ArchaeoAstronomy and Space Archaeology : a link between

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Abstract : This article is a brief introduction to ArchaeoAstronomy and Space Archaeology, two research fields both issued from the crossing of knowledge and techniques specific to Archaeology, History, Astronomy, and to the Space field. Within this introductory article, I choosed to more particularly focus on the similarities and the differences between ArchaeoAstronomy and Space Archaeology, and to explain why developing Space Archaeology, in close collaboration with worldwide Archaeologists, Egyptologists, Astronomers and Space Engineers, is a continuation of the research work in ArchaeoAstronomy I started about fifteen years ago. A further article, to be published within the Cahiers Caribéens d'Egyptologie n°15 (2011b), will detail the way contributing to the development of both ArchaeoAstronomy and Space Archaeology by using XXIth century's tools.

1. A few lines about ArchaeoAstronomy

As you may know, carrying out research into ArchaeoAstronomy amounts to studying the astronomical orientation or content of any archaeological remain : monument, bas-relief, text, drawing, etc. As detailed within a previous article (Gadré, 2008b), to be complete and valid, any archaeoastronomical study must bring together Archaeologists, Historians, Philologists and Astronomers, and follow the few steps below :

1. gathering similar vestiges within a dedicated database ;
2. dating and locating the vestiges which make up the database, then determining the optical conditions of celestial observation at the epoch and location considered ;
3. developing or using a visibility model of star in order to accurately recreate the visibility conditions of the stars in the sky at the time and location considered ;
4. applying, to the results of the numerical model, several criteria of archaeological, historical, philological and astronomical natures, in order to decrease the number of acceptable results ;
5. checking the validity of everyone of the possible results, then isolating the most probable result(s).

Applied to ancient Egypt, this modern approach led to identify everyone of the ninety old Egyptian decanal stars whose hieroglyphic names appear on one hundred stellar clocks, water clocks and astronomical ceilings dating from the Old to the New Kingdom (Gadré, 2008a), and to determine the astronomical source of orientation of a sample of thirteen Old Kingdom pyramids on the one hand, of the Dendara temples of Isis and Hathor on the other hand (Gadré, 2011a). The same approach is to be applied, in a near future, to many other ancient Egyptian monuments and artefacts characterized by a specific astronomical orientation or content.

2. A short introduction to Space Archaeology

The monuments and artefacts which show a specific astronomical orientation or content are only a few of the hundreds of thousands of vestiges which were discovered during these last two centuries of ground excavations in Egypt. Specialists agree to say that these hundreds of thousands of vestiges should represent only a few per cent of the vestiges of the ancient Egyptian civilization. So, the question is : are we going to dig the whole land of Egypt with one's hands ? Do we actually have time and money enough to going on excavating part of the Earth surface and subsurface this way ? Will the Egyptian authorities – the Supreme Council of the Antiquities in this case – ask for pieces of evidence that something interesting is *for sure* buried at a given place before granting excavation authorizations in a near future ? Is there any modern, not very costly and effective approach, able to make us obtain excavation authorizations and funding relatively easily in the future ? The answer is yes : there is space technology, which can be used in close combination with more classical ground survey – to be more precise, prior to any classical ground survey – but which *can not* supersede it.

Space technology began to develop during the second part of the XXth century. Youri Gagarine in 1961, next the crews of the successive Appollo missions (1968-72), were the very first humans to see our Earth from space. The very first space mission devoted to the observation of the Earth was launched in 1972 : this was the Earth Resources Technology Satellite 1, lately renamed LandSat-1. Then began the observation of the Earth from space on part of the electromagnetic spectrum ranging from ultraviolet to microwave going through the visible and the infrared domains. With time, the spatial resolution of the satellite imagery increased, as well as the number of spectral bands under which the Earth was observed, so that more and more details about our Earth (rock, soil, water canals, vegetation, deep ocean, continents, atmosphere, etc.) became available to us and new research fields appeared : remote detection, signal processing, meteorology, space oceanography, etc. A few decades later, it is possible to manage natural resources or to follow the migration of Earth species from space. The time for space applications has come and is now encouraged by several authorities.

Space Archaeology is one of several space applications. This research field appeared in 1984, when, for the first time, NASA engineers and archaeologists decided to collaborate (Parcak, 2009). Very early, the need for high-resolution space imagery was underlined. Starting from the nineties, satellites were equipped with sensors able to detect ground details whose size was less than 10 meters, even 5 meters. Today, the spatial resolution of space imagery can be as low as one meter. We have entered a Very-High Resolution era. In parallel, remote sensing softwares were developed in order to facilitate the analysis of space imagery. Their use, in close combination with Geographic Information Systems, led to targeted ground excavations which, for most, confirmed what space imagery had revealed, i.e., the discovery of thousands of new vestiges all around the world : monuments, cities, roads, irrigation canals, etc.

According to Sarah Parcak, hundreds of thousands of vestiges are still to be discovered by way of space imagery (Parcak, 2009). These are vestiges which can not be seen from the ground since they are located beneath luxurious vegetation or beneath modern cities or beneath the earth surface. To discover new archaeological remains by way of space imagery, the following approach must be undergone :

1. acquiring high spatial resolution and broad spectral resolution space imagery among space engineers working for space agencies ;
2. analyzing space imagery by means of remote sensing softwares developed by signal processing experts in order to find possible traces of human artefacts ;
3. inserting space imagery within the Geographic Information Systems familiar to the archaeologists in order to locate possible traces of human artefacts ;
4. looking for excavation authorizations at the place suggested by space imagery ;
5. going on targeted ground excavations in order to confirm or not the existence of human artefacts at the place considered.

Following this approach presupposes the establishment of close collaborations between space engineers, signal processing experts (who often work in the field of Astronomy) and archaeologists (Gadré, 2011b).

3. The link between ArchaeoAstronomy and Space Archaeology

In conclusion, ArchaeoAstronomy and Space Archaeology are both interdisciplinary fields of research : carrying out research into the one or the other fields requires the knowledge, skills and tools specific to Archaeology, History, Astronomy, and to the Space field, indeed. It furthermore requires the development and the use of numerical models : visibility models in the case of ArchaeoAstronomy, remote sensing softwares and Geographic Information Systems in the field of Space Archaeology. The only differences between ArchaeoAstronomy and Space Archaeology are the viewing angle and the spectral band under which the vestiges are sighted (see the Images 1 to 4). In the case of ArchaeoAstronomy, you look at vestiges from the surface of the earth in the visible domain ; in the case of Space Archaeology, you look for vestiges from space in a spectral band ranging from the ultraviolet to the microwave domain, indeed. Two slight differences seemingly, which tell all the difference in reality !

Image 1 : The pyramids of Giza, viewed from space in the visible domain by the Quickbird satellite (2007)

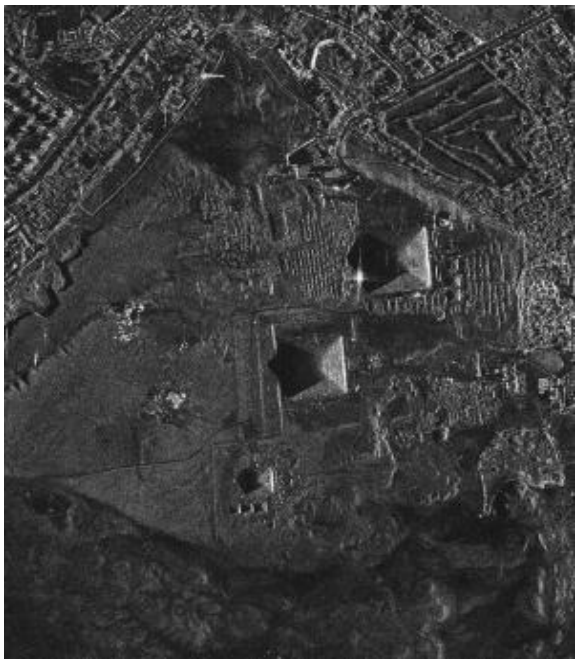

Image 2 : The pyramids of Giza, "viewed" from space in the radar domain by the TerraSAR-X satellite (2007)

Image 3 : The pyramids of Giza, viewed from the Earth surface in the visible domain (© Culture Diff', 1998)

Image 4 : Setting of the sun behind Khaphre's pyramid (© Culture Diff', 1998)

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