Circum-Arctic river discharge and its geological record: An introduction

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EDITORIAL

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Introduction

The Arctic Ocean and its marginal seas are key areas for understanding the global climate system and its change through time. The present state of the Arctic Ocean itself and its influence on the global climate system strongly depend on the large river discharge. Presently, the annual freshwater inflow by major rivers reaches a total of 3300 km^3 which is eqivalent to 10% of the global runoff. Major contributors are the Yenisei (620 km^3/year), the Ob (429 km^3/year), the Lena (525 km^3/year), and the MacKenzie (249 km^3/year; Fig. 1; Aagaard and Carmack 1989; Gordeev et al. 1996). The importance of Arctic river discharge in the Arctic and global ocean systems is summarized as follows:

1. The fluvial fresh-water supply is essential for the maintainance of the ca. 200-m-thick low-salinity layer of the central Arctic Ocean and, thus, contributes significantly to the strong stratification of the near-surface water masses, encouraging sea-ice formation. Changes in the fresh-water balance would influence the extent of sea-ice cover. The melting and freezing of sea ice result in distinct changes in the surface albedo, the energy balance, the temperature and salinity structure of the upper water masses, and the biological processes.
2. The fresh-water exported from the Arctic Ocean through Fram Strait influences the global thermohaline circulation. Presently, the annual liquid fresh-water export with the East Greenland Current is approximately 1160 km^3. Estimates based on sea-ice export even reach values of 1680 km^3/year (Aagaard and Carmack 1989). Changes in these export rates of fresh-water would result in changes of deep-water formation and, thus, in global thermohaline circulation ("global conveyor belt"; Broecker 1997) and ventilation. Because factors such as the global thermohaline circulation as well as sea-ice cover and earth albedo have a strong influence on the earth's climate system, the freshwater input to the Arctic and its change through time may have triggered global climate changes in the past (e.g., the initiation of the Northern Hemisphere Glaciation during mid-Pliocene times; Driscoll and Haug 1998).
3. Major quantities of nutrients controlling surface-water productivity are supplied by rivers (e.g., Martin et al. 1993; Gordeev et al. 1996). Relatively high contents of chlorophycean algae, phaeopigments, and specific marine biomarkers in the surface sediments near the river mouths and on the shelf, indicating increased primary productivity, document this strong fluvial influence (Heiskanen and Keck 1996; Fahl and Stein 1997; Kunz-Pirrung 1999; Boucsein and Stein 2000).
4. The Arctic rivers transport large amounts of dissolved and particulate material (e.g., chemical elements, siliciclastic and organic matter) onto the shelves (Fig. 1; Table 1) where it is accumulated or further transported by different mechanisms (e.g., sea ice, icebergs, turbidity currents) toward the open ocean (Stein and Korolev 1994; Dethleff et al., this volume). For example, most of the organic matter accumulated on the Arctic shelves and adjacent continental slopes is allochthonous, supplied by the major rivers (e.g., Macdonald et al. 1998; Rachold and Hubberten 1999; Stein and Fahl 2000; Boucsein et al., this volume; Müller-Lupp et al., this volume). Furthermore, the different rivers carry suspension loads characterized by different mineralogical and geochemical tracers, dependent on the geology of the hinterland. These tracers

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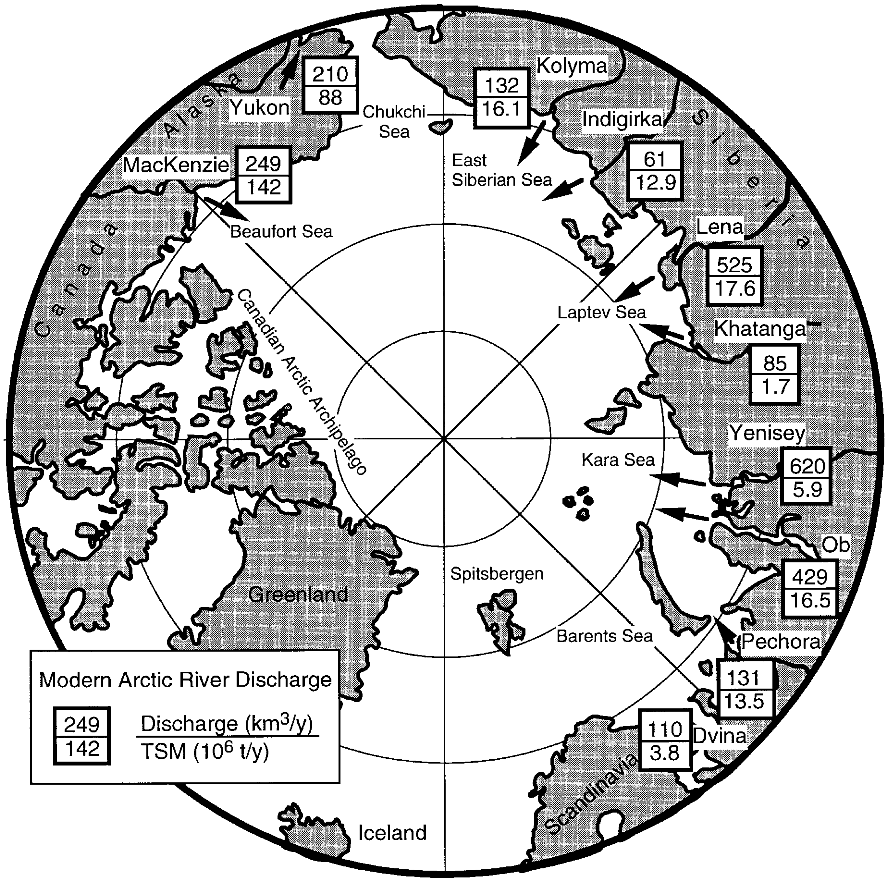

Fig. 1 Modern annual circum-Arctic river discharge, according to Aagaard and Carmack (1989) and Gordeev et al. (1996). *TSM* total suspended matter

Table 1 Modern annual circum-Arctic river discharge, according to Aagaard and Carmack (1989), Gordeev et al. (1996), Macdonald et al. (1998), and Rachold and Hubberten (1999). *TSM* total suspended matter; *TOC* total organic carbon; *POC* particulate organic carbon; *DOC* dissolved organic carbon

River	Discharging to	Discharge (km^3 $year^{-1}$)	TSM (10^6 t $year^{-1}$)	TOC (10^6 t $year^{-1}$)	POC (10^6 t $year^{-1}$)	DOC (10^6 t $year^{-1}$)
Pechora	Barents Sea	131	13.5	1.7		
Ob	Kara Sea	429	16.5	3.1	0.3	2.8
Yenisey	Kara Sea	620	5.9	4.6		
Khatanga	Laptev Sea	85	1.7	0.5		
Lena	Laptev Sea	525	17.6	5.3	0.8	4.5
Indigirka	East Siberian Sea	61	12.9	0.5		
Kolyma	East Siberian Sea	132	16.1	1.1		
Mackenzie	Beaufort Sea	249	142	3.4	2.1	1.3
Yukon	Bering Sea	210	88	1.3	1.1	0.2

(such as clay-minerals and heavy-minerals as well as major, minor and rare earth trace elements) can be used as indicators for specific source areas and reconstruction of pathways of terrigenous matter in the ocean (e.g., Behrends et al. 1999; Wahsner et al. 1999; Dethleff et al., this volume; Schoster et al., this volume). Thus, river-derived material contribute in major proportions to the entire Arctic Ocean sedimentary and chemical budgets.

5. The Arctic rivers may also transport major amounts of anthropogenic pollutants (e.g., radioactive elements, heavy metals) which are trapped in near-coastal sediments and/or transported toward the open ocean (Landa et al. 1998; Nies et al. 1998).

Having in mind the importance of the Arctic Ocean river discharge on the global climate system, the Arctic Ocean Sciences Board very recently initiated a new multidisciplinary and international research program on river discharge and its change through time ("Arctic Paleo-River Discharge, APARD"). The APARD Science Plan was published in 1998 (Stein 1998). During the past years a large number of research activities have been performed in the western as well as eastern Arctic continental margin, and a huge amount of new data on circum-Arctic river discharge was obtained (e.g., for river discharge data from the Laptev Sea see Kassens et al. 1999, and references therein). The overall task of this special issue of "International Journal of Earth Sciences" (formerly "Geologische Rundschau") is to present new data and an overview of the present knowledge of research on circum-Arctic river discharge and its change through geological times. This issue is divided into two chapters:

1. "The Modern System: Processes and proxies of Arctic river discharge." This chapter contains a series of papers dealing with the characterization and quantification of modern Arctic river discharge. Special emphasis is devoted to the different sedimentological, mineralogical micropaleontological, and geochemical proxies which can be used as tracers for river discharge in the Arctic.
2. "The Ancient System: Variability in Arctic river discharge through geological time." This chapters contains papers which concentrate on detailed reconstructions of Late Quaternary Arctic paleo-river discharge, using the sedimentological, mineralogical, micropaleontological, and geochemical tracers outlined in the other chapter as well as physical property and high-resolution acoustic profiling data.

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