

DAGMARA CHYLIŃSKA<sup>a</sup>

## Deep Ocean and Caves: the Ultimate Frontiers in Tourism

**Abstract.** In the ever-shrinking world, the tourism industry is looking for new spaces to explore. It is redefining the known ones and reaching for new ones, which are often located right on geographical peripheries. While it may seem that only space travel remains a challenge for tourism today, terrestrial environments of the deep ocean and deep caves are still beyond the reach of not only mass tourism, but tourism in general. The goal of the article is to identify objective and subjective, stable or variable, external and internal conditions that explain why the deep ocean and caves represent the ultimate frontiers for tourism. The author questions to what extent this situation will continue in the future and discusses the attractiveness and development prospects of various niche forms of tourism based on the features of the underworld and deep waters which, at first sight, constitute barriers or threats to most tourism activities.

**Keywords:** caves, deep ocean, frontiers, niche tourism

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### 1. Introduction

In line with the idea of the ever-shrinking Earth, contemporary tourism seems to have no boundaries. Spaces that used to be inaccessible because of their remoteness or harsh environmental conditions are attracting growing numbers of tourists. The most inhospitable parts of our planet, including the highest mountain ranges or the ice-covered areas of both hemispheres, are becoming increasingly available to mass tourism. Every year, hundreds of climbers reach the Earth's highest peak, and tourists can visit the Arctic and Antarctic from the decks of enormous cruise ships. The Earth no longer appears to present thrill-seeking extreme tourists with

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<sup>a</sup> University of Wrocław, Institute of Geography and Regional Development, [dagmara.chylinska@uw.edu.pl](mailto:dagmara.chylinska@uw.edu.pl), <https://orcid.org/0000-0003-2517-2856>

challenges equal to those faced by 19<sup>th</sup> century explorers. The only possibilities in this regard are offered by space travel. Meanwhile, vast deep-sea areas and the deepest, longest, completely submerged or simply the most technically difficult caves in the world remain a kind of ‘terra incognita’. In spite of technological advances, these semi-mythical lands are still the ultimate frontiers for tourism. Their gloomy character, depicted in the prose of Jules Verne (*Twenty Thousand Leagues Under the Seas*, 1870; *Journey to the Center of the Earth*, 1864), Edgar Allan Poe (*A Descent into the Maelström*, 1841) or Herbert George Wells (*The Time Machine*, 1895), has invariably intrigued many for centuries, enticing some into the heart of darkness.

The aim of this article is to review the exploratory potential of two types of environment which, by their very nature, are accessible only to a small group of tourists at the moment, thus challenging the claim that only space resists the man’s desire to explore, dominate and control. These inaccessible spaces offer opportunities for a number of niche types of tourism, such as frontier tourism, escape tourism, adventure tourism, science tourism, etc. They have also been associated with the concepts of liminality<sup>1</sup> and flow states<sup>2</sup>, otherwise known as being in the zone. To illustrate the challenging nature of these environments, the author analyses selected geographical and physical constraints that make exploration of such places physically and mentally difficult. The concluding discussion seeks to determine the future of these environments from the perspective of tourism taking into account efforts aimed at preserving, overcoming or eliminating the characteristics which currently make them the ultimate frontiers for tourism.

## 2. Deep Ocean and Caves – into the Unknown

According to MacFarlane (2020, p. 19), “The Underland closely guards its secrets”. Although caves and, to a lesser extent, caverns have had symbolic (as sacred land of the dead) and utilitarian (as shelter) function for at least tens of thousands of

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<sup>1</sup> The term used to describe the psychological process of transitioning across boundaries and borders. The concept was first applied to psychology as the technical name for the perceptual threshold, the degree of stimulus intensity that would just be noticed as audible or visible or detectable in any sensory mode. Its contemporary usage comes from the anthropologist Arnold van Gennep (1873–1957) and refers to rites of passage (Larson, 2014).

<sup>2</sup> The term refers to a complex subjective experience characterized by deep concentration, absorption and enjoyment. It was first identified by Csikszentmihalyi in the mid-1970s with the aim to investigate the phenomenology of subjective experience while performing autotelic activities, that is, activities that are rewarding in and of themselves (Delle Fave & Bassi, 2014).

years, they are still, for many reasons, beyond the reach of most people. According to one definition, a cave is “a natural cavity in a rock which acts as a conduit for water flow between input points, such as streamsinks, and output points, such as springs or seeps” (White, 1984, as cited in Gillieson, 1995, p. 1). In simple terms, they are natural rock voids accessible to humans (the smallest diameter of a passage is about 30cm, Gillieson, 1995, p. 3). They can be formed either as a result of karst processes in carbonate rocks or other phenomena in non-karst rocks, which ultimately lead to the formation of voids in rocks (e.g. pseudo-karst in basalts, ice, sandstone with carbonate binder, lava caves, fissure and debris caves, coastal caves, etc., Gillieson, 1995, p. 2; Migoń, 2006, p. 289).

Today, there is a dynamic development of knowledge about caves, their distribution, physical characteristics or processes conditioning their formation or shaping their physiognomy, thermal conditions and, in some cases, their ecology. Some caves are accessible for mass tourism as show caves (Fig. 1). In 1995, Réseau Jean-Bernard cave in France (with the then-known depth of 1602 m, Gillieson, 1995, p. 6) was considered to be the deepest cave in the world. However, in 2021, it lost this title to the Lamprechtsofen cave in Austria, (already known in 1995 and considered to be the second deepest), as well as five others, including the deepest one known to date, namely Veryovkina Cave in Georgia (2012 m) (Fig. 2). The longest caves, most notably Mammoth Cave in the USA (675.9 km), are up to several hundred kilometers long, creating complex labyrinths of underground passages and chambers, often flooded. The system of corridors of Mammoth Cave is almost twice as long as that found in Sistema Sac Actun in Mexico (335 km), which is the second longest cave (Palmer, 2016). In terms of exploration conditions, caves entirely filled with water constitute a separate category. In fact, they are a hallmark of some karst regions. For example, on the Yucatán Peninsula in Mexico, there are more than 4 caves/km<sup>2</sup> along a stretch of approximately 200 km of the north-central Caribbean coast. Globally, 700 km of underwater cave passages have been explored to date, accessed from the surface by so-called cenotes, i.e. sinkholes (Beddows et al., 2007). In 2019, the Hranice Abyss cave in Czechia was considered to be the deepest flooded cave with a known depth of 404 m (or 473.5 m if non-flooded parts are included, Vysoká et al., 2019). Other flooded, deep caves, as reported by Vysoká and her team (2019, p. 2325), are located in Italy (Pozzo del Merro, 392 m; Caramanna, 2002), France (Fontaine de Vaucluse, 308 m; Audra and Palmer, 2015), Croatia (Red Lake, 350 m; Andrić and Bonacci, 2014), Mexico (Zacaton, 335 m; Gary, 2017), Brazil (Lagoa Misteriosa, 220 m; Auler, 2017), and South Africa (Boesmansgat, 283 m; Farr, 1991). The so-called ‘blue holes’ in the Bahamas reach similar depths (Farr, 1991).



Figure. 1. A spectacular speleothem of Postojnska jama, part of the 34 kilometer-long Postojna-Planina Cave System in Slovenia. The well-lit and enormously spacious cave chambers of the most famous show caves give only a hazy idea of typical severe conditions of extreme cave exploration.

Source: Photo taken by the author





Figure 2. The world's ten deepest caves (2021). 1. Veryovkina Cave, Abkhazia/Georgia; 2. Krubera-Voronja Cave, Abkhazia/Georgia; 3. Sarma Cave, Abkhazia/Georgia; 4. Snezhnaja Cave, Abkhazia/Georgia; 5. Lamprechtsofen, Austria; 6. Gouffre Mirola, France; 7. Gouffre Jean-Bernard, France; 8. Sistema del Cerro del Cuvón, Spain; 9. Hirlatzhöhle, Austria; 10. Sistema Huautla, Mexico

Source: Own elaboration

The world of caves continues to hold many secrets. New discoveries can result from deliberate exploration (as exemplified by the history of Mammoth Cave exploration, Sides, 2017), can happen by accident (as in the case of Lascaux Cave in France, Martin-Sanchez, Miller & Saiz-Jimenez, 2015, p. 282), e.g. as a side effect of human activity (the discovery of the Bear Cave in Poland during the exploita-

tion of marble deposits, Igielski, 1968), or as a consequence of natural processes, sometimes of a sudden or catastrophic nature (e.g. mass wasting, earthquakes).

The deep ocean, or deep sea, is another habitat that is still largely inaccessible for (not only tourist) extensive exploration (Fig. 3). The term is used to describe the area of the ocean that includes water layers and the seabed below the depth of 200 m. According to Herring (2001), it represents 65% of the globe's surface and over 95% of the Earth's mostly unexplored biosphere. Approximately 50% of the deep sea is located over 3000 m below the water surface (Corinaldesi, 2015). It is estimated that only 5% of the deep ocean has been satisfactorily explored. Moreover, as Corinaldesi (2015) reports, no more than 0.001% of this vast habitat has been researched in terms of biodiversity. Ocean depths are typically oligotrophic, with occasionally limited oxygen content, low temperatures, impenetrable darkness (visible light disappears below 1000 m depth), and extremely high pressure (from 20 to over 1100 atm) (Danovaro et al., 2017). The last three properties have the greatest impact on the possibilities of exploration. Despite technological developments in the field of deep-sea exploration, there is currently no possibility of repeating a feat like the legendary lunar walk on the bottom of the ocean. It is therefore all the more surprising that ocean life adapted to extremely harsh conditions occurs even at depths of nearly 11 000 m (Danovaro et al., 2017).



Fig. 3. The mystic line between the two worlds. While frightening, the open sea held promise of great rewards for daredevils who ventured to sail. However, marine depths inspired fear, hiding mysterious creatures living on the edge of the known world.

Source: Photo taken by the author

### 3. Caves and the Deep Ocean — the Boundaries of Exploration

Many caves, not only the extremely deep or long ones, have been used for the purpose of tourism (in the modern sense of the word) for centuries (e.g. Mammoth Cave since the beginning of 19<sup>th</sup> century, Palmer, 2016). Cave tourism in its most accessible and organized form caters for motivations typical of tourism in general: the need to experience novelty and a change from the everyday-life routine. Tourists visit caves for their health-promoting qualities: the mineralised or thermal waters, accumulated organic sediments (e.g. guano) or their microclimate (e.g. salt or radon caves), which plays a role in health, spa tourism (Gillieson, 2011). According to Antić et al. (2022), other popular motivations include the desire for adventure, knowledge (geography, geomorphology, paleozoology, paleoanthropology or archaeology), the need to socialise with other tourists and locals, their environment and culture, as well as contact with nature as a way of relieving the stress of living in an urbanised environment (hedonistic wellbeing). There are two types of cave tourists: those who visit generally accessible caves (so-called recreational cavers), and those who practise a more specialised form, known as spelunking, which requires knowledge of specialist climbing or diving techniques and the use of special equipment. What both groups have in common, however, is their curiosity about the underground world (Ganter, 1998). The second group of cave explorers refer to themselves as ‘cavers’, which underlines their deep emotional relationship with caves.

Caves, even those developed for tourism and equipped with the necessary infrastructure for comfortable exploration, are still inaccessible to some, non-dedicated tourists, which is why they can be viewed as the ultimate frontiers for tourism. This is not only because some of them are physically hard to access or geographically remote. Cave exploration by tourists is also limited by psychological and health factors, including an extreme fear of the dark (nyctophobia), claustrophobia (Antić et al., 2022), cardiovascular diseases. Staying in caves even for a short period of time can affect the human body, causing dysfunctions of the visual, circulatory and endocrine-metabolic systems, as well as different immune-haematological and muscular responses (Zuccarelli et al., 2019). Interestingly, conditions found in deep and isolated caves could provide scientists with clues so as to what life would hypothetically be like under planetary conditions, in space bases located beneath the surface of planets (see Zuccarelli et al., 2019). In unfavourable conditions, cave dwellers are at risk of hypothermia and various pathogens, since caves are also the habitat of various species of biota. There is therefore a risk of developing illnesses such as pulmonary histoplasmosis, leptospirosis, schistosomiasis, and endemic mycosis (Lottenberg et al., 1979; Gundacker, Rolfe & Rodriguez, 2017).

Exploring caves, especially those that are least accessible or most extreme in terms of their conditions, remains a challenge in many respects. Although our ancestors lived in caves, and although nowadays people venture into labyrinths of passages equipped with special gear or advanced technology, they are constantly exposed to potential dangers and can only rely on themselves and their companions. These conditions can be regarded as elements of an adventure (in adventure tourism), which are all the more attractive when the experience is non-commercialised, the route is unknown and the end uncertain. The risk associated with cave exploration is best exemplified by well-known rescue operations, such as the one that took place in the Tham Luang Nang Non cave in Thailand or in the Bavarian Riesending cave. In the former case, on July 12, 2018, rising water left 12 members of the Wild Boers youth club and their adult coach stranded 4.7 km from the cave exit. As reported in the 'Thai Cave Rescue. Symposium Report' (Australian Government, 2018, p. 2), up to 10 000 people were involved in the safe return of the boys and their coach. Among them were members of the Royal Thai Army special operations unit, Navy Seals, emergency department staff of the Thai government, specialised rescue units, and foreign consultants (also from Australia). The entire extremely difficult and largely underwater rescue operation lasted three days (08–10 July) and ended, remarkably, with an almost<sup>3</sup> complete success. During the rescue operation in Germany's longest and deepest cave, Riesending, which lasted for 12 days, more than 700 people were involved in rescuing a seriously injured cave explorer from a depth of almost 1 km (Wolf, Vogel & Knolle, 2017). As these two examples show, cave explorers are constantly at risk of getting lost, getting stuck in tight passages, being cut off from the outside world due to collapse or flooding of passages, falling from heights, drowning, being injured or dying due to a rockfall or a landslide of rock masses, or lack of air or accumulation of poisonous gases.

Another problem faced by cave explorers is a kind of liminal experience resulting from sensory deprivation, which can lead to altered states of consciousness. Deprived of external stimuli, the human brain provides itself with stimulation in the form of fantastic visions, illusions or the impression of someone's presence. Ustinova (2009) points out that basically since the dawn of humanity, people have been visiting underground spaces in search of altered states of consciousness, hidden truth, prophecy, revelation or vision. Visits to caves were probably a common element of Palaeolithic shamanic practices (Górzyński, 2018). Cave exploration, even in modern times, can be a spiritual experience; in some cultures it is a symbolic return to the womb of the Earth. Caves have been used as natural sacred places in

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<sup>3</sup> One of the rescuers died. A group of boys and their coach were rescued after spending almost three weeks in the flooded cave.



Buddhism, Hinduism, Greco-Roman religions, Judaism, Christianity, and more recently, also in neo-pagan practices (Kiernan, 1997, 2004, 2015). Entering a cave can be associated with a rite of passage: a symbolic entry into another world, from light into darkness, from the known into the unknown, from the ordinary into the extraordinary. It is also a kind of time travel, into spaces 'frozen' in time, full of remnants of past worlds, cultures, ancestors and cousins (see von Petzinger, 2016). Prehistoric cave art emerging from the darkness of the cave, mysterious signs, hand prints, hunting or shamanic scenes offer underground explorers an opportunity to deepen their (tourist) experience with emotions and sensations unavailable in most other forms of travel.

Bearing in mind the extraordinary and exclusive nature of the cave experience, sensory deprivation can be seen as an element enhancing its attractiveness in the eyes of potential explorers. However, it can constitute a significant obstacle or potential difficulty for those eager to explore caves outside of standard commercialised tourist experience. While a short stay in a cave is unlikely to cause sensory deprivation, longer stays will most probably be accompanied by negative effects resulting from a lack of stimuli. Although sensory deprivation can be a desirable state and a source of unusual sensations for some, it is potentially dangerous. When exploration requires increased focus, effort, including mental effort, often in unpredictable situations, factors such as disorientation, confusion and hallucinations can have tragic consequences.

Diving in flooded caves is another challenge, often close to the limits of human endurance. According to Vysoká and her team (2019), most cave spaces are accessible to humans up to a maximum depth of 100 m below the water table. Crossing horizontal, fully flooded cave passages, as well as descents to the bottom of flooded cave chambers requires what is known as scuba diving<sup>4</sup>. Together with wreck diving, it is the most dangerous type of diving because it involves the use of special gas mixtures for breathing (so-called trimix: oxygen, nitrogen, and helium) and having to comply with decompression tables when coming back to the surface. The secrets and challenges of deep-sea diving are comprehensively explained in Finch (2009). Divers (and therefore underwater tourist-explorers) need to have exceptional psycho-physical resilience, not only in planned exploration, but also in unexpected situations. According to Nuno Gomes, a deep-sea diver known for both deep-sea (Red Sea, 2005, 318.25 m) and cave (Boesmansgat, 1996, 282.6 m) descents, the main risks of cave diving include hypothermia and losing one's way due to disorientation in dark, tight tunnels, often with low visibility due to siltation (Sawa & Gomes, 2014). Other hazards include equipment failure, unexpect-

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<sup>4</sup> Diving with the use of a self-contained underwater breathing apparatus.

edly strong water currents in flooded passages, sudden changes in water level, changes in pressure, water contamination, barotrauma and poisoning by gases that accumulate in the diver's body (nitrogen narcosis), which occurs as a result of breathing air in its atmospheric proportions rather than a specially prepared gas mixture (trimix) and causes dizziness, confusion and hallucinations (Sümen & Aktas, 2019). According to Mitchell (2009), when divers use normal air, symptoms of narcosis can appear already at a depth of 30 m (4 atm abs) and will definitely occur at a depth of 80 m (9 atm abs). The intoxicating effect of nitrogen amplifies hypercapnia, elevated carbon dioxide levels in the blood. Although diving alone can be an extremely liminal experience for a diver, it is not recommended in caves and in deep-sea diving.

Challenges associated with the exploration of the deep ocean resemble those encountered in deep or flooded caves. The deep sea can attract explorers (as well as underwater tourists) for symbolic (Earth's last 'terra incognita'), scientific and practical reasons. In addition to being home to much biodiversity, habitat diversity (including hydrothermal vents, cold seeps, whale falls, seamounts, oceanic trenches and many others), the deep ocean offers many opportunities for underwater archaeology and the extraction of natural resources hidden in the ocean floors. While it is now possible to send exploration equipment into ocean depths — remote operated vehicles (ROVs), and autonomous underwater vehicles (AUVs) — exploration by means of human-occupied vehicles (HOVs) is still a big challenge (Liang et al., 2021). The first manned vehicle to reach the deepest place on Earth (the Challenger Deep in the Mariana Trench) was the bathyscaphe 'Trieste' designed by August Piccard (Piccard & Dietz, 1961). Its crew, Don Walsh and Jaques Piccard, spent only 20 minutes at the bottom of the ocean trench, but their feat started an underwater odyssey that continues to this day with Deep Submergence Vehicles (DSVs) such as the Deepsea Challenger, the DSV Limiting Factor and, in the future, the DSV Rainbow Fish and the Shenhai Yongshi submersible (Vescovo et al., 2021).

According to Vescovo et al. (2021), underwater exploration of the deep ocean by means of manned and unmanned vehicles is associated with the risk of an underwater vehicle becoming entangled in thin fibre-optic cables lying at the bottom or floating, which are used to communicate with the mothership on the surface.

## 4. Tourism and the Earth's Extreme Locations

Owing to their remote location and extreme conditions, caves and ocean depths have a great potential for niche forms of tourism, such as frontier tourism and science tourism. The main attraction of these tourism activities is the fact that these environments are geographically (spatially) and symbolically beyond the reach of most people, including tourists. As Laing and Crouch (2011, p. 1516 as cited in Cohen, 2004) point out, this form of tourism “involves tourists travelling solo, or in small groups with a guide, to remote and risky locations at the geographic as well as cultural peripheries of our world, including trekking to the poles and across deserts, sailing or ballooning around the globe, deep-sea diving, climbing the world's highest peaks such as Mount Everest and even travelling into space.” It is worth noting, however, that frontiers in tourism can be understood more broadly than merely in a spatial, geographical sense. They can also refer to economic challenges, environmental management problems, the protection of attractions, etc. which need to be overcome in other forms of tourism. Frontier tourism is widely motivated by the desire to participate in something authentic, something that guarantees new and unique experiences. These remote destinations are perceived as unspoilt environments (Frost & Frost, 2022, p. 2264). It is also a way to earn prestige among other travellers, especially when the trip is presented as an exploration or an adventure rather than (mundane, mass) tourism. According to Laing and Crouch (2011, p. 1525), people are also motivated to engage in frontier tourism to get a taste of legendary explorations of the far corners of the world to feel like past adventurers and relive their achievements. Visiting the world's remote locations can also part of escape tourism (Chylińska, 2022). Nothing separates one from the rest of the world and its problems better than pitch black darkness or thousands of metres of water above one's head. As Eijgelaar, Thaper & Peeters (2010) pointed out, frontier tourism in environments at risk of severe changes due to global warming or other human impact can be described as ‘last chance tourism.’ Tourists want to see these unique worlds before they vanish.

Science tourism is defined as travelling, usually by scientists, but also by science enthusiasts, to places requiring investigation or verification of their knowledge, to identify new fields of research. Corinaldesi (2015, p. 8) notes that “deep-sea ecosystems have an enormous potential for the discovery and development of new compounds and bioactive molecules of microbial origin (i.e., pharmaceuticals, molecular probes, enzymes, cosmetics, nutritional supplements, and agrichemicals) for technological and industrial purposes.” In other words, in addition to being motivated by curiosity about unexplored environments (ocean floors, underwater tectonic trenches, thermal vents, caves etc.), science tourism has a practical

dimension, mainly economic, but also (geo)political. Given the growing demand for energy resources or rare minerals, deep sea mining is an opportunity to extract valuable raw materials from the bottom of the seas and oceans (Childs, 2022).

Frontier tourism, escape tourism, and science tourism can all be part of adventure tourism in caves and ocean depths, which is sometimes called 'extreme tourism'. Based on a review of adventure tourism literature, Stipanović, Rudan & Zubović (2019, p. 166) define adventure tourism as typically physical, mostly outdoor activities, often treated as a challenge, requiring tourists to take risks, resulting in high levels of emotional stimulation, adrenaline or 'healthy' fear. In the case of cave and deep ocean exploration, specific skills and the use of specialised equipment are required, which is also one of the characteristics of adventure tourism (e.g. Cater, 2013). Faced with extreme difficulties, underwater and underground explorers need high levels of concentration when performing activities which their lives depend on. Although the literature is quite scarce in this regard (see Cater et al., 2021), it can be assumed that this extreme focus caused by external conditions (isolation, lack of communication, darkness) helps people exploring ocean floors and caves to achieve a state of flow (Csikszentmihalyi, 1975, 1990), in which they completely concentrated, calm and all their senses are fully activated (Cater, 2008). Underwater exploration and extreme cave descents can therefore be treated as liminal experiences. Natural environments, especially those challenging for humans or posing real risks, become places where tourists experience inspiring, metaphysical or transformational borderline experiences (Conti & Heldt Cassel, 2020).

Adventure tourism can also take place in a cultural environment, usually in the form of eco-ethno-tourism. Tourists experience an adventure in a radically different cultural environment by participating in a more or less commodified form in the daily life of exotic communities. It would therefore seem that for obvious reasons, in caves and at the bottom of ocean depths such an adventure cannot be experienced.<sup>5</sup> However, this is not true: exploration of caves can often involve surprising encounters with the past of the human species in the form of discoveries such as traces of prehistoric people, prehistoric art, while sea depths hide many valuable objects for underwater archaeology. Discoveries of wrecks of famous ships resting on the ocean bottom, such as the famous RMS Titanic (Fye & Fye, 1986), were preceded by years of patient searching by underwater explorers and enthusiasts. Deep-sea diving to explore wrecks or areas of the seabed or deep ocean waters that are inaccessible to most people is increasingly becoming an exclusive tour-

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<sup>5</sup> For centuries these inaccessible environments were associated with various myths and legends (about mermaids or civilisations submerged or lost in the seas) and, more recently, have become the subject of mass pop culture.



ism product, only available to select few owing to high costs (see e.g. OceanGate Expeditions, 2022).

The largely unknown underwater and underground world is home various unique forms of life that have adapted to extreme habitats hidden in absolute darkness or under immense pressure and cannot be found anywhere else on Earth, thus providing opportunities for the development of wildlife-based tourism.

Finally, it is worth emphasising that despite (or perhaps because of) the high degree of difficulty and risk that such journeys involve, explorers of underwater and underground extreme environments often treat them as opportunities for spiritual travel. This phenomenon goes well beyond religious tourism and is associated with feelings of transcendence and strong spiritual, existential experiences. Immersion in water has a spiritual (cleansing) significance in many religious and secular practices, in festive and everyday contexts. Experiencing the immensity of the deep ocean, which is indifferent, enveloping and awe-inspiring, can be likened to encountering the Absolute. The unique silence and apparent emptiness, much like what can be experienced in high mountains or the open sea (cf. Okupnik, 2011), sharpens the senses. Descending into the underground is often seen as an encounter with the unknown, accompanied by the awareness of the lack of a definite end: there is no light at the end of the tunnel.

## 5. Discussion and Conclusions

Taking into account the features of caves and the deep ocean, i.e. their unique nature and resistance to mass tourism, a question arises regarding their place in future tourism and how long they will continue to be remain the ultimate frontiers for tourism. Will they share the fate of the world's highest mountains, visited by growing number of tourists or the disappearing Arctic as a result of climate change?

In 2001, Hall wrote (p. 601): "Ocean and coastal tourism is widely regarded as one of the fastest growing areas of contemporary tourism". Over two decades later, seas and oceans remain popular destinations for both leisure and water sports (including technical diving). Sailing, including deep-sea sailing, has not only become more accessible to but also safer for an average person, due to the development of modern navigation tools or new durable and long-lasting materials which boats and yachts are made of. Tourist exploration of ocean depths, however, is still in its infancy, and the dream of building exclusive underwater hotel complexes has largely remained a mere mirage, even for Middle Eastern countries, which are famous for the development of futuristic tourist architecture. However, it is worth

noting that technological advances could make oceanic depths and deep caves, especially the flooded ones, more accessible. In the first case, access can become available to a larger number of enthusiasts through the use of unmanned vehicles descending into the depths and enabling an unparalleled observation of the world hidden from the eyes of most people on Earth. Taking part in such expeditions can still be experienced by their participants as something special, more like exploration than tourism. No such opportunities, however, exist in the case of extreme cave exploration. According to Kambesis, 2007, p. 57, “cave exploration is a fundamental element of cave research and cave-related science”. The latest technologies that can be used in the development of underwater tourism can be obtained from companies involved in deep sea mining. At the same time, as in the case of marine fishing and marine ecosystems (Miller et al., 2018), the race for resources hidden on and under ocean bottoms poses a threat to this form of tourism.

In addition to the limitations mentioned above, the bottom and depths of the sea and extremely deep or long caves will remain largely inaccessible owing to specially human limitations. Even the best equipment or financial resources cannot overcome problems such as fear of the dark, claustrophobia, weak mental strength or insufficient body capacity. Therefore, even assuming that technological advances make it cheaper or safer to explore these remote and unknown environments, they will remain out of reach for most people. For example, as Illife and Bowen (2001) point out, exploration of flooded caves remains one of the most difficult forms of technical diving, requiring highest skills in every aspect involved. One can therefore ask if such great risks and the high likelihood of death can be reconciled with the definition of tourism for the majority of people? After all, even the boldest tourist adventure is supposed to end with a safe return home. It seems, then, that the status of caves and ocean depths as ultimate frontiers for tourism is not only the result of their remoteness and difficulties associated with their exploration, but also stems from the fact that for most tourists today they are inherently excluded from the tourist space. In addition, high costs of commercial expeditions to such places constitute an insurmountable barrier for most tourists. As in the case of space travel, this form of extreme tourism is only available to very wealthy people (Webber, 2013; Cohen & Spector, 2019; Yazici & Tiwari, 2021).

There is no doubt caves and ocean depths have much potential for tourism. While surface area of ocean bottoms or ocean bathymetry are known variables (even though these environments are still largely unexplored), the underground world to a much greater extent remains a complete mystery: the question of how far, how deep it is possible to descend into the Earth is unlikely to be definitively answered soon. However, optimism and excitement at the prospect of new discoveries is increasingly accompanied by fairly bitter reflections. Considering the

possibility of new discoveries in the world of caves, Ganter (1998) wrote: “Together we wait expectantly for new discoveries. Whether directly or vicariously we are all explorers, accepting and enjoying the proceeds as one of the last terrestrial frontiers is pushed back. The caves are never the same, because as we explore we also destroy. Frontier is not a renewable resource.” In other words, in some respects the development of frontier tourism involving caves and ocean depths resembles the case of the Roman god Saturn, who devoured his own children (Morford, 2003). As soon as a new unknown is discovered, it succumbs to the human desire to know, collect, and conquer. In this case, contrary to the myth, the leading motivation is curiosity, not fear.

It can therefore be concluded that extreme cave exploration will never become part of mass tourism, at least in the same way as other extreme places, such as highest peaks, greatest depths or longest routes. In the case of the immeasurable, it is the explorer himself who sets the end of the exploration, taking the risk that others will go further, descend deeper, or stop in front of an obstacle that only seemingly represents the end of his or her journey.

Trends in modern tourism are frequently shaped by fads or positive opinions expressed by perceived authorities, or, as is increasingly the case, by social media influencers. In order to thrive in non-obvious or challenging environments, tourism needs strong and opinionated personalities (or media) that highlight positive attributes of these environments. Examples of such personalities include David Attenborough, who has greatly contributed to the promotion of various forms of wildlife tourism (nature-based tourism or ecotourism) or Elon Musk with his vision of space tourism facilitated by SpaceX. Another iconic figure associated with deep-sea and ocean exploration was Jacques-Yves Cousteau, a pioneer of research using underwater research vessels, which were used to capture images of the underwater world. Unfortunately, top speleologists well-known have so far failed to reach equal fame. Moreover, it is difficult to unequivocally identify a successor to Jacques-Yves Cousteau in the exploration of the ocean depths and the popularisation of extreme underwater travels.

At the moment, it seems that the best prospects for the exploration of ocean depths and caves are associated with science tourism. There are two main reasons for this. Curiosity is the main driver of scientific research, and both environments will continue to provide opportunities for the exploration of the unknown for a long time to come. In the case of ocean bottoms and depths, research involves, on the one hand, searching for natural resources materials and the development of methods of extracting them, and on the other, the study of the biodiversity of aquatic ecosystems and its consequences for human life and economy. This is supported by Corinaldesi (2015, p. 1), who points out that “the exploration of the

microbial life in deep-sea sediments is needed not only because it is fundamental for understanding its role in the global ecological and biogeochemical processes, but also because it provides important goods and services for ameliorating human activities and health.” Although, according to Kambesis (2007, p. 46), “caves have not generally attracted the attention of mainstream scientists”, apart from developing the existing knowledge of cave systems, cave exploration could bring other benefits. For example, enzymes produced by certain bacteria that inhabit caves could be used to treat dangerous diseases. Since conditions in some caves resemble those that exist on other planets, they have been studied by NASA (for example Lechuguilla Cave in New Mexico, USA)(Kambesis, 2007, p. 56).

The second, rather mundane, reason for the development and potential success of science tourism in these environments is that outside the academic world supported by governmental or international institutions, only few people can afford such research (travel and exploration) (Valdés, 2017). The organisation of underwater research expeditions requires the collaboration of specialists from different disciplines, the use of expensive and specialised equipment, vessels equipped with modern navigation and research equipment, including autonomous or remotely operated underwater vehicles (AUVs and ROVs). Worldwide, there are relatively few marine units designed for expensive and high-tech research, only a few hundred (371 in 2015) as reported in the 2015 Global Ocean Science Report. Deep ocean descents are highly risky as demonstrated by the catastrophe of the experimental submarine ‘Titan’ in June 2023.

The prospects of frontier tourism involving caves and deep ocean can therefore be linked with the broad meaning of the term ‘frontier’, which are associated with superlatives such as ‘the most remote’, ‘the biggest’, ‘the deepest’, ‘the longest’, ‘the narrowest’, ‘the most desolate’, ‘the most dangerous’, etc. As demonstrated by tourism surrounding the world’s highest mountains, their ‘frontier’ character remains largely unaffected despite thousands of people who have already managed to conquer them. New, more challenging ways of reaching the highest peaks, like solo climbing, climbing without oxygen use, extremely fast climbing, free climbing, open new possibilities for feats and achievements (Apollo & Wengel, 2021). Similarly, challenges and limits regarding caving and ocean exploration are probably going to be (re)defined with new discoveries and technological achievements.

It can therefore be concluded that caves and ocean depths will most likely continue to be the ‘ultimate frontiers’ for tourism for a long time to come, and retain their status as last examples of ‘terra incognita’.



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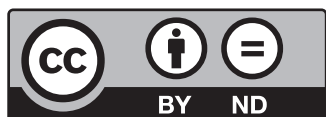
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## Głęboki ocean i jaskinie: granice ostateczne w turystyce

**Streszczenie.** W obliczu wciąż kurczącego się świata branża turystyczna szuka nowych obszarów eksploracji. Redefiniuje te znane, sięga po nowe, często znajdujące się wprost na geograficznych peryferiach. Choć może się wydawać, że tylko podróże kosmiczne stanowią dziś wyzwanie dla turystyki, ziemskie środowiska głębokiego oceanu oraz ekstremalnych jaskiń pozostają nadal nie tylko poza zasięgiem masowej turystyki, ale i turystyki w ogóle. Celem artykułu jest wskazanie uwarunkowań obiektywnych i subiektywnych, stałych lub zmiennych, zewnętrznych i wewnętrznych, z powodu których głęboki ocean i jaskinie wyznaczają granice ostateczne turystyki. Autorka zastanawia się, do jakiego stopnia taki stan rzeczy utrzyma się w przyszłości oraz omawia atrakcyjność i perspektywy rozwoju różnych niszowych form turystyki wykorzystujących te cechy podziemi i głębokiego oceanu, które na pierwszy rzut oka stanowią bariery lub zagrożenia dla podejmowania większości aktywności turystycznych.

**Słowa kluczowe:** jaskinie, głęboki ocean, granice, turystyka niszowa



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