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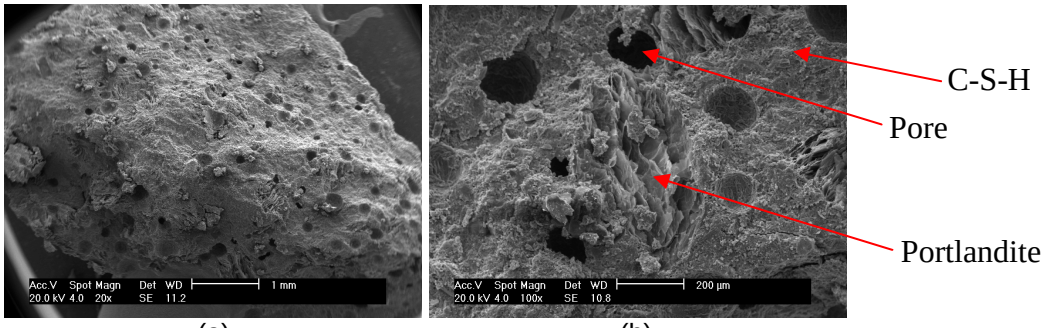
Effect of vermiculite hydrophobization and mixing order on the mechanical properties of cement slurries

P.S. Gouveia(1)*; E.N.M.G. Pinto(1); E.R.D. Nunes (1); A.E. Martinelli(1); D.M.A. Melo(1); M.A.F. Melo(1)

(1) PPGCEM, Universidade Federal do Rio Grande do Norte, priscilagouveia_materiais@yahoo.com.br.
* Corresponding author.

Abstract – Cement slurries are usually used in oilwells to counteract relatively high fracture gradients. In order to obtain useful slurries, different kinds of loads are used in their composition, including microspheres, vermiculite and bentonite. Expanded vermiculite is a high surface area material containing high amounts of silica. The goal of this study was to evaluate the effect of the vermiculite hydrophobization and mixing order on the mechanical properties of hardened oilwell cement slurries. Slurries prepared using dry hydrophobized vermiculite depicted the best performance for oilwell cementing.

Cementing is one of the most important operations to assure hydraulic isolation of oil wells. The cementing operation consists in pumping cement slurries into the annular space located between the metallic casing and rock formation of a well [1]. Appropriate cement formulations ensure structural stability of the well, avoiding accidental oil production or spillage. Oil wells with high fracture gradients do not withstand large fluid injection pressures and therefore require lightweight slurries. A variety of materials can be used to reduce the density of cement slurries, including microspheres, bentonite, vermiculite or air entraining admixtures. Vermiculite is a mica-like mineral, basically consisting of aluminum silicates and magnesium. When heated, water trapped between its layers vaporizes, particles blow up and result in flake-shaped particles that trap air, which makes the material an excellent candidate to produce low-density slurries. The obtained product is odorless, does not irritate skin or lungs, has low electrical conductivity and is leached by hot fluoric acid [2]. On the down side, low-density slurries are usually characterized by limited mechanical strength. Literature reports and preliminary laboratory tests showed that the mixing order of vermiculite in the slurry can affect the compressive strength of the hardened material, since high speed mixing can break the vermiculite flakes, reducing its efficiency. Moreover, the addition of expanded vermiculite also absorbs significant volumes of water, increasing the viscosity of the slurry, which impairs its pumping ability. Hydrophobized vermiculite can be used to reduce the adsorption of water. In this scenario, this study assessed the mechanical properties of cement slurries formulated using Portland cement, water and vermiculite. The effect of vermiculite hydrophobization was investigated. The slurries were either dry mixed or low speed mixed. Mechanical strength tests were performed using samples prepared according to NBR-9828 guidelines [3] and cured in water for 7 days at 38º C. X-Ray diffraction and scanning election microscopy were performed to evaluate crystalline and morphological changes in the hardened slurry as well as to verify if the vermiculite structure was affected by the change in the mixing order. The results showed that the strength of hardened slurries decreased with increasing the concentration of vermiculite. In the SEM analysis was verified a large number of pores, and the presence of portlandite and CSH as indicated in Fig. 1. The best results were obtained using hydrophobized vermiculite added to the slurry as a dry mixture.



(a) (b)

Figure 1: (a) Micrograph of cement and vermiculite slurry (20x); (b) Micrograph of cement and vermiculite slurry, 100x, showing the formation of pore, C-S-H e Portlandite.

References

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[3] NBR 9828 – Cimento Portland destinado à cimentação de poços petrolíferos – Determinação da resistência à compressão, Jul 1993.