Introduction

Conventional power plants generate electricity by combustion of fossil fuels. The emission of CO\(_2\) gas, which is a greenhouse gas, as a result of this combustion has led to increase in CO\(_2\) concentration in atmosphere. Carbon sequestration can be defined as the reduction of CO\(_2\) by capture from the point sources like power plants and subsurface storage. The subsurface CO\(_2\) storage can be achieved by injection of CO\(_2\) for sequestration in aquifers by means of mineral trapping and hydrodynamic trapping (Gunter et al., 1996), depleted oil and gas reservoirs by taking advantage of naturally available seal, coal seams, or viscous oil recovery by CO\(_2\) flooding. According to EPA’s Energy CO\(_2\) inventory, the state of Alaska emitted 41 Million tons of CO\(_2\) during the year of 2000. The combustion of fossil fuels from industrial and electric utilities contributed around 20 Million tons to the total CO\(_2\) emissions. Due to absence of any CO\(_2\) sequestration studies for Alaska, the current project, the study of CO\(_2\) sequestration options in Alaska, will open new avenues for the assessment of carbon dioxide disposal options in Alaska.

Methods

The amount of CO\(_2\) emitted from power plants and other processing utilities, which are present on ANS, was determined by using EPA’s eGRID database. GIS study was performed by using ArcGIS 9.0 to create a layer map (Figure 1) of CO\(_2\) source and oil pools.

The ranking of the oil reservoirs (Table 1) to evaluate the technical feasibility with respect to their CO\(_2\)-EOR potential was performed by calculating the rank of the reservoirs for EOR studies by comparing the parameters like oil gravity (ºAPI), porosity (\(\Phi\)), permeability (k), temperature (T), pay zone thickness (h), oil saturation (\(S_o\)) and minimum miscible pressure (MMP) with the optimum reservoir parameters (Rivas et al., 1992). The detailed step-wise procedure for ranking is given as follows:

1. Normalization of parameter

Normalized parameter (X) is given by, 
\[
X_{i,j} = \frac{|P_{i,j} - P_{o,j}|}{|P_{w,j} - P_{o,j}|}
\]

(Equation 1)

j - parameter, i - reservoir, 
P - magnitude of parameter (ºAPI, temperature etc) 
o - optimum: best case scenario 
w - worst case scenario

2. Transformation to exponential parameter

A \(i,j = 100\times \exp\left(-4.6 \times X_{i,j}^2\right)\)

(Equation 2)

Exponential function is better than linear function for comparing different elements in same set
### 3. Generation of weighted grading Matrix

\[
W_{i,j} = A_{i,j} \times w_j \quad \text{(Equation 3)}
\]

- \( W_{i,j} \): weight of the parameter (obtained from studies by Rivas et al., 1992)
- \( W_{i,j} \): weighted grading matrix

### 4. Rank of the reservoir

\[
R_i = 100 \ W_{i,j} \times W_{j,i} / R_o \quad \text{(Equation 4)}
\]

- \( W_{j,i} \): transpose of matrix \( W_{i,j} \)
- \( R_o \): sum of array of weighted properties of optimum reservoir

West Sak oil pool was selected (Rank = 13 in Table 1) for prediction of oil production due to viscous nature of West Sak crude (19°API). In spite of having lower rank with respect to CO\(_2\)-EOR potential, West Sak oil pool is a potential candidate for CO\(_2\) flooding studies because over 25 billion barrels of oil in place was estimated to be present in West Sak (Panda et al., 1989). The phase behavior of any reservoir fluid by CO\(_2\) injection involves mass transfer and changes in composition. Traditionally, different equations of state have been used to predict reservoir fluid phase behavior at various conditions. The most common and reliable EOS, Peng-Robinson (PR-EOS), was used in this study The original form of the PR-EOS (Peng and Robinson, 1976) is:

\[
P = \frac{RT}{V - b} - \frac{a}{V(V + b) + b(V - b)}
\]

\( \text{(Equation 5)} \)

Where, \( a \) and \( b \) (attractive and repulsive terms) are functions of critical properties and ascentric factors

The inherent deficiencies of EOS for multi-component mixtures are widely known. Tuning of EOS (Ali, 1998) helps to improve the predictions of phase behavior. CMG-Winprop simulator, which minimizes the sum of squares of the relative errors by regression technique, was used to predict the phase behavior for West Sak crude and CO\(_2\) mixture by tuning the equation of state (EOS). Regression of critical properties, ascentric factors, and \( \omega_A \) and \( \omega_B \) of C\(_7^+\) components (Abrishami et al., 1997) was accomplished by previous laboratory constant composition expansion (CCE) experimental data (Figure 2). To investigate the miscibility condition of West Sak crude with CO\(_2\), the pseudo ternary plots were plotted at different pressures. The ternary plots are plotted as shown in Figure 3.

For future production prediction studies, well log data interpretation for West Sak, obtained from work of Panda et al., 1989 were used to interpolate the values of porosity, saturation and net pay thickness at unsampled locations by using conditional simulation technique. In case of conditional simulation, \( Z \) estimates are based on a form of stochastic simulation in which measured data values are honored at their locations

The predictions of heavy oil productions by CO\(_2\) flooding in West Sak oil pool are under way. In future, the impact of permafrost on long-term CO\(_2\) storage will be investigated by Subsurface Transport over Multiple Phases (STOMP) computer model (developed by PNNL), and the

### Table 1: Screening of oil pools, present on ANS, according to their potential for enhanced oil recovery (oil pools with respect to optimum reservoir are shown here)

<table>
<thead>
<tr>
<th>Pool</th>
<th>( T, ^\circ F )</th>
<th>( \Phi, % )</th>
<th>( k, md )</th>
<th>( S_o )</th>
<th>( h, ft )</th>
<th>( ^\circ \text{API} )</th>
<th>( P/ \text{MMP} )</th>
<th>( R_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarn</td>
<td>142</td>
<td>20</td>
<td>9</td>
<td>0.6</td>
<td>40</td>
<td>37</td>
<td>1.64</td>
<td>1</td>
</tr>
<tr>
<td>Meltwater</td>
<td>140</td>
<td>20</td>
<td>10</td>
<td>0.6</td>
<td>95</td>
<td>36</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>Sag River</td>
<td>234</td>
<td>18</td>
<td>4</td>
<td>0.6</td>
<td>30</td>
<td>37</td>
<td>1.86</td>
<td>3</td>
</tr>
<tr>
<td>North Prudhoe</td>
<td>206</td>
<td>20</td>
<td>590</td>
<td>0.6</td>
<td>20</td>
<td>35</td>
<td>2.07</td>
<td>4</td>
</tr>
<tr>
<td>Pt. McIntyre</td>
<td>180</td>
<td>22</td>
<td>200</td>
<td>0.6</td>
<td>156</td>
<td>27</td>
<td>1.27</td>
<td>5</td>
</tr>
<tr>
<td>Hemlock</td>
<td>180</td>
<td>10.5</td>
<td>53</td>
<td>0.7</td>
<td>290</td>
<td>33.1</td>
<td>2.34</td>
<td>6</td>
</tr>
<tr>
<td>Alpine</td>
<td>160</td>
<td>19</td>
<td>15</td>
<td>0.8</td>
<td>48</td>
<td>40</td>
<td>1.81</td>
<td>7</td>
</tr>
<tr>
<td>Lisburne</td>
<td>183</td>
<td>10</td>
<td>1.5</td>
<td>0.7</td>
<td>125</td>
<td>27</td>
<td>1.03</td>
<td>8</td>
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<tr>
<td>Prudhoe</td>
<td>200</td>
<td>22</td>
<td>265</td>
<td>0.7</td>
<td>222</td>
<td>28</td>
<td>0.94</td>
<td>9</td>
</tr>
<tr>
<td>Kupurak River</td>
<td>165</td>
<td>23</td>
<td>40</td>
<td>0.7</td>
<td>35</td>
<td>22</td>
<td>0.76</td>
<td>10</td>
</tr>
<tr>
<td>Schrader Bluff</td>
<td>80</td>
<td>28</td>
<td>505</td>
<td>0.7</td>
<td>70</td>
<td>17.5</td>
<td>0.4</td>
<td>11</td>
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<tr>
<td>Kupurak-Milne</td>
<td>160</td>
<td>20</td>
<td>150</td>
<td>0.9</td>
<td>100</td>
<td>24</td>
<td>0.79</td>
<td>12</td>
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<tr>
<td>West Sak</td>
<td>75</td>
<td>30</td>
<td>1007.5</td>
<td>0.7</td>
<td>70</td>
<td>19</td>
<td>0.41</td>
<td>13</td>
</tr>
<tr>
<td>Ivishak</td>
<td>254</td>
<td>15</td>
<td>200</td>
<td>0.5</td>
<td>125</td>
<td>44</td>
<td>4.11</td>
<td>14</td>
</tr>
</tbody>
</table>

*Note: The data provided in Table 1 is for screening oil pools based on their potential for enhanced oil recovery, with West Sak oil pool ranked 13th.*
a) Liquid Volume in percentage  
b) Relative oil volume  

Figure 2 (a & b): Regression of CCE data to tune EOS  

Fig. 3 (a-d): Pseudo ternary plots at different pressures for West Sak Crude + CO₂ mixtures. Where, component 1: C₇₊ as the heavy fraction (H), component 2: N₂, C₁ as the light fraction (L), and component 3: C₂, C₃, C₄, C₅, C₆, and CO₂ as the intermediate fraction (I)
corresponding incremental benefits of CO\textsubscript{2} storage will be compared with CO\textsubscript{2}-EOR.

**Conclusions**

The characterization of Alaskan oil pools with help of screening technique has the advantage of studying EOR potential of the oil pool as far as CO\textsubscript{2} injection is considered. True evaluation of storage technique is dependent on economics originating from transportation, compression, and injection. Thus, the GIS technique could prove, in future, to be essential tool to gain insight into related economics and in turn, assisting policy makers to make prudent decisions.

Due to the presence of heavy hydrocarbons in the West Sak crude, the miscibility of the crude with CO\textsubscript{2} is achieved by condensing/ vaporizing multiple contact mechanism (Zick, 1986).

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**References**


