(22) DIFFERENT TYPES OF IRON PRECIPITATIONS DURING REDUCTION – IN- SITU- OBSERVATIONS BY A MODIFIED SCANNING ELECTRON MICROSCOPE (SEM) –

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1. Introduction.

During the reduction of wustite the formation of different iron phases with variable physical and chemical properties can be observed:
Porous iron guarantees an unaffected reducing process (1), whereas topochemical- or fibrous iron precepitations cause negative effects: Layerlike segregated iron on wustite, for instance, decreases the rate of reduction (1); fibrous metallic iron is responsible for abnormal swelling of iron ores and pellets (2). These SEM- investigations are aimed to explain the fundamental growth mechanisms of the various iron formations in order to find the most efficient type for each technical reduction process.

2. Experimental.

The specimens - hematite powder sintered at 1250 °C for 6 hours - were crushed and screened. 50 mg with the particle size of 0.2- 0.25 mm was isothermally reduced (5 min) on a directly heated platinum boat of the attachment unit (see Fig. 1) in the SEM (3), in which A) CO/CO_2- mixed gas was filled up to 0.4 atm ('intermittent run') or B) the gas was passed over the specimen through a capillary tube ('continuous run').

3. Results and discussion.

As already proved by the isothermal reduction results of natural magnetite iron ores (4,5) each possible type of iron precipitation can also be produced on reduced, synthetic hematite (Photo.1,2 and 3) by variation of temperature and CO/CO_2- gas mixture:
Topochemical iron growth is favoured by low temperatures (500 °- 600 °C)and high reducing potentials (e.g.: 100 % CO). After short reducing times spheroidal nuclei (Photo.1) grow to finally build a dense, close packed iron layer, which inhibits subsequent reduction.
Porous, spongelike iron (Photo.2) originates at higher temperatures (> 800 °C) and high reducing rates (100 % CO).
Favourable conditions for fibrous iron exist close to the Fe/FeO- equilibrium mainly in the α- Fe- area, which is determined by relatively weak gas potentials (e.g.: CO/CO_2= 7/3) and temperatures of about 800° C (Photo.3).
The investigations show that iron growth is more a result of specific ratio of the surface reaction rate and the rate of diffusion of reduction products than a function of the oxidation- degree of a specimen (6).

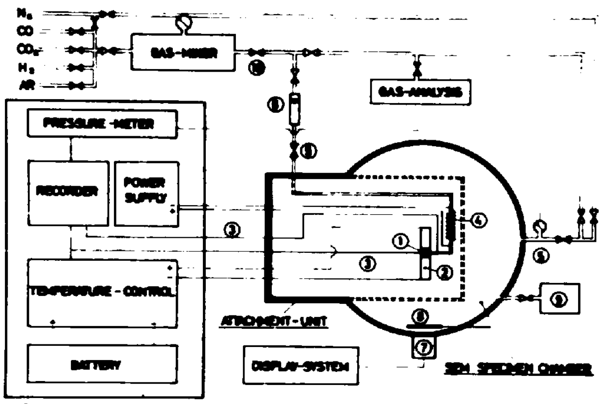

Fig.1: SEM- attachment unit and its additional equipment: 1:specimen, 2:heating Pt- boat, 3:thermocouples, 4:capillary tube, 5: needle valve, 6:flowmeter, 7:scintillator, 8:shadowing plate, 9:turbomolecular pump, 10:stop valve.

References:
(1) H.K. Kohl and H.- J.Engell: Arch. Eisenhüttenwes.,34(1963),411.(2) S.Watanabe and M. Yoshinaga: Tetsu- to- Hagané,51(1965),583. (3)W. Gudenau, W.Burchard and H.Rupp: Proc. of AIME, 38(1979),230.(4) C.Schaefer: Thesis RWTH Aachen, to be published.(5) M.Kobayashi et al.: Tetsu- to Hagané,68(1982), 831 .(6) L.v.Bogdandy et al.: Berichte Bunsengesellschaft,67(1963),958.

Photo.1
Reduced sintered hematite:
Topochemical iron growth - formation of dense iron layers.

Photo.2
Reduced sintered hematite:
Porous, sponge- like iron growth

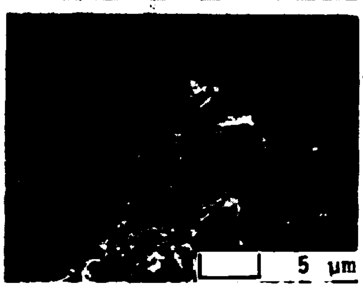

Photo.3
Reduced sintered hematite:
Fibrous iron growth