

Ancient extractive metallurgy and metal manufacturing processes in Ancient Egypt

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Outlines

- Background
- Metals worked by the ancient Egyptians
- Precious metal production in Ancient Egypt
- Sources of Information
- Archeological sites that show metal production processes
- Gold Mines
- Turin Papyrus Map from Ancient Egypt
- Metal production operations
- Weighing processes
- Melting processes
- Casting (MOULDING)
- Refining, polishing, coloring, quality, testing, coating & soldering from LEYDEN PAPYRUS
- Conclusions



GENERAL REMARKS and BACKGROUND



- History of civilizations has been related to development in metallurgy and material technology.
- Metals were entirely monopolies of the state, the management of mines and quarries being entrusted to the highest official and sometimes even to the sons of pharaoh.
- Metallurgical practice were of extreme importance to the State and were carefully guarded from the common people.
- Metal production in Egypt known from the 4th millennium B.C.



GENERAL REMARKS and BACKGROUND (Cont.)



- The ancient Egyptians explored mineral ores in Egypt and in other countries.
- Established mining processes, and transport heavy loads for long distances, by land and sea.
- Eight metals including Gold, Silver, Copper, Silver, Copper, Lead, Iron, Zinc, Antimony and Mercury were worked by the ancient Egyptians.



Gold

- Gold was produced in Egypt before pharaonic times and gold artefacts, dating back as far as the predynastic time about 4000-3500 B.C.
- Gold was one of the first metals to be exploited.
- It was used in vast quantities by the pharaohs.



Gold Qualities

- The Ancient Egyptians used expressions like fine gold, gold doubly refined, white gold, green gold, native gold and many others.
- The physical properties of gold could not be improved as refining was unknown until the latter half of the first millennium B.C.



Silver

- Silver has been known since very ancient times (C.3600 BC)
- Ancient records throw no light on the source of silver although all gold mines contained silver in the range of 9 - 24%.
- In the 18th Dynasty stated to be received from various countries in Asia.
- In the 19th Dynasty described as coming from Libya, Syria, Palestine as well as Asiatic countries.
- Silver alloy with gold is called electrum.
Electrum is either natural or prepared.
Electrum is limited to an alloy of pale yellow colour.
Employed principally for jewelry and also for overlaying obelisks.
- There is evidence that 2 obelisks were entirely made of electrum.
- Greeks termed elektron, while Roman termed electrum.



Copper

- The earliest recorded use of copper by man in Egypt was around 7000 BC.
- Found in ores containing 10-12% copper
- Small quantity produced annually during the Bronze Age reached ~ 4 tons
- Copper had to be imported from Syria, Cyprus and other countries of the region



Lead

- Lead was used by the ancient Egyptians Essentially for glazing pottery (C.7000 - 5000).
- Welding of small human and animal figures and the making of snikers for fishingnets.



Iron

- Iron was found in meteoric form and used since 4th B.C.
- Iron ore deposits were not exploited in ancient Egypt until the Late Period
- It was called in ancient Egypt "*the metal of heaven*" or *bia-n-pet*



Zinc

- Zinc has been in use as a constituent of brass and bronze for more than 2000 years. As a distinct metal, it had been known since as early as 1000 AD .



Antimony and Mercury




- Antimony, a rare metal until comparatively recently, was known to the ancient Egyptians from as early as 945 BC.
- Mercury, its uses preparation and its amalgams with tin and copper.



Precious metal production in ancient Egypt

- Special Attention will be given to Precious metal namely gold, silver and electrum
- Usage: Jewelry, household items, coffins, death, masks, funerary sandals, head bands, statues, temple doors and jambs ..etc.



- Gold is called  nbw (nebw).
- There was no Egyptian word for silver but was called the white gold  hedj.
- Electrum (alloy of gold & silver) was called  djaam; known only in Ancient Egypt.





Value of Gold to Silver:

- Old Kingdom: Silver was highly priced than gold and was relatively a rare metal.
- Middle & New Kingdom: Silver was less valuable, the price was ~ half that of gold, ratio 1:2.
- Ptolemy II: Gold: Silver Ratio fixed to 13:1.



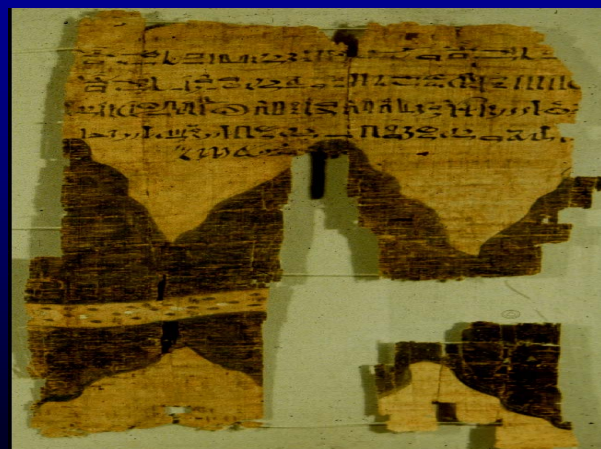
Precious Metal Connection to Gods

- Gold was considered a divine metal that never be tarnished, thus, flesh of the Gods was made from it.
- Bones of the Gods as well as the moon were shaped from silver



Sources of information:

- archeological sites,
- papyrus records,
- museums, and
- literature





Archeological sites that show metal production processes

- Total number of sites 39, exist in GIZA, SAQQARA, MIDDLE EGYPT, THEBES (LUXOR), ASWAN.
- Oldest scenes were from tombs of Old Kingdom, 2686 - 2181 BC.
- Recent ones from the tomb of Petosiris, Ptolemaic Period (300 B.C.)



- Some of the scenes are provided with hieroglyphic texts or script which serve as legend to the specific process.
- They also express snatches of dialogue between individuals working with metals.



Archeological Sites

- GIZA
- SAQQARA
- MIDDLE EGYPT
- THEBES (LUXOR)



GIZA (7 sites)

OWNER	DATE
MERESANKH, KING'S DAUGHTER	4 th DYN. TIME OF KHUFU TO SHEPSESRAF
NEBEMAKHET, CHIEF JUSTICE AND VIZIER	4 th DYN. TIME OF KHAEFRE TO MENKAURE
KHAFRE'S SON OF NEBEMAKHET	4 th DYN. TIME OF MENKAURE
WEPEMNEFERT, SECRETARY OF THE TOILET-HOUSE	MIDDLE OF 5 th DYN.
PTAHSHEPSES, CHIEF JUSTICE AND VIZIER	5 th DYN. TIME OF NIUSERRE
IYMERY, PRIEST OF KHUFU,	5 th DYN. TIME OF NIUSERRE
SEEDJEMIB, CHIEF JUSTICE, VIZIER,	5 th DYN. TIME OF UNAS



SAQQARA (12 sites)

OWNER	DATE
TEPEMANKH, WAAB-PRIEST OF THE 3 PYRAMIDS	MIDDLE OF 5 th DYN.
NIANKHKHNUM AND KHNUMHOTEP, BOTH PRIESTS OF RE	MIDDLE OF 5 th DYN.
TI, OVERSEER OF THE PYRAMIDS OF NEFERIRKARE AND NIUSERRE	5 th DYN. TIME OF NIUSERRE TO END OF 5 th DYN.
PTAHHOTEP, CHIEF JUSTICE AND VIZIER,	5 th DYN. TIME OF ISESI TO UNAS
KING UNAS	5 th DYN. TIME OF UNAS
MERRERUKA, CHIEF JUSTICE & VIZIER,	5 th DYN. TIME OF UNAS



SAQQARA

(Cont.)

OWNER	DATE
KAEMREHU, SECRETARY OF THE TOILET-HOUSE	LATE OF 5 th DYN.
NEFER, INSPECTOR OF THE WAABET, DIRECTOR OF SINGERS	LATE OF 5 th DYN.
KAIRER	END OF 5 th TO EARLY 6 th DYN.
ANKHEMAHOR, CHIEF JUSTICE & VIZIER	EARLY OF 6 th DYN.
KAGEMNI, CHIEF JUSTICE & VIZIER	6 th DYN. TIME OF TETI
MEHU, CHIEF JUSTICE & VIZIER	6 th DYN. TIME OF PEPI I



MIDDLE EGYPT (6 sites)

OWNER	DATE
PEPIANKH (Assuit)	6 th DYNASTY TIME
IBI (Assuit)	6 th DYNASTY TIME
BAQET III (Menia)	11 th DYNASTY
KHETY (Menia)	11 th DYNASTY
AMENEMHAT, NOMARCH AND COMMANDER (Menia)	12 th DYNASTY TIME OF SENWSERT I
PETOSIRIS (Menia)	PETOLEMAIC PERIOD (300 B.C.)



THEBES (LUXOR) (13 sites)

OWNER	DATE
BENIA	EARLY 18TH DYN.
PUYMRE	18 th DYN. THUTMOSES III
MENKEPERRE-SENB	18 th DYN. TIME OF THUTMOSES III
REKHMIRE	18 th DYN. THUTMOSES III
MENTIWY	18 th DYN. THUTMOSES III
Nebamun	18 th DYNASTY AMENHOTEP II



THEBES (LUXOR)

Cont.

OWNER	DATE
MERY	18 th DYNASTY AMENHOTEP II
HEPU	18 th DYNASTY THUTMOSES IV
AMENHOTEP-SASE	18 th DYNASTY THUTMOSES IV
SOBKHOTEP	18 th DYNASTY THUTMOSES IV
PASER	19 th DYNASTY RAMSES II
NEFERRENPET	19 th DYNASTY RAMSES II
IBI	26 th DYNASTY PSAMTIK I



Gold MINES

- Gold of Coptos,
- Gold of Wawat,
- Gold of Kush,
- Gold of Ombos,
- Gold of Edfu,
- Gold of the Water
- Gold of the Mountains



In the treasury of Rameses III at Madinet Habu there were inscriptions of these gold mines on seven different sacks.



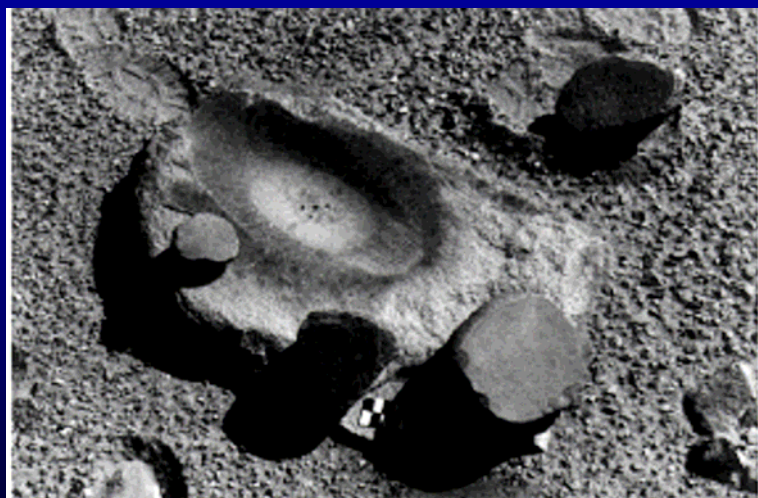
Mining Operations

- Traced back to Pre-dynastic time.
- All mining & smelting processes are discussed in details in Deodorus records.
- Remnants of mines operation and tools found in Eastern Desert are shown in the following slides.



Tools Used:

Stone hammers
Old and Middle
Kingdom
Eastern Desert



Grinding stones,
oval shaped, New
Kingdom, southern
Eastern Desert



Turin Papyrus Map from Ancient Egypt

- Oldest surviving geological map (1160 B.C.), and Geographic Information System, reign of Ramesses IV.
- The map drawn on a scroll of papyrus paper measures 2.8m X 0.41m.
- Discovered at Dier el-Madina.



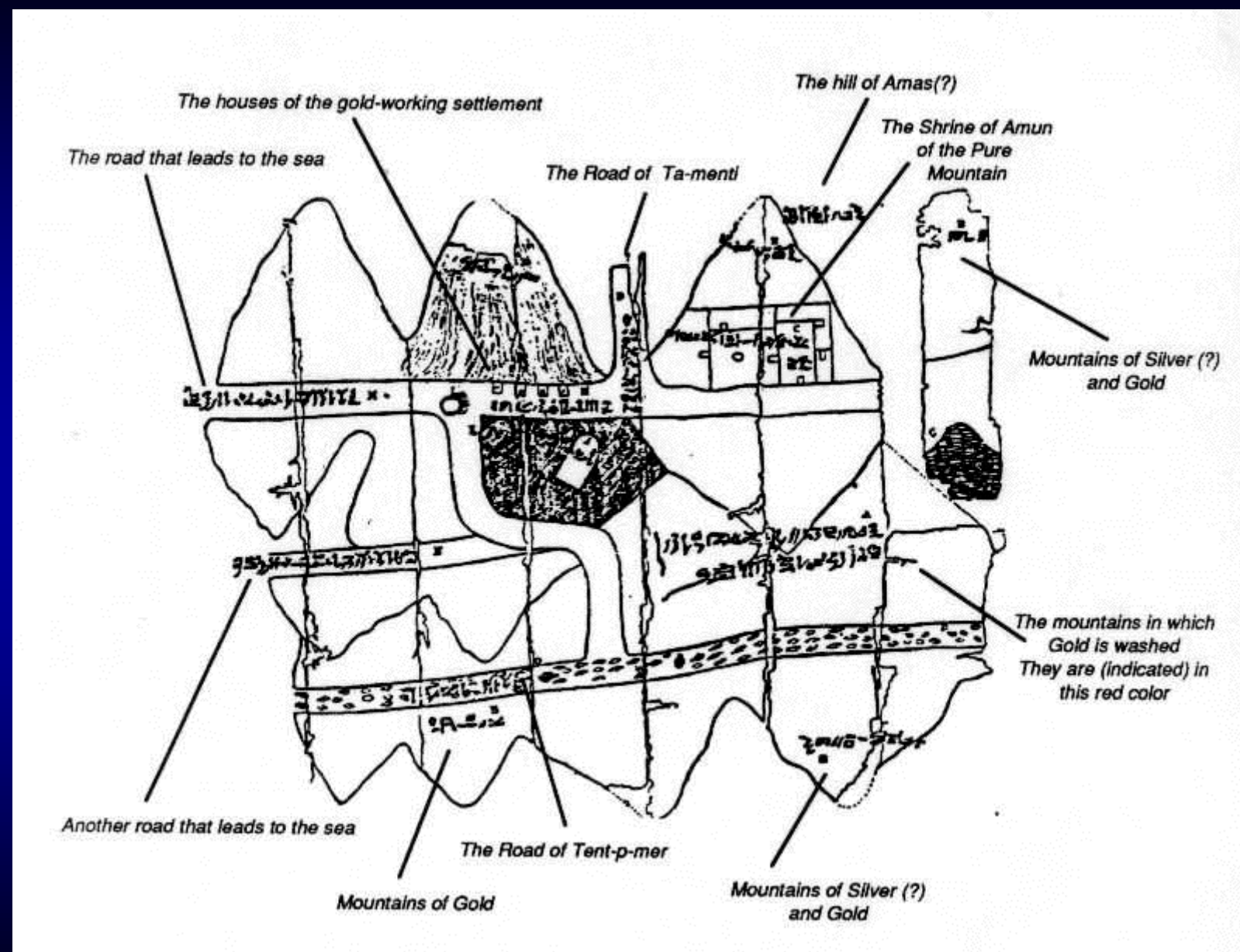
- Depicts the quarry for bekhen-stone, gold mine and gold mine settlement at Bir Umm Fawakhir (Eastern Desert).
- It has annotations in hieratic script, form of hieroglyphic writing.
- Kept in the Egyptian Museum of Turin.



0 50 100 cm



Turin Papyrus Map, as reconstructed by Harrell



Simplified Turin Papyrus map, by J.A. Harrel



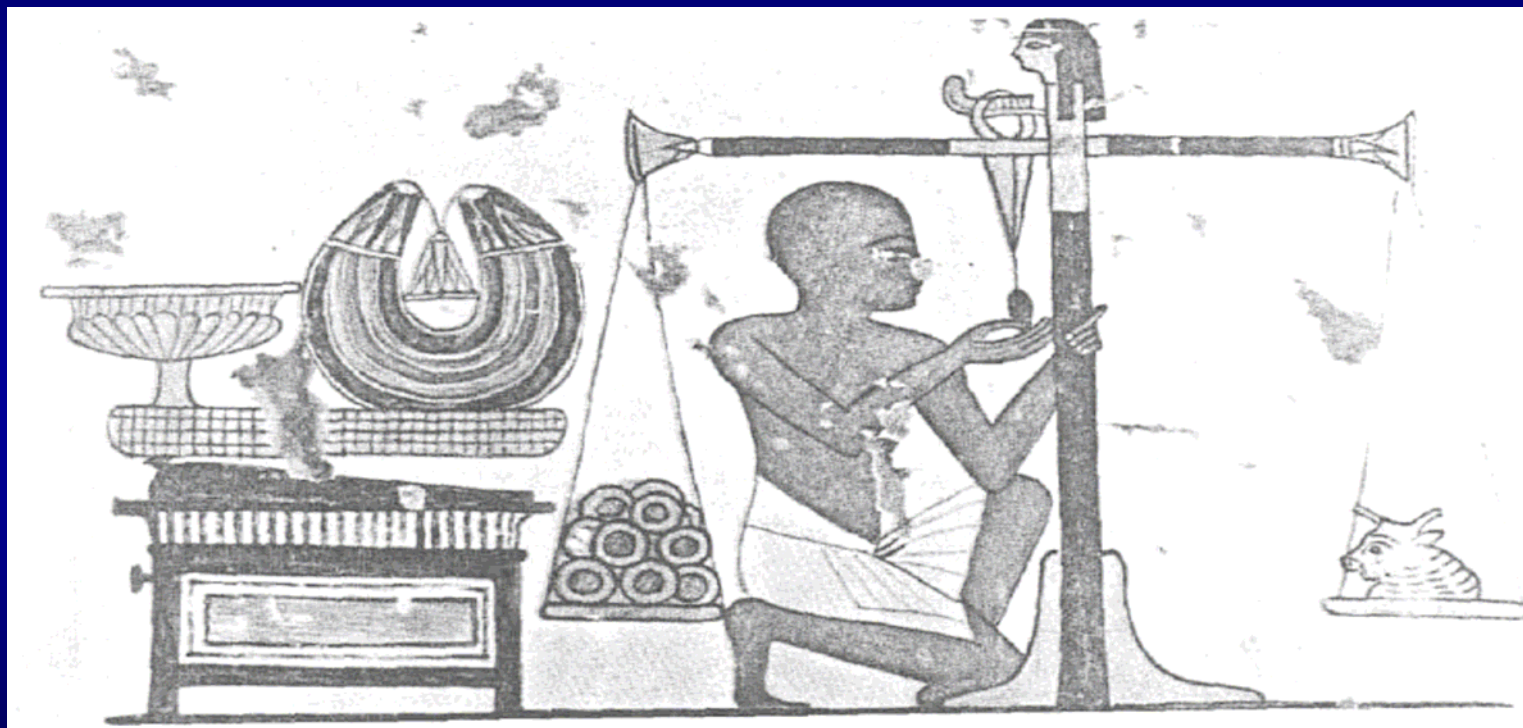
Metal Production Operations

Weighing, Melting, Hammering, Casting,
Plate Production, Jewelry Making,
Welding, Coating, Polishing

These Operations can be seen
in the following photos



Weighing Processes



A balance crowned by the head of the goddess Maat.



- Weighing of metals using balances or scales can be seen on walls of many tombs (tomb of Mastaba of Merreruka, tomb of Rekhmire ..etc)
- Balances were crowned by the head of the goddess Maat (daughter of the Sun God RE), symbol of truth & justice.



Melting Processes

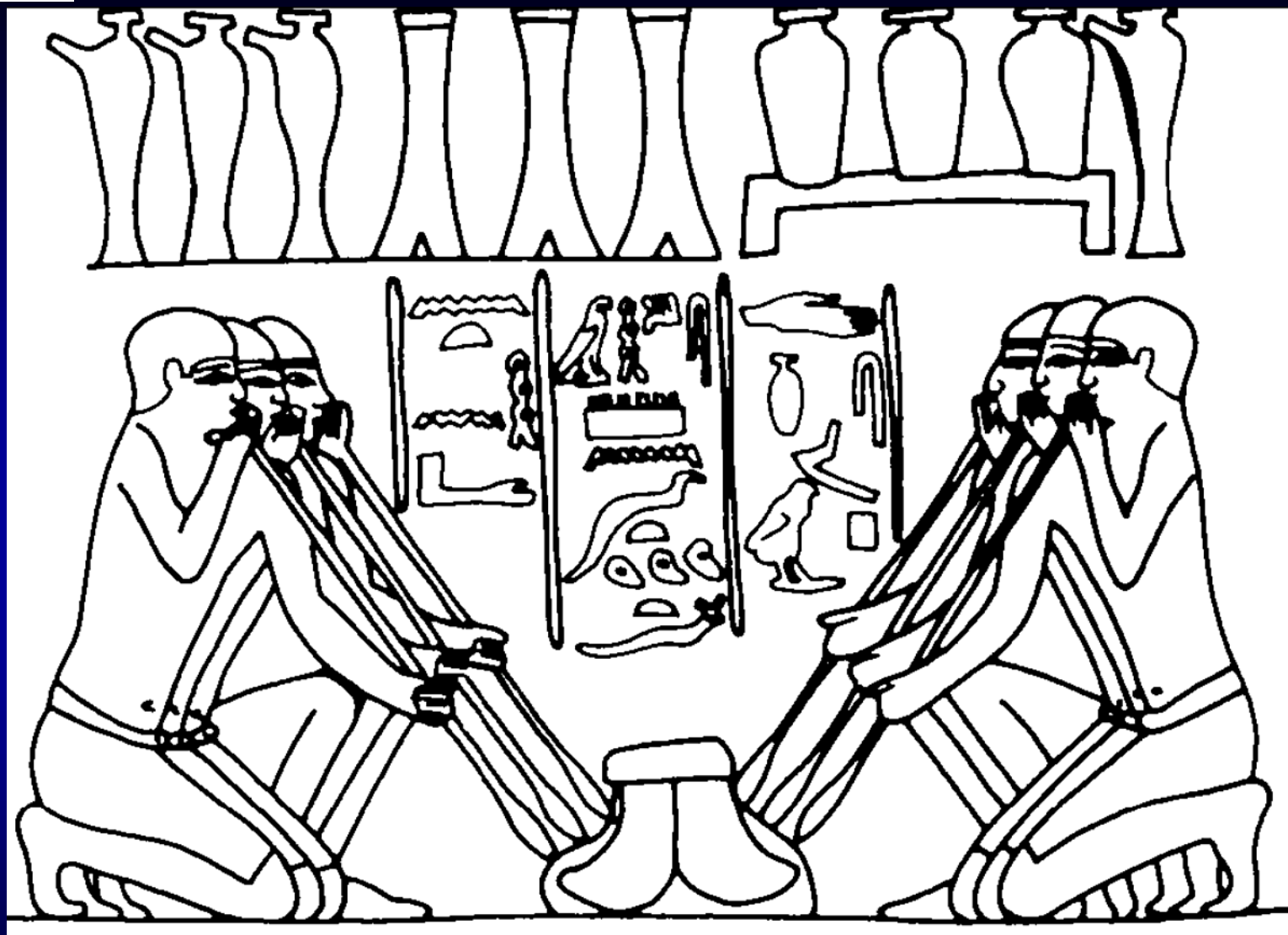
- Metal working scenes & inspections shows technological innovations in melting processes from Old Kingdom to Ptolemaic Period.
- Metal was melted or extracted in a crucible furnace where ore & coal were mixed together.
- Both melting & extraction furnaces was heated by direct-open fire process or by ceramic fire furnaces
- Development from open fire to shaft furnace takes long time



Melting of wax before core casting of the molten metal (Rekhmire 18th Dyn.)



- Air-blowing technique was used to get better efficiency of firing and shorter melting time
- Air-blowing with mouth ,through blow-pipes was essential on working with small quantities of material, as in jewelry workshop



Fireplace, two crucibles side by side fanned by six melters using blowpipes (Mastaba of Mereruka, 5th Dyn.)



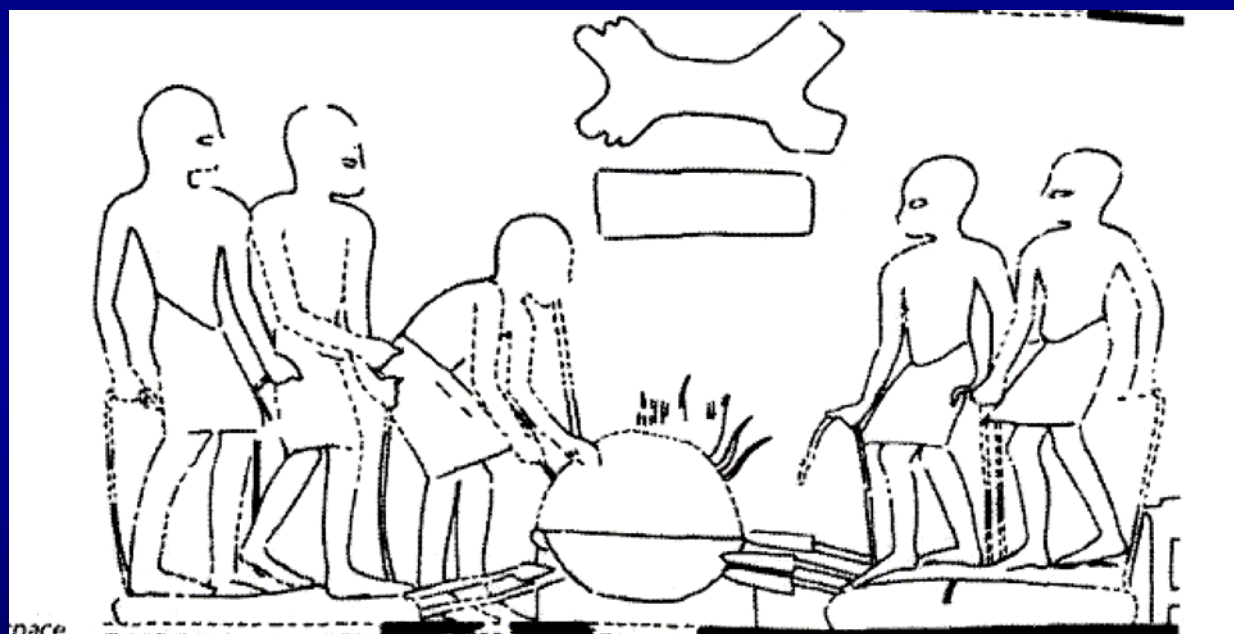
- **Blowing Techniques** were developed in the following order:
 - In Early Times: fans of foliage were used
 - Old Kingdom: simple mouth blow piece made of reed and tipped with clay
 - Middle Kingdom: Skin bellows of a goat or a gazelle were used
 - New Kingdom: blowing tools were developed such as pot, drum or dish bellows.



- **Furnaces** were also developed:
 - Old & Middle Kingdom: furnace was a pottery bowl upon a stand filled with glowing charcoal (open-fired furnaces)
 - New Kingdom: Blast or shaft furnace introduced, worked by leather bellows actuated by feet and cords.



- To give sufficient volume of blast-air to a furnace, some sort of pump was used.



Blast Furnace

A line drawing depicting a ritual scene. On the left, a figure is bent over, possibly performing a task. On the right, a figure is seated, facing the first figure. Between them is a grid of 18 symbols arranged in 3 rows and 6 columns. The symbols include various geometric shapes, a bird, a snake, a human head, and other abstract forms.

Pouring the molten metal & Casting (Rock-Tomb of Meir)



- Inspection of cast pieces from ancient Egypt indicate that different techniques were used
- In Early Dynastic times: simple open mould was used
- Old Kingdom: more sophisticated form, use of two-part moulds
- Old & Middle Kingdom: Lost-wax casting technology was used.



- New Kingdom: Core casting was used for manufacturing of larger objects.
- Ancient Egyptians used also "master form" technique to make large number of the same piece.
- Wood & stone were employed in making patterns or models for cast pieces.
- Sand & clays were used for making moulds.



Floor moulding process was used specially for casting big pieces

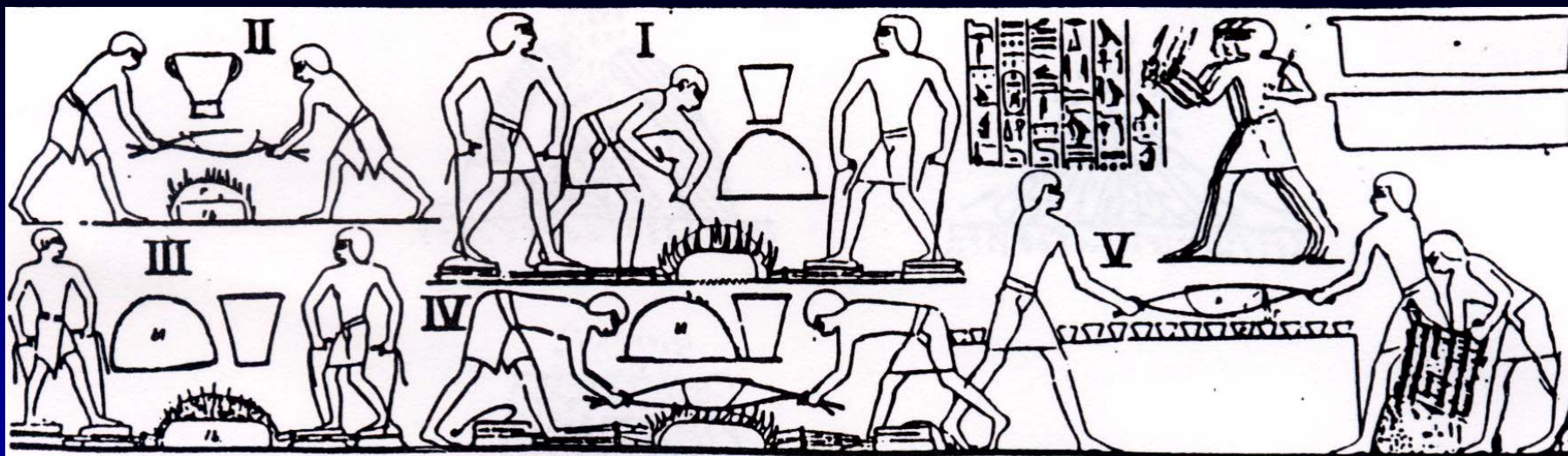
- Small sand-hill was prepared
- Casting forms (patterns or models) were printed by pressing the patterns (wood or stone)
- Typical form ready for pouring to get final casting shape
- Blade axes, chisels, arrow tips and knives were used as tools in this technique.



- **Lost wax process**
used for solid casting
 - Model in beewax, either formed by hand or moulded made of the object to be cast
 - then coated with suitable material (clay or clay mixture) to form mould
 - Embedded in sand or earth, which acts nearly as a support, whole mass then heated.



- When wax melted, it was either burnt away or let out through the hole or holes provided to receive molten metal
- Mould became rigid, hard and ready for use
- Molten metal was poured-in and allowed to cool



Melting & Casting from a tomb in Thebes, 1500 BC

- Fire preparation with coal and blast-air
- Putting the crucible
- Covering the crucible with coal
- Stopping air-blasting & crucible lifting
- pouring

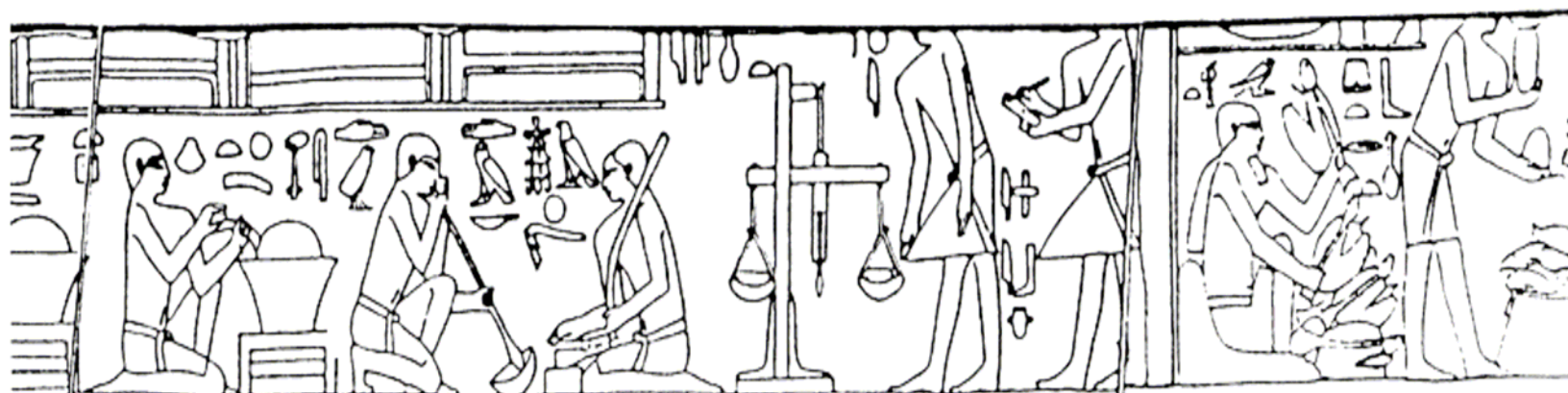
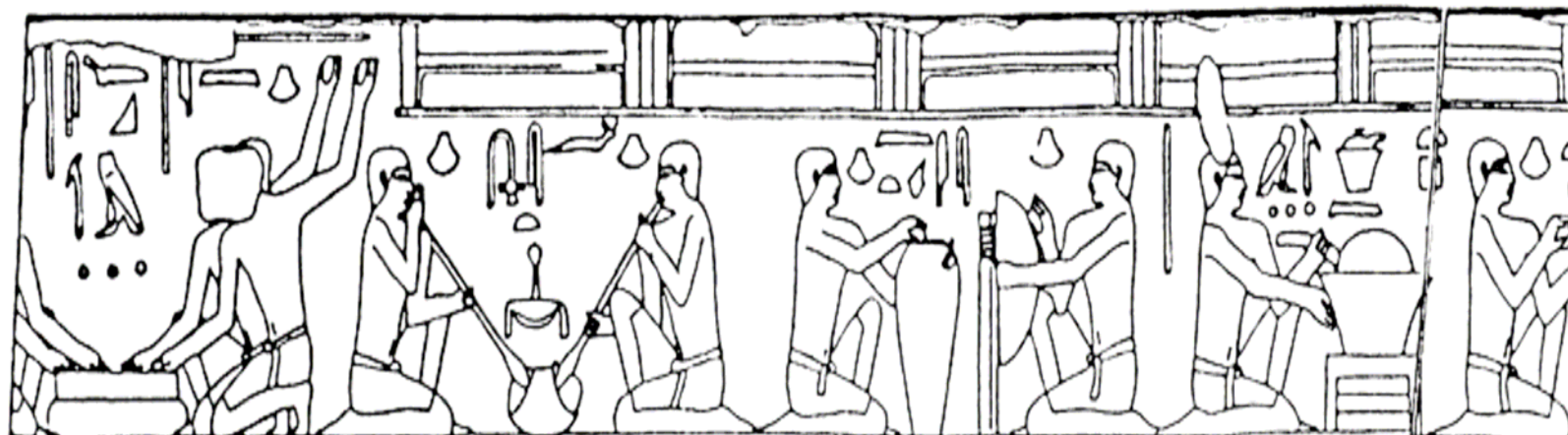


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Foundry-men, furnaces, melting, casting, tools used (Rekhmire, 18th Dyn.)



Heating, blowing (Kaemrehu, late of 5th Dyn.)



Weighing, blowing, melting, hammering of electrum sheet,
relief from the causeway of king Unas, (5th Dyn.)



Blowing, melting, jewelry making
(Niankhkhnum & Khnumhotep, Middle of 5th Dyn.)



Weighing, blowing, casting, beating and jewelry making (Mastaba of Mereruka, 5th Dyn.)



Refining, Polishing, Coloring, Quality Testing, Coating & Soldering From LEYDEN PAPYRUS



LEYDEN PAPYRUS

Discovered at Thebes.

Written in Greek.

Contains about seventy-five recipes dealing with metal finishing.

Displayed now in Leyden University in the Netherlands.



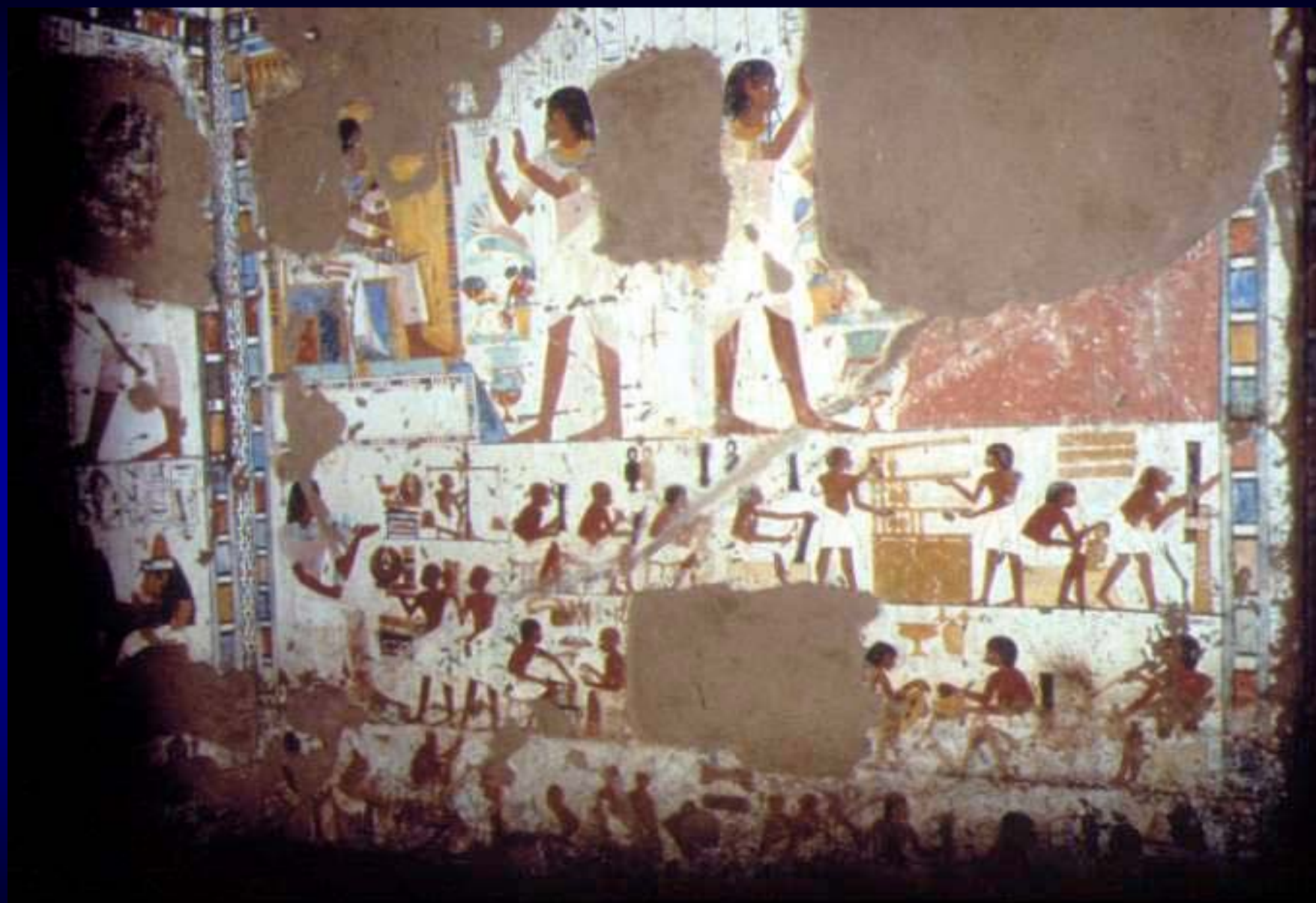
Refining:

- Dated to New Kingdom (1360 BC)
- Explained in Leyden Papyrus as the cupellation process
- Impure metals (copper, tin, lead..) were oxidized by the hot gas.
- The oxides were absorbed by porous cuples.
- Unoxidizable noble metals (silver, gold..) were left in the bottom of cupel



Polishing

- Special stones were used to smooth uneven patches on metal objects
- Metal surfaces finished using abrasives (emery or sand)
- Gleaming surfaces on pieces were obtained by final burnishing with small ball made of leather, felt or other textile.



Polishing, annealing on brazier (Sobkhotop, 18th Dyn.)



Alloying

- By end of 18th Dynasty, Egyptians learnt how to make an alloys of copper and gold.
- Ancient gold work acquired (grey, reddish brown or plum-purple) patina due to the tarnishing of copper.
- Some of jewels of Tut-ankh-amun gold changed its color over centuries as a result of introduction of other metals to alloy with it.



Coating

- Two techniques were used:
 - Hammering gold leaves on the surfaces
 - Sticking the leaves to surface with an adhesive



Soldering

- By 4th Dynasty, Egyptian knew how to join metal with hard solder.
- A clear example of soldering is bed canopy which belonged to Queen Hetep-her-es.
- Leyden Papyrus described in detail the manufacturer of Chrysocola and other solders.



Jewelry Decoration and Wire Making

- Wires were produced by using hand-made wire
- By New Kingdom; block-twisting method and rolling were introduced
- In 19th Dyn.; wires were made by means of soldering granules.



Jewelry workshop (Nebamun, 18th Dyn.)



CONCLUSION

- Metal production techniques were highly developed in ancient Egypt.
- Moulding techniques such as lost wax and master form still applied in the modern foundries of today.
- Excelled skills in fine hand-made objects, delicate ornamental wirework, decoration of jewelry.
- Some of the used soldering techniques are not known until now.



THANK YOU

