THE ROMAN QUARRIES AT ANTINOOPOLIS (EGYPT):
DEVELOPMENT AND TECHNIQUES

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The Antinoopolis quarries - Egypt

Superficie: 998.002 Km²
Abitanti: 69.537.000 (stime 2001)
Densità: 70 ab/Km²

Forma di governo: Repubblica presidenziale
Capitale: Il Cairo (6.500.000 ab.,
13.000.000 aggl. urbano)
Altre città: Alessandria 3.585.000 ab.,
Giza 2.200.000 ab.,
Shubra el-Khema 710.000 ab.,
Porto Said 400.000 ab.
Gruppi etnici: Arabi 85%, Beduini,
Nubiani, Berberi e altri 15%
Paesi confinanti: Libia a OVEST,
Sudan a SUD, Israele e Palestina
ad EST

Monti principali: Jabal Katrina
2637 m
Fiumi principali: Nilo 1550 Km
(tratto egiziano, totale 6671 Km)

Lingua: Arabo (ufficiale), dialetto arabo-egiziano, Inglese, Francese
Religione: Musulmana sunnita 90%, Cristiani copti 7%
Moneta: Sterlina egiziana

6ky of history

• EGIPTYAN
• MACEDONES
• TOLOMEI
• ROMANS
• BIZANTINI
• OMAYYADI
• ABBASIDI
• MAMELUCC
• TURKIS
• ENGLISH
• EGYPT
GEODYNAMICS

EGYPT IS IN THE AFRICAN SHEIELD ON THE WEST SIDE OF THE RED-SEA RIFT WHICH DIVIDES IT FROM THE ARABIAN PLATE.

The geological history of Egypt is dominated by vertical uplifts and faults on the Red-Sea border.

Egypt is a no seismic area, but shocks related to great earthquakes in the Red-Sea rift and Ethiopian rift valley can occur.
THE EGYPTIAN GEOLOGICAL SUCCESSION HAS A PROTOARCHEAN AND PRECAMBRIAN CRISTALLINE AND METAMORPHIC BASEMENT

IN THE EARLY PALAEZOIC THERE WAS A CLASTIC CONTINENTAL SEDIMENTATION FOLLOWED IN THE CARBONIFEROUS BY RAMP DEPOSITS

DURING TRIASSIC, JURASSIC AND EARLY CRETACEOUS THE NUBIAN SANDSTONES DEPOSITED, THEY ARE REFERABLE TO PARALIC AND RAMP ENVIRONMENTS

CHALK OF SEDIMENTATION OCCURRED IN THE LATE CRETACEOUS IN A RESTRICTED CARBONATE PLATFORM

SEDIMENTS OF CARBONATE PLATFORM DEPOSITED IN THE EOCENE AND OLIGOCENE
ANTINOOPOLIS WAS SEATTLED BY THE EMPEROR HADRIAN IN THE YEAR 130 A.D. IN MEMORY OF HIS FAVORITE ANTINOO HERE SUNKED IN THE NILE.

ANTINOOPOLIS WAS A WELL KNOWN QUARRING SITE AND AN IMPERIAL PREFECTURE UNDER THE EMPEROR DIOCLETIAN.
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IN THE ANTINOOPOLIS AREA, ON THE WEST OFFSHOOTS OF THE GEBEL EL'ADILA, IT OUTCROPS A EOCENE CARBONATE SEDIMENTARY SEQUENCE REFERABLE TO AN INNER LAGOON ENVIRONMENT.

THE MAIN LITHOLOGICAL UNIT IS THE MINIA FORMATION: “soft white limestone, fine- to coarse-grained packstones and grainstones with mainly echinoids and foraminifera (nummulitids, alveolinids and orbitolids), and lesser amounts of other invertebrates, especially pelecypods (mainly oysters).

THIS UNIT PRESENTS LAYERS REFERABLE TO EMERSION, KARST AND CLASTIC REDEPOSITION EPISODES.

THE MINIA FORMATION CAN REACH 150m IN THICKNESS.
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THE QUARRIES

GPS AIDED FIELD SURVEY ALLOWED TO PLACE ALL THE QUARRIES OPENED IN THE AREA BY PALM-PC

ALL THE QUARRIES ARE LOCATED IN THE FIRST OFFSHOOTS OF THE GEBEL EL’ADILA IN THE LIMESTONES OF THE MINIA FORMATION
BY MEANS OF A PALM-PC ALL THE DATA SURVEYED IN THE FIELD WERE DIRECTLY IMPLEMENTED IN A GIS WHICH RELATES:

- GPS POSITION IN WGS84
- TYPOLOGICAL CHARACTERS
- PHOTOS
- WORKING TRACES

THE TYPOLOGICAL FEATURES SURVEYED ARE:

- QUARRY TYPE: OPEN PIT / UNDERGROUND
  EX GRAVE / COPTOS RE-USE

- DIMENSIONS: SMALL / WIDE / CONCATENATE

- WORKING TRACES: PRIMITIVE / ADVANCED / COMPLEXES / BLAST

- DAMAGES: SIDE ROCK-FALL / COLLAPSE / WEDGE-FALL / SPALLING
THE STUDY OF THE WORKING TRACES ALLOWED TO DEFINE THE QUARRYING TECHNIQUES AND THE WORKING METHODS

THE RESULTS OF THIS STUDY WHERE MATCHED TO QUARRY DIMENSION AND TYPE AND TO THE QUARRY LOCATION AS AN ISOLATED QUARRY OR WITHIN AN EXTRACTIVE AREA OR IN A COMPLEX EXTRACTIVE BASIN

THAT ANALYSIS LED TO CATHEGORIZE THE QUARRIES ACCORDING TO SEVERAL HISTORICAL CONTEXTS:

- **MIDDLE KINGDOM EGYPTIAN GRAVES**: SITES OF BURIAL, WITH PRIMITIVE WORKING TRACES
- **PRE-IMPERIAL QUARRIES**: SITES OF REUSE OF GRAVES AS QUARRY, WITH PRIMITIVE WORKING TRACES AND SMALL DIMENSIONS
- **EARLY IMPERIAL QUARRIES**: ISOLATED AND FAR SINGLE OR CLUSTER OF QUARRIES, WITH WELL ORGANISED AND ADVANCED WORKING TRACES, COVERING A WIDE AREA
- **IMPERIAL QUARRIES**: LARGE CLUSTER OF QUARRIES CONSTITUTING AN EXTRACTIVE BASIN, WELL ORGANISED AND ADVANCED WORKING TRACES
- **COPTOS SITES**: RE-USE OF QUARRY SITES FOR RELIGIOUS PURPOSE AND FOR TOMBS
MIDDLE KINGDOM GRAVES

HAVE WORKING TRACES
PRIMITIVE, REFERABLE TO
THE USE OF A SIMPLE PICK
IN ORDER TO ONLY DIG THE
ROCK

THEY ALL ARE ON THE
LOWER SLOPE OF THE
GEBEL EL’ADILA TOWARDS
THE NILE PLANE
The Antinoopolis quarries - Egypt

PRE-IMPERIAL QUARRIES

DERIVE FROM A RE-USE OF ANCIENT GRAVES OR ARE NEW SMALL QUARRIES

THEY ARE SMALL AND PRESENT PRIMITIVE WORKING TRACES

THEY ARE ON THE SLOPE AND ON THE NEAR TOP OF THE GEBEL EL’ADILA FACING THE NILE PLANE
EARLY IMPERIAL QUARRIES

THEY ARE ISOLATED AND FAR EXTRACTION SITES, BUT WITH ADVANCED AND COMPLEX WORKING TRACES

THEY ARE WIDE TO VERY WIDE SITES ALSO WITH UNDERGROUND EXCAVATIONS

THEY ARE ON TOP OF THE GEBEL EL’ADILA AND PRESENT SEVERE PROBLEMS IN TRANSPORTING BLOCKS TO THE NILE
IMPERIAL QUARRIES

THESE QUARRIES ARE ALL UNDERGROUND, ORGANISED ON MORE LEVELS AND PANELS

THEY PRESENT WELL ORGANISED AND COMPLEX ADVANCED WORKING TRACES

THEY ARE GROUPED IN A SINGLE WIDE EXTRACTION BASIN WITH AN EASY LINK TO THE NILE
COPTOS SITES

THEY ARE PLACES OF RE-USE OF A QUARRY AS CHURCH AND FOR TOMBS IN THE COPTO TIMES

THEY ARE LOCATED IN LOWER SLOPE OF THE GEDEL EL ADILA

THEY PRESENT WORKING TRACES REFERABLE TO NOT PROFESSIONAL TOOLS
1 – MIDDLE KINGDOM GRAVES:

THEY PRESENT PRIMITIVE WORKING TRACES REFERABLE TO THE USE OF PICK TOOLS, EVEN IN CHERT (we positively did it with chert coming from the local limestone), USED TO DIG THE ROCK BROCKING IT, ONLY AT THE END THE GRAVE SIDES WERE ROUGTHLY REGULARISE BY MEANS OF LONG ENGRAVEING HITS
2 – PRE-IMPERIAL QUARRIES:

THEY PRESENT PRIMITIVE WORKING TRACES COMPATIBLE TO THE USE OF PICK AND DOUBLE HEAD HAMMER, BUT THE EXTRACTION TRACES SHOW THEY WERE ORGANISED IN ORDER TO QUARRY OUT REGULAR BLOCKS IN ROWS AND SUBSEQUENT DEEPENINGS.
3 – EARLY IMPERIAL QUARRIES:
THEY PRESENT ADVANCED, WELL ORGANISED AND COMPLEX WORKING TRACES REFERABLE TO THE CLASSIC ROMAN TOOLS
EXPLOITATION WAS ORGANISED IN ROWS AND SUBSEQUENT DEEPENINGS IN ORDER TO EXTRACT REGULAR BLOCKS
4 – IMPERIAL QUARRIES:
THEY PRESENT A VERY WELL ORGANISED EXPLOITATION SYSTEM WITH ADVANCED AND PROFESSIONAL WORKING TRACES FOCUSED TO EXTRACT REGULAR BLOCK IN STANDARD ROMAN SIZES
WORKING TRACES ARE TYPICAL FROM THE ROMAN CLASSIC TOOLS
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**EXCAVATION METHOD**

1 – FROM THE FRONT OF AN OPEN QUARRY IT WAS DIGGED AN UNDEGROUND OPENS

2 – THE DEBRIS OF THE NEAR UNDERGROUND CUTS WERE DISCHARGED DOWNSLOPE THE ENTRANCE

3 – CULTIVATION PROCEEDED BY VERTICAL BLOCKS OF REGULAR ROMAN STANDARD SIZES

4 – DEBRIS FROM UNDERGROUND CUTS WERE ACCUMULATED IN THE MIDDLE OF THE CHAMBER IN ORDER TO AVOID USELESS WORK

5 – UNDERGROUND EXCAVATION WAS DONE WITH LARGE CHAMBERS AND A FEW PILLARS
THE SERVICE POST

IN THE MIDDLE OF THE MAIN QUARRY AREA THERE ARE RUINS OF BUILDINGS WHICH CAN REPRESENT THE SERVICE POST MANAGING THE QUARRIES

BRICK WERE MADE BY DRIED MUD AND STRAW, WALLS WERE PLASTERED AND PAINTED

LATER ON, IN COPTOS TIME, THIS SITE WAS USED AS A MONASTERY
THE TRANSPORT

Traces and elements related to the transport were only found in connection to the imperial quarries, they consist in sledge-ways and truck-ways leading down to the wadi.
THE CONNECTION TO THE NILE

DETAILED FIELD SURVEY AND ANALYSIS OF GOOGLE IMAGES ALLOWED TO IDENTIFY THE MAIN SLEDGE-WAYS COLLECTING THE BLOCKS FROM THE QUARRIES TOWARDS THE NILE BANK
SHIPPING ON THE NILE

AT ANTINOOPOLIS, ALONG THE NILE ANCIENT RIGHT BANK THERE ARE TRACES OF TWO DOCKS: ONE IS IN THE CITY OF ANTINOOPOLIS, ONE IS SOUTH OF THE CITY CLOSER TO THE IMPERIAL QUARRY SITE AND TO THE ARMY BARACKS (this last was destroyed in the 2009 by the locals for collecting its big stone blocks !!!)

THE DOCKS WERE BUILT WITH THE BLOCKS NORMALLY PLACED IN RESPECT TO THE RIVER IN ORDER TO AVOID RIVER-WAVE EROSION
THE UNSUSPECTED WIDENESS OF THE UNDERGROUND QUARRIES DID NOT ALLOW A SATISFACTORY SURVEY WITH THE AVAILABLE TOOLS. THEREFORE WE CAN ONLY SURVEY SMALL SHAFTS AND A PORTION OF A LARGER ONE AS A CASE HISTORY.

- LASER BEAM LEVEL AND DISTANTIOMETER WITH AZIMUTHAL ALIDADA
- ULTRASONIC DISTANTIOMETER AND ROLLER METER
- KOMPASS + GPS
- FRONTAL LAMP

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**THE RESTITUTION**

All the surveyed data were processed by CAD 2D and 3D.
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THE GREAT LATOMIA

In the area of the post service we tried to map one of the very wide underground quarries, but due to the lack of adequate light we were only able to map a limitate portion of it.
In the ancient Egypt anything was owned by the Pharaoh because He was the Egypt, therefore also quarries were owned by the Pharaoh.

The Romans took this concept as property of the Emperor as institution, the Emperor managed the quarries by means of the praefecta marmorum.

The concept of State ownership derives from this institution.

The presence at Antinoopolis of Imperial Quarries implies the local presence of a full administrative office and of professional technicians.

Therefore we can think about the presence of a praefectum marmorum who managed all the activities related to quarrying and of his staff constituted by probator, officials, guardians, quarriers (both slaves and specialized free workers), but also offices and technical sites had to be at the main extraction sites.

At a whole a complete industrial organization well articulated and focused to the best exploitation of the local natural stone resource which constituted a primary good for the Empire.
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### THE ROMAN MEASURES

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### THE MEASURES ARE MODULAR MULTIPLES OF SMALL INTEGER, OFTEN IN AN EURITHMIC SEQUENCE

THE ROMAN MEASURES ARE ANTHROPOMETRIC AND COMPOSIBLE, USEFUL TO A MODULAR STANDARDIZATION OF THE CONSTRUCTIONS

THE RESPECT OF THE STANDARD SIZES ALLOWED THE OPTIMIZATION IN THE USE OF THE MATERIALS, IN KEEPING THE TIME AND IN USING THE SAME MODULAR CONSTRUCTION RULES ALL AROUND THE EMPIRE (like IKEA !)
THE LIFE OF THE "QUARRIER"

AT THE TIME OF THE EMPEROR HADRIAN TO DIOCLETIAN THE IMPERIAL QUARRIES ALL AROUND THE EMPIRE WERE UNDER THE MANAGEMENT OF A CENTRAL TECHNICAL OFFICE AND IN THE QUARRIES SLAVES AND FREE SPECIALIZED WORKERS WERE EMPLOYED.

THESE LAST (mercenarii) COULD BE WITH A PERMANENT POSITION (familia) OR EMPLOYED WITH A TIME CONTRACT (pagani, with contract until 6 months or 1 year or for 1 day).

THE SALARY WAS:
- INFANTRY LEGIONARY  →  300 denarii/year
- QUARRIER/MINER      →  141 denarii/year
- WORKER              →  80 denarii/year
- CIVIL EMPLOYER      →  75 denarii/year

Diocletian price edict (301 d.C.):
It defined the maximum price for some goods:

- 1 Libra of pig - 12 denarii    →  72 Euro
- 1 Libra of beef - 8 denarii   →  64 Euro
- 1 modius of salt - 100 denarii →  800 Euro
- 1 sextarius of olive oil - 40 denarii →  320 Euro
- 1 modius of corn - 100 denarii →  200 Euro
- 1 modius of oat - 60 denarii   →  480 Euro
- 1 sextarius of Falerno wine - 30 denarii →  240 Euro
- 1 pair of fashion shoe - 150 denarii →  1,200 Euro
- 1 pair of woman shoe - 60 denarii →  480 Euro
- Wool from Tarentum - 175 denarii for 1 Libra →  1,400 Euro
- White silk - 12,000 denarii for 1 Libra →  96,000 Euro

THE SALARY OF A QUARRIER ALLOWED THE LIFE OF A 5 PEOPLE FAMILY.
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DAMAGES

- THE BIG UNDERGROUND QUARRIES HAS BEEN AFFECTED BY:
  - COLLAPSE
  - WEDGE ROCK-FALL
  - SPALLING
  - SINK-HOLE
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GEOMECHANICS
MINJA LIMESTONE PRESENTS:
SCATTERED FRACTURES,
$\sigma_c = 34$MPa, MA OTTIME
VERY GOOD CONDITIONS OF THE RARE DISCONTINUITIES
A PERMAMENTE DRY SITUATION

$\Rightarrow$ RMR$_B$ = RMR$_D$ = 80
$\Rightarrow$ GSI = 75

Analysis of Rock Strength using RocLab

Hoek-Brown Classification
intact uniaxial compressive strength = 34 MPa
GSI = 75 mi 8 Disturbance factor = 0

Hoek-Brown Criterion
$mb = 3.276$ $s = 0.0622$ $a = 0.501$

Mohr-Coulomb Fit
cohesion = 1.380 MPa friction angle = 51.70 deg

Rock Mass Parameters
tensile strength = -0.645 MPa
uniaxial compressive strength = 8.457 MPa
global strength = 10.289 MPa
modulus of deformation = 24588.92 MPa
STABILITY ANALYSIS

IN ORDER TO UNDERSTAND THE GENERAL STABILITY CONDITION OF SUCH A LARGE UNDERGROUND OPENINGS, STILL STABLE AFTER 2,000 YEARS, WE RUN A FEW FEM ANALYSIS

DUE TO THE LOW STRESS STATE THE ROCK-MASS WORKS IN THE ELASTIC AND BRITTLE FIELDS

THE PREDICTED BEHAVIOUR HAS A STRICT CORRESPONDENCE IN THE DAMAGES WHICH ARE PRESENT IN THE OUTER PILLARS, IN THE MIDDLE OF THE ROOF AND ON BACK OF THE QUARRY IN THE SLOPE, SUCH US IN THE COLLAPSES AND WEDGE ROCK-FALLS OCCURRED
FINAL REMARKS

THE STUDIES WE DID AT ANTINOOPOLIS ALLOWED TO IDENTIFY THE PRESENCE OF A STRONG AND LONG HISTORICAL QUARRYING ACTIVITY, BUT MAINLY REFERABLE TO THE ROMAN EMPIRE (FROM HADRIAN, 130 A.D., TO DIOCLETIAN, 280 A.D.)

THE WORKING TRACES OF THIS ACTIVITY CAN BE READ FROM ITS PRIMITIVE EXPRESSION MAYBE OF THE MIDDLE KINGDOM UP TO A COPTOS REUSE OF THE PREVIOUS STRUCTURES AND OPENS

FURTHER STUDIES WILL BE DEVOTED TO THE ARCHAEOLOGICAL EXCAVATIONS AND THE DEFINITION OF THE HISTORICAL CONTEXT OF THIS HISTORICAL AND CULTURAL WORLD