Magnetic and geochemical characteristic of the relict charcoal hearths – unique pre-coal industrial and cultural heritage

Presence of minerals (mainly iron oxides and hydroxides) may affect the magnetic properties of soils, depending on geological, soil and environmental conditions. Near-surface soil horizons can have stronger magnetic signals than the parent material, and such a phenomenon is called 'magnetic enhancement.' In the light of the project's proposal, the main focus is on the ferrimagnetic minerals such as magnetite or maghemite, which have been identified as the main carriers of the soil magnetic enhancement. However, this does not mean that antiferromagnetic minerals like haematite, goethite, lepidocrocite, which are generally much more abundant in soil than ferrimagnetic minerals, will be excluded or omitted in this project.

Remains of the historical production process of charcoal, the so-called 'relict charcoal hearths (RCHs),' have been found and described in many forests, and various landscapes in Europe, and especially in Poland and Germany, as well as in the USA. The RCHs have unique morphological properties, e.g. embankments with a diameter of *circa* 15-20 m and a height of *circa* 0.5 m. The combustion process in the RCHs has been known since the Roman Times until the modern times and the development of metallurgy, i.e. when the need for charcoal to smelt metals from ores was high. This former technological process was commonly used until the middle of the 19th century, in particular wherever pre-coal industry took place.

The research hypothesis adopted in the project proposal is based on the assumption that the formation of ferrimagnetic and antiferromagnetic minerals as a result of fires is one of the factors responsible for the magnetic enhancement in soils. Hence, the fire-affected soils have specific magnetic properties of topsoil genetic horizons, which can be successfully characterized and described by the magnetic parameters, as in the case of the RCHs.

The principal aim of the project is to create a magnetic description of soils characterized by a charcoal-enriched horizon as a result of a long-term (over 200 years) charcoal production process and to compare it with reference soils (i.e. the same type of soil, but without the presence of a horizon enriched with charcoal). Moreover, the aim of the research will be to determine the differences between RCH soils and reference soils in terms of spatial distribution of magnetic particles in the horizons of the topsoil using a new three-dimensional (3D) modeling and visualization tool with greater precision and resolution than conventional methods. For this purpose, the author (i.e. principal investigator – PI) compiles multidisciplinary, and interdisciplinary approach. Thus, the various magnetic methods and techniques will be used, *inter alia*, magnetic prospection, magnetic mineralogy, measurements of magnetic susceptibility, and magnetic loop hysteresis. Moreover, magnetic features will be supported by physical-chemical soil analyses, content of selected elements and specific forms of iron, digital microscopy, and X-ray diffractometry.

The research will be carried out in mountain, upland, and lowland forests of northern, southern, and southeastern parts of Poland. Unique research materials (soil and charcoal samples) will be take from soil profiles from each separated genetic horizon. The tested soils (both RCH and reference soil profiles) from individual study plots will be diversified in terms of bedrocks, soil types, and forest stands.

Currently, there are no studies reporting RCHs using magnetic analyses, and this gap is addressed in the project proposal. Thus, the importance of the proposed research is fundamental for geophysics, soil science, forestry, and archeology. The obtained data may serve as reference data for a variety of environmental magnetic studies, in particular a historical charcoal production characteristic as a unique pre-coal industrial and cultural heritage. In addition, these data may influence the development of research into: (1) environmental magnetism (pyrogenic magnetic enhancement of soils); (2) forestry (the effect of charcoal on the properties of forest soils); (3) archeology (methods and techniques for archeological prospection). Nevertheless, the historical process of charcoal production should be considered not only in the context of iron metallurgy (and discovered objects as industrial heritage), but also in the context of cultural heritage. Therefore, it is planned to prepare publications and information materials not only for the scientific community, but also for a wider audience (society, forestry and local administrative units).