

DETERMINING THE INTERNATIONAL SIGNIFICANCE OF GEOSITE BASED ON NEW IUGS GUIDELINES 2023, AT KEBUMEN UNESCO GLOBAL GEOPARK, INDONESIA

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Abstract: In 2023, the UNESCO Global Geopark Network (GGN) issued new regulations regarding the internationally significant value of geosites. These guidelines are referenced from the IUGS document (Document code: SC/EES/2023/UGGp/4), so all aspiring UNESCO Global Geoparks (aUGGp) must comply with these guidelines. To become a UNESCO Global Geopark, each UNESCO Global Geopark candidate must possess a geological heritage of international value. The Kebumen Geopark, which was proposed as an aUGGp, must prepare this document. This study was conducted according to IUGS standards through dossier reviews, field studies, expert team reviews, and assessments. Based on the assessment of 42 geosites, 13 geosites in the Kebumen area have international value. Ten Geosites in the northern part include G1, G3, and G5, as paleontology of geological interest, exotic blocks of bedded radiolarian chert and calcareous red claystone. The history of Geoscience interests are G4 and G5; the geological interest of Igneous petrology is G7. Geological structure and tectonic interest include G10 and G14. The geological interests of nummulite paleontology are G11 and G16. The international significance geosites in the southern part with geohydrological interest are geosites G27 (Jatijajar cave complex), G28 (Barat Cave), and G30 (Petruk Cave). This paper aims to apply the IUGS assessment guidelines to the Kebumen aUGGp proposed in November 2023. Hopefully, this paper can serve as an example for other geopark candidates seeking UNESCO Global Geoparks (UGGp) designation.

Keywords: UNESCO Global Geopark, Kebumen Geopark, international significance, IUGS, new guideline

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INTRODUCTION

1. Background study

According to UNESCO (2023), a Global Geopark must have clear boundaries, be of sufficient size to fulfill its function, and contain a geological heritage of international importance, independently verified by scientific professionals. UNESCO Global Geoparks (UGGp) should use such heritage, in conjunction with all other aspects of the region's natural and cultural heritages, to raise awareness of the main issues facing society in the context of the dynamic planet we live on, including but not limited to increasing knowledge and understanding of geoprocessing; geographic hazards; climate change; the need for sustainable use of the Earth's natural resources; evolution of life and empowerment of indigenous communities (Figure 1).

Geoparks are a sustainable development concept with three main components: geological diversity as the primary basis, biological diversity, and cultural diversity. These three components are used for education, conservation, and community economic development. Therefore, policies are needed for area management (spatial planning), conservation, and tourism activities. There is also a need to increase public awareness, community capacity, the creative economy, and infrastructure improvements (Ansori, 2018; Ansori et al., 2022, 2025). A UGGp must be an area whose management body has a legal existence recognized by national legislation. The management body must have adequate tools to handle the UGGp area. The management demonstrated the evidence provided of how UGGp status will add value by being branded independently and in collaboration with other designations. While a UGGp must demonstrate a geological heritage of international significance, the purpose of a UGGp is to explore, develop, and celebrate the links between geological heritage and all other aspects of the natural, cultural, and intangible heritages within the area. It is about reconnecting human society at all levels to the planet we call home and celebrating how our planet and its 4,600 million-year-long history have shaped every aspect of our lives and societies. UGGp must have a geological heritage of international value. Scientific professionals

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assess this value as part of the UGGp Evaluation Team. Based on the international peer-reviewed, published research conducted on the geological sites within the area, scientific professionals make a globally comparative assessment to determine whether the geological sites constitute global values (UNESCO, 2023).

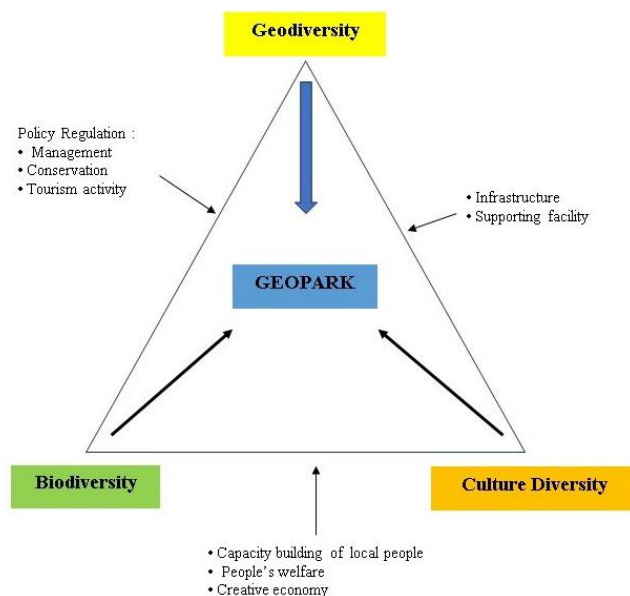


Figure 1. Geoparks are composed of three components in the form of geological, biological, and cultural diversity for conservation, education, and local economic development (Ansori, 2018)

The International Geoscience and Geoparks Programme (IGGP) is implemented through two activities: the International Geoscience Programme, a cooperative venture with the International Union of Geological Sciences (IUGS), and the UGGp. They shall coordinate their work through a shared UNESCO Secretariat and joint coordination meetings of their respective bureaus, which will convene as necessary. The chairpersons of the two individual Councils will co-chair the IGGP. The International Geoscience Programme (IGCP), as part of the IGGP, fosters international interdisciplinary geoscientific research among researchers through joint projects, meetings, and workshops. Since its creation in 1972, IGCP has supported over 350 projects in about 150 countries. IGCP brings together scientists worldwide and provides them with seed money to devise and conduct joint international research and collectively publish the results. High on the list of selection criteria are scientific quality and the extent of the global, multidisciplinary cooperation likely to be generated by a proposed project.

UNESCO Global Geoparks within the IGGP are the mechanism of international cooperation by which areas of geological heritage of international value, conserving that heritage through a bottom-up approach, support each other in engaging with local communities to promote awareness of that heritage and adopt a sustainable approach to the development of the area. Through the IGGP, these areas can apply to UNESCO for designation as a “UNESCO Global Geopark,” drawing upon the broader mandate of the Organization.

This paper intends to apply the latest IUGS Guidelines 2023 as a complete dossier as a part of the Annex-2 attachment of dossier, with a case study on the Kebumen National Geopark, which has been submitted as an aspiring UNESCO Global Geopark (aUGGp) by the Indonesian National Committee for UNESCO (INCUN) through IGGP.

2. New IUGS Guideline 2023

The new guideline announced in September 2023 is a broad and in-depth discussion between January 2021 and July 2023, and was adopted by the UGGp council (Document code: SC/EES/2023/UGGp/4) (UNESCO and IUGS, 2023). The IUGS Guideline is based on the critical formulation in the UNESCO Guideline that the international significance of the geological heritages is linked to the scientific value of sites and landscapes of aUGGp. In the aUGGp checklist document in attachment-1, there are several questions that aUGGp should contain: A well-documented inventory - data base of geological sites; A geological map (as precise as possible) with appropriate symbols, coloring, and an appropriate legend including the geochronological periods recognized by the IUGS; a relevant and exhaustive list of scientific publications about the geology of the territory, highlighting international publications (IUGS, 2023). Geological heritage of international significance in a UGGp is based on a significant representation of one or more processes or elements of geology that make a meaningful contribution to the understanding of the Earth, its climate, or life history and evolution, or to the advancement of the geological sciences in a specific context. The applicant must justify the international significance based on the scientific knowledge available for the territory and follow the provided template. This justification is based on a well-described list of geological sites, with scientific citations, which, as a whole, provides a general view of the geological value of the territory.

The term "international" should not be considered strictly in an administrative sense, but rather in a regional context. The geological heritage of international significance must include geological features regarded as among the best examples of their kind at the country level, within the Global Geopark's regional network (European Geoparks Network–EGN, Asia

Pacific Geoparks Network–APGN, Latin America and Canada–GeoLAC), and within the framework of their main geological context. Geosite is a Geological Heritage object within a Geopark area with specific characteristics, both individual and multiple objects, and is an integral part of the evolutionary story of the formation of an area of significant geological or geomorphological interest, making it valuable for scientific study, education, or tourism (Perpres 9/2019, Zhyrnov et al., 2025). Kebumen Unesco Global Geopark has 42 geosites. Geological features encompass related disciplines such as stratigraphy, sedimentology, paleontology, tectonics, petrology, volcanology, mineralogy, geomorphology, hydrogeology, pedology, impact structures, and the history of geosciences, among others. An aUGGp can typically have geological features included in more than one type of geological interest or discipline. At least one primary geological kind of interest is considered to be of international scientific significance. An aUGGp should ideally have distinctive and complementary geological features compared to existing geoparks in the same geological context.

There are eleven types of geological interest: 1) History of Geosciences, fundamental to understanding the foundations, the development, and the history of Geosciences, like global timescale or sites where significant geological processes of rocks, or deposit types are described. 2) Stratigraphy, sedimentology, and past climate. The geological time scale is represented in sedimentary rocks, their structures and sequences, stratotypes of major boundaries (GSSPs), chronostratigraphy, biozones, type sites of broad significance, and palaeomagnetic reference sequences. 3) Paleontology, all evidence of past life, including macro-and microfossils, trace fossils, and plant remains, biogenic structures, chemofossils, and biomarkers—including evidence of past ecosystems, evolution, biozones, and exceptional preservation sites. 4) Igneous and metamorphic petrology, Igneous and metamorphic rocks and complexes, with crucial information to understand the origin and evolution of the Earth's interior and its geodynamic evolution. 5) Volcanology, Important volcanic features, forms (dome, cone, crater, caldera, maar), and their products (lava flows, dyke complexes, volcanoclastic deposits), current eruptions, and geothermal manifestations. 6) Tectonic and structural geology, deformation structures at different types and scales (folds, faults, thrusts) that represent geodynamic contexts and processes (orogenic belts, island arcs, subduction zones, rifts, ophiolites) that help understand the evolution of the lithosphere and the forces that cause its deformation, including neotectonics and current and historical earthquakes. 7) Mineralogy and metallogeny, processes and economic (ores) and non-economic minerals of all types, metallogenic processes through time, metallic and non-metallic sources, mineral type localities, assemblages. 8) Geomorphology, landforms, and exogenous related processes (fluvial, karst, coastal, desert, glacial and periglacial, mass movement features) that allow understanding of the current landscape and its evolution through time, including pedological features. 9) Hydrogeology, hydrological processes, and elements related to groundwater and surface water: aquifers, springs, groundwater, mineral waters, lakes, rivers, and human water treatment. 10) Geological hazards are natural hazards related to geological processes like earthquakes, volcanic eruptions, mass wasting, floods, tsunamis, and rising sea levels. 11) Impact structures and extraterrestrial rocks, rock and landscape evidence of extraterrestrial processes (e.g., geochemical anomalies and impact products), meteorite craters, and meteorites (IUGS, 2023).

3. Location of the geopark

The geopark is located at Kebumen Regency, Central Java Province, around 455 km east of Ciletuh-Palabuhanratu UGGp and 100 km west of Gunungsewu UGGp. On the same island, about 600 km farther east, is Ijen UGGp at Banyuwangi and Bojonegoro Regencies, East Java Province (Figure 2). The theme of Kebumen aUGGp is "**The Glowing Mother Earth of Java.**" The toponym of Kebumen is derived from the word "*Kibumian*," referring to Kyai Bumi, or Prince Bumi Dirdjo. *Kabumian*, commonly called Earth science, is expected to be the light source of Earth's knowledge, sincerely presenting geological, biological, and cultural diversities to humans as a mother loves his children. Mother Earth also states that the origin of the story about the formation of Java Island is in Kebumen, and it explains that the Kebumen area is the oldest rock in Java, formed by subduction during the Cretaceous era.



Figure 2. Location map of Kebumen aUGGp based on UNESCO standard maps

METHOD

This research began with an in-depth review of the IUGS guidelines for establishing internationally significant geological values. This was followed by a review of the prepared dossier and all international geological diversity and geoheritage publications on the geopark area. Fieldwork was conducted to verify, photograph, and observe accessibility, amenities, scientific value, and community involvement in maintaining geosites with potential international value. Studio activities were conducted to create maps in accordance with IUGS guidelines and to assess the potential of geosites that had undergone field verification. Focus group discussions with expert groups also accompanied this compilation process. A geosite of international value may have more than one feature, but verification must be carried out on the most substantial value of the geosite. The results of this process were then translated into a document on internationally significant geosite values (Figure 3).

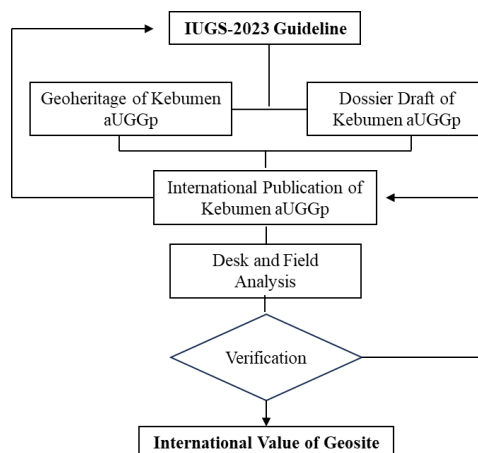


Figure 3. Research methodology flow chart

RESULT AND DISCUSSION

1. Geological setting

The current condition of Java is the result of geological processes from the Neogene period to the present. However, traces of older geological processes can still be observed in pre-Tertiary rocks. These ancient rocks are exposed in Ciletuh, West Java; Karangsambung-Kebumen, Nanggulan-Kulonprogo, and Bayat-Klaten, which continue towards the Meratus Mountains at the southeastern part of Kalimantan Island. Those are part of the Late Cretaceous-Paleocene subduction zone (Asikin, 1974; Hamilton, 1979; Suparka, 1988; Parkinson et al., 1998; Wakita, 2000). Meanwhile, the Tertiary magmatic belt along Java Island shows a younger Tertiary subduction system (Soerija-Atmadja et al., 1994). The development of the magmatic arc and subduction zone from the Cretaceous to the Oligocene appears to have shifted from the NNE to the west-east direction (Katili, 1975; Sujanto & Sumantri, 1977). The change in subduction direction in Karangsambung, Kebumen Geopark, was caused by a stretching process that produced a shallow-sea basin in the north and a deep-sea basin in the south, and by the inclusion of the East Java microcontinent. The entry of the East Java microcontinent made the Karangsambung-Meratus subduction zone inactive, which then experienced reactivation in the Oligocene era in an east-west direction (Prasetyadi, 2007)

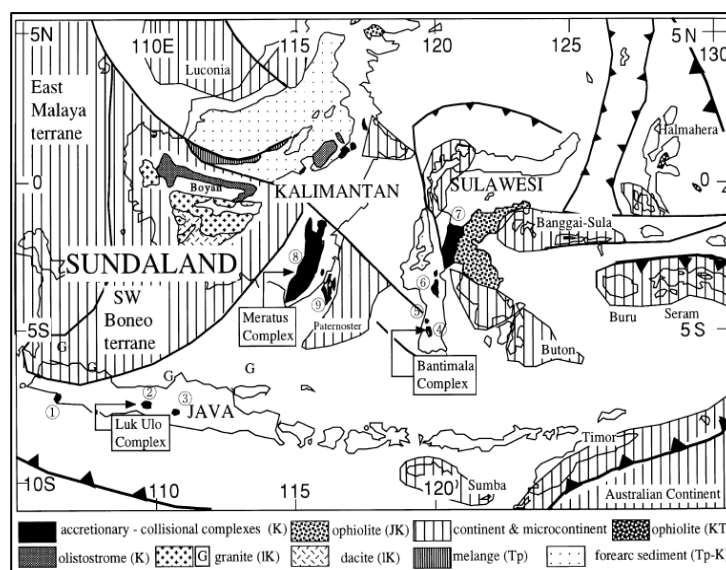


Figure 4. The distribution of Cretaceous age accretion complexes in Indonesia, such as the Luk Ulo Complex, is included in the Kebumen Geopark area (Wakita, 2000).

The geomorphological conditions of the geopark area vary greatly. There are structural landforms (15 units), denudational landforms (8 units), solutional/karstic landforms (1 unit), alluvial (6 units), and marine landforms (3 units) (Ansori et al., 2020). The structural landform (S) origin is composed of rock layers, either those disturbed by pressure or those not concerned with and formed due to an endogenous process of tectonism or diastrophism. The structural landforms are influenced by folds (anticline, syncline), faults, and joints. Structural landforms are often found in the northern part of the study area, especially in the mélangé complex, characterized by faults and joint alignment patterns. The denudation process (D) tends to change the shape of the Earth's surface, called the process of denudation. The primary process is degradation in the form of weathering, which produces regoliths and saprolites, erosion, transportation, and mass movement processes. This process is typical in hilly units with perishable and unstructured material. The degradation process causes aggradation on the slopes of the hilly legs, producing colluvial deposits with mixed material (pediment). Karst landform (K) is the appearance of a typical landscape on limestones or dolomites caused by the dissolution process. The appearance of karst landscapes due to the dissolution process is distinguished from other landscapes, such as the typical shape of a conical hill, a sinusoidal hill, as well as pepino hill, and the remaining tower karst. Geomorphologically, the karst region is the dominant area of carbonate rock. A karst area is an area that is easily damaged. The fluvial process is a physical and chemical process that results in changes of the shape of the Earth's surface, which is caused by the action of surface water, whether it is water that flows in an integrated manner (rivers), or water that is not concentrated (sheet water). Fluvial landform (F) is located around Sruweng, Karanganyar, and Gombong areas, bordered by alluvial plains and denudational mountains in the north. The pattern of parallel rivers in the upstream becomes centered toward the outlet. Some indicate the existence of alluvial fans. The coastal plain landscapes in Kebumen area is divided into Young Coastal Sediment (M.4), Old Coastal Sediment (M5), and Fluvio-Marine Sediment (MF) (Figure 5). The difference is based on river flow patterns, the shape of sandbanks, land conditions, and morphogenesis that control the formation of the landscapes (Ansori et al., 2020).

The geology of the geopark area is interesting and unique. The geological diversity in this area is reflected in the variety of rocks and geological structures. There are 21 rock groups/formations with 42 geosites spread from north to south (Figures 6 and 7). The geological history of Kebumen Geopark reflects 6 historical periods of the formation of Java Island (Figure 8).

The first period (119 – 55 m.y.a), was initiated by the collision of East Java with the southeastern margin of Sundaland, which can be proven by the deposition of deep-sea trenches, forming a mélangé complex with various types of rocks resulting from the unification of two microcontinents (Asikin et al., 2007; Hall, 2002; 2012; Hamilton, 1979; Prasetyadi, 2007). The rock consists of typical oceanic floor rocks in the mélangé, such as pillow lava, chert, gabbro, and ultramafic, combined with ordinary continental rocks, such as sandstone, conglomerate, and claystone. The initial phase of this collision is called the subduction phase.

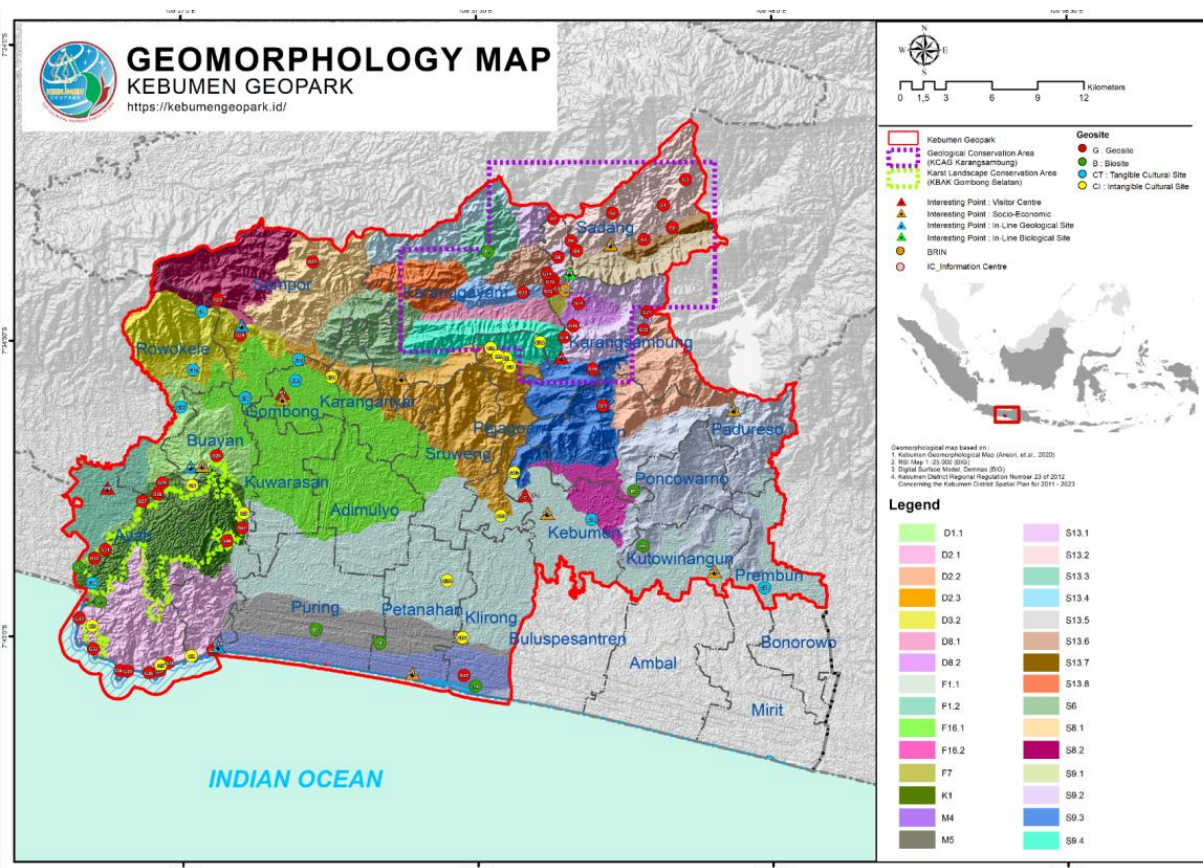


Figure 5. Geomorphological map of Geopark area composed of structural (S), denudational (D), Karst (K), Fluvial (F), and Marine (M) with geoheritage area (modified from Ansori C et al. 2020)

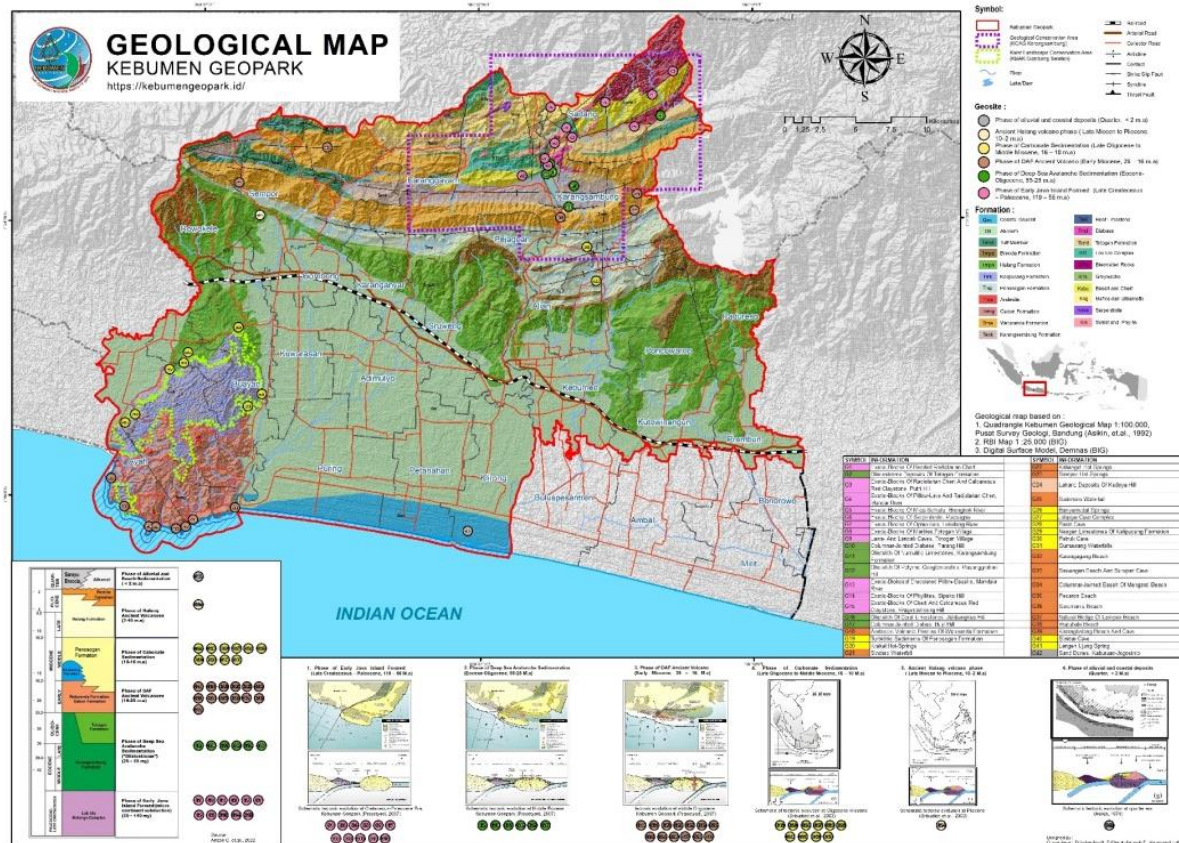


Figure 6. Geological map of Kebumen Geopark (modified from Asikin et al., 2007)

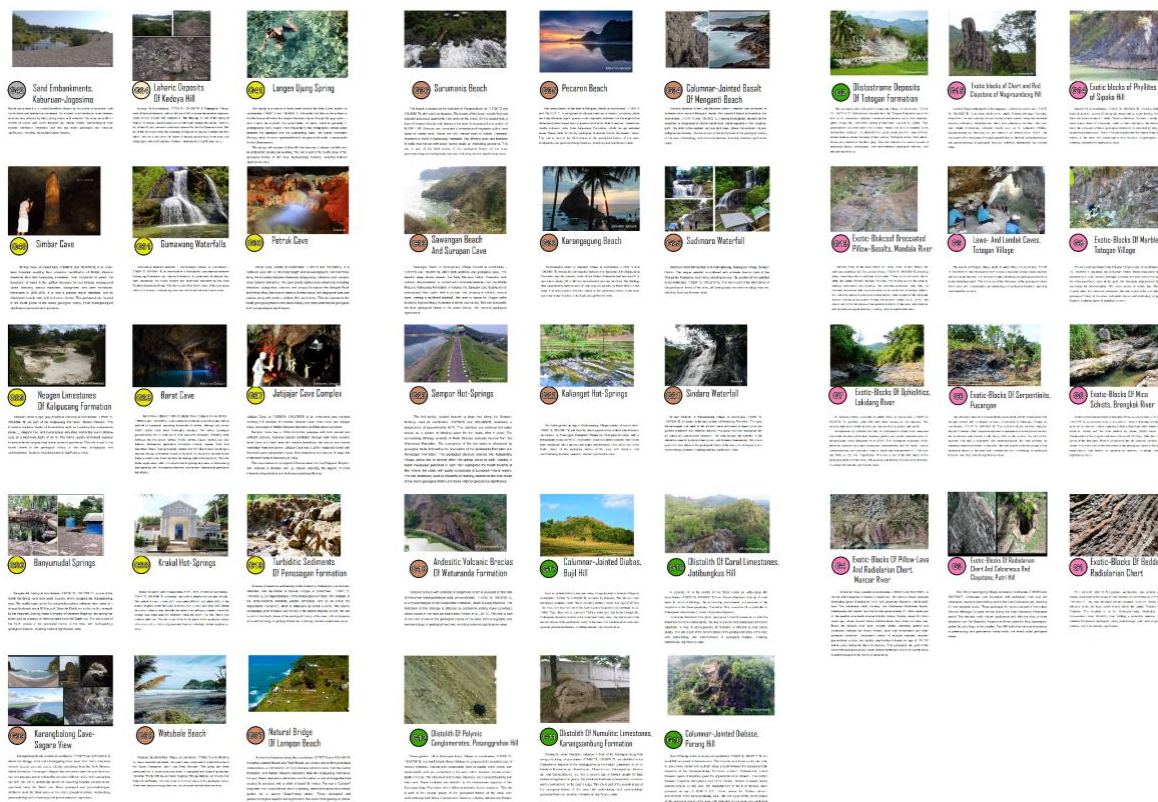


Figure 7. Geosites photos in Kebumen Geopark

The second phase is deep-sea avalanche sedimentation (55-15 m.y.a); Java Island was lifted after plate subduction and collision approximately 65 million years ago (Prasetyadi, 2007). During this phase, ancient volcanoes and sedimentary basins in Java began to form. In the Karangasambung area, the sedimentary basin is a deep-sea trench (Asikin et al., 2007). All the

rocks from the prior period were deposited in the Karangsambung area through the process of deep-sea gravity-driven avalanches (olistostrome) to form the Karangsambung and Totogan Formations (Asikin et al., 2007; Prasetyadi, 2007).

The third phase is OAF Ancient Volcanoes (25-16 m.y.a). The increasing rate of the northward movement of the Australian continent is estimated to continue as far as the Middle Oligocene (Hall, 2002; 2012). This event triggered volcanic activities related to the emergence of the OAF volcanic zone in southern Java, forming the southern mountain zone in the Waturanda, and Gabon Formations (Setijadji et al., 2006). The fourth phase, Carbonate Sedimentation (16-10 m.y.a), is characterized by a decrease in ancient volcanoes due to rising sea levels, and is characterized by marine sedimentary rock, such as carbonate and bioclastic limestones. This appointment is marked by massive carbonate deposition, such as the Wonosari Formation in Central Java and the Punung Formation in East Java, and active inversion development of Neogene formations in the northern part of the Rembang and Kendeng Zones (Prasetyadi, 2007).

The carbonates formations in the Kebumen Geopark area are known as the Penosogan Formation in Karangsambung and the Kalipucang Formation in Karangbolong (Ansori et al., 2022). The fifth phase, Halang Ancient Volcanoes (10-2 m.y.a). As a result of the inactivity of the OAF, the Australian plate is moving northward, and the Java volcanic path shifts to the north to form the Pliocene volcanic arc located in the central part of Java Island (Soeria-Atmadja et al., 1994; Setijadji et al., 2006). This volcanic activity produced thick marine sedimentary rocks alternating tuffaceous sandstone and tuffaceous clay of the Halang and Peniron Formations' volcanic member breccias (Prasetyadi, 2007).

The repetition of volcanic rock groups proves the reactivation of tectonic and magmatic processes in Java. The activity was not as massive as in the First Ancient Volcano Phase because evidence of ancient volcanic rocks in Phase 2 was uneven or local, only found in several areas, one of which was in Kebumen. The presence of the Ancient Halang Volcano marks the Pliocene volcanic arc. This volcano's path has continued to the present day as the Modern Volcanic Arc (e.g., Mount Merapi). The sixth phase, Alluvial and beach sedimentation (< 2 m.y.a). Alluvial and coastal deposits are the last phase of Java Island's tectonic evolution, during which karst morphology and recent volcanoes formed. Many active volcanic clusters, such as Merapi and Lawu volcanoes, are in the middle of Java.

2. Main geological arguments and headline

The Karangsambung area is an excellent natural geological laboratory where various rock types of different ages and environments are found, and the concept of plate tectonics can be studied and tested. Subduction and collision in this area were developed during the Cretaceous-Paleocene era (119–55 Ma) (Afling et al., 2021; Hall, 1996, 2002, 2012; Hoffmann et al., 2019; Parkinson et al., 1998; Hamilton, 1979). Types of igneous, sedimentary, and metamorphic rocks with different environments and ages were mixed into the Luk Ulo Mélange Complex (Asikin et al., 2007). The Karangsambung area is similar to a textbook with many pictures and models. Notably, this area directly provides geological field evidence of the plate tectonic concept in the form of outcrops and morphology (Ansori, 2018; Ansori et al., 2016). The Karangsambung area is a structural mountain product of the Cretaceous oceanic spreading and subduction zone. Based on these geological characteristics, the subtheme of the geopark is *the ancient oceanic floor and subduction zone* (Ansori et al., 2022).

The morphology of the Karangbolong is cockpit karst with conical residual hills. The area exhibits slightly different morphological characteristics governed by the jointing system, topographical position, and uplift history and type (Haryono et al., 2017). The depression density of the Karangbolong karst (5.78 depression/km²) is lower than that of Gunung Sewu (6.43 depression/km²) (Haryono & Day, 2004). Both areas have the same general physiography, climate, and carbonate facies. However, the major joints in the Karangbolong area are more closely spaced than those in the Gunung Sewu (Haryono & Day, 2004). Regarding karst development, the morphological characteristics of the Karangbolong karstic area appear to be in the stage of mature karst, where karst development starts from joint-controlled dissolution within the plateau (Haryono & Day, 2004). The mature development of Karangbolong karst is also shown by the development of karst aquifers and the mapping of cave passages. Karangbolong has a conical karst landscape above old volcanic rocks with many underground rivers and caves. As part of geopark area, the subtheme of Karangbolong is *conical karst landscapes* (Ansori et al., 2022).

Kebumen Geopark has unique and complex geological conditions that differ from two other global geoparks in Java. Kebumen Geopark is an integral part of the evolutionary history of Southeast Asian tectonic plates. This region has enormous geodiversity because of the development of its long geological history with varied biological, and cultural diversity, with a total of 42 geosites. The geopark's history covers six geological phases, from the trace of the ocean floor and subduction zone spreading to the formation of karst landscapes and Quaternary deposits. The geological condition of Kebumen Geopark is a combination of Ciletuh-Palabuhanratu UGGp (subduction zone) and Gunung Sewu UGGp (karst landscapes). Considering the representation of the geological process (subduction process) in the Early Cretaceous, there are similarities in the geological process in Ciletuh-Palabuhanratu UGGp and cockpit karst similarities in Gunung Sewu UGGp. Based on the geological condition, the proposed geological theme for Kebumen Geopark is *The Best Evidence of Plate Tectonic Theory in Southeast Asia and Karstic Landscapes* (Ansori et al., 2022).

3. Distinctive geological features

There are two UGGp and three national geoparks on Java Island. The Ciletuh-Palabuhanratu UGGp is in the western part of Java, and its theme is The First Land of the Western Java Island; Gunung Sewu UGGp is in the eastern part of Java, and its theme is The Phenomenal Tropical Conic Karst Hill Landscape. In Indonesia, there are several other geoparks with subduction zone themes, such as Ciletuh Pelabuhanratu Geopark, Meratus Geopark, and Maros-Pangkep Geopark. A comparison of their geological diversity can be seen in Table 1.

Table 1. Comparison of Ciletuh-Palabuhanratu UGGp, Kebumen aUGGp, and Gunung Sewu UGGp, (Ansori et al., 2022), Meratus aUGGp (Wakita et al., 1998, Satyana, 2014; Soesilo et al., 2015), and Maros-Pangkep UGGp (Wakita et al., 1996, Satyana, 2014; Maulana et al., 2013, 2015)

Criteria	Ciletuh-Palabuhanratu UGGp	Kebumen Geopark	Gunung Sewu UGGp	Meratus Geopark	Maros Pangkep UGGp
Rock assemblages (mélange)	Ophiolite (peridotite, gabbro, diabase, pillow basalt), greywacke, limestone, tuff, red shales, serpentinite, phyllite, greenschist. Ophiolite is mostly not a mid-oceanic ridge but subduction-generated. Badak Mt. pillow basalt is considered not ophiolite, but it could be Jampang volcanism (22.4 Ma)	Ophiolite (pillow basalt, diabase, gabbro, serpentinitized peridotite); quartz porphyry-rhyolitic tuff; chert, siliceous shale, red limestone; sandstone, pebbly shale, basaltic conglomerate; phyllite, blueschist, eclogite, gneiss, quartzite, marble, dacite, plagiogranite	-	Ophiolite (serpentinitized peridotite, pyroxenite with gabbro and plagiogranite intrusions, basalt); limestone, chert, clastic and carbonate sediments: phyllite, schists, granite, tonalite, trondhjemite, diorite. Paternoster micro continent	ophiolite (serpentinitized peridotite, basalt); sandstone, shale, conglomerate, chert, siliceous shale; schist, schist breccia, eclogite; felsic intrusives & rhyolitic tuff. Paremba Sandstone (Gondwana micro continent)
Nature of rocks	Tectonic blocks, mélange	Tectonic blocks, mélange	-	Tectonic blocks, mélange	Tectonic blocks, mélange
Age of subduction	55–38 Ma (on greenschist)	119–55 Ma (high-pressure metamorphic rock)	-	165–56 Ma (on green schist)	137–70 Ma
Age of Radiolaria	No radiolarian chert is found	Early Cretaceous-late Latest Cretaceous	-	Early Jura – Early Cretaceous	mid- late Cretaceous (Albian-early Cenomanian)
Overlying formations, age	Slope deposits, Ciletuh Fm (?), middle Eocene (?) – mid-Miocene	Slope deposits, Karangsambung Fm, Totogan Fm (Middle Eocene-Oligocene)	-	slope – volcanoclastic deposits, Pitap and Haruyan Groups (Late Cretaceous), Tanjung Fm (Eocene)	slope deposits, Balangbaru (Late Cretaceous)
	Bayah Fm, Jampang Fm	Waturada Fm, Gabon Fm, Penosogan Fm (Early Miocene)	Nglanggran Fm, Sambipitu Fm, Oyo Fm, Nampol Fm (Early Miocene)	Bebulu Fm, Berai Fm (Oligocene)	Melawa sandstone, Bua Volcanic, Camba Volcanic (Paleogen)
Karst Landscape	-	Polygonal/Cockpit Karst, Kalipucang Fm (Middle Miocene)	Kagel Karst: labyrinth-cone, polygonal or cockpit, and residual cone karst, Wonosari Fm, (Middle Miocene)	Warukin Fm, Pulaubalang Fm (Middle-Late Miocene)	Tonasa Limestone, Kagel karst with the oldest rock painting in the world (40,000 years)
Other Formation	-	Halang Fm (Late Miocene–Pliocene)	Kepek Fm (Late Miocene–Pliocene)	Dahor Fm (Plio-Pliocene)	Baturape Cindako volcanic

The unique international value of the Karangsambung area is that its geological processes are an important part of understanding the concept of plate tectonics, and its diversity is the key to the evolution of tectonic plates during the Cretaceous period in Southeast Asia at G4 and G15 geosite. The uniqueness of this area lies in the Karangsambung geoheritage, which includes evidence of subduction-related rocks and ancient ocean-floor rock groups. This area was mapped by Verbeek (1896), who published a geological map of Java-Madura, which included a sheet of the Loh Oelo terrain map at a scale of 1:100,000. Harloff (1933) remapped on sheet 67 Banjarnegara, later updated by Tjia (1966), who performed structural mapping on pre-Tertiary rocks in the north. Asikin (1974) remapped the area using the concept of plate tectonics, producing new findings under the term Luk Ulo Mélange Complex, which is used today. The uniqueness of the Karangsambung region has made it a reference for geological mapping methods in Earth science education at various universities in Indonesia since 1964. Every year, more than 12,000 students from different universities in Indonesia and foreign universities and junior and senior high schools come to Karangsambung. The geological conditions and uniqueness are well known; Karangsambung is Southeast Asia's best evidence for *plate tectonic theory* (Ansori, 2022).

The Luk Ulo Mélange Complex is a chaotic mixture of types of sedimentary, igneous, and metamorphic rocks unconformably overlain by the Eocene Karangsambung Formation (Kadariusman et al., 2007; Parkinson et al., 1998; Wakita et al., 1994). High-pressure rocks like eclogite and blueschist are exposed in narrow areas within the low-grade schist and serpentinite zones (Kadariusman et al., 2007; Setiawan et al., 2013; 2020). Greenschist facies rocks in the Karangsambung area are derived from pelitic (e.g., garnet–muscovite–tourmaline–quartz schist), meta-basic (e.g., garnet–chlorite–epidote–muscovite schist), and calc-silicate protoliths (e.g., garnet–zoisite–muscovite schist) (Setiawan et al., 2013). Karangsambung in Central Java and Meratus in South Kalimantan have a similar trend of NE–SW, which might have been derived from a single subduction zone during the Cretaceous period (Alfing et al., 2021; Hoffman et al., 2019; Ketner et al., 1976; Parkinson et al., 1998; Setiawan et al., 2013; 2020), with the position of the Meratus Complex being more proximal than that of the Luk Ulo Mélange Complex (Alfing et al., 2021; Parkinson et al., 1998). K–Ar and Rb–Sr radiometric dating of the metamorphic rocks yielded an Early Cretaceous age of 119–101 Ma (Alfing et al., 2021; Hoffmann et al., 2019; Parkinson et al., 1998;

Suparka, 1988), whereas *radiolarian* fossils yielded the Early Cretaceous (Wakita et al., 1994). Nannofossils from sediments on the mélangé complex are a mixture of Paleocene to Eocene fauna (Asikin, 1974; Sapri et al., 1998). These data assume that the mélangé complex ages range from the Early Cretaceous to Paleocene. Coarse and fine blocks of rocks are tectonically mixed with a scaly clay matrix and irregular shear joint directions (Sapri et al., 1998; Asikin, 1974; Prasetyadi, 2007). The unique international value of this area is also marked by the critical role of the sites in this area, which are models of Cretaceous subduction for the Eurasian plate with the Indian-Australian plate, which is a subduction model by several researchers.

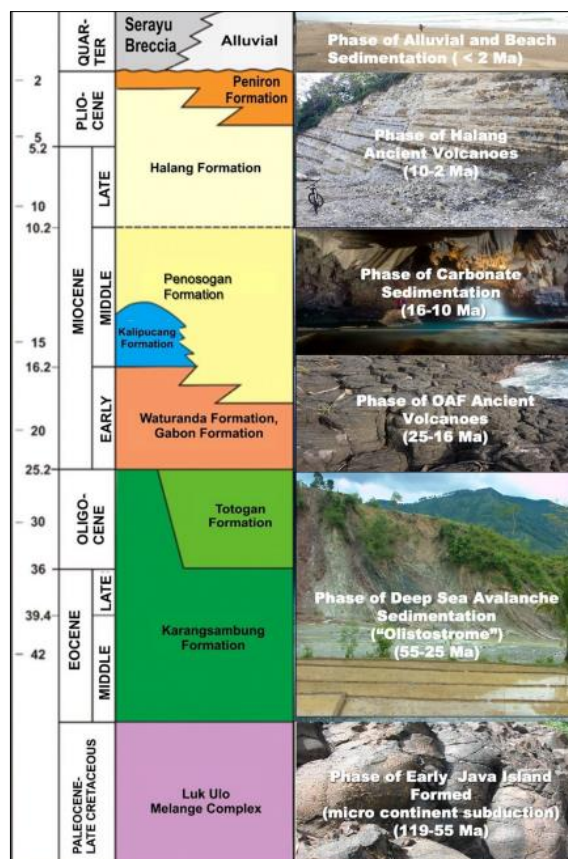


Figure 8. Geological history of Kebumen Geopark. From bottom to top: phase of Early Java or Subduction zone (119–55 Ma), phase of deep-sea avalanche sedimentation or olistostrome (55–25 Ma), phase of old andesite volcanic activity (25–16 Ma), phase of carbonate sedimentation (16– 10 Ma), phase of Halang volcanic activity (10–2 Ma), and phase of Alluvial and beach sedimentation (<2 Ma), respectively (Ansori et al, 2022)

4. Geological sites list

Kebumen Geopark area is 1,160.68 km², spread over 22 sub-districts and 374 villages, with a population of 1,167,934 people. Kebumen Geopark has 42 geological sites. The density level of geological sites compared to the geopark area is 0.0362 sites/km². In the Kebumen Geopark area, geological evolution includes 6 phases from the Cretaceous to the Holocene. The distribution of geological sites in this area consists of 6 stages of Kebumen earth history, with the distribution shown in Table 2 and Figure 8. Geographically, 25 geological sites are distributed in the northern part of the region, while the remaining 17 are in the southern part. The northern part covers the Karangsambung area up to the national highway, while the southern area includes the Karangbolong high area to the south of the national road (Figures 6, and 7).

Table 2. Geological sites distribution

Evolution Phase/ periods	Sum of Geosites
1 (Early Java of the Subduction Zone)	11
2 (Deep-sea avalanche sedimentation/olistostrome)	6
3 (Old andesite volcanic activity)	13
4 (Carbonate sedimentation)	10
5 (Halang volcanic activity)	1
6 (Alluvial and beach sedimentation)	1
Total	42

In the Kebumen aUGGp area, there are 42 geological sites covering geological interest related to the history of geoscience, stratigraphy and sedimentology, paleontology, igneous and metamorphic rocks, volcanology, mineralogy and metallogeny, geomorphology and hydrogeology. Meanwhile, the significance level includes international, national, and local levels with 6 (six) geological periods (Table 3).

Table 3. List of Geological Sites

No	Site Code	Name of geological sites	Type of Geological Interest	Level of significance			Geological phase
				International	National	Local	
1	G1	Exotic-blocks of bedded radiolarian chert, Sadang wetan	3 (Paleontology)	√	-	-	1
2	G3	Exotic-blocks of radiolarian chert and calcareous red claystone, Putri Hill	3 (Paleontology)	√	-	-	1
3	G4	Exotic-blocks of pillow-lava and radiolarian chert, Muncar River	1 (History of Geoscience)	√	-	-	1
4	G5	Exotic-blocks of mica schists, Brengkok River	1 (History of Geoscience)	√	-	-	1
5	G7	Exotic-blocks of ophiolitic Lokidang River	4 (Igneous Rock)	√	-	-	1
6	G10	Columnar-jointed diabase, Parang Hill	6 (structural geology)	√	-	-	2
7	G11	Olistolith of numulitic limestones, Karangsambung Formation	3 (Paleontology)	√	-	-	2
8	G14	Exotic-blocks of phyllites, Sipako Hill	6 (tectonic and structural geology)	√	-	-	1
9	G15	Exotic-blocks of chert and calcareous red claystone, Wagirsambeng Hill	3 (Paleontology)	√	-	-	1
10	G16	Olistolith of coral limestones, Jatibungkus Hill	3 (Paleontology)	√	-	-	2
11	G27	Jatijajar cave complex	9 (Hydrogeology)	√	-	-	4
12	G28	Barat cave	9 (Hydrogeology)	√	-	-	4
13	G30	Petruk cave	9 (Hydrogeology)	√	-	-	4
14	G2	Olistostrome deposits of the Totogan Formation	2 (stratigraphy, sedimentology)	-	√	-	2
15	G6	Exotic-blocks of serpentinite, Pucangan	7 (mineralogy, metallogeny)	-	√	-	1
16	G8	Exotic-blocks of marble, Totogan Village	4 (Igneous, metamorphic rock)	-	√	-	1
17	G12	Olistolith of polymic conglomerates, Pasanggrahan Hill	2 (stratigraphy, sedimentology)	-	√	-	2
18	G13	Exotic-block of brecciated pillow basalts, Mandala River	6 (tectonic, structural geology)	-	√	-	1
19	G17	Columnar-jointed diabase, Bujil Hill	4 (igneous petrology)	-	√	-	2
20	G18	Andesitic volcanic breccias of Waturanda Formation	2 (stratigraphy, sedimentology)	-	√	-	3
21	G19	Turbiditic sediments of Penosogan Formation	2 (stratigraphy, sedimentology)	-	√	-	4
22	G20	Krakal hot-springs	1 (History of geoscience)	-	√	-	4
23	G23	Sempor hot-springs	1 (History of geoscience)	-	√	-	3
24	G26	Banyumudal springs	9 (Hydrogeology)	-	√	-	4
25	G29	Neogen limestones of Kalipucang Formation	2 (stratigraphy, sedimentology)	-	√	-	4
26	G33	Sawangan beach and Surupan cave	8 (geomorphology)	-	√	-	3
27	G34	Columnar-jointed basalt of Menganti beach	5 (Volcanology)	-	√	-	3
28	G36	Surumanis beach	8 (geomorphology)	-	√	-	3
29	G37	Natural bridge of Lampon beach	8 (geomorphology)	-	√	-	3
30	G38	Watubale beach	8 (geomorphology)	-	√	-	3
31	G39	Karangbolong Cave - Sagara View	8 (geomorphology)	-	√	-	3
32	G40	Simbar cave	9 (geomorphology)	-	√	-	4
33	G42	Sand Embankment, Kaburuan-Jogosimo	10 (geological Hazard)	-	√	-	6
34	G9	Lawa- and Landak caves, Totogan Village	7 (mineralogy, metallogeny)	-	-	√	1
35	G21	Sindaro Waterfall	2 (stratigraphy, sedimentology)	-	-	√	3
36	G22	Kalianget hot-springs	1 (History of geoscience)	-	-	√	3
37	G24	Laharic deposits of Kedoya Hill	2 (stratigraphy, sedimentology)	-	-	√	5
38	G25	Sudimoro waterfall	2 (stratigraphy, sedimentology)	-	-	√	3
39	G31	Gumawang waterfalls	2 (stratigraphy, sedimentology)	-	-	√	4
40	G32	Karangagung beach	8 (geomorphology)	-	-	√	3
41	G35	Pecaron beach	2 (stratigraphy, sedimentology)	-	-	√	3
42	G41	Langen Ujung Spring	9 (hydrogeology)	-	-	√	4

5. Type of geological interest and level of significance

IUGS has designated six geological frameworks, and it was implemented in Kebumen aUGGp. The geological framework and level of significance can be seen in Table 4.

Table 4. Geological Framework and Level of Significance







Geological framework	Level of significance			
	Global reference	International	National	Local
1. History of Geosciences	-	√	-	-
2. Stratigraphy and Sedimentology	-	√	-	-
3. Paleontology	-	√	-	-
4. Igneous and Metamorphic Petrology	-	√	-	-
5. Volcanology	-	-	√	-
6. Tectonics and Structural Geology	-	√	-	-




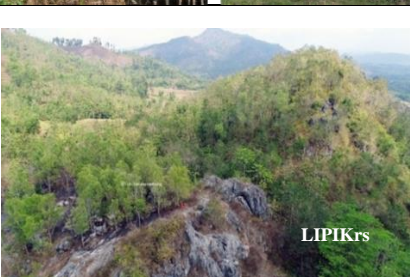
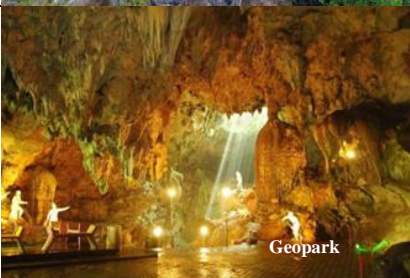

7. Mineralogy and metallogeny	-	√	-	-
8. Geomorphology	-	√	-	-
9. Hydrogeology	-	-	√	-
10. Geological hazards	-	-	√	-
11. Impact structures and extraterrestrial rocks	-	-	-	-

6. Justification of the International Significance

Based on the literature review, assessments, and field observations of geosites in the Kebumen Geopark area, 13 geological sites were proposed as of international value. These geosites are listed in Table 5.

Table 5. Geological Sites with International Value

No	Geosite name and Location Geological Interest and Phase	Geosite Photo	Remark	Bibliography
1	G1. Exotic blocks of bedded radiolarian chert, Sadang Wetan, -7.5164 °S; 109.7400 °E. 3 (Paleontology), 1 (early Java Formed)		The red chert, which is fine-grained, well-layered, and contains <i>radiolaria</i> fossils. characterized by Late Cretaceous age, within the Lukulo Tectonic Melange Complex.	Wakita (2000), Wakita et al. (1994), Ansori et al. (2022)
2	G3. Exotic blocks of radiolarian chert and calcareous red claystone, Putri Hill, Kedung Gong, -7,4810 °S; 109,7491 °E, 3 (Paleontology), 1 (early Java Formed)		This Exotic block is alternating <i>radiolaria</i> chert and red calcareous claystone. These deep-sea siliceous rocks are large exotic blocks within the Lukulo Tectonic Melange Complex.	Wakita (2000), Wakita et al. (1994), Ansori et al. (2022)
3	G4. Exotic blocks of pillow-lava and radiolarian chert, Muncar River, Seboro; -7.5008 °S, 109.7058 °E 1 (History of Geoscience), 1 (Early Java Formed)		Exotic block of Luk Ulo Melange Complex. The best outcrop of sea floor spreading, pillow lava as a product of the upper part of the Ophiolite rock (81 mya), with Cretaceous <i>radiolarian</i> chert. There is eclogite as a high-grade metamorphic rock	Alfing J. et al. (2021). Kadarusman et al. (2007), Hoffman et al. (2019), Setiawan et al. (2013, 2020); Ansori et al. (2022)
4	G5. Exotic blocks of mica schists, Brengkok River, Sadang Wetan, -7.5100 °S; 109.7078 1 (History of Geoscience), 1 (Early Java Formed)		the micaceous schist of the Brengkok River is considered the old exposed bedrock on Java Island, K-Ar dating 117 mya (Ketner, 1976), Rb-Sr 119 mya (Hoffman et al., 2019)	Ketner et al. (1976), Kadarusman et al. (2007), Hoffman et al. (2019), Setiawan et al. (2013, 2020), Miyazaki et al., 1998, Ansori et al. (2022)
5	G7. Exotic blocks of ophiolites, Lokidang River, Giri Tirta, -7,5039 °S, 109.6709 °E 4(Igneous rock), 1 (Early Java Formed)		Karangsambung ophiolite complex comprises cherts from deep-sea sediments, basaltic pillow lava, diabase, gabbro, and partial serpentinization of clinopyroxene rocks. Basal and diabase were 81 ± 4.06 mya and 85.03 ± 4.25 mya	Setiawan et al. (2020), Ansori et al. (2022)
6	G10. Columnar-jointed diabase, Parang Hill, -7.5453 °S, 109.6717 °E 6 (Structural), 2 (Deep-sea avalanche sedimentation & intrusion)		a small hill composed of diabase rocks. This intrusive rock forms a columnar joint. the K-Ar diabase, which produces an age of 39.86 ± 3.31 m.y.a (Soeria Atmadja, 1994)	Setiawan et al., 2011, Soeria-Atmadja (1994); Ansori et al. (2022); Mareta et al. (2019)

7	<p>G11. Olistolith of nummulitic limestones, Karangsambung Formation, -7.5467 °S, 109.6678 °E</p> <p>3 (Paleontology), 2 (Deep-sea avalanche sedimentation & intrusion)</p>	 <p style="text-align: right;">Chusni</p>	<p>Limestone is rich in fossils of <i>Nummulite sp.</i>, <i>Alveolina sp.</i>, <i>Flosculina sp.</i>, <i>Pellatispira sp.</i>, <i>Assilina sp.</i>, and <i>Quinqueloculina sp.</i>. This is Eocene age or formed around 55 m.y.a. It is an olistolith in the Olistostrome deposits of the Karangsambung Formation</p>	<p>Paltrinieri et al. (1976), Ansori et al. (2022), Prasetyadi (2007), Prasetyadi et al. (2006)</p>
8	<p>G14. Exotic blocks of phyllites, Sipako Hill, Wono Tirto; -7.5403 °S, 109.6672 °E</p> <p>6 (Tectonic and structural geology), 1 (Early Java Formed)</p>	 <p style="text-align: right;">Chusni</p>	<p>The low-grade metamorphic rocks forming these small folds are exotic blocks in Lukulo Tectonic Melange Complex. Faults cut their outcrops in the direction of the river; these geological structures are indicated by drag-fold and slickenside</p>	<p>Ketner et al. (1976), Kadarusman et al. (2007), Hoffman et al. (2019), and Setiawan et al. (2013, 2020). Miyazaki et al. (1998), Ansori et al. (2022)</p>
9	<p>G15. Exotic blocks of chert and calcareous red claystone, Wagirsambeng Hill, Wono Tirto, -7.5475 °S, 109.6525 °E,</p> <p>3 (paleontology), 1 (Early Java Formed)</p>	 <p style="text-align: right;">Chusni</p>	<p>alternating reddish-brown chert, and calcareous red clay; well-layered deep-sea sediment deposits. The chert layer found Cretaceous <i>radiolaria</i> fossils such as <i>C. sphaerica</i> (White), <i>Spongocapsula sp.</i>, <i>Novixitus sp.</i>, and <i>Alievium sp.</i> (Wakita et al., 1994).</p>	<p>Wakita (2000), and Wakita et al. (1994), Ansori et al (2021, 2022)</p>
10	<p>G16. Olistolith of coral limestones, Jatibungkus Hill; Banioro; -7.5675 °S, 109.6822 °E</p> <p>3 (Paleontology), 2 (Deep-sea avalanche sedimentation & intrusion)</p>	 <p style="text-align: right;">LIPIKrs</p>	<p>The big olistolith in Paleogene (Eocene-Oligocene) Karangsambung olistostrome deposits. Coral limestone consists of boundstone, baffle stone, nummulitic limestone, and conglomeratic limestone. the surrounding environment is composed of the scaly clay of the Karangsambung Formation</p>	<p>Paltrinieri et al., (1976), Prasetyadi, (2007), Prasetyadi et al., (2006); Ansori et al. (2022)</p>
11	<p>G27. Jatijajar cave complex, Jatijajar; -7.6685 °S, 109.4705 °E</p> <p>9 (hydrogeology), 4 (Carbonate sedimentation)</p>	 <p style="text-align: right;">Geopark</p>	<p>Jatijajar Cave Complex includes Dempok Cave, Intan Cave and Jatijajar Cave were developed in the Middle Miocene limestone of the Kalipucang Formation. There are stalactites, stalagmites, flowstones, and still actively forming pillars</p>	<p>Haryono et al. (2017); Saefudin, (2011); Ansori (2011); Ansori, 2017; Ansori et. al (2022)</p>
12	<p>G28. Barat Cave, Jatijajar; -7.6662 °S, 109.4356 °E</p> <p>9 (hydrogeology), 4 (Carbonate sedimentation)</p>	 <p style="text-align: right;">Geopark-Kbm</p>	<p>The Barat Cave is a multilevel cave with a labyrinthine pattern of passages reaching thousands of meters in length, and about 3,305 m has been mapped in detail. Large flowstone waterfalls and steps are named Ulysses Falls and Superman Steps.</p>	<p>Haryono et al. (2017); Saefudin, (2011); Ansori (2011); Ansori, 2017; Ansori et. al (2022)</p>
13	<p>G30. Petruk cave, Redisari; -7.7041 °S and 109.3980 °E</p> <p>9 (hydrogeology), 4 (Carbonate sedimentation)</p>	 <p style="text-align: right;">Chusni</p>	<p>The multilevel cave with an underground river that flows out of the cave is about 100 m long. The underground river flows in the stratigraphic boundary between the limestone (Kalipucang Formation) and volcanic rocks (Gabon Formation).</p>	<p>Haryono et al., (2017); Saefudin, (2011); Ansori (2011); Ansori, 2017; Ansori et al., (2022), Rahmadi & Harvey (2008).</p>

Geosites with international values mainly come from the northern area of the Geopark in Karangsambung with ten geosites, while three are in the southern part of the area in Karangbolong height. The three geosites (G1, G3, G15) in Karangsambung are mainly related to paleontological features in the form of *radiolaria* fossils, as the history of the Cretaceous subduction zone. The two geosites (G4, G5) are related to the Earth's history of a Cretaceous Subduction Zone in Southeast Asia. One geosite (G7) describes igneous rocks, especially as an ophiolitic series. Two geosites (G10, G14) relate to tectonics and geological structures in igneous and metamorphic rocks. Two geosites (G11, G16) are related to paleontology in the form of *nummulite* fossils and sedimentology of olistostrome. Meanwhile, three geosites in the southern part (G27, G28, G30) are related to hydrogeology and stratigraphy. Every geology student studying in Karangsambung must take an excursion to the G4 and G15 geosite locations. They are not considered geologists if they have not observed these sites.



Figure 9. Researchers and students from various countries who carried out field research in the Karangsambung area

International values are related to fossil concerns at lower-upper Cretaceous *Radiolaria* fossils found at G1, G3, G4, and G15 sites and Eocene-aged nummulites fossils at sites G11 and G16. The existence of *radiolaria* fossils is mainly obtained from research by Wakita (2000) and Wakita et al. (1994). In addition to determining rock ages, it is also related to the geological evolution of the subduction zone in this area.

Nummulite fossils were found in limestone olistoliths in the Karangsambung Formation, Totogan Formation, Bulukuning, and Larangan members. Both formations are underwater deposits from gravity avalanches that form olistostromes. Some researchers call them sedimentary melange. The presence of nummulite fossils in olistoliths indicates the occurrence of olistostromes during the Eocene. *Nummulites* can be observed at geosites G-11 and G-16.

Geosites associated with metamorphic rocks include exotic blocks of mica schists, Brengkok River (G5), Exotic blocks of phyllites, and Sipako Hill (G14). The sites were chosen for their ease of access and for representing medium- and low-grade metamorphic rocks, while the high-grade metamorphic rock geosites are located around the exotic blocks of pillow lava and radiolarian chert, Muncar River (G4). The existence of these rocks has been revealed by Alfing et al. (2021), Kadarusman et al. (2007), Hoffman et al. (2019), and Setiawan et al. (2013, 2020).

Most of the metamorphic rocks in the Luk Ulo Complex are muscovite schist, in which albite, quartz, and muscovite are abundant (Miyazaki et al., 1998). The epidote amphibolite, in which barroisite, garnet, epidote, albite, biotite, and phengite are present, is intercalated with garnet-bearing pelitic schists (Miyazaki et al., 1998). Small amounts of garnet amphibolite, eclogite, glaucophane rock, and jadeite-quartz-glaucophane rock occur as tectonic blocks embedded in sheared serpentinite (Miyazaki et al., 1998; Setiawan et al., 2020). The HP/LT (eclogite and garnet-glaucophane rock) and MP/HT (garnet amphibolite, amphibolite) metamorphic rocks predominantly occur as boulders on the rivers in the western part of the complex (Muncar and Luk Ulo Rivers). Most medium- to low-grade metamorphic rocks could be found in the eastern part of the complex (Loning River). The boundary of these rock types is between the Muncar and Loning Rivers. The metamorphic rocks occurring in this complex include HP metabasites (eclogite, garnet-glaucophane schist, and glaucophane schist), MP metabasites (amphibolite, garnet amphibolite), and pelitic schist (garnet-muscovite schist, muscovite schist). Other variations of low-grade schists found in this area are garnet-albite-actinolite schist, garnet-biotite-muscovite schist, apatite-quartz-muscovite schist, and chlorite (Setiawan et al., 2020).

International geosites are related to the geological features of igneous rocks, the history, and the geological structure of exotic blocks of ophiolitic rocks, the Lokidang River (G7), and Columnar-jointed diabase, Parang Hill (G10). Many studies on the existence of ophiolite have been published in international proceedings and journals.

The morphology of the Karangbolong karst generally resembles the typical karst of high-intensity rainfall areas, typified by cockpit karst with conical residual hills. The results show that the area exhibits slightly different morphological characteristics governed by the jointing system, topographical position, and uplift history and type. There is no evidence that lithological facies have an essential role in the morphological differentiation within the area (Haryono et al., 2017). Concerning karst development, the morphokarst development starts from joint-controlled dissolution within the plateau. The mature development of Karangbolong karst is also shown by the development of the karst aquifer and mapped cave passages in the area. A well-developed karst aquifer is characterized by diffuse infiltration, internal runoff, sinking streams, and conduit flow found in the area (Haryono et al., 2013). Five major cave systems and underground rivers were found in the area where a conduit aquifer has developed characteristics of Karangbolong karst, which appears to be in the stage of mature karst. A combination of aligned valleys with conical hills typifies the morphology of the Karangbolong karst. Though the area is already in a mature stage of karst development, not all of the karst area is occupied by enclosed depressions (cockpits). Differentiation of morphological characteristics in the area was found to be governed by jointing, topographical position, and detachment tectonics during the uplift. The jointing system in the area regulates the development of aligned valleys, elongated enclosed depressions, and conical karst morphology. Tight joint spacing has resulted in the sharp peaks of conical hills. Topographical position governs the differentiation of relief magnitude in the karst morphology (Haryono et al., 2017).

Geosites of international value in the southern part of the geopark are caves, which are part of the cockpit karst morphology. These geosites include Barat Cave (G28), Petruk Cave (G30), and Jatijajar Cave Complex (G27). Barat Cave is a horizontal cave with a long underground drainage pattern. At the entrance hall was a dry hole in a phosphate excavation. After that, there is an underground river with a direction of N 310° E and a water depth of about 0.5-1.0 m. This zone has 3,305 m long, with stalactites, rapid underground rivers, waterfalls, and river branches.

Petruk Cave, including a 450 m long horizontal cave, is ideal for providing morphological, hydrological, and cave faunas, and the origin mechanism of a limestone cave for speleologists and adventure tourism is very challenging and fun. Speleothems flourishing along the cave are breast stones, panthers, semar, crocodile, Maria Park, beard, stone stamps, and others. It has also provided cave tour guide packages in combination with other geotourism attractions. Besides enjoying the panoramas in the cave, get an explanation of the cave's ornaments. Cave tracking takes about 1.5 hours through the slippery, watery alleyways and sometimes has to creep through underground rivers. Local communities use this cave for rituals. In dark zones, there is cave fauna, such as bats. There are *Stygophrynus* insects in Petruk Cave, like in Lampung, Ujungkulon, Sukabumi, and Ciamis (Rahmadi, 2008).

Jatijajar Cave is a mainstay of tourism objects at Kebumen Geopark. It is a horizontal cave of 250 m in length, 25 m in width, and 15 m in height in the limestone rock of Kalipucang Formation. This formation is unconformity above the breccia of the Gabon Formation. At the entrance of the cave, compact limestone is found. Cave ornaments are generally not active, except in the middle part. There are 32 statues depicting the legend of Raden Kamandaka. A sediment containing *mollusk* fossils (*gastropods* and *pelecypods*) is preserved in brownish-brown clay sediments at the right of the entrance. A visible canopy remains a line of *Pelecypoda* fossils, north-south-trending, parallel to the direction of the cave passage. Springwater of Mawar, Kantil, and Jombor are underground rivers that are sanctioned by local people with the legend of Kamandaka, Kyai Klantung, and Dewi Nawang Wulang.

CONCLUSION

The international value must also consist of several geological features related to the history of geosciences: stratigraphy, sedimentology, and past climate; paleontology; igneous and metamorphic petrology; volcanology; tectonic and structural geology; mineralogy and metallogeny; geomorphology; hydrogeology; geological hazards; and impact structures and extraterrestrial rocks. The presentation of geological maps as the main discussion must also be more accessible to the wider public, without losing sight of their essence as maps that depict the distribution of rock formations, geological structures, the order of their formation, and topographic conditions. The geological map must also display the geological/tectonic history, the site name and distribution, its stratigraphic position using different colours/symbols, and a photo of the site. The writing system includes geopark locations based on UNESCO map standards, geological setting, main geological arguments and headlines, type of geological interest/level of significance table, geological map with sites, geological main feature, geological history/evolution, and distinctive geological features. A list of geological sites, in the form of the number and distribution of geological sites and description files for selected geological sites. Justification of the international significance, unique global value, scientific tradition and bibliography.

In the Kebumen Geopark, there are 13 geosites of international value. In the northern part ten geosites are found; *radiolaria* paleontology of geological interest includes geosite G1 (Exotic blocks of bedded *radiolarian* chert, Sadang Wetan), G3 (Exotic blocks of *radiolarian* chert and calcareous red claystone, Putri Hill), and G15 (Exotic blocks of chert and calcareous red claystone, Wagirsambeng Hill). History of Geoscience interests are G4 (Exotic blocks of pillow lava and *radiolarian* chert, Muncar River) and G5 (Exotic blocks of mica schists, Brenkok River). The geological interest of Igneous petrology is G7 (Exotic blocks of ophiolites, Lokidang River). Geological structure and tectonic interest include G10 (Columnar-jointed diabase, Parang Hill) and G14 (Exotic blocks of phyllites, Sipako Hill). The geological interests of *nummulite* paleontology are G11 (Olistolith of *nummulitic* limestones, Karangsembung Formation) and G16 (Olistolith of coral limestones, Jatibungkus Hill). Meanwhile, international significance in the southern part of the geopark of the karst area with geohydrological interest are geosites G27 (Jatijajar cave complex), G28 (Barat Cave), and G30 (Petruk Cave).

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