Figure 12. A schematic diagram illustrating the major influences on the distribution of TEIs in the ocean. Four major ocean interfaces (blue) and four major internal processes (red) are responsible for ocean TEI patterns. Within GEOTRACES, interface processes form the basis of Theme 1, while internal cycling processes are the basis of Theme 2.

Seawater chemistry reflects the sources and sinks of material to and from the ocean. These sources and sinks result from exchange of material between the solid Earth and the ocean: a process that occurs through four pathways (Figure 12; see also Bruland and Lohan, 2003).

In the first pathway, material derived from the continents is transported, in particulate or gaseous form, through the atmosphere to be deposited on the sea surface. Second, continental crust is eroded by chemical and physical processes and transported, in dissolved or particulate form, to the ocean margins by flow in rivers and groundwaters. Third, marine sediments act as a chemical reactor to release and adsorb chemical species to and from seawater. Finally, exchange with the Earth's crust and mantle occurs primarily through interaction with mid-ocean ridge basalts, both at high and low temperature.

The fluxes of TEIs occurring at each of these ocean interfaces are generally not well known. This lack of knowledge represents a fundamental problem for any of the diverse disciplines that require assessment of regional or global biogeochemical budgets. Improved understanding of the fluxes at each of these four ocean interfaces therefore represents a central theme of the GEOTRACES programme.

Although many of these fluxes can be measured directly, and such measurement programmes are now being implemented in parallel research initiatives (LOICZ, SOLAS, IMBER, etc.), the large spatial and temporal variability of the processes involved renders global integration and budget calculations difficult. GEOTRACES intends to follow a complementary approach, which will take advantage of the fact that the magnitude and pattern of TEI fluxes at ocean interfaces is reflected in the distribution of TEIs within the ocean. Improved knowledge of ocean distributions of TEIs, particularly in regions where such boundary fluxes are of special importance (e.g., dust plumes, estuaries, ocean margins, mid-ocean ridges) will therefore provide direct information about these fluxes.

Knowledge of TEI distributions will also lead to understanding of the processes involved in exchange between the solid Earth, the atmosphere, and the ocean. Mineral dissolution, mineral surface adsorption/desorption, biological utilisation, element speciation, and a wide range of similar biological and chemical processes ultimately control the fluxes of elements to and from the ocean, and therefore the distribution of TEIs. An important goal of GEOTRACES is to develop sufficient understanding of each of these processes so that changes in TEI cycles in response to future global change can be predicted accurately.

Understanding TEI fluxes and the processes that control these fluxes will rely on an integrated approach that puts new chemical measurements into a rigorous physical and biological framework at each of the ocean interfaces and within the ocean itself. Integration of multiple TEI measurements will also provide important information. Aluminium and Mn, for instance, provide tracers of Fe.