Pakistan J. Sci. Ind. Res., Vol. 17, Nos. 4-5, August-October 1974

GEOLOGICAL INTERPRETATION OF THE MAGNETIC MEASUREMENTS IN PACHINKOH-LUFTO IRON ORE PROSPECTS

ABUL FARAH and MOHAMMAD ALI MIRZA

Geological Survey of Pakistan, Quetta

(Received April 20, 1974)

Abstract. Magnetic measurements were carried out in Pachinkoh–Lufto areas, 50 miles northwest of Nokundi District Chagai, Baluchistan, to delineate the subsurface distribution, attitude and structure of the magnetite–hematite lenses reported from these areas. Eight sites for test-drilling were recommended on the basis of the interpretation of the vertical magnetic-intensity anomaly map. Three of the recommended sites have been drilled. The geological interpretation of the magnetic data supported by test drilling results are discussed in this report.

The geological and geophysical investigations carried out in Baluchap area, 20 miles north of Dalbandin[4] and in Chilgazi area about 32 miles northwest of Dalbandin[5] provided positive evidence that several small deposits of iron ore can be developed in Chagai District for industrial use on a modest scale. In pursuance of this approach, the Mineral Development Cell of Pakistan Industrial Development Corporation in collaboration with the Geological Survey of Pakistan initiated geological prospecting of iron ore occurrences in Pachinkon–Lufto area, about 50 miles northwest of Nokundi, in 1972. To delineate the subsurface distribution, attitude and structure of the magnetite-hematite lenses and to select test drilling sites for reserves estimation in Pachinkoh–Lufto areas, detailed magnetic measurements were carried out during September–October 1972.

The iron ore bodies are intercalated in the form of lenses in the andesitic volcanic rocks. The thickness of the individual ore body varies from 2 to 20 ft and the length ranges between 150–350 ft. The ore is in oxide form and appreciably magnetic. The iron content on an average is 50%. The magnetic measurements have, therefore, proved useful in delineating the subsurface distribution and structure of the iron ore bodies in Pachinkoh–Lufto areas as described and discussed in this paper.

Mode of Mineralization. Iron ore mineralization in Pachinkoh and Lufto areas is in the form of lenses irregularly interspersed in the volcanic rocks—agglomerate, tuff and andesite. In Pachinkoh area (Fig.1) about 25 iron ore (magnetite–hematite) bodies have been mapped. Lufto area is about 2½ miles southeast of Pachinkoh area. The intervening part is occupied by apparently unmineralized volcanic rocks. Two prominent iron ore bodies have been noted in Lufto area in a small ridge. The thickness of the individual ore body in the two areas ranges from 2 to 20 ft. The length of the lenses ranges between 150–350 ft. The lenses are concordant with the host rocks. In Pachinkoh area, the lenses are structurally regular and dip at about 55° towards north. In Lufto area, the iron ore bodies are disturbed and dislocated by faults and fractures.

The study of thin sections of the ore under microscope by Siddiqui[8] has revealed that the ore is impure, porous in texture and contains grains of quartz, chalcedony, chlorite and calcite. Magnetite appears to be replaced by hematite (martitization). The replacement is more pronounced in the eastern part of the mineralized zone. The process of martitization should contribute to reduction of bulk magnetic susceptibility of the ore. It is evidently borne out by the decreasing magnitude of the magnetic anomalies in the eastern section of the mineralized areas.

The iron mineralization in Chagai District in general has been described as a result of contact metamorphism.[7] In case of the deposits of Pachinkoh and Lufto areas, the interlayering of the iron bands with the volcanic rocks (andesites and agglomerates) and a comparatively very low content of MgO and P_2O_5 in the ore are indicative of a volcanic parentage of mineralization.[9] There is a strong possibility that the mineralization in the area under discussion is a result of 'submarine volcanic exhalations' associated with various phases of eruption.[1]

Magnetic Measurements. For the magnetic measurements Askania torsion balance No. 6214 with a total range of 140,000 gammas was used. In Pachinkoh area 8 million ft^2 and in Lufto area 1½ million ft^2 were covered by 467 and 180 magnetic observations respectively. The field observations were corrected for diurnal variation obtained from the observations at the base station made at a regular interval of 1 hr during the working period. The diurnal variation on the whole ranged from 20 to 60 gammas. The latitude correction was not considered necessary as the observations were within one-mile radius of the base station. The base station was located outside the mineralized area. The computed magnetic anomalies (Figs.2 and 4) are with reference to the local base station.

Analysis of the Magnetic Data

Pachinkoh Area. The pattern of the magnetic anomaly contours confirms that the trend of mineralization is east–west conformable with the general strike direction of the volcanic rocks. The pattern is sharply peaked and prominently elongated suggestive of lenticular mode of mineralization. Three prominent positive anomaly closures have been delineated. These closures have associated strong

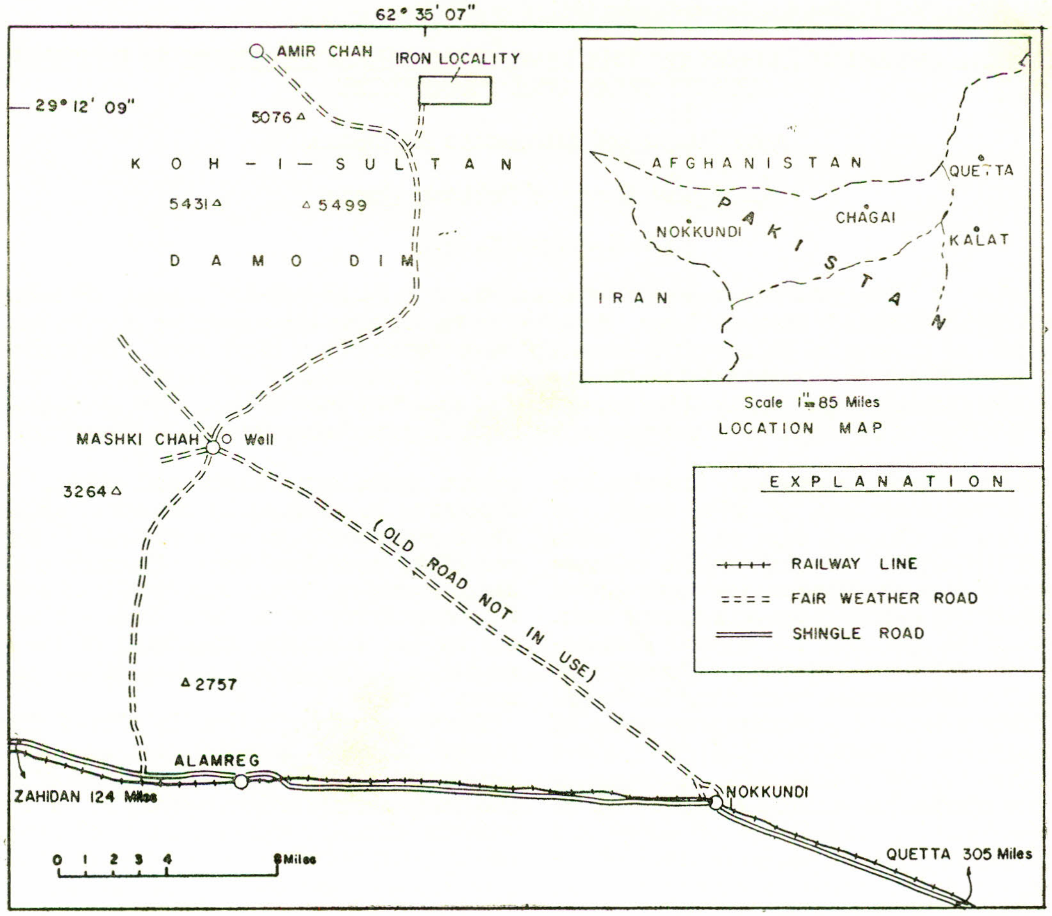

Fig. 1. Location maps of Pachinkoh-Lufto iron deposits, Chagai district, Baluchistan, Pakistan.

negative closures indicating that the dipolar magnetic body is not deeply buried. The magnetic closure with a magnitude of +40,000 gammas at the western margin of the area and the next positive closure (+13000 gammas) eastward are intervened by a smooth and weak field extending linearly over a distance of 1500 ft. The lineation of the second closure shows a shift towards south with respect to that of the first closure. It indicates that the iron ore lenses corresponding to the two closures have been displaced by a north–south trending tear fault. This geophysical interpretation has subsequently been confirmed by detailed surface geological mapping.[10] From the direction and high magnitude of the magnetic gradient it is inferred that the magnetic body is steeply dipping towards north. The intensity and the extent of the anomalous zone suggest that the body causing the anomaly may thicken in depth. The third positive closure in the eastern margin of the area with a maximum value of 9000 gammas also shows a shift towards south with respect to the second closure which may be due to a fault (Fig. 2).

The quantitative interpretation of a magnetic body with limited strike and depth dimensions is more complicated. However, a general guidance is obtained by assuming certain simple geometrical form of the anomalous body considering only induced magnetism and by using simple mathematical formulas. The lenticular deposit of Pachinkoh area has been approximated to a 'ribbon' and the analytical technique for estimating the ratio of strike length (y) and width (l) of a uniformly magnetized finite ribbon has been used.[6] The principal profiles AB and CD (Fig. 2) passing through the peak of the anomaly in a direction perpendicular to the strike of the 'ribbon' are sharply peaked indicating a near surface anomalous body. These profiles have been used for calculating the ratio of y and l. Assuming a strike length of 800 ft in case of profile AB and 400 ft in profile CD for the iron ore vein, a width (l) or depth extent of 200 and 150 ft respectively has been estimated. From a purely empirical approximation that in the north–south direction of a magnetic closure the margins are from a point little south of the maximum value to a point quarter of the maximum on the northside, a width or depth extent of 175 ft for each of the anomalies AB and CD has been estimated. These estimates provide a plausible figure for width dimension in calculating the reserves of the ore bodies causing the magnetic anomalies.

The intensity curves AB and CD are slightly asymmetrical and both sides of the curves appear to cross the X-axis suggesting a case of a finite vein dipping north at an angle equal to the angle of magnetic

Fig. 2. Vertical magnetic anomaly contours: Pachinkoh area Nokundi, Baluchistan, Pakistan.

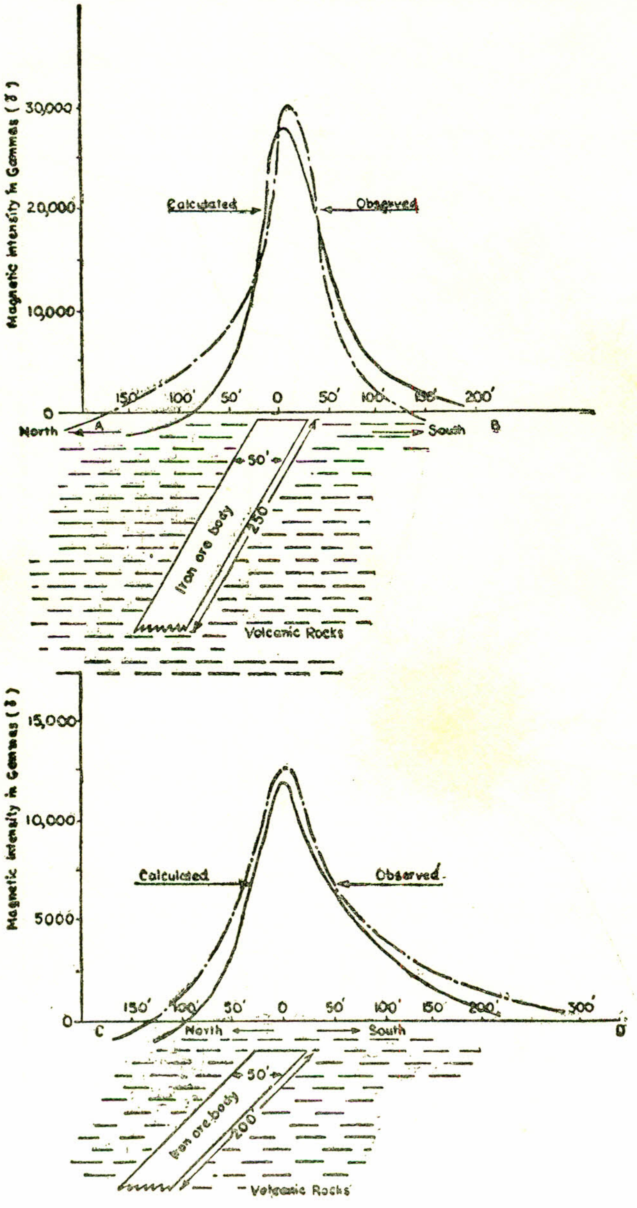

Fig. 3. Comparison of the abserved and the calculated magnetic intensity curves across finite inclined iron ore vein in Pachinkoh area, Nokundi, Baluchistan.

inclination. In case of an infinite inclined vein, both sides of the curve do not cross the X-axis.[3] Theoretical curves calculated for finite veins dipping north at an angle equal to the angle of magnetic inclination[3] with the parameters given in Table show a reasonably good correlation with the observed curves AB and CD (Fig. 3).

The figure of 50 ft for the horizontal width of the ore body used in computing the theoretical magnetic intensity is very close to the actuality. In holes Nos.2 and 5 (Fig.2) drilled to a depth of 270 and 325 ft near the maximum magnetic intensity corresponding to profile AB, six iron ore bodies of a composite thickness of 56 ft and two bodies of total thickness of 32 ft were encountered respectively. In drill hole

TABLE 1

Curve	Dip (°C)	Depth to the upper surface (ft)	Assumed horizontal (d) (ft)	Calculated depth extent (l) (ft)	Susceptibility contrast: magnetite–hematite against andesite	Magnetic inclination (°C)
AB	55 North	5	50	250	0.186 (For 80% magnetite content by volume)	45
CD	45 North	25	50	200	0.136 (For 60% magnetite content by volume)	45

No.4 near the magnetic closure of profile CD (Fig.2) drilled to a depth of 120 ft, three ore bodies of a total thickness of 33 ft were recorded. The holes recommended for confirming the depth extent of the ore bodies have not yet been drilled. The geological evidence strongly supports the authenticity of the depth extent values used in the quantitative analysis of the principal profiles.

Assuming a total strike length of 2000 ft, depth extent of 200 ft, average thickness of 30 ft and taking 8 ft^3 of ore for a ton a probable reserve of 1.5 million tons of ore has been estimated in Pachinkoh mineralized area.

Lufto Area. Magnetic closures arranged in a more or less circular pattern (Fig.4) have been observed in this area. The magnitude of the maximum magnetic anomaly is of the order of +9000 gammas, appreciably less than that observed in Pachinkoh area. On the basis of the parameters used in interpreting the profile C–D of Pachinkoh area and taking a value of 32000 gammas for the vertical magnetic force in the area it has been calculated that the magnetic susceptibility of the ore body causing a maximum anomaly of +9000 gammas is 0.11. Assuming that the susceptibility of a magnetite body with 100% magnetite by volume is 0.25,[3] it is summarised that the magnetite content in the ore deposit of Lufto area is about 45% by volume. This is in conformity with the petrological evidence that the ratio of magnetite–hematite is comparatively lower in this area.

Assuming the composite dimensions of the ore bodies as 1000 × 200 × 30 ft and taking 8 ft^3 of ore for a ton a probable reserve of 750,000 tons is estimated in Lufto area. It may be mentioned that this is a conservative estimate.

Conclusions

The vertical magnetic intensity anomaly maps of Pachinkoh and Lufto areas have been found very useful in the study of the subsurface distribution and structure of the iron ore deposits. The quantitative analysis of the magnetic data clearly points out that the ratio of magnetite–hematite in the ore body is decreasing eastward and that the ore body is lenticular in form and dips steeply towards north. The results of the bore holes so far drilled have confirmed the geological interpretation of the magnetic anomaly maps. A conservative estimate of the probable

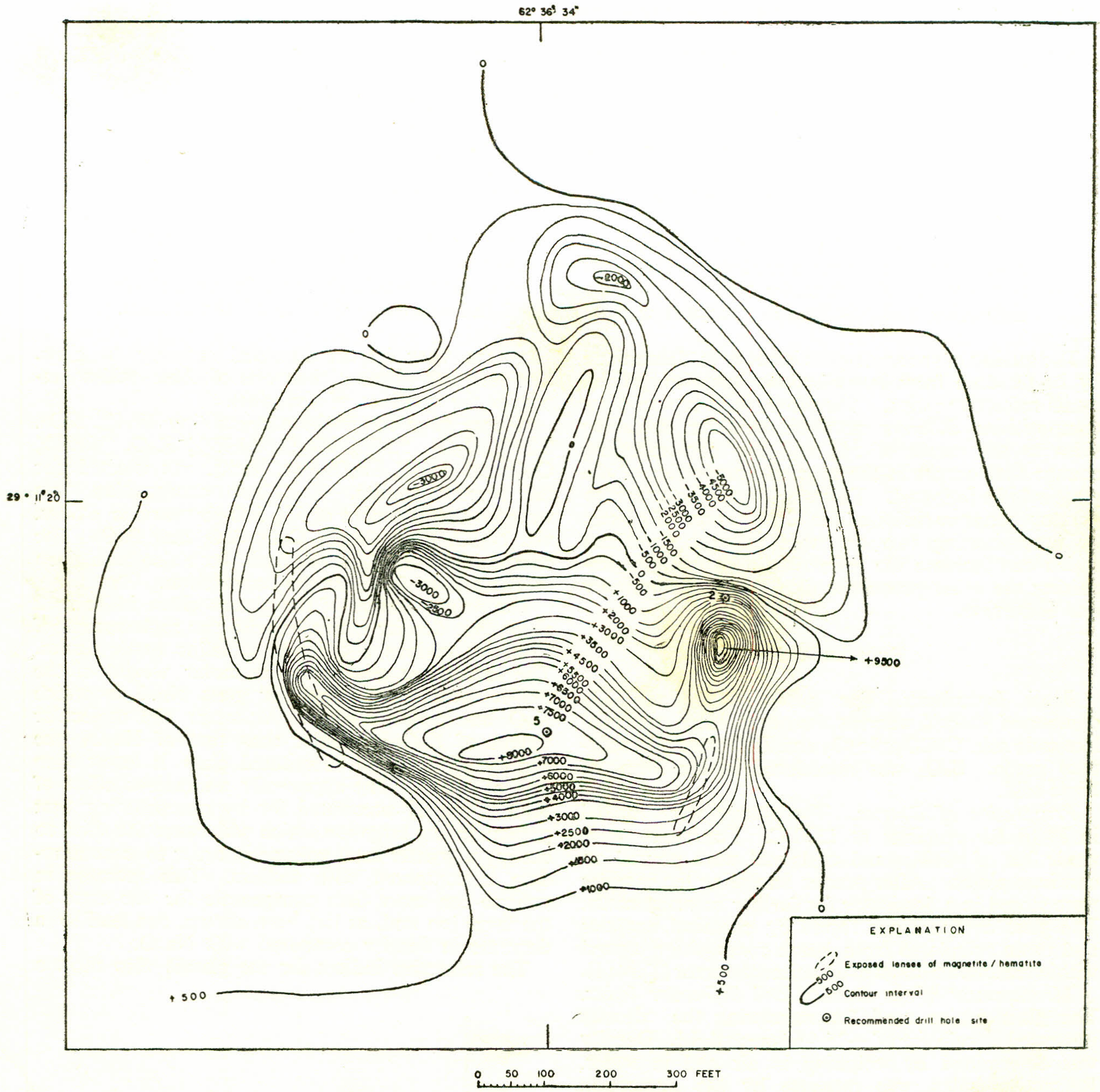

Fig. 4. Vertical magnetic anomaly contours: Lufto area, Nokundi, Baluchistan, Pakistan.

reserves of the ore in Pachinkoh–Lufto areas is about 3 million tons. The iron ore deposits of Pachinkoh–Lufto areas and those of Dalbandin and Chilghazi areas hold out a definite hope of exploitation of the ore deposits for industrial use.

References

1. S.N. Ahmad, personal communication.
2. M.Q. Bari, Geodetic Note No.3, Geomagnetic Components, Survey of Pakistan, 1973.
3. K.L. Cook, Geophys., **15,** 667 (1950).
4. A. Farah and M. Aslam, Pakistan J. Sci., **10,** 255 (1958).
5. H. Faroque and M. A. Rahman, Records Geological Survey of Pakistan, **20,** 23 (1970).
6. F.S. Grant and G.F. West, *Interpretation Theory in Applied Geophysics* (McGraw, New York, 1965), p.324.
7. Hunting Survey Corporation, *Reconnaissance Geology of Part of West Pakistan* (Government of Canada for the Government of Pakistan, 1960), p. 448.
8. F. Siddiqui, unpublished data.
9. R. L. Stanton, *Ore Petrology* (McGraw, New York, 1972), p. 242.
10. A.M. Subhani, Geonews, **3** (1973).