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LEAD ISOTOPE INVESTIGATIONS OF VARYING STYLES OF MINERALIZATION IN THE MT READ VOLCANIC BELT (TASMANIA) AND THEIR EXPLORATION SIGNIFICANCE

BRIAN L. GULSON +
PATRICIA M. PORRIT +
ROSS R. LARGE ++

+
CSIRO Division of Mineralogy,
P.O. Box 136,
North Ryde NSW 2113
Australia

++
GEOPEKO
P.O. Box 598,
Devonport TAS 7310
Australia

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DISTRIBUTION LIST

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SUMMARY

Lead isotopic ratios for 38 samples from 7 geochemical anomalies in the Elliott Bay and East Mackintosh area have been measured in order to establish if the various styles of Pb-Zn mineralization can be discriminated using lead isotopes.

As exploration was directed towards volcanogenic Pb-Zn-Ag-Cu mineralization, the 'target' isotope ratios are those of the Que River-Rosebery-Hercules-Mt Lyell deposits.

Surprisingly, Voyager 2 and 19 anomalies at Elliott Bay have isotope ratios which are homogenous but more than 0.6% different and less radiogenic than the 'target' isotopic signature. The Voyager 2 and Prover 3 (East Mackintosh) anomalies are over 100 km apart and yet their isotopic ratios are identical. On the other hand, the isotope ratios in Prover 3 are more than 0.6% different from those in the nearby Que River (West Mackintosh) deposit. We have yet to find two distinct isotopic signatures for the same style of massive sulfide deposit in the one volcanic belt. The isotopic data are interpreted to signify major differences between the source material for the mineralization at Elliott Bay (and East Mackintosh) and that within the Central Lava Belt. There are, however, significant isotopic differences between this possibly new style of massive sulfide mineralization and vein mineralization. These differences are imprinted in the soils and so the lead isotope technique should play a major role in exploration in this area.

1. INTRODUCTION

The Mt Read Volcanic belt of Cambrian age is host to the major massive sulfide deposits of Tasmania. These deposits (Que River, Rosebery, Hercules, Comstock Lode at Mt Lyell) are characterized by lead isotopic compositions summarized in Table 1 which:

(i) exhibit limited dispersion within each deposit; the variation in $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ ratios is $< \pm 0.1\%$,

(ii) exhibit limited differences in their average isotopic compositions between each deposit,

(iii) plot very slightly below (but not in excess of twice experimental error) the reference curves (so-called 'growth curves') on which the bulk of other major lead-rich massive sulfide deposits either lie or plot slightly above.

In contrast, low-tonnage or minor vein-style mineralization such as at Mt Farrell (analysed by Ostic et al., 1967), Queen Hill (old area) and at the Murchison River area are characterised by isotopic compositions which:

(i) exhibit either a similar or larger dispersion than the massive sulfide deposits,

(ii) may be different from one locality to another (Mt Farrell, Murchison River, Table 1),

(iii) are usually more radiogenic (higher $^{206}Pb/^{204}Pb$ lower $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$) than the massive sulfides.

From an exploration viewpoint, these two main styles of mineralization unfortunately give rise to similar surface geochemical anomalies and, apart from drilling, no other technique appears to be satisfactory in discriminating between them. However, the distinctive isotopic differences between the two styles of mineralization offer a potential discriminant.

On this basis, we undertook an investigation of some 40 samples covering 7 anomalies from Geopeko's licence areas at Elliott Bay and East Mackintosh on the west coast of Tasmania. The exploration target was volcanogenic massive sulfide Pb-Zn-Ag-Cu deposits of the

Rosebery/Que River type and so the 'target' isotopic signatures are those given in Table 1, i.e.

$^{208}Pb/^{206}Pb$ 2.082 - 2.085, $^{207}Pb/^{206}Pb$ 0.8520 - 0.8544

and

$^{206}Pb/^{204}Pb$ 18.27 - 18.34

The anomalies were masked and initially an assessment was made solely on the basis of lead isotopes, a situation which we would normally not encounter as information on the geology and exploration target is usually supplied. These assessments were discussed with R.R. Large and G. Sherrington on April 27, 1982, and the following interpretation of the results is now integrated with geological and drilling information.

2. GEOLOGY/SAMPLING

2.1 Elliott Bay Area

Exploration by Geopeko at Elliott Bay has concentrated on the search for volcanogenic massive sulphide Pb-Zn-Ag-Cu deposits within the Lewis River Volcanics, interpreted to be stratigraphically equivalent to the Mt Read Volcanics further north.

The major rock units in the area are listed below:

			Thickness (approx. m)
Tertiary	-	unconsolidated gravels	<50
Ordovician	-	conglomerate and quartzite	900+
Cambrian	-	Tyndal Group Correlates	100-500
	-	Dundas Group Correlates	1000+
	-	Mainwaring Group	2500
	-	Lewis River Volcanics	7000
Precambrian	-	Arthur Group	

Correlation between the Lewis River Volcanics at Elliott Bay and the Mt Read Volcanics, which host the Rosebery and Mt Lyell massive sulfide deposits, is based on stratigraphic and structural position plus volcanic lithologies (e.g. White, 1975).

2.1.1 Lewis River Volcanics (Mt Read Group)

Consist predominantly of rhyolitic pyroclastics and lavas. The lack of marker horizons prevents the establishment of a detailed stratigraphy, however the definition of broad scale units has been possible by Geopeko geologists. From the stratigraphic top to base (i.e. west to east across the Exploration Licence) the Lewis River Volcanics have been divided into four major units (Figure 1).

1.	Western Sequence	dominantly argillites and phyllites with minor rhyolite tuffs.
2.	Wart Hill Pyroclastics	mixture of massive rhyolite pyroclastics (dominantly ash-flow tuffs) and lavas plus minor quartz-pebble conglomerates and sandstones.
3.	Hudson River Pyroclastics	predominantly chloritic dacite-rhyolite tuffs and lavas with horizons of greywacke and siltstone.
4.	Elliott Bay Porphyry	massive coarse grained quartz-feldspar-biotite porphyry.

Three bodies of granite intrude the Lewis River Volcanics in the southern portion of the area.

The Wart Hill Pyroclastics and Hudson River Pyroclastics are considered to be equivalent to the Central Lava Belt of Corbett (1981).

2.1.2 Samples selected for Pb isotope study

Samples were selected from four separate prospects within the area.

Voyager 2 (Batch C): consists of disseminated stratabound galena-sphalerite mineralization within a unit of rhyolitic crystal tuffs in the Hudson River Pyroclastics. The samples come from a drill hole intersection of 5 metres averaging 2.2%Pb and 29g/tAg.

Vogager 19 (Batch B): lenses of massive bedded sphalerite-galena mineralization have been located within quartz crystal tuffs toward the top of the Wart Hill Pyroclastics. The bedded mineralization has identical textures to the Rosebery and Que River ore. The selected samples come from a bedrock costean cut across a weakly mineralized portion of the zone.

Voyager 31 (Batch D): vein style mineralization of galena-sphalerite which occurs along a fault zone marking the contact between the Western Sequence and the Wart Hill Pyroclastics. The samples were collected from outcrop.

Vogager 24 (Batches A and F): dissiminated and vein style galena-sphalerite associated with quartz veins and gold mineralization within a siliceous rhyolitic agglomerate in the Wart Hill Pyroclastics. Batch A is from drill core and Batch F from B-horizon soil samples.

2.2 Mackintosh East Area

The Mackintosh East project is a Joint Venture with Aberfoyle on an area of the Mt Read Volcanics 15 km east of Que River. A generalized geological map is shown in Fig. 2.

Minor lead-zinc mineralization has been defined within cherty sediments and rhyolitic tuffs at the base of the Mt Read Volcanics along a strike length of about 11 km.

The Prover 1 and Prover 3 (Fig. 3) areas cover soil geochemical anomalies about six kilometres apart. The samples selected are from C-horizon soils.

2.3 Sample Treatment

Lead was separated from the samples using anion exchange chromatographic and electrodeposition techniques as described in Gulson and Mizon (1979). Lead isotope ratios were measured on the fully automated Isomass 54E solid source thermal ionization mass spectrometer. From replicate analysis of standards and samples our precision to the 2 σ level is $< \pm 0.10\%$ for the $^{208}Pb/^{206}Pb$ ratios, $< \pm 0.06\%$ for the $^{207}Pb/^{206}Pb$ ratios and $\pm 0.1\%$ for the $^{206}Pb/^{204}Pb$ ratios. All the data have been normalized to the NBS Standard SRM 981 and Broken Hill Standard Pb 18 using a factor of + 0.08% per mass unit.

3. RESULTS, DISCUSSION AND ASSESSMENT

The lead isotope ratios and Pb concentrations (the latter supplied by Geopeko) are given in Table 2. The lead isotope data are plotted on conventional diagrams utilizing the U-Pb system ($^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$, Figure 4a) and Th-U-Pb system ($^{208}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$, Figure 4b). These composite plots are supplemented by plots for the individual anomalies given at the back of the report.

3.1 Elliott Bay Area

3.1.1 Hudson River Volcanics

3.1.1.1 Voyager 2 (Batch C; Group 3 in Figures 4a, 4b)

Drilling intersected disseminated stratabound galena-sphalerite mineralization. Only one batch of crushed core samples was analysed from this unit; lead concentrations ranged from 0.08 to 2.96%.

The isotopic ratios for the six samples:

a) are homogeneous exhibiting a spread of ± 0.08% for the $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ ratios,

b) plot slightly below the reference curves (Figure 4a and b), and

c) are less radiogenic (lower $^{206}Pb/^{204}Pb$, higher $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ and differ from the 'target' isotopic signature by > 0.6%.

Assessment - The homogeneity of the isotope ratios would elicit a favourable assessment. However, the isotopic difference of this anomaly and the 'target' isotopic signature requires caution and further interpretation.

In our experience to date, we have not encountered two different isotopic signatures for the same type of major Pb-rich target in the one metallogenic province and this applies particularly to volcanogenic massive sulfides. Consequently, unless future major mineralization is located with the isotopic signature of Voyager 2, we would interpret the data to signify a derivation from pods in which the metals were leached from the enclosing and/or basement rocks. The less radiogenic nature of the mineralization relative to the Rosebery-style may reflect either the isotopic characteristics of the enclosing rocks (which could be checked by analysis of 3 or 4 barren whole rocks) or derivation from U-poor basement rocks of Precambrian age.

It is interesting that the isotopic ratios in Voyager 2 are identical with those at Prover 3 (Batch G) in the Mackintosh East area, some 120 km to the north (see Table 1 and 2).

Summary - with the proviso that no major mineralization is known from the Mt Read Volcanics with the Voyager 2 and Prover 3 isotopic signature, this anomaly would be given an unfavourable assessment on the basis of lead isotopes.

3.1.2 Wart Hill Pyroclastics

Four anomalies were tested from this unit.

3.1.2.1 Voyager 19 (Batch B; Group 1 in Figs. 4a, 4b).

The bedrock auger samples from the weakly mineralized protion of the zone have Pb concentrations ranging from 1750 ppm to 5%.

The isotope ratios for the seven samples:

a) Are homogeneous exhibiting a spread of ± 0.07% for the $^{207}Pb/^{206}$ Pb and $^{208}Pb/^{206}Pb$ excluding the sample (KR 7277) with the lowest Pb concentration of 1750 ppm. This discrepant sample may be either from the fringes of mineralization or from a different ore lens. As its ratios are the same as those from Voyager 2, the latter interpretation is favoured at this stage.

b) Plot slightly below the reference curves (Figs. 4a, 4b), and

c) are different from the 'target' isotopic signature by > 0.8% for the $^{207}Pb/^{206}Pb$.

Assessment - Isotopically, this anomaly has the same problems as Voyager 2 in that its isotope ratios are completely different to the Rosebery-type of mineralization. Alternatively, as outlined above for Voyager 2, this isotopic composition is characteristic of a type of deposit hitherto undiscovered in Tasmania. Its isotope ratios are quite similar to deposits in the Lachlan Fold Belt (Woodlawn, Captains Flat) but the $^{208}Pb/^{206}Pb$ is lower by more than 0.6% probably reflecting differences in the Th/U of the source material or different mechanisms of ore formation.

In the past we have found that the least radiogenic lead (lowest $^{206}Pb/^{204}Pb$, highest $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$) in an area is that of the major mineralization. This observation was also made by Loveless (1975). However, in one of our recent case histories, vein-style mineralization contained less radiogenic isotope ratios than those of the orebodies. Consequently, use of the least radiogenic leads as an indication of major massive sulfide mineralization needs to be treated with caution.

3.1.2.2 Voyager 31 (Batch D; Group 4 in Figs. 4a, 4b)

These five rock chip (outcrop) samples of a vein-style Pb-Zn-Ag mineralization along a fault zone (Figure 1) have Pb concentrations ranging from 1.0 to 5.5%. Samples KR 7435 and 7436 are splits from the one sample and their isotopic ratios are in excellent agreement.

The isotope ratios, relative to the Rosebery-style target isotopic signature, are characterized by:

a) a small dispersion (> ± 0.1%) in the $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$, and
b) are more radiogenic.

They are very much more radiogenic - by 0.8% in the $^{208}Pb/^{206}Pb$ and 1.5% in the $^{207}Pb/^{206}Pb$ - than the bedded mineralization at Elliott Bay.

Assessment - The isotopic data for Voyager 31 are consistent with vein mineralization from other parts of the Mt Read Volcanics and would be deemed uninteresting from an exploration viewpoint.

3.1.2.3 Voyager 24

This is a disseminated and vein-style Pb-Zn-Au mineralization from which six drill core (Batch A; Group 2 on Figs. 4a, 4b) and only four B-horizon soil samples (Batch F; Group 6 on Figs. 4a, 4b) were analysed.

It should be noted that we have not previously analysed samples of soils and gossans for gold exploration and so our interpretation is only applicable to the base metal aspects. Furthermore, the number of soil samples is rather limited.

The isotopic ratios have the following features.

a) Those for the drill core exhibit considerable variation compared with the soils. For example the variation in $^{207}Pb/^{206}Pb$ ratio for the drill core is > ± 0.3% and in the soils ± 0.1%. The smaller dispersion in the soils may be the result of homogenization of the lead isotopes, as we have found for gossans.

b) In the drill core, the two samples with the highest Pb concentrations (1650 and 1150 ppm) contain the least radiogenic lead isotope ratios but, in contrast to other deposits we have studied, there is no consistent trend of Pb concentration and isotope ratios e.g. the three samples with Pb concentrations in the 700-780 ppm range have more radiogenic isotopic compositions than the sample with 415 ppm Pb (KR 7465).

c) The isotope ratios in the soils, except for the sample (TS 10407) with the lowest Pb concentration of 40 ppm, are similar to the 'target' isotopic ratios.

Assessment - In the initial stages of exploration, the relative homogeneity and isotopic composition of the soils would elicit further interest. However, as one sample out of four is deviant, a follow-up program of soil isotopic analysis would be recommended. If the hole had been drilled on the basis of the soil isotopic data the variability in isotope ratios found in the drill core material would lead to reassessment of the anomaly: the isotopic data for the drill core material are more consistent with other vein-style mineralization we have analysed. Because of the isotopic differences in the soils and drill core, the source of the lead anomaly in the soils may not necessarily be from the drill core material.

3.2 East Mackintosh Area

The 'target' isotopic ratios are once again those of the Rosebery-Que River mineralization.

3.2.1 Prover 1 (Batch E; Group 5 in Figs. 4a, 4b)

This anomaly was considered to represent potential Rosebery-style mineralization. The five C-horizon soil samples contained Pb concentrations from 120 to 12600 ppm.

The isotopic ratios have the following characteristics:

a) they are variable (> ± 0.4% in $^{207}Pb/^{206}Pb$),

b) there is no correlation between Pb concentration and lead isotopic composition, e.g. two samples with ~ 350 ppm Pb have isotopic compositions which vary by 0.7% in their $^{207}Pb/^{206}Pb$ ratio.

c) the least radiogenic lead ratios for TS 7358 are much lower than the 'target' isotopic signature but may reflect mixing of lead from a number of sources, one of which is found in Prover 3.

Assessment - The variability and inconsistency with Pb concentrations of the isotope ratios and difference in the least radiogenic lead compared with the 'target' isotopic composition would lead to an assessment of non viable mineralization. This anomaly would be given a lower priority than Prover 3 (see below) in any exploration program utilizing lead isotopes. The metals have probably been leached out of the country rocks.

3.2.2 Prover 3 (Batch G: Group 7 in Figs. 4a, 4b)

These five C-horizon soil samples are from a Pb-Zn anomaly of possible vein-type mineralization and in which the Pb concentrations ranged from 235 to 780 ppm with one sample containing 3000 ppm Pb. At the time of analysis this anomaly was undrilled.

The isotope ratios are:

a) homogoneous (± 0.08% in $^{207}Pb/^{206}Pb$) even for low-Pb samples,

b) different from the 'target' isotopic signature by > 0.6% and are also less radiogenic, and

c) almost identical with those from Voyager 2 at Elliott Bay.

Assessment: The homogeneity in lead isotope ratios would elicit further interest but the difference and less radiogenic nature of the anomaly relative to the 'target' isotope ratios suggests caution - as in the case of Elliott Bay.

Until major massive sulfide mineralization with the isotopic compositions as measured in Prover 3 and Voyager 2 (and also Voyager 19) is found in the Mt Read Belt, our interpretation for Prover 3 and Voyager 2 has to be that these anomalies are derived from non-viable mineralization.

4. SPECULATIONS ON THE RELATIONSHIP OF THE MT READ VOLCANICS AND MINERALIZATION

The Central Lava Belt of the Mt Read Volcanics is considered to be host to the major massive sulfide deposits such as Que River-Rosebery-Hercules-Mt Lyell (Corbett, 1981). Comparisons have been drawn between this Belt and the Wart Hill and Hudson Bay Pyroclastics at Elliott Bay, where exploration has been directed towards Rosebery-style targets. It is commonly accepted that the massive sulfide mineralization is genetically related to the host volcanics and therefore should be of the same Cambrian age.

We can subdivide the lead isotope data for the Mt Read Volcanic Belt into three main groups:

a) that for the major deposits in the Central Lava Belt which have homogeneous ratios within the deposit and are essentially the same for each deposit,
b) that for mineralizations at East Mackintosh (Prover 3) and Elliott Bay (Voyager 2 and Voyager 19) which have homogeneous ratios within the anomaly but are considerably less radiogenic than (a), and
c) that for vein-style mineralizations which have uniform or variable isotope ratios and are often more radiogenic than the associated massive sulfides.

The major isotopic differences between the Rosebery-type deposits and the Voyager anomalies would appear to preclude a common origin for their mineralization i.e. if the Wart Hill and Hudson River Pyroclastics are part of the Central Lava Belt they should have similar initial isotopic compositions. Another explanation for the isotopic differences may be that the Central Lava Belt is missing at Elliott Bay and by inference, the Elliott Bay mineralization is not of Rosebery size.

The host rocks for the Prover 3 anomaly at East Mackintosh and Voyager 2 at Elliott Bay are thought to lie at a similar stratigraphic level, viz. lower in the Mt Read Volcanics and close to the Precambrian Basement. This lower part may continue into the Precambrian. The isotopic similarity over distances of > 100 km, of what is as yet unproven major Pb-rich mineralization, is striking, but not unique - we

have observed the same pattern in minor Pb-Zn-Ag-W mineralization around Broken Hill.

With regard to the origin of the metals in this Belt, the following need to be considered:

a) The so-called 'model ages' of the Rosebery-type mineralization are ~ 280 Ma (errors of at least ± 100 Ma are usually given for these ages) which is inconsistent with the Cambrian stratigraphic age of the host volcanics based on fossil evidence (Corbett, 1981). In other volcanogenic massive sulfide deposits of varying ages the 'model age' is similar to the stratigraphic age e.g. Halls Peak (Ostic et al., 1967), Woodlawn (Gulson, 1977), Captains Flat (Ostic et al., 1967), Benambra (Gulson and Mizon, unpublished data), Kidd Creek (Bugnon et al., 1980) and Vihanti (Vaasjoki, 1981).

b) The 'model age' for the Rosebery-style deposits considering the error limits imposed on it, is very broadly speaking similar to that of widespread granitic activity on the west coast of Tasmania dated about 350 Ma (Brooks, 1966; Brooks and Compston, 1965).

c) The isotopic data for the massive sulfide deposits, the Elliott Bay mineralization, all vein-style mineralization and some whole rocks from Que River, scatter about a linear array which has an intercept of 0.075 on a $^{207}Pb/^{206}Pb$ vs $^{204}Pb/^{206}Pb$ plot. This line also intersects the reference curve of Cumming and Richards (1975) at ~ 1300 Ma. L. Black (personal communication, 1981) has found ~ 1000 Ma old lead in zircons from granites and volcanics from the Mt Read Belt.

One highly speculative interpretation of these data is that the source of the lead in the volcanics of mineralization was > 1000 Ma old and at ~ 500 Ma volcanism and mineralization of the Elliott Bay and East Mackintosh (Prover 3) type were formed. In the Devonian/Carboniferous, prolific granitic activity led to remobilization and concentration of metals in the Central Lava Belt to form the massive sulfide orebodies of the Rosebery-type. In the period from ~ 500 to 350 Ma a sufficient amount of radiogenic lead would probably have been produced in the disseminated mineralization to change the isotope ratios from a $^{206}Pb/^{204}Pb$ ratio of 18.09 (Voyager 19) to 18.30 (Rosebery-type).

Unfortunately, this cannot be rigorously tested because of lack of data on the U and Pb concentrations in the Cambrian material. The high Pb accumulations in the Elliott Bay area were unaffected by mixing or resetting of their isotopic compositions by any granitic activity, or alternatively, relatively little granitic activity was present in this area. Such granitic activity in the Carboniferous may have led to local remobilization of metals within the Mt Read Volcanics to form the vein-style mineralization, or alternatively, the remobilization may have occurred much later in response to Jurassic volcanism.

Although highly speculative, this interpretation of the data would imply that the mineralization at Que River and Rosebery is epigenetic. But this is not consistent with geological features such as the bedded nature of the ore. Another and probably more realistic alternative is that even though the source of the Pb in the volcanics and mineralization was > 1000 Ma old, the emplacement of the volcanics and formation of the orebodies took place at ~ 500 Ma, consistent with the Cambrian fossil age for the volcanics (Corbett, 1981). Remobilization of disseminated mineralization in the volcanics occurred during Devonian/Carboniferous granitic activity to give the vein-style mineralization.

It is interesting that there are small differences in isotopic composition of the major orebodies northwards from Comstock to Rosebery/Hercules and Que River. This may be a reflection of the differences in the underlying basement source rocks and as suggested for the Elliott Bay area, could be tested by analyses of barren volcanics. Lead isotopic analyses of fresh pyroxene may achieve the same results (D. Whitford, pers. comm. 1982). If the north-south isotopic variations in the deposits are due to differences in the underlying source rocks, then these differences must be very local in view of the major isotopic variations over relatively short distances as in Voyager 2 and 19 at Elliott Bay and the Que River deposit and Prover 3.

To explain the unusual isotopic compositions of the Lyell-Rosebery-Hercules-Que River deposits compared with other known volcanogenic massive sulfides requires derivation of the Pb from Precambrian source rocks with lower U/Pb ratios such as granulites in which U depletion has occurred during metamorphism. Alternatively,

rather than being largely derived from remelted > 1000 Ma old continental crust, the volcanics may have some mantle component.

The Proterozoic lead source suggested for the mineralization in the Mt Read volcanics may be compared with the Tertiary Au-Ag-Cu-Pb-Zn veins in the San Juan volcanics, south western Colorado (Doe et al., 1979). Here the source of the lead is considered to be the underlying 1400-1800 Ma old metamorphic complexes. On the other hand, the San Juan mineralization is vein style and not massive sulfide. It would appear that the Rosebery-style mineralization in the Mt Read Volcanics is unique amongst massive sulfide deposits in its demonstrably old lead source and radiogenic nature.

5. OVERALL ASSESSMENT

5.1 Geochemical anomaly assessment in Elliott Bay Area

If it is assumed that Voyager 19 represents a major accumulation of massive sulfide mineralization, its unique isotopic signature ('target' isotopic signature) allows a discrimination between it and other types of mineralization in this area.

It would appear that, up to the present time, there is no mineralization at Elliott Bay having the isotopic characteristics of the Rosebery-Que River-Hercules-Mt Lyell deposits. This may reflect a difference in the source material of the volcanics.

5.2 Geochemical anomaly assessment in the East Mackintosh area.

If the style of mineralization at Voyager 19 proves to be of significant tonnage, then in view of the similarities between Prover 3 and Voyager 2, a reassessment of the 'target' isotopic signature will be necessary. Currently, the 'target' signature is that of Que River. However, the Prover 3 and Voyager 2 mineralization may be only a reflection of the source material which has given rise to the disseminated Pb-Zn mineralization as at Voyager 2.

6. FUTURE WORK

Besides routine isotopic testing of other geochemical anomalies in the Elliott Bay area, it would be most interesting to analyse 3-4 samples of each of the volcanic units in both the Elliott Bay and Mackintosh East areas, to try and establish the isotopic characteristics of the units and their relationship to the base metal mineralization.

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TABLE 1 COMPARISON OF ISOTOPIC DATA FOR DIFFERENT STYLES OF MINERALIZATION IN THE MT READ VOLCANIC BELT

MINERALIZATION	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
Central Lava Belt Massive Sulfides					
Que River	2.0820±9	0.8520±2	18.337±10	15.623	38.178
Rosebery	2.0848±26	0.8541±5	18.289±19	15.621	38.129
Hercules	2.0842±15	0.8538±1	18.276±11	15.604	38.090
Mt Lyell (Comstock)	2.0855±12	0.8544±3	18.269±8	15.609	38.100
Vein Style					
Mt Farrell	2.0744	0.8424	18.603	15.671	38.590
Queen Hill	2.0740±29	0.8438±10	18.519±33		
Murchison River	2.0757±9	0.8433±8	18.529±20	15.626	38.461
Elliott Bay Massive					
Voyager 19 (Batch B)	2.0966±12	0.8619±5	18.093±6	15.594	37.934
Voyager 2 (Batch C)	2.0940±13	0.8588±6	18.176±10	15.608	38.058
Vein Style					
Voyager 31 (D)	2.0772±22	0.8462±11	18.473±14	15.631	38.370
Mackintosh East					
Prover 3 (G) (Supposed vein) cf with Voyager 2	2.0946±11	0.8590±6	18.162±13	15.601	38.042

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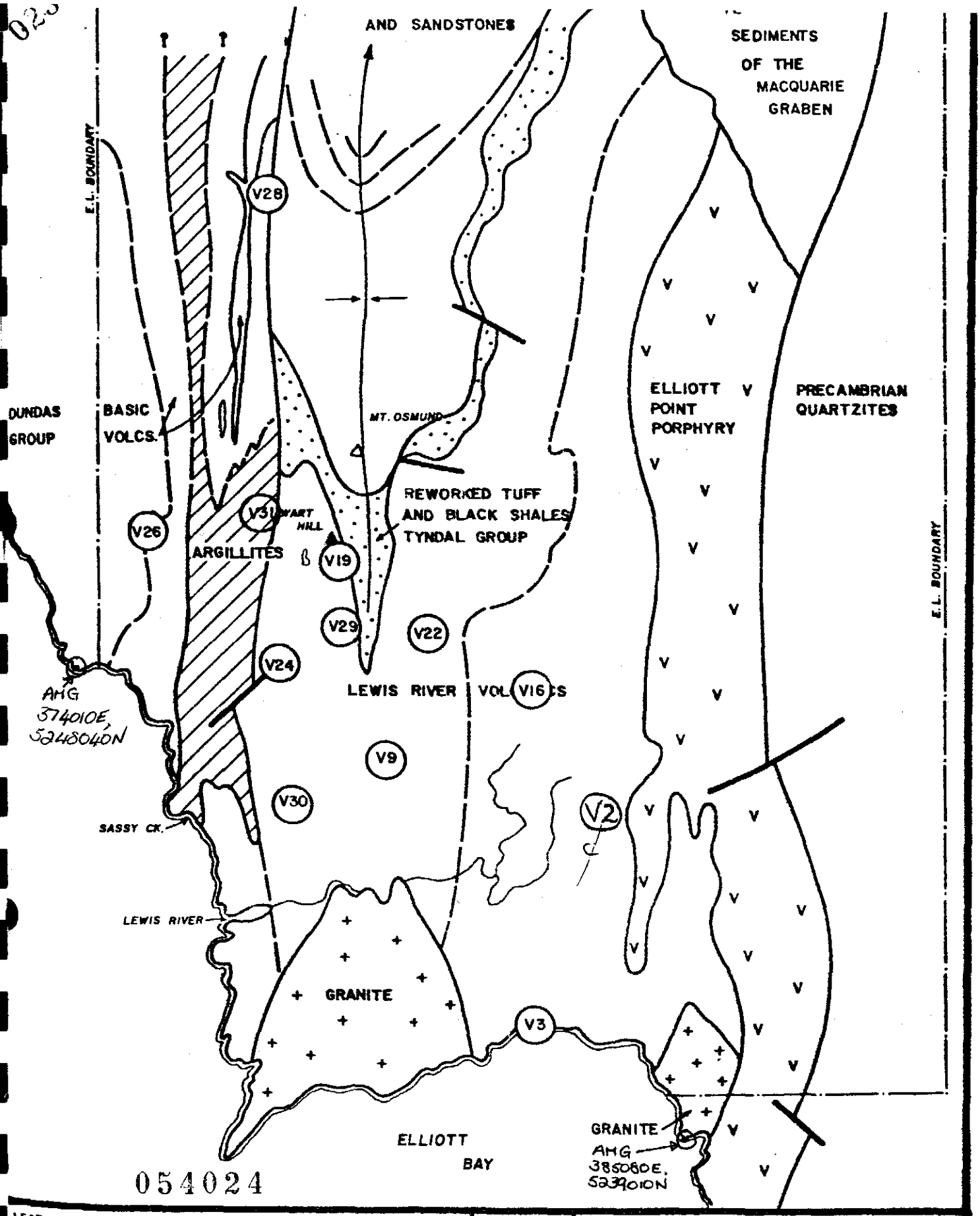
LEAD ISOTOPIC ANALYSIS FOR ELLIOTT BAY AND EAST MACKINTOSH

054023

Sample	208/206	207/206	206/204	207/204	208/204	Pb(ppm)
ELLIOT BAY VOYAGER 24	GROUP 2	(BATCH A)				
KR 7464	2.0782	0.8477	18.409	15.605	38.257	780
KR 7465	2.0841	0.8506	18.359	15.616	38.262	415
KR 7466	2.0887	0.8541	18.300	15.631	38.223	1,650
KR 7467	2.0790	0.8480	18.414	15.615	38.283	700
KR 7468	2.0786	0.8478	18.414	15.611	38.275	725
KR 7469	2.0872	0.8538	18.286	15.613	38.165	1,150
ELLIOT BAY VOYAGER 19	GROUP 1	(BATCH B)				
KR 7277	2.0928	0.8590	18.163	15.602	38.010	1,750
KR 7278	2.0950	0.8615	18.093	15.587	37.904	6,000
KR 7279	2.0974	0.8621	18.104	15.608	37.972	16,000
KR 7280	2.0956	0.8614	18.098	15.589	37.925	11,500
KR 7281	2.0976	0.8619	18.091	15.592	37.947	4,500
KR 7282	2.0981	0.8627	18.087	15.603	37.948	50,000
KR 7283	2.0962	0.8617	18.089	15.588	37.917	3,100
ELLIOT BAY VOYAGER 2	GROUP 3	(BATCH C)				
KR 5810	2.0938	0.8587	18.167	15.600	38.038	29,600
KR 5811	2.0937	0.8584	18.160	15.588	38.022	24,000
KR 5812	2.0955	0.8594	18.186	15.629	38.109	17,600
KR 5813	2.0942	0.8591	18.176	15.615	38.063	20,000
KR 5814	2.0950	0.8592	18.180	15.621	38.087	20,800
KR 5815	2.0918	0.8579	18.185	15.600	38.040	8,000
ELLIOT BAY VOYAGER 31	GROUP 4	(BATCH D)				
KR 7435	2.0764	0.8454	18.490	15.632	38.392	55,000
KR 7436	2.0754	0.8454	18.477	15.620	38.348	50,000
KR 7437	2.0756	0.8454	18.476	15.619	38.348	18,000
KR 7438	2.0782	0.8471	18.453	15.632	38.350	12,000
KR 7439	2.0805	0.8476	18.466	15.652	38.419	10,000
EAST MACKINTOSH PROVER 1	GROUP 5	(BATCH E)				
TS 7357	2.0942	0.8578	18.218	15.627	38.151	340
TS 7358	2.0930	0.8577	18.188	15.601	38.069	12,600
TS 7359	2.0886	0.8550	18.255	15.607	38.126	560
TS 7360	2.0855	0.8516	18.332	15.612	38.232	360
TS 7362	2.0845	0.8507	18.345	15.606	38.240	120
ELLIOT BAY VOYAGER 24	GROUP 6	(BATCH F)				
TS 10407	2.0930	0.8535	18.290	15.610	38.281	40
TS 10408	2.0825	0.8515	18.331	15.609	38.173	200
TS 10409	2.0820	0.8527	18.292	15.598	38.084	160
TS 10410	2.0850	0.8520	18.328	15.616	38.213	345
EAST MACKINTOSH PROVER 3	GROUP 7	(BATCH G)				
TS 7033	2.0952	0.8591	18.163	15.604	38.056	560
TS 7034	2.0934	0.8585	18.166	15.595	38.028	235
TS 7036	2.0934	0.8586	18.161	15.592	38.019	780
TS 7037	2.0957	0.8590	18.178	15.615	38.094	760
TS 7038	2.0954	0.8599	18.142	15.599	38.013	3,000
REF QUE RIVER						
	2.0808	0.8517	18.331	15.613	38.143	
	2.0836	0.8521	18.359	15.644	38.253	
	2.0833	0.8540	18.270	15.603	38.062	
	2.0884	0.8548	18.310	15.651	38.239	
	2.0842	0.8541	18.260	15.596	38.057	
	2.0866	0.8547	18.273	15.618	38.128	
	2.0827	0.8538	18.265	15.595	38.041	
	2.0857	0.8537	18.286	15.611	38.139	
	2.0747	0.8424	18.550	15.627	38.486	
	2.0765	0.8437	18.528	15.632	38.473	
	2.0727	0.8414	18.578	15.632	38.507	
	2.0755	0.8430	18.635	15.709	38.677	



LEGEND:

Generalized geological map of E.L.27/76 showing:

e.g. (V9) Location of Voyager 9

MT READ VOLCANICS.

5 cm

GEOPEKO

SCALE 1:100 000

Fig. 1

DATE: 30/10/86

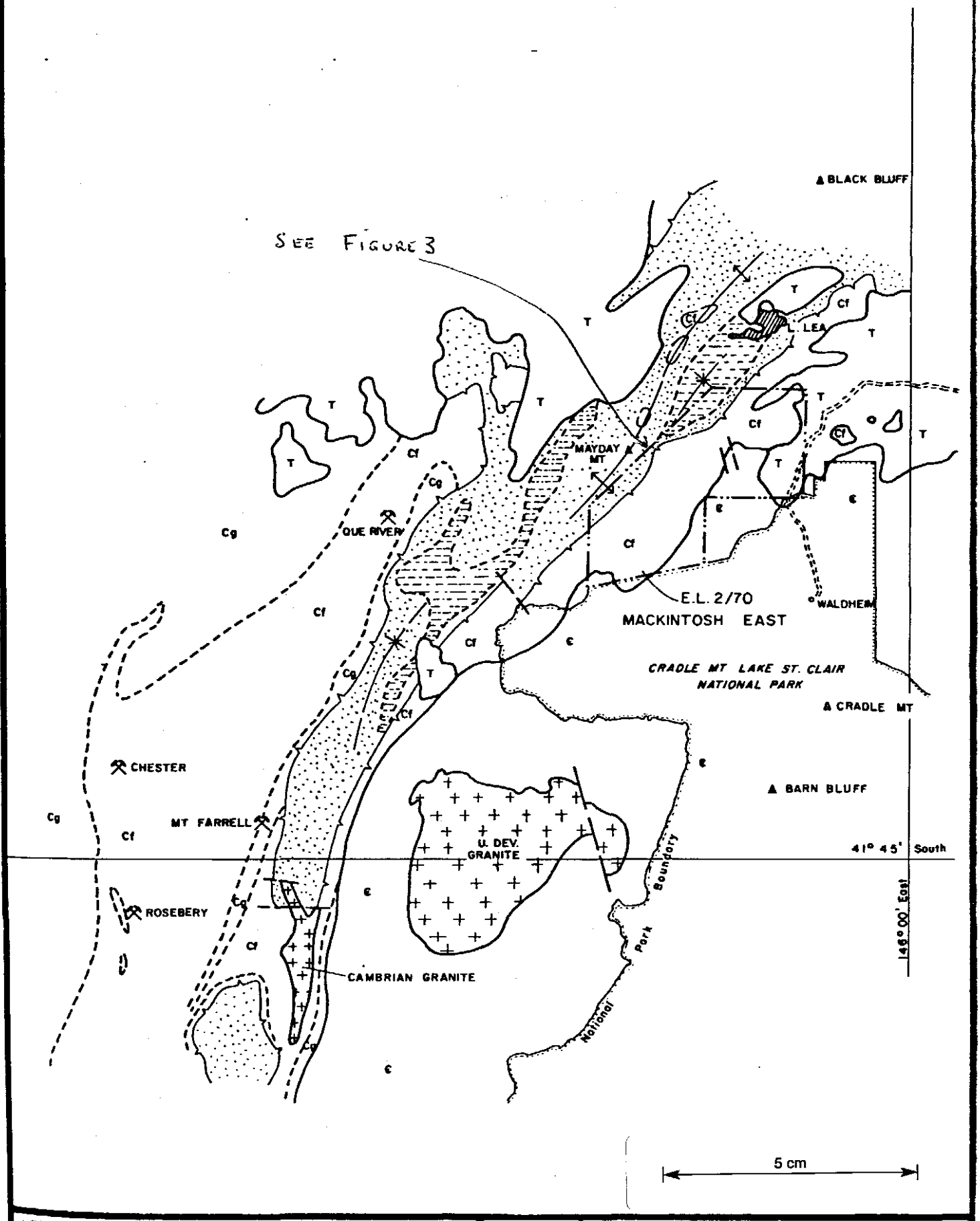
GEOL: W.H., PAW

DWN: R.TOB.

CHKD:

ELLIOTT BAY
E.L. 27/76
VOYAGER LOCATION MAP.

AMG REFERENCE POINTS ADDED



LEGEND:

T	TERTIARY:	Basalt
	ORDOVICIAN:	Siliceous conglomerate, sandstone, siltstone/limestone
Cf / Cg	CAMBRIAN:	Felsic to intermediate volcs. volcaniclastics, intrusives. /greywacke turbidite sequences.
€	PRECAMBRIAN:	Metamorphosed quartzites, pelitic schists

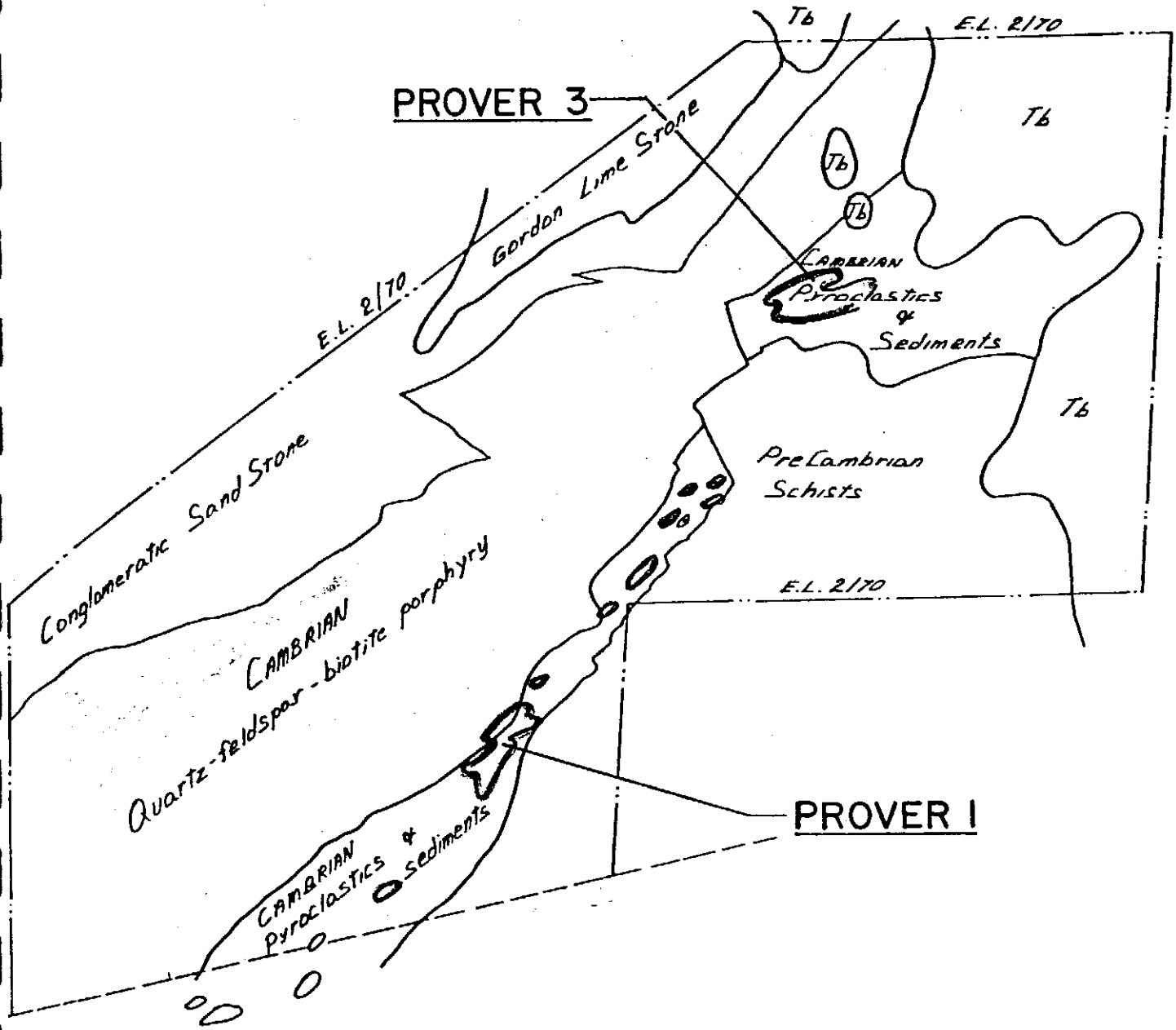
DATE: JUNE'80
GEOL: W. H.
DWN: J. P. M.
CHKD:

GEOPEKO
A DIVISION OF PEKO WALLSEND OPERATIONS LTD

Scale: 1: 2 500 000 | FIG. 1

E.L. 2/70 MACKINTOSH EAST

LOCALITY PLAN with REGIONAL GEOLOGICAL SETTING



LEGEND

Areas of B-Horizon Lead soil Geochemical anomalies

5 cm

Fig. 3

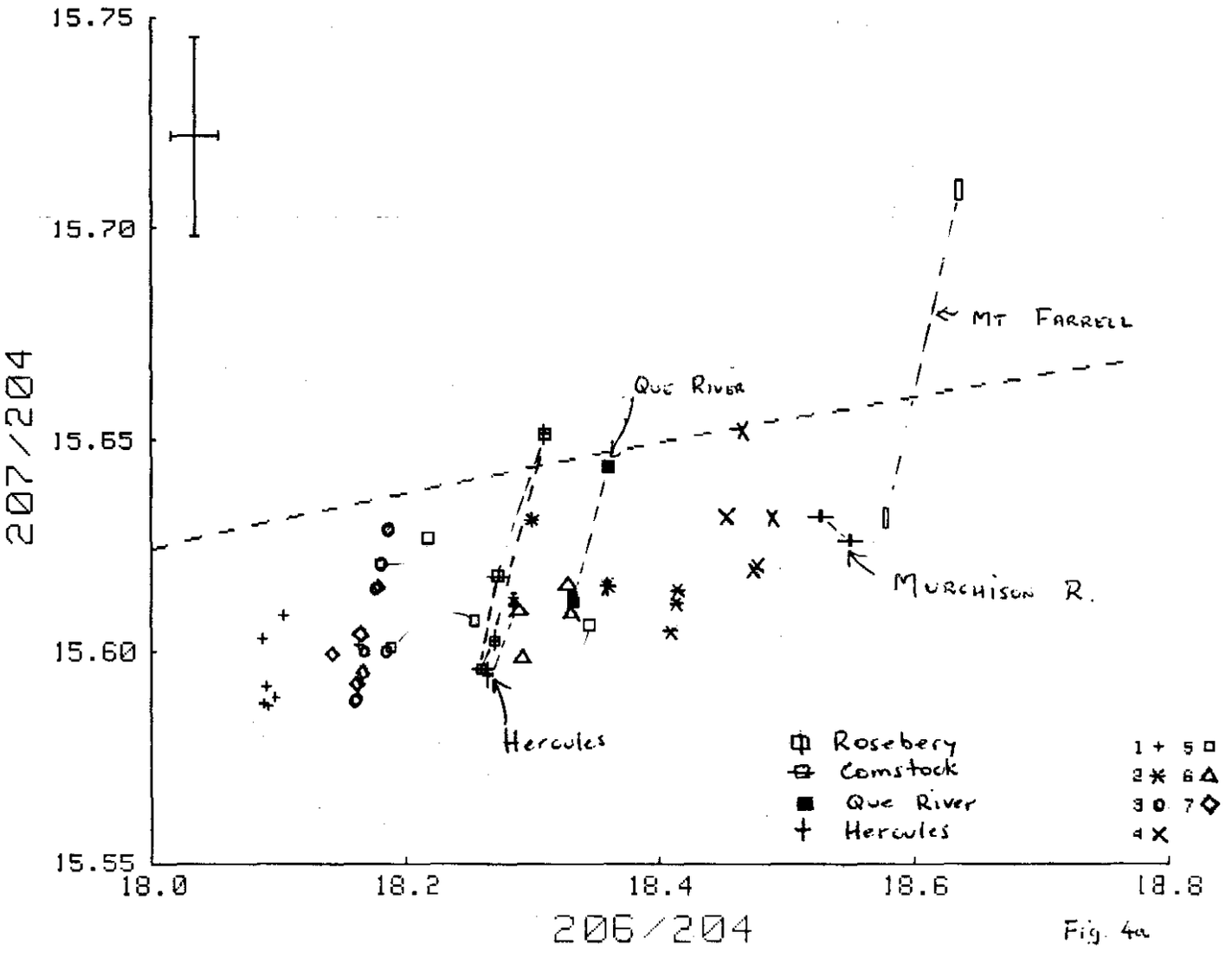

15.75
15.70
15.65
15.60
15.55
207/204
18.0
18.2
18.4
18.6
18.8
206/204
MT FARRELL
QUE RIVER
MURCHISON R.
Hercules
Rosebery
Comstock
Que River
Hercules
1 + 5 □
2 ✱ 6 △
3 ○ 7 ◇
4 ×

Fig. 4a

COEFF. OF VARIATION= .96758 0 DELETIONS
SLOPE= 1.0874 Y INTERCEPT= 18.284 MEAN X= 18.256 MEAN Y= 38.134

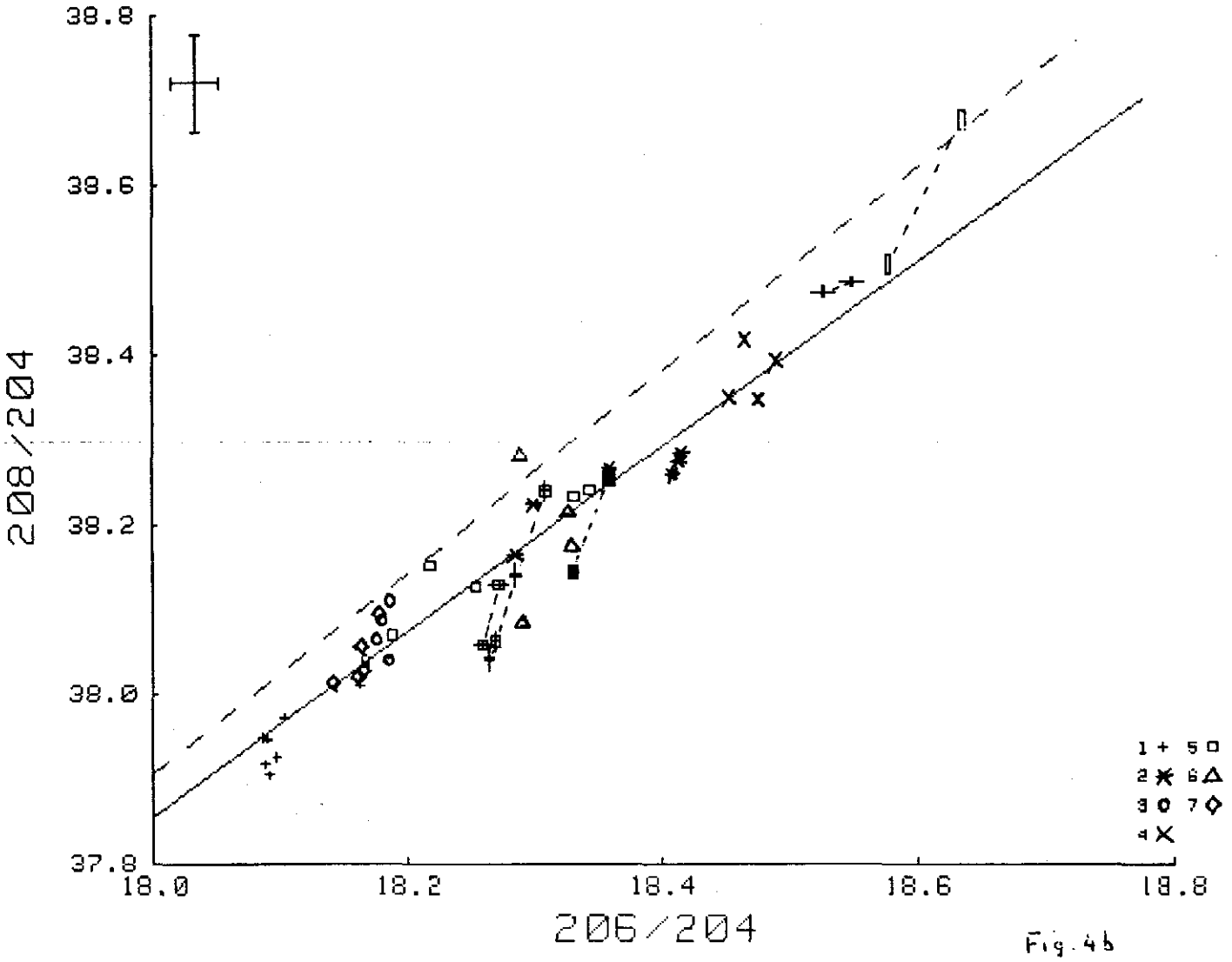
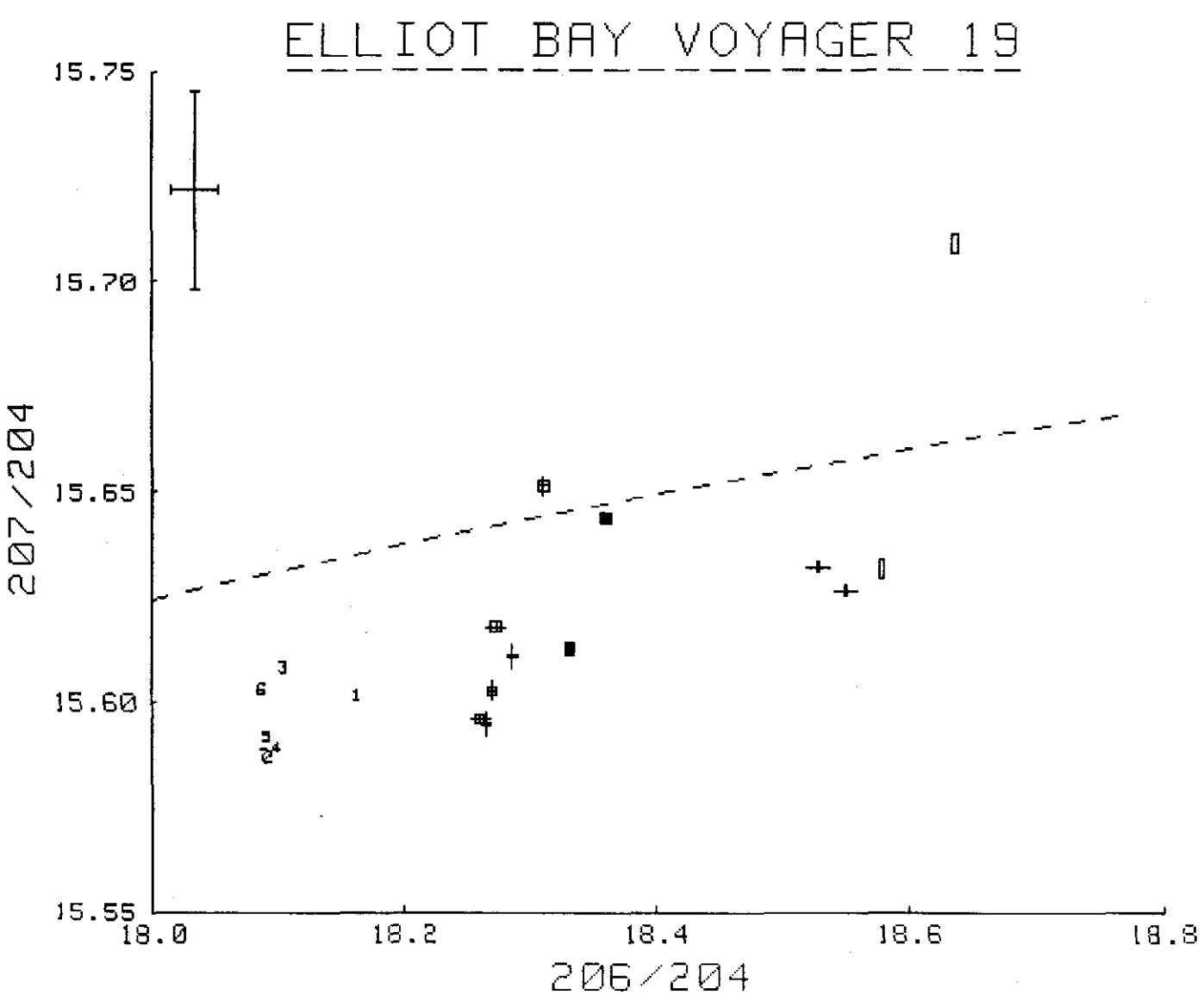
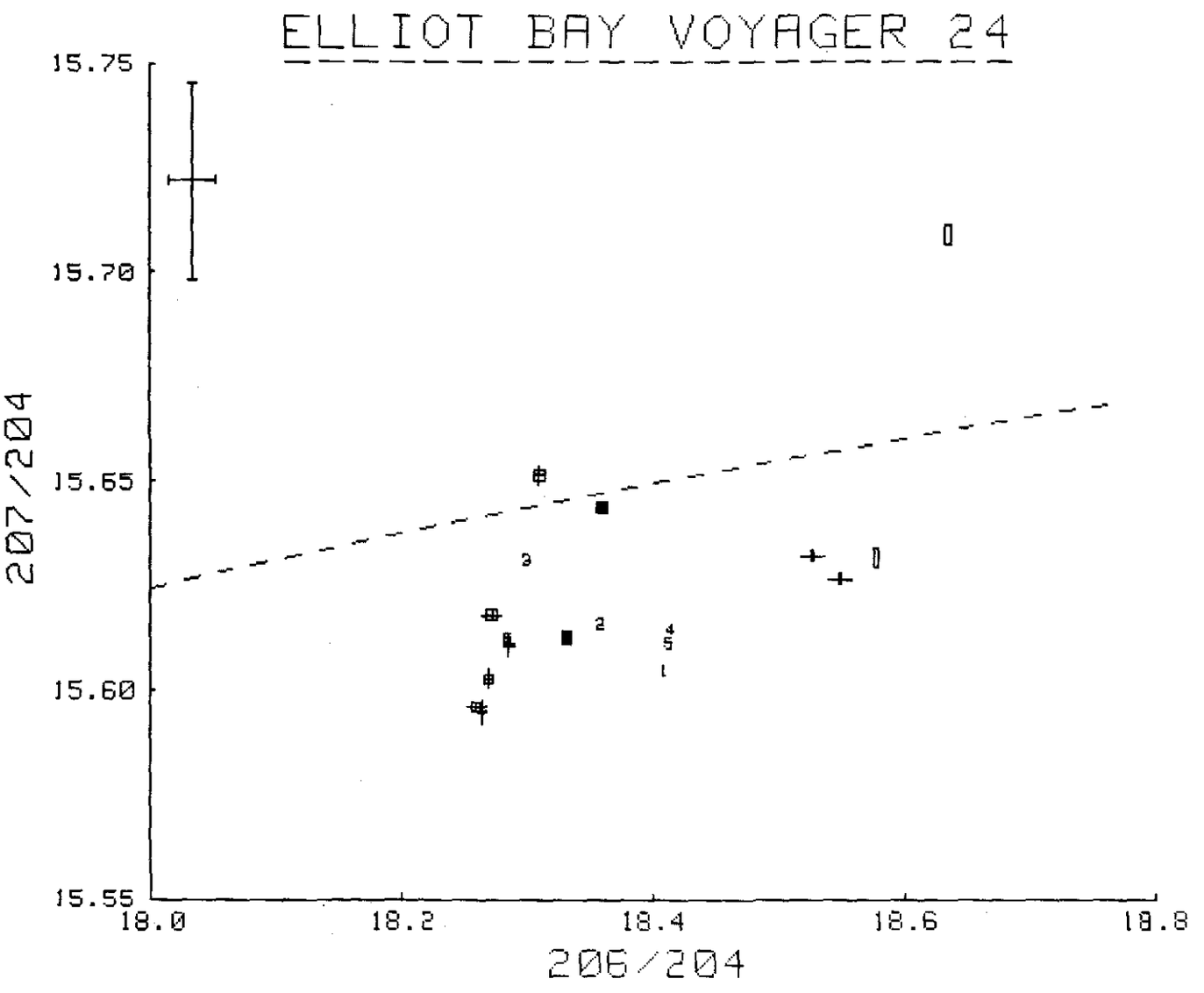


Fig. 4b

COEFF. OF VARIATION= .39098 0 DELETIONS
SLOPE= .12571 Y INTERCEPT= 13.32 MEAN X= 18.103 MEAN Y= 15.596
INTERSECTION AT T=2.004 X=15.1110 Y=15.2200
INTERSECTION AT T= .116 X=18.6300 Y=15.6620

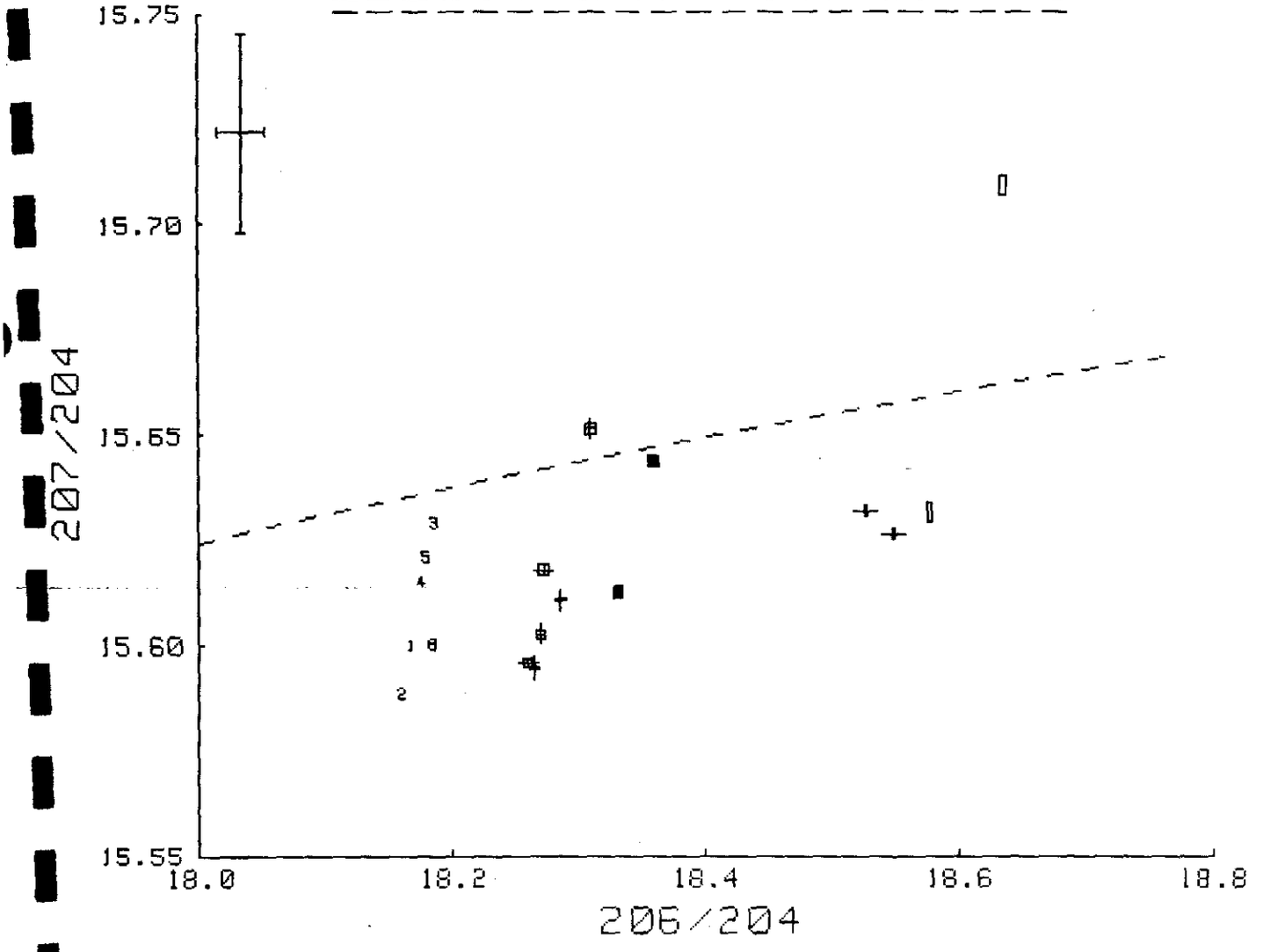


COEFF. OF VARIATION=-.58568 0 DELETIONS
SLOPE=-.087011 Y INTERCEPT= 17.213 MEAN X= 18.364 MEAN Y= 15.615
INTERSECTION AT T= .398 X=18.1470 Y=15.6340

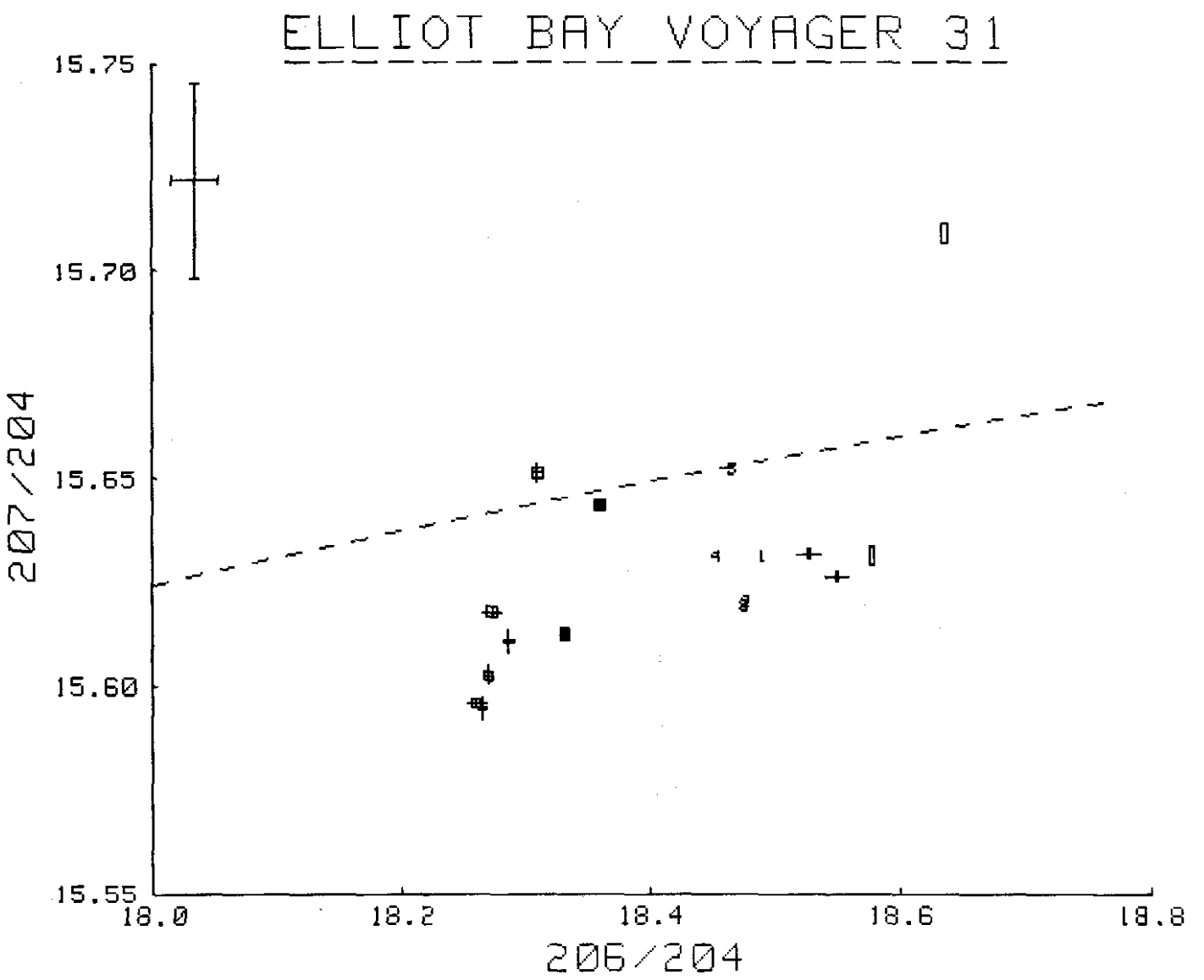


COEFF. OF VARIATION= .73202 0 DELETIONS
SLOPE= 1.0898 Y INTERCEPT=-4.1997 MEAN X= 18.176 MEAN Y= 15.609
INTERSECTION AT T= .366 X=18.2020 Y=15.6380

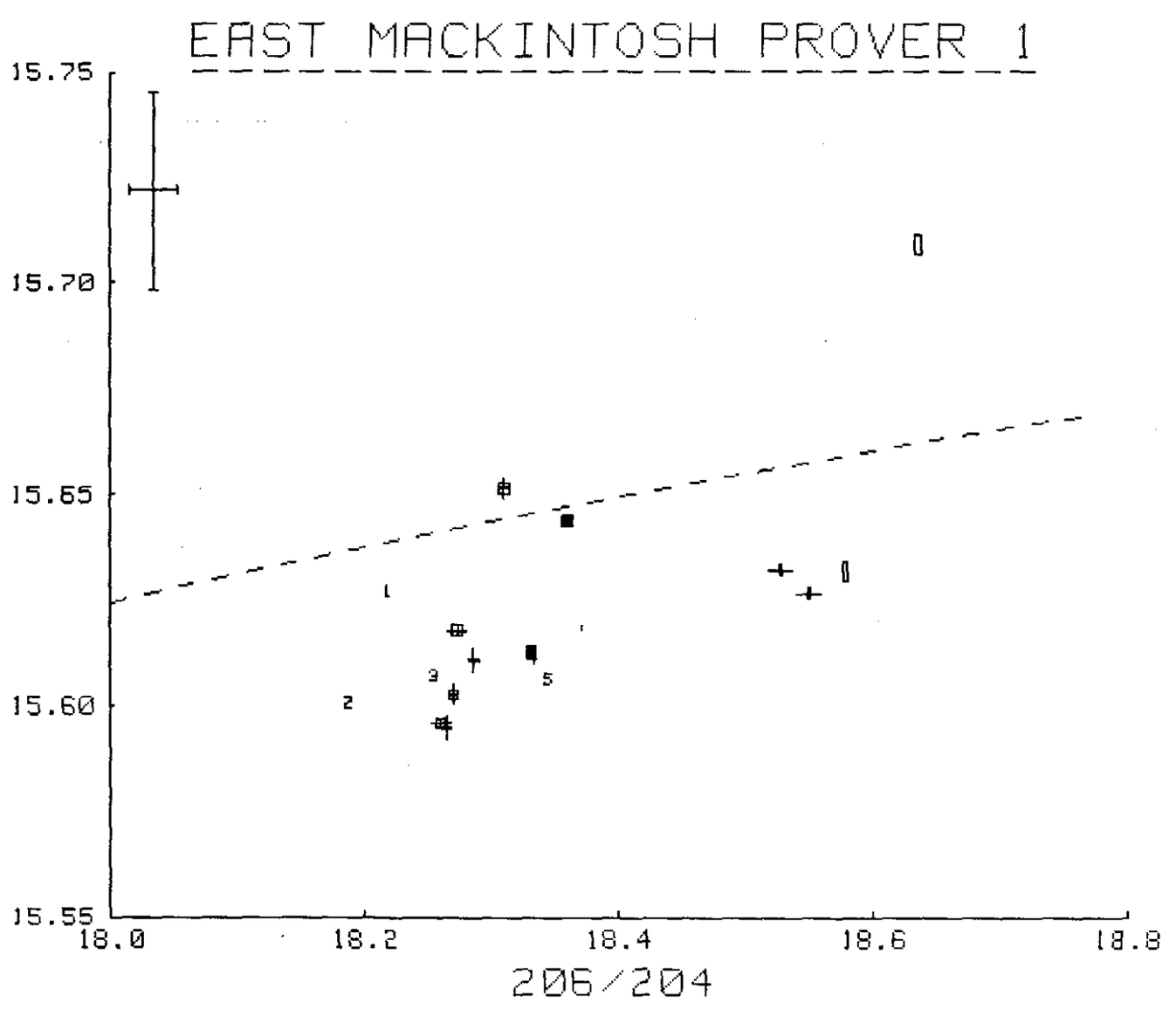
ELLIOT BAY VOYAGER 2



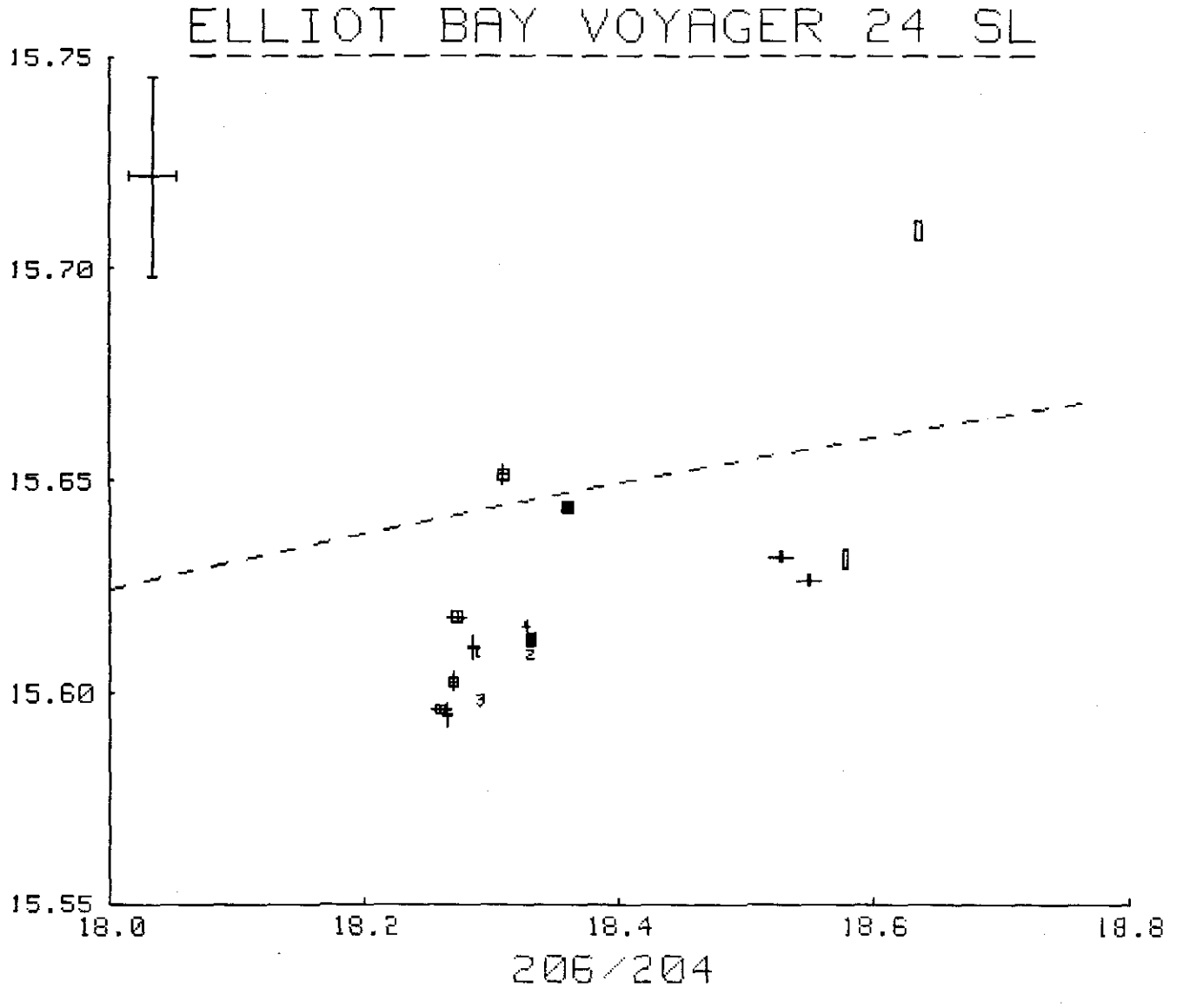
COEFF. OF VARIATION=-.31768 0 DELETIONS
SLOPE=-.30753 Y INTERCEPT= 21.312 MEAN X= 18.472 MEAN Y= 15.631
INTERSECTION AT T= .244 X=18.4120 Y=15.6500



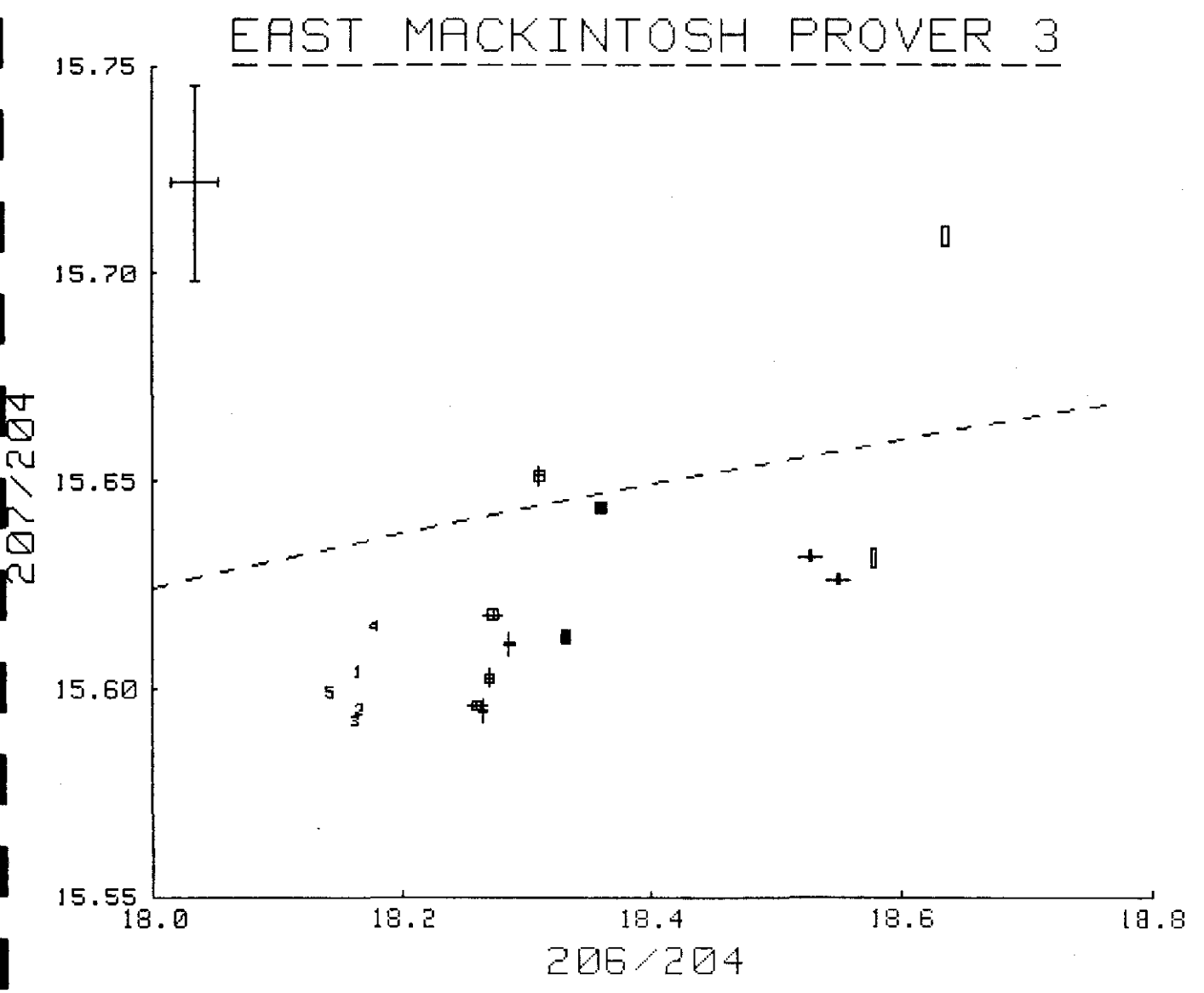
COEFF. OF VARIATION=-.10682 0 DELETIONS
SLOPE=-.01545 Y INTERCEPT= 15.893 MEAN X= 18.267 MEAN Y= 15.611
INTERSECTION AT T= .545 X=17.8890 Y=15.6170



COEFF. OF VARIATION= .62365 0 DELETIONS
SLOPE= .2041 Y INTERCEPT= 11.871 MEAN X= 18.31 MEAN Y= 15.608
INTERSECTION AT T=2.840 X=13.3270 Y=14.5910
INTERSECTION AT T= .161 X=18.5540 Y=15.6580

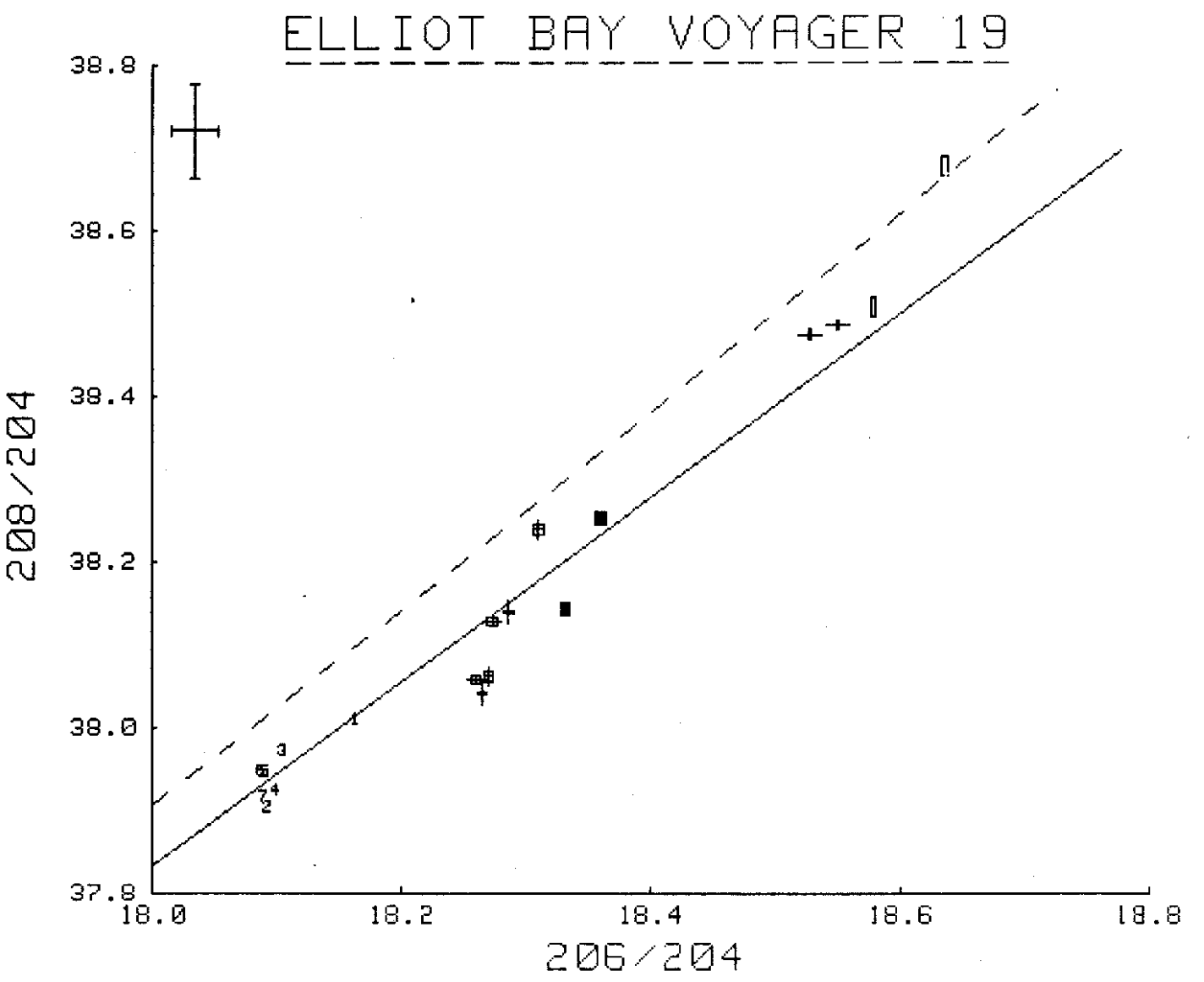


COEFF. OF VARIATION= .51801 0 DELETIONS
SLOPE= .35679 Y INTERCEPT= 9.1212 MEAN X= 18.162 MEAN Y= 15.601
INTERSECTION AT T=3.704 X=11.3240 Y=13.1620
INTERSECTION AT T= .322 X=18.2780 Y=15.6420

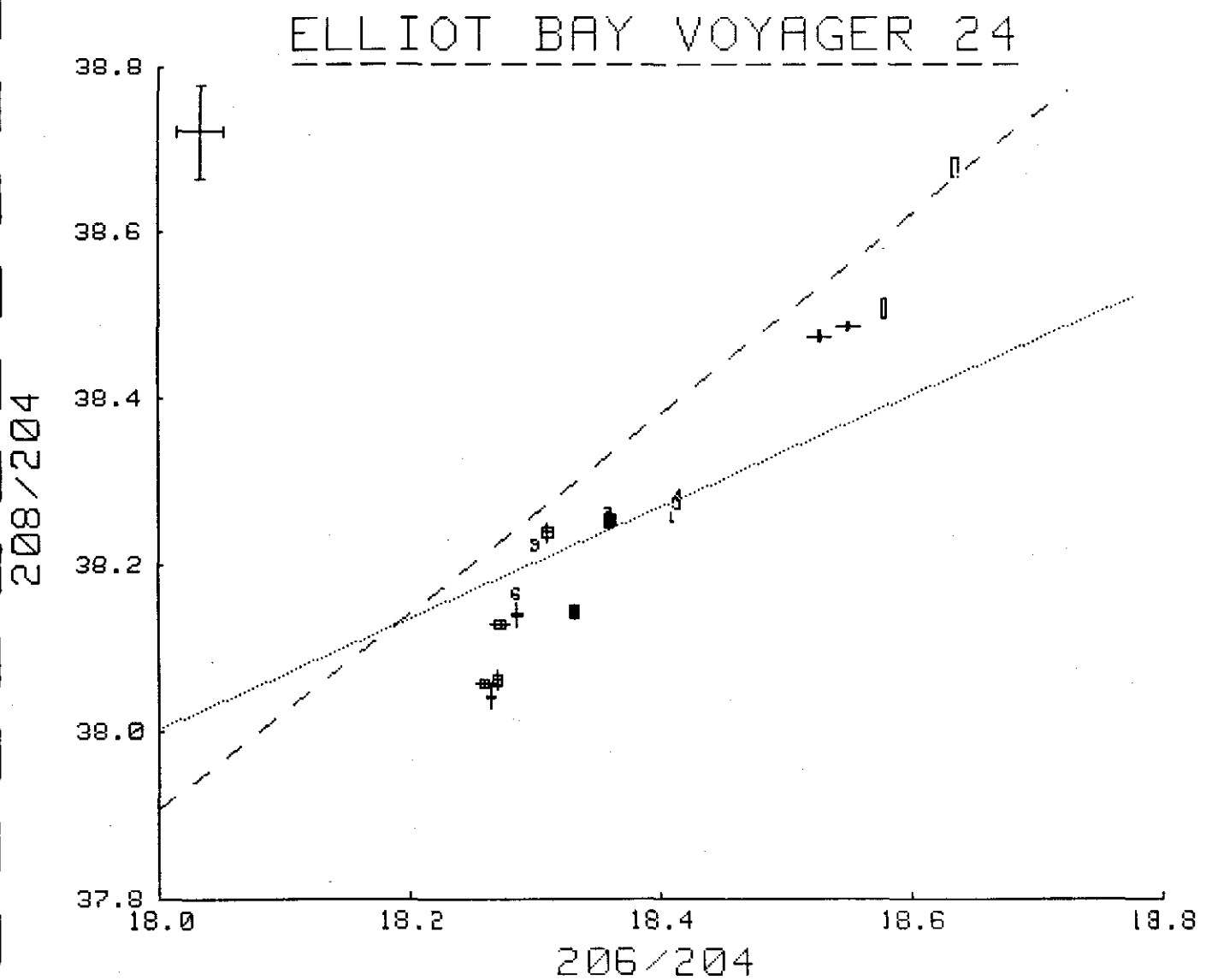


COEFF. OF VARIATION= .65951 0 DELETIONS
SLOPE= .034700 Y INTERCEPT= 14.244 MEAN X= 18.256 MEAN Y= 15.609

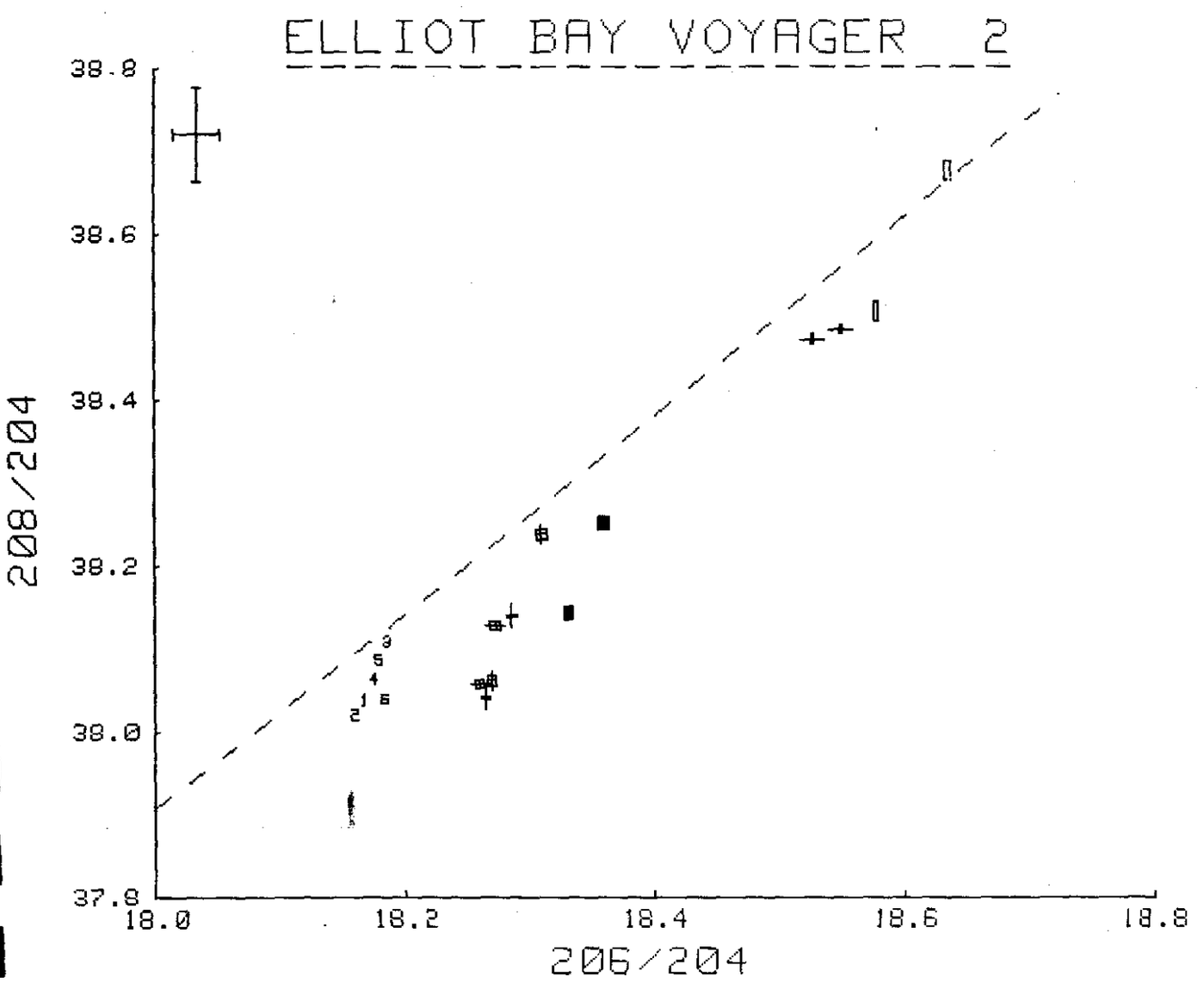
COEFF. OF VARIATION= .82436 0 DELETIONS
SLOPE= 1.1132 Y INTERCEPT= 17.794 MEAN X= 18.103 MEAN Y= 37.946
NO INTERSECTION WITH GROWTH CURVE



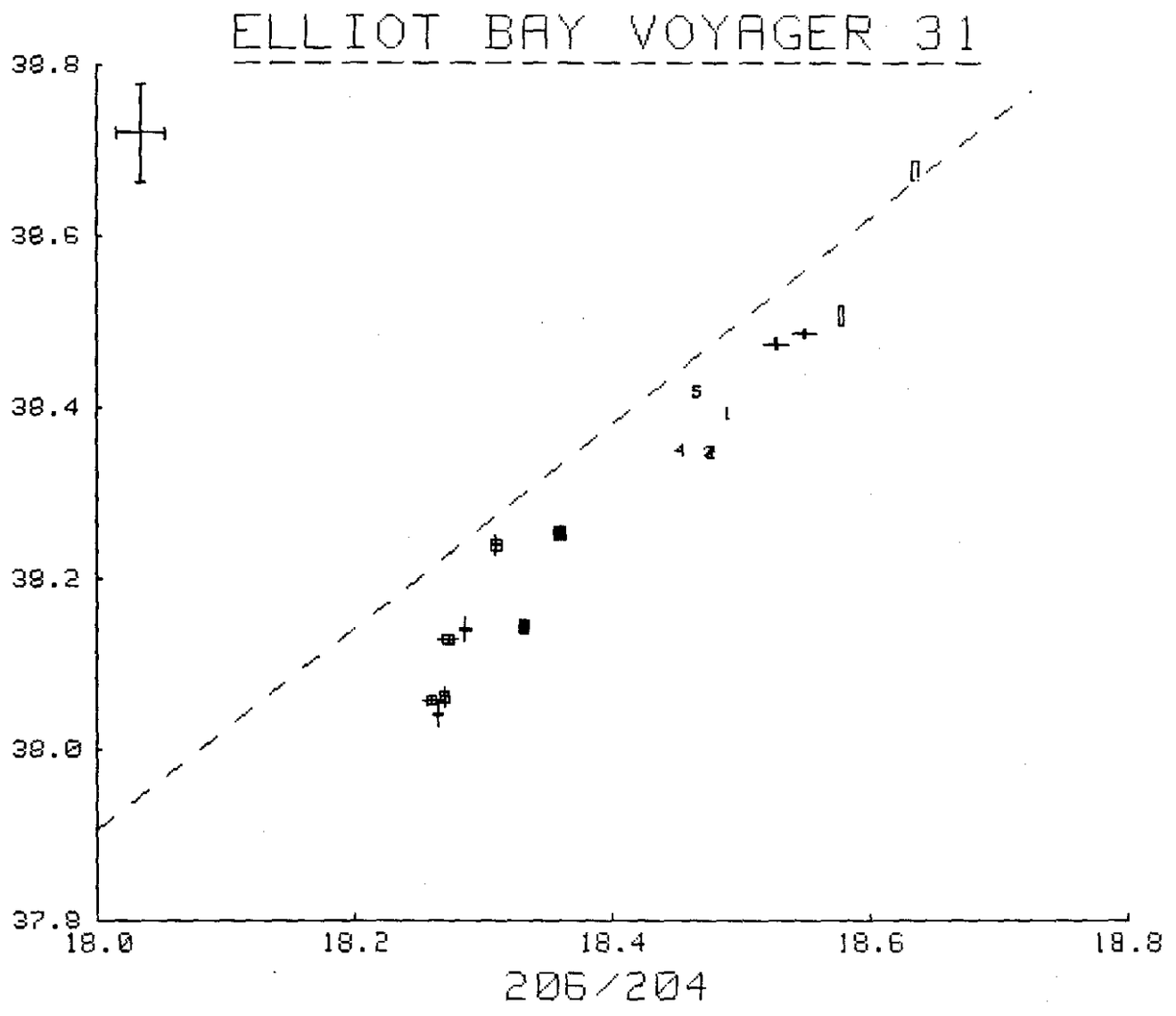
COEFF. OF VARIATION= .89213 0 DELETIONS
SLOPE= .66921 Y INTERCEPT= 25.955 MEAN X= 18.364 MEAN Y= 38.244
INTERSECTION AT T= .375 X=18.1870 Y=38.1260



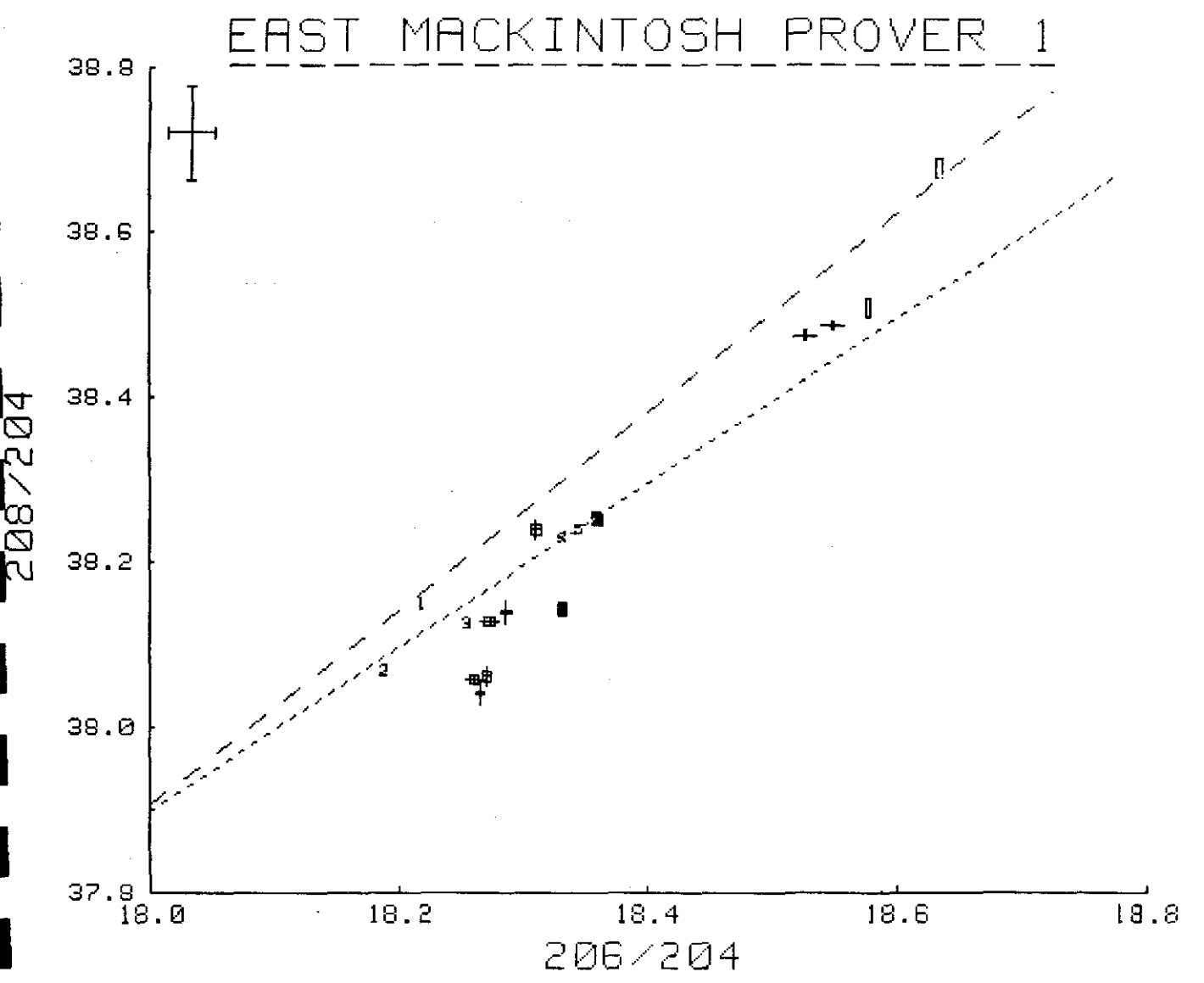
COEFF. OF VARIATION= .70988 0 DELETIONS
SLOPE= 2.2999 Y INTERCEPT=-3.7414 MEAN X= 18.176 MEAN Y= 38.06
INTERSECTION AT T= .353 X=18.2250 Y=38.1710



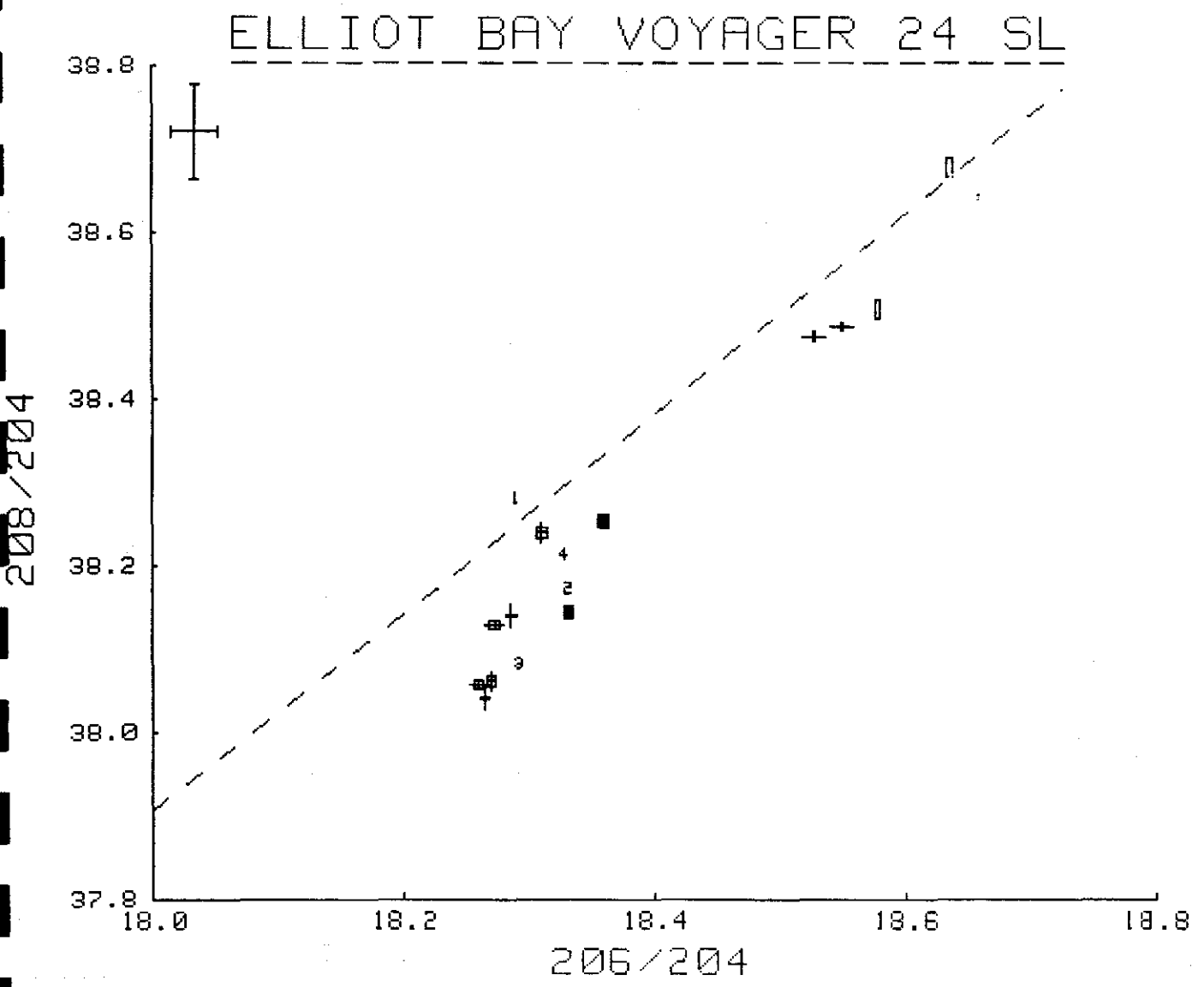
COEFF. OF VARIATION= .15515 0 DELETIONS
SLOPE= .36994 Y INTERCEPT= 31.538 MEAN X= 18.472 MEAN Y= 38.371
INTERSECTION AT T= .276 X=18.3580 Y=38.3290



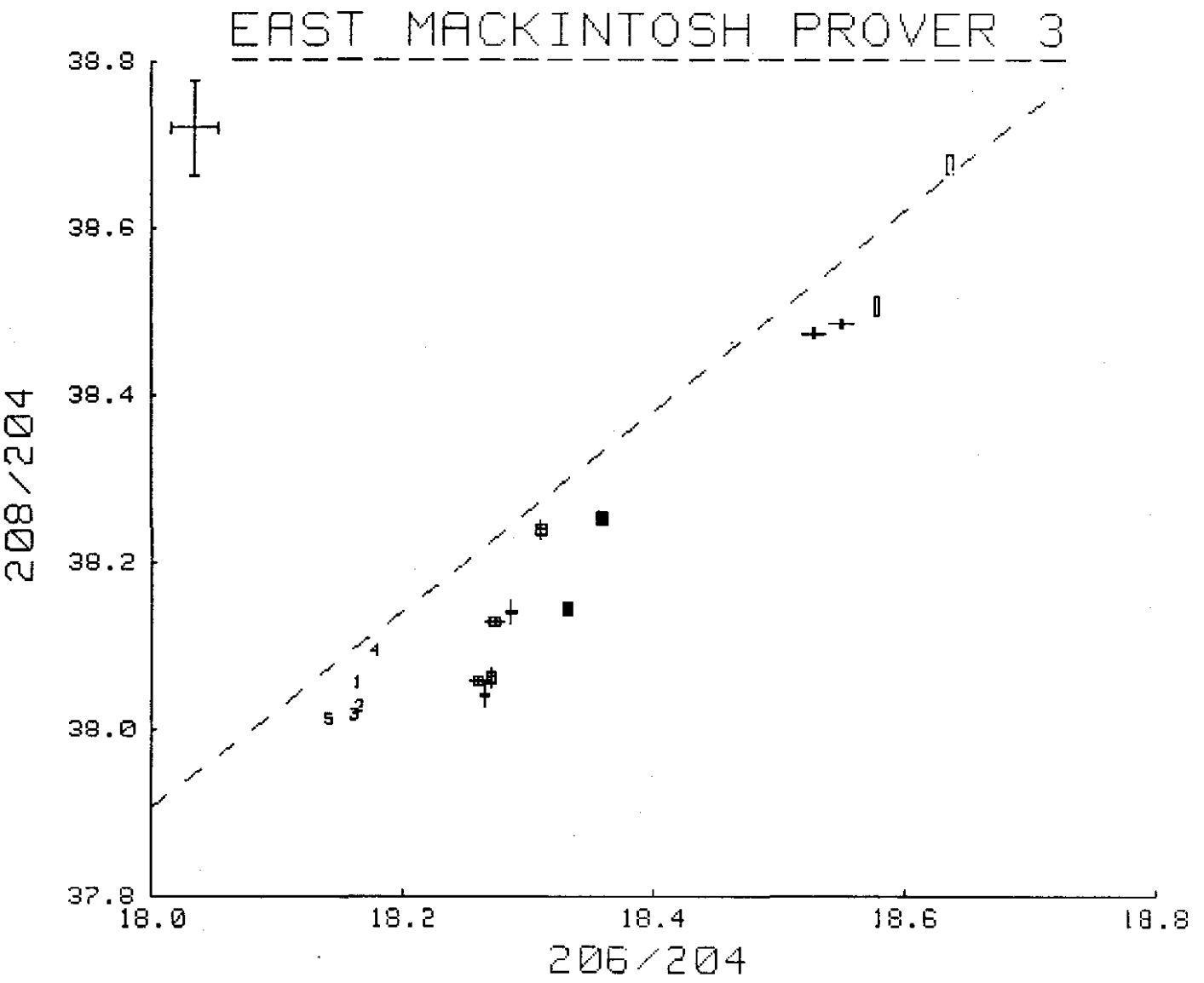
COEFF. OF VARIATION= .94493 0 DELETIONS
SLOPE= .99066 Y INTERCEPT= 20.067 MEAN X= 18.267 MEAN Y= 38.163
INTERSECTION AT T=4.032 X=10.5200 Y=30.4880
INTERSECTION AT T= .508 X=17.9540 Y=37.8530



COEFF. OF VARIATION= .027553 0 DELETIONS
SLOPE= .10221 Y INTERCEPT= 36.316 MEAN X= 18.31 MEAN Y= 38.188
INTERSECTION AT T= .348 X=18.2330 Y=38.1820



COEFF. OF VARIATION= .79513 0 DELETIONS
SLOPE= 2.0411 Y INTERCEPT= .97225 MEAN X= 18.162 MEAN Y= 38.042
INTERSECTION AT T= .352 X=18.2270 Y=38.1740


EAST MACKINTOSH PROVER 3
208/204
206/204
38.8
38.6
38.4
38.2
38.0
37.8
18.0
18.2
18.4
18.6
18.8
1
2
3
4
5