Promotion of responsible quarry development in line with Geopark principles in Itoigawa UNESCO Global Geopark, Niigata Prefecture, central Japan

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Abstract

Bodies of early Carboniferous to middle Permian limestone called Omi Limestone are widely distributed around Mt. Kurohime, Itoigawa City. Omi Limestone is not only a geological heritage of Itoigawa UNESCO Global Geopark with a high academic value, but also actively quarried for cement and carbide products, supporting industry and employment in Itoigawa for generations.

In 2020, local quarry companies announced a joint development plan for a new quarry. The basic principles of geopark activities are to conserve geological heritage and realize sustainable societies. Therefore, efforts must be made to minimize environmental impact, conserve natural resources and record those which may be lost. To that end, an academic investigation committee consisting of experts, academics and landowners was newly established within the Itoigawa Geopark Council. Under this system, several field surveys and committee meetings were held from 2020 to 2022.

To make effective use of limited natural resources and minimize the associated environmental impact, it is necessary to have opportunities for all stakeholders in the region to sit at the same table. The activity of this committee was the first opportunity for all stakeholders to exchange ideas about the balance between the conservation of natural resources and the local economy, based on the principles of UNESCO Global Geoparks. This is a significant and meaningful achievement of Itoigawa's geopark activities and represents a pioneering challenge involved in promoting responsible quarry development in line with Geopark principles for the Global Geopark Network.

Keywords: local resource conservation, responsible quarry development, Omi Limestone, Itoigawa UNESCO Global Geopark.

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Introduction

Itoigawa City records the history of the formation of the Japanese Archipelago (an island arc) and its geological diversity has nurtured rich ecosystems and culture. In recognition of its geological and cultural significance, Itoigawa Geopark became one of Japan's first three Global Geoparks (alongside Toya-Usu and Unzen Volcanic Area) in 2009. The year 2015 marked a significant milestone in the world of geological heritage conservation with the formal recognition of Global Geoparks as an official program by UNESCO. UNESCO Global Geoparks play a pivotal role in the conservation and promotion of Earth's geological heritage, fostering sustainable development, education and community engagement (UNESCO, 2015). The recognition as a UNESCO Global Geopark is contingent upon meeting specific criteria that reflect a commitment to geological heritage preservation, sustainable practices, and community involvement.

Mt. Kurohime is located in the central region of Itoigawa UNESCO Global Geopark and hosts a wide distribution of early Carboniferous to middle Permian limestone bodies called Omi Limestone (Nagamori et al., 2010). Omi Limestone is a geological heritage of high academic value, recording the growth of Paleo-Pacific reef-type limestone and environmental changes over 80 million years (Hasegawa and Goto, 1990). However, Omi Limestone is also actively quarried for cement and carbide products, supporting industry and employment in Itoigawa for generations. In 2020, as operation in the current quarry is nearing its end, local quarry companies announced a joint development plan for a new quarry. The basic principles of geopark activities are to conserve geological heritage and realize sustainable societies. Therefore, efforts must be made to minimize environmental impact, conserve natural resources and record those which may be lost. To that end, an academic investigation committee consisting of experts, academics and landowners was newly established within the Itoigawa Geopark Council to deliberate on the validity of the quarry's environmental impact assessment, as well as consider methods of investigation, recording, conservation and the impact on the lives of residents. Under this system, several field surveys and committee meetings were held from 2020 to 2022.

This paper describes the activities of the academic investigation committee on quarry development and outlines the pioneering challenges involved in promoting responsible quarry development in line with Geopark principles in Itoigawa UNESCO Global Geopark.

Geological background and topographical features of Mt. Kurohime

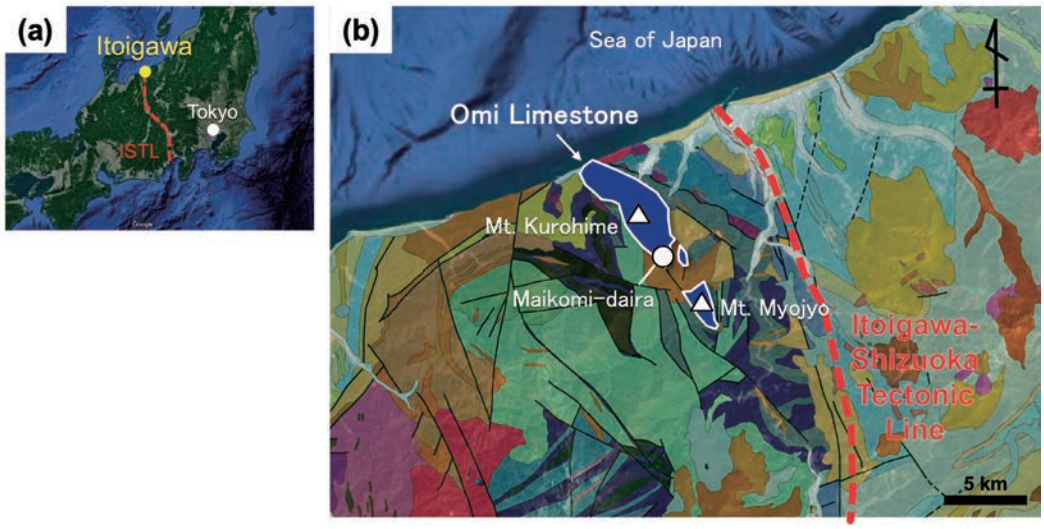

Fig. 1. (a) Index map showing the location of Itoigawa City (modified after Google map). (b) Generalized geological map around the centre of Itoigawa City (modified after Seamless Digital Geological Map of Japan published by Geological Survey of Japan, AIST). Highlighted blue shows the distribution of Omi Limestone. Location of the Itoigawa-Shizuoka Tectonic Line (ISTL) is shown by red line.

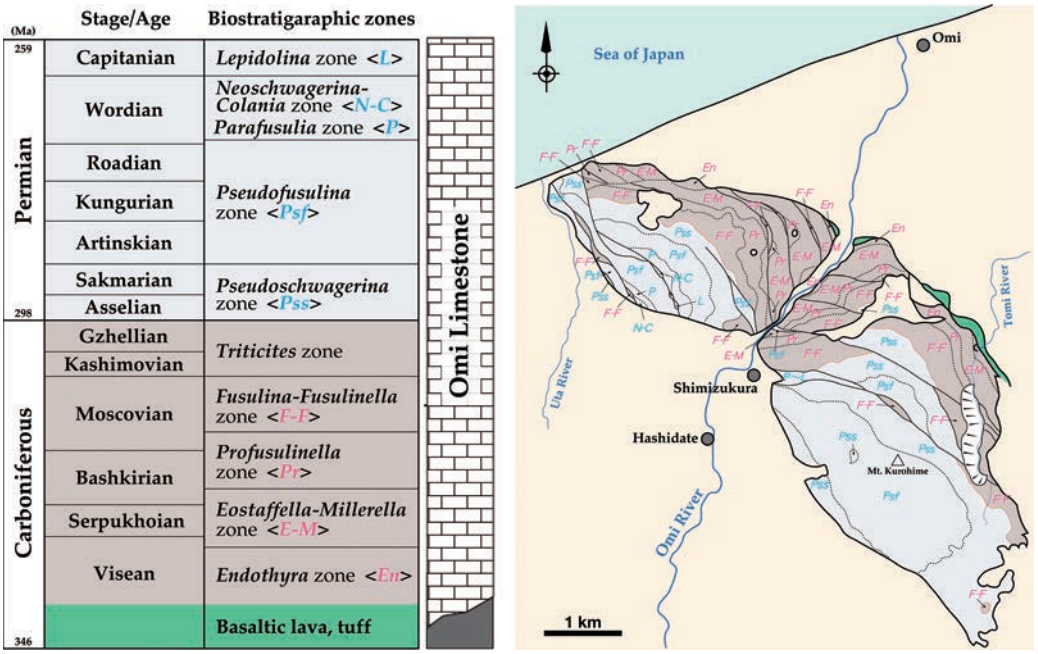

Fig. 2. Stratigraphic distribution and distribution map of fusulinids in Omi Limestone (Nagamori et al., 2010) after Hasegawa and Goto (1990). Stages and ages referred to Cohen et al. (2013).

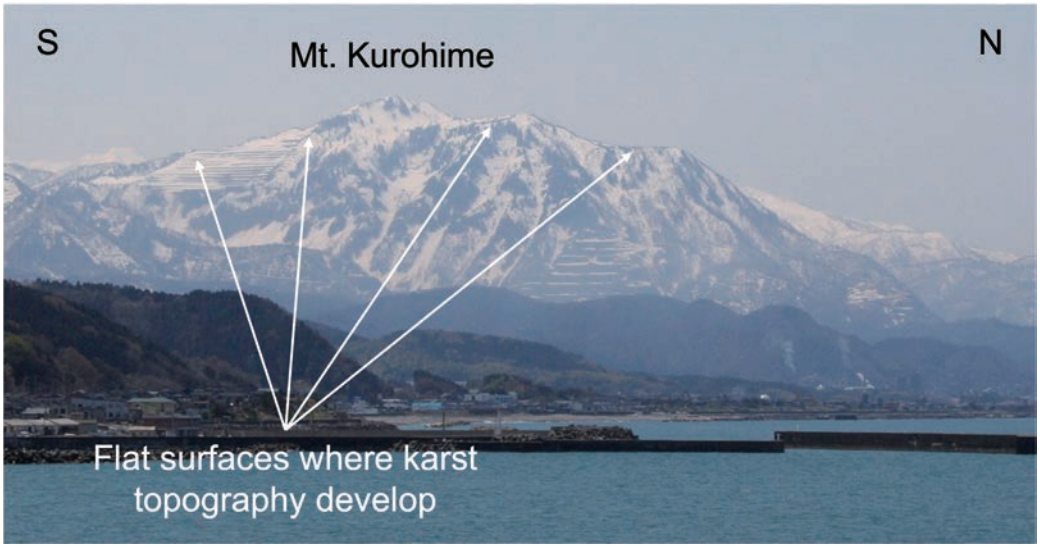

Fig. 3. View of Mt. Kurohime from the Uramoto Coast.

Mt. Kurohime (1,221 m) is composed of a Carboniferous-Permian limestone body called Omi Limestone (Figs. 1 and 2). It is one of giant limestone bodies in the Akiyoshi terrane, a geologic entity in the Inner zone of Southwest Japan. These giant limestone bodies are Akiyoshi, Taishaku, Atetsu and Omi, representing a distance of over 1,000 km from Yamaguchi Prefecture in the west to Niigata Prefecture in the east. They are regarded as seamount cap originated in the Panthalassic Ocean in the late Paleozoic. The bodies record a long-term history in the pelagic environments in the Panthalassic Ocean from early Carboniferous to middle Permian over the span of up to 80 million years. Fossil records of various biota in the limestone bodies have a potential to reveal their evolutionary history in pelagic reef environments. Detailed biostratigraphic research on benthic foraminifer has been performed on Omi Limestone (Hasegawa and Goto, 1990).

Another aspect of Omi Limestone is its topography. Karst topography is formed in limestone by water erosion and sometimes forms deep vertical caves (Fig. 3). The most representative vertical caves around Mt. Kurohime are found in Maikomi-daira, which is located on the south side of the summit (Fig. 1b). Figure 4 shows a schematic cross-sectional view of Maikomi-daira and lists the depth ranking of vertical caves in Japan. Maikomi-daira has many vertical caves, including the 4 deepest vertical caves in Japan (Fig. 4), making it one of the country's representative karst topographies. Due to this particular topography, it is also home to many precious animals and plants. For these reasons, it is protected as a Prefectural Environmental Conservation Area. In order to conserve and utilize this valuable heritage, Itoigawa Geopark Council operates environmentally responsible tours in partnership with local organizations. To avoid overtourism and reduce environmental impact, these tours are limited to no more than 10 per year, held at intervals of at least two weeks. From 2019 until 2022 the access road to this site was closed due to typhoon damage,

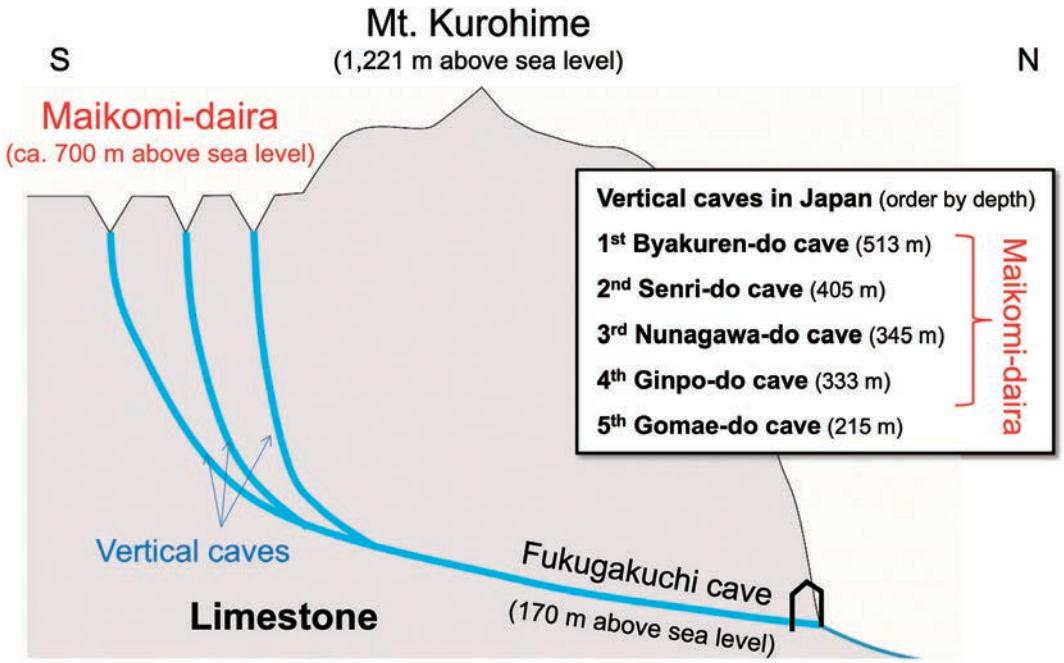

Fig. 4. Schematic cross-sectional view of Maikomi-daira and list of vertical caves in Japan by depth.

but tours have restarted since the 2023 season, and are as popular as ever.

It is important to note that as a Conservation Area, Maikomi-daira is excluded from the quarry development area, but care will have to be taken to assure that nearby quarry development does not negatively affect protected sites.

Academic investigation committee in response to quarry expansion

In Itoigawa City, there are two large companies engaged in quarrying around Mt. Kurohime. One is Denka CO., Ltd., established in 1921, and the other is Myojyo Cement CO., Ltd., established in 1958. The south side area with steps on the mountain is the current quarry of Myojyo Cement (Fig. 3). The limestone quarried around Mt. Kurohime is used not only as a raw material for cement, but also as a raw material for carbide products, and has supported industry and employment in Itoigawa for generations. In 2020, as operation in the current quarry is nearing its end, these two companies have announced a joint development plan for a new quarry.

In Japan, there are strict laws that must be cleared when developing quarries, and development can only start if criteria such as the completion of an environmental impact assessment are cleared. However, both Denka and Myojyo Cement are aware of the local Geopark's efforts to protect and conserve natural heritage, therefore, they have provided the City of Itoigawa an opportunity to evaluate the area's academic value and to pass on that value to future generations.

Table 1. List of the Academic Investigation Committee membership. Affiliation and position are as of the time of the committee.

	Name	Position, Affiliation	Subcommittees
Member	Atsushi MATSUOKA	Professor, Niigata University	topography/geology
	Toshiyuki KURIHARA	Associate professor, Niigata University	
	Kotaro YAMAGATA	Professor, Joetsu University of Education	
	Katsunori FUKUI	Professor, University of Tokyo	
	Yu IOKAWA	Professor, Joetsu University of Education	flora/fauna
	Hiroshi YASHIKI	Member, The Mammal Society of Japan	
	Jun HASHIZUME	Senior researcher, Niigata Prefectural Museum of History	archaeology/history
	Tsutomu KIJIMA	Director, Chojagahara Archaeological Museum	
	8 other members	Landowners etc.	-
Observer	Denka CO., Ltd.		
	Myojyo Cement CO., Ltd.		
	Taiheiyo Cement CO., Ltd.		
	Joetsu Environmental Science Center		
	Agency for Cultural Affairs, Government of Japan		
	Ministry for the Environment		
	Cultural Affairs Division, Niigata Prefectural Government		
	Land Use Division, Niigata Prefectural Government		
	Environmental Policy Division, Niigata Prefectural Government		
	Itoigawa Regional Development Bureau, Niigata Prefectural Government		
Secretariat	Itoigawa Geopark Council Secretariat		

An academic investigation committee was newly established within the Itoigawa Geopark Council to deliberate on the validity of the results of the environmental impact assessment, including its methods of investigation, recording, conservation and the expected impact on the lives of local residents. The members of the committee are shown in Table 1. The committee consists of experts such as university professors and landowners. In addition, related national ministries, agencies and prefectural departments participated as observers. Under this system, from 2020 to 2022, several field surveys and committee meetings were held.

In this committee, three subcommittees focusing on topography/geology, flora/fauna and archaeology/history were established to delve into discussions within their respective domains. While this paper does not provide detailed results from each subcommittee, considering perspectives such as nature conservation, the environmental impact and value of the quarry site could be discussed academically and specifications and systems for mitigating environmental impact and recording lost resources could be established. The summary regarding conservation efforts for quarry development within the committee was passed to Itoigawa City in 2022 as follows:

1. Scientific evaluation and validity of natural and cultural resources in Omi Limestone

The committee assessed the validity of the environmental impact assessment (self-assessment) conducted by the quarry companies. As a result, the surveyed contents were deemed to meet the requirements as laid out by prefectural ordinance and the contents of the environmental conservation measures were considered generally valid. In order to evaluate the scientific value of natural and cultural resources in Omi Limestone, the committee conducted additional investigations to address deficiencies identified in the self-assessment. The results of the self-assessment and the committee's investigations suggest the potential presence of significant features in Omi Limestone, including Japan's deepest vertical caves, well-developed karst topography unique to snowy regions and traces of prehistoric human utilization. Additionally, the distinctive terrain supports the existence of valuable subalpine flora and mammals, contributing to its remarkable scientific value in Japan.

2. Evaluation and validity of conservation and development areas in Omi Limestone

As mentioned above, the vicinity of Mt. Kurohime holds remarkable scientific value in Japan, associated with legends rooted in its topography and serving as a stage for mountain worship. Particularly, Maikomi-daira's designation as a Niigata Prefectural Natural Environmental Conservation Area, acknowledges numerous natural and cultural resources representative of Omi Limestone, establishing its exceptionally high scientific value. For this reason, it is deemed appropriate to strength Maikomi-daira's designation as a legally protected area, with the assumption of necessary environmental conservation measures based on the records of the development area, justifying the development plan in the designated area. It is also suggested to consider designating Maikomi-daira as a National Natural Monument, proposing further sustainable conservation methods.

3. Examination and implementation of academic surveys for record and conservation

Detailed investigation of natural resources lost due to development is academically significant. Therefore, from a scholarly perspective, surveys of the shapes, sediments, and plant life within representative dolines and geological stratigraphy are proposed. The accumulated data, rocks, and boring cores should be centralized and stored in facilities such as the Itoigawa City's Fossa Magna Museum, enabling academic utilization. Moreover, insights gathered about future natural and cultural resources can be considered for display in museums and exploration as geopark resources.

4. Impact on the Lives of Local Residents

The items covered in the environmental impact assessment are deemed to meet the requirements laid out by prefectural ordinance, with minimal impact on residents' lives. It should be noted as commendable that after conducting hearings and explaining the content

and results of the self-assessment to residents, further investigations were conducted on items identified as lacking (such as water quality). However, thorough measures to ensure the safety of residents during the transportation of large materials, considerations for noise and continuous monitoring of water quality and quantity at predicted impact points are necessary.

5. Framework for Future Conservation Systems

To continue the conservation of natural and cultural resources, it is essential to establish a framework that aligns with the progress of development and the content of record conservation. Preparations for the period leading up to mining include activities such as deforestation, topsoil removal, and bench formation, which are expected to change the current terrain rapidly compared to post-quarrying activities. Therefore, several surveys, primarily focusing on terrain and biodiversity, are anticipated. For this reason, there is a need to promptly establish a new ongoing survey committee and develop a framework that can respond to continuous investigations. Following the commencement of quarry activities, when geological stratigraphy will be the primary focus, and considering the extended project duration, it is deemed appropriate for the local government and the quarry companies to collaborate on continuous surveys, incorporating expert opinions. Furthermore, when planning the next development, it is hoped that a framework similar to this committee, allowing discussions on the environmental impact and conservation and utilization of regional resources, will be established.

Responsible quarry development in line with Geopark principles

Although quarry development leads to the loss of natural resources, it is an important industry that has supported the local economy and employment for over one hundred years. One means of balancing conservation and development is to draw a line between areas to be conserved and areas to be developed based on their academic value. While this method is clear, it potentially creates division between the two sides. To make effective use of limited natural resources and minimize the associated environmental impact, it is necessary to have opportunities for all stakeholders in the region to sit at the same table. Until now, there had never been an opportunity to dialogue with quarry companies at such a level. This committee created a valuable first opportunity for all stakeholders to exchange ideas about the delicate balance between natural resource conservation and local economic development, based on the principles of UNESCO Global Geoparks. It is the authors' belief that this is a significant and meaningful achievement of geopark activities within the City of Itoigawa and represents a new opportunity to proactively promote a sustainable society which strikes an effective balance between conservation and responsible development to meet the needs of local stakeholders and residents.

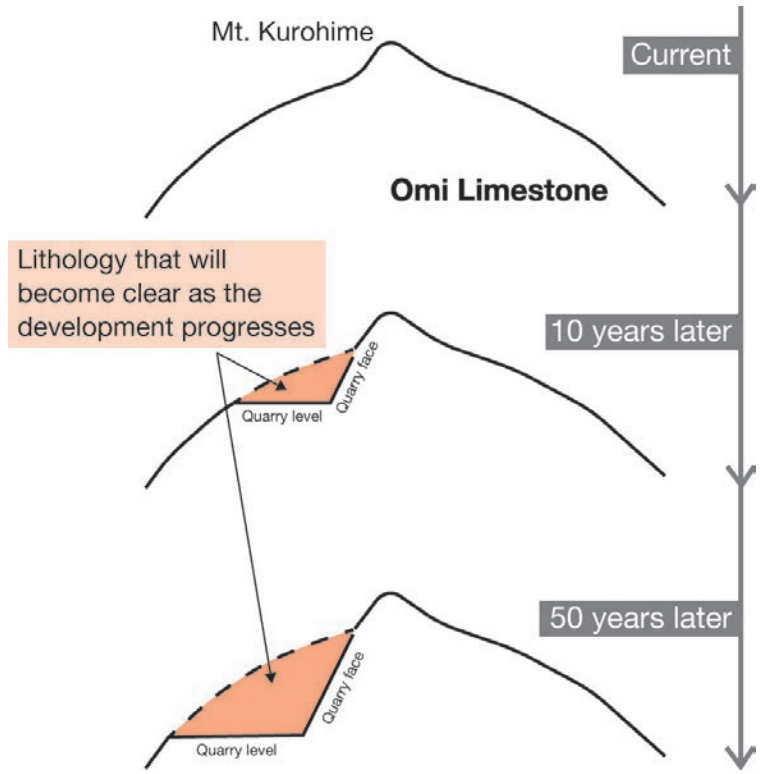

Fig. 5. Conceptual image of layered records of lithology that will become clear as the development progress.

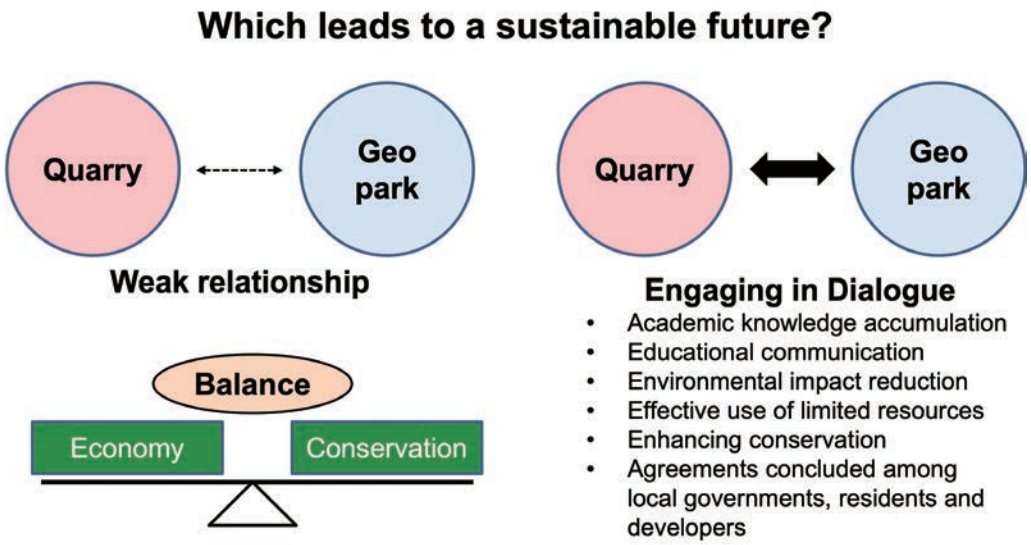

Fig. 6. Diagram illustrating the relationship between quarry companies and Itoigawa Geopark. On the left is the relationship before the establishment of this committee in 2020. On the right is the relationship after the establishment of this committee in 2020.

Concluding remarks

The authors strongly concluded that it is necessary to continue academic investigations and environmental conservation monitoring of the quarry activities in accordance with the progress of development. A successor committee was established in 2022 to continue this investigation and conservation work. For example, efforts are being made to relocate populations of low-migratory mice and rare plants to preserve regional biodiversity. In addition, a plan is in place to obtain layered records of lithology that will become clear as the development progresses (Fig. 5). With the cooperation of a research institute, quarry company and the Itoigawa Geopark Council, field surveys, rock sampling and UAV monitoring of the quarry-face will be conducted in accordance with development progress. These monitoring surveys are expected to contribute significantly not only to academia but also to the promotion of science education (Fig. 6).

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