Università degli Studi di Ferrara

ANTROPOLOGIA

Lezione 4
Anno accademico 2019/2020

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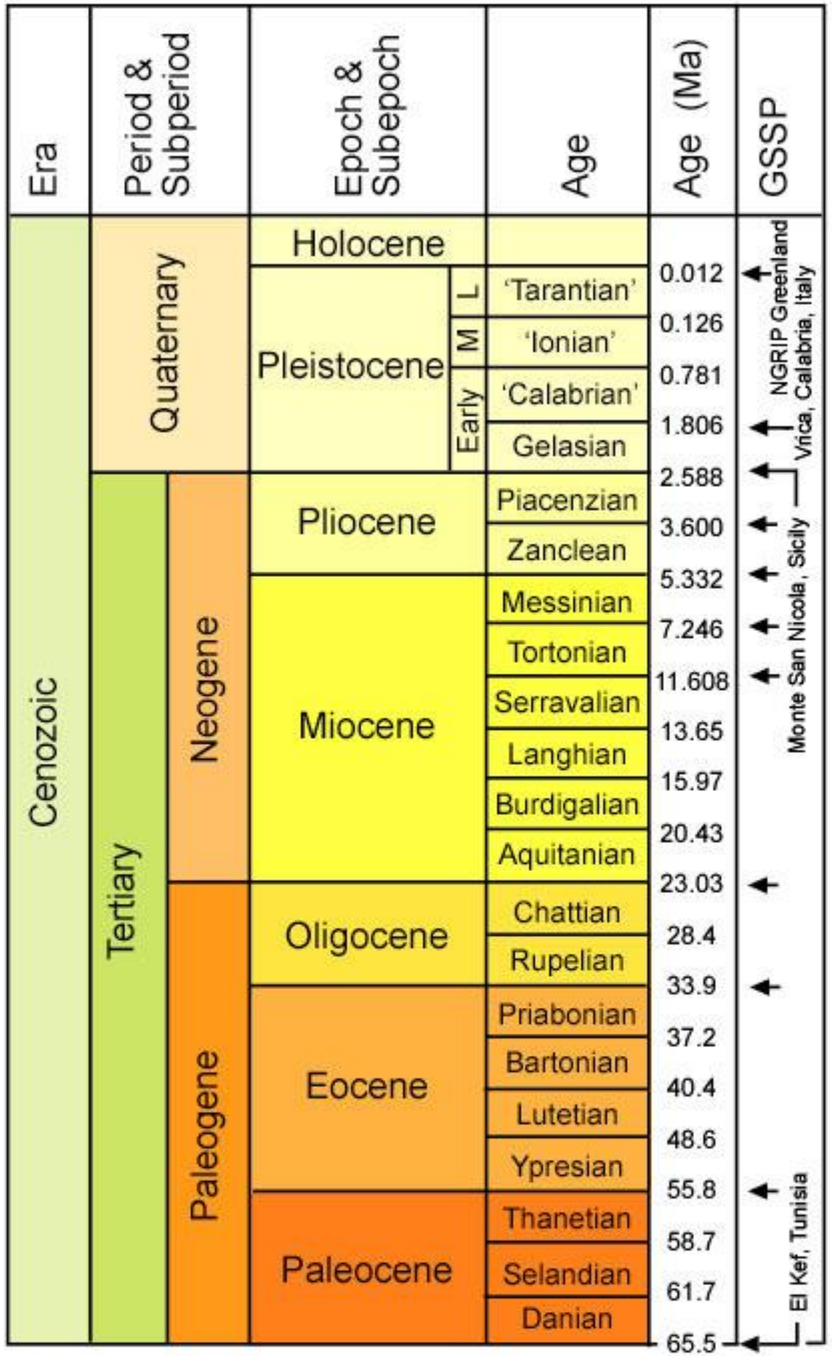
CRONOLOGIA DEL QUATERNARIO

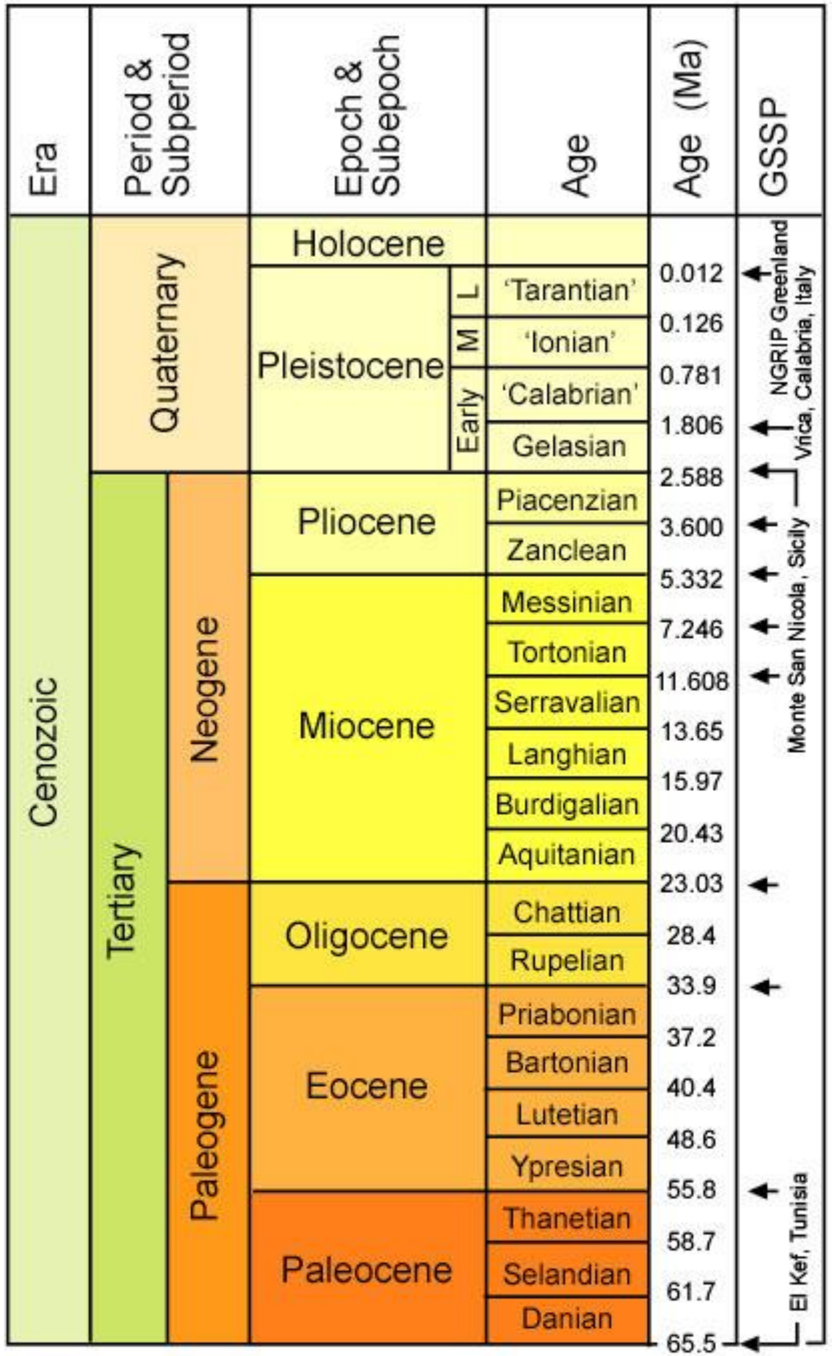


Subcommission of Quaternary Stratigrphy, 2009

If we compare the duration of Quaternary times to that of the Earth's history (scaled on a one year cycle), Quaternary times should have begun on December 31st, at c. 8,30 pm

Il Quaternario è l’era geologica attuale, caratterizzata da una grande mobilità e dinamicità dei fenomeni fisici e biologici.

Questa mobilità è attestata da numerosi cambiamenti, molto rapidi alla scala dei tempi geologici, degli equilibri naturali. In particolare, importanti variazioni si sono prodotte a livello climatico ed hanno determinato la fluttuazione delle nicchie ecologiche della maggior parte delle specie animali e vegetali.



The Quaternary is a subdivision of geological time (the Quaternary Period) which covers the last two million years up to the present day. (The exact duration is a matter of debate with estimates of the onset of the Quaternary Period placed at between 1.8 million years and 2.6 million years by different authors). **The Quaternary and the Tertiary Periods together form the Cenozoic Era**. The Quaternary can be subdivided into two epochs; the Pleistocene (two million years to ten thousand years ago) and the Holocene (ten thousand years ago to the present day).

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si difficile à préciser, quant au nombre, aux limites et aux équivalens, rentrerait plus ou moins dans l'esprit des grands travaux déjà publiés sur ces terrains, et je ne prétends pas y introduire de distinctions nouvelles ; je dirai seulement que *ces bassins ne contiendraient*, selon moi, *que les terrains tertiaires d'âge ancien et d'âge moyen*, dépôts inégalement répandus dans d'autres bassins, où se sont formées des couches plus récentes (bassins de la Loire, de la Gironde, de l'Hérault, du Rhône, d'Italie, etc.). Ce que je désirerais surtout prouver, c'est que la série des terrains tertiaires s'est prolongée, et même a commencé dans des bassins plus nouveaux, long-temps peut-être après que celui de la Seine a été entièrement comblé, et que ces formations postérieures, *Quaternaires* (1) pour ainsi dire, ne doivent pas plus conserver le nom d'alluvions que les vrais et anciens terrains tertiaires, dont il faut également les distinguer.

Terrains tertiaires plus récens que ceux du bassin de la Seine.

L'admission du principe contraire comme loi générale, et l'entrainement à identifier, formation à formation, avec les types du bassin de la Seine, les terrains tertiaires observés en d'autres contrées, semblent sur-

(1) Cette expression n'est employée ici que pour abréger et non point pour établir une limite tranchée entre ces terrains tertiaires récens et les terrains tertiaires plus anciens, jusqu'ici reconnus ; limite qui ne me semble pas exister, et qui peut-être même serait plus complète entre le groupe inférieur et le groupe moyen des terrains plus récens que ceux de la Seine. La crainte de voir mal comprise, ou exagérée, mon opinion à cet égard, m'a fait renoncer au mot *quaternaires*, que j'avais d'abord voulu appliquer à tous les terrains plus récens que ceux du bassin de la Seine.

Desnoyer, 1829

Quaternary represent "post-tertiary" times

(171)

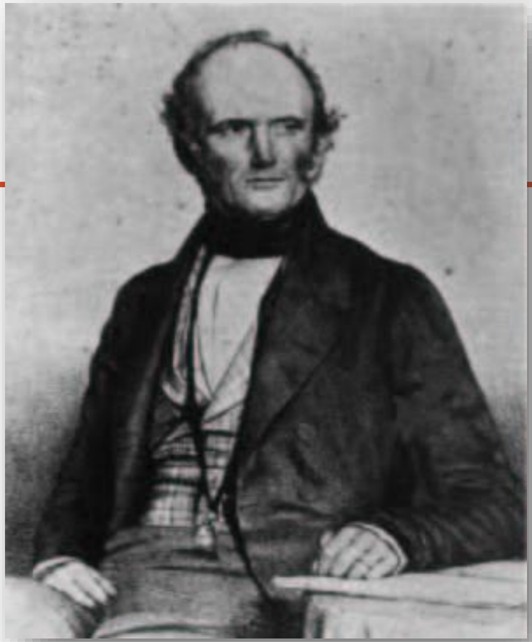
OBSERVATIONS *sur un ensemble de dépôts marins plus récens que les terrains tertiaires du bassin de la Seine, et constituant une* Formation géologique *distincte ; précédées d'un* APERÇU de la non simultanéité des bassins tertiaires ;

PAR M. J. DESNOYERS.

L'étude spéciale des terrains tertiaires du bassin de la Loire, compris entre la Sologne et la mer, m'avait depuis plusieurs années convaincu que ces terrains marins étaient non-seulement plus nouveaux que la formation du Calcaire grossier de Paris, mais plus nouveaux encore que la formation marine postérieure au Gypse. J'exprimai brièvement cette opinion dans un Mémoire sur les terrains tertiaires du Cotentin, et je concluais dès-lors, de l'examen comparatif des fossiles et des roches, qu'une *partie de ces terrains du Cotentin, ceux de la Loire, une grande partie de ceux du Rhône, les sables supérieurs des collines subapennines, certains calcaires de la Sicile, de l'Autriche, de la Hongrie, paraissaient constituer, avec le* CRAG *d'Angleterre, la formation tertiaire la plus moderne.* (*Mém. Soc. d'Hist. nat. de Paris*, t. 2, 1825, p. 238.)

Depuis, toutes les observations nouvelles que j'ai pu recueillir soit sur le même bassin, soit sur des bassins analogues, m'ont de plus en plus convaincu que ces dépôts appartenaient à une période particulière, à une grande formation très-répandue en Europe, et cependant à peine connue et non caractérisée.

Il termine Quaternario è stato creato nel 1829 da J. Desnoyer per definire i depositi marini successivi ai terrazzi terziari del bacino parigino. È nel 1833 che H. Reboul pubblica la prima "Geologia del Quaternario"; qualche anno dopo C. Lyell propone il termine Pleistocene per definire il periodo nel quale vengono collocate le principali glaciazioni. Il termine Olocene è stato creato nel 1967 da P. Gervais per indicare l'epoca postglaciale.



Lyell, 1839 (Principes of Geology)

Most of (70%) living species (molluscs) in London and Paris Basins disappear

Forbes, 1846

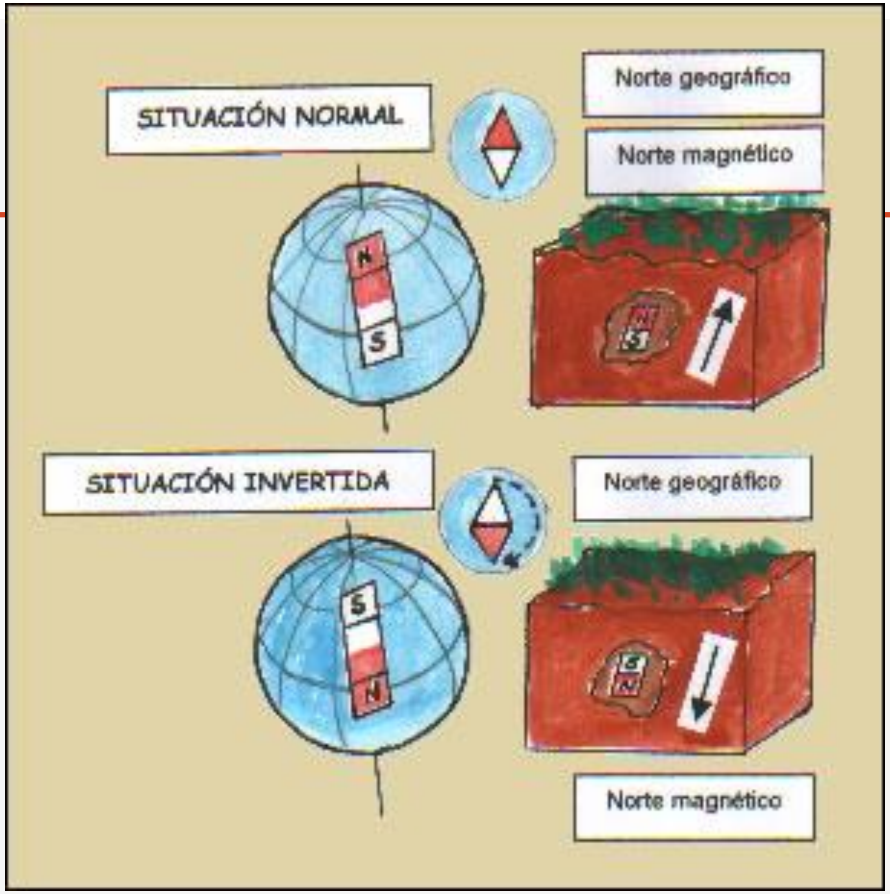
Pleistocene = “Galacial”

Present is an “interglacial”

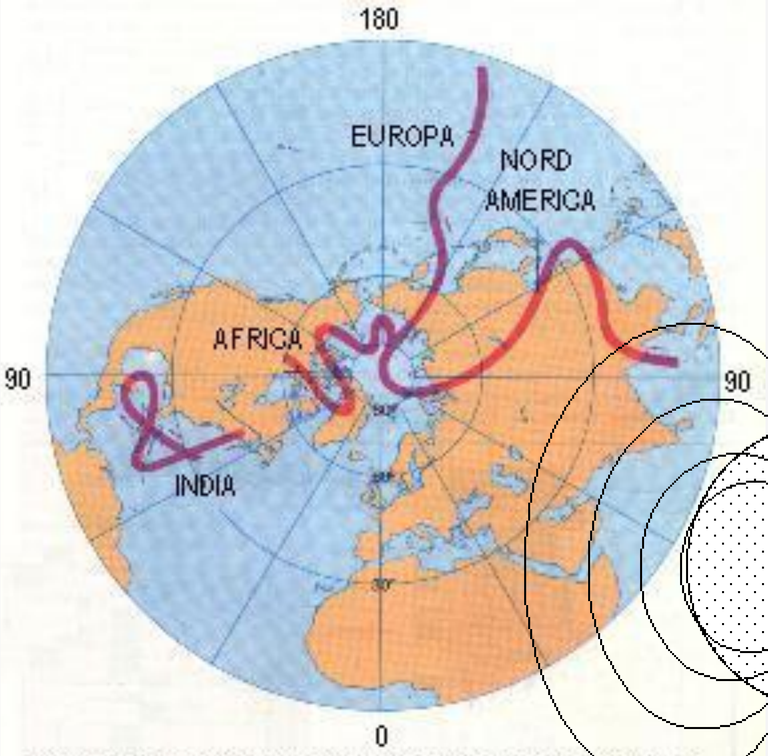
L'Illustration, 1909

The time of humans

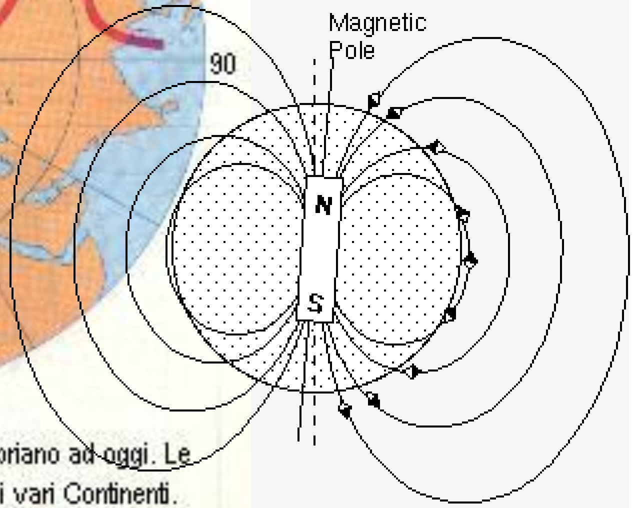
The time of ice

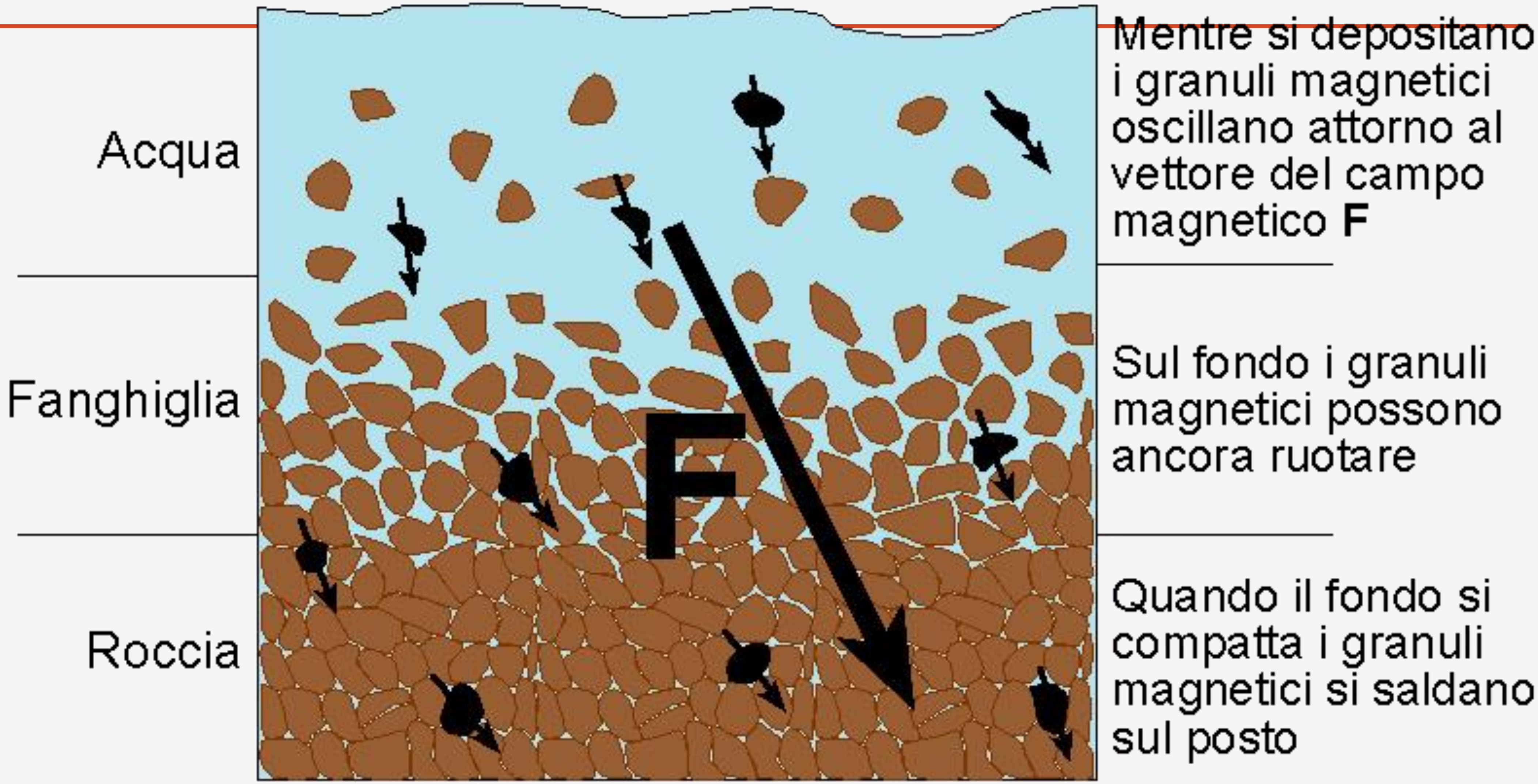


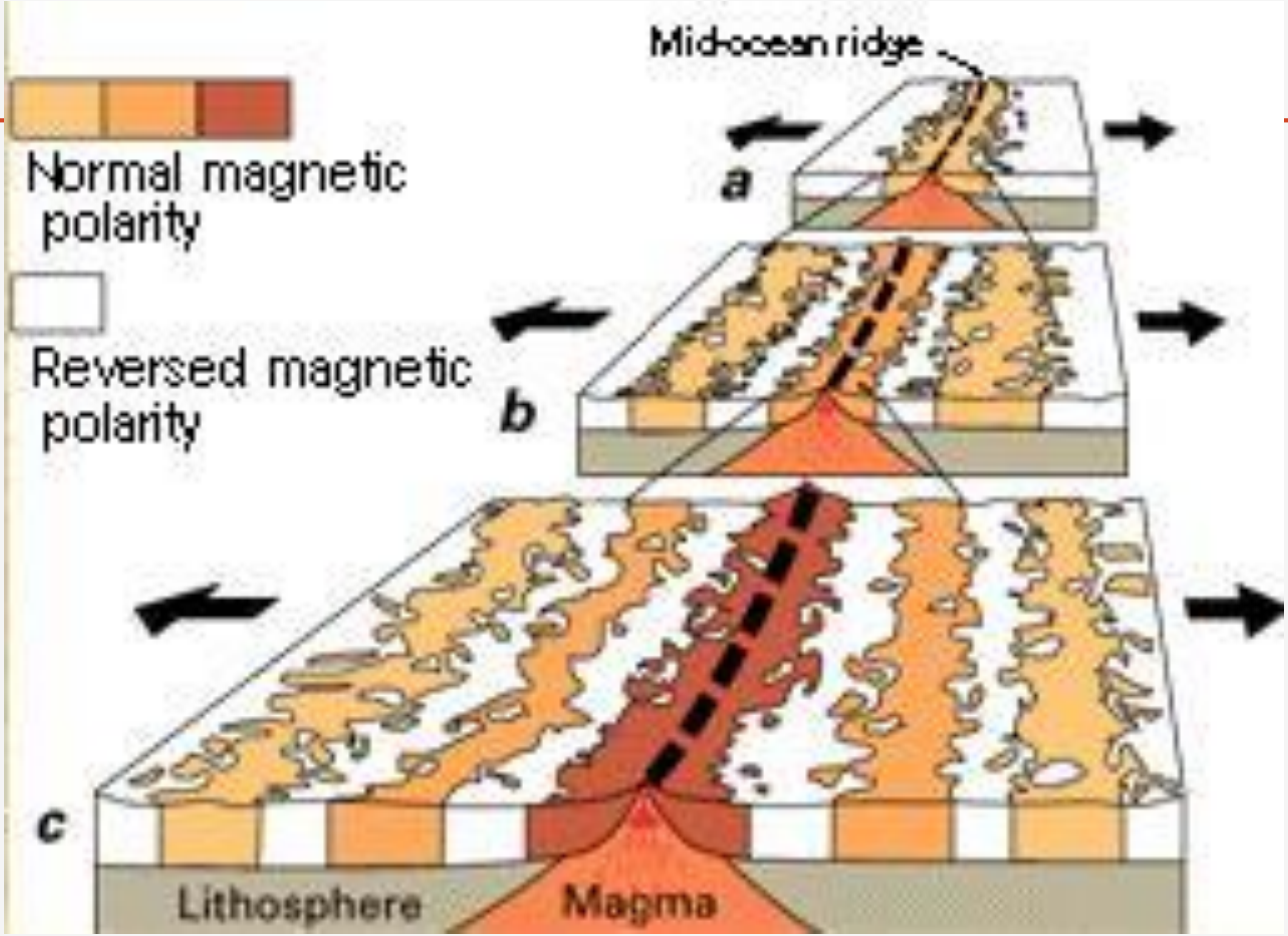
Il paleomagnetismo si occupa dello studio della magnetizzazione naturale delle rocce



Migrazioni apparenti del Polo Nord dal cambriano ad oggi. Le tracce indicano gli spostamenti relativi dei vari Continenti.




Acqua
Fanghiglia
Roccia
F
Mentre si depositano i granuli magnetici oscillano attorno al vettore del campo magnetico **F**
Sul fondo i granuli magnetici possono ancora ruotare
Quando il fondo si compatta i granuli magnetici si saldano sul posto


Mid-ocean ridge
Normal magnetic polarity
Reversed magnetic polarity
a
b
c
Lithosphere
Magma

In funzione delle variazioni climatiche il Pleistocene è stato presto diviso in tre parti: Pleistocene antico, medio e recente.
L'inizio del Quaternario veniva definito come Villafranchiano, termine creato nel 1865 da L. Pareto per definire i depositi lacustri e continentali del bacino piemontese di Villafranca d'Asti. In effetti il Villafranchiano interessa un periodo più lungo, comprendente anche il Pliocene. Allo stato attuale delle ricerche questo termine ha solo una valenza biostratigrafica e non cronologica.

Mastodon arvernensis, Elephas meridionalis, Rhinoceros etruscus, Equus stenonis

I limiti dei differenti piani del Quaternario sono leggermente variabili a seconda delle province geografiche, dei depositi considerati e dei criteri utilizzati.

Il problema più delicato è la definizione del **limite Terziario – Quaternario**. Climatologi, geologi e paleontologi ne hanno lungamente dibattuto. Ai congressi internazionali di geologia di Londra (1948), di Algeri (1952), di Mosca (1982) e di Ottawa (1987) era stato deciso che l'inizio del Quaternario sarebbe corrisposto al primo grande deterioramento climatico registrato in Europa circa **1,8 Ma**, testimoniato dall'arrivo degli "ospiti freddi" nel Mediterraneo. Nei successivi congressi di Pechino (1991) e di Berlino (1995) numerosi ricercatori hanno proposto di abbassare il limite a **2,4-2,6 Ma**, scelta dettata dalla convergenza di una serie di avvenimenti intorno a questa data: le variazioni climatiche divengono più rapide con un generale raffreddamento del clima, alcune specie floristiche e faunistiche terziarie spariscono in un breve lasso di tempo, importanti movimenti tettonici interessano diverse zone del globo.

https://quaternary.stratigraphy.org/majordivisions/

Following the International Geological Congress in 2004 in Florence, INQUA and ICS set up a task force to consider the issue. The task force was charged with making a recommendation, within one year, to ICS on the status of the Quaternary in the Geological Time Scale. It issued its report before a meeting of ICS in Leuven, Belgium, in September 2005. Its recommendation to ICS was as follows:

That the Quaternary should be recognized as a formal chronostratigraphic/ geochronological unit.

That the lower boundary of the Quaternary coincide with the base of the Gelasian Stage (2.6 Ma) and thus be defined by the Gelasian GSSP*.

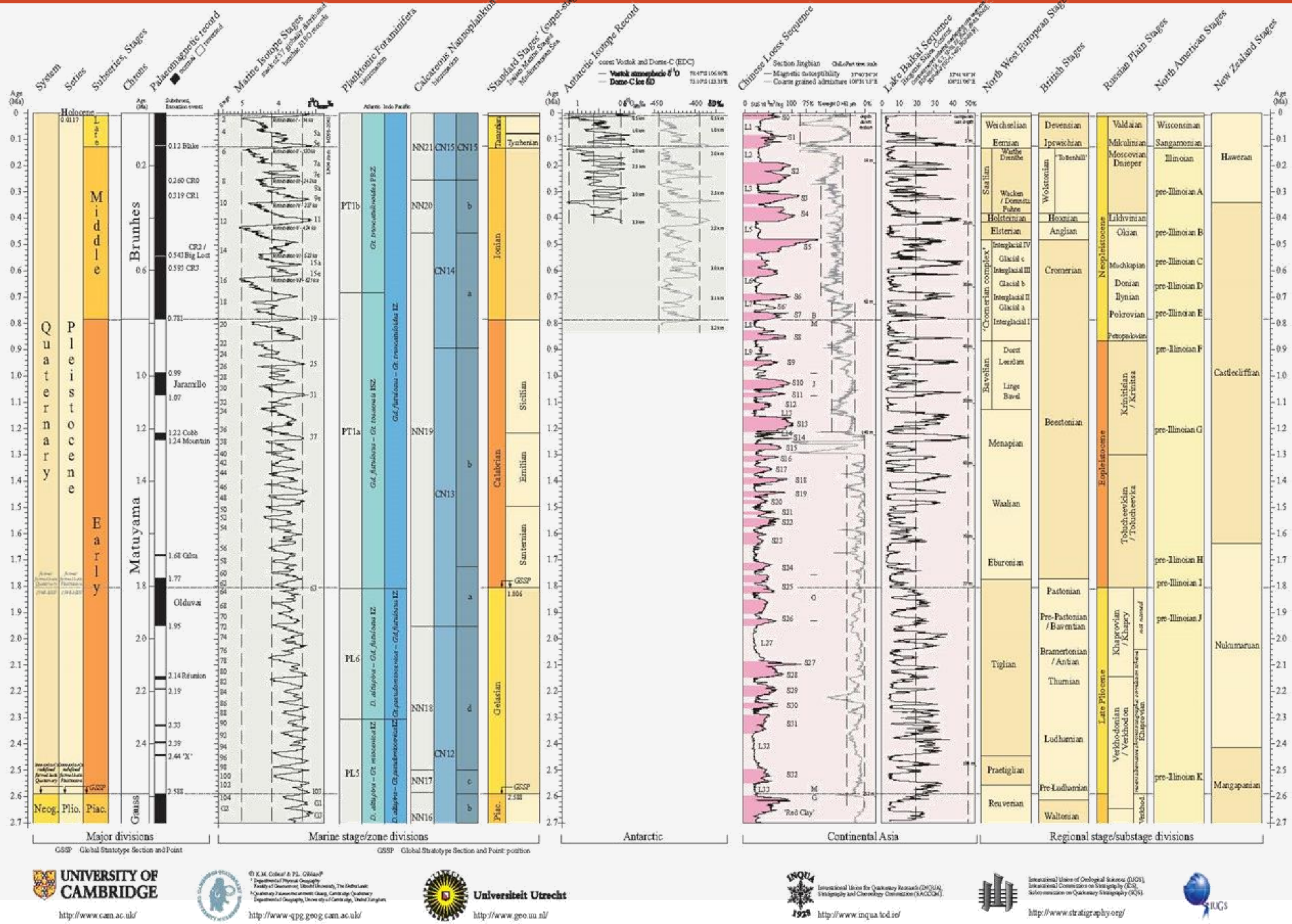
That the Quaternary will have the rank of either:

- System/Period at the top of the Neogene System/Period, with its lower boundary marking the top of a shortened Neogene, or
- Sub-Erathem/Sub-Era correlative with the upper part of the Neogene System/Period

**Global Stratigraphic Section and Point*

Global chronostratigraphical correlation table for the last 2.7 million years

v. 2011



The Quaternary is a Sub-Erathem/Sub-Era correlative with the upper part of the Neogene System/Period and with a lower boundary coincident with the base of the **Gelasian Stage** (2.6 Ma)

Pros:

Quaternary remains a formal chronostratigraphic/geochronologic unit.

Base of the Quaternary is pinned at 2.6 Ma.

ICS has accepted this option.

Cons:

The Quaternary is no longer a Period/System.

The base of the Quaternary and that of the Pleistocene are no longer the same (the base of the Pleistocene remains at 1.8 Ma; the base of the Quaternary becomes 2.6 Ma).

Gibbard *et al.* 2009

Definition of Pleistocene and Holocene

IUGS ratification of the Quaternary System/Period and the Pleistocene Series/Epoch with a base at 2.58 MA.

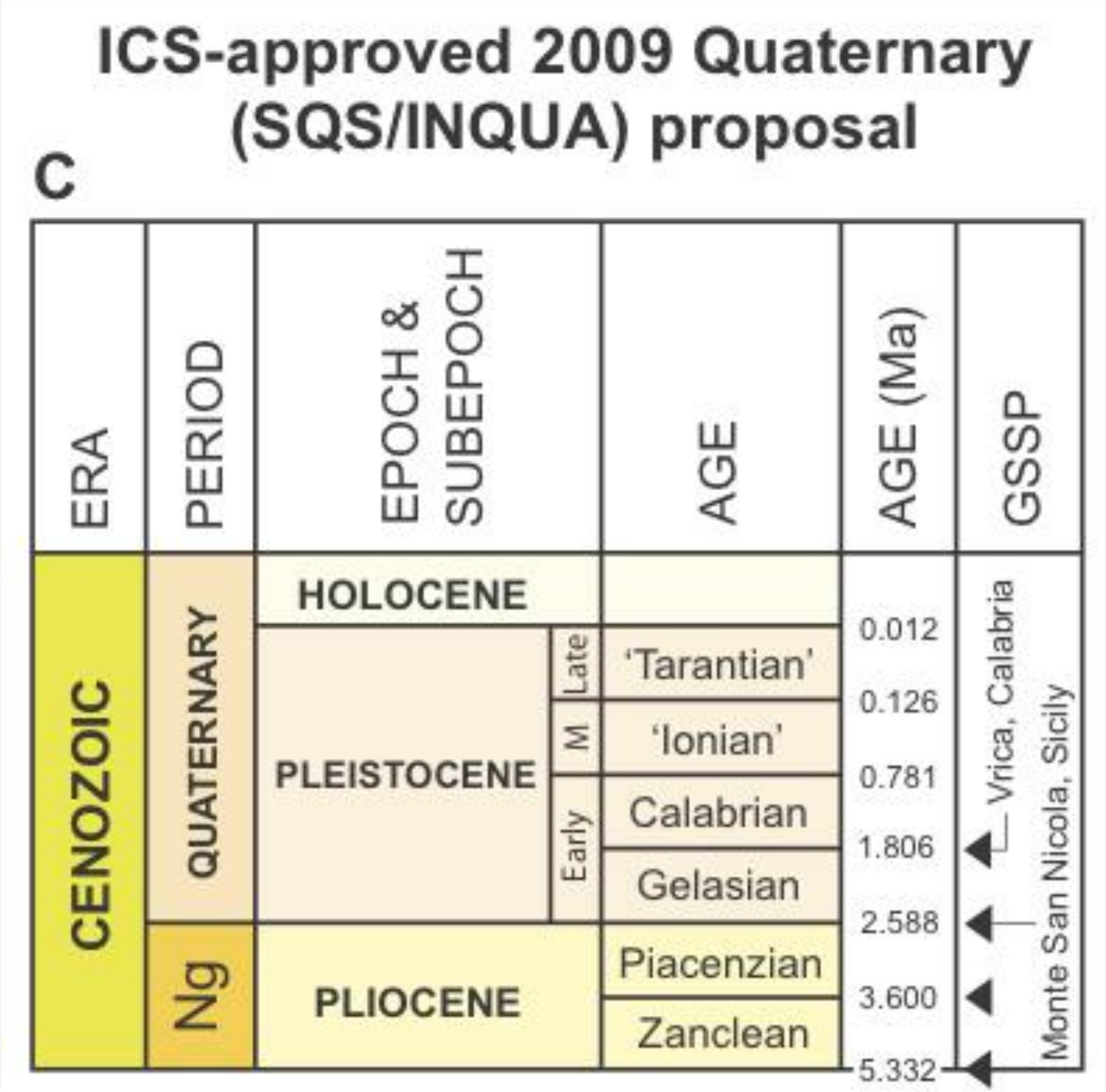
By

Gibbard, Ph. & Head, M J. *Quaternaire*, 20, (4), 2009, 411-412

ABSTRACT - The International Union for Geological Sciences (IUGS) on 29 June, 2009 ratified a proposal by the International Commission on Stratigraphy that the base of the Quaternary System/Period and the base of the Pleistocene Series/Epoch be lowered to that of the Gelasian Stage/Age. The Gelasian is transferred accordingly from the Pliocene to the Pleistocene. The Global Stratotype Section and Point at Monte San Nicola, Sicily, Italy, with an estimated age of 2.58 Ma, defines the lower boundary of the Gelasian, Pleistocene and Quaternary. Details of the ratification are given, and implications discussed.

https://quaternary.stratigraphy.org/definitions/

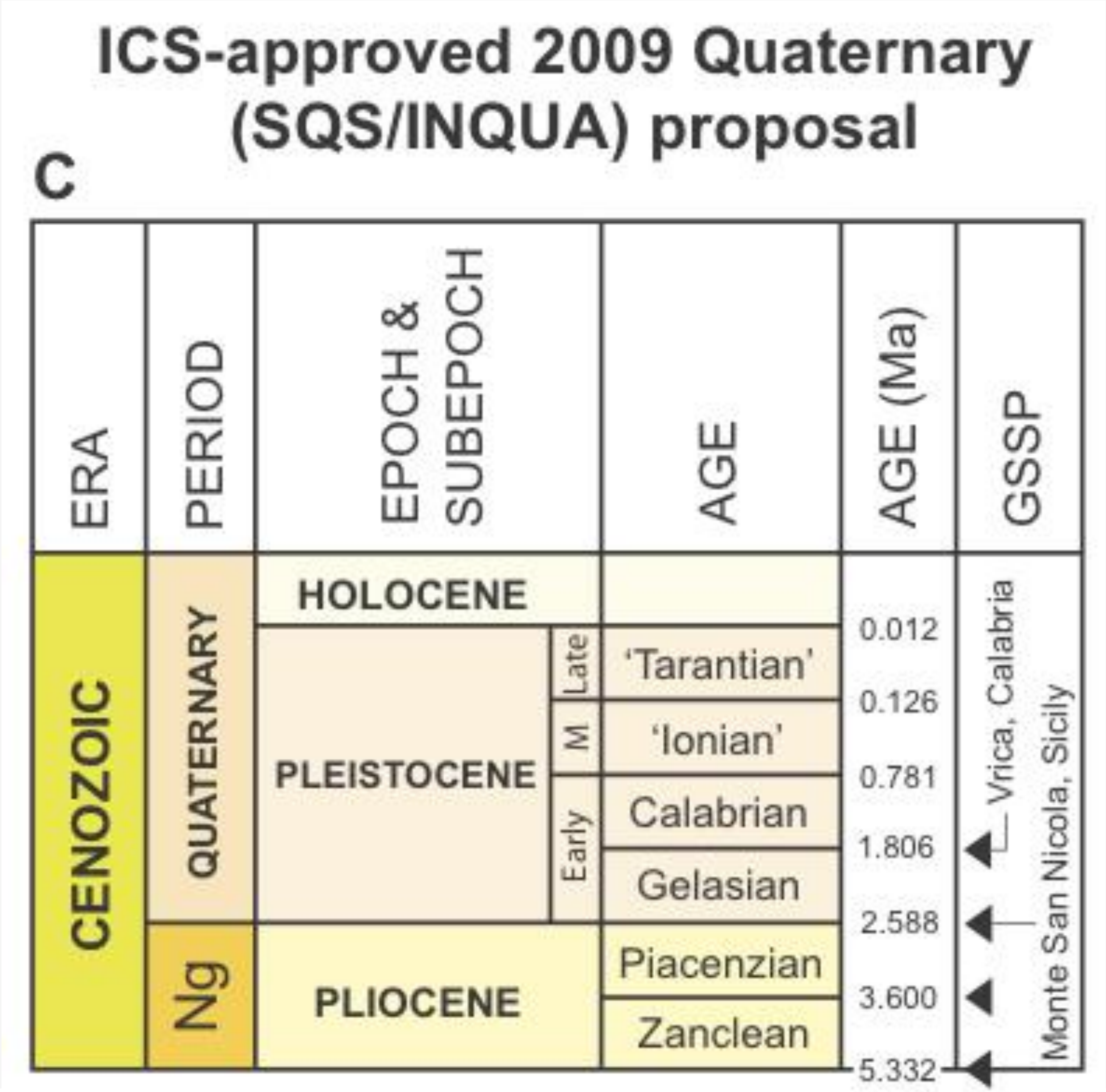
Formal subdivision of the Pleistocene Series/Epoch



The **beginning of the Middle Pleistocene** should be so defined as to either coincide with or be linked to the **Matuyama Reversed Epoch and the Brunhes Normal Epoch of palaeomagnetic chronology**. A similar recommendation was made by the INQUA Commission on Stratigraphy/ICS Working Group on Major Subdivision of the Pleistocene, at the XIIth INQUA Congress in Ottawa in 1987, which placed the Lower–Middle boundary at the Brunhes–Matuyama magnetic reversal. However, although potential GSSP's in Japan, Italy and New Zealand were discussed, no decision was reached. It was also advocated the Matuyama-Brunhes boundary (MBB), emphasising that it constituted the most recognisable chronostratigraphic marker in weathered continental deposits.

https://quaternary.stratigraphy.org/definitions/pleistocenesubdivision/

Formal subdivision of the Pleistocene Series/Epoch

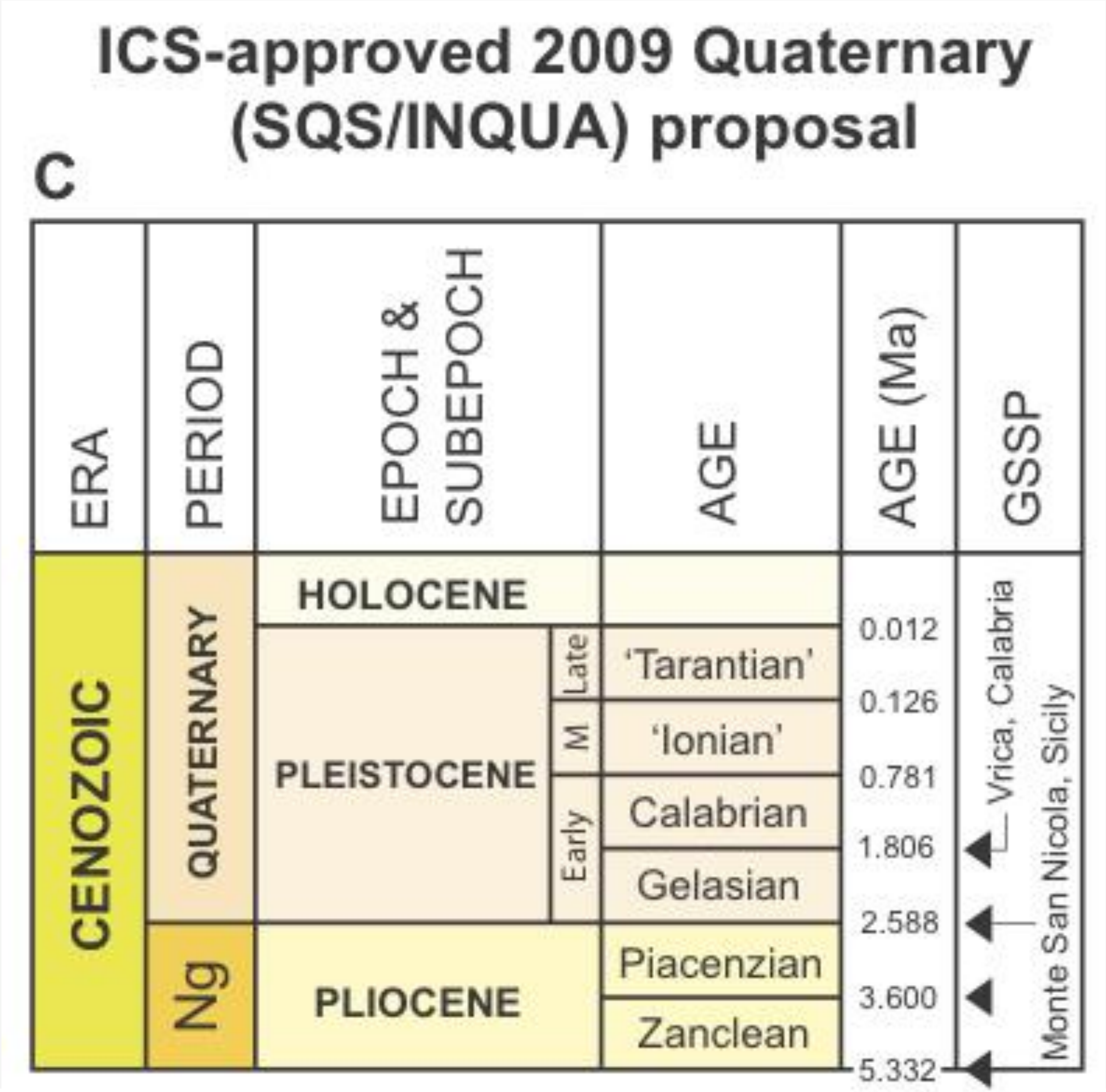


The boundary between the **Middle and Upper Pleistocene has yet to be formally defined by IUGS**. However, as long ago as the 2nd INQUA Congress in Leningrad in 1932, a decision was made to to define the boundary at the base of the Last Interglacial (Eemian Stage). More recently, the lower boundary of the Upper Pleistocene has been placed **at the base of Marine Isotope Stage 5 (MIS 5), based on a proposal from the INQUA Commission on Stratigraphy**. This proposal naturally follows from the acceptance that MIS 5, substage e, is the ocean equivalent of the terrestrial northwest European Eemian Stage interglacial. Detailed pollen analyses of deep sea cores west of Portugal have shown that the base of MIS 5 is some 6 ka earlier than the base of the Eemian. Consequently, it has been proposed that, in keeping with the historical association of the boundary with the base of the Eemian, the GSSP should be defined in a high-resolution core sequence from the Amsterdam Terminal – which is both the parastratotype and unit-stratotype of the Eemian Stage.

An age of 127.2 ka is estimated for the base of the Eemian from a varved-dated record at Monticchio, in Italy.

https://quaternary.stratigraphy.org/definitions/pleistocenesubdivision/

Formal subdivision of the Pleistocene Series/Epoch



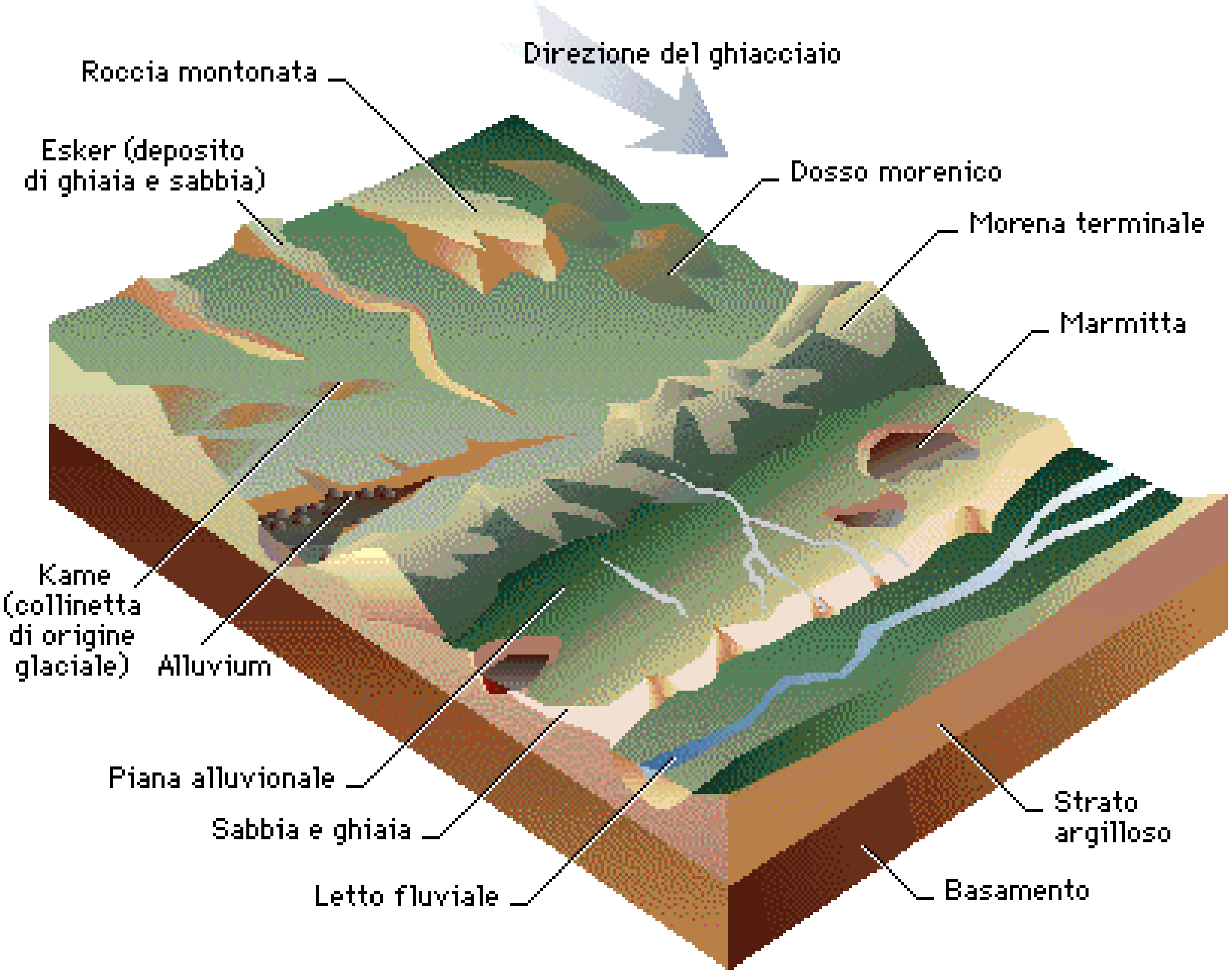
The working group on the Holocene GSSP published their proposed definition in the NGRIP Greenland ice core, in the *Journal of Quaternary Science (2009, Vol 24, p. 3-17)*:
by
Mike Walker, et al.

ABSTRACT - The Greenland ice core from NorthGRIP (NGRIP) contains a proxy climate record across the Pleistocene-Holocene boundary of unprecedented clarity and resolution. Analysis of an array of physical and chemical parameters within the ice enables the base of the Holocene, as reflected in the first signs of climatic warming at the end of the Younger Dryas/Greenland Stadial 1 cold phase, to be located with a high degree of precision. This climatic event is most clearly reflected in an abrupt shift in deuterium excess values, accompanied by more gradual changes in 18O, dust concentration, a range of chemical species, and annual layer thickness. A timescale based on multi-parameter annual layer counting provides an age of 11 700 calendar yr b2 k (before AD 2000) for the base of the Holocene, with a maximum counting error of 99 yr. A proposal that an archived core from this unique sequence should constitute the Global Stratotype Section and Point (GSSP) for the base of the Holocene Series/Epoch (Quaternary System/Period) has been ratified by the International Union of Geological Sciences. Five auxiliary stratotypes for the Pleistocene-Holocene boundary have also been recognised.
(c) *Walker et al. 2009, Journal of Quaternary Science, 24, p. 3-17, John Wiley & Sons, Ltd.* Digital Object Identifier (DOI) 10.1002/jqs.1227

Nel 1905 E. Bruckner e A. Penck definirono quattro glaciazioni successive sulla base delle formazioni fluvio-glaciali delle Alpi Bavaresi, che denominarono <u>Günz, Mindel, Riss, Würm</u> (nomi di quattro affluenti del Danubio). Successivamente due glaciazioni più antiche furono aggiunte a questo modello: <u>Biber e Donau</u>. Queste fasi fredde sono intercalate da fasi temperate, dette interglaciali e designate dai nomi delle glaciazioni tra cui sono comprese.

Tuttavia, a parte l'ultima glaciazione caratterizzata in modo più preciso, questo modello è controverso poiché si basa esclusivamente sulla granulometria e sulla morfometria dei sedimenti. Inoltre esso pone seri problemi di datazione dovuti in primo luogo all'alterazione dei sedimenti, e all'avanzata delle morene frontali (deposito grossolano deposto al fronte di un ghiacciaio) che, in alcuni casi, hanno completamente obliterato le tracce di raffreddamenti anteriori.

La cronologia alpina così definita viene utilizzata ancora attualmente in archeologia, benché la stratigrafia isotopica permetta di avere una scala cronologica più precisa ed ubiquitaria.


Roccia montonata
Direzione del ghiacciaio
Esker (deposito
di ghiaia e sabbia)
Dosso morenico
Morena terminale
Marmitta
Kame
(collinetta
di origine
glaciale)
Alluvium
Piana alluvionale
Sabbia e ghiaia
Letto fluviale
Strato
argilloso
Basamento

ALPINE	N. EUROPE	ENGLAND
WÜRM	Weichsel	Weichsel
Riss-Wurm	Eem	Ipswich
RISS	Warthe	Gipping
Mindel-Riss	Saale/Warthe	Hoxne
MINDEL	Saale	Lowestoft
Gunz-Mindel	Holstein	Cromer
GUNZ	Elster	Beeston
	Cromerian	Paston
	Menapian	Baventian

Central North American "Midwestern" Glacial Chronology

	WISCONSIN	
SANGEMON		(Co. Ill.)
	ILLINOIAN	
YARMOUTH		(Iowa)
	KANSAN	
AFTONIAN		(Afton Junction, Iowa)
	NEBRASKAN	

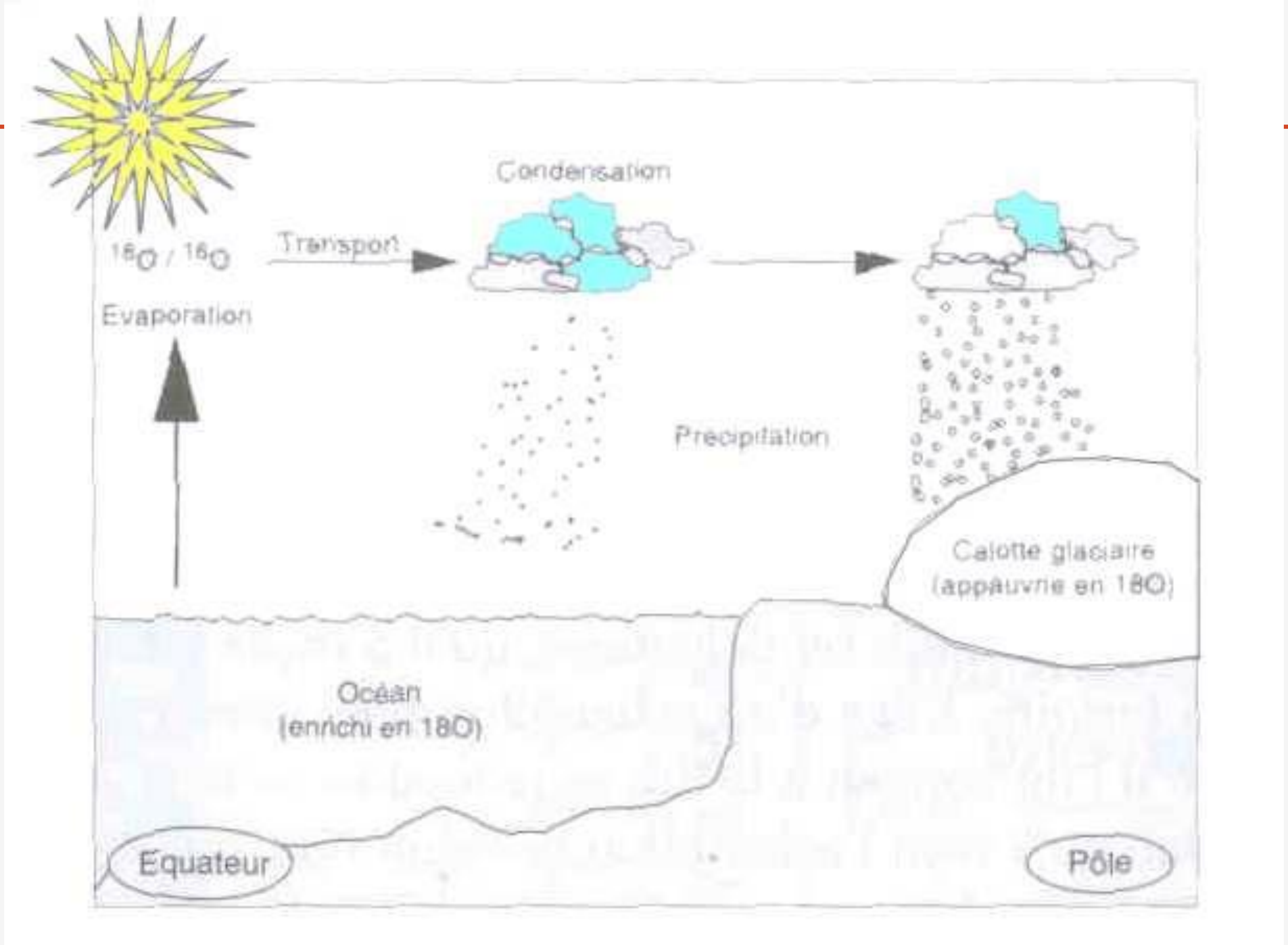
CRONOLOGIA ISOTOPICA

Il frazionamento che avviene negli oceani di isotopi pesanti e leggeri dell'ossigeno nell'acqua, nel biossido di carbonio e nel carbonato di calcio, dipende dalla temperatura e dalla salinità. Misure dei rapporti isotopici in test carbonatici sui foraminiferi fossili permettono una valutazione della temperatura del mare e del volume degli oceani, ambedue corrispondenti a variazioni del volume delle coperture glaciali e dei ghiacciai. I rapporti isotopici del ghiaccio danno un quadro della temperatura media dell'aria. Oggi si ha una documentazione continua comprendente quasi tutto il Quaternario.

C. Emiliani (1955) proposed a chronology for the history of Pleistocene fluctuations of the ratio of $^{18}O/^{16}O$ in the tests of foraminifera (more ^{18}O during glacials). Measured relative to arbitrary standard. Positive indicates grater than standard. More positive (= less negative) values indicate colder, BUT positive delta ^{18}O values occur only in coldest periods.

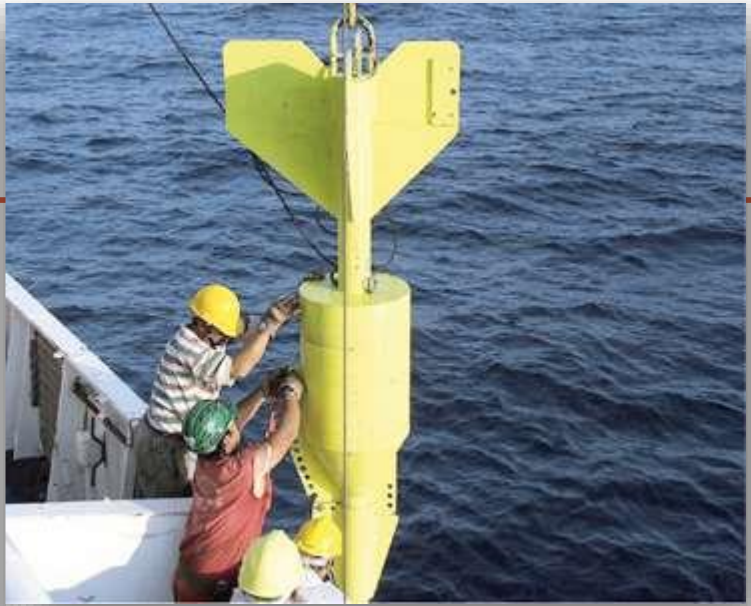
Two causes were initially proposed for $^{18}O/^{16}O$ fluctuations:
a. Biological **fractionation** in foram tests (Emiliani favored) 18O/16O ratio in living forams increases 0.023 % C-1 (colder = more 18O)
b. 18O **enrichment** in oceans because 16O deposited in continental glaciers.
More ice = more 18O left in ocean (Shackleton, 1967)

http://www.geo.arizona.edu/palynology/geos462/06ocencore.html



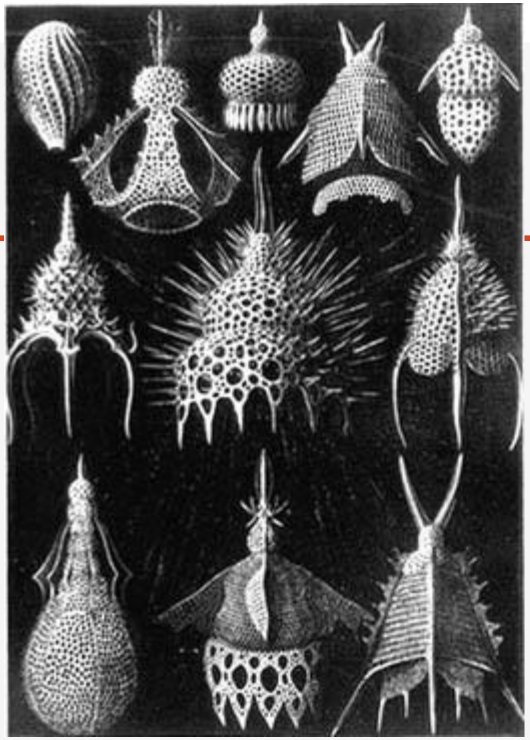
Modificato da «Histoire d'Ancetres»


5
4
National Geophysical Data Center NOAA
http://www.ngdc.noaa.gov/paleo/slides.html

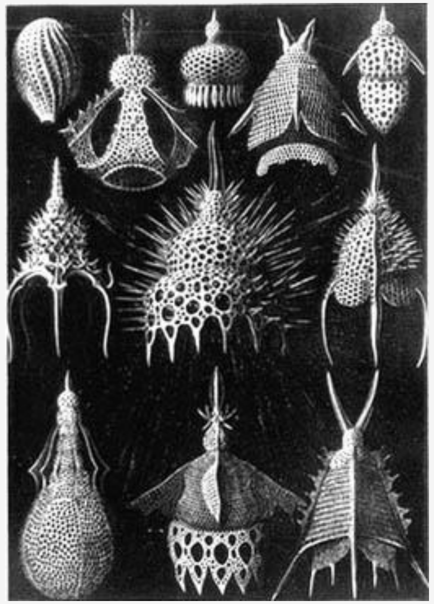


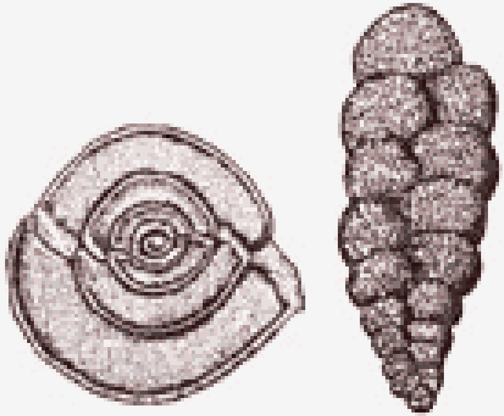
FORAMINIFERI

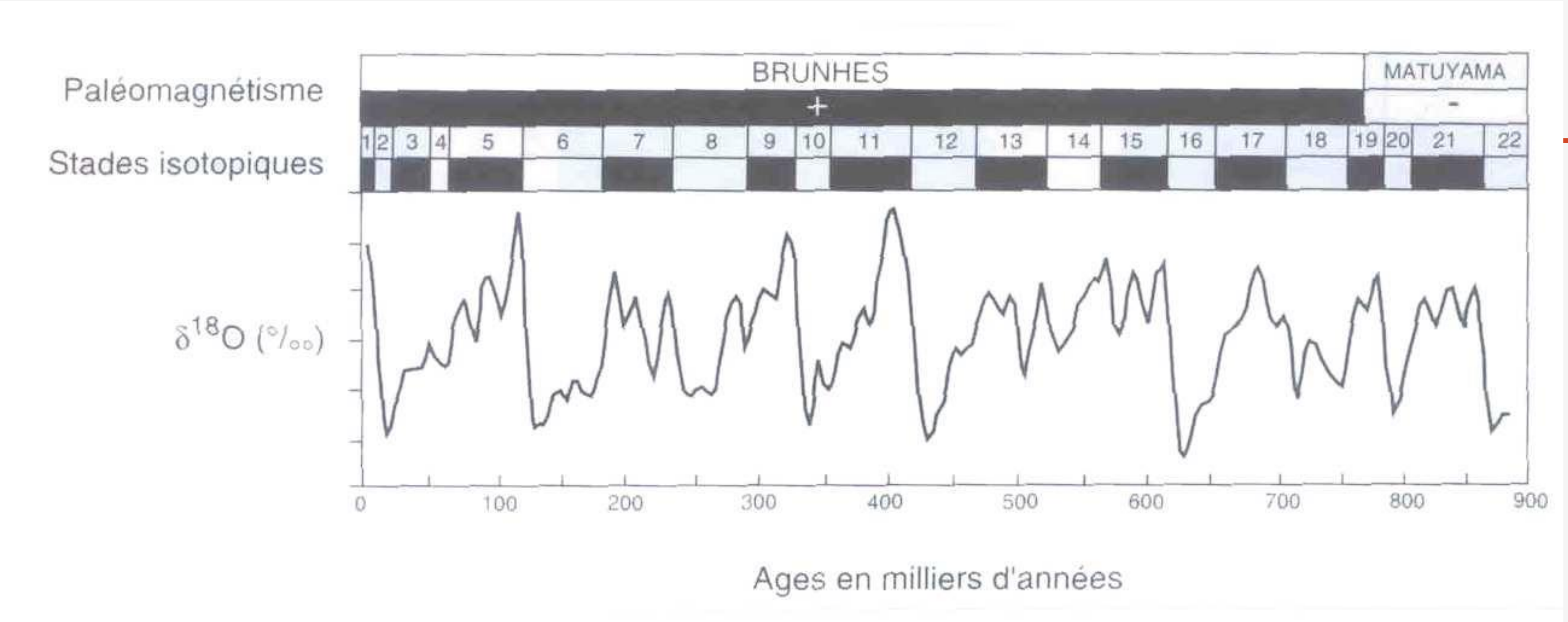
Ordine di Protozoi Sarcodini. Di origini antichissime, sono considerati utili fossili guida, specie nella ricerca di formazioni petrolifere. Hanno guscio calcareo con numerosi fori da cui escono i sottilissimi pseudopodi. Sono quasi tutti marini e i loro gusci formano negli abissi oceanici ingenti depositi (fango a Foramminiferi). Tra i generi viventi: *Globigerina, Rotalia, Textularia*; tra i fossili, le grandi Nummuliti.

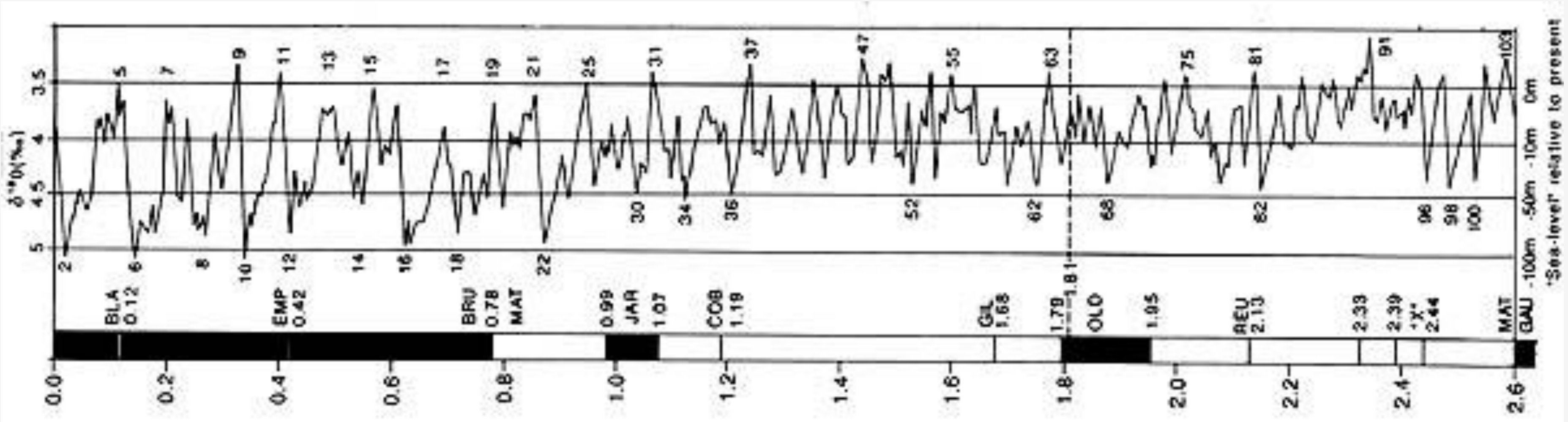


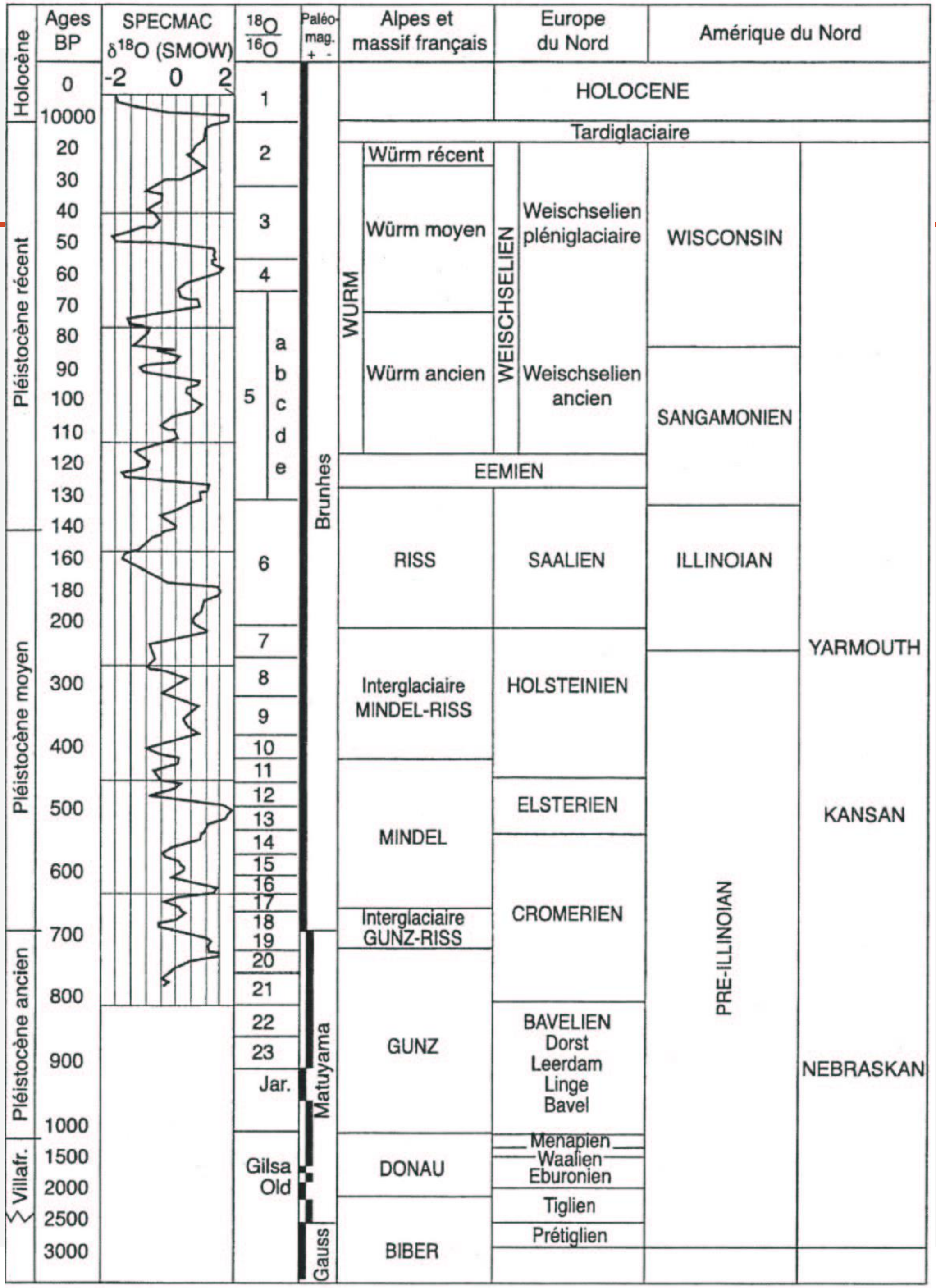
RADIOLARI – Impalcatura silicea






Paléomagnétisme
BRUNHES
MATUYAMA
+
-
Stades isotopiques
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
δ18O (°/oo)
0 100 200 300 400 500 600 700 800 900
Ages en milliers d'années


BLA 0.12
EMP 0.42
BRU 0.78
MAT
0.99
JAR 1.07
COB 1.19
OLO
REU 2.13
GAU
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6
"Sea-level" relative to present

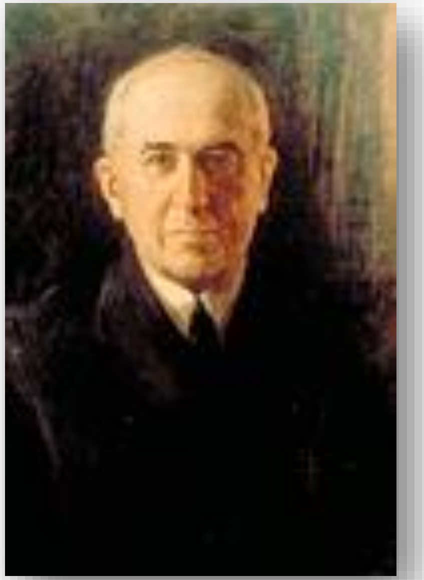


Such continental
(and more or less continue)
chronologies are correlated to the
isotopic marine chronology

TEORIA ASTRONOMICA DEL CLIMA

CALIBRAZIONE ASTRONOMICA

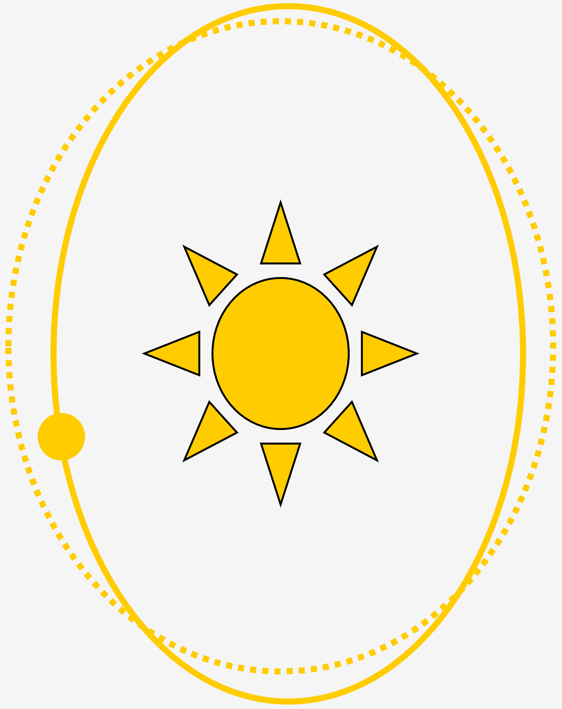
*Proposta nel 1924 da Milankovich: **LE VARIAZIONI DEI DIFFERENTI PARAMETRI ORBITALI**, MODIFICANDO L'INSOLAZIONE RICEVUTA DALLA TERRA, **SONO ALL'ORIGINE DEI GRANDI CICLI CLIMATICI CHE CARATTERIZZANO IL QUTERNARIO***



- Durante i periodi glaciali, le calotte glaciali dell'emisfero nord ricevono un minimo di irraggiamento solare che non consente alle nevi polari di sciogliersi.
- L'aumento dell'albedo conseguente induce l'amplificazione del fenomeno conducendo al progressivo allargarsi dei ghiacci.

IL CALCOLO DELLA DISTRIBUZIONE STAGIONALE E GEOGRAFICA DELL'INSOLAZIONE, SECONDO M., DIPENDE PRINCIPALMENTE DA TRE PARAMETRI ORBITALI

Variazione dell'eccentricità dell'orbita terrestre

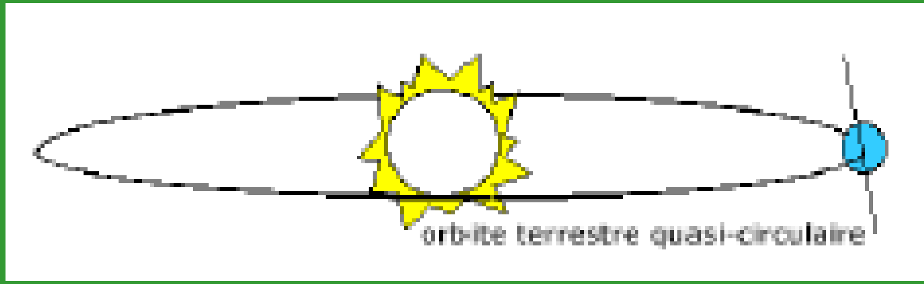


Ciclo di 100.000 a 400.000 anni

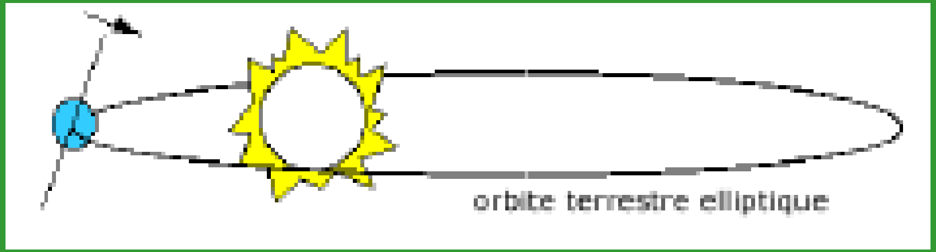
Modifica la distanza media, annuale tra Sole e Terra

Energy received at Northern Latitudes during summer

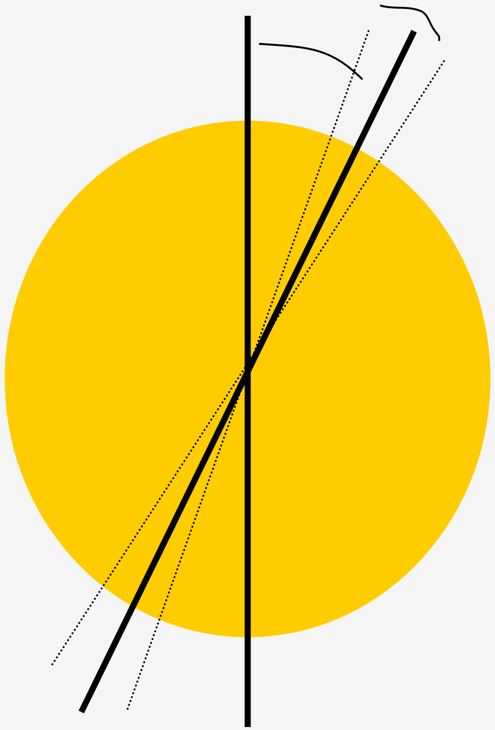
Glacial configuration



Interglacial configuration



Variazione dell’obliquità



22°- 25°

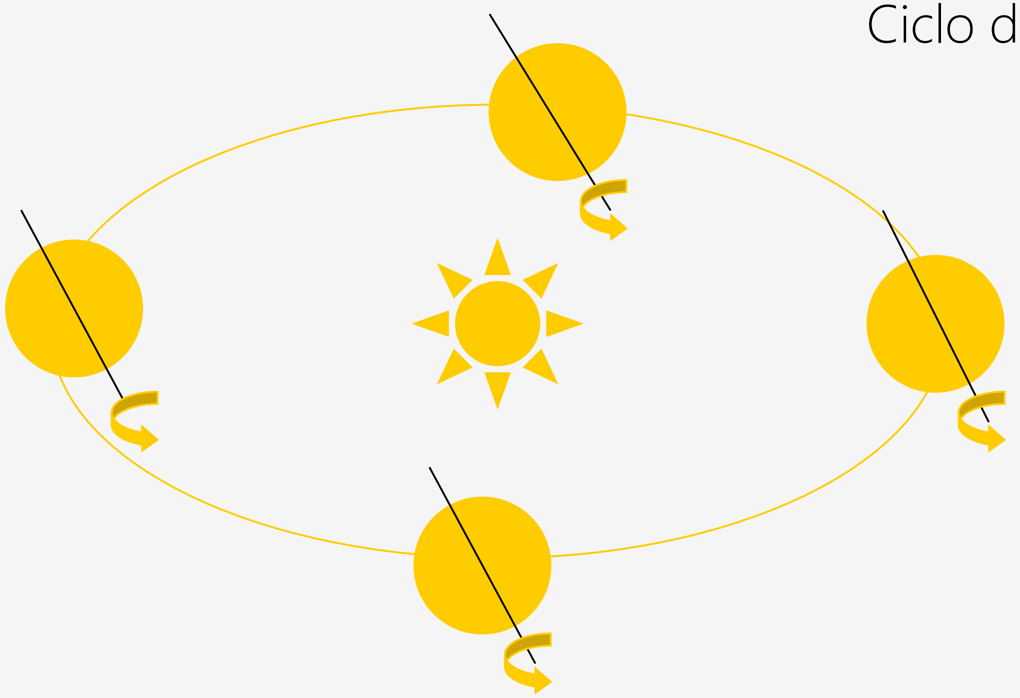
Ciclo di 41.000 anni

Quando l’inclinazione è massima, le zone polari ricevono un’insolazione più forte; ne deriva un contrasto stagionale più marcato, caratteristico dei periodi interglaciali

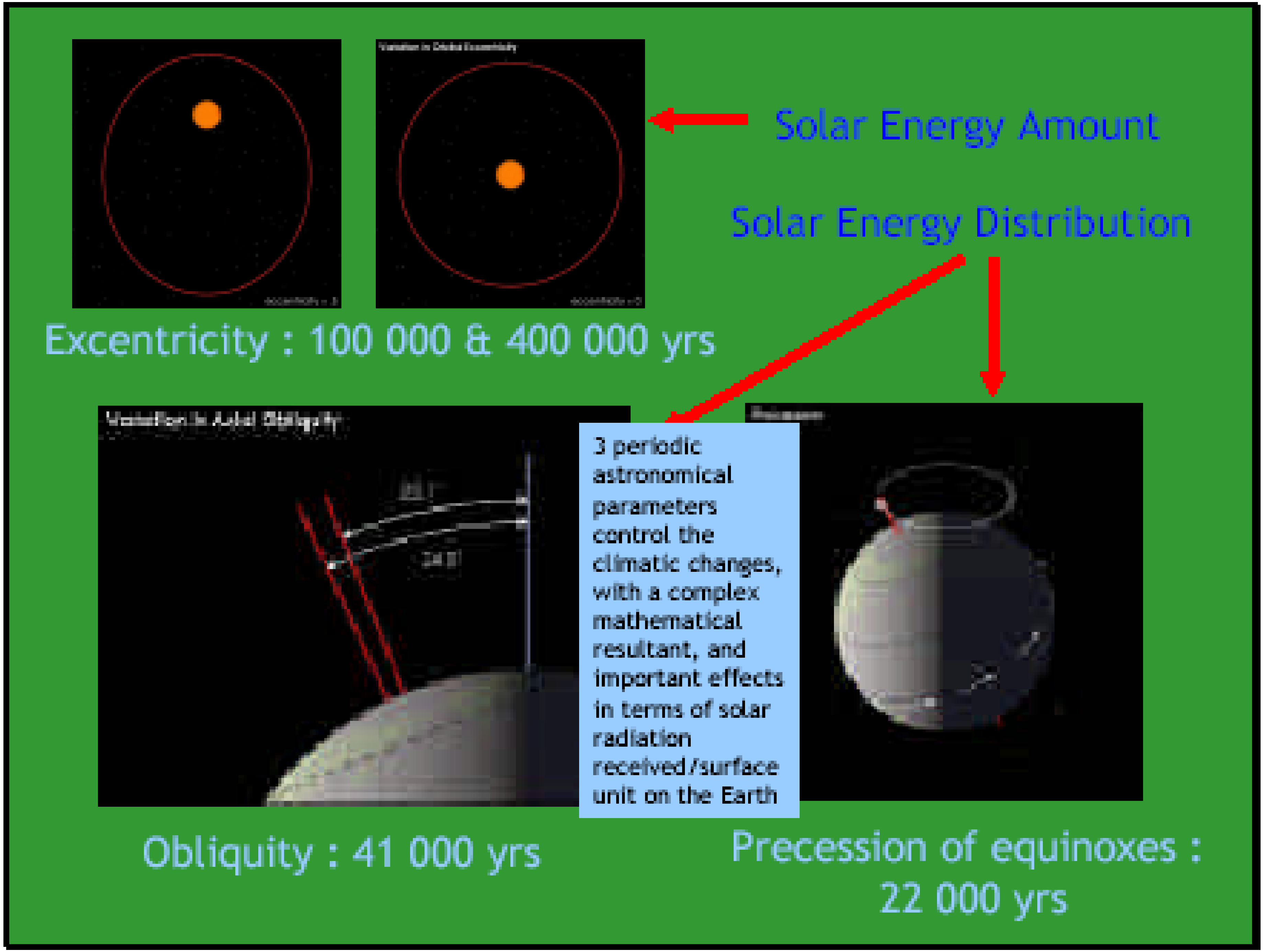
Precessione* degli equinozi

*In un corpo animato da moto rotatorio attorno a un asse (giroscopio, trottola), lento moto dell'asse di rotazione attorno a un secondo asse (*asse di p.*), tale da descrivere un cono con il vertice nel punto di intersezione tra i due assi.

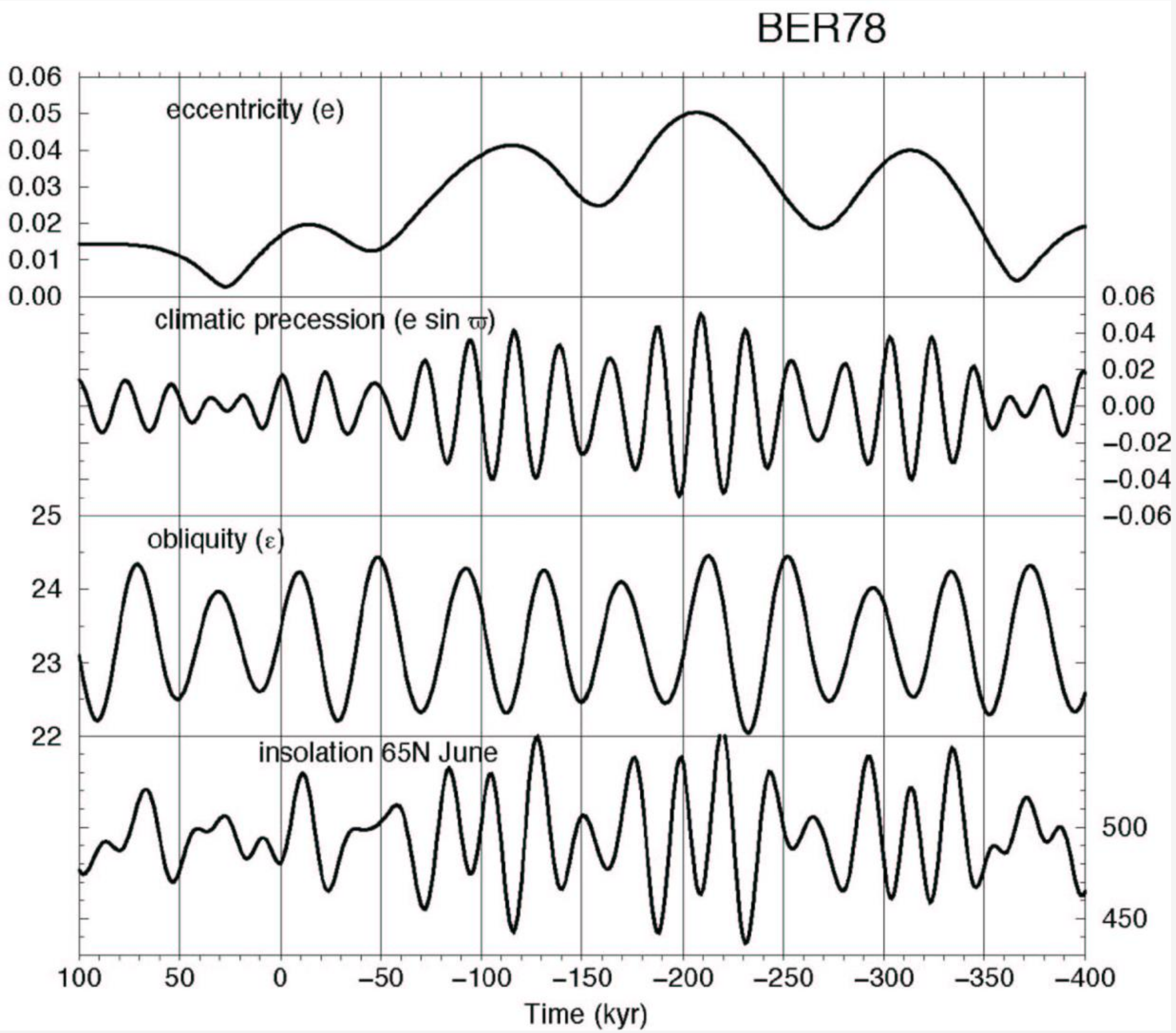
Ciclo di 19.000 e 23.000 anni



Poiché la terra non è perfettamente sferica, l'asse di rotazione oscilla sotto l'effetto della attrazione gravitazionale della luna, del sole e dei pianeti. A questa precessione dell'asse si aggiunge la rotazione dell'orbita terrestre attorno al sole, derivante dalla perturbazione della traiettoria terrestre sotto l'influenza dei pianeti. La combinazione di questi due movimenti implica che il momento in cui il Polo Nord punta verso il sole, vari di anno in anno.



Solar Energy Amount
Solar Energy Distribution
Excentricity : 100 000 & 400 000 yrs
3 periodic astronomical parameters control the climatic changes, with a complex mathematical resultant, and important effects in terms of solar radiation received/surface unit on the Earth
Obliquity : 41 000 yrs
Precession of equinoxes : 22 000 yrs


BER78
eccentricity (e)
climatic precession (e sin ϖ)
obliquity (ε)
insolation 65N June
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
25
24
23
22
500
450
100
50
0
−50
−100
−150
−200
−250
−300
−350
−400
Time (kyr)

CRONOLOGIA DEL QUATERNARIO ≠ CRONOLOGIA DEL PALEOLITICO

QUANDO INIZIA IL PALEOLITICO INFERIORE?

QUANDO INIZIA IL PALEOLITICO MEDIO?

QUANDO INIZIA IL PALEOLITICO SUPERIORE?

QUANDO INIZIA IL PALEOLITICO INFERIORE?

3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya

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Human evolutionary scholars have long supposed that the earliest stone tools were made by the genus *Homo* and that this technological development was directly linked to climate change and the spread of savannah grasslands. New fieldwork in West Turkana, Kenya, has identified evidence of much earlier hominin technological behaviour. We report the discovery of Lomekwi 3, a 3.3-million-year-old archaeological site where *in situ* stone artefacts occur in spatio-temporal association with Pliocene hominin fossils in a wooded palaeoenvironment. The Lomekwi 3 knappers, with a developing understanding of stone's fracture properties, combined core reduction with battering activities. Given the implications of the Lomekwi 3 assemblage for models aiming to converge environmental change, hominin evolution and technological origins, we propose for it the name 'Lomekwian', which predates the Oldowan by 700,000 years and marks a new beginning to the known archaeological record.

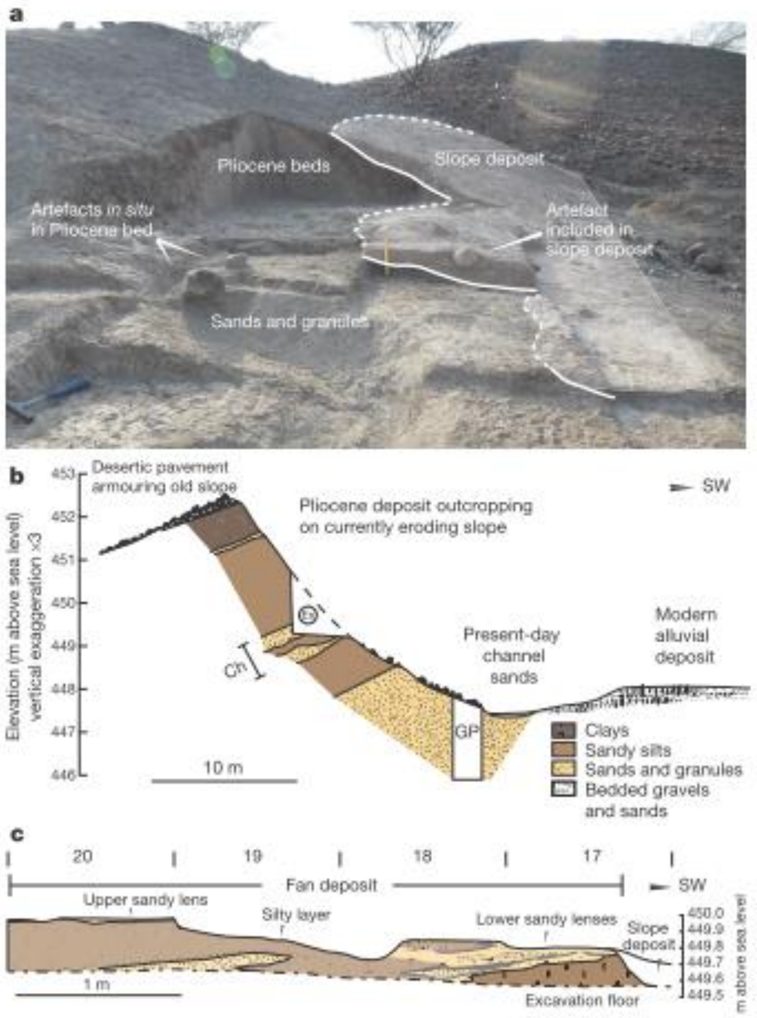
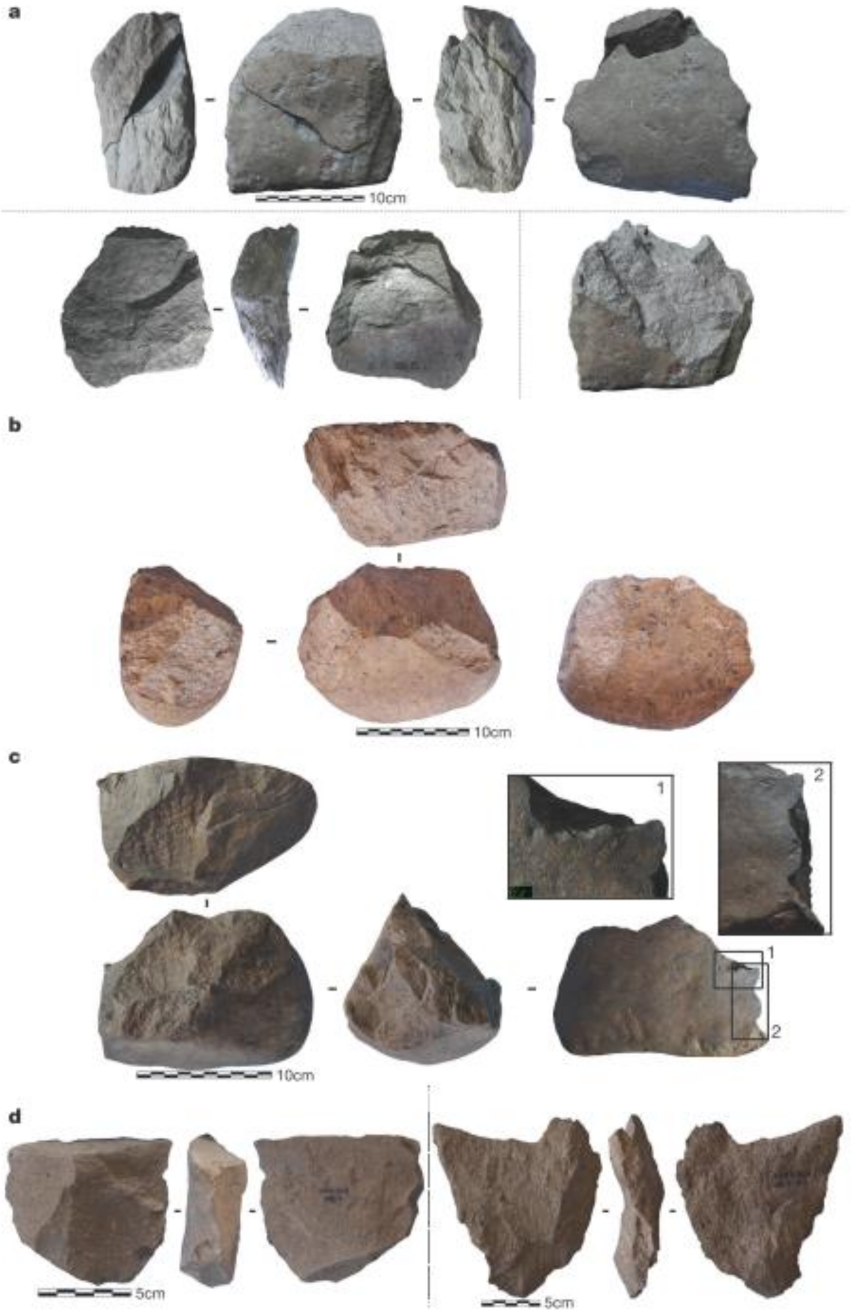


Figure 2 | LOM3 lithological context. **a**, View of the excavation, facing east, showing relationship between surface, slope deposit, and *in situ* contexts containing the artefacts and fossils. Scale in midground is 20 cm. Lower-leftmost artefact is the anvil LOM3-2012-K18-2, shown in Fig. 5a.
b, Topographic profile and stratigraphic units at site level showing the excavation zone (Ex), the geological trench made at the base of the section (GP); the artefacts and fossils derive from a series of lenses of sand and granules making up a ~1 m thick bed (Ch). **c**, Section at the excavation along bands I and J (indicated by the black line in Extended Data Fig. 1a) showing the sediments which form the fan deposits containing the artefacts.



QUANDO INIZIA IL PALEOLITICO MEDIO?

The end of the Lower Paleolithic in the Levant: The Acheulo-Yabrudian lithic technology at Misliya Cave, Israel

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A R T I C L E   I N F O

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Lithic technology
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A B S T R A C T

The end of the Lower Paleolithic in the Levant is marked by the emergence of a new techno-complex known as Acheulo-Yabrudian (350–250 ka BP). Stratigraphically placed at the transition between the Acheulian and Mousterian techno-complexes, the Acheulo-Yabrudian is crucial for the understanding of biological, cultural and behavioral evolution from the Lower to the Middle Paleolithic in the Levant.

Misliya Cave, Mount Carmel, is one of the rare Levantine sites in which both the Acheulo-Yabrudian and Early Mousterian are present, allowing direct comparison between the two industries. Here we present the analysis of an Acheulo-Yabrudian lithic assemblage from the site and discuss its place within Levantine technological and cultural frameworks.

Three technological systems were identified in Misliya Acheulo-Yabrudian assemblage:

1) Bifacial shaping.

2) Production of thin flakes from hierarchical-surfaces cores – The hierarchical-surfaces cores exhibit some of the criteria of the Levallois concept but lack the major characteristics of the Levallois, namely the preparation of the flaking surface and predetermination. The thin-flake production phenomenon has not been previously discussed in relation to the Acheulo-Yabrudian. The large quantities of simple thin flakes at Misliya Cave indicate their relative importance in hominin subsistence strategies.

3) Production of large and thick, often cortical, flakes from unprepared cores – The flakes were used for manufacturing handaxes or large scrapers by Quina or semi-Quina retouch.

The two former systems are well-known from the Upper Acheulian assemblages in the Levant, suggesting regional continuity, while the production of Quina scrapers seems to be a major technological innovation of the Acheulo-Yabrudian.

The three Acheulo-Yabrudian technological systems described above were not identified in the Early Middle Paleolithic assemblages of Misliya Cave. Moreover, Levallois and laminar technologies, and production of retouched points that mark the emergence of the Middle Paleolithic in the Levant, are absent from the Acheulo-Yabrudian of Misliya Cave, further supporting the view that a marked technological break in the region occurred ca. 250 ka ago with the onset of the Middle Paleolithic.

RESEARCH ARTICLE

Identifying Major Transitions in the Evolution of Lithic Cutting Edge Production Rates

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Abstract

The notion that the evolution of core reduction strategies involved increasing efficiency in cutting edge production is prevalent in narratives of hominin technological evolution. Yet a number of studies comparing two different knapping technologies have found no significant differences in edge production. Using digital analysis methods we present an investigation of raw material efficiency in eight core technologies broadly representative of the long-term evolution of lithic technology. These are bipolar, multiplatform, discoidal, biface, Levallois, prismatic blade, punch blade and pressure blade production. Raw material efficiency is assessed by the ratio of cutting edge length to original core mass. We also examine which flake attributes contribute to maximising raw material efficiency, as well as compare the difference between expert and intermediate knappers in terms of cutting edge produced per gram of core. We identify a gradual increase in raw material efficiency over the broad sweep of lithic technological evolution. The results indicate that the most significant transition in efficiency likely took place with the introduction of small foliate biface, Levallois and prismatic blade knapping, all introduced in the Middle Stone Age / Middle Palaeolithic among early *Homo sapiens* and Neanderthals. This suggests that no difference in raw material efficiency existed between these species. With prismatic blade technology securely dated to the Middle Palaeolithic, by including the more recent punch and pressure blade technology our results dispel the notion that the transition to the Upper Palaeolithic was accompanied by an increase in efficiency. However, further increases in cutting edge efficiency are evident, with pressure blades possessing the highest efficiency in this study, indicating that late/epi-Palaeolithic and Neolithic blade technologies further increased efficiency.

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Introduction

Technological efficiency is a key aspect of palaeoanthropological debates surrounding such topics as cognition, skill, intentionality, modernity, technological organisation and technological diversity [1–11]. It is commonly argued that innovations in lithic technology over the sweep of human evolution were accompanied by greater striking precision, longer reduction sequences, finer retouch, greater recursion and hierarchical planning, a greater variety of percussive and pressure flaking techniques, more intensive platform preparation, and