Geology of Caves and Rockshelters

Caves and rockshelters often preserve archaeological evidence of long sequences of human occupations. This is because these settings were frequently used by prehistoric populations, and because these geologic contexts protected deposits from erosion and scattering.

Study of the cave sediments yields direct evidence of past environments. Cave/shelter deposits also provide a stratigraphic framework for data on a) prehistoric occupation horizons and b) paleontological evidence (bones, pollen, coprolites, etc.) of past environments. We will briefly compare cave/shelter depositional processes in two very different settings: the Perigord region of France and the Mediterranean coast of Israel (Tabun Cave). This comparison allows us to see different processes of cave/shelter geologic evolution in a temperate-glacial setting (Pleistocene France) and a subtropical-Mediterranean setting (Israel).

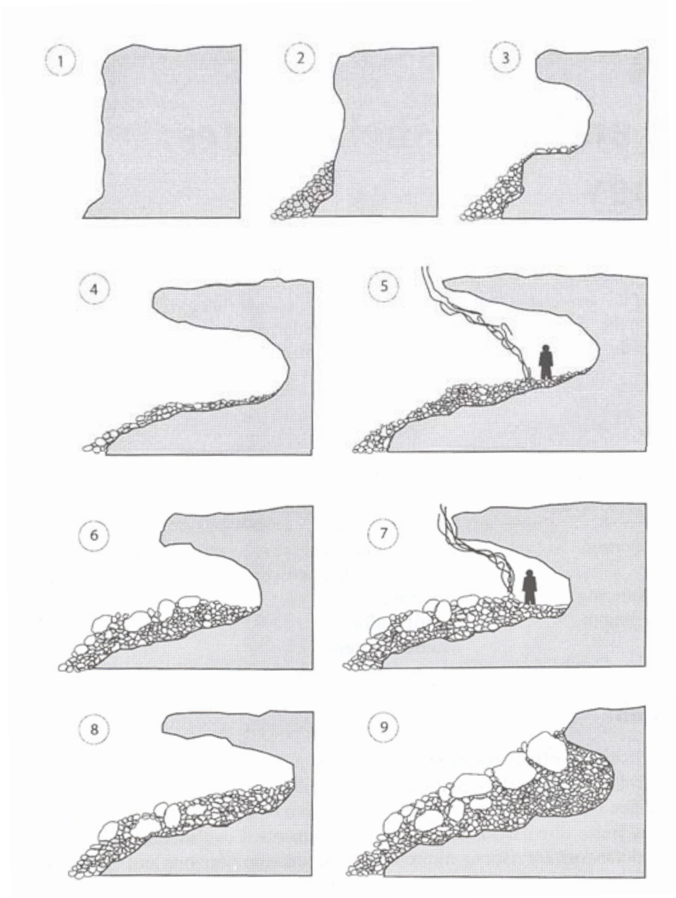
Pleistocene France: Evolution of Rockshelters

A **rockshelter** (in French: **Abri**) is basically an overhang that formed in rocks (usually limestone). These provided minimal but important shelter for prehistoric inhabitants (see figure below). Rockshelters are created when rocks with different resistance to weathering are exposed along a cliff. The resistant rocks form the roof of the shelter, while the less resistant rocks are removed, permitting continuous development of the shelter. As the shelter grows back into the cliff face, the roof becomes unstable; periodically, parts of the roof collapse. Thus, the shelter never changes much in size, but it does continue to change in shape and position. It is important to note that because they are shallow, the shelter's interior walls and roof are always exposed to weather conditions, such as temperature and humidity.

Weathering Effects on the Cave Walls and Roof

Weathering of the walls and roof of the shelter simultaneously enlarges the shelter and fills it with sediments. There are two kinds of weathering of the bedrock that produce sediment: **Physical weathering** entails the breaking and spalling of rock from the shelter roof and walls. This is most intense during periods of cold (glacial) climate, when freeze-thaw action is highest. Water or moisture gets traps in cracks and crevices in the walls or roof of the shelter. When the water freezes, it expands about 9% and can cause parts of the walls or roof to break off. This freeze-thaw action generates angular fragments called **eboulis**. The colder the weather is, the larger the fragments are. Cold-wet conditions will usually generate more eboulis and finer sediment; while cold-dry conditions generate medium to large eboulis without much finer material (called “eboulis sec” (dry eboulis) in French).

Chemical weathering involves processes such as dissolution or oxidation, which attack the rocks in the shelter. During warmer, humid phases the walls and roof are weathered by dissolution (dissolving) of the limestone. This produces cave travertines (stalactites/stalagmites). Clay, which is a component of most limestone, is often released during chemical weathering. Very little is released during physical weathering.



ROCKSHELTER FORMATION

1-3 Weathering of soft rock starts shelter.

4-5 Shelter enlarged

6-7 Progressive spalling and retreat of shelter

8-9 final collapse

In addition to these internal processes, some sediment may be introduced from outside the shelter. In glaciated Europe, wind-blown dust comprised of clay and silt, called loess, was deposited over huge areas south of the glaciers. This sometimes was added to the rockshelter sediments. [Note our fertile soils in the Midwestern US are comprised of loess.]

Weathering Effects on the Cave Sediments

The same processes that affect the roof/walls must affect the sediment that already is contained within the shelter.

Cold climate processes

During periods of cold,

- Little chemical weathering takes place.
- However, physical weathering through freeze-thaw mixes deposits.
- Angular eboulis remain angular.

Moisture		
Wet	**Physical Weathering** • Lots of eboulis of different sizes • Some fine sediments • Rapid weathering	**Chemical Weathering** • Fine sediment – mostly clay • Rounding of eboulis • Weathering of existing sediments (soil formation) • Increase in clay • Increase in carbonates • Rubification
Dry	**Physical Weathering** • Course eboulis	**Physical & Chemical Weathering** • Eboulis rare • Little sediment • Slowest weathering
	Cold	**Warm**
	Temperature	

Warm climate processes

During warm climates, chemical weathering increases, resulting in the following:

- Limestone fragments are dissolved, rounding the eboulis.

- With the increased limestone dissolution, carbonates are released into the soil and percolate down through the underlying sediment, where they re-precipitate.

- Clay freed from the dissolving limestone accumulates in **soil horizons**.

- Also as result of the weathering, iron and aluminum are oxidized causing **rubification** or the reddening of soils.

This is a rockshelter in the Republic of Georgia. Test excavations showed that there are about 5 meters of sediment here, containing stratified Mousterian and Upper Paleolithic occupations, with extremely rich faunas. Because this shelter formed in a steep cliff, it has not collapsed.

These rockshelter deposits from a partially excavated site near the one above also contain Mousterian and Upper Paleolithic occupations. Notice the eboulis sec layer in the foreground, underlain by rounded eboulis associated with a soil. Note also that the deposits change in character towards the back of the shelter. Why?

Recall that soils form in sediments that have already been deposited, usually after a change in climate. The sediments are thus the *parent material* for the soil. So the sediments indicate one climate, and the soil that formed in them may register different climatic conditions. Also recall that soils form when the surface is stable or when deposition rates are very slow.

So, if you find evidence for a soil in cave deposits, you would likely conclude that a change in climate took place, but the evidence for the two climates (first climate = parent material, second climate = soil) would be found in the *same* stratum). You have to be careful to note which kinds of climate promote soil formation, and which kinds of climate promote deposition.

Cave Geology

Caves have completely different geologic origins and processes than we saw with rocksheleters. Caves begin as subterranean caverns, like Carlsbad in New Mexico. They form by the action of groundwater that creates long and complex systems of chambers and passages.

Mouth of Djudjuana Cave in the Republic of Georgia. Note the steep face of bedrock, created by erosion that exposed this cave. Its deposits contain a thick sequence of Upper Paleolithic occupations. Most of the sediments in the cave are alluvium, deposited when the floor of the valley was much higher.

When faulting and/or erosion transect a cave, it can be exposed, usually along a steep bedrock slope in a valley. Once the cave opening is revealed, sediment can enter via wind activity, or from streams that flow in front of the cave. Additionally, a breach to the surface, called a chimney, can allow sediment to wash in from the surface above the cave. Once a chimney is opened, the cave may fill rapidly with sediment that resembles colluvium, containing large and small clasts mixed with finer material.

As for rockshelters, sediments near the openings or mouths of caves are susceptible to the climatic conditions that prevail, so soils can form in the cave deposits near the mouth. As one proceeds farther into the cave, the effects of climate and sedimentation diminish. However, in some caves, such as Djudjuana in the Republic of Georgia shown above, water may flow through the cave (from its deep interior to the mouth) for long periods, having entered from groundwater sources. This can actually deliver sediment. This was not the case for Tabun Cave in Israel, however, which we shall see in the following description of that famous site.

Geology of Tabun Cave

Tabun Cave is located is Israel at the abrupt junction between the Mediterranean coastal plain and the rugged hills of Galilee. These steep hills are called the Carmel, and good wines are made there. Tabun was excavated in the 1930's by Dorothy Garrod, one of the most famous archaeologists of that period, and one of the few women to work in archaeology then. [Her name will come up in a later lab dealing with faunal analysis at Tabun.]

Photograph of Tabun Cave during excavations in 1970. Lower deposits are Stratum E and D. Paul Goldberg (on ladder) is at top of Stratum C. Note coarse sediments of Stratum B, delivered from the chimney above.

As described above, Tabun formed first as a subterranean cavern in limestone. Later faulting exposed the cave, and it faces towards the coastal plain. It has filled mainly with eolian (wind blown) sand and silt. The uppermost layers (Principally Stratum B) were deposited quickly after a chimney opened, permitting sediment to wash in from above.

The archaeological record at Tabun is a long one, beginning at the end of the Lower Paleolithic, with Acheulean occupations in Strata G and F. Stratum E contains numerous occupations of the Jabrudian cultural tradition, characterized by Mousterian-like tools associated with some small bifaces. All the overlying strata (D-B) contain Levantine Mousterian occupations, including a Neandertal skeleton. Very close to Tabun is Skhul Cave, in which Garrod excavated the famous skeletons of early Modern Humans which you read about in your text.

Geologic investigations at Tabun were conducted during reexcavation of the site in the 1970's by William Farrand and Paul Goldberg. Their work produced the data we consider here.

Data from Tabun deposits include:

- **Sediment texture** (sand-silt-clay) tells us about depositional processes. High energy wind deposition, associated with a nearby beach, would result in more sand being deposited. Low energy deposition would result in finer particles (silt, clay) being deposited in the cave.

- **Carbonates** (CaC0_3) form as part of soil profiles, as described above.
- **Phosphates** are derived from bone weathering and are among the best evidence for human occupation.
- **Organic Matter** (OM) is also derived from human occupation debris (mainly plants brought into the cave). Unlike phosphates, however, organic matter will decay and be gradually lost from older sediments.
- The minerals **epidote** and **hornblende** (Epi+Hb) weather over time, and disappear.