Moya

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HOLOCENE STRATIGRAPHY ALONG THE COAL CREEK, IN THE ELDORADO SPRINGS AND LOUISVILLE QUADRANGLES, COLORADO.

By: Juan Carlos Moya

ABSTRACT.

The Holocene stratigraphic history of Coal Creek, in the Eldorado Springs and Louisville area, Colorado, is represented mainly by three sedimentary units, which show the climatic and geomorphological conditions developed in this period. These units are known as; Broadway alluvium (QBal), Piney Creek alluvium (Qpcal), and Post Piney Creek (Qppcal) alluvium. In the mountain area Broadway is represented by strath terraces formed on debris flow deposits. In the piedmont area is formed by a wide plain which indicate that Coal Creek had many times more energy that the recent events. Broadway alluvium corresponds to Post Pinedale events which present soils with a well development of a B horizon. Piney Creek and Post Piney Creek were formed associated to a channel which denuded Broadway deposits. Both units, are characterized by soils which lack of B horizon. This characteristic can be produced by different reasons: these units are younger than 4,000 years and the content of fine materials (silt and clay) have been poor because the sediments arriving to the creek have consisted of coarse materials produced by talus, colluvium, and debris flow deposits.

INTRODUCTION.

The Coal Creek area, located in the Louisville and Eldorado Springs quadrangles, Colorado, contains a fluvial geomorphology sequence of Late Pleistocene to the recent.

In the past, this zone has had different stages of geomorphological development recorded by different types of deposits which occurred during the Quaternary climatic episodes (Malde, 1955, Scott, 1963, and Machette 1975). Because these fluvial deposits are well distributed and exposed in Eldorado and Louisville area, it is possible to reconstruct the Holocene fluvial history. These changes are well exposed in Coal Creek; one of the most important creeks in the zone.

The fluvial deposits recorded in the area from the Upper Pleistocene to the Holocene are known as, Broadway, Piney Creek and Post-Piney Creek or Piney Creek II (Malde, 1955, Scott, 1963, and Machette, 1975).

Although the deposition history of the zone has been documented, at the moment, no data had been collected to describe in detail the events along Coal Creek during the Late Pleistocene to Holocene. This work intends to reconstruct the stratigraphic history of Coal Creek during the Holocene.

PURPOSE AND METHODS OF STUDY.

Although the Quaternary history along the front range near Boulder is very intersting, there are a few works about Holocene stratigraphy and Geomorphology of the area.

The most significant characteristic of Coal Creek is that is very short and its basin has received less influence from the glaciation epochs. In other creeks located along of the Rocky Mountains front range, the influence of moraines, deglaciacion processes, sediments produced by big ice melting loads, and area covered by ice has been more important.

This work intends to define the erosional and depositional history that occurred along Coal Creek in Eldorado Spring and Louisville quadrangles, (figure 1) from Late Pleistocene to Present. This paper compared the characteristics of the fluvial deposits and soils developed in each unit with the periods of erosion or deposition occurred, and the developed geomorphological profile.

Twelve cross-section profiles were prepared to define the stratigraphic and geomorphologic characteristics of Coal Creek from the upper part of the basin until the Town of Superior (figure 2). This transect included 15 km approximately along the channel.

The area is located in the U.S.G.S. topographic maps of El Dorado Spring and Louisville at scale of 1:20,000.

Quantitative and qualitative physical properties were described for each unit, including the:

- Nature of soils developed over each deposit,
- Location of deposits in the geomorphological context,
- Presence of carbonate horizons if present,
- Paleogeomorphological location as compared with recent location,
- Grade of dissection and gully erosion as an indicator of relative geomorphological age if available,
- Lichenometry,
- Presence of talus deposits,

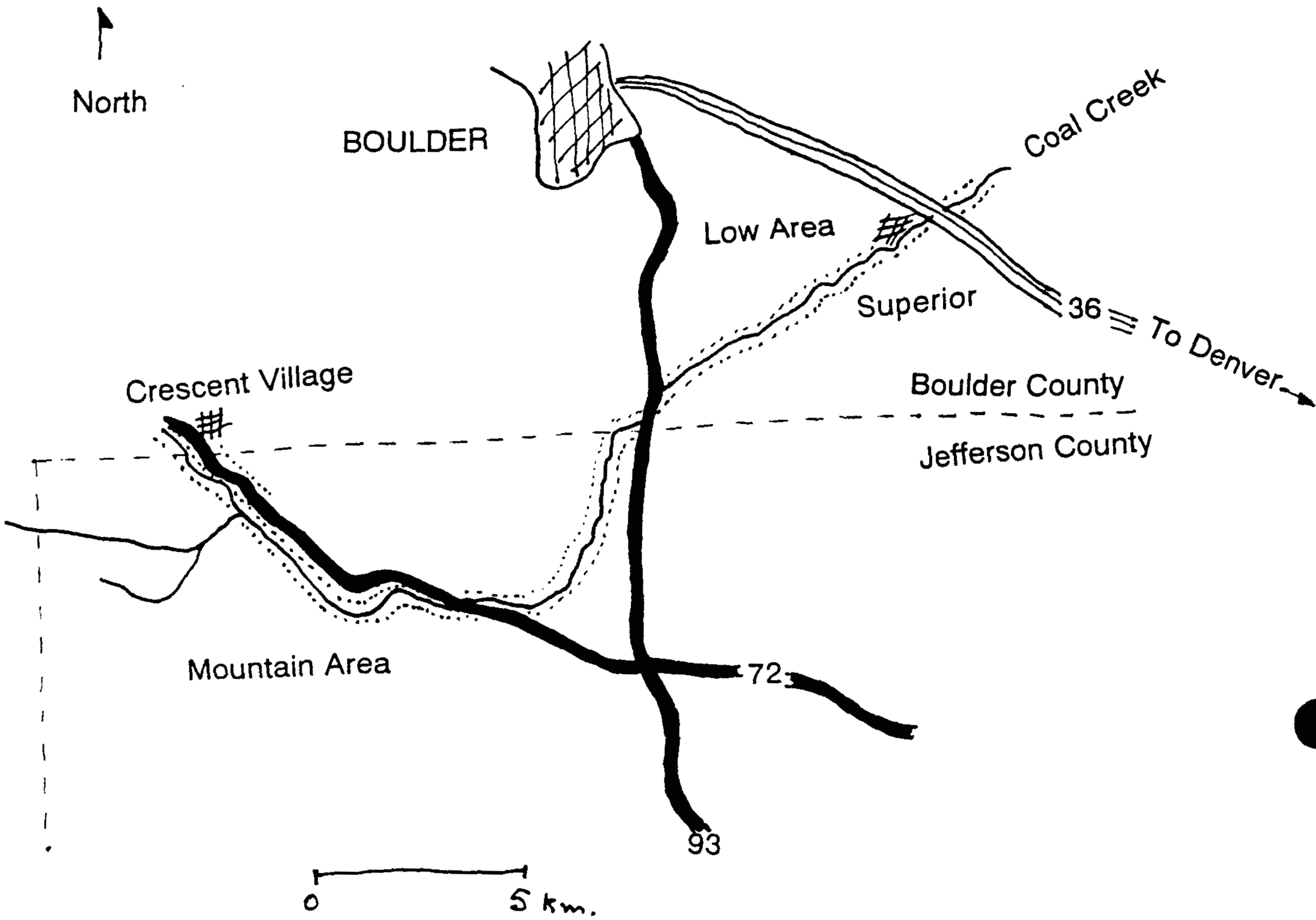


Figure 1. Location of the Study Area.

LONGITUDINAL PROFILE ALONG COAL CREEK

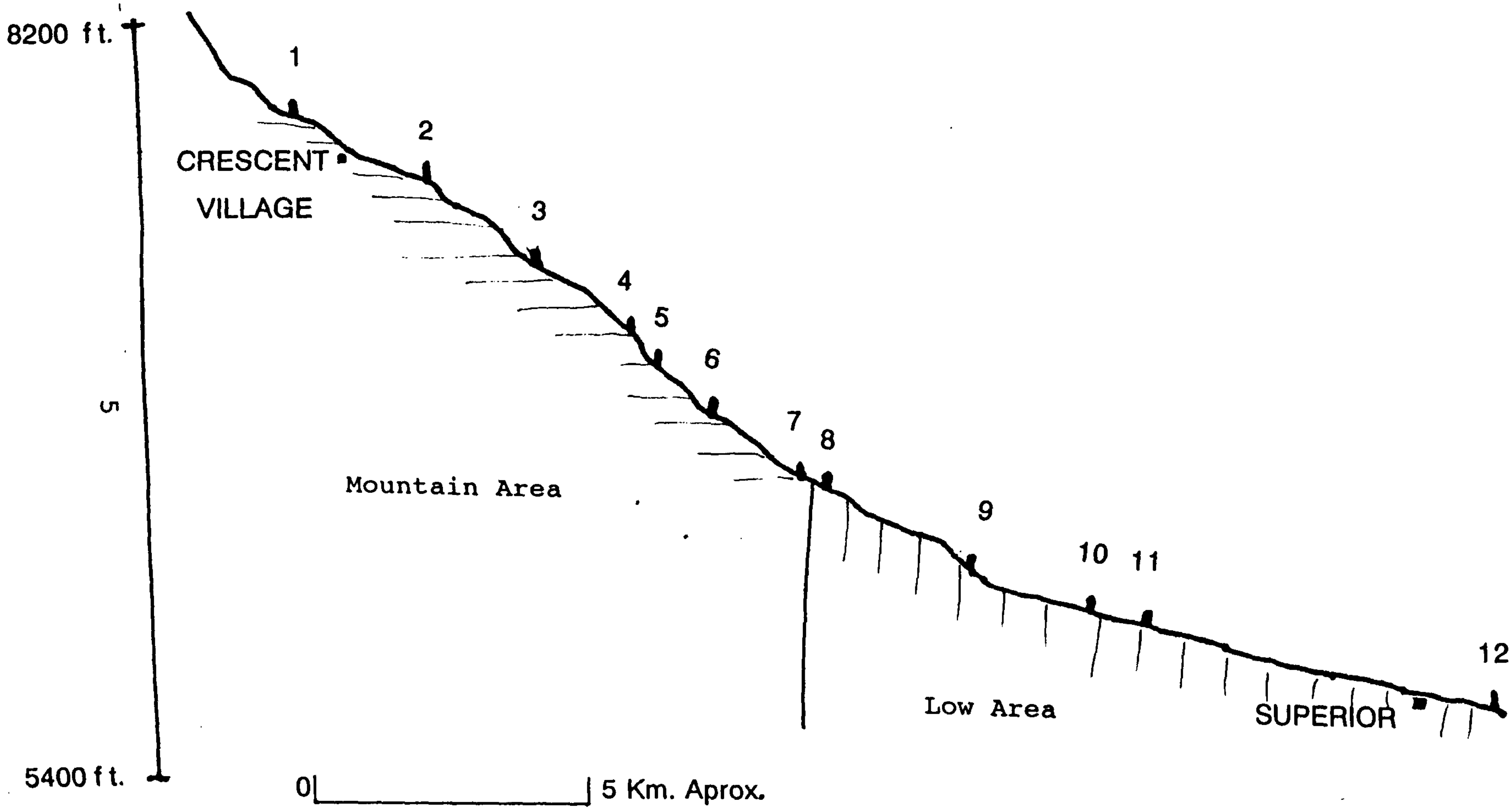


Figure 2. Location of cross-section profiles along Coal Creek.

- The comparative characteristics of other units located in the Rocky Mountain Front Range as defined by other authors: Malde (1955), Scott (1963), Baker (1974), Machette (1975); Hunt and Sokoloff (1950); Hunt (1954); Scott (1960) and (1963); Spencer (1961); and Baker (1973) and (1974).

PREVIOUS WORK.

The Holocene fluvial deposits known in the area have been compared with the deposits defined in the Denver area by Hunt (1954), and named as: Pre-Piney Creek, Piney Creek, and Post Piney Creek (Hunt, 1954). All have been named as Post Pinedale deposits (Malde, 1995). All the deposits of Post Pinedale time consist of younger alluvium deposited after the Pinedale glacial event, over the older fluvial deposits known in the zone as: Rocky Flats, Verdos, Slocum, Louviers, and Broadway (Trimble and Machette, 1979).

Physical and chemical characteristics of the fluvial deposits and soils have been used and compared with the works of Malde, (1955); Scott, (1963); Machette, (1975); and Birkeland (1984). Also, to prepare the stratigraphy of the Holocene events along the area, the author have used the general physical characteristic of soils.

GEOLOGY OF COAL CREEK.

For this purpose study, Coal Creek has been divided in two main geomorphological units: a) the mountain area and b) the piedmont area (see figure 2 and 3).

a) The Mountain Area.

In the mountain area Coal Creek probably dates back to Miocene age (Malde, 1955). It cuts along Precambrian and Mesozoic rocks consisting of quarzites, schists, granites, and gneiss (Trimble and Machette, 1979). Ancient erosional surfaces can be recognized near the up-basin near of the ridges as evidence of this long period of erosion.

b) The Piedmont area.

In this area, Coal Creek runs over two units: the Pre-Quaternary rocks and Quaternary deposits (Trimble and Machette, 1979).

The Pre-Quaternary rocks are characterized by two Upper Cretaceous Formations: the Laramie Formation and the Pierre Shale. The Laramie Formation is characterized by shales, claystones, silstones and sandstones. The Pierre Shale is characterized by olive-gray marine shales and interbedded sandstones (Trimble and Machette, 1979).

The Quaternary deposits represents the history of the fluvial events which are the expression of the erosional process which occurred in the mountain area during this time.

The periods of erosional activity along Coal Creek in the mountain area have not been quantified, particularly those occurred during the Quaternary. However, the periods of sedimentation in the mountain front have been well defined in time as well as in terms of physical characteristics. Along the margin of the mountain front (in the piedmont and the plain areas), a sequence of nine alluvial, two colluvial, and two eolian depositional units have been recognized (Machette, 1975).

Coal Creek has cut different Pre-Quaternary Formations as well as some Quaternary Formations. According to Malde, (1955); Scott, (1963); Machette (1975); and Trimble and

Undifferentiated Pre-Quaternary rocks: Yxp, Xqm, Xbs, Xs, Xp, Xq, PPf, Kp, Kf.

Quaternary deposits:

Qp= Piney and Post Piney Creek Alluvium (Holocene)

Qb=Broadway Alluvium (Pleistocene)

Qlo=Louviers Alluvium (Pleistocene)

Qs=Slocum Alluvium (Pleistocene)

Qv=Verdos Alluvium (Pleistocene)

Qrf=Rocky Flats Alluvium (Pleistocene)

Qn=Nussbaum Alluvium (Pleistocene)

0 4 km.

Figure 3. Geology of the Study Area.

Machette (1979), the stratigraphic column of the Quaternary fluvial deposits consist of nine units characterized by the following:

Post-Piney Creek Alluvium Qppcal
Piney Creek Alluvium Qpcal
______________________ **Holocene**
Pre-Piney Creek Alluvium **Upper Pleistocene**
Broadway Alluvium Qbal
Louviers Alluvium
Slocum Alluvium
Verdos Alluvium
Rocky Flats Alluvium
______________________ **Lower Pleistocene**
Pre-Rocky Flats Alluvium **Upper Pliocene**

Characteristics of sediments and soils.

Piney Creek (Qpcal) and Post-Piney Creek (Qppcal) units have been deposited after the Pinedale glaciation (after the Broadway deposition). In Coal Creek, these units Qpcal and Qppcal were formed over a channel developed on the Broadway deposits. By this reason, only these units have been described in detail, mainly because these units were developed from the Late Pleistocene to the present.

Figure 4 shows the idealized soil profile developed for each deposit in Lafayette (Machette, 1975). The characteristics of the deposits and soils developed are as follows:

A. Broadway Alluvium and soil profile development (Pinedale Glaciation).

This deposit first was named by Scott, (1960). Malde (1955), defined this deposit as "Wisconsin deposits" in the Louisville Quadrangle, and Machette re-defined them as Broadway Alluvium (Qbal).

According to Machette, these deposits in the Lafayette area consist of light-gray-brown, to light-brown moderately well-sorted fine sand and silt and minor clayey gravel lenses near the base. Alluvium is crossbedded and generally finer grained upward in the deposit.

The upper part of alluvium has a weakly developed zonal soil with a poorly developed calcium carbonate-enriched (Cca) horizon. Machette (1975) states that these deposits are correlated with the Pinedale Glaciation. The average thickness of the unit is >6 m (20 ft) along Coal Creek at the north edge of the Lafayette quadrangle.

The soil profile developed by this unit according to Machette (1975) is presented in figure 4.

B. Piney Creek Alluvium (Qpcal) and soil profile development (Upper Holocene).

This alluvium has been dated by the abundance of archeological objects and of remains of Bison bison fossils, Malde (1955). In the Louisville quadrangle, Piney Creek alluvium (Qpcal) ranges in texture from fine silty sand to clayey silt and usually contains gravel lenses at the base. Their thickness usually exceeds 10 feet.

In the upland valleys the tops of the deposits are remarkably flat and end abruptly along the valley walls. The alluvium was deposited in relatively narrow, deep arroyos, implying a preceeding interval of erosion.

In the Lafayette Quadrangle, Piney Creek alluvium is a gray to light gray-brown well stratified , locally crossbedded sand, silt and occasional clay which forms small terraces cut as channels in older alluvium (Machette, 1975). According to this author, where terraces are present, the upper surface is 1.8 to 2.6 meters (6-8 feet) above stream level. Along this area of Coal Creek, Piney Creek alluvium occupies most of the floodplains. The soils in this area are soils that do not have a well developed argillic B horizon (see figure 4). This is considered as one of the best characteristic by which to recognize these soils from the older deposits (Malde, 1955, and Machette, 1975).

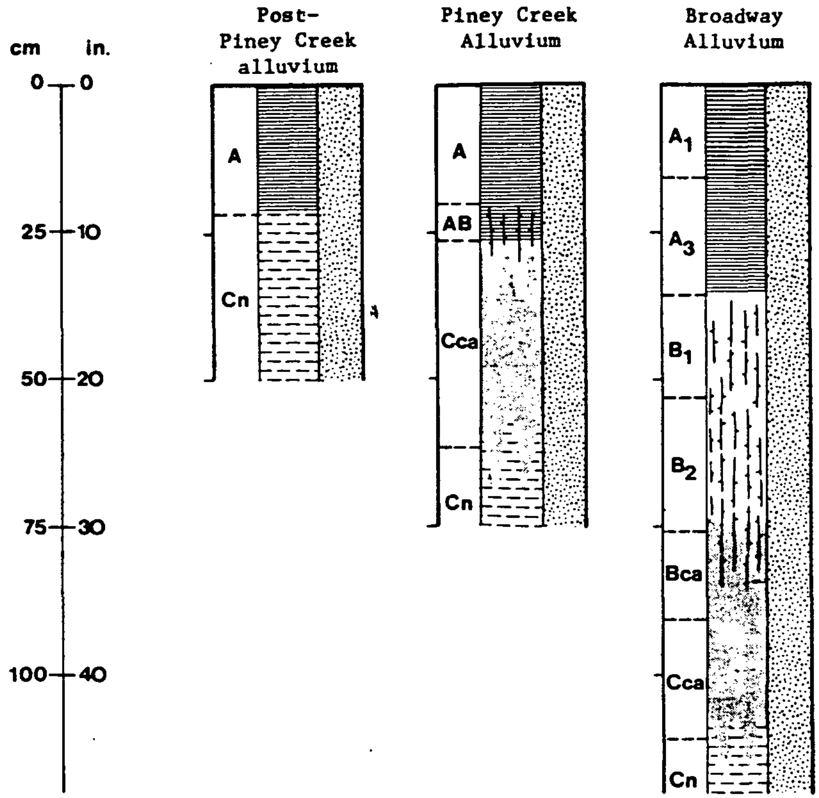


Figure 4. Idealized profile of maximum soil development in the Late Quaternary in the Lafayette quadrangle. (From Machette, 1975).

C. Post Piney Creek Alluvium (Qppcal) and soils profile development.

According to Malde (1955), part of the Coal Creek flood plain is mantled by Post-Piney Creek alluvium. This corresponds to areas that were periodically flooded before the advent of irrigation. These deposits range in size from fine sand to silt, but lenses of pebble and cobble gravel are commonly interbedded near the base of the alluvium.

The same author mentions that along Coal Creek this basal gravel probably was derived from an upstream source and not from the adjacent gravel fill and the Piney Creek Alluvium. This alluvium is essentially noncalcareus.

Machette (1975) has defined this unit in the area of Lafayette as Dark-gray to gray-brown sand, silt, and clay, except along Coal Creek where lenses and channels of gravelly to pebbly sand are common. Major seasonal floods overtop this unit. Thickness is more or less 2-3 m.

It is important to note that in previous studies, Coal Creek presents differences with respect to other areas in the same zones, mainly in the characteristics of recent deposits, as for example, the location of gravels and the source of the sediments. It will further expand more on this topic because it is a important characteristic of Coal Creek.

GEOMORPHOLOGICAL EVOLUTION OF COAL CREEK.

Twelve (12) cross section profiles were prepared to define the morphological and stratigraphic characteristics of Coal Creek developed during the Holocene (figures 5 to 16).

These profiles were prepared to illustrate the changes and the the characteristics of each unit (Broadway, Piney Creek and Post-Piney Creek) according to the type of soil, type of deposits, and the geomorphological units (i.e. number of terraces, drainage pattern, etc). Location of the profiles are shown in figure 2.

To simplify the description of Coal Creek, it was subdivided in two areas of study: the mountain area and the piedmont area or low area. In addition, the stratigraphic column and associated descriptions are presented as follows:

Late Quaternary Stratigraphy in the Study Area.

Qppcal	**Ql**	**Upper Holocene**	
Qpcal			**Holocene**
Qb		**Pinedale Glaciation**	
		Bull Lake Glaciation	**Pleistocene**
		Undifferentied Pre-Quaternary Rocks	

Description of the Stratigraphic units along Coal Creek prepared for this work using field information:

Qppcal. POST PINEY CREEK ALLUVIUM (LATE HOLOCENE): "Mainly" dark brown, dark reddish brown, dark yellowish brown, very dark gray brown, dark grayish brown, dark brown to brown, yellowish brown, dark brown to brown, sandy-silt, sand, silt, gravelly to pebbly and cobbly sand. Commonly form terraces from 20 cm to 1.4 meters high, and commonly presents more than one channel running over previous deposits (Piney Creek Alluvium). Occasionally appear cutting talus and debris flow deposits from the Holocene to Late Pleistocene age. Major season floods overtop this unit and the secondary channels. Minor accumulations of organic matter in the upper part unless removed by recent flood activity. Thickness could be from 20 cm to 1.5 meters. The soils formed presents A horizons less than 8 cm deep and C horizons formed by recent (Late Holocene) fluvial deposits.

Qpcal. POST PINEY CREEK ALLUVIUM (LATE PLEISTOCENE TO LATE HOLOCENE): "Mainly" black, dark reddish brown, very dark grayish brown, dark grayish brown, dark yellowish brown, dark grayish brown, dark brown, olive brown, dark brown to brown silty-sand, sandy-silt, silty-clay, sand, with gravels, pebbles, cobbles and boulders subangular to subrounded. Commonly form terraces from 60 cm to 2.0 meters cut on Broadway deposits (Late Pleistocene) or on talus and debris flow deposits (also Late Pleistocene) and occasionally on older Formations (Pre-Quaternary). This unit is also cut by the Post Piney Creek Deposits. Over this unit Coal Creek has formed more than one channel recently in extraordinary flood events. Occasionally, very high floods can cover some areas or completely this unit. Thickness of this unit could be from 2 to 4 meters. Accumulation of Organic matter appear more developed than Qpcal, but Late Holocene and recent floods may have removed the soils formed. These present A horizon sometimes more than 10 cm deep and sometimes enriched with silt and clay in the contact with C Horizon, but without forming a B horizon. These deposits were formed after the Pinedale glaciation when Broadway deposits had developed a well developed B horizon.

Ql. QUATERNARY LANDSLIDES TALUS AND COLLUVIAL DEPOSITS (HOLOCENE AND LATE PLEISTOCENE): Landslides associated deposits are formed of heterogeneous mixtures of rock fragments, mainly very angular gravels, pebbles, cobbles, and boulders, produced by debris flows on steep slopes consisting mainly of weathered granitic, quartzite, and metamorphic rocks. Talus deposits includes angular fragments of rock below the cliffs or steep rocky slopes. Colluvium includes slope wash and heterogeneous mixtures of silt, sand, gravels, pebbles, cobbles, and boulders which can appear integrated with talus. Maximum thickness could be up to 10 meters.

Qbal. BROADWAY ALLUVIUM (PINEDALE GLACIATION). (From: Machette, 1980) Light-gray-brown to light-brown moderately well sorted fine sand and silt; minor clayey gravel lenses near the base. Alluvium is crossbedded and generally finer grained upward in the deposit. Forms terraces 3-4 m (10-13 ft) above the modern flood plain of Big Dry Creek. Radiocarbon dates of charcoal collected near the base of the alluvium are greater than 45,910 yrs B.P. Upper part is poorly developed calcium carbonate-enriched (Cca) horizon. Correlated with the Pinedale Glaciation. Thickness is 5-6 m (17-20 ft) along Big Dry Creek; >6m (20 ft) along Coal Creek at the north edge of the Lafayette quadrangle.

Stratigraphic Profile of the Mountain Area.

The mountain area is characterized by a channel which cuts through older rocks along the up basin. It is fed with talus and debris flow deposits at the side of numerous small creeks and active areas of landslides. In Coal Creek the slopes are formed by rocky cliffs where where the soils have been removed perhaps by periglacial and fluvial erosion (see profiles 1 to 7 in figures 5 to 11.

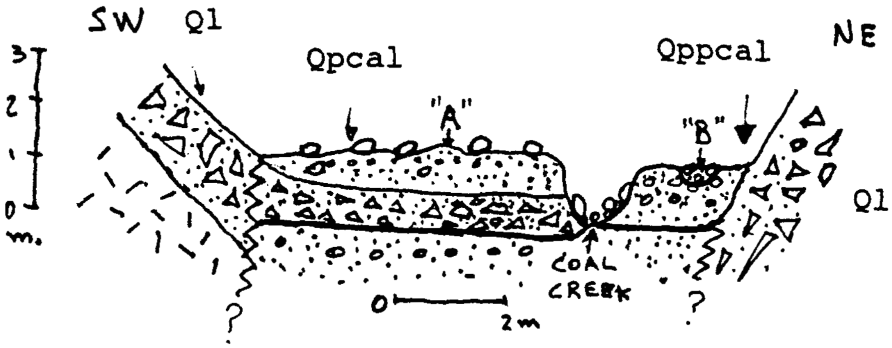
The deposits in the mountain area formed along the channel are characterized by angular to subangular blocks and subangular to subrounded gravels, pebbles, cobbles, and boulders. The matrix is sandy and rarely contains clay or silt.

Some areas can be defined by terraces eroded over talus and debris flow deposits. These terraces are located at higher elevations than recent levels of the Creek. Profiles 4 and 5 show a difference of approximatly 5 to 10 meters with respect to the modern channel. The age of these terraces is unknown but their location suggests a Late Pleistocene to Holocene age.

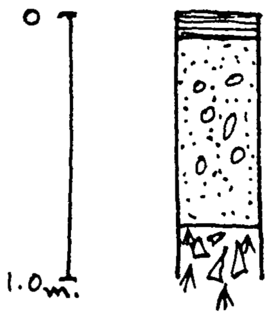
Figure 17 is an idealized profile of the Mountain area using the first seven cross-sections. This figure shows a strath terrace formed before Piney Creek Alluvium. This terrace was formed over talus, colluvium, and debris flow deposits. The height is approximately 4 to 5 meters in average. The content of the organic matter in these terraces is higher than those of more recent events, but it cannot be defined as a well developed "B" horizon.

As mentioned before, an age of Pre-Holocene has been defined to these kind of terraces. The author have defined it as representative of a Broadway event because it is the closer to the level of the Piney Creek deposits. In addition, the terraces formed have not been affected by the development of gullies as have been other strath terraces older and topographically higher also located in the area. Fluvial erosion of talus and debris flow occurred after the formation of the strath terraces (by the Broadway event) Piney Creek deposition followed these units.

The Broadway and Piney Creek events are differentiated in the up-basin: It is likely that Broadway has been an erosive event, eroding completely the talus deposits, while Piney Creek was a fluvial cumulative event characterized by the sedimentation of fluvial deposits in contact with the talus deposits previously formed.

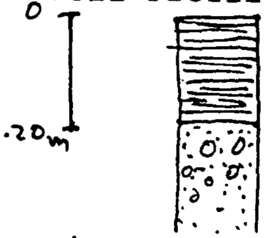


Soil Profile "A"



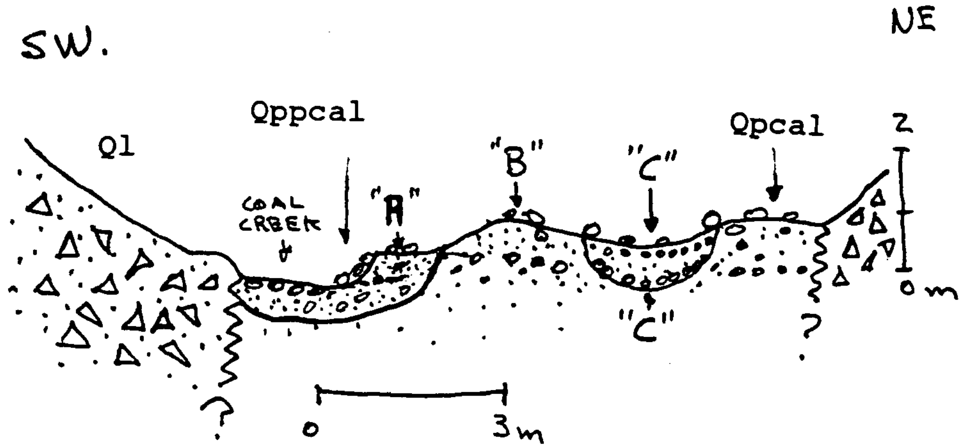
A Wet: 5YR 2/1 Black Sandy-clay.
Dry: 5YR 2/2 Dark redish brown.
Cn Wet: 10YR 3/2 Very dark grayish brown.
Dry: 10YR 4/2 Dark greyish brown Sandy loam.
C Talus rocks and roots. Rock product of earth flows and talus deposits. Granitic cobbles and boulders very angular.

Soil Profile "B"

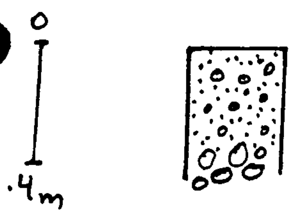


A Wet: 5YR 2/2 Dark redish brown 5YR 2/2. Sandy-clay.
Cn Wet: 10YR 4/4 Dark yellowish brown. Sandy-loam.

Figure 5. Cross-section 1.

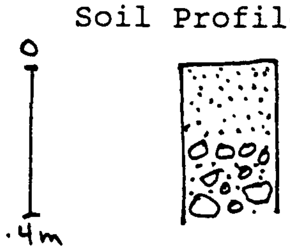


Soil Profile "A".

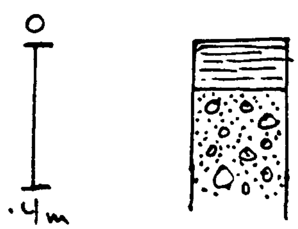


Cn Wet: Dark yellowish brown 10YR 4/2. Silty-sand. With mica and quarz. Gravels and Cobbles in the lower part of the profile.

Soil Profile "B".



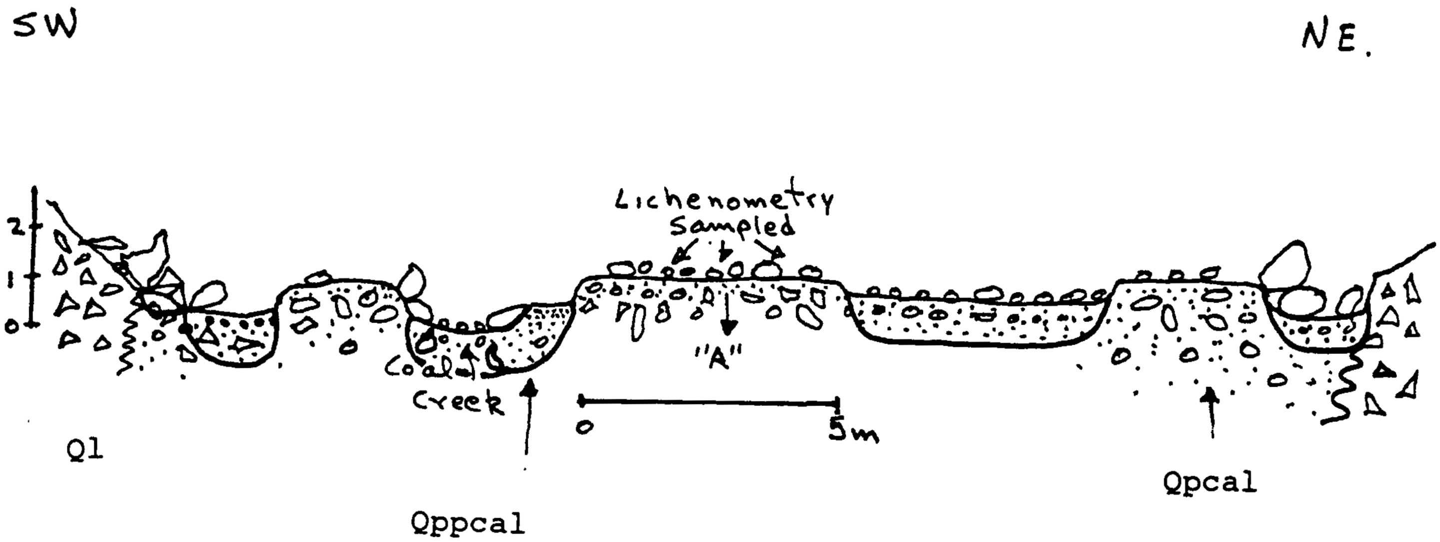
Cn Wet: Dark yellowish brown 10YR4/4 Sandy loam, with high concentrations of quartz. Gravels and cobbles in the lower part of the profile.



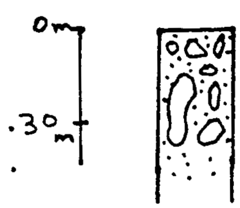
A Wet: Dark hyellowish brown 10YR 4/4. Sandy with high concentrations of quartz.

Cn Wet: Very dark greyish brown 10YR 3/2. Sandy gravel with high concentrations of quartz.

Figure 6. Cross-section profile 2.



Soil Profile "A"

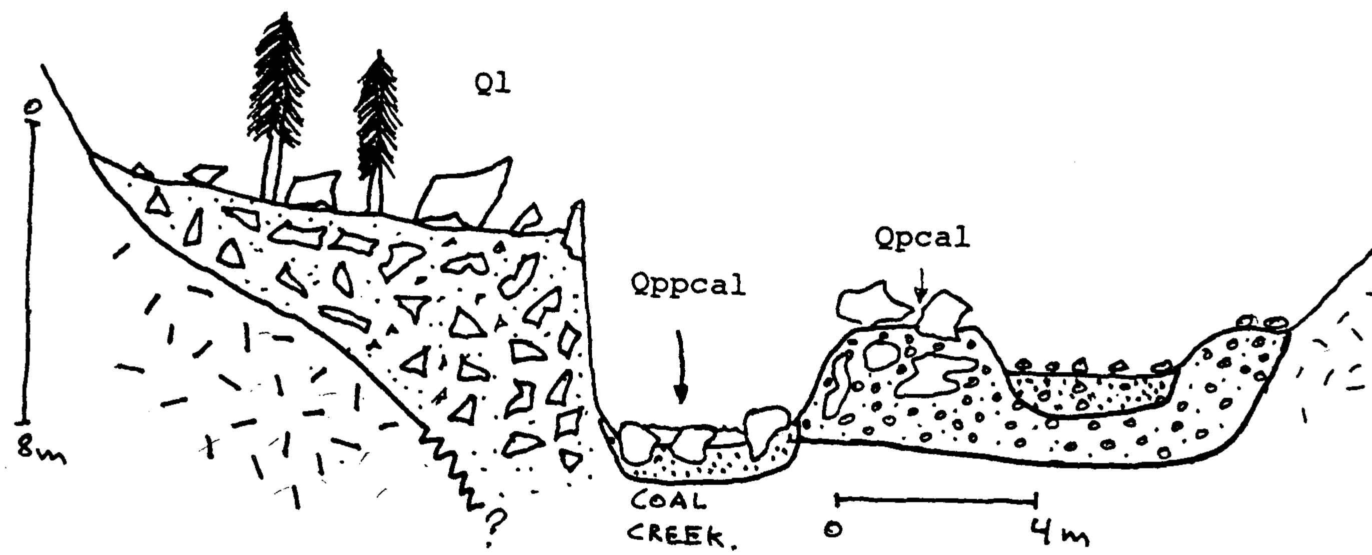


Cn Wet: Dark grayish brown 10YR 4/2. Sandy with pebbles and Cobbles.

Diameter of Lichenometry on Cobbles located on the terrace where Soil profile "A" was described:(in milimeters).
15, 12, 10, 10,10, 15, 15, 15, 10, 11, 10, 15, 10.

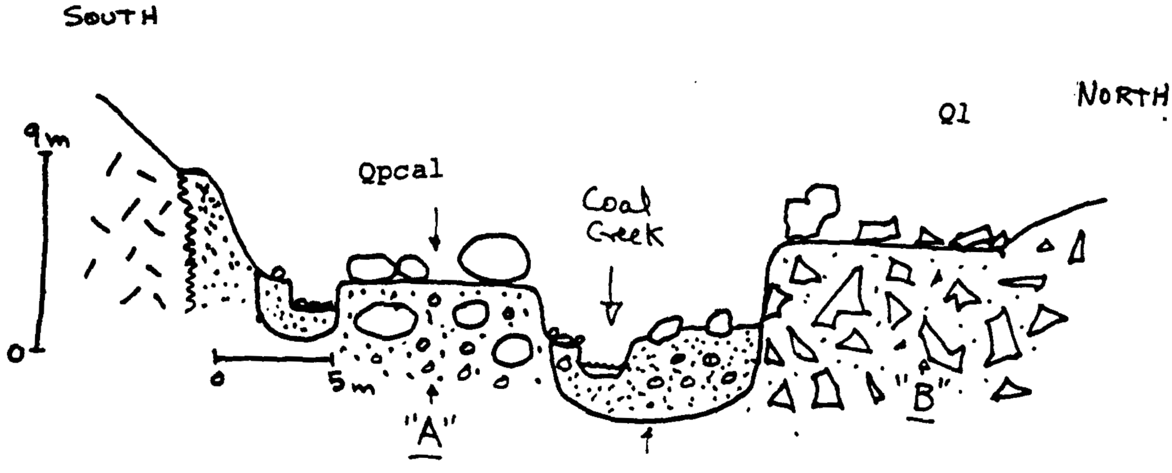
Mean: 12.5 mm Mode: 10 and 15 mm Median: 11 mm

Figure 7. Cross-section profile 3.

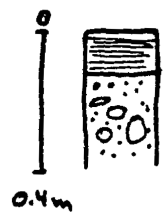


No soil profiles were described. Private land ownership.

Figure 8. Cross-section profile 4.



Soil Profile "A".



A Wet: 5YR 2/2 Dark redish brown. Sandy-clay.

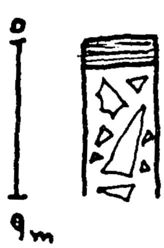
Cn Wet: 10YR 2/1 Black. Sands, gravels, pebbles, cobbles and boulders.
Dry: 10YR 3/3 Dark brown.

Diameter of Lichenometry: Lichens in the rock surface were greater than 35 mm.(in milimeters).
All the rocks presented lichens greatr than 35 mm. Because the of great development of lichens on the rocks, were mesured the area covered on the surface by lichens and the diameter of the rock in meters. %=area covered by lichens in each rock/ diameter of rocks im meters.

90 %/2.0 m, 70 %/1.0 m, 60 %/1.25 m, 45 %/1.25 m, 80 %/2.00, 80 %/1.0 m, 90 %/.40 m, 90 %/2.00 m.
Mean: 75.6 % Mode:90% Median:80%

All the rocks measured were subrounded and rounded rocks

Soil Profile "B".



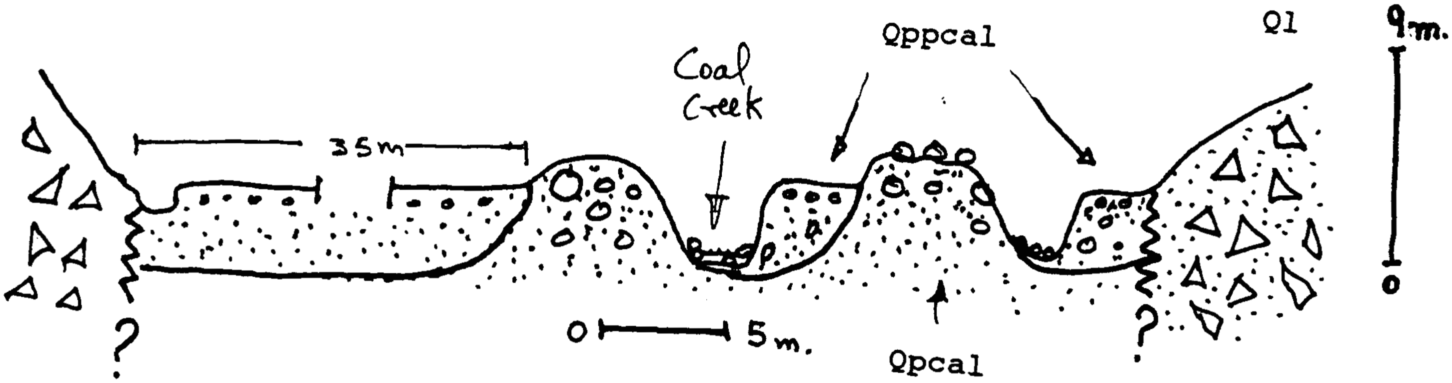
A Wet: 10YR 3/1 Very dark grey. Silty-silt and gravels, cobbles and boulders.

Cn: Wet: 10YR 3/2 Very dark grayish.
Dry: 10YR 6/2 Light brownish gray. Sandy clay. Very angular pebbles, cobbles and boulders.

Again, because all the lichens sampled were greater than 35 mm, the exposed surface covered by the lichens was measured versus the diameter of the rocks in meters.
65 %/2.5 m, 90 %/0.42 m, 50 %/1.00 m, 35 %/1.20 m, 40 %/1.0 m, 40 %/ 2.2 m, 35 %/0.50 m, 50 %/1.00 m.
Mean: 50.62 % Mode:35, 40 and 50 % Median:40-50 %

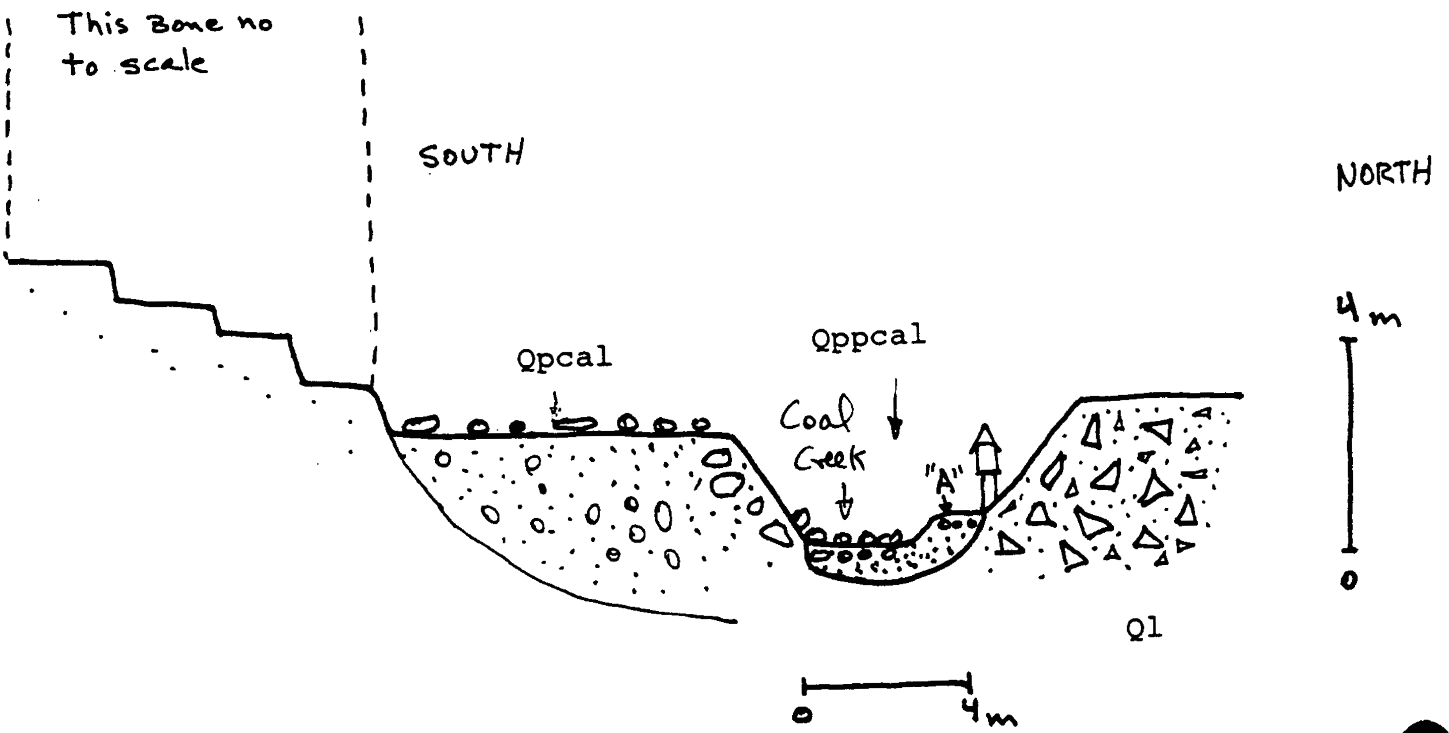
All the rocks measured were angular and subangular rocks.

Figure 9. Cross-section profile 5.

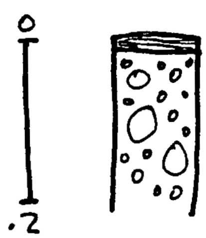


No soils were described, private land ownership -tresspasing prohibited.

Figure 10. Cross-section profile 6.



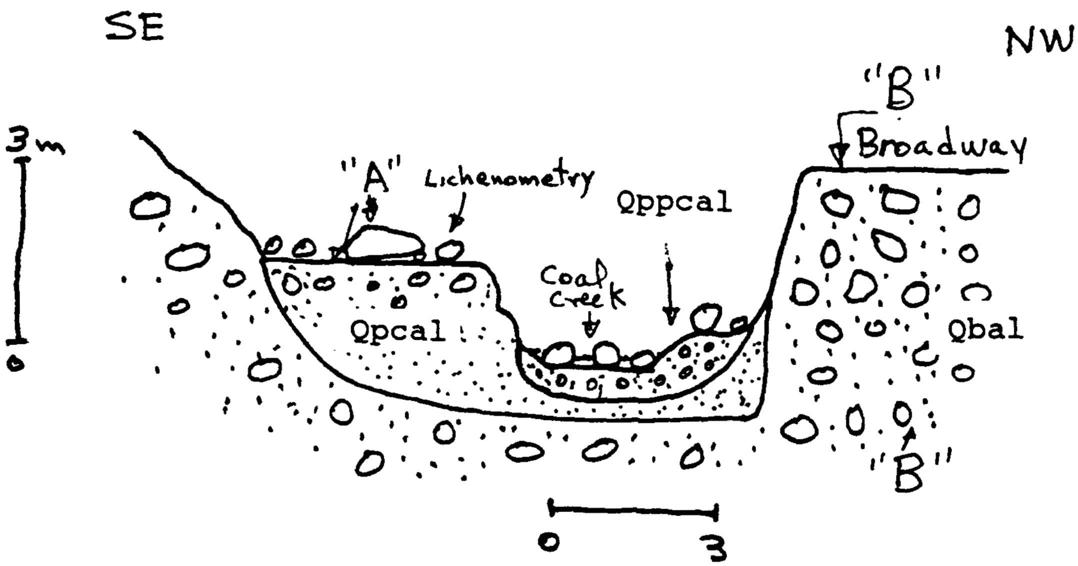
Soil Prifile "A".



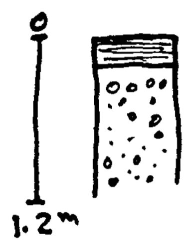
A Wet: 10YR 3/2 Very dark grays brown. Silty-sand.

Cn Wet: 10YR 3/3 Dark Brown. Sandy-Clay, and pebbles well rounded.

Figure 11. Cross-section profile 7.



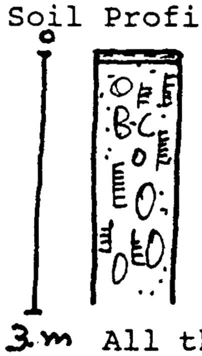
Soil Profile "A".



A Wet: 10YR 3/2 Very dark grayish brown. Sandy-clay.

Cn Wet: 10YR 4/4 Dark yellowish brown.
Dry: 10YR 3/3 Dark brown.

Soil Profile "B".



A Wet: 10YR 2/2 Very dark brown. Sandy-silt.

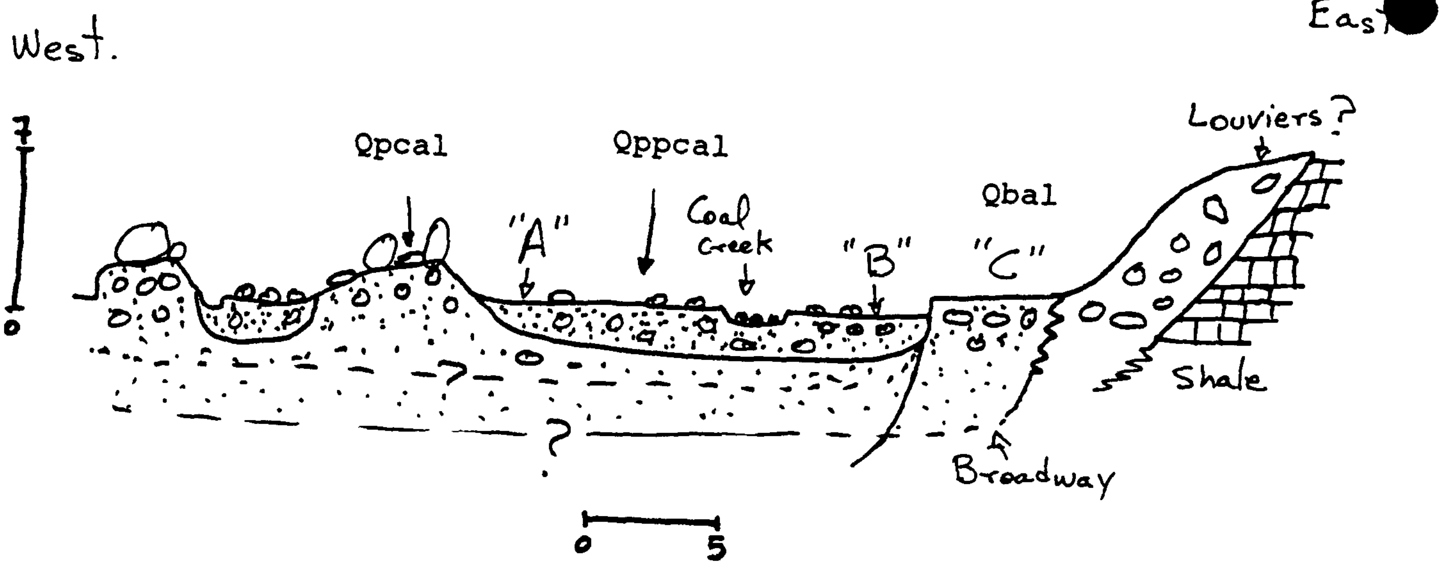
Cn Wet: 10YR 2/1 Black. Sandy-silt, pebbles, cobbles, and rounded boulders.

All the rocks presented lichens greater tha 20 mm. Due to the large development of lichens on the rocks, were mesured the surface areas covered by lichens and the diameter in proportion of the rock in meters. Lichen %/rock diameter im meters.

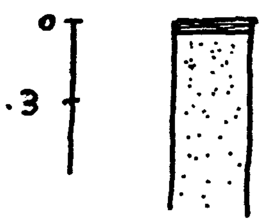
60 %/.40 m, 20 %/.20 m, 60 %/.30 m, 60 %/.40 m, 85 %/.40 m, 75 %/1.0 m, 90 %/.30 m, 85 %/.40 m, 95 %/.60 m, 95 %/.50 m, 90 %/.50 m.

Mean:74 %   Mode: 60%   Median 85%

Figure 12. Cross-section profile 8.



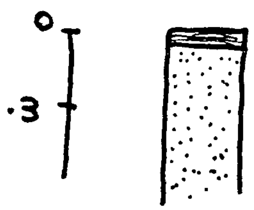
Soil Profile "A".



A Wet:10YR 4/2 Dark greyish brown. Silty-sand.

Cn Wet: 10YR 4/3 Dark brown to brown. Sandy.
Dry: 10YR 5/3 Brown.

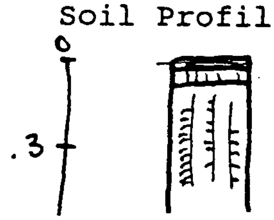
Soil Profile "B".



A Wet: 10YR 3/2 Dark brown. Sandy-clay.

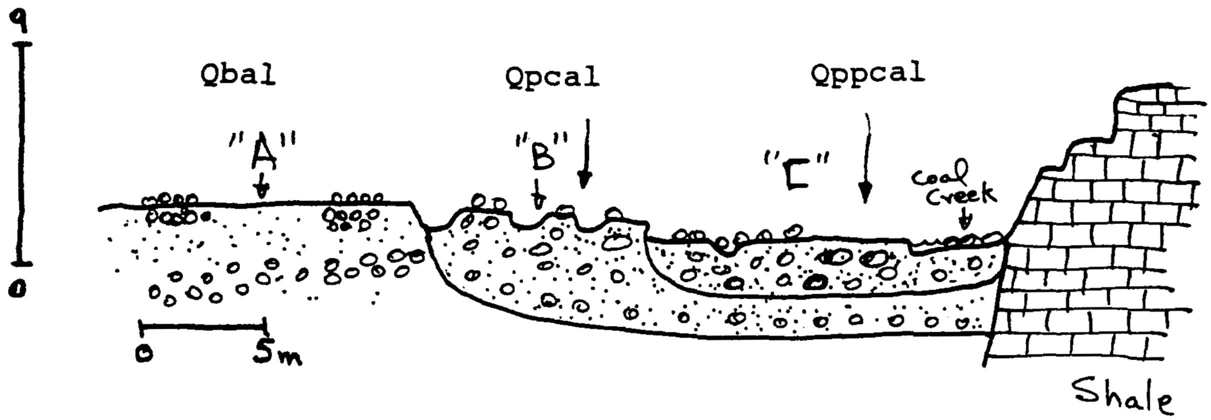
Cn Wet: 10YR 5/6 Yellowish brown. Sandy, gravels, and pebbles.

Soil Profile "C".

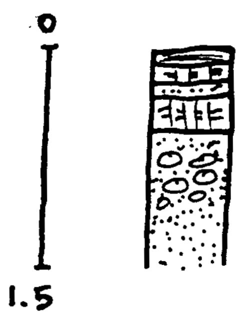


A Wet: 2.5Y 2/2 Dark greyish brown. Silty-clay.
B Wet: 10YR 4/4 Dark yellowish brown. Sandy-clay.
AB Wet: 2.5Y 4/4 Olive Brown. Sandy loam.

Figure 13. Cross-section profile 9.



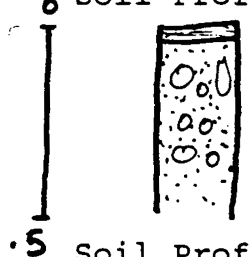
Soil Profile "A".



A Wet: 10YR 3/3 Dark brown. Sandy-silt.
B Wet: 10YR 4/2 Dark greyish brown. Silty-clay.
Cn Wet: 10YR 5/3 Brown. Silty-Clay.

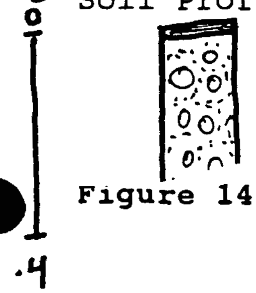
B Wet: 10YR 3/3 Very dark grayish brown. Silty-sand.
Cn Wet: 10YR 5/6 Yellowish brown. Silty-sand, gravels, and cobbles.

Soil Profile "B".



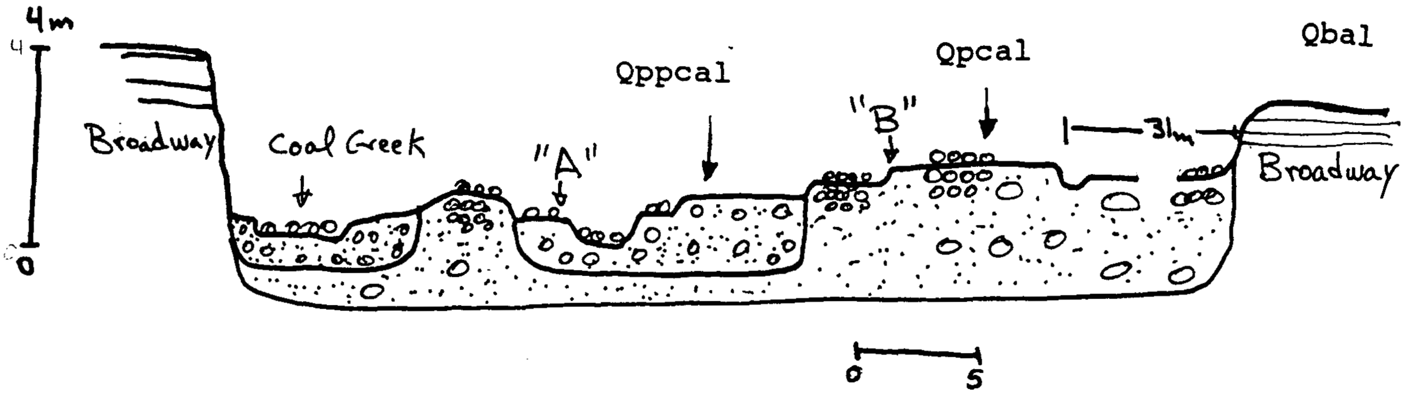
A Wet: 10YR 3/2 Very Dark greyish brown. Sandy.
Cn Wet: 10YR 4/3 Dark brown to brown. Sandy-silt and gravels.

Soil Profile "C".

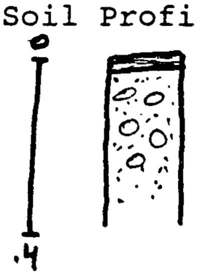


A Wet: 10YR 3/3 Dark Brown. Silty-sand.
Cn Wet: 10YR 5/6 Yellowish brown. Coarse Sand.

Figure 14. Cross-section profile 10.

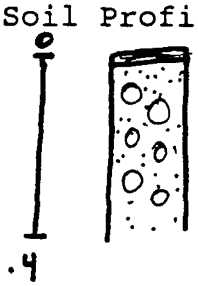


Soil Profile "A".



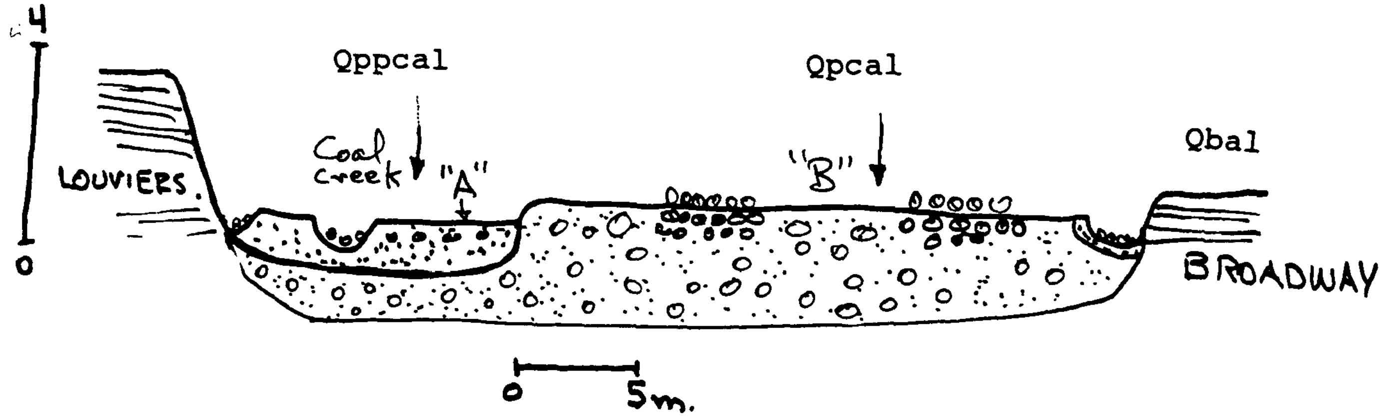
A Wet: 10YR 2/2 Very dark Brown. Snady silt.
Cn Wet: 10YR 4/3 Dark brwon to brown. Coarse sand and cobbles.

Soil Profile "B".

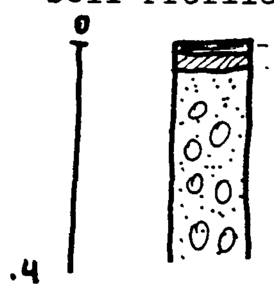


A Wet: 10YR 4/3 Dark brown to brown. Silty-clay.
Cn Wet: 10YR 3/3 Dark brown. Sandy-clay and cobbles.

Figure 15. Cross-section profile 11.

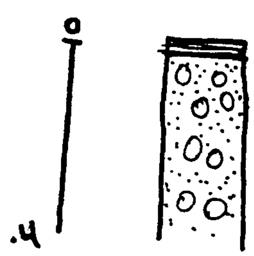


Soil Profile "A".



A Wet: 10YR4/6 Dark grayish brown. Silty-sand. Mottled layer oxidized. Silty-sasnd.
Cn Wet: 10YR 4/4 Dark yellowish brown. Sand, gravels, and cobbles.

Soil Profile "B".



A Wet: 10YR 3/3 Very dark grayish brown. Sandy-silt.
Cn Wet: 10YR 4/3 Dark brown to brown. Sand, gravels, and cobbles.

Figure 16. Cross-section profile 12.

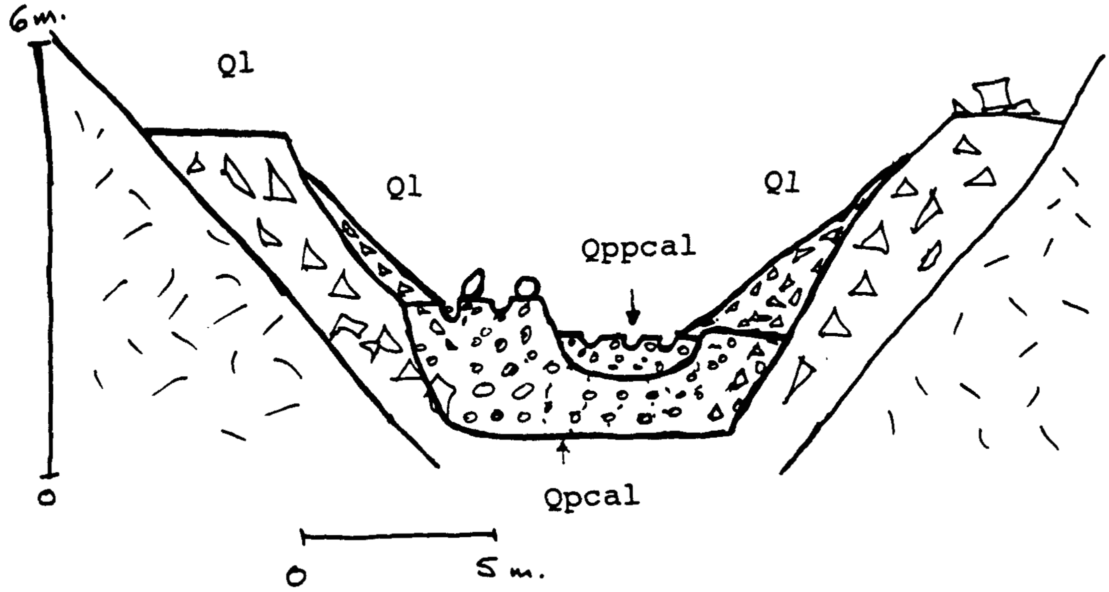


Figure 17. Idealized profile of the stratigraphy of Coal Creek in the mountain area, using profiles 1 to 7 (figures 5 to 11).

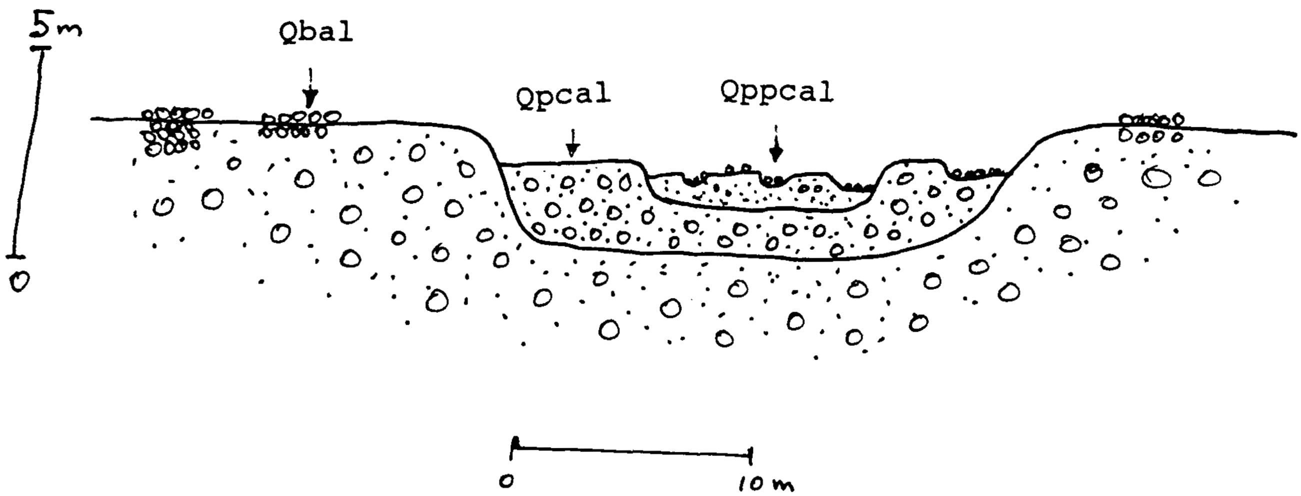


Figure 18. Idealized profile of the stratigraphy of Coal Creek in the piedmont area. Profile developed from comparison of profiles 8 to 12 (figures 12 to 17).

At beginning of the Piney Creek event, Coal Creek cut the talus and debris flow deposits, but didn't form strath terraces. The deposit is characterized by sand, coarse sand, and subangular and subrounded gravels, pebbles, cobbles and in some cases, subangular boulders: This is typical of the fill terraces formed during this period. The chaotic deposition of these sediments have been interpreted to represent a fluvial environment with high energy. After the formation of Piney Creek, talus and debris flow deposits covered part of the borders of the formed channel. Afterwards, Post Piney Creek began to be deposited over Piney Creek.

The dynamics of the Post Piney Creek deposits show some differences with respect to Piney Creek. The channel is very narrow and presents evidence that more than one channel was developed during extraordinary floods, including the formation of channels over the flood plain of Piney Creek deposits.

The small amount of fine materials (silt and clay) in the matrix and the soils might be indicative that the up-basin source is basically coarse materials. Based on field observations, the source of sediments in the mountain area are talus, colluvium, and debris flow deposits with a very low content of clay and silt.

Soil descriptions for the twelve profiles prepared, shows that Piney Creek and the Post Piney Creek deposits correspond mainly to sandy soils without the development of a B horizon. The A horizon is generally very shallow, never more than 10 cm deep and with low content of organic matter.

There is not a characteristic soil color nor a clear profile in the mountain zone. In the profiles 1 to 7 (figures 5 to 11) the colors of each horizon can be seen.

There are some terraces where lichens have grown on the rock surface. In some cases lichenometry analysis was used on talus and fluvial deposits. This dating method helped to differentiate Piney Creek from the Post Piney Creek deposits. Although lichen density measured is very small, it is sufficient to show differences between units. Lichen density for Post Piney Creek rocks has not developed as rocks on Piney Creek has done. Perhaps lichenometry has been one of the better indicators, when available, to distinguished between Piney Creek and Post Piney Creek deposits in the mountain area.

In addition, Post Piney Creek has not developed lichens because the activity of the creek during floods is very active and the deposits are continuously removed.

Stratigraphic Profile in the Piedmont Area.

Figure 18 represents the profile of the piedmont area using the last five cross-sections. It shows that, Coal Creek cuts fluvial terraces formed in the Quaternary. The modern channel runs mainly over Broadway deposits. Piney Creek and Post-Piney Creek deposits, and ocassionaly, affect Louviers deposits.

An idealized profile was prepared using as reference the stratigraphy interpreted of cross sections 8 to 12 (figures 12 to 16). This profile is slightly different to that prepared by Machette (1975) for the Lafayette quadrangle (figure 19).

In this area the creeks are located closer to the local base level and the evolution of the channel is slightly different.

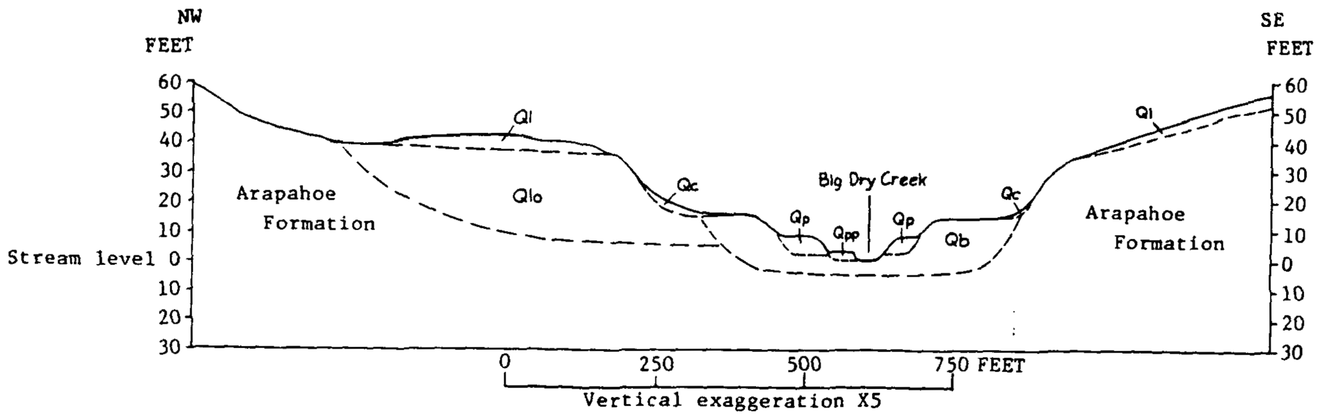
In the piedmont area, Broadway deposits were deposited in very wide channels. There is evidence near the town of Superior of a major sinuosity in the channel pattern of the creek if compared with the Piney Creek and Post Piney Creek deposits. The width of the channel is aproximately 5 times larger than the more recent events.

It is evident, that during Broadway deposition, Coal Creek had a meandering or anastomosed fluvial pattern which left some banks of gravel and pebbles in the fluvial plain, showing the past activity of the creek.

The soils developed in the low area of this unit are slightly similar to those defined by Machette in the Lafayette quadrangle (see figure 4). In the area of Superior, the recent channel of Coal Creek is cutting part of the Louviers deposits. This is more evident in the area where the Creek current forms lateral erosion. However, Louviers deposits has lttle or not significant influence in the behavior of the Creek in recent times.

At the beginning of the Piney Creek event, Coal Creek dissected directly the Broadway deposits. The channel formed by Piney Creek cut the plain formed by the Broadway deposits, but likely with less energy than the Broadway event. The width of the channel is very short if compared with Broadway. It's measure presented an amplitude of approximately 35 meters in the wider zone.

The characteristics of the deposits and soils developed in Piney Creek in the piedmont area are lightly similar as those described by Malde (1955) and Machette (1975), with the exception of the Cca horizon as defined by Machette for the same unit in the Lafayette quadrangle. The difference in the presence f this horizon could be due to the influence of changes in the water table in the low area havenot been very significant or pronounced as in the Lafayette area. The piedmont area of Coal Creek in the Louisville quadrangle could be considered as transitional with respect to the local base level where the influence of fluctuations in the water table has been low (?).



Ql: Quaternary landslides

Qc: Colluvium

Qb: Broadway deposits

Qp: Piney Creek

Qpp: Post Piney Creek

Figure 19. Idealized profile prepared by Machette (1975) showing the stratigraphic relationship between the different units in the Lafayette quadrangle.

Finally, at the beginning of the Post Piney Creek event, Coal Creek dissected the sediments deposited on the small plain of the Piney Creek event. The modern channel is very narrow and during times of big floods, the main channel is overtopped by the current and new channels are formed on the modern plain or on the Broadway plain.

DISCUSSION ABOUT THE STRATIGRAPHIC CHANGES THAT OCCURRED DURING THE HOLOCENE IN COAL CREEK.

It is not easy to define in which period of development Coal Creek is at this moment. Mainly, because the mountain zone as well as the low area has been highly affected by human disturbance. For example, irrigation channels, bridges, farming, roads, cattle, housing, and apecially mining for aggregates.

The deposits left by Post Piney Creek events in the past show that these were deposited in an environment with less energy than those deposited during Piney Creek and Broadway. The presence of boulders or inclusive cobbles is not common. Also, the presence of silt and clay is rare, perhaps because the source of fine materials from the up-basin is very low. The modern source of sediments in the mountain area is associated to debris flow and talus deposits with low content of fine sediments.

The influence of climatic changes during the Holocene in the area is not well known. However, it is clear that Broadway, Piney Creek and Post Piney Creek correspond to 3 different conditions of erosion and deposition which left 3 different stratigraphic units.

As mentioned by Malde (1955) and Machette (1975), Broadway was deposited as result of Pinedale glaciation and Piney Creek as result of a stage of less energy and less influence of ice melted water. But the change from Piney Creek to Post Piney Creek might have been formed by a decrement in the energy of the current produced by a increment in the load (coarse particles) produced by a major activity in the debris flow, colluvium and talus deposits.

The formation of some channels parallel to the main channel in Coal Creek show that during floods, Coal Creek doesn't have the capacity to discharge the entire load in the main channel, thus, it must occupy other channels.

The lack of fine materials (silt and clay) over these channels could be interpreted as an indicator that the load (before arrival of the "white man") consisted mainly of coarse materials product of the talus, colluvium and debris flow deposits coming to the creek from the up-basin. This condition is different to the Broadway deposition. Broadway was more rich in fine materials content.

The increment in talus activity may be interpreted as an dry period where soil and vegetation development have been poor, and the influence of gravity and torrencial rains have been very important during the Holocene. It can explain the presence of very active zones with waste mass processes in the mountain area and the poor content of fine materials in the fluvial sediments in the low area.

CONCLUSION.

There is a great influence of talus, colluvium, and debris flow deposits in the basin after the Pinadale glaciation. These deposits have influenced the stratigraphy formed along the Coal Creek during Piney Creek (Qpcal) and Post Piney Creek (Qppcal).

The differences in the stratigraphy of Piney Creek and Post Piney Creek might be due to the influence of these deposits the mountain area and in the low area.

The soils developed in Piney Creek and Post Piney Creek not present a B horizon. Generally are soils with a very shallow A horizon, and with a Cn horizon characterized by coarse materials. Also, there is not a characteristic color of the soils both units. The variations in colors are associated mainly with the kind of material coming to the basin (type of rock).

An importan factor in the creek is the minor presence of fine materials (silt and clay) in the matrix of the Piney Creek and Post Piney Creek. Again, this can be produced by the influence of talus deposits with high content of coarse materials.

RECOMENDATIONS.

Would be interesting to quantify the content of the silt and clay in Qpcal and Qppcal and the relationship of these materials with the Holocene conditions in the area. This is an important factor to determine the environmental conditions in the basin of Coal Creek.

Also, is very relevant to measure the magnitude of the influence of talus, colluvium and debris flow deposits in the load of Coal Creek and mainly, the content of fine materials (silt and clay) in it's influence in the load of the creek. There is qualitative evidence that the influence of these fine materiales is very poor in this moment, but it must be quantified.

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