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Eocene–Oligocene paleoecology and the diatom genus *Kisseleviella* Sheshukova-Poretskaya from the Victoria Land Basin, Antarctica

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Abstract

The Cape Roberts Project (CRP) recovered a composite Eocene to lower Miocene stratigraphic sequence from the Victoria Land Basin, Antarctica, which includes four new species, described herein, of the biostratigraphically useful fossil marine diatom genus *Kisseleviella*. Specimens of this extinct genus occur predominantly in neritic sediments, which along with the chain-forming nature and morphological similarity to extant benthic genera (e.g. *Cymatosira*) suggest that *Kisseleviella* was tychopelagic. The species of *Kisseleviella* described here appear to be endemic to the Antarctic region with an ecological preference for nearshore environments. The polythermal, subpolar glacial regime invoked for the late Eocene–early Miocene may have acted as a significant driver of speciation events in Antarctic *Kisseleviella*. Phylogenetic analysis of fossil genera such as *Kisseleviella* allows the development of a neritic biostratigraphic zonation. New taxa formally proposed are: *Kisseleviella tricoronata*, *Kisseleviella cicatricata*, *Kisseleviella gaster* and *Kisseleviella faballiforma*.

Keywords: marine diatoms; Antarctica; Eocene; Oligocene; Miocene; taxonomy; endemism; paleoecology

1. Introduction

Siliceous microfossils (including diatoms, silicoflagellates, ebridians) are particularly useful for both biostratigraphic and paleoenvironmental studies in Cenozoic Antarctic shelf sediments, where calcareous microfossils are rare. The presence/absence of siliceous microfossils may indicate ice conditions, for example seasonal sea ice cover or ice shelf/ice sheet expansion. Specific taxa may provide information on a wide range of environmental parameters, such as salinity, water depth, bottom substrate, water column stratification and nutrient conditions. Furthermore, fossil taxa with discrete geographical ranges and continuous stratigraphic records may be used to infer evolutionary processes.

Taxonomic study of four new species of the extinct marine diatom genus *Kisseleviella* reveals new evidence that helps determine its systematic position. In stratigraphic and paleoenvironmental context, the analysis provides impetus for the development of new hypotheses concerning Antarctic endemism and speciation in neritic and littoral environments. Paleoenvironmental interpretation of the new taxa described herein agrees with previous sedimentological and multi-proxy

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studies in inferring a temperate polythermal glacial regime for the Victoria Land Basin area of the Ross Sea during the late Eocene to early Miocene.

The extinct diatom genus *Kisseleviella* was first described as monospecific, with *K. carina* as the type species, by Sheshukova-Poretskaya (1962) from Miocene strata on the Schmidt Peninsula of Sakhalin Island, Russia. *Kisseleviella carina* was later reported from Miocene strata in the North Pacific Ocean, for example, Koizumi (1973), Akiba (1986) Akiba and Yanagisawa (1986), and from lower Oligocene to middle Miocene strata of eastern Hokkaido Island, Japan (Morita et al., 1996). Excellent illustrations of *K. carina*, as well as a discussion of its vegetative cell/resting spore relationships, are given by Akiba and Yanagisawa (1986).

In addition to *K. carina*, three other species of *Kisseleviella* have been formally described: *K. ezoensis* Akiba (1986) *from lower Miocene strata of eastern Hokkaido, Japan; K. magnaareolata Akiba and Yanagisawa (1986) from presumed Oligocene strata from central Japan; and K. cuspidata Gleser et al. (1986) from upper Eocene to probable lower Oligocene strata from eastern Kamchatka.*

Several authors report the occurrence of "*K. carina*" from Antarctic waters, e.g. Harwood (1986, 1989), Baldauf and Barron (1991) and Barron and Mahood (1993), although all illustrations identified as *K. carina* from Antarctica differ from *K. carina* sensu strictu. Some of the taxa described in these papers are synonymous with new species of *Kisseleviella* described here (see synonymies for details).

The closely related extant genera *Cymatosira* Grunow (1862), with an emended diagnosis given in Hasle et al. (1983), and *Rutilaria* Greville (1863), with a major revision by Ross (1995), are also considered. These two genera share many morphological characters with *Kisseleviella* and provide useful points of comparison.

2. Materials and methods

Upper Eocene to lower Miocene sediment was recovered from the CRP-2/2A and CRP-3 drillcores. These were drilled in 1998 (CRP-2/2A) and 1999 (CRP-3) in the McMurdo Sound region of the Victoria Land Basin, Ross Sea, Antarctica. Recovered sedimentary successions were interpreted as deposited within a near-shore glacimarine environment, which accounts for variance in siliceous microfossil preservation and abundance throughout the cores (Harwood, 1989; Scherer et al., 2001; Fielding et al., 2001; Harwood and Bohaty, 2002). Many intervals contain diverse and well-preserved siliceous microfossil assemblages. Stratigraphic ranges of the taxa described in this study are well-documented for each particular core, but the interpretation of age ranges is difficult because first and last occurrences are often coincident with sedimentary hiatuses (Harwood, 1989; Scherer et al., 2001; Harwood and Bohaty, 2002; Naish et al., 2001; Wilson et al., 2002).

Samples were processed for light microscopic examination following the method of Scherer (1994), which is based on distributing a slurry of sample of known mass over a known area of a cover glass, allowing quantitative analysis. Samples from well-preserved intervals were sieved at 5 μm, 10 μm or 20 μm, or floated using sodium polytungstate heavy liquid separation techniques, for scanning electron microscope (SEM) examination. Morphometric characterization of the *Kisseleviella* species was carried out using a Leica DM R light microscope and Image Pro digital image capture software. A JEOL 5610 LV instrument operated in high vacuum mode was used for SEM examination. Aliquots of dilute sample were strewn onto 12 mm circular glass cover-slips and mounted on SEM stubs using carbon paint, then sputter-coated in gold using a Denton Vacuum Desk II evaporator.

3. Discussion

3.1. Paleoecology

Reports of *Kisseleviella* species, from diverse geographical locations, make it apparent that the genus is not confined latitudinally, but is almost certainly restricted (in optimum life habit) to nearshore environments. *Kisseleviella* is generally very rare in offshore deposits in the Southern Ocean (Baldauf and Barron, 1991). However, it is common in continental shelf sections in the Ross Sea (Scherer et al., 2001; Harwood and Bohaty, 2002) and in Prydz Bay (Barron and Mahood, 1993; Baldauf and Barron, 1991). *Kisseleviella* is also reported (in low abundance) at sites with relatively shallow paleo-depths, for instance, the middle–upper Eocene of the Tasmanian Gateway (Exon et al., 2001). Fenner (1982) reported three informal species of *Kisseleviella* occurring in low abundance in sediments from the continental slope and rise off the coast of northwest Africa.

The ecological affinity suggested for the species described in this paper is based on the morphological relationship to extant taxa of the order Cymatosirales (see below), and by the spatial distribution of sediments