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Study of New Solutions for Acid-Resistant Cements

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Abstract

In the near future, the production of oilfields with high contents of associated sour gases will increase. Research on technologies to produce such fields are therefore of utmost importance. Due to the presence of corrosive gas, special attention has to be paid to the design of well materials (casing, cementing materials). However, published data on degradation mechanisms of cement-based materials exposed to H₂S environments are very scarce. When placed in contact with acid fluid, portland cement will dissolve and become, at some time, fully degraded. In this case, the zonal isolation will be no more effective. New solutions are required to ensure long-term integrity of cementing materials. One potential solution is to incorporate chemicals in the cementitious matrix. The key idea is to incorporate additives that react preferentially with H₂S and not with hydrated phases of the cement. The goal of this work was to assess this solution.

The paper is dealing with cement formulations that incorporate mineral admixtures. These mineral admixtures have been chosen because of their high chemical affinity with hydrogen sulphide. We first give properties (density, compressive strength, rheological behaviour) of the novel formulations. Then we describe the static ageing tests performed in H₂S-saturated brine at 120°C and 15 MPa. By combining different analytical techniques, the chemical evolution of the new formulations has been investigated.

The results are dependent on the nature of the reactive mineral admixture. We show that, in some particular case, the incorporation of specific mineral admixtures leads to a strong damaging effect for the cement matrix. Consequently, for the design of H₂S-resistant cement, these specific mineral admixtures should be discarded. The proposed solution (addition of reactive chemicals) is promising but requires more investigation in order to carefully control the reactivity of the different chemical species.

Introduction

In the next decades, the hydrocarbon production will have to be increased to meet the global energy demand. A solution to increase hydrocarbons production will be to develop new reserves located in extreme environments (ultra-deep offshore, very sour gas, very heavy crude,...) thanks to innovative technologies. For instance, in the near future, production of fields with high contents of associated sour gases will increase. We estimate that 40% of the world remaining gas reserves contain more than 2% mol. CO₂ and/or more than 100 ppm H₂S. High contents of acid gases make the exploitation more difficult because these gases induce a degradation of wells construction materials. So, due to their presence, special attention has to be paid to the design of well construction and to the selection of materials (casing alloy, cementing material) to ensure long term borehole infrastructures. Therefore, research on technologies, and especially on materials, are of utmost importance to produce such fields.

Corrosion of steel due to brines containing acid gas is well documented in the literature, and to a lesser extent, data about the degradation mechanisms by wet CO₂ or wet H₂S can be found. For cementitious materials, one can find abundant literature dealing with deterioration of cement pastes due to CO₂ environments. However, published data on degradation mechanisms of cement-based materials exposed to H₂S environments are more scarce. When placed in contact with acid fluids, portland cement will dissolve and will be, at some time, fully degraded. When this happens for oil wells, there is a risk that the zonal isolation becomes ineffective. So, development of new solutions to ensure long-term integrity of cementing materials in such harsh environments is required.