Research activities in Alberta University based on International Training Program (ITP) in 2009

Hiroyuki Kono, Master Student
Depart of Earth Resource Engineering, Faculty of Engineering, Kyushu University

Based on International Training Program (ITP) supported by Japan Society for the Promotion of Science (JSPS), I had carried out research activities within 3 months (4th August～17th October in 2009) in Alberta University, Edmonton city, Canada. Here, I would like to explain the outline of Edmonton and Alberta University, the introduction of cooperative staffs belonging to Department of Civil & Environmental Engineering, field trip and research activities.

1. Outline of Edmonton and Alberta University

Alberta University is located in Edmonton, Alberta, Canada. Surroundings of Alberta University are written below.

① Edmonton, which is the capital of Alberta State, is located in the northeast part of the state. You have to fly to Edmonton via Vancouver because there is no flight from Japan to Edmonton. It takes approximately 40 minutes from Edmonton airport to downtown by taxi or shuttle bus.

② Calgary is the biggest city which is near from Edmonton and has Japan embassy. If you meet with some troubles, you might be able to solve them as early as possible.

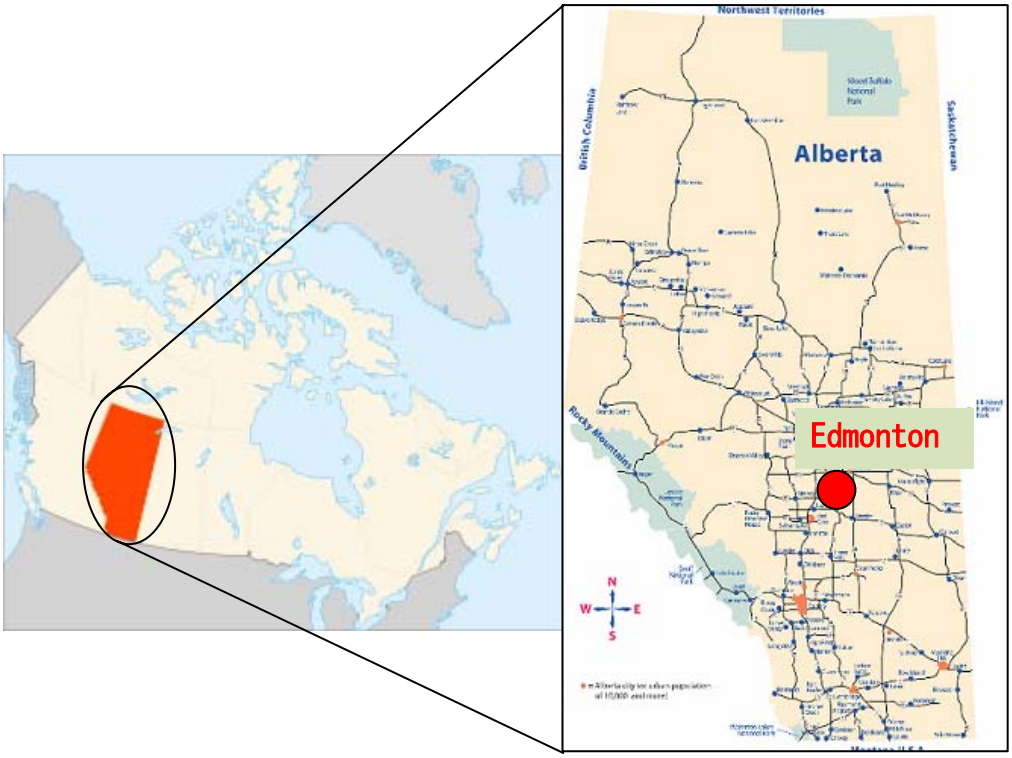
③ After World War Ⅱ oil was discovered surrounding of Edmonton so Edmonton has been developed especially since oil shock occurred and now is the big city which more than 1 million people live. Considering the name of the professional ice hockey team is "Oilers", you can understand how oil has contributed to Edmonton.

④ It is so convenient that you can go from everywhere to University by bus and subway. I recommend that you buy commuter pass, which costs about 7000 yen, so that you can ride bus and subway however you want. You can buy the pass in the university.

⑤ There are supermarkets, shopping centers, banks, post offices, Japanese restaurants, and so on in the downtown. There is "West Edmonton Mall", which is the biggest shopping mall in the North America and has Chinatown where you can buy Japanese foods, amusement park and many kinds of shops in suburb which is accessible from downtown or university with about 30 minutes.

⑥ You can eat foods which are from various countries such as hamburgers, tacos and Japanese food. I recommend that you eat at Japanese restaurant "Edo".

⑦ In summer it is so comfortable because it is dry. However, from the middle of October we have snow everyday so we can't go out without heavy clothes.



Location of Edmonton




View of Alberta University

２． Cooperative staffs in Alberta University

I will introduce the staffs who kindly supported my stay and research in Alberta Un iversity. I really appreciate their kindness.

・Prof. Tayfun Babadagli
He is the director of the Enhanced Oil and Gas Recovery and Reservoir Characteriza tion Rearch Group (EOGRRC), who is very famous around the world. He arranged about classes for me and gave me a lot of advice about my research.

・Assistant Prof. Japan Trivedi
He let me attend his class and gave me a chance to talk about my research to high school students on open campus day.

・Khosrow Naderi（PHD）
He kindly taught me how to use instruments and chemicals and deal with some pro blems.

3. Field trip at Fort McMurray

I fortunately could join the field trip which was held in the other program. I visited Fort McMurray which is famous for oil sands. I want to introduce JACOS and Sync rude which are famous as oil sand developer.

3-1. Syncrude

Syncrude is the oil sand developing company which was established in1964 and now is t he biggest company in Canada. Syncrude digs 1.4 million ton/day. 0.7 million ton of the m are oil sands and 437,500 bbl of bitumen are produced every day. In the digging area which Syncrude has developed oil sands will have been developed for 50 to 80 years. In the other area Syncrude will have developed for 20 years. In so broad mining area there are many shovels and trucks. The capacity of shovel and truck is 100 ton and 400 ton (biggest in the world). The shovel loads the truck with oil sands and truck takes them to the crusher plant. I show how to produce synthetic oil from oil sands.

① Crusher plant
Oil sands which crushed here are slurried with hot water and go to floatation plant with pipeline.

② Floatation plant
Oil sands are divided into three parts, bitumen, water and sands by difference of spe cific gravity. However, specific gravity of bitumen is similar to that of water. Theref ore air (bubble) which is hydrophobic is used to separate bitumen from water.

③ Naphtha addition
Bitumen is so viscous that it is difficult to carry bitumen with pipeline. Therefore na phtha which is light component is added to decrease the viscosity.

④ Upgrading
Hydrogen is added at another plant and synthetic oil is produced. Then the sulfur is also produced as a byproduct but what they can do is only to build them up. Thi s is a problem.

Syncrude is green company and reclaim the fields which have been finished to develop with big money. 22% of the fields have been reclaimed until now and protect bison whos e the amount is decreasing because of the oil sands mining there. In addition, 88% of the discharged water has been recycled. One of their aim is to make the crusher plant porta ble in order to reduce the distance which trucks must travel in the digging are.


View of mining field（Left：Broad mining field　Right：Huge amount of sulfer）


Machine for mining（Left：Truck　Right：Bucket of shovel）


Ceremonial photo（Left：With tire of truck　Right：Bison which is protected）

3-2. JACOS

JACOS（Japan Canada Oil Sands Limited）is an oil sands developing company which was established as a affiliate company of JAPEX in 1978. SAGD method for bitumen producing was established in the middle of 1990s and JACOS has produced bitumen in its own digging area. JACOS has studied about SAGD method and is one of the oldest oil sands developing company in the field. SAGD method stands for Steam Assisted Gravity Drainage Method and is the way to produce extra heavy oil called bitumen. Two horizontal wells are drilled through oil sand reservoir and hot steam is pressurized from the upper well (injection well) and bitumen is produced from the lower well (production well). This method is effective for the reservoir 80 to 500m below the surface which is not economical with open pit mining.

Now production is 8000 bbl/day with 19 pairs of wells but JACOS planned to increase the amount of well and production and finally the production will be 30000 bbl/day in 2014. Recovery ratio of bitumen is 70 to 80% of the steam chamber. Temperature and pressure of the steam are approximately 260ºC and 4.7 to 5.0MPa. Many thermometers are set at the injection and production well and measure each temperature of the steam in order to arrange the amount of the steam (If the difference is large, more steam will be injected, and vice versa). Surface of hot water is set at the middle of the wells.

JACOS is also a green company. Hot water which is produced is separated into water and waste such as silica and sulfur and 70 to 80% of the water is recycled. A problem is that 66% of the operating cost is spent to make the hot steam. The solution may be to reduce the amount of the hot steam by injecting naphtha or CO2 at a time.

SAGD method（Left：Pattern diagram of SAGD method　Right：Deviated well head）

View of tour for study（Left：At field　Right：With engineers）

４．Study at Alberta University

Theme : Basic study about relation between oil saturation and oil swelling caused by CO2 dissolution

4-1. Background and Purpose

In recent years CO2 EOR has been conducted as gas injection around the world. Swelling of crude oil caused by carbon dioxide dissolution contributes to oil recovery in CO2 EOR. There are two advantages. First, oil swelling decreases the viscosity of oil. Second, oil swelling increases oil saturation so that the relative permeability of oil also increases. Thus oil swelling makes some of the residual oil mobile. Therefore the research of oil swelling will help us to understand oil recovery mechanisms in CO2 EOR process.

In our previous research it was shown that both swelling speed and swelling rate increases with the specific contact area between oil and CO2. In reservoir the contact area depends on the oil saturation so the relation between oil swelling and oil saturation was investigated in this research.

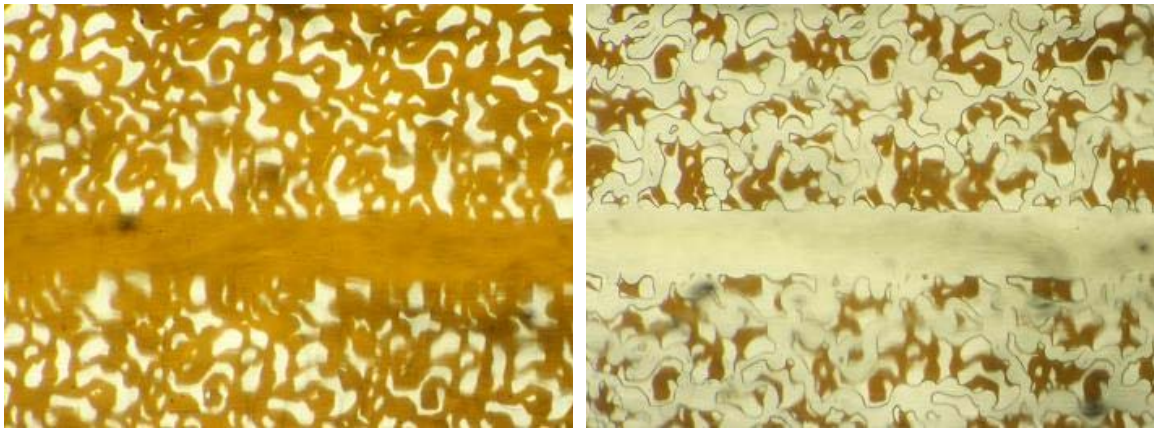
4-2. Instrument and Procedure

Transparent 2-D heterogeneous glass micromodel (porosity: 76.2%) which was etched networks representing the rock pore structure with fracture has been used to identify pore-scale events. This micromodel was set inside the pressure cell and this experiment was conducted like below.

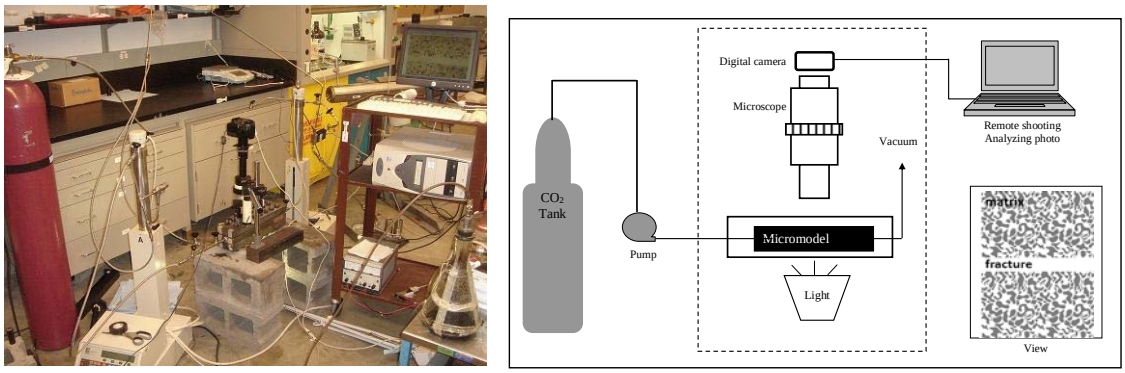
(1)Inject CO2 sufficiently to replace air inside the cell with CO2.
(2)Inject crude oil and to fill micromodel up.
(3)Inject CO2 for flooding and regulate the oil saturation. The oil saturation here is initial oil saturation.
(4)Pressurize CO2 until 350 kPa so slowly that the oil saturation does not change and shut CO2 in the cell.
(5)Take a picture of the micromodel every 10 minutes to observe oil swelling until swelling finishes.
(6)Analyze the picture with a software “Image-Pro” to calculate swelling factor. Swelling factor B is defined with initial oil saturation S_i and last oil saturation S_l as

$$B = S_l/S_i$$

(7)Conduct with different initial oil saturation and find the relation between S_i and B.



Micromodel（Left：after filled up with oil、Right：after CO2 flooding）

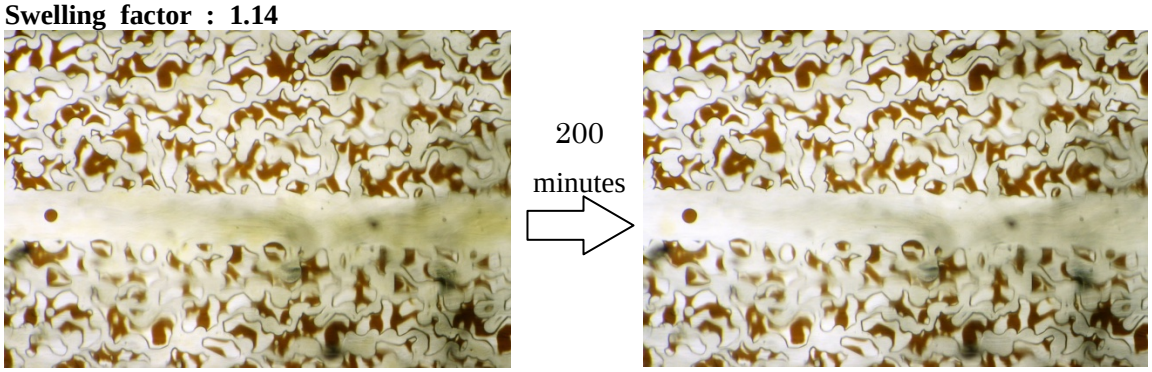


Equipment

4-4. Result and conclusion

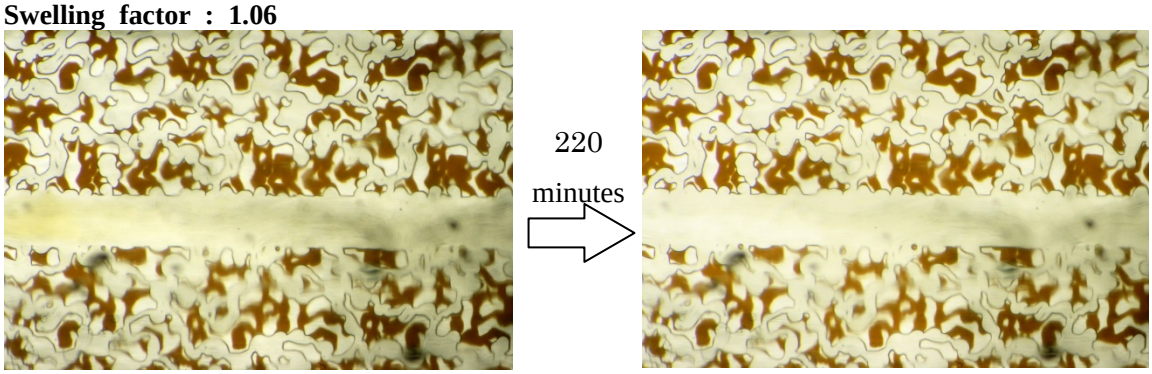
Results are shown like below. As a result, at lower saturation it took shorter time to ach ieve equilibrium and swelling rate was higher. These results show that in CO2 EOR the in fluence which oil swelling effects on the reservoir at lower oil saturation is more than that at higher oil saturation. In a reservoir the oil should swell more because the pressure is much higher than 350kPa so that CO2 can dissolve in oil more.

Swelling factor : 1.14



Result at S_I=16.8%（Left : Initial Right : Final）

Swelling factor : 1.06



Result at S_I=26.0%（Left : Initial Right : Final）

5. Acknowledgements

I greatly appreciate financially-supported JSPS program (International Training Program: ITP), people who are related to ITP, people in Alberta University, professor and assistant professor. I had thought that I wanted to work especially for oil sands developing in oil field overseas and this is why I applied for ITP. My stay in Canada encouraged my decision more.

In the classes and our laboratory I could know that oversea students were so conscious and I was so inexperience objectively. In my study I could educate myself by reading various papers to find my subject and understand difficulty to complete one study in a strange place.

In field trip I could see the directional well heads which indicate SAGD method and feel the tremendous amount of oil sands reserves in my bones. In addition, I could spend more than two months with only English and my English became better. This is very good for me who will work overseas. I spent fruitful time in Canada and would like to appreciate ITP. I will study hard and make time fruitful with the precious lesson in Canada.

I would like to appreciate ITP again. ITP is really fantastic training program. I hope that ITP will give young researchers opportunity to spend precious time as I did.