Identification of NRM carriers in chromite ores by alternating field and thermal demagnetization studies

I. V. Radhakrishna Murthy and S. K. G. Krishnamacharyulu

Department of Geophysics, Andhra University, Visakhapatnam 530 003, India

Alternating field and thermal demagnetization studies on selected chromite ores show that they can contain two magnetic carriers, viz. the chromite mineral possessing the end member magnetite, and the magnetite occurring as an associate mineral in the ores. The chromite mineral is magnetically hard with a blocking temperature of 350° C. By determining the blocking temperature of the ore and its hardness, the nature of chromite mineralisation in the ore can be ascertained.

THE chemical composition of chromite mineral is complex and its magnetic properties are highly variable. The susceptibility of the chromite mineral is correlated to the percentage of its constituent end member magnetite[1]. Thus, its magnetic susceptibility can vary from zero for chromites without the end member magnetite constituent, to as large as 0.05 CGS units for minerals dominated by the end member magnetite. The saturation remanent magnetization properties of chromite ores are found to be similar to those of magnetite ores, and this similarity was attributed to the presence of end member magnetite in the chromite mineral[2]. Anil Kumar and Bhalla[3] reported a blocking temperature of approximately 350° C for their carefully isolated and chemically treated (to ensure absence of magnetite association) chromite minerals against the normal figure of about 580° C for the magnetite mineral.

The results of alternating magnetic field (AF) and thermal demagnetization tests of a few specimens of chromite ores collected from four localities in Andhra Pradesh, India viz; Tekuru (17° 36′ N : 81° 24′ E), Kondapalli (16° 35′ N : 80° 30′ E), Jannaram (17° 18′ N : 80° 24′ E), and Vinobanagar (17° 22′ N : 80° 28′ E), are reported here. While the samples from Tekuru and Kondapalli were from old working mines, those from Jannaram and Vinobanagar were from float.

The chromite at Tekuru is associated with ultramafic rocks dominated by pyroxenites with khondalite as the country rock. The chromite deposits of Jannaram and Vinobanagar are associated with basic and ultrabasic rocks like dunites, peridotites and pyroxenites within anorthosites and amphibolites. In Kondapalli, chromite occurs in association with pyroxenites and hypersthene bearing gneisses, in a charnockitic environment.

AF demagnetization was carried out on an apparatus similar to that designed by Creer[4] and thermal demagnetization on the thermal demagnetizer (model TSD-1, USA). The NRM of each specimen was initially measured on a sensitive astatic magnetometer. For AF demagnetization, the specimen was subjected to progressively increasing alternating magnetic field of 2.5, 5, 10, 15, 20, 30, 40, 60, 80, 100 mT and its NRM was measured after each demagnetization step. For thermal demagnetization, the specimen was heated progressively to temperatures of 100, 200, 300, 350, 400, 450, 500, 550, 600° C and its NRM measured after each step.

Some typical AF demagnetization intensity decay curves for eight specimens representing the four locations are shown in Figure 1. They present two categories of demagnetization behaviour with 'hard' and 'soft' natures indicating two types of magnetic carriers in the specimens. Soft specimens lost more than 80% of their normal intensity at fields of 10–20 mT, whereas hard specimens can carry a higher intensity even at fields equal to 100 mT. Thus the two specimens from Kondapalli are soft, while those from Vinobanagar are typically hard. The other two locations viz; Tekuru and Jannaram bring out both the soft and hard varieties, the specimens T5, J4 being hard and T3, J6 being soft. It may be concluded that these ores are associated with one or more minerals of different magnetic characters.

Figure 2 shows the AF vector migration plots for four specimens two each belonging to the soft (K1, T3) and hard (V4, J4) categories. All the four specimens are magnetically stable as indicated by the cluster of vectors around the mean positions and hence their magnetic hardness or softness is not related to their magnetic stability.

Thermal demagnetization curves for eight specimens

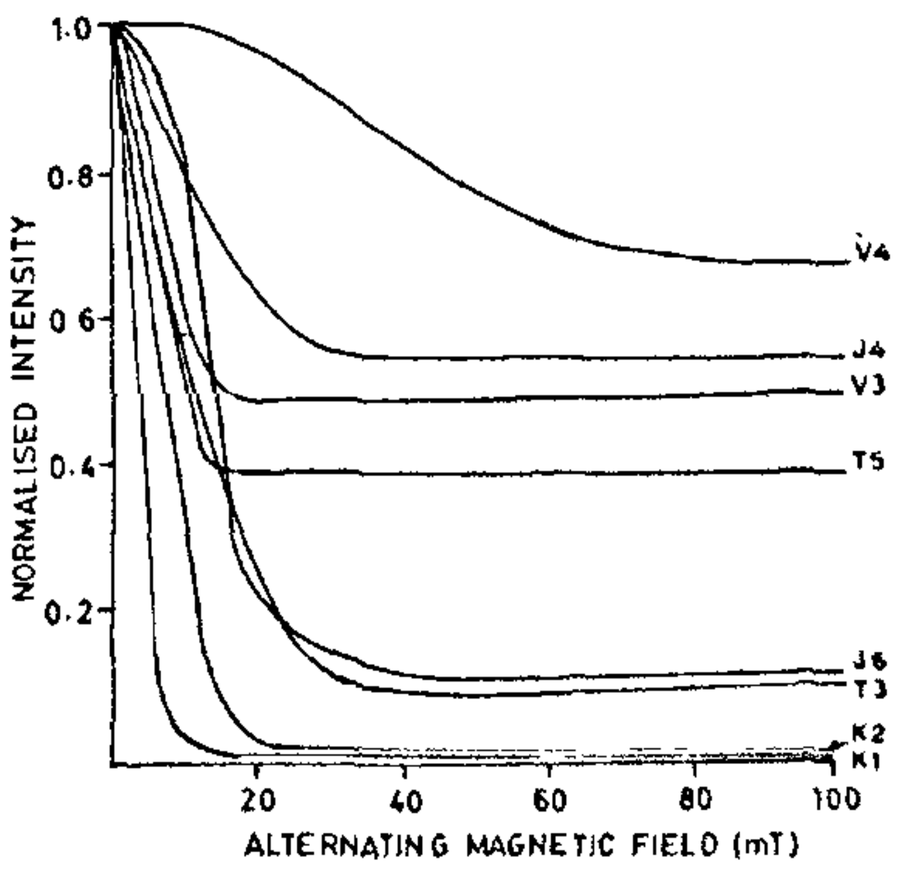

Figure 1. AF demagnetization intensity decay curves of chromite ores.

from the four locations are shown in Figure 3. The blocking temperatures are identified at points of steepest slopes of the thermal decay curves and also at the points where the intensity falls to a level less than the accuracy of measurement[5]. All the specimens from Vinobanagar exhibit a blocking temperature around 350° C in addition to the one at 580° C, corresponding to the Curie temperature of magnetite. However, some specimens from the other locations (e.g. J6, T3) have a single blocking or Curie temperature at 580° C, while others (e.g. J4, T5) show two blocking temperatures again at 350° C and 580° C. The specimens from Kondapalli show a typical step-like appearance in their thermal decay curves with the blocking temperatures at 200° C and 580° C. The thermal demagnetization tests also thus indicate the presence of atleast two magnetic carriers in the chromite ores.

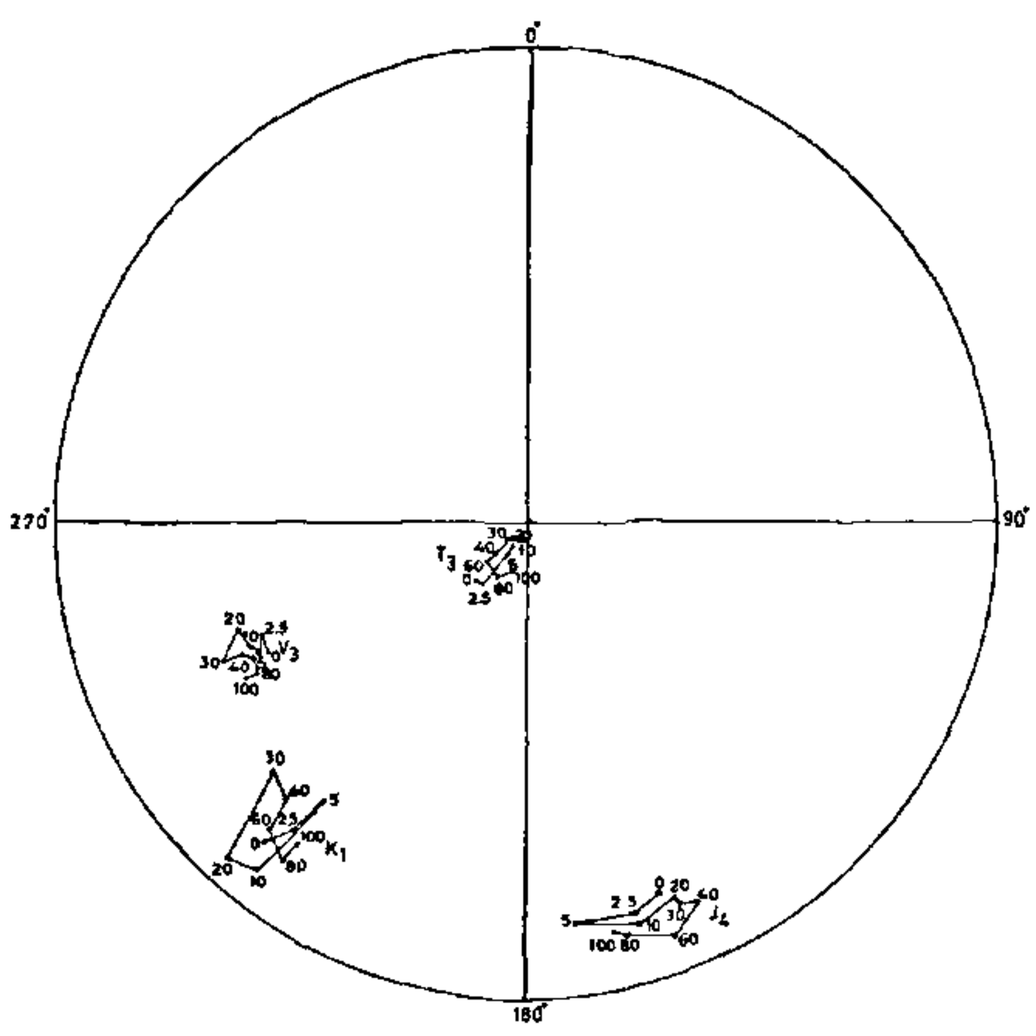

Figure 2. AF vector migration plots.

The thermal vector migration plots for three representative specimens are shown in Figure 4. The specimen V4 from Vinobanagar shows a large migration of the magnetization vector between 300° C and 350° C and again between 550° C and 600° C, which may correspond to the blocking or Curie temperatures for the specimen. Similarly, the specimen T3 is identified with a single blocking temperature between 550° C and 600° C, while for the specimen K2 from Kondapalli, the blocking temperatures are between 150° C and 200° C and again between 550° C and 600° C.

The blocking temperature around 350° C can be attributed to chromite mineral with the end member magnetite constituent according to the results of Anil Kumar and Bhalla[3], while the Curie temperature of 580° C is clearly due to magnetite mineral associated with the chromite in the ore. Thus the chromite ores with magnetite association, but possessing no end member magnetite in their chromite mineral, exhibit only the Curie temperature at 580° C, while those ores with chromite mineralisation with the end member magnetite can show two blocking temperatures around 350° C and 580° C respectively.

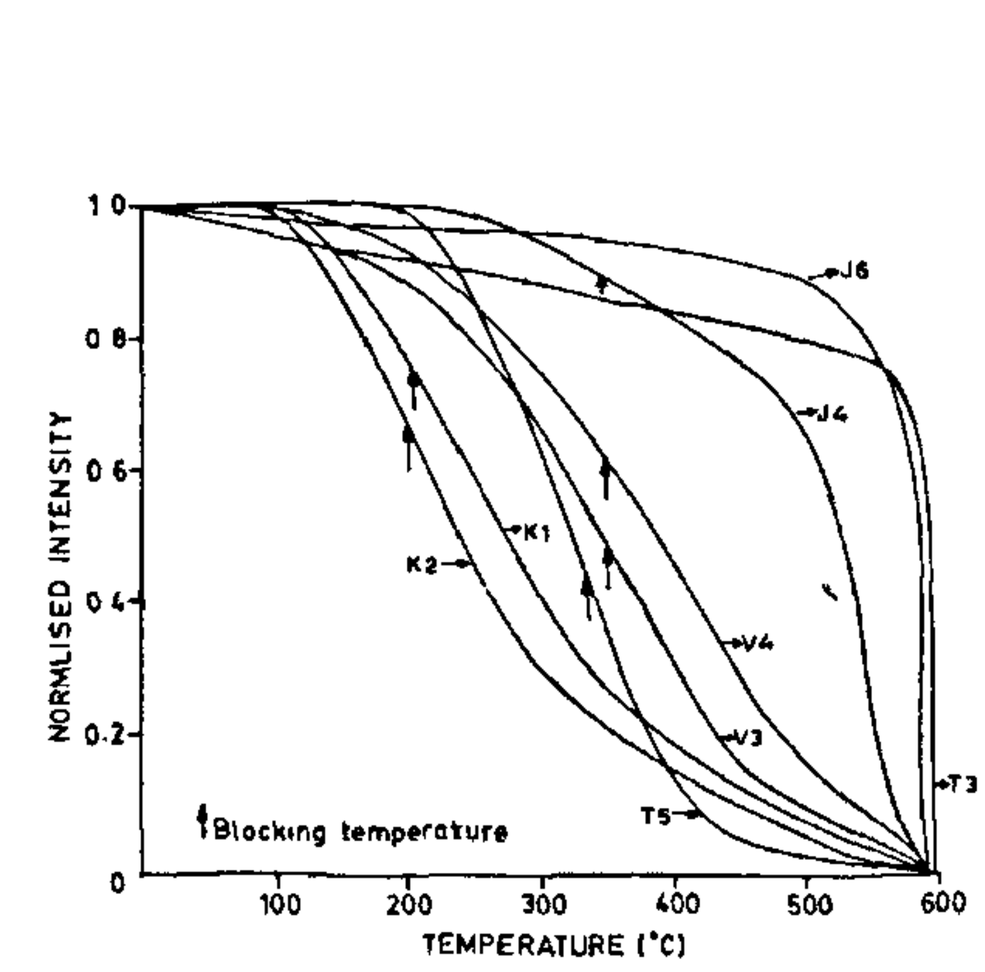

Figure 3 Thermal demagnetization intensity decay curves of chromite ores.

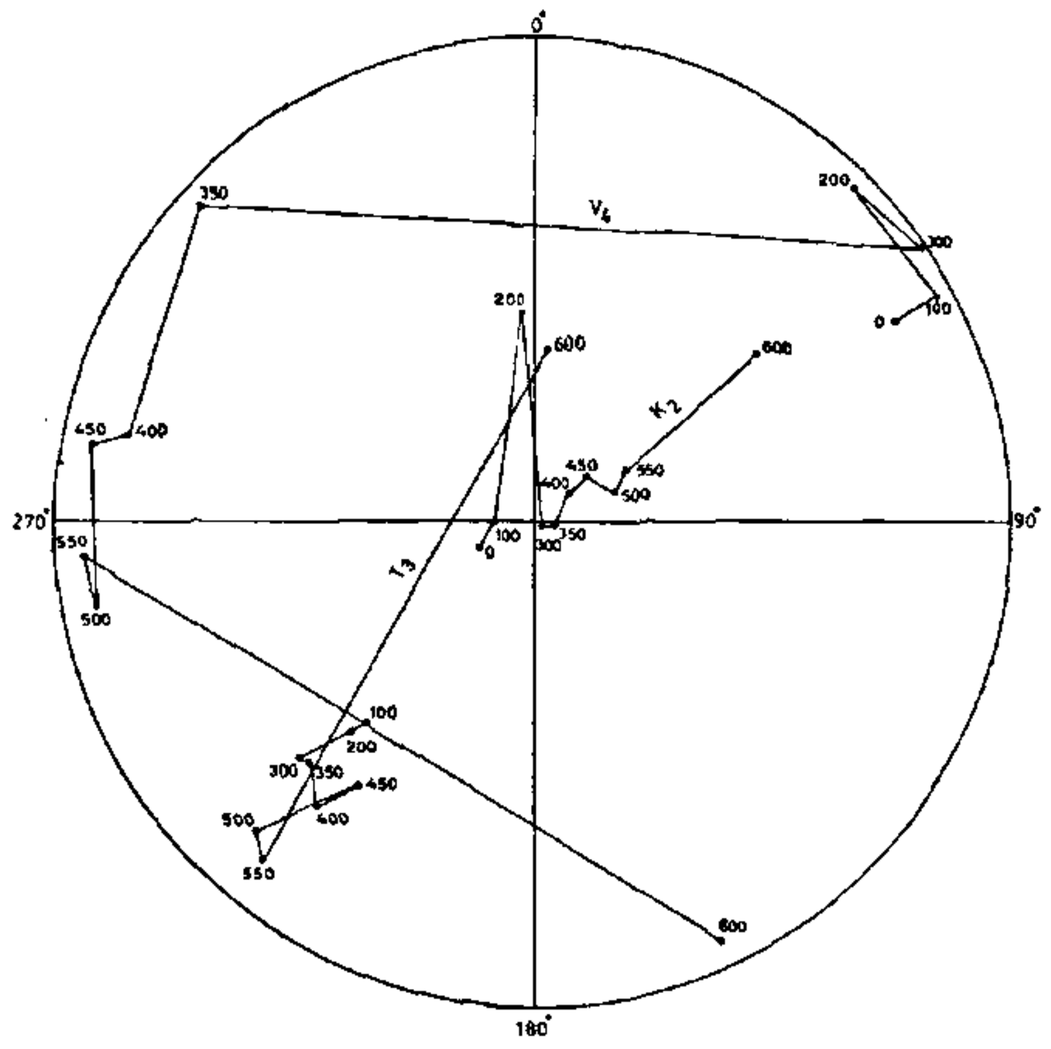

Figure 4. Thermal vector migration plots.

From a comparison of the thermal and AF decay curves of different specimens, it can be concluded that the samples showing blocking temperature at 350° C are hard (e.g. T5, J4, V3, V4), while those with a single blocking or Curie temperature of 580° C are typically soft (e.g. T3, J6). It then follows that the chromite mineral with the end member magnetite is magnetically hard. The typical step-like appearance of thermal demagnetization curves and the lower blocking temperature around 200° C for Kondapalli specimens can be attributed to their association with titanoferous magnetite[5]. This is possible because the country rock in this locality is a strongly magnetic charnockite.

The present study shows that the chromite mineral possessing end member magnetite is magnetically hard and has a blocking temperature of approximately 350° C. Conversely, by determining the blocking temperature and hardness of the chromite ore, it will be possible to identify the nature of chromite mineralization in the ore.

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Temporal changes in the chemical quality of groundwater in Ludhiana area, Punjab, India

K. P. Singh

Punjab State Council for Science and Technology, SCO: 2935–36, Sector 22–C, Chandigarh 160 022, India

The temporal changes in the chemical quality of groundwater of Ludhiana area have been studied. The results from 1983 to 1992 have been compared. The study indicates that samples containing cyanide have increased as it cannot be absorbed and remains in the hydrogeological environment. Other trace elements do not show any significant change. Remedial measures to control pollution of groundwater have been discussed.

LUDHIANA is one of the most industrialized cities in the state of Punjab where largely electroplating units, bicycle industry, woolen and dyeing units are the dominant industries in addition to other small-scale industrial units. Groundwater is the only source of drinking water supply to the city and its quality is getting degraded due to increasing industrialization and urbanization[1–5]. An attempt has been made to study the temporal changes in the quality of groundwater around the industrial area where a decade ago trace element geochemistry of groundwater was investigated in detail[3].

The area studied is a part of the Indo-Gangetic Alluvial plain mainly composed of unconsolidated clay, silt, sands of different grades along with varying proportions of gravels, pebbles and kankar. The area forms a complex inter-mixture of multiple aquifer system (Figure 1). However, the top aquifers are generally unconfined in nature. Clay lenses of varying thickness occur at various depths and are generally not extensive in nature specially up to a depth of 95 m and get pinched out at shorter or longer distances. In general, the sand is thicker in the central part compared to northern and western parts[1]. The subsurface geology indicates no regional confining impermeable strata up to 95 m.

Budha Nallah forms a part of the palaeochannel of river Sutlej. The study of sub-surface geology of boreholes around Budha Nallah indicates high permeability of sediments around it.

A perusal of water level data indicates that the depth to water in the area ranges from 3 m to 15 m below the land surface. The water level in the area along Budha Nallah is shallow and ranges between 3 and 5 m below ground level[1]. The water table tends to deepen gradually away from Budha Nallah and in other parts of the city, it varies from 10 to 15 m below land surface. The unsaturated zone is highly permeable and primarily consists of sands of various grades, allowing the industrial effluents to reach groundwater quickly. Groundwater flow direction is from south-east to north-west with variations from south-south-east to north-north-west. However, around Budha Nallah, groundwater flow is from east-north-east to west-south-west. Hydraulic parameters do not show much variation within the area studied. Specific yield of top phreatic aquifers ranges between 20 and 25%. Hydraulic conductivity of top phreatic aquifer also remains uniform (20–30 m/day). The uniformity of hydraulic parameters is also reflected in the contour map (Figure 2) and it has been observed that hydraulic gradient remains almost uniform (1.2 m/km) except in the Central part where the steeper hydraulic gradient ranging between 1.5 and 1.9 m/km is attributed to heavy pumping in the central part of the area.

Samples of unsaturated zone were also analysed for chromium and cyanide at selected sites at an interval of 1 m depth. The results are shown in Table 1. In the unsaturated zone, the movement of pollutants is controlled by hydraulic conductivity, moisture content of