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Concepts and controversies in phosphogenesis – an introduction

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Phosphorus (in the form of phosphate) is an essential nutrient in the marine and terrestrial biosphere, known to have limiting properties in landlocked, shallow-marine eviron-ments (e. g. Bothnian Sea and eastern Mediterranean Sea; e. g. Granéli et al. 1990, Krom et al. 1991), pastoral and agricultural ecosystems (e. g. Smith 1992, Crews 1993), and freshwater communities (e. g. Caraco et al. 1989). According to many authors, phosphorus may limit bioproductivity in general, mainly because of its capability to regulate nitrogen fixation in a variety of terrestrial and aquatic ecosystems (e. g. Holland 1978, Broecker & Peng 1982, Smith 1992, Mackenzie et al. 1993, Berner et al. 1993, Filippelli & Delaney 1994; however, compare also Codispoti 1989, 1994). As such, phosphorus may be the important driving force behind photosynthetic fixation processes of carbon and oxygen. Furthermore, through the stimulation of bioproductivity, phosphorus may profoundly influence marine and terrestrial ecology through the structuring of food-web networks which are very much dependent on the amount of nutrients and rates of primary production. Through the control of export production (i. e. the amount of organic matter that is not reused within the trophic zone of production; e. g. Berger et al. 1989), phosphorus may also influence oxygen availability in areas where the exported organic matter is oxidized. All this renders phosphorus a biophile element with extensive regulating capacities with regards to climate (in forcing the transformation atmospheric CO_2 → organic carbon), oxygen content and ecology.

In the last two decades we have seen an increasing recognition of the crucial role phosphorus plays in the environment. Many aspects of the biogeochemical and environmental interactions of phosphorus, however, need further elucidation, especially in the light of the considerable anthropogenic increase in phosphorus flux rates. Bulk phosphorus flux rates have been more than doubled by human activity on a global scale (Froelich 1984, Caraco 1993), and this may be beneficial in the short term (e. g. the use of phosphorus in fertilizers), but it certainly devastating in the long term (in affecting and altering complex ecosystems such as coral reefs in tropical seas and biological communities in general in fresh-water lakes and peripheral seas; e. g. Caraco 1993). Besides this, phosphorus may already have an impact on present-day climate by compensating for approximately 10% of the annual increase in atmospheric CO_2 from anthropogenic sources (Mackenzie et al. 1993).

Oberservation of present-day phosphorus behaviour is our prime source of understanding, in giving invaluable information on biogeochemical transformation processes. The geological record of preserved phosphate-containing phases from various paleoenvironments adds considerably to our knowledge in giving additional information on long-term processes and interactions of phosphorus and the environment. Moreover, the geo-

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logical past may serve as a template for testing our present-day observations and interpretations in a deductive approach; for instance, through the observation and numerical modeling of temporal relations between natural fluctuations in the global phosphorus cycle, paleoclimate and paleoecological change (e. g. Compton et al. 1993, Filippelli & Delaney 1994, Van Cappellen & Ingall 1994).

One of the incentives for organizing the Symposium and workshop "Concepts and Controversies in Phosphogenesis" (Matten near Interlaken, Sept. 6–10, 1993) was to provide a possibility for scientists working in recent natural and experimental environments, scientists working in environments of the geological past, and representatives of the phosphate-exploiting industry to convene and explore the various aspects of phosphogenesis in an integrated approach, under the auspices of IGCP 325 "Correlation of palaeogeography with phosphorites and asscociated authigenic minerals". During the meeting, we emphasized round-table discussions, arranged for a full-day workshop, and provided ample time for discussions. The size (45) and mixture of participants from industry and research groups in the USA (7), Russia (4), Canada (1), Mexico (1), Argentina (1), Tahiti (1), India (1), Pakistan (1), Egypt (2), Jordan (5), Israel (2), Albania (1), Spain (1), Portugal (1), France (6), Germany (2), United Kingdom (2), Poland (1) and Switzerland (5) allowed for a lively and yet informal meeting. The first three days were devoted to three different themes: 1) "Phosphorus, sedimentology and paleoceanography"; 2) "Phosphorus, geochemistry, agriculture, and industry"; and 3) "Phosphorus, the microbiosphere, and interactions of phosphorus with other biophile elements". In the morning, the theme of the day received an overview in three of four introductory talks and a subsequent poster session. In the afternoon, concepts and controversies central to the theme were explored in two round-table discussions, each guided by two chairmen and one rapporteur. On the fourth day, we formed three working groups, each devoted to one of the themes. These working groups summarized their findings in three reports, which served as a base for the three review papers presented here. The working group papers were compiled with the objective to provide a synoptic, multi-authored view of the status-quo in research and industry with regard to various physical, biogeochemical, and environmental aspects of the phosphorus cycle (Jarvis et al. 1994, Krajewski et al. 1994 and Glenn et al. 1994).

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