AN INTEGRATIVE GEOLOGICAL MAPPING SYSTEM FOR FOSSIL DISTRIBUTION OF JEONNAM REGION IN KOREA

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Abstract - This research was preceded in the following order: collecting fossil data in Jeollanam-do (hereinafter referred to as Jeonnam) province in Korea, classifying and organizing materials, and designing the distribution map. Cartographers usually use the geological map management system and metadata when creating geological maps, but this paperhas utilized the results of previous research collected through retrieval, skipped the process and immediately initiated to cartograph. This study tried to create a distribution map using Google My Maps and change the value of input color according to the type of fossil. As a result, the distribution pattern of other fossils in the whole Jeonnam area could be analyzed.The basic platform was initially planned to be built with GIS (Geographic Information System) integrated with VR (Virtual Reality Technology) to visualize the above fossil distribution map more vividly in 3D (three-dimensional) way, and this part remains as an ongoing project.

Index Terms - Jeonnam Province in Korea, Fossil Distribution, Geographic Information System, Virtual Reality, Google My Maps

I. INTRODUCTION

Nowadays, fossils play a role as an indicator showing evidences for the past and important clues to perform geological studies. Nevertheless, there is no any sufficient documents or digital media that summarizes characteristics of fossils, although they exist all around Korean peninsula where this research has focused on. Especially, many meaningful fossils have been found throughout Jeonnam province in this area, and it is necessary to review whole internal factors retrieved from initial sources and categorize them accordingly in right orders.

Currently, there are several indexes for categorizing fossils such as ecological forms and preservation types, and this study has majorly used biological and formal criteria. And, an investigation has followed based on the above categories in order to make an information system that shows distribution maps for fossils in the region and visualizes their properties in a few cutting-edge technologies; this study has basically employed Google My Maps to create geological maps using standard colors and/or symbols, ArcGIS to integrate shape data and collected information about fossils, and CosmoPlayer to run a virtual reality platform with the matching syntax which is described in VRML 2.0 format. Last two procedures remain as an ongoing part at this time.

In this sense, the proposed3D-based geographic information system will be able to serve for providing all the materials in both textual and graphical formats and for showing sensitivity of environmental changes and great geological effects happening in the Earth from the prehistoric age. The purpose of this paper is, therefore, to suggest one of fundamental portals or platforms to handle with scientific and historical facts in more effective, integrative technological ways.

II. THEORETICAL AND TECHNOLOGICAL SETTINGS

A.Index Fossils

Fossils are the preserved remains or traces of animals, plants, and other organisms from the remote past. The totality of fossils, both discovered and undiscovered, and their placement in fossil-containing rock formations and sedimentary layers is known as the fossil record. [1] There are two main types of fossils, body fossils and trace fossils. Body fossils are the preserved remains of a plant or animal’s body. Trace fossils are the remains of the activity of an animal, such as preserved trackways, footprints, fossilized egg shells, and nests. [2]

The process of fossilization varies according to tissue type and external conditions. First of all, per mineralization is a process of fossilization that occurs when an organism is buried. This process can occur in very small spaces, such as within the cell wall of a plant cell. Small scale per mineralization can produce very detailed fossils. For per mineralization to occur, the organism must become covered by sediment soon after death or soon after the initial decay process. The next process is authigenic mineralization. This is a special form of cast and mold formation. If the chemistry is right, the organism can act as a nucleus for the precipitation of minerals such as siderite, resulting in a nodule forming around it. [3][11]

Then, a replacement occurs when the shell, bone or other tissue is replaced with another mineral. A shell is said to be recrystallized when the original skeletal compounds are still present but in a different crystal form, as from aragonite to calcite. After that, compression fossils, such as those of fossil ferns, are the result of chemical reduction of the complex organic molecules composing the organism's tissues. In this case the fossil consists of original material, albeit in a geochemically altered state. This chemical change is an expression of diagenesis. Carbonaceous films are thin coatings which consist predominantly of the chemical element carbon. [3]

In fossils after the above stage, soft tissues of organisms are made largely of organic carbon compounds and during diagenesis under reducing conditions only a thin film of carbon residue is left which forms a silhouette of the original organism. Finally, bioimmuration occurs when a skeletal organism overgrows or otherwise subsumes another organism, preserving the latter, or an impression of it, within the skeleton. Through these processes, fossils are formed and fossilization is occurred. [3][12]

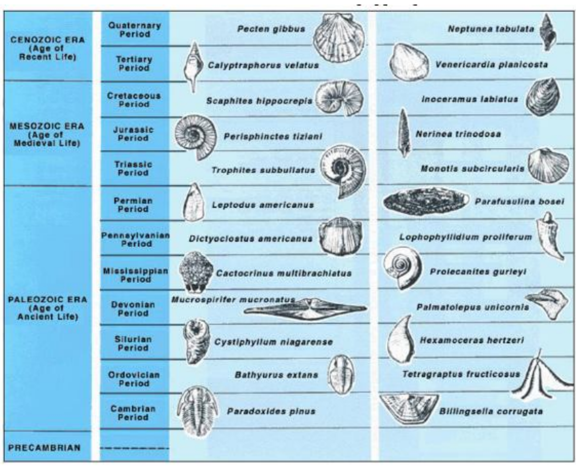


Figure1.Indicator or Index Fossils[4]

Fossils are normally indexed biologically and botanically. Indicator fossils are used to define and identify geologic stages. They work on the premise that, although different sediments may look different depending on the conditions under which they were laid down, they may include the remains of the same species of fossil. The best index fossils are common, easy-to-identify at species level, and have a broad distribution—otherwise the likelihood of finding and recognizing one in the two sediments is minor. [4]

B. Geological Map Codes and Symbols

The geological map means a graphical material that shows distribution of geological information like rocks and fossils [5], and Table 1 shows the geological symbols when the map indicates constituent rocks among various geological indexes. On the other hand, it also utilizes typical colors to show the characteristics of their formation periods.

Table 1.SampleGeological Symbols [5]

Rock Type	Sub Category	Geological Symbols
Igneous	Plutonic	Jbgr, Jgr, Jfgr, Jdi, Kan, Ksy, Kdi, Khgr, kgr, Kagr, Kbgr, Kap, Kad, Kid, PCEfgr, PCEan, TRpgr, TRfgr
	Volcanic	Kiv, Kav, SF, Qta, Qta(S), Qtb(I), Qtb(I)T, Qb(I), Qtb(II), Qb(II), Qtb(III)S, Qtb(III), Qtb(IV)S, Qtb(IV), Qs, Qt, Qtb(V), Qtb(VI), Qb(III)S, Qb(III), Qtb(VII), Qtb(VIII)

Figure2.Digital Map Codes of Geological Periods [6]

C. Constituent Rocks in Jeonnam Province in Korea

Constituent rocks in Jeonnam Province in Korea are normally divided by each relevant geological period into the following: Precam, Age-unkn, Carb-Tria, Tria, Jura, Creta and Quater. [7]

They are specially categorized by the following indexes with the number of the presence: Sindong-layer-group (3), Yoocheon-layer-group (5), Jinan-layer-group (6), Bulguksa-insolated-rocks (8) and other landfills (3) among twenty five specimens in total. These groups can be converted to 0.61%, 31.83%, 3.01%, 1.44% and 4.85% (41.29% in total) in aspects of area and make the biggest spot of geological periods in Jeonnam region. Figure 3 indicates this fact in a format of the geological map.

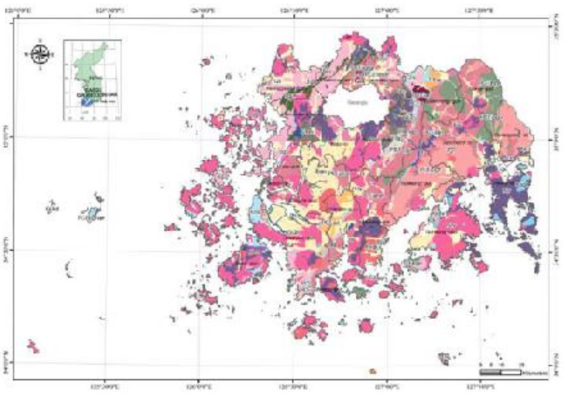


Figure3.Rock Distribution Map of Jeonnam Province in Korea by Geological Period [8]

In this map, capital letters like PCE (Pre-Cambrian period)mean the age of the ground layer and other terms such as kay (Cretaceous Rhyolitic Tuff), kiy (Andesite Tuff), knas (Sand Rock and Clay Rock) and knst (Sand Rock and Tuff) points out types of constituent rocks for the target area.

D.Geographic Information System with Geological Maps

The history of using computers for mapping and spatial analysis shows that there have been parallel developments in automated data capture, data analysis, and presentation in several broadly related fields such as cadastral and topographical mapping, thematic cartography, civil engineering, geology, geography, hydrology, spatial statistics, soil science, surveying and photogrammetry, rural and urban planning, utility networks, and remote sensing and image analysis.The overall objective of a GIS is to allow the efficient analysis and sharing of geo-information. This objective is supported by the data models, structures, management systems and access methods discussed in earlier paragraphs. [9]

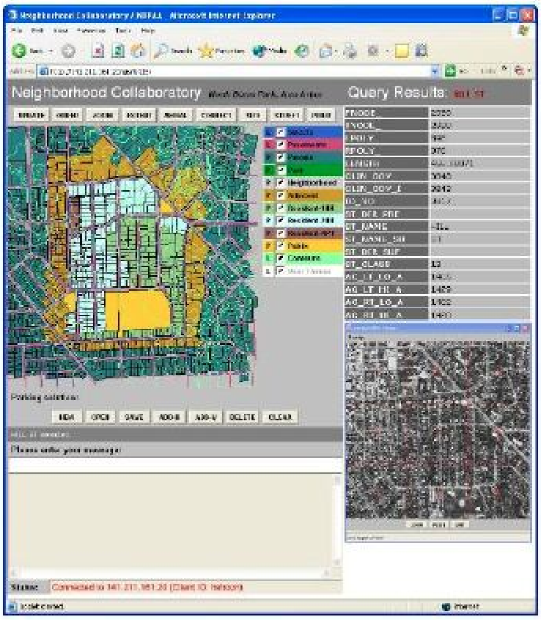


Figure4.Web-based GIS Map with Geological Data [9]

There are several professional programs to generate geological maps such as BizMap, OpenGDKand so on. In addition, GIS provides more functions to handle detailed geo-information and express various analyses from metadata integrated with the geography. ArcGIS or XrGIS is commonly used for GIS applications. On the other hand, currently, Web-based GIS tools have also been developed for public use and Google My Maps is a freeware utilized on the Internet.

Google My Maps has many advantages. First, it can be easily customized for the purpose of the research and conveniently accessed based on Google Maps via Internet using PC or mobile devices. Second, Google My Maps can load representative formats of geographical maps like KML and GeoRSS, and may also export to them or other GIS programs with high compatibility. Finally, this program provides an easy interface to work with geological maps and many fancy iconic palettes to distinguish associated data easily with textual information as well. This research has employed Google My Maps at the first stage in order to make simple distribution maps due to those reasons and will use ArcGIS to add more analyses in the future.

E. Virtual Reality and Animated Presentation

For the virtual environment, interactive architectural 3D scenes - scenes through which people can navigate, interact, and affect, so that each visit leaves its own mark as we do in real world have been built. The choice of 3D scene description language was influenced by the fact that our primary network target is the Internet and the hypermedia system it supports. [10]

A significant effort was necessary to produce an equivalent 3D description language that works well in the Internet. This language is referred to as the VRML, which provides the essential 3D building blocks to construct virtual worlds, and Java is the glue that animates the worlds and links them to the Internet.

Figure5.Internet-based Virtual Reality Browser [9]

In this paper, geological mapshave been constructed with Google My Maps and the VRML 2.0 models are beingmanipulatedwith a VR browser called CosmoPlayer. For a testing environment of the 3D-based online visualization, a ground layer inJeonnam region is selected and relative fossils are planned to be modelled. Any associated data on the geological map will have links to VR models and provide 3D geo-information including fossil specimens when users try to access to those using GUI (Graphical User Interface) more easily and effectively.

III. EXPERIMENTS AND INVESTIGATIONS

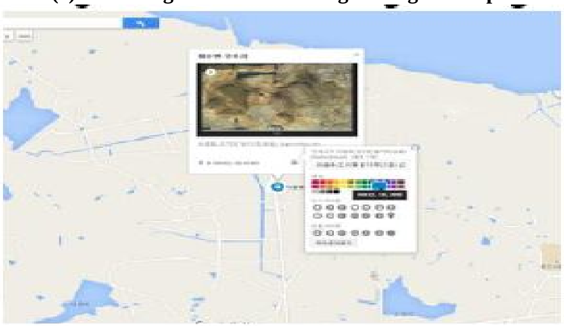
The first step of the investigation for fossil distribution in Jeonnam province was collecting regional data including ten major towns such as Goheung, Gurye, Mokpo, Bosung, Suncheon, Sinan, Yeosu, Jindo, Hampyoung, Haenam, Hwasun especially focused on seashore and island areas where target fossils were found all around. This paper have used a variety of sources including governmental institutes.

The next step was categorizing target fossils and distinguishing geological symbols and map codes to make inputs for generating geological maps as mentioned in the previous chapter. Basically, representative color indexes follow default values provided by Google My Maps. After this process, it was necessary to set up the boundary of the target area to help investigate geo-information more conveniently. Figure 6 (a) shows a step for creating geological maps using color indexes and icons with collected fossil data. All data should properly be engaged with precise coordinates on the map, and verification for this job is one of the most important factors for the investigation.

Once the map was created with linked fossil data, more graphical data such as 3D models and/or VR instances and detailed plug-in information should be added and uploaded to perform appropriate queries by the users connecting online. For this, manipulating metadata is required to give functions for suggesting outputs in both 2D textual and 3D graphical formats used for electronic devices like PC or smart phones. Recently, GPS (Global Positioning System) is being engaged with the geological maps and this will make many user-based services and mobile apps available.

Using Web tags and HTML (Hypertext Markup Language), various maps from user queries could be plotted out and these results could also be shared via emailing and social networking services.

(a) Collecting Data and Creating Geological Maps



(b) Linking 3D Model and Detailed Fossil Information

(c) Analyzing for Queries with the Satellite Map

Figure 6. Overall Architecture of the Proposed 3D Geological Information System

Figure 7 is the completed fossil distribution map linked with associated textual, audial and visual data in Jeonnam province in Korea. A VR browser will be implemented to integrate the whole data mentioned above and this way will make the map possible to handle in stereoscopic way more intuitively by the users.

Figure 7. Suggested Integrative Fossil Distribution Map

CONCLUSION

The research aimsat suggesting a fundamental portal platform to handle with scientific and historical facts about fossils focusing on a region in a country in Fareast Asia in more integrative technological methods.With multiple experiments and investigations, some meaningful outputs have been produced and they can be summarized as the following.

- First, it was proved that the proposed system surely provided more convenient way for performing fossil researches. Collected data from the hardcopies could successfully be converted to geo-information using map codes and symbols, and it means any additional data could easily be merged to the fundamental database at any time.
- Second, the suggested integrative platform utilized with GIS, GPS, Mapping techniques and other media technologies was useful to retrieve fossil information by universal devices widely used worldwide.
- Third, the proposed system performed successful analyses from user queries. With a simulative investigation with the platform, it was turned out that most fossils of Jeonnamregion in Korea were initiated from the Cretaceous period, since 40% of land properties in this area consists of ground layers formed at the same age. Then, it was also found that next 30% was layered in the pre-Cambrian period and fossils were hardly found at that time due to metamorphism phenomenon.

The proposed system is expected to be applied not only a narrow region and global areas around the world as well, and it will cover from the Triassic period to the Jurassic age that were not covered by this paper. A new application for using big data and 3D VR media regarding fossils will play a role as an essential database containing valuable research resources in near future.

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