

## RESEARCH ARTICLE

## Exploration of The Magnetic Rocks Potential of Mount Penanggungan: A Study of Myth, History, and Its Implications for Educators and Mountaineers

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### Abstract

This study explores the potential of magnetic stones on Mount Penanggungan and their relation to history and myths circulating in the community and climbers. This research is important to do in order to minimize the rate of injury caused by fatigue for climbers on this mountain. In addition, aspects of physics and history can be implications for educators to deliver material on the subject. This research uses a qualitative design with the type of case study—data collection methods through observation, interviews, and document studies. The results of this study show that some rocks on Mount Penanggungan, especially when approaching their peak, have a magnetic field anomaly up to 4 times larger than the magnetic field on the earth's surface, characterized by its darker color or cave walls. Based on the mythical and historical review, the role of magnetic stones underlies the reason ancient people performed hermitage on rocks and in Mount Penanggungan. This study implies that it can be information for climbers that rocks with a strong magnetic field magnitude can accelerate the relaxation of the body. In addition, educators can integrate this research's findings, including physical phenomena and historical/mythical aspects on Mount Penanggungan, into learning.

**Keywords:** Magnetic Rocks, Mount Penanggungan, Educators, Mountaineers

### 1. Introduction

Mount Penanggungan is a mountain located in Pasuruan Regency and Mojokerto Regency with an altitude of 1,653 Meters Above Sea Level (MASL) (Paripurno *et al.*, 2018). This mountain offers natural beauty, so many tourists want to visit (M N L Khakim *et al.*, 2020). This mountain is a stratovolcano type with a uniqueness that is almost perfectly conical in shape (Kusumayudha, Putra and Pratiknyo, 2018). Therefore, when it is already at the top of this mountain, the beautiful scenery of the surrounding city will be seen.

Because of its extraordinary beauty, Mount Penanggungan is one of the favorite places for mountaineers (Atmadi, 2019). Although classified as having a low altitude, this mountain has an uphill terrain, especially when it is about to reach its peak with an elevation angle of up to 70° (Fahmi, 2021). This has caused many climbers to suffer injuries, such as fatigue and sprains, especially when mountaineers climb at night with low vision.

One of the efforts that climbers can use to reduce injuries, especially due to fatigue, is to relax blood vessels (Govindaraj *et al.*, 2016). This relaxation can be done through magnetic field therapy because it can facilitate human blood circulation (Akar, Esfahani and Mousavi Shaegh, 2019). When blood flow increases, oxygen and other nutrients will automatically be distributed to the body faster. Sources of magnetic fields can be encountered through some natural objects, such as rocks containing magnetite (Ojo, Omotoso and Adekanle, 2014). Mount Penanggungan has many stones with unique characteristics that can only be found when going to the top, as

shown in Figure 1. The stone has a magnetic field anomaly that can affect the body's condition. This can be an educational aspect regarding physical and biological phenomena in humans.



Fig 1. One example of a rock located at an altitude of 1535 MASL of Mount Penanggungan

Since long ago, Mount Penanggungan has been considered sacred by the surrounding community. This is closely related to

the myths and history that developed in the community and climbers of Mount Penanggungan. According to legend, this mountain is one of the sacred mountains on Java Island (Munandar, 2013). According to Ancient Javanese beliefs, its sanctity is not located on the top of the mountain. However, the entire area of Mount Penanggungan, including its slopes, is a sacred area. This is corroborated by the discovery of temple site relics and ancient objects in this mountain area totaling 198 (Moch. Nurfaurul Lukmanul Khakim *et al.*, 2020). In addition, many histories record that many great people hermit until they reach their *moksa* on this mountain. So many myths circulate about natural phenomena that occur on this mountain. Until now, there has been no research on exploring magnetic phenomena and their relation to the history and myths on Mount Penanggungan.

Therefore, this study explores the potential of magnetic stones on Mount Penanggungan and its relation to history and myths circulating in the community and mountaineers. This research is important to do in order to minimize the rate of injury caused by fatigue for climbers on this mountain. In addition, aspects of physics and history can be implications for educators to deliver material on the subject.

## 2. Research Method

This research uses a qualitative design with the type of case study (Creswell and Creswell, 2018). A case study can be interpreted as the process of in-depth, detailed, and detailed investigation or examination of a particular event. This research will investigate in-depth the potential of magnetic stones on Mount Penanggungan and its relation to myths and history. This research was carried out on July 9, 2022, on the Mount Penanggungan Hiking Track via Tamiajeng, Trawas, Mojokerto.

The instrument in this study is a magnetic field detection device installed on a mobile phone application. Three different applications are used to get accurate measurements: Magnetic Field & DC Current Detector, Magnetometer, and Physics Toolbox Magnetometer. The three applications are used to measure the magnitude of the magnetic field found in rocks close to the top of Mount Penanggungan. In addition, the main instrument in qualitative research is the researcher himself (Wambaleka, 2020).

Data collection techniques in this study are through observation, interviews, and document studies. Observations are carried out through the results of magnetic field readings using three different applications so that more accurate data is obtained. Interviews are unstructured with the surrounding community so that more in-depth and natural data are obtained. Finally, document studies are carried out by reading documents related to the history of Mount Penanggungan.

The collected data was analyzed using the Miles and Huberman model (Suliyana *et al.*, 2021), which includes data reduction, data presentation, and verification. In addition, to increase the trustworthiness of the data that has been collected, triangulation of data sources is carried out by comparing data through three methods: observation, interviews, and document studies (Sugiyono, 2020).

## 3. Results and Discussion

### 3.1 Potential of Magnetic Rocks in Mount Penanggungan

Based on the results of observations utilizing three different magnetic field-measuring smartphone applications, data was obtained as in Table 1. It can be seen that some rocks have magnetic field anomalies, as in stone number 3, which has a magnitude (116; 106; 115)  $\mu\text{T}$ . While stones number 1 and 2 have magnetic field magnitudes (43; 61; 46)  $\mu\text{T}$  and (34; 39;

34)  $\mu\text{T}$ , respectively. In contrast to stone number 4, the wall of a cave with a magnetic field magnitude (226; 110; 230)  $\mu\text{T}$ .

The measurement results using three applications show differences in each application. This difference is due to the different spatial orientations of the application, where in App 1 and App 3, it has a portrait measurement orientation, while in App 2 it has a landscape orientation. According to Arribas *et al.* (2015) research, the XYZ spatial axis of a mobile phone used to measure the magnetic field can affect the magnitude of the measurement results, as shown in Figure 2.

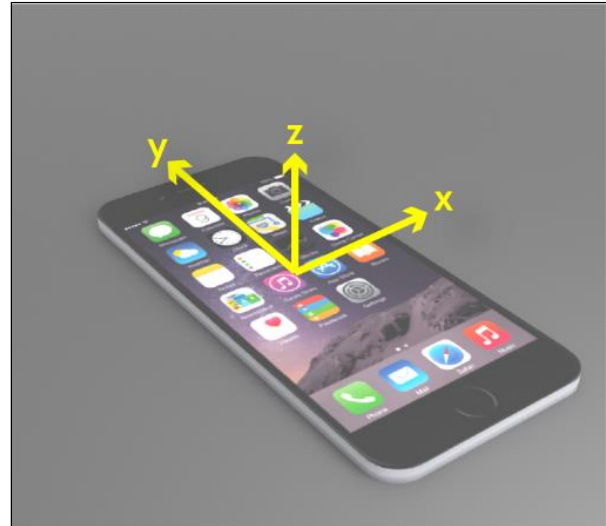


Fig 2. Spatial Orientation on Smartphones

Stones number 3 and 4 can be said to be anomalous because they have a magnitude of the magnetic field above the general. According to Khan *et al.* (2017), the magnitude of the magnetic field on the earth's surface is 25 to 65  $\mu\text{T}$ . Thus, rock number 3 has twice the magnitude of the magnetic field, and rock number 4 has a magnitude four times greater than the average magnitude. This is because this rock is included in the igneous rock type because based on previous research shows that this mountain has been dormant for about 1000 years, and the last eruption is estimated to have occurred around 200 M. These rocks are the result of the eruption of Mount Penanggungan since thousands of years ago. The magma that erupted then cooled to form igneous rock. These rocks have a high magnetic field because they contain iron-bearing minerals (Cox, Bell and Pankhurst, 1979; Li *et al.*, 2010). Iron is a compound that has the properties of elementary magnets that are easily regulated so that it is easy to produce magnetism.

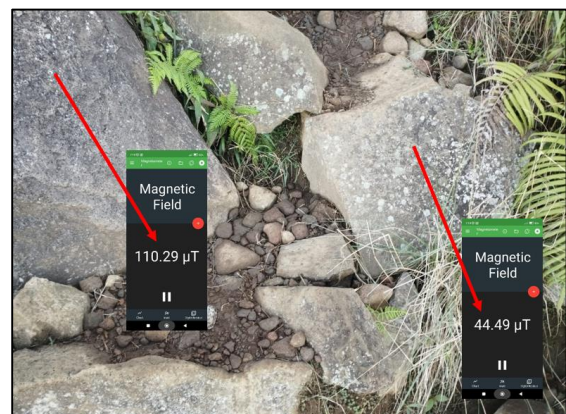














Fig 3. Comparison of magnetic field magnitudes in two darker (left) and brighter (right) rocks

Additionally, when viewed based on the characteristics of the rock, stones number 1 and 2 have a lighter color than stones number 3 and 4. This is because dark-colored rocks are composed of mafic minerals, while brighter rocks are composed of felsic minerals. Iron material is easier to associate with mafic minerals and become a constituent element of these minerals

(Cao *et al.*, 2019; Singh and Singh, 2019). Hence, dark-colored rocks have a greater magnetic field magnitude than brighter ones. It also supported by the measurement results of two stones adjacent to the level of color darkness, as shown in Figure 3. However, brighter rocks may be due to exposure to dust which can reduce the intensity of the magnetic field that appears.

Table 1. Results of Magnetic Field Measurements on Several Rocks on Mount Penanggungan

Rock Number	Magnetic Field & DC Current Detector (App 1)	Magnetometer (App 2)	Physics Toolbox Magnetometer (App 3)	Remarks
1				This rock is located on a track with an altitude of ± 1606 masl
2				This rock is located on a track with an altitude of ± 1573 masl
3				This rock is located on a track with an altitude of ± 1535 masl
4				This rock is the wall of a cave at an altitude of ± 1561 masl

### 3.2 Mythical and Historical Review

Mythical and historical review of the magnetic rocks of Mount Penanggungan is known based on the results of interviews and document studies. Some interviewees claim that ancient people performed hermitage on rocks as well as in the caves of Mount Penanggungan. It is expressed by them as follows.

*“It could be that people used to ‘niteni’ (=observe) when sitting on the rock feeling something different, such as feeling fitter, being able to think more smoothly. In addition, the rock is also located on the east side of the mountain, making it the ideal place to enjoy the sunrise.”*

This opinion is also supported by other interviewees, as follows.

*“Some ancient people were devotees of the solar god, which was called Surya Sewana so that it became a tribute to the rising sun. The position of rock on Mount Penanggungan is also located on the east side without any barriers. They worship the sun god when the sun rises from the east.”*

Based on this claim, there is some perception that the ancestors or ancient peoples used stones or caves on Mount Penanggungan as a medium in carrying out asceticism. This is because ancient society was still thick with the ancestors' animism and dynamism beliefs. People tend to believe in the mystical power of an object or spirit of the ancestors. Generally, many people do hermitage on stones or caves to pray to their ancestors. People believe in using stone pedestals as hermitages because they give rise to one's own strength or more focused concentration (Kasnadi, 2017). In addition, the ancient people believed that in order to gain powerful power, they had to go to the hermitage for days in caves and stones where their ancestors were. The ancients considered the use of caves as a place of tranquility and focus when praying, while stone pedestals were used as a sense of comfort because they could blend into nature (Putri and Sukarman, 2022).

Furthermore, Mount Penanggungan is one of the clearest evidences of the historical relics of Puratrophobic, which became an honorable place and a holy place of worship. According to the view of the Javanese people, Mount

Penanggungan is a reflection of the sacred place in India, namely Shang Nyang Mahameru. This is because Mahameru is one of the mountains where the gods reside (Muhammad and Pamungkas, 2016). When the god arrived on Java Island, he left several lands of Mount Mahameru until he arrived at mountains like Mount Penanggungan. The rest of several Mahameru Mountains, namely the top, are released to form their own mountain, namely Mount Penanggungan with the name Pawitra (Sidomulyo, 2013).

In Sanskrit, Pawitra is defined as clear, holy, and clean. Thus, Mount Penanggungan became a sacred site for worshipping the gods or practicing asceticism to the gods. This is also evidenced by the relics of inscriptions and buildings around Mount Penanggungan. Moreover, the sacred inscription (851 saka) tells the story of Maharaja Reke Hino Mpu Sindok, who ordered the relocation of Cunggurang Village to Sima due to the obligation to maintain the village's sacred buildings, namely *Shanghyang Dharmasrama ing Pawitra* and *Shanghyang Prasada Silunglung* (Munandar, 1990). In addition, in ancient times, Mount Penanggungan was also used as a hermitage during the time of King Airlangga. As is known, King Airlangga cannot be separated from the lives of three religions, namely Shiva, Buddhism, and asceticism. King Airlangga led a hermit life during difficult times. Airlangga was depressed when there was a massacre of his army carried out by Wura-Wari troops, so that he had to divide the kingdom into two, namely Jenggala and Panjalu. Therefore, to calm down and refocus, Airlangga did asceticism on Mount Penanggungan (Muhammad and Pamungkas, 2016).

According to this story, Mount Penanggungan sent a moral message as a sacred building during the royal period, demonstrating the presence of religious diversity in the area. Generally, until now, there were still people who practiced worship or asceticism in the Penanggungan area as a form of worship. This is evidenced by the discovery of many relics in the form of pathirtans, hermitage caves, and sacred buildings (temples), as seen in Figure 4, that were used as communication with gods. Reliefs scattered in sacred buildings (temples) also have the meaning of the distribution of culture and religious life from time to time (Muhammad, 2016). Thus, Mount Penanggungan exemplifies the diversity of religions found throughout Indonesia, with a cultural pattern emerging from time to time.

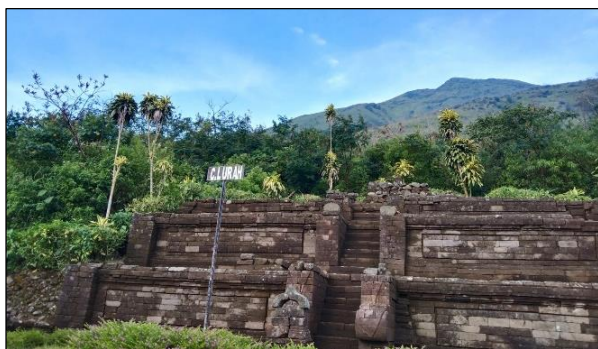


Fig 4. Candi Lurah, one of the sacred temple in Mount Penanggungan

### 3.3 Implications for Educators

Educators can incorporate both the phenomenon of magnetism and the historical review of the findings of this study into aspects of learning, such as teaching materials. The relevant lesson with this material is Physics and History at the high school level. In addition, the university can also study more deeply the phenomenon of magnetism that occurs in rocks on Mount Penanggungan. Historical reviews of the ancestors reflecting positive moral values can be actualized in learning.

Learning that is integrated with this local phenomenon is called ethnosience-based learning.

The ethnosience approach is a strategy to create an environment and design student learning experiences based on the phenomenon of the secular environment (Solheri, Azhar and Yohandri, 2022). The phenomenon is magnetism in the rocks of Mount Penanggungan as part of the learning process of science or myth and history on this mountain. Ethnosience learning is still rarely taught to students by revealing potential phenomena and cultures in the local area (Nurcahyani et al., 2021). Therefore, science learning with this ethnosience approach needs to be applied and developed by combining surrounding phenomena. Science learning with an ethnosience approach aims to allow students to get to know the original science of a society that has developed by carrying out direct investigations such as observation and then being associated with scientific science (Dewi, Khery and Erna, 2019).

### 3.4 Implications for Mountaineers

The track conditions when approaching the top of Mount Penanggungan have a slope angle of up to almost 70°. This has left many mountaineers injured due to the difficulty of the track. It is coupled with the track conditions, a mixture of fine sand and rocks, so mountaineers will slip easily. Therefore, mountaineers can rest on rocks with a high magnetic field magnitude when they feel exhausted. Based on this study's findings, rocks with a high magnetic field are characterized by their darker color or are cave walls.

Magnetic fields' biological impacts have frequently been related to nitric oxide (NO), which is responsible for changes in vessel width following magnetic field exposure (McKay, Prato and Thomas, 2007). Magnetic fields have recently been found to benefit various human systems. Varshney et al. (2010) reveal that low-intensity magnetic fields can increase blood flow in most of the human body. This can certainly accelerate the relaxation of the body when feeling exhausted due to the faster flow of oxygen circulating throughout the body. In addition, exposure to magnetic fields can also increase the speed of nerve regeneration (Suszyński et al., 2014).

Other studies have also noticed that humans are electromagnetic objects because they contain iron ions (Fe) in hemoglobin, making blood magnetic (Zhang, Yarema and Xu, 2017; Mayda et al., 2020). Some other fluids in the body that contain hydrogen (protons) are also magnetic. Therefore, exposure to magnetic fields in the rocks of Mount Penanggungan can affect and facilitate human blood circulation, especially among mountaineers.

### 4. Conclusion

Some rocks on Mount Penanggungan, especially when approaching its peak, have magnetic field anomalies up to 4 times larger than the magnetic field on the earth's surface. This rock is characterized by its darker color or cave walls. This rock is a type of igneous rock that was formed after this mountain erupted thousands of years ago. The ancient people used stones and caves as a medium for asceticism or meditation. This is due to several reasons, such as the beliefs of the ancestors of animism and dynamism, *niteni*, and worshipping the sun god.

This research has implications for educators to integrate the findings of this research which include physical phenomena and historical/mythical aspects on Mount Penanggungan in learning. The relevant subjects are physics and high school history, hoping to provide a real learning experience for students based on the surrounding environment. In addition, this study also has implications for mountaineers, when feeling tired while climbing Mount Penanggungan, they can rest on rocks or caves that have been mentioned because they can speed up the body's relaxation process. This relaxation process is

faster due to the influence of the magnetic field on the physiological and biological body of the human body.

The limitations of this study are: 1) the lack of the number of rocks explored by their magnetic field; 2) not specifying the measured rock; and 3) the time in conducting the interview is too short. Therefore, the recommendations for future research are: 1) increase the number of stones explored while specifying each stone in order to obtain better data and evidence. This can be done through experimental studies to determine the characteristics of rocks with the strongest magnetic field magnitude. 2) Conduct more in-depth interviews so they can dig up much information about myths and histories believed by the people around Mount Penanggungan.

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