TR17_79_87

16. Geophysics of the Lefroy goldfield.

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Geophysical surveys of selected portions of the Lefroy goldfield have been undertaken to appraise:

(1) which methods can yield useful information;
(2) whether structural controls can be detected; and
(3) if the vein systems can be traced and what types of anomalies are directly associated.

GEOLOGY

The geology of the area, the location of the main workings and the nomenclature of the worked reefs has been described by Groves (1965). Geologically, the area may be divided into two regimes.

(1) North of Lefroy where most of the reefs are concealed by recent sedimentation and basalt.
(2) South of Lefroy where most reefs and workings are exposed although outcrop of both the reef material and the country rock is very poor.

The reef material is predominantly quartz which is interspersed as lodes in slate, quartzite, siltstone and sandstone. Little is known of structural controls for the mineralisation and no source of the gold-bearing quartz is apparent. However, a regional gravity survey of the central north of Tasmania (Leaman *et al.*, 1973) has revealed an anomaly pattern which can be interpreted as due to a granodiorite stock centred south of Lefroy.

PART 1. GEOPHYSICAL SURVEY

This section covers the use of simple geophysical methods in the Lefroy area. Three methods were selected for the initial survey; resistivity, self potential and temperature, although some seismic refraction and magnetic surveys were also attempted. The resistivity methods were selected because it was anticipated that should the reef-bearing areas be either massive or fractured and water-bearing, there would be significant changes in resistivity. Reef structures which are water bearing or have marginal weathering of the slates developed, are good sources of self potentials. Temperature anomalies are possible if the reef at depth, is water-bearing or massive, because there are thermal conductivity differences between water regimes, 'normal' slate and massive quartz. Water anomalies would be expected to be warmer whilst quartz anomalies would be cooler.

The survey methods were restricted to the simpler geological situation south of Lefroy and, in particular, to the region including the Windermere, Leefloyd, Golden Crest, Reward, New Years Gift and Land O'Cakes reefs.

RESULTS

Windermere-Leefloyd reefs

Resistivity and self potential profiles are shown in Figure 19. The resistivity profile shows a distinct step from a value of about 200 Ω-m to about 50 Ω-m. The gradient extends across 60 m with the Leefloyd and Windermere reefs located at inflexions of the gradient. There are some excavations between the reefs and the angular nature of the profile south of the Windermere reef suggests the presence of further quartz reefs. The overall shape of the profile could imply a junction between two rock types with the reefs introduced near the footwall. The dip of such a rock junction would be to the south at a high angle. Alternatively the higher resistivity values may represent quartz rich zones. The profile is too short to confirm this solution (*cf* Specimen Hill anomalies). The self potential profile shows much less character, but the overall depression in the profile correlates with the resistivity step with the minimum potential associated with the Windermere reef.

Land O'Cakes reef

Only a resistivity profile is available (fig. 19, south end line 1). No special characteristics were noted in the area of the Bannock pit and there is no excessive angularity or significant maximum in the profile. Lithologic differences of any importance cannot be ascribed, the resistivity ranging between 280 and 400 Ω-m. The major anomaly 130 m north of the Bannock shaft is discussed below and may represent the true position of this reef.

Specimen Hill reefs-Golden Crest, Reward, New Years Gift

Resistivity and self potential profiles are presented for the main reef area and a western extension in Figure 19. Several points can be noted from the profiles.

(1) The marked angularity of the resistivity profile is observed only between points C and D (line 1) which may be contrasted with that part of the profile associated with the Land O'Cakes workings and the minor workings south of point C (*cf* Windermere profile).
(2) There is no correlation between the amount of surface quartz and the angularity of the resistivity profile.
(3) Major negative potentials are not necessarily associated with those zones where the resistivity profile is angular.
(4) Very few resistivity-self potential anomalies show reverse correlation suggestive of particular reef zones, for example, a-a', b-b', (line 1) and c-c' (line 3). Such correlations are probably of marginal importance in view of the major features in the resistivity profiles.
(5) The background variation in resistivity has a range of about 100 Ω-m and a wavelength of 15 m (see north end line 3 and south end line 1). The background variation in self potential has a range of about 100 mV and a wavelength of 12-15 m. These values suggest alternating lithologies of approximately 5-6 m in thickness.
(6) The resistivity profiles show a marked anomaly, apparently south of most workings and is best seen in lines 1 and 3. The trend of the anomaly is south-west (sketch map, fig. 19).
(7) Although the temperature profiles are restricted to short traverse lengths elevated temperatures are related to zones of major workings (fig. 19, line 4) and to the northern side of the resistivity anomalies (fig. 19, especially line 1, and to some extent line 3). Normal temperatures appear to be 12-12.4°C and temperatures in excess of 13°C are certainly anomalous.

In this trial survey the self potential profiles were too restricted to examine the effects of the unexpected high resistivity zone. However an indication of probable results is given in Figure 19, line 3. Due to boring and slope difficulties the thermal profile for line 3 is also too short.

A trial cross-fired refraction survey was undertaken along line 3 from points E to F in order to test if any velocity asymmetries could be detected which might be related to varying joint frequency, lithology or veins. The seismic results did not reveal definite information about the vein system but did show that the rocks possessed a NW-SE asymmetry; probably the strike trend. The survey did indicate deep weathering to at least 15-20 m, explaining why the remnant quartz veins have such an excellent resistivity contrast in the top 10 m.

A ground magnetometer traverse across the resistivity anomalies of lines 2 and 3 produced null results. It was thought that if a high concentration of quartz were present a slight negative anomaly might be observed. It is indeed possible that a 10-20 γ anomaly is present but the magnetometer used was at its highest sensitivity and the results must be regarded as very doubtful.

DISCUSSION OF METHODS

Several technical difficulties have been noted for surveys of this type:

(1) As the reefs are relatively narrow, observation points should not be more than 3-5 m apart as detail and profile character is easily lost.

(2) Separation for resistivity traversing (Wenner) should not exceed 10-15 m.

(3) All self potential observations should be checked and preferably re-read on a standard pattern at each point. Results should be averaged. Due to the significant potential gradients associated with thin bodies or zones such re-reading is useful in locating edge effects and removal of spurious results.

(4) It is possible to resistivity traverse between 700 and 1000 m/day reading at 3 m intervals in this area.

Self potential traversing is slower at 600-800 m/day assuming base adjustments and re-reading.

Temperature probing is much slower, only 60 stations per day can be read with the equipment available, allowing one hour stabilisation. This therefore should only be used in critical areas.

CONCLUSIONS AND RECOMMENDATIONS

The principal workings of the areas examined are related to the northern long slope side of a peaked resistivity anomaly. The anomaly is due either to a lithological change or a quartz vein concentration.

Correlation and interpretation of the self potential anomalies is difficult, but significant negative values indicate concentrations of quartz and, or, increased water flows due to increased fracturing. It is however certainly possible to detect 'normal' host rock, (rock that is lacking in mineralisation), by all three methods used. Irregular and high resistivities, low self potentials and high temperatures appear to be related to quartz reefs.

The major resistivity anomaly observed in traverses across the Specimen Hill reefs has a SW-NE orientation. It is noteworthy that due west of the main workings only minor workings are present and these are more sparse westward. The lack of significant workings west of the old Launceston-Lefroy road suggests that either no mineralisation is present or that it was not to be found in the inferred E-W direction. The mineralised zone may be en echelon E-W with a south-west offstep.

Some trial pits or a bore hole should be sited to confirm the inferences of the south-west extension of the ore veins. If such tests are positive then further surveys should be undertaken to locate true extensions of the ore. Certainly it is necessary to establish the cause of the resistivity anomaly before further surveys can be usefully undertaken.

PART 2. TELLURIC CURRENTS

During a series of tests for piezoelectric effects from the quartz veins of the Lefroy goldfield telluric potentials were observed. The equipment in use at the time included two porous pots containing copper sulphate-copper electrodes and a sensitive voltage chart recorder. Electrode separation was 19 m. The chart recorder was capable of displaying clearly all variations of voltage in excess of 2 μV.

OBSERVATIONS

As only one orientation was recorded it is not possible to unambiguously describe the source directions of the current. Figure 20 indicates the waveforms present during almost 25 minutes of recording. The following information may be directly deduced from the record.

Maximum amplitude 30 μV (10 m spread). Amplitude equivalent to 3 mV/km.
Normal periods 3, 5, 6-6.5 units or 18, 30, 36-39 s.
Frequencies 1.5-3.5 Hz.

Superimposed on the more obvious short period vibrations are others with an amplitude of about 10 μV and period 90 seconds. Various interference effects can be noted in the record, for example points A, B and C (fig. 20).

Several periods of quiescence may be seen and several marked change points are present (indicated by arrows). Therefore it would have been possible to simply correlate with other records had they been made.

DISCUSSION

The voltages recorded are sufficiently large and bear adequate character to permit regional investigations. It may be possible to develop telluric techniques to examine structural relationships within the apparently invariable and monotonous Mathinna Beds sequence. Major structures have been suspected but are difficult to prove due to uniform lithology and lack of marker horizons. However, such structures as major faults, thrusts, nappe blocks or fold structures should produce significant asymmetries in the telluric field, enabling pinpointing of their location. Further development of this method is recommended.

PART 3. TEST OF PIEZOELECTRIC METHODS

As quartz is a peculiarly sensitive piezoelectric material it was considered that attempts could be made to evaluate the goldfield using piezoelectric methods. Unfortunately neither commercially designed or built equipment nor developed field techniques were available. Only Russian scientists have attempted experiments in this field and most of these have been laboratory trials. In addition much of the literature is inaccessible, with the notable exception of such summaries as Parkhomenko (1971).

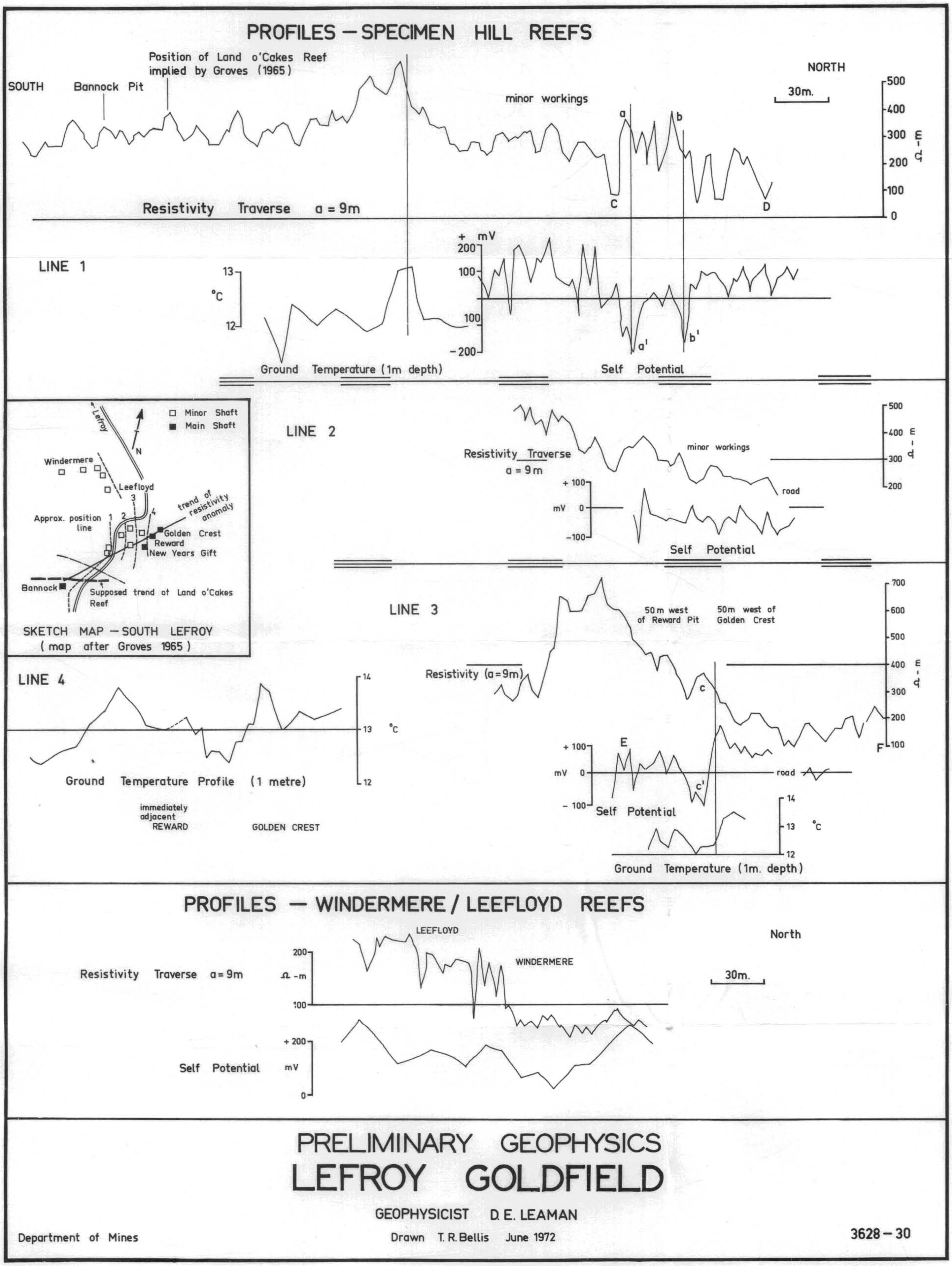


Figure 19.

5 cm

TR17_79_87

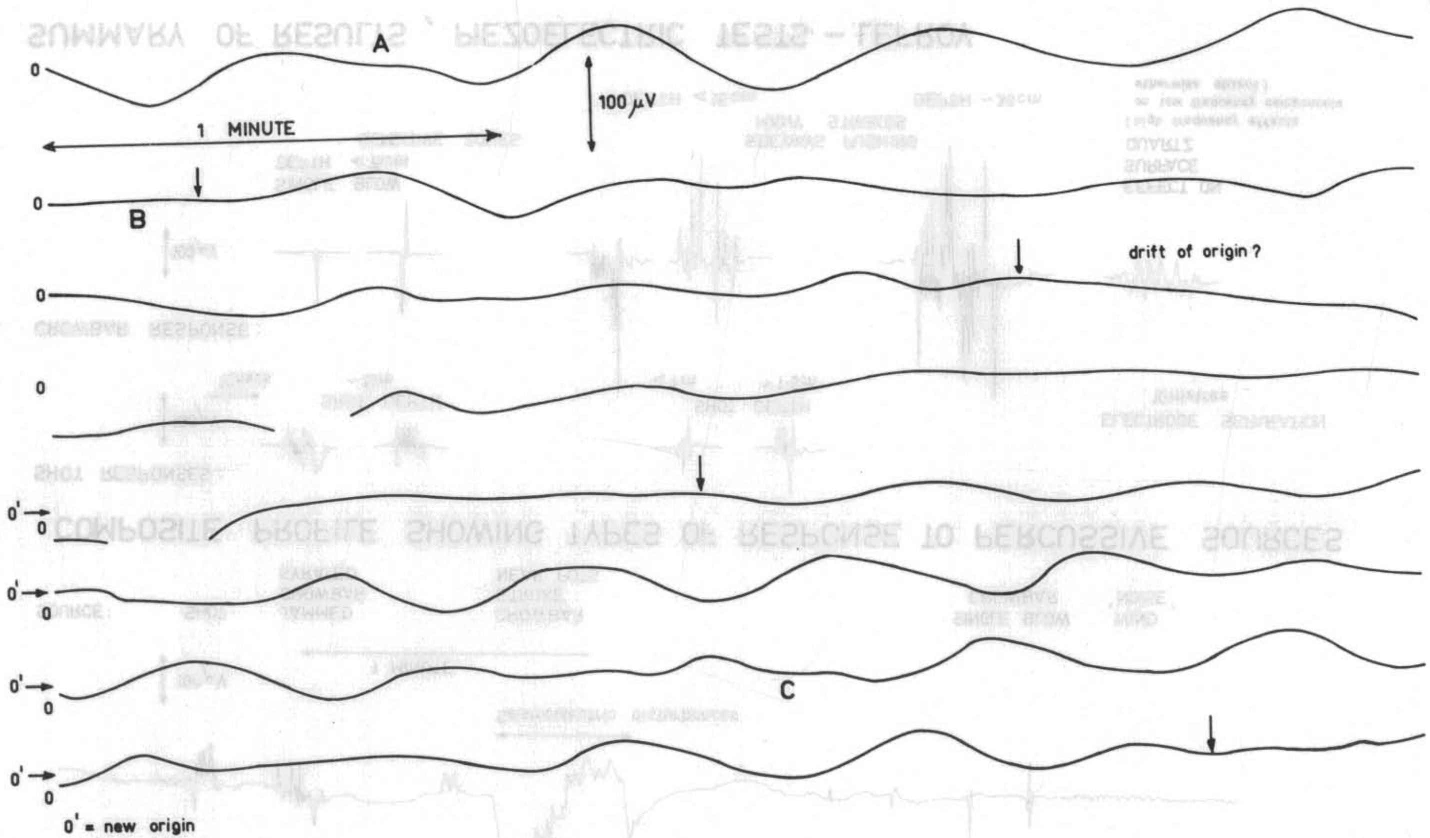
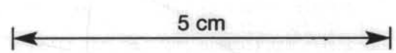


Figure 20. *Wave form, telluric voltage, Lefroy.*



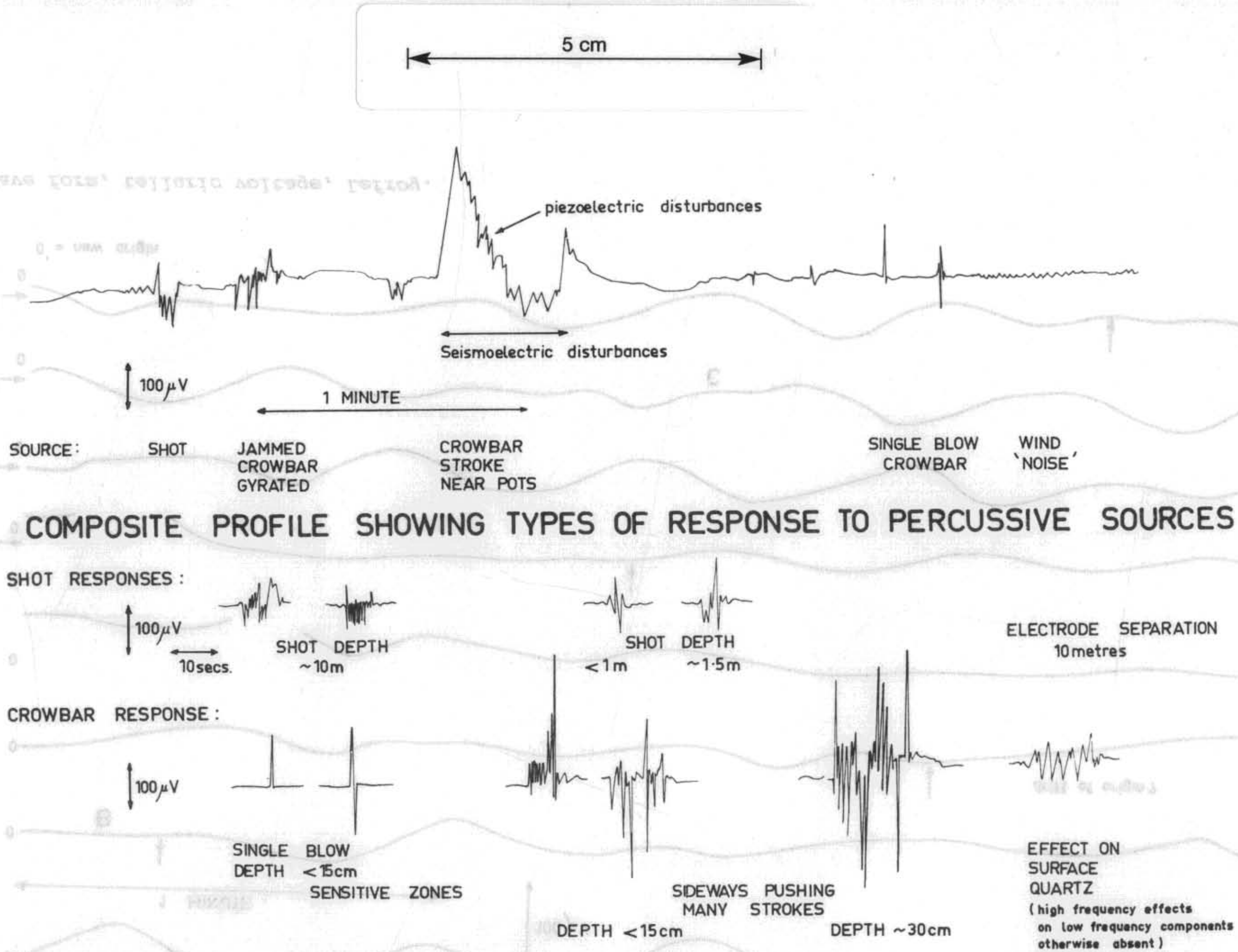


Figure 21. SUMMARY OF RESULTS, PIEZOELECTRIC TESTS – LEFROY

Laboratory trials (Parkhomenko, 1971) have been relatively small scale and have used two small electrodes and an energy source. Field trials (*op. cit.*) have been of larger scale but have used explosives as energy sources. In addition seismic records are kept and comparison of the arrival times for both seismic and piezoelectric effects have been used to pinpoint the piezoelectric material. Such field techniques require good position control but are not economic since a large number of charges are required for each ground sample examined and the records produced may be difficult to analyse. No established procedures are available for the interpretation of such records.

The tests described in this report included explosive charges and hammer blows as energy sources, but unlike the Russian work the vibration source was moved around the area occupied by the electrodes for any given time. Thus a form of traversing was undertaken.

EFFECT OF METHOD AND ENERGY SOURCE

Figure 21 shows the type of response achieved with different types of energy source. Also shown, for comparison purposes, is the nature of a seismoelectric effect. In general 'seismoelectric' effects have a greater amplitude, a larger decay time and are due to motion of the pot electrodes. Piezoelectric effects can be related to the impulse imparted by the energy source (note the form from a single blow as compared to motion of the vibrating source).

In each case explosive charges produced a band response, usually of about 5 seconds duration, irrespective of the shot-location with respect to the electrode layout. This could be due to either repeated vibration from the shot producing several responses from a single vein or, more likely, interference from several veins. It is thus nearly impossible in a situation like Lefroy, to use the Russian field technique and obtain useful results on vein location. This is due to the multiplicity of small veins and there is no way to separate the response from any one vein due to time overlap from nearby veins. The shot band width was more pronounced with increasing shot depth.

Direct percussive actions, such as jumping or tapping with a crowbar produced much clearer and unambiguous results. With this source it was possible to examine an area with a radius about that of the spread separation, where the centre for such an area is the midpoint of the electrode line. The crowbar was the most effective energy source used and in the tests was not consistently dropped from a uniform height or probed to the same depth. It was dropped at a large number of points along a line through the electrodes. Where a response was evoked the drop was repeated and then the immediate area was similarly tested. In this way it was possible to delineate sensitive zones. By moving the bar sideways whilst embedded in the ground the effect could be enhanced in certain ground conditions. By systematic tapping it was possible to trace each vein laterally for several metres.

FACTORS CAUSING VARIATION OF RESPONSE

The following discussion applies only to crowbar drops since as already mentioned, explosive sources were neither selective enough nor capable of infinite variation of site.

Strength of the blow. The more energy that could be applied in the region of a vein the greater the response.

Placement of the blow. Maximum response was observed where drops were over dipping veins or beside nearly vertical veins. In each case more compaction and squeezing of the response resulted. It must be noted that in the Lefroy area, the veins remain as massive residual accumulations in totally decomposed host rock. Therefore, for good energy transmission and piezoelectric voltage production, the vein or residual quartz must be very close to the 'strike' position. Displacement of 3-5 cm may be sufficient to prevent any voltage being generated.

Depth of blow stroke. The deeper the bar probed, the greater the response, due to better energy propagation and greater section of influence.

Number of blows. If the bar is moved whilst seated in the ground a great increase in voltage will be noted when the compressive direction is perpendicular to the vein strike. No response is evoked with motions parallel to the vein. As suggested in Figure 21, motion of the bar will give confirmation of vein presence, imply direction and magnify the response by about three times over the effect from vertical dropping. It is therefore good practice to move the bar at each observation point.

Vein size has not been shown to be a factor although only veins 3-10 cm in thickness were tested.

RESULTS

Wherever a markedly sensitive area was found which could be traced laterally for at least 2 m, it was pegged and then excavated. In every case with one exception, a quartz vein was found. In the exception, the test hole was not dug to a great enough depth to encounter the vein. The veins located all trended ENE-WSW, had dips between 30° and 90°, were between 3 and 10 cm in thickness and occurred as coherent masses at depths less than 50-60 cm.

SUMMARY

In regions where there are large numbers of veins, unless it can be shown that larger veins, say several metres wide, have different responses, explosive sources do not provide easy means of vein location. A bar or dropped source moved along a traverse line or the line of the electrodes, provides better results and definitely locates veins. In cases where larger veins are present, or where veins are at greater depth, more energy will be required, perhaps more than can be applied with such a source. Examples of this type need to be found and tested.

The equipment required is simple, easily moved and robust. Care must be taken to use water with a salinity approaching that of the local groundwater around the electrodes or bias balance will not be possible on the voltmeter at the sensitivity required.

The types of response noted are characteristic, being derived from impulsive sources and cannot be confused with telluric effects.

Surface or coherent vein quartz can be distinguished by the form of the response; the former produces broad swells with high frequency effects superimposed. The high frequencies are directly related to the piezoelectric effect and the broader swells (of high frequency compared to telluric effects) are due to interference from many detached pieces of quartz.

Seismoelectric effects are normally only observed at Lefroy, within 20 cm of the electrodes and are of much greater magnitude than the piezoelectric effect. The seismoelectric effect can be virtually overcome by seating the electrodes well and by providing good contact conditions. The seismoelectric effect discussed here refers to the direct motions of the electrode itself, which is possible since porous pots are used.

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