Correlation of Aeolian, Alluvial and Lacustrine Deposits Related to Past Climates and Culture Change

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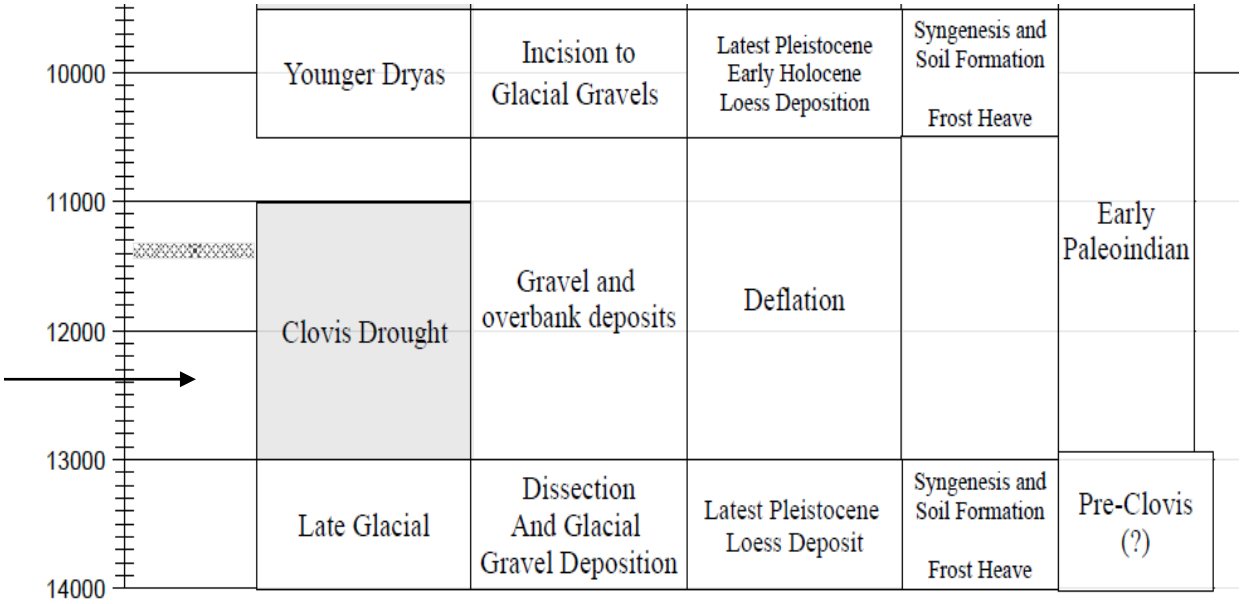
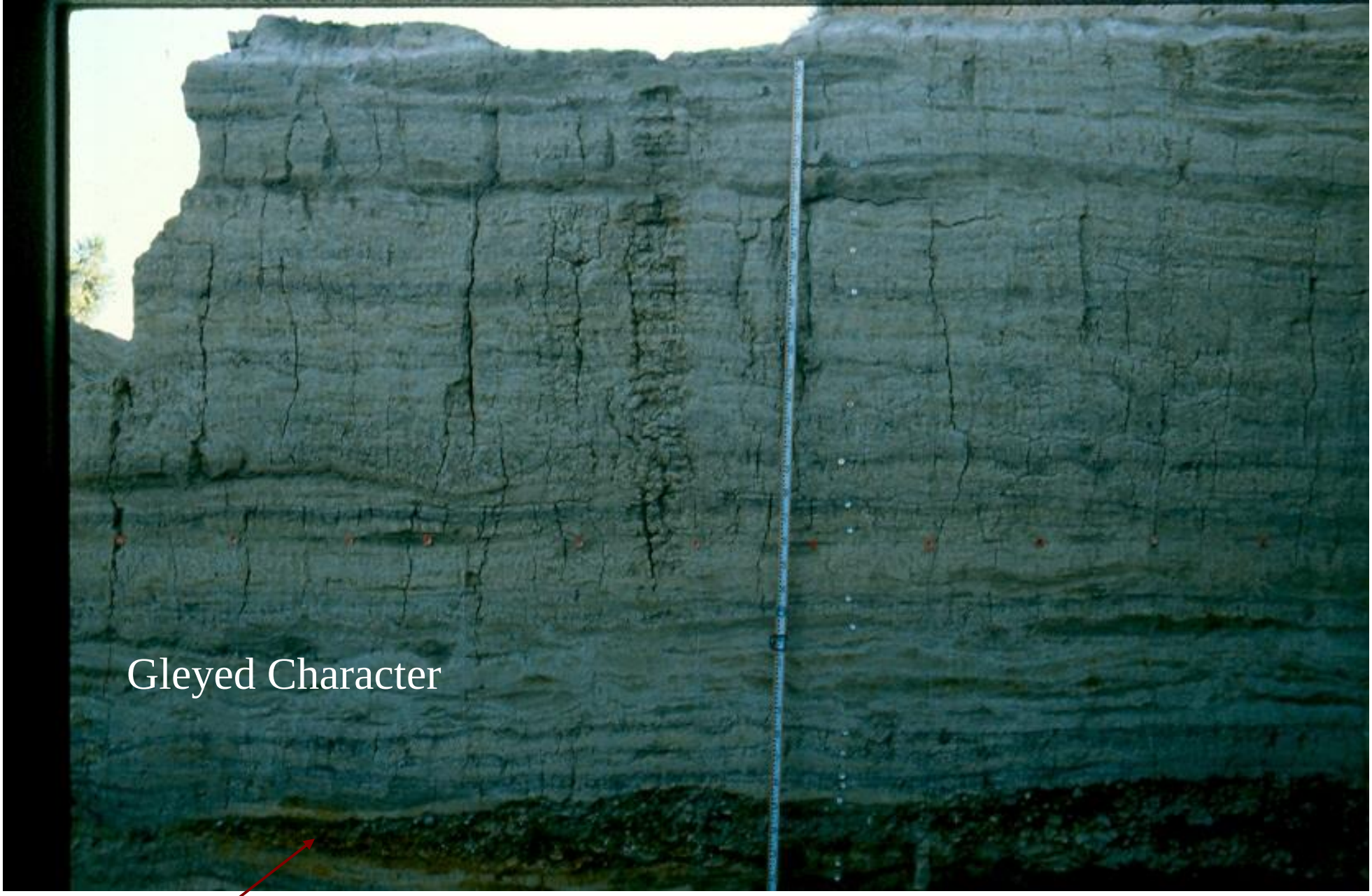
Past climate of western Colorado since 14,000 RCYBP varied from extreme drought to moderating conditions. Alluvial and aeolian deposits react to changing climates. Incision in alluvium and stabilization of aeolian deposits correspond to cool/wet conditions; alluvial deposition, aeolian deflation, and, in one period, dune formation correlate to warm/dry intervals. Subsistence and settlement patterns vary from large group size and low mobility in cooler intervals to small group size and high mobility in warmer intervals. The major droughts occurred 13,000 to 11,000, 9500 to 6500, 4000 to 2800, and 1000 to 600 RCYBP. Lake level data from Colorado, Wyoming and Utah, and PDSI (tree ring) data support the model. Identified droughts correspond to the Clovis drought, Paleoindian to Early Archaic and Middle Archaic to Late Archaic transitions, and organized warfare on the Plains. Middle Holocene and Late Holocene ameliorations correlate to house pits through the Rockies and BMII.



Loess slowly aggraded since about 30,000 years ago and thick Pleistocene soils developed through the loess

Alluvial valleys were dissecting and cut to the deepest level at this time and deposited coarse (i.e., boulder-sized) gravel in the bottoms

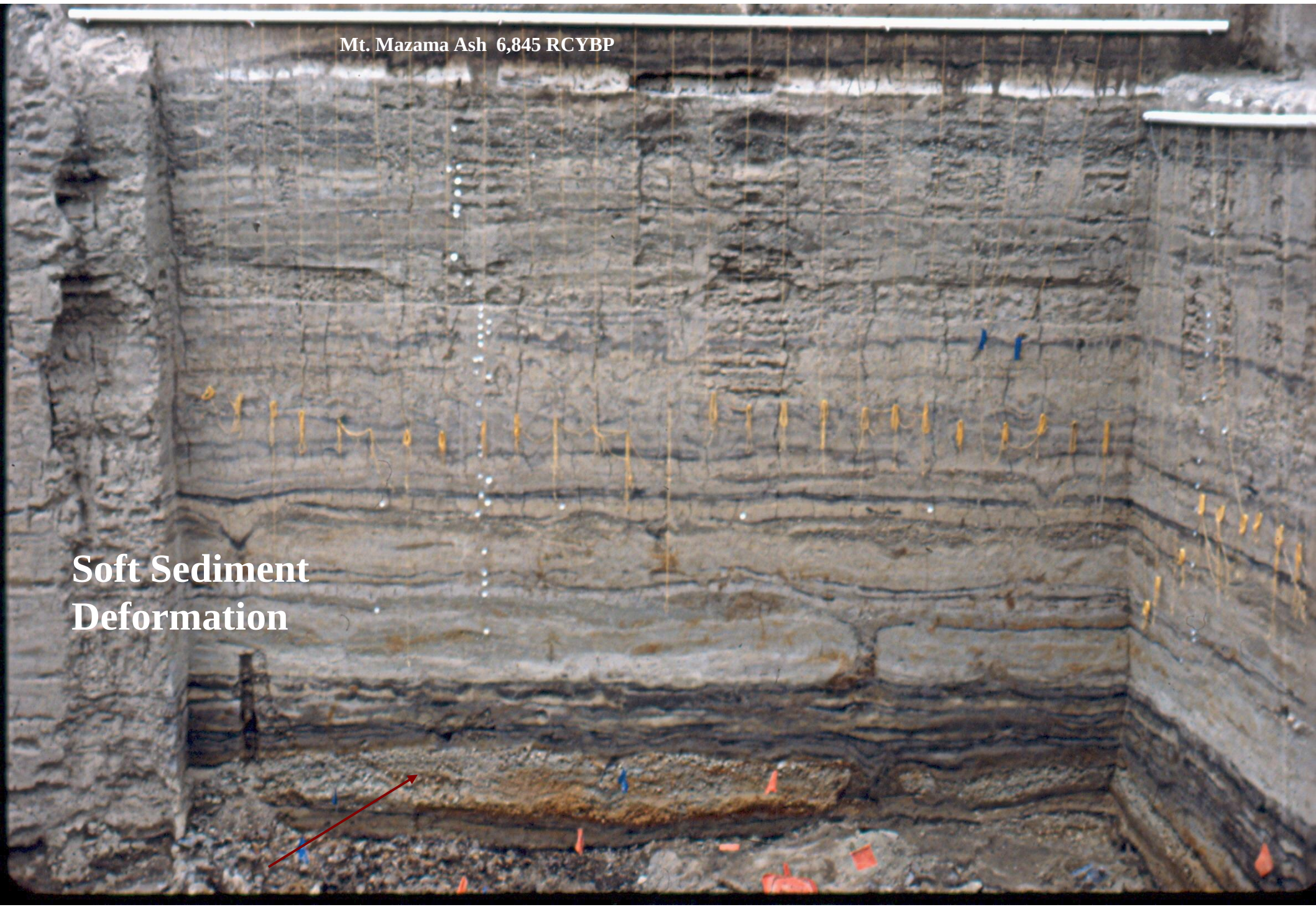
Sea level was at its lowest (see Rampino et al. 1984) and the continental ice sheets reached the southern limit of advance (Clayton and Moran 1982).


Gleyed Character
Pleistocene Gravels

In the Allerød or Clovis drought, reduced capacity and competence in streams, and deposition of smaller gravel is accompanied by clay overbank deposits on the channel margins and valley floor.

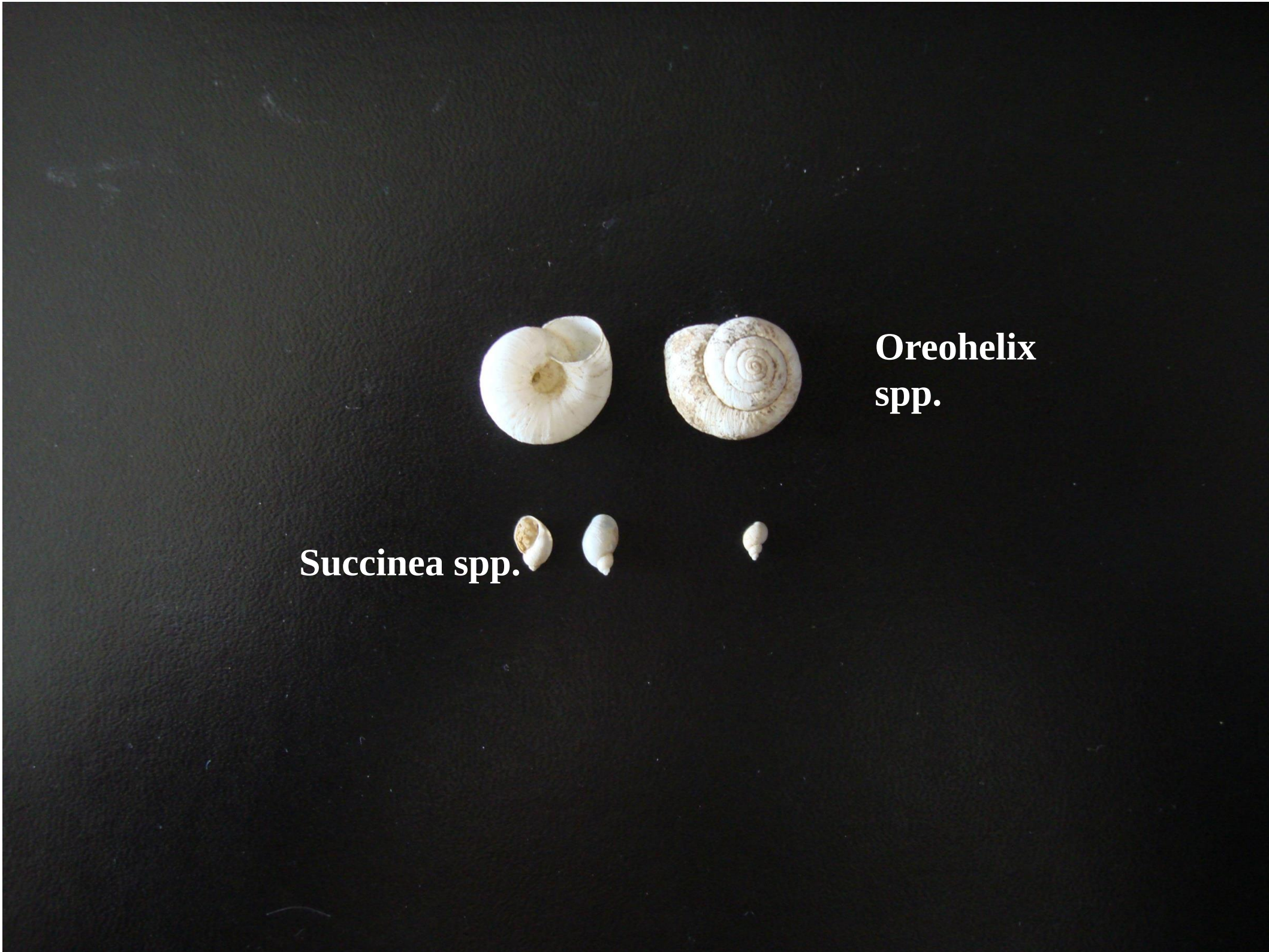
The deflation of the Late Pleistocene loess and soil began, but the unconformity is barely recognizable in loess deposits because of the lack of coarse particles in the loess — it is only identifiable by the volume of secondary sulfide and mica minerals above and below the contact.

Lake levels started to fall and sea level began to rise more rapidly.



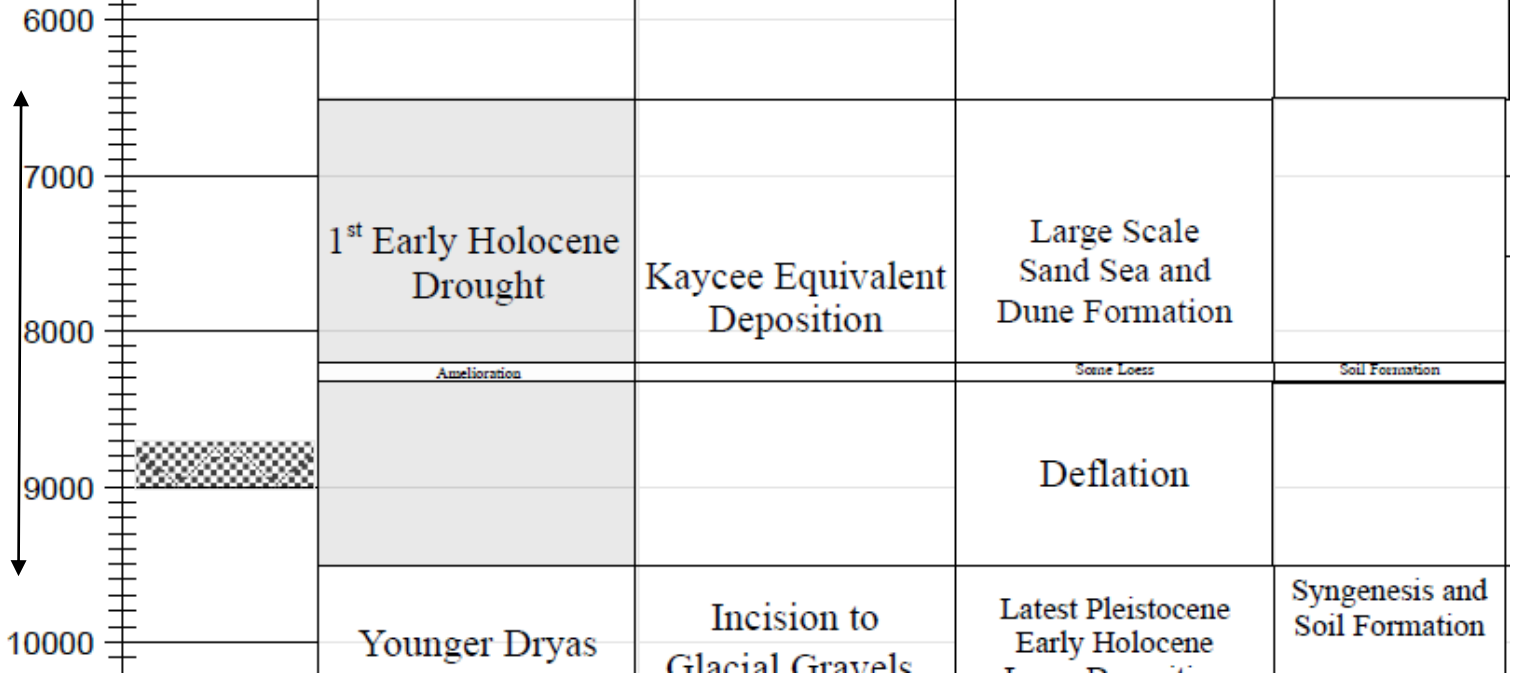
Late Pleistocene oxidation due to increased permiability

Frost heaved clasts deflated to Pleistocene C horizon


Oreohelix spp.
Succinea spp.

Kaycee equivalent alluvium fills Pleistocene dissection.

True dune activations



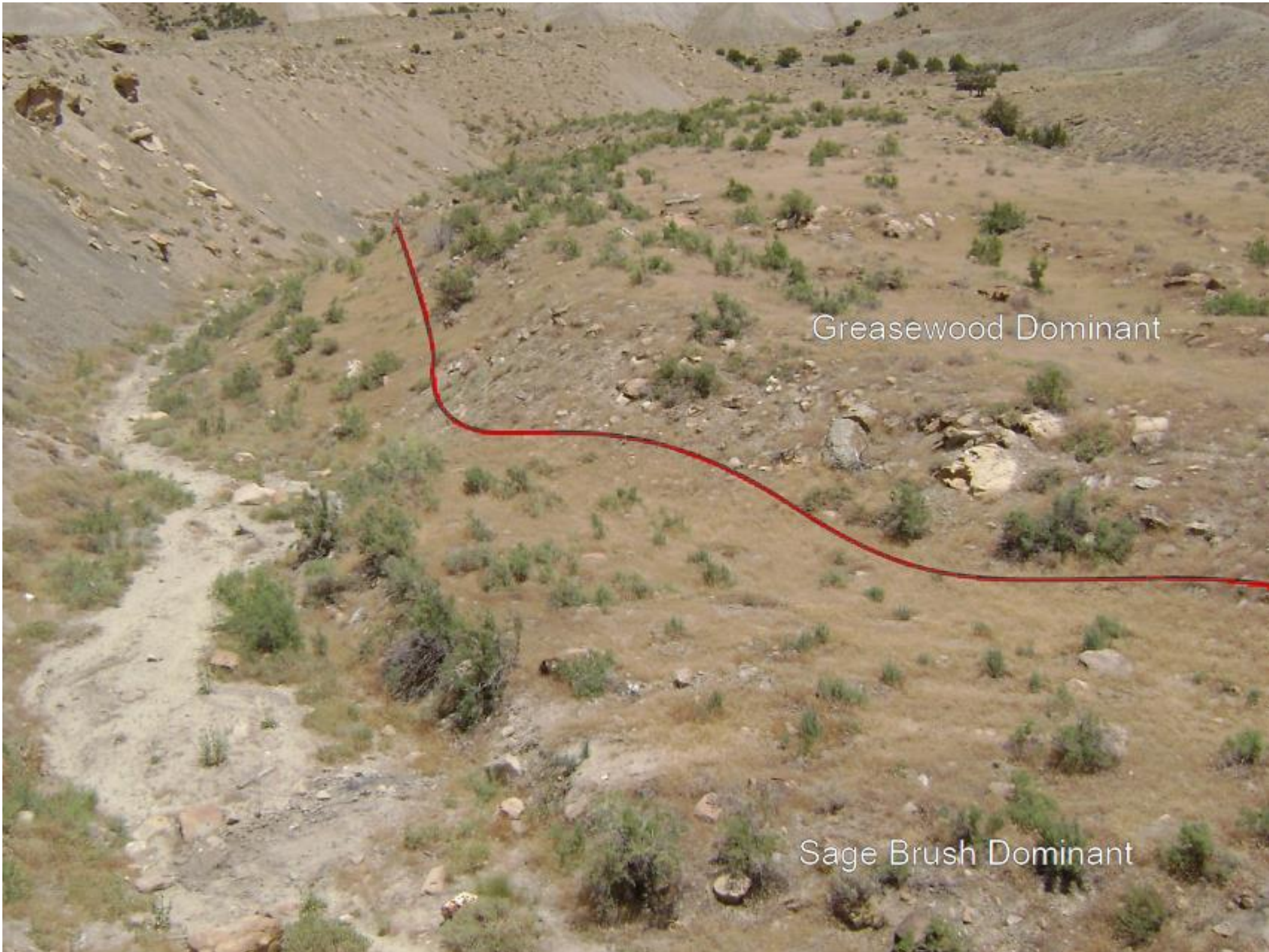
From about 10,000 RCYBP down to about 6500 RCYBP the most severe drought in the Holocene occurs

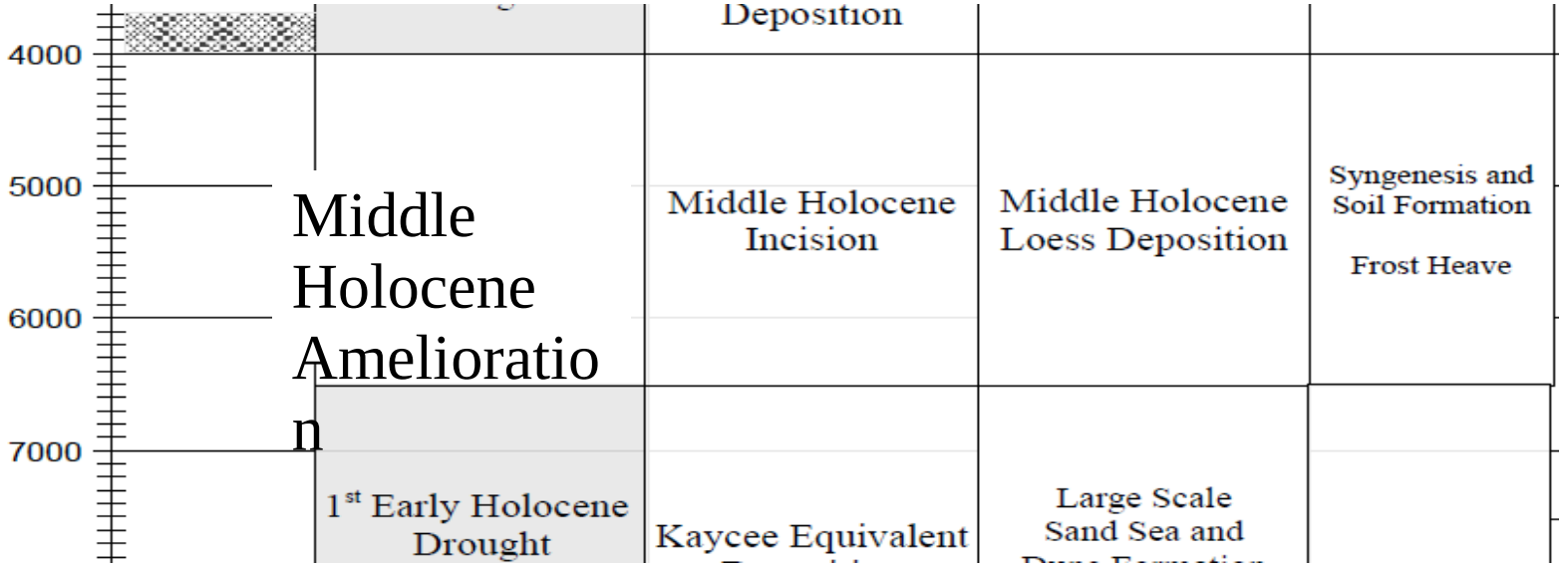
Many important Paleoindian sites are in these deposits, and aeolian sand seas or ergs form in the west (Ahlbrandt 1973; Gaylord 1983; Miller 1992; Miao et al. 2007; Halfen et al. 2010)

Sand seas and smaller dune fields dates almost exactly overlap , but where alluvial deposition dominates only the closing phase of aeolian activity, coppice mounds overlying alluvium, is present

Sea level rise is most rapid in this interval, but slows appreciably around 6500 to 6000 years ago


Kaycee Eq.
Late Glacial Gravels


Greasewood Dominant
Sage Brush Dominant



The middle Holocene amelioration indicates more moderating conditions from 6,500 to 4,000 RCYBP.

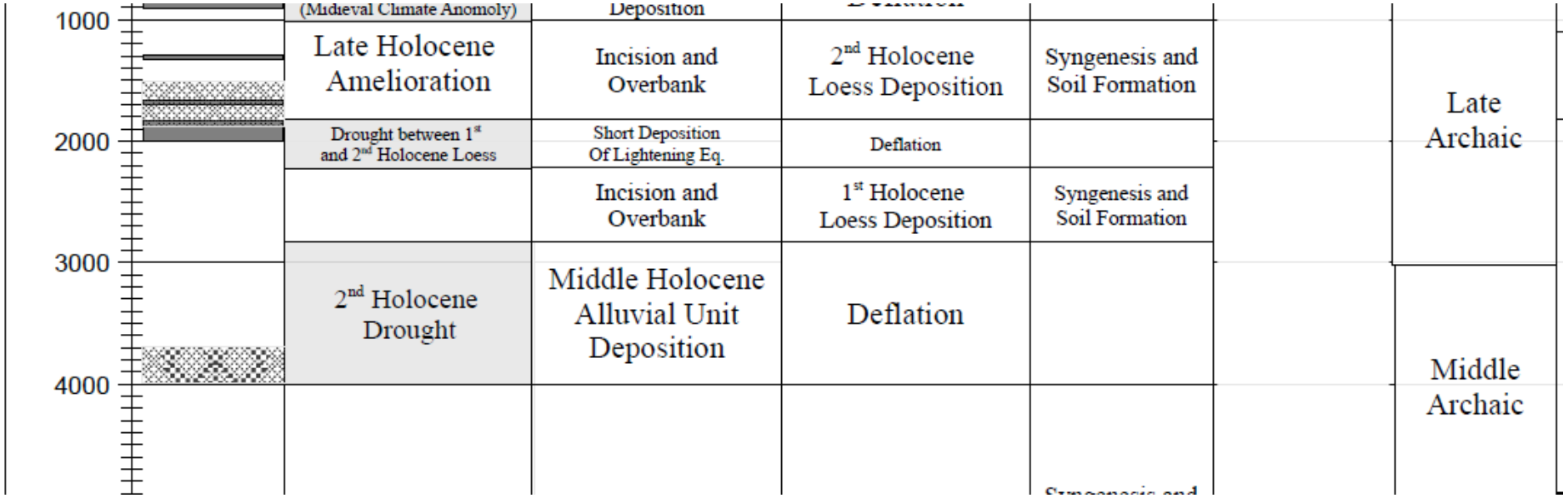
The dunes and sand seas of the early Holocene stabilized and phytogenic aeolian deposits — sand sheets and shadows, and loess — throughout the region begin accumulating (Miller 1992; Miller et al. 2011a).

Vegetation coverage and density increases largely due to stored pore water sustained by cooler temperatures

Alluvial incision ensues due to increased stream power, but incision can not penetrate glacial gravel and many streams start a cycle of valley widening. Frost heave in the interval is present.

In-place or syngenetic weathering produced secondary smectite and calcite which cement the deposits and give it a resistant character (Miller et al. 2011a); oxy-hydroxides (goethite and limonite) and, sometimes sulfide minerals also help identify the deposits.

Murchison (1989) reports that the Great Salt Lake expanded 4600km^2 in the early part of this interval, and other more recent studies indicate that alpine lakes were expanding at the same time (Shinker et al. 2010; Shuman et al. 2010). Also, sea level rise levels off for the first time since the end of the Pleistocene.



The temperature shift towards drought conditions after the middle Holocene amelioration begins and ends sometime between 4,000 and 2,800 RCYBP (Miller et al. 2011a).

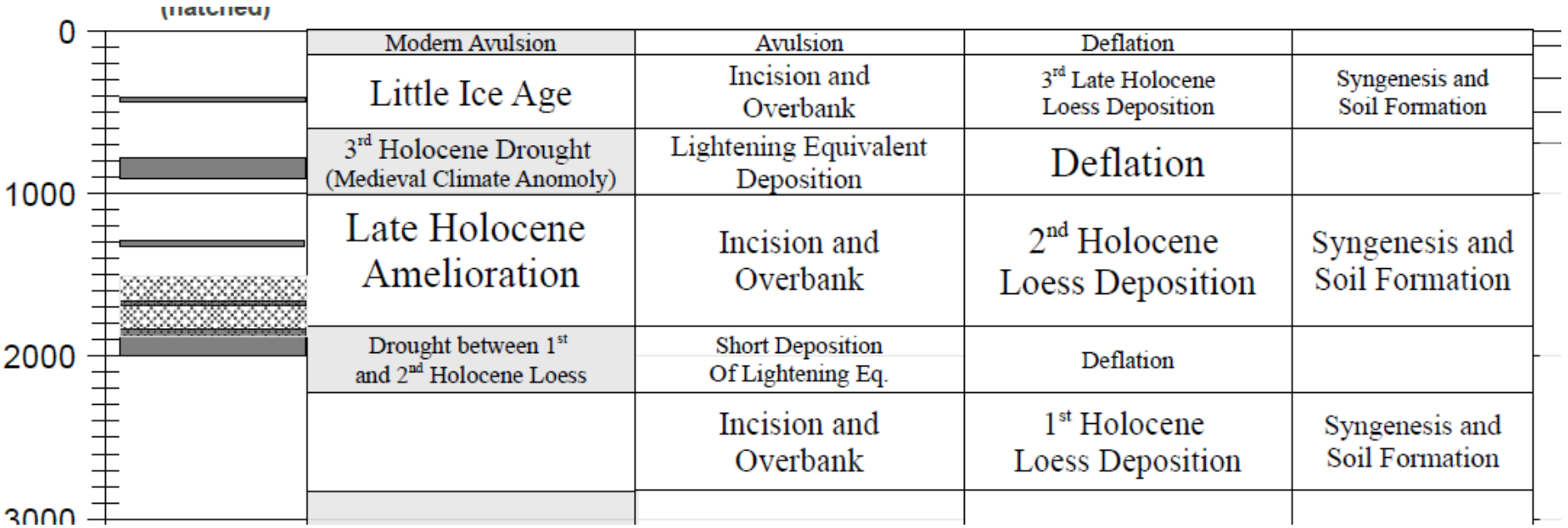
The middle Holocene drought is related to the unnamed middle to late Holocene alluvium. The period correlates to deflation of the middle Holocene loess

Hill slope instability and deflation provide the sediment source for the alluvium.

This contact or unconformity also marks the transition from Middle Archaic to Late Archaic


Middle Holocene
Alluvium

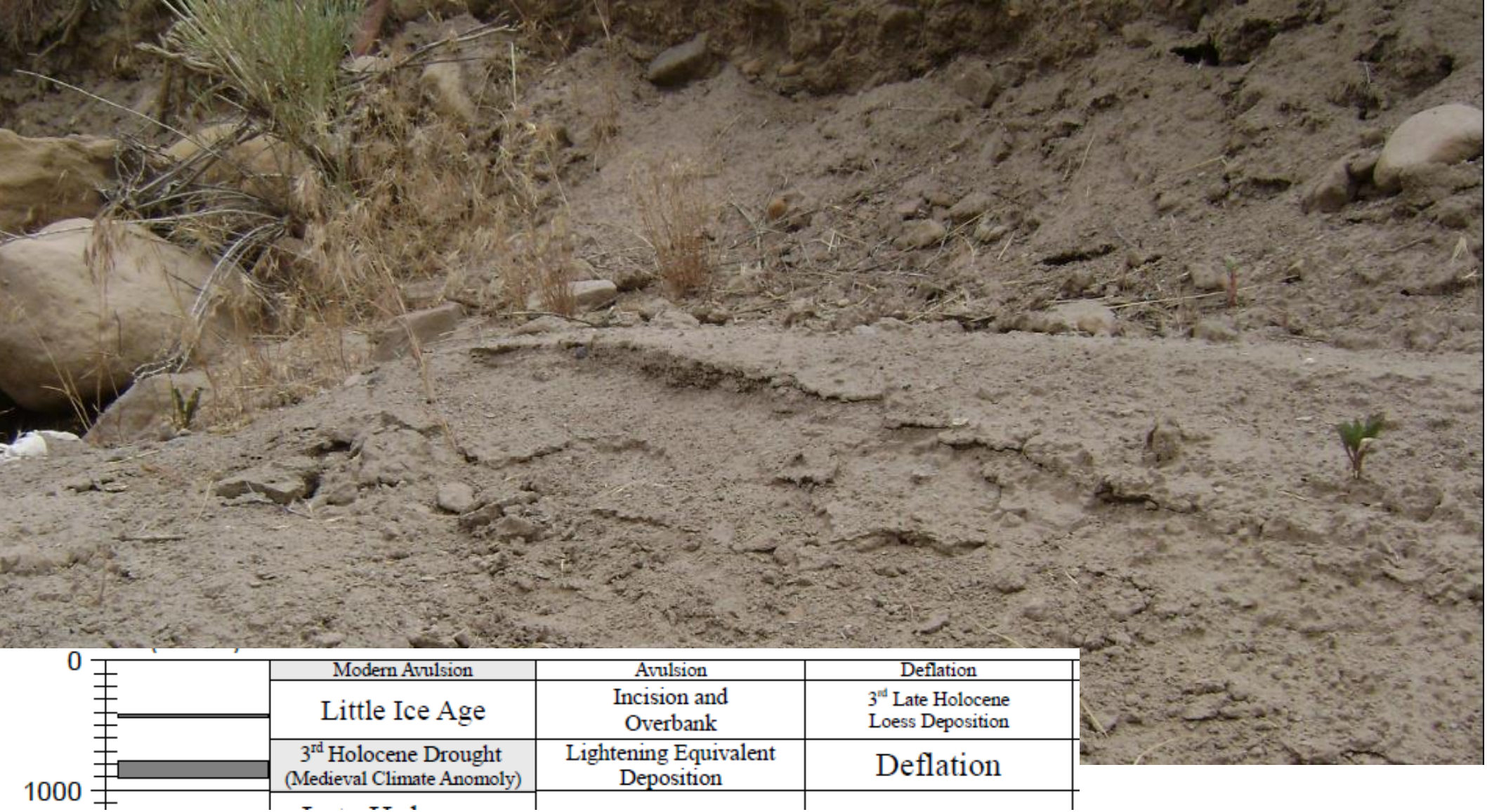
Middle Holocene alluvium cross section on Leach Creek



The late Holocene amelioration is another shift towards moderate climate from 2,800 to 1,000 RCYBP with a short drought from 2,200 to 1,800 RCYBP (Miller et al. 2011a, 2011b; Grand River Institute, in progress).

Alluvial deposition during the drought is the early deposition of the Lightning-equivalent alluvium, but the distinction is not always noticeable as the second half of the amelioration sometimes removed the early deposits.

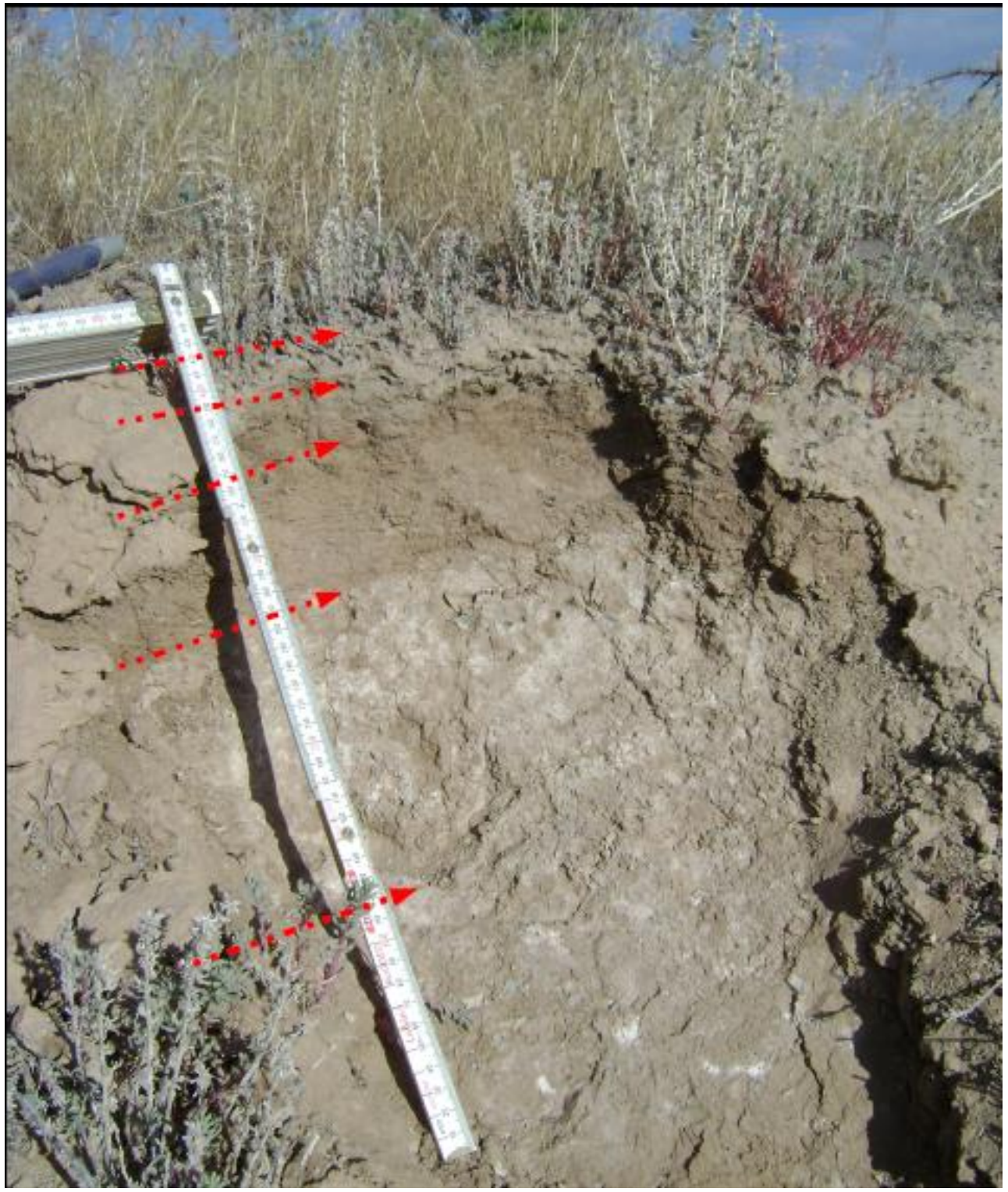
Lake levels increased in the interval (Shinker et al. 2010; Shuman et al. 2010).



Late Holocene drought conditions return after 1,000 RCYBP continuing until the Little Ice Age near 600 RCYBP (Miller et al, 2011).

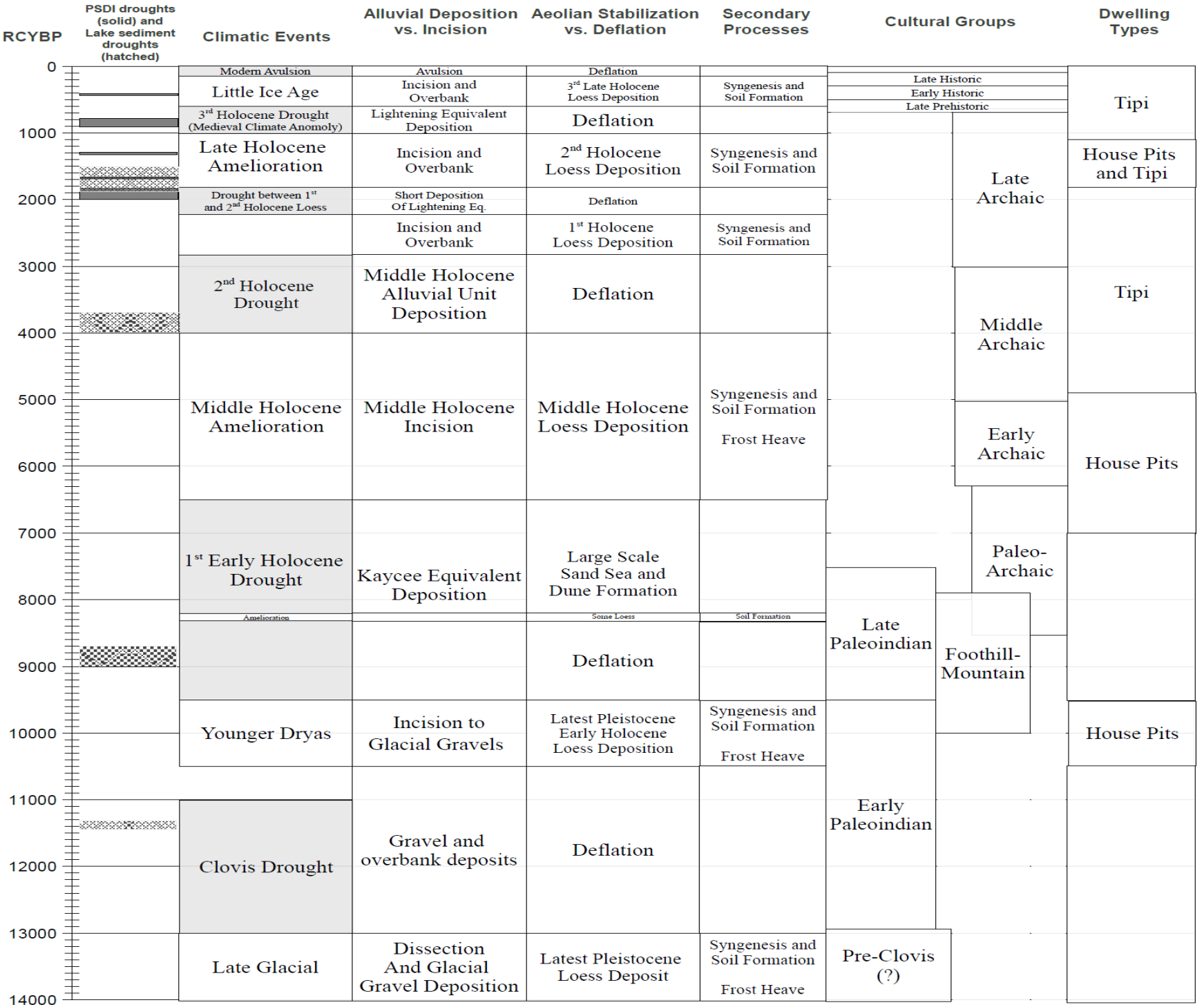
The late Holocene alluvium deposition, like the middle Holocene alluvium, occurs during this drought. This unit can also occur as inset or overbank deposits.

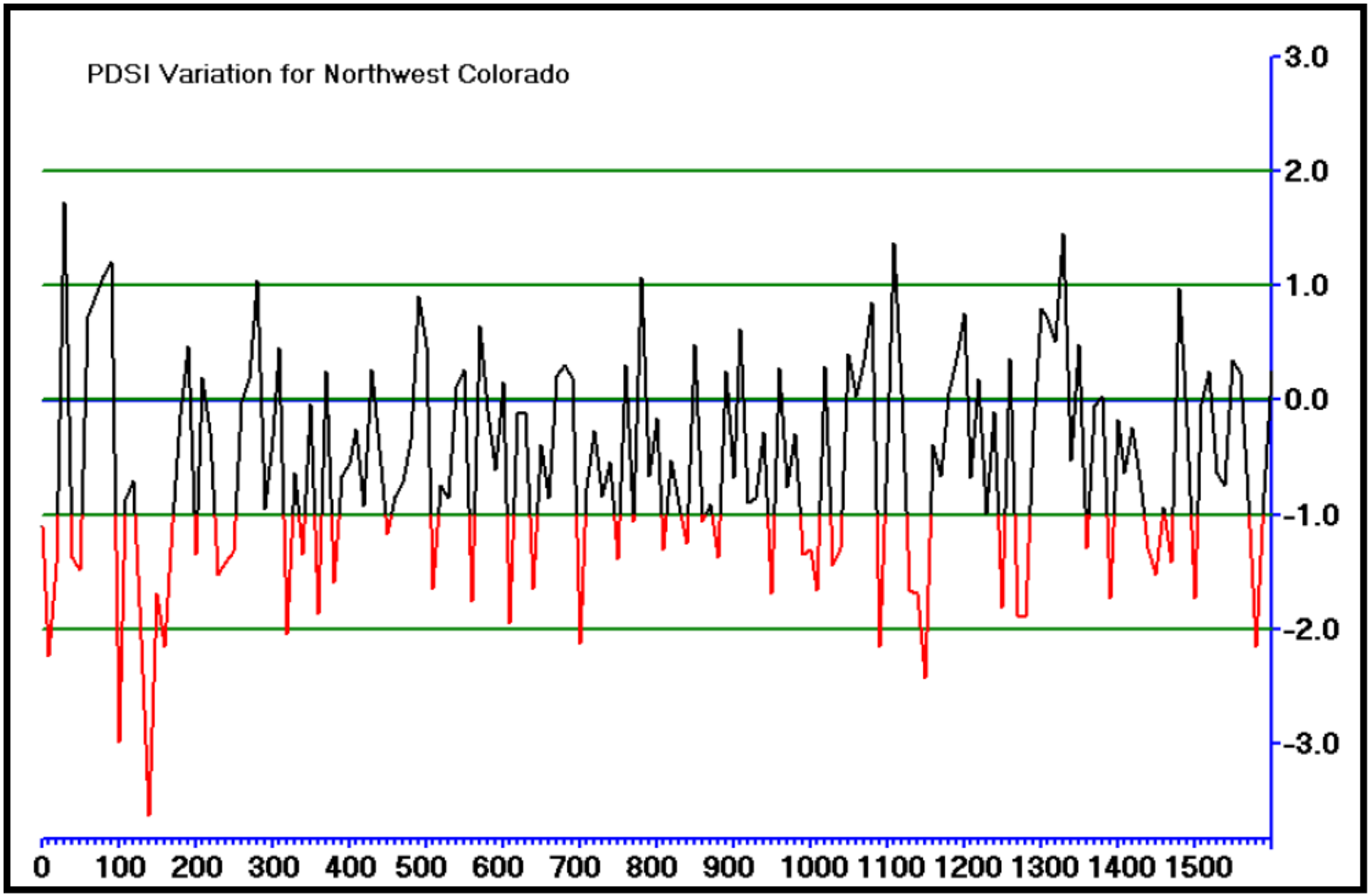
Leopold and Miller (1954) name this small terrace the Lightening Formation after where it was first described on Lightening Creek in eastern Wyoming.



The Little Ice Age marks the latest Holocene amelioration forming the third late Holocene loess sheet and an incision forms in the Lightening equivalent alluvium.

This loess sheet is the youngest and exhibits the least amount of weathering. The Little Ice Age sheet forms between 600 and 300 RCYBP (Miller 2010a)

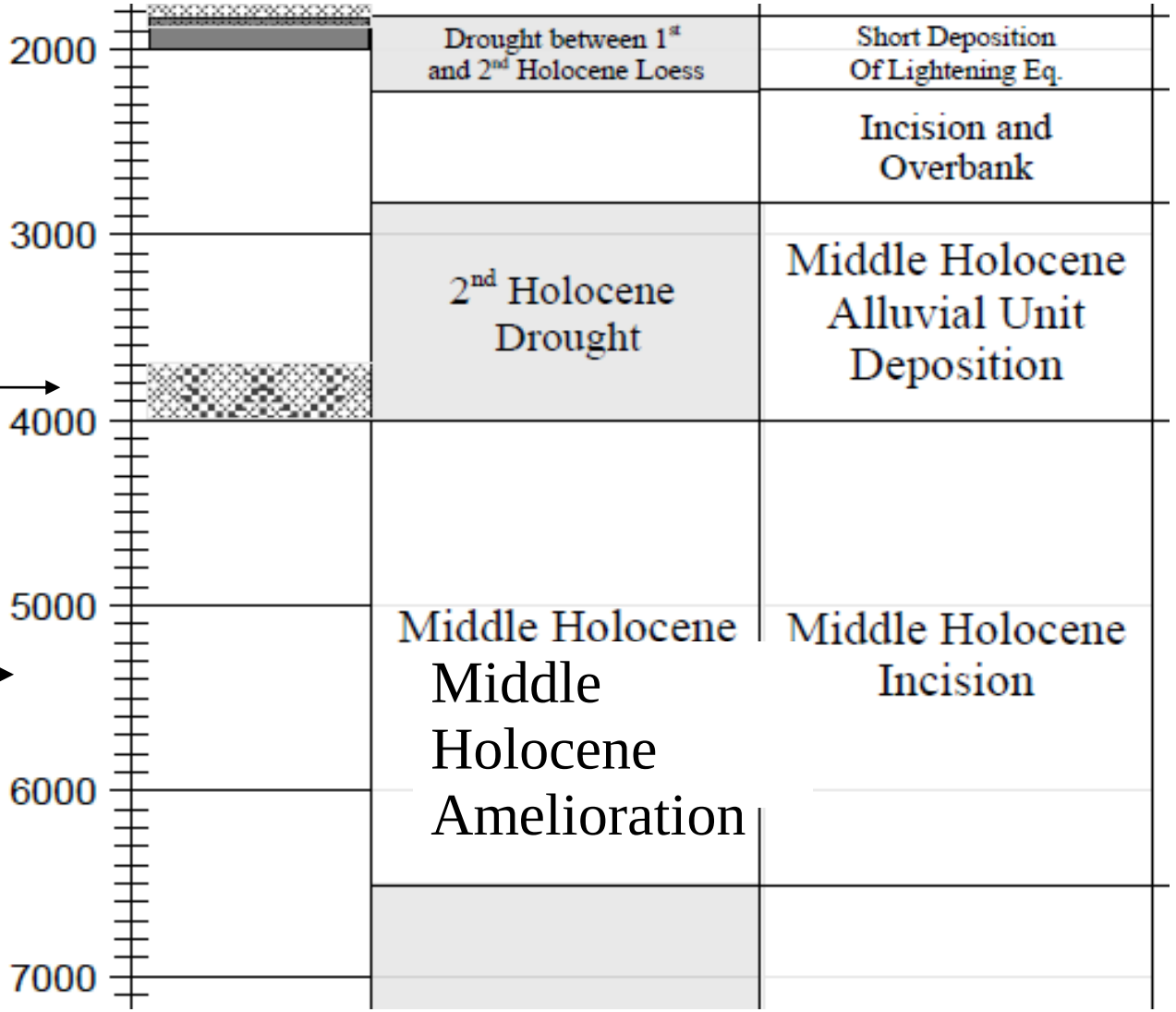

RCYBP
PSDI droughts (solid) and Lake sediment droughts (hatched)
Climatic Events
Alluvial Deposition vs. Incision
Aeolian Stabilization vs. Deflation
Secondary Processes
Cultural Groups
Dwelling Types
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
Modern Avulsion
Little Ice Age
3rd Holocene Drought (Medieval Climate Anomoly)
Late Holocene Amelioration
Drought between 1st and 2nd Holocene Loess
2nd Holocene Drought
Middle Holocene Amelioration
1st Early Holocene Drought
Amelioration
Younger Dryas
Clovis Drought
Late Glacial
Avulsion
Incision and Overbank
Lightening Equivalent Deposition
Incision and Overbank
Short Deposition Of Lightening Eq.
Incision and Overbank
Middle Holocene Alluvial Unit Deposition
Middle Holocene Incision
Kaycee Equivalent Deposition
Incision to Glacial Gravels
Gravel and overbank deposits
Dissection And Glacial Gravel Deposition
Deflation
3rd Late Holocene Loess Deposition
Deflation
2nd Holocene Loess Deposition
Deflation
1st Holocene Loess Deposition
Deflation
Middle Holocene Loess Deposition
Large Scale Sand Sea and Dune Formation
Some Loess
Deflation
Latest Pleistocene Early Holocene Loess Deposition
Deflation
Latest Pleistocene Loess Deposit
Syngenesis and Soil Formation
Syngenesis and Soil Formation
Syngenesis and Soil Formation
Syngenesis and Soil Formation
Frost Heave
Soil Formation
Syngenesis and Soil Formation
Frost Heave
Syngenesis and Soil Formation
Frost Heave
Late Historic
Early Historic
Late Prehistoric
Late Archaic
Middle Archaic
Early Archaic
Paleo-Archaic
Late Paleoindian
Foothill-Mountain
Early Paleoindian
Pre-Clovis (?)
Tipi
House Pits and Tipi
Tipi
House Pits
House Pits


PDSI Variation for Northwest Colorado
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

Broad Spectrum Global Context

Thera or Santorini eruption and fall of Minoans

Rise of Sumer city states



Broad Spectrum Global Context

1095 to 1291 AD

Medieval Warm Period