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Characteristics of Alpine Karst in Korean Peninsula

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I. Introduction

Karst in Korean peninsula is not widely known. Since karst studies had been initiated a few hundred years ago based on the historic records "Dong Guck Ye Jee Seoung Lam" and "Sae Jong Sill Rok Gee Ri Jee" (1993, Oh), modern caves during the 60s have inactively started to search on the karst phenomena to the eastern mountainous areas.

After the Korean Speleological Society was established in 1972, members of the society were widely exploring and researching the karst features. At present, five out of 209 recorded limestone caves are commercially operated for the visitors. On the other hand, the Pleistocen vulcanospeleoscophic features in the islands are very characteristics in length and in scales. Other pseudokarst like sea cliff caves and pseudolimestone caves also forms.

II. Distribution of karstificaiton

Distribution of the karst is two different categories : holokarst (limestone karst), and pseudokarst (vulcano and pseudolimestone karst). In terms of the holokarst, the surface and subsurface karstic formations are sculptured on the major mountain ranges, mostly in the Taebecg and Sobecg Mts., of the east central part of the Korean peninsula. A minor portion of the karstification distributes in the southwestern part, end of the Sobecg Mts., of the peninsula.

There are three types of the pseudokarst, lava karst, sea cliff karst, and terrestrial karst. the lava karst are distributed in the major Figure 1. Distribution of the carbonate bedrocks and karst in Korea

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Table 1. Karst distribution in North Korea

Source: Compiled by J. Oh (1992)

Systems	Karst Localities	Exhibitions
Ordovician Lower Level Great Limestones	Pyungan-namdo South of HamKyung-namdo Northeast of Whanghaedo	Major
Cambrian	East of Whanghaedo	Minor
Upper PreCambrian Middle PreCambrian Lower PreCambrian	-West and mideast of Whanghaedo -North of Kangwondo -Southwest of Pyungan-namdo and Wansan areas, Pyungan-buckdo (Yanpuuing and Eyeju)	Major Minor
PreCambrian	North of Gyunggido Northwest of Ganwondo Middle of Hankyun-namdo Southest of Hankyung-buckdo (Chilbo Mts.)	Minor

(Hong, 1985).

islands in Cheju Island and ullnung Island. 62 documented lava caves are in these Islands. The second type of the pseudokarst is the karst forms in coasts as the sea-cliff caves. The sea-cliff caves in the Iskabds like Hong Do and east, south and west coast lines. The third type is the pseudolimestone caves formed in the Mesozoic bedrocks in Uyi Seung (Oh, 1993 unpublished doc.). Additionally, there are several artificial caves for the military purposes in the DMZ.

Alpine karst in Korea is characterized as the mountain karst due to the factor that the surface and subsurface karst forms are developed on the mountain ranges of the east central part of Korea. Around 30% of the Karstification is developed in the 500-700 meter- high mountains. The karst terrain is very characteristic because of the superposed folded and faulted limestones caused by tectonics related geologic activities between the Creteceous and Lower Jurassic Periods. Most karst is developed on the intersections between joints and strikes of overturned and overthrust beds which are mostly Cambro-Ordovician limestone and dolostone. Hence many caves are very steeper.

1. Karst in north Korea

Table 2. Limestone geology of North Korea
Source: Geology Map in Korea, 1989, National Geography Bureu, p.10

Geologic Times	Systems	Bedrocks
Paleozoic	Ordovician	Lower Great Limestone
	Cambrian	Yangduck
PreCambrian		Sangwon Yeonchun Machunrung Complex Matamorphics

Although pseudocarbonic caves are mainly developed on the cross sections of joints and layers, limestone caves are significantly related to action of the water table, so that they are called as fluvial-caves. It is a special features that a current exhibition of the high leveled mountain caves were generated before the erosional base level had been uplifted.

Distribution of the karst landforms is mainly formed on the relationship between geologic bedrocks and surficial topologies. Occurrence of surficial karst topography including sinkholes will provide not only a predictional function of subterrenean passages, but also steeper cave existing in Korean cases.

There are many different geologic stages in terms of karst landforms distribution of North Korea region, such as PreCambrian to Paleozoic sedimentary rocks. Karst distribution of the north Korea based on geologic systems is as follows (Table 1):

Total counted depressions are 1,388 (size: >50meters) and the number of documented caves are 35. Actually there are many dolines are missing due to counting operabilities (mainly impossible to do the fieldworks) from the 1:50,000 map scales. It is predictable that if the counting is used in the bigger scaled maps, 3-5 times more dolines will be found. Counting caves in North Korea use documented information so that actually numbers will be more than doubled, because area of the limestones in North Korea is about 10 times bigger than south Korea's limestone areas. We can predict that caves in South Korea display >300. Further karst work in the area is needed when the unification is placed in the peninsula.

2. Karst in south Korea

Alpine karst in south Korea is characterized as the geologically folded and faulted backgrounds. Surface and subsurface karstic formations are developed on the mountain ranges, mostly Taebecg and Sobecg Mts., of the east central part of the Korean peninsula. Karst terrain and cave systems are very characteristic because of the superposed folded and faulted limestones caused by geologic activities during the Lower Jurassic Period. Most cave are developed on the intersections between joints and strikes of overturned and overthrust beds which are mostly Cambro-Ordovician limestones and minor dolostones.

Around 90% of karst is formed in Ordovician limestone and the rest is Cambrian limestone. Carbonate consist of CaO (50-53.6%), MgO (1.2-1.4%), SiO2 (1.4-5.4%), and others. Thickness of Ordovician limestone are usually 1,000-1,300 meters. The alpine karst landfomrs are sinkhols, uvalas, poljes, karren, springs, caves, and residual clays. Documented number of caves is 269 included 60 lava caves in Cheju Island. some paleo-karst phenomena, pre-Quaternary formations, are found in the southern boundary of the carbonate distribution. Active karstification could be mostly occurred during Pleistocene water table fluctuation periods. Hence, many caves are very steeper and vertically extended.

The alpine karst terrains consist of dolines, uvualas, poljes, karren fields, springs, hum, vertical shaft, and weathered carbonate residual soils. A few karren fields are found on the mountain areas, but they are mostly covered by residuum. It is called as the overburden karst. Covered karren features display significant morphological varieties. These reddish-brown clays (about 1-2 meters thick) covered limestone karren is the typical humid region karstic features.

Digressional features of the alpine karst terrain in south Korea exhibit a solutional origin rather than a collapsed derivation. Dolines generally appear on the river terraces or on the lower, meddle and high level mountains. They are mostly clustered. Shapes of dolines are very uniform as very gently curved bowl types, which sometimes have holes to the lower passages. Sizes of them are mostly 30-50 meters wide and 20-30 meters deep.

Most cave systems are formed in Ordovician limestones. Documented

number of limestone caves is 209 (excluded 60 lava caves in Cheju Island). Caves are mostly about 800-1600 meters long, consist of significant size of speleothem like stalactites, stalagmites, columns, flowstone, limestone dams, pools, pisolites, cave pearls, cave corals and helectites. Cave terrains related to the cave development contain conopies, rock terraces, cave meandering, vadose tubes, bell holes, layer pipings and water table marks. In particular, conopies, located middle of cave walls, contain various size of pebbles and clay materials which are strongly cemented. Most pebbles' roundness is 0.4-0.5, and exhibits noncarbonated rocks such as, garnet, quantize, and others. These allogenic sediments indicate that the cave channels used to be connected to the Han River stream so that, these kind of caves are called as the vadose caves rather than phreatic caves. Evidences of the vadose origin will be existing a great size of curvature like cave meanders, differential erosional remnants like rock terraces, and allogenic sedimentary deposition like conopies.

In terms of the provenance of the alpine karst in south Korea, a geologic relation between uplifting land masses and lowing erosional base level must have a strong correlation to the steeper cave development. Mostly active karstifcation could be occurred during the Pleistocene water table fluctuations. Because of the geologic deformation of the Taeback and Soback Mountain ranges, therefore, the secondary permeability (faults, joints, and layers) mostly takes place to the alpine karstification rather than the primary permeability (pore spaces).

Karst in Korean peninsula

Characteristics of the alpine karst

Alpine karst in south Korea is characterized as extensively folded and faulted structure (Oh, 1990). Karst terrain and cave systems are very characteristic because of the superposed folded and faulted limestones caused by geologic activities during the Lower Jurassic Period. Most caves are developed on the intersections between joints and strikes of overturned and overthrust beds which are mostly Cambro- Ordovician limestones and minor dolostones (Table 1, 2).

The alpine karst terrains consist of surface and subsurface formations . The surface karstfication has dolines, uvualas, poljes, karren fields, springs, hum, vertical

shaft, and weathered carbonate residual soils. Few karren fields are found on the mountain areas, but they are mostly covered by residuum. It is called as the overburden karst. Covered karren features display significant morphological varieties. These reddish-brown clays (about 1-2 meters thick) covered limestone karren is the typical humid region karstic features.

Digressional features of the alpine karst terrain in south Korea exhibit both a solutional

Alpine karst in south Korea has many different kinds of surface and subsurface features. The Cambro-Ordovician limestones exhibited significant karstic formations due to their structural deformations although the heavy residuum is covered. The surface karst presents a great size of structural and solutional depressions with a small size of collapsed sinkholes.

Residuum covering over the bedrocks in the alpine karst is another typical feature in the region. It is called as an overburden karst. Overburdens, reddish-brown sticky clays, are generally 1.5-2 meters thick. This thick carbonate residual materials over the bedrocks are the factor due to the surficial erosional rates of the humid climatic regions are lower than that of the tropical climatic region karst. Thus the alpine karst has a few exposure of the karren fields.

Alpine caves, subterrenean passages, are extensively controlled by folds and faults. Caves of the regions demonstrate a significant dip of the passages due to the structural deformations. There are many vertical voids and shafts. Speleoloscapes in

Table 1. Surface karst formations of the limestones in central east Korea (Oh, 1994).

	Dissolutional and fluvial Productions	Others
Surface formations and landforms	-cockpit -depressions -hum -karren fields -polje -springs -uvale -Lapie features -Natural bridges -terraces near cavities	-animal bones -archaeological remnants -cave entrances -dropped layers -karst windows -residuum -steeper cavities

Table 2. Subsurface karst formations of the limestones in central east Korea (Oh, 1994)

Caves	Dissolutional and fluvial Productions	Speleothems
Subsurface formations and landforms	-anastomoses -bellholes/pockets -chambers -canopies -cave sediments -cave channels -cavities -limpools -ceiling channels -meander trench -multilevel cavities -niches -notches -phreatic tubes bore passages -phreatic pendants -pools/ponds -rock span -scallops -solutional tubes -sponge work -vadose pendants -vadose tubes -vertical shafts -vertical groovings -water table marks	-anthodites/gypsum flower -aragonite -helectites: eccentric -bacon like sheet -cave pearls -cave cotton -cave raft -cave rope -cave blisters -cave corals -cave bubble -columns -conulites -draperies/curtain like stalactites -floating calcite -flowstone -limestone dams -mountain milk -muddy stalagmites -oolites -pisolites -plates -shields -spherical stalactites -splash cup -stalactites -stalagmites -straw/tubular rock and sediments -terraces

the internal caves are various. Calcite formations show the water table alternations which indicate the uplifting and erosional base level droppings during at least the Quaternary.

Around cave entrenches there are remnants of the fluvial terraces on the middle of the hills. These relationship between cave locations and terraces will generate a key to the Plestocene history of the south Korean peninsula. Hence, the Korean karst is turned as "the overburden alpine karst".

III. Conclusions

Alpine karst in Korea is characterized as the mountain karst because surface and subsurface karst forms are developed on the mountain ranges of the southwestern part in north Korea and east central part in south Korea. Around 30% of the Karstification is developed in the 500-700 meter- high mountains. The karst terrain is very characteristic because of the superposed folded and faulted limestones caused by tectonics related geologic activities between the Creteceous and Lower Jurassic Periods. Most karst is developed on the intersections between joints and strikes of overturned and overthrust beds which are mostly PreCambrian (Sangwon, Yeonchun, Machunrung, Complex Matamorphics) limestones in north Korea and Cambro-Ordovician limestones in south Korea. Commonly caves are generally formed on steeper mountainous areas but uncommonly bedrocks of north Korean karst is much older than that in south Korea. Distribution of sinkholes display large sized and dispersed in north Korea but that small sized and scattered in south Korea. These heterogeneous appearances of karstification between north and south Korea may be caused by different aged petrogenetics, morphogenetics, or fluvio-dynamics.

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