A NEW OCCURRENCE OF TITANOMAGHEMITE FROM SOUTH INDIA

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ABSTRACT

Titanomaghemite occurs in association with hematite, ilmenite, maghemite, pleonaste, limonite and silicates (olivine and pyroxene) in titaniferous iron ore segregations found in a peridotite band, occuring in basic charnockites, about 27 kilometers west of Ongole, in Andhra Pradesh, South India. The x-ray and chemical data for the mineral are furnished. Textural studies under the ore microscope revealed the original formation of two generations of magnetite (one containing Mg, Al and subordinate Ti, and the other containing mainly Ti) and ilmenite along with the silicate phases, under high temperature magmatic conditions. The mineralogy and textural characters of the ore are attributed to exsolution, oxidation and alteration of primary minerals.

A band of peridotite occurring amidst basic charnockites is found about 1.2 kilometers north of the 17th milestone, along the Ongole-Podili road, in Guntur District, Andhra Pradesh, South India. The peridotite exhibits segregational layering, with a strike of N 30° W — S 30° E and dip of 70° in a N 60° E direction. The present investigation deals with the mineralogical and textural studies of the thin bands of titaniferous iron ores found in this rock.

The titaniferous iron ore is hard and massive with a steel-grey colour. On weathered surface, it shows a thin yellowish orange crust of limonite. The ore is ferromagnetic and shows strong polar magnetism.

Under the ore microscope, the ore exhibits intergrowths of hematite — maghemite — ilmenite — pleonaste, and titanomaghemite — ilmenite, together with the discrete grains of ilmenite, limonite, and silicates.

Silicates (olivine and pyroxene) mostly occur as anhedral granular crystals and are interstitial to the surrounding opaque minerals. They also occur as minor veinlets cutting the ore minerals.

Hematite, the predominant constituent of the ore, occurs pseudomorphous after maghemite. It is greyish white in colour and shows a faint anisotropism. The reflectivity of the mineral, as determined with a

Leitz Slit Microphotometer, is 27°, and shows relatively higher reflectivity than maghemite that occurs as minute, skeletal, relict grains in it. The alteration of maghemite to hematite has taken place along its octahedral parting planes, and is almost complete. Hematite and maghemite contain extremely small, irregularly distributed, sublamellae of ilmenite and also exsolution blebs of pleonaste. The latter mineral occurs in favourable grains, as two sets of long, thin, and mutually perpendicular, non-opaque spikes (Fig. 1). It is believed that the host mineral forming this intergrowth was originally a magnetite, containing Mg, Al, and subordinate Ti. The cooling of the magnetite resulted in the exsolution of pleonaste and ulvöspinel; and this intergrowth, on subsequent oxidation, gave rise to maghemite, formed from magnetite, and ilmenite from ulvöspinel, while the pleonaste remained unchanged. The secondary development of ilmenite from ulvöspinel is supported by the fact that the ilmenite lamellae show inclined extinction with reference to their long directions (Ramdohr, 1953). Later alteration, under hydrothermal conditions, resulted in the formation of hematite from maghemite.

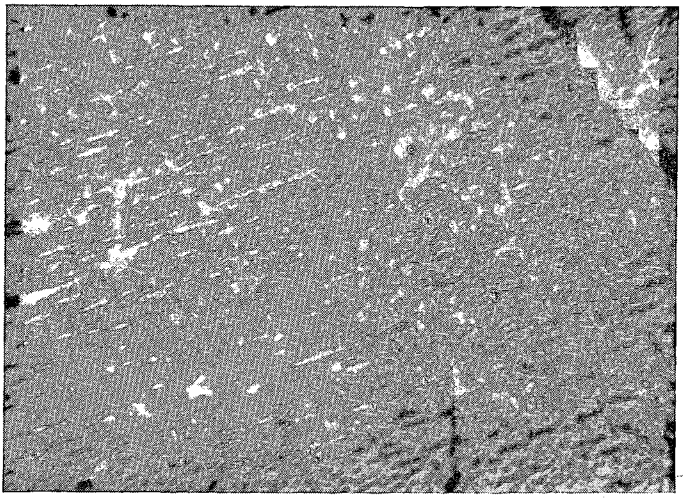


FIG. 1. Microphotograph of hematite with exsolution blebs of pleonaste and relict patches of maghemite (grey), ordinary light, × 104.

Ilmenite is brownish grey in colour and is distinctly anisotropic. It shows a reflectivity of 19° and this figure is distinctly low compared to that of hematite or titanomaghemite. The mineral occurs as discrete granular or bladed crystals, in addition to the lamellae of exsolution or oxidation found in titanomaghemite and hematite.

Limonite characteristically shows an orange internal reflection, and is found as irregular patches in other minerals.

Titanomaghemite is greyish white in colour with a bluish tinge and is isotropic. The reflectivity of the mineral is 23°. It exhibits very thin elongated blebs of ilmenite along the octahedral parting planes (Fig. 2). This suggests that the original mineral was a titaniferous magnetite which, on cooling, gave rise to the exsolution lamellae of ilmenite. Subsequent oxidation of titanomagnetite resulted in the formation of titanomaghemite.

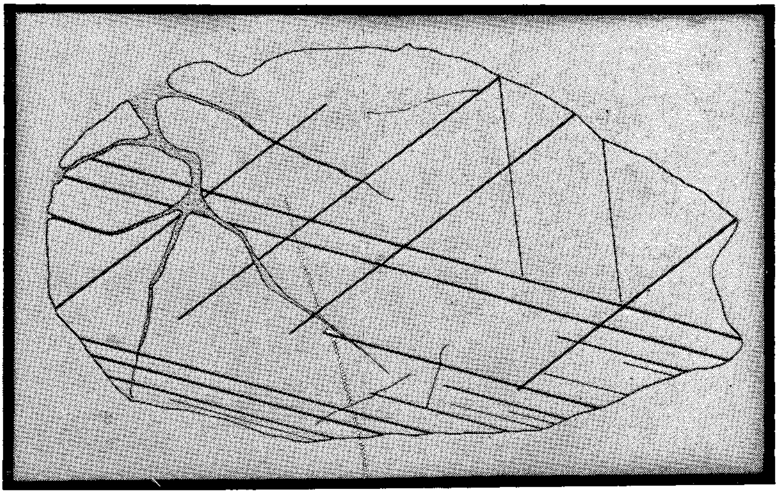


FIG. 2. Titanomaghemite (white) with exsolution lamellae (black) of ilmenite and cracks filled with limonite (spotted), camera lucida diagram, × 133.

Titanomaghemite is separated from the finely pulverized ore by repeated magnetic separation, using a Frantz isodynamic separator, utilizing the residual magnetism of the pole pieces when no current is passed; and by gravity separation using Clerci solution.

The *x*-ray powder photograph of the separated mineral showed that it is extremely pure except for a very minute amount of ilmenite. The interpretation of the powder photograph revealed the unit-cell edge of the titanomaghemite to be 8.345 ± 0.001 Å. The cell edge of the mineral compares very well with that of the titanomaghemite collected from Bon Accord, Transvaal (Basta, 1959).

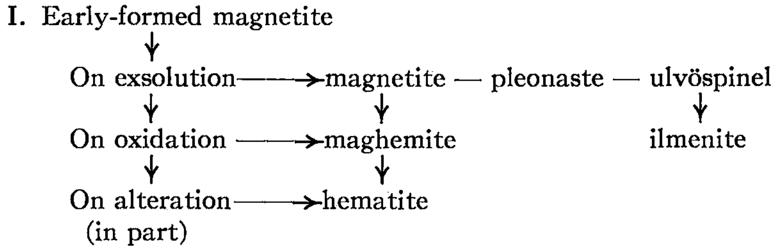
The partial chemical analysis of titanomaghemite, with the recalculation into end members, is given below:

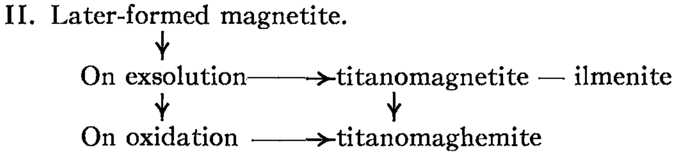
FeO	9.98 wt.%	FeO. TiO_2	19.26 wt. %
Fe_2O_3	76.43	FeO. Fe_2O_3	2.78
TiO_2	10.14	γ Fe_2O_3	74.51
	96.55		96.55

Molecular ratio FeO : TiO_2 = 1.09.

The present studies indicate the existence of two generations of magnetite, one containing Mg, Al, and subordinate Ti, and the other containing mainly Ti. It is not uncommon to find magnetites of two generations in an assemblage, but, whenever they are found, the early-formed magnetite is poorer in Ti, compared to the later-formed magnetite. (Deer, *et al.*, 1962).

The early-formed magnetite, on oxidation, gave rise to maghemite, while the later-formed magnetite (titanomagnetite) resulted in the formation of titanomaghemite. Later alteration under hydrothermal conditions resulted in the formation of hematite from maghemite, while titanomaghemite exhibits no such signs of alteration. This lack of alteration in the latter case is attributed to the high titanium content of the mineral. This is because hematite formed at low temperatures cannot accommodate appreciable amounts of Ti in its structure. The grains of titanomaghemite and discrete ilmenite show curvilinear sealed boundaries, indicating that they are formed more or less contemporaneously. The latest mineral to form is limonite, which is a consequence of weathering.





Oxidation of titanomagnetite to titanomaghemite generally takes place at temperatures below 550° C. (Basta, 1959). Lepp (1957) states that oxidation of magnetite to maghemite commences at about 200° C. and culminates at about 400° C.; at temperatures higher than this, maghemite is generally unstable. From this, it may be inferred that the oxidation of the two generations of magnetite, under study, resulting in the formation of maghemite and titanomaghemite, took place at temperatures between 200° C. and 400° C.

Buddington, *et al.* (1955) have discussed the petrogenetic significance of the titaniferous magnetite that occurs in association with discrete grains of ilmenite in both igneous and metamorphic rocks, and concluded that its composition has considerable value for relative geological thermometry. Since the chemical analysis of titanomaghemite shows a high content of titania, it may be inferred that the primary ore minerals were formed along with the silicate phases at high temperatures of magmatic crystallization.

The present work indicates the possibility of the country rocks also having been formed as a consequence of magmatic crystallization. Further work relating to the magnetic studies of the mineral is under progress.

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