Rock Magnetism, Paleomgnetism & Environmental Magnetism

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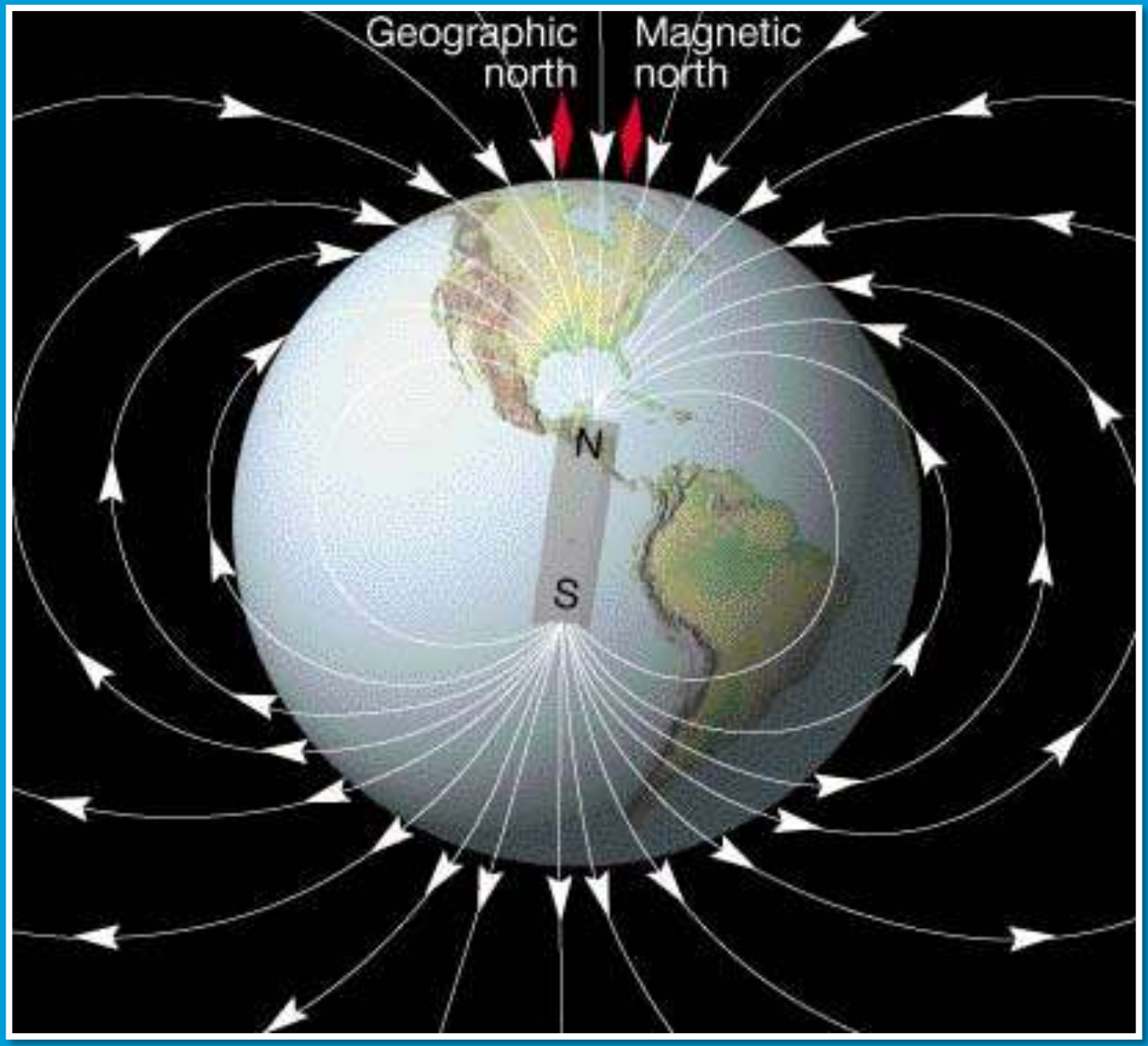
Geographic north
Magnetic north
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S

Rock Magnetism

* Is the study of the magnetic properties of rocks, sediments and soils to understand how rocks record the Earth's magnetic field

* The magnetic remanence is carried by certain minerals

* Strongly magnetic minerals have properties that depend on the size, shape, defect structure and concentration of the minerals in a rock

* provides non-destructive methods for analyzing

Types of magnetic order

* The contribution of a mineral to the total magnetism of a rock depends strongly on the type of magnetic order or disorder

* Magnetically disordered minerals (diamagnets and paramagnets) contribute a weak magnetism and have no remanence

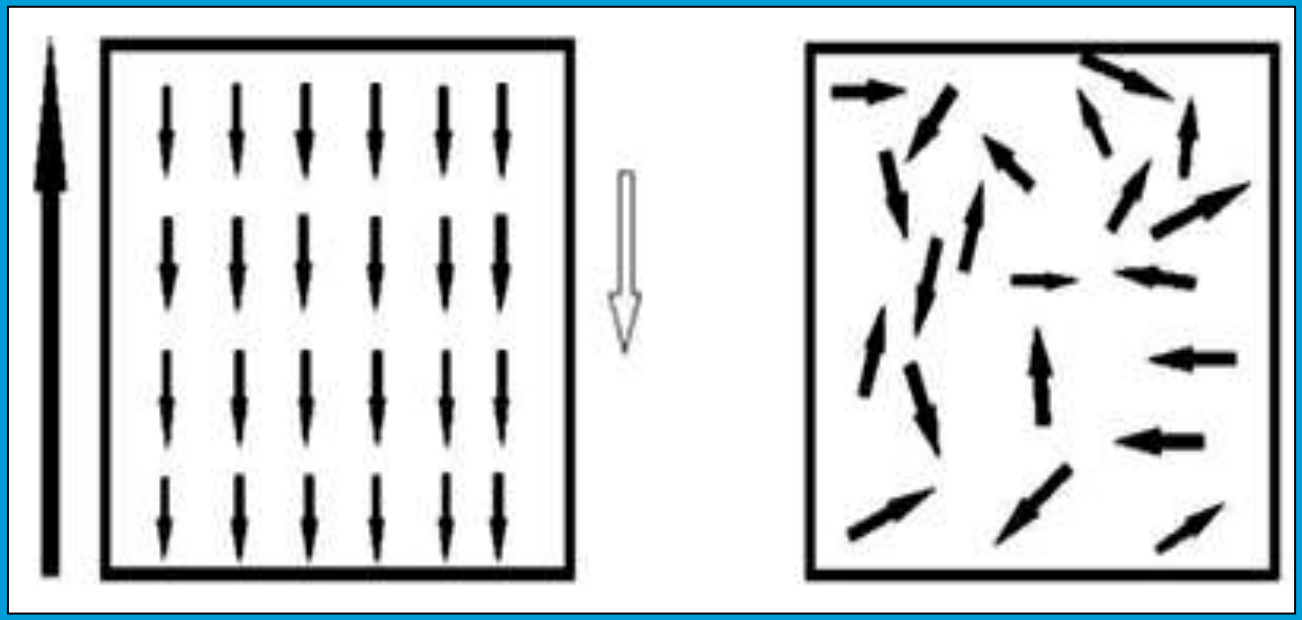
* The more important magnetically ordered minerals are the ferromagnets, ferrimagnets and certain kinds of antiferromagnets. These minerals have a much stronger response to the field and can have a remanence

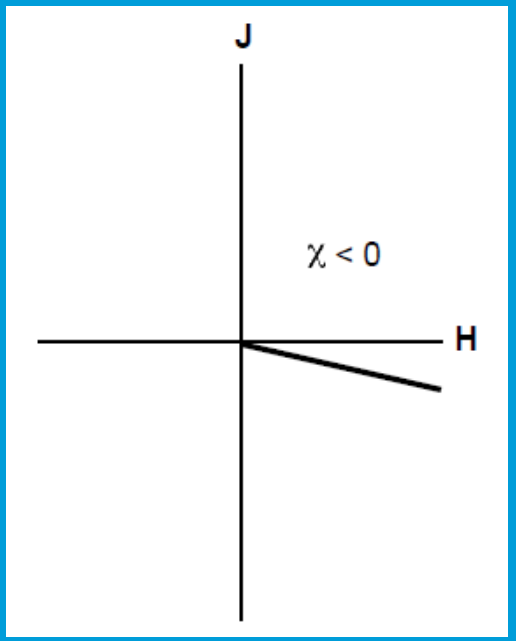
Diamagnetism

* is a magnetic response shared by all substances

* the moment produced is in the opposite direction to the field and the susceptibility is negative

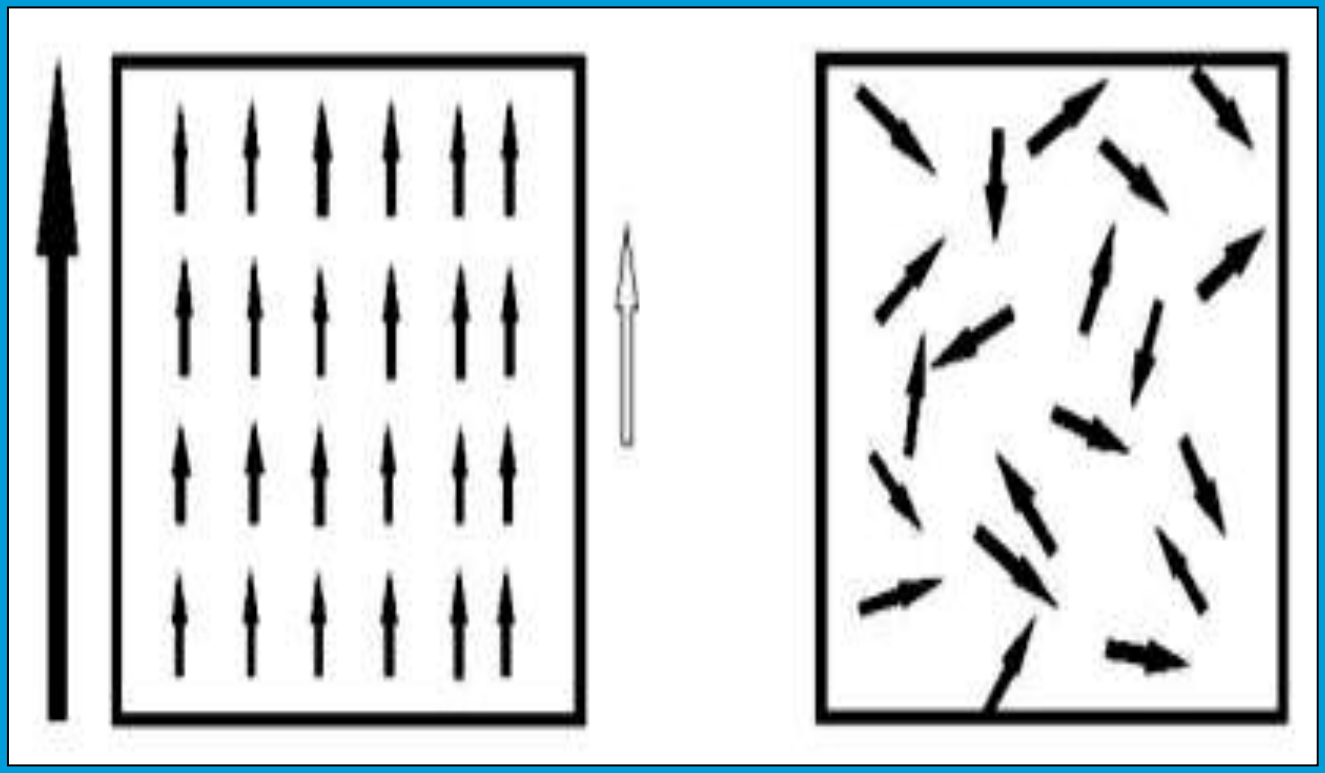
* This effect is weak but independent of temperature

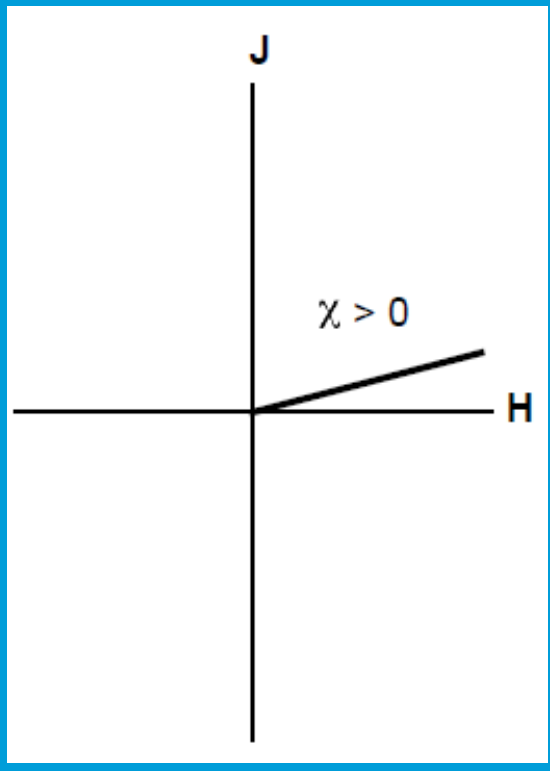




Paramagnetism

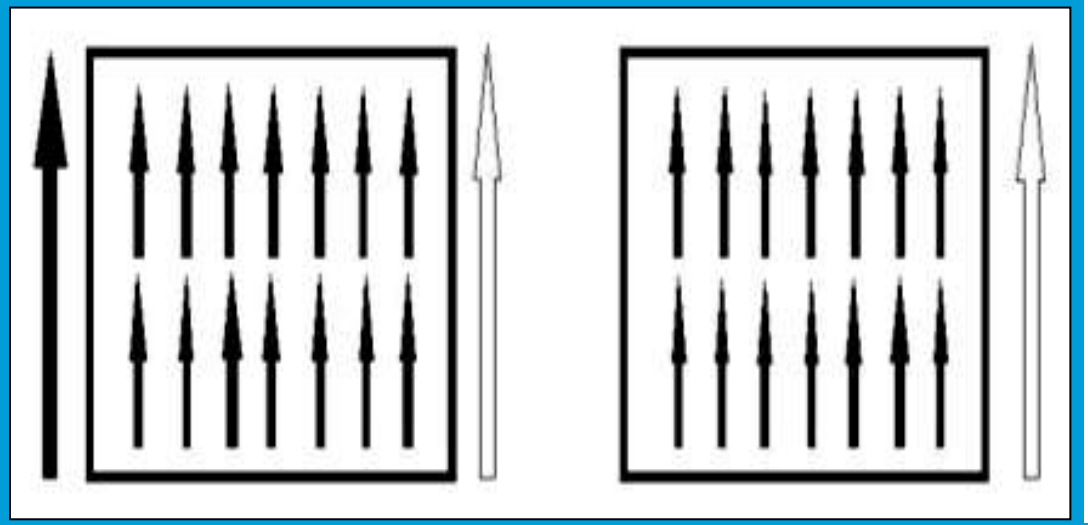
* is a weak positive in a magnetic field due to rotation of unpaired electron spins in one of iron shells
* Susceptibility is inversely proportional to the T°

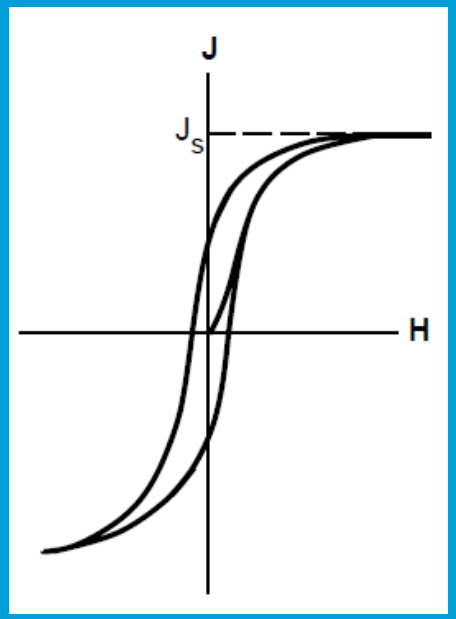




Ferromagnetism

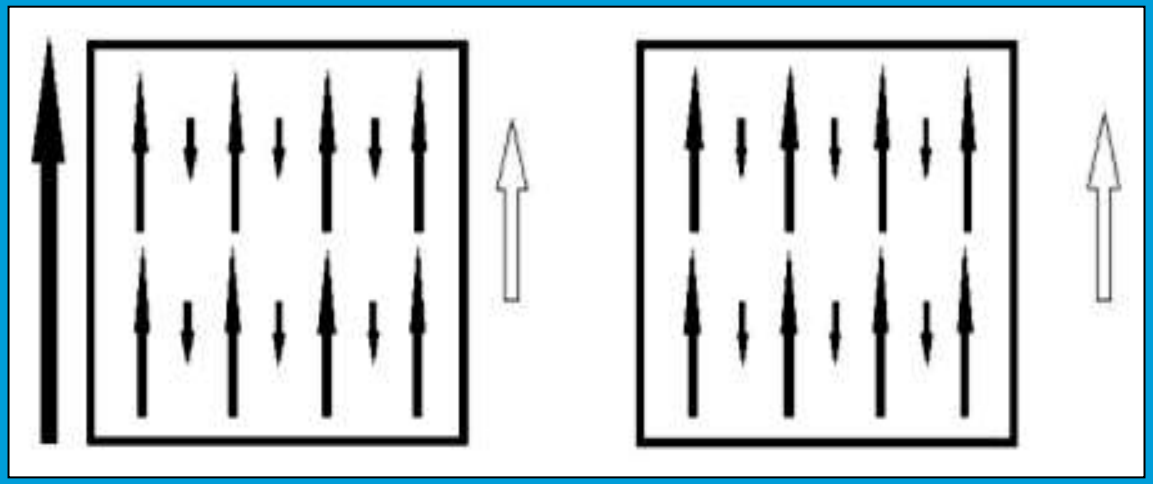
* A magnetic ordering where neighboring electron spins are aligned by the exchange interaction
* Below the Curie temperature, ferromagnets(Iron, Nickel, Cobalt) have a spontaneous magnetization and show hysteresis in an applied magnetic field
* They have remanence, and record the Earth's field
* Iron is usually found in iron oxides, oxyhydroxides and sulfides forms

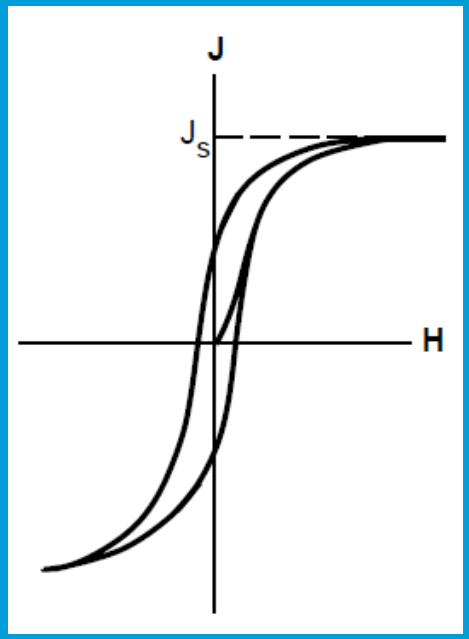




Ferrimagnets

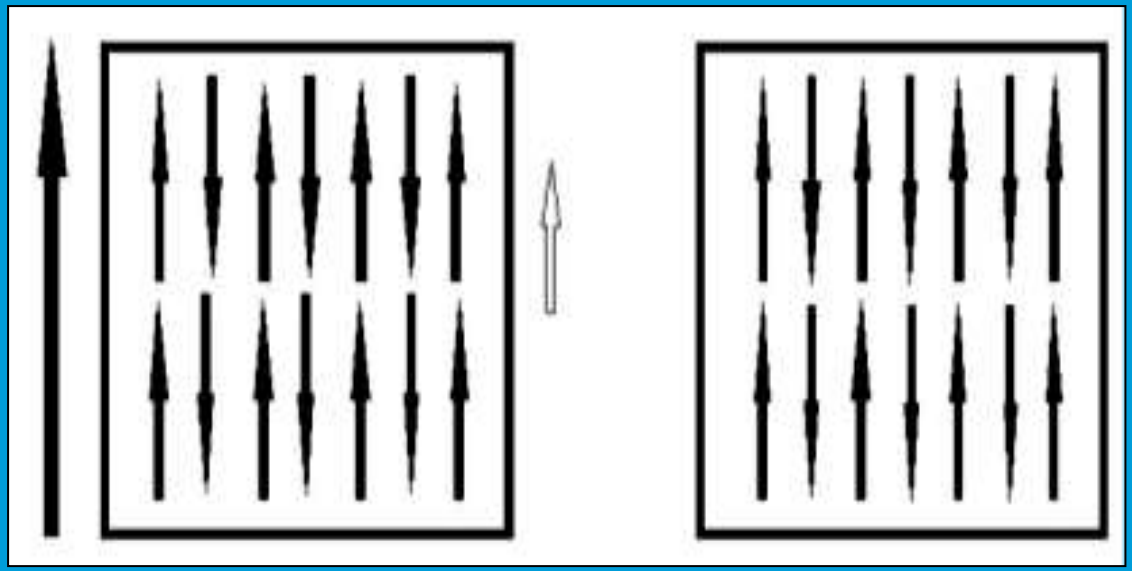
* Have two sublattices with opposing moments, one with largerer moment, so there is a net unbalance
* Ferrimagnets often behave like ferromagnets, but the temperature dependence of their spontaneous magnetization can be quite different
* Magnetite, is the most important ferrimagnetic mineral

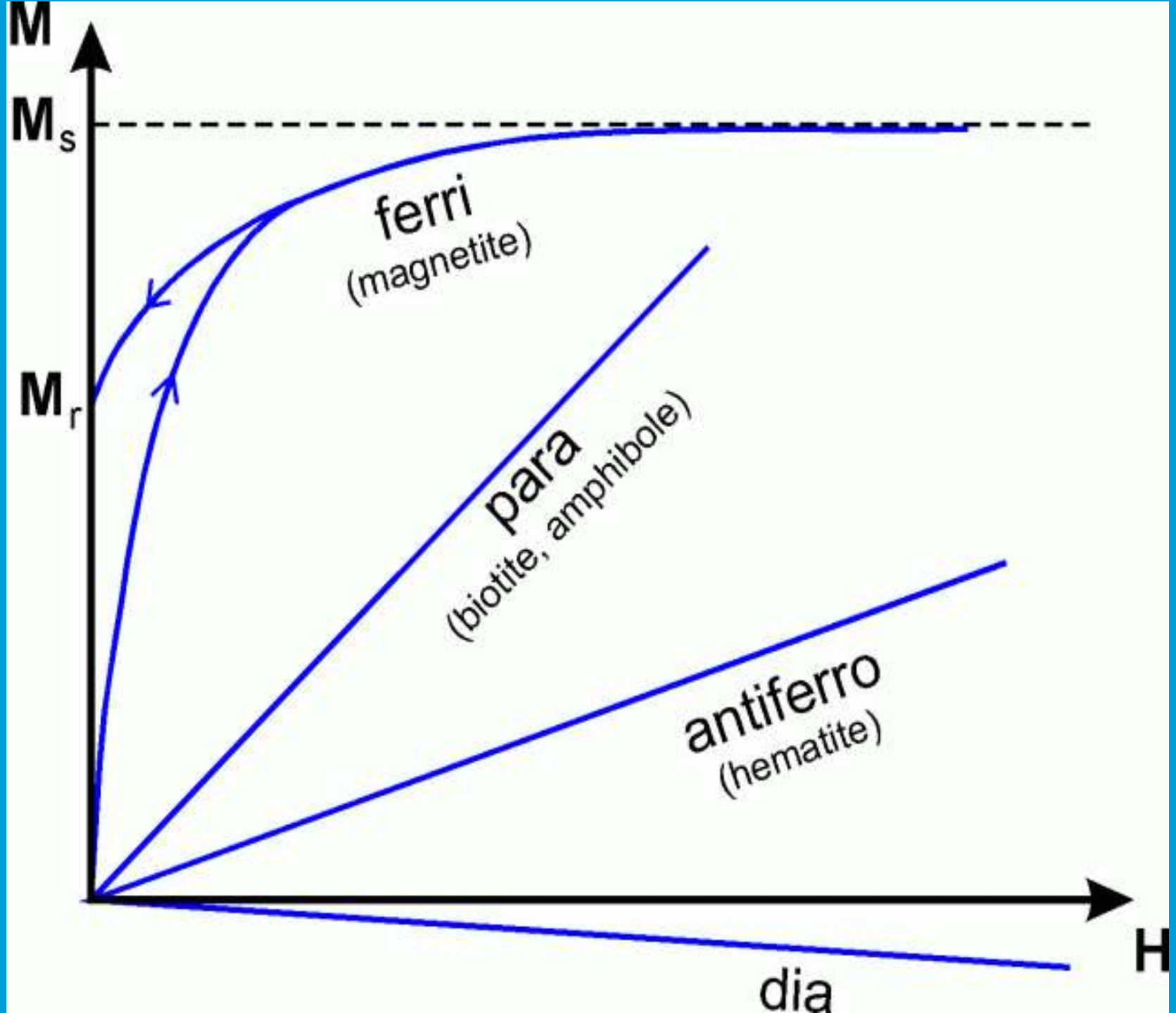




Antiferromagnets

* **Like ferrimagnets, have two sublattices with opposing moments, but with equal moments in magnitude.**
* **Moments are not exactly opposed, and the moments can be tilted (spin-canting), resulting in a moment nearly at right angles to the moments of the sublattices(Hematite, Goethite)**




M
M_s
M_r
ferri
(magnetite)
para
(biotite, amphibole)
antiferro
(hematite)
dia
H

Magnetic remanence

A central part of rock magnetism is the study of magnetic remanence, both as Natural Remanent Magnetization (NRM) in rocks obtained from the field and remanence induced in the laboratory

NRM = primary NRM + secondary NRM

Types of NRM

* Thermoremanent magnetization (TRM)
* Chemical (or crystallization) remanent magnetization (CRM)
* Detrital remanent magnetization (DRM)
* Viscous remanent magnetization (VRM)
* Isothermal remanent Magnetization (IRM)

Application of rock magnetism

1- Magnetic anomalies

* Is a local variation in the Earth's magnetic field resulting from variations in the chemistry or magnetism of the rocks

* The magnetic variation in successive bands of ocean floor parallel with mid-ocean ridges is important evidence supporting the theory of seafloor spreading, central to plate tectonics

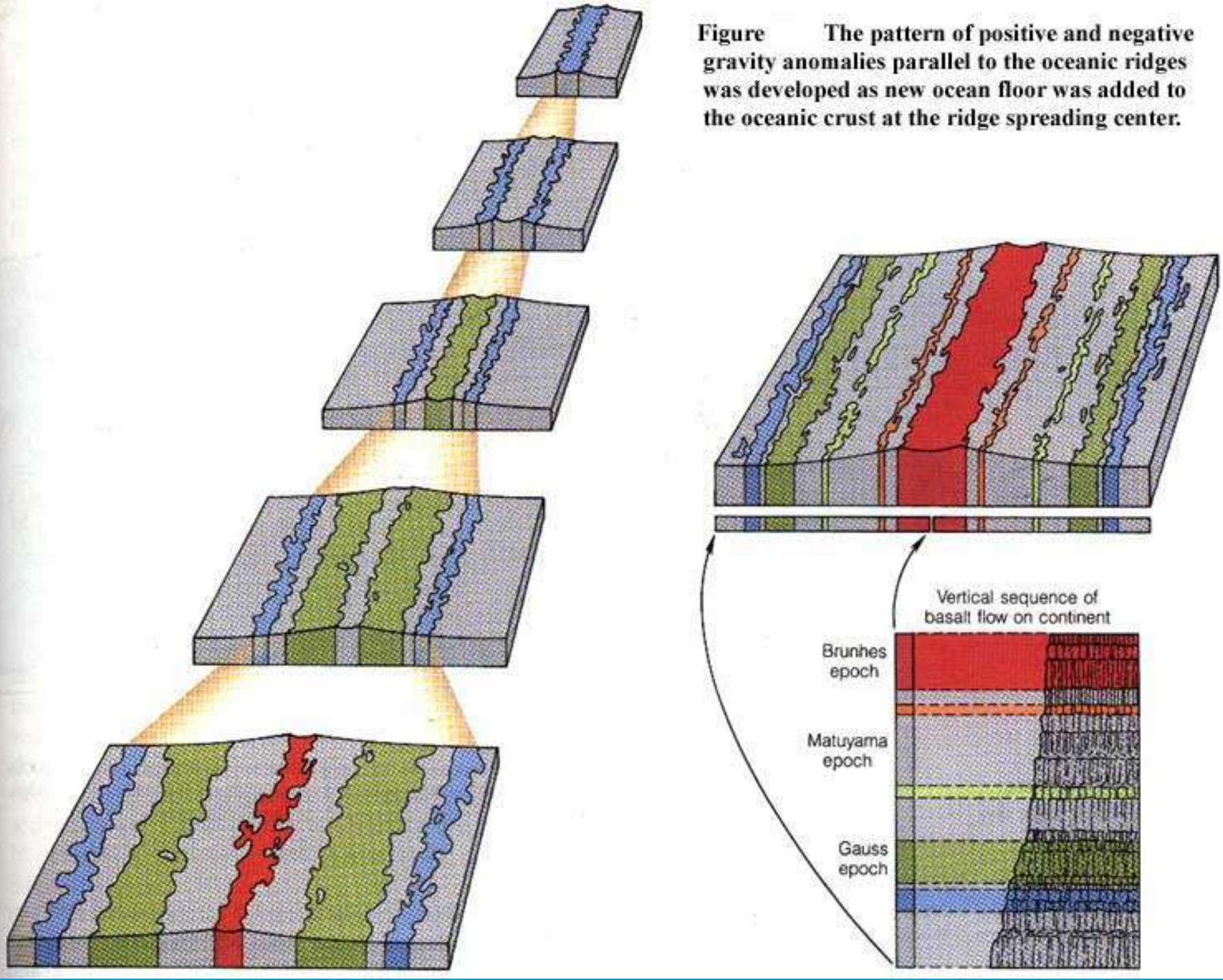


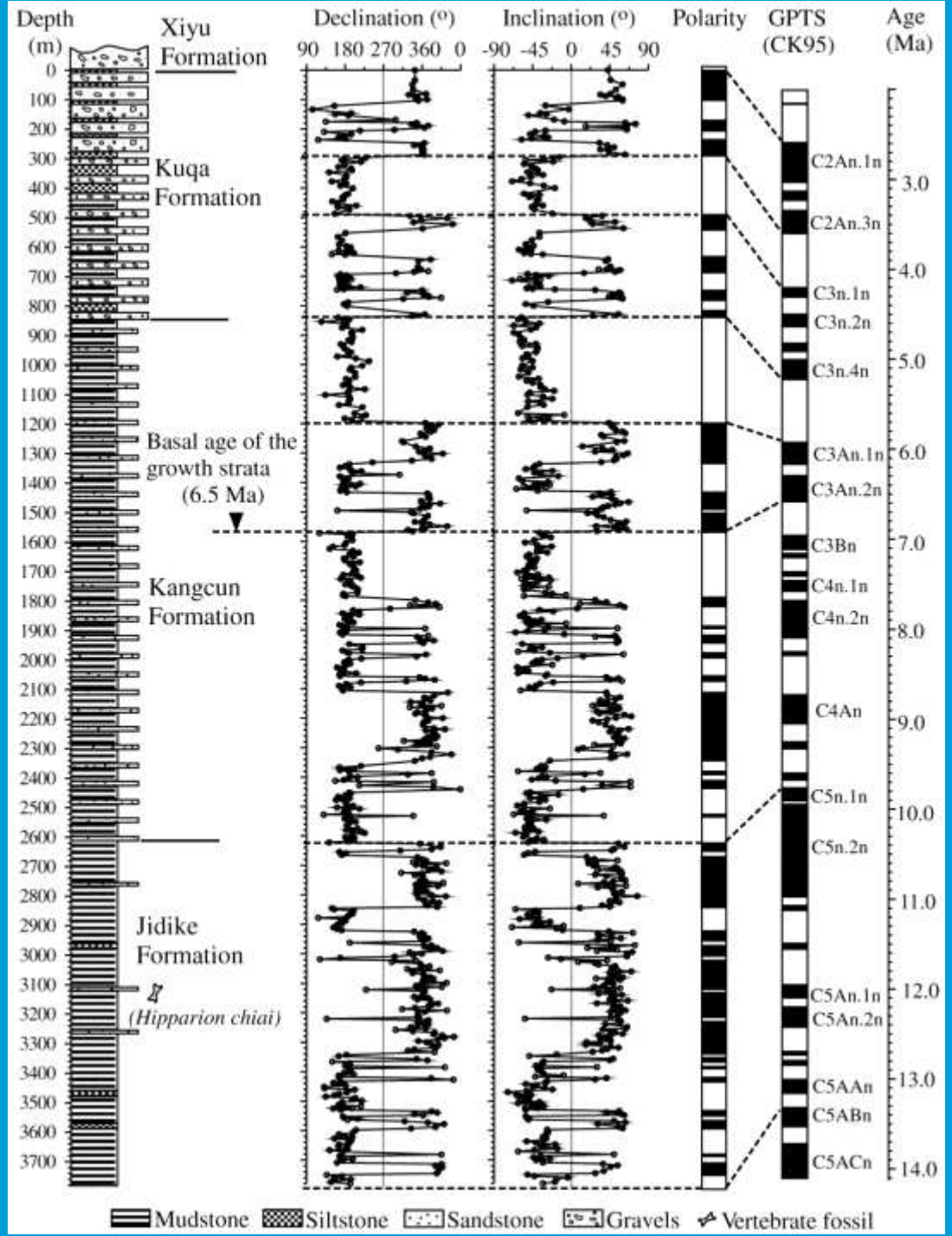
Figure The pattern of positive and negative gravity anomalies parallel to the oceanic ridges was developed as new ocean floor was added to the oceanic crust at the ridge spreading center.

2- Magnetostratigraphy

* **Is a geophysical correlation technique used to date sedimentary and volcanic sequences**

* **The method works by collecting oriented samples at measured intervals throughout the section**

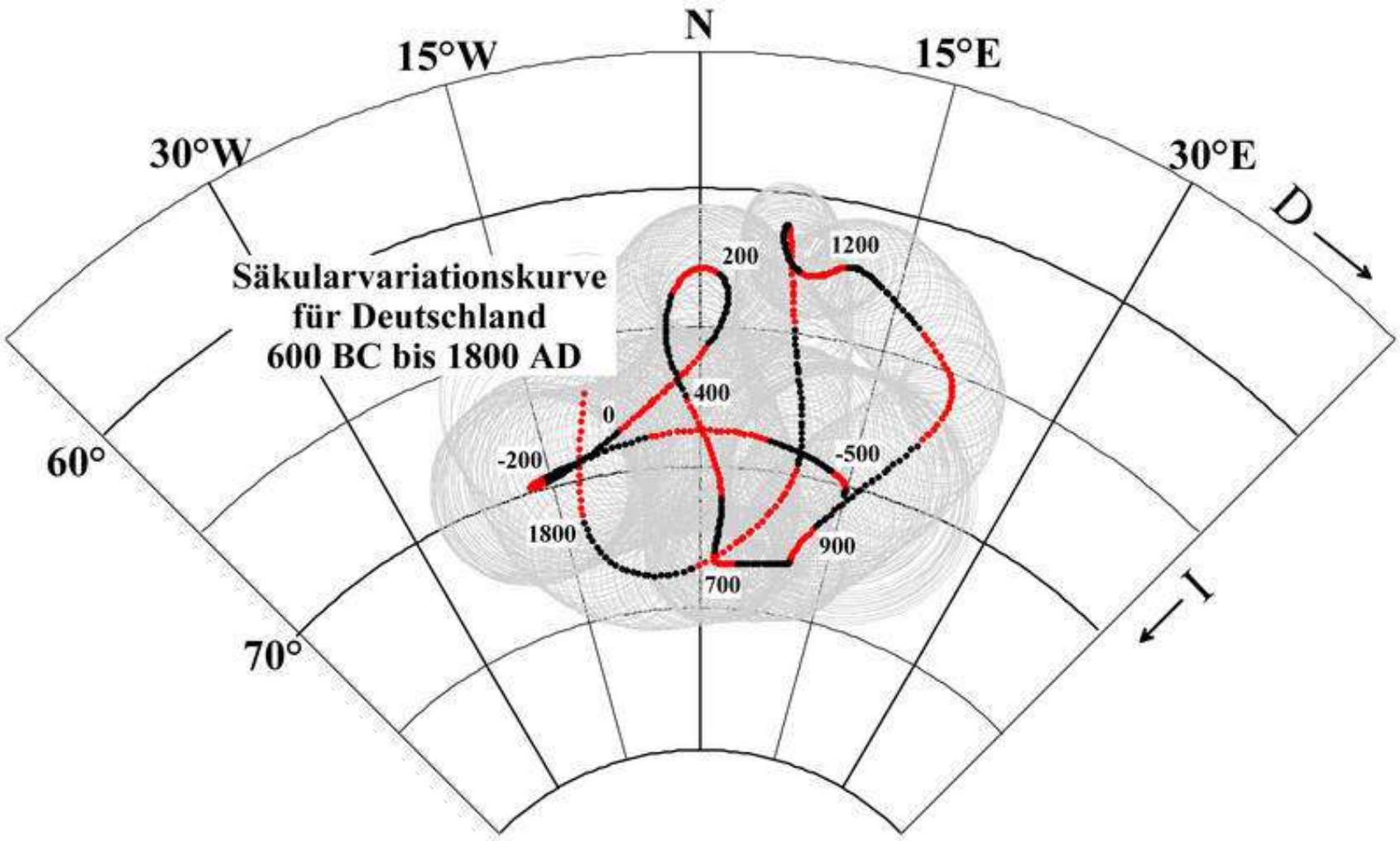
* **The samples are analyzed to determine their *characteristic remanent magnetization* (ChRM), that is, the polarity of Earth's magnetic field at the time a stratum was deposited**


Depth
(m)
Xiyu Formation
Kuqa Formation
Basal age of the growth strata (6.5 Ma)
Kangcun Formation
Jidike Formation
(Hipparion chiai)
Declination (°)
Inclination (°)
Polarity
GPTS (CK95)
Age (Ma)
C2An.1n
C2An.3n
C3n.1n
C3n.2n
C3n.4n
C3An.1n
C3An.2n
C3Bn
C4n.1n
C4n.2n
C4An
C5n.1n
C5n.2n
C5An.1n
C5An.2n
C5AAn
C5ABn
C5ACn
Mudstone
Siltstone
Sandstone
Gravels
Vertebrate fossil

3- Geomagnetic secular variation

* Refers to changes in the Earth's magnetic field on time scales of about a year or more

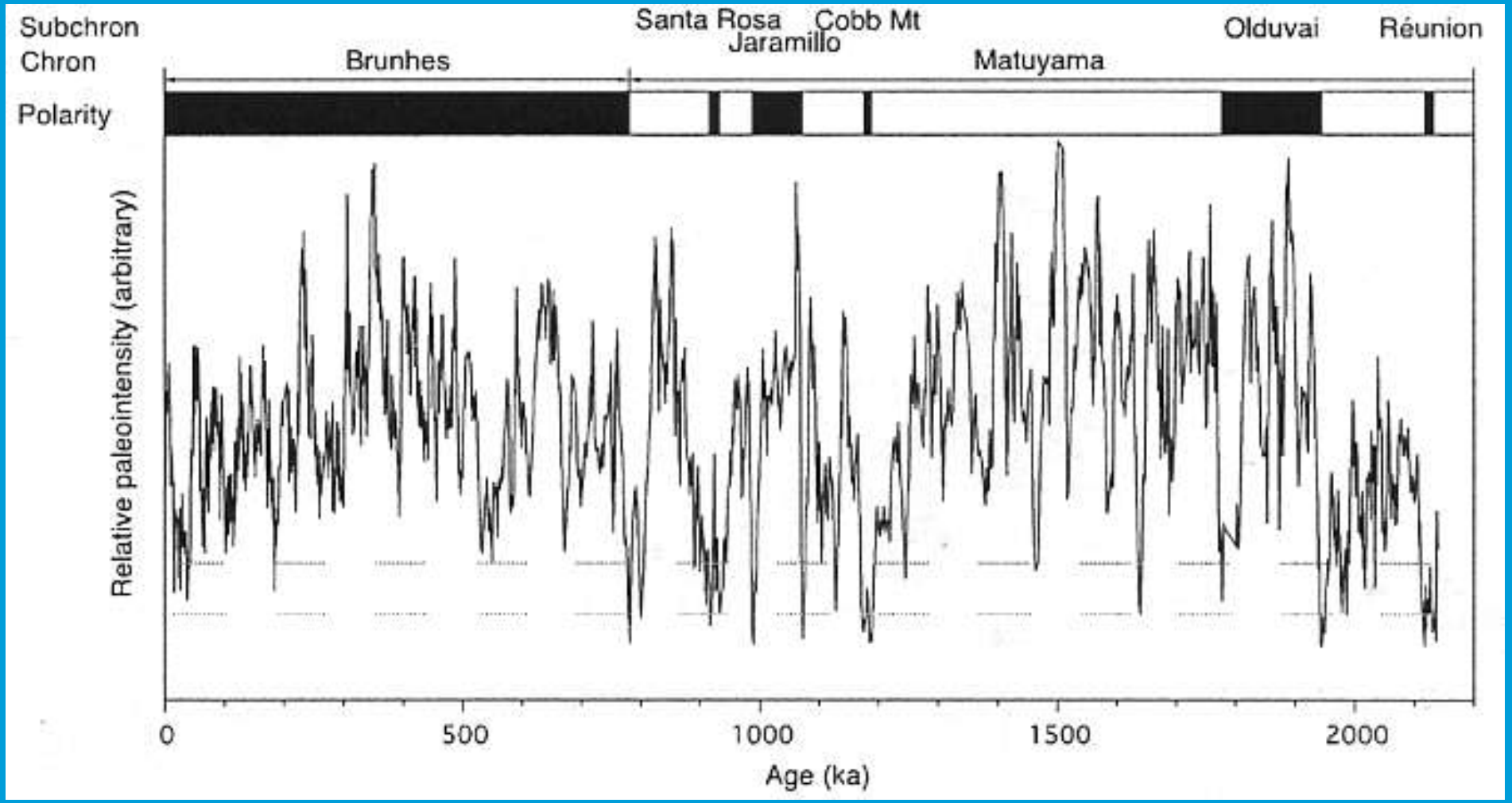
* These changes mostly reflect changes in the Earth's interior, while more rapid changes mostly originate in the ionosphere or magnetosphere


N
15°W
15°E
30°W
30°E
D
I
60°
70°
Säkularvariationskurve
für Deutschland
600 BC bis 1800 AD
200
1200
400
0
-200
-500
1800
900
700

4- Paleointensity

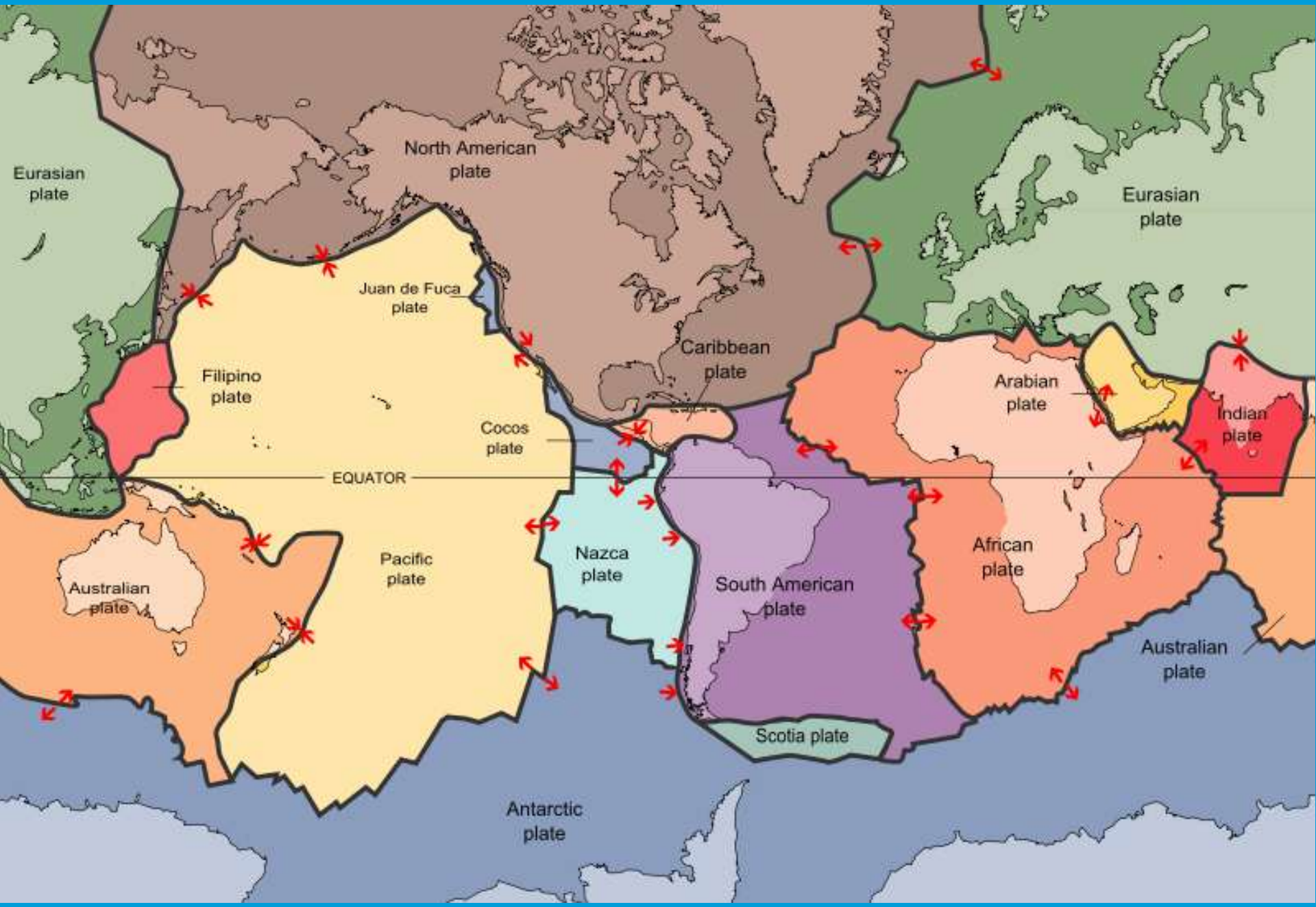
The intensity of geomagnetism at a given location

at a particular time in the geologic past


Subchron
Chron
Polarity
Santa Rosa
Cobb Mt
Jaramillo
Olduvai
Réunion
Brunhes
Matuyama
Relative paleointensity (arbitrary)
0
500
1000
1500
2000
Age (ka)

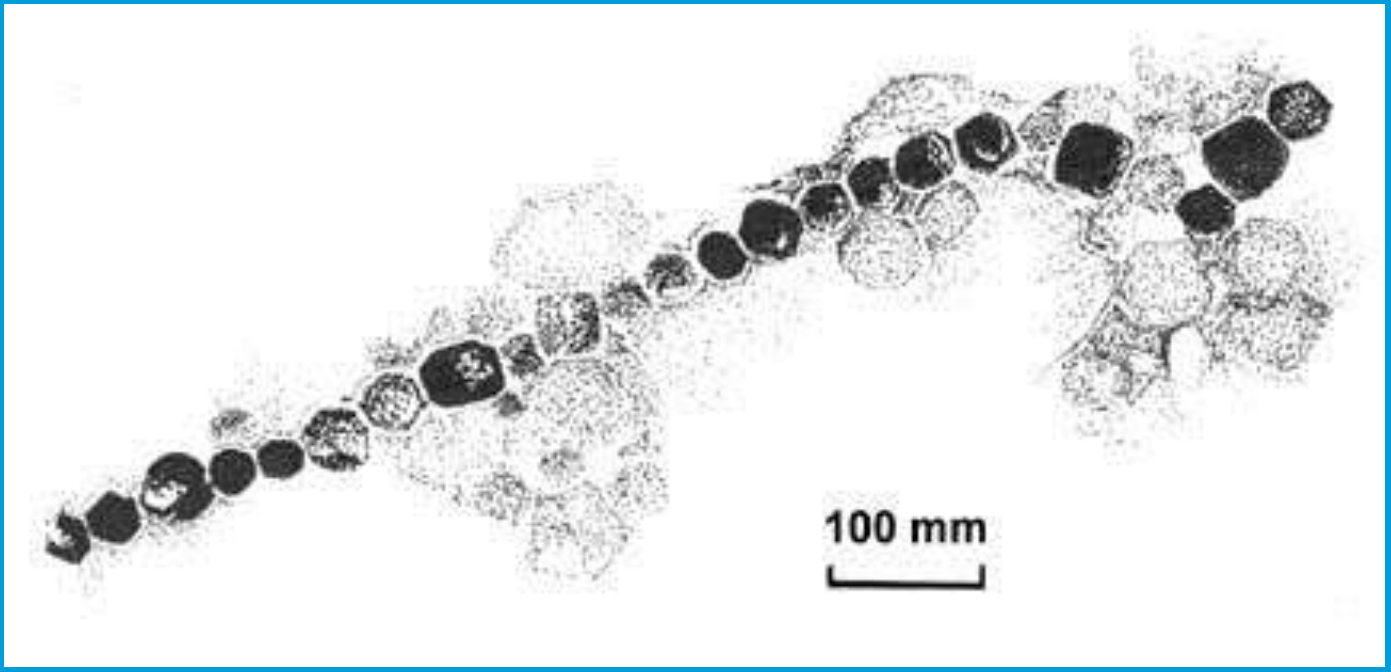
5- Plate tectonics

* Is a scientific theory that describes the large-scale motions of Earth's lithosphere. The model builds on the concepts of continental drift
* The lithosphere is broken up into tectonic plates, where plates meet, their relative motion determines the type of boundary: convergent (subduction carries plates into the mantle), divergent (seafloor spreading), or transform.
* Earthquakes, volcanic activity, mountain-building, and oceanic trench formation occur along these plate boundaries.


Eurasian plate
North American plate
Eurasian plate
Juan de Fuca plate
Caribbean plate
Filipino plate
Arabian plate
Indian plate
Cocos plate
EQUATOR
Pacific plate
Nazca plate
South American plate
African plate
Australian plate
Australian plate
Scotia plate
Antarctic plate

6- Biomagnetism

Is the phenomenon of magnetic fields *produced* by living organisms; it is a subset of bioelectromagnetism.



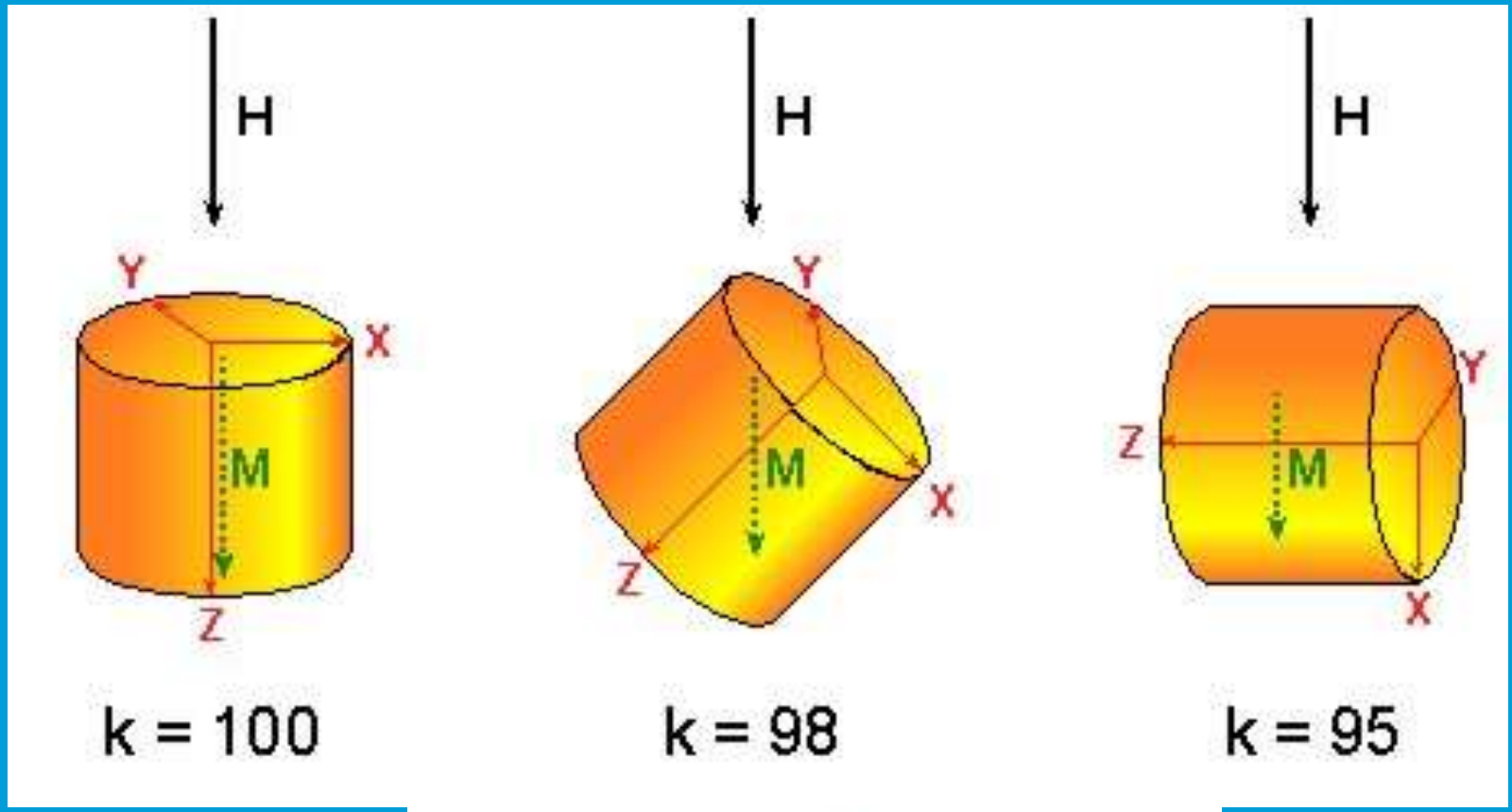
7- Environmental magnetism

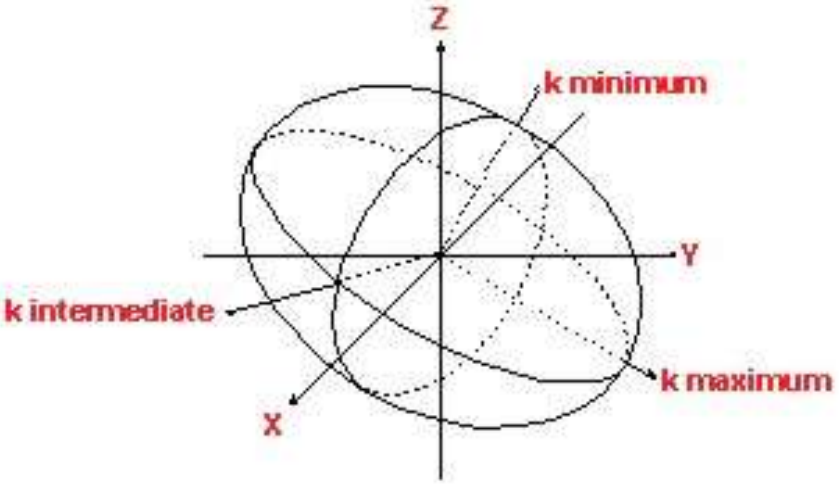
* Is the study of magnetism as it relates to the effects of climate, sediment transport, pollution and other environmental influences on magnetic minerals
* It makes use of techniques from rock magnetism and magnetic mineralogy
* The magnetic properties of minerals are used as proxies for environmental change in applications such as paleoclimate, paleoceanography, studies of the provenance of sediments, pollution and archeology
* Magnetic minerals are almost can be found every where and magnetic measurements are quick and non- destructive

7- Magnetic fabrics

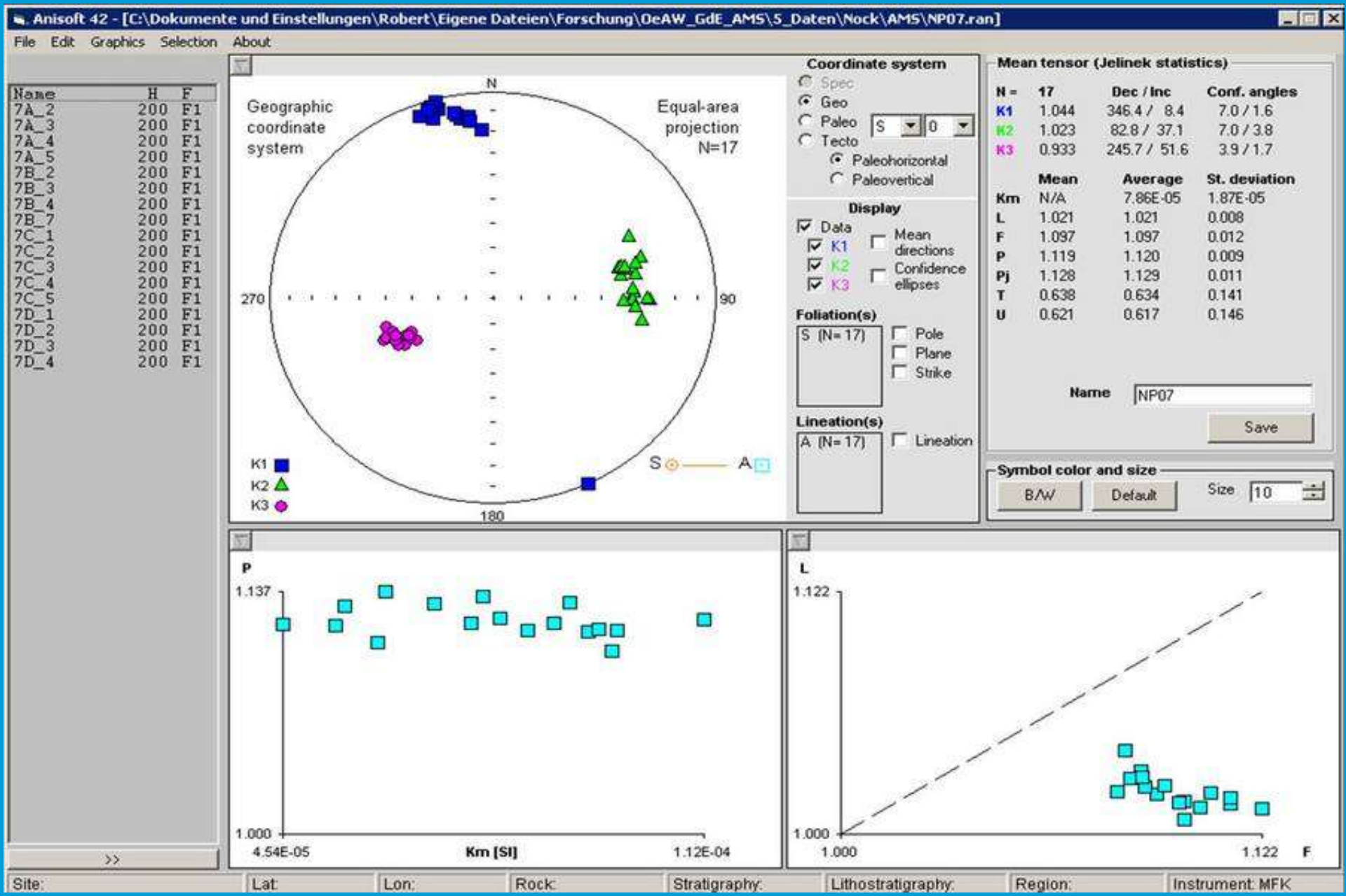
* Is a technique that is used to measure the petrofabric of rocks so that their mode of emplacement, structural evolution, flow direction can be determined

* Is used to determine the angle of collusion between two plates (geodynamic application)





Ellissoide della suscettività magnetica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File Edit Graphics Selection About
Name H F
7A_2 200 F1
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7A_4 200 F1
7A_5 200 F1
7B_2 200 F1
7B_3 200 F1
7B_4 200 F1
7B_7 200 F1
7C_1 200 F1
7C_2 200 F1
7C_3 200 F1
7C_4 200 F1
7C_5 200 F1
7D_1 200 F1
7D_2 200 F1
7D_3 200 F1
7D_4 200 F1
Geographic coordinate system
Equal-area projection N=17
N
90
180
270
K1
K2
K3
S
A
Coordinate system
Spec
Geo
Paleo
Tecto
Paleohorizontal
Paleovertical
Display
Data
K1
K2
K3
Mean directions
Confidence ellipses
Foliation(s)
S (N=17)
Pole
Plane
Strike
Lineation(s)
A (N=17)
Lineation
Mean tensor (Jelinek statistics)
N = 17
Dec / Inc
Conf. angles
K1 1.044 346.4 / 8.4 7.0 / 1.6
K2 1.023 82.8 / 37.1 7.0 / 3.8
K3 0.933 245.7 / 51.6 3.9 / 1.7
Mean
Average
St. deviation
Km N/A 7.86E-05 1.87E-05
L 1.021 1.021 0.008
F 1.097 1.097 0.012
P 1.119 1.120 0.009
Pj 1.128 1.129 0.011
T 0.638 0.634 0.141
U 0.621 0.617 0.146
Name NP07
Save
Symbol color and size
B/W
Default
Size 10
P
1.137
1.000
4.54E-05
Km [SI]
1.12E-04
L
1.122
1.000
1.000
1.122
F
Site:
Lat:
Lon:
Rock:
Stratigraphy:
Lithostratigraphy:
Region:
Instrument: MFK

Paleomagnetism

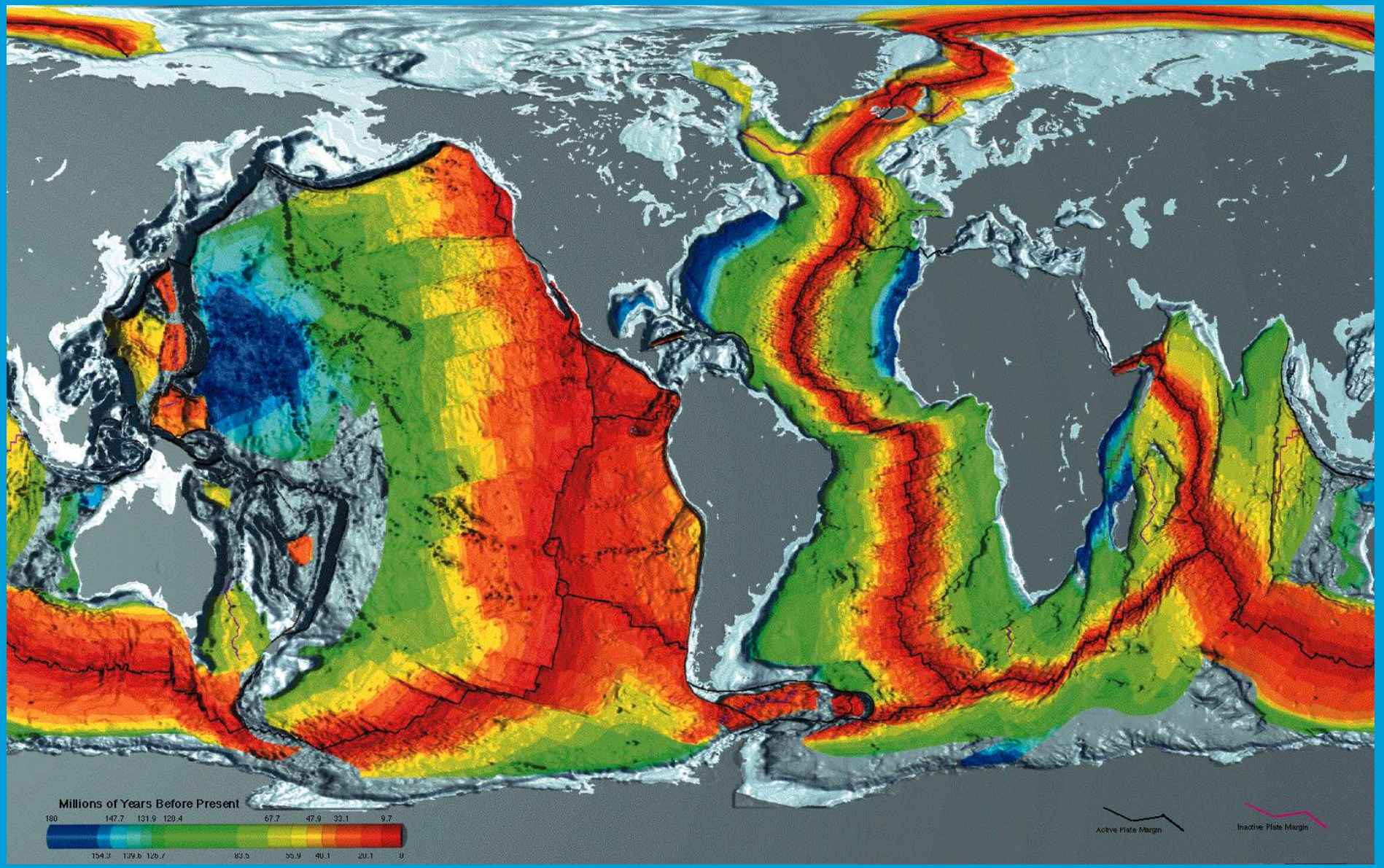
* **Paleomagnetism** is the study of the record of the past ***Earth's magnetic field*** in rocks
* Certain ***minerals in rocks*** lock-in a record of the direction and intensity of the magnetic field when they form
* This record provides information on the past behavior of Earth's magnetic field and the past location of ***tectonic plates***
- The record of ***geomagnetic reversals*** preserved in ***volcanic*** and ***sedimentary rock*** sequences

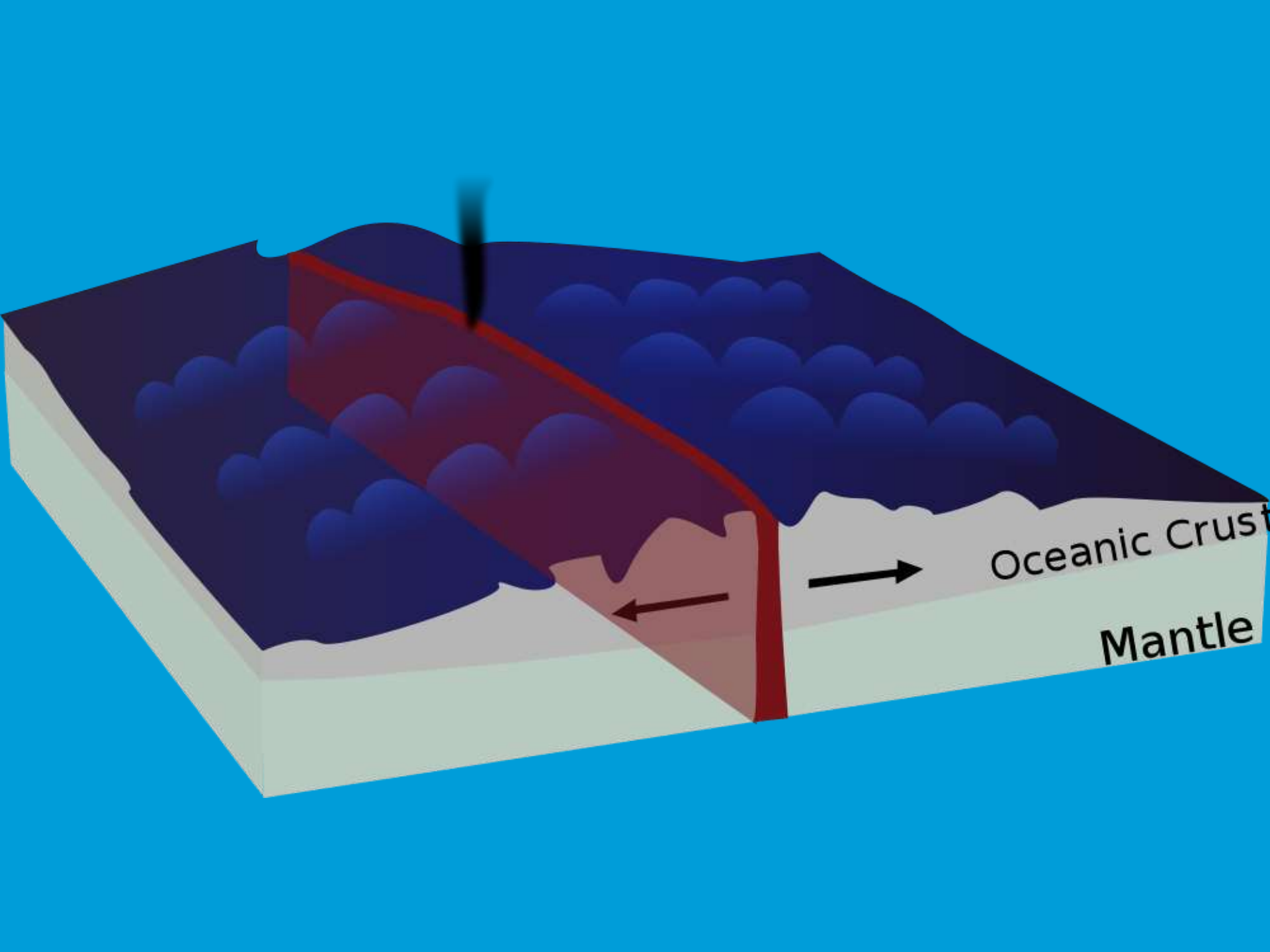
  provides a time-scale that is used as a ***geochronologic*** tool

* Paleomagnetists led the revival of the theory of:
* ***Continental drift*** and its transformation into ***plate tectonics***

* ***Apparent polar wander*** paths provided the first clear geophysical evidence for ***continental drift***, and

* ***Magnetic anomalies*** did the same for ***seafloor spreading***


Millions of Years Before Present
180
147.7
131.9
120.4
67.7
47.9
33.1
9.7
154.3
139.6
126.7
83.5
55.9
40.1
20.1
0
Active Plate Margin
Inactive Plate Margin


Oceanic Crust
Mantle

Paleomagnetism is studied on a number of scales:

* ***Secular variation studies*** look at small-scale changes in the direction and intensity of the Earth's magnetic field (palaeodirectional measurements of ***magnetic declination*** and ***magnetic inclination*** and palaeointensity measurements)

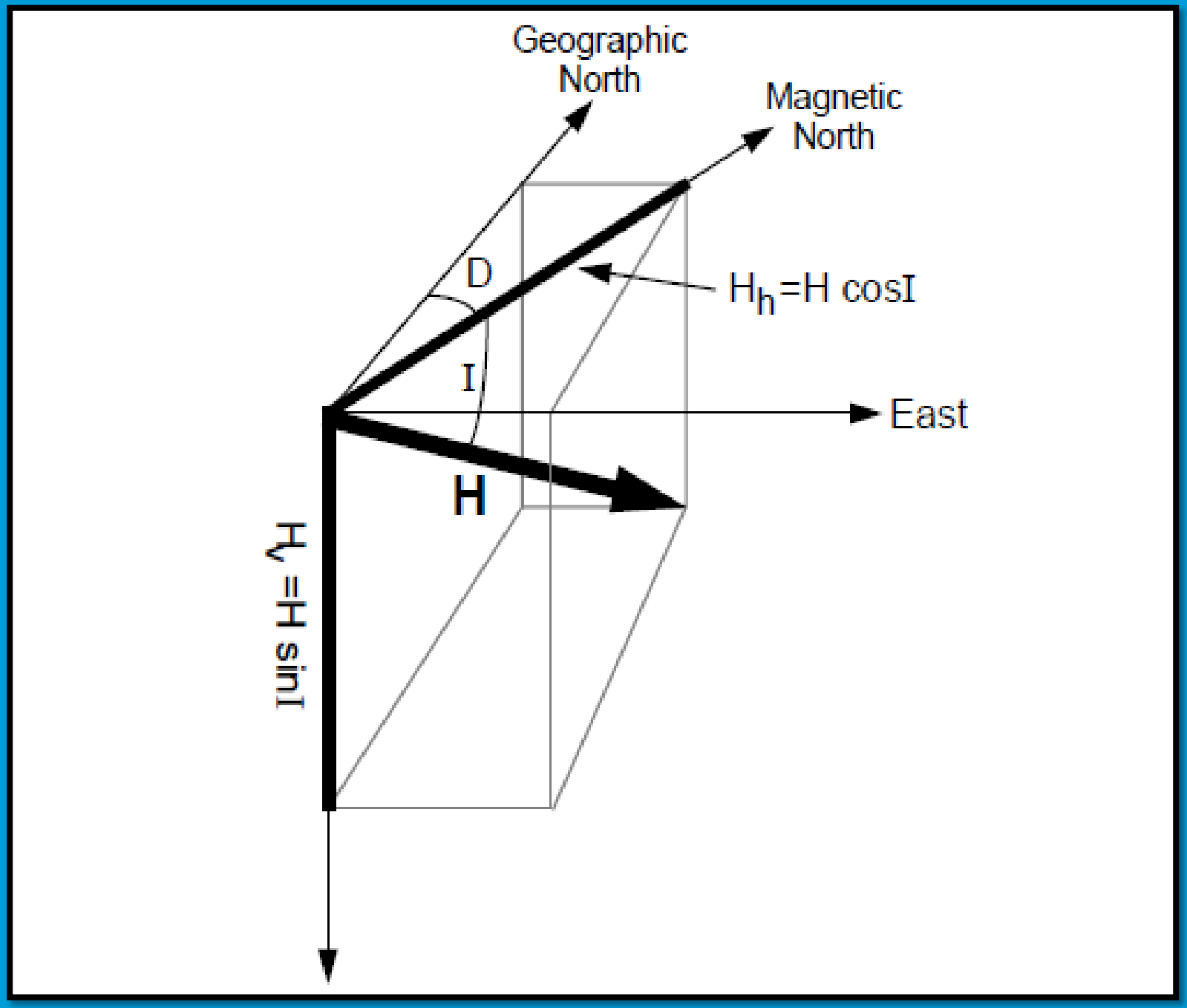
* ***Magnetostratigraphy*** uses the ***polarity*** reversal history of the Earth's magnetic field recorded in rocks to determine the age of those rocks. ***Reversals*** have occurred at irregular intervals throughout

* Mode of emplacement of intrusive bodies using **Anisotropy of Magnetic Susceptibility (AMS)**

* Determination of **paleolatitude** in relation to plate tectonics and paleogeography

* Reconstruction of **paleoclimatical** conditions using magnetic susceptibility and other parameters

* As a new tool in **air pollution** mapping


Geographic
North
Magnetic
North
D
H_h=H cosI
I
East
H
H_v=H sinI

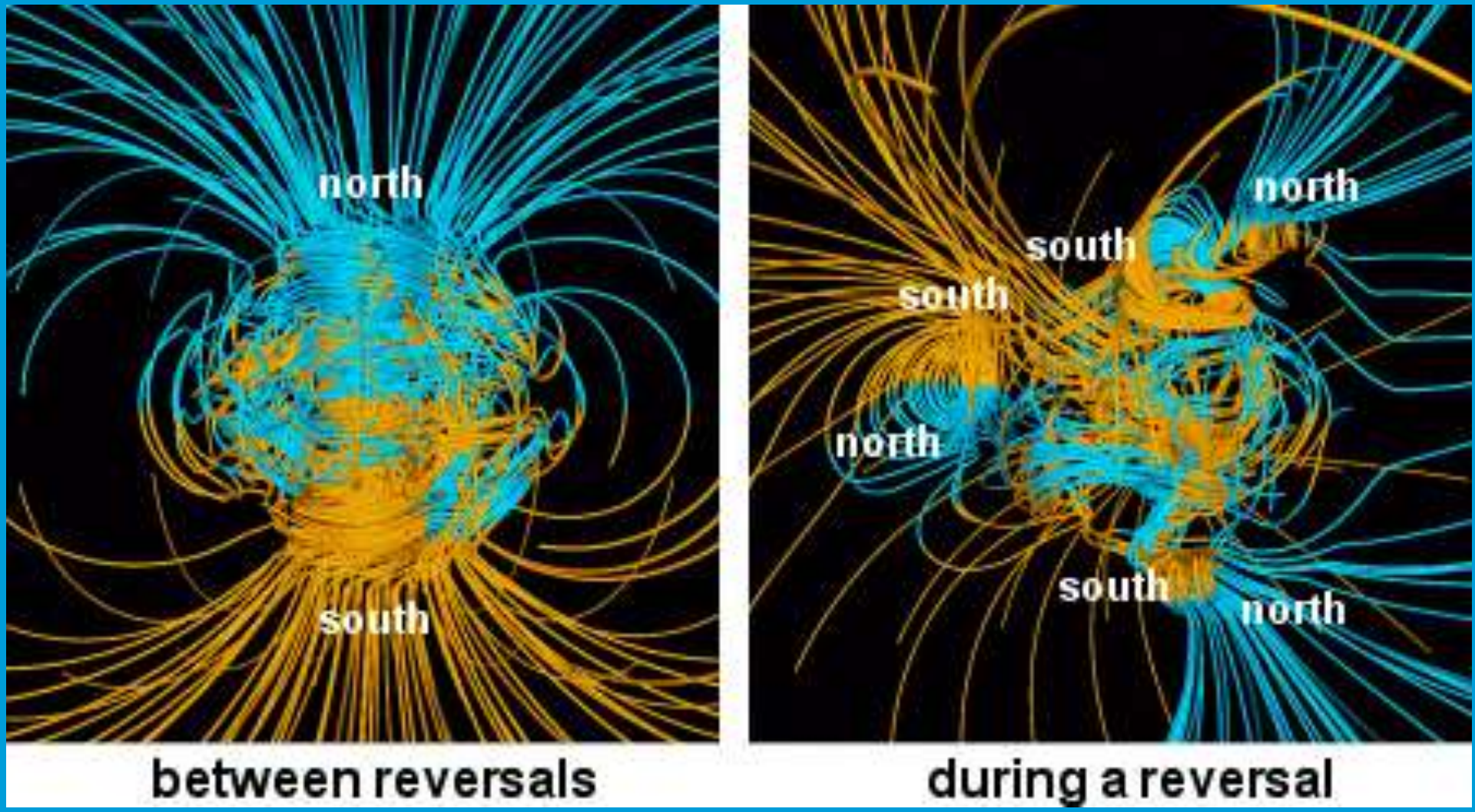
Principles of remanent magnetization

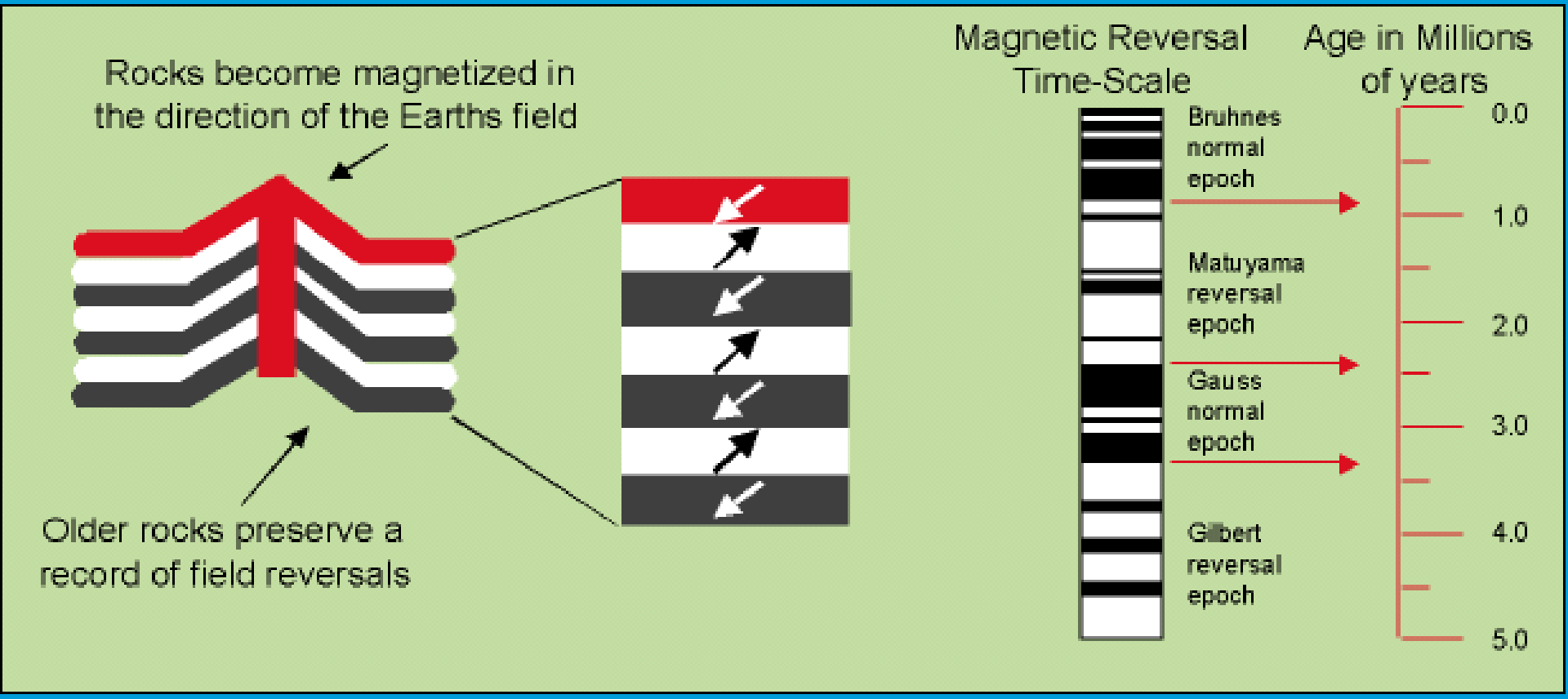
* Thermoremanent magnetization
* Partial thermoremanent magnetization
* Detrital remanent magnetization
* Chemical remanent magnetization
* Isothermal remanent magnetization
* Viscous remanent magnetization

Magnetostratigraphy

* **Magnetostratigraphy** is a ***geophysical*** correlation technique used to date ***sedimentary*** and ***volcanic*** sequences
* The method works by collecting oriented samples at measured intervals throughout the section
* The samples are analyzed to determine their ***Characteristic Remanent Magnetization*** (ChRM), that is, the polarity of ***Earth's magnetic field*** at the time a ***stratum*** was deposited
* Volcanic flows acquire a ***thermoremanent magnetization*** and sediments acquire a ***depositional remanent magnetization***, both of which reflect the direction of the Earth's field at the time of formation

* magnetic properties of rocks may vary stratigraphically, then they may be the basis for related but different kinds of stratigraphic units known collectively as ***magnetostratigraphic units (magnetozones)***
* change in the direction of the remanent magnetization of the rocks, caused by ***reversals in the polarity of the Earth's magnetic field***
* basis for the subdivision of the sequence into units characterized by their magnetic polarity. Such units are called "magnetostratigraphic polarity units" or chrons


north
south
between reversals
north
south
south
north
south
north
during a reversal


Rocks become magnetized in the direction of the Earths field
Older rocks preserve a record of field reversals
Magnetic Reversal Time-Scale
Age in Millions of years
Bruhnes normal epoch
Matuyama reversal epoch
Gauss normal epoch
Gilbert reversal epoch
0.0
1.0
2.0
3.0
4.0
5.0

Sampling procedures

* Oriented paleomagnetic samples are collected using a rock core drill
* Minimum of three samples is taken from each sample site level
* Spacing of the sample sites within a stratigraphic section depends on the rate of deposition and the age of the section
* In sedimentary layers, the preferred ***lithologies*** are ***mudstones***, ***claystones***, and very fine-grained ***siltstones***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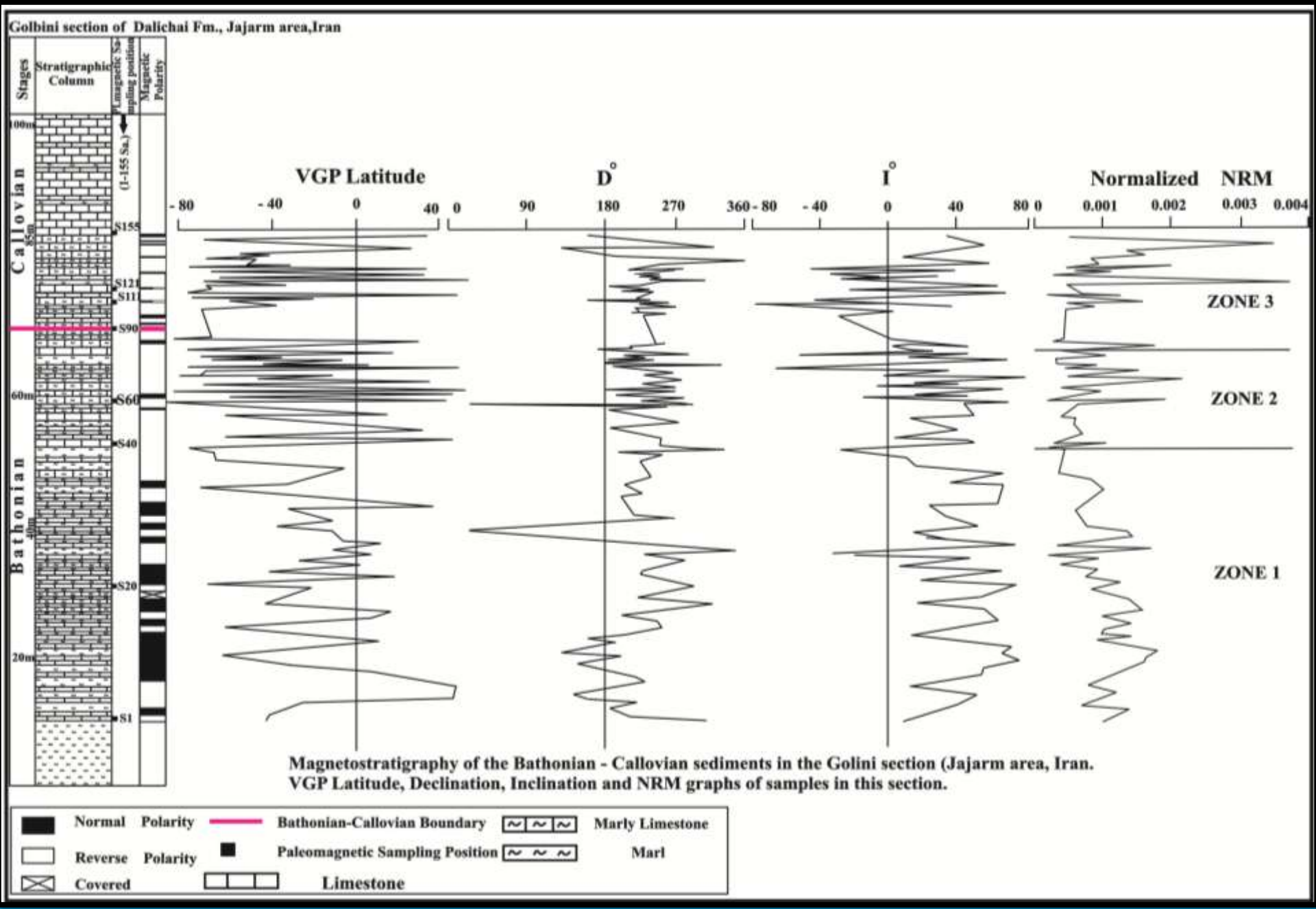
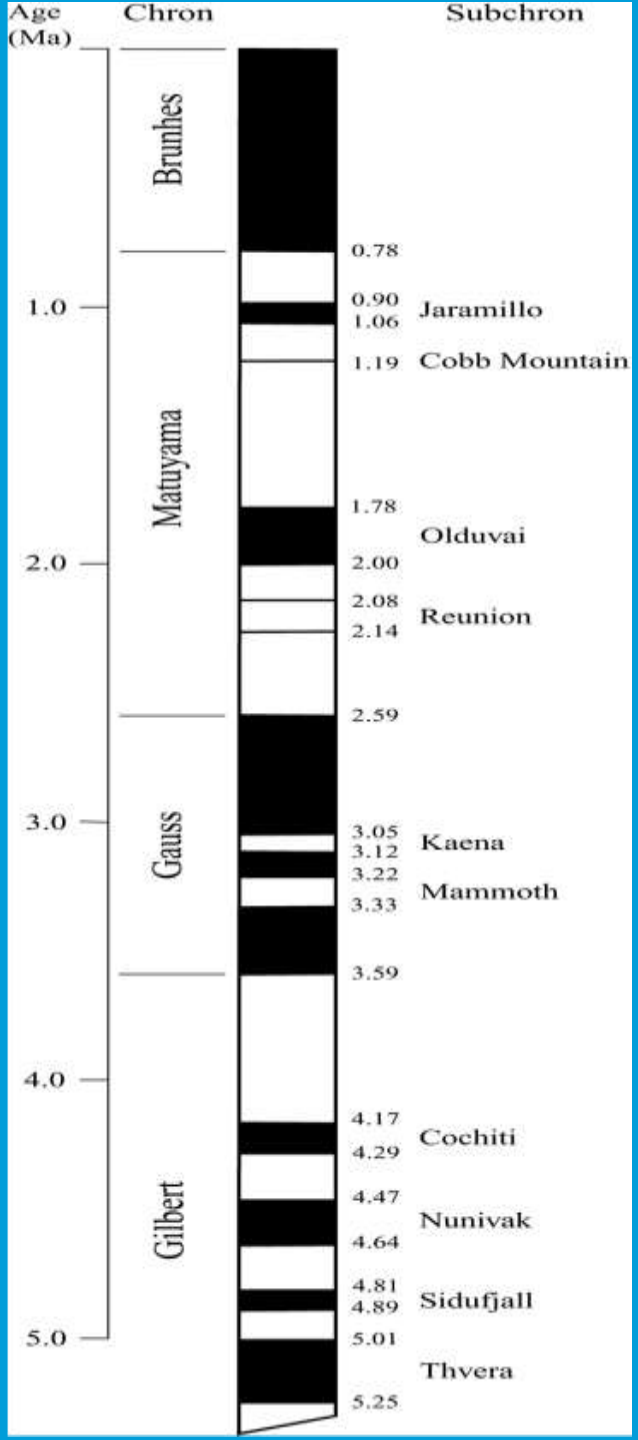
Analytical procedures

* Samples are first analyzed in their natural state to obtain their ***natural remanent magnetization*** (NRM)
* The NRM is then stripped away in a stepwise manner using thermal or alternating field demagnetization techniques to reveal the stable magnetic component
* Average magnetic polarity is determined with ***directional statistics***
* Latitudes of the ***Virtual Geomagnetic Poles*** (VGP) from those sites determined
* VGP's are plotted against stratigraphic levels
* Data are showed as ***black (normal polarity)*** and ***white (reversed polarity)***

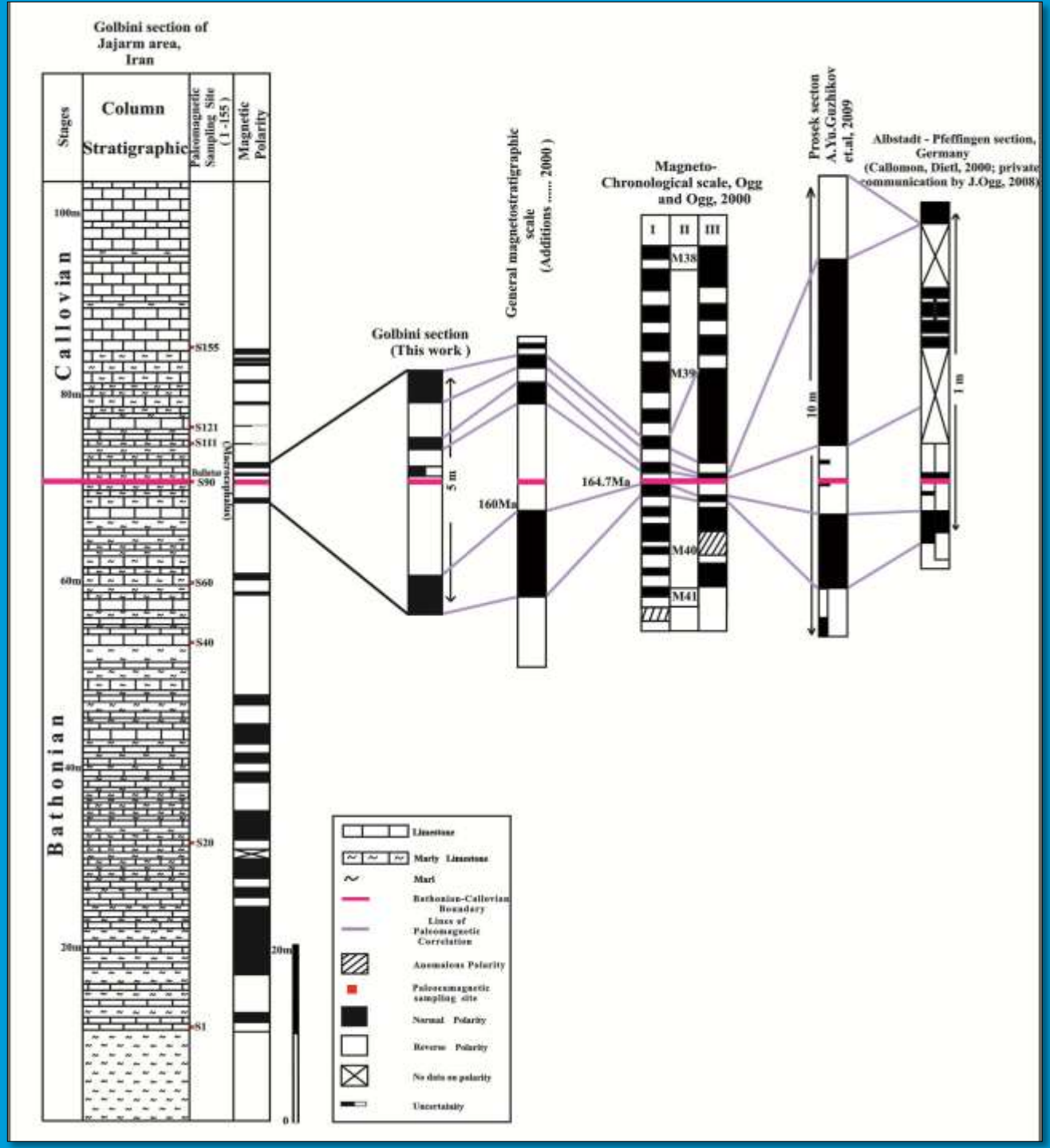


Magnetostratigraphy of the Bathonian - Callovian sediments in the Golini section (Jajarm area, Iran.
VGP Latitude, Declination, Inclination and NRM graphs of samples in this section.


Age (Ma)
Chron
Subchron
Brunhes
Matuyama
Gauss
Gilbert
1.0
2.0
3.0
4.0
5.0
0.78
0.90
1.06
Jaramillo
1.19
Cobb Mountain
1.78
Olduvai
2.00
2.08
Reunion
2.14
2.59
3.05
Kaena
3.12
3.22
Mammoth
3.33
3.59
4.17
Cochiti
4.29
4.47
Nunivak
4.64
4.81
Sidufjall
4.89
5.01
Thvera
5.25

Correlation and ages

* The polarity of a stratum can only be normal or reversed
* Variations in the rate at which the sediment accumulated can cause the thickness of a given polarity zone to vary from one area to another
* To avoid confusion at least one ***isotopic age*** needs to be collected from each section
* In sediments, this is often obtained from layers of ***volcanic ash***. Failing that, one can tie a polarity to a ***biostratigraphic*** event that has been correlated elsewhere with isotopic ages
* With these ages, the local magnetostratigraphic column is correlated with the Global Magnetic Polarity Time Scale (GMPTS)
* These ages provide relatively precise dates for features in the rocks such as ***fossils***, changes in sedimentary rock composition, changes in depositional environment, etc
* They also constrain the ages of cross-cutting features such as ***faults***, ***dikes***, and ***unconformities***


Golbini section of Jajarm area, Iran
Stages
Column Stratigraphic
Paleomagnetic Sampling Site (1 -155)
Magnetic Polarity
Callovian
Bathonian
100m
80m
60m
40m
20m
S155
S121
S111
Bulletacrassicostatum (Quenstedtoceras)
S90
S60
S40
S20
S1
20m
0
Golbini section (This work)
5 m
160Ma
General magnetostratigraphic scale (Additions ..... 2000)
164.7Ma
Magneto-Chronological scale, Ogg and Ogg, 2000
I
II
III
M38
M39
M40
M41
Prosek section A.Yu.Guzhikov et.al, 2009
10 m
Albstadt - Pfeffingen section, Germany (Callomon, Dietl, 2000; private communication by J.Ogg, 2008)
1 m
Limestone
Marly Limestone
Marl
Bathonian-Callovian Boundary
Lines of Paleomagnetic Correlation
Anomalous Polarity
Paleomagnetic sampling site
Normal Polarity
Reverse Polarity
No data on polarity
Uncertainty

Sediment accumulation rates

* The most powerful application magnetostratigraphic data is to determine the rate at which the sediment accumulated
* This is accomplished by plotting the age of each reversal (in millions of years ago) vs. the stratigraphic level at which the reversal is found (in meters).
* This provides the rate in meters per million years which is usually rewritten in terms of millimeters per year
* Changes in sedimentation rate revealed by magnetostratigraphy are often related to either climatic factors or to tectonic developments in nearby or distant mountain ranges

Environmental Magnetism

History

Environmental magnetism was first identified as a distinct field in 1978 and was introduced to a wider audience by the book *Environmental Magnetism* in 1986. Since then it has grown rapidly, finding application in and making major contributions to a range of diverse fields, especially paleoclimate, sedimentology, paleoceanography, and studies of particulate pollution

* Is the study of magnetism as it relates to the effects of climate, sediment transport, pollution and other environmental influences on magnetic minerals
* It makes use of techniques from rock magnetism and magnetic mineralogy
* The magnetic properties of minerals are used as proxies for environmental change in applications such as paleoclimate, paleoceanography, studies of the provenance of sediments, pollution and archeology
* Magnetic minerals are almost can be found every where and magnetic measurements are quick and non- destructive

Fundamentals

* Environmental magnetism is built on two parts of rock magnetism: magnetic mineralogy, which looks at how basic magnetic properties depend on composition; and magnetic hysteresis, which can provide details on particle size and other physical properties that also affect the hysteresis
* Parameters such as magnetic susceptibility and various kinds of remanence have been developed to represent certain features of the hysteresis
* These parameters are then used to estimate mineral size and composition

* The main contributors to the magnetic properties of rocks are the iron oxides, including magnetite, maghemite, hematite; and iron sulfides (particularly greigite and pyrrhotite)
* These minerals are strongly magnetic because, at room temperature, they are magnetically ordered (magnetite, maghemite and greigite are ferrimagnets while hematite is a canted antiferromagnet)
* To relate magnetic measurements to the environment, environmental magnetists have identified a variety of processes that give rise to each magnetic mineral

* These include erosion, transport, fossil fuel combustion, and bacterial formation.

* The latter includes extracellular precipitation and formation of magnetosomes by magnetotactic bacteria.

Applications

Paleoclimate

* Magnetic measurements have been used to investigate past climate. A classic example is the study of loess, which is windblown dust from the edges of glaciers and semiarid desert margins

* In north-central Iran, blankets of loess that were deposited during glacial periods alternate with paleosols (fossil soils) that formed during warmer and wetter interglacials

* The magnetic susceptibility profiles of these sediments have been dated using OSL method and correlated with climate indicators such as oxygen isotope stages

* Ultimately, this work allowed environmental magnetists to map out the variations in the climate cycle during the Quaternary

* Loess is an aeolian sediment formed by the accumulation of wind-blown silt, typically in the 20–50 micrometre size range, twenty percent or less Clay and the balance equal parts sand and silt that are loosely cemented by calcium carbonate

* A glacial period is an interval of time (thousands of years) within an ice age that is marked by colder temperatures and glacier advances.

* Interglacials, are periods of warmer climate within an ice age. The last glacial period ended about 15,000 years ago; The Holocene epoch is the current interglacial.

Magnetic susceptibility

* **The magnetic susceptibility is a dimensionless proportionality constant that indicates the degree of magnetization of a material in response to an applied magnetic field**

Paleoceanography

is the study of the history of the oceans in the geologic past with regard to circulation, chemistry, biology, geology and patterns of sedimentation and biological productivity. Paleoceanographic studies using environment models and different proxies enable the scientific community to assess the role of the oceanic processes in the global climate by the re-construction of past climate at various intervals.

Pollution

* Monitoring present-day environmental pollution, and identification of airborne particulate matter (PM) sources and dispersal patterns

* High concentration of fine PM are associated with adverse impacts on human health

* Fine-grained ferrimagnetic phases are released in the atmosphere as a by-product of human activities and are generally associated with heavy metals.

* Magnetic data may therefore represent reliable proxies

Province of sediments

* Magnetic Fe-oxide inclusions within framework clastic grains in sediments provide an indication of the provenance of the enclosing host silicate particles

* Magnetic mineral inclusion characterisation is performed using a variety of magnetic properties that are related to magnetic mineral abundance, magnetic grain size (domain state), oxidation state and magnetic grain interaction(NRM, IRM, SIRM)

* The magnetic methodology extends that based on a conventional set of environmental magnetic measurements

Archeology

Magnetic susceptibility is often used for:

* **Site prospection, to identify areas of archaeological potential prior to excavation**
* **Identifying hearth areas and the presence of burning residues in deposits**
* **Explaining whether areas of reddening are due to burning or other natural processes such as gleying (waterlogging).**

The relationship between soil formation and magnetic susceptibility means that it can also be used to:

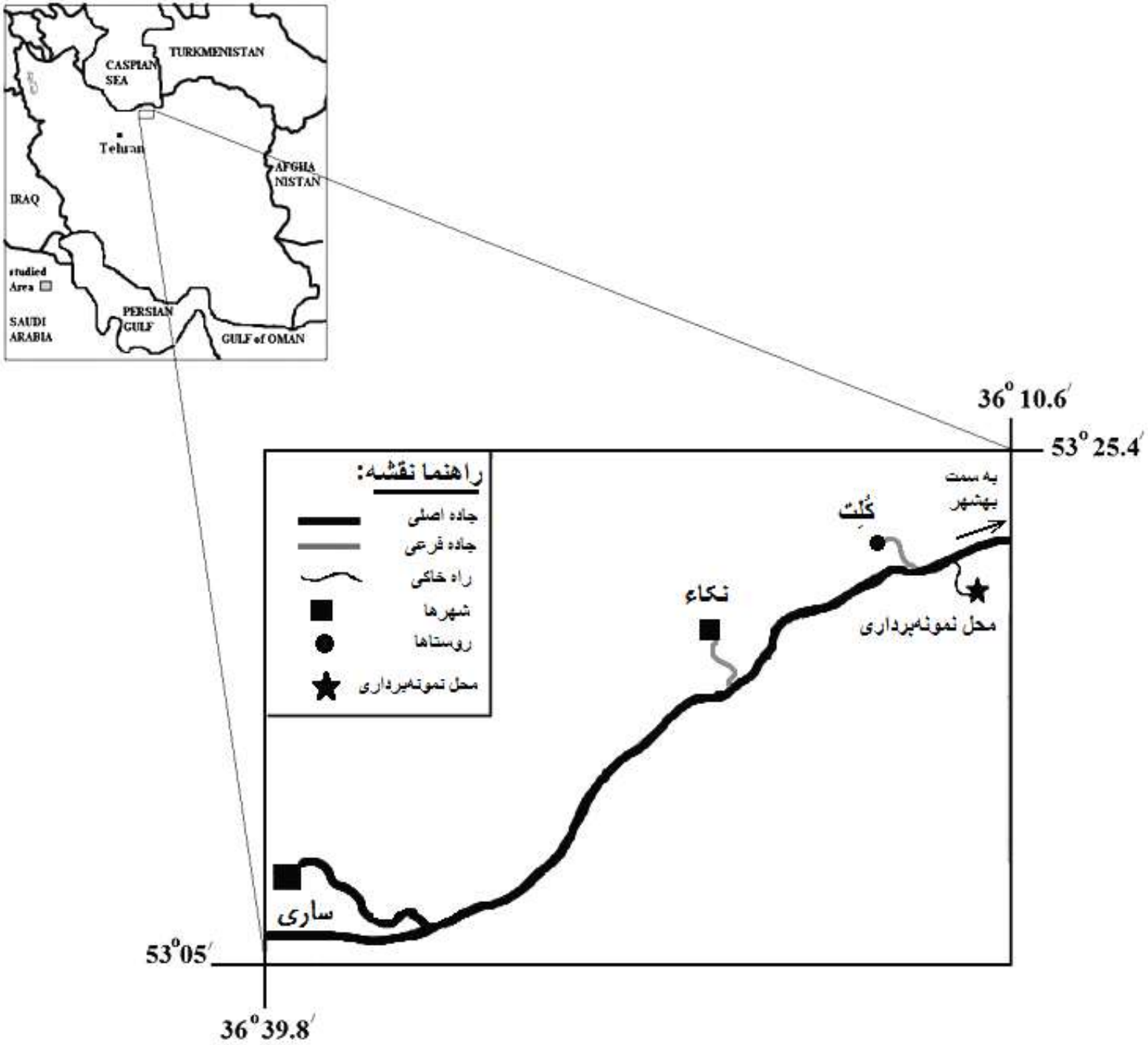
* **Identify buried soils in depositional sequences.**
* **Identify redeposited soil materials in peat, lake sediments etc.**

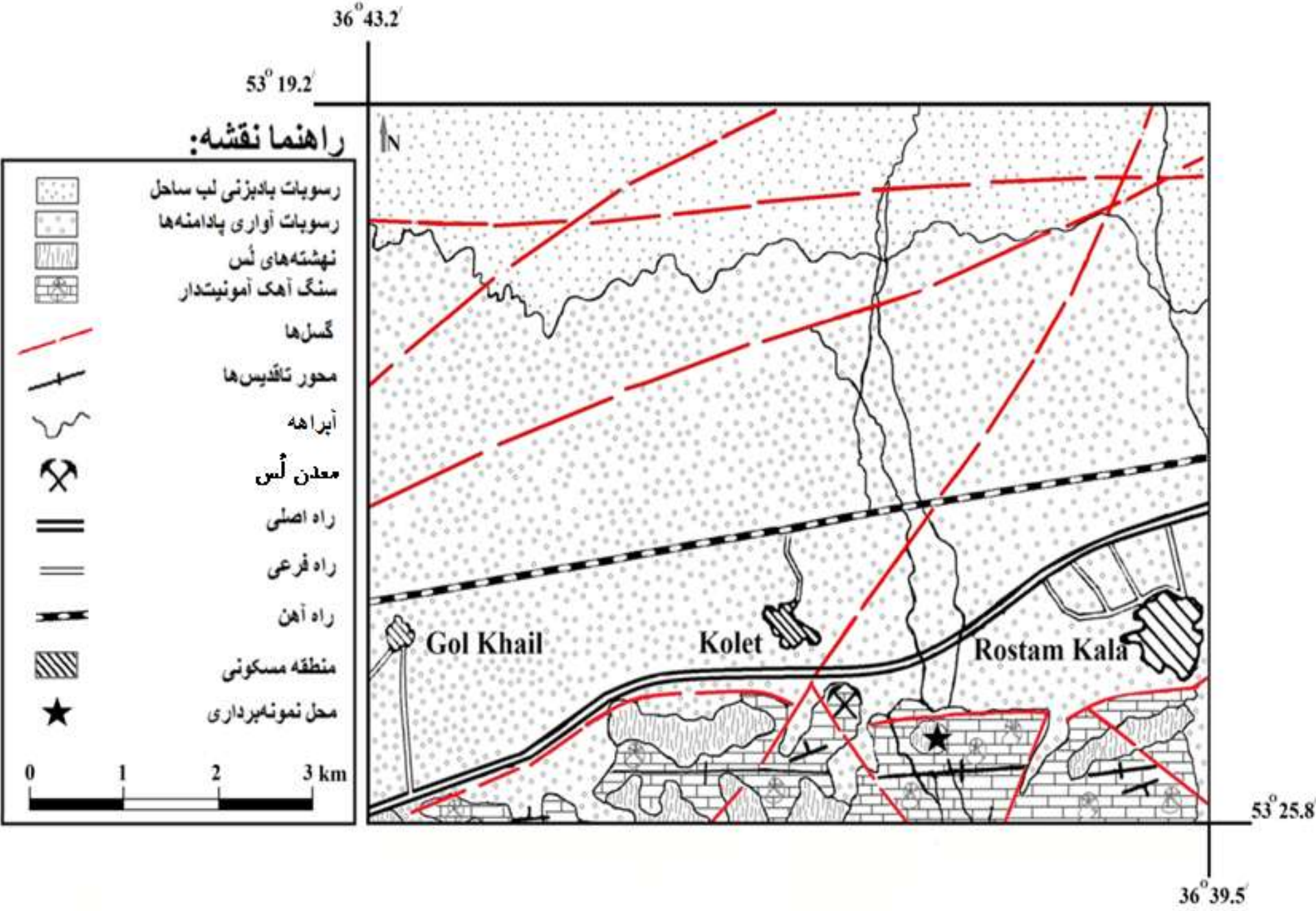
Case studies

Reconstruction of Late Quaternary climatical conditions at part of Eastern Alborz, Iran, using Magnetic Parameters and Techniques

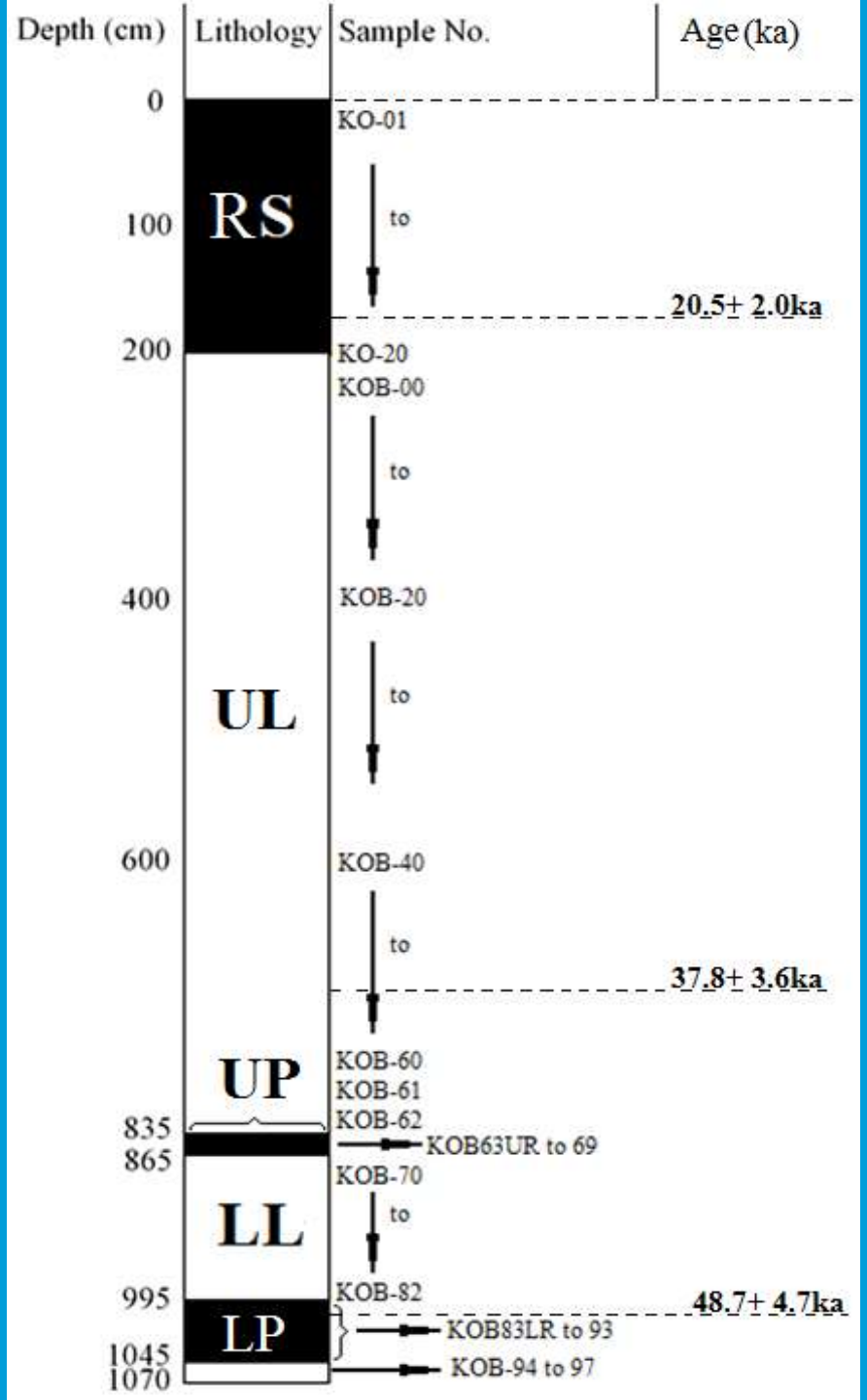
F. M. Haskouei, H. Alimohammadian, M. Ahmadzadeh Heravi, J. Sabouri and F. Ansari

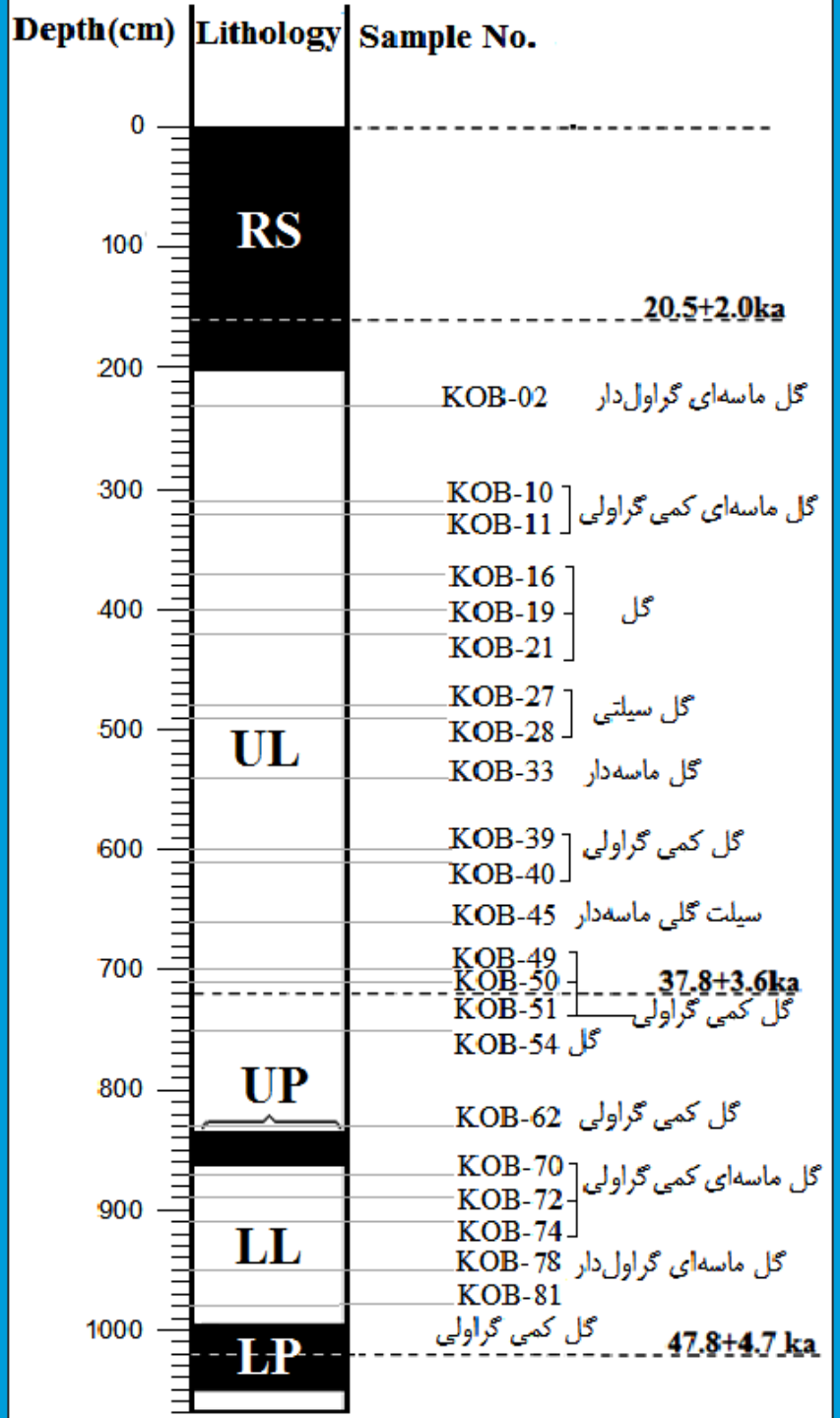
M.SC. Thesis

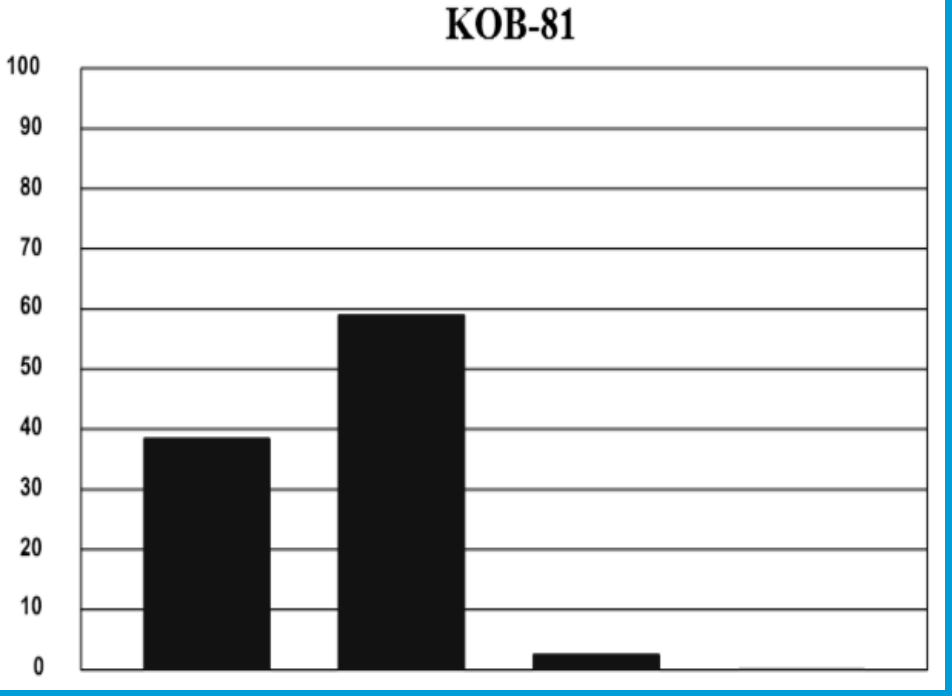

CASPIAN SEA
TURKMENISTAN
Tehran
AFGHANISTAN
IRAQ
studied Area
PERSIAN GULF
SAUDI ARABIA
GULF of OMAN
36° 10.6′
53° 25.4′
راهنما نقشه:
جاده اصلی
جاده فرعی
راه خاکی
شهرها
روستاها
محل نمونه‌برداری
به سمت بهشهر
کُلت
نکاء
محل نمونه‌برداری
ساری
53°05′
36°39.8′

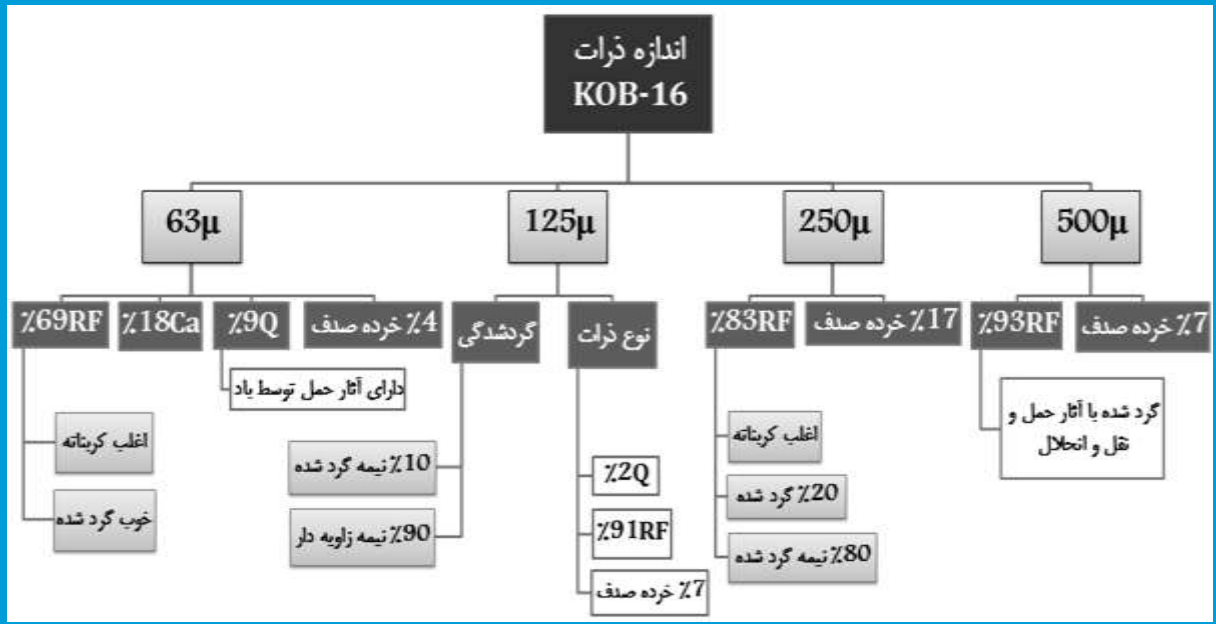

36° 43.2′
53° 19.2′
راهنما نقشه:
N
رسوبات بادبزنی لب ساحل
رسوبات آواری پادامنه‌ها
نهشته‌های لُس
سنگ آهک آمونیتدار
گسل‌ها
محور تاقدیس‌ها
آبراهه
معدن لُس
راه اصلی
راه فرعی
راه آهن
منطقه مسکونی
محل نمونه‌برداری
0 1 2 3 km
Gol Khail
Kolet
Rostam Kala
53° 25.8′
36° 39.5′

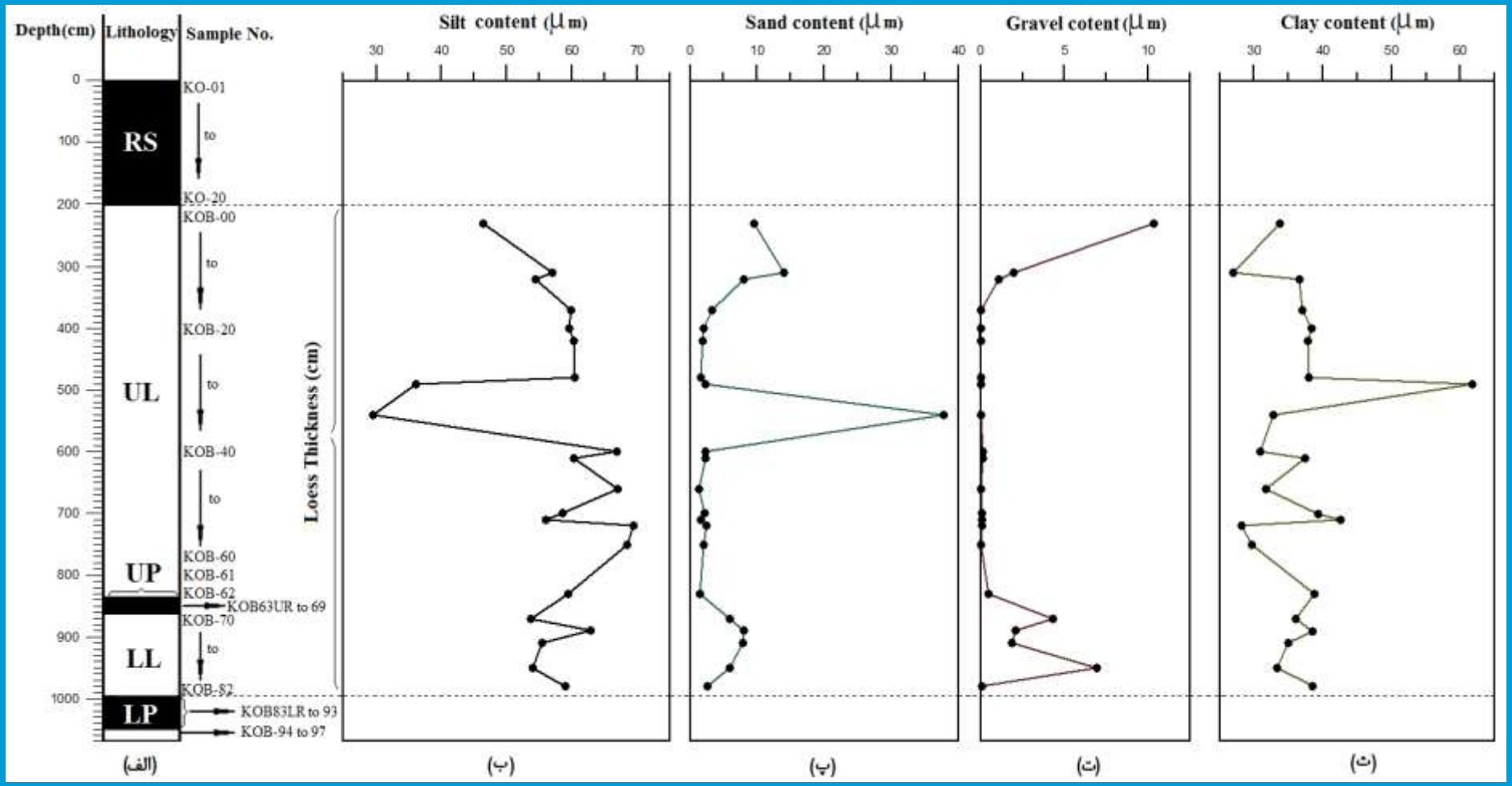

خاک عهد حاضر (RS)
واحد لَس بالایی (UL)
خاک دیرینه بالایی (UP)
واحد لَس پائینی (LL)
خاک دیرینه پائینی (LP)


Depth (cm)
Lithology
Sample No.
Age (ka)
0
100
200
400
600
835
865
995
1045
1070
RS
UL
UP
LL
LP
KO-01
to
20.5+ 2.0ka
KO-20
KOB-00
to
KOB-20
to
KOB-40
to
37.8+ 3.6ka
KOB-60
KOB-61
KOB-62
KOB63UR to 69
KOB-70
to
KOB-82
48.7+ 4.7ka
KOB83LR to 93
KOB-94 to 97


Depth(cm)
Lithology
Sample No.
0
100
200
300
400
500
600
700
800
900
1000
RS
UL
UP
LL
LP
20.5+2.0ka
37.8+3.6ka
47.8+4.7 ka
KOB-02
گل ماسه‌ای گراول‌دار
KOB-10
KOB-11
گل ماسه‌ای کمی گراولی
KOB-16
KOB-19
KOB-21
گل
KOB-27
KOB-28
گل سیلتی
KOB-33
گل ماسه‌دار
KOB-39
KOB-40
گل کمی گراولی
KOB-45
سیلت گلی ماسه‌دار
KOB-49
KOB-50
KOB-51
گل کمی گراولی
KOB-54
گل
KOB-62
گل کمی گراولی
KOB-70
KOB-72
KOB-74
گل ماسه‌ای کمی گراولی
KOB-78
گل ماسه‌ای گراول‌دار
KOB-81
گل کمی گراولی


KOB-81
100
90
80
70
60
50
40
30
20
10
0
Clay%
Silt%
Sand%
Gravel%


اندازه ذرات
KOB-16
63µ
125µ
250µ
500µ
٪69RF
٪18Ca
٪9Q
٪4 خرده صدف
گردشدگی
نوع ذرات
٪83RF
٪17 خرده صدف
٪93RF
٪7 خرده صدف
اغلب کربناته
خوب گرد شده
دارای آثار حمل توسط باد
٪10 نیمه گرد شده
٪90 نیمه زاویه دار
٪2Q
٪91RF
٪7 خرده صدف
اغلب کربناته
٪20 گرد شده
٪80 نیمه گرد شده
گرد شده با آثار حمل و نقل و انحلال



نمودار 2.28. تغییرات نمودار گوناگونی دانه‌بندی ذرات رسوبی نسبت به ضخامت برش رسوبات در واحدهای لُس برش رسوبات کُلت. (الف) ستون چینه‌ای برش رسوبات کُلِت- نکاء؛ (ب) درصد تجمعی ذرات سیلتی نسبت به ضخامت رسوبات؛ (پ) درصد تجمعی ذرات ماسه‌ای نسبت به ضخامت رسوبات؛ (ت) درصد تجمعی ذرات گراولی نسبت به ضخامت رسوبات؛ (ث) درصد تجمعی ذرات رسی نسبت به ضخامت رسوبات.

الف

ب

ب

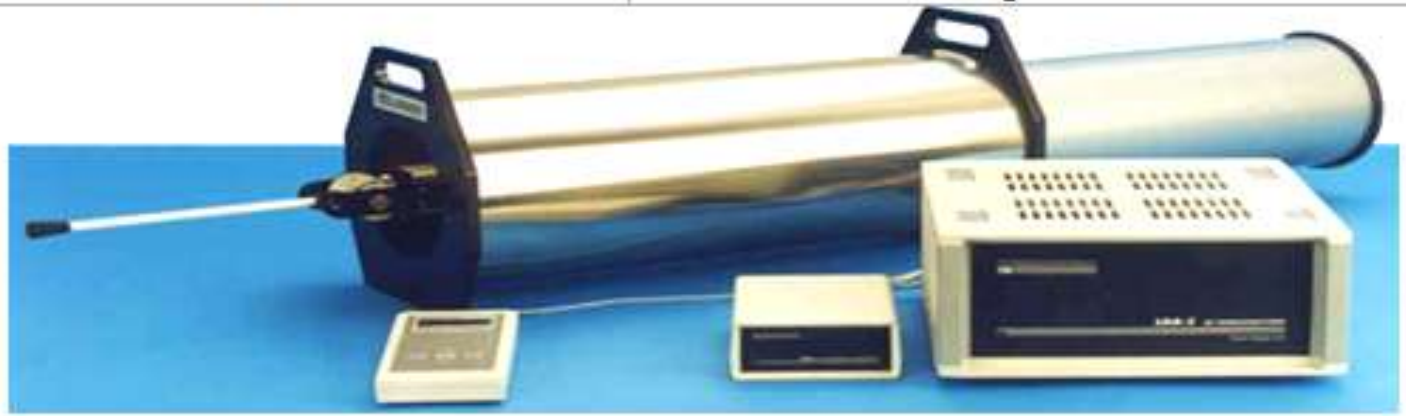
الف

الف

ب

ج

د



ه


11 15 cpm
5,52 A/m


137 2E-03

الف

ب

ج

د

ه

و


MFK1-A
MULTI-FUNCTION KAPPABRIDGE

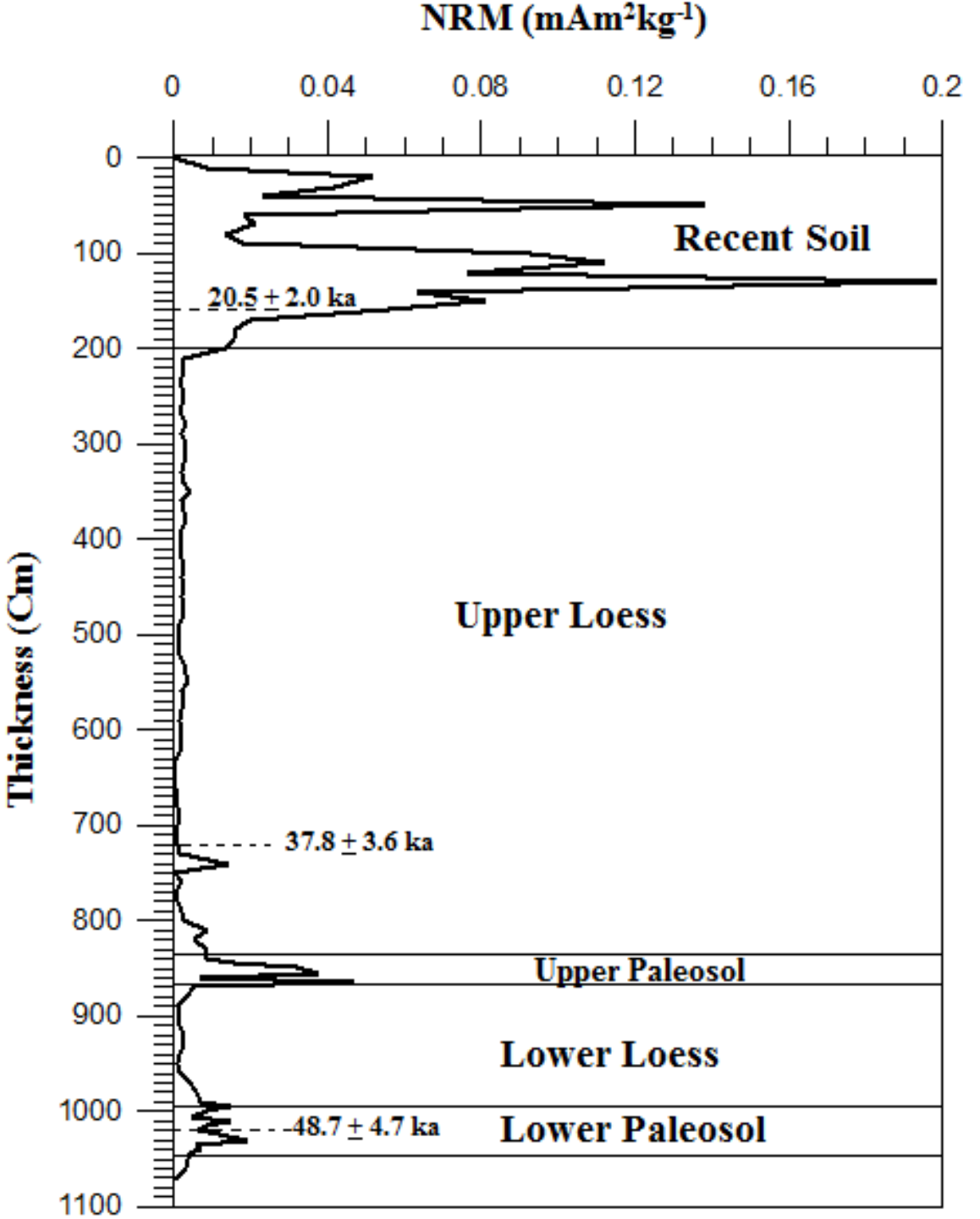

AGICO

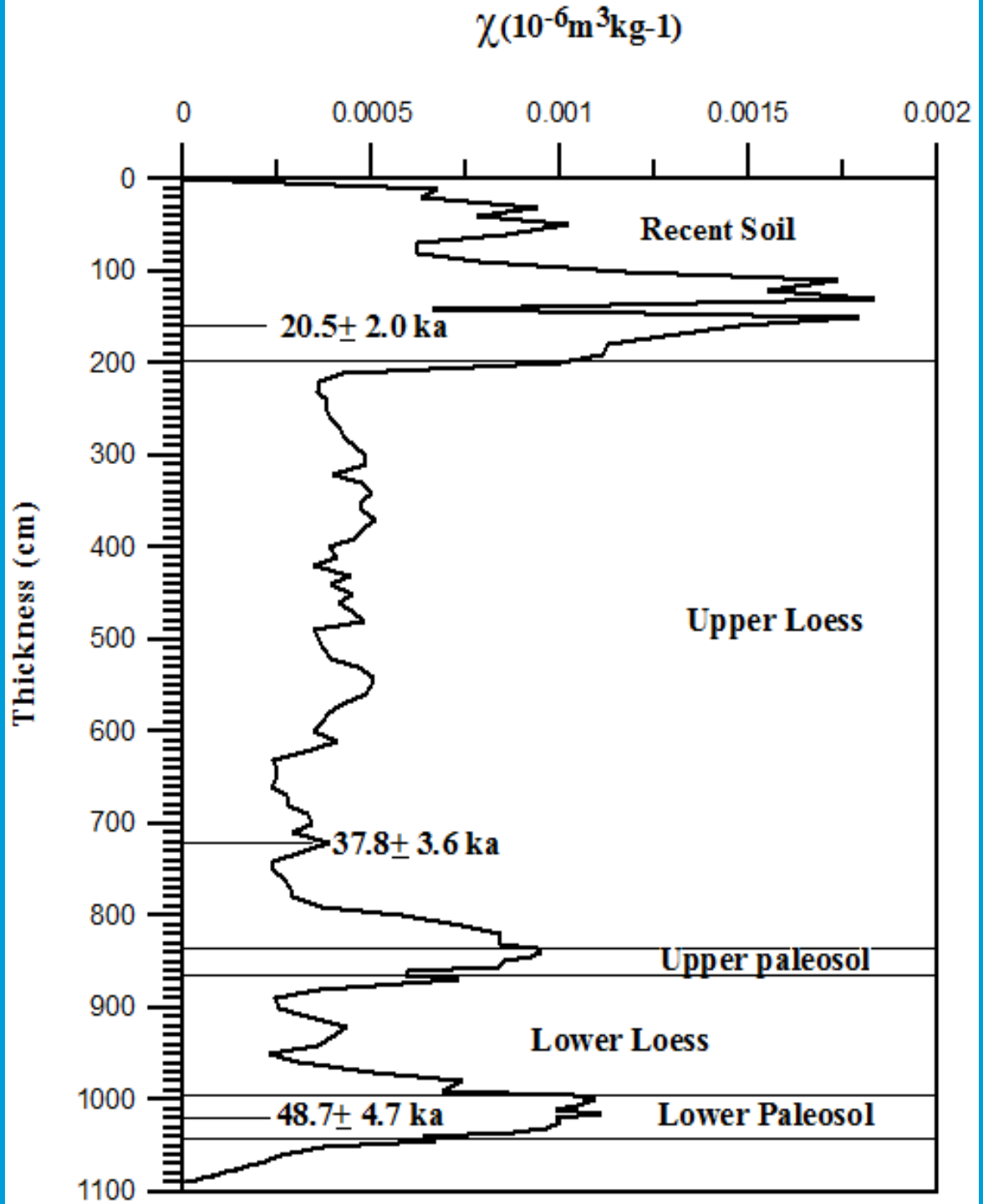

LDA-3A AF DEMAGNETIZER

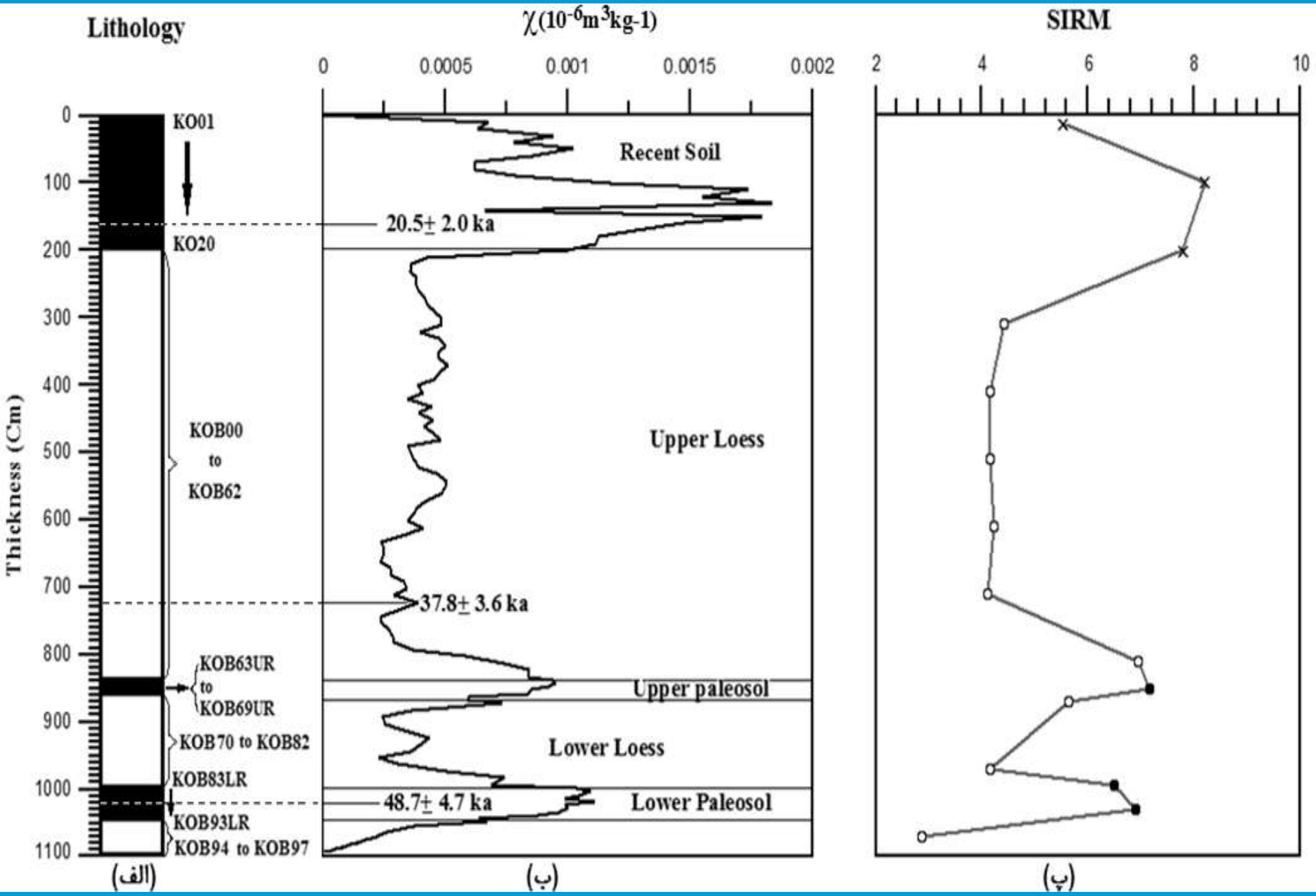

LDA-3A AF DEMAGNETIZER

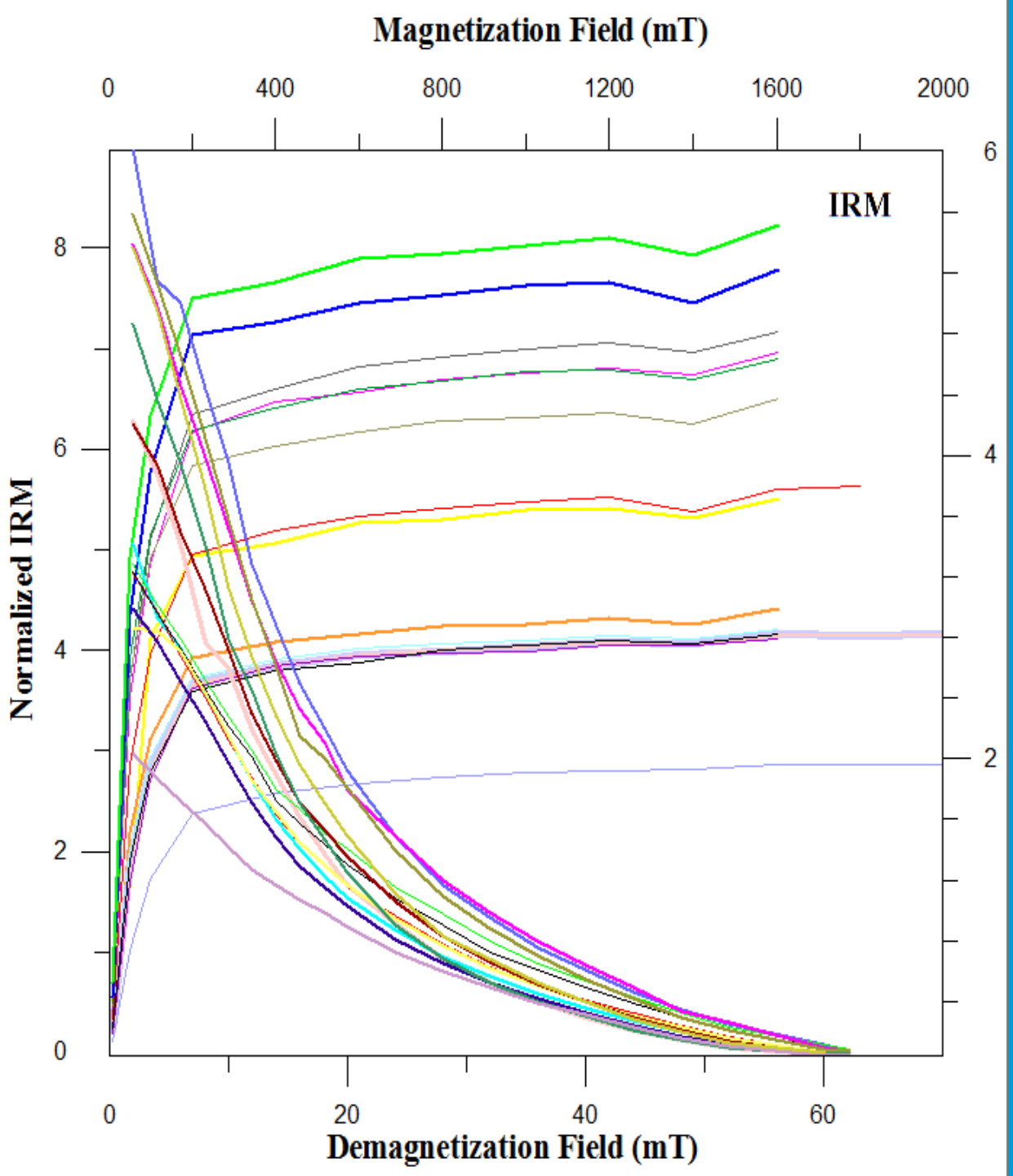

LDA-3A

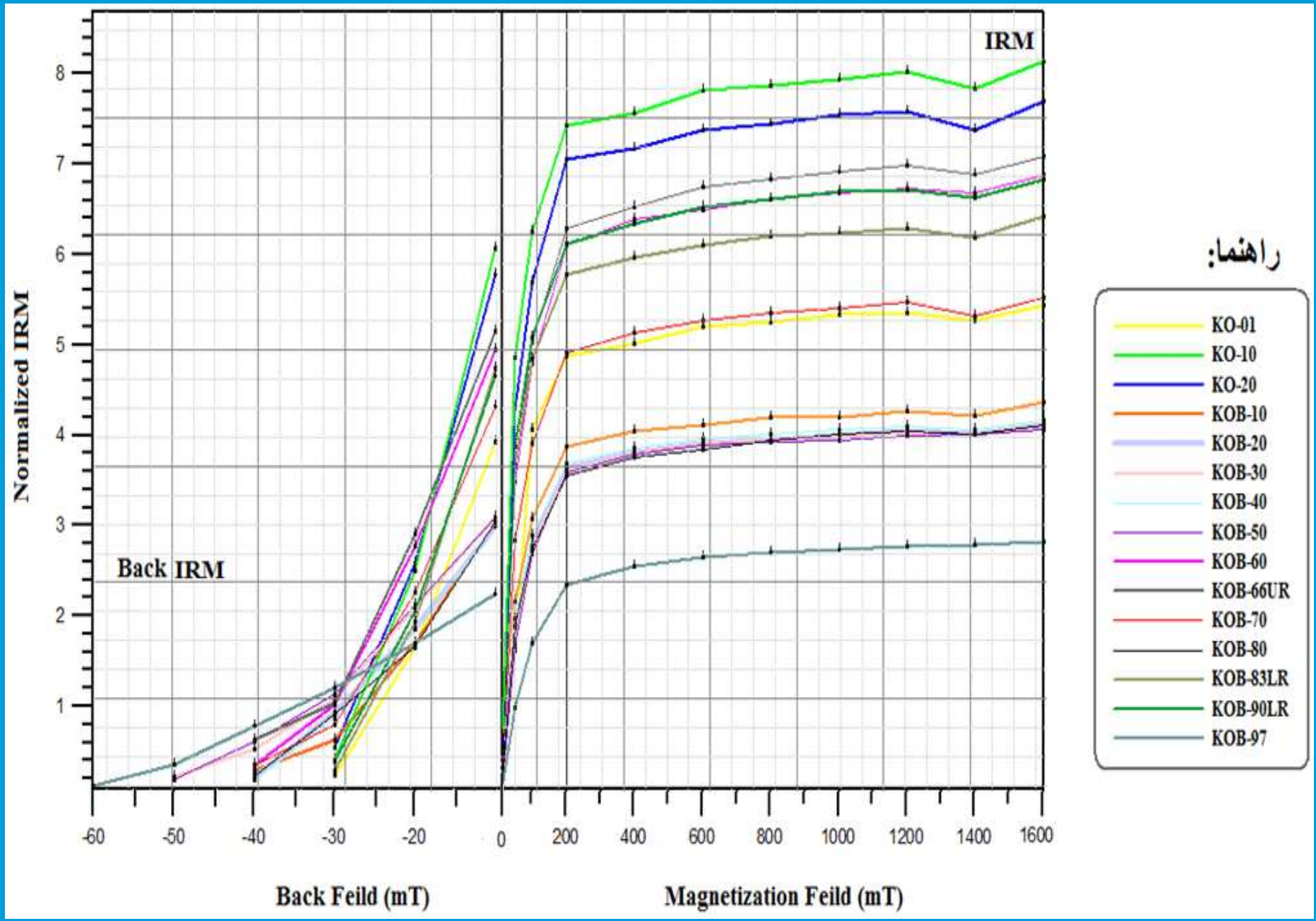

LDA-3A

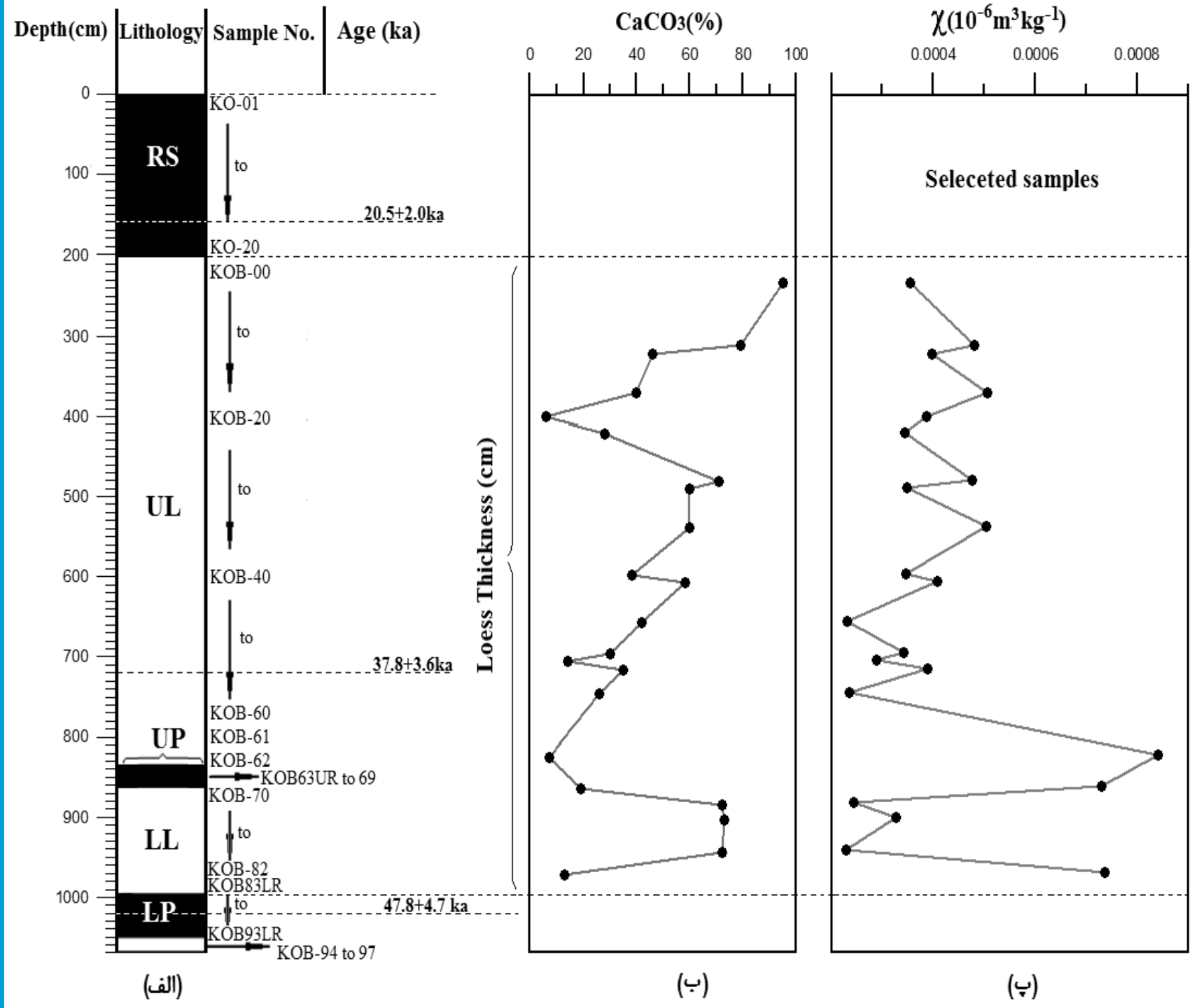

NRM (mAm²kg⁻¹)
0
0.04
0.08
0.12
0.16
0.2
Thickness (Cm)
0
100
200
300
400
500
600
700
800
900
1000
1100
Recent Soil
20.5 ± 2.0 ka
Upper Loess
37.8 ± 3.6 ka
Upper Paleosol
Lower Loess
48.7 ± 4.7 ka
Lower Paleosol

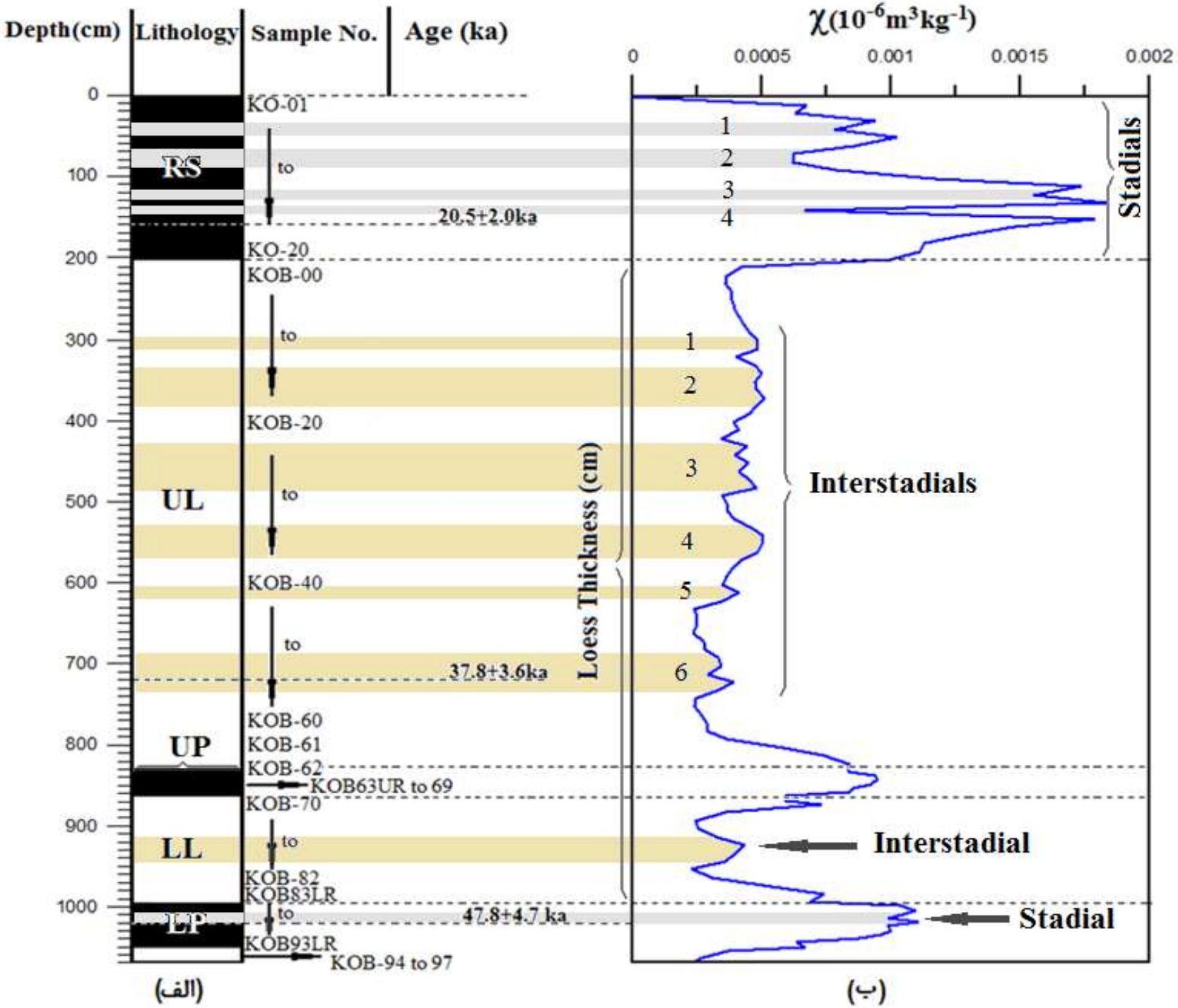

χ(10-6m3kg-1)
0
0.0005
0.001
0.0015
0.002
Thickness (cm)
0
100
200
300
400
500
600
700
800
900
1000
1100
Recent Soil
20.5± 2.0 ka
Upper Loess
37.8± 3.6 ka
Upper paleosol
Lower Loess
48.7± 4.7 ka
Lower Paleosol

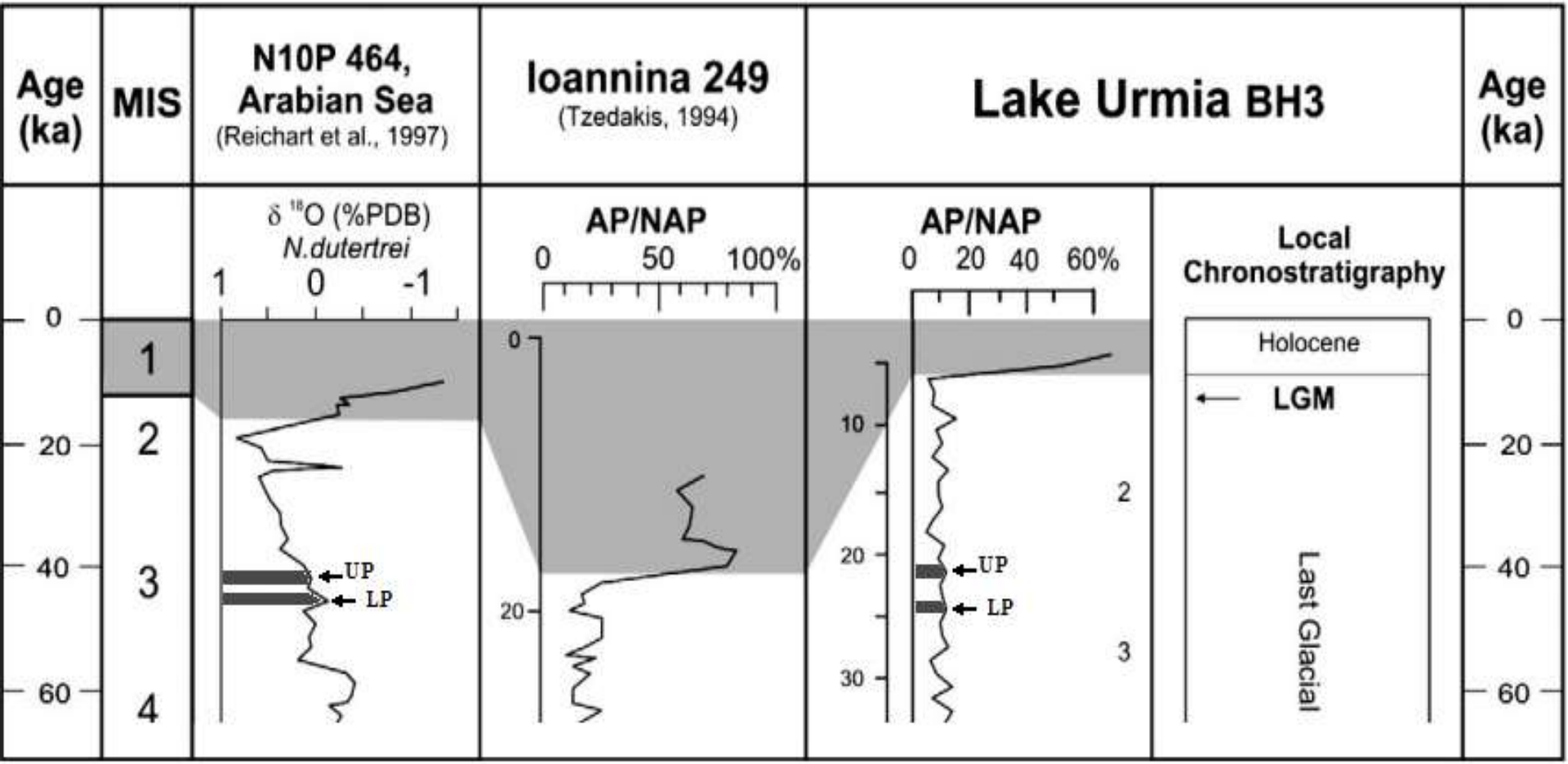

Lithology
χ(10-6m3kg-1)
SIRM
0
0.0005
0.001
0.0015
0.002
2
4
6
8
10
Thickness (Cm)
0
100
200
300
400
500
600
700
800
900
1000
1100
KO01
KO20
KOB00
to
KOB62
KOB63UR
to
KOB69UR
KOB70 to KOB82
KOB83LR
KOB93LR
KOB94 to KOB97
Recent Soil
20.5± 2.0 ka
Upper Loess
37.8± 3.6 ka
Upper paleosol
Lower Loess
48.7± 4.7 ka
Lower Paleosol
(الف)
(ب)
(پ)


Magnetization Field (mT)
0
400
800
1200
1600
2000
IRM
Normalized IRM
8
6
4
2
0
6
4
2
0
20
40
60
Demagnetization Field (mT)

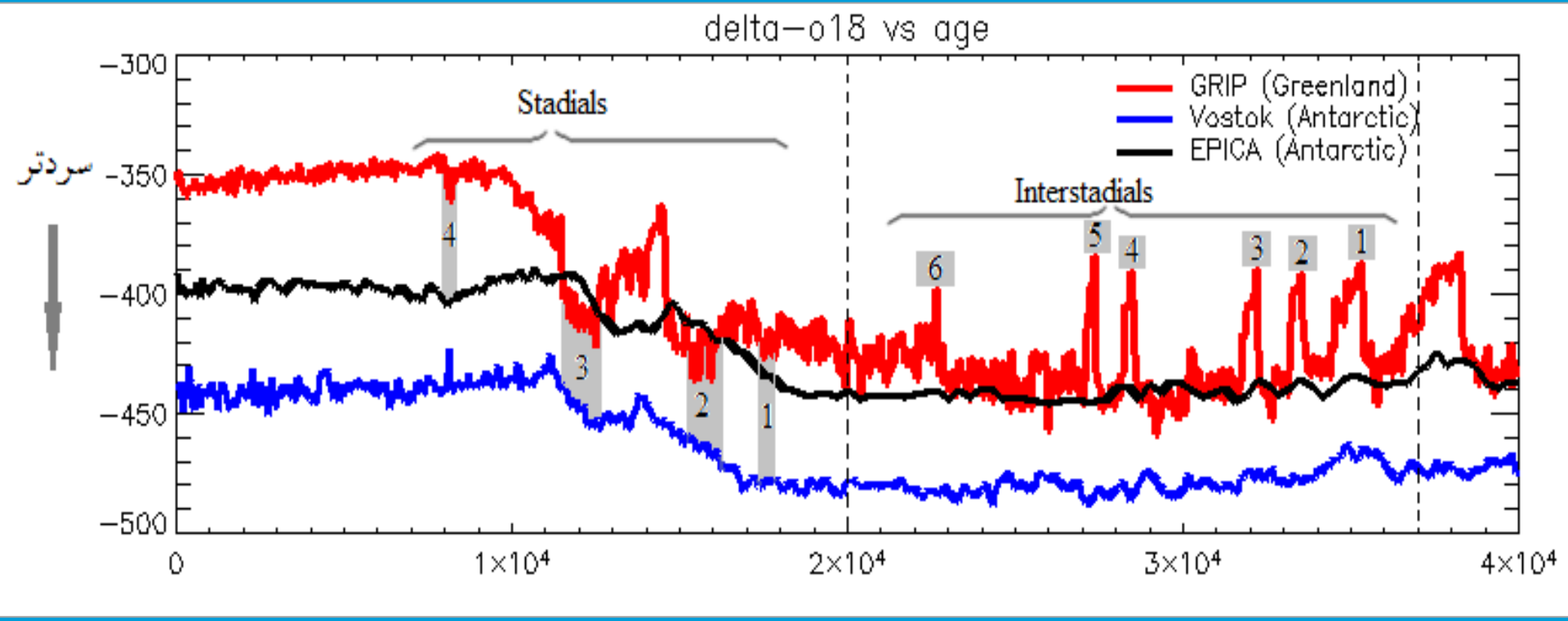

IRM
Back IRM
Normalized IRM
Back Feild (mT)
Magnetization Feild (mT)
راهنما:
KO-01
KO-10
KO-20
KOB-10
KOB-20
KOB-30
KOB-40
KOB-50
KOB-60
KOB-66UR
KOB-70
KOB-80
KOB-83LR
KOB-90LR
KOB-97


Depth(cm)
Lithology
Sample No.
Age (ka)
CaCO3(%)
χ(10-6m3kg-1)
0
20
40
60
80
100
0.0004
0.0006
0.0008
Seleceted samples
RS
UL
UP
LL
LP
KO-01
to
KO-20
20.5±2.0ka
KOB-00
to
KOB-20
to
KOB-40
to
37.8±3.6ka
KOB-60
KOB-61
KOB-62
KOB63UR to 69
KOB-70
to
KOB-82
KOB83LR
to
47.8±4.7 ka
KOB93LR
KOB-94 to 97
Loess Thickness (cm)
0
100
200
300
400
500
600
700
800
900
1000
(الف)
(ب)
(پ)

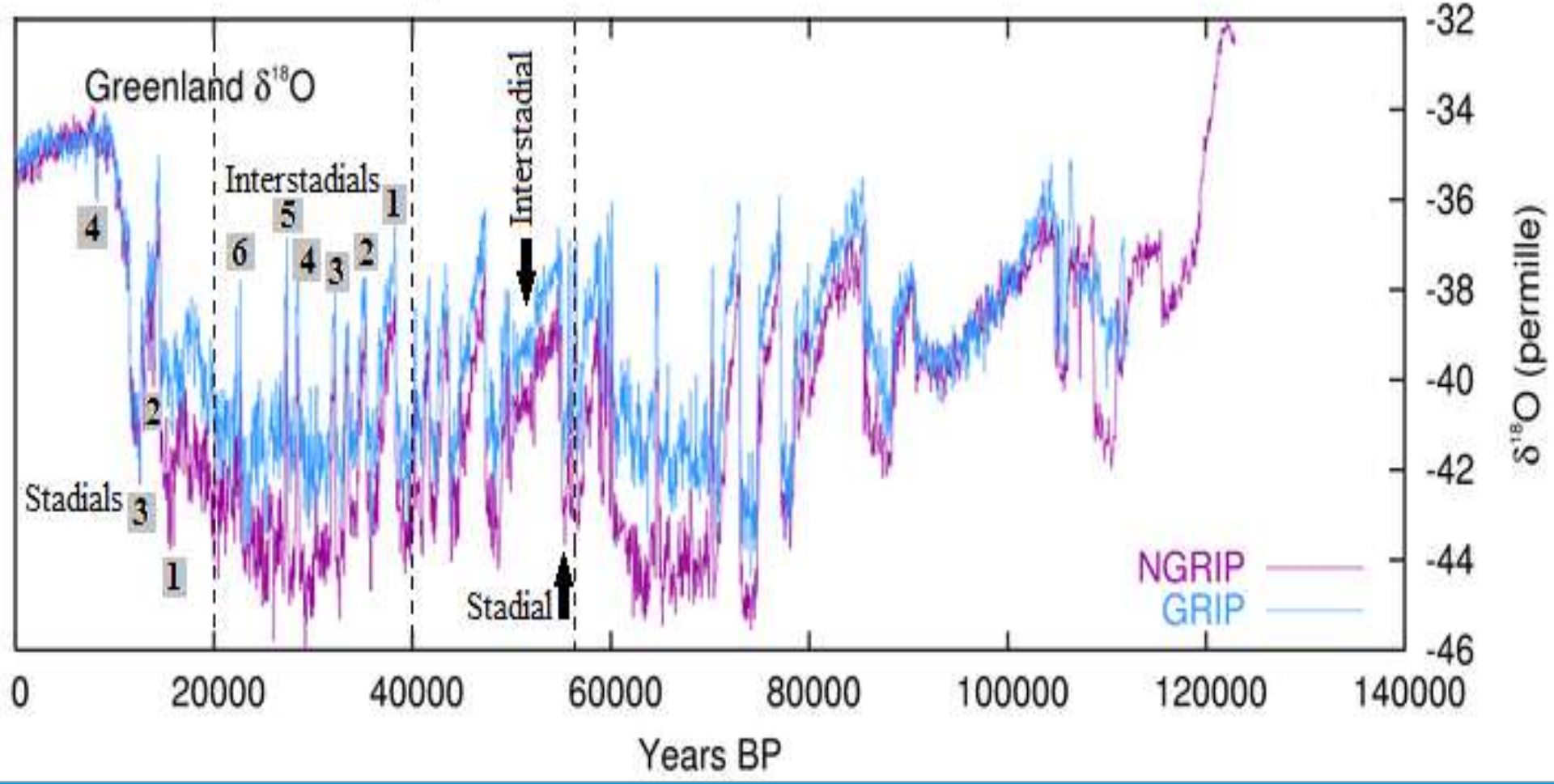

Depth(cm)
Lithology
Sample No.
Age (ka)
χ(10⁻⁶m³kg⁻¹)
0
0.0005
0.001
0.0015
0.002
KO-01
RS
to
20.5±2.0ka
KO-20
KOB-00
to
KOB-20
UL
to
KOB-40
to
37.8±3.6ka
KOB-60
KOB-61
UP
KOB-62
KOB63UR to 69
KOB-70
LL
to
KOB-82
KOB83LR
to
47.8±4.7 ka
LP
KOB93LR
KOB-94 to 97
Loess Thickness (cm)
1
2
3
4
Stadials
1
2
3
4
5
6
Interstadials
Interstadial
Stadial
(الف)
(ب)



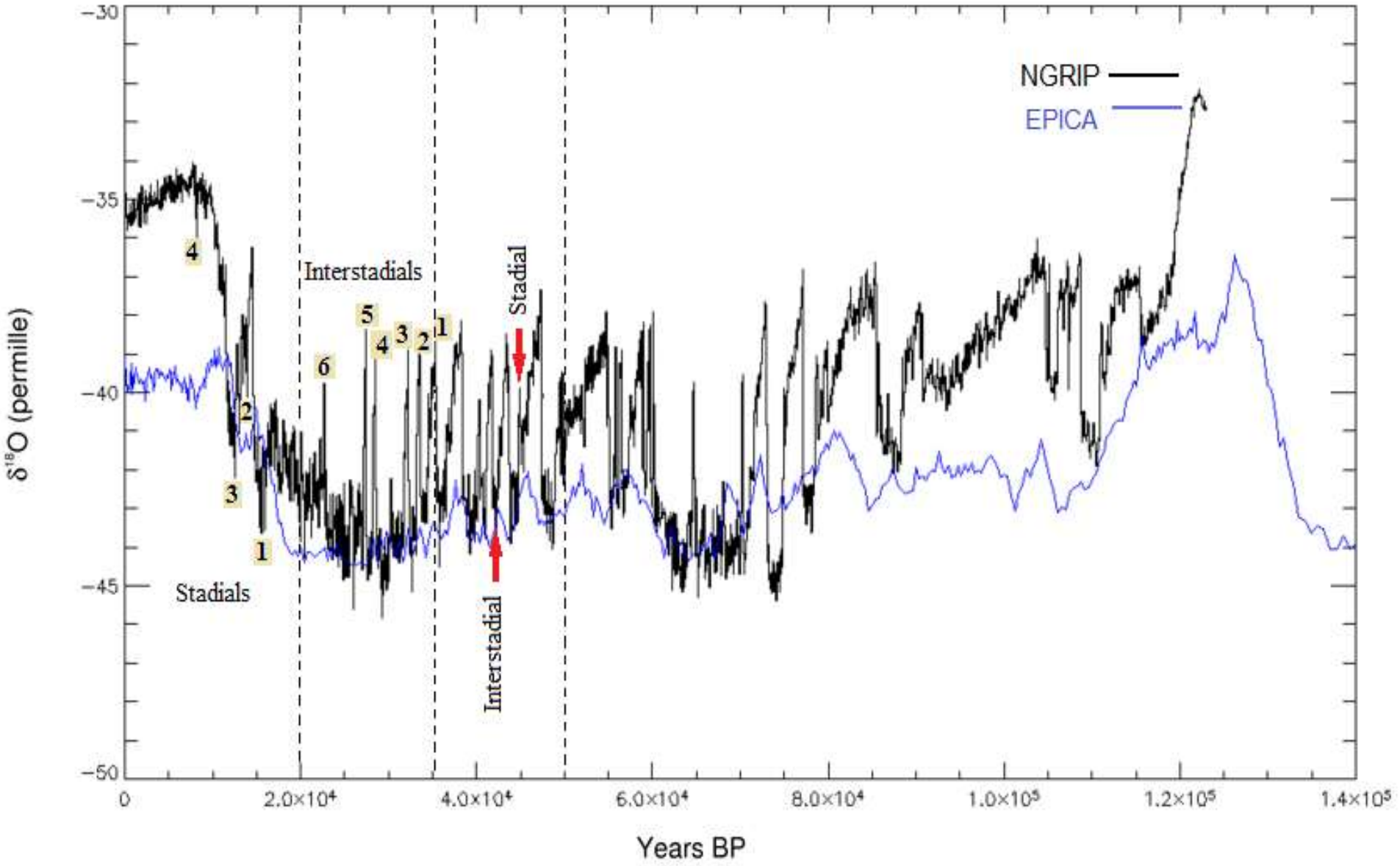
نگاره 3.17. مقایسه نتایج داده‌هاي قابلیت پذیرفتاري مغناطیسی به دست آمده برش کُلِت با نتایج گرده‌شناسي از مغزه رسوبي دریاچه ارومیه (Djamali *et al.*, 2008) و نتایج آزمایش ایزوتوپ اکسیژن 18 مغزه رسوبي دریاي عرب (Tzedakis, 1994) و نتایج گرده‌شناسي مغزه رسوبات دریایي از یونان (Reichart *et al.*, 1997). در این نمودار محل واحد خاک دیرینه بالایی و پایینی برش رسوبی کُلِت به ترتیب با نماد UPو LPنشان داده شده‌اند


delta–o18 vs age
GRIP (Greenland)
Vostok (Antarctic)
EPICA (Antarctic)
Stadials
Interstadials
4
3
2
1
6
5
4
3
2
1
سردتر
–300
–350
–400
–450
–500
0
1×10⁴
2×10⁴
3×10⁴
4×10⁴

Isotope data for Greenland ice cores



Isotope data for Greenland ice cores



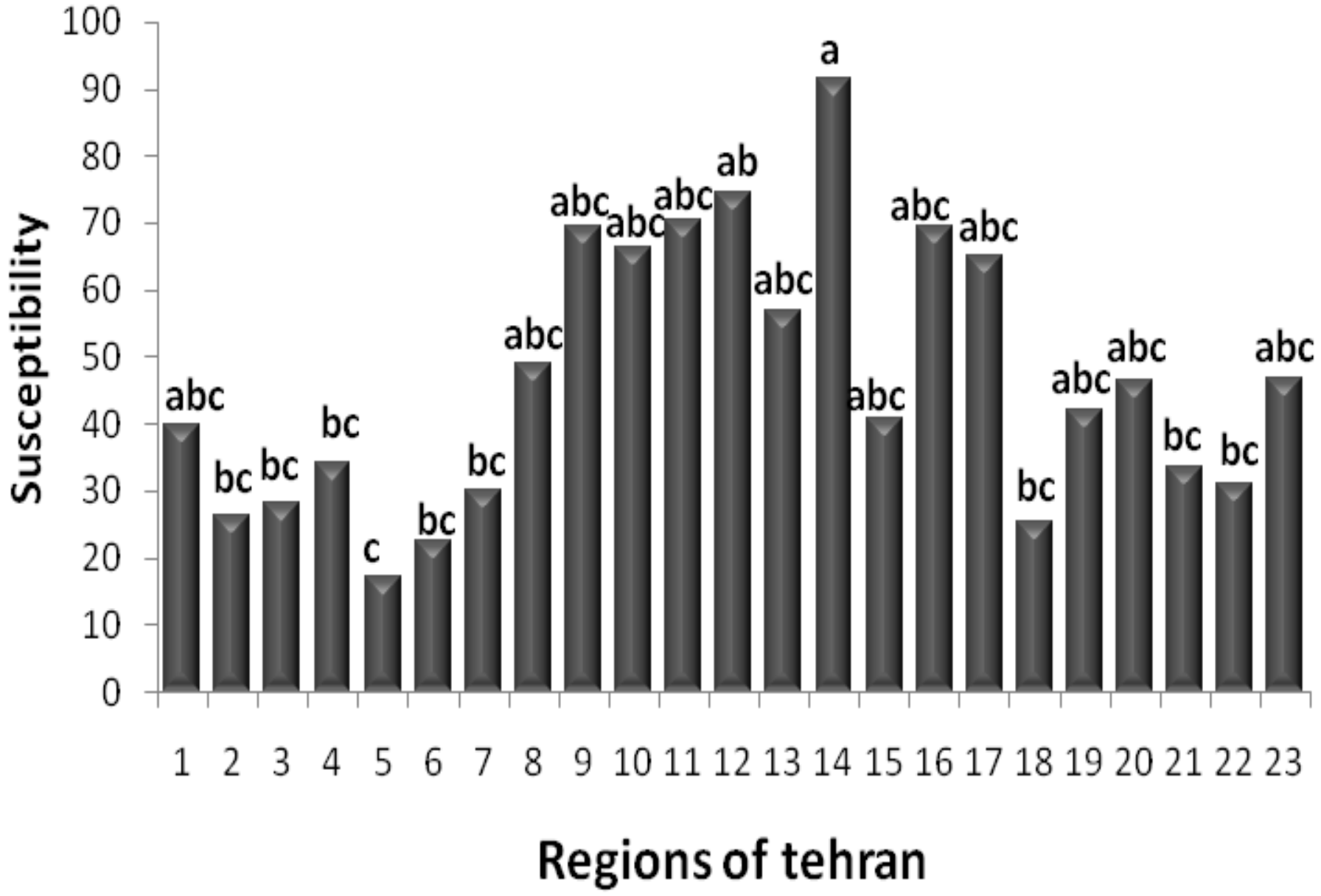
در بازسازی تغییرات آب و هوایی 50 هزار سال گذشته در برش رسوبی کُلِت، می‌توان چنین بیان کرد، که در بیش از 48 هزار سال پیش، شرایط گرم و مرطوب یک دوره بین‌یخچالی بر آب و هوای شمال ایران حاکم بوده است، که سبب تشکیل لایه خاک دیرینه پائینی شده است. در ادامه تا 10 هزار سال بعد دو دوره یخچالی و یک دوره بین‌یخچالی دیگر مکرراً به وقوع پیوسته است که به ترتیب دو واحد لُس بالایی و پائینی و نیز لایه خاک دیرینه پائینی تشکیل شده‌اند. در انتهای واحد لُس بالایی در حدود بیش از 20 هزار سال پیش، آخرین دوره یخچالی به پایان رسیده و دوره بین یخچالی امروزی آغاز شده است، که خیلی بیشتر از سن در نظر گرفته شده برای هولوسن (7/11 هزار سال پیش) می‌باشد. این ممکن است دال بر این باشد که شمال ایران در منطقه حاشیه یخچالی قرار داشته است.

Mapping Air Pollution Using Magnetometery (new method) on Tree Leaves of Tehran Metropolitan, Iran

Maryam Mollashahi, Habib Alimohammadian, Seyed Mohsen Hosseini and Alireza, Riahi

Ph.D. Thesis


MFK1-A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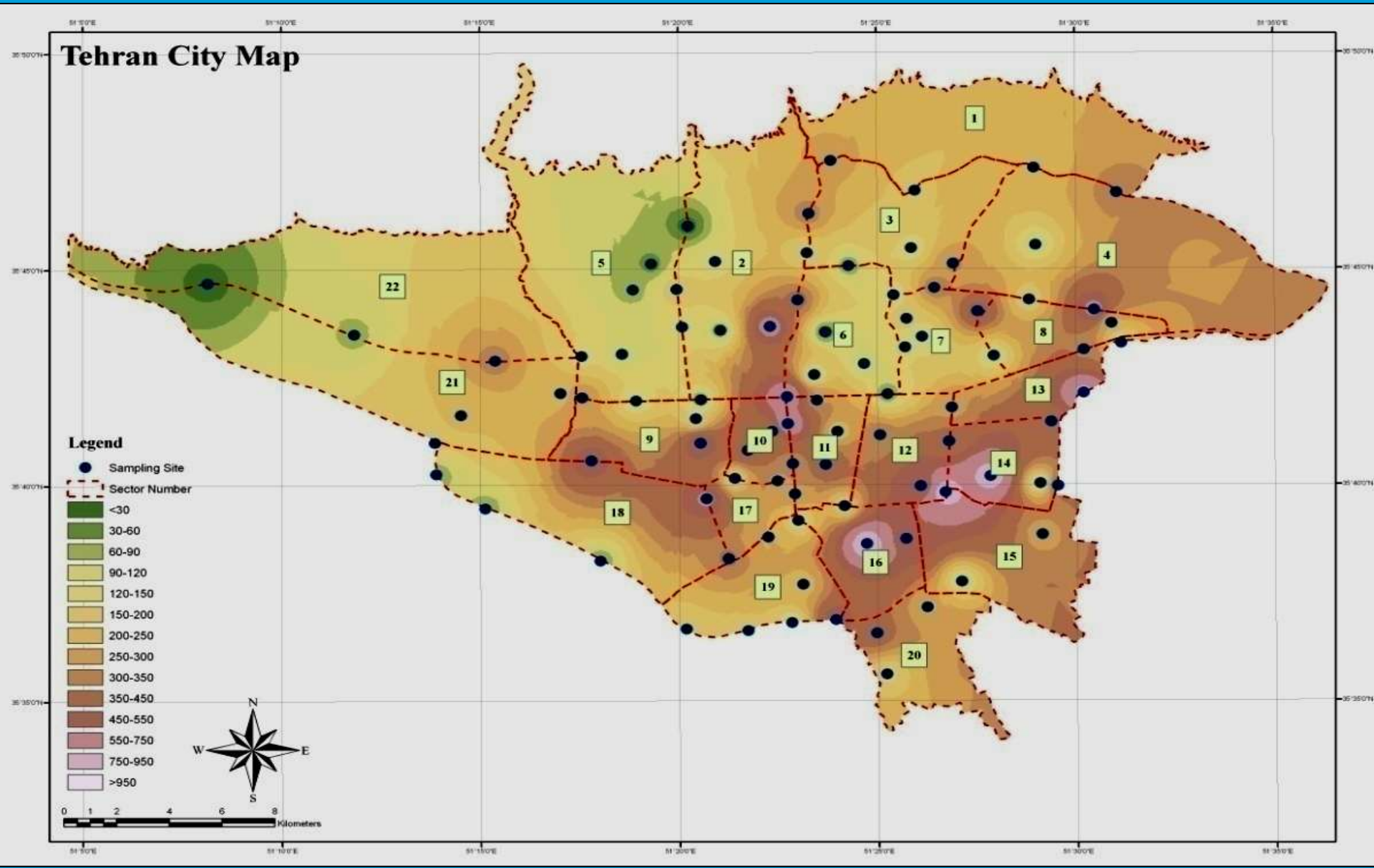
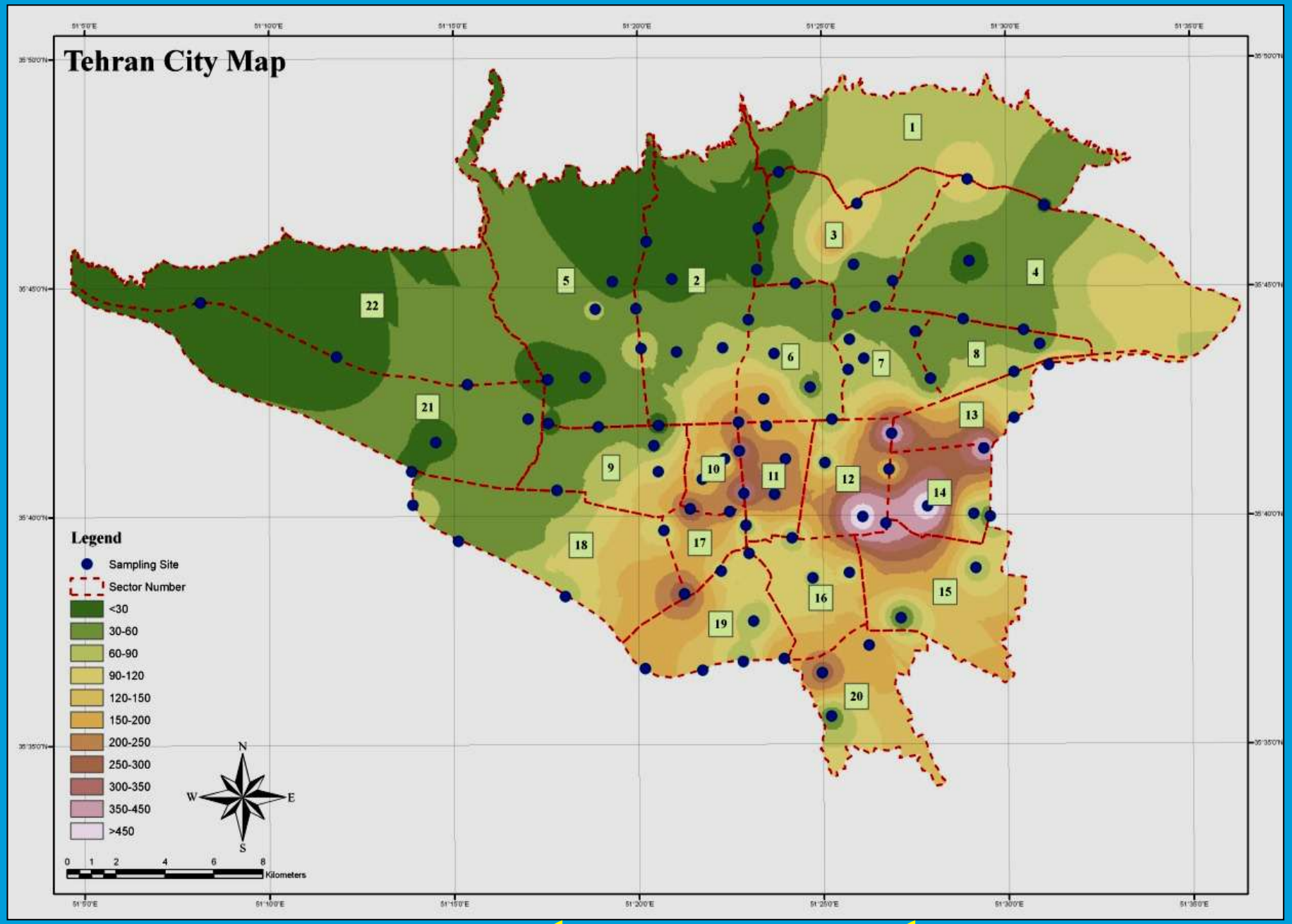
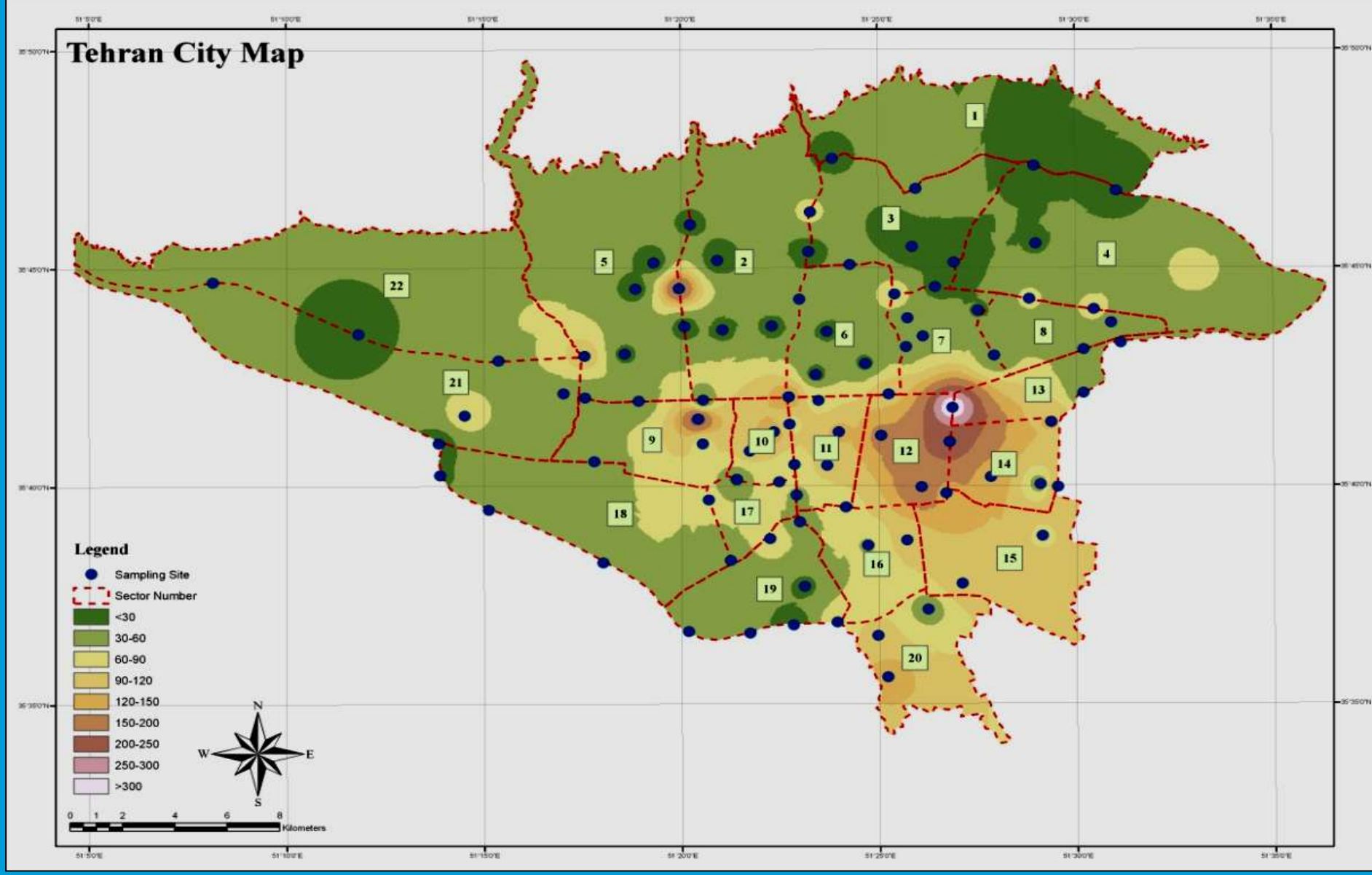
Regions of tehran



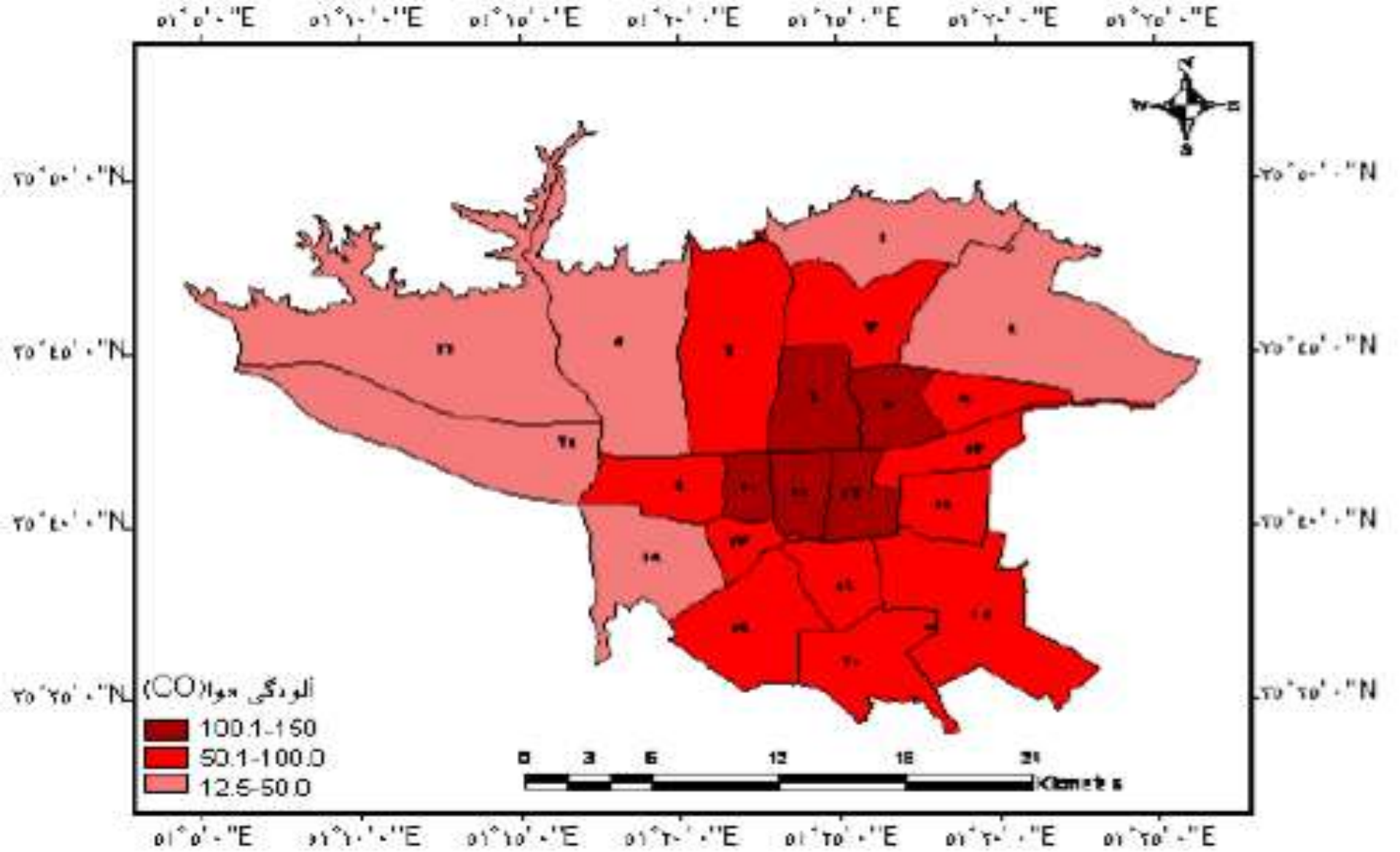
گونه درختی توت



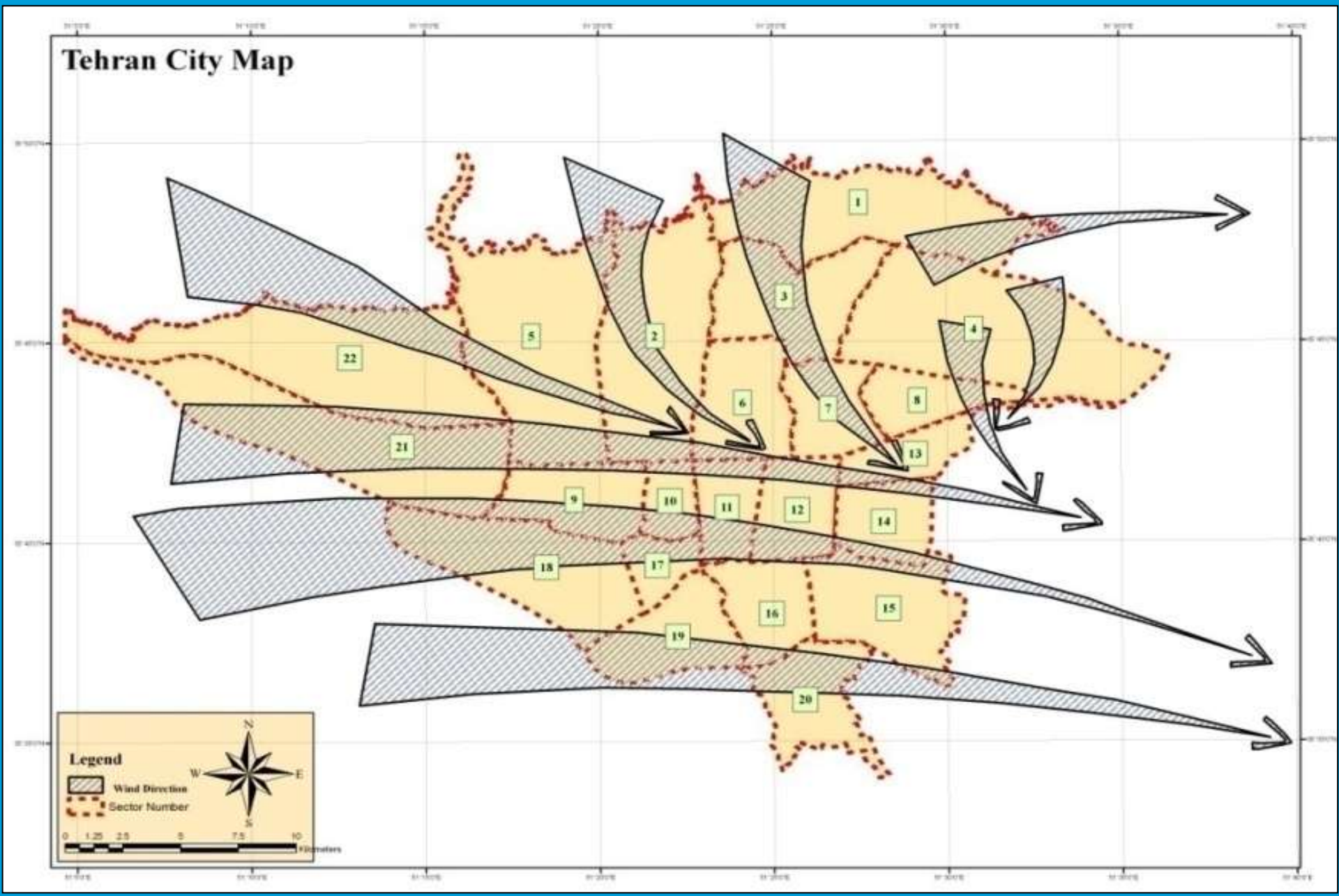
گونه درختی زبان گنجشک



گونه درختی کاج تهران



پراکنش آلودگی هوا دی اکسید کربن (دوره آماري 2002-2005)



جريانات هوايي شهر تهران در فصل پاييز (مهندسين مشاور عرصه،1384)

نتیجه گیری

* در اين تحقيق براي اولين بار به بررسي تاثير گونه‌هاي مختلف درختي در جذب آلودگي‌هاي ناشي از ترافيک وسائل نقليه با استفاده از پارامتر پذيرفتاري مغناطيسي پرداخته شده است

* استفاده از تکنيک پذيرفتاري مغناطيسي بسيار سريع، غير مخرب و با هزينه معقول انجام پذير مي باشد. لذا در اين تحقيق به پهنه بندي آلودگي هوا با استفاده از خاصيت مغناطيسي سه گونه درختي در سطح شهر تهران گرديد

* از ميان گونه‌هاي موجود در حاشيه خيابان‌ها و بزرگراه‌هاي شهر تهران سه گونه که تقريبا در تمامي سطح شهر پراکنش داشتند انتخاب شدند. گونه‌هاي مورد نظر توت، زبان گنجشک و کاج تهران مي‌باشند

* تمامي نمونه‌ها در مهرماه و در طي 15 روز برداشت شدند

* نتايج به دست آمده از تحقيق نشان داد كه فضاهاي سبز قابليت جذب آلودگي را دارند

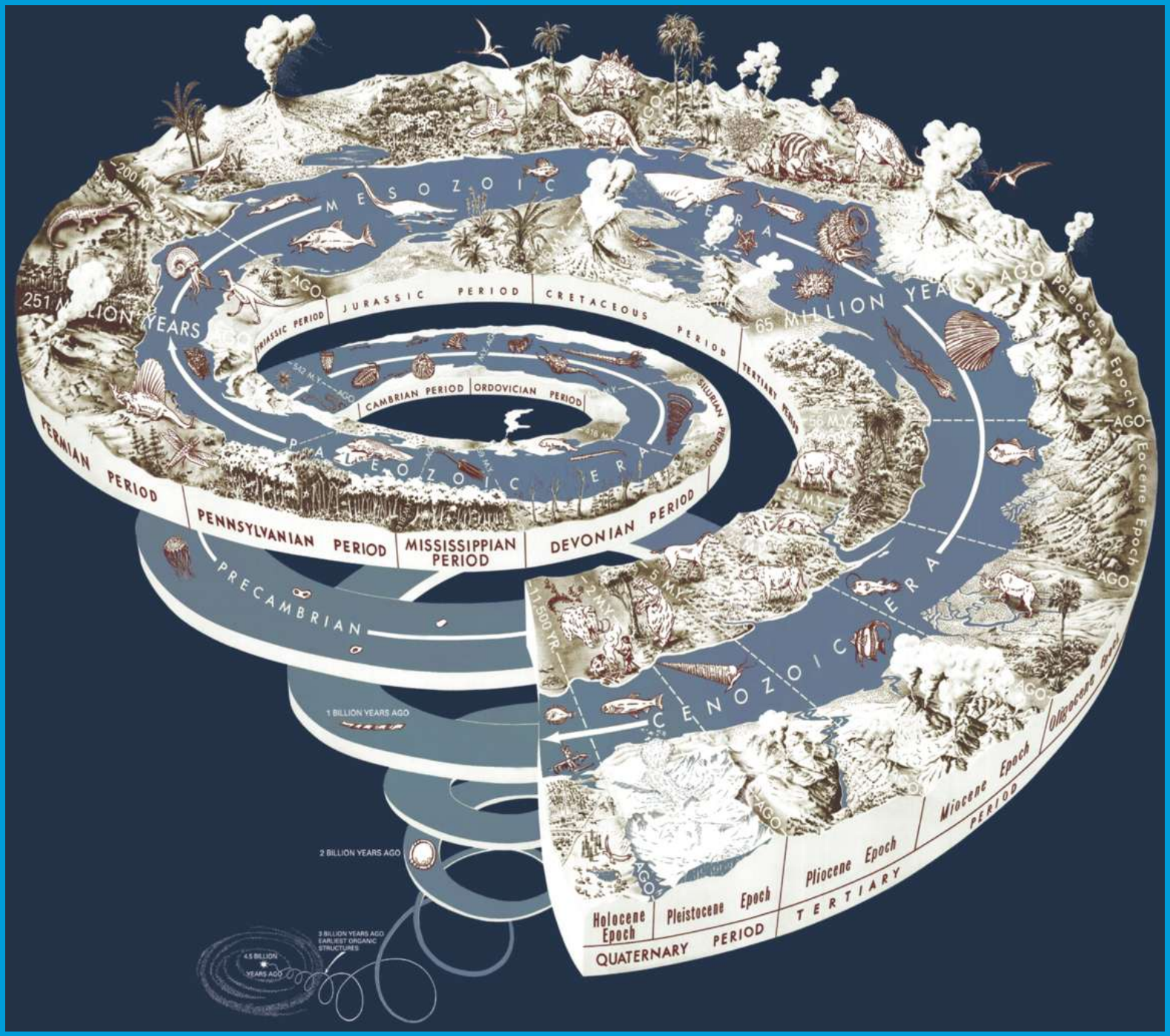
* پهنه‌بندي آلودگي هواي تهران نشان داد كه بيشترين آلودگي‌ها در شرق و جنوب شرق تهران تمركز دارند و به سمت شمال و غرب تهران از ميزان آلودگي‌ها كاسته و غرب و شمال غرب تهران كمترين ميزان آلودگي را نشان داده است

* دليل اين امر را مي‌توان در جهت حركت بادها و همچنين ميزان ترافيک موجود در سطح شهر تهران و نوع ماشين هاي در حال حركت دانست

* در بين گونه هاي مورد مطالعه ميزان جذب آلودگی توت بيشتر از بقيه گونه ها بود. به طوري كه ميزان مغناطيس اندازه گيري شده اين گونه در بخش هاي شرقي و جنوب شرقي تهران بيش از 950 بود در حالي كه اين ميزان برای دو گونه زبان گنجشک و کاج به ترتيب حدود 450 و 300 است

* دليل اصلي بالا بودن ميزان جذب گونه توت نسبت به دو گونه ديگر را مي توان در اندازه سطح اين گونه دانست. توت يكي از گونه هاي پهن برگ بوده و داراي سطح زيادي است و اين عامل باعث شده تا ميزان جذب نيز بالا برود

* بر اساس نتايج به دست آمده از اين تحقيق، كاشت گونه هاي پهن برگ در محيطهاي شهري به دليل جذب بيشتر آلودگي هوا پيشنهاد مي گردد


MESOZOIC ERA
PALEOZOIC ERA
CENOZOIC ERA
PRECAMBRIAN
TRIASSIC PERIOD
JURASSIC PERIOD
CRETACEOUS PERIOD
CAMBRIAN PERIOD
ORDOVICIAN PERIOD
SILURIAN PERIOD
DEVONIAN PERIOD
MISSISSIPPIAN PERIOD
PENNSYLVANIAN PERIOD
PERMIAN PERIOD
TERTIARY PERIOD
QUATERNARY PERIOD
Paleocene Epoch
Eocene Epoch
Oligocene Epoch
Miocene Epoch
Pliocene Epoch
Pleistocene Epoch
Holocene Epoch
65 MILLION YEARS AGO
1 BILLION YEARS AGO
2 BILLION YEARS AGO
3 BILLION YEARS AGO
EARLIEST ORGANIC STRUCTURES
4.5 BILLION YEARS AGO

THANK YOU