Ancient-Tombs of Italy and Korea

Subjects: Others

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Biological growth represents one of the main threats to the conservation of subterranean cultural heritage. The knowledge of the conditions which favor the various taxonomic groups is important in design their control methods. Combining our experience regarding hypogea in Italy and the Republic of Korea, we aim to perform a critical review and comparison of the Biodeterioration Patterns (BPs) found, the materials used, and the conservative treatments applied. For this purpose, we focused on Etruscan tombs (Italy, 7th to 3th century BC) and the ancient tombs of the Baekje Dynasty (Republic of Korea, 6th to 7th centuries AD), most of which have been designated UNESCO World Heritage Sites, collecting original and bibliographic data as well as institutional documents. Results highlight the rich biodiversity of the bacterial and fungal species. Phototrophs were observed only in niches with sufficient light and the development of roots was also detected. Changes in humidity and temperature, the nature of the soil, nutrient accumulation, and vegetation above the hypogea along with human activities explain the different BPs. The effects of biocide treatments are also discussed, such as the emergence of dangerous fungal species. The shared data also enhance the role of overlaying tumuli and vegetation as well as protective barriers to reduce biological risk.

Keywords: cultural heritage conservation ; biodeterioration ; mural paintings ; fungal degradation ; bacterial degradation ; Cyanobacteria

1. Introduction

Subterranean sites such as caves and catacombs are generally characterized by limited air circulation, a limited variation in temperatures throughout the year, a high level of humidity, and at times, pronounced gradients of light [1]. Hypogea show similarities but also differences with caves due to their more limited size which leads to greater fragility also on the basis of the variability of materials used by human activities [2][3]. In fact, they were often embellished by wall paintings, stuccos, ceramics, bricks, and mosaics for decorative and augural purposes, as well as by statues, sarcophagi, and funerary objects which need to be preserved as the testimony of their cultural heritage [4][5]. Moreover, the tombs which often maintained an environment cut off from the exterior world for hundreds of years, undergo substantial environment changes after excavations and consequent weathering [6][7].

Literature on biological colonization in caves is becoming highly relevant, with hundreds of papers describing the microbial diversity and the relationship with environmental conditions, whereas much less is available for tombs. The most common inhabitants of subterranean sites are oligotrophs (bacteria, represented mainly by *Actinobacteria*, and fungi), accustomed to long periods of starvation, and, phototrophs (cyanobacteria, green algae, diatoms, mosses, ferns) that have adapted to scarce light [4][5][6][8][9][10][11][12][13]. The current knowledge of the ecological succession of microbial communities in hypogea in relation to environmental factors, such as the efficiency or risks of different control methods seems insufficiently addressed. The peculiarities of hypogea, which vary according to different cultures also deserve special attention, as they give rise to distinct biodeterioration phenomena. This study is focused on the review of data on the Etruscan tombs in Italy and The Ancient Tombs of Baekje Dynasty in the Republic of Korea. In Italy the practice of building hypogea and decorating them with mural paintings was developed in several Etruscan from the 7th to the 3rd century BC. Our data set collected information on biodeterioration phenomena in 23 Etruscan tombs in Latium (in Tarquinia, Cerveteri, and Veio), and in Tuscany (Chiusi). Since 2004, both the Necropolises of Cerveteri and Tarquinia (Latium) have become UNESCO World Heritage sites in consideration of their painted tombs which have extraordinary importance as they reflect the daily life and burial practices of the Etruscans and bear witness to the achievements of their culture.

In the Republic of Korea during the Baekje Dynasty, three tomb styles developed: (1) a stone mound tomb, (2) a brick chamber tomb, (3) a corridor-style stone chamber tomb. In this study, the attention was focused on

Ancient Tomb No. 6 in Songsan-ri, Gongju, a brick-chamber tomb, and Ancient Tomb No. 1 in Neungsan-ri (Buyeo), a corridor-style stone chamber tomb, in Baekje Dynasty, listed as UNESCO World Heritage Sites since 2004.

2. Etruscan Tombs in Italy

The practice of building hypogea and decorating them with mural paintings was developed in several Etruscan cities especially in northern Latium, Tuscany, Umbria and Romagna covering a period from the 7th to the 3rd century BC. Since 2004, both the Necropolises of Cerveteri and Tarquinia (Latium) have become UNESCO World Heritage sites in consideration of their painted tombs which have an extraordinary importance as they reflect the daily life and burial practices of the Etruscans and bear witness to the achievements of their culture [14][15].

Our data set collected information on biodeterioration phenomena in 23 Etruscan tombs present in three necropolises in Latium (in Tarquinia: Lotus, Jugglers, Mercareccia, Pulcella, Hunting and Fishing, Bulls, Shields, Ogre, Moretti, Blue Demons, Lions, Animas, Hunters, Elderly Men, Painted Vases, Giustiniani, Bartoccini, Lionesses, Caronti, in Cerveteri: Triclinium, Well, Reliefs) [16][17][18][19][20][21][22][23][24][25][26], and in Veio (Tomb of the Ducks) [27][28]. A further two tombs that were studied belong to a necropolis in Chiusi, Tuscany (Tombs of Hill and of the Monkey) [29][30][31].

These tombs were dug in different geological substrata to obtain the sepulchral chambers, which lie at depths that vary from 2 m to 8 m. In Tarquinia, the geological features were calcarenites banks (Macco), which is an organogenic limestone rich in small shells. This bank constituted the top of the “Monterozzi” hill which was in contact with the underlying Pliocene clays that were more pliable and erodible. Both in Cerveteri and Veio, the characteristic tuffs, containing fragments of pumice arising from ignimbrite deposits, were preferred by sculptors and builders thanks to their softness and low permeability [32]. In the Chiusi necropolises, the tombs are situated in a lithological complex made from Pliocene sands (quartz, feldspars and a smaller amount of calcite) with clay cement [27].

From a bioclimatic point of view, the Cerveteri, Tarquinia and Veio sites fall within the Mediterranean macrobioclimate, with lower mesomediterranean thermotype and a lower subhumid ombrotype, whereas the Chiusi area has temperate characteristics [33]. In most of the Etruscan tombs of this study, the microclimate was found to be quite stable, with temperatures ranging from 10–15 °C to 17–20 °C and relative humidity (RH) between 90% and 100%. Such values sometimes led to dew point temperature, with water condensation on surfaces, especially in the cooler tombs [34].

The necropolises were often characterised by the presence of a large number of tumuli (circular tombs covered by earth mound, varying in diameter and height) and sometimes of different shapes such as “dadi” (cube tombs). In the various necropolises, the original tumuli were often dismantled and only sometimes rebuilt for the purpose of protection, without considering the original shape [15][35].

The materials of Etruscan mural paintings were made utilising several mineral pigments, such as hematite, Egyptian blue and charcoal black which were then deposited on a previously prepared thin clay layer on the surface [29][35].

Several weathering phenomena of these tombs have accentuated both the physic-chemical weathering as well as biological issues. Each tomb has a specific history and problem, and we will subsequently describe the recurrent phenomena as well as some peculiar ones.

3. The Ancient Tombs of Baekje Dynasty in Republic of Korea

Many of the tombs with wall paintings were built by the people of Goguryeo in the Korean Peninsula. Goguryeo tombs are found throughout North Korea and in the Jian region, China. Sixty-three of these tombs have been designated as UNESCO World Heritage Sites since 2004. There are approximately ten tombs of this type in Republic of Korea, constructed from the 5th to 15th centuries. They have been managed as historical sites for their cultural importance and currently, access to these tombs is restricted due to damage caused by exposure to the external environment and influx [36].

During the Three Kingdoms period (Goguryeo: 37 BC–668 AD; Baekje: 18 BC–660 AD; and Silla: 57 BC–668 AD), three tomb styles developed in the Baekje Kingdom: “(1) a stone mound tomb (tomb made by piling up the stone) in the Hansung period, (2) a brick chamber tomb (a tomb style made by laying bricks for the tomb’s corridor and the main chamber and constructing a tumulus on top of them) in the Ungin period, (3) a corridor-style stone chamber tomb (a tomb style where the corridor and main chamber were made of stone then covered with soil on top) in the Ungin/Sabi period” [37][38]. In lieu of previous reports and investigations [39][40][41][42][43][44][45][46], we selected Ancient Tomb No. 6 in Songsan-ri, Gongju, a brick-chamber tomb, and Ancient Tomb No. 1 in Neungsan-ri (Buyeo), a corridor-style stone chamber tomb, in Baekje Dynasty, listed as UNESCO World Heritage Sites for this study.

Tomb No. 6 was built in the mid-6th century as a royal tomb pertaining to the Baekje Dynasty. It has double corridors under an arch-shaped ceiling and a long rectangular brick chamber. It was discovered in 1933 and opened to the public after its excavation. Four guardian deities (east: blue dragon; west: white tiger; south: red phoenix; and north: black tortoise) are painted on the four walls. In addition, the “sun and moon” were also painted on the southern wall. Plastering the white lime upon the black ground on surface of the bricks, the only white pigments were painted on top of the ground layer made with soil [47]. The mural paintings were executed utilising only white pigment which was obtained either from oyster shells ($CaCO_3$) or chalk ($CaCO_3$) [49]. Today, only traces of these mural paintings remain, hence it is difficult to discern the original figures [36][47][50].

Tomb No. 1 was constructed between the late 6th and 7th centuries. It is considered the King and the Royal Family’s tomb and the outer shape consists of a circular tumulus. It is a corridor-style stone chamber tomb dug from the ground with the east, west, and north walls made of well-trimmed stone slabs [36][51][52][53]. Four types of rock were used for main chamber: “(1) augen gneiss: on the northern and eastern wall, (2) two-mica granite: on the western wall, (3) hornblende schist: on the floor, and (4) granodiorite: on the ceiling” [54][55]. Four guardian deities are painted on the four walls of the burial chamber inside the tomb, with lotuses and clouds engraved on the ceiling. It was excavated in 1916 and the layout of the murals was clear at that time [45]. After excavation, it was opened to the public, but the murals gradually faded leaving only a faint trace, hence it was closed in 1971 to preserve the wall paintings.

Republic of Korea is geographically located in the mid-latitude temperate climate zone with four distinctive seasons (spring, summer, autumn, and winter: the annual average temperature is 10–15 °C, the highest temperature ranges 23–26 °C, and the lowest temperature of minus 3–6 °C, with an annual relative humidity of 60–75% [56]. The indoor temperature of the two tombs differed from the outdoor temperature, as there was little heat transfer due to the tumuli [57][58]. The indoor temperature of Tomb No. 6 ranged from 13.6 to 20.6 °C, and the annual average temperature was 17.0 °C, with the lowest values in April, and the highest in September and October (environmental data from April 2018 to March 2019) [59]. The indoor temperature of Tomb No. 1 ranged from 12.9 to 18.0 °C and the annual average temperature was 15 °C, with the lowest values in May and the highest in November (environmental date from January to December 2019) [60]. The indoor relative humidity of the two ancient tombs was maintained at approximately 100% throughout the year. The shape of the tombs was reassembled when repair and restoration work took place [61][62][63][64]. Moreover, these two tombs were passively controlled without a specific environmental control system.

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