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Mechanistic study of nanoparticle retention in porous media using the DLVO theory

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Nanoparticles are small enough to transport through the porous media. However, they can be retained on the pore walls by electrostatic interaction with the rock surface minerals. DLVO theory is used to understand the nanoparticle interaction with the pore walls at different ionic strength, temperature, and pH. For the case where the total interaction is repulsive, where an energy barrier exists between the nanoparticles and the pore walls, the rate of deposition has been derived. The maximum capacity of the rock surface is assumed to be monolayer coverage and follows the Langmuir isotherm. Rates of deposition of different nanoparticles onto different rocks are different due to their surface chemical properties. The rate of deposition and maximum deposition capacity onto sandstone were observed to be less than that of limestone. When energy barrier is present, rate of deposition decreases as temperature increases and when energy barrier vanishes, rate of deposition increases as temperature increases. High ionic strength increases rate of deposition. At certain condition, a critical ionic strength, which may be no less than 0.1 M (~ 0.3 wt% NaCl), exists. Above this critical ionic strength, the rate of deposition has a high value and increases gradually. At low and high pH, rate of deposition is limited due to the presence of energy barrier. However, the rate of deposition becomes high as the pH is in between the isoelectric points of nanoparticles and rock. The time-dependent rate of deposition decreases as more nanoparticles cover the pore walls.

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Effectiveness analysis of water-sealing for underground LPG storage

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With the developed transient UPNM, numerical simulations are carried out to analyse the seepage field of the underground petroleum storage project in Jingzhou, China. The 3D discrete fracture pipe network model is adopted to systematically analyse the effects of the water curtain system (different water curtain states, water curtain pressure, length and spacing and the angles of the horizontal water curtain system) on the water-sealing effectiveness of the rock caverns in the fractured rock mass in both construction phase and storage phase. Water-sealing performances of different water curtain system schemes with various fracture networks are also discussed. It is found that the effect of the horizontal water curtain is more important than the vertical water curtain. Reducing the pressure of water curtain, length of the water curtain boreholes and increase of spacing of water curtain borehole can deteriorate the seal effect of the water curtain, increase of angles of horizontal water curtain can't improve waterseal. And effective connectivity of fractures is found to be dominant factor to determine water-sealing results. In addition, it is worth mentioning that the fracture network is highly irregular in the flow domain, which greatly influence the seepage field, and the failure of the water seal effect can occur locally. The locally connected unsaturated flow paths have been observed in the study, which cannot be found by using the continuous simulation model. Finally, optimal water curtain system design is recommended. Furthermore, one connectivity evaluation criteria is developed to determine the effectiveness of water-sealing system in the field, according toLugeon, effectiveness and TEM site test.

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