Excavation and Sampling Methodologies

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MPI-SHH
SUMMER SCHOOL
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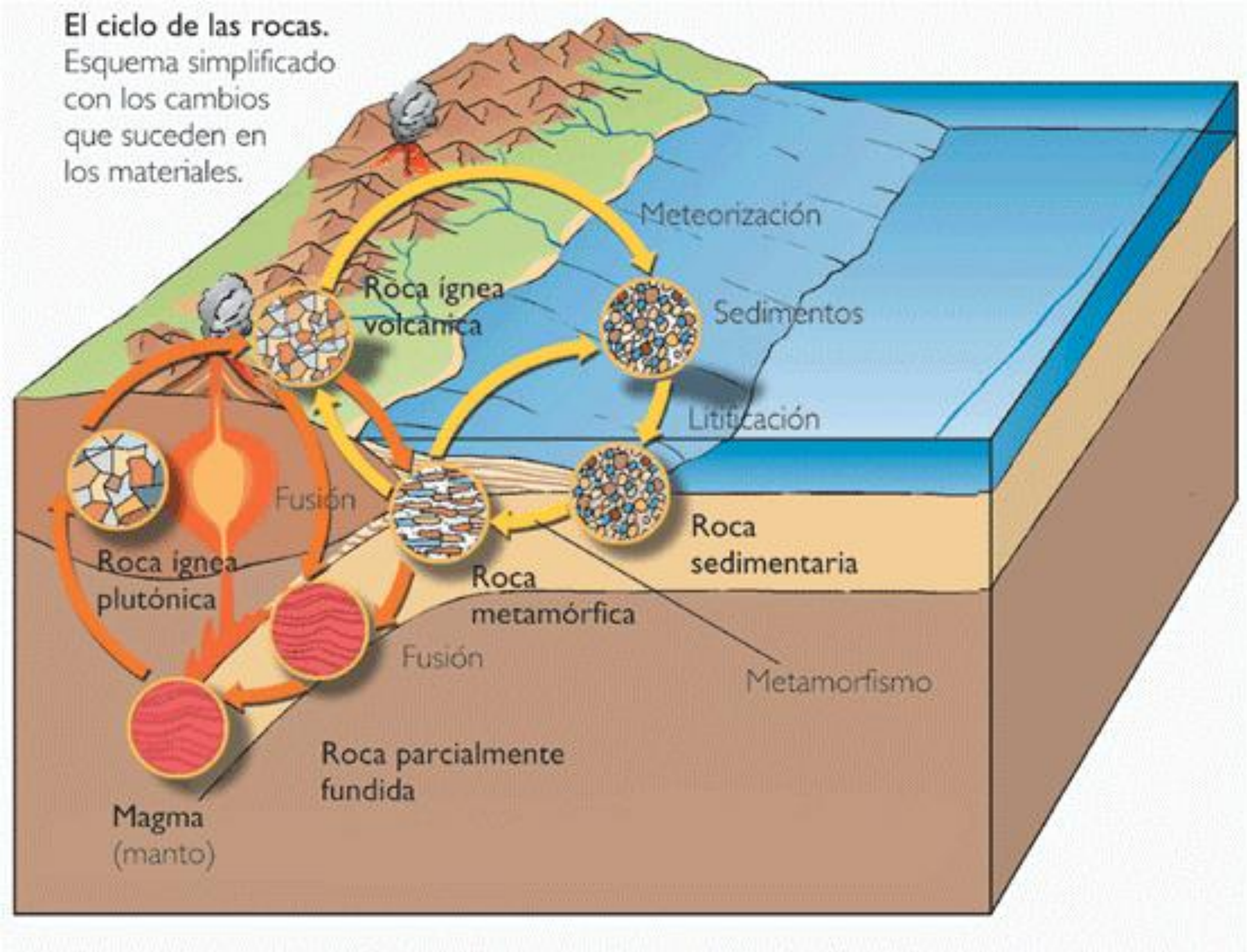
Doorway
to Human History

Stratigraphy

Stratigraphy



Stratigraphy

Stratigraphic Laws are basic principles used in deciphering the spatial and temporal relationships of rock layers. These laws were developed in the 17th to 19th centuries based upon the work of Niels Steno, James Hutton and William Smith, among others.

Stratigraphic laws include the following rules:

1. **Original Horizontality**
2. **Lateral Continuity**
3. **Superposition**
4. **Cross-Cutting Relations**
5. **Law of Faunal Succession**

Original Horizontality

All sedimentary rocks are originally deposited horizontally. Sedimentary rocks that are no longer horizontal have been tilted from their original position.

Lateral Continuity

Sedimentary rocks are laterally continuous over large areas.

“Material forming any stratum were continuous over the surface of the Earth unless some other solid bodies stood in the way." Steno (1669)

Superposition (for magmatic and sedimentary rocks)

The oldest layer occurs at the base and is overlain by progressively younger rock layers at the top.

Cross-Cutting Relations (for sedimentary rocks)

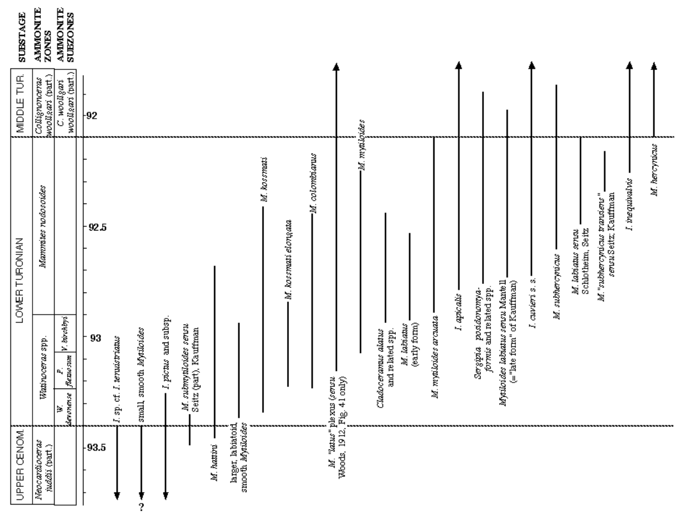
This law is typically used to determine the relative age of rocks.

"If a body or discontinuity cuts across a stratum, it must have formed after that stratum." Steno (1669)

Law of Faunal Succession

This law was developed by William Smith who recognized that fossil groups were succeeded by other fossil groups through time.

PRELIMINARY RANGE ZONE DISTRIBUTION IN AMERICA OF EARLY AND EARLY MIDDLE TURONIAN INOCERAMIDAE



(E. G. Kauffman & P. J. Harries, Dec. 1993)

Stratigraphy

Stratigraphy implies:

1. The study of the geological and archaeopaleontological levels: **Units** and **levels**

2. The study of the sequences of deposition.

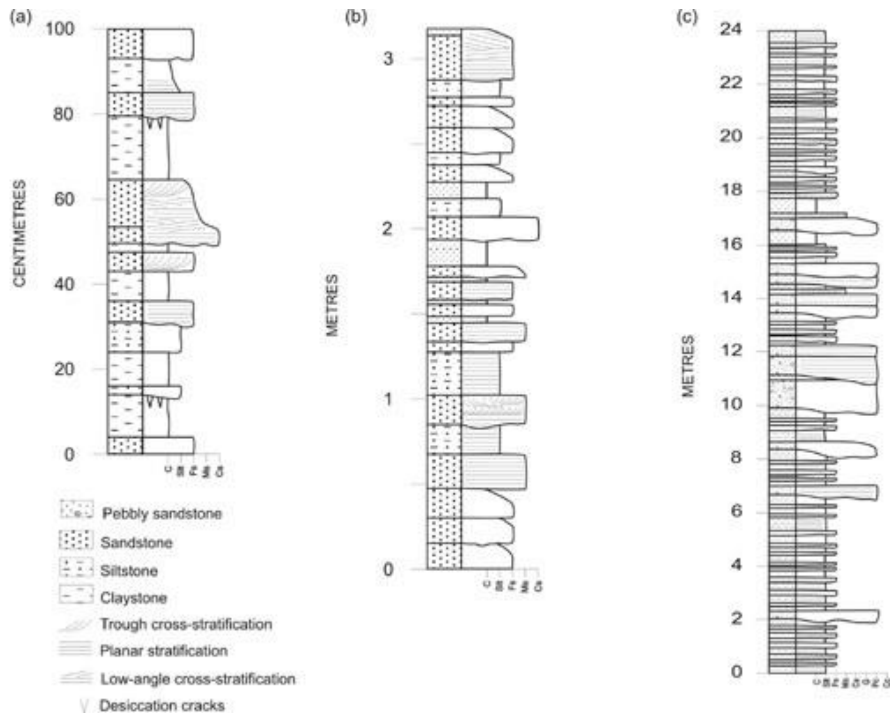
3. Correlation of units from one to another profile.

Stratigraphy

Stratigraphic methods	**Action**	**Units**
Litostratigraphy	**Litological** comparison of sequences of rocks.	Layer, stratum, member, formation, group
Biostratigraphy	Correlation of equivalent **fossiliferous** horizons	Zone
Magnetostratigraphy	Correlation of strata with similar **paleomagnetic** properties.	Zone, chrone
Chronostratigraphy	Correlation of profiles by means of **absolute dating**	System, substratum, series.
Climatostratigraphy	Comparison with a referential **paleoclimatic** sequence, preferably dated	Glacial stage, Interglacial stage, Glacial, Interglacial

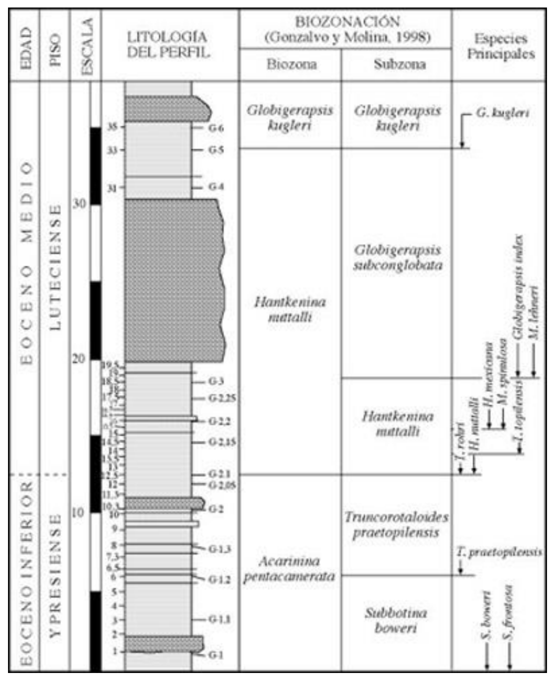
Litostratigraphy

Lithological comparison of sequences of rocks. Their units are layer, stratum, member, formation, group.



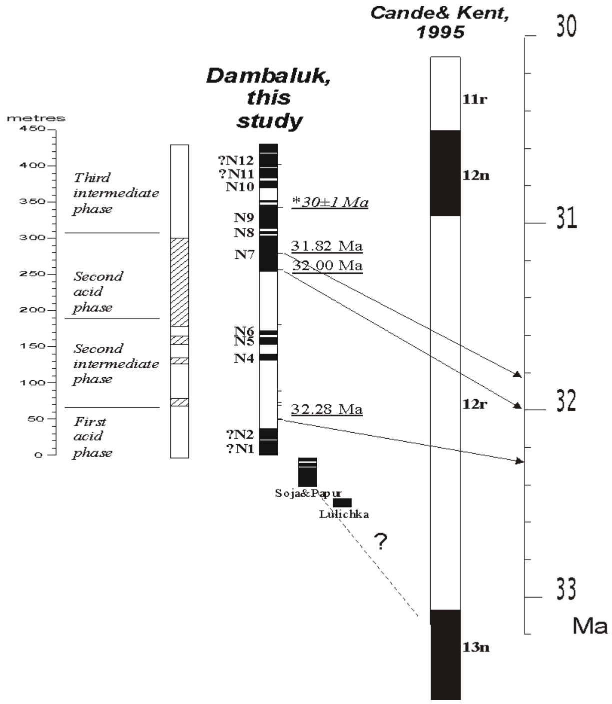
Biostratigraphy

Correlation of equivalent fossiliferous horizons. Its unit is the Zone.



Magnetostratigraphy

Correlation of strata with similar paleomagnetic properties. Its units are Zone and Chrone.



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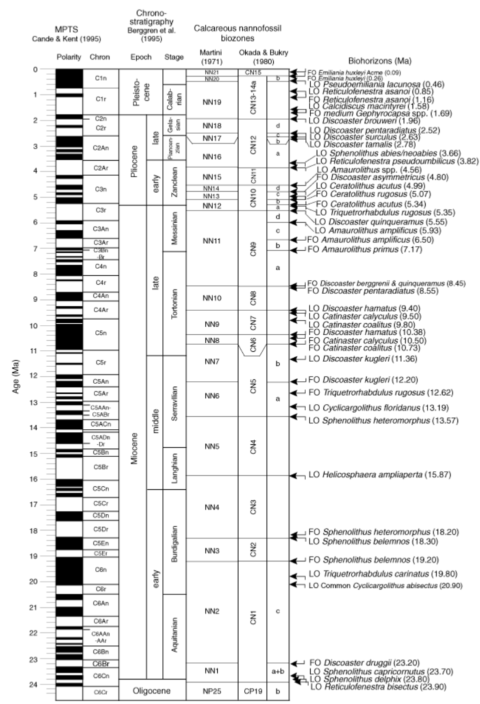
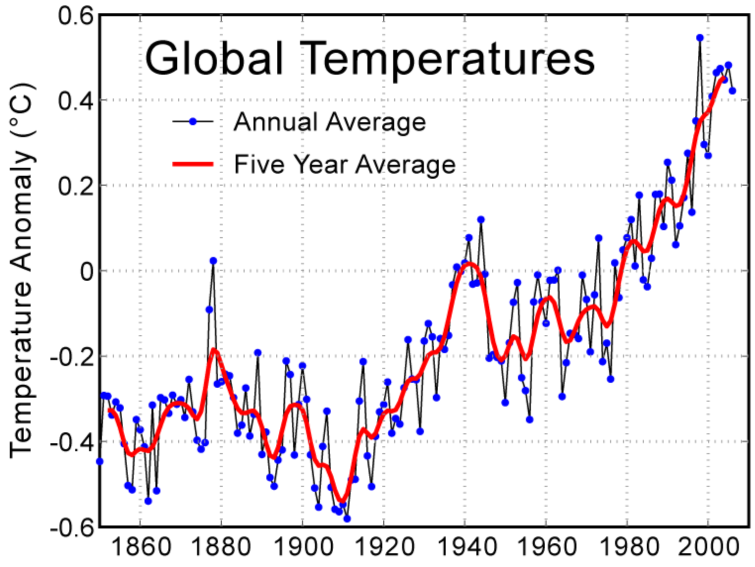
Chronostratigraphy

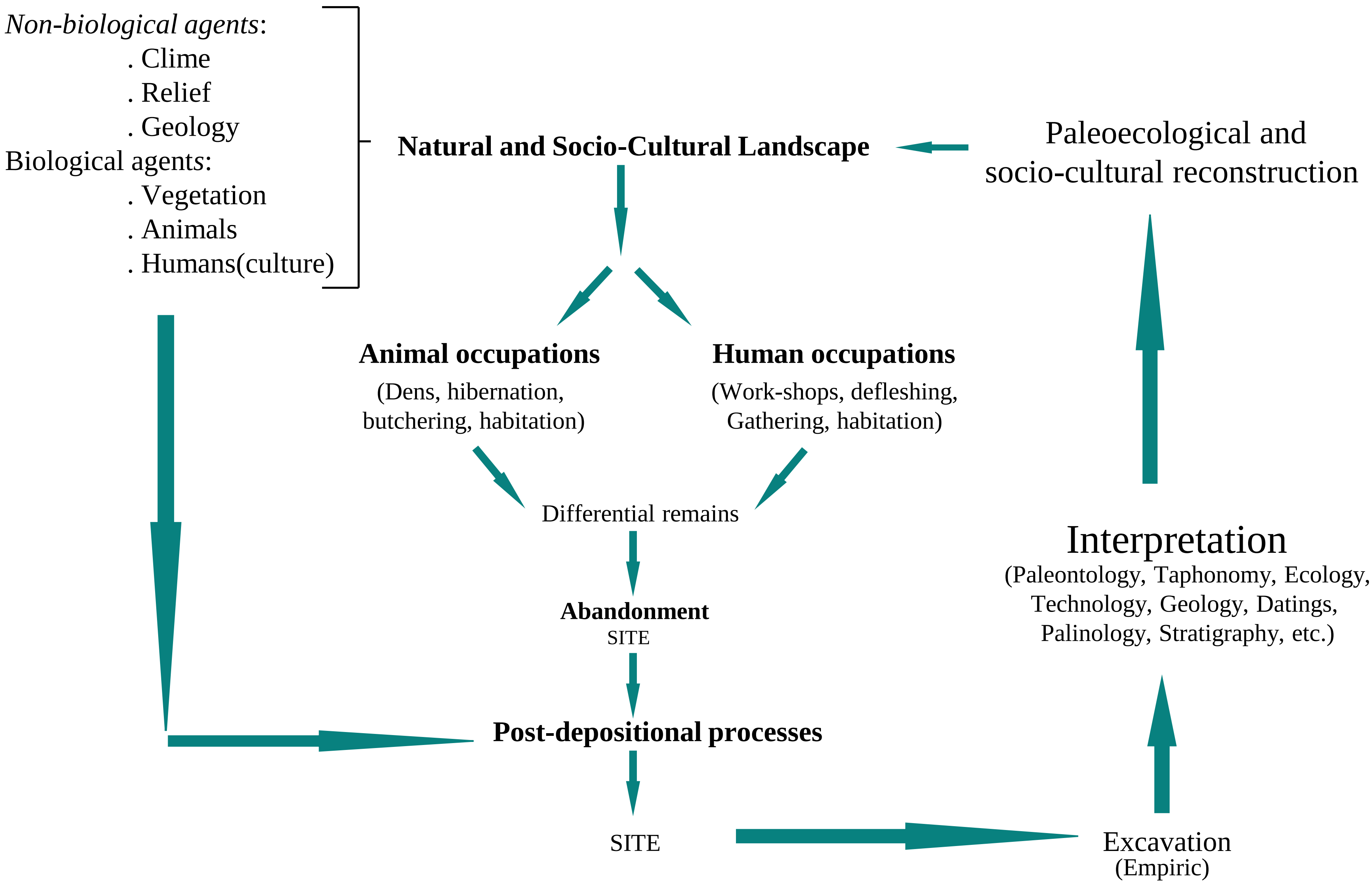
Correlation of profiles by means of absolute dating.
Their units are system, substratum, series.



Climatostratigraphy

Comparison with a referential paleoclimatic sequence, preferably dated. Their units are glacial stage, Interglacial stage, Glacial, Interglacial, etc.





Non-biological agents:
. Clime
. Relief
. Geology
Biological agents:
. Vegetation
. Animals
. Humans(culture)
Natural and Socio-Cultural Landscape
Paleoecological and socio-cultural reconstruction
Animal occupations
(Dens, hibernation, butchering, habitation)
Human occupations
(Work-shops, defleshing, Gathering, habitation)
Differential remains
Abandonment
SITE
Post-depositional processes
SITE
Excavation
(Empiric)
Interpretation
(Paleontology, Taphonomy, Ecology, Technology, Geology, Datings, Palinology, Stratigraphy, etc.)

Taphonomic Processes

I. Cáceres

Sedimentary Environments

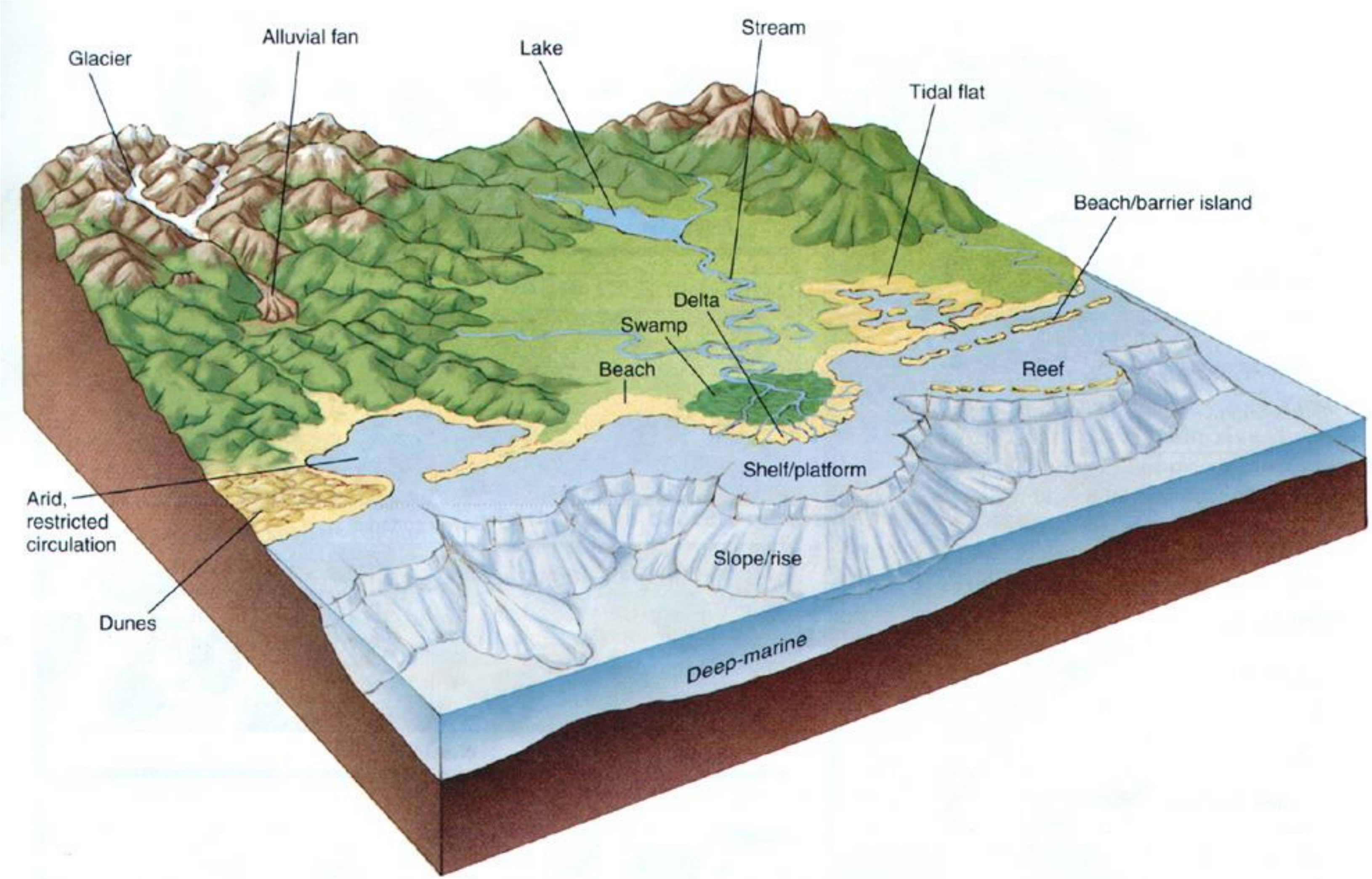


FIGURE 4.2
Typical sedimentary depositional environments.

(Adapted from Jones, 2001: Laboratory Manual for Physical Geology, 3rd edition.)

Archaeological Sediments

BY COMPOSITION

PHYSICAL COMPONENTS:
They reflect:
- Erosion, transport, sedimentation (level micro)
- Climate condtions (humidity, ice, dry conditions)

BIOLOGICAL COMPONENTS:
They reflect the activities of animals and plants.

ANTHROPOGENIC COMPONENTS:
They include:
- Physical components: (raw material for knapping, etc.)
- Biological components: coprolits, bones, wood, etc.

BY LOCALIZATION

PRIMARY CONTEXTS (*In situ* sediments):
- Decantation clays (caves), limes and marls (lakes and flood areas)

SECONDARY CONTEXTS (Derived sediments):
- High energy contexts (rivers) and solifluxion, i.e.

Particles, Sediments and Deposits

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Features of particles, sediments and deposits

1. Types of stratification
2. Thickness of deposits
3. Organization of sediments
4. Orientation of particles
5. Degree of consolidation
6. Size and morphology of particles
7. Coloration of sediments
8. Structure of sedimentary particles

Types of stratification

TYPES OF STRATIGAPHIES

HORIZONTAL:
- Slow water energy, blocked waters
- High energy floods
- Eolic sedimentation (loess and dunes)

SLOPE:
- Water flowing sediments close to deposition
- Some slope hill sediments (*ébulis ordonnés*)

CROSSED:
- Alterning depositon and erosion + changing direction
- Fluvial, marine and eolic deposits
- Dunes when wind changes the vector

RIPPLES
Fast increase of water speed.
Rapids, waterfalls

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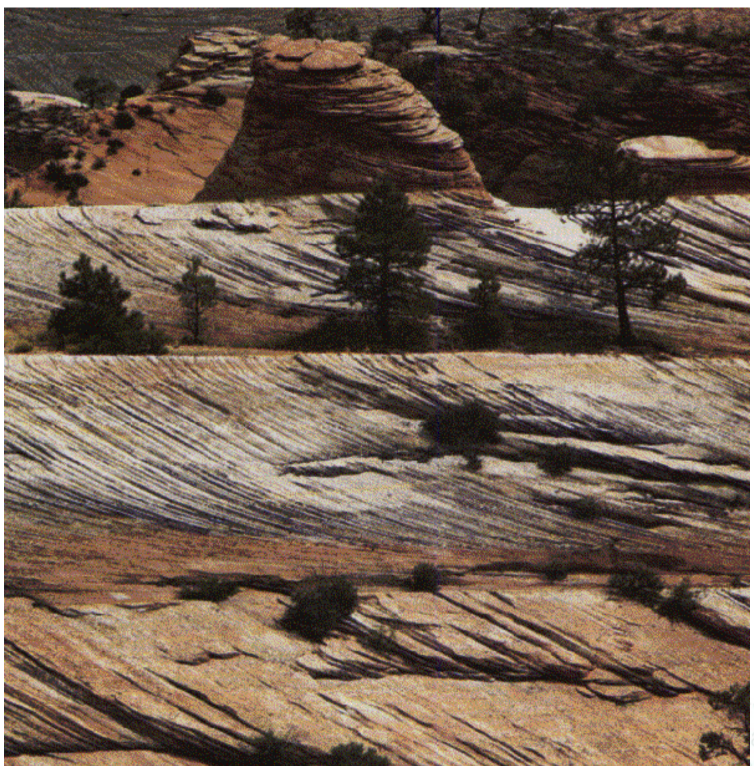

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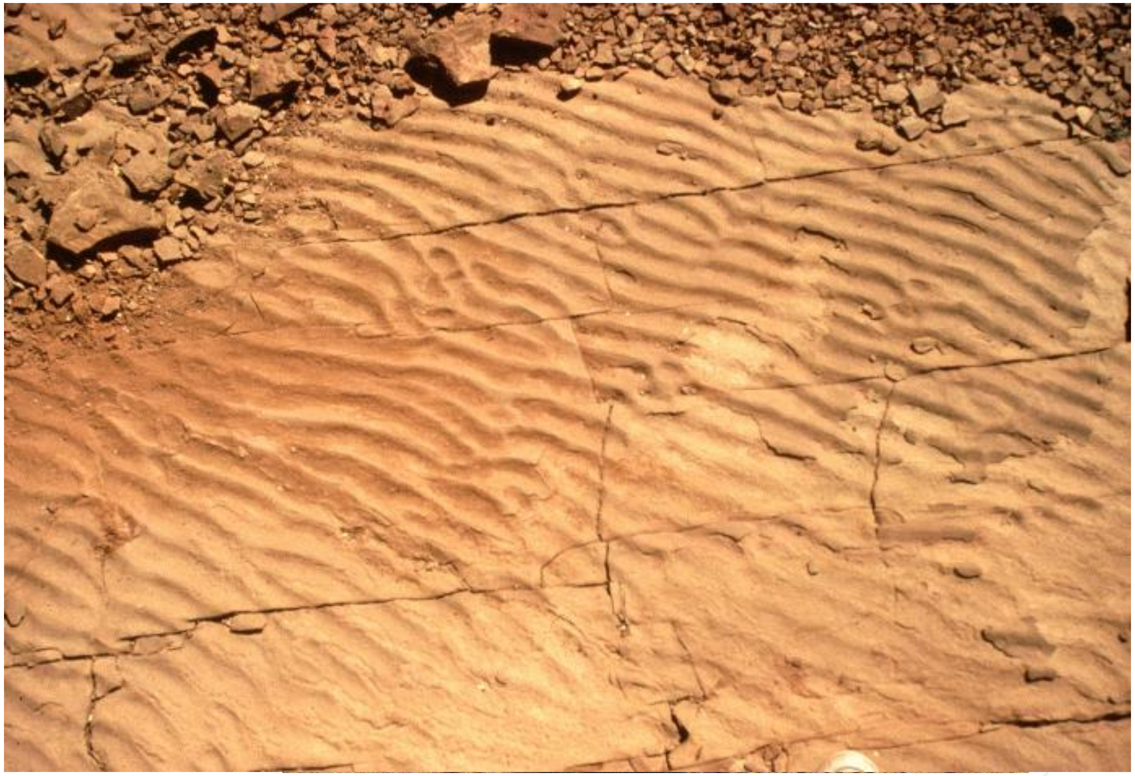


Thickness of deposits

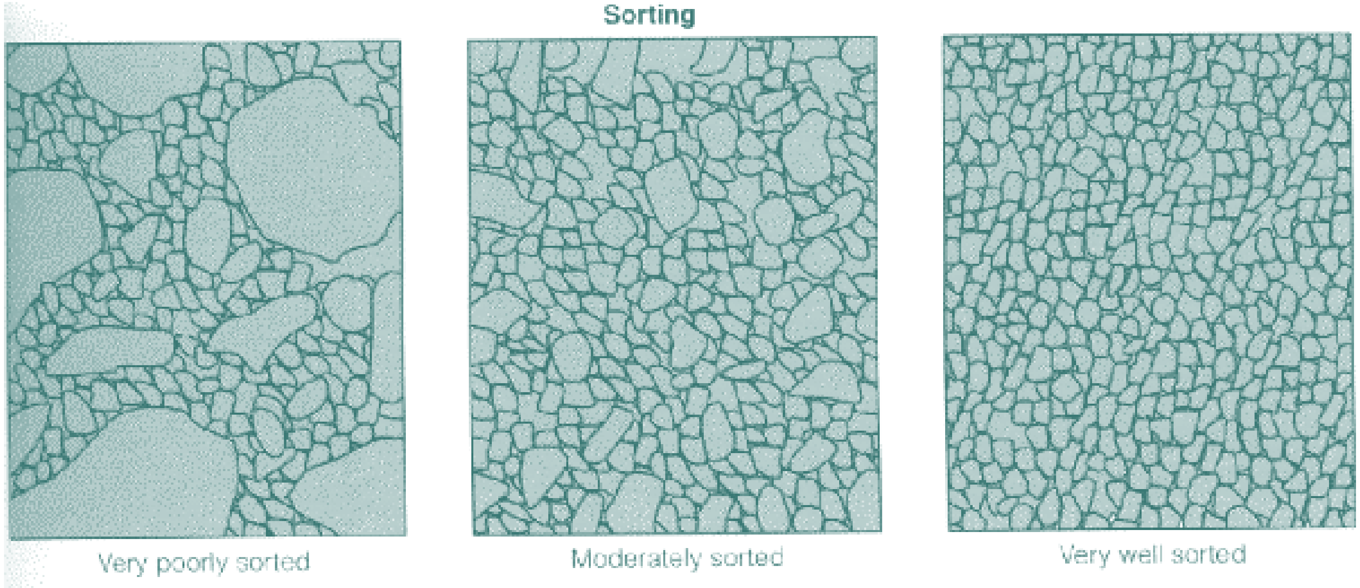
2 to 5 cm ➔ <u>Thin</u> deposits ➔ Stages of low energy to medium energy stream.

5 to > 10 cm ➔ <u>Thick</u> deposits ➔ Stages of high energy or flood streams.

Organization of sediments

Well sorted: Gradual change in the particles size

Not sorted: Abrupt change in size



Orientation of particles

It informs about the vectors of movement and the agents of transport.

Example:

1. Movements of low flow water streams: The length axe of the pebble will be positioned PARALELL and PERPENDICULARLY to the stream direction.
2. Movements of massive flows: The length exe of the pebble use to be positioned IN PARALELL to the massive flow (I.e. moraines).

Degree of consolidation

Low consolidation – soft sediment (younger)

Strong consolidation – hard sediment (older)

Size and morphology of particles

Aggregate name	Other names	Size range (metric)
Boulder	Boulder	256 mm <
Cobble	Cobble	64–256 mm
Very coarse gravel	Pebble	32–64 mm
Coarse gravel	Gravel	16–32 mm
Medium gravel		8–16 mm
Fine gravel		4–8 mm
Very fine gravel		2–4 mm
Very coarse sand	Sand	1–2 mm
Coarse sand		½–1 mm
Medium sand		¼–½ mm
Fine sand		125–250 µm
Very fine sand		62.5–125 µm
Silt	Silt (mud)	4–62.5 µm
Clay	Clay (mud)	1-4 µm

Coloration of soils and sediments

Grey and black: organic materials.

Dotted black: Oxide of Mn (Manganese). Seasonal shallow floods.

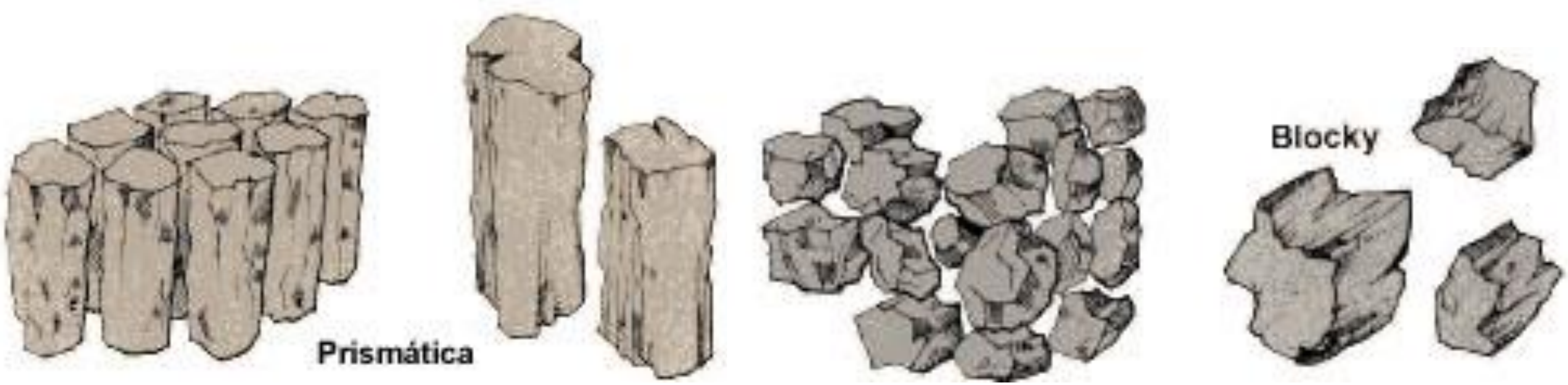
Grey and greenish: deposition in non-oxygenated environments (reductores) ➔ Permanent floods.

Brownish and yellowish: Weathering: chemical alteration.

White: Carbonized bones, salt, gypsum, carbonates, etc.

Structure of the sedimentary particles

Prismatic: dehydration of fine materials. Arid and semiarid environments.
Angular -Subangular: low degree of cohesion.
Flakes and plates: soils and sediments poorly drained, but with seasonal, regular underground floods.



Processes of Natural Formation and Alteration

Natural Formation Processes

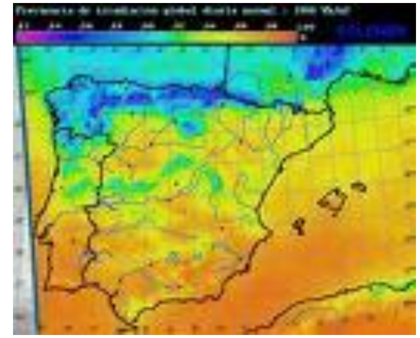
ALTERATION AGENTS:

1. Chemical agents
2. Physical agents
3. Biological agents.

Chemical agents:

a. Atmosphere contains water and oxygen, which is enough to start many chemical reactions, what includes oxidation of organic materials and corrosion of some metals.

   Temperature influences the rate of the chemical reactions, particularly those where water is present: a general consideration is that the rate of reaction duplicates for each thermal increase of 10º. Therefore, the rates of chemical damage generally increase when increasing the temperature.



b. **Irradiation of sunlight** on any material induces to photochemical reaction; particularly, ultraviolet rays breaks the chemical chains in polymerized segments such as cellulose. The sunlight also heats the objects, causing a faster reaction.

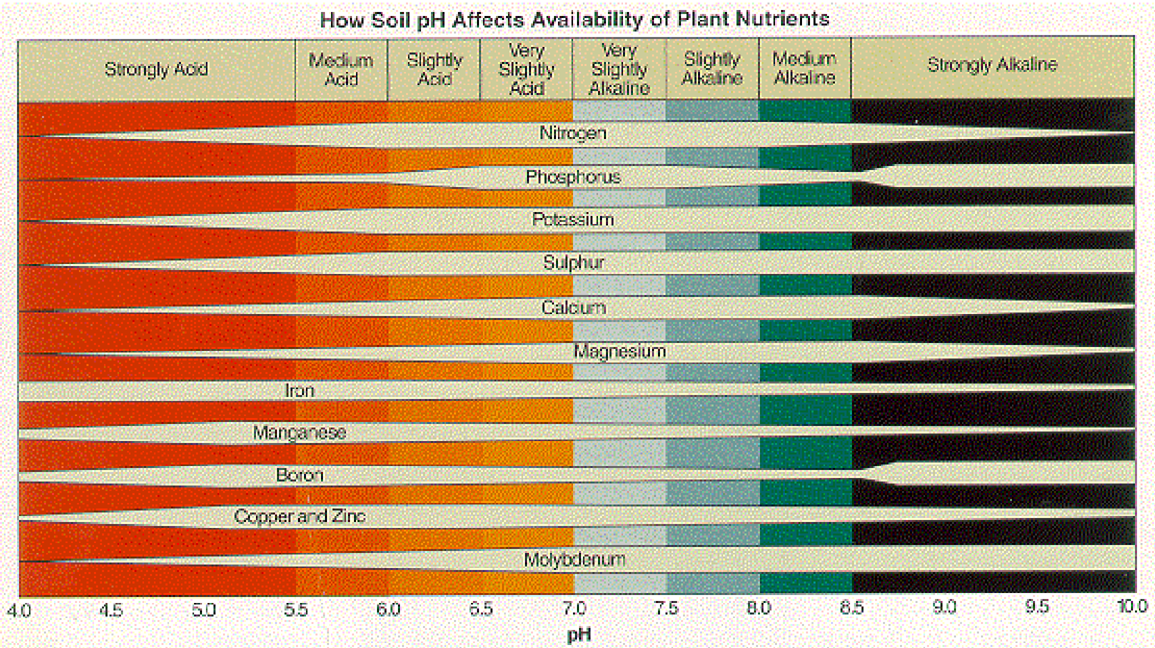
c. **Atmospheric pollution** chemically reacts with the materials, from metals to paper, leading to chemical corrosion and other reactions.

d. **Water of rain** contains carbon dioxide, and sometimes nitrogen dioxide and sulphates. These gases react with the water, forming acids corrosive of metals and damaging other materials. Close to the coast, water contains salts that fasten the damage of many materials.

e. The environment of **many buried objects** often favours the fast chemical changes: underground is often wet, favouring the chemical reactions. Also the ground contains reactive elements such as acids and alkaline components, which participate in many damage processes.

f. **Acid soils or sediments dissolve the bones**, while alkaline soils damage the pollen. Many archaeological deposits also contain salt concentrations, which neutralize the acid and alkaline components.

g. Sediments with high concentration of **salts** restrain the degradation of some biological components, but they lead to a strong corrosion of metals like iron, silver, cupper, and also damage stones and pottery.



Soil pH impacts micronutrient availability to plants. The wider portions of the horizontal bars indicate increased micronutrient availability at a given pH.

Natural Formation Processes

Physical agents:

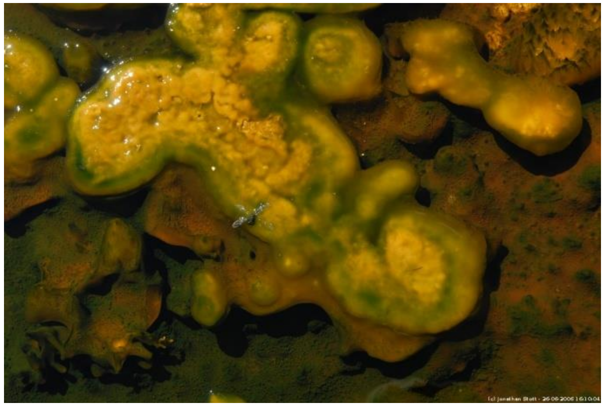
a) **Water**, especially *running water*, is one of the MOST POWERFUL and common agents. It moves, crash and erode the artefacts.
b) **Drainage of rain** erode walls and structures. In porous materials (wood), the alternation of dry and wet conditions provokes cracking.
c) **Iced water** is a strong agent, since it has a greater volume than as liquid, what makes the materials to crash.
d) **Wind** modifies artefacts and all kinds of materials, specially when it transports particles that polish the surface of objects
e) **Sunlight** is also an agent of physical damage, as it entails short cycles of thermal expansion and contraction of objects due to radiating heat.

Natural Formation Processes

Biological agents: Bacteria

Bacteria: ubiquitous.

1) They use to tolerate more extreme conditions than other organisms.
2) They are the first to colonize dead organic material, initiating the process of degradation.
3) They also are responsible for some corrosive marine processes.



Natural Formation Processes

Biological agents:
Bacteria

Fungi:

1) They are the main consumers of dead vegetal material.
2) Most of processes considered as putrefaction are produced by fungus.
3) They are as widespread as bacterias, but they are much more destructive for some materials, such as wood.
4) Their action requires a high percentage of wet and temperate conditions.

Natural Formation Processes

Biological agents: others

Plants roots have a well known role in the damage and alteration of sites and structures (they move the artefacts both horizontally and vertically), but also they chemically damage the artefacts, since they segregate acids that corrode bones, for example.

Also, **animals that excavate burrows**, scavengers and also rodents. All of them modify the buried remains, especially bones.

Scavengers such as hyenas must break very hard bones, so their mandibles are very powerful. Also, they have almost the strongest stomach acids, so chemical alteration is also guaranteed. Since babies, they are trained to chew and break bones. On the other hand, rodents need to sharp regularly they incisors as they grew (continuous growing).

Let’s Excavate!

Setting up an excavation

1. Demarcating the area
2. Clearing vegetation
3. Setting up the aerial grid ➔ Setting the North Point and Level 0
4. Numbering and naming squares or sectors
5. Finding out the deepness * (test pits?)
6. Setting up the topography of the surface
7. Setting up the structure where excavators will work
8. Controlling sedimentary and archaeopaleontological levels (test pits)

The Fundamentals

1. Tools to excavate
2. Where we should start and how deep we should remove the surface
3. Finding an item: leaving all the items in surface (when possible): spatial distribution, photos.
4. Preservation? Chemical solutions
5. Recovering items: size range, micromamals and level bags
6. The label
7. Saving all the sediment
8. Field sheets (PDA) and report
9. Graphical documents: photographs, sections, profiles.

Tools

Depends on the softness, cementation of the sediment: if possible, wooden tools. If new to excavation, try to avoid trowels, because they could damage archaeological materials.

Where to dig and how deep?

In general, we should start from the highest topographic point of the designated area.

The deepness to reach depends on the features of the level:

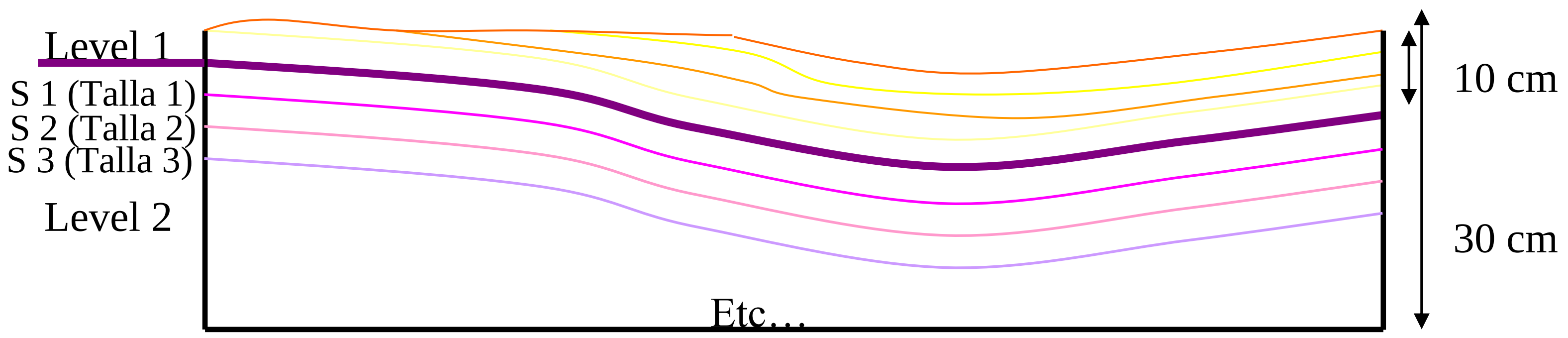
1. Is it a palimpsest?
2. Is it a thin occupation floor?
3. Is it sterile?

Artificial measurements and paleosurfaces

1) Squares must be excavated by stripping the surface.

2) Best measures for stripping are around 1 cm at once (maximum 2 cm), but it depends on the richness of the level.

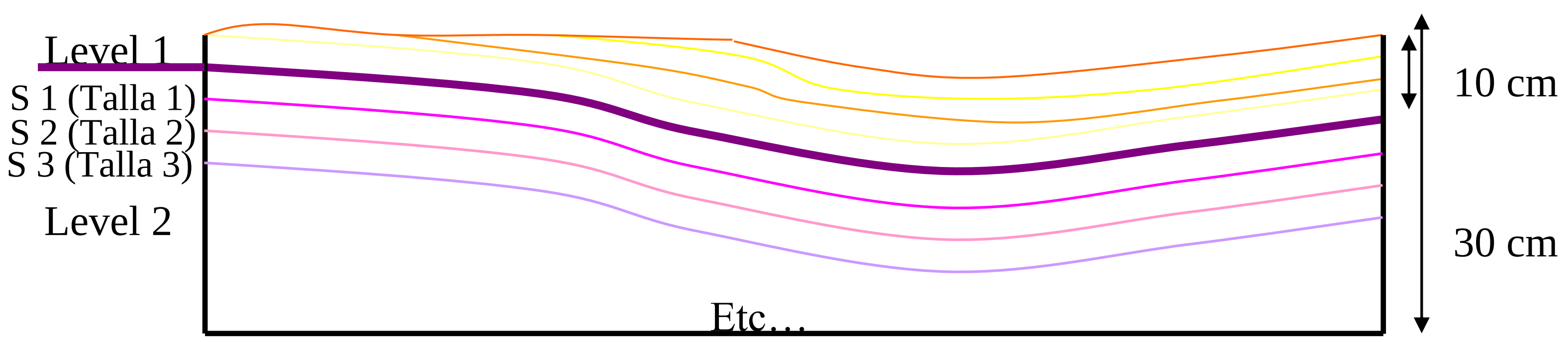
3) Our goal is excavate following the paleosurfaces; that is, the occupational surfaces. They can only be controlled if we have occupations (paleontological or archaeological occupations).



Artificial measurements and paleosurfaces

4) Both if you have not occupational remains to be guided, as well as if the level is very thick, or you are excavating a test pit (vertical stratigraphic control) of several meters, you can excavate following artificial measures (between 5 and 10 cm, but never all these cm at once), ALTHOUGH always trying to keep the real slope of the paleosurface.

5) Independently of the artificial scaling, you must coordinate all items or, at least, take the square, the quadrant and the Z (deepness) of each item.

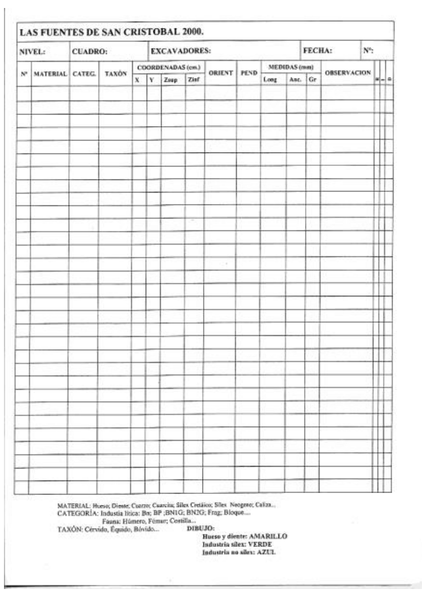


When you find something

Leave all the items *in situ* and record them first
(spatial distribution, photos)

Context (field) sheets

Data included in field sheets have to be loaded into a database in the lab. Field sheets must be kept, and never throw away.



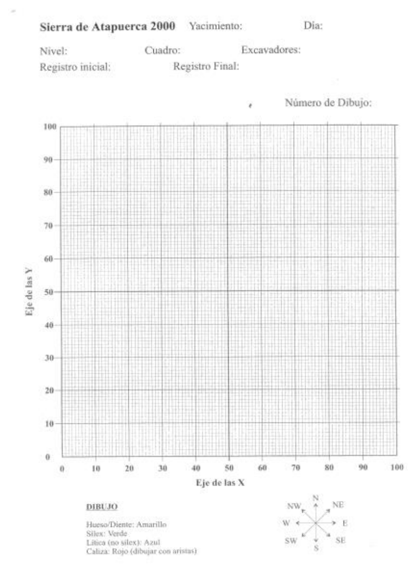
LAS FUENTES DE SAN CRISTOBAL 2000.

NIVEL: | CUADRO: | EXCAVADORES: | FECHA: | Nº:

Nº	MATERIAL	CATEG.	TAXÓN	COORDENADAS (cm.)				ORIENT	PEND	MEDIDAS (mm)			OBSERVACION			
				X	Y	Zsup	Zinf			Long	Anc.	Gr				

MATERIAL: Hueso; Diente; Cuarzo; Cuarcita; Silex Cretácico; Silex Neogeno; Caliza...
CATEGORÍA: Industia lítica: Bn; BP ;BN1G; BN2G; Frag; Bloque....
Fauna: Húmero, Fémur; Costilla...
TAXÓN: Cérvido, Équido, Bóvido...

DIBUJO:
Hueso y diente: AMARILLO
Industria silex: VERDE
Industria no silex: AZUL



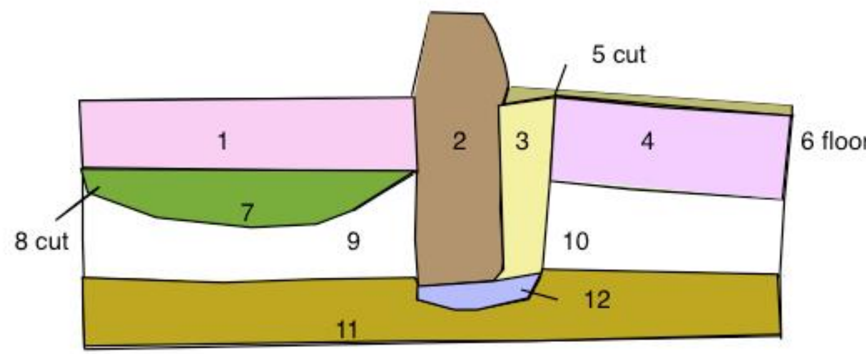
Sierra de Atapuerca 2000 Yacimiento: Día:
Nivel: Cuadro: Excavadores:
Registro inicial: Registro Final:
Número de Dibujo:

DIBUJO
Hueso/Diente: Amarillo
Silex: Verde
Litica (no silex): Azul
Caliza: Rojo (dibujar con aristas)

1. **Site**
2. **Field season**
3. **Level**
4. **Square**
5. **Excavators**
6. **Date**
7. **Page number** (it goes with the drawing field sheet)
8. **Item number:** numeration starts again every time we start a new level.
9. **Material:** bone, sandstone, ivory…
10. **Category:** flake, core, tibia, femur…
11. **Taxa:** Hominidae, Bos, Canis, etc.
12. **Coordinates** (X, Y, Zsup, Z inf) (in cm)
13. **Orientation** (two cardinal points)
14. **Slope** (S, N, etc.) **or inclination** (23º)
15. **Measures of items** (in mm)
16. **Observations:** cemented sediment, etc.
17. **End column:** arrival to lab., information loaded to Databases, drawing, photo, analysis, etc.

Harris Matrix

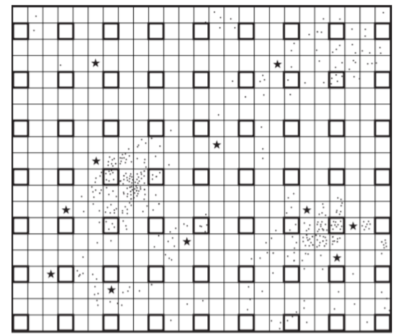
1. A horizontal layer
2. Masonry wall remnant
3. Backfill of the wall construction cut (sometimes called construction trench)
4. A horizontal layer, probably the same as 1
5. Construction cut for wall 2
6. A clay floor for wall 2
7. Fill of shallow cut 8
8. Shallow pit cut
9. A horizontal layer
10. A horizontal layer, probably the same as 9
11. Natural sterile ground formed before human occupation of the site
12. Trample in the base of cut 5



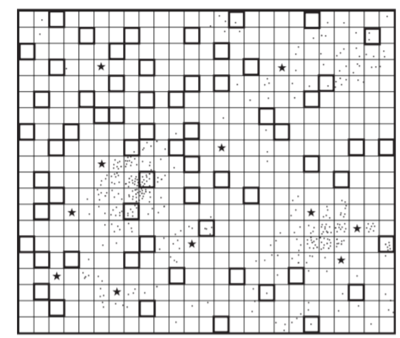
Sampling strategies

Basic aerial strategies

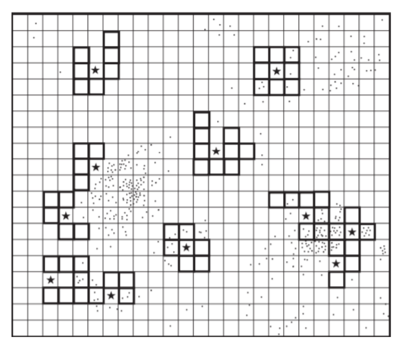
1. Systematic
    1. equal and unbiased coverage of a suspected site



2. Random
    1. least biased sampling method

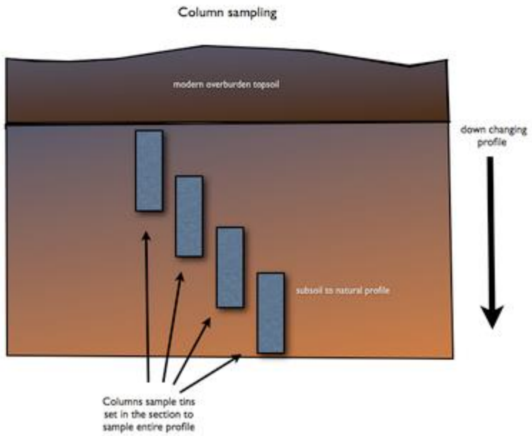


3. Judgemental
    1. highest degree of bias



On site sampling strategies

Geological (bulk, geomorphological, sedimentological)



Lacustrine and Marine Coring

Paleoenvironmental

Off site sampling strategies

Material culture and organic matter sampling (bone, calculus, charcoal, pottery, geological; dating, archaeogenetic, isotope, proteomics…)

Residue sampling (material culture and organic matter)

Laboratory excavation

Things to consider when sampling

CROSS CONTAMINATION

Always double bag

Clean tools in between sampling

Wear clean clothing if necessary

LABELLING

Make sure to double label everything

For bigger samples use arrows for upper and lower portions

RECORDING

Track all sampling steps and locations by keeping detailed notes

Take photographs for later use in publications

Thank you!