Investigating CO_2 Storage Potential of Carbonate Rocks during Tertiary Recovery from a Billion Barrel Oil Field, Weyburn, Saskatchewan: Part 1 – the Geoscience Framework (IEA Weyburn CO_2 Monitoring and Storage Project)

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1. Introduction

In Western Canada, the application of CO_2 injection for enhanced 'tertiary' oil recovery is a relatively recent addition to the arsenal available to reservoir engineers. The first successful application of CO_2 as a miscible fluid in Western Canada began in 1984 at Joffre Field, a Cretaceous marine siliciclastic reservoir in southern Alberta. A significant portion of the remaining proven conventional oil reserves in Western Canada resides in large, mature Paleozoic carbonate fields such as the Mississippian Weyburn Field in southeastern Saskatchewan. In combination with economically dictated tertiary recovery schemes, these large fields have potential as suitable sites for future geological storage of anthropogenically produced greenhouse gases. An immediate challenge to geoscientists is to assess the ability of these carbonate containers to store CO_2 for geologically significant lengths of time. Storage of this kind is currently in progress in siliciclastic rocks beneath the North Sea, where, at the Sleipner Field, the Norwegian oil company, Statoil, has been injecting about one million tons/year CO_2 into a saline aquifer, the 1000 m deep Middle to Late Miocene Utsira Formation, since 1996.

The CO_2 miscible flood recently initiated by PanCanadian at the Weyburn Field provides an ideal natural laboratory to begin an investigation into a carbonate-reservoir assessment process. To this end, the International Energy Agency (IEA) and a consortium of industry and government partners have designed a comprehensive suite of research and monitoring activities with, as their prime objective, assessing the capacity of a carbonate oil reservoir to store CO_2 over time. For monitoring purposes, the Weyburn Field has several advantages over Sleipner, in particular its easy access, the availability of very extensive pre-CO_2 injection geological and reservoir data dating from the field's discovery in 1954, and the dense drilling pattern that will help enable CO_2 movement to be readily tracked. A multinational, multidisciplinary approach is being used, with six main task areas initially involved: 1) collecting field data and samples; 2) investigating the wider geoscience framework; 3) geochemical sampling, monitoring, and prediction; 4) monitoring CO_2 movement; 5) evaluating CO_2 storage performance; and 6) calculating the economics of CO_2 storage. Project and task interim results are expected to be reported at regular intervals in a variety of ways including future *Summaries of Investigations*, with final products becoming publicly available in 2004 or 2005. The overall budget is estimated at over $14 million (Canadian). Whilst a substantial proportion of the required funding is now in place, efforts to obtain the balance continue.

2. Objectives

To help the project meet its objective, the main problems to be investigated in the geoscience framework task area include: i) the distribution of porosity and permeability within the Weyburn reservoir, in laterally equivalent strata and in underlying and overlying rocks; ii) the distribution and role of fractures within the Weyburn reservoir, in laterally equivalent strata and in underlying and overlying rocks; iii) the distribution of fluids within the Weyburn reservoir, in laterally equivalent strata and in underlying and overlying rocks; iv) factors controlling the distribution of porosity, permeability, fractures, and, ultimately, fluid flow; v) migration pathways of the injected CO_2; and vi) CO_2 trapping mechanisms in the reservoir. Resolving such problems requires understanding of the relationships between sedimentation, diagenesis, salt dissolution, tectonics, and fluid flow pathways and barriers of the entire sedimentary section from the contact of Precambrian crystalline basement with Cambrian sediments to the present-day surface over a distance of up to 100 km from the Weyburn Field (Figure 1).

3. Project Structure

The geoscience framework project has been subdivided into five main components: 1) pre-Mississippian geology; 2) Mississippian and post-Mississippian

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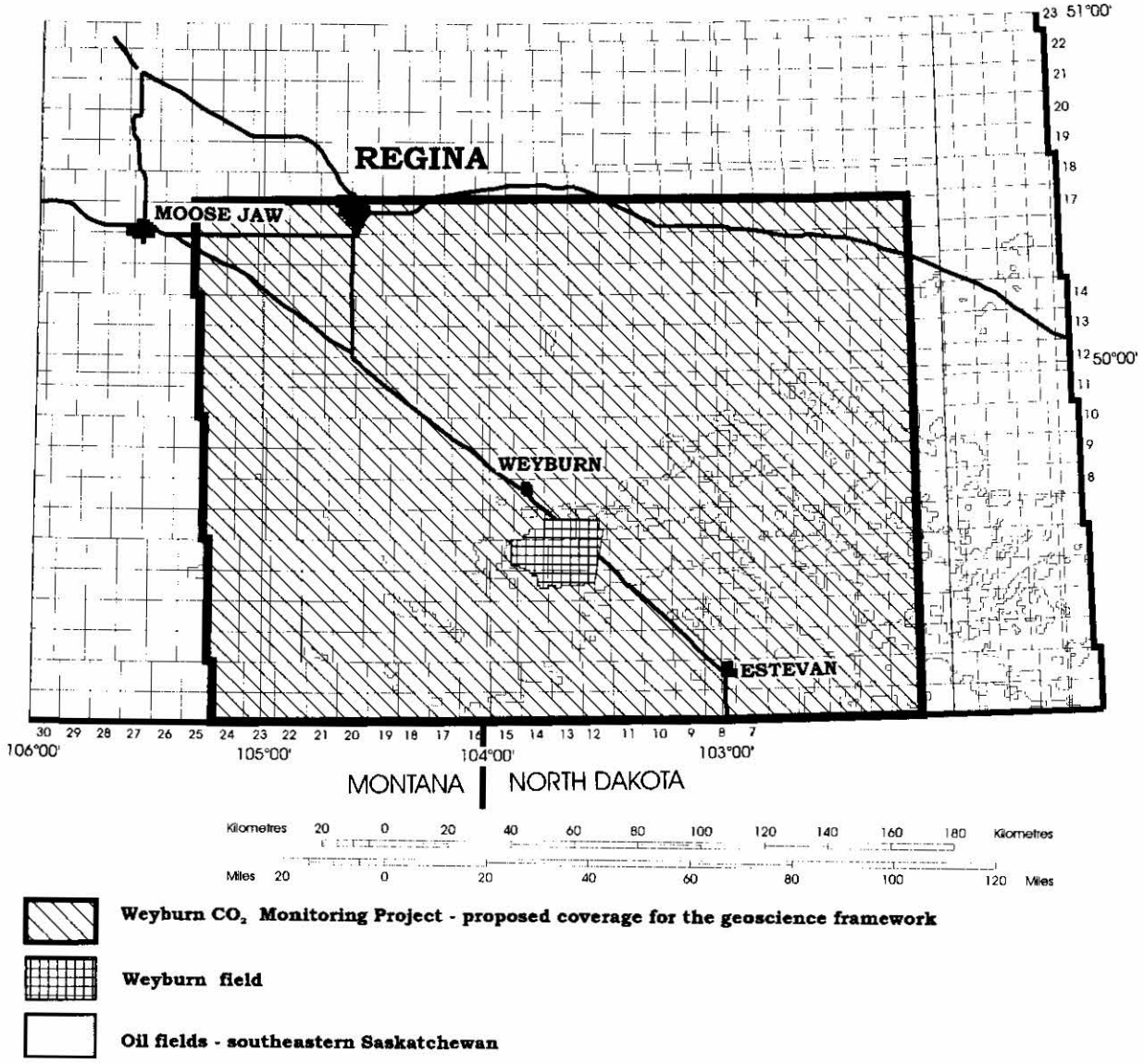

Figure 1 - Location of the IEA CO_2 Monitoring and Storage Project's Geoscience Framework study area.

geology; 3) hydrogeology; 4) reflection seismic studies; and 5) geoscience synthesis (Figure 2). In addition, detailed Weyburn Field geological information from PanCanadian and other sources will be incorporated into all components as necessary.

In order to produce valid and valuable results, the need to assemble a team with expertise in different geoscience disciplines was recognized from the project's early beginnings in 1999. Saskatchewan Energy and Mines took a lead role in inviting experts from the earth sciences departments of several western Canadian universities to participate (Figure 2). Also recognized was the need for a contract research scientist who, based with Saskatchewan Energy and Mines, will co-ordinate the various tasks and have overall responsibility for synthesizing and interpreting the various datasets to build a comprehensive geoscience framework of the study area.

4. Project Participants

Saskatchewan Energy and Mines, under the leadership of Chris Gilboy, is responsible for pre-Mississippian geology and for co-ordination of the project. The study of the geology of Devonian strata, with emphasis on evaporite distribution in the study area, will be led by Kim Kreis. Fran Haidl will co-ordinate studies of the influence of the geological evolution of pre-Mississippian strata on the sedimentology, diagenesis, and distribution of porosity and permeability in Mississippian reservoirs.

The University of Alberta, under the leadership of Dr. Ben Rostron, is responsible for quantifying the 3-D fluid-flow rates and directions with a primary objective of identifying potential CO_2 leakage pathways.

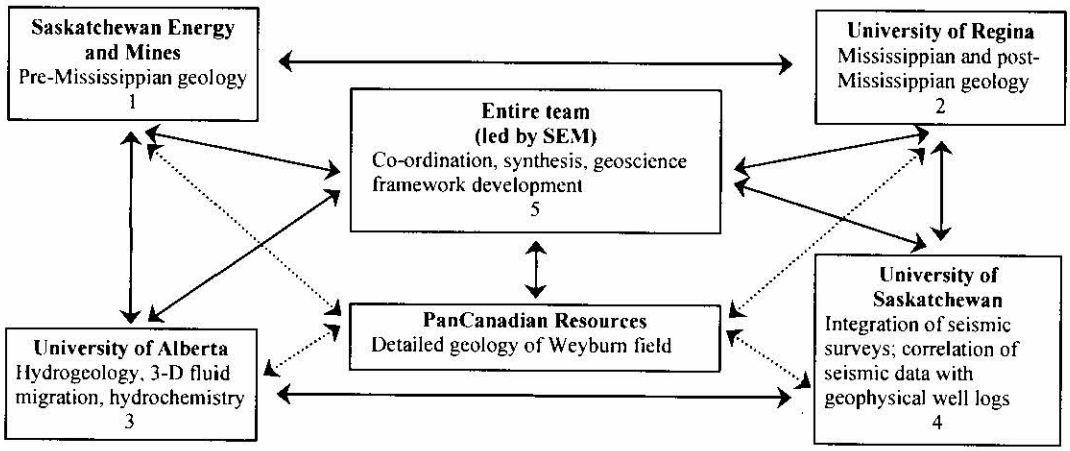

Figure 2 - Information-flow diagram for participants in the Geoscience Framework synthesis (not shown are the direct links between 1 and 4, and 2 and 3).

The University of Saskatchewan, under the leadership of Dr. Zoli Hajnal, is initially to reprocess existing seismic reflection and wireline information, then, in collaboration with the co-ordinating geoscientist, to integrate the resulting data with geological information supplied by other team members to build a three-dimensional stratigraphic model of the study area.

The University of Regina, under the leadership of Dr. Hairuo Qing, is to study the geology of Mississippian and post-Mississippian strata with emphasis on stratigraphic, sedimentological, diagenetic, and fracture-trend analyses. Dr. Katherine Bergman is a co-researcher with responsibility primarily for clastic strata above Mississippian rocks.

PanCanadian Resources, through its Voyageur Business Unit, will provide geological expertise and information that is helpful towards clarifying understanding of geological relationships in and immediately around the Weyburn Field.

5. Current Status

In mid-February 2001, budgets were allocated to team partners in the following amounts:

University of Alberta	$50,000
University of Saskatchewan	$148,000
University of Regina	$50,000
Saskatchewan Energy and Mines	$110,000
Total	**$358,000**

At the time of writing (early March 2001), various agreements have yet to be signed and other minor logistical obstacles overcome before research into the geoscience framework of the wider Weyburn area begins in earnest.