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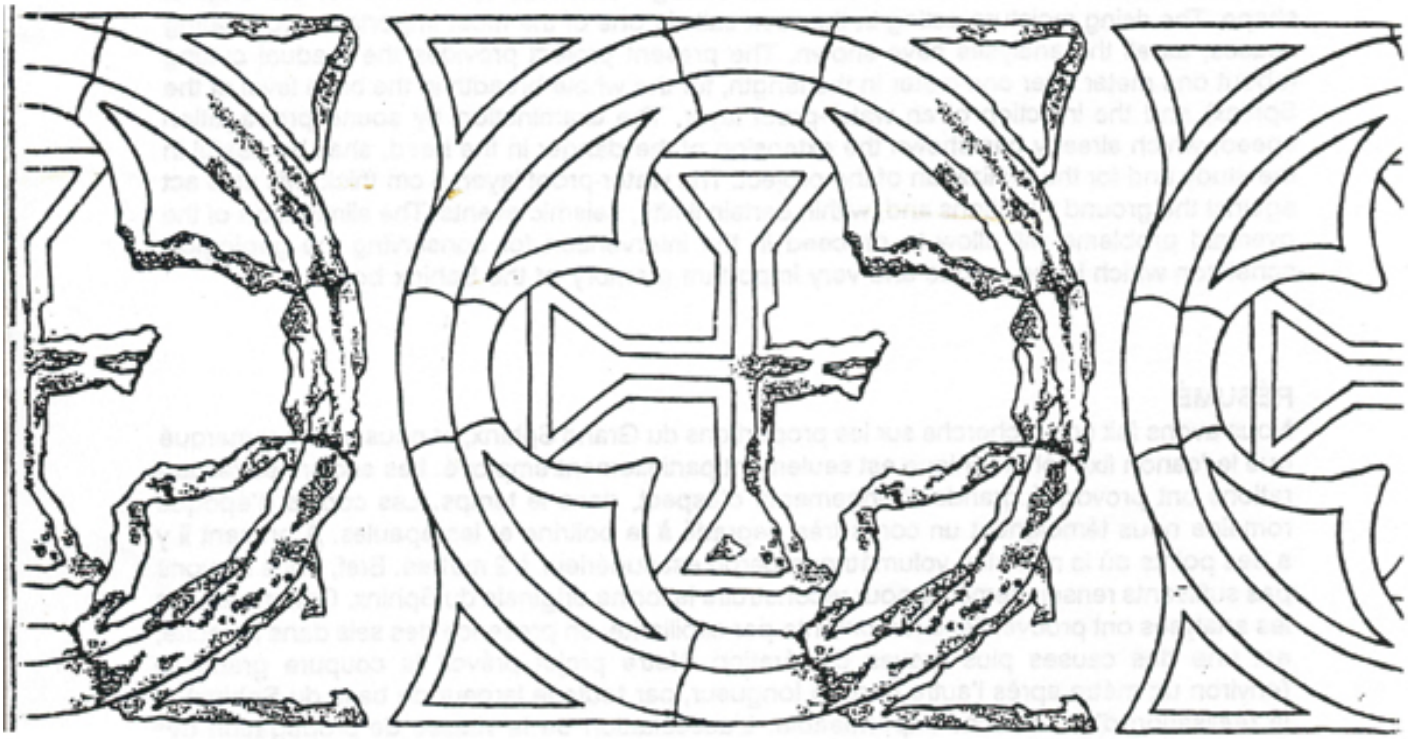

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FOR AN EXECUTIVE PROJECT OF THE SPHINX ARCHAEOLOGICAL CONSERVATION

Pour un projet de conservation archèologique du Sphinx

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SUMMARY
We have carried on a study on the proportions of the Great Sphinx: we have remarked that the Pharaonic "fixed canon" is only partially used in this case. The ancient restorations caused many changes of the shape during the time. The Roman copies show a very degradated body in the breast and shoulders. At present in some places more than 2 meters of the volumetric material is lost. So we have not enough elements to reconstruct the original shape. The rising moisture acting in the rock salts is one of the most important degradating causes, as all the analyses have shown. The present project provides the gradual cutting (about one meter after one meter in the length, for the whole breadth in the base level of the Sphinx) and the injection of an water-proof layer. The examination by sound propagation speed, which already has shown the extension of the danger in the head, shall be useful in the study and for the realization of the project. The water-proof layer, 5 cm thick, will also act against the ground vibrations and, within certain limits, seismic events. The elimination of the oversaid problems will allow to proceed in the intervention for conserving the geological scheleton which is the unique and very important memory of the Sphinx body.

RÉSUMÉ
Nous avons fait une récherche sur les proportions du Grand Sphinx, et nous avons remarqué que le "canon fixe" pharaonique est seulement partiellement employé. Les anciennes restaurations ont provoqué grands changements d'aspect, dans le temps. Les copies d'époque romaine nous témoignent un corps très degradé à la poitrine et les épaules. À present il y a des points où le matériau volumétrique perdu est supérieur à 2 mètres. Bref, nous n'avons pas suffisants renseignements pour reconstruire la forme originale du Sphinx. Comme toutes les analyses ont prouvé, l'eau remontante par capillarité, en presence des sels dans la roche, est une des causes plus graves d'altération. Notre projet prévoit la coupure graduelle (environ un métre après l'autre dans la longueur, par toute la largeur de base du Sphinx) et la réalisation d'une couche impérmeable. L'auscultation de la vitesse de propagation des ondes ultra-soniques (qui a déjà montré l'extension des cassures de la tête) sera très utile pour l'étude et l'exécution du projet. La couche imperméable, de 5 cm d'épaisseur, servira contre les vibrations du sol et, dans quelque mesure, les tremblements de terre aussi. L'élimination des susdits problèmes principaux permettra d'avancer le programme de conservation du squelette géologique qui est le seul important reste du corps du Sphinx.

1.INTRODUCTION

1.1 The project has been presented synthetically but in all its aspects to the Egyptian Minister of Culture, Mr. Faruk Hosny, by Mr. Giuseppe Fanfoni, Director of the Italian-Egyptian Restoration Center in Cairo since 1988, when a block of stone broke off the breast of the Great Sphinx.
The program I have been charged to introduce, and I had the chance to give to Mr. Mamillan in Cairo few months ago (in occasion of the International Symposium of the Sphinx), is an executive project: it is the only one which, in the opinion of a group of specialists who have confirmed the diagnosis and the solution of the problem, may stop the inexorable decay of the Sphinx.
Let me mention at least some of them, beside the author of the project, Giuseppe Fanfoni, and myself, as Egyptologist: Prof. Lorenzo Lazzarini (Rome University), Dr. Nazzareno Gabrieli (Vatican Museums), Mr. Giuseppe Scala (C.N.R.), and the mining engineers Francesco Retacchi and Gabriele Orsini.
All the oversaid persons and many others (I cannot list everyone) are members of the "Centro Formazione Professionale Restauro".

1.2 The project of intervention on the Sphinx must hold in consideration, as every restorative and conservative program, historical knowledges and scientific-technical data; the two interacting between themselves.
In fact, only the historical knowledge can decide the opportunity of removing ancient restoration works, the limits of cleaning and of conservative operations and give the documentation for eventual modern reconstructions, in the respect of artistic considerations.
In the same time, the scientific-technical research engages firstly, the elaboration of a diagnosis (by studying the geological nature and the used materials of the monument, the factors of decay linked with intrinsec properties, the external damages due to the environment and the recent human interventions), secondly, the planning of the intervention, on the basis of a previous sperimentation.

2.ARCHAEOLOGICAL,HISTORICAL AND ARTISTICAL INVESTIGATION

2.1 The archaeological and historical information we have at disposal for the most ancient times, when the monumental Sphinx was carved, are particularly scanty and fragmentary.
The Great Sphinx is chronologically referable to the 4th Dynasty, most probably to the reign of the Pharaoh Chefren (about 2.500 b.C.), whose face should be represented in the monument.
We don't be sure of the original techniques of working, that is if the body was entirely cut in the mother-rock, plastered and painted (according to a well-known technique for realising reliefs and statues in limestone), or filled in some parts with blocks of stone of better quality than the mother-rock. The latter technique was employed for the restoration works carried on the Sphinx in ancient times, since the age of Tuthmosis the 4th, at least (as testified by the famous dream-stela), till the Roman Period, when a rough and heavy layer of little blocks was probably put over the degradated paws.

2.2 We know that a canon [1] had already been fixed in that age, and the proportions of the elements of the figures (head, face, body, arms, legs,etc.) were constantly determined on it: the canon introduced in the Old Kingdom was not changed till the Late Period,about two thousands later.
A research on statues and reliefs representing sphinxes has proved that the proportions were fixed, as usually, on an unit of length determined by the parts of the face.
In the case of the Great Sphinx, since the face is well preserved, we may affirm that the prospect in the vertical proportions respects the "fixed canon" we find in the classical sphinxes; on the contrary the longitudinal proportion is much longer in comparison with the parallels [fig. 1]. We allow ourselves to propose that the choose was due to architectural and artistic considerations on the links between the mother-rock and the natural environment.
Besides, we know that the decay of the Sphinx had become evident since ancient times: the Roman sphinxes, without beard and so narrow in the shoulders in comparison with the classical ancient models, are more than probably reproducing the degradated Great Sphinx, as it had a special veneration in that period [fig. 2].
The lack of canonical parallels, and the enormous degradation on the other hand, suggest in our opinion to keep the ancient restorations, but advise against trying any kind of integration which shall result historically groundless, contrary to the modern restoration rules provided by the International Committee (art. n. 15 of "Charter for conservation and restoration of monuments and sites", Venice 1964), and in contrast with the original aesthetical aspect, exalting the matheric links between the monument and the surrounding geologic environment.

2.3 The only moral problem which has to be fronted at present is deciding between two possibilities: or to leave the Great Sphinx to her natural destiny of progressive decay and death (the same destiny of the mountains and of other rock-cut monuments), or to block the actual situation with effective modern technics of conservation, in order to convey the monument in its present authenticity and ideological value (recovering every original element of the historical and natural modification linked to the suffered life of the Sphinx) to the rising generation, and to allow a continuity of study and a better knowledge of the monument itself.

3. TECHNICAL DIAGNOSIS

3.1. The degradation of the Egyptian stone monuments is a quite particular case. In 1902 Lucas [2] wrote: "The disintegration is entirely a physical and not a chemical phenomenon, and is caused by the crystallization of various salts, chiefly sodium chloride, underneath the surface layers of the stone. For such crystallization to take place three conditions are necessary: first the presence of water-soluble salts, secondly the presence of water to dissolve the salts, and thirdly opportunity for the salts to be brought to the surface of the stone and there to crystallize out by the evaporation of the water holding them in solution".
His diagnosis remains correct till now, although a limited industrialization of the country is adding some decay factors,

known by Lucas in Europe and North America only.
The oversaid mechanism of degradation concerns all the Egyptian monuments, as the salts are in great quantity present in the geological formations exploited for building materials. Moreover, the moisture rises from the ground level inside the monuments, in quantity depending on the depth of the ground water-table, or the heat transfer caused by the thermic difference between the base and the upper parts of the monuments irradiated by the sun: the height of the moistened level depends on the porosity of materials and geological strata and the cross-section sunction of the water-ground.
The photogrammetric mapping and the complementary tests (published [3,4,5] by various articles and books) allow to remark that the deterioration and erosion concerning the whole body and not the head, have damaged in particular the base and the neck.
The actual volumetric shape, caused by the deterioration, has links with the history of the Sphinx; during the most ancient period the erosion concerned mainly the lowest level at the base, where various pharaonic restorations are present. The body, and principally the shoulders and the neck, were touched by the decay in concomitance with the rising of the sand and its various levels.
Numerous pictures represent, till the last century, only the head emerging from the sand. The erosion above the level of the shoulders (that is the largest cross-section sunction) caused a considerable reduction of the material of the neck, but, in the same time, the reduction of the cross-section and of the water rising to the head. Consequently the head, is in much better conditions, although it is of the same geological layer and consistency of texture as the neck and was, much more than the rest, touched by wind erosion: in fact it was much less injured by the principal factor of decay, that is the water rising by capillarity.
The decay mechanism of the Sphinx, we have synthetically delineated, is confirmed by many studies made in the last fifteen years. It results also by the report of the Italian "Istituto centrale di restauro", in 1988. The recent analyses made in the "Istituto per le tecnologie applicate ai beni culturali" (C.N.R.) for the "Centro italo-egiziano per il restauro" and finally the Mamillan report [6] have reaffirmed the situation: the tests have pointed out that the quantity of salts in the body of the Sphinx is gradually decreasing from the lower levels to up, and demonstrated that the salts are conveyed with the water rising from the base, while, in the upper part, the wind is the most important factor of deterioration, linked with the moisture (even if not so abundant) aspirated by the surface warmed by the sun.
The test of the salt quantity checked externally and internally in one horizontal layer of the body under the shoulders should be an important research in order to verify if the presence of the accumulated sand was a factor of increasing the quantity itself from the surface inside.

3.2. Conservative attempts by covering the external surface of the Sphinx have resulted even dangerous not only because the used materials were improper, but also because any kind of the structure resting on the Sphinx, necessarily causes a loss of the original core in the case of the removal; and this is contrary to the principle of reversibility in the restoration.

3.3. The water rising by capillarity is the only one that may be completely eliminated among the "Lucas" oversaid factors of decay (salts, water, temperature differences and wind), without interfering in the environment, and in the shape and the material substance of the monument; the only efficacious and the most realizable intervention seems to remain, at present, to block the rising water at the ground level, according to the project proposed by Giuseppe Fanfoni in 1988, and synthetically exposed to the Egyptian Minister of Culture.

4. PROJECT OF CONSERVATIVE INTERVENTION

4.1 The most advanced and tested technologies for preventing the rising ground water aim actually at producing a water-proof stratum at the base of buildings and monuments; the purpose is attained or by injecting resins and liquid chemical materials in holes (made in the thickness of the wall in two rows and at a distance of about 30 cms.) or by cutting and inserting a water-tight layer.

4.2 The injection system is effective only in the presence of particular kinds of masonry: no doubt that it reduces the cross-section sunction of the walls, but doesn't allow a good control on the spreading of the injecting materials. Besides, as the "Italian-Egyptian Restoration Centre" has tested in the walls of an Islamic Sama'Khana, [7] the success is assured by the help of auxiliary techniques we cannot use for the Sphinx.

4.3 The system of cutting is more expensive, as it requires the use of a different kind of machinery and the presence of high specialized workmen.
But the technique can boast a more than twenty-years experience and has improved both the working machines and the waterproof materials.

4.4 The system for blocking the rising water in walls of particular interest (supporting frescoes and paintings, important archaeological remains, etc.) was firstly realised [8] by driller machines executing very close holes, and linking them between, in order to create a damp-proof layer to be filled with special materials (polyesther and epoxy resins) or water-thick sheets.

4.5 Presently, the system of blocking the damp consists on cutting the walls by a sprocket-chain; it is a dry-operating machinery, in order to avoid the use of water, as it results dangerous in the case of ancient and much decayed structures.
At present the most advanced system of that kind of machinery is utilizing a blade 4-5 metres in breadth; consequently, by operating on the two sides of a structure, the maximum breadth is 8-10 metres in width. The machinery grants a very high warranty of operative result. The blade, made in a special alloy steel, lodges the sprocket-chain operating the cutting; it is controlled by an hydraulic drive, and, hanging on one side, moves on a truck apt for a motion of 120 cms.(horizontally) for 58 cm. (vertically). The cut is 2 cm. wide in the patented machinery, which is actually in use and is self-propelling and radio-controlled.

4.6 The C.F.P.R. is proposing a variation of the oversaid

machinery, elaborated on the project of Prof. G.Fanfoni by the Italian firm, Umiblok.
The project provides a vibration-proof and dry-working operating blade, 17 ms. long, moving by hidraulic action and carried by two parallel rails put on the sides of the Sphinx. The traction of the chain is placed on one of them.
An automatic system of levelling will be applied in order to prevent the normal flexion due to the length of the blade. All the operative function will be put under computerized control.
The cutting step will be 1-2 ms. of length (it will depend on the consistency of the rock) and 5 cms. thick: this space will allow the use of optical soundings in order to control the internal rock (the presence of eventual fissures, archaeological data, etc.) before inserting the materials for the water-proof layer.

4.7 The space will be filled with a special expansion-controlled and sulphate-proof ferric cement ("Pagel italiana") without chlorides. Fluidifying mixed substances will grant a good penetration without shrinks, in order to prevent settlements.
The cement density will keep from capillary penetration in the rock; the mortar layer will be a separate body which may be removed by the same machinery and system used for inserting it, in the observance of the modern reversibility principle in the restoration field.
The method of inserting a water-proof layer in the walls of monuments usually provides at present a polyester sheet immersed in the filling mortar. In the Sphinx, although the titanium steel plate should be more lasting in the time, we prefer, in order of the reversibility principle, specially designed PVC elements (the most recent material actually used), as they may be easily destroyed in the case of removal of the whole layer.

4.8 The filling will be checked on the comparison between the empty space and the volume of the injected material. The final control may be made by using the measurement of sonic waves.

5. PRELIMINARY INVESTIGATION AND EXECUTIVE INTERVENTION

5.1 The horizontal sectioning must be preceeded by preparatory phases and a study specifically looking for the executive intervention.
It's necessary to remove all the most recent superfetations; they are not historical documents of the life of the Sphinx, and, because tottering, will be a danger for the operating workers.

5.2 The general map of the fissures and cracks, carried on by reliefs outside and sound-propagation inside, will allow the knowledge of the static condition of the rock.

5.3 Afterwards will be necessary to carry on the consolidation of the external tottering parts of the Sphinx.

5.4 Meanwhile sperimental tests of cutting and inserting the mortar layer may be achieved in the adjacent rock-layer of the same geological formation, in order to control the consistency and the porosity of the rock, and to analyse by experience the phases of the technical process in order to eliminate any case of contingency.

6. INDICATIVE PROGRAM FOR A TOTAL CONSOLIDATION

6.1 The removal of external salts can be taken in consideration after the water-proof layer of the basis; anyhow, it must be very carefully experimented before, as the treatment may act on the consistency of the rock itself.
In any case, we should keep in view that the removal of the salts may be carried on only in a very limited depth in comparison with the thickness of the rock (which is more then 15 ms. wide in some parts).
Moreover, if the rising water will not be blocked down, the salts will appear again on the surface, requiring other interventions; every desalting will involve a loss of the mother-rock.
On the contrary the sectioning at the base will cause, probably in a rather long period, the dewatering of the rock-block and the stabilization of the salts sharing to the texture of the rock itself.

6.2 The stabilization process may be supported by an imbibition of reversible resins, from inside through canalization placed at the ground-level: the salts may be incorporated and fixed gradually on the same way of the capillary dewatering, after the cutting of the base.

6.3 Studies and tests for improving the project may be carried on the neighbouring rock-layers having the same geological characters as the body of the Sphinx.
* shall be cut

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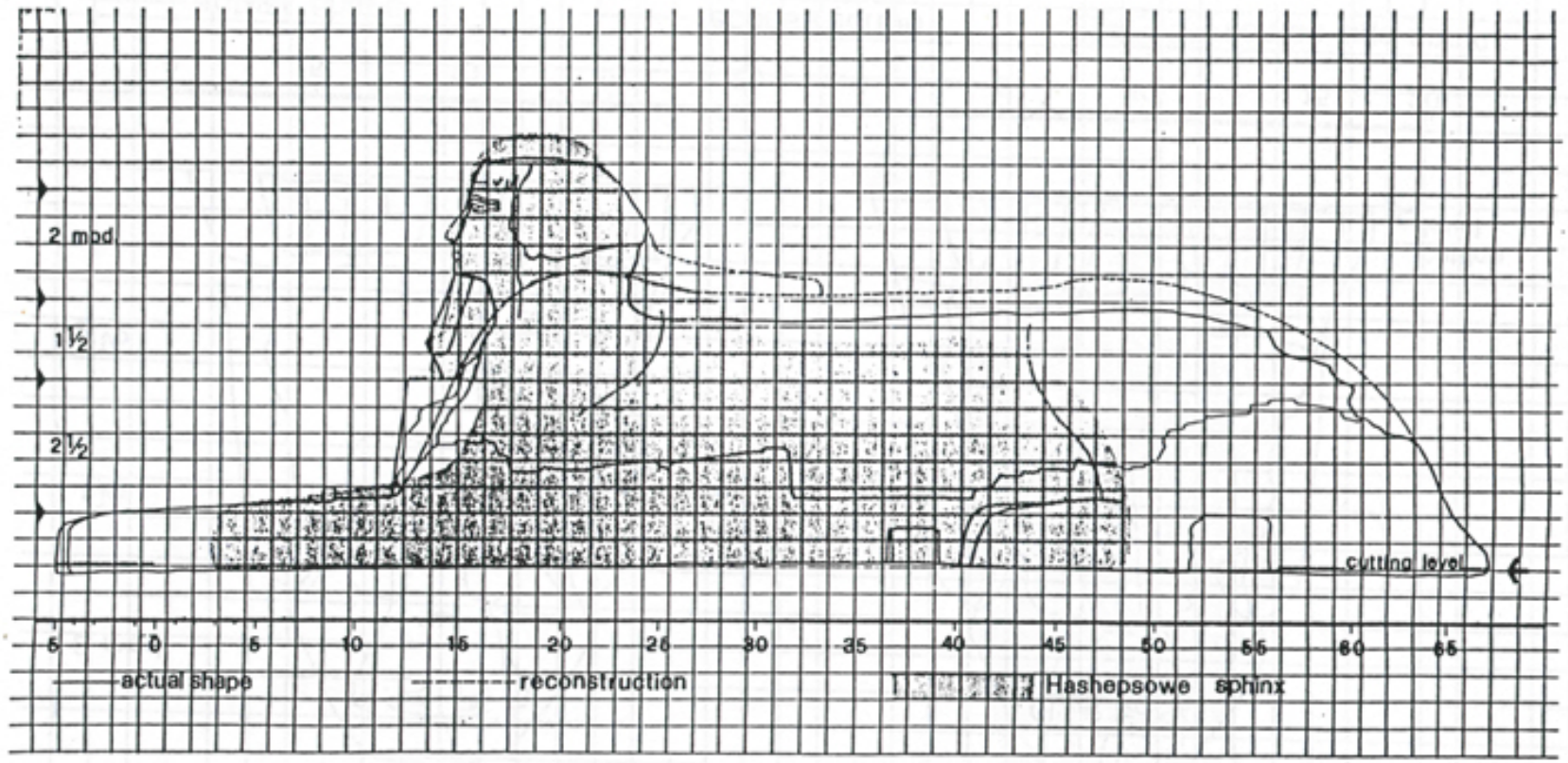
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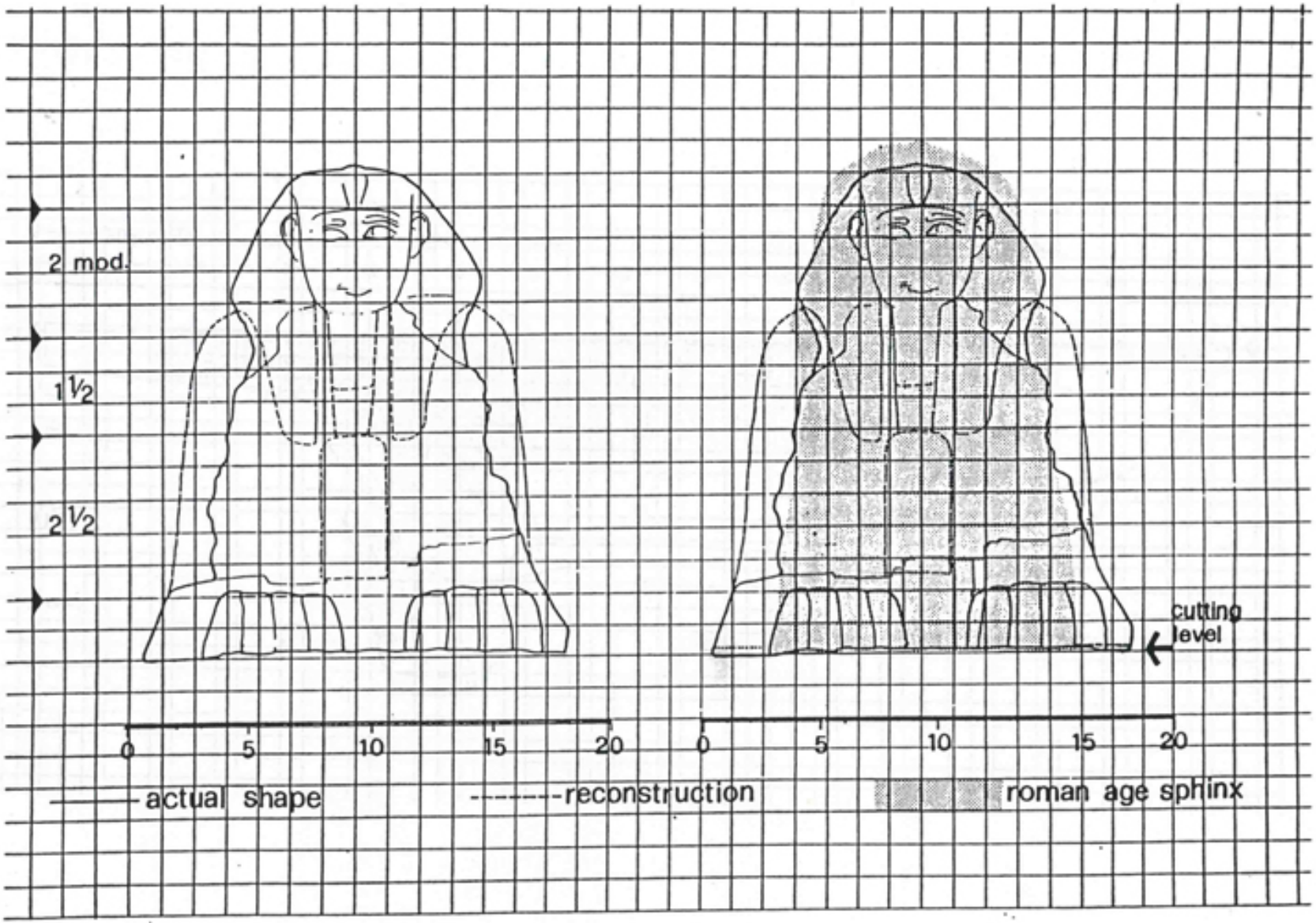
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