Bergvesenet

Postboks 3021, N-7441 Trondheim

Rapportarkivet

Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
5506				

Kommer fra ..arkiv	Ekstern rapport nr	Oversendt fra	Fortrolig pga	Fortrolig fra dato:
Ni&Ol	R 054/03	Ni&Ol		

Tittel

OMS-logg Test Survey at Nikkel & Olivin A/S, 24. - 26.10.1995

Forfatter	Dato	År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Letho, Jukka	18.12	1995	Outokumu Metals & Resources for Ni & Ol

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Ballangen	Nordland		13311	Narvik

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Geofysikk		Bruvannsfeltet Råna Østmalmen Vestmalmen

Råstoffgruppe	Råstofftype
Malm/metall	Ni, Cu

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

OMS er et geofysisk borhulls-loggesystem som måler gamma-gamma, naturlig gamma, sp.v., magn. susept. og el. (indusert) ledningsevne.
Her er benyttet gamma-gamma, magn. susept. og indusert ledningsevne, alt logget inn på felt-PC.
Målingene er utført i borhull på Vestmalmen, både i kjernehull og i slamborhull.

Resultatet er at alle måletyper, unntatt naturlig gamma, viser klare sammenhenger med Ni-innhold.
Testene viser at OMS-logg kan benyttes til å avgrense malmen både i kjernehull og muligens også i slamborhull.
det er potensiale til å bestemme malmgrensene innen +- 0,05% Ni, når en er godt vant til å benytte utstyret og når en er nøyaktig i forhold til bruken og geologiske data. kalibrering er viktig.

outokumpu metals & resources

Jukka Lehto/rst 18.12.1995

OMS-LOGG TEST SURVEY AT NIKKEL OG OLIVIN A/S

24.-26.10.1995

OMS-logg

OMS-logg system has been designed for fast determination of ore contacts and grades in mine planning.

- *minimize dilution and ore loss*
- *reduce expensive core drilling*
- *reduce sampling and assay costs*
- *get analyzing results at once*

outokumpu metals & resources **TIEDOTE** **MESSAGE**

J. Lahti 28.12.95

Vastaanottaja Addressee	Tiedokaisaaja tai huomautukset Copy to or comments
Lisbeth Storhaug	
Nikkel og Olivin	

Viite Reference

☐ Sopimus As per agreement ☐ Puhelu Phone ☐ Telex ☐ Kirje Letter ☐ ☐

Asia Subject

Toimenpide Proceedings

☒ Tiedoksenne For your information ☐ Käsiteltäväksenne For your attention ☐ Hyväksyttäväksenne For your approval ☐ Lausuntoanne varten For your comments

☐ Allekirjoitettavaksenne Please sign ☐ Palautamme We return ☐ Pyydämme palauttamaan Please return ☐

OHS-logg test report.

Wishing a Happy New Year

Liitteet ja allekirjoitus Enclosures and signature

J. Lahti

Postiosoite
Kummunkatu 34, PL 15
83500 OUTOKUMPU

Address
P.O.Box 15
FIN-83501 OUTOKUMPU FINLAND

Puhelin
Vaihde (973) 5561
Ohivalinta (973) 556...

Telephone
National (973) 5561
International +358 73 5561

Telex
121461 outo fi

Telefax
Nat (973) 556 263
Int + 358 73 556 263

Painoin Paino

OMS-LOGG TEST AT NIKKEL OG OLIVIN A/S in 24.-26.10.1995

The OMS-logg system used in test survey comprised

- gamma-gamma probe with Cs137 gamma radiation source (GG)
- natural gamma probe (NG)
- magnetic susceptibility probe (MS)
- inductive conductivity probe (IC)
- GEO-KTP field computer
- KTP-DHI interface unit
- DEPTER depth transducer unit
- cable reel with stiff cable of 150 meters.

Measurements were taken in the new ore body Westmalmen which is of lower grade than the almost finished Östmalmen. OMS-logg has been earlier tested in Östmalmen with somewhat irregular but promising results. Equipment problems occurred also during the measurements at that time. Now the aim was to investigate if OMS-logg is applicable for use in Westmalmen. The equipment has also been upgraded after the previous survey.

At the 100 meter level 8 diamond drill holes and 3 sludge holes were measured. Core assays of nickel is reported intervals and assays from sludge holes at 90 cm intervals are available. A lot of holes were tried but some of them were blocked. Measurements were taken at every 10 cm along the holes. Test survey was carried out and results processed by Jukka Lehto MTG/OMR and Martti Liimatainen OKME/FINNMINES. The contact person at the mine was Lisbeth Storhaug.

RESULTS

Most holes were measured twice, once when pushing in the probe and again when pulling it out. The results show that both logs have the same response, although the signal level of MS and IC is very low and the count rate variation of GG is very small. So the variation is caused by characteristics of the rock and not by instability or noise of the instrument.

A. Diamond drill holes

A.1. Gamma-gamma results

The processed gamma-gamma results are presented in Appendix 1.

In scattering diagrams in fig. 1-3 (App.1) the GG counts have been integrated according to assay intervals of core and plotted against Ni assays of core added with the calibration curve used for drawing calibrated GG results. The correlation is surprisingly good. The deviation of all holes is mostly less than ±0.1% Ni and for horizontal holes better than ±0.05% Ni. The hole 530 behaves differently and closer look shows that correct calibration curve for it would be the dashed line in fig.3 (App.1). The reason for that could be smaller diameter of the hole.

The calibrated GG Ni% profiles fit nicely with the core assays in fig. 4-12 (App.1) above 0.3% Ni which has generally been the analysis limit of core. Two different calibrations used for hole 530 in fig 11 and 12 (App.1). In *per, opy* and *nor* rocks in NO's notations GG-measurement has a good potential for use in ore boundary detection in Nikkel og Olivin in drill holes.

The main risk is that 0,1% unit change in Ni content represents only the change of about 4% in GG counts, which means that although the variation along the hole can be reliably measured the basic level of count rate may be affected by changes in hole diameter.

A.2. Magnetic susceptibility results (MS)

Susceptibility response is very sharply peaked (App. 5) what means that small depth error between core assays and logging results may cause significant variation when core assays are plotted against MS values. Before further processing the voltage drift in each MS profile has ben corrected by adjusting the minimum measured values to zero voltage. Corrections have been from 6mV to 8mV (fig2,App.2), when the difference of minimum and maximum values in MS-logs are 2-3mV. So the drift correction is critical when interpreting the results. Calibration curve is drawn according to hole 485 (fig5, App.2) where the variation is within 0.1% Ni.

Calibrated MS Ni% profiles follow rather well assay histograms in fig. 3-8 (App,2) except the hole 480. It is obvious by looking at the fig. 2 and 3 that the used voltage drift correction method is not applicable in this hole, because there is no real zero Ni% value in the hole. If the base line is shifted 1 mV the points will be in the middle of calibration curve. The correct procedure for baseline adjustment should be registering the base line voltage when starting and finishing the measurement of hole and using these values for correction.

In the hole BH530 (fig.8, App.2) there is highly conductive zone from 26,5 to 29,5 meter, which makes MS result zero (actually negative).

A.3. Electrical conductivity results (IC)

The scattering diagram of all IC measurements (fig.1,App.3) shows that conductivity response in a way wakes up at the level of 0.5% Ni, although below 0,5% there is also some response. The base line drift is corrected for each hole varying between 3mV and 5,4mV (fig2, App.3). Drift voltage is again quite high compared to signal variation along the hole which is less than 1 mV. So the drift correction is extremely critical. Fortunately in IC-logs there are non-conductive zones in each hole.

The calibrated results are presented using 0,45% Ni as the threshold level meaning that only the values above it has been drawn. There is very clear correlation with assay histograms. There are very conductive zones in BH530 (fig.8, App.3) at 12-13m with Cu analysis of 0.12% and at 26,5-29,5 without Cu analyzed.

A.4. Rock type classification

The measured gamma-gamma counts are classified according to rock types based on geologists's report using Nikkel og Olivin's rock codes (App.4). The number in codes refers to Ni% so that for instance *per 5* means peridotite with more than 0.5% Ni. The integrated GG count rates in different zones vary logically; with higher Ni content the number of counts is lower. Notice that the changes are only a few hundreds in total count rates of about 10 000 cps.

Very narrow zones can be identified with GG counts, see holes BH481,510 and 511 (App.4). Reported pegmatite gang zones in hole 485 (fig.3, App.4) at 18,60-18,65 m and 26,65-26,75 m can be seen as sharp peaks as well as the talk zone of 5 cm at 21,45-21,50 in hole 481. Strong variation in the lower part of hole BH530 is probably caused by fractures.

For comparison also susceptibility profiles are plotted in figures of Appendix 4.

A.5. Unprocessed results of drill holes

The raw results of all probes in each hole are plotted in the same picture in Appendix 5. So all methods can be compared with each other.

Natural gamma radiation has been measured only in the holes 481,485 and 496. Count rate is almost zero with few very low peaks of about 30 cps, which does not give much additional information.

B. Sludge holes

Three sludge holes were measured from which only hole K10082 had reasonable variation in Ni content. Unprocessed results are presented in App.6. Proper calibration based on sludge assays is impossible at this low Ni level, but may be used for evaluating the trends.

Gamma-gamma counts have been inverted to Ni% in fig. 1-4 (App.7). Separate inversion curve has been used for K10082 (fig.4, App.7) because of bigger hole diameter. The form of profiles has substantial coherence with sludge assay histograms especially in hole K10082, although only 1.3%

change in count rate represents 0,1% unit in Ni content. Still better coherence can be seen in fig.5 (App.7) where MS log in mV is compared to sludge Ni assay.

Conductivity probe behaves as in drill holes waking up at about 0,5% Ni (calibration curves in fig. 6, App.7). The profiles drawn with 0,45% Ni threshold level show surprisingly good correlation with sludge assay.

The correct way to calibrate the OMS-logg for sludge holes is to ream the diamond drill hole to sludge hole and to compare the OMS-logg results from reamed hole to the core assay. This procedure has been successfully used for instance in LKAB Malmberget and OK Tara.

CONCLUSIONS

The test material has been processed very thoroughly because nickel content in the ore is so low. The results show that all methods except NG had clear response to Ni content. The application is very close to the limits of the equipment. The main error sources are variation in hole diameter in GG and voltage drift in MS and IC caused by temperature change or instability of the probe.

From the results it seems that OMS-logg could be used for ore delineation in Nikkel og Olivin in diamond drill holes and probably in sludge holes, too. To be on safe side at least two or rather all three methods should be applied. To make sure the performance in percussion drill holes more test measurements should be carried out.

There is potential for determining the ore boundary within +-0.05% Ni by experienced user with proper calibration, careful execution of logging and utilization of several methods plus geological data. The calibration should be continuously maintained by measuring the available drill holes with OMS-logg as well.

APPENDIXES

Appendix	1	Processed gamma-gamma results of drill holes
	2	Processed susceptibility results of drill holes
	3	Processed conductivity results of drill holes
	4	Rock type classification
	5	Unprocessed results of drill holes
	6	Unprocessed results of sludge holes
	7	Processed results of sludge holes

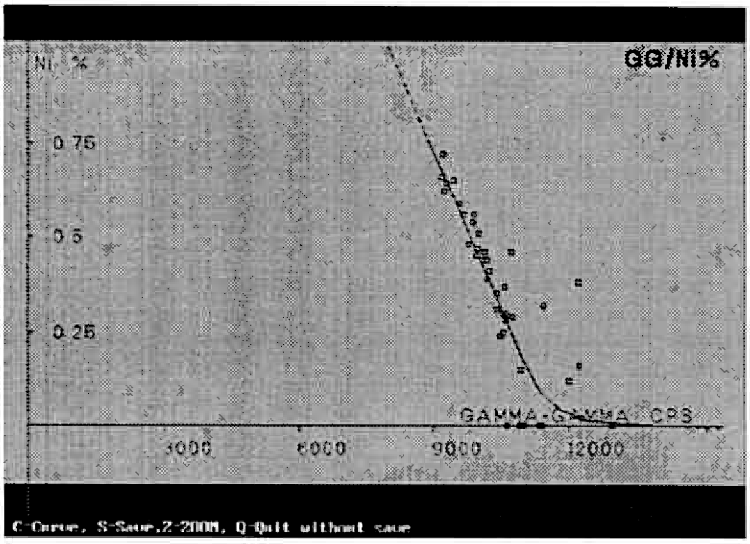
CC Nikkel og Olivin A.S.: Markus Ekberg, Lisbeth Storhaug
MTG: PL, JLe, MJL, Archive
OMR: Circulating PSV, EAus

1

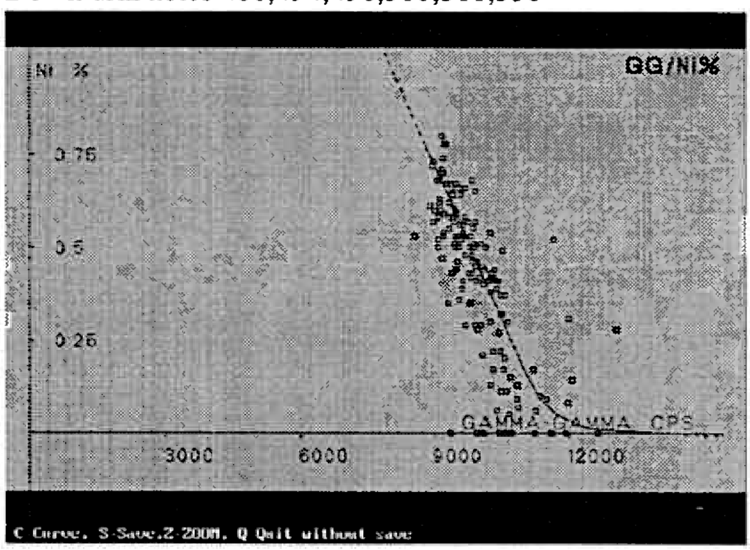
NIKKEL og OLIVIN, GAMMA-GAMMA vs. Ni%
Drill holes

Appendix 1
Fig 1/12

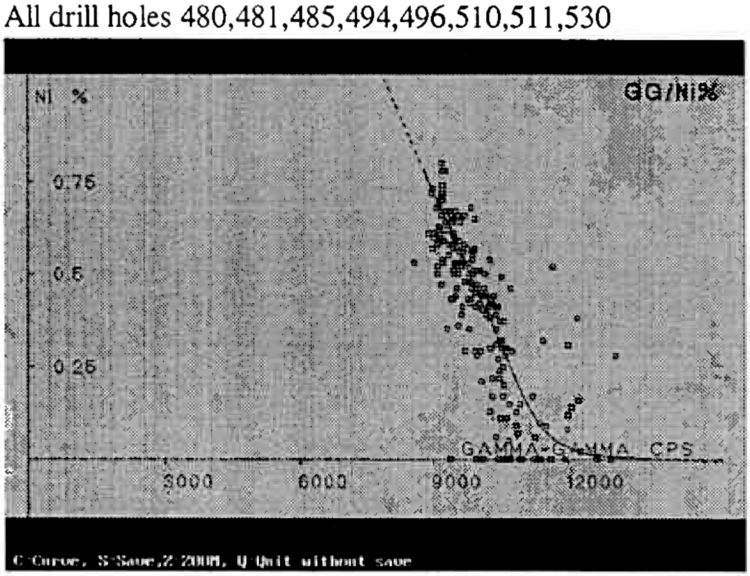
Horizontal drill holes: 481,485



Down drill holes 480,494,496,510,511,530

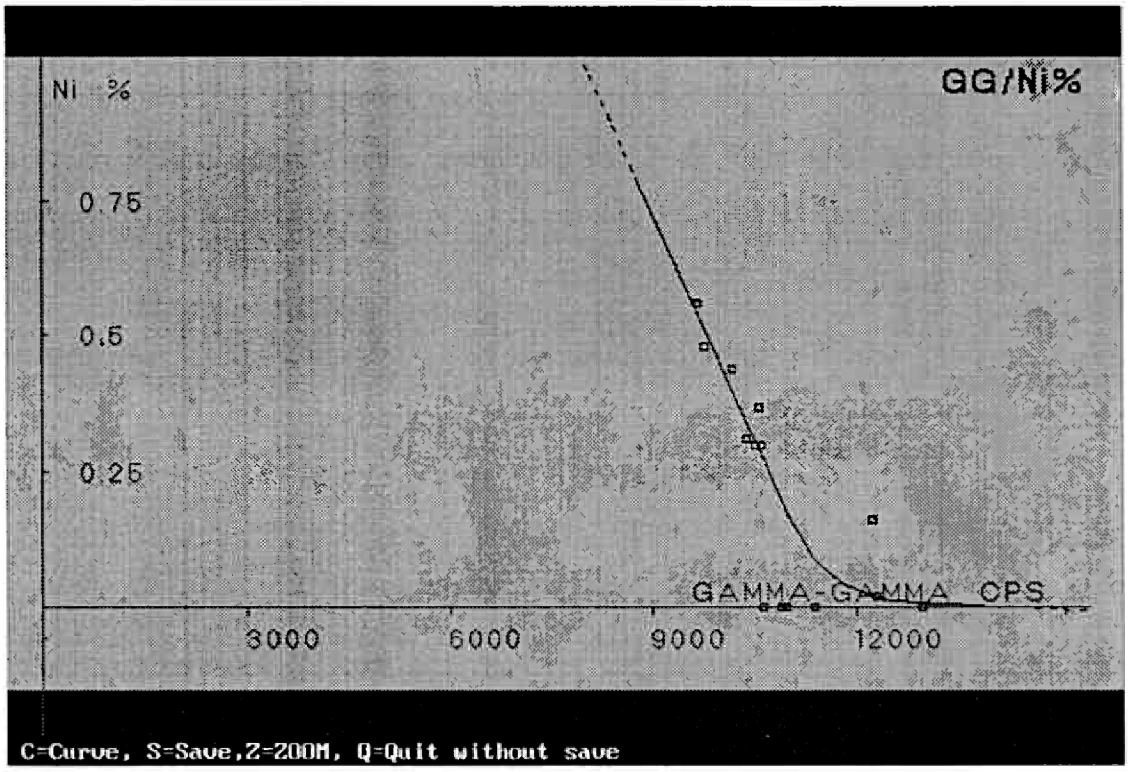


All drill holes 480,481,485,494,496,510,511,530

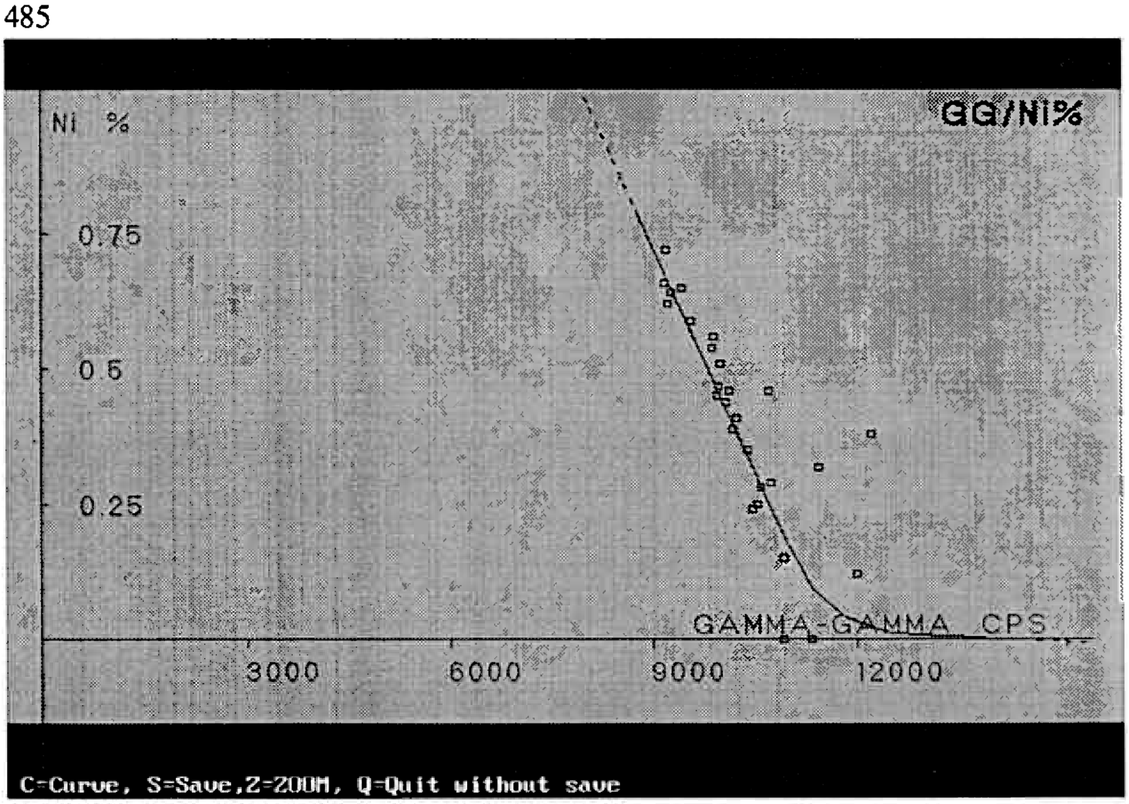


NIKKEL og OLIVIN, GAMMA-GAMMA vs. Ni%
Horizontal drill holes

481



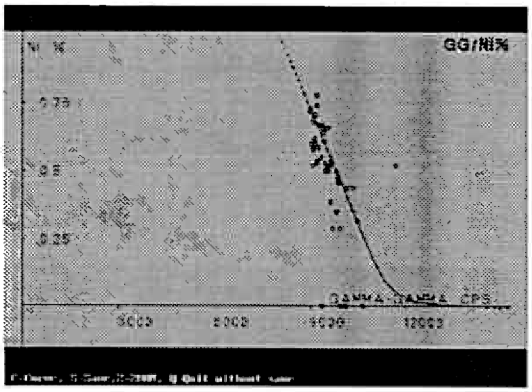
485



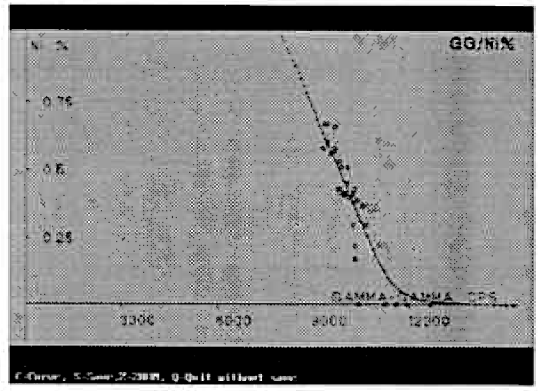
NIKKEL og OLIVIN, GAMMA-GAMMA vs. Ni%
Down drill holes

Appendix 1
Fig 3/12

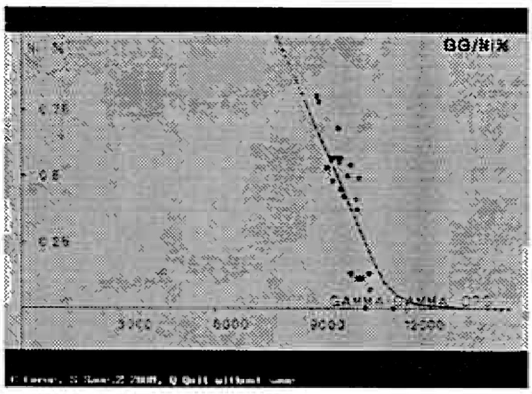
480



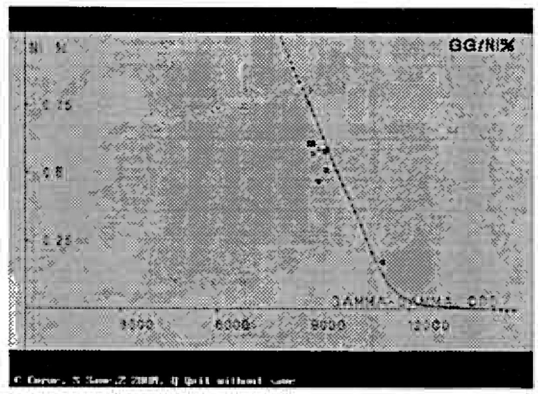
494



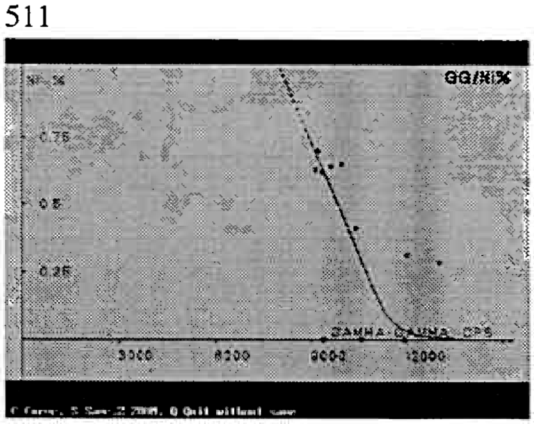
496



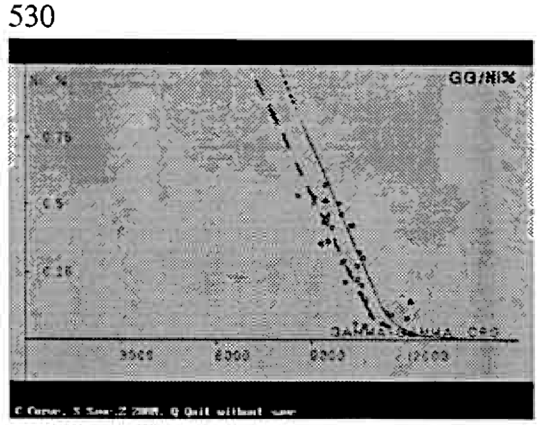
510

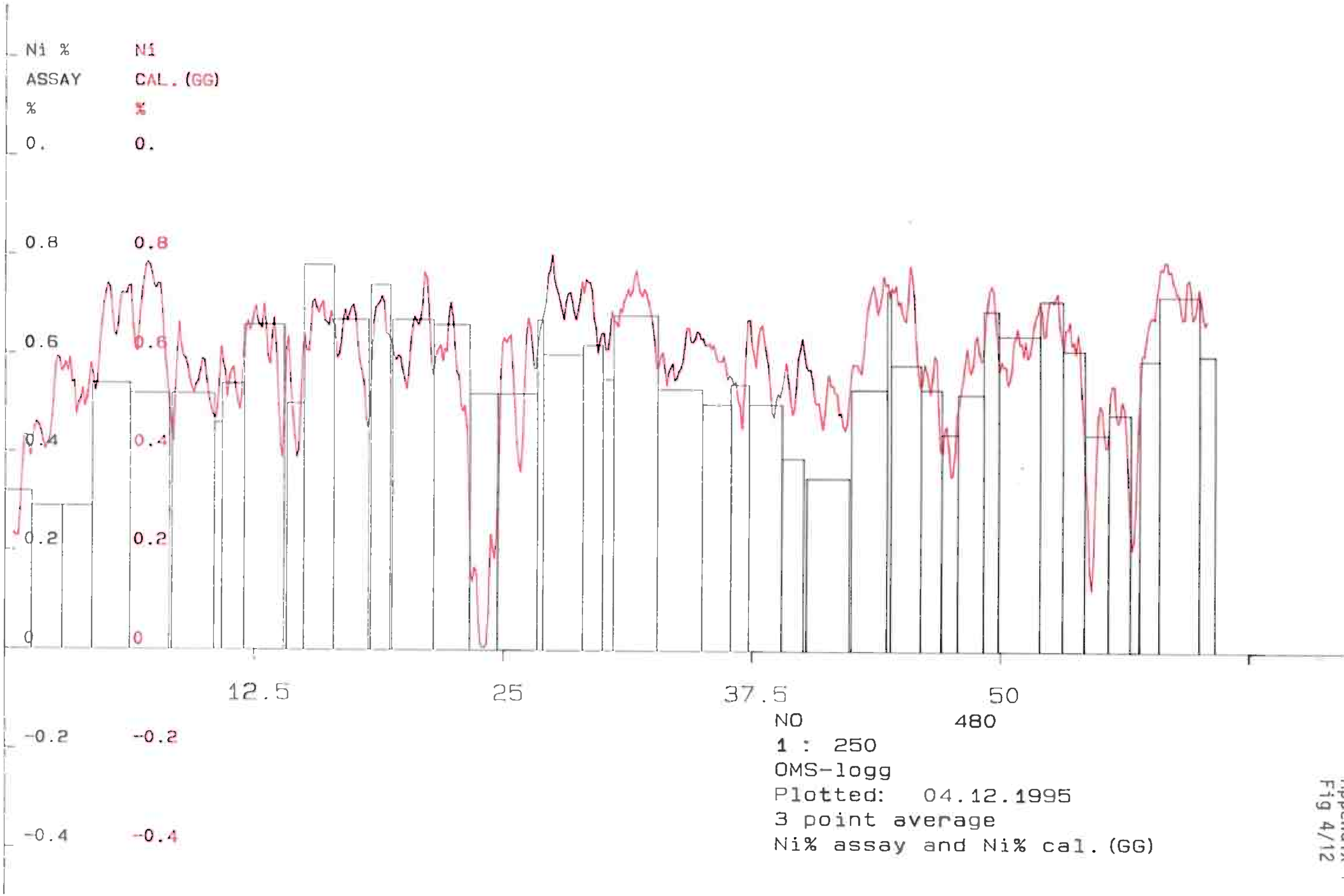


511

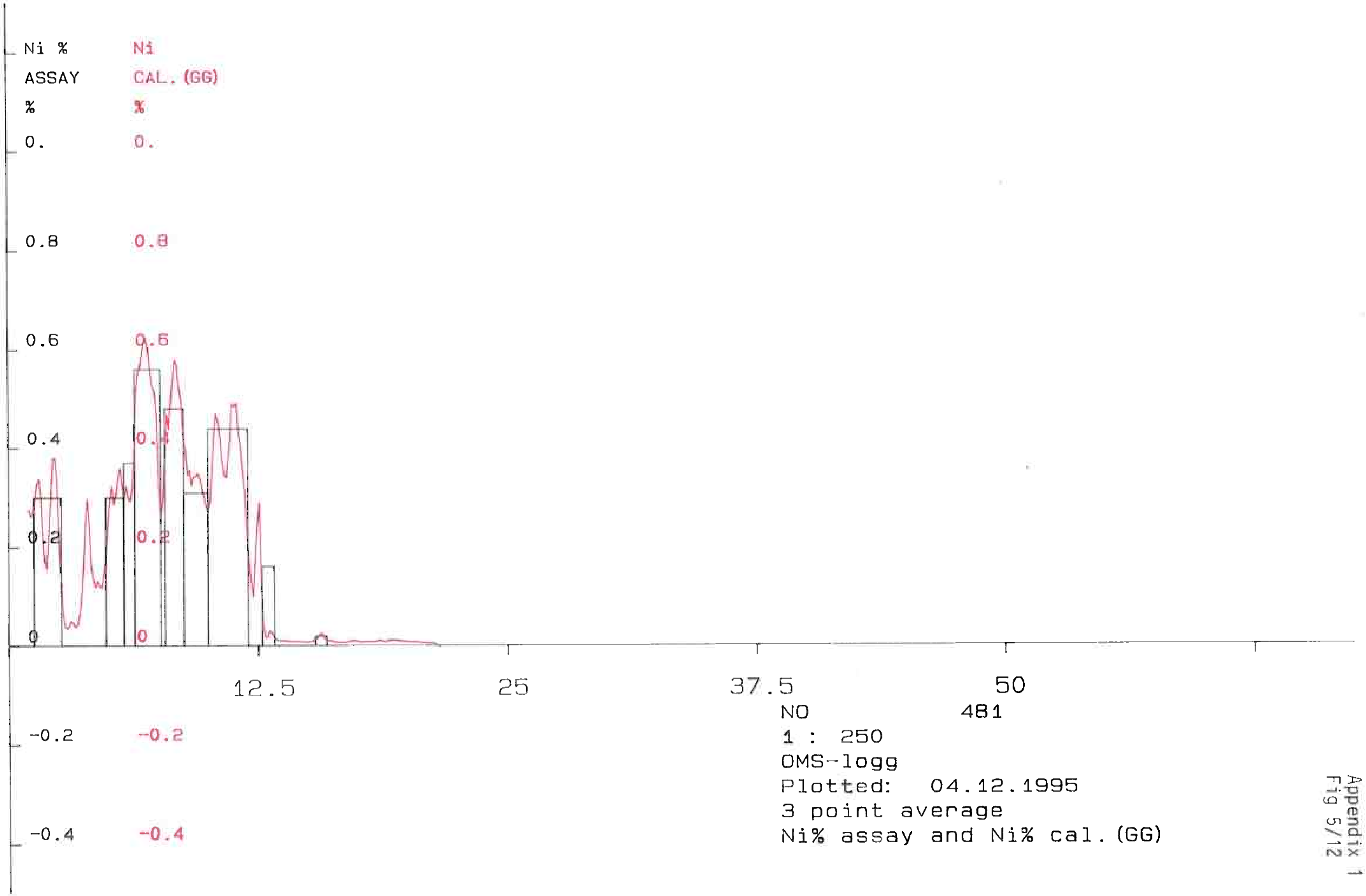


530

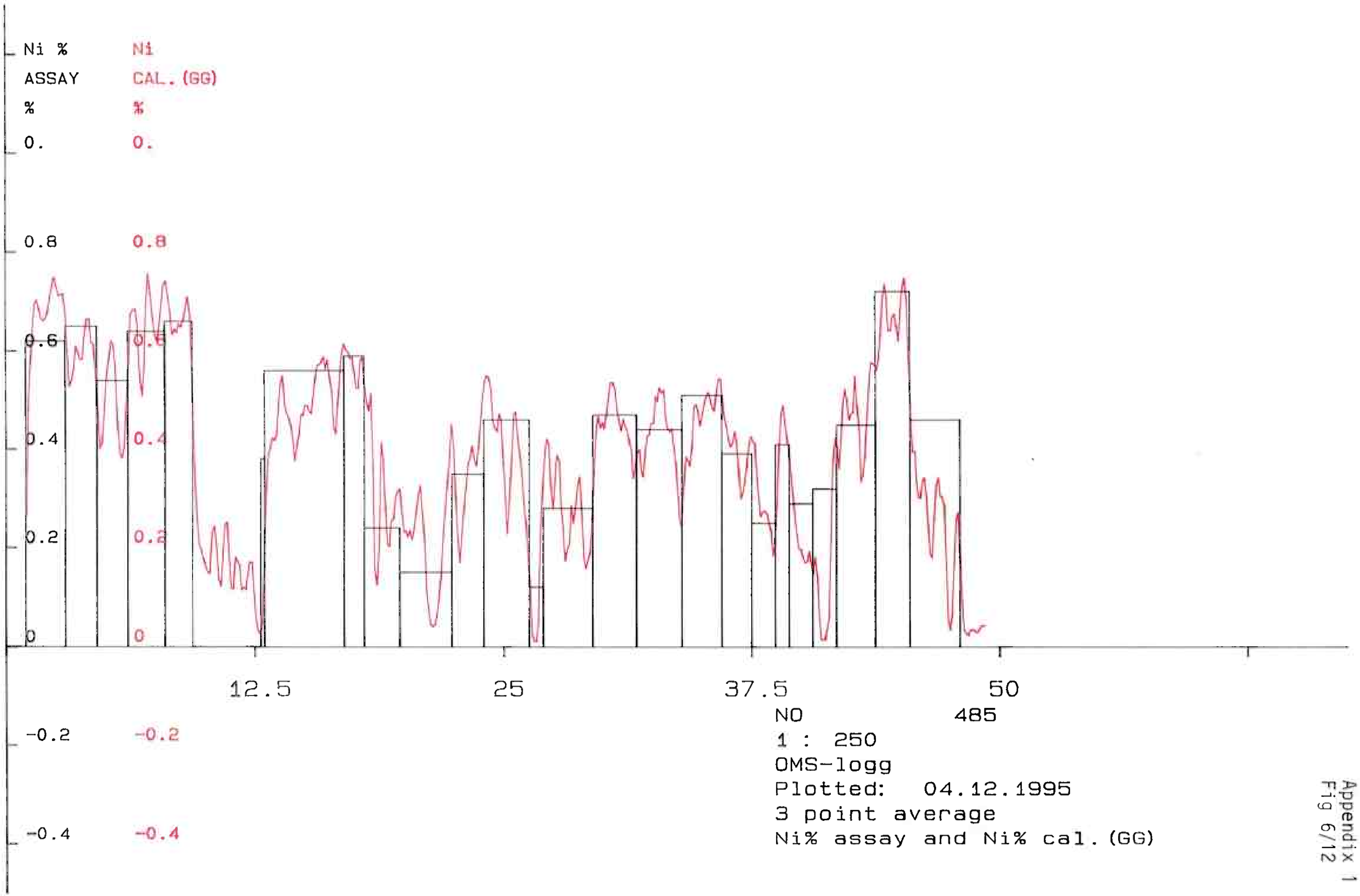




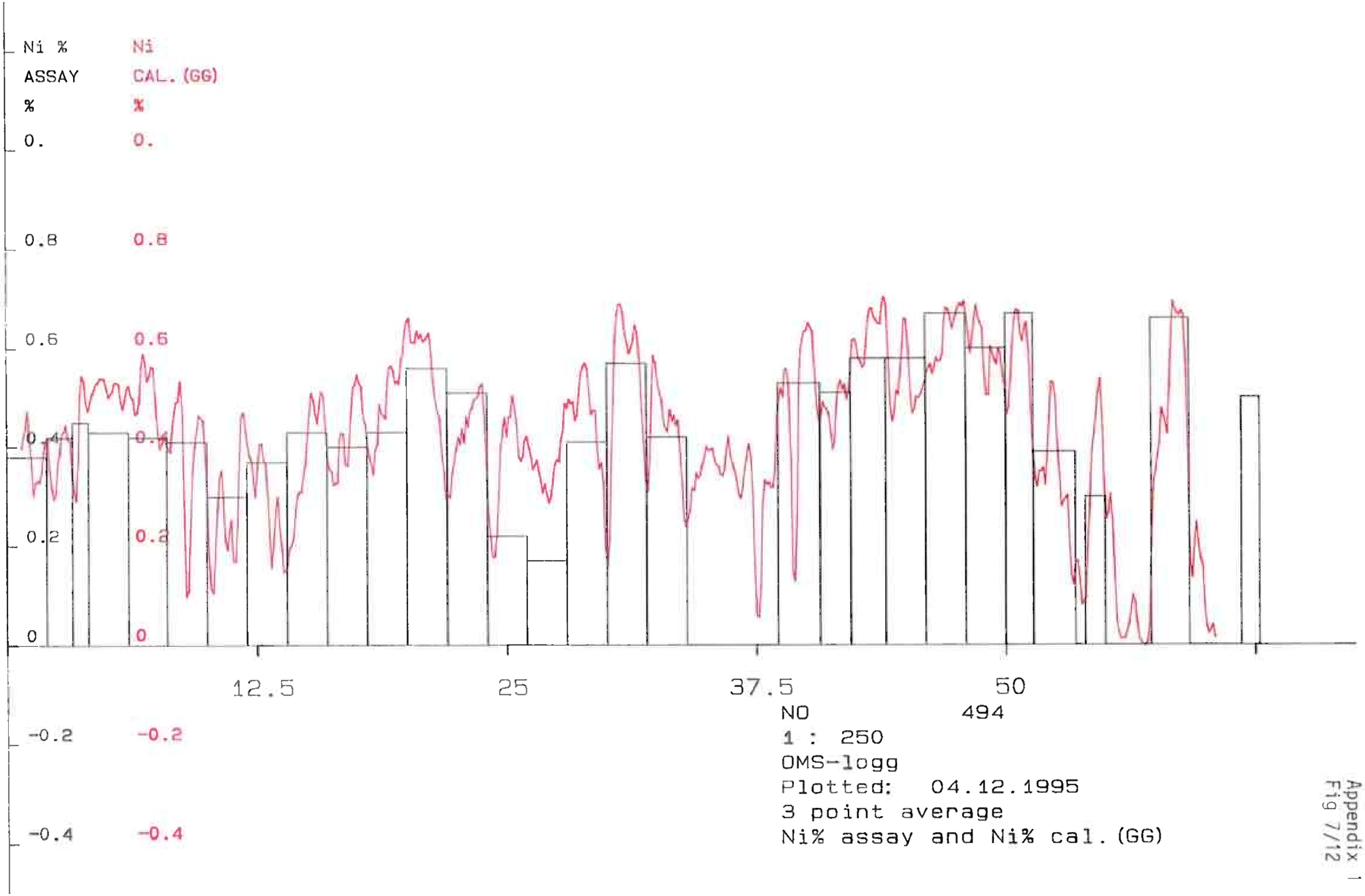
Appendix 1
Fig 4/12



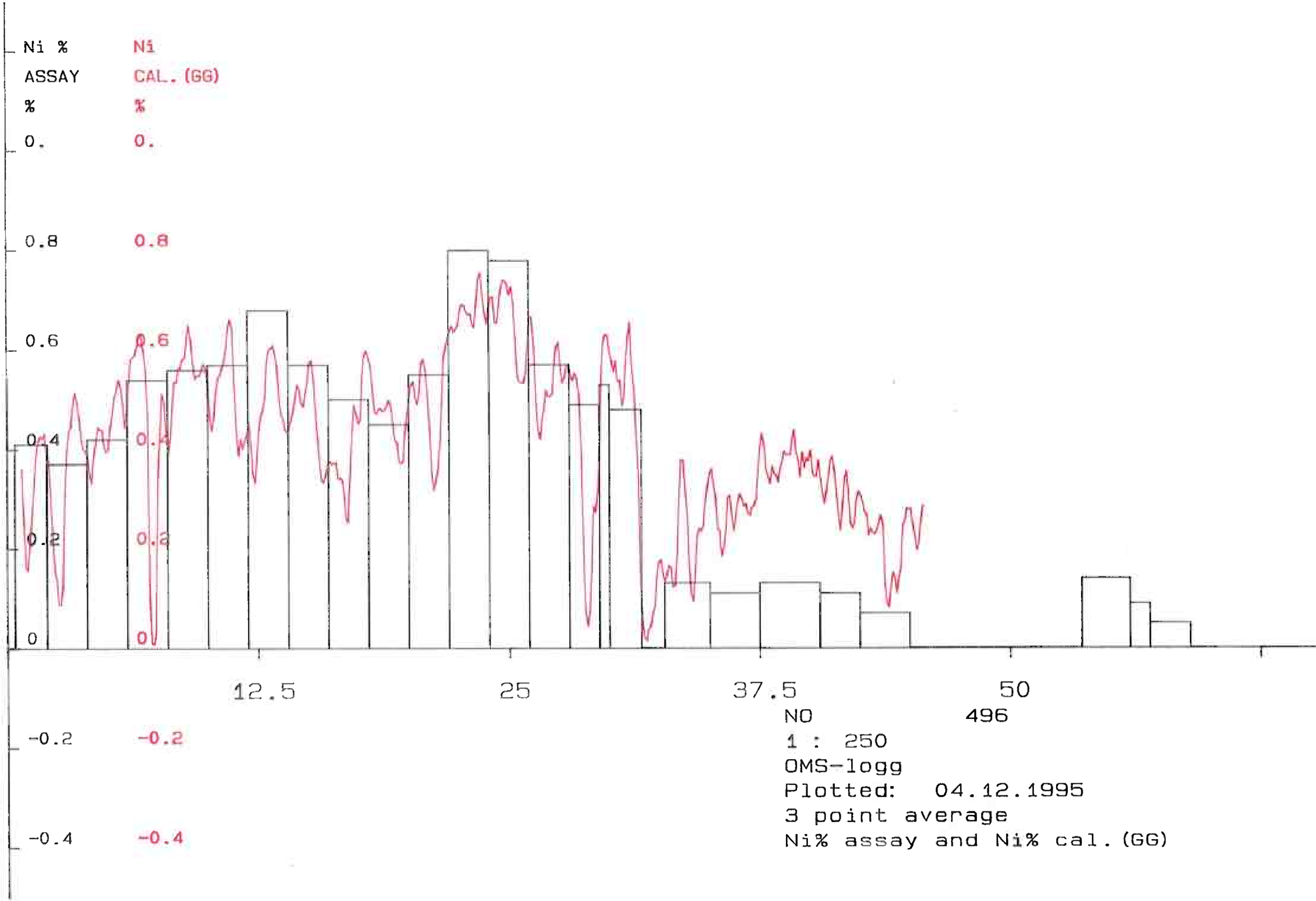
Appendix 1
Fig 5/12



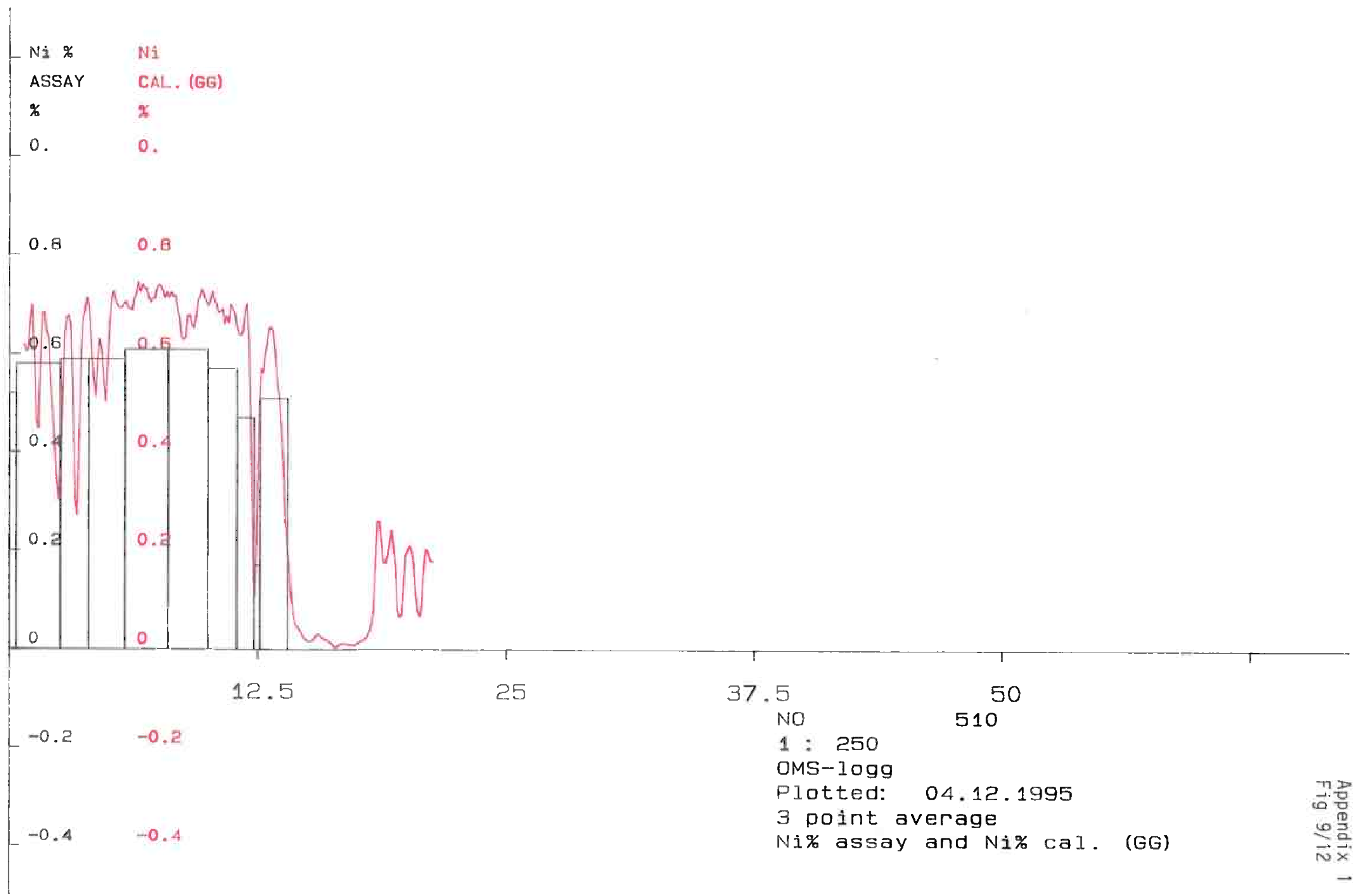
Appendix 1
Fig 6/12



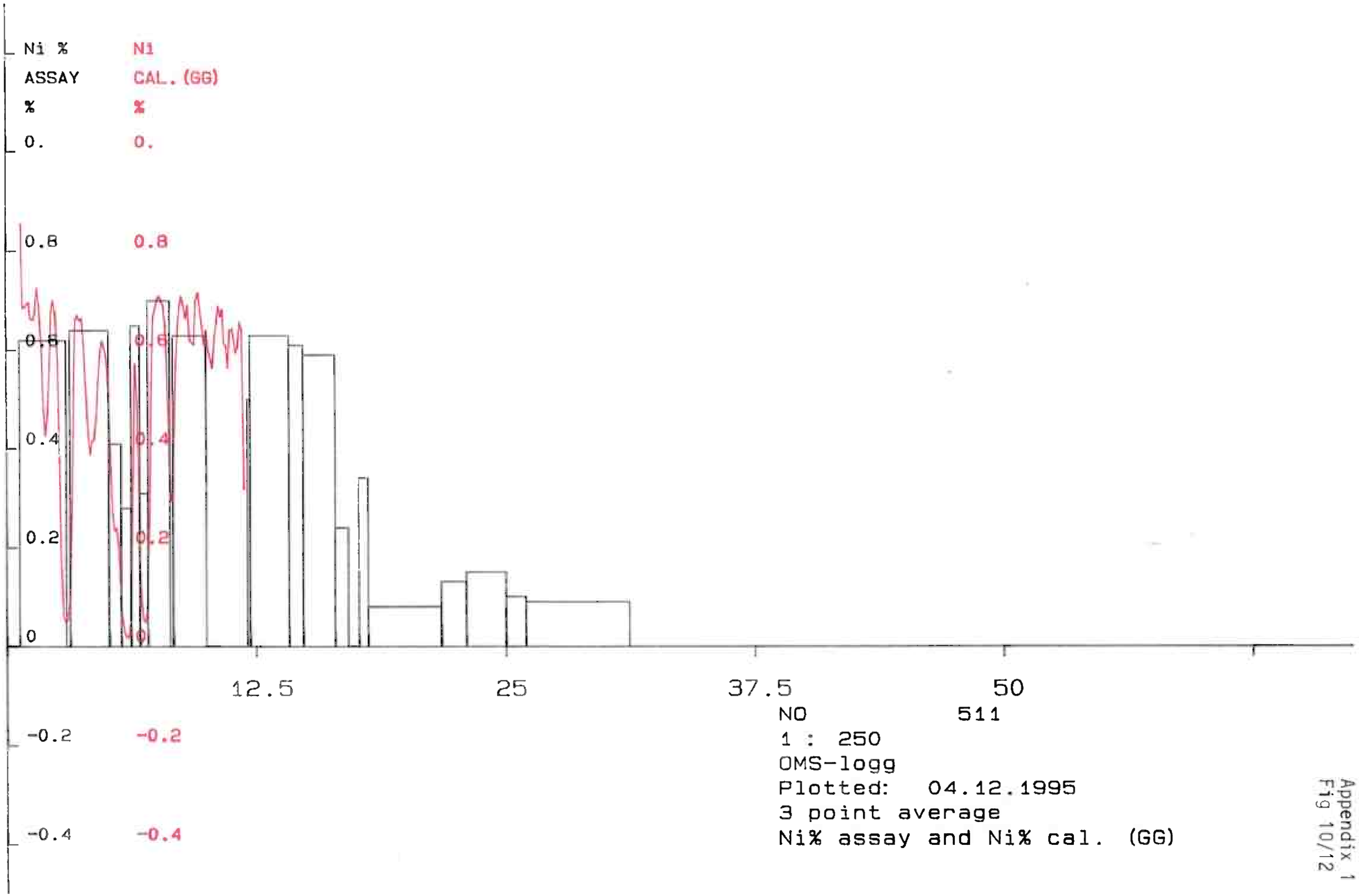
Appendix 1
Fig 7/12



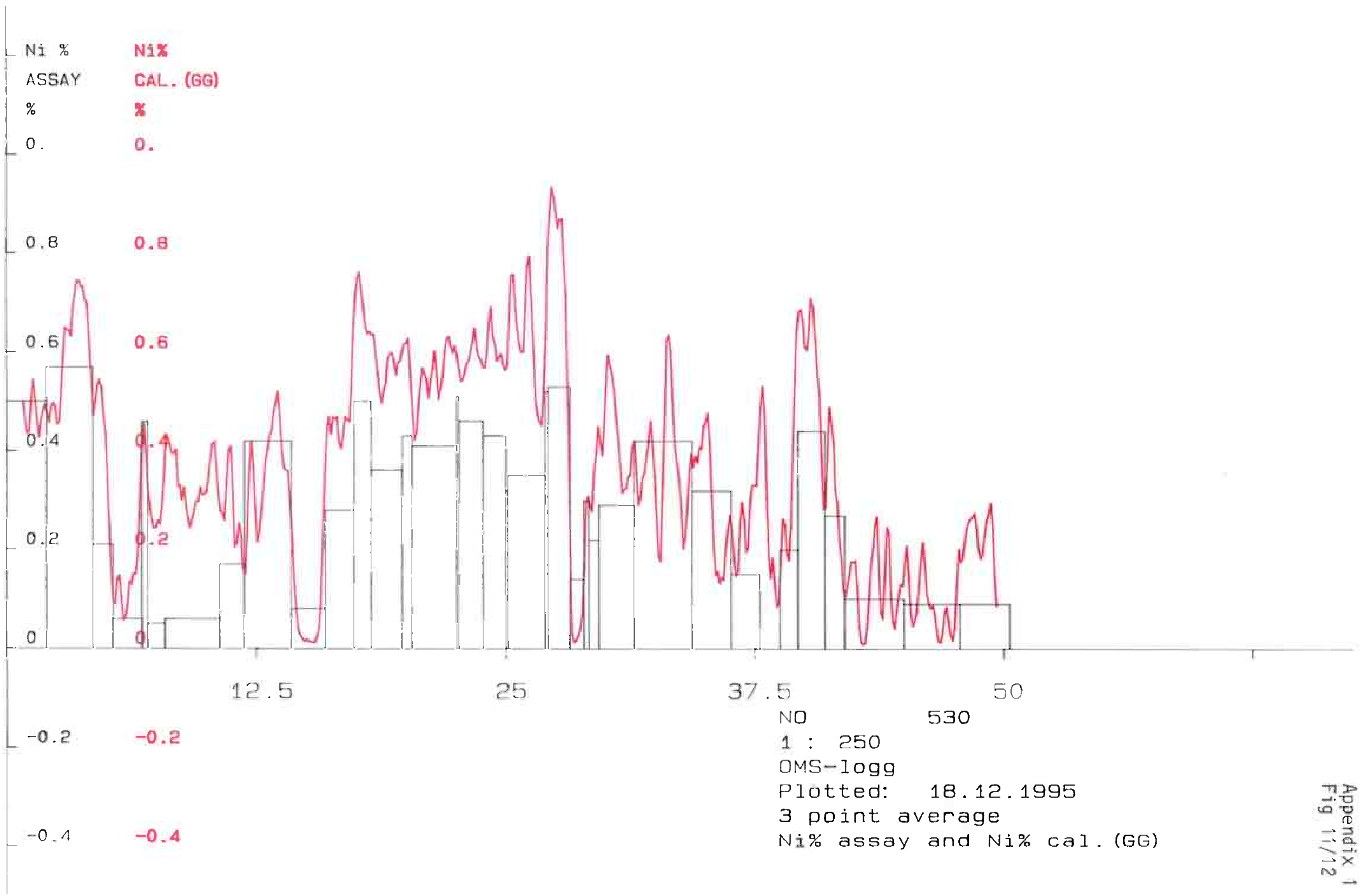
Appendix 1
Fig 8/12



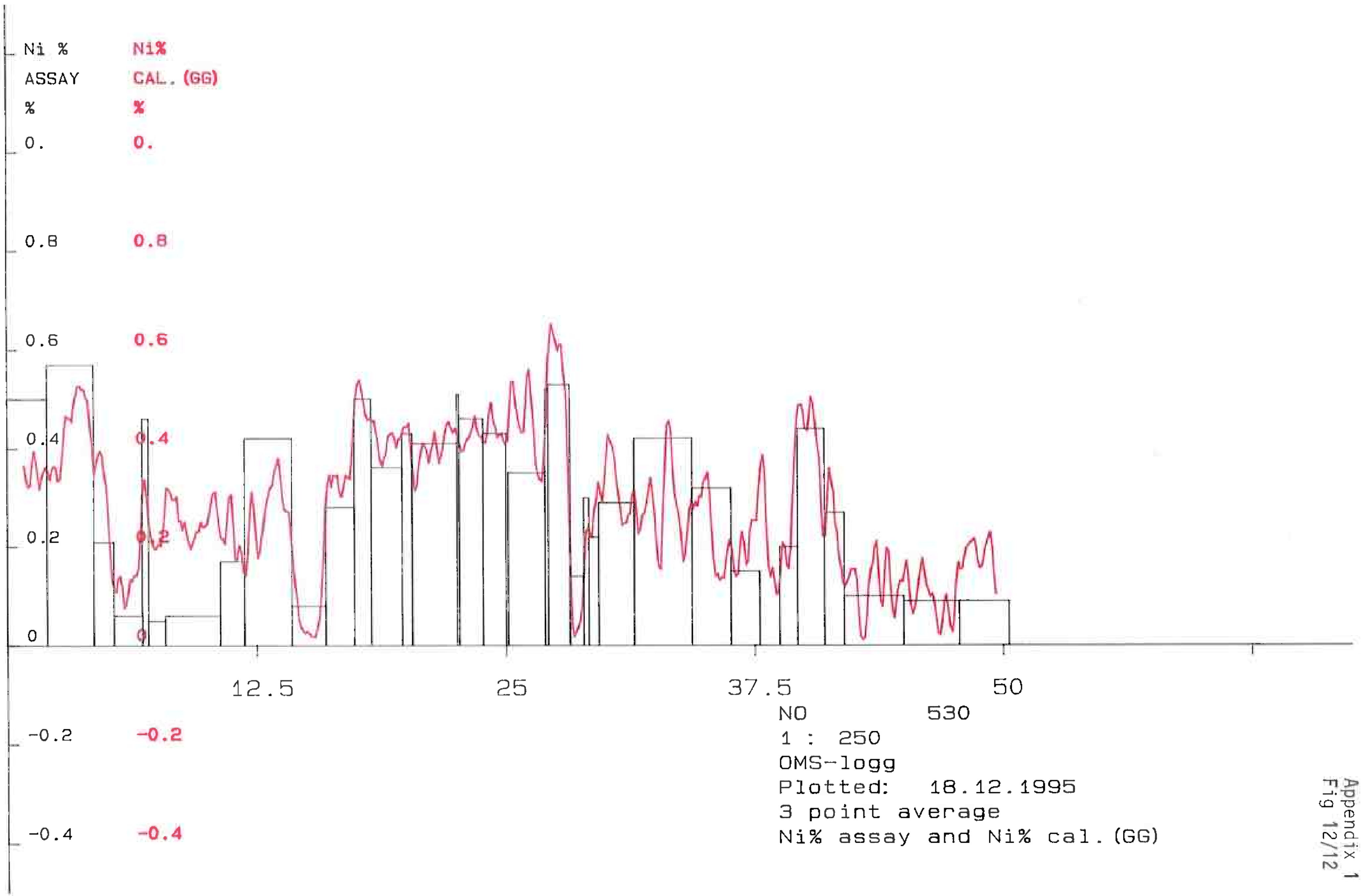
Appendix 1
Fig 9/12



Appendix 1
Fig 10/12



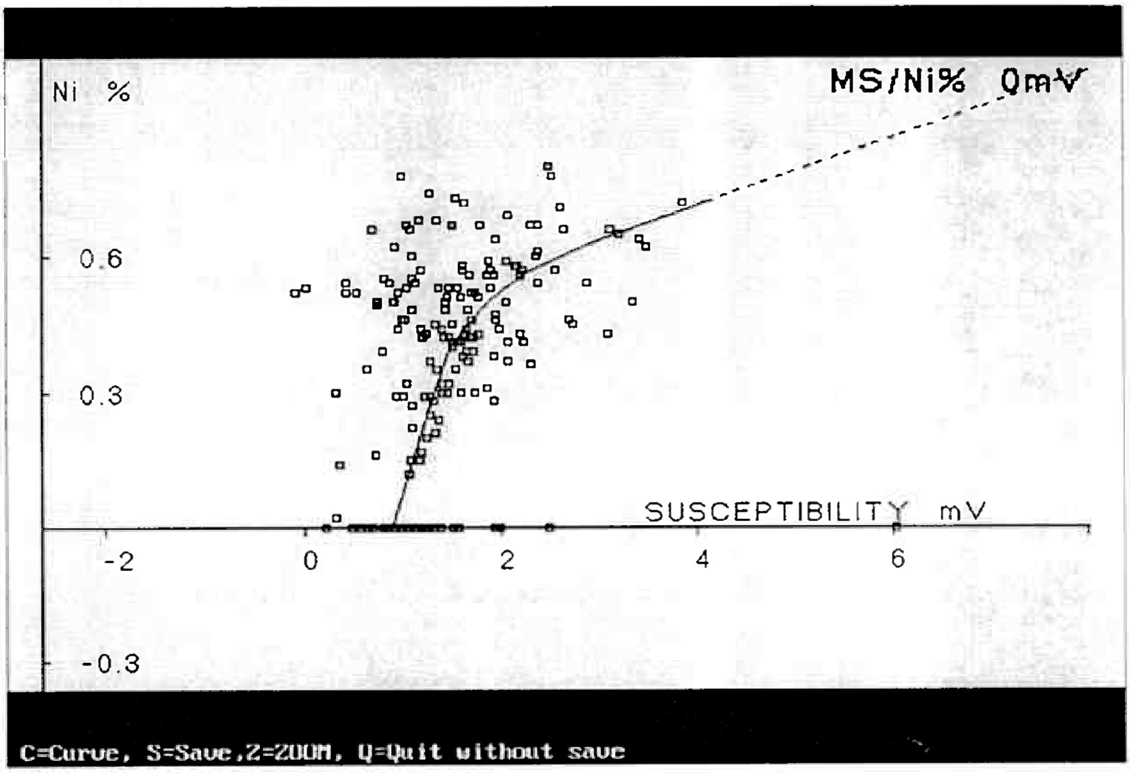
Appendix 1
Fig 11/12



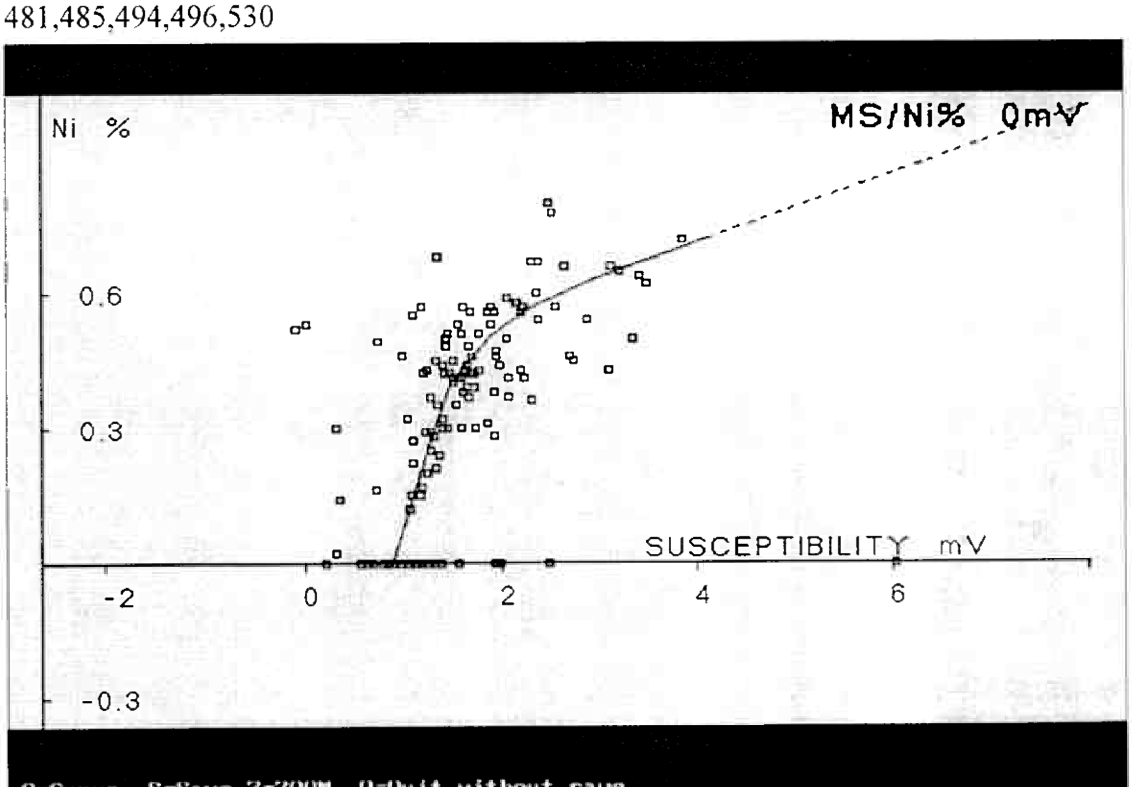
Appendix 1
Fig 12/12

2

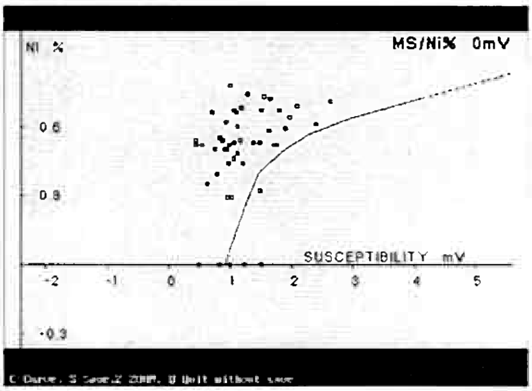
480,481,485,494,496,530



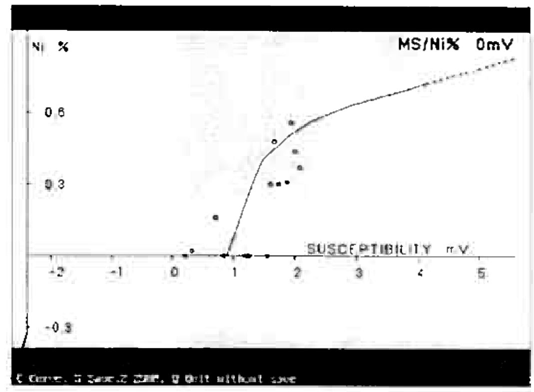
481,485,494,496,530



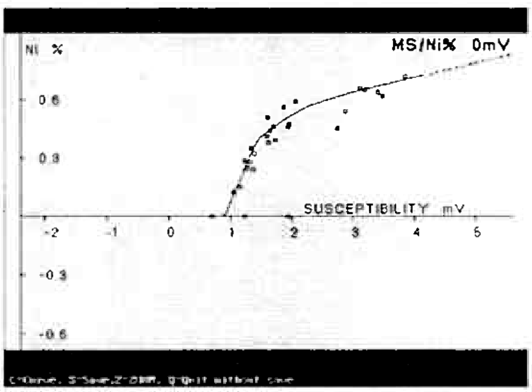
480
7.84 mV...8.0 mV



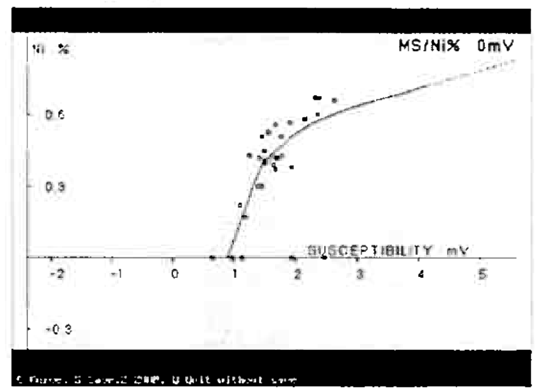
481
5.84 mV...5.84 mV



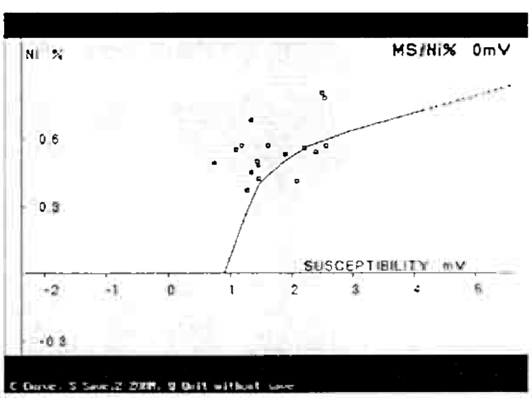
485
5.95 mV...5.68 mV



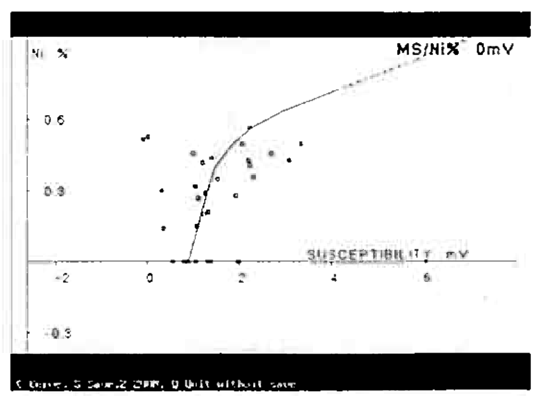
494
7.63 mV...7.32 mV

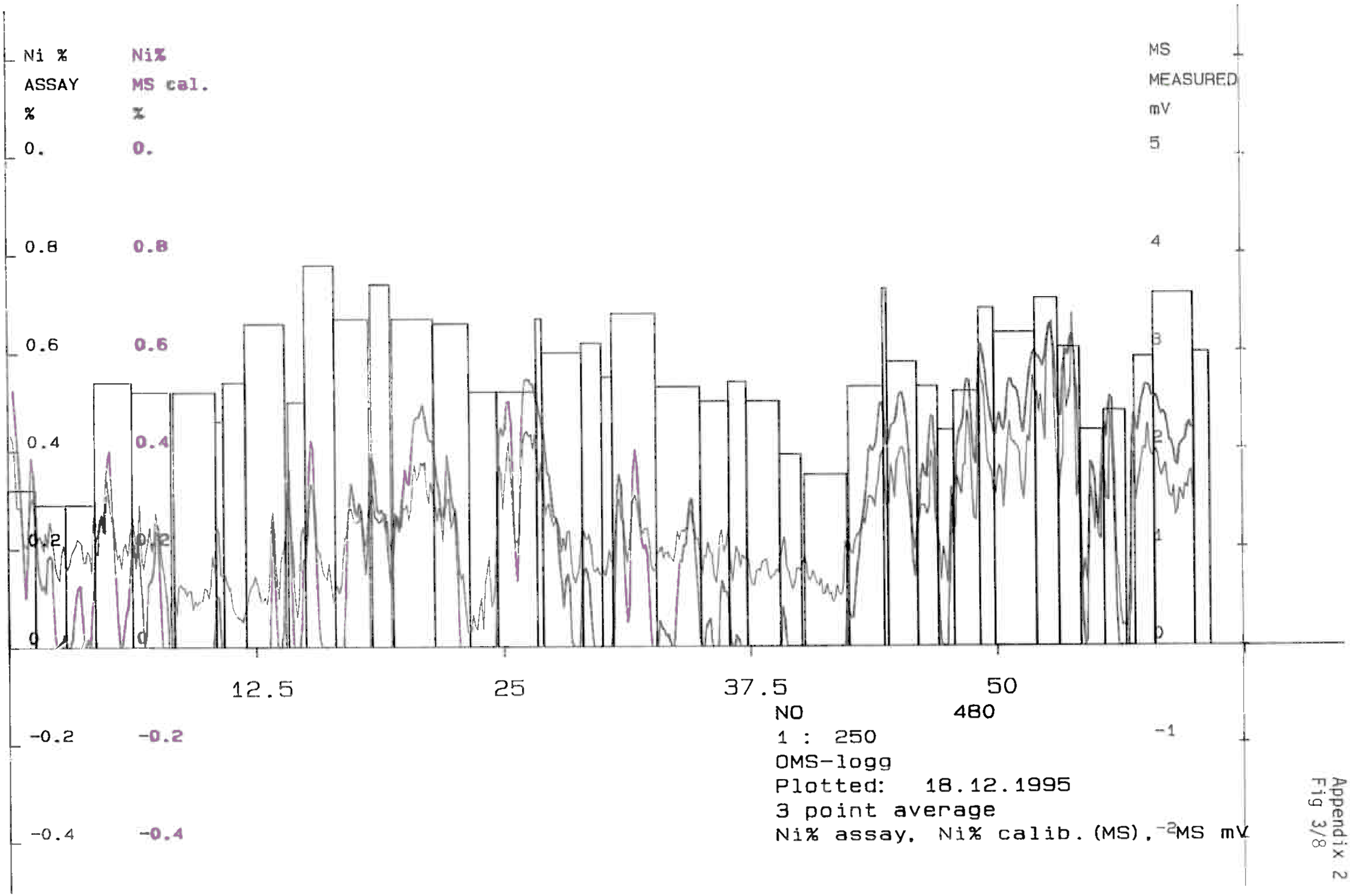


496
8.95 mV...8.37 mV

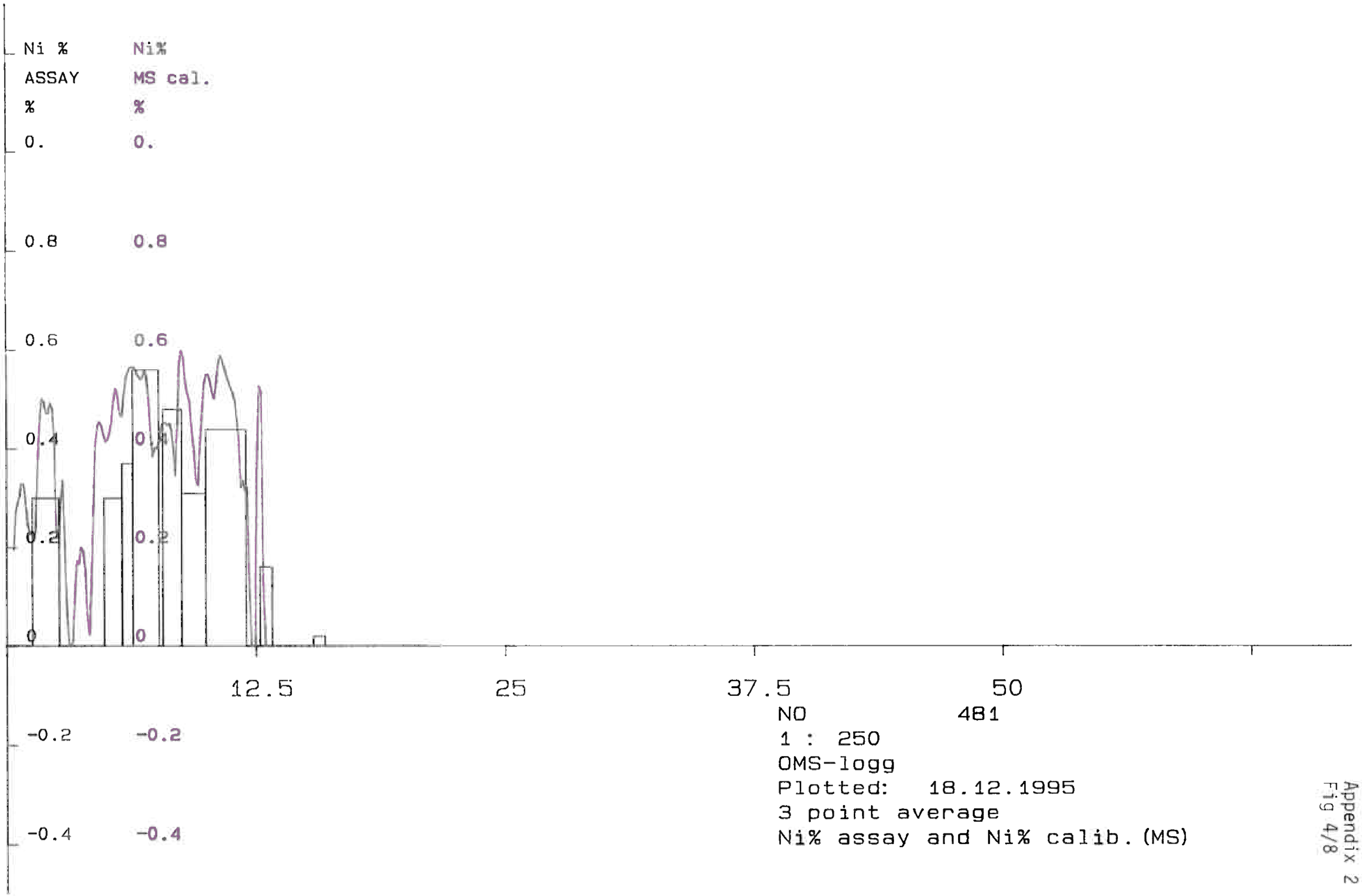


530
5.84 mV...5.84. MV

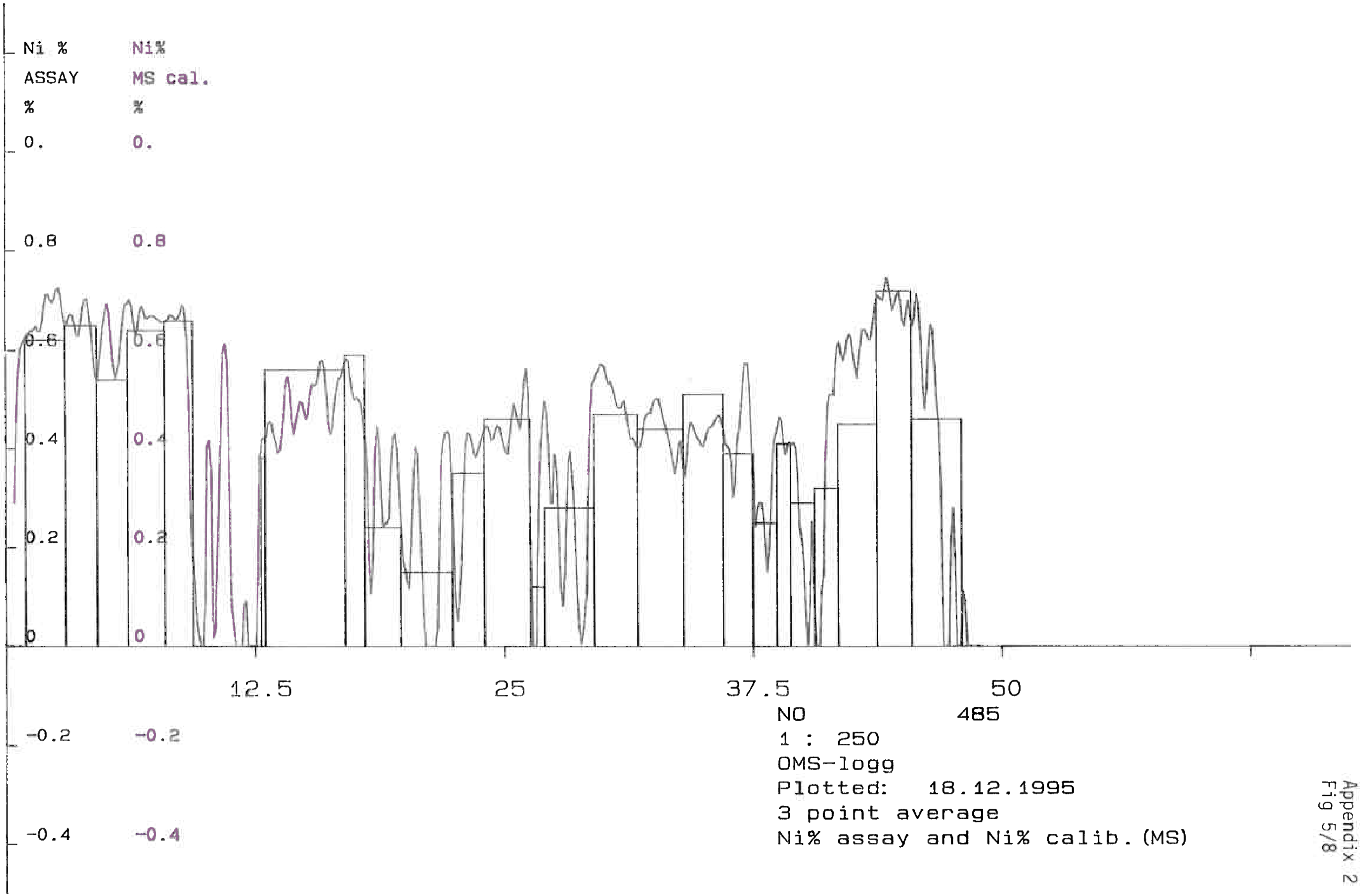




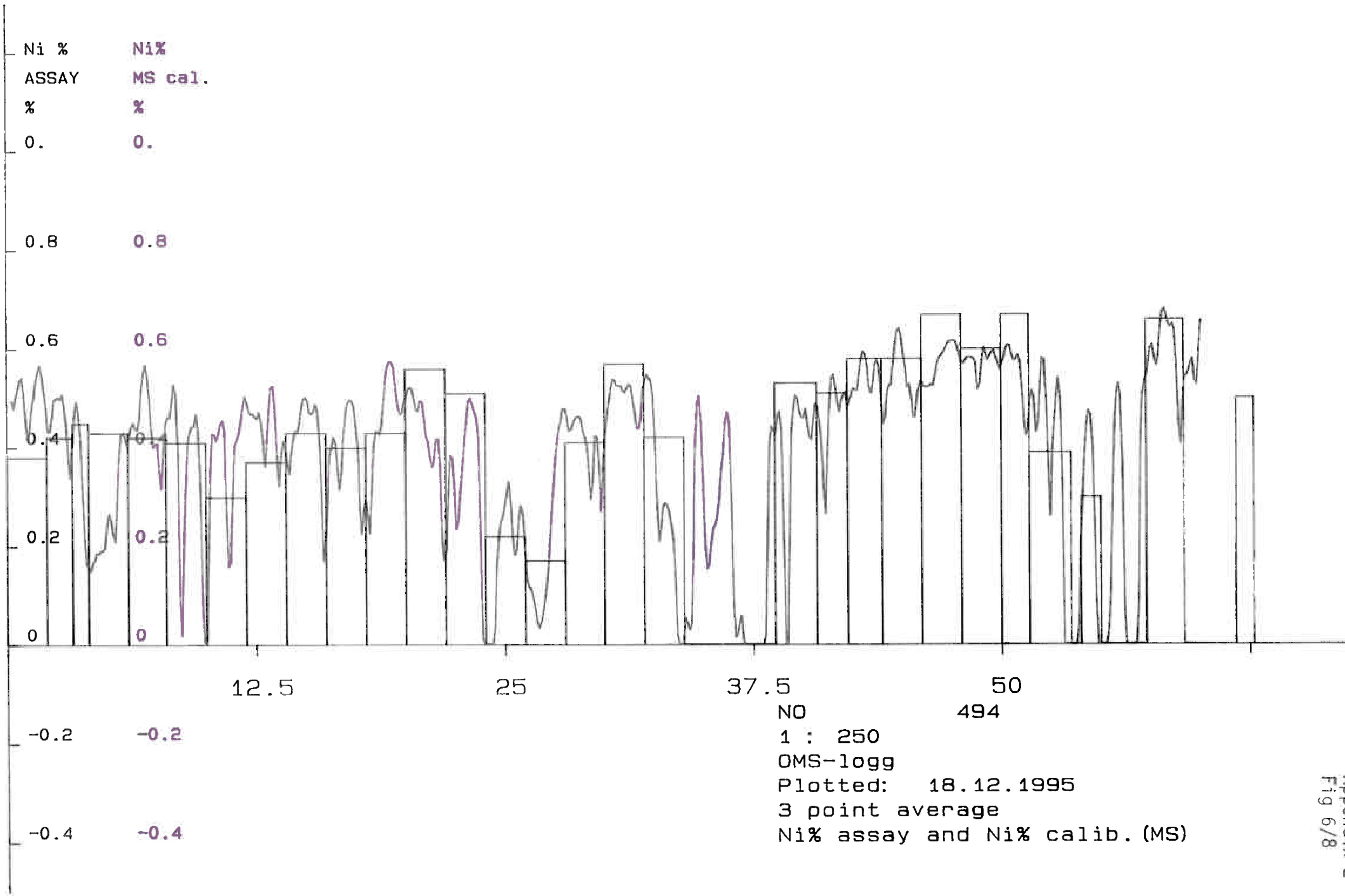
Appendix 2
Fig 3/8



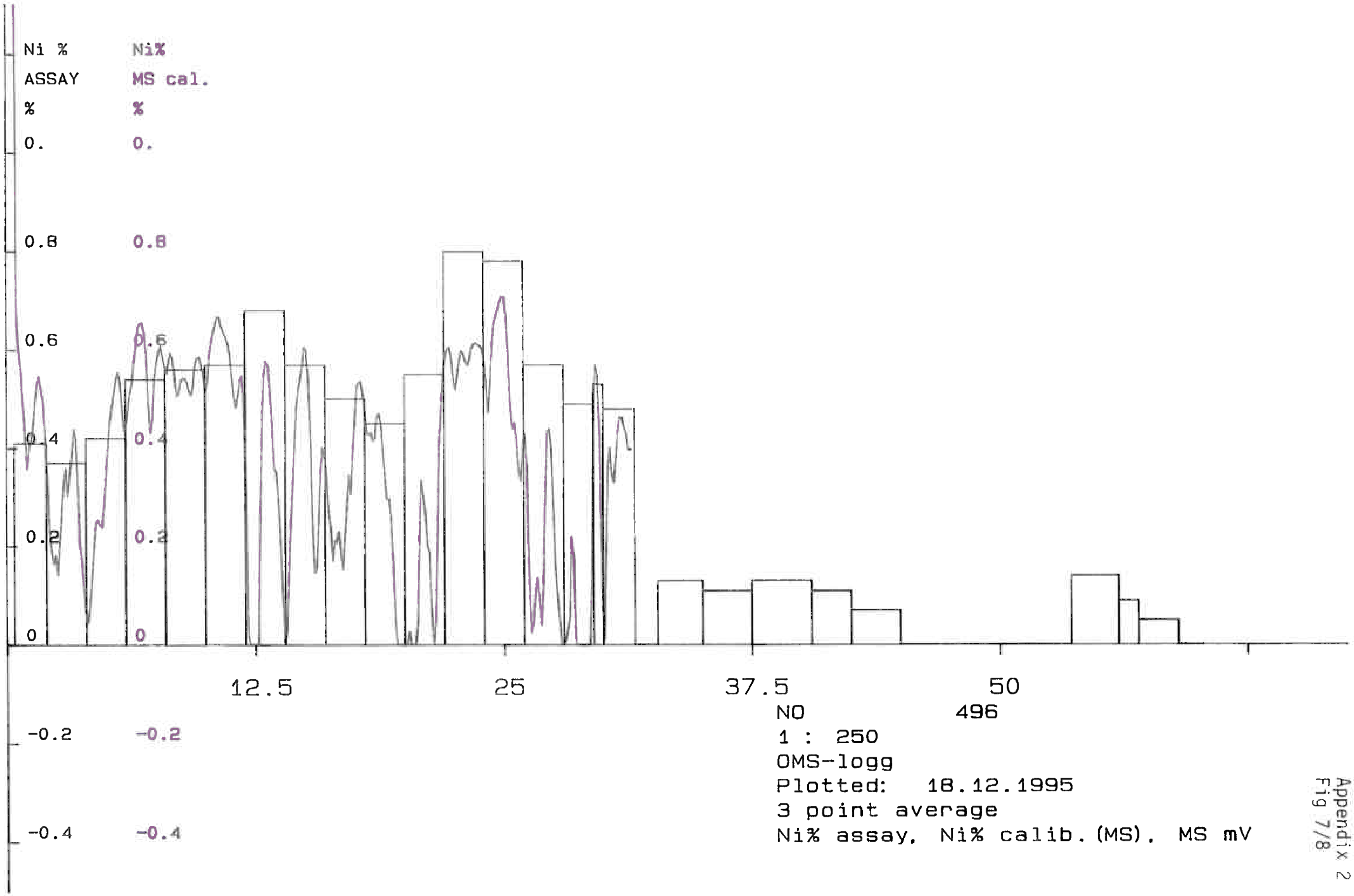
Appendix 2
Fig 4/8



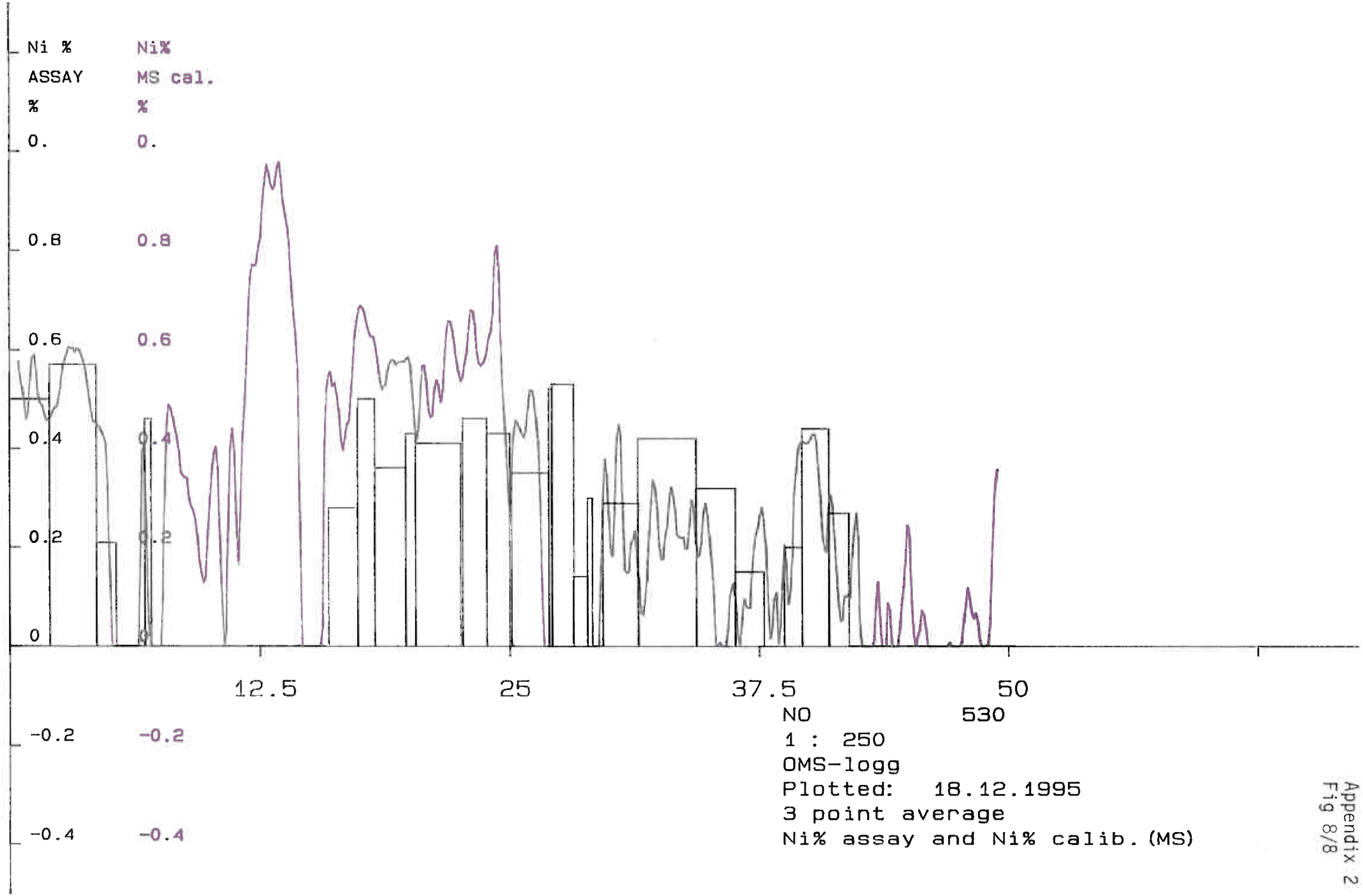
Appendix 2
Fig 5/8



Appendix 2
Fig 6/8



Appendix 2
Fig 7/8

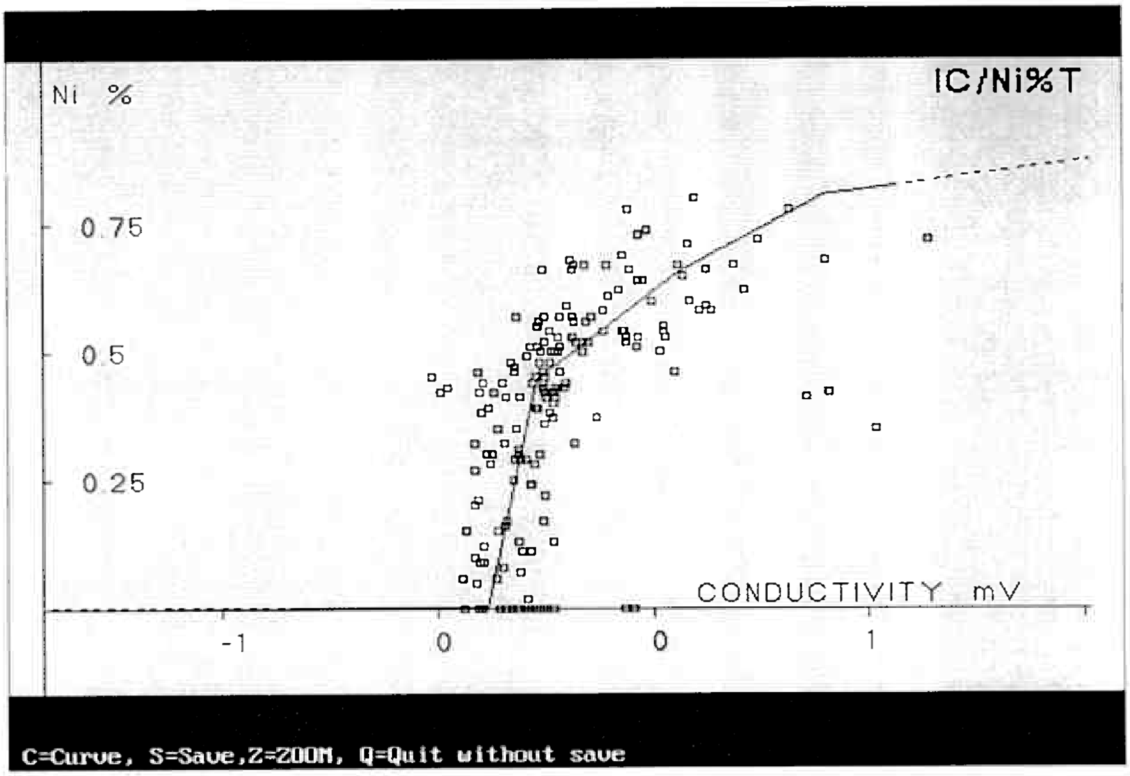


NO 530
1 : 250
OMS-logg
Plotted: 18.12.1995
3 point average
Ni% assay and Ni% calib. (MS)

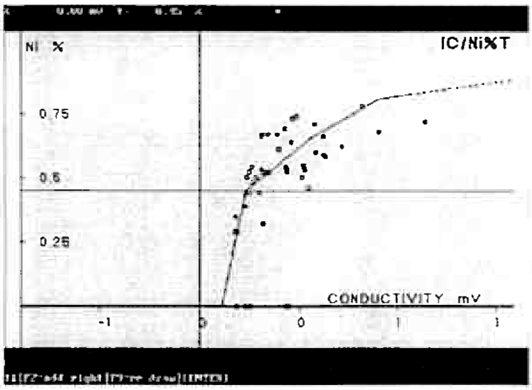
Appendix 2
Fig 8/8

3

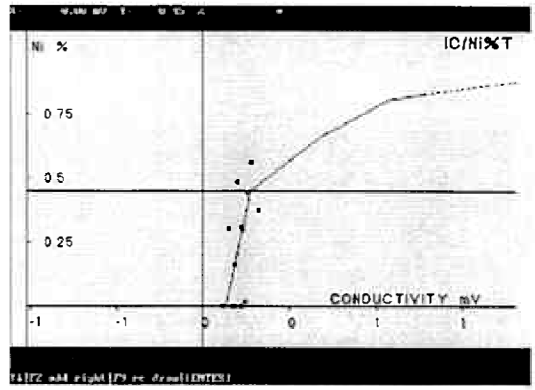
480,481,485,494,596,530



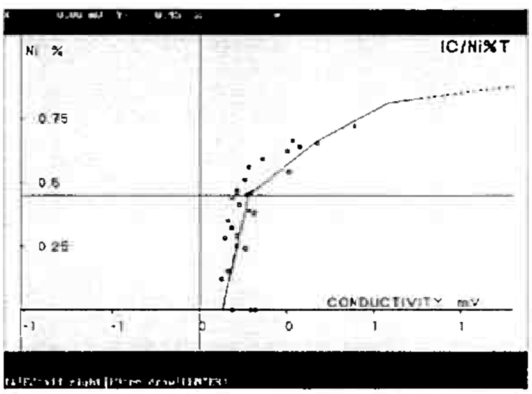
480
3.00 mV...4.0 mV



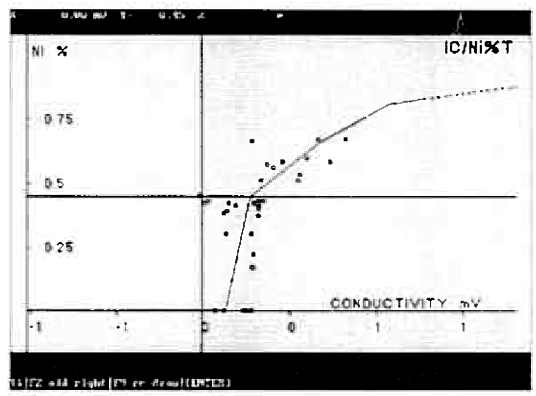
481
3.0 mV...3.26 mV



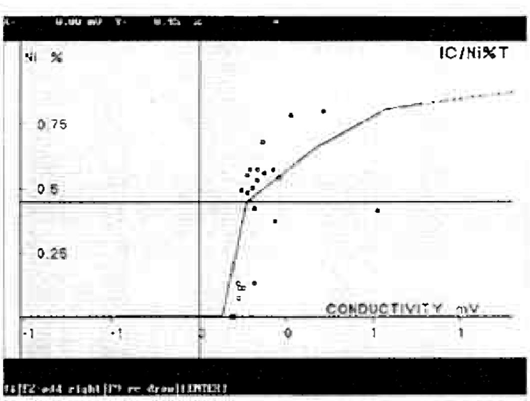
485
3.12 mV...3.74 mV



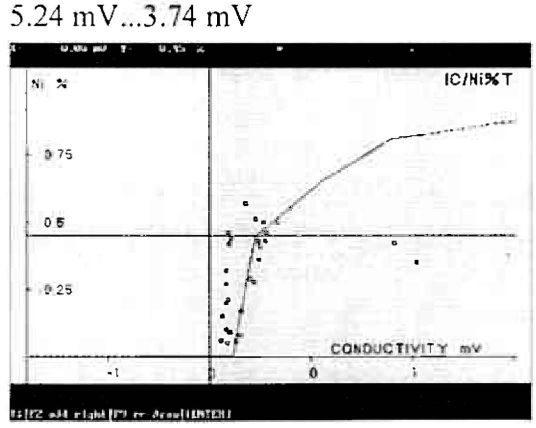
494
3.21 mV...4.32 mV

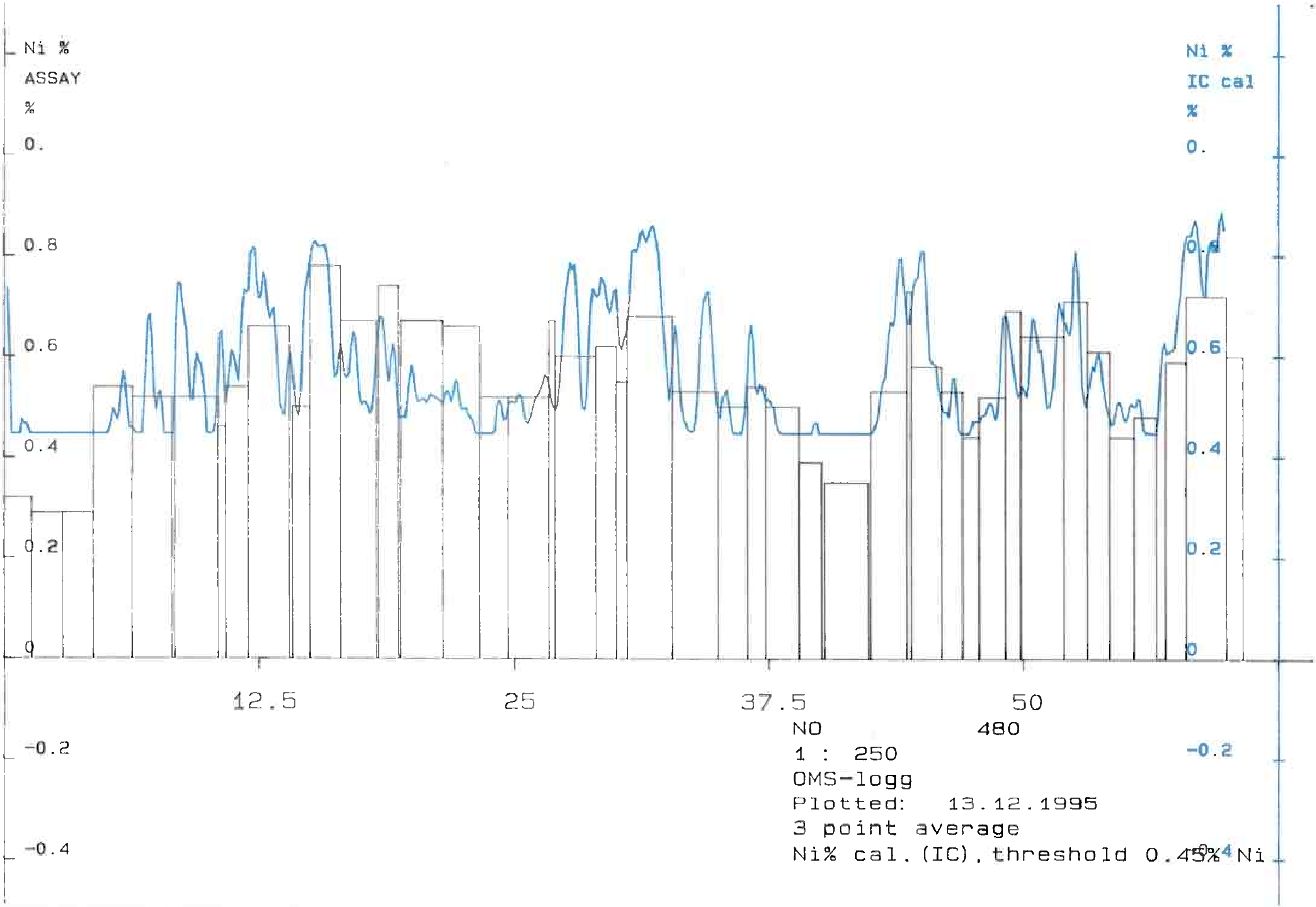


496
4.21 mV...3.74 mV

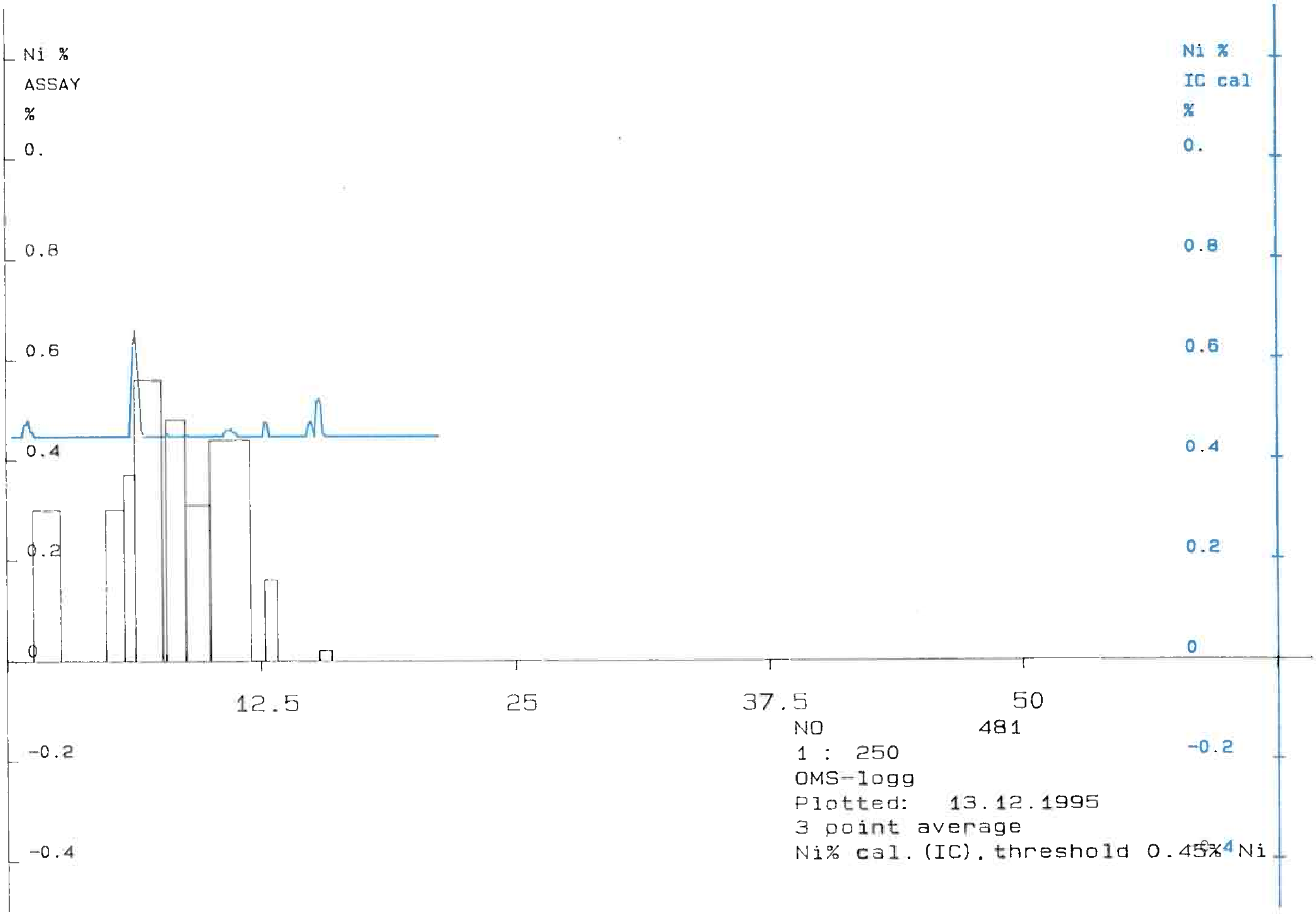


530
5.24 mV...3.74 mV

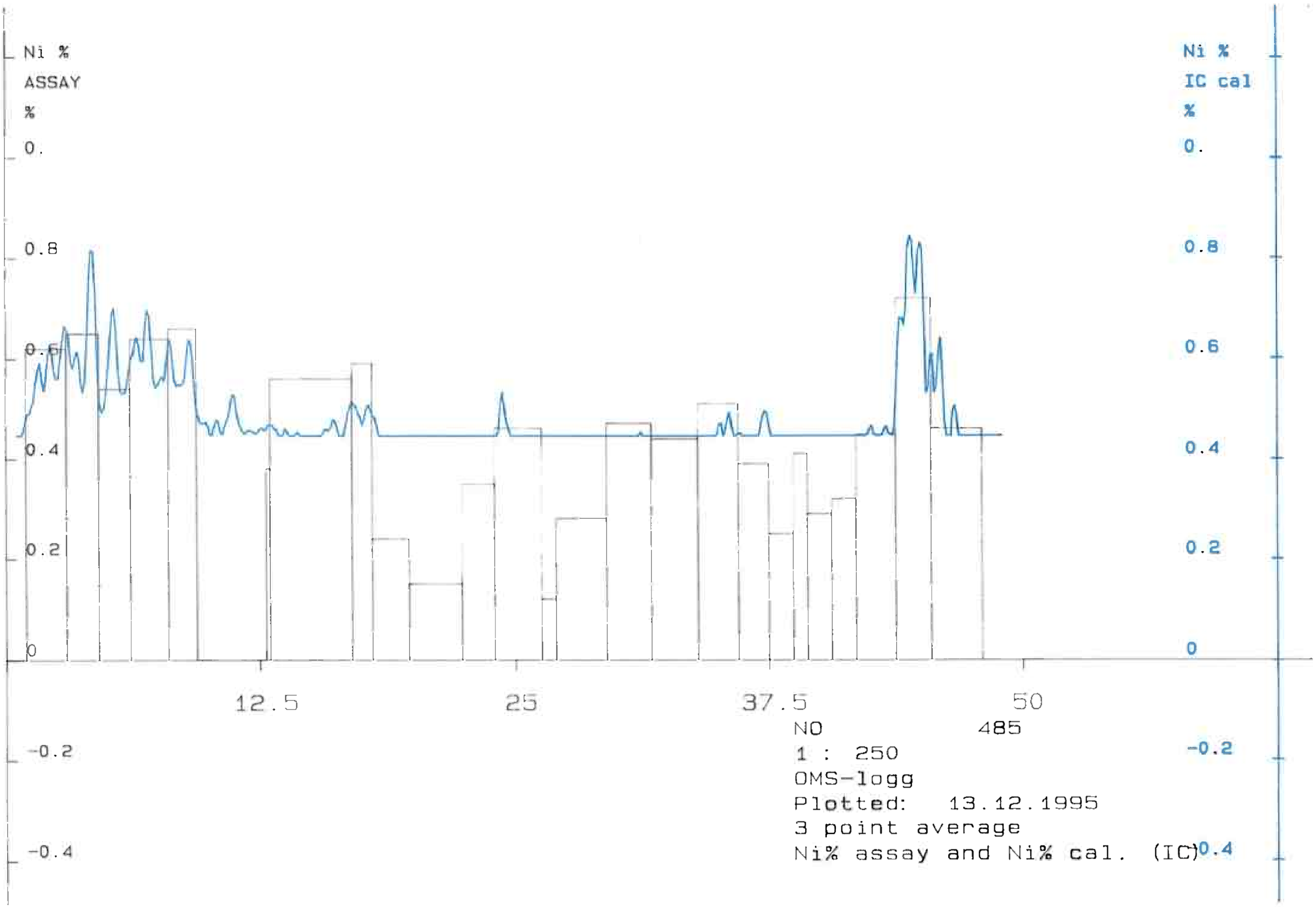




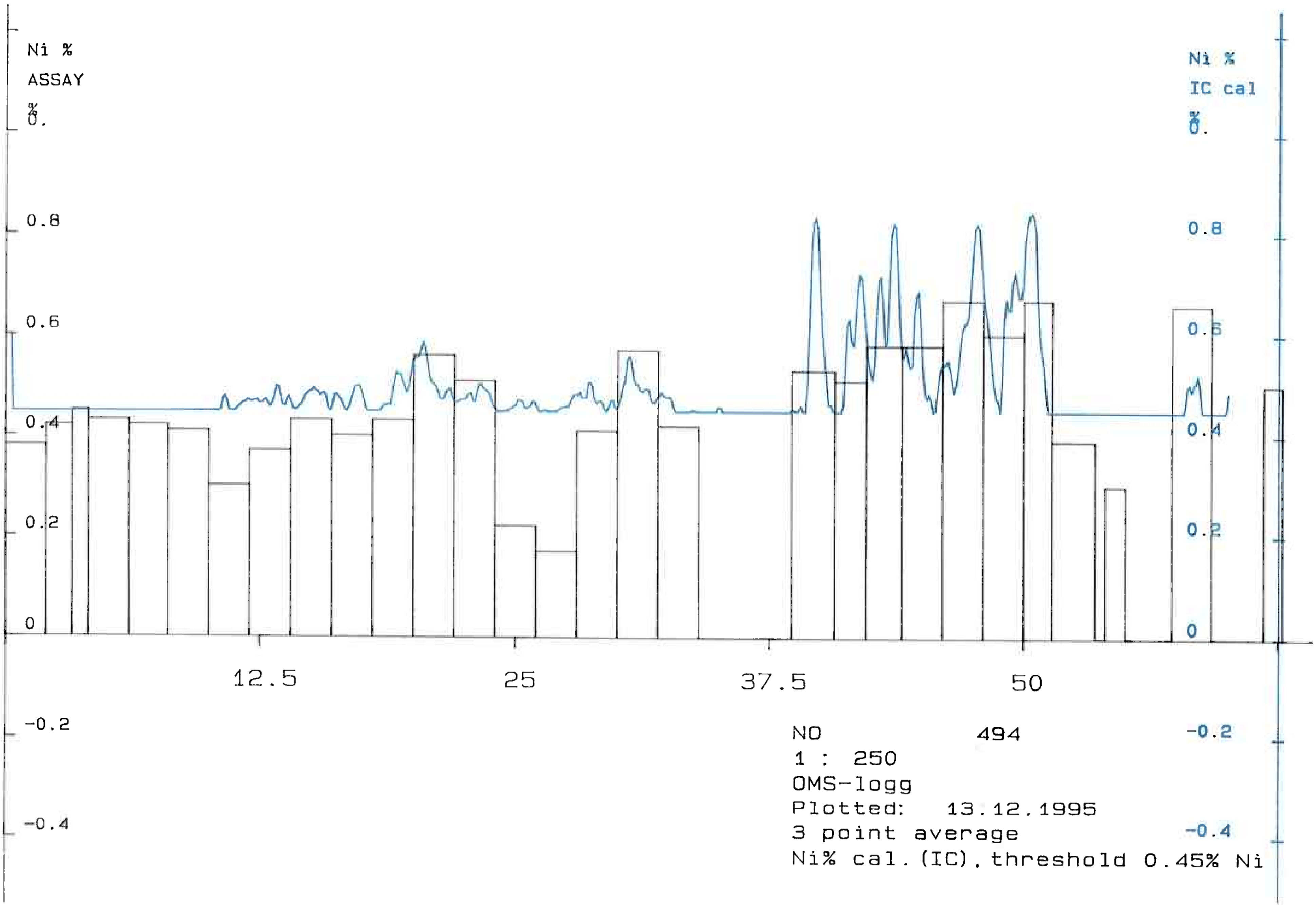
Appendix 3
Fig 3/8



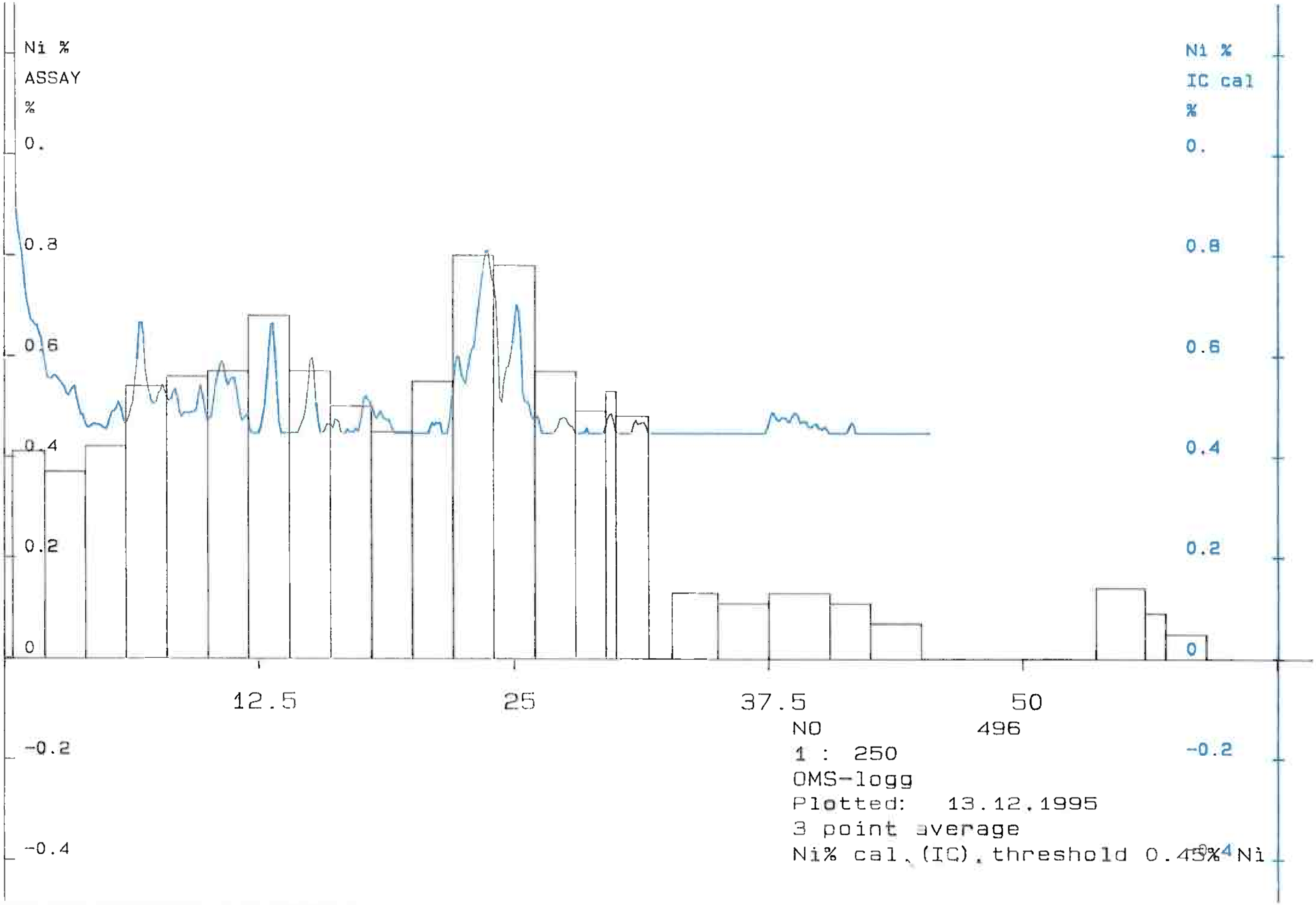
Appendix 3
Fig 4/8



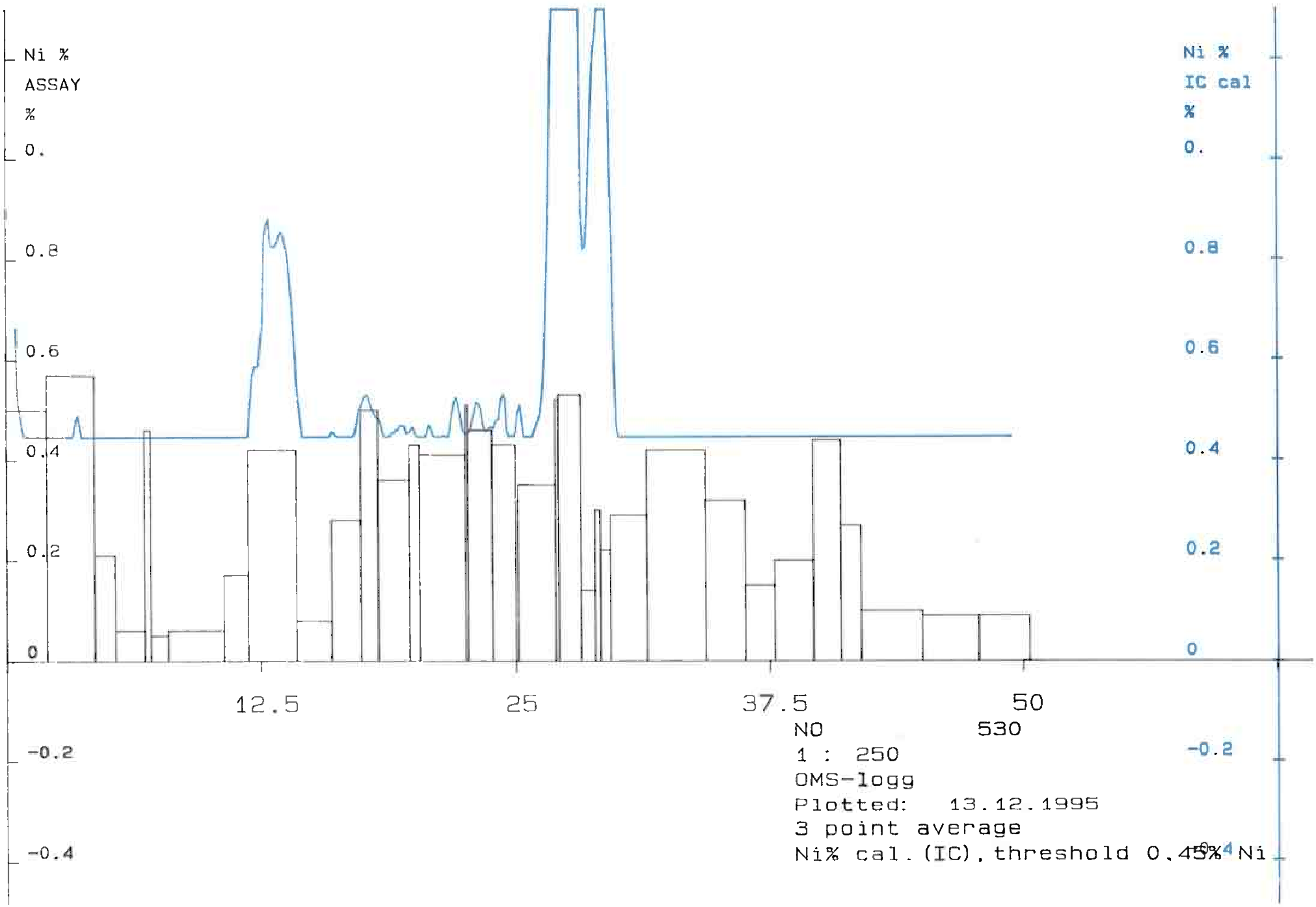
Appendix 3
Fig 5/8



Appendix 3
Fig 6/8

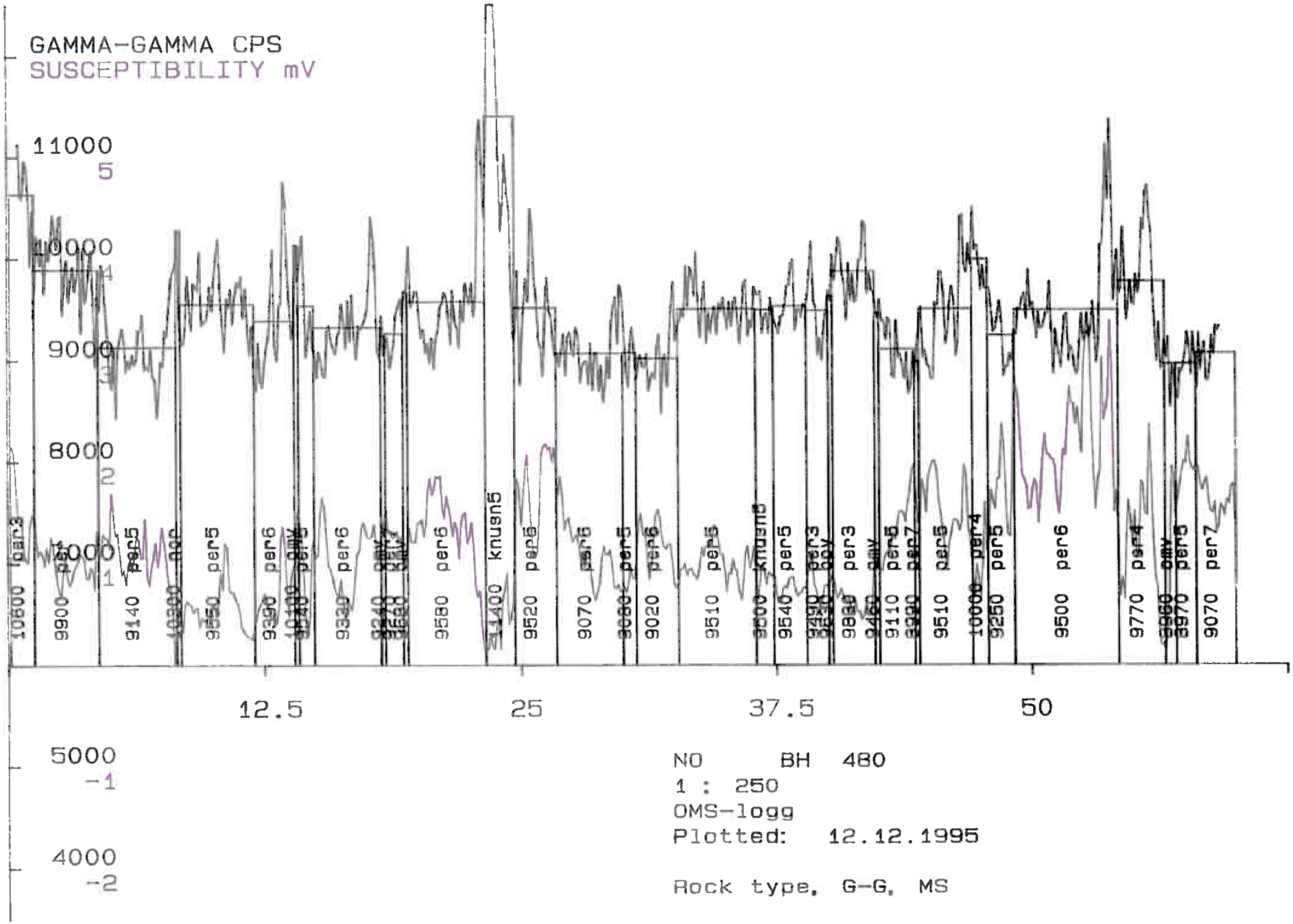


Appendix 3
Fig 7/8



Appendix 3
Fig 8/8

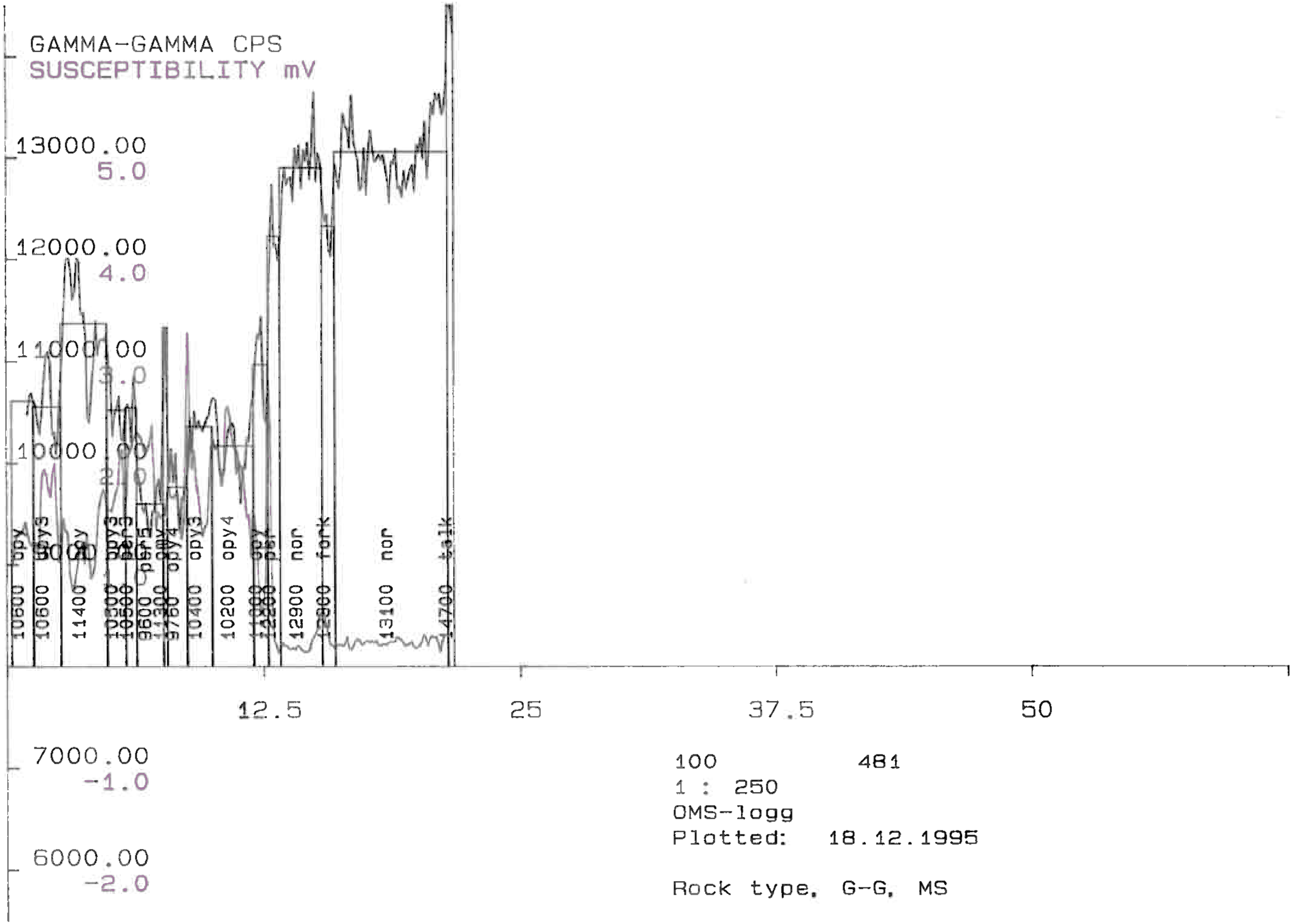
4



NO BH 480
1 : 250
OMS-logg
Plotted: 12.12.1995

Rock type, G-G, MS

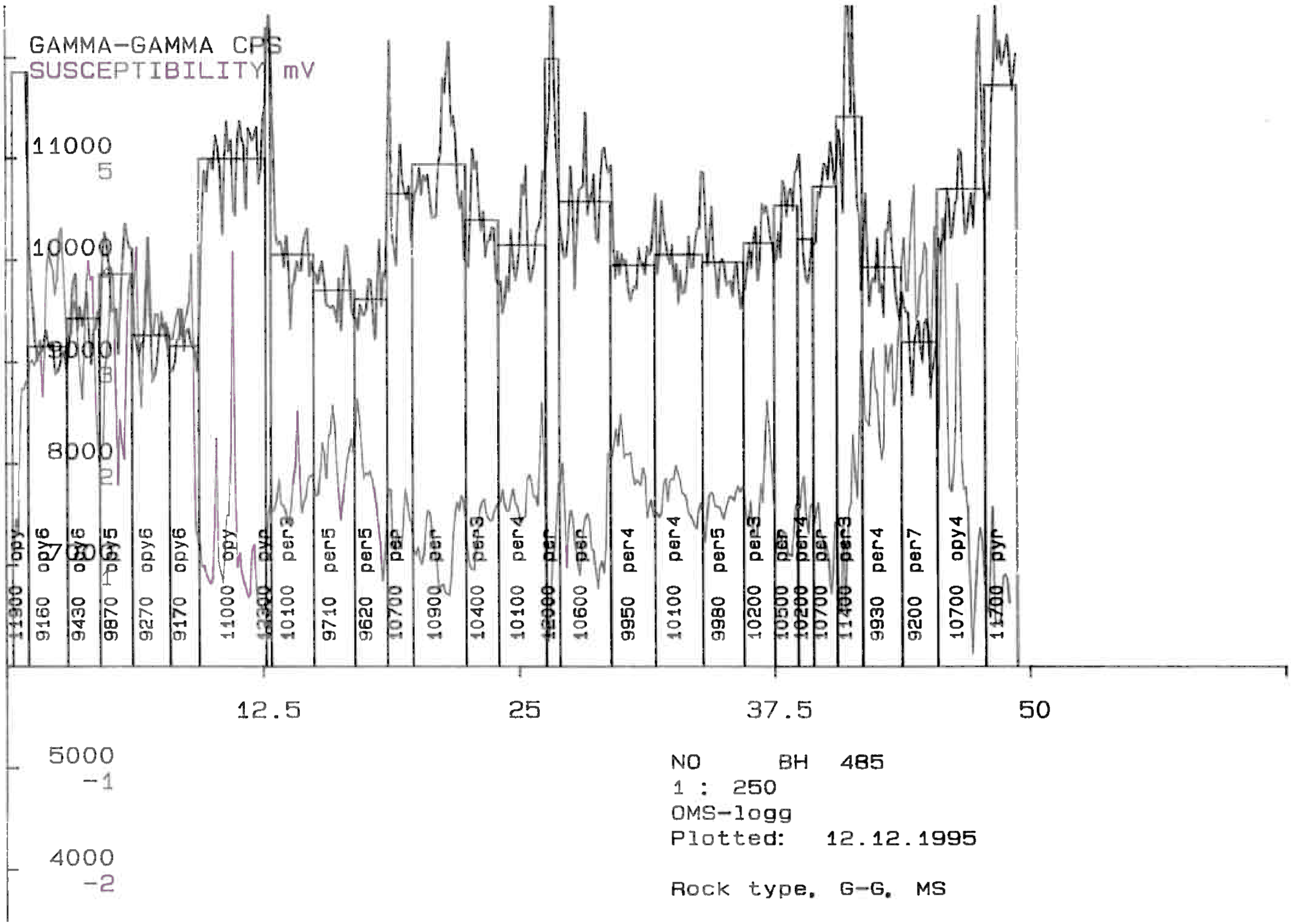
Appendix 4
Fig 1/8



100 481
1 : 250
OMS-logg
Plotted: 18.12.1995

Rock type, G-G, MS

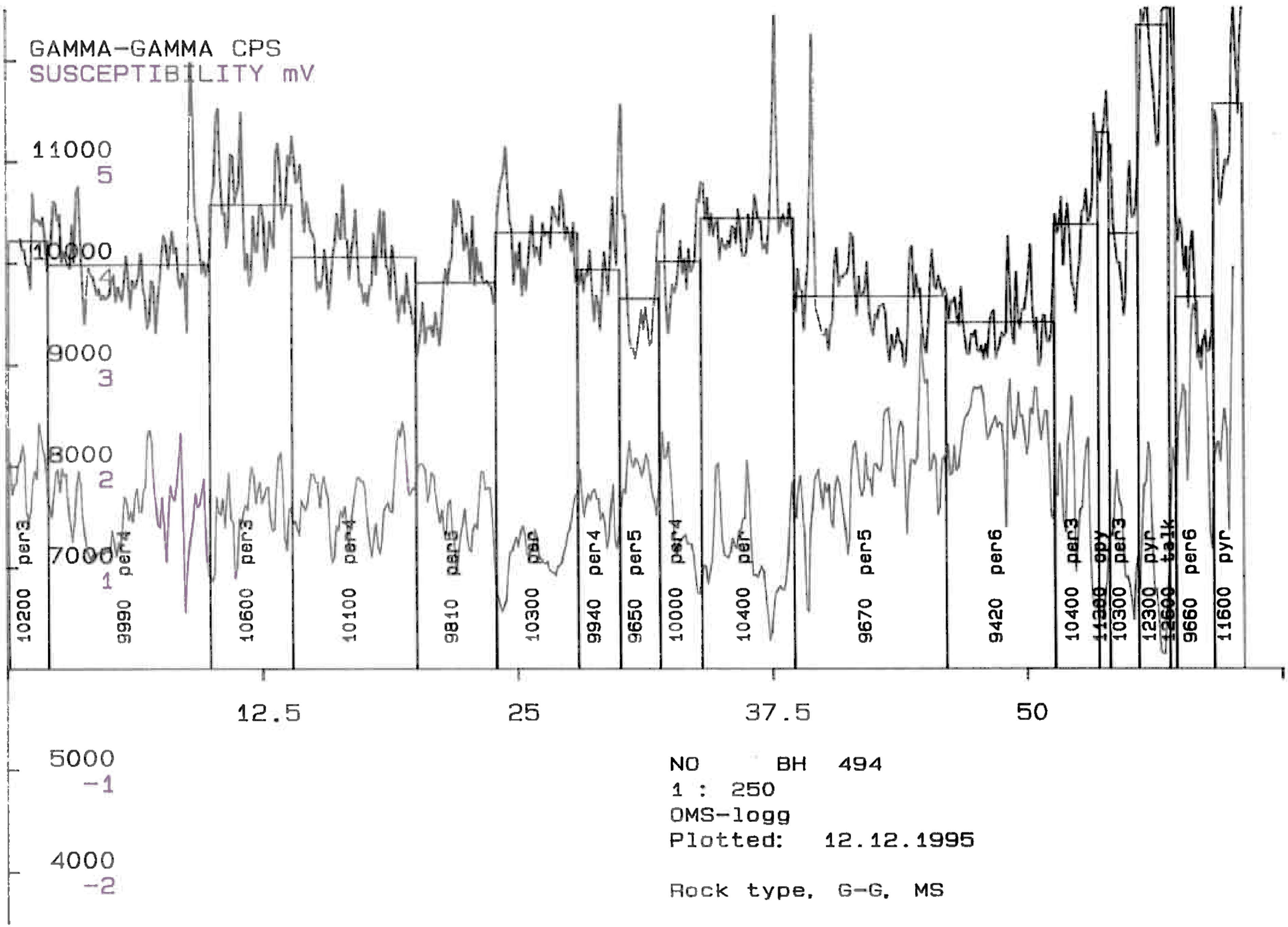
Appendix 4
Fig 2/8



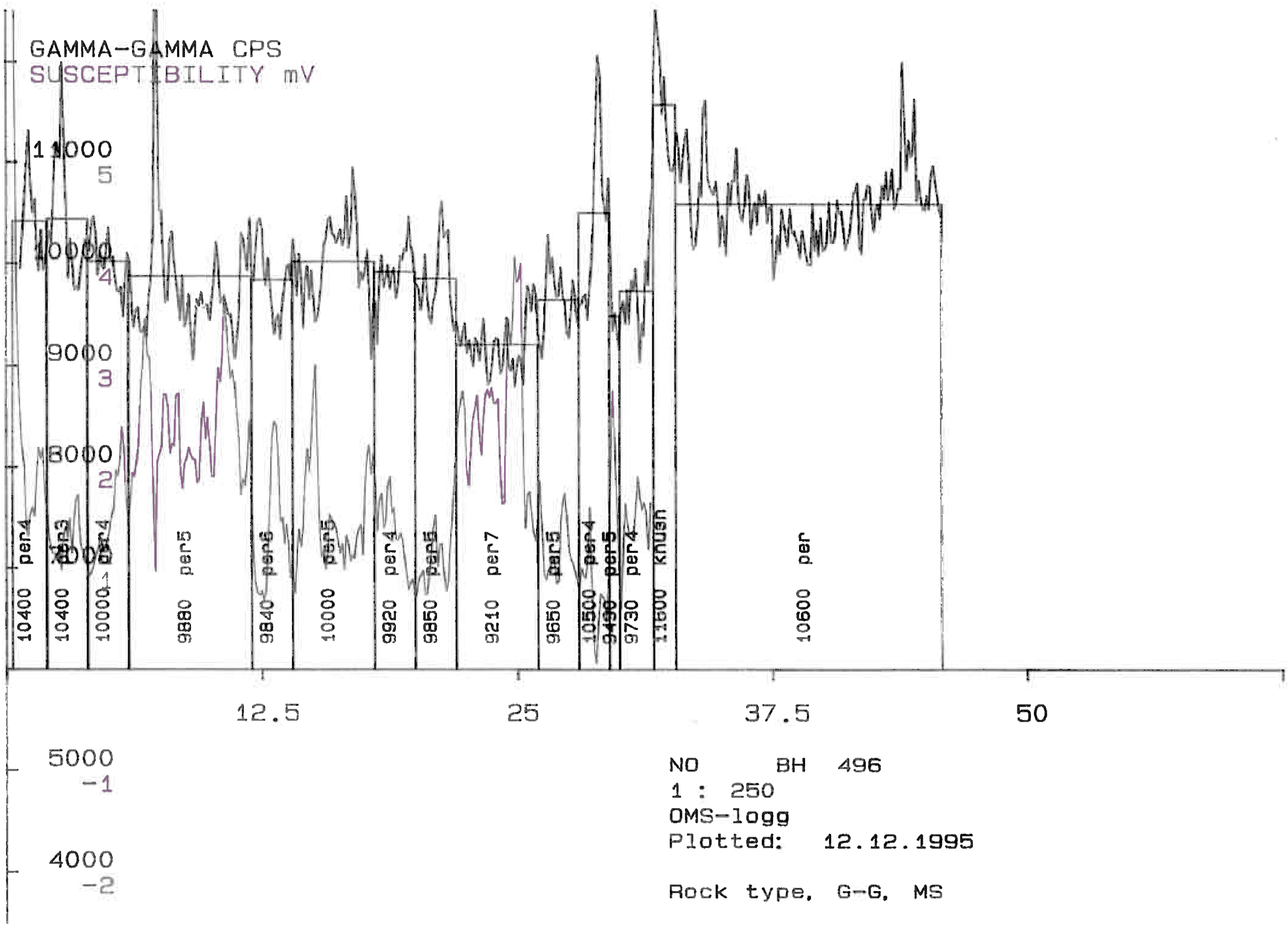
NO BH 485
1 : 250
OMS-logg
Plotted: 12.12.1995

Rock type, G-G, MS

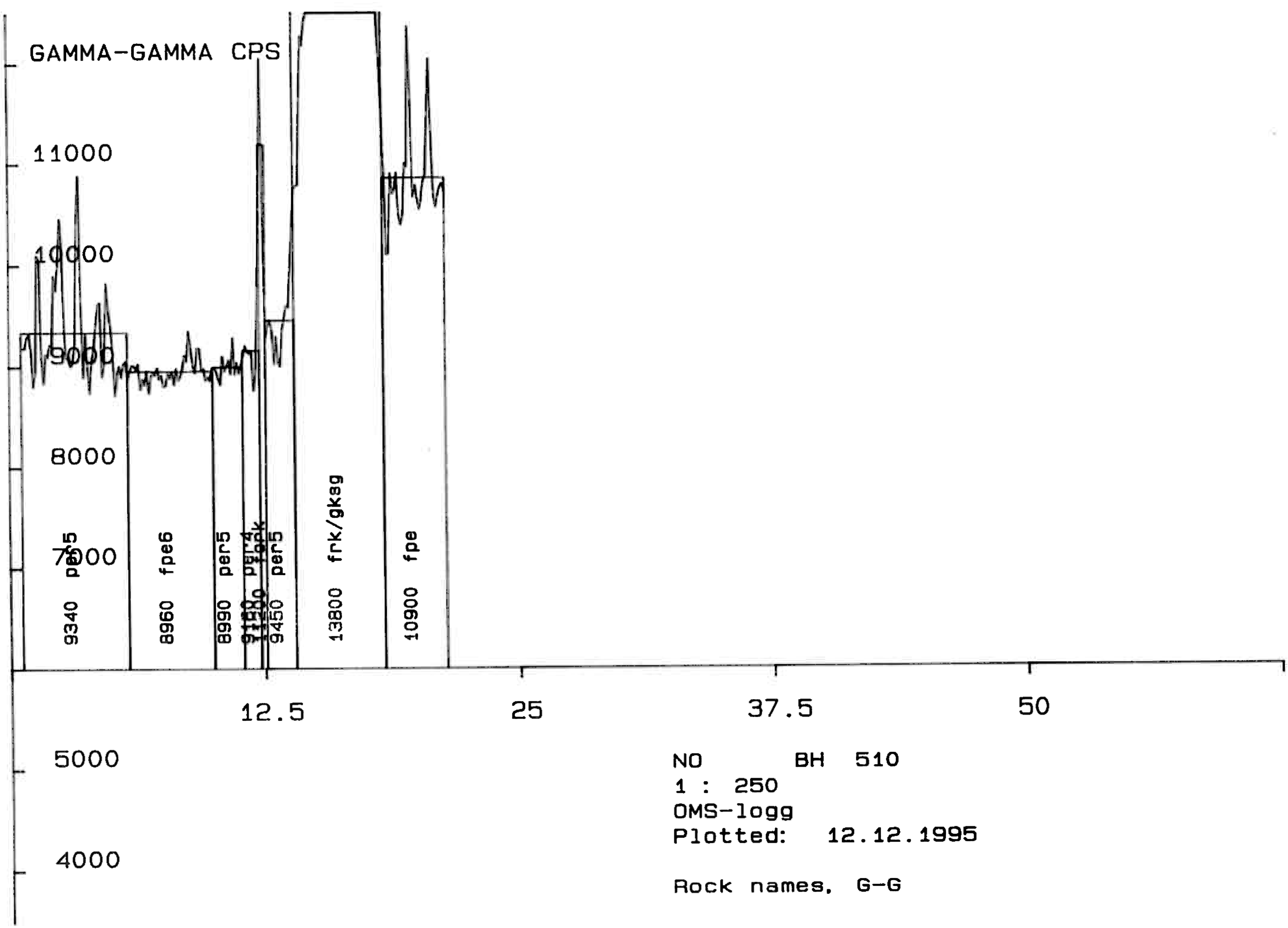
Appendix 4
Fig 3/8



Appendix 4
Fig 4/8



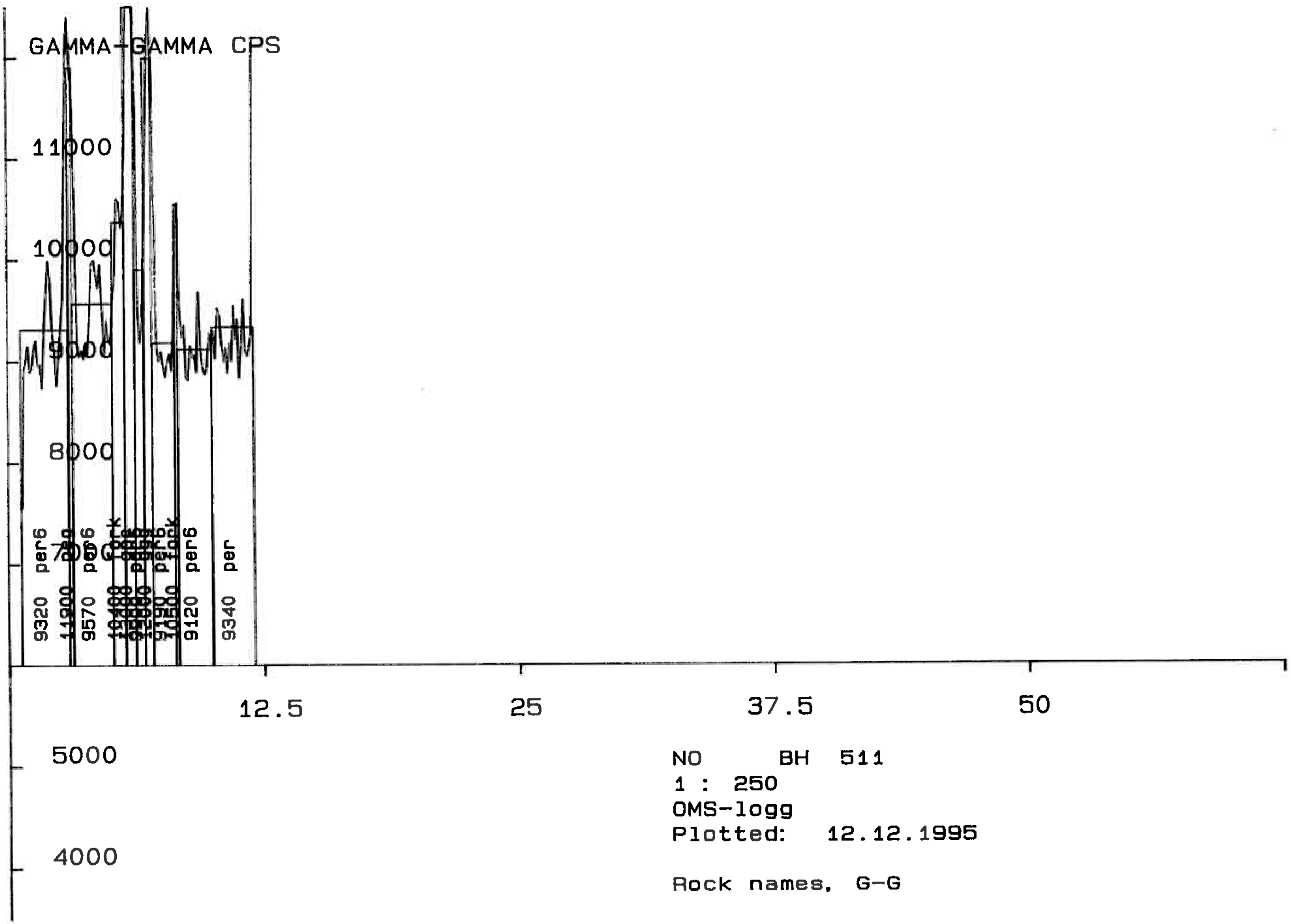
Appendix 4
Fig 5/8



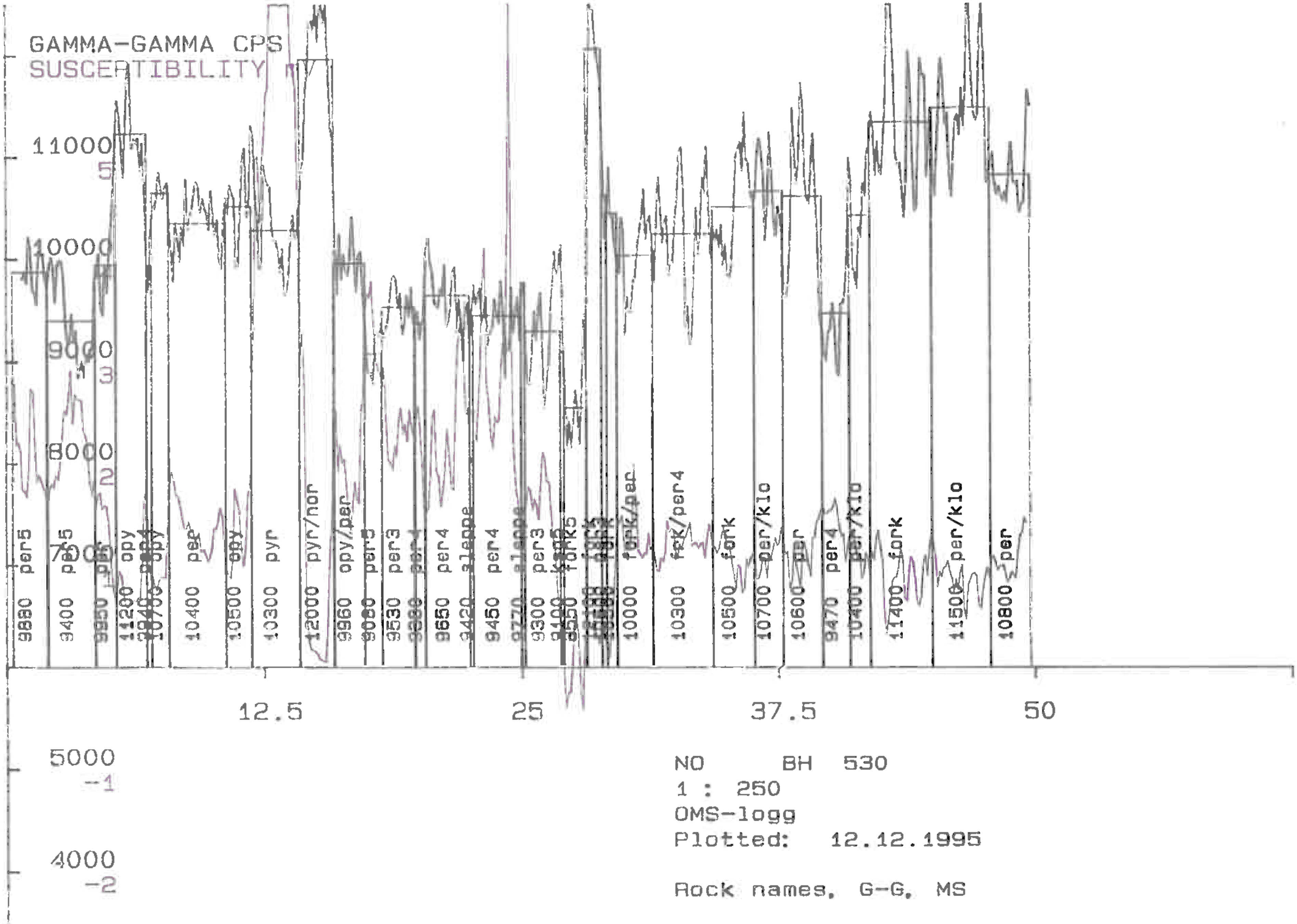
NO BH 510
1 : 250
OMS-logg
Plotted: 12.12.1995

Rock names, G-G

Appendix 4
Fig 6/8



Appendix 4
Fig 7/8

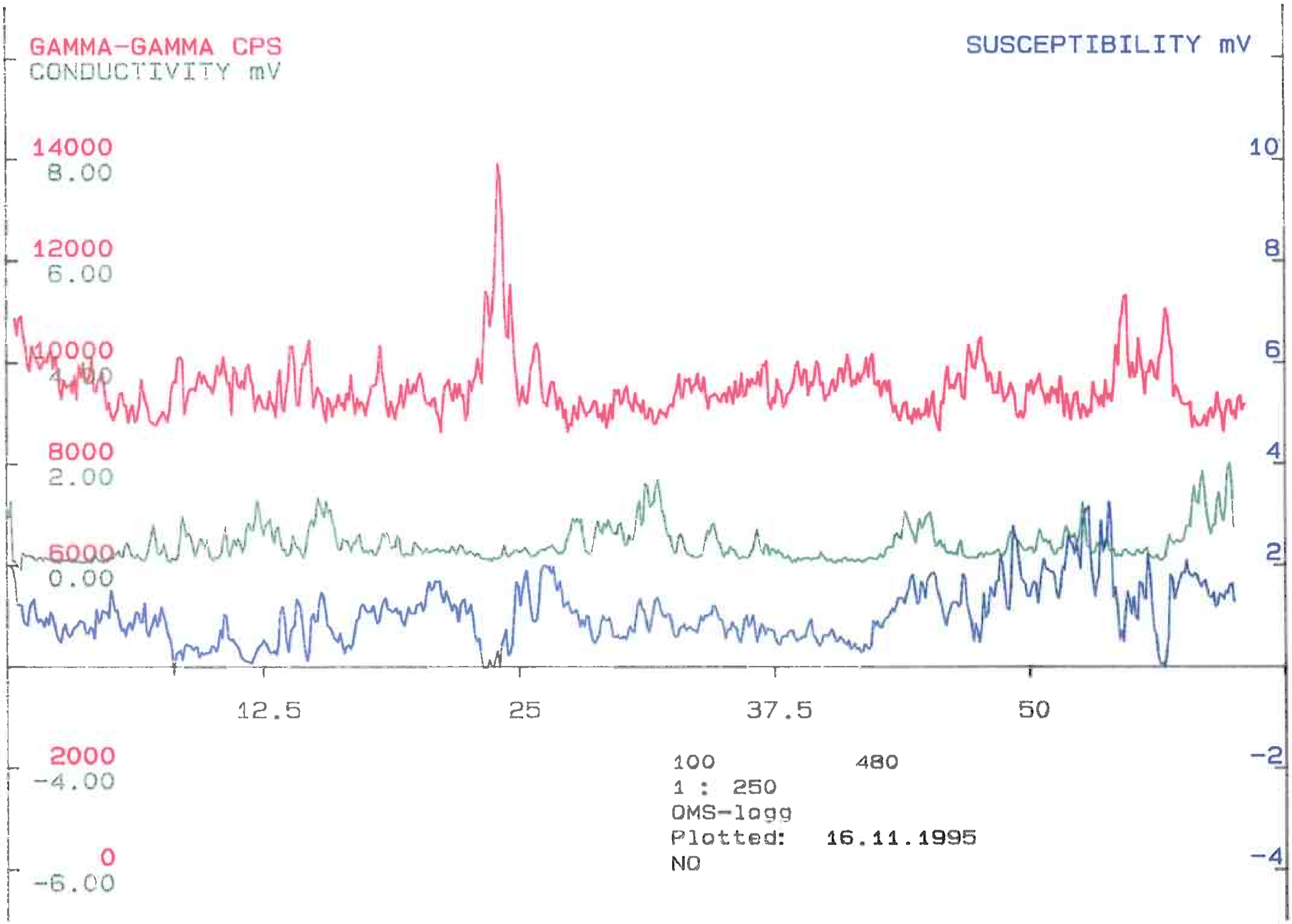


NO BH 530
1 : 250
OMS-logg
Plotted: 12.12.1995

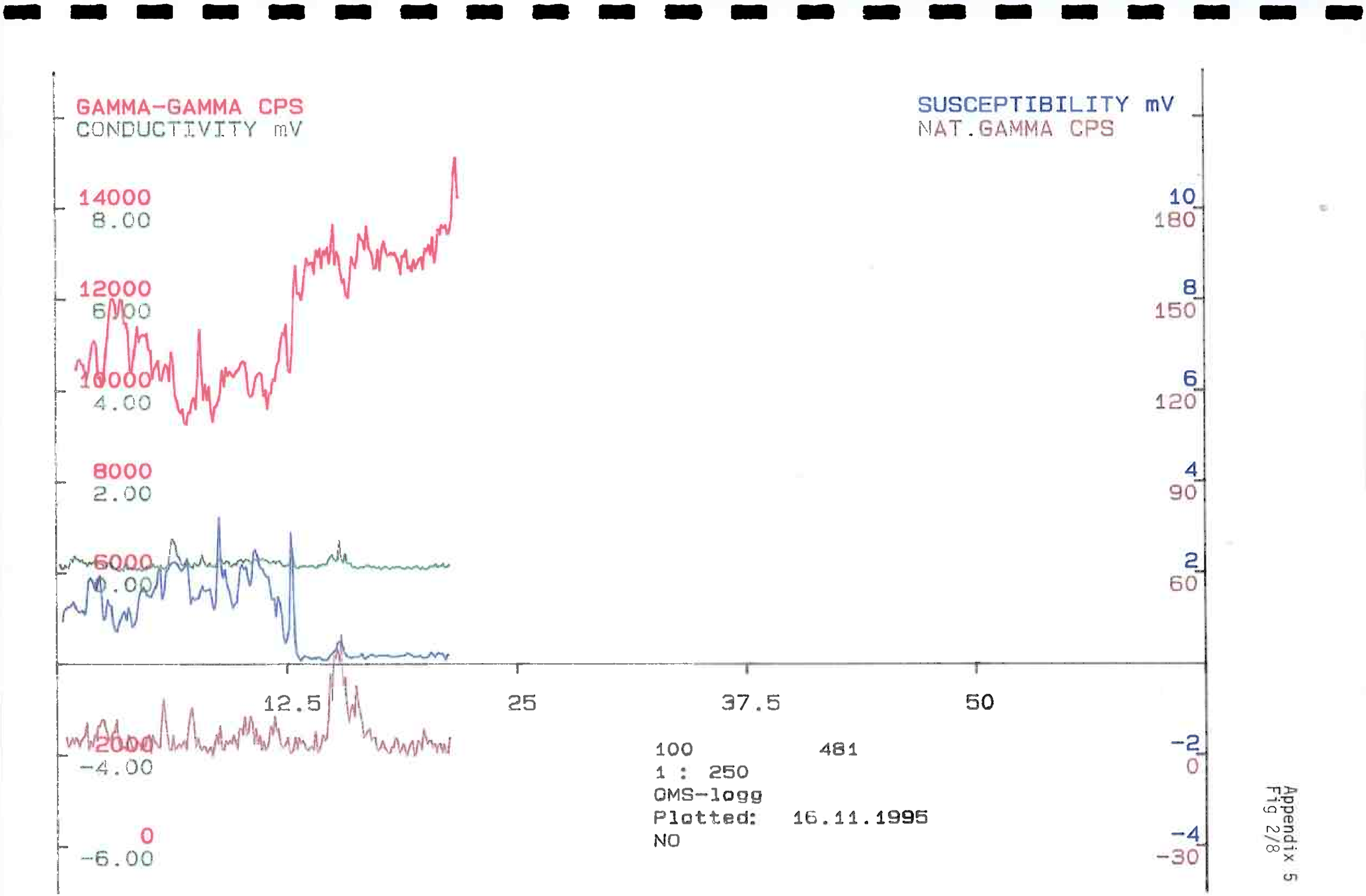
Rock names, G-G, MS

Appendix 4
Fig 8/8

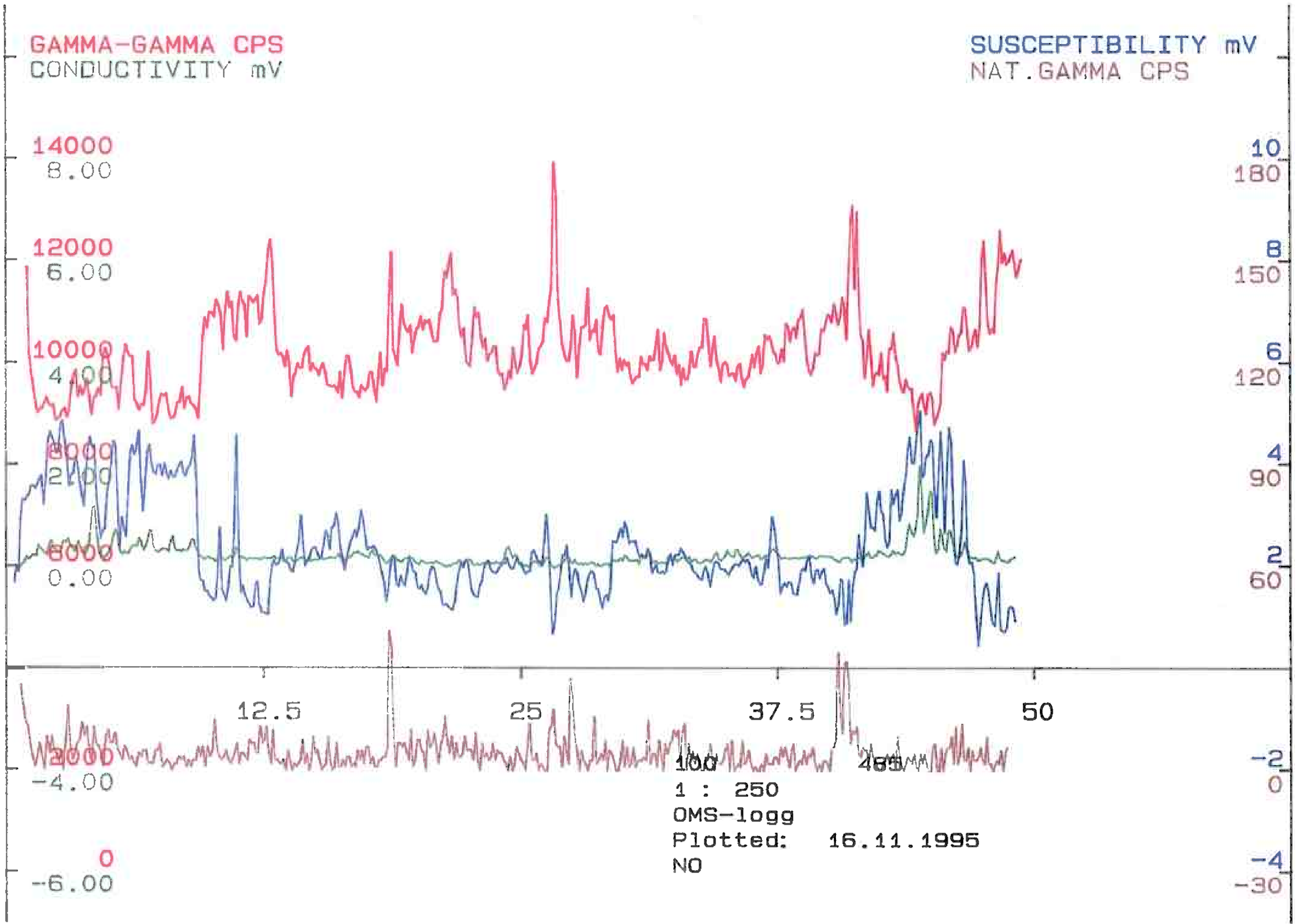
5



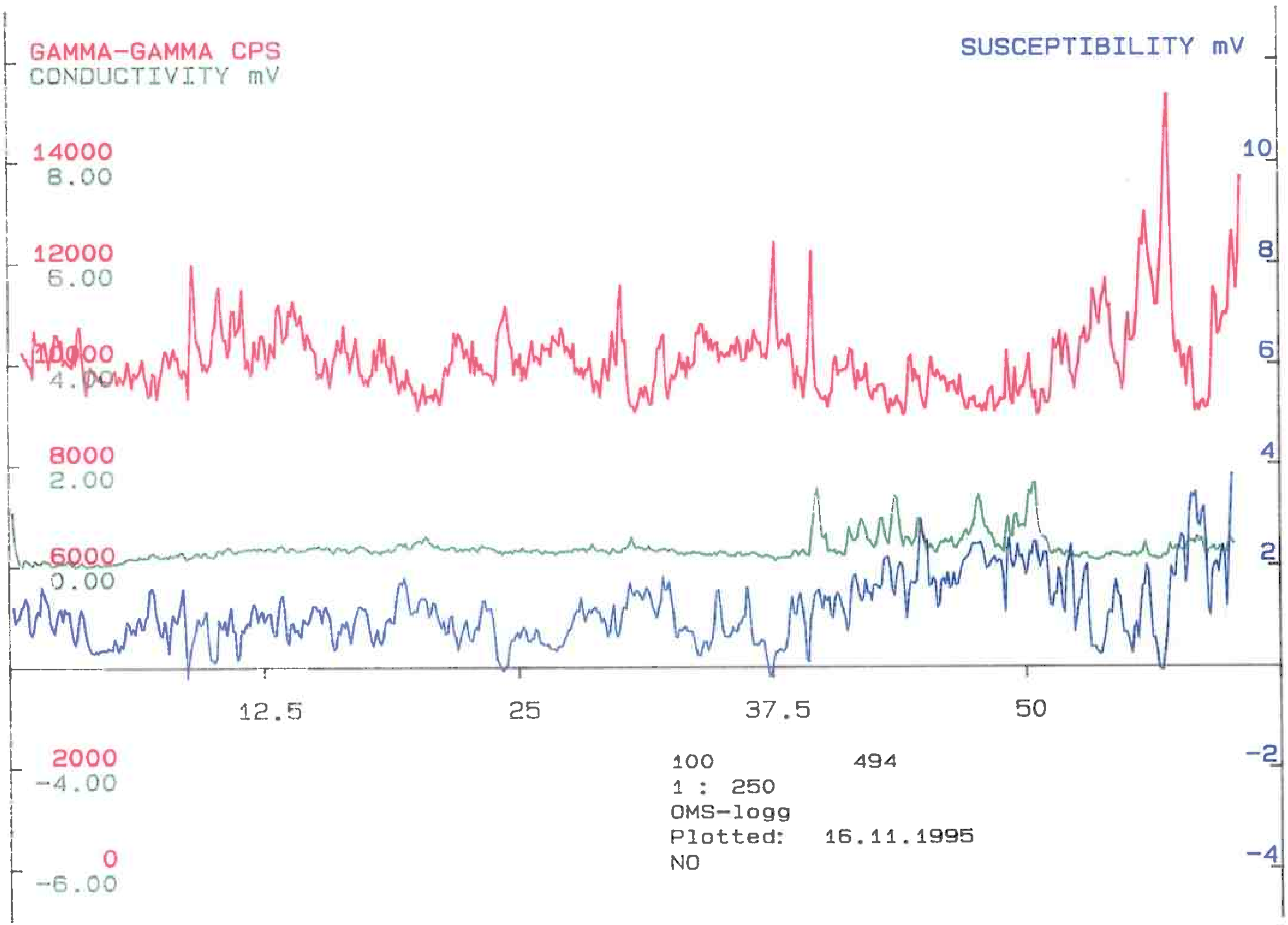
Appendix 5
Fig 1/8



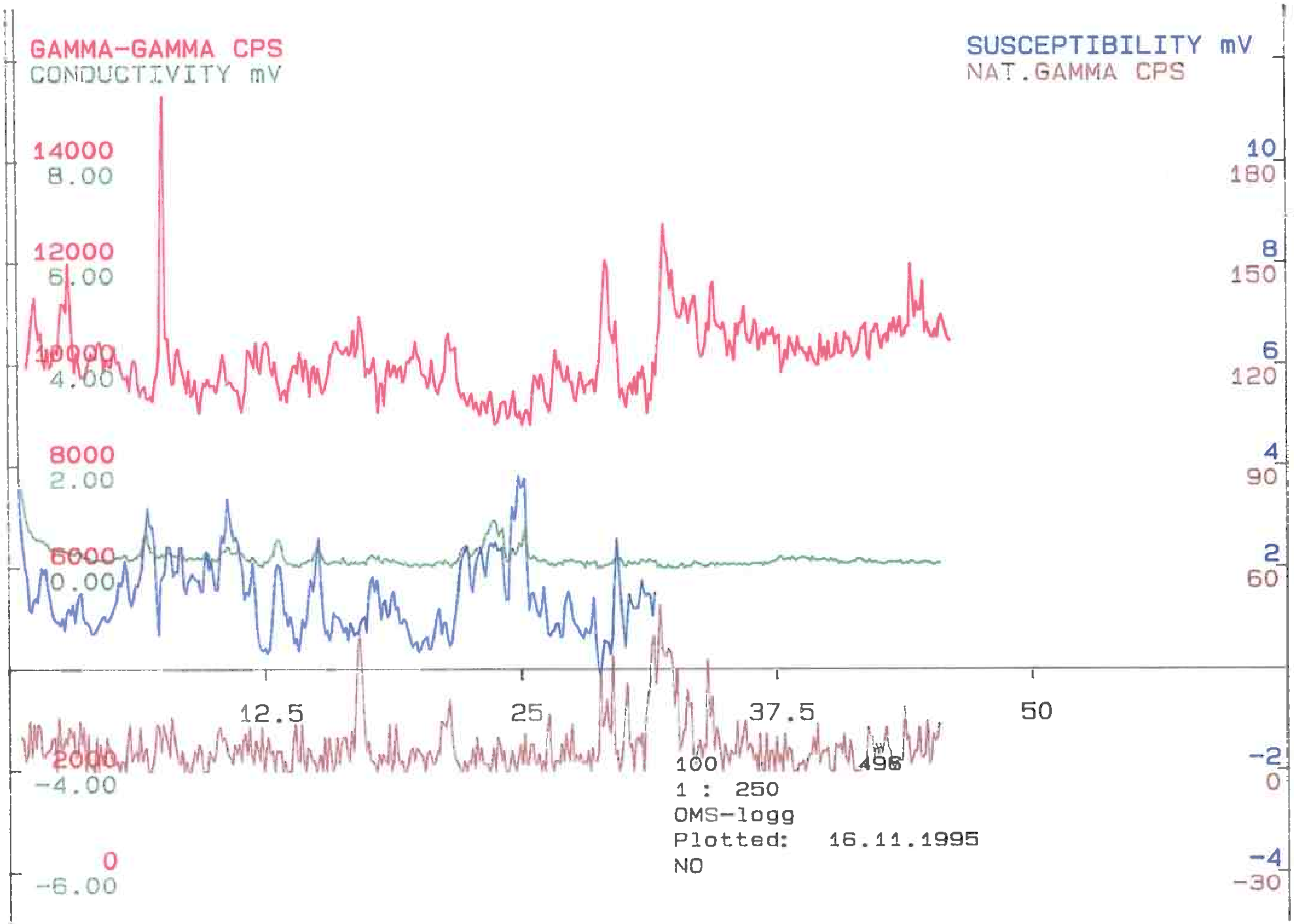
Appendix 5
Fig 2/8



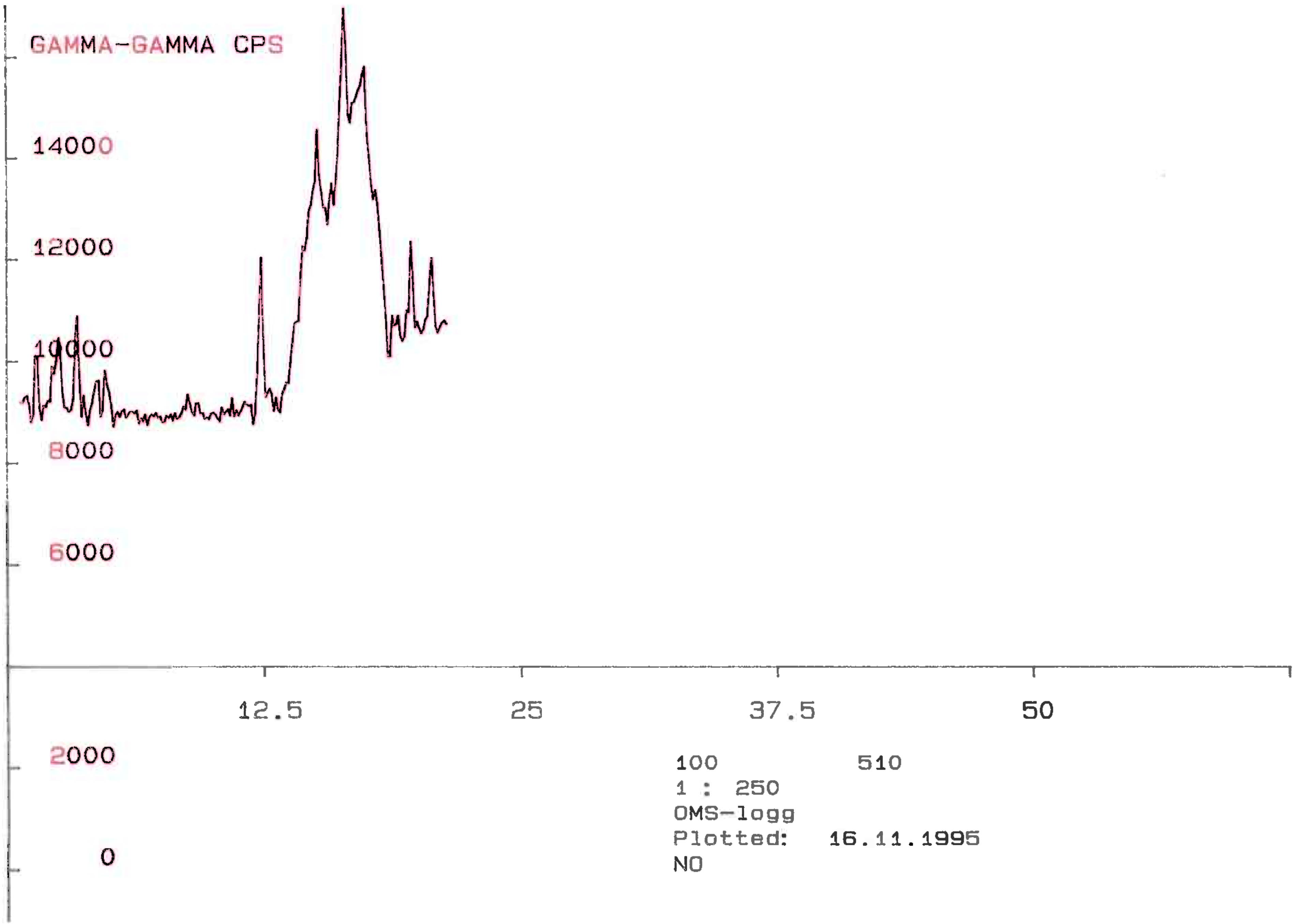
Appendix 5
Fig 3/8



Appendix 5
Fig 4/8

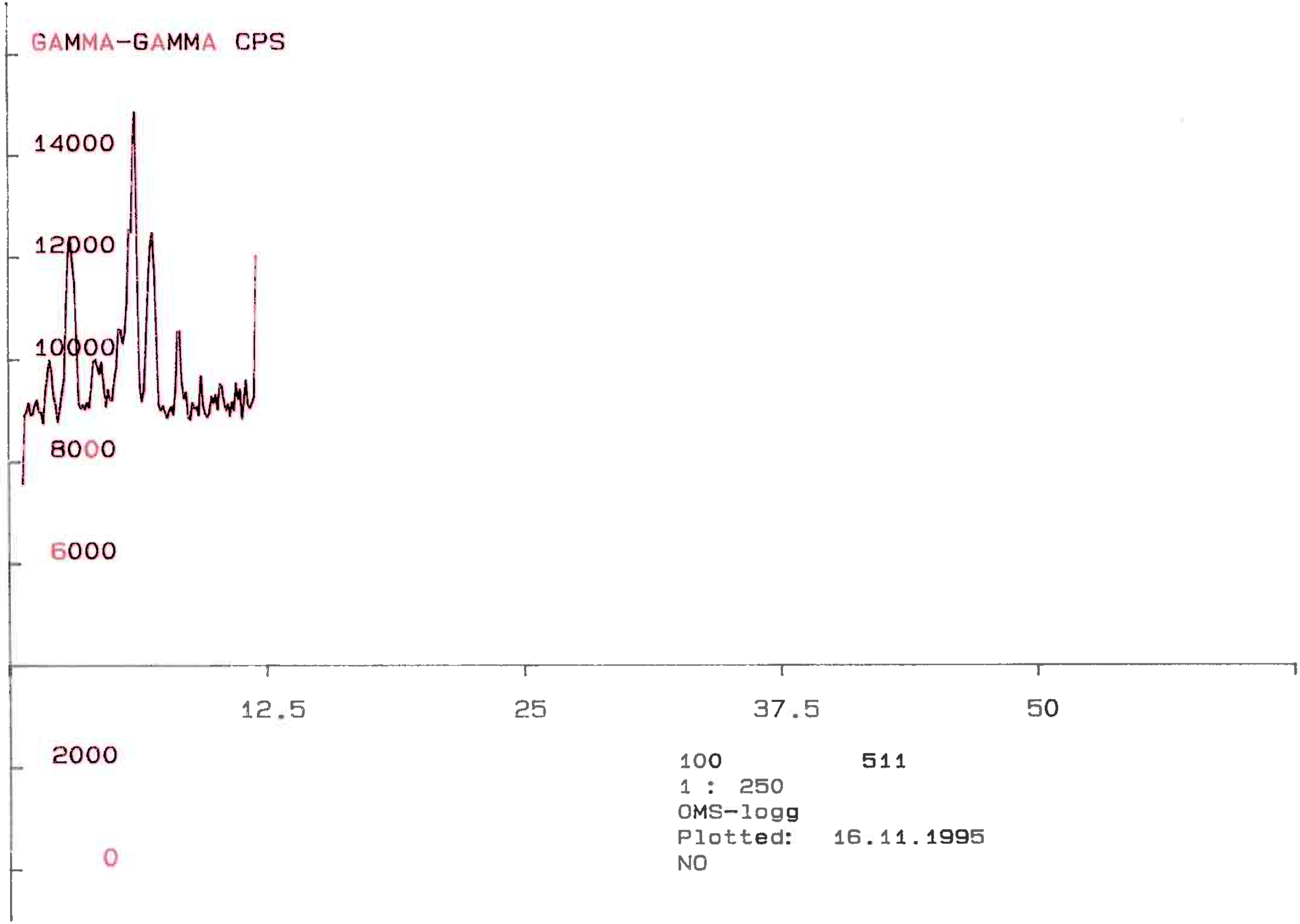


Appendix 5
Fig 5/8

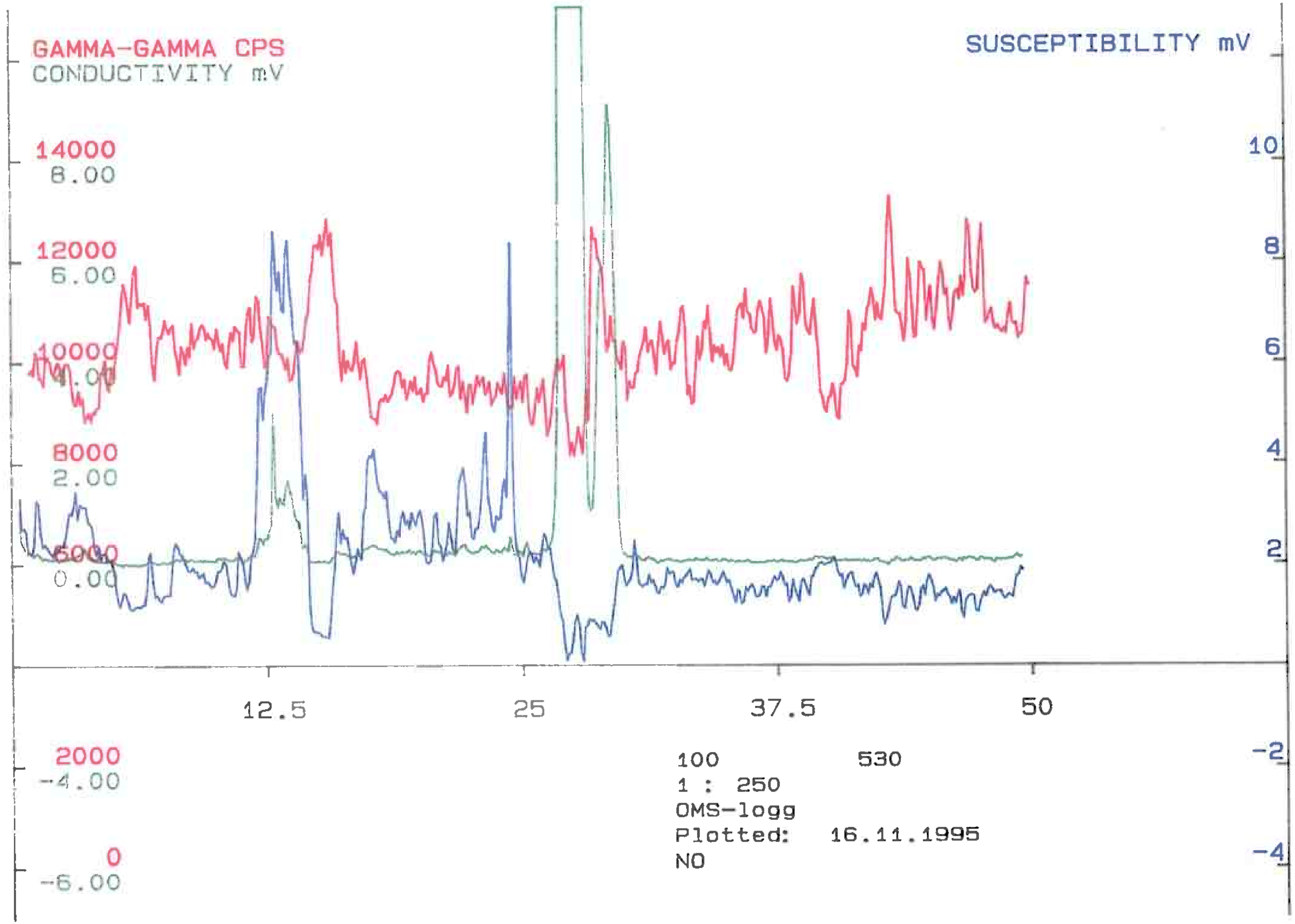


100 510
1 : 250
OMS-logg
Plotted: 16.11.1995
NO

Appendix 5
Fig 6/8

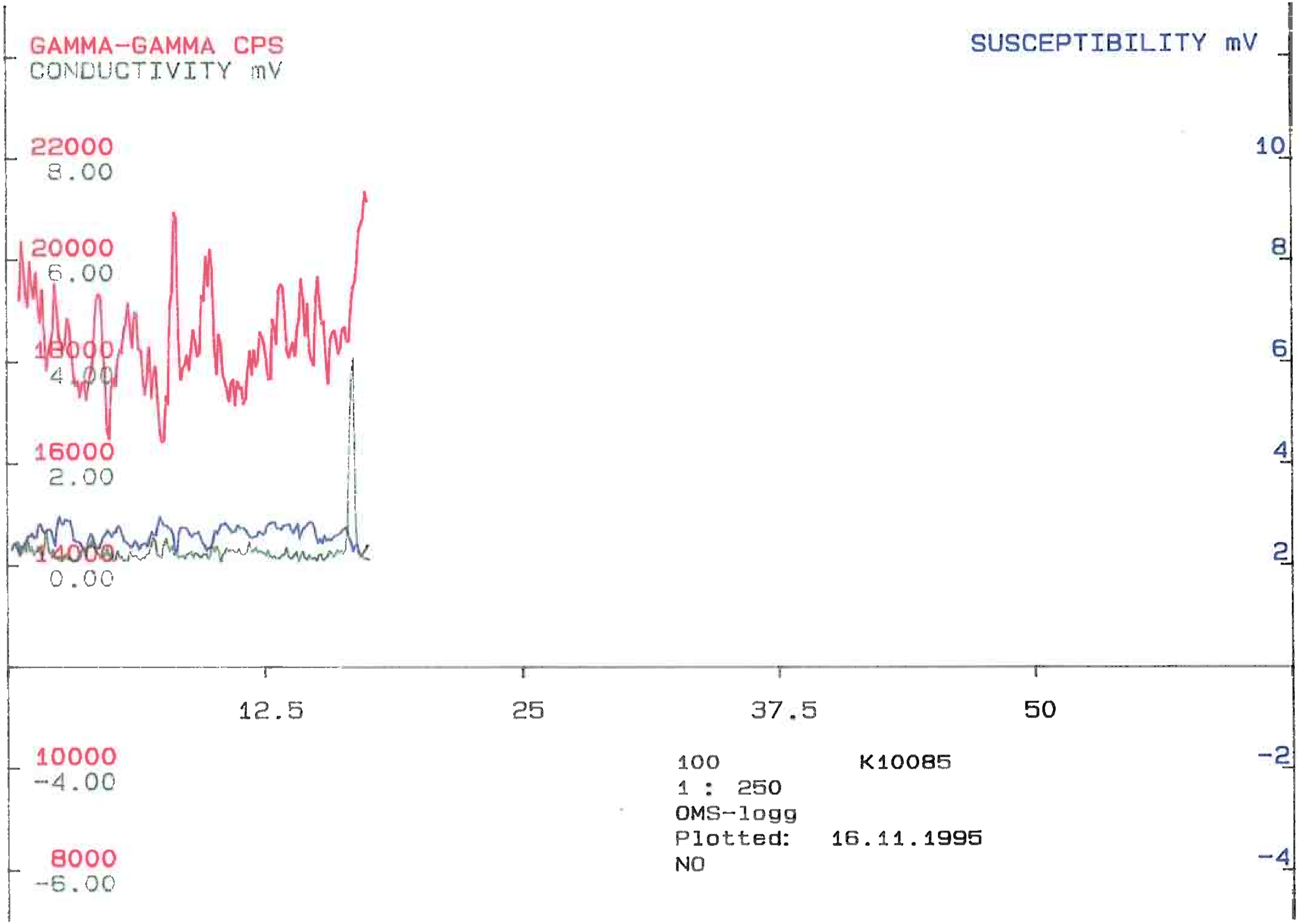


Appendix 5
Fig 7/8

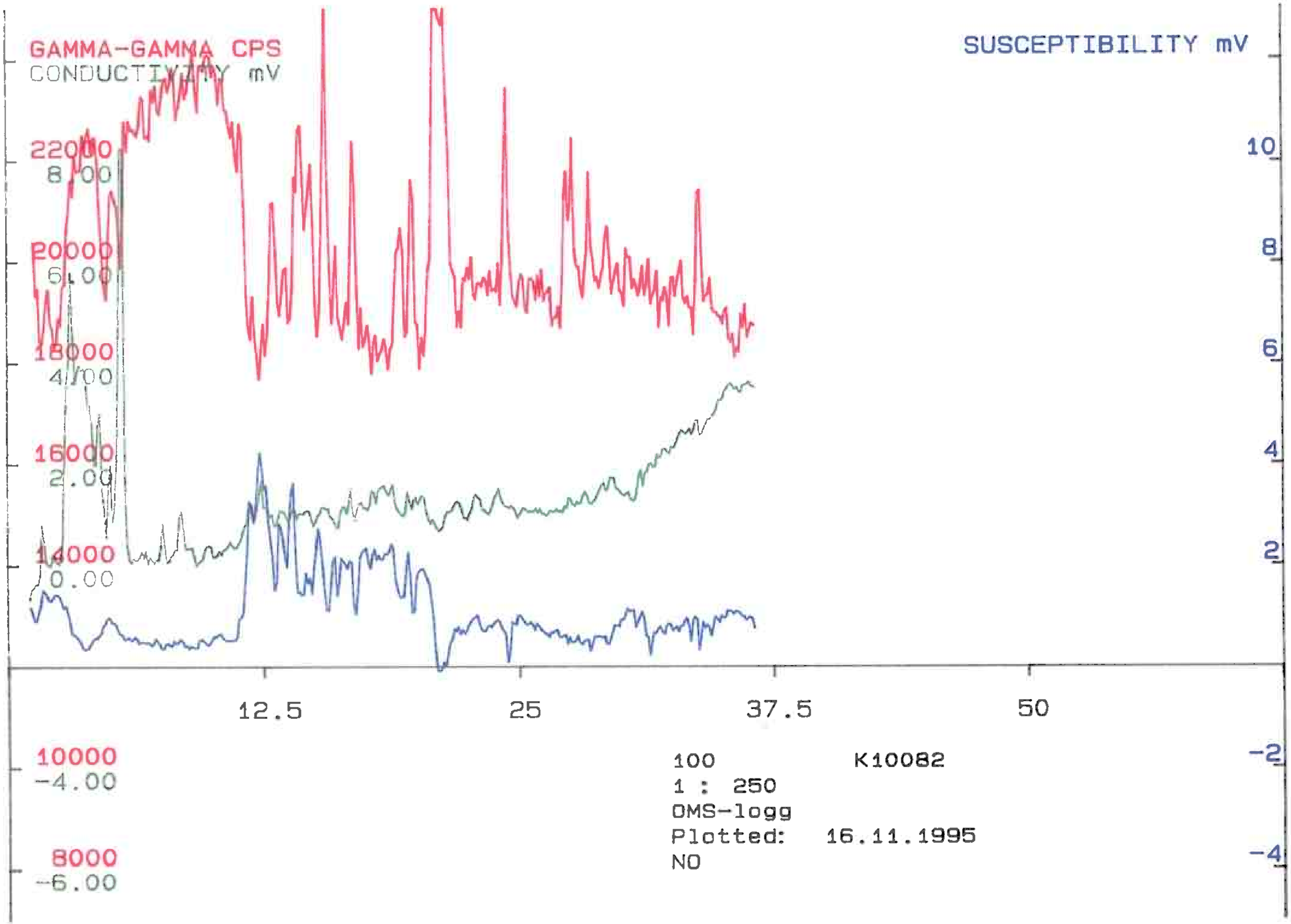


Appendix 5
Fig 8/8

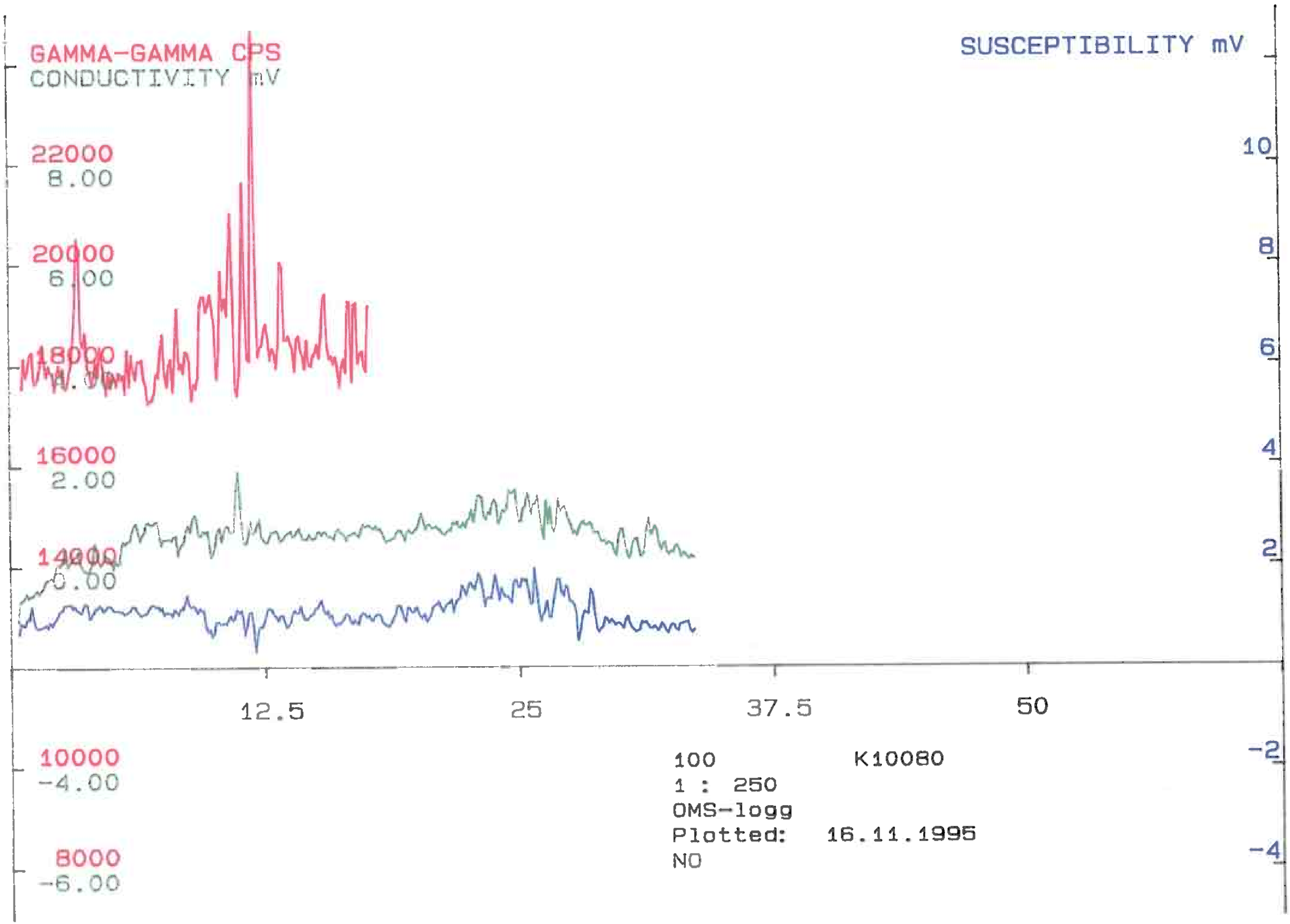
6



Appendix 6
Fig 1/3



Appendix 6
Fig 2/3

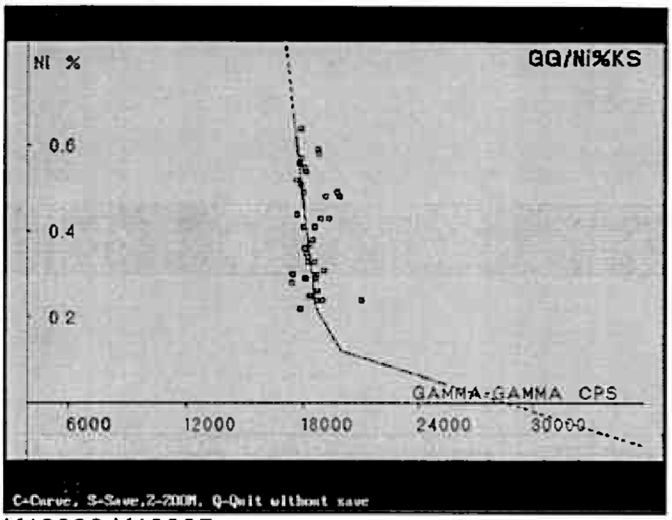


Appendix 6
Fig 3/3

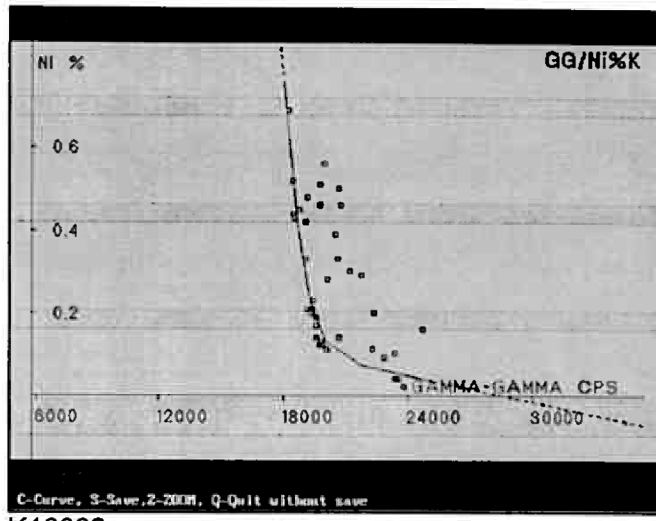
7

Appendix 7
Fig 1/9

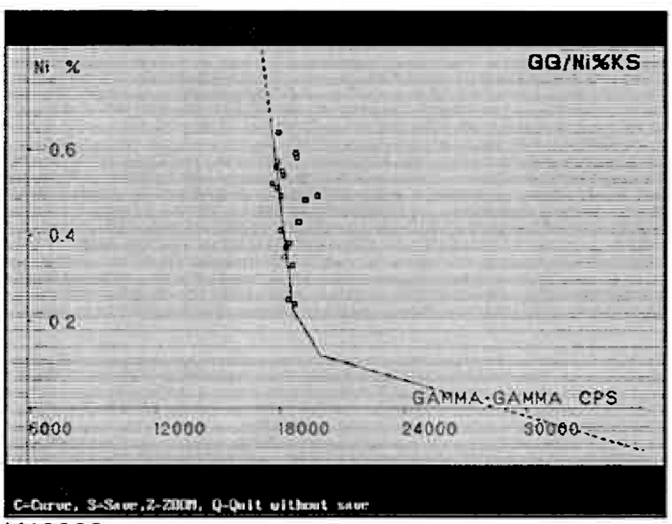
NIKKEL og OLIVIN, GG v. Ni%
Sludge holes



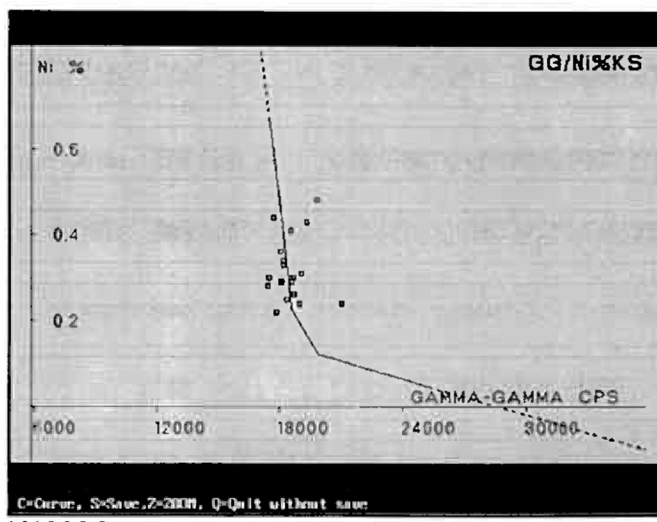
K10080,K10085



K10082

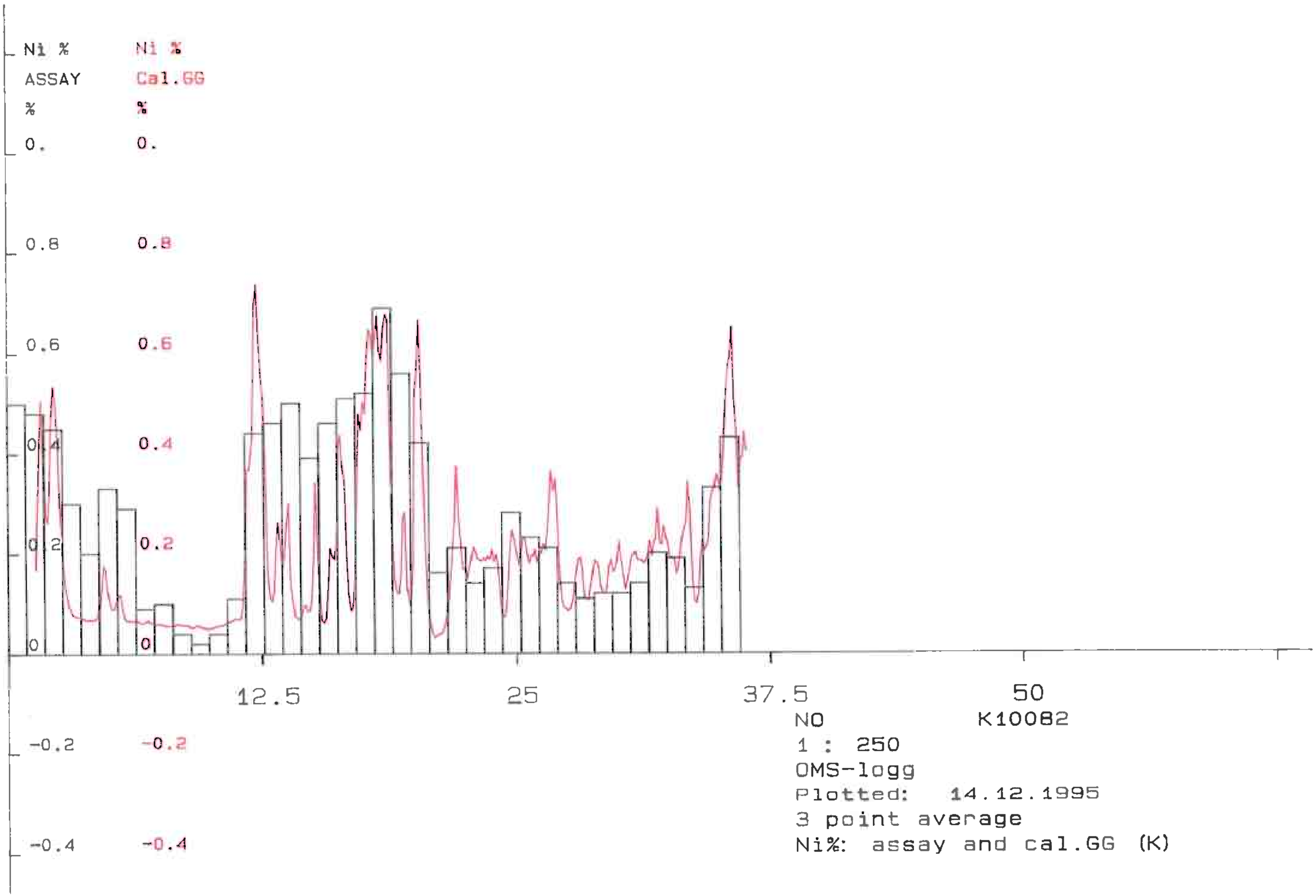


K10080

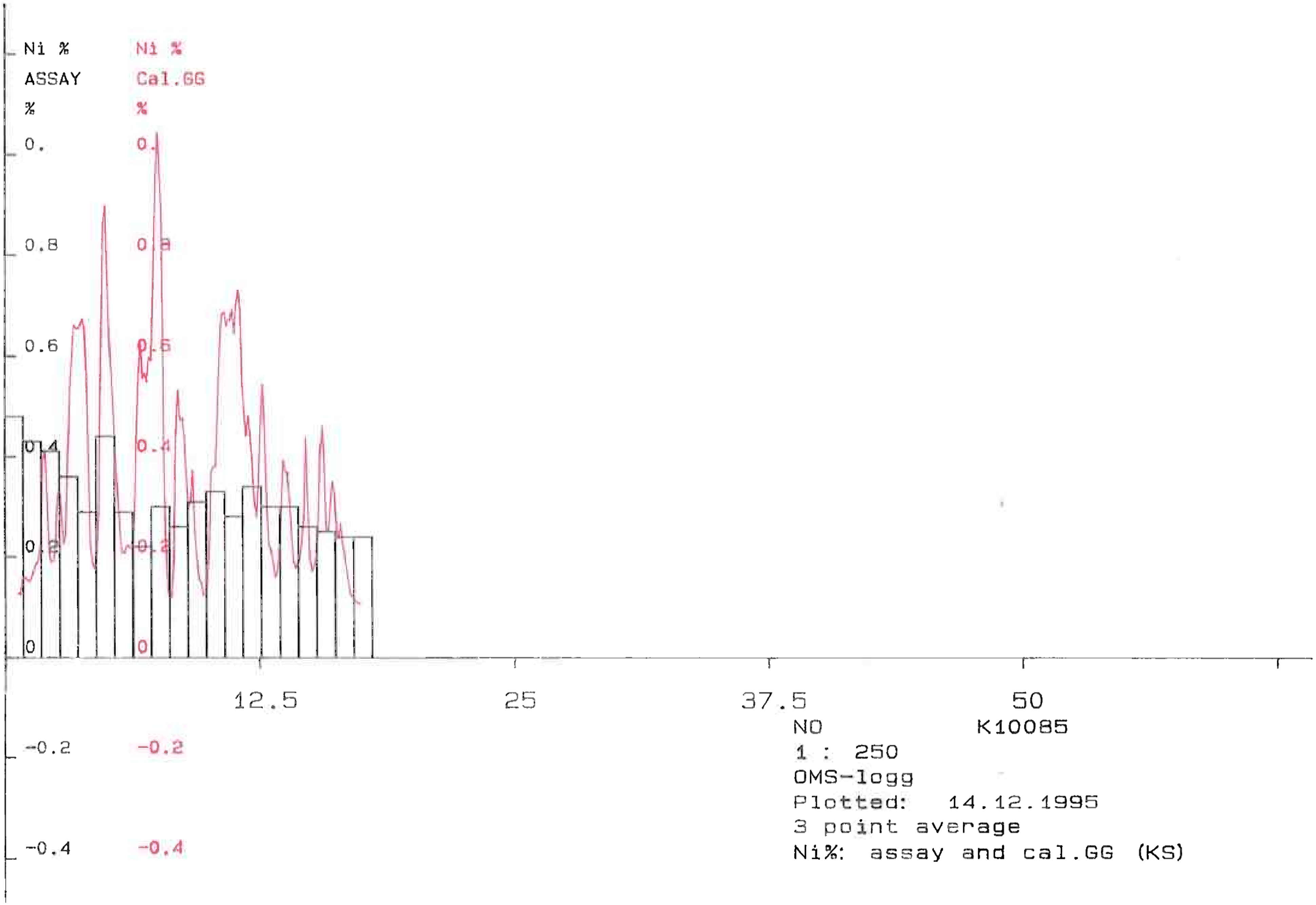


K10085

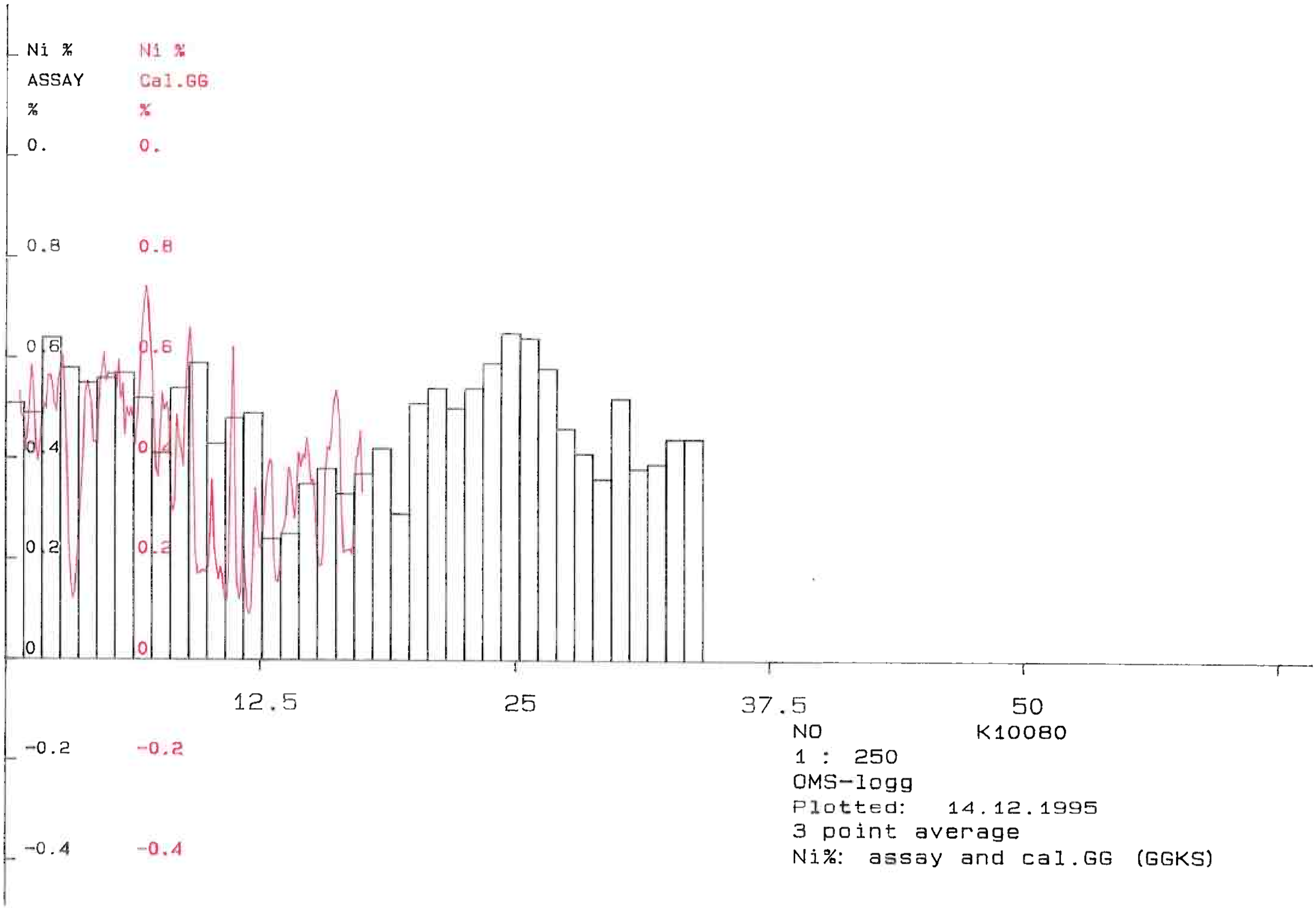
noggkcal 14.12.95



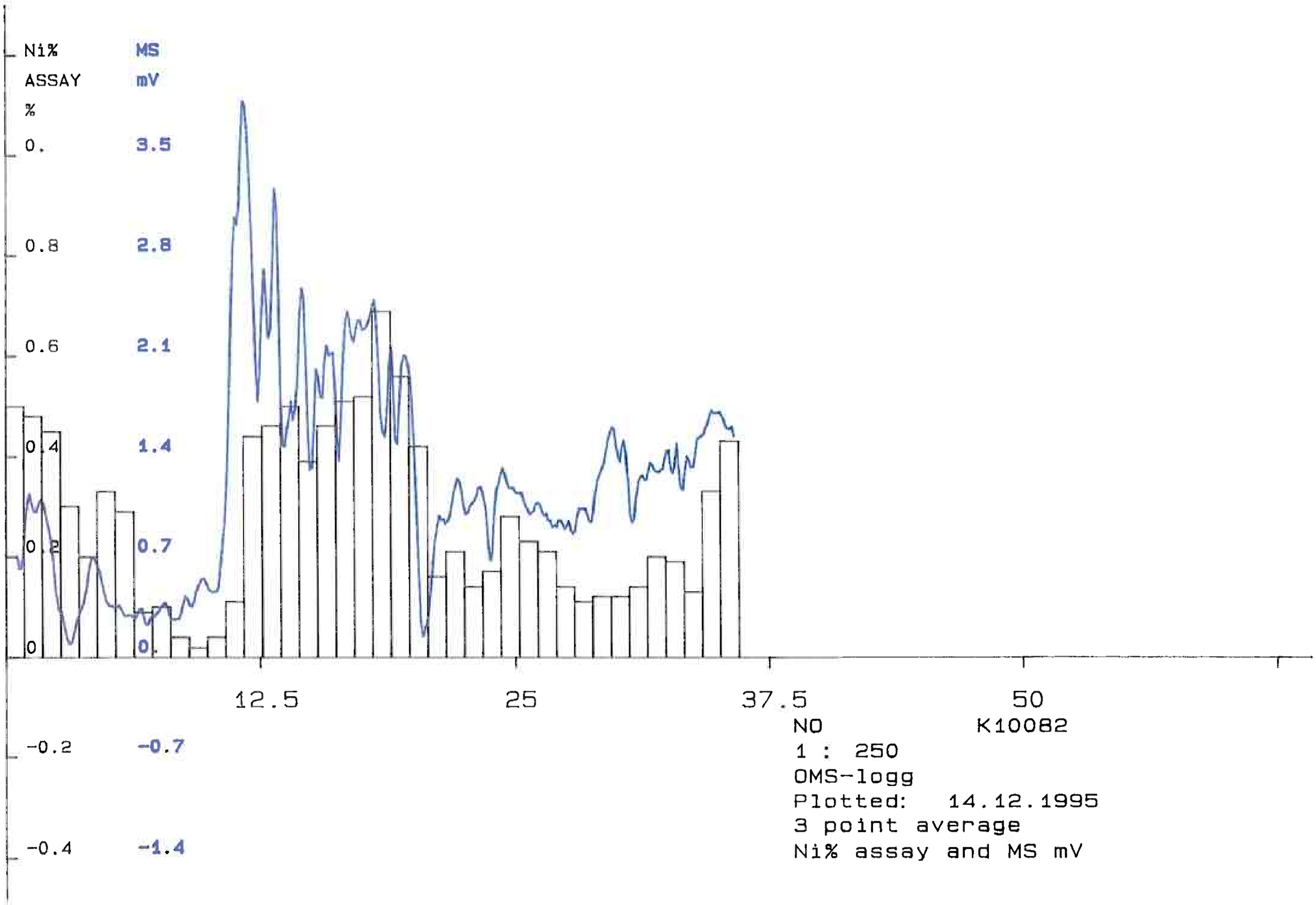
Appendix 7
Fig 2/9



Appendix 7
Fig 3/9



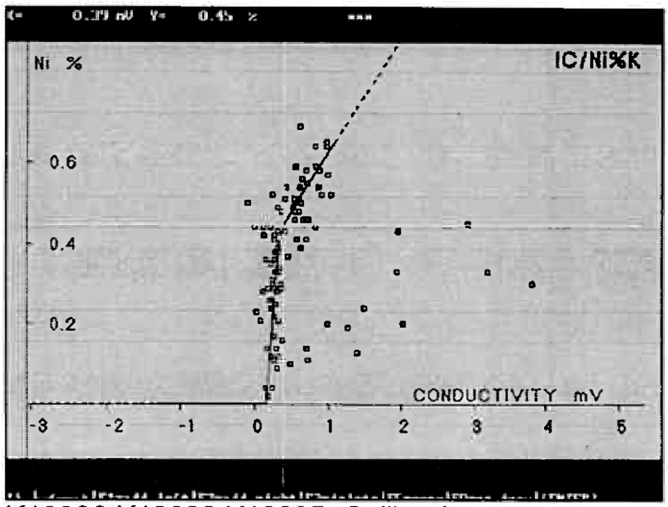
Appendix 7
Fig 4/9



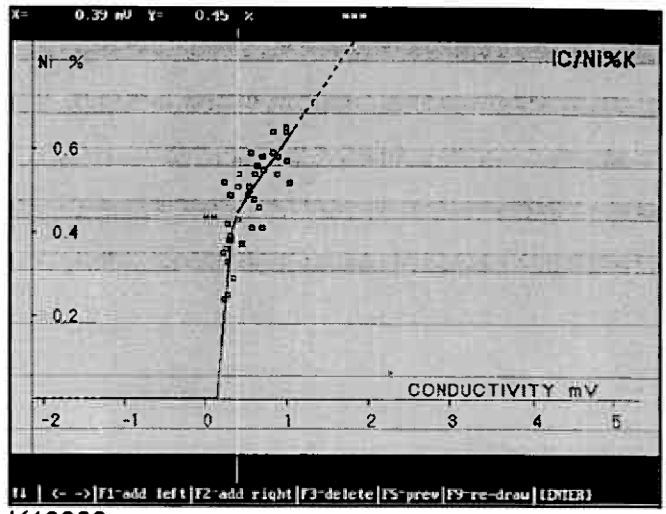
Appendix 7
Fig 5/9

NIKKEL og OLIVIN, IC v. Ni%
Sludge holes

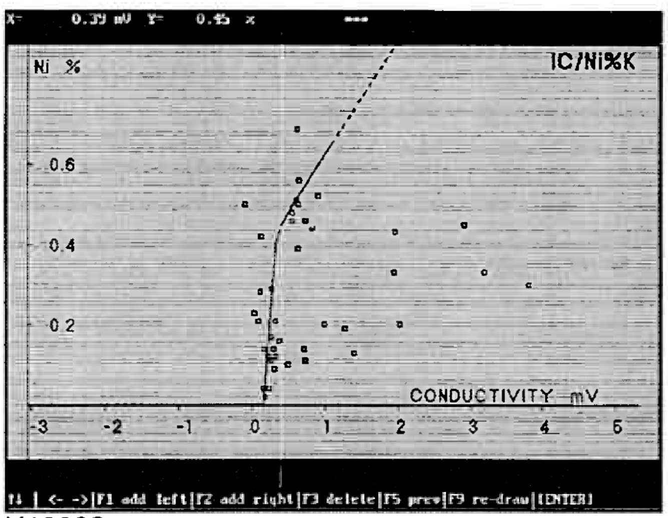
Appendix 7
Fig 6/9



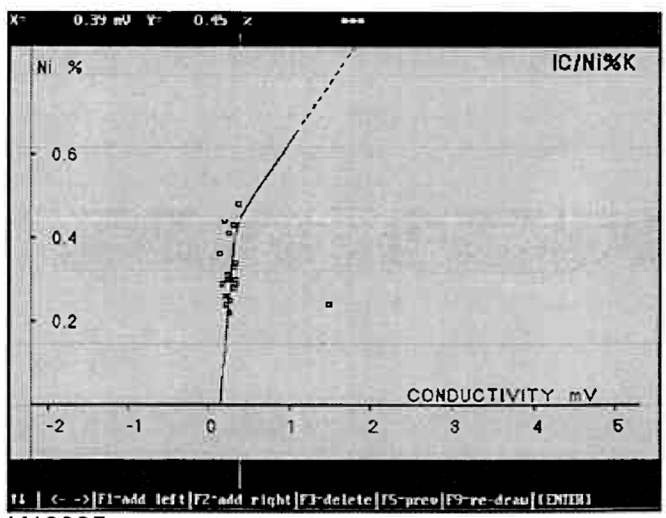
K10080,K10082,K10085, Calibration curve



K10080
Voltage drift correction -1,16mV...0,68mV

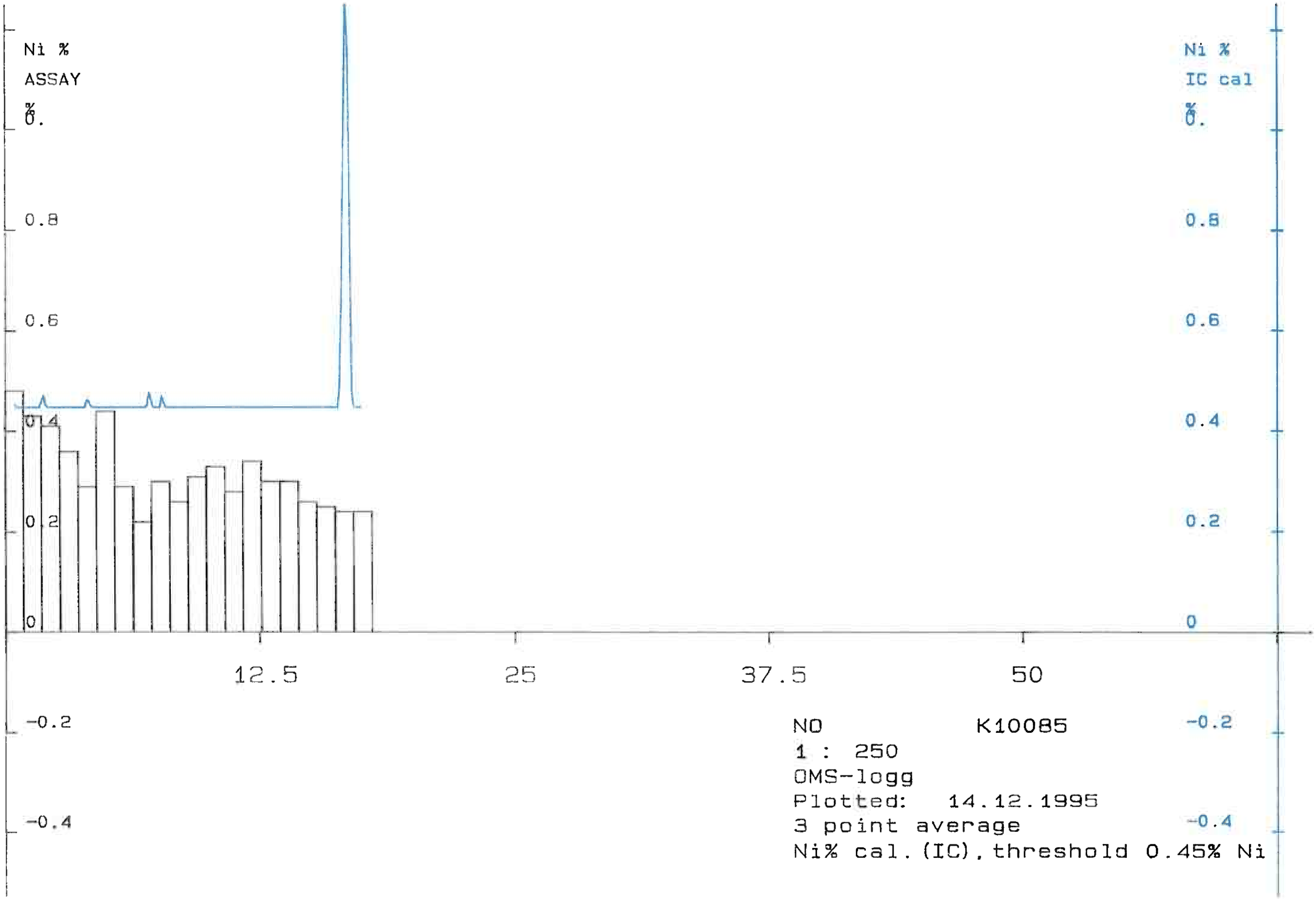


K10082
Voltage drift correction -0,65mV...1,58mV

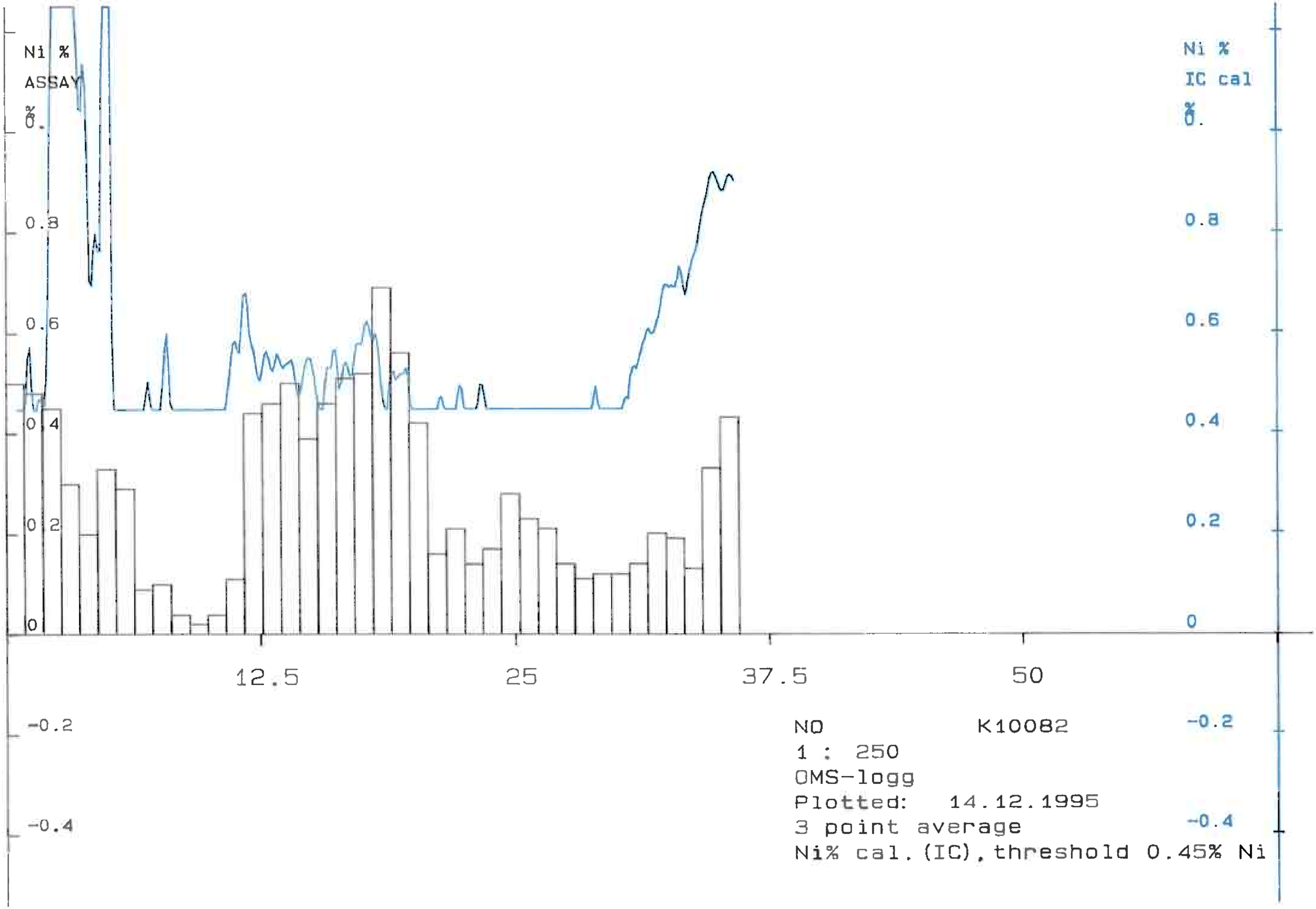


K10085
Voltage drift correction -1,47mV...-0,79mV

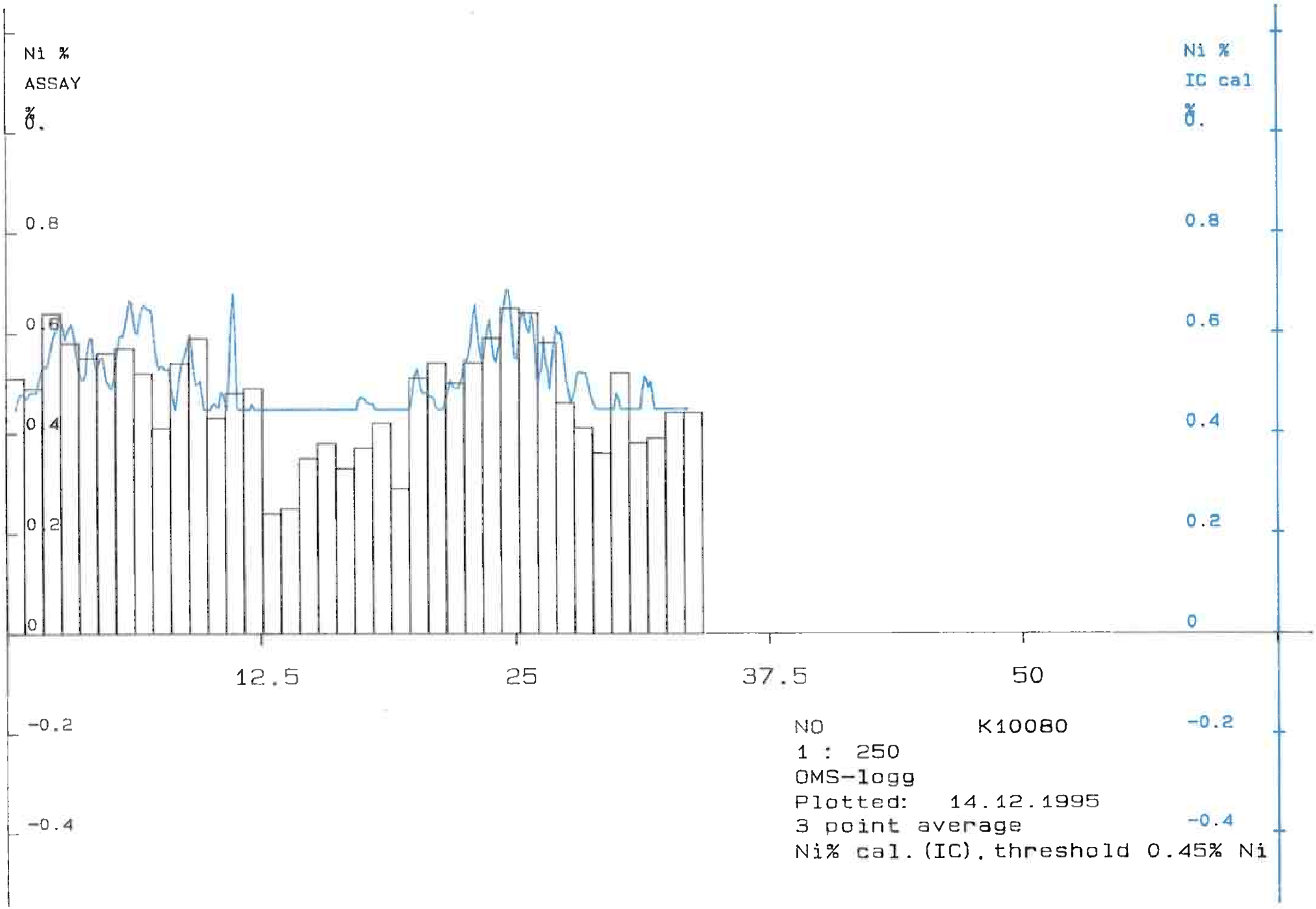
noickcal 14.12.1995, JLe



Appendix 7
Fig 7/9



Appendix 7
Fig 8/9



Appendix 7
Fig 9/9