

FOSSILI UTILI IN BIOSTRATIGRAFIA

Conodonti

Conodonti

I Conodonti sono denti microscopici di organismi estinti. Sono fatti di apatite e hanno dimensioni comprese tra 30 e 1500 μm (la maggior parte misura 150-300 μm).



Distribuzione stratigrafica

Cambriano sup. - Triassico

Composizione mineralogica

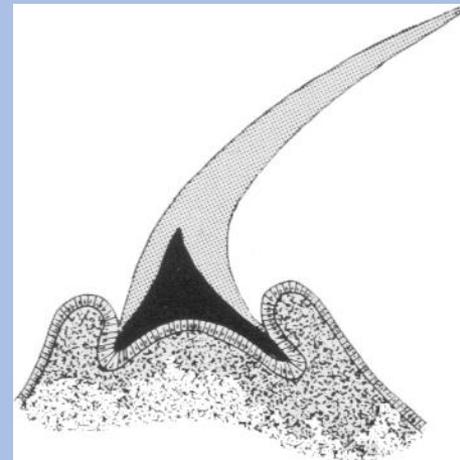
Apatite

Struttura del dente

Cartilagine basale

Smalto

Dentina



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CLASSIFICAZIONE ARTIFICIALE

Spathognathodus inclinatus inclinatus (Rhodes)

Ozarkodina media (Walliser)

Trichodella excavata (Branson & Mehl)

Neoprioniodus excavatus (Branson & Mehl)

Plectospathodus extensus (Rhodes)

Hindeodella equidentata (Rhodes)

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CLASSIFICAZIONE NATURALE

Anteriore ↑

ELEMENTI DISCERNENTI

M Sa M

Sc Sc Sb Sb Sc Sc

SIMMETRIA

ELEMENTI CONTUNDENTI

Pb DI Pb

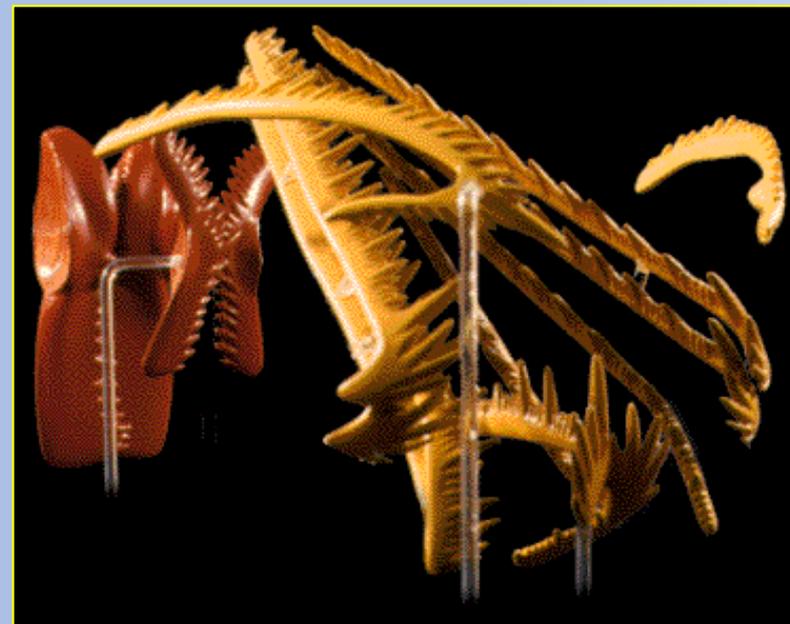
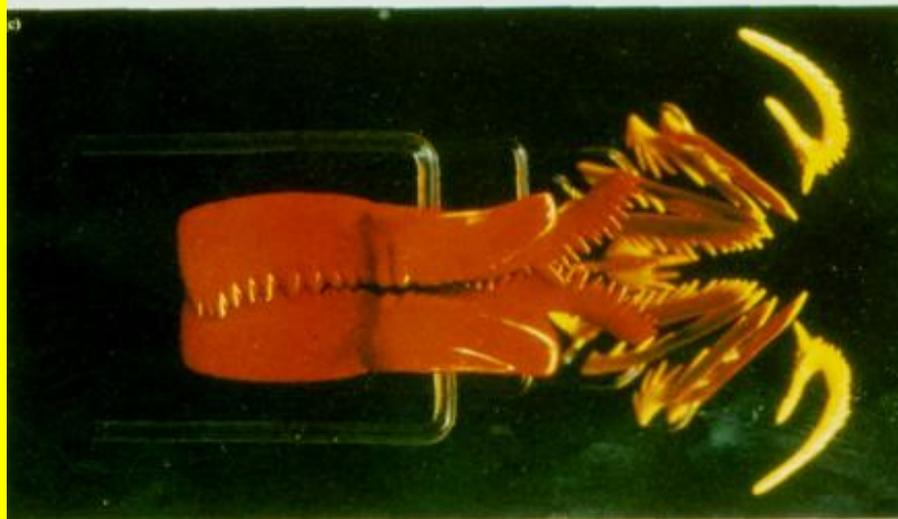
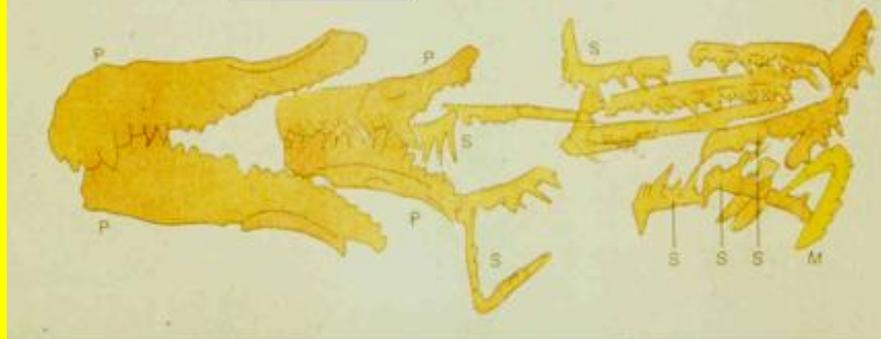
PIANO

Pa Pa

Wurmiella excavata (Branson & Mehl)

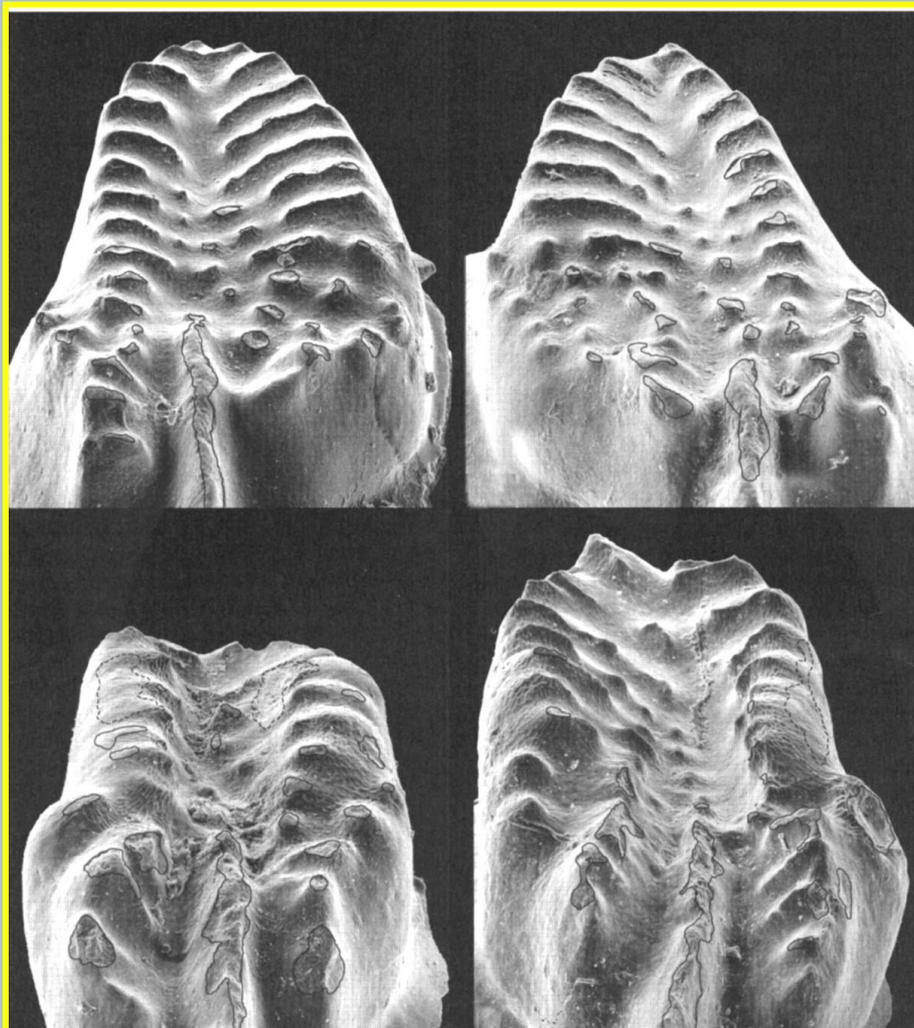


1 mm



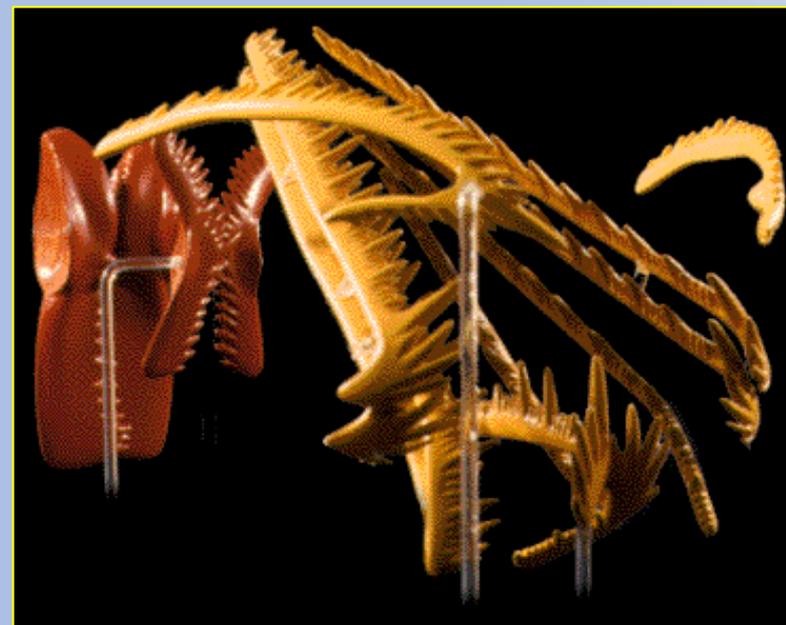
Idiognathodus sp.

Carbonifero sup. - USA



Purnell et al. (1998)

Segni di usura sulla superficie di elementi P1 (sinistri e destri).



Idiognathodus sp.

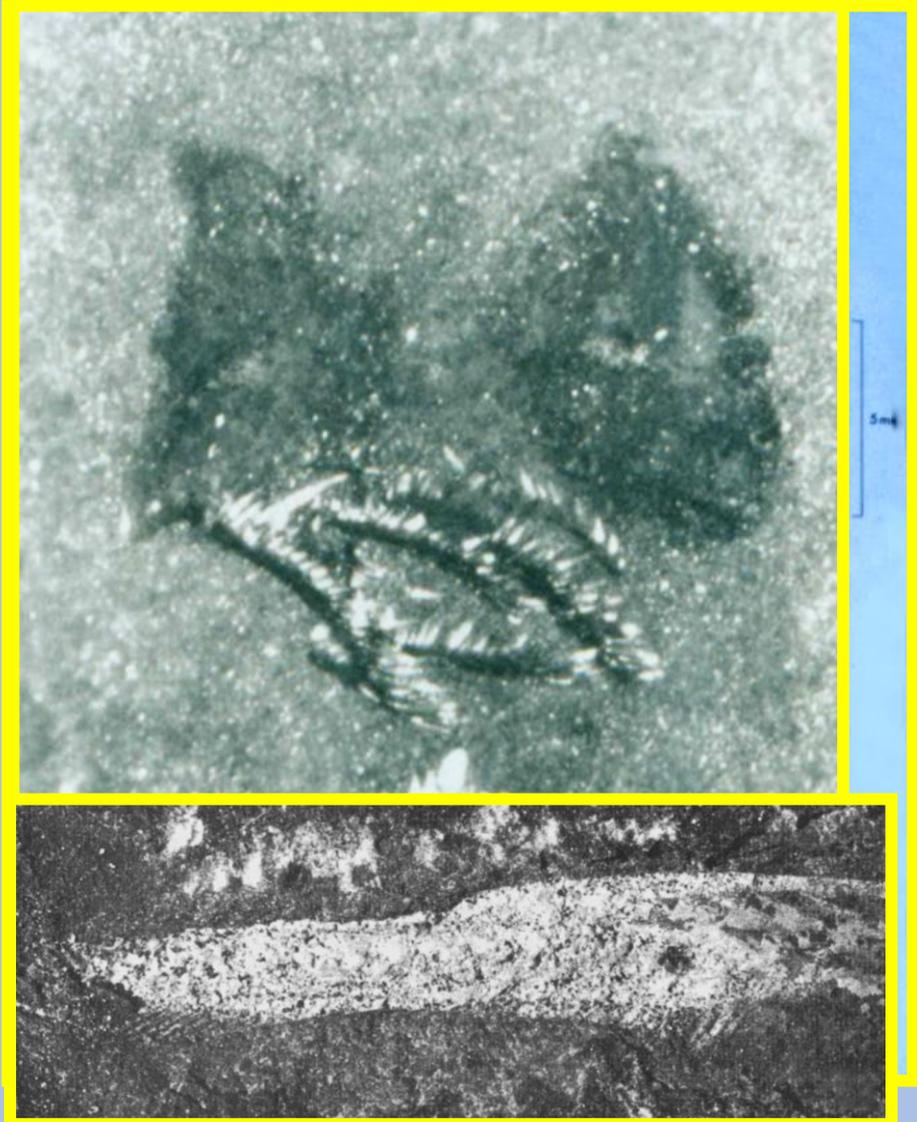
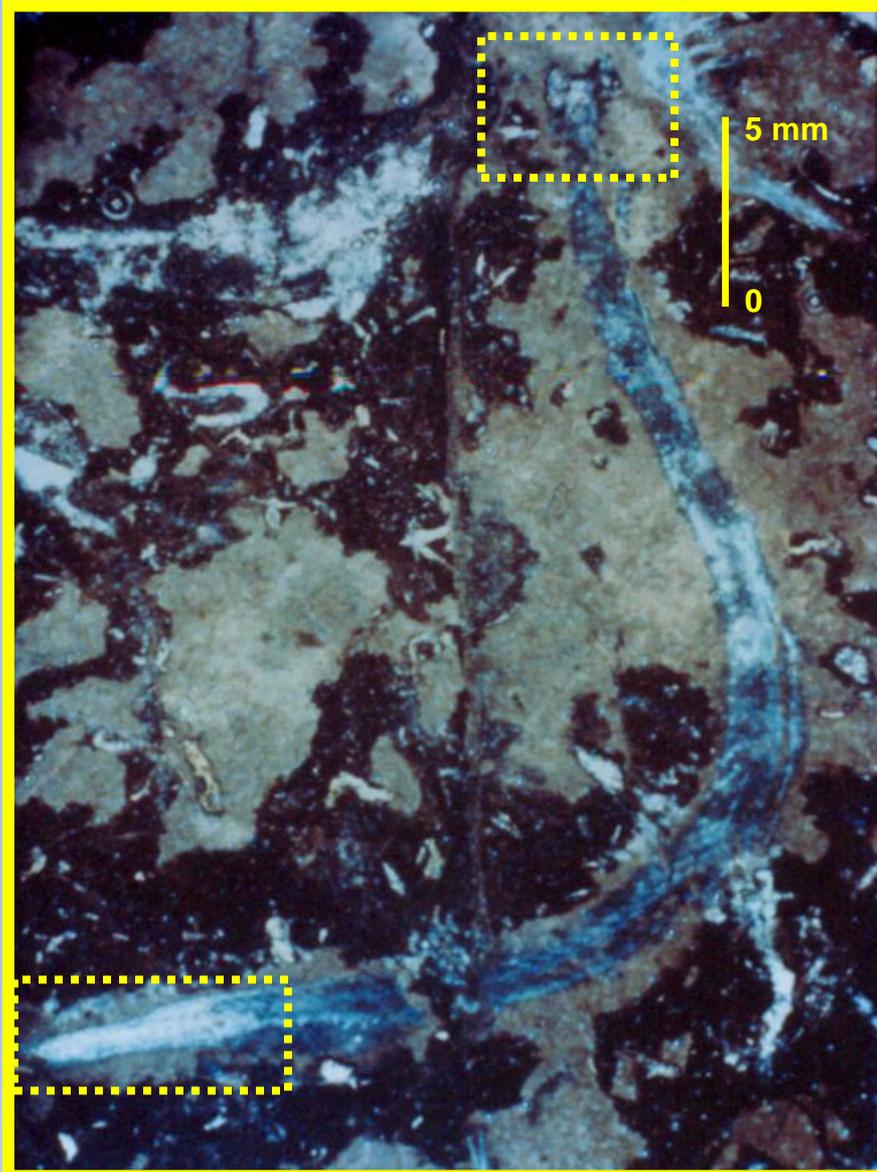
Carbonifero sup. - USA

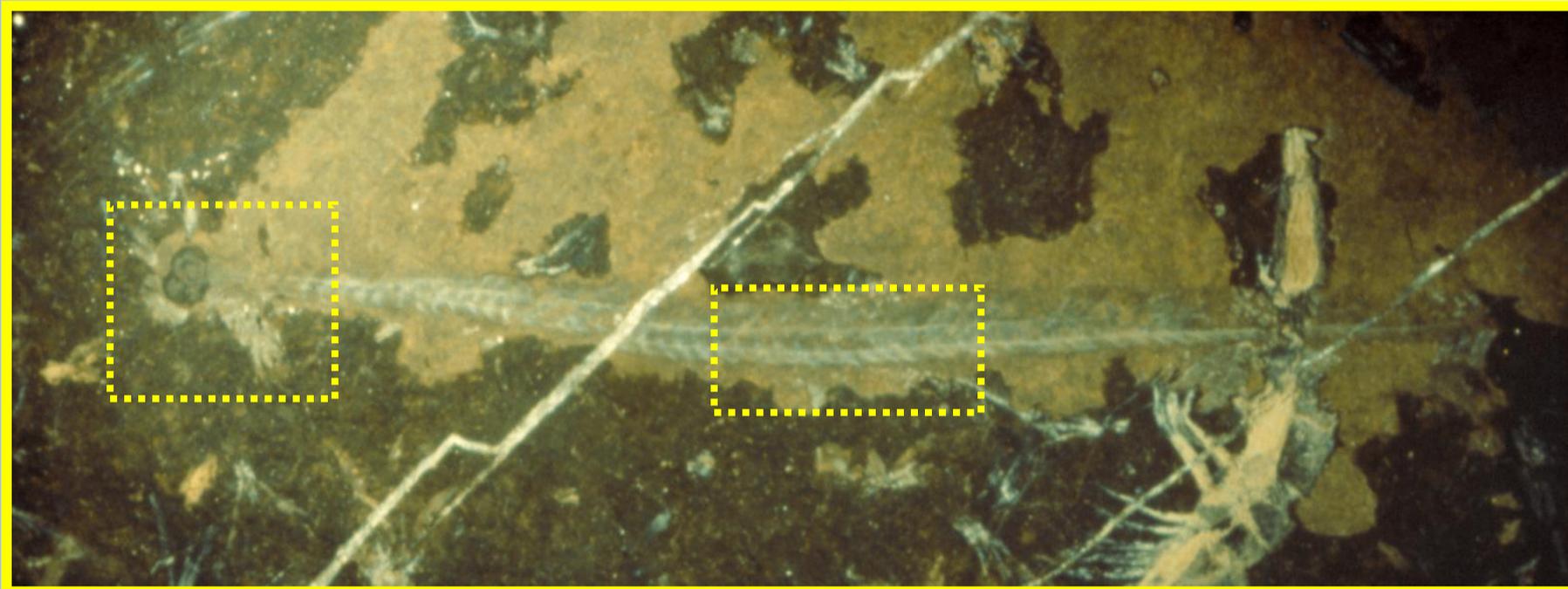
COELEENTERATA	Bischoff (1973)
TENTACULATA	Lindström (1973), Conway Morris (1976)
ARTHROPODA	Harley (1861), Barrande <i>et al.</i> (1867)
MOLLUSCA	Owen (1861), Owen (1967), Morse (1975), Stimpson (1875), James (1894), Woodward (1898), Loomis (1936), Pilsbury (1937), Tiller & Cuif (1986)
ANELLIDA	Owen (1861), Owen (1967), Ulrich (1878), Zittel & Rohon (1886), Woodward (1898), Scott (1934), Dubois (1934), Rhodes (1952)
ASCHELMINTHES	Denham (1944), Missarzhevsky (1973), Hofker (1974)
CHETOGNATHA	Rietschel (1973), Szaniawski (1982)
GNATHOSTOMULIDA	Durden (1969), Ochielli & Cailleux (1969), Rodgers (1969)
PLANTS	Fahlbusch (1964), Nease (1969)
CHORDATA	Pander (1856), Newberry (1875), Agassiz (1875), Hinde (1879), Rolle (1882), Clarke (1885), Bryant (1921), MacFarlane (1923), Ulrich & Bassler (1926), Holmes (1928), Kirk (1929), Stauffer & Plummer (1932), Schmidt (1934), Branson & Mehl (1936), Delmanet (1939), Beckmann (1949), Schmidt (1950), Gross (1954), Rhodes (1954), Rhodes & Wingard (1957), Schmidt (1964), Halstaed (1968), Scott (1969), Melton & Scott (1973), Aldridge <i>et al.</i> (1986), Nowlan & Carlisle (1987), Kreisa <i>et al.</i> (1990), Aldridge <i>et al.</i> (1993), ...
PHYLUM INDIPENDENTE	Clark (1981), Briggs <i>et al.</i> (1983), Gould (1983), Clark (1987), Sweet (1988)



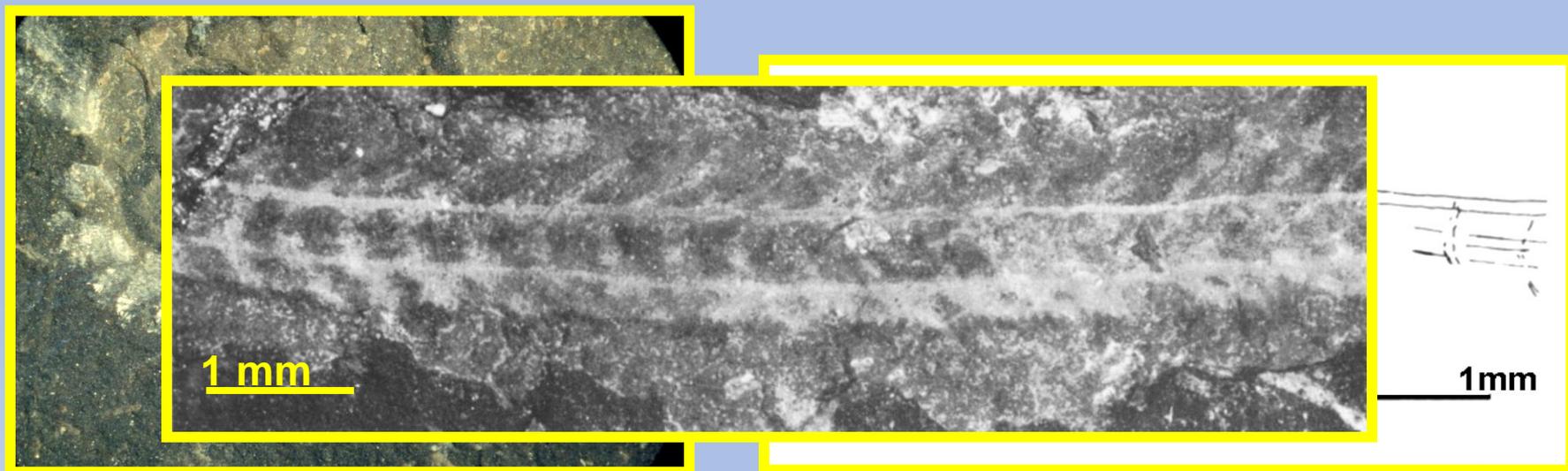
Clydagnathus windsorensis

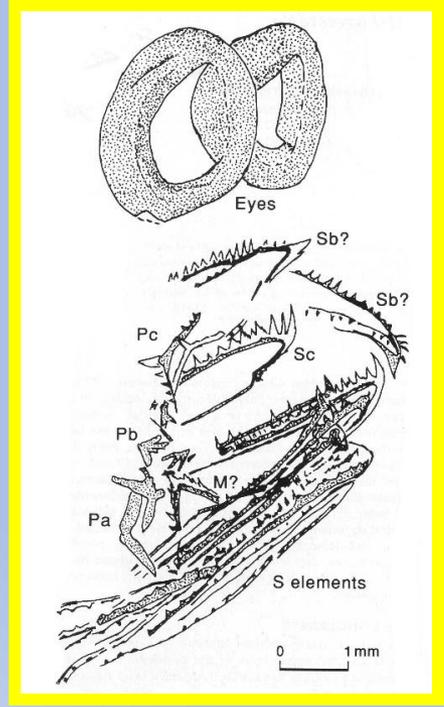
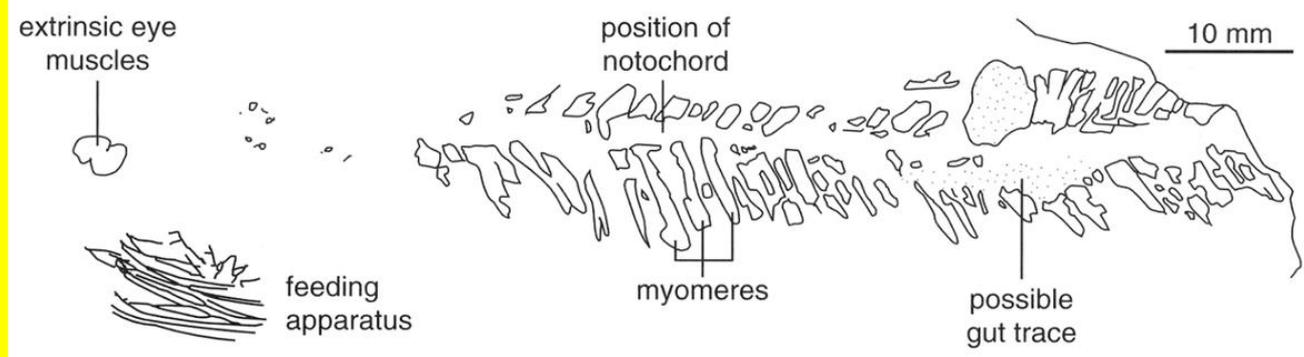
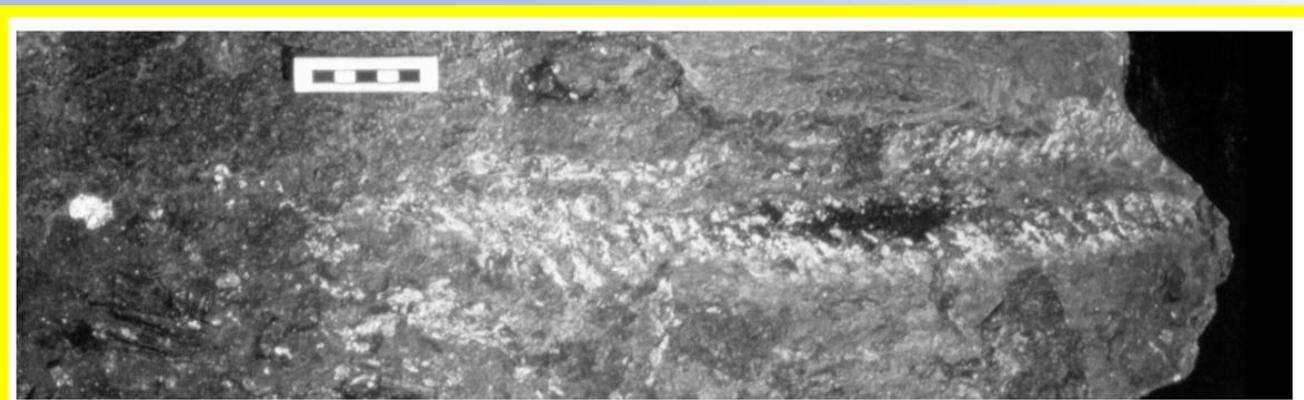
(esemplare 1) Carbonifero inf. - Scozia



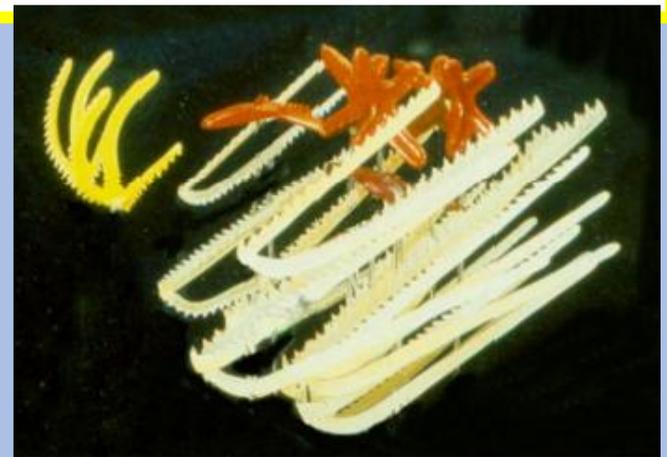


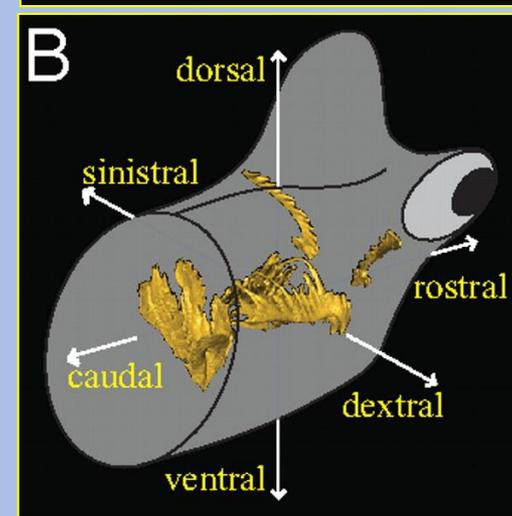
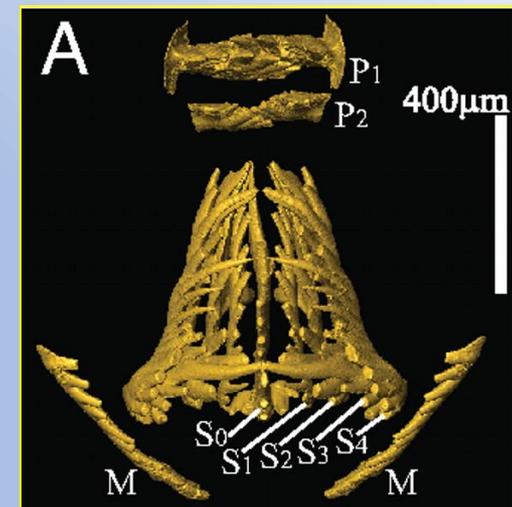
Clydagnathus windsorensis - (esemplare 5), Carbonifero inf. - Scozia





Promissum pulchrum
Ordoviciano Sup.
Sud Africa





Caratteristiche dei conodonti sono:

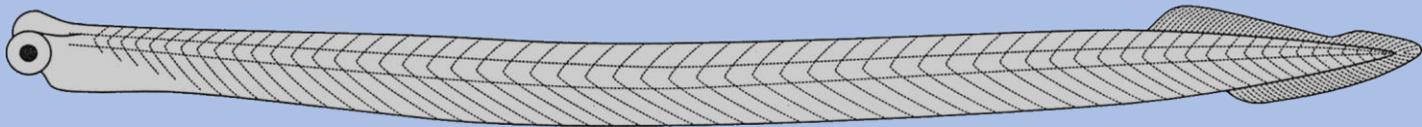
la notocorda

la muscolatura divisa in miomeri a forma di V

la coda con una pinna;

la simmetria bilaterale del corpo

la composizione e istologia delle parti dure mineralizzate



CORDATI

Il *phylum* Chordata comprende tre *subphyla*:

1. Urochordata (Tunicata)
2. Cephalochordata
3. Craniata (Vertebrata)

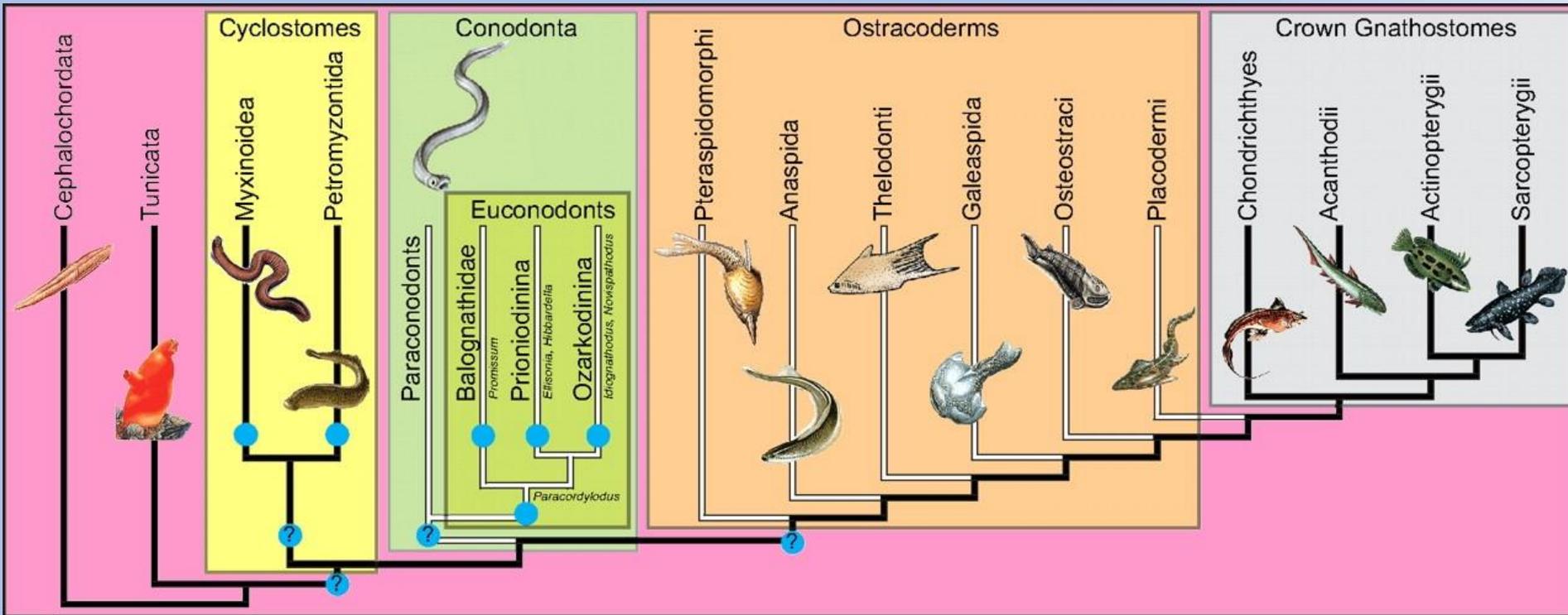
I Vertebrati si dividono in:

1. Agnati
2. Gnatostomi

Secondo la presenza o meno di mandibole e mascelle

I CONODONTI sono AGNATI

Filogenesi



Goudemand et al. (2013)

Colore



Colore



Epstein et al. (1984)

Temperatura

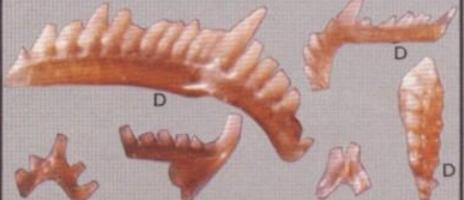
L'alterazione di colore dipende dal TEMPO e dalla TEMPERATURA.

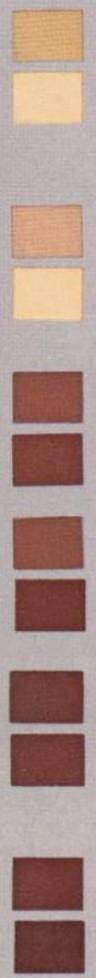
L'alterazione di colore è PROGRESSIVA, CUMULATIVA e IRREVERSIBILE.

La pressione non accelera né ritarda il processo di alterazione di colore.

C.A.I

(Color Alteration Index)

COLOR ALTERATION INDEX	EXPERIMENTALLY PRODUCED COLOR ALTERATION	COLOR ALTERATION IN FIELD COLLECTIONS	TEMPERATURE RANGE, °C	FIXED CARBON RANGE
1			<50°-80°	<60%
1½			50°-90°	55% to 70%
2			60°-140°	
3			110°-200°	70% to 80%
4			190°-300°	80% to 95%
5			+300°	+95%



C.A.I

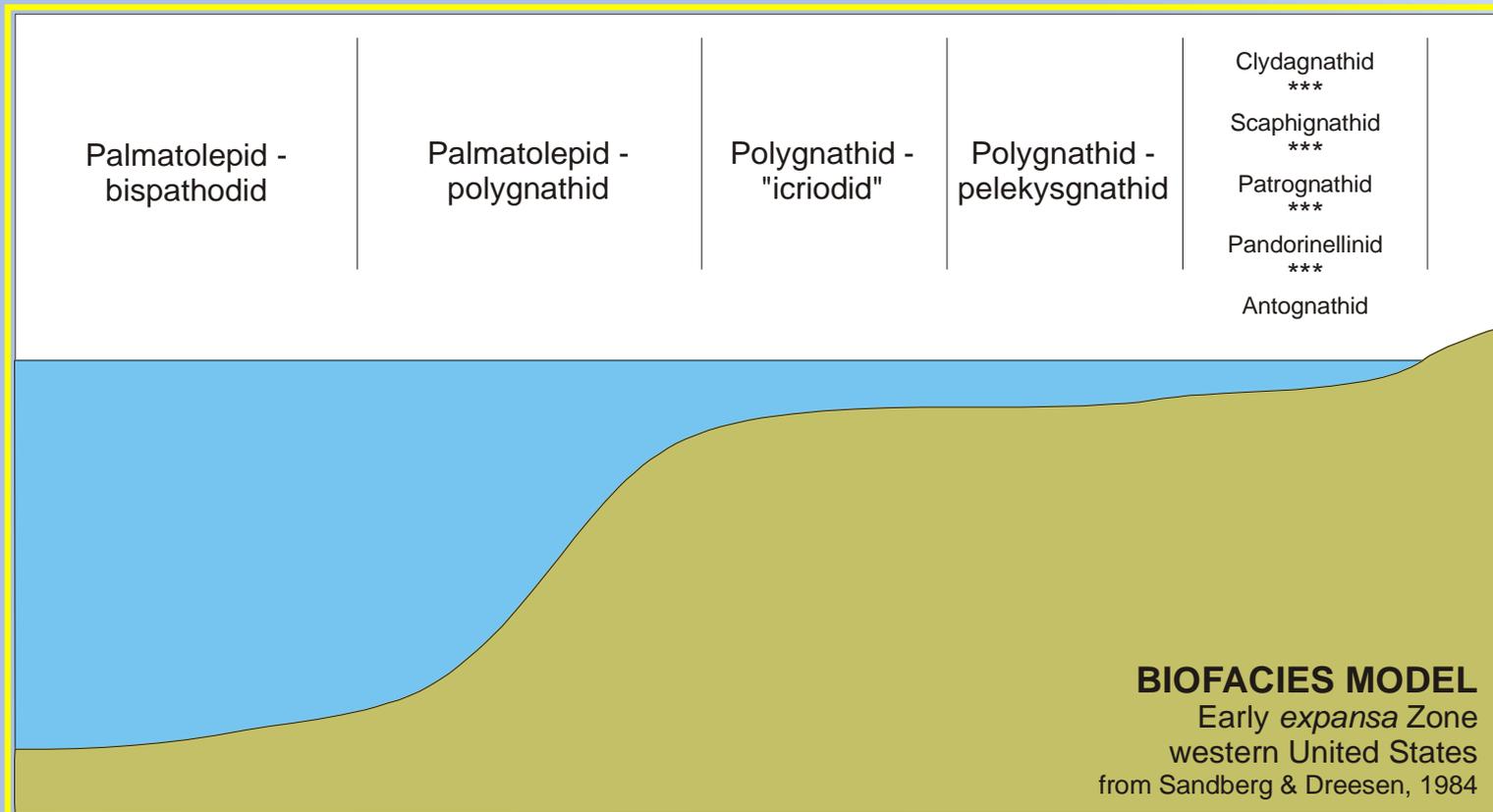
(Color Alteration Index)

COLOR ALTERATION INDEX (CAI)	EXPERIMENTALLY INDUCED COLOR ALTERATION	NATURAL COLOR ALTERATION FROM FIELD COLLECTIONS	TEMPERATURE RANGE, °C	MUNSELL ROCK COLOR
5			300° - 480°	BLACK (N1)
6			360° - 550°	MEDIUM DARK GRAY TO MEDIUM GRAY (N4-N5)
6 1/2			440° - 610°	MEDIUM LIGHT GRAY TO LIGHT GRAY (N6-N7)
7			490° - 720°	VERY LIGHT GRAY TO WHITE (N8-N9)
8			> 600°	COLORLESS OR CRYSTAL CLEAR

APPLICAZIONI

- **STRATIGRAFIA**
- **PALEOECOLOGIA e PALEOCLIMA**
- **GEOLOGIA REGIONALE**
- **RICERCHE PETROLIFERE**

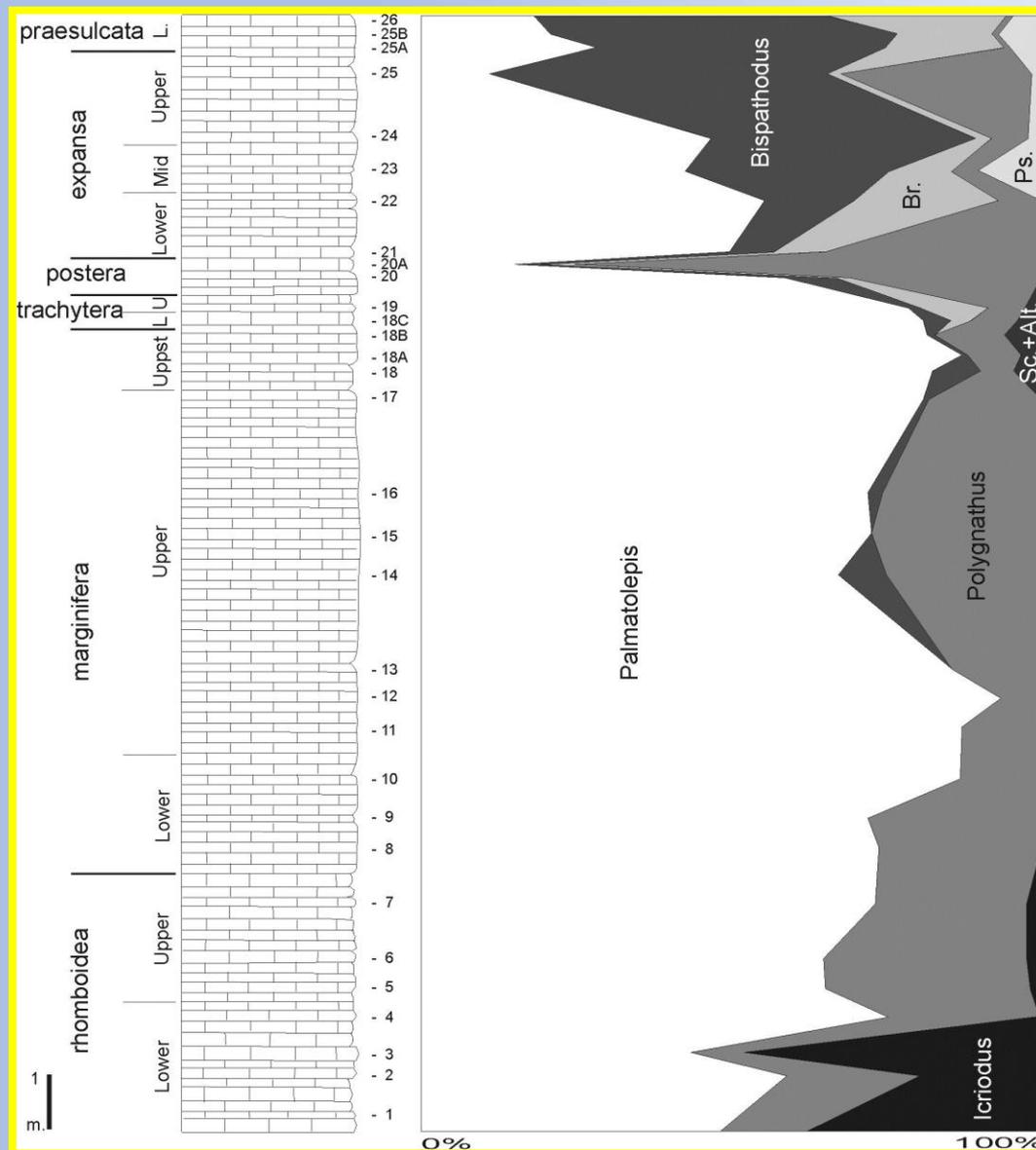
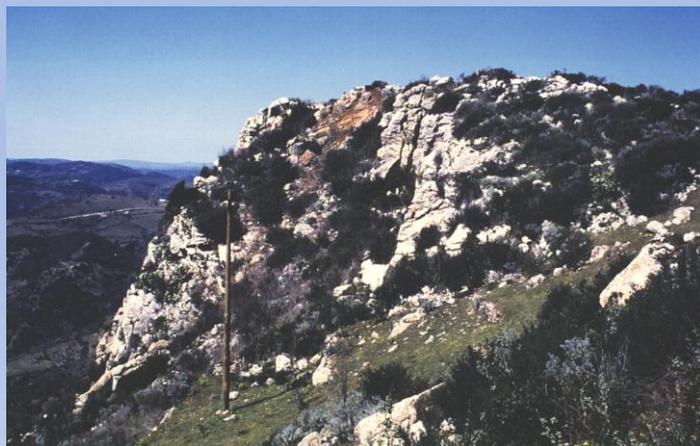
Ricostruzioni paleoambientali



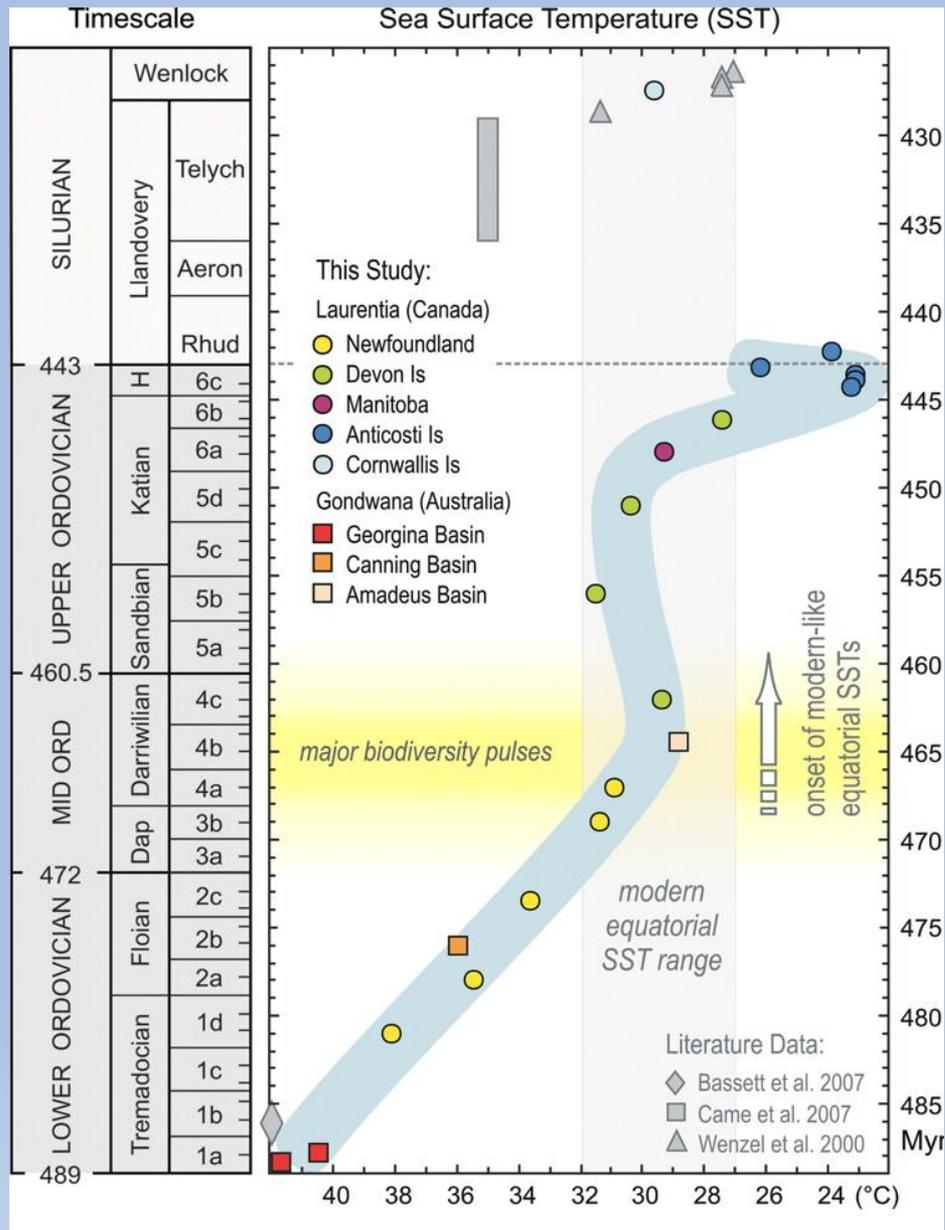
Ricostruzioni paleoambientali

Sezione Corona Mizziu I

Devoniano Sup. – Sardegna



Ricostruzioni paleoclimatiche



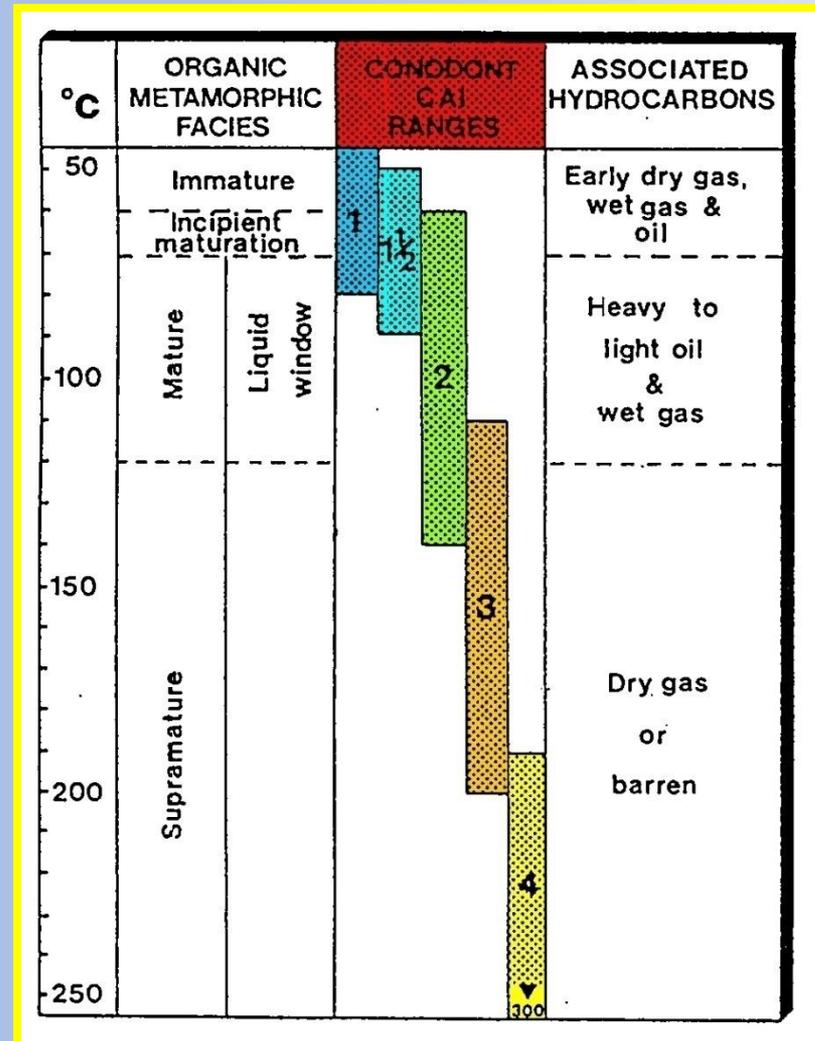
Curva delle temperature del mare durante l'Ordoviciano basata su $\delta^{18}\text{O}$ misurato nei conodonti

Applicazioni del C.A.I

Conoscere la storia termica di un bacino sedimentario, fornendo informazioni sulle aree e sugli intervalli stratigrafici che potrebbero contenere idrocarburi.

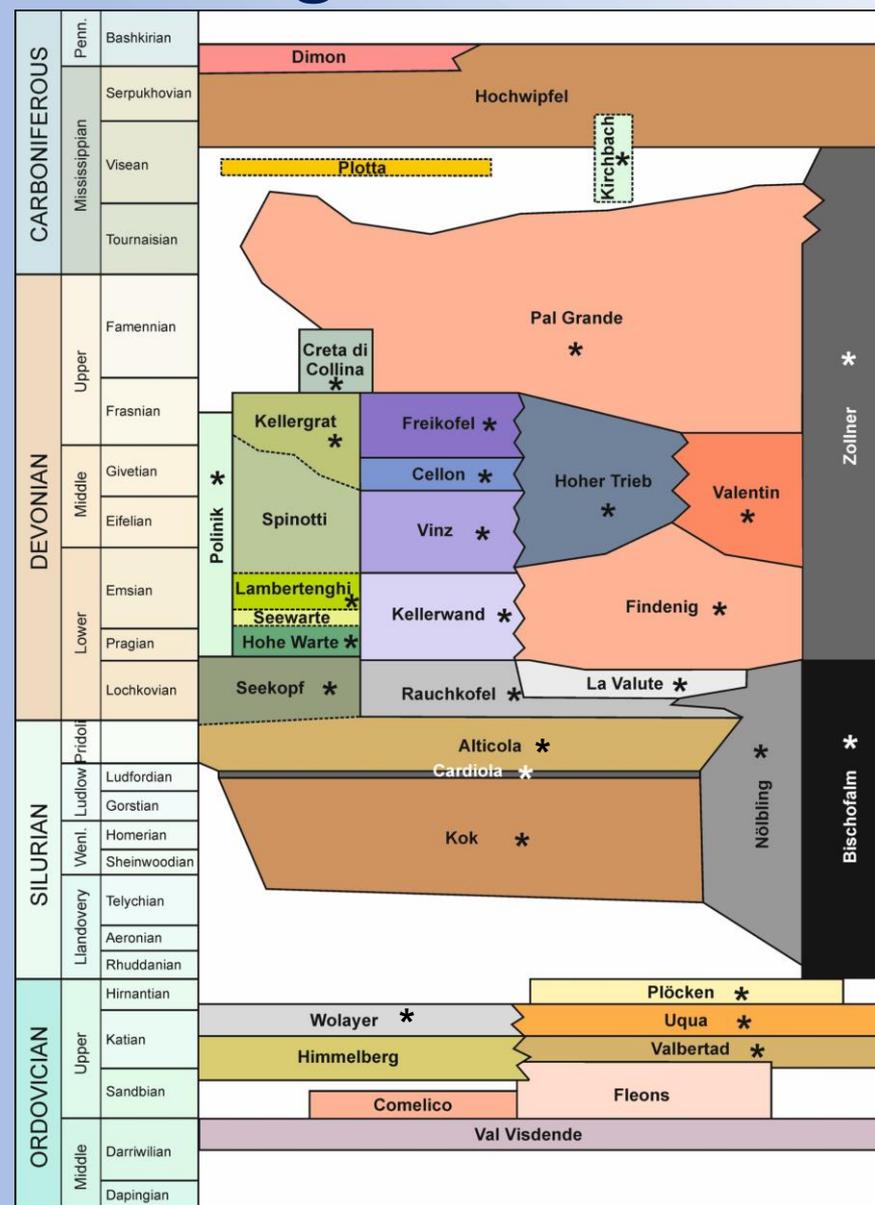
Identificare intrusioni localizzate, e quindi contribuire all'individuazione di depositi minerali.

Identificare effetti tettonici locali, che hanno provocato flussi di calore (grandi sovrascorrimenti o rifting).

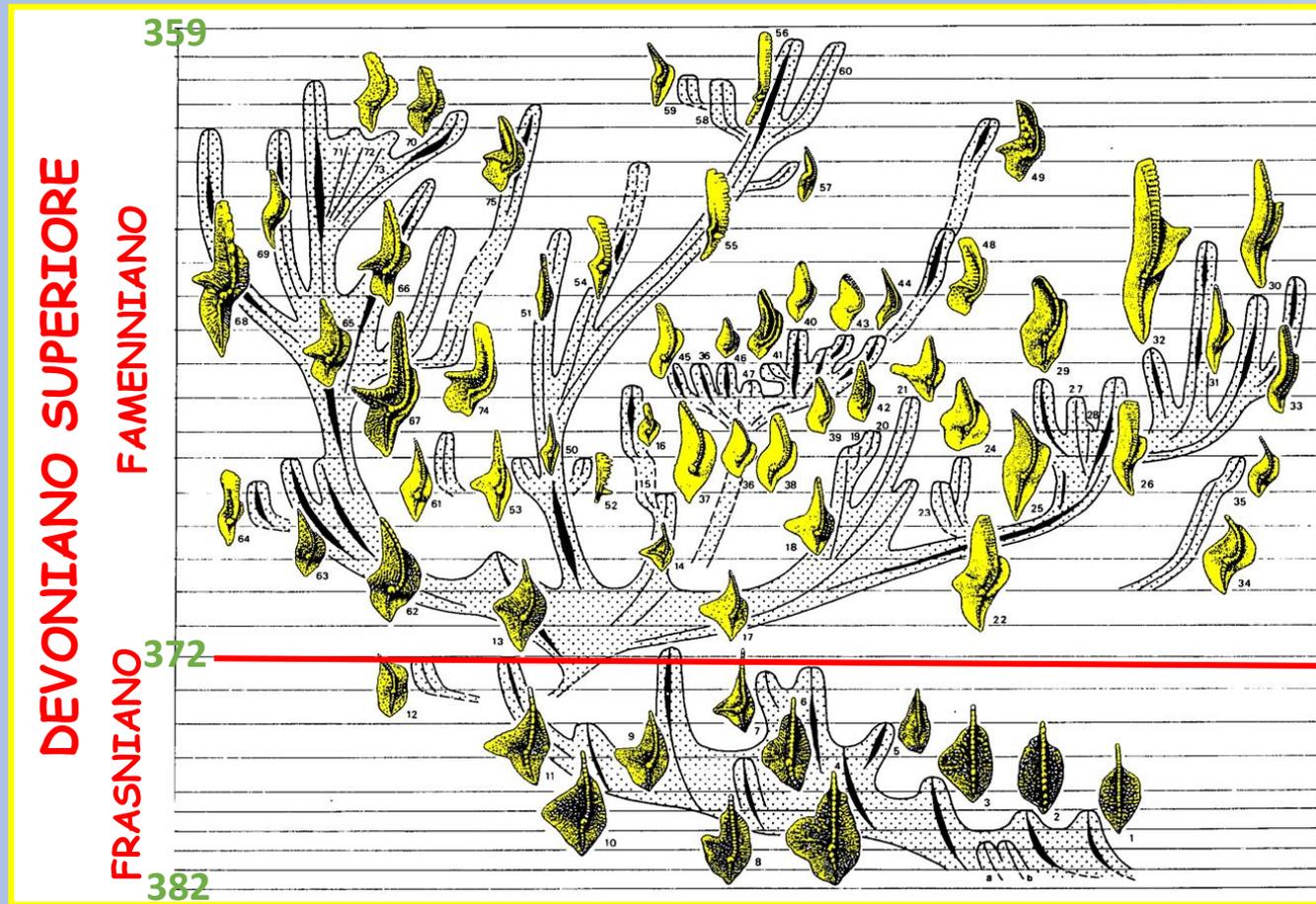


Contributo alla Litostratigrafia

SEQUENZA PRE-VARISICA DELLE ALPI CARNICHE



Biostratigrafia



DEVONIANO SUPERIORE

FAMENNIANO

FRASNIANO

359

372

382

FAMENNIAN CONODONT ZONATION
<i>Protognathodus kockeli</i>
<i>Bispathodus ultimus</i>
<i>Bispathodus costatus</i>
<i>Bispathodus ac. aculeatus</i>
<i>Palmatolepis gr. expansa</i>
<i>Palmatolepis gr. manca</i>
<i>Polygnathus styriacus</i>
<i>Pseudopolygnathus granulatus</i>
<i>Palmatolepis r. trachytera</i>
<i>Scaphignathus v. velifer</i>
<i>Palmatolepis m. utahensis</i>
<i>Palmatolepis m. marginifera</i>
<i>Palmatolepis gr. gracilis</i>
<i>Palmatolepis rhomboidea</i>
<i>Palmatolepis gl. pectinata</i>
<i>Palmatolepis gl. prima</i>
<i>Palmatolepis termini</i>
<i>Palmatolepis crepida</i>
<i>Palmatolepis m. minuta</i>
<i>Palmatolepis del. platys</i>
<i>Palmatolepis triangularis</i>
<i>Palmatolepis subperlobata</i>

Genere *Palmatolepis*

Biostratigrafia

Esistono schemi di biozonazione dettagliati e largamente usati per le rocce carbonatiche dal Cambriano superiore al Triassico.

Silurian Time Scale								
AGE (Ma)	Epoch/Age (Stage)	Stage Slices	Graptolites	Conodonts	Chitinozoan	Spores	Vertebrates	
419.0	Devonian		<i>Uncinograptus uniformis</i>	<i>Caudicriodus hesperius</i>	<i>Eisenackitina bohemica</i> Interval Range Biozone		<i>Trimerolepis timanica</i>	
420		Pridoli	<i>Istrograptus transrediens</i> / <i>"M." perneri</i>	<i>Oulodus elegans detortus</i>	<i>Angochitina superba</i>	not zoned	<i>Paracanthodes punctatus</i>	
421			<i>"Monograptus" bouceki</i>				<i>Nostolepis gracilis</i>	
422	Ludfordian	Pr1	<i>Neocolonograptus lochkovenski</i> / <i>N. branikensis</i>	Ozarkodina eosteinhornensis s.l. Interval Zone	<i>Margachitina elegans</i>	<i>Synorisporites tripapillatus-Apiculiretusispora spicula</i>	<i>Thelodus admirabilis</i>	
423			<i>Neocolo. ultimus</i> / <i>N. parulimus</i>		<i>Fungochitina kosovensis</i>		<i>Thelodus sculptilis</i>	
423	Ludlow	Lu3	<i>Formosograptus formosus</i>	<i>Ozarkodina crispata</i>	<i>Eisenackitina barrandei</i>	<i>Lophozonotriletes? poecilomorphus - Synorisporites libycus</i>	<i>Andreolepis hedei</i>	
424		Lu2	<i>Neocuculogr. kozlowski</i> / <i>Polonogr. podoliensis</i> Zone	<i>Pedavis latiatata</i> / <i>Ozarkodina snajdri</i> Interval Zone	<i>Eisenackitina phillipi</i>			
425		Lu1	<i>Bohemograptus</i>	<i>Polygnathoides siluricus</i>	<i>Angochitina elongata</i>			
425.01	Gorstian	Go2	<i>Saetograptus leintwardinensis</i>	<i>Ancoradella ploeckensis</i>			<i>Phlebolepis elegans</i>	
426			Go1	<i>Lobograptus scanicus</i>	<i>Kockelella variabilis</i> Interval Zone	not zoned	<i>Sclya. downiei - Concen. sagittarius</i>	<i>Phlebolepis ornata</i>
426.74	Homerian	Ho3	<i>Neodiversogr. nilsoni</i>	<i>Kockelella crassa</i>		<i>Artemopyra brevicostata - Hispanaediscus verrucatus</i>	<i>Paralogania martinsoni</i>	
427			Ho2	<i>Colonograptus? deubeli</i> / <i>C? praedeubeli</i>	<i>Kockelella ortus absidata</i>			<i>Sphaerochitina lycoperdoides</i>
428				<i>Gothograptus nassa</i> / <i>Pristiograptus parvus</i>	<i>Ozarkodina bohemica longa</i>			
429	Wenlock	Ho1	<i>Cyrtograptus lundgreni</i>	<i>Ozarkodina sagitta sagitta</i>	<i>Conochitina pachycephala</i>		<i>Loganellia einari</i>	
430			Sheinwoodian	Sh3	<i>Cyrtogr. rigidus</i> / <i>Monogr. antennularius</i> / <i>M. belophorus</i>	<i>Kockelella amsdeni</i> / <i>K. walliseri</i> SuperZone		<i>Overia adraini</i>
431	Sh2				<i>Ozarkodina sagitta rhenana</i>	<i>Cingulochitina cingulata</i>	<i>Loganellia grossi</i> <i>Archipelepis bifurcata</i> / <i>Arch. turbinata</i>	

Cronostratigrafia

Devonian	Upper	Famennian	FAD <i>Palmatolepis subperlobata</i>	Triassic	Upper	Rhaetian	FAD <i>Misikella posthernsteini</i>
		Frasnian	FAD <i>Ancyrodella rotundiloba pristina</i>			Norian	
	Middle	Givetian	FAD <i>Polygnathus hemiansatus</i>			Carnian	
		Eifelian	FAD <i>Polygnathus partitus</i>		Middle	Ladinian	
	Lower	Emsian	FAD <i>Polygnathus kitabicus</i>			Anisian	FAD <i>Chiosella timorensis</i>
		Pragian	FAD <i>Eognathodus sulcatus sulcatus</i>		Olenekian	FAD <i>Novispathodus waageni</i>	
		Lochkovian			Induan	FAD <i>Hindeodus parvus</i>	
Silurian	Pridoli			Permian	Lopingian	Changhsingian	FAD <i>Clarkina postbitteri</i>
		Ludfordian				Wuchiapingian	FAD <i>Jinogondolella postserrata</i>
	Ludlow	Gorstian			Capitanian	FAD <i>Jinogondolella aserrata</i>	
		Homerian			Wordian	FAD <i>Jinogondolella nankingensis</i>	
	Wenlock	Sheinwoodian			Roadian		
		Telychian			Kungurian	FAD <i>Neostreptognathus pnevi</i>	
	Llandovery	Aeronian			Cisuralian	Artinskian	FAD <i>Sweetognathus asymmetricus</i>
Rhuddanian			Sakmarian	FAD <i>Mesogondolella monstra</i>			
Hirnantian			Asselian	FAD <i>Streptognathodus isolatus</i>			
Ordovician	Upper	Katian		Carboniferous	Pennsylvanian	Gzhelian	FAD <i>Idiognathodus simulator</i>
		Sandbian				Kasimovian	FAD <i>Idiognathodus heckeli</i>
	Middle	Darriwilian			Moscovian	FAD <i>Diplognathodus ellesmerensis</i>	
		Dapingian	FAD <i>Baltoniodus triangularis</i>		Lower	Bashkirian	FAD <i>Declinognathodus noduliferus</i>
	Lower	Floian				Upper	Serpukhovian
Tremadocian		FAD <i>Iapetognathus fluctivagus</i>	Middle	Visean			
Cambrian	Furongian	Stage 10		Mississippian	Lower	Tournaisian	FAD <i>Siphonodella sulcata</i>
		Jiangshanian					
		Paibian					

blue: candidate criterion

Cronostratigrafia

GSSPs of the Devonian Stages, with location and primary correlation criteria

Stage	GSSP Location	Latitude, Longitude	Boundary Level	Correlation Events	Reference
* Famennian	Coumiac Quarry, near Cessenon, Montagne Noire, France	43°27'40.6"N 3°02'25"E*	base of Bed 32a	Conodont, FAD of <i>Palmatolepis subperlobata</i> , Conodont, LAD of <i>Palmatolepis bogartensis</i>	Episodes 16/4, 1993
* Frasnian	Col du Puech de la Suque, Montagne Noire, France	43°30'11.4"N 3°05'12.6"E*	base of Bed 42a at Col du Puech de la Suque section E	Conodont, FAD of <i>Ancyrodella rotundiloba pristina</i>	Episodes 10/2, 1987
* Givetian	Jebel Mech Irdane, Morocco	31°14'14.7"N 4°21'14.8"W*	base of Bed 123	Conodont, FAD of <i>Polygnathus hemiansatus</i>	Episodes 18/3, 1995
* Eifelian	Wetteldorf, Eifel Hills, Germany	50°08'58.6"N 6°28'17.6"E*	21.25 m above the base of the exposed section, base of unit WP30	Conodont, FAD of <i>Polygnathus partitus</i>	Episodes 8/2, 1985
* Emsian	Zinzil'ban Gorge, Uzbekistan	39°12'N 67°18'20"E	base of Bed 9/5 in the Zinzil'ban Gorge in the Kitab State Geological Reserve	Conodont, FAD of <i>Eocostapolygnathus kitabicus</i> New Emsian base under discussion, potentially FAD of <i>Eolinguipolygnathus excavatus</i> M114	Episodes 20/4, 1997
* Pragian	Velká Chuchle, Prague, Czech Republic	50°00'53"N 14°22'21.5"E*	base of Bed 12 in Velká Chuchle Quarry	Conodont, just above FAD of <i>Eognathodus irregularis</i>	Episodes 12/2, 1989
Lochkovian	Klonk, near Prague, Czech Republic	48.855°N 13.792°E**	within Bed 20	Graptolite, FAD of <i>Uncinatograptus uniformis</i>	IUGS Series A, 5, 1977

* according to Google Earth, ** derived from map

Cronostratigrafia

GSSPs of the Carboniferous Stages, with location and primary correlation criteria

Stage	GSSP Location	Latitude, Longitude	Boundary Level	Correlation Events	Reference
* Gzhelian	Candidates are in southern Urals or Nashui (South China)			Conodont, FAD of <i>Idiognathodus simulator</i> (candidate)	
* Kasimovian	Candidates are in Usolka, Russia, Nashui (South China)			Conodont, FAD of <i>Idiognathodus heckeli</i>	
* Moscovian	Candidates are in southern Urals or Nashui (South China)			Conodont, FAD <i>Diplognathodus ellesmerensis</i> (candidate)	
* Bashkirian	Arrow Canyon, Nevada, USA	36°44'00" N, 114°46'40" W**	82.9 m above the top of the Battleship Formation in the lower Bird Spring Formation	Conodont, FAD of <i>Declinognathodus noduliferus</i>	Episodes 22/4, 1999
* Serpukhovian	Candidates are Verkhnyaya Kardailovka (Urals) or Nashui (South China)			Conodont, FAD of <i>Lochriea zieglerei</i> (candidate)	
Visean	Pengchong, South China	24°26'8.88"N, 109°27'19.49"E	base of bed 83 in the Pengchong Section	Foraminifer, FAD of <i>Eoparastaffella simplex</i>	Episodes 26/2, 2003
* Tournaisian (GSSP under reevaluation)	La Serre, France	43°33'19.9"N 3°21'26.3"E*	base of Bed 89 in Trench E' at La Serre, (but FAD now known to be at base of Bed 85)	Conodont, FAD of <i>Siphonodella sulcata</i> s.l.	Episodes 14/4, 1991; Kölner Forum Geol. Paläont., 15, 2006

* according to Google Earth, ** derived from map

Cronostratigrafia

GSSPs of the Permian Stages, with location and primary correlation criteria

Stage	GSSP Location	Latitude, Longitude	Boundary Level	Correlation Events	Reference
* Changhsingian	Meishan, Zhejiang Province, South China	31°4'55"N 119°42'22.9"E	base of Bed 4a-2, 88 cm above the base of Changxing Limestone at the Meishan D Section	Conodont, FAD of <i>Clarkina wangi</i>	Episodes 29/3, 2006
* Wuchiapingian	Penglaitan, Guangxi Province, South China	23°41'43"N 109°19'16"E	base of Bed 6k in the Penglaitan Section	Conodont, FAD of <i>Clarkina postbitteri postbitteri</i>	Episodes 29/4, 2006
* Capitanian	Nipple Hill, SE Guadalupe Mountains, Texas, U.S.A	31°54'32.8"N 104°47'21.1"W	4.5 m above the base of the outcrop section of the Pinery Limestone Mbr of the Bell Canyon Formation	Conodont, FAD of <i>Jinogondolella postserrata</i>	
* Wordian	Guadalupe Pass, Texas, U.S.A	31°51'56.9"N 104°49'58.1"W	17.6 m above the base of the Getaway Ledge outcrop section of the Getaway Limestone Mbr of the Cherry Canyon Formation	Conodont, FAD of <i>Jinogondolella aserrata</i>	
* Roadian	Stratotype Canyon, Texas, U.S.A	31°52'36.1"N 104°52'36.5"W	42.7 m above the base of the Cutoff Formation	Conodont, FAD of <i>Jinogondolella nankingensis</i>	
* Kungurian	<i>candidate Mechetlino Quarry section, Russia</i>	55°21'42"N 57°59'57"E	Bed 19	FAD of conodont <i>Neostreptognathodus previ</i>	
* Artinskian	<i>candidate Dal'ny Tulkas section, Russia</i>	53°53'18.5"N 56°30'58.15"E	2.7 m above the base of Bed 4	FAD of conodont <i>Sweetognathus asymmetrica</i>	
* Sakmarian	Usolka section, Russia	53°55'28.86"N 56°31'43.38"E	55.4 m above the base of the Usolka section in Bed 26/3	Conodont, FAD of <i>Mesogondolella monstra</i>	Episodes accepted 2020
* Asselian	Aidaralash Creek, Kazakhstan	50°14'45"N 57°53'29"E*	27m above the base of Bed 19	Conodont, FAD of <i>Streptognathodus isolatus</i>	Episodes 21/1, 1998

* according to Google Earth

Cronostratigrafia

GSSPs of the Triassic Stages, with location and primary correlation criteria

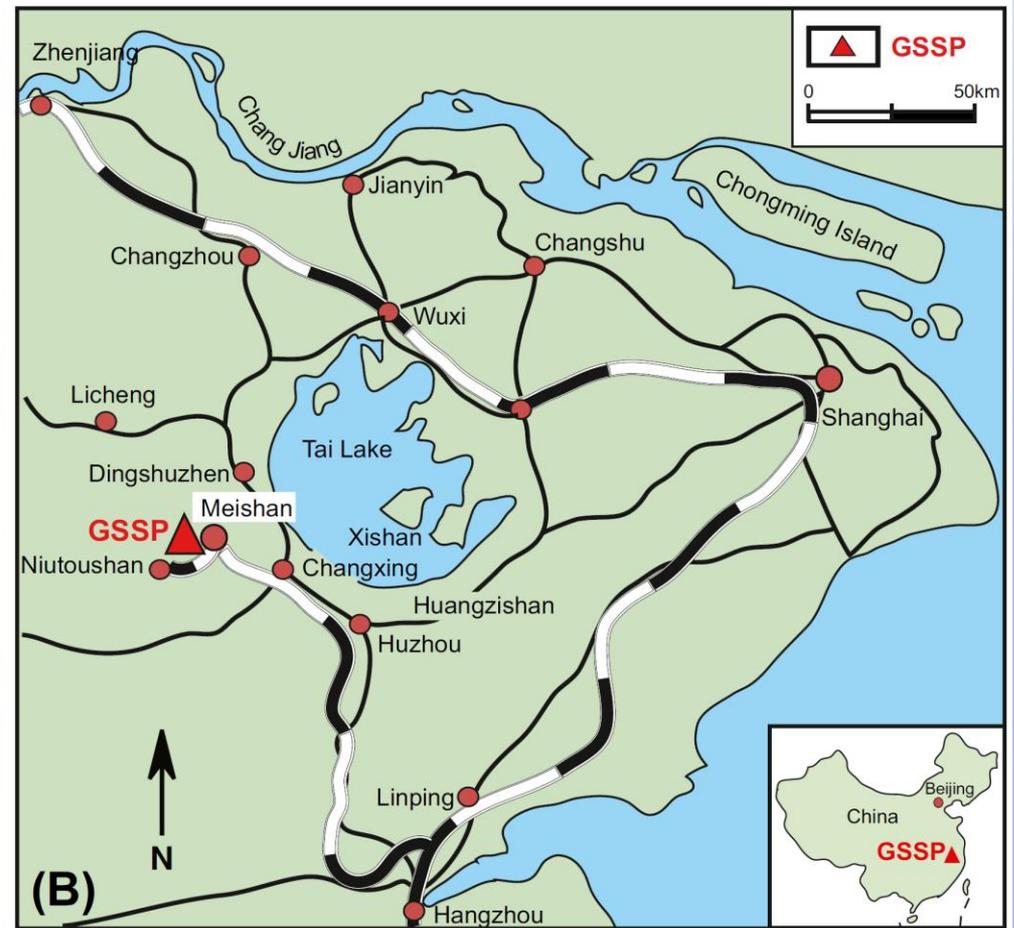
Stage	GSSP Location	Latitude, Longitude	Boundary Level	Correlation Events	Reference
Rhaetian	Candidates are Pizzo Mondello, Sicily, Italy, and Steinbergkogel, Austria			Near FADs of conodont <i>Misikella posthernsteini</i> s. s. or <i>Misikella posthernsteini</i> s.l.	
Norian	Candidates are Black Bear Ridge in British Columbia (Canada) and Pizzo Mondello, Sicily, Italy			FAD of conodont <i>Metapolygnathus parvus</i> . Near base of <i>Stikinoceras kerri</i> ammonoid zone and FAD of bivalve <i>Halobia austriaca</i>	
Carnian	Section at Prati di Stuares, Dolomites, Italy	46°31'37"N 11°55'49"E	GSSP is base of marly limestone bed SW4, 45 m from base of San Cassiano Formation	FAD of ammonoid <i>Daxatina canadensis</i> , conodont <i>Quadralella polygnathiformis</i> and <i>Halobia</i> bivalves	Episodes 35/3, 2012
Ladinian	Bagolino, Province of Brescia, Northern Italy	45°49'09.5"N 10°28'15.5"E	base of a 15 – 20 cm thick limestone bed overlying a distinctive groove ("Chiesense groove") of limestone nodules in a shaly matrix, located about 5 m above the base of the Buchenstein Beds	Ammonoid, FAD of <i>Eoprotrachyceras curionii</i>	Episodes 28/4, 2005
Anisian	Candidates are Desli Caira (Romania), Kçira (Albania), Wantou (Guangxi Province, S. China) and Guandao (Guizhou Province, S. China)			FAD of conodont <i>Chiosella timorensis</i> or base of magnetic normal- polarity chronozone MT1n	
Olenekian	Candidates are Chaohu, China and Mud (Muth) village, Spiti Valley, India			FAD of conodont <i>Novispathodus waageni</i> , near base of <i>Flemingites</i> ammonoid genera	
Induan	Meishan, Zhejiang Province, China	31°4'47.28"N 119°42'20.90"E	base of Bed 27c in the Meishan Section	Conodont, FAD of <i>Hindeodus parvus</i>	Episodes 24/2, 2001

* according to Google Earth



Cronostratigrafia

Base of the Induan Stage of the Triassic System at Meishan, China



Cronostratigrafia

