

European Community Position Paper on Joint European-USA Research on Weathering Systems Science (WSS)

Background

The National Science Foundation (NSF) supported an USA community meeting in autumn 2003 to explore the need for a concerted research programme in the area of 'Weathering Systems Science'. European scientists, with support from the Worldwide Universities Network, convened a round table discussion in London on the 14th of October 2004, that included a programme manager from NSF and a representative of the Principle Investigator from the USA. The outcome from that meeting is the following position paper that establishes the scientific framework for a joint European-US research programme in Weathering Systems Science.

Weathering Systems Science

Weathering describes a core set of Earth systems processes that help create and maintain the “critical zone” for life that exists between the bedrock and the canopy of the biosphere. A key concept inherent in Sustainable Management of the critical zone, is that of the “*whole system life cycle*”. Weathering science inherently addresses the whole life of soil; where inputs from the uplifting bedrock, atmosphere and hydrosphere are internally cycled and eventually removed as the products of chemical, biological and physical erosion. The weathering products feed the geological cycle of the earth's crust. The processes of this *weathering engine* are also central controls on the cycling of biomass, nutrients and pollutants; their accumulation and release. A crucial challenge is to place the rates of these processes that dictate the mass stocks and fluxes of soil components, within the context of anthropogenic disturbance to soil sustainability. Sustainable soil management is a major challenge that links directly with the EU strategy for a new Sustainable Soils Directive.

EU Strategy for a new Sustainable Soils Directive

High quality weathering data pertinent for the various European regions are needed for the development of the Sustainable Soils Directive as are integrated models that can use these data. With such an approach the entire life cycle of soil systems is addressed, which can underpin their sustainable management. This approach is needed since anthropogenic soil erosion may exceed natural erosion in many places in the EU. Exact figures can at present not be given since quantification of soil formation rates on an European scale is lacking. The integrated approach will also be relevant for other important policy issues such as:

- Carbon sequestration and the impact of anthropogenic forcing of climate;
- Assessing pollutant lifetimes and fluxes; e.g. solute budgets and environmental risk and scientifically justified critical limits and loads of potential pollutants such as heavy metals and organic compounds;
- Soil loss through human impacts – replenishment through the weathering engine.

Important scientific issues involved are e.g.:

- Resolving the scale dependency of soil properties and processes;
- Quantifying biological drivers of soil properties and processes.

General approach of the proposed research

Weathering Systems Science provides the temporal framework for the analysis of soil processes and evolution. Modern anthropogenic forcing of soil systems is placed in the context of earth systems on geological time scales. This allows an understanding of the role of human impacts on the evolution of modern soils and predictions of future changes that must be managed and establishment of permissible critical loads of chemicals in the system. It integrates across the broad array of disciplines from geology, soil science, biology, ecology and hydrology and has the potential to combine these with novel molecular and imaging science and powerful numerical modelling methods.

The key scientific questions that need addressing in the early 21st century include:

- How can the dominant factors governing weathering be quantified?
- How are the biological, chemical and physical processes driving weathering coupled?

- How can we predict such processes?
- How can this knowledge be used to inform decision makers about pedosphere deterioration and to manage the soil systems in a sustainable manner?

Innovation Potential

The vision is to develop quantitative, integrated models that describe in detail the linkages between key biological, chemical and physical processes, developed at the scale of the soil profile, and supported with fundamental understanding of mechanisms. There is tremendous potential to move from ecosystem-specific, empirical approaches to predictive capabilities that are established more firmly from first principles and that can be transferred across a wide range of temporal and spatial scales. This is brought about by the innovative incorporation of extant knowledge with exciting new tools such as cosmogenic isotope profiling, advanced spectroscopy, tomographic imaging, reporter genes, micro-electrodes and other sensors to collect field data at high spatial resolution and environmental informatics. Powerful new computational methods such as parallel load balancing of numerical codes can now incorporate fully coupled descriptions of solute transport and detailed reaction mechanisms while accounting for spatial variability in soil properties. These modelling approaches provide a platform to develop a detailed description of how such processes interact with soil biology and other factors. A key requirement for this development is international collaboration to develop critical data sets. This includes comprehensive field studies at highly instrumented sites using agreed state-of-the-art methodologies applied to the full depth of soil profiles; termed *node sites*¹. At the same time, a wider range of conditions; biota, climate, latitude, elevation, lithology, etc. can be studied with a common set of protocols; e.g. at globally-distributed *network sites*.

Strategy

Members of the European academic community championing the potential for a joint EC-NSF programme in WSS will be present at the Vienna Workshop on Soil Protection in Vienna, October 28-29, 2004. A workshop in Saratoga, New York on June 26 this year and the October 14 round-table discussion in London established a commitment between European and US researchers to pursue the possibility for a joint directed programme between the EC and NSF as a longer term strategy to build an international WSS Consortium that could contribute substantially to the delivery of EU research on the Sustainable Management of Soils (EU Soil Directive – now being drafted) and Sustainable Management of Water (EU Water Directive – now being implemented). At present the European and international communities are addressing many of the outlined weathering and soil issues, but in a fragmented manner. Here we are proposing a holistic way to advance our knowledge of the life cycle of the entire soil system by using an integrated multi-disciplinary approach.

Participants List: European-US Round Table Discussion with NSF, 14th October 2004

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