Preface

Primary cementing is one of the most crucial steps in well construction. Poor quality of annular cement is likely to affect the well integrity during the entire subsequent life of the well. Ensuring high quality of well cementing jobs requires a good grasp of physics and mechanics of primary cementing as well as of the subsequent behavior of annular cement when the well is subject to mechanical and thermal loads during its lifetime. Such loads may be induced, e.g., by changes in the casing pressure, by evolution of in situ stresses due to hydrocarbon production, or by injection of cold or hot fluids into the well (water, steam, CO_2, etc.).

Primary cementing and subsequent mechanical or thermal loading involve multiscale and multiphysics processes. For instance, formation temperatures affect the rheological properties of the fluids injected during primary cementing. In situ stresses affect the possible formation fracturing and lost circulation during cement pumping. Cement properties affect the stresses in set cement, which, later on, will affect cement failure during, e.g., casing pressurization.

In this concise monograph, we will make an effort to write the story of well cement from the perspective of physics and mechanics of the basic processes at play. We will follow cement from the time it is pumped down the hole, to the time when it breaks (or does not) under mechanical and thermal loads during well life.

Primary well cementing is a huge area, with technological advances made every year. It would be impossible to cover all the aspects of physics and mechanics of primary cementing in a short text. Therefore, we chose to focus on several selected topics which we believe are most important for both short-term and long-term well integrity.

Chapter 1 covers the basics of primary (annular) well cementing.

In Chap. 2, physical and mechanical properties and behavior of cement are discussed. Familiarity with these properties is essential for understanding the subsequent chapters, where these properties are used.

Chapter 3 covers the physics and mechanics of mud displacement and cement placement during a primary cementing job. The effects of fluid properties (rheology, density), flow regimes, pipe eccentricity and motion, and wellbore cross section (washouts, breakouts, irregular walls) on the displacement efficiency are summarized.

In Chap. 4, different types of defects inevitably created during cement placement are discussed. These defects may facilitate the leakage and affect the service of the annular cement during the entire life of the well.

Chapter 5 takes a closer look at the cement failure caused by in situ stresses and casing pressure variation. The role of the defects discussed in Chap. 4 becomes clear when we consider debonding at casing–cement and cement–rock interfaces as well as stress concentrations and subsequent failure caused by gas-filled voids and mud channels left in the cement.

Chapter 6 concludes our story of cement by demonstrating the effects of casing heating or cooling on the integrity and failure of the adjacent cement sheath.

Primary cementing is an essential step in drilling and completion of wells in the oil and gas industry. It also plays a crucial role in the geothermal industry by ensuring safe exploitation of geothermal resources. Primary cementing of injection wells during underground storage of greenhouse gases (in particular CO_2) aims to prevent the leakage of the stored gases from the subsurface, also in the long-term perspective. The focus on integrity of geothermal and CO_2 injection wells will only increase in the future. The safety- and environment-related requirements to these wells may be even stricter than those used in the oil and gas industry. In Chap. 7, we discuss the current knowledge gaps and unresolved issues related to the physics and mechanics of primary well cementing.

The authors are thankful to Pierre Cerasi for reading an earlier version of the manuscript and providing useful comments and suggestions. The preparation of this monograph was made possible through the grant "Closing the gaps in CO_2 well plugging" provided by the Research Council of Norway (Grant No. 243765).

Trondheim, Norway
May 2016

Alexandre Lavrov
Malin Torsæter

http://www.springer.com/978-3-319-43164-2

Physics and Mechanics of Primary Well Cementing
Lavrov, A.; Torsæter, M.
2016, VIII, 108 p. 62 illus., 9 illus. in color., Softcover
ISBN: 978-3-319-43164-2