



## Utilization of Geodiversity of Mount Gamalama Eruption Products as Geotourism Activities on The Batu Angus Geotrail, Aspiring Ternate Geopark

Abdul Kadir D Arif <sup>1✉</sup>, Ida Bagus Oka Agastya <sup>2</sup>, Reza Permadi <sup>2,5</sup>, Rizal Marsaoly<sup>3</sup>, dan Ida Kurnia Waliyanti <sup>4</sup>

<sup>1</sup> Ikatan Ahli Geologi Indonesia Pengurus Daerah Maluku Utara / Universitas Muhammadiyah Maluku Utara, Ternate, Indonesia, Email : -

<sup>2</sup> Ikatan Ahli Geologi Indonesia, Jakarta, Indonesia, Email : -

<sup>3</sup> BP Aspiring Geopark Ternate, Ternate, Indonesia, Email : -

<sup>4</sup> Program Studi Teknologi, Fakultas Petanian dan Perikanan, Universitas Muhammadiyah Maluku Utara, Ternate Indonesia, Email : -

<sup>5</sup> Universitas Khairun Ternate, Ternate, Indonesia, Email : -

✉ Korespondensi : Abdul Kadir D Arif, Universitas Muhammadiyah Maluku Utara  
Email : [deddygeo.arif@gmail.com](mailto:deddygeo.arif@gmail.com)

### Info Artikel :

Artikel Penelitian     Artikel Pengabdian     Riview Artike

\*Diterima : 14 Juni 2024    \*Disetujui : 19 Juli 2024    \*Publikasi On-Line : 20 Juli 2024

## Abstrack

*Mount Gamalama is an active strato-type volcano composed of volcanic material consisting of lava, pyroclastics and lahars. Geographically, it is located at 0° 48' N and 127° 19.5' E with a height of 1715 meters above sea level. Administratively it is located in Ternate City, North Maluku Province. The first known eruption was in historical times in 1538. The eruption activities of Gamalama Volcano produced various volcanic materials which ultimately became a geological diversity on Ternate Island. Where the identified geodiversity consists of rock types, landscapes, beaches, hot springs and underwater geology which are very beautiful and interesting. In an effort to support the development of geotourism activities in the Aspiring Ternate geopark area, research is needed regarding the use of geological diversity, especially in the Batu Angus Geotrail, to provide an overview of how it can be utilized in geotourism activities and at the same time create opportunities for economic growth. This research uses a qualitative approach utilizing the inventory of geological diversity issued by the Geological Agency, 2017 with mapping and field observations related to geological diversity and its use in geotourism activities. The geological diversity resulting from the eruptive activity of Mount Gamalama, namely producing aa lava flow, blocky lava, spatter cone, spatter vent, lava tumuli, hornito lava, lava tube, channel lava, blocky lava flow, blocky lava smoother, accreted lava, lava walls and fracture. The geological diversity contained in the Batu Angus Geotrail is used for geotourism activities in the form of trekking activities, sport tourism activities (trail running, jogging, gymnastics, yoga), adventuring, research activities, jeep tours, Geo-Edu (field trips and excursions), art attraction stages & culture and conservation activities. Utilization of the geological diversity of eruption products from Mount Gamalama provides opportunities for local communities and regional governments to develop sustainable tourism activities in the form of geotourism.*

**Keyword:** Geotourism, Geotrail, Batu Angus, Ternate, Geopark

## I. INTRODUCTION

Mount Gamalama is an active strato-type volcano composed of volcanic material consisting of lava, pyroclastics and lahars. Geographically, it is located at 0° 48' N and 127° 19.5' E with a height of 1715 meters above sea level. Administratively it is located in Ternate City, North Maluku Province. The first known eruption was in historical times in 1538. Gamalama volcano is formed in complex tectonic areas which are built by interactions between the Philippine plate in the north, the Pacific plate in the east, the Eurasian plate in the west, and the Indo-Australian plate in the south [4, 17]. Gamalama volcano has an eruption interval that takes 50 years and is the shortest in one year. Gamalama Volcano eruptions usually produce a space in the crater core that is almost always magmatic, except for the 1907 eruption that occurred on the eastern hill (next to the eruption) and produced lava (Batu Angus) all the way to the beach [5]. The eruption activities of Gamalama Volcano produced various volcanic materials which ultimately became a geological diversity on Ternate Island. Where the identified geodiversity consists of rock types, landscapes, beaches, hot springs and underwater geology which are very beautiful and interesting. In an effort to support the development of geotourism activities in the Aspiring Ternate geopark area, research is needed regarding the use of geological diversity, especially in the Batu Angus Geotrail, to provide an overview of how it can be utilized in geotourism activities and at the same time create opportunities for economic growth.

## II. LITERATURE REVIEW

### Geotourism Concept

In 2010, Newsome & Dowling proposed one of the most widely used definitions of geotourism: "Geotourism is a form of tourism to natural areas that focuses specifically on geology and landscapes. It promotes tourism to geosites, conservation of biodiversity, and understanding of earth sciences through appreciation and learning. This is achieved through independent visits to geological features, use of geo trails and viewpoints, guided tours, geo activities, and support of geosite visitor centers."

Emphasizing that knowledge of geology is essential for a full understanding of the geological processes occurring in a particular area or region, and for this reason, geotourism uses the 'ABC' approach, meaning that the Abiotic components (geology and climate) determine the Biotic components (flora and fauna), and the combination of both determines the Cultural elements, such as the lifestyle of the community [8]. One of the objectives of implementing the concept of geotourism is to promote its importance and provide protection for geoheritage [10].

Referring to the Regulation of the Minister of Energy and Mineral Resources Number 1 of 2020, geoheritage is geological diversity that has more value as a heritage because it is a record of what has or is happening on earth, which because of its high scientific value, is rare, unique, and beautiful, so it can be used for research and earth education purposes. Closely related to the relationship between the implementation of geotourism and the preservation of geological heritage. Geotourism also plays an important role in the preservation of geoheritage (geoconservation) by utilizing educational tourism activities that are useful in providing environmental incentives and sustainable economic benefits [6, 9].

Geotourism on Ternate Island involves the exploration and appreciation of its geoheritage, which includes volcanic landscapes, coastal formations, and unique geofeatures. Geotourism on Ternate Island can offer visitors the opportunity to learn about the volcanic history of the island, its geological features, and their significance in the context

of geology and natural history. Geotourism on Ternate Island can also contribute to the local economy through the development of tourism infrastructure and services, such as guided tours, accommodation, and local businesses. In addition, geotourism on Ternate Island can encourage environmental conservation by raising awareness of the importance of preserving and protecting its unique geosites. By involving local communities in the planning and management of geotourism activities, Ternate Island can maximize the benefits of tourism while ensuring the preservation of its geological heritage and supporting the livelihoods of local residents.

Based on previous research conducted by Arif et al., 2023 [1] developed a geotourism route named the Spices Tour Geotourism geotrail consisting of 5 (five) geotrail routes, namely Geourban Tourism Geotrail, Tolire Geotrail, Hiri Island Geotrail, Batu Angus Geotrail, and Kampung Tua Geotrail. Each geotrail has its own advantages and themes, all of which highlight the natural and cultural richness of the spice city owned by Aspiring Ternate Geopark. Starting from the geological diversity on Ternate Island and Hiri Island, the biodiversity of the mangrove ecosystem, birdwatching, spice agrotourism to historical tourism such as the Ternate Sultanate Palace, historical Portuguese-Dutch buildings, and megalithic prehistoric traces. In this study, researchers focused on the use of geological diversity as a geotourism product in the Batu Angus geotrail area (Figure 1).

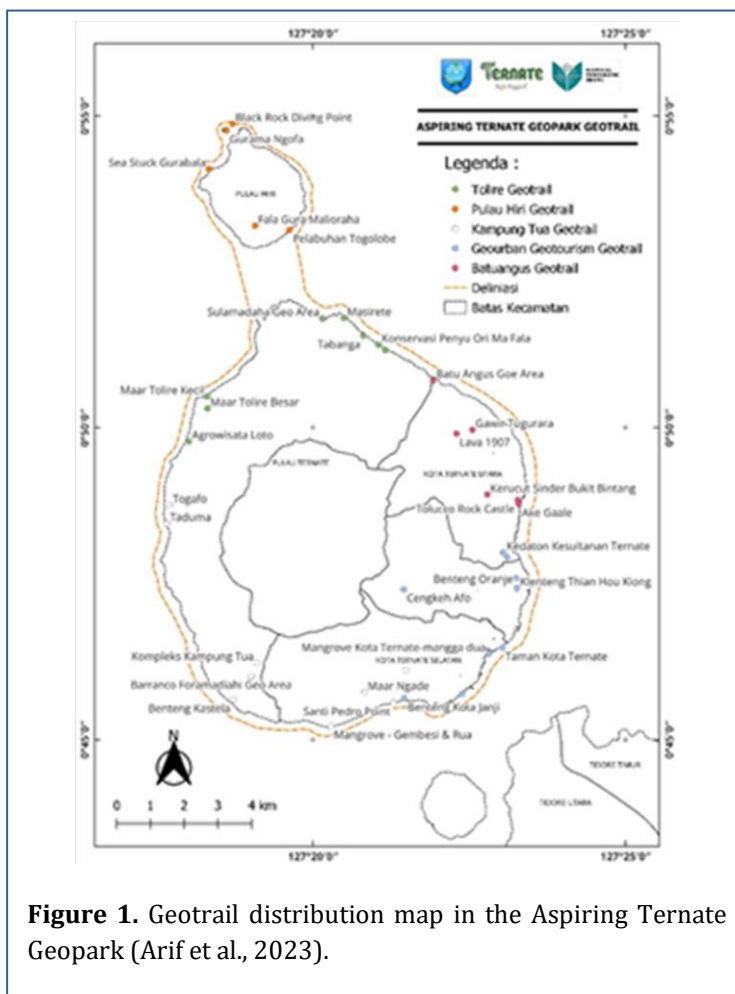


Figure 1. Geotrail distribution map in the Aspiring Ternate Geopark (Arif et al., 2023).

**Regional Geology of Ternate Island**

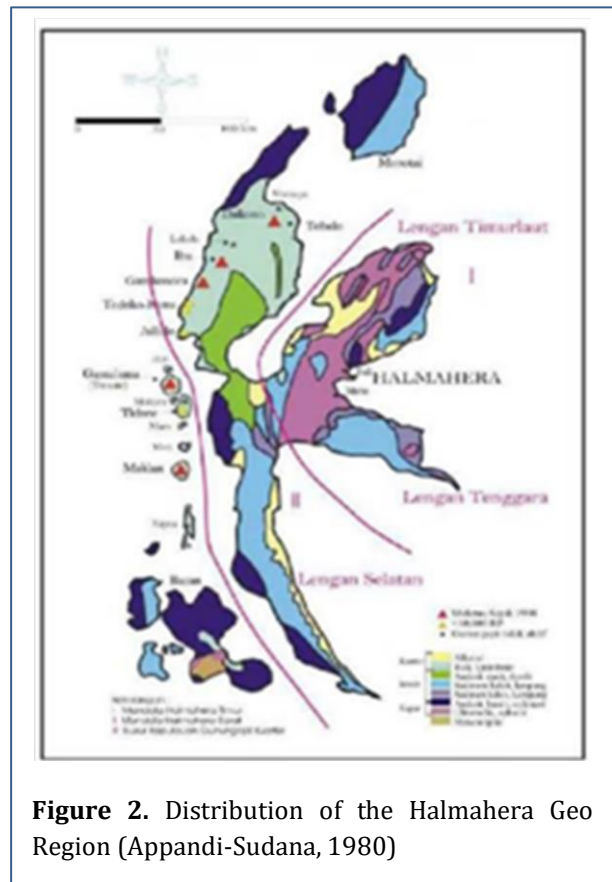
Ternate Island is part of the Quaternary volcanic region, consisting of small islands west of Halmahera and a series of Quaternary volcanoes, some of which are still active. Western Halmahera is part of a young volcanic belt composed of Tertiary to Quaternary volcanic and sedimentary rocks, which is an extension of Morotai through West Halmahera, Ternate, and Tidore to Bacan. Eastern Halmahera is an extension eastward through Gebe Island and towards the northern part of the Bird's Head of Papua. In addition, in Central Halmahera, an active volcano that crosses the islands of Ternate and Tidore is now located west of the western arm of Halmahera, indicating a shift in volcanic activity westward of about 30 km, which must have occurred in the mid-Late Pleistocene [11]. This section consists of the northeastern and southeastern arms of Halmahera, which are outer arcs composed of ultramafic rocks, Tertiary sediments, and Quaternary sediments in the coastal area [2]. Topographically, Ternate Island is shaped like a circular cone (stratovolcano) with a diagonal area of 13 km from north to south, 11 km from west to east, and a 55 km long island boundary covering lowlands and slopes. In addition, the topographic characteristics of most of its areas are mountains and hills, and there are volcanic and coral islands [17]. Ternate Island is

composed of volcanic material from Mount Gamalama in the form of andesite, basalt, pyroclastic, and lahar deposits, which are part of the Quaternary volcanic region consisting of small islands west of Halmahera and a series of Quaternary volcanics, some of which are still active.

**Regional Stratigraphy of Ternate Island**

Regionally [2] Ternate Island is a Holocene volcanic island arc, which is composed of volcanic material from Mount Gamalama in the form of andesite, basalt, pyroclastic, and lahar deposits. Ternate is located in the central-proximal facies. Volcanism in Ternate began in the Quaternary as part of the Halmahera island arc, which is divided into three facies, namely the old Gamalama facies, the mature Gamalama facies, and the young Gamalama facies [18].

- Old Gamalama is in the southern part of the Gamalama mountain landscape, or right in the administrative area of Ternate Pulau District. Composed of massive old lava, ignimbrite, lahar deposits, altered lava, pyroclastic deposits, and andesite intrusion plugs.
- Adult Gamalama, exposed in the administrative areas of North Ternate District, South Ternate District, and West Ternate District. Composed of andesite block flow lava, massive lava, lahar deposits, pyroclastic fall deposits, litoral eruption deposits, and pyroclastic flow deposits.
- Young Gamalama, exposed in the administrative areas of Central Ternate District and South Ternate District. Composed of massive lava, andesite block deposits, basaltic andesite lava, young lava deposits - andesite chunks, splash breccia - volcanic eruptions, tolire phreatic deposits, pyroclastic flow deposits, young pyroclastic flow deposits, old pyroclastic flow deposits, lava 1 - andesite block, lava 4 - andesite block, lava 5 - andesite block, lagoon phreatic deposits, and lava block 1763.
- Surface deposits, composed of alluvium and pyroclastic debris.



**Figure 2.** Distribution of the Halmahera Geo Region (Appandi-Sudana, 1980)

Marine sediment deposits, in the form of exposed coral reefs on Tobololo Beach, Tabanga Beach, The history of the eruption of Mount Gamalama shows that the eruption occurred several times, starting in 1538 with an effusive eruption, and then in 1687 there was also an effusive lava flow to the west. A very effusive or explosive volcanic eruption can damage the surrounding environment [7]. The eruption of Mount Gamalama occurred again in 1772 and claimed 40 lives. In 1775, it erupted again with a lava flow to the east. Gamalama has been active for decades, and its largest eruption history occurred in 1775, which claimed around 141 lives and destroyed several villages around the mountain [13]. In 1839 and 1843, the lava flow occurred again; the lava flow headed north, while in 1864 the lava flow headed northwest. The Batu Angus rock unit of Mount Gamalama occurred in 1907. The lava flows to the northeast and flows to the beach [3].

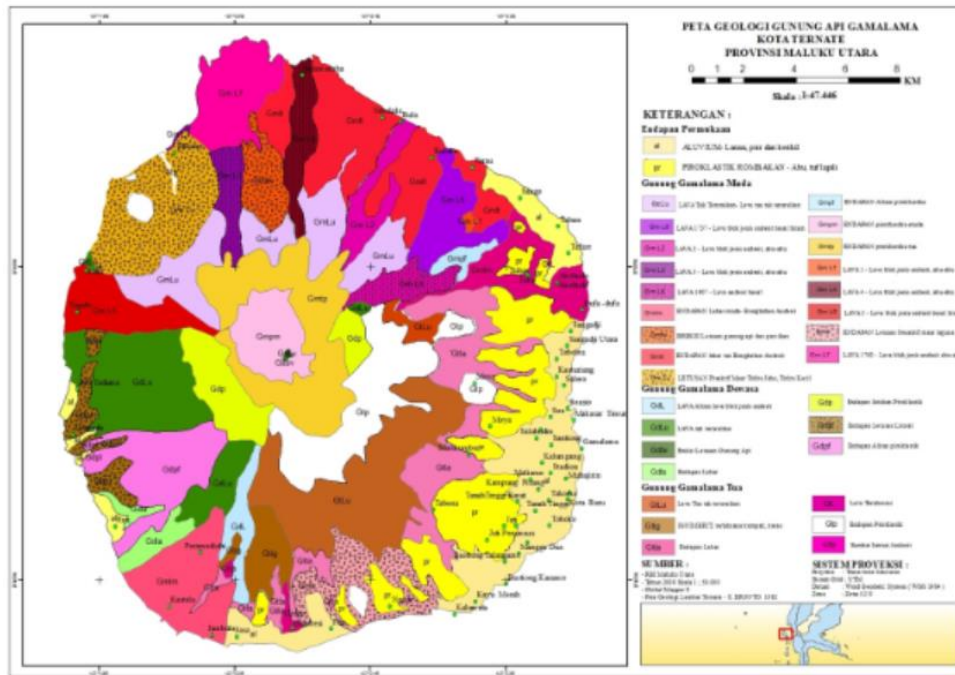


Figure 3. Map of volcanoes and facies of gamalama volcano (Bronto, 1982)

### III. DATA AND METHOD

This research will discuss about utilization of geodiversity of mount gamalama eruption products as geotourism activities on the batu angus geotrail, aspiring ternate geopark uses a qualitative approach utilizing the inventory of geological diversity issued by the Geological Agency, 2017 [15] with mapping and field observations related to geological diversity and its use in geotourism activities. Data collection was carried out based on literature studies, previous research data, and in addition, observations were made in the field, including taking photos and describing and mapping the sites that would later become geotrail routes.

Through an inventory matrix approach and characterization of geological diversity, it can be seen that any geological diversity that exists in the Batu Angus geotrail can be used for education, tourism or conservation purposes. Next, a synthesis is carried out to produce conclusions and suggestions which can later be used in utilizing geological diversity as a geotourism object in the Batu Angus area to support the development of the Aspiring Geopark Ternate (Figure 4).

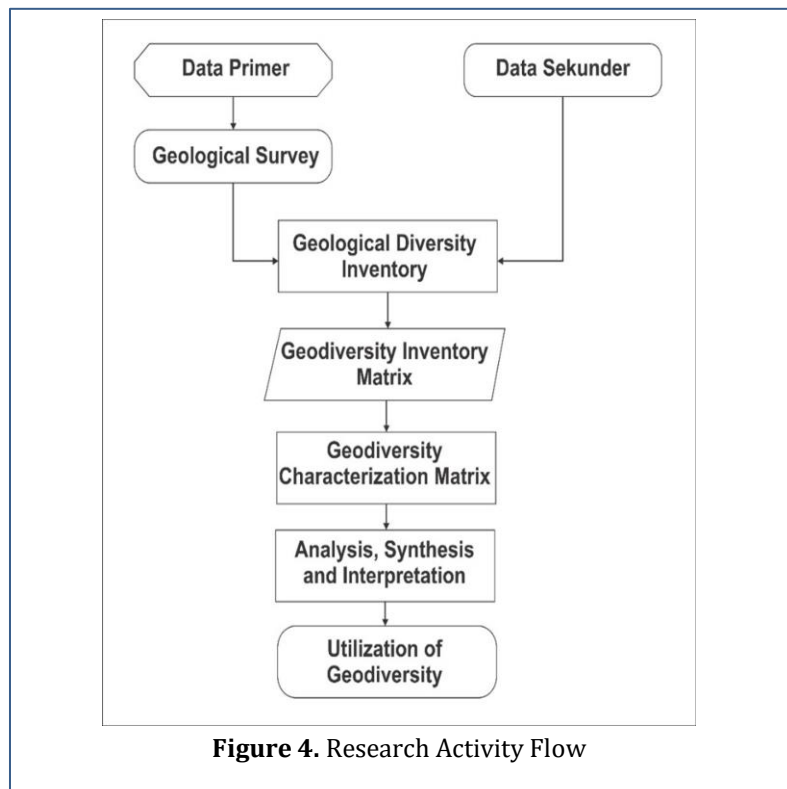


Figure 4. Research Activity Flow

## IV. RESULT AND DISCUSSION

### Geological Diversity Inventory

Based on field observation activities regarding the geodiversity in the Batu Angus Geotrail, several geosites were obtained with the following geological diversity (Table 1).

### Geo Area Batu Angus

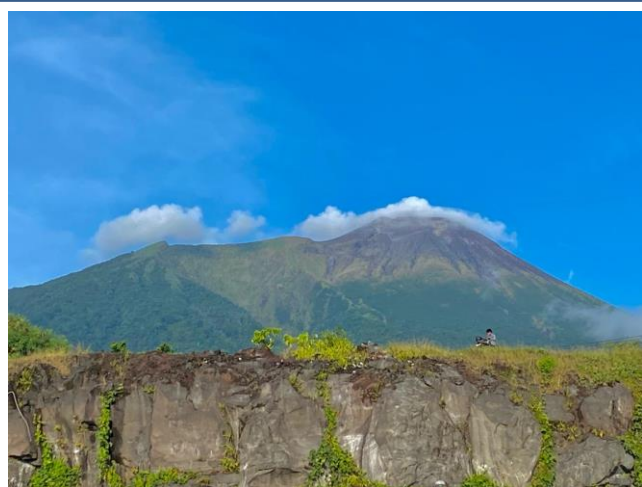
The geodiversity exposed in the Batu Angus geosite complex consists of volcanic landscapes (lava flow areas), which form the interior of lava, especially in the products of 1907. This Geo Area is also part of the groundwater support of Ternate City, with 3 BWS drill points. Based on the results of the petrographic analysis in the laboratory, it was concluded that Batu Angus contained plagioclase minerals, pyroxene, opaque minerals, and glass minerals, so that it can be concluded that Batu Angus is one of the andesite pyroxene igneous rocks [3]. The geological features found are AA lava flows, blocky lava, hornito lava, and lava tumuli. While the existing landscape features are volcanic slope landscapes. The utilization of geological sites is in the form of camping grounds, education, tourist destinations, conservation, and sport tourism (Figure 5).



**Figure 5.** Geodiversity At Batu Angus Geosite Geo Area; Accretion Lava; Lava Tube; And Lava Ball North Ternate

### Geosite Gawir Tugurara

Tubo Geodiversity in the form of the Tugurara River, which is the main river that is the depositional path of Gamalama's lahar deposits, has a history of disasters that occurred in 2015 with fatalities and some that have not been found until now. This location also shows how lava deposits form unique escarpment morphology and is a story of how thick the lava flow is from Mount Gamalama. The geological features found are in the form of Tugurara lahar flow deposits, with the utilization of geological sites in the form of educational activities related to disasters, tourism, and environmental conservation (ecology) (Figure 6).



**Figure 6.** Appearance of the tugurara escarpment with mount gamalama in the background, with show lava flow structures.

### Geosite Rock Castle Tolucco

The geodiversity of Rock Castle Tolucco consists of young Gamalama pyroclastic deposits, volcanic intrusion hills exposed as fortifications by the Portuguese. The geological features found are intrusion hills composed of andesite, volcanic foot landscapes, and the cultural diversity of Portuguese-era forts. The utilization of geological sites is in the form of cultural heritage and geological and historical educational activities (Figure 7).



**Figure 7.** The appearance of geodiversity at the Ake Ga Ale geosite in the form of the emergence of spring water sources on the coast and Rock Castle Tolucco.

### Geosite Ake Ga Ale

Geodiversity in the Sangaji area is the Ake Ga Ale spring, a geological phenomenon where the main groundwater source has emerged, which has been utilized by PDAM Kota Ternate to meet the clean water needs in the city of Ternate. The aquifer system that has developed is the "coastal aquifer" which is composed of volcanic mudflow and alternates with coastal deposits. The geological feature found is the Ake Ga Ale Spring, where the utilization of this geological site is as a source of clean water for the city of Ternate (Figure 7).

### Geosite Bukit Bintang

Geodiversity located in the North Sangaji area is a hill formed from the old volcanic activity of Mount Gamalama, which forms a cinder cone with a height of approximately 94 meters above sea level. The geological features found are layers of pyroclastic deposits and volcanic cone landscapes. The use of this geological site as a tourist destination and view point towards Ternate City (Figure 8).

### Characterization of Geodiversity

The results of the geodiversity inventory were continued by characterizing the geodiversity in the Batu Angus Geotrail. The purpose of this characterization is to see how the geodiversity will be in the classification, ranking, assessment, meaning, and clustering categories in an effort to utilize it both as a geoheritage and in the development of geotourism and geoparks. From the results of the characterization of geodiversity in the Batu Angus Geotrail, it was found that the classification category of



**Figure 8.** Appearance of Ternate City from the Bukit Bintang Cinder Cone Geosite.

geodiversity in the Batu Angus Geotrail is dominated by the diversity of volcanic landscapes, volcanic rock areas, internal processes in the form of volcanic eruption activity in Gamalama, external processes in the form of weathering and erosion, active tectonics, and quaternary geological evolution, where the evolution has been ongoing until now. The ranking of geological diversity in the Batu Angus Geotrail is included in the high-leading geological diversity (Table 2).

In terms of the assessment category of geodiversity, it consists of high-value geodiversity-leading because it contains scientific records, specific geological settings or landscapes, meaningful evidence of important geological events, and has more or leading ecological functions that can be utilized for research, education, understanding nature and culture, conservation, and sustainable tourism that can trigger the growth of local and national economic value. While only one has medium value, namely the Ake Gaale geosite, because it contains important scientific records that can only be utilized for research and education.

In terms of the category of meaning of the geodiversity of the geosite in the Batu Angus Geotrail, in general, it has a scientific meaning where it is a record and evidence of the evolution of the earth related to Ternate Island and especially the activity of the Gamalama volcano; an aesthetic meaning because it has the uniqueness and natural beauty of volcanic activity and beautiful landscapes; a recreational meaning where the existing geosite has the potential to be developed as a tourism activity, namely geotourism; and a cultural meaning because some geosites have historical and cultural aspects related to the Ternate Sultanate and the colonial period in Indonesia.

Meanwhile, based on the geosite clustering category on the Batu Angus Geotrail, it has clustering as an artifact of the earth's history, where geodiversity has the ability to explain the history of the earth, the information of which can be used as a basis for managing geological component resources, including predictions of future geological events as found in almost all existing geosites. Clustering is a key record of a geological event that can provide information about the phenomenon of the origin and development of geology that forms geodiversity, especially because the geodiversity is rare such as the Batu Angus Geo Area geosite. Clustering as a special landscape where the geological diversity in the Batu Angus Geotrail is also inseparable from the phenomenon of volcanic activity on Mount Gamalama, based on its aesthetic value, it can be determined that its geological diversity is unique, such as the Lava 1907 geosite, Batu Angus Geo Area, Tolluco Rock Castle, Bintang Hill Cinder Cone, and Tugurara Gawir. Meanwhile, ecological clustering is where geodiversity has an influence on biological life and other diversity, so that the close relationship between geology and biology as well as the environment can be depicted in geodiversity, such as in the Lava 1907 geosite, Batu Angus Geo Area, and Ake Gaale.

### **Geotourism Activities at Batu Angus Geotrail and Its Development Potential**

Based on the research that has been conducted on the development of spice tour geotourism geotrail in Aspiring Geopark Ternate, it states that Batu Angus geotrail has the potential to be developed as geotourism, where geotrail development can be a new tourism package option in the Geopark area, thus increasing the diversification of tourism packages [1]. The Batu Angus thematic geotrail is a geotrail located in the north of Ternate Island, where Batu Angus means lava flow in the local language. This geotrail can offer trekking and other outdoor adventure activities by following the trail of the eruption of Mount Gamalama. Through lava flow products, the Batu Angus geotrail can take us to travel through time and learn about disaster mitigation and cultural history created from the interaction of nature and humans. This geotrail has a travel time of about 2 hours and a distance of up to 7.8 km, accessible by motorized vehicles and cars (Figure 9).



**Figure 9.** Geotrail Map of Batu Angus Aspiring Ternate Geopark.

The geological diversity contained in the Batu Angus Geotrail is used for geotourism activities in the form of trekking activities, sport tourism activities (trail running, jogging, gymnastics, yoga), adventuring, research activities, jeep tours, Geo-Edu (field trips and excursions), art attraction stages & culture and conservation activities. The utilization of geodiversity in Batu Angus Geotrail can also be utilized as a thematic geotourism activity, namely visiting the traces of Mount Gamalama's eruption activity and the existing cultural history, wildlife observation activities in the geosite area, field trip activities for the introduction of the dangers and risks of Mount Gamalama disasters, volcanology and geology research laboratories, and the utilization of unique geological features such as lava flows as artistic objects. In addition, by referring to the characterization of geodiversity in Batu Angus Geotrail, it has the potential to be developed with scientific, aesthetic, recreational, and cultural meanings.

With the potential for geodiversity in the form of the Gamalama Volcano phenomenon, the Batu Angus Geotrail has the potential to develop a tourist market for nature lovers, researchers, geology practitioners, volcano researchers, and adventure tourism enthusiasts. Supporting facilities in the form of fairly accessible road connectivity make the development of the Batu Angus Geotrail very possible, with a travel distance and duration of activities ranging from 2–3 hours and a location that is quite close to the city center and other tourist attractions and adequate public facilities. The challenges of future development that are needed are in terms of human resources, especially from the side of geotourism guides who can properly explain the geological, biological, and cultural diversity in the Batu Angus Geotrail, and also the next challenge to be developed in the form of making geotourism packages with affordable storytelling and prices for tourists.

## V. CONCLUSION

The geological diversity resulting from the eruptive activity of Mount Gamalama, namely producing aa lava flow, blocky lava, spatter cone, spatter vent, lava tumuli, hornito lava, lava tube, channel lava, blocky lava flow, blocky lava smoother, accreted lava, lava walls and fracture. The geological diversity contained in the Batu Angus Geotrail is used for geotourism activities in the form of trekking activities, sport tourism activities (trail running, jogging, gymnastics, yoga), adventuring, research activities, jeep tours, Geo-Edu (field trips

and excursions), art attraction stages & culture and conservation activities. Utilization of the geological diversity of eruption products from Mount Gamalama provides opportunities for local communities and regional governments to develop sustainable tourism activities in the form of geotourism. The development of geotourism from the utilization of geological diversity in the Batu Angus Geotrail can be a diversification of the tourism market in addition to eco-tourism and conventional tourism that already exist in Ternate City.

## V. CONCLUSION

We would like to express our gratitude to the team that supported this research activity, such as the Aspiring Ternate Geopark Management Agency, Bapelitbangda Ternate City, the Indonesian Association of Geologists and the North Maluku Regional Management of the Indonesian Association of Geologists.

## REFERENCES

1. Arif, A.K.D., Agastya, I.B.O., Permadi, R., Marsaoly, R. (2023) Development of Spices Tour Geotourism Geotrail in Supporting Geotourism Activities at Aspiring Ternate Geopark. Geo Tourism Internasional Conference 2023 Geopark: Sustainable Journeys, Thriving Destinations.
2. Appandi, Sudana, 1980 Peta Geologi Regional Ternate, KESDM.RI
3. Awal, S., Kamur, S., Ajid,. 2020. The Phenomenon of existence Batu Angus on the eastern slopes of mount Gamalama Ternate Island North Maluku, Journal of Physics : Conference Series doi: 10.1088/1742-6596/1511/1/012084
4. Andreas, A., & Putra, A.: Perbandingan Karakteristik Batuan Beku Erupsi Gunung Gamalama dan Gunung Talang. Jurnal Fisika Unand, 7(4), 293-298 (2018).
5. Badan Penanggulangan Bencana Kota Ternate, 2011.
6. Bentivenga, M., Cavalcante, F., Mastronuzzi, G., Palladino, G., & Prosser, G. (2019). Geoheritage: The Foundation For Sustainable Geotourism. Geoheritage, 11(4), Hal. 1367-1369. <https://doi.org/10.1007/S12371-019-00422-W>.
7. Carra B B, Clarke B A and Vitturic M M 2019 Volcanic conduit controls on effusive explosive transitions and the 2010 eruption of Merapi Volcano (Indonesia) AGU Journals 43 595-602
8. Dowling, R.K. Global geotourism—An emerging form of sustainable tourism. Czech J. Tour. 2013, 2, 59–79. [CrossRef]
9. Ehsan, S., Leman, M. S., & Ara Begum, R. (2012). Geotourism: A Tool For Sustainable Development Of Geoheritage Resources. Advanced Materials Research, 622-623, Hal. 1711-1715. <https://doi.org/10.4028/Www.Scientific.Net/Amr.622-623.1711>
10. Hasria, Hasan, E.S., Masri, Haraty, S.R., Okto, A., Hamimu, L. (2022). Pemetaan Sebaran Geosite untuk Pengembangan Kawasan Geowisata Air Terjun Ulunese melalui Pemberdayaan Masyarakat Lokal di Kecamatan Kolono Timur Kabupaten Konawe Selatan, Provinsi Sulawesi Tenggara. Jurnal Abdidas Volume 3 Nomor 6 Tahun 2022 Halaman 994-958.
11. Hall, R., Audley-Charles, M.G., Banner, F.T., Hidayat, S., Tobing, S.L. 1998. Late Paleogene-Quaternary geology of Halmahera, Eastern Indonesia: initiation of a volcanic island arc. Journal of the Geological Society, London, Vol. 145, pp. 577-590.
12. Menteri Esdm. (2020). Peraturan Menteri Energi Dan Sumber Daya Mineral Republik Indonesia Nomor 1 Tahun 2020 Tentang Pedoman Penetapan Warisan Geologi (Geoheritage). Kementerian Esdm. Jakarta. 20 Hal.

13. Mei W T S, Sari M I, Fajarwati A and Safitri D 2016 Assessing the Social Economic and Physical Vulnerabilities to Gamalama Volcano. International Conference on Geography and Education Proceeding ICGE 2016
14. Newsome, D.; Dowling, R.K. Setting an agenda for geotourism. In Geotourism: The Tourism of Geology and Landscape; Newsome, D., Dowling, R., Eds.; Goodfellow Publishers Limited: Oxford, UK, 2010; pp. 1-12.
15. Pusat Survey Geologi. (2017). Petunjuk Teknis Asesmen Sumberdaya Warisan Geologi. Badan Geologi. Bandung. 32 Hal.
16. Rahman, R. A., & Firmansyah, D. P. 2010. Identifikasi Tingkat Risiko Bencana Letusan Gunungapi serta Arahan Mitigasi Bencana di Wilayah Kota Ternate (Doctoral dissertation, Fakultas Teknik Unpas)
17. Setyowati, D.L., Suharini, E., Djafar, F.A. 2021. The Local Wisdom of the Takome Community in Facing the Gamalama Volcano Eruption Disaster. Advances in Social Science, Education and Humanities Research, volume 578
18. Bronto,S.,1982 Fasies Gunungapi Gamalama, PVMBG.



**Table 1.** Geodiversity Inventory Matrix on The Batu Angus Geotrail

No	Name of Geodiversity Objects	Location	Coordinate	Featured Geological Components (Minerals/Rocks/Fossils/Geomorphology/Geological Processes)	Description of Potential Geoheritage
1	Lava 1907	Sango, District of North Ternate City, Ternate City, North Maluku	X 127.371601; Y 0.831768	A. Geomorphology B. Rocks C. Geological Processes	<p><b>A.</b> The dominant landscape at the location is lava flow, lava channel and lava tumuli as a result of the effusive eruption of Mount Gamalama in 1907 flowing towards the northeast.</p> <p><b>B.</b> The rocks are composed of lava with a blocky structure, hornito lava, accretionary lava showing several fractured structures with andesitic rock types.</p> <p><b>C.</b> This geodiversity is formed from the geological process of the Gamalama volcanic activity which produces lava flows, after freezing occurs and undergoes further geological processes, leaving behind a lava flow landscape as if it were a lava savanna.</p>
2	Batu Angus Geo Area	Kulaba, Ternate Island District, Ternate City, North Maluku	X 127.365436; Y 0.845995	A. Geomorphology B. Rocks C. Geological Processes	<p><b>A.</b> The dominant landscape at the location is lava flow, lava channel and lava tumuli as a result of the effusive eruption of Mount Gamalama in 1907, 1737 and old lava deposits flowing north - northeast.</p> <p><b>B.</b> Rocks are composed of lava with andesitic rock types of AA lava flow, blocky lava, spatter cone, spatter vent, lava tumuli, hornito lava, lava tube, Lava channel, blocky lava flow, blocky lava smoother, accretion lava (Ball), interior lava (Lava Wall), fracture (Fracture).</p> <p><b>C.</b> Geological processes are influenced by the material products of the Gamalama volcano, the Young Gamalama facies (Bronto, 1982) consists of Young Lava Deposits, Lava 1907, Lava 1737 and Old Lava Deposits.</p>
3	Tolluco Rock Castle	North Sangaji, District of North Ternate City, Ternate City, North Maluku	X 127.387975; Y 0.813998	A. Rocks B. Geological Processes	<p><b>A.</b> Rocks consist of pyroclastic deposits of Young Gamalama, a volcanic intrusion hill exposed as a fortification by the Portuguese.</p> <p><b>B.</b> The geological process that occurred at the location was the formation of a hill due to volcanic intrusion and after that pyroclastic deposits were deposited from the eruption of Young Gamalama.</p>
4	Bintang Hill Sinder	Dufa Dufa,	X 127.379798; Y	A. Geomorphology	<b>A.</b> The landscape is in the form of a hill formed from the

	Cone	District of North Ternate City, Ternate City, North Maluku	0.815482	B. Geological Processes C. Rocks	volcanic activity of Mount Gamalama in the form of a cinder cone. <b>B.</b> The geological process is influenced by the volcanic activity of Mount Gamalama. <b>C.</b> The constituent rocks are in the form of pyroclastic deposits from the eruption of Mount Gamalama.
5	Gawir Tugurara	Tabam, District of North Ternate City, Ternate City, North Maluku	X 127.375805; Y 0.832772	A. Geomorphology B. Rocks C. Geological Processes	<b>A.</b> The landscape in the form of a scarp in the form of the Tugurara River, which is the main river that is the depositional path of the Gamalama lahar deposits and has a history of disasters that occurred in 2015 with fatalities and some that have not been found until now. <b>B.</b> The constituent rocks in the form of lahar deposits such as andesitic boulders followed by sandy matrix from the eruption of Mount Gamalama. <b>C.</b> The geological process that formed the Tugurara scarp was influenced by the volcanic landscape of Mount Gamalama and pyroclastic deposits.
6	Ake Gaale	Sangaji, District of North Ternate City, Ternate City, North Maluku	X 127.388201; Y 0.812992	A. Geological Processes	<b>A.</b> Geodiversity Sangaji, namely Ake Gaale spring, as the main groundwater source that has been utilized by PDAM for clean water services in the city of Ternate. The aquifer system that develops in the "coastal aquifer" is composed of volcanic mudflow and transitional coastal deposits.

**Table 3.** Geoiversity Characterization Matrix on The Batu Angus Geotrail

No	Name Geosite	Location	Coordinate	Geodiversity Classification	Geodiversity Ranking	Geodiversity Assessment	Geodiversity Meaning	Geodiversity Clustering
1	Lava 1907	Sango, District of North Ternate City, Ternate City, North Maluku	X 127.371601; Y 0.831768	A. Volcanic landscape B. Volcanic rocks in the form of andesitic lava C. Internal processes in the form of volcanic eruptions and external processes in the form of weathering and erosion D. Active tectonics E. Quaternary geological evolution that is still ongoing today	Outstanding	High	Scientific Aesthetics Recreation	As an artifact of earth history; As a special landscape; As an ecological supporter
2	Batu Angus Geo Area	Kulaba, Ternate Island District, Ternate City, North Maluku	X 127.365436; Y 0.845995	A. Volcanic landscape B. Volcanic rocks in the form of andesitic lava C. Internal processes in the form of volcanic eruptions and external processes in the form of weathering and erosion D. Active tectonics E. Quaternary geological evolution that is still ongoing today	Outstanding	Outstanding	Scientific Aesthetics Recreation Culture	As an artifact of earth history; as a key record; As a special landscape; As an ecological supporter
3	Tolluco Rock Castle	North Sangaji, District of North Ternate City, Ternate City, North Maluku	X 127.387975; Y 0.813998	A. Volcanic landscape B. Volcanic rocks in the form of andesitic intrusions C. Internal processes in the form of igneous rock intrusions and external processes in the form of weathering and erosion E. Quaternary geological evolution that is still ongoing today	Very High	Outstanding	Scientific Aesthetics Recreation Culture	As an artifact of earth history; As a special landscape
4	Kerucut Sinder Bukit Bintang	Dufa Dufa, District of North Ternate	X 127.379798; Y 0.815482	A. Volcanic landscape B. Volcanic rocks in the form of pyroclastic deposits C. Internal processes in the form	Very High	High	Scientific Aesthetics Recreation	As an artifact of earth history; As a special landscape

		City, Ternate City, North Maluku		of volcanic eruptions and external processes in the form of weathering and erosion <b>E.</b> Quaternary geological evolution that is still ongoing today				
5	Gawir Tugurara	Tabam, District of North Ternate City, Ternate City, North Maluku	X 127.375805; Y 0.832772	<b>A.</b> Volcanic landscape <b>B.</b> Volcanic rocks in the form of andesitic lava flows <b>C.</b> Internal processes in the form of volcanic eruptions and external processes in the form of weathering and erosion <b>E.</b> Quaternary geological evolution that is still ongoing today	Very High	High	Scientific Aesthetics Recreation	As an artifact of earth history; As a special landscape
6	Ake Gaale	Sangaji, District of North Ternate City, Ternate City, North Maluku	X 127.388201; Y 0.812992	<b>A.</b> Volcanic landscape <b>B.</b> Volcanic rocks in the form of pyroclastic deposits <b>C.</b> Internal processes in the form of volcanic eruptions	High	Intermediate	Scientific Recreation	As a supporter of ecology