INFLUENCE OF VISCOSITY HIERARCHY ON DENSITY-UNSTABLE FLUID-FLUID DISPLACEMENT IN VERTICAL CONCENTRIC ANNULI

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ABSTRACT

Primary cementing of a casing string involves removing drilling fluid from the annular space behind the casing string and replacing it with a cement slurry. The annular cement sheath should provide zonal isolation along the well and prevent leakage of formation fluids to the environment. In the conventional cementing operation, the cementing fluids are pumped down the well inside the casing and up toward the surface within the annulus to be cemented. In reverse circulation cementing operations, the cementing fluids are instead injected directly to the annulus from the surface, and the drilling fluids is displaced downward from the surface. Since reverse cementing requires less circulation pressure, it may be preferrable to use the reverse circulation method when cementing across weak formations. However, it may also lead to an increased risk of fluid contamination during mud displacement since the denser cementing fluids are now displacing the drilling fluid downward in a density-unstable configuration. We present an experimental study of reverse circulation displacement of a vertical concentric annulus. Our focus is on the effect of the viscosity hierarchy of fluids on the displacement. Our results show that there is a strong tendency for backflow and transverse flow during density-unstable displacements. When considering displacements involving fluid pairs with a fixed mean viscosity, we find a stabilization of the displacement when the displacing fluid is the more viscous of the two. When the less viscous Newtonian fluid is displacing the more viscous shear thinning fluid, the displacing fluid elongates more along the annulus. Investigation of iso-dense fluid pairs shows that there is a clearer interface between two fluids when the displaced fluid is more viscous than the displaced fluid, but the shape of the interface between two fluids is not steady.