


MODULE-4
EXCAVATION AND DATING
TECHNIQUES
TOPIC- DATING METHODS

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DATING METHODS- ABSOLUTE AND RELATIVE DATING TECHNIQUES

- Archaeologists have **used many methods to find out the date of artifacts collected from the archaeological sites.**
 - They are mainly **classified into three;**
 - 1. **Relative Dating Methods** that **identify the order in which sites or artifacts were used in a sequence from earliest to latest.** It include historical dating, typology, sequence dating series, geological timescales, varve, pollen analysis, stratigraphy, Geochronology etc
 - **Absolute Dating (Chronometric)** that **try to establish an exact or approximate calendar date for a site or artifacts.** It includes Radio-carbon dating, Potassium- argon method, Uranium series method, Thermoluminescence, Electron spin resource (ESR), Dendrochronolgy etc
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- Along with these two broad categories there is another technique named **derivative dating method** that includes **Fluorine test, Uranium test, Nitrogen test, Amino acid test, Obsidian hydration dating, Archaeomagnetic dating, Cation-ratio dating (CR) etc.**



DENDROCHRONOLOGY

- **A.E Douglass** has developed this method in the **first half of 20th century**.
- This is the **most accurate chronometric dating method**.
- It is an approach **based on counting the annual growth rings observable in the cross-sections of cut trees**.
- Every year trees produce a visible ring of new wood under their bark.
- Early in the annual growing season trees produce thin walled 'early wood cells'.
- Towards the end of the year thick walled 'late wood' cells are produced. This cycle produces a visible 'ring' in the wood each year.



- The **rings are wider in good weather conditions** than in poor ones and can **provide a record of local climate variation.**
- **Trees in the same area will have similar ring patterns,** which mean wood from different periods can be matched in overlapping sequences.
- These are tied to historical dates by modern trees.
- **Scientists have prepared a sort of calendar based on tree ring samples for the last three thousand years.**
- By comparing a sample with these calendars or charts, the archaeologist can estimate the age of that sample.





RADIO CARBON DATING

- Radiocarbon dating also known as carbon dating or C-14 dating is a method for determining the age of an object
- This is one of the most important methods of dating **organic materials** collected from the archaeological sites, **which contain some carbon in them.**
- **Willard F. Libby** discovered this method in **1946.**
- This method is **more reliable one for the dating of the pre-historic material remains.-bone & charcol**
- The radiocarbon dating is the oldest and perhaps the most widely used in archaeology.



- **All living things absorb several types of carbon isotope from the atmosphere in similar ratios until death.**
- **About one percentage of these carbons is an unstable isotope known as C14 (Carbon 14), which decays at a known rate.**
- It is based on the principle that radiocarbon C-14 is constantly been formed in the atmosphere by the interaction of cosmic rays with the nitrogen present in the atmosphere.
- The resulting C-14 combines with atmospheric oxygen to form radioactive carbon dioxide which is absorbed by the plants by means of photosynthesis and by animals through eating.

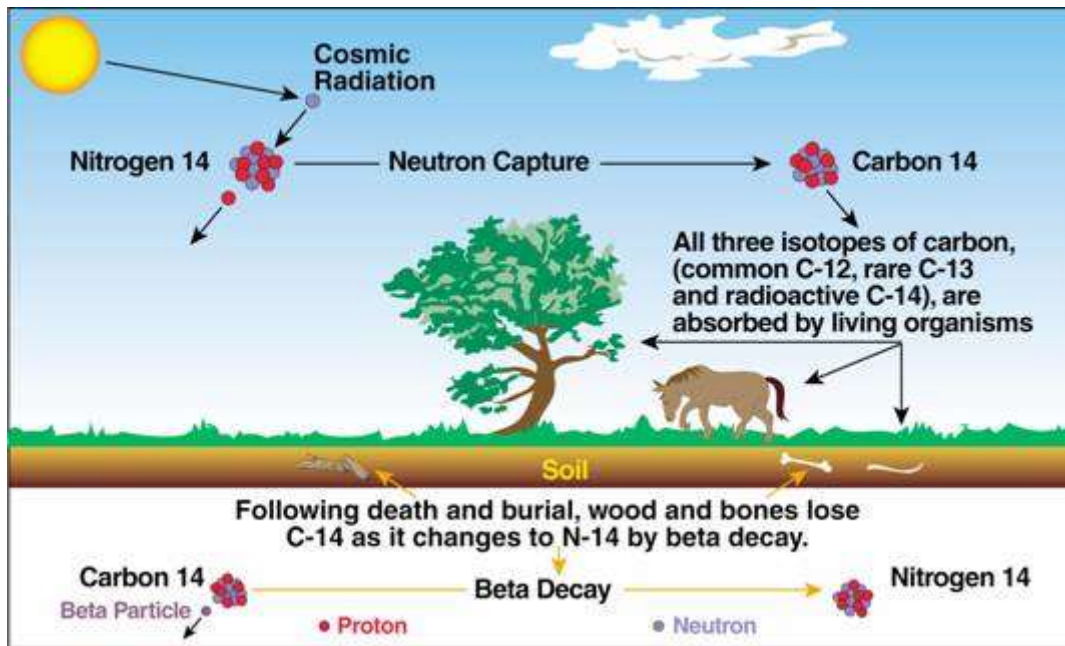


- When the plant or animal ceases to be living it stops receiving fresh supply of C-14.
- The existing C-14 now undergoes a process of decay which is called radioactivity.
- C-14 is a radioactive isotope or element of C-12, and both are present in equal amounts.
- We may measure the decaying C-14 with reference to C-12, and find out the number of years that have elapsed since the decay began.



- The object which contains less C-14 proves to be older in age, and that which contains more C-14 turns out to be younger.
- This measurement is based on the fact that the half-life of C-14 is 5568 years.
- The half-life of a radioactive material is defined as the period during which one-half of the amount of the material decays out.
- Since most organic materials perish in due course, charcoal because of its high content of carbon is the commonest material utilized for radiocarbon dating.





THERMO LUMINESCENCE DATING

- **Farrington Daniels** has developed a method known as Thermoluminescence measurements **for dating the ancient pottery in 1953.**
- This method is **useful to all terracotta materials like pottery, tiles, bricks and all other terracotta objects.**
- Thermoluminescence is the **release in the form of light of stored energy from a substance when it is heated.**
- **All ceramic material contains certain amounts of radioactive impurities (uranium, thorium, potassium).**
- **Radioactive decay in the quartz crystal found in clay leads to a buildup of electric charge at a known rate.**
- **The electrical charge is released as light when the crystals are heated.**



- **When the ceramic is heated the radioactive energy present in the clay until then is lost, and fresh energy acquired gradually depending on the time of its existence.**
- **The thermoluminescence observed is a measure of the total dose of radiation to which the ceramic has been exposed since the last previous heating, i.e. in the kiln.**
- **For calculating dates, the sample is heated up to 500°C and thermoluminescence observed as a flame is measured with very sensitive instruments.**
- **The glow emitted is directly proportional to the radiation it received multiplied by the years.**



- However, it is **significantly less accurate than C-14 dating and can give false readings due to radiation from the soil or if the initial firing at low temperature.**
- It is **useful for older periods and instances where there are no organic remains such as dating pre-historic times.**



ELECTRO SPIN RESONANCE DATING

- This method is useful to date the bone and calcite material remains discovered from the archaeological site.
- It has developed by Ikeya and Miki in 1980.
- Electro spin Resonance (ESR) measures radiation-induced defects or the density of trapped electrons in bone and calcite remains.
- The tooth enamel particularly with the thick enamel layers is the best material for ESR studies.
- On counting on the amount of electrons trapped in the bone, the date is determined



FISSION TRACK

- **Fleischer, Price and Walker** has jointly developed this method.
- It is known that many minerals and natural glasses (obsidian, tektites) contain very small quantities of uranium.
- Through time, the uranium undergoes a slow spontaneous process of decay.
- The natural splitting (fission) of Uranium-238 atoms present in obsidian (volcanic lava) and other glassy volcanic minerals, leaves traces called fission tracks.



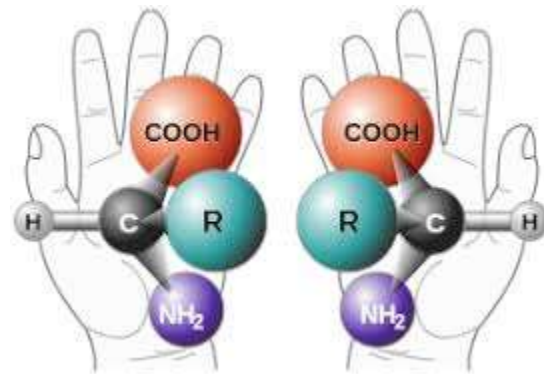
- **This method of dating depends upon the measurements of detectable damage called tracks in the structure of glasses caused by the fission.**
- **These tracks disappear when the glass is heated above a critical temperature and fresh tracks formed in course of time.**
- **The fresh tracks are counted to date the sample.**
- **This method is suitable for dating objects which have undergone heating process some 100,000-1,000,000 years ago.**



AMINO ACID RACEMIZATION

- Amino acid method is useful to find out the age of bone.
- **Jeffrey L. Bada** has developed this method.
- This method depends on cumulative changes in amino acids in bone after the creature has died.
- Among the 20 kinds amino acid present in the modern bone, only 1 kind of amino acid (Aspartic acid) exist in two mirror-image forms.
- As long as the organism is alive, the amino acid molecules are in left-handed form (or L-isomer form) but at death, they began to change to distinct right handed form (D-isomers). This process of change called Racemization.
- If one knows the racemization rate, one could be able to calculate the date of the bone.





OBSIDIAN (GLASS) HYDRATION

- **Irving Friedman and Robert Smith**, two geologists, began looking into **obsidian's potential as a time marker in 1948** and introduced the **obsidian hydration dating method to the archaeological community in 1960.**
- Obsidian hydration dating is a **geochemical method of determining age in either absolute or relative terms of an artifact made of obsidian.**
- **Obsidian is a volcanic glass that was used by prehistoric people as a raw material in the manufacture of stone tools such as projectile points, knives, or other cutting tools through knapping, or breaking off pieces in a controlled manner.**



- **The surface of many geological materials undergoes chemical changes through time.**
- **These weathering reactions create a visibly distinct surface layer or patina.**
- **When obsidian artifacts are buried, they start absorbing water and form a layer called hydration layer.**
- **The thickness of the layer depends on how long the article has been buried; the surrounding temperature condition, long term change in the soil humidity and the petrographic nature of the sample.**
- **The sample is dated by measuring the thickness of the hydration layer.**



FLUORINE DATING METHOD

- Fluoride (or fluorine) dating is a **relative dating method that can be used to date archaeological bone.**
- As a relative dating method, it can **determine the relative age of specimens, but cannot provide a calendrical date unless the fluoride chronology is calibrated with an absolute dating method.**
- Bones are primarily composed of the mineral calcium hydroxy apatite. When exposed to water that contains fluoride, a fluoride ion (F⁻) can replace a hydroxyl ion (OH⁻) in the bone mineral.



- The resulting fluorapatite is more stable than the original form, thus the fluoride content of a bone will increase over time if it is exposed to a solution containing fluoride ions.
- Fluoride ions are present in trace amounts in most soils and ground waters.
- Over time, buried bones pick up fluoride ions from soil moisture or exposure to groundwater.
- Older specimens have higher fluoride contents than younger ones when burial conditions are identical.
- The requirement of identical burial conditions means that fluoride dating works best when it is applied within a single site with little variation in soil chemistry.



URANIUM DATING AND URANIUM SERIES DATING

- Uranium dating is a radiometric dating method. It is useful to date ancient rocks.
- Uranium series dating is a radiometric dating technique commonly used to determine the age of calcium carbonate materials such as speleothem (structure formed in caves by deposition of minerals from water) or coral.
- These methods are based on the radioactive decay of isotopes of uranium.
- The process whereby a radioactive isotope of uranium ^{238}U decays into ^{235}U is calculated.
- The date is determined based on the amount of ^{235}U that had accumulated through radioactive decay.



NITROGEN DATING

- This derivative dating method is **useful to date bone remains from the archaeological sites.**
- Bone basically consist of calcium phosphate, fat and bone protein or collagen.
- **On death, fats gradually disappear. The collagen survives much longer though it decays at a uniform rate.**
- These can be measured by a nitrogen assay.
- The rate of decay depends on physical, chemical and other factors of the soil. Therefore, it is not universal.
- However, bone of different dates in a single deposit can be distinguished based on nitrogen content.



VARVE ANALYSIS

- **De Geer and Antevs** are developed the Varve dating method.
- The **annual deposit of sediment in the lake bed is called varves, which can be counted.**
- They note a **regular alteration between the coarser silts deposited by glacial melt water in the summer, and fine clays deposited as suspended particles settled during the winter months when the lake was covered with ice.**
- The recurring pattern of coarse and fine sediments could be read as a yearly record of glacial discharge.



- Geologist established a dated sequence of varve by moving back in time from recent layer of known age.
- The thickness of the varve pairs varies from year to year, depending upon the amount of glacial melting.
- This also serves as a sequential landmark. Some of the ancient shorelines were established through this system.
- Considerable deposits of varves were found in Scandinavia, representing thousands of years, stretching from the present back to the beginning of the retreat of the glacial ice sheets in Scandinavia some 13,000 years ago.





SERIATION

- This is a **method of determining the age of the artifacts based on style type and technique.**
- It is broadly **divided in to two categories; Stylistic seriation and Frequency seriation.**
- The **first one refers to a technique through which artifacts and attributes are ordered according to similarity in style.**
- For example **dish on stand, S-shaped jar and perforated jar are some of the diagnostic styles available in Harappan style.**
- This will **help the archaeologist to determine the cultural phases**



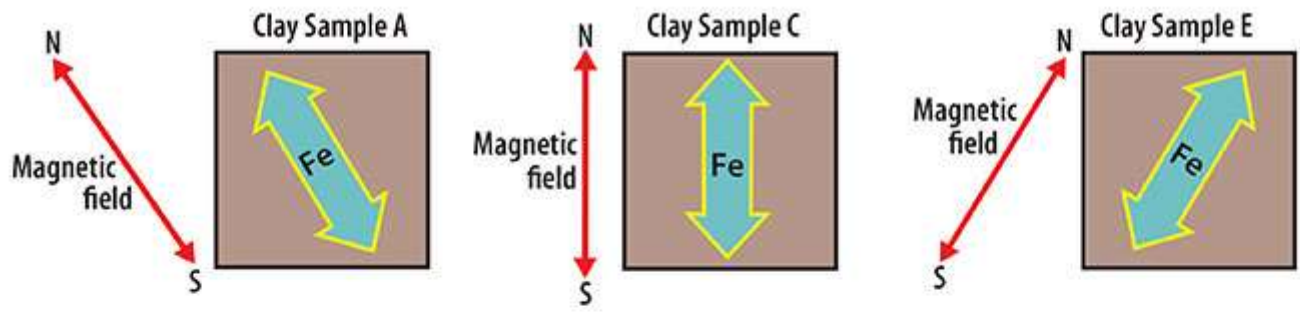
- **The second one is more strictly oriented to chronological ordering of the artifacts and assessing the origin, popularity and disuse of the artifacts.**
- **The length of time and degree of popularity would be assessed in the given archaeological context.**
- **For example, Painted Gray Ware, Northern Black Polished Ware, Black and Red Ware are noticed in a particular time range only.**



ARCHAEO-MAGNETIC DATING

- This method is based on the fact that the earth's magnetic field varies through time.
- It is based on the constant change, both in direction and intensity, of the earth's magnetic field.
- The location of magnetic north pole changes its position both horizontally as well as vertically.
- The direction of that magnetic field at a particular time is recorded in any baked clay structure like oven, kiln, hearth etc that has been heated to a temperature of 650° to 700° C.
- At that temperature, the iron particles in the clay permanently take up the earth's magnetic direction and intensity at the time firing.
- This helps to date the newly discovered fired clay samples directly by using the archaeomagnetic data.





An archaeomagnetic sample collected from the clay lining of an ancient hearth is compared with the archaeomagnetic reference curve to determine the date of the last hot fire in the hearth.

