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The Potential for Using Video Games to Teach Geoscience: Learning About the Geology and Geomorphology of Hokkaido (Japan) from Playing Pokémon Legends: Arceus

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Abstract.
In recent years, the concept of using video games as a form of geoscience communication has been gaining momentum. Popular commercial video games see millions of people around the world immersed in wonderous landscapes, many filled with real geological features including volcanoes, mineral deposits, and dinosaurs. Even though these features can be overlooked by many players as simple video game tropes, if utilised in educational environments or scientific outreach events, such video games could be used to encourage and stimulate the teaching of geoscientific concepts, both in the classroom or in their own time. This paper will focus on the geo-educational potential of *Pokémon Legends: Arceus*, the latest game in the popular Pocket-Monster franchise, *Pokémon*. Released at the start of 2022 on the Nintendo Switch, the game saw over 6.5 million players in its first week explore the virtual open-world landscape of Hisui. Unlike several popular commercial video games that are set in a fictional landscape, Hisui is directly based on the real-world island of Hokkaido, northern Japan. From an educational standpoint, *Pokémon Legends: Arceus* could be used as a powerful tool to help younger students engage more in their learning by utilising their natural affinity to the popular game and showcasing the many geological and geomorphological features found across the landscape of Hisui. This paper showcases how geological and geomorphic features can be identified in the game and researched using formal (peer-reviewed literature) and informal (online websites) resources to learn about the geological origin of their real-world counterparts on Hokkaido. Applications for this study could prove to be extremely useful for not only increasing interest and facilitating the self-learning of geoscience worldwide, but also for teaching in educational environments.

1. Introduction

1.1. Learning via Video Games

Video games are commonly used to teach primary subjects for younger audiences (e.g. basic arithmetic and simple logic-based skills), however learning via video games has also previously been explored in various advanced educational topics for several years (Adams, 1998; Squire, 2005; Pew Research, 2008; Squire et al., 2008; de Freitas, 2008). In many cases, specifically designed games have been developed to teach players about particular topics, with the gameplay focussing on presenting players with information and then allowing them to apply the information they have learnt to pass certain tasks and progress (Shute et al., 2013; Mani et al., 2016; Kerlow et al., 2020). However, such 'educational' or 'serious' games can cause players to rapidly lose interest as they can find the gameplay not engaging enough, resulting in the game's educational potential being nullified (Kerawalla and Crook, 2005; Van Eck, 2006; Floyd and Portnow, 2012). 'Commercial' or 'entertainment' video games on the other hand prioritise engaging and entertaining gameplay over educational learning. This can even go as far as players ignoring their educational potential, as they believe the virtual content to be more fictional than it is (Floyd and Portnow, 2012; Brown et al., 2014). As a result, for those wishing to use video games as an educational tool, this prioritisation of entertainment over education could be disconcerting.

In recent years, the blurring of educational vs. entertainment based gaming has become increasingly obscure, partly due to the video games frequently being based, for example, on real world events or locations (Brown et al., 2014). Video games provide exposure and greater appreciation of base subject matter with several studies noting players exploring the real-world implications of the gaming subject (Brown et al., 2014). Due to commercial video games voluntarily capturing the undivided attention of millions world-wide and immersing them in rich landscapes for countless hours (Mayo, 2009), it could be seen as a logical choice to utilise such games to boost geoscience communication and education.

Video games can be used for educational purposes through four overarching themes: (1) through the use of game mechanics such as the often-required ability to map read, (2) game narratives including an expansion in vocabulary, (3) communication between other players, principally social skills including teamwork and communication, (4) and finally via tangential learning - self-learning inspired by being exposed to a topic one already enjoys (Floyd and Portnow, 2012; Turkay and Adinolf, 2012). This study attempts to highlight themes 1, 2 and 4. The only exception is theme 3 which addresses multiplayer based or forum orientated games, which the game explored here is not.

Recent work by Hut et al. (2019), McGowan and Scarlett (2021) and Clements et al., (2022) illustrate how popular commercial games (including *Legend of Zelda: Breath of the Wild* and *Minecraft*) could be used as a form of geoscience communication to promote and educate the wider public, covering topics such as volcanology and palaeontology. If effectively used in an educational setting or at outreach events, commercial video games could become a very powerful tool to stimulate geoscientific education and engagement in students. However, despite the previously mentioned work, both on the use of video

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games in education in general and those directly applied to geoscience, video games are currently a rare resource tool used to teach geological concepts (Jolley et al., 2022).

Video games also have further benefits to those with learning difficulties, (for example, attention deficit hyperactive disorder; ADHD or dyslexia), who struggle to maintain focus using more conventional educational methods (Griffiths, 2002; Marino and Beecher, 2010; García-Redondo et al., 2019). In most cases, studies have shown video games to improve a student's measured attention, as tested using the d2 test measures of attention, and motivation towards educational learning (García-Redondo et al., 2019). Additional benefits also include improved comprehension and mathematics skills (Franceschini et al., 2013), mental agility, strategic reasoning (García-Redondo et al., 2019), time management and planning and organization (Bul et al., 2016).

1.2 Background of Pokémon Legends: Arceus

Released worldwide on the 28 January 2022, *Pokémon Legends: Arceus* is part of the eighth generation of Pokémon games spanning over a 25-year period. The game was extremely popular, selling over 6.5 million copies worldwide during the first week of release, making it the fastest selling game of the franchise at the time of writing (Knezevic, 2022).

For those familiar with the Pokémon franchise, they will be aware that each generation of the core series is set in a unique region, which is based on a real-world location. This not only inspires the design of the explorable game map (including layout, geography and environments), but also the Pokémon (based on real and mythological animals associated with that region), clothing, culture, food, and architecture. The first four generations, are set in fictional versions of Japan while later generations are based on other countries and states, including New York, USA (*Pokémon Black/White*) and the United Kingdom (*Pokémon Sword/Shield*; O'Farrell, 2018). The fictional region of Hisui in *Pokémon Legends: Arceus* is directly based on the island of Hokkaido, Japan (Nintendo, 2022).

Part of *Pokémon Legends: Arceus*' popularity lies in the game's graphics, as it provides some of the most modern and realistic visuals seen in the franchise to date. Additionally, the gameplay has dramatically shifted from a fixed formulaic style with set paths for players to follow, to providing several open world biomes for players to freely explore to research the Pokémon in their natural habitats.

This combination of improved three-dimensional graphics with fully accessible environments, as well as being based on a real-world location, makes *Pokémon Legends: Arceus* an excellent choice to explore the potential of video games in educating players on geographic and geological features. It is important to note that even though much of the player base is likely to be classified as non-geoscientists, players are still likely to be able to identify differences between fake and realistic landscapes to inform their learning (Hut et al., 2019).

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This paper intends to be used as an example – in addition to the other 'geo-gaming' literature – to highlight how commercial video games could be applied in an educational setting (facilitated learning) and encourage the player's own self-learning (tangential learning; Floyd and Portnow, 2012; Brown et al., 2014) of geoscientific topics (e.g. McGowan and Scarlett, 2021; Clements et al., 2022). Specifically for this paper, *Pokémon Legends: Arceus* shall be used as an example to illustrate the potential for players to learn about the geology and physical geography of Hokkaido, Japan, and relevant geoscientific concepts, based on features that are found within the game.

2. Methods

Authors identified geological and geomorphological features which were tied to key moments within the game's main narrative. This approach is inspired by past work (McGowan & Scarlett, 2021), where geoscientific features are identified in popular commercial video games and then compared to real-world examples. The justification for the choice of features and areas is due to the necessity to traverse them to progress the game and therefore guaranteeing player-interaction. Features encompass extremely visible landmarks, including volcanoes, or frequently referred to locations that contain geological context in their name.

Real-world counterparts of the in-game features were identified based on geographical location and physical characteristics, with their geological origin being researched through online literature reviews. Comparisons between the evidence and the literature content were made to determine if they form suitable explanations for the inspiration behind each feature.

It should be noted that *Pokémon Legends: Arceus* was developed to be played by the average person and not specifically for the academically inclined. Therefore, informal sources (for example, Wikipedia and online magazines) will also be used alongside peer-reviewed literature. This is due to the average player, whom this paper is attempting to mimic, potentially preferring this type of resource (Nisbet and Scheufele, 2009) or because they cannot access scientific papers due to them not having an association to an academic establishment.

3. In-Game Features

When comparing the in-game map of Hisui and those of Hokkaido, Japan, including topographic and geological maps (Ayalew et al., 2011), striking similarities can be seen (Fig 1). Therefore, locations within *Pokémon Legends: Arceus* can be identified based on their relative geographic location and similarities (e.g. volcanic craters identifiable in topographic maps).

3.1. Obsidian Fieldlands

The first open area that players are allowed to explore is the Obsidian Fieldlands: a lush grass land, with hilly ground in the centre, a large, forked river cutting northeast to southwest and a dense forest in the south of the area. Due to the locality's name, one could assume obsidian can be found naturally occurring in this part of the island.

Indeed, obsidian is a common volcanic material found on Hokkaido, having at least 21 confirmed primary sources of the glass found across the island (Izuho and Sato, 2007). In contrast to Hisui, however, the majority of the sites are located in the northeast of Hokkaido, around the Kitami Mountains, over 100 km from the Ishikari Lowland (Izuho and Sato, 2007; Akai, 2008), where the Obsidian Fieldlands are paralleled in *Pokémon Legends: Arceus* (Fig. 1).

The obsidian of Hokkaido was a very important resource to Palaeolithic inhabitants on the island, where it was shaped into microblade tools. Such tools were created between 26-10 ka (Akai, 2008; Yakushige and Sato, 2014), and were widely transported across the island, including the Ishikari Lowland and even Honshu, Japan's main island (Yakushige and Sato, 2014). X-ray fluorescence analysis of the obsidian microblades have allowed individual Lowland tools to be traced back to their primary origin, including Akaigawa, ~40 km to the west, and Shirataki, over 170 km northeast (Akai, 2008).

An additional homage to Hokkaido obsidian is in the newly released *Pokémon*, Kleavor. It can be obtained using black augurite (a fictional mineral) or caught in the wild. While black augurite may be fictional, its item design and Kleavor's mirror obsidian. Furthermore, the official description of Kleavor states Hisuians used to use the chipped pieces of stone that fell off Kleavor as tools (Pokémon Legends, 2022), reminiscent of the Hokkiado inhabitants using obsidian tools.

Despite the area's name suggesting obsidian would be naturally present within the Obsidian Fieldlands, this is false. Instead, obsidian was likely transported in from elsewhere on the island. It therefore suggests the name could be more of a homage to the once important resource to the Palaeolithic inhabitants.

3.2.1 Cobalt Coastlands

The Cobalt Coastland, found on the east coast of Hisui is another open access area. Just like with the Obsidian Fieldlands, one could expect cobalt to be found in this coastal region. Whilst cobalt is mined on Hokkaido in the central regions (Khoeurn et al., 2019), none is conducted on the eastern coast. This draws question to the use of 'cobalt' in the area's name. Is it purely a developer's idea of a catchy use of alliteration, or is there greater geological influence?

The area's name could be related to the popular tourist destination known as the Blue Pond, a man-made pond famous for its "cobalt" blue waters (Biei Tourist Association, 2017; Smart Magazine, 2018). Following the 1988 eruption of Tokachi-Dake volcano, concrete dams were built to divert volcanic mudflows (lahars) away from populated areas (Ministry of Land, Infrastructure, Transport & Tourism, 2016; Smart Magazine, 2018). Lahars are amongst the deadliest volcanic hazards, ranking third (primary lahars) and forth (secondary lahars) out of thirteen in terms of total number of fatalities

(Brown et al., 2017). Not only can they flow tens to hundreds of kilometres from the flanks of a volcano, but secondary lahars can occur years after the primary event (Brown et al., 2017). An unexpected result of the dams was that aluminium-rich spring water from the volcano was also diverted, leading to formation of a pond with a distinctively blue hue (Smart Magazine, 2018).

While the Blue Pond is in central Hokkaido, not near the east coast where the Cobalt Coastlands are in *Pokémon Legends: Arceus* – the pond did drown a number of larch trees, which as they died became silvery-white (Smart Magazine, 2018). Such trees are found within the southern part of the Cobalt Coastlands in the area named Deadwood Haunt, which contains numerous ghost type *Pokémon*, possibly a tribute to the drowned trees of the Blue Pond (Fig 2). This adds further merit to the theory that the Cobalt Coastlands are named and based upon the popular tourist destination.

3.2.2 Veilstone Cape – Volcanic Chains, Arches and Caves

One of the most prominent geomorphic features in the Cobalt Coastlands is the Veilstone Cape,a tall, narrow rocky headland. On Hokkaido, the comparable feature is known as the Shiretoko Peninsula. The real-world peninsula is the result of several overlapping volcanic complexes (Neogene to Holocene in age) that form the Kuril Volcanic Chain, running NEE-SWW from central Hokkaido to the eastern end of Shiretoko Peninsula (Minato et al., 1972). The volcanic chain constitutes part of the Kuril Island-arc System, a 1175 km arc system produced by the subduction of the Pacific Plate along the Kuril Trench (Khomich et al., 2019), and through submarine volcanism, uplift and continued terrestrial volcanism resulted in the steep topography along the Shiretoko Peninsula (Chakraborty, 2018).

Along the Veilstone Cape in *Pokémon Legends: Arceus*, caves and arches cut through the coastal cliff (Fig 3a). While the comparable erosional features in Hokkaido are not as well reported as other elements mentioned in this paper, the cause may be due to the Shiretoko Peninsula being much wider and less steep than the in-game Veilstone Cape. As the fictional cape is taller and narrower than its real-world counterpart, it would be easier for coastal erosion to create the prominent arches seen at the end of the peninsula. Travelling inland the arches decrease in size, eventually forming only sea caves, where the coastal waters have yet to erode through and connect both sides, cleverly demonstrating the progressive evolution and formation of natural sea arches (BBC, 2022; Fig 3b).

The major inaccuracy of Veilstone Cape is the size of the headland. In the real-world the Shiretoko Peninsula is much longer, wider and has a gentler profile. However, this is likely a calculated resizing by developers to ensure the headland remains visually impressive without making it feel like a chore for players to traverse, something games with large maps can receive bad reviews for (Tassi, 2018).

3.2.3. Firespit Island – Active Volcano

Off the coast of the Cobalt Coastlands, in the northeast of the region, is Firespit Island (Fig 4a). This is in fact a fictional location without a real-world equivalent in Hokkaido. Firespit Island is a large volcanic edifice, likely to be a stratovolcano due to its physical nature, tectonic setting and this being the most common type of video game volcano (McGowan and Scarlett, 2021). It has a very

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distinguishable crater rim that is taller in the east, presumably the product of a violent explosive eruption that destroyed the rest of the cone. To the west is a gap in the outer slopes and a shallow fan reaching into the sea. Together this points to a lateral or sector collapse of the main edifice, producing a debris avalanche deposit that forms the fan (Romero et al., 2021).

Lava pours out of the vent of a new volcanic cone within the centre of the collapsed edifice (one of the most common volcanic attributes seen in video games; McGowan and Scarlett, 2021). Post-collapse volcanism is common in volcanoes around the world, including Anak Krakatoa (Indonesia), Mt St Helens (USA), Soufrière Hills (Montserrat) and Mount Teide (Tenerife) (Masson et al., 2002; Watt et al., 2012; Watt 2019). After progressing further through the storyline of the game, the lava ceases and solidifies into a mass within the vent forming a plug (Fig 4b and c).

Even though it is typical for mafic stratovolcanoes in arc settings, like that of Hokkaido, to rapidly build themselves upwards, producing steep slopes up to 40° (Romero et al., 2021), the central vent on Firespit Island exceeds this, producing an unrealistically steep cone. This is another common trope of video game volcanoes, with other steep volcanoes also seen in *Legend of Zelda: Breath of the Wild* and *Monster Hunter: Generations Ultimate* (McGowan and Scarlett, 2021).

3.5. Spirit Lakes – Flooded Calderas

During the storyline, players are tasked with venturing to three lakes found across Hisui. Upon reaching the islands in the centre of Lake Verity in the Obsidian Fieldlands (west) and Lake Valor in the Crimson Mirelands (east) a character named Volo explains that many believe these lakes to have formed after volcanoes erupted and the craters later filling with water (Fig 5). Based on the geographical location of the two Hisuian lakes, it can be assumed they are the in-game versions of Lake Tōya (Lake Verity, west) and Lake Kussharo (Lake Valor, east).

Mirroring the description of how Lake Verity in *Pokémon Legends: Arceus* formed, Lake Tōya is the product of a caldera-forming eruption. Tōya Caldera formed around 110 ka, through a series of six continuous rhyolitic eruptions, producing the < 80 m thick Tōya Ignimbrite. The first five were phreatomagmatic and it has been suggested the water originated from a pre-existing lake (Machida et al., 1987; Goto et al., 2018). Post-caldera volcanism (around 40-45 ka) produced an andesitic to dacitic dome complex, in the centre of the lake, called Nakajima, (Goto et al., 2018).

Lake Kussharo (Lake Valor equivalent) is also situated within a caldera, Kussharo Caldera. The last major caldera-forming eruption is estimated around 30 ka (Fujiwara et al., 2017). Like Tōya Caldera, a post-caldera dome complex formed, producing a dacitic to rhyolitic island, also called Nakajima (Smithsonian, 2013a). In addition, another caldera complex, the Atosanupuri Caldera, formed within the eastern half of Kussharo Caldera later during the Holocene (Fujiwara et al., 2017).

This means that in both scenarios, the geomorphology of the Spirit Lakes and the descriptive dialog in *Pokémon Legends: Arceus,* accurately portrays that of real-world caldera lakes and post-caldera lava domes on Hokkaido.

3.6. Coronet Highlands – Volcanic Peaks

The centre of Hisui houses a large mountainous area known as the Coronet Highlands where the tallest mountain on the island, Mount Coronet is located. Given the 'tallest mountain' status, it can be presumed that the Hokkaido equivalent of Mount Coronet is Mount Asahi, a 2,291 m stratovolcano within the Daisetsuzan Mountain Range, located in central Hokkaido.It is part of the Taisetuszan volcano group, a complex of numerous stratovolcanoes and lava domes and is one of several volcanic groups in the Daisetsuzan Mountain Range (Smithsonian, 2013b).

The Coronet Highlands were a barrier of progress in the modern day setting of *Pokémon Diamond/Pearl/Platinum* and likely represent the roughly north-south trending Hidaka mountains on Hokkaido. The Hidaka mountains were initially formed through the collision of Eurasia and North American plate boundaries approximately 13 Ma within the Hidaka collision zone (Niida, 2010; Ichihara et al., 2019).

The Coronet Highlands also contain a "special magnetic field" that allows the evolution of certain *Pokémon.* While magnetic minerals are not uncommon, naturally magnetized minerals are rare (Wasilewski and Kletetschka, 1999; Mills, 2004). The creation of lodestones, a rare form of magnetite (Mills, 2004), is still debated but has been suggested to be driven by lightning remanent magnetization, supporting lodestones being found at Earth's surface as opposed to at depth (Wasilewski and Kletetschka, 1999). Lodestones were often used in compasses, an inspiration for the *Pokémon* Nosepass, which is not only one of the *Pokémon* which evolves in the "special magnetic field" but also is noted to always point north and is checked by travellers to get their bearings (Bulbapedia, 2022).

3.7. Alabaster Icelands

Lake Acuity is the third Spirit Lake found within Hisui. Unlike the two previously mentioned flooded caldera Spirit Lakes (Section 3.5), Volo does not say that this lake formed due to a volcanic eruption. Instead, the character states it contains seawater, but does not know whether this is related to its geography, or a Pokémon. The features of Lake Acuity however, are similar to the previously mentioned lakes – a high-seated circular lake with an island in the middle - so it can be assumed that it is also a flooded caldera with a central lava dome complex. However, when consulting a geological map (Fig. 1c), no comparable volcanic activity can be found in the real-world region, suggesting that Lake Acuity did not form in the same way as the other two Spirit Lakes and instead has a non-volcanic origin.

The lake is the most northern in Hisui so it can be assumed that its real-world equivalent is Lake Onuma, Wakkanai, the most northern lake in Hokkaido. Due to Lake Onuma's proximity to the ocean at Soya Bay, tidal inflows can bring seawater into the lake (Ministry of the Environment, 2015). Despite none of the literature directly stating the lake's origin, it is more akin to a coastal lagoon than a volcanic lake and explains Volo's change of dialog.

4. Discussion

4.1. Tangential Learning about Hokkaido

Pokémon Legends: Arceus utilises a wide range of resources to communicate the geology to the player, including maps, physical structures/graphics, and dialogue from characters. Together, they help to facilitate learning for players by offering opportunities to stimulate curiosity and allow for the learning of a vast amount about the geology of Hokkaido. From the topics covered in this paper alone, *Pokémon Legends: Arceus* can be used to teach volcanology, hazard-mitigation, economic geology and more. Whilst this knowledge was mostly applied to Hokkaido, the general principles could also be transferred to other similar geological settings around the world.

While not every topic covered was explored in extreme detail, this is realistic of the expectations for a player to do online searches to quickly understand more about features they have seen in the game. At the same time, these seem to be sufficient to gain a basic understanding of the regions primary geological and geomorphological landscape.

It is not logical to expect every player to share enough interest in geoscience related topics to stimulate any desire for tangential learning. However, as noted by Floyd and Portnow (2012), even if only 0.1% of players were to conduct online research on a single aspect of the features we have mentioned, *Pokémon Legends: Arceus* has successfully facilitated geoscientific learning in over 6,500 people worldwide.

Even in situations such as explaining the use of 'cobalt' in the name of the Cobalt Coastlands, where the outcome was not as conclusive as others (e.g. the flooded caldera lakes with direct real-world equivalents), players are presented with the opportunity to learn about both mining on Hokkaido and lahar risk-management, while critically analysing the in-game evidence to draw a conclusion.

There is also the possibility that by being able to learn about the real-world origins of a single feature found in the game, it could stimulate further interest in players to conduct even more tangential learning on similar topics. For example, learning that Lake Verity/Lake Tōya formed due to a volcanic caldera-forming eruption, players could continue to research the volcanism of Hokkaido by investigating Firespit Island due to its very prominent volcanic features (crater, active vent, molten lava etc), or the similar looking Lake Acuity and discover its origin is not related to volcanic activity at all. This could even expand into players conducting extra tangential learning on features that are not specifically found in the game, or on a much larger scale than a single feature (e.g. plate-tectonics and island-arc formation that resulted in the formation of the entirety of Hokkaido).

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Caution should still be taken when using video games for education as not every aspect included is factually correct and may result in accidental learning of false information. Lake Acuity is a good example, players are informed on two previous occasions that the lakes formed via volcanic activity, it would not be difficult to assume the third would be any different. Even though Volo gives a different story for Lake Acuity, this could be interpreted as the game developers wishing to prevent boredom through repetition. Instead, a quick fact-check would allude players to the lack of volcanic activity in the area, and therefore suggest there is merit to Volo's change in dialog. The facilitation of video games, or portions of video games, in a prescribed educational setting would allow these issues to be prevented.

Furthermore, tangential learning through commercial gameplay can also be conducted using other games. For example, numerous mineralogical items are considered resources in video games that can ultimately lead to players better understanding the real world. A case of this was presented by Robb (2013) when interpreting mineral deposits in *Elder Scrolls V: Skyrim*, or the numerous games covered by Clements et al., (2022) on palaeontological topics.

4.2. Using Video Games in Geoscience

Despite professional instructors rarely utilising video games to teach geological concepts (Jolley et al., 2022), this case study shows how they can be used to teach about a wide range of topics in an engaging way. Compared to other literature on the subject matter that investigate a single topic across numerous commercial video games (McGowan and Scarlett, 2021; Clements et al., 2022), the focus of this paper, shows how one game can teach numerous geoscientific topics. This should reassure geoscience educators that they do not require access to multiple different video games to provide sufficient examples for their course. Instead, if correctly chosen, a single video game can be enough.

The shift to electronic 'online-based' learning following the COVID-19 pandemic has seen, and will continue to see, an increase in other rarely utilised teaching methods, including virtual field trips (MacKay, 2020; Bond et al., 2021) and other digital resources (Pringle et al., 2017; Jeffrey et al., 2021). Such changes can be used to encourage the addition of video games as an educational tool. The use of virtual learning, including video games, holds numerous benefits, including increased accessibility for students who cannot attend field-based teaching due to costs or physical disabilities, as well as the ability to visit places that could be too risky to attend in person (Stainfield et al., 2000; Pringle et al., 2017).

The high standard of graphics, gameplay and internal functions of commercial video games takes considerable time and funding (Mayo, 2009) but do not require educators to develop the game themselves. However, this time gained could be lost if specific areas or features require significant amount of gameplay to reach. This highlights the necessity to inspect the game beforehand to make sure it is appropriate for use. If the video game does require significant time to reach desired locations, alternative solutions could be used. For example, YouTube or Twitch Streams have access to thousands of video game walkthroughs, where people have uploaded videos of themselves playing the game already. One could select the appropriate video that covers the desired location or feature to show students in the classroom. The downside to this is reduced control over what is shown and the opportunity for students to directly engage in gameplay. However, it can be very beneficial to students who dislike playing video games or do not have access to them. Educators could also set homework to investigate the geology observed in a video game (either through direct gameplay or via videos), with further prompts and questions to help guide the students learning and promote tangential learning at home.

Further to the specific knowledge-based learning showcased, *Pokémon Legends: Arceus* also provides players with opportunities to develop other skills whilst playing. For example, throughout the game, topographical maps are available for all explorable regions, providing the player context to practice map reading skills and exposure to the utility of topographical maps.

Pokémon Legends: Arceus could also prove to be extremely useful for geoscience communication to the wider public at geoscience outreach events. The game has a generally relaxed gameplay style and quick to understand controller mechanics, therefore, the game could be offered to non-geoscientists at outreach events and allow them to casually explore while being talked through the features they can see by a geoscientist. *Pokémon Legends: Arceus* is also rated PEGI 7, meaning it is appropriate for everyone over the age of seven, making it very accessible to a wide range of people.

5. Conclusion

Pokémon Legends: Arceus includes a wide range of geological and geomorphological aspects within its design that show direct inspiration from features found on Hokkaido. This ability to directly compare virtual and real-world counterparts could stimulate tangential learning in players should they be curious enough. Even if only a small fraction of the player base conducts such learning, because the game is so popular and sold millions of copies, *Pokémon Legends: Arceus* can easily facilitate the geoscientific learning of Hokkaido in thousands of players worldwide. This reach can be taken further if the game were to be used within educational settings where educators use the game as a prompt, which could have the added benefit of increased classroom engagement in students due to their interest in playing video games. Furthermore, the popularity of commercial video games with the wider public could be utilised at geoscientific outreach events to teach them about certain parts of the world, using their familiarity of the video game to help their unknown understanding of geoscience. In this case, *Pokémon Legends: Arceus* could be used to teach the wider public about geoscientific subjects and the geology of Hokkaido in an engaging and entertaining way, without the necessity of them ever having to go to that part of the world. Therefore, if utilised correctly, a single popular commercial game could become a very powerful tool for geoscience communication and education.

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Data Availability

All data was collected through playing Pokémon Legends: Arceus on the Nintendo Switch. We do not have permission from the developers to share free access to each game. However, they are all publicly accessible to purchase.

Author Contribution

Conceptualization: McGowan & Alcott. **Methodology:** McGowan & Alcott. **Investigation:** McGowan & Alcott. **Formal Analysis:** McGowan & Alcott. **Resources:** McGowan & Alcott. **Data Curation:** McGowan & Alcott. **Writing – Original Draft:** McGowan & Alcott. **Visualization:** McGowan. **Supervision:** N/A. **Funding Acquisition:** This project is not directly funded; however, E. G. McGowan is funded by the NERC CENTA DTP studentship. L. J. Alcott is funded by a Hutchinson Postdoctoral Fellowship from the Yale Institute for Biospheric Studies.

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Competing Interests

The authors declare that they have no conflict of interest.

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Figures

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Figure 1: Maps of Hisui and Hokkaido. (A) Annotated in-game map of Hisui from *Pokémon Legends: Arceus.* Note the non-traditional angle of viewing and artistic style © The Pokémon Company (2022). (B) Terrain map of Hokkaido, Japan (Bourrichon, 2019). (C) Geological map of Hokkaido, Japan (Ayalew et al., 2011).

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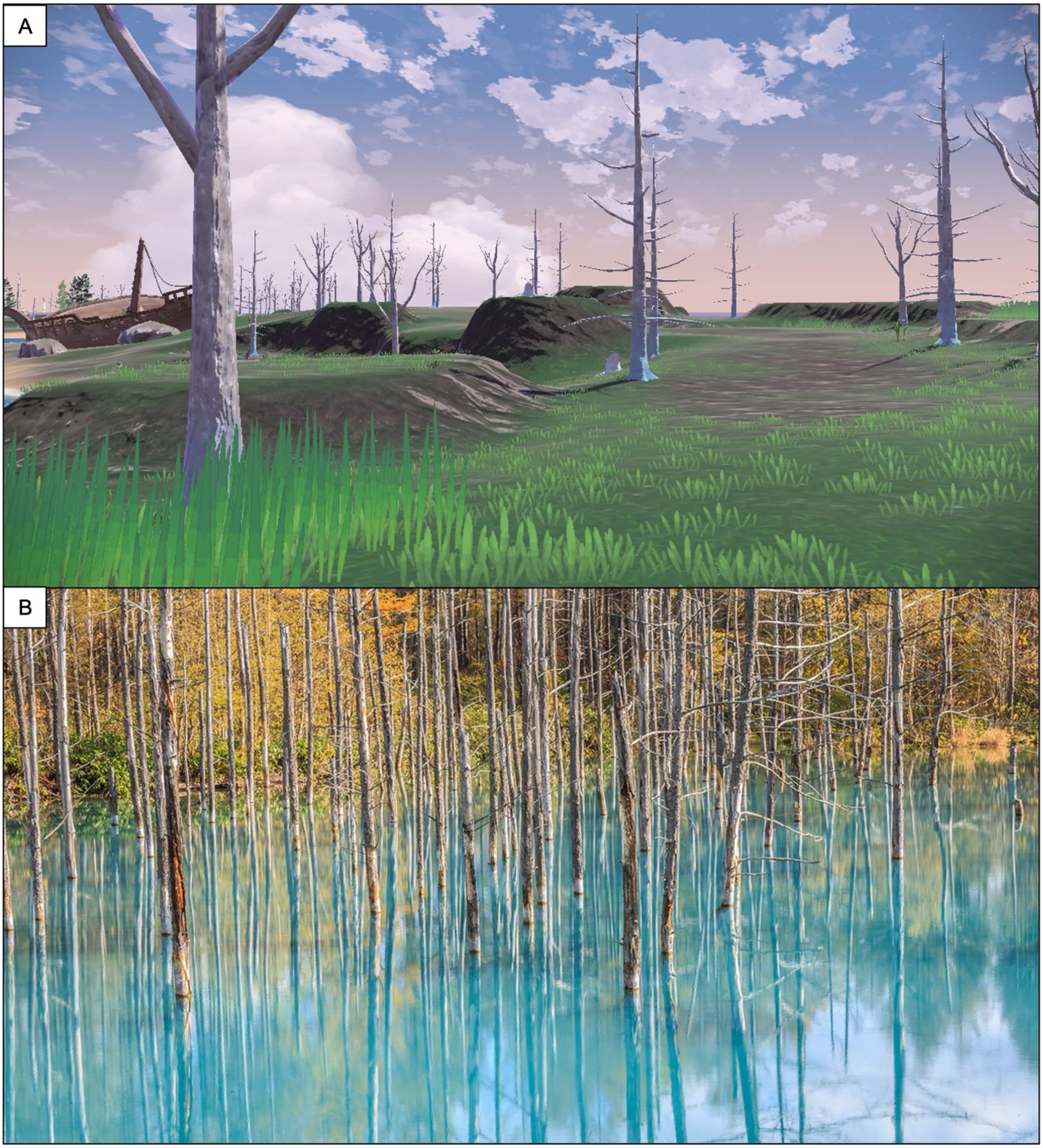
620 

Figure 2: Comparison image of in-game and real-world inspiration. (**A**) White trees found in Deadwood Haunt, Cobalt Coastlands in *Pokémon Legends: Arceus,* © The Pokémon Company (2022). (**B**) Dead larch trees, Blue Pond, central Hokkaido (Gilad Rom, 2015).

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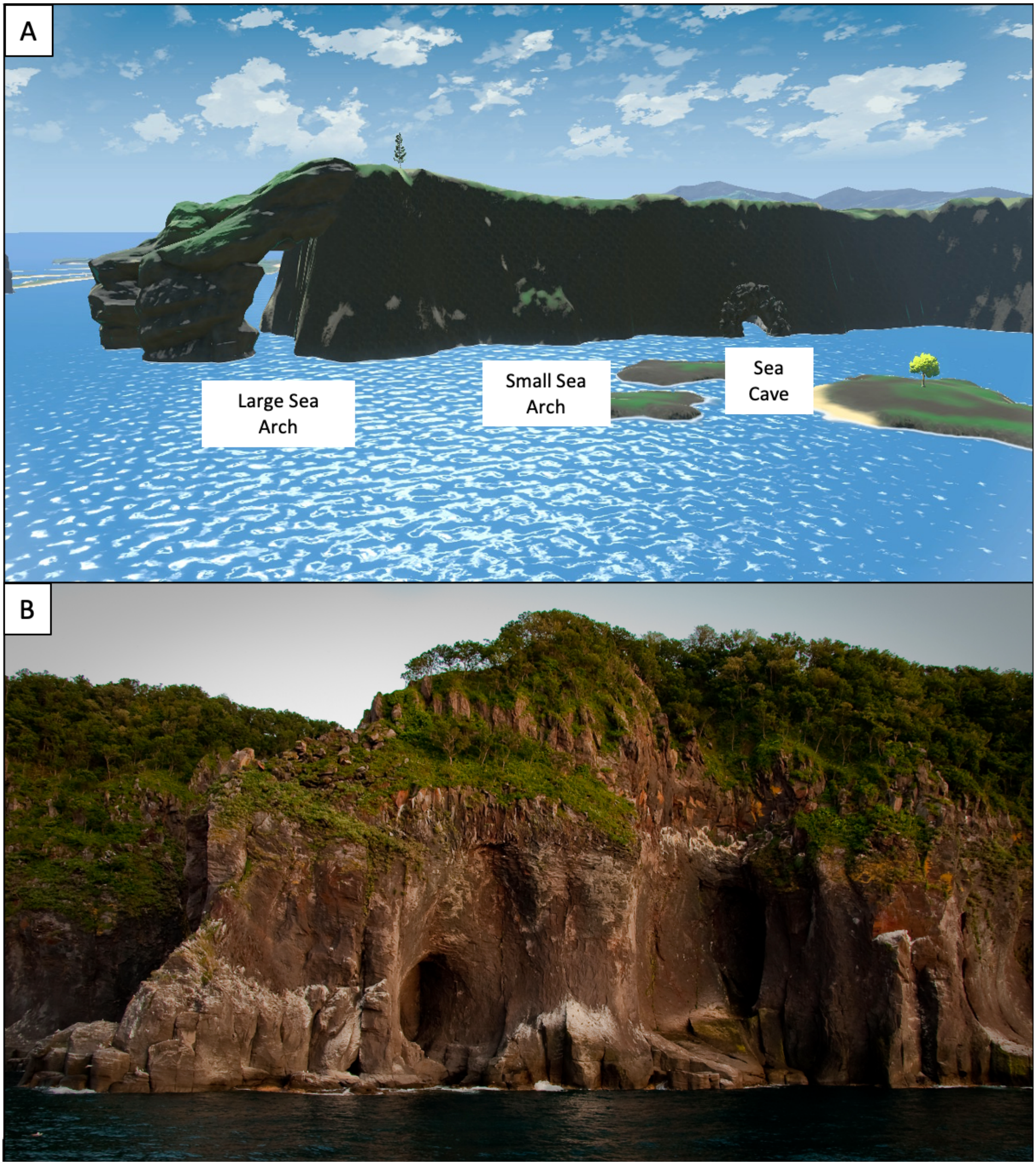

625
Figure 3: Sea arches and sea caves that can be found along Veilstone Cape in Cobalt Coastlands, *Pokémon Legends: Arceus,* © The Pokémon Company (2022). (B) Coastal arches found along the Shiretoko Coast (civ33, 2009).

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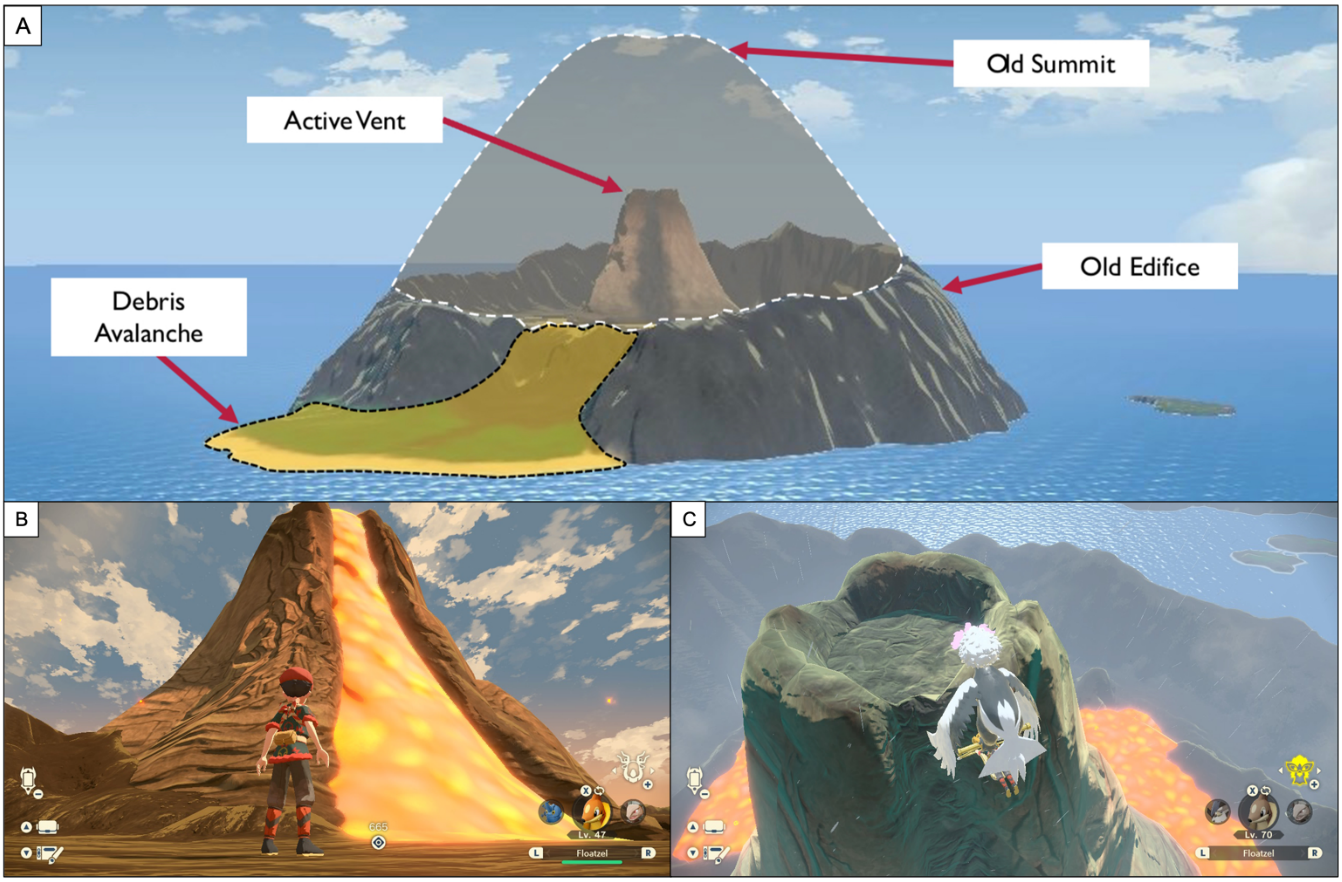

Figure 4: Images of the volcano, Firespit Island, located in the Cobalt Coastlands in *Pokémon Legends: Arceus* (**A**) Annotated schematic of Firespit Island showing a hypothetical look of the volcano pre-sector collapse and highlighting the resulting debris avalanche. (**B**) Close up of the steep, central active vent with lava flowing out (**C**) Volcanic plug that forms after the lava eruption ceases. © The Pokémon Company (2022).

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Figure 5: Comparison image of in-game and real-world inspiration. (**A**) Lake Verity, Obsidian Fieldlands, with caldera rim and lava dome island in *Pokémon Legends: Arceus* © The Pokémon Company (2022). (**B**) Lake Tōya, Hokkaido, with Nakajima Island (633highland, 2013).