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The Global Boundary Stratotype Section and Point (GSSP) for the base of the Albian Stage, of the Cretaceous, the Col de Pré-Guittard section, Arnayon, Drôme, France

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Following the unanimous approval of the Executive Committee on the International Union of Geological Sciences as notified on April 8, 2016, the Global boundary Stratotype Section and Point for the base of the Albian Stage of the Cretaceous is defined at the first occurrence datum of the planktonic foraminiferan Microhedbergella renilaevis Huber and Leckie, 2011 at a level 37.4 meters above the base of the Marnes Bleues Formation and 40 cm above the base of the Niveau Kilian marker bed in the section SSE of the Col de Pré-Guittard, Arnayon, Drôme, France. The first occurrence of Microhedbergella renilaevis is placed within a 100-m section of argillaceous sediments with 28 secondary markers including calcareous nannofossils, planktonic foraminifera, an inoceramid bivalve, ammonites, stable carbon isotopes, and local marker beds.

Introduction

The present document defining a Global boundary Stratotype Section and Point for the base of the Albian Stage of the Lower Cretaceous arises from one of the recommendations of the Albian Working Group of the Subcommission on Cretaceous Stratigraphy at its meetings during the Second International Symposium on Cretaceous Stage boundaries held in Brussels from September 8–15, 1995 (Hart et al., 1996), and the subsequent publications of Petrizzo et al. (2012, 2013) and Kennedy et al. (2014).

Historical Background

The Étage Albien was introduced by Alcide d'Orbigny in 1843 (in d'Orbigny, 1842–3, p.404), as follows:

"Gault. L'étage ainsi nommée de ses argiles varie on ne peut d'avantage sous le rapport minéralogique. II est en effet forme d'argiles, à ses parties moyennes, à Wissant (Pas-de-Calais), aux Côtes Noires (Haute-Marne), à Gaty, à Maurepaire, à Dienville (Aube), et à Folkestone (Angleterre); mais à Wissant même, à Ervy (Aube); à Saint-Florentin (Yonne), à la pêrte du Rhône (Ain) , à Macheromenil (Ardennes), à Varennes (Meuse) , il est aussi composé de grès verts, de grès blanchatres; à Escragnolle (Var), il est représenté par une véritable glauconie crayeuse; à la Montagne-des-Fis (Savoie), par des roches noirâtres compactes. On voit donc que les noms de *gault,* de *glauconie sableuse,* de *grès vert inférieur,* ne peuvent non plus être proprément appliqués dans tous les cas, ce qui me détermine à proposer, pour cet étage, le nom de terrain ALBIEN, 1'Aube (*Alba*) le traversant à Dienville et sur beaucoup d'autres points".

The succession in Aube was carefully documented by Rat et al. (1979), Amédro et al. (1995) and Colleté (2010). Although of considerable historic interest, the area is unsuitable for defining the base of the stage in contemporary terms. As Amédro et al. (1995, p. 34) note, "1'Albien type reste incomplétement connu. Cette situation est liée à 1'absence des coupes continues et à 1'importance de la couverture végétale qui rend les affleurements très rares et éphémères."

It is this lack of suitable permanent sections that makes Aube unsuitable as a location for a GSSP. Furthermore, the lowest fossiliferous Albian recognized is a condensed phosphatic nodule bed at the top of the Sables Verts de 1'Aube (Amédro et al., 1995), which has yielded *Hypacanthoplites milletioides* Casey, 1961, *H. milletianus* (d'Orbigny, 1841), *Leymeriella (L.) tardefurcata* (d'Orbigny, 1841)*, L. (N.) regularis* (d'Orbigny, 1841), and *Douvilleiceras mammilatum* (Schlotheim, 1813). The underlying Sables Verts have not yielded diagnostic fossils, and rest unconformably on Aptian Argiles à Plicatules (Rat et al., 1979; Amédro et al., 1995).

At the conclusion of the meeting of the Working Group on the

Albian Stage, held during the Second International Symposium on Cretaceous Stage boundaries, held in Brussels from September 8–16, 1995 (Hart et al., 1996), the succession at the Col de Pré-Guittard, Arnayon, Drôme, France was discussed, and a number of possible palaeontological markers for the boundary noted:

- The first occurrence of the ammonite *Leymeriella tardefurcata* (d'Orbigny, 1841)
- the first occurrence of the ammonite *Douvilleiceras* ex gr. *mammilatum* (Schlotheim, 1813)
- the first occurrence of the coccolithophore *Prediscosphaera columnata* (Stover, 1966)
- the last occurrence of the ammonite *Hypacanthoplites jacobi* (Collet, 1907)
- the top or bottom of the Paquier 'oceanic anoxic event'
- the topmost organic-rich bed of the faisceau Kilian
- or "any other datum" (Hart et al., 1996, p. 51).

The first option was pursued by Kennedy et al. (2000), but eventually failed to find favour with the Cretaceous Subcommission (Premoli Silva, 2010).

Following documentation of a major planktonic foraminiferal turnover across the Aptian–Albian interval (Huber and Leckie, 2011; Huber et al., 2011), the first occurrence of planktonic foraminiferan *Microhedbergella renilaevs* Huber and Leckie, 2011 was proposed as the biomarker to define the base of the Albian, first by Petrizzo et al. (2012, 2013) and then by Kennedy et al. (2014).

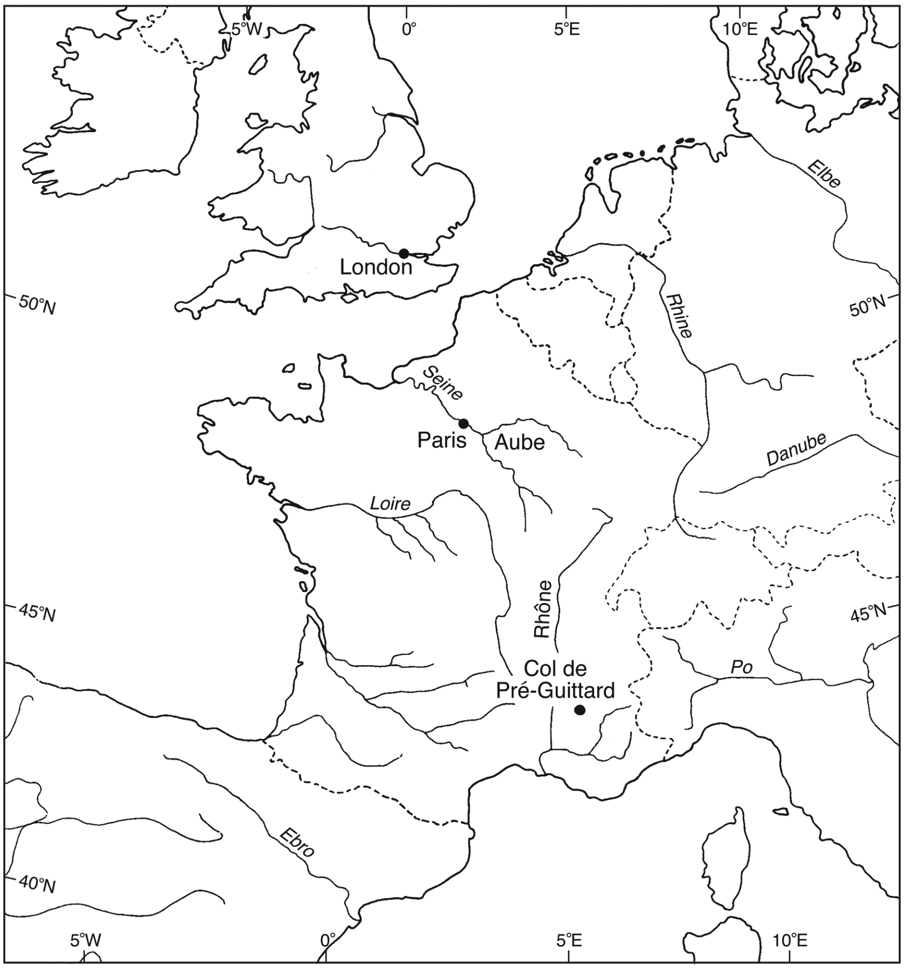

Figure 1. Localities in France mentioned in the text.

The Global Boundary Stratotype Section and Point for the Base of the Albian Stage

Location

The GSSP lies north of the 877 spot height east of the D173 road, 400 m south of the Ferme de Pré-Guittard, and 830 m SSE of the Col de Pré-Guittard in the Commune of Arnayon (Figs. 1–3). The Pré-Guittard section (Figs. 1, 2, and 5) lies 11 km north-northwest of Rémuzat and 19 km northwest of Rosans in the Départment of Drôme at 44°29′47″N, 5°18′41″E on the 125:000 topographic sheet Série Bleu 3138E, La Motte-Chalançon (It should be noted that although referred to as the Col de Pré-Guittard section in the literature it is some distance to the south of the col, as noted above).

Access

The GSSP is reached by taking the D173 west from its junction with the D61, 2 km south of La Motte-Chalançon. The locality lies above and below the road just north of spot height 877, 400 m east of south of the Ferme Pré-Guittard. Previous key accounts of the section are presented by Bréhéret et al. (1986), Bréhéret (1997 and references therein), Kennedy et al. (2000, 2014) and Petrizzo et al. (2012, 2013).

Description of the Global Stratotype Section

The section is exposed over a distance of several hundred metres in a series of gullies and ravines in outcrops on the eastern and western sides of the D173 road (Fig. 2). A general view of the outcrop to the east is shown in Figure 3, and a lithostratigraphic log in Figure 4. As the name suggests, the Marnes Bleues Formation is a predominantly argillaceous sequence with a varying but generally low carbonate fraction. The base is drawn at the boundary with the highest well-cemented limestone of the Faisceau Fromaget (Figs. 3 and 4), which provides the zero datum in this account. There is a series of marker beds of regional extent:

- The Niveau Jacob at the 2.5 to 4.0 m level. This is an interval with laminae rich in organic matter with bedding planes covered in crushed ammonites.
- The Niveau Kilian the base of which is at the 37-m level; a meter-thick unit moderately rich in organic matter, with some laminated intervals.
- The Niveau Paquier, the base of which is at the 68-m level; a 1.5-m unit of black, laminated organic-rich shale. Individual bedding planes are plastered with ammonites with powdery remnants of original white aragonitic shell material.

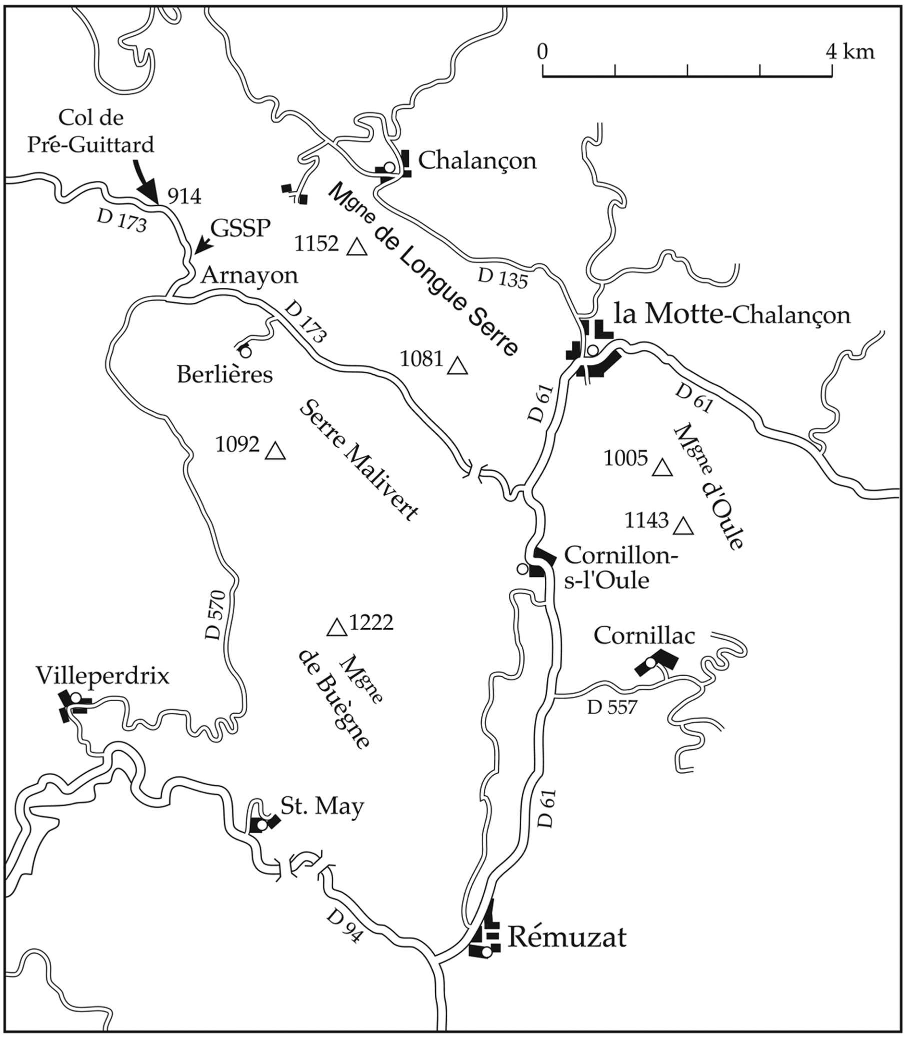

Figure 2. Location map for the Col de Pré-Guittard, Arnayon (Drôme). Rémuzat lies about 50 km northeast of Orange.

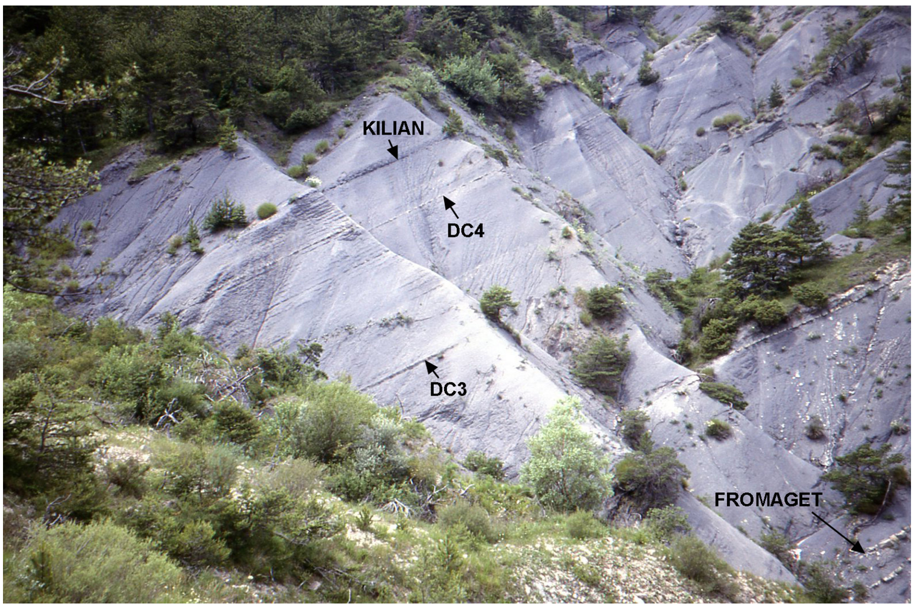

Figure 3. The Global boundary Stratotype Section: view from the D173 road. DC = "délits calcaires" of Bréhérét (1997).

- The Niveau Leenhardt, a pair of laminated organic-rich shales with fish debris, ammonites, and inoceramid bivalves, the base being at the 101.5-m level.

Also present are a series of what Bréhérét (1997, p. 9) referred to as "délits calcaires (calcaires délités)" (DC) of which there are five in the lower 45 m of the section (Figs. 3 and 4). As better cemented levels, their weathering profile makes them valuable secondary lithological markers in the sequence.

The Boundary Level: Primary and Auxiliary Markers

(1) The topmost limestone of the Faisceau Fromaget, PGO, the zero datum.

(2) The Niveau Jacob, at 2.5–4.0 m.

(3) The first occurrence of subcircular examples of the nannofossil *Prediscosphaera columnata* at 6 m. [The *columnata* lineage is widely distributed in both Boreal and Tethyan Realms, Ocean Drilling Program (ODP), Deep Sea Drilling Project (DSDP), and International Ocean Discovery Program (IPOD)sites, and is used as a global marker.]

(4) The first occurrence of circular examples of the nannofossil *Prediscosphaera columnata* and the lowest occurrence of the nannofossil *Helicolithus trabeculatus* at 29.5 m. (The *columnata* lineage is used as a global marker. *H. trabeculatus* is widely distributed in both Boreal and Tethyan realms, DSDP, ODP and IPOD sites.)

(5) The last occurrence of the planktonic foraminiferan *Hedbergella infracretacea* at 33.5 m. (This species is cosmopolitan in marine settings beyond the inner shelf in all biogeographic realms.)

(6) The last occurrence of the planktonic foraminiferan *Hedbergella aptiana* at 34.75 m. (This species is cosmopolitan in marine settings at middle shelf and greater depths with occurrences in all biogeographic realms.)

(7) The last occurrence of the planktonic foraminiferan *Paraticinella rohri* (= *Ticinella bejaouensis* and *Paraticinella eubejaouensis* in previous literature; see Premoli Silva et al., 2009; Ando et al., 2014) at 34.75 m. (This species is cosmopolitan in middle shelf and deeper marine settings with occurrences in all biogeographic realms, and is cosmopolitan in middle shelf and deeper marine settings.)

(8) The first occurrence of the planktonic foraminiferan *Microhedbergella miniglobularis* at 35 m. [This species has been identified at northern subtropical deep sea sites on the Blake Plateau

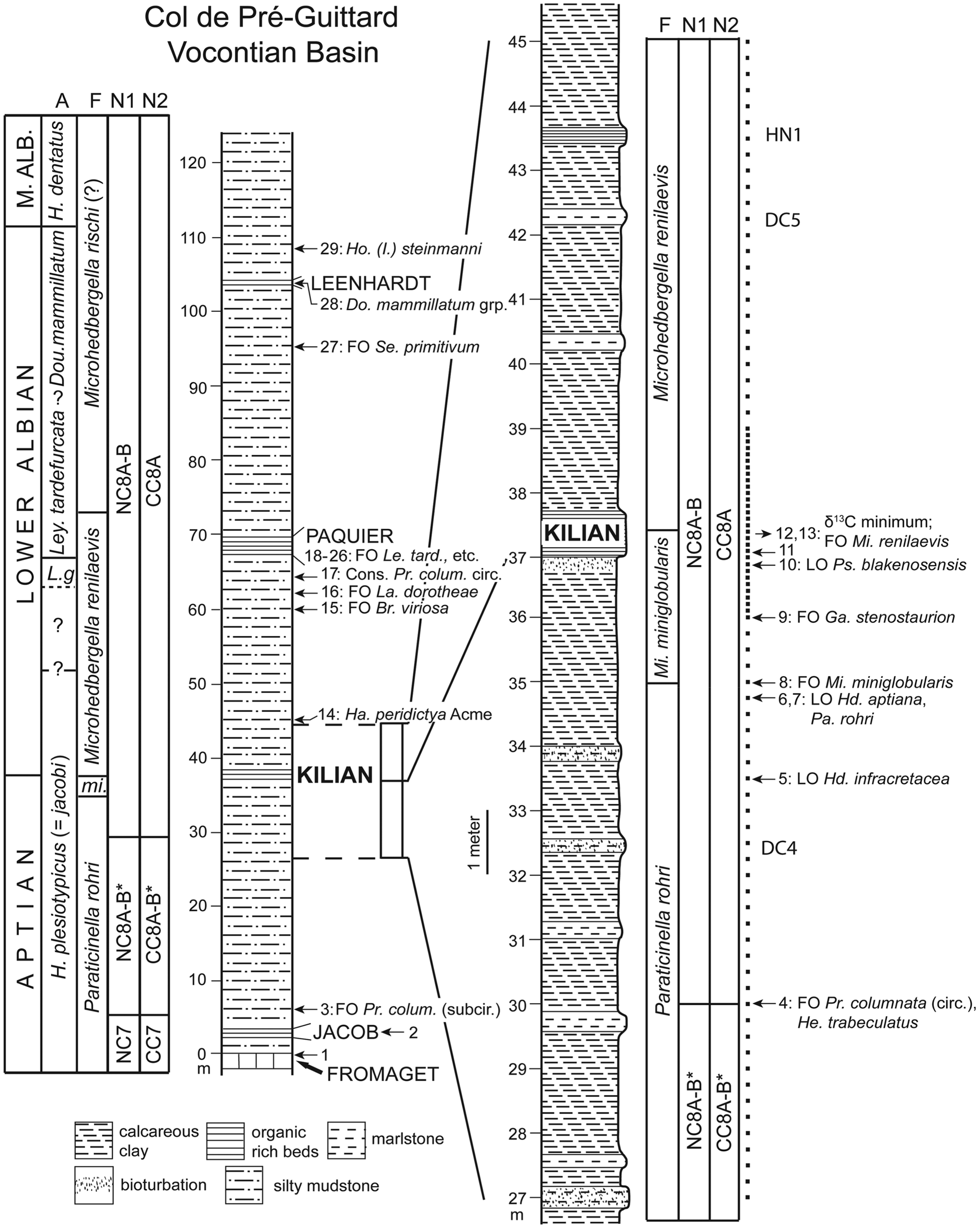

Figure 4. The succession at the Col de Pré-Guittard, Arnayon (Drôme), showing local marker beds Fromaget, Jacob, Kilian, Paquier and Leenhardt. Numbers 1–29 refer to the sequence of events described in the text for the GSSP including the first occurrence of the planktonic foraminiferan Microhedbergella renilaevis, event 13, at the 37.4 m level (modified after Petrizzo et al., 2012). See text for complete spellings and explanation for unnamed events. Columns include A (ammonites – Kennedy et al., 2000), PF (planktonic foraminifera – Petrizzo et al., 2013, with modification of Pa. rohri Zone, the equivalent of previously identified Pa. eubejaouaensis Zone), N1, calcareous nannofossils (NC = Roth 1978 scheme) and N2, calcareous nannofossils (CC = Sissingh 1977 scheme). FO = first occurrence, LO = last occurrence. DC = "délits calcaires" of Bréhérét (1997). Abbreviated ammonite names are; L.g., Leymeriella germanica; Ley, Leymeriella; Dou., Douvilleiceras; H., Hoplites. The small squares to the right of the right column represent levels of samples taken for the study of Petrizzo et al. (2012).

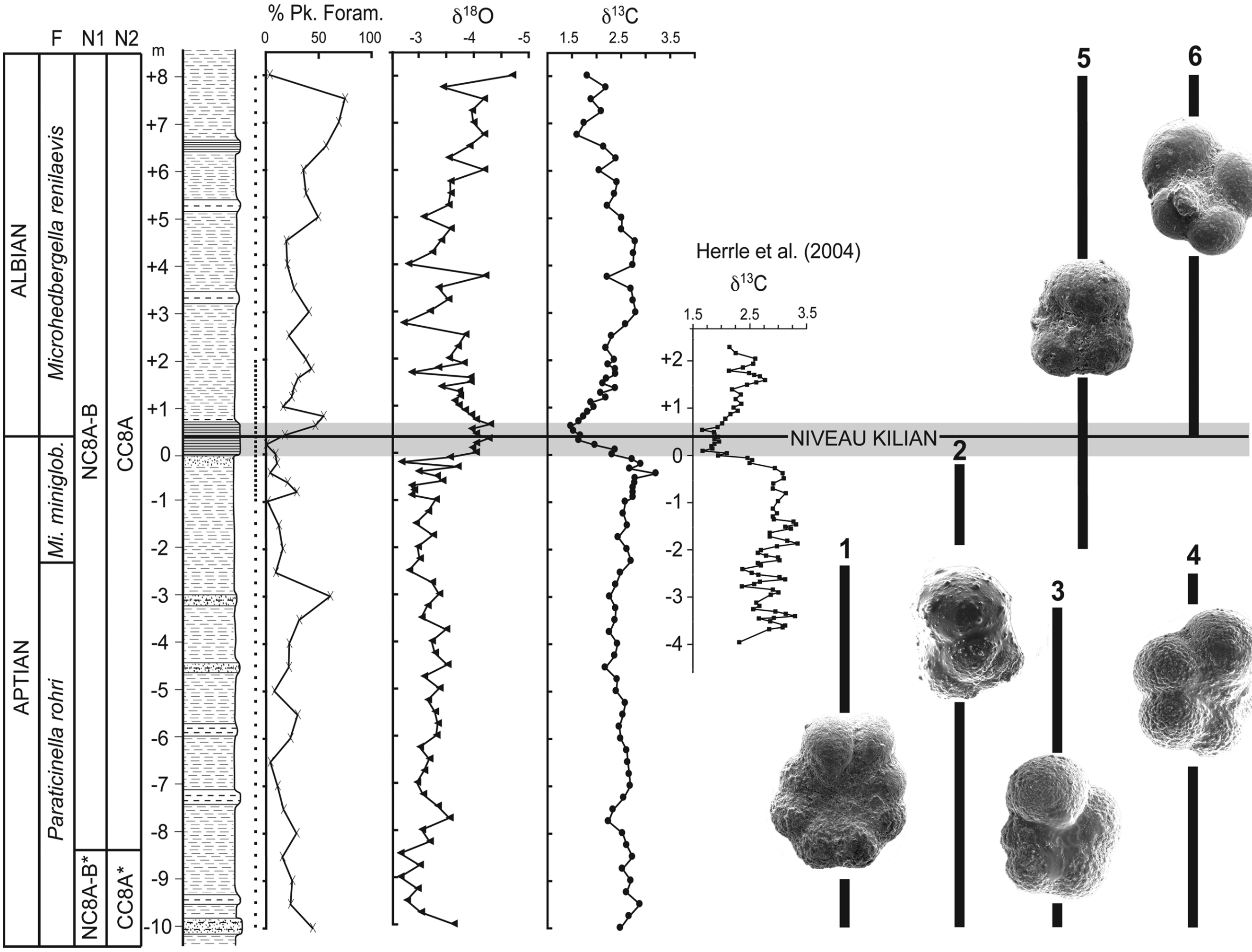

Figure 5. Abundance (%) of planktonic foraminifera and oxygen- and carbon-stable isotope stratigraphy from Petrizzo et al. (2012, 2013), and carbon-isotope data from Herrle et al. (2004) through the Niveau Kilian at Pré-Guittard. Species illustrated (not to scale) with their ranges include: 1, Paraticinella rohri; 2, Pseudoguembelitria blakenosensis; 3, Hedbergella infracretacea; 4, Hedbergella aptiana; 5, Microhedbergella miniglobularis; 6, Microhedbergella renilaevis.

(North Atlantic, DSDP Site 390, ODP Site 1049) on the Falkland Plateau at southern high latitudes (southern South Atlantic, DSDP Site 511), the Exmouth Plateau (subtropical south-eastern Indian Ocean, Hole 763B) and in the western Tethys including the Vocontian Basin].

(9) The first occurrence of the nannofossil *Gartnerago stenostaurion* at 36 m. (The species is widely distributed in both Boreal and Tethyan **r**ealms, DSDP, ODP and IPOD sites.)

(10) The last occurrence of the planktonic foraminiferan *Pseudoguembelitria blakenosensis* at 36.8 m. (This species was recorded at Blake Nose ODP Holes 1049A, 1049B, and 1049C in the subtropical western North Atlantic and western Tethys, including the Vocontian Basin, southeast France.)

(11) The base of the laminated Niveau Kilian at 37 m.

(12) The minimum value of the negative excursion of $\delta^{13}C$ at 37.4 m. (This is a global phenomenon.)

(13) The proposed candidate boundary marker: the first occurrence of the planktonic foramininferan *Microhedbergella renilaevis* at 37.4 m. (This species has been identified at northern subtropical deep sea sites on the Blake Plateau (North Atlantic, DSDP Sites 390, ODP Site 1049) on the Falkland Plateau at southern, high latitudes (southern South Atlantic, DSDP Site 511), the Exmouth Plateau (subtropical southeastern Indian Ocean, Hole 763B) and in the western Tethys (Vocontian Basin, southeast France).

(14) The acme of the palynomorph *Hapsocysta peridictya* at 46 m. (This palynomorph has a cosmopolitan distribution in ODP cores and occurs onshore in both Boreal and Tethyan realms.)

(15) The first occurrence of the nannofossil *Broinsonia viriosa* at 60 m. (Originally described from the Boreal Realm (southern England), and now recorded from the Vocontian Basin)

(16) The first occurrence of the nannofossil *Laguncula dorotheae*, at 63.3 m. (This species is widely distributed in both Boreal and Tethyan realms, DSDP, ODP and IPOD sites.)

(17) The first consistent occurrence of circular examples of the nannofossil *Prediscosphaera columnata*, at 66.6 m. (This species is widely distributed in both Boreal and Tethyan realms, DSDP, ODP and IODP sites.)

(18) The base of the Niveau Paquier at 68 m. This level coincides with a minor discontinuity at the Col de Pré-Guittard.

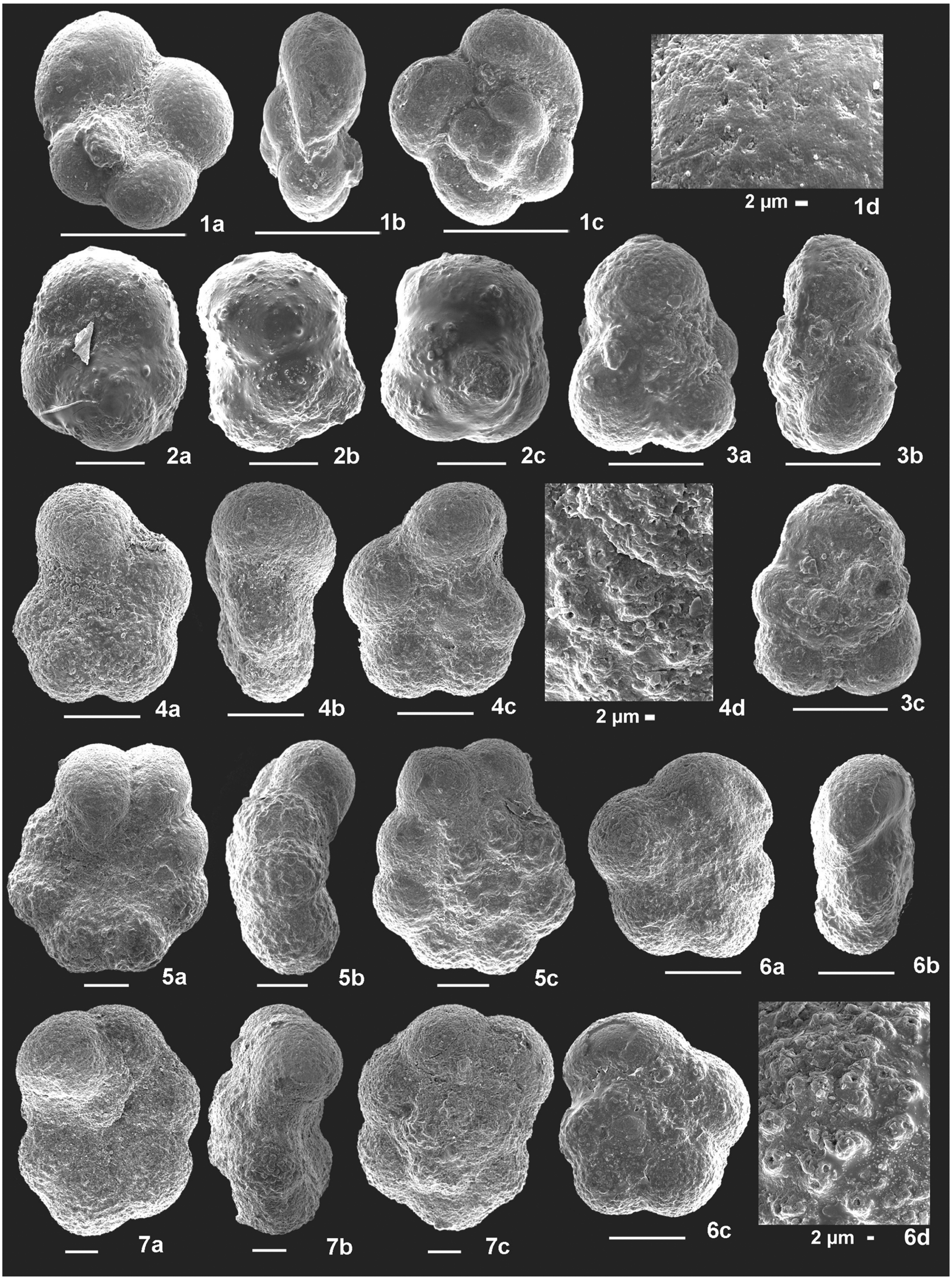

Figure 6. Planktonic foraminifera across the Niveau Kilian at Pré-Guittard illustrated in Petrizzo et al. (2012): (1a–c) Microhedbergella renilaevis, sample FK+7.0; (2a–c) Pseudoguembelitria blakenosensis, sample FK-0.8; (3a–c) Pseudoguembelitria blakenosensis, sample FK-9.0; Hedbergella aptiana, sample FK-9.0; (4a–d) Hedbergella aptiana, sample FK-9.0; (5a–c) Paraciticinella rohri, sample FK-9.0; (6a–d) Hedbergella infracretacea, sample FK-10.5; (7a–c) Paraticinella transitoria, sample -10.0. Scale bars represent 100 µm for Figures 1 and 4–7, except where indicated otherwise, and 50 µm for Figures 2 and 3; a = umbilical view, b = lateral view, c = spiral view.

	Col de Pré-Guittard samples	Meters	Radiolaria	Preservation	*Guembelitria* sp.	*Hd. aptiana*	*Hd. excelsa*	*Hd. gorbachikae*	*Hd. infracretacea*	*Hd.* cf. *occulta*	*Hd. praelippa*	*Hd. ruka*	*Hd. trocoidea*	*Mi. miniglobularis*	*Mi. renilaevis*	*Mi.* cf. *pseudoplanispira*	*Mi.* aff. *rischi*	*Pa. rohri*	*Pa. transitoria*	*Ps. blakenosensis*	Age	Planktonic Foraminifera Zone
	FK +8.0	8.00		M										X	X		X				Early Albian	*Microhedbergella renilaevis*
	FK +7.5	7.50	R	M										X	X		X					
	FK +7.0	7.00		M										X	X		X					
	FK +6.5	6.50		M										X	X		X					
	FK +6.0	6.00		M										X	X		X					
	FK +5.5	5.50		M										X	X		X					
	FK +5.0	5.00	R	P										X	X		X					
	FK +4.5	4.50		P										X	X							
	FK +4.0	4.00	R	M										X	X							
	FK +3.5	3.50		P										X	X							
	FK +3.0	3.00		P										X	X							
	FK +2.5	2.50		P										X	X							
	FK +2.0	2.00		P										X	X							
	FK +1.8	1.80		P	X?									X	X							
	FK +1.6	1.60	R	P	X									X	X		X					
	FK +1.4	1.40		P	X?									X	X		X					
	FK +1.2	1.20	R	M										X	X							
	FK +1.0	1.00	R	P										X	X		X					
NIVEAU KILIAN	FK +0.8	0.80		P										X	X							
	FK +0.6	0.60		M										X	X	X	X					
	FK +0.4	0.40		P			X?							X	X							
	FK + 0.2	0.20		P																	Late Aptian	*Mi. miniglobularis*
	FK 0	0.00		P										X			X					
	FK -0.2	-0.20	R	P										X			X			X		
	FK - 0.4	-0.40		P						X				X		X	X					
	FK -0.6	-0.60	R	P										X		X	X					
	FK -0.8	-0.80	R	M			X							X						X		
	FK -1.0	-1.00	R	P										X								
	FK -1.5	-1.50		P			X			X							X					
	FK -2.0	-2.00		P							X?			X		X			X	X		
	FK -2.25	-2.25		P		X												X				*Paraticinella rohri*
	FK -2.5	-2.50		P													X	X		X		
	FK -3.0	-3.00		P		X											X	X		X		
	FK -3.5	-3.50		P		X			X?								X	X				
	FK -4.0	-4.00		M		X			X?								X			X		
	FK -4.25	-4.25		P		X			X									X				
	FK -4.5	-4.50	R	P		X			X								X	X	X			
	FK -5.0	-5.00		P		X														X		
	FK -5.5	-5.50		M					X									X		X		
	FK -6.0	-6.00		P		X						X						X		X		
	FK -6.5	-6.50		P		X																
	FK -7.0	-7.00		P														X	X	X		
	FK -7.5	-7.50	R	P		X					X	X						X	X			
	FK -8.0	-8.00	R	M							X							X	X	X		
	FK -8.5	-8.50		M							X	X	X					X		X		
	FK -9.0	-9.00		M		X		X	X		X	X						X	X	X		
	FK -9.5	-9.50		M		X	X	X	X		X	X						X	X	X		
	FK -10	-10.00		M		X	X	X	X		X	X						X	X	X		

Figure 7. Stratigraphic distribution of planktonic foraminifera in the Col de Pré-Guittard section.

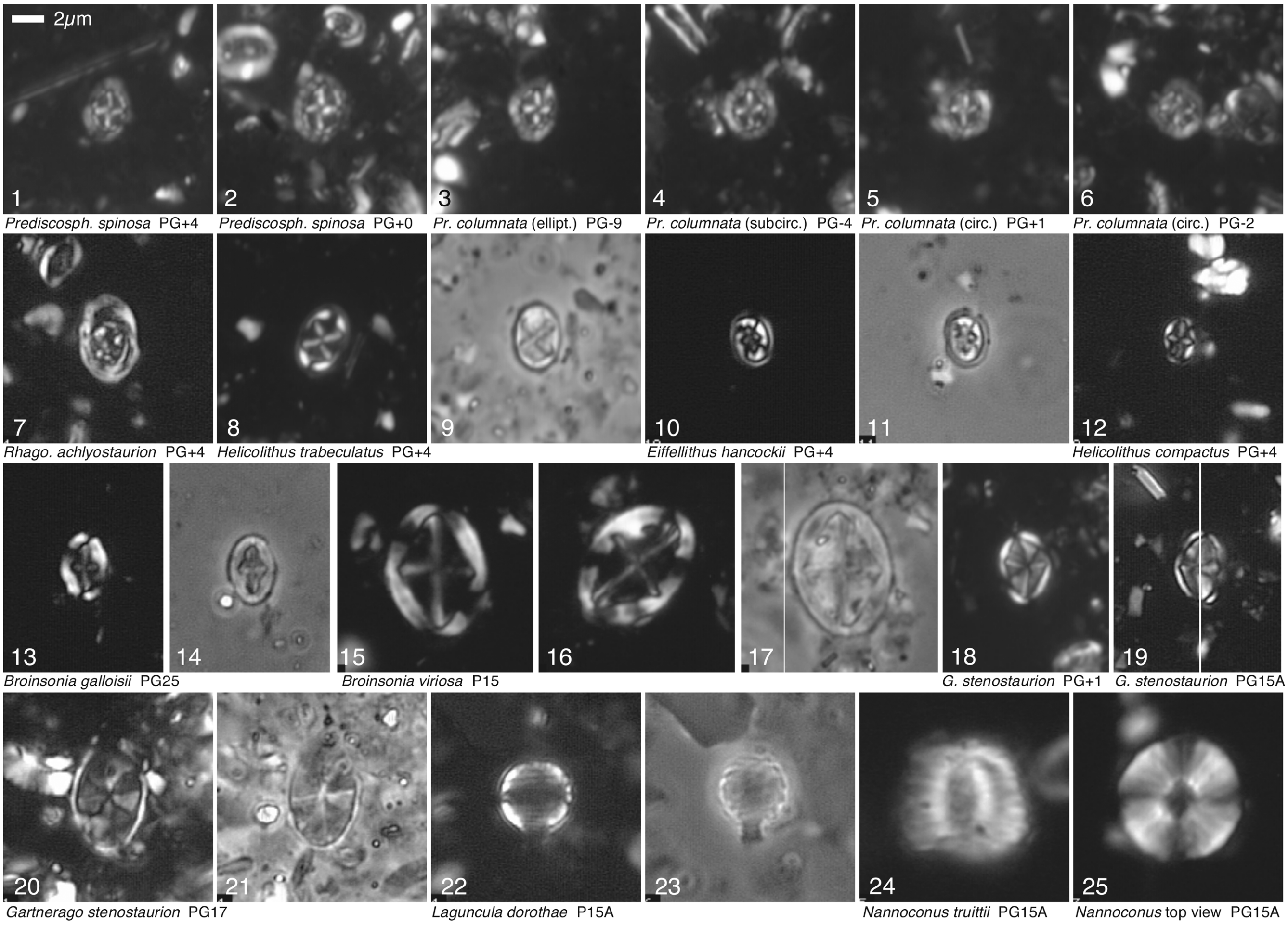

Figure 8. Nannofossils from the Col de Pré-Guittard section. 1, 2: Prediscospharea spinosa, 1: PG+4, 2: PG+0; 3: Prediscosphaera columnata (elliptical form), PG-9; 4, 5: Prediscosphera columnata (subcircular), 4: PG-4, 5: PG-1; 6: PG-2; 7: Rhagodiscus achyostaurion, PG-4; 8, 9: Helicolithus trabeculatus, PG+4; 10, 11: Eifellithus hancockii, PG+4; 12: Helicolithus compactus, PG+4; 13, 14: Broinsonia galloisi, PG25; 15–17: Broinsonia viriosa, PG15; 18–22, Gartnerago stenostaurion, 18: PG+1, 19: PG15A, 20, 21: PG17, 22; 23: Laguncula dorothae, PG15a; 24, 25: Nannoconus truittii.

(19) The first occurrence of the ammonite *Leymeriella (L) tardefurcata* at the base of the Niveau Paquier at 68 m. This datum corresponds to a distinctive geochemical signal in the organic matter present, a result of a significant contribution from Archaea (Kuypers et al., 2001, 2002). (The currently known distribution of *Leymeriella (L) tardefurcata* is Ardennes, Meuse, Aube, Drôme, Hautes Alpes, Alpes-de-Haute-Provence and Isère in France, southern England, Denmark, Germany, Switzerland, Austria, Bulgaria, the Caucasus, Kopetdag, Iran, and Turkmenistan.) The first occurrence of *Leymeriella tardefurcata* is a useful proxy for the base of the Albian in successions without calcareous microfossils (Seyed-Emami and Wilmsen, 2016).

(20) The first occurrence of the bivalve *Actinoceramus salomoni coptensis* at the base of the Niveau Paquier at 68 m. (The currently known distribution of the bivalve *Actinoceramus salomoni coptensis* is southern England, south-eastern France and Kazakhstan; *salomoni sensu stricto* is known from southern England, France, Switzerland, Kazkhstan, Georgia, and Azerbaijan. The *Actinoceramus* lineage is cosmopolitan.)

(21) The distinctive negative carbon-isotope excursion that begins just above the base of the Niveau Paquier in the Vocontian Basin, and is a local manifestation of Oceanic Anoxic Event (OAE) 1b. (This is a global event.)

(22) The first occurrence of the ammonite genus *Douvilleiceras* within the Niveau Paquier. (The currently known distribution of this genus is southern England, France, Switzerland, Germany, the Helvetic Zone of western Austria, Poland, Bulgaria, Romania, eastwards to Kazakhstan, Turkmenia, northern India, Pakistan, Japan, British Columbia, California, Arizona, New Mexico, and Texas in the United States, Peru, Colombia, Brazil, Tunisia, Algeria, Gabon, Angola, KwaZulu-Natal in South Africa, Mozambique, Somalia, and Madagascar.)

(23) The first occurrence of the ammonite genus *Oxytropidoceras* within the Niveau Paquier. (The geographic distribution of this genus extends from Western Europe (where it is very rare outside of south-eastern France) to Morocco, Tunisia, Angola, KwaZulu-Natal in South Africa, Madagascar, Pakistan, California, Texas, Mexico, Puerto Rico, Venezuela, Colombia, Peru, and Brazil.)

(24) The last occurrence of the ammonite *Hypacanthoplites anglicus* in the upper part of the Niveau Paquier. (The currently known distribution of this species is southeast and northern France, southern England, Germany, the Caucasus and Central Asia.)

(25) The termination of the negative carbon-isotope excursion,

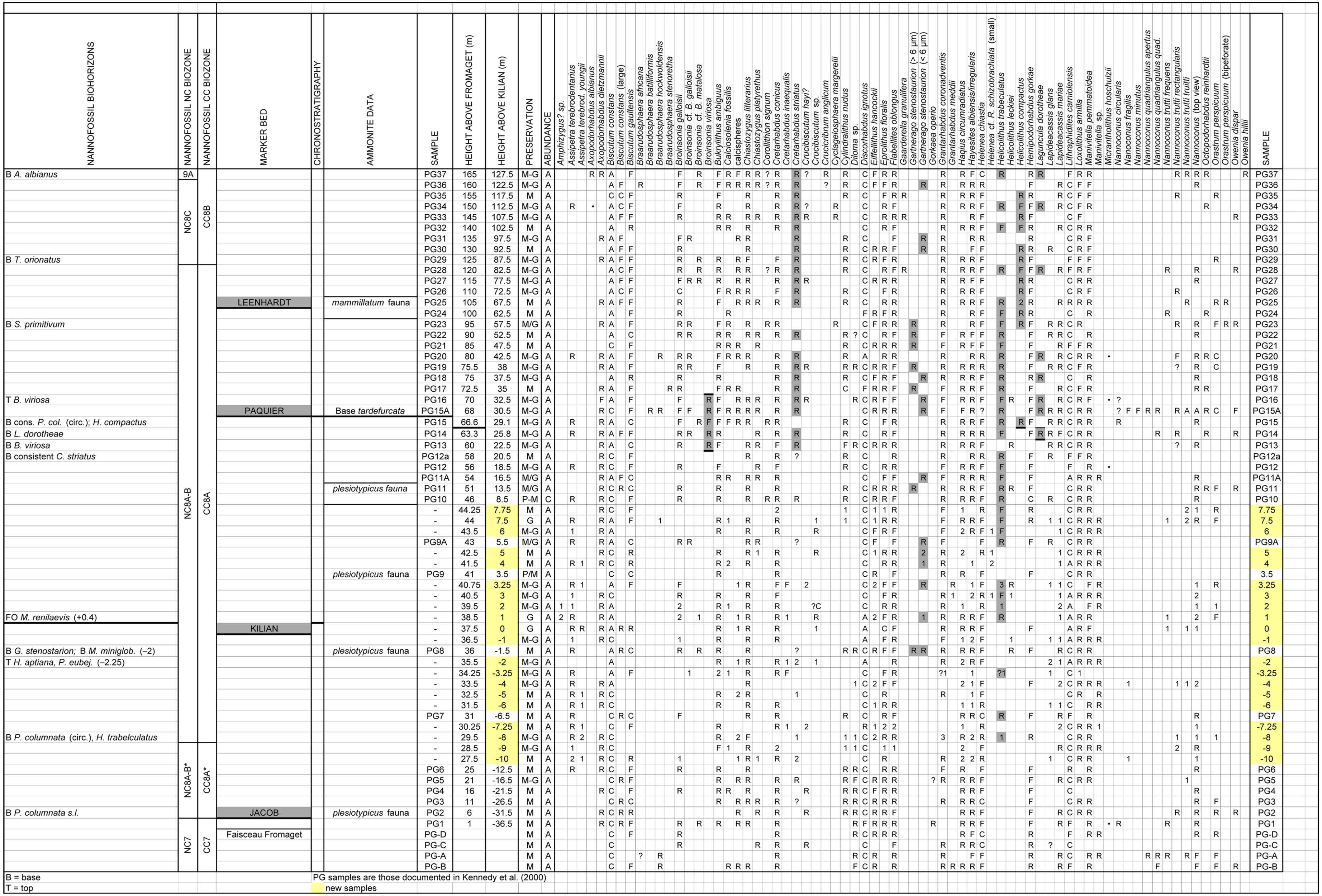

Figure 9. Stratigraphic range chart for calcareous nannofossils. Biostratigraphic marker species and other notable occurrences are shaded. Species abundance: A, > 10/field of view (FOV); C, 1–10/FOV; F, 1/2–10 FOV; R, 1/11–100 FOV; •, one or two specimens only; ?, questionable occurrence. Nannofossil abundance: A, > 10%; C, 1–10%; F, 0.1–1%; R, < 0.1%; B, barren. Nannofossil preservation: G, good; M, moderate; P, poor. Base (B) and Top (T) are used in the Biohorizons column. The lowermost parts of zones NC8 and CC8 are denoted with an asterisk to highlight the incoming of the two morphotypes of P.columnata.

Owenia partitum	Percivalia fenestratus	Percivalia howardii	Pickelhaube furtiva	Placozygus cf. P. fibuliformis	Prediscosphaera columnata (circular)	Prediscosphaera columnata (elliptical)	Prediscosphaera columnata (subcirc.)	Prediscosphaera spinosa	Prediscosphaera spines	Radiolithus hollandicus	Radiolithus orbiculatus	Radiolithus planus	Repagulum parvidentatum	Retecapsa crenulata	Retecapsa cf. P. madingleyensis	Retacapsa surirella	Rhabdophidites parallelus	Rhagodiscus achlyostaurion	Rhagodiscus achlyostaurion (no spine)	Rhagodiscus amplus	Rhagodiscus angustus	Rhagodiscus asper	Rhagodiscus asper (large, narr rim)	Rhagodiscus gallagheri	Rhagodiscus hamptonii	Rhagodiscus infinitus	Rhagodiscus sageri	Rhagodiscus splendens	Rotelapillus laffittei	Seribiscutum primitivum	Staurolithites canthus	Staurolithites crux	Staurolithites gausorhethium	Staurolithites glaber	Staurolithites cf. S. imbricata	Staurolithites mitcheneri	Staurolithites mutterlosei	Staurolithites siesseri	Staurolithites spp.	Stoverius achylosus	Stoverius baldiae	Stradnerlithus geometricus	Tegumentum stradneri	Tetrapodorhabdus coptensis	Tranolithus gabalus	Tranolithus orionatus	Tranolithus praeorionatus	Tubodiscus burnettiae	Watznaueria barnesae	Watznaueria bayackii	Watznaueria biporta	Watznaueria britannica	Watznaueria fossacincta	Watznaueria manivitiae	Zebrashapka vanhintei	Zeugrhabdotus bunwellensis	Zeugrhabdotus cf. Z. clarus	Zeugrhabdotus diplogrammus	Zeugrhabdotus cf. Z. diplogrammus	Zeugrhabdotus embergeri	Zeugrhabdotus embergeri (small)	Zeugrhabdotus howei	Zeugrhabdotus streetiae	Zeugrhabdotus scutula	Zeugrhabdotus trivectis?	Zeugrhabdotus xenotus	Zeugrhabdotus sp. small	SAMPLE	SPECIES RICHNESS
R	R				R			R		R	R	R	C	R		F		C		R	F	F		R	R	R		R	F	R			R	R			R	R	F	F			R		R	F		R	A		F		C					C		F	R	C	R		F	F	A	PG37	76
	R				F		R	F	R			C	F		F		C		R	C	F			R	R		R	F	R	R		R	R			R	R	F	F			F	R	R	F	R	F	A			F	R		R		C		R		F				F	A	PG36	68
R					F		R	R	F			C			C		C		F	F	C		F	R			R	F	F			F	F			R		F	F			R	R	R	R	R	R	A		R	C	R				F		R	R	F	R			F	A	PG35	62
	R	R			F		R	R	R	?		R	C	F	R	F		C	R	R	F	F			R	R		R	F	R	R		F	F				R	F	F			F	F	R	R	R	R	A		R	F	R				F		F	R		F			C	A	PG34	71
					F		R					C	F	R	F		C		F	F	C			R	R		R	F	R	F			F			R			R			F	F			R		A				F	R				F		F		F				F	A	PG33	53
					R		R					R	F			F		C			F	C			R			R	F	R	R			R			R	R	F	F			F		R	R			A		R		C					F		F		F				F	A	PG32	49
	R						R	R			R	R	F		F		C	R	F	F	F				R		R	F	R			F	R					F	F			F					R	A				F					C	R	F	R	F	R			C	A	PG31	51
		R			R					R	R	F			F		C	R	R	F	F						R	F				R					R	F	R			R		R		R	R	A				F					F		R	R	F	F			F	A	PG30	50
		R	R		R		R				F	C	R		F		C		F	C	F		F	R			R	F	R	?		F	R				R	F	R			R	R	R	R		R	A			R	F			R		C		F	R	C	R	R		C	C	PG29	65
	R								R		R	F			F		F		R	C	C			R			R	F	R	?			F			R		F				R	R	R		R		A		R	R	F			?		C		F		F	R			C	A	PG28	64
					R		R		R		R	R	R		F		C	R	F	C	F			R			R	F	R			R					R	F	R			F		R				A				F	R				F		F	R	F	R	R	R	R	A	PG27	59
													C	R		F		C	R	R	F	C			F	R		R	F	R				R			R	R				F				R	R	A				F					F		F	F	F	F			F	A	PG26	51
R	R			R	R		R		R	?	R	R	C			F		F		R	F	F		R	R				F	R	R		F	R				R	C	R			F		R			R	A				C					F		F		F	R			F	C	PG25	64
	R				R								F			F		R	R	R	F	F			R			F	F	R	R		F		R			R				R		F			R	A									R		F		F	R			F	A	PG24	44
R	R				R		R				R	C	R		F		C		R	F	F			R				F	R	F				R		R	R		R			R	R	R			R	A				C					C		F	R	F	R			R	A	PG23	63
	F				R		R						A	F		F		F	R	F	F	F			R	R		R	F		F				R									R	R				R	A		R	R	C		•			F		F		F	R			F	C	PG22	57
	R		R		R		F				R	C			F		F	F	R	F	F			R	R		F	C		R			R			R	F	C				R	F	R			R	A			R	C					F		F		F	R			F	C	PG21	55
	R				?		R	R				A	R		F		F		R	F	F		F				R	F					R	R				C				R	R	R			R	A			R	C			?		F		R	R	F				F	A	PG20	62
	R				R		F	F		R	R	C			C		F	R	R	F	F		R	R			F	C			F	?	R	F		R	F	C	R			F	R	R			F	A		R	R	C					R		R	R	F				F	A	PG19	69
	R			R	R		F	R	R	R	R	R	C		R	F		R		R	F	C		F	F	R		F	F				?	R	R		R	F	F	R			R	F	R			R	A			R	C			R		R		F		R	R			C	A	PG18	64
R	R				R		F	R				R	C		R	F		R		F	F	F		F	F	F		F	F				?	F			R	F	C	R			F	R	R			F	A			R	C					R		F	R	F	R			F	C	PG17	66
	F			R	1		F	R	R		R	R	C	R		F		F	R	F	C	C		F	F	R		F	F					R			R	R		R	R		F	F	R			F	A			R	C	F		R		F		F	F	F	R			C	A	PG16	73
R	R			R	1		R	R				R	F	R		R		R	R	R	F	F		C	F	R		F	C		?	F		?					F	F	R		R	F	R		R	F	C			F	C			R		R	R	F	F	F	R			F	C	PG15A	85
	R		R	R	1		R	R		?	F		C	R		F		F	R	R	F	F			R	R		F	F			R	R	R	R		R	R		R	R		F	F			R	R	A			R	C			R		F	R	F	F	F	R			C	A	PG15	75
			R				F	R			R		C	R		F		F	R	F	F	F		F	F	F		R	R			F	F		R		R	F	F	R			R	R	R			R	A		?	R	C			F		F	R	R	F	R	R		R	F	C	PG14	74
	R						F	R			R		F			F		F	F	R	F	C		C	R	R		R	F			F	F		R			R	C	R			R	R	R		R	R	A			R	C			F		F		F		F	R	R		F	C	PG13	65
	R						R	R			R	R	R	F		F			R	R	F	F		F	R	R			F			F					R	F	C	R			R	R				F	A		?		C	F		R		C	F	F		R	R	C		F	C	PG12a	55
							R	R				F			F		R	R	R	F	F		F	R	R		R	F					R				R	F	R			R	R	R			F	A			R	C			R		C	F	F	R	F	F	C		F	C	PG12	55
	R						R	R			R	C			F		F		F	C	F		R	R	R			F			F	F				R	F	C	F			R	F	R			F	A				C			F		F	R	R	F	F	R	?		F	C	PG11A	59
R							R	F			R	C			F		F	R	F	F	C		F	R				F				R	R	R			R	C	R			R	R	R		R	R	A		R	R	C			R		F		F	R	F	R		?	F	C	PG11	65
			R				F	R		R		R			F	R	F		F	R	F		F	R	R			F			F	?					F		R								F	C			R	F					F		R	R	R	R			F	C	PG10	55
			1				3	R				C			F		C		R	C	C			R				F								1	R	F	F			R	R				F	A	R								R		F		F	R	R		R	C	7.75	46
	1		F			2	1	3				F			F	R	F		F	C	F			R	R	1	R	F						R		1	F		F		1	R	F	R		R	F	A	F	R	F						C		F		C		R		F	A	7.5	67
			2			4	3				R	F			F		F	R	R	C	F			R				F						R			F	C	F			R	F				F	A	F		R	F	R		R		C		F		F		R		F	C	6	53
	R						R	R			R	C			F		F		R	C	C		F	R	R			C								R	R		F			F	F				F	A			R				R		C		F		R		R		F	C	PG9A	49
												F			F		R		R	C	C			F	R	R		F						R		R	R	C	F			R	F				F	A		R	F	C	?R		R		C	F	F	1		R			C	A	5	52
					1	1	3	1				C			F		R	R	R	F	C			R	R			F								R	R	C	F		1	F	C	R			F	A	F	R		C			R		C		F	1	R	R			F	C	4	56
												R	F	R		F		R		R	F	F		F	R				F			F						R	F	R			R	R			R	F	A			R	C					C		F						C	C	3.5	40
												F	C	F		F		F		3	C	F			R	F			F			R			R	?1	1	R	C	F			2	R				R	A							F		F	C	F	R	C	R			F	C	3.25	57
			1				2	1	1			R	C			F		R	1		R	F			R	F			F									R	C	F			R	C	R			R	A	F	R	F				F		C		F			R			C	C	3	53
						1		1	2				C	1		F		F	1	F	F	F			R	F	1		F					2				R	C	F			R	C			1	F	A	F	R	R	C			F		C		F		R	F			C	A	2	56
	1		1		1		R	R				R	C			F		F		F	C	F		R	R	R			F			C			1			R	C	F		2	F	C	R			R	A	F	R		C					C	R	R	R	C	R			F	A	1	65
					R	1	F	1	1			R	F	R		F		F		F	F	C		R		R			C			F				R	R	F	F	F			F	C	R			R	A	F	R	R	C					F		R		F	F			F	A	0	61
							F						1	C			F		R		R	F	C			R	1			F								R		C	F			F	C				F	A		R	R	C	R		R		C		F	R		R	R		C	A	-1	50
					?		F	R		R	R	R			R	R	R	R	R	F	C		C	R	R			R					?				F	F	R			R	R	F		R	F	A		R	R	R	R		R		F	F	F	R	F	R			F	A	PG8	66
			1		3	1	F				1	C			F		R			F	F	2	F		R			F			F				?1	F	F	C	R			R	F	F			F	A	R		R	C	F				C	F	F		F	R	R	?	F	F	-2	57
						1	1						C	F		F			2	F	R			R	F			R										F	F			1	F	1			R	A	F						F		F		R		F	R			F	F	-3.25	43
					2	2	R						R			F	R	R		R	F	C	1	R	1				F								R	R	C	R			F	F				F	A	F						1		C		F	R	C				F	A	-4	51
					1		1				R	C							R	R	F	3	R		R			F									R	C	F			F	F	R			R	A	F	R	R	C			R		C		R		C	R			F	C	-5	45
						2	1								F		F		R	R	C				R			F									R	C	R			R	F			1	F	A		R		F					C		F		C	R			F	C	-6	43
							R				R	R	R		C			R	R	R	F		F	R	R			F			F							C				R	F				R	A			R	C					C	R	F	R	F		R		F	A	PG7	48
						1	5				2	R			F		F		R	F	F				2			F									R	C	R			R					R	A	R		R	C	F		R		C		R	1	R	1	1		F	C	-7.25	49
	2				4	1	F						F			F			R		F	F								F									R	C	R			R	F				F	A		R			R			3	C		R		F	R			F	F	-8	51
	1						1	1						R			F		R		R	F	C	2		R	1			F							R	R	C	F			F	F	R			F	A	R	R					R		C		R		F	R			F	C	-9	51
	2							4						R			F		R		R	F	C	1		R	1			F								1	R	C	R			R	F	R			F	A	R		1	F	R		R		C		R	R	F	R			R	C	-10	55
	R						•			?	R	R		R		F		R		R	R	C		C	R			R	R									R		R			R	R	R			R	A				C	R		F		F		R		R	R			R	C	PG6	49
	R		R				R					F			F		R		R	R	C		C		R		R	F				R				R	R	C	R			R	F	R			F	A			R	C					F		R		F	R			F	C	PG5	55
							•	R			R	R	R			R			R		F		F	R	R			R								R	F				R	R				R	A			F	C					F		F		R	F			R	C	PG4	46
R							•	R			R		R			F		R		F		C		C				R	R			F			R				F	C			R	R			R	R	A			R	C			F		C		F		F	R			R	C	PG3	54
R	R						2	R			R		R	R		R			R	F	R	C		C		F			F								R	F	C	R			R	R	R		R	R	A			F	C	R		R		F		F		R	R	?		R	C	PG2	61
	R							R			R	R	R	R		F		R	R	R	R	F		F	R	R		R	F			F						R				R	R	R			R	A			F	C	R				F		R		F	R			R	C	PG1	59
1			•							R					F						F		C					R						R			R	F				F	R					A			R	C	R				F		R		R	R			R	A	PG-D	39
										F	R		R		R			R		F		C					R			R						R	F				R	R					A			R	C					F		R		F				F	C	PG-C	34
R										R		F	R							C		C					F						R			R	F				R						A			R	F					C		R		F	R			F	A	PG-A	41
R										R	R	C			R			R	R	?	F		C					F									R		R			R	R					A			R	C					F		R		R	F			R	C	PG-B	47

Figure 9. (continued).

which is situated at the top of the Niveau Paquier (OAE 1b) in the Col de Pré-Guittard section at approximately 70 m. (This is a global event.)

(26) The last occurrence of the nannofossil *Broinsonia viriosa* at 70 m. (Originally described from Boreal Realm (southern England), and now recorded from the Vocontian Basin.)

(27) The first occurrence of the nannofossil *Seribiscutum primi-*

tivum at 95 m. (This species is widely distributed in both Boreal and Tethyan realms, DSDP, ODP and IODP sites.)

(28) The Niveau Leenhardt, with ammonites of the *Douvilleiceras mammillatum* group, 101.5 m above the top of the Faisceau Fromaget at Pré-Guittard. (The currently known distribution of ammonites of the *Douvilleiceras mammillatum* group is southern England, France, Germany, Switzerland, Poland, Romania, Bulgaria, Kazakhstan, Turkmenistan, Iran, north-western India, northern Pakistan, Tunisia, Angola, northern KwaZulu-Natal in South Africa, Madagascar, and possibly Peru.)

(29) The occurrence of the ammonite *Hoplites (Isohoplites) steinmanni*, 109.5 m above the top of the Faisceau Fromaget at Pré-Guittard. (The currently known distribution of this species is southern England, France, Germany, Switzerland, Austria, Poland, Bulgaria, Russia, and Kazakhstan.)

Figure 4 plots selected markers against a lithostratigraphic log of the section. Figure 5 plots stable isotope data and planktonic foraminiferal ranges. Figure 6 illustrated key planktonic foraminifera. Figure 7 plots the stratigraphic distribution of planktonic forminifera. Figure 8 illustrates key nannofossils. Figure 9 plots the stratigraphic distribution of nannofossils.

Conclusions

It will be seen that the Pré-Guittard section provides:

- A Global boundary Stratotype Section and Point for the base of the Albian Stage that can be identified using the first occurrence of the planktonic foraminiferan *Microhedbergella renilaevis*, set within a matrix of secondary markers.
- The boundary point lies within the widely recognized crisis interval that affected planktonic foraminifera over wide areas of the globe within the lowermost NC8/CC8 nannofossil Zone.
- The boundary point coincides with the minimum value of a negative excursion of approximately 1‰ in carbonate $d^{13}C$ that can be traced into the Atlantic region (Trabucho Alexandre et al., 2011).
- The boundary point lies some distance beneath the onset of the negative stable carbon-isotope excursion associated with the Niveau Pacquier, recording the globally recognizable OAE 1b, as demonstrated through the work of Herrle (2002; see also Herrle, 2003; Herrle and Mutterlose, 2003; Herrle et al., 2003; Herrle et al., 2004) elsewhere in the Vocontian Basin, and recognised in the Col de Pré-Guittard section. It should be noted that some authors include the Niveau Kilian as a partial manifestation of a longer lasting episodic OAE1b or OAE1b cluster to accompany the Niveau Paquier and Niveau Jacob (Leckie et al., 2002: Trabucho Alexandre et al., 2011).
- The succession that contains the boundary is rhythmically bedded in the Vocontian Basin, and so has the potential for development of an orbital timescale.

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