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# GEOLOGICAL, GEOARCHAEOLOGICAL, BIOLOGICAL, AND HISTORICAL HERITAGE OF LENGGONG GEOPARK DEVELOPMENT

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## Abstract

The Lenggong Valley is uniquely significant in national and international geological heritage and was declared a UNESCO Archaeological Heritage Site in 2012. The Lenggong Valley was formed 550 million years ago. It is one of the oldest in Peninsular Malaysia, equivalent to the rock formations in Langkawi and Jerai. The geological evolution in the Lenggong Valley also produced biodiversity and the history of early human prehistoric to the present time. Due to this privilege, the Lenggong Geopark nomination development effort started in 2020 by forming the Geopark Promotion and Development Committee. Lenggong Geopark covers an area of 2,068 $km^2$ (enclosed by the boundaries of the Lenggong Parliament). A total of 27 geosites have been identified, depicting four important geological and historical tectonic evolutions and special geomorphic features in the Lenggong Valley. Eight biosites are still preserved, involving granite mountain, limestone, and lowland ecosystems covered by different forest types. It is the limestone hills that contain a large number of rare and endemic flora species. In addition, eight geoarchaeological sites were also identified that depicts the interaction between early humans and the geological landscape. The unique and preserved traditions of life, art and culture have added value to the geopark. Therefore, active efforts continue to be carried out in the development of geosites and programs with the local community to foster a high sense of pride and belonging to a place, in addition to an understanding of the preservation and conservation of natural and cultural heritage in Lenggong Geopark. Various activities based on tourism activities are also planned to stimulate the economy and introduce Lenggong as the second national geopark area in the State of Perak.

***Keywords***: Geosite, biosite, geoarchaeological, geotourism, local community, sustainability

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## INTRODUCTION

Lenggong Geopark, which is located in Hulu Perak district in Perak, has a unique geological, biological, archaeological and cultural heritage. Its geological history begins since the Cambrian period, closely related to stratigraphic, tectonic, igneous and morphological evolutions (JKPPLG, 2021). Evidence of the history of geological evolution is still abundantly exposed in Lenggong and has a heritage of national and regional value. Therefore, this region is suitable for developing a geopark.

In line with the recommendation from the National Geopark Committee in 2020 to create the second geopark in the state of Perak, Lenggong Valley was chosen. Geopark is a vision of Regional Sustainable Development (PLW) that focuses on sustainable and integrated development between natural heritage conservation, improving the well-being and socioeconomics of local communities, and generating national wealth through the geotourism industry (Zuoros, 2016; Komoo & Patzak, 2018; Komoo, 2019; UNESCO, 2020; UNESCO, 2020a; Mohd Zulhafiz Said *et al.,* 2021).

Lenggong Valley has a high heritage value, especially from the geoarchaeological aspect and biological and cultural diversity, which has yet to be fully explored for the benefit of the tourism industry and the socioeconomic development of the local community. Lenggong was declared a UNESCO World Heritage Site in 2012 and involved an area of around 22 square kilometres. It is currently managed by the National Heritage Department under the National Heritage Act 2005.

## LENGGONG GEOPARK DEVELOPMENT

Lenggong Geopark development efforts began in 2020 with the formation of the Lenggong Geopark Promotion and Development Committee (JKPPLG). The committee members are the Center for Global Archaeological Research (CGAR), Universiti Sains Malaysia (USM), Universiti Kebangsaan Malaysia (UKM) and the Department of Minerals and Geosciences (JMG) Perak. JKPPLG is assisted by the Lenggong Geopark Scientific and Development Committee (JKSPLG) for research, conservation and geosite characterisation, as well as the preparation of Lenggong Geopark development documents (JKPPLG, 2021).

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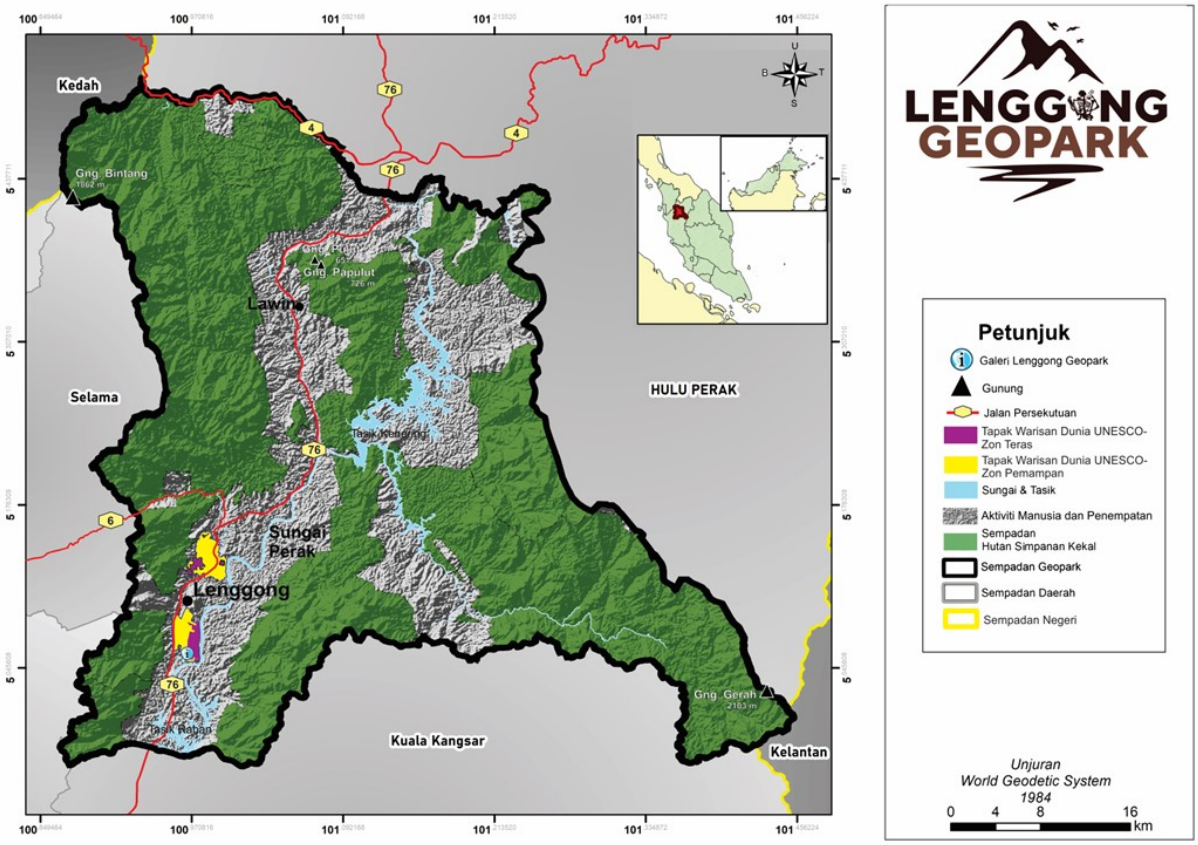


**Figure 1**: Lenggong Geopark boundaries

Through JKSPLG, preparation towards building a geopark is conducted in order to develop the geosites. Some of these efforts include conducting conducting fieldwork to identify the geological and cultural heritage sites, presenting proposal papers to the Perak State government authorities, preparing nomination documents (dossiers), producing information panels, and carrying out promotional activities to all stakeholders and residents of Lenggong such as organising seminars, briefings, exhibitions and even managing the evaluation mission of Lenggong Geopark.

Lenggong Geopark is located in four sub-districts, namely Durian Pipit, Temelong, Lenggong and Kenering sub-districts, with an area of around 2,068 square kilometres, including the boundaries of the Lenggong Parliament. The selection of Lenggong Geopark boundaries is based on all sub-districts within the Lenggong Parliament (P.055) and the ability of the Lenggong District Council to take responsibility for the development, management, and administration. This


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selection also facilitates the support system and financial assistance for infrastructure development.

Geoparks can promote natural and cultural heritage resources through integrated development, geotourism development, preservation of heritage sites and empowerment of local communities (Komoo *et al.*, 2019; Mohd Zulhafiz Said *et al.,* 2021). By fostering a sense of community among the local community, it could indirectly preserve and conserve natural treasures, as well as celebrate and harmonise innovative tourism activities at Lenggong Geopark. The four main factors that underpin the empowerment of Lenggong Geopark are geological heritage, biological heritage, geoarchaeological heritage and cultural heritage.

**Geological Heritage Lenggong Geopark**

Lenggong Geopark is a unique area with the relationship of rock types, minerals, structures, landscapes and unique geological features due to geological processes that occurred since about 550 million years ago. This area is located along a narrow valley bounded by the Titiwangsa Range in the east and the Bintang Range in the west. Based on technostratigraphy, Lenggong is part of the tectonic belt in the West Belt. This strip is part of the Sibumasu Block, west of the Bentong-Raub suture. This block was exhumed from the Gondwana continent at the end of the Early Permian during the opening of the Meso-Tethys Ocean (Metcalfe 2011a, 2011b, 2013). The bedrock in the Western Belt is dominated by clastic and carbonate sedimentary rocks that represent the sedimentary sequence of the Gondwana continental margin since the Lower Paleozoic to the Permian.

The geological evolution of Lenggong describes the age relationship with geological processes and the resulting geodiversity. This evolution can be divided into four main phases: stratigraphic, tectonic, igneous, and morphological.

**Evolution of Stratigraphic Geology**

The first deposition of sediments during the Cambrian period in the vicinity of shallow seas produced a group of sandy clastic sedimentary rocks. This rock, known as Papulut Formation, represents the oldest rock in Hulu Perak and Lenggong Geopark, equivalent to Machinchang Formation and Jerai Formation found in Langkawi and Gunung Jerai in Kedah. Next, the deposition of sedimentary rocks in the deeper sea environment resulted in a mixture of Ordovician to Carboniferous age rocks (490–300 million years) from the Kroh Formation and Kubang Pasu Formation rocks.

The Cambrian rocks are conformably overlain by a succession of Ordovician to Carboniferous rocks consisting of clastic and carbonate sedimentary rocks. The clastic rock units are Ordovician-Silurian (490-419 Ma)

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from the Kroh Formation, Devonian (419-359 Ma) from the Lenggong Limestone and Carboniferous (359-300 Ma) from the Kubang Pasu Formation exposed in contact with the granite of the Titiwangsa Range. The Kroh Formation rocks are composed of shale, shale phyllite and limestone. Next, the deposition of limestone sediments continued until the Devonian period (419-359 Ma) by the Lenggong Limestone Formation. Deposit by the Kubang Pasu Formation in the Carboniferous (359-300 Ma) is characterised by interlayered rocks of dark grey sandstone and shale.

Rocks from the Kubang Pasu Formation were deposited in the vicinity of the shallow Tethys Ocean during the Carboniferous age (359–300 million years) before the entire area was uplifted by the Triassic age granite thrusts and formed the land. The last phase of terrestrial sediment deposition occurred, filling small inland basins formed by faults during the Neogene period. The Neogene sedimentary rocks are exposed in several localities in Lawin, known as the Lawin Basin. All of these rocks were then overlain by terrestrial sediments in the form of colluvium, river and beach alluvium of the Quaternary age.

**Tectonic & Igneous Geological Evolution**

Large-scale volcanic activity had occurred based on the existence of several volcanic facies found in the northern part of Lenggong. The oldest detected volcanic activity is 480-460 million years old (Long 2018). Tectonic activity in the Permian age (300-255 million years) in the Southeast Asian region caused the collision between the Sibumasu Block and the East Malaya Block. Most of the sedimentary bedrock in Lenggong Geopark has undergone regional metamorphism due to very high pressure and temperature, resulting in various grades of rock ranging from phyllite and slate to high grade. This event may co-occur with the rock folding phase in the northwest and northern parts, known as the Langkawi folding phase by Koopmans (1965).

Next, there was a large-scale invasion of granite to form the Titiwangsa Range and the Bintang Range in the Triassic age (255-210 million years), which caused the lifting of the entire Peninsular Malaysia into the land. During the stratification of granite, the rocks in contact with it have turned into thermal metamorphism rocks. Limestone has changed to marble, while the clastic rock facies has changed to hornfels, phyllite and quartzite. The stratification of granite bodies had also caused regionally metamorphosed rocks before that to undergo further metamorphism into schists or higher grades. The last phase of sediment deposition occurred in the land's vicinity after uplifting due to granitic intrusion. This tectonic event and granite succession became an important geological history for Malaysia and Southeast Asia.


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**Morphological/Landscape Geological Evolution**

When Malaysia became land, the humid tropical climate caused high weathering and erosion processes, continuously carving and producing a variety of beautiful landscapes at this time, such as limestone karst, sedimentary rock lowlands and domes and granite ridges. During the Neogene (23.3–2 million years), there were several depositions of young terrestrial sediments, and one of them was at Lawin.

In the Quaternary age, the Perak River changed course, causing erosion and sedimentation processes along its course, now producing a series of river sedimentation terraces that form the Lenggong Basin located between the Bintang and Titiwangsa Ranges. The limestone landscape of the Lenggong Formation creates a mature karst topography with many caves. Most of these caves have been prehistoric human settlements and important archaeological sites, while rock material from river terrace deposits was used as stone tools.

The most important and last geological event in Lenggong occurred in 1.83 million years, which was the impact of a body from outer space (meteorite) that produced a crater with a diameter of 8 km with an impact reflection hill in the middle of the crater. This impact has also created the youngest type of new rock known as Bukit Bunuh Unit, which consists of impactite rock (suevite). The mega eruption of Toba volcano in Sumatra 74,000 years ago has affected most life on earth. Evidence of this eruption can be found in the Lenggong area, in the form of piles of volcanic dust over 6 m thick. Much of it has been eroded and the best site to see evidence of this is at Bukit Sapi, where the thickness of Toba dust reaches 6 m. In 1928, a hydroelectric dam was built in Chenderoh, Sungai Perak, in the southern part of Lenggong Geopark. In 1983 another hydroelectric dam was completed in the central region, the Kenering Dam.

The construction of these two dams changed the landscape of the Lenggong basin by creating two large artificial lakes (65.2 $km^2$). Tasik Chenderoh, or Tasik Raban, has become a mature lake habitat resembling a natural lake. The geological landscape translated from the events that took place over 550 million years ago is not only evidence of the history of the formation of the earth but also produces a variety of rocks and terrain as the basic building blocks for the variety of geology and habitats. In Lenggong, among the habitats that can be found are lowland habitats, karst habitats, sandstone habitats and granite mountain habitats. At the same time, the geological landscape is also responsible for providing a suitable environment for prehistoric human life.

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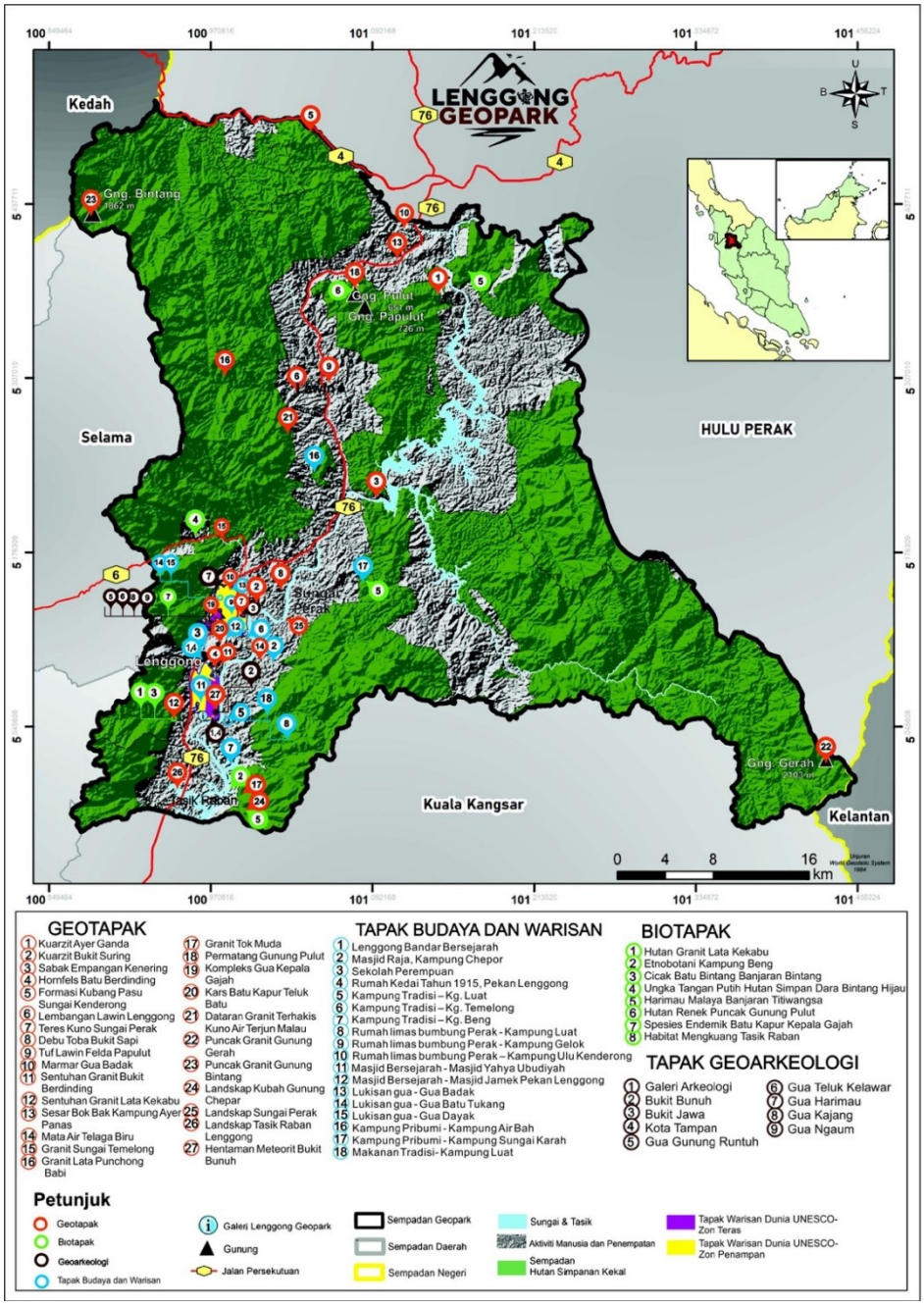


**Figure 2**: Lenggong Geopark Map and Distribution of Geosite, Biosite and Cultural Site


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All this field evidence supporting geological evolution over such a long period is a valuable geological heritage that must be preserved well to understand the homeland's history, which is the pride of all its communities.

**Lenggong Geopark Geosite**

For the development of Lenggong Geopark, the evidence of the geological process is classified according to age and processed from old to young as a geological heritage site for Lenggong Geopark, as listed in Table 1. From 550 million years ago to today, the geological process has left evidence as a backup and can be studied further. Examples of the main geosites in Lenggong Geopark are as depicted in Figures 3 and 4.

**Table 1**: List and Explanation of 27 Lenggong Geopark Geological Heritage Sites

| Nos. | Evolution | Geosite |
|---|---|---|
| 1 | Sediment/ Stratigraphy | Ayer Ganda quartzite |
| 2 | | Bukit Suring quartzite |
| 3 | | Kenering Dam slate |
| 4 | | Batu Berdinding hornfels |
| 5 | | Kubang Pasu Sungai Kenderong formation |
| 6 | | Lawin Lenggong basin |
| 7 | | Sungai Perak ancient terrace |
| 8 | | Toba ash in Bukit Sapi |
| 9 | Tectonic | Lawin Felda Papulut tuff |
| 10 | | Gua Badak marble |
| 11 | | Bukit Berdinding granite contact |
| 12 | | Lata Kekabu granite contact |
| 13 | | Bok Bak Kampung Ayer Panas fault |
| 14 | | Telaga Biru spring |
| 15 | | Sungai Temelong granite |
| 16 | | Lata Punchong Babi granite |
| 17 | | Tok Muda granite |
| 18 | Morphology | Gunung Pulut ridge |
| 19 | | Gua Kepala Gajah complex |
| 20 | | Teluk Batu limestone karst |
| 21 | | Ancient eroded granite plain of Air Terjun Malau |
| 22 | | Granite peak of Gunung Gerak |
| 23 | | Granite peak of Gunung Bintang |
| 24 | | Kubah Hunung Chepar lanscape |
| 25 | | Sungai Perak lanscape |
| 26 | | Tasik Raban Lenggong lanscape |
| 27 | | Bukit Bunuh meteorite impact |

*Source: JKPPLG, 2021*

**Figure 3**: Bukit Berdinding granite contact

**Figure 4**: Bukit Bunuh meteorite impact

**Biological Heritage**

The coverage of the forest reserve in Lenggong Geopark is 1,402.8 km$^2$, and the percentage of protected forest area is 31.5%, while 66.2% is a conservation forest for logging based on the Selective Management System (SMS). The main forest types included in Lenggong Geopark are mixed lowland and hill dipterocarp forests, limestone forests and mountain forests. The distribution of these different types of forest depends on the type of soil, which is the most important factor because of the relationship with geology (type of rock) and topography (such as the steepness of cliffs and flat land) (Main & Fatimah, 2011; Fatimah *et al.,* 2013).

The vegetation in Lenggong consists of limestone forest, lowland dipterocarp forest, hill dipterocarp forest, mountain forest, orchard area and secondary forest (Mohammad Saiful Mansor, 2012). Each limestone hill is estimated to have 200–300 species of flora, and each hill has a different combination of species. It is the limestone hills that contain a large number of rare and endemic flora species. Limestone vegetation is most threatened due to the exploitation of limestone resources for commercial use. That is why the limestone hills are identified as an Environmentally Sensitive Area (ESA).

Lenggong is a locality with five species of rare limestone flora and deserves to be designated as an Important Vegetation Area (IPA). The lower-level mountain forest covers the Bintang Range and the Titiwangsa Range. The forest here is characterised by medium-tall and emergent trees, especially the Dipterocarpaceae family. Among the rare mountain, animals are the desert goat and the mountain goat (*Polyplectron inopinatum*). Bovidae is the only wild goat in Malaysia (sub-Family Craprinae) among the endemic fauna (JKPPLG, 2021).

Chenderoh Lake is the oldest man-made lake, built in 1928, formed from the construction of Chenderoh Hydroelectric Dam. The area of the water reservoir is 25 km$^2$. Aquatic vegetation on the banks of the lake is dominated by


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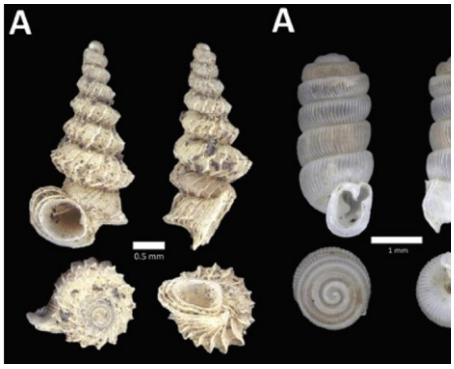
*mengkuang* (*Pandanus helicopus*), the type commonly used to make woven baskets, mats and so on. Raban Lake, included in the Chenderoh Lake area, is popular among anglers because it is rich in freshwater fish (S.N. Ismail *et al.,* 2019).

Tiger




Snail

Elephant

Lar Gibbon

**Figure 5**: Iconic Species in the Lenggong Geopark

Among the iconic species in Lenggong Valley as seen in Figure 5 are Malayan tigers; snails (*Sinoennea lenggonegensis* and *Diplommatina lenggonegensis*), lar gibbons (*Hylobates lar*), and Asian elephant (*Elephas maximus*) (JKPPLG, 2021).

**Geoarchaeological Heritage**

Geoarchaeological heritage is the legacy of evidence of early human discovery closely related to the use of geological resources. From the geoarchaeological aspect, the Lenggong Valley is very special and has now been declared a

UNESCO World Heritage Site on July 2, 2012. The declaration as a UNESCO World Heritage Site is based on: (i) the region being inhabited continuously from time to time throughout prehistoric times (Palaeolithic, Neolithic and Metal Age) from more than 1.83 million to around 1,000 years ago, (ii) the region has many Palaeolithic stone tool manufacturing sites that are still *in-situ* that successfully reveal the Palaeolithic technology, (iii) the region has some of the earliest evidence of Palaeolithic culture outside of Africa which dates back to more than 1.83 million years ago (Figure 6), and (iv) the discovery of the Palaeolithic human skeleton Perak Man, which is the only prehistoric human skeleton in the world that was found to have the genetic disease Brachymesophalangia Type A2 (Figure 7).

**Figure 6**: Palaeolithic stone tools such as this hand-held axe embedded in suevite rocks as evidence of the earliest Palaeolithic culture over 1.83 million years ago, which also suggests the existence of an ancient Perak River clerical enclave at that time.

**Figure 7**: The Prehistoric Perak Man skeleton found in Gua Gunung Runtuh, Lenggong.

Almost all evidence of this ancient civilisation is closely related to geological sources. The Lenggong Valley UNESCO World Heritage Site consists of two clusters, i.e. Cluster 1 is related to Bukit Bunuh meteorite impact evidence and ancient Perak River gravel deposits in Kota Tampan, while Cluster 2 is closely related to limestone cave formations and ancient Perak River gravel deposits in Bukit Jawa.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## THE POTENTIAL OF NEW INNOVATIVE GEOTOURISM

Lenggong Valley was recognised as a UNESCO World Heritage Site based on geoarchaeological heritage in 2012. Since then, several basic programs and facilities for heritage conservation and tourism activities have been introduced. A large part of the Lenggong community has become familiar with and involved in successful heritage conservation and heritage-based tourism activities. Lenggong also has high-value geological heritage resources (geosite) that have not yet been recognised and utilised.

The Lenggong community, through the Promotion and Development Committee, agreed that the Lenggong region should also be developed as a national geopark. This vision not only encourages integrated heritage conservation efforts but can develop heritage resources sustainably through geotourism. It can also encourage new tourism activities such as geotourism, geotrail and knowledge tourism. While geotourism pays attention to nature exploration, learning natural science, respecting nature and promoting sustainable tourism practices as well as an integrated relationship between nature and humans (Komoo *et al.*, 2018; Komoo, 2019); Mohd Zulhafiz Said *et al.,* 2021). The construction of a potential geotrail aims to reveal to tourists the uniqueness of the landscape with a beautiful view, as well as records of the history of the earth and life, such as fossils preserved in the rocks (Komoo *et al.*, 2018) are being explored.

Geotourism is an innovative tourism product that involves heritage components in geosites, especially those closely related to geological, archaeological, biological, and cultural heritage. Several geo-pioneers were introduced as new tourism products in Perak as a development program with the concept of education and recreation. There are 15 main packages divided into geo-initiating within geosites (7) and geo-initiating connecting several geosites (8).

Most Lenggong residents are still marginalised from the current development and have low incomes. Geopark development can increase job opportunities and the socioeconomic status of the local community. Lenggong Geopark can maintain the natural environment in its original state and reduce the threat of damage to heritage resources and the environment.

## CONCLUSION

Lenggong Geopark celebrates local natural, archaeological, and cultural heritage resources through integrated development involving heritage resource tourism, i.e., geotourism, archaeotourism, integrated heritage site conservation and socioeconomic development for the local community's well-being. The recognition of Lenggong Valley as a geopark will raise the name of Hulu Perak and Lenggong and attract tourists fond of geotourism, archaeology and

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ecotourism activities. The development of geotourism will open up more business space and employment opportunities for the local community. This situation will help improve the socioeconomic status and well-being of the local community.

As a tourist area, infrastructure development will also grow rapidly, which will have more impact on the physical development of Lenggong Valley. With the geopark concept, the public education process that wants to ensure that people always love the natural environment will be achieved and assisted by a joint management approach for the conservation of integrated heritage and the use of natural resources without destruction in addition to developing a spirit of love for the region and a sense of belonging which economic development is more felt by the local community making Lenggong successfully prove and succeed in the concept and practice of Regional Sustainable Development. A large part of the Lenggong community has been recognised and involved in successful heritage conservation and heritage-based tourism activities because the Lenggong Valley was recognised as a UNESCO World Heritage Site based on geoarchaeological heritage in 2012. At the same time, they are fostering a sense of pride among the local people and strengthening their identity with the area, as well as stimulating new sources of income through geotourism while protecting geological, biological, archaeological and cultural resources in the region (Komoo & Patzak, 2008; Komoo, 2010).

Lenggong Geopark can maintain the natural environment in its original state and reduce the threat of damage to heritage resources and the environment. This vision not only encourages integrated heritage conservation efforts but can develop heritage resources sustainably through geotourism. Geopark development can increase job opportunities and the socioeconomic status of the local community.

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