

**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  $\mu\text{m}$  (la maggior parte misura 150-300  $\mu\text{m}$ ).



## Distribuzione stratigrafica

Cambriano sup. - Triassico

## Composizione mineralogica

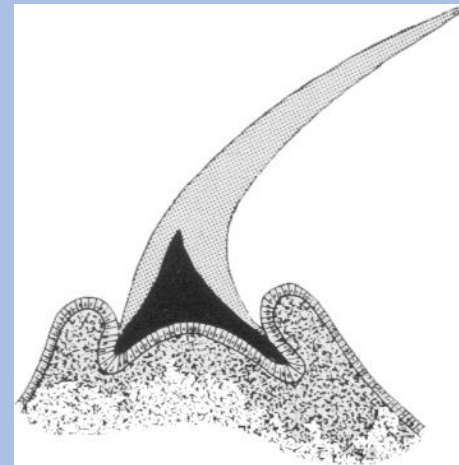
Apatite

## Struttura del dente

Cartilagine basale

Smalto

Dentina



M  
O  
R  
F  
O  
L  
O  
G  
I  
C  
H  
E  
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M  
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I

**CLASSIFICAZIONE ARTIFICIALE**

*Spathognathodus inclinatus inclinatus* (Rhodes)

*Ozarkodina media* (Walliser)

*Trichodella excavata* (Branson & Mehl)

*Neoprioniodus excavatus* (Branson & Mehl)

*Plectospathodus extensus* (Rhodes)

*Hindeodella equidentata* (Rhodes)

A  
P  
P  
A  
R  
A  
T  
O

**CLASSIFICAZIONE NATURALE**

Anteriore ↑

ELEMENTI DISCERNENTI

Sc Sc Sb Sb Sc Sc

SIMMETRIA

ELEMENTI CONTUNDENTI

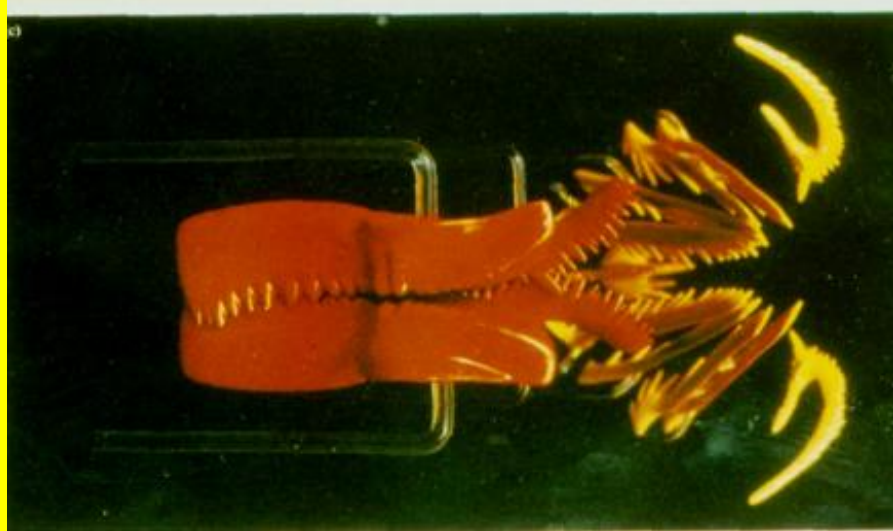
Pb Pb Pa Pa

*Wurmiella excavata* (Branson & Mehl)



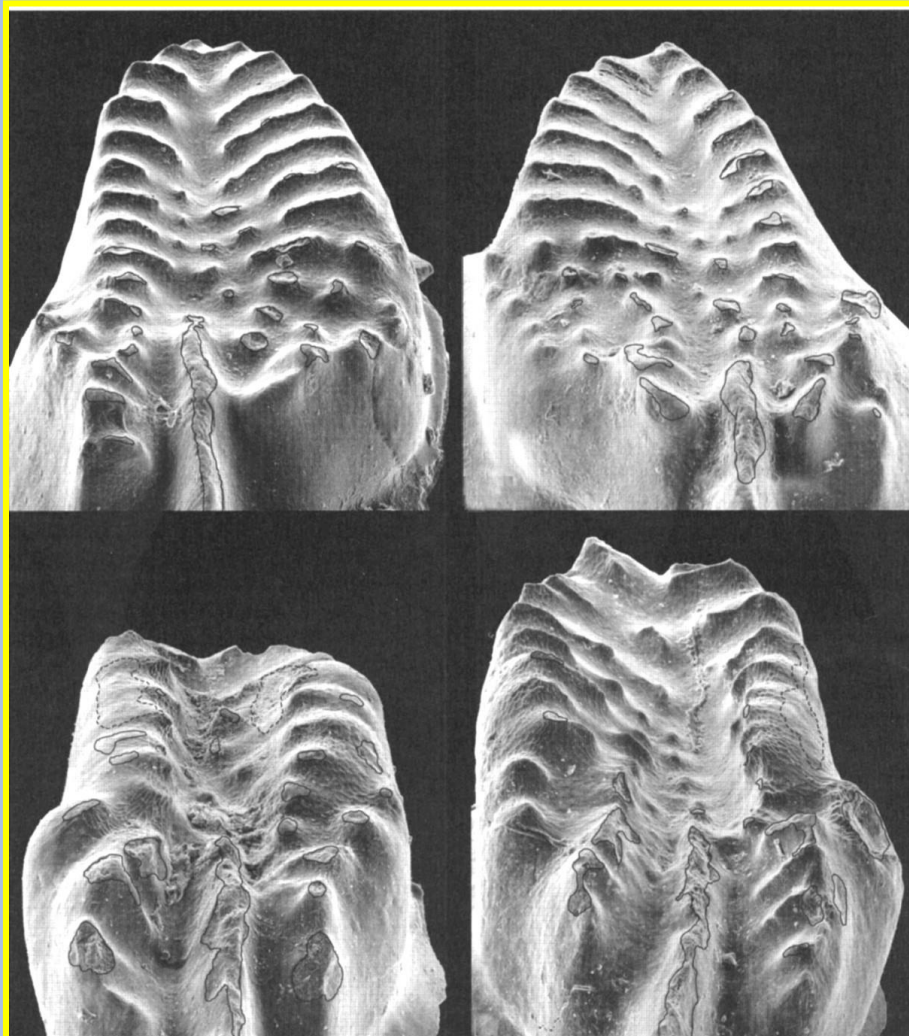


1 mm



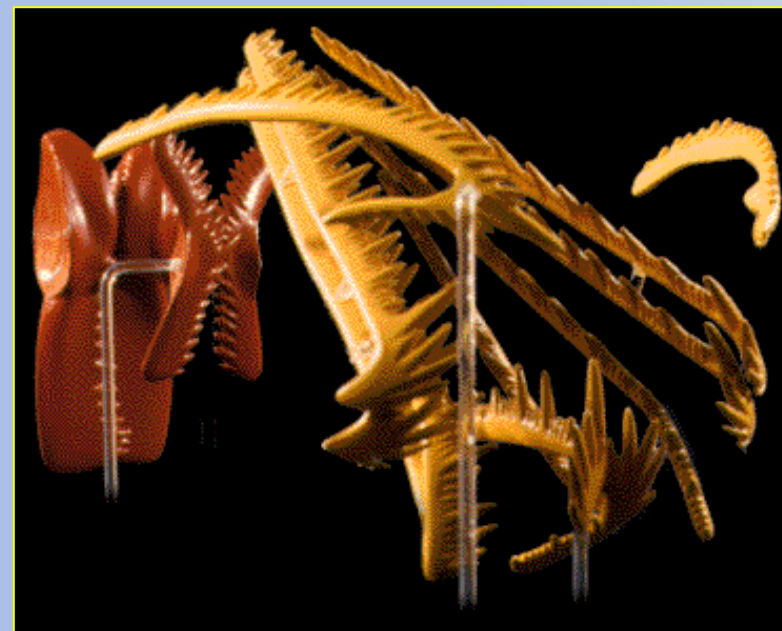
*Idiognathodus* sp.

Carbonifero sup. - USA



Purnell et al. (1998)

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



*Idiognathodus* sp.

Carbonifero sup. - USA

<b>COELENTERATA</b>	Bischoff (1973)
<b>TENTACULATA</b>	Lindström (1973), Conway Morris (1976)
<b>ARTHROPODA</b>	Harley (1861), Barrande <i>et al.</i> (1867)
<b>MOLLUSCA</b>	Owen (1861), Owen (1967), Morse (1975), Stimpson (1875), James (1894), Woodward (1898), Loomis (1936), Pilsbury (1937), Tiller & Cuif (1986)
<b>ANELLIDA</b>	Owen (1861), Owen (1967), Ulrich (1878), Zittel & Rohon (1886), Woodward (1898), Scott (1934), Dubois (1934), Rhodes (1952)
<b>ASCHELMINTHES</b>	Denham (1944), Missarzhevsky (1973), Hofker (1974)
<b>CHETOGNATHA</b>	Rietschel (1973), Szaniawski (1982)
<b>GNATHOSTOMULIDA</b>	Durden (1969), Ochielli & Cailleux (1969), Rodgers (1969)
<b>PLANTS</b>	Fahlbusch (1964), Nease (1969)
<b>CHORDATA</b>	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), ...
<b>PHYLUM INDIPENDENTE</b>	Clark (1981), Briggs <i>et al.</i> (1983), Gould (1983), Clark (1987), Sweet (1988)

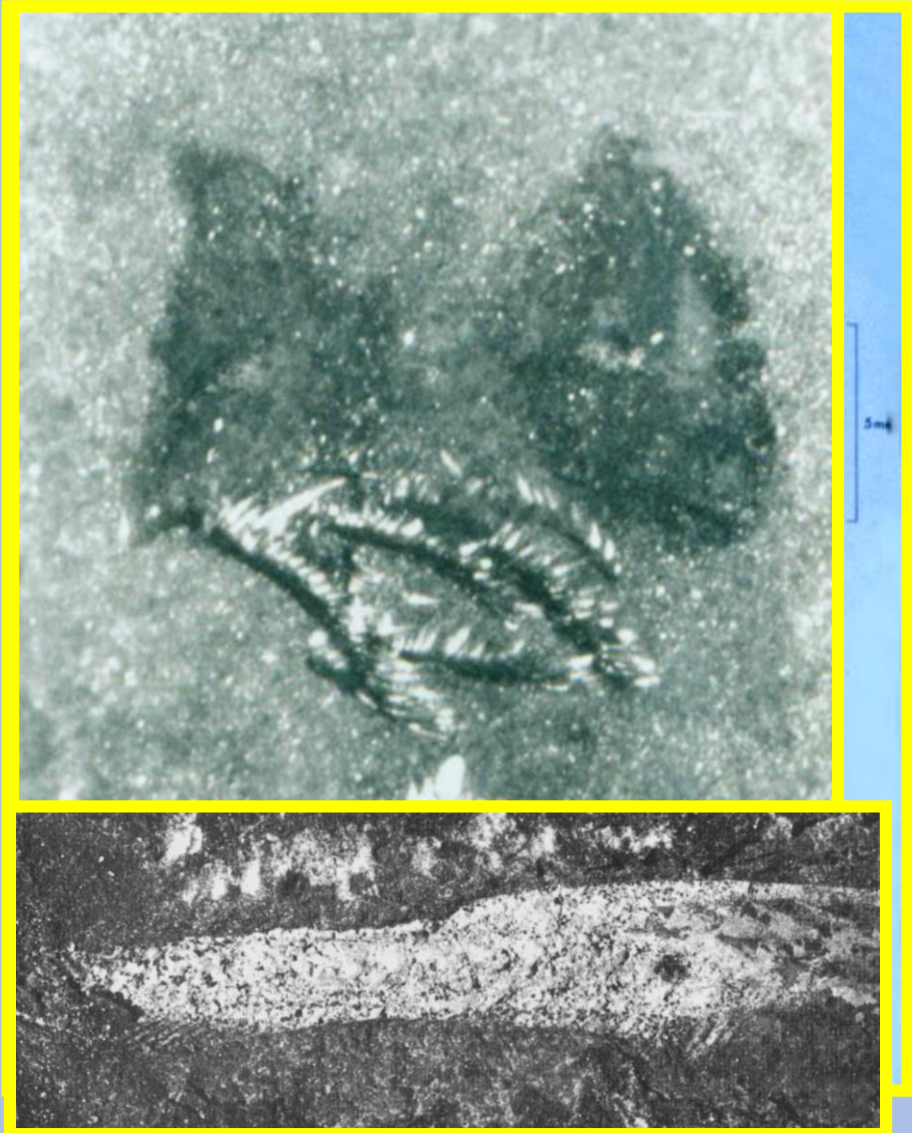
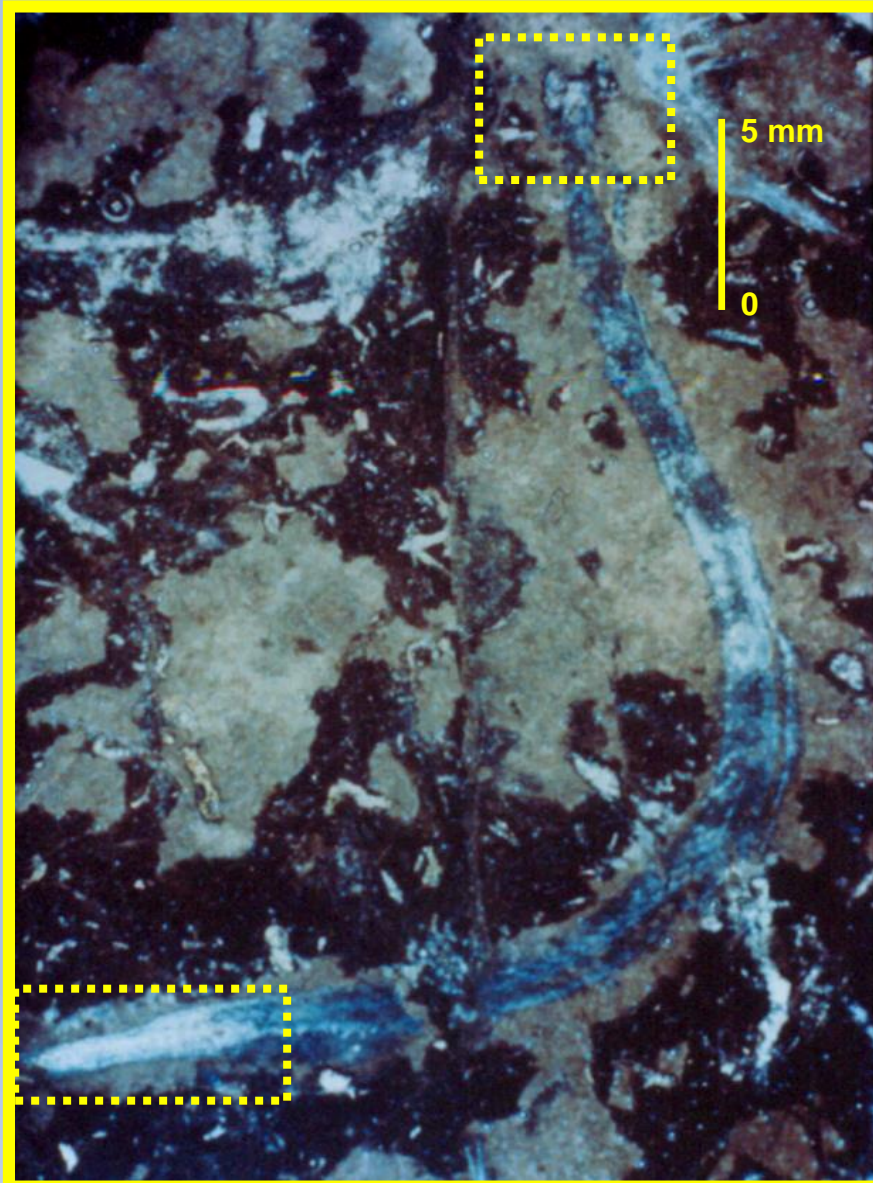




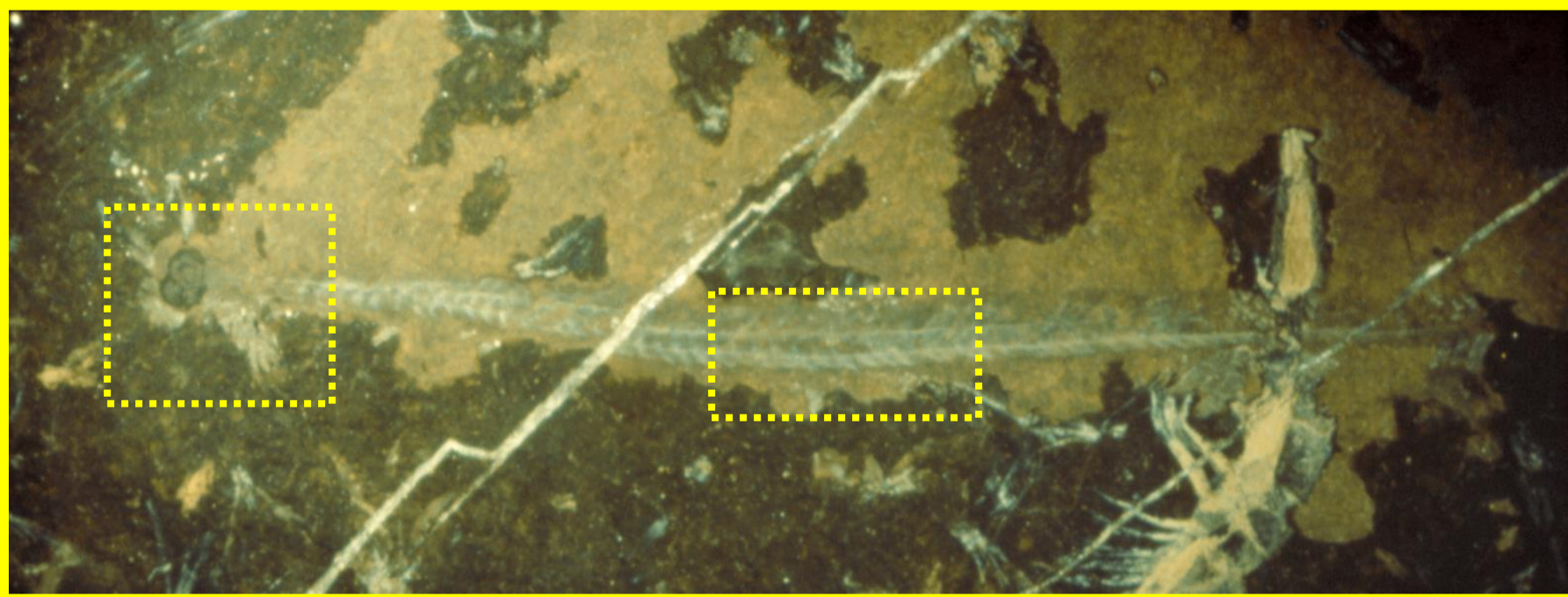


*Clydagnathus windsorensis*

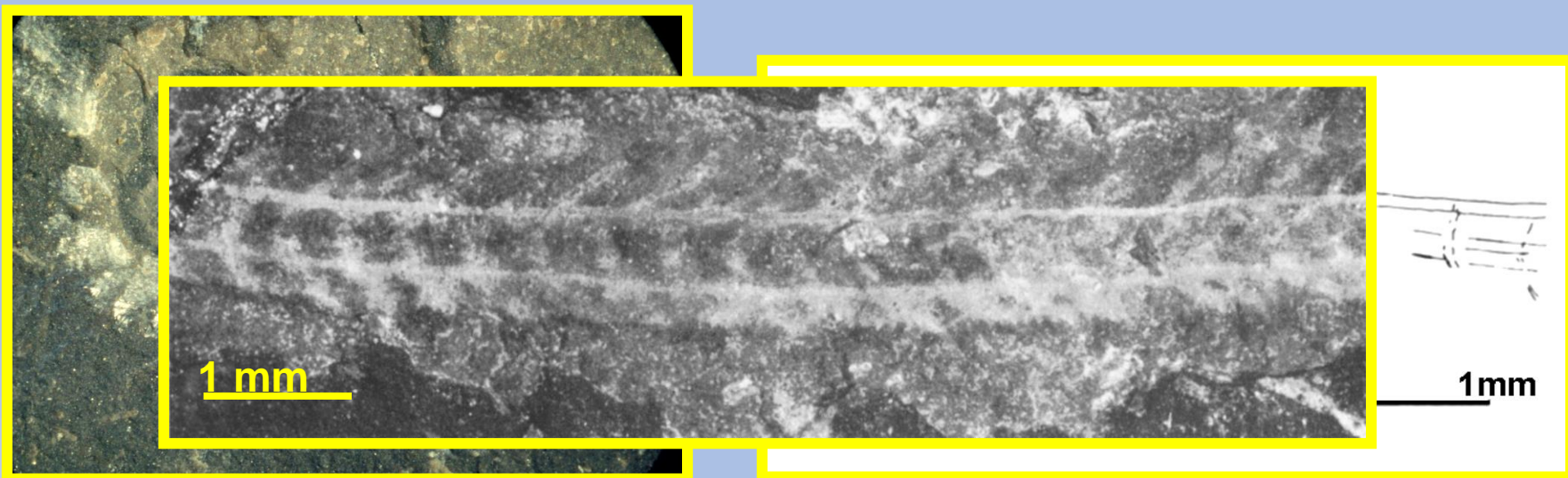
(esemplare 1) Carbonifero inf. - Scozia

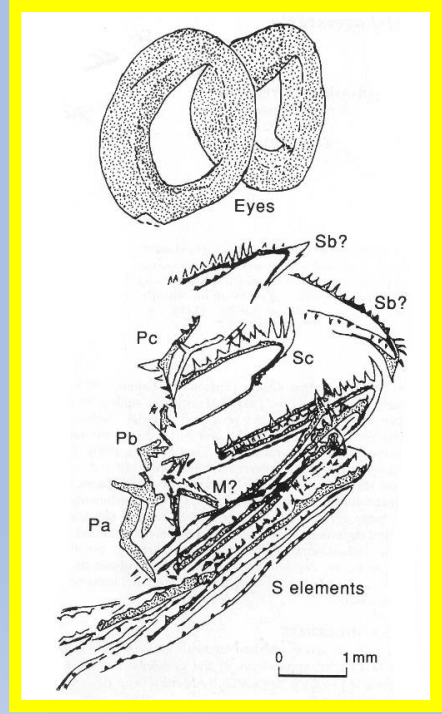
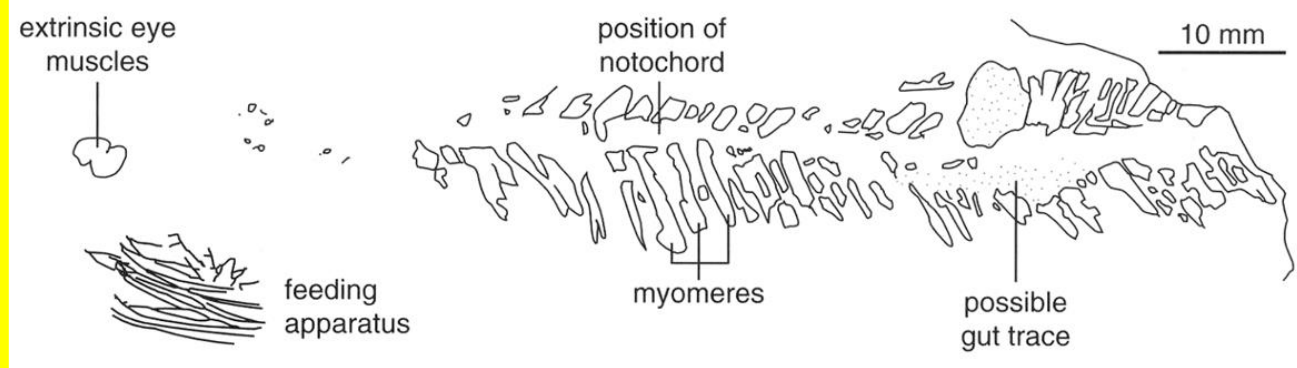
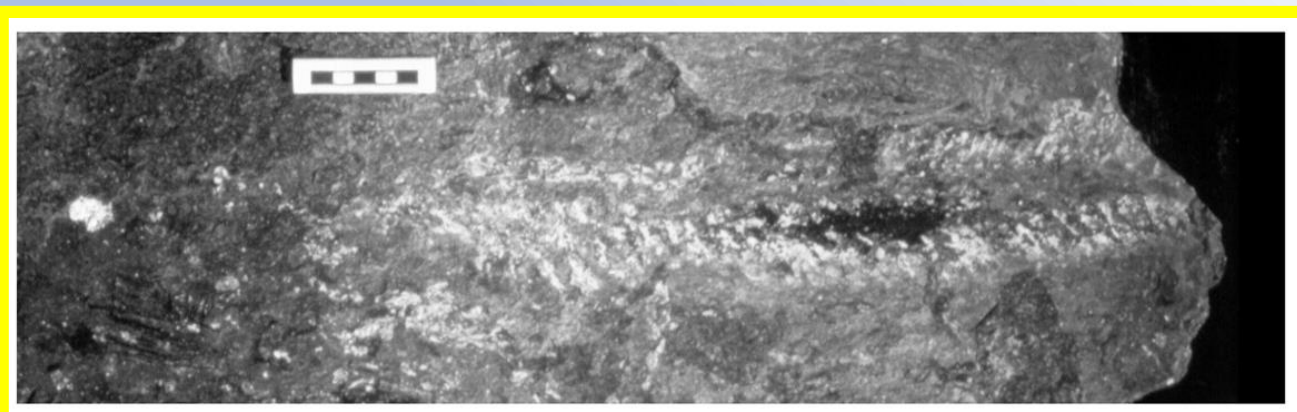






*Clydagnathus windsorensis* - (esemplare 5), Carbonifero inf. - Scozia

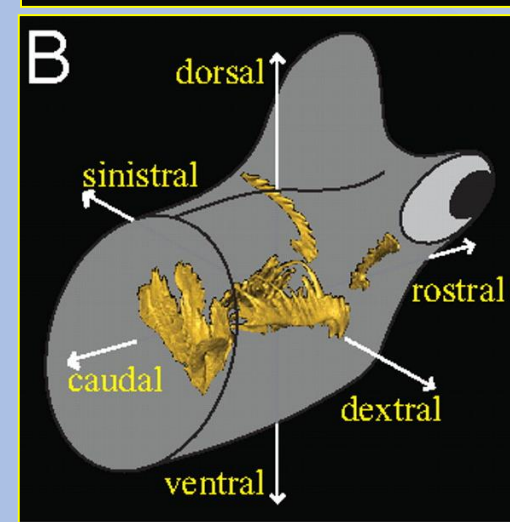
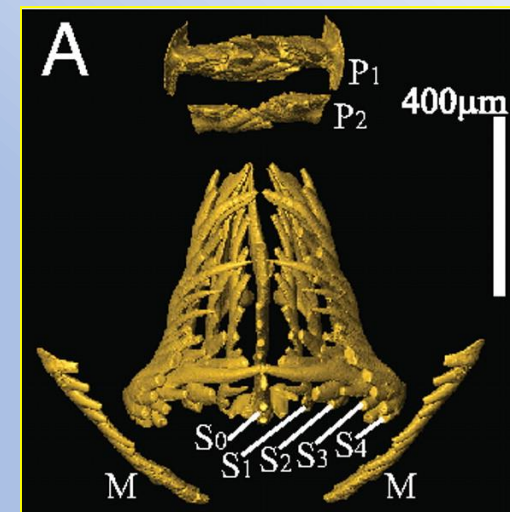




*Promissum pulchrum*  
Ordoviciano Sup.  
Sud Africa









# Caratteristiche dei conodonti sono:

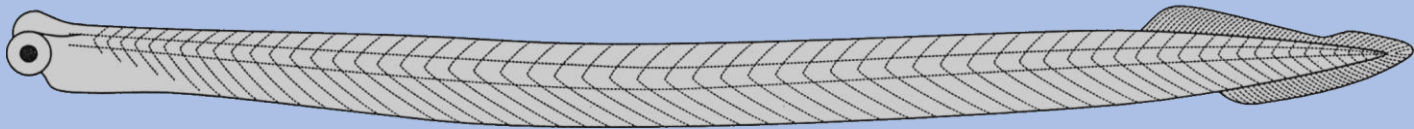
la notocorda

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)

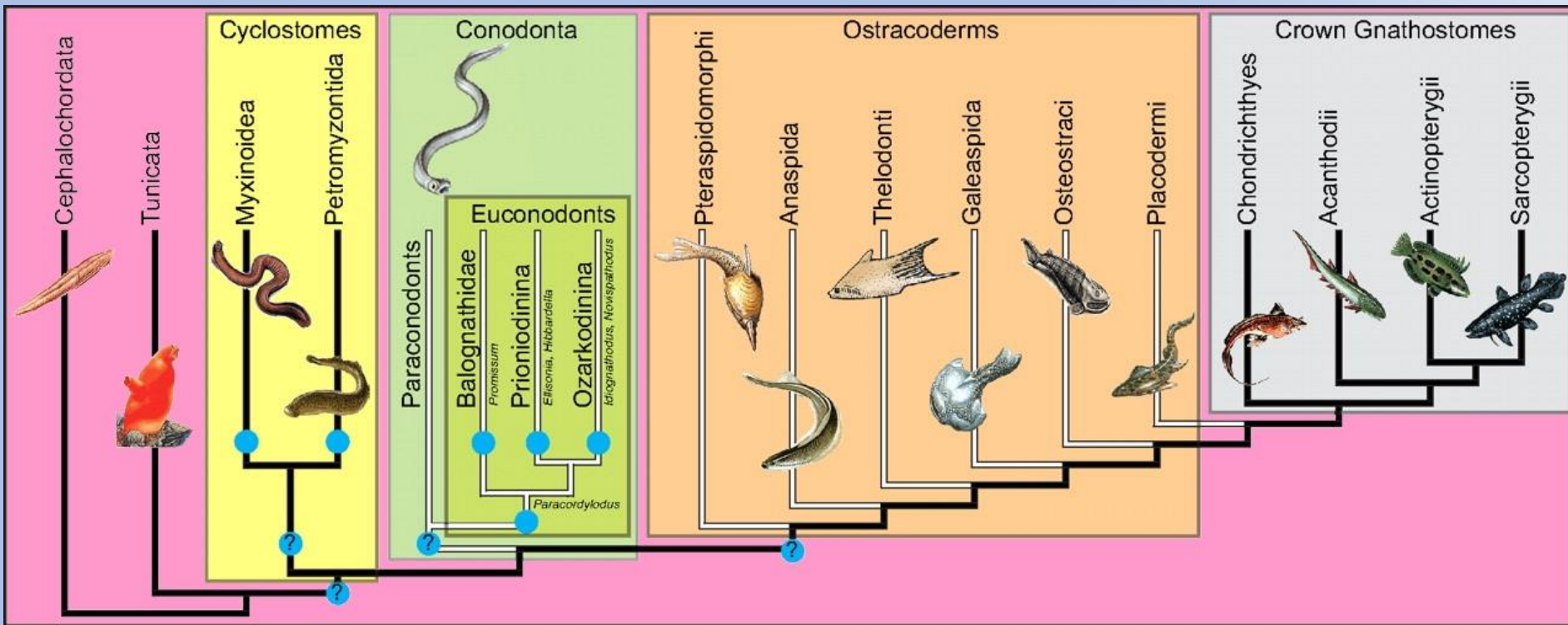
I Vertebrati si dividono in:

1. Agnati
2. Gnatostomi

Secondo la presenza o meno di mandibole e mascelle

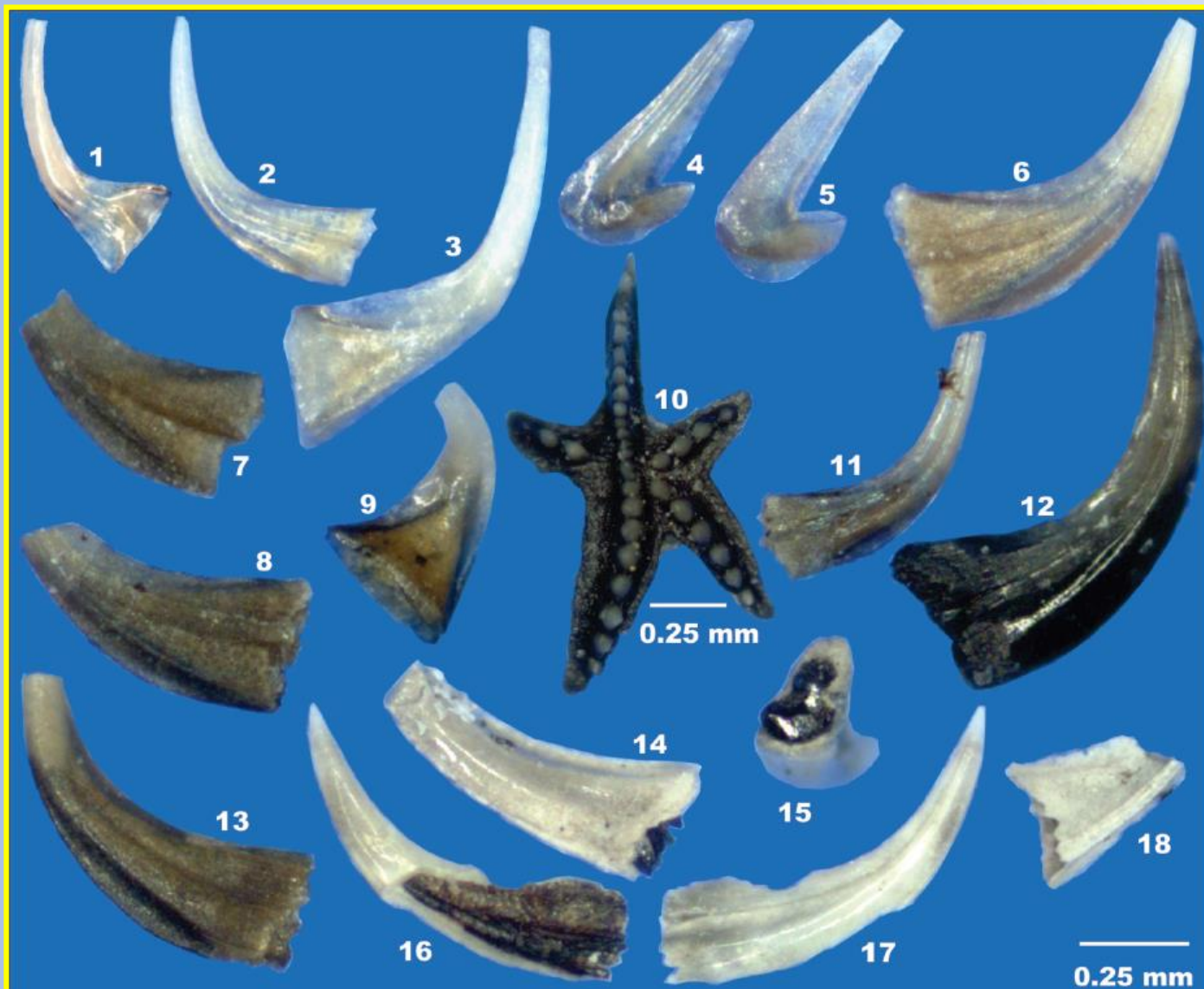
**I CONODONTI sono AGNATI**

# Filogenesi



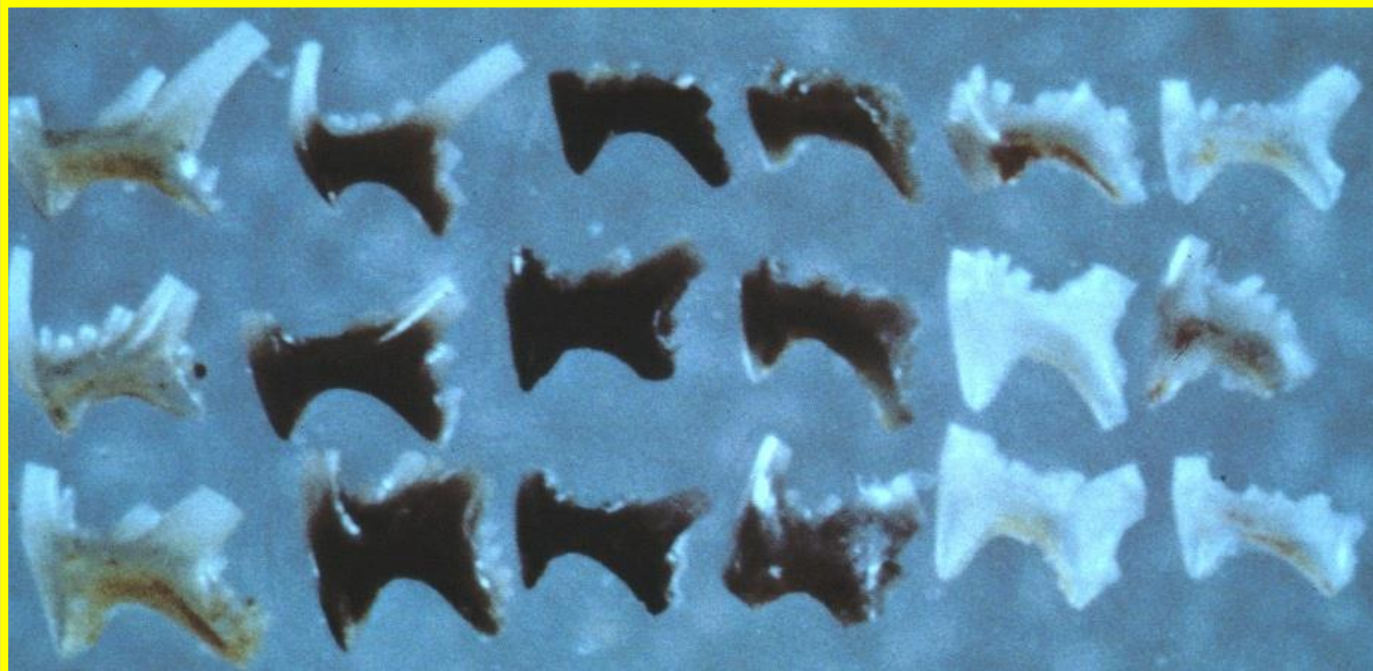
Goudemand et al. (2013)

# 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°	70% to 80%
3			110°-200°	80% to 95%
4			190°-300°	+95%
5			+300°	





# C.A.I

(Color Alteration Index)

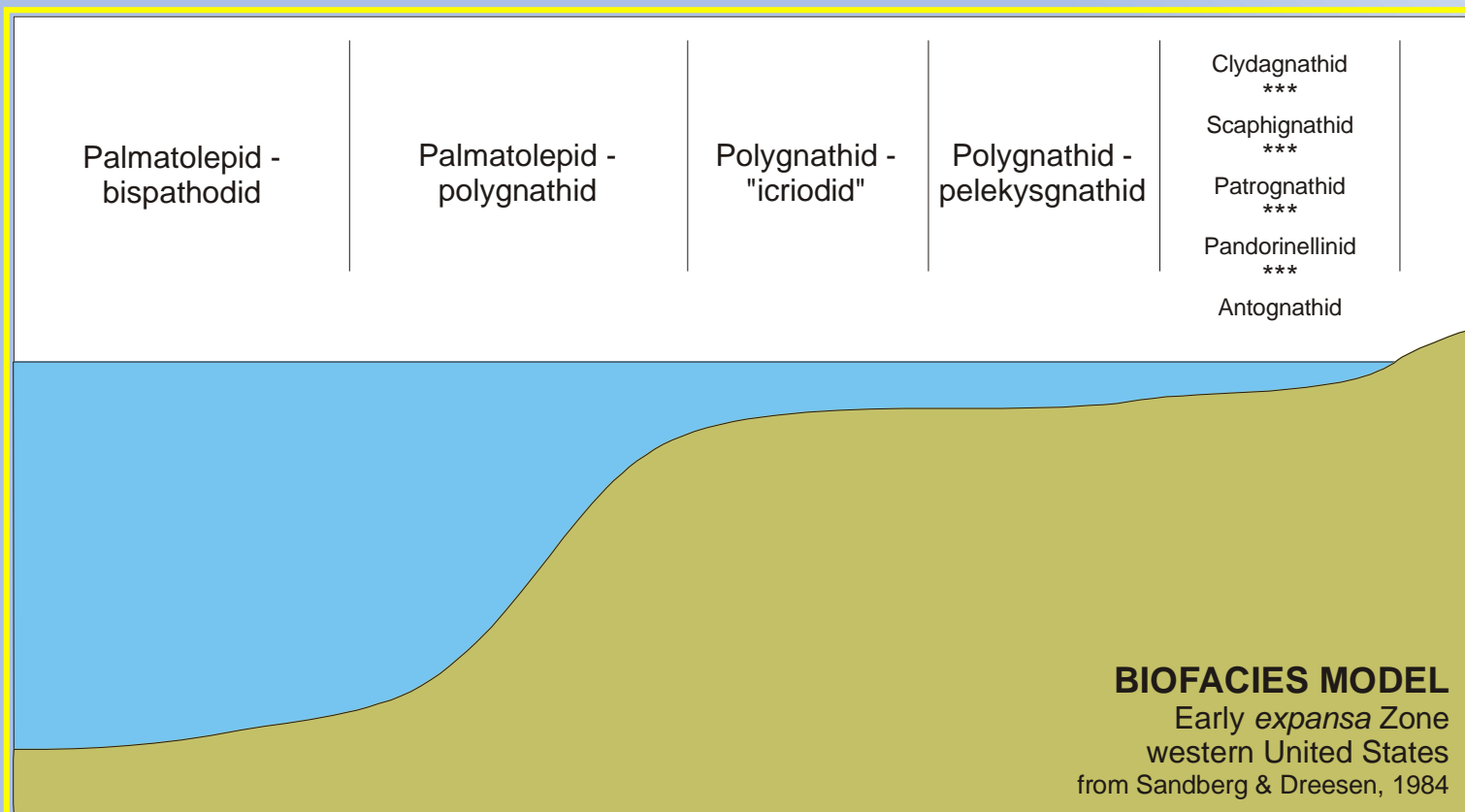
COLOR ALTERATION INDEX (CAI)	EXPERIMENTALLY INDUCED COLOR ALTERATION	NATURAL COLOR ALTERATION FROM FIELD COLLECTIONS	TEMPERATURE RANGE, °C	MUNSELL ROCK COLOR
5			300° - 480°	BLACK (N1)
6			360° - 550°	MEDIUM DARK GRAY TO MEDIUM GRAY (N4-N5)
6 1/2			440° - 610°	MEDIUM LIGHT GRAY TO LIGHT GRAY (N6-N7)
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**



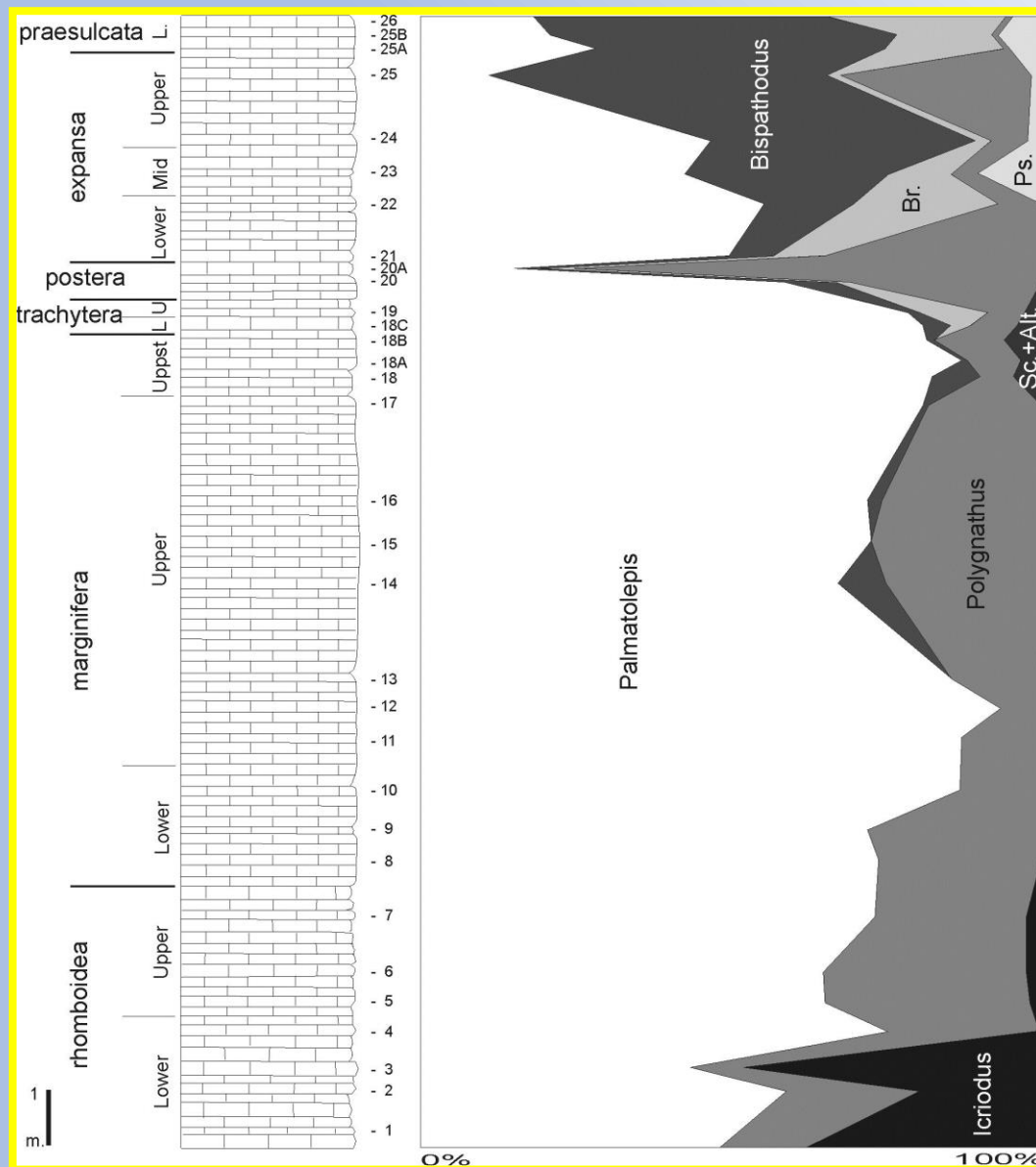
# Ricostruzioni paleoambientali



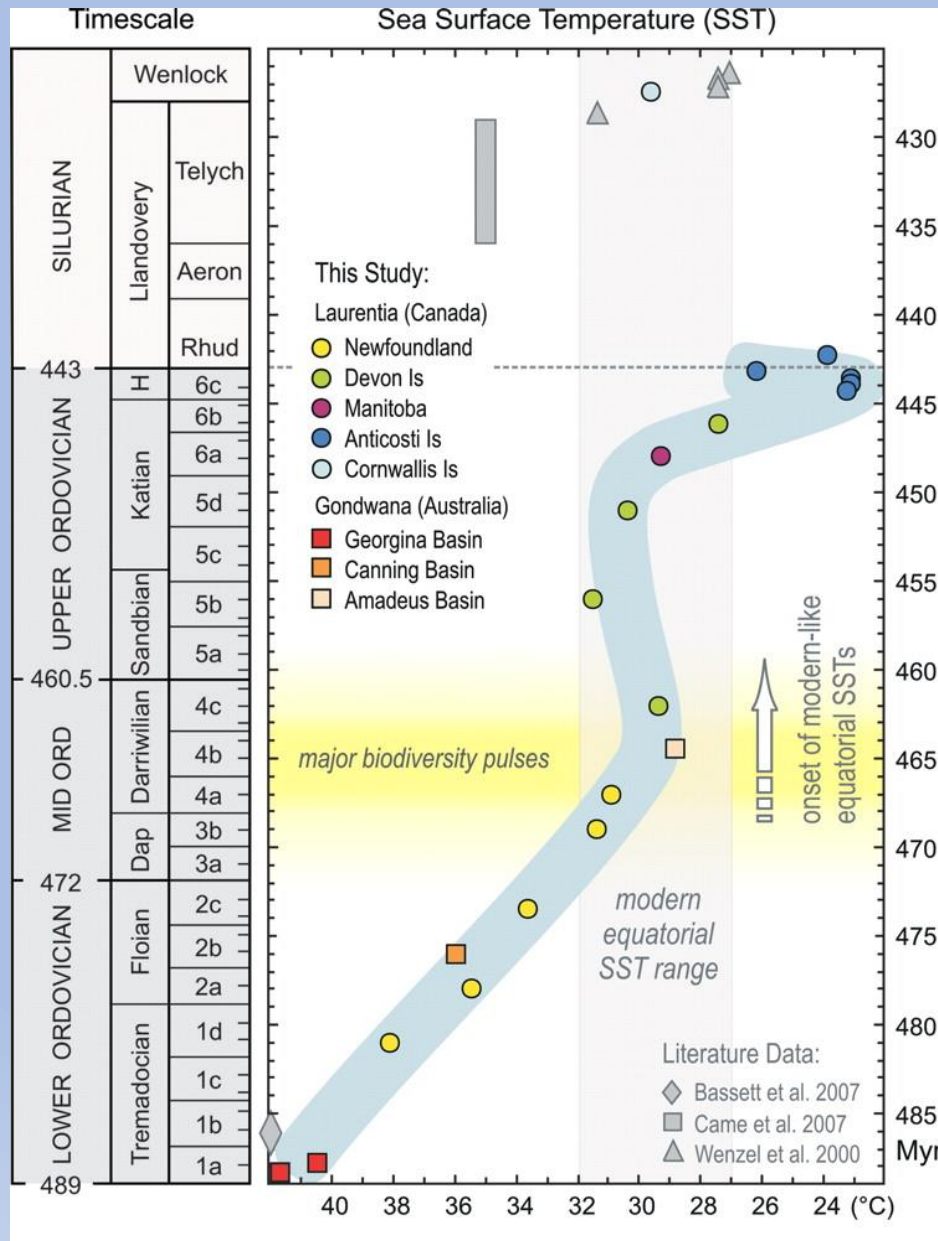
# Ricostruzioni paleoambientali

## Sezione Corona Mizziu I

Devoniano Sup. – Sardegna



# Ricostruzioni paleoclimatiche



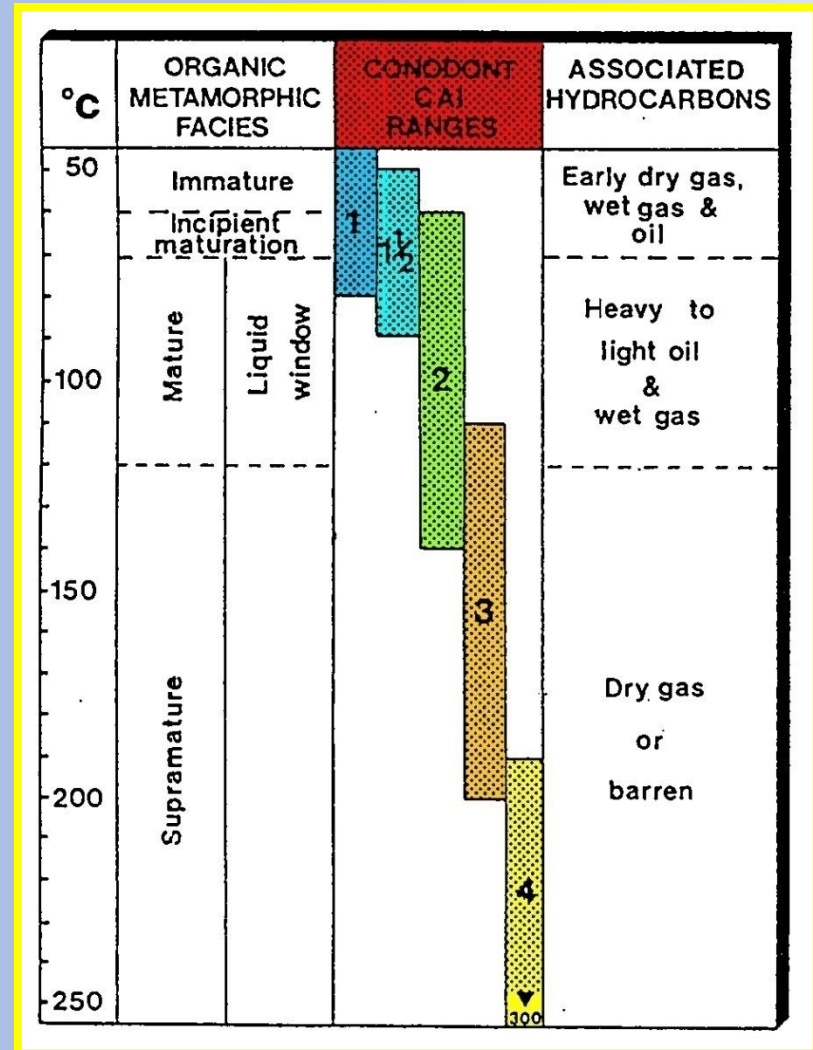
Curva delle temperature del mare durante l'Ordoviciano basata su  $\delta^{18}\text{O}$  misurato nei conodonti

# 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.

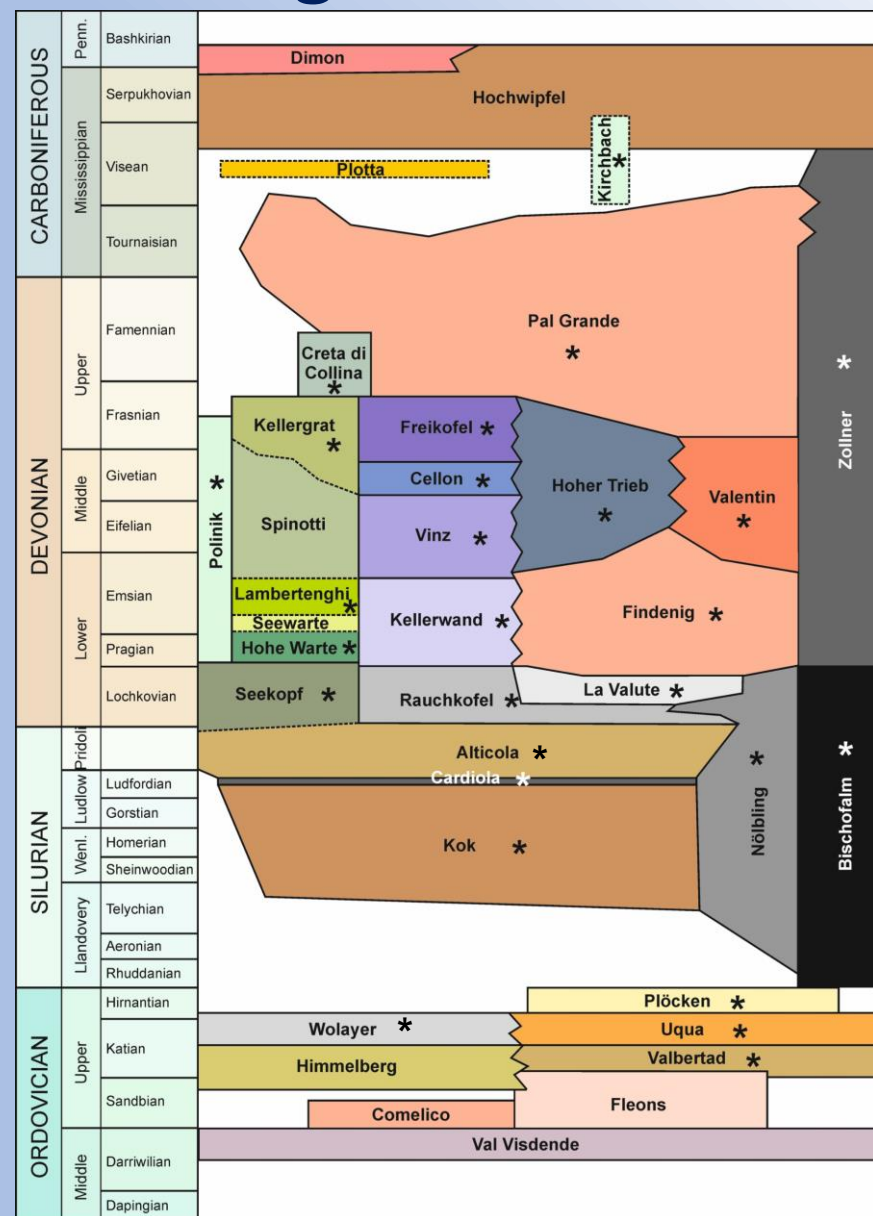
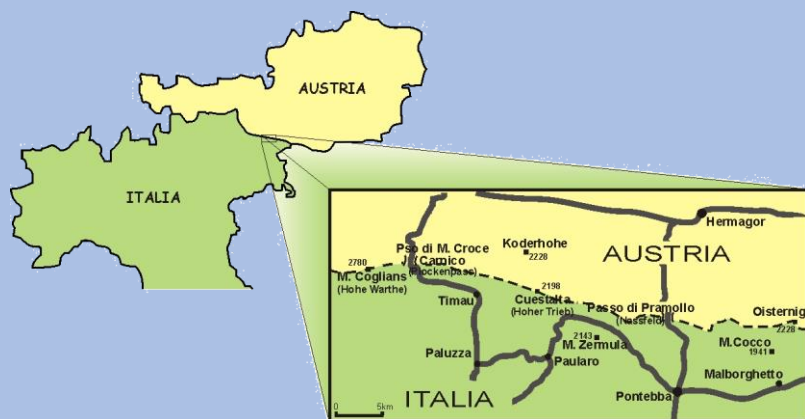
**Identificare effetti tettonici locali,** che hanno provocato flussi di calore (grandi sovrascorrimenti o rifting).



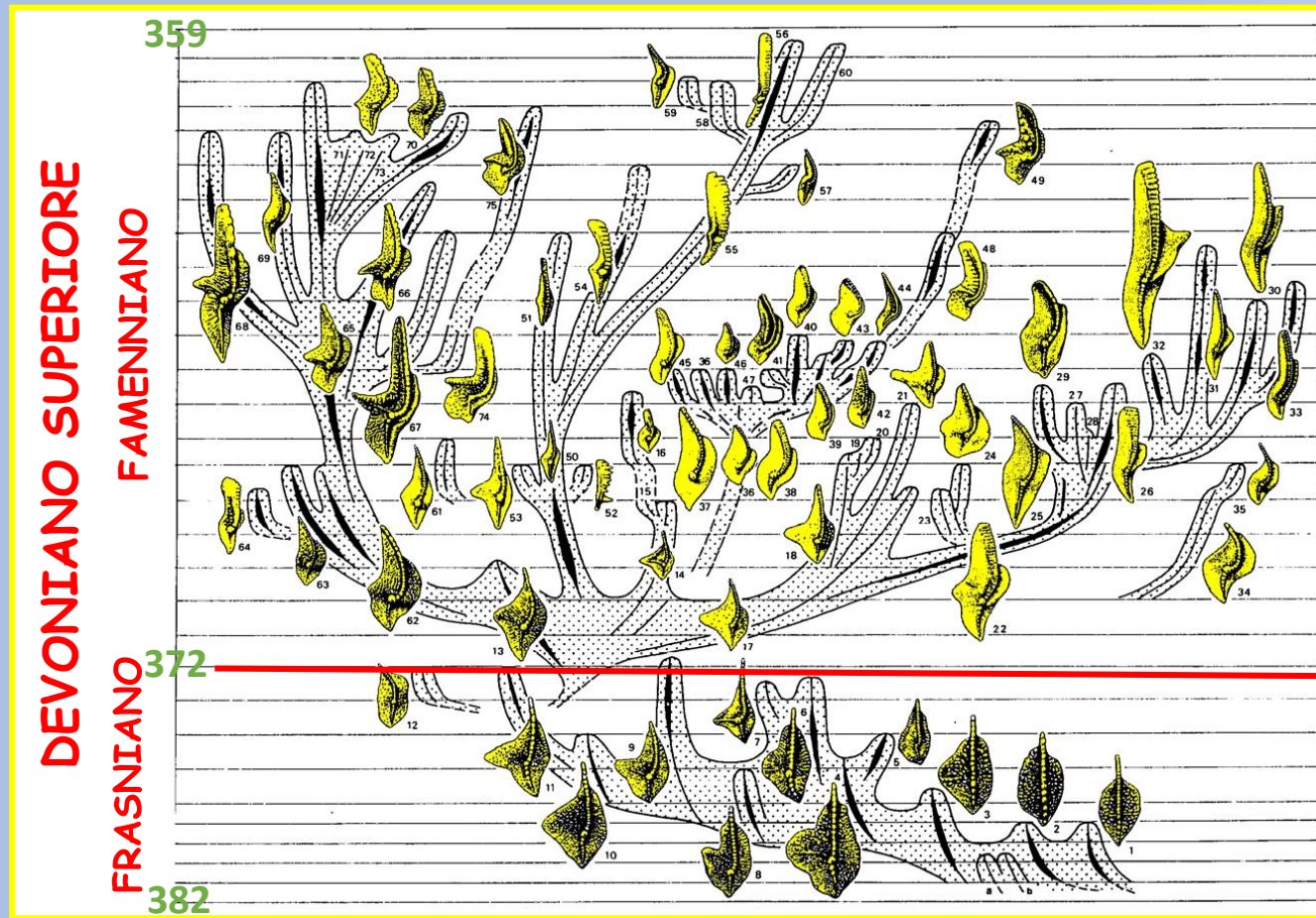


# Contributo alla Litostratigrafia

## 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>Urcinatograptus uniformis</i>	<i>Caudicriodus hesperius</i>	<i>Eisenackitina bohemica</i> Interval Range Biozone		<i>Trimerolepis timanica</i>
420		Pridoli	Pr2	<i>Istrograptus transrediens</i> / <i>"M". perneri</i>	<i>Oulodus elegans detortus</i>	<i>Angochitina superba</i>	not zoned
421	<i>"Monograptus" bouceki</i>			Ozarkodina eosteinhornensis s.l. Interval Zone	<i>Margachitina elegans</i>	<i>Synorisporites tripapillatus-Apiculiretusispora spicula</i>	<i>Nostolepis gracilis</i>
422	Pr1	<i>Neocolonograptus lochkovensii</i> / <i>N. branikensis</i>	<i>Fungochitina kosovensis</i>				<i>Thelodus admirabilis</i>
423		<i>Neocolo. ultimus</i> / <i>N. parultimus</i>	<i>Formosograptus formosus</i>	<i>Ozarkodina crispata</i>	<i>Eisenackitina barrandei</i>	<i>Thelodus sculptilis</i>	
424	Ludfordian	Lu3	<i>Neocucullogr. kozlowski</i> / <i>Polonogr. podoliensis</i> Zone	<i>Pedavis latialata</i> / <i>Ozarkodina snajdri</i> Interval Zone	<i>Eisenackitina phillipi</i>	<i>Lophozonotriletes? poecilomorphus - Synorisporites libycus</i>	<i>Andreolepis hedei</i>
425		Lu2	<i>Bohemograptus</i>	<i>Polygnathoides siluricus</i>	<i>Angochitina elongata</i>		<i>Phlebolepis elegans</i>
426	Gorstian	Lu1	<i>Saetograptus leintwardinensis</i>	<i>Ancoradella ploeckensis</i>			<i>Phlebolepis ornata</i>
427		Go2	<i>Lobograptus scanicus</i>	<i>Kockelella variabilis</i> Interval Zone	not zoned	<i>Sclya. downiei - Concen. sagittarius</i>	
428	Homerian	Go1	<i>Neodiversogr. nilsoni</i>	<i>Kockelella crassa</i>			<i>Paraloganella martinsoni</i>
429		Ho3	<i>Colonograptus ludensis</i>	<i>Kockelella ortus absidata</i>	<i>Sphaerochitina lycoperdoides</i>	<i>Artemopyra brevicostata-Hispanaediscus verrucatus</i>	
430	Ho2	<i>Colonograptus? deubeli</i> / <i>C? praedeubeli</i>	<i>Gothograptus nassa</i> / <i>Pristiograptus parvus</i>	<i>Ozarkodina bohemica longa</i>	<i>Conochitina pachycephala</i>		
431	Sheinwoodian	Ho1	<i>Cyrtograptus lundgreni</i>	<i>Ozarkodina sagitta sagitta</i>			<i>Loganella einari</i>
432		Sh3	<i>Cyrtogr. rigidus</i> / <i>Monogr. antennularius</i> / <i>M. belophorus</i>	<i>Kockelella amsdeni</i> / <i>K. walliseri</i> SuperZone	<i>Archaeozonotriletes chulus nanus - Archaeozonotriletes chulus chulus</i>	<i>Overia adraini</i>	
433		Sh2		<i>Ozarkodina sagitta rhenana</i>	<i>Cingulochitina cingulata</i>	<i>Loganella grossi</i> <i>Archipelepis bifurcata</i> / <i>Arch. turbinata</i>	



# Cronostratigrafia



**CONODONTI**    **AMMONIODI**  
**GRAPTOLITI**    **FORAMINIFERI**  
**TRILOBITI**



# 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 Cair (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

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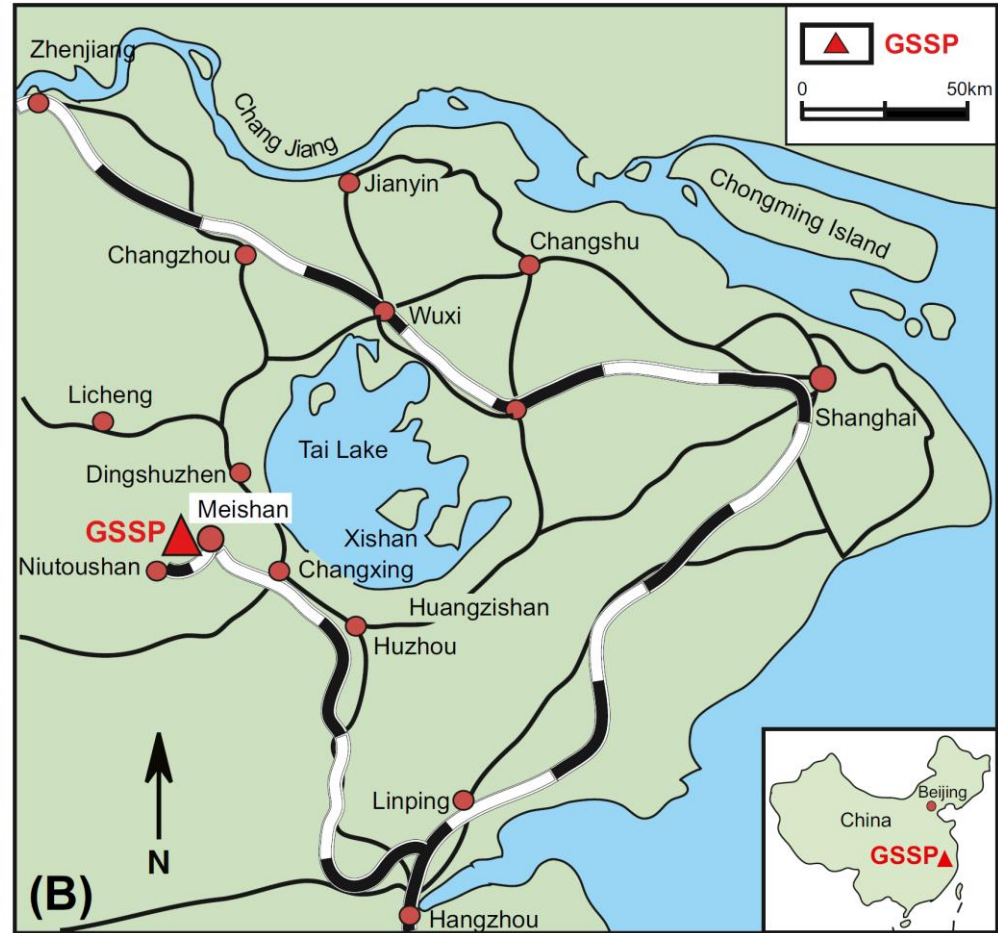
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# Cronostratigrafia

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





# Cronostratigrafia

