Volcanic soils of Europe

Soils of volcanic regions are unique natural resources. When volcanic materials are exposed to weathering, short-range order minerals, such as allophane, imogolite and ferrihydrite are formed, as well as specific types of humic substances. These colloidal materials give the soils distinctive properties, collectively termed andic properties, which separate volcanic soils from other types of soils. These properties include high organic carbon content, variable charge characteristics, high phosphorus retention, low bulk density and great water retention capacity. These kind of soils are named Andosols (FAO-WRB) or Andisols (Soil Taxonomy), a term derived from Japanese, where “an” means black and “do” is soil. Andosols are typically relatively young soils, but when left to prolonged weathering, other soil types can develop, but the evidence of their volcanic origin can be preserved for a long time.

Volcanic soils cover only 1–2% of the world’s land surface. They are often among the most fertile soils and therefore are the foundations for some of the most densely populated areas of the world. They often occur in scenic areas and are commonly subjected to extreme pressures from tourism. The unique physical and chemical properties of Andosols make these ecosystems susceptible to disturbance. They have effective pollutant binding properties resulting in possible accumulation of toxic substances. Degradation of volcanic soils also includes salinization by irrigation, reduced ground-water quality and loss of fertility, particularly under humid climates and intense leaching. The low bulk density of Andosols, often low amount of lattice clay minerals, and sometimes the presence of light tephra grains make them both prone to wind erosion and sometimes erosion by water. Their peculiar thixotropic behavior, with unstable solid state which can become liquefied upon disturbance, explains the relatively common occurrence of catastrophic landslides in volcanic areas. Understanding the fundamental properties of soils in volcanic areas is therefore important for
developing policies for the use and protection of these important soil resources.

Volcanic areas occur in many parts of the world, but most studies on soils of volcanic areas have been conducted in Japan, New Zealand and the Americas. Such soils have received less attention in Europe. This book is dedicated to soils of volcanic regions of Europe with a comprehensive coverage of most aspects of such soils in Europe. It is the largest such publication on soils of volcanic regions to date and presents results of research that has international implications.

**Geographic differences**

The range of environmental conditions shaping the soils discussed in this publication is noteworthy as is evident from the first part of the book. The climate ranges from Mediterranean Italy to the southern Massif Central in France and the continental climate of the Carpathian basin and mountains of Germany, to the warm Atlantic of the Azores, Madeira and Canary Island and sub-arctic Iceland. Rarely has such a wide variety of environmental conditions for soil development been summarized in one publication. The diversity in geology, including the chemistry and morphology of the parent materials is substantial.

The largest European volcanic area is in Iceland, under wet and cold climate. It is characterized by a variety vitric, allophanic and peaty Andosols together with of vitric volcanic soils on barren surfaces or deserts. The Andosols exhibit well expressed andic features often with a peaty texture in wetland soils. Cryoturbation and hydromorphic features are common.

In the Mediterranean countries such as Greece, continental Italy, Sicily and southern France there is a large variety of young volcanic soils, such as vitric and typical Andosols on young pyroclatic materials. More evolved soils, such as Brown soils Alfisols and Vertisols occur on older volcanic materials. Millennia of cultivation and fertilization have deeply modified many of the volcanic ash soils, and caused erosion.

Typical allophanic Andosols are found on young pyroclastic materials in Continental Europe, such as in the Chaine des Puys and the Cantal in France, Eifel and Vogelsberg in Regions in Germany and Carpathian countries (Hungary, Slovakia, Romania). Andosols rich in organo-aluminium complexes appear on older volcanic formations together with other soil types. Under cold and wet climate of some European mountains, soils with
andic properties and rich in organo-aluminium complexes are also observed on old basic, non-volcanic plutonic rocks.

In the Atlantic Canary, Madeira and Azores Islands, there is a large variety of climates, from sub-tropical to temperate temperatures, and from very wet to semi-arid moisture regimes. The volcanic deposits are mostly basaltic of variable age. The results in diversity of volcanic soils depending on the age and climatic conditions: vitric and typical Andosols on young pyroclastic materials, Andosols rich in organo-aluminium complexes or more evolved soils on old volcanic formations. A peculiar type of Andosol, characterized by a extreme water retention capacity is found on the Azores Islands. Paleosols are often well preserved on these Atlantic Islands.

Physical and chemical degradation of volcanic soils is also common in Europe, depending on climate and land use. Landslides regularly occur in European volcanic areas, some catastrophic and causing losses of human lives and property damage. An example is the slide near Napoli, Italy in 1998, which left 161 people dead, and causing huge property damage.

The COST-622 Action joint research approach

This comprehensive publication is the result of European funded scientific collaboration program entitled “COST-622; Soil Resources of European Volcanic Systems”. The program was initiated in 1998, leading to a fruitful co-operation among scientists from Belgium, France, Germany, Greece, Hungary, Iceland, Italy, the Netherlands, Portugal, Slovakia, Spain, and the United Kingdom. It included a number of scientific workshops and conferences hosted by the participating countries, often within volcanic areas. The program has already resulted in two special issues of scientific journals (Bartoli et al. 2003, Arnalds and Stahr 2004). This program was completed in 2004.

The objectives of the COST-622 program were to assess the impact of age and nature of volcanic parent materials, climatic parameters and anthropic effects on the formation and properties of the European volcanic soils. This task was undertaken by (i) joint sampling and analysis of number of reference pedons in the countries (2–4 in each country); and (ii) by collaborative research efforts between European institutes working on Andosols.

Descriptions of the selected European volcanic soils were made and both undisturbed and bulk soil samples were obtained. The undisturbed soil samples were used for micromorphological and physical studies. The
bulk soil samples were distributed to the various laboratories of the participating countries for research on mineralogy and weathering, organic and mineral chemistry, physical chemistry and biological studies. We conclude that this multi-disciplinary and multinational approach is quite unique for soil sciences.

The aim of the research included:

- obtaining more detailed information about the nature and distribution of volcanic soils in Europe, which included collaboration with and reference soil collection by ISRIC, the Netherlands
- a genetic study of the reference pedons and the development of soil classification considerations for volcanic soils (WRB)
- to investigate the mineral and organic soil constituents in volcanic soils, weathering, bio-geochemical processes, physical-chemical properties and physical properties of European volcanic soils
- and to adapt methods for three-dimentional studies of macrostructure, particle size, chemical dissolution techniques, and pyrolysis of soil organic materials

Data handling and integration includes multivariate statistical analysis. The results generated in these studies have international relevance for volcanic soils and soil science in general.

**Organization of this book**

This book is divided into five sections. Section I describes the diversity of European volcanic soil resources and their environments and provides background information for the reference pedons. Section II provides discussion on parent materials and it provides results on mineral composition and genesis of the soils. Results on chemical, biological and physical characteristics are presented in Sections III and IV. The scale of observation ranges from the meter and centimeter scale, for soil descriptions and down to the micrometer scale for characterization of soil constituents, interrelationships and reactivity, soil structure, and soil properties. In Section V, examples of the soil behavior is given with respect to soil properties and land use considerations, together with a synthesis of geographical data. Finally, the content of the accompanying CD is presented.

English is the language of this book. However, the authors come from a variety of language areas, and allowance is be made for letting the original or native tongue and the style of each author to show through as much as possible, as long as the contents are clear and of high quality, and the English is reasonably correct.
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References

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