Quaternary Research
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Introduction to the 50th Anniversary Issue of *Quaternary Research*

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The first issue of *Quaternary Research: An Interdisciplinary Journal* was published in September 1970, making it the first international journal dedicated to the study of the Quaternary by scientists of all disciplines. The journal was also one of the very first to stress the importance of interdisciplinary efforts, emphasizing the relevance of one line of inquiry to another. For example, studies of palynology, geomorphology, and sedimentology help to understand the environmental settings in which early humans lived. Professor A. Lincoln Washburn, the founding editor, understood that history and process could not be understood in isolation from one another, especially in studies of recent Earth and its varied inhabitants.

When *Quaternary Research* began, it was unusual for researchers to cross disciplinary boundaries. By the turn of the millennium it was so common that we dropped "*An Interdisciplinary Journal*" from our title. By then, it had become widely recognized that many Quaternary studies would necessarily cross those lines. For the last half-century, and for the next one as well, our editorial policy therefore has emphasized interdisciplinary relevance as well as scientific quality: an article should have clear significance for workers in two or more disciplines. We hope you agree that this original goal continues to be achieved. Paraphrasing from the editorial introduction to the journal's first issue: because all research of the Quaternary emphasizes the causes and interactions that shape our surroundings, it provides insight into the nature and variable effects of environmental processes with time and their interactions with humans.

By way of introduction to this 50th anniversary issue of *Quaternary Research*, we have assembled 25 abstracts of noteworthy past research articles that the journal has been honored to publish. We sought representative articles that collectively display the topical and geographical diversity of the journal's portfolio, drawing from among the most widely read and highly cited articles in each of the journal's five decades of publication. They document the significant advances in our understanding of the Quaternary and the causes and effects of the climate and sea-level changes that characterize this period of earth history.

Of the six articles from the 1970's included here, half of their citations are less than 14 years old—and the first (Shackleton and Opdyke, 1973, 3(1):39–55) has received as many citations since 1997 as it did from its publication to that date. The continued reference to published research more than four decades old validates the journal's original editorial emphasis on relevant, interdisciplinary research. As the long-term value of such research continues to be affirmed by today's scientists, we look forward to supporting these efforts for the next 50 years of the journal's continuing history.

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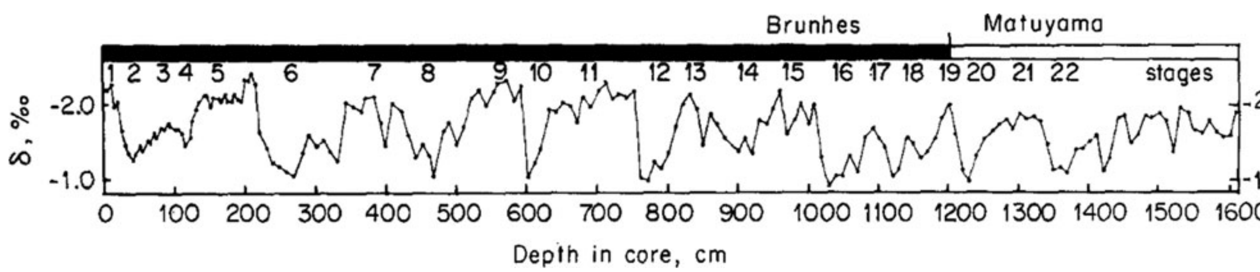
1970s

Shackleton, N.J., Opdyke, N.D. 1973. Oxygen isotope and palaeomagnetic stratigraphy of Equatorial Pacific core V28-238: Oxygen isotope temperatures and ice volumes on a 10^5 year and 10^6 year scale. *Quaternary Research* 3, 39–55. *Cited 1760 times*.

ABSTRACT Core Vema 28-238 preserves an excellent oxygen isotope and magnetic stratigraphy and is shown to contain undisturbed sediments deposited continuously through the past 870,000 yr. Detailed correlation with sequences described by Emiliani in the Caribbean and Atlantic Ocean is demonstrated. The boundaries of 22 stages representing alternating times of high and low Northern Hemisphere ice volume are recognized and dated. The record is interpreted in terms of Northern Hemisphere ice accumulation, and is used to estimate the range of temperature variation in the Caribbean.



Oxygen isotopic composition of *G. sacculijera* in core X28-238 complete record to 1600 cm, expressed as deviation so from Emiliani Bl standard.

Denton, G.H., Karlén, W. 1973. Holocene climatic variations–Their pattern and possible cause. *Quaternary Research* 3, 155–205. *Cited 580 times*.

ABSTRACT In the northeastern St. Elias Mountains in southern Yukon Territory and Alaska, C^{14}-dated fluctuations of 14 glacier termini show two major intervals of Holocene glacier expansion, the older dating from 3300–2400 calendar yr BP and the younger corresponding to the Little Ice Age of the last several centuries. Both were about equivalent in magnitude. In addition, a less-extensive and short-lived advance occurred about 1250–1050 calendar yr BP (A.D. 700–900). Conversely, glacier recession, commonly accompanied by rise in altitude of spruce tree line, occurred 5975–6175, 4030–3300, 2400–1250, and 1050–460 calendar yr BP, and from A.D. 1920 to the present. Examination of worldwide Holocene glacier fluctuations reinforces this scheme and points to a third major interval of glacier advances about 5800–4900 calendar yr BP; this interval generally was less intense than the two younger major intervals. Finally, detailed mapping and dating of Holocene moraines fronting 40 glaciers in the Kebnekaise and Sarek Mountains in Swedish Lapland reveals again that the Holocene was punctuated by repeated intervals of glacier expansion that correspond to those found in the St. Elias Mountains and elsewhere. The two youngest intervals, which occurred during the Little Ice Age and again about 2300–3000 calendar yr BP, were approximately equal in intensity. Advances of the two older intervals, which occurred approximately 5000 and 8000 calendar yr BP, were generally less extensive. Minor glacier fluctuations were superimposed on all four broad expansion intervals; those of the Little Ice Age culminated about A.D. 1500–1640, 1710, 1780, 1850, 1890, and 1916. In the mountains of Swedish Lapland, Holocene mean summer temperature rarely, if ever, was lower than 1°C below the 1931–1960 summer mean and varied by less than 3.5°C over the last two broad intervals of Holocene glacial expansion and contraction. Viewed as a whole, therefore, the Holocene experienced alternating intervals of glacier expansion and contraction that probably were superimposed on the broad climatic trends recognized in pollen profiles and deep-sea cores. Expansion intervals lasted up to 900 yr and contraction intervals up to 1750 yr. Dates of glacial maxima indicate that the major Holocene intervals of expansion peaked at about 200–330, 2800, and 5300 calendar yr BP, suggesting a recurrence of major glacier activity about each 2500 yr. If projected further into the past, this Holocene pattern predicts that alternating glacier expansion-contraction intervals should have been superimposed on the Late-Wisconsin glaciation, with glacier readvances peaking about 7800, 10,300, 12,800, and 15,300 calendar yr BP. These major readvances should have been separated by intervals of general recession, some of which might have been punctuated by short-lived advances. Furthermore, the time scales of Holocene events and their Late-Wisconsin analogues should be comparable. Considering possible errors in C^{14} dating, this extended Holocene scheme agrees reasonably well with the chronology and magnitude of such Late-Wisconsin events as the Cochrane-Cockburn readvance (8000–8200 C^{14} yr BP), the Pre-Boreal interstadial, the Fennoscandian readvances during the Younger Dryas stadial (10,850–10,050 varve yr BP), the Alleröd interstadial (11,800–10,900 C^{14} yr BP), the Port Huron readvance (12,700–13,000 C^{14} yr BP), the Cary/Port Huron interstadial (centered about 13,300 C^{14} yr BP), and the Cary stadial (14,000–15,000 C^{14} yr BP). Moreover, comparison of presumed analogues such as the Little Ice Age and the Younger Dryas, or the Alleröd and the Roman Empire-Middle

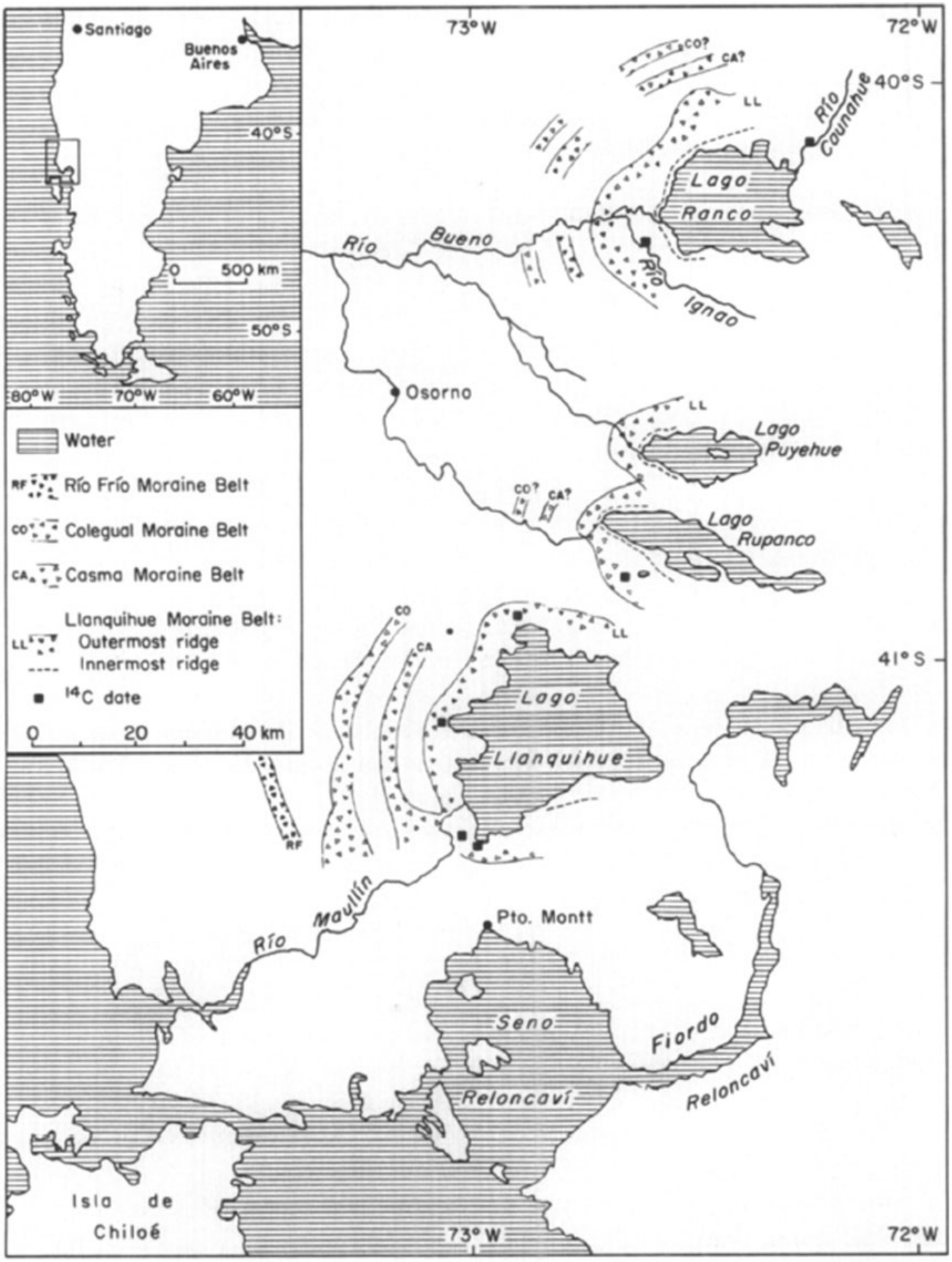
Ages warm interval, show marked similarities. These results suggest that a recurring pattern of minor climatic variations, with a dominant overprint of cold intervals peaking about each 2500 yr, was superimposed on long-term Holocene and Late-Wisconsin climatic trends. Should this pattern continue to repeat itself, the Little Ice Age will be succeeded within the next few centuries by a long interval of milder climates similar to those of the Roman Empire and Middle Ages. Short-term atmospheric C^{14} variations measured from tree rings correlate closely with Holocene glacier and tree-line fluctuations during the last 7000 yr. Such a correspondence, firstly, suggests that the record of short-term C^{14} variations may be an empirical indicator of paleoclimates and, secondly, points to a possible cause of Holocene climatic variations. The most prominent explanation of short-term C^{14} variations involves modulation of the galactic cosmic-ray flux by varying solar corpuscular activity. If this explanation proves valid and if the solar constant can be shown to vary with corpuscular output, it would suggest that Holocene glacier and climatic fluctuations, because of their close correlation with short-term C^{14} variations, were caused by varying solar activity. By extension, this would imply a similar cause for Late-Wisconsin climatic fluctuations such as the Alleröd and Younger Dryas.

Heinselman, M.L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. *Quaternary Research* 3, 329–382. *Cited 613 times*.

ABSTRACT Fire largely determined the composition and structure of the presettlement vegetation of the Boundary Waters Canoe Area as well as the vegetation mosaic on the landscape and the habitat patterns for wildlife. It also influenced nutrient cycles, and energy pathways, and helped maintain the diversity, productivity, and long-term stability of the ecosystem. Thus the whole ecosystem was fire-dependent. At least some overstory elements in virtually all forest stands still date from regeneration that followed one or more fires since 1595 A.D. The average interval between significant fire years was about 4 yr in presettlement times, but shortened to 2 yr from 1868 to 1910 during settlement. However, 83% of the area burned before the beginning of suppression programs resulted from just nine fire periods: 1894, 1875, 1863–1964, 1824, 1801, 1755–1959, 1727, 1692, 1681. The average interval between these major fire years was 26 yr. Most present virgin forests date from regeneration that followed fires in these years. Significant areas were also regenerated by fires in 1903, 1910, 1936, and 1971. Most major fire years occurred during prolonged summer droughts of subcontinental extent, such as those of 1864, 1910, and 1936. Many fires were man-caused, but lightning ignitions were also common. Lightning alone is probably a sufficient source of ignitions to guarantee that older stands burned before attaining climax. Dry matter accumulations, spruce budworm outbreaks, blowdowns, and other interactions related to time since fire increase the probability that old stands will burn. Vegetation patterns on the landscape were influenced by such natural firebreaks as lakes, streams, wetlands, and moist slopes. Red and white pine are most common on islands, and to the east, northeast, or southeast of such firebreaks. Jack pine, aspen-birch, and sprout hardwood forests are most common on large uplands distant from or west of such firebreaks. A Natural Fire Rotation of about 100 yr prevailed in presettlement times, but many red and white pine stands remained largely intact for 150–350 yr, and some jack pine and aspen-birch forests probably burned at intervals of 50 yr or less. There is paleoecological evidence that fire was an ecosystem factor before European man arrived, and even before early man migrated to North America. Probably few areas ever attained the postulated fir-spruce-cedar-birch climax in postglacial times. To understand the dynamics of fire-dependent ecosystems fire must be studied as an integral part of the system. The search for stable communities that might develop without fire is futile and avoids the real challenge of understanding nature on her own terms. To restore the natural ecosystem of the Canoe Area fire should soon be reintroduced through a program of prescribed fires and monitored lightning fires. Failing this, major unnatural, perhaps unpredictable, changes in the ecosystem will occur.

Mercer, J.H. 1976. Glacial history of southernmost South America. *Quaternary Research* 6, 125–166. *Cited 374 times*.

ABSTRACT In southernmost South America, an incomplete radiometrically dated glacial chronology has been obtained by KAr dating for the interval 3.5–1 MY ago, and a more detailed chronology by C-14 dating for the last 25,000 years, with some older minimal ages. The first major glaciation was about 3.5 MY ago during the middle Pliocene. Little is yet known about glacial fluctuations during the interval 3.5–2.1 MY ago. Between 2.1 and 1 MY ago many glaciations occurred, probably including the greatest of late Cenozoic time which took place after 1.2 MY and, according to inconclusive evidence, before 1 MY ago. The Patagonian Gravel in its type area is mid-Pliocene to early Pleistocene glacial outwash that accumulated from the first to the greatest glaciations. During the late Pleistocene several glaciations occurred, but only the most recent has been radiometrically dated. During the last glaciation the glaciers were most extensive before 56,000 BP. Successively smaller advances that culminated about 19,500 BP and, probably, about 13,000 BP were separated by an interstade when glaciers shrank by more than half. The glaciers receded rapidly after 13,000 BP and were within their present borders by 11,000 BP; they remained so during the European Younger Dryas Stade 11,000–10,000 BP. Neoglacial regional readvances culminated 4600–4200 BP, probably 2700–2000 BP, and during the last three centuries; most glaciers reached their Neoglacial maxima during the first episode. Between readvances, the glaciers shrank within their present borders.



Location map, southern part of the Chilean lake region, showing positions of end moraine belts, where traced, and sites of C-14 dated samples. Provincia de Llanquihue, Provincia de Osorno, and Provincia de Valdivia, Chile.

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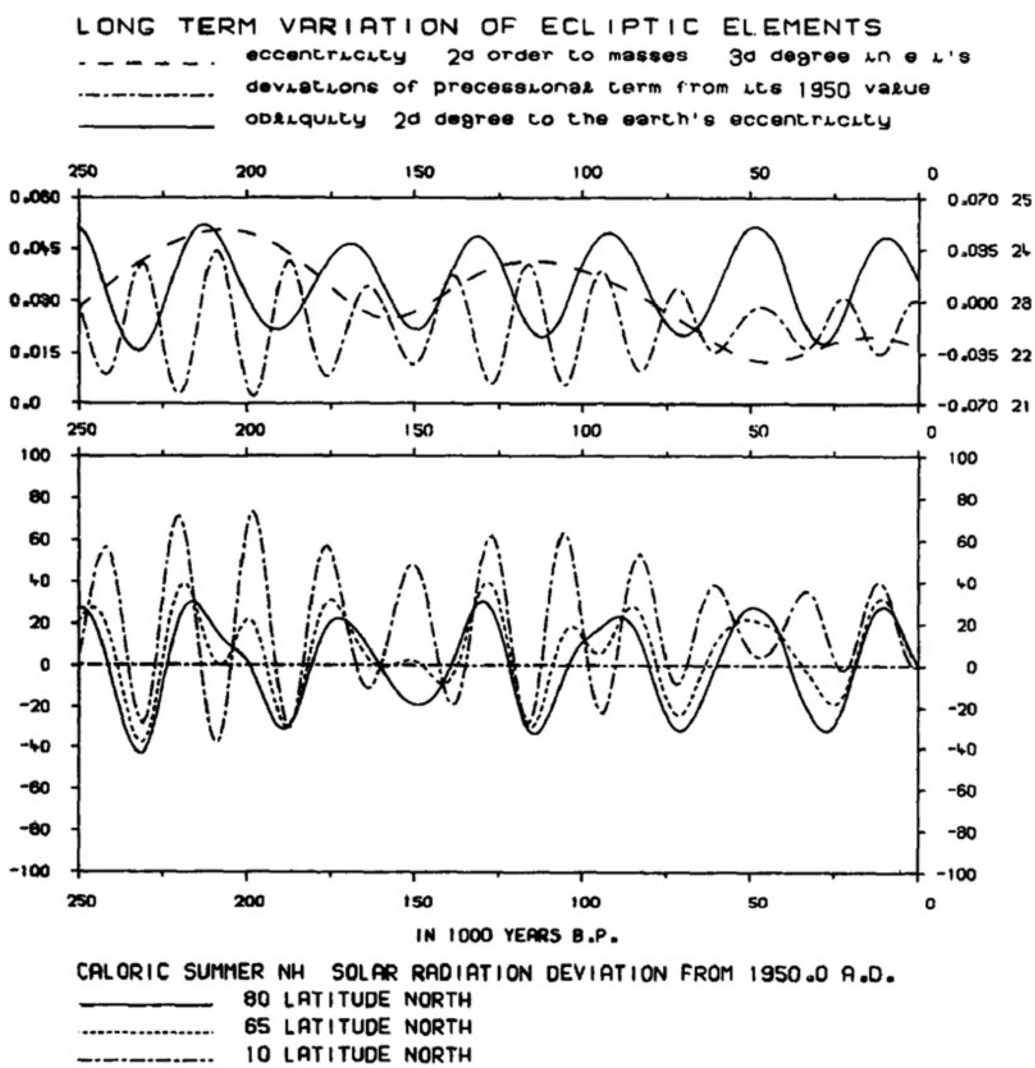
Berger, André L. 1978. Long-term variations of caloric insolation resulting from the earth's orbital elements. *Quaternary Research* 9, 139–167. *Cited 884 times*.

ABSTRACT A contribution to a global a priori model of climatic changes for the Quaternary Ice Age is tentatively proposed. Special emphases are put on the astronomical problem and on the insolation available in the assumption of a perfectly transparent atmosphere. It is shown that for these two steps an accurate solution can be obtained, limiting the cumulative effect of computational approximation and allowing input to a climatological model to be of real value. For the earth's orbital elements, the proposed solution includes terms dependent to the second degree on disturbing masses, to third degree on planetary eccentricities and inclinations and, for the obliquity and the annual general precession in longitude, also to the second degree on earth's eccentricity. Improvements introduced by this solution upon the insolation computed through the Milankovitch series are deduced from the differences between Vernekar's results and present ones. The relative agreement between results clearly shows that the new astronomical solution is probably close to the ideal one from a paleoclimatological point of view.



Long-term variations of astronomical parameters defining insolation climates and of insolation for various latitudes. The upper part shows eccentricity, e (dotted line), the deviations of precessional parameter $\Delta(e \sin \hat{\omega})$ from its 1950 AD value (dash-dot line), and obliquity, ε (full line).The left-hand scale is related to e, the right-hand scales, respectively, to $\Delta(e \sin \hat{\omega})$ and ε. The lower part shows the deviations of solar radiation (cal cm^{-2} day^{-1}) from their 1950 AD values for the caloric Northern Hemisphere summer half-year at 80°N (full line), 65°N (dotted line), and 10°N (dash-dot line). a, 0–250,000 yr ago; b, 250,000–500,000 yr ago; c, 500,000–750,000 yr ago; d, 750,000–-1,000,000 yr ago; e, 0–250,000 yr from now.

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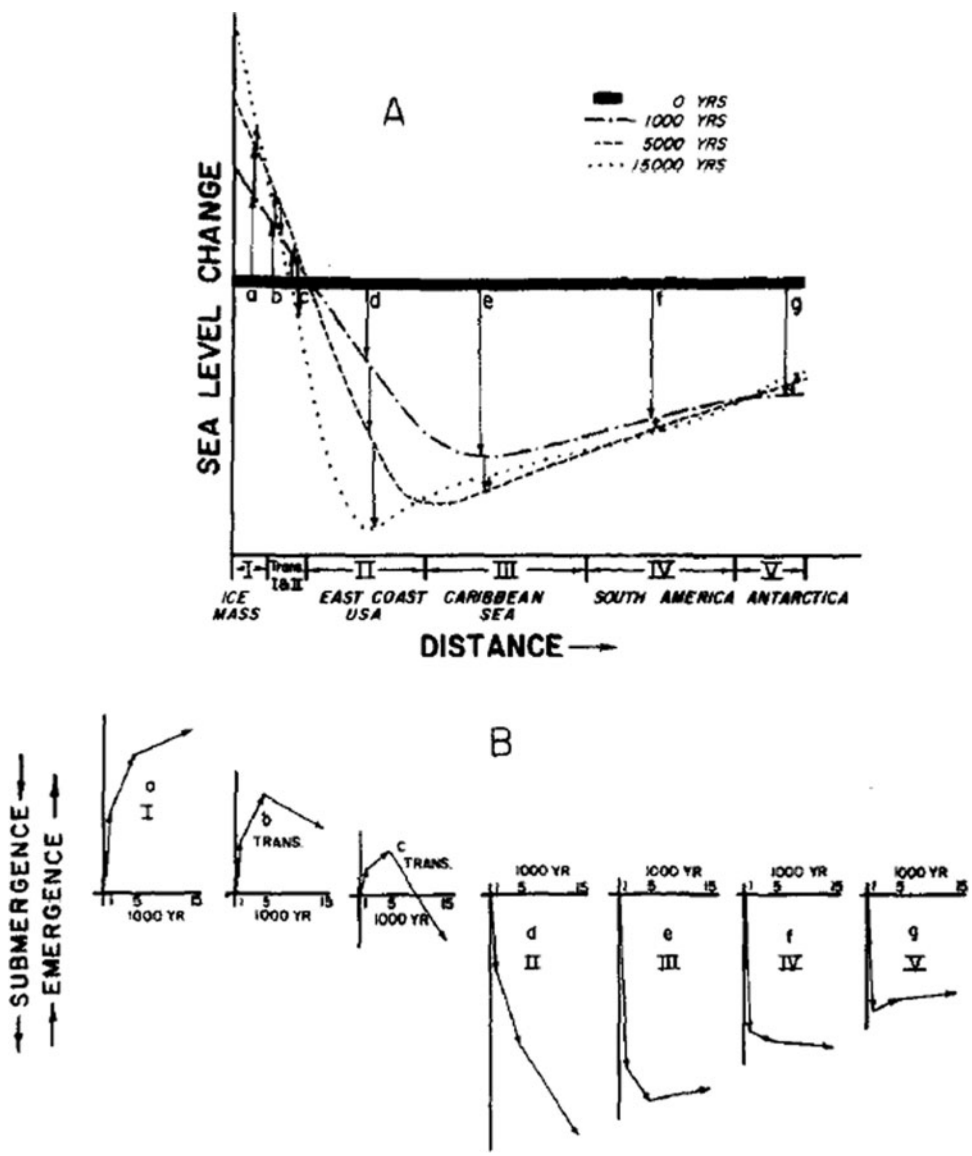
Clark, J.A., Farrell, W.E., Peltier, W.R. 1978. Global changes in postglacial sea level: A numerical calculation. ***Quaternary Research*** **9, 265–287.** ***Cited 500 times*****.**

ABSTRACT The sea-level rise due to ice-sheet melting since the last glacial maximum was not uniform everywhere because of the deformation of the Earth's surface and its geoid by changing ice and water loads. A numerical model is employed to calculate global changes in relative sea level on a spherical viscoelastic Earth as northern hemisphere ice sheets melt and fill the ocean basins with meltwater. Predictions for the past 16,000 years explain a large proportion of the global variance in the sea-level record, particularly during the Holocene. Results indicate that the oceans can be divided into six zones, each of which is characterized by a specific form of the relative sea-level curve. In four of these zones emerged beaches are predicted, and these may form even at considerable distance from the ice sheets themselves. In the remaining zones submergence is dominant, and no emerged beaches are expected. The close agreement of these predictions with the data suggests that, contrary to the beliefs of many, no net change in ocean volume has occurred during the past 5000 years. Predictions for localities close to the ice sheets are the most in error, suggesting that slight modifications of the assumed melting history and/or the rheological model of the Earth's interior are necessary.



A schematic illustration of the Heaviside Green function. The distortion of a reference shoreline 1000, 5000, and 15,000 years after the melting of a point ice mass is illustrated in (A). Five distinct spatially dependent sea-level regions are given on the distance axis, which is only approximate. The sea-level change relative to the initial reference shoreline at selected locations in (A) is given in (B). Each region has a distinctly different expression in the sea-level record. In Region I, for example, the land rises continuously relative to the sea (a); whereas in Region V, sea level rises rapidly initially, but this submergence is followed by slow emergence (g).

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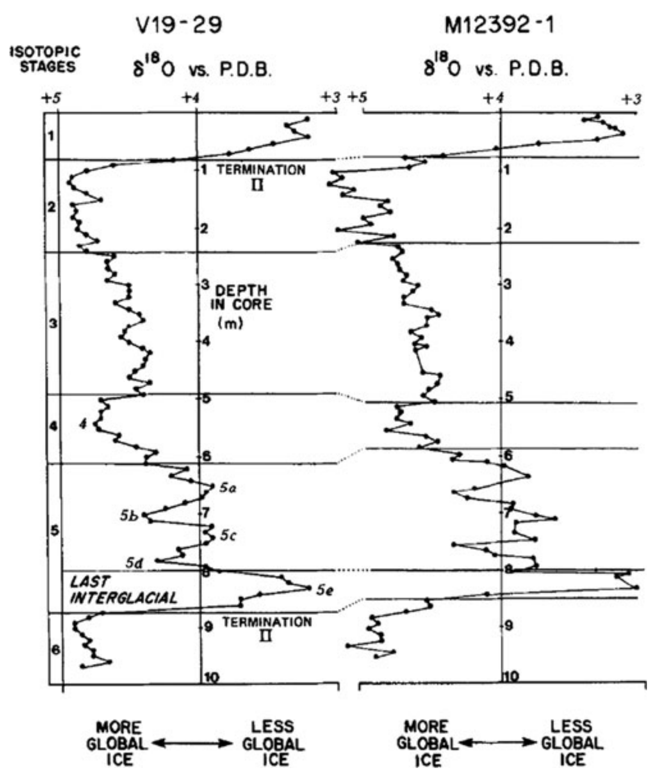
1980s

CLIMAP Project Members, Ruddiman, W.F., Cline, R.M.L., Hays, J.D., Prell, W.L., Ruddiman, W.F., Moore, T.C., Kipp, N.G., *et al*. 1984. The last interglacial ocean. *Quaternary Research* 21, 123–224. *Cited 298 times*.

ABSTRACT The final effort of the CLIMAP project was a study of the last interglaciation, a time of minimum ice volume some 122,000 yr ago coincident with the Substage 5e oxygen isotopic minimum. Based on detailed oxygen isotope analyses and biotic census counts in 52 cores across the world ocean, last interglacial sea-surface temperatures (SST) were compared with those today. There are small SST departures in the mid-latitude North Atlantic (warmer) and the Gulf of Mexico (cooler). The eastern boundary currents of the South Atlantic and Pacific oceans are marked by large SST anomalies in individual cores, but their interpretations are precluded by no-analog problems and by discordancies among estimates from different biotic groups. In general, the last interglacial ocean was not significantly different from the modern ocean. The relative sequencing of ice decay versus oceanic warming on the Stage 6/5 oxygen isotopic transition and of ice growth versus oceanic cooling on the Stage 5e/5d transition was also studied. In most of the Southern Hemisphere, the oceanic response marked by the biotic census counts preceded (led) the global ice-volume response marked by the oxygen-isotope signal by several thousand years. The reverse pattern is evident in the North Atlantic Ocean and the Gulf of Mexico, where the oceanic response lagged that of global ice volume by several thousand years. As a result, the very warm temperatures associated with the last interglaciation were regionally diachronous by several thousand years. These regional lead-lag relationships agree with those observed on other transitions and in long-term phase relationships; they cannot be explained simply as artifacts of bioturbational translations of the original signals.



Oxygen isotopic records of the last 150,000 yr from Pacific core V19-29 and Atlantic core M12392-1 (data from Shackleton (1977)). Last interglacial level (Substage 5e) marks the last time that isotopic values were as light as they are today, suggesting global ice volumes at least as small as those today.

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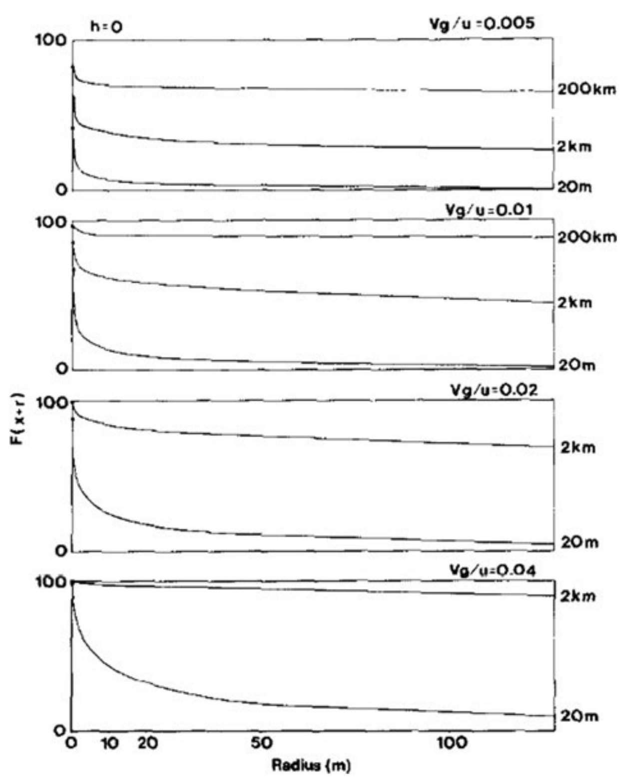
Jacobson Jr., G.L., Bradshaw, R.H.W. 1981. The selection of sites for paleovegetational studies. *Quaternary Research* 16, 80–96. *Cited 678 times*.

ABSTRACT The judicious selection of sites for paleovegetational and paleoclimatic studies permits paleoecologists to answer specific research questions that go beyond primary descriptions of past vegetation. We present a model that describes the relationship between basin size and pollen source area and predicts the proportions of local, extralocal, and regional pollen sampled by lake basins of different size. The distinctive sampling properties of lakes, peats, and small hollows can be exploited to provide details of pattern in paleovegetation so long as attention is given to the limitations and problems of these types of sites. Combinations of site types in a single study most fully exploit the information contained in sediments.

Prentice, I.C. 1985. Pollen representation, source area, and basin size: Toward a unified theory of pollen analysis. *Quaternary Research* 23, 76–86. *Cited 535 times*.

ABSTRACT The concepts of pollen source area and of production and dispersal biases in pollen representation are quantified by means of a simple theoretical model. Source areas and relative pollen representation are shown to depend on basin size according to functions that describe the amount of pollen remaining airborne at increasing distances from single pollen sources. The form of these functions is determined by physical processes. Standard formulas for elevated sources do not apply, but the integrated form of Sutton's equation for particle dispersal from a ground-level source gives useful approximations applicable to pollen transport over a forest canopy. Simulations using this equation yielded source areas that increased realistically with basin size, showed substantial differences between source areas for pollen grains with different deposition velocities, and predicted that lighter pollen grains should become better represented with increasing basin size. All of these predictions are qualitatively consistent with present knowledge of the characteristics of pollen assemblages in different depositional environments. The model further allows parameters that can be estimated by statistical calibration methods to be predicted from underlying physical quantities. This extension suggests procedures for testing the theory with quantitative data on surface pollen and forest composition. Preliminary results showed reasonable agreement between estimated and predicted values of dispersal indices for the most abundant taxa in pollen spectra from the northern midwestern United States.



Simulated pollen source areas for individual taxa. The graphs show the percentage of pollen originating within specified distances of the basin margin: the diagrams form a series with the graphs for the lightest pollen type at the top. These simulations were based on Sutton's equation for a ground-level particle source. This equation gives a convenient approximation for the deposition behavior of tree pollen types dispersed over a forest canopy.

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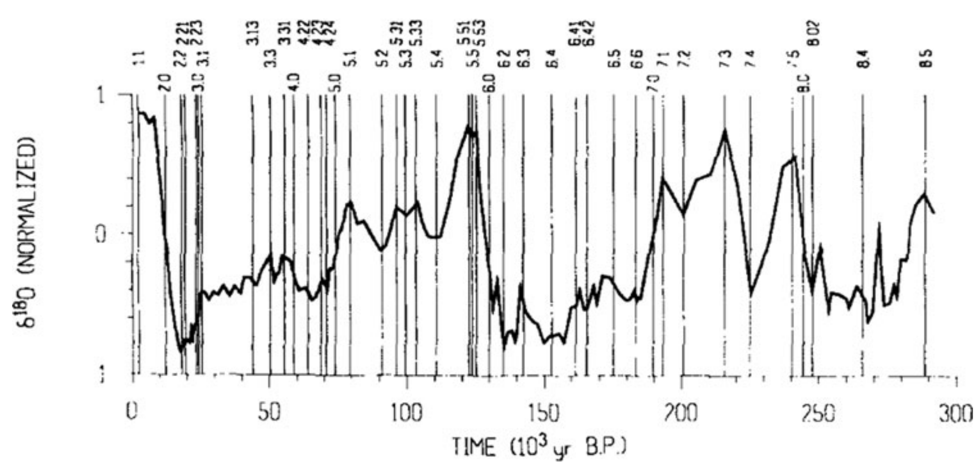
Overpeck, J.T., Webb III, T., Prentice, I.C. 1985. Quantitative interpretation of fossil pollen spectra: Dissimilarity coefficients and the method of modern analogs. *Quaternary Research* 23, 87–108. *Cited 686 times*.

ABSTRACT Dissimilarity coefficients measure the difference between multivariate samples and provide a quantitative aid to the identification of modern analogs for fossil pollen samples. How eight coefficients responded to differences among modern pollen samples from eastern North America was tested. These coefficients represent three different classes: (1) unweighted coefficients that are most strongly influenced by large-valued pollen types, (2) equal-weight coefficients that weight all pollen types equally but can be too sensitive to variations among rare types, and (3) signal-to-noise coefficients that are intermediate in their weighting of pollen types. The studies with modern pollen allowed definition of critical values for each coefficient, which, when not exceeded, indicate that two pollen samples originate from the same vegetation region. Dissimilarity coefficients were used to compare modern and fossil pollen samples, and modern samples so similar to fossil samples were found that most of three late Quaternary pollen diagrams could be "reconstructed" by substituting modern samples for fossil samples. When the coefficients indicated that the fossil spectra had no modern analogs, then the reconstructed diagrams did not match all aspects of the originals. No modern analogs existed for samples from before 9300 yr B.P. at Kirchner Marsh, Minnesota, and from before 11,000 yr B.P. at Wintergreen Lake, Michigan, but modern analogs existed for almost all Holocene samples from these two sites and Brandreth Bog. New York.

Martinson, D.G., Pisias, N.G., Hays, J.D., Imbrie, J., Moore Jr., T.C., Shackleton, N.J. 1987. Age dating and the orbital theory of the ice ages: Development of a high-resolution 0 to 300,000-year chronostratigraphy. *Quaternary Research* 27, 1–29. *Cited 2637 times*.

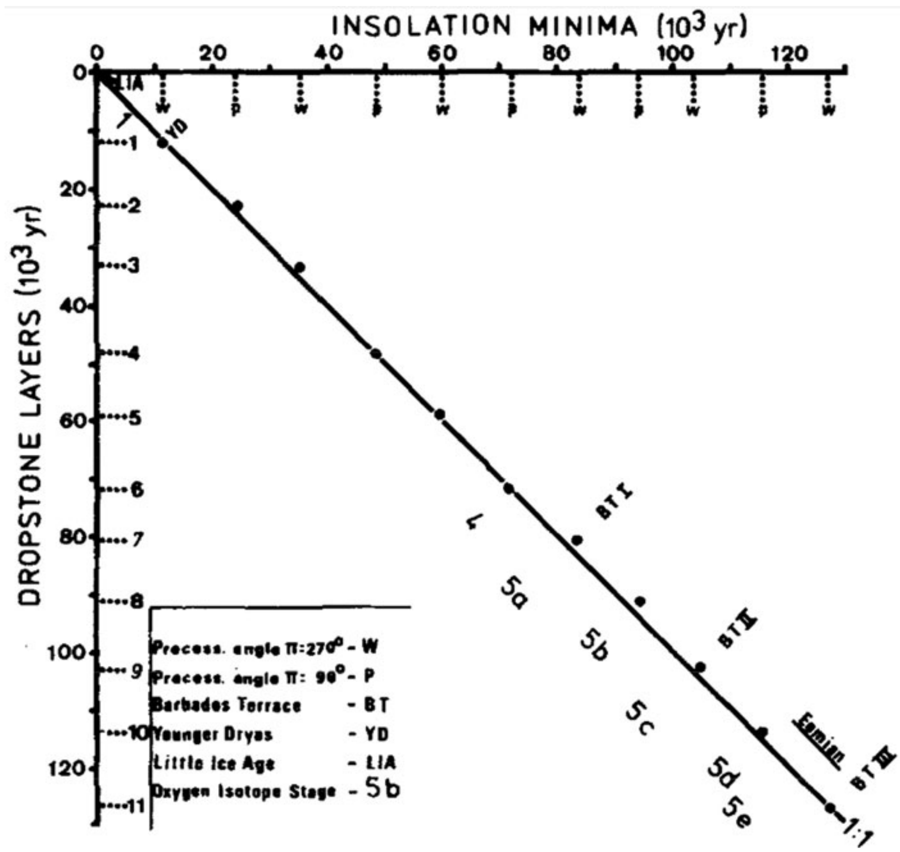
ABSTRACT Using the concept of "orbital tuning", a continuous, high-resolution deep-sea chronostratigraphy has been developed spanning the last 300,000 yr. The chronology is developed using a stacked oxygen-isotope stratigraphy and four different orbital tuning approaches, each of which is based upon a different assumption concerning the response of the orbital signal recorded in the data. Each approach yields a separate chronology. The error measured by the standard deviation about the average of these four results (which represents the "best" chronology) has an average magnitude of only 2500 yr. This small value indicates that the chronology produced is insensitive to the specific orbital tuning technique used. Excellent convergence between chronologies developed using each of five different paleoclimatological indicators (from a single core) is also obtained. The resultant chronology is also insensitive to the specific indicator used. The error associated with each tuning approach is estimated independently and propagated through to the average result. The resulting error estimate is independent of that associated with the degree of convergence and has an average magnitude of 3500 yr, in excellent agreement with the 2500-yr estimate. Transfer of the final chronology to the stacked record leads to an estimated error of ± 1500 yr. Thus the final chronology has an average error of ± 5000 yr.



Final orbitally based chronostratigraphy (= stacked oxygen-isotope record of Pisias et al., 1984). Numbered vertical lines indicate identifiable features of the record, defined by Pisias et al. (1984). Age estimates for these features are given in Table 2. Descriptions of the features are given in Pisias et al. (1984; their Table V).

Heinrich, H. 1988. Origin and consequences of cyclic ice rafting in the Northeast Atlantic Ocean during the past 130,000 years. *Quaternary Research* 29, 142–152. *Cited 1380 times*.

ABSTRACT Deep-sea sediment cores recovered from the Northeast Atlantic Ocean were examined in order to elucidate the influence of the Earth's orbital parameters on major ice rafting. Analyses of coarse-grained ice-rafted debris and planktonic foraminifers revealed a strong reaction to the precession signal. Since 130,000 yr B.P., dropstone layers have been deposited each half period of a precessional cycle (11,000 ± 1000 yr). Ice rafting occurs during times of winter minimum/summer maximum insolation and summer minimum/winter maximum insolation. In the first case, high summer insolation forces meltwater discharge from the ice sheets into the polar seas which subsequently enhances formation of sea ice during the winter. In the second case, growth of continental ice enhances iceberg production which also leads to a salinity reduction of surface seawater. Both situations result in a southward penetration of polar water. Thus, the marine record of dropstones documents ice rafting not only during Weichselian stades but also during cold events within interstades. The regularity of ice rafting yields a useful framework to calibrate and elucidate climatic changes, not only in the region of the North Atlantic Ocean but also in remote areas such as the Pacific Ocean and the Antarctic.



Relationship of dropstone ages and times of insolation minima (from Vemekar, 1972).

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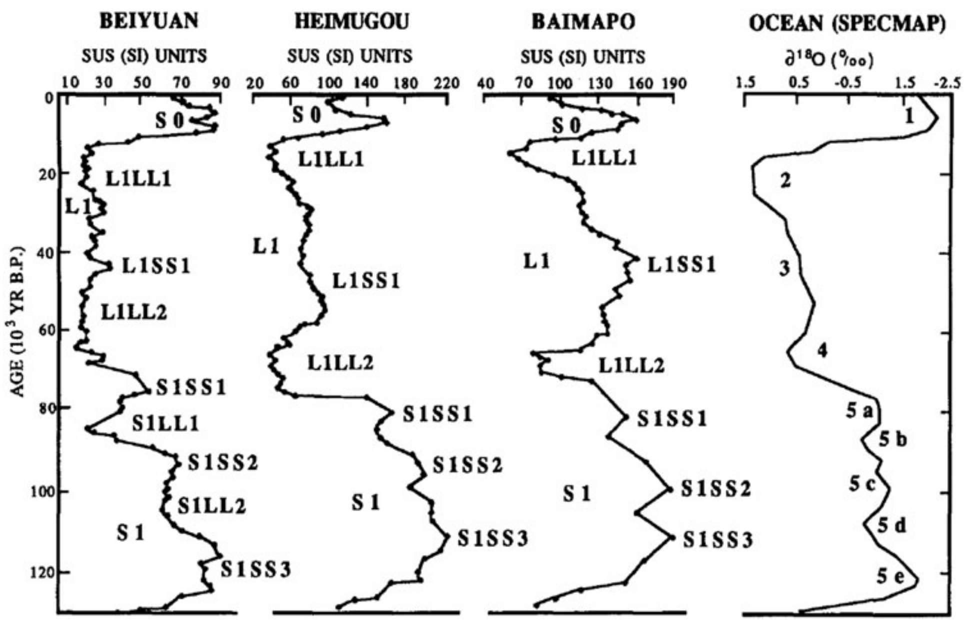
1990s

An, Z., Kukla, G.J., Porter, S.C., Xiao, J. 1991. Magnetic susceptibility evidence of monsoon variation on the Loess Plateau of central China during the last 130,000 years. *Quaternary Research* 36, 29–36. *Cited 631 times*.

ABSTRACT The magnetic susceptibility of loess and paleosols in central China represents a proxy climate index closely related to past changes of precipitation and vegetation, and thus to summer monsoon intensity. Time series of magnetic susceptibility constructed for three loess-paleosol sequences in the southern part of the Chinese Loess Plateau document the history of summer monsoon variation during the last 130,000 yr. They correlate closely with the oxygen isotope record of stages 1 to 5 in deep-sea sediments. Soils were forming during intervals of strong summer monsoon, whereas loess units were deposited at times of reduced monsoon intensity. The Chinese loess-paleosol sequence can thus be viewed as a proxy record of Asian monsoon variability extending over the last 2.5 myr.



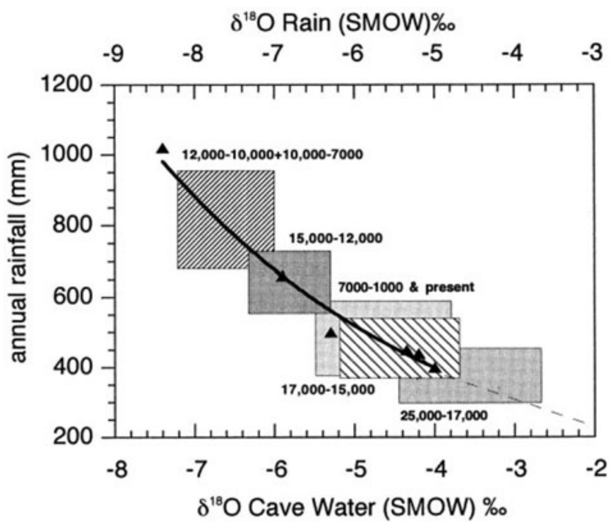
Susceptibility of the three loess sequences plotted on the susceptibility time scale of Kukla et al. (1988), compared with the SPECMAP oxygen isotope record of Imbrie et al. (1984) and Prell et al. (1986).

Sugita, S. 1993. A Model of Pollen Source Area for an Entire Lake Surface. *Quaternary Research* 39, 239–244. *Cited 371 times*.

ABSTRACT A model of pollen deposition on the surface of an entire basin is developed to estimate pollen source area, and results are compared with those for a point at the center of a basin (I. C. Prentice, 1985, Quaternary Research 23, 76–86; 1988, "Vegetation History," (pp. 17–42, Kluwer Academic). This model is more appropriate for approximating the source area of pollen in lake sediment, since mixing in lake water and focusing of sediment redistribute pollen originally deposited over the entire surface. In general, the pollen source radius for the entire basin surface is 10–30% smaller than the source radius for a point at the center; the difference in the source radius is more profound for heavier pollen types such as spruce and sugar maple than for lighter types such as oak and ragweed. The average pollen input to the entire surface is more strongly influenced by nearby pollen sources than pollen deposition at the center. The pollen record from a lake may therefore provide different spatial resolution than the record from a bog of similar radius.

Bar-Matthews, M., Ayalon, A., Kaufman, A. 1997. Late Quaternary Paleoclimate in the Eastern Mediterranean Region from Stable Isotope Analysis of Speleothems at Soreq Cave, Israel. *Quaternary Research* 47, 155–168. *Cited 455 times*.

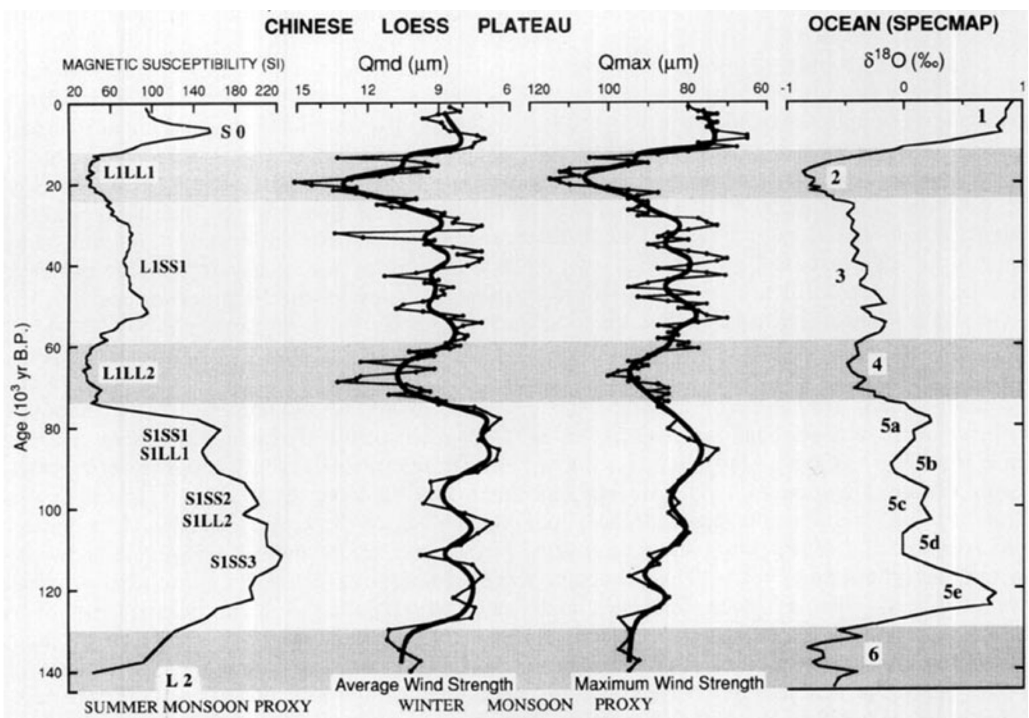
ABSTRACT The eastern Mediterranean continental paleoclimate during the past 25,000 years was determined by a high-resolution petrographic, stable isotopic, and age study of speleothems from Soreq Cave, Israel. $\delta^{18}O$–$\delta^{13}C$ trends indicate that all speleothems older than 7000 yr formed under conditions that differ from those of today. The period from 25,000 to 17,000 yr B.P. was characterized by the highest $\delta^{18}O$ and $\delta^{13}C$ values, which indicate deposition at temperatures of 12°–16°C, annual rainfall of 300–450 mm, and vegetation typical of a mixed C3–C4 type. From 17,000 to 10,000 yr B.P. (deglaciation in northern Europe) $\delta^{18}O$ values dropped progressively, correlative with warming (2°–3°C) and a gradual increase in precipitation. A simultaneous decrease in $\delta^{13}C$ gives a range expected for C3-type vegetation. This period also shows significant $\delta^{18}O$ and $\delta^{13}C$ "spikes" which are correlatable with global events (e.g., Heinrich events and the Younger Dryas Stade). The speleothems that grew between 10,000 and 7000 yr B.P. have a unique petrography showing irregular thin laminae of various colors and much detritus. They have the lowest $\delta^{18}O$ (corresponding to ~1000 mm rain) coupled with the highest $\delta^{13}C$ (caused by flooding events which stripped the soil cover). From 7000 to 1000 yr B.P. conditions became closer to those of today. This study demonstrates that global events which were recognized in Northern Europe and North Africa are also evident in the eastern Mediterranean and are reflected principally by large changes in the rainfall rate.



Ranges of estimated annual rainfall (mm) and cave water $\delta^{18}0\%_0$ (SMOW) values which apply to the various time periods superimposed on the present-day rainfall–cave water vs $\delta^{18}0$ plot.

Xiao, J., Porter, S.C., An, Z., Kumai, H., Yoshikawa, S. 1995. Grain size of quartz as an indicator of winter monsoon strength on the loess plateau of central china during the last 130,000 yr. *Quaternary Research* 43, 22–29. *Cited 359 times*.

ABSTRACT The Chinese loess-paleosol sequence constitutes an important record of variations in Asian monsoon climate over the past 2.4 myr. Magnetic susceptibility of loess and paleosols has been used as a proxy for summer monsoon intensity, while median grain size has been regarded as a measure of the strength of winter monsoon winds that were responsible for most of the dust transport. However, median grain size is only an approximate index of winter monsoon strength because both paleosols and loess have been modified, to various degrees, by weathering processes that have produced pedogenic clay. The quartz component of loess and paleosols is largely unaffected by weathering processes and therefore constitutes a more reliable proxy index of monsoon wind strength. Median grain size (Qmd) and maximum grain size (Qmax) values of monomineralic quartz isolated from the loess-paleosol section at Luochuan in the central Loess Plateau are characterized by two main intervals during the last ca. 130,000 yr when these parameters were significantly greater than 9 and 85 μm, respectively, and three main intervals when they were lower. The data imply that the winter monsoon weakened during the intervals with low Qmd and Qmax values, which coincide with marine oxygen isotope stages 5, 3, and 1, and was strongest ca. 67,000 and 20,000 yr ago during isotope stages 4 and 2. However, both quartz grainsize records display second-order high-frequency, high-amplitude variations, which are lacking in the magnetic susceptibility record, that imply rapid and significant changes in atmospheric conditions that affect dust transport and deposition.



Correlation of the Luochuan Qmd and Qmax records with the magnetic susceptibility record of the same section (An et al., 1991a) and the SPECMAP $\delta^{18}0$ chronology of Martinson et al. (1987). See text regarding derivation of the chronology of the magnetic susceptibility and quartz grain-size records. Bold lines superimposed on the Qmd and Qmax plots represent five-point running means.

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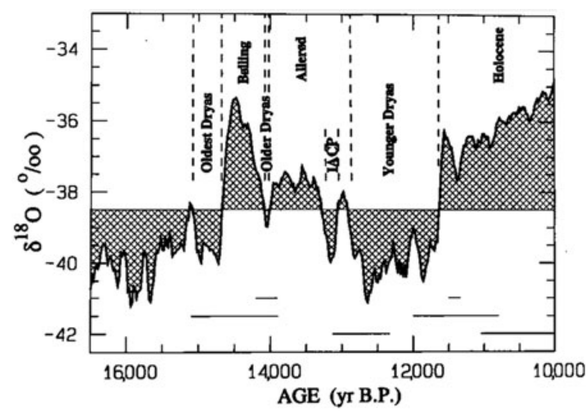
Stuiver, M., Grootes, P.M., Braziunas, T.F. 1995. The GISP2 $\delta^{18}O$ climate record of the past 16,500 years and the role of the sun, ocean, and volcanoes. *Quaternary Research* 44, 341–354. *Cited 760 times*.

ABSTRACT Measured $^{18}O/^{16}O$ ratios from the Greenland Ice Sheet Project 2 (GISP2) ice core extending back to 16,500 cal yr B.P. provide a continuous record of climate change since the last glaciation. High-resolution annual $^{18}O/^{16}O$ results were obtained for most of the current millennium (A.D. 818–1985) and record the Medieval Warm Period, the Little Ice Age, and a distinct 11-yr $^{18}O/^{16}O$ cycle. Volcanic aerosols depress central Greenland annual temperature (~1.5°C maximally) and annual $^{18}O/^{16}O$ for about 4 yr after each major eruptive event. On a bidecadal to millennial time scale, the contribution of solar variability to Holocene Greenlandic temperature change is ~0.4°C. The role of thermohaline circulation change on climate, problematic during the Holocene, is more distinct for the 16,500–10,000 cal yr B.P. interval. (Analogous to ^{14}C age calibration terminology, we express time in calibrated (cal) yr B.P. (A.D. 1950 = 0 cal yr B.P.)). The Oldest Dryas/Bølling/Older Dryas/Allerød/Younger Dryas sequence appears in great detail. Bidecadal variance in $^{18}O/^{16}O$, but not necessarily in temperature, is enhanced during the last phase of lateglacial time and the Younger Dryas interval, suggesting switches of air mass transport between jet stream branches. The branched system is nearly instantaneously replaced at the beginning of the Bølling and Holocene (at ~14,670 and ~11,650 cal yr B.P., respectively) by an atmospheric circulation system in which $^{18}O/^{16}O$ and annual accumulation initially track each other closely. Thermodynamic considerations of the accumulation rate-temperature relationship can be used to evaluate the $^{18}O/^{16}O$–temperature relationship. The GISP2 ice-layer-count years of major GISP2 climate transitions also support the use of coral ^{14}C ages for age calibration.



Major $\delta^{18}0$ climate transitions (solid line is a five-point (100-yr) moving average of Figure 10 $\delta^{18}0$ values) and European pollen zone boundaries (see text). Horizontal lines denote suggested periods of rapid sealevel rise (top, Blanchon and Shaw, 1995; middle and bottom, estimated, respectively, from Fairbanks et al., 1992 and Edwards et al., 1993).

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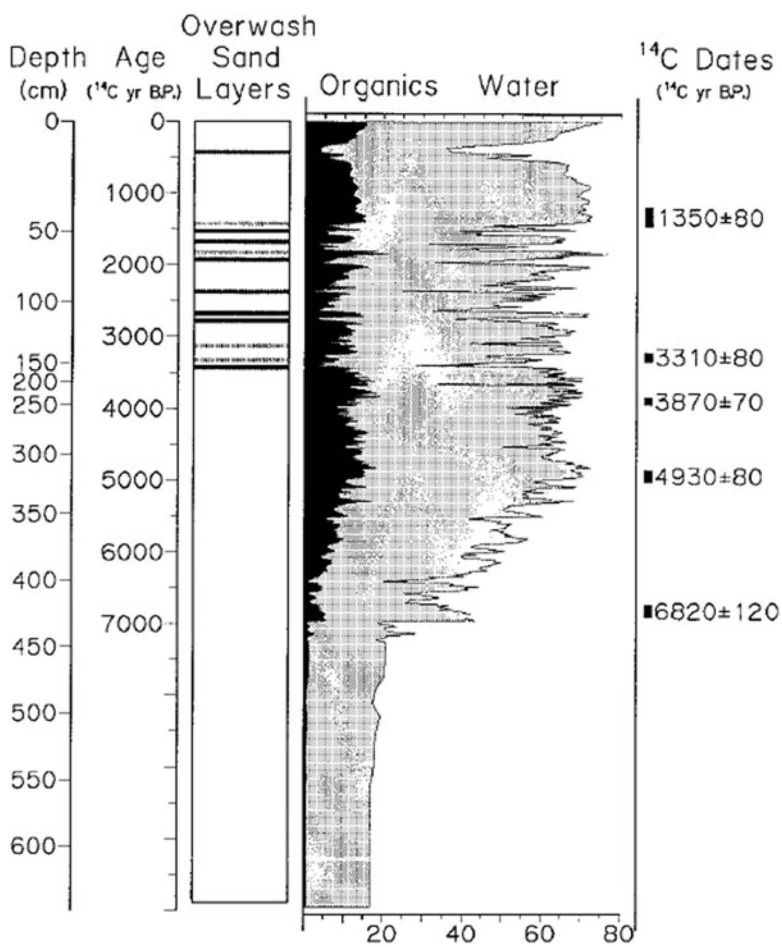
2000s

Liu, K.-B., Fearn, M.L. 2000. Reconstruction of prehistoric landfall frequencies of catastrophic hurricanes in Northwestern Florida from lake sediment records. *Quaternary Research* 54, 238–245. *Cited 271 times*.

ABSTRACT Sediment cores from Western Lake provide a 7000-yr record of coastal environmental changes and catastrophic hurricane landfalls along the Gulf Coast of the Florida Panhandle. Using Hurricane Opal as a modern analog, we infer that overwash sand layers occurring near the center of the lake were caused by catastrophic hurricanes of category 4 or 5 intensity. Few catastrophic hurricanes struck the Western Lake area during two quiscent periods 3400–5000 and 0–1000 ^{14}C yr B.P. The landfall probabilities increased dramatically to ca. 0.5% per yr during an 'hyperactive' period from 1000–3400 ^{14}C yr B.P., especially in the first millennium A.D. The millennial-scale variability in catastrophic hurricane landfalls along the Gulf Coast is probably controlled by shifts in the position of the jet stream and the Bermuda High. (C) 2000 University of Washington.



Loss-on-ignition curves showing water content (% wet weight: gray curve) and organic content (% dry weight; black curve) for core 1 from Western Lake. Sand layers are reflected by abrupt drops in percentage water and organic matter. The stratigraphic column shows prominent sand layers (dark horizontal lines) and less prominent sand layers and lenses (light horizontal lines) occurring in the top 1.6 m. The conventional radiocarbon elates are uncalibrated ^{14}C ages determined from bulk organic sediments. Curves were plotted according to radiocarbon timescale in yr B.P. Corresponding depths (cm) in the core are also shown.

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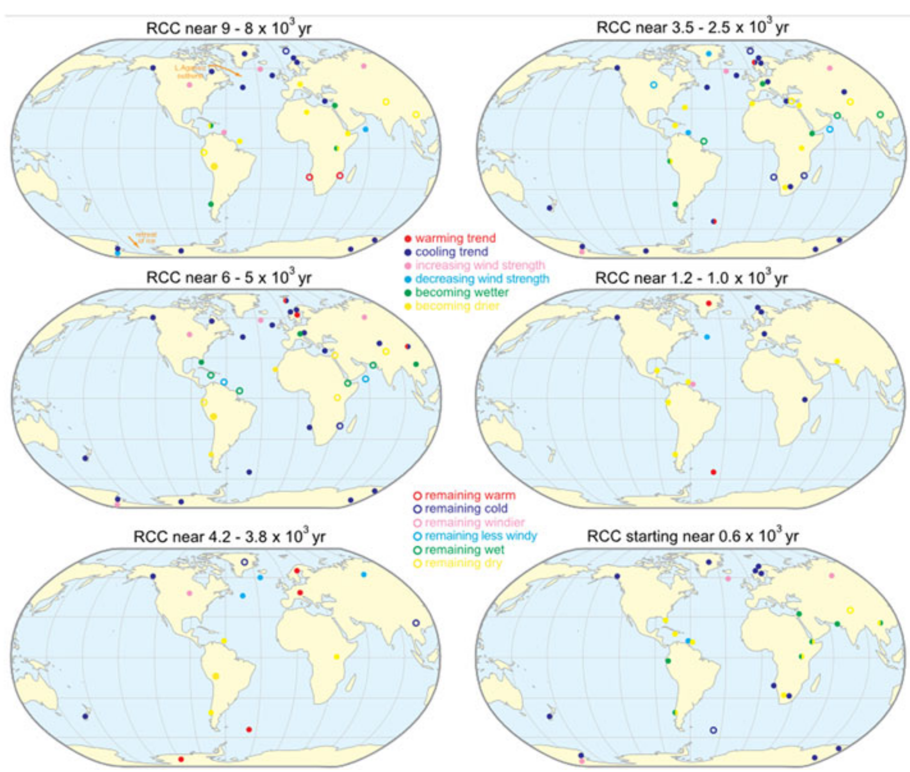
Putkonen, J., Swanson, T. 2003. Accuracy of cosmogenic ages for moraines. ***Quaternary Research*** **59, 255–261.** ***Cited 284 times*****.**

ABSTRACT Analyses of all published cosmogenic exposure ages for moraine boulders show an average age range of 38% between the oldest and youngest boulders from each moraine. This range conflicts with the common assumption that ages of surface boulders are the same as the age of the landform. The wide spread in boulder ages is caused by erosion of the moraine surface and consequent exhumation of fresh boulders. A diffusion model of surface degradation explains the age range and shows that a randomly sampled small set of boulders (n = 3-7) will always yield a lower age limit for the moraine. The model indicates that for identical dating accuracy, six to seven boulders are needed from old and tall moraines (40,000–100,000 yr, 50–100 m initial height) but only one to four boulders from small moraines (20,000–100,000 yr, 10–20 m). By following these guidelines the oldest obtained boulders age will be ≥90% of the moraine age (95% probability). This result is only weakly sensitive to a broad range of soil erosion rates. Our analysis of published boulder ages indicates that <3% of all moraine boulders have prior exposure, and 85% of these boulders predate the dated moraine.

Mayewski, P.A., Rohling, E.E., Stager, J.C., Karlén, W., Maasch, K.A., Meeker, L.D., Meyerson, E.A., ***et al*****. 2004. Holocene climate variability.** ***Quaternary Research*** **62, 243–255.** ***Cited 1431 times*****.**

ABSTRACT Although the dramatic climate disruptions of the last glacial period have received considerable attention, relatively little has been directed toward climate variability in the Holocene (11,500 cal yr B.P. to the present). Examination of ~50 globally distributed paleoclimate records reveals as many as six periods of significant rapid climate change during the time periods 9000–8000, 6000–5000, 4200–3800, 3500–500, 1200–1000, and 600–150 cal yr B.P. Most of the climate change events in these globally distributed records are characterized by polar cooling, tropical aridity, and major atmospheric circulation changes, although in the most recent interval (600–150 cal yr B.P.), polar cooling was accompanied by increased moisture in some parts of the tropics. Several intervals coincide with major disruptions of civilization, illustrating the human significance of Holocene climate variability.



Map displaying state of climate proxies during RCC's *[Rapid Climate Changes]* near 9000–8000, 6000–5000, 4200–3800, 3500–2500, 1200–1000, and since 600 cal yr B.P.

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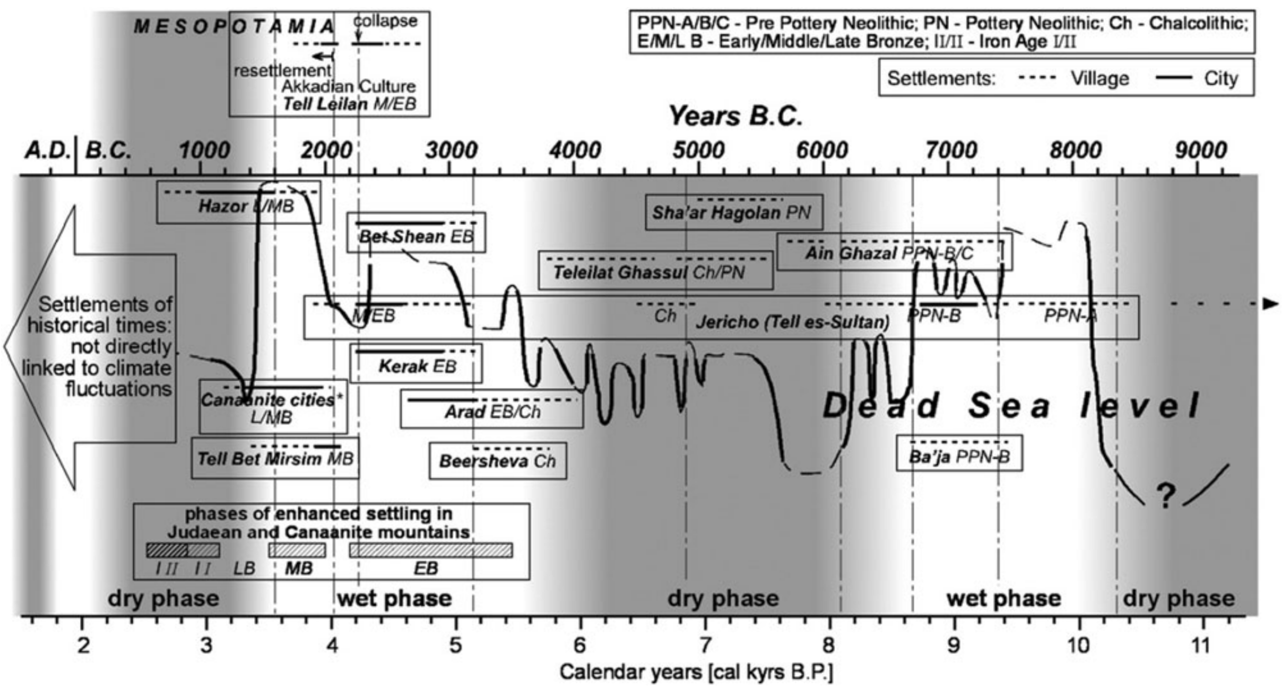
Migowski, C., Stein, M., Prasad, S., Negendank, J.F.W., Agnon, A. 2006. Holocene climate variability and cultural evolution in the Near East from the Dead Sea sedimentary record. *Quaternary Research* 66, 421–431. *Cited 230 times*.

ABSTRACT A comprehensive record of lake level changes in the Dead Sea has been reconstructed using multiple, well dated sediment cores recovered from the Dead Sea shore. Interpreting the lake level changes as monitors of precipitation in the Dead Sea drainage area and the regional eastern Mediterranean palaeoclimate, we document the presence of two major wet phases (~ 10–8.6 and ~ 5.6–3.5 cal kyr BP) and multiple abrupt arid events during the Holocene. The arid events in the Holocene Dead Sea appear to coincide with major breaks in the Near East cultural evolution (at ~ 8.6, 8.2, 4.2, 3.5 cal kyr BP). Wetter periods are marked by the enlargement of smaller settlements and growth of farming communities in desert regions, suggesting a parallelism between climate and Near East cultural development.



A comparison of the climate variability and cultural development in the Dead Sea region. The establishment of favorable climate conditions appears to parallel the expansion of villages into cities and the spread of fanning communities into the Negev Desert. Deteriorating climate conditions are generally characterised by fewer settlements confined to the vicinity of water resources along the Jordan valley.

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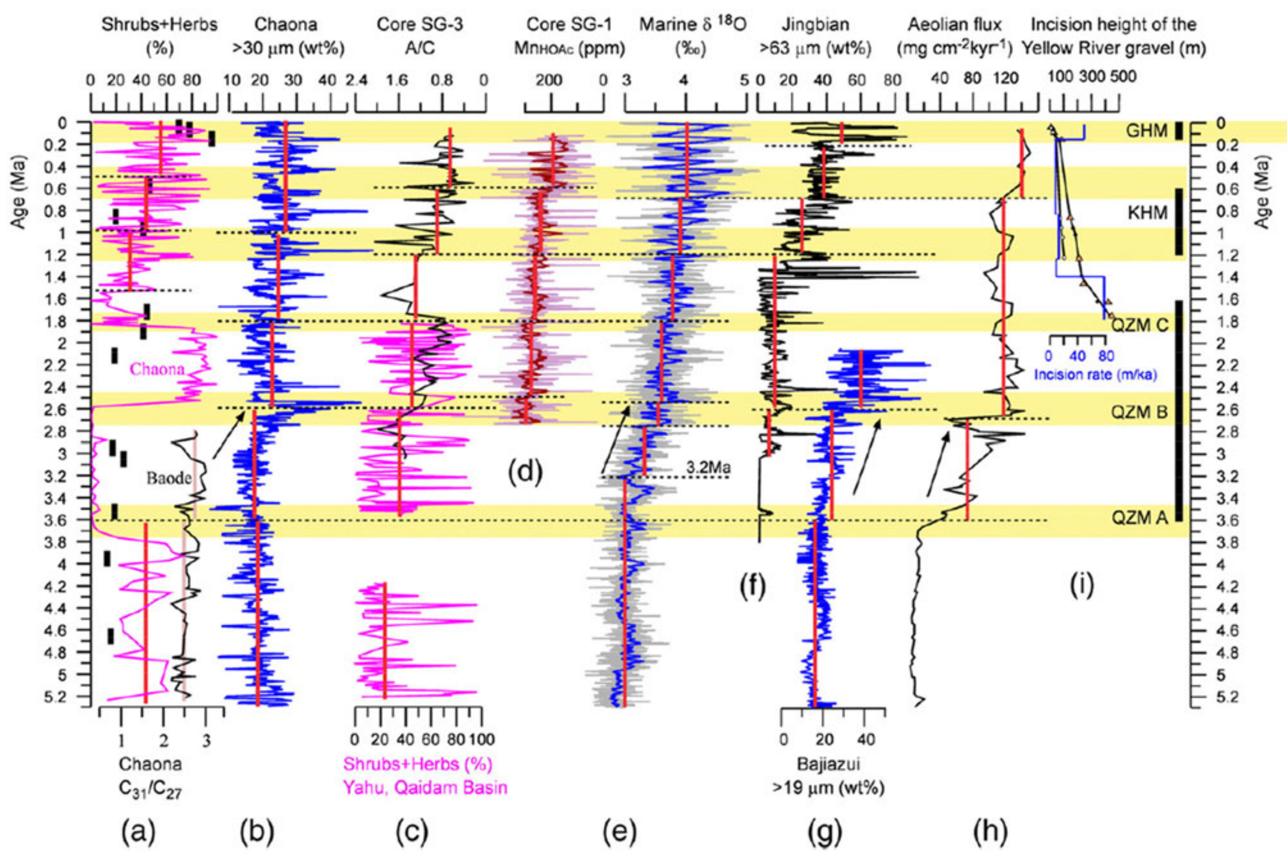
2010s

Li, J., Fang, X., Song, C., Pan, B., Ma, Y., Yan, M. 2014. Late Miocene-Quaternary rapid stepwise uplift of the NE Tibetan Plateau and its effects on climatic and environmental changes. *Quaternary Research* 81, 400–423. *Cited 134 times*.

ABSTRACT The way in which the NE Tibetan Plateau uplifted and its impact on climatic change are crucial to understanding the evolution of the Tibetan Plateau and the development of the present geomorphology and climate of Central and East Asia. This paper is not a comprehensive review of current thinking but instead synthesises our past decades of work together with a number of new findings. The dating of Late Cenozoic basin sediments and the tectonic geomorphology of the NE Tibetan Plateau demonstrates that the rapid persistent rise of this plateau began ~8 ± 1 Ma followed by stepwise accelerated rise at ~3.6 Ma, 2.6 Ma, 1.8–1.7 Ma, 1.2–0.6 Ma and 0.15 Ma. The Yellow River basin developed at ~1.7 Ma and evolved to its present pattern through stepwise backward-expansion toward its source area in response to the stepwise uplift of the plateau. High-resolution multi-climatic proxy records from the basins and terrace sediments indicate a persistent stepwise accelerated enhancement of the East Asian winter monsoon and drying of the Asian interior coupled with the episodic tectonic uplift since ~8 Ma and later also with the global cooling since ~3.2 Ma, suggesting a major role for tectonic forcing of the cooling.



Comparisons of the climatic records from the Chaona section on the Loess Plateau and the Qaidam Basin on the NE Tibetan Plateau with the incision history of the Yellow River and the global oxygen isotope climatic change (Zachos et al., 2008) since the Pliocene. For the Chaona section, the sporopollen records are compiled from Wu et al. (2004), Ma et al. (2005b) and Li et al. (2011); the organic biomarker record is from Bai et al. (2009); and the grain-size record is from Lu et al. (2001). For the Qaidam Basin, the sporopollen records were compiled from Wu et al. (2007) and Cai et al. (2012); and the MnHOAc records of the core SG- 1 are from Yang et al. (2013). Grain size records from other sections on the Loess Plateau (the Bajiazui section from An et al., 2001; the Jingbian section (Ding et al., 2002) and North Pacific Ocean (Rea et al., 1998)) are also plotted for comparison.

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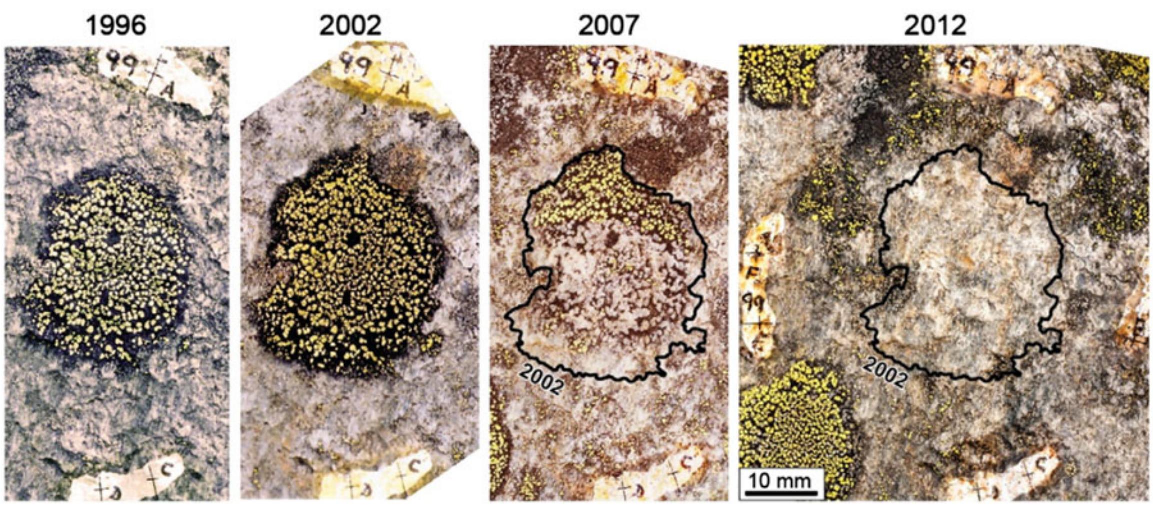
Osborn, G., McCarthy, D., LaBrie, A., Burke, R. 2015. Lichenometric dating: Science or pseudo-science? *Quaternary Research* 83, 1–12. *Cited 39 times*.

ABSTRACT The popular technique of estimating ages of deposits from sizes of lichens continues despite valid criticism, and without agreement on range of utility, treatment of error, and methods of measurement, sampling, and data handling. A major source of error is the assumption that the largest lichen(s) colonized soon after deposition and will survive indefinitely. Recent studies on lichen mortality suggest that this assumption is untenable. Meanwhile, the use of "growth curves" constructed from independently dated substrates is problematic for many reasons, but this has not prevented the publication of baseless claims of accuracy and ages that are extrapolated well beyond data. Experiments indicate that numeric lichenometric ages are not reliable, and in general do not advance the cause of Quaternary science. There are a few studies suggesting reliability, and indeed there may be cases where lichens and growth curves actually provide realistic numerical ages. But it cannot be foretold which lichen assemblages will provide good ages and which bad ages. The logical conclusion is that no assumption of good ages can be made, and that it is folly to assign numerical ages to a deposit on the basis of lichen sizes.



Death of an *R. geographicum agg.* thallus at the Illecillewaet Glacier lichen monitoring site. First photographed in the summer of 1996 (McCarthy, 2003), this thallus looked healthy and was growing in the summer of 2002. A sketch line shows the outline of the thallus in 2002. Dieback was well developed by the summer of 2007 and the thallus was no longer on the rock in 2012. Often, *R. geographicum agg.* thalli at this site have disappeared from the rock within two years of showing dieback, but sometimes thalli experiencing dieback have recovered and regrown.

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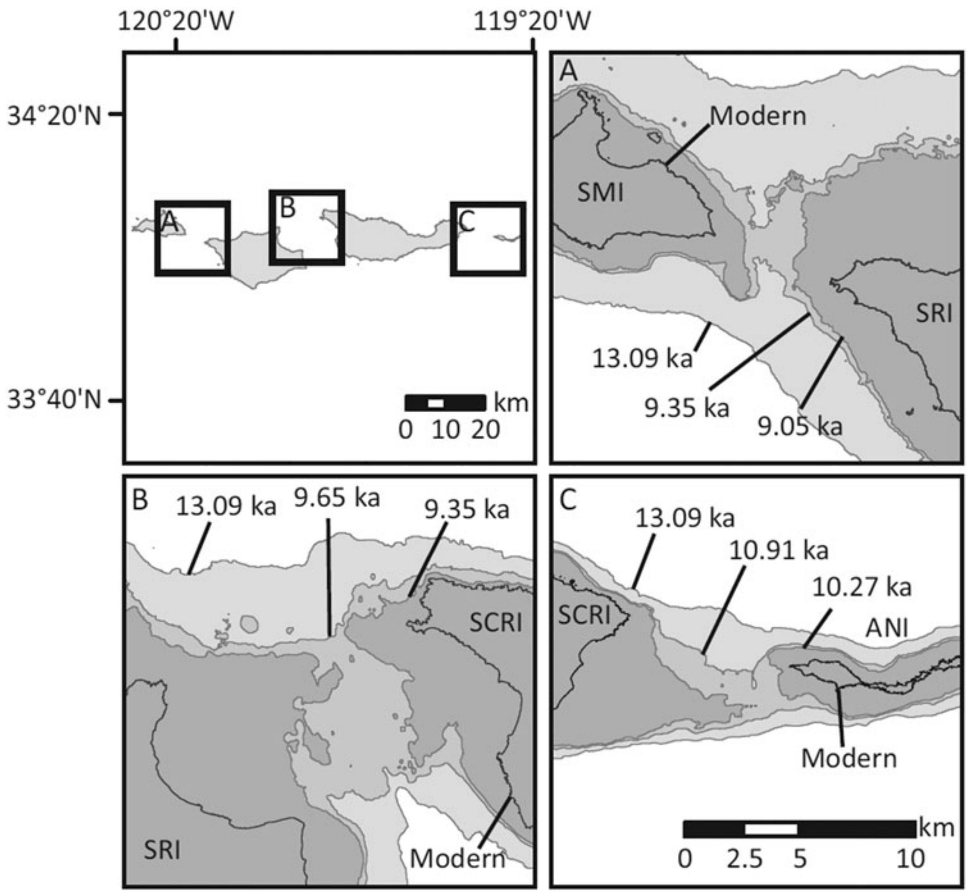
Reeder-Myers, L., Erlandson, J.M., Muhs, D.R., Rick, T.C. 2015. Sea level, paleogeography, and archeology on California's Northern Channel Islands. *Quaternary Research* 83, 263–272. *Cited 39 times*.

ABSTRACT Sea-level rise during the late Pleistocene and early Holocene inundated nearshore areas in many parts of the world, producing drastic changes in local ecosystems and obscuring significant portions of the archeological record. Although global forces are at play, the effects of sea-level rise are highly localized due to variability in glacial isostatic adjustment (GIA) effects. Interpretations of coastal paleoecology and archeology require reliable estimates of ancient shorelines that account for GIA effects. Here we build on previous models for California's Northern Channel Islands, producing more accurate late Pleistocene and Holocene paleogeographic reconstructions adjusted for regional GIA variability. This region has contributed significantly to our understanding of early New World coastal foragers. Sea level that was about 80–85 m lower than present at the time of the first known human occupation brought about a landscape and ecology substantially different than today. During the late Pleistocene, large tracts of coastal lowlands were exposed, while a colder, wetter climate and fluctuating marine conditions interacted with rapidly evolving littoral environments. At the close of the Pleistocene and start of the Holocene, people in coastal California faced shrinking land, intertidal, and subtidal zones, with important implications for resource availability and distribution.



Detail of the sequence of island separation.com pared to the shoreline at the earliest known human occupation about 13,000 cal yr BP. SMI is San Miguel Island, SRI is Santa Rosa Island, SCRI is Santa Cruz Island, and ANI is Anacapa island.

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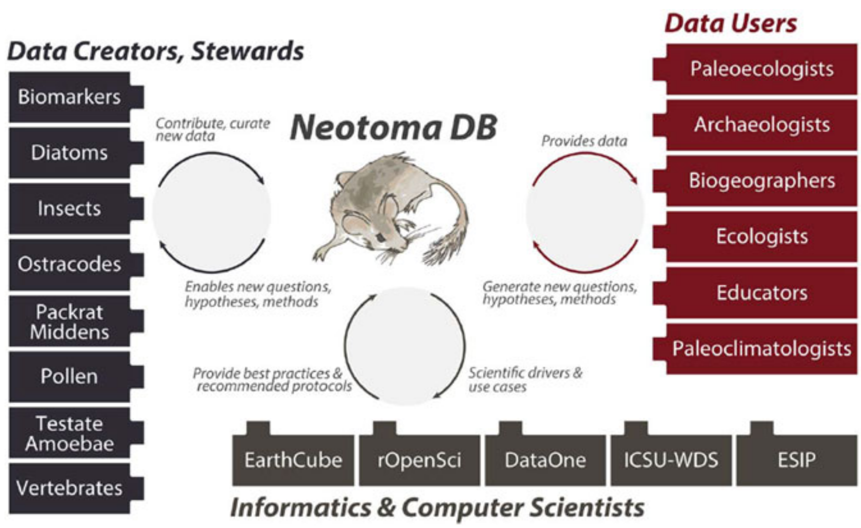
Williams, J.W., Grimm, E.C., Blois, J.L., Charles, D.F., Davis, E.B., Goring, S.J., Graham, R.W., *et al*. 2018. The Neotoma Paleoecology Database, a multiproxy, international, community-curated data resource. *Quaternary Research* 89, 156–177. *Cited 25 times*.

ABSTRACT The Neotoma Paleoecology Database is a community-curated data resource that supports interdisciplinary global change research by enabling broad-scale studies of taxon and community diversity, distributions, and dynamics during the large environmental changes of the past. By consolidating many kinds of data into a common repository, Neotoma lowers costs of paleodata management, makes paleoecological data openly available, and offers a high-quality, curated resource. Neotoma's distributed scientific governance model is flexible and scalable, with many open pathways for participation by new members, data contributors, stewards, and research communities. The Neotoma data model supports, or can be extended to support, any kind of paleoecological or paleoenvironmental data from sedimentary archives. Data additions to Neotoma are growing and now include >3.8 million observations, >17,000 datasets, and >9200 sites. Dataset types currently include fossil pollen, vertebrates, diatoms, ostracodes, macroinvertebrates, plant macrofossils, insects, testate amoebae, geochronological data, and the recently added organic biomarkers, stable isotopes, and specimen-level data. Multiple avenues exist to obtain Neotoma data, including the Explorer map-based interface, an application programming interface, the neotoma R package, and digital object identifiers. As the volume and variety of scientific data grow, community-curated data resources such as Neotoma have become foundational infrastructure for big data science.



Neotoma serves many communities and acts as a boundary organization (Guston, 2001) among these communities. Neotoma serves paleoecologists by providing a high-quality repository for their paleoecological data, with value added via digital object identifiers to facilitate data citation, data curation, and a flexible data model. Neotoma serves data users by providing a wellstructured, open-access, and easy-to-use source of paleoecological data, specializing in time scales that bridge the boundary between global change ecology and geology (Jackson and Hobbs, 2009; Dietl and Flessa, 2011; Betancourt, 2012; Jackson and Blois, 2015; Kidwell, 2015; Jackson, in press). In return, these communities generate new questions and analytical approaches for paleoecological data. Neotoma serves educators, students, and the general public seeking to learn about the past distributions of charismatic species such as the Pleistocene megafauna and the effects of climate change on species distribution and diversity. Neotoma also serves as a boundary organization between geoscientists and computer scientists, passing data, new research questions, best practices and protocols, and geoscientific use cases and priorities.