RGNZ/MGPB

Rudarsko-geološko-naftni zbornik
(The Mining-Geology-Petroleum Engineering Bulletin)
UDC: 550.8
DOI: 10.17794/rgn.2025.1.1

Original scientific paper

Central Sumatra Basin: The First Sedimentary Basin for Geothermal Energy Development in Indonesia?

Luhut Pardamean Siringoringo[1]*; Zakaria Situmeang[1]; Novita Meka[1]

[1] *Department of Geological Engineering, Faculty of Industrial Technology, Institut Teknologi Sumatera, Lampung Selatan 35365, Lampung, Indonesia*

Abstract

Indonesia heavily relies on the volcanic arc as an area for geothermal energy exploration and exploitation. Several Geothermal Power Plants (GPP) such as Sibayak (North Sumatra), Sarulla (North Sumatra), Salak (West Jawa), and Kamojang (West Java) use energy within the Quaternary volcanic arc region. However, alongside the Central Sumatra Basin (CSB), which exhibits strong heat flow, the construction of power plants clashes with socio-economic and environmental concerns. Therefore, this research aimed to use geothermal data from 326 oil wells in the CSB in order to better understand the geothermal and geological features, as well as the opportunities for energy development. The results showed that the outcropping rocks in the CSB have low to very high thermal conductivity (from 1.7 to over 2.1 W/m°C), as well as very high values of geothermal gradient (from 30 to over 120°C/km), and a heat flow ranging from 70 to >150 m/Wm^2. As a result, the CSB became known across the world as the sedimentary basin with unusually strong heat flow. This elevated heat flow in the CSB originated from the upwelling asthenosphere, triggered by processes such as slab roll-back and pull-apart during the Tertiary age. The processes led to a significantly thin crustal thickness of 27 km in the CSB, along with the formation of normal faults. Comparative analysis with other basins worldwide underscored the enormous potential for geothermal exploitation within the CSB. This research was expected to redirect the focus of geothermal energy adoption towards the CSB, to minimize social and environmental effects while striving for zero emissions by 2060.

Keywords:
geothermal energy; Central Sumatra Basin; heat flow; back-arc basin; geothermal gradient

1. Introduction

The adoption of renewable energy cannot be postponed due to increasingly severe climate change originating from the use of fossil fuels and and the increasing demand of energy (**Gaillot et al., 2023; Höök and Tang, 2013; Johnsson et al., 2019; McNeil et al., 2019; Megía et al., 2021; van Ruijven et al., 2019**). Indonesia features abundant renewable energy sources, among which geothermal energy stands at 23,965.5 MW. However, the realization of geothermal plants in Indonesia remains around 10% (**Sh, 2024**), predominately occurring within the volcanic arc area. Several Geothermal Power Plants (GPP), such as Sibayak (North Sumatra), Sarulla (North Sumatra), Salak (West Java), and Kamojang (West Java) incorporate the energy in the Quaternary volcanic arc area. Despite its enormous potential, the use of geothermal energy is not without risk, particularly when dealing with high-temperature geothermal fluids, for which social and environmental problems can occur (**Anggreta et al., 2022; Hanum et al., 2023; Malau et al., 2020; Muslihudin et al., 2023; Semedi et al., 2017; Xu et al., 2022**). The slow progress of geothermal energy exploration in Indonesia could be the reason behind the energy shortage. However, achieving the zero-emission target by 2060 remains essential regardless of the challenges (**Resosudarmo et al., 2023**).

One method of utilizing geothermal energy as effectively as possible is to optimize its potential in the Sumatran back-arc basins. **Artemieva and Mooney (2001)** stated that a heat flow over 80 mW/m^2 was recorded in the Sumatran back-arc basins, with the Central Sumatra Basin (CSB) having the greatest surface heat flow. Generally, the Sumatran back-arc basins are still used for oil and gas energy exploitation, although many old wells are no longer actively producing.

In order to identify a particular region for the greatest energy adoption, this research sought to more precisely ascertain the degree of heat flow, thermal conductivity, and geothermal gradient, as well as their distribution throughout the CSB. The CSB was selected for this research because previous publications showed that the basin has the highest heat flow in Sundaland (**Artemieva and Mooney, 2001; Hall and Morley, 2004**) (see **Figure 1**). Furthermore, an investigation of the geological factors influencing the elevated heat flow within the CSB will be conducted. A full assessment of the CSB's

---

* Corresponding author: Luhut Pardamean Siringoringo
e-mail address: luhut.pardamean@gl.itera.ac.id

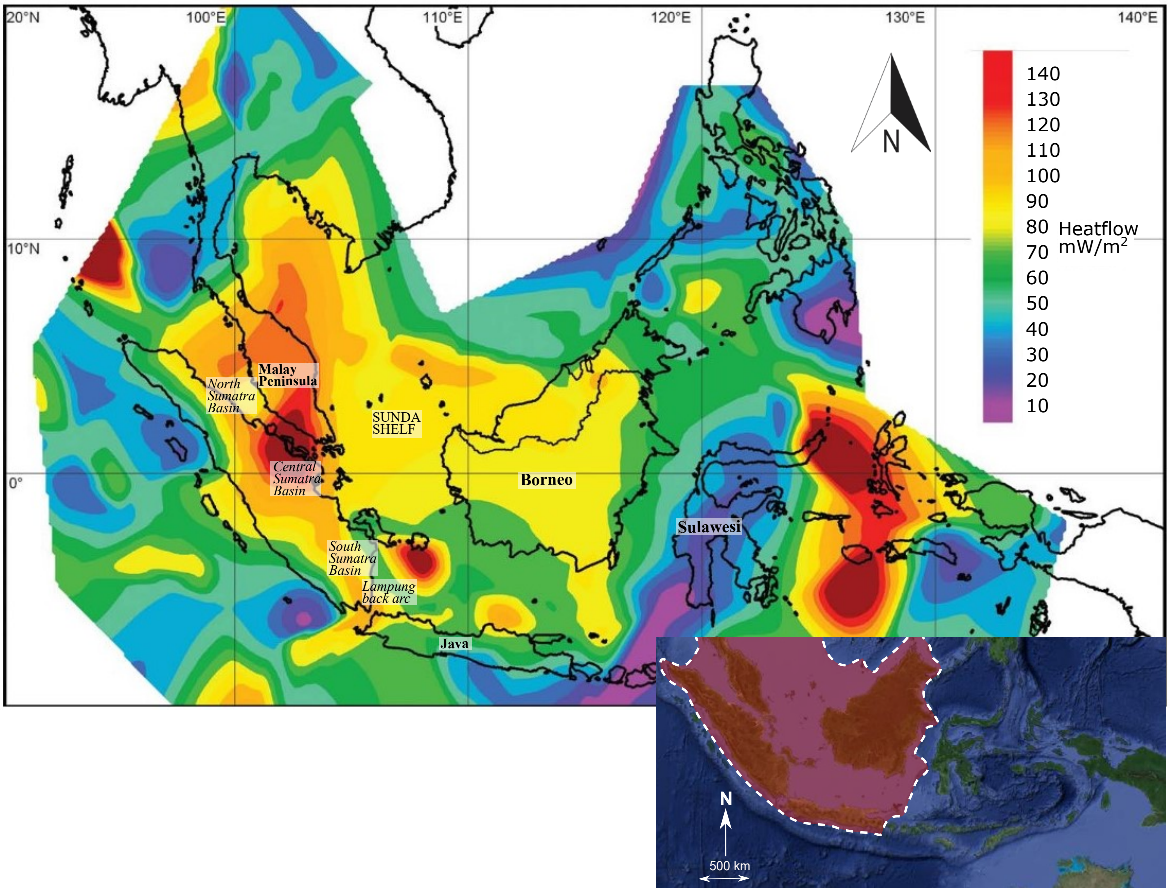

Figure 1: Surface heat flow distribution within Sundaland. The figure was modified based on the work of **Hall and Morley (2004)**. The inset figure is a map of Indonesia with the Sundaland area (the red area).

potential for producing geothermal energy will be obtained through comparisons with other sedimentary basins across the globe. The research is anticipated to be crucial since it will shed light on the CSB's potential for geothermal energy development, supporting the goal of zero emissions by 2060 without causing major social or environmental concerns.

2. Geological background of Central Sumatra Basin

The structural configuration and stratigraphy of the CSB shows that from Late Cretaceous to Early Paleogene, Sundaland's Pre-Tertiary basement stretched to the modern forearc islands, undergoing an erosional process, as shown in **Figure 2** (**Barber et al., 2005**). During the Early Paleogene, the region experienced the pre-rift or last stage of the stable Sundaland craton, which persisted until the Late Eocene extension phase (**Barber et al., 2005; Williams and Eubank, 1995**). There is barely any evidence of well-recorded stratigraphic units to elucidate the pre-rift phase in most areas of the Sumatran back-arc basins, particularly until the Late Eocene. This scarcity suggested that the area was stable up until a shift in the local tectonic regime in the Late Eocene (**Barber et al., 2005**).

During the Late Eocene and Early Oligocene periods, there was a widespread regional extension over a sizable portion of Southeast Asia. Simultaneously with the collision between India and the southern margin of the Asian continental plate, the Sundaland Block was extruded and rotated to the southeast of the collision site (**Barber et al., 2005; Tapponnier et al., 1982**). The extension created horsts and grabens, which significantly influenced the stratigraphic evolution during the period.

During the Horst and Graben stages, silt was carried short distances and deposited in a large portion of the Sumatra region (**Barber et al., 2005**). As a result, the pace of subsidence in the grabens was greater than the rate of sedimentation, resulting in the dense build-up of lacustrine deposits rich in organic matter. Along the lakeshore, sediments that were still in their immature stages were also deposited (**Barber et al., 2005**). Even though the current back-arc basins were not created during this time of graben development, sedimentary deposits of this period were nonetheless identifiable in specific stratigraphic nomenclature in Sumatra's existing basins. The sedimentary deposits found in the CSB were identified as the Pematang Group, deposited unconformably on top of the basement. This stratigraphic unit consisted of a variety of fine to medium sandstones, shales, and claystone conglomerates and breccia in shades of red, green, and black (**Barber et al., 2005**). The sediments were described as continental scree, alluvial fan, fluvial, and lacustrine deposits with a small amount of marine impact and limited euxinic conditions (**Barber et al., 2005**). The Pematang Brown Shale formation included the euxinic shale, which was an important source rock for the CSB (**Barber et al., 2005; Doust and Noble, 2008**). Following the rift sediments that were deposited during the Horst and Graben stages, there was a shift in the tectonic activity of the region during the Late Oligocene. This change caused the Barisan Mountains and other areas in the fore-arc and back-arc basins to rise while other areas continued to experience sedimentation. The shift also caused local inversions, which resulted in a regional mismatch between later and the rift deposits (**Barber et al., 2005**).

After the Late Oligocene tectonic regime shift, the region underwent a transgression stage brought on by regional sag (**Barber et al., 2005**). The early transgressive stage commenced in the Early Miocene, marking the initial differentiation between the Barisan Mountains and the fore-arc and back-arc basins. The Barisan Mountain's location made it a significant source of sedimentation for the basins (**Barber et al., 2005; Nugraha et al., 2023**). Although subsidence rates initially favored the back-arc regions over other areas, it did not exceed the sedimentation rate. As a result of the linked fluvial and deltaic systems, the sediments were carried over great lengths in the back-arc regions, far beyond the pre-existing rift borders (**Barber et al., 2005**). The lower Sihapas and Menggala Formation, as well as the lower portion of the Sihapas Group, were characterized by the early transgression stages in the CSB (**Barber et al., 2005**). It was determined that these stratigraphic strata consisted of small fluvial-deltaic shales, local tuffaceous, coal seams, and fine to coarse sandstones with pebble conglomerates (**Mertosono and Nayoan, 1974**).

Around the late Early to Mid-Miocene, there was a regional sag that was followed by the uplift of Barisan Mountain (**Barber et al., 2005; Pubellier and Morley, 2014**). Therefore, the pace of subsidence surpassed the frequency of sedimentation, leading to the change from a deltaic and fluvial system to an open marine one (**Barber et al., 2005**). This geological event was nevertheless recognized in the stratigraphic categorization of the CSB as the higher Sihapas Group, which includes the Duri, Telisa, and higher Sihapas Formations. The upper part of Sihapas was found to be constituted of fluvial-deltaic sandstone that originated in the Malaysian Shield and was deposited in a network of braided and deltaic rivers, whereas the Telisa Formation consisted of marine shales (**Barber et al., 2005**). Mid-Miocene Sumatra saw its highest transgression stage, which was defined by maximum marine shale deposition and minimum clastic input (**Barber et al., 2005; Doust and Noble, 2008**). This highest incursion in the CSB was shown as a large amount of marine shale deposition in the Telisa Formation's uppermost section (**Barber et al., 2005**).

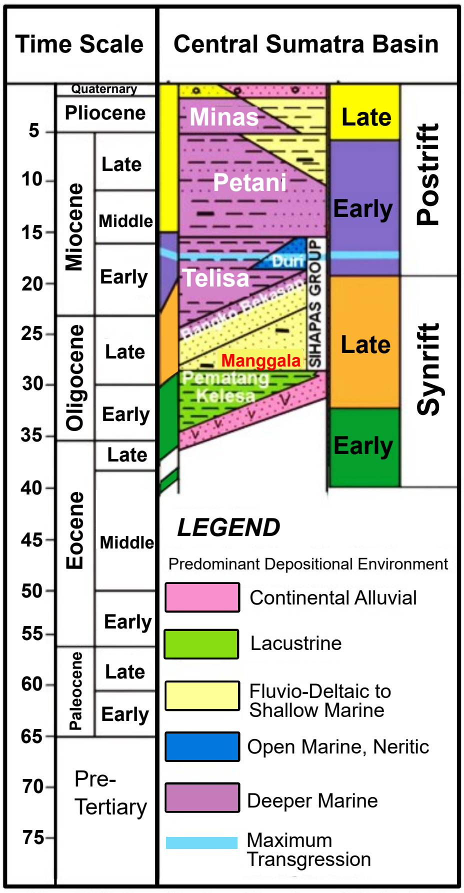

Figure 2: Regional Stratigraphic Column of the CSB According to **Doust and Noble (2008)** and **Apendi (2019)**

The regional sag began to decelerate compared to the uplift of the Barisan Mountain from the mid-Miocene onwards, initiating a regressive stage (**Barber et al., 2005**). The Barisan Mountains developed further during this time, acting as a major supply of sediment, while the fore-arc and back-arc basins continued to recede (**Barber et al., 2005**). The Sumatran Fault System continued to move along in both transpressional and transtensional directions to the present day (**Barber et al., 2005; Berglar et al., 2017**). As evidenced by the Lower Petani Formation in the CSB, turbiditic sandstone increased in the Late Miocene (**De Coster, 1974**). When these deposits were recognized as the Upper Petani Formation in the CSB in the Late Miocene and Early Pliocene, they progressively changed into shallow marine, sublittoral, and deltaic sediments (**De Coster, 1974**). Terrestrial sands and clay dominated the deposited sediments by the Late Pliocene, identified as Minas Formation (**Cameron et al., 1981**). The Barisan Mountains saw extreme uplift, erosion, and violent volcanism in the Late Pliocene (**Barber et al., 2005; Harbury and Kallagher, 1991**). This incident also occurred at the same time as inversion tectonics, which is connected to displacement along the Sumatran Strike-Slip Fault, in the back-arc region

pp. 1-12, DOI: 10.17794/rgn.2025.1.1

(**Eubank and Makki, 1981**). After the latest inversion tectonics, quaternary sediments were unconformably deposited over the structures' degraded surfaces (**Barber et al., 2005**). These deposits included swamp deposits along the eastern shoreline, river deposits further from the mountains, coarse conglomerates containing volcanic debris from Barisan in nearby locations, and deep-sea clays and turbidites in the offshore area (**Barber et al., 2005**).

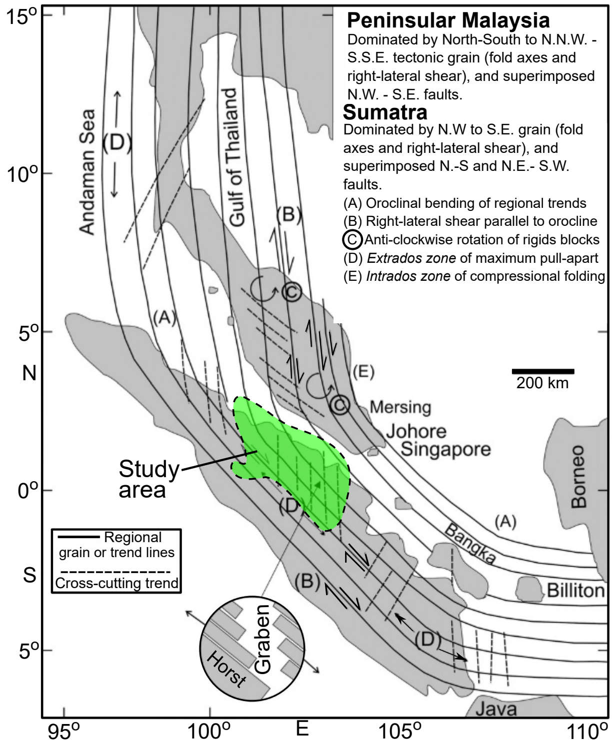

Figure 3: The Extrados Zone-induced right-lateral strike-slip fault movements (transtensional type) affecting the CSB formation (the green area). The figure was updated using **Hutchison's (2010)** research as a basis, and **Barber et al.'s (2005)** work was followed to determine the basin boundaries.

3. Geothermal review of Central Sumatra Basin

The Central Sumatra Basin (CSB) is a sedimentary basin that has produced billions of barrels of oil through thousands of oil wells. Among these, most of the production is detected at the Minas and Duri oil fields. In particular, for this study 326 oil wells throughout the CSB were selected allowing for a mapping area in the CSB where the geothermal potential is maximized. The majority of geothermal studies currently only focus on volcanic arc areas, thus social and environmental issues are serious challenges in this region. This detailed geothermal study is the first to be carried out specifically for a back-arc sedimentary basin in Indonesia as an effort to reduce the impact of climate change and meet energy needs.

The CSB is a back-arc basin that has experienced extensional deformation in the Tertiary age. The implication of this extensional deformation is the formation of normal faults trending in north-south and northwest-southeast direction (see **Figures 3-5**). Thus, the CSB is included in Non-magmatic geothermal = extensional domains according to the classification from **Moeck (2014)** controlled by normal faults (see **Figure 6**).

However, there are other types of geothermal source that also play a role in increasing heat flow in the CSB.

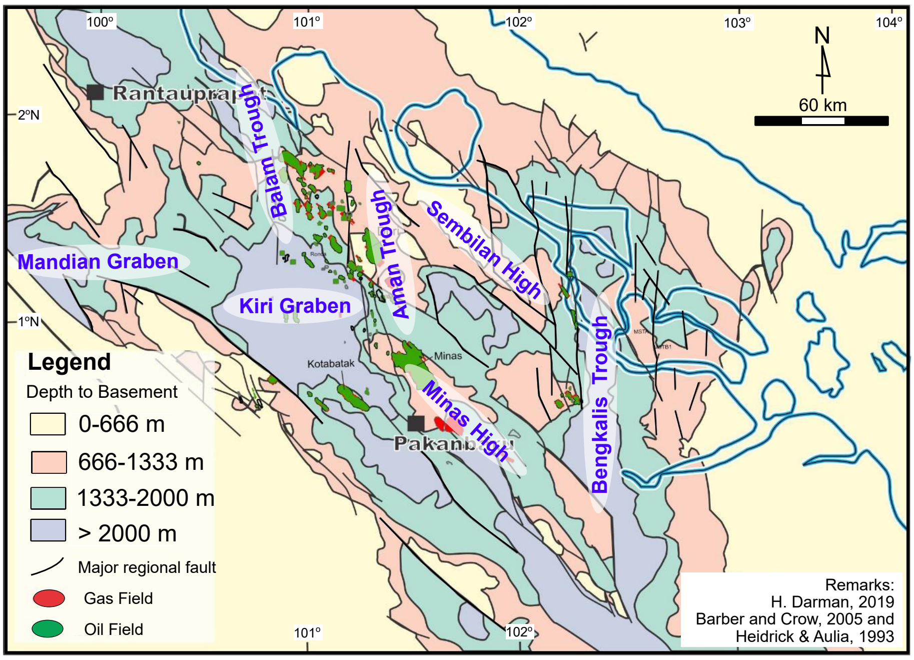

Figure 4: Isochore contours with basement structures in the CSB showing highs and depressions. These structures controlling tertiary sedimentation (modified from **Darman and Ady, 2020**)

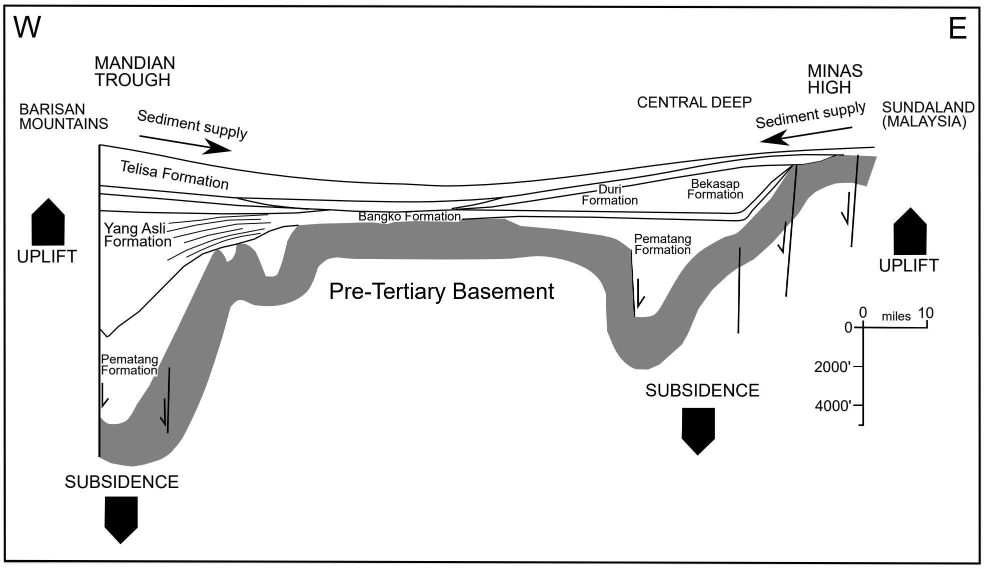

Figure 5: Diagrammatic east-west cross-section across the western part of the CSB showing the development of normal faults indicated by troughs and highs (**Williams and Eubank, 1995**)

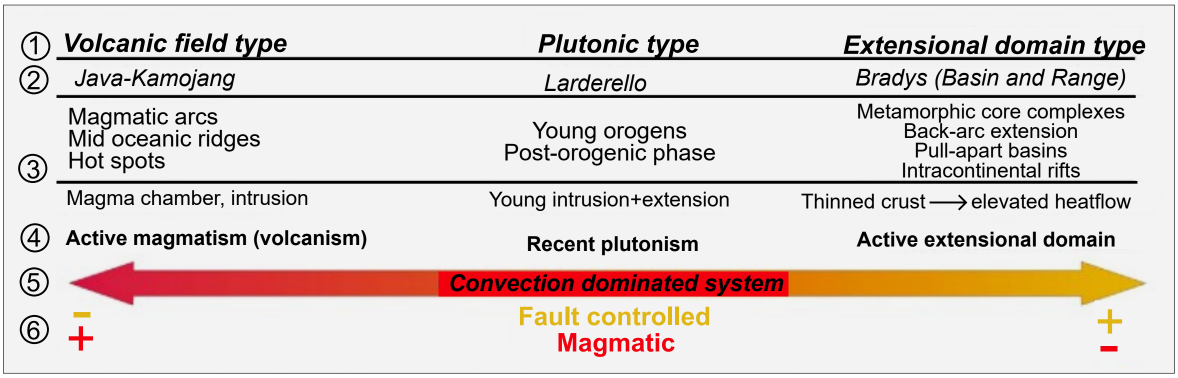

Figure 6: Catalog scheme for convection dominated geothermal play systems based on the geologic controls (**Moeck, 2014**). The CSB is located in the extensional domain type.

The geothermal source types include: a magmatic geothermal source– volcanic field and plutonic type and an igneous geothermal type. The magmatic geothermal source–volcanic field and plutonic types are more dominant in areas close to Bukit Barisan such as in the Mandian Graben. The igneous geothermal type–refers to a basement that contains radiogenic heat producing elements such as thorium or uranium. This type of geothermal is not expected to be very significant in increasing heat flow in the CSB because the thickness of the crust is only around 27 km. Thus, the dominant type of geothermal source in the CSB is the convection-dominated geothermal type, while the sub geothermal play type is a non-magmatic geothermal source – extensional domains.

4. Method

4.1. Evaluation of geothermal data

This research looked at geothermal information gathered from 326 oil wells located inside the CSB. The data obtained from the ‘heat flow’ website includes 289 oil wells (**Jennings and Hasterok, 2023**) and 37 oil wells were sourced from GFZ data services (**Fuchs et al., 2023**). Geothermal information consists of geothermal gradient average, heat flow, and thermal conductivity. Except for the oil well data from GFZ data services, the geothermal data primarily included heat flow data. The Fourier formula was used to evaluate the heat flow in the CSB.

$$q = -\lambda.\Gamma \tag{1}$$

Where λ is the thermal conductivity (W/m°C), which is an intrinsic physical property of a specific type of rock. The following formula was used to further compute the thermal conductivity.

$$\lambda = \frac{Cu.\Delta Tu.h}{S.(Tu-Tl).\Delta t} \tag{2}$$

Where Cu is the thermal capacity (J^{o}C^{-1}) of the measured outcropping rock, ΔTu (°C) is the temperature change of the upper formation during a certain time d*t*, h

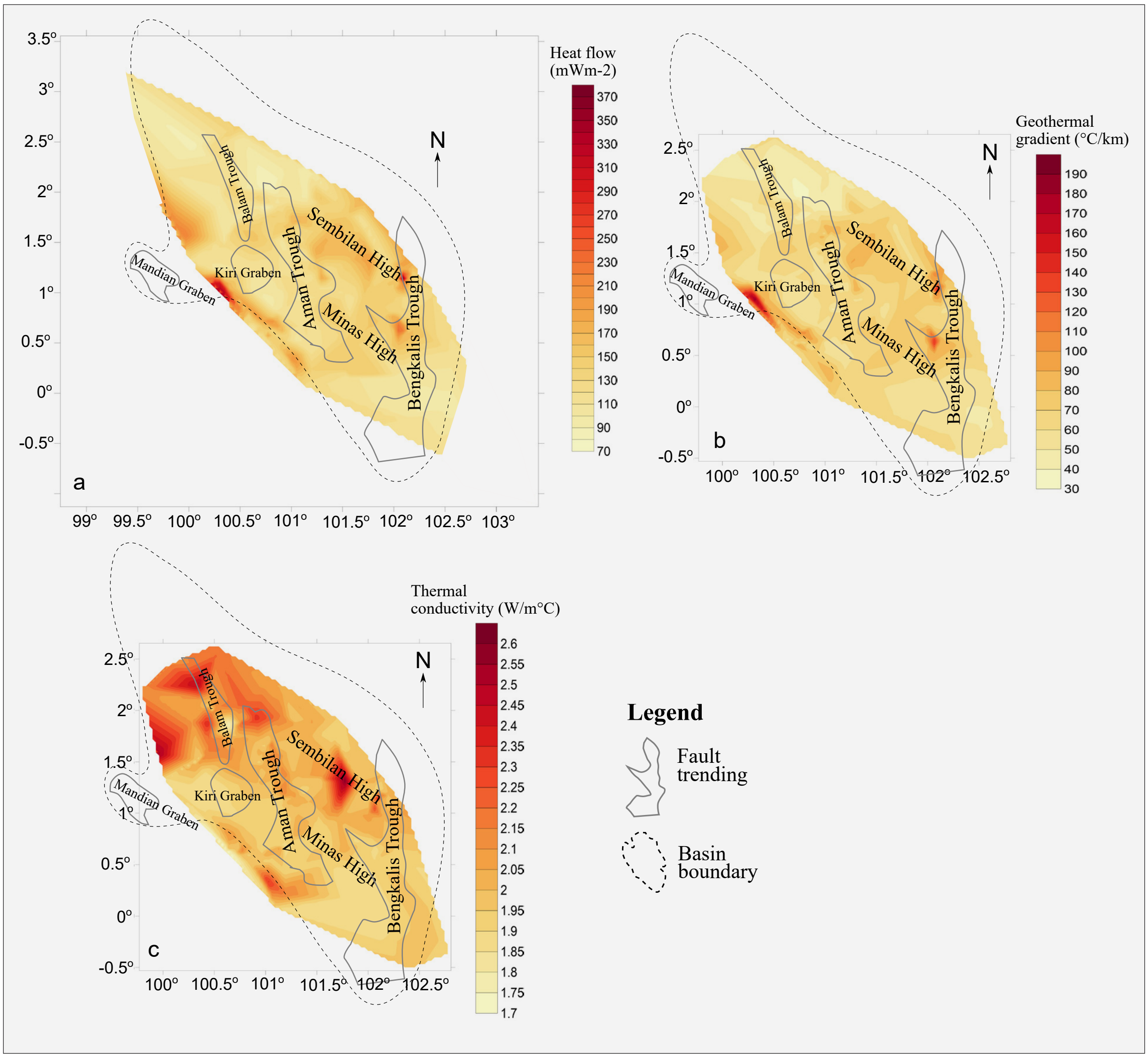

Figure 7: Distribution of (a) Heat Flow, (b) Geothermal Gradient, and (c) Thermal Conductivity in the CSB based on 289 oil wells with the basin boundaries following the work of **Barber et al. (2005)**

(m) and S (m^2) are the height and the cross-sectional area of the oil well, Tu−Tl is the average difference between the temperature values of the upper (Tu) and lower (Tl) geological units over a certain time Δt (**Giordano et al., 2019**).

Γ is the geothermal gradient (°C/km) within the designated range (**Jennings and Hasterok, 2023**). Q is the amount of heat that is transferred from the Earth's subsurface to the surface (mW/m^2). According to this formula, a larger thermal gradient is correlated with a higher heat flow value. The following formula was used to further compute the geothermal gradient.

$$\Gamma = (T2 - T1) / \Delta z \tag{3}$$

where T2−T1 denotes the temperature differential, and Δz signifies the separation between two locations. In this research, Δz specifically referred to the depth of the well.

4.2. Realization of the geothermal maps

In this study, geothermal gradient, heat flow, and thermal conductivity maps were created using the calculated geothermal data with the methodology discussed in the previous sections. Aimed at realizing these maps, Surfer 13 software (**Surfer® from Golden Software, LLC, 2015**), was used employing a triangulation with a linear interpolation gridding method. The main technical features of this software are described in **Pardamean et al. (2024)** and **Siringoringo and Maulana (2020)**, to which the main reference is made. The Triangulation with Linear Interpolation was chosen because this statistical method only uses data in the grid area. This gridding method is fast and does not extrapolate beyond the Z value of the data range. In addition, Triangulation with Linear Interpolation does not create data that is outside the data limits (**Golden Software, 2024**). Apart from statistical aspects, we arranged the “z” (geothermal gradient/heat flow/thermal conductivity variable) value according to the minimum and maximum values found in the actual data. This was done to obtain a more accurate area for exploiting its geothermal potential. The maps that have been formed were then overlaid with the geological structure map (see **Figure 4**). Setting the Z value and overlaying it with a geological structure map was done to obtain a more accurate area for utilizing geothermal potential.

5. Results

A broad variety of geothermal parameters such as heat flow, thermal conductivity, and geothermal gradient in the CSB have been measured. Heat flow values vary from 70 to 370 mW/m^2, in the Balam Trough, the Kiri Graben, the Bengkalis Trough, Sembilan High, and in the vicinity of Mandian Graben, typically registering high and extremely high values (see **Figure 7a**). Geothermal gradients vary from 30 to >120°C/km, with a dominance of high to very high gradients. The Bengkalis Trough and the Mandian Graben have extremely high geothermal gradients, while the high values are spread throughout the Kiri Graben, Sembilan High, and the the Balam Trough (see **Figure 7b**). Additionally, the range of thermal conductivity is 1.7 to over 2.1 W/m°C, with high to extremely high values predominating. The Minas High and in the vicinity of Mandian Graben are regions with high thermal conductivity, and the Sembilan High and the Northwestern portion of the CSB exhibit extremely high values (see **Figure 7c**). Overall, these parameters collectively contribute to the abundant geothermal resources within the CSB, making the basin an attractive region for energy development.

6. Discussions

6.1. Geothermal and geology analysis

The thin crustal thickness of the basin is what accounts for the strong heat flow in the CSB. Previous research shows that the thickness of the Sumatran basins crust measures around 27-30 km (**Bora et al., 2016; Curie and Hyndman, 2006**), directly proportional to the lithosphere thickness of approximately 85-92 km (**Yu et al., 2017**). Both values, however, fall short of the continental lithosphere’s typical thickness, which ranges from 100 to 125 km (**Rychert and Shearer, 2009**). In sedimentary basins, surface heat flow density is greatly influenced by radiogenic heat production in addition to crustal thickness (**Frone et al., 2015; Guillou-Frottier et al., 2010; Schütz et al., 2012; Waples, 2002**). Despite the presence of sedimentary rocks with an average thickness of around 1000 m in the CSB, the heat contribution is not substantial (**Bora et al., 2016; Darman and Ady, 2020**). The thin crustal thickness and the effect of normal fault structures are the main causes of the basin’s significant heat flow. The Middle Eocene to Late Oligocene, subduction rollback mechanism is responsible for the CSB’s crustal thinning and the development of normal faults (**Balázs et al., 2021; Chen et al., 2016; Feng et al., 2021; Pubellier and Morley, 2014; Schellart and Moresi, 2013; Xue et al., 2022**). During this period, the process of forming a pull-apart basin occurred due to the collision of the Indian and Eurasian plates (**Hutchison, 2010**), leading to the formation of normal faults trending in a north-south direction as depicted in **Figures 3-5**. The main regulators of geothermal fluid circulation are normal faults (**Husein et al., 2015; Nukman and Moeck, 2013; Yamanlar et al., 2020**) as well as conduits for heat sources (**Daruwati, 2014; Kaya et al., 2017; Liao et al., 2023**). Based on observations, volcanic intrusions at Bukit Barisan are most likely the source of the significant heat flow in the eastern part of Mandian Graben or southwestern part of Kiri Graben. However, heat flow from this area does not have a significant impact on overall heat flow due to the locality (**Hochstein and Sudarman, 1993**). These tectonic characteristics also have an impact on the anomalous geothermal gradient in the CSB. The CSB’s geothermal gradients vary from 30 to >120°C/km, with a dominance of high to very high gradients. The Bengkalis Trough and the Mandian Graben have extremely high geothermal gradients, while the high values are spread throughout the Kiri Graben, Sembilan High, and the the Balam Trough. The CSB’s geothermal gradient is an anomaly because the geothermal gradient for continental settings is around 25°C/km for basins with sediment thicknesses of around 1.5-2.5 km (**Kolawole and Evenick, 2023**).

Thermal conductivity is influenced by many variables consisting of mineralogical composition, porosity, fracture density, texture, pressure, rock temperature and degree of saturation and nature of the fluid (**Harlé et al., 2019**). The CSB has high to extremely high thermal conductivity, which ranges from 1.7 to over 2.1 W/m°C. The high thermal conductivity (1.7 to 2.1 W/m°C) is ascribed to the Bekasap and Duri formations’ sandstone lithologies (**Thamrin, 1985**) which are common in the Minas High region. Previous studies show that the sandstone of the Bekasap Formation from 548 m to 640 m has an average porosity of 25% (**Andriyani et al., 2023**) and 243 m to 259 m from 22-34% (**Ordas et al., 2023**). Meanwhile, the northwestern portion of the basin and the Sembilan High area, the basement’s extremely high thermal conductivity (over 2.1 W/m°C) is attributable to lithologies of quartzite, graywacke, and occasionally granite (**Carvalho et al., 1980**). In the Sembilan High Area, the thickness of sedimentary rock reaches 1333 m. Here it can be seen that the thermal conductivity of rocks generally increases with a decrease in porosity and depth. This is consistent with previous studies (**Guo et al., 2017; Mielke et al., 2017**).

Table 1: Comparison of the CSB with selected sedimentary basins in the world based on variable basin crust thickness and average heat flow

No	The Name of Sedimentary Basin	Crustal Thickness Estimation (km)	Average Heat flow Estimation (mW/m^2)	Status	References
1	Central Sumatra Basin, Indonesia	27	120	No Status	**Bora et al., 2016**
2	Gonghe Basin, China	35-40	102.2	Exploration	**Yang et al., 2024**
3	Anticosty sedimentary Basin, Canada	35-40	68.9	Exploration	**Gascuel et al., 2020**
4	The Upper Rhine Graben, Germany	28-30	184±15	Producing	**Harlé et al., 2019;** **Schwarz and Henk, 2005**
5	Buyuk Menderes Basin, Turkey	33	140	Producing	**Kaya et al., 2017**
6	The Northern Part of Thrace Basin, Turkey	30	65.8 ± 11.3	Exploration	**Ates et al., 2012;** **Erkan and Balkan-Pazvantoğlu, 2023; Karabulut et al., 2013**
7	The Western Canada Sedimentary Basin	33 ± 3	60.4	Exploration	**Hyndman, 2017;** **Weides and Majorowicz, 2014**

6.2. Comparison with other regions worldwide

The research examines six sedimentary basins currently in the exploration and exploitation stage for geothermal energy production, as depicted in **Table 1**. They are the Gonghe Basin (China), the Anticosty sedimentary Basin (Canada), the Upper Rhine Graben (Germany), the Buyuk Menderes Basin (Turkey), the northern part of the Thrace Basin (Turkey), the Western Canada Sedimentary Basin (Canada). This table reveals that the average heat flow of the CSB is more than 100 mW/m^2 or one of the highest of the seven basins. In this section, geothermal in the CSB is compared with The Upper Rhine Graben (Germany) and Buyuk Menderes Basin (Turkey) because these two basins have entered the production stage.

The CSB heat flow data ranges from 70 mW/m^2 to more than 150 mW/m^2 with an average heat flow of 120 mW/m^2. The distribution is quite even, almost throughout the entire CSB area (see **Figure 7**). Referring to the heat flow value, it can be seen that the heat flow interval is very wide. In fact, information from the legend shows that the highest heat flow value reaches 370 mW/m^2 which is to the southwest of the Kiri Graben. If observed in more detail, the potential for geothermal field development can be carried out in the Balam Trough, Kiri Graben, Bengkalis Trough, Sembilan High, and the area of Mandian Graben. Heat flow data in these areas has more than sufficient heat flow values (>150 mW/m^2) for geothermal development. As a comparison, the Soultz-sous-Forêts site, a geothermal power plant in the Upper Rhine Graben, shows a heat flow value of around 184 ± 15 mW/m^2 (**Harlé et al., 2019**) and in the Buyuk Menderes Basin, there is a heat flow value of around 140 mW/m^2 (**Kaya et al., 2017**).

Apart from being based on the heat flow value, the geothermal gradient value also shows consistency with the heat flow value. The geothermal gradient in the CSB shows a value of 30°C/km to more than 120°C/km. In the areas of the Balam Trough, Kiri Graben, Bengkalis Trough, Sembilan High, and the area of Mandian Graben, values show more than 80°C/km. If further clarified, the Bengkalis Trough area and the area of Mandian Graben have a very high geothermal gradient reaching 150°C/km. For comparison, the geothermal gradient at the Soultz-sous-Forêts site reaches 110°C/km (**Pribnow and Schellschmidt, 2000**) and the Buyuk Menderes Basin shows a geothermal gradient value of around 100°C/km (**Kaya et al., 2017**).

Thermal conductivity shows a value of 1.7 W/m°C to more than 2.1 W/m°C. The highest distribution is in the northwestern portion of the basin and the Sembilan High area. For comparison, the thermal conductivity at the Soultz-sous-Forêts site reaches 1.71 ± 0.23 W/m°C in rocks of Tertiary age (**Harlé et al., 2019**) and in the Buyuk Menderes Basin where the thermal conductivity value is around 2.56 W/m°C in the conglomerate-sandstone-mudstone lithology (**Balkan-Pazvantoğlu et al., 2021**). Based on these geothermal variables and the comparability with the Upper Rhine Graben and Buyuk Menderes Basin, the CSB's geothermal potential can be exploited. This is also supported by other studies in basins that have lower heat flows than the CSB, providing recommendations for exploiting geothermal potential in these basins.

The adoption of geothermal energy in the CSB can include repurposing abandoned oil wells or when necessary, re-drilling existing wells for deeper extraction and use for electrical purposes. When compared with investment in drilling new geothermal wells, adopting energy from existing oil wells proves to be more cost-effective. Furthermore, leveraging existing infrastructure helps minimize potential social conflicts and environmental pollution associated with drilling new wells or constructing power plants. Local communities surrounding geothermal energy development projects have adapted to oil well development which commenced decades ago.

7. Conclusions

This research reveals that the Central Sumatra Basin (CSB) has great potential for the development of geothermal energy. Based on data from 326 oil wells within the CSB, significant variations in heat flow, thermal conductivity and geothermal gradient were found. The heat flow in the CSB ranges from 70 to 330 mW/m^2, with a geothermal gradient between 30 and 160°C/km, and a thermal conductivity between 1.7 to more than 2.1 W/m°C.

Several areas, such as Minas High, Sembilan High and Bengkalis Trough show very high values for these three parameters, making the CSB an area with abundant geothermal resources. This is mainly due to the thin crust thickness in the CSB, which is around 27 km, which is thinner than continental crust in general. This crustal thinning is caused by the subduction rollback mechanism and the formation of pull-apart basins in the Tertiary age. Apart from thinning the crust, the normal faults that form act as regulators of geothermal fluid circulation and conductors for heat sources.

Comparison with other sedimentary basins around the world shows that the CSB has heat flows that are no less high than several basins that are already in the exploration or geothermal energy production stage, such as the Upper Rhine Graben in Germany and the Buyuk Menderes Basin in Turkey. Therefore, the CSB has enormous potential to be utilized as a source of geothermal energy, which can significantly contribute to achieving the zero emissions target by 2060. The development of geothermal energy in the CSB can be done in Minas High, Sembilan High and Bengkalis Trough.

However, the development of geothermal energy in the CSB is not without challenges. Social and environmental risks need to be well managed to avoid conflicts and negative impacts. One proposed strategy is to utilize inactive oil wells for geothermal exploitation, which can reduce costs and minimize environmental impacts.

Overall, this research provides in-depth insight into the geothermal potential in the CSB and supports the importance of developing renewable energy to reduce the impacts of climate change and meet increasing energy needs.

Acknowledgement

The authors would like to thank Samuel Scott Jennings, Derrick Hasterok, and GFZ who generously provided the data used in this research for free. Apart from that, thanks are also expressed to the editors and reviewers of the journal for their criticism and recommendations which helped improve the quality of this article.

8. References

Andriyani, D. C., Winardi, S. and Surjono, S. S. (2023): Petrophysical Study and Rock Type Determination of Siliciclastic Reservoir: Case Study Sand of Bekasap Formation, AF Field, Central Sumatra Basin, Indonesia. Journal of Applied Geology, 7(2). https://doi.org/10.22146/jag.83471

Anggreta, D. K., Somantri, G. R. and Purwanto, S. A. (2022): Social Acceptance: Mapping the Perspectives of Stakeholder in the Development of Geothermal Power Plants in West Sumatra, Indonesia. International Journal of Sustainable Development and Planning, 17(4), 1053–1065. https://doi.org/10.18280/ijsdp.170402

Apendi, I. A. (2019): Lithospheric-scale thermal characterization of Central Sumatra Basin, Indonesia. Utrecht University.

Artemieva, I. and Mooney, W. D. (2001): Thermal thickness and evolution of Precambrian lithosphere: A global study. Journal Gephysical Research, 106(16), 387–414.

Ates, A., Bilim, F., Buyuksarac, A., Aydemir, A., Bektas, O. and Aslan, Y. (2012): Crustal Structure of Turkey from Aeromagnetic, Gravity and Deep Seismic Reflection Data. Surveys in Geophysics, 33(5), 869–885. https://doi.org/10.1007/s10712-012-9195-x

Balázs, A., Faccenna, C., Ueda, K., Funiciello, F., Boutoux, A., Blanc, E. J. P. and Gerya, T. (2021): Oblique subduction and mantle flow control on upper plate deformation: 3D geodynamic modeling. Earth and Planetary Science Letters, 569, 117056. https://doi.org/10.1016/j.epsl.2021.117056

Balkan-Pazvantoğlu, E., Erkan, K., Salk, M., Akkoyunlu, B. O. and Tayanç, M. (2021): Surface heat flow in Western Anatolia (Turkey) and implications to the thermal structure of the Gediz Graben. Turkish journal of earth sciences, 30(SI-2), 991–1007. https://doi.org/10.3906/yer-2105-28

Barber, A., Crow, M. and Milson, J. (2005): Sumatra: Geology, Resources and Tectonic Evolution. The Geological Society London.

Berglar, K., Gaedicke, C., Ladage, S. and Thöle, H. (2017): The Mentawai forearc sliver off Sumatra: A model for a strike-slip duplex at a regional scale. Tectonophysics, 710–711, 225–231. https://doi.org/10.1016/j.tecto.2016.09.014

Bora, D. K., Borah, K. and Goyal, A. (2016): Crustal shear-wave velocity structure beneath Sumatra from receiver function modeling. Journal of Asian Earth Sciences, 121, 127–138. https://doi.org/10.1016/j.jseaes.2016.03.007

Cameron, N. R., Aspden, J. A., Miswar, and Rock, N. M. (1981): The geology of Tebingtinggi quadrangle, Sumatra (Quadrangle 0719) scale 1:250,000. Geological Survey of Indonesia, Directorate of Mineral Resources, Geological Research, and Development.

Carvalho, H. D. S., Purwoko, Siswoyo, Thamrin, M. and Vacquier, V. (1980): Terrestrial heat flow in the tertiary basin of central Sumatra. Tectonophysics, 69(1–2), 163–188. https://doi.org/10.1016/0040-1951(80)90132-8

Chen, Z., Schellart, W. P., Strak, V. and Duarte, J. C. (2016): Does subduction-induced mantle flow drive backarc extension? Earth and Planetary Science Letters, 441, 200–210. https://doi.org/10.1016/j.epsl.2016.02.027

Curie, C. A. and Hyndman, R. D. (2006): The thermal structure of subduction zone back arcs. Journal of Geophysical Research: Solid Earth, 111(8), 1–22. https://doi.org/10.1029/2005JB004024

Darman, H. and Ady, D. (2020): Sedimentary Basins of Indonesia: Outline and Thickness Variation Understanding. Berita Sedimentologi, 45, 39–52. https://journal.iagi.or.id/index.php/FOSI/article/view/48/19

Daruwati, I. K. A. (2014): Fault Modelling Based on Local Magnetic Anomaly Data in Geothermal Prospect Area Rajabasa Lampung. Proceedings of The 4th Annual International Conference Syiah Kuala University (AIC Unsyiah) 2014 In conjunction with The 9th Annual International Workshop and Expo on Sumatran Tsunami Disaster and Recovery – AIWEST-DR 2014, 72–78.

De Coster, G. (1974): The geology of the Central and South Sumatra basins. In IPA (Ed.), Proc. Indon. Petrol. Assoc., 3rd Ann. Conv. (hal. 77–110). AAPG.

Doust, H. and Noble, R. (2008): Petroleum systems of Indonesia. Mar. Petrol. Geol, 25, 103–129.

Erkan, K. and Balkan-Pazvantoğlu, E. (2023): Distribution of surface heat flow and effects on the subsurface temperatures in the northern part of Thrace Basin, NW Turkey. Geothermal Energy, 11(1), 13. https://doi.org/10.1186/s40517-023-00253-7

Eubank, R. T. and Makki, A. C. (1981): Structural geology of the Central Sumatra Back-arc Basin. Proc. Indon. Petrol. Assoc., 10th Ann. Conv., 1981.

Feng, G., DIlek, Y., Niu, X., Liu, F. and Yang, J. (2021): Geochemistry and geochronology of OIB-type, Early Jurassic magmatism in the Zhangguangcai range, NE China, as a result of continental back-arc extension. Geological Magazine, 158(1), 143–157. https://doi.org/10.1017/S0016756818000705

Frone, Z. S., Blackwell, D. D., Richards, M. C. and Hornbach, M. J. (2015): Heat flow and thermal modeling of the Appalachian Basin, West Virginia. Geosphere, 11(5), 1279–1290. https://doi.org/10.1130/GES01155.1

Fuchs, S., Neumann, Florian Norden, B., Beardsmore, Graeme Chiozzi, P., Colgan, W., Dominguez, A., Paulina, A., Duque, M. R. A., Ojeda Espinoza, O. M., Forster, F., Förster, A., Fröhder, R., Fuentes, K., Hajto, M., Harris, R., Jõeleht, A., Liebing, H., Liu, S., Lüdtke, Gwendolin Madon, M., Negrete-Aranda, Raquel Poort, J. and Wu, J.-N. (2023): Global Heat Flow Data Assessment Group. https://doi.org/https://doi.org/10.5880/fidgeo.2023.008

Gaillot, T., Beauchet, S., Lorne, D. and Krim, L. (2023): The impact of fossil jet fuel emissions at altitude on climate change: A life cycle assessment study of a long-haul flight at different time horizons. Atmospheric Environment, 311, 119983. https://doi.org/10.1016/j.atmosenv.2023.119983

Gascuel, V., Bédard, K., Comeau, F.-A., Raymond, J. and Malo, M. (2020): Geothermal resource assessment of remote sedimentary basins with sparse data: lessons learned from Anticosti Island, Canada. Geothermal Energy, 8(1), 3. https://doi.org/10.1186/s40517-020-0156-1

Giordano, N., Chicco, J., Mandrone, G., Verdoya, M. and Wheeler, W. H. (2019): Comparing transient and steady-state methods for the thermal conductivity characterization of a borehole heat exchanger field in Bergen, Norway. Environmental Earth Sciences, 78(15), 460. https://doi.org/10.1007/s12665-019-8397-7

Golden Software. (2024): A Basic Understanding of Surfer Gridding Methods – Part 1. www.goldensoftware.com

Guillou-Frottier, L., Lucazeau, F., Garibaldi, C., Bonte, D. and Couëffe, R. (2010): Heat flow and deep temperatures in the Southeast Basin of France: Implications for local rheological contrasts. Bulletin de la Société Géologique de France, 181(6), 531–546. https://doi.org/10.2113/gssgfbull.181.6.531

Guo, P. Y., Zhang, N., He, M. C. and Bai, B. H. (2017): Effect of water saturation and temperature in the range of 193 to 373K on the thermal conductivity of sandstone. Tectonophysics, 699, 121–128. https://doi.org/10.1016/j.tecto.2017.01.024

Hall, R, and Morley, C. K. (2004): Sundaland Basin. In P. Clift, P. Wang, W. Kuhnt, & D. E. Hayes (Ed.), Continent-Ocean Interactions within the East Asian Marginal Seas (hal. 55–85). American Geophysical Union.

Hall, Robert, and Morley, C. K. (2004): Sundaland basins. In Geophysical Monograph Series (Vol. 149, Nomor January 2004, hal. 55–85). American Geophysical Union. https://doi.org/10.1029/149GM04

Hanum, W. N., Handayani, I. G. A. K. R. and Tegnan, H. (2023): The Geothermal Development Policy on Environmental in Indonesia and the USA. Journal of Human Rights, Culture and Legal System, 3(2), 160–184. https://doi.org/10.53955/jhcls.v3i2.85

Harbury, N. A. and Kallagher, H. J. (1991): The Sunda outer-arc ridge, North Sumatra, Indonesia. Journal of Southeast Asian Earth Sciences, 6(3–4), 463–476. https://doi.org/10.1016/0743-9547(91)90088-F

Harlé, P., Kushnir, A. R. L., Aichholzer, C., Heap, M. J., Hehn, R., Maurer, V., Baud, P., Richard, A., Genter, A. and Duringer, P. (2019): Heat flow density estimates in the Upper Rhine Graben using laboratory measurements of thermal conductivity on sedimentary rocks. Geothermal Energy, 7(1), 38. https://doi.org/10.1186/s40517-019-0154-3

Hochstein, M. P. and Sudarman, S. (1993): Geothermal resources of Sumatra. Geothermics, 22(3), 181–200. https://doi.org/10.1016/0375-6505(93)90042-L

Höök, M. and Tang, X. (2013): Depletion of fossil fuels and anthropogenic climate change – A review. Energy Policy, 52, 797–809. https://doi.org/10.1016/j.enpol.2012.10.046

Husein, S., Setianto, A., Trianggo Nurseto, S. and Koestono, H. (2015): Tectonic Control to Geothermal System of Way Panas, Lampung, Indonesia. Proceedings World Geothermal Congress, October, 19–25. https://doi.org/10.13140/RG.2.1.1228.3605

Hutchison, C. S. (2010): Oroclines and paleomagnetism in Borneo and South-East Asia. Tectonophysics, 496(1–4), 53–67. https://doi.org/10.1016/j.tecto.2010.10.008

Hyndman, R. D. (2017): Lower-crustal flow and detachment in the North American Cordillera: a consequence of Cordillera-wide high temperatures. Geophysical Journal International, 209(3), 1779–1799. https://doi.org/10.1093/gji/ggx138

Jennings, S. S. and Hasterok, D. (2023): HeatFlow.org. http://heatflow.org/

Johnsson, F., Kjärstad, J. and Rootzén, J. (2019): The threat to climate change mitigation posed by the abundance of fossil fuels. Climate Policy, 19(2), 258–274. https://doi.org/10.1080/14693062.2018.1483885

Karabulut, H., Paul, A., Afacan Ergün, T., Hatzfeld, D., Childs, D. M. and Aktar, M. (2013): Long-wavelength undulations of the seismic Moho beneath the strongly stretched Western Anatolia. Geophysical Journal International, 194(1), 450–464. https://doi.org/10.1093/gji/ggt100

Kaya, A. L. I., Aydin, A. L. I., Taşdelen, S. and Akyol, E. (2017): An assessment on Heat Source of Geothermal Fields in Buyuk Menderes and Gediz Grabens , Sw Turkey. Proceedings of 59th IASTEM Internaltional Conference, June, 38–44.

Kolawole, F. and Evenick, J. C. (2023): Global distribution of geothermal gradients in sedimentary basins. Geoscience Frontiers, 14(6), 101685. https://doi.org/10.1016/j.gsf.2023.101685

Liao, Y., Zhang, W., Rong, Y., Liu, F., Wei, S., Li, L., Zhao, Z. and Li, M. (2023): A high geothermal setting in the Linyi geothermal field: Evidence from the lithospheric thermal structure. Energy Exploration & Exploitation, 41(6), 1899–1918. https://doi.org/10.1177/01445987231185850

Malau, H., Fajri, H., Yuanjaya, P., Saputra, B. and Maani, K. D. (2020): Knowledge of Local Communities Affected by the Development of Geothermal Energy. IOP Conference Series: Earth and Environmental Science, 448(1), 012112. https://doi.org/10.1088/1755-1315/448/1/012112

McNeil, M. A., Karali, N. and Letschert, V. (2019): Forecasting Indonesia's electricity load through 2030 and peak demand reductions from appliance and lighting efficiency. Energy for Sustainable Development, 49, 65–77. https://doi.org/10.1016/j.esd.2019.01.001

Megía, P. J., Vizcaíno, A. J., Calles, J. A. and Carrero, A. (2021): Hydrogen Production Technologies: From Fossil Fuels toward Renewable Sources. A Mini Review. Energy & Fuels, 35(20), 16403–16415. https://doi.org/10.1021/acs.energyfuels.1c02501

Mertosono, S. and Nayoan, G. A. S. (1974): The Tertiary Basinal Area of Central Sumatra. In IPA (Ed.), 3rd IPA Annual Convention Proceedings (hal. 63–76). AAPG.

Mielke, P., Bär, K. and Sass, I. (2017): Determining the relationship of thermal conductivity and compressional wave velocity of common rock types as a basis for reservoir characterization. Journal of Applied Geophysics, 140, 135–144. https://doi.org/10.1016/j.jappgeo.2017.04.002

Moeck, I. S. (2014): Catalog of geothermal play types based on geologic controls. Renewable and Sustainable Energy Reviews, 37, 867–882. https://doi.org/10.1016/j.rser.2014.05.032

Muslihudin, M., Santosa, I., Tugiyanti, E., Suyono, S., Dewi, P. S. and Santoso, J. (2023): The Urgency of Social Aspects in Environmental Assessment: A Case Study of a Sustainable Geothermal Power Plant Development in Banyumas, Indonesia. Environmental Research, Engineering and Management, 79(2), 88–98. https://doi.org/10.5755/j01.erem.79.2.33331

Nugraha, G. S., Sunardi, E., Haryanto, I., Adhiperdana, B. G., Fakhruddin, R., Fitriany, R. and Gunarsih, D. (2023): Facies analysis, biostratigraphy, and provenance of the late Neogene Seulimeum Formation, Northwest Aceh basin, Sumatra (Indonesia). Heliyon, 9(9), e20032. https://doi.org/10.1016/j.heliyon.2023.e20032

Nukman, M. and Moeck, I. (2013): Structural controls on a geothermal system in the Tarutung Basin, north central Sumatra. Journal of Asian Earth Sciences, 74, 86–96. https://doi.org/10.1016/j.jseaes.2013.06.012

Ordas, P. R., Abdurrokhim, Sendjaja, Y. A. and Nainggolan, T. B. (2023): Identifikasi Parameter Petrofisika dan Jenis Fluida Berdasarkan Sw dan Sequence Stratigraphy di Pesisir Cekungan Sumatra Tengah. Jurnal Geosains dan Remote Sensing, 4(1), 49–58. https://doi.org/10.23960/jgrs.2023.v4i1.150

Pardamean, L., Sapiie, B., Rudyawan, A., Bagus, I. G. and Sucipta, E. (2024): Energy Geoscience Origin of high heat fl ow in the back-arc basins of Sumatra : An opportunity for geothermal energy development. Energy Geoscience, 5(3), 100289. https://doi.org/10.1016/j.engeos.2024.100289

Pribnow, D. and Schellschmidt, R. (2000): Thermal tracking of upper crustal fluid flow in the Rhine graben. Geophysical Research Letters, 27(13), 1957–1960. https://doi.org/10.1029/2000GL008494

Pubellier, M. and Morley, C. K. (2014): The basins of Sundaland (SE Asia): Evolution and boundary conditions. Marine and Petroleum Geology, 58(PB), 555–578. https://doi.org/10.1016/j.marpetgeo.2013.11.019

Resosudarmo, B. P., Rezki, J. F. and Effendi, Y. (2023): Prospects of Energy Transition in Indonesia. Bulletin of Indonesian Economic Studies, 59(2), 149–177. https://doi.org/10.1080/00074918.2023.2238336

Rychert, C. A. and Shearer, P. M. (2009): A Global View of the Lithosphere-Asthenosphere Boundary. Science, 324(5926), 495–498. https://doi.org/10.1126/science.1169754

Schellart, W. P. and Moresi, L. (2013): A new driving mechanism for backarc extension and backarc shortening through slab sinking induced toroidal and poloidal mantle flow: Results from dynamic subduction models with an overriding plate. Journal of Geophysical Research: Solid Earth, 118(6), 3221–3248. https://doi.org/10.1002/jgrb.50173

Schütz, F., Norden, B. and Förster, DESIRE Group, A. (2012): Thermal properties of sediments in southern Israel: a comprehensive data set for heat flow and geothermal energy studies. Basin Research, 24(3), 357–376. https://doi.org/10.1111/j.1365-2117.2011.00529.x

Schwarz, M. and Henk, A. (2005): Evolution and structure of the Upper Rhine Graben: insights from three-dimensional thermomechanical modelling. International Journal of Earth Sciences, 94(4), 732–750. https://doi.org/10.1007/s00531-004-0451-2

Semedi, J. M., Willemen, L., Nurlambang, T., van der Meer, F. and Koestoer, R. H. (2017): Developing a framework for assessing the impact of geothermal development phases on ecosystem services. IOP Conference Series: Earth and Environmental Science, 103(1), 012003. https://doi.org/10.1088/1755-1315/103/1/012003

Sh, I. (2024): Potensi Geotermal Indonesia Terbesar Kedua di Dunia, Pertamina Siap Gandeng Mitra Global AIPF. https://indeks.kompas.com/profile/1936/Inang.Sh

Siringoringo, L. P. and Maulana, S. (2020): Unconfined Groundwater Flow Pattern and Facies Changes At Way Huwi Village, South Lampung. RISET Geologi dan Pertambangan, 30(1), 109. https://doi.org/10.14203/risetgeotam2020.v30.1076

Surfer® from Golden Software, LLC. (2015): www.goldensoftware.com

Tapponnier, P., Peltzer, G., Le Dain, A. Y., Armijo, R. and Cobbold, P. (1982): Propagating extrusion tectonics in Asia: New insights from simple experiments with plasticine. Geology, 10(12), 611. https://doi.org/10.1130/0091-7613(1982)10<611:PETIAN>2.0.CO;2

Thamrin, M. (1985): An investigation of the relationship between the geology of indonesian sedimentary basins and heat flow density. Tectonophysics, 121(1). https://doi.org/10.1016/0040-1951(85)90267-7

van Ruijven, B. J., De Cian, E. and Sue Wing, I. (2019): Amplification of future energy demand growth due to climate change. Nature Communications, 10(1), 2762. https://doi.org/10.1038/s41467-019-10399-3

Waples, D. W. (2002): A New Model for Heat Flow in Extensional Basins: Estimating Radiogenic Heat Production. Natural Resources Research, 11(2), 125–133. https://doi.org/10.1023/A:1015568119996

Weides, S. and Majorowicz, J. (2014): Implications of Spatial Variability in Heat Flow for Geothermal Resource Evaluation in Large Foreland Basins: The Case of the Western Canada Sedimentary Basin. Energies, 7(4), 2573–2594. https://doi.org/10.3390/en7042573

Williams, H. H. and Eubank, R. T. (1995): Hydrocarbon habitat in the rift graben of the Central Sumatra Basin, Indonesia. Geological Society, London, Special Publications, 80, 331–371. https://api.semanticscholar.org/CorpusID:140667446

Xu, Y., Li, Z., Chen, Y., Jia, M., Zhang, M. and Li, R. (2022): Synergetic mining of geothermal energy in deep mines: An innovative method for heat hazard control. Applied Thermal Engineering, 210, 118398. https://doi.org/10.1016/j.applthermaleng.2022.118398

Xue, K., Schellart, W. P. and Strak, V. (2022): Overriding Plate Deformation and Topography During Slab Rollback and Slab Rollover: Insights From Subduction Experiments. Tectonics, 41(2), 1–19. https://doi.org/10.1029/2021tc007089

Yamanlar, S., Korkmaz, E. D. and Serpen, U. (2020): Assessment of geothermal power potential in Buyuk Menderes Basin, Turkey. Geothermics, 88(July 2019), 101912. https://doi.org/10.1016/j.geothermics.2020.101912

Yang, Y., Zhang, J., Wang, X., Liang, M., Li, D., Liang, M., Ou, Y., Jia, D., Tang, X. and Li, X. (2024): Deep structure and geothermal resource effects of the Gonghe basin revealed by 3D magnetotelluric. Geothermal Energy, 12(1), 6. https://doi.org/10.1186/s40517-024-00281-x

Yu, C., Shi, X., Yang, X., Zhao, J., Chen, M. and Tang, Q. (2017): Deep thermal structure of Southeast Asia constrained by S-velocity data. Marine Geophysical Research, 38(4), 341–355. https://doi.org/10.1007/s11001-017-9311-x

SAŽETAK

Središnji sumatranski bazen: prvi sedimentni bazen za razvoj geotermalne energije u Indoneziji?

Indonezija se snažno oslanja na vulkanski luk kao područje za istraživanje i eksploataciju geotermalne energije. Nekoliko elektrana na geotermalnu energiju (GPP) poput Sibayaka (Sjeverna Sumatra), Sarulle (Sjeverna Sumatra), Salaka (Zapadna Java) i Kamojanga (Zapadna Java) koristi se energijom unutar regije vulkanskoga luka iz kvartara. Međutim, uz Središnji sumatranski bazen (CSB) koji pokazuje snažan protok topline, izgradnja elektrana sukobljava se s društveno-ekonomskim i ekološkim pitanjima. Stoga se u ovome istraživanje ne temelju geotermalnih podataka iz 326 naftnih bušotina u CSB-u analiziraju geotermalne i geološke značajke te prilike za razvoj energije. Rezultati su pokazali da izdanci stijena u CSB-u imaju nisku do vrlo visoku toplinsku provodljivost (od 1,7 do preko 2,1 W/m°C), kao i vrlo visoke vrijednosti geotermalnoga gradijenta (od 30 do preko 120 °C/km) i protok topline koji se kreće od 70 do >150 m/Wm². Kao rezultat toga, CSB je postao poznat širom svijeta kao sedimentni bazen s neuobičajeno snažnim protokom topline. Taj povišeni protok topline u CSB-u potječe od uspinjanja astenosfere, potaknut procesima poput povratka ploče i razdvajanja tijekom tercijara. Ti procesi doveli su do vrlo tanke debljine kore od 27 km u CSB-u, zajedno s formiranjem normalnih rasjeda. Komparativna analiza s drugim bazenima diljem svijeta istaknula je golem potencijal za geotermalnu eksploataciju unutar CSB-a. Očekuje se da će ovo istraživanje preusmjeriti fokus prihvata geotermalne energije prema CSB-u kako bi se minimizirali društveni i ekološki učinci dok se istovremeno teži nultim emisijama do 2060. godine.

Ključne riječi:
geotermalna energija, Središnji sumatranski bazen, protok topline, stražnji lučni bazen, geotermalni gradijent

Author's Contribution

Luhut Pardamean Siringoringo (1) (Lecturer in Geological structure and Tectonics) performed the writing of the manuscript, data analysis, reviewing and editing of the manuscript. **Zakaria Situmeang (2)** and **Novita Meka (3)** (researchers) performed data curation. All the authors have read and agreed to the published version of the manuscript.