Dating techniques for the Cultural Heritage

Marco Martini
Archaeometry Laboratory
INFM & Materials Science Department
Università di Milano Bicocca
Via R.Cozzi 53, 20125 Milano

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

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Archaeometry: Analysing the Cultural Heritage

Archaeometry is an interdisciplinary field of research, where the studied objects stem from archaeological to cultural and historical domains whereas the approach of investigation is based on science.

Main physical techniques in Archaeometry:

Dating techniques (Dendrochronology, Radiocarbon, Thermoluminescence)

X-ray spectrometry

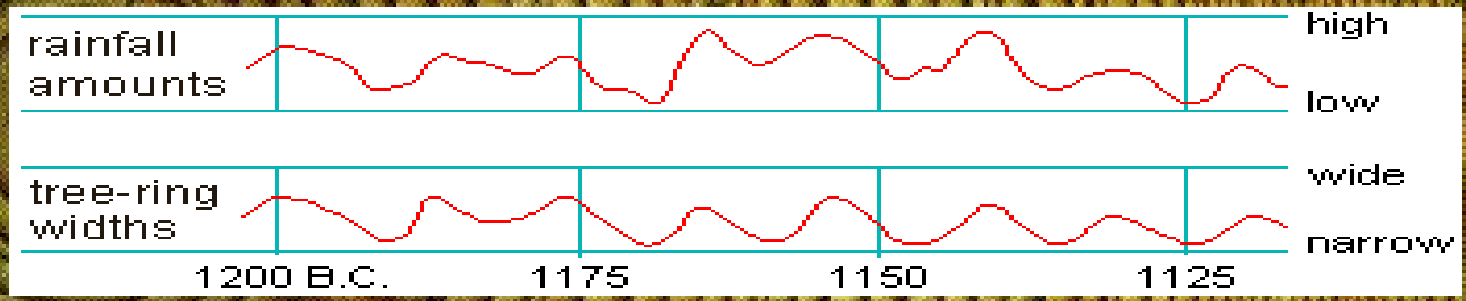
Radiography and Tomography

Nuclear techniques

Dendrochronology: dating and study of annual rings in trees

A.E. Douglas, astronomer, Tree-ring Laboratory, University of Arizona, 1937.

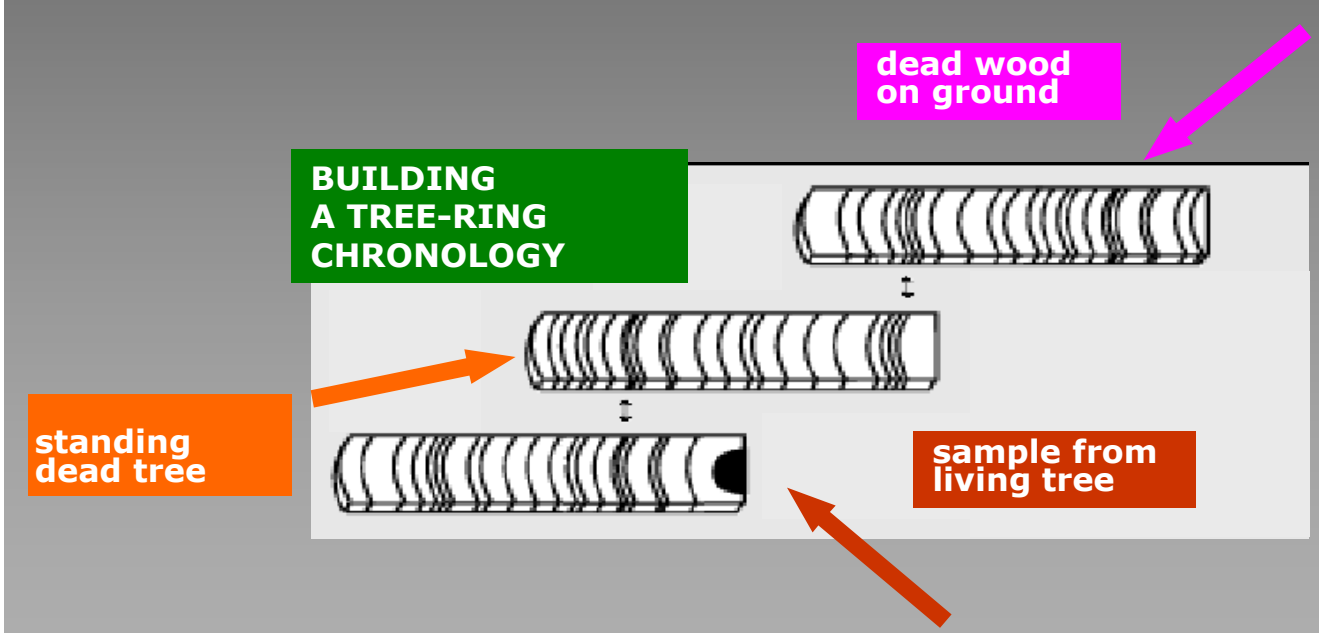
Trees respond to temperature, rainfall and environmental conditions by altering growth. In propitious years, the tree adds extra tissue and the ring will be correspondingly thick. During adverse years, growth is slowed and rings are thinner



Year-to-year changes in the weather create patterns, whose study allows to:

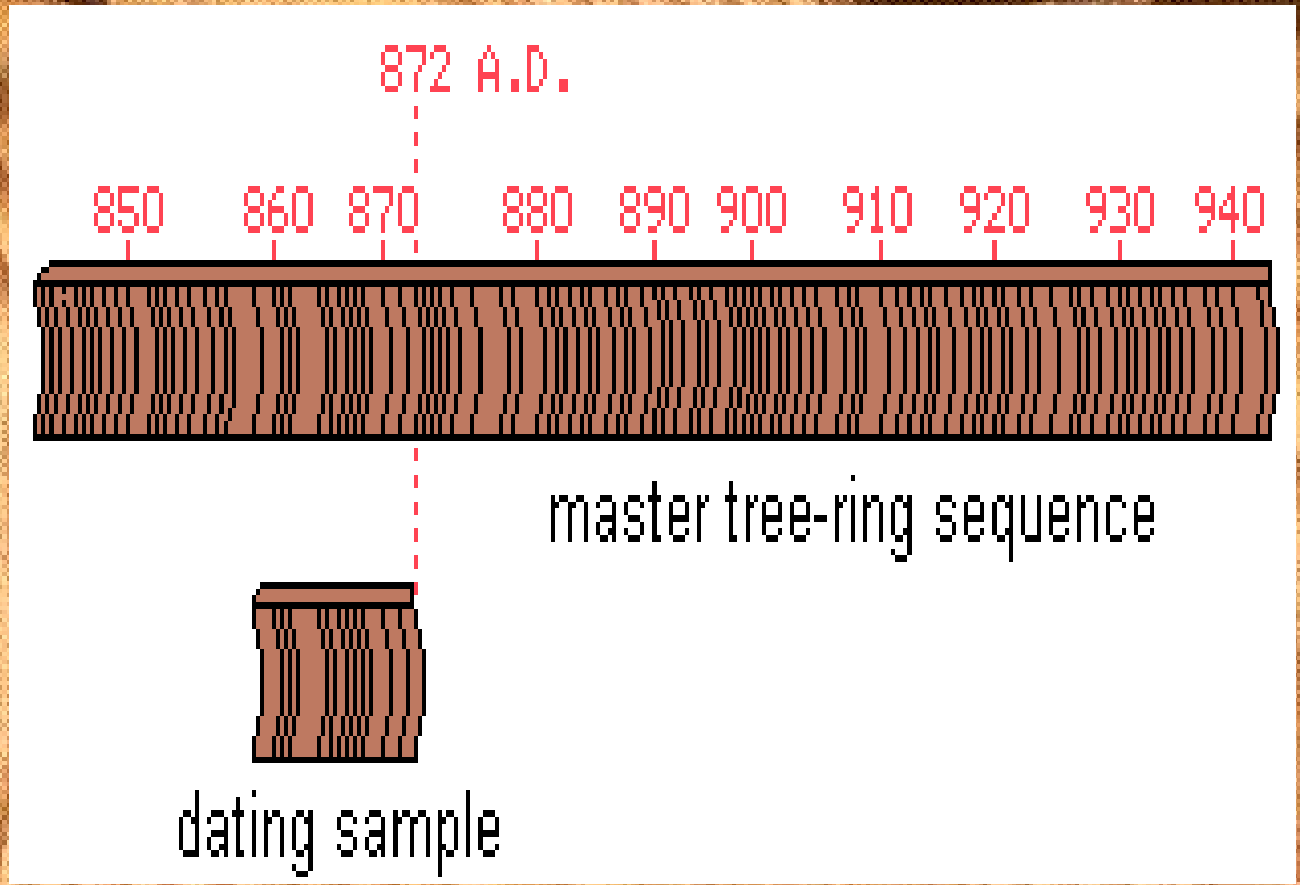
- **Reconstruct past climate variations**
- **Reconstruct past insect infestations**
- **Estimate frequency and intensity of fires**
- **Reconstruct rain fall in the past**

Crossdating: process of matching rings of different trees of the same species in a homogeneous area, based on patterns of ring widths produced by regional climate



CREATION OF A MASTER SEQUENCE

DATING:
The ring pattern of an undated wood is compared to that of the corresponding master tree-ring sequence, to find where they match.

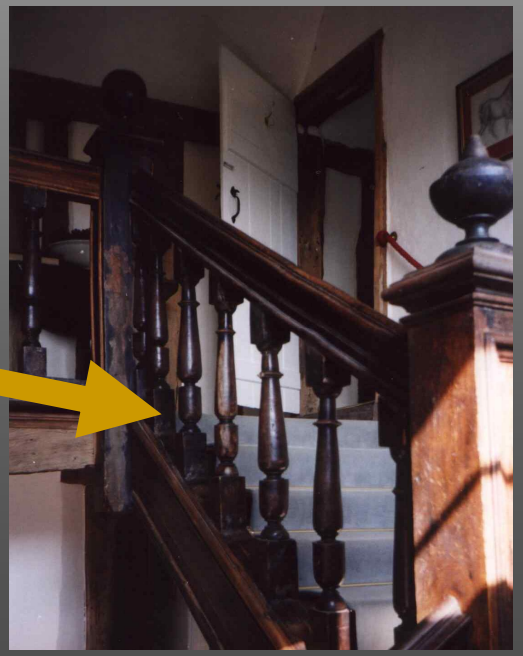


Coolham Barn, W.Sussex, England.
Dating of ten oak building timbers of the first building phase

Timber felling date:
spring-summer AD 1549

XVII century staircase:

Timber felling date:
AD 1653-1685



RADIOCARBON DATING

(W.F. Libby, Nobel Prize in Chemistry in 1960)

Radiocarbon (half-life 5730±40y), is produced through cosmic ray interactions in atmosphere

$^{14}N + n \Rightarrow {}^{14}C + p$

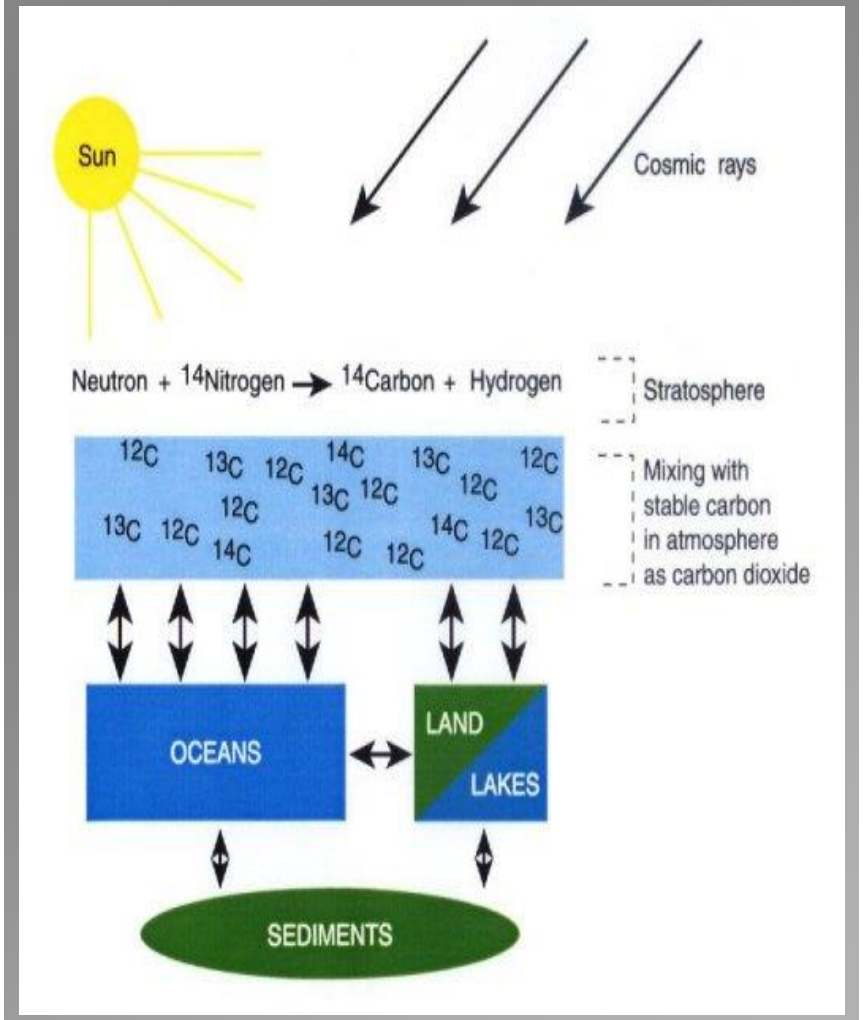
$^{14}C + O_2 \Rightarrow {}^{14}CO + O$

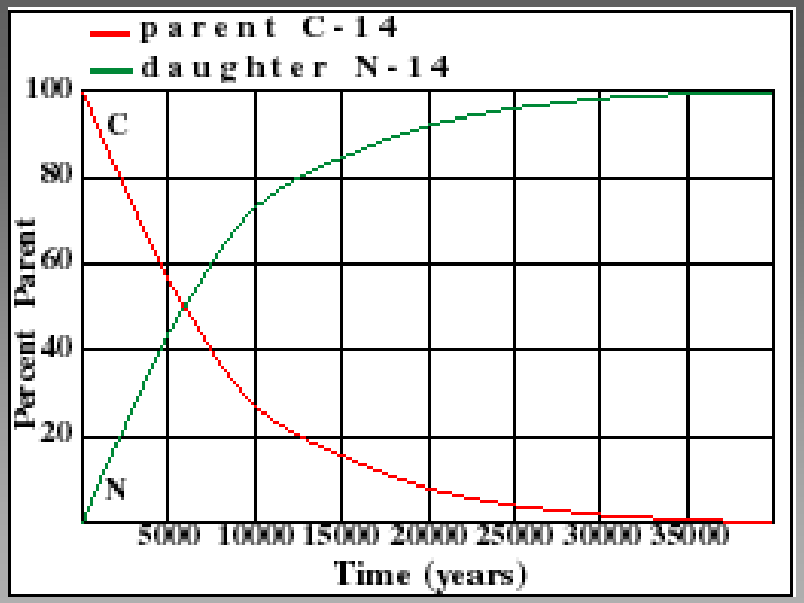
$^{14}CO + OH \Rightarrow {}^{14}CO_2 + H$

It stays in the atmosphere for ten years, getting well mixed with stable CO_2.
It eventually enters the terrestrial reservoirs (hydrosphere and biosphere).

An equilibrium between production rate and radioactive decay is established on a global scale.
The average $^{14}C/^{12}C$ atomic ratio in carbon which is in exchange with the global ^{14}C reservoir is constant (10^{-12}).

Once the exchange ceases (through death of biomaterials), the radioactive clock starts running and the age of an object can be determined from the decreasing $^{14}C/^{12}C$ ratio.





Ideal conditions for radiocarbon dating depend on the assumptions:

1. The atmosphere has had the same ^{14}C concentration in the past as now (constant production, constant and rapid mixing, exchange and transfer rates, constant size of reservoirs). As a corollary, the same 14C concentration exists in all parts of the biosphere.
2. The death of a plant or animal is the point at which it ceases to exchange with the environment.
3. After ceasing exchange, the ^{14}C concentration in a plant or animal is only affected by radioactive decay.

None of them is strictly correct, beyond a rough first approximation.

CAVE OF CHAUVET-PONT-D'ARC FRANCE

Three samples taken from charcoal drawings of two rhinoceroses and one bison have yielded dates between 30,340 and 32,410 BP, the earliest currently known for rock art in the region.

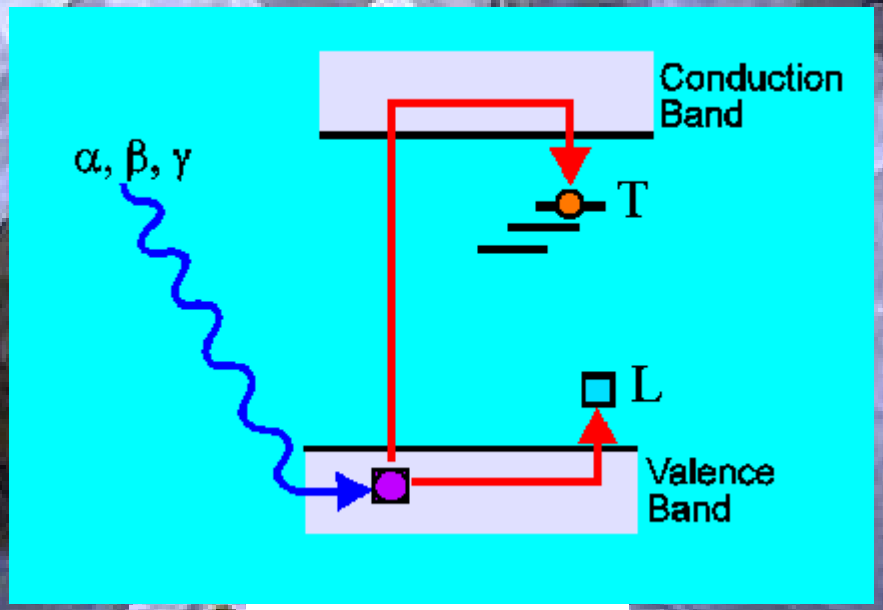
DEAD SEA SCROLLS

The scrolls consist of some 800 manuscripts in Hebrew and Aramaic discovered near Qumran. They include the oldest known manuscripts of the Old Testament.

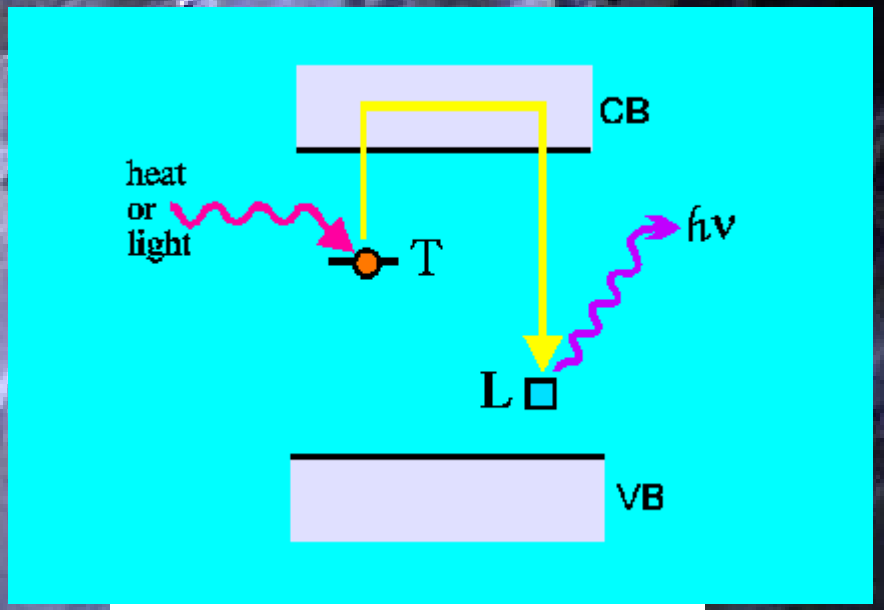
The parchment from the Habakkuk commentary was dated between 150 and 5 BC (95% confidence interval)

TERMOLUMINESCENCE DATING

Thermally Stimulated Luminescence (TSL) is the light emission that occurs when heat is applied to an insulator or a semiconductor which has been previously irradiated by ionising radiations.



1-TRAPPING



2-RECOMBINATION

ABSOLUTE DATING OF ARCHAEOLOGICAL CERAMICS: THE IDEA

DOSIMETERS: THE NATURAL CLAY MINERALS

CERAMICS: SOURCE OF NATURAL IRRADIATION
(INTERNAL)

ENVIRONMENT: SOURCE OF NATURAL IRRADIATION
(EXTENAL)

$$\text{AGE (years)} = \frac{\text{TOTAL ABSORBED DOSE}}{\text{ANNUAL DOSE-RATE}}$$

TSL DATING: APPLICATIONS

1-Ceramics and bricks

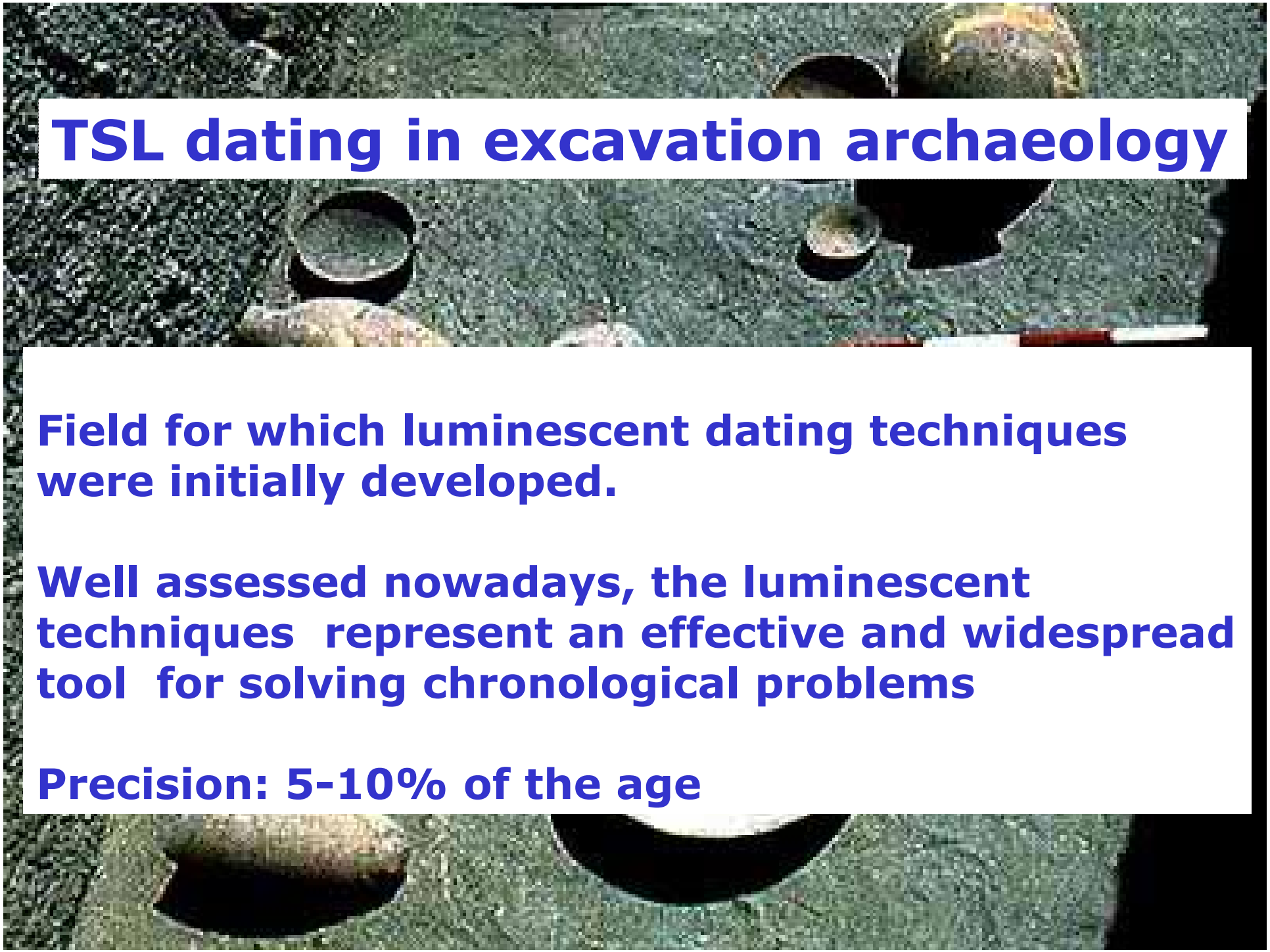
(archaeological excavations and historical buildings)

2-Clay-cores

3-Burnt flints

4-Glasses

5-Metallurgical slag



TSL dating in excavation archaeology

Field for which luminescent dating techniques were initially developed.

Well assessed nowadays, the luminescent techniques represent an effective and widespread tool for solving chronological problems

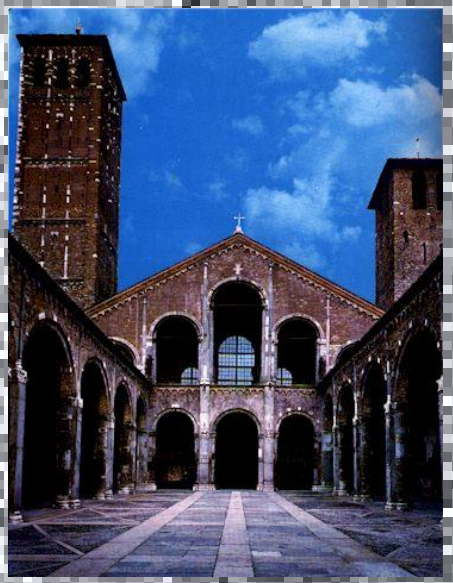
Precision: 5-10% of the age

TL dating in architecture (brick structures)

The main advantages of this application are:

1. **The availability of large quantities of material**
2. **The homogeneity of environmental radioactivity**
3. **The lesser extent of humidity fluctuation with respect to excavation archaeology**

Precision higher than in excavation archaeology



CLAY-CORES

INDIRECT DATING of bronzes (lost-wax casting)

PROBLEMS:

1-Often “bad” TSL behaviour

2-Available material and sampling

3-External dose-rate evalution
(shielding effect)

5-Radiographs