

## Short Note

## Carbonate Content in CRP-3 Drillcore, Victoria Land Basin, Antarctica

H.G. DIETRICH\*, D. KLOSA &amp; C. WITTICH

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Stilleweg 2, D-30655 Hannover - Germany

Received 6 February 2001; accepted in revised form 9 July 2001

## Introduction

Determinations of total carbonate contents in the CRP-3 core yield additional information and knowledge, in the context of integrated investigations, thus enabling or enhancing the interpretation and characterization of depositional environment, sedimentation, and diagenesis. In the case of drilling profiles, they help to discern vertical gradation of facies sequences with repeating patterns or with changes in time.

A total of 98 bulk samples originating from the Palaeogene strata (Early Oligocene and ?Late Eocene) in the CRP-3 borehole were studied, the depth interval being 0-823.11 metres below sea floor (mbsf). Ages for the Cenozoic strata (Fig. 1) are taken from the Cape Roberts Science Team (2000a, 2000b), Bücker et al. (this volume), and Sagnotti et al. (2000, this vol.) and are shown in the columns A and B of figure 1. No investigations were performed on the underlying ?Devonian strata from 823.11-939.42 mbsf (final depth). Twenty-eight of a total of 34 lithostratigraphic Cenozoic units of the borehole were sampled (Appendix 1). Forty-seven samples (8.97-349.78 mbsf) are from the Early Oligocene section, whereas 51 samples (357.80-788.94 mbsf) originate from the Early Oligocene or ?Late Eocene strata. The sampling intervals are on average about 5-9 m for the Early Oligocene section and about 6-11 m in the Early Oligocene/?Late Eocene strata. All the samples were taken from sections of the profile of not more than 1-2 cm thickness. The samples were split; the portions of the samples were used for investigations with regard to clay minerals (Ehrmann, this volume), heavy minerals (Ehrmann, this volume), and mineralogy as revealed by XRD analyses (Neumann & Ehrmann, this volume).

## Methods

The bulk samples were freeze-dried, ground, and homogenized before analysing for carbonates. In order to determine total carbonate contents, a method was applied which measures the CO<sub>2</sub> set free in the carbonate-acid reaction not volumetrically, like in

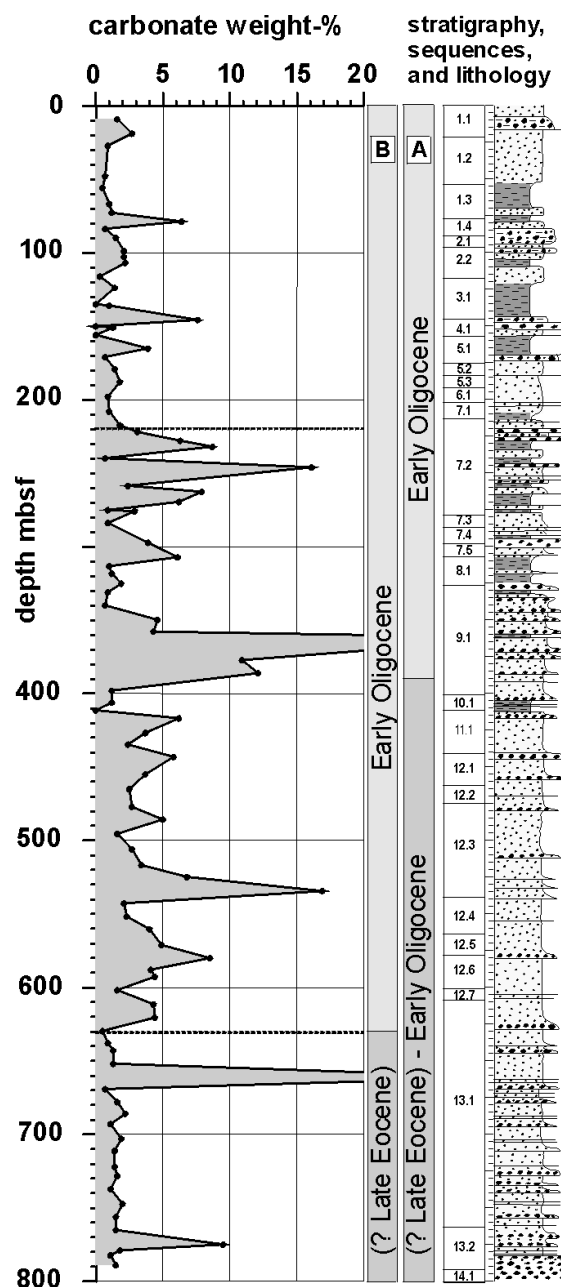
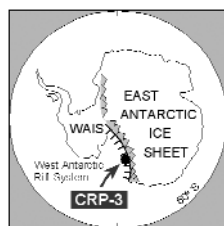


Fig. 1 - Profile of total carbonate contents in CRP-3 bulk samples. Lithology, sequences and stratigraphy (column A) according to Cape Roberts Science Team (2000a). Column B shows the stratigraphy according to Sagnotti et al. (2000 and this volume).

\*Corresponding author (present address: Paul Pfizer-Str. 22, 72762 Reutlingen - Germany)

gasometric standard analyses, but by measuring the pressure in the reaction vessel as a function of time, using pressure sensors and a PC-based data acquisition system for the digitized data (Dietrich et al. 2000, Klosa 1994).

## Results

The plot of carbonate contents versus depth (Fig. 1) exhibits a trend of a general subdivision into three parts with an increase of carbonate contents in the lower part of the Early Oligocene (column B of Fig. 1). An increased percentage (> 30% in weight) of carbonates was measured in the CRP-3 profile only in two sections (unit 9.1 and 13.1), with peaks of 32.5% and 30.7% in weight, respectively (Fig. 1). A slightly elevated percentage (> 10% in weight) of carbonates was measured in the CRP-3 profile only in four sections (units 7.2, 9.1 and 12.3), with peaks between 10.9-16.9% in weight (Fig. 1). The remainder of the sediments in the profile shows lower carbonate contents.

With the exception of two samples (6.4% and 7.6% in weight: units 1.4 and 4.1 resp.), carbonate contents in Early Oligocene sediments above c. 220 mbsf range from 0.0 to 3.9% in weight. In the middle borehole section, between about 220-630 mbsf (Early Oligocene), carbonate contents range from 0.7 to 8.5% in weight except for four peaks with > 10% in weight. These values are somewhat higher than those of the upper section. In the lower section of the profile from about 630-790 mbsf (units 13.1 and 13.2) in Early Oligocene/?Late Eocene or ?Late Eocene sediments (column A and B of Fig. 1), the measured values are generally < 2.2% in weight (0.5-2.2% in weight), except for two peaks with > 9.5% in weight. The carbonate profile in the lower part shows less variation than that of the younger sediments. In spite of the rather coarse sampling in some units or subunits and the limited number of determinations, especially in the Early Oligocene and ?Late Eocene strata (Sagnotti et al. 2000 and Sagnotti et al., this vol.), and considering the results of the studies of the Cape Roberts Science Team (2000a, 2000b) available so far, several characteristics are apparent:

It is obvious from appendix 1 that carbonate contents in all lithologies have been determined nearly exclusively in horizons that lack calcareous skeletal material, except for three samples, in which carbonate cement is probably associated with calcareous macro/micro fossil fragments and/or shell debris. In addition, it can be said that the carbonate bulk analyses in this Cenozoic strata, as presented here, offer the possibility, to discriminate between different lithologic sequences or different stratigraphic units.

Carbonate contents of the investigated samples of the Cenozoic sedimentary sequence (0-823 mbsf) are of diagenetic origin, as shown by several macro/microscopic features (Cape Roberts Science Team 2000a, 2000b):

1 - Carbonate contents above c. 220 mbsf (upper part

of Early Oligocene) are linked to local patches of carbonate cement or weakly carbonate-cemented horizons (especially sandy mudstones, muddy and/or fine-grained sandstones), to a carbonate-cemented matrix in diamictites and conglomerates, to carbonate-cemented and/or carbonate-bearing sandstone and pebble clasts, and to carbonate-filled (hairline) veins and thin fractures;

- 2 - the middle part of the profile at depths of c. 220-630 mbsf (lower Early Oligocene and ?Late Eocene) are characterized by extensively carbonate-cemented sandstone and conglomerate lithologies. The carbonate cementation occurs as patches or nodular carbonate cement, carbonate cement enhanced stratification and carbonate-filled veins and fractures, especially where carbonate contents are higher than 3-4% in weight;
- 3 - at depths from c. 630 to 790 mbsf (?Late Eocene), most of the lithological units contain weakly or locally carbonate-cemented, muddy, very fine to fine-grained sandstones. Some elevated or slightly elevated carbonate contents are caused by nodular carbonate cement or carbonate-filled fractures.

Correlations of these first results with results of detailed palaeontological, sedimentological, mineralogical, petrographical, and geochemical investigations will be done as soon as these other investigations are complete. For this purpose, because of the low carbonate contents, the measurements of the total carbonate (calcite, dolomite siderite and carbonate mixtures contents) will be repeated. In addition, results obtained so far will be supplemented by bulk chemical analyses (XRF) and selective dissolution of the carbonates in the sediment combined with ICP-MS analyses, in order to be able to determine carbonate components of the samples quantitatively.

## REFERENCES

- Bücker C.J., Jarrard R.D., Niessen F. & Wonik T., 2001. Statistical analysis of wireline logging data of the CRP-3 drillhole, Victoria Land, Antarctica. This volume.
- Cape Roberts Science Team, 2000a. Initial Report on CRP-3, Cape Roberts Project, Antarctica. *Terra Antarctica*, **7**, 1-209.
- Cape Roberts Science Team, 2000b. Core Logs and Core Box Images, Supplement to Initial Report on CRP-3, Cape Roberts Project, Antarctica. *Terra Antarctica*, Supplement to **7**, 305p.
- Dietrich, H.-G., Klosa, D. & Wittich, C., 2000. Carbonate Contents in CRP-2/2A, Victoria Land Antarctica. *Terra Antarctica* 2000, **7**, 355-357.
- Neumann M., 2001. Preliminary investigations of the heavy mineral record from CRP-3 drillcore, Victoria Land Basin, Antarctica. This volume.
- Klosa D., 1994. Eine rechnergestützte Methode zur Bestimmung des Gesamtkarbonatgehaltes in Sedimenten und Böden. *Z. angew. Geol.*, **40**, 18-21.
- Neumann M. & Ehrmann W., 2001. Mineralogy of sediments from CRP-3, Victoria Land Basin, Antarctica, as revealed by X-ray diffraction. This volume.
- Sagnotti, L., Roberts, A.P., Verosub, K.L., Florindo, F., Wilson, G.S. & Cape Roberts Science Team 2000. An Environmental Magnetic Record of Cenozoic Antarctic Climate. American Geophysical Union, Fall Meeting San Francisco, 15.-19.12.2000, Abstract Volume, F753p.
- Sagnotti L., Verosub K.L., Roberts A.P., Florindo F. & Wilson G.S., 2001. Environmental magnetic record of the Eocene-Oligocene transition in CRP-3 drillcore, Victoria Land Basin, Antarctica. This volume.

Appendix 1 - Sample intervals and first results of carbonate content of CRP-3 samples (notes of lithology combined after Cape Roberts Science Team, 2000a, 2000b).

Box 3 (No.)	Sample Depth (mbsf)	Lithostratigraphic Subdivision		Carbonate Content (Wt - %)
		Unit (No.)	Sediment Type in Sampled Section	
2	8.97	1	1.1 clast-poor sandy diamictite; pyrit- and carbonate-cemented (?)	1.6
5	18.95	2	1.2 weakly laminated, muddy sandstone; dispersed clasts, carbonate-cemented	2.7
7	27.07	3	1.2 weakly laminated, muddy medium-grained sandstone with dispersed clasts	0.9
14	47.85	4	1.2 sandstone with dispersed clasts	0.7
16	55.84	5	1.3 sandy mudstone with dispersed clasts; brecciated zone ?	0.5
20	66.73	6	1.3 sandy mudstone, brecciated zone	1.0
21	72.77	7	1.4 thinly bedded very fine-grained sandstone; carbonate-cemented (?)	1.2
24	78.74	8	1.4 very fine sandstone; carbonate-cemented and carbonate-filled fractures (?)	6.4
26	83.72	9	2.1 clast-poor sandy diamictite	0.7
28	89.88	10	2.1 clast-poor sandy diamictite; carbonate-cemented clasts ?	1.5
31	98.91	11	2.2 clast-poor muddy diamictite; thin carbonate-filled veins; fossils ?	2.1
32	102.78	12	2.2 sandy clast-poor diamictite; patchy carbonate cement, carbonate-filled fractures?	2.1
34	106.95	13	2.2 sandy mudstone, dispersed clasts; carbonate-filled fractures and veins ?	2.2
37	116.12	14	2.2 muddy fine-grained sandstone with a few dispersed clasts	0.3
39	123.81	15	3.1 sandy mudstone; patchy carbonate cement	1.4
43	135.02	16	3.1 sandy mudstone with dispersed clasts	0.0
43	135.94	17	3.1 sandy mudstone with dispersed clasts; carbonate cement (?)	1.0
47	145.72	18	4.1 sandy conglomerat; carbonate-cemented matrix and carbonate-filled veins	7.6
48	150.01	19	4.1 sandy, pebble conglomerat; matrix: poorly sorted	0.0
48	150.83	20	4.1 sandy, pebble conglomerat; matrix: poorly sorted; carbonate cementation	1.3
50	155.97	21	4.1 mudstone, interbedded in fine- to medium-grained sandstone	0.0
53	165.09	22	5.1 sandy mudstone, dispersed clasts; carbonate-filled fractures; fossil fragments ?	3.9
55	170.95	23	5.2 muddy fine-grained sandstone; clast-rich	0.7
58	179.06	24	5.3 very fine- to fine-grained sandstone; patchy carbonate cement	1.4
61	187.92	25	6.1 muddy fine sandstone with dispersed clasts; patchy carbonate cement	1.8
64	197.88	26	6.1 fine-grained sandstone with dispersed clasts; carbonate-cemented	0.9
67	208.00	27	7.1 medium-grained sandstone; patchy carbonate cement	1.0
70	217.32	28	7.2 Mudstone, very fine-grained sandstone; carbonate-filled hairline fractures (?)	1.8
72	221.91	29	7.2 pebbly sandstone, poorly sorted matrix; carbonate-filled thin fractures	3.1
74	227.90	30	7.2 pebbly conglomerate, poorly sorted; nodular carbonate cement (?)	6.3
75	231.98	31	7.2 sandy mudstone with abundant fractures; carbonate-filled thin fractures	8.7
78	239.84	32	7.2 medium-grained sandstone with dispersed clasts; carbonate cement ?	0.7
80	246.03	33	7.2 medium sandstone; nodular carbonate cement, carbonate-filled thin fractures	16.1
84	258.57	34	7.2 heavily brecciated mudstone, dispersed clasts; carbonate-filled fractures ?	2.4
85	262.70	35	7.2 strongly fractured medium sandstone with clasts; carbonate-filled veins (?)	7.9
87	269.51	36	7.3 sandy mudstone, dispersed clasts; nodular carbonate-cemented (?)	6.2
89	275.10	37	7.4 medium-grained sandstone with dispersed clasts; carbonate-cemented	0.9
89	275.81	38	7.4 sandy mudstone, rare dispersed clasts; carbonate-filled fractures	2.9
92	283.90	39	7.4 fine-grained sandstone, well-sorted and well-stratified; carbonate-cemented	0.9
96	297.31	40	7.5 pebble conglomerate, moderately sorted; carbonate-cemented	3.9
99	307.21	41	8.1 pebbly medium sandstone; patchy carbonate cement, carbonate-filled fractures	6.1
101	313.31	42	8.1 sandy mudstone with dispersed clasts; patchy carbonate cement	1.0
103	318.36	43	8.1 muddy medium sandstone, dispersed clasts; carbonate cement; fossils ?	1.2
105	325.10	44	9.1 muddy fine-grained sandstone with dispersed clasts; carbonate-cemented	1.9
107	330.97	45	9.1 fine-grained sandstone; preferentially carbonate-cemented	0.9
110	339.98	46	9.1 muddy fine-grained sandstone with dispersed clasts	0.7
113	349.78	47	9.1 pebbly medium sandstone; scattered nodular and patchy carbonate cement (?)	4.6
115	357.80	48	9.1 medium-grained sandstone; scattered nodular carbonate cement	4.3
116	361.92	49	9.1 slightly muddy, fine sandstone; carbonate-cemented; carbonate-filled fractures	32.5
120	377.23	50	9.1 medium sandstone with dispersed small gravel; (?) nodular carbonate-cemented	10.9
121	386.13	51	9.1 pebbly conglomerate; medium sandstone matrix; carbonate-filled fracture	12.1
124	397.97	52	9.1 medium-grained sandstone; patchy carbonate cement	1.2
126	406.09	53	10.1 sandy mudstone; carbonate-cemented	1.2
127	411.29	54	10.1 mudstone, apparently unstratified	0.0
129	416.80	55	11.1 pebbly, coarse sandstone; carbonate-cemented; carbonate-filled fractures ?	6.2
131	426.72	56	11.1 fine-grained sandstone; nodular carbonate cement ?	3.7
133	434.62	57	11.1 fine-grained sandstone with dispersed small clasts; carbonate cement	2.4
135	443.05	58	11.1 pebble conglomerate; carbonate and pyrit cements	5.8
138	454.95	59	12.1 fine-grained sandstone; carbonate-cemented and carbonate-filled fracture ?	3.7
140	464.95	60	12.3 fine-grained sandstone; nodular carbonate cement	2.5
143	477.01	61	12.3 fine-/medium sandstone, carbonate-cemented; carbonate-filled fracture (?)	2.7
145	485.63	62	12.3 medium-grained sandstone, poorly sorted; carbonate and pyrit cement	5.0
148	495.39	63	12.3 medium sandstone with small gravel; scattered carbonate and pyrit cement	1.6
149	505.82	64	12.3 fine-grained sandstone; nodular carbonate cement, pyrit cement (?)	2.7
152	516.68	65	12.3 fine-/medium-grained sandstone; carbonate-cemented	3.4
154	524.78	66	12.3 pebbly coarse sandstone; carbonate-cemented, carbonate-filled fracture	6.8
156	534.39	67	12.3 medium sandstone; carbonate cementation and carbonate-filled fractures	16.9
158	542.73	68	12.4 fine sandstone; carbonate-cemented, carbonate cementation around clasts	2.1

## Appendix 1 - Continued.

Box 3 (No.)	Sample Depth (mbsf)		Lithostratigraphic Subdivision		Carbonate Content (Wt - %)
			Unit (No.)	Sediment Type in Sampled Section	
158	542.73	68	12.4	fine sandstone; carbonate-cemented, carbonate cementation around clasts	2.1
160	551.69	69	12.4	fine-grained sandstone; carbonate cementation	2.3
162	560.24	70	12.5	fine sandstone; carbonate cementation, carbonate-filled fractures (?)	4.0
165	571.10	71	12.5	medium-grained sandstone, with clasts; nodular carbonate-cemented	4.9
167	579.95	72	12.6	coarse sandstone; dispersed small gravel; extensive carbonate cementation	8.5
169	587.89	73	12.6	fine sandstone; nodular carbonate cement, carbonate-filled fractures (?)	4.1
170	592.71	74	12.6	fine sandstone; nodular carbonate cementation	4.4
172	601.75	75	12.6	fine sandstone; dispersed gravel; carbonate cementation	1.6
175	611.42	76	13.1	fine/medium-grained sandstone; nodular carbonate cement	4.3
177	620.48	77	13.1	fine-grained sandstone; nodular carbonate cement	4.4
179	629.58	78	13.1	fine-grained sandstone, dispersed gravel; weak carbonate cement	0.5
181	637.79	79	13.1	muddy, fine-grained sandstone; carbonate-cemented	0.9
182	642.81	80	13.1	muddy, fine sandstone with dispersed gravel; carbonate-cemented	1.3
184	651.81	81	13.1	muddy, very fine sandstone; carbonate cemented, small carbonate nodules (?)	1.3
186	661.05	82	13.1	slightly muddy, fine sandstone; extensive carbonate cementation, (?) nodules	30.7
188	669.06	83	13.1	fine-grained sandstone, slightly muddy; carbonate-cemented ?	0.7
191	677.91	84	13.1	medium-grained sandstone with dispersed gravel; carbonate-cemented	1.6
193	685.93	85	13.1	fine-grained sandstone, dispersed gravel; carbonate cement	2.2
194	692.85	86	13.1	myddy, fine-grained sandstone, dispersed gravel; carbonate-cemented (?)	1.1
197	702.94	87	13.1	myddy, fine-grained sandstone; carbonate-cemented, carbonate-filled fracture	1.9
199	711.07	88	13.1	coarse-grained sandstone with clasts; carbonate-cemented	1.4
202	721.92	89	13.1	fine-grained muddy sandstone, carbonate-cemented	1.4
203	728.17	90	13.1	pebbly medium/coarse-grained sandstone; carbonate-cemented	1.6
205	737.09	91	13.1	fine-grained muddy sandstone; diffuse carbonate cementation	1.1
208	747.25	92	13.1	fine-grained sandstone; carbonate cementation	2.0
210	755.95	93	13.1	fine-grained sandstone; carbonate-cemented	1.5
212	765.01	94	13.1	very fine-grained sandstone with sandy mudstone; carbonate-cemented	1.5
215	774.87	95	13.2	pebbly medium/coarse-grained sandstone; strongly carbonate-cemented	9.5
216	778.93	96	13.2	slightly muddy, medium sandstone; carbonate-filled hairline fractures (?)	1.8
217	782.25	97	13.2	muddy fine-grained sandstone; carbonate-cemented	1.1
218	788.94	98	13.2	muddy, very fine sandstone; carbonate-cemented	1.5