

Forms of energy involved in soil formation

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Abstract

Four different forms of energy involved in soil formation are described: gravity, orogenic energy, solar energy and anthropogenic energy, in order to understand and to measure soil formation under different physio-geographic and environmental conditions.

Key Words

Soil formation, forms of energy, weathering, critical zone research

Introduction

Soils are providing goods and services of paramount importance for sustaining human societies and the environment (Blum, 2005; Frossard *et al.*, 2006; Costanza *et al.*, 1997).

In view of the world wide losses of soil, e.g. through erosion, information about the time scale of soil formation becomes increasingly important (European Commission 2006). Until today, we have measurements and assessments regarding soil losses, but no solid data about the pace of soil formation. Therefore, the question arises: How much soil is formed with time, under different climatic, geological, topographical, hydrological and biotic conditions, under the influence of human activities, including climate change. An international research group on critical zone processes is targeting this issue (Chorover *et al.*, 2007).

Methods

For answering this question, a first approach could be to identify the basic forms of energy involved in soil forming processes. With such an approach, it would also be possible to develop a comprehensive concept, which would allow to describe processes of soil formation as well as methods to measure them, e.g. weathering of rock parent material and the development of the regolith zone, as well as the further development from regolith to soil. This concept could also allow to define indicators for the different characteristics of rock, regolith and soil.

Results

Soil formation is driven by four main forms of energy: gravity, orogenic energy, solar energy and anthropogenic energy. Gravity influences all movements of solid, liquid and gaseous materials. It is an inherent form of energy and influences the vector and the velocity of fluxes within soils as well as at their surface. – Gravity is also the main factor of morphogenesis.

Orogenic energy is the second form of energy and is inherited from the rock parent material, which was formed through orogenesis, an endogenic process which created very diverse types of rocks and minerals under high temperature and pressure. This endogenic energy, which can also be called orogenic energy, is still contained in rocks and in the rock forming minerals. This energy is normally not renewed for a long time, except in cases such as volcanic activities and others. – Through exogenic forces, derived from solar energy, e.g. through processes of weathering and transport (e.g. erosion), this orogenic energy pool is constantly lowered. Primary minerals, such as micas and feldspars contain more energy, derived from orogenesis as their weathering products, e.g. clay minerals and oxides. Moreover, the resistance of different minerals against weathering or the buffer capacity of soils against acidification can also be explained by orogenic energy. Orogenic energy is manifest in the texture and structure of rocks and the crystallography of minerals and their resistance to exogenic forces, which is mainly explained by the form and density of the mineral package in the rocks or the element package in the crystal structure of minerals. – Orogenic energy is also manifest in the chemical composition of minerals, which plays an important role, e.g. through the content of alkaline and earth alkaline cations in relation to silica, aluminium and metals such as iron, manganese, copper, zinc and others.

Solar energy is the third form of energy, deriving directly from solar radiation or from diffuse radiation through reflection and indirectly from organic matter and biomass, which can be considered as a secondary form of solar energy, with a different dimension in space and time. Both, direct and indirect forms of solar energy e.g. organic matter are the basis of exogenic forces, driving biochemical and physico-chemical processes in soils. – Solar energy also influences the velocity of bio-physico-chemical reactions. – In the past, soils developed under different climatic conditions (paleoclimates), especially in the tropics and subtropics, which makes it difficult to use current climatic data, such as temperature and/or precipitation to explain soil formation.

Anthropogenic energy is the fourth form of energy, deriving from anthropogenic activities. It is a mixture of different energy forms, including human labour, and is mainly based on fossil energy and non-renewable resources, such as oil, coal, rocks and minerals.

Since the end of the 18th century, anthropogenic influences on terrestrial and aquatic ecosystems have been exceeding the natural impacts (Crutzen, 2002; Blum and Eswaran, 2004).

Conclusions

In order to understand soil formation under different environmental, social, economic, technical and cultural conditions, it seems to be interesting to use the energy concept in order to make soil formation understandable and measurable. This is the current task of the critical zone approach.

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