International Pittsburgh Coal Conference and Istanbul Technical University

4–9 October 2023
Istanbul, Turkey

Text ● Theodora Noely Tambaria
(Postdoctoral, Department of Earth Resources Engineering, Kyushu University)

一般財団法人日本鉱業振興会による「少壮研究者による海外科学技術研究調査助成」を受け実施された，海外渡航についての報告を紹介します。
（資源・素材学会事務局）

1. STATEMENT OF PURPOSE

To join the International Pittsburgh Coal Conference (PCC) and to learn about the most recent innovations in coal-clean technology, I am undertaking this trip with the support of the Mining and Materials Processing Institute of Japan (MMIJ).

PCC is the premier annual conference dedicated to all aspects of coal, energy, and the environment. Its ultimate objective is to maximize the use of coal while minimizing its impact on the environment. This conference provides an opportunity for industry, government, and academia representatives to exchange technical information and policy issues in an in-depth and focused manner. Several countries have hosted the conference, and this year marks its 40th anniversary. The conference was held in Istanbul this year and was organized in collaboration with the Istanbul Technical University.

At Istanbul Technical University (ITU), there is a mine ventilation and safety laboratory where the properties of coal used are determined using modern instruments. In addition, various studies have been conducted to recover gas products from coal.

Visiting Istanbul presents an opportunity to participate in PCC and explore ITU's laboratory visit efficiently. The ensuing report aims to highlight the networking opportunities and accomplishments that were realized as a result of these visits (Appendix A).

2. INTRODUCTION

Clean coal technology is a set of methods and technologies aimed at reducing the environmental impact of coal-based energy production and mitigating the negative effects of burning coal, a fossil fuel known for its significant carbon emissions and other pollutants.

I am interested in proposing an innovative solution for clean coal technology by storing CO_2 on a coal seam. Given my research background and experience, I strongly believe that the potential of the storage of CO_2 in coal can achieve the objectives of clean coal technology.

2.1 Why did I choose to join PCC and visit ITU?

The storage of CO_2 can be achieved by injecting it into coal seams. However, this process can cause the coal to swell, reducing its permeability. Since most coal seams have low permeability, it becomes challenging to adsorb CO_2 and extract coalbed methane.

One solution to this problem is to use a chemical treatment that can fracture the coal matrix, improve the fracture or cleat, and demineralize the coal matrix. Alkali treatment, for example, can increase the active functional sites for CO_2 by introducing basic groups. To this end, our research proposes treating coal with NaOH to enhance permeability for CO_2 sequestration (Appendix B).

PCC recently held a conference on innovative clean coal technology, covering topics such as gasification, CO_2 storage, value-added products, coalbed methane, shale gas,

Figure 1 Picture showing (a) a presentation from a keynote speaker, Prof. Dr. Iskender Gokalp, and (b) a presentation from a fellow presenter, Katlego Mphahlele.

Figure 2 Picture showing the entrance of the faculty of mining.

combustion technologies, and extraction of rare earth elements from coal. The keynote speakers presented predictions on the usefulness of coal, innovative bulk removal of CO_2 in coal power plants, upgrading the usefulness of coal, and innovation of coal-based products. Another presenter shared insights and enriching experiences on a related topic (Figure 1).

Istanbul Technical University (ITU) is a highly regarded public institution in Turkey, acclaimed for its diverse and culturally rich campuses. Located in Istanbul, the university houses a specialized mine ventilation and safety laboratory under the faculty of mining, overseen by the esteemed academic, Assoc. Prof. Dr. Abdullah Fisne. The laboratory is dedicated to the desorption of coal bed methane in Turkey and is committed to advancing research and innovation in this field (Figure 2).

This laboratory works on the estimation of methane emissions in underground coal mines (Figure 3), planning ventilation systems, and providing a safe working environment. This estimation can used in designing drainage

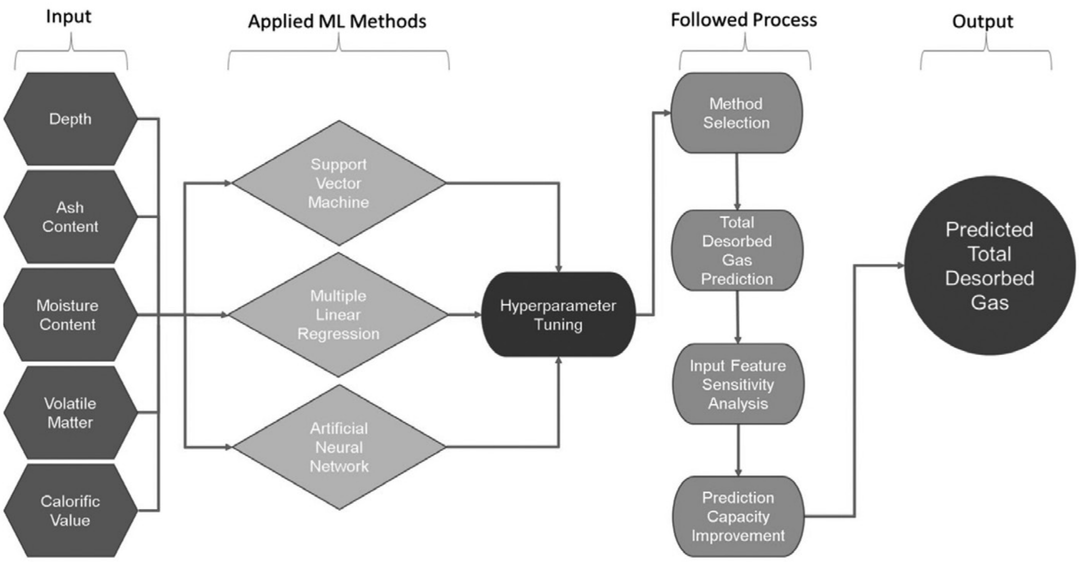

Figure 3 Schematic diagram of predicted total desorbed gas (Applied Energy, 2023, 121499)

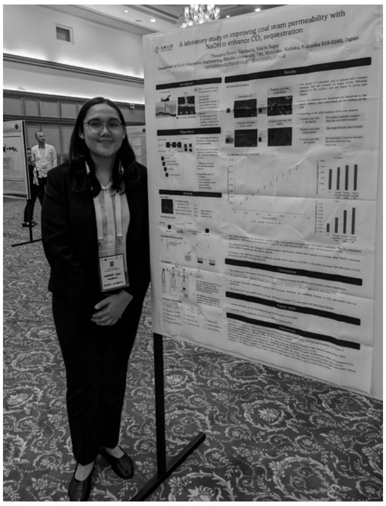

Figure 4 I am standing beside the poster in the picture.

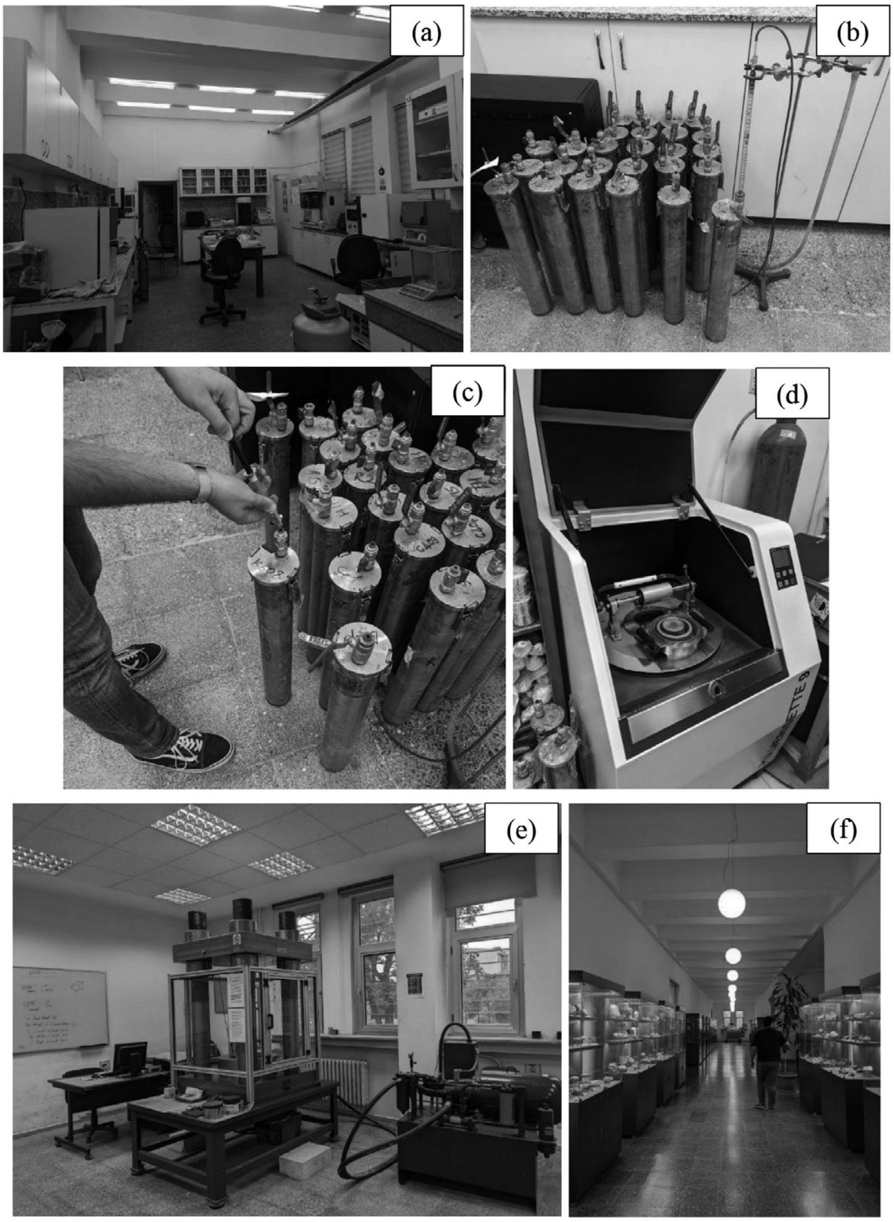

Figure 5 Picture shows (a) Assoc. Prof. Dr. Abdullah Fisne's laboratory, (b) canister for test desorbed gas, (c) Samed explained how to obtain the gas from the canister, (d) sealed mill for detecting residual gas, (e) rock mechanics laboratory, and (f) geological engineering laboratory.

systems to reduce methane emissions.

The estimation can be obtained based on reservoir studies in order to economically produce coalbed methane as an unconventional gas resource. I was interested in the prediction desorption of coal bed methane since my research was focused on CO_2 adsorption with the possibility of future research of enhanced coal bed methane.

2.2 What Have I Accomplished?

I presented a poster at PCC on improving coal seam permeability for CO_2 sequestration using NaOH, and it was well-received (Figure 4). During the conference, I attended several sessions and had productive discussions with other presenters. I was fortunate to meet Prof. Dr. Mehmet Sabri Celik from ITU's mineral processing laboratory, who suggested a chemical that could further enhance coal permeability.

During my visit, I had the chance to meet with Samed Bozdogan, who is a master's student working in the laboratory of Assoc. Prof. Dr. Abdullah Fisne. He gave me a detailed explanation of the equipment used in their laboratory and how it works. This helped me to understand the basics of the process, including getting lost gas (Q1),

Figure 6 (a) Hagia Sophia (b) Galata Tower

desorbed gas (Q2), and residual gas (Q3). Additionally, he also showed me around other laboratories, such as the Rock Mechanics Laboratory and the Geological Engineering Laboratory (Figure 5).

3. WHERE ELSE HAVE I VISITED

During my visit to Istanbul, I had the opportunity to explore two of its most iconic landmarks - the Hagia Sophia and the Galata Tower (Figure 6). The grandeur of Hagia Sophia is indescribable. Originally a Byzantine cathedral and later converted into an Ottoman Mosque, it is now a museum that showcases its diverse history. I relish traditional Turkish dishes such as kebabs and baklava at a nearby café.

On the way to Galata Tower, an unmistakable landmark with panoramic views of the city, I could not help but appreciate the city's rich history and vibrant culture. These two landmarks are timeless symbols of Istanbul's heritage, making my trip an unforgettable and enlightening experience.

4. OVERALL SUMMARY OF TRAVEL EXPERIENCE

I am happy to report that my recent visit was well worth the travel expenses. During my time there, I gained valuable experience that I can now implement in our university and laboratory. I also learned new methods for designing materials that could help sustain our proposed endeavor.

The networking opportunities were also very beneficial. While there, I had the chance to speak with experts in the treatment of coal with chemical and desorption gas for ECBM. They provided me with tips and useful information for my project (Appendix B).

Additionally, the meals and refreshment breaks were excellent. Overall, I am extremely satisfied with everything I gained from my visit with the support of MMIJ. I look forward to witnessing the outcomes of this trip in the future.

5. APPENDIXES

APPENDIX A: Grantee and Conference Coordinator/Host Information

- **Grantee Information**

Name ▶ Theodora Noely Tambaria
Date of Birth (MM-DD-YYYY) ▶ 12-19-1991
Affiliation ▶ Kyushu University
Department ▶ Earth Resources Engineering
Address ▶ 744 Motooka, Fukuoka, 819-0395, Japan
Position ▶ Postdoctoral
Telephone ▶ +81-80-2000-4050
Email ▶ tambaria.noely.theodora.921@m.kyushu-u.ac.jp

- **Conference Coordinator Information**

Name ▶ Nicole Drebsky
Affiliation ▶ University of Pittsburgh
Department ▶ Swanson School of Engineering
Address ▶ 3700 O'Hara St. 940 Benedum Hall, Pittsburgh, USA
Telephone ▶ +1(412)624-7440

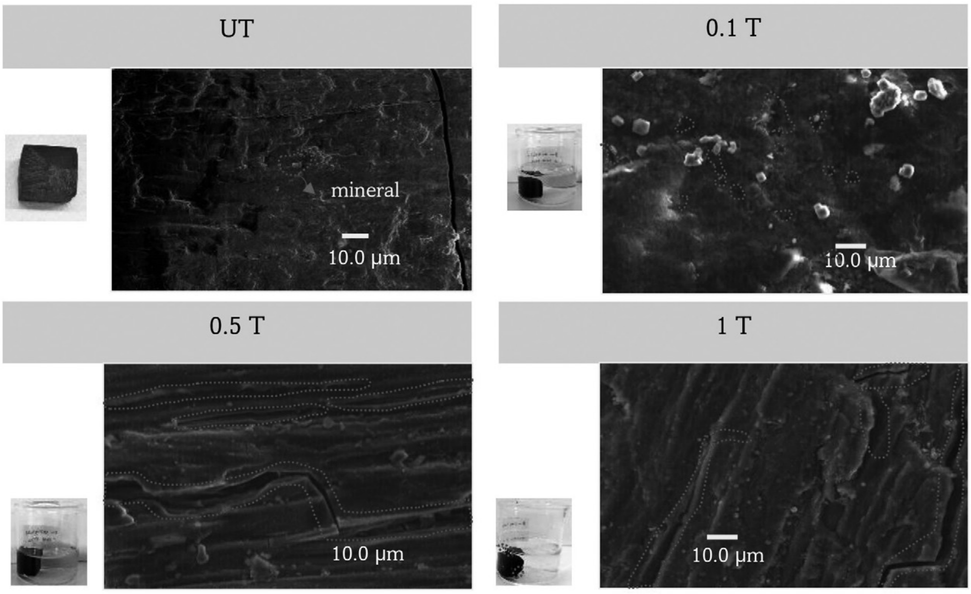

Fig a SEM images of coal samples on untreated coal and treated coal with NaOH in different concentrations.

Email ▶ ipcc@pitt.edu

● **Host Information**

Name ▶ Abdullah Fisne

Affiliation ▶ Istanbul Technical University

Department ▶ Mining Engineering

Address ▶ Maslak, 34469, Istanbul, Turkey

Position ▶ Associate Professor

Telephone ▶ +90(212)285-6363

Email ▶ fisnea@itu.edu.tr

APPENDIX B: A Laboratory Study on Improving Coal Seam Permeability with NaOH to Enhance CO_2 Sequestration

Coal is an organic-rich sedimentary rock that is commonly used as fossil fuel. In coal seams, methane (CH_4) is largely adsorption in micropores. The extraction of methane from coal seams improves coal mine safety and provides a source of clean energy that is environmentally friendly. Coal seam methane can be extracted directly with a recovery rate of between 20-60%, which can be further improved using other methods. Injecting gas into the coal seam and pushing methane out of the cleat and into the well is known as one of the most effective methods. In the process of coalification, it undergoes physical and chemical changes that result in the formation of coalbed methane (CBM). In coal seams, methane (CH_4) is largely adsorption in micropores. The extraction of methane from coal seams improves coal mine safety and provides a source of clean energy that is environmentally friendly. Coal seam methane can be extracted directly with a recovery rate of between 20-60%, which can be further improved using other methods. Injecting gas into the coal seam and pushing methane out of the cleat and into the well is known as one of the most effective methods. Enhancing Coal Bed Methane (ECBM) involves injecting CO_2 since CO_2 could adsorb easily into micropores and drive methane upward more readily. The injection of CO_2 also results in the storage of CO_2. However, CO_2 adsorption onto coal causes the coal to swell and decreases its permeability. In addition, most coal seams in Japan have low permeability, making it difficult to adsorb CO_2 and extract coalbed methane. Furthermore, Japanese coal contains minerals, such as calcite, pyrite, clay minerals, and dawsonite, that appear on the coal surface and may block the adsorption of CO_2.

Numerous technologies have been used for enhancing permeability can be classified into physical and chemical stimulation methods. There are physical stimulation techniques such as hydraulic fracturing, microwave heating, and blasting. Nevertheless, there are major issues with water obstruction and limited penetration depths of microwaves. The chemical solution can fracture the coal matrix, improve the fracture or cleat, and demineralize the coal matrix. Chemical stimulation such as alkali treatment can lead to more active functional sites for CO_2 through the use of basic groups. Additionally, kaolinite is a common coal mineral that is highly dispersed in an alkaline environment. It has been found that monoethanolamine (MEA) and diethanolamine (DEA) can increase CO_2 adsorption capacity, whereas other studies have found that CO_2 adsorption capacity decreases. Other commonly used chemicals are NaOH and KOH. A KOH solution intercalates between carbon layers, whereas a NaOH solution reacts with surface energies. Further, NaOH was particularly appealing because of its low cost, ease of handling, and low corrosion potential.

The purpose of this study was to evaluate the effect of sodium hydroxide on increasing coal permeability to increase CO_2 adsorption capacity. The coal used in this study has low moisture content and high ash yield. The coal samples were dried and prepared into untreated coal samples that were then treated with sodium hydroxide at different concentrations (0.1 M, 0.5 M, and 1M) over a period of six hours. A volumetric apparatus was used to measure the amount of CO_2 adsorption on both untreated and treated coal samples in order to determine the effect of operating pressure on the amount of CO_2 adsorption. The coal sample is high-rank coal, drying did not result in any significant changes, but after treatment with NaOH for 6 hours, the coal samples showed evidence of breakage, along with increasing NaOH concentrations. According to SEM results, untreated coal has minerals that fill up the pores, whereas treated coal has opened pores, created fractures, and a fracture network (Fig a). In CO_2 adsorption experiments, the sample treated with NaOH exhibited an increase in CO_2 adsorption capacity with increasing concentration and pressure. Accordingly, the results of the study indicate that NaOH increases coal permeability and enhances CO_2 adsorption.