

PRELIMINARY REPORT ON MINERALISATION IN THE DALMENY AREA

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1. APPROACH

Involved core examination, polished thin section examination and study of 16 whole rock analyses of 16 samples from two drill holes DP 259 and DP 292 and comparison of these results with geochemical data from drill holes in the Rosebery-Grand Centre area.

2. RESULTS**(a) CORE EXAMINATION AND THIN SECTION EXAMINATION**

Observations both on a macroscopic and a microscopic scale were in good agreement with the logging of DP 282 and 259 but there was little correlation with the log of DP 292. In the latter log there was serious underestimation of the proportion of volcanoclastic rocks in the succession.

A critical feature was the estimation of the location of the footwall/hangingwall contact in each drill hole. DP 282 was easy, the quartz-phyric nature and generally granular texture throughout the hole indicated, together with thin section examination, indicated a thick accumulation of typical quartz-phyric epiclastic.

These were conspicuous by their absence in DP 259 and DP 292. Thin section examination indicates that the sample DP 259 @ 202.8 m is a hangingwall or host rock epiclastic. Three strongly corroded quartz crystals and two probable Precambrian-derived clasts are present and the high Cr content of this sample supports a partly Precambrian provenance (the Animal Creek Greywacke is Cr-rich). The next sample down (DP 259 @ 208.2 m) is a typical footwall pyroclastic.

In DP 292 distinction of the footwall-hangingwall contact was much more equivocal. DP 292 @ 170.4 m is a carbonate-altered lithic-crystal tuff with feldspar and quartz crystals and is probably hanging wall. The next sample down the hole at 192.3 m is a coarse grained plagioclase-rich crystal-pumice tuff with alteration characteristic typical of the footwall pyroclastics. Sericitisation increases in intensity below about 180 m and between 178.5 and 180.8 m there is a distinctive interval of bedded epiclastics. The footwall-hangingwall contact is tentatively placed at 180.8 m. The bulk of the hangingwall rocks are feldspar- and lesser quartz-phyric snowflake porphyries. The nature of most of these rocks is obscure but flow banding in DP 292 @ 127.3 m suggests that they may be at least partly extrusive in origin.

In DP 282 most thin sections show strong evidence of Devonian metamorphism and metasomatism. Biotite is common (at 231 m feldspar phenocrysts have been replaced by biotite) and tourmaline veinlets are present, at 85.9 m. This may suggest the proximity to Devonian faulting in this area.

The zinc-lead mineralisation is clearly Cambrian and epigenetic. The more strongly mineralised intervals occur in sericite-quartz schist in which primary features of the rocks are strongly obscured. Much of the mineralisation in these rocks occurs in strongly recrystallised, bondinaged quartz veinlets. Replacement of plagioclase by sphalerite is a feature and alteration of albite to K-feldspar and carbonate is common particularly towards the top of the footwall sequence. The alteration and mineralisation style is very similar to that of the Pinnacles area. The alteration facies is similar to that developed on the fringes of the Hercules alteration pipe. In the less mineralised sections it appears that mineralisation is more strongly developed at the finer grained tops of graded units.

I did not identify a mylonite in the hangingwall rocks in DP 292. The drilling interval between the base of the limestone and the interpreted footwall-hangingwall contact differs in the two holes: in DP 259 it is 22.65 m and in DP 292 it is 66.5 m. The effect of faulting may be relatively minor and the impression I get is that there is an abrupt

facies change between DP 259 and DP 282. This may be controlled by a Cambrian growth fault and if so the thick hangingwall epiclastic sequence in DP 282 would suggest that the northern side was down thrown. If this is a plausible scenario then the host rock north of the fault might be a favourable site for ponded massive sulphide mineralisation, but presumably RLP 297, which I have not seen, has already tested this possibility.

(b) GEOCHEMISTRY

The data from DP 259 and DP 292 were transferred to the Rosebery data base and a large number of graphs were constructed to:

1. Compare the intensity of alteration in the holes with others in the Lake Bull-Rosebery Lodes area.
2. Compare the intensity of Devonian alteration with the other holes.
3. Attempt to correlate between the holes using "stable element" geochemistry.
4. Compare the intensity of mineralisation and alteration between the two holes.

(i) Intensity of alteration compared with other areas

In terms of Zn content the Dalmeny samples are among the highest analysed from the footwall. Cu contents do not exceed 1000 ppm (Fig. 1) in agreement with the core assays and samples from the Rosebery ore zone locally display higher Cu contents and Cu/Zn ratios.

In comparison with samples from Lake Bull and Rosebery Lodes the rocks from Dalmeny are clearly anomalous in both metals (Fig. 2).

The rocks from the Dalmeny area are not rich in Fe and S compared with those from the footwall of the ore body (Fig. 3) but the more

mineralised samples are enriched in Fe and S compared with rocks from Rosebery Lodes (Fig. 4). There is little evidence to suggest that they are particularly depleted in pyrite compared with rocks with a similar Fe content elsewhere.

They also are significantly depleted in Na compared with rocks from Rosebery Lodes (Figs. 5, 6) and very strong anomalism in Zn is a feature (Fig. 6). In agreement with the data from elsewhere in the Rosebery area, Ba does not appear to be a Useful halo indicator. Only one sample from DP 259 would appear to have barite (Fig. 7).

By comparison with the alteration pipe at Hercules where a central quartz-chlorite is flanked by quartz-sericite, MgO might give some indication of proximity to a major alteration zone. The graph of K_2O vs MgO shows little difference in the values for these oxides between DP 259 and DP 292, but these oxides are generally higher in these holes compared with others at Lake Bull and Rosebery Lodes.

(ii) Devonian alteration

Despite the petrographic evidence that the zinc-lead mineralisation at Dalmeny is Cambrian in age it is important to assess whether Devonian overprinting is likely to have played a significant part in redistribution of Cambrian geochemical patterns. This evaluation applies only to the samples analysed in this study in which visually obvious veinlets of tourmaline and/or iron oxides were not present in the intervals selected.

In a previous study (Green, 1990) it was shown that the Rb/K ratio provided a useful indicator of the degree of Devonian magmatic hydrothermal alteration. Features indicating this included:

Unlike other elements or element ratios showing distinct anomalism, high Rb/K ratios were not restricted to the footwall and host rock sequences but also occurred in the hangingwall.

- . The highest values of the Rb/K₂O ratio did not coincide with the Rosebery orebody, but peaked to the south in agreement with independent estimates of the locus of the crest of the interpreted granite ridge derived from interpretation of gravity data.
- . Haloes of enriched Rb (and Rb/K ratios) have been well established around Devonian magmatic hydrothermal deposits in Tasmania (Cleveland, Queens Hill).

Figure 9 shows a plot of the Rb/K₂O ratio vs depth (drilling depth below the interpreted footwall/hanging wall contact at Dalmeny, depth below the uppermost sample analysed in other areas). At shallow depths most samples from the Lake Bull area, which show no evidence of Cambrian alteration, have higher Rb/K ratios than those at Dalmeny, consistent with the interpreted southward deepening of the granite contact in this area. At depths below about 130 m the Rb/K ratios in both DP 259 and DP 292 show a dramatic increase. This is consistent with petrographic evidence, but it should be noted that samples from DP 282 indicate that significant Devonian metamorphism occurs at shallower depths in this locality.

Figure 10 compares the Rb/K ratio with the alteration index ($100 \times (K_2O + MgO) / (Na_2O + CaO + K_2O + MgO)$). The two variables are essentially independent but significant geographical grouping of the Alteration Index exist (e.g. Lake Bull, RLP 287) suggesting that the intensity of alteration is largely unrelated to Devonian processes. It may also be significant that more samples from DP 259 cluster towards higher A.I. values than those from DP 292.

Chalcopyrite is a common associate of Devonian tourmaline veinlets in the Rosebery area, but Fig. 11 shows no correlation with high Rb/K ratios and a similar conclusion is reached when considering Fe (Fig. 12).

In summary, although unequivocal Devonian veining exists at Dalmeny, the basic geochemical signatures are a product of Cambrian processes. As expected, the intensity of Devonian alteration increases with depth, and the possibility of extensive base metal remobilisation at depths more than about 300 m vertically below surface become a consideration.

(iii) Immobile element geochemistry

Previously I suggested that ratios of immobile elements might provide a useful tool for stratigraphic correlation in rocks subjected to intense hydrothermal alteration (Green, 1990). Subsequent data from the area north of Rosebery (drill holes 107R, 109R) indicated that the technique might be limited by analytical uncertainty (Green, 1991). The data base from the Dalmeny area with critical elements (Ti, Zr) analysed by XRF rather than ICP and the inclusion of other elements in the data (Nb, Nd, Y) enabled a better comparison to be made.

To be effective such sampling should be on the scale of depositional units, or better still of parts of depositional units, in sequences like the footwall pyroclastics in which substantial sorting of lithic, crystal and vitric components may occur within a depositional unit. Close examination of the lower, less altered, section of DP 292 enabled identification of thick doubly-graded pyroclastic units one from 396.3 m to 440.3 m (E/H), i.e. 45 m+, and one from 367 to 396.3 m, about 20 m. In more strongly altered rocks the distinction of flow units is impossible. For example, the original logger of DP 292 did not recognise the volcanoclastic nature of the rocks, but he did select similar intervals as distinctive lithological units. (I choose DP 292 for this comparison because the log of this hole was not available when I examined the core).

The depth vs element or element ratio plots are based on drilling intervals with hangingwall/footwall contacts located at 204.85 m in DP 259 and 166.9 m in DP 292. As discussed above, the contact in DP 292 is now considered to be at about 180.8 m so the curves for this hole need to be shifted upwards by 14 m direct comparison at the top of the

hole. No allowance has been made for variable core axis/bedding intersection angles: both holes have similar azimuths and identical initial dips but DP 259 flattened faster than DP 292. The use of downhole depths should not introduce gross errors.

In the initial alteration data base, it was considered that "immobile" element ratios rather than absolute values of individual elements would be better indicators of original lithotypes because the effects of gross addition of ore elements or mobilisation of major elements would cancel out. This is the philosophy behind Floyd-Winchester plots. Although there were marked fluctuations within individual drill holes the Ti/Zr ratio in the Rosebery area showed an overall increase to the south which appeared to be independent of proximity to footwall alteration zones. It was therefore surprising to see the lack of coherence between the Ti/Zr ratios in the upper parts of DP 259 and DP 292 (Fig. 13). DP 292 has similar ratios to other holes in the Rosebery Lodes-Lake Bull area, but for the most part rocks from DP 259 have surprisingly lower values. The only portion of the holes showing any coherence is at depth where the effect of Devonian metasomatism is at a maximum. This suggests that if fractionation of Ti relative to Zr is real, rather than a sampling accident or analytical artifact, it is related to Cambrian, rather than Devonian, hydrothermal processes.

The source of this behaviour is clearly related to Ti rather than Zr (figs. 14, 15).

Other elements may show generally coherent patterns: Cr (Fig. 16 - as mentioned earlier the high Cr content of the uppermost sample from DP 259 may be a result of incorporated Precambrian detritus), Nb/Y (Fig. 17, basically a steep positive slope), Al_2O_3/Nd (Fig. 18) and the Zr/Nd ratio (Fig. 19) shows some similarity in pattern.

It is clear that the utility of "immobile" elements as a correlation tool is limited by sampling density and also probably by analytical precision. The cause of the gross discrepancy in the Ti contents of samples from the two holes is unknown - If it is due to alteration (and this would be somewhat surprising given the similarity in

mineralisation style and other geochemical alteration indicators between the two holes) it is clear that Cambrian rather than Devonian processes are responsible because the misfit is most marked in the upper parts of the holes.

As mentioned above, variation in the content of relatively inert elements in mineralised rocks can be due to their passive depletion when other elements are added to the rock. Inverse correlations exist between Zn and Zr (Fig. 20) and Cu and Zr (Fig. 21) consistent with such a process. However plots of metals against other elements did not show similar trends. It may be that Zr content in the graded flows is governed to some extent by mechanical concentration of zircon in the coarser basal parts of flow units whereas mineralisation is preferentially associated with fine grained flow tops.

In summary, sufficient correlation exists between the spatial patterns of the relatively immobile elements to suggest a stratigraphic correlation, but Ti remains enigmatic.

(iv) A comparison between DP 259 and DP 292 in terms of intensity

Plots of Fe (Fig. 22), S (Fig. 23), Cu (fig. 24), Zn (fig. 25) and Pb (Fig. 26) against depth for the two holes suggest that DP 292 is the more mineralised, a suggestion reinforced by the generally higher Cu/Zn ratios in the former.

However this may be an artifact of the sampling and a quick inspection of the core assays suggests little difference between the holes.

A characteristic of the footwall pipes at Rosebery and Hercules is that alteration extends to greater stratigraphic depths closer to mineralisation. Hence plots of the Alteration Index (Fig. 27) and K_2O (Fig. 28) show that higher values of these quantities persist to greater depths in DP 259 as do lower values of Na_2O (Fig. 29). This is in accord with visual core examination.

Consequently, it may be concluded that although geochemical differences between rocks from DP 259 and DP 292 are subtle, the greater depth extent of alteration in DP 259 suggests that this hole may be the more proximal to mineralisation.

CONCLUSIONS

1. Mineralisation in the Dalmeny drill holes is epigenetic and of Cambrian age, but it may be concentrated in the tops of graded flow units. Both veining and replacement (particularly of feldspars by sphalerite) processes were involved.
2. Stratigraphic similarity between the two holes suggests that a facies change rather than major thrust faulting may be responsible for the dramatic thinning of the quartz-phyric hangingwall epiclastics south of DP 282. If this model is correct the lack of major mineralisation may reflect the lack of a period of volcanic quiescence (as expressed by the lack of fine grained host rocks).
3. Geochemically DP 259 and DP 292 are very similar. Although samples from DP 292 have higher maximum Cu, Pb, Zn, Fe and S values, stronger alteration persists to greater depths in DP 259 suggesting that this hole may be more proximal to the centre of the alteration zone.
4. If the suggested facies change between DP 259 and DP 282 is related to Cambrian growth faults potential for massive sulphide deposition might exist north of DP 259.

REFERENCES

Green, G.R., 1990. Alteration mineralogy, whole rock geochemistry and oxygen isotope zonation in the area north of the Grand Centre Prospect, Rosebery Mine Leases. Unpub.Rep. for Pasminco Mining Rosebery.

Green, G.R., 1991. On the extent of hydrothermal alteration in volcaniclastic rocks from drill hole DP 107, Rosebery. Unpub.Rep. for Pasminco Mining Rosebery.

19 April 1991

Fig. 1 Cu vs Zn, ROSEBERY FW

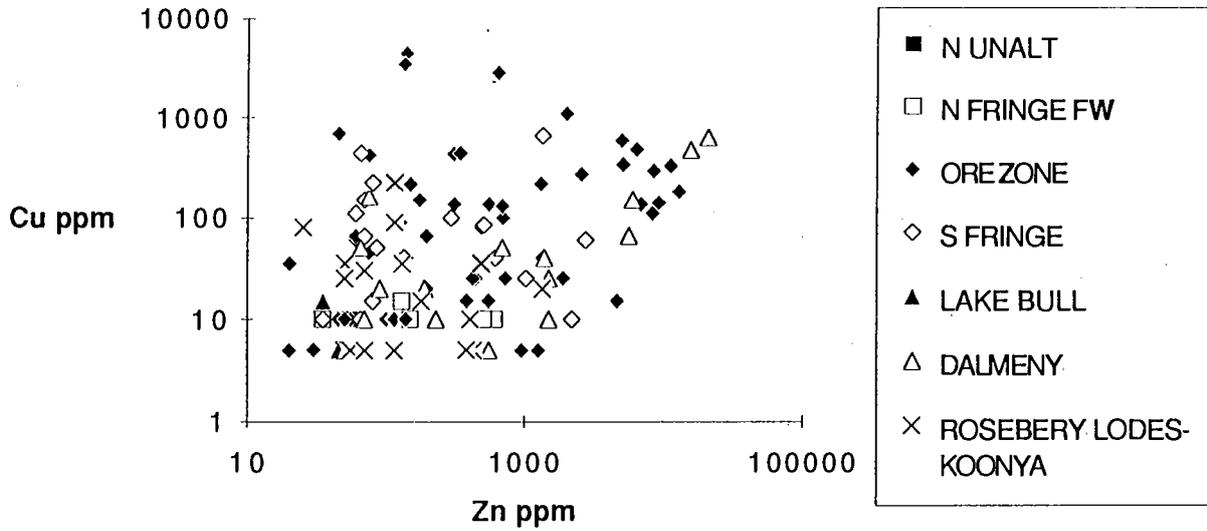


Fig. 2 Cu vs Zn, Lake Bull, Dalmeny, Rosebery Lodes

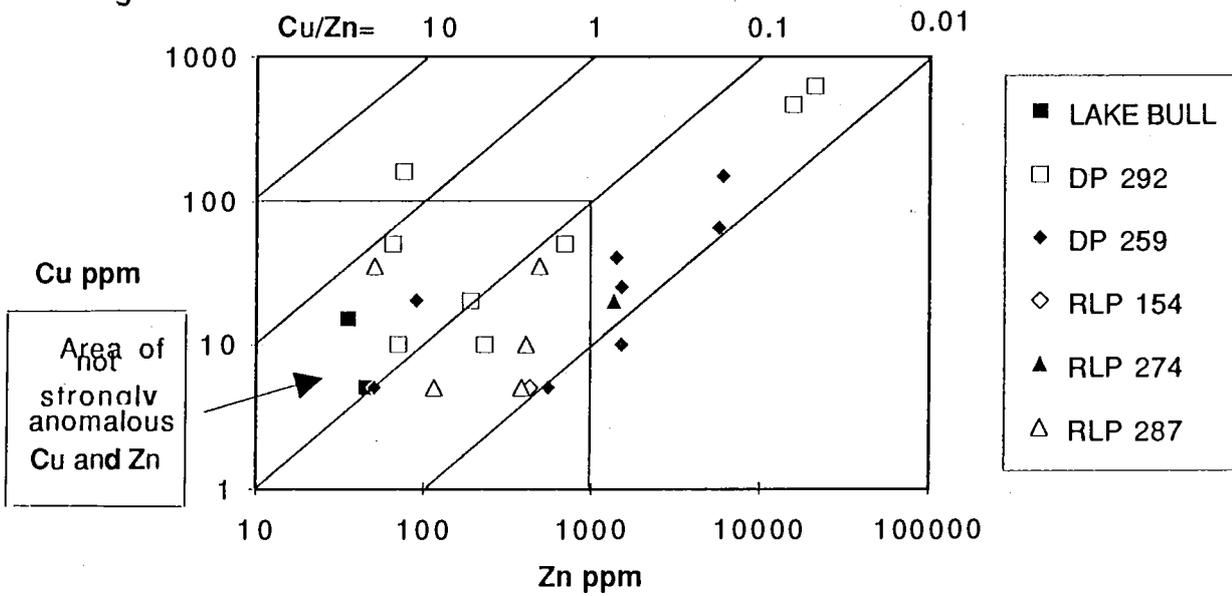


Fig. 3

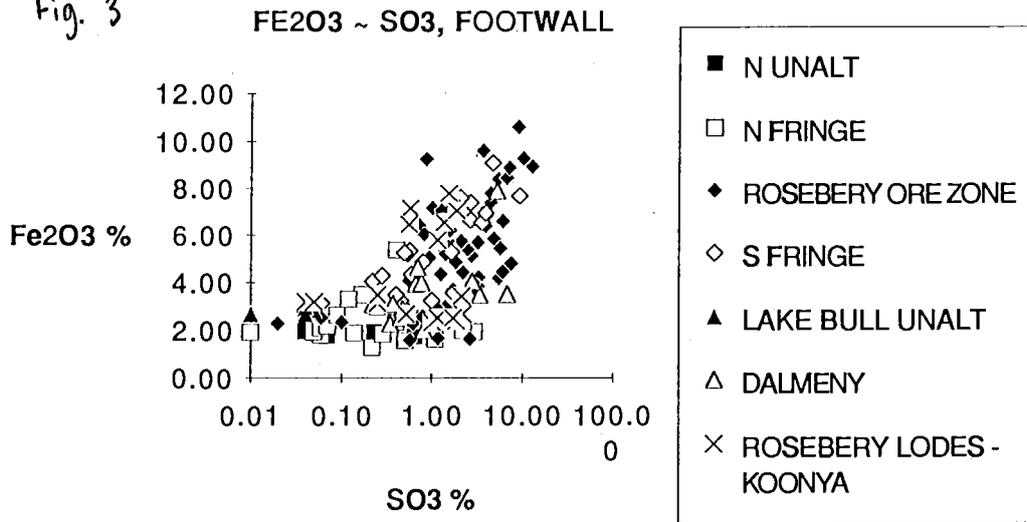


Fig. 4

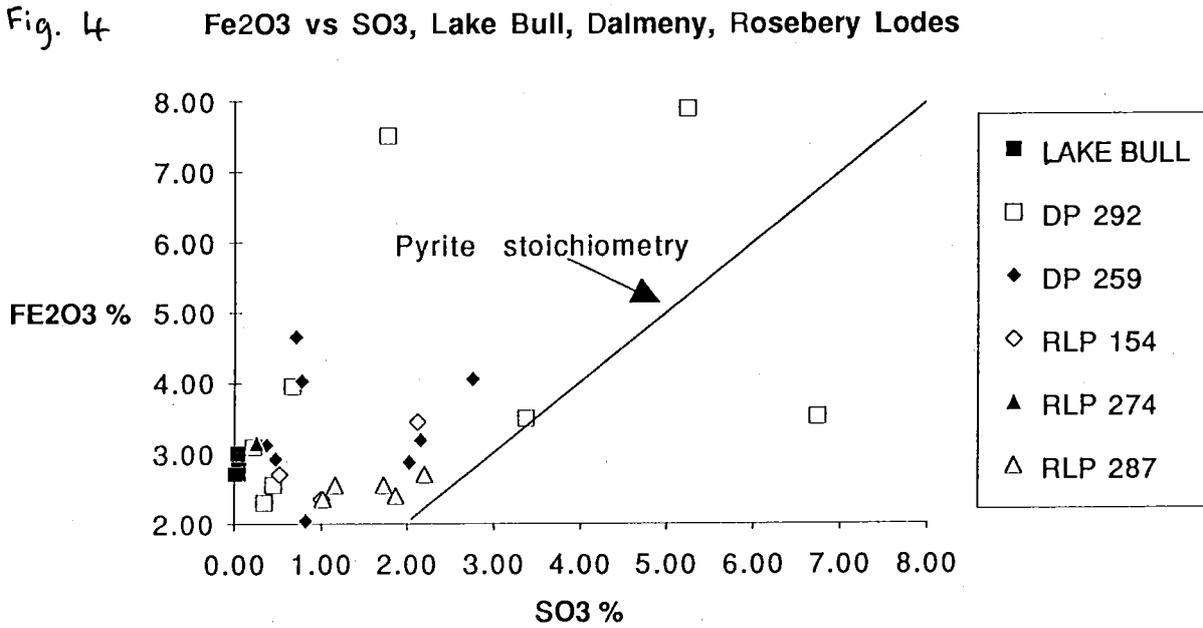


Fig. 5

Na₂O/K₂O vs Cu, Lake Bull, Dalmeny, Rosebery Lodes

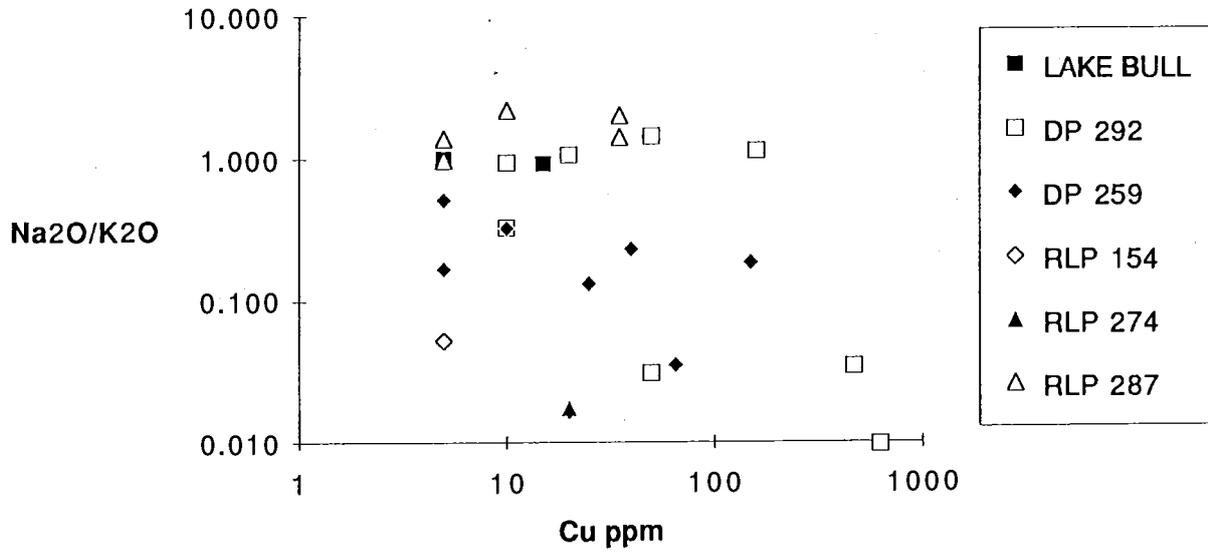


Fig. 6

Na₂O vs Zn, Lake Bull, Dalmeny, Rosebery Lodes

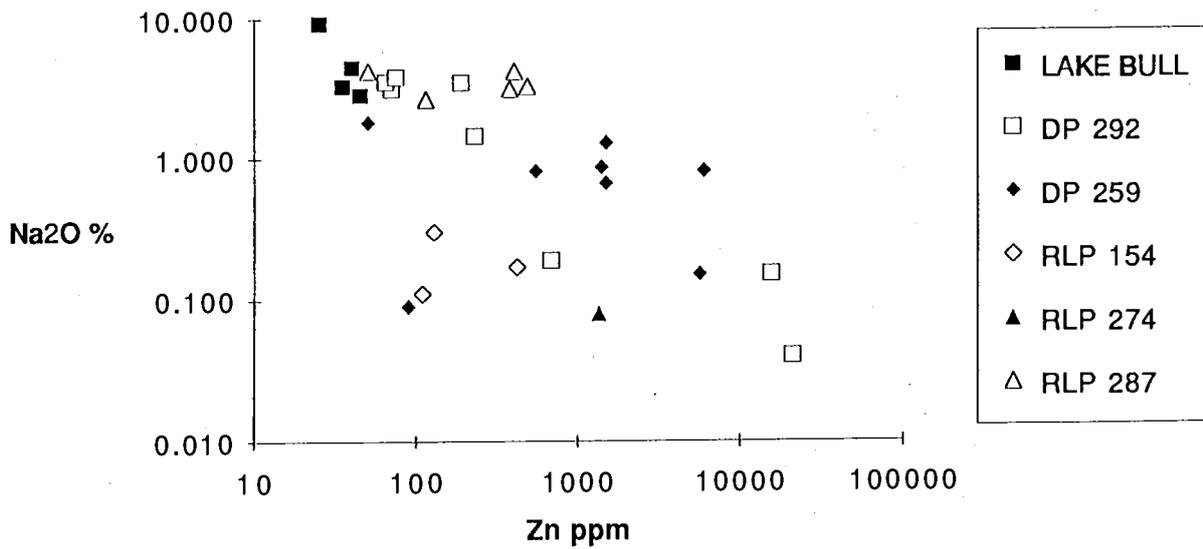


Fig. 7

Zn vs Ba, Lake Bull, Dalmeny, Rosebery Lodes

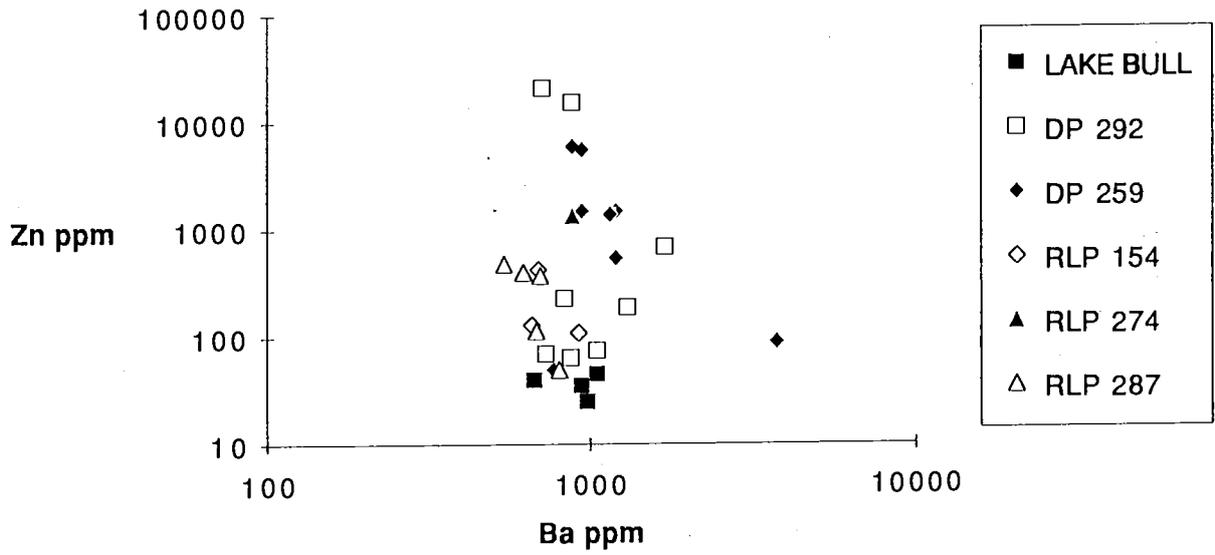


Fig. 9

Downhole depth vs Rb/K2O, Lake Bull, Dalmeny, Rosebery Lodes

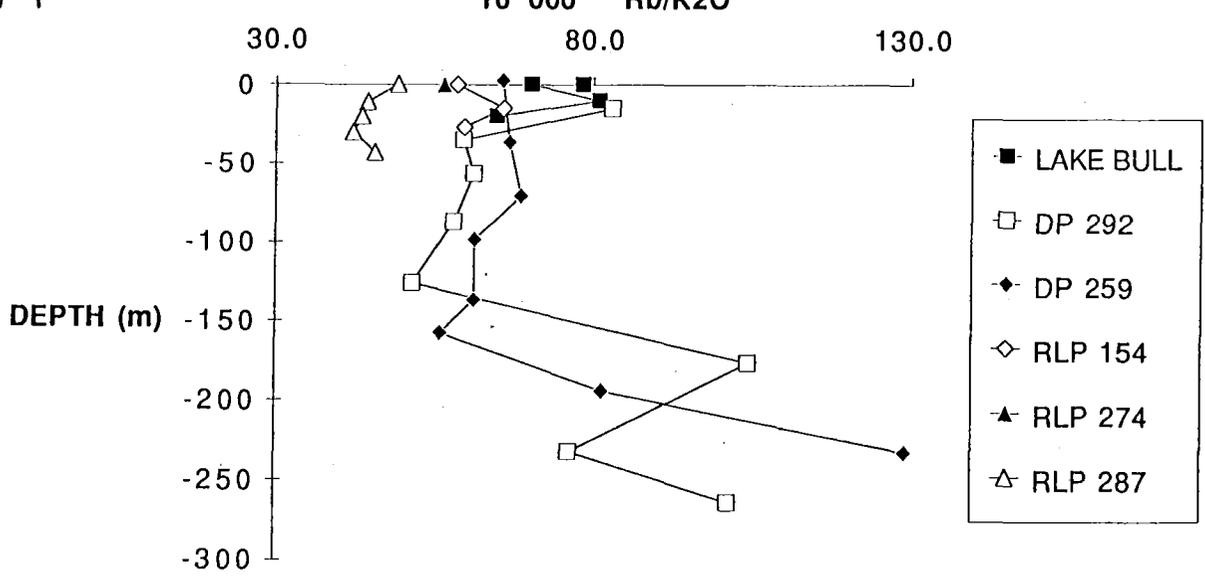


Fig. 10

10000*Rb/K2O vs A.I., Lake Bull, Dalmeny, Rosebery Lodes

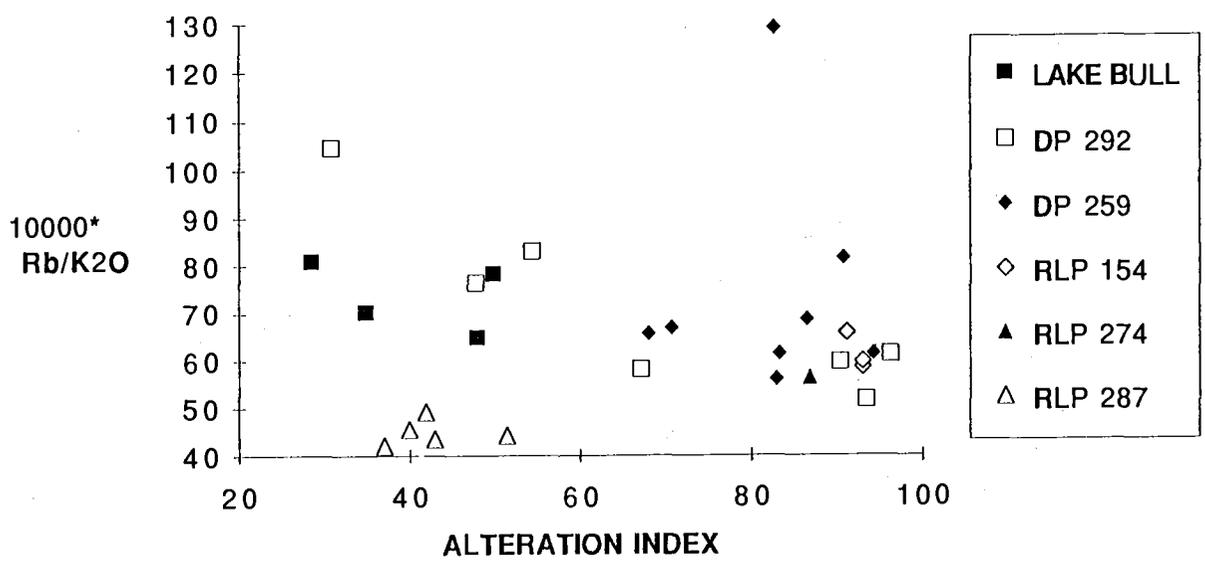


Fig. 11

Cu vs Rb/K2O, Lake Bull, Dalmeny, Rosebery Lodes

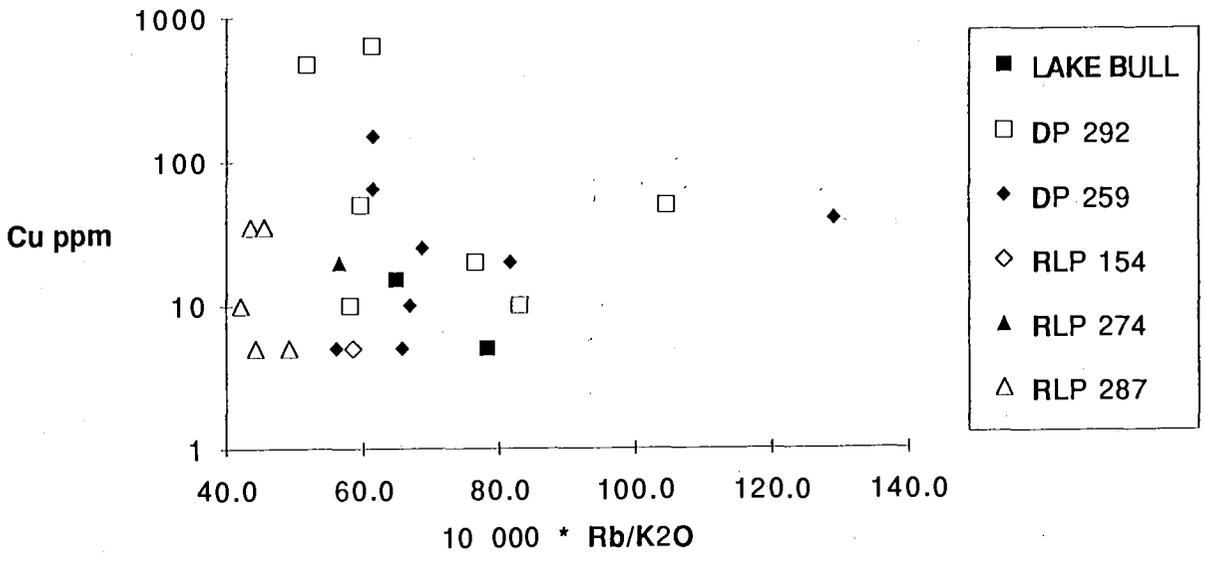


Fig. 12

Fe₂O₃ vs Rb/K₂O, Lake Bull, Dalmeny, Rosebery Lodes

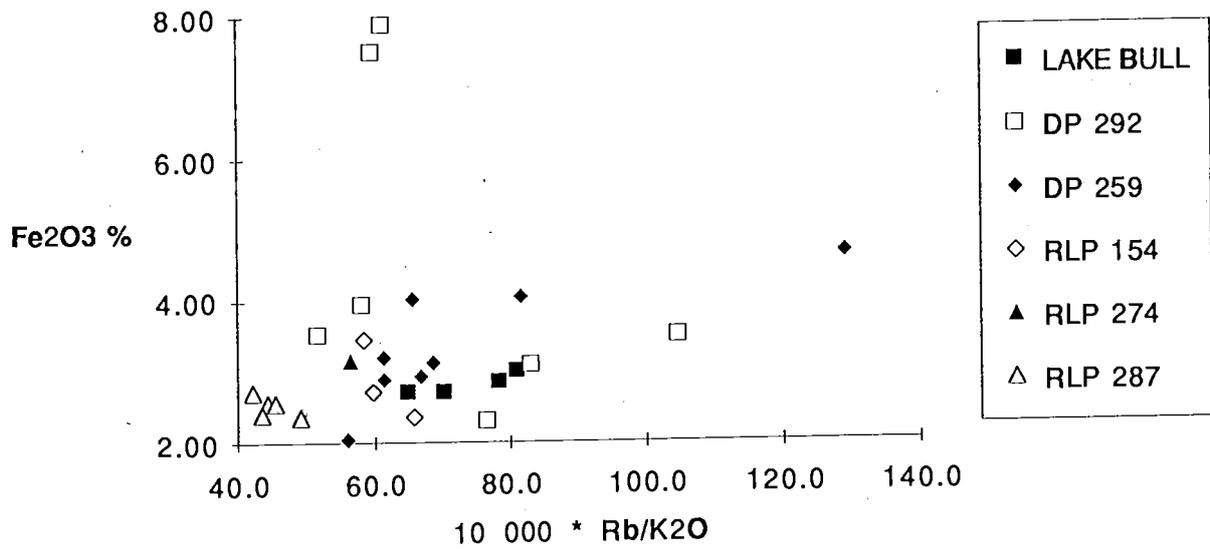


Fig. 13

Downhole depth (m) vs Ti/Zr, Lake Bull, Dalmeny, Rosebery Lodes

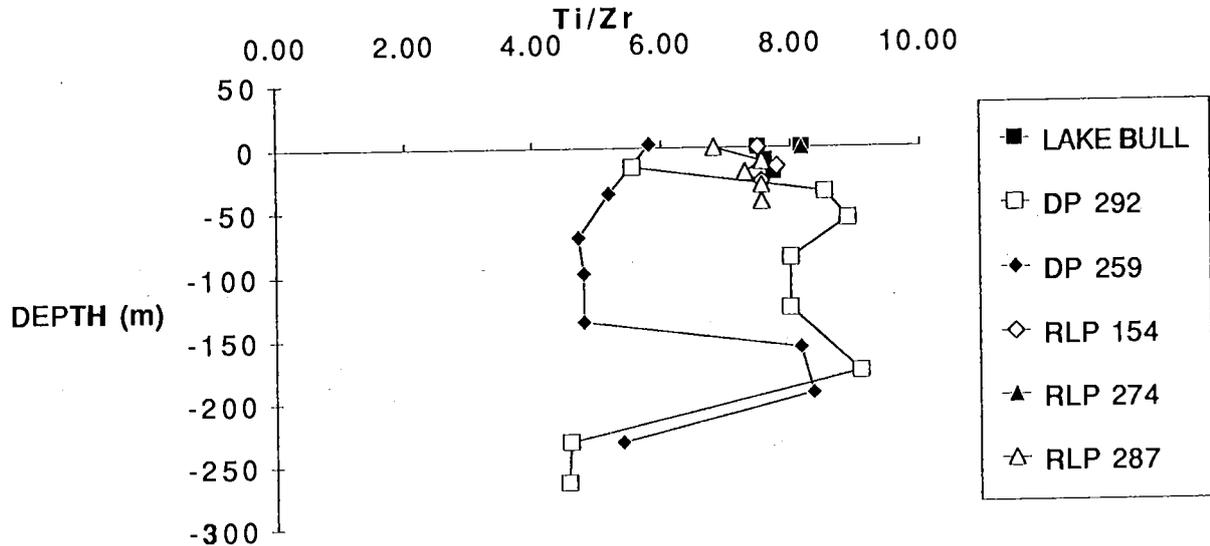


Fig. 14

Downhole depth (m) vs TiO₂ %, Lake Bull, Dalmeny, Rosebery Lodes

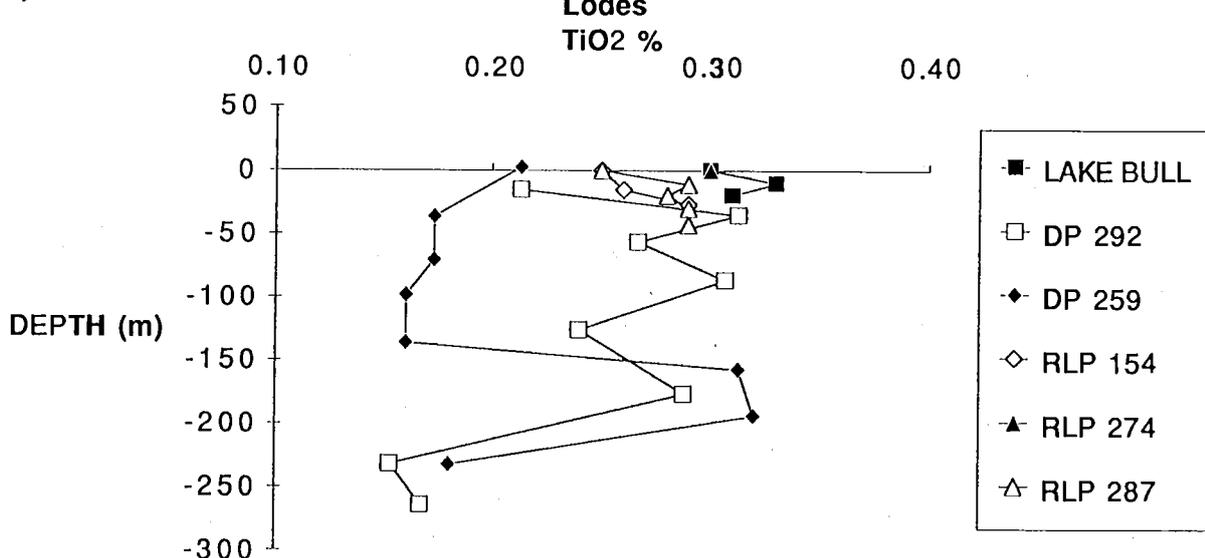


Fig. 15

Downhole depth (m) vs Zr, Lake Bull, Dalmeny, Rosebery Lodes

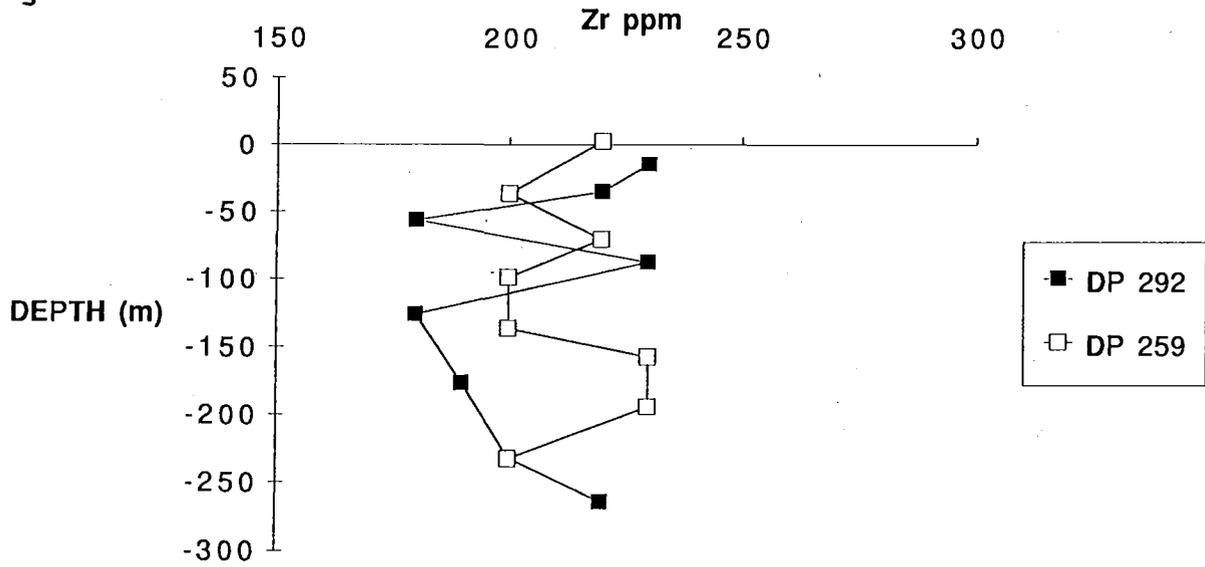


Fig. 16

Downhole depth (m) vs Cr, Dalmeny

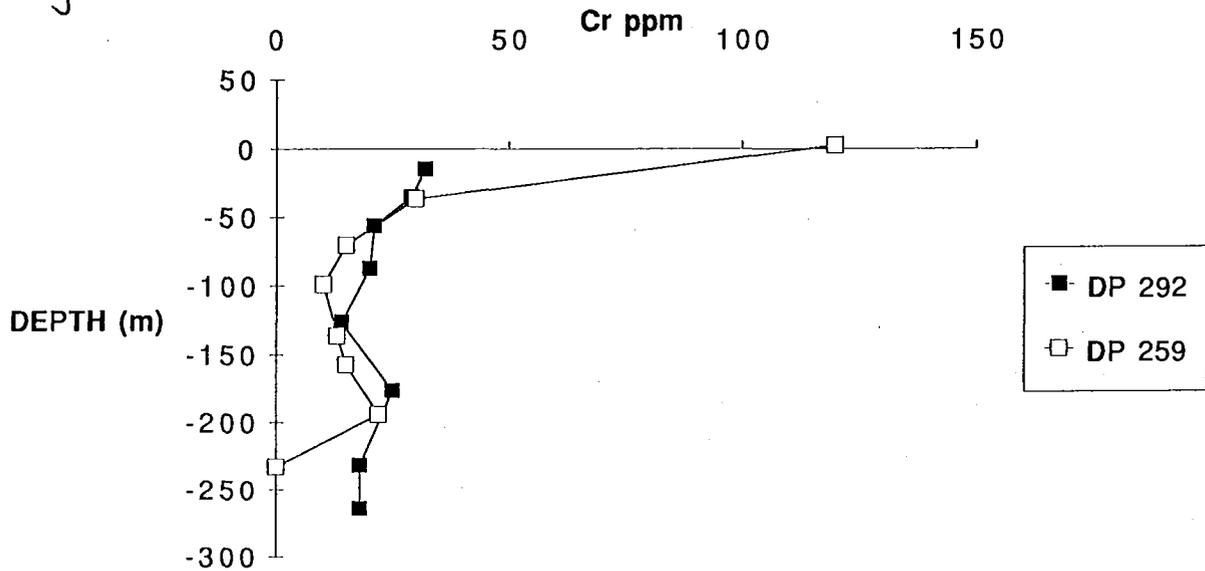


Fig. 17

Downhole depth (m) vs Nb/Y, Dalmeny

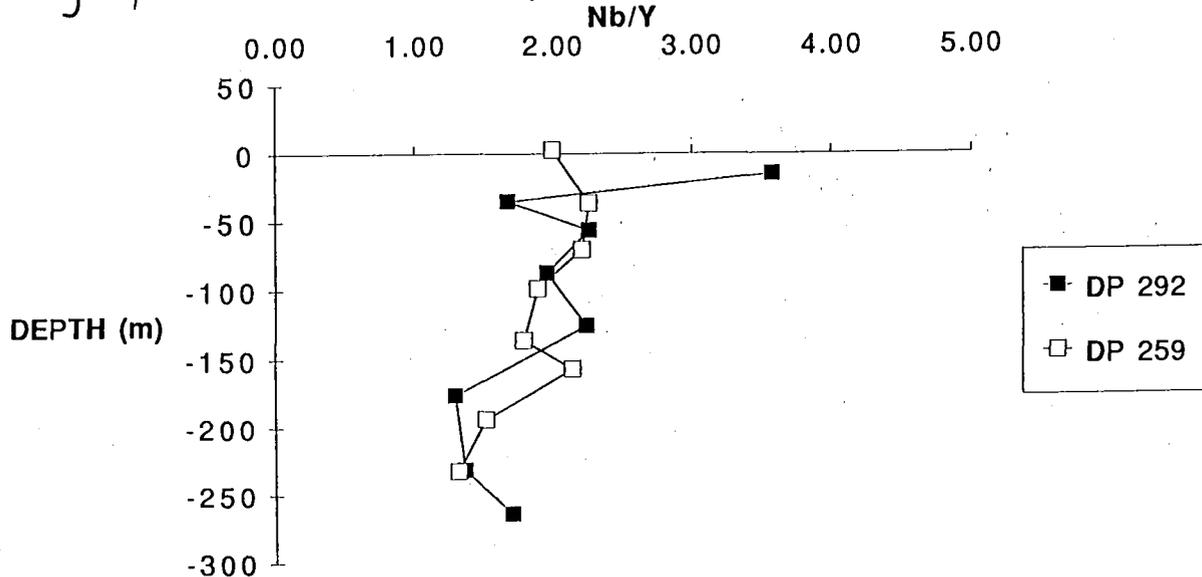


Fig. 18

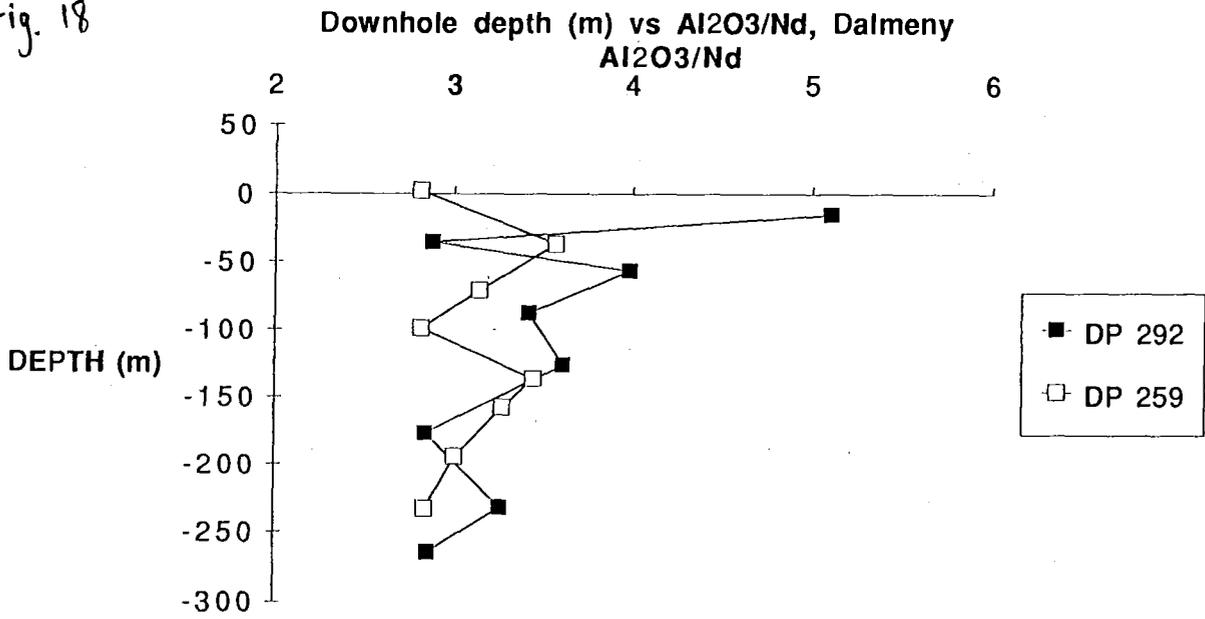


Fig. 19

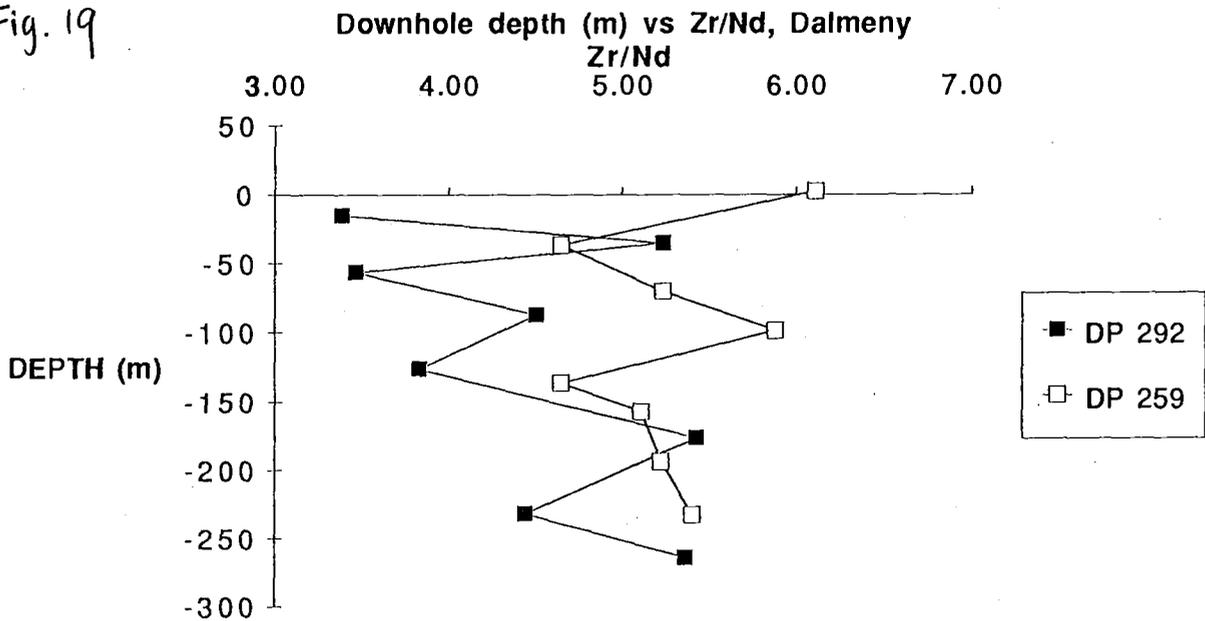


Fig. 20

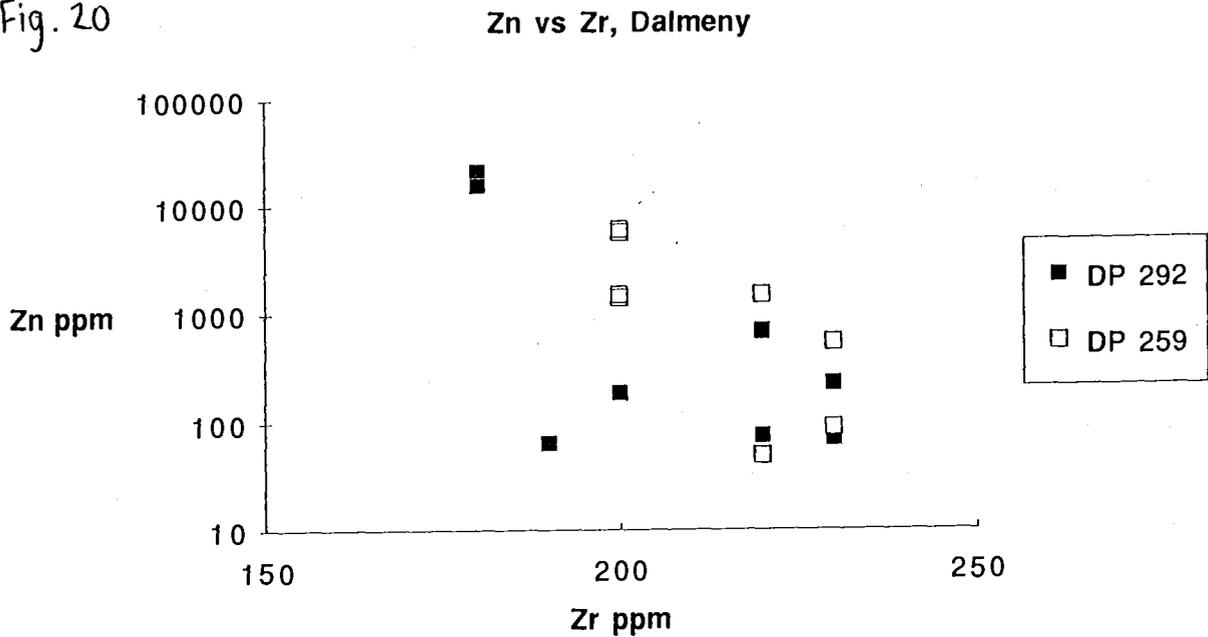


Fig. 21

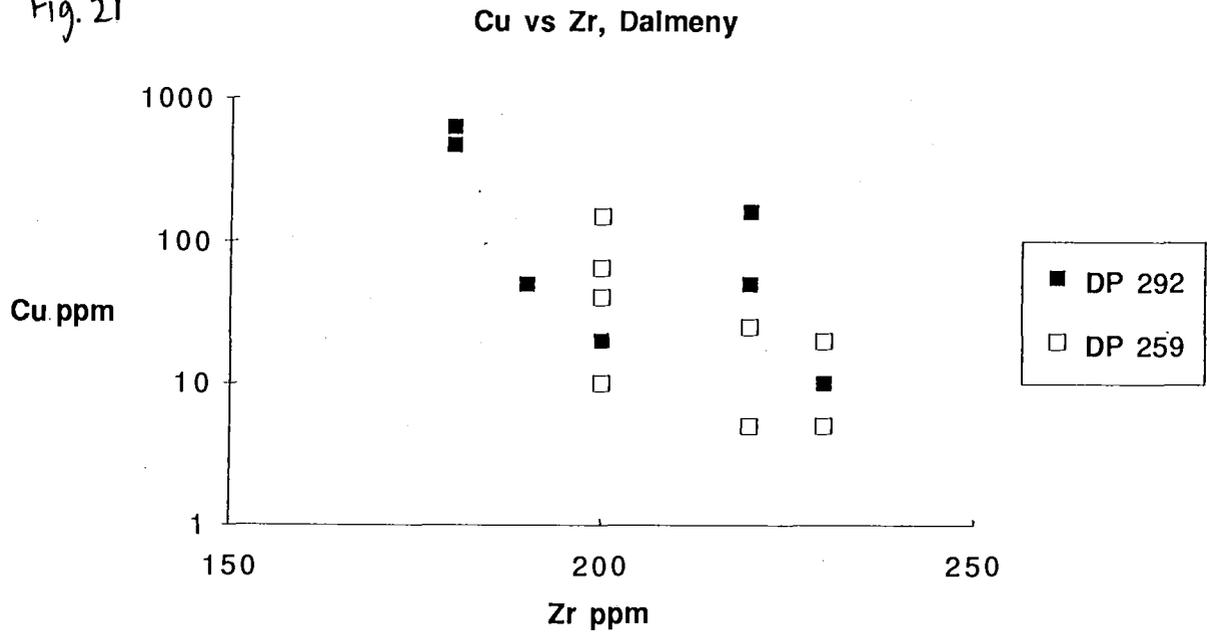


Fig. 22

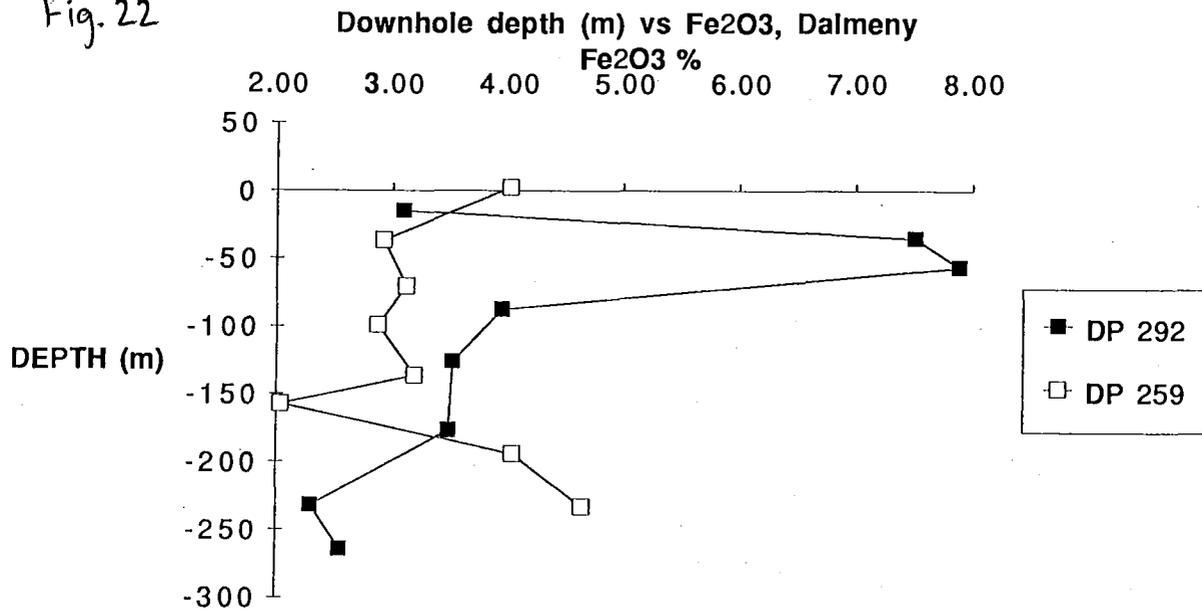


Fig. 23

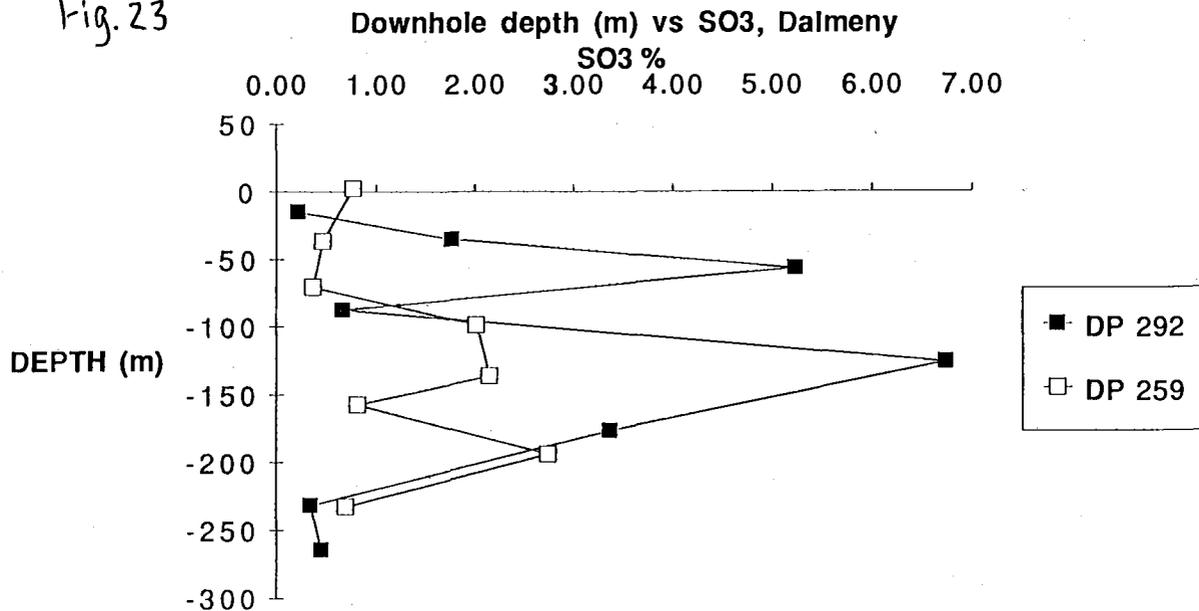


Fig. 24

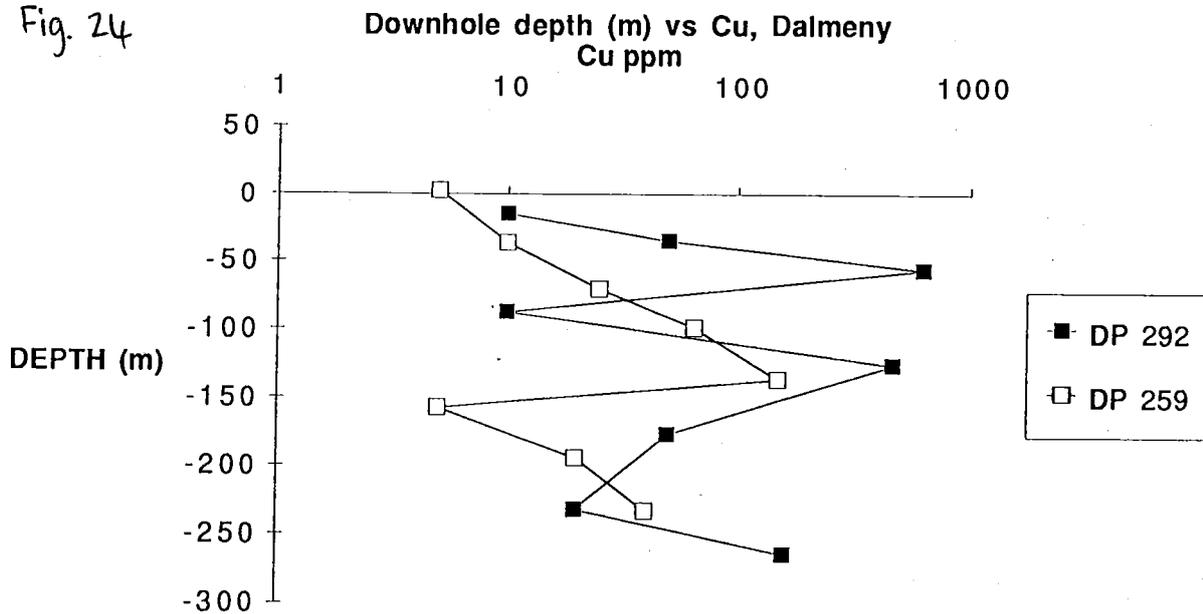


Fig. 25

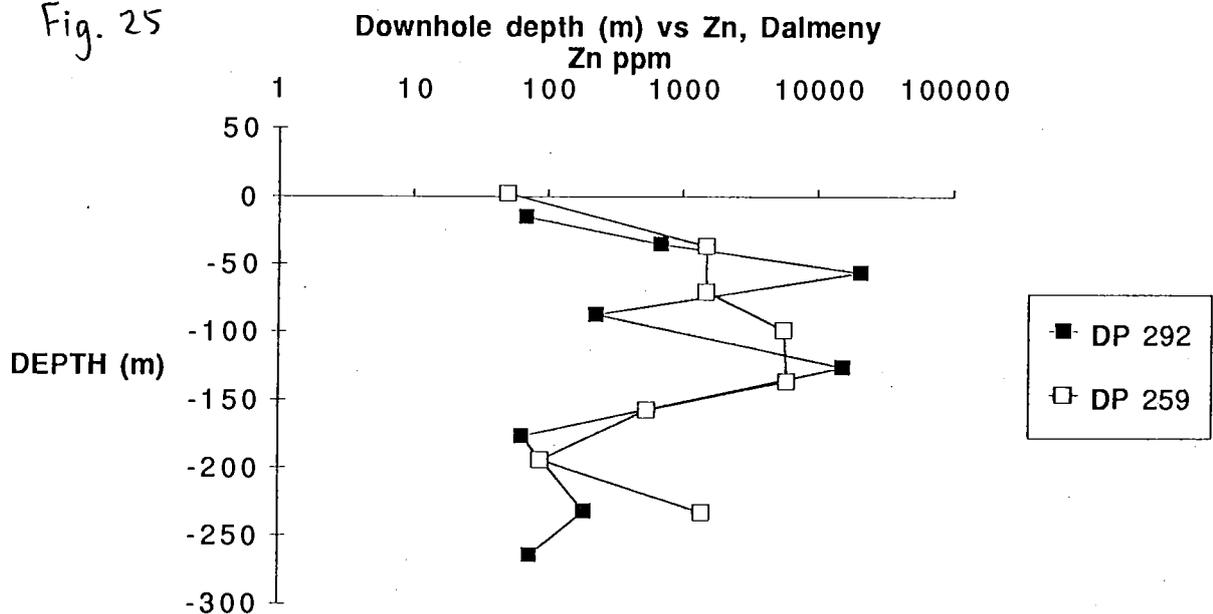


Fig. 26

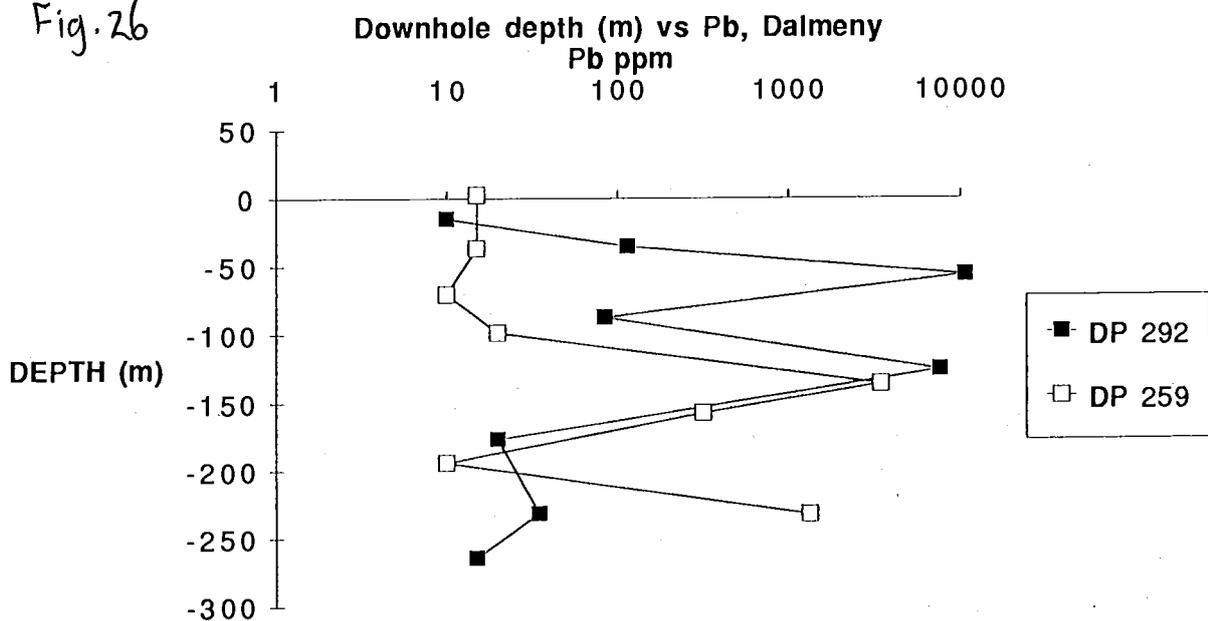


Fig. 27

Downhole depth (m) vs A.I., Lake Bull, Dalmeny, Rosebery Lodes

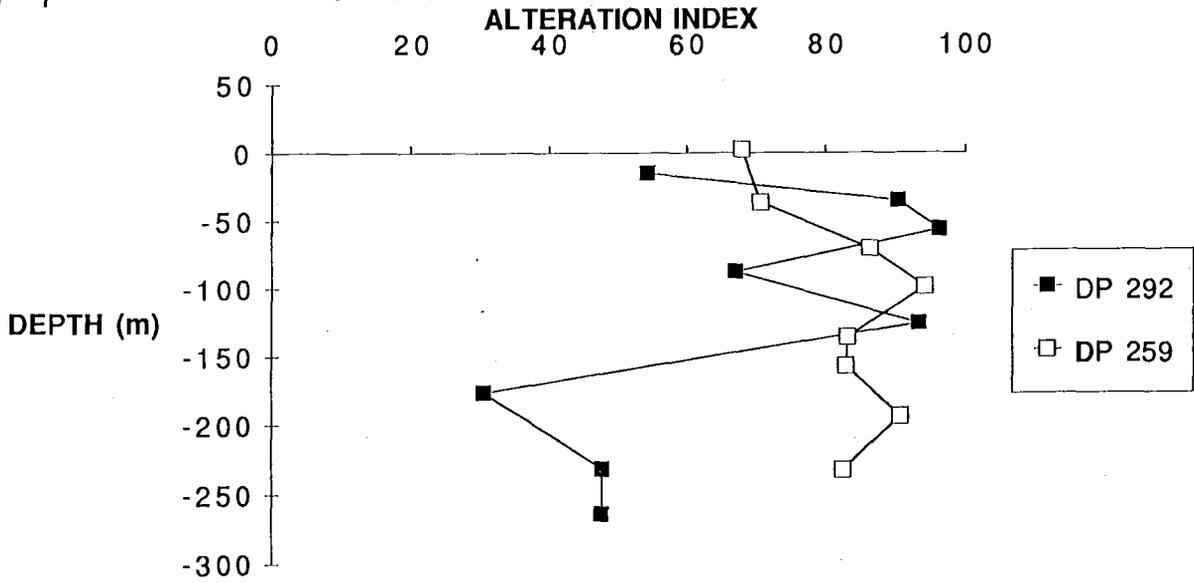


Fig. 28

Downhole depth (m) vs K2O %, Dalmeny

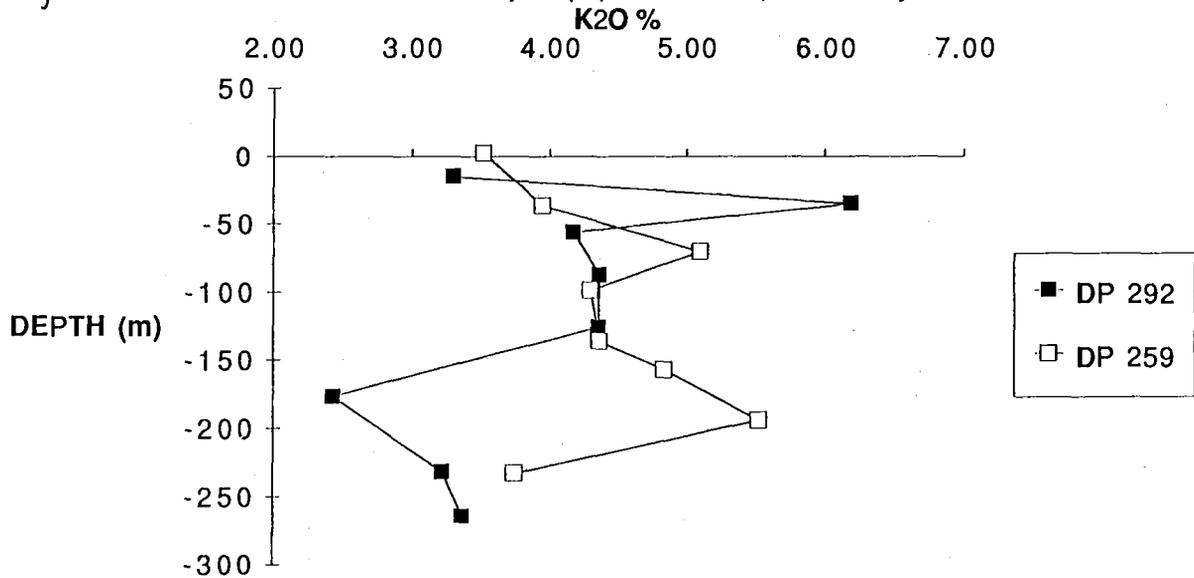


Fig. 29

Downhole depth (m) vs Na2O %, Dalmeny

