The ABC Concept—Value Added to the Earth Heritage Interpretation?

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Abstract

Holistic interpretation of Earth heritage is one of the most important tasks of UNESCO Global geoparks. The ABC (abiotic, biotic, and cultural interconnections) concept is a potential interpretive approach used in Earth heritage popularization through geotourism. Apart of the deeper understanding of this concept, this study explores the application of this concept in selected geoparks. The Colca and Volcanoes Andagua UNESCO Global Geopark (Peru) and Muroto UNESCO Global Geopark (Japan) served as a case study in the frame of this qualitative research conducted during the summer 2019. Results show that the ABC approach is nearly perfectly understood by both geoparks, however there are both internal and external factors which influence the extent and form of how this concept is applied in practice. Except for specific geographical settings, different stages of geopark product development, and different managerial approaches, they mainly include the level of scientific knowledge and general education in the given geopark, as well as level of knowledge management and networking with another UNESCO global geoparks. The more experienced Muroto Geopark interpretation exhibits a comparatively higher level of visible ABC application, while the Colca and Volcanoes Andagua Geopark can benefit in the future from the natural inclination and ability of the local people to integrate the cultural aspects into their Earth heritage interpretation.

Keywords ABC concept · Geopark · Earth heritage · Geotourism product · Interpretation

Introduction

When looking for the roots of major environmental problems, the disconnection of human from nature can be seen as common denominator, as a tax paid by humankind for its progress.

Geoparks are territories with an ambition to face these challenges together! They strive, in mutual synergy, to enhance human progress and to prevent the aforementioned gradual disconnection. One of their essential tools for revival or strengthening of human connection to Earth is the efficient interpretation of its geoheritage and its dissemination through enjoyable experience of the geotourism products. And one of the best opportunities to communicate the complex human-Earth interrelation is through “geostory” (Yuhora et al. 2014) reflected in development of interpretive materials, an activity typical for modern scientific diffusion. In this way geoparks can achieve their objective of making geoscience accessible and understandable to society, educating and informing non-experts (Hilario 2018).

The ABC (abiotic, biotic, and cultural interconnections) concept represents an optimal way to elucidate the mutual links between abiotic, biotic, and cultural components of the geopark heritage, enabling a holistic understanding of its area. Geosites represent frequently specific habitats of various organisms, as well as sanctuaries or shrines for local and indigenous people (e.g., Pásková 2018). They can serve as a source of energy, an essential component of the fertile soil, both

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decorative and constructive material, and material for medicine, as well as an artistic inspiration, tourism attraction, or therapeutic space.

The enrichment of the geoparks concept by the ABC interpretive concept was an important milestone. The ABC interpretive concept was coined, comprehensively described by, and summarized by Dowling (2013). This approach represents a significant basis for the Earth heritage interpretation and is related not only to geotourism development, but also to the development of ecotourism in geoparks (Jaafar et al. 2014, 2015). The method of interpretation (Neches 2016), as well as that of evaluation of the geoheritage (Fassoulas et al. 2012; Forte et al. 2012; Brilha 2016; Kubalíková 2013, 2017), including their classifications for the way they should be interpreted, have also been developed (Neches 2016:80). Geodiversity (Gray 2008; Thomas 2016; Brilha et al. 2018) and related geosystem services (or abiotic ecosystem services—Gray et al. 2013:661–662) represent a fundamental basis for Earth heritage interpretation within the ABC concept (Fig. 1), as aptly formulated by Gray (2020:228). These mutual interrelationships are articulated in the description of the development of geodiversity

and biodiversity in the history of the Earth (Gray 2008:289).

Another starting point for the interpretation within the ABC concept is the other two components of ecosystem services (Gray 2011)—biotic ecosystem services and cultural ecosystem services (Gordon 2018; Kubalíková 2020)—which, according to Gordon (2018), arise as a result of human interaction, their values, and the environment. Modrej, Fajmut Štruel and Hartmann (2018:106–109) presented examples of the best practice in the interpretation of geosites, including the ABC approach. The same applies to the technology and step-by-step manuals used for the interpretation of biotic, abiotic, and cultural heritage (FACET 2018). The specific "ABC synthesis" is paleontological heritage presentation and interpretation (e.g., Bruno et al. 2014; Moroni et al. 2015).

Ren, Simonson, and Pan (2013:119) emphasize the involvement of all the senses in transmitting awareness and experience of the abiotic, biotic, and cultural components of the geopark heritage to the visitor. They also stress the systemic concept of interpretive communication with the geopark visitor (Ren et al. 2013: 120).

Increased attention is paid to the research on perception of geological and other natural and cultural heritage (e.g., the

Fig. 1 Geodiversity and related geosystem services as a fundamental basis for Earth heritage interpretation within the ABC concept. Source: Based on Gray (2011:273), further developed

visitor-employed photography method, Fung and Jim 2015) so that the way of presenting and interpreting this heritage can be optimized.

Theoretical Background

In recent years (Newsome et al. 2012; Du and Girault 2018), geotourism has become one of the major themes of sustainable tourism development (e.g., Farsani et al. 2009; Farsani et al. 2011; Farsani et al. 2013; Newsome and Dowling 2010; Pásková and Zelenka 2018a; Pásková and Zelenka 2018b). An important part of the development of geoparks is the protection of their geological heritage (de Carvalho 2014; Migoń and Pijet-Migoń 2016, 2017; Crofts 2019). There is an intense exchange of experiences in the geopark networks (at various geographical levels of this networking—national, continental, and global) and rich diversity of services for visitors are empirically described (e.g., Kajima et al. 2017; Tomić et al. 2015). However, a consistent approach to creating, promoting, segmenting, describing, and personalizing geopark products focused on the Earth heritage interpretation is still missing. According to Dowling (2013:65), geotourism product “*embeds geoconservation, communicates and promotes geological heritage, and helps build sustainable communities through appropriate economic benefits.*” This definition is consistent with the essential concept of geoparks (e.g., Farsani et al. 2009; Farsani et al. 2011). The real challenge of this concept is how to achieve understanding of the mutual interconnections between geological, biological, and cultural heritage, and subsequently how to implement the abovementioned ABC concept (Dowling 2013) in the daily practice of Earth heritage interpretation.

The following scheme (Fig. 2) is inspired by the described role of geosites in the geoparks’ offerings and by an analysis of the certification process of global geoparks (Pásková and Zelenka 2018a). It compares two different situations in the certified geoparks – the usual situation of a geopark product development (left side in Fig. 2) and the situation, when geopark management applies the ABC interpretive concept at the very beginning of its geotourism product development. Ideally, it should be applied in the first stage of the geosites’ inventory and interpretation process (right side in Fig. 2). The usual situation (left side in Fig. 2) means that the geopark team gradually develops its products under specific external and internal conditions and certification rules, and gradually comes to understand the importance and benefits of the ABC concept. The right side in Fig. 2 demonstrates the situation in which the geopark team, after an initial geosites’ interpretation development with emphasis on the abiotic component of the Earth heritage, moves quickly to developing geopark products within the ABC concept. Embracing this interpretive concept early results not only in faster deployment

of more comprehensive geopark products but also in unlocking a much higher potential for better geopark product personalization, sustainability of development, improved destination management (e.g., Zelenka and Kacel 2013), as well as to higher level of social capital and tourism sustainability. Such geoparks enjoy a competitive advantage compared to others and reduce their product development costs since no additional reinterpretation needs to be realized to enhance the geotourism product and to achieve the three-dimensional Earth heritage interpretation.

The scheme in Fig. 3 recalls conditions and contexts which should be considered and respected when developing a geopark product. When interpreting a geosite and creating a geopark product, it is appropriate to use different time scales (geological time, ecosystem time, psychological time) within the time context. In the spatial context, individual services for visitors and individual geopark products should be linked to the extensive thematic geopark product. In addition to the ABC interpretative concept, the application of the three-level product concept (total product; e.g., Horner and Swarbrooke 2016) is also recommended.

Another view of the holistically approached and interdisciplinary interpreted geopark product, seen in other contexts, reveals a mental map (Fig. 4), which was designed with the aim to reflect following questions:

- What can inspire and stimulate the geopark product in its different development stages and in its different domains, e.g., in its designing, realizing, or interpreting?
- Which concepts or approaches and what kind of cooperation enable the development and introduction of the geopark product?
- What represents the basis or essence of the geopark product, respectively, which conditions and criteria of its creation or development and its Earth heritage interpretation have to be fulfilled?

Methodology

The conceptual intention of the article was to provide a comprehensive set of appropriate approaches to the creation of geotourism products (specifically geopark products) focusing on application of the ABC interpretative concept. The qualitative strategy was adopted to frame this quest. Firstly, an extensive search of professional databases (especially ScienceDirect database) was carried out, complemented by the search of metainformation for professional articles using Google and Google Scholar. In this search, the focus was placed on geotourism, geotourism products (geoproductions) and geopark products, services offered to geoparks visitors,

Fig. 2 Geopark product development scheme showing the process of a gradual understanding of the importance of respecting the ABC concept (left side), as well as the consistent use of the ABC concept from the early stages of geopark development (right side). Source: Based on Rodrigues and Carvalho (2009), Dowling (2013), Kubalíková (2013), and Gentilini (2016)

the geopark management process, the ABC interpretative concept, and the concept of three product levels (total product). The findings were expressed graphically in diagrams showing the comparison of geoproduct development with respect to the ABC interpretative concept at different stages of geopark product development, and in a schematic and mental map defining different contexts and different conditions of creation and development of geopark products.

This theoretical background was then applied to two case studies carried out in the Colca and Volcanoes Andagua UNESCO and the Global Geopark and Muroto UNESCO Global Geopark. The selection of these two research areas was driven by the intention to analyze

application of the ABC concept in different geographical settings, as well in different developmental stages of geopark products, Earth heritage interpretation, and management approach. The aim of these case studies was to find out how the ABC concept is applied in the interpretation of both geoparks, in the context of global trends, theoretical background of geoproduct development and current knowledge of Earth heritage interpretation.

The interpretation of the selected geosites was analyzed through evaluation of the interpretive panels with the aim of detecting how the interrelationships between its abiotic, biotic, and cultural dimensions (ABC components) are clarified. For each analyzed geosite, the ABC components

Fig. 3 Geopark product context. Source: Based on Dowling (2013), Zelenka et al. (2013), Horner and Swarbrooke (2016), and Pásková and Zelenka (2018a)

were identified, and then the evaluation of ABC concept applied in the interpretation of its Earth heritage followed. This assessment focused not only on the description of the ABC components of the Earth heritage of the given geosite but also on identification and explanation of their mutual interconnections. Additionally, in the case of absence of the interpretive panels, other types of accessible interpretative materials were assessed. The key methods thus consisted in the field research focused on the documentation of the interpretative panels at the selected geosites and semistructured interviews with key geoparks' informants (one for each geopark) focused on the interpretation system and development in the given geopark. Then, the qualitative analysis of collected data followed, supported by their comparison with the outcomes of the synthetic compilation of current theoretical knowledge.

As a frame for this research, the following mutually interrelated questions were formulated: In which way and intensity is the ABC concept applied in the geoparks' interpretative products? Which factors have influenced the development of the ABC concept application in the Colca and Volcanoes Andagua UNESCO Global Geopark and which ones in the Muroto UNESCO Global Geopark? Is the ABC concept application rather idiographic or rather nomothetic? To which

extent is the application of this interpretive concept realized in one geopark replicable in another one?

Case Studies

The Case of Colca and Volcanoes Andagua Geopark

The Colca and Volcanoes of Andagua UNESCO Global Geopark (CVAUGG) was designated recently, in 2019. It covers a relatively large area of 6582.43 km² situated in southern Peru (Fig. 5) which incorporates 19 districts of the Castilla and Caylloma provinces (Zavala et al. 2019). The highly complex geological history of this area is reflected in its exceptional geoheritage, recognized by Peruvian geologists and foreign researchers who made it known to the world. Among the most outstanding features belong more than twenty-five volcanic cones, as well as 100 km long and 3 km deep Colca Canyon, one of deepest in the world (Zavala et al. 2019).

There are the oldest rocks of the geopark in the Colca Canyon sector. They correspond to gneiss, amphibolites, and Precambrian granulites (Basal de la Costa Complex; 540 Ma; Caldas 1993). In discordance, and with Paleozoic absence, it exhibits a small sector with volcanic and marine calcareous

Fig. 4 Mental map of development of the interpretive geopark products. Source: Based on Azman et al. (2010), Dowling (2013), Rutherford et al. (2015), Martínez-Graña et al. (2017), Farsani et al. (2017), Kajima et al. (2017), and Pásková and Zelenka (2018a)

Jurassic rocks (174–163 Ma). A marine transgression occurs in the late Jurassic and throughout the Cretaceous. Sandstones, shales, and limestone strata with marine fossils, evaporite levels, and continental red capes indicate a gradual withdrawal from the Cretaceous seas (177–66 Ma), occupying the west geopark sector (Romero and Ticona 2003). Intrusive bodies of the Andean Batholith, folding in the Mesozoic strata are associated with a regional uprising and the first Andean tectonic phase (66–28 Ma), generating thick sequences of conglomerates, sandstones, and volcanic breccia. Between 23 and 13 Ma, intense volcanic activity was generated, related to a second Andean tectonic phase. Thick sequences of lava, ignimbrites and volcanoclastic material occur at this time. The oldest stratovolcanoes originate between 6 and 4 Ma. They occupy the upper slopes of the Colca Valley; one of them the Mismi volcano, a snowy geosite which gives rise to the Amazon River. Wide volcanic plains and ignimbrites plateaus and lava flows are associated with this volcanism. It is

followed by volcanoes of the second generation (4 and 2 Ma), highlighting lava flows from the Hualca Hualca volcano occupying the most pronounced Colca Canyon section (Zavala et al. 2019). The youngest volcanoes are Ampato and Sabancaya with eruptive historical activity.

The Plio-quaternary geodynamic and neotectonic activity shapes the current geopark landscape. The volcanic avalanche of Hualca Hualca and the deposits of the Colca paleolake that occupy the valley are relevant; seismite structures in the deposits show a high seismicity of active faults that predominate to date (Benavente et al. 2017). One of the stages geologically known as Andagua Volcanism occurred during the Pleistocene-Holocene (0.53 and 0.2 Ma). It covers and fills large areas in the Colca region, creating an impressive landscape, unique in the country, which shows the Andagua Volcanoes Valley (Zavala et al. 2016). From dates of eroded hanging lavas in the Colca Valley, two incision stages of the Colca Canyon

Fig. 5 Map of the Colca and Volcanoes Andagua UNESCO Global Geopark. Source: UNESCO (2015)

have been differentiated: one 1.6 Ma ago and the other between 0.65 and 0.61 Ma ago (Thouret et al. 2007).

The soil in the Colca Valley, which is predominantly of alluvial and lacustrine character with fragments of volcanic material, is noted for its natural fertility. This property encouraged the ancient Peruvians (including Incas) in the construction of *andenerias* (system of agricultural terraces) enabling the control of soil erosion and landslides, water regime and proper management of crops (Málaga 1986). On the other hand, these platforms modified the soil and climate conditions, in the way appropriate for agriculture on steep slopes. There are many other phenomena related to the relationship between human activities and geological processes in the Colca Valley, documenting the human occupation of this geographical space like stone *colcas*, pre-Inca circular storage constructions made of the local volcanic and sedimentary rock or *chullpas*, funerary stone towers originally constructed for noble persons. Altogether, these features represent good

examples of interrelated ABC components of the CVAUGG Earth heritage.

The geopark has 119 geosites, five of them have been assigned as sites of international value (Colca Canyon; El Mismi - Headwaters of the Amazon River; Andagua Volcanoes Valley; Mamacocho lagoon resurgent aquifer; Neotectonic trench El Trigar fault). The work of the Polish experts (Paulo and Galaś 2008) contributed substantially to the geopark's Earth heritage description. It includes the geopark's landscape and the human modifications and adaptations for coexisting with the phenomena of this territory (glaciers, volcanoes, rivers, and mountains), so called cultural landscape, which interrelates human, nature, and its landscape, giving it a cultural identity.

The Case of Muroto Geopark

The Muroto UNESCO Global Geopark (MUGG) was designated as a UNESCO Global Geopark in 2011. It is located in

Fig. 6 The location of the Muroto UNESCO Global Geopark.
Source: UNESCO (2019)

Kochi Prefecture on Shikoku Island, in the southwestern part of the Japanese archipelago (Fig. 6), and includes all the administrative territory of Muroto City (UNESCO 2019). Majority of its area has mountainous character, and the mountain range at its northern margin is approximately 1000 m high (UNESCO 2019). The MUGG is geologically characterized by accretionary complex formation and associated magmatic intrusion, sedimentation on top of the accretionary complex and uplift caused by earthquakes.

This territory shows one of the best-understood and youngest accretionary complexes in the world (Paleogene to Neogene). It contains many proofs of the typical sedimentation process that occurs at a subduction zone. Ridge subduction during the accretion process resulted in igneous activity leading to the formation of gabbroic rocks and volcanic rock, pillow lava, both of which were formed approximately 15 to 14 Ma. The alternating sandstone and mudstone layers which constitute the accretionary complex, adjacent to the igneous rock, were affected by contact metamorphism. The upheaval of Cape Muroto is best represented by the Quaternary marine terraces on the west coast of the cape. Several wave-cut platforms of varying heights formed in this region 160,000 years ago. Each of the platforms here was formed by the glacial–interglacial sea level changes and coseismic uplifts (Muroto Geopark Promotion Committee 2011).

Around the Nankai Trough, large subduction-zone earthquakes of magnitude eight have repeatedly occurred at an interval of 100 to 150 years, and caused massive tsunamis. The MUGG is the only UNESCO Global Geopark expecting a large-scale earthquake predicted in the near future, so they collaborate with scientific partners to establish a prediction model of such earthquakes by drilling in seismogenic faults, as well as state-of-the-art research using ocean bottom seismometers. This has been conducted as a national project at the

Nankai Trough. The Muroto Geopark has 78 geosites; 16 of them have been assigned by the Muroto Geopark as international value sites, e.g., the Cape Muroto area—Turbidites and Nishiyama Plateau—Marine Terraces. The Geopark works as a link between the local municipality and locals to promote collaborative conservation efforts. Local guides serve a vital role in site protection, as they patrol sites and give tours nearly every day (Muroto Geopark Promotion Committee 2019).

Results

The Current Application of the ABC Concept in the CVAUGG

In the Colca and Volcanoes of Andagua UNESCO Global Geopark, the analysis carried out to interpret the CVAUGG geosites had from the very beginning the philosophy of registering abiotic Earth heritage components and evaluating them for their scientific, tourist and educational value, but also highlighting associated aspects regarding biodiversity (living nature aspects) and the human presence (cultural aspects). The 119 geosites found in the geopark territory mainly present geological phenomena, and another 51 focuses on cultural characteristics. However, among these 170 sites, a large number comprise two or three of these ABC aspects.

The interpretation evolution of the geopark's Earth heritage through geosites, geotrails, geoguides, interpretive panels, brochures, books, magazines, videos, etc., enables researchers to approach it in a different way and improve the future CVAUGG implementation plans. The importance of local and indigenous knowledge for the interpretation of the CVAUGG Earth heritage has been recognized from the early

stages of this process; however, it is still not used significantly in the interpretative panels at the touristic geosites.

Based on the local socio-cultural context, the CVAUGG team has naturally embraced the potential of the "geostory" (Yuhora et al. 2014) and "geomyths" (Vitaliano 2007; Kirchner and Kubalíková 2015) for interpreting its Earth heritage. The evaluation carried out to explain the processes of land formation and define its geological heritage was developed by the CVAUGG geologist. Geographical and cultural information is perceived by the CVAUGG team as an integral part of the interpretive message that has to be adjacent to each geosite interpretation in the future (Fig. 7).

Regarding the development of interpretive panels, a major challenge for the CVAUGG team is to "*explain Earth Sciences for school-age children*." For this purpose, local geoscientists work together with other personnel (journalists, cartoonists, historians, etc.) and also with local and indigenous people. The advantage of the locals is their ability to spread cultural and historical information of the Colca and Andagua Volcanoes region. The CVAUGG team communicates intensively with local municipalities to promote collaborative conservation efforts. Local geoguides are being trained to play a vital role in the Earth heritage presentation and conservation.

In the mission of carrying out geoeducational work and promoting Earth heritage through geotourism and revitalizing the CVAUGG economy, the first interpretive panels provide information on main geological processes and strategic geopark localities (10 panels). These panels try to elucidate the concept of the geopark, and the value of the local geoheritage in the most attractive sites, drawing attention of visitors to geological aspects that affect them (volcanoes, landslides, earthquakes, faults). In this sense, the intention is to "provoke," through interpretation, curiosity to learn more about the origin of a landscape, which has a great component

in geology, despite the difficulties of understanding geological time or excessive physical magnitudes, which are often abstract. The biotic and culture aspects of the given geosite and their links to the geological and other abiotic phenomena are interpreted there just marginally or they are not interpreted at all.

The CVAUGG team strives to achieve the geopark's potential to reach sustainable development goals: (Aranibar and Ayerbe 2015) "To let local and indigenous people value what is known" (geoheritage); (Azman et al. 2010) to let them understand that there are spectacular sites waiting for explanation; (Benavente et al. 2017) to let them understand climate change and the origin of disasters; (Brilha 2016) to enhance sustainability of their use of natural resources; and (Brilha et al. 2018) to support with scientific knowledge their intuitive understanding that the geodiversity is the basis for biodiversity, traditions, history, customs, gastronomy, life style, and rural/urban development. Communicating these connections between geoheritage, the ecosystems, and the culture of the Earth to the local inhabitants and visitors, the panels cover different domains. For main geological aspects of the CVAUGG territory (for example, explaining particular rock aspects and their natural environment), this can be done with a small panel, linking the two, using simple words and pictures. Instead, to convey more complete information on each geosite, focusing on its "geostory," a large panel will be required. Its location should be attractive to the visitor or local inhabitant, showing a geographical history of that connection between nature and people's lives. This is planned to be undertaken in various geosites that are described below, which will allow the ABC concept to be further developed.

Geoparks are not static, and new interpretations may emerge reflecting their dynamics. Even the initial inventory

Fig. 7 The reflection of ABC concept in the interpretive approach of the Colca and Volcanoes Andagua UNESCO Global Geopark. Source: Colca and Volcanoes Andagua (2020)

of geosites requires periodical update. As documented by Pásková (2018), participatory knowledge management, realized by involvement of people from the local and indigenous communities, allows that. This way of showing the connection between geology/geography, ecosystems, and culture more clearly made by the exchange of experiences in GEOLAC (Latin American and Caribbean Geoparks Network), or through the GGN (Global Geoparks Network), need to be considered. The local population then feel more committed and proud when some geosites located in their community are included (e.g., Pásková 2018). The CVAUGG team also promotes Earth heritage care and geoconservation. In the 170 geosites, the inventory matrix is divided into three categories: geological, combined, and historical–cultural.

The improvement and update of the geosite inventory allow the review of the initial design of the interpretive panels within the Geopark. Ten analyzed geosites, for which the new interpretive panels are prepared, contain the ABC information. An analytic description and sample of cultural and ecological information, in addition to the geological (abiotic) one, are described in Table 1. Illustrative graphics on the origin of the landscape, photos, and didactic description show how the not only “pure” geology but also the cultural environment around the site, such as the development of festivities and traditional or local ancestral customs that make up the “Pachamama” philosophy, are interpreted.

Methods for interpreting the Earth heritage in the CVAUGG have changed over time. The strict application of geoscientific knowledge has not proved to be optimal. In this sense, the work with the association of local guides, tourism students in the Colca Canyon and in the Andagua Volcanoes Valley, as well as interaction with official tourist guides in Arequipa, has potential for developing the interpretation skills in geological, geographic, ecological, and cultural processes and their mutual relationships. The approach to development of the new geotrails in cooperation with the local students and guides is described in the CVAUGG Geotourism Development Plan.

As documented by Pásková (2018), the territorial knowledge of the geopark through interviews or conversations with indigenous people allows registering cultural and historical events that many do not know. According to her, transmission of this kind of knowledge is very important for the territorial identity of local population. One of the examples, described in Table 1, shows the elaboration of stories by local children, esteeming a Laguna Mamacocha geosite through the book “*My grandfather told me.*” The local Elders are proud to pass that knowledge to younger generations. They generally do so through stories, myths, or legends about their natural environment or Earth heritage. They are important resources for the CVAUGG team to know how the Earth heritage in the region has been recognized and interpreted by its local people.

The Current Application of the ABC Concept in the MUGG

In the Muroto UNESCO Global Geopark, “geostorytelling” has come to be the basis for Earth heritage interpretation. First, “geostory” was developed by a geologist, and had thus a purely geological character explaining land formation processes. Then more complex, geographical information was added to the geostory to reach a more comprehensive interpretation of each of the geosites (Matsuki and Sasao 2015). Geostory is really a key word for the MUGG team to consider Earth heritage interpretation. A former MUGG geographer, major in anthropogeography, defined “geostory” in two categories: (Aranibar and Ayerbe 2015) geological story which explains mutual influence/relations of geological phenomenon, and (Azman et al. 2010) geographical story which explains relations between landscape and geology (nature) and people’s lives including local ecosystems (Yuhora et al. 2014).

The biggest change since its designation as UNESCO Global Geopark is that the MUGG team worked to improve the inventory and assessment of geosites based on recommendations from a revalidation mission realized by UNESCO experts in 2015. There used to be 22 geosites covering wide areas and focusing on several different themes (Muroto Geopark Promotion Committee 2019). Those 22 geosites were separated into multiple sites with specific locations, with themes falling into three categories (geological, ecological, and cultural). In 2018, a new geosite inventory was developed with 51 geosites, 10 ecological sites, and 17 cultural sites. Each of the new sites focuses on a more definitive and specific theme. It allowed the MUGG to show connections between geology/geography, ecosystem, and culture more clearly, as described in Table 2. After this geosite-inventory improvement in 2018, the MUGG team started to revise all the interpretive panels within the geopark. Ten new interpretive panels were also introduced at this time.

Developing interpretive panels is perceived by the MUGG team as one of the best opportunities to conceptualize Earth heritage interpretation as a geostory. According to the MUGG team and as it is visible from the interpretive panels, the big theme of interpretation developing has been always “*explaining Earth science for 12-year-old children.*” Therefore, the local Earth scientists work together with other staff or locals who are not specialists in geology and bring the cultural context of Muroto including its intangible heritage which is crucial for the geostory.

Regarding the MUGG interpretation system, a geopark has two types of interpretive planes: one has a small format (35 panels) which mainly tells visitors specific information about geological phenomenon; and one is a large format (33 panels) which tries to tell visitors about connections between Earth heritage, ecosystem, and culture. Those differently sized panels have different roles. Cape Muroto, as the area covering

Table 1 Analysis of the ABC concept application in the interpretation of the Colca and Volcanes de Andagua UNESCO Global Geopark

Geosite	ABC component of the geosite's Earth heritage			Evaluation of the ABC concept application in the geosite interpretation
	Abiotic (A)	Biotic (B)	Cultural (C)	
<p><u>Maca settlement affected by active landslide</u></p> <p>Maca is located on an alluvial terrace whose main activity is agriculture. Area with wetlands. Colca River left bank. An earthquake in 1990 affected part of the town and its church. Passage site in the tourist circuit. Landslide has evolved in the last three decades affecting the part of the agricultural area and access to plots.</p>	<p>Maca town settled in the body of an ancient rotational landslide (approx. 3.7 km length of scarp). Reactivations with retrogressive-progressive advance, generate loss of crops (platforms) affecting several sections of the tourist access road to the Colca Canyon. Shallow groundwater table. Diatomaceous deposits were exploited until three decades ago. Rock avalanche deposits. Landslide is monitored by the national geological service, with the support of the local municipality.</p>	<p>The Colca River runs at the foot of the landslide. The villagers fish in the river. The staggered platforms are still used to cultivate so called basic grains (corn, beans, peas), potatoes and alfalfa for their cattle (Robles 2008). American camelid breeding (alpacas and llamas).</p>	<p>Agriculture in Collagua developed taking advantage of about ten springs as a traditional use of its adjacent slopes. Rites and collective tasks are traditions dedicated to the cult of water. They represent very old annual activities (Aranibar and Ayerbe 2015). They consist of repairing, cleaning and suitably adapting the irrigation infrastructure (channels). This deep-rooted Andean tradition is called <i>yarqa aspiy</i> in the area, or ditch digging (cleaning the ditches, celebrated on August 28). Another festivity is <i>El Qamile</i> (feast of planting corn celebrated on October 7).</p>	<p>The A component is profoundly reflected in the content of the interpretative panel, while both B and C components are practically absent. From this reason, the mutual links between ABC are not described there. Only the know-how of the morphology changes monitoring is mentioned and visualized in the pictures. Except of text in the columns B and C, the fertile soil, which represents an iconic object for the ABC concept application, could be mentioned there. Regarding its material aspect, it is decomposed abiotic material mixed with organic one used by man for cultivation. Immaterially, it is subject of ancestral farming know-how and rituals based on indigenous cosmology (Pásková 2018a).</p>
<p><u>Mismi snow-capped volcano</u></p> <p>Massif of volcanic origin that reaches 5,597 masl (Cordillera Chila). Sacred mountain for the various Colca communities, who use the water that comes from its slopes for agriculture. Continental watershed towards the north side with the Apurímac River basin, a source that gives rise to the great Amazon River.</p>	<p>Stratovolcano complex on the right bank of the Colca River, carved by glacial erosion forming cirques, valleys and moraines (Mismi, Qehuisha snowcapped mountains, among others). Large area of lava flows and volcanic products for more than 45 km that extends between the districts of Tuti in the east to the Molloco River in Tapay in the west. There are trekking routes and unpaved roads from Lari, such as between Tuti-Sibayo by Ran Ran and another one above the Uyo Uyo archaeological complex, which</p>	<p>The shortage of water for agricultural irrigation in rough terrain has been resolved by the residents. They take advantage of its seasonal springs, and thaws of the glacial slope of the Mismi. In recent decades, the glacier surface has decreased (INAIGEM 2016). Wetlands and small lagoons store water that is regulated downstream. The important farming activities are camelid raising and growing potatoes and basic grains (broad beans, corn, quinoa) and vegetables.</p>	<p>In the Colca Valley, the main mountains are sacred. One of them, the Snowy Mismi (to which the Quehuisha and Gulluncuya glaciers are annexed), represents the main deity for the communities of Coporaque, Yanque, Ichupampa, Lari, Madrigal and Tapay, which settle on its slopes. La Iranta, a ceremonial act is organized by the valley communities to ask them not to be short of water. Camelids are found in the highlands (<i>vicuñas</i> and <i>alpacas</i>). Citadel like Uyo Uyo (ancient Yanque community) and other archaeological remains in the heights of Coporaque and Tuti communities, are found on this volcanic slope.</p>	<p>The A component (geological, geomorphological and hydrological) is interpreted in detail. The B and C components and their mutual interrelation as well as their link to the A component are represented by the mention of farming. However, the importance of the Snowy Mismi providing water for agriculture and its reflection in culture (beliefs, rituals and festivities) is not expressed there. These are potential A-C and A-B links to be used in the interpretation of this geosite. The local rests of the ancient constructions built</p>

	ascend to the Mismi.			of the local volcanic material should be also mentioned to enrich the A-C interpretation aspects.
<p>Mamacocha lagoon resurgent aquifer</p> <p>An oasis, in a depression generated by several lava flows, whose waters include fish, the Pacific otter, unique and vulnerable fauna. It represents a tourist site and icon of the Ayo district, which can be accessed by a carriage trail, or a walking trail. On its right bank, remains of human occupation of the first settlers can be observed. The lagoon drains into the Colca River.</p>	<p>Resurgent aquifer in lavas of the Andagua Group that gives rise to the Mamacocha lagoon, in the Ayo district, valley of the volcanoes. The waters that are lost or infiltrate the Chachas lagoon, below lava flows, run as an underground river for 17 km and resurface in Mamacocha with a flow of $10.5 \text{ m}^3 / \text{s}^{-1}$, an exceptional lagoon originated by three lava flows. The porous lavas behave like an aquifer, while the sedimentary units found underneath, as an impermeable basement.</p>	<p>According to geopark informant, the Andean otter population would be the only one found between northern Peru and southern Chile, perhaps related to the Amazonian otter. This ecosystem registers an important grouping of bats, with seven species, that disperse cactus seeds, and allow thus regeneration of vegetation; they pollinate the flowers of the cacti, promoting their reproduction; they also contribute to the control of the insect populations.</p>	<p>The <i>huallaque</i> or Andean otter" is thought to be the true <i>Mayopuma</i> venerated in Andean cultures. There are also preserved rock art samples along a path that goes down to the lagoon (rock paintings on the rocky walls). They express the art of the pre-Inca period, with figures of llama herding and people. An example of imprint of the Ayo's cultural memory is the storybook titled "<i>My grandfather told me: Ayo stories, myths and legends.</i>" There are 29 short stories written by children, with the support of parents and grandparents highlighting the value of Laguna Mamacocha. This book will be re-edited for further dissemination.</p>	<p>There is not an interpretive panel at this geosite yet, however the images of the geoguide book (Zavala, Mariño and Varela, 2016) and the CVAUGG Facebook posts provide some insights into its interpretation. The A component represented by the volcanic lagoon origin is linked to the B one through the otter living there. The interconnection between the A, B and C components is reflected by the geomythologic storybook "<i>My grandfather told me: Ayo stories, myths and legends.</i>" The photography of the cave paintings illustrates another ABC interlinks: The A component represented by cave rock, the B one by figures of llamas observed in the past by the pre-Inca people and the C component is reflected by their artistic expression.</p>
<p>Fossilized remains of logs Tururunca</p> <p>Slopes of the Tururunca hill (4,337 masl), west of the town of Huambo, on the left bank of the Colca River. It is accessed from the Huambo-Pedregal highway by a paved trail.</p>	<p>Fossilized log fragments, recrystallized in sandstones of the Hualhuani Formation. Paleontological investigations have revealed these fossils as the first evidence of paleoflora (Metapodocarpoxylo n) in the center-west of the Gondwana of the Jurassic - Cretaceous. Similar log fragments have been found in the channel of the Huambo River.</p>	<p>Surrounding slopes in a northwesterly direction with abundant presence of forests or <i>rodales</i> of Puyas de Raimondi (<i>Huankares</i>), queen of the largest species of bromeliad. Its population counts more than 120 individuals (5 individuals / ha). Its landscape condition according to size is classified as regular to low, compared to others in the Arequipa region (Salazar and Villasante 2012).</p>	<p>The Tururunca hill is an <i>apacheta</i>, a mountain whose summit reaches 4,669 masl. It is part of the watershed of the Majes-Colca and Quilca-Vitor basins. One of the old footpaths, before there was no road that accessed the Huambo municipality, is the one that connects Huambo with the Majes Valley (Aplao) that passes through the foot of the Tururunca hill.</p>	<p>TURURUNCA, RESTOS DE UN BOSQUE PETRIFICADO TURURUNCA, REMAINS OF A PETRIFIED FOREST</p> <p>The A component is described. Its connection to the B one is provided by explanation of the origin of a fossilized trunk in an alluvial environment.</p>

				The present-day unique vegetation and its determination by the specific environment could be mentioned. The same pays for the antient human mobility through the foot of the Tururunca hill.
<p>Llunta Canyon</p> <p>The Colca River canyon sector. In the vicinity of the canyon, there is an agricultural landscape developed by the population of Canocota a municipality. On the slopes of the canyon, archaeological remains are visible.</p>	<p>The canyon section of the Colca River in the Canocota sector (Tuti), carved out on fissure lava of the Andagua volcanism. The location of these lavas in the valley produced a closure of the Colca River, originating a paleolake, which extends several kilometers upstream. This was broken through later. There is a viewpoint from the Tuti-Chivay highway; a recent paved road leading to Canocota accesses the canyon.</p>	<p>An iconic cultural landscape created by the agricultural activity practiced on lake deposits as well as volcanic soil on both banks of the Colca River. Terraces are arranged on both sides of the canyon, with greater extension upstream at the foot of the Canocota municipality. They bring to the local population the typical local crops consisting of the of the basic grains and potatoes. Eventually, the local residents use to fish the trout in the Colca River.</p>	<p>The volcanic and river landscape is combined with archaeological rests (circular storage constructions called <i>colcas</i> by the indigenous Aymara) and pre-Hispanic terraces (<i>andenes</i>). To appreciate them, it is necessary to descend to the Colca River. On the left bank of the river, there is a large pre-Inca road that connects Callalli, Canocota and Chivay communities. It is a Collagua path on which the trekking is carried out.</p>	<p>At this geosite, where the interpretive panel is also still missing, the photos from the CVAUGG Facebook shows the interpretation potential for discovering of the ABC links (e.g. stone <i>colcas</i> storing the local vegetable crops in the past). The interpretation of <i>andenes</i> filled with the fertile soil could reveal the ABC interlinks through the paleolake's sediments and volcanic minerals.</p>
<p>Chachas lagoon and countryside</p> <p>Geoheritage forms associated with the damming of the Andagua River due to the emplacement of a lava field in the Pleistocene - Holocene, at the foot of the of Chachas community with its pre-Hispanic agricultural terraces.</p>	<p>Depression caused by placement of lavas of several generations, to the foot of the Chachas village. It is fed by the discharge of the Andagua River, where a large alluvial fan is currently seen at its mouth. Approximately three km downstream, the drainage of the lagoon is lost or infiltrates below the lava field. Terraced slopes with platforms, built on volcanic soil, occupy a part of the southwest flank of the Puca Mauras Chachas</p>	<p>This eminently agricultural district excels in a sophisticated use of fertile volcanic soils, which are irrigated by gravity and in a lower percentage by rains (dryland farming). The main crops are potato, wheat, corn and beans.</p>	<p>Chachas, titled as the “Pearl of Castile District” is a purely agricultural and livestock district. There are two communities located near the lagoon: Chachas and Nahuira. The church of San Pedro de Chachas, constructed of the local volcanic material, is one of the oldest in the Castilla province. It is estimated that it was completed in 1635, and it remains very well preserved. The Chachas lagoon, its terraces and platforms as well as its temple are included in the shield of arms of the Chachas community, reflecting thus its territorial</p>	<p>Another geosite which is not yet interpreted, however some briefly commented photos, provided by geopark informant as a basis for future geosite interpretation, exist. They indicate the A component interpretation (geological, geomorphological and hydrological aspects) through explanation of the volcanic origin of lagoon and the role of Andagua River. The ABC interrelation is visualized by pointing out the fertile volcanic soil used for farming as well as on statue</p>

	monogenetic cone made up of lava.		identity.	expressing farming and the ancient church, both built of the local volcanic stone. The same for the shield of arms of the Chachas community which integrates all the three Earth heritage components (volcanic lagoon, cattle, camelids and terraces).
<p>Colca Canyon</p> <p>Tourist viewpoint of the geopark, where it is possible to see the greatest depth of the Colca Canyon and observe the iconic bird of its territory: the Andean condor. The landscape carved in the walls of volcanic origin, rugged and deep. Presence of the local artisans offering products made from alpaca wool and some local food products for daily consumption.</p>	<p>100 km long and more than 3,000 meters deep canyon with pronounced slopes in volcanic, intrusive, metamorphic and sedimentary rocks. Colluvial deposits, flows of hanging lavas and volcanic plateaus, settled by populations that maintain their ancestral traditions and customs (mainly connected to agriculture). It concentrates geological aspects that show volcanotectonic activity, hot springs, waterfalls, etc. and different geological aspects of the Precambrian-Jurassic-Cretaceous-Paleogene-Neogene.</p>	<p>The Colca River crosses the bottom of the canyon between 2,950 and 1,150 masl, passing through different ecological levels; slopes with farming terraces using different microclimates and with rural settlements on both banks (Tapay, Cabanaconde, Conishua, Llanca, Acopalca and Choco). The key viewpoint called Mirador Cruz del Cóndor, an emblematic Andean bird that is perceived by tourists as great attraction for its flight, and by indigenous people as a lord of the canyon.</p>	<p><i>Andenería</i>, system of terraces used by farmers, located on both sides of the canyon, constructions that come from the <i>Collaguas</i>, people of the pre-Inca culture. Manifestations of local culture by the local and indigenous people in their traditional clothing, practicing their customs and rituals like <i>El Pago a la Tierra</i> - payment to the Mother Earth (<i>Pachamama</i>) at different times of the year. Pre-Hispanic cobblestone roads, used as trekking routes, connected to hidden villages.</p>	<p>The A component (geological, geomorphological, and hydrological) is interpreted in detail, however too expertly. With an exception of two pictures of the ancient fortress and path on columnar lavas, the B and C components and their mutual interrelation as well as their link to A component are practically not reflected. E.g., the determination of the iconic systems of agriculture parcels (<i>andenerías</i>) by the specific geology, geomorphology and hydrology, as well as specifics of condor habitat should be mentioned.</p>
<p>Andagua Volcanoes Valley viewpoint</p> <p>Natural viewpoint in Antaymarca, which shows a panoramic view of the Andagua Volcanoes Valley. It combines geological aspects of recent emplacement of lava in the valley and pre-Hispanic occupation in the area, as well as its current use of fertile land and natural products.</p>	<p>Main sector of the Andagua Volcanoes Valley which concentrates a 360 ° view 10 of the 24 existing monogenetic cones. Lava fields, where municipalities such as Andagua and Soporó as well as an agricultural countryside are located. At the foot of the viewpoint, there is a citadel built of blocks of basaltic andesites from the Andagua Volcanoes. It is a landscape generated by an Andean volcanism during the Pleistocene - Holocene. Slag</p>	<p>The dominant vegetation is represented by cacti species, one of them with the fruit called <i>sancayo</i> (or <i>sanky</i>), growing wild there, thus being 100% ecological (without any agrochemicals or pesticides). Its consumption is like any other fruit. Currently, it is used for its acid flavor for production of drink known as the <i>sancayo sour</i> (mixed with <i>pisco</i>, national drink) or ice creams, among others. Due to its</p>	<p>At the foot of the Antaymarca hill, there is an outcrop of older volcanic rocks in which reddish slag fragments stand out. Towards its northeast side, there is a pre-Inca construction, entirely built of slaggy and dark volcanic rock, the Antaymarca Citadel. The material used in their enclosures or dwellings, as well as in funerary contexts, has been elaborated of the volcanic material ejected from the monogenetic cone called Ayapucara or <i>Canalla Mauras</i>. Due to their dark color, it is not possible to recognize these constructions from a greater distance than 100 m. Walking on the</p>	<p>Another geosite, where the interpretive panel is still missing. However, the images of the geoguide book (Zavala, Mariño and Varela, 2016) and the CVAUGG Facebook posts provide insight into its future conception. The interpretive potential for A component is presented, except for the volcanic activity model, by the photos of the monogenetic volcanoes and lava fields. The photos of pre-Inca dwellings and pre-Hispanic cobblestone road, both built of local volcanic material offer visualization of the A-C</p>

	cones and lava flows of various times can be distinguished in the ancient alluvial valley.	high content of vitamin C and potassium, it has healing properties (e.g. an antioxidant effect).	trails, the pottery fragments from the place can be observed.	interlink. The simple interpretive text focusing on the B component (cactus fruit <i>sancayo</i> and its healing effects) exists. It should be enriched to reflect ABC interlinks (specific soil characteristics and the <i>sancayo sour</i> as a part of local culture).
Colcas Shininea Remains of storage tanks, called <i>colcas</i> , located in the canyon section of the Colca River.	The canyon section of the Colca River in the Yanque district, made up of lake deposits from the Colca Formation generated by a large paleolake, caused by a large volcanic avalanche that dammed the Colca River. The vertical walls present deformation structures ("seismites and slumps"), frequently found in some sandstone strata. They represent seismic activity in the recent geological past associated with neotectonics in the	Suspension bridge linking both banks of the Colca used by local people to get to the grazing areas with their livestock (cattle and camelids) and to transport their products. The surrounding terrain is used for farming. On the Colca paleolake deposits, large platforms were constructed to stabilize slopes. A few hundred meters upstream, "Colca Amphitheater" or <i>andeneria</i> , an extraordinary system of these	Pre-Inca stone buildings of circular shapes, <i>colcas</i> , dating back to 800 years ago. They served as special warehouses for the conservation of seed corn, quinoa and potatoes. Its special and whimsical location, on a canned, refrigerated and ventilated space. The first Colca communities (Collaguas) built large warehouses to conserve corn and meat <i>charqui</i> , dried fruits, among other products. The Colca Valley and Colca Canyon owe their name to this ancient pantry of this Andean region.	This geosite has just a very brief and simple, rustically elaborated, but really apt interpretation. It connects the explanation of the ancient storage constructions in the specific microclimate (A and C components) with the local germplasm and its conservation (B and C components).
	area. The greatest thickness of this paleolake was located in Yanque.	pre-Hispanic terraces, is located.		The photo prepared for the intended interpretative panel indicate this ABC interlink as well, stressing the cultural use of geomorphology of the site. Another photo reflects local A component (paleo-seismology and neotectonics). However, the geological and geomorphological essence of the site need to be interpreted, in connection to <i>colcas</i> .
Panagua Canyon and ice waterfall Small canyon located south of Orcopampa, carved out on folded and faulty strata in Jurassic sedimentary rocks. A small interior circuit has been built, where it is possible to see an ice waterfall, the local flora species a waterfall.	Hidden canyon, south of Orcopampa (13.5 km), carved out of Hualhuani (Jurassic) quartz sandstones. A small waterfall and an impressive seasonal icefall (June-August) can be observed there. Large fallen rock blocks, smooth folding (anticline) on the right side of the valley and a normal type geological fault on the left side of the valley are remarkable. Clean waters flow from the Pacque gorge, from the slopes of the Chuañuma hill. The local landscape is result of the fluvial and glacial erosion.	The landscapes of different geological origin, carved on sandstones, are complemented by natural vegetation and reduced cultivation areas in the valley. A cobblestone circuit trail shows the flora of this place.	From the main viewpoint of this canyon, it is possible to observe the Challhua Mauras volcano and the snowy Coropuna, venerated as <i>Apu</i> (protective mountain deities of the area). Before entering this geosite, it is possible to see the ceramic work of the local people called <i>tinajas</i> ; evidently offered in the direction pointing to the snowy Coropuna.	This geosite is not interpreted yet, just the photos prepared for its interpretive panel exist. They visualize mainly the potential A-C interlink of the future interpretive panel, through the cultural / spiritual importance of the local summits. The geological and hydrological aspects (A component) seem to be also well indicated. The B component (local flora) and its connection to the A one (determination by local rock, soil, as well as both geomorphologic and hydrologic conditions) should be integrated into the future interpretation.

Table 2 Analysis of the ABC concept application in the interpretation of the Muroto UNESCO Global Geopark

Geosite	ABC component of the geosite's Earth heritage			Evaluation of the ABC concept application in the geosite interpretation
	Abiotic (A)	Biotic (B)	Cultural (C)	
<p><u>Nakagawauchi community on a fluvial terrace</u></p> <p>A small village, called Nakagawauchi, located on a fluvial terrace, conserves local tradition which is very specific compared with life of communities in the coastal area. Hanegawa River plays a crucial role for the Nakagawauchi community life and development.</p>	<p>In Nakagawauchi village, topography formed by river can be observed; fluvial terrace which is a flat land has the village located on it at an elevation of ten meters above the river. Due to its high altitude from the river surface, the village rarely experiences floods. Therefore, traditional culture has been conserved and passed down for many generations.</p>	<p>Hanegawa River preserves high water quality. Since local communities are formed along the river, locals have spent their time by the river, catching river fish or swimming in the river. Local elementary school also did a water quality survey with local residents; evaluating its quality based on transparency and species presence in 2016 and 2017.</p>	<p><i>Gicho</i> Shrine is located on this fluvial terrace. In the 14th century a samurai called <i>Gicho</i> fled to this area along with his household, due to trouble in his political career. This shrine hosts a festival every November in his name. Locals make 263 potato cakes for the 263 people who fled with <i>Gicho</i>. Nakagawauchi also preserves a traditional lion dance performed at <i>Shinto</i> festival, praying for safety of forestry work and good harvest.</p>	<p>The A and C components are well integrated into the simplified geostory through description and visualisation of the hydrographic, geomorphological, tectonic and other geological characteristics as well as related cultural aspects of the geosite. The B component (e.g. life in the river) is missing there.</p>
<p><u>Nishiyama plateau</u></p> <p>It is area of well-known farm fields. These flat lands have been cultivated by villagers for more than 200 years. Local community continues in this specific kind of the agricultural development.</p>	<p>The step-like shape of marine terraces has been formed by the combination of sea level changes due to climatic variation and coseismic uplifts in the western part of Muroto. The flat parts of the terraces are utilized for farming, taking advantage of the favourable terrain and rich content of minerals in the soil.</p>	<p>Many species of fruit and vegetables such as sweet potatoes, eggplants, various types of the citrus fruit or watermelons are grown on the terraced fields where they receive abundant sunshine and good drainage (the land used to be under the ocean). Sea breeze from the ocean also gives a beneficial stress on crops which makes them specifically delicious.</p>	<p>Even after cultivation of the plateau by local villagers, the amount of water for agriculture was not sufficient because of its location. Local inhabitants therefore made 23 reservoirs of various size in the territory of the community. Thanks to these reservoirs, Nishiyama plateau is well-known for high-quality agricultural crops.</p>	<p>All the three components of the Earth heritage of this geosite are integrated in its interpretation. A brief text and an easily understandable scheme illustrates the A component (a geological / geomorphological origin of the terraces). Farming is interpreted as a cultural activity (C) bringing delicious local crops (B). Just the minerals (A) contained in the soil and the local microclimate determined by the specific geomorphology</p>

				could be mentioned as factors beneficial for the local farming.
<p>Kiragawa townscape</p> <p>The town preserves traditional architecture style and techniques, designed to cope with typhoons and earthquakes. These beautiful buildings could be constructed because the town gained wealth by trade in raw lumber and Tosa <i>binchotan</i> charcoal from the late 1800s to early 1930s.</p>	<p>Kiragawa townscape is also located on marine terraces created by past earthquakes and wave erosion. Houses are built low (one-storey) on the higher ground and tall (two-storey) on lower ground. This is to avoid the storm wind hitting the taller buildings. Local carpenters understood geographical and climate characteristics of the town and designed houses in harmony with natural environment.</p>	<p>Since forestry area covers most part of Kiragawa, local people have abundant <i>ubame</i> oak tree which are raw material of Tosa <i>binchotan</i> charcoal. Local inhabitants exported high-quality <i>binchotan</i> charcoal to other parts of Japan and gained wealth which was reflected in Kiragawa's beautiful and unique architecture.</p>	<p>Since charcoal producing and its business were main industries of this town, Kiragawa has been blessed by unique culture compared with other parts of Muroto City territory. <i>Onda</i> Hachimangu Shrine, located in the centre of the town, is the heart of many local festivals: <i>Onda</i> Festival prays for good harvest in May 3rd every other year. It is designated as national important intangible cultural property.</p>	<p>This cultural geosite is obviously interpreted predominantly by</p> <p>C component. The A component is correlated to the C one through photographs of the special style of architecture which can withstand earthquakes and typhoons. And the B component is correlated to the C one through the <i>binchotan</i> charcoal whose export enabled the construction of the splendid buildings. However, the importance of local forest with an abundance of <i>ubame</i> oak tree as a raw material for this charcoal is not mentioned there. The B component is also reflected in the sketch of local immaterial cultural heritage (festival) devoted to improvement of harvests.</p>

<p>Murotsu Port</p> <p>Murotsu Port area is the biggest fishing town in Muroto. Many restaurants and local businesses have started as tuna-fishing flourished from the late 1960s.</p>	<p>Murotsu Port was built by excavation bedrock. This process had to be repeated each time an earthquake struck, uplifting the land and making the port shallower. As the land was uplifted the port was dug deeper, creating the difference in height between the sea level and the buildings that surround the port.</p>	<p>The port is well known landing port for <i>Kimme-dai</i> (alfonsina), deep-sea fish. Off shore of Muroto, there are steep cliffs and the seabed suddenly deepens near the coast, which provides deep-sea fishing points (400–700 m below sea level) not far from the port. <i>Kimme-dai</i> is one of the representative fishes of Muroto Geopark.</p>	<p>There are many temples and shrines around Murotsu Port: Ichiki shrine honors a civil engineer who established the port; Chudoji temple holds spirit tablets for whales. Before tuna fishing, Muroto prospered throughout the 19th century due to whaling. These tablets reflect gratitude of local people towards the whales for substantial support of their subsistence.</p>	<p>This is real example of the ABC concept application. All three components are integrated in the text of the interpretive panel as well as their mutual interlinks. The architecture and urbanistic history reflect C component as a result of A component. The spiritual life reflected in the local temples (C) is interconnected with life in the sea (B), because whaling represented an important source of the local subsistence in the past. The life in the deep see water is even connecting all the three components: specific underwater geomorphology caused by volcanic and tectonic activities in the past (A) enabling the abundance of the <i>Kimme-dai</i> fish (B) which is the raw material for the delicious dish as a part of the distinguished local cuisine (C).</p>
<p>Nabae-Sakamoto coast</p> <p>This geosite shows that local inhabitants accept blessings and struggles brought to Muroto by the warm Kuroshio current; many subtropical flowers and plants are observed. On the other hand, this area had to experience big damage caused by typhoons.</p>	<p>Along the Sakamoto Coast, red rocks with green and white layers are observed. It is the result of volcanic ash that mixed with mud on the sea floor. Iron within the volcanic ash oxidizes and turns red. When the amount of iron is small, the rock becomes green or white. These rocks were used for construction of walls and as garden stones. It served also as raw material for production of inkwells used in calligraphy.</p>	<p>Due to the warm Kuroshio Current off the coast of Muroto, there is a warm climate all the year round. Subtropical plants are observed throughout Muroto. The rapeseed blossoms (<i>na-no-hana</i> in Japanese) bloom in this area first within the City. The name Nabae comes from the words <i>na</i>, meaning rapeseed in blossom and <i>bae</i> meaning to grow, to live, or to blossom.</p>	<p>Not only blessings, but also struggles are brought by the warm current, typhoon hits Muroto every year. Especially typhoons which hit this area in 1934 and 1961, called “Muroto Typhoon,” and renowned all over Japan, caused extreme damage to this area. Local people built stone memorials in Nabae, Sakamoto, Tsuru (a neighbour community) as a typhoon memento to warn future generations.</p>	<p>The content of this interpretive panel gives an idea how the local specific abiotic natural conditions determines the local life including the local culture and identity. The explanation of the climate phenomena and hydrometeorological hazard (Kuroshio current, typhoon, component A) includes clarification of their impacts on the marine and terrestrial ecosystems (B component) as well as on the life of local communities (typhoon stone memorials and horticulture).</p> <p>Another interpretation of A component of the coastal Earth heritage focused on the underwater geology demonstrates its interlink to the local culture (ornamental gardening and calligraphy).</p>

<p>Mitsu-Maruyama</p> <p>Mitsu-Maruyama districts are located in eastern coast of Muroto City, where net-fishing has been traditionally practised by local inhabitants. Also, in this area, deep sea water industry has flourished since the 1990s.</p>	<p>Maruyama coast is extremely flat, made up to 15–28 million years old mélange, mostly composed of dark mudstone surrounding lighter chunks of sandstone. Beside the mélange about 14-million-year-old igneous rock (dolerite) is observed. As the harder igneous rock is more resistant to erosion, it forms a small mountain, sticking up near the coast. Kitano Shrine is on the mountain for fishery prosperity.</p>	<p>A large variety of creatures live along this shore due to the nutrient-rich deep seawater disposed of in the ocean by a deep-sea water laboratory. In Mitsu Coast, fossilized bivalve group (<i>Akebiconcha uchimuraensis</i>) is found. It lived deep in the ocean and survived using methane and sulphur that bubbles up from underwater vents. It was designated as a municipal cultural property in June 2019 by local high school students works.</p>	<p>Muroto Municipality is blessed by underwater topography which nurtures deep sea water. In Muroto, deep sea water research has started in 1989 for the first time in Japan. Later, private companies, handling deep sea water, were established along the east coast of Muroto. Deep sea water industry became a new representative industry of Muroto which creates employment opportunities for local people.</p>	<div data-bbox="863 161 1426 630"> </div> <p>The A component is well represented by both terrestrial and underwater geological and geomorphologic phenomena, produced mainly by volcanic activity and erosional processes. It is also well related to the B component - rich marine life stimulated though abundance of minerals. The AB interlink is also represented by description of the fossils and clarification of the past life conditions of these fossilised creatures. Regarding the C component, with exception of the indication of the Kitano Shrine on the satellite map, it is rather missing there. It would be appropriate to mention the origin / essence and importance of the deep-sea water industry for the Muroto peninsula.</p>
<p>Sakihama (Kanagi landslide and Mt. Dannotani)</p> <p>Sakihama prospered from the late 1800s to the early 1900s by transporting firewood and binchotan charcoal. The mountainous area in Sakihama formed a unique culture, different from the coastal area.</p>	<p>The Kanagi area, located upstream along the Sakihamagawa River, has suffered repeatedly from landslides caused by earthquakes and heavy rains. The landslides buried Sakihama port, the communities and farmlands in the area. The remains of the restoration work (1917 – 1964), such as log barriers and stone dams, are preserved and they indicate period's construction method.</p>	<p>In the upstream part of Sakihamagawa River (on the slope at about 675–900 masl), there are 33 large wild cedar trees. Some of them have trunks reaching up to 13 meters in girth. The inland area of Muroto has many steep slopes which receive large amount of rain, making it a favourable habitat for cedar trees. The cedar tree community is protected as a part of national forest. A local guide association is licenced to conserve and offer guided tour in the area.</p>	<p>At a lower altitude from the wild cedar tree community, there used to be a small settlement called “Dan”. The local people focused on forestry until around 1970s. The number of foresters gradually decreased, and the remaining families left the mountain soon after. In the middle of tour to wild cedar tree, an elementary school (closed in 1971), can be observed. The building still remains rest of period's local life style.</p>	<div data-bbox="863 957 1236 1669"> </div> <p>BC interlink is presented by the production of the Tosa binchotan charcoal enabled by the abundance of the wood in the local forests</p>

the main geological features of the MUGG territory, has the biggest number of small panels. A small panel focuses on explaining specific rocks, geological phenomena, and ecosystems with easy words and graphics. Therefore, the small panel does not really tell visitors a holistic geostory which is a connection between nature and people's lives. A large panel, on the other hand, aims to show the connection and tells more comprehensive information of each geosites, more focusing on a contextual geostory. The large panel is easier to find compared with a small one, so visitors look first at the large one and then find small panels with more specific interpretations. The large panel has always on its left side the same interpretation giving through the brief text and simple graphics the key geostory of the geopark (Fig. 8). This brief text really reflects an ABC philosophy: *"Where the Ocean and the Land Meet—The Forefront for the Birth of New Habitable Land. A Geopark is a park where you can feel the heartbeat of the Earth. Here you can experience first-hand the relationship between us and our planet Earth."* This geostory always conveys to the visitor the notion of formation of the Muroto lands and integrates successfully the A, B, and C components of the MUGG Earth heritage. Through this system, the MUGG team is trying to explain geological phenomena in the context of the human and physical geography of the given geosite, e.g., a formation process of fluvial terrace with a simple illustration (see "Nakagawauchi Village on a Fluvial Terrace" in Table 2). It explains the process with words which conjured up illustration or photos when preventing the use of expert terms which are not important for understanding of the interpreted phenomena. The MUGG team also researched the cultural environment around the site, such as traditional festivals or local customs. Then the cultural and ecological information were put deliberately on a same interpretive panel with geological information. The fluvial terrace interpretive panel shows how local inhabitants have established their lifestyle on the terrace.

The interpretation method of Earth heritage has been changing day by day with local specialists who explain the situation and phenomena of their place by their own words. The MUGG geoscientists regularly work with a local guide association (Muroto City Tourist Guide Association) with the aim of improving the interpretive skills of local geological/geographical phenomena. To develop a new geotrail, they investigate potential sites together and role-play for interpreting those sites. Throughout such interactions with local guides, the MUGG has improved its interpretive method of Earth heritage.

Moreover, the MUGG team has frequently interviewed senior locals to record cultural and historical events in the geopark territory. For example, they shared how the local traditional festivals have developed under the influences of local industries which are strongly connected to the local natural environment. There are legends or myths related to the local natural environment in the geopark territory which have

been handed down from generation to generation. Such legendary stories are also important resources for the MUGG to know how Earth heritage in the region has been recognized and interpreted by locals. Local people are in the forefront to experience transformation of local natural environment. Their involvement, therefore, is crucial for initial Earth Science investigation and following Earth heritage interpretation in the MUGG territory.

Discussion and Conclusion

In the Colca and Volcanoes of Andagua UNESCO Global Geopark territory, there are many cultural sites which are interrelated with local geography and geology (ecological floors, stone use and other geological resources). However, mainly because of the recent designation of this area as a UNESCO global geopark and relatively difficult socioeconomic conditions, the ABC concept application is presently not sufficiently visible in the terrain interpretation. The terrain interpretation does not reflect the biotic and cultural components of the Earth heritage presented on the evaluated geosites in a sufficient way; the same applies to their explicit or implicit links to the abiotic components, to the concrete geological phenomena. It is obvious from the interpretive panels whose content is analyzed in Table 1. On the other hand, this interpretive approach was intuitively used in the process of geopark project promotion, e.g., during its presentation on the "Regional Workshop Geoparks in Latin America" (Zavala 2015).

According to the CVAUGG team, the people involved in geopark work, actually absorbed the ABC concept as a "geopark philosophy." The CVAUGG team clearly perceives this concept as a way of integrating different aspects of Earth heritage by attracting professionals from different specialties to work together. According to the Andean worldview, transmitted by the local indigenous peoples from one generation to another, the cultural and natural aspects of Earth heritage cannot be mutually separated. The local and indigenous people highly appreciate the location of their communities, and they also express deep respect for what is provided by their environment, Mother Earth (*Pachamama*). It is a real strength of this geopark, the territorial identity and sustainability exhibited by intuitive perception of the value of the ecosystem services provided by the Mother Earth. The further reflection on the local community knowledge of Earth heritage in the geopark interpretation will help the CVAUGG team to develop genuine interpretative panels and geotrails, and mobilize local people as interlocutors.

Geological, geographical, or ecological study results (Earth science field in the broad sense) on the Muroto UNESCO Global Geopark area have been accumulated so far. Abiotic and biotic aspects out of ABC concept, therefore, have a firm

Fig. 8 The left side the of the large interpretive panel of the Muroto Geopark. Source: Muroto (2020)

scientific background there. Cultural information, on the other hand, still needs to be considered and researched very carefully when shared on interpretive panels or communicated through guided tours. Scientific interpretation, such as land formation processes or fauna and flora related to the local climate environment, always becomes a foundation storyline of geostory which can be endorsed by the geopark Earth scientists. It tends to be believed that the cultural aspect is “added information” to the foundation storyline in the MUGG territory.

Moreover, when discussing “culture” as a term, there is a trend to base it on cultural information or events already summarized and written in a series of local history books edited and published by the Muroto Municipality, such as urban development, traditional industries, traditional festivals, or religious rituals. The MUGG had already a sort of “model” to show connections between culture (human lives) and Earth science. The content of the MUGG’s interpretive panels, analyzed in Table 2, includes the local agriculture, fishery, or local festivals which are referred to show ABC connections in a whole geostory. Showing connections between human lives and Earth science is one of “models” because it is really easy to understand.

The MUGG should identify and protect its cultural “endemic phenomena,” cultural specifics determined by the local specific climate and environment, found only in its territory, and performed just by the Muroto community. They need to be further transmitted and used in the Earth heritage interpretation, through application of the ABC concept. Due to the lack of anthropological research in the geopark area, some cultural information has not so far been documented. According to the MUGG team, it could be called as “*local small narratives*.” For example, several Muroto communities have their unique cuisine or recipes which would reflect the community’s characteristics nurtured by the local natural environment. The MUGG team conducts interview surveys to document and conserve such recipes and related immaterial heritage as a part of local knowledge on natural resources usage. That geocultural information can be shared at guided tours to show and explain the geopark Earth heritage comprehensively to its visitors. Although the MUGG exhibits high level of ABC concept application (and understandingly more mature interpretation in general than the recently designated CVAUGG), it needs to continue research and discussions dedicated to the cultural aspect to enrich further its geostories’ development.

To sum up, the mutual ABC interconnections of the interpreted Earth heritage are well understood and perceived by both geopark teams. The MUGG team, after a process of development influenced by global geopark networking and knowledge sharing, applies the ABC concept in systematic and efficient way. In accordance with the left side of Fig. 2, the MUGG team has gradually developed its geoproducts in

the specific environment determined and influenced by specific factors, and gradually learned to apply and enjoy the ABC concept. Nowadays, some of the interpretive panels located in this geopark can serve as a best practice example of application of this interpretive concept.

Regarding the CVAUGG case, it has to be considered that it is in the initial phase of its development. Without sufficient experience and knowledge transmission enabled by participation on networking, this geopark fails to apply the ABC concept at its touristically used geosites in all its breadth and depth. One important strength of the CVAUGG interpretation has been identified, which regards the local and indigenous people and geoguides, and other providers of tourism services. They are able to interrelate the local legends, myths, traditions, and cosmology, as well as both material and immaterial origin of cultural monuments with the geological and other natural heritage of their geopark. This ability is visible in the performance of local geoguides and some simple interpretive centers or booklets. The CVAUGG is evidently in a similar situation as was the MUGG in the past (left side of Fig. 2), consisting of the gradual learning by experience. Even though the local and indigenous people living in this geopark have the gift of an intuitive and naturally holistic perception of the Earth heritage, recognizing and interlinking all its three (ABC) dimensions, the first generation of the CVAUGG interpretive panels do not significantly reflect this approach. The content of these panels is mainly focused on the geological components of the Earth heritage and frequently uses too many expert terms. On the other hand, there are also other, aforementioned interpretive materials and personal geoguiding in the CVAUGG, which manage to reflect the ABC concept.

The state of art of the ABC concept application in both geoparks is influenced mainly by the level of scientific knowledge and general education in the given geopark, as well as the level of knowledge management and length of networking with other UNESCO global geoparks. The ABC concept application can be considered as partially idiographic and partially nomothetic. There are some regular patterns that can be used in all the geoparks; however, their replicability is limited by the specific geographical settings, different stages of geopark product development, and different management approaches of the given territory. Among the key common patterns is the position of farming as an “interconnector” of the A, B, and C components, including phenomena as local soil, climate, and gastronomy. The same applies to the position of immaterial cultural heritage, which reflects the geological/geomorphological phenomena and processes, as well as the living nature determined by them in various religious, artistic, and other cultural expressions.

There is a high potential to apply the ABC concept in the frame of interpretation of rich Earth heritage of Colca and Volcanoes Andagua UNESCO Global Geopark and Muroto UNESCO Global Geopark, as well as of others geoparks. To

further develop its application, interdisciplinary cooperation both in research and practice of each geopark is needed. Especially the transboundary disciplines like anthropogeography, ethnogeology, or the emerging special field called geomorphology deserve attention of geoparks' practitioners and researchers in geoparks to empower their interpretation and to make their interpretive panels, guides, leaflets, and ICT-based means of interpretation more holistic and communicative.

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Availability of Data and Material (Data transparency)

Code Availability Not applicable.

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Declarations

Conflict of Interest The authors declare no competing interests.

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