CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

CONTROLLED COPY NO. 621

Initial Entry

This Notebook incorporates a variety of materials supplementary to the former Geochemical Natural Analog Research project conducted for NRC Office of Research.

E. C. [signature]

12/17/2003

[initials] 12/17/03

ZCP
12/17/03

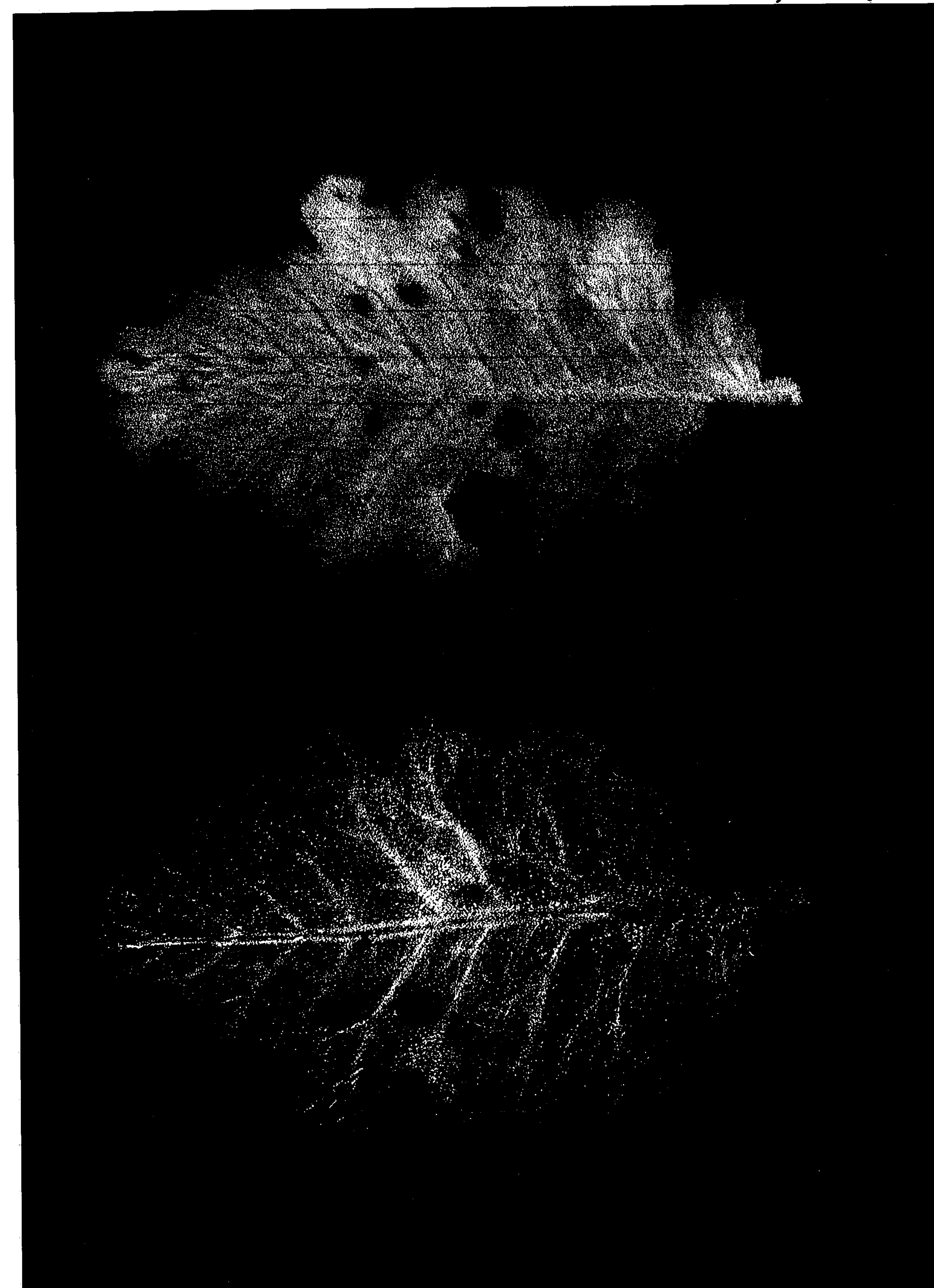
On following pages, are items that (p. 5 - 13) provide supplementary documentation for work reported in:

Leslie, B.W., Pickett, D.A., and Pearcy, E.C., 1999, "Vegetation - Derived Insights on the Mobilization and Potential Transport of Radionuclides from the Nopal I Natural Analog Site, Mexico" MRS Proceedings Vol. 556, pp. 833 - 842.

ZCP
12/17/03

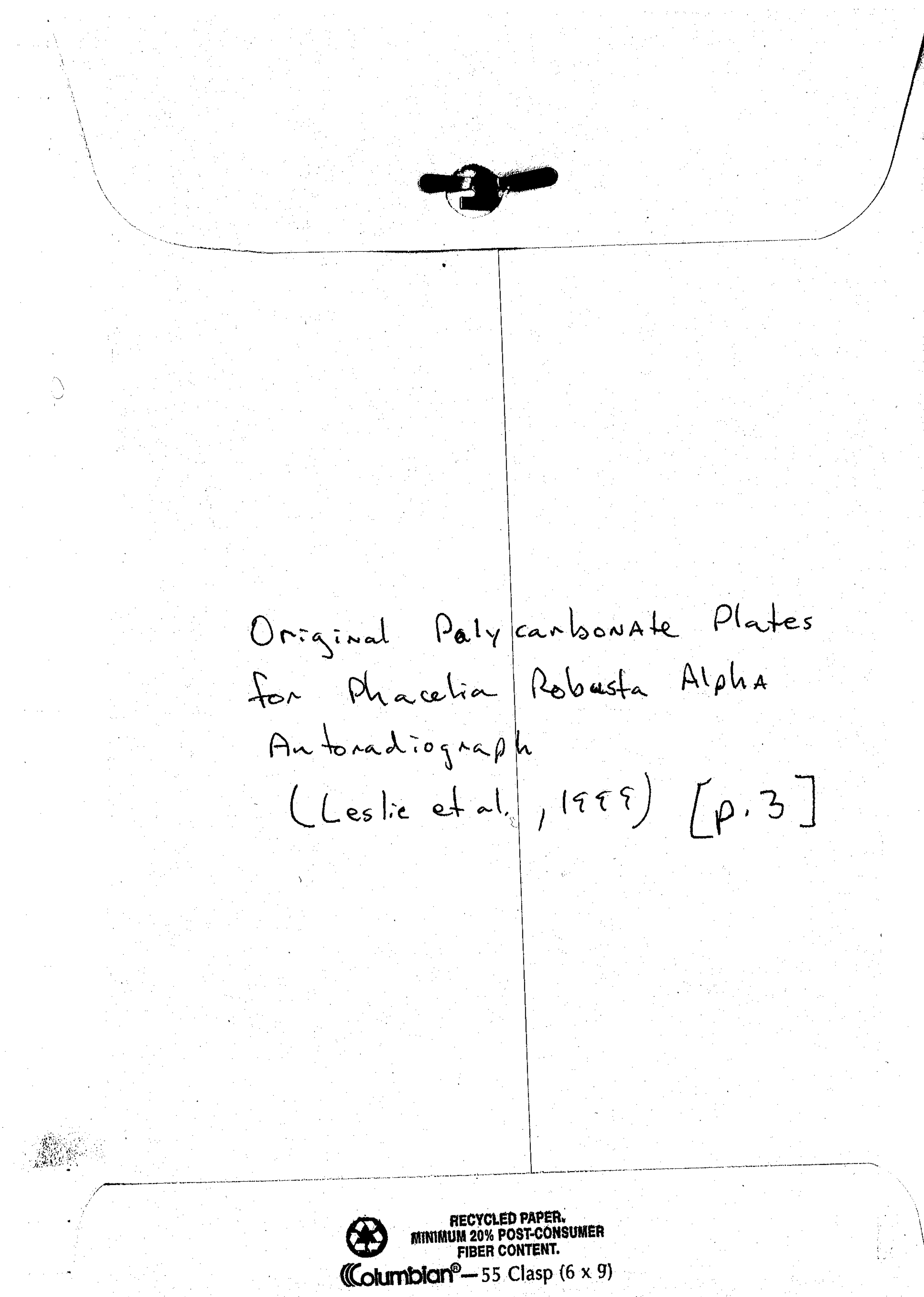
12/17/03

Phacelia Robusta Alpha Autoradiograph (Leslie et al., 1999)



(see page 3)

ECP 12/17/03



ECP 10/23/2003

12/17/03

No. ....

Name ....

Order ....

Remarks ....

Retouched ....

Order Finished ....

Reorder ....

[Photo Negative of Autoradiograph plates on page 7]

ECP 10/23/2003

ECP 12/17/03

No. ....

Name ....

Order ....

Remarks ....

Retouched ....

Order Finished ....

Reorder ....

[Photo Negative of Autoradiograph plates on page 7]

ECP 10/23/2003

ECP 12/17/03

ECP
10/23/2003

Scan of Alpha
Autoradiograph
(page 5)

ECP 12/17/03

Microthermometric investigation on samples from the Peña Blanca District (Chihuahua, Mexico) 1

(S. F. Thomas)

ECP 10/24/03

Petrographic research was conducted on volcanic rocks and veins therein of the Uranium deposit in the NOPAL formation of the Sierra Peña Blanca (Chihuahua, Mexico). This work was done in relation with the *Project Plan for Geochemical Analog of Contaminant Transport in Unsaturated Rock,* for the *Center for Nuclear Waste Regulatory Analyses* (CNWRA) at the Southwest Research Institute (SwRI).

The purpose of this research was to gain data on fluid inclusions in order to gain more insight into the thermal history of the area. Another goal was the attempt to get an evaluation of the validity of previously collected data on fluid inclusions in this area that had provided much of the basis for the establishment of various mineralization and alteration stages of this Uranium deposit. Most of these data were published by B. ANIEL and her coworkers (e.g., ANIEL, 1983; ANIEL & LEROY, 1985; GEORGE-ANIEL, LEROY & POTY, 1991).

A short summary of the findings of the authors quoted above on mineralization events in relation to fluid inclusions studies will be given here:

STAGE I:

Vapor-phase crystallization of quartz and other minerals (e.g., alkali feldspar) in lithophysal cavities as a result of devitrification of rhyolitic tuff. During this process uranium got mobilized and leached out of the volcanic tuff and precipitated around Fe(-Ti) oxides within a so-called "breccia pipe". Temperatures of the circulating fluids are estimated to be between 300° and 400°C.

Data on fluid inclusions assumed to be associated with this event ("type I"):
Presence of aqueous fluids with CO_2 and N_2; the fluid inclusions show two phases at room temperature (liquid and vapor), the vapor to liquid ratio is high (about 0.90), homogenization temperatures are "around 400°C" (GEORGE-ANIEL, LEROY & POTY, 1991). An earlier publication (ANIEL & LEROY, 1985) distinguishes between two generations of fluid inclusions: the first is characterized by "abundant" CO_2 ("solution of $CO_2 + H_2O + N_2$", salinites not determined) and homogenization temperatures between **350° and +420°C,** the second ("solution of $H_2O + CO_2 + N_2$") homogenizes between **+300° and +350°C.** No salinities have been determined for fluid inclusion from the vapor-phase crystallizaion, and salinities up to 5 NaCl-eq. wt % have been determined from fluid inclusions from samples within the breccia pipe.

2

STAGE II:

Percolation of hot aqueous fluids lead to kaolinization of the rhyolite and to oxidation and partial remobilization of uranium. Pitchblende (fine grained uraninite) or associations of pitchblende and pyrite precipitated in areas where mixing of those aqueous fluids with waters rich in H_2S occurred (e.g., in the "breccia pipe"). Temperatures during this mineralization event dropped from initial 250° to 150°C.

Data on fluid inclusions assumed to be associated with this event ("type II"):
fluid inclusions found within the breccia pipe are "water filled", the inclusions show one (probably vapor) or two phases (liquid and vapor) at room temperature. When the fluid inclusions show a disseminated array the volumes of vapor to liquid are variable; when fluid inclusions are arranged in healed fractures their vapor/liquid ratio is constant at about 0.20. The aqueous fluid inclusions formed in relation with the kaolinization event homogenize at temperatures between **150° and 300°C;** fluids trapped in inclusions that are related to the appearance of pitchblende + kaolinite are composed of H_2S in addition to H_2O and homogenize between **180° and 250°C** (in table 2 in ANIEL & LEROY, 1985, temperature values of "180 - 350°C" are given; the latter value being inconsistent with the temperature estimates for stage II in ANIEL & LEROY, 1985 (between 180 and 250°C); GEORGE-ANIEL et al., 1991 bracket stage II between 190 and 250°C. It is assumed that "350°C" is a typographical error.) Both types of fluid inclusions have salinities up to **5 NaCl-equivalent weight percent.**

STAGE FOLLOWING STAGE II ("hydrothermal", "supergene"):

Various stages follow that led
first, to an oxidation of the mineralization, formation of montmorillonite, and heulandite
second, to formation of hexavalent uranium minerals (such as uranophane, soddyite, weeksite, etc.)
third, formation of an association of uranophane + opal + iron oxides.
The temperatures for these last stages are estimated to have been between 100° and 150°C.

Data on fluid inclusions assumed to be associated with this event ("type III"):
Fluid inclusions with low **salt contents of 1.7 NaCl-eq. wt. %** at the maximum from late opals associated with uranophane give homogenization temperatures **around 150°C.** These inclusions have irregular shapes and contain one or two phases at room temperature; no CO_2 has been detected.

ECP 10/24/03

MICROTHERMOMETRIC RESULTS 3

The measurements were conducted on a heating/freezing stage (H/F stage) designed by FluidInc. First, the H/F stage was calibrated following the description in the FluidInc Instruction Manual (from Dec. 1991, p.24 and 30ff). Also compare with notes in the scientific note book **AN-2 (Analogs #2, CNWRA controlled copy 075).**

1. The tip of the thermocouple was immersed in a bath of ice cubes.
It turned out that the "trendicator" needs no adjustment.

2. Repeated measurements with several temperature calibration standards by SYNFLINC. No corrections necessary for the "negative span" of the trendicator while using the method of "cycling". If the stage is allowed to warm up just by itself without trials to stop and to reverse the temperature course, the obtained temperature is 0.2°C too high (-56.4°C instead of -56.6°C).

3. The temperature value obtained with standard #4 (pure H_2O) depended on the position of the observed fluid inclusion in relation to the tip of the thermocouple:
- melting occurred 0.2°C lower when fluid inclusion was somewhat distant from the thermocouple (at 0.0°C) than in a position fairly close to it (at 0.2°C).
The "zero settting" was adjusted for an intermediate position of the observed fluid inclusion, a position that is more likely to occur during the performance of routine measurements.
The temperature gradient across the area of the thick section might yield **too low a melting temperature** of a flud inclusion situated too far away from the tip of the thermocouple and then result in **too high salinity values.**
The "zero-setting" was checked a second time about a month later. A new correction led to a position of the brass screw close to the position that it had prior to the first calibration.

4. Measurements of the high-temperature standard (374.1°C) showed that no corrections are necessary.

It also turned out that the use of an infrared filter is essential; its use leads to a temperature drop in the chamber (at room temperature) of more than 3°C.

ECP 10/24/03

During the course of the measurements some problems with the mounting medium and/or the impregnating epoxy turned up: 4

during heating runs: increasing darkening of the samples was observed at temperatures above 250°C, the surface of the samples also seemed to be crumpeling, both phenomena made observations very difficult to impossible.

Immersion of sample fragments in acetone for several hours did not have the wanted effects: there is still epoxy visible at the rims, the sample still started to smell faintly burned at temperatures above 180°C, and the darkening and crumpeling of the surface started as before at temperatures above 250°C.

Immersion of a previously heated and a pristine sample in methylene chloride did not lead to the removal of any of the gluey rims.

Microthermometric results from samples of the Peña Blanca district

Fluid inclusion (f.i.) measurements were carried out on samples from the Nopal formation, involving the minerals quartz and calcite. The results of microthermometrical investigations are summarized in the table below. A more detailed description of the individual samples and results is listed in the Appendix. Records of individual fluid inclusion measurements can be found in a binder labeled "FLUID INCLUSION DATA - PENA B:LANCA, CHIHUAHUA, MEXICO).

List of frequently used abbreviations:

L = liquid phase
V = vapor phase
P = primary fluid inclusion
PS = pseudosecondary fluid inclusion
S = sedondary fluid inclusion
T_H (L) = homogenization temperature in the liquid phase

Densities were estimated after POTTER, II, R.W. & D.L.BROWN (1977). Salinities (given in NaCl-equivalent weight %) were calculated with the program "FLINCOR" in a version "MacFlinCor" for the Macintosh PC (see BROWN, P.E., 1989). The composition of the salts in solution were inferred from the initial melting temperatures of the frozen brines assuming that these temperatures were close to the eutectic temperatures in the pertinent systems.

ECP 10/24/03

Sample	Description	F.I. Type	V/V+L ratio	Salinity [wt %]	Composition	T_H [°C] in liquid phase	Density [g/cm3]	Comments
NOPI-ECP-39	quartz	L+V; P	0.05	2.6 to 4.2	$NaCl+MgCl_2+CaCl_2$	135 to 310	0.73 to 0.95	B
NOPI-ECP-39	quartz	L+V; S	0.10-0.25	0.7 to 1.6	$NaCl+MgCl_2+CaCl_2$	120 to 235	0.82 to 0.95	B, V
NOPI-ECP-39	quartz	L+V; P or PS	0.10-0.20 (0.05-0.45)	3.3 to 4.2	$NaCl+MgCl_2$	170 to 275 (135)	0.80 to 0.94 (0.95)	V, P_H
NOPI-ECP-39*	quartz	L+V; PS	0.20 -0.30	2.1 to 2.5	?	143 to 216	0.87 to 0.94	B
NOPI-ECP-39*	quartz	L+V; ?	0.15-0.40	2.0 to 2.5	?	135 to 250	0.81 to 0.95	V
22.5/10.4-TS 3	quartz	L+V; P or PS	0.40-0.60	?	$NaCl+MgCl_2+CaCl_2$	above 350	?	P, E
393-5.5/32.7	calcite	L+V; P or PS	0.15-0.25	up to 0.5	$NaCl + MgCl_2$	165 to 200	0.87-0.93	B, V
393-7.5/33.8	calcite	L+V; PS	0.10-0.15	0.7 wt %	$NaCl+MgCl_2+CaCl_2$	146 to 295	0.82-0.94	P
393-7.5/33.8	calcite	L+V; S_1	0.05-0.10-0.15	up to 2.5	$NaCl+MgCl_2+CaCl_2$	80(?) 295	0.75-0.98 ?	C
393-7.5/33.8	calcite	L+V; S_2	0.01-0.02	up to 0.3	?, clathrates ?	46 to 50	0.99	B, V

* = measurements taken by J.D. Prikryl

Explanation for Comments:

B = bubbles collapse due to pressure of ice crystals during freezing runs
C = carbonate minerals precipitated within decrepitated fluid inclusions
E = burning of epoxy impedes observation
P = precipitation of solids after/during freezing run or during heating run
P_H = precipitation of solids after homogenization temperature
V = vapor phase expands or bubbles appear during/after freezing run

ECP 10/24/03

Evaluation of the Microthermometrical Results 6

In any given sample there is a remarkable range of homogenization temperatures but a narrow range of salinities. In context with the tendency of the vapor bubbles to expand during runs on the heating stage a natural readjustment of previously trapped fluid inclusions during a younger stage of the multi-stage thermal history of the studied area seems very likely.

Results on samples **NOPI-ECP-39** and **other comparable quartz samples ("vapor phase quartz"):**

The presence of CO_2 or N_2 could not be confirmed. Two phases (liquid and vapor) were present at room temperature as in the descriptions of ANIEL & LEROY(1985) and GEORGE-ANIEL et al. (1991) but the vapor/liquid ratio observed in NOPI-ECP-39 and the other quartz samples was with 0.05 to maximum 0.45 much lower than ANIEL & LEROY's values of around 0.90. The obtained homogenization temperatures between 120 and 310°C barely overlap the range of homogenization temperatures between 300 and 420°C given by ANIEL & LEROY (1985).

Sample **22.5/10.4-TS 3** (quartz phenocrysts collected from a kaolinized tuff with uranyl silicates) was checked for fluid inclusions that contained fluid of stage II. There results obtained on this sample are not sufficient for a rigorous comparison. The measured salinities (up to 5 wt %) corroborate the data of ANIEL & LEROY (1985) and GEORGE-ANIEL et al.(1991). The homogenization temperatures with more than 350°C, though, are far beyond the values of ANIEL & LEROY (1985) and GEORGE-ANIEL et al.(1991) that gave T_H between 190 and 250 °C (the value "350°C" given in ANIEL & LEROY, 1985, is probably a typographical error). Microthermometric observations did not yield any indications of the presence of H_2S in sample 22.5/10.4-TS 3 such as the formation of H_2S-H_2O hydrates. A proof of the presence of H_2S in low concentrations is only possible with chemical analytical or spectroscopical methods (e.g. by Raman).

The results obtained from the stained calcite sample **393-5.5/32.7**, possibly formed during stage II: V/V=L ratio between 0.15 and 0.25, salinities up to 0.5 NaCl-eq. wt %, T_H between 165 and 200°C reflect the microthermometric results given by ANIEL & LEROY (1985) and GEORGE-ANIEL et al. (1991) for this stage.

Sample **393-7.7/33.8** (calcite) shows quite an array of homogenization temperatures: from 46 (!) to 295°C with no obvious cluster of values. The salinities are lower than 2.5 NaCl-eq. wt % corresponding to the findings of ANIEL & LEROY (1985) and GEORGE-ANIEL et al. (1991), rep. for stages I (f.i. within the breccia pipe) and II (in relation with kaolinization and uraninite precipitation). The range in T_H is too large to link this sample genetically to any of the three stages. Calcite due to its softness

ECP 10/24/03

and good cleavage is in any regard a far less reliable candidate for fluid inclusions investigations than quartz. 7

OTHER RESULTS

Several samples were checked with a UV (ultraviolet light) lamp to distinguish late groundwater precipitates such as opal from higher temperature precipitates such as "vapor-phase" quartzes originating from magmatic fluids.

Opals from sample **NOPI-ECP-19.0/5.0** showed a strong fluorescence as expected. This sample and another amygdule filling of sample **NOPI-ECP-15.2/10.1** were the only ones that fluoresced. A listing of the checked samples can be found in the notebook **AN-2** (CNWRA controlled copy 075).

ECP 10/24/03

Outlook

The range in homogenization temperatures (over all from 46 to more than 350°C, with the bulk T_H lying between 135° and 300°C makes more fluid inclusion measurements necessary if microthermometric investigations should help to unravel the complex thermal history of the area. Notably absent are measurements on opal samples, that are formed during the late supergene or hydrothermal stage (III).

As mentioned before, calcite is not a prime candidate for fluid inclusion investigation, but the reliability of microthermometric studies might be checked if stable isotope data (e.g., $^{18}O/^{16}O$) are available from the same specimens.

Another effort should be made to search the field area for suitable quartz and opal samples.

One of the handicaps during the measurements was the decomposition of the mounting medium and the impregnating epoxy during heating experiments.
Several mounting cements with low preparation temperatures are recommended (ROEDDER, 1984, p.155):
- **Duco** (a cellulos nitrate base cement)
- **"Super-glue"** (cyanonitrile-type contact cements, sets at room temperature, soluble in acetone)
- **"Elmer's Wonderbond** (cyanoacrylate adhesive, soluble in acetone or nitromethane)

Recommended epoxy resins for impregnation:
- **DER 332 with TETA hardener** (DOW Chemical Co.)
- **Araldite 105** (CIBA Corp.)

Further recommandations for sample preparation are given in BARKER & REYNOLDS (1984).

Sample thick sections with a thickness of about 0.5 mm are preferable over thinner ones.

ECB
10/24/03

References

ANIEL, B. (1983):
Les gisements uranifères associés au volcanisme acide tertiaire de la Sierra Peña Blanca (Chihuahua, Mexico). - Géol. Géochim. Uranium, Nancy, Mém. **2**, 291p.

ANIEL, B. & J. LEROY (1985):
The reduced uraniferous mineralization associated with the volcanic rocks of the Sierra Peña Blanca (Chihuahua, Mexico). - Am. Min. **70**, 1290-1297.

BARKER, C.E. & T.J. REYNOLDS (1984):
Preparing doubly polished sections of temperature sensitive sedimentary rocks. - J. Sediment. Petrology **54/2**, 635-636.

BROWN, P.E. (1989):
FLINCOR: a fluid inclusion data reduction and exploration program. - PACROFI II, vol. **2**, January 1989, Blacksburg VA.

GEORGE-ANIEL, B., LEROY, J.L. & B.POTY (1991):
Volcanogenic Uranium Mineralizations in the Sierra Peña Blanca District, Chihuahua, Mexico: Three Genetic Models. - Econ. Geol. **86/2**, 233-248.

POTTER, II, R.W. & D.L. BROWN (1977):
The volumetric properties of aqueous sodium chloride solutions from 0° to 500°C and pressures up to 2,000 bars based on a regression of the available data in the literature. - U.S. Geol. Survey Bull. **1421-C**, 36 p.

E. ROEDDER (1984)
Fluid Inclusions. P.H. Ribbe (ed) - Min. Soc. Am., Review in Mineralogy **12**, 644 p.

ECB
10/24/03

APPENDIX

10

Sample: **NOPI-ECP-39-FI**

Locality/ further description: quartz crystals from vesicles on the +20 m level of Nopal I, Nopal formation; a similar sample (NOPI-20-28/1) was identified as "vapor-phase quartz" by Linda Kovach

Mineral: **Quartz**

Results, sample NOPI-ECP-39-FI:
Type: L + V; **P**
V/V+L ratio: 0.05
Salinity [NaCl-eq. wt %]: between 2.6 and 4.2
Salts present: NaCl + $CaCl_2$ + $MgCl_2$ (?)
other compounds (e.g., CO_2, N_2, CH_4, H_2S) : no indications
Homogenization temperatures: between 135° and 310°C (L)
density [g/cm^3]: 0.73 - 0.95
further observations/comments: most of the vapor bubbles collapse during freezing runs and do not return in time to measure the final melting temperature of ice; this makes the salinity determination uncertain (some do not return after several days).

Results, sample NOPI-ECP-39-FI:
Type: L + V; **S**
V/V+L ratio: 0.10 - 0.25
Salinity [NaCl-eq. wt %]: between 0.7 and 1.6
Salts present: NaCl + $CaCl_2$ + $MgCl_2$ (?)
other compounds (e.g., CO_2, N_2, CH_4, H_2S) : no indications
Homogenization temperatures: between 120° and 235°C (L)
density [g/cm^3]: 0.82 - 0.95
further observations/comments: most of the vapor bubbles collapse during freezing runs and do not return in time to measure the final melting temperature of ice; this makes the salinity determination uncertain. Vapor bubbles in many inclusions reappear after the heating runs.

Most f.i. in this sample are on irregular and curved planes, most of them have one phase (presumably vapor) at room temperature.

Results, sample similar to NOPI-ECP-39-FI:
Type: L + V; **P** or **PS**
V/V+L ratio: 0.05 - 0.45, mostly between 0.10 and 0.20
Salinity [NaCl-eq. wt %]: between 3.3 and 4.2
Salts present: NaCl + $MgCl_2$ (?)
other compounds (e.g., CO_2, N_2, CH_4, H_2S) : no indications
Homogenization temperatures: between 135° and 275°C (L)
density [g/cm^3]: between 0.80 and 0.94 (0.95)
further observations/comments: bubbles (in larger inclusions) tend to enlarge after freezing runs; precipitation of a solid observed after first homogenization (L)

ECd 10/24/03

Results of measurements of the samples NOPI-ECP-39-FI 1-A, NOPI-ECP-39-FI 1-B1 and NOPI-ECP-39-FI 1-B2, done by J. Prikryl:

11

Results, sample NOPI-ECP-39-FI 1-A:
Type: L + V; **P**
V/V+L ratio: 0.20 - 0.30
Salinity [NaCl-eq. wt %]: between 2.1 and 2.5
Homogenization temperatures: between 143° and 216°C (L?)
density [g/cm^3]: between 0.87 and 0.94
further observations/comments: "bubble did not return after heating previous inclusion"

Results, sample NOPI-ECP-39-FI 1-B1 and NOPI-ECP-39-FI 1-B2:
Type: L + V; **?**
V/V+L ratio: 0.15 - 0.40
Salinity [NaCl-eq. wt %]: between 2.0 and 2.5
Homogenization temperatures: between 135°C and 250°C
density [g/cm^3]: between 0.81 and 0.95
further observations/comments: "heating ... caused many more bubbles to appear"

Many of the optically and microthermometrically studied **quartz samples from kaolinized tuffs** contain more solid (glass) than fluid inclusions.

Sample: **22.5/10.4-TS 3**

Locality/ further description: sample collected from the +10 m level of the Nopal I deposit along 2 traverses; kaolinized tuff with uranyl silicates

Mineral: **Quartz** (phenocrysts)

Results, sample 22.5/10.4-TS 3:
Type: L + V; **P** or **PS**
V/V+L ratio: 0.40 - 0.60
Salinity [NaCl-eq. wt %]: ?
Salts present: NaCl + $CaCl_2$ + $MgCl_2$ (?)
other compounds (e.g., CO_2, N_2, CH_4, H_2S) : no indications
Homogenization temperatures: above 350°C (L?)
density [g/cm^3]: ?
further observations/comments: elongate greenish crystals without visible double refraction (?apatite) appeared in some f.i. during the first freezing run, these crystals seem to change in shape and thickness upon heating but do not disappear. Epoxy running over the wafer at temperatures above 280°C prevents observation at temperatures above 350°C.

ECd 10/24/03

Sample: **393-5.5/32.7**

Locality/ further description: sample collected from N-S running calcite vein

Mineral: **Calcite** (large grain size, several mm)

The calcite is stained with iron oxides/hydroxides giving it a dark appearance. This sample was chosen because B. ANIEL (1983) had distinguished two calcite generations, relating the deposition of a "dark calcite" with the kaolinization event (stage II). No microthermometric results were given in the publications by ANIEL (1983), ANIEL & LEROY (1985) or GEORGE-ANIEL et al. (1991).

Results, sample 393-5.5/32.7:
Type: L + V; **P** or **PS**
V/V+L ratio: 0.15 - 0.25 %
Salinity [NaCl-eq. wt %]: up to 0.5
Salts present: NaCl + $MgCl_2$ (?)
other compounds (e.g., CO_2, N_2, CH_4, H_2S) : no indications
Homogenization temperatures: between 165° and 200°C (L)
density [g/cm^3]: 0.87 - 0.93
further observations/comments: many bubbles tend to collapse after or during the freezing runs; others seem to have formed at the same time and appear after the freezing runs suggesting that the volume in preexisting L+V inclusions also might have changed.

ECB 10/24/03

Sample: **393-7.5/33.8**

Locality/ further description: sample collected from a calcite/caliche crust

Mineral: **Calcite**

This sample was selected because the calcite crystals display growth zones (that enhances chances to find primary fluid inclusions). Calcite crystals have minute inclusions of hematite (or ilmenite?).

Results, sample 393-7.5/33.8:
Type: L + V; **PS**
V/V+L ratio: 0.10 - 0.15
Salinity [NaCl-eq. wt %]: could rarely be observed, 0.7
Salts present: NaCl + $MgCl_2$ + $CaCl_2$ (?)
other compounds (e.g., CO_2, N_2, CH_4, H_2S) : no indications
Homogenization temperatures: 80° and 274°C (L)
density [g/cm^3]: 0.75 - 0.98
further observations/comments: in many cases bubble size doesn't seem to change so that no measurements of the final melting or homogenization temperatures were possible. Also: precipitation of solids was repeatedly observed after the freezing and during the heating run.

Results, sample 393-7.5/33.8:

Type: L + V; **S_1**
V/V+L ratio: 0.05 - 0.15, mostly 0.10
Salinity [NaCl-eq. wt %]: up to 2.5
Salts present: NaCl + $MgCl_2$ + $CaCl_2$ (?)
other compounds (e.g., CO_2, N_2, CH_4, H_2S) : no indications
Homogenization temperatures: between 146° and 295°C (L)
density [g/cm^3]: 0.82 - 0.94
further observations/comments: many carbonate minerals are observed within decrepitated former fluid inclusions that are arranged on growth zones, suggesting that the fluid for primary f.i. has contained some CO_2.

Results, sample 393-7.5/33.8:
Type: L + V; **S_2** (S_2 inclusions much smaller than f.i. type S_1)
V/V+L ratio: 0.01 - 0.02
Salinity [NaCl-eq. wt %]: up to 0.3
Salts present: (?)
other compounds (e.g., CO_2, N_2, CH_4, H_2S) : deformation of bubble might indicate presence of clathrates or hydrates
Homogenization temperatures: between 46° and 50°C (L)
density [g/cm^3]: 0.99

further observations/comments: Since the volume of the gas phase in f.i. of type S was often less than 10% the bubbles tend to disappear during freezing runs and quite often did not return, rendering results on the final melting temperature of ice useless and inhibiting measurement of T_H. Stretching of the calcite leads to a second higher homogenization temperature of 213°C for the inclusion with measured T_H of 46°C.

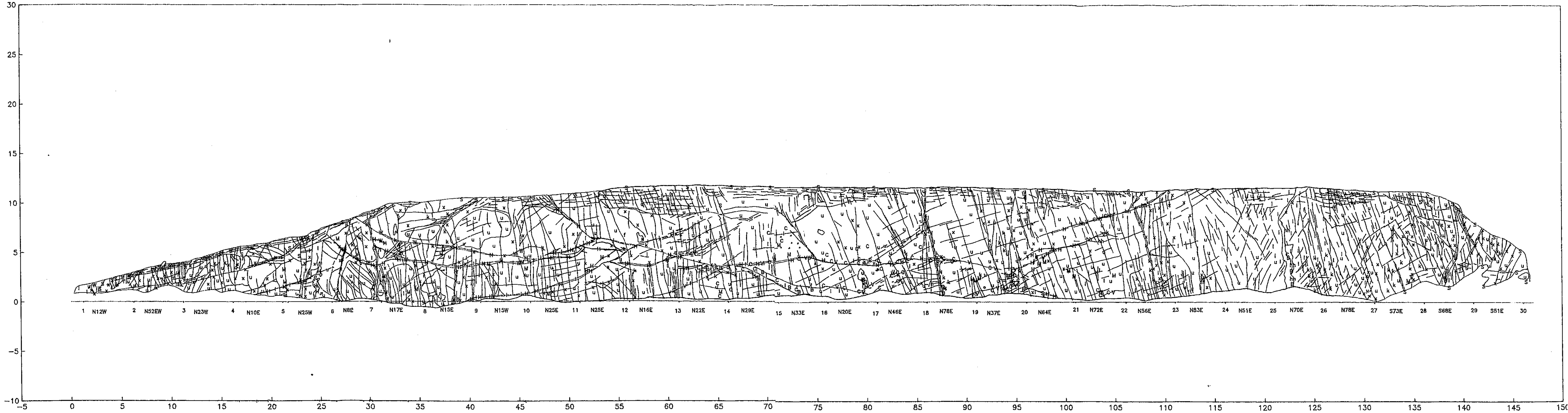
ECB 10/24/03

The vertical sections on pages 29 - 35 are fracture maps of the vertical surfaces at the Nopal I deposit. The scales are in meters. The lines are the fracture traces. The letters refer to a rock alteration nomenclature that was not used. The letters should not be taken as having meaning. The approximate azimuths of the vertical face sections are indicated below each section. Mapping was done by Prof. Ignacio Reyes of the University of Chihuahua.

E. C. [signature]

10/24/2003

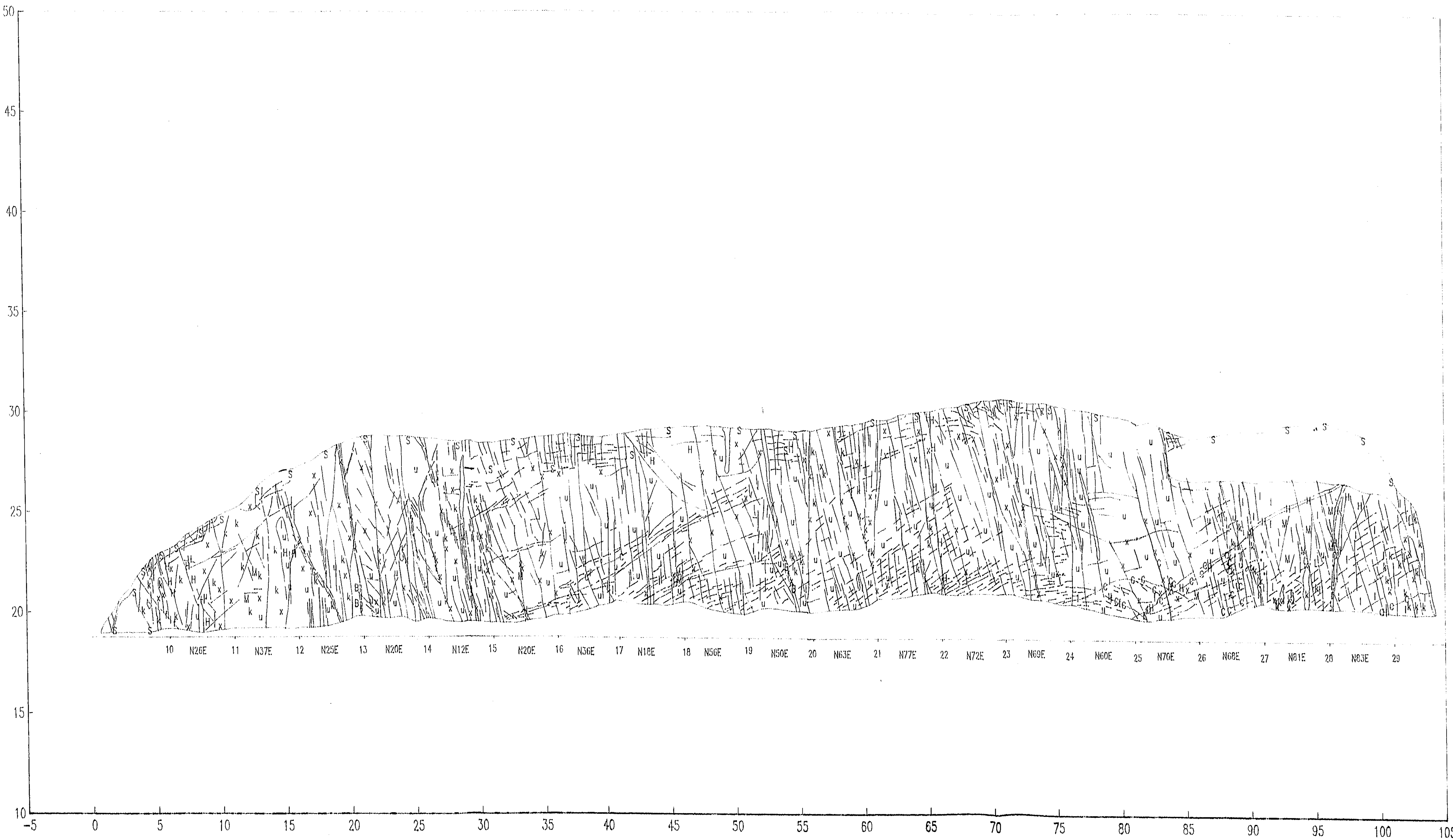
LEVEL +10 EL NOPAL I



ECB
24/03

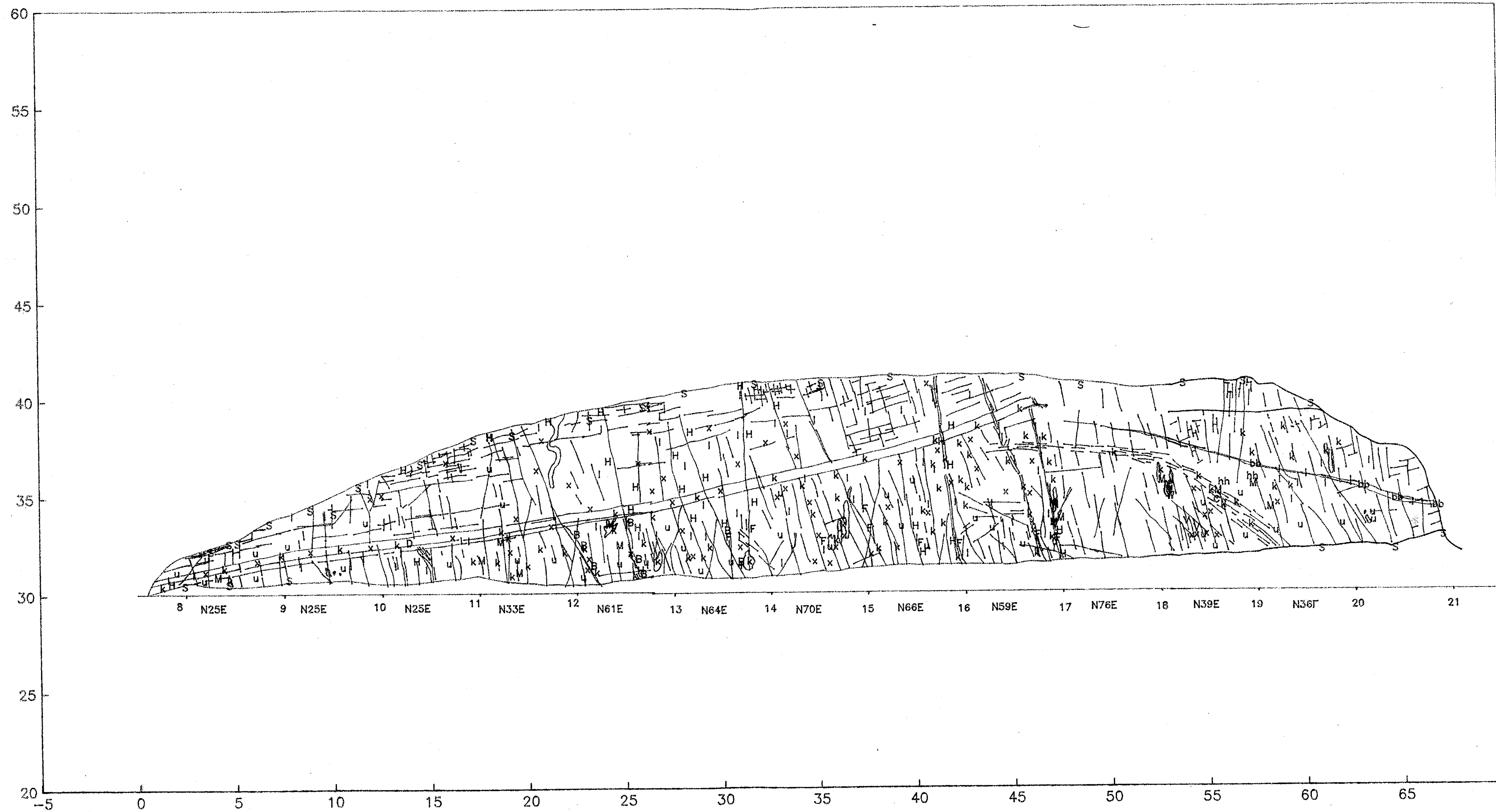
12/17/03

LEVEL +20 EL NOPAL I



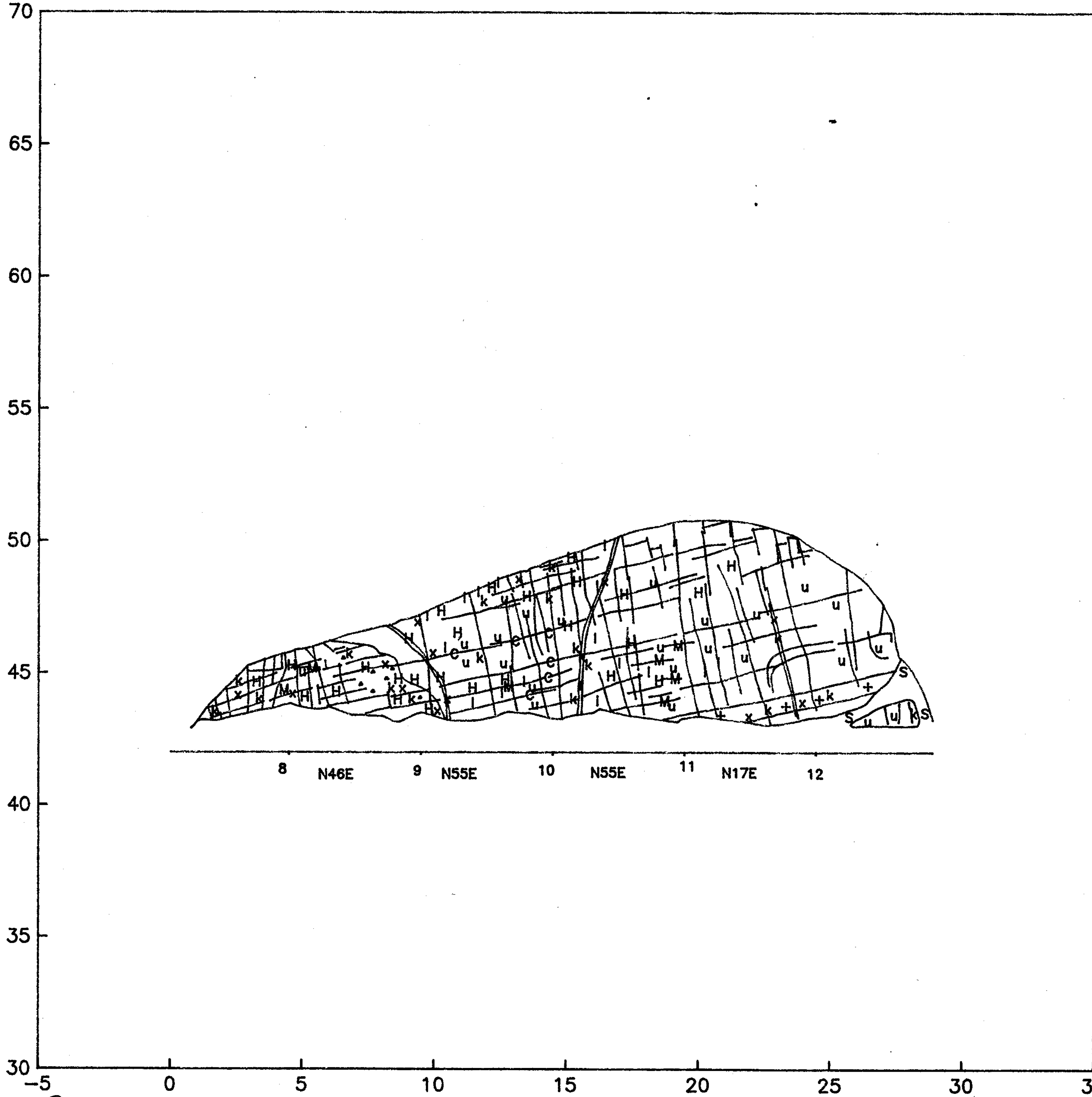
12/17/03

LEVEL +30 EL NOPAL I



RO 12/17/03

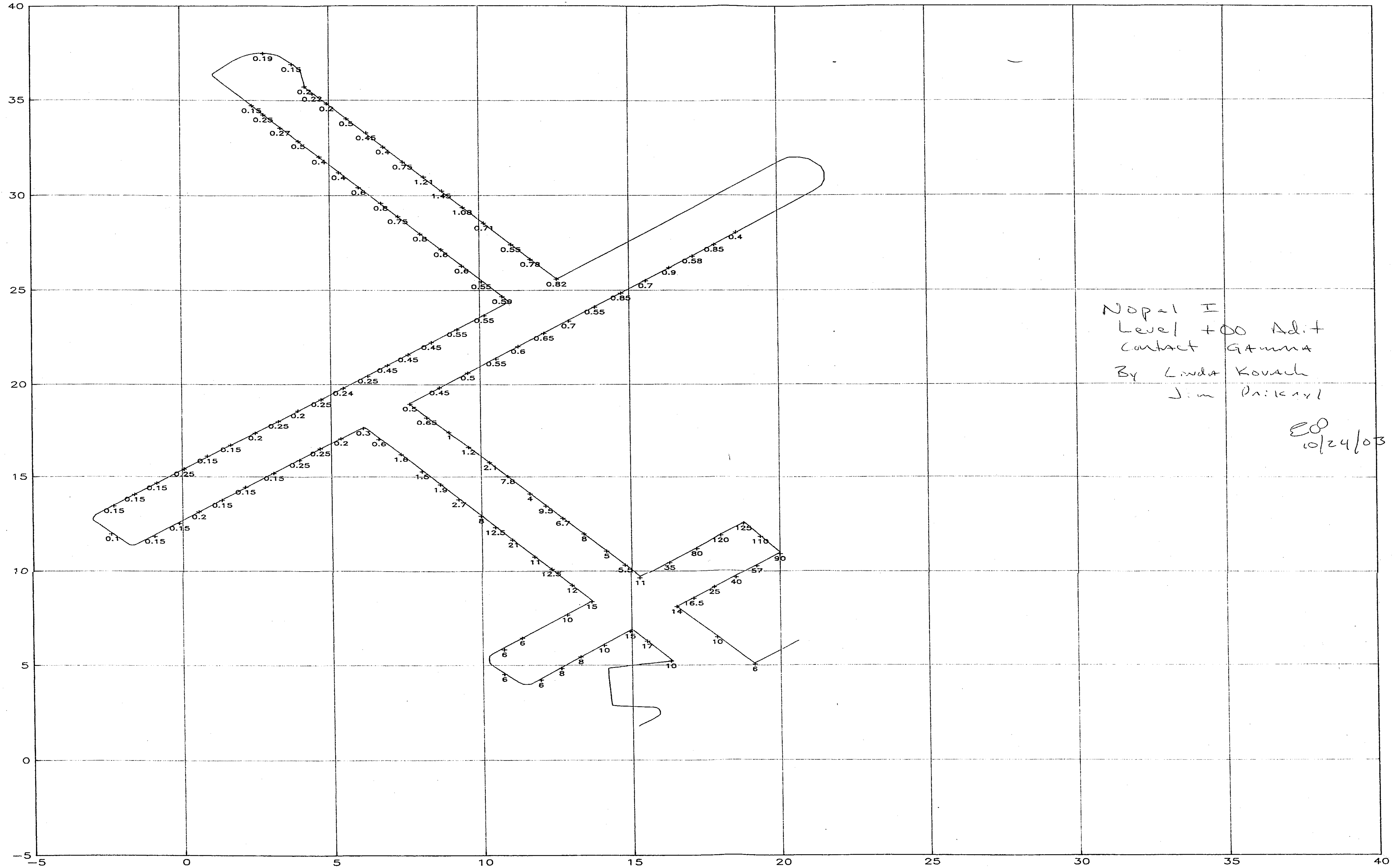
LEVEL +40 EL NOPAL I



ECP 10/24/03

[illegible] 12/17/03

Adit Gamma Readings



Nopal I
Level +00 adit
contact gamma measmnts

These measmnts should be used only as a qualitative indication of gamma intensity.

ECS
10/24/2003

ECS
10/24/03

12/17/03

No further Entries
12/17/03

I have reviewed this scientific notebook and find it in agreement with QAP-001. There is sufficient information regarding methods used for conducting tests, acquiring and analyzing data so that another qualified individual could repeat the activity.

E.C.P.
12/17/03