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Institute of Geological Sciences

Mineral Reconnaissance Programme Report

A report prepared for the Department of Industry

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No. 16
Report on Geophysical and Geological Surveys at Blackmount, Argyllshire

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Summary

Blackmount, on the southern fringe of Rannoch Moor is largely drift covered but, where exposed, the underlying Precambrian Moine psammite contains granitic veins which probably stem from the adjacent (Devonian) Moor of Rannoch granite. These veins are generally pyritiferous and, at one locality, carry small amounts of molybdenite. Blackmount is also traversed by the Ericht-Laidon Fault, which, in theory, and by analogy with a similar fault to the south-east (the Tyndrum Fault), could be a site of significant sulphide mineralisation. Magnetic, very low frequency electro-magnetic (VLF EM), slingram EM and induced polarisation measurements carried out in the area of the veins suggest that the mineralisation has little or no lateral or depth continuation. Similar surveys were successful in locating the Ericht-Laidon Fault beneath drift, but suggest no associated mineralisation down to the greatest depth investigated.

INTRODUCTION

During a routine investigation, in the area of Blackmount, Argyllshire, it was noted that the granite veins exposed in a roadside cutting [NN 309 453] on the A82 trunk road, 6 km north of Bridge of Orchy, had appreciable sulphide contents and showed conspicuous alteration, which also affected the adjacent Moine metasedimentary rocks. Exposure of bedrock over the area is generally poor, but there are several other features which, it was thought, could result in it being the locus of significant mineralisation. In particular, the mineralised veins lie approximately 1 km south east of the Ericht-Laidon Fault and, in a similar situation, the neighbouring parallel Tyndrum Fault is strongly mineralised. Also, considerable shattering is evident in the Moine rocks north of the cutting which, irrespective of its association with faulting or granite emplacement, could provide likely sites for sulphide concentrations. On a more theoretical note, the area, like the Tyndrum Mine, lies close to one of Kutina's (1968) strain trajectories.

Because members of the Geochemical Division staff were fully committed elsewhere in the Dalradian, the Blackmount investigation was undertaken as a geophysical project supported by limited reconnaissance geological surveys.

Topographical features

Blackmount, lying within the bounds of Ordnance Survey 1-inch sheet 47, forms the southern sector of the mountainous rim encircling the upland plateau of Rannoch Moor. The area investigated is between 230 and 400 m OD occupying, mostly, the gently inclined south-western and western flanks of Glas Bheinn, but also extending westwards onto the relatively flat ground in the valley bottom. Much of the area is drained by a pattern of southerly flowing streams which flow, by way of the Water of Tulla, into Loch Tulla. The course of the westernmost stream is largely controlled by the line of the Ericht-Laidon Fault, with the result that the drainage is to the south-west though an eventual entry is made on the western side of the Loch Tulla.

GEOLOGY

The portion of Blackmount which was investigated sits astride the boundary of 1-inch geological sheets 46 (Balquhidder) and 54 (Rannoch), but is covered in full by the Memoir to the latter (Hinxman and others, 1923). In brief the area consists of Precambrian Moine metasedimentary rocks and granites of Lower Old Red Sandstone age (Fig. 1). It is cut by the Ericht-Laidon Fault, a major wrench fault with a sinistral displacement of 7.3 km.

Over much of the area the bedrock is concealed beneath a blanket of peat and moraine, but exposures of Moine psammites and quartzites occur in a small cutting on the north-east side of the A 82 and in a partly overgrown, abandoned road-metal quarry to the west. Similar rocks are exposed in the three stream sections to the north east, where they are closely jointed and, more rarely, brecciated.

The northern part of the area, to the east of the Ericht-Laidon Fault, is occupied by hornblende-biotite granodiorite, which constitutes the southern margin of the Moor of Rannoch Granite pluton. Exposure of the granodiorite, particularly in the north-east, is generally better than that of the Moine, but nowhere is the contact between the two rock types visible. However, in the easternmost stream, the Moine rocks 100 to 150 km south of the proposed southern margin of the granodiorite are intensely veined by granite. The presence, within this net-vein complex, of angular Moine fragments suggests that the strong shearing and brecciation noted previously is more likely to have resulted from the forceful intrusion of the Moor of Rannoch Granite than from movements along the Ericht-Laidon Fault.

Just south of the net-veined Moine the stream drops into a narrow, fault-controlled, north-east/south-west trending gorge which exposes highly-sheared psammite, and a calcite-cemented breccia, up to 10 cm thick. About 400 m to the south-west, along this line, there is a similarly orientated lamprophyre dyke.

The Ericht-Laidon Fault, on evidence from adjacent areas, passes through the drift-covered depression in the north-west part of this area. By comparing granite outcrops across the fault, Hinxman and others (1923) were able to show that there had been a net sinistral displacement of approximately 7.3 km, with little or no apparent vertical component. The Ericht-Laidon Fault is one of the Great Glen suite of parallel north-east/south-west trending wrench faults and evidence from other members of the suite, in the Glen Lyon and Loch/Tay areas, suggests that, in most places, these faults comprise broad movement zones, in which there are several parallel dislocations and much associated cataclasis. Hence, the small fault in the easternmost stream and the apparently fault-controlled lamprophyre are probably related to the Ericht-Laidon Fault.

Mineralised granite veins

Nine sulphide-bearing granitic veins, ranging in thickness from 2 to 10 cm, are exposed in the quarry and roadside cutting (Fig. 1). They are all probably separate veins, but individuals seem to bifurcate and others to terminate abruptly, so the exact number is in doubt. A vertical or steep easterly dip is general and the strike ranges from north to north-west; the orientations of those veins in the quarry is controlled by joints in the Moine rocks.

These veins comprise, essentially, a medium-grained intergrowth of quartz and microcline. The microcline in the central part of the veins is white, but on the edges it has a distinctive reddish pink hue, which also pervades the adjacent metasedimentary rocks. The change in colouration is thought to be the result of alteration, but the rocks have not been examined mineralogically. One of the veins in the road cutting also contains calcite.

Almost all of the veins examined contain pyrite, the concentration varying from 1 per cent to around 80 per cent (over a 2 to 3 cm interval). In general, the veins in the cutting tend to be richer than those in the quarry. The form of the pyrite varies from fine disseminations to aggregates (up to 2 cm across) which form trails parallel to the vein margins. Some of the larger grains show skeletal intergrowths with quartz and microcline. At least one of the veins in the cutting has, in addition, fine-grained molybdenite which forms irregular patches up to 1 cm across. The mineral may be intergrown with pyrite and/or quartz and feldspar. Both pyrite and molybdenite are present, in minor amounts, in the adjacent country rock.

Outwith the quarry and cutting, the veins are considerably coarser grained and frequently reach pegmatitic proportions. They are principally of quartz and brick-red microcline with minor pyrite, which is also present in the surrounding Moine rocks.

GEOPHYSICAL SURVEYS

Geophysical work carried out at Blackmount extended over a period of two weeks during June 1976. The proximity of the known outcropping mineralisation and the Ericht-Laidon Fault suggested that a composite survey should cover both target areas simultaneously. The location of the traverses used during the survey are shown in Fig. 1, their orientation being approximately perpendicular to the assumed strike of the outcropping veins and the trend of the Ericht-Laidon Fault. It was subsequently discovered that the strike of the veins was perpendicular to that of the Fault. Some operational difficulties were incurred because the veins crop out close to the busy A82 (T) road.

The measurements

If present in sufficient quantity, base metal sulphides will produce conductivity values significantly higher than those which may be obtained from psammitic rocks. To investigate quickly the occurence of any such anomalies the fast, very low frequency electro-magnetic (VLF EM) technique was employed using a Geonics EM 16 receiver tuned to the radio transmitter at Oswestry (GBZ 19.6 KHz). The in-phase and out-of-phase vertical component of the induced magnetic vector were sampled every 15 m along all traverses. Follow up EM work along selected traverses used the double frequency (880, 2640 Hz) ABEM gun unit in a slingram arrangement with a 60 m separation between transmitter and receiving coils. Total field magnetic intensity observations were recorded along all traverses and some crosslines using an ELSEC proton precession magnetometer. Finally, limited induced polarisation and resistivity surveys were undertaken with a time-domain HUNTEC MK III IP instrument. The 'dipole-dipole' configuration was used as it is known to have a large response to anomalous zones whilst giving good resolution (Coggan, 1973). A dipole length of 30 m was considered suitable for sufficient penetration beneath the glacial overburden. All traverses were levelled with an Abney level.

Description of results

(i) Very Low Frequency EM (VLF EM)

The results are presented as profiles of the in-phase and out-of-phase component values obtained over the two target areas (Figs. 3a-7a) and also as a contoured map, (Fig. 2) after Fraser (1966), of in-phase component values for the whole survey area. This latter presentation converts proper crossover anomalies on profiles into positive peak readings, discards reverse crossovers and smooths the large geologic noise inherent in the observations due to the relatively high frequency of the Oswestry transmitter.

Examination of the contoured map reveals one major and several small conductivity anomalies, which have been labelled A to G. The major anomaly (A), exceeding 80 per cent in places, is essentially colinear across all traverse lines and trends north-east/south-west. This anomaly is undoubtedly associated with the south-westerly extension of the Ericht-Laidon Fault. The asymmetry of the in-phase component about the zero line, in the profiles of Figs 6a, 7a, is due to the strike of the fault being sub-parallel to the primary transmitter field from Oswestry. The presence of an effective conducting overburden is revealed from these profiles by the positive out-of-phase component west of the crossover anomaly. The smaller north-south anomaly (B), and its apparent extension (C) are less readily explainable. In the north, anomaly (B) corresponds with the A 82 (T) road whereas, in the south the road is absent. Anomaly (C) is not associated with a local topographic depression or stream course and cannot therefore be related to an obvious surface phenomenon. On the other hand, smaller anomalies also trending approximately north-south, (D, E and F), do correspond to local topographic hollows with their inherent thickening of conductive overburden. Although there is no anomaly directly associated with the mineralised veins, (see Figs 2, 3a), a small inflection anomaly (G) occurs nearby. This, however, is probably due to the juxtaposed motor layby.

(ii) Slingram EM

This survey was a follow up to investigate in detail the anomalies revealed by the previous VLF EM work. However, in the event, the EM gun failed to give any response across the major VLF anomaly (A). Generally, both the in-phase and out-of-phase components remained at a background level. The anomalies obtained, after careful corrections for terrain, were of narrow width (less than 60 m) with steep gradients and showed no trend from one profile to another. These shallow depth anomalies may readily be attributed to the frequent occurrence in the area of waterlogged overburden. Extensive waterlogged overburden is found over the Ericht-Laidon Fault and constitutes a horizontal conducting slab. Similar occurrences in Canada (Telford, 1976) have successfully masked any response from vertical conductors no more than 20 m below ground.

(iii) Magnetics

Selected profiles from the magnetic results are presented in Figs 3b-7b for the two target areas. Three features of the results are apparent. First, the absence of any anomaly across or near to the outcropping veins (Fig. 3b). Second, the short wavelength (less than 50 m), moderately small (less than 100 nT) anomalies indicate a shallow origin and respresent local fluctuations in ground susceptibility. In some instances, larger (200 nT) anomalies have been found to be coincident with exposed glacial moraines. Finally there is a significant change (between 100 and 200 nT) in the observed magnetic background level (Figs 6b, 7b which is coincident with the major VLF EM anomaly (A). This change occurs across a continuously level topographic surface and contrasts with the eastern section of the survey, where the larger wavelength magnetic variations are seen to correlate with topographic changes.

(iv) Resistivity

The resistivity survey was restricted to the area around the mineralised veins and the zone of the major VLF EM anomaly (A). The presence of the A 82 (T) road prevented measurements being made directly over the exposed veins. The results are presented as vertical pseudo-sections, (Figs 4c-7c) where the apparent resistivities have been calculated after Telford and others (1976).

It is evident from Figs 4c and 5c that neither of these traverses show any significant lows. However, a small anomaly does coincide with a VLF EM inflection anomaly, (G in Fig. 2), and its limited depth supports the idea that both anomalies are due to the motor layby.

On the other hand, Fig. 6c and more especially Fig. 7c clearly indicate a zone of low resistivity extending to depth. Both these anomalies coincide with the major VLF EM anomaly and the change in background magnetic level. The essentially symmetrical nature of the contours and their association with the VLF EM anomaly trend, suggest (Coggan, 1973) that the source is a narrow (less than 30 m wide) vertical body which parallels the trend of the VLF EM anomaly (A) and whose upper surface comes close to ground level. The anomalous electrical soundings extend to the maximum depth investigated, which for a homogeneous crust would be 90 m. In practice, however, these soundings represent information from lesser depths.

(v) Induced polarisation

Concomitant with the resistivity survey, time domain induced polarisation measurements were recorded from which apparent chargeabilities have been computed (Hutchins, 1971). Here, chargeabilities represent the transient decay voltage integrated over a 420 ms interval and normalised with respect to the primary voltage. The results are presented as pseudo-sections in Figs 4d-7d from which a background value of 4 to 8 ms is evident. The larger chargeability value (12 ms) recorded between 120 and 150E on line 130S (Fig. 4d), extends to depth. This is the only recorded high IP anomaly, and its close association with the position of the abandoned quarry suggests a connection with the mineralised veins observed therein. No such anomalies occur elsewhere, the results north-east of the outcropping veins along line 100N, (Fig. 5d), typifying a general background nature.

The occurrence of significantly lower than background chargeabilities (less than 2 ms) on traverses 200N and 100S, (Figs 6d, 7d), is evident. The depth extent of these anomalies is exactly that of the low resistivity values.

Assessment of results

In assessing the geophysical anomalies obtained from this survey the effect of man-made and geological noise should be borne in mind. For this survey, man-made noise represents the juxtaposition of the A 82 (T) road and layby close to the exposed veins while geological noise is the masking effect of the surface glacial debris and waterlogged overburden on desirable target anomalies.

(i) Mineralised granite veins

From the profiles of the VLF EM and magnetic traverses, (Fig. 3), taken directly over these veins no anomaly was evident. The busy A 82 (T) road precluded any Slingram EM or induced polarisation work being carried out over the veins. It is evident, however, from the collective results obtained along traverses 130S and 100N, (Figs 4, 5) which flank the veins, that there is little sign of significant conductive mineralisation. It is now known that the mineralisation does strike subparallel with lines 130S and 100 N but a significant enrichment seems unlikely in view of the background values obtained from this section of lines 50N, 00, 70S and 100S. The only exception is the IP anomaly which extends to depth and is close to the quarry where limited mineralisation occurs. Since this anomaly has no associated resistivity low, it may be due to a narrow zone of small non-connected veins. Such an occurrence could give the observed chargeability anomaly while not reducing the apparent resistivity. That such occurrences have been observed on the surface in the quarry lends support to the idea that this anomaly represents an extension of this minor mineralisation to depth.

(ii) Ericht-Laidon Fault zone

There can be little doubt as to the cause and effect relationship existing between the Ericht-Laidon Fault and the associated geophysical anomalies. In order to assess whether or not these anomalies reflect the presence of concealed sulphide mineralisation, a comparison of aeromagnetic Sheet 17 and one-inch geological sheet 54 was made. This revealed three pertinent facts. Firstly, the Moor of Rannoch pluton has a considerably higher and more variable magnetic polarisation than do the surrounding Moine rocks. Secondly, the magnetic pattern observed over the pluton continues across the whole survey area in spite of the geologically mapped glacial drift and Moine, thereby implying that granite underlies the whole survey area at a shallow depth. Thirdly, the Ericht-Laidon Fault is associated with a magnetic lineation that crosses the whole of the Moor of Rannoch pluton. This fault is known from geological evidence to be of sinistral, essentially strike-slip type with near vertical contacts which have undergone some 7 km of slip movement. Frequently, the fault trace lies along the bottom of troughs or submerged in the long narrow "two dimensional" Lochs Ericht and Laidon.

In view of the foregoing it seems reasonable to suggest a deep, narrow (less than 30 m wide) "two dimensional" trough in the granite bedrock in association with a water-filled shear zone as a model to account for the observed anomalies. This 'overburden trough' idea is in keeping with the geological facts and anomalies for the following reasons. The constraint that the fault is strike slip suggests that a susceptibility contrast alone, across the vertical fault contact, is sufficient to account for the change in background magnetic level over the fault. Certainly large spatial variations in magnetic susceptibility occur within the pluton and a movement of 7 km seems sufficient to bring different 'susceptibility provinces' into contact across the fault plane. Also, in such a fault zone, it is not unreasonable to expect a shatter zone close to the vertical contact. The observation that the fault trace elsewhere is generally associated with narrow troughs or lochs suggests a like occurrence beneath the survey area. If this is so, the resistivity results which suggested a vertical conducting body may be due to a narrow and deep water-saturated overburden-filled trough, and the lower than background chargeability values observed across the Fault reflect the absence of granitic bedrock, (the granite with its clayey weathered surface being the source of the background values). A subsequent emplacement of overburden infill, having little or no overvoltage properties, could then be a source for the low chargeabilities. The major VLF EM anomaly could therefore be attributed to the near surface lateral conductivity contrast of the trough infill and granitic bedrock interface. The lack of any anomalous response of the Slingram EM results is due to a combination of the small impedance contrast (at two thousand hertz) of the trough infill with overlying glacial drift and the latter's masking effect of any induced field. Similar occurrences of lack of sensitivity have been reported by Volgelsang (1974) and by A. J. Burley (personal communication). With this model in mind it is believed that within the area surveyed the Ericht-Laidon Fault has no associated sulphide mineralisation down to the depth investigated. It is noteworthy that a similar case history in Canada of a conducting zone, revealed by EM and resistivity with lower than background chargeabilities, was later proven by drilling to be due to overburden conduction in a bedrock trough (Seigel, 1970).

CONCLUSIONS

It is evident from the results obtaining over and in the vicinity of the exposed mineralised veins that any significant extension both laterally and to depth must be generally precluded. The zones of exposed sulphides should therefore be regarded as having little economic value. The Ericht-Laidon Fault has been successfully located beneath drift and appears within the greatest depth investigated to be barren of any sulphide mineralisation.

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Aeromagnetic map of Great Britain. 1963 (1:63 360). Open file worksheet No. 17, Inst. Geol. Sci.

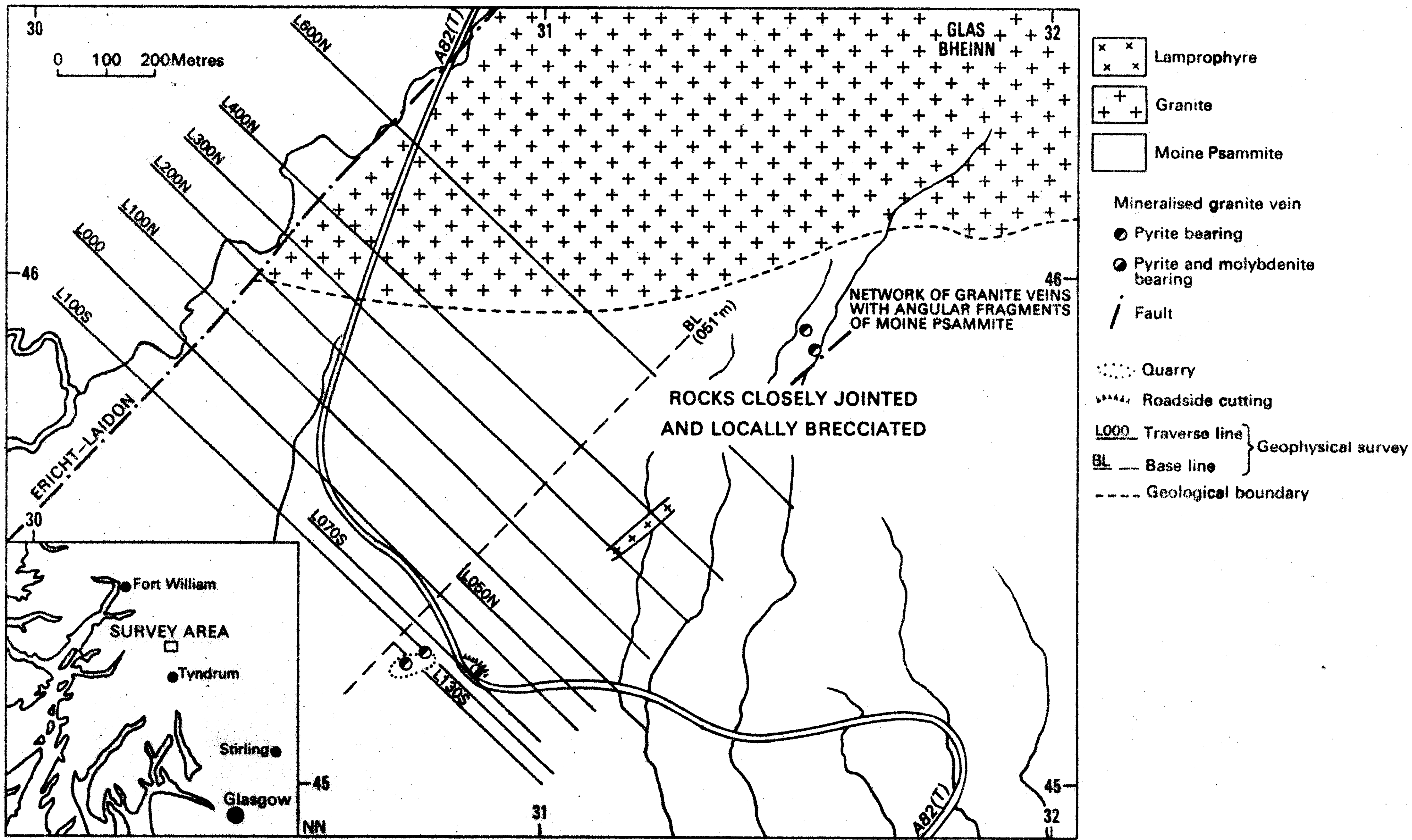

Fig 1 Blackmount: location, geology and geophysical survey lines
National Grid co-ordinates are shown at the edge of the map

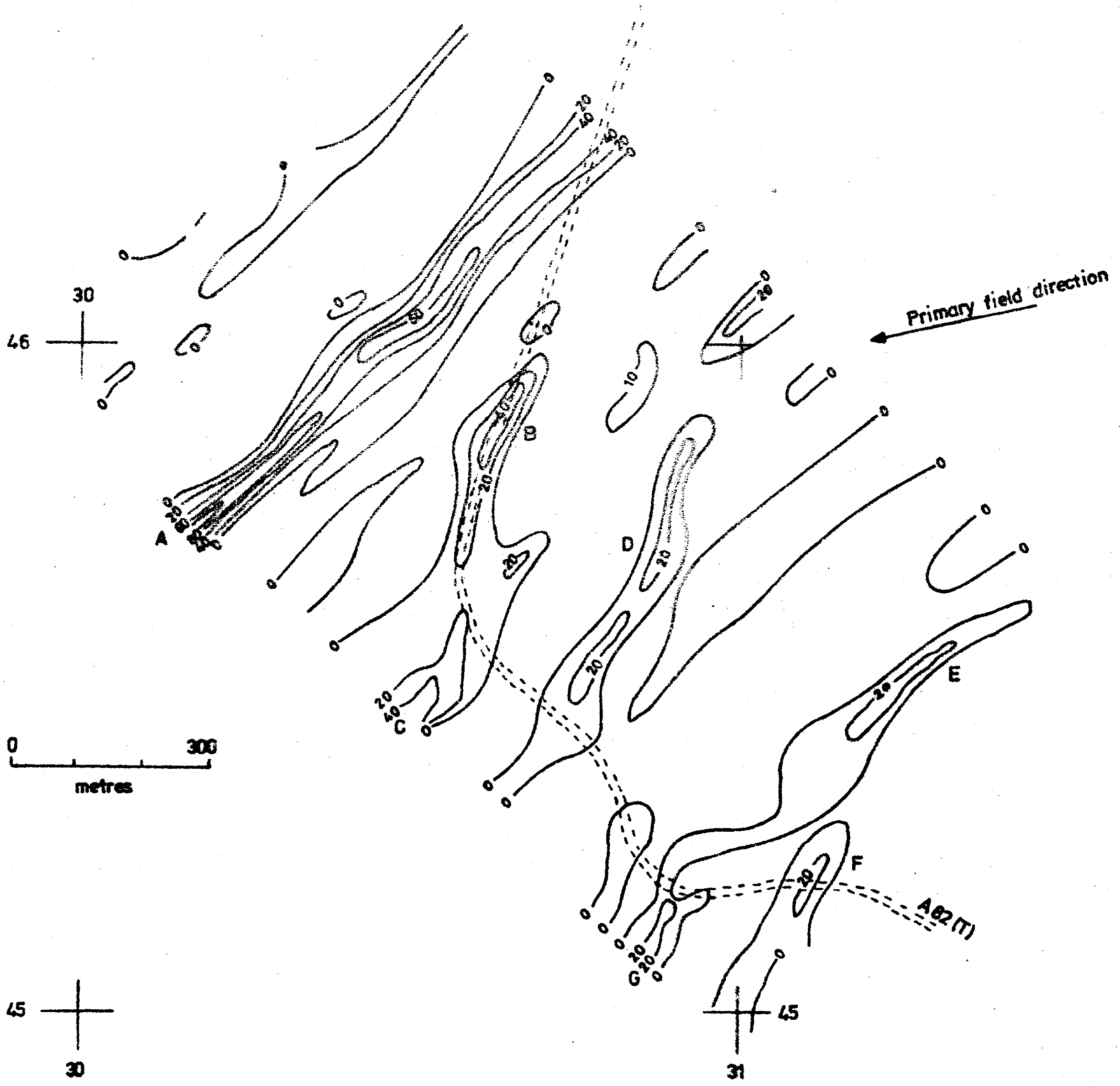

FIG. 2. Contoured map of filtered in-phase VLF EM component for survey. Contour interval 20%.

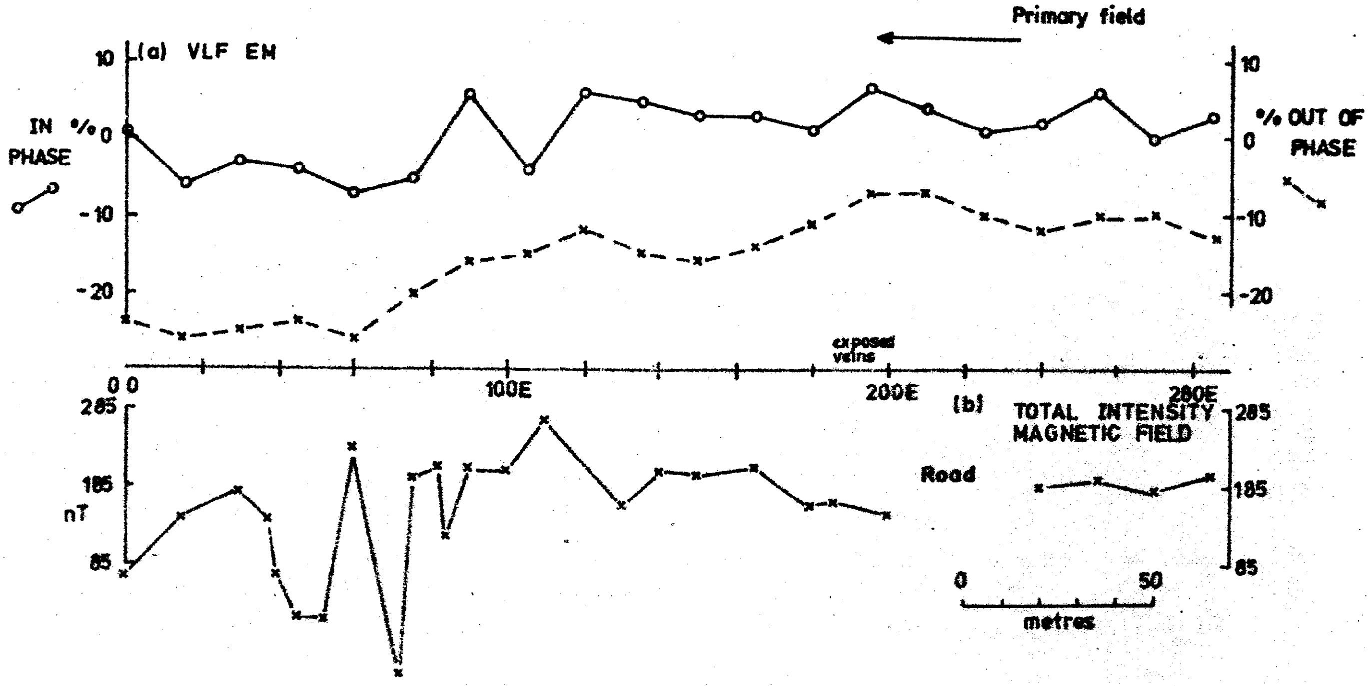

FIG. 3 VLF EM, and magnetic profiles over the outcroping veins L 70S

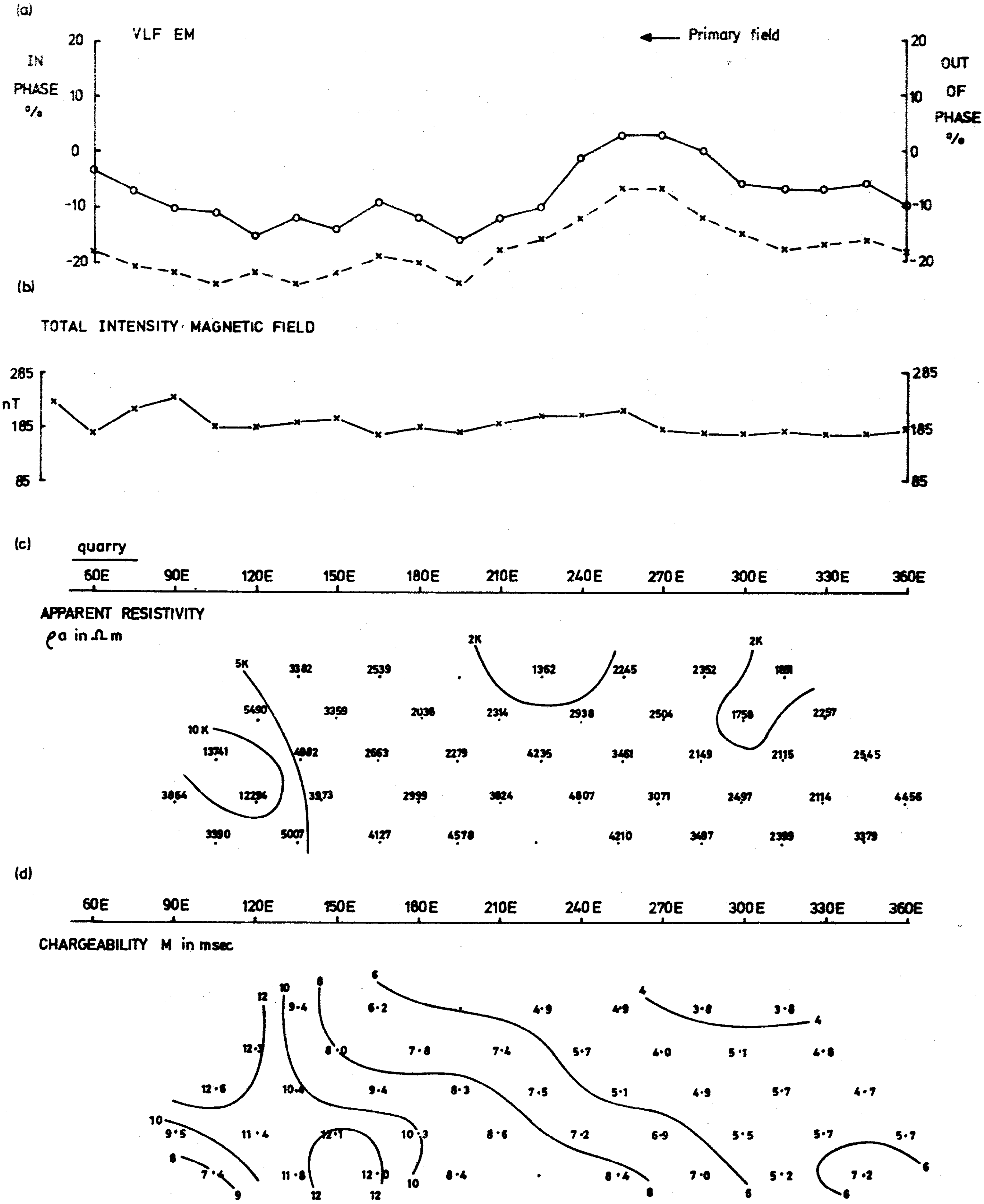

FIG. 4 VLF EM, magnetic profiles and resistivity, chargeability pseudo-sections L130S

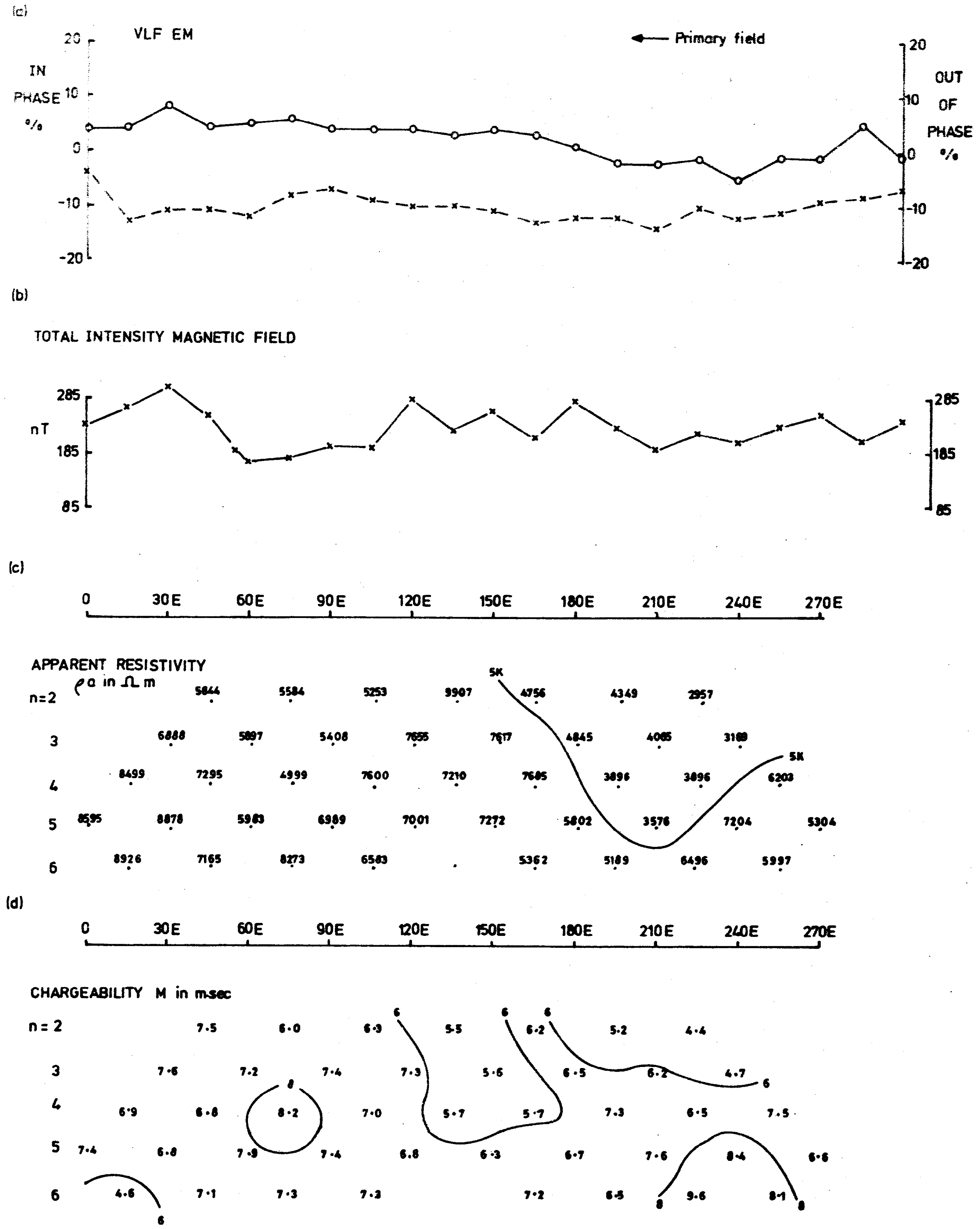

FIG. 5. VLF EM, magnetic profiles and resistivity, chargeability pseudo-sections L 100 N

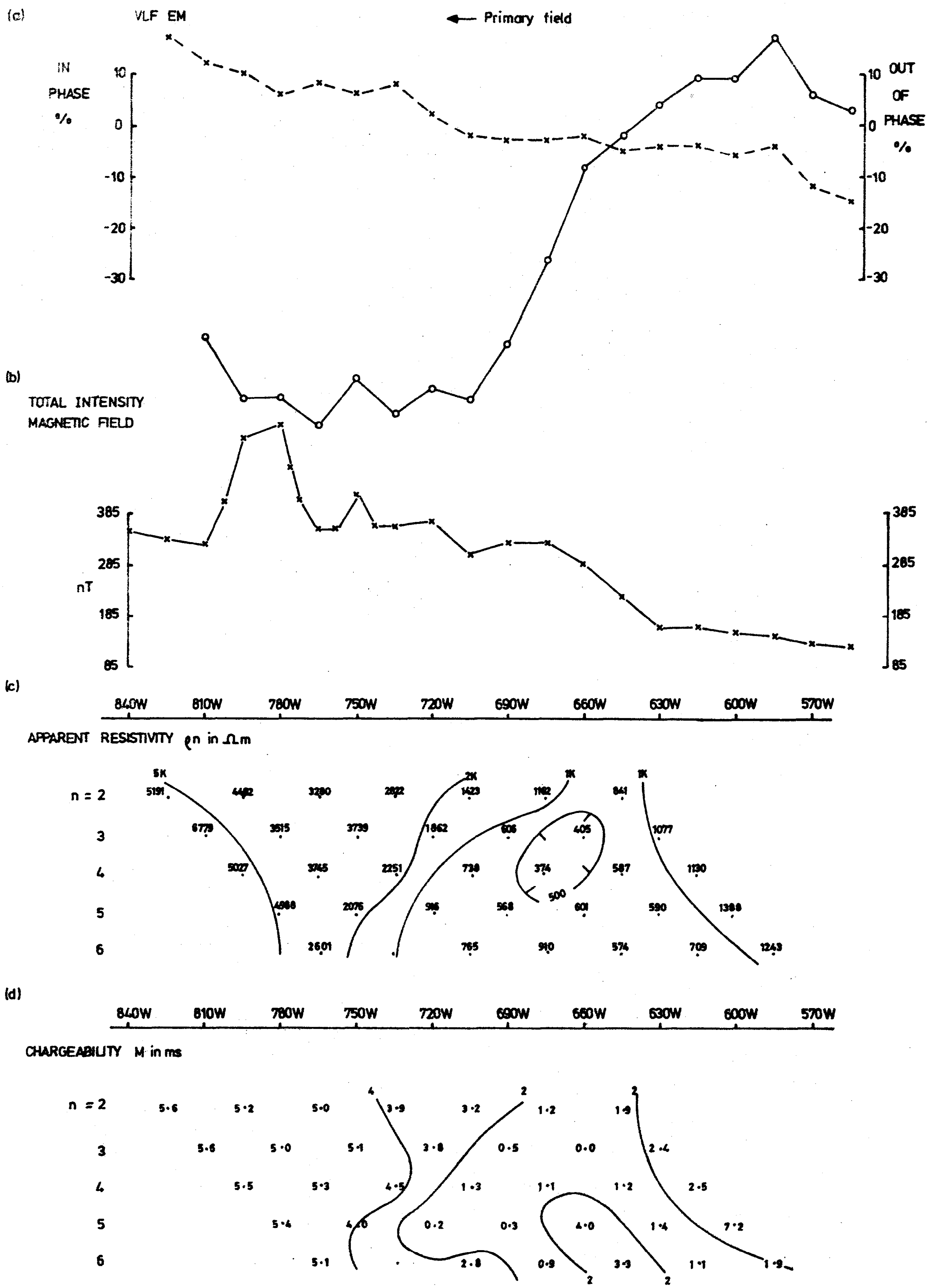

FIG. 6 VLF EM, magnetic profiles and resistivity, chargeability pseudo-sections L 200 N

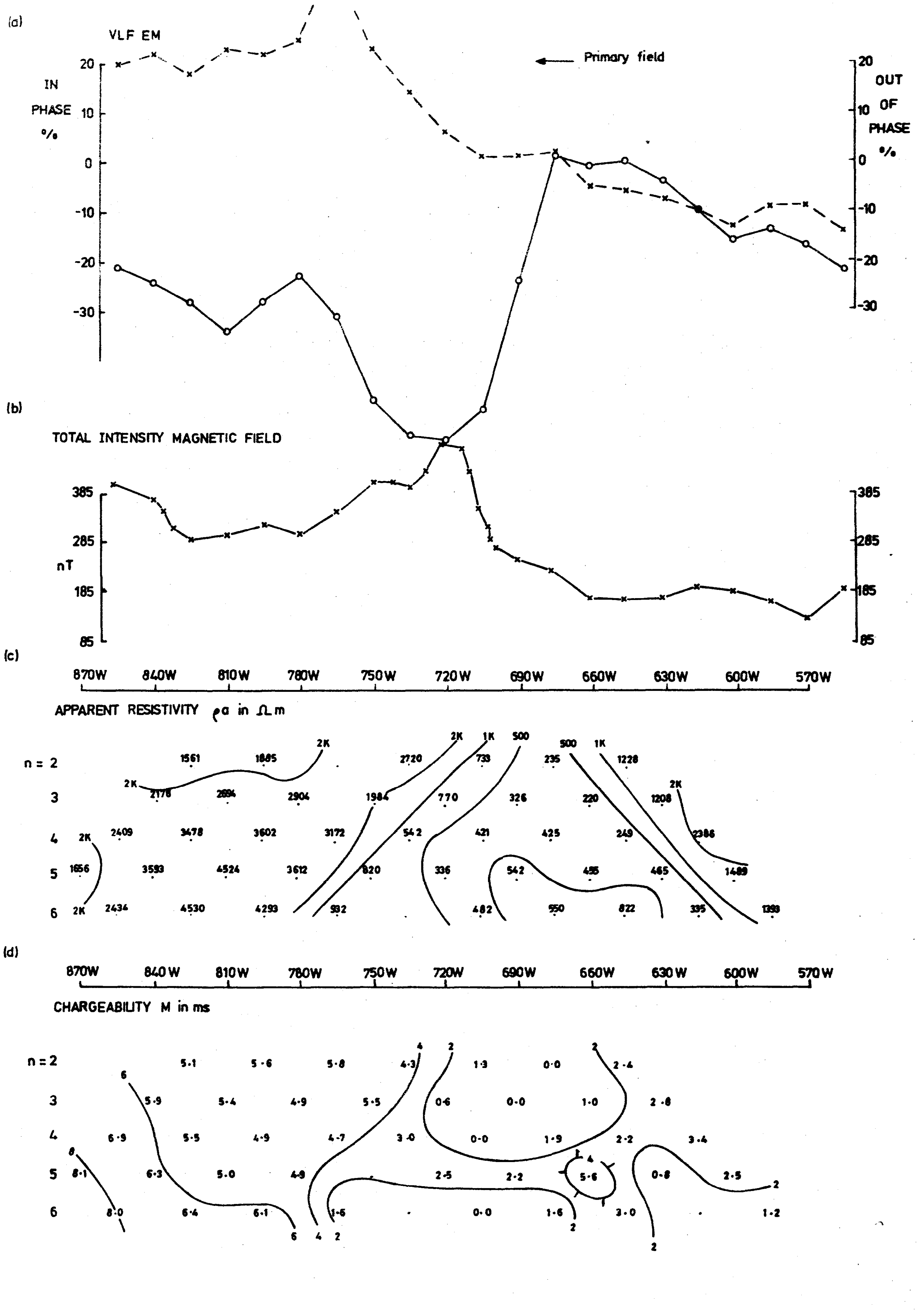

FIG. 7 VLF EM, magnetic profiles and resistivity, chargeability pseudo-sections L 100 S