THE INORGANIC CARBON CYCLE

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Introduction

The Earth contains about 10^{23} g of carbon, which appears partly as organic carbon (SOC), partly as inorganic carbon (SIC) (Lal, 2004). The distribution of SOC and SIC in the various "spheres" is presented in Table 1.

The significance and importance of the geochemical (inorganic) carbon cycle

The geochemical carbon cycle is schematically illustrated by Figure 1. The SIC exists in soil as primary and secondary minerals. Primary or lithogenic carbonates originate from parent rock material. Primary carbonates are the source material for the formation of secondary carbonates when they are dissolved and translocated by water with organic acids and/or CO_2 from the soil and atmosphere. Secondary or pedogenic carbonates form when dissolved CO_2 precipitates carbonate and bicarbonate with Ca^{2+} and Mg^{2+} from outside the system. Under conditions of decreased moisture or increased pH, cations, bicarbonate (HCO_3^-), dissolved carbonates and CO_2 can react with available cations to form secondary carbonate coatings on primary soil particles (Bronick and Lal, 2005).

Soils and near-surface geological resources – as a biogeochemical interface between the spheres of the Earth system (Table 1) – play a strategic role in the global C balance. Their inorganic C pool is considerably higher, but more stable and less reactive than the SOC pool. Their importance is often ignored in spite of the fact that pedogenic processes of carbonate leaching, silicate-mineral weathering are important processes in carbon sequestration.

According to the estimation of Schlesinger and Eswaran (In: Lal *et al.,* 1995) the inorganic carbon pool on Earth is 170 Pg C, mainly carbonates: $CaCO_3$, $MgCO_3$ and (to a smaller extent) Na_2CO_3.

The significance, importance and direction of the $CO_2 + H_2O \leftrightarrow H_2CO_3$ reaction completely differ under various climate, water regimes and land use practices. The most important approach is that:

acid volatiles + igneous rocks = sedimentary rocks + salty oceans/seas

(much more than the $0.018+0.13\times10^{15}$ g C per year emission from volcanic activities).

The C balance in the various climatic/hydrologic/vegetation/soil zones shows very high spatial and time variability on Earth, as it is schematically illustrated by Figure 2 (Drees *et al.,* 2001).

Pathways, reasons and consequences of the inorganic carbon cycle

Soil is a dynamic system and during weathering and soil genesis considerable changes take place in the soil carbon. The main processes are as follows:

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- physical, chemical and biological weathering;
- dissolution
- precipitation
- leaching
- accumulation

depending on soil properties, e.g. soil reaction, carbonate status, texture, structure, moisture regime.

These processes are strongly influenced by climate (and climate changes), surface and subsurface hydrology, vegetation and land use pattern and various human activities.

In the Alpok–Adria region, especially in the Carpathian Basin the main carbonate resources are the calcareous Quaternary (Pleistocene) loess deposited to drylands or into water and waterlogged territories; calcareous Holocene aeolian sand; calcareous alluvial deposits of rivers coming from limestone watersheds; calcareous colluvial materials transported by lateral erosion from carbonatic surroundings. Surface and subsurface waters play an important, often decisive role in their state, horizontal and vertical distribution, and their significance in the carbon cycle and carbon sequestration (Várallyay, 1985, 2002).

In Hungary – due to various reasons (acid rain, improper fertilizer application etc.) – a quite serious $CaCO_3$-loss was measured. Part of the dissolved carbonates was leached by downward filtration, while another part was „destroyed" completely ($CaCO_3 + 2H^+ \rightarrow H_2CO_3 \rightarrow H_2O + CO_2$) and contributed to the increase in CO_2 concentration of the surrounding atmosphere.

Table 1. Major C reservoirs in the Earth System (Drees et al., 2001)

Sphere	SIC	SOC	Total C
	10^{15} g		
Atmosphere	760	–	760
Biosphere	–	560	560
Pedosphere	1 700	1 500	3 200
Hydrosphere	38 000	1 000	39 000
Lithosphere	48 000 000	17 000 000	65 000 000

Remark: SIC: soil inorganic carbon; SOC: soil organic carbon