
The Subcommittee on Cambrian Stratigraphy: the status quo

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BRIEF HISTORY

Following proposals accepted at the Norden International Geological Congress (IGC) at Copenhagen in 1960, the Subcommittee on Cambrian Stratigraphy (SCS) was established in 1961 with the late Sir James Stubblefield as founding Chairman. One of the initial tasks of the Subcommittee was to define the Precambrian-Cambrian boundary. Accordingly, a Working Group on the Precambrian-Cambrian Boundary, with John Cowie as Chairman, was formed at the Canadian IGC (Montreal) in 1972. This WG, whose primary task was to select a Global Stratotype Section and Boundary Point (GSSP), held 23 field meetings between 1973-1990 in France, Siberia, Australia, China, USA, Canada, England, Sweden, Morocco, Portugal and Spain. During that period, this WG, augmented by International Geological Correlation Projects 29 and 303, generated a huge amount of biostratigraphic, magnetostratigraphic, chemostratigraphic and chronometric information, largely summarized by Cowie and Brasier (1989). A GSSP for the base of the Cambrian was finally ratified in 1992 at the base of the *Trichophycus pedum* (= *Phycodes pedum*) Zone at the Fortune Head, on the Burin Peninsula, southeastern Newfoundland (Cowie, 1992; Landing, 1992, 1998).

To tackle the upper boundary of the Cambrian System, a Working Group on the Cambrian-Ordovician Boundary (COBWG I) was established in 1974, and regrouped as COBWG II in 1993. This WG also generated a volumi-

nous quantity of multidisciplinary stratigraphic information as a result of visiting candidate GSSPs in Australia, Kazakhstan, China, Scandinavia, UK, Canada and USA. A proposed GSSP for the base of the Ordovician System, hence top of the Cambrian, is at Green Point, in the lower Broom Point Member of the Green Point Formation, at the first appearance of the conodont *Iapetognathus fluctivagus* NICOLL, MILLER, NOWLAN, REPETSKI and ETHINGTON, 1999 (Cooper and Nowlan, 1999). This proposal has been endorsed by the Subcommittee on Ordovician Stratigraphy, the Bureau of the Commission on Stratigraphy, and has been ratified by the International Union of Geological Sciences.

In the 1970s the International Subcommittee on Cambrian Stratigraphy temporarily established Working Groups on the Lower-Middle and Middle-Upper Cambrian boundaries. However, these WGs were not able to develop sufficient dynamics to overcome the enormous problems arising from regionally different stratigraphic philosophies, simple deficiencies of knowledge, and lack of interest during these times.

Other Working Groups currently operating in SCS include the Cambrian Correlations WG, and the Cambrian Stage Subdivision WG, which includes the Cambrian Global Subdivision Project (CGSP). Correlation Charts and Explanatory Notes have been already published for The Near and Middle East (IUGS Publication 15, 1983), Australia, New Zealand and Antarctica (IUGS Publication

KAZAKHSTAN				NORTH CHINA			SOUTH CHINA			AUSTRALIA			LAURENTIA				
ORDOV.	UNGUIRIAN			ORD.	XINCHANGIAN				ORD.				ORDOVICIAN				
	Cordylodus caseyi Cordylodus prion C. oklahomensis Cordylodus proavus																Dikelocephalina Euloma limitaris - Taoyuania
UPPER CAMBRIAN	BATYR-BAIAN		Lotagnostus hedini	UPPER CAMBRIAN	FENGSHANIAN			UPPER CAMBRIAN	HUNANIAN	TAOYUANIAN			UPPER CAMBRIAN	MILLARDAN	SUNWAPTAN		
	AKSAYAN				Mictosaukia Sinoeremoceras Quadratricephalus Proconodontus postero-costatus Ptychaspis-Tsinania Proconod. tenuiserratus					Mictosaukia striata - Fatocephalus Archeuloma taoyuanense - Leignostus cf. bexelli Lotagnostus punctatus - Hedinaspis regalis Probinacunaspis nasalis - Onchonotellus Eolotagnostus decorus - Kaolishaniella					Saukiella junia Saukiella pyrene-Rasettia maga		
	SAKIAN		Kaolishania pustulosa Shirakiella xiaoshiensis Maladioidella splendens Changshania conicalvingella taizhuoensis			Rhaptnagnostus ciliensis - Onchonotellus cf. kuruktagensis Agnostotes clavata - Irvingella angustilimbata				Sauiella							
	ARYUSOK-KANIAN		Drepanura premesnili Blackwelderia paronai			Corynexochus plumula-Sinop. cf. khangshansis Innitagnostus inexpectans Proceratopyge protracta Glyptagnostus reticulatus Glyptagnostus stolidotus Linguagnostus reconditus Proagnostus bulbus				Sauiella							
MIDDLE CAMBRIAN	ZYAN-RYKIAN		Lejopyge laevigata	MIDDLE CAMBRIAN	CHANGHSIAN			MIDDLE CAMBRIAN	WULINGIAN	WANGCUNIAN			MIDDLE CAMBRIAN	LATE TEMPLETONIAN/ FLORAN	MARJUMAN		
	TYESAIAN				Damesella/Yabeia Leiopaishania					Lejopyge laevigata					Lejopyge laevigata		
	"LENAN"		Taitzuia/Poshania Amphoton			Goniagnostus nathorsti Ptychagnostus punctuosus				Goniagnostus nathorsti Ptychagnostus punctuosus							
	MAOCHUANGIAN		Crepicephalina			Oryctocephalus indicus				Ptychagnostus gibbus							
LOWER CAMBRIAN	TSANGLANG-PUJAN		Megapalaeolenus	LOWER CAMBRIAN	MAOCHUANGIAN			LOWER CAMBRIAN	QIANGDONGIAN	DUYUNIAN			LOWER CAMBRIAN	EARLY TEMPLETONIAN	DELAMARAN		
	CHUANG-CHUSSUAN				Shantungaspis Yaojayuella					Bathynotus Protoryctocephalus					Pararaia janeae Pararaia bunyeroensis Pararaia tatei		
	"MEISHUCUNIAN"		Qiaotouaspis			Arthrocephalites - Changaspis Arthrocephalus Sichuanolenus - Chengkouia				"Abadiella" huoi							
	CHUANG-CHUSSUAN		Redlichia nobilis Redlichia chinensis			Hupediscus-Sinodiscus Sinosachites - Lapworthella				"Nevadella"							
LOWER CAMBRIAN	TSANGLANG-PUJAN		no zones established	LOWER CAMBRIAN	NANGAOIAN			LOWER CAMBRIAN	DIANDONGIAN	MEISHUCUNIAN			LOWER CAMBRIAN	WUOCOBAN	MONTEZUMAN		
	CHUANG-CHUSSUAN				? ? ?					? ? ?					"Fallotaspsis"		
	CHUANG-CHUSSUAN		? ? ?			? ? ?				? ? ?							
	CHUANG-CHUSSUAN		? ? ?			? ? ?				? ? ?							
LOWER CAMBRIAN	CHUANG-CHUSSUAN		no zones established	LOWER CAMBRIAN	JINNINGIAN			LOWER CAMBRIAN	DIANDONGIAN	MEISHUCUNIAN			LOWER CAMBRIAN	WUOCOBAN	MONTEZUMAN		
	CHUANG-CHUSSUAN				Anabarites - Circotheca					Paragloborilus - Siphonouchites					"Wyattia"		
	CHUANG-CHUSSUAN		? ? ?			? ? ?				? ? ?							
	CHUANG-CHUSSUAN		? ? ?			? ? ?				? ? ?							

CORRELATION CHART FOR MAJOR CAMBRIAN AREAS, by G. Geyer, S. Peng and J. H. Shergold for ISCS (revised version, 2001)

19, 1985), Eastern Asia (IUGS Publication 24, 1988), East European Platform (IUGS Publication 25, 1990), Siberian Platform (IUGS Publication 27, 1991), and The Foldbelts of Russia and Mongolia (IUGS Publication 32, 1995). In preparation are Charts for the Mediterranean Region and Central Europe, Avalonia, Laurentia and Central Asia.

The rationale of the Stage Subdivision WG is to visit areas where important recent work has been conducted on stages which may be pertinent to the Cambrian Global Subdivision Project, the current main task of SCS. Field meetings have been organized in Morocco (Geyer and Landing, 1995), Iberia (1996, see Special Issue of *Revista Española de Paleontología*, December 1998), Avalon (1997, see Landing and Westrop, 1998), Sweden (Ahlberg, 1998), The Great Basin, USA (Palmer, 1999), Argentina (Aceñolaza and Peralta, 2000), Hunan and Guizhou Provinces in China (Peng et al., 2001), and The Montagne Noire, France (Álvaro and Clausen, 2002).

The Cambrian Global Subdivision Project is inspired by the need to establish an internationally agreed left-hand column for global correlations. We need to decide how many Cambrian Series are most appropriate and what are the most potentially useful biohorizons for the correlation of disparate Cambrian terranes. To accelerate the progress of this mission, a comprehensive correlation table has been assembled by Geyer, Peng and Shergold and was presented at the Swedish field meeting. Additionally, Shergold and Geyer (1998) and Geyer and Shergold (2000) have reviewed potential correlation levels with explanatory remarks. Reviewed biohorizons include the lowest occurrences of *Cordylodus proavus*, *Irvingella* with *Agnostotes*, *Glyptagnostus reticulatus*, *Glyptagnostus stolidotus*, *Linguagnostus reconditus*, *Lejopyge laevigata*, *Ptychagnostus punctuosus*, *Acidusus atavus*, *Triplagnostus gibbus*, *Eliasum-Cristallinum* assemblage, *Oryctocephalus indicus*, the base of the *Protolenus-Hamatoenus-Cobboldites-Oryctocara* band, the base of the *Hebediscus attleboensis-Calodiscus-Serrodiscus-Triangulaspis* band, at the first occurrence of trilobites. While it is possible to obtain quite detailed correlation levels in the Middle and Upper Cambrian, we acknowledge the difficulties in subdividing the Lower Cambrian biostratigraphically (e.g. Palmer, 1998), especially using trilobites as indices. Other biological groups will need to be investigated in detail, and it will be necessary to calibrate the biostratigraphy using isotope profiles based on carbon, oxygen, strontium and sulphur, and magnetostratigraphy.

Besides these WG activities, there have been three international symposia on the Cambrian System. The first of these was held in conjunction with the 20th International Geological Congress in Mexico in 1956. The second was held in Golden, Colorado in 1981, and the third in Novosibirsk in 1993. A fourth is currently being discussed for China in 2004.

FUTURE TASKS AND RECENT DEVELOPMENTS

The major future task, demanded by the International Commission on Stratigraphy, is to establish GSSPs for internationally agreed Cambrian Stages. Currently, the Cambrian and Carboniferous Systems lack defined GSSPs internally. Response for polled Voting Members of the SCS, suggest that there is majority support for defining the first Cambrian GSSP at the level of *Glyptagnostus reticulatus*. It is therefore necessary to commence assessment of suitable sections. According on the Guidelines for the establishment of GSSPs (Remane et al., 1996), geological requirements to be satisfied include exposure over an adequate thickness, continuous sedimentation, sufficiently rapid sedimentation rate, absence of metamorphism and diagenesis. Biological requirements are for abundance and diversity of well preserved fossils, absence of vertical facies changes and favourable facies for long-range correlation. Other desirable requirements are suitability for radioisotope dating, magnetostratigraphy, chemostratigraphy and sequence stratigraphy, by a permanently fixed marker, avoidance of very remote locations, free access by researchers regardless of nationality, free access for research and permanent site protection. Ideally, then, undeformed carbonate sections are required, which rules out sections in Baltic for example, but favours sections in Siberia, south-central China and western Queensland, Australia.

An examination of potential GSSPs took place during the field excursions of the *China 2001* conference, when the occurrence of *Glyptagnostus reticulatus* and the rock successions were studied in Hunan, accompanied with examination of various aspects critical for the value of these sections for international correlation. The scientific session offered contribution to the *G. reticulatus* level issue. Coupled with South China 2001 were field activities of the Working Group on a *Glyptagnostus reticulatus* level GSSP.

Discussions during the *South China 2001* conference showed that only the Hunan sections and the sections in the Maly Karatau were generally regarded as suitable for a GSSP. A multi-person team performed additional studies in the Paibi section, Hunan, and submitted a formal proposal for a GSSP in this section to the *International Subcommittee on Cambrian Stratigraphy* by January 2002.

This "Proposed Global Standard Stratotype-Section and Point for the Paibian Stage and Furongian Series" recommended the base of the first calcilutite layer containing the cosmopolitan agnostoid trilobite *Glyptagnostus reticulatus* in the Huaqiao Formation in the Paibi section (Peng et al., 2001a) as the base of a newly established **Paibian Stage** and of the equally new **Furongian Series** (as a synonym of the revised Upper Cambrian). The FAD of *G. reticulatus* in the Paibi section corresponds to a position 369.06 m above the base of the Huaqiao Formation according to the measured section of Peng et al. (2001b).

This base of the Paibian Stage and Furongian Series corresponds to the base of the Waergangian Stage and Hunanian Series as used in South China (Peng and Robison, 2000; Peng and Babcock, 2001).

The Paibi GSSP was the subject of a ballot by the Subcommission held in February-March 2002, which ended with a 82,4 percent agreement and thus the approval of the proposal. The proposal was submitted to the *International Commission on Stratigraphy* and was accepted by the ICS bureau at the meeting in Urbino, Italy, mid-June 2002 and passed for the final ratification.

The clear majority support for defining the Cambrian GSSP at the level of *Ptychagnostus* (or *Acidusus*) *atavus* and the *Cordylodus proavus* level led to a ballot for an approval of formal Working Groups. Both suggested WGs were approved in June/July 2002. New data on the potential GSSP of the *Ptychagnostus* (or *Acidusus*) *atavus* level in the Drum Mountains, Utah, were presented at the meeting in Caunes, Montagne Noire, southern France, in September 2002, and submitted for publication.

Readers of this document who may wish to keep up with activities generated by the SCS are invited to access the Subcommission's internet homepage at <http://www.uni-wuerzburg.de/palaeontologie/ISCS/index.html>, which is maintained by Gerd Geyer.

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