GEODIVERSITY OF CILETUH-PALABUHANRATU UNESCO GLOBAL GEOPARK, SUKABUMI, WEST JAVA

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ABSTRACT

Ciletuh-Palabuhanratu UNESCO Global Geopark (CPUGG) is located in the southwest of Sukabumi Regency, West Java, Indonesia. It covers an area of 126,000 ha or 1260 km^2. CPUGG has several rare geodiversity features that can be classified into the theme: "The subduction zone uplifted, Ancient magmatic zone shifting and fore arc evolution". This paper presents a summary of geodiversity features within CPUGG, Data sources are to be found on CPUGG's website and in the scientific publications in the references. Within CPUGG 24 geosites contain one or more objects. All are of local, national, and international value. In addition, each geosite has also applications in scientific research, educational and touristic value or both. The geosites are: Cisolok Geyser (the only geyser in Indonesia), the Mega Amphitheatre (the Biggest Natural Amphitheatre in Indonesia), the Pasir Luhur Complex (Metamorphic Rocks) and the Gunung Beas Complex (Ophiolites). Some heritage sites contain rare rocks and fossils such as Ciletuh Formation (Batu Naga, Karang Daeu, etc.) the oldest sedimentary deposits in West Java.

Keywords: *Geodiversity, Geopark, Mega Amphitheater, Cisolok Geyser, Metamorphic Rocks, Ophiolite, Ciletuh-Palabuhanratu, Sukabumi*

INTRODUCTION

The Ciletuh-Palabuhanratu Geopark is located in the southwest of Sukabumi Regency, West Java, Indonesia. It covers an area of 126,000 Ha, or 126 km^2 and is bound by the following coordinates:

- in the north: 106^{0}31'33.96" East Longitude and -6^{0}46'6.6 South Latitude;
- in the east of 106^{0}41'27.6" East Longitude and -7^{0}1'41.88" South Latitude;
- in the west part of 106^0 34'20.64" East Longitude and -7^{0}25'9.12" South Latitude; and
- in the north 106^{0}22'9.12" East Longitude and -7^{0}14'3.84" South Latitude.

The Ciletuh–Palabuhanratu Geopark is easily accessible from major cities nearby such as Jakarta, Bandung, Bogor and Sukabumi (Figure 1). It is situated in a tectonically active zone; the subduction zone between the Eurasian plate and the Indo-Australian (Indian Ocean) plate. They continue to move toward each other at nearly 4 mm/year. Evidence of a similar subduction process during the Cretaceous can be seen in the southern part of Ciletuh- Palabuhanratu Geopark in rock formations that were formed within a very deep trench created by subduction. The complex of rock formations includes ophiolithic mantle rocks (peridotite, gabbro, plagiogranite, amphibolite and pillow lava basalts); metamorphic rocks formed by medium to low metamorphic processes during sub-



Figure 1: *Location of Ciletuh-Palabuhanratu Geopark*

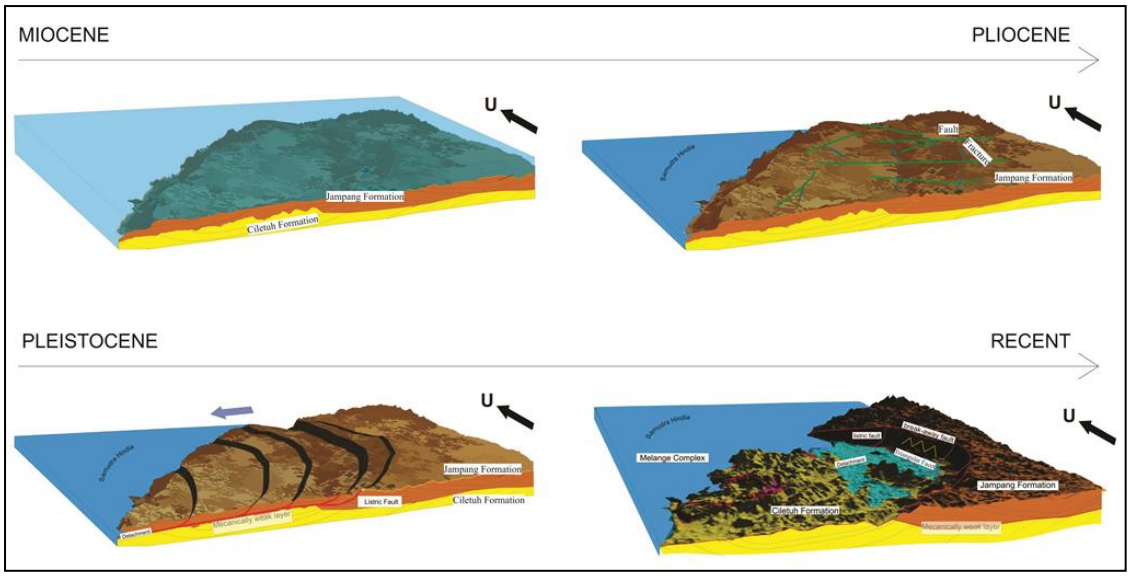


Figure 2: *Model of Gravity Collapse mechanism in formation of Ciletuh Amphitheatre (Nugraha, 2016)*

duction; (mica schist, greenschist and serpentine) and deep marine mixed sedimentary rocks as a melange complex of Ciletuh Formation.

This area can be called "the first emerging land of Western Java Island". The center part of the geopark area the Jampang highland or "Jampang Plateau", composed of epiclastic products deposited in a marine environment. The northern part of the geopark is active volcanic as shown by a geyser, several hot springs and associated travertine deposit. It also has hydrothermal potential (Rosana, 2016).

DATA AND METHODS

Gray (2004) defines geodiversity as a range of diverse geological features and appearances like rocks, minerals and fossils; geomorphologic landforms and their forming physical processes) and soil formation including their assemblages, relationships, nature, properties and systems as well as the interpretations of such features. Simply defined, geodiversity includes all materials, structures and processes that make and shape the earth. Materials include minerals, rocks, fossils, soil and water; while the structures include folds, faults; and the landscape; as well as the relationship between rock units. While the processes include tectonic activity, sedimentation, soil formation (weathering), volcanic activity, and others.

Geodiversity, according to Gray (2005), could have a range of values that can be grouped under the following criteria: Intrinsic or Existence values, related to the existence of natural resources disregarding the value of their; Cultural Values, including folklore, archeology or history associated with the rock formation or the landscape, spiritual sensation / imagination; Aesthetic value in the form of landscapes appeal to a wide range of geo-touristic impressions activities including, inspiration for painting and photography; Economic Value, covers the natural resources that provide beneficial economic aspects such as energy resources, industrial minerals, metallic minerals, gemstone, construction materials; Functional value includes subsurface rocks as the reservoirs of water, oil and gas; mineral resources vital to health; radioactive waste storage area; as filter of water. Soils are vital for agriculture, viticulture, and forestry; and important source to prevent flooding; and are part of an ecosystem. Scientific values, for research, education and training of earth science, history of the planet, climate change processes, as well as human life.

Geological sites in the Ciletuh-Palabuhanratu Geopark can be grouped by type as follows:

1. Landscape
2. Geyser
3. Waterfall
4. Rare rocks
5. Small islands
6. Beach
7. Aesthetic rocks

LANDSCAPE

The Biggest Natural Amphitheatre or Mega Amphitheater landscape is 15 x 9 km² in diameter and is believed to be the largest natural amphitheater in Indonesia. This spectacular landform is caused by gravity collapse as shown in Figure 2. The phenomenon is rare and valuable and shows movements that have occurred in the earth crust. Such gravity collapse structures also result

in tectonically induced triangular faced morphology and in several waterfalls along the amphitheater wall. The flat stratification layering of the sediment is clearly visible within the waterfall.

GEYSER

Cisolok geyser is evidence of magmatic and hydrothermal activity in the Southern part of West Java. Its existence cannot be seen in separation from ongoing plate movement and subduction processes in southern Java. Geysers work through a combination of heat, water and an underground plumbing system. Without any of these factors the geyser cannot spray steam into the air.

Geyser bursts occur when the magma heats the surrounding rocks that heat underground water, and produce enough pressure at temperatures above the boiling point. When the over pressured water works its way up to the surface, the pressure is released, which causes a sudden, massive boil over. This ejects the water creating a geyser. A spray of water on the surface produces a white precipitate called travertine (carbonate) because on the way to the surface, the water dissolves carbonate rock formations or limestone.

Sometimes it also produces a yellow sulfurous precipitate.

Some hot springs are also encountered along the Cisolok River, but they do not have the plumbing system required to generate the pressure needed to form a geyser. Therefore, hot springs just come out as seepages and not as bursts of hot water to the surface.

Spouting geysers and hot springs have temperatures ranging from 40-98°C, and approaching an acidity of pH 7. They are relatively safe to use as bathing place. The Cisolok has geothermal potential for about 50 Mw.

In the Cisolok area, one also finds an alteration of rocks due to hydrothermal process that are associated with the formation of gold and silver bearing quartz veins (Mandradewi and Herdianita, 2010).

WATERFALL

The formation of waterfalls is closely related to activity of normal faults along which most of the plateau experienced a large avalanche that forms an overall horse-shoe morphology. That became known as the mega amphitheater of Ciletuh. There are at least ten spectacular waterfalls in Ciletuh-Palabuhanratu Geopark. They are generally found on the walls surrounding the mega amphitheater, and are from north to south: Cimarinjung, Sodong, Ngelai, Cikanteh, Cikaret, Puncakjeruk, Awang, Tengah, Puncakmanik, and Luhur waterfalls. In addition, there are some more waterfalls.

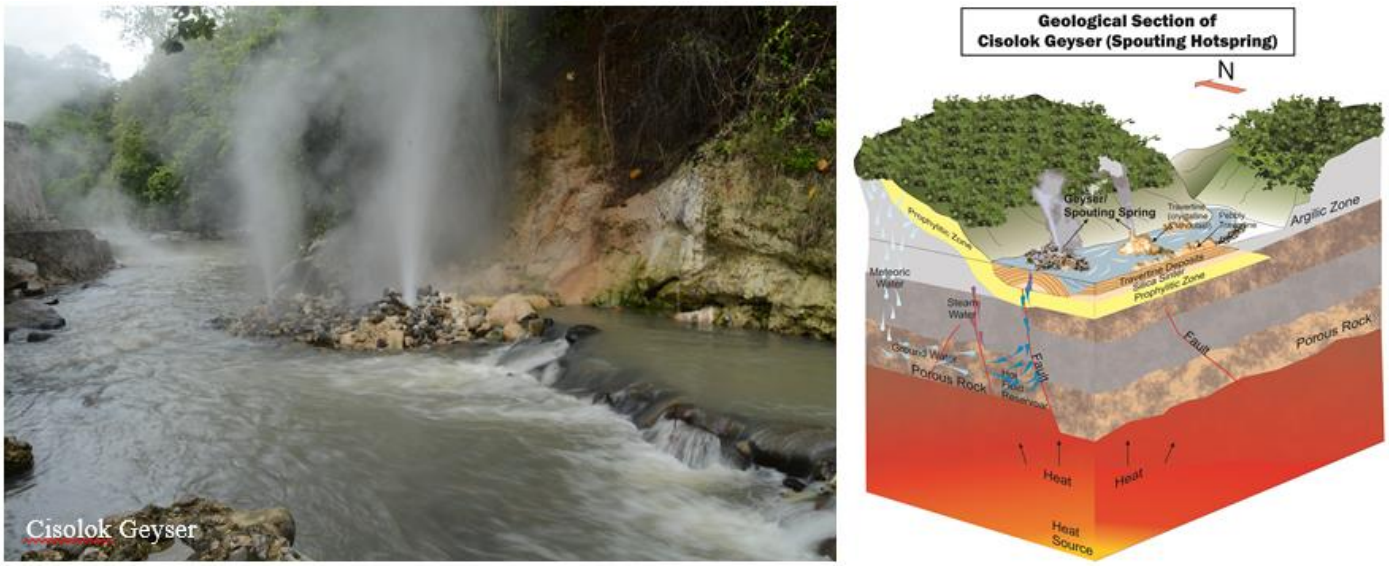


Figure 3: *Geological Section of Cisolok geyser*



Figure 4: *Formation of a waterfall*

RARE ROCKS AND FOSSILS

Some geological heritage sites are rare rocks and fossils such as ophiolite rocks and metamorphic rocks older than 60 million years and sedimentary rock composed of mélanges of rock types including some with Nummulites fossils of Eocene age. Ophiolite rocks are derived from oceanic crust and consist of: peridotite, layered gabbro, gabbro dike, plagiogranite, and pillow lava that is covered by deep sediments of chert. The metamorphic rock results from the subduction process between the continental and the oceanic crust, due to high pressures and/or high temperatures. This rock consists of: mica schist, green schist, amphibolite and serpentinite. The sedimentary rocks consist of quartz sandstone at the top and a mélange of rock types at the bottom. This sedimentary rock is named the Ciletuh Formation.



Figure 5a: *Outcrops of Rare Rocks (Oldest rocks in West Java)*



Figure 5b: *Another outcrops of Rare Rocks (Oldest rocks in West Java)*

SMALL ISLAND

There are some exotically shaped small islands in the Ciletuh-Palabuhanratu Geopark, generally composed of fresh rock and covered by a few small trees and grasses. These islands sometimes have unique shapes resembling animals, such as turtles, rhino's heads, and crouched rabbits or lying poodles. The unique shape of those islands is the result of erosion, and abrasion by seawater. The islands that can be visited by boat from Palangpang waterfront are: Karang Daeu, Mandra, Manuk, Kunti and Batubelah islands.





Figure 6: *Small islands of Ciletuh-Palabuhanratu Geopark*

BEACH

The beauty of the beaches in the Ciletuh-Palabuhanratu Geopark is well known by tourists. The beaches are quite spacious and form ramps, as well as white sandy beaches. However, not all beaches are safe for swimming and for boat approach. Boats are generally only able to land on the Palangpang, Cikadal, Batununggul, Cikepuh and Ujunggenteng beaches. The other the beaches are difficult to land on by boat, because rocks and reefs make approach unsafe. Some beaches often serve for nesting by green turtles. Examples are Cibulakan, Citirem and Pangumbahan beaches.

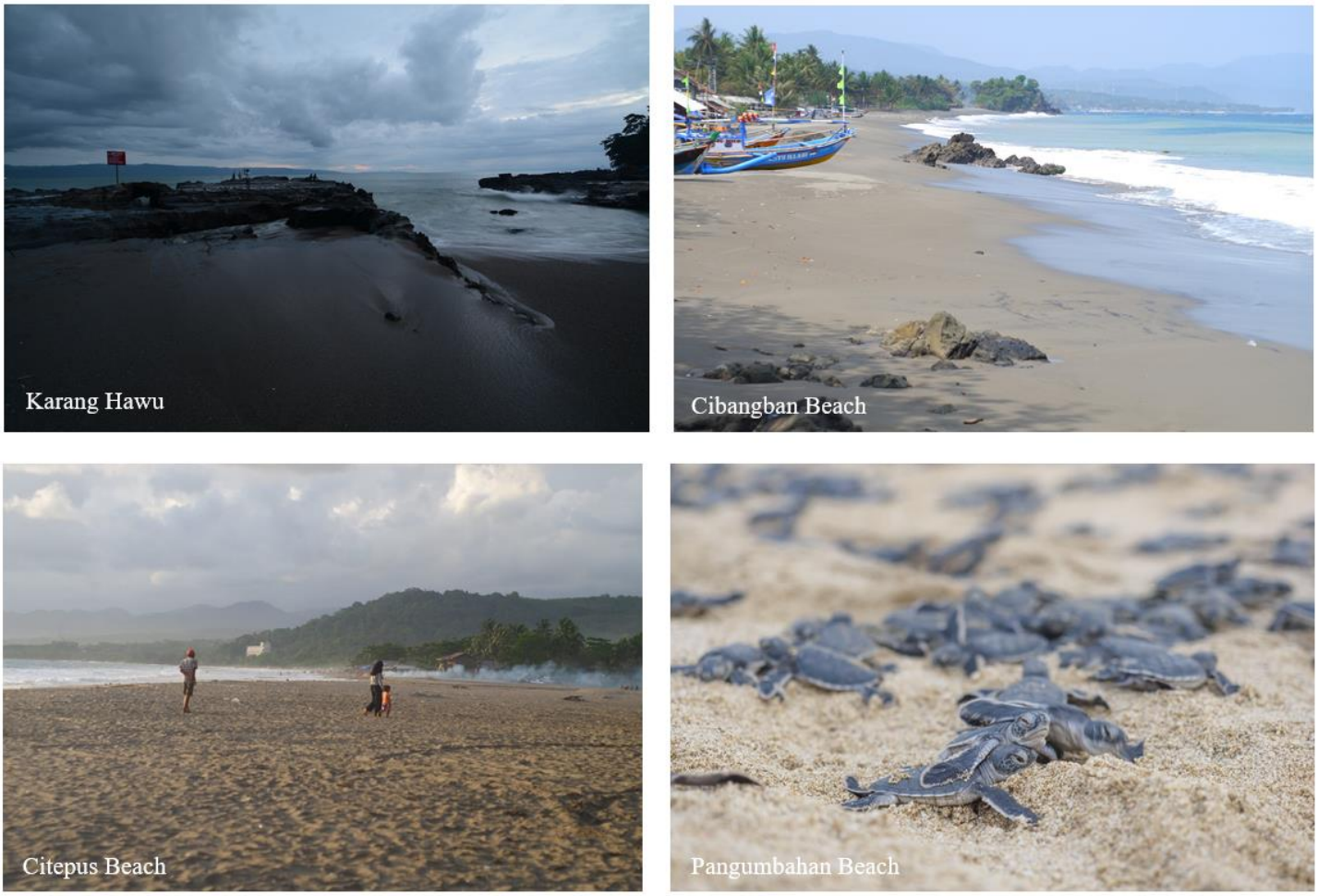


Figure 7: *Beach of Ciletuh-Palabuhanratu Geopark*

AESTHETIC ROCK

Along the coast between Cikadal, Batununggul until Cikepuh, there are a number of uniquely shaped rocks, resembling various types of animal, such as frogs, the head of a rhino, buffalo, crocodile, and head of komodo, dragon, lion's head, the eagle's head and a fence as well as the batik pattern. Such unique sedimentary rocks are composed of quartz sandstone parts of the Ciletuh Formation. They were formed in deep sea environments and are older than 45 million years. Geological processes brought these rocks to the surface where they underwent erosion and abrasion by waves. This resulted in their current forms. It is advisable to visit these rocks between April to November, when sea conditions are relatively calm and the waves are not harmful. Outside of those months the monsoon generally causes very large ocean waves to form which makes shipping dangerous. The ocean waves are usually very large near these rocks, so that the boat cannot approach and land at this location.

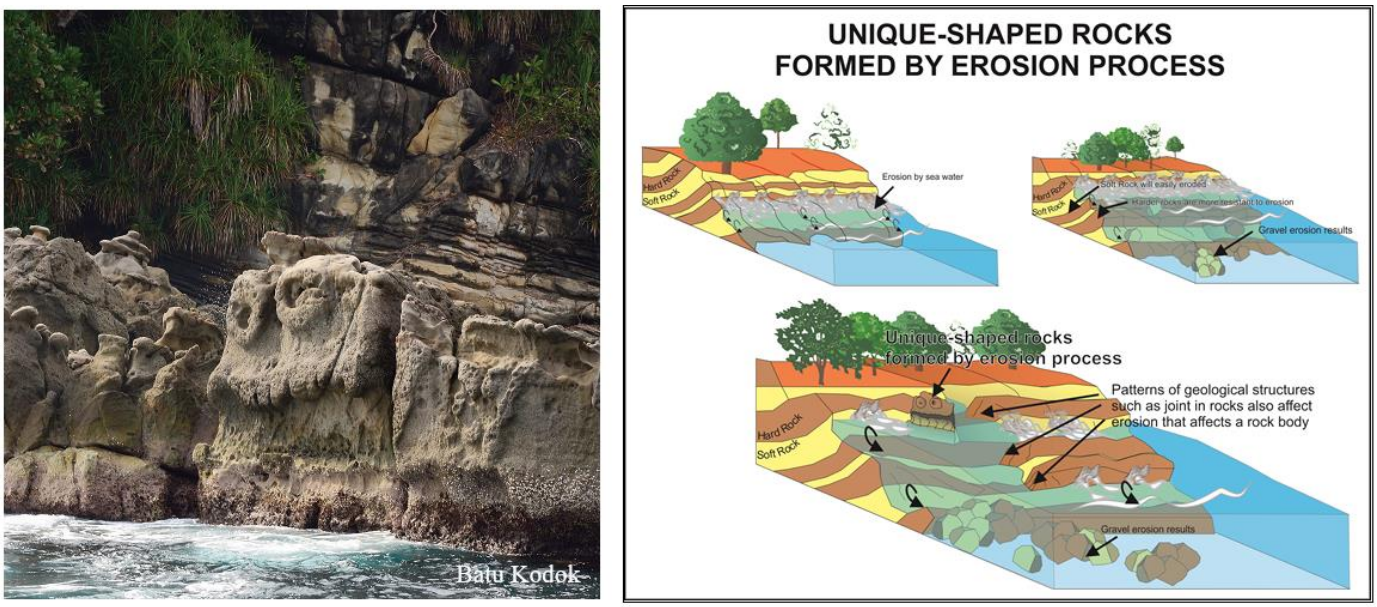


Figure 8: *Unique-Shape Rocks formed by erosion process (Ikhram et al., 2017)*

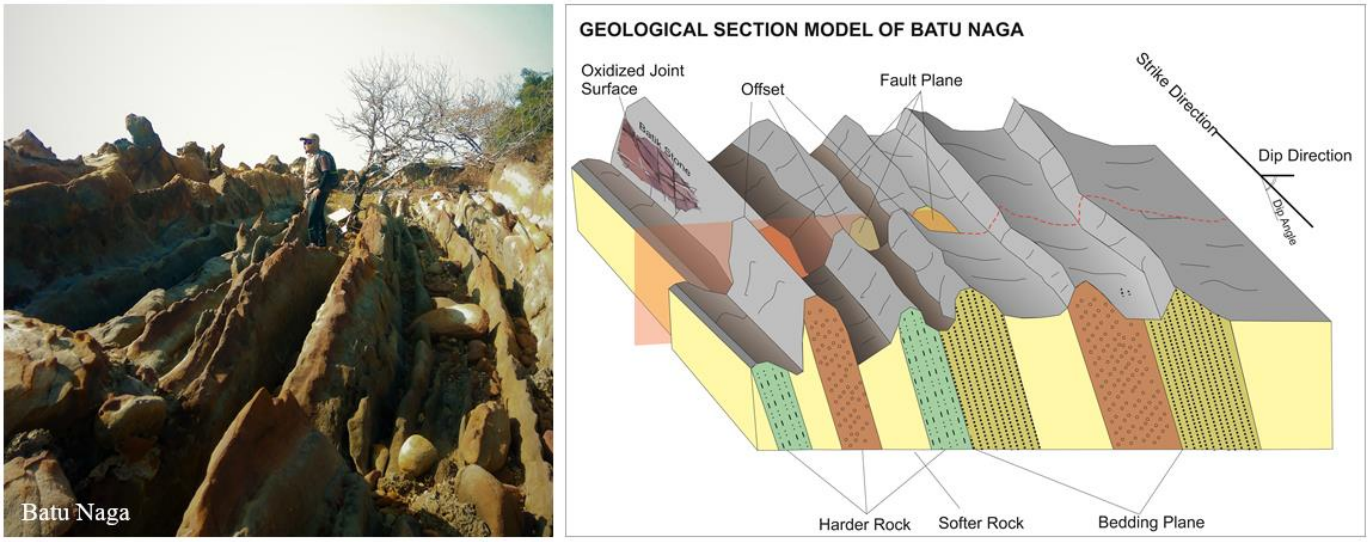


Figure 9: *Geological section model of Batu Naga (Ikhram et al., 2017)*

CONCLUSION

Ciletuh-Palabuhanratu Geopark has 24 geosites with different characteristics; four of them are considered the most outstanding because they are very unique and rarely found in other places both in Indonesia and around the world. Thus, they have international significance and educational and tourism appeal. They are: Cisolok Geyser: The only geyser in Indonesia, Mega Amphitheatre: The Biggest Natural Amphitheatre Landscape in Indonesia, Pasir Luhur Complex (Metamorphic Rocks) and Gunung Beas Complex (Ophiolite): Geological heritage site exists in the form of rare rocks and fossils, Ciletuh Formation (Batu Naga, Karang Daeu, etc.). The oldest sedimentary deposits in West Java.

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