ISSN 2830-2818
Volume 12, 2024

# 12TH ITB INTERNATIONAL GEOTHERMAL WORKSHOP 2023

***"Geothermal for Accelerating Post-Pandemic Economic Recovery"***

# PROCEEDING BOOK

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**Taufiq Rachman, 2024**

ISSN 2830-2818
Volume 12, 2024

# Proceeding Book 12th ITB International Geothermal Workshop 2023

**June 6-7, 2023**

"Geothermal for Accelerating
Post-Pandemic Economic Recovery"

Published by ITB Press, 2023
Institut Teknologi Bandung

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June, 6 – 7th

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**"Geothermal for Accelerating Post-Pandemic Economic Recovery"**

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| Wahyu Utomo | Head of Center for State Budget and Expenditure Policy – Ministry of Finance Republic of Indonesia | Government program in economic recovery through sustainable energy usage |
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| Satya Widya Yudha | National Energy Council Republic of Indonesia | Position of Geothermal in Energy Mixed Program in Indonesia |
| Harris | Director of Geothermal at Directorate General of New Renewable Energy and Energy Conservation – Ministry of Energy and Mineral Resources Republic of Indonesia | Implementation of the Latest Geothermal Regulations in Indonesia |
| Hilmi Panigoro | President Director of PT. Medco Power Indonesia | Business Strategy to Accelerate Geothermal Development |
| Rio Supriadinata | Director of Operation & HSSE of PT. Geo Dipa Energi Indonesia | Geothermal Funding Condition Post Pandemic |
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| Arias Sugandhi | Head of Department Darajat Asset Management Star Energy Geothermal | From Steam to Energy: A Quarter Century of Geothermal Success Stories at Darajat |
| Fernando Pasaribu | Vice President Reservoir of PT. Pertamina Geothermal Energy | Pertamina Geothermal Energy: Future Green Development |
| Novi Ganefianto | Vice President Exploration and Subsurface PT. Supreme Energy | Current Status and Future Planning of PT. Supreme Energy Geothermal Working Areas |
| Dion Murdiono | President Director of PT. Ormat Geothermal Indonesia | Indonesia and Ormat |
| Ruly Husnie Ridwan | Chief of Transformation Officer PT. Geo Dipa Energi (Persero) | Transformative Business Plan PT. Geo Dipa Energi |

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# PREFACE

Three years ago, we faced a COVID-19 pandemic that changed many aspects of our lives. No more face-to-face meetings, the global economic rate was devastated, and a lot of workforces was fired. Ever since the vaccines start to spread globally, people are able to continue their work and activities like they used to, striving to make a living, to raise economic level to a stable state. Geothermal as a tool to attract international attention to engage in economic partnership between countries, needs to be maximized in its development in order to help the national's economy growth. Thus, the Geothermal Master Program of Institut Teknologi Bandung (ITB) organized the Twelfth Annual ITB International Geothermal Workshop (IIWG) in 2023, establishing its commitment to support national and global geothermal energy development. This annual event is to gather academicians, governmental, industrial, and all communities to share and unify ideas, point of views, and successful stories in geothermal development among the countries of the world.

The theme for 12th IIGW 2023 is "**Geothermal for Accelerating Post-Pandemic Economic Recovery**", focusing on the global economy's bounce back after the pandemic concluded, with a particular emphasis on ramping up geothermal energy growth. This event, which includes pre-workshop and mid-workshop courses, plenary sessions, technical sessions, geothermal field camp, and geothermal field trip, was held on June 5-9, 2023 at Campus Center (CC) and Energy Building, Institut Teknologi Bandung Campus, Bandung, Indonesia.

On behalf of the committee, I thank all the geothermal energy stakeholders that participated in this event. Together we contribute to accelerating the post-pandemic economic recovery through geothermal.

Sincerely

Dr. Eng. Suryantini, S.T., Dipl. Geothermal En. Tech., M.Sc.
Chairperson of the 12th ITB International Geothermal Workshop (IIGW) 2023

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# WORKSHOP EVENTS

ITB International Geothermal Workshop 2023 is an annual event organized by ITB Geothermal Master's degree program as a contribution to global geothermal development especially in Indonesia. This year's event was the first IIGW conducted offline after the pandemic struck the globe. IIGW 2023 was held from June 5-9, 2023 at ITB Ganesa Campus with the theme "Geothermal for Accelerating Post-Pandemic Economic Recovery".

The event consisted of 4 workshop courses on the days preceding main event, 2 days of main event seminar and paper presentation, and after main event activities: field camp and field trip. This year's courses are Leapfrog software for Geothermal by Seequent, Landmark software for Geothermal Drilling by Halliburton Indonesia, Geothermal drilling course by Jakarta Drilling Society in collaboration with IAGI, and Remote Sensing for Geothermal by Asep Saepuloh in collaboration with IAGI. On the first day of the main event, there are three sessions: the first session discusses about Geothermal Energy: Post-Pandemic Economic Recovery, the second session discusses about Geothermal Energy: Post Pandemic Acceleration Program, and the third session discusses about updates from geothermal companies in Indonesia. The speakers are experts from geothermal companies as well as from the government. Technical paper sessions are on the second day of main event. There were 28 out of 37 submitted papers that were presented, and the rest were presented as posters. In this technical session, there were also invited speakers, experts from academics, government, to consultants, from Indonesia, USA, Philippines, and Swiss, to discuss various topics with the participants. Field camp was conducted to give on-field knowledge to participants about geothermal system in Indonesia, data collection, and group discussion. This year's field camp was conducted at Mount Tangkuban Perahu. Field trip was conducted to give knowledge about geothermal power plant operation. This year's field trip was conducted at Pertamina Geothermal Energy (PGE) Kamojang Area.

IIGW 2023 has gathered more than 300 participants from various countries over all events. There were 14 participants attended Landmark software course, 30 participants attended Leapfrog Software course, 23 participants attended Geothermal Drilling Course, 30 participants attended Remote sensing for Geothermal course, 28 Field camp participants, 40 Field trip participants, and more than 200 main event participants.

**Location of organizers:**
Geothermal Engineering Master Program,
Gedung Energi, Lt. 2
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**12th ITB Geothermal Workshop 2023 Website:**
https://geothermal.itb.ac.id/workshop2023/

**IIGW 2023 Events on YouTube Playlist:**
https://bit.ly/YouTubePlaylistIIGW2023

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# ABSTRACTS OF IOP CONFERENCE SERIES

Available online at:
IOP Conference Series: Earth and Environmental Series Vol 1293
https://iopscience.iop.org/issue/1755-1315/1293/1

## EXPLORATION



## ENGINEERING

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# Analysis and Interpretation of Gravity data to modelling 'PB' Geothermal Field

Fanzly Togap Zisochi Lase[1], Tony Widiatmoro[2], Prihadi Sumintadireja[1,3], and Angga Bakti Pratama[1]

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The 'PB' field is located on the island of Sumatra which is related to the volcanic activity of Kaba hill which still retains residual heat from the magma. One of the geophysical methods used in this case is the gravity method where this method can be applied to determine the location of reservoirs, possible locations for reservoirs, and even to examine geological features and heat sources. In this paper, gravity data is used to interpret the structure and possibility of modelling the heat source in the 'PB' geothermal field. The gravity data was analyzed using integrated gradient interpretation techniques such as Horizontal Gradient (HG) and Euler Deconvolution (ED) methods. The CBA map produced shows two dominants high Bouguer anomalies underlying the 'PB' geothermal field associated with the presence of dacite and andesitic rocks. Analysis of fault structure based on geological data, HG and ED enhancement data on gravity anomalies was used as a reference for the initial model of subsurface conditions in the inversion model. The 2-D modelling results reflected high-density rocks associated with active 'PB' mountain volcanism. The conclusion obtained from the analysis and interpretation of the 'PB' geothermal system is that this area still has active volcanism, which is a heat source, with the presence of diatreme found through 2D gravity inversion modeling. The conceptual model results obtained by combining the integration of each reference and existing research show that the upflow zone is at the top of Kaba Hill and the outflow zone is at Babakan Bogor hot spring and Suban hot spring. Thus, these results can provide comprehensive information in analyzing and interpreting as well as the use of enhancement data gravity HG, ED and 2D slice inversion in the description of structures and modelling in the Geothermal 'PB' field.

Available at: https://iopscience.iop.org/article/10.1088/1755-1315/1293/1/012001

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# Assessment of Medical Geology from Major Element Trilinear Diagrams Cl- $SO_4$-$HCO_3$ and Na-K-Mg from Geothermal and Non-Geothermal Springs; Case Study the Wayang Windu Geothermal Area, West Java, Indonesia

R. Maria[1], R Prasetio[2], R.M Shoedarto[1], H Nurohman[1], A. Yuliyanti[1], H. Lestiana[1], E.N. Dida[1], Aminuddin[1], and Y. Rahayudin[3]

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Medical geology research involves the processes, deficiencies, and excessive exposure of significant elements and minerals to present solutions to health problems. Minerals from volcanic aquifers from geothermal and non-geothermal springs interest medical geology research. Major elements in source rocks essential for our health come from the rocks beneath the earth's surface. This study aims to evaluate the medical geology of major elements in the water from volcanic aquifers in the Wayang Windu Geothermal Area. The methods used are trilinear analysis of major elements, Piper diagram, and statistical analysis. We have investigated six cold springs, four hot springs, and three dug wells surrounding the Wayang Windu geothermal area. The results of hydrochemical study and field checking identified the location of water sources that have potential uses in medical geology and balneotherapy. The primary relationship elements in the Piper Diagram defined five major water types: CaCl, MgCl, CaMgHCO3, and CaHCO3. Results from hydrochemical analyses, statistics, and trilinear diagrams were used to identify springs suitable for medical geology and balneotherapy. Hot springs with good health criteria that meet the balneotherapy requirements are found at locations H1, H2, H3, and H4. Hydrochemical data shows that hot springs in several areas of Pangalengan are suitable for bathing and body contact activities but not for drinking water. Cold springs at locations C1, C2, C3, C4, C5, and C6 meet the drinking water criteria surrounding the Wayang Windu geothermal area.

Available at: https://iopscience.iop.org/article/10.1088/1755-1315/1293/1/012002

# Experimental Preliminary Measurements of CO2 Flux for Exploring Hidden Geothermal Systems

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Geothermal energy is a promising renewable energy source, and to enhance its use, identifying Hidden Geothermal Systems (HGS) without thermal manifestations on the surface is a challenging subject. Soil CO2 flux monitoring has become an effective method for detecting HGS, different from traditional methods that target thermal indicators. Expensive portable CO2

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gas analyzers are commonly used for this purpose, but their high cost prevents wide applications. Thus, this study tries to design and test a cost-effective solution for measuring CO2 flux while keeping high accuracy and reliability of measured data. The method incorporates a self-made accumulation chamber connected to a relatively inexpensive CO2 portable meter, the GasLab Pro Carbon Dioxide Sampling Data Logger CM-1000. The device uses non-dispersive infrared (NDIR) to detect CO2 and is equipped with a data logger for continuous monitoring. The CO2 flux measurement is performed using the accumulation chamber method. The reliability of this tool for detecting CO2 flux is evaluated, and the experimental results are verified by comparing them with an intelligent gas flow meter, the Shimadzu Intelligent Flow Meter DFM-1000. The tool is tested in various conditions, with CO2 flux values ranging from 3.30 to 1013.02 g $m^{-2}$ $day^{-1}$, proving capable of measuring CO2 flux up to 1000 g $m^{-2}$ $day^{-1}$. Field tests were conducted at 60 sites to evaluate the tool's performance. The results suggest that the lower measurement limit of the tool is approximately 0.1 g $m^{-2}$ $day^{-1}$. Overall, the cost-effective solution holds promise as a reliable tool for investigating HGS, with potential applications in other environments with similar or higher CO2 flux rates. In addition, conducting further comparison studies with a common sophisticated automatic flux tool such as LI-COR 850 can help improve the accuracy and reliability of the tool.

Available at: https://iopscience.iop.org/article/10.1088/1755-1315/1293/1/012003

## Geochemistry of Cold Springs in Geothermal Exploration Stage – Case Study of Candi Umbul Telomoyo, Central Java

Yuniar Z. Abdillah, Ridwan P. Sidik, Zefanya M.D.C.W. Putra, Djoko A. Wibowo, Arif Darmawan, Reza S. Mulyana, and Budi A. Kristianto

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Cold springs in geothermal fields are often overlooked during the exploration stage. The best practice of geothermal exploration suggests thermal manifestation as an indicator of a geothermal system in the subsurface. This common practice neglects cold springs as valuable information points related to the system. Thermal-contaminated cold springs can be helpful to indicate the presence of inferred geothermal activity below the surface during the exploration stage. It becomes important where thermal features are absent or limited, as in Candi Umbul Telomoyo. Candi Dukuh, Candi Umbul, and Pakis Dadu thermal springs are located at the periphery of the Telomoyo Volcanic Complex, at relatively low altitude. Those thermal springs are used to construct the existing conceptual models of the geothermal system. In this study, the authors tried to consider the presence of slightly acidic cold springs (pH 5.24-5.61). Located within the Suropati Depression in the North, and the flank of Mt. Telomoyo in the South, both Keningar and Sendang Ari Wulan cold springs are located at higher altitude with higher TDS and are enriched in Cl and SO4 compared to the others. These cold springs are associated with the argillic alteration zone and observed to have iron oxide deposition at the discharge area. Sendang Ari Wulan fluid is plotted at the same zone as the thermal springs on Na-Cl•SO4 facies of the Piper diagram, while Keningar fluid is plotted on HCO3-Ca•Mg facies are similar to other cold springs. Although Sendang Ari Wulan shows a better correlation to the thermal springs, based on Piper diagram, both Keningar and Sendang Ari Wulan cold springs are classified as HCO3-SO4 and SO4-HCO3-Cl. These observations show the possibility of contamination of the geothermal system occurring below the Keningar and Sendang Ari Wulan

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cold springs, which is higher than the thermal springs. This interpretation is supported by the anomaly of high Hg and CO2 surrounding the acidic Keningar and Sendang Ari Wulan cold springs, three temperature gradient wells that prove the presence of three times higher-than-normal geothermal gradient. The research concludes that cold springs data are indeed useful in aiding the interpretation, especially during the exploration stage.

Available at: https://iopscience.iop.org/article/10.1088/1755-1315/1293/1/012004

## Structural Model Update on the Patuha Geothermal System, West Java, Indonesia

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The Patuha geothermal field is a steam-dominated geothermal system lying on a quaternary volcanic unit in West Java Province, Indonesia. The existence of manifestations in this field is interpreted from the structure control and rock deformation that generate steam production in reservoir zone. This updated study is aimed to further describe the geometry and kinematics of the geological structures model to estimate the permeable areas. The model also will explain the link between the larger tectonic framework and the detailed structure model scale in Patuha. The analysis consists of reassessment the LiDAR data, surface structure features measurement fromfieldwork, and review the updated subsurface data such as feed zones, new borehole images, and re-visit the geophysical data such as microearthquakes and gravity. The surface structural interpretation is drawn from a larger area to understand the regional tectonic framework and the relation with small detail from faults and non-tectonic features. Later, the new structural framework from surface data is correlated with subsurface data that indicates permeable features, including feed zones and conductive fractures, then coupled with the geophysical data. The latter part, which concerns validating surface fault traces using subsurface data, is currently being developed and will be included in the subsequent paper. An integrated reviewof the geological structure of the lineament found that a strike-slip system developed in the larger Patuha area with the main fault trending NE-SW, while the accompanying fault is en echelon faults trending relatively NNE-SSW.

Available at: https://iopscience.iop.org/article/10.1088/1755-1315/1293/1/012005

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# Ground Displacement Analysis in the Sarulla Geothermal Field Using Persistent Scatterer Interferometric Synthetic Aperture Radar (PS-InSAR) method

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The Sarulla geothermal field is aggressively developed in Indonesia, reaching 330 MW in two consecutive years. Furthermore, the field is situated along the active Great Sumatra Fault. This condition has the potential to induce surface deformation phenomena attributed to exploitation activities, tectonic activities, or a combination of both. The Persistent Scatterer-Interferometric Synthetic Aperture Radar (PS-InSAR) method is a multi-temporal Synthetic Aperture Radar (SAR) image processing technique employed to detect surface deformations with millimeter-level accuracy. PS-InSAR has been applied in this paper over the Sarulla geothermal field, which comprises two exploited prospects (Silangkitang and Namora-I-Langit) and two unexploited prospects (Donotasik and Sibualbuali). The objective of this paper is to analyze the characteristics of ground displacement over the exploited and unexploited geothermal areas. Multi-temporal images of SENTINEL-1A with ascending and descending orbital modes from 2017 to 2021 were processed using PS-InSAR method. A series of interferograms from the selected primary image were paired with secondary images using SNAP program and Python-based program snap2stamps. The generated interferograms were used as input for the StaMPS program to obtain the persistent scatterers as the best coherent points. Ground displacement towards the satellite line of sight was observed within those two exploited geothermal areas adjacent to the production and injection zones. The descending images resulted in more significant PS points than ascending images. The exploited geothermal area shows a clustered pattern of PS points with a significant rate of ground displacement, whereas the unexploited area suggests a wide dispersion of PS points with a slight amount of displacement rate. Additionally, the detected ground displacement that occurred adjacent to the Great Sumatran Fault may indicate the active movement of the fault.

Available at: https://iopscience.iop.org/article/10.1088/1755-1315/1293/1/012006

# Technical and Business Evaluation of Geothermal Dryhouse for Coffee in Kamojang, West Java, Indonesia

Cecep U. Farouq[1], Vincentius A. Brilian[2], Ahmad N. Fathurrodin[3], Muhammad I. Pradipta[1], Primatika P. Dewi[1], Adi Rahmadi[1], and Muhammad N. Fauzan[1]

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The coffee farmers in Kamojang still currently rely on conventional drying method using direct sun radiation. However, the cold ambient temperature and fluctuative weather in Kamojang brings challenges to this method. Therefore, PT PGE Area Kamojang built a trial geothermal dryhouse with a heating pipe connected to a blowdown on the existing geothermal steam

ISSN 2830-2818
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pipeline as the heat source. In this study, the existing geothermal dryhouse is evaluated from the technical and business aspects. The technical evaluation studies the thermal performance of the heating pipe to calculate the dryhouse heating load, the required heating pipe length, the effect of heating pipe operation on the dryhouse temperature, and the suggested technical improvements. Meanwhile, the business evaluation studies qualitatively about the relationship between the potential farmer profit enhancement and the possible coffee-drying duration reduction from previously 2-3 weeks to 1-2 weeks by substituting conventional drying method with the use of geothermal dryhouse. Aside from that, it was expected to retain the coffee's pleasant flavor and not have any sulfur odor problems. The technical evaluation is performed using analytical and experimental methods. The analytical results show that the required heating load is 10.94 kW and the heat transfer rate per unit length of the heating pipe is 0.2618 kW/m. Hence, the required heating pipe length is 41.79 m. The Subsequently, the heating pipe was tested operational three times on 16 – 18 January, 27 April – 4 May, and 31 May – 5 June 2023. On Trial 1, the heating pipe performance was not optimal due to condensate built-up inside the heating pipe. Therefore, steam traps were installed to reduce the condensate built-up. On Trial 2, the heating pipe performance was better, which was indicated by the higher and stable dryhouse temperature during the night. Hence on Trial 3, the technical improvement involving rearrangement of steam trap and bypass valve considerably improved the heating pipe performance. It reaches the design temperature and being maintained above 40°C for a maximum of 50°C longer than it did previously. The business evaluation expects a significant profit enhancement for the farmers if the drying duration could be cut into 1-2 weeks using the geothermal dryhouse.

Available at: https://iopscience.iop.org/article/10.1088/1755-1315/1293/1/012007

## Inspection Based Corrosion Rate Mapping for Remaining Strength and Remaining Life of Two-Phase Geothermal Steel Piping

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Geothermal as green energy has many advantages for power generation due to cleanness, zero waste, and renewable. However, during the operational period, corrosion and scaling in two-phase geothermal steel piping are two main challenges that can cause leaks, reduce flow performance, and reduce safety. Therefore, the two-phase geothermal steel piping remaining strength and life analysis are conducted to manage its integrity. This paper presents a case study on the corrosion rate mapping, excessive corrosion, and scaling for a two-phase flow line in Well Pad B, one of the geothermal production facilities in Unit 1 Dieng, PT Geo Dipa Energi. The data used for this assessment refer to the results of the wall thickness inspection; meanwhile, the data used for scaling and corrosion analysis refer to field observation results.

ISSN 2830-2818
Volume 12, 2024

The results of the remaining strength calculation, using both ASME B31G Original and Modified methods, indicate that the remaining strength of all tested points was deemed acceptable in 2020. The remaining life calculation, based on API 579, reveals that the longest remaining life is 9.08 years and the shortest is 0.83 years in the long-term scenario. In the short-term scenario, the longest remaining life is 57.29 years and the shortest is 11.01 years. The corrosion rate is classified as Class I, based on the total key species, with a predictive corrosion rate value > 1.3 mm/year or 51.1 mpy (poor level). In the long-term scenario, the highest corrosion rate recorded is 258.7 mpy (unacceptable level), while the lowest is 39 mpy (fair level). In the short-term scenario, the highest corrosion rate observed is 23 mpy (fair level), and the lowest is 9 mpy (good level). Furthermore, based on the calculation of the Ryznar Stability Index, the fluid has the potential to generate heavy scale, with an RSI value of 4.1.

Available at: https://iopscience.iop.org/article/10.1088/1755-1315/1293/1/012008

ISSN 2830-2818
Volume 12, 2024

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## ENGINEERING

# DOCUMENTARY PICTURES

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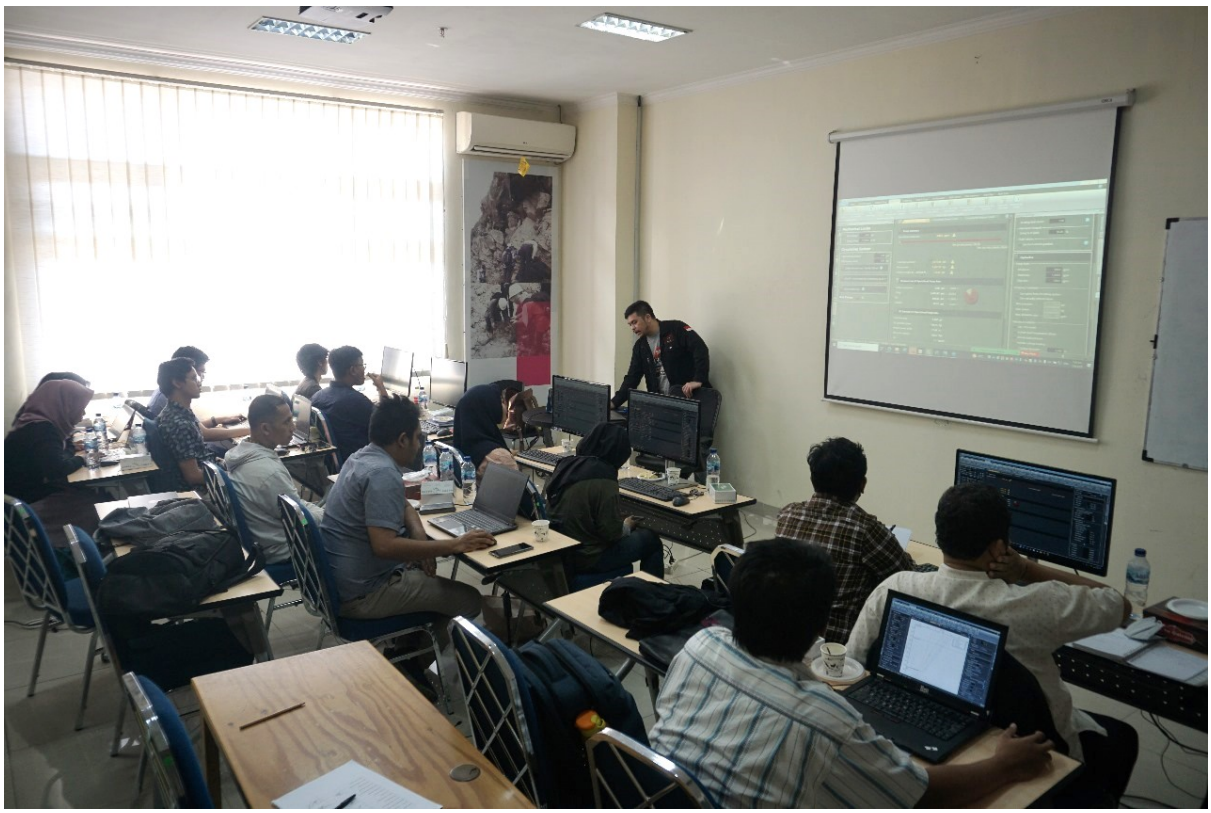
# Geothermal Course: Leapfrog software

# Geothermal Course: Landmark software



# Geothermal Course: Remote Sensing


Geothermal
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# Main Event day 1
# Opening, Plenary, Gala dinner



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# Main event day 2
# Technical paper presentation, poster, closing


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# Field camp at Tangkuban Perahu

# Field trip at PGE Kamojang Area


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www.itbpress.id
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Anggota Ikapi No. 043/JBA/92
APPTI No. 005.062.1.10.2018

ISSN 2830-2818
9 772830 281003