Pleistocene climatic changes in New Mexico, USA

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Abstract

A study of the pollen and minerals from an intermontane basin in the Basin and Range Province in New Mexico, USA, shows a nearly continuos pattern of climatic changes during the Pleistocene. Evidence of these changes comes from analyses of a 645 foot core taken outside the limits of continental glaciation. These analyses indicate not only climatic changes but suggest regional uplift.

CLISBY and SEARS, and FOREMAN reported on several shallow cores ranging in depth from 10 to 100 feet, and one almost continuous 645 foot core which have been secured from the dried lake bed of the San Augustin Plains, a high, intermontane basin on the continental divide, in the Datil-Mogollon volcanic plateau of western New Mexico, U. S. A. This old lake is situated beyond the limits of continental glaciation and affords conditions under which an uninterrupted sequence of fossil pollen might be deposited and preserved during the age of the basin. From a study of this pollen and of the sediments a record of climatic fluctuations and/or geological events may be inferred. Basin and highland altitudes range between 6000—12 000 or more feet and so furnish within a small geographical area, flora normally distributed between subarctic and subtropic and between humid and desert climatic zones. The general features of the plains have been described by BRYAN and POWERS. STEARNS regards the plains as having the general form of a graben, the principal development post-dating Pliocene (?) volcanics. The pluvial Lake San Augustin with a maximum area of 255 square miles still shows fresh shoreline features. From well logs it is known that unconsolidated sediments reach a depth of over 1000 feet. STEARNS finds no geologic evidence of local volcanic activity since the beginning of sedimentation in the basin and there is no evidence of either volcanic or tectonic activity reflected in the sediments of the 645 foot core on hand at Oberlin.

The sediments are calcareous clayey silts and silty clays with an allogenic sand zone between the 50 and 200 foot interval.

A study of the current vegetation of the SAP area has been published by POTTER. The flora of the basin is now alkaline semi-desert, with greasewood-seepweed association, dominated by *Sarcobatus vermiculatus*. Saltbush-grama association dominated by *Atriplex canescens* and *Bouteloua gracilis*, is found on sandy soils. The grama grassland association dominated by blue grama is on the well-drained soils surrounding the basin. The pinyon, *Pinus edulis,* dominates the woodland zone. The ponderosa pine, *Pinus ponderosa,* is higher and farther away, except where it descends locally in occasional canyons or on sandy soil. On the highest elevations and in protected sites of the ponderosa belt may be found limber pine, *Pinus flexilis.* Douglas fir, *Pseudotsuga taxifolia,* and white fir, *Abies concolor,* Spruce, *Picea* ssp., so far as known, is confined to high elevations beyond the present limits of the basin drainage (POTTER).

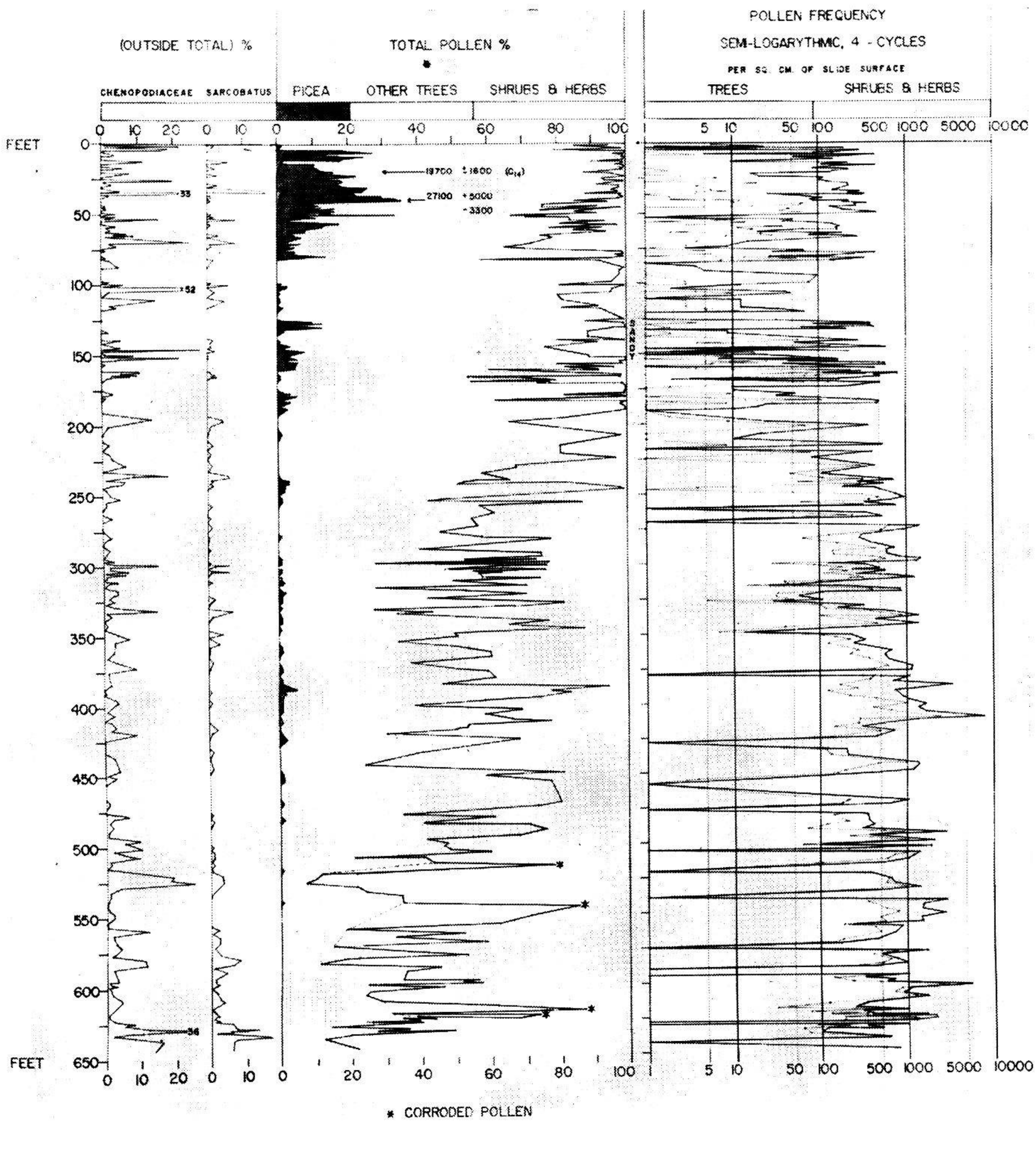
While this general pattern of zonation is subject to considerable local variation because of slope, soil and exposure, any consistent shift in vegetation as indicated by the pollen profile should be evidence of climatic change. Specifically, an increase in spruce pollen in the deposits would indicate low temperature. In addition the presence of ostracod tests and lacustrine algae serve to show periods of moisture sufficient to maintain water in the basin. In times of greater aridity such lakes would become more saline and gradually dry up resulting in an increase of the alkaline semi-desert scrub.

In the accompanying graph the current vegetation of the area is clearly reflected in the upper 3$^1/_2$ feet of the pollen profile by an absence of spruce pollen and an increase of alkaline scrub against a background of pine. The pollen between 4 and 70 feet gives ample evidence of climatic fluctuations during the last glacial stage and adds details that have heretofore been conjecture. At lower depths the pollen profile is not commensurate with the theories of glacial temperatures unless one attributes the consistent lowering of the spruce pollen curve to a change in regional elevation. During the time span involved in the accumulation of 645 feet of sediments in the basin there is an overall change in vegetation pattern from that of a herbaceous and scrub community to a montane forest. The AP curve dominated by Pinus indicates a continuing decrease in temperature from the bottom of the core toward the surface, while the Picea curve furnishes evidence of fluctuating colder temperatures within the long trend cooling stage.

Chenopodiaceae, including *Sarcobatus,* have been calculated outside the total pollen sum and *Sarcobatus,* at least, is assumed to indicate shallow water levels because of its present occurrence on the undrained calcareous plains.

The NAP below 500 ft. is dominated by *Artemisia,* between 500 and 200 ft. grass and *Artemisia* are about equal, above 200 ft. grass is dominant. *Quercus, Juniperus, Tubuliflorae, Ambrosia, Liguliflorae,* and *Ephedra* are represented at intervals throughout the profile but are seldom over two percent of the total pollen. Their exclusion from this generalized graph is not meant to minimize their indicator importance.

In this preliminary paper we are attempting only to demonstrate long range climatic and epeirogenic trends.



Pollen frequency has been plotted on a semi-logarythmic curve per sq. cm. of slide surface. Sediment horizons with no pollen include oxidized zones, silt and clay free sands, and soils.

Horizons of pollen corrosion are found below 510 ft. and are indicated by broken lines in the AP curve, in order to point out a suggestion that *Pinus* may be highly over-represented both in the frequency and percentage composition curves.

More than three-quarters of the samples above the 400 ft. level contain ostracods while below that level the percentage is less than 8 percent. Below 425 ft. there are 12 horizons in which oolites occur. CO_2 (69 samples) exceeds 5 percent only three times above the 235 ft. horizon, while below this level the average is close to 8 percent, and between 400 and 500 ft. the average is over 10 percent (65 samples). Carbonate above the 250 ft. horizon is fine grained with no single crystals of sand size while that below has most of the calcite in sand size particles either as single crystals or coarse aggregates.

The evidence in the sediments that would favor a semiarid climate in the lower horizons are as follows. The oolites are a likely indicator of an evaporite association in turbulent waters. Conditions of carbonate precipitation are complex, although waters of high alkalinity can carry more Ca and CO_3 ions than those of low alkalinity and a higher alkalinity could be expected in a semiarid climate, resulting in the higher carbonate content of the lower beds.

Pollen is absent in the sandy zone between the depths of 80 to 125 ft. where the sands contain little or no silt and clay, but is present where these fine sizes make up 20 percent or more of the sample. In the deeper zones, however, the conditions seem to be more complex. In a general way it may be stated that the zones of no pollen or with corroded pollen are more variegated in color and more crumbly in texture than those without pollen. The colors vary from olive brown through yellow brown to give either a mottled or a streaked appearance. These mottlings and streaks are usually to be measured from less than one to five millimeters in thickness, but there are zones where the bright colors of the highly oxidized sediments measure up to 10 cm. At this time it can only be said that pollen is absent in fairly clean sands and may be absent or corroded in those zones that carry oxides.

The work has already given new insight into past plant assemblies and conditions of sedimentation. This core has yielded an almost continuous record of pollen and sediments that is unique. It is known that these sediments continue far below the 645 ft. level and we hope to continue this study to a much greater depth — to the 1600 ft. level or 1000 ft. below the present core. It is not yet certain whether the age of the sediments at the 645 ft. level is still in the Pleistocene or has penetrated into the Pliocene, an extra 1000 ft. of core would without doubt pass this boundary and go a considerable distance into the sediments of the earlier epoch. This should give valuable information concerning the vegetation changes over this critical time span and from which climatic changes could be inferred.

Without deeper coring, interpretation of climatic changes from the pollen profile seems to revolve around regional uplift. There are three arguments that could be propounded for the age of this core until data is obtained from deeper sediments:

1. two glacial stages — one interglacial — part of a second interglacial,
2. three glacial stages — two interglacial — part of a third interglacial,
3. the entire Pleistocene and a significant section of the Pliocene.

During the past summer at the International Pollen Conference in Switzerland and the INQUA meetings in Spain new evidence was brought to our attention from montane areas in Inner Mongolia and Spain. Pollen profiles (analyzed by Russians), from the Fergano Basin in the Tien Shan Mountains appear similar to our profile. From stratigraphic evidence the Russian scientists concluded that the lower zone dominated by *Artemisia*-grass pollen, was deposited during the Pliocene and that regional uplift had been between 500 and 1000 meters in the Pleistocene. Horst REMY reported a dominance of Artemisia-grass-chenopod pollen from calcareous sediments in the Spanish Pyrenees stratigraphically Villafranchian fauna. In the Colorado Rocky Mountains, U. S. A., Estella LEOPOLD has found an Artemisia-grass pollen dominance from sections described as Pliocene. Thomas van der HAMMEN is studying a deep core from Bogota, Colombia, South America.

If the stratigraphy is properly interpreted, these records from forested montane areas widely separated geographically, all exhibit a semiarid scrub vegetation in the Plio-Pleistocene boundary. Continued studies in comparable sites should afford a complete climatic history of the last two geologic eras.

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Diskusion. U. HAFSTEN: On asking about the statistical basis of the pollen analysis — i. e. how many pollen grains usually counted in each sample — Mrs CLISBY answered: Usualy 400 pollen grains. The number depended on the sediments, ranging from a few in sandy horizons to 1000 in deposits being rich in organic matter. — H. GAMS: Aehnliches Pollendiagram aus dem Balchaschgebiet von GRITSCHUK, vorwiegend Gramineen und Chenopodiaceen, zeitweise viel Artemisia, Kaltzeiten mit *Picea Schrenkiana.*

Annotation from K. H. CLISBY:

We have received necessary financial assistance from the National Science Foundation to continue our drilling in the San Augustin Plains. To date we have reached a depth of 1200 feet. Small samples of the core at ten foot intervals have been airmailed to Oberlin and analyzed for pollen. The deeper sediments rule out suggested ages numbers 1 and 2 on Page 25. I think now we can safely say that in the 645 foot core the late Pliocene is represented below 545 feet and that pollen from sediments below 1000 feet are reflecting at least middle Pliocene flora. The following table presents the climatic sequence as I see it:

Depth Feet	Dominant flora	Dominant pollen	Sediment
0— 525	Forest and Woodland	Spruce-pine	Clayey silts, silty clays, allogenic sands
525— 850	Semiarid scrub	Artemisia, Chenopods, grass	Clayey silts, silty clays, authogenic sands (calcite)
850—1000	No pollen		Rhyolitic tuff
1000—1200	Tertiary	Juglandaceae Platanus	Basaltic clastics cemented with fine carbonates, silts, and clays