ST5 301

ARCHAEOLOGY I
(A Short Summery)

1. Introduction
2. Metals and metallurgy
   - Ores and mining
   - Smelting
   - Metal structure and alloys
   - Development of ancient Cu, Ag, Pb, Sn, Au, Zn, As and Fe metallurgy
3. Decay and corrosion
4. Dating methods in archaeology

RECONSTRUCTION OF HUMAN CULTURAL HISTORY REQUIRES THE ESTABLISHMENT OF

• His biological evolution
• His natural environment
• His means of subsistence
• His material culture (artifacts)

ASSESSMENT OF CULTURAL DEVELOPMENT OF A GIVEN SOCIETY CAN BE MADE BY INDEPTH ANALYSIS OF THE FOLLOWING SYSTEMS

• Economic
• Political
• Social
• Ideological
• Technical
ARCHAEOLOGISTS ASK THE FOLLOWING QUESTIONS

• What is it?
• How old is it?
• How has it been made?
• Who made it?
• Was it made locally or did it come to the site by trade?

“ARCHAEOOMETRY” is a synthetic term indicating that “ancient things and phenomenon” relate to them are to be “measured and quantified”

ARCHAEOOMETRY DEALS WITH

• Composition of materials
• Dating of artifacts
• Conservation of artifacts
• Prospecting sites
• Source analysis
• Trade patterns
• Ancient technology
• Authentication of artifacts

DISCIPLINES COOPERATING WITH ARCHAEOLOGISTS

• Physical, chemical and biological sciences: identity, source, date and manufacturing technology.
• Natural sciences: botanists, soil scientists, zoologists.
• Geophysics: prospecting
• Anatomy and physiology: biological aspect of humans.
MATERIALS

Human’s enjoyment, exploitation and eventual explanation of the inner qualities of MATERIAL is one of the more fascinating aspects of human history. Materials have fundamentally determined what man could do at every stage of history.

CLASSIFICATION OF MATERIALS

- Raw materials: stones, wood, clay
- Separated materials: skin of animals, bone tools
- Extracted materials: metals
- Compounded materials: bronze, glass, pottery
- Constructed materials: basket weaving, textiles

ARCHAEOLOGICAL MATERIALS

<table>
<thead>
<tr>
<th>Material</th>
<th>Naturally Occurring</th>
<th>Manufactured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic Metals</td>
<td>Gold, silver, iron (the ten active metals)</td>
<td>All metals and alloys excluding those occurring naturally</td>
</tr>
<tr>
<td>Building materials</td>
<td>Lime, stone, brick, marble, sugar, etc.</td>
<td>Lime, plaster of Paris, baked brick, and tile</td>
</tr>
<tr>
<td>Cements</td>
<td>Clay, obsidian, flint</td>
<td>Clay body-cements, glass, fenestra</td>
</tr>
<tr>
<td>Pigments</td>
<td>Ocher, chalk, enamel</td>
<td>Egyptian blue, lead white</td>
</tr>
<tr>
<td>Organic Vegetables</td>
<td>Wood, main, pithon</td>
<td>Gum, resins, gums, lacca, fibra</td>
</tr>
<tr>
<td>Animal</td>
<td>Hide, bone, horn, ivory, feathers, hair, blood, fat, wool</td>
<td>Glass, leather, fibres</td>
</tr>
</tbody>
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TIME LINE OF ANCIENT NEAR EAST

- 10,000 -9,000 BC  Mesolithic Age
- 9,000 -7,000 BC  Proto Neolithic Age
- 7,000 -5,600 BC  Neolithic Age
- 5,600 -5,000 BC  Early Chalcolithic
- 5,000 -4,000 BC  Middle Chalcolithic
- 4,000 -3,200 BC  Late Chalcolithic
- 3,200 -2,000 BC  Early Bronze Age
- 2,000 -1,600 BC  Middle Bronze Age
- 1,600 -1,200 BC  Late Bronze Age
- 1,200 BC  Iron Age
GEOLOGICAL TIMES

- Precambrian 4.6 B - 570 M years
- Paleozoic (Ancient life) 570 M - 225 M years
- Mesozoic (Middle life) 225 M - 65 M years
- Cenozoic (New life) 65 M - Present

ANCIENT ATMOSPHERE

PALEOZOIC ERA
570 - 250 M years

- 570 x 10^6 years: Early shelled organisms
- 480 x 10^6 years: Early fish
- 420 x 10^6 years: Early land plants
- 380 x 10^6 years: Early Trees, formation of coal deposits
- 300 x 10^6 years: Early reptiles
- 240 x 10^6 years: Final assembly of Pangaea
Formation of Pangea

NATURAL CATASTROPHES
AND LIFE ON EARTH

EXTINCTION

MASS EXTINCTIONS

1. Ordovician (440 M years ago): 57% of marine invertebrate genera.
2. Devonian (370 M years ago): large amounts of biomass died, tropic reefs vanished.
5. Cretaceous-Tertiary (65 M years ago): Impact of an asteroid, end of the age of reptiles (dinosaurs) and beginning of the age of mammals.
PLATE TECTONICS DURING MESOZOIC ERA

- Continents drifted to almost present positions
- Atlantic and Indian Oceans opened at a pace of 2 cm/year
- Africa swung around Gibraltar and squeezed the Mediterranean
- India raced north from Antarctica slamming into Asia to form the Himalayas
- Australia moving north separated from Antarctica

MASS EXTINCTIONS

- Mesozoic Era came to an end abruptly 65 M years ago together with the mass extinction of plants and animals
- The principal casualties among the reptiles were the dinosaurs.
- LW Alvarez recognized 2 cm clay later at the Mesozoic (Cretaceous) and Cenozoic (Tertiary) boundary enriched with iridium (30 times) at several places around the world.
- Iridium is poor in silicous Earth crust but found extensively in iron meteorites.
- It is now believed that an asteroid with 10 Km diameter hit the Earth. This impact would eject debris to space which would block sunlight for a long time (Possibly years)
REAL REASON WHY DINOSAURS BECAME EXTINCT

CENOZOIC ERA
65 M - Present
- $65 \times 10^6$ years: Early primates
- $53 \times 10^6$ years: Separation of Australia and Antartica
- $40 \times 10^6$ years: Collision of India with Asia
- $20 \times 10^6$ years: Formation of Himalaya
- $1.8 \times 10^6$ years: Oldest stone tools
- $1.4 \times 10^6$ years: Homo Erectus
- $0.1 \times 10^6$ years: Neanderthal man

ICE AGES (GLACIATIONS)

FAMILY TREE OF HOMINIDS
MIGRATION OF HOMO ERECTUS

CLIMATE DURING PLEISTOCENE
15,000 years old dwelling made out of mammoth bones in Mazhirich, Ukraine.

CIVILIZATIONS OF ANATOLIA

- 10,000 - 9,000 BC: Mesolithic Age
- 9,000 - 5,500 BC: Neolithic Age
- 5,500 - 3,200 BC: Chalcolithic
- 3,200 - 1,000 BC: Bronze Age
- 1,200 - BC: Iron Age

NEOLITHIC REVOLUTION

- Beginning of agriculture
- Domestication of animals
- Invention of pottery
- Beginning of settlements
- Use of new stone implement
STONE TOOLS

Olduvan
2.5 million years

Acheulean
1.5 million years

Mousretian
200,000–40,000 years

Upper Paleolithic
40,000–12,000 years

Catalhoyuk
dagger

OBSIDIAN TOOLS

Brittle, hard, volcanic glass composed of mainly quartz ($\text{SiO}_2$), feldspar (aluminum silicate minerals). It can be flaked into sharp tools.

OBSIDIAN MIRROR

NEOLITHIC OBSIDIAN TRADE
**MARBLE**
Soft metamorphic stone of CaCO$_3$ and CaMgCO$_3$

Cycladic sculpture (3rd. Mil BC)

**ANATOLIAN IDOLS**

Karatas

Beycesultan

Kültepe

**MARBLE STATUES**

**BASALT/DIABASE**
Igneous rock with high iron content. Used as grinding and crushing tools and sculpture

Hittite Goddess Kubaba
Paleoanthropological examination of human bones yield information on subsistence strategy, dietary habits, environmental conditions and diseases and famines. DNA analysis of bones also yield information on social structure, as well as migrations.

**Human remains**

- Preserved body of Otze in Alps (2500 BC)
- Sacrificed Inca boy
- Preserved body in Hot desert sand

**Study of human remains**

- Human bodies can be preserved under extremely cold, dry or in locations where bacteria cannot survive.
  - Preserved bodies in bog (tar sediment) (1500 AD)
  - An Egyptian Mummy, 2500 BC

- Skulls and upper part of a human skeleton.
PIGMENTS

Finally divided, water insoluble colored materials applied on surfaces with a binder. They are generally colored inorganic minerals.

- White: Calcium carbonate (Ca\(_2\)CO\(_3\))
- Black: Lamp black
- Yellow: Orpiment (As\(_2\)S\(_3\))
- Red: Red Ochers (Fe\(_2\)O\(_3\))
- Green: Malachite Cu\(_2\)CO\(_3\)(OH)\(_2\)
- Blue: Azurite Cu\(_3\)(CO\(_3\))\(_2\)(OH)\(_2\)

SOME NATURAL DYES

- Indigo (blue) from *Indigofera tinctoria*
- Alizarin (red) from *Rubia tinctorum*
- Saffron (yellow) *Crocus sativus*
- Bark of oak tree, walnut hulls, oakgalls, (brown and black)
- Henna (reddish-orange)

IVORY

Urartian ivory carvings from 1st century BC

AMBER

- It is the fossil resins derived from the coniferous trees (sunlight solidified by the sea waves).
- Baltic sea region contains the main deposits of amber formed about 60 million years ago.
- It is possible to provenance marble determining:
  a) succinic acid content
  b) trace element analysis
  c) use of infra red spectroscopy
ANCIENT AMBER

PYROTECHNOLOGY

• Cooking of food  100,000 years ago
• Annealing stone  25,000 years ago
• Baked clay   9,000 BC
• Plaster   9,000 BC
• Smelting of ores   6,000 BC
• Glaze   4,000 BC
• Glass   2,000 BC

CHEMISTRY INTRODUCED BY PYROTECHNOLOGY

• Oxidation: Burning organic material.
• Reduction: Reducing metals from their ores
• Aggregation: Preparation of alloys, pottery
• Heat Separation: Distillation

ACHIEVEMENTS PROVIDED BY PYROTECHNOLOGY

• 100-150 °C: Roasting of gypsum (CaSO₄) to obtain plaster
• 450-600 °C: Structural water of clay is lost, clay is irreversibly changed
• 800-1000 °C: Vitrification of clay is completed
• 1100-1200 °C: Smelting of most metals from its ores
• 1200-1500 °C: Extraction of iron from its ore, turning silicates into glass
GLAZE

- Glaze are vitreous coatings applied to the surface of wares to decorate them or make them impermeable.
- An aqueous suspension of glaze ingredients (modifiers and colorants) are sprayed or painted onto the pottery surface.
- After drying, it is fired in a kiln with proper temperature and atmosphere.
Glass is a generic term for a transparent material that has the rigidity of a crystal with the largely random molecular structure of a liquid. Main components of glass are:

- Sand: Silica (SiO₂)
- Soda: Sodium carbonate (Na₂CO₃)
- Lime: Calcium oxide (CaO)
**ARCHAEOLOGICAL WOOD**

- Can be preserved for long periods of time under extremely cold, wet, dry or anoxic conditions.
- Buried archaeological wood generally undergoes changes turning into dust, humus, coal or mineralize depending on the environmental conditions.
- Waterlogged wood may undergo diagenesis where sedimentary materials are slowly compacted eventually to form rock.

**WOOD FROM TUTANKHANUM’S GRAVE**

**SWEEDISH WARSHIP VASA**
BASIC PRINCIPLES OF DATING

- Decay of radioactive isotopes
- Variations in the direction and intensity of earth’s magnetic field
- Time dependent chemical changes occurring subsequent to burial
- Annual occurrence of natural rhythmic processes
- Sequence of floral and faunal developments

RADIOACTIVE DATING METHODS

1. Methods depend on radioactive decay:
   a) Radiocarbon (<50,000 y)
   b) Potassium-Argon (>500,000 y)
2. Radiation damage dating:
   a) Fission track (>1000 y)
   b) Thermo luminescence (>100 y)
   c) Electron spin resonance (<10^6 y)

NON-RADIOACTIVE DATING METHODS

1. Methods depending on the continuous natural and chemical changes:
   a) Archaeomagnetism (unlimited)
   b) Amino acid racemization (<10^6 y)
   c) Uranium-fluoride concentration
   d) Obsidian hydration (<100,000 y)
2. Methods depending on natural cycles:
   a) Dendrochronology (<7,000 y)
   b) Varne chronology (unlimited)
DATING METHODS

- Dendrochronology
- Radiocarbon dating
- K-Ar and 40Ar/39Ar decay
- Thermoluminescence
- Fission-track dating
- Obsidian hydration
- Archaeomagnetism
- Palaeomagnetism
- Bone analysis (U/Pb & Re/Os)
- Amino acid analysis

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Dating