Contamination Resistant Phosphate Ceramic Cement for Arctic Applications
Nilesh Limaye, Prachi B. Vohra, Shirish L. Patil, Santanu Khataniar, Gang Chen, and Abhijit Y. Dandekar

University of Alaska Fairbanks
Fairbanks, Alaska, USA

ABSTRACT
Designing an effective cement for arctic applications is challenging. The ideal arctic cement needs to have a unique combination of physical properties, which are difficult to achieve simultaneously. Even though custom designed formulations of conventional API Portland cements are often used in the arctic, such cements have limited applicability. A novel chemically bonded phosphate cement was recently developed, and was shown to provide superior characteristics for arctic applications. However, in the course of normal field practice when a slurry of the new ceramic cement is prepared using on site equipment, there is a good possibility of its being contaminated by leftover Portland cement in the mixing equipment. Some preliminary tests conducted by an oilfield service provider showed that the contamination of ceramic cement by Portland cements could significantly reduce the ceramic cement’s applicability in arctic conditions. In order to investigate this matter further and develop possible remedies, effect of Portland cement contamination on ceramic cement was studied using new formulations of ceramic cement. The results from this study showed that contamination of these ceramic cement formulations by Portland cement did not adversely affect the desirable properties of the ceramic cement. In fact, in some cases, the “contaminated” ceramic cement showed superior properties than the pure ceramic cement.

KEY WORDS: Arctic; Portland cement; Ceramicrete; Permafrost.

INTRODUCTION
Oil well cements for the arctic have to perform the essential task of providing zonal isolation like the conventional cements but at the same time these cements need to have unique characteristics to set in cold temperatures and protect the permafrost from deteriorating during the production operation. “Permafrost” is the region that has remained frozen for at least two consecutive years. To achieve well integrity and ensure it is maintained during the operating life of the well, it is important to prevent the permafrost from thawing. Although the conventional API (American Petroleum Institute) Portland cements have been used for arctic applications, they suffer from limitations such as freezing of water before the cement sets, development of cracks due to the freezing of water in the capillaries of the cement, thawing of the permafrost due to the heat released during the exothermic process of cement hydration. Therefore, in order to complete the wells in the arctic using these conventional cements, it is necessary to follow tedious procedures depending on the wellbore conditions.

API class A, C or G cements available for arctic applications cannot be used for unconsolidated formations that are frozen since they have low compressive strength, tendency to freeze at temperatures below freezing and exhibit low compressive strength, short life and uncontrolled expansion (Goodman, 1977). The ice network formed due to use of conventional cements in the arctic can be disturbed by heat and thus may lead to well integrity issues (Nelson and Drecq, 2001).

API class A, C or G cements available for arctic applications cannot be used for unconsolidated formations that are frozen since they have low compressive strength, tendency to form cracks if contaminated by sodium chloride and increased permeability in presence of hydrates and due to freeze thaw cycle (Mair et al, 1971). Significant research has been done to formulate cement that can be satisfactorily used for permafrost applications. Cements with high proportions of calcium aluminate can set at low temperatures and have found successful applications in Canada and Alaska North Slope. But its contamination with Portland cement can lead to abrupt setting (Mair et al, 1971). A blend of Portland cement with gypsum can develop strength at lower temperatures and has a low heat of hydration of 20 Btu/lb however; Ettringite formation and its high cost make it less favorable (Mair et al, 1971). Under arctic conditions, freeze temperature depressants are required to lower the freezing temperature of water so that cement hydration and placement can take place below freezing temperatures. The commonly used freeze point depressants are (i) salts and (ii) alcohol and polymers. Sodium Chloride (NaCl) is the most common freeze temperature depressant salt used for permafrost cement formulation along with fly ash in ‘Ciment Fondu’. Calcium Chloride (CaCl2) is already added in Class G cements. Hence for permafrost would include gypsum cement, Class G cement and NaCl for controlling the thickening time. Methanol and Diethylene glycol (DEG) also work well as freeze point depressants. Commercially available DEG acts as a cement retarder and hence, should not be used in cement formulation.