Advanced Interconnection Technology Laboratory
Westinghouse Defense and Electronics Center
P.O. Box 746 M/S V-29
Baltimore, Maryland 21203
(301)993-6879

ANALYSIS REPORT

Report Number: 88-003

Sample Submitted: Sandy soil from four TPS-63E radar sites.

Sample Submitted By: Dean Estes

Results Reported To: Dean Estes
John Holden

Analytical Method: Scanning Electron Microscopy, Energy Dispersive X-Ray Analysis

Analyst: Scott Dahne
Dale Weaver

Date: 12-9-88

Abstract: Samples of sandy soil were submitted for analysis in order to attempt to correlate the constituent elements of the soils with prior analyses performed on the corroded leads of integrated circuits (ICs) from TPS-63E radars situated along the Egyptian coast of the Mediterranean Sea. Results of the analysis show conclusively that the constituent elements of the soil samples are identical to those elements found in the corroded areas of the IC leads.

Samples of sand collected from four different radar sites were submitted for analysis. The sites were Port Said, Baltim, Amiriya, and Sidi Barrani. The sites are along the Meditteranean coast of Egypt between Libya and the Suez Canal. The samples were submitted in an attempt to correlate the results of previous analyses (PCL CAR# 1522-88 dtd 4/7/88 and RAL# 88138 dtd 10/25/88) of contaminated and corroded Integrated Circuit (IC) leads with possible sources of contamination. Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Analysis (EDXA) were used to qualitatively determine the contaminants present in all cases and the relative proportions of each individual contaminate to the total elemental composition of the sample.

The elements present in the sand samples analyzed included (in decreasing relative amounts ratioed to silicon on the EDXA) calcium, silicon, chlorine, aluminum, magnesium, iron, sulfur, sodium, potassium and titanium. A brief explanation of natural occurrence of each element is described in the following paragraphs in an attempt to isolate potential sources of the contaminate.

Calcium (Ca) is the fifth most abundant element in the Earth's crust (3.0%). It is also the essential constituent of seashells in the form of calcium carbonate ($CaCO_3$).

Silicon (Si) is the second most abundant element in the Earth's crust (25.7%). It is principally found in nature as silicon dioxide (SiO_2) or sand.

Chlorine (Cl) is a constituent of salts such as sodium chloride (NaCl) which is common table salt and the principle salt in seawater and potassium chloride (KCl) or sylvite.

Aluminum (Al) is the most abundant metal to be found in the Earth's crust (8.1%). It is found occuring naturally as aluminum oxide (Al_2O_3) in rubies and sapphires.

Magnesium (Mg) is the eigth most abundant element in the Earth's crust and is found in brines, wells, and seawater. Magnesium is present as magnesium chloride ($MgCl_2$) in seawater and accounts for 0.13% of the composition of seawater.

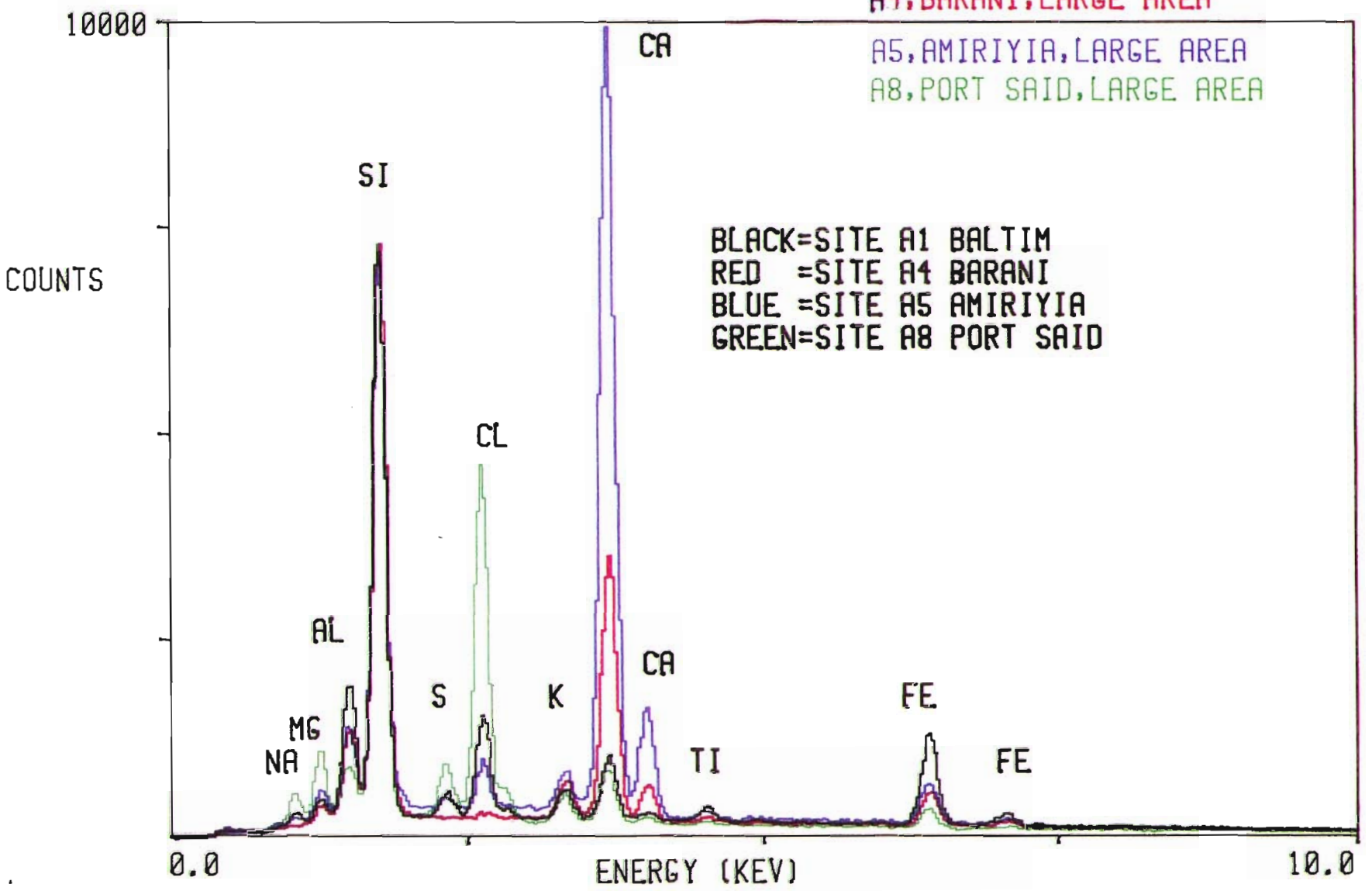
Iron (Fe) is the fourth most abundant element in the Earth's crust and is found in many forms to include magnetite which is frequently seen as "black sand" on beaches and stream banks.

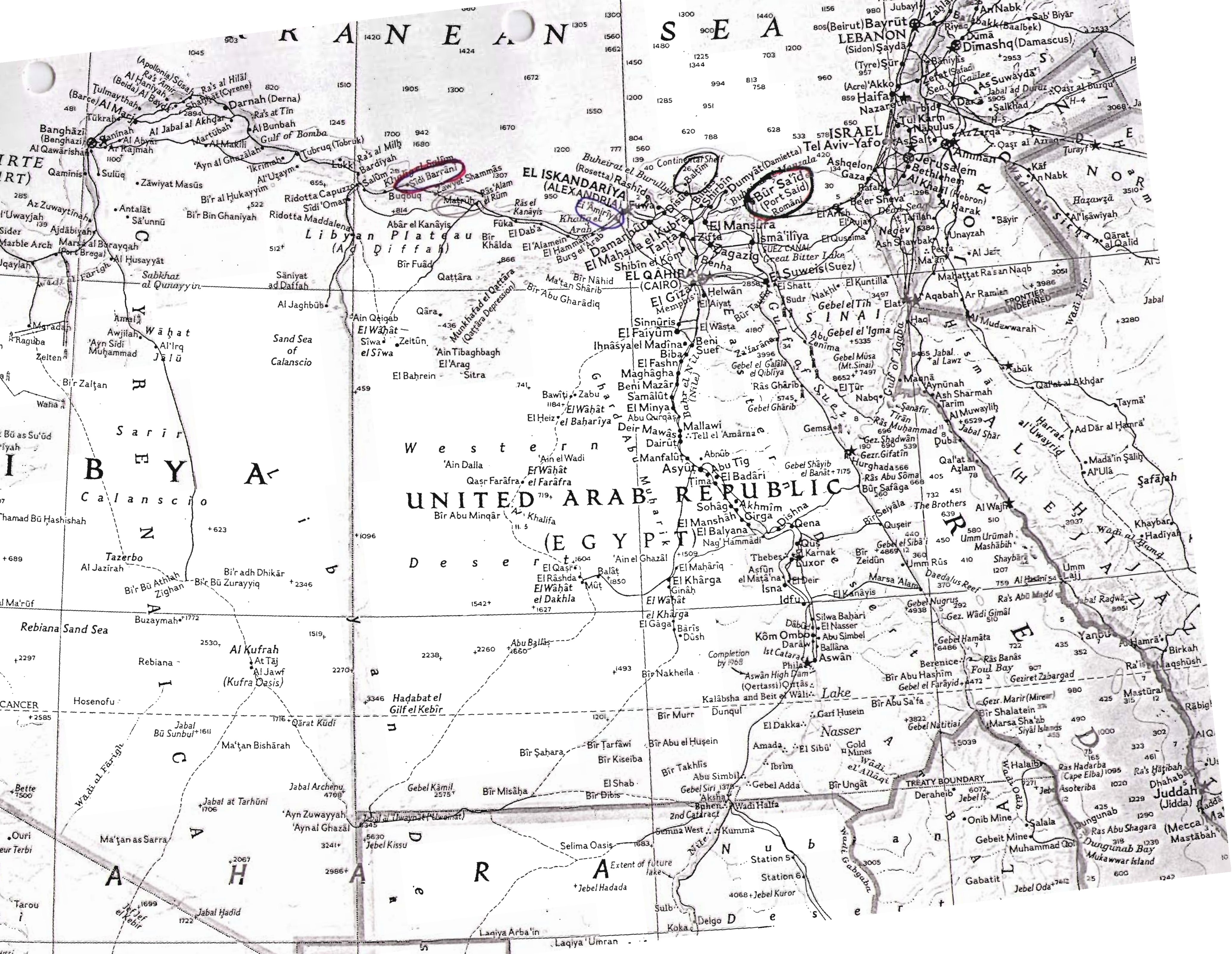
Sulfur (S) is found in nature in salt domes along coastal areas and in natural gas and petroleum crudes.

Titanium (Ti) is the ninth most abundant element in the Earth's crust. Titanium can be found in igneous rocks and their sediments and in many iron ores.

The amount of silicon remained relatively constant between samples which is understandable due to the prime constituent of the sandy soil in the area being SiO_2. Calcium was found in greater amounts in the samples from Amiriya, Matruh, and Barrani possibly due to a closer proximity to the Meditteranean where more seashells would be ground up into the sandy soil. The samples from Port Said and Matruh contained a far greater amount of chlorine and magnesium than the other samples. This may be due to a closer proximity of the radar site to wells or briney areas.

Based upon the results of the previous analyses on actual corroded IC leads and the contaminates found on those leads and the analysis of the soil samples provided, it is evident that the corrosion is a result of contamination from dust and sand in conjunction with the close proximity to the environment of the Mediterranean Sea.


SAND A1,A4,A5 & A8 12/6/88
A1,BALTIM,LARGE AREA
A4,BARANI,LARGE AREA
A5,AMIRIYIA,LARGE AREA
A8,PORT SAID,LARGE AREA
10000
COUNTS
BLACK=SITE A1 BALTIM
RED =SITE A4 BARANI
BLUE =SITE A5 AMIRIYIA
GREEN=SITE A8 PORT SAID
SI
CA
CL
AL
MG
NA
S
K
CA
TI
FE
FE
0.0
ENERGY (KEV)
10.0



MEDITERRANEAN SEA
UNITED ARAB REPUBLIC
(EGYPT)
LIBYA
Western Desert
Libyan Plateau
SINAI
LEBANON
ISRAEL
JORDAN
EL QÂHIRA (CAIRO)
EL ISKANDARÎYA (ALEXANDRIA)
Bûr Sa'îd (Port Said)
Dimashq (Damascus)
Bayrūt (Beirut)
Jerusalem
Amman
Tel Aviv-Yafo
Haifa
Gaza
El Suweis (Suez)
Gulf of Suez
Gulf of Aqaba
Asyût
Luxor
Aswân
Lake Nasser
Wadi Halfa
Siwa
El Wâhât el Dakhla
El Khârga
Al Kufrah (Kufra Oasis)
Sand Sea of Calanscio
Rebiana Sand Sea
Tubruq (Tobruk)
Darnah (Derna)
Banghāzī (Benghazi)
Matrûh
Sîdi Barrâni
El 'Alamein
Juddah (Jidda)
Mecca
Munkhafad el Qattâra (Qattâra Depression)
CANCER

CHEMICAL ANALYSIS REQUEST FORM

Date 12/6/88

Name DEAN ESTES Contract EGYPT $-$ CO PRO TPS-63E

Extension x 4809 Part Name

Mail Stop Identification

Charge Number L 50180 HCC

Explanation of Analysis Requested: SPECTRA OF SAND. Looking for Cl. Have all 4 SPECTRA FOR COMPARISON

Please give any information you can about sample:

DISK 20

DE01DW to

John Holden x 4509

Chemical Analyst Date

L#192

C.E.B. 4/21/77

Si and Ca - sand

more prevalent in AMIRIYIA and BARANI samples are these drier desert areas - especially AMIRIYIA ?

Cl, Na - salt (possibly from seawater)

Mg

more prevalent in PORT SAID sample - possible due to proximity to Mediterranean and Suez Canal is shelter is in exposed windy area, possibly high ground

ratio of Si/Cl/Ca in sample from MATRUH is consistent with new results (RAL report 88-138)

	Cl	Si	Ca
PORT SAID	5	4	1
BALTIM	3	3	2
AMIRIYIA	2	2	5
MATRUH	4	1	4
BARRANI	1	5	3

WORK POLLING

5 is highest amount in proportion to other sites

C. Frankfield	MS X7
T. Parr,Jr.	MS G-16
R. Zeigler	MS 125
R. Barnes	MS 124
E. Stombler	MS 368
S. Dahne	MS V-29
D. Weaver	MS V-29

dist.txt

WESTINGHOUSE ELECTRIC CORPORATION

PROCESS CONTROL LABORATORY

CHEMICAL ANALYSIS REPORT

Report No. 1522-88

Sample Submitted: An IC (641A799) from TPS-63 system with three leads completely corroded away an a brown residue on the body of the IC.

Sample Submitted By: C. Frankenfield Date: 3/25/88

Results Reported To: C. Frankenfield

Analytical Method: X-ray fluorescence

Notes: See attached report

Chemical Analyst: C. Elliott Byrdsong Date: 4/7/88

PCL Form No. 193 Rev. A CEB 3/24/88

An IC from a TPS-63 system with three of its 16 pins completely corroded away and a brown residue on its surface was analyzed by x-ray fluorescence for elemental composition. The surface of a clean pin, a corroded area and residue removed from the package were each analyzed separately.

Figure 1, below, is the x-ray spectrum of a clean surface on an uncorroded lead. The lead appears to be coated with only tin. The iron and nickel is from the base metal.

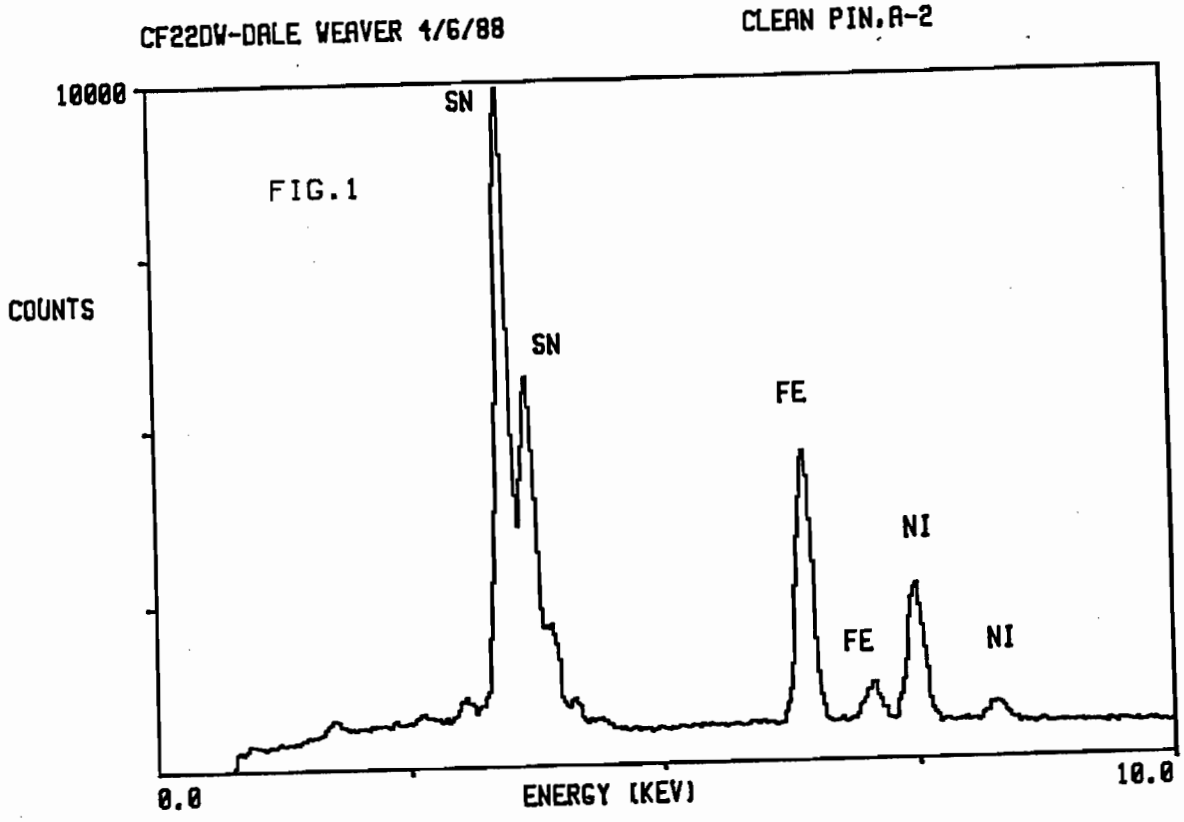


FIG.1

Figure 2 is a spectrum of a corroded area on a lead. This spectrum contains large amounts of iron and tin, with lesser amounts of nickel and chlorine, and trace amounts of silicon, sulfur and calcium.

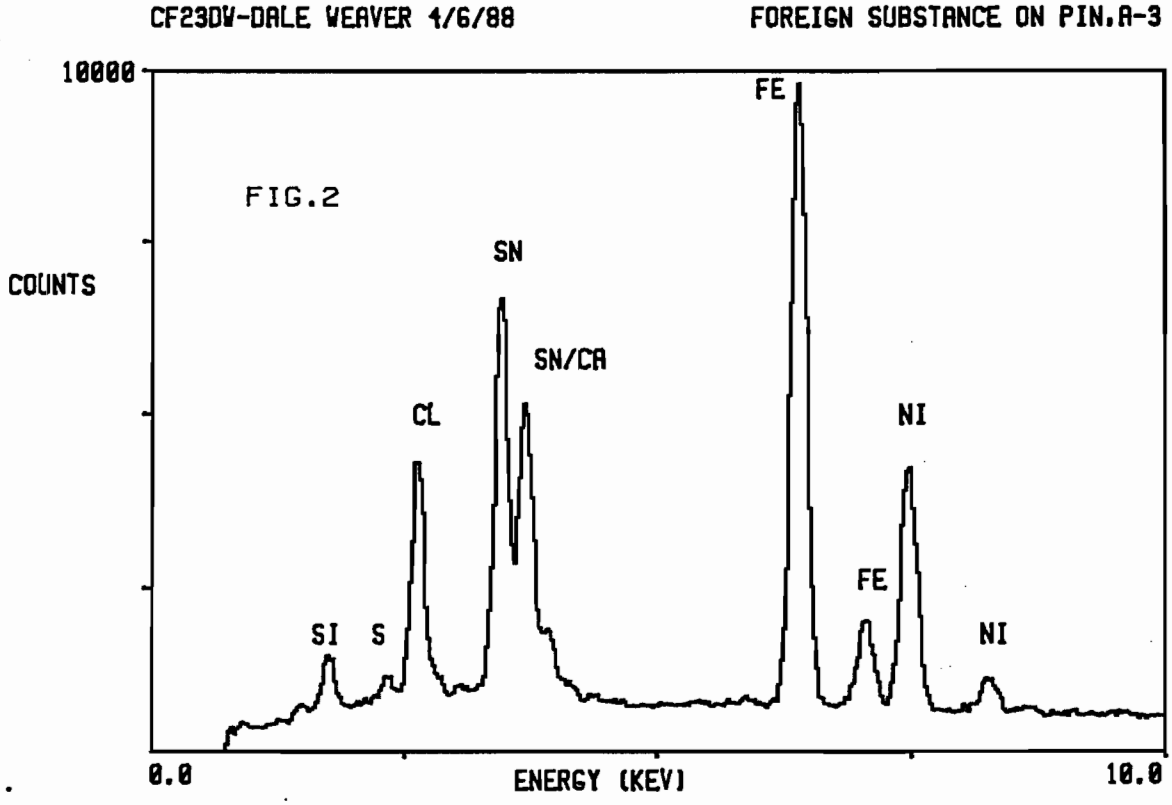
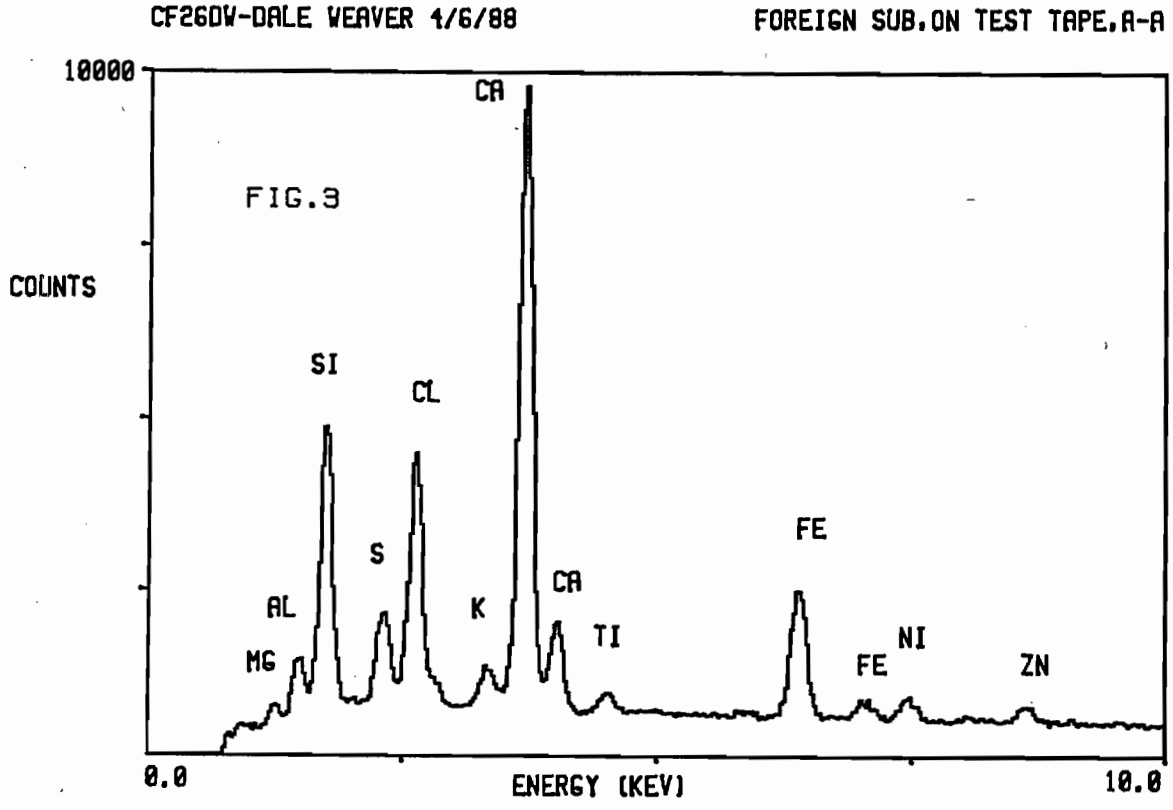


Figure 3 is the spectrum of some of the residue removed from the body of the IC. This material contains large amounts of calcium, lesser amounts of silicon, chlorine, and iron, and trace amounts of aluminum, magnesium, sulfur, zinc, potassium, titanium and nickel.



Conclusion

The elemental composition of the residue in figure 3, removed from the body of the IC, suggest the prescence of residues left from the evaporation of ground water. Since the amount of calcium and silicon present in the sample is greater than the amount of chlorine, the residue could not have come from sea water. The porpotions of the constituents in the sample also seems precludes the idea that condensation could have been the source of the water.

CHEMICAL ANALYSIS REQUEST FORM

Date 3/25/88

Name C. Frankenfeld Contract TPS-63

Extension 3811 Part Name IC

Mail Stop X7 Identification 04147 99

Charge Number S50180/ICC-

Explanation of Analysis Requested: IDENTIFY FOREIGN SUBSTANCE ON DEVICE SURFACES AND PINS

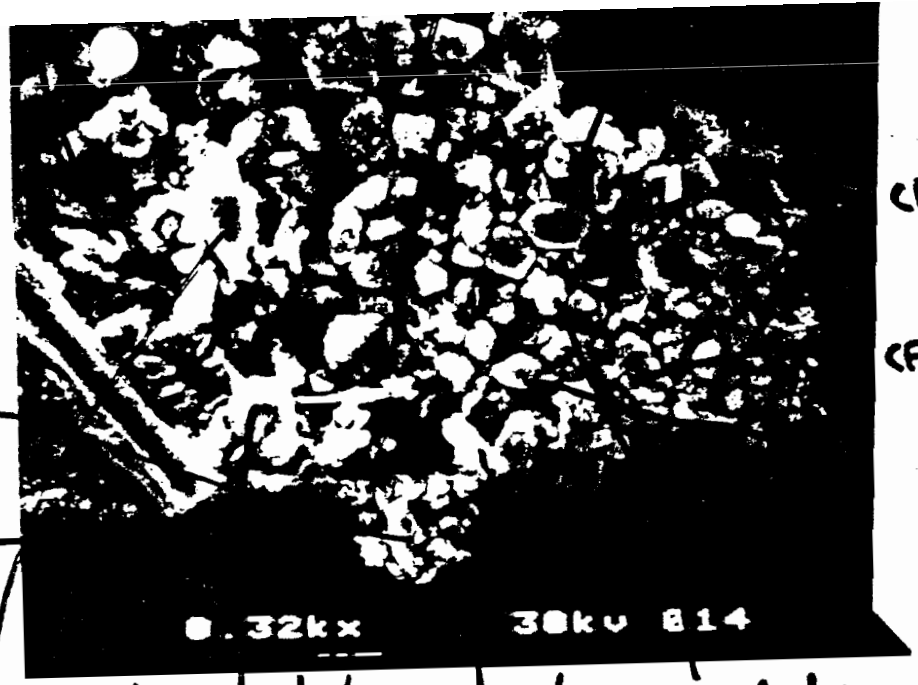
Please give any information you can about sample: THIS DEVICE WAS RETURNED FROM EGYPT. SUSPECT SAND AND DUST AND MOISTURE.

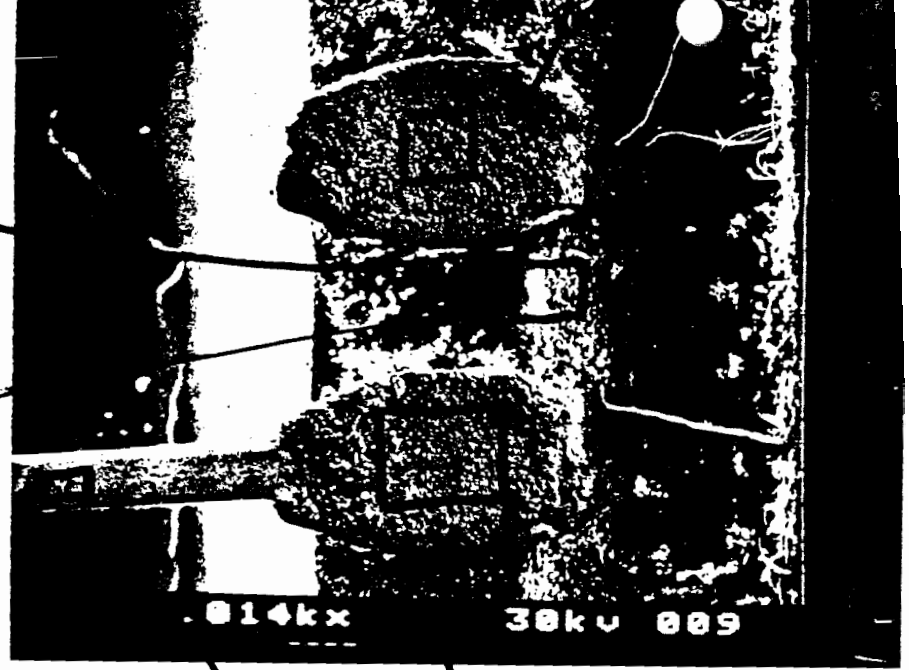
EDAX REDUC & CLEAN AREA NEAR

LOOKS LIKE GROUND WATER

Chemical Analyst _____ Date _____

PCL#192 C.E.B. 4/21/77





CF25W

CF24DW

Si/Al/Ca

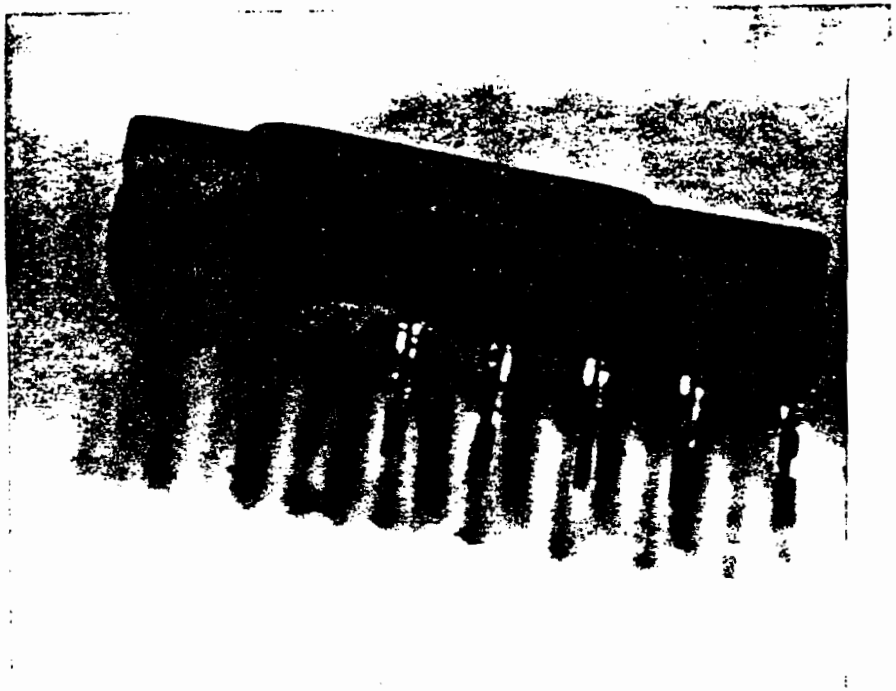
Si/Ca/Cl

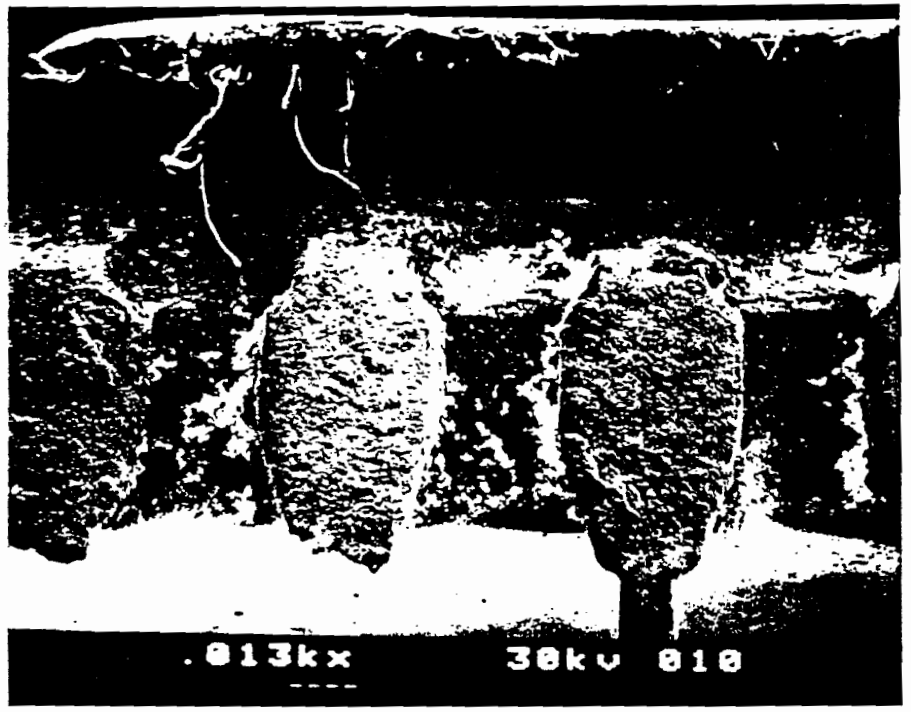
Cl/Ca

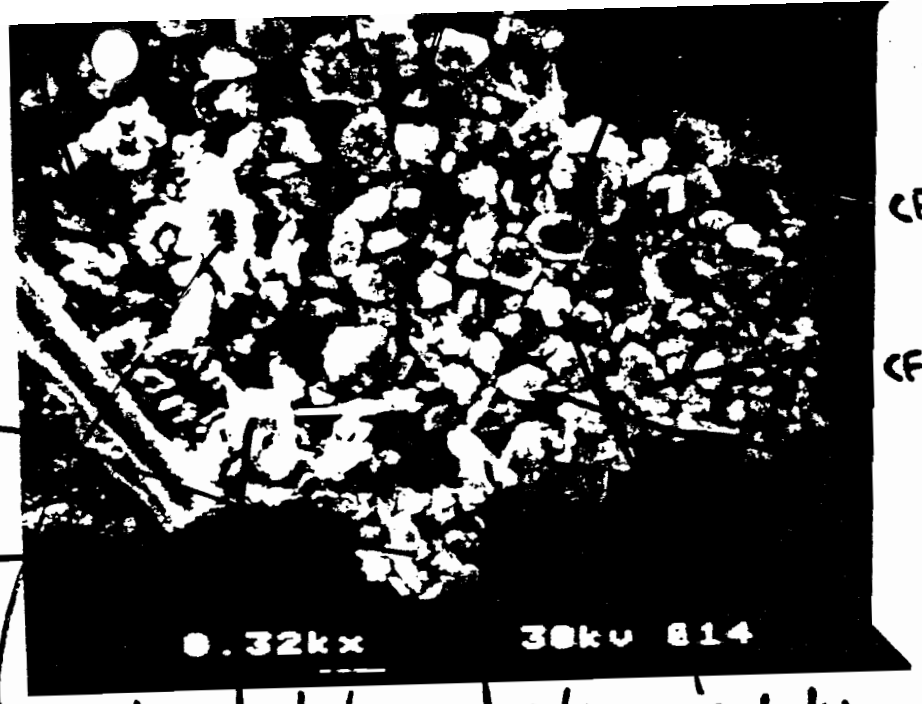
Ca/Si/Cl

CF23DW

CF23W







Fe

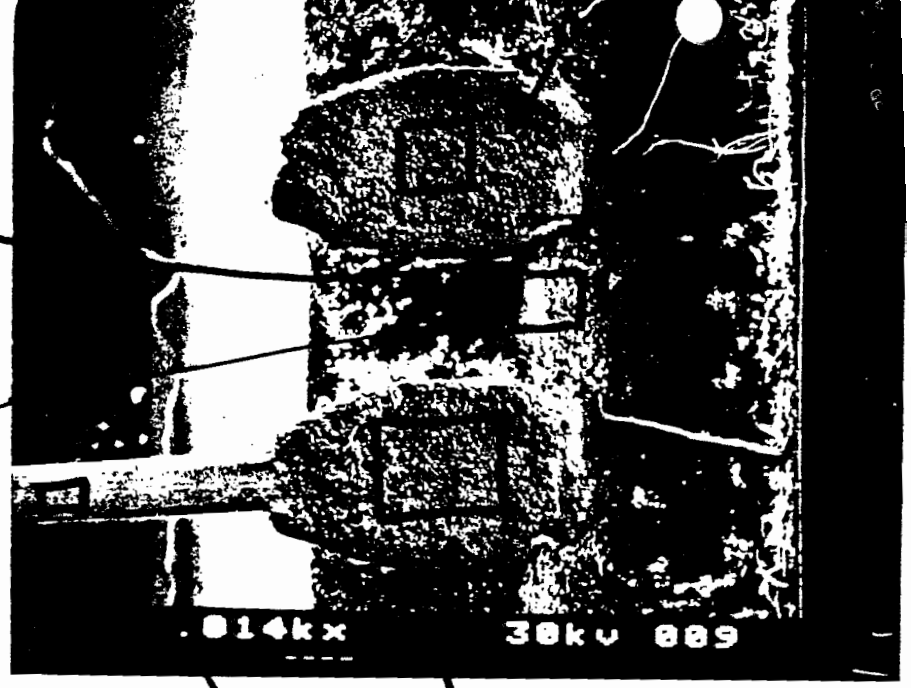
Ca

Si/Al/Ca

Si/Ca/Cl

Cl/Ca

Ca/Si/Cl

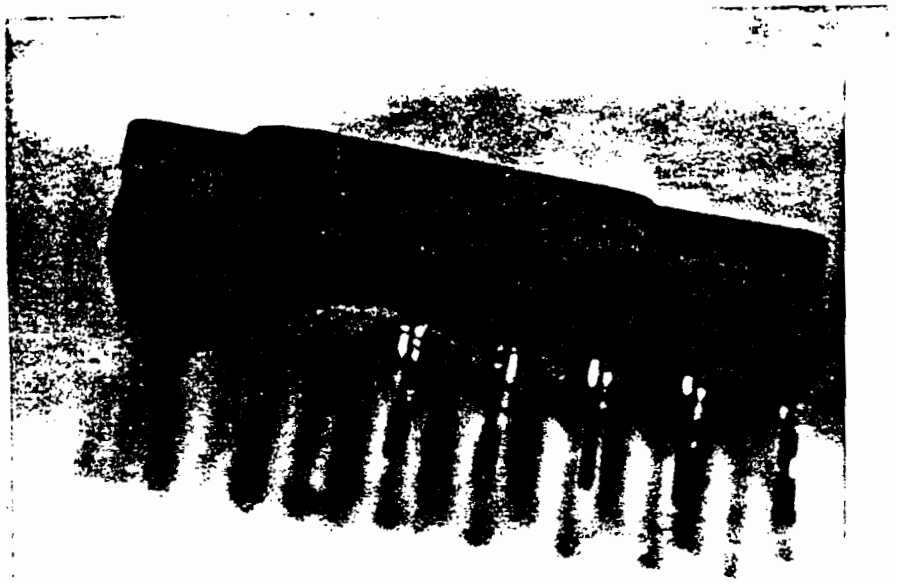


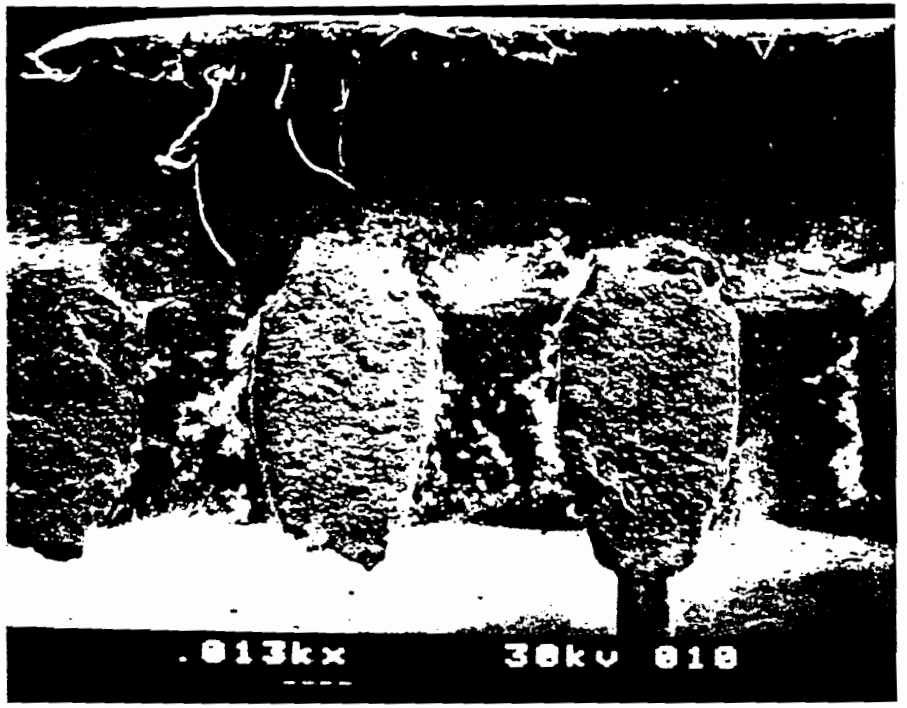
CF23DW

CF24DW

CF23DW

CF23DW





WESTINGHOUSE ELECTRIC CORPORATION
RELIABILITY ANALYSIS
LABORATORY REPORT

PROGRAM:	TPS-63E	ADDENDUM TO RAL REPORT 88-138	
PART NAME:	BOARD ASSEMBLIES, WIREWRAP	NR NO.:	N/A
PART NO.:	SEE BELOW	SERIAL NO.:	SEE REPORT
MANUFACTURER:	WESTINGHOUSE	QTY.:	2
DATE RECEIVED:	09/26/88	DATE CODE:	N/A
ANALYSIS REQUESTED BY:	JOHN HOLDEN	PHONE:	5-4509
ANALYSIS CONDUCTED BY:	PAUL WANGLEE	PHONE: 5-6513	DATE: 10/25/88

This addendum is being released to correct or clarify geographic inaccuracies in the stated location of TPS-63E sites in Egypt.

1. The Wadi Hoff (not Wade Hoff as previously spelled) site is located southeast of Cairo, not along the coast as was stated in the report. The observations made of board maintenance still hold true.

2. Three sites located near (several kilometers) the coast are Barani, Port Said and Matruh. Barani was not mentioned in the report.

In addition to these corrections/clarifications, the following observation from the Barani site should be included: "The Barani site showed no signs of corrosion on the printed circuit boards. The boards were very clean and well maintained versus the Matruh site [boards] which were dusty and poorly maintained."

WESTINGHOUSE ELECTRIC CORPORATION
RELIABILITY ANALYSIS
LABORATORY REPORT

PROGRAM:	TPS-63E	RAL REPORT NO.:	88-138
PART NAME:	BOARD ASSEMBLIES, WIREWRAP	NR NO.:	N/A
PART NO.:	SEE BELOW	SERIAL NO.:	SEE BELOW
MANUFACTURER:	WESTINGHOUSE	QTY.:	2
DATE RECEIVED:	09/26/88	DATE CODE:	N/A
ANALYSIS REQUESTED BY:	JOHN HOLDEN	PHONE:	5-4509
ANALYSIS CONDUCTED BY:	PAUL WANGLEE	PHONE: 5-6513 DATE:	10/17/88

SUMMARY

Two boards were returned from the field (Matruh, Egypt) for documentation and analysis of contamination and corrosion of MED leads. Energy dispersive x-ray analysis (EDXA) of several samples of the contamination/corrosion, combined with information gathered on an on-site trip, led to the conclusion that sand, salt and moisture from the on site environment were the sources of the corrosion.

PROBLEM STATEMENT

Two wirewrap board assemblies from the TPS-63 signal processor (see table below for part information) were returned from the field (Egypt - Matruh site) to be analyzed for suspected corrosion and contamination. The system these boards were from (system A6) was delivered in 1982. A lead of a MED from one of the boards was broken off at the site. Both assemblies were functional at the time of removal.

NAME	P/N	WSN
ECM Alarm	1D13532G01	1035
PAU	3640865G01	1030

The boards were sent to the Reliability Analysis Laboratory (RAL) for documentation and analysis of the corrosion and contamination.

A previous analysis of a similar problem, corroded MED pins sent to Westinghouse from the Port Said site, was documented in a Process Control Laboratory chemical analysis report (#1522-88) written by Charles Byrdsong. This report concluded that the contamination was the residue from the evaporation of ground water.

The TPS-63 system hardware is housed in a shelter to isolate the electronics from the outside environment. The operating environments range from salt flats to desert and coastal regions.

ANALYSIS

Visual inspection of each of the boards revealed that the contamination was most prevalent on one particular edge of the board. It was noted that this edge was the edge closest to the floor of the shelter when the board is installed in its rack. The MEDs that display signs of lead corrosion are also located near this edge.

Four types of samples of the contaminant/corrosion were collected from the board and analyzed by EDXA. The first were light sandy brown particles collected from U95 of the PAU board (photograph 1). They were found to be composed of calcium, silicon, a chloride, iron, nickle and tin (see figure 1). Charles Byrdsong, a chemical analyst, determined that these elements were indicative of sand, salt and the MED's lead metals. The second sample collected was a reddish brown particle collected from U95 of the PAU board (see photograph 2). The elemental composition of this sample was primarily lead, tin, iron, nickle and a chloride (see figure 2). This was determined to be a piece of corroded lead material and salt. The third sample, also taken from U95 of the PAU board, was a collection of light brown particles. This was primarily composed of silicon and calcium (see figure 3) and was determined to be a collection of sand particles.

The fourth sample was a solution containing the water soluble elements from the ECM alarm board (see photographs 3 and 4). The sample was collected by spraying the ECM alarm board with de-ionized water, collecting the run-off and filtering the run-off. The filtrate contained sodium, chlorine, calcium, sulpher and potassium. Sodium chloride is salt and the other elements are frequently found in sand or dirt (see figure 4).

CONCLUSION

The corrosion and contamination seen on these boards are due to exposure to sand, salt and moisture. Observations of on-site conditions made by James Graham (Westinghouse-ESG) support this conclusion.

BARANI

The two boards examined in this failure analysis report were taken from the Matruh site. The three radar sites mentioned in the site report (Port Said, ~~Wadi Hoff~~ and Matruh) are located in northern Egypt, on the Mediterranean coast. The shelter in which the system hardware is housed is a stand alone unit. The filters of the air conditioning unit were said to be in place, but the only barrier between the outside environment and the interior of shelter is a single door.

The parts from Port Said, examined in the previous report, had pins that were severely corroded (see photograph 5). The site report for this unit at Port Said stated "door of shelter open upon arrival - all of the printed circuit boards were dusty and dirty." This shelter is also a stand alone unit and is situated on a spit of land in the Nile delta between a drainage basin and the Mediterranean.

[redacted] WADI HOF

The site report from ~~Wadi Hoff~~, in contrast, stated that the "boards and shelter look good - inspected all PC boards and found no discrepancies." This shelter is located inside a bunker and is thus isolated from the desert/coastal environment outside.

The corrosion on these boards is a serious reliability risk. The corrosion, resulting from exposure to chlorine and moisture, and subsequent errosion and embrittlement of MED leads, can result in the broken leads and open circuits seen in Port Said and Matruh parts.

CORRECTIVE ACTION

Responsibility for implementation of corrective action lies with the requestor, John Holden.

2 of 7

PHOTOGRAPH 1
15X

Pin 8 of U95 from the PAU board.

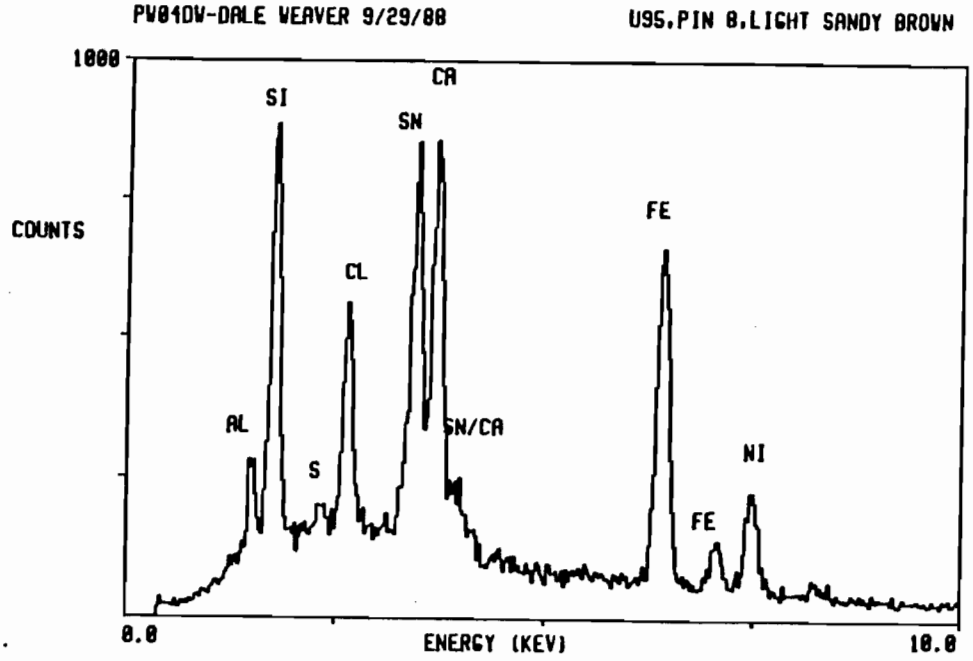


FIGURE 1

EDXA spectrum of sample of "light sandy brown" particles.

PHOTOGRAPH 2
15X

Broken pin 9 of
U95 of PAU board.

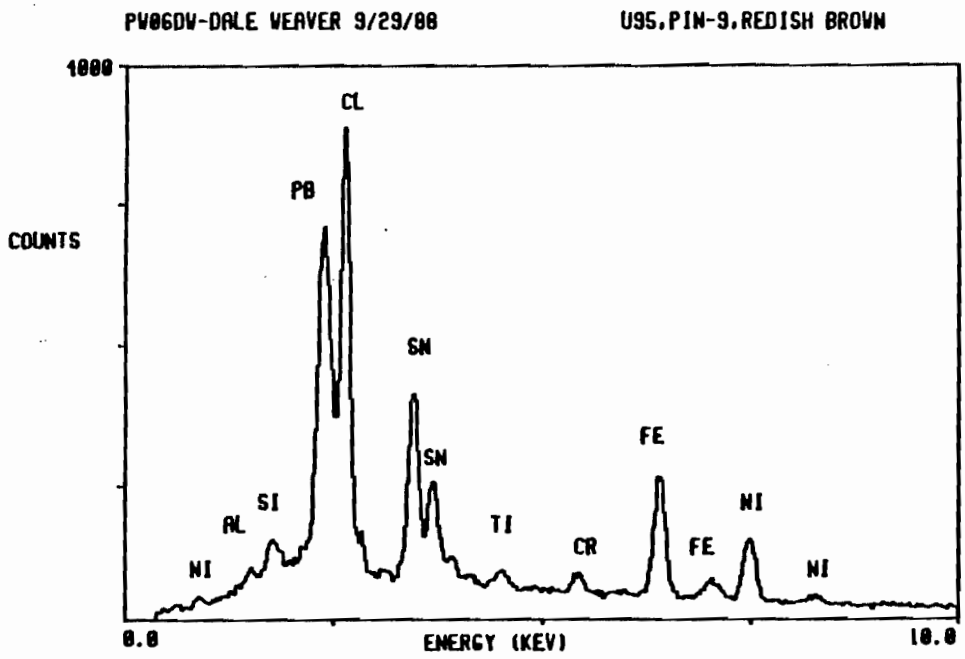


FIGURE 2

EDXA spectrum of
"reddish brown"
particle.

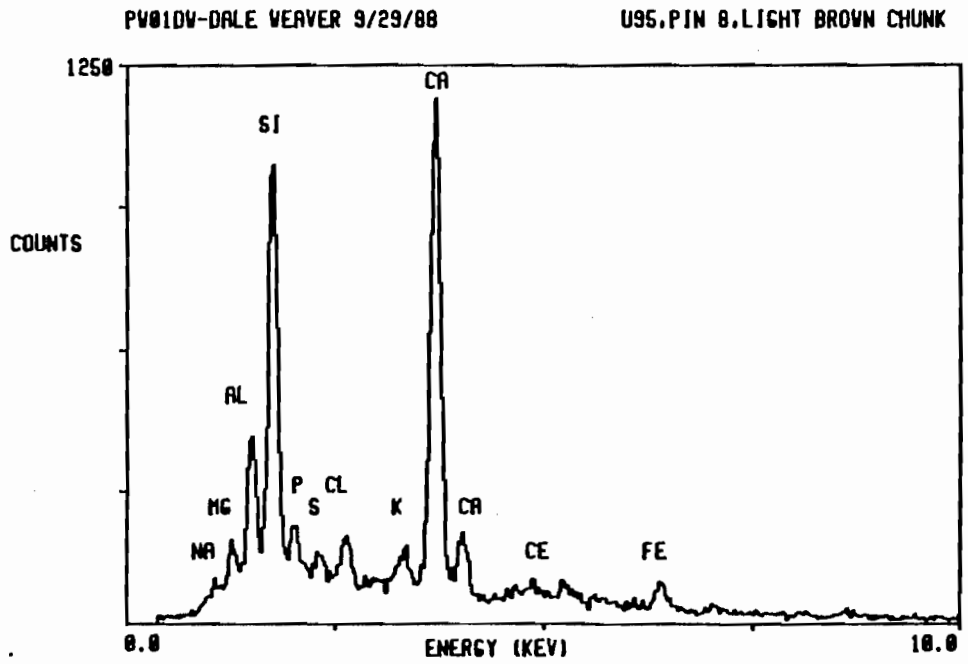


FIGURE 3

EDXA spectrum of "light brown" particles from U95.

PHOTOGRAPH 3
15X

Pin 8 of U94 of ECM alarm board.

PHOTOGRAPH 4
15X

Pin 9 of U96 of
ECM alarm board.

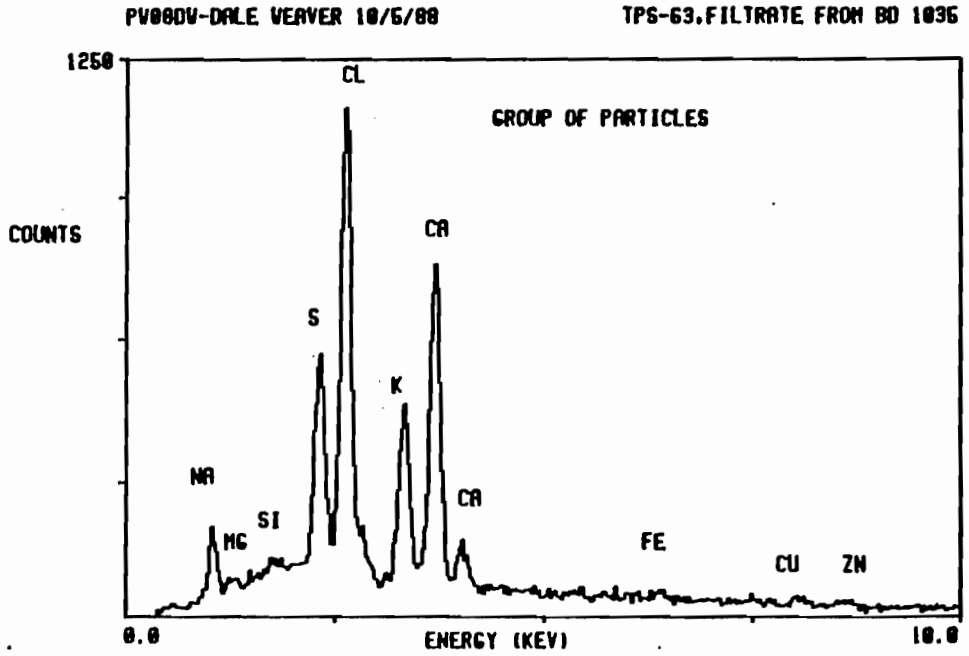


FIGURE 4

EDXA spectrum of
ECM alarm board
filtrate.

691

PHOTOGRAPH 5
8X

Corroded pins of MED from Port Said site.