v. 3, n. 3, 2023

Journal of
Engineering
Research

GEOIMMERSION: EXPANSION IN GEOLOGY FOR MINECRAFT

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Abstract: The objective of Minecraft is the survival of the player, who needs to extract natural resources, such as wood and ores, to equip himself and build bases. Without the expansion, the progression is given in a simple way: the player uses a pickaxe to break the ores, found in generic and nameless rocks, anywhere, processes them in an oven, and becomes better equipped with the resources obtained. Geoimmersion implements a new layer of gameplay that, in addition to adding more content to the game, makes the player learn geology during the experience, which ends up being pleasant and educational. 200 new blocks and around 180 new items were added, as well as new biomes and structures based on real geology, making the player experience much more immersive. Among the blocks are dozens of metamorphic, igneous and sedimentary rocks, with variations that carry mineral resources, which completely change the mechanics of collecting and exploring the base game. The added items are mainly minerals, which accompany an explanatory encyclopedia about them, as well as metals, chemical reagents, tools and fossils.
Keywords: Minecraft, education, educational games, geosciences, geology, Geoimmersion.

INTRODUCTION

THE GEOIMMERSION PROPOSAL

Whether as a product, artistic medium or media format, video games have become popular as a recurrent element of everyday social life, either as part of personal life or as an article recurrently quoted in other media. From this, it is not surprising when educational projects aim to apply these games as a teaching tool. Within this context, the idea of *Geoimmersion*, a way to make use of video games to educate and raise awareness of subjects related to earth sciences, with a focus on geology. To accomplish this, it was decided to develop a mod (a term used in the industry for unofficial "modifications" of a video game), a practice that is widely common in the gaming industry, since developing a new game would be out of the question due to technical limitations, practices and budget of the project creators.

CHOOSING MINECRAFT AS A PLATFORM

*Minecraf*t is a *sandbox*, adventure and survival electronic game, created by the company Mojang in 2011, being acquired by Microsoft in 2014. Resources within the game often have similarities and inspirations of real-life resources, such as the obsidian block being based on the volcanic glass of the same name or elements such as copper having their counterpart within the game. Jens *Bergensten*, one of the creators of Minecraft, stated in an interview during *Minecraft* Live 2020 that one of *Minecraft's* design principles is said to be "One block at a time". An interaction with the game world through one block at a time allows the user to retain information and learning in a more succinct and gradual way, in which a broken block will lead to the curiosity of the next one to be investigated.

Whether its use by Colégio Padre João Bagozzi in Curitiba for the construction of virtual models of historic buildings (Torquato & Torquato, 2017); or by *The Nature Conservancy* for the awareness and preservation of mangroves around the world (*The Mangrove Restoration Project*, 2022), the *Minecraft* has several uses for environmental awareness and education. The concept of *Geogame* It was first mentioned in the literature by Schlieder et. al. (2006), meaning a game based on georeferenced information, and being used in conjunction with the *Minecraft* for a learning and urban planning project for the city of Tirol, in Espírito Santo, entirely

done by children (de Andrade et. al., 2020). Given its great popularity among children and young people, its use in teaching became inevitable. Created in 2016 by itself *Mojang*, the version of the game called *Minecraft Education Edition* aims to create science and technology learning lessons for students.

Several native Minecraft features bear similarities to existing geological features and resources, such as the aforementioned copper, as well as a plethora of minerals and rocks. During the 2020 COVID-19 pandemic, many geology courses faced the difficulty of keeping field activities in the curriculum, so Professor Erika Rader and her colleagues at the University of Idaho chose to create field method courses within Minecraft (Rader et al., 2021). There is also BetterGeoEdu (Godfirnon et al. 2020), a learning project about geological resources in partnership with several European institutions, such as the Geological Survey of Sweden and the University of Liège, whose objective is similar to that of Geoimmersion.

The choice of *Minecraft* as the teaching platform for this project was made based on the relationship between awareness and environmental preservation of mineral resources, and the various basic geological characteristics of the game that allow basic and advanced learning on the topic. Furthermore, it is the perfect tool to reach the target audience: elementary and high school students, or even higher education students.

METHOD AND DEVELOPMENT

PROGRAMMING BY MCREATOR

The program *MCreator* is a Java platform *open source* designed to facilitate and streamline the programming of *mods* for the *Minecraft*. The program has support for GitHub, a cloud data sharing system. The *MCreator* its main tools are ways to create objects and items in the game in a more simplified way (Figure 1), since it separates each part to be programmed into elements. There is also the possibility of programming using the visual system of puzzle logic blocks (Figure 2) and classic programming by line of code (Figure 3).

Figure 1: Gabbro block creation tab.

Figure 2: logic programming in Geologist's Hammer puzzle format.

```
public class GraniteFeature extends OreFeature {
    public static GraniteFeature FEATURE = null;
    public static Holder<ConfiguredFeature<OreConfiguration, ?>> CONFIGURED_FEATURE = null;
    public static Holder<PlacedFeature> PLACED_FEATURE = null;

    public static Feature<?> feature() {
        FEATURE = new GraniteFeature();
        CONFIGURED_FEATURE = FeatureUtils.register("geoimmersion:granite", FEATURE,
                new OreConfiguration(GraniteFeatureRuleTest.INSTANCE, GeoimmersionModBlocks.GRANITE.get().defaultBlockState(), 64));
        PLACED_FEATURE = PlacementUtils.register("geoimmersion:granite", CONFIGURED_FEATURE,
                List.of(CountPlacement.of(128), InSquarePlacement.spread(),
                        HeightRangePlacement.uniform(VerticalAnchor.absolute(24), VerticalAnchor.absolute(256)), BiomeFilter.biome()));
        return FEATURE;
    }
```

Figure 3: Granite Generation code line programming.

MODELING AND ART

An essential part of the implementation of the *mod's* elements is its visual appearance. *Minecraft* is structured in 16x16 pixel resolution textures, making the game extremely light and maintaining a pleasant look, however imposing certain graphic limitations in terms of art. For Geoimmersion, we opted to follow the game's art style, although higher resolutions were supported, to make the mod's implementation as smooth as possible — while utilizing the aesthetics players are already familiar with. Representing the rocks in 16x16 blocks is not simple, and, in fact, it would be impossible to try to maintain an extremely detailed and realistic look with so little resolution. Therefore, a more cartoonish approach was chosen, aiming to highlight the main elements of each type of rock, in its most common variations, so that it would be possible to give an identity to each block added by the mod without losing its educational potential.

The results obtained by this design choice were very positive, producing rocks and blocks of bright and different colors, with very characteristic and easily differentiated appearances (Figure 4) — which, although not what happens when it comes to geology real, greatly enhances the aesthetic appeal of the *mod* and enhances the educational factor, bearing in mind the target public of the project. Furthermore, variations of the same rock (such as granite, Figure 6), had their differences exacerbated, so that the player or student can easily distinguish between them and understand the vastness of the different mineral compositions that exist, which, in real practice, eventually can only be differentiated by microscope. In general, giving up realism has gained a lot in the attractive, captivating, educational and playability aspects of the product.

As for the tools used, the arts were made in classic image editing software, mainly Paint. Net and GIMP, with the exception of some details edited directly by MCreator. Since this is a game that uses blocks, most of the textures used the same model composed of a simple cube, however, in some exceptions, there

Figure 4: All rocks added by Geoimmersion.

was a need to make more complex three-dimensional models and their respective textures, and for that we used the Free Blockbench program, made specifically for developing 3D models for Minecraft, and even officially used by the game's developer, Mojang, in recent game updates. In this software, blocks such as columnar basalt were modeled (Figure 4), and even some creatures, called mobs within the game, later discarded.

GEOIMMERSION

MOD CONTENT

The mod has 28 rocks, which are subdivided into variations with a high concentration of a specific mineral. These rocks are:

- Granite
- Basalt / Basalt Columnar
- Diorite
- Andesite
- Diabásio
- Calcareous
- Limestone
- Sandstone
- Metarenito
- Gabbro
- Marble
- Quartzite
- Rhyolite
- Gneisse
- formation
- Banded Iron (BIF)
- Kimberlite
- Travertine
- Peridotite
- Slate
- Sulfur Block
- Sodium Nitrate
- Silvita
- Bauxite
- Galena
- Schist
- Meteorite
- Evaporite
- Skarnite

Below are some comparative examples of Minecraft without and with Geoimmersion (Figure 5ab).

Minerals

Some rocks have variations with mineral deposits of interest to the player. An example is granite, which can have its variations with Apatite, Spodumene, Cassiterite, Fluorite, and Torbenite, each rock providing one of these respective minerals, some of them with applications, such as Apatite that can be used in fertilizers, and Cassiterite for get tin. (Figure 6).

Below is a complete list of minerals, with uses ranging from tool making to chemical, agricultural and energy uses.

- Quartz
- Feldspar
- Biotite
- Grenade
- Hornblende
- Pencil lazúli
- Diamond
- Cassiterite
- Olivine
- Emerald
- Wolframite
- Torbernite
- Fluorite
- Osmium tetroxide
- Calcite
- Apatite
- Sodium Nitrate
- Potassium chloride
- Carbide
- Amethyst
- Sulfur
- Spodumene
- Magnetite
- Tourmaline
- Rutile
- Pyrite

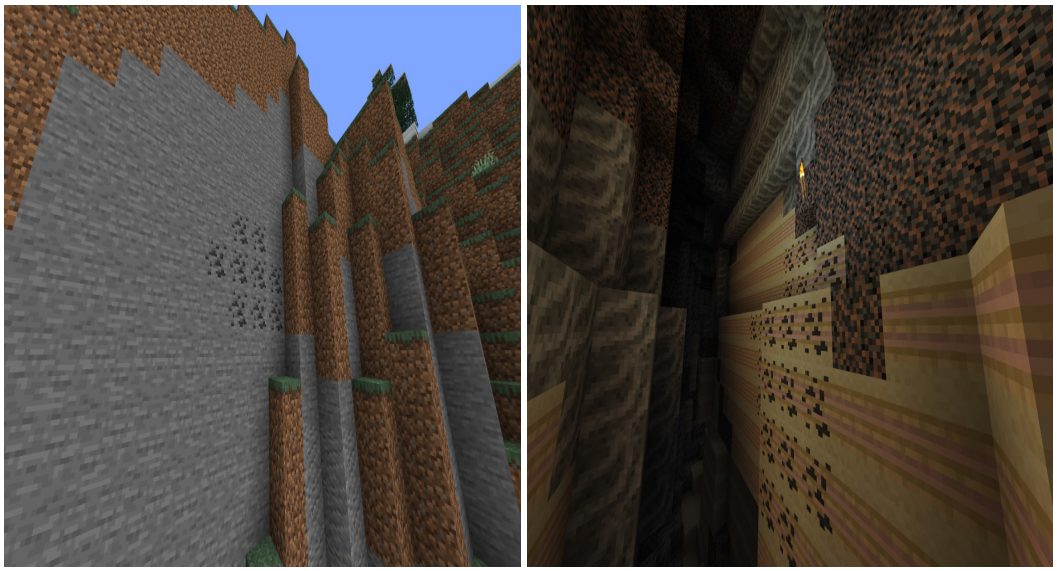


Figure 5a: Arbitrary and common generation with Geoimmersion not installed (left) and generation only in sedimentary and metasedimentary rocks with Geoimmersion installed (right).

Figure 5b: Random generation in any rock and without differentiation of chemical deposits without Geoimmersion installed (left) and Banded Iron Formations (BIFs), the main source of iron, with Geoimmersion installed (right).

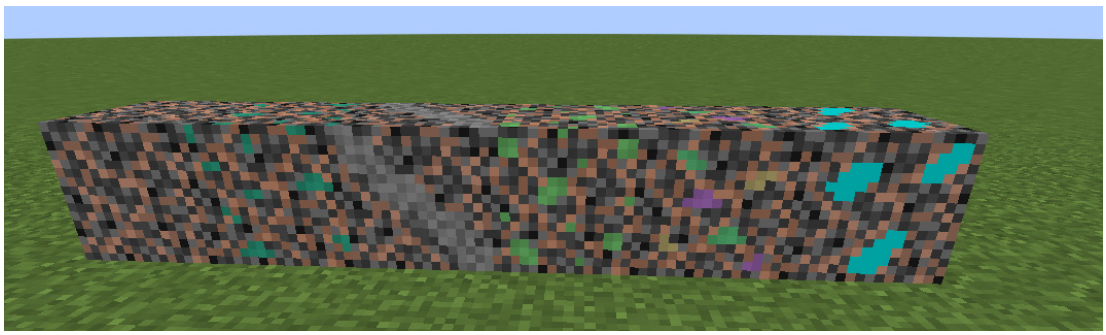


Figure 6: all types of granite in order: Granite, Fluorite, Cassiterite, Torbenite, Spodumene and Apatite.

- Sphalerite
- Vanadinite

Figure 7: all minerals and metals in the mod.

One of the main items in Geoimmersion is the Geologist's Hammer, which has several variations within the game, with the main objective being a tool for collecting minerals. When used, it collects the minerals separately instead of the rock as a massive block.

Figure 8: comparison between the Geoimmersion Geologist's Hammer and a real Geologist's Hammer. Public domain image (right).

GEOLOGY

The mod combines the enhanced lithology with the game world, so the relief changes depending on the lithology.

Figure 9a-e.

These rocks can be collected either by the game's own pickaxe, or by the tool provided by the mod, the Geologist's Hammer, providing different items according to the tool used.

Figure 9a: Sandstone cliffs with banded iron formations around a lake.

Figure 9b: Granitoid mountains representing an orogen.

Figure 9c: Abandoned mine in limestone cave.

Figure 9d: Rhythmic intercalations between limestone and sandstone in a geological fault.

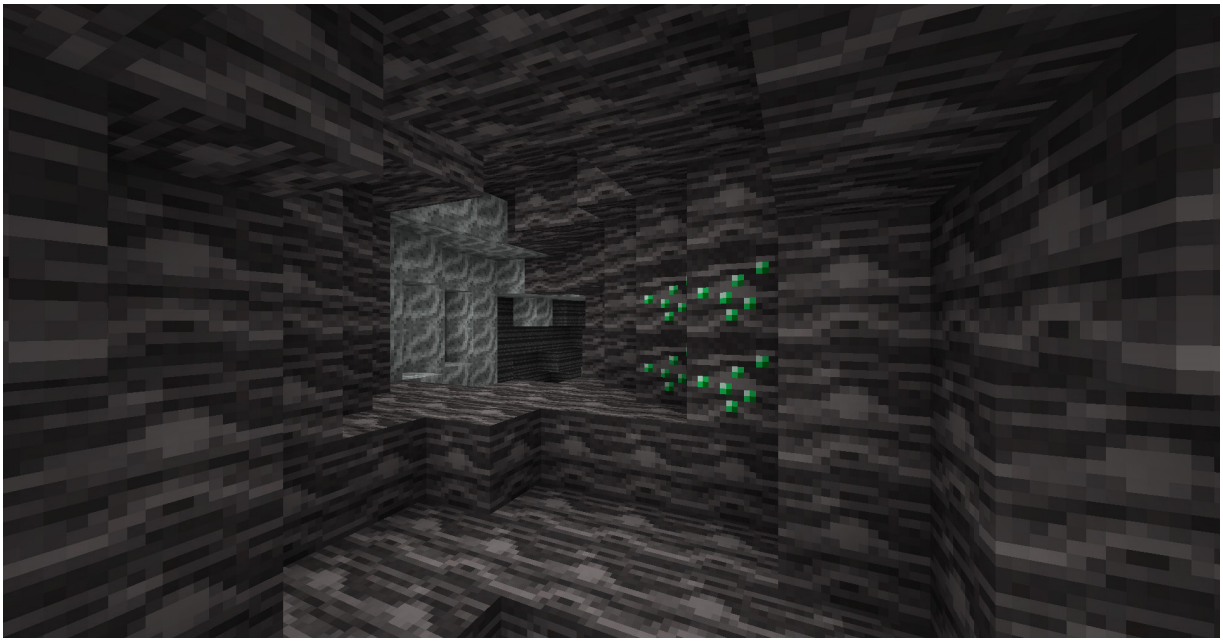


Figure 9e: Metamorphic rocks in contact, Gneiss (more abundant) and Schist, with the presence of emerald.

STRUCTURES AND BIOMES

The Minecraft game has several aspects that are used to create content in it. Structures and Biomes (terms used by the game) were used as mechanisms for implementing geological content by the mod, programming realistic geological features as part of these. Both are widely available for customization within the MCreator program, whose simplicity of use in generating the game world was essential for the development of this project. In the division established by Geoimmersion for Structures, characteristics from the study areas in which they originate are retained, separated as Geological, Paleontological or Geomorphological.

Established by James Hutton, in the 19th century (Theory of the Earth; or an Investigation of the Laws Observable in the Composition, Dissolution, and Restoration of Land upon the Globe, 1788), the term plutonism refers to the consolidation of magma on the Earth's crust, on which two types of magmatic rocks can be found, intrusive and extrusive. Geological Structures of the mod maintains this same division, being judged in Structures of intrusive bodies and Structures of extrusive bodies. Batholiths and dykes (Figure 10a) are some of the intrusive bodies capable of being generated through the aforementioned structures, which are also programmed to be generated at certain predetermined depths. The extrusive bodies, on the other hand, remain concentrated in Volcanic Terrain biomes (Figure 10b), to facilitate their generation. There are structures such as: columnar basalts, volcanoes, pahoehoe lava and magmatic chambers.

Paleobotanical sites of Arenite Mata, in Rio Grande do Sul, have some of the most important specimens of petrified trees on the planet (Sommer & Scherer, 1999). This range of existing references made it possible to create a Paleontological Structure in the mod, Fossilized Wood. Depositional characteristics, explained by Sommer & Scherer (1999), dictate how the petrified trunks of the Arenito Mata site are found on a sedimentary fluvial depositional environment, parameters implemented in the generation of the structure in play (Figure 11). The combination of both previously mentioned structures, together with the implementation of customized biomes in the mod, give rise to the Geomorphological Structures. These structures represent the main method used by Geoimmersion to create more complex geological features.

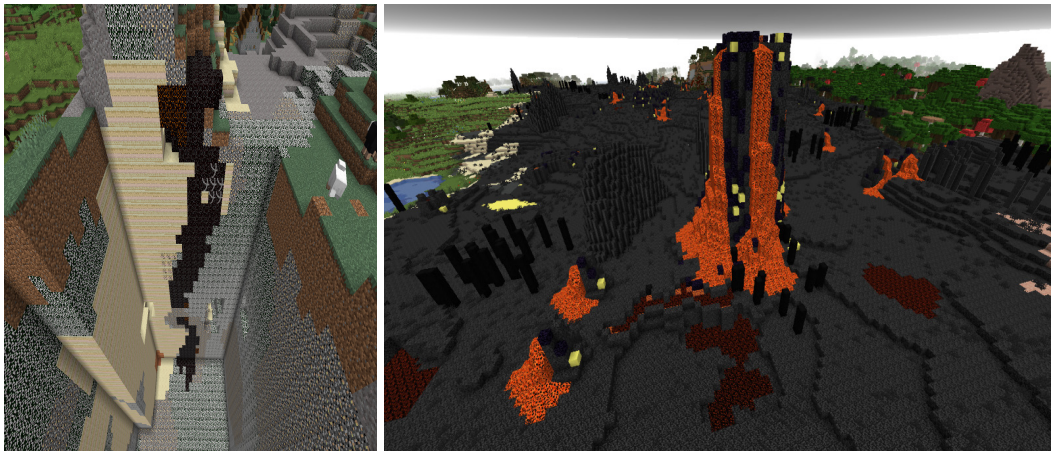


Figure 10a: Stratigraphic section showing a gabbro dike formed by Geoimmersion. It is also possible to see the high depth at which the dike is formed. Figure 10b: Extrusive bodies formed by Geoimmersion in a basaltic flow plain.

Figure 11: Comparison between rolled logs in the Jardim Paleobotânico Mata/RS, modified by Sommer & Scherer, 1999, and the fossilized wood structure in play.

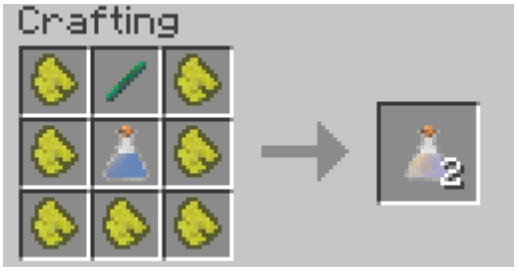
MINERALS AND THEIR USES

One of the main objectives of the mod is to present not only mineralogy and petrology, but also applications of these items in everyday life and in industry as raw material. This way, there are items in the mod that can be crafted using these collected materials. Geoimmersion is programmed to be used with other mods, that is, it is possible to use the rocks and minerals found in other mods installed.

Below are some examples of applications of Geoimmersion raw materials in the mod itself:

- Gunpowder: Existing item in Minecraft, however it is possible with Geoimmersion to obtain it more realistically by combining potassium nitrate, sulfur and coal.

- Sulfuric acid: aims to be the basis for the production of dynamite. For manufacturing, sulfur, vanadium (as catalyst) and an Erlenmeyer with water are required.



- Nobel dynamite: Based on the original recipe by Alfred Nobel (1867), Nobel's dynamite aims to facilitate mining, to make it you need paper, sand, nitroglycerin and a wick.

- Alloy Steel: It is possible to make steel using bars of iron, tungsten, vanadium and coal.

There are dozens of other uses, e.g. tools, armatures, sandpaper, paints, ornaments, construction material and concrete. New forms of use must come with future updates, as the ultimate goal is for all raw materials to have practical application.

TEXTUAL IDENTIFICATION

Another essential part of Geoimmersion are the texts that accompany the elements implemented by the mod, such as rocks, tools, minerals and ores. The texts were developed to be simple, concise and educational texts in order to inform the player about the uses and origins of the item he has. The texts are automatically displayed to the player when they interact with the item in their in-game inventory.

Aiming at greater reach, the texts were developed in English. However, texts in Brazilian Portuguese were also written and are in the initial implementation stage.

Figure 12.

CONTENT UNDER DEVELOPMENT

Although the *mod* has a vast amount of content, future updates are still planned, with corrections of possible problems and addition of new elements. The focus, currently, is to implement mechanics of environmental awareness and sustainable development, through systems such as the addition of machinery, air quality in the game world, local contamination and production and waste management, thus rewarding players who take due care. by processing mineral resources, while irresponsible players are forced to deal with problems posed by their actions. Furthermore, thematic expansions are planned for the *mod*, released as

- Basalt

Basalt is a dark-colored igneous rock with fine-grained crystals formed by the rapid cooling of magma.

When broken with the Geologist's Hammer, it has the following possible drops:

Common - Basalt

Uncommon - Olivine, Feldspar, Magnetite

- Basalto

O basalto é uma escura rocha ígnea com cristais invisíveis a olho nu devido ao rápido resfriamento do magma.

Quando quebrado com o Martelo de Geólogo, tem os possíveis produtos:

Comum – Basalto

Incomum – Olivina, Feldspato, Magnetita

Figure 12 - Example of educational texts implemented in Geoimmersion. In this case, Basalt texts implemented by the mod, offering a succinct description of the rock and its formation, as well as the possible products obtained when the player collects this block.

separate mods that complement the original, focusing on other aspects without taking the focus away from the main material and its objectives, such as, for example, a mod that adds new animals to the biomes implemented by *Geoimmersion*. Such goals will be facilitated by the recruitment of new volunteer developers to the project, which is expected to happen in 2023.

APPLICATIONS

Mojang, which owns Minecraft, remains largely open about mods, so the encouragement and accessibility of these mods is heavily amplified in the game's community, making their installation more convenient. Several free platforms are used to install mods, so that any user who owns the game can install any mod they want.

Casual Minecraft players and members of the mod community were also given the opportunity to play Geoimmersion. The mod was posted on a popular Minecraft mod community platform and forum where other players who create their mods can post their creations called CurseForge. As of January 2023, the mod has accumulated 3,393 downloads. (Figure 13).

Geoimmersion's educational applications are comprehensive for two types of main target audience: Elementary and High School students, seeking to increase interest in Geology. In both cases, Geoimmersion presents the versatility of presenting itself as a digital teaching tool, thus making remote teaching possible, in addition to the flexibility of content administered by teachers. Minecraft's appeal in teaching stems mainly from its popularity among young people, and its ability to make teaching fun and rewarding.

School learning projects could benefit from such a tool, as demonstrated by de Andrade et. al. (2020), as well as institutions could benefit from creating distance geoscience courses for adolescents and young adults. Whatever the application, Geoimmersion remains a free tool for educational uses.

With regard to scientific dissemination, Geoimmersion seeks to disseminate geosciences in general, mainly Geology. By making new generations aware of geosciences and their importance in everyday life, it is hoped that Geoimmersion will contribute to the formation of new geoscientists in future generations.

CONCLUSION AND RESULTS

Geoimmersion presents a contemporary concept of teaching that is little explored in Brazil, not only in terms of the use of technology as a teaching platform, but as the application of popular electronic games, in this case, *Minecraft*. The good evaluations indicate that the project fulfills its objective, to teach and entertain young people about what Geology is, about the different *lithotypes*, their minerals, their industrial applications and applications in everyday life.

With *Geoimmersion*, there is a gateway to not only learning, but also to fostering a new

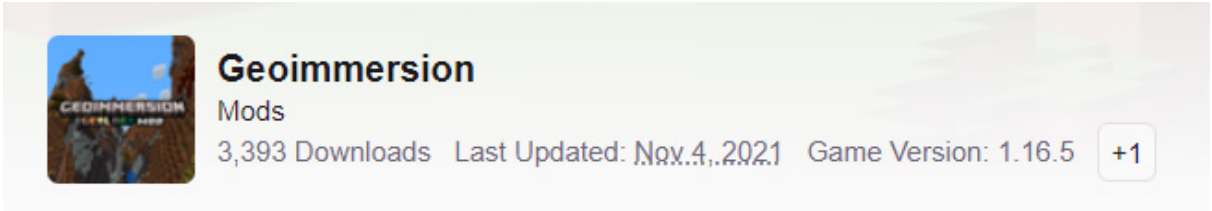


Figure 13: CurseForge website showing download numbers and other Geoimmersion data.

generation aware of the social importance of geosciences, introducing players to more in-depth topics on the subject, thus generating interest in earth sciences. A generation's awareness of geology, its processes and products has a positive impact on society (Carneiro et al. 2004). Lack of knowledge can generate misinformation about the origin of some raw material, as well as negatively bias those who do not understand the importance and true application of mineral resources.

In order to know the impact of *Geoimmersion* on users who played the mod, a form was made available in which players could leave their messages and feedback on the *mod*, in addition to the comments section of the forum where the *mod* was published. Comments are available in Appendix I.

ACKNOWLEDGMENTS

Geoimmersion would not have been possible without the support of CNPq (National Council for Scientific and Technological Development), which financed the project over a year of development, and without the guidance of Prof. doctor Paulo César Boggiani (Institute of Geosciences - USP), always helping us with any geological questions — to which we are immensely grateful. We also have to thank the developers of MCreator and Blockbench, software that was essential for the realization of the project, making it possible to achieve it by allowing geologists new to programming to put their ideas into practice.

The work presented here has only reached its level of refinement and quality thanks to all the mod's volunteer players, especially our colleagues at Geologia USP, who have followed it since its first version, helping us to find any problems and bugs, as well as providing feedback. and suggestions. Without them, *Geoimmersion* would not exist, and for their support we are very grateful.

Finally, we would like to thank Atena Editora for the invitation and for the opportunity to publish our project. We would never have imagined that something we started as a hobby would go this far, thank you for providing us with a channel through which we can share our work with the world.

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APPENDIX I: USE REPORTS

"The game was very important for me to fix the main and accessory mineralogy of the rocks present in the game."

- Giovanni, Geoimmersion player.

"I found the more realistic formations that the mod generates interesting"

- Renato, Geoimmersion player.

"This mod sure has some cool features."

- kr8vzn, Geoimmersion player.
(comment taken from foreign forum).

"I was able to understand the mineralogical compositions of each rock and the economic and industrial uses of ores. Especially alongside other mods, Geoimmersion still plays a great role."

- Anonymous User.

"Thanks! I'll keep an eye on this mod. Looks cool!

- arthademon, Geoimmersion player.
(comment taken from foreign forum)