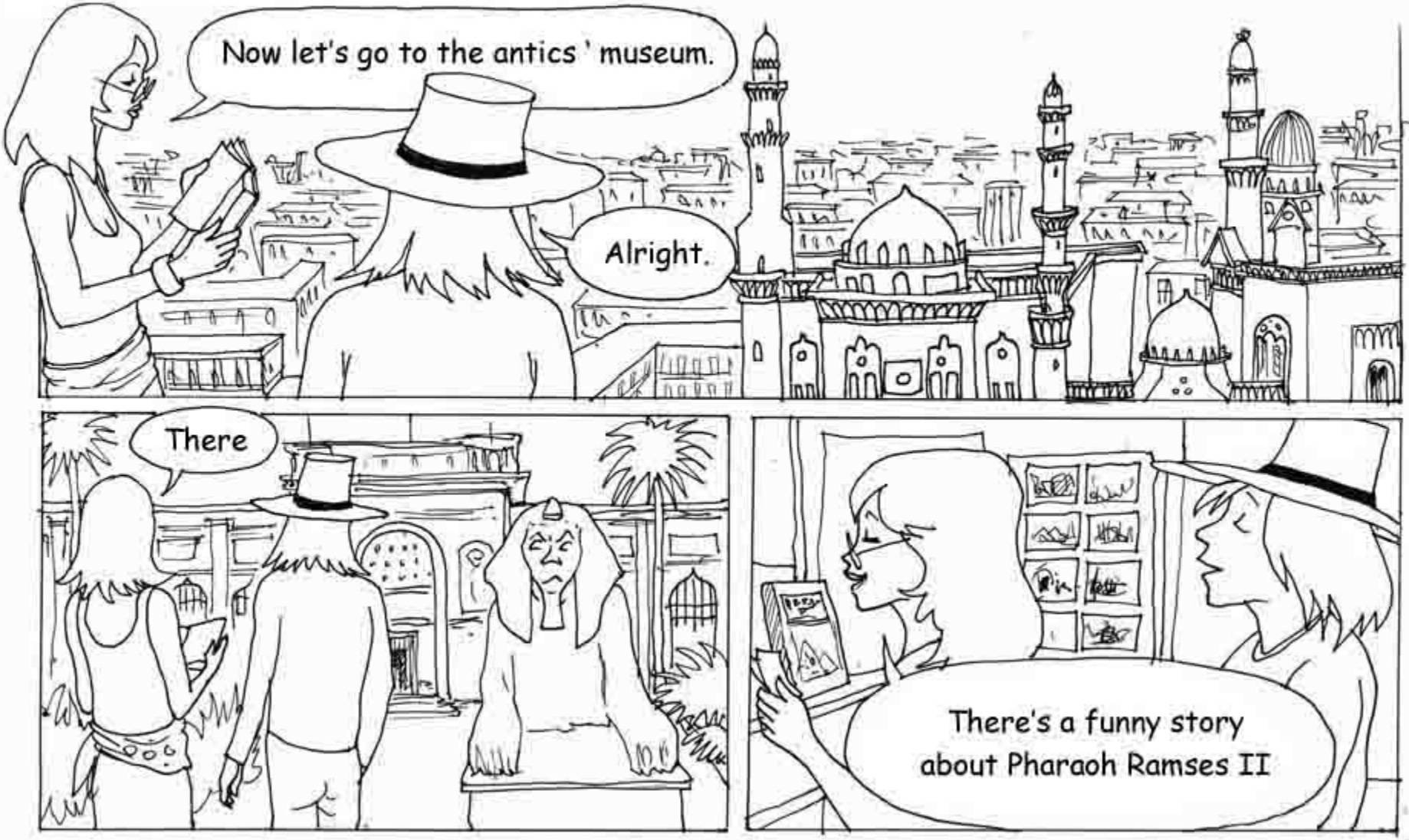
PYRAMIDS :
THE SECRET OF IMOTHEP

CAiRO


Now let's go to the antics ' museum.
Alright.
There
There's a funny story
about Pharaoh Ramses II

The graves of the pharaohs located in the Valley of the Kings were quickly desecrated and plundered. The priests who were given custody of those ended up taking all the mummies one night and sheltered those in a cave overhanging the Valley of the Kings

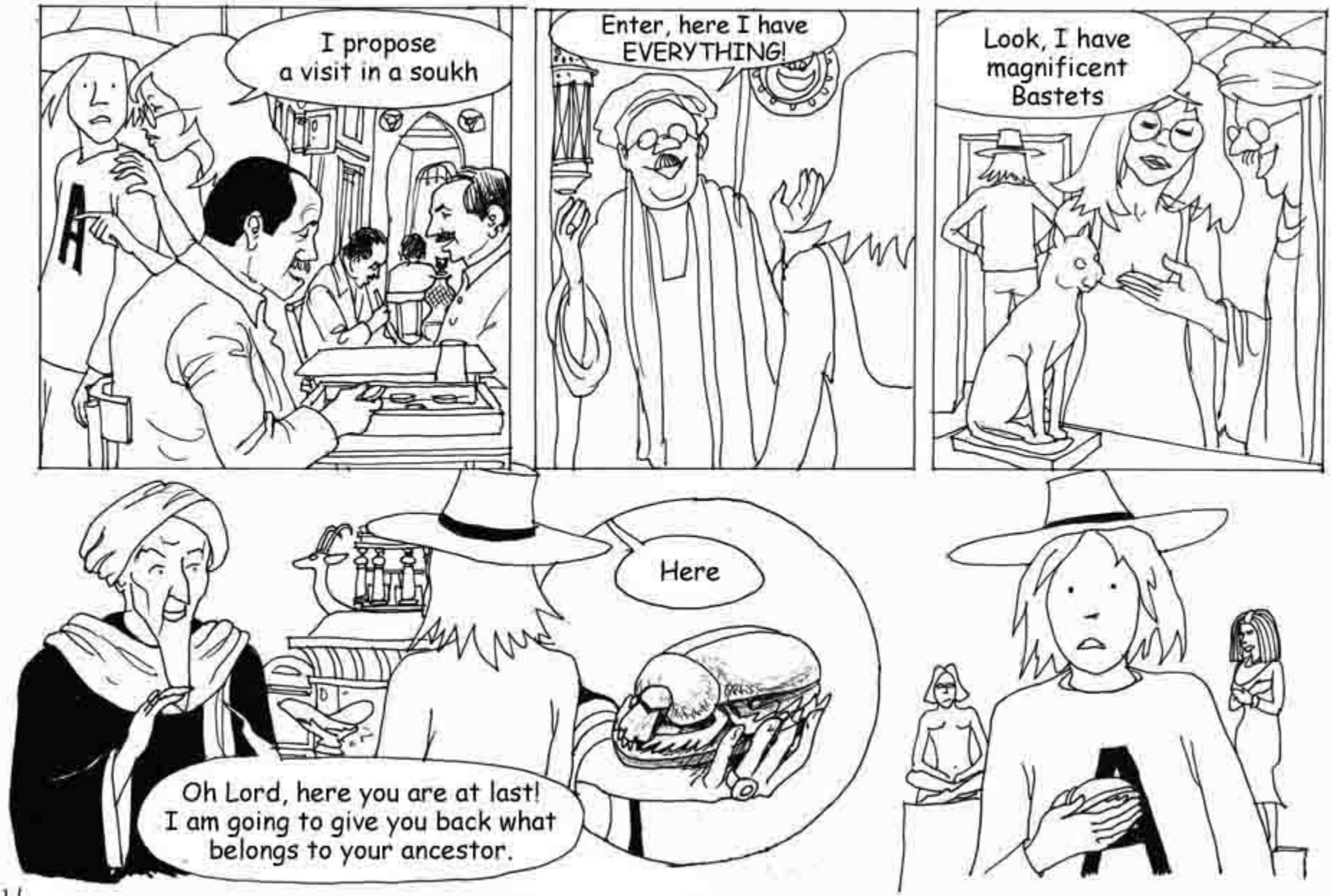
And so was saved the mummy of Ramses II

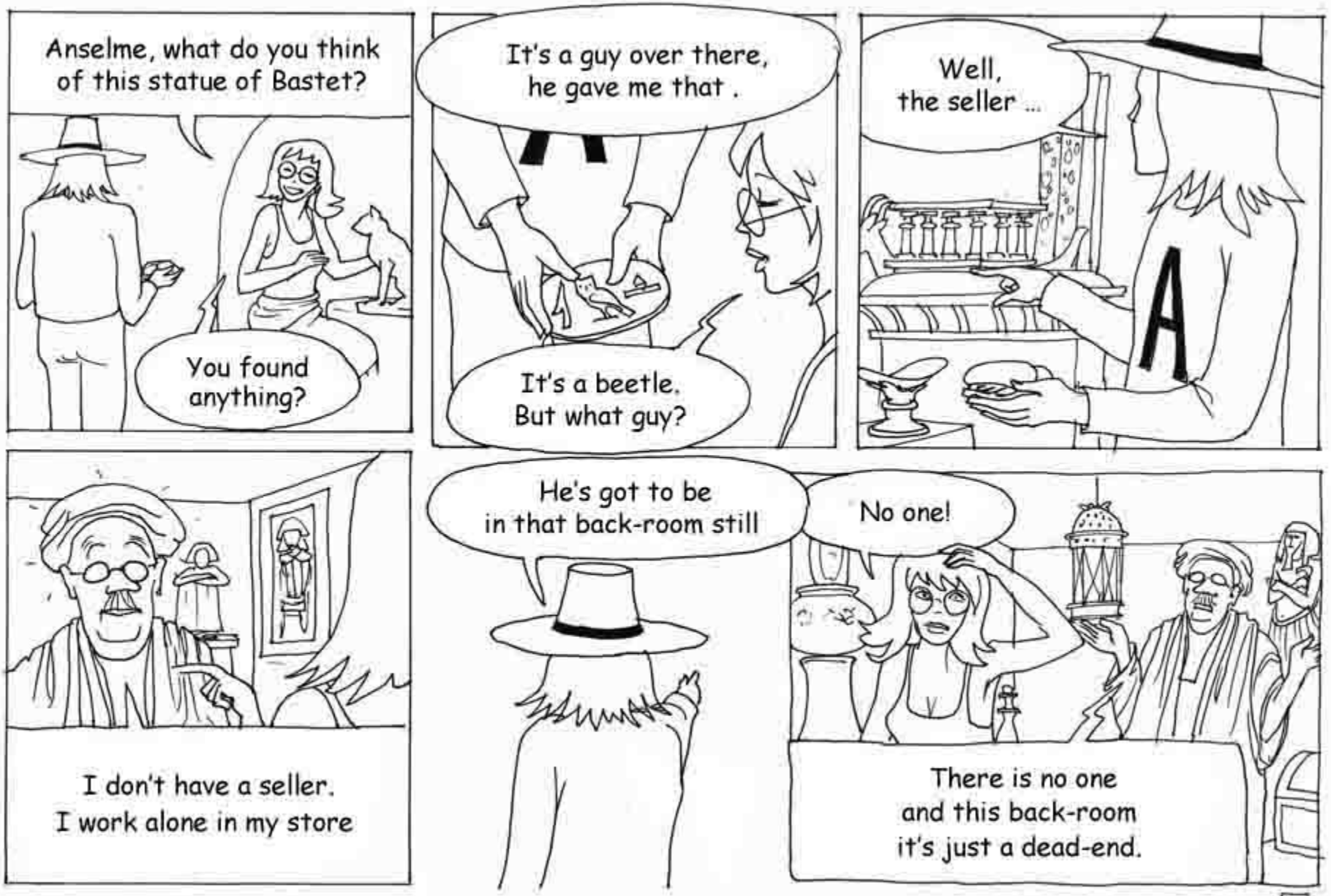
The mummy of Ramses II was displayed at the entrance of the museum to attract the visitors. According to the custom, Ramses had his two arms crossed on his chest.

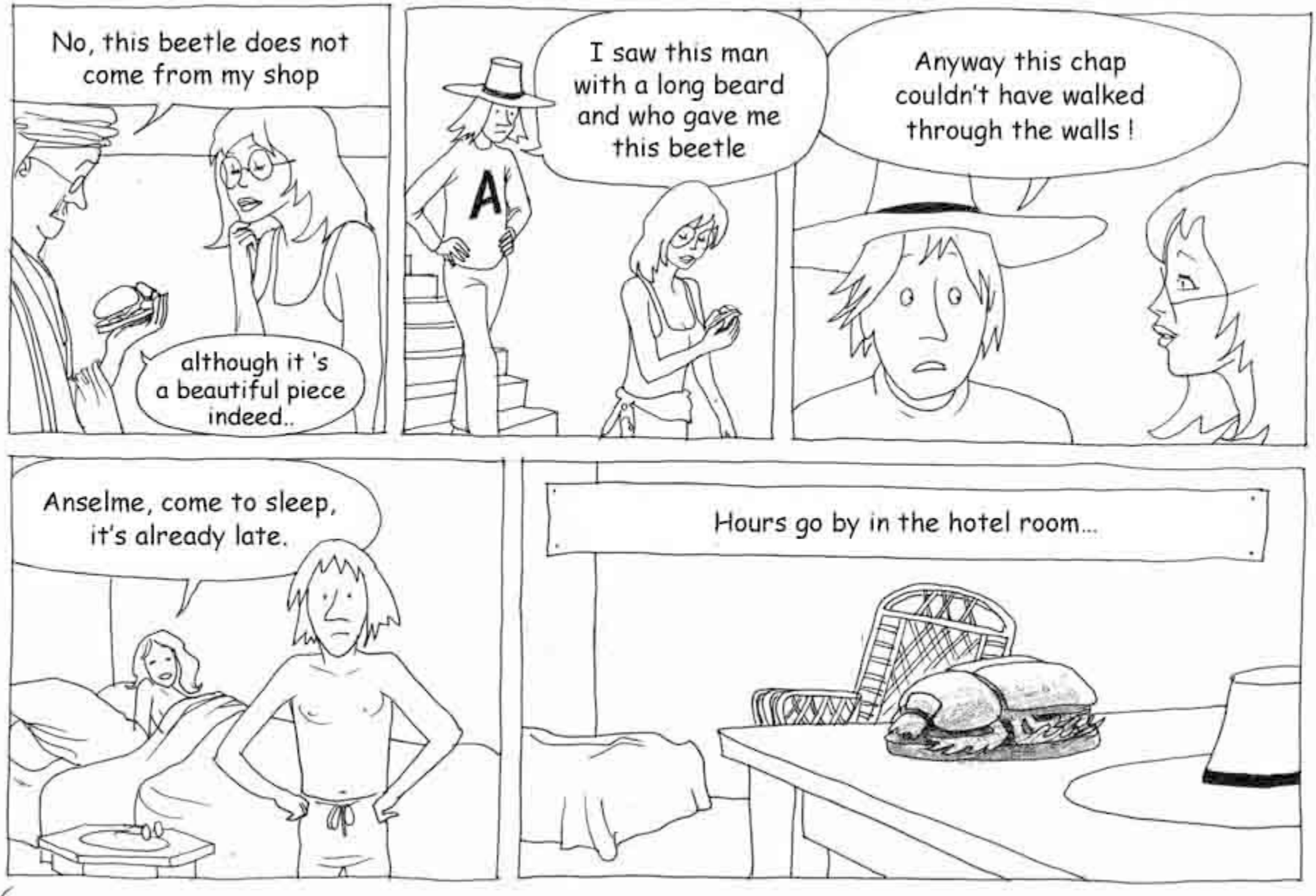
One day, Ramses II moved his left hand 10 centimeters away with a sinister sound.. Terrified, the guard ran away and never came back again in the museum, considering this place haunted !

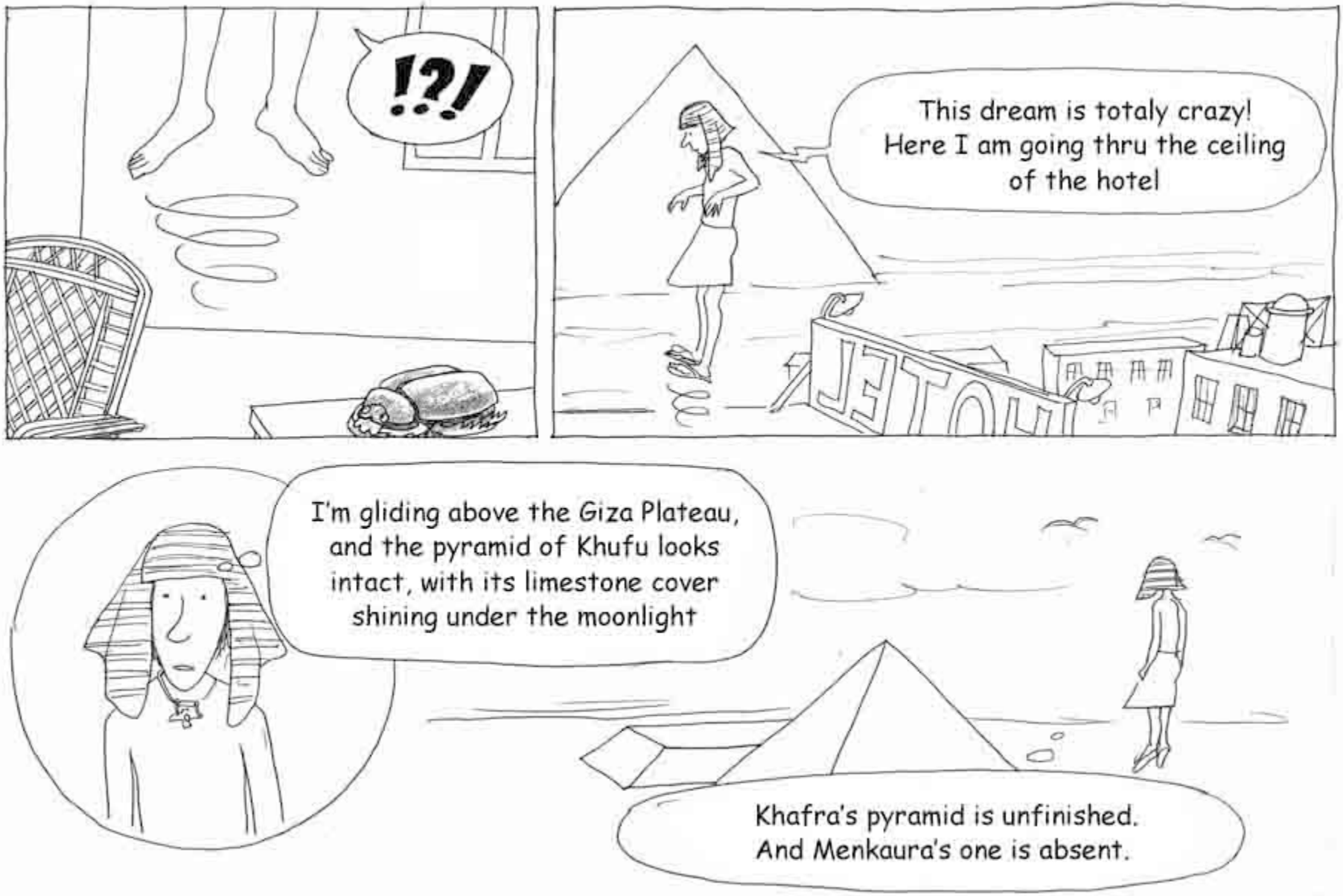
CRAC !


Anselme, come here
Here is the 4500 years old statues of Rahotep, Khéops half brother and of his wife Nefret, endowed with glass paste eyes, so realistic that when in 1871 the workers discovered them in the necropolis of Meïdoum, they ran away convinced that the graves were hosting living beings
Isn't it interesting, this statue of the prince with his mustaches? He looks like a Parisian dandy who would have been transported in the old egyptian empire..
What's wrong Anselme? You don't seem too well since we arrived in Egypt.


I propose a visit in a soukh
Enter, here I have EVERYTHING!
Look, I have magnificent Bastets
Here
Oh Lord, here you are at last! I am going to give you back what belongs to your ancestor.


Anselme, what do you think of this statue of Bastet?
You found anything?
It's a guy over there, he gave me that .
It's a beetle. But what guy?
Well, the seller ...
A
I don't have a seller. I work alone in my store
He's got to be in that back-room still
No one!
There is no one and this back-room it's just a dead-end.

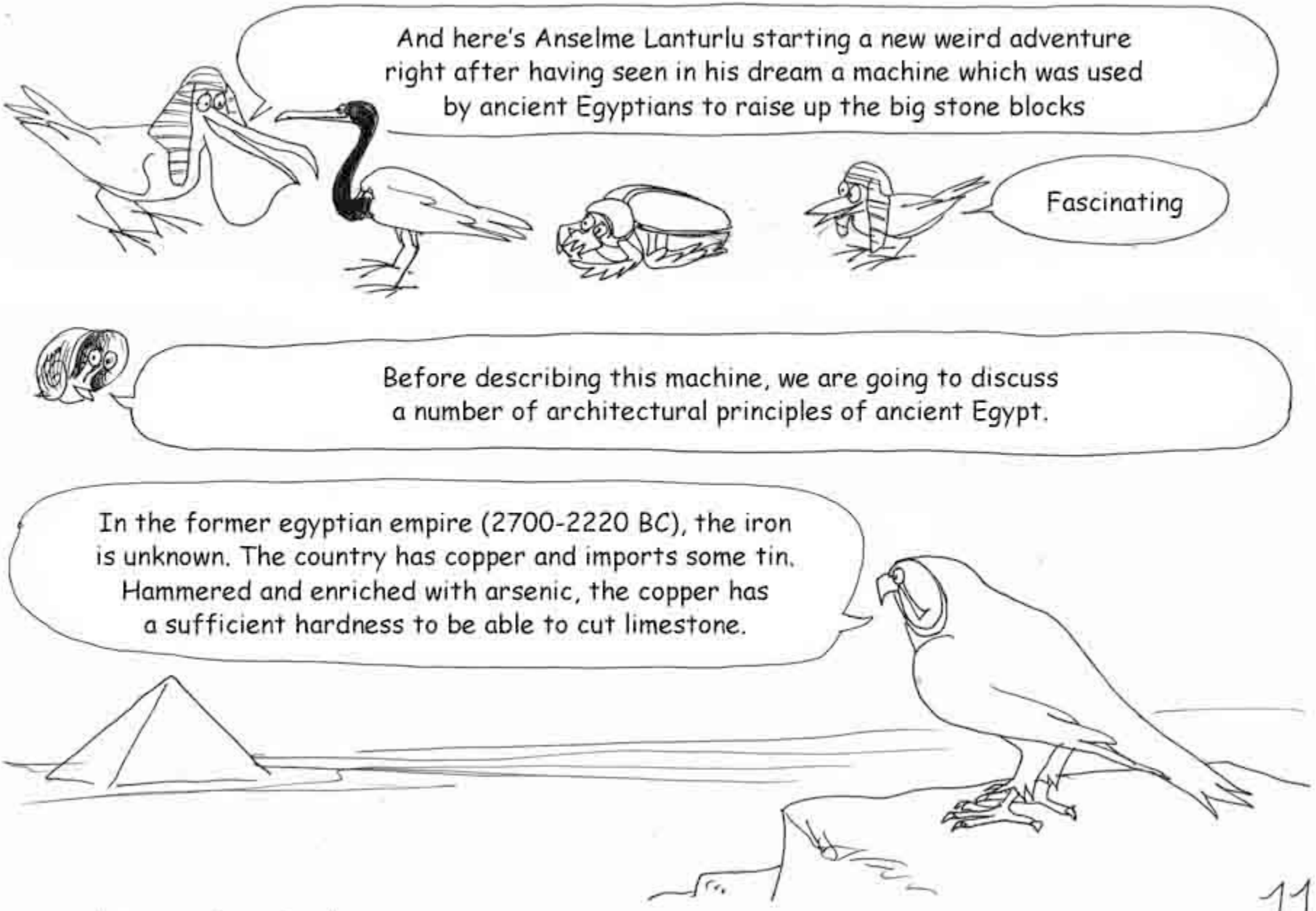

No, this beetle does not come from my shop
although it 's a beautiful piece indeed..
I saw this man with a long beard and who gave me this beetle
Anyway this chap couldn't have walked through the walls !
Anselme, come to sleep, it's already late.
Hours go by in the hotel room...


!?!
This dream is totaly crazy!
Here I am going thru the ceiling
of the hotel
HOTEL
I'm gliding above the Giza Plateau,
and the pyramid of Khufu looks
intact, with its limestone cover
shining under the moonlight
Khafra's pyramid is unfinished.
And Menkaura's one is absent.


Who's shouting over there?
It is not necessary to yell like that. I do not understand a single word of what you're saying.
It is crazy that we manage to make dreams so realistic, so detailed
all those details...

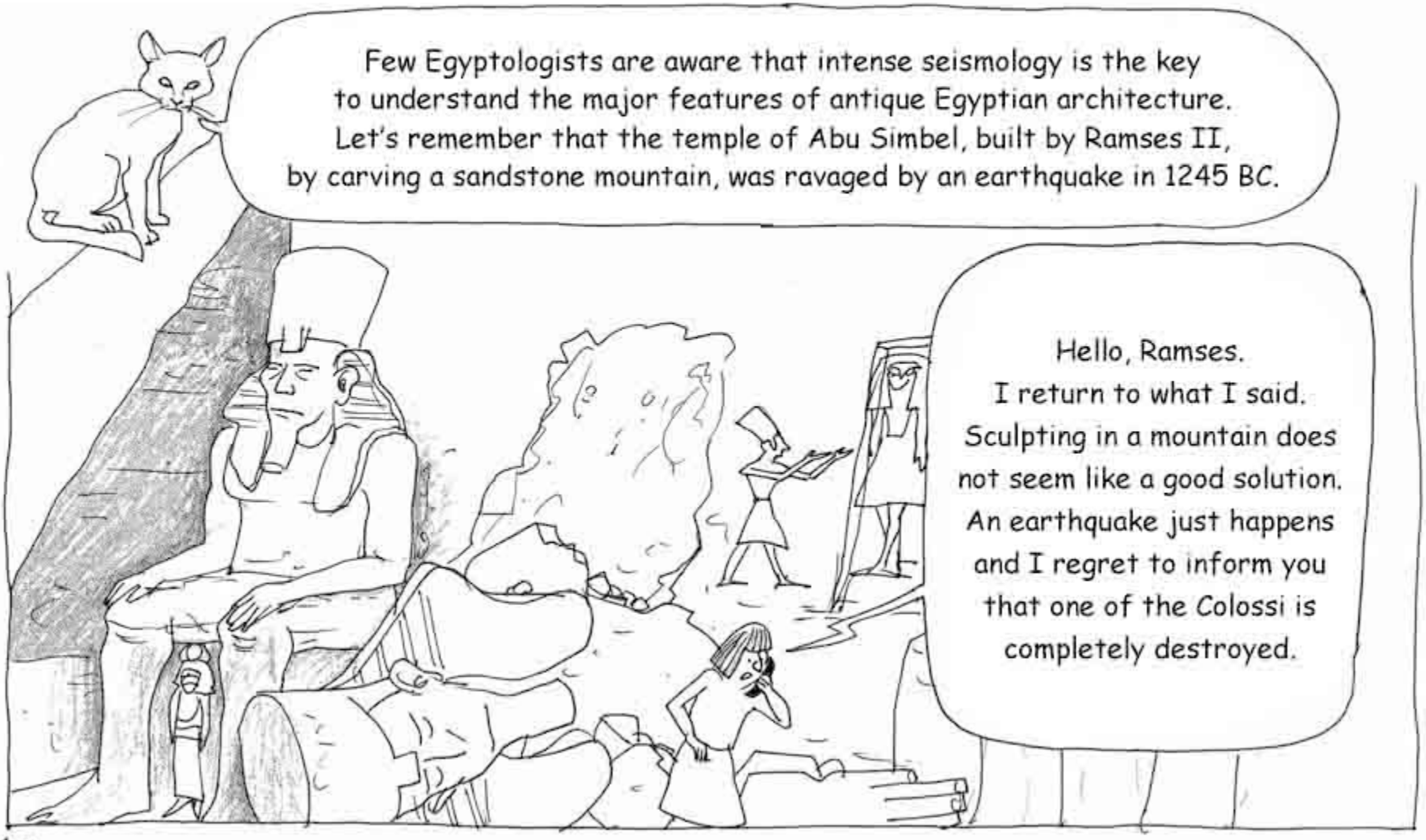

What is this kid doing on this stone block?
I have to look at it closer
Even if it's a dream, I absolutely have to sort this out
Wow!


What an extraordinary dream! I absolutely have to take notes
Anselme, what are you doing? It's three o'clock in the morning!
Look, I saw how we used to carry the very big stone blocks in order to build the Great pyramids.
Now that's a very interesting dream!
I spent the night writing down all the details which showed up in this dream

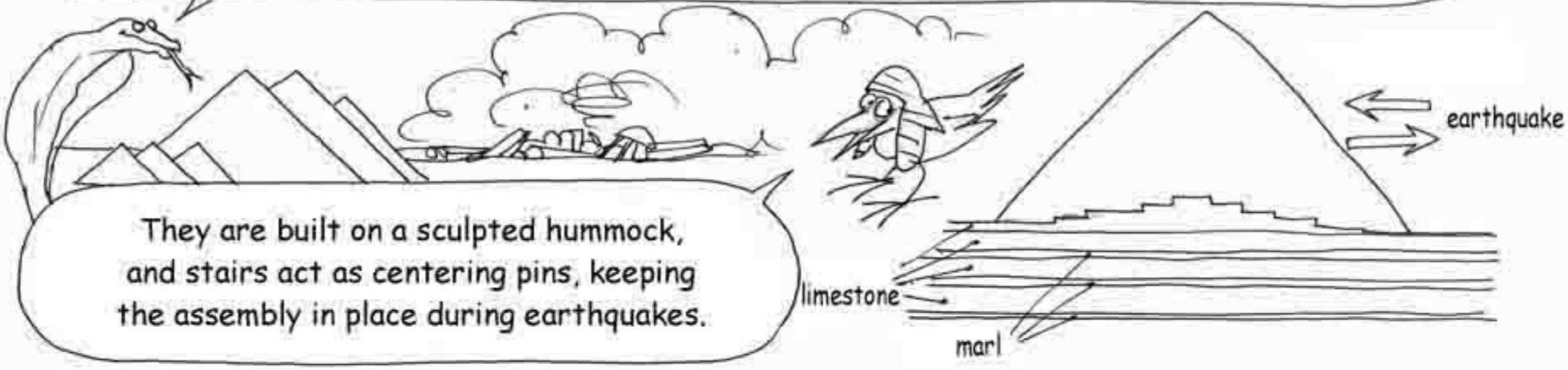


translation and graphical set in progress...

SEiSMiCiTY


Few Egyptologists are aware that intense seismology is the key to understand the major features of antique Egyptian architecture. Let's remember that the temple of Abu Simbel, built by Ramses II, by carving a sandstone mountain, was ravaged by an earthquake in 1245 BC.
Hello, Ramses. I return to what I said. Sculpting in a mountain does not seem like a good solution. An earthquake just happens and I regret to inform you that one of the Colossi is completely destroyed.

A basement consisting of mechanically different layers, as in Giza,
is an optimum seat for mitigating earthquakes. This played a major role in choosing the site.
When in ... BC Cairo was ravaged by an earthquake, the pyramids remained intact.



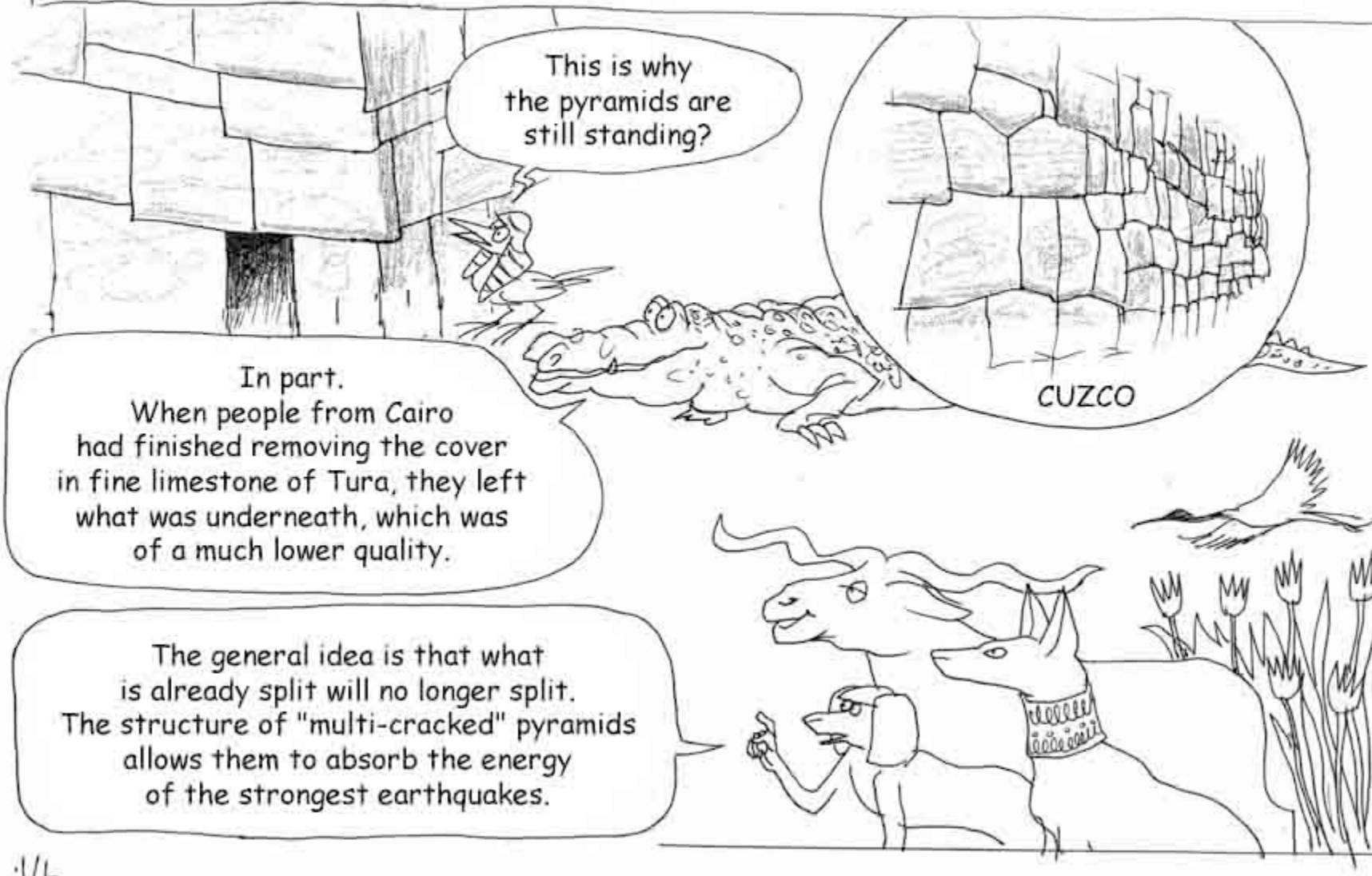
They are built on a sculpted hummock,
and stairs act as centering pins, keeping
the assembly in place during earthquakes.

This is found in various parts of the world, where some kind
of "steps" are interpreted as seats of a "board room",
while their role is to maintain the construction in place.

The "throne of
the Inca"

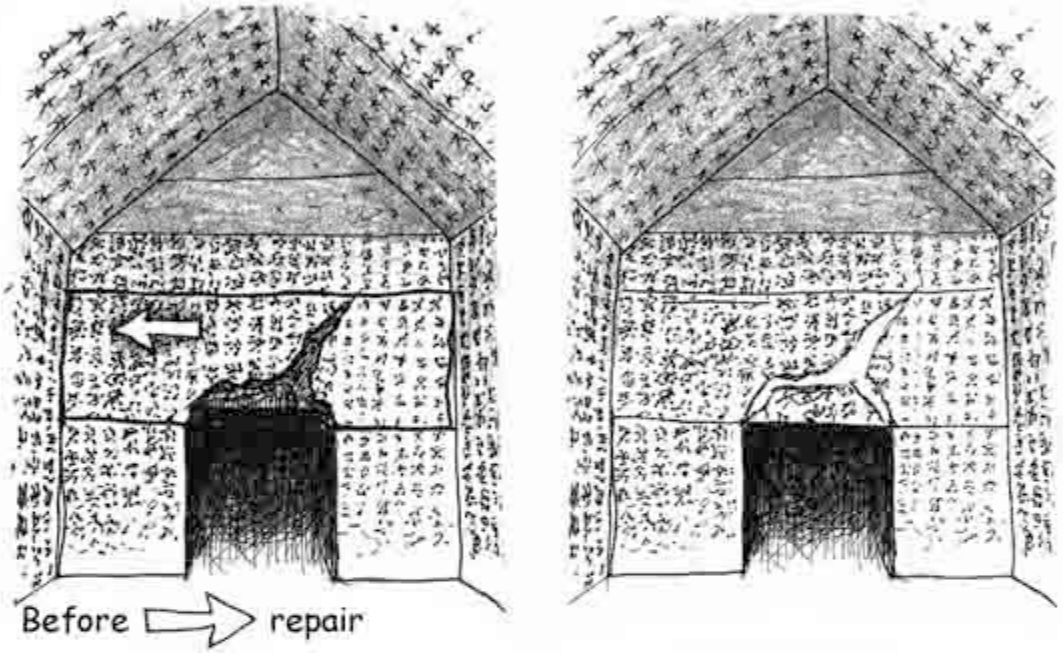
Whose stones have disappeared,
having been recovered.

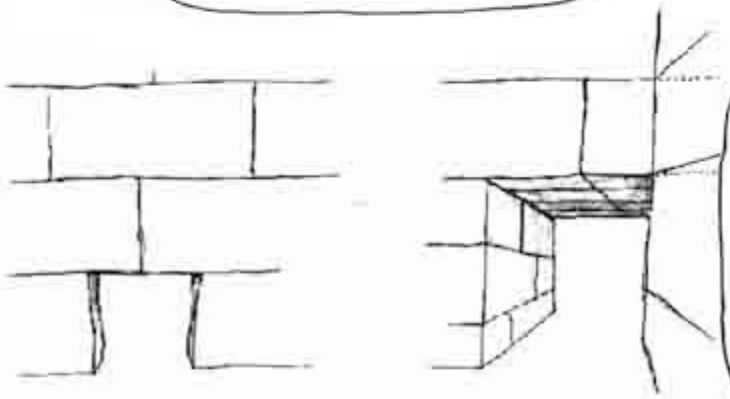
The earthquake resistance suggests avoiding any regularity.
Examples: the temple which is at the foot of the Sphinx or the famous Inca wall in Cuzco.



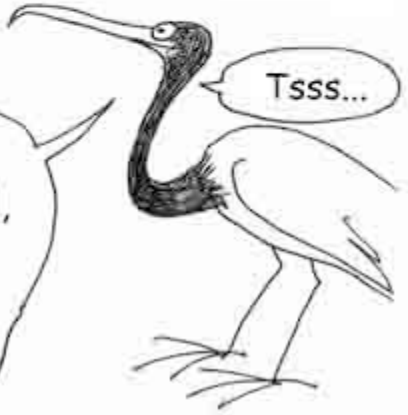
Still, our architects-priests must do their job properly, by arranging the blocks.

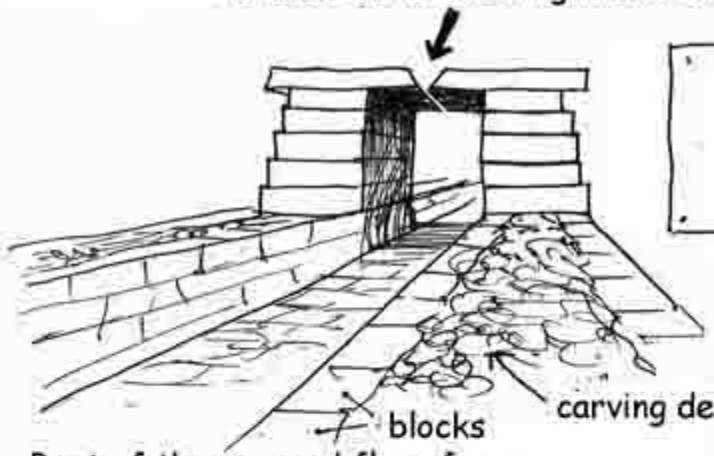
By not applying the "split lintel" technique.





The architect of the Pharaoh Unas (2350 BC) thought that massive blocks were the solution. But the enormous lintel, undergoing shear stress, cracked. Repaired (to the right), it shall split to the next earthquake.

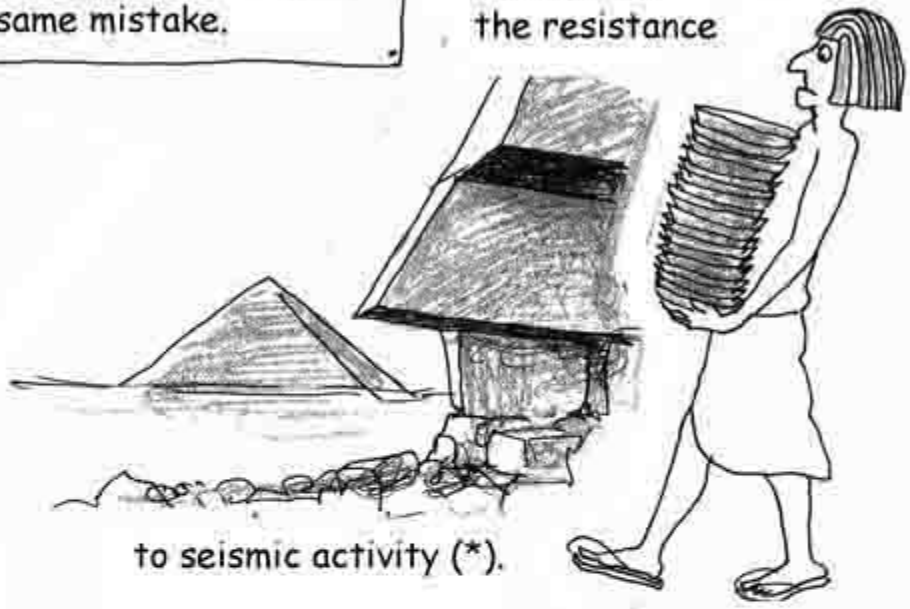




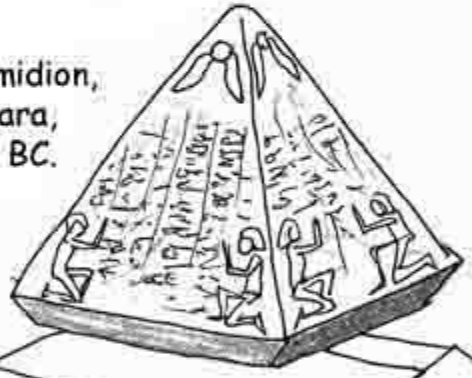
Rest of the covered floor from the pyramid of Unas (Sakkara)

But a little further, his colleague did not make the same mistake.

For whom is a little watchful, all Egyptian architecture is based on the resistance



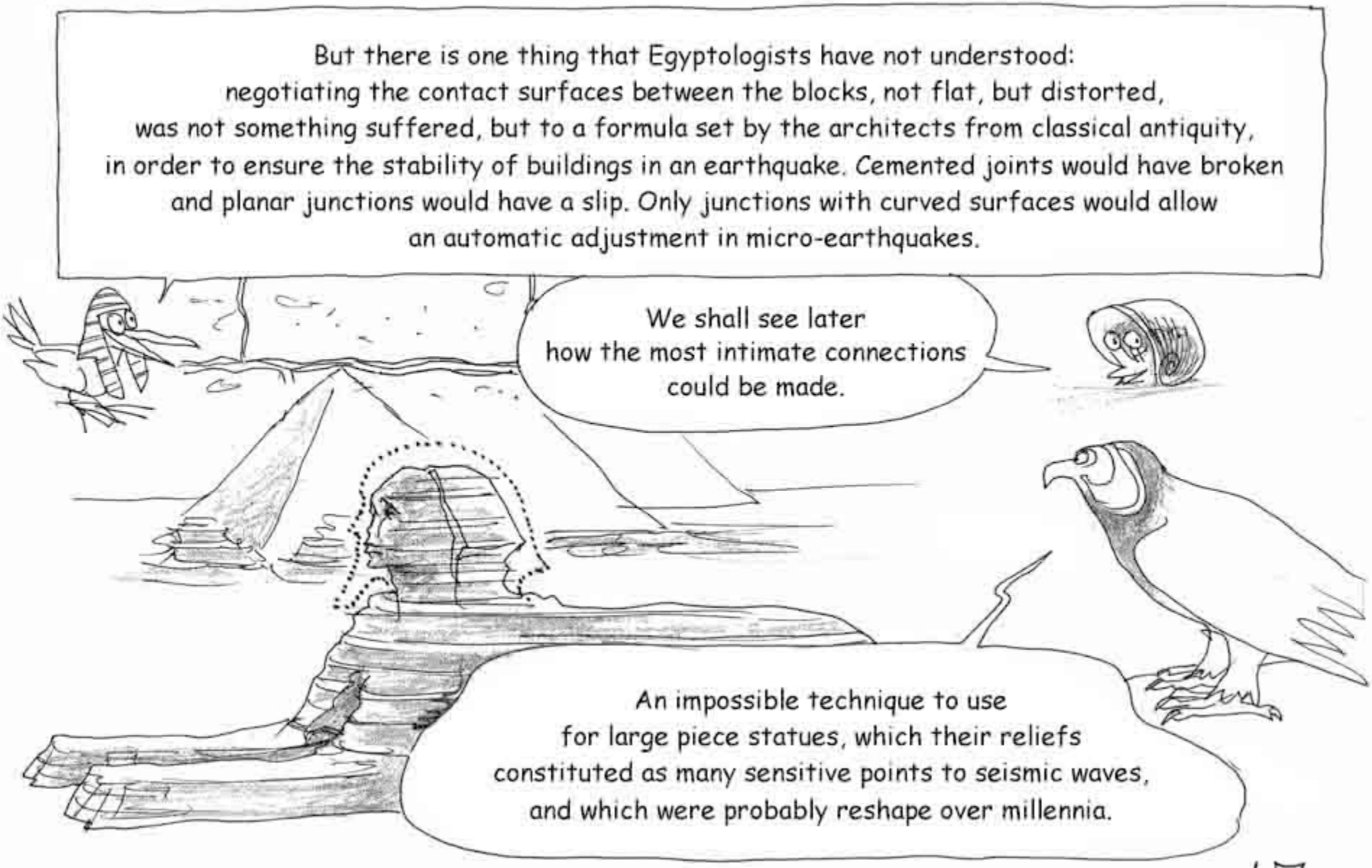
to seismic activity (*).



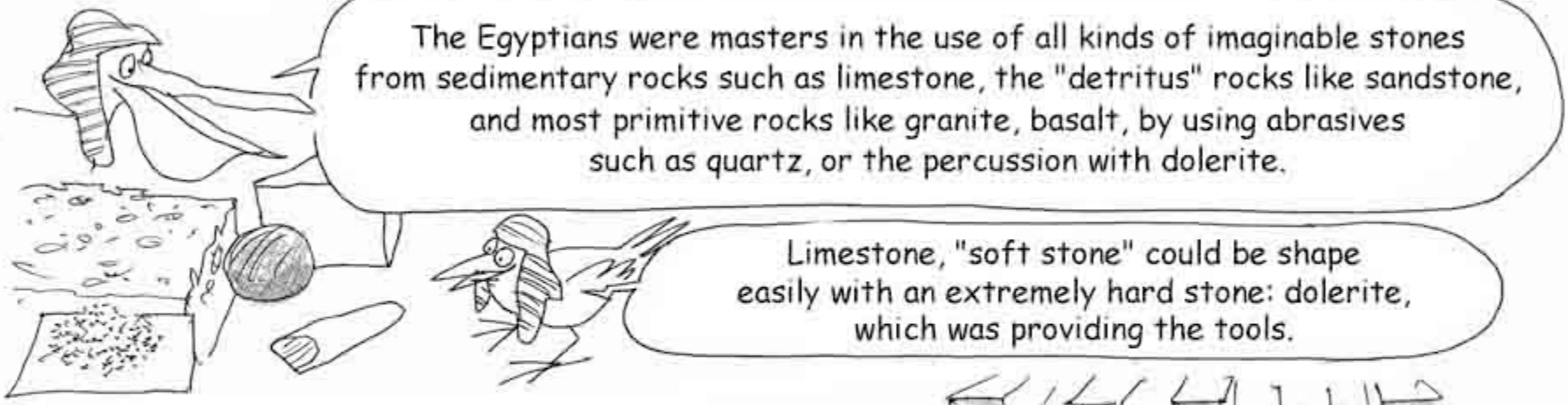
Pyramidion, Sakkara, 1230 BC.

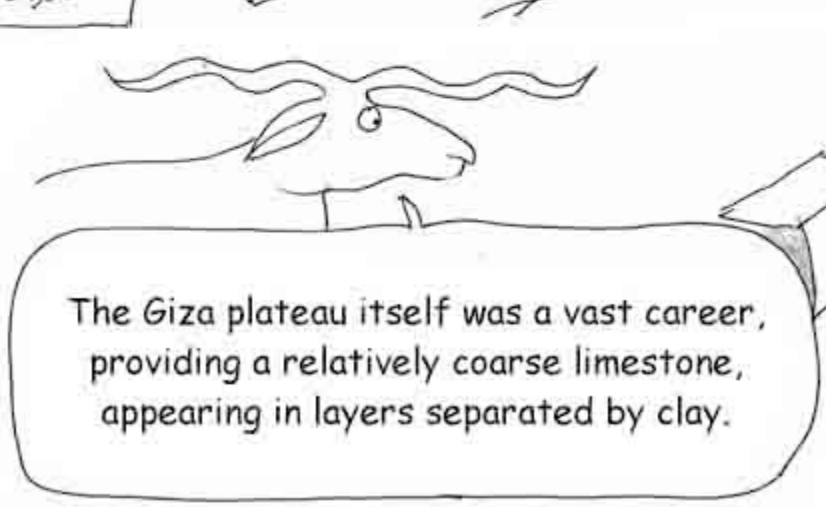
Even the **pyramidion**, uppermost piece of the pyramid, was designed to stay in accommodation in strong earthquake.

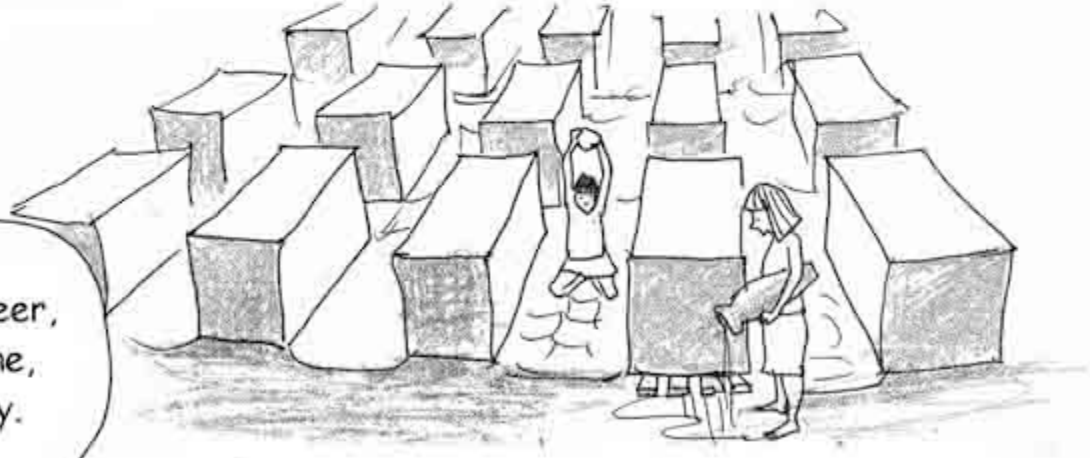
(*) In the foreground, the blocks of the **Bent Pyramid**, showing the inclination of the stone, and in the background the **Red Pyramid**, at Dahshur.


But there is one thing that Egyptologists have not understood:
negotiating the contact surfaces between the blocks, not flat, but distorted,
was not something suffered, but to a formula set by the architects from classical antiquity,
in order to ensure the stability of buildings in an earthquake. Cemented joints would have broken
and planar junctions would have a slip. Only junctions with curved surfaces would allow
an automatic adjustment in micro-earthquakes.
We shall see later
how the most intimate connections
could be made.
An impossible technique to use
for large piece statues, which their reliefs
constituted as many sensitive points to seismic waves,
and which were probably reshape over millennia.

MATERIALS AVAILABLE

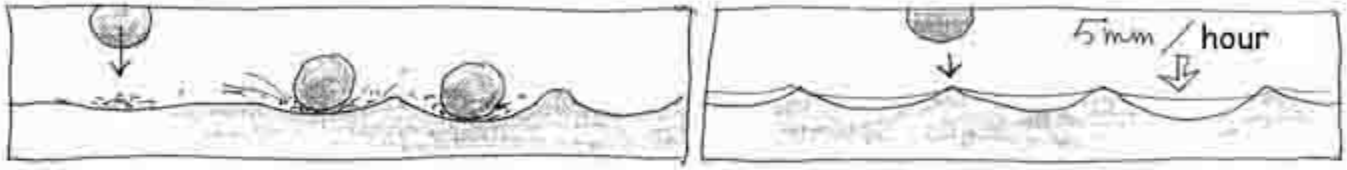




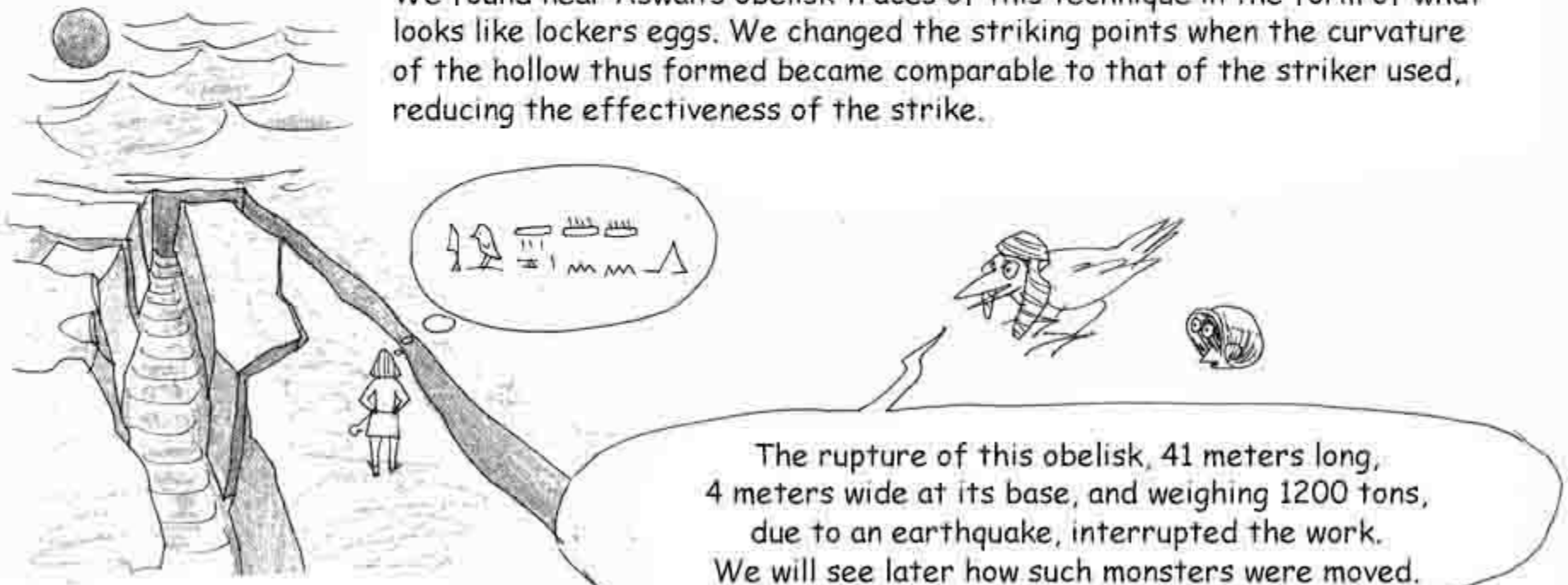


The blocks were removed by swelling of wooden wedges (Georges Goyon).

From lack of steel, iron and having trouble procuring bronze import, Egyptians of the Ancient Empire (*) practiced efficiently a **MACHINING PERCUSSION** (**). Granite was containing inclusions in the form of **DOLERITE BALLS**, which the size could reach that of a man's head.

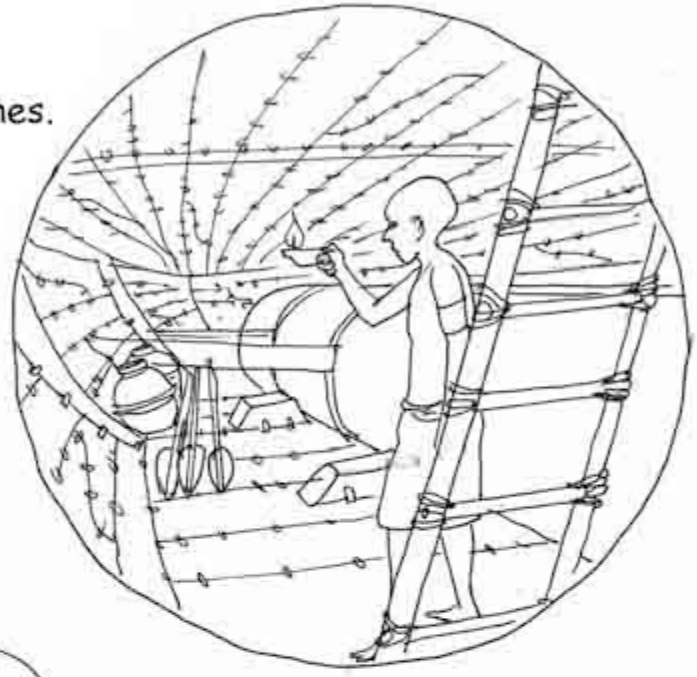


We found near Aswan's obelisk traces of this technique in the form of what looks like lockers eggs. We changed the striking points when the curvature of the hollow thus formed became comparable to that of the striker used, reducing the effectiveness of the strike.

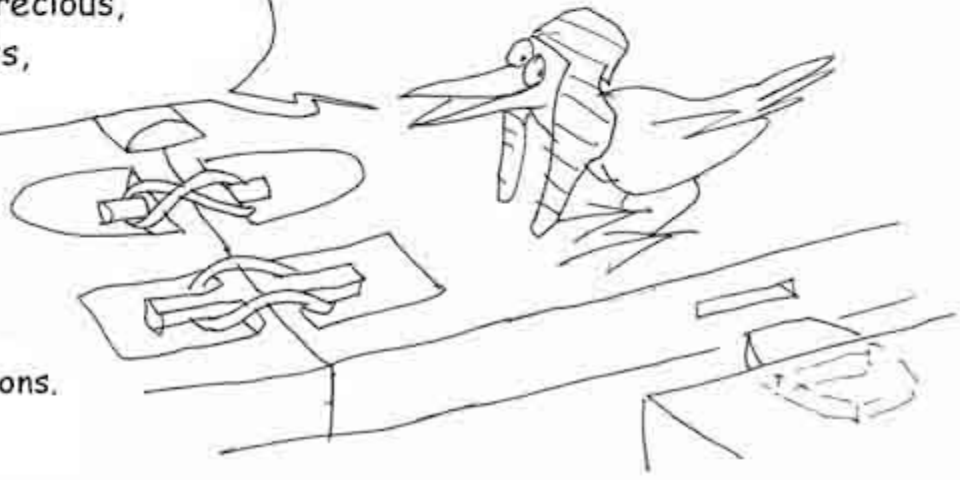


(*) From 2700 to 2200 BC.
(**) Efficient on limestone, bronze tools did not attack the "hard stone" like granite.

Acacia wood was a local production.
Large parts had to be cut from the trunks of cedar,
imported from Lebanon. The resins supplied glues and varnishes.
Ancient Empire Egyptians knew very well how to make
hemp ropes, as strong as modern strings (*)



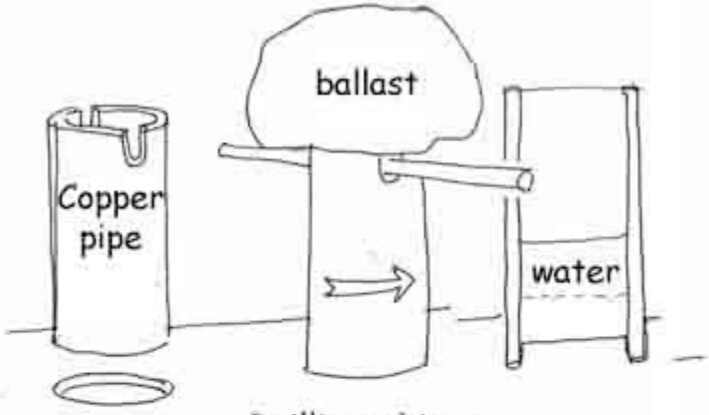
But as the wood was something rare and precious,
the Egyptians used it in complex arrangements,
with "seams" using the rope to retrieve
the smallest fragment.



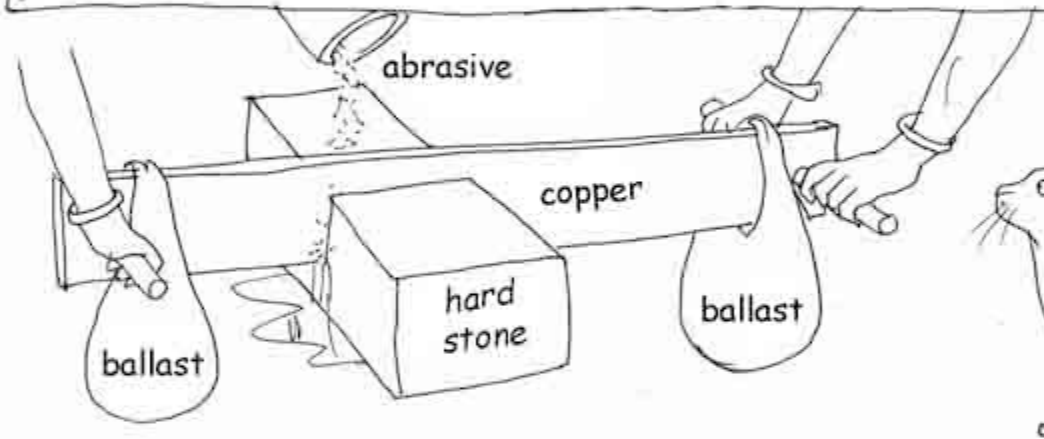
(*) A cord of 50mm diameter can pull 4 tons.

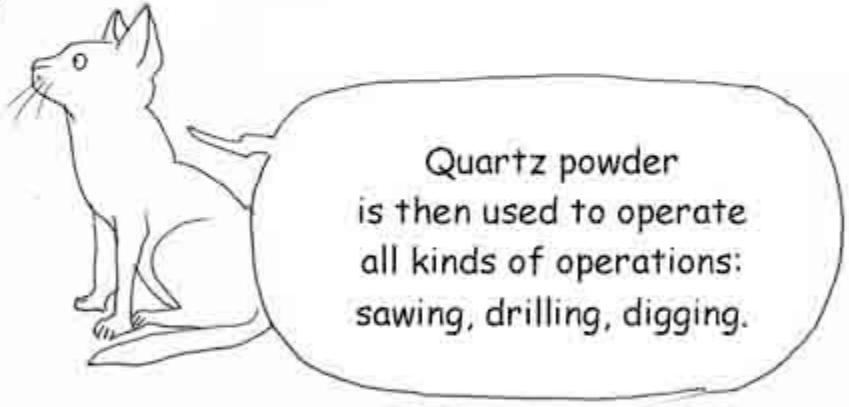
THE TOOLS

In the Ancient Empire, as practically the only available metal was copper, when the direct strike of materials was not possible (e.g. with a saw with teeth) was used **ABRASION**.



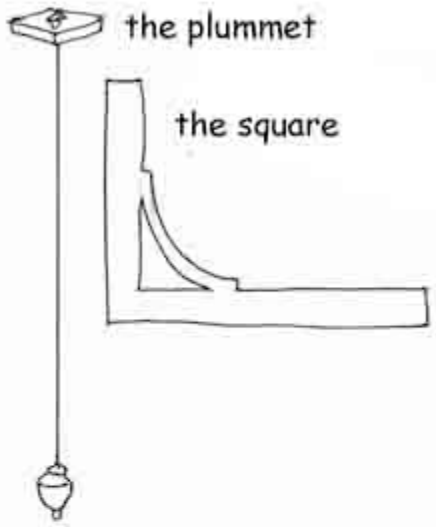
Drilling a hinge

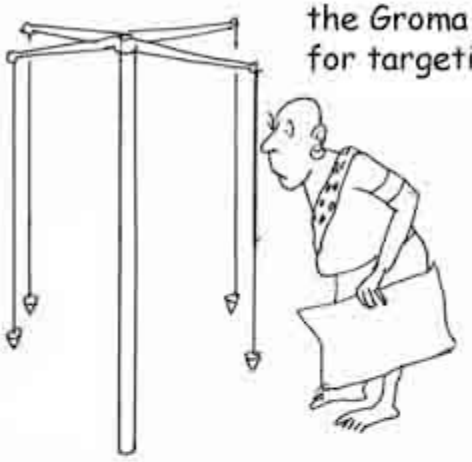


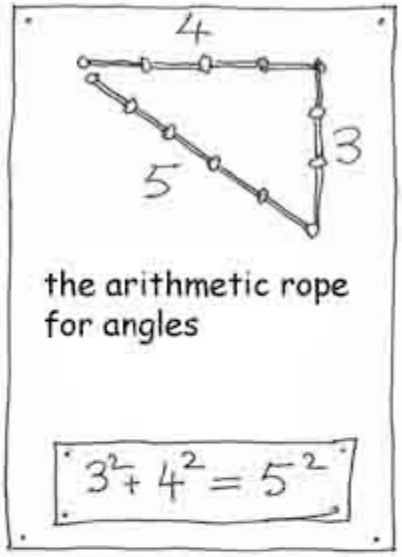


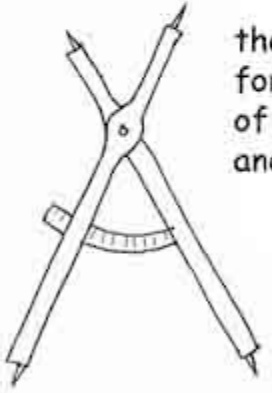
Sandstone, composite rock, contains its own abrasive. We then use sandstone polishers.

MEASURiNG iNSTRUMENTS





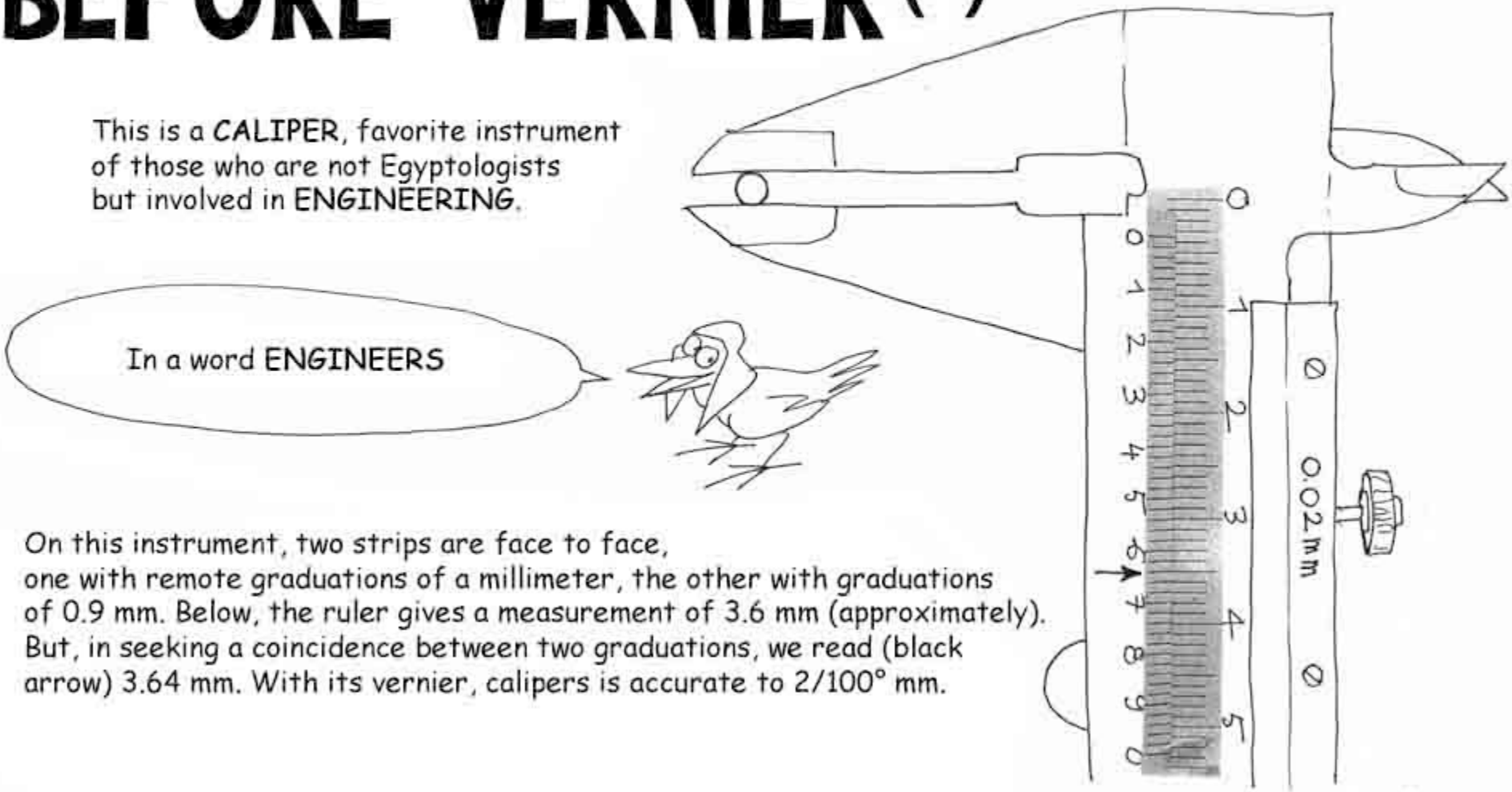




The roller, for distances, revealing the number π wherever we evaluate lengths reports

3000 YEARS BEFORE VERNIER (*)

This is a **CALIPER**, favorite instrument of those who are not Egyptologists but involved in **ENGINEERING**.



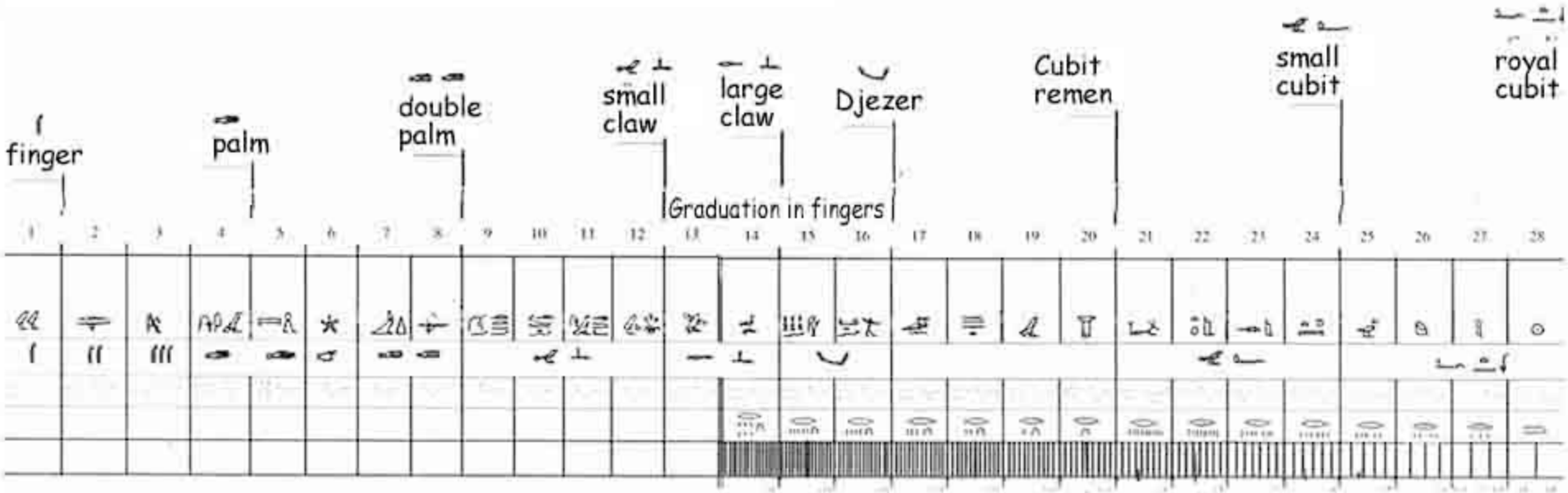
On this instrument, two strips are face to face, one with remote graduations of a millimeter, the other with graduations of 0.9 mm. Below, the ruler gives a measurement of 3.6 mm (approximately). But, in seeking a coincidence between two graduations, we read (black arrow) 3.64 mm. With its vernier, calipers is accurate to 2/100° mm.

(*) Pierre Vernier, French mathematician, who (re)invented this item in 1631.

THE EGYPTIAN CUBIT

Cubit Amenothep II, 1559-1539 (Louvre)

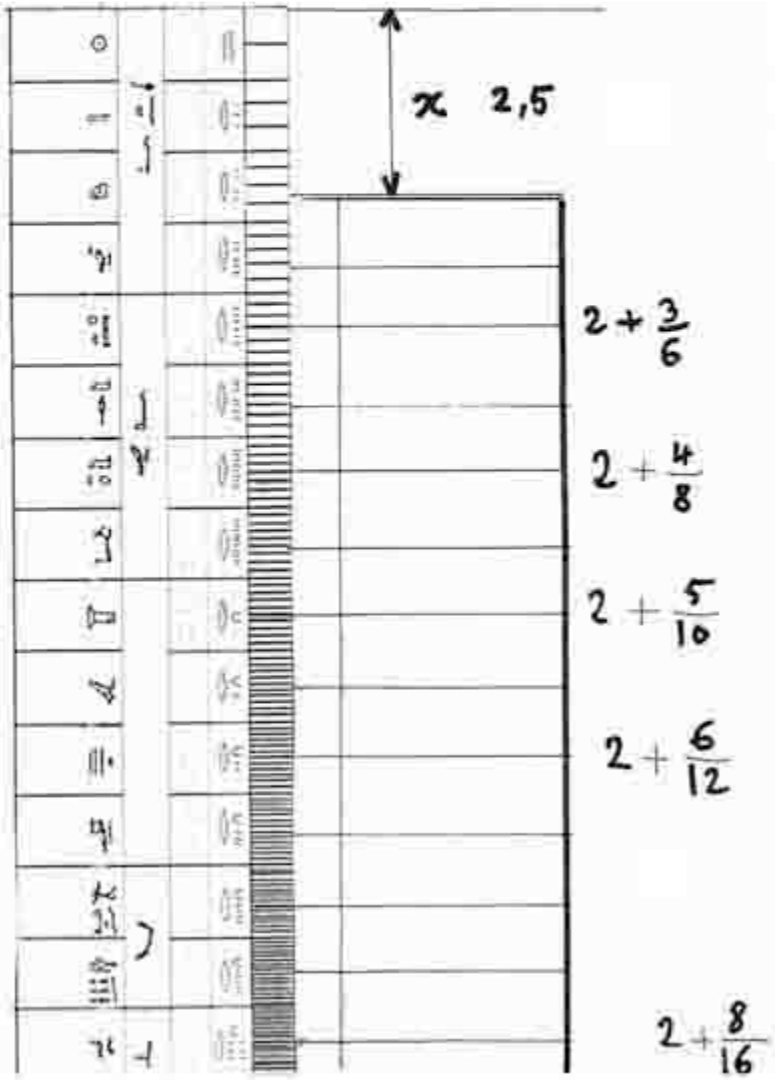
Egyptian cubits wear subdivisions increasingly tightened



From the right, subdivisions "finger" are themselves subject to progressive subdivisions by 2 , then 3 , 4 , etc. The symbol "Eye of Horus" resulting in "divided by". The progressive nature of these subdivisions, as well as the fact that it appears only on half of the elbow, had not been explained to now.

LET'S GIVE THE KEY OF THE MYSTERY

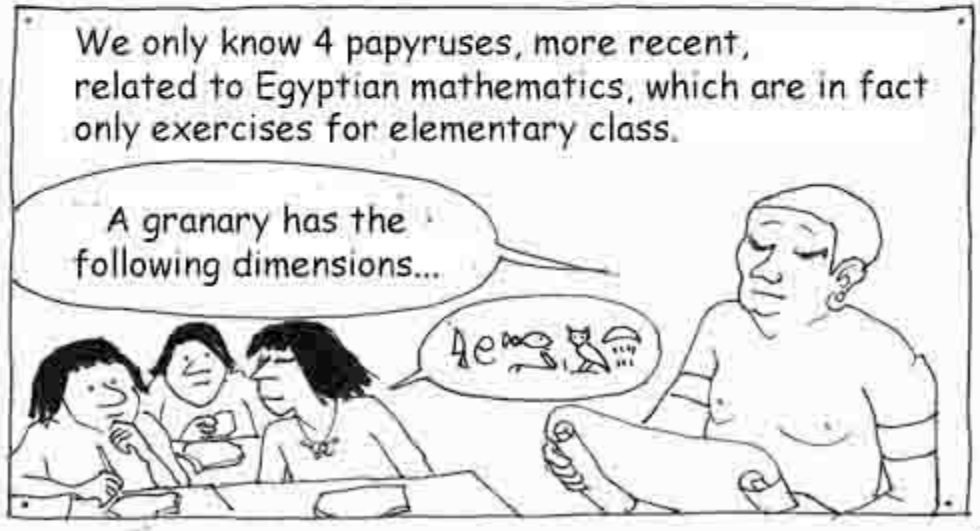
A **MEASURE**, in ancient Egypt, was expressed as the sum of a number and the ratio of two numbers, either to read a map, or to record a data on it. The Egyptians were then using, not **ONE** cubit, but **TWO**, by turning the second at 180°.

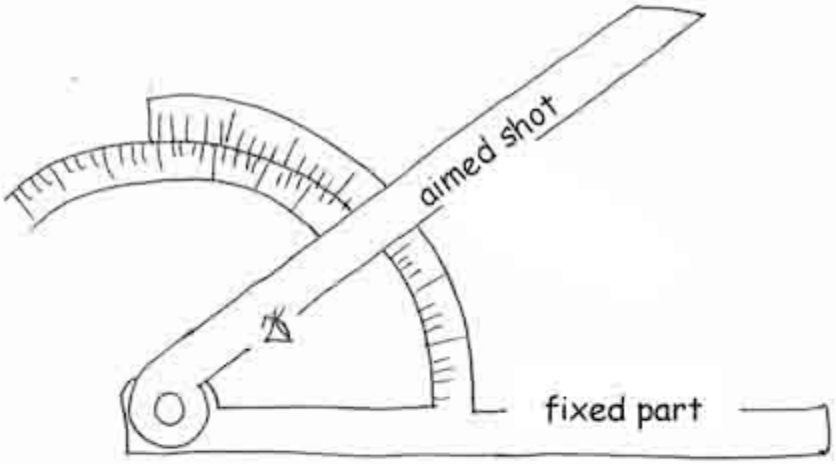


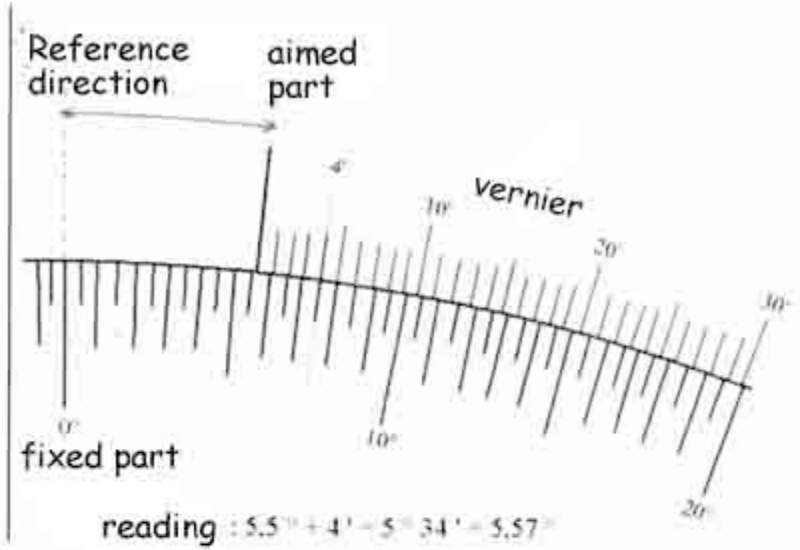
By shifting the second cubit (by 2.5 cm here), the search of coincidences between two graduations will be found to:

$$\frac{3}{6} = \frac{4}{8} = \frac{5}{10} = \frac{6}{12} = \frac{8}{16}$$

Thus the Royal Egyptian cubit has a "**MULTI-VERNIER**" system allowing accurate measurements at one sixteenth of a finger, thus at 0.116 finger close.







A **GONIOMETER**, a tool to measure angles,
is a "wrapped caliper" with an angular vernier. Again, we proceed by searching the coincidence between the graduations of two strips, with different spacing graduations. The goniometer allows measurements to a few hundredths of a degree.

Although we have not found
Egyptian goniometers, given the great precision
attached to their constructions, it is highly probable
that they used them in 2600 BC.

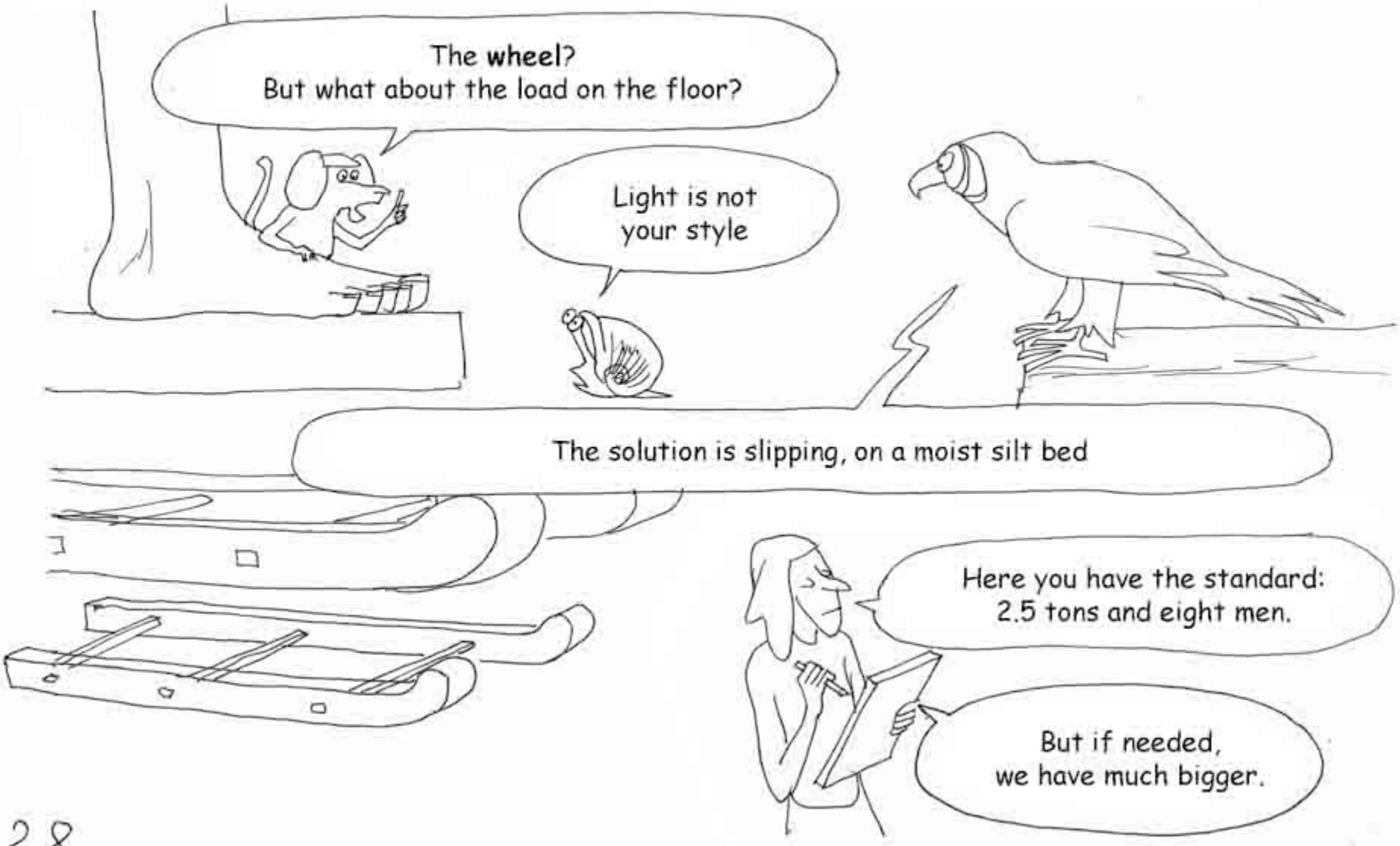
(*) The mathematician Pedro Nunes (1502-1568) provided the Portuguese Navy with VERNIER **ASTROLABES** (a century before he "invented" them...).

When it is not attached to reconstruct the history of ancient peoples, archeology tries to enlighten on the science and technology of the past. It then focuses on the tools, measuring instruments and machines of all sizes and for all uses, which were achieved with these elements. It sometimes has the description of a particular modus operandi in the form of diagrams, drawings or written texts. But the discovery of these is an exceptional event. When ancient people ignore the writing, they are simply absent. So nobody will ever know the recipes of these experienced metallurgists who were the Gauls. Regarding Egypt, the vastness of the elapsed time does not make things easier. Where are the hundreds of millions of pyramids builders' tools? Where are their technical drawings? Where are the calculations of their engineers?

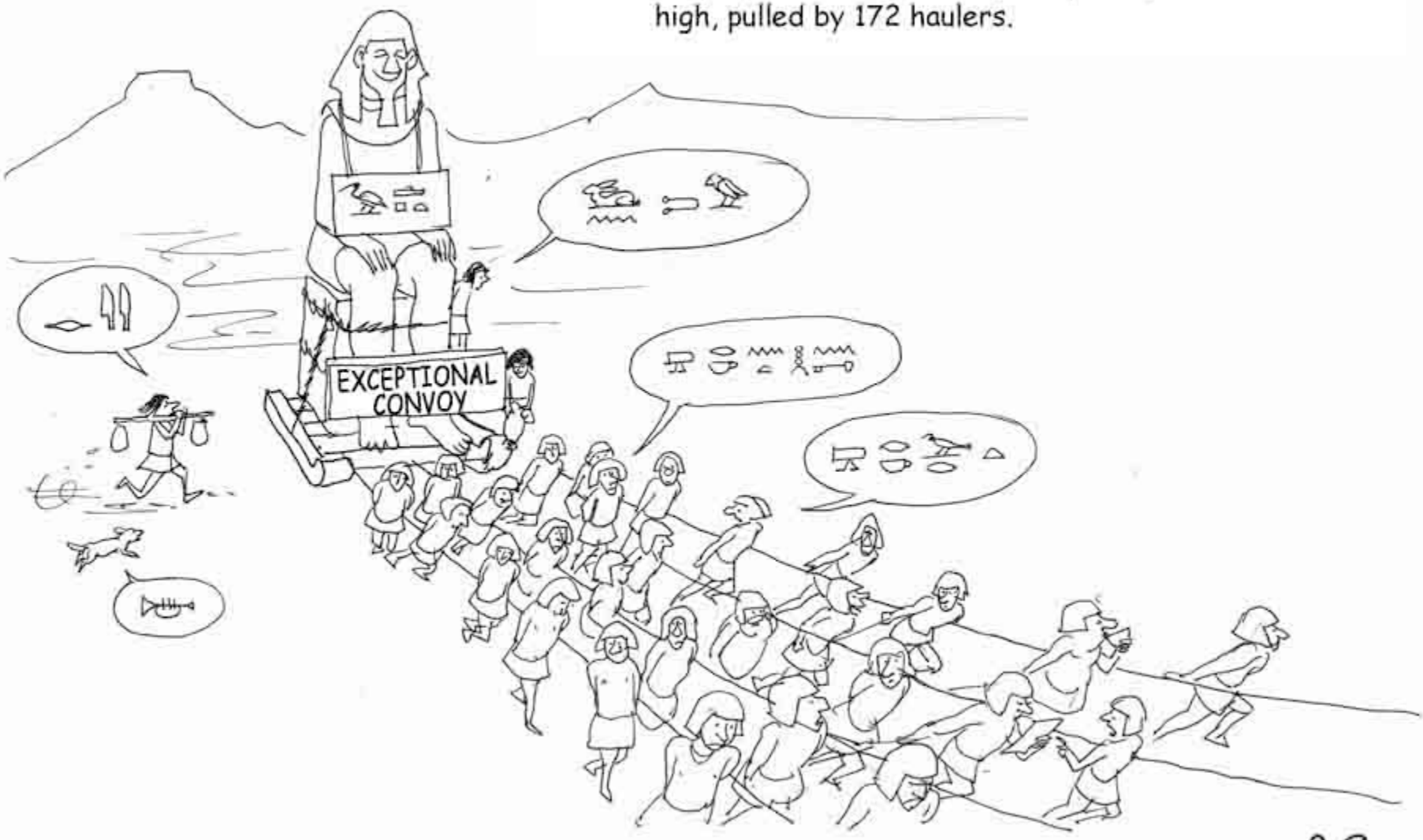
Everything was almost lost during these forty centuries that separate us from the old days. Without clues, our specialists baffled at the enormity, the monstrosity of what history gives to see, construct a paradigm, leaning on a consensus, based on the idea they have of what such people could know, and do not know at the time. All this based on an evolutionary scheme which excludes any recession, a real cult to progress. We then hear phrases like "the ancient Egyptians did not know the chemistry, nor the wheel or the pulley. They did not practice ocean navigation. They were poor mathematicians and poor surveyors. Otherwise they would have managed to leave us all this in writing".

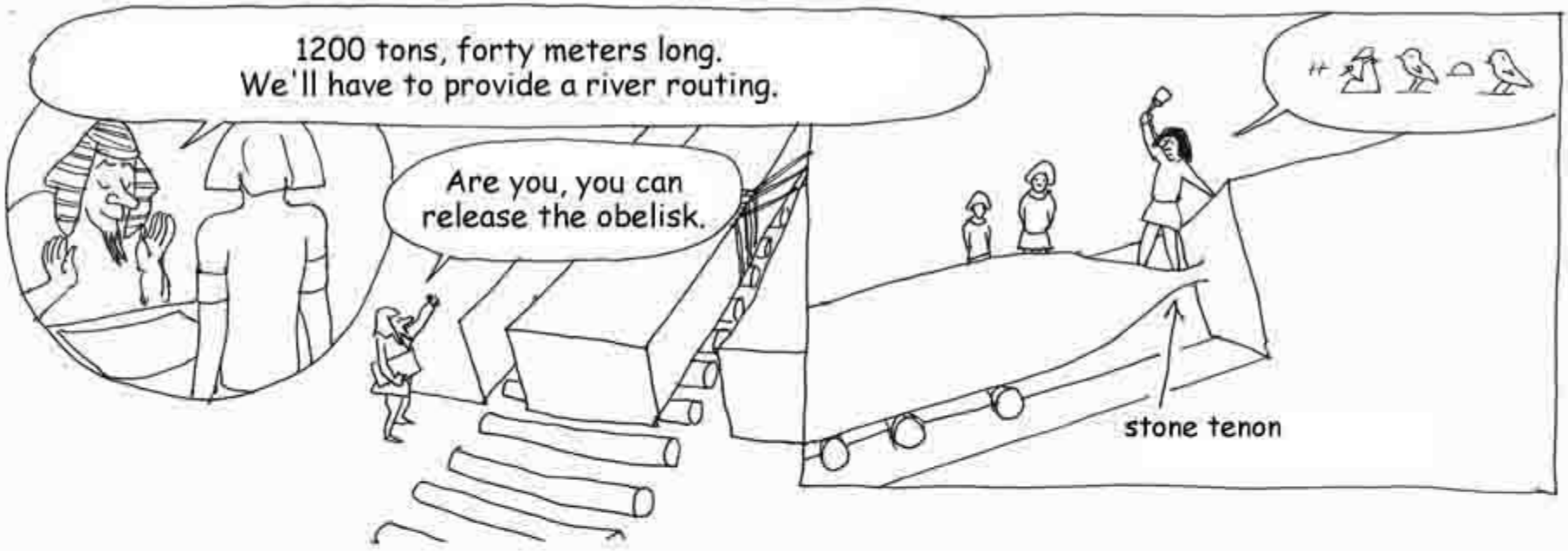
Of course...

METHODS OF TRANSPORTATION



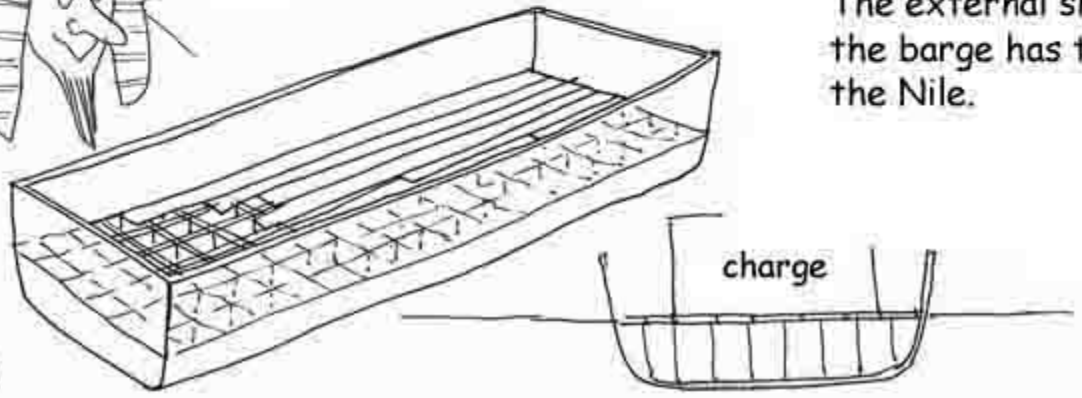
The statue of Djehudihotep (his name is on the sign, simple provincial governor) sixty tons, seven meters high, pulled by 172 haulers.



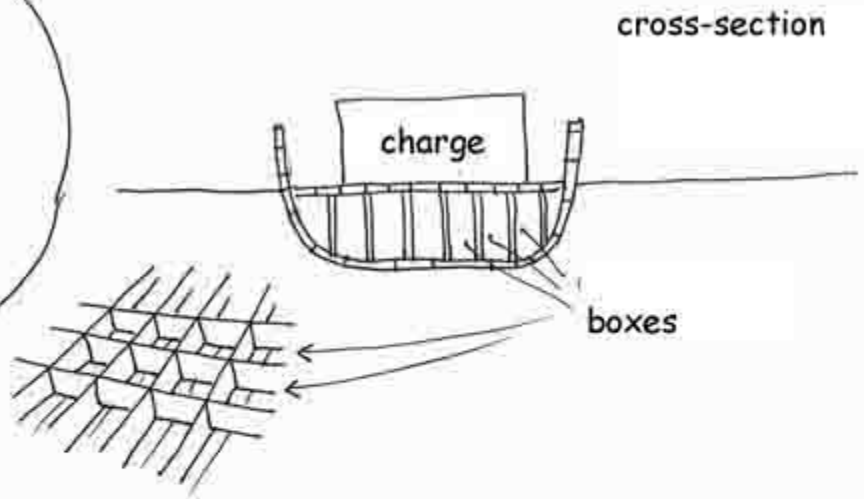


For these hyper-heavy transports we use barges specially designed for such loads.
They have a background in boxes, intended to better distribute the load.

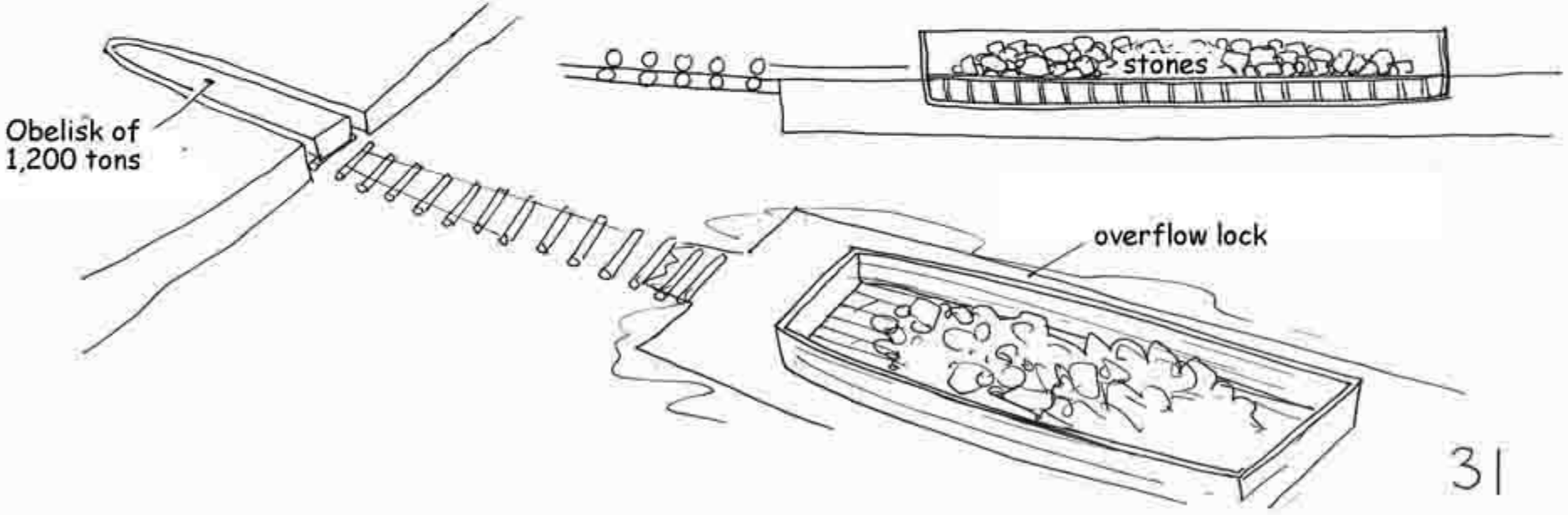
The external shape don't need to be hydrodynamic, the barge has to be hauled over a channel along the Nile.



(thanks to Thiéry Pierre for his remarks)

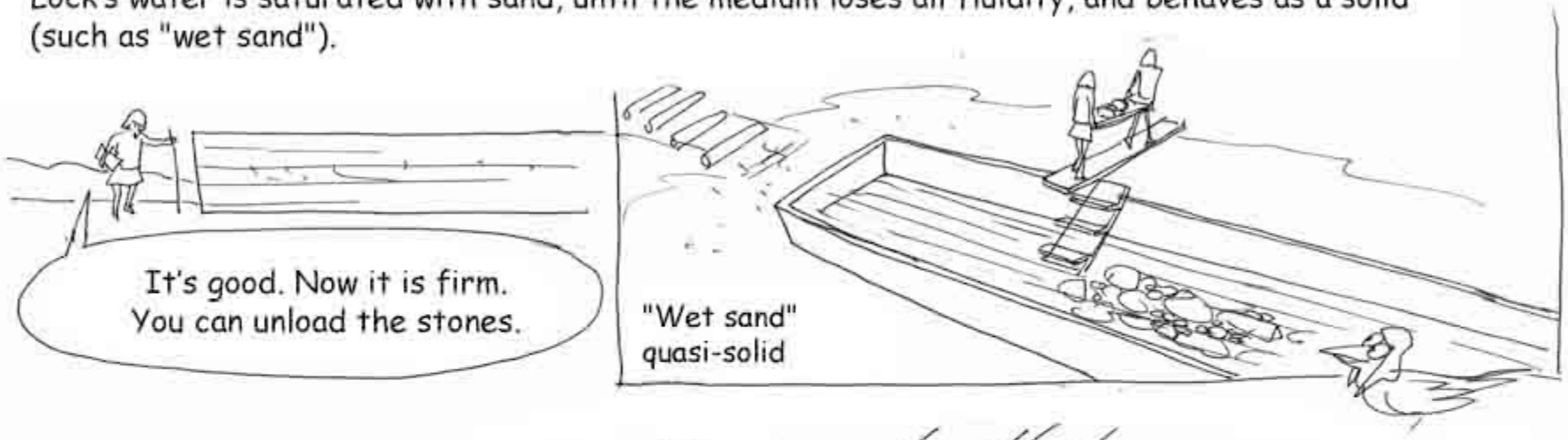


Then we brought the barge in an **OVERFLOW LOCK**, after loading it with an equivalent quantity of stones.

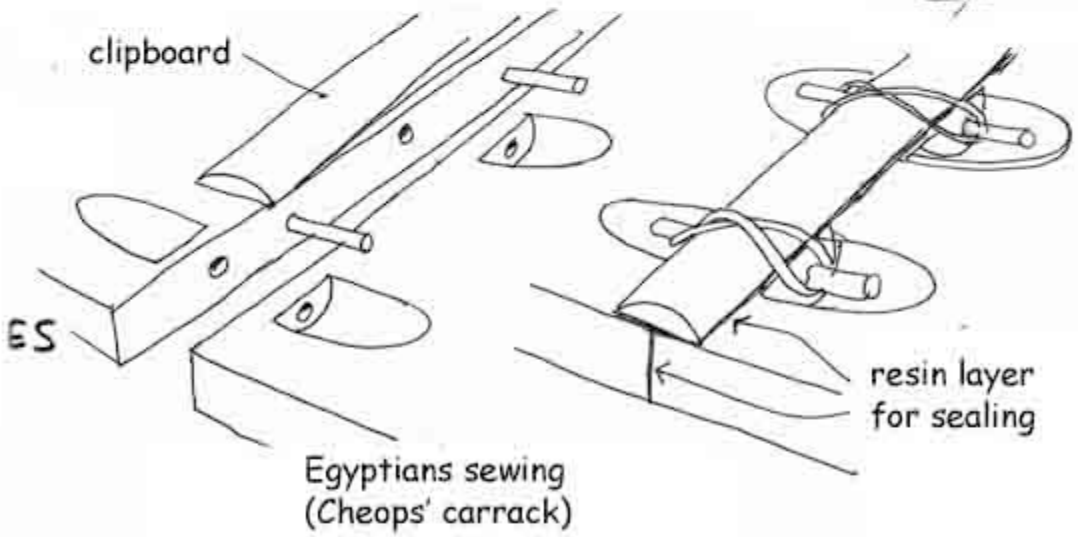


THE SAND LOCK

Lock's water is saturated with sand, until the medium loses all fluidity, and behaves as a solid (such as "wet sand").

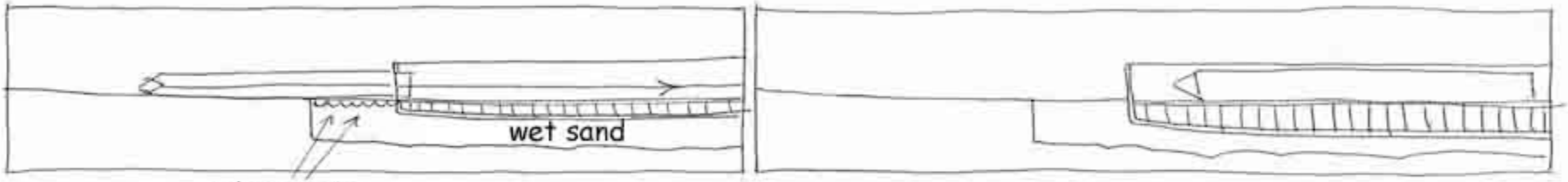


All Egyptian ships had hulls made of planks, whose elements were bound by ropes, so-called "SEWED HULLS".

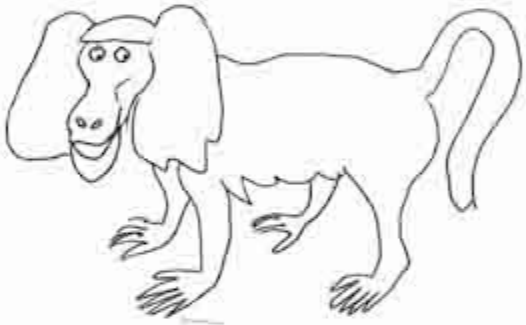


Egyptians sewing
(Cheops' carrack)

The sand lock allowed loading of the obelisk by rolling it, or sliding it on a wet clay bed to the floor of the barge



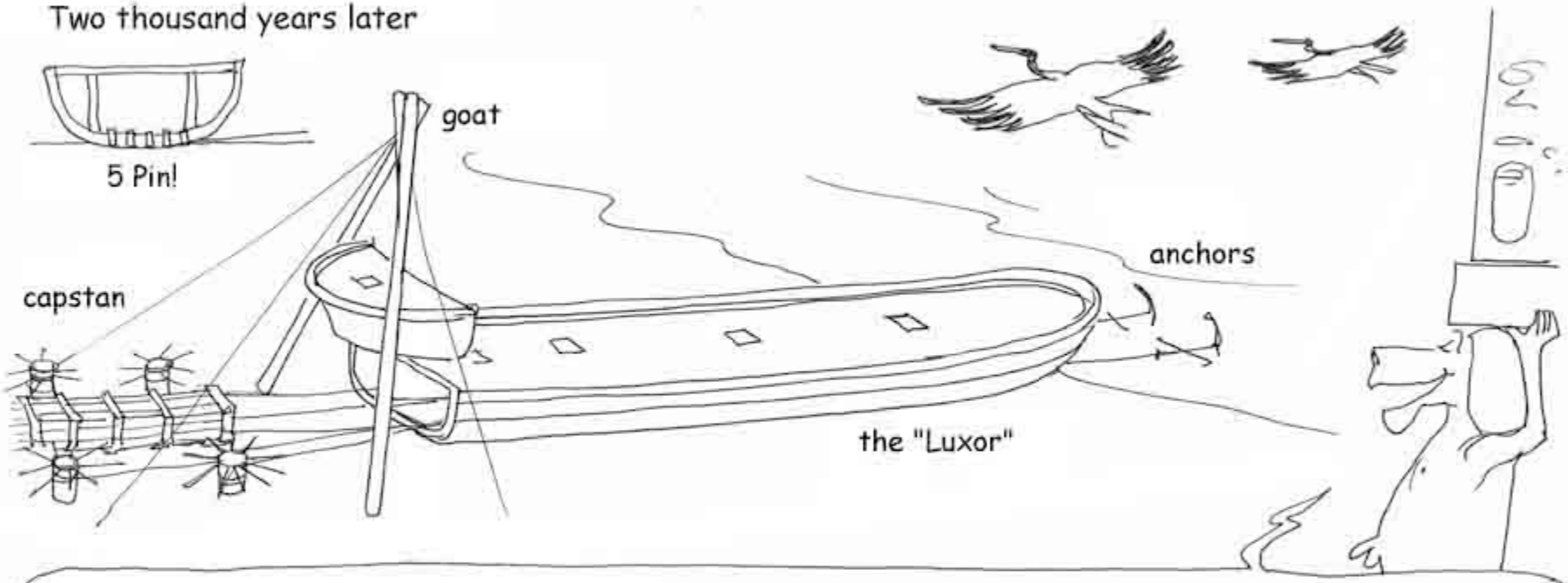
It only remained to "sew"
the front of the barge, then replace
the wet sand with water, so the barge can
float again, and then borrow the channel
and be routed to destination.



There unloading is performed
by using another sand lock and doing
the operations in reverse order.

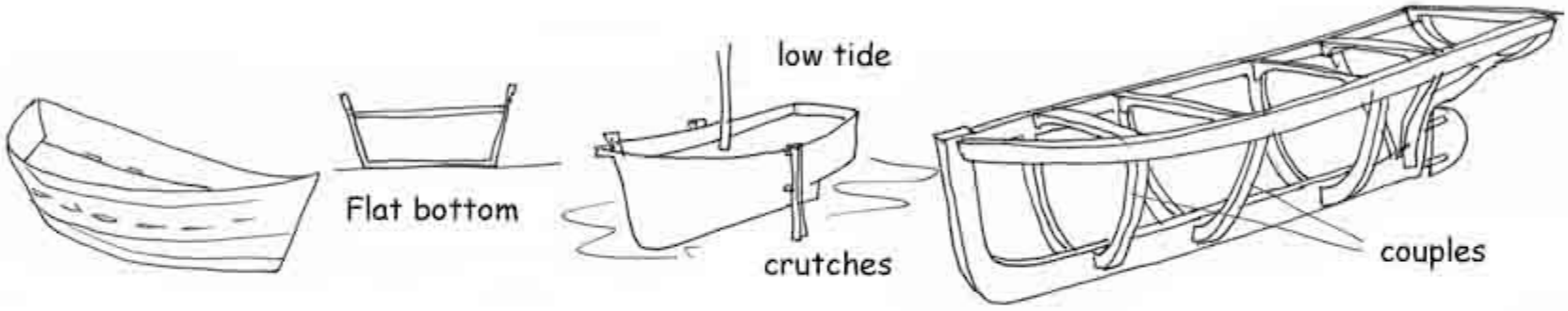
All this being big trick strength and magic.

1830:
Two thousand years later



The French, for the transportation of the obelisk of 23 meters and 230 tons,
which was installed Place de la Concorde, used a flat-bottomed boat, specially designed for this purpose
(five pins) with a removable front. Initially this obelisk was resting on a square base decorated
with four times four baboons, standing on their hind legs. As their sexes were apparent,
another carrier was carved in pink granite

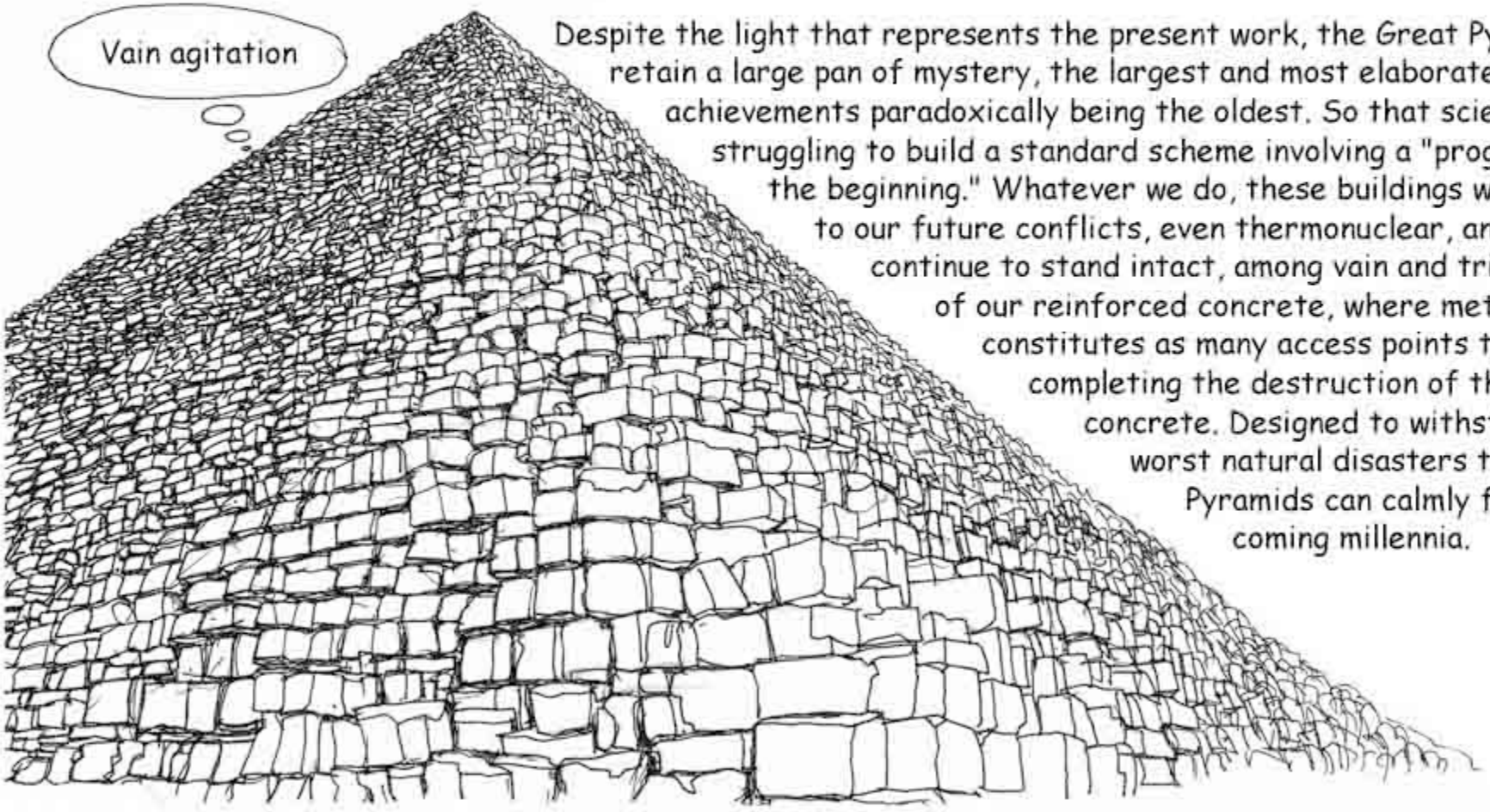
Historians have documented that this mode of loading and unloading was used in ancient Egypt. Furthermore this technique of sewed hulls allowed the transport of units, completely disjointed, from Nile to the Red Sea, where we found in several units stored in caves (*). A 43 meters long vessel was discovered in 1954 as detached and numbered parts, in a pit close to the pyramid of Cheops (**). This possibility of quick detachment excludes an assembly by ankles. Combining economy of wood, lightness and strength, this technique had to be abandoned when the ship had to face the tidal phenomenon, typical of the northern seas.



Which involved the phenomenon of **GROUNDING**.

Besides, access to large wood resources, from various essences, allowed the end of **WORKING COATING HULL** in favor of a hull-keel assembly with **HATCHES** for loading and unloading cargo.

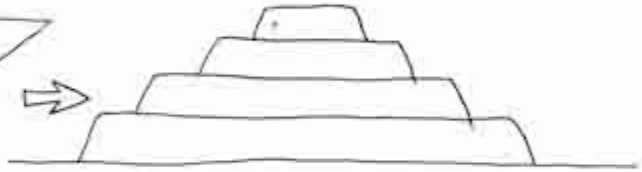
RAMPS AND MACHINES OF ALL KINDS



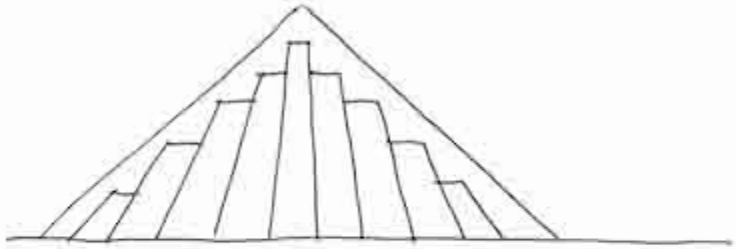
Despite the light that represents the present work, the Great Pyramids retain a large pan of mystery, the largest and most elaborate achievements paradoxically being the oldest. So that scientists are struggling to build a standard scheme involving a "progress from the beginning." Whatever we do, these buildings will survive to our future conflicts, even thermonuclear, and will continue to stand intact, among vain and trivial debris of our reinforced concrete, where metal constitutes as many access points to rust, completing the destruction of the concrete. Designed to withstand the worst natural disasters the Great Pyramids can calmly face the coming millennia.

About the internal structure we are faced with two ways of thinking. If the pyramids are an extension of graves that are **MASTABAS**, then some might see them as successive stacks of them. In contrast, in 1930, the German Egyptologist Borchardt considered a juxtaposition of stone layers, on slopes, supported one under each other. But this would have meant, for the pyramid of Cheops, two million and a half blocks.

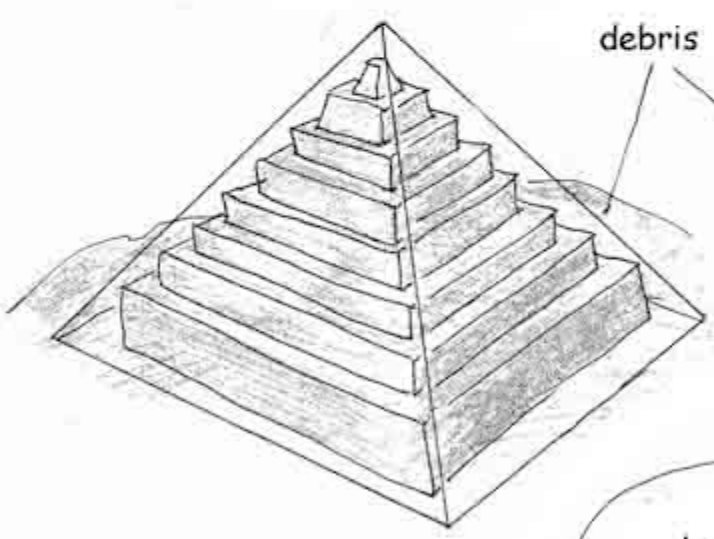
underground grave with Mastaba.

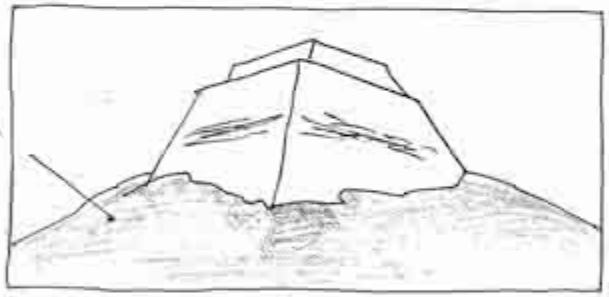


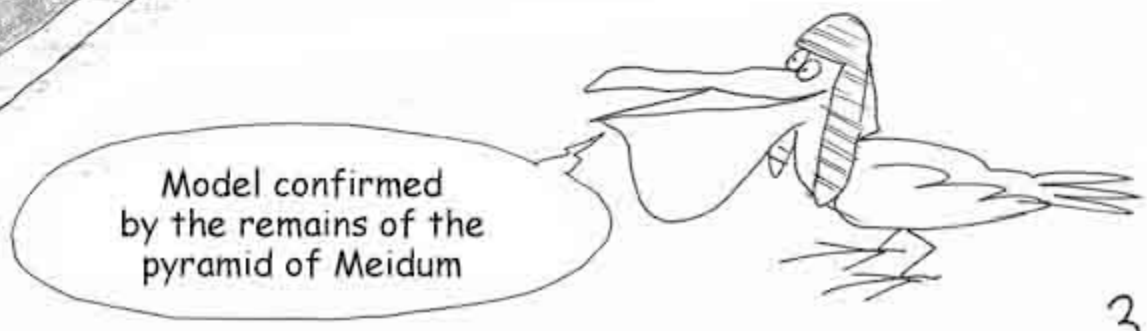
Djozer pyramid at Sakkara: classical interpretation



Borchardt model with "accretion".

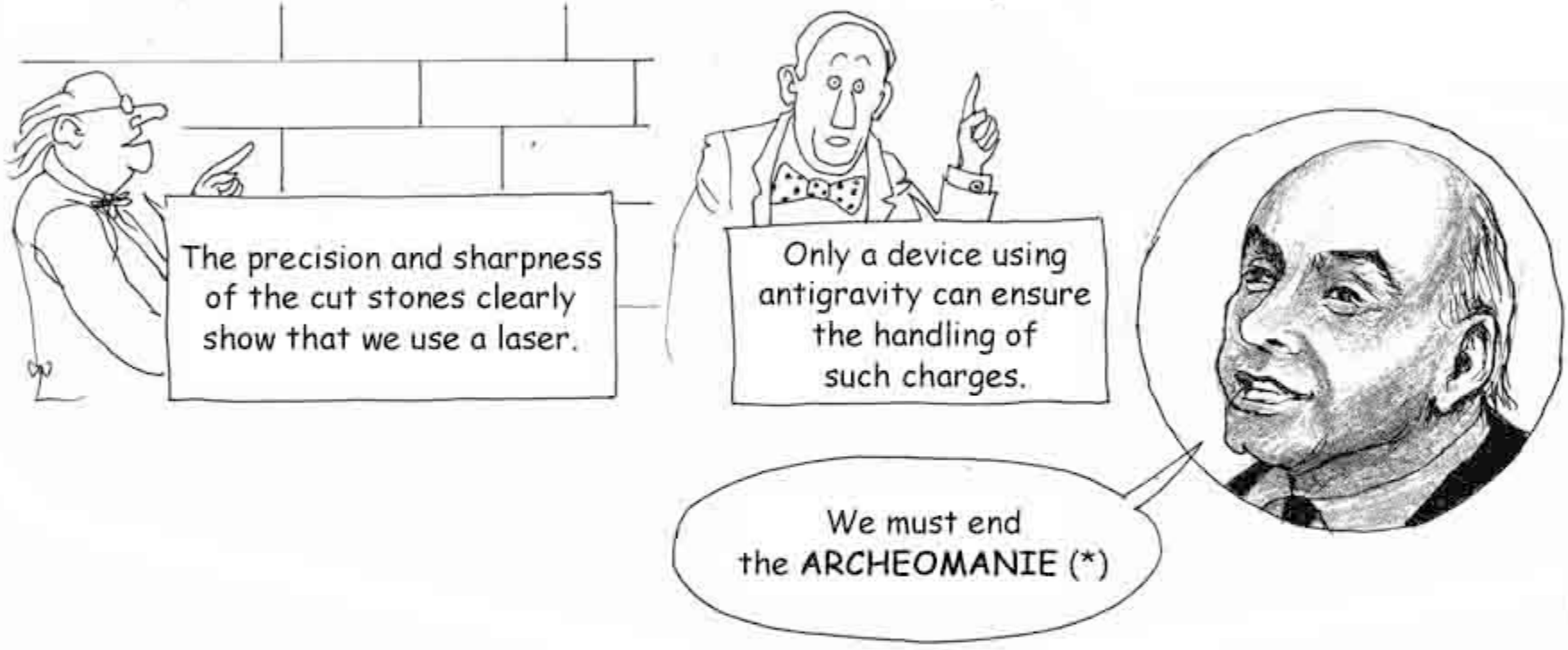






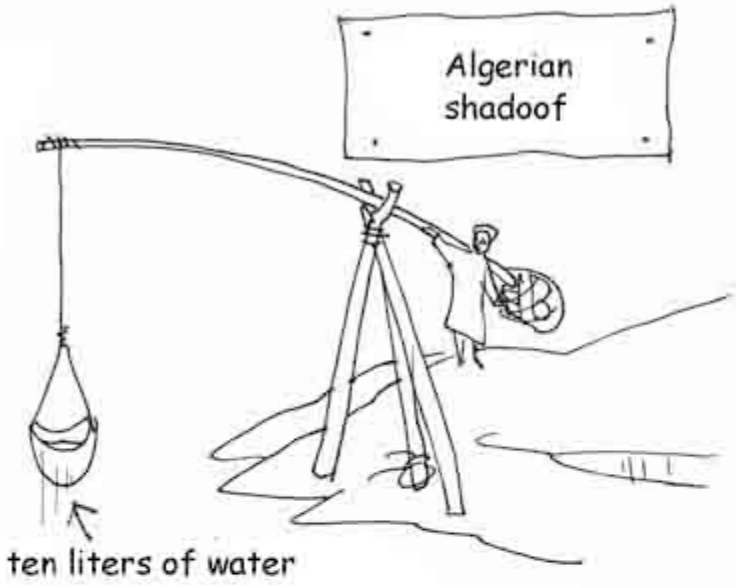
Given the difficulty to reconstruct the techniques that allowed building the pyramids, we have seen emerging sententious theories involving external aid.

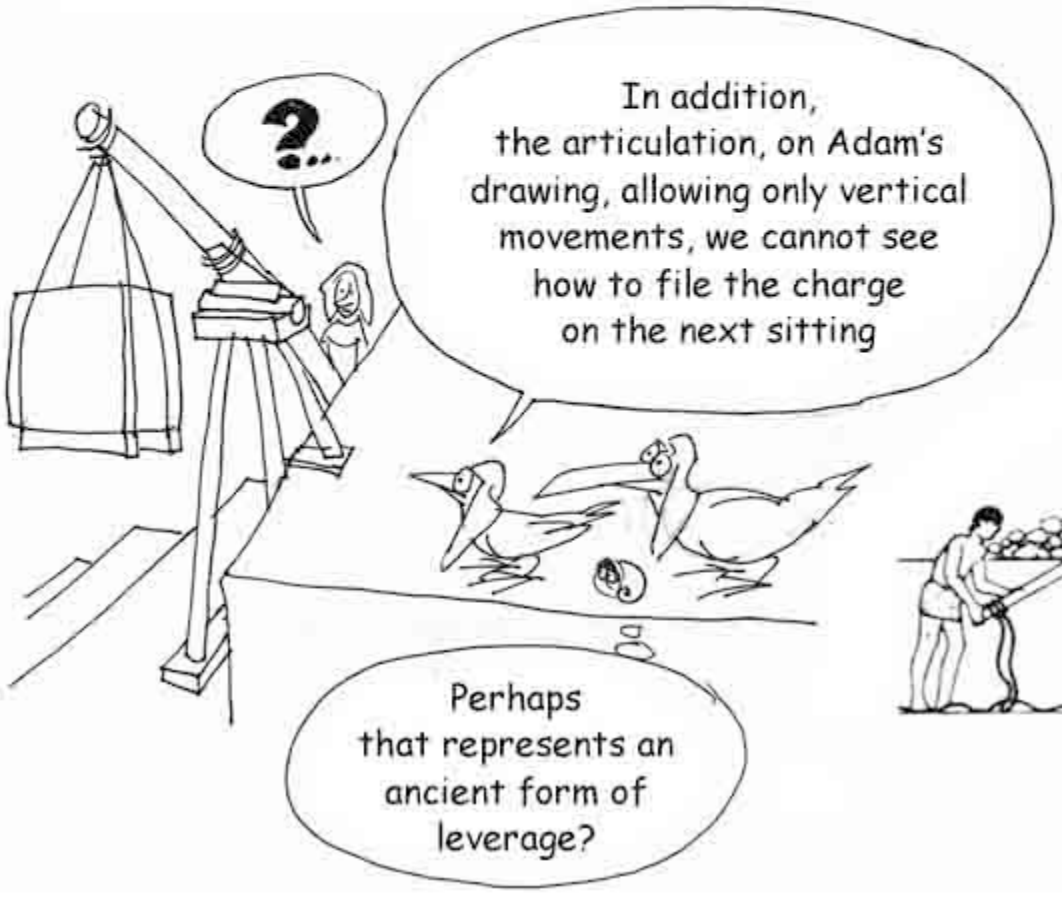
In France, since 1975, the architect **JEAN-PIERRE ADAM**, ubiquitous on all media, fights vigorously any theory that does not come from the Egyptologists community.

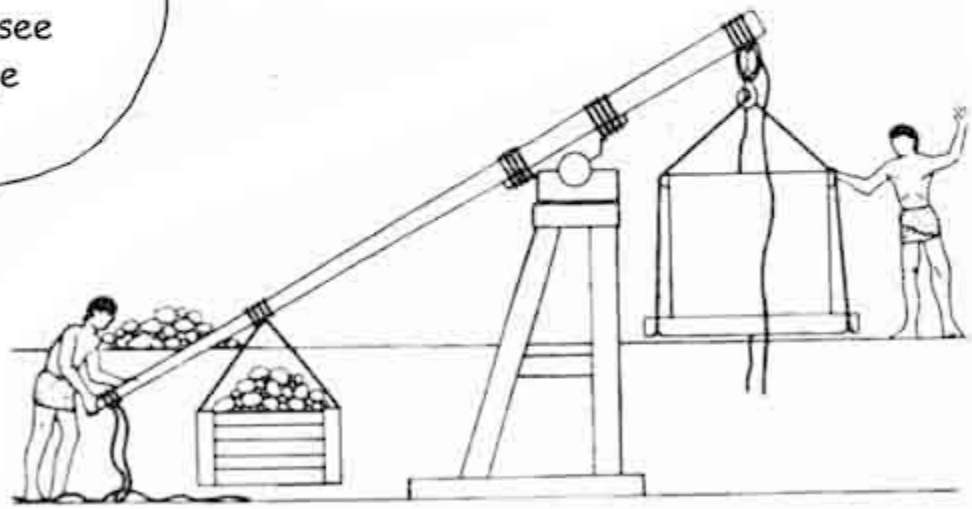


(*) Director of Ancient Architecture Bureau in Paris, 1972-2003. Author of the book "Archaeology face imposture", Editions Laffont, 1975.

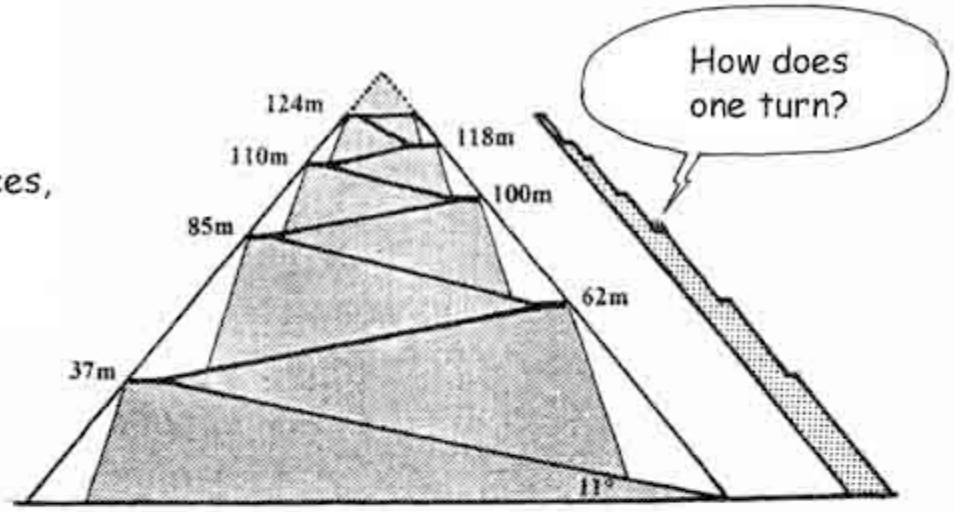
Adam begins to join the **MACHINISTES CLUB**, by proposing to raise the stones with a model derived from the oriental **SHADOOF**. This drawing, from his book, is physically absurd, the ratio of the **LEVER ARMS** is 1.6: to lift a block of 2.5 ton, we should use a stone load of 2500/1.6 = 1562 kilos, which is clearly not the case.

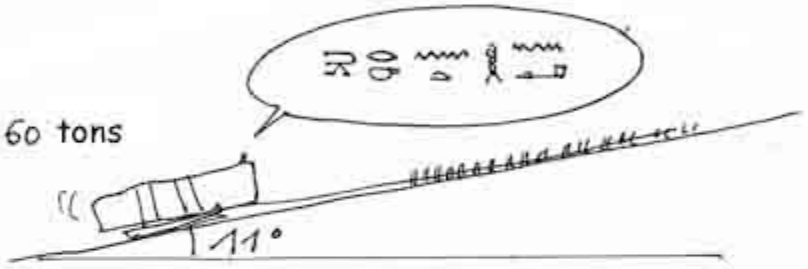


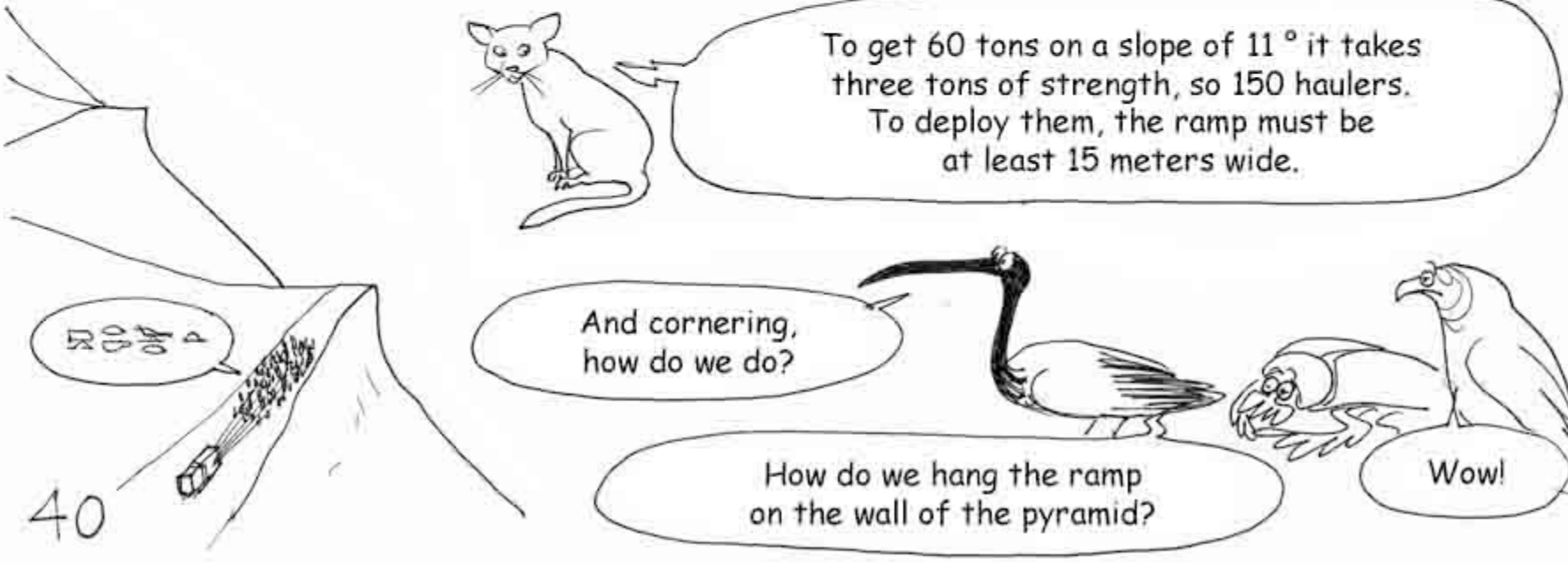


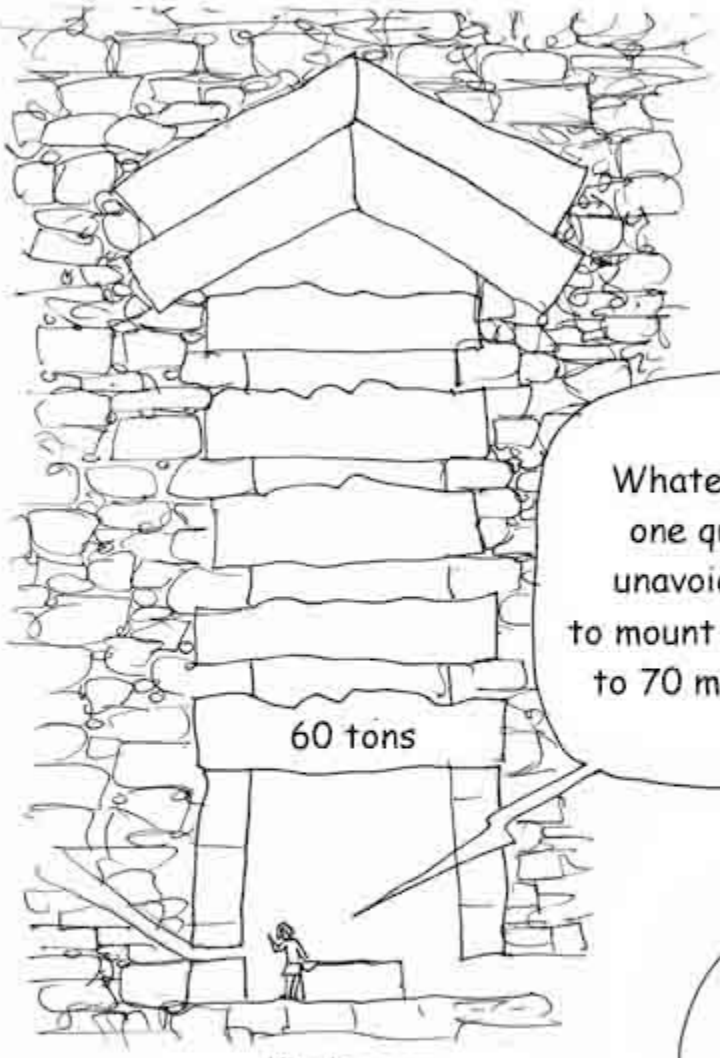


Always relying on his imagination,
and what he considers his GOOD SENSE,
Adam becomes **RAMPISTE**.
He opts for a **contiguous ramp** on one of its faces,
with a **slope of 11 °**.





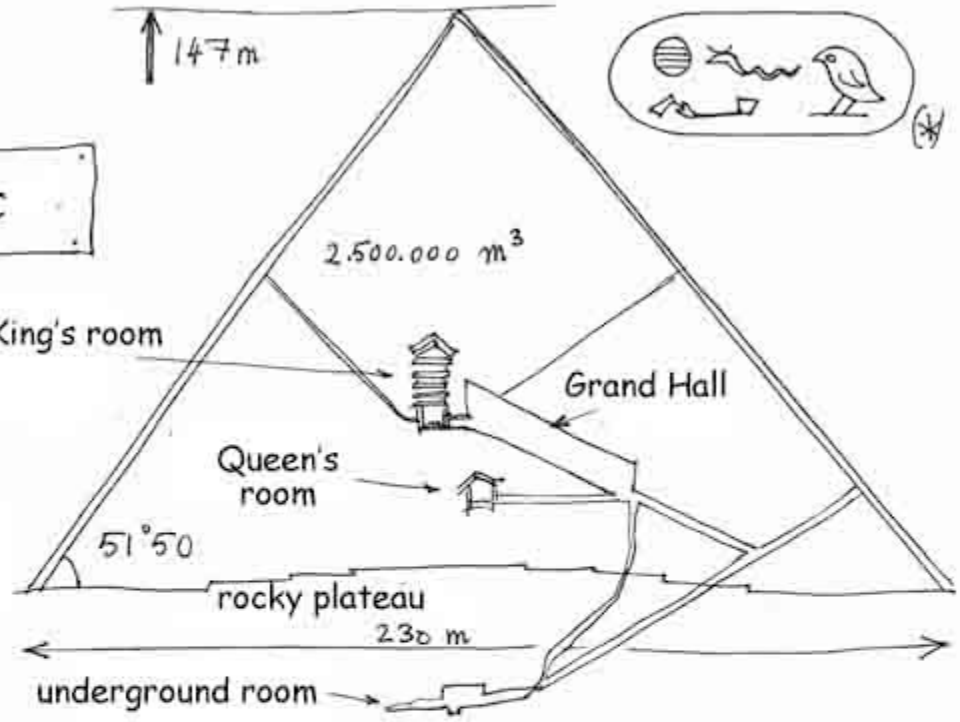




King's room,
Cheops' Pyramid

2560 BC

Whatever we do, one question is unavoidable: how to mount these blocks to 70 meters high?

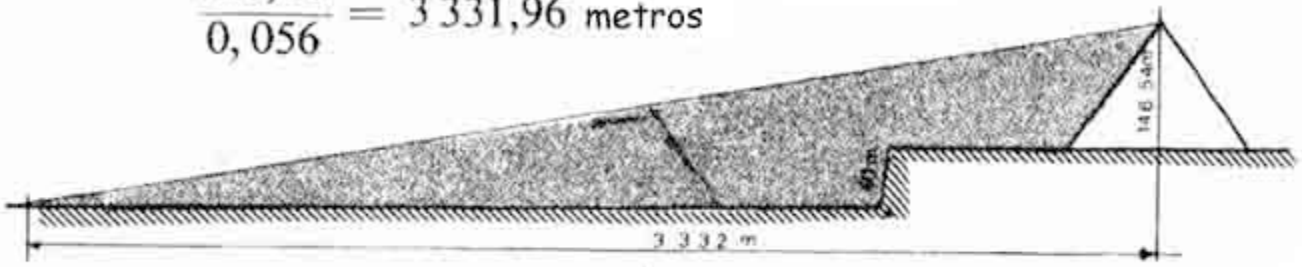


(*)

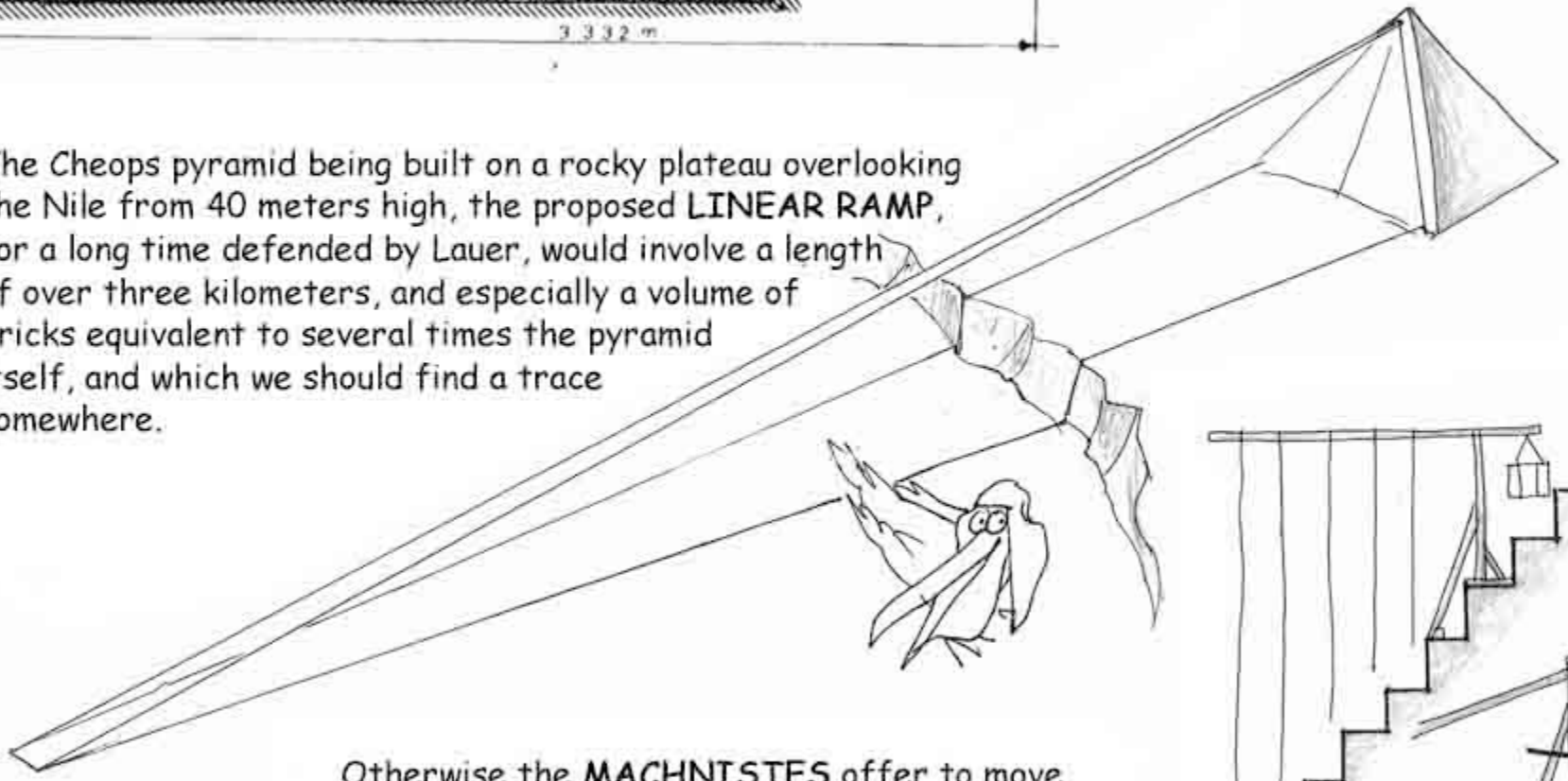
The first idea was a linear ramp in mud bricks, armed with wood beams.

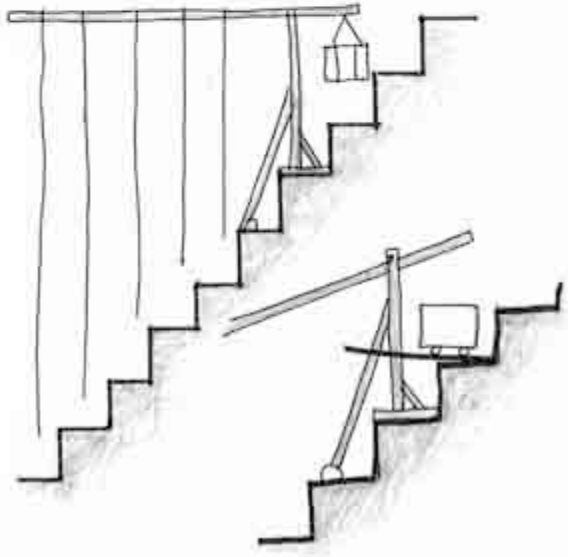
(*) Pronounced "Koufou" (Cheops)

$$\frac{186,59}{0,056} = 3\,331,96 \text{ metros}$$

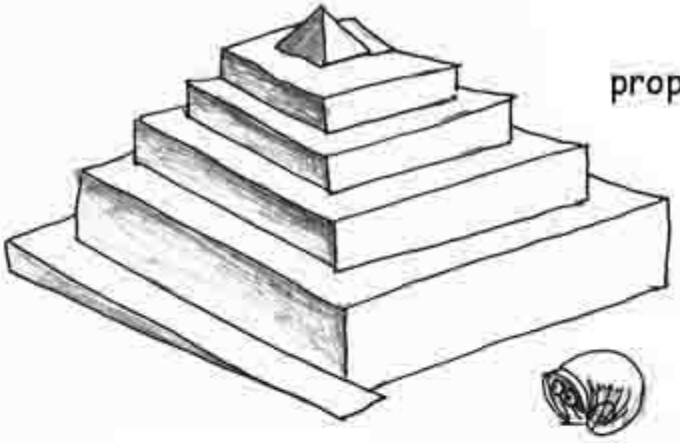


The Cheops pyramid being built on a rocky plateau overlooking the Nile from 40 meters high, the proposed **LINEAR RAMP**, for a long time defended by Lauer, would involve a length of over three kilometers, and especially a volume of bricks equivalent to several times the pyramid itself, and which we should find a trace somewhere.

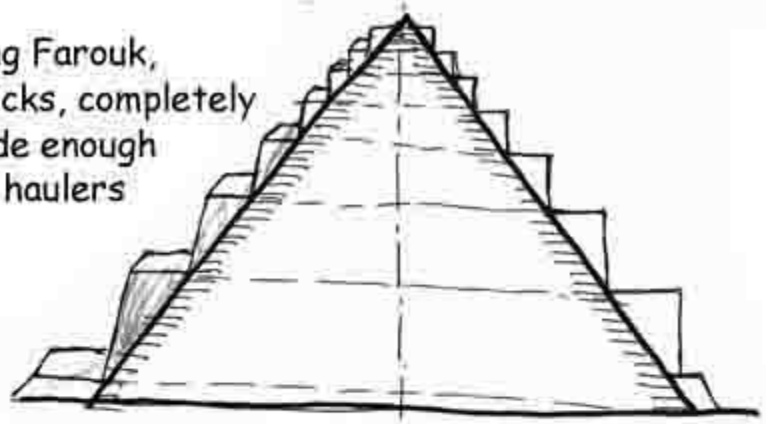




Otherwise the **MACHNISTES** offer to move to a **MULTI-SHADOOF** system where the beam is always working in **BENDING**.

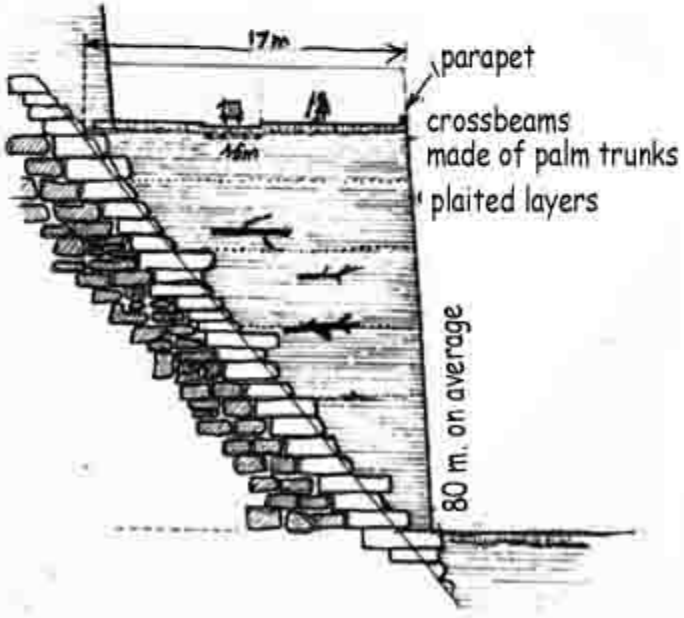


Georges Goyon,
official Egyptologist of King Farouk,
propose a helical ramp in mud bricks, completely
enveloping the pyramid, wide enough
(15 meters) to allow 200 haulers
to move.



But the mechanical strength of such a ramp attached to the reliefs of the cover stone, is problematic.

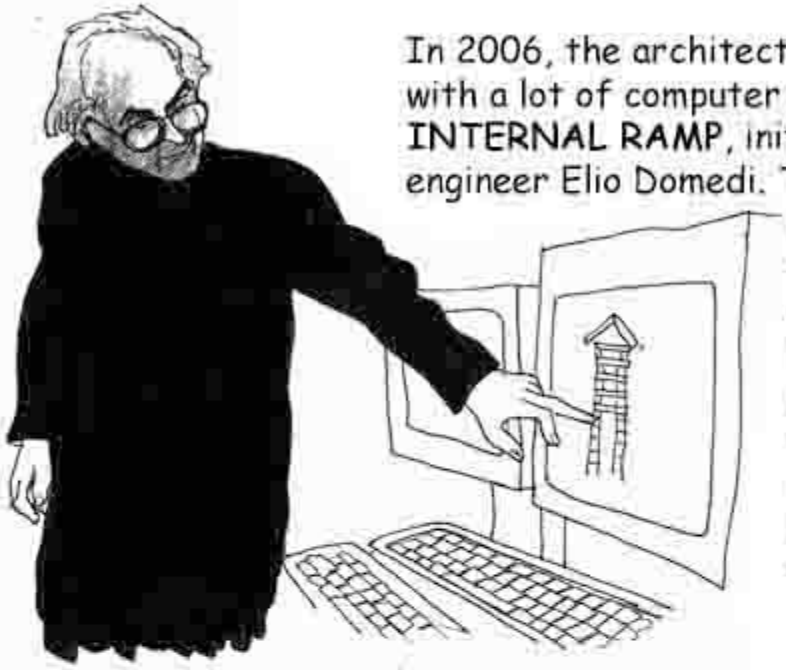
Another disadvantage: we lose contact with the surface of the pyramid.



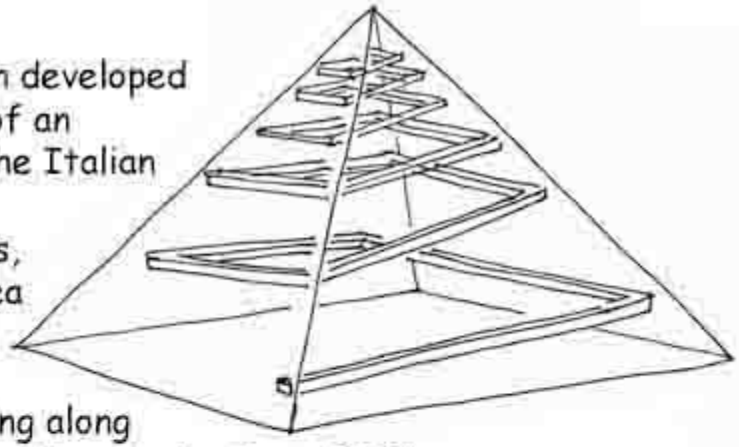
Georges Goyon, CNRS
1905 - 1996

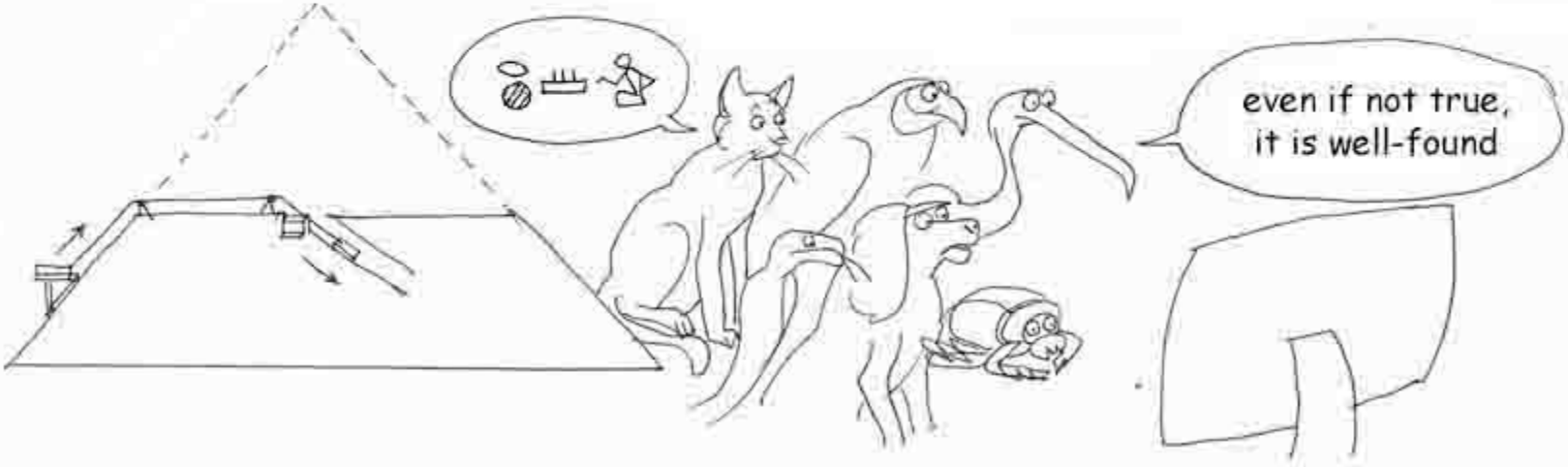
The erection of the pyramid involves at any time centimeter-tracking of all its components, which implies access to its axis, with a plumb line in a central well.

(*) "Le secret des bâtisseurs des Grandes Pyramides-Kheops", reissued in 1997. Editions Pygmalion, France

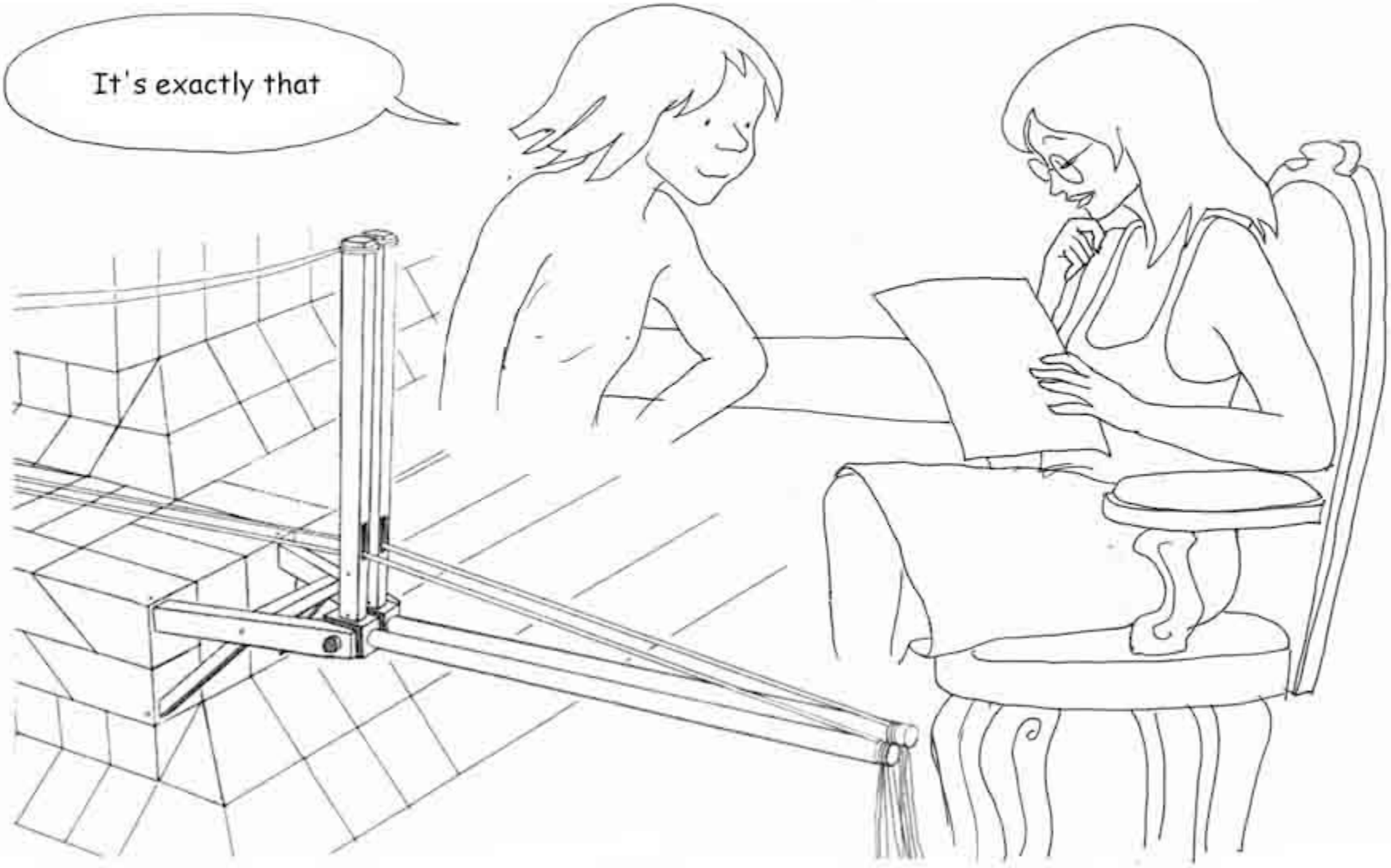


In 2006, the architect Jean-Pierre Houdin developed with a lot of computer graphics, the idea of an **INTERNAL RAMP**, initially proposed by the Italian engineer Elio Domedi. To ensure the rise of very large blocks, following up the idea of Pierre Crozat, Houdin uses a counterweight sliding along the Grand Gallery, with an inclination of 50°. So a forklift, using a counterweight operating in the Grand Hall, would have allowed this ancestor of the funicular to run.





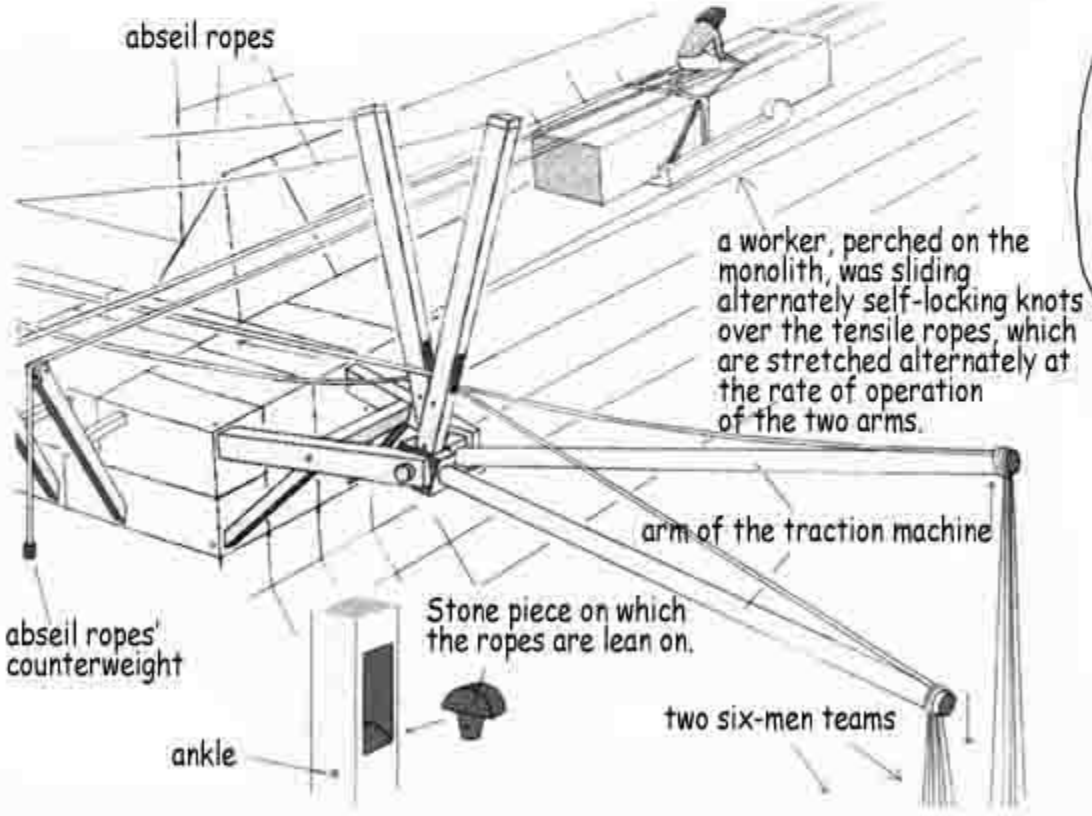
VISION OF ANSELME (*)



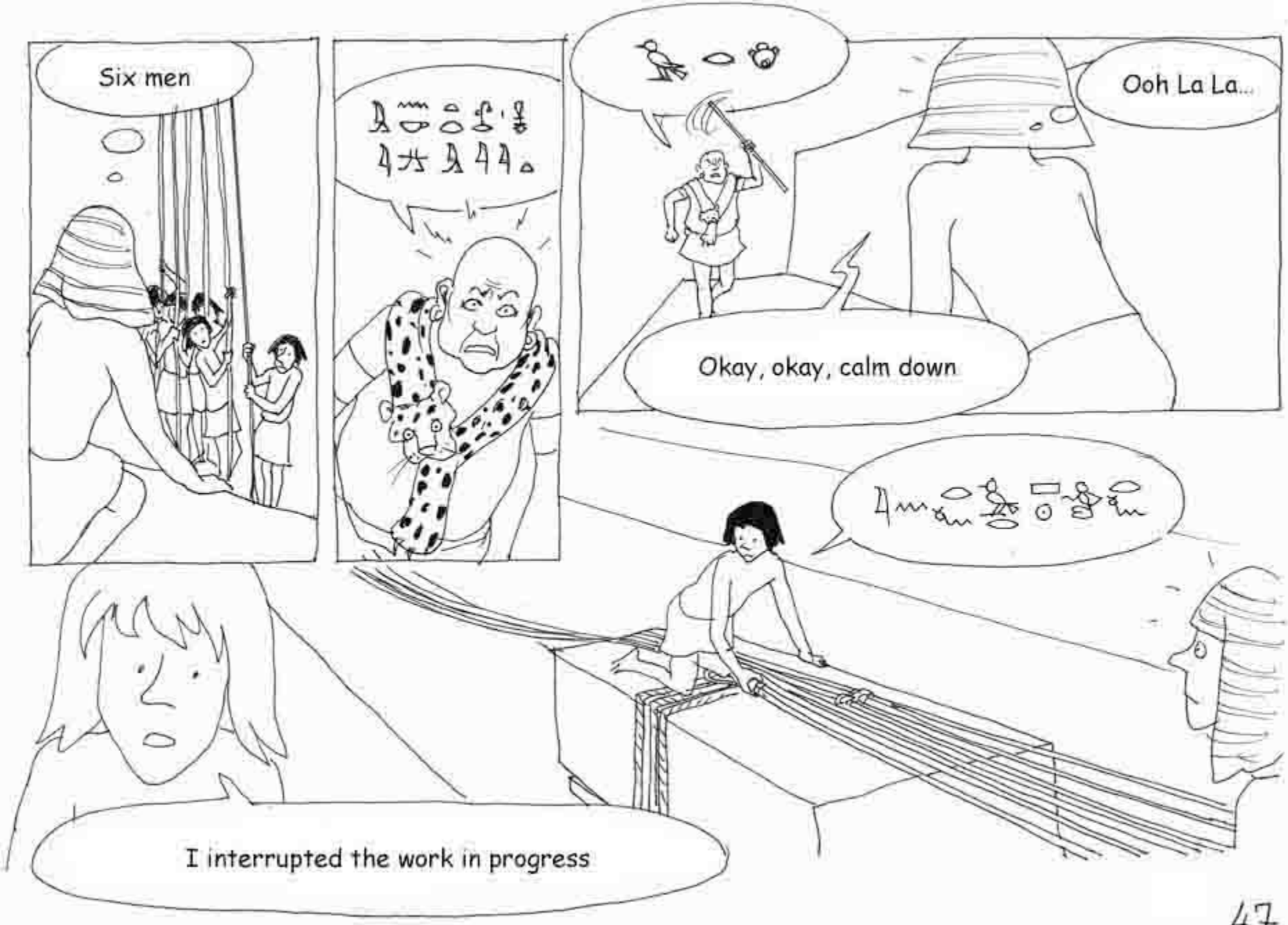
(*) See video http://www.jp-petit.org /VIDEOS/pyramide_montage.mov

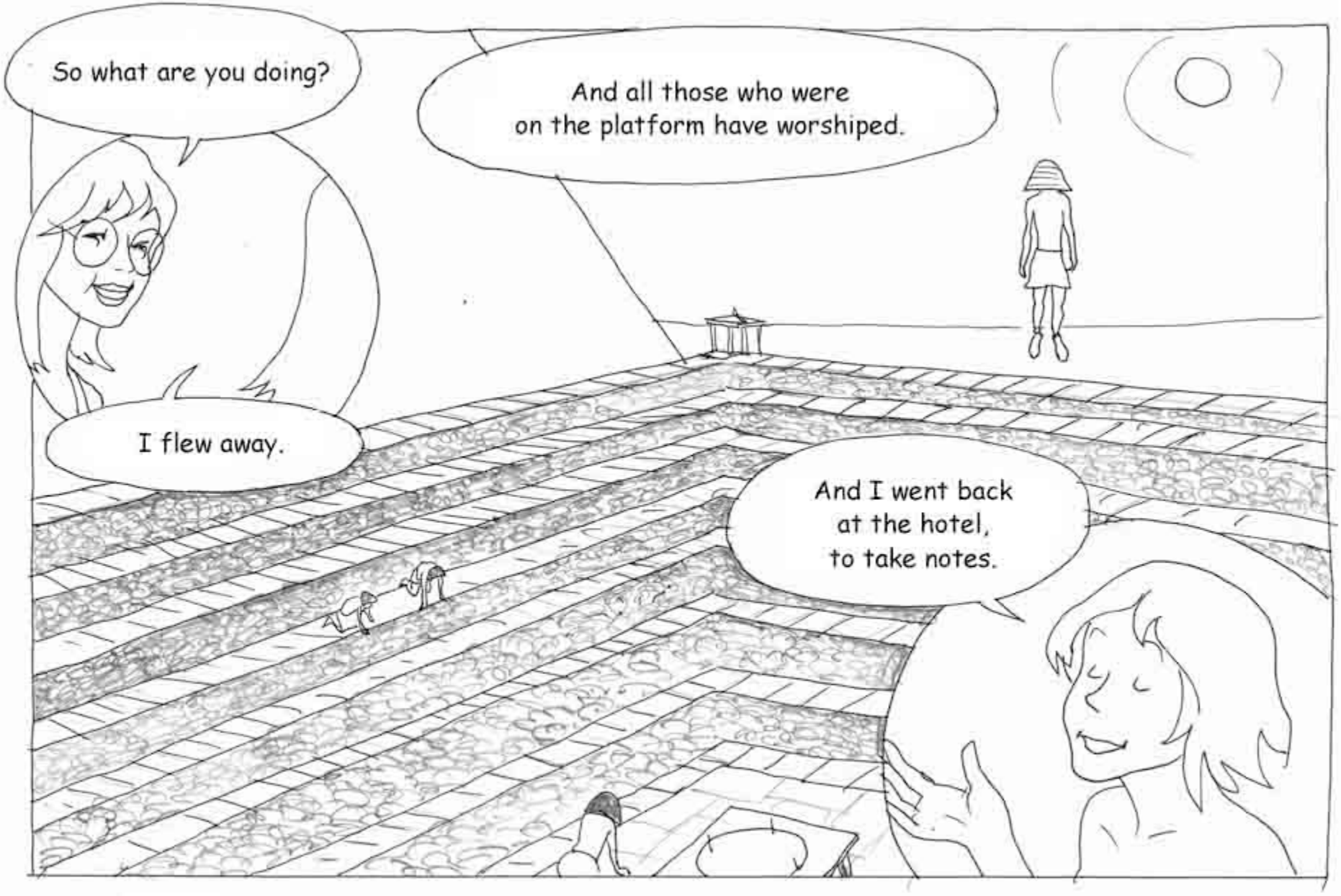
I saw two arms going up and down.

What was moving them?



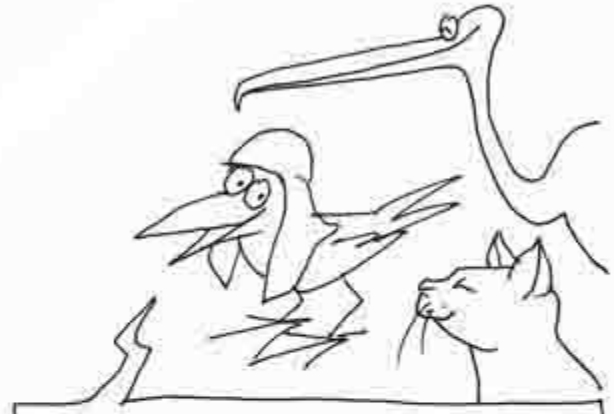
I climbed the ramp to see and that's when I had trouble with this guy with a shaved head, wearing a panther skin.


Six men
Ooh La La...
Okay, okay, calm down
I interrupted the work in progress

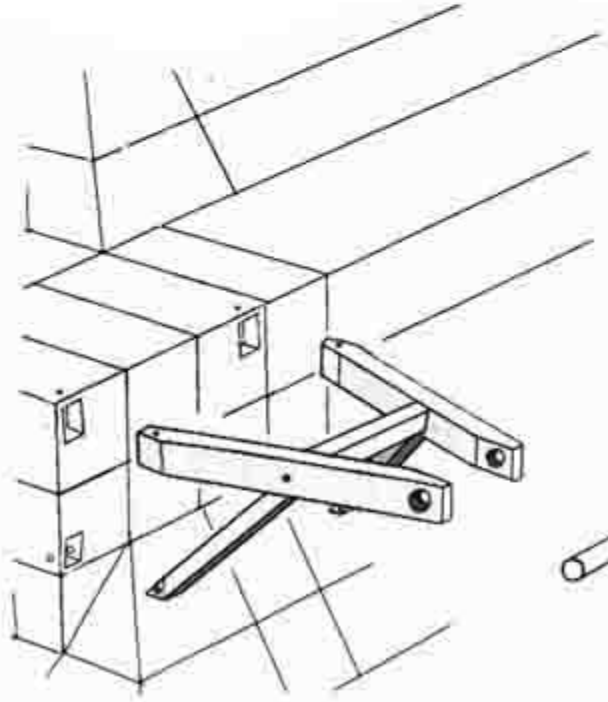

So what are you doing?
I flew away.
And all those who were
on the platform have worshiped.
And I went back
at the hotel,
to take notes.

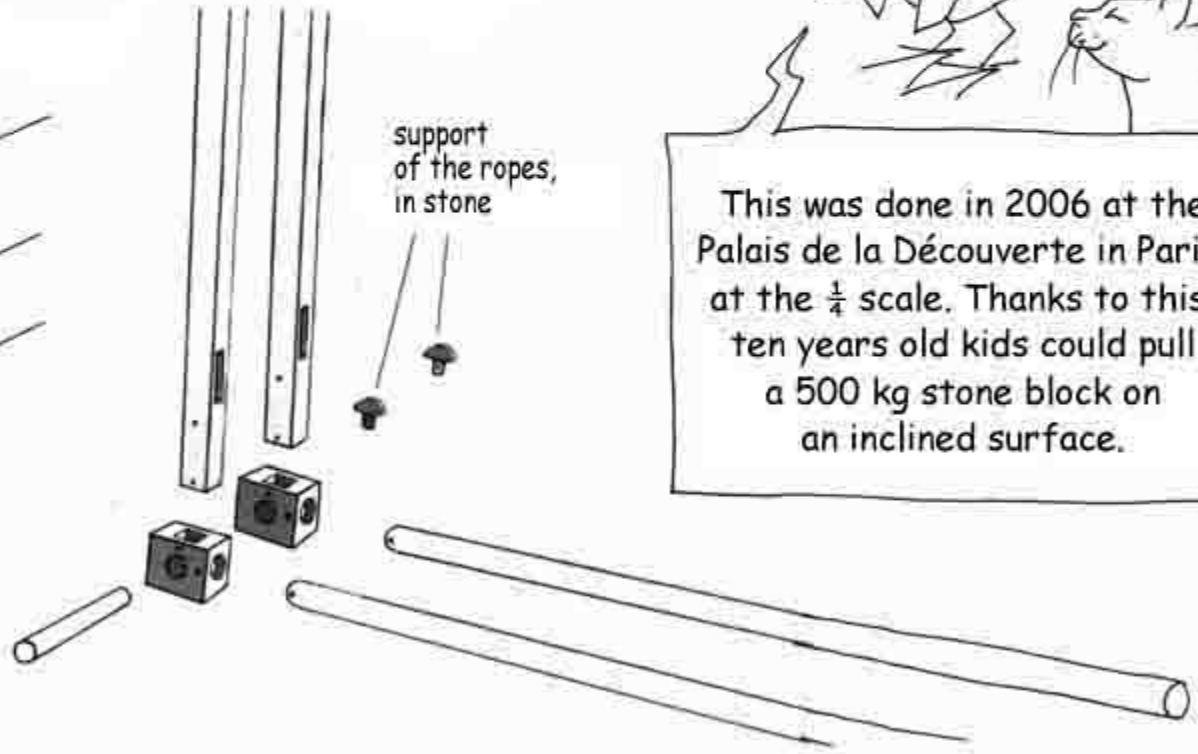
This machine, could you describe it entirely?

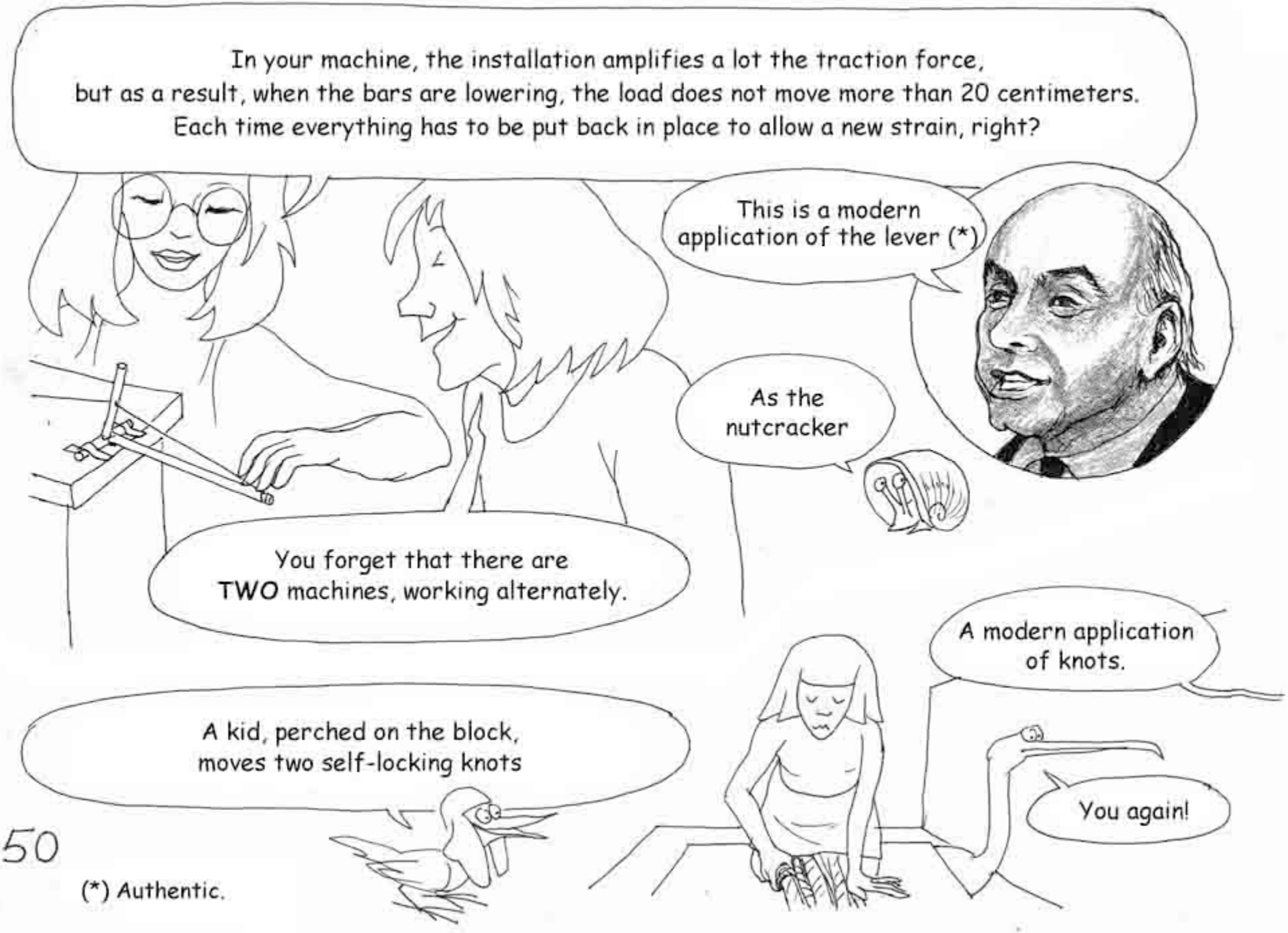
Even rebuild it!



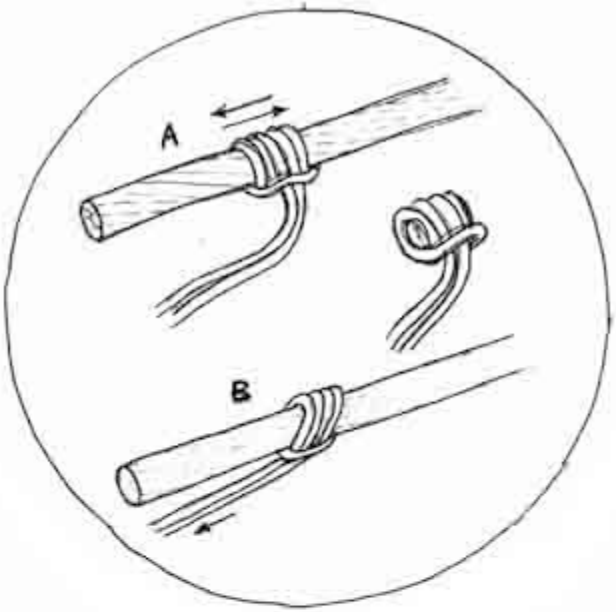
This was done in 2006 at the Palais de la Découverte in Paris, at the $\frac{1}{4}$ scale. Thanks to this, ten years old kids could pull a 500 kg stone block on an inclined surface.






In your machine, the installation amplifies a lot the traction force,
but as a result, when the bars are lowering, the load does not move more than 20 centimeters.
Each time everything has to be put back in place to allow a new strain, right?
This is a modern application of the lever (*)
As the nutcracker
You forget that there are TWO machines, working alternately.
A modern application of knots.
A kid, perched on the block, moves two self-locking knots
You again!

(*) Authentic.



You can try
with a broom handle and a string,
it works very well

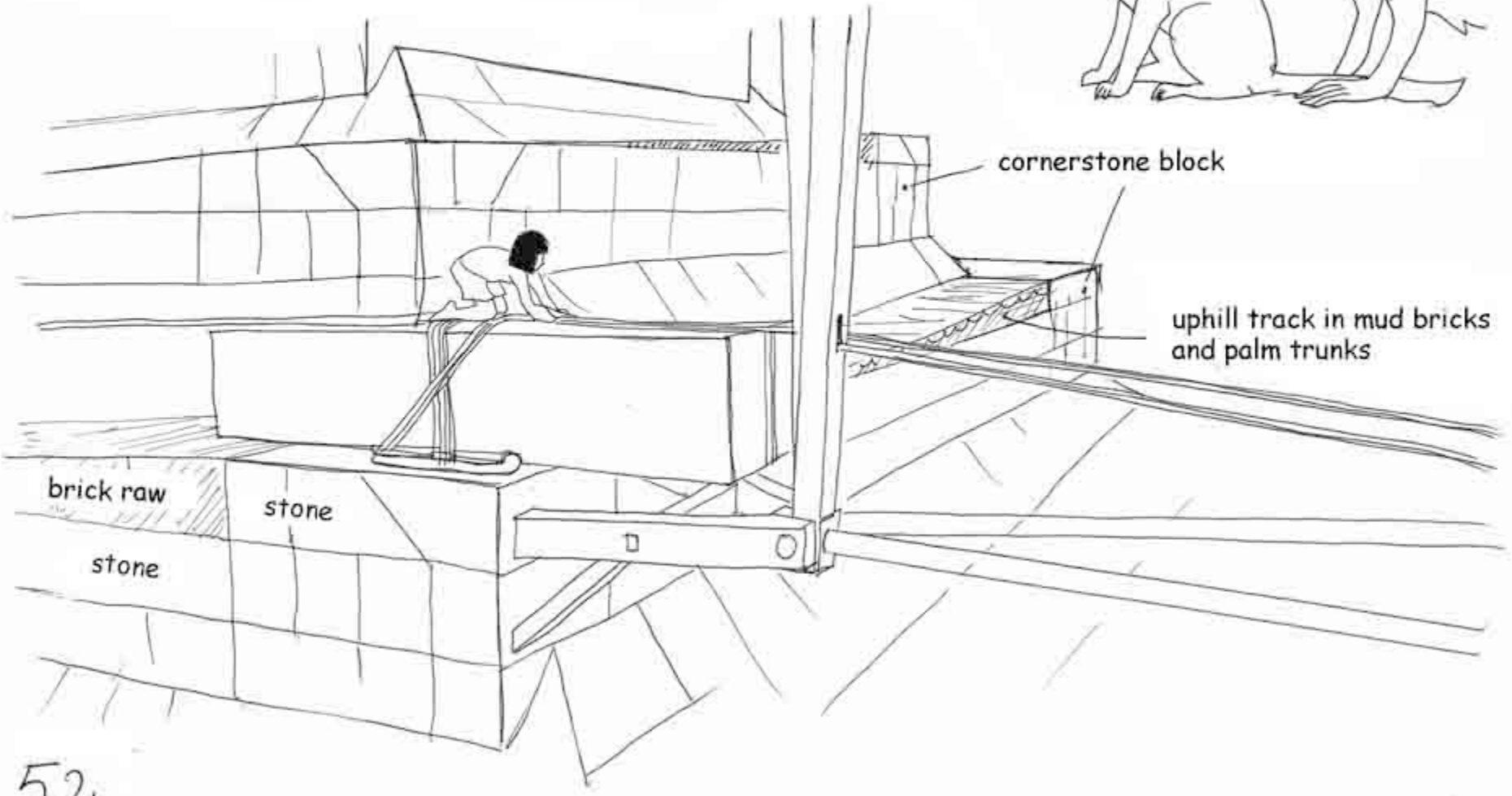
The block went up
rather quickly,
without a pause

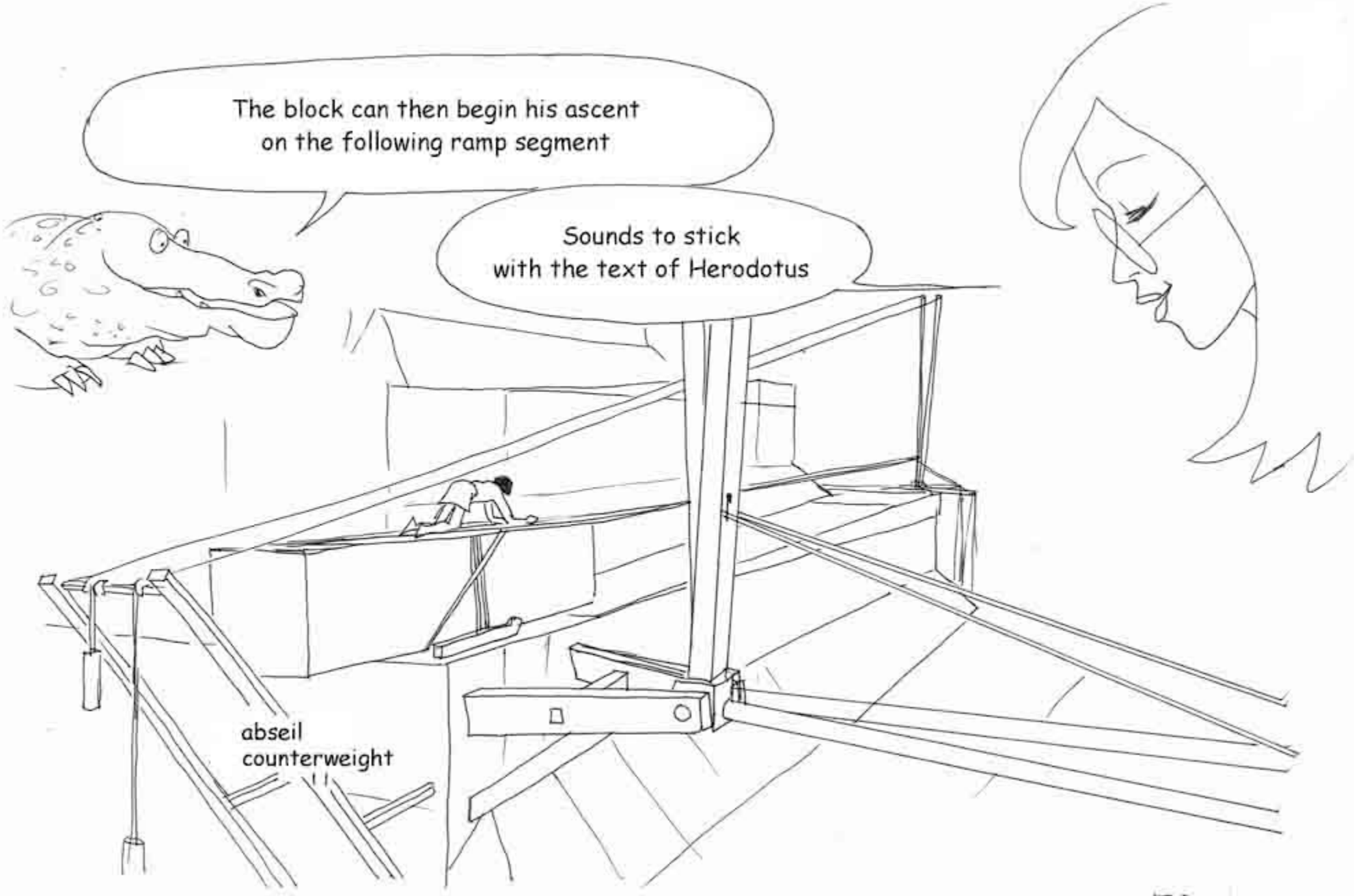
Yes, but how
things go, when you arrive
at the corner?

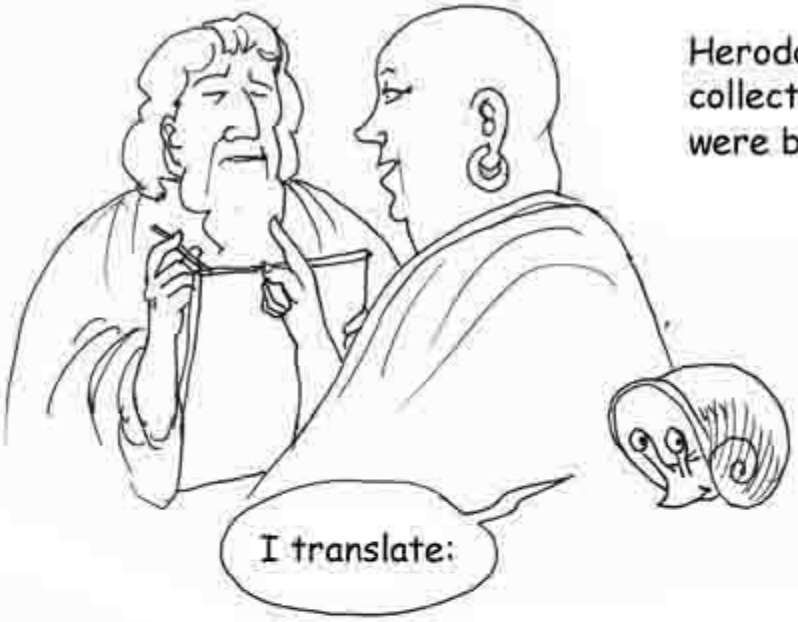
No problem

The Goyon ramp was in mud bricks.
This is stone

When the block reaches the angle,
it is positioned on a horizontal stone platform,
made slippery by wet silt. It can then
be slewing on this support.




The block can then begin his ascent on the following ramp segment
Sounds to stick with the text of Herodotus
abseil counterweight

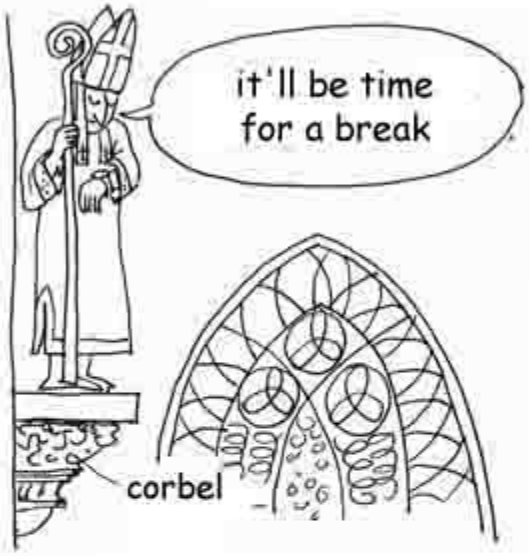


Herodotus, the Greek historian, living in the fifth century BC, collected from the tales of the Egyptian priests how the pyramids were built, and made the following account:

Επoιήθη δὲ ὧδε αὕτη ἡ πυραμὶς ἀναβαθμῶν τρόπον, τὰς μετεξέτεροι κρόσσας, οἱ δὲ βωμίδας ὀνομάζουσι· ταιαύτην τὸ πρῶτον ἐπείτε ἐποίησαν αὐτήν, ἤειρον τοὺς ἐπιλοίπους λίθους μηχανῆσι ξύλων βραχέων πεποιημένῃσι, χαμᾶθεν μὲν ἐπὶ τὸν πρῶτον στοῖχον τῶν ἀναβαθμῶν ἀείροντες· ὅκως δὲ ἀνίοι ὁ λίθος ἐπ' αὐτόν, ἐς ἑτέρην μηχανὴν ἐτίθετο ἑστεῶσαν ἐπὶ τοῦ πρώτου στοίχου, ἀπὸ τούτου δὲ ἐπὶ τὸν δεύτερον εἵλκετο στοῖχον ἐπ' ἄλλης μηχανῆς. Ὅσοι γὰρ δὴ στοῖχοι ἦσαν τῶν ἀναβαθμῶν, τοσαῦται καὶ μηχαναὶ ἦσαν, εἴτε καὶ τὴν αὐτὴν μηχανὴν ἐοῦσαν μίαν τε καὶ εὐβάστακτον μετεφόρεον ἐπὶ στοῖχον ἕκαστον, ὅκως τὸν λίθον ἐξέλοιεν· λελέχθω γὰρ ἡμῖν ἐπ' ἀμφότερα, κατὰ περ λέγεται. Ἐξεποιήθη δ' ὧν τὰ ἀνώτατα αὐτῆς πρῶτα, μετὰ δὲ τὰ ἐχόμενα τούτων ἐξεποίευν, τελευταῖα δὲ αὐτῆς τὰ ἐπίγαια καὶ τὰ κατωτάτω ἐξεποίησαν.

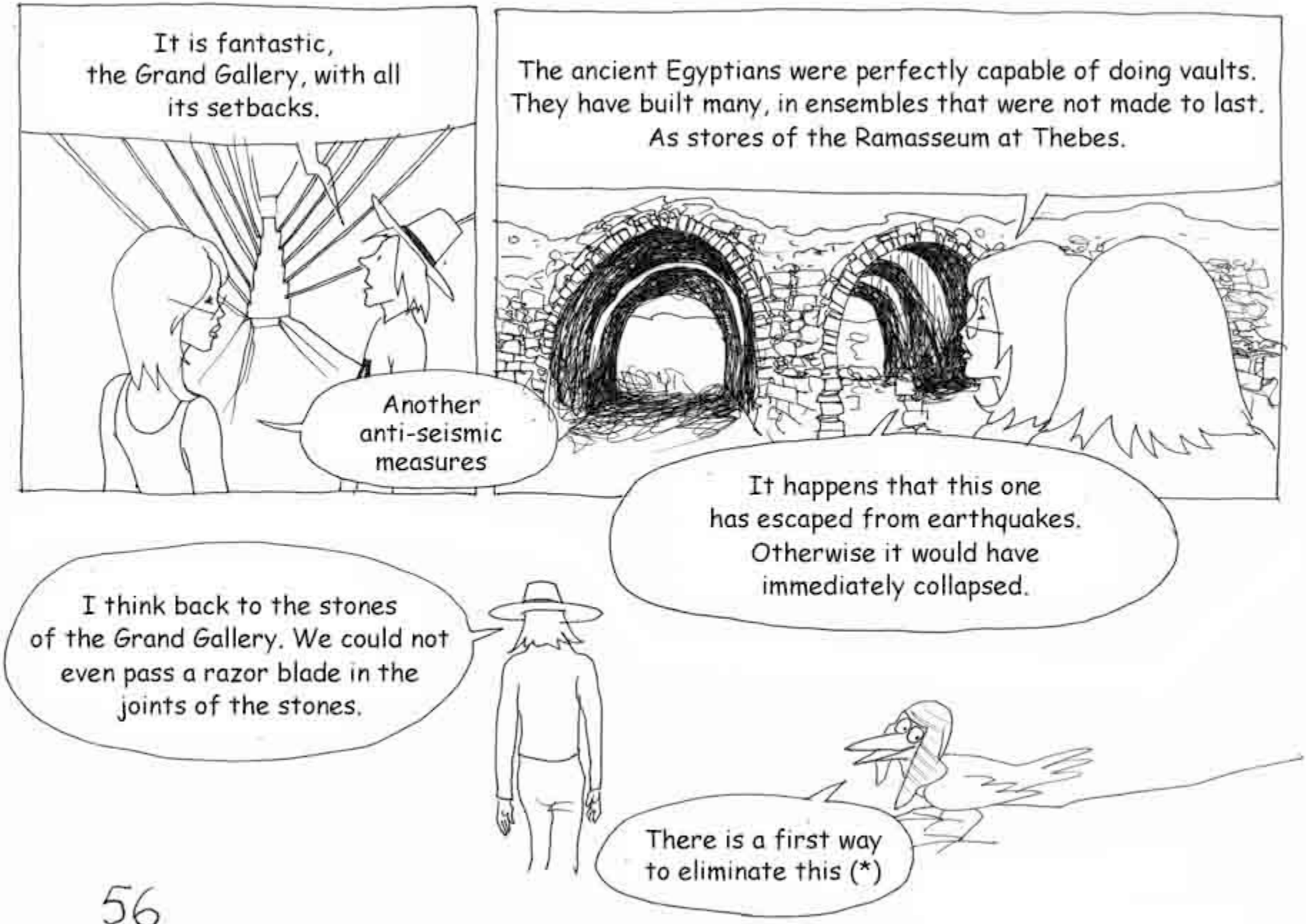
"This pyramid was made after the manner of steps, which some call "rows" and others "bases": and when they had first made it thus, they raised the remaining stones with machines made of short pieces of timber, raising them first from the ground to the first stage of the steps, and when the stone got up to this it was placed upon another machine standing on the first stage, and so from this it was drawn to the second upon another machine; for as many as were the courses of the steps, so many machines there were also, or perhaps they transferred one and the same machine, made so as easily to be carried, to each stage successively".

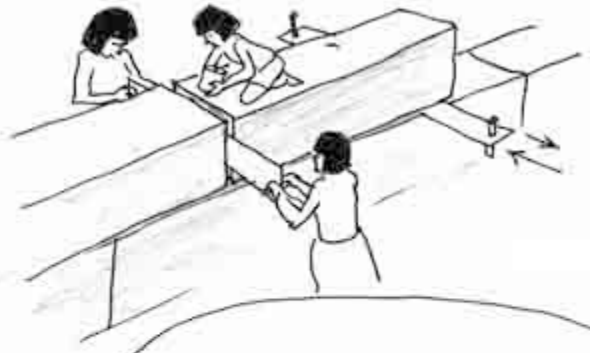
Anselme's system is a combination machine + ramp, with the difference that the ramp is in stone. The Krossai (κροσσαι) are stones that protrude from the surface of the pyramid, what architects call **CORBEAUX**. Thus, the entire load rests on horizontal parts.



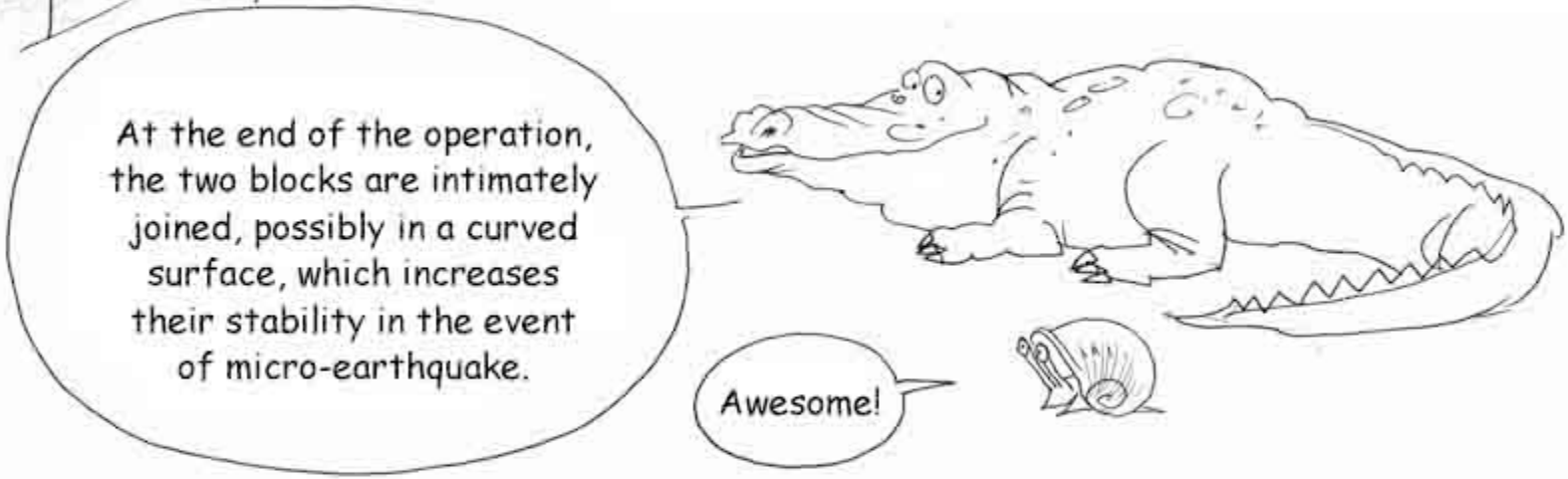
The bomides (βομιδαι) are these angle platforms on which it is possible to cornering heavy loads. As Herodotus says, these stones are then supported by the next machine, etc. Anselme and Sophie have worked a lot with cardboard and glue, to establish the consistency of what Anselme saw in his dream. You'll find all this in the Annex, which will allow you, if you want, to build your own model. As this ramp is in stone, it can withstand loads of tens of tons.

This ramp is wide enough for the teams who are going down to cross carts which are holding the blocks. Finishing work leave very few non-recoverable waste (triangular blocks), the rest can be re-used to build other pyramids, as part of their external ramps. That's how Sneferu, father of Cheops, built his two pyramids at Dahshur. In the same way his son Cheops, his grand-son Kepren and his great grandson Mykerinos built their own.



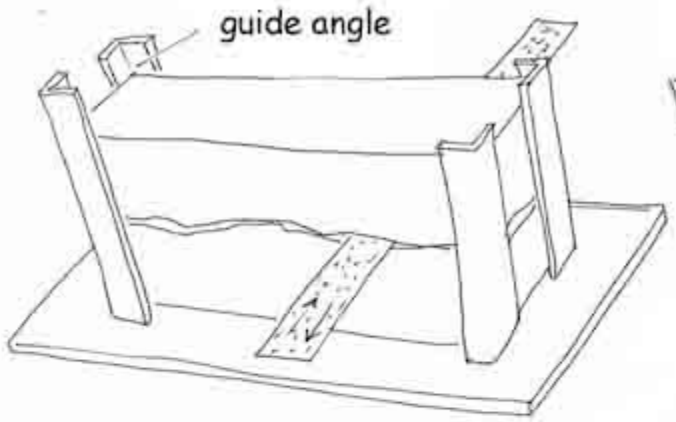


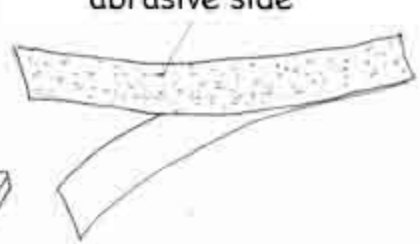
In 2004 Jean-Pierre Petit suggested that workers were able to treat in situ the joints by abrading the opposing faces with a copper strip and quartz dust (*). For vertical joints, this abrasive paste that can be mixed with silt, to obtain an abrasive paste.



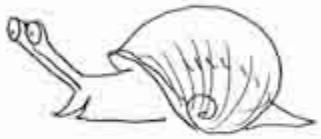
You can illustrate this concept by taking two blocks of balsa. Start by destroying the flatness of two opposite faces, using any instrument.Then abrade the two opposing faces using a strip of "dual face sandpaper" you have made by sticking two strips.

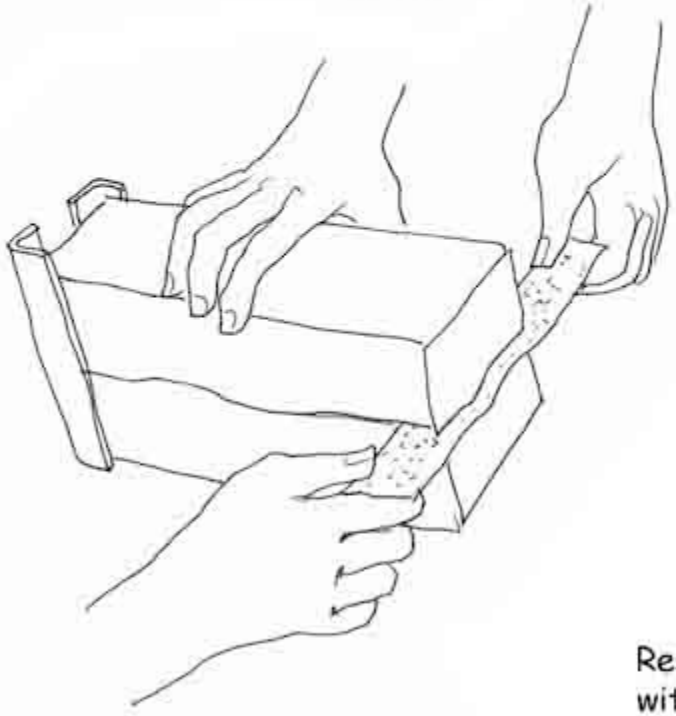
(*) Of corydon, very abundant in Aswan, in southern Egypt.

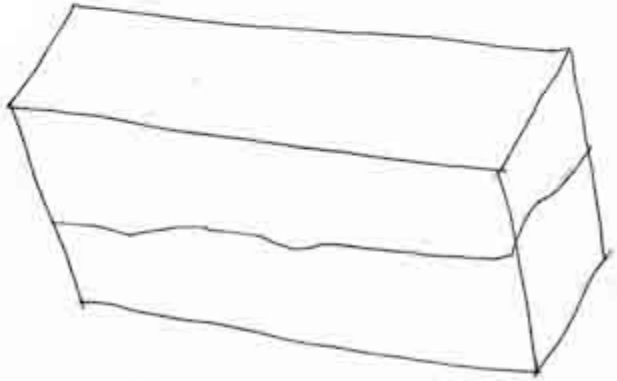




two strips of abrasive paper
and pasted against each other

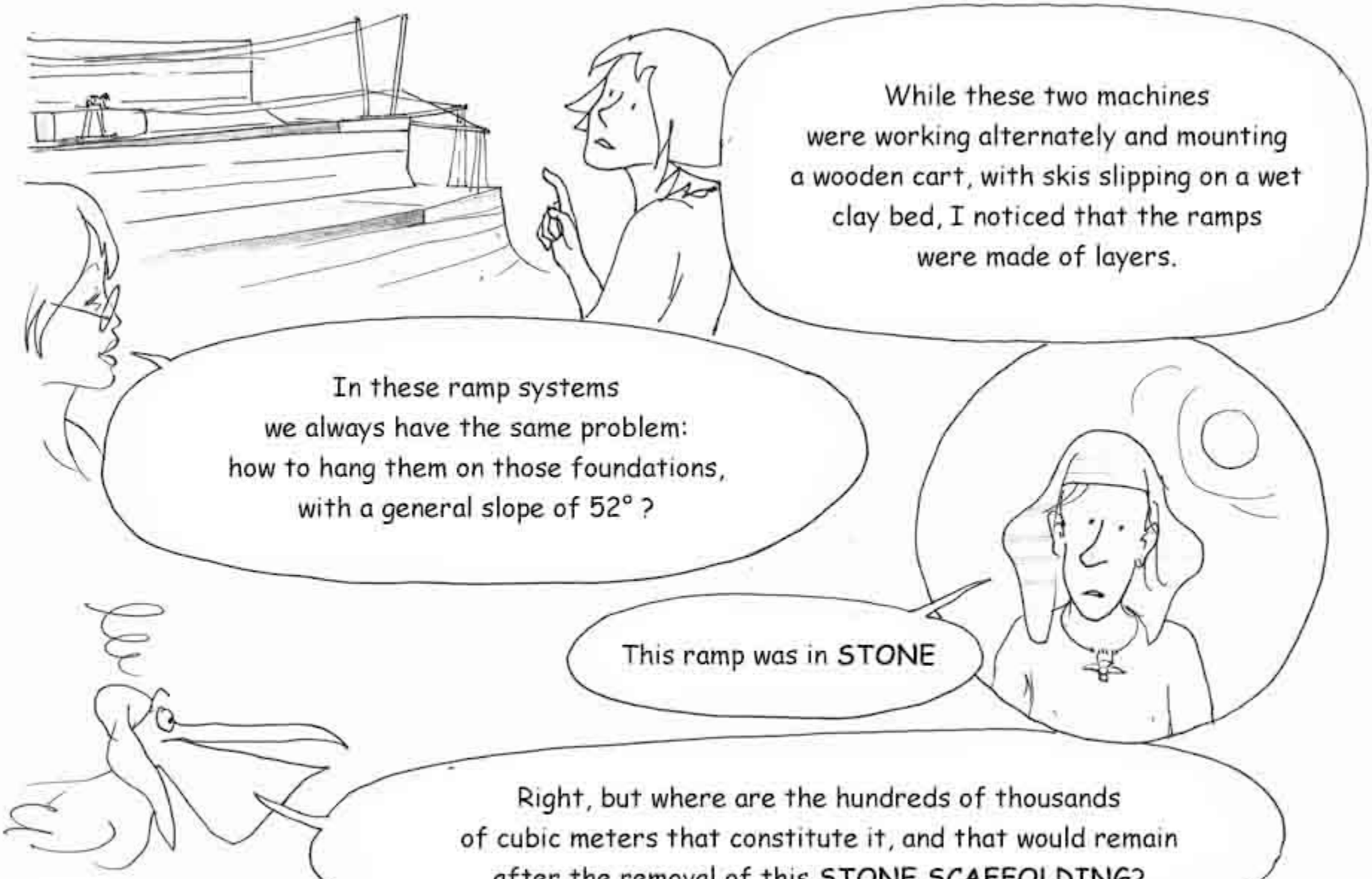




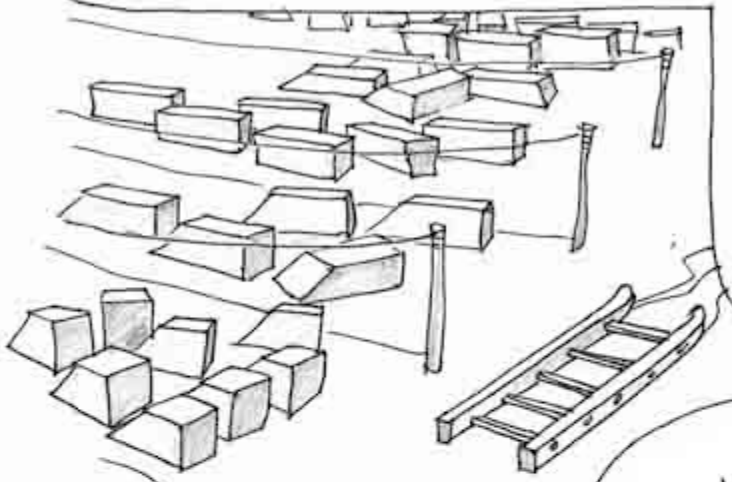


Result: the two blocks have two sides
with curved surfaces, parallel, and closely joined.

From ancient constructions in South America, Jean-Pierre Petit suggested (2004) that the abrasion of the two opposite faces could be achieved with a wool blanket filled with abrasive powder.


While these two machines were working alternately and mounting a wooden cart, with skis slipping on a wet clay bed, I noticed that the ramps were made of layers.
In these ramp systems we always have the same problem: how to hang them on those foundations, with a general slope of 52° ?
This ramp was in STONE
Right, but where are the hundreds of thousands of cubic meters that constitute it, and that would remain after the removal of this STONE SCAFFOLDING?

On the plateau I saw a lot of blocks, arranged by type.
Some, cut carefully, were in fine limestone.
Others, made of a coarse limestone, only had two parallel horizontal faces, perfectly flat.
There was also a mass of size debris that workers put in bags.

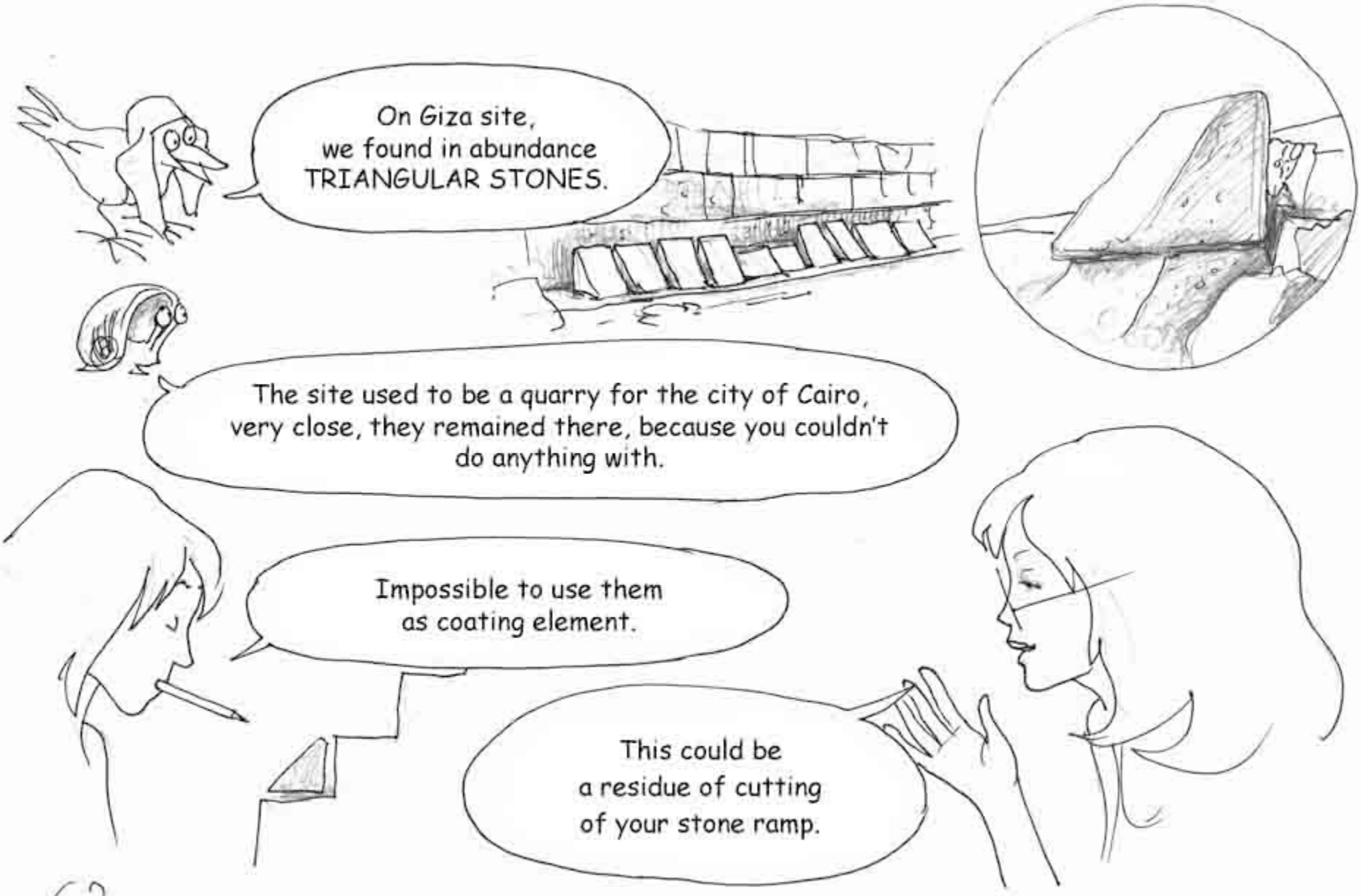


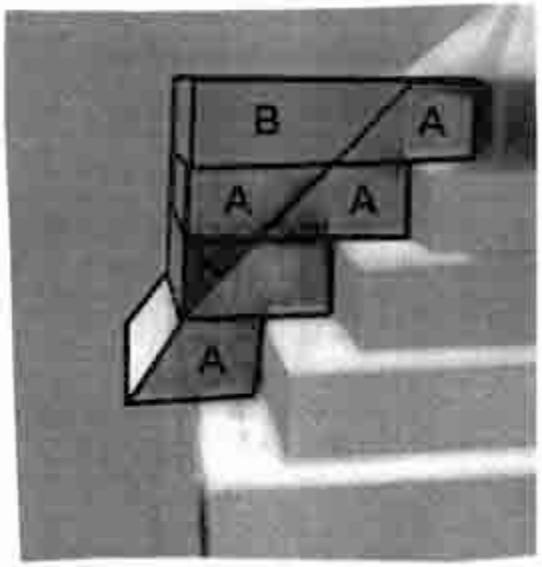
Let see the archaeological side.
We found many of these stones on the site.
What you say suggests that the stones of the coating were brought to the site
ALREADY ROUGHLY CARVED.

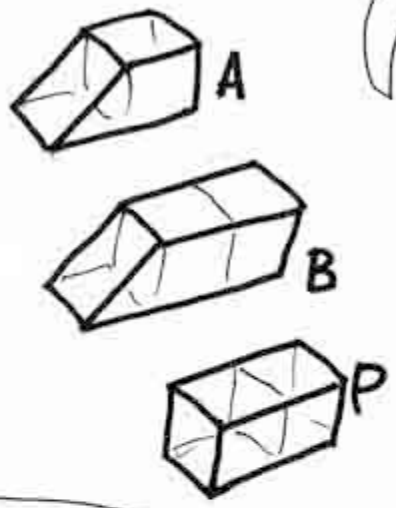
Coating of the pyramid of Unas, at Saqqara

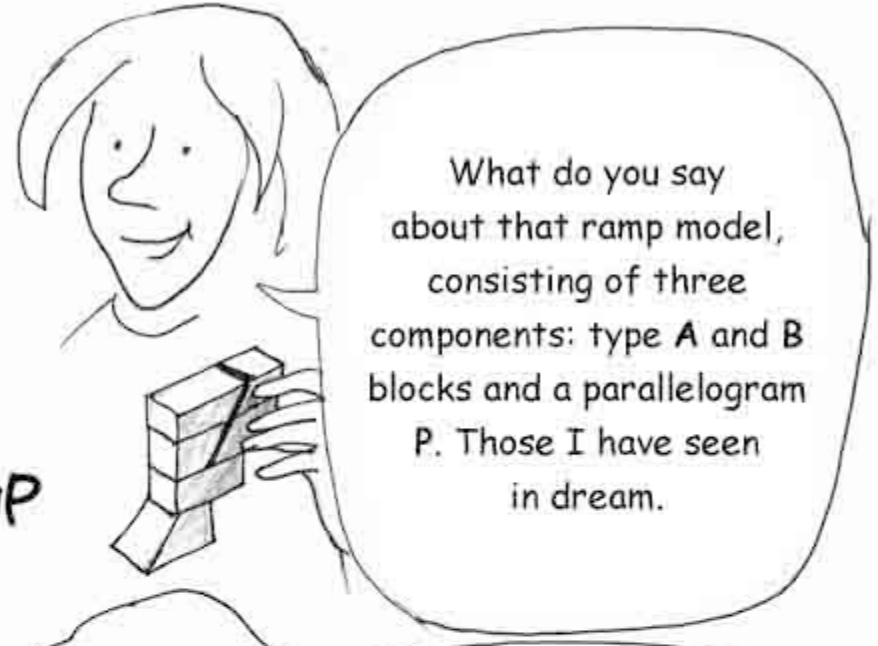
Cheops, the base

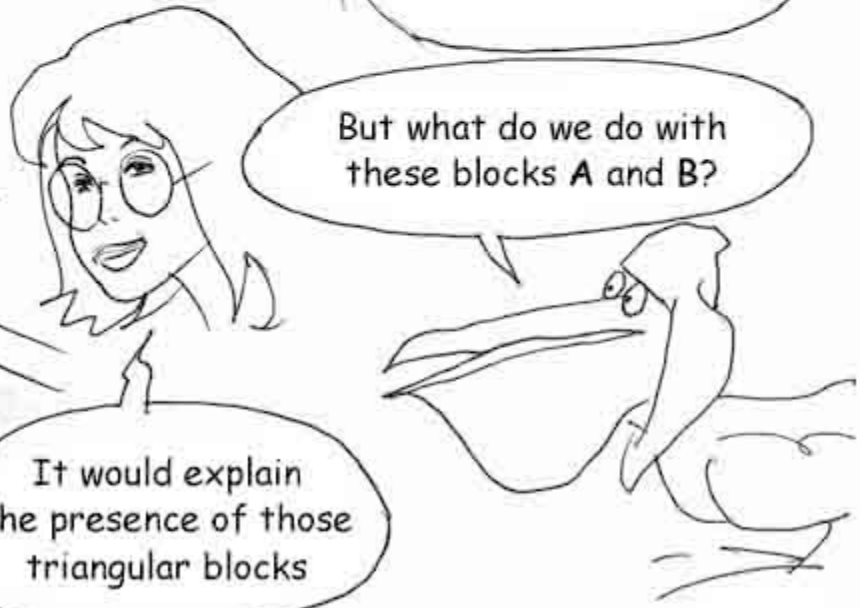
Coating of the Bent Pyramid


On Giza site,
we found in abundance
TRIANGULAR STONES.
The site used to be a quarry for the city of Cairo,
very close, they remained there, because you couldn't
do anything with.
Impossible to use them
as coating element.
This could be
a residue of cutting
of your stone ramp.

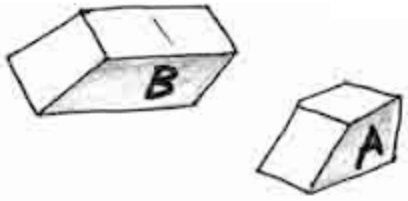


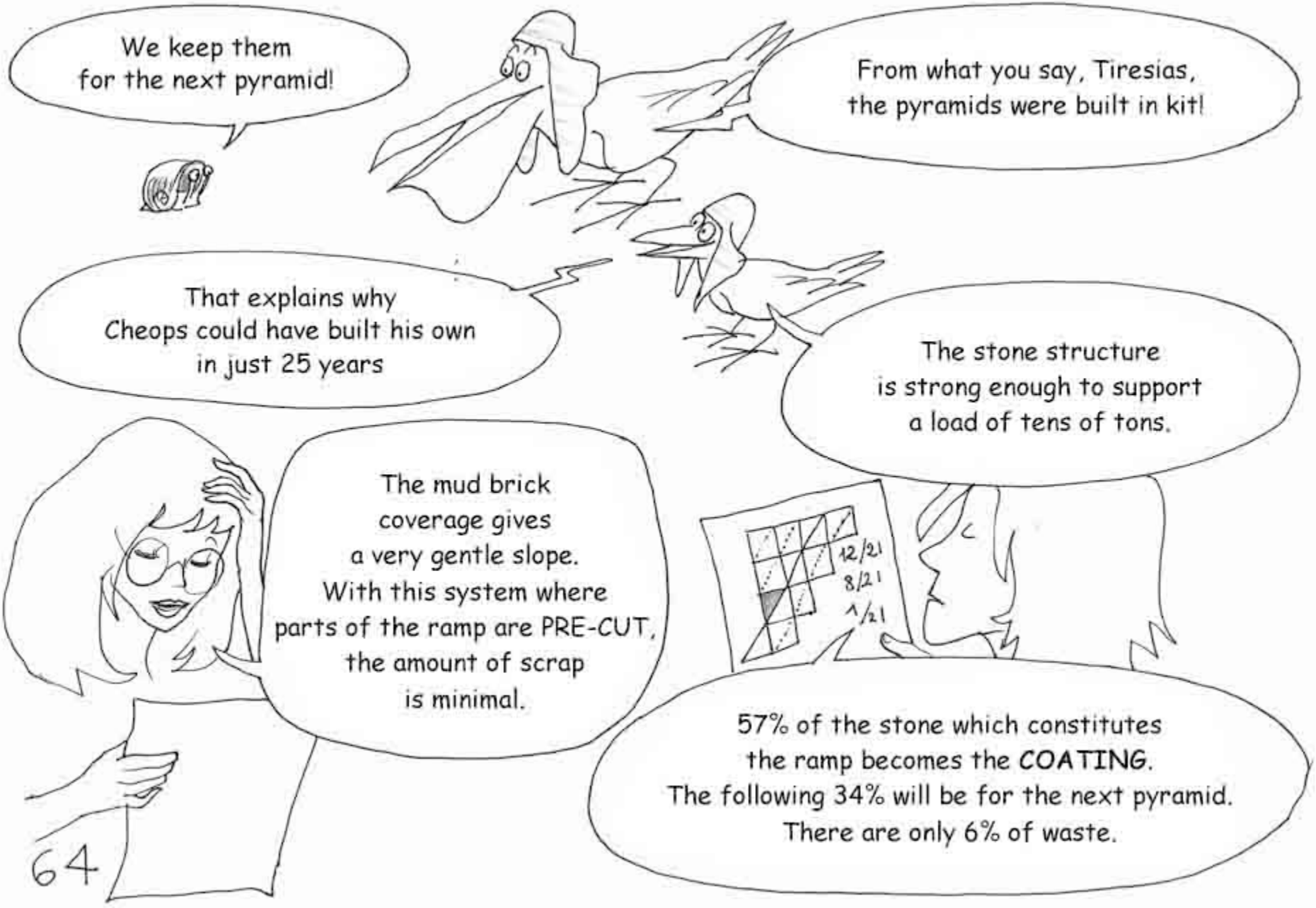






When the pyramid is completed, we just have to remove both components A and B, and to conduct the cutting of the shaded area to get the face of the pyramid




We keep them for the next pyramid!
From what you say, Tiresias, the pyramids were built in kit!
That explains why Cheops could have built his own in just 25 years
The stone structure is strong enough to support a load of tens of tons.
The mud brick coverage gives a very gentle slope. With this system where parts of the ramp are PRE-CUT, the amount of scrap is minimal.
12/21
8/21
1/21
57% of the stone which constitutes the ramp becomes the COATING. The following 34% will be for the next pyramid. There are only 6% of waste.
64

It remains to understand how this ramp (Krossai) is closing at the corners on these platforms (bomides).

THE STONE RAMP BY JEAN-PIERRE PETIT

Sophie and Anselme started by building models using Bristol paper with a grid of 5 mm by 5 mm.

We will also start there.

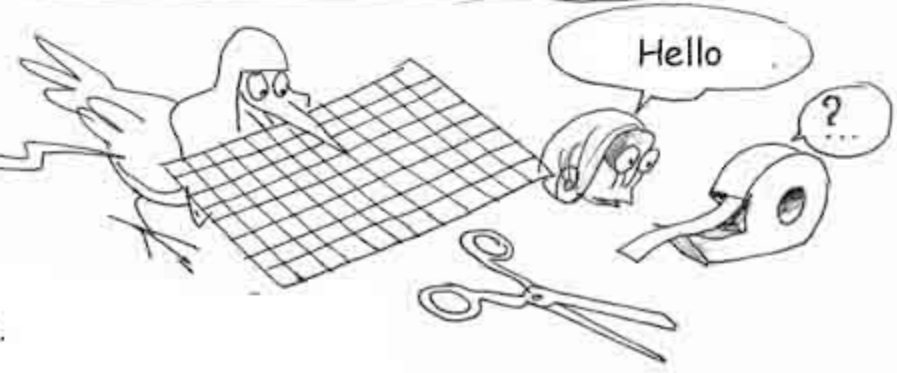
THE ALGORiTHM

It is the solution of the following geometric problem:

How to create by **RECURSION** an object with a symmetry
of order 4 (a pyramid) by using an object following an uphill trajectory
and spiraling at the same time?

Then we want this object, stick to the foundations
of an underlying pyramidal structure, to be both a
STONE SCAFFOLDING, enabling the delivery
of blocks on an uphill ramp and, once the building completed,
the coating. And this with minimal non-reusable scrap (*)

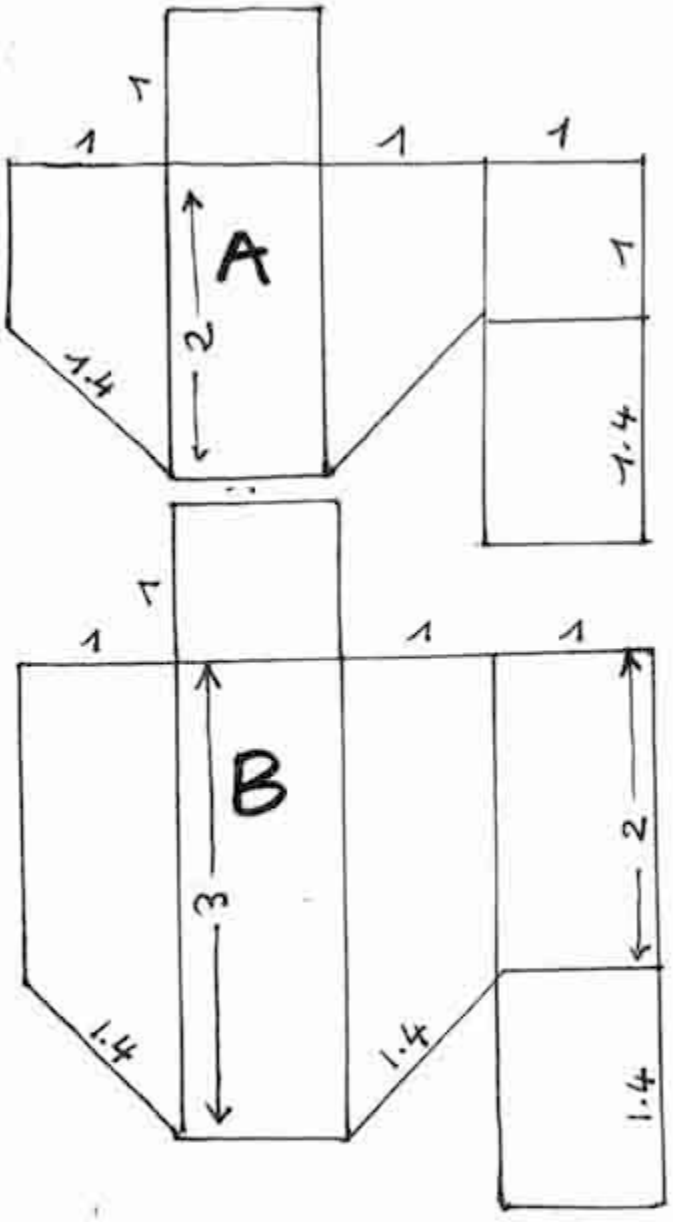
We will start by working
with grid Bristol paper.

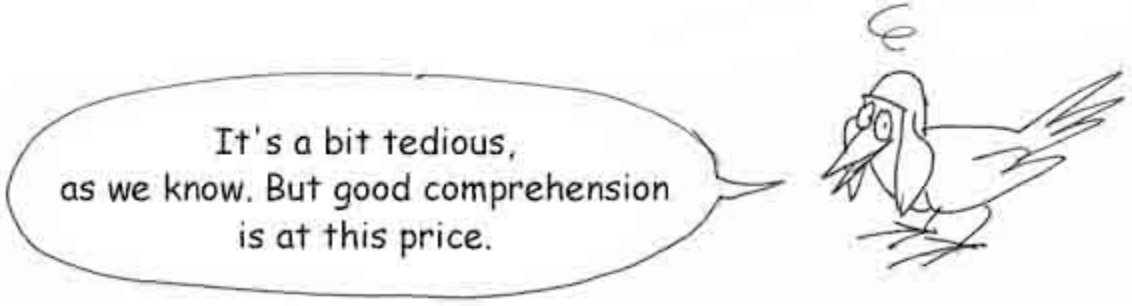


(*) The triangular blocks,  abundant on Giza site.

You are the new Pharaoh Cheops. Snefrou, your dad, has left you a mountain of stones already cut, which itself has used to build his **RED PYRAMID** and his **BENT** pyramid, further south, on the site of DAHSHUR. A real kit, that can be used as a stone scaffolding; these stones will allow you to build a super-pyramid in just twenty years. Thanks also to other stones, easily extracted from the quarry of Giza, which have readily horizontal flat faces, since they come from sedimentary layers of coarse limestone, which are separated by clay layers.

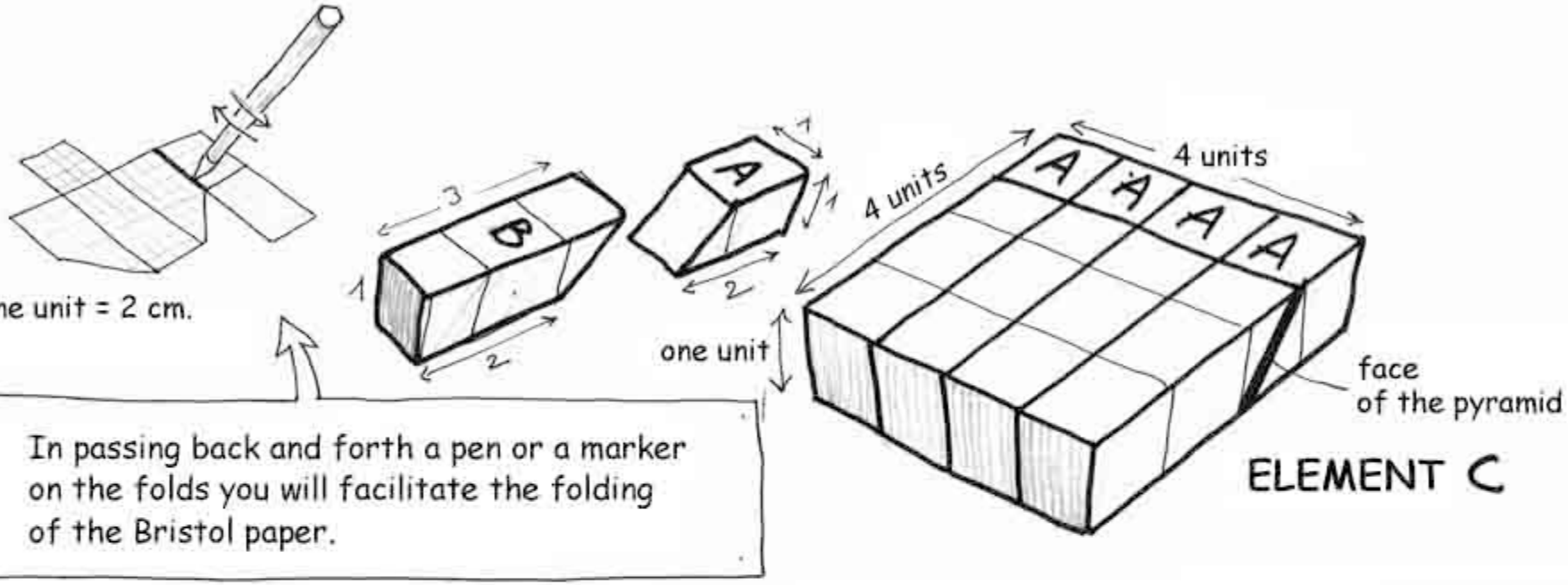
You will be making type **A** blocks and type **B** blocks (*).





(*) If you choose carpentry, cut these components into strips with a 2 cm by 2 cm section.

These lengths are only indicative. This is unit **u**.



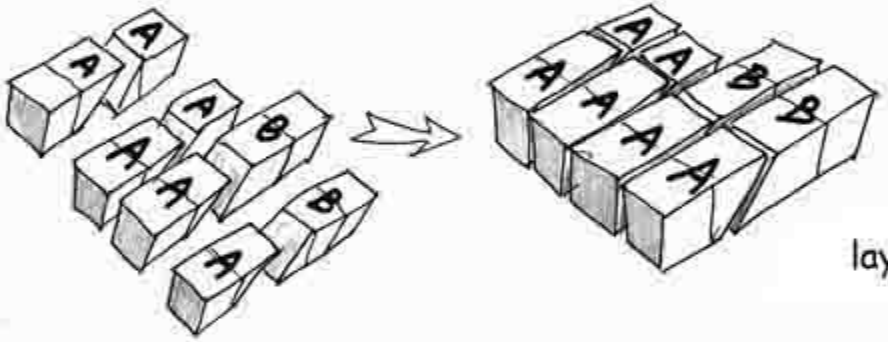
In passing back and forth a pen or a marker on the folds you will facilitate the folding of the Bristol paper.

By placing four elements of type **A** and four elements of type **B** you'll get the set **C** which is the corner platform on which monolith of 20 to 60 tons (52 in total in the Cheops pyramid) will be cornering at 90° on a wet bed of clay, a technique mentioned in a relief where we see 172 haulers pulling the statue of Djehudihotep. See page 29.

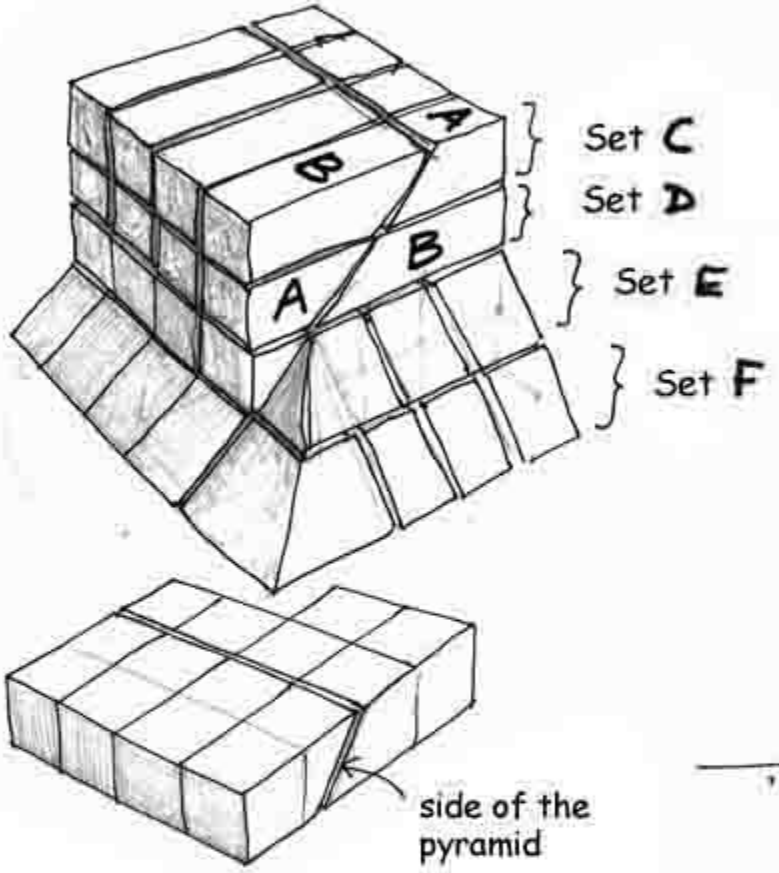
If you doubt about the effectiveness of this technique, sprinkle dishwashing liquid on the floor of your bathroom. Then try to cross the room without smashing your face!

The **CORNER PIECE** consists of four layers of precut stones.

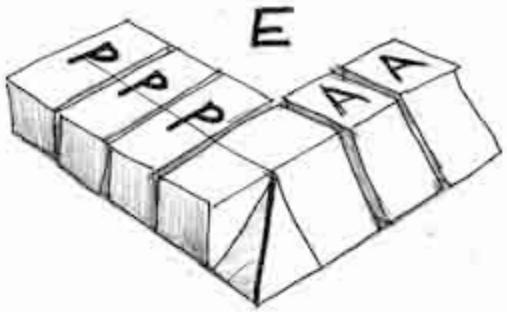
Below is how to make the next layer, the layer **D**, still from standard **A** and **B** blocks.

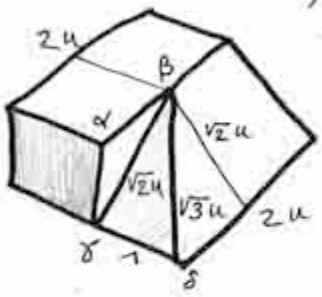


layer **D**

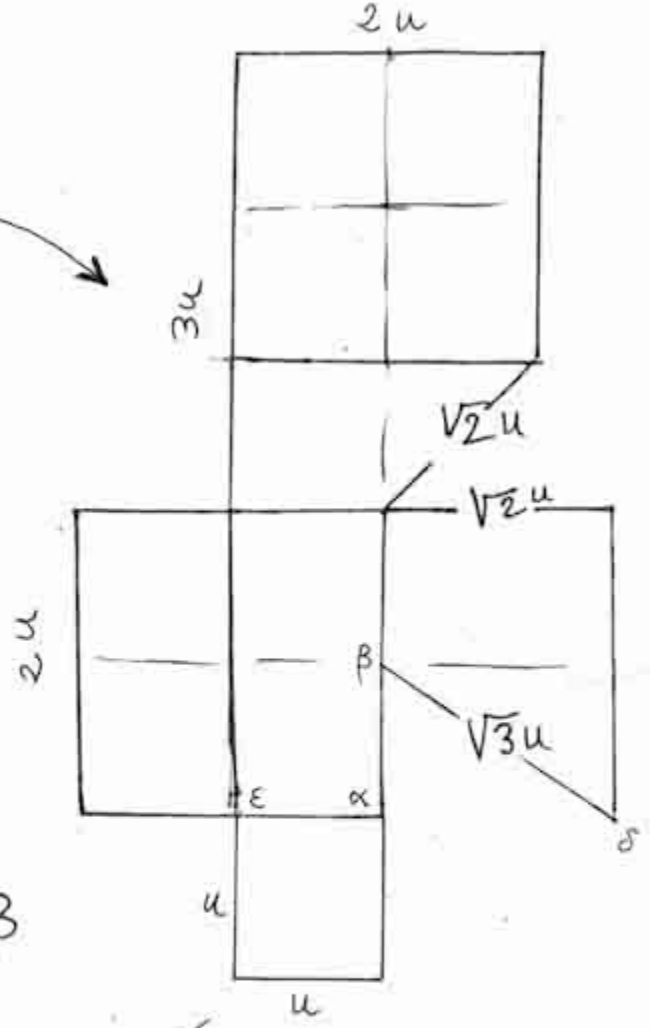


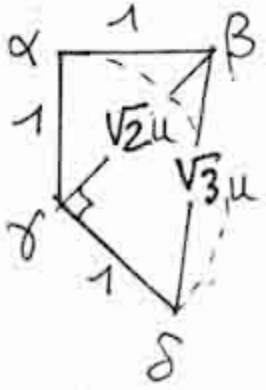
In all the following, we will act like the faces of the slope are the unity, they make a 45 ° angle with the horizontal. But the pyramids had more inclined faces. The slope of Kheops' is 14/11, which corresponds to an angle of 51 degrees 30 minutes 34 seconds. Purists shall enter this data by replacing the unit value for horizontal grids by 11/14 u i .e. 0.7857 u.

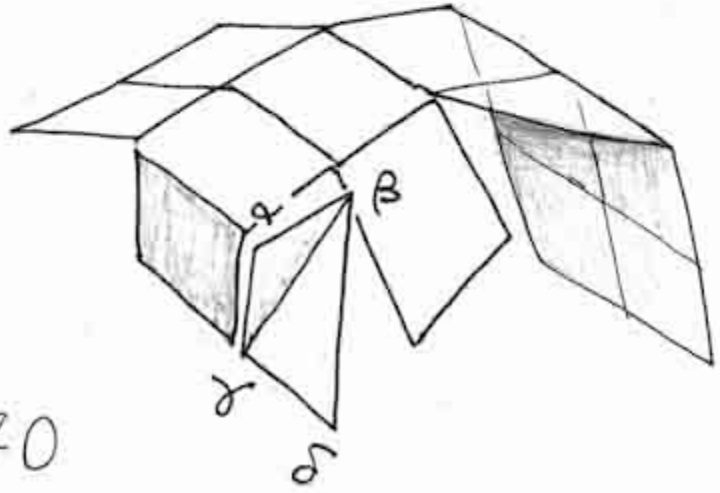




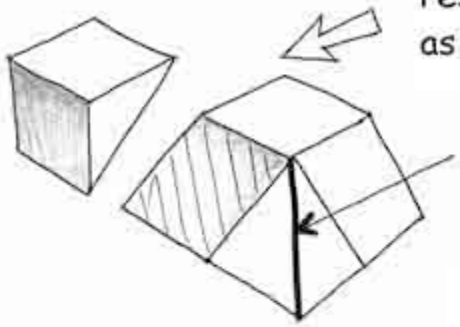
The set E consists of two blocks of type **A**, three parallelepipeds **P** with sides **u** × **u** × **2u** and a block with its cutting below gives you the form.



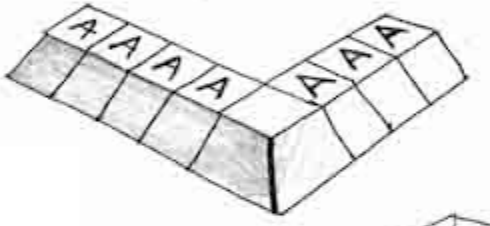


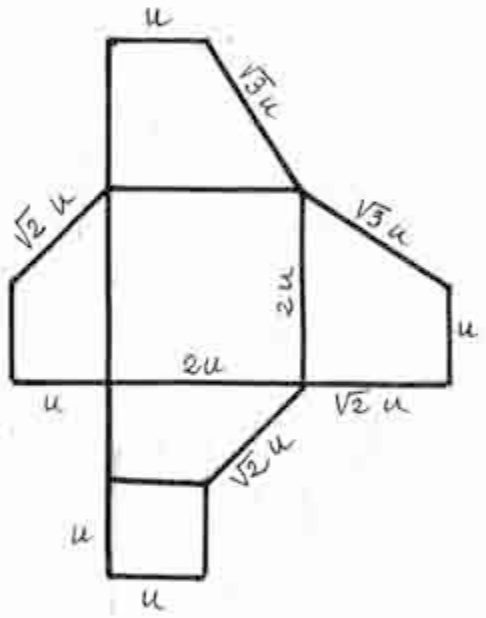


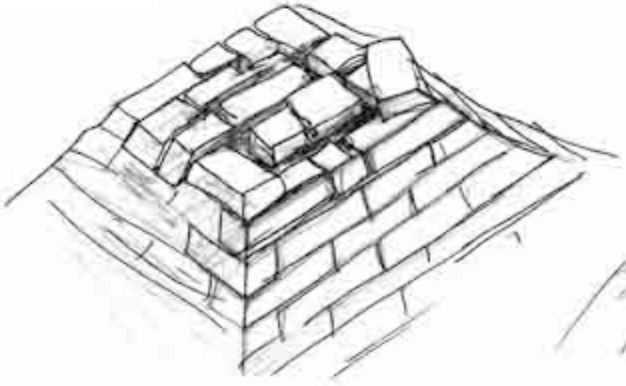
The cutting of this piece of type E provides the only identifiable scrap, resulting from this block: a **TRIANGULAR BLOCK**, as found on Giza site in abundance.

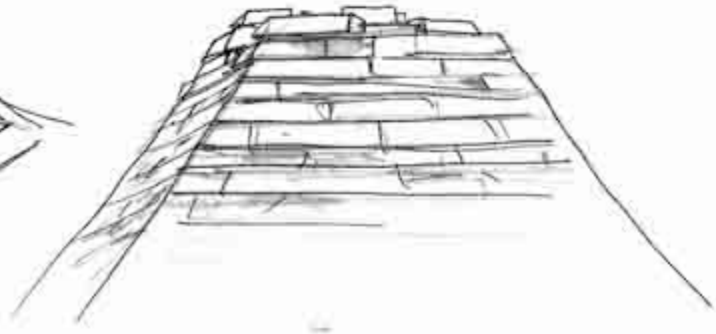


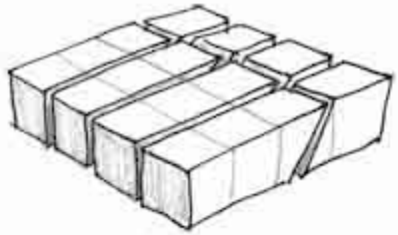
The last layer **F** consists of 7 blocks of type **A** and a block that corresponds to the cutting below. All are part of the coating. There are combinations of such blocks in the remains of the upper part of the pyramid of Kephren.



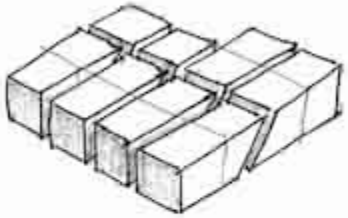




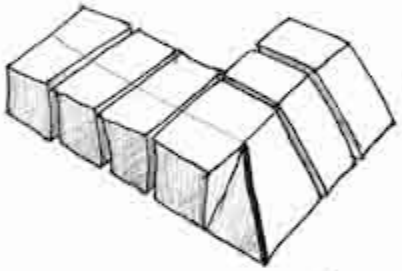




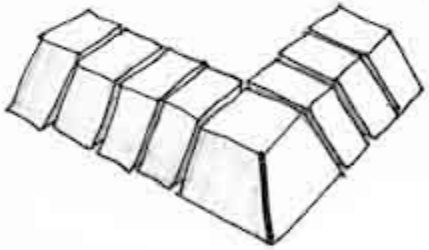
C



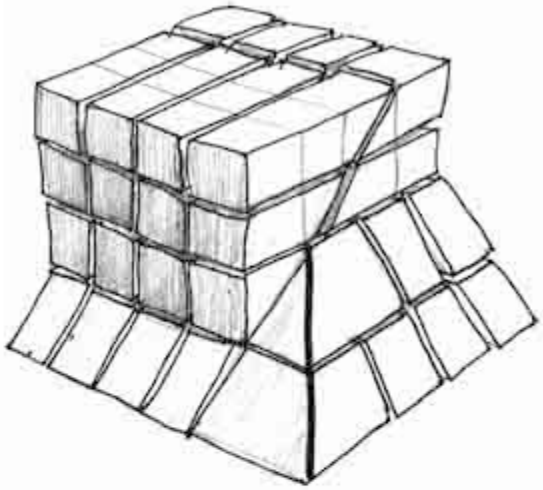
D

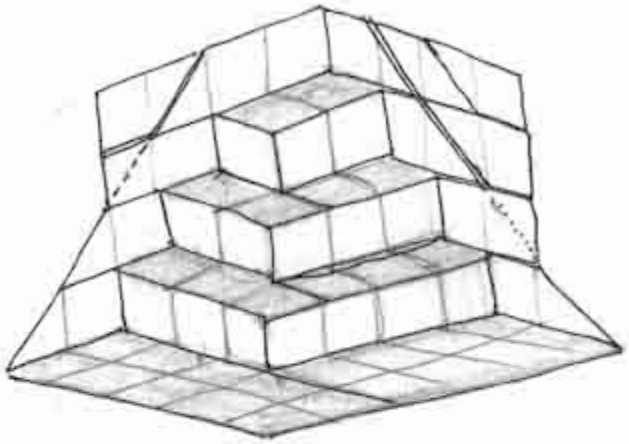


E

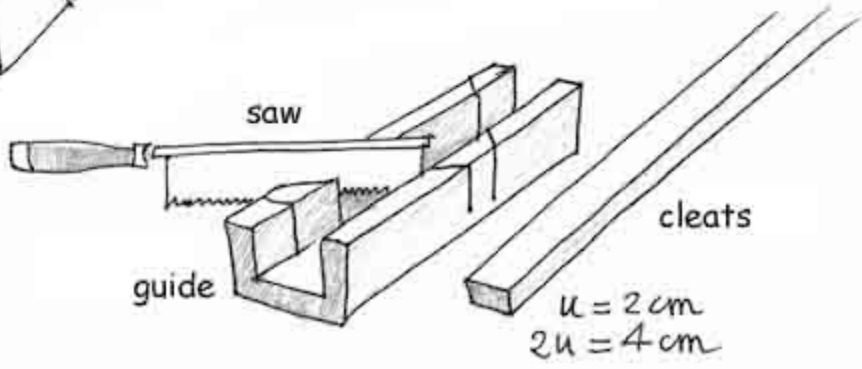


F





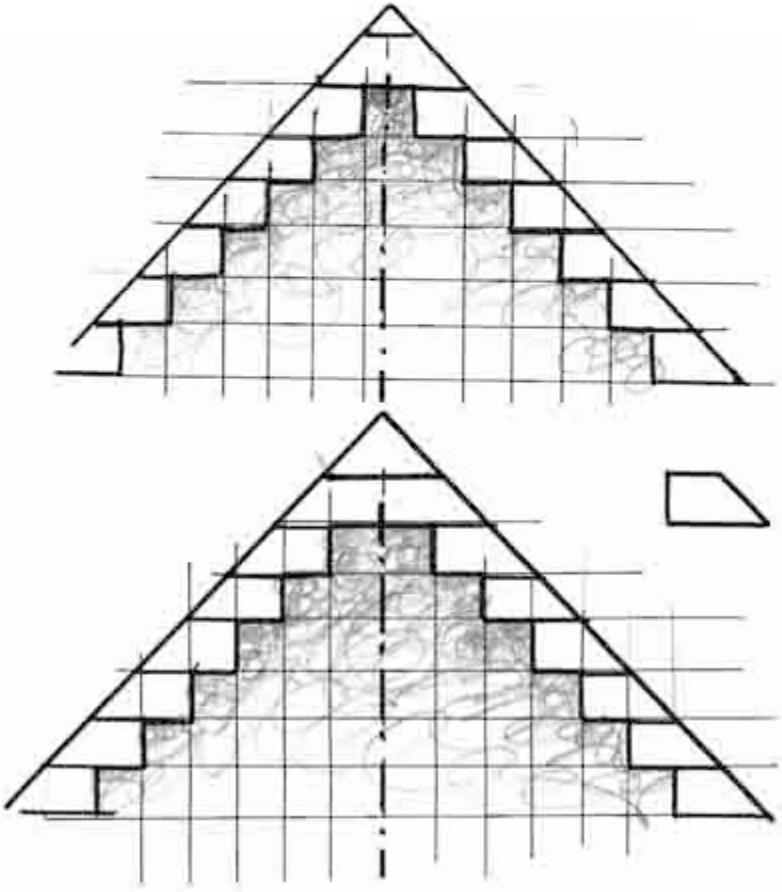
To understand how these angle blocks lie, compared to foundations ones, it is essential to build a model. For the foundations it is easier to create them from wooden sticks

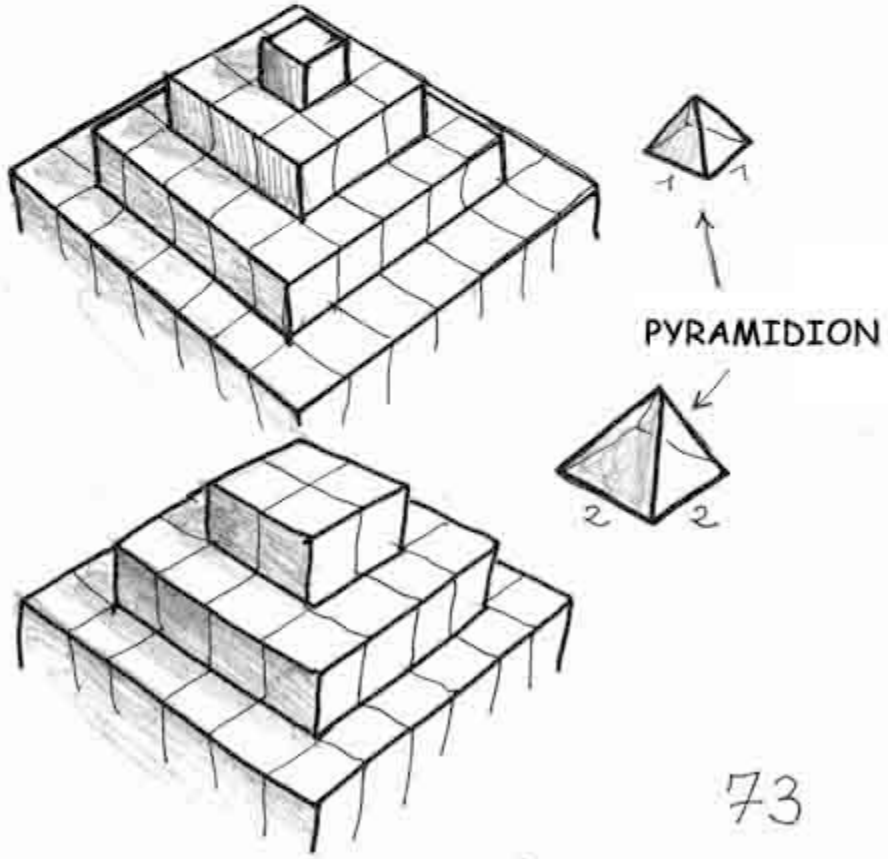


glue

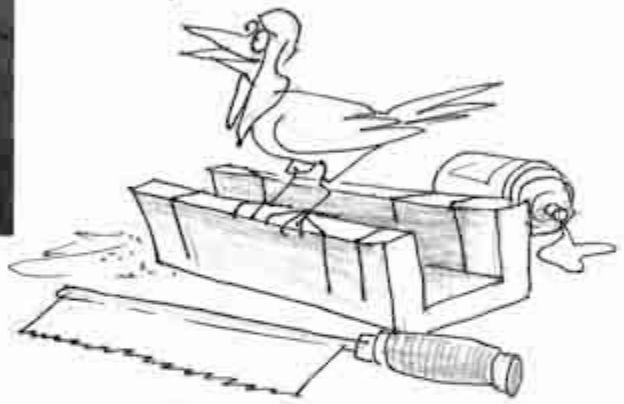
We assume that you have now several **ANGLE SETS** of this type.
We will now see how they take over, from a base to the other, in constituting the resistant support of an uphill path, a **HELICOIDAL RAMP STONE.**
For this you will need to make the foundation.

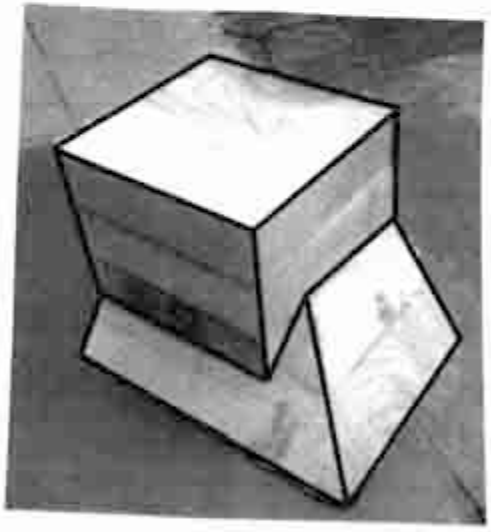
There are two kind of foundations geometry, illustrated by the following drawings.
The sides are identical. The pyramids differ only in the arrangements of the last elements of their top parts.

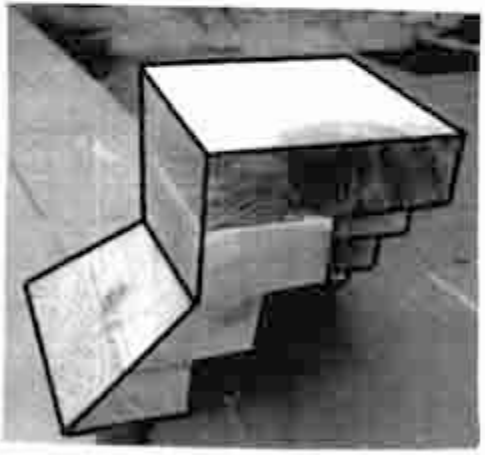




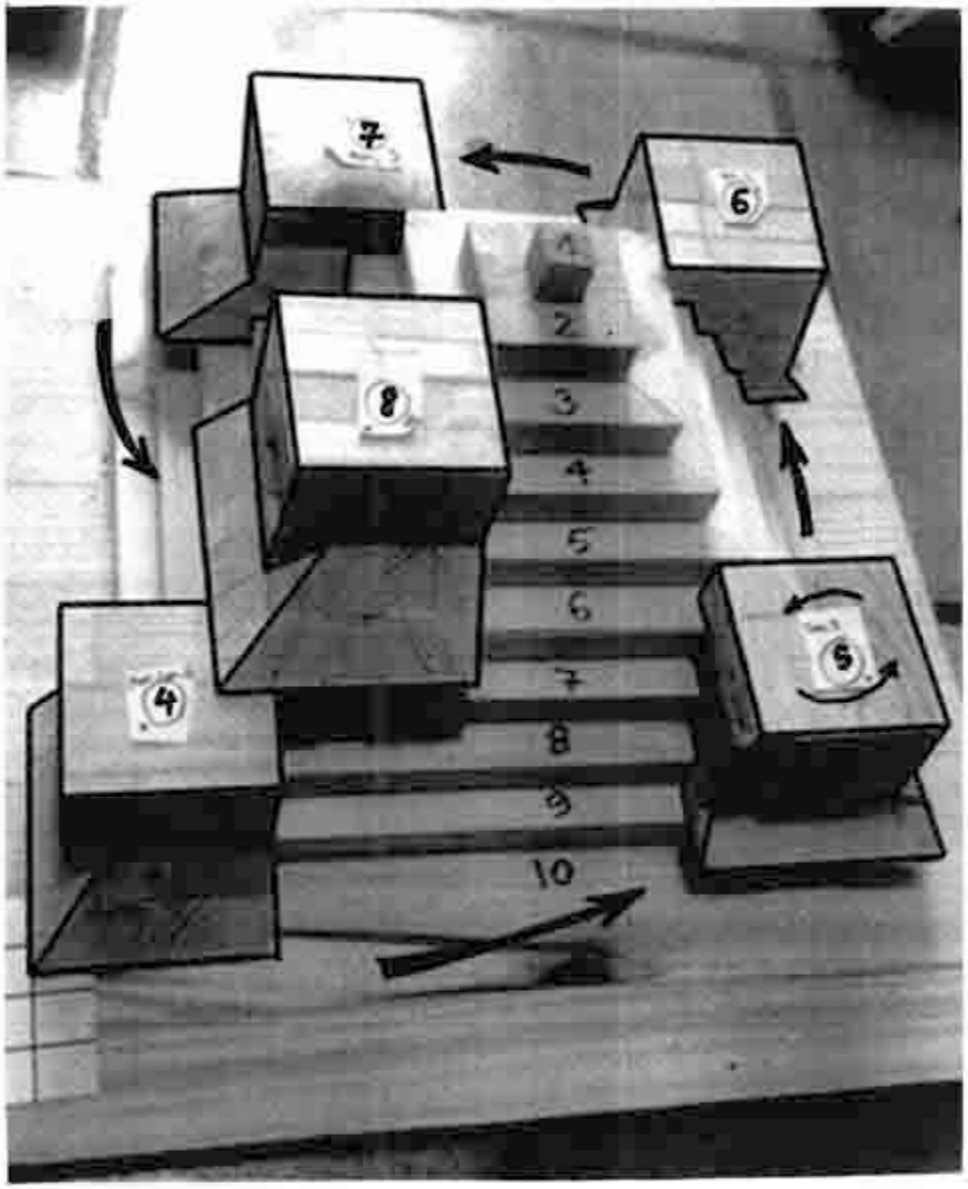
Here is a model
with some foundations,
made from slats of 2 cm
by 4 cm, a saw and glue.

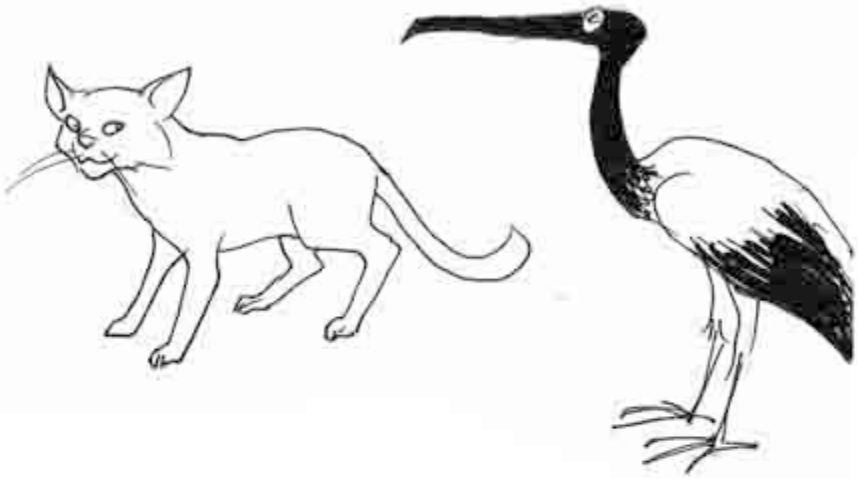






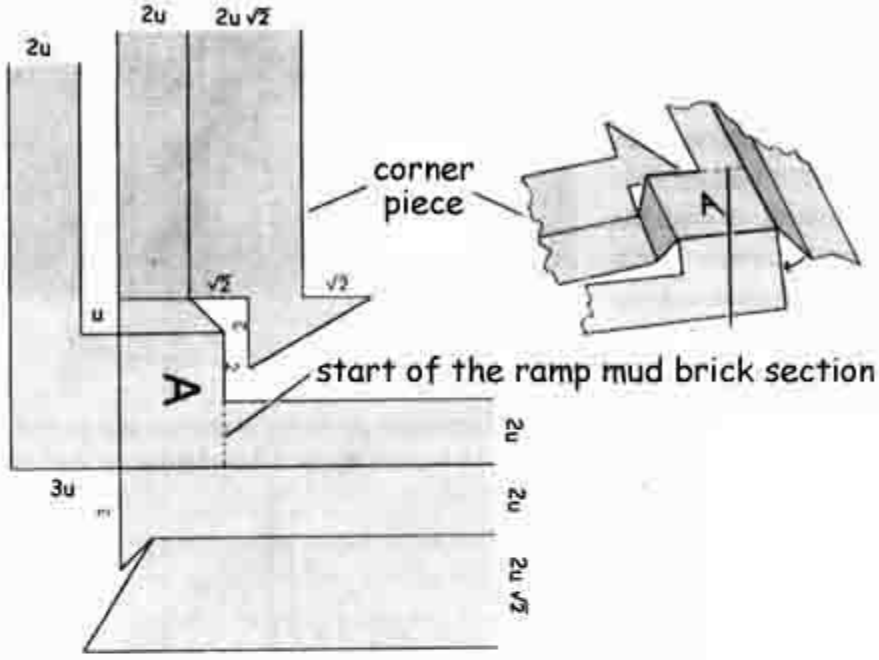
And corner pieces
made of wood



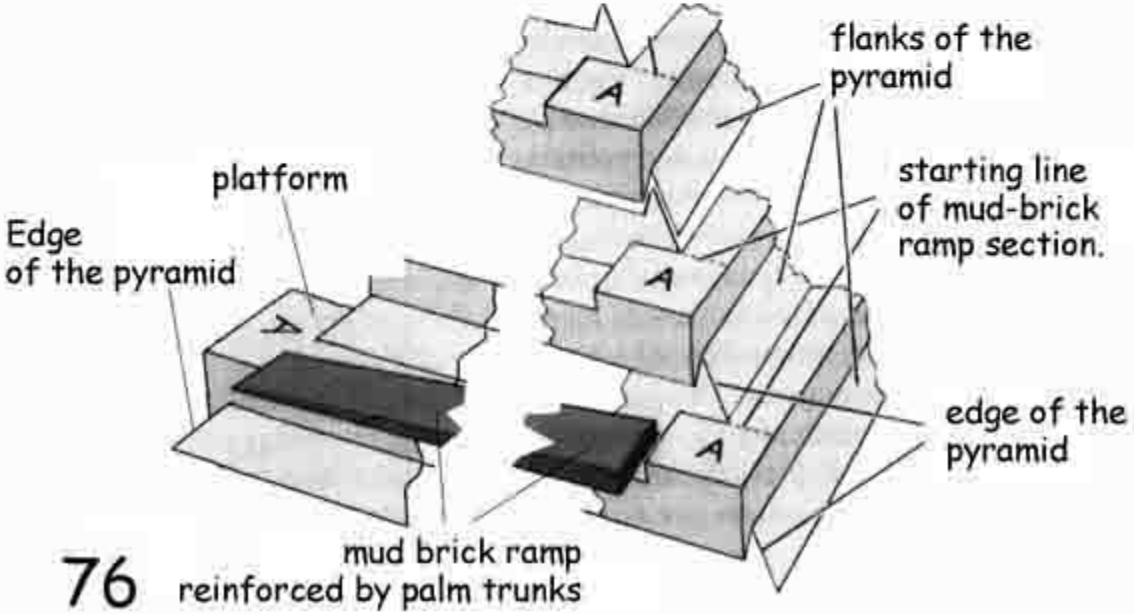


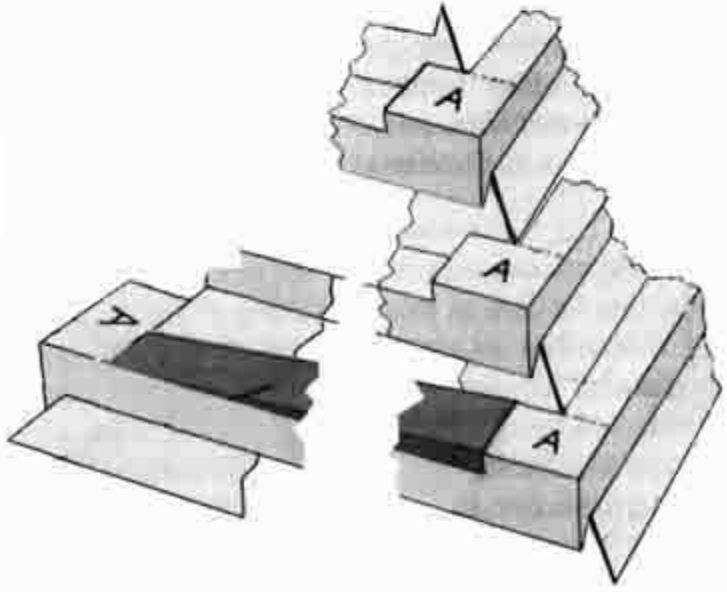
This form provides a solution to the problem.
Let start from his position 4, enveloping
the foundations. We slide it along the base.
At the next angle we give it a rotation of +90°
and a vertical movement equivalent to a foundation
height (position 5). We do the operation again in 6,
7, and 8. The part is then positioned against the 4,
as indicated. Through this **RECURSIVE** scheme we
get the algorithm generating the STONE RAMP. (*)

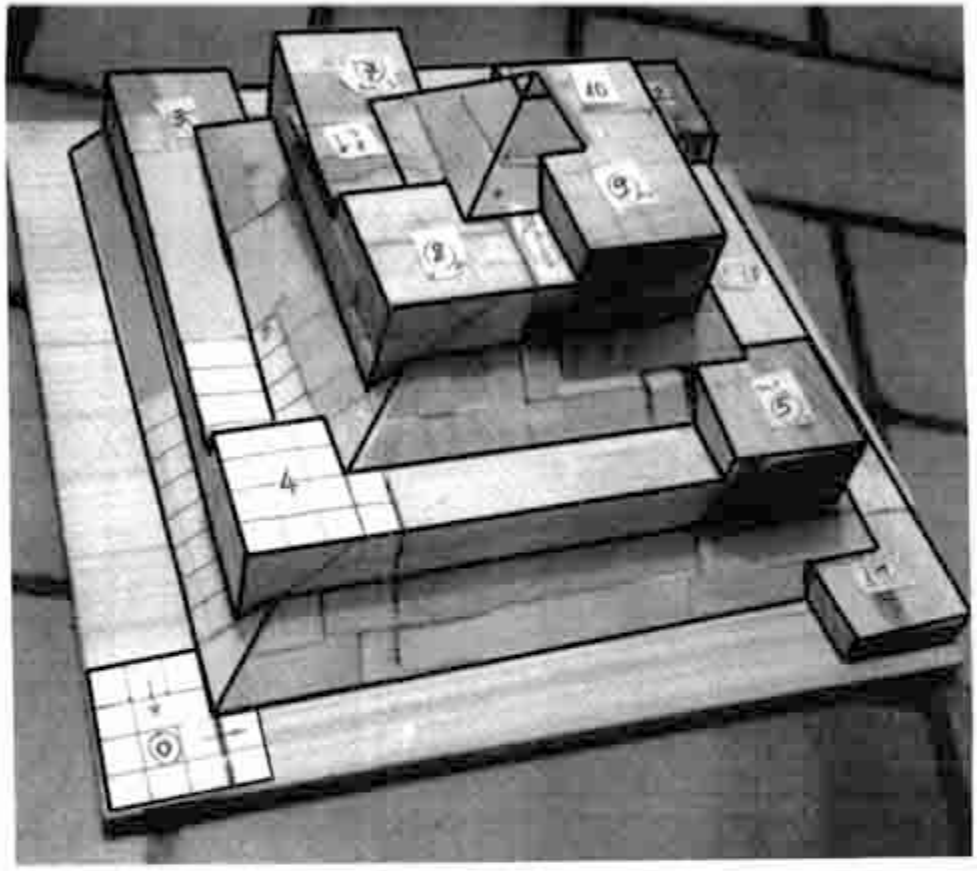
(*) **RECURSION** is a concept that will appear in mathematics in the nineteenth century.

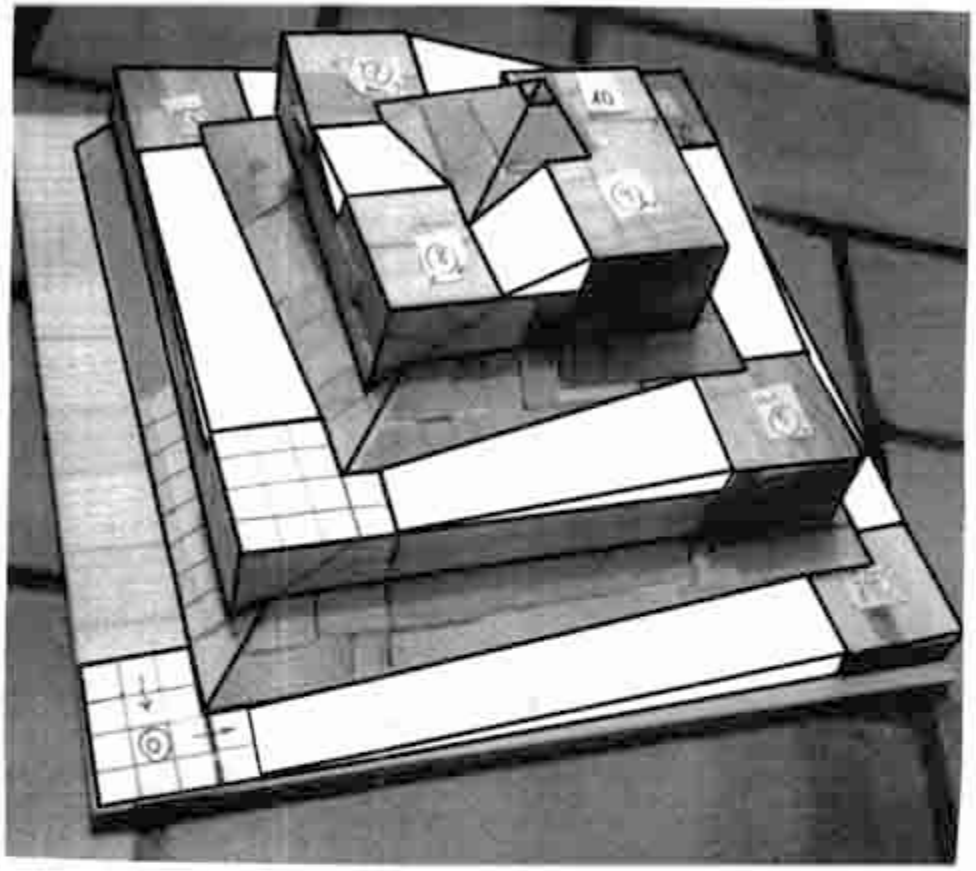


THIS CUTTING ALLOWS
TO UNDERSTAND HOW THE CORNER
PIECES ARE JOINING,
MATERIALIZING THE EDGE
OF THE PYRAMID.



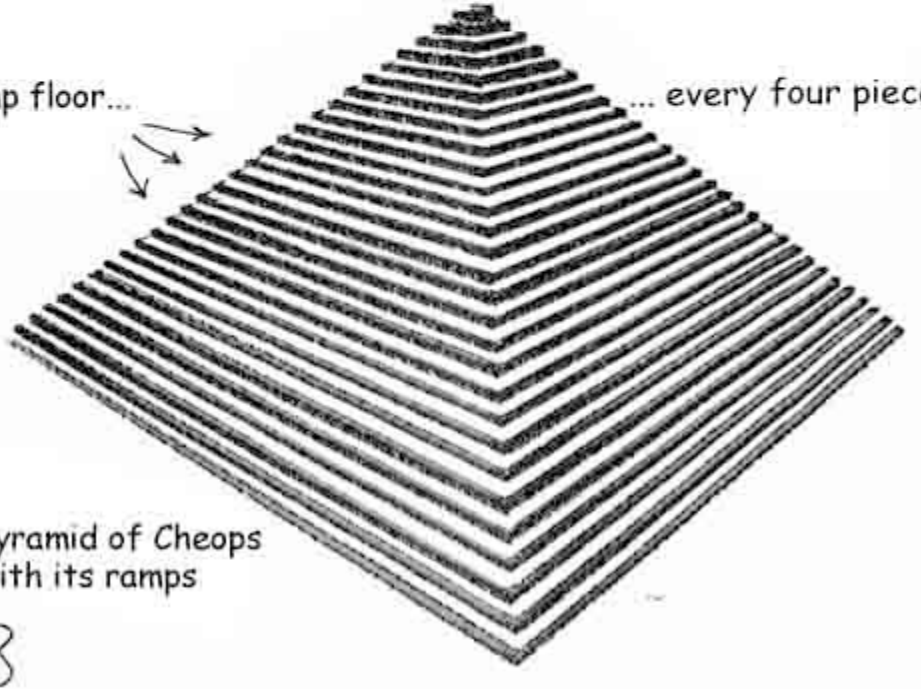




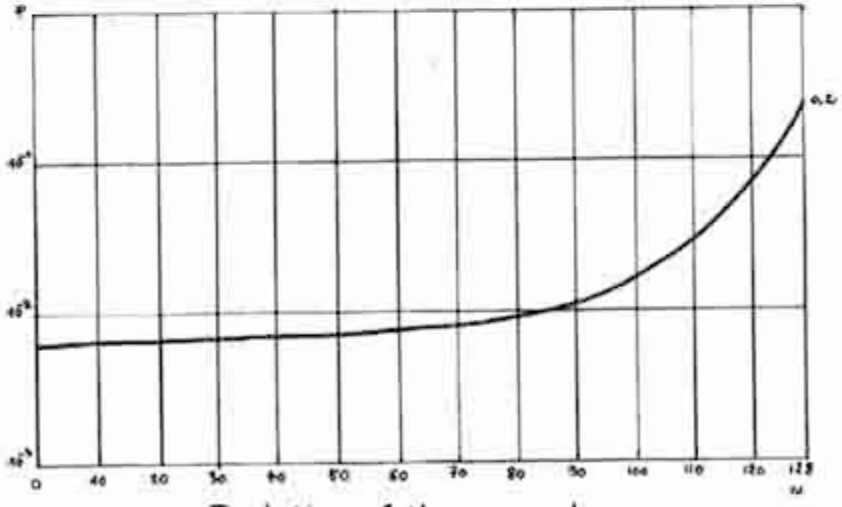


It is easy to complete the establishment of CORNER BLOCKS 4 to10 with type **A** and **B** blocks and parallelepipeds with (u, u, 2u) sides. This is what has been done on the model of the left picture.
On the right, shown in white, we added the inclined ramps in mud brick, reinforced with palm trunks.
For those who want to understand the sophisticated geometry, we have made an **appendix** which describes in pictures all stages of a model assembly process and the final stripping to release the COATING.

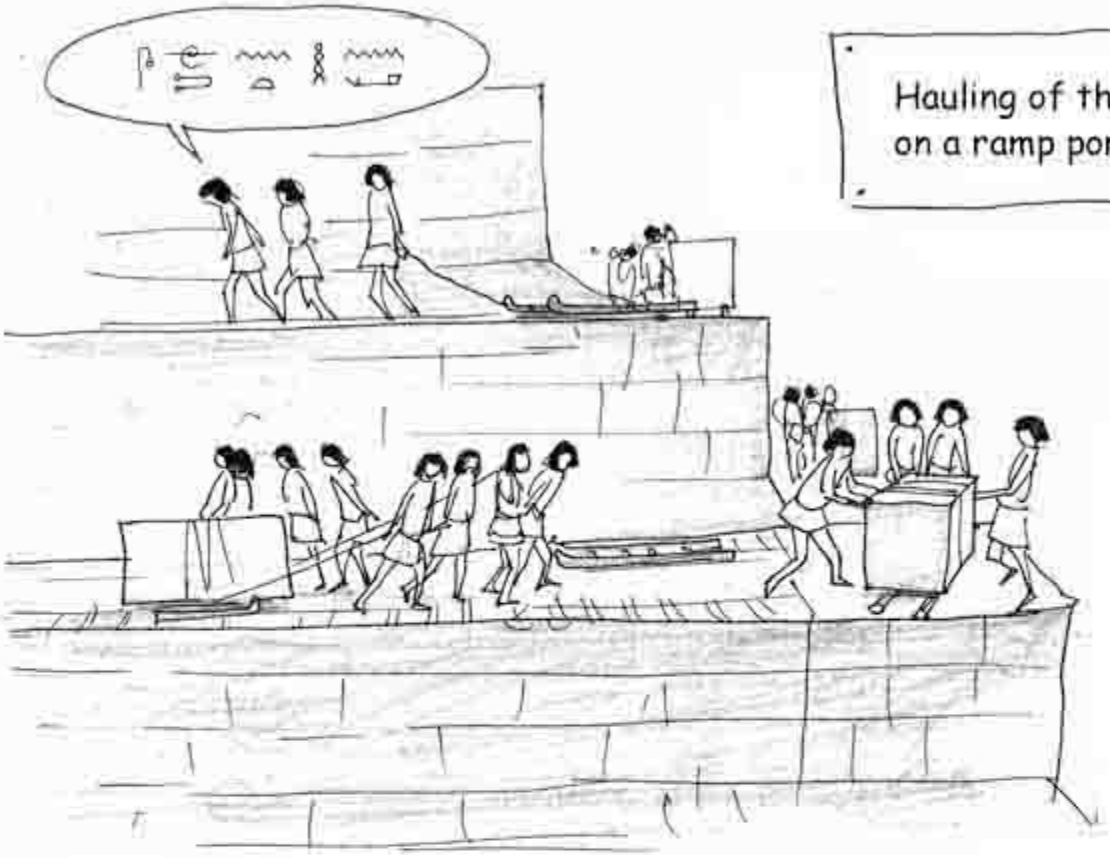
Well, let's take a moment. We have a routing system for the pyramid components using a narrow stone ramp, but wide enough to allow a double movement of workers, some pulling uphill trolleys carrying blocks of two tons and a half, and other going back down with the empty trolleys. In the 4/5 of the climb, the slope of the ramp is less than 1%, in a way that the towing force needed is essentially to overcome the friction on the wet silt bed. It can then be created by only few men. At the corners, the rotation can be provided by shifting. This ramp of about thirty laps sees its slope increase in the last laps, in its upper part.
The complete course on the ramp for the Cheops pyramid is 13 kilometers.



Pyramid of Cheops with its ramps

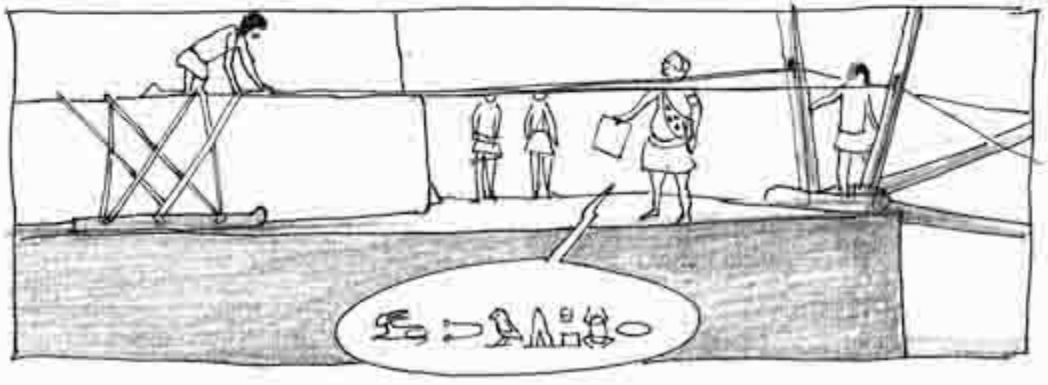


Evolution of the ramp slope

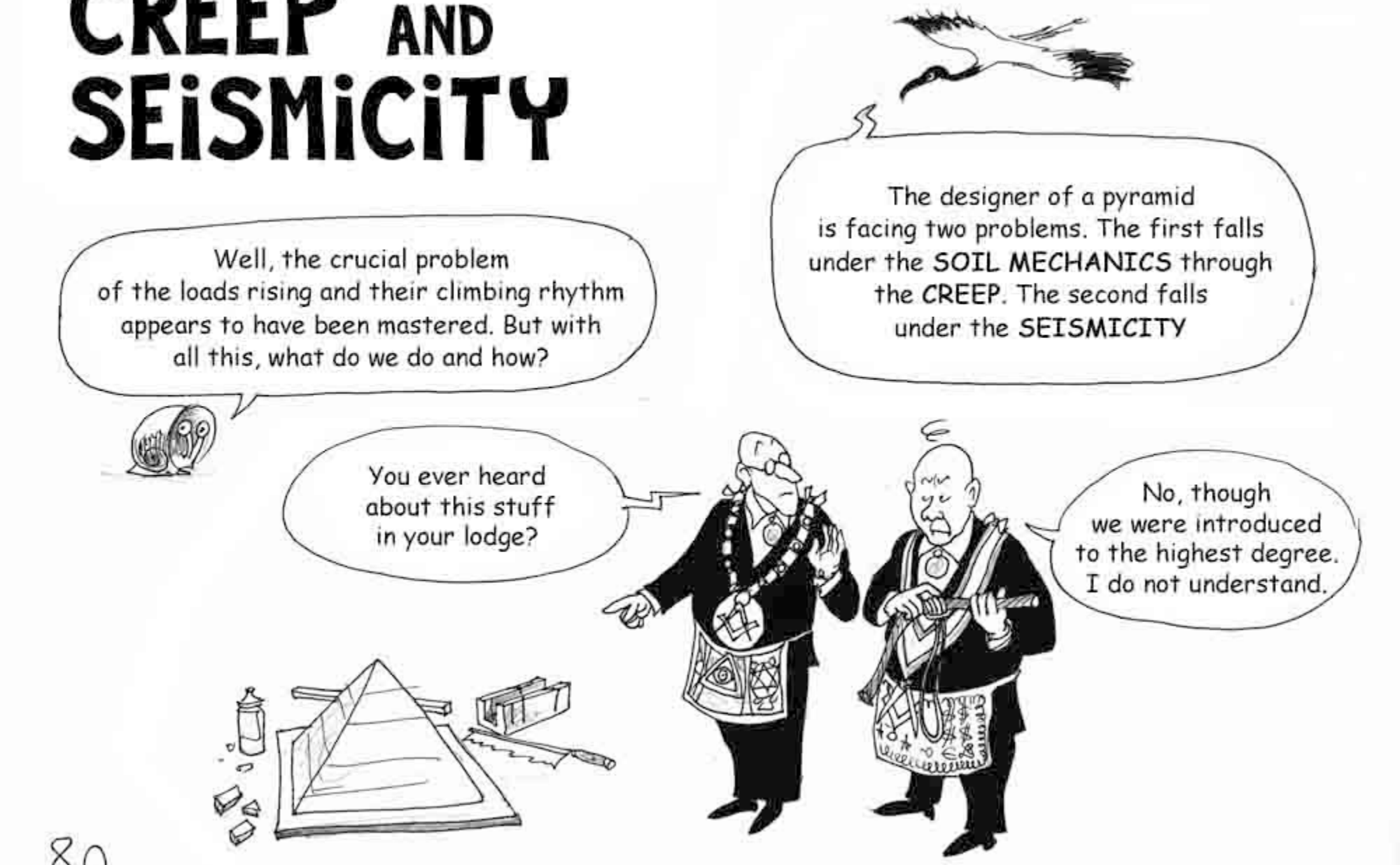


Hauling of the "standard" blocks
on a ramp portion with a very low slope.

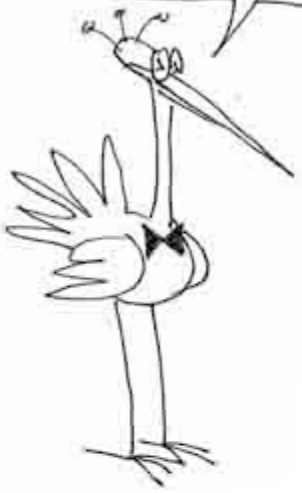
When the program involves
the setting up of the 52 granite
monoliths, we change the technique:
machines (see pages 45-53).
Thanks to them, two half-dozen
of men can create alternating
tensile forces of 400
to 1200 kilos.



CREEP AND SEISMICITY

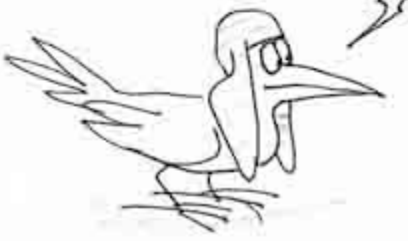


The volume of the Cheops pyramid is 2.5 million cubic meters. With an average volume of one cubic meter per block, it represents two and a half million blocks, right?



The discovery in the nineteenth century of the **TEXT OF THE PYRAMIDS** gives to them and to their **FUNERAL COMPLEX** the nature of metaphysical machinery, associated with a complex theme. This aspect encouraged Egyptologists to decipher these structures in a **SYMBOLIC** point of view. Thus the reference to a "staircase allowing the Pharaoh to reach heaven" led them to think that this sentence could have been the source of **STEP PYRAMIDS**.

Is the architecture of pyramids a "hard" translation of a religious theme?

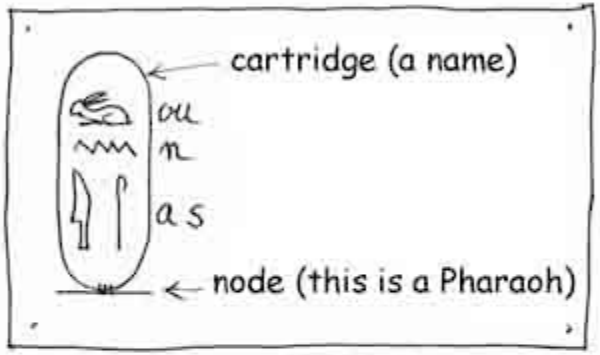


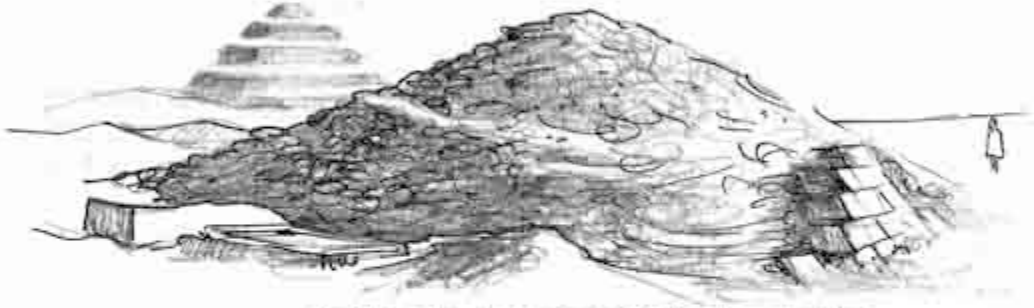
Or, conversely, is the religious texts are not a form of encoding solutions imposed by technical requirements?

The step structures are ubiquitous under the pyramids, for example in the three satellite pyramids of that of Menkaure (which is visible in the background). It seems reasonable to think that such step may also exist under the superficial parts of the Giza Pyramids, less degraded than others, due to the systematic robbery by stone thieves, practiced throughout all the ancient and modern history of Egypt. To the point that we can wonder if the oldest pyramid, the one of Pharaoh **DJOZER**, at Saqqara, built by **IMOTHEP**, was not initially a **SMOOTH PYRAMID**, transformed into a Step Pyramid because of the **STONE-ROB** game, which would have revealed its underlying steps.

The pyramid of Pharaoh Djozer at Sakkara (2600 BC)

On the sixty identified pyramids in Egypt, most of them, if their underground structures can be very rich, offer a very dilapidated appearance because of the stone robbery, operated even from the Pharaonic period. Below, that of Pharaoh Unas (2320 BC), which the interior (see page 15) contains the TEXT OF THE PYRAMIDS.

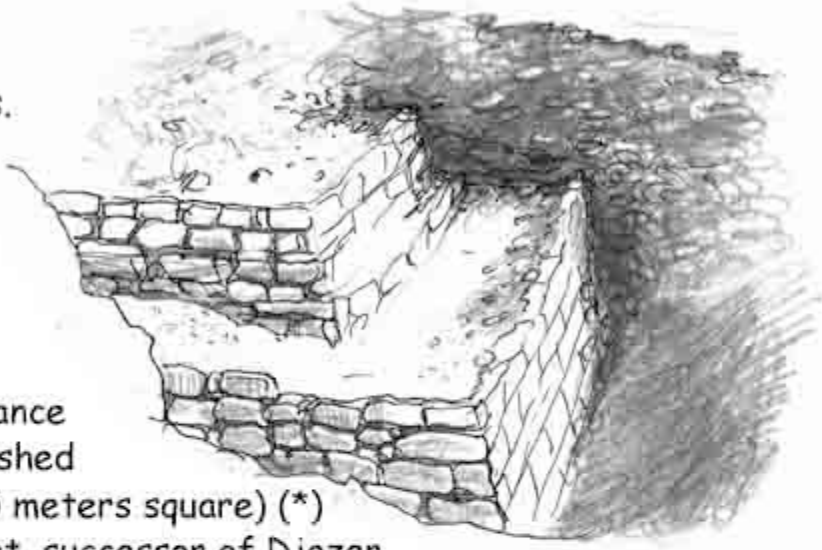




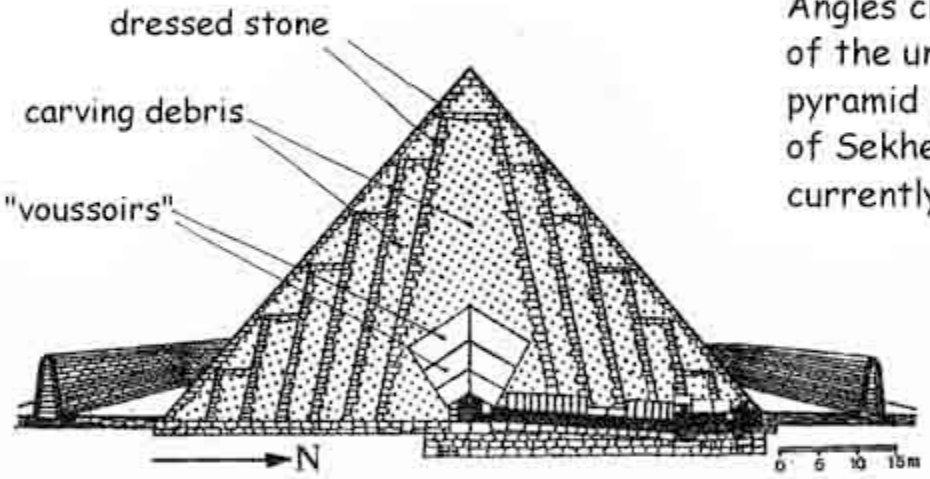
Sakkarah, remains of Unas' pyramid
Original height 43 meters. Today: 11 meters

(*) Limestone is a sedimentary rock.

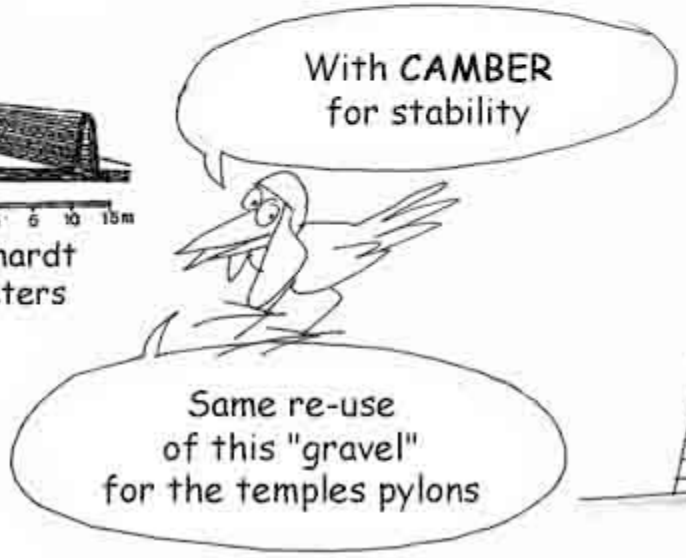
The fact that some pyramids reveal
their internal structure indicates that we mingled
"sloping walls", in "Russian Dolls," and carving debris.
This led some Egyptologists in 1900,
as the German Ludwig Borchardt,
to consider the diagram below.



Angles clearance
of the unfinished
pyramid (105 meters square) (*)
of Sekhemket, successor of Djozer,
currently completely covered by sand.

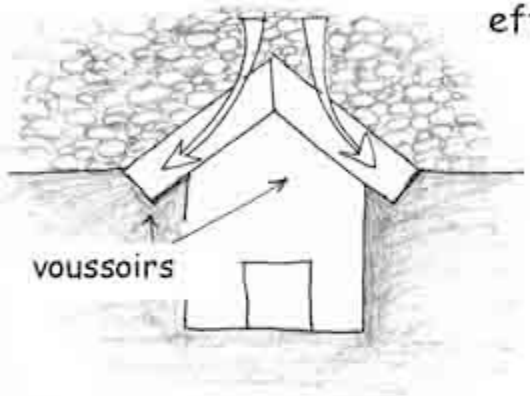


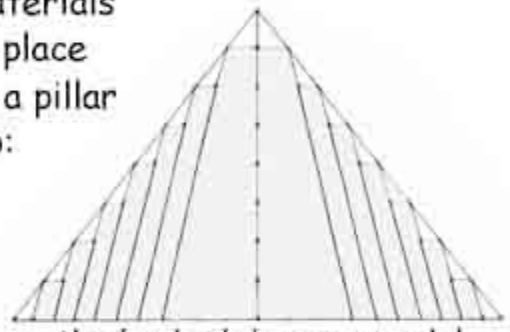
Section of Sahure pyramid according to Borchardt
Before degradation 47 meters. Today: 36 meters



(*) It is the same size as that of Djozer.

As in the pyramid of Unas, the wish is to locate the sepulchral chamber as high as possible, outside the ground level. This has prompted designers to use "voussoirs" for laterally redistribute the tremendous compressive forces created by the mass of stones located above. This is a very effective system in case of earthquake and accommodates well with a distribution "in bulk" of the materials located above. But this desire to place higher imposed that it is based on a pillar of paired stone, this leading to:





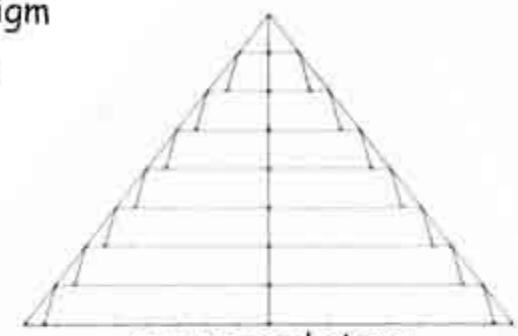
the backed degrees model.

Many specialists and experts still believe that pyramids designers of the Ancient Egyptian Empire (2700-2200 BC) proceeded by **EMPIRICISM**. Determined to create sustainable structures and aware of the major importance of **SEISMICITY**, they knew rather well where they were going, involving as sophisticated and original solutions, ingenious at all levels.

But none had probably expected that the survival of a pyramid was based mainly on the choice of a stone of very poor quality.

But Borchardt idea did not make time and with the years, with little justification, and inconsistent with the observations made on site, arrived the paradigm that step pyramids, inspired by MASTABAS, that predated them, should be **STACKS OF MASTABAS.**

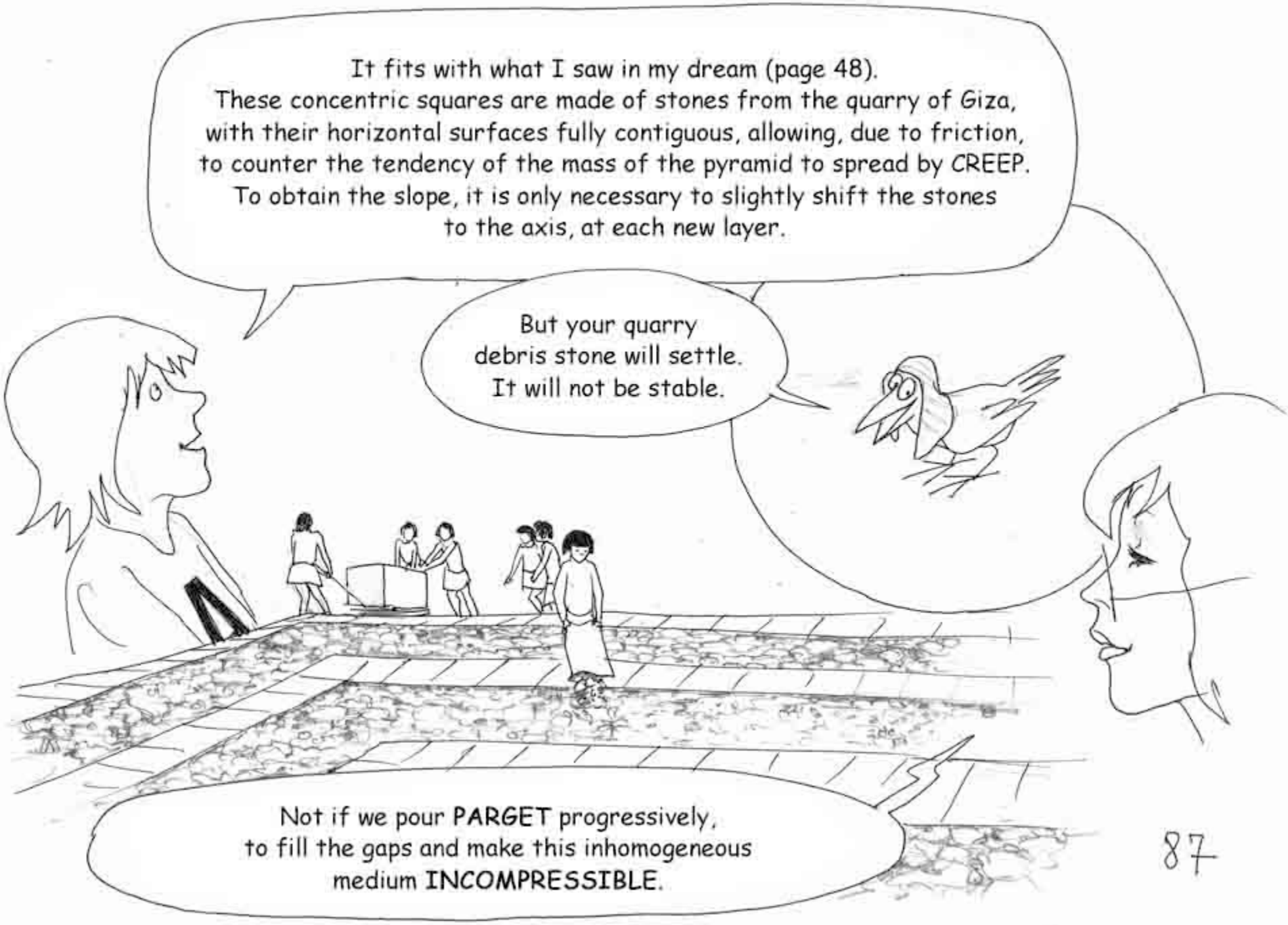
mastaba



superposed steps.

Layered accretion, with strong slopes. Djozer pyramid.

(*) Debris that are strangely absent on pyramids sites.


It fits with what I saw in my dream (page 48).
These concentric squares are made of stones from the quarry of Giza, with their horizontal surfaces fully contiguous, allowing, due to friction, to counter the tendency of the mass of the pyramid to spread by CREEP.
To obtain the slope, it is only necessary to slightly shift the stones to the axis, at each new layer.
But your quarry debris stone will settle. It will not be stable.
Not if we pour PARGET progressively, to fill the gaps and make this inhomogeneous medium INCOMPRESSIBLE.

It makes me think of one thing.
It is classically considered that the Bent Pyramid was initially planned to have a slope greater than fifty degrees. But this structure would have proved unstable.

CRAAAK

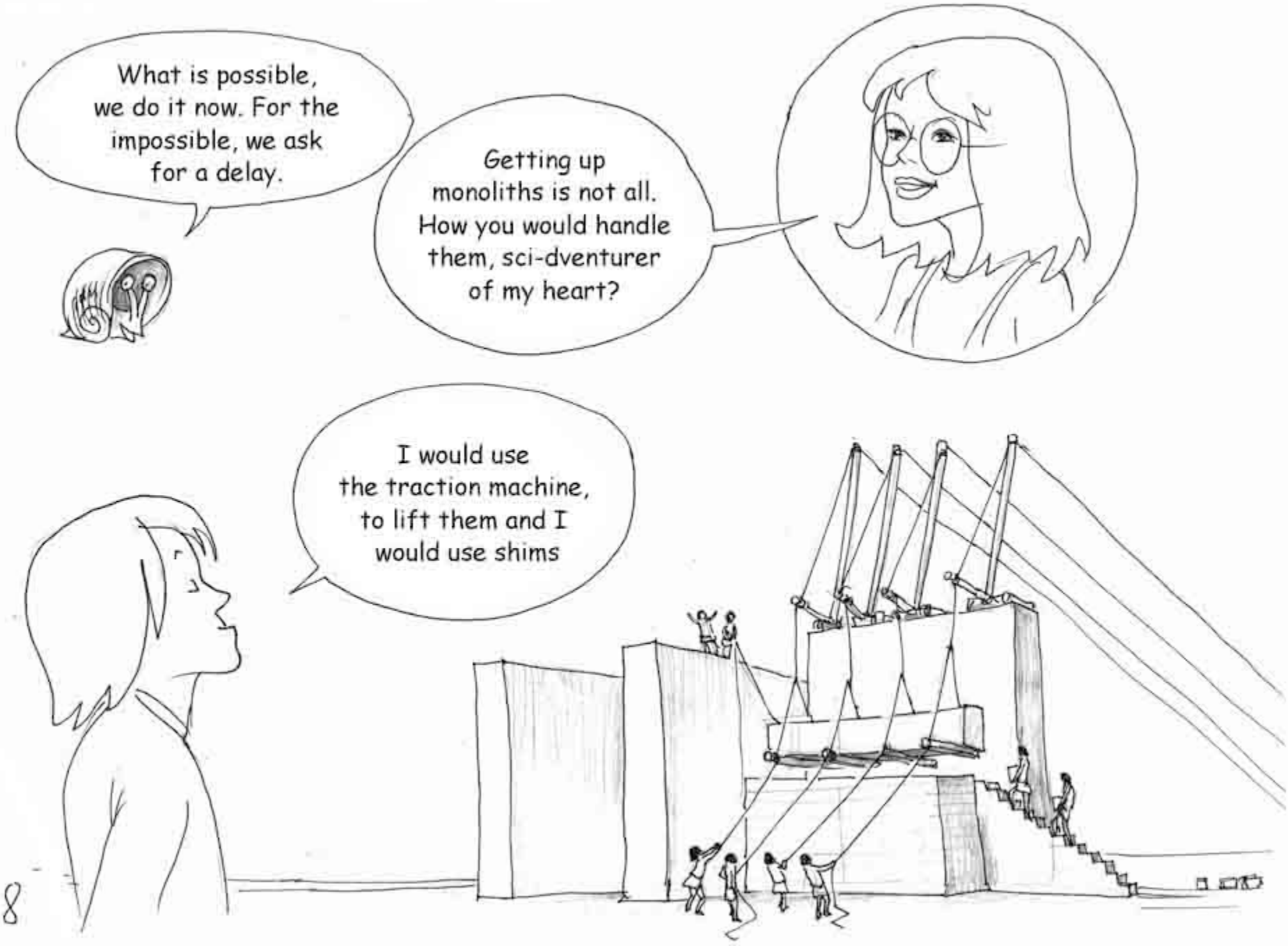
The architects-priests then decided to reduce the slope to 43°, hence its peculiar geometrical shape.

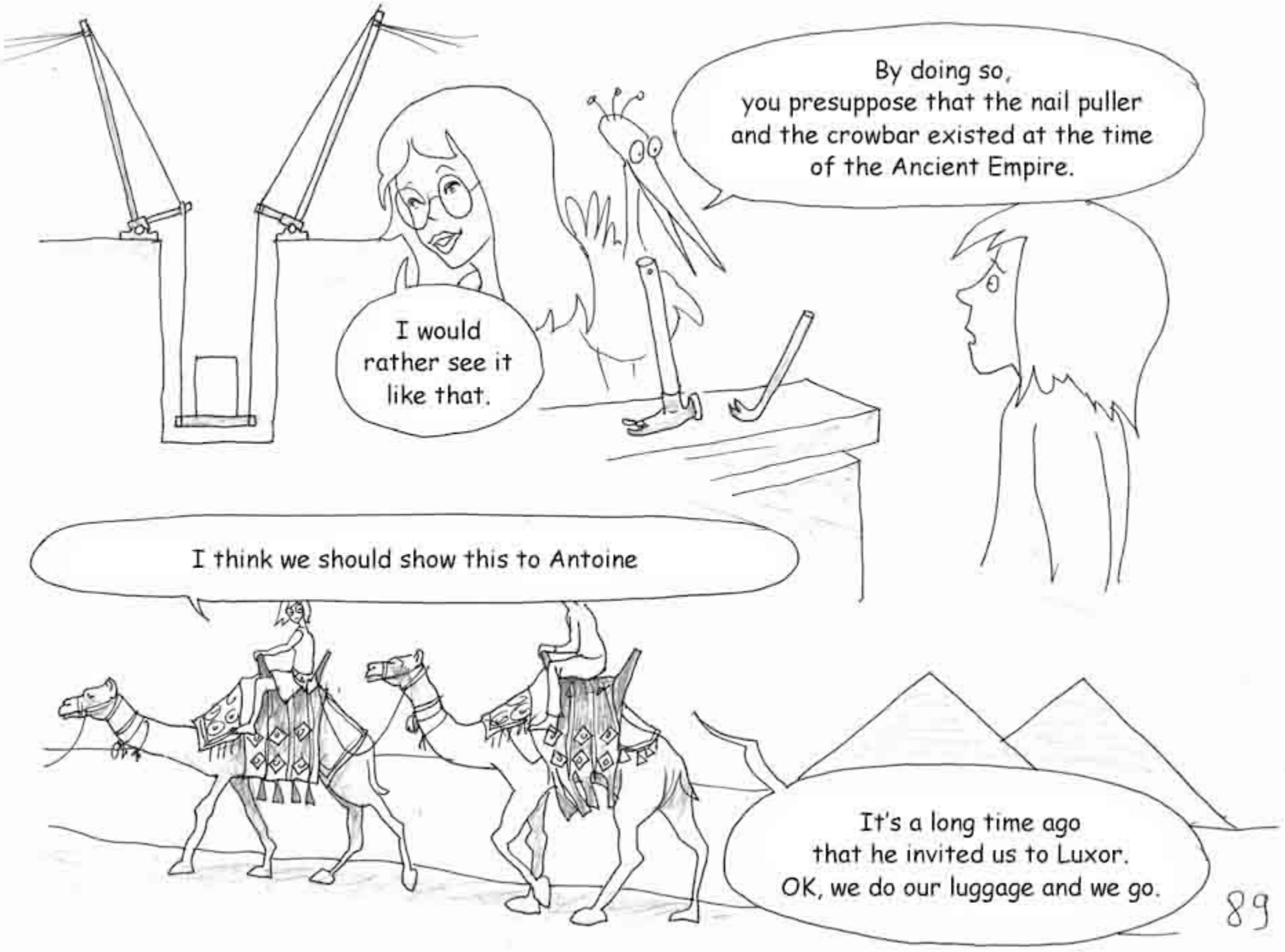
But another idea is to imagine that the pyramid, once completed, was plundered, affecting its first foundations.

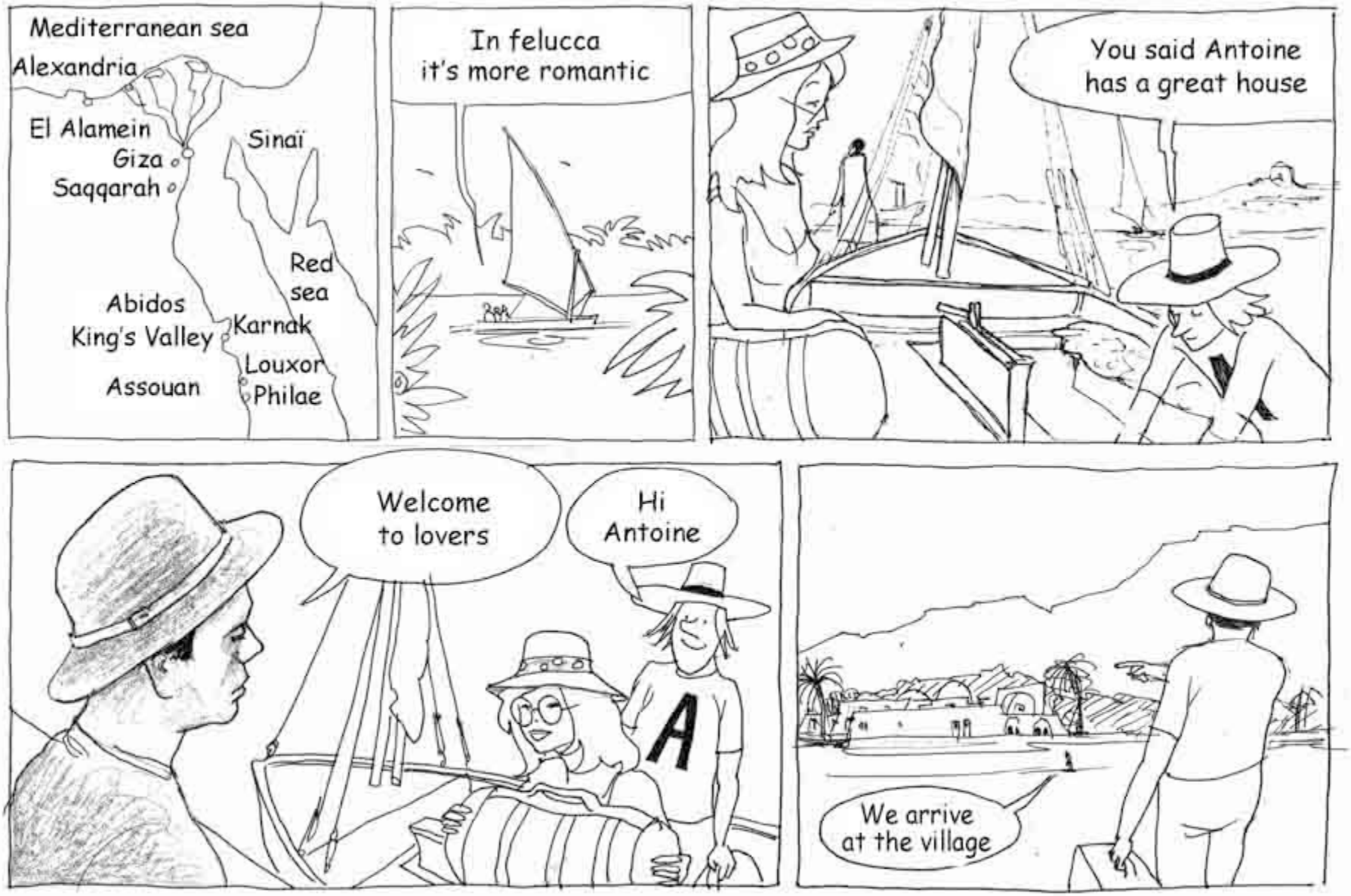
And its current form would result from reparation, plating facing stones on the apparent oblique foundation.

Without such undressing and the reparation that followed, it would have been a copy of the Red Pyramid (in the background).

87 bis


What is possible, we do it now. For the impossible, we ask for a delay.
Getting up monoliths is not all. How you would handle them, sci-dventurer of my heart?
I would use the traction machine, to lift them and I would use shims


By doing so,
you presuppose that the nail puller
and the crowbar existed at the time
of the Ancient Empire.
I would
rather see it
like that.
I think we should show this to Antoine
It's a long time ago
that he invited us to Luxor.
OK, we do our luggage and we go.

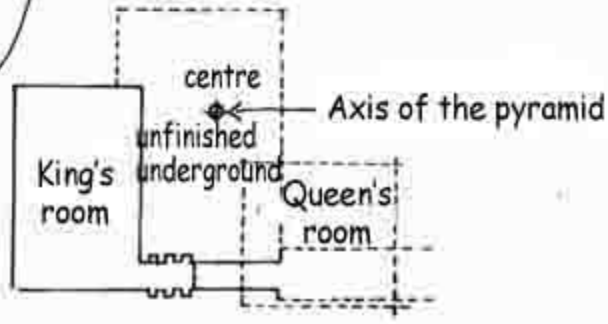

Mediterranean sea
Alexandria
El Alamein
Giza
Saqqarah
Sinaï
Red sea
Abidos
King's Valley
Karnak
Louxor
Philae
Assouan
In felucca it's more romantic
You said Antoine has a great house
Welcome to lovers
Hi Antoine
A
We arrive at the village

The object described by Anselm, in his machine, which avoids strings wear, exists. Made of basalt, it was discovered in 1932 in Giza by Egyptologist Selim Hassan near the ruins of the pyramid of Queen Khentkaoues.

I looked at the notes that you sent me

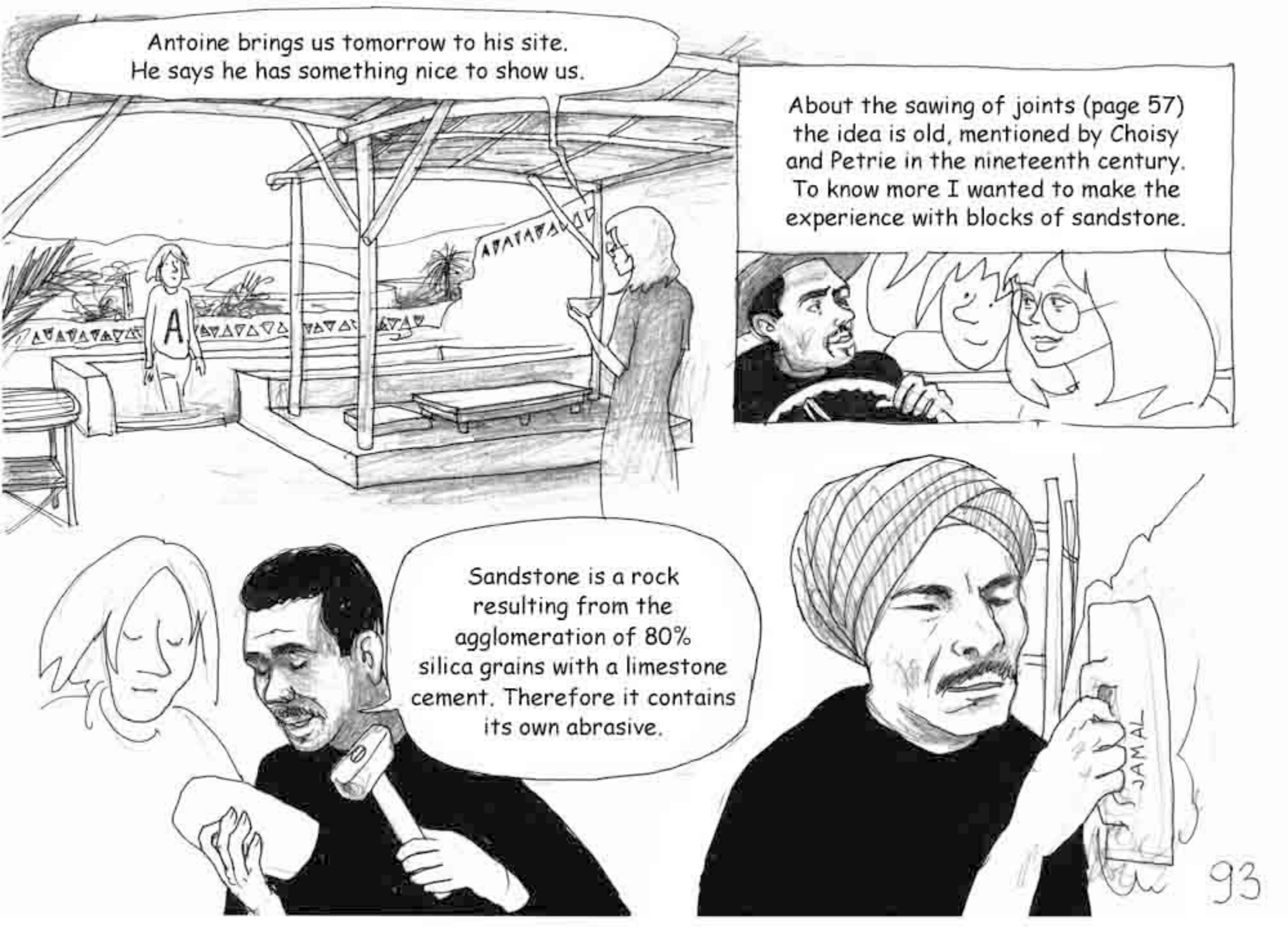
We checked. Except when the rooms are underground, in all the pyramids, they are always off the axis.

The stone ramp: not bad. And you pick up the idea of the central pillar. But how do you place the rooms inside the pyramid of Cheops?



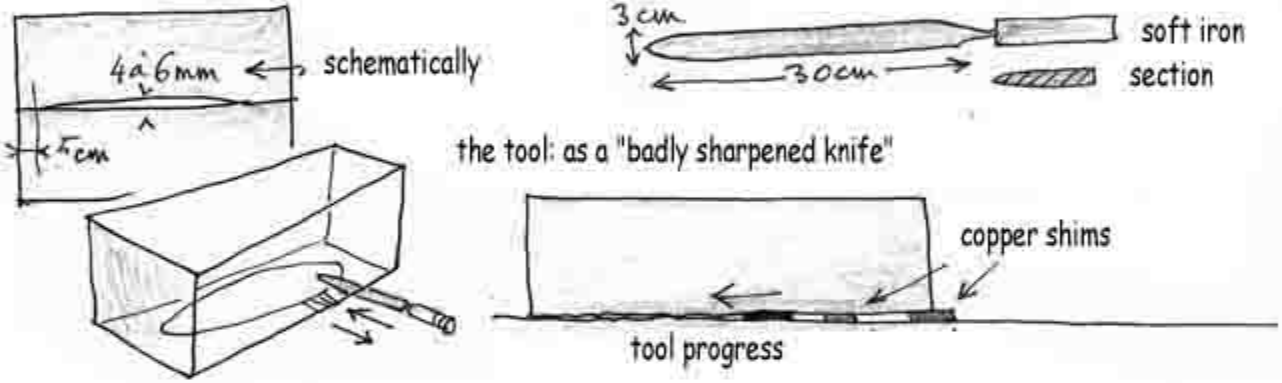
Cheops


The triangular blocks? I rather see them as cutting residues carried out by robbers, at the ground. But it is only an opinion. It would be simpler to consider a facelift at loss, on the top. As for the "withdrawal blocks," I go instead for a deterioration of the stone. This is not nearly as stable and consistent as you think. Blocks already carved, yes, but with bosses which must disappear during finishing.
And concerning arguments based on the absence of mud bricks, you should know that unlike the carving debris, it is a reusable material. I made the experience at Karnak.
Well, the one who knows the stone, it's you. That is why we came to see you.

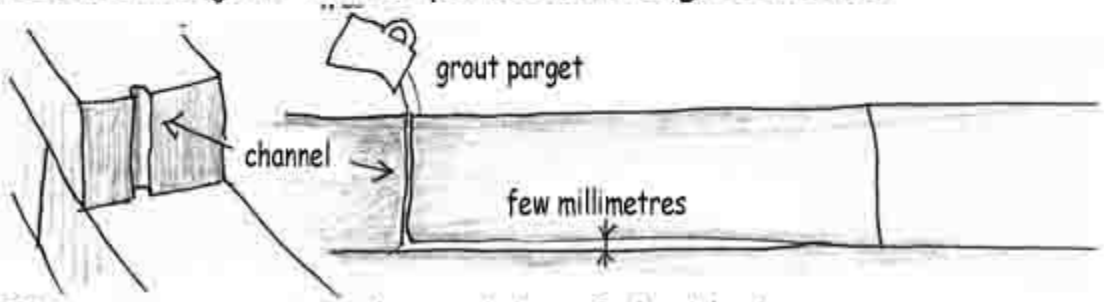

Antoine brings us tomorrow to his site.
He says he has something nice to show us.
About the sawing of joints (page 57) the idea is old, mentioned by Choisy and Petrie in the nineteenth century. To know more I wanted to make the experience with blocks of sandstone.
Sandstone is a rock resulting from the agglomeration of 80% silica grains with a limestone cement. Therefore it contains its own abrasive.
JAMAL

At all times, including the Ancient Empire, we see that stones of all sizes are joined so tightly that we cannot drag a razor blade in the joints. Moreover, these joints are sinuous. Since the nineteenth century, Egyptologists have suggested that these seals have been "worked". Antoine has focused his attention on relatively recent buildings (the Ptolemaic period (*), in sandstone. The examination showed traces of tool (saw joints)). The facing stones were not worked through their entire contact surface but only on their periphery, on 3 to 5cm deep. The rest of the surface was "refined". We create on both opposite faces concavities of 3 to 4mm.

The sawing of the joint is then undertaken. In the sandstone, silica particles detaches and provide the desired abrasion resistance. The tool progresses by 4cm per minute. We place copper shims progressively.

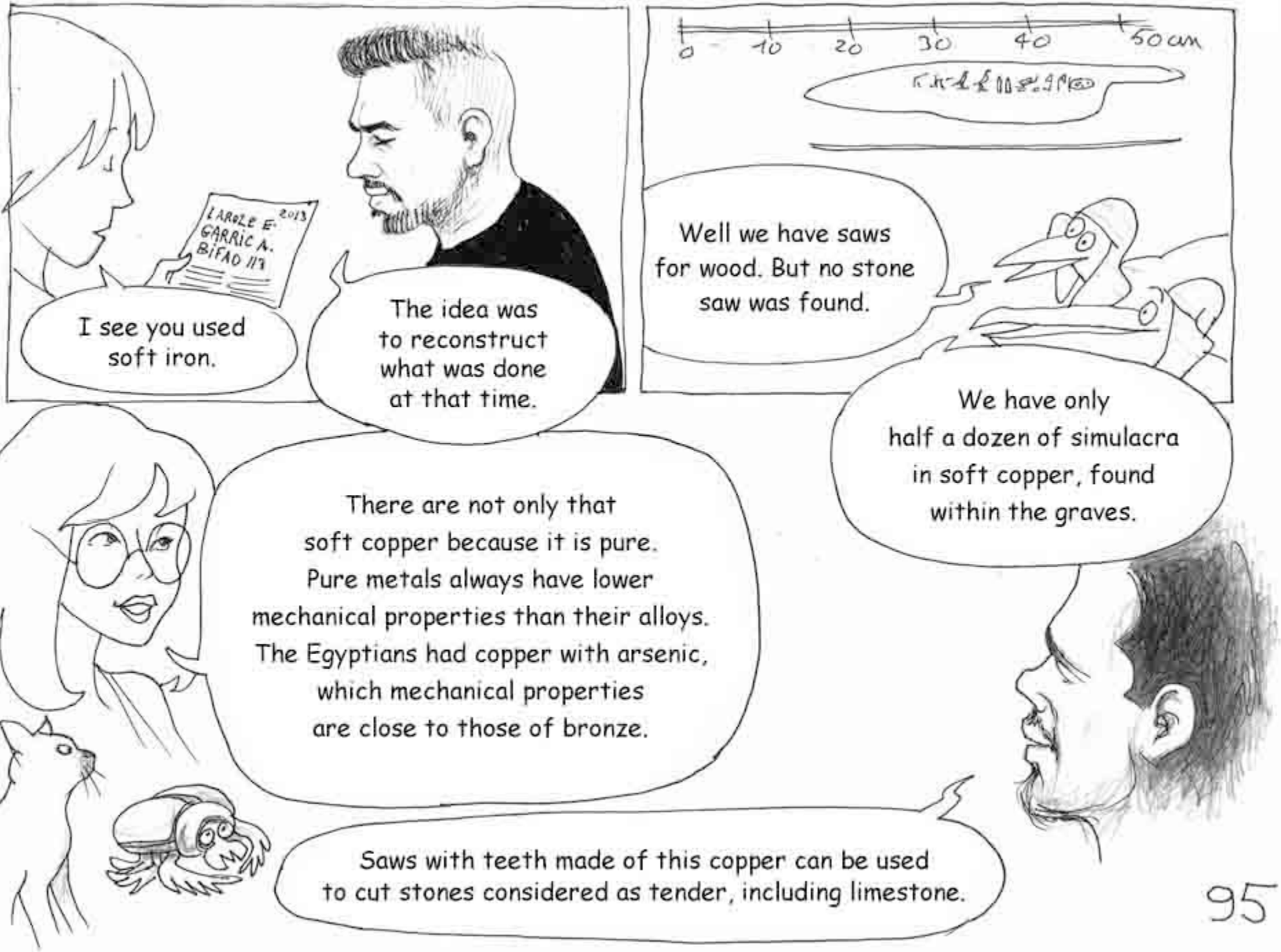


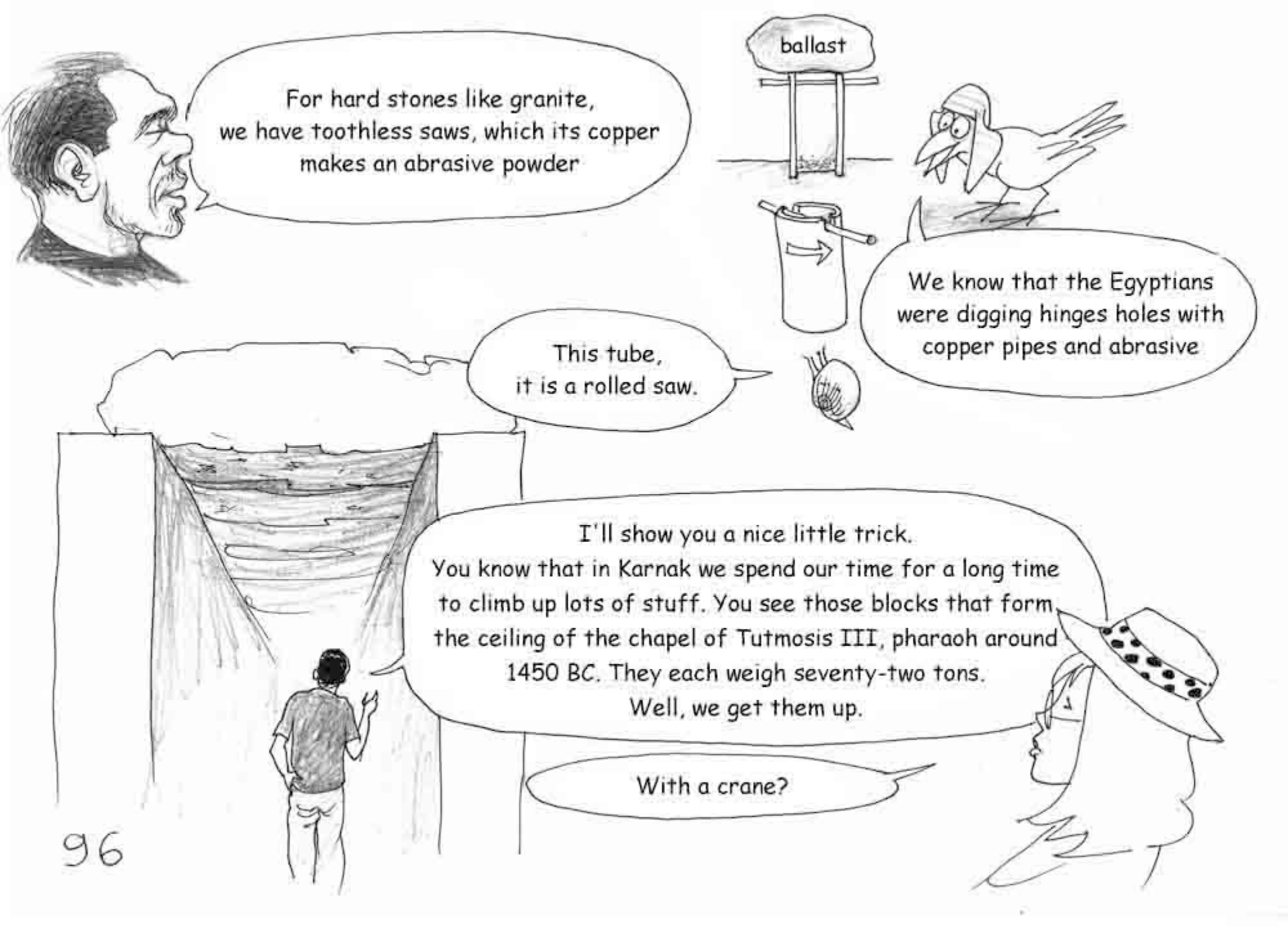
When the loop is made, the shims are removed and the joint is then perfect. Through a channel created for this purpose, we pour parget into the inter-joint space. The contact between the two blocs is both intimate and total over the entire surface.



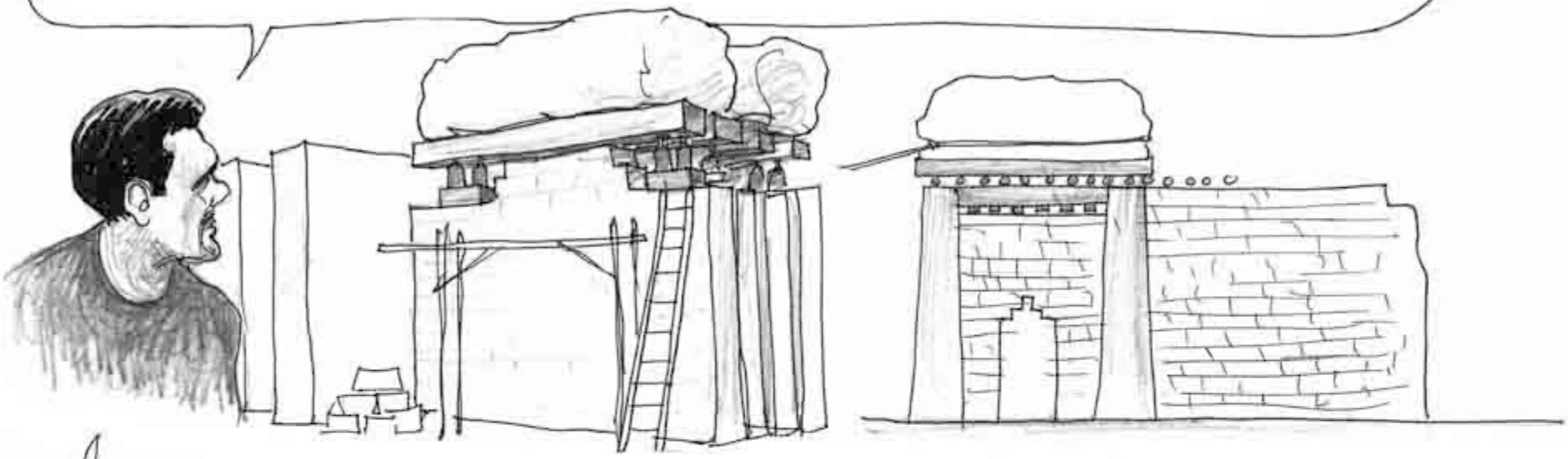
A final sinuosity of a few millimeters is sufficient to guarantee the wedging of the blocks.

(*) From 300 BC to 30 BC.


I see you used soft iron.
LAROZE E. GARRIC A. BIFAO 2013
The idea was to reconstruct what was done at that time.
0 10 20 30 40 50 cm
Well we have saws for wood. But no stone saw was found.
We have only half a dozen of simulacra in soft copper, found within the graves.
There are not only that soft copper because it is pure. Pure metals always have lower mechanical properties than their alloys. The Egyptians had copper with arsenic, which mechanical properties are close to those of bronze.
Saws with teeth made of this copper can be used to cut stones considered as tender, including limestone.


For hard stones like granite,
we have toothless saws, which its copper
makes an abrasive powder
ballast
We know that the Egyptians
were digging hinges holes with
copper pipes and abrasive
This tube,
it is a rolled saw.
I'll show you a nice little trick.
You know that in Karnak we spend our time for a long time
to climb up lots of stuff. You see those blocks that form
the ceiling of the chapel of Tutmosis III, pharaoh around
1450 BC. They each weigh seventy-two tons.
Well, we get them up.
With a crane?

Our crane at Karnak has a maximum lifting capacity of 23 tons. But I like challenges.
I wanted to know if I could negotiate it with simple hydraulic jacks, wooden beams and stones.



We did play alternating uprisings by hydraulic jacks, the use of wooden blocks and accompaniment based on a stone wall mounted progressively. When the block was at 4.25 meters, we dragged it and finally we dismantled all the extra masonry.

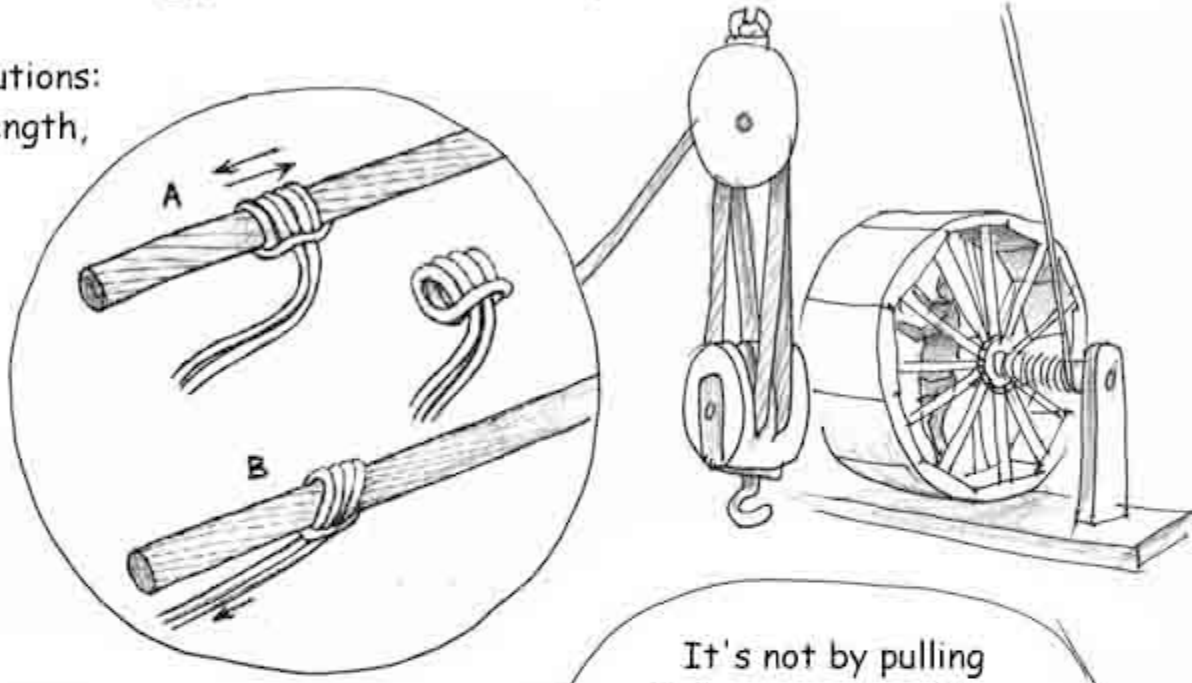
Awesome,
but Tutmosis III
did the same without
hydraulic jacks!

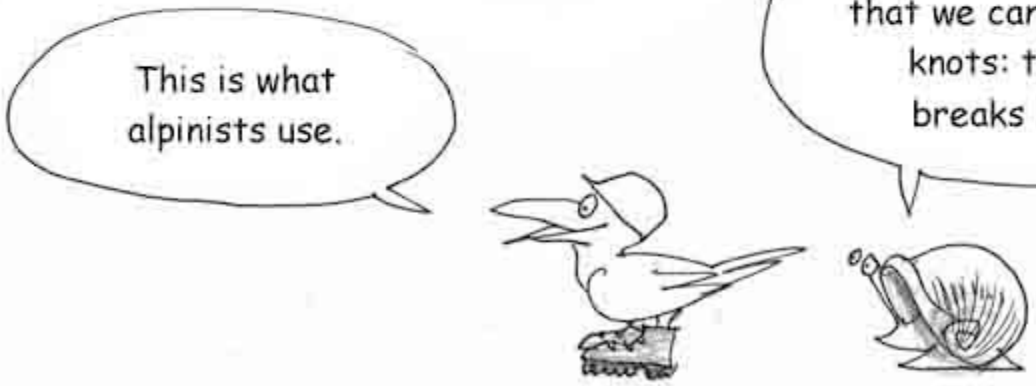
Hmm ...
mud brick ramp,
ropes and people!

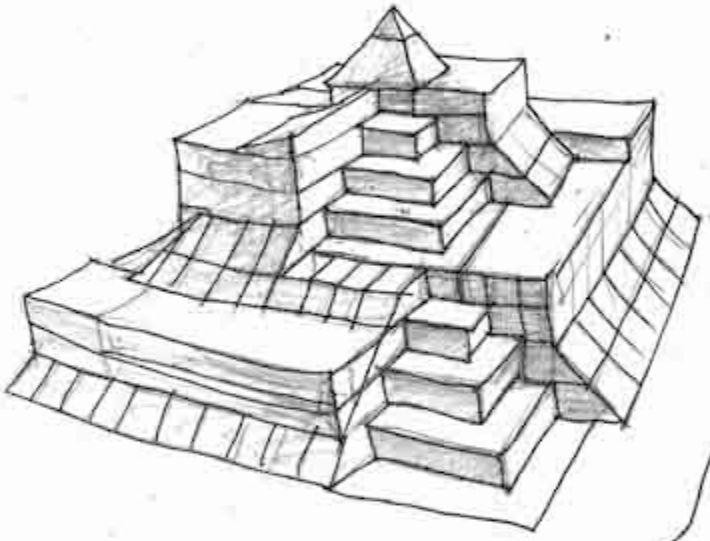
The Greeks and Romans had all kinds of machines. We attribute the invention of the muffle to Archimedes. What do we known about machines of the ancient Egyptians? It remained only rare specimens of the tools they used to carve stone.

Finally, for heavy loads there are two solutions: to act continuously by leveraging the strength, or by sequences, as did Antoine.

Without a solid metal to make pins, the ropes system with self-locking knots is logically necessary.



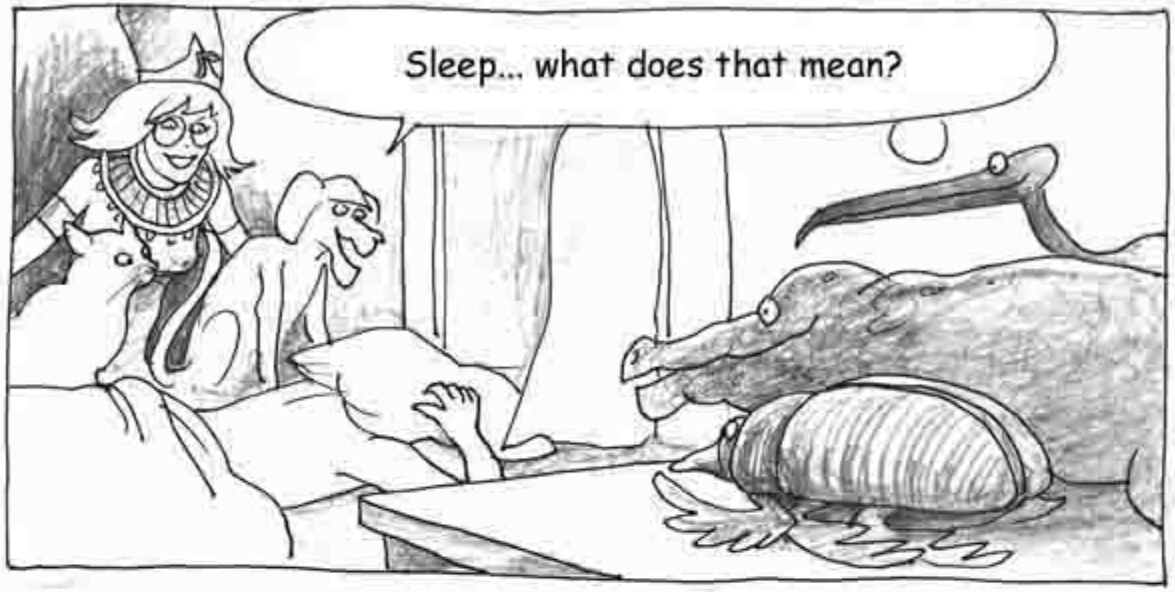


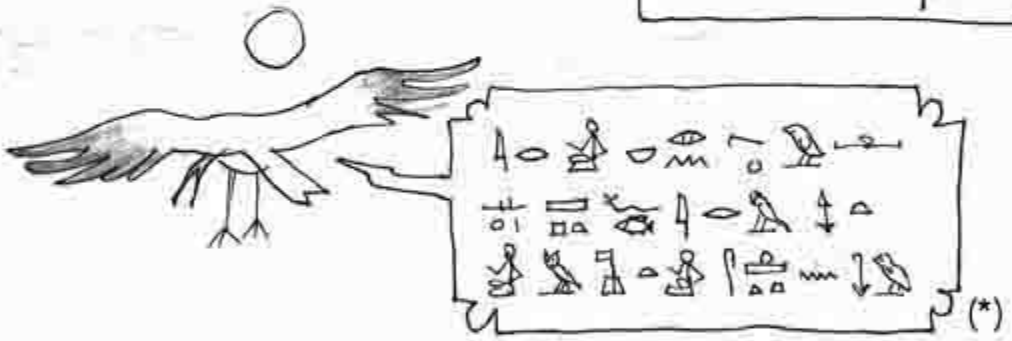


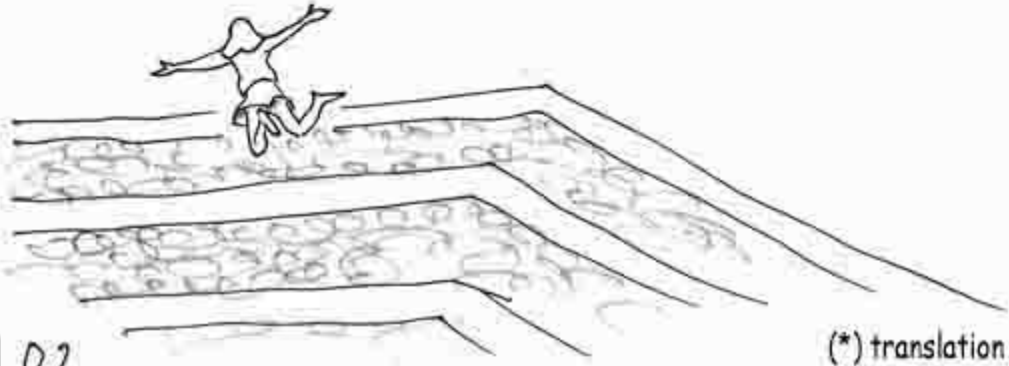
Your model is nice.
It's a very nice puzzle. But something is missing. The pyramid stones are not nearly as regular. Successive foundations have heights that vary within a factor from one to three! It depends on the thickness of the vein from which they are extracted. You need an accurate tracking system for blocks positions.


Well, welcome back to you both!
Say, I thought to what Antoine said about the problem of identifying the blocks. Is a small turn in this past life...?
Stop with this nonsense, want you?
Me, what I was saying, it was for Egyptology...
You are back in Cairo. Good, because when you left you had forgotten something.

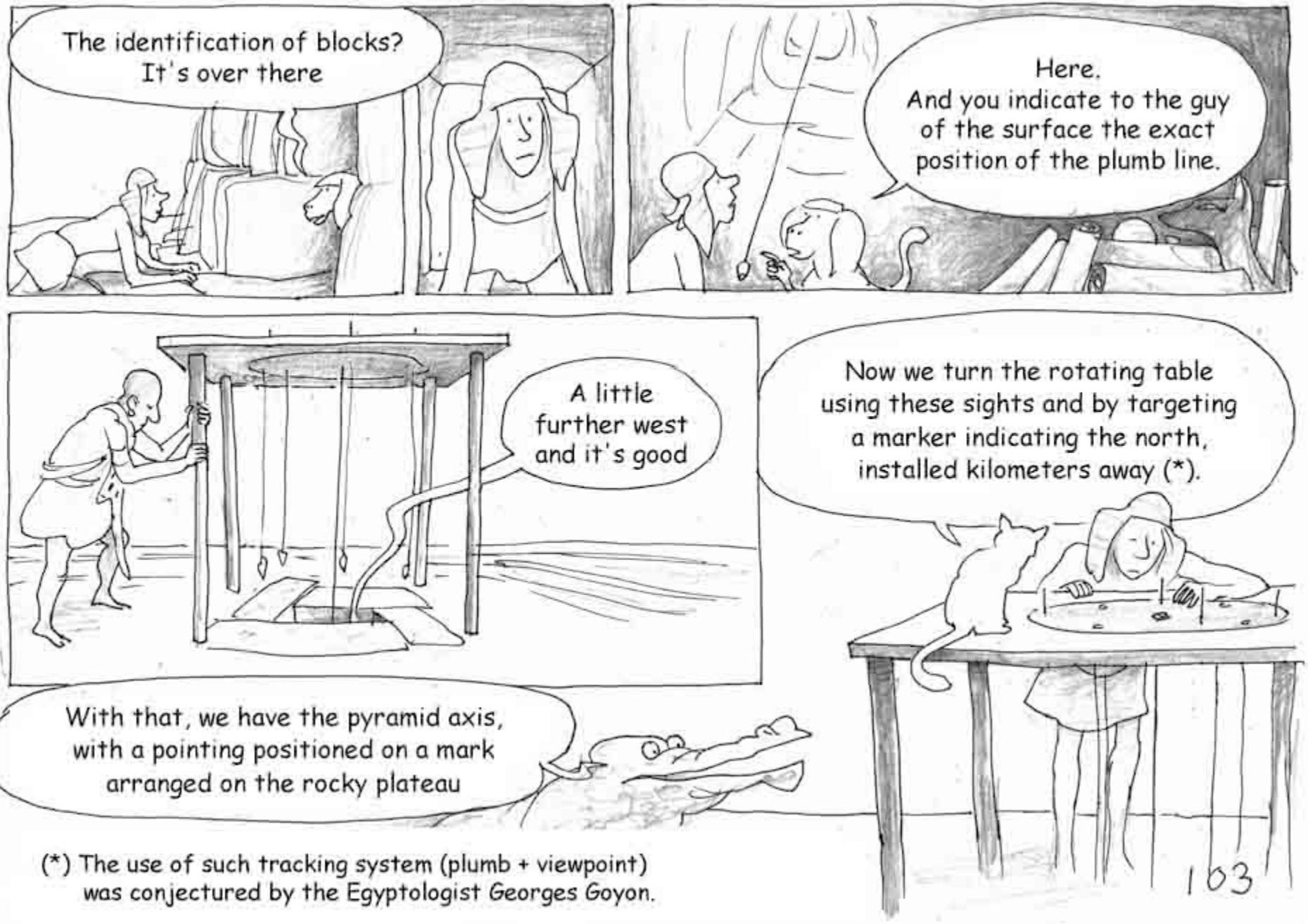

What was that,
the thing we had forgotten?
The beetle
That's... what gave me
a guy in the soukh.
Are you
coming ?
I am coming




(*)

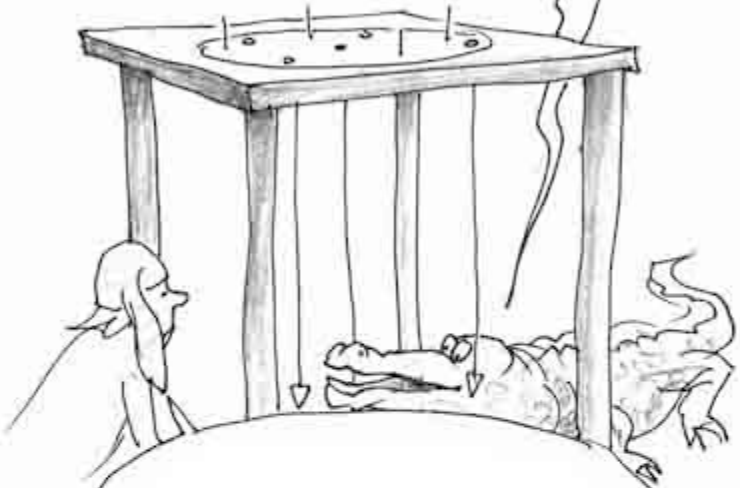


(*) translation of the hieroglyph: "Every man who has done this (the tomb) for me, he will never have to repent; sculptor or carrier, I will reward him".

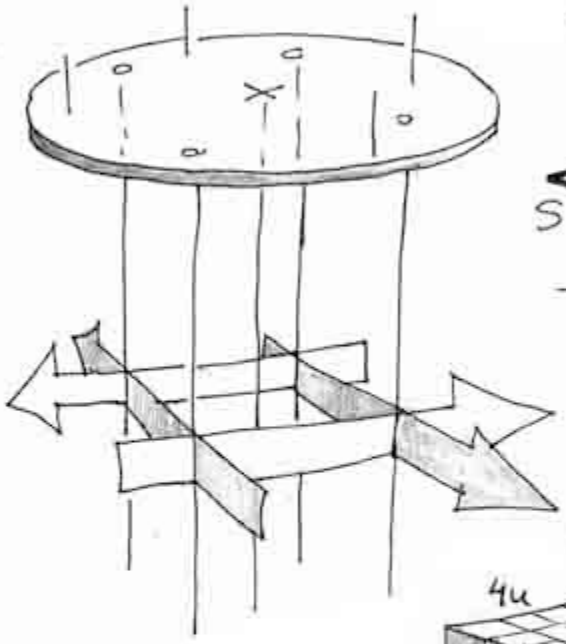


(*) The use of such tracking system (plumb + viewpoint) was conjectured by the Egyptologist Georges Goyon.

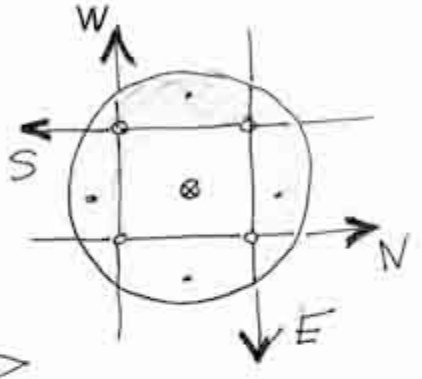
Then we use weighted wires, part of the rotary table, which are arranged such that, taken in pairs, they point with great precision towards the four cardinal points N-S-E-W

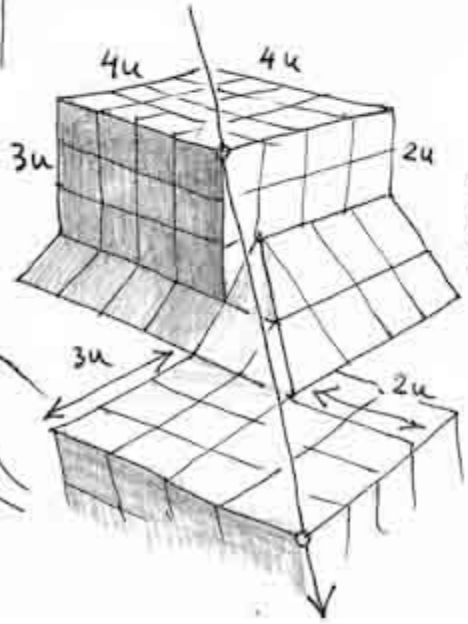


But these pointing directions don't pass through the pyramid axis?



alignment rotary table



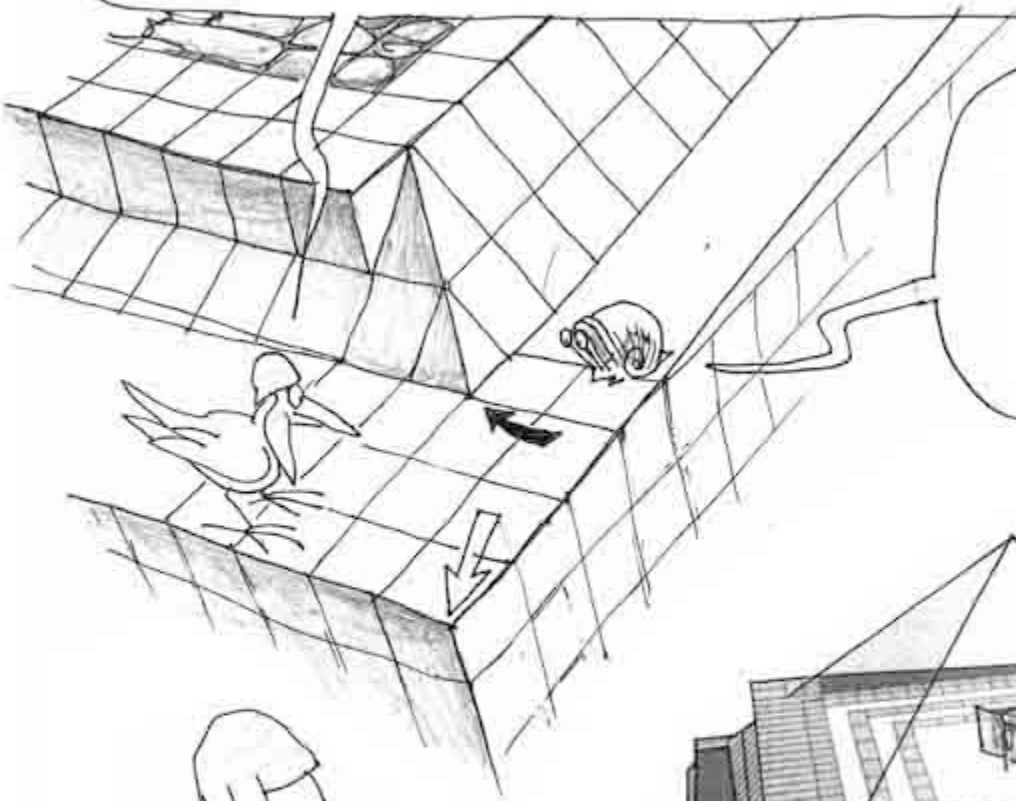


successive corner pieces

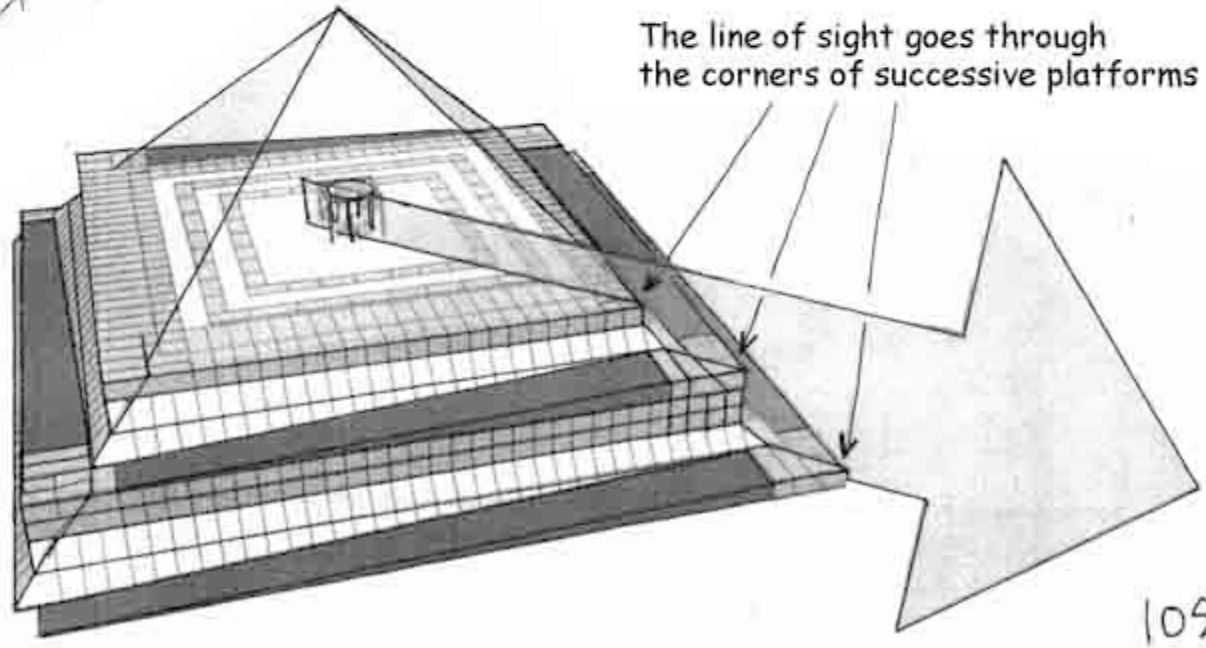
Even if the foundations exhibit some irregularity, if the angle blocks are positioned regularly, then a tracking becomes possible, then we can situate with precision the position of the corners of the blocks in space.

Indeed, if we know the precise position of the platform corner,
we can use it to position the edge, from one to the other

The advantage is that
as the construction goes, we can locate these
corners with centimeter accuracy in relation
to the ground, and not with each other,
otherwise errors would eventually accumulate.

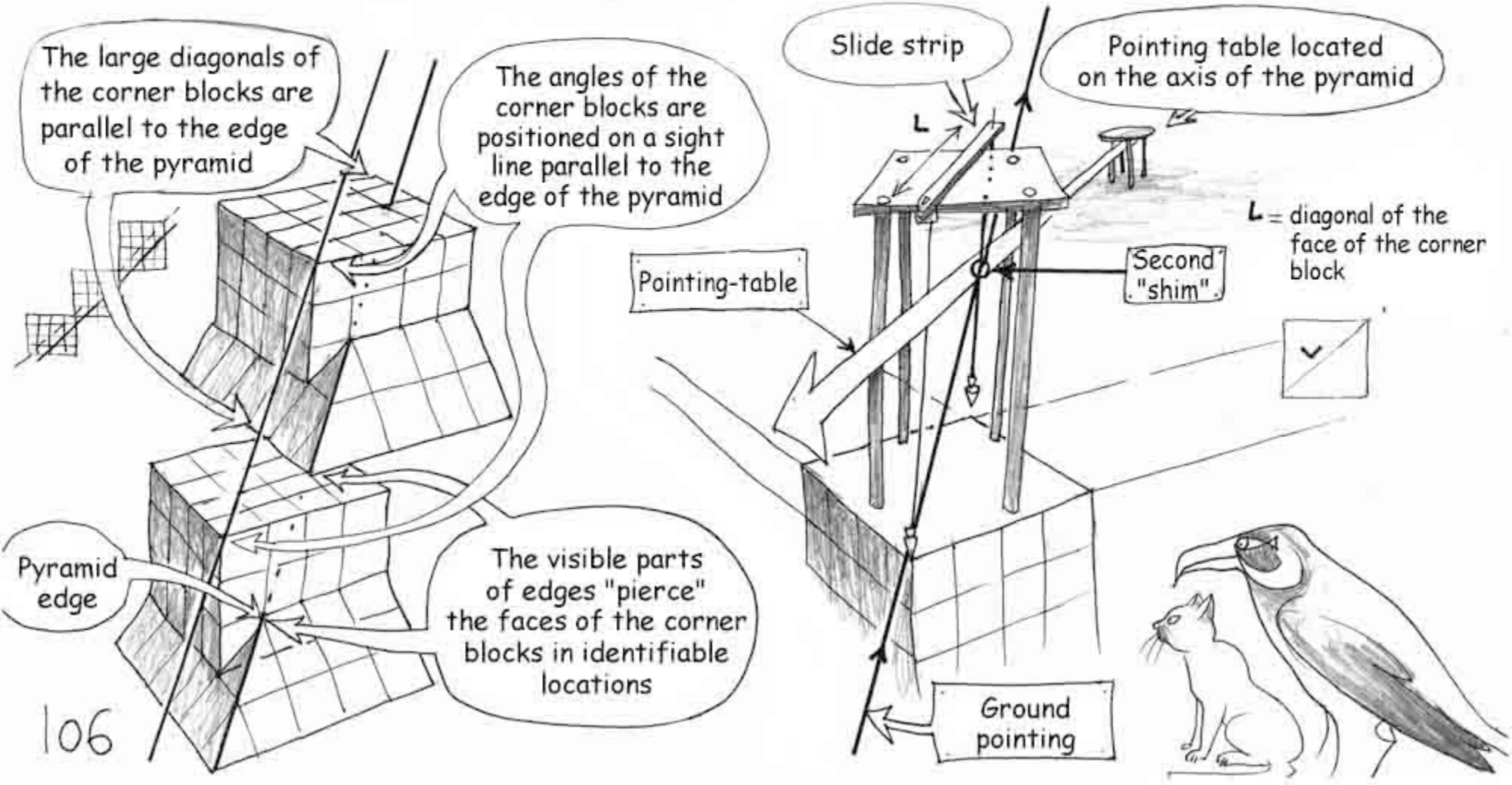


This gives ONE
pointing direction
but we need others

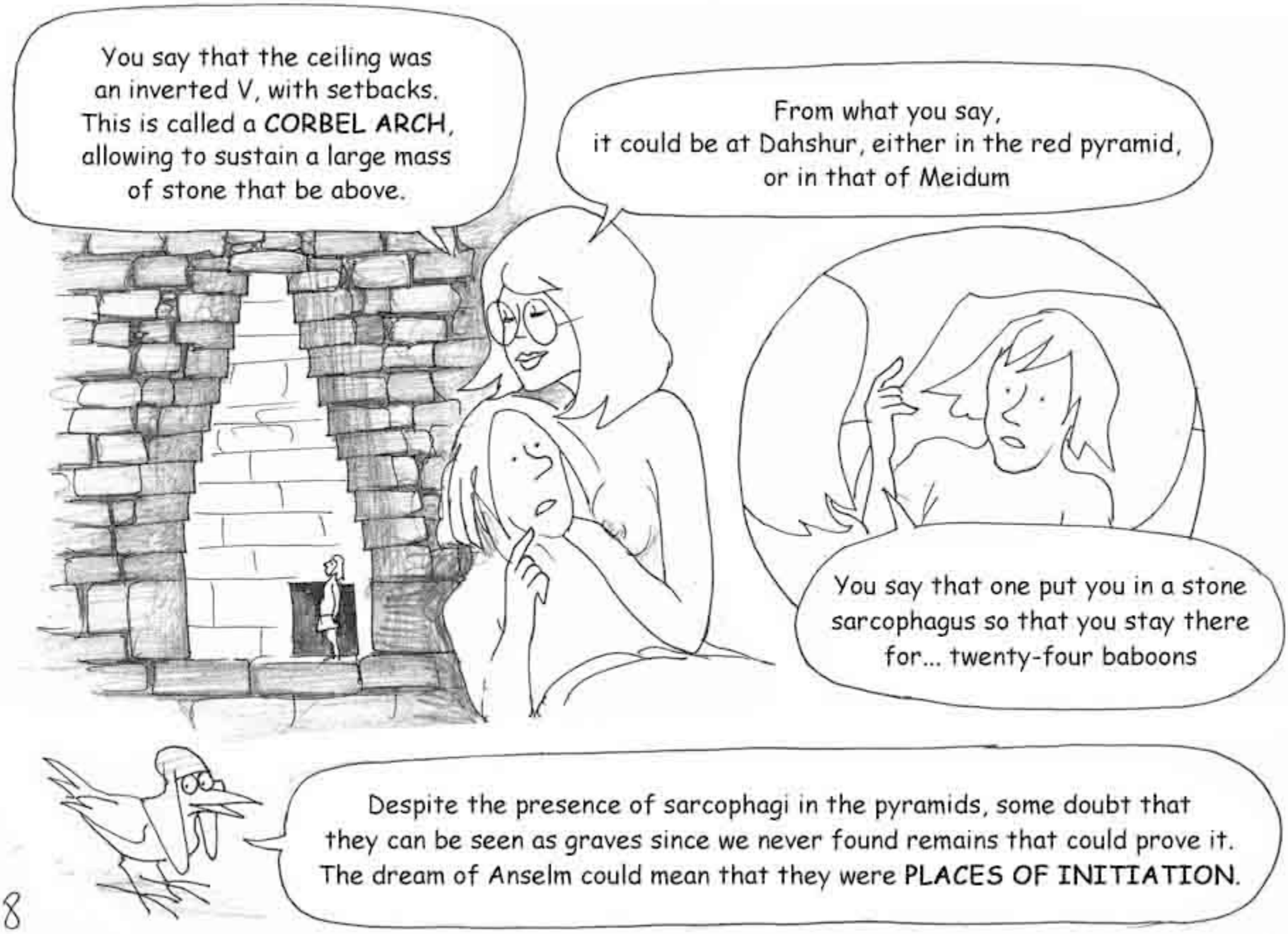


The line of sight goes through
the corners of successive platforms

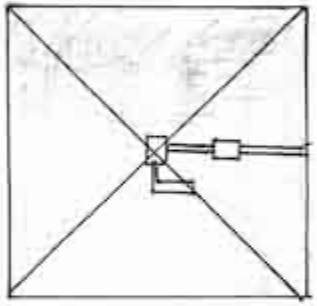
A pointing table like that allows to locate with great accuracy any point supposed to belong to the surface containing the angles of block corners, if they are aligned and equidistant. The diagonals of the upper faces of the corner blocks are parallel to the projection of the edges of these faces and the major diagonals of the parallelepiped corner block are parallel to the edges of the pyramid.



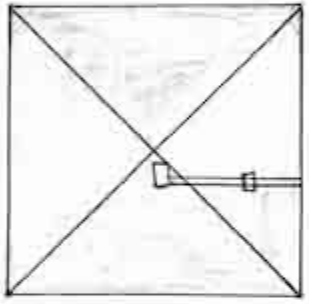

If you want to live, you must die
We will return in twenty-four baboons
Anselme, what happens? First you talk alone, and then you keep screaming "how much twenty-four baboons?"
Hee hee
I'll tell you everything


You say that the ceiling was an inverted V, with setbacks. This is called a CORBEL ARCH, allowing to sustain a large mass of stone that be above.
From what you say, it could be at Dahshur, either in the red pyramid, or in that of Meidum
You say that one put you in a stone sarcophagus so that you stay there for... twenty-four baboons
Despite the presence of sarcophagi in the pyramids, some doubt that they can be seen as graves since we never found remains that could prove it. The dream of Anselm could mean that they were PLACES OF INITIATION.

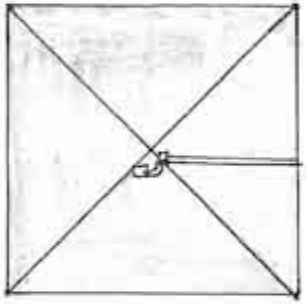
You know, Sophie, I think of two things:
Firstly if there is an axial well in the pyramids,
this could explain why the rooms, when they are
not underground, are all outside of the axis



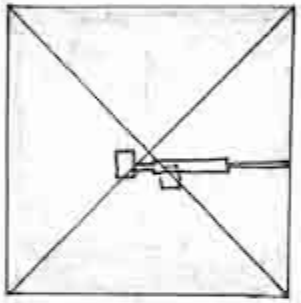
Mykerinos



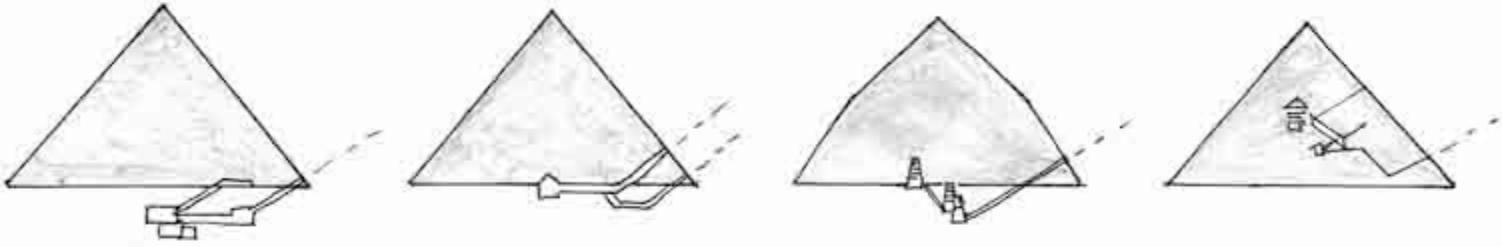
Khafre



Bent

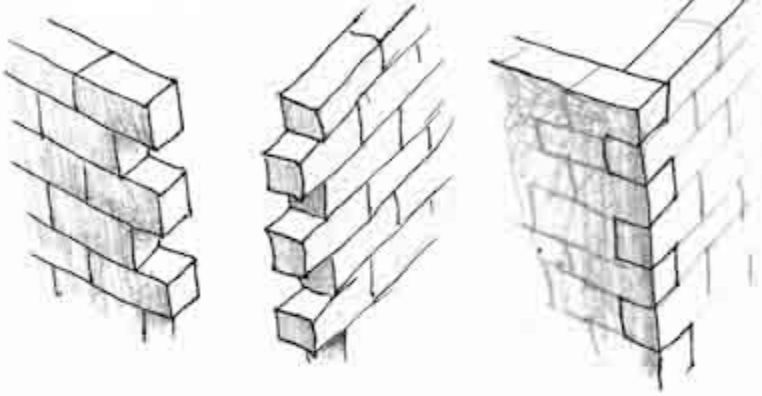


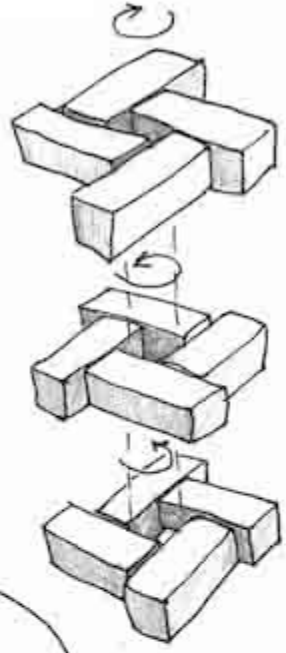
Cheops



Secondly all the "descents" and "ventilation tubes" are oriented almost exactly in the same direction and the same angle, which is convenient to be able to illuminate with mirrors.

In the corner of a wall we cross the stones to increase strength

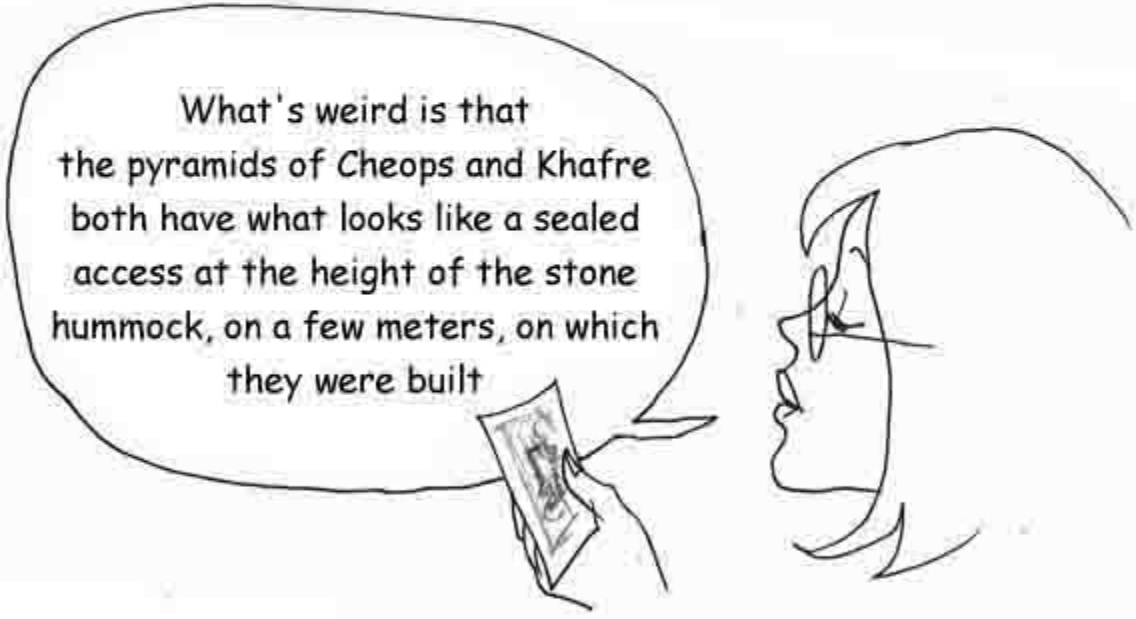




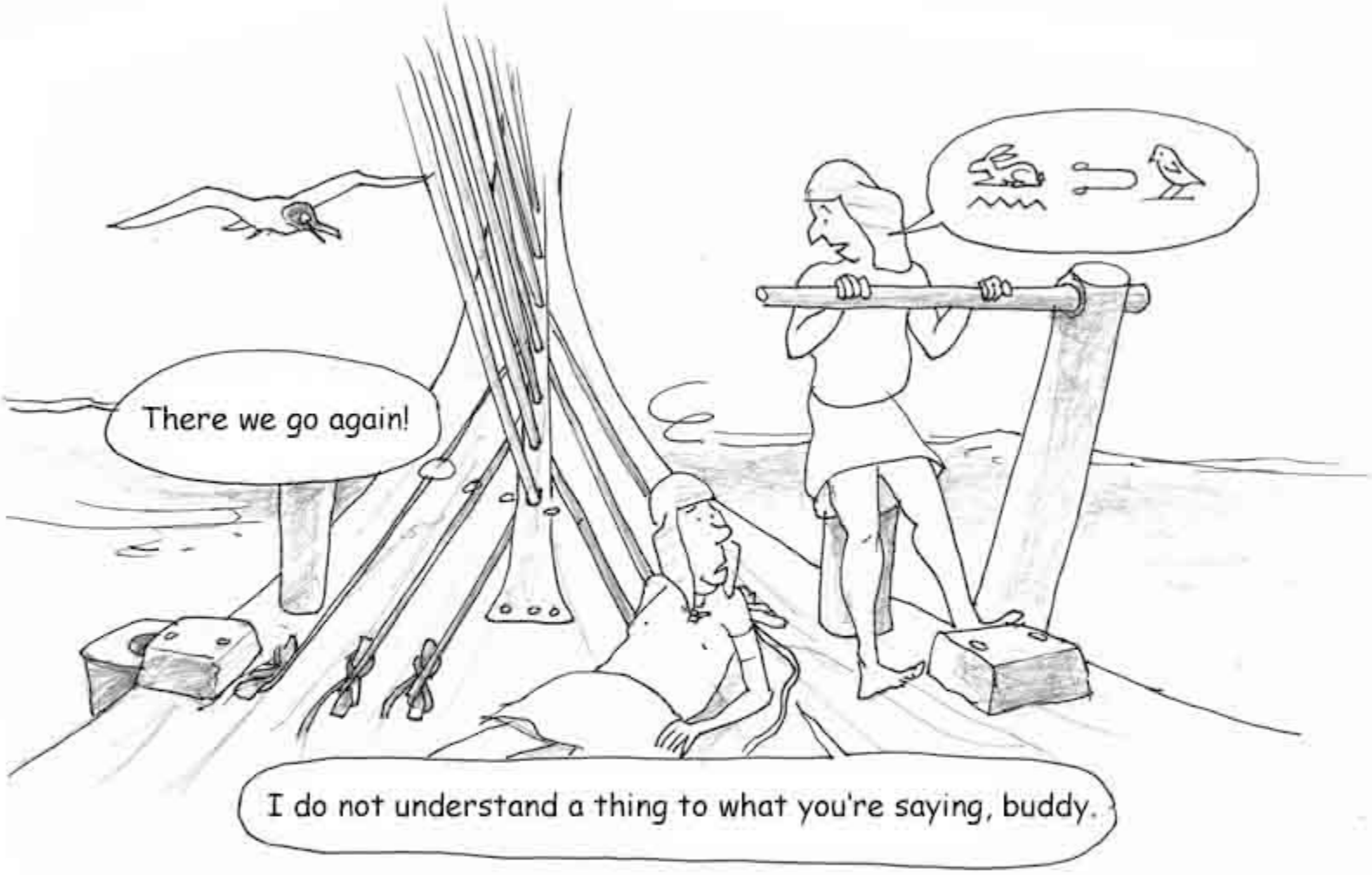
To ensure the strength of the well and avoid that it can be closed, made unusable in the event of an earthquake, which would be catastrophic, the stones should be arranged as follows.

(*) Images taken with a drone would be welcome.

All this seems to respond to the criticism of Antoine, on the centimetric marking of blocks. It requires access by the bottom or the one who positions the plumb-line be quickly short on oxygen.



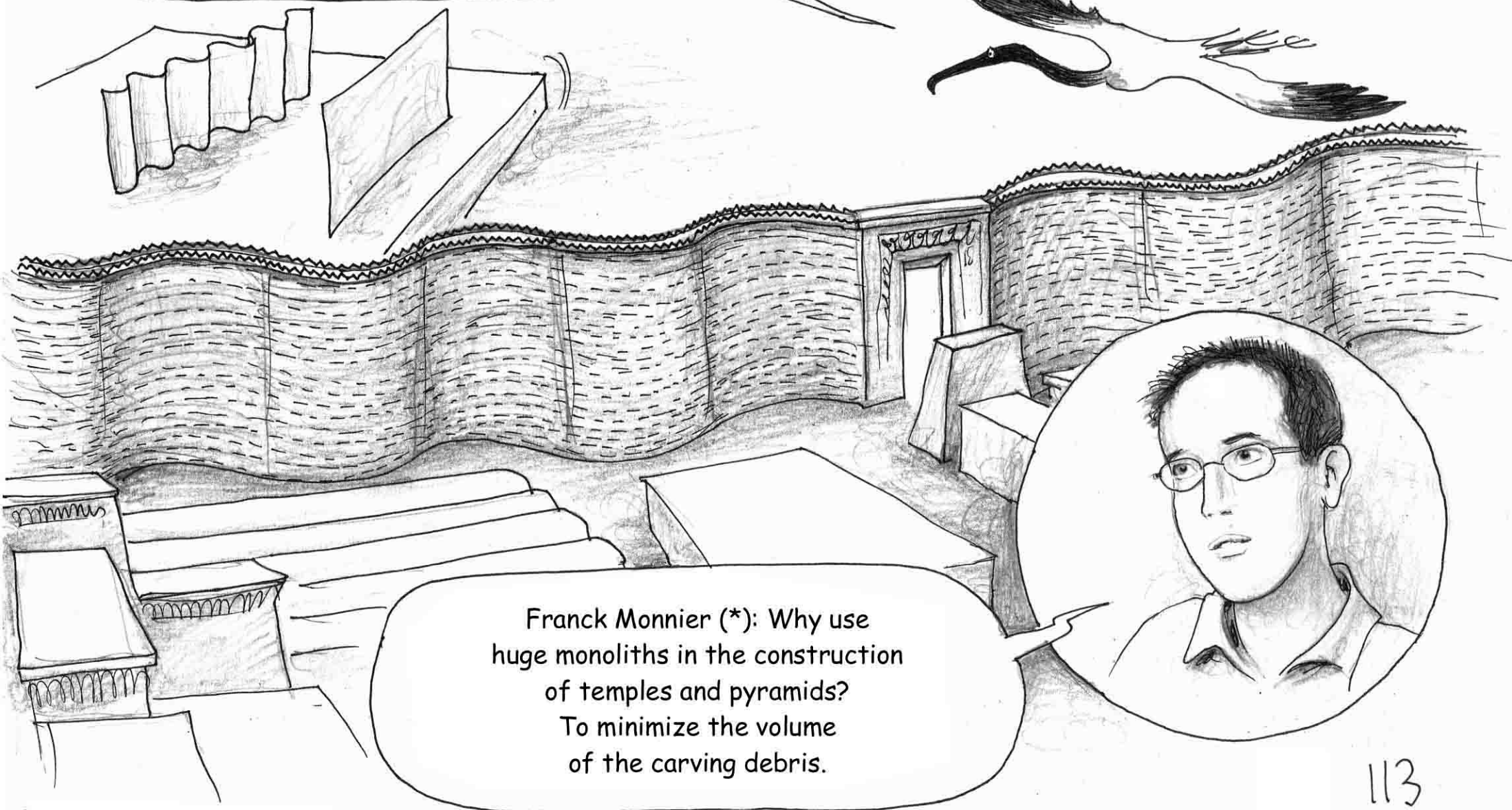
THE END



TO BE CONTiNUED

POST SCRIPTUM

The temples were surrounded by a wall structured as a corrugated sheet to better withstand earthquakes.

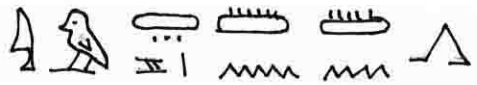


Franck Monnier (*): Why use huge monoliths in the construction of temples and pyramids? To minimize the volume of the carving debris.

(*) www.egyptian-architecture.com

p. 9  Go away ! Go away !

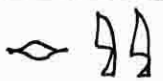
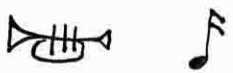
p. 9  Be careful !

p. 19  The earth trembled

p. 25  A cubit is seven palms

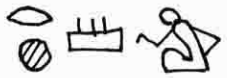
p. 29  Hurry up !

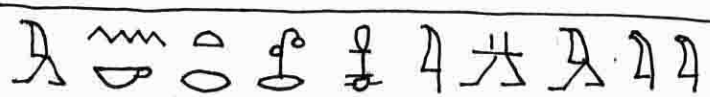
 Pull, comrade !

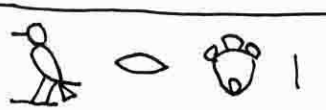
 I do ! 

 Pull hard !

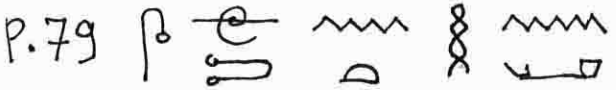
p. 30  Pay attention !

p. 44  May I understand !

p. 47  How did you come back?

 Insolent !

 Is on this that I'm going to spend the day?

P. 79 

Drag, comrade !

Hurry up, end this !

P. 87 bis (1)

This is not a lie, it's perfect

P. 87 bis (2)

See this site, it's not bad

Personal pronoun "I" negative determinative of abstract ideas

I do not want to count

Thanks to Thierry Bergerot and his daughter, Egyptologists.