国 际 年 代 地 层 表 v 2017/02

国 际 地 层 委 员 会

www.stratigraphy.org

宇(宙)	界(代)	系(纪)	统(世)	阶(期)	GSSP	年龄值(Ma)
						现今
显生宇	新生界	第四系	全新统		✓	0.0117
显生宇	新生界	第四系	更新统	上阶		0.126
显生宇	新生界	第四系	更新统	中阶		0.781
显生宇	新生界	第四系	更新统	卡拉布里雅阶	✓	1.80
显生宇	新生界	第四系	更新统	杰拉阶	✓	2.58
显生宇	新生界	新近系	上新统	皮亚琴察阶	✓	3.600
显生宇	新生界	新近系	上新统	赞克勒阶	✓	5.333
显生宇	新生界	新近系	中新统	墨西拿阶	✓	7.246
显生宇	新生界	新近系	中新统	托尔托纳阶	✓	11.63
显生宇	新生界	新近系	中新统	塞拉瓦莱阶	✓	13.82
显生宇	新生界	新近系	中新统	兰盖阶		15.97
显生宇	新生界	新近系	中新统	波尔多阶		20.44
显生宇	新生界	新近系	中新统	阿基坦阶	✓	23.03
显生宇	新生界	古近系	渐新统	夏特阶	✓	27.82
显生宇	新生界	古近系	渐新统	吕珀尔阶	✓	33.9
显生宇	新生界	古近系	始新统	普利亚本阶		37.8
显生宇	新生界	古近系	始新统	巴顿阶		41.2
显生宇	新生界	古近系	始新统	卢泰特阶	✓	47.8
显生宇	新生界	古近系	始新统	伊普里斯阶	✓	56.0
显生宇	新生界	古近系	古新统	坦尼特阶	✓	59.2
显生宇	新生界	古近系	古新统	塞兰特阶	✓	61.6
显生宇	新生界	古近系	古新统	丹麦阶	✓	66.0
显生宇	中生界	白垩系	上白垩统	马斯特里赫特阶	✓	72.1 ±0.2
显生宇	中生界	白垩系	上白垩统	坎潘阶		83.6 ±0.2
显生宇	中生界	白垩系	上白垩统	圣通阶	✓	86.3 ±0.5
显生宇	中生界	白垩系	上白垩统	康尼亚克阶		89.8 ±0.3
显生宇	中生界	白垩系	上白垩统	土伦阶	✓	93.9
显生宇	中生界	白垩系	上白垩统	塞诺曼阶	✓	100.5
显生宇	中生界	白垩系	下白垩统	阿尔布阶	✓	~ 113.0
显生宇	中生界	白垩系	下白垩统	阿普特阶		~ 125.0
显生宇	中生界	白垩系	下白垩统	巴雷姆阶		~ 129.4
显生宇	中生界	白垩系	下白垩统	欧特里夫阶		~ 132.9
显生宇	中生界	白垩系	下白垩统	瓦兰今阶		~ 139.8
显生宇	中生界	白垩系	下白垩统	贝里阿斯阶		~ 145.0

宇(宙)	界(代)	系(纪)	统(世)	阶(期)	GSSP	年龄值(Ma)
						~ 145.0
显生宇	中生界	侏罗系	上侏罗统	提塘阶		152.1 ±0.9
显生宇	中生界	侏罗系	上侏罗统	钦莫利阶		157.3 ±1.0
显生宇	中生界	侏罗系	上侏罗统	牛津阶		163.5 ±1.0
显生宇	中生界	侏罗系	中侏罗统	卡洛夫阶		166.1 ±1.2
显生宇	中生界	侏罗系	中侏罗统	巴通阶	✓	168.3 ±1.3
显生宇	中生界	侏罗系	中侏罗统	巴柔阶	✓	170.3 ±1.4
显生宇	中生界	侏罗系	中侏罗统	阿林阶	✓	174.1 ±1.0
显生宇	中生界	侏罗系	下侏罗统	托阿尔阶	✓	182.7 ±0.7
显生宇	中生界	侏罗系	下侏罗统	普林斯巴阶	✓	190.8 ±1.0
显生宇	中生界	侏罗系	下侏罗统	辛涅缪尔阶	✓	199.3 ±0.3
显生宇	中生界	侏罗系	下侏罗统	赫塘阶	✓	201.3 ±0.2
显生宇	中生界	三叠系	上三叠统	瑞替阶		~ 208.5
显生宇	中生界	三叠系	上三叠统	诺利阶		~ 227
显生宇	中生界	三叠系	上三叠统	卡尼阶	✓	~ 237
显生宇	中生界	三叠系	中三叠统	拉丁阶	✓	~ 242
显生宇	中生界	三叠系	中三叠统	安尼阶		247.2
显生宇	中生界	三叠系	下三叠统	奥伦尼克阶		251.2
显生宇	中生界	三叠系	下三叠统	印度阶	✓	252.17 ±0.06
显生宇	古生界	二叠系	乐平统	长兴阶	✓	254.14 ±0.07
显生宇	古生界	二叠系	乐平统	吴家坪阶	✓	259.8 ±0.4
显生宇	古生界	二叠系	瓜德鲁普统	卡匹敦阶	✓	265.1 ±0.4
显生宇	古生界	二叠系	瓜德鲁普统	沃德阶	✓	268.8 ±0.5
显生宇	古生界	二叠系	瓜德鲁普统	罗德阶	✓	272.3 ±0.5
显生宇	古生界	二叠系	乌拉尔统	空谷阶		283.5 ±0.6
显生宇	古生界	二叠系	乌拉尔统	亚丁斯克阶		290.1 ±0.26
显生宇	古生界	二叠系	乌拉尔统	萨克马尔阶		295.0 ±0.18
显生宇	古生界	二叠系	乌拉尔统	阿瑟尔阶	✓	298.9 ±0.15
显生宇	古生界	石炭系 宾夕法尼亚亚系	上	格舍尔阶		303.7 ±0.1
显生宇	古生界	石炭系 宾夕法尼亚亚系	上	卡西莫夫阶		307.0 ±0.1
显生宇	古生界	石炭系 宾夕法尼亚亚系	中	莫斯科阶		315.2 ±0.2
显生宇	古生界	石炭系 宾夕法尼亚亚系	下	巴什基尔阶	✓	323.2 ±0.4
显生宇	古生界	石炭系 密西西比亚系	上	谢尔普霍夫阶		330.9 ±0.2
显生宇	古生界	石炭系 密西西比亚系	中	维宪阶	✓	346.7 ±0.4
显生宇	古生界	石炭系 密西西比亚系	下	杜内阶	✓	358.9 ±0.4

宇(宙)	界(代)	系(纪)	统(世)	阶(期)	GSSP	年龄值(Ma)
						358.9 ± 0.4
显生宇	古生界	泥盆系	上泥盆统	法门阶	✓	372.2 ±1.6
显生宇	古生界	泥盆系	上泥盆统	弗拉阶	✓	382.7 ±1.6
显生宇	古生界	泥盆系	中泥盆统	吉维特阶	✓	387.7 ±0.8
显生宇	古生界	泥盆系	中泥盆统	艾菲尔阶	✓	393.3 ±1.2
显生宇	古生界	泥盆系	下泥盆统	埃姆斯阶	✓	407.6 ±2.6
显生宇	古生界	泥盆系	下泥盆统	布拉格阶	✓	410.8 ±2.8
显生宇	古生界	泥盆系	下泥盆统	洛赫考夫阶	✓	419.2 ±3.2
显生宇	古生界	志留系	普里道利统		✓	423.0 ±2.3
显生宇	古生界	志留系	罗德洛统	卢德福特阶	✓	425.6 ±0.9
显生宇	古生界	志留系	罗德洛统	高斯特阶	✓	427.4 ±0.5
显生宇	古生界	志留系	温洛克统	侯墨阶	✓	430.5 ±0.7
显生宇	古生界	志留系	温洛克统	申伍德阶	✓	433.4 ±0.8
显生宇	古生界	志留系	兰多维列统	特列奇阶	✓	438.5 ±1.1
显生宇	古生界	志留系	兰多维列统	埃隆阶	✓	440.8 ±1.2
显生宇	古生界	志留系	兰多维列统	鲁丹阶	✓	443.8 ±1.5
显生宇	古生界	奥陶系	上奥陶统	赫南特阶	✓	445.2 ±1.4
显生宇	古生界	奥陶系	上奥陶统	凯迪阶	✓	453.0 ±0.7
显生宇	古生界	奥陶系	上奥陶统	桑比阶	✓	458.4 ±0.9
显生宇	古生界	奥陶系	中奥陶统	达瑞威尔阶	✓	467.3 ±1.1
显生宇	古生界	奥陶系	中奥陶统	大坪阶	✓	470.0 ±1.4
显生宇	古生界	奥陶系	下奥陶统	弗洛阶	✓	477.7 ±1.4
显生宇	古生界	奥陶系	下奥陶统	特马豆克阶	✓	485.4 ±1.9
显生宇	古生界	寒武系	芙蓉统	第十阶		~ 489.5
显生宇	古生界	寒武系	芙蓉统	江山阶	✓	~ 494
显生宇	古生界	寒武系	芙蓉统	排碧阶	✓	~ 497
显生宇	古生界	寒武系	第三统	古丈阶	✓	~ 500.5
显生宇	古生界	寒武系	第三统	鼓山阶	✓	~ 504.5
显生宇	古生界	寒武系	第三统	第五阶		~ 509
显生宇	古生界	寒武系	第二统	第四阶		~ 514
显生宇	古生界	寒武系	第二统	第三阶		~ 521
显生宇	古生界	寒武系	纽芬兰统	第二阶		~ 529
显生宇	古生界	寒武系	纽芬兰统	幸运阶	✓	541.0 ±1.0

	宇(宙)	界(代)	系(纪)	GSSP GSSA	年龄值(Ma)
					~541.0±1.0
前寒武系	元古宇	新元古界	埃迪卡拉系	GSSP	~ 635
前寒武系	元古宇	新元古界	成冰系		~ 720
前寒武系	元古宇	新元古界	拉伸系	GSSA	1000
前寒武系	元古宇	中元古界	狭带系	GSSA	1200
前寒武系	元古宇	中元古界	延展系	GSSA	1400
前寒武系	元古宇	中元古界	盖层系	GSSA	1600
前寒武系	元古宇	古元古界	固结系	GSSA	1800
前寒武系	元古宇	古元古界	造山系	GSSA	2050
前寒武系	元古宇	古元古界	层侵系	GSSA	2300
前寒武系	元古宇	古元古界	成铁系	GSSA	2500
前寒武系	太古宇	新太古界		GSSA	2800
前寒武系	太古宇	中太古界		GSSA	3200
前寒武系	太古宇	古太古界		GSSA	3600
前寒武系	太古宇	始太古界		GSSA	4000
前寒武系	冥古宇				~ 4600

所有的全球年代地层单位均需通过其底界的全球标准层型剖面和点位（GSSP）界定，包括长期以来由全球标准地层年龄（GSSA）界定的太古宇和元古宇的各单位。各种图件及每个已批准GSSP的详情参见国际地层委员会官网。本图件的网址见右下角。

年龄值仍在不断修订；显生宇和埃迪卡拉系的单位不能由年龄界定，而只能由GSSP界定。显生宇中没有确定GSSP或精确年龄值的单位，则标注了近似年龄值（~）。

更新统下部、古近系上部、白垩系、三叠系、二叠系和前寒武系的年龄值由各分会提供；其他年龄值均引自Gradstein等的《地质年代表2012》。

各单位的颜色依据世界地质图委员会的色谱(http://www.ccgm.org)

K.M. Cohen、D.A.T. Harper和P.L. Gibbard制表

(c)国际地层委员会，2017年2月（英文版）
(c)国际地层委员会，2017年5月（中文版）

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http://www.stratigraphy.org/ICSchart/ChronostratChart2017-02Chinese.pdf

INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

www.stratigraphy.org

International Commission on Stratigraphy

v 2017/02

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	numerical age (Ma)
					present
Phanerozoic	Cenozoic	Quaternary	Holocene		0.0117
			Pleistocene	*Upper*	0.126
				Middle	0.781
				Calabrian	1.80
				Gelasian	2.58
		Neogene	Pliocene	Piacenzian	3.600
				Zanclean	5.333
			Miocene	Messinian	7.246
				Tortonian	11.63
				Serravallian	13.82
				Langhian	15.97
				Burdigalian	20.44
				Aquitanian	23.03
		Paleogene	Oligocene	Chattian	27.82
				Rupelian	33.9
			Eocene	Priabonian	37.8
				Bartonian	41.2
				Lutetian	47.8
				Ypresian	56.0
			Paleocene	Thanetian	59.2
				Selandian	61.6
				Danian	66.0
	Mesozoic	Cretaceous	Upper	Maastrichtian	72.1 ±0.2
				Campanian	83.6 ±0.2
				Santonian	86.3 ±0.5
				Coniacian	89.8 ±0.3
				Turonian	93.9
				Cenomanian	100.5
			Lower	Albian	~ 113.0
				Aptian	~ 125.0
				Barremian	~ 129.4
				Hauterivian	~ 132.9
				Valanginian	~ 139.8
				Berriasian	~ 145.0

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	numerical age (Ma)
					~ 145.0
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian	152.1 ±0.9
				Kimmeridgian	157.3 ±1.0
				Oxfordian	163.5 ±1.0
			Middle	Callovian	166.1 ±1.2
				Bathonian	168.3 ±1.3
				Bajocian	170.3 ±1.4
				Aalenian	174.1 ±1.0
			Lower	Toarcian	182.7 ±0.7
				Pliensbachian	190.8 ±1.0
				Sinemurian	199.3 ±0.3
				Hettangian	201.3 ±0.2
		Triassic	Upper	Rhaetian	~ 208.5
				Norian	~ 227
				Carnian	~ 237
			Middle	Ladinian	~ 242
				Anisian	247.2
			Lower	Olenekian	251.2
				Induan	251.902 ±0.024
	Paleozoic	Permian	Lopingian	Changhsingian	254.14 ±0.07
				Wuchiapingian	259.1 ±0.5
			Guadalupian	Capitanian	265.1 ±0.4
				Wordian	268.8 ±0.5
				Roadian	272.95 ±0.11
			Cisuralian	Kungurian	283.5 ±0.6
				Artinskian	290.1 ±0.26
				Sakmarian	295.0 ±0.18
				Asselian	298.9 ±0.15
		Carboniferous – Pennsylvanian	Upper	Gzhelian	303.7 ±0.1
				Kasimovian	307.0 ±0.1
			Middle	Moscovian	315.2 ±0.2
			Lower	Bashkirian	323.2 ±0.4
		Carboniferous – Mississippian	Upper	Serpukhovian	330.9 ±0.2
			Middle	Visean	346.7 ±0.4
			Lower	Tournaisian	358.9 ±0.4

Eonothem / Eon	Erathem / Era	System / Period	Series / Epoch	Stage / Age	numerical age (Ma)
					358.9 ± 0.4
Phanerozoic	Paleozoic	Devonian	Upper	Famennian	372.2 ±1.6
				Frasnian	382.7 ±1.6
			Middle	Givetian	387.7 ±0.8
				Eifelian	393.3 ±1.2
			Lower	Emsian	407.6 ±2.6
				Pragian	410.8 ±2.8
				Lochkovian	419.2 ±3.2
		Silurian	Pridoli		423.0 ±2.3
			Ludlow	Ludfordian	425.6 ±0.9
				Gorstian	427.4 ±0.5
			Wenlock	Homerian	430.5 ±0.7
				Sheinwoodian	433.4 ±0.8
			Llandovery	Telychian	438.5 ±1.1
				Aeronian	440.8 ±1.2
				Rhuddanian	443.8 ±1.5
		Ordovician	Upper	Hirnantian	445.2 ±1.4
				Katian	453.0 ±0.7
				Sandbian	458.4 ±0.9
			Middle	Darriwilian	467.3 ±1.1
				Dapingian	470.0 ±1.4
			Lower	Floian	477.7 ±1.4
				Tremadocian	485.4 ±1.9
		Cambrian	Furongian	*Stage 10*	~ 489.5
				Jiangshanian	~ 494
				Paibian	~ 497
			Series 3	Guzhangian	~ 500.5
				Drumian	~ 504.5
				Stage 5	~ 509
			Series 2	*Stage 4*	~ 514
				Stage 3	~ 521
			Terreneuvian	*Stage 2*	~ 529
				Fortunian	541.0 ±1.0

Eonothem / Eon	Erathem / Era	System / Period	GSSP / GSSA	age (Ma)
				541.0 ±1.0
Precambrian – Proterozoic	Neo-proterozoic	Ediacaran		~ 635
		Cryogenian		~ 720
		Tonian		1000
	Meso-proterozoic	Stenian		1200
		Ectasian		1400
		Calymmian		1600
	Paleo-proterozoic	Statherian		1800
		Orosirian		2050
		Rhyacian		2300
		Siderian		2500
Precambrian – Archean	Neo-archean			2800
	Meso-archean			3200
	Paleo-archean			3600
	Eo-archean			4000
Precambrian – Hadean				~ 4600

Units of all ranks are in the process of being defined by Global Boundary Stratotype Section and Points (GSSP) for their lower boundaries, including those of the Archean and Proterozoic, long defined by Global Standard Stratigraphic Ages (GSSA). Charts and detailed information on ratified GSSPs are available at the website http://www.stratigraphy.org. The URL to this chart is found below.

Numerical ages are subject to revision and do not define units in the Phanerozoic and the Ediacaran; only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.

Numerical ages for all systems except Lower Pleistocene, Upper Paleogene, Cretaceous, Triassic, Permian and Precambrian are taken from 'A Geologic Time Scale 2012' by Gradstein et al. (2012); those for the Lower Pleistocene, Upper Paleogene, Cretaceous, Triassic, Permian and Precambrian were provided by the relevant ICS subcommissions.

Colouring follows the Commission for the Geological Map of the World (http://www.ccgm.org)

Chart drafted by K.M. Cohen, D.A.T. Harper, P.L. Gibbard

(c) International Commission on Stratigraphy, February 2017

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Global chronostratigraphical correlation table for the last 2.7 million years

v. 2016a

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http://www.35igc.org/

International Union of Geological Sciences (IUGS),
International Commission on Stratigraphy (ICS),
Subcommission on Quaternary Stratigraphy (SQS).

http://www.stratigraphy.org/

International Union for Quaternary Research (INQUA),
Stratigraphy and Chronology Commission (SACCOM).

http://www.inqua-saccom.org

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http://www.qpg.geog.cam.ac.uk/

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Global chronostratigraphical correlation table for the last 2.7 million years, v. 2016a

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The table provides a correlation of chronostratigraphical subdivisions of late Cenozoic geological time, spanning the last 2.7 million years. The formal division of the Quaternary is the responsibility of the IUGS International Commission on Stratigraphy's (ICS) Subcommission on Quaternary Stratigraphy (SQS), in partnership with the International Union for Quaternary Research's (INQUA) Commission on Stratigraphy and Chronology (SACCOM). Previous versions of the chart (see websites[1]) were published as Gibbard *et al*. (2004, 2005) and Gibbard & Cohen (2008). Since then semi-annually updated versions have appeared on the web (e.g. Cohen & Gibbard, 2010). A major update is in progress. This 2016a version is a minor update, prepared for the 35th International Geological Congress held at Cape Town, South Africa from August 27th to September 4th 2016.

Chronostratigraphy and the base of the Quaternary

The timescale is based on the internationally-recognised formal chronostratigraphical/geochronological subdivisions of time: the Phanerozoic Eonathem/Eon; the Cenozoic Erathem/Era; the Quaternary System/Period; the Pleistocene and Holocene Series/Epoch, and finally the Early/Lower, Middle, Late/Upper Pleistocene Subseries/Subepoch (Cohen *et al.*, 2013). At present the Subseries (Subepoch) divisions of the Pleistocene are not formalised. Series, and thereby systems, are formally-defined based on Global Stratotype Section and Points (GSSP) of which two divide the Quaternary System into the Holocene and Pleistocene Series. The formal base of the Pleistocene, as ratified in 2009, coincides with a GSSP at Monte San Nicola in southern Italy, marking the base of the Gelasian Stage (Rio *et al.*, 1994, 1998). The Gelasian GSSP at 2.58 Ma replaces the previous Pleistocene base GSSP (~1.8 Ma, defined at Vrica, southern Italy), following 60 years of discussion in international stratigraphical commissions and congresses. However, the latter continues as the GSSP for the base of the Calabrian Stage. The chart extends to 2.7 million years to include the very end of the preceding Piacenzian Stage of the Pliocene Series.

Since 1948 there has been a consensus that the boundary should be placed at the first evidence of climatic cooling of ice-age magnitude. This was the original basis for placing the boundary at ~1.8 Ma in marine sediments at Vrica in Calabria, in Italy (Aguirre & Pasini, 1985). It is now known that a major cooling occurred earlier, at *c*. 2.55 million years (Cita, 2008), and even earlier cooling events are known from the Pliocene. The closure of Central American Seaways between the Pacific and Atlantic ocean, in three steps starting 3.2 Ma, significantly restructured oceanic and atmospheric circulation on the Northern Hemisphere, causing increased high latitude precipitation, freshening of the Arctic Ocean and increased sea-ice cover amplifying cooling through albedo feedbacks (Bartoli *et al.*, 2005; Lunt *et al.*, 2007; Sarnthein *et al.*, 2009). Fully completed Panama Isthmus closure by 2.7 Ma is believed to explain the palaeoenvironmental transitions observed at the Pliocene-Pleistocene boundary and to have culminated in the Quaternary glacial-interglacial oscillating climate mode. Since its definition at 1.8 Ma there had been strong pressure for the basal Quaternary / Pleistocene boundary to be moved downwards better to reflect the initiation of major global cooling (Pillans and Naish 2004; Gibbard *et al.* 2005; Bowen & Gibbard 2007; Cita & Pillans, 2010), effectively corresponding to the Gauss / Matuyama magnetic Chron boundary (e.g. Partridge, 1997; Suc *et al*., 1997). See also: Ogg & Pillans (2008); Head *et al.* (2008); Lourens (2008); Gibbard & Head (2009a, b) and Gibbard *et al.* (2009).

Pleistocene GSSPs

Formal GSSPs for the Pleistocene Subseries will be proposed shortly. The INQUA Commission on Stratigraphy/ICS Working Group on Major Subdivision of the Pleistocene agreed to place the Early/Lower - Middle boundary at the Brunhes / Matuyama magnetic reversal Chron boundary (Richmond, 1996). A stratotype locality has yet to be identified, but two candidate sections are being considered by an ICS Working Group (Head *et al.*, 2008). Following recent re-evaluation, the Middle –

[1] http://www.quaternary.stratigraphy.org.uk/charts; also at: www.stratigraphy.org and www.inqua-saccom.org

Late/Upper boundary is placed, following historical precedent in NW Europe, at the Saalian-Eemian Stage boundary. The former is positioned at the basal-boundary stratotype of the Eemian in the Amsterdam-Terminal borehole, the Netherlands (Gibbard, 2003; Litt & Gibbard, 2008).
The start of the Eemian in NW Europe (defined on pollen biostratigraphy) lags the start of MIS 5e by a few 1000 years (Sánchez-Goñi et al., 1999; Sier et al., 2015). Establishing the exact lag time is an important current research goal, tying global sea-level, ice-mass and crustal glaciohydro-isostasy studies with regional climatic variation, oceanography and palaeomagnetics (e.g. Shackleton et al., 2003; Lourens, 2004; Lambeck et al., 2006; Sier et al., 2015). Accurate age-control on the timing of the Eemian and the relation to MIS 5e is important as it is frequently used to deduce background tectonic uplift/subsidence rates, which is in turn input sea-level rise and glacio-isostatical adjustment studies for the Late Pleistocene and Holocene (e.g. Dutton & Lambeck, 2012; Dutton et al. 2015). Accurate age-control on the last interglacial is also of importance as input to astronomically tuned timescales that in the Quaternary are used for the Middle and Early Pleistocene (e.g. Head et al. 2008) and in the Neogene, Paleogene and beyond (Lisiecki and Raymo, 2005).

The Holocene is generally regarded as having begun 10,000 radiocarbon years before 1950 AD, or 11.7k calendar years before 2000 AD (cf. Wolff, 2008). This boundary has been defined as a Global Stratotype Section and Point (GSSP) in the North-GRIP ice core of the Greenland Ice-Core Project (NGRIP: Rasmussen *et al.*, 2006; Walker *et al.*, 2008, 2009; Hoek, 2008). Auxiliary stratotypes are also defined, for example, in an annually-laminated lake sequence in western Germany (Litt *et al*., 2001). The Holocene Series is not divided into named stages, however, at the time of writing formal definition of stage subdivisions is under consideration by the ICS. At the same time ICS are discussing the possibility of formalising the definition of subseries for the same period (Early, Middle and Late Holocene cf. Walker *et al*. 2012).

Marine stage / zone divisions

Isotope studies from the bottom sediments of the world's oceans have indicated that as many as 52 cold and interspersed warm climate periods, often referred to as glacials and interglacials, occurred during the last 2.6 million years. In contrast to the deep sea, continental evidence is so incomplete and regionally variable that terrestrial glacial-interglacial stratigraphies must refer to the ocean record for a global chronological foundation.

Here the deep-sea based, climatically-defined stratigraphy is taken from oxygen isotope data obtained from tests of fossil benthonic (ocean-floor dwelling) foraminifera, retrieved from deep-ocean cores from 57 locations around the world. The plots depict $\delta^{18}O$ (the ratio of ^{18}O *versus* ^{16}O) of a stacked record as processed by Lisiecki and Raymo (2005). Their calibrated ages for the last seven major glacial terminations are included. The inventory of geomagnetic chrons, subchrons and excursions on the chart, is taken from the compilation of Lai & Channell (2007: their Tables 2 and 3). Geomagnetic excursions and reversals occur at times of low magnetic field intensity and their ages are updated after Channell *et al.* (2009; 2016). Shifts in this ratio are a measure of global ice-volume, which is dependent on global temperature and which determines global sea-level. Planktonic foraminifera and calcareous nannoplankton provide an alternative biostratigraphical means of subdivision of marine sediments. The micropalaeontological zonation is taken from Berggren *et al*. (1995).

'Standard stage' ('super-stage') global divisions

The desire to divide Quaternary/Pleistocene time into 'standard stages', that is units of approximately the same duration as those in the pre-Quaternary time (i.e. Paleogene, Neogene), has been advocated on occasions. The only succession that has been divided in this way is the shallow marine sequence in the Mediterranean region, especially in southern Italy, based principally on faunal and protist biostratigraphy. For various reasons the scheme was considered unsatisfactory for use beyond this region. Renewed investigation in recent years has led to the proposal of units based on multidisciplinary investigation. The Italian shallow marine stages are derived from Van Couvering (1997) modified by Cita *et al*. (2006) (cf. also Cita & Pillans, 2010). In view of their duration, covering multiple climate cycles and periods for which regional stage units of markedly shorter duration have been defined, these 'standard stages' are considered as 'super-stages'.

Early–Middle Pleistocene transition ('mid-Pleistocene revolution')

The chart shows the time between c. 1.2 and 0.5 Ma to have been a transition period in which low-amplitude 41-ka obliquity-forced climate cycles of the earlier Pleistocene were replaced progressively by high-amplitude 100-ka cycles. These later cycles are indicative of slow ice build-up and subsequent rapid melting, and imply a strongly non-linear forced climate system compared to before, accompanied by substantially increased global ice volume during glacials after 940 ka. The Early-Middle Pleistocene transition, through the increased severity and duration of cold stages, had a profound effect on the biota and the physical landscape, especially in the northern hemisphere (Head & Gibbard 2005). Orbital and non-orbital climate forcing, palaeoceanography, stable isotopes, organic geochemistry, marine micropalaeontology, glacial history, loess–palaeosol sequences, pollen analysis, large and small mammal palaeoecology and stratigraphy, and human evolution provide a series of discrete events identified from Marine Isotope Stage (MIS) 36 (c. 1.2 Ma) to MIS 13 (c. 540–460 Ma). Of these, the cold MIS 22 (c. 880–870 ka) is the most profound. On this basis Head & Gibbard (2005) and Head *et al.* (2008), following earlier suggestions (e.g. Richmond 1996), concluded that on practical grounds the Matuyama–Brunhes palaeomagnetic Chron boundary (mid-point at c.773-4 ka, with an estimated duration of 7 ka; within MIS 19; Channell *et al.* 2004; Channell *et al.* 2008) is the best overall point for establishing the Early–Middle Pleistocene Subseries boundary.

Major continental records: Antarctic ice, Chinese loess, Lake Baikal

Two plots of isotope measurements from Antarctic ice-cores are shown. The first is the 420 ka-long plot from the Vostok core and shows atmospheric $\delta^{18}O$ (Petit *et al*. 1999), determined from gas bubbles in the ice. This atmospheric $\delta^{18}O$ is inversely related to $\delta^{18}O$ measurements from seawater and therefore is a measure of ice-volume. It can also be used to separate ice volume and deepwater temperature effects in benthic foraminiferal $\delta^{18}O$ measurements. The deuterium measurements (δD) for the last 800 ka are from the 3.2 km deep EDC core in Dome C (EPICA community members, 2004; Jouzel *et al.*, 2007). They come from samples of the ice itself and give a direct indication of Antarctic surface palaeotemperature.

For the Chinese loess deposits the chart shows the sequence of palaeosols (units S0 to S32) for the Jingbian site in northern China (Ding *et al.*, 2005). High values of magnetic susceptibility indicate repeated episodes of weathering (soil formation), predominantly in interglacials with relative strong summer monsoon. In intercalated strata (units L1 to L33; accumulated during glacials) the proportion of coarser grains (grains > 63 µm, % dry weight) is a signal of progressive desertification in Central Asia. The magnetic and grain-size data is plotted on the Chinese Loess Particle Time Scale (Ding *et al.*, 2002). Alternating loess-palaeosol sequence accumulation throughout NE China coincides with the begin of the Pleistocene and buries the more intensively weathered Pliocene 'Red Clay' Formation (An Zhisheng *et al*., 1990).

The Siberian Lake Baikal provides a bioproductivity record from the heart of the world's largest landmass, an area of extreme continental climate. High concentrations of biogenic silica indicate high aquatic production during interglacials (i.e., lake diatom blooms during ice-free summer seasons), mimicked in other proxy-records from the lake (e.g. Prokopenko et al., 2010, exemplified for MIS 11). The composite biogenic silica record from cores BDP-96-1, -96-2 and -98 is plotted on an astronomically tuned age-scale (above 1.2 Ma: Prokopenko et al., 2006; below 1.2 Ma: Prokopenko & Khursevich, 2010).

Regional stage/substage divisions

The continuous sequences, above, provide the comparison for a selection of continental and shallow marine stage-sequences from around the world reconstructed from discontinuous sediment successions. Solid horizontal lines on the plots indicate observed boundaries, where no lines separate stages, additional events may potentially be recognised in the future.

The NW European stages are taken from Zagwijn (1992) and De Jong (1988). The British stages are taken from Mitchell *et al*. (1973); Gibbard *et al*. (1991) and Bowen (1999). The Russian Plain stages are from the Stratigraphy of the USSR: Quaternary System (1982, 1984), Krasnenkov et al. (1997), Shik et al. (2002), Danukalova (pers. comm.), Gerasimenko (pers. comm.). In addition, the Russian Pleistocene is also frequently divided into the Eopleistocene, equivalent to the Early Pleistocene Subseries, and the Neopleistocene, equivalent to the Middle and Late Pleistocene Subseries. The North American stages are taken from Richmond (pers. comm.). The New Zealand stages are from Pillans (1991) and Beu (2004).

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