PROCESSES OF DOLOMITIZATION — IMPORTANT FACTORS INFLUENCING PORE GEOMETRY AND RESERVOIR QUALITY IN MISSISSIPPIAN INNER SHELF CARBONATES OF SOUTHEASTERN SASKATCHEWAN

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ABSTRACT

The origin of the dolomites that form hydrocarbon reservoirs in inner shelf lime mudstones and wackestones of the Mississippian Midale and Ratcliffe Beds of southeastern Saskatchewan is not clearly understood. However, studies of the geometry of pore systems using capillary pressure mercury injection analyses supplemented by scanning electron microscopy aid elucidation of the processes that created the dolomitized reservoir rocks.

There is fairly good evidence that entry pressures obtained from capillary pressure mercury injection analyses are markedly influenced by the “calcareousness” of the carbonate reservoir rock; the greater the proportion of dolomite present, the lower the entry pressure. In addition, it has been shown that the best dolomite reservoir is one in which 75% to 90% of the rock has been dolomitized (inhibition boundary stage of crystal growth). When the degree of dolomitization increases beyond 90% the dolomite crystals enter a compromise boundary stage of growth, resulting in a reduction of pore volume and permeability. Attainment of the inhibition boundary stage is not sufficient to produce a good reservoir; it must be accompanied by dissolution of the remnant host rock, creating porosities ranging from 25% to 38% and permeabilities on the order tens of millidarcies. An additional factor that creates good reservoir rock in the inhibition boundary stage of crystal growth is the uniform size of crystals and pore throats, easily recognized on capillary pressure mercury saturation plots.

The most likely dolomitizing mechanism by which both inhibition boundary stage and remnant host rock dissolution could be facilitated is the mixing zone process. Fresh meteoric waters capable of dissolving the remnant host rock would enter the dolomitized rock proceeding the passage of the mixing zone through it. In contrast, reflux dolomitization would be more likely to cause either a compromise boundary stage of dolomitization or produce a calcareous dolomite.

INTRODUCTION

Over the past eight years the senior author and a number of graduate students in the Department of Geology, University of Regina, have been involved in investigations into the nature of pore systems in a variety of hydrocarbon reservoirs in the carbonate rocks of the Mississippian System of southeastern Saskatchewan. The studies have been threefold in nature, including microfacies analyses of the rocks in the field areas, pore geometry studies employing mercury injection capillary pressure (MICP) techniques, and an interpretation of the influence of diagenesis on the porosity as determined from light and scanning electron microscopy. To date, fairly detailed investigations have been completed on four fields and one of the present authors (JBB) is examining three other fields, Flat Lake, Lake Alma, and Oungre (Fig. 1). All of the fields studied present a fairly broad cross section of reservoir rock types with some distinct differences in pore geometry characteristics. In several of the fields, most production is from dolomitized lime mudstones or skeletal and peloidal wackestones. These rocks exhibit marked variations in the degree of dolomitization, and hence, in reservoir quality. It appears that the extent of dolomitization could be related to the mechanism of dolomitization.

The fields considered in this paper include: Flat Lake, Lake Alma and Oungre, all producing from the Ratcliffe Beds, as well as Benson and Glen Ewen producing from the Midale Beds (Fig. 1).

Fig. 1 - Location map of southern Saskatchewan, showing the fields studied.

Geological Setting

Kent (this volume) has shown that the Mississippian rocks of the northeast flank of the Williston Basin consist of a prograding, shallow upward mega sequence within which there are a number of high and low energy shallowing upward cycles, as well as some brining upward cycles. The succession can be separated into several facies ranging from anaerobic basin through dysoaerobic basin slope to aerobic shallow shelf and peritidal. Hydrocarbon reservoirs are commonly found in partly or totally dolomitized inner shelf lime mudstones and wackestones or in the shelf marginal and shelf creetal skeletal

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