

Corso

Geoarcheologia, morfologia e processi formativi

- Prof. Stefano Lugli

Struttura del corso

- Quaternario
- Stratigrafia e sedimentologia
- Ambienti fluviali e di transizione
- Suoli
- Geoarcheologia di Pompei e Ercolano

Il Quaternario

-Terziario... Quaternario!
- Era glaciale!





DNAG

DECADE OF NORTH AMERICAN GEOLOGY GEOLOGIC TIME SCALE

GEOLOGICAL SOCIETY
OF AMERICA

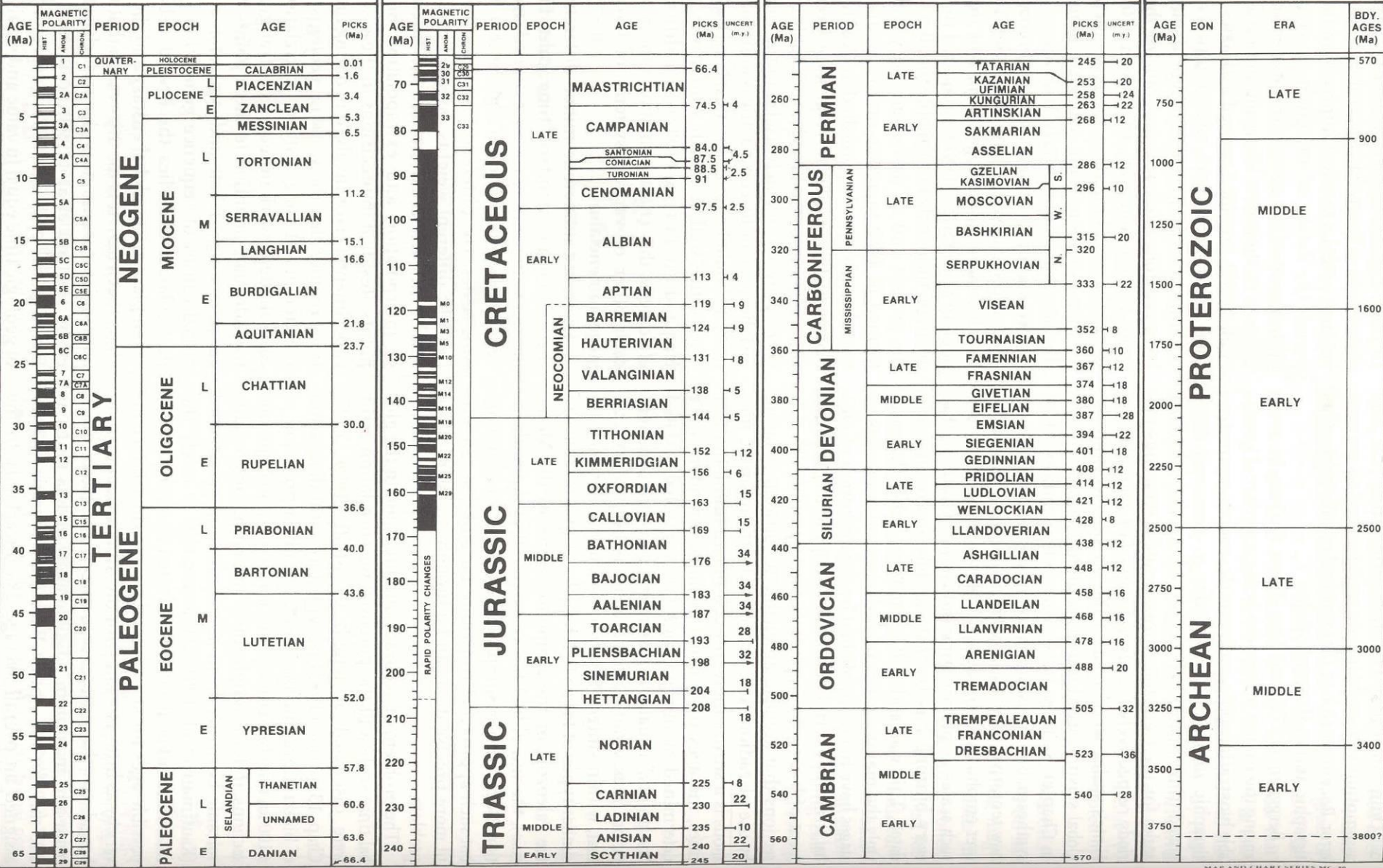


CENOZOIC

MESOZOIC

PALEOZOIC

PRECAMBRIAN




Il Quaternario

- Era glaciale (periodi glaciali e interglaciali)
- Ultimi 800 ka 10 cicli completi rapidi ed ampi (nel Quaternario circa 50 oscillazioni)
- Avanzamento/ritiro dei ghiacci, alternanza di fasi aride e umide
- Complessità di forme morfologiche, di sedimenti, di associazioni biologiche, tra cui quelle **antropiche**

Ricostruzioni ambientali

- Caratteristiche stratigrafiche → quadro geologico
- Analisi degli indicatori (proxy record) nelle successioni stratigrafiche → ricostruzioni paleoambientali
- Successione degli eventi → quadro cronostratigrafico
- Relazioni tra stratigrafie → correlazioni
- Approccio integrato → sintesi paleoambientale regionale


Problemi

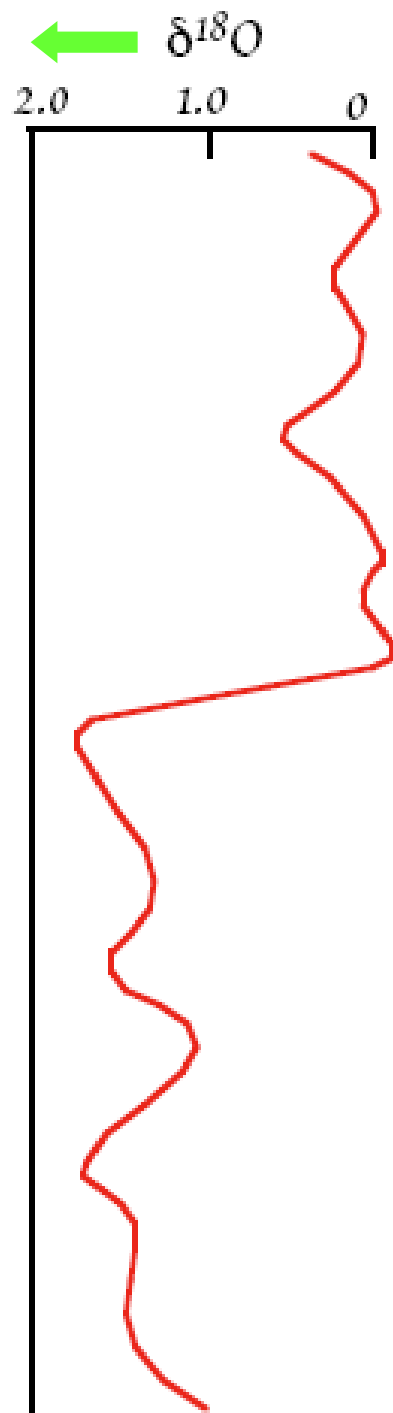
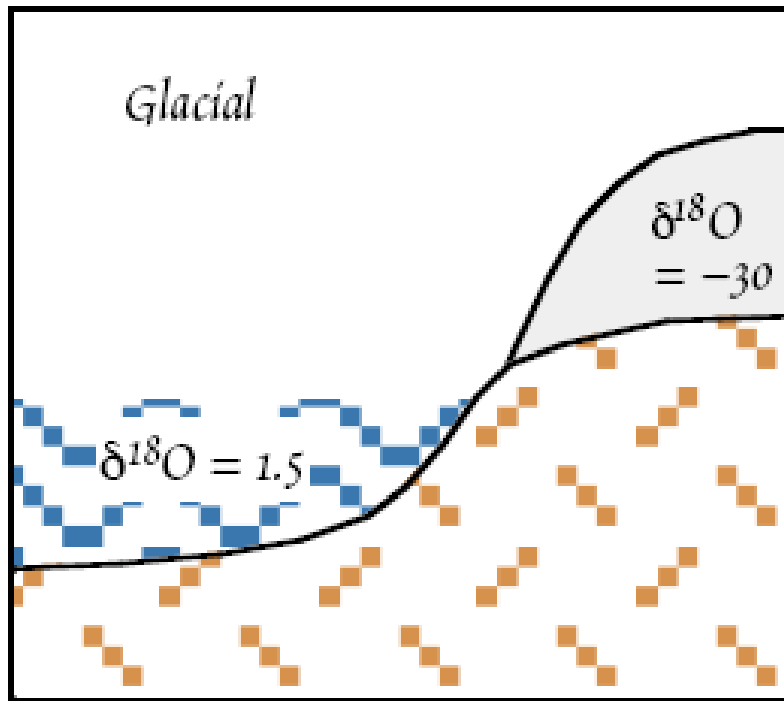
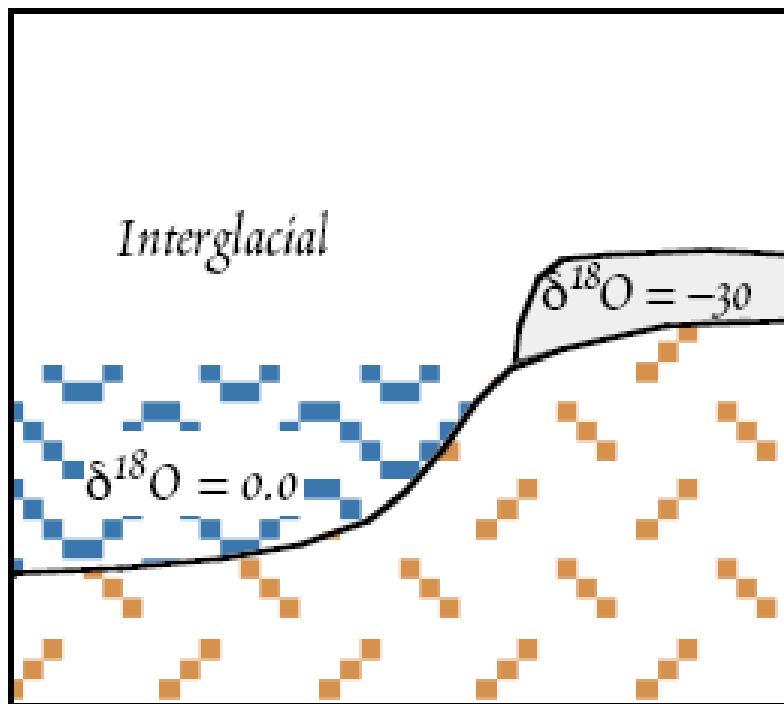
- Documentazione in ambiente continentale è molto frammentaria (scarsità affioramenti, lacune)
- Ciclicità dei cambiamenti climatici ha prodotto simili condizioni e ambienti in tempi diversi 
correlazioni incerte (spesso non possibili datazioni dirette)
- Si procede con studi interdisciplinari: **stratigrafia**, **sedimentologia**, botanica, zoologia archeologia, geochimica, ecc.

Era glaciale

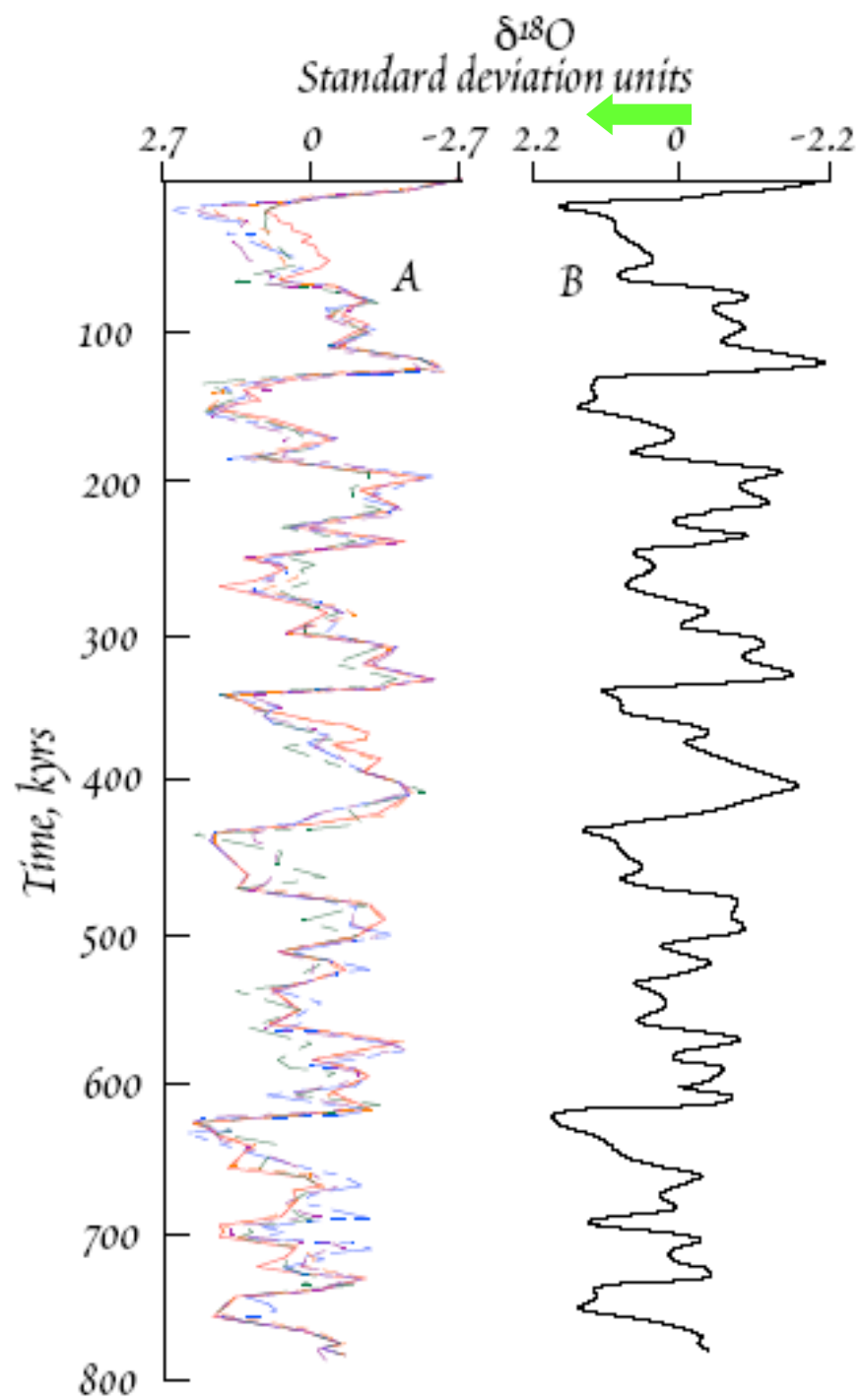
- 5 glaciazioni Donau, Gunz, Mindel, Riss, Wurm
- Teoria glacio-eustatica: variazioni del livello del mare
- Fasi espansione glaciale estensione della tundra a latitudini più basse: zone **periglaciali**

Studi dei sedimenti quaternari

- Analisi **sedimentologica** e **stratigrafica sequenziale**
- Perforazioni, indagini paleomagnetiche e sismiche
- Analisi paleontologiche e paleovegetazionali (pollini, dendrocronologia)
- Datazioni assolute (carbonio, amino-stratigrafia, risonanza elettronica, luminescenza, radioisotopi)
- Isotopi ossigeno su microfossili marini (stratigrafia completa, temperatura dell'acqua)
- Perforazioni dei ghiacci polari: condizioni atmosferiche e climatiche del passato (isotopi O  stadi isotopici, gas atmosferici, composti chimici, polvere)
- Modellizzazione della circolazione atmosferica globale (modelli descrittivi e predittivi)



$$\delta^{18}\text{O} = \frac{^{18}\text{O}}{^{16}\text{O}}$$



Struttura del Quaternario

- **Periodi glaciali**: fasi fredde di lunga durata con espansione glaciale
- **Episodi stadiali**: episodi freddi di minor durata con espansione glaciale di minor durata
- **Periodi interglaciali**: fasi di lunga durata con temperature medie simili o maggiori a quelle attuali (e Olocene)
- **Episodi interstadiali**: episodi temperati di relativo riscaldamento in una fase di generale raffreddamento con temperature che non raggiunsero quelle attuali



INTERNATIONAL STRATIGRAPHIC CHART

International Commission on Stratigraphy



Eonothem Era	System Period	Series Epoch	Stage Age	Age Ma	GSSP		
Phanerozoic	Cenozoic	Quaternary*	Holocene		0.0117		
			Upper Pleistocene	Upper	0.126		
				"Ionian"	0.781		
			Lower Pleistocene	Calabrian	1.806		
				Gelasian	2.588		
		Neogene	Pliocene	Piacenzian	3.600		
				Zanclean	5.332		
				Messinian	7.246		
			Miocene	Tortonian	11.608		
				Serravallian	13.82		
	Langhian			15.97			
	Burdigalian			20.43			
	Aquitanian			23.03			
	Oligocene			Chattian	28.4 ± 0.1		
				Rupelian	33.9 ± 0.1		
				Priabonian	37.2 ± 0.1		
				Eocene	Bartonian	40.4 ± 0.2	
					Lutetian	48.6 ± 0.2	
		Ypresian	55.8 ± 0.2				
	Paleocene	Thanetian	58.7 ± 0.2				
		Selandian	~ 61.1				
		Danian	~ 61.1				
		Maastrichtian	65.5 ± 0.3				
		Campanian	70.6 ± 0.6				
	Mesozoic	Cretaceous	Upper	Santonian	83.5 ± 0.7		
				Coniacian	~ 88.6		
				Turonian	93.6 ± 0.8		
			Cenomanian	99.6 ± 0.9			
Albian			112.0 ± 1.0				
Lower		Aptian	125.0 ± 1.0				
		Barremian	130.0 ± 1.5				
		Hauterivian	~ 133.9				
		Valanginian	140.2 ± 3.0				
		Berriasian	145.5 ± 4.0				

Eonothem Era	System Period	Series Epoch	Stage Age	Age Ma	GSSP	
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian	145.5 ± 4.0	
				Kimmeridgian	150.8 ± 4.0	
				Oxfordian	~ 155.6	
			Middle	Callovian	161.2 ± 4.0	
				Bathonian	164.7 ± 4.0	
		Lower	Bajocian	167.7 ± 3.5		
			Aalenian	171.6 ± 3.0		
			Toarcian	175.6 ± 2.0		
		Triassic	Upper	Pliensbachian	183.0 ± 1.5	
				Sinemurian	189.6 ± 1.5	
	Hettangian			196.5 ± 1.0		
	Rhaetian			199.6 ± 0.6		
	Norian			203.6 ± 1.5		
	Middle		Carnian	~ 228.7		
			Ladinian	237.0 ± 2.0		
	Lower		Anisian	~ 245.9		
			Olenekian	~ 249.5		
			Induan	251.0 ± 0.4		
	Paleozoic	Permian	Lopingian	253.8 ± 0.7		
			Wuchiapingian	260.4 ± 0.7		
			Capitanian	265.8 ± 0.7		
			Wordian	268.0 ± 0.7		
			Roadian	270.6 ± 0.7		
		Carboniferous	Upper	Kungurian	275.6 ± 0.7	
				Artinskian	284.4 ± 0.7	
				Sakmarian	294.6 ± 0.8	
			Middle	Asselian	299.0 ± 0.8	
				Gzhelian	303.4 ± 0.9	
Lower	Kasimovian	307.2 ± 1.0				
	Moscovian	311.7 ± 1.1				
	Bashkirian	318.1 ± 1.3				
Paleozoic	Carboniferous	Upper	Serpukhovian	328.3 ± 1.6		
			Visean	345.3 ± 2.1		
		Middle	Tournaisian	359.2 ± 2.5		
			Guadalupian	~ 249.5		
	Ordovician	Upper	Changhsingian	251.0 ± 0.4		
			Changhsingian	253.8 ± 0.7		
		Lower	Tremadocian	478.6 ± 1.7		
			Floian	471.8 ± 1.6		

Eonothem Era	System Period	Series Epoch	Stage Age	Age Ma	GSSP	
Phanerozoic	Paleozoic	Devonian	Upper	Famennian	359.2 ± 2.5	
				Frasnian	374.5 ± 2.6	
			Middle	Givetian	385.3 ± 2.6	
				Eifelian	391.8 ± 2.7	
				Emsian	397.5 ± 2.7	
		Lower	Pragian	407.0 ± 2.8		
			Lochkovian	411.2 ± 2.8		
		Silurian	Pridoli	Pridoli	416.0 ± 2.8	
				Ludfordian	418.7 ± 2.7	
			Wenlock	Gorstian	421.3 ± 2.6	
	Homerian			422.9 ± 2.5		
	Llandovery		Sheinwoodian	428.2 ± 2.4		
			Telychian	428.2 ± 2.3		
	Aeronian		Aeronian	436.0 ± 1.9		
			Rhuddanian	439.0 ± 1.8		
	Cambrian		Upper	Himantian	443.7 ± 1.5	
				Katian	445.6 ± 1.5	
		Sandbian		455.8 ± 1.6		
		Darriwilian		460.9 ± 1.6		
		Dapingian		468.1 ± 1.6		
		Lower	Floian	471.8 ± 1.6		
			Tremadocian	478.6 ± 1.7		
			Stage 10	488.3 ± 1.7		
			Stage 9	~ 492*		
			Stage 8	~ 496*		
	Paleozoic	Ordovician	Paibian	~ 499		
			Guzhangian	~ 503		
			Drumian	~ 506.5		
Stage 5			~ 510*			
Series 3		Stage 4	~ 515*			
		Stage 3	~ 521*			
		Stage 2	~ 528*			
		Fortunian	542.0 ± 1.0			

Eonothem Era	System Period	Age Ma	GSSP/GSSA	
Precambrian	Proterozoic	Ediacaran	542	
		Neo-proterozoic	Cryogenian	~ 635
			Tonian	850
		Meso-proterozoic	Stenian	1000
			Ectasian	1200
			Calymmian	1400
	Paleo-proterozoic	Statherian	1600	
		Orosirian	1800	
		Rhyacian	2060	
	Archean	Neoproterozoic	Siderian	2300
			Neoproterozoic	2500
		Mesoarchean	Neoproterozoic	2800
			Paleoarchean	3200
		Eoarchean	Eoarchean	3600
			Hadean (informal)	~ 4000
	Hadean (informal)		~ 4600	

Subdivisions of the global geologic record are formally defined by their lower boundary. Each unit of the Phanerozoic (~542 Ma to Present) and the base of Ediacaran are defined by a basal Global Standard Section and Point (GSSP), whereas Precambrian units are formally subdivided by absolute age (Global Standard Stratigraphic Age, GSSA). Details of each GSSP are posted on the ICS website (www.stratigraphy.org).

Numerical ages of the unit boundaries in the Phanerozoic are subject to revision. Some stages within the Cambrian will be formally named upon international agreement on their GSSP limits. Most sub-Series boundaries (e.g., Middle and Upper Aptian) are not formally defined.

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The listed numerical ages are from 'A Geologic Time Scale 2004', by F.M. Gradstein, J.G. Ogg, A.G. Smith, et al. (2004; Cambridge University Press) and 'The Concise Geologic Time Scale' by J.G. Ogg, G. Ogg and F.M. Gradstein (in press).

This chart was drafted by Gabi Ogg. Intra Cambrian unit ages with * are informal, and awaiting ratified definitions. Copyright © 2008 International Commission on Stratigraphy

* The status of the Quaternary is not yet decided. Its base may be assigned as the base of the Gelasian and extend the base of the Pleistocene to 2.6 Ma. The "Tertiary" comprises the Paleogene and Neogene and has no official rank.



INTERNATIONAL STRATIGRAPHIC CHART



ICS

International Commission on Stratigraphy

eonothem Eon	erathem Era	system Period	series Epoch	stage Age	age Ma	GSSP	
Phanerozoic	Cenozoic	Quaternary	Holocene				
				Upper	0.0117	↗	
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				Zanclean	3.600	↗	
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				Tortonian	7.246	↗	
				Serravallian	11.608	↗	
	Paleogene	Oligocene	Langhian	13.82	↗		
			Burdigalian	15.97	↗		
			Aquitanian	20.43	↗		
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		Paleocene	Ypresian	48.6 ± 0.2	↗		
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			Danian	~ 61.1	↗		
				~ 65.5 ± 0.3	↗		
	Mesozoic	Cretaceous	Upper	Maastrichtian	65.5 ± 0.3	↗	
				Campanian	70.6 ± 0.6	↗	
				Santonian	83.5 ± 0.7	↗	
				Coniacian	85.8 ± 0.7	↗	
					~ 88.6	↗	
Lower			Turonian	93.6 ± 0.8	↗		
			Cenomanian	99.6 ± 0.9	↗		
			Albian	112.0 ± 1.0	↗		
			Aptian	125.0 ± 1.0	↗		
			Barremian	130.0 ± 1.5	↗		
Paleozoic		Hauterivian		~ 133.9	↗		
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				Toarcian	175.6 ± 2.0	↗	
			Lower	Pliensbachian	183.0 ± 1.5	↗	
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			Ladinian	~ 228.7	↗		
		Lower	Anisian	237.0 ± 2.0	↗		
			Olenekian	~ 245.9	↗		
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		Paleozoic	Permian	Lopingian	Changhsingian	251.0 ± 0.4	↗
					Wuchiapingian	253.8 ± 0.7	↗
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				Cisuralian	Roadian	268.0 ± 0.7	↗
	Kungurian		270.6 ± 0.7		↗		
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				Katian	445.6 ± 1.5	↗
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		Tremadocian	478.6 ± 1.7	↗		
			488.3 ± 1.7	↗		
	Cambrian	Furongian	Stage 10	~ 492 *	↗	
			Stage 9	~ 496 *	↗	
			Paibian	~ 499	↗	
			Guzhangian	~ 503	↗	
			Drumian	~ 506.5	↗	
Series 3		Stage 5	~ 510 *	↗		
		Stage 4	~ 515 *	↗		
		Stage 3	~ 521 *	↗		
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			~ 635	↗		
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			Calymmian	1600	↗	
		Paleo-proterozoic	Statherian	1800	↗	
			Orosinian	1800	↗	
			Rhyacian	2050	↗	
	Siderian		2300	↗		
			2500	↗		
	Archean	Neoproterozoic	Neoproterozoic	2800	↗	
			Mesoarchean	3200	↗	
		Paleoarchean	Paleoarchean	3600	↗	
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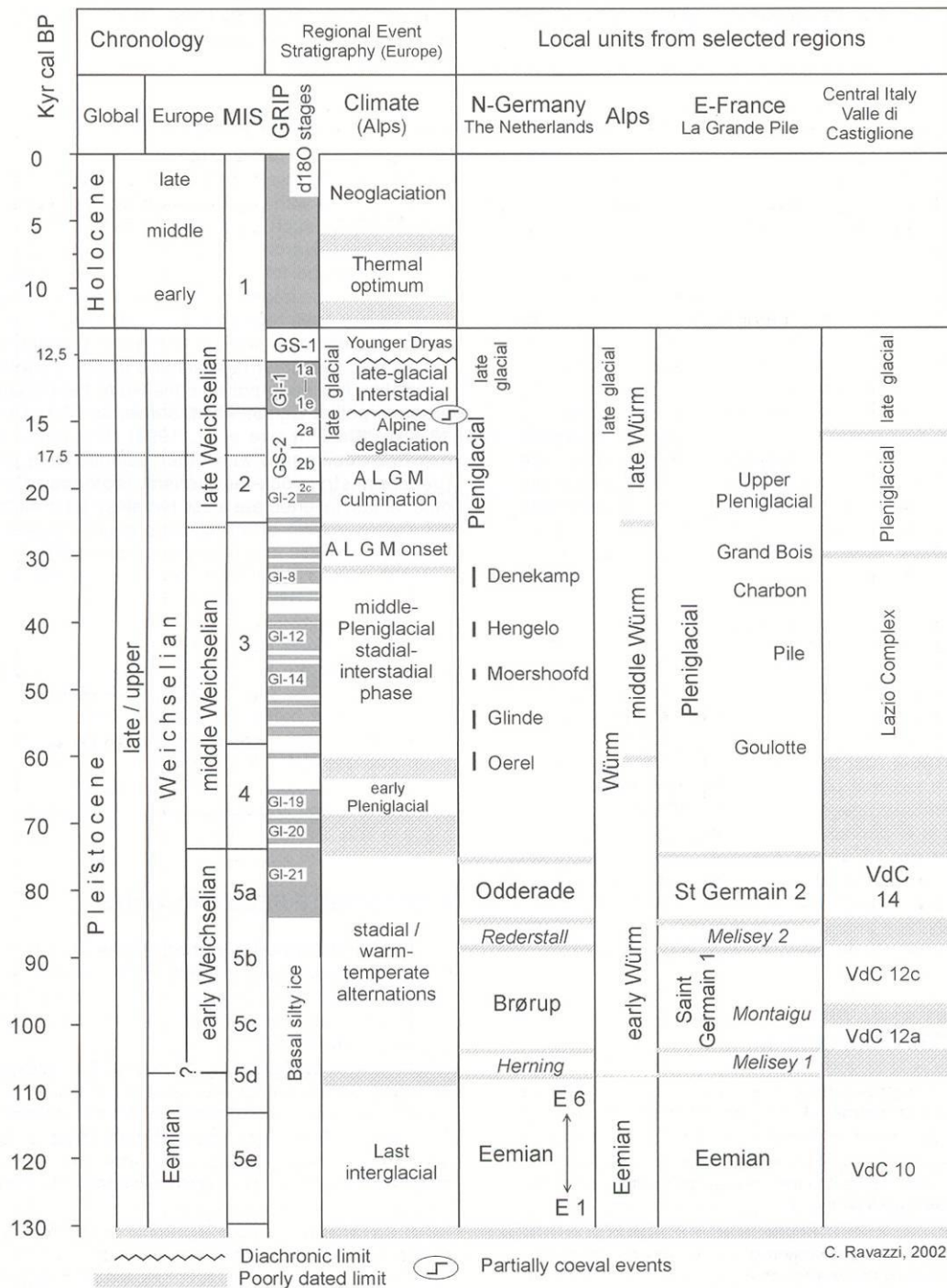
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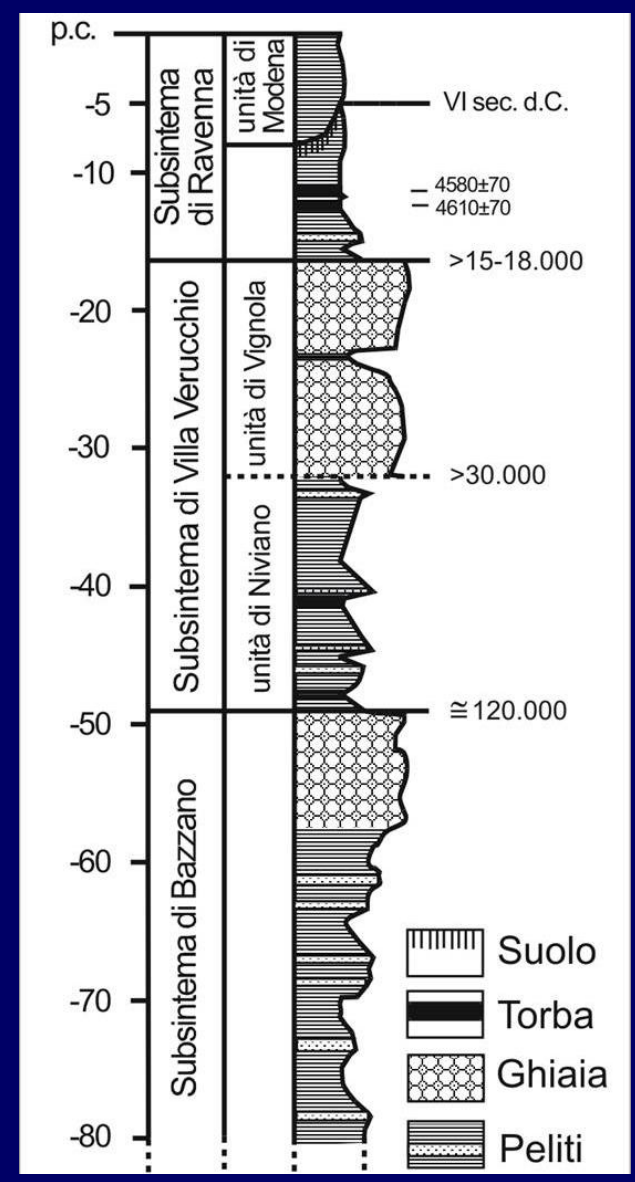
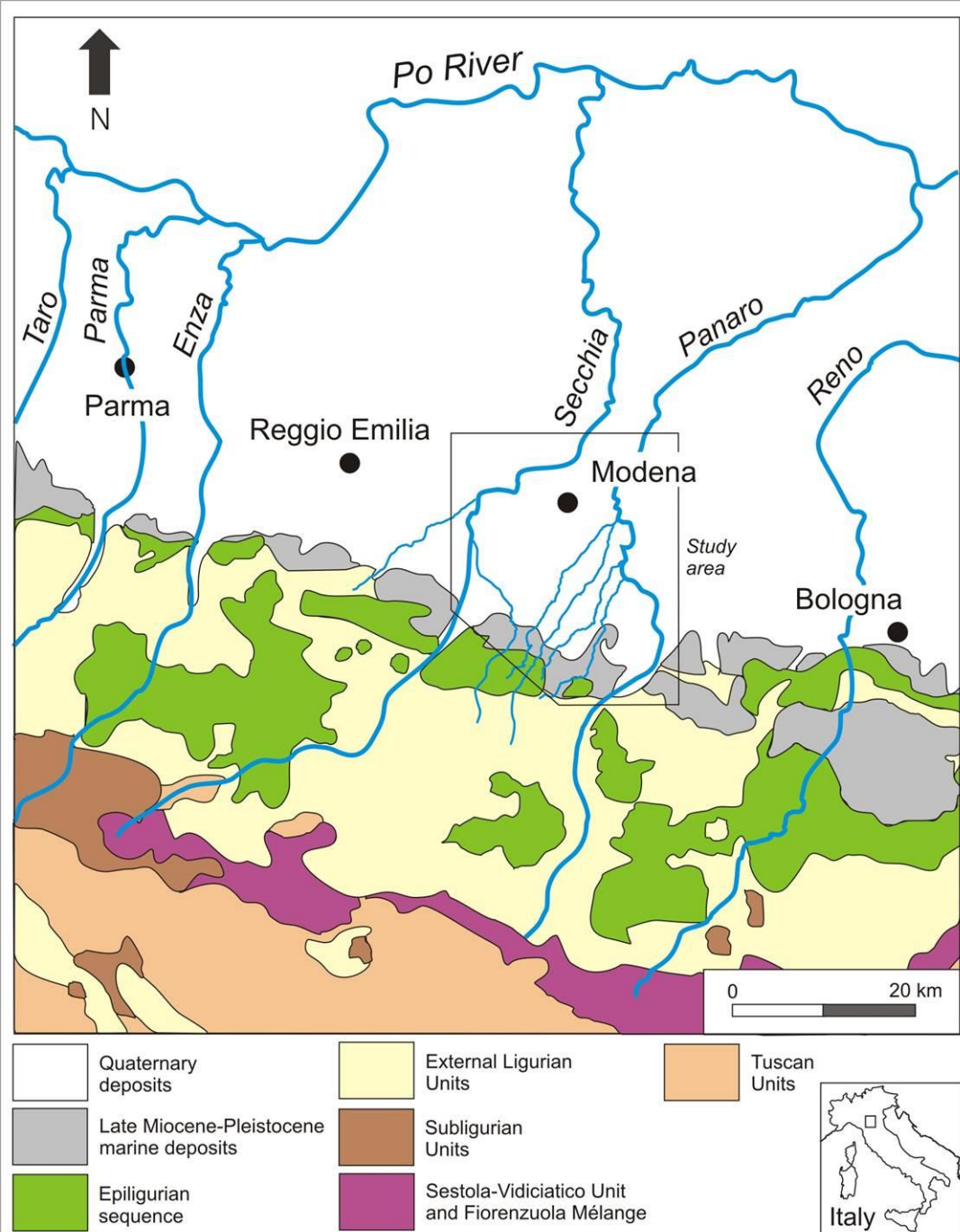
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Diachronic limit Poorly dated limit Partially coeval events

C. Ravazzi, 2002

Epochs	Stage	INFORMAL SUBDIVISIONS (*1)	climato-stratigraphic subdivisions (*1)	CHRONO ZONES (Holocene only)	Conventional age ¹⁴ C yr BP	Calibrated age cal ¹⁴ C BP (*2)	Varve chronology from German and Polish lakes (Litt et al., 2001)
					Mangerud et al., 1974, 82; Litt et al., 2001	Stuiver et al., 1998	
HOLOCENE		LATE	NEOGLACIATION	Subatlantic			
				Subboreal	2500	2728-2476	
				Atlantic	5000	5728 5657-5828	
				Boreal	8000 (* 5)	8776-9004	
				Preboreal	9000	10.189 9944 - 10.004	
PLEISTOCENE	Würm = Weichselian	Late glacial	Younger Dryas (* 4)	10.000	11.268 - 11.553	11.480-11.590	
			late glacial interstadial	c. 10.700	12.840 12.896 - 12.644	12.650-12.680	
			"early late glacial"	c. 12.300	14.289 15.416 - 14.101	14.450	
			Last Glacial Maximum (Alps)	c. 15.500			



Lugli et al (2011)

In Bettelli e De Nardo (2001), modificata





Aprile 2004

Ottobre 2005



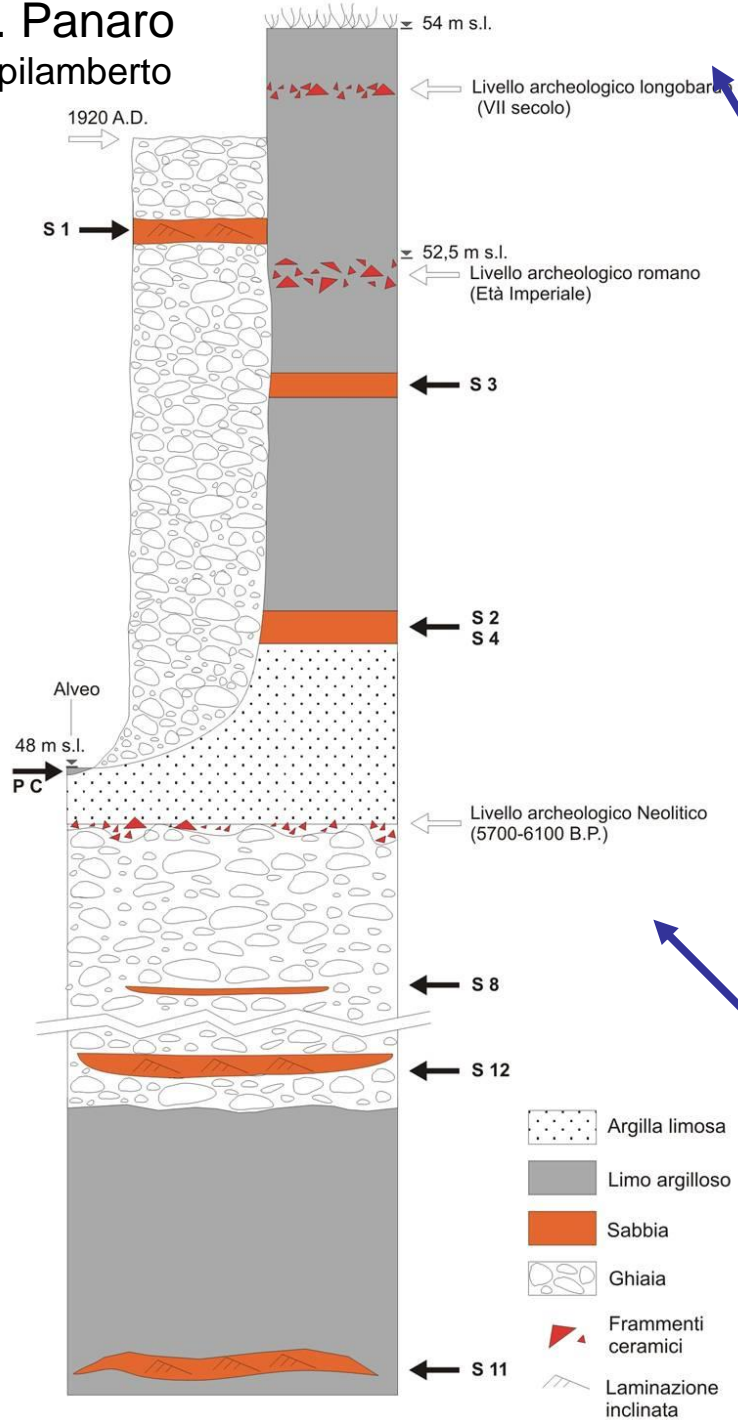
*Fiume Secchia
Campogalliano*

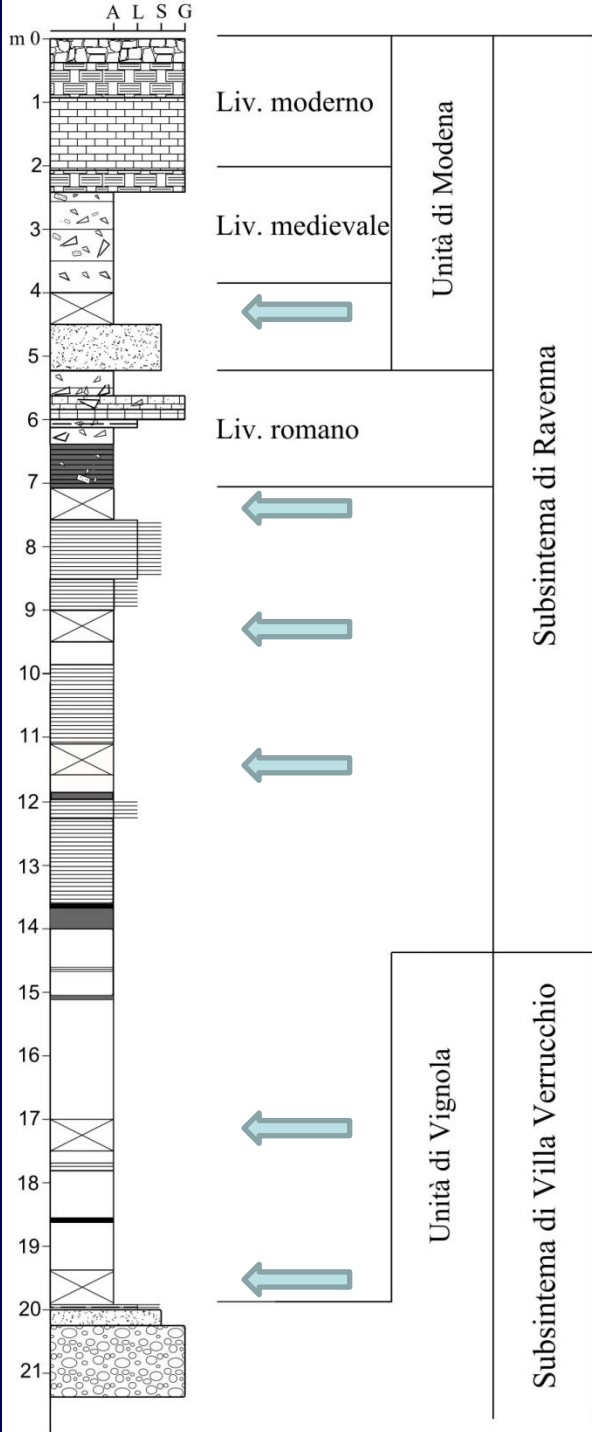




centimeters
www.sepm.org
Society for Sedimentary Geology
SEPM
inches

F. Panaro Spilamberto





Legenda

-  Torba
-  Argilla organica
-  Argilla
-  Limo
-  Sabbia
-  Ghiaia
-  Laminazione
-  Materiale lapideo
-  Laterizio
-  Conglomerato cementizio
-  Malta
-  Frammenti di laterizi
-  Frammenti di malte

Argentino, 2013



Legenda

Argilla



Limo



Sabbia



Ghiaia



Materiale lapideo



Laterizio



Conglomerato cementizio



Malta



Torba



Argilla organica



Tracce di carbone



Frammenti di laterizi



Gasteropodi



Calcinelli



Resti vegetali



Frammenti di malte



Screziature



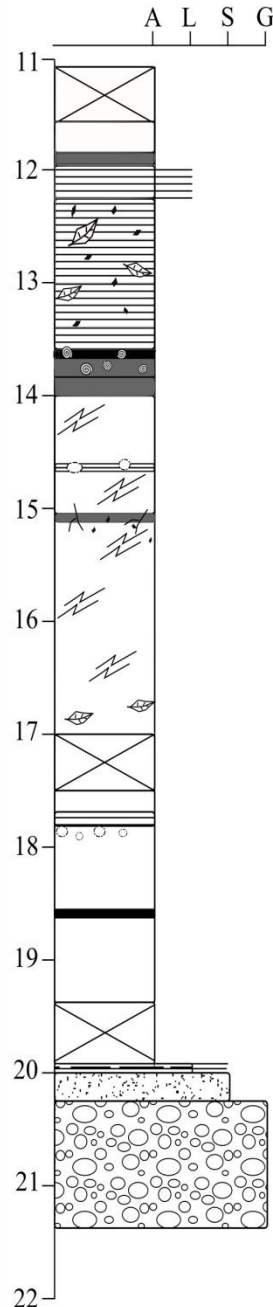
Ciottoli



Laminazione



Radici



C4

Argilla

Colore 2.5y 3.1 very dark grey
Argilla torbosa grigio scura da 11,81 m a 11,93 m
Laminazione Argilla/Limo da 11,93 m a 12,25 m

Argilla limosa

Colore 2.5y 4.1 dark reddish grey; sono presenti resti vegetali e frequenti tracce di carbone millimetriche. Si trovano lamine di argilla più scura ricca in sostanza organica fino a 13,25 m

Argilla limosa con lamine organiche

Colore 2.5y 4.1 dark reddish grey; tracce di carbone millimetriche
Torba con resti di gasteropodi da 13,66 m a 13,69 m

Argilla torbosa nera con frammenti di gasteropodi da 13,69 m a 13,81 m

Argilla nera omogenea, priva di resti organici macroscopici da 13,81 m a 14 m

Argilla limosa screziata (screziature distanziate tra loro di 10 cm circa) da 14 m a 15 m
Colore 2.5y 3.1 very dark grey

Lamine di argilla più scura con presenza di calcinelli millimetrici da 14,60 m a 14,68 m

Argilla screziata con tracce poco diffuse di carbone (concentrate tra 15 m e 15,25 m)
Livello d'argilla organica tra 15,04 m e 15,06 m; presenza di radici

Argilla limosa. Colore 2.5 y 4.1 dark reddish grey

Screziature marroni-rossicce presenti da 16,10 m a 16,70m

Alla base sono presenti resti vegetali legnosi (di lunghezza inferiore a 3 cm)

C7

Argilla limosa. Colore 2.5y 4.1 dark reddish grey

Lamine di argilla organica da 17,70 m fino 17,85 m; calcinelli concentrati a 17,90 m

Torba

Argilla limosa grigia, più chiara alla base (2.5y 4.2 dark greysh brown - 2.5y 3.1 very dark grey)

C8

Limo argilloso con sottili lamine di sabbia fine-finissima. Presenza di leggere screziature rossastre. Colore 2.5y 5.1 grey

Sabbia medio-fine argillosa. Colore 2.5y 5.1 grey

Ghiaia

Clasti di diametro variabile (0,5- 5 cm)

Variazione di colore della matrice: sfumature marrone chiaro alla base tendenti al grigio verso il tetto (2.5y 4.4 olive brown - 2.5y 5.1 grey)



Intervallo 00-15



Intervallo 20-21,3 m

MATERIA ANIMALE

MATERIA VEGETALE

Campione	Profondità	Campione	Profondità	Campione	Profondità
SG1	2,45 m	SG15	5,33 m	SG12	4,77 m
SG3	2,85 m	SG17	6,42 m	SG13	4,77 m
SG4	3,07 m	SG23	6,75 m	SG14	5,07 m
		SG24	6,90 m	SG18	6,43 m

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LAPIDEI

Campione	Profondità
SG9	3,40 m
SG10	3,80 m
SG11	3,88 m
SG16	5,42 m

Sezioni sottili

nicol //	nicol X

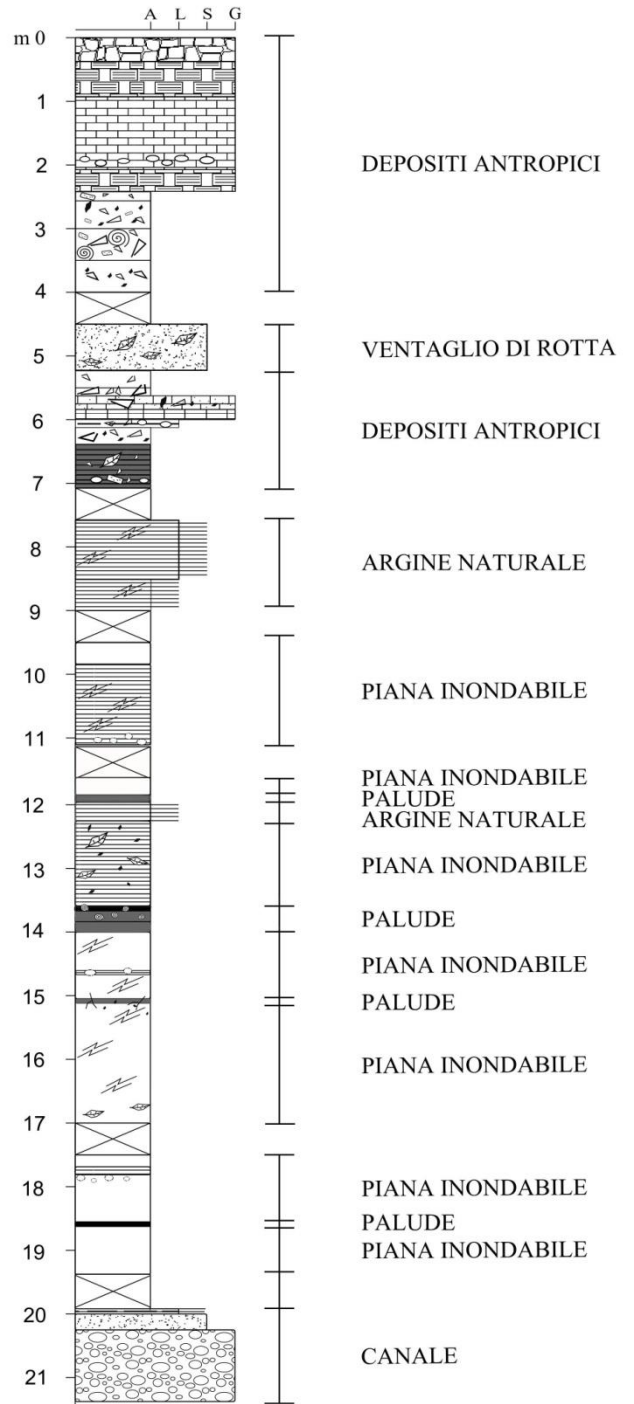
ANTROPICI

Campione	Profondità	Campione	Profondità	Campione	Profondità
SG2	2,48 m	SG20	6,45 m	SG22	6,72 m
SG19	6,45 m	SG21	6,72 m		

deposizionali

Sono state individuate 5 facies

- ❖ Facies di canale
- ❖ Facies di piana inondabile
- ❖ Facies di palude
- ❖ Facies di argine
- ❖ Facies di ventaglio di rotta



Ricostruzione del profilo di sottosuolo

NE

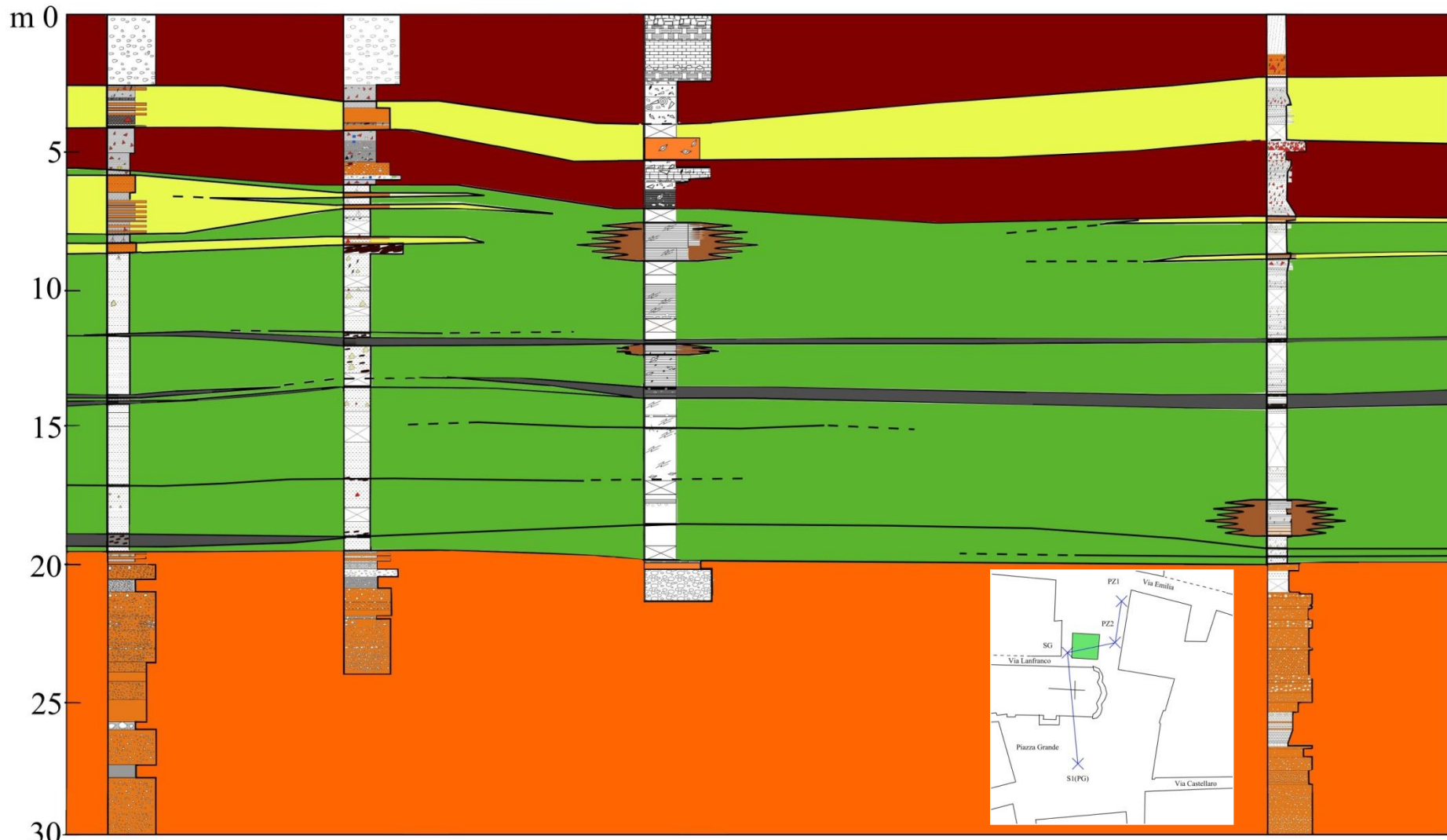
SO

PZ1 (2010)

PZ2 (2010)

SG (2012)

S1(PG) (2008)



10 m

- Depositi antropici
- Canale
- Argine naturale
- Rotte fluviali
- Piana inondabile
- Palude