

## 巨大石造建造物探査へのミュオグラフィの応用：エジプトのピラミッドに対する建築技術の発展過程 An Application of Muography to Exploring Gigantic Masonry Architectures: Evolution in Pyramid Construction Technique

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Since the technique of Muography was used for the pyramid of Khafre (second pyramid of Giza) by L. W. Alvarez in 1970, academic researches using non-destructive testing methods have been applied to some huge stone structures (ex. the Pyramid of the Sun in Teotihuacan, Mexico, by A. Menchaca-Rocha). Although Alvarez and his team attempted to find a new chamber in the pyramid, they couldn't find any hidden chambers. However, now it is thought that the result was unreliable because their muon detector was an old type. After Alvarez the muon detector was developed and contributed to the elucidation of mechanism of a volcanic eruption in recent years (e.g. Asama volcano and Satsuma-Iwojima Volcano by H. Tanaka et al). Applying this technique, the internal structures of the Shiva temple in the Prambanan temple compounds (Indonesia) and the Parthenon (Greece) is explorable. On the basis of those results, we are going to go back to the roots of Muography by Alvarez by revisiting the pyramid.

It is assumed that if it is possible to use Muography for the pyramids in Egypt (the oldest huge stone building in the world), in terms of the usage and volume of differing density of the stone (limestone and granite), it would make clear the developmental sequence and construction way of pyramids which has been impossible to know until now. Therefore, we can confirm the human ingenuity of earthquake-proof structures by ancient Egyptians. Most of the pyramids were made of limestone. Harder granite was sometimes used to encase the pyramids. If it can be made clear where two different kinds of stones were used and how much stone were used for the pyramids, we can take possession of previously-unattainable new information in the study of earthquake-proof structures of pyramids.

The developmental sequence of burial of ancient Egyptian kings and the transition of the outer shape are as follows: 1. Simple graves, 2. Mastabas, 3. Step Pyramids, 4. Bent Pyramid, 5. Red Pyramid (true pyramid), 6. Pyramid of Khufu (true pyramid), 7. Pyramid of Khafre (true pyramid), 8. Pyramid of Menkaure (true pyramid).

Judging from the above-mentioned process, it is assumed that there were further stages in the development of pyramids. However, it is still not clear. If we have the opportunity to use muography to the above pyramids (from the step pyramid of Netjerykhet to three true pyramids in Giza), we can put an end to speculation as to the evolution theory of the pyramid from the viewpoint of earthquake-proof structures and advancement of civilization.

### References

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