Early Oligocene Siliceous Microfossil Biostratigraphy of Cape Roberts Project Core CRP-3, Victoria Land Basin, Antarctica

D.M. HARWOOD1* & S.M. BOHATY2

1Department of Geosciences, University of Nebraska-Lincoln, Lincoln, NE 68588-0340 - USA
2Earth Sciences Department, University of California, Santa Cruz, CA 95064 - USA

Received 29 October 2000; accepted in revised form 19 November 2001

Abstract - Early Oligocene siliceous microfossils were recovered in the upper c. 193 m of the CRP-3 drillcore. Although abundance and preservation are highly variable through this section, approximately 130 siliceous microfossil taxa were identified, including diatoms, silicoflagellates, ebridians, chrysophycean cysts, and endoskeletal dinoflagellates. Well-preserved and abundant assemblages characterize samples in the upper c. 70 m and indicate deposition in a coastal setting with water depths between 50 and 200 m. Abundance fluctuations over narrow intervals in the upper c. 70 mbsf are interpreted to reflect environmental changes that were either conducive or deleterious to growth and preservation of siliceous microfossils. Only poorly-preserved (dissolved, replaced, and/or fragmented) siliceous microfossils are present from c. 70 to 193 mbsf. Diatom biostratigraphy indicates that the CRP-3 section down to c. 193 mbsf is early Oligocene in age. The lack of significant changes in composition of the siliceous microfossil assemblage suggests that no major hiatuses are present in this interval. The first occurrence (FO) of Cavittatus jouseanui at 48.44 mbsf marks the base of the Cavittatus jouseanui Zone. This datum is inferred to be near the base of Subchron C12n at c. 30.9 Ma. The FO of Rhiicosolenia antarctica at 68.60 mbsf marks the base of the Rhiicosolenia antarctica Zone. The FO of this taxon is correlated in deep-sea sections to Chron C13 (31.1 to 33.6 Ma). However, the lower range of R. antarctica is interpreted as incomplete in the CRP-3 drillcore, as it is truncated at an underlying interval of poor preservation; therefore, an age of c. 31.1 to 30.9 Ma is inferred for interval between c. 70 and 50 mbsf. The absence of Hemianthus caracteristicus from diatom-bearing interval of CRP-3 further indicates an age younger than c. 33 Ma (Subchron C13n) for strata above c. 193 mbsf. Siliceous microfossil assemblages in CRP-3 are significantly different from the late Eocene assemblages reported CIROS-1 drillcore. The absence of H. caracteristicus, Stephanopyxis splendidus, and Pierotheca danica, and the ebridians Ebiopsis coronata, Pyrebropsis fallax, and Pseudammodiscus dicytoides in CRP-3 indicates that the upper 200 m of the CRP-3 drillcore is equivalent to part of the stratigraphic interval missing within the unconformity at c. 366 mbsf in CIROS-1.

INTRODUCTION

Cape Roberts Project drillcore CRP-3 is the third in a series of drillcores that sampled eastward dipping strata on the western edge of the Victoria Land Basin, Ross Sea, Antarctica. Cores CRP-1, CRP-2/2A, and CRP-3 represent a composite section of c. 150 m through lower Miocene to lower Oligocene strata. Combined, these drillcores provide a proxy record of climate and sea level change between c. 17 and 33 Ma on the Ross Sea margin of East Antarctica. These strata were deposited in a marine environment, and consist largely of elastic sediment that exhibits influence from cyclic sedimentation thought to be a result of both glacio-eustatic variation and local glacial advance and retreat. The recovery of this composite section enables the development of a biostratigraphic framework for the lower Oligocene through lower Miocene based on siliceous microfossils (marine diatoms, silicoflagellates, ebridians, chrysophycean cysts and endoskeletal dinoflagellates). Calibration of siliceous microfossil datums to the magnetic polarity time scale will advance future age determinations of the Oligocene and Miocene on the Antarctic shelf.

The CRP-3 site is located 12 km east of Cape Roberts (77.01°S, 163.64°E) at 295 m water depth. The CRP-3 drillhole was cored from a depth of 2.80 to 939.42 mbsf with 97% recovery. Glaciomarine strata between c. 3 and 823 mbsf were tentatively dated as early Oligocene in age, although a latest Eocene age is possible for the lower part of this section based on magnetic polarity data (Cape Roberts Science Team, 2000; Florindo et al., this volume). Sediment-accumulation rates were most likely high through this section; the chronology of the CRP-2/2A drillcore (Wilson et al., 2000) identifies Oligocene accumulation rates that approach and likely exceed 1000 m/m.y. Beacon Sandstone of mid Devonian age underlies the Palaeogene strata of CRP-3 between

*Corresponding author (dharwood@unlserve.unl.edu)
contains only trace to rare diatoms. Only rare, poorly preserved assemblages are present in the interval between 71.3 and 193.2 mbsf, and all samples below 193.2 mbsf are barren.

Approximately 120 marine diatom taxa, 6 silicoflagellate taxa, 8 ebridian and other siliceous flagellate taxa, and 3 chrysophyte cyst taxa were identified in the rich interval of siliceous microfossils above c. 70 mbsf (Tab. 2). This upper interval corresponds to Lithostratigraphic Units (LSU) 1.1, 1.2, and 1.3 (2.85 to 66.71 mbsf) (Cape Roberts Science Team, 2000). Many samples in this section contain a high species richness of siliceous microfossils (Fig. 1), and excellent preservation is exemplified by the presence of articulated valves of *Pyxilla* spp. and *Ezoressia irregularis* (see Plate 3, Figs. 1-3; Plate 4, Figs. 1, 2, 5, 8).

Poorly-preserved diatom specimens between 193 and 85 mbsf are commonly etched, fragmented, or replaced (i.e. silicified casts are present). Assemblages in this interval have undergone significant diageneric alteration and are interpreted to represent "residual" assemblages that were once rich in siliceous microfossils (e.g. c. 120-130 mbsf and c. 190-195 mbsf). Although the section currently resides at relatively shallow seafloor depths, prior burial at much deeper levels may have resulted in extensive opal dissolution.

### CRP-3 BIOSTRATIGRAPHY

Several diatom taxa present in CRP-3 assemblages are well-documented in Southern Ocean drillcores (Harwood & Maruyama, 1992). As discussed above, however, most Southern Ocean taxa, are rare in CRP-3 and occur sporadically. Until a biozonation is developed for Antarctic shelf sediments, correlation and age control for CRP-3 must be derived through linkage to the Southern Ocean diatom biostratigraphy.

In CRP-3, the first occurrence (FO) of *Cavitatus joueasius* occurs between 48.44 and 49.68 mbsf and marks the base of the *Cavitatus joueasius* Zone of Scherer et al. (2000). The top of this zone is identified by the last occurrence (LO) of *Rhizosolenia antarctica*, which is noted in the CRP-2A drillcore at a depth of 441.85 mbsf (Scherer et al., 2000).
The age of the FO of *Cavitatus jouseanus* has been determined at several Southern Ocean sites, but is applied in the present study with some caution. In ODP Hole 748B (Kerguelen Plateau), this datum occurs within the lower part of the calcareous nannofossil *Chiasmolithus altus* Zone. near the boundary between Subchrons C12n and C12r (Baldauf & Barron, 1991; Banon et al., 1991, Fig. 10). Fenner (1984)

The age of the FO of *Cavitatus jouseanus* has been determined at several Southern Ocean sites, but is applied in the present study with some caution. In ODP Hole 748B (Kerguelen Plateau), this datum occurs within the lower part of the calcareous nannofossil *Chiasmolithus altus* Zone. near the boundary between Subchrons C12n and C12r (Baldauf & Barron, 1991; Banon et al., 1991, Fig. 10). Fenner (1984)

<table>
<thead>
<tr>
<th>Upper Depth (mbsf)</th>
<th>Lower Depth (mbsf)</th>
<th>Ecological Notes</th>
<th>Planktonic Species Richness</th>
<th>Diatoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.38</td>
<td>2.36</td>
<td>12</td>
<td>R R R R R R R X X R R R R X X R R</td>
<td></td>
</tr>
<tr>
<td>3.05</td>
<td>3.06</td>
<td>24</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>5.01</td>
<td>5.02</td>
<td>28</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>6.07</td>
<td>6.08</td>
<td>32</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>1.83</td>
<td>1.84</td>
<td>36</td>
<td>R X X X X X X X X X X X X X X X X</td>
<td></td>
</tr>
<tr>
<td>8.15</td>
<td>8.16</td>
<td>40</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>6.09</td>
<td>6.10</td>
<td>44</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>10.36</td>
<td>10.37</td>
<td>48</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>13.64</td>
<td>13.65</td>
<td>52</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>13.52</td>
<td>13.53</td>
<td>56</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>14.46</td>
<td>14.47</td>
<td>60</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>22.70</td>
<td>22.71</td>
<td>64</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>23.40</td>
<td>23.41</td>
<td>68</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>28.44</td>
<td>28.45</td>
<td>72</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>32.09</td>
<td>32.10</td>
<td>76</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>32.39</td>
<td>32.40</td>
<td>80</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>34.58</td>
<td>34.59</td>
<td>84</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>36.61</td>
<td>36.62</td>
<td>88</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>37.29</td>
<td>37.30</td>
<td>92</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>38.78</td>
<td>38.79</td>
<td>96</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>39.12</td>
<td>39.13</td>
<td>100</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>40.00</td>
<td>40.01</td>
<td>104</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>40.13</td>
<td>40.14</td>
<td>108</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>44.18</td>
<td>44.19</td>
<td>112</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>44.91</td>
<td>44.92</td>
<td>116</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>46.31</td>
<td>46.32</td>
<td>120</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>46.73</td>
<td>46.74</td>
<td>124</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>48.64</td>
<td>48.65</td>
<td>128</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>49.64</td>
<td>49.65</td>
<td>132</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>50.23</td>
<td>50.24</td>
<td>136</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>51.56</td>
<td>51.57</td>
<td>140</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>54.19</td>
<td>54.20</td>
<td>144</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>54.77</td>
<td>54.78</td>
<td>148</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>56.18</td>
<td>56.19</td>
<td>152</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>57.71</td>
<td>57.72</td>
<td>156</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>57.37</td>
<td>57.38</td>
<td>160</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>61.70</td>
<td>61.71</td>
<td>164</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>62.08</td>
<td>62.09</td>
<td>168</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>63.64</td>
<td>63.65</td>
<td>172</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>64.44</td>
<td>64.45</td>
<td>176</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>66.70</td>
<td>66.71</td>
<td>180</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>68.39</td>
<td>68.40</td>
<td>184</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>73.00</td>
<td>73.01</td>
<td>188</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>74.00</td>
<td>74.01</td>
<td>192</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>75.77</td>
<td>75.78</td>
<td>196</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>77.80</td>
<td>77.81</td>
<td>200</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>78.24</td>
<td>78.25</td>
<td>204</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>80.00</td>
<td>80.01</td>
<td>208</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>80.00</td>
<td>80.01</td>
<td>212</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
<tr>
<td>80.00</td>
<td>80.01</td>
<td>216</td>
<td>R R R R R R R R R R R R R R R R</td>
<td></td>
</tr>
</tbody>
</table>

*Tab. 7: Relative abundance and occurrence data for selected siliceous microfossil taxa in the upper 200 metres of CRP-3. Ecology notes column reflects the occurrence of ecological diatom groups: n = neritic; b = bathic; Ch. = Chaetoceros rich. Codes for the table are indicated in the Methods section of the text. Drillcores listed in brackets indicate the origin of informal taxonomic de-signations: MSSTS-1 = Harwood (1986); CIROS-1 = Harwood (1989); 79/C = Barron and Mahood (1993); CRP-2/A = Scherer et al. (2000); and CRP-3 = this paper.*
questioned the utility of the FO of *Cavitatus jouseanus* due to its rare and sporadic occurrence within the *Rhizosolenia oligocaenica* Zone in DSDP Site 274. The record in ODP Hole 748B also reflects this rare and sporadic occurrence in the lower range of *C. jouseanus*, suggesting the age of this datum could be slightly older than reported above. A more conservative approach places the FO of *Cavitatus jouseanus* within the upper part of Subchron C12r (c. 31.5 to 30.9 Ma).

The FO of *Rhizosolenia antarctica* between 68.60 and 70.61 mbsf in CRP-3 marks the base of the *Rhizosolenia antarctica* Zone of Fenner (1984). The top of this zone is coincident with the base of the overlying *C. jouseanus* Zone. Fenner (1984) notes that the base of this zone occurs in DSDP Hole 511 within the uppermost part of the calcareous nannofossil *Blackites spinosus* Zone (within Subchron C12r). In ODP Hole 744A, the FO of *Rhizosolenia antarctica* is recorded within Chron C13r in the lower *Blackites spinosus* calcareous nannofossil Zone (Baldauf & Barron, 1991; Barron et al., 1991). Based on this occurrence, the lower range of *Rhizosolenia antarctica* is interpreted as incomplete in the CRP-3 drillcore, as it is truncated due to an underlying interval of poor preservation (i.e. below c. 70 mbsf).
Given the high sediment accumulation rates in lower Oligocene sediments at the mouth of Mackay Valley (at Site CRP-3), the lowest occurrence of *R. antarctica* at 68.60 mbsf most likely represents a position well above the F0 of this taxon. An age of c. 33.1 to 30.9 Ma is therefore inferred for the interval between c. 50 and 70 mbsf in CRP-3.

The FO of *Rhizosolenia oligoecaenic* is inferred to be below the stratigraphic interval recovered in CRP-3, due to the presence of this well-dated diatom datum (c. 34 Ma from CIROS-1 drillcore and 33.3 Ma in the Southern Ocean) below CRP-3 in the CIROS-1 drillcore (Fig. 2).

The section of CRP-3 below c. 70 mbsf is unzoned at the present time due to poor preservation. Moderately diverse, but poorly-preserved assemblages of siliceous microfossils, however, are noted sporadically down to c. 193 mbsf. In general, only the more robust and heavily-silicified forms, such as *Chaetoceros* spores, *Hemiaulus disimilis*, *Pyxilla reticulata*, and *Stephanopyxis* spp., are preserved in this interval.

The absence of the heavily-silicified, hyaline remnants of *Hemiaulus characteristicus* in CRP-3 is notable, even in the poorly-preserved interval from c. 70 to 200 mbsf. The FO of this resistant and

---

### Diatom Zonation

<table>
<thead>
<tr>
<th>Upper Depth (mbsf)</th>
<th>Lower Depth (mbsf)</th>
<th>Diatom Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.3</td>
<td>19.0</td>
<td><em>Cavitatus jousenus</em> Zone</td>
</tr>
<tr>
<td>20.6</td>
<td>15.7</td>
<td><em>Rhizosolenia antarctica</em> Zone</td>
</tr>
<tr>
<td>15.7</td>
<td>7.0</td>
<td>Unzoned</td>
</tr>
<tr>
<td>7.0</td>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>

---

**Tab. 2 - Continued.**
A distinctive diatom occurs within Subchron C13n in ODP Hole 744A (Baldauf & Barron, 1991). The LO of *H. caracteristicus* is also known from DSDP Hole 511 within the lower part of the *Blackites spinosus* calcareous nannofossil Zone (see Fenner, 1984), but it occurs several 10s of meters below the FO of *Rhizosolenia antarctica* in DSDP Hole 511 (discussed above). From these data, the absence of *H. caracteristicus* in CRP-3 supports an age assignment of younger than c. 33 Ma (Subchron C13n) for sediments above 200 mbsf.

**OTHER AGE INFORMATION**

The dominantly reversed polarity between 0 and 340 mbsf in CRP-3 is interpreted to represent a portion of Chron C12r. High sediment accumulation rates enabled the identification of numerous cryptochrons of normal polarity (Florindo et al., this volume). Below 340 mbsf, the magnetic polarity data are interpreted to represent Chrons C13n and C13r, with the Eocene-Oligocene boundary somewhere between 650 to 700 mbsf.
CORRELATION TO OTHER DRILLCORES

Comparison of the diatom assemblages present near the bottom of CRP-2A with those in the upper intervals of CRP-3 provides a means to estimate the overlap of these two drillcores. However, the poor preservation and absence of siliceous microfossils in the lower 60 m of CRP-2A limits the resolution of this approach. Figure 2 presents the ranges of key siliceous microfossil taxa between these two drillcores. Note that 6 taxa present at the top of the CRP-3 drillcore do not continue into the lowest diatom-bearing intervals of CRP-2A at c. 564 mbsf. Taxa present in CRP-3, but not present in CRP-2A, include: Hemiaulus rectus v. twista, Skeletonema atriculosa, Sphenocoelatus pacificus, Stictodiscus kittonianus, Skeletonema? penicillus and Ebrinarula paradoxa. Kisseleviella sp. G is common in CRP-3 samples, but occurs only rarely in 2 samples from CRP-2A. Additional evidence for the lack of a significant overlap between these drillcores comes from taxa in CRP-2A that do not occur, or are of limited range, in CRP-3. Pseudammodocidum lingii occurs down to 465.00 mbsf in CRP-2A, but is absent in CRP-3. Calicipedidium sp. A occurs consistently down to 364.66 mbsf in CRP-2A, and only one questionable occurrence was noted at 7.86 mbsf in the CRP-3 drillcore. Siliceous microfossil assemblages in the upper portion of CRP-3 are sufficiently different from those in the lower portion of CRP-2A to argue for little to no overlap of these two drillcores.

The siliceous microfossil assemblages of CRP-3 are significantly different from the early Oligocene to late Eocene assemblages reported from the CIROS-1 drillcore (Harwood et al., 1989; Bohaty & Harwood, 2000). Several taxa present in the Rhizosolenia oligocenica Zone, below the unconformity at c. 366 mbsf in CIROS-1 (Harwood et al., 1989a, Fig. 1), are absent from the diatom-bearing intervals of CRP-3. These taxa include the diatoms Hemiaulus caracteristicus, Stephanopyxis splendidis, and Pterotheca danica, and the ebridians Eriopsis crenulata (litoricace and non-litoric forms), Parebriopsis fallax, and Pseudammodocidum dictyoide. This indicates that the upper c. 200 m of the CRP-3 drillcore is equivalent to part of the interval missing within the unconformity at c. 366 mbsf in CIROS-1.

A lowermost Oligocene diatom assemblage is also reported from ODP Hole 739C in Prydz Bay, Antarctica (Barron & Mahood, 1993; Mahood et al., 1993). This assemblage is interpreted to be equivalent to a portion of the Rhizosolenia oligocenica Zone of Harwood et al. (1989a) from CIROS-1 and is calibrated to Subchrons C13n and C12r, within the calcareous nannofossil Blackites spinosus Zone (Barron & Mahood, 1993). Similar neritic diatom assemblages were recovered in CRP-3, but are slightly younger than those in the Prydz Bay section. This interpretation is based on the absence in CRP-3 of Hemiaulus caracteristicus, Pseudotriceratium adleri, and Stephanopyxis splendidis, all of which characterize the Prydz Bay assemblage.

Recent drilling in Prydz Bay during ODP Leg 188 also recovered a Palaeogene section containing well-preserved siliceous microfossils (Leg 188 Science Team, 2000). Assemblages present in Hole 1166A are similar to those in Hole 739C and below c. 366 mbsf in CIROS-1. Important diatom taxa common to the CIROS-1, 739C, and 1166A assemblages include Kisseleviella sp. G, Hemiaulus caracteristicus, Pterotheca danica, and Stephanopyxis splendidis. However, the absence of several taxa in Hole 1166A, such as Skeletonemopsis mahoodii and Sphagnocoelatus pacificus, tentatively indicates that the 1166A section is slightly older than the diatom-bearing intervals of CRP-3, CIROS-1, and Hole 739C (Leg 188 Science Team, 2000).

DIATOM PALAEOENVIRONMENTS

The combined presence of nannofossils and planktic marine diatoms in the upper c. 200 m of CRP-3 indicates normal marine conditions during deposition of these strata. Peak abundance of nannofossils is noted between c. 127 and 95 mbsf (Cape Roberts Science Team, 2000), and peak abundance of diatoms is noted between c. 64 and 35 mbsf. The abundant occurrence of diatoms or nannofossils in these intervals may reflect the influence of eutrophic vs. oligotrophic surface-water conditions, respectively (Cape Roberts Science Team, 2000). Poor preservation of biosiliceous material below c. 70 m, however, obscures the exact relationship between diatom and nannofossil occurrence.

Diatom assemblages recovered from CRP-3 are relatively uniform in composition and are dominated by marine neritic-planktic taxa of the genera Chaetoceros, Stephanopyxis, Skeletonemopsis, Kisseleviella, Ikebea, Kanoa, Pseudotriceratium and Pyxilla (Tab. 2). Benthic diatom taxa occur throughout this interval, but represent <5% of the total assemblage. Low abundance of benthic taxa and sporadic stratigraphical occurrence suggest displacement from an adjacent coastal-littoral zone into a depositional setting inferred to be below the euphotic zone. Based on these inferences, we interpret palaeo-water depths to be greater than 50-70 m. No significant changes in water depth were identified from the diatom assemblage data, and diatom genera associated with freshwater environments were not encountered in CRP-3.

Above c. 80 mbsf in CRP-3, several fluctuations in siliceous microfossil occurrence and abundance are noted, which are interpreted to reflect environmental changes. Low numbers of diatoms, and the poor state of preservation most likely reflects their ecological
exclusion due to a combination of influences high sediment input (turbidity), ice cover and low salinity. Generally, when sunlight, open marine conditions are present, diatoms will exploit this condition and deposition of diatom-rich sediments will result. Low numbers of diatoms, in conjunction with fragmented assemblages often indicate recycling and re-sedimentation of existing diatomaceous sediment.

Nearly all of the siliceous microfossil taxa present in CRP-3 are extinct. This precludes interpretation of palaeoenvironmental conditions based on the known distribution of modern taxa. The presence or absence of sea ice during sedimentation of the CRP-3 sequence is equivocal due to the unknown ecological affinities of Palaeogene taxa. Some diatom taxa have affinities of Palaeogene taxa. Some diatom taxa have affinity of sea ice palaeoenvironmental conditions based on the known distribution of modern taxa. The presence or absence of sea ice during sedimentation of the CRP-3 sequence is equivocal due to the unknown ecological affinities of Palaeogene taxa. Some diatom taxa have indirect (lineage) links to the modern sea ice environment. Fragilaria sp. A, for example, in the lower Miocene section of CRP-2/2A may indicate the presence of sea ice (Scherer et al., 2000). Similar taxa were not recognized in the CRP-3 drillcore.

**SUMMARY**

The upper c. 70 m of CRP-3 contains abundant and well-preserved siliceous microfossil assemblages. Siliceous microfossils are present below this interval down to c. 200 mbsf, but are poorly preserved. All samples examined below 200 mbsf are barren. Well-preserved assemblages in the upper section are assigned a stratigraphical position of lower Oligocene, based on the presence of Cavitatun jouseanus (FO at 48.43 mbsf), Rhizosolenia oligozaenica (present from 3.05 to 63.64 mbsf), and Rhizosolenia antarctica (present from 3.05 to 68.59 mbsf). The FO of Cavitatun jouseanus is calibrated at c. 31 Ma from Southern Ocean cores, although it is rare and sporadic near its base. Additionally, the absence of Hemiaulus characteristicus in the upper 200 m of CRP-3 indicates an age younger than ~33 Ma, based on its calibrated LO from ODP Hole 744A.

Siliceous microfossil assemblages recovered in the CRP drillcores provide important new data toward the development of an Antarctic shelf biostratigraphy for the lower Miocene to middle lower Oligocene (CRP-2/2A) and the lower lower Oligocene (CRP-3). CRP drillcores span the interval from ~17 to 33 Ma, and provide a composite section to build a biostratigraphical framework based on siliceous microfossil datums. Calibration of zones and siliceous microfossil datums in CRP drillcores to the magnetic polarity time scale will considerably advance future age determinations of the Oligocene and lower Miocene on the Antarctic shelf.

New information on the stratigraphical distribution of siliceous microfossil assemblages from the Oligocene drillcores fills a stratigraphical gap that is present within the disconformity at c. 366 mbsf in the CIROS-1 drillcore. Collectively, the CIROS-1 (Harwood, 1989), CRP-1 (Harwood et al., 1998), CRP-2/2A (Scherer et al., 2000) and CRP-3 (this report) drillcores document the history of Antarctic-neritic diatom evolution and southern high-latitude palaeobiography for the early Miocene to latest Eocene (c. 17 to 36 Ma).

**TAXONOMIC LIST AND RELEVANT SYSTEMATIC PALAEOONTOLOGY**

The following is a listing of taxa or taxonomic groups encountered in this study. Many diatoms are reported only to genus level and many taxa are reported under informal names. Informal taxonomy presented here reflects the “work-in-progress” state of the Cape Roberts Project diatom studies. We do not include detailed reference to these taxa: the reader should refer to the works of Schrader & Fenner (1976), Fenner (1985), Harwood (1986), Harwood (1989), Harwood et al. (1989b), Harwood & Maruyama (1992), Barron & Mahood (1993), Mahood et al. (1993) for synonymy. Where necessary, we cross reference to species names used in the above papers, if names or taxonomic concepts have changed recently.

**DIATOMS**

Actinoptychus senarius (Ehrenberg) Ehrenberg.

Actinoptychus plundens (Shadbolt) Ralls in Pritchard.

Acanthus sp.

Arachnoidiscus spp. Comments: Rare specimens of Arachnoidiscus spp. are present in CRP-3, which commonly occur as fragments.

Asterolampra puncifera (Grove) Hanna; Gombos & Ciesielski, 1983, p. 600, fig. 431, pl. 2, figs. 4-8, pl. 5, figs. 8-10; Barron & Mahood, 1993, p. 38, pl. 4, fig. 13; Scherer et al., 2000, pl. 6, fig. 1.

Asteromphalos oligocenicus Schrader & Fenner; Gombos & Ciesielski, 1983, p. 600, pl. 5, figs. 5-7.

Biddulphia sp. A includes simple spores and vegetative cells of the variety abundant in samples examined below 200 mbsf. This morphology appears to be characteristic of "early forms" of C. jouseanus. (PI. 1, Figs. 1-2) Cavitatus jouseanus (Sheshukova) Williams; Akiba et al., 1993, p. 20-22, figs. 6-19, 6-20. Comments: Specimens of Cavitatus jouseanus present in CRP-3 differ from C. jouseanus s.s. in that they are smaller and more lightly silicified with narrow, tapered ends, rather than broadly-rounded ends. This morphology appears to be characteristic of “early forms” of C. jouseanus. (Pl. 1, Figs. 1-2)

Cavitatus sp. cf. C. miocenicus (Schrader) Akiba & Yanagisawa in Akiba. (Pl. 1, Fig. 3)

Chaetoceros panduriformis (Pantoceek) Gombos; Scherer et al., 2000, p. 431, pl. 5, fig. 11.

Chaetoceros spp. and related spore-forming genera. Comments: Many distinct morphotypes of Chaetoceros are recognised, but are combined for this report. Group A includes simple Hyaloclate spores and vegetative cells of the variety abundant in modern Antarctic sediments (see Harwood, 1986, pl. 7, figs. 1-12). Group B includes larger spores with
Plate 1 - Scale bar equals 10 μm. All figures are valve views unless indicated otherwise.
Figures 1-2. *Cavitatus jouseaunii* (Sheshukova) Williams - "early form": (1) CRP3-44.93-.99 mbsf; (2) CRP3-48.43-.44 mbsf. Figure 3. *Cavitatus* sp. cf. *C. minicenicus* (Schrader) Akiba & Yanagisawa; CRP3-38.78-.79 mbsf. Figure 4. *Sceptroneis talwani* Schrader & Fenner; CRP3-9.69-.70 mbsf. Figures 5-12. *Kisseleviella* sp. G of Scherer et al. (2000); (5) CRP3-37.29-.30 mbsf; (6) CRP3-12.19-.20 mbsf; (7) CRP3-28.44-.45 mbsf; (8) CRP3-10.78-.79 mbsf; (9) CRP3-12.19-.20 mbsf; (10) CRP3-10.78-.79 mbsf; (11) Girdle view, CRP3-54.77-.78 mbsf; (12) Girdle view, CRP3-54.19-.20 mbsf. Figures 13, 15. *Kisseleviella* sp. D of Scherer et al. (2000); (13) CRP3-43.70-.71 mbsf; (15) CRP3-3.05-.06 mbsf. Figure 14. *Kisseleviella/Camatosira* sp., CRP3-3.05-.06 mbsf. Figures 16-17. *Kisseleviella* sp. F of Scherer et al. (2000); (16) CRP3-33.95-.96 mbsf; (17) CRP3-28.70-.71 mbsf. Figures 18-22. *Ikebea* sp. D; (18) Girdle view, CRP3-5.47-.48 mbsf; (19) Girdle view, CRP3-12.19-.20 mbsf; (20) Girdle view, CRP3-7.85-.86 mbsf; (21) CRP3-33.95-.96 mbsf; (22) CRP3-28.70-.71 mbsf. Figure 23. *Grammatophora marina* (Lyngbye) Kützing; Girdle view, CRP3-57.71-72 mbsf. Figure 24. *Rhizosolenia oligoecentica* Schrader; CRP3-5.47-.48 mbsf. Figure 25. *Rhizosolenia* sp.; CRP3-3.05-.06 mbsf. Figure 26. *Pseudopyxilla americana* (Ehrenberg) Fori; CRP3-28.70-.71 mbsf. Figure 27. Genus et sp. indet.; CRP3-48.43-.44 mbsf. Figure 28. *Ikebea* sp. B of Scherer et al. (2000); Colony. CRP3-12.19-.20 mbsf. Figure 29. *Cocconeis* sp.; CRP3-44.18-.27 mbsf.
Plate 2 - Scale bar equals 10 μm. All figures are valve views unless indicated otherwise.

Figures 1-2. Stictodiscus? kittenianus Greville: (1) CRP3-7.85-.86 mbsf; (2) CRP3-49.67-.68 mbsf. Figures 3-4. Thalassiosira? mediacomexa Schrader & Fenner: (3) CRP3-44.93-.94 mbsf; (4) CRP3-54.19-.20 mbsf. Figures 5-6. Skeletonomonopsis mahoodii Sims: (5) Girdle view, CRP3-55.77-.78 mbsf; (6) CRP3-57.71-.72 mbsf. Figure 7. Skeletononema? penicillus Grunow in Van Heurck: Two specimens in girdle view, CRP3-33.95-.96 mbsf. Figure 8. Stelligera microtricis Hasle & Sims: High/low focus, CRP3-10.78-.79 mbsf (note presence of only two central labiate processes). Figures 9-12. Skeletononema? uricolosum Brun: (9) CRP3-5.47-.48 mbsf; (10) Girdle view, CRP3-49.67-.68 mbsf; (11) CRP3-10.78-.79 mbsf; (12) Girdle view, CRP3-37.29-.30 mbsf. Figure 13. Sphynctolethus pacificus (Hajós) Sims; CRP3-7.85-.86 mbsf. Figures 14-15. Sphynctolethus sp. A; CRP3-54.19-.20 mbsf.
Ikebea sp. D: Genus et sp. indet. D of Harwood, 1989, pl. 4, p. 82, figs. 26-28. Description: This form is hyaline and rounded in girdle view. Considerable variability in length is noted (compare fig. 19 and fig. 21 on pl. 1). Specimens were commonly observed in girdle view paired with another valve (see pl. 1, figs. 18-20). Marginal spines were observed on some specimens. (Pl. 1, Figs. 18-22; Pl. 9, Fig. 4)

Isthmia spp. Comments: Fragments of Isthmia spp. occur throughout the diatom-bearing interval of CRP-3.

Kunaua bastaia Kunaura, 1980, p. 376, text-fig. 3, pl. 46, figs. 13a-b; Scherer et al., 2000, p. 434, pl. 1, figs. 26-27; Ikebea tennis (Brun) Akiba of Harwood, 1989, p. 79, pl. 4, fig. 34.

Genus Kisseleviella Sheshukova. Comments: Several diatom taxa observed in CRP-3 samples are assigned to the genus Kisseleviella. Informal designation for these forms follow from those applied in the CRP-2/2A report; see Scherer et al. (2000, p. 434, 436) for additional comments.

Kisseleviella sp. C of Scherer et al., 2000, p. 436, pl. 1, figs. 8-13. Description: Valve 20 to 40 μm in length with maximum width of ~6 μm, covered by faint pores; valve is inflated-lanceolate in shape with protruded, rounded apices. The central array of linking spines is arranged in a disorganized fashion. Location of secondary or lateral linking structures is not obvious and when present represented by single elements.

Kisseleviella sp. D of Scherer et al., 2000, p. 436, pl. 1, figs. 14-17. Description: Valve 10 to 15 μm in length with a maximum width of ~6 μm; valve is lanceolate in shape with very slightly protruded apices. Many specimens also show a slight bilateral asymmetry with "rotated" apices. 3 to 10 linking spines are commonly present arranged in a single, central ring or disorganized fashion. Kisseleviella sp. C and Kisseleviella sp. D may represent different size cells of the same taxon. (Pl. 1, Figs. 13, 15)

Kisseleviella sp. F of Scherer et al., 2000, p. 436, pl. 1, fig. 19; Resting spore B of Barron & Mahood, 1993, p. 44, pl. 5, figs. 17, 19. Description: Valve is linear-lanceolate and bilaterally asymmetrical in shape with sharply tapered (or apiculated) apices, ~25 μm in length with a maximum width of ~8 μm. (Pl. 1, Figs. 16-17)

Kisseleviella sp. G of Scherer et al., 2000, p. 436, pl. 1, figs. 20-21: Kisseleviella carina sensu Harwood, 1989 (in part), p. 79, pl. 4, fig. 37, not figs. 35, 36. Description: Valve shape is inflated-lanceolate with apiculated, sub-capitate apices, 20 to 30 μm in length with a maximum width of ~12 μm; 5 to 10 central linking spines are arranged in a single, offset ring, or in a random distribution. Secondary or lateral linking spines consist of a single "post-and-crown" (or spiny and annular tubercle) structure, and are bilaterally offset. (Pl. 1, Figs. 5-12)

Kisseleviella sp. H. Remarks: This diatom is morphologically similar to Kisseleviella sp. G, but differs in possessing a greater inflation of the sub-capitate apices to nearly the width of the central inflated area, and the apices are mucronate.

Kisseleviella? sp. / Cymatosira? sp. (Pl. 1, Fig. 14).

Early Oligocene Siliceous Microfossil Biostratigraphy of Cape Roberts Project Core CRP-3
Plate 3 - Scale bar equals 10 μm. All figures are valve views unless indicated otherwise. Arrows denote positions of labiate processes. Figures 1-8. *Enrossia irregularis* var. *irregularis* (Greville) Sims: (1-3) Complete heterovalve frustule, low/middle/high focus of the same specimen, CRP3-54.77-.78 mbsf; (4-5) Centrally-swollen hypovalve, high/low focus of the same specimen, CRP3-49.67-.68 mbsf; (6) CRP3-28.70-.71 mbsf; (7) Centrally-swollen hypovalve, oblique view, CRP3-54.19-.20 mbsf; (8) CRP3-7.85-.86 mbsf. Figure 9. *Psuedotriceratium radiosoreticulatum* (Grunow in Van Heurck) Penner; (9) CRP3-57.71-.72 mbsf. Figures 10. *Goniothecium odontella* Ehrenberg; Girdle view, CRP3-10.78-.79 mbsf. Figures 11, 12. *Goniothecium decoratum* Brun; (11) Girdle view, CRP3-28.70-.71 mbsf; (12) Girdle view, CRP3-49.67-.68 mbsf.
Liradiscus ovalis Greville; Hajós, 1976, p. 826, pl. 17, figs. 1, 2; Harwood & Bohaty, 2000, p. 95, pl. 9, figs. 7, 8.

Navicula? spp. Comments: Small, lightly-silicified forms possibly belonging to the genus Navicula were observed in several CRP-3 samples.

Odontella fimbrata (Greville) Schrader in Schrader & Fenner; Barron & Mahood, 1993, p. 40, pl. 4, figs. 6a, b.

Paralia sol var. marginalis (Peragallo) Harwood, 1989, p. 79, pl. 5, fig. 12. (Pl. 5, Fig. 14)

Paralia sulcata (Ehrenberg) Cleve.

Psammodesmus Round & Mann sp.

Pseudopyxilla americana (Ehrenberg) Forti. (Pl. 1, Fig. 26)

Pseudotriceratium radiosoreticulatum (Grunow in Van Heurck) Fenner; Baron & Mahood, 1993, p. 42, pl. 3, fig. 5; Mahood et al., 1993, p. 259, figs. 45-48, 72; Scherer et al., 2000, p. 436, pl. 4, fig. 3. (Pl. 3, Fig. 9)


Pterotheca sp. B of Harwood, 1989, p. 80, pl. 3, fig. 18.

Pterotheca sp. C of Harwood, 1989, p. 80, pl. 3, fig. 20.

Pterotheca? sp. D of Harwood, 1989, p. 80, pl. 5, figs. 16-17.

Pygugyopsis eocaena Hendy; Scherer et al., 2000, p. 436, pl. 5, fig. 9. Remarks: Compare with Miocene diatom Bittuario de Ulva Komura 1999, p. 22, 25, figs. 11-13, 96-112, text figure 2 and Pyxilla spp. (Pl. 4, Fig. 5)

Pyxilla johnsoniana Greville. (Pl. 4, Figs. 2, 6-8, 10)

Pyxilla reticulata Grove & Sturt; Harwood, 1989, p. 80, pl. 3, figs. 7-10; Barron & Mahood, 1993, p. 42, pl. 7, figs. 1-3. (Pl. 4, Figs. 1, 3, 4, 9)

Radialiplicata clavigera (Grunow in Van Heurck) Gieser. (Pl. 5, Figs. 1-2)

Rhabdonema japonicum Tempère & Brun group.

Rhabdonema sp. cf. R. elegans Tempère & Brun; Harwood, 1989, p. 80; Scherer et al., 2000, p. 436, pl. 5, fig. 12; Gen et sp. uncertain 1 of Harwood, 1986, p. 87, pl. 5, figs. 11-12.

Rhabdonema sp. A of Harwood, 1989, p. 80, pl. 6, figs. 7-8. Comments: This form is present in one sample at 48.18 mbsf.

Rhabdonema spp. /Grammatophora spp. Comments: Specimens of several unknown Grammatophora spp. and Rhabdonema spp. are present in many CRP-3 samples (see Scherer et al., 2000, pl. 2, figs. 17, 20; for illustrated examples).

Rhizosolenia antarctica Fenner, 1984, p. 333, pl. 2, fig. 5; Scherer et al., 2000, pl. 3, figs. 1-2.

Rhizosolenia hebeyata Bailey group; Scherer et al., 2000, pl. 3, figs. 6-7.

Rhizosolenia oligoecenica Schrader, 1976, p. 635, pl. 9, fig. 7; Barron & Mahood, 1993, p. 42, pl. 5, figs. 1-2; Scherer et al., 2000, p. 436, pl. 3, figs. 3-4. (Pl. 1, Fig. 24)


Rhizosolenia sp. B of Harwood, 1989, p. 80, pl. 3, fig. 27.

Rhizosolenia sp. C of Harwood, 1989, p. 80, pl. 3, fig.

Sperchonia praecitata (Fenner) Fenner ex Kim & Barron; Scherer et al., 2000, p. 436, pl. 6, fig. 6.

Rhizosolenia sp. (Pl. 1, Fig. 25)


Sceptreneis lingulatus Fenner; Gombos & Ciesielki, 1983, pl. 24, fig. 8; Harwood, 1989, p. 80, pl. 6, fig. 11; Barron & Mahood, 1993, p. 42, pl. 5, fig. 10.


Sceptreneis talwani Schrader & Fenner, 1976, pl. 24, figs. 28-29; Barron & Mahood, 1993, p. 42, pl. 5, fig. 9, pl. 7, figs. 4a-b. (Pl. 1, Fig. 4)

Skeletoneoma? penicillus Grunow in Van Heurck; Harwood, 1989, p. 80, pl. 5, figs. 14-15; Sims, 1994, p. 402-405, figs. 37-40, 53; Corethron penicillus (Grunow) Fenner, 1994, p. 109, pl. 4, fig. 4. (Pl. 2, Fig. 7)

Skeletoneoma? utriculosa Brun; Sims, 1994, p. 402, figs. 33-36, 51-52. Comments: This taxon should be transferred out of Skeletoneoma and placed within or near the recently proposed genus Trochosirella Komura, 1996, p. 9-10. Komura (1996) distinguishes this taxon from Trochosirella by the “type of areolae, the exit morphology of the rimportules and the architecture in the greater part of the valve face.” Some specimens that lack the ring of lingulate elevations are interpreted to be separation valves. (Pl. 2, Figs. 9-12)

Skeletoneopsis mahoodii Sims, 1994, p. 397-402, figs. 25-32, 48; Scherer et al., 2000, p. 440, pl. 2, figs. 8-12; Skeletoneopsis barbadesis sensu Barron & Mahood, 1993, p. 42, pl. 6, fig. 1. (Pl. 2, Figs. 5-6; Pl. 9, Fig. 6)

Sphyctyotheles hemiauloides Sims, 1986, p. 246, figs. 16-22, 64-65.

Sphyctyotheles pacificus (Hajós) Sims, 1986, p. 250, figs. 29-34, 69; Harwood, 1989, p. 80, pl. 4, fig. 8. (Pl. 2, Fig. 13)

Sphyctyotheles sp. A. (Pl. 2, Figs. 14-15)

Stellarina microtria Hasle & Sims. (Pl. 2, Fig. 8)

Stellarina primalabiata (Gombos) Hasle and Sims.

Stellarina stellaris (Roper) Hasle & Sims.

Stephanopyxis megapora Grunow.

Stephanopyxis oamaruaensis Hajós, 1976, p. 825, pl. 19, figs. 5-8; Harwood, 1989, p. 81, pl. 2, figs. 27-29; Barron & Mahood, 1993, p. 42, pl. 2, fig. 5; Scherer et al., 2000, p. 440, pl. 5, fig. 7. Remarks: SEM examination will likely indicate that this taxon should be transferred to genus Stephanopyxites, and perhaps be conspecific with Stephanopyxites variegatus Komura 1999, p. 33-37, text-figure 4, figs 20-22, 46, 164-195.

Stephanopyxis spinosissima Grunow; Schrader & Fenner, 1976, p. 1000, pl. 31, fig. 5; Harwood, 1989, p. 81; Stephanopyxis sp. A of Harwood, 1986, p. 87, pl. 4, fig. 2.


Stephanopyxis sp. cf. S. superba (Greville) Grunow. (Pl. 7, Figs. 7-8; Pl. 9, Fig. 3)
Plate 4 - Scale bar equals 10 μm.
Figures 1, 3, 4, 9. *Pisilla reticulata* Grove & Sturt: (1) CRP3-10.78-.79 mbsf; (3) CRP3-54.19-.20 mbsf; (4, 9) CRP3-7.85-.86 mbsf. Figures 2, 6, 7, 8, 10. *Pisilla johnsoniana* Greville: (2, 8) CRP3-54.19-.20 mbsf; (6) CRP3-5.01-.02 mbsf; (7, 10) CRP3-49.67-.68 mbsf. Figure 5. *Pygenyxis eocena* (Hendy); (5) CRP3-7.85-.86 mbsf.
Plate 5 - Scale bar equals 10 μm. All figures are valve views unless indicated otherwise.

Figures 1-2. Radialiplicata clavigera (Grunow in Van Heurck) Gieser: (1) CRP3-33.95-.96 mbsf; (2) CRP3-28.70-.71 mbsf. Figure 3. Asteromphalus oligocenicus Schrader & Fenner; CRP3-37.29-.30 mbsf. Figures 4, 5. Roccella praevitida (Fenner) Fenner ex Kim & Barro; (4) CRP3-10.78-.79 mbsf; (5) CRP3-54.19-.20 mbsf. Figures 6, 8, 12, 13. Chaetoceros spp.; (6, 12) CRP3-28.70-.71 mbsf; (8) CRP3-49.67-.68 mbsf; (13) CRP3-48.43-.44 mbsf. Figures 10-11. Genus et sp. indet. C of Harwood (1989); (10) CRP3-44.93-.94 mbsf; (11) CRP3-33.95-.96 mbsf. Figure 7. Archaeosphaeridium tasmaniae Perch-Nielsen (chrysophyte cyst); CRP3-50.47-.48 mbsf. Figure 9. Vulcanelia hamnae Sims & Mahood; CRP3-5.47-.48 mbsf. Figure 14. Paralia sol var. marginalis (Peragallo) Harwood; CRP3-7.85-.86 mbsf.
Plate 6 - Scale bar equals 10 μm. All figures girdle view except figs. 9-10.

Figures 1-2. *Hemiaulus* sp. D (1) CRP3-44.18-.27 mbsf; (2) CRP3-54.19-.20 mbsf. Figure 3. *Hemiaulus* sp. B of Scherer et al. (2000); (3) CRP3-7.85-.86 mbsf. Figures 5-8. *Hemiaulus dissimilis* Grove & Sturt; (5) CRP3-28.70-.71 mbsf; (6) CRP3-5.01-.02 mbsf; (7) CRP3-5.47-.48 mbsf; (8) CRP3-10.78-.79 mbsf. Figures 9-10. *Hemiaulus rectus* var. twista Fenner; (9) CRP3-54.19-.20 mbsf; (10) CRP3-33.95-.96 mbsf. Figure 11. *Stephanopyxis* sp. 7: CRP3-55.77-.78 mbsf. Figures 12-15. *Stephanopyxis turris* (Greville & Arnott) Ralfs in Pritchard; (12-13) High/low focus, CRP3-54.19-.20 mbsf; (14-15) High/low focus of the same specimen. CRP3-54.19-.20 mbsf. Figure 16. 21. *Stephanopyxis* sp. 2; (16) CRP3-57.71-.72 mbsf; (21) CRP3-57.71-.72 mbsf. Figures 17-18. *Stephanopyxis* sp. 9; (17-18) High/low focus of the same specimen, CRP3-54.19-.20 mbsf. Figures 19-20. *Stephanopyxis* sp. 4; (19-20) High/low focus of the same specimen. CRP3-37.29-.30 mbsf.
Plate 7 - Scale bar equals 10 μm. All figures are valve views.

Figure 1. Stephanopyxis sp. 5: High/low focus of the same specimen, CRP3-54.19-20 mbsf (note presence of two central processes). Figure 2. Stephanopyxis sp.; (2) High/low focus of the same specimen, CRP3-54.19-20 mbsf. Figures 3, 5. Stephanopyxis sp. 8; (3) High/low focus of the same specimen, CRP3-54.19-20 mbsf; (5) High/low focus of the same specimen, CRP3-54.19-20 mbsf. Figures 4, 6. Stephanopyxis sp. 3; (4) High/low focus, CRP3-54.19-20 mbsf; (6) High/low focus of the same specimen, CRP3-54.19-20 mbsf. Figures 7-8. Stephanopyxis sp. cf. S. superba (Greville) Grunow (7) High/low focus of the same specimen, CRP3-54.19-20 mbsf; (8) High/low focus of the same specimen, CRP3-54.19-20 mbsf.
Plate 8 - Scale bar equals 10 μm. All figures are valve views.
Figures 1-4, *Stephanopyxis* sp. 1: (1) High/low focus of the same specimen, CRP3-28.70-.71 mbsf; (2) High/low focus of the same specimen, CRP3-37.29-.30 mbsf; (3) High/low focus of the same specimen, CRP3-12.19-.20 mbsf; (4) High/low focus of the same specimen, CRP3-57.71L.72 mbsf. Figure 5, *Stephanopyxis* sp. 3: High/low focus of the same specimen, CRP3-54.19-.20 mbsf. Figure 6, *Stephanopyxis* sp. 10: High/low focus of the same specimen, CRP3-57.71-.72 mbsf. Figure 7-8, *Stephanopyxis* sp. 6: (7) High/middle/low focus of the same specimen, CRP3-54.19-.20 mbsf; (8) High/low focus of the same specimen, CRP3-37.29-.30 mbsf.
Plate 9 - SEM photomicrographs. Scale bar for figs. 1, 3, 5 (upper left) equals 10 μm; scale bar for figures 2, 4, 6 9 (lower right) equals 2 μm.

Figures 1-2. Stephanopyxis sp. 5: (1) Internal view of valve, CRP3-43.70-.72 mbsf; (2) Close-up of wall structure for specimen shown in fig. 1. Figure 3. Stephanopyxis sp. cf. S. superba (Greville) Grunow. CRP3-43.70-.72 mbsf. Figure 4. Ikebea sp. D: CRP3-57.80-.81 mbsf. Figure 5. Stephanopyxis sp. 8; CRP3-43.70-.72 mbsf. Figure 6. Skeletonemopsis mahoelii Sims; CRP3-57.80-.81 mbsf.
**Stephanopyxis turris** (Greville & Arnott) Ralfs in Pritchard. (Pl. 6, Figs. 12-15)

**Stephanopyxis spp.** Comments: Taxa included commonly in *Stephanopyxis* spp. are abundant in CRP-3 samples. Many morphologies are present, which we have tentatively attempted to split into several informal groups. Further SEM work is required to identify the structure and positions of valve processes to clarify these divisions and better understand the taxonomic placement in recently proposed genera *Stephanonycites*, *Eustephanias*, *Dactylacanthis* of Komura (1999). These genera were unknown to the authors at the time of data collection for CRP-3. Related taxa reported from other drillcores in the western Ross Sea will also need to be evaluated in future studies. Comments are given below to help guide future work in resolving these taxa. *Stephanopyxis* sp. B of Harwood, 1986, pl. 14, fig. 5 could be *Stephanonycites variegates* Komura, and *Pyxilla* sp. A of Harwood, 1989, pl. 1, figs. 21-25 is likely a species of *Eustephanias*. (Plate 7, Fig. 2)

**Stephanopyxis sp. 1** Description: Valve face circular, low convex dome; regular hexagonal areolae (2.5 to 3 in 10 µm) arranged in regular tangential rows across the valve face; margin hyaline, 1-2 µm in width; ring of marginal spines (1 in 15-20 µm). In LM, a circular line around the valve is visible below the inner edge of the outermost ring of areolae in some focal planes. This line reflects the interior edge of a broad marginal zone. (Pl. 8, Figs. 1-4)

**Stephanopyxis sp. 2** Description: Valve cylindrical to spherical; areolae hexagonal of variable size on valves of the same frustule (3 in 10 µm and 4-5 in 10 µm); ring of long spines, often broken, arise vertically from the valve shoulder. Remarks: This diatom should be placed within *Dactylacanthis* Komura (1999), pending further SEM study. (Pl. 16, 21)

**Stephanopyxis sp. 3** Description: Valve face circular, hemispherical, with steep mantle; hexagonal areolae (3 in 10 µm) arranged in tangential rows across valve face and mantle; cross-sectional structure of areolae visible in LM across the steep mantle. In LM, a circular line around the valve is visible beneath the inner edge of the outermost ring of areolae, and the most distinctive character is the optical effect that produces a diffuse circular area in the center of the valve, when the focal plane is on the base of the valve, as clearly visible in the illustrated specimens; this diffuse circular area may be off-center if the valve is tilted. This optical effect is enhanced by closing the condenser diaphragm. Under high magnification, this appears to be created by the presence of a thin siliceous septa that extends 2 to 3 µm toward the center of the valve, at a level parallel to the valve base. (Pl. 7, Figs. 4, 6; Pl. 8, Fig. 5)

**Stephanopyxis sp. 4** Description: Frustule ovoid in girdle view comprised of two circular valves; areolae hexagonal (7 in 10 µm) arranged in close packing tangential rows; valve face and mantle covered with dense small spines, longer on the valve face. Remarks: This taxon likely belongs in genus *Stephanonycites*, near *S. variegates*. (Pl. 6, Figs. 19-20)

**Stephanopyxis sp. 5** Valve hemispherical with steep mantle; regular hexagonal areolae (3.5 in 10 µm at the valve center and 5 in 10 µm at the margin) arranged in close-packed tangential rows; 2 to 5 labiate processes are present at the valve apex within 2 to 4 areolae from the valve center. Remarks: This taxon should be included within genus *Eustephanias* Komura (1999), and several species of *Eustephanias* were likely included here, including *E. quaternarius* and *E. inermus* (Pl. 7, Fig. 1; Pl. 9, Figs. 1-2).

**Stephanopyxis sp. 6** Description: Valve circular, slightly convex, often with flat central area; hexagonal areolae (6-7 in 10 µm) arranged in tangential rows, decreasing in size toward the margin; valve surface sparsely ornamented with short spines, and often bearing a central ring of small spines at 1/3 valve radius, near the edge of the flat central area; margin, hyaline and narrow (1-2 µm). Remarks: This diatom appears close to genus *Stephanonycites*, nearer to *S. coronus* Komura than to other species. (Pl. 8, Figs. 7, 8)

**Stephanopyxis sp. 7** (Pl. 6, Fig. 11)

**Stephanopyxis sp. 8** Remarks: No apical processes were noted in this diatom, but a ring of short spines/external tubes of processes occurs near the margin. (Pl. 7, Figs. 3, 5; Pl. 9, Fig. 5)

**Stephanopyxis sp. 9** Remarks: This small diatom is distinguished by the heterovalve valves of different size on a single frustule. (Pl. 6, Figs. 17-18)

**Stephanopyxis sp. 10** (Pl. 8, Fig. 6)

**Stictodiscus hardmanianus** Greville; Harwood, 1989, p. 81, pl. 1, fig. 6; Scherer et al., 2000, p. 440, pl. 4, fig. 4.

**Stictodiscus? kittonianus** Greville; Harwood, 1989, p. 81, pl. 1, figs. 7-8; Barron & Mahood, 1993, p. 44, pl. 2, fig. 8. Remarks: As noted by Komura (1999) this diatom may belong within the recently proposed genus *Stictolecanon* Komura, 1999, p. 42-46, but SEM analysis is needed to verify this taxonomic position. (Pl. 2, Figs. 1-2)

**Thalassiosira? mediaconvexa** Schrader & Fenner, 1976, pl. 36, fig. 1; Barron & Mahood, pl. 4, fig. 9, 12; Scherer & Koç, 1996, p. 89, pl. 4, figs. 8-9. (Pl. 2, Figs. 3-4)

**Triceratium pulvinar** Schmidt.

**Trigonium arcticum** (Brightwell) Cleve.

**Trinacria excavata** Heiberg; Scherer et al., 2000, pl. 4, fig. 8; pl. 6, fig. 5.

**Trinacria racovitzae** Van Heurck; Harwood, 1986a, p. 87, pl. 5, figs. 2-6; Scherer et al., 2000, p. 440, pl. 4, figs. 6, 10-11.

**Trophosira spinosus** Kitton; Scherer et al., 2000, p. 440, pl. 2, figs. 4-6.

**Vulcanaella hannae** Sims & Mahood, 1998, p. 115, figs. 1-12, 44-48; *Cotyledon fogedi* (Hendey) Harwood, 1989; *Tumulopsis fogedi* Hendey sensu Barron & Mahood, 1993 p. 44, pl. 2, figs. 7, 9, 10. (Pl. 5, Fig. 9)


**Genus et species indet. C** of Harwood, 1989, p. 82, pl. 3, figs. 32-33. (Pl. 5, Figs. 10-11)

**Genus et species indet.** (Pl. 1, Fig. 27)
REFERENCES

Clohisey apiculata apiculata (Lehmann) Hanna.
Clohisey tricantha (Ehrenberg) Hanna.
Dicyocha deflandrei Frenguelli ex Glezer.
Dicyocha frenguelli Deflandre.
Dicyocha spp.
Distephanus crassus (Ehrenberg) Dumitrice.
Distephanus raupii Bukry.

EBRIDIANS

Amniodochium rectangle (Schulz) Deflandre; Bohaty & Harwood, 2000, p. 121-122, pl. 1, figs. 2, 3; pl. 3, figs. 4-8; pl. 4, figs. 7-8; pl. 5, fig. 9; pl. 9, fig. 11; pl. 10, fig. 14.
Falsebna ambigua Deflandre /Hovasen brevispinosa (Hovasse) Deflandre group; Scherer et al., 2000, pl. 6, figs. 8-10; Bohaty & Harwood, 2000, p. 125, p. 126, pl. 5, fig. 5.
Micromarsupium sp. cf M. curticanum Deflandre; Bohaty & Harwood, 2000, p. 130, pl. 5, fig. 8; pl. 6, figs. 1-2, 5.
Pseudamniodochium sp. Hovasse; Bohaty & Harwood, 2000, p. 134, pl. 5, fig. 6; pl. 10, figs. 7-8.

Comments: Both single and double-skeleton morphologies of Pseudamniodochium sp. are noted in the CRP-3 drillcore.

ENDOSKELETAL DINOFLAGELLATES

Carduiolip gracilis Hovasse; Bohaty & Harwood, 2000, p. 151, pl. 4, fig. 1.
Callicepedinia sp. A of Scherer et al., 2000, p. 440-441, pl. 5, fig. 8.

CHRYSOPHYTE CYSTS

Archaosphaeridium australis Perch-Nielsen; Bohaty & Harwood, 2000, p. 150, pl. 10, fig. 11.
Archaosphaeridium tasmaniae Perch-Nielsen; Bohaty & Harwood, 2000, p. 150, pl. 10, figs. 12, 18. (Pl. 5, Fig. 7)
Archaosphaeridium edwardsii Perch-Nielsen; Harwood, 1989, p. 82, pl. 6, fig. 13.

ACKNOWLEDGEMENTS - Support for the Cape Roberts Project comes from the international consortium consisting of the national research programs of Australia, Germany, Italy, US, New Zealand, United Kingdom and United States. Support for this research came from NSF grant OPP-9420062. J. Barron, J. Fenner and A. Gladenkov provided helpful comments in review. We offer our thanks to V. Thorn for technical assistance in the darkroom, to D. Watkins for noting diatom occurrences in nanofossil preparations, to D. Winter for SEM photomicrographs, and to R. Scherer for helpful discussions. We applaud the excellent studies by S. Komura to document the morphological structures of many diatoms that now seem less problematic as a result of his fine work.

REFERENCES


