Magnetic and Mossbauer study of Fe-compounds in relicts of Iron Age slags in Denmark (reconstruction of historical iron smelting process).

T. S. Gendler[1], N. Abrahamsen [2], A.N. Antonov[3], A. A. Novakova[3]

[1] Institute of Physics of the Earth RAS, Moscow, Russia
[2] Department of Earth Sciences, Aarhus University, Denmark
[3] Moscow M.V. Lomonosov State University, Moscow, Russia

Corresponding author: gendler06@mail.ru

Abstract: Magnetic surveying has been used in archeology since ~~about~~ 1960 (e.g. Aitken, 1961), in Denmark it has been in use since 1964 for mapping of iron-age slag pits. The total number of slag pits in Denmark was estimated as more than 50000 after magnetic mapping [Smekalova et al., 1993]. One of these iron-producing areas is Snorup situated in SW Jutland comprising 23 or more smelting sites with remains of slag-pit furnaces dating for the period 100-700 AD (Voss, 1993b). Local production of metallic iron ~~has~~ had occurred earlier in Denmark, mainly between ~~about~~ 2nd century BC and 1300 AD [ ]. This production was based upon the local bog-iron ore and locally produced charcoal. Results of detailed paleomagnetic investigations as dating of individual slag bodies by using magnetic secular variations data were presented earlier [Abrahamsen et al. 1998, Abrahamsen et al., 2003].

This work is an attempt to study not only TRM carriers but complete mineral composition of the samples drilled from some iron-age slag-blocks excavated in Snorup area [Abrahamsen et al. 1998], and make a reconstruction of ancient local smelting process basing on phases relation. Another important point is to determine the sutability of these slags for the paleointensity determinations. X-ray and thermomagnetic (J(T), Jr(T)) analyses as well as the Mossbauer spectroscopy were used as three independent complementary methods of solid state physics. Mossbauer spectroscopy on 57Fe gives not only all Fe-containing both crystallized and amorphous phases discrimination but also a quantitative estimation of different phases content and common Fe(II)/Fe(III) ratio. The combining results of the three methods mentioned above for samples from 7 complete slag bodies (E16, E24, E25, E10, KA1,KA2, KA3) and bottom plates (F4, F1) are the following:
1) all slags are "silicate" type with high inhomogeneity; 2) six crystalline phases are stable since slag was cooling down after the last heating and excavation, namely olivine (mainly fayalite), "wustite", "magnetite", titanomaghemite, Fe-met. , SP-hematite; 3) these phases are in different combinations and relative content in different slag blocks, so there was no one absolutely similar slag block with the same composition; 4) the transformation of thermally unstable phases such as wustite, Fe met., or titanomaghemite, and their variable content result in irreversible nonidentical

thermomagnetic curves of different slag blocks founded in one site (Fig.1); 5) no "silicate glass phases"were detected in slags what indicates slow cooling rate. Using the qualitative and quantitave determination of the mineral phases in slags, reconstruction of historical iron smelting process in Snorup area was considered and oxidation-reduction reactions are discribed. Main smelting parameteres such as temperature and the oxygine fugasity were estimated basing on well known thermodinamic data for the obtained minerals relationship.

Keywords: iron slag, rock magnetism, archaeomagnetism, Mossbauer spectroscopy

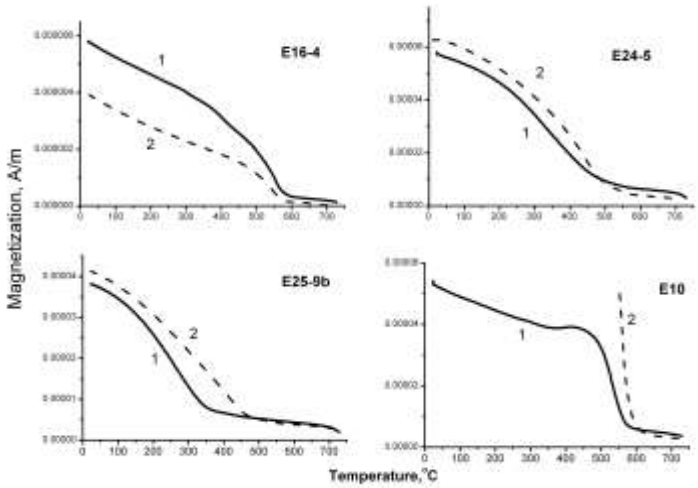

Figure 1: Thermomagnetic curves of the samples from forth slag bodies in Snorup area.

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