand as Filtration Reducer in Drilling Fluids

Sondaj Sıvılarında Filtrasyon Azaltıcı Olarak Kuvars Kumunun Araştırılması

ONUR ESER KÖK Orcid: 0000-0002-7061-2921

Iskenderun Technical University, Department of Petroleum and Natural Gas Engineering, 31200, Hatay, Turkey

Geliş (received): 27/03/2025 Kabul (Accepted): 11/06/2025

ÖZ

Sondaj işlemleri, birincil enerji kaynaklarının üretimi ve kullanımı için çok önemlidir ve sondaj sıvısı ile doğrudan etkileşim halindedir. Bu nedenle, başarılı bir sondaj için verimli bir sondaj sıvısı gereklidir. Sondaj sıvısının akış özellikleri, filtrasyon özellikleri başta olmak üzere birçok parametreye bağlı olarak değişmektedir. Bu çalışmada, ticari kuvars kumunun su bazlı sondaj sıvılarında filtrasyon azaltıcı bir katkı malzemesi olarak kullanılabilirliği araştırılmıştır. Deneysel çalışmalarda, sondaj uygulamalarına uygun spud tipi sondaj sıvıları hazırlanmış ve ardından kuvars kumları farklı oranlarda (ağırlıkça %0,25-0,50-1,0-1,5-2,0) ilave edilmiştir. Daha sonra farklı sürelerde (15-30-60 dk) filtrasyon ölçümleri gerçekleştirilmiştir. Ölçümler sonucunda kuvars kumunun önemli ölçüde filtrasyonu azaltıcı etkiye sahip olduğu ve spud tipi sondaj sıvılarında kullanılabileceği tespit edilmiştir.

Anahtar Kelimeler: Kuvars kumu, Sondaj, Filtrasyon, Sondaj akışkanları

Onur Eser Kök oeser.kok@iste.edu.tr

İskenderun Teknik Üniversitesi, Mühendislik ve Doğa bilimleri Fakültesi, İnşaat Mühendisliği Bölümü, Hatay

DOI: 10.70054/geosound.1666845

ABSTRACT

Drilling operations are significant for producing and utilising primary energy resources and directly interacting with drilling fluid. Therefore, efficient drilling fluid is required for successful drilling. The flow properties of drilling fluid vary depending on many parameters, especially filtration properties. In this study, investigated the usability of commercial quartz sand as a filtration-reducing additive material in water-based drilling fluids. In the experimental studies, spud-type drilling fluids were prepared suitable for drilling applications, and then quartz sands were added at different ratios (0.25-0.50-1.0-1.5-2.0 wt.%). Then, filtration measurements were performed at different times (15-30-60 min). As a result of the measurements, it has been determined that quartz sand has a significant filtration-reducing effect and can be used in spud-type drilling fluids.

Keywords: *Quartz sand, Drilling, Filtration, Drilling fluids*

1. INTRODUCTION

Nowadays, many energy sources are used. Despite the wide use of renewable energy sources (geothermal, solar, wind, etc.), there is still a need and demand for primary energy sources (oil, coal, natural gas, etc.). The high-efficient production and utilization of primary energy resources are important from environmental and economic perspectives (Balat, 2007). Nowadays, drilling method is one of the most common methods to produce primary energy resources. Drilling is very important for exploring and producing to fossil energy resources (Abas et al., 2015; Forsberg, 2009).

A successful drilling operation which is completed in a short time is an important factor in producing of the energy source. For this reason, many parameters should be carried out together and harmoniously for drilling to succeed. Drilling fluid is one of the most important factors for a successful drilling operation. Other factors such as drilling time, rate of penetration, cost, and production efficiency are directly depended to the drilling fluid (Caenn & Chillingar, 1996).

Drilling fluid has many tasks in any drilling operation such as cleaning the hole, lubricating the drill string, cooling the bit, suspending cuttings at no circulation condition, and balancing formation pressure. Thus, ensure these tasks, different types of drilling fluids are used, and rheology and flow properties are controlled with organic or inorganic additives (Caenn et al., 2011).

Many factors related to drilling are determined by drilling fluids. Its are prepared according to formation type, targeted depth, type of energy source, drilling method, and equipments. For a general drilling, three basic drilling fluids (Spud, Lignosulfonate, and Polymer type) and base additives (bentonite, caustic soda, soda ash, barite etc.) are used. However, spud-type drilling fluid which is the most common type in first stage of drilling operations is used (Davoodi et al., 2024).

Spud-type drilling fluids consist of basic additive components (bentonite, sodium hydroxide, sodium carbonate, barite, and water). However, flow parameters are controlled with many additives to ensure their tasks due to deepening of the drilling and the differences in the formation structure and flow properties in borehore. These additives are used to control the parameters such as fluid loss (filtration), viscosity, and pH (Bleier, 1990).

Filtration control is important among the spud-type drilling fluid flow properties. It should be controlled to prevent formation collapses and fluid leaks and monitoring the flow properties of the drilling fluid. For this reason, many organic and inorganic additives are used in current industrial applications. However, scientific and sectoral researches for enhance low-cost, eco-friendly, and highly efficient additives are continuing, nowadays (Glenn et al., 1957; Bezemer & Havenaar, 1966).

Quartz sand is industrial raw material formed as a result of the weathering of quartz-rich rocks and has a quartz content of at least 95% contains low amounts of clay, feldspar, iron oxide, and carbonate, and has grain size below 2 mm, white-cream-pink colour, high Mohs hardness and porous structure (Derakhshani et al., 2015). According to industrial consumption, it's among the world most consumed low-cost raw materials. It is widely used in sectors such as the foundry industry, brick production, glass production, purification and filtration, sandblasting, construction, and metallurgy (Shaffer, 2006; Moss, 1966).

This study aims to evaluate quartz sand as a new low-cost filtration-reducing additive material for drilling operations. Quartz sand was chosen because of its a lot of advantages (such as low-cost, production abundance, easy supply, and easy storage conditions) in comparison with the materials used in industrial applications. The novelty of this study is the development of a new low-cost and high-efficiency fluid loss control material. In this purpose, quartz sand was experimentally investigated and its use in drilling muds was evaluated both as an import substitute product and as a new product that is easily and abundantly available. For this reason, in the experimental studies carried out within the scope of the study, spud-type drilling fluids were prepared, different amounts of quartz sand were added, and their effects on filtration properties were examined at different times. The optimum additive ratio and filtration time were determined by the results obtained.

2. MATERIALS AND METHOD

The materials were obtained from commercial factories. Bentonite (drilling grade) was taken from RBS in Niksar, Turkey. Sodium hydroxide (NaOH) and sodium carbonate (Na_2CO_3) were taken from TEKKIM Company as technical grade. Barite ($BaSO_4$) was taken from Barit Maden Turk Company in Osmaniye, Turkey, as micronized size. Quartz sand was taken from SİSECAM in Mersin, Turkey. Its technical properties are given in Table 1 and digital microscope images are given in Figure 1.

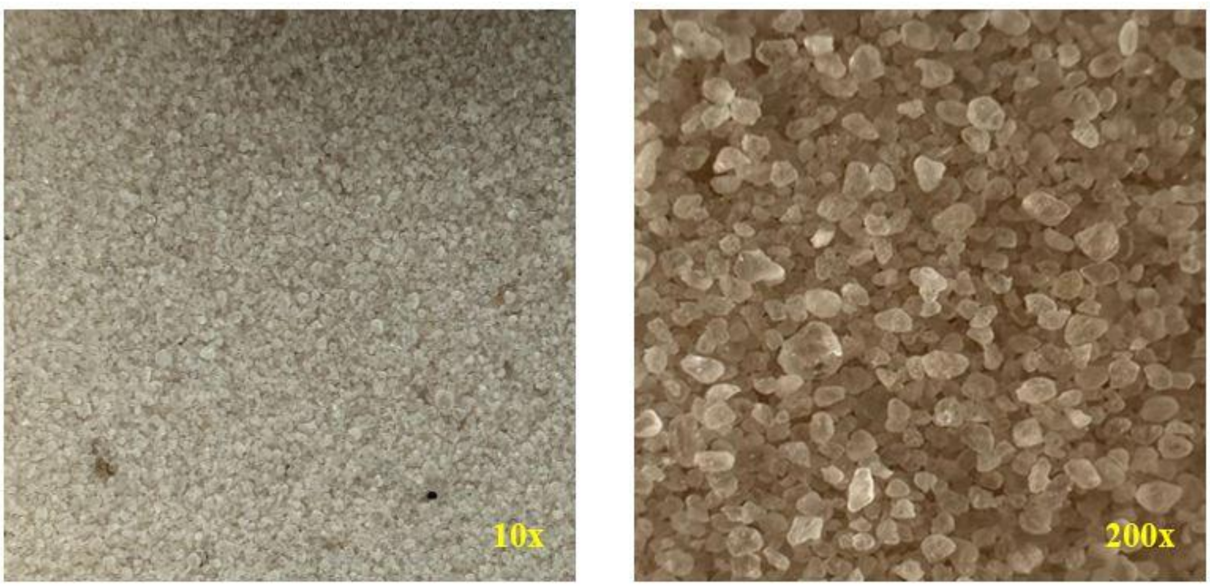

Figure 1. Digital microscope images of quartz sand

Table 1. Properties of the quartz sand (SISECAM, 2025)

Chemical Content (%)	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O
	97.00	1.05	0.112	<0.08	<0.39	0.11	<0.02	0.72
Particle Size (%)	**-1000 +500 µm**		**-500 +300 µm**		**-300 +106 µm**		**-106 µm**	
	<0.2		11.3		71.5		17.0	
Moisture (%)	<7.0							

The drilling fluids were prepared with the above materials according to spud-type drilling mud concentrations. Quartz sand was added to the drilling fluids in different amounts. All of the drilling fluids were prepared in atmospheric pressure and room temperature conditions. The preparation properties of the drilling fluids are given in Table 2.

Table 2. Preparation properties of the drilling fluids

Materials and Concentrations (ppb: pound per barrel, wt.%: weight percentage)	**Details of the Drilling Fluids**
Bentonite - 25 ppb NaOH - 0.30 ppb Na_2CO_3 - 0.35 ppb $BaSO_4$ - 2.5 ppb	Base drilling fluid
Base Drilling Fluid + 0.25 wt.% Quartz sand (QS-1) Base Drilling Fluid + 0.5 wt.% Quartz sand (QS-2) Base Drilling Fluid + 1.0 wt.% Quartz sand (QS-3) Base Drilling Fluid + 1.5 wt.% Quartz sand (QS-4) Base Drilling Fluid + 2.0 wt.% Quartz sand (QS-5)	Quartz sand added drilling fluids

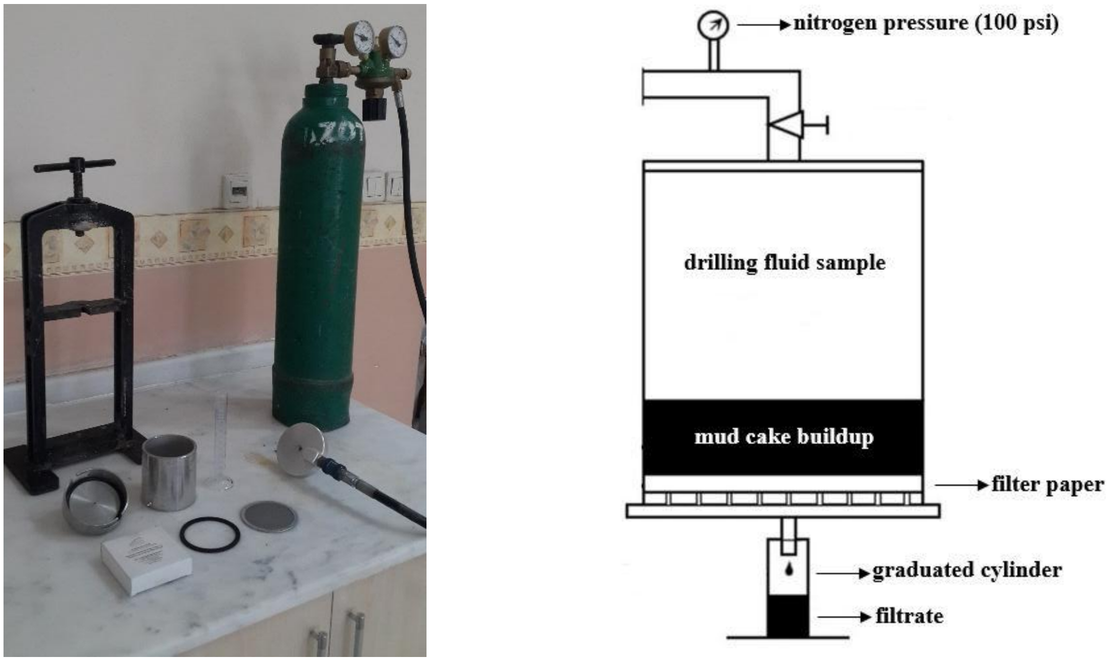

Figure 2. API filtration kit and schematic sketch of filtration cell (Sharma et al., 2025)

Filtration measurements were applied using API filtration kit developed by the American Petroleum Institute (see Fig. 2) at 15, 30, and 60 min. under 100 psi nitrogen pressure. The filtrates were collected in graduated cylinder, and the amounts were recorded. The measurements were applied according to the API RP 13B-1 test procedure (API, 2017).

3. RESULTS AND DISCUSSION

Filtration measurements were applied according to the average non-circulation times of the drilling. The times were determined as 15 minutes for adding or removing drill pipe, 30 minutes for compliance with API standard, and 60 minutes for long-term non-circulation time, such as cementing or failures. The results were also compared with base drilling fluid to determine the effects of quartz sand, and all results are shown in Figure 3.

Firstly, it was determined that the results showed that the filtrate volumes were decreased with the addition of quartz sand in all drilling fluids. According to the results, it is seen that there is a decrease in filtrate volumes due to the increase in the amount of quartz sand at all measurement times. However, this decrease is not in linear; although linear, although there are sharper decreases at low additive rates, the rate of decrease decreased at high additive rates.

According to the additive ratios, the filtrate volumes decreased by 1.92 ml, 4.93 ml, 8.21 ml, 11.77 ml and 12.87 ml for the samples coded QS-1 (0.25 wt.%), QS-2 (0.5 wt.%), QS-3 (1.0 wt.%), QS-4 (1.5 wt.%) and QS-5 (2.0 wt.%) at 15 min. measurement time, respectively. At 30 min. measurement time, the decreases in filtrate volumes were determined as 2.71 ml, 6.97 ml, 11.62 ml, 16.65 ml, and 18.20 ml, respectively. At 60 min. measurement time, the decreases in filtrate volumes were determined as 3.83 ml, 9.86 ml, 16.43 ml, 23.55 ml, and 25.74 ml, respectively. According to the average effect of quartz sand, it was determined that it had a filtration reduction effect of 2.82%, 7.25%, 12.09%, 17.32%, and 18.94% for drilling fluids coded QS-1, QS-2, QS-3, QS-4, and QS-5, respectively.

According to the American Petroleum Institute (API), the filtrate volumes obtained as a result of 30 min. filtration should be a maximum of 15 ml. For this reason, it was seen that the prepared base drilling fluid does not meet API requirements. However, according to the decreases in the filtrate volumes with the addition of quartz sand, it was seen that it complies with the API standard with a filtrate volume of 14.71 ml after 1 wt.% additive ratio (QS-3). This indicates that quartz sand addition should be at least 1% for drilling applications.

Statistical evaluation shows that all the filtration measurements have a polynomial slope. According to 15 min. filtration time, the optimum equation is determined as $y=0.0342x^2-3.0167x+22.041$ and $R^2=0.9858$. In the 30 min. filtration time, the optimum equation is determined as $y=0.0484x^2-4.2661x+31.17$ and $R^2=0.9855$. In the 60 min. filtration time, the optimum equation is determined as $y=0.0685x^2-6.0345x+44.09$ and $R^2=0.9857$. The results showed that the measurements and results were applied with high accuracy according to the R^2 values.

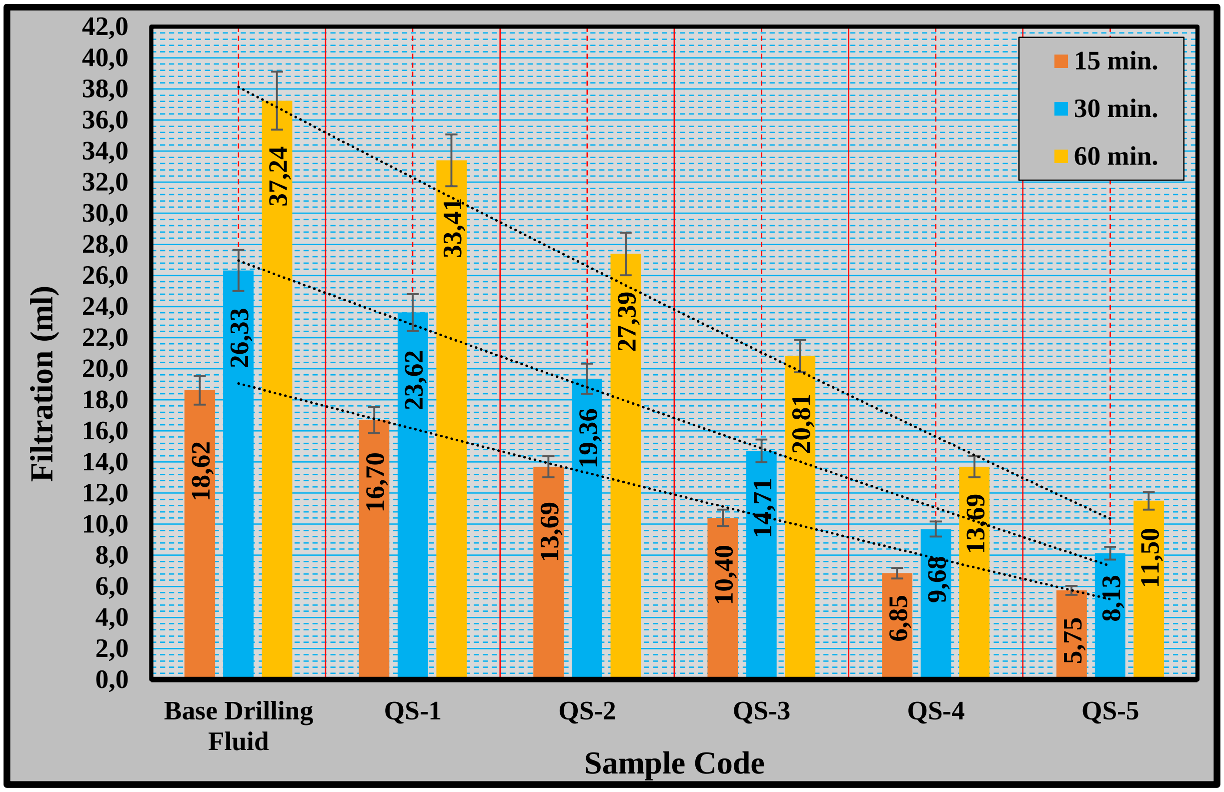

Figure 3. Filtration results of the drilling fluids

In the literature studies, there are generally studies on the filtration properties of drilling fluids with SiO_2 additives. The use of quartz shows the originality of this study. Ismail et al. (2016) determined that SiO_2 improved the filtration properties of drilling fluids. However, no comparison was made with basic drilling fluids. Salih and Bilgesu (2017) determined that increasing the concentration of SiO_2 reduced the filtrate volume of drilling fluids. Smith et al. (2018) determined that SiO_2 (<12 nm) reduced filtrate volume up to 0.5 wt.%. Bardhan et al. (2024) synthesized mesoporous silica for the performance of water-based drilling fluids and reported that a significant reduction in fluid loss was achieved by mesoporous silica. Li et al. (2024) used hydrophobic SiO_2 in water-based drilling fluids and reported that hydrophobic SiO_2 contributes to reducing filtration of drilling fluids in room temperature conditions. According to the results obtained from the experimental studies of this study, filtrate volumes of the quartz sand added drilling fluids were measured in the range of 5.75-16.7 ml, 8.13-23.62 ml, and 11.5-33.41 ml at 15-30-60 min. test times, respectively. These results showed that quartz sand has a reducing effect on the filtration of water-based drilling fluids and is compatible with the literature. In addition, polyanionic cellulose (PAC) is used as a major filtration control agent in water-based drilling fluids in industrial applications. Saadi et al. (2025) investigated to effect of PAC variants such as PAC-R (regular), PAC-L (low viscosity) and PAC-UL (ultra-low viscosity) on filtration properties of water-based drilling fluids. The base mud was prepared with 26 g bentonite (sodium type) and 350 ml distilled water. Then, PAC variants were added at 0.1, 0.3, 0.5, 0.7 and 0.9 by weight of percentage and filtration measurements were made at 30 min. time. The results show that filtrate volumes are between 6.5-5.0 ml. for PAC-R added drilling fluids, 8.3-5.5 ml for PAC-L added drilling fluids and 8.4-6 ml for PAC-UL added drilling fluids. Also, carboxymethyl cellulose (CMC) is one of the most commonly used filtration control materials in water-based drilling fluids after PAC. Iscan and Kok (2007) investigated to API fluid loss of CMC added drilling fluids. They prepared drilling fluids with 350 ml distilled water, 22.5 g bentonite and 45.8 g barite, then CMC added with between 0-4 g and recorded of API fluid loss as between 7.8-9.2 ml. Okon et al. (2014) prepared drilling fluids with 350 ml distilled water, 25 g bentonite and 5 g Na_2CO_3, and then 2.5-10 g CMC added in the drilling fluids. Results showed that API fluid loss varies between 17.5-38.5 ml. Saboori et al. (2018) investigated to effect of CMC addition on the filtration properties of drilling fluids. They prepared to drilling fluids with 350 ml distilled water, 10 g bentonite and 1-10 g CMC. Results showed that API fluid loss of the samples is between 8-15 ml. According to performance comparisons between QS and two important fluid loss control material used in drilling operations (PAC and CMC), it is determined that QS has lower yield than PAC. However, it can be an alternative for CMC in some industrial applications. In addition, QS can be used as supporting additive material for PAC and CMC added drilling fluids.

4. CONCLUSION

This study investigated the effect of quartz sand as a filtration reducer additive material in drilling fluids. Experimental studies showed that quartz sand has a decreasing effect on the spud-type drilling fluids at all additive ratios. However, at 1.0 wt.% and more ratios, the filtrate volumes were obtained as suitable to API standard. With the laboratory experiments, quartz sand (>1.0 wt.%) could be used in drilling operations for filtration reducer. However, it may vary in field applications depending on drilling conditions.

REFERENCES

Abas, N., Kalair, A., Khan, N., 2015. Review of Fossil Fuels and Future Energy Technologies. Futures, 69, 31-49. https://doi.org/10.1016/j.futures.2015.03.003

American Petroleum Institute (API). (2017). 13B-1. Recommended practice standard for field testing water-based drilling fluids.

Balat, M., 2007. Status of Fossil Energy Resources: A Global Perspective. Energy Sources, Part B: Economics, Planning, and Policy, 2(1), 31-47. https://doi.org/10.1080/15567240500400895

Bardhan, A., Vats, S., Prajapati, D. K., Halari, D., Sharma, S., Saxena, A., 2024. Utilization of Mesoporous Nano-Silica as High-Temperature Water-Based Drilling Fluids Additive: Insights into the Fluid Loss Reduction and Shale Stabilization Potential. Geoenergy Science and Engineering, 232, 212436. https://doi.org/10.1016/j.geoen.2023.212436

Bezemer, C., Havenaar, I., 1966. Filtration Behavior of Circulating Drilling Fluids. Society of Petroleum Engineers Journal, 6(04), 292-298. https://doi.org/10.2118/1263-PA

Bleier, R., 1990. Selecting a Drilling Fluid. Journal of Petroleum Technology, 42(07), 832-834. https://doi.org/10.2118/20986-PA

Caenn, R., Chillingar, G. V., 1996. Drilling fluids: State of the Art. Journal of Petroleum Science and Engineering, 14(3-4), 221-230.

Caenn, R., Darley, H. C., Gray, G. R., 2011. Composition and Properties of Drilling and Completion Fluids. Gulf professional publishing.

Davoodi, S., Al-Shargabi, M., Wood, D. A., Rukavishnikov, V. S., Minaev, K. M., 2024. Synthetic Polymers: A Review of Applications in Drilling Fluids. Petroleum Science, 21(1), 475-518. https://doi.org/10.1016/j.petsci.2023.08.015

Derakhshani, S. M., Schott, D. L., Lodewijks, G., 2015. Micro–Macro Properties of Quartz Sand: Experimental Investigation and DEM Simulation. Powder Technology, 269, 127-138. https://doi.org/10.1016/j.powtec.2014.08.072

Forsberg, C. W., 2009. Sustainability by Combining Nuclear, Fossil, and Renewable Energy Sources. Progress in Nuclear energy, 51(1), 192-200. https://doi.org/10.1016/j.pnucene.2008.04.002

Glenn, E. E., Slusser, M. L., Huitt, J. L., 1957. Factors Affecting Well Productivity-I. Drilling Fluid Filtration. Transactions of the AIME, 210(01), 126-131. https://doi.org/10.2118/720-G

Iscan, A., Kok, M. V., 2007. Effects of Polymers and CMC Concentration on Rheological and Fluid Loss Parameters of Water-Based Drilling Fluids. Energy Sources Part A Recovery Utilization and Environmental Effects, 29, 939–949. https://doi.org/10.1080/00908310600713966

Ismail, A. R., Wan Sulaiman, W. R., Jaafar, M. Z., Ismail, I., Sabu Hera, E., 2016. Nanoparticles Performance as Fluid Loss Additives in Water-Based Drilling Fluids. In Materials science forum, 864, 189-193. https://doi.org/10.4028/www.scientific.net/MSF.864.189

Li, X., Wang, K., Lu, Y., Shen, X., Zhang, H., Peng, J., Jiang, S., Duan, M., 2024. Compatibility and Efficiency of Hydrophilic/Hydrophobic Nano Silica as Rheological Modifiers and Fluid Loss Reducers in Water-Based Drilling Fluids. Geoenergy Science and Engineering, 234, 212628. https://doi.org/10.1016/j.geoen.2023.212628

Moss, A. J., 1966. Origin, Shaping and Significance of Quartz Sand Grains. Journal of the Geological Society of Australia, 13(1), 97-136. https://doi.org/10.1080/00167616608728607

Okon, A. N., Udoh, F. D., Bassey, P. G., 2014. Evaluation of Rice Husk as Fluid Loss Control Additive in Water-Based Drilling Mud. In Paper presented at the SPE Nigeria Annual International Conference and Exhibition.

Saadi, R., Hamidi, H., Wilkinson, D., 2025. Optimizing Filtration Properties of Water-Based Drilling Fluids: Performance of PAC Variants and Synergistic Effects. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 136590. https://doi.org/10.1016/j.colsurfa.2025.136590

Saboori, R., Sabbaghi, S., Kalantariasl, A., Mowla, D., 2018. Improvement in Filtration Properties of Water-Based Drilling Fluid by Nanocarboxymethyl Cellulose/Polystyrene Core–Shell Nanocomposite. Journal of Petroleum Exploration and Production Technology, 8(2), 445–454. https://doi.org/10.1007/s13202-018-0432-9

Salih, A. H., Bilgesu, H., 2017. Investigation of Rheological and Filtration Properties of Water-Based Drilling Fluids using Various Anionic Nanoparticles. In SPE Western regional meeting. SPE. https://doi.org/10.2118/185638-MS

Shaffer, N. R., 2006. The Time of Sands: Quartz-Rich Sand Deposits as a Renewable Resource. Electronic Green Journal, 1(24). https://doi.org/10.5070/G312410669

Sharma, G., Tandon, A., Guria, C., 2025. An Improved Model for Static Filtration of Water-Based Drilling Fluids and Determination of Mud Cake Properties. Fuel, 393, 134882.

SISECAM, Internet resources: https://www.sisecam.com.tr/en/business-segments/mining/silica-sand Access: January, 22, 2025.

Smith, S. R., Rafati, R., Haddad, A. S., Cooper, A., Hamidi, H., 2018. Application of Aluminium Oxide Nanoparticles to Enhance Rheological and Filtration Properties of Water-Based Muds at HPHT Conditions. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 537, 361-371. https://doi.org/10.1016/j.colsurfa.2017.10.050