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Potential Geotourism Attractions on Nusa Penida Island, Klungkung Regency, Bali

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ABSTRACT

Nusa Penida Island is one of the leading tourist destinations in Bali Province. Tourist destinations on the Island consist of various types of beaches, hills, caves to unique landscapes formed due to the karstification process. Nusa Penida Island is geologically composed of limestones (the Selatan Formation) with various types such as clastic limestones and coral limestones(Hadiwidjojo et al, 1998). In addition to the unique geology of Nusa Penida Island, it also has archaeological uniqueness. The Gede Cave shows that Nusa Penida was once inhabited by prehistoric humans (Abdillah, 2011). During the COVID-19 pandemic, tourism seems to be forced to accelerate and requires new tourist attraction innovations that support sustainable tourism. This research discusses geotourism-based tourist attractions that can be developed and explored in Nusa Penida. The approach used is geological diversity inventory method (Geological Agency, 2017). Primary data was obtained through survey activities. From the research carried out, it can be concluded that 10 geological site locations in the Nusa Penida area have the potential to be developed as areas with geotourism attractions, which offer unique geology, especially regarding karts landscape processes and one of the key geological history on the island of Bali. In addition, Nusa Penida Island has the potential to be developed as a geopark as an effort to develop sustainable tourism in Klungkung Regency.

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1. INTRODUCTION

Nusa Penida Island is one of the leading tourist destinations in Bali Province. Tourist destinations on Nusa Penida Island consist of various types of beaches, hills, caves, and unique landscapes formed due to the karstification process. Some famous tourist attractions on Nusa Penida Island are Kelingking beach, Giri Putri Cave, Teletubies Hill, Broken Beach, and many others. Several existing tourist objects can be developed and explored for their potential as tourist attractions with the existing geodiversity. Geotourism is tourism that visits areas of unique geological diversity with the aim of recreation, admiring natural beauty, appreciation, and learning (Dowling & Newsome, 2006). Meanwhile, based on the Presidential Regulation of the Republic of Indonesia No. 9 of 2019 concerning the Development of Earth Parks (Geoparks), what is meant by Geological Diversity (Geodiversity) is a description of the uniqueness of geological components such as minerals, rocks, fossils, geological structures, and landscapes that are the essential wealth of an area and their existence, wealth, distribution and conditions, which can represent the geological evolution of the area.

Nusa Penida Island is geologically composed of limestones of various types, such as clastic and coral limestones that enter the Selatan Formation (Hadiwidjojo et al., 1998). The Selatan Formation occupies the southern peninsula of the island of Bali. The lithology is mostly hard limestone. According to Kadar (1972), the thickness ranges from 600 meters, and the slope is between 7o-10o. Fossil content consisting of Lepidocyclina, Cycloclypeus Sp, and Operculina Sp indicates Miocene age. In addition to the southern part of the island of Bali, this formation also occupies the island of Nusa Penida. The Southern Formation

is generally deposited in a reef environment; some are found as a mixture of carbonates and volcanics (Agastya, 2014).

In general, the landscape and geological conditions on the island of Nusa Penida are controlled by karstification activities. Karst morphology dominates the landscape on Nusa Penida Island. However, the landscape has undergone erosion and weathering, forming hills and is covered by grasslands, dry fields, and only the traces of dry river nicks and rather cliffs overgrown with various vegetation. Astjario, 2008). Because it is dominated by limestone, many unique landscapes typical of karst areas are formed on the island of Nusa Penida, such as karst caves, dolines, karst towers, karst bays, conical hills, and others.

In addition to the unique geology of Nusa Penida Island, it also has archaeological uniqueness where Gede Cave is found, which is one of the archaeological sites that shows that Nusa Penida was once inhabited by prehistoric humans (Abdillah, 2011). During the COVID-19 pandemic, tourism seems to be forced to accelerate and requires new tourist attraction innovations that support sustainable tourism. This study discusses the nature/geotourism-based tourist attraction that can be developed and explored for its potential in Nusa Penida.

2. DATA AND METHOD

This study discusses the nature/geotourism-based tourist attraction that can be developed and explored for its potential in Nusa Penida. The approach is qualitative research using the geological diversity inventory method (Geological Agency, 2017). This method includes field data collection and data processing. The data collection methods carried out in the field are geological and geomorphological descriptions at each site location and identify geological diversity, which will be displayed in the form of a geological diversity inventory matrix and a geological diversity characterization matrix.

3. RESULT AND DISCUSSION

From the research carried out in several locations of potential geotourism attractions, it is found that about eight geological sites and two cultural sites exist. The geotourism attraction can potentially become a geological heritage site spread over several areas can be seen on the map of the distribution of geological sites and cultural sites (figure 1). The geotourism attraction is distinguished by sites as evidence of historical geological activity (geovidences) and forms due to geological processes (geological features).



Figure 1. Geosite Distribution of Nusa Penida Island

Geosite Sihkhole/Doline Broken Beach (SG-1)

This geological site is located in the Sakti Village area, Nusa Penida District, Klungkung Regency, Bali. This site is in the middle of Nusa Penida Island, a karst landscape in the form of dolines or sihkhole formed from dissolving activity in limestone, which is influenced by wave erosion activity and the presence of geological structures, where the geological diversity can be seen in table 1.

Geosite Crystal Bay (SG-2)

This geological site is located in the Sakti Village area, Nusa Penida District, Klungkung Regency, Bali. This site is located in the western part of Nusa Penida Island, a karst landscape in the form of tower karts, karst bays, and conical hills formed from dissolving activities in limestone, which are influenced

by wave erosion activity and the presence of geological structures, where the geological diversity can be seen in table 2.

Geosite Spring Penida (SG-3)

This geological site is located in the Sakti Village area, Nusa Penida District, Klungkung Regency, Bali, where this site is located in the western part of Nusa Penida Island, which is a spring formed from the dissolving activity of limestone, which is influenced by the activity of the geological structure, where the geological diversity can be seen in table 3.

Geosite and Cultural Site Goa Giri Putri Temple (SG-4)

This geological site is located in the Suana Village area, Nusa Penida District, Klungkung Regency, Bali. This site is located in the eastern part of Nusa Penida Island, a karst cave formed from dissolving activity in limestone, which is influenced by the geological structure. This cave is also used by the people of Nusa Penida and Bali as a place of worship for Hindus, where the geological diversity can be seen in table 4.

Geosite Teletubies Hill (Conical Hills) (SG-5)

This geological site is located in the Tanglad Village area, Nusa Penida District, Klungkung Regency, Bali where this site is located in the southeastern part of Nusa Penida Island, which is a range of karst hills called conical hills, which are formed from dissolving activities in limestone which are influenced by the presence of structural geology. Where the geological diversity can be seen in table 5.

Geosite Kelingking Beach (SG-6)

This geological site is located in the Mekar Village area, Nusa Penida District, Klungkung Regency, Bali. This site is located in the southwest part of Nusa Penida Island, which is a karst landscape in the form of a karst tower in the form of a little human finger formed from dissolving activities in limestone are influenced by geological structures and erosion from ocean waves. Where the geological diversity can be seen in table 6.

Geosite Guyangan Spring (SG-7)

This geological site is located in the Batu Kandik Village area, Nusa Penida District, Klungkung Regency, Bali where this site is located in the southern part of Nusa Penida Island, which is a karst landscape in the form of cliffs and where the emergence of springs with extensive water discharges formed from activities dissolution of limestone which is influenced by the presence of geological structures in the form of faults and erosion from ocean waves. Where the geological diversity can be seen in table 7.

Cultural Site and Geosite Puncak Mundi Temple (SB-1)

This cultural and geological site is located in the Klumpu Village area, Nusa Penida District, Klungkung Regency, Bali. This site is located in the middle of Nusa Penida Island, the highest peak on Nusa Penida Island. The existence of this cultural site is closely related to the mythological history of the formation of Nusa Penida Island, and Puncak Mundi Temple is also the main temple which is a place of worship for the people of Nusa Penida and Bali in general. It can be seen in table 8.

Cultural Site Dalem Ped Temple (SB-2)

This cultural site is located in the Ped Village, Nusa Penida District, Klungkung Regency, Bali. Where this site is located in the northern part of Nusa Penida Island is the main temple, which is a place of worship for the people of Nusa Penida and Bali in general, which has a cultural history related to the existence of Nusa Penida Island can be seen in table 9.

Geosite Diamond Beach and Bukit Atuh (SG-8)

This geological site is located in Pejukutan Village, Nusa Penida District, Klungkung Regency, Bali where this site is located in the eastern part of Nusa Penida Island, which is a karst landscape in the form

of cliffs, beaches, karst towers, and conical hills formed from dissolving activities in limestone that influenced by the geological structure in the form of faults and erosion from ocean waves. Where the geological diversity can be seen in table 10.

The Characteristic of Geological Diversity in Nusa Penida Island

From the field survey results and analysis of the geological diversity inventory from 10 locations, it is obtained that the geological salt characterization has a geological diversity rating from high to leading, with an assessment of geological diversity from high to leading in the existing geological site. In addition, several major geological sites in Nusa Penida have complete meanings ranging from scientific, aesthetic, recreational, and cultural meanings. Because almost all geological sites surveyed are tourist and cultural objects that already exist or are well known. For a more detailed explanation, see table 11.

4. CONCLUSIONS

In principle, the study of Geotourism Destination Development on Nusa Penida Island, Nusa Penida District, Klungkung Regency, Bali is to develop geotourism tourism destinations so the length of visiting tourists to Nusa Penida Island can be increased. In addition, the results of the study of the geological diversity inventory and the characterization of the geological diversity of 10 geological and cultural sites in the Nusa Penida area have the potential to be developed as an area with geotourism attraction, which offers unique geology, especially about karts landscape processes and is one of the keys to geological history on the island of Bali. In the future, Nusa Penida Island has the potential to be developed as an Geopark as an effort to develop sustainable tourism in Klungkung Regency.

Recommendations for sustainable development strategies and policies related to geotourism that can be carried out by the Klungkung Regency Government, Bali, related to the determination of geological heritage sites. Where with the protection of geological sites through the Decree of the Regent and the Geological Heritage of the Geological Agency. The Klungkung Regency Government needs to propose to the Geological Agency the determination of the geological heritage (geoheritage) in Nusa Penida. It is necessary to involve several agencies such as the Archaeological Center, LIPI, and the KLHK Natural Resources Conservation Center to take an inventory of the diversity of cultural sites and biodiversity as part of the main pillars of the geopark. Further research is needed to support the readiness of Nusa Penida as a national geopark.

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DATA ATTACHMENT

Table 1. Geological Diversity at the Doline Geosite of Uug Beach (Broken Beach) (SG-1)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Geosite Doline or Sihkhole Pantai Uug "Broken Beach" (SG-1)	
Location	Klumpu Village, Kec. Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 115 27' 04,3" X : 08 43' 59,0"	
Outstanding Geology Component	A. Geological Process B. Geomorphology C. Limestone	
Description	A. Karstification process, dissolution by rainwater, and fractures in rocks control the formation of dolines at broken beaches, which can be seen from traces of dissolution in rocks and fracture structures around the site. B. Karst landscapes dominate the geological phenomena found in the form of dolines or sinkholes due to the limestone dissolution process. The unique landscapes in the Nusa Penida area are easily accessible and effortless to observe. C. Limestone found at the location is clastic limestone, namely calcarenite-calsirudite with some fragments of coral and pelecypods belonging to the Southern Formation of Miocene age.	 

Table 2. Geological Diversity at Geosite Crystal Bay (SG-2)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Geosite Crystal Bay (SG-2)	
Location	Sakti Village, Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 08 42' 56,8" X : 115 27' 32,7"	
Outstanding Geology Component	A. Geological Process B. Geomorphology	

Description	A. The dominant geological process is the karstification or dissolution of limestone, in addition to the presence of faults, fractures, and the effect of erosion from sea waves to form a landscape in a crystal bay. B. The unique landscape that can be found in this crystal bay is in the form of a karst tower called Batu Menjinong island, a plain that juts out from the mainland as Crystal Bay (Crystal Bay) and conical hill hills along the bay.	 

Table 3. Geological Diversity at Geosite Penida Spring (SG-3)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Geosite Penida Spring (SG-3)	
Location	Sakti Village, Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 08 43' 0,7" X : 115 27' 35,0"	
Outstanding Geology Component	A. Geological Process B. Structure Geology	
Description	A. The dissolution process in the karst area affects the formation of this Penida spring, which is thought to originate from an underground river flow system. B. The geological structure affects the formation of this spring which is influenced by the presence of fracture zones found in the limestone around the location.	

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Table 4. Geological Diversity at Geosite and Cultural Site Giri Putri Cave Temple (SG-4)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Geosite and Cultural Site Giri Putri Cave Temple (SG-4)	  
Location	Pejukutan Village, Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 08 42' 33,4" X : 115 35' 06,1"	
Outstanding Geology Component	A. Geological Process B. Geomorphology C. Culture D. Limestone	
Description	A. Giri Putri Cave is formed as a result of the dissolving process in limestone, which forms an underground cave system, besides that the process is also influenced by tectonic activity which is estimated to have been formed as a result of the lifting process of Nusa Penida Island and dissolving as it was lifted so that it was formed. Cave with fairly large size. In addition, Goa Giri Putri also found a spring which indicates the hydrogeological system in the cave is quite good. B. The dominant landscape found in this area is conical hills C. Goa Giri Putri has a special cultural meaning where the existence of Goa Giri Putri is symbolic of protecting water on the island of Nusa Penida, besides being a place of worship for Hindus in Bali to gain prosperity because, in the cave, we can also find many temples as a place of worship for Hindus. D. Limestone found at the location is clastic limestone, namely calcarenite-calsirudite, with some fragments of coral belonging to the Southern Formation of Miocene age.	

Table 5. Geological Diversity at Geosite Teletubies Hill (*Conical Hills*) (SG-5)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Geosite Teletubies Hill (*Conical Hills*) (SG-5)	
Location	Tanglad Village, Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 08 47' 07,8" X : 115 34' 28,9"	
Outstanding Geology Component	A. Geomorphology B. Geological Process C. Structure Geology D.Limestone	
Description	A. Landscape is the dominant thing found in Teletubies Hill in Tanglad Village, in the form of a	

	conical hill resulting from karstification activities. B. The geological process that affects the formation of conical hills in Tanglad Village is a fracture or joint geological structure, which is also influenced by the process of dissolving limestone due to rainwater. Rainwater that enters the rock crevices formed from geological structure activities causes the limestone to dissolve more easily and forms the conical hill range in geological time. C. Geological structure also has an important role in forming this conical hill landscape, namely in the form of fractures/joints controlled by north-south tectonic processes due to plate subduction zones. This process causes the formation of fractures in the limestone, which is then flowed by rainwater so that it undergoes a dissolution process. D. Limestone found at the location is clastic limestone-coral limestone, namely calcarenite, with some fragments of coral belonging to the Miocene Southern Formation.	  

Table 6. Geological Diversity at Geoste Kelingking beach (SG-6)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Geosite Kelingking Beach (SG-6)	
Location	Bunga Mekar Village, Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 08 45' 03,6" X : 115 28' 26,8"	
Outstanding Geology Component	A. Geomorphology B. Process Geology	

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Description	A. The landscape is the dominant geological phenomenon found on the little finger beach, namely the formation of a karst tower formed from the dissolution of limestone and erosion from sea waves to form a cliff wall that uniquely resembles a little human finger, so the name of the beach is called Kelingking Beach. B. The geological structure also controls the formation of the tower karst phenomenon. On some sides of the cliffs, fault patterns and fractures are still visible on the limestone walls, indicating the control of the geological structure in forming this landscape.	  

Table 7. Geological Diversity at Geosite Guyangan Spring (SG-7)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Geosite Guyangan Spring (SG-7)	
Location	Batu Kandik Village, Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 08 46' 51,8" X : 115 31' 03,9"	
Outstanding Geology Component	A. Geological Process B. Structure Geology C. Limestone D. Culture	
Description	A. Geological processes that affect the formation of Guyangan springs are closely related to tectonic processes and geological structures. The appearance of Guyangan springs is controlled by the presence of reverse faults with several signs such as drag folds and several joints that become spaces for	

	the flow or discharge of the springs. This process may have coincided with lifting the island of Nusa Penida, creating large cave spaces as sources of groundwater that emerged as springs in Guyangan. This geological phenomenon is significant because the existence of the Guyangan spring site also has an essential role as a water source on Nusa Penida Island and also as evidence of the importance of the karst ecosystem as a source of groundwater in Nusa Penida. B. The geological structure that plays a role in the formation of the Guyangan spring is the presence of rising and common faults that form steep limestone walls and spring outflow paths due to the dissolving process in limestone. C. Along the way down to the springs, we will see clastic limestones that form a fine layering pattern consisting of calsilutite-calsirudite limestones with several layers showing fragments in the form of coral-shell fragments and some in the form of Boundstone with corals in the form of fringing coral and head coral. D. In Guyangan Springs, a temple is also used as a place of worship for Hindus—addressed to Baruna God as the ruler of the sea.	 

Table 8. Geological Diversity Cultural Site and Geosite Puncak Mundi Temple (SB-1)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Cultural SIte and Geosite Puncak Mundi Temple (SB-1)	 
Location	Klumpu Village, Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 08 43' 55,7" X : 115 31' 27,2"	
Outstanding Geology Component	A. Culture B. Geomorphology	
Description	A. Puncak Mundi Temple is a temple located at the highest point on the island of Nusa Penida and, at the same time, the oldest temple on the island of Nusa Penida. The existence of this temple is also related to the religion and culture of the people of Nusa Penida. B. The karst plateau landscape where the position of Puncak Mundi Temple is at the highest point of Nusa Penida Island.	

Table 9. Geological Diversity at Cultural Site Dalem Ped Temple (SB-2)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Cultural Site Dalem Ped Nusa Penida Temple (SB-2)	 
Location	Ped Village, Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 08 40' 40,2" X : 115 31' 5,7"	
Outstanding Geology Component	A. Culture	
Description	A. The cultural site Pura Dalam Ped is one of the prominent temples on the island of Nusa Penida. The existence of Pura Dalam Ped also has a close relationship with the culture and religion of the people of Nusa Penida Island. This temple is located on the north coast of Nusa Penida Island.	

Table10. Geological Diversity at Geosite Guyangan Spring (SG-8)

Names of Geological Diversity Objects (Geodiversity) & Cultural Sites	Geosite Diamond Beach and Atuh Hill (SG-8)	  
Location	Pejukutan Village, Nusa Penida District, Klungkung Regency, Bali	
Coordinate	Y : 08 46' 30,5" X : 115 37' 12,8"	
Outstanding Geology Component	A. Geomorphology B. Geological Process	
Description	A. The dominant landscapes found on Berlian Beach and Bukit Atuh are hills with cliffs facing the Indian Ocean directly. Besides that, karst towers and limestone islands are also found, separated from the main island of Nusa Penida due to sea wave erosion. Another unique formation found is a karst tower that forms a diamond shape so that it becomes an icon of a tourist attraction. Also, we can see the unique formation of the island that resembles an elephant animal. B. The unique formation of the landscape on Berlian Beach cannot be separated from the geological processes that influence it, namely the control of limestones that experience fractures and fractures due to tectonic processes that take place on Nusa Penida Island gradually undergo a process of dissolution and erosion due to ocean waves from the Indian Ocean so that they carve out landscape formations. Beautiful as we can see today.	

Table 11. Results of the Assessment of the Characterization of Geological Diversity on the Island of Nusa Penida

No	Name of Geosite	Clasification of Geological Diversity	Geological Diversity Ranking	Geological Diversity Assessment	The Meaning of Geological Diversity	Geological Diversity Clustering
1	Geosite Doline Broken Beach (SG-1)	A. Doline Kars Landscape B. Limestone Sedimentary Rock Area C. Its formation is influenced by tectonic processes, weathering processes, dissolution and erosion by ocean waves. D. Active tectonics E. The Geological Evolution of Nusa Penida Island (Quarter Age) and is still ongoing today	Outstanding	Outstanding	Scientific Aesthetics Recreation	As an Earth History Artifact As a Key Record of a Geological Event As a Special Landscape
2	Geosite Crystal Bay (SG-2)	A. Kars Landscape B. Limestone Sedimentary Rock Area C. Its formation is influenced by tectonic processes, weathering processes, dissolution and erosion by ocean waves. D. Active tectonics E. The Geological Evolution of Nusa Penida Island (Quarter Age) and is still ongoing today	Outstanding	Outstanding	Scientific Aesthetics Recreation	As an Earth History Artifact As a Key Record of a Geological Event As a Special Landscape
3	Geosite Penida Spring (SG-3)	A. Kars Landscape B. Limestone Sedimentary Rock Area C. Its formation is influenced by tectonic processes, weathering processes, dissolution and erosion by ocean waves.	High	High	Scientific Aesthetics	As a Key Record of a Geological Event As a Special Landscape As an Ecology Supporter
4	Geositei and Cultural Site Giri Putri Cave Temple (SG-4)	A. Kars Landscape B. Limestone Sedimentary Rock Area C. Its formation is influenced by tectonic processes, weathering and dissolving processes D. Active tectonics E. Geological Evolution of Nusa Penida Island (Quarter Age)	Outstanding	Outstanding	Scientific Aesthetics Recreation Culture	As an Earth History Artifact As a Key Record of a Geological Event As a Special Landscape As an Ecology Supporter

5	Geosite Teletubies Hill (*Conical Hills*) (SG-5)	A. Kars Landscape B. Limestone Sedimentary Rock Area C. Its Formation is Influenced by Tectonic Processes, Weathering Processes, Dissolution and Erosion D. Active tectonics	High	Outstanding	Scientific Aesthetics Recreation	As an Earth History Artifact As a Key Record of a Geological Event As a Special Landscape
6	Geosite Kelingking Beach (SG-6)	A. Kars Landscape B. Limestone Sedimentary Rock Area C. Its formation is influenced by tectonic processes, weathering processes, dissolution and erosion by ocean waves. D. Active tectonics E. The Geological Evolution of Nusa Penida Island (Quarter Age) and is still ongoing today	Outstanding	Outstanding	Scientific Aesthetics Recreation	As an Earth History Artifact As a Key Record of a Geological Event As a Special Landscape
7	Geosite Guyangan Spring (SG-7)	A. Kars Landscape B. Limestone Sedimentary Rock Area C. Its formation is influenced by tectonic processes, weathering processes, dissolution and erosion by ocean waves. D. Active tectonics	High	Outstanding	Scientific Aesthetics Recreation Culture	As an Earth History Artifact As a Key Record of a Geological Event As a Special Landscape As an Ecology Supporter
8	Cultural Site Puncak Mundi Temple (SB-1)	A. Kars Landscape B. Limestone Sedimentary Rock Area C. Its formation is influenced by tectonic processes, weathering processes, dissolution and erosion by ocean waves. D. Active tectonics	High	High	Scientific Culture	As a Special Landscape
9	Cultural Site Dalem Ped Nusa Penida temple (SB-2)					

10	Geosite Diamond Beach and Atuh Hill (SG-8)	A. Doline Kars Landscape B. Limestone Sedimentary Rock Area C. Its formation is influenced by tectonic processes, weathering processes, dissolution and erosion by ocean waves. D. Active tectonics E. The Geological Evolution of Nusa Penida Island (Quarter Age) and is still ongoing today	Outstanding	Outstanding	Scientific Aesthetics Recreation	As an Earth History Artifact As a Key Record of a Geological Event As a Special Landscape