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CNWRA
CONTROLLED
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Projectwork performed under 20-5708-471 ?	
20-5708-461	
Researcher F. Michael Conway (10331)	

Investigation into the Pliocene Funeral Formation of the Greenwater Range

The purpose of this investigation is to provide insight into the formation of the Pliocene-age Funeral Formation that mantles the northern plateau of the Greenwater Range.

To this end we intend to:

- Identify vents presently exposed in the northern Greenwater Range.
- Identify locations of buried vents using U.S. Borax data.
- Examine the relationship between structures and vents.
- Characterize geochemistry of Funeral Formation basalts.
- Catalog radiometric dates for volcanics from the Greenwater Range and surrounding areas.
- Estimate volumes of Funeral Formation basalts.
- Estimate the rate of vent formation and volume flux.
- Compare results, particularly vent formation rates, with data from the Quaternary to determine if this rate has changed with time or remained constant.

Researchers involved in this work, in some form or another, include:

Michael Conway,
Britt Hill,
Chuck Connor,
Ronald Martin,
David Ferrill.

Michael Conway will take the lead in this investigation with major input expected from Britt Hill. Other investigators, will in all likelihood, play a supporting role. Advice and suggestions of Dr. Connor and Dr. Ferrill will be solicited in the areas of volcanology and tectonics, respectively. Ron Martin will help with digital data processing in Arc/Info and Erdas.

FMC 6 Oct 96

Laboratory and Field Activity

Analysis will largely involve digital data sets of remotely sensed satellite and airborne data: Landsat TM, SLAR (side-looking airborne radar), SPOT 10-m resolution data. Thus, the bulk of the work will be completed using computer software designed to handle large data sets. In particular, we envision much of the analysis will be completed using Arc/Info, Erdas, and EarthVision. The latter software will be used extensively for estimating basalt volumes and constructing geologic models of the northern Greenwater Range.

Some field work has been completed in the Greenwaters. The field work was designed to ground truth vent identification made on Landsat TM, SLAR, and SPOT images. Also, six samples from basalt outcrops were collected for XRF and INAA analysis. The data will be combined with previously published data (e.g., Wright et al., 1991) for the purpose of characterizing Funeral Formation basalts and for comparing them with Quaternary basalts from the Crater Flat volcanics.

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6Oct96

Data Directory

Data presently available at CNWRA for analysis of the northern Greenwater Range.

- Landsat TM scene (040 035 04/18/89) (25 m resolution)
- SPOT Orthorectified Scene
- SPOT scenes (00202 543/277 930517-1) and (00203 543/277 930613-1) (10 m resolution)
- DEM from SPOT orthorectified scene (00200 Beatty) (20 m resolution)
- SLAR scene (resolution 12 m)
- 1:24,000 topographic maps
- 1:24,000 geologic maps of McAllister (1970, 1973)
- Geologic literature describing Greenwater Range and environs

Data pending

- XRF and INAA analysis for 6 basalts

FMC 6Oct96

Other Data

FMC 6Oct96. Well-log description from 152 wells in central portion of N. Greenwater Range. Data supplied by Steve Carpenter (U.S. Borax) Valencia, Ca.

Stratigraphic picks made by M. Conway w/ assistance and confirmation from Steve Carpenter.

Forward Header

Subject: Re: Z units
Author: Francois Zamora at SICORP
Date: 7/15/96 10:05 AM

Colleen,

The DEM has been delivered with the following formula:

Elevation (m) = (Pixel value - 10000) / 10

Mike can load the DEM in ArcInfo and ask during his course how to:

- apply this formula and saving the output file,
- make a 3D visualization with the Orthoimage overlaid _in transparency_ on top of his DEM
- how to integrate his other layers of information

Thanks,

Francois

Elevation correction for SPOT-DEM data. The correction was made in Sept 96 & checked against topographic maps. The data appear to be accurate.

FMC Oct/6/96

DEM Analysis

Data was inputed into Arc/Info.

Converting arc coverages to Tin for use in EarthVision

1) Create Tin for arc coverage:
   eg. TIN grwtr_cov grwtr_tin DEPTH1
2) Ungenerate Tin via "ungeneratetin" command
3) Use nawk code "**tin2ev_pnts.sh**" to strip off mass points and deal double precision pbl with EV importer.
   e.g., tin2ev_pnts.sh DEPTH1.pnt > depth1.data
   tin2ev_pnts.sh is stored in "usr2/mconway/shellscripts/.
4) Import "depth1.data" into EV via scattered data venue.
5) Set projection and Z parameters in EV/Files/Header -- very impt because this keeps projection data established in Arc/Info

Initial processing in EarthVision

1) Modeling: 2-D tension gridding
2) Visualization : construct Base and Contour Maps.

FMC

7 Oct 96

Earthvision Structure modelling

① Ungenerated data x, y, z brought in from Arc/Info
> Dem.dat
> US borax.dat
> geologic map interpretation of Funeral formation thickness - conservative estimates -

In EV.
- data are gridded to same x y z dimensions to allow for geologic structure models to be compiled

I attempted several different models
A) Collar7 & Depth1.vs8
b) DEM-4k & Depth1vs8

> I selected Collar7 & Depth1vs8 for further work because of spurious data pbls. in DEM-4k that resulted in incompatible grids.

JMC

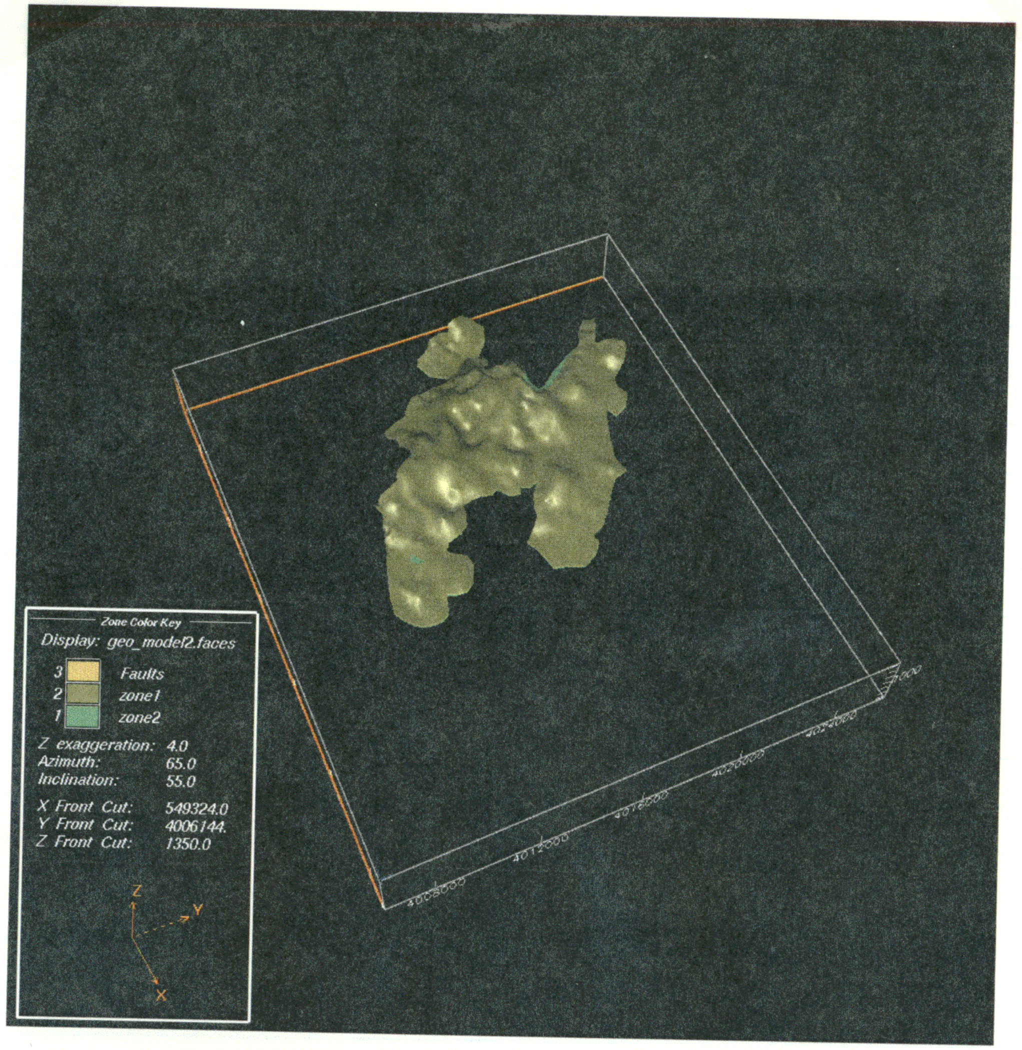

```
#!/bin/sh -e

FEATURE=ev-gmx/svp
LOGFILE=ev2.log
SEQFILE=geo_model2.seq
OUTSEQFILE=ev3.seq

if [ ! -f $OUTSEQFILE ]
then cp $SEQFILE $OUTSEQFILE
fi
ev_seq -o $OUTSEQFILE -F $FEATURE -l $LOGFILE $OUTSEQFILE
ev_flyfaces -o geo_model2.faces -O $OUTSEQFILE -F $FEATURE -l $LOGFILE $OUTSEQFILE
rm -f $OUTSEQFILE
```

7 Oct 96.

Example of shell script that generates an geologic structural model. - JMC

EV - image produced by this code is shown on the following page.

A clipping polygon (bwr_master_poly1) was used to confine the image to that area where Funeral formation basalt crops out.



Geo_Model2: A geologic model consisting of Collar7.2grd and depth1_vers8.2grd. 7 Oct 96.

FMC

7 Oct 96

Volume Calculations for Greenwater-Funeral Formation

Grids used in calc: → collar7.2grd
→ depth1_vers8.2grd

FMC

total # of data points involved ≈ 3768

Volume calculation completed in volumetrics!
see following example of Report

```
                    2-D Volumetrics Report

              VOLUMETRICS REPORT

                       Run by: mconway
                      Version: 3.0
                         Date: 10/08/96
                  Report file: vol_east2_poly.2vrpt

                 Polygon file: gwr_east2_poly.ply
              Zone definintion: Operational
         Deposition operation: collar7.2grd
         Deposition operation: depth1_vers8.2grd
          Global yield factor: 1.0
                Primary field: Polygon ID
               Sorting method: Polygon order
                  Input units: meters square by meters
Volumetrics conversion factor: 1
                 Output units: Same as input
     Global minimum thickness: 0.0

------------------- Zone name: collar7          --------------------

                    Minimum z: none
                    Maximum z: none
            Minimum thickness: 0.0
                 Yield factor: 1.0

                    2-D Volumetrics Report

                    Zone name: collar7
 Polygon ID
      Polygon Class
                                  Area           Volume        Positive Area
---------------------      --------------  --------------  --------------

                          453,338.789063  11,355,695.451  453,338.789063
```

7 oct 96

Summary Report of Volumes calculated for polygons of Funeral Fm. outcrops in Funeral Fm Range

2-D volumetrics Report for Northern Greenwater Range
7-Oct-96

Funeral Fm thickness are estimated from 1) U.S. Borax and 2) from McAllister (1970, 1973)
Thickness estimates are conservative.
Volume estimates were made with subjacent layers collar7.2grd and depth1_vers8.2grd in EarthVision

Layer volumetrics program in EV was used for calculating volumes.

Eight clipping polygons were used to constrain volume calculations to those areas underlain by basalts of the Funeral Formation.

No #	Polygon Name	Poly Area (m2)	Poly. Pos. Area	Volume (m3)	Ave Thickness (m)
1	gwr_central_poly.ply	47026947	47026947	3550318905	75.5
2	gwr_east_poly.ply	10563766	10563766	518006980	49.0
3	gwr_east2_poly.ply	453338	453338	11355695	25.0
4	gwr_north1_poly.ply	377073	377073	9842071	26.1
5	gwr_north2_poly.ply	72509	72509	1812414	25.0
6	gwr_west_poly.ply	3105750	3105750	88068005	28.4
7	gwr_south_poly1.ply	2238559	2238559	75308811	33.6
8	gwr_south_poly2.ply	601621	601621	16953325	28.2

Funeral FM **total Volume** 4271666206 m3

total volume 4.27166621 km3

Avg. Thickness = volume/positive area

Total volume values represent conservative minimum values.
The total volume of Funeral Fm basalts is 90 % of the total calc. volume, the remaining 10% consists of conglomerate. These proportions were determined from U.S. Borax well logs and from discussion with Steve Carpenter (Geologist) who has worked in the area for nearly 20 years.

Area values for selected polygons were checked with a second software package, ERDAS, and the results were positive and similar areas were determined.

A check on the quality of the volume calc can be semi-quantitatively made by examining the average thickness (volume/positive area) and comparing with thickness from the U.S. Borax data and from McAllister geologic maps. The calculated volumes are reasonable and of good quality.

The number of points used in making the collar7.2grd and depth1_vers8.2grd is approximately 2500 points.

DWC

FWC 8 oct 96

DWC

Using Erdas & working w/ Landsat TM scene I constructed a master polygon encompassing all Northern Greenwater (North of Greenwater Canyon), including areas bet exposures where Fu Fm basalts have been presumably removed by erosion.

The area of the master polygon is 33.706 miles & the polygon perimeter is 71677 m. Discrepancy in units is due to limitation of area in Erdas.

Converting area in sq miles to sq. km yields:
w/ $1 mi^2 = 2.59 km^2$

$= 87.3 km^2$

Assuming an average thickness of 75m - consistent w Average thickness of Central part of range yields a Volume of:
$6.5 km^3$ ⟸ assume 15 to 20% cong'l'm basalt = 5.5^3 to $6.2 km^3$

Assuming 50m thickness yields:
$4.4 km^3$

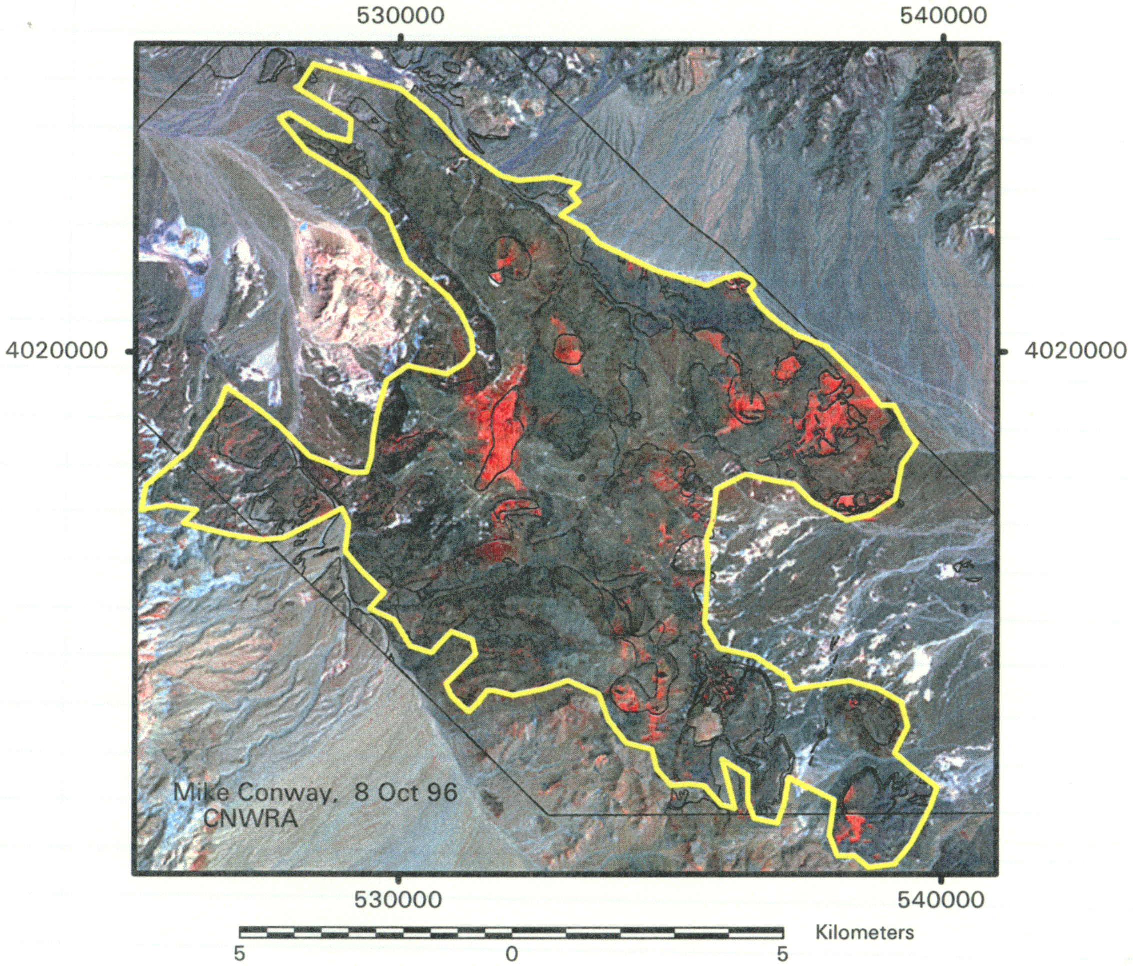
Because my estimate of paleo extent of Funeral Fm. ~~was~~ is conservative, the 1st solution ($6.5 km^3$) is pbl. more likely to be correct

See the following page for the polygon used in the above calculation.

Data used to make master polygon: McAllister 1970, 1973 Drewes, 1963, Landsat-TM scene (next page) & Slope plot from Greenwater DEM

Oct 8 96

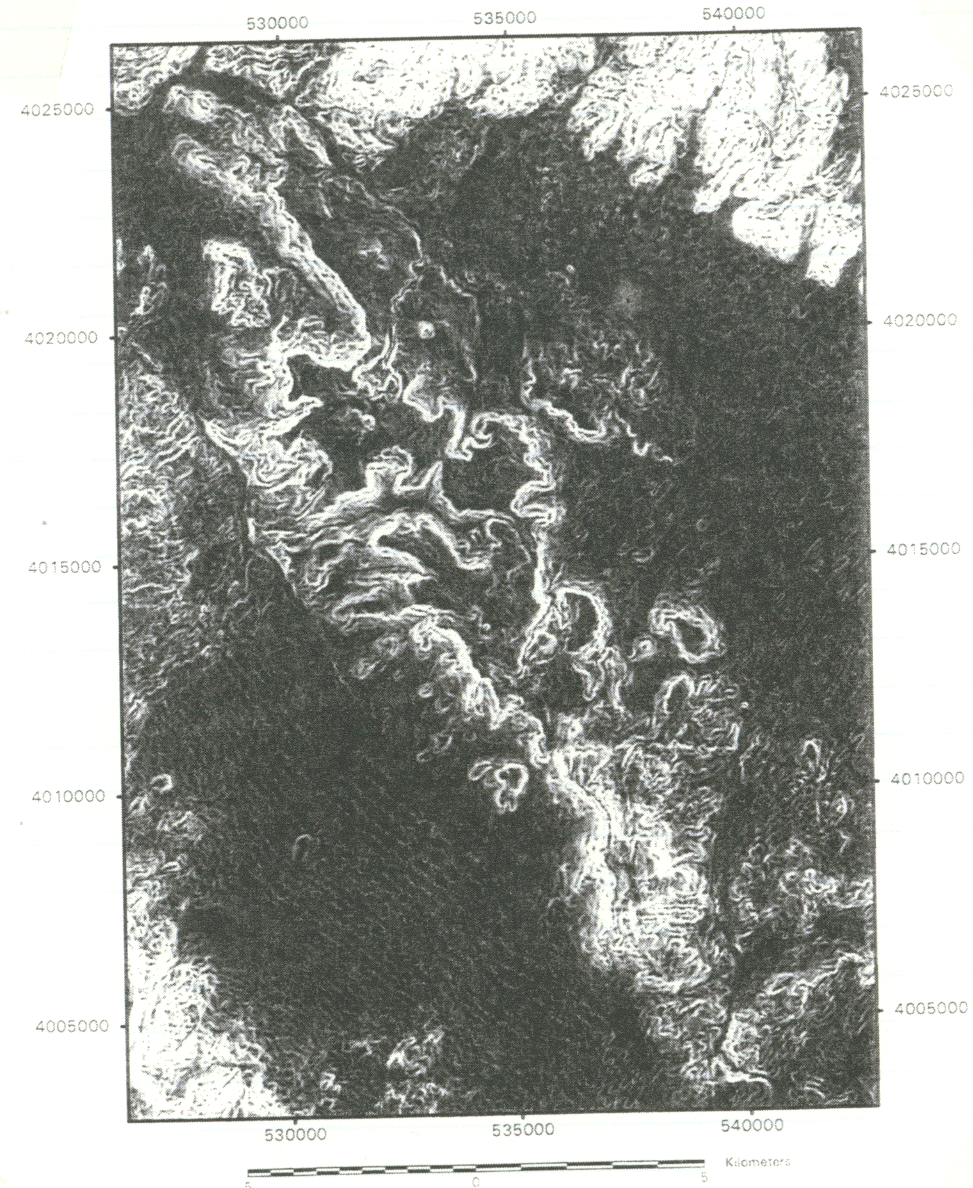
Master Polygon assessing probable paleo extent of Funeral Formations basalts of Northern Greenwater Range



Extent of Funeral Formation based on geologic mapping of McAllister (1970, 1973), Drewes (1963), and Landsat TM mapping

FWC

Northern Greenwater Range: Slope Model from Erdas



Slope image of Greenwater Range.
Constructed in ERDAS
8 Oct 96.

9 Oct 96

Registering
grnwtr_tm_3x3ee.rgb to DEM for purpose of draping Landsat image on top of Greenwater DEM in EV.

Step 1

1) Export AOI from Erdas as TIFF file

2) In XV convert ~~Rgb~~ TIFF file to RGB

3) Using Erdas & XV get registration coordinates (3) for registration of images in EV.

3A) Registration coordinates

	ERDAS UTM		XV image space	
	x	Y	x	Y
(1)	530138	4024891	176	28
(2)	540079	4016008	572	383
(3)	529115	4015426	134	405
(4)	531724	4018105	238	298

points selected to give good triangulation across central part of range.

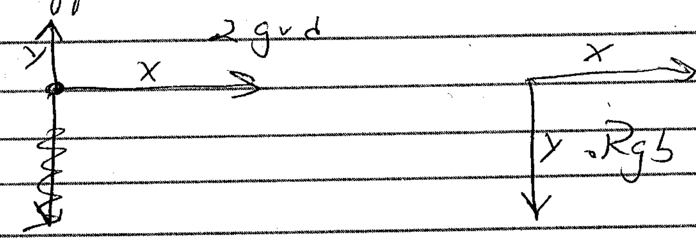
JWC

9 oct 96

~~grnwtr_tm_3x3ee.rgb~~
~~530138. 4024891.~~
~~176. 28.~~
~~540079. 4016008.~~
~~572. 383.~~
~~529115. 4015426.~~
~~134. 405.~~

Registration File:
> grnwtr_spot_img/grw_tm_rgb.imreg
greenwtr_spot

These coordinates did not work because the origin of the .2grd & the .RGB are located in different locales

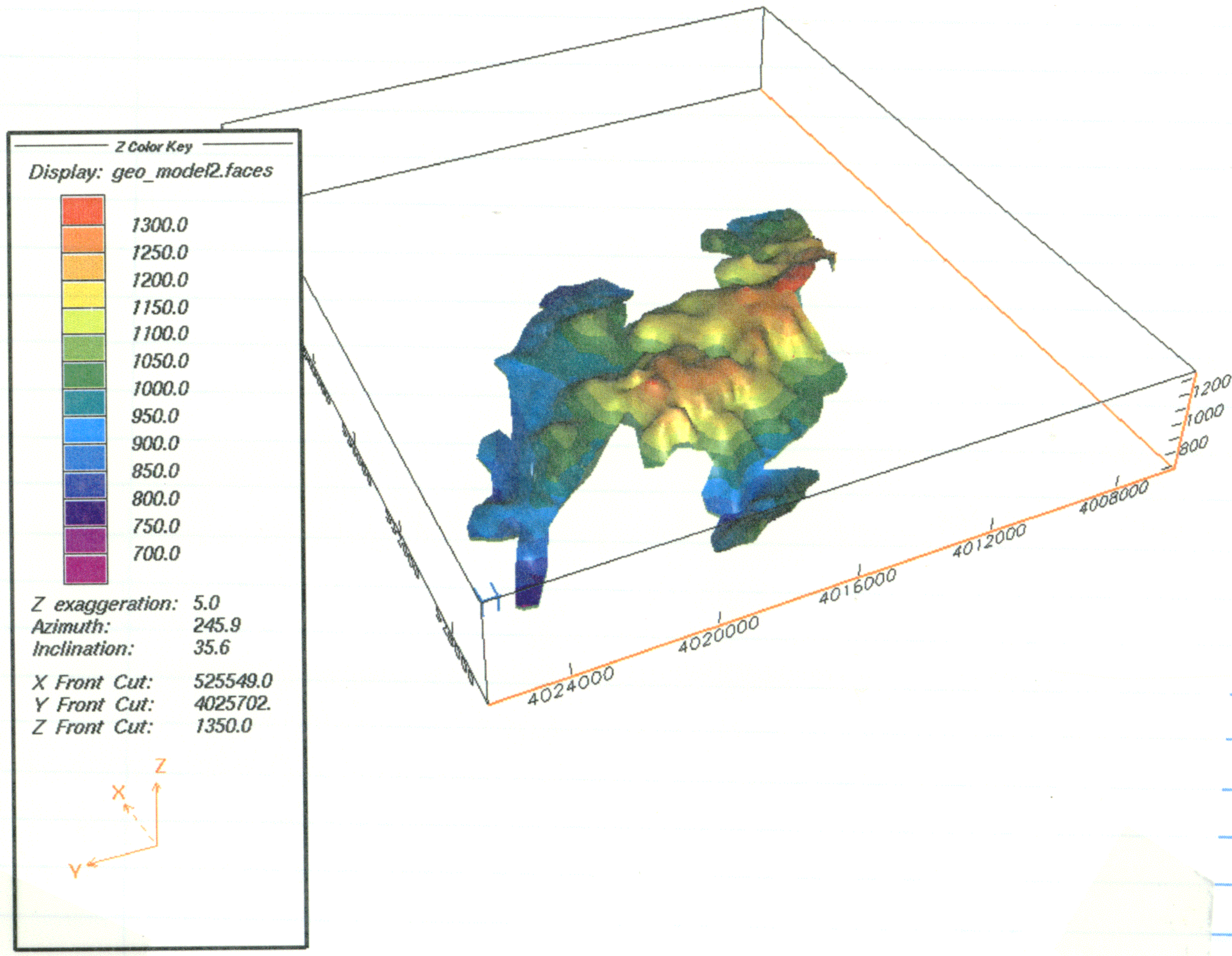


The image was accurately registered in the registration window of EV using easily located & prominent sites.

A final final is constructed using the 4k Dem data and the registered Landsat image!

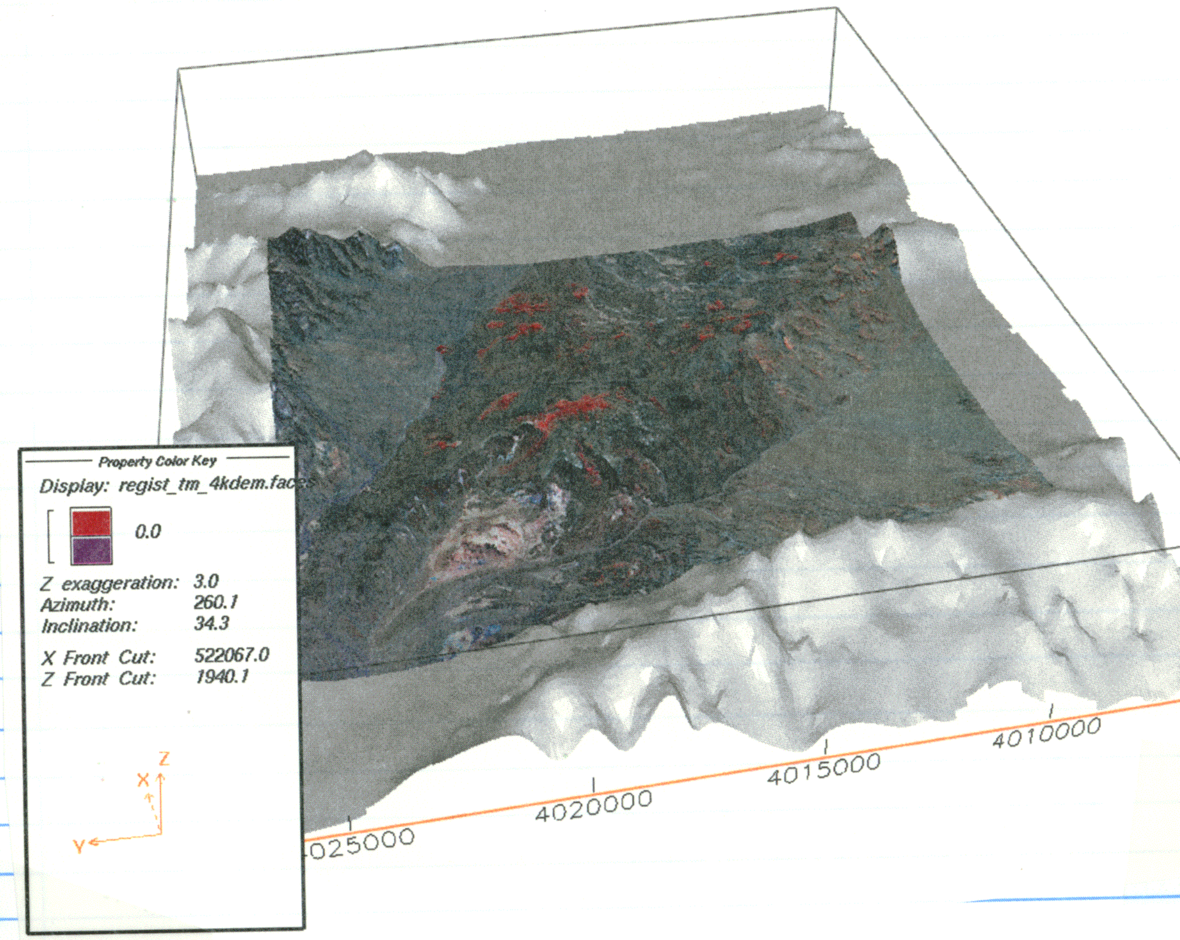
JWC

Northern Greenwater Range: Funeral Formation
Geo–model2: DEM + Depth1



JWC

Northrn Greenwater Range
Landsat TM Draped on DEM



Landsat - registered image on DEM 4K! JWC

14 Oct 96

The following 4 pages contain Excell sheet detailing the ~~so~~ 150 wells drilled in the North central Greenwater Range by U.S. Borax Inc

U.S. Borax Contact → Steve Carpenter

Well Log Data from Steve Carpenter, US Borax Corp., Valencia Corp.
29-30 May 1996; Drill Hole locations from Map received 6 June 1996
M. Conway 11 July 1996

Well Log locations were digitized off US Borax 1:12,000 version of 7.5 minute 1:24,000 topographic Map on 10 July 1996
Well Log locations were projected into UTM projection
Digitizing tablet set by Rick Klar, and Rick provided support during digitizing work.

Comment Statements Have checked by Steve C. some question about stratigraphic picks.
VF = possible vent facies
Cngl = Significent interbedded conglomerate in Funeral Formation
Ph = Palagonitized ash suggesting site of phreatomagmatic activity
Qal = With significant thickness of Qua. alluvium cover (50 to 150+ ft.)

Thickness reported as 999 indicates that the hole ended or information was generally unavailable immediately below the contact between the Funeral FM, and the underlying unit.

** The absent of a percentage i this column reflects congl not

Well ID #	Well ID# Arc/Info	Collar Elevation (ft)	Collar Elevation (m)	Funeral Formation	Funeral FM Thickness	Funeal FM (Thickness(m	Greenwater Formation	Grnwtr FM Thickness	Grnwtr FM Thick (m)	Furnace Crk Formation	Furnace Crk Thickness	Furnace Crk Thickness (m	Comments	**Estimated thickness FF conglomerate	Well ID #
1	1	4111.59	1253.5	FUFM	295	89.9	GWFM	0	0.0	FCFM	999	304.6			1
2	2	4087.89	1246.3	FUFM	582	177.4	GWFM	0	0.0	FCFM	1418	432.3			2
3	3	4031.7	1229.2	FUFM	510	155.5	GWFM	0	0.0	FCFM	750	228.7			3
4	4	4025.52	1227.3	FUFM	265	80.8	GWFM	0	0.0	FCFM	265	80.8			4
5	5	3977.6	1212.7	FUFM	170	51.8	GWFM	0	0.0	FCFM	480	146.3		15	5
6	6	4070.58	1241.0	FUFM	450	137.2	GWFM	0	0.0	FCFM	910	277.4	SC	6.7	6
7	7	4112.36	1253.8	FUFM	138	42.1	GWFM	0	0.0	FCFM	252	76.8		0	7
8	8	4168.99	1271.0	FUFM	374	114.0	GWFM	0	0.0	FCFM	256	78.0		1	8
9	9	4039.33	1231.5	FUFM	442	134.8	GWFM	0	0.0	FCFM	538	164.0			9
10	10	4044.84	1233.2	FUFM	440	134.1	GWFM	0	0.0	FCFM	500	152.4		2.5	10
11	11	4139.61	1262.1	FUFM	480	146.3	GWFM	0	0.0	FCFM	760	231.7			11
12	12	4023.94	1226.8	FUFM	475	144.8	GWFM	310	94.5	FCFM		0.0	VF,Ph		12
13	13	4083.04	1244.8	FUFM	295	89.9	GWFM	355	108.2	FCFM		0.0	SC	8	13
14	14	3821.59	1165.1	FUFM	524	159.8	GWFM	250	76.2	FCFM		0.0		0	14
15	15	3944.45	1202.6	FUFM	780	237.8	GWFM	0	0.0	FCFM	220	67.1	VF	2.5	15
16	16	4194.85	1278.9	FUFM	648	197.6	GWFM	0	0.0	FCFM	900	274.4		2.7	16
17	17	4178.53	1273.9	FUFM	390	118.9	GWFM	0	0.0	FCFM	660	201.2		1	17
18	18	4066.98	1239.9	FUFM	360	109.8	GWFM	0	0.0	FCFM	340	103.7		0	18
19	19	4308.61	1313.6	FUFM	730	222.6	GWFM	260	79.3	FCFM		0.0	SC	9	19
20	20	3431.36	1046.1	FUFM	335	102.1	GWFM	0	0.0	FCFM	665	202.7		0	20
21	21	3518.92	1072.8	FUFM	440	134.1	GWFM	0	0.0	FCFM	260	79.3		11.5	21
22	22	3493.17	1065.0	FUFM	630	192.1	GWFM	0	0.0	FCFM	999	304.6		30	22
23	23	3553.3	1083.3	FUFM	380	115.9	GWFM	0	0.0	FCFM	400	122.0		47	23
24	24	3475.79	1059.7	FUFM	520	158.5	GWFM	0	0.0	FCFM	340	103.7		33	24
25	25	3430.39	1045.9	FUFM	760	231.7	GWFM	0	0.0	FCFM	240	73.2		34	25
26	26	4187.87	1276.8	FUFM	320	97.6	GWFM	0	0.0	FCFM	360	109.8	VF	2	26
27	27	4180.51	1274.5	FUFM	350	106.7	GWFM	0	0.0	FCFM	220	67.1		0	27
28	28	4183	1275.3	FUFM	480	146.3	GWFM	0	0.0	FCFM	290	88.4	VF	0	28
29	29	4107.44	1252.3	FUFM	500	152.4	GWFM	0	0.0	FCFM	230	70.1		0	29
30	30	4167.18	1270.5	FUFM	580	176.8	GWFM	0	0.0	FCFM	330	100.6		2	30
31	31	4104	1251.2	FUFM	392	119.5	GWFM	0	0.0	FCFM	228	69.5		2	31
32	32	4052.19	1235.4	FUFM	315	96.0	GWFM	0	0.0	FCFM	315	96.0	VF		32
33	33	3426.91	1044.8	FUFM	184	56.1	GWFM	0	0.0	FCFM	445	135.7			33
34	34	4109.66	1252.9	FUFM	364	111.0	GWFM	0	0.0	FCFM	270	82.3			34
35	35	4219.38	1286.4	FUFM	560	170.7	GWFM	0	0.0	FCFM	190	57.9		1	35
36	36	4204.25	1281.8	FUFM	634	193.3	GWFM	0	0.0	FCFM	140	42.7			36

37	37	4038.32	1231.2	FUFM	390	118.9	GWFM	0	0.0	FCFM	155	47.3			37
38	38	4209.75	1283.5	FUFM	640	195.1	GWFM	0	0.0	FCFM	250	76.2			38
39	39	4047.63	1234.0	FUFM	150	45.7	GWFM	0	0.0	FCFM	550	167.7		25	39
40	40	4222.1	1287.2	FUFM	630	192.1	GWFM	140	42.7	FCFM	999	304.6	SC		40
41	41	4064.22	1239.1	FUFM	110	33.5	GWFM	0	0.0	FCFM	999	304.6		14	41
42	42	4197.5	1279.7	FUFM	385	117.4	GWFM	0	0.0	FCFM	999	304.6			42
43	43	4104.76	1251.5	FUFM	480	146.3	GWFM	0	0.0	FCFM	999	304.6			43
44	44	4114.44	1254.4	FUFM	130	39.6	GWFM	0	0.0	FCFM	999	304.6		16	44
45	45	4049.19	1234.5	FUFM	200	61.0	GWFM	0	0.0	FCFM	999	304.6			45
46	46	4158.65	1267.9	FUFM	525	160.1	GWFM	0	0.0	FCFM	999	304.6			46
47	47	4075.82	1242.6	FUFM	770	234.8	GWFM	0	0.0	FCFM	90	27.4		19	47
48	48	4126.42	1258.1	FUFM	250	76.2	GWFM	0	0.0	FCFM	999	304.6		18	48
49	49	4171.73	1271.9	FUFM	245	74.7	GWFM	0	0.0	FCFM	999	304.6		15	49
50	50	4064.34	1239.1	FUFM	490	149.4	GWFM	0	0.0	FCFM	60	18.3		10	50
51	51	3067.96	935.4	FUFM	0	0.0	GWFM	0	0.0	FCFM	999	304.6	Qal		51
52	52	3007.3	916.9	FUFM	0	0.0	GWFM	0	0.0	FCFM	350	106.7	Qal		52
53	53	2931.54	893.8	FUFM	0	0.0	GWFM	0	0.0	FCFM	999	304.6	Qal		53
54	54	2965.44	904.1	FUFM	0	0.0	GWFM	0	0.0	FCFM	550	167.7	Qal		54
55	55	3148.67	960.0	FUFM	0	0.0	GWFM	0	0.0	FCFM	90	27.4	Qal		55
56	56	2946.46	898.3	FUFM	0	0.0	GWFM	0	0.0	FCFM	140	42.7	Qal		56
57	57	4232.65	1290.4	FUFM	540	164.6	GWFM	0	0.0	FCFM	999	304.6		1	57
58	58	4018.13	1225.0	FUFM	352	107.3	GWFM	0	0.0	FCFM	999	304.6	VF		58
59	59	3944.75	1202.7	FUFM	340	103.7	GWFM	0	0.0	FCFM	999	304.6	SC; VF		59
60	60	4102.41	1250.7	FUFM	525	160.1	GWFM	0	0.0	FCFM	100	30.5		12	60
61	61	3904.51	1190.4	FUFM	207	63.1	GWFM	0	0.0	FCFM	999	304.6		3	61
62	62	4080.48	1244.0	FUFM	315	96.0	GWFM	0	0.0	FCFM	150	45.7			62
63	63	4094.35	1248.3	FUFM	260	79.3	GWFM	0	0.0	FCFM	999	304.6		10	63
64	64	4052.25	1235.4	FUFM	420	128.0	GWFM	0	0.0	FCFM	999	304.6	Ph		64
65	65	3294.38	1004.4	FUFM	130	39.6	GWFM	0	0.0	FCFM	999	304.6		7	65
66	66	4111.52	1253.5	FUFM	460	140.2	GWFM	999	304.6	FCFM	0	0.0	SC		66
67	67	4058.23	1237.3	FUFM	370	112.8	GWFM	0	0.0	FCFM	999	304.6		5	67
68	68	3916.5	1194.1	FUFM	106	32.3	GWFM	0	0.0	FCFM	230	70.1		7	68
69	69	3943.43	1202.3	FUFM	145	44.2	GWFM	0	0.0	FCFM	999	304.6		3.5	69
70	70	3964.33	1208.6	FUFM	23	7.0	GWFM	0	0.0	FCFM	150	45.7		1.3	70
71	71	3925.36	1196.8	FUFM	200	61.0	GWFM	0	0.0	FCFM	160	48.8		2.5	71
72	72	3779.82	1152.4	FUFM	285	86.9	GWFM	0	0.0	FCFM	100	30.5			72
73	73	3786.61	1154.5	FUFM	305	93.0	GWFM	0	0.0	FCFM	70	21.3	VF; Ph	14	73
74	74	3740.48	1140.4	FUFM	180	54.9	GWFM	120	36.6	FCFM		0.0		11	74
75	75	unknown		FUFM	195	59.5	GWFM	0	0.0	FCFM	999	304.6	Collar elevati	7.7	75
76	76	3694.627	1126.4	FUFM	320	97.6	GWFM	0	0.0	FCFM	999	304.6			76
77	77	3796.186	1157.4	FUFM	300	91.5	GWFM	0	0.0	FCFM	100	30.5	VF	10	77
78	78	3833.238	1168.7	FUFM	340	103.7	GWFM	0	0.0	FCFM	999	304.6			78
79	79	3821.478	1165.1	FUFM	330	100.6	GWFM	0	0.0	FCFM	999	304.6	VF		79
80	80	4146.52	1264.2	FUFM	600	182.9	GWFM	0	0.0	FCFM	999	304.6	VF		80
81	81	4160.49	1268.4	FUFM	594	181.1	GWFM	0	0.0	FCFM	999	304.6		4	81
82	82	4124.47	1257.5	FUFM	556	169.5	GWFM	0	0.0	FCFM	999	304.6		6.1	82
83	83	3770.3	1149.5	FUFM	320	97.6	GWFM	0	0.0	FCFM	120	36.6	VF	15	83
84	84	3849.41	1173.6	FUFM	370	112.8	GWFM	0	0.0	FCFM	50	15.2	VF	5	84
85	85	4025.72	1227.4	FUFM	470	143.3	GWFM	480	146.3	FCFM	999	304.6		10	85
86	86	3995.77	1218.2	FUFM	490	149.4	GWFM	999	304.6	FCFM		0.0		5	86
87	87	4014.59	1224.0	FUFM	500	152.4	GWFM	260	79.3	FCFM		0.0			87
88	88	3957.8	1206.6	FUFM	395	120.4	GWFM	999	304.6	FCFM		0.0		8	88
89	89	3953.3	1205.3	FUFM	390	118.9	GWFM	40	12.2	FCFM		0.0		7.1	89
90	90	4021.37	1226.0	FUFM	470	143.3	GWFM	50	15.2	FCFM		0.0	VF	6	90
91	91	3789.03	1155.2	FUFM	290	88.4	GWFM	100	30.5	FCFM	999	304.6		17	91
92	92	3739.6	1140.1	FUFM	270	82.3	GWFM	0	0.0	FCFM	130	39.6		10	92
93	93	3770.43	1149.5	FUFM	310	94.5	GWFM	0	0.0	FCFM	60	18.3		15	93

94	94	3742.1	1140.9	FUFM	350	106.7	GWFM	0	0.0	FCFM	25	7.6		31	94
95	95	3936.81	1200.2	FUFM	435	132.6	GWFM	0	0.0	FCFM	999	304.6		9	95
96	96	3737.98	1139.6	FUFM	240	73.2	GWFM	0	0.0	FCFM	50	15.2		6	96
97	97	4058.51	1237.4	FUFM	480	146.3	GWFM	0	0.0	FCFM	80	24.4		20	97
98	98	4115.07	1254.6	FUFM	510	155.5	GWFM	170	51.8	FCFM	0	0.0			98
99	99	4143.35	1263.2	FUFM	500	152.4	GWFM	70	21.3	FCFM	999	304.6		7.2	99
100	100	4054.53	1236.1	FUFM	530	161.6	GWFM	180	54.9	FCFM	999	304.6		18	100
101	101	3785.1	1154.0	FUFM	290	88.4	GWFM	110	33.5	FCFM	100	30.5		3	101
102	102	4193.4	1278.5	FUFM	460	140.2	GWFM	80	24.4	FCFM	999	304.6		3	102
103	103	4178.6	1274.0	FUFM	580	176.8	GWFM	30	9.1	FCFM	999	304.6		3	103
104	104	3830	1167.7	FUFM	330	100.6	GWFM	190	57.9	FCFM	999	304.6			104
105	105	4148	1264.6	FUFM	495	150.9	GWFM	0	0.0	FCFM	999	304.6		12	105
106	106	4229	1289.3	FUFM	630	192.1	GWFM	0	0.0	FCFM	999	304.6		55	106
107	107	4251	1296.0	FUFM	560	170.7	GWFM	0	0.0	FCFM	999	304.6		19	107
108	108	4119	1255.8	FUFM	480	146.3	GWFM	120	36.6	FCFM	999	304.6		10	108
109	109	3870	1179.9	FUFM	465	141.8	GWFM	155	47.3	FCFM	999	304.6		73	109
110	110	3967	1209.5	FUFM	540	164.6	GWFM	260	79.3	FCFM	999	304.6		19	110
111	111	4124	1257.3	FUFM	530	161.6	GWFM	390	118.9	FCFM	999	304.6		40	111
112	112	4114	1254.3	FUFM	530	161.6	GWFM	310	94.5	FCFM	999	304.6		56	112
113	113	4183	1275.3	FUFM	570	173.8	GWFM	120	36.6	FCFM	999	304.6		17	113
114	120	3786	1154.3	FUFM	148	45.1	GWFM	0	0.0	FCFM	999	304.6			114
115	114	3944	1202.4	FUFM	640	195.1	GWFM	999	304.6	FCFM		0.0		30	115
116	115	4133	1260.1	FUFM	200	61.0	GWFM	0	0.0	FCFM	999	304.6			116
117	116	4164	1269.5	FUFM	590	179.9	GWFM	0	0.0	FCFM	999	304.6		2	117
118	117	3270	997.0	FUFM	0	0.0	GWFM	0	0.0	FCFM	999	304.6			118
119	118	3775	1150.9	FUFM	260	79.3	GWFM	20	6.1	FCFM	490	149.4			119
120	119	3991	1216.8	FUFM	430	131.1	GWFM	260	79.3	FCFM	90	27.4			120
121	121	4033	1229.6	FUFM	350	106.7	GWFM	0	0.0	FCFM	999	304.6		8	121
122	122	4165	1269.8	FUFM	530	161.6	GWFM	450	137.2	FCFM	999	304.6			122
123	123	3802	1159.1	FUFM	580	176.8	GWFM	190	57.9	FCFM	999	304.6			123
124	124	3987	1215.5	FUFM	565	172.3	GWFM	35	10.7	FCFM	999	304.6	SC	2	124
125	125	4077	1243.0	FUFM	440	134.1	GWFM	30	9.1	FCFM	999	304.6		9	125
126	126	4102	1250.6	FUFM	430	131.1	GWFM	85	25.9	FCFM	999	304.6		2	126
127	127	4291	1308.2	FUFM	450	137.2	GWFM	0	0.0	FCFM	999	304.6			127
128	128	4085	1245.4	FUFM	630	192.1	GWFM	0	0.0	FCFM	999	304.6		2	128
129	129	3847	1172.9	FUFM	330	100.6	GWFM	0	0.0	FCFM	999	304.6	VF		129
130	130	4272	1302.4	FUFM	570	173.8	GWFM	0	0.0	FCFM	999	304.6	VF	3.5	130
131	131	4003	1220.4	FUFM	490	149.4	GWFM	190	57.9	FCFM	999	304.6		4.5	131
132	132	3890	1186.0	FUFM	550	167.7	GWFM	120	36.6	FCFM	999	304.6	Ph	10	132
133	133	3791	1155.8	FUFM	500	152.4	GWFM	999	304.6	FCFM		0.0		15	133
134	134	3825	1166.2	FUFM	570	173.8	GWFM	130	39.6	FCFM	999	304.6		2	134
135	135	3745	1141.8	FUFM	310	94.5	GWFM	0	0.0	FCFM	999	304.6		1	135
136	136	4204	1281.7	FUFM	465	141.8	GWFM	999	304.6	FCFM		0.0	SC	5	136
137	137	3946	1203.0	FUFM	475	144.8	GWFM	15	4.6	FCFM	999	304.6	SC	5	137
138	138	3822	1165.2	FUFM	510	155.5	GWFM	140	42.7	FCFM	999	304.6			138
139	139	3797	1157.6	FUFM	530	161.6	GWFM	100	30.5	FCFM	999	304.6		2	139
140	140	3895	1187.5	FUFM	550	167.7	GWFM	50	15.2	FCFM	999	304.6		10	140
141	141	3898	1188.4	FUFM	470	143.3	GWFM	80	24.4	FCFM	999	304.6	VF	21	141
142	142	3947	1203.4	FUFM	560	170.7	GWFM	999	304.6	FCFM		0.0	SC	10	142
143	143	4033	1229.6	FUFM	540	164.6	GWFM	160	48.8	FCFM	999	304.6		7	143
144	144	4214	1284.8	FUFM	440	134.1	GWFM	20	6.1	FCFM	999	304.6	VF		144
145	145	4042	1232.3	FUFM	120	36.6	GWFM	0	0.0	FCFM	999	304.6	VF	5	145
146	146	4080	1243.9	FUFM	360	109.8	GWFM	0	0.0	FCFM	999	304.6		7	146
147	147	3947	1203.4	FUFM	435	132.6	GWFM	275	83.8	FCFM	999	304.6			147
148	148	4208	1282.9	FUFM	810	247.0	GWFM	30	9.1	FCFM		0.0	SC	7	148
149	149	3874	1181.1	FUFM	640	195.1	GWFM	120	36.6	FCFM	999	304.6		0	149
150	150	3813	1162.5	FUFM	640	195.1	GWFM	200	61.0	FCFM	999	304.6	SC	0	150

151	151	3842	1174.3		FUFM	780	237.8	GWFM	999	304.6	FCFM		0.0		6.4		151
152	152	3804	1159.8		FUFM	660	201.2	GWFM	230	70.1	FCFM	999	304.6				152
VC1	153					70	21.3	GWFM	0	0.0	FCFM	999	304.6	Fu. Fm basalt capped by 50 ft of alluvium			
P-1	154																P-1
												Average % Conglomerate in Funeral FM			10.87	perc	
Average thickness of Funeral Fm Holes 1 - 50 inclusive														Note conglomerate on the west side of the			
131.0	meters													at sites 21,22,23,24,25 , up to 30 to 50 %.			
Average thickness of Funeral Fm holes 57 - 152 inclusive																	
129.3	meters																

15 Oct 96.

Isolated > neither 500 ft separated by intervening drill holes!

Well # — comment

facies Depth to wt — Drill holes with vent facies at depth.

50-200+ ft — 12 — isolated — Phreatomag.
130-170 ft. — 15 — isolated — 64
220-250 ft — 26 — isolated — 12
sub-surf. — 28 — isolated — 73, 132
upper section — 32 — isolated
120-160 ft — 58, 59 — 189m
75-130m
Sub 0-125 ft — 73, 77, 79 — 154m — adjacent holes — 4 to 90 ft. — 79 → 0-150 ft
87m

22 with volcanic phreatomag.

80 0-75 ft
83 — 0-130 ft.
84 — adjacent 157m → 0-140 ft.
90 — subsurf to 140 ft
isolated 500m
129 — 136m adjacent to 144.
130
141 — isolated
144 → subsurf to 70 ft → 0-240 ft
145 — isolated → 0-120 ft.
140 isolated; subsurf to 280m

~15%

129 — 153m from 83. — possible link!
Subsurf to 180 ft

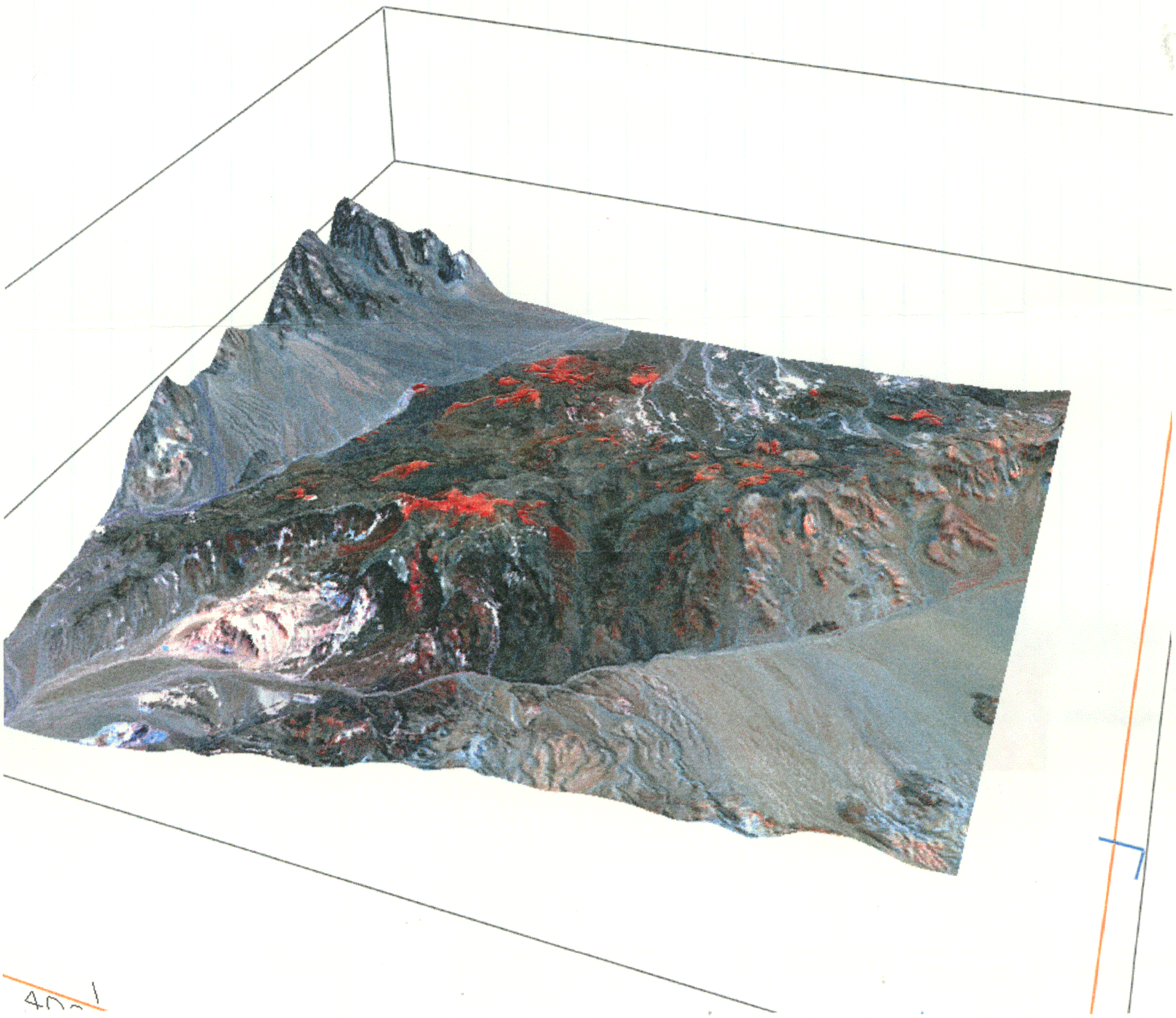
minimum — 13 isolated vents in area.

how to select? plot?

sel.

Landsat TM - draped on 4k DEM scene!

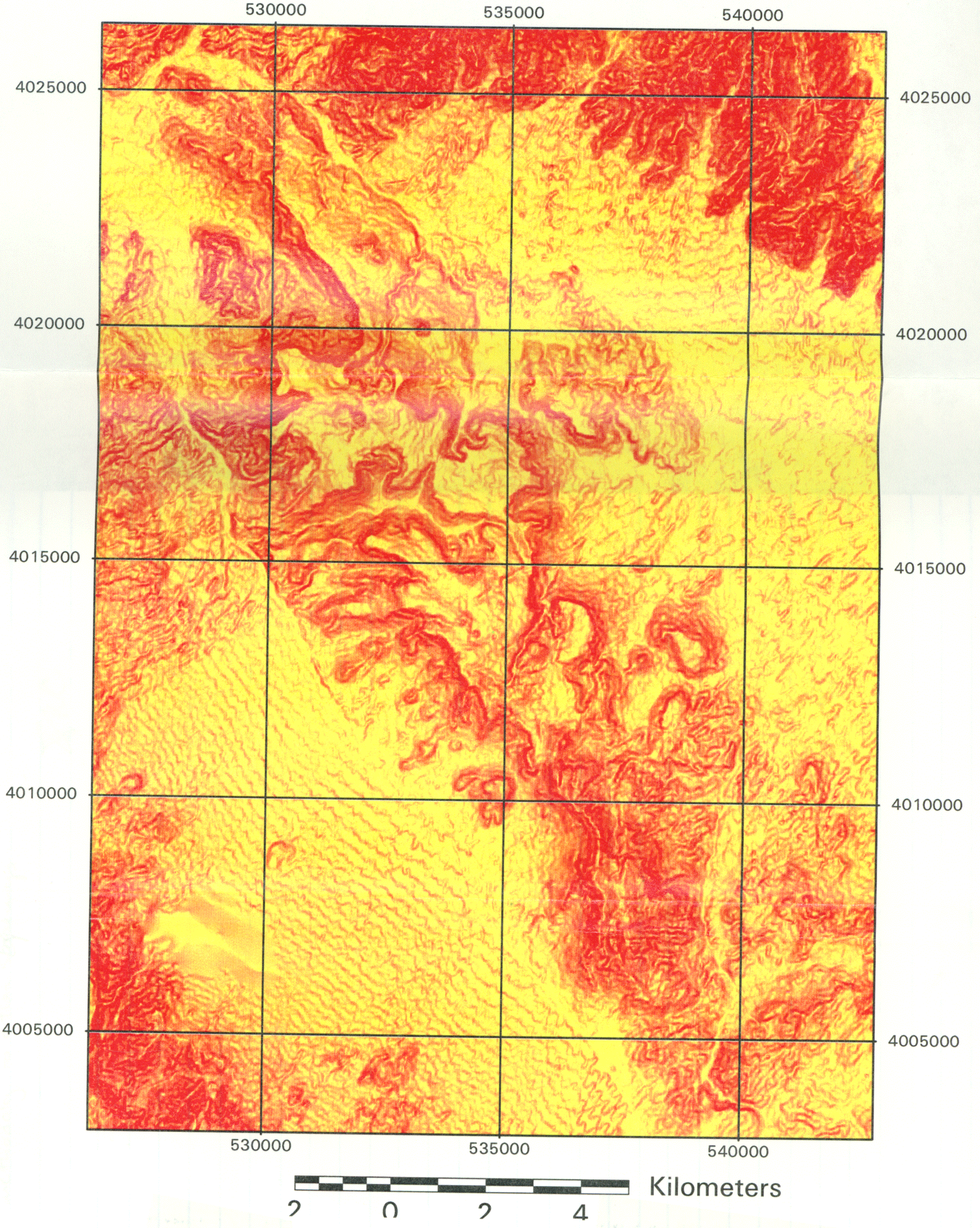
Northern Greenwater Range:
Landsat TM Draped on 30–m DEM



TM_DEM_cut_away • rgb
• ps
• showcase.

Nov 18, 96

"Slope map used in AGU poster."



17 Feb 97

grn_vents_ungen2

Greenwater Range Vent Locations

Interpretations are based on geologic mapping of area (McAllister 1970, 1973) and satellite interpretation of SLAR, SPOT, and Landsat TM imagery. This ungenerate arc/info file of vent locations was produced on 18 February 1997 by Michael Conway

2	536160.5	4021203.5
0	536241.75	4021334.75
5	532135.5	4021528.5
6	533098	4020022.25
7	531966.75	4018459.75
8	531723	4018566
9	531735.5	4018128.5
0	531741	4017871
11	531909	4017199
13	535269	4017403
15	534381	4013563
16	534141	4013767
17	534777	4013479
19	538389	4013599
20	538185	4017307
21	538461	4017043
22	537729	4018603
23	537033	4019551
24	537897	4019407
24	540489	4015279
25	541449	4014655
27	538401	4011463
28	542241	4010203
30	535689	4013671
0	536073	4013991
33	546260.5	4007053.5
34	539785.5	4004441
14	534836.5	4014090.5
33	538874.875	4017329.5
32	545759.25	4009405
35	546131	4007497.5
36	541118.375	4008214.5
12	536336.5	4019070.5
4	531964.813	4021695
	End of File	

18 Feb 97 M Conway

The following page contains a listing of locations for the Greenwater Range Volcanic Field Vents.

Vent locations are from geologic maps (McAllister 1970, 1973) and from satellite interpretation of SLAR, SPOT, and Landsat TM data. Satellite Interpretation is supported by field truthing conducted by M. Conway & Britt Hill in 1996 in the Greenwater Range.

Vent locations listed here are for use by C. Connor in assessing cluster analysis & vent alignments trends in Greenwater Range.

[signature]

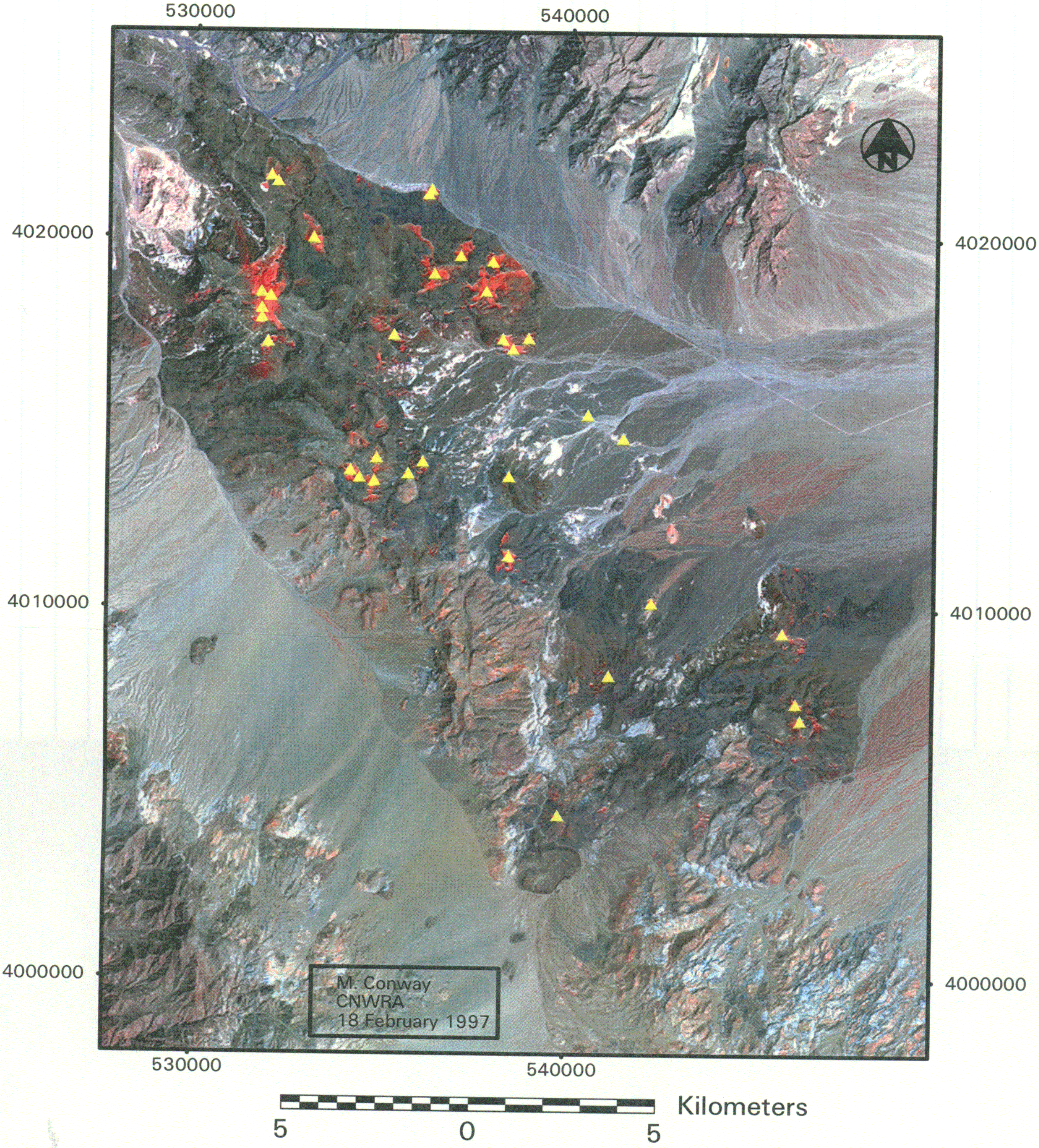
18 Feb 97

Following page contains a map w/ vent locations corresponding to Vent used in location file on pg 26.

Mccrory

RMC

Greenwater Range: Vent Locations



March 2 97

Registration of Cottonwood Range

Georectification of SPOT image of Cottonwood Range

A registered TM scene (UTM, Zone 11), 041 034 07/30/89, was used for georeferencing the SPOT image.

A linear registeration was done using 3 location points. This method and the few number of points was suggested by the ERDAS Technical Support.

Source		Landsat TM	
x	y	x	y
798.5	755.6	477135.7	4105287.8
1651.5	5724.6	473806.2	4055369.4
4975.5	2677.2	513891.7	4078990.7

RMS x	RMS y	Total RMS
0.000	0.000	0.000

A visual check using the swipe tool in ERDAS at scales of 1:125,000 and 1:62500 confirmed that registration was good.

RMC

3 March

Cottonwood scene & Saline Spot scenes were mosaiced together → results were good to excellent.

RMC

16 March 97

SIAR images of area North of Greenwater, including Cottonwood, Last Chance & Saline Ranges were registered using a 30-m Landsat TM image.

Software used for this was ERDAS Imagine

— Processing Imaging & Registration Process —

Radar Strip (1700 x 10000) 12-m cells

↓

Subset to area of interest

↓

Speckle suppression & brightness control → Hist Eq (results poor)

↓

Registration to Registered Landsat TM (30-m) res. image [3 to 6 points used in registration]

↓

Projection assigned.

Examples of Registration process on following page

JUC.

For Notebook (export 3 dir

SLAR 2050_ Landsat sal_cttnwood_hog_utm

	Source		Reg (Tm	
Lct	X	Y	X	Y
~~SW~~	~~8~~			
SW	566.4	6005.2	443550	4049429.7
SC	1494.9	6302.4	454728.0	4053645.0
EC	1548.5	6897.5	455503.0	4060173.4
NE	1465.8	8854.7	454100.0	4083667.0
NW corner	372.3	9699.6	440846.9	4093760.9

	X'	Y'
Coef	-39014.277	-331276.15
X	0.0824	-0.000288
X	0.000738	0.0833

Rms Error

X Rms 5.844

Y Rms 0.44

Total Rms 5.86

2030 [illegible]

SLAR image 2030

Landsat TM

	X	Y	X	Y
S central	613.9	2004.6	~~4125~~25.0	4044217.0
E centre	~~87.0~~			
NE centre	1409.6	3807.4	422537.5	4065802.0
↳	~~1389.6~~	~~5046.4~~	~~422313.~~	~~4080645.~~
	1388.4	5048.4	422275.0	4080654
NW	1038.62	5972.9	417825.0	4091664.0

Transform File

	X'	Y'
Const	-32427.69	-336203.34
X	0.079	-0.0004
Y	0.000095	0.08367

Rms error

X 0.6797

Y 0.67583

Total 0.95854.

Scenes registered

2010	2040	2070
2020	2050	2080.
2030	2060	

From Inyo Mtn East to Grapevine Mtn!

[signature]

21 March 97

Following pages contain detailed volumetric Report to supplement results on pg 9.

FWe

2-D Volumetrics Report

VOLUMETRICS REPORT

```
                     Run by: mconway
                    Version: 3.0
                       Date: 10/04/96
                Report file: fin_gwr_east_poly.2vrpt

               Polygon file: gwr_east_poly.ply
           Zone definintion: Operational
       Deposition operation: collar7.2grd
       Deposition operation: depth1_vers8.2grd
       Global yield factor: 1.0
              Primary field: Polygon ID
             Sorting method: Polygon order
                Input units: meters square by meters
Volumetrics conversion factor: 1
               Output units: Same as input
   Global minimum thickness: 0.0

-------------------- Zone name: collar7 --------------------

                  Minimum z: none
                  Maximum z: none
          Minimum thickness: 0.0
               Yield factor: 1.0
```

2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	10,563,766.422	518,006,980.54	10,563,766.422

Avg Z = 49.0

Vol = 0.518 km^3

25 m permit

21 March 97

Following pages contain detailed volumetric Report to supplement results on pg 9

VOLUME REPORT for EAST POLY in GWR RANGE

5 October 1996

Final EAST Poly Volume

Run by: mconway
Version: 3.0
Date: 10/04/96
Report file: fin_gwr_east_poly.2vrpt

Polygon file: gwr_east_poly.ply
Zone definintion: Operational
Deposition operation: collar7.2grd
Deposition operation: al_dpth1_v8.2grd
Global yield factor: 1.0
Primary field: Polygon ID
Sorting method: Polygon order
Input units: meters square by meters
olumetrics conversion factor: 1
Output units: Same as input
Global minimum thickness: 0.0

------------------ Zone name: collar7 --------------------

Minimum z: none
Maximum z: none
Minimum thickness: 0.0
Yield factor: 1.0

2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	10,563,766.422 sq m	451,512,705.5	10,563,766.422

Average Z = Vol / p.Area = 42.7m

Volume = 0.451 Km^3

10m perimeter

FWC

21-3-97

2-D Volumetrics Report

VOLUMETRICS REPORT

Run by: mconway
Version: 3.0
Date: 10/08/96
Report file: vol_south2_poly.2vrpt

Polygon file: gwr_south_poly2.ply
Zone definintion: Operational
Deposition operation: collar7.2grd
Deposition operation: depth1_vers8.2grd
Global yield factor: 1.0
Primary field: Polygon ID
Sorting method: Polygon order
Input units: meters square by meters
Volumetrics conversion factor: 1
Output units: Same as input
Global minimum thickness: 0.0

------------------ Zone name: collar7 --------------------

Minimum z: none
Maximum z: none
Minimum thickness: 0.0
Yield factor: 1.0

2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	601,621.296875	16,953,325.458	601,621.296875

FWC

21-3-97

seeps
9

2-D Volumetrics Report

VOLUMETRICS REPORT

Run by: mconway
Version: 3.0
Date: 10/08/96
Report file: vol_central_poly.2vrpt

Polygon file: gwr_central_poly.ply
Zone definintion: Operational
Deposition operation: collar7.2grd
Deposition operation: depth1_vers8.2grd
Global yield factor: 1.0
Primary field: Polygon ID
Sorting method: Polygon order
Input units: meters square by meters
Volumetrics conversion factor: 1
Output units: Same as input
Global minimum thickness: 0.0

Zone name: collar7

Minimum z: none
Maximum z: none
Minimum thickness: 0.0
Yield factor: 1.0

2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	47,026,947.422	3,550,318,905.	47,026,947.422

FUC

21-3-97

2-D Volumetrics Report

VOLUMETRICS REPORT

Run by: mconway
Version: 3.0
Date: 10/04/96
Report file: fin_gwr_east_poly.2vrpt

Polygon file: gwr_east_poly.ply
Zone definintion: Operational
Deposition operation: collar7.2grd
Deposition operation: depth1_vers8.2grd
Global yield factor: 1.0
Primary field: Polygon ID
Sorting method: Polygon order
Input units: meters square by meters
Volumetrics conversion factor: 1
Output units: Same as input
Global minimum thickness: 0.0

Zone name: collar7

Minimum z: none
Maximum z: none
Minimum thickness: 0.0
Yield factor: 1.0

2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	10,563,766.422	518,006,980.54	10,563,766.422

FUC

2-D Volumetrics Report

VOLUMETRICS REPORT

Run by: mconway
Version: 3.0
Date: 10/08/96
Report file: vol_east2_poly.2vrpt

Polygon file: gwr_east2_poly.ply
Zone definintion: Operational
Deposition operation: collar7.2grd
Deposition operation: depth1_vers8.2grd
Global yield factor: 1.0
Primary field: Polygon ID
Sorting method: Polygon order
Input units: meters square by meters
Volumetrics conversion factor: 1
Output units: Same as input
Global minimum thickness: 0.0

-------------------- Zone name: collar7 --------------------

Minimum z: none
Maximum z: none
Minimum thickness: 0.0
Yield factor: 1.0

2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	453,338.789063	11,355,695.451	453,338.789063

Ʀuc

2-D Volumetrics Report

VOLUMETRICS REPORT

Run by: mconway
Version: 3.0
Date: 10/08/96
Report file: vol_north1_poly.2vrpt

Polygon file: gwr_north1_poly.ply
Zone definintion: Operational
Deposition operation: collar7.2grd
Deposition operation: depth1_vers8.2grd
Global yield factor: 1.0
Primary field: Polygon ID
Sorting method: Polygon order
Input units: meters square by meters
Volumetrics conversion factor: 1
Output units: Same as input
Global minimum thickness: 0.0

-------------------- Zone name: collar7 --------------------

Minimum z: none
Maximum z: none
Minimum thickness: 0.0
Yield factor: 1.0

2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	377,073.109375	9,842,071.3802	377,073.109375

Ʀuc

21-3-97

2-D Volumetrics Report

VOLUMETRICS REPORT

```
                     Run by: mconway
                    Version: 3.0
                       Date: 10/08/96
                Report file: vol_north2_poly.2vrpt

               Polygon file: gwr_north2_poly.ply
            Zone definintion: Operational
        Deposition operation: collar7.2grd
        Deposition operation: depth1_vers8.2grd
         Global yield factor: 1.0
               Primary field: Polygon ID
              Sorting method: Polygon order
                 Input units: meters square by meters
Volumetrics conversion factor: 1
                Output units: Same as input
    Global minimum thickness: 0.0

-------------------- Zone name: collar7 --------------------

                   Minimum z: none
                   Maximum z: none
           Minimum thickness: 0.0
                Yield factor: 1.0
```

2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	72,509.203125	1,812,414.3048	72,509.203125

21-3-97

2-D Volumetrics Report

VOLUMETRICS REPORT

```
                     Run by: mconway
                    Version: 3.0
                       Date: 10/08/96
                Report file: vol_west_poly.2vrpt

               Polygon file: gwr_west_poly.ply
            Zone definintion: Operational
        Deposition operation: collar7.2grd
        Deposition operation: depth1_vers8.2grd
         Global yield factor: 1.0
               Primary field: Polygon ID
              Sorting method: Polygon order
                 Input units: meters square by meters
Volumetrics conversion factor: 1
                Output units: Same as input
    Global minimum thickness: 0.0

-------------------- Zone name: collar7 --------------------

                   Minimum z: none
                   Maximum z: none
           Minimum thickness: 0.0
                Yield factor: 1.0
```

2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	3,105,750.4141	88,086,005.09	3,105,750.4141

2-D Volumetrics Report

VOLUMETRICS REPORT

```
                     Run by: mconway
                    Version: 3.0
                       Date: 10/08/96
                Report file: vol_south1_poly.2vrpt

               Polygon file: gwr_south_poly1.ply
            Zone definintion: Operational
        Deposition operation: collar7.2grd
        Deposition operation: depth1_vers8.2grd
         Global yield factor: 1.0
               Primary field: Polygon ID
              Sorting method: Polygon order
                 Input units: meters square by meters
Volumetrics conversion factor: 1
                Output units: Same as input
    Global minimum thickness: 0.0

-------------------- Zone name: collar7 --------------------

                   Minimum z: none
                   Maximum z: none
           Minimum thickness: 0.0
                Yield factor: 1.0
```

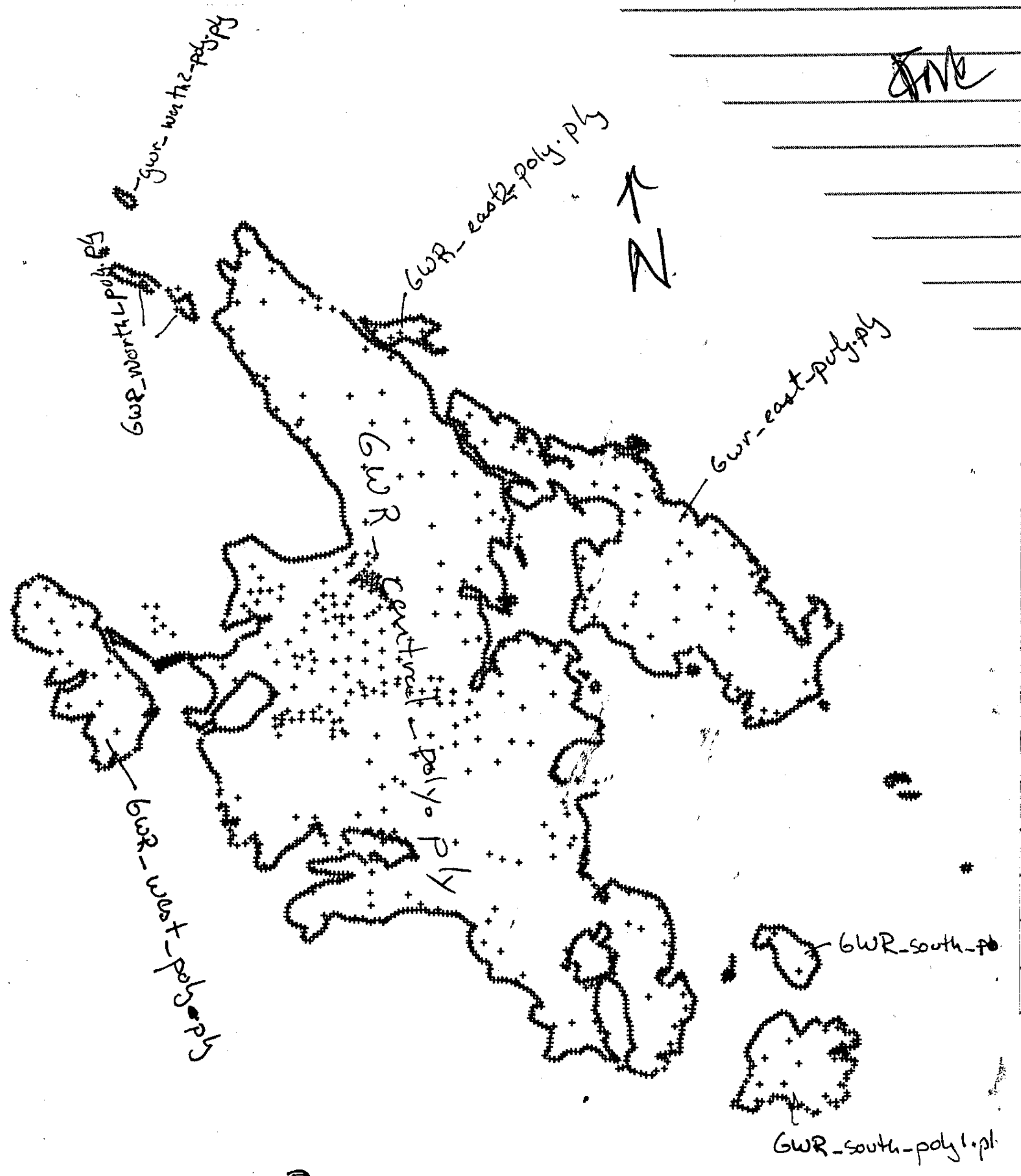
2-D Volumetrics Report

Zone name: collar7

Polygon ID / Polygon Class	Area	Volume	Positive Area
	2,238,559.6016	75,308,811.627	2,238,559.6016

22-3-97

Master polygon showing sites used to constrain thickness of Funeral formation
Includes well logs as well as sites whose thickness of Funeral Fm. is estimated from geologic maps of area & from cross-sectional views



Polygon Master Sheet

22-5-97

Copy of letter to Steve Carpenter introducing CNWRA interest in Greenwater Range.

Dr. Michael Conway
(210) 522-6829

1 April 1996

Mr. Steve Carpenter
Geologist
U.S. Borax Inc.
26877 Tourney Road
Valencia, CA 91355

Dear Steve:

I enjoyed talking with you about the Greenwater Range last Friday. As I mentioned then, I'm at the Center for Nuclear Waste Regulatory Analyses and am involved, along with several colleagues, in a study of Pliocene-Quaternary volcanism of the Basin and Range. We undertook this research on behalf of the Nuclear Regulatory Commission with the goal of understanding and characterizing volcanism in the vicinity of the proposed Yucca Mountain High-Level Nuclear Waste facility.

The Greenwater Range volcanics are of particular interest to us because of their proximity to Yucca Mountain and because of similarities in the style of volcanism with that of the Crater Flat volcanoes, just south of Yucca Mountain. My colleague, Britt Hill, and I will be in the Greenwaters between 19 April and 22 April, to initiate reconnaissance work delimiting the number and distribution of volcanic vents there. At present, we are compiling geologic data on the Pliocene basalts of the Greenwater Range.

At the advice of your colleague, Dr. Barry Watson, we are approaching you about data you may have on volcanics of the Greenwater Range. In particular, data from drill hole logs noting characteristics of the Funeral Formation basalt -- number of flows, flow thickness, total thickness of basalts, downhole petrologic or geochemical variation -- would be tremendously helpful. Other types of information that we would greatly appreciate would be any radiometric ages or geochemical analyses of Funeral Formation basalt. We are just beginning our work in the Greenwaters and any information that you can share with us will, I'm certain, be of tremendous help.

Britt and I thank you in advance for any assistance you can provide. As I mentioned during our phone conversation, we will be more then happy to share any findings we make with you, and we will of course gratefully acknowledge any assistance that we receive.

Yours sincerely,

Michael Conway

3-4-97

Data Sets for the Greenwater Range.available on 20 September 1996

Digital Data Sets:
Landsat TM Image: 040 035 04/18/89
7 bands, resolution 25 m.
SPOT Image: Orthorectified image and two offset images used to generate a DEM image. Each image has 1 band and 10 m resolution.
SPOT DEM: DEM produced by SPOT Image Corp from satellite pairs. Effective resolution is 20-m.
Geologic Map of McAllister (1970, 1973) with polygons representing volcanic outcrop of the Funeal Formation.

Arc/Info Data coverages of DEM, Geologic Maps, and U.S. Borax well log data.

Geologic Data:
Well-logs from 154 wells in Northern Greenwater Range supplied by U.S. Borax Corp. Well-log data breaks out contact between Funearl Formation and the underlying Greenwater or Furnace Creek Formation.
Geologic Maps of McAllister (1970, 1973) at 1:24,000 of Northern Greenwater Range.
Geologic Description by Drewes (1963), McAllister (1970, 1973), Wright et al. 1991).

Developing a digital data set for calculating thickness of the Funeral Formation of the Northern Greenwater Range, Inyo County, California

The basis of thickness calculation are well-log data from 154 wells in the north-central part of the Northern Greenwater Range. The data was supplied by Mr. Steven Carpenter (Geologist) of the U.S. Borax Corp from wells drilled over the past 15 years. Mr Carpenter personally logged nearly 100 drill holes. The remainder of the holes were logged by other geologists under Mr. Carpenters supervision. The base of the Funeral Formation was picked by myself with Mr Carpenters assistance and guidance during a two-day session at U.S. Borax Headquarters in Valencia, CA. Well-log data is complemented by estimates of the basal elevation of the Funeral Formation interpreted from geologic maps (McAllister (1970, 1973) and by projecting outcrop of underlying formations beneath the Funeral Formation. In areas where little data is available on the depth to or attitude of underlying formations, the well-log data was used as a guide for estimating Funeral basalt thickness. In general, I was conservative and estimated thickness is probably a minimum value. In resulting volume calculation, this should yield a conservative minimum volume.

FMC

3-4-97.

Preceding page includes brief description of scientific method for calculating volumes of lava erupted in Funeral Formation. Volumes were calculated in Earthvision as described earlier (beginning pg 9).

FMC

Notes on Assigning Thickness values to the Funeral Formation of the Greenwater Range

The Funeral Formation of the northern Greenwater Range consists predominantly of basalt lava flows (typically 5 to 10 m thick; Wright et al., 1991) intercalated with subordinate conglomerates and fanglomerates. The Funeral Formation once formed a thin veneer over much of the central part of the Death Vally volcanic field, but due to erosion and burial by later alluvium is now restricted to mesa tops and ridge-capping dip slopes (Wright et al. , 1991). Using well-log data provided by U.S. Borax Inc, we constrained thickness of the Funeral Formation in the north-central and northwest part of the Greenwater Range to between 20 m and 230 m, with an average thickness of ≈ 130 m.

In order to model the Funeral Formation of the northern Greenwater Range and to estimate volumes of basalts erupted there, it was necessary to augment well-log data with estimates of formation thickness from the present-day perimeter of the Formation. Whenever possible, we used the stratigraphy and structural information provided by McAllister (1970 and 1973), Drews (1963), and Wright et al., (1971) to constrain thicknesses. On the east side of the field, where the contacts between the Funeral Formation and the broadly folded volcanics and volcaniclastics of the Furnace Creek Formation are reasonably well-exposed, estimating thickness was trivial, and we have a great degree of confidence in these values. To the southwest, where stratigraphic contacts are commonly masked by Quaternary alluvium, estimating thickness is more difficult. Fortunately, several wells drilled just north of this area provide a baseline for estimating thicknesses.

Estimating Percent Conglomerate in the Funeral Formation (16 Sept. 96)

Basalt lava flows, agglomerate, and agglutinate of the Funeral Formation commonly overlie, and less commonly are intercalated with, basalt-bearing conglomerates and rare sandstones. Well log data provide constraints, locally, on the importance of conglomerates in the section. Geologists logging the drill-holes carefully noted the occurrenc of conglomeratic beds and frequently estimated the thickness and composition. Most conglomerates occur as basalt-bearing basal conglomerates overlying the Greenwater or Furnace Creek formations. Petrography of basalt cobbles are similar to basal lava flows of the Funeral Formation and are believed to originate from that unit (S. Carpenter; pers comm??). Thickness of conglomerates in the Funeral Formation vary considerably from virtually 0% at a number of drill holes, to as much as 73% at drill hole # 109. Averaging all of the estimated conglomerate data yields an average conglomerate thickness approximately equal to 11 % of the Funeral Formation. Steve Carpenter, US Borax, agreed that 11 percent was a reasonable value for the thickness of conglomerates in the northern Greenwater.

3-4-97.

Preceding page includes brief description of scientific method for calculating volumes of lava erupted in Funeral Formation. Volumes were calculated in Earthvision as described earlier (beginning pg 9).

[initials]

Use of EarthVision

I imported ungenerated tins into EV as Dat files. The final dat files reflect a 25 m basalt thickness at the edge of the areal extent of Funeral Formation outcrop. The dat files were converted into *.2grd files in EV. Volumetrics was used to calculate volumes between two subjacent grids using clipping polygons to limit lateral extent of solution. The polygon areas were checked in ERDAS and found to be accurate. Backcalculating the average thickness from volume solution resulting in reasonable thickness for the FF.

5-4-97

Sample List from 19 April Trip to Greenwater, Crater Flat, Thirsty Mountain

Sample ID	Location	Sample Comments
GW 4-19-96 1	E GWR Eroded Cone	Oxidized vent cinders
GW 4-19-96 2	E GWR Cone Complex	Oxidized vent cinders
GW 4-19-96 3	E GWR Road Cones	Oxidized vent cinders
GW 4-19-96 3a	E GWR Road Cones	Unoxidized near vent mtrl.
GW 4-19-96 3b	E GWR Road Cones	Unoxidized near vent mtrl.
GW 4-20-96 4	Deadman Pass Plio Volc	Unoxidized Block lava flow
GW 4-20-96 5	GWCentral Eroded Dike-vent	Oxidized to unox. near vent
GW 4-20-96 6	GWC Tuff (pseudo-lava tubes)	Oxidized ignimbrite deposit
GW 4-20-96 7	GW Plateau (vent Breccia)	Oxidized near vent facies
GW 4-20-96 8	GW Plateau (vent breccia)	Oxidized near vent facies
MC 4-21-96 9	Northern Cone	Oxid & unoxid near vent mtrl
MC 4-21-96 10	Red Cone	Oxidized Stromb vent mtrl.
MC 4-21-96 11	Lathrop Wells Cone	Unoxidized scoria
MC 4-21-96 11b	Lathrop Wells Cone	Oxidized scoria
MC 4-23-96 12	Little Black Peak	Oxidized Scoria from fumarole zone
MC 4-23-96 13	SW slope of LBP	Oxidized scoria
MC 4-23-96 14	S slope of LBP	Oxidized scoria
MC 4-23-96 15	W slope of LBP	Unoxidized scoria of west slope
MC 4-25-96 16	E adj. Sleeping Butte	Oxidized ignimbrite
MC 4-25-96 17	SE slope of Hidden Cone	Unox to Oxidized scoria and rock
MC 4-25-96 18	E slope of Hidden Cone	Mix of Oxidiz and Unoxid scoria

End of Samples from Trip
Sample Descriptions are from fieldnotes.
24 May 1996

Sample descriptn from trip to Greenwater
Map is included in field notes.
All samples are vent-proximal scoria
deposits collected for spectographic analysis

5/4/97

27 May 1996
CNWRA - SWRI
Mike Conway
Operator: David Herrera (Div. 1)

Visible to mid-IR Spectroscopy Pilot Study of Scoria

Purpose: To characterize and compare reflected spectra of oxidized and unoxidized scoria.

Five to seven specimans from four sample sites are to be used.
Output will consist of % Reflectance vs Wavelength (or wavenumber).

Sample List

MC 4-21-96 11 Lathrop Wells Cone unoxidized scoria
MC 4-21-96 11b
MC 4-23-96 12
MC 4-23-96 15

Please note the general size of individual specimans prior to test using the following size criteria.

fine	< 5 mm dia.
medium	5 mm to 15 mm
coarse	> 15 mm

Samples delivered to David Herrera for analysis.

Samples consist of example of oxidized and unoxidized basaltic scoria.

5-4-97

Spectral Analysis of Greenwater scoria

Rationale & discussion w David Herrera.

Spectral Analysis of Basaltic Scoria and Dense Rocks from Greenwater Range

Conversation with David Herrera (Div 1: Chemistry)

Discussion focused on capability of Chem to:
1) Complete spectral characterization of scoria samples from Greenwater R. and Crater Flat -- Thirsty Mountain area.
2) Examine samples using a Fluoresence Transfir Infra-Red machine to identify causative IR signature of vent and off-vent samples.

- Sensing Capability of Reflectometer (Perkins-Eldin): 0.19 to 2.4 microns -- UV to mid-IR -- sensor can be adjusted to variable range (ie., .7 to 2.4 microns)

- Data is loaded unto UNIX machine and is plotted as:
  Reflectance% vs. Spectral Reflectance (I.e., wavelength)

- App. 5 minutes required per scan (3 min. scan & 2 - 4 min setup and data download).

- We estimated that 7 samples per site were required to accurately characterize spectral signature of each site

- We agreed to pilot study of 4 sites, 7 samples per site, and at least in several cases several scans per sample using different incident angles. This is to determine the role of incident angle on results. Given the uniformly rough and irregular nature of the scoria samples, I hypothesize that incident angle will not be a factor in data quality.

- We discussed the use of the FTIR machine to provide insight into chemical control on spectral signature. The Chem people thought it might provide a handle on O-bonding, but they were not specific and noted that Bill McMahon (retired SWRI) was the person to contact about specifics.

Conversation with Bill McMahon (Retired SWRI- Consultant)

Received a call from Bill McMahon (**344-1987**) at 11:00 a.m.

- Bill said that very careful sample prep and analysis using a K-bromide (KBr) standard can yield semi-quantitative results on the FTIR.

A technique referred to as diffuse reflectance is used.

- He further pointed out that IR and near-IR spectra exist for known minerals and compounds and suggested that we refer to "Sadtler Standard Spectra" and said that Gene Jones might know of a copy.

JMC.

5-10-97

5-12-97

2-D volumetrics Report for Northern Greenwater Range

07-Oct-96 Last update 22 November 96

Funeral Fm thickness are estimated from 1) U.S. Borax and 2) from McAllister (1970, 1973)
Thickness estimates are conservative.
Volume estimates were made with subjacent layers collar7.2grd and depth1_vers8.2grd in EarthVision

Layer volumetrics program in EV was used for calculating volumes.

Eight clipping polygons were used to constrain volume calculations to those areas underlain by basalts of the Funeral Formation.

No #	Polygon Name	Poly Area (m2)	Poly. Pos. Area	Volume (m3)	Ave Thickness (m)
1	gwr_central_poly.ply	47026947	47026947	3550318905	75.5
2	gwr_east_poly.ply	10563766	10563766	518006980	49.0
3	gwr_east2_poly.ply	453338	453338	11355695	25.0
4	gwr_north1_poly.ply	377073	377073	9842071	26.1
5	gwr_north2_poly.ply	72509	72509	1812414	25.0
6	gwr_west_poly.ply	3105750	3105750	88068005	28.4
7	gwr_south_poly1.ply	2238559	2238559	75308811	33.6
8	gwr_south_poly2.ply	601621	601621	16953325	28.2
	Funeral FM	**64439563 m2**		**4271666206 m3**	**total Volume**
		64.439563 km2		**4.27166621 km3**	**total volume**
	Avg. Thickness = volume/positive area			**3.84E+09 m3**	**total Basalt Volume**

Total volume values represent conservative minimum values.
The total volume of Funeral Fm basalts is 90 % of the total calc. volume, the remaining 10% consists of conglomerate. These proportions were determined from U.S. Borax well logs and from discussion with Steve Carpenter (Geologist) who has worked in the area for nearly 20 years.

Area values for selected polygons were checked with a second software package, ERDAS, and the results were positive and similar areas were determined.

A check on the quality of the volume calc can be semi-quantitatively made by examining the average thickness (volume/positive area) and comparing with thickness from the U.S. Borax data and from McAllister geologic maps. The calculated volumes are reasonable and of good quality.

The number of points used in making the collar7.2grd and depth1_vers8.2grd is approximately 2500 points.

Flux Rate for the Greenwater Range given an eruptive lifespan of 0.8 Ma

Minimal Basalt volume is) **3.84E+09** m3
Maximum Basalt volume is **5.50E+09** m3

Minumum Flux Rate is volume (m3) / time (years) **4805.62448** m3/year
Maximum Flux Rate is volume (m3) / time (years) **6875** m3/year

Maximum flux rate is result of estimating a larger area previously covered by Funeral Formation basalts. The larger area is designed to adjust eruptive material lost to erosion or buried by alluvium.

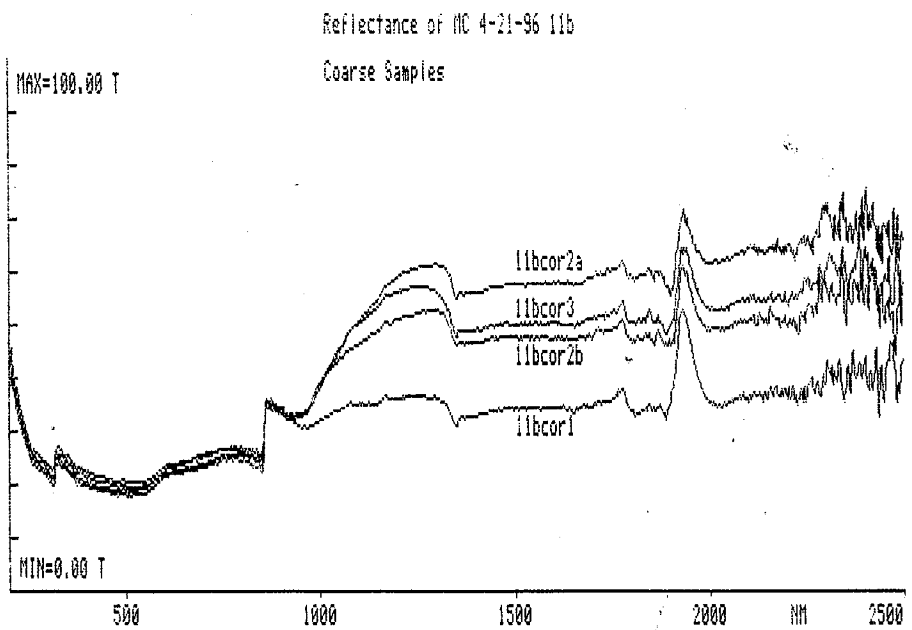
5-12-97

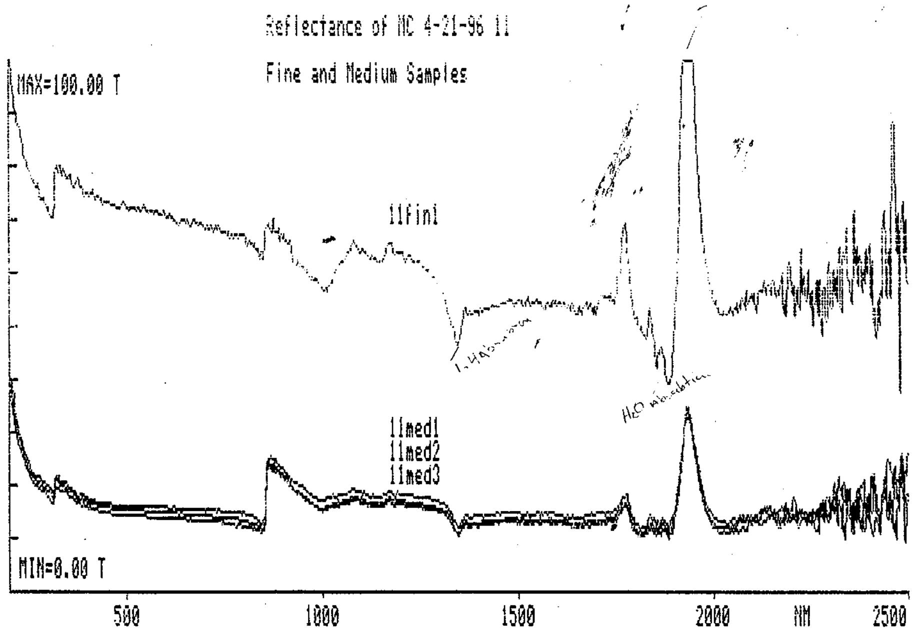
Final numbers of volume estimates of Greenwater along w total volume & estimated flux rate.

5/13/97

Results of Spectrographic Analysis of David Helsera. See page 48-49 for sample code & ID's.

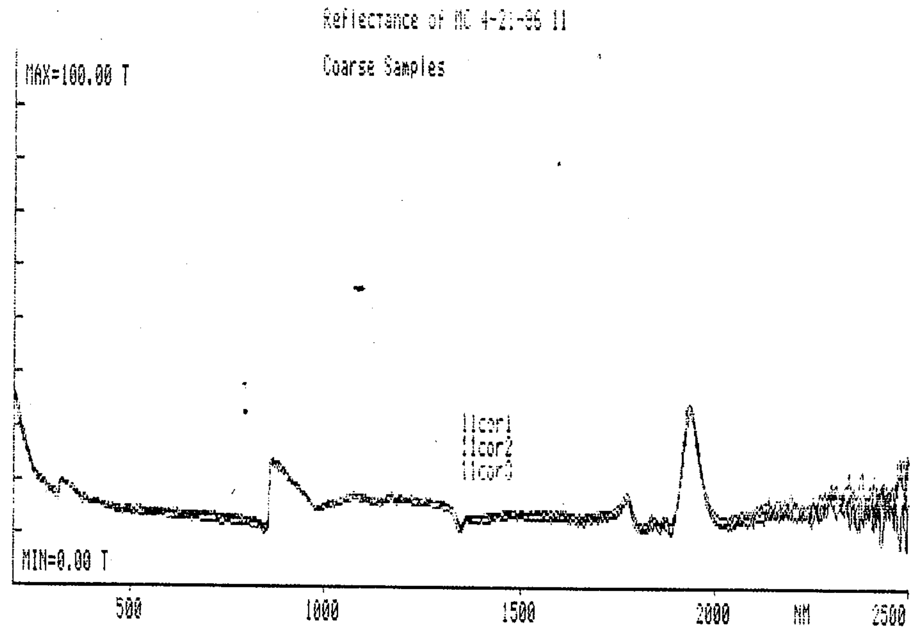
SMC

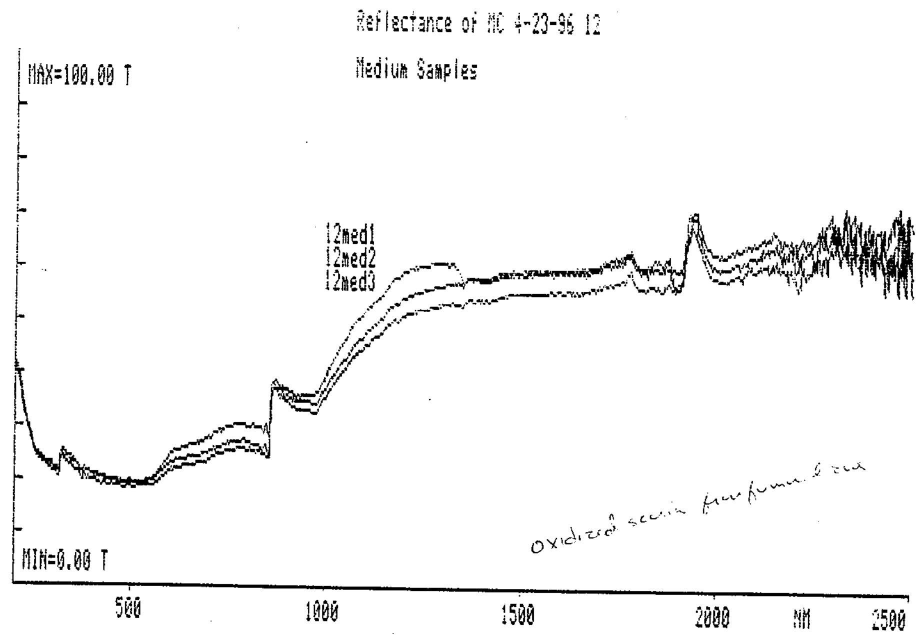




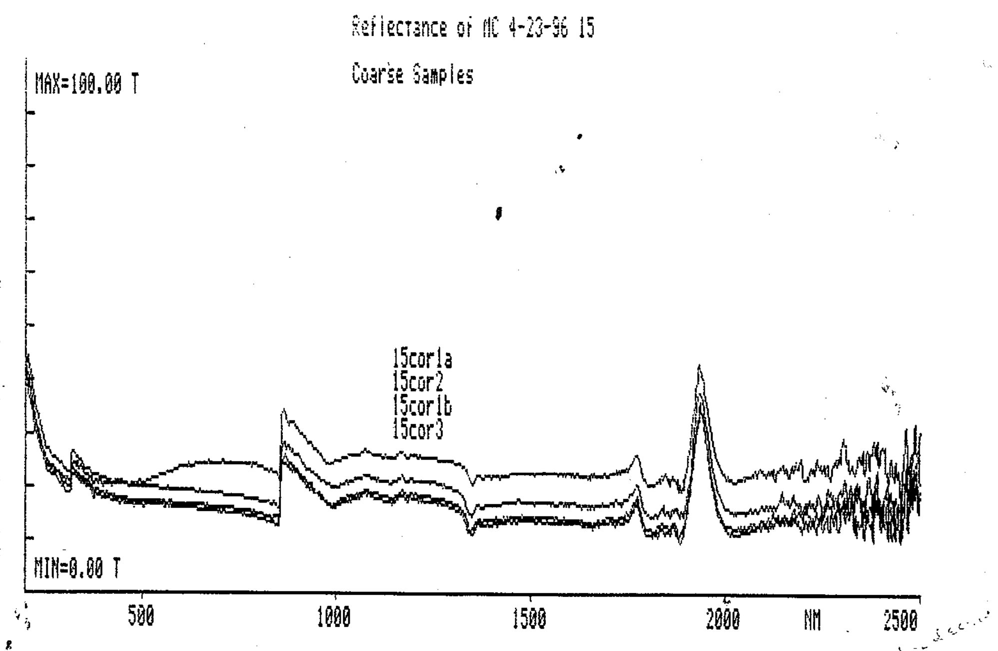
5/13/97

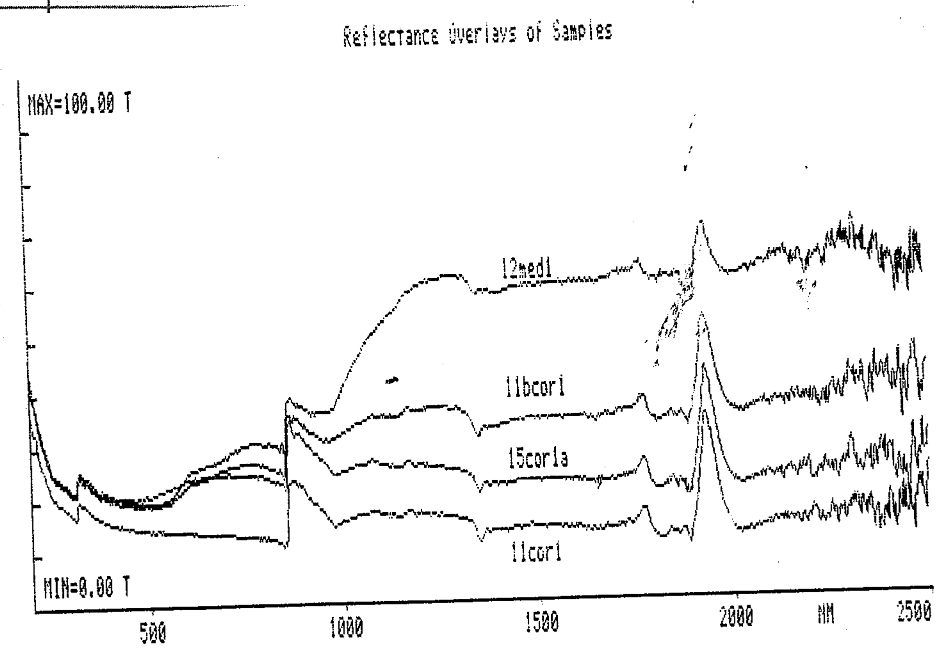
FMC





5/13/97 DHC





Spectrographic Parameters for David Herrera thru pg 59 -

SP: 2302 2500 - 199 1.00 19.36 73.74 T AC1 12med2

Refl. of MC 4-23-96 #12; 2nd medium sample; 1/4" aperture

SP: 2302 2500 - 199 1.00 18.35 72.35 T AC1 12med3

Refl. of MC 4-23-96 #12; 3rd medium sample; 1/4" aperture

SP: 2302 2500 - 199 1.00 17.37 43.10 T AC1 15cor1a

Refl. of MC 4-23-96 #15; 1st coarse sample(light brown side); 1/4" apert

SP: 2302 2500 - 199 1.00 9.76 44.12 T AC1 15cor1b

Refl. of MC 4-23-96 #15; 1st coarse sample(dark side); 1/4" aperture

SP: 2302 2500 - 199 1.00 13.83 45.09 T AC1 15cor2

Refl. of MC 4-23-96 #15; 2nd coarse sample; 1/4" aperture

SP: 2302 2500 - 199 1.00 8.75 40.54 T AC1 15cor3

Refl. of MC 4-23-96 #15; 3rd coarse sample; 1/4" aperture

5/13/97

JWC 5/13/97

SP. 2302 2500 - 199 1.00 18.59 52.90 T AC1 11bcor1
Refl. of MC4-21-96 11b; 1st coarse sample; 1/4" aperture

SP: 2302 2500 - 199 1.00 19.41 75.71 T AC1 11bcor2a
Refl. of 4-21-96 11b; 2nd coarse sample with whitish spots;1/4" aperture

SP: 2302 2500 - 199 1.00 17.91 62.78 T AC1 11bcor2b
Refl of 4-21-96 11b; 2nd coarse,side opposite white spots,1/4" aperture

SP: 2302 2500 - 199 1.00 20.29 67.63 T AC1 11bcor3
Refl. of 4-21-96 11b; 3rd coarse sample; 1/4" aperture

SP: 2302 2500 - 199 1.00 8.64 36.62 T AC1 11cor1
Mike Conaway's samples: MC 4-21-96 11 refl. of coarse size;1/4" aperture

SP: 2302 2500 - 199 1.00 11.50 37.61 T AC1 11cor2
Refl. of MC 4-21-96 11; 2nd coarse sample; 1/4" aperture

FWC 5/13/97

SP: 2302 2500 - 199 1.00 5.83 37.31 T AC1 11cor3
Refl. of MC 4-21-96 11; 3rd coarse sample; 1/4" aperture

SP: 2302 2500 - 199 1.00 35.82 117.24 T AC1 11fin1
Refl. of MC 4-21-96 11; 1st fine sample; .12" aperture

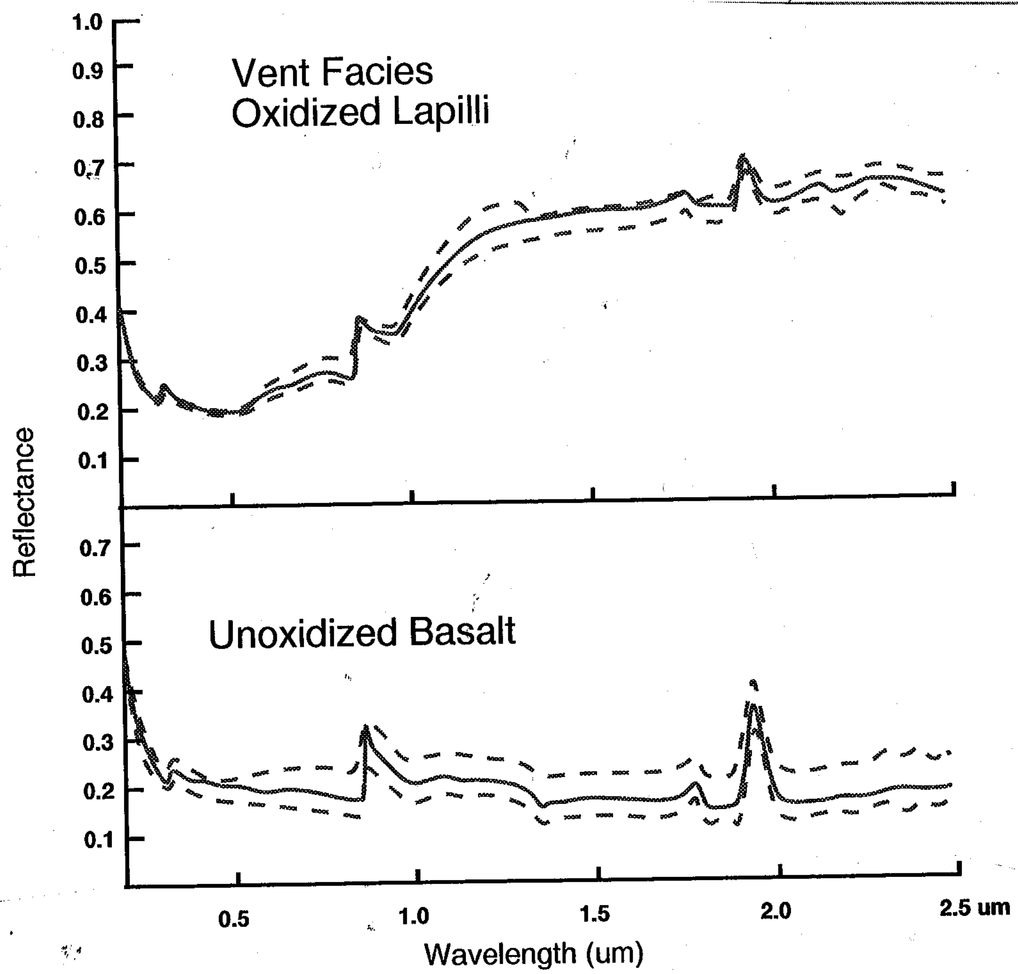
SP: 2302 2500 - 199 1.00 7.99 39.75 T AC1 11med1
Refl. of MC 4-21-96 11; 1st medium sample; 1/4" aperture

SP: 2302 2500 - 199 1.00 9.08 37.14 T AC1 11med2
Refl. of MC 4-21-96 11; 2nd medium sample; 1/4" aperture

SP: 2302 2500 - 199 1.00 11.81 41.22 T AC1 11med3
Refl. of MC 4-21-96 11; 3rd medium sample; 1/4" aperture

SP: 2302 2500 - 199 1.00 19.31 72.01 T AC1 12med1
Refl. of MC 4-23-96 #12; 1st medium sample; 1/4" aperture

5/13/97



Synthesis of Spectrographic analysis showing the significant difference between oxidized & unoxidized basalt. This difference can be used to differentiate vent proximal facies (oxidized) from distal scoria facies (unoxidized) & surrounding basalt flows.

Tme.

Final well log Analysis of Greenwater Range for US Borax Wells — 182 total

6 June 1997

Well Log Data from Steve Carpenter, US Borax Corp., Valencia Corp.
29-30 May 1996; Drill Hole locations from Map received 6 June 1996 7
M. Conway 11 July 1996 7

Well Log locations were digitized off US Borax 1:12,000 version of 7.5 minute 1:24,000 topographic Map on 10 July 1996
Well Log locations were projected into UTM projection
Digitizing tablet set by Rick Klar, and Rick provided support during digitizing work.

1 of two

Thickness reported as 304.6 m indicates that the hole ended or information was generally unavailable
immediately below the contact between the Funeral FM. and the underlying unit.

Well ID #	Well ID# Arc/Info	UTM Easting	UTM Northing	Collar Elevation (m)	Funeral Formation	Funeral Base (m)	Greenwater Formation	GWR Base (m)	Furnace Cr Formation	FCK Base (m)
1	1	530228	4018704	1253.5	FUFM	1163.6	GWFM	1163.6	FCFM	859.0
2	2	530318	4018611	1246.3	FUFM	1068.9	GWFM	1068.9	FCFM	636.6
3	3	530484	4019147	1229.2	FUFM	1073.7	GWFM	1073.7	FCFM	845.0
4	4	530104	4017529	1227.3	FUFM	1146.5	GWFM	1146.5	FCFM	1065.7
5	5	529903	4017746	1212.7	FUFM	1160.9	GWFM	1160.9	FCFM	1014.5
6	6	530598	4018087	1241.0	FUFM	1103.8	GWFM	1103.8	FCFM	826.4
7	7	531005	4017433	1253.8	FUFM	1211.7	GWFM	1211.7	FCFM	1134.9
8	8	531420	4016923	1271.0	FUFM	1157.0	GWFM	1157.0	FCFM	1079.0
9	9	530355	4019320	1231.5	FUFM	1096.7	GWFM	1096.7	FCFM	932.7
10	10	530788	4018822	1233.2	FUFM	1099.0	GWFM	1099.0	FCFM	946.6
11	11	531317	4017861	1262.1	FUFM	1115.7	GWFM	1115.7	FCFM	884.0
12	12	532622	4017583	1226.8	FUFM	1082.0	GWFM	987.5	FCFM	987.5
13	13	532814	4018195	1244.8	FUFM	1154.9	GWFM	1046.7	FCFM	1046.7
14	14	533479	4017394	1165.1	FUFM	1005.4	GWFM	929.1	FCFM	929.1
15	15	532836	4016929	1202.6	FUFM	964.8	GWFM	964.8	FCFM	897.7
16	16	531600	4016661	1278.9	FUFM	1081.4	GWFM	1081.4	FCFM	807.0
17	17	531601	4017409	1273.9	FUFM	1155.0	GWFM	1155.0	FCFM	953.8
18	18	531155	4018333	1239.9	FUFM	1130.2	GWFM	1130.2	FCFM	1026.5
19	19	531445	4019110	1313.6	FUFM	1091.0	GWFM	1011.8	FCFM	1011.8
20	20	532060	4020901	1046.1	FUFM	944.0	GWFM	944.0	FCFM	741.3
21	21	533143	4016700	1072.8	FUFM	938.7	GWFM	938.7	FCFM	859.4
22	22	532906	4016380	1065.0	FUFM	872.9	GWFM	872.9	FCFM	568.3
23	23	532293	4016686	1083.3	FUFM	967.5	GWFM	967.5	FCFM	845.5
24	24	532177	4016276	1059.7	FUFM	901.2	GWFM	901.2	FCFM	797.5
25	25	533155	4016167	1045.9	FUFM	814.1	GWFM	814.1	FCFM	741.0
26	26	531396	4017131	1276.8	FUFM	1179.2	GWFM	1179.2	FCFM	1069.5
27	27	531279	4017688	1274.5	FUFM	1167.8	GWFM	1167.8	FCFM	1100.8
28	28	531606	4017844	1275.3	FUFM	1129.0	GWFM	1129.0	FCFM	1040.5
29	29	531127	4017902	1252.3	FUFM	1099.8	GWFM	1099.8	FCFM	1029.7
30	30	531262	4017995	1270.5	FUFM	1093.7	GWFM	1093.7	FCFM	993.0
31	31	531733	4018553	1262.0	FUFM	1142.5	GWFM	1142.5	FCFM	1073.0
32	32	531189	4018564	1235.4	FUFM	1139.4	GWFM	1139.4	FCFM	1043.4
33	33	531024	4021552	1044.8	FUFM	988.7	GWFM	988.7	FCFM	853.0
34	34	531052	4017758	1252.9	FUFM	1142.0	GWFM	1142.0	FCFM	1059.7
35	35	531620	4016894	1286.4	FUFM	1115.7	GWFM	1115.7	FCFM	1057.7
36	36	531724	4016923	1281.8	FUFM	1088.5	GWFM	1088.5	FCFM	1045.8
37	37	530623	4018947	1231.2	FUFM	1112.3	GWFM	1112.3	FCFM	1065.0
38	38	531604	4016765	1283.5	FUFM	1088.3	GWFM	1088.3	FCFM	1012.1
39	39	530977	4016918	1234.0	FUFM	1188.3	GWFM	1188.3	FCFM	1020.6
40	40	531760	4016759	1287.2	FUFM	1095.2	GWFM	1052.5	FCFM	747.9
41	41	531121	4016929	1239.1	FUFM	1205.6	GWFM	1205.6	FCFM	901.0
42	42	531553	4017052	1279.7	FUFM	1162.3	GWFM	1162.3	FCFM	857.8
43	43	531014	4017924	1251.5	FUFM	1105.1	GWFM	1105.1	FCFM	800.5
44	44	531128	4017036	1254.4	FUFM	1214.8	GWFM	1214.8	FCFM	910.2
45	45	530738	4017824	1234.5	FUFM	1173.5	GWFM	1173.5	FCFM	869.0
46	46	531870	4018538	1267.9	FUFM	1107.8	GWFM	1107.8	FCFM	803.2
47	47	530432	4018769	1242.6	FUFM	1007.9	GWFM	1007.9	FCFM	980.4
48	48	531311	4016937	1258.1	FUFM	1181.8	GWFM	1181.8	FCFM	877.3
49	49	531300	4017049	1271.9	FUFM	1197.2	GWFM	1197.2	FCFM	892.6
50	50	531871	4019387	1239.1	FUFM	1089.7	GWFM	1089.7	FCFM	1071.4
51	51	528978	4018373	935.4	FUFM	935.4	GWFM	935.4	FCFM	630.8
52	52	528839	4018490	916.9	FUFM	916.9	GWFM	916.9	FCFM	810.2
53	53	528691	4018674	893.8	FUFM	893.8	GWFM	893.8	FCFM	589.2
54	54	528876	4018676	904.1	FUFM	904.1	GWFM	904.1	FCFM	736.4
55	55	529129	4018238	960.0	FUFM	960.0	GWFM	960.0	FCFM	932.5
56	56	528849	4018281	898.3	FUFM	898.3	GWFM	898.3	FCFM	855.6
57	57	531630	4019281	1290.4	FUFM	1125.8	GWFM	1125.8	FCFM	821.2
58	58	531930	4019532	1225.0	FUFM	1117.7	GWFM	1117.7	FCFM	813.1
59	59	532126	4019548	1202.7	FUFM	1099.0	GWFM	1099.0	FCFM	794.4
60	60	531805	4019365	1250.7	FUFM	1090.7	GWFM	1090.7	FCFM	1060.2
61	61	530777	4016672	1190.4	FUFM	1127.3	GWFM	1127.3	FCFM	822.7
62	62	531737	4018441	1244.0	FUFM	1148.0	GWFM	1148.0	FCFM	1102.3
63	63	531628	4018542	1248.3	FUFM	1169.0	GWFM	1169.0	FCFM	864.4
64	64	530479	4018940	1235.4	FUFM	1107.4	GWFM	1107.4	FCFM	802.8
65	65	530815	4016846	1004.4	FUFM	964.8	GWFM	964.8	FCFM	660.2
66	66	530329	4018921	1253.5	FUFM	1113.3	GWFM	808.7	FCFM	808.7
67	67	531885	4019477	1237.3	FUFM	1124.5	GWFM	1124.5	FCFM	819.9
68	68	530831	4016922	1194.1	FUFM	1161.7	GWFM	1161.7	FCFM	1091.6
69	69	530830	4016996	1202.3	FUFM	1158.1	GWFM	1158.1	FCFM	853.5
70	70	530909	4017054	1208.6	FUFM	1201.6	GWFM	1201.6	FCFM	1155.9

71	71	530720	4016943	1196.8	FUFM	1135.8	GWFM	1135.8	FCFM	1087.0
72	72	532072	4019269	1152.4	FUFM	1065.5	GWFM	1065.5	FCFM	1035.0
73	73	532204	4019235	1154.5	FUFM	1061.5	GWFM	1061.5	FCFM	1040.1
74	74	532141	4019375	1140.4	FUFM	1085.5	GWFM	1048.9	FCFM	1048.9
75	75	532234	4019477	1155.0	FUFM	1095.5	GWFM	1095.5	FCFM	791.0
76	76	532089	4020038	1126.4	FUFM	1028.8	GWFM	1028.8	FCFM	724.3
77	77	532042	4019132	1157.4	FUFM	1065.9	GWFM	1065.9	FCFM	1035.4
78	78	531942	4019141	1168.7	FUFM	1065.0	GWFM	1065.0	FCFM	760.4
79	79	531998	4019205	1165.1	FUFM	1064.5	GWFM	1064.5	FCFM	759.9
80	80	531864	4018876	1264.2	FUFM	1081.3	GWFM	1081.3	FCFM	776.7
81	81	532123	4018564	1268.4	FUFM	1087.3	GWFM	1087.3	FCFM	782.8
82	82	532224	4018620	1257.5	FUFM	1087.9	GWFM	1087.9	FCFM	783.4
83	83	532192	4019046	1149.5	FUFM	1051.9	GWFM	1051.9	FCFM	1015.3
84	84	532040	4019029	1173.6	FUFM	1060.8	GWFM	1060.8	FCFM	1045.6
85	85	532343	4018883	1227.4	FUFM	1084.1	GWFM	937.7	FCFM	633.1
86	86	532359	4018951	1218.2	FUFM	1068.8	GWFM	764.3	FCFM	764.3
87	87	532423	4018841	1224.0	FUFM	1071.5	GWFM	992.3	FCFM	992.3
88	88	532488	4018701	1206.6	FUFM	1086.2	GWFM	781.6	FCFM	781.6
89	89	532507	4018787	1205.3	FUFM	1086.4	GWFM	1074.2	FCFM	1074.2
90	90	532323	4018705	1226.0	FUFM	1082.7	GWFM	1067.5	FCFM	1067.5
91	91	532185	4018957	1155.2	FUFM	1066.8	GWFM	1036.3	FCFM	731.7
92	92	532201	4019142	1140.1	FUFM	1057.8	GWFM	1057.8	FCFM	1018.2
93	93	532115	4019095	1149.5	FUFM	1055.0	GWFM	1055.0	FCFM	1036.7
94	94	532120	4019190	1140.9	FUFM	1034.2	GWFM	1034.2	FCFM	1026.6
95	95	531864	4019092	1200.2	FUFM	1067.6	GWFM	1067.6	FCFM	763.1
96	96	532303	4019192	1139.6	FUFM	1066.5	GWFM	1066.5	FCFM	1051.2
97	97	532354	4017758	1237.4	FUFM	1091.0	GWFM	1091.0	FCFM	1066.6
98	98	532100	4017860	1254.6	FUFM	1099.1	GWFM	1047.3	FCFM	1047.3
99	99	531807	4017637	1263.2	FUFM	1110.8	GWFM	1089.4	FCFM	784.9
100	100	532079	4017436	1236.1	FUFM	1074.6	GWFM	1019.7	FCFM	715.1
101	101	532277	4019077	1154.0	FUFM	1065.6	GWFM	1032.0	FCFM	1001.6
102	102	532365	4018023	1278.5	FUFM	1138.2	GWFM	1113.8	FCFM	809.3
103	103	532100	4018151	1274.0	FUFM	1097.1	GWFM	1088.0	FCFM	783.4
104	104	532269	4018992	1167.7	FUFM	1067.1	GWFM	1009.1	FCFM	704.6
105	105	532359	4018332	1264.6	FUFM	1113.7	GWFM	1113.7	FCFM	809.1
106	106	531805	4018750	1289.3	FUFM	1097.3	GWFM	1097.3	FCFM	792.7
107	107	531617	4018224	1296.0	FUFM	1125.3	GWFM	1125.3	FCFM	820.7
108	108	531879	4017362	1255.8	FUFM	1109.5	GWFM	1072.9	FCFM	768.3
109	109	532405	4017348	1179.9	FUFM	1038.1	GWFM	990.9	FCFM	686.3
110	110	532240	4017388	1209.5	FUFM	1044.8	GWFM	965.5	FCFM	661.0
111	111	532096	4017317	1257.3	FUFM	1095.7	GWFM	976.8	FCFM	672.3
112	112	532020	4017516	1254.3	FUFM	1092.7	GWFM	998.2	FCFM	693.6
113	113	531839	4017892	1275.3	FUFM	1101.5	GWFM	1064.9	FCFM	760.4
114	120	532975	4017199	1154.3	FUFM	1109.1	GWFM	1109.1	FCFM	804.6
115	114	531439	4018661	1202.4	FUFM	1007.3	GWFM	702.7	FCFM	702.7
116	115	531877	4018301	1260.1	FUFM	1199.1	GWFM	1199.1	FCFM	894.5
117	116	534775	4018233	1269.5	FUFM	1089.6	GWFM	1089.6	FCFM	785.1
118	117	532291	4019173	997.0	FUFM	997.0	GWFM	997.0	FCFM	692.4
119	118	532407	4018916	1150.9	FUFM	1071.6	GWFM	1065.5	FCFM	916.2
120	119	533660	4018174	1216.8	FUFM	1085.7	GWFM	1006.4	FCFM	979.0
121	121	532591	4019133	1229.6	FUFM	1122.9	GWFM	1122.9	FCFM	818.3
122	122	532560	4018447	1269.8	FUFM	1108.2	GWFM	971.0	FCFM	666.5
123	123	533696	4016952	1159.1	FUFM	982.3	GWFM	924.4	FCFM	619.8
124	124	532810	4017370	1215.5	FUFM	1043.3	GWFM	1032.6	FCFM	728.0
125	125	532635	4017888	1243.0	FUFM	1108.8	GWFM	1099.7	FCFM	795.1
126	126	531813	4017192	1250.6	FUFM	1119.5	GWFM	1093.6	FCFM	789.0
127	127	531446	4018884	1308.2	FUFM	1171.0	GWFM	1171.0	FCFM	866.5
128	128	530913	4018146	1245.4	FUFM	1053.4	GWFM	1053.4	FCFM	748.8
129	129	531923	4019120	1172.9	FUFM	1072.3	GWFM	1072.3	FCFM	767.7
130	130	531592	4018875	1302.4	FUFM	1128.7	GWFM	1128.7	FCFM	824.1
131	131	532607	4017498	1220.4	FUFM	1071.0	GWFM	1013.1	FCFM	708.5
132	132	533224	4017299	1186.0	FUFM	1018.3	GWFM	981.7	FCFM	677.1
133	133	533469	4017206	1155.8	FUFM	1003.4	GWFM	698.8	FCFM	698.8
134	134	533850	4017026	1166.2	FUFM	992.4	GWFM	952.7	FCFM	648.2
135	135	534222	4017361	1141.8	FUFM	1047.3	GWFM	1047.3	FCFM	742.7
136	136	531333	4018767	1281.7	FUFM	1139.9	GWFM	835.4	FCFM	835.4
137	137	533142	4017596	1203.0	FUFM	1058.2	GWFM	1053.7	FCFM	749.1
138	138	533482	4017381	1165.2	FUFM	1009.8	GWFM	967.1	FCFM	662.5
139	139	533729	4017226	1157.6	FUFM	996.0	GWFM	965.5	FCFM	661.0
140	140	533228	4017411	1187.5	FUFM	1019.8	GWFM	1004.6	FCFM	700.0
141	141	533278	4017585	1188.4	FUFM	1045.1	GWFM	1020.7	FCFM	716.2
142	142	533003	4017393	1203.4	FUFM	1032.6	GWFM	728.0	FCFM	728.0
143	143	532405	4017520	1229.6	FUFM	1064.9	GWFM	1016.2	FCFM	711.6
144	144	531611	4018739	1284.8	FUFM	1150.6	GWFM	1144.5	FCFM	839.9
145	145	531481	4018476	1232.3	FUFM	1195.7	GWFM	1195.7	FCFM	891.2
146	146	530803	4019011	1243.9	FUFM	1134.1	GWFM	1134.1	FCFM	829.6
147	147	532341	4019007	1203.4	FUFM	1070.7	GWFM	986.9	FCFM	682.3
148	148	531809	4016713	1282.9	FUFM	1036.0	GWFM	1026.8	FCFM	1026.8
149	149	533271	4017200	1181.1	FUFM	986.0	GWFM	949.4	FCFM	644.8
150	150	533519	4016855	1162.5	FUFM	967.4	GWFM	906.4	FCFM	601.8
151	151	533526	4016562	1171.3	FUFM	933.5	GWFM	629.0	FCFM	629.0
152	152	533863	4016647	1159.8	FUFM	958.5	GWFM	888.4	FCFM	583.8
		534491	4019826							
		530727	4016811							

6 June 97
FWC.

Vent Locations of Vents in Greenwater Range from
1) geologic maps, 2) interpretation of Landsat TM +
3) interpretation of U.S. Borax well log data.

grn_vents_ungen2

Greenwater Range Vent Locations

Interpretations are based on geologic mapping of area (McAllister 1970, 1973)
and satellite interpretation of SLAR, SPOT, and Landsat TM imagery.
This ungenerate arc/info file of vent locations was produced on
18 February 1997 by Michael Conway

2	536160.5	4021203.5
0	536241.75	4021334.75
5	532135.5	4021528.5
6	533098	4020022.25
7	531966.75	4018459.75
8	531723	4018566
9	531735.5	4018128.5
0	531741	4017871
11	531909	4017199
13	535269	4017403
15	534381	4013563
16	534141	4013767
17	534777	4013479
19	538389	4013599
20	538185	4017307
21	538461	4017043
22	537729	4018603
23	537033	4019551
24	537897	4019407
24	540489	4015279
25	541449	4014655
27	538401	4011463
28	542241	4010203
30	535689	4013671
0	536073	4013991
33	546260.5	4007053.5
34	539785.5	4004441
14	534836.5	4014090.5
33	538874.875	4017329.5
32	545759.25	4009405
35	546131	4007497.5
36	541118.375	4008214.5
12	536336.5	4019070.5
4	531964.813	4021695

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Geological/Geochemical/ Tectonic history of the Greenwater Range and parallels with volcanism of neighboring Yucca Mountain

To do: 1) Put together Geochemistry section incld isotopes of the Funeral Formation.

2) *List out Figures and Tables*

3) Look for aerial-mag anomalies north of Greenwater Range

- Examine other basaltic fields for volcanic activity at 4.9 to 4.0 Ma
- Look for structural hook
- If YM and GWR part of same isotopic system than structural domain is secondary
- Note that Pliocene basalts of both YM and GWR are lithologically enriched magmas
- Role of tectonic activity in magma production and effusion onto Earth's surface

3) Solidify introduction.

4) Note difference in structural domain.

5) Note absence of other work that constrains volume and established flux rate in area.

6) DV-Pancake zone of Farmer et al (89) -- distb. of Pliocene age rocks linke to melting anomalies in lithospheric mantle.

7) Possible hook -- detachment zone exhumed and extension largely falling off in the area, result at 5 to 4.0 Ma the volcanism shuts down after first going through change from silicic dominated to basaltic dominated -- see Farrill for more on/

Introduction

Pliocene age basalts erupted in the Northern Greenwater Range, Inyo County, CA, are part of the Amargosa Valley Isotropic Province (Yogodzinski and Smith, 1995) that includes the Pliocene-Quaternary volcanic rocks of the Yucca Mountain area, which lies adjacent to the proposed site of the U.S. High-Level Nuclear Waste Repository. The Greenwater Range is situated in the Death Valley Volcanic Field about ≈ 60 km south of Yucca Mountain, NV. On the basis of similar 87Sr/86Sr values (≈ 0.707) and episilon Nd (≈ -8.5 to -11.9), Yogodzinski and Smith (1995) suggested that Pliocene and younger basalts of the northern Greenwater Range and the Yucca Mountain area are derivatives of the same magmatic system. The two areas occury dramatically different structural domains. If Yogodinski and Smith are correct, however, it can be inferred that magmatic systems are relatively blind to crustal structures.

Here we use satellite and high-resolution SLAR imagery in conjunction with well-log data to identify previously unmapped Pliocene volcanic vents, including some buried vents, in the northern Greenwater Range. Coupling well log data and geologic mapping (McAllister 1970, 1973) with a 30-m digital elevation model (DEM), we estimate, with a reasonably high degree of accuracy, volumes of Funeral Formation basalts erupted in the northern Greenwater Range. Sparse K-Ar age determinations of these basalts suggest that the rate of vent emplacement here is similar to that of basaltic volcanism of the Yucca Mountain area. This indicates steady-state behavior throughout this isotopic province from the Pliocene to the present. These results are contradictory to other interpretations (Crowe et al) that suggest basaltic volcanism in the area is waning.

Geologic Setting

The Greenwater Range represents a complex succession of Neogene magmatic and tectonic events attributable to crustal extension and regional strike-slip faulting (Wright et al., 1991). Along with the Black Mountains, the Greenwater Range is situated in highly-extended terrane between the en echelon, right-stepping terminations of two right-lateral fault zones (Fig. 1): Furnace Creek to the north and Sheephead to the south. To the east and west, the block is bounded by west-dipping, high-angle, range-front faults of the Resting Spring Range and the Black Mountain, respectively. High rates of subsidence as evinced by more than 3600-m thick sedimentary deposits of the Neogene Funeral, Furnace Creek, and Artist Drive Formations reveal a significant vertical component to the right-lateral Furnace Creek Fault located just west of the Greenwater Range (Wright et al., 1991). The Greenwater Range extends about 35 km N-S and 5 to 10 km E-W. South of Greenwater Canyon, the Greenwater Range is cut by northeast-trending normal faults. North of Greenwater Canyon, faulting largely consists of poorly exposed (?) and discontinuous north- and northwest-trending faults.

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Volcanism of the Greenwater Range

Volcanic rocks erupted in the Greenwater Range are part of the larger Death Valley Volcanic Field that extends over an areas of 1300 km2 (Figure 1). Onset of volcanism here was coeval with late Cenozoic extension and began before 13.4 Ma and continued through the late-Pleistocene (Wright et al., 1991). On the basis of age, aerial distribution, petrologic character, and geochemistry, Wright et al. (1991) subdivided volcanic rocks of the Greenwater Range into five lithologic sequences: Pre-Shoshone, Shoshone, Greenwater, Funeral, and Pleistocene valley basalts. Outcrop patterns of the five sequences suggests a gradual northwest-ward migration of vent complexes (Drewes, 1963; McAllister, 1970 and 1973; Haefner, 1976). Poorly preserved remnants of the pre-Shoshone volcanic sequence, exposed in the southern part of the Greenwater Range, are all that remain of the earliest volcanic sequence. Pre-Shoshone volcanics include rhyolitic ash-flow tuffs and subordinate intermediate through silicic lava flows erupted in the interval 10.4 to 9.4 Ma; source area for the ash-flow tuffs remain unknown. Locally, tuffs are intruded by granitic plutons that floor parts of the southeastern part of the Range and account for local propylitic-alteration of the rocks.

The Shoshone Volcanics comprise silicic lava flows and tuffs that unconformably overlie pre-Shoshone volcanics (Haefner, 1976). Exposures of the Shoshone volcanics are limited to a nearly continuous, 26-km-long north-trending belt extending through the south and central Greenwater Range. As defined by Haefner (1976), the Shoshone volcanic sequence includes the upper part of the "older volcanics" of Drewes (1963). Tuffs were largely erupted in the interval 8.7 to 7.5 Ma and accompanied unroofing of the Black Mountain/Greenwater Range block (Holm and Dolka). On the basis of geologic mapping and sparse radiometric data, there is some suggestion that lava flows and tuffs young to the northwest (Fleck, 1970). Of the five volcanic sequence, this one is the most chemically restricted with SiO2 of lava flows and tuffs ranging from 65 to 74 wt. % (Wright et al., 1991).

Mafic through silicic lava flows and ash-flow tuffs of the Greenwater Volcanics unconformably overlie the highly faulted and tilted (≈ 40o east) Shoshone Volcanics (Haefner, 1976). Greenwater volanics were largely emplaced in the 7 to 5 Ma interval (Fleck, 1970). In the north, the Greenwater volcanics unconformably overlie or, less frequently, are interbedded with the Furnace Creek Formation, which consists of tuffaceous sediments and evaporites and subordinate mafic through intermediate lava flows and silicic ash-flow tuffs (Drewes, 1963). To the south, the basal portion of the Greenwater Volcanics consists of basalts and andesite lava flows interbedded with thin, non-welded silicic ash-flow tuffs and tuffaceous sediments. Higher in the section, rhodacite and rhyolitic ash-flow tuffs and glassy dacite lava flows and flow breccias associated with dome complexes dominate the sequence (Drewes, 1963; McAllister, 1970; Wright et al., 1991). Chemically, volcanic

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rocks of the Greenwater Formation range from low-silica basalt through high-silica rhyolite and show a distinctive calc-alkaline affinity (Wright et al., 1991). The next volcanic sequence, the Pliocene Funeral Formation, unconformably overlies the Furnace Creek and Greenwater Formations and is generally confined to the Greenwater Range north of Greenwater Canyon.

Pliocene Volcanism of the northern Greenwater Range. The northern Greenwater Range hosts numerous Pliocene basalt volcanic centers. Most eruptive centers are cinder cones, but at least one deeply eroded shield volcano, comprising at least 20 cooling units, is exposed in the walls of an avalanche scarp at the northern end of the range. Radiometric dates for Neogene basalts are sparse, but a K-Ar date of 5.4 $\pm$ 0.2 for the uppermost vitrophyre member of the underlying Greenwater Formation provides a maximum age for basalts of the Funeral Formation (Fleck, 1970). Additionally, several K-Ar age determinations from Funeral Formation basalts exposed in the northern Greenwater Range and along the eastern slopes of Black Mountain indicate basalts were largely emplaced in the interval 4.8 to 4.0 Ma (Fleck, 1970; McAllister, 1973). The scarcity of interbedded conglomerates in northern Greenwater basalts is consistent with rapid effusion of basalts unbroken by sedimentation (Drewes. 1963). Funeral Formation basalts are geneally unfaulted and either tilted gently to the east (between 5 to 15^{o}) or are flatlying indicating that the rate of tectonic deformation in the eastern Death Valley area has decreased during the past 5 Ma.

Vents in the northern Greenwater Range are situated between 925 to 1325 m above MSL with the majority of vents cropping out in the Range interior several hundred meters above the neighboring valley floor. Although highly dissected, vents remain in conspicuous positive relief and are distinquished by the presence of vent breccias, bombs, scoria, and occasionally by palagontonized tuffs. According to Wright et al. (1991), vents of the northern Greenwater Range generally young to the northwest. Previous mapping (McAllister, 1970, 1973) noted the distribution of agglomerate associated with vent facies, but did not resolve individual vents. Using Landsat TM images (25-m resolution) in tandem with high-resolution SPOT panchromatic (10-m resolution) and x-band side-looking airborne radar (12-m resolution) images, we were able to identify individual vents. This method works largely because highly oxidized and hydrated basaltic glass and rock of vent facies have a distinctive signature in the reflected near-IR range (2.08 to 2.35 µm corresponding to Landsat band #7) (Farrand and Singer, 1992), which permits there ready discrimination from surrounding basaltic lavas and alluvium.

Using the satellite and airborne rader data, we identified 25 basaltic vents from Greenwater Canyon north to the northwest perimeter of the Range (Fig Slar/TM). Field investigation and geologic maps (McAllister, 1970, 1973) confirmed the accuracy of this method. Figure slar/tm (map) reveals that vent density increases northwestward, reaching a maximum on the basaltic plateau south of

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Ryan. In addition, we identified at least 9 buried vents in wells drilled by U.S. Borax. Identification of buried vents is based on well-log descriptions of material representative of vent facies deposits, including: agglomerate, consisting of oxidized bombs and coarse scoria, agglutinate, and rarely, orange-brown palagonitized tuff. Probable vent facies deposits were reported from 20 wells, but a number of these were either very closely spaced < 150 m, or situated adjacent to exposed vents and in all likelihood represent replicate samplings of a previously identified vents. Buried vent deposits ranged from 15 m to 40 m thick and were generally encountered at shallow depths, between 5 to 10 m below the surface. Four vents, however, were encountered at depths of 40 to 70 m. In summary, at least 35 vents erupted in the northern Greenwater Range in the interval 4.8 to 4.0 Ma, yielding a vent production rate of slightly more than 4 vents per 0.1 Ma.

Geochemistry and Isotopic Composition of Funeral Formation Basalts

The Funeral Formation consists predominantly of basalts with subordinate basaltic andesites and rare andesites; SiO2 ranges from 45 wt% to 57 wt %. (McAllister 1970, 1973; Wright et al., 1991). Basalts contain less than 10 modal % olivine, clinopyroxene, and plagioclase phenocrysts in a groundmass of plagioclase, clinopryoxene, and Fe-Ti oxides. Geochemically, these rocks straddle the alkaline and subalkaline fields and both nepheline and hypersthene normative rocks occur. Basalts of the Funeral Formation are typical of Pliocene mafic volcanics of the southern Great Basin (Crowe, 1983; Wright et al., 1991).

In the most detailed isotopic study of the Greenwater Range yet, Milling (1993) showed that Funeral Formation basalts epsilion Nd compositions between - 4.3 and - 13.6, and $^{87}Sr/^{86}Sr$ from 0.7067 to 0.7097. Pliocene and younger basalts of exposed near Yucca Mountain, NV, On the basis of isotopic composition (largely epsilon Nd 87Sr/86Sr values), Yogodzinski and Smith (1995) grouped Pliocene and younger basalts of the Death Valley volcanic field, including basalts of the northern Greenwater Range, with similar aged basalts of the Yucca Mountain area into the Amargosa Isotopic Province (Fig. 1). According to the author, basalts of the Amargosa Isotopic Province are characterized by exceptionally low epsilon Nd (≈8.5 to 11.9) and high $^{87}Sr/^{86}Sr$ (≈ 0.707). Yucca Mountains

In the Yucca Mountain area, Thirsty Mountain erupted at 4.6 Ma contemporaneous with volcanism in the northern Greenwater Range. The activity at Thirsty Mountain, however, followed a nearly 3 Ma hiatus in volcanism at Yucca Mountain.

Volume of Funeral Formation Basalts

The Funeral Formation consists predominantly of basalt lava flows (typically 5 to 10 m thick; Wright et al., 1991) intercalated with subordinate conglomerates and

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fanglomerates (Drewes, 1963). At one time basalts of the Funeral Formation probably formed a thin veneer over much of the central part of the Death Vally volcanic field (Wright et al., 1991). Due to erosion and burial by later alluvium basalt outcrops are now restricted to mesa tops and ridge-capping dip slopes (Wright et al. , 1991). From 1982 to 1995, U.S. Borax, Inc. drilled 145 wells through the Funeral Formation in the north-central part of the Greenwater Range. Using well-log descriptions provided by geologists of U.S. Borax, Inc., , we constrained thickness of the Funeral Formation in the north-central and northwest part of the Greenwater Range to between 20 m and 230 m, with an average thickness of ≈ 130 m. Contribution of basal conglomerate and sparse interbedded conglomerates to Funeral Formation thickness ranges broadly from < 1 % to 73 %, but on average makes up about 11% of total formation thickness. Thus, in the Range interior, basalt lava flows and vent facies deposits comprise nearly 90% of the total thickness of the Funeral Formation.

Because well-log data are confined to the north-central part of the Range, we augmented well-log data with estimates of formation thickness inferred from geologic maps (McAllister 1970 and 1973; Drewes, 1963) in order to accurately estimate volumes of Funeral Formation basalts. Along the east perimeter of the Range, contact with the underlying, broadly folded volcanics and sedimentary rocks of the Furnace Creek Formation is reasonably well-exposed, allowing thickness estimates to be made with little difficulty. To the southwest, stratigraphic contacts are commonly masked by Quaternary alluvium hampering thickness estimates. Fortunately, U.S. Borax wells drilled just north of this area provide a baseline for estimating formation thicknesses.

Volume calculations were made using the layer volumetrics package in Earthvision© (Table 1). The uppermost surface of the Funeral Formation was constrained using a digital elevation model (DEM) with a resolution of about 30 m. Local accumulations of Quaternary alluvium, which are generally 1 to 5 m thick, were ignored. A basal surface for the Funeral Formation was constrained with thickness data described above. This surface contains more than 3000 data points, most of which define the perimeter of basaltic outcrops of the Funeral Formation. For calculation purposes, a suite of eight clipping polygons (total area ≈ 64. 4 km^2) were used to laterally isolate basaltic outcrops of the Funeral Formation from adjacent areas. Volumes of the eight polygons range from 3.5 km^3, for the north-central plateau, to 0.018 km^3 for isolated outcrop north of the Range proper (Table 1). A total volume of 4.27 km^3 was calculated for the Funeral Formation of the northern Greenwater Range. Approximately 90% of this, or 3.8 km^3, represents basaltic vents and lava flows; the remaining 10% includes basal conglomerate. Because of erosion of the northern Greenwater Range and because of burial of basalts by alluvium in Greenwater Valley and Furnace Creek Wash, the calculated volume represents a minimum for basaltic magma erupted in this area. In order to constrain a likely maximum of basaltic magma erupted in the northern Greenwater

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Range, we made a conservative estimate of the total area once covered by Funeral Formation basalts (87 km^2) and assumed an average thickness of 75 m. This latter value seems appropriate because it represents the average thickness determined for the north-central part of the range where formation thickness is well-constrained by well log data. The resulting volume is 6.5 km^3. Because the enlarged area encompasses the lower flanks of the Range, including portions of the Greenwater Valley and the Furnace Creek Wash, it is reasonable to expect a greater contribution of basal conglomerate to the total the volume of the Funeral Formation. Assuming that the proportion of basal conglomerate increases from 10% to 15 or 20% of the total thickness, the resulting volume of Pliocene basalt erupted in the northern Greenwater Range is between 5.5 to 5.2 km^3.

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Greenwater Range Contacts

Borax

US Borax Inc.
Jerry Aiken (Senior Geologist)
5671 N. Oracle Road, Suite 1101
Tucson AZ 85704
520 293-3650
Fax 520 293-4017

US Borax Inc.
Dr. Barry N. Watson (Chief)
International Borate Exploration
5671 N. Oracle Road, Suite 1101
Tucson AZ 85704
520 293-3650
Fax 520 293-4017

US Borax Inc.
Steve Carpenter (Geologist)
26877 Tourney Rd.
Valencia 91355
805 287-5558

Spoke with Watson on 30 March he gave me Carpenter's number.

Spoke with Steve Carpenter on 30 March and he provided the following info:

- US Borax has drilled about 100 holes through Funeral Fm. basalts
- Use air method -- down-the-hole hammer and std circulation
- Reverse circ. a pbl because of perched aquifer in Funeral and more typ Furnace fm.
- Geologist on site samples basalts every rod (20 ft)
- Steve indicated that they had gotten some basalts analyzed and dated.
- He estimated that basalt thickness ranged from 100 to 600 ft thick.
- They have plans to drill 8 holes over the next 4-5 months, 2 to 3 miles SE of Ryan.
- Steve is on drill site sporactically, once or twice a month but will meet with us sometime in the summer if we like -- he is on vacation during the April trip.

Other Contacts:

Bob Green -- USGS emeritius, Menlo Park, retired -- recent abstract
Ren Thompson -- USGS, Denver

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Note on DEM of Greenwater supplied by SPOT

SPOT DEM Panchromatic

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Note on DEM of Greenwater supplied by SPOT

```
C_1 = 10.00
C_2 = 1000.000
D_0 = 4052010
D_1 = 10.00
D_2 = -1000

X Y (UTM11) ---> I J (PIXELS)

I = ( C_0 + C_2*X ) / C_1
J = ( D_0 + D_2*Y ) / D_1

--- I* -----------------------------------------------

--- I* -----------------------------------------------
END OF BEATTY JUN 28 1996 COPYRIGHT ISTAR 1996
--- I* -----------------------------------------------
ISTAR IS A REGISTERED TRADE MARK OF ISTAR INC
--- I* -----------------------------------------------
```

8 June 97

Note on DEM of Greenwater supplied by SPOT —

```
FILE : orthor_502_4052_10.bil          ORTHO RIGHT PANCHROMATIC

        ZONE : BEATTY
        COMPUTED JUN 28 1996 FROM:

               SPOT DEM PANCHROMATIC REF : BEATTY JUN 28 1996

                SPOT PANCHROMATIC RIGHT
                       SPOT     : 2
                       CAMERA : HRV1
                       DATE     : JUNE 13 1993
                       ANGLE    : 20.6 EAST
                       LEVEL    : 1A
                       K-J      : 543 277

        PIXEL_SIZE: 10.00 METRES
        FORMAT: BIL

        IMAGE SIZE: 6900 LINES 7600 COLUMNS
        IMAGE SIZE:
                X AXIS ALONG LINES    : 76 KILOMETRES FROM WEST TO EAST
                Y AXIS ALONG COLUMNS: 69 KILOMETRES FROM SOUTH TO NORTH

COORDINATES AND GEOMETRIC TRANSFORMATION MODELS

        CARTOGRAPHIC PROJECTION      : UTM11
        REFERENCE ELLIPSOID          : NAD27
        REFERENCE MAP                : 1/24000 USGS

        COORDINATES OF CORNERS

                IMAGE COORDINATES

                C1: CENTER OF PIXEL    1       1       FIRST LINE FIRST PIXEL
                C2: CENTER OF PIXEL    1       7600    FIRST LINE LAST PIXEL
                C3: CENTER OF PIXEL    6900    1       LAST LINE FIRST PIXEL
                C4: CENTER OF PIXEL    6900    7600    LAST LINE LAST PIXEL

                CARTOGRAPHIC COORDINATES

                C1:       X = 502
                          Y = 4052
                C2:       X = 577.990
                          Y = 4052
                C3:       X = 502
                          Y = 3983.010
                C4:       X = 577.990
                          Y = 3983.010

        COORDINATES OF PIXEL : I J

                A_0 = 501.990
                A_1 = 0.010
                B_0 = 4052.010
                B_1 = -0.010

                I J (PIXELS) ---> X Y (UTM11)

                X = A_0 + A_1*I
                X = B_0 + B_1*J

        IMAGE COORDINATES OF GROUND POINT : X Y

                C_0 = -501990
```

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Note on DEM of Greenwater supplied by SPOT

AVERAGE ALTITUDE : 762.1 METRES

ESTIMATED ALTIMETRIC RMS: 11 METRES

NOTE :

THE DIFFERENCE BETWEEN THE TWO SHOTS IS 28 DAYS WHICH GIVES THE MATCHING ALGORITHM GOOD ACCURACY AND DECREASES THE MAXIMUM ERRORS. VISUAL INSPECTION AND CORRECTION CONFIRMED THAT GOOD MATCHING WAS OBTAINED.
THE SURFACE COVERED BY THE DTM IS 3599.954 SQUARE KILOMETRES

COORDINATES AND GEOMETRIC TRANSFORMATION MODELS

CARTOGRAPHIC PROJECTION : UTM11
REFERENCE ELLIPSOID : NAD27
REFERENCE MAP : 1/24000 USGS

COORDINATES OF CORNERS

IMAGE COORDINATES

C1: CENTER OF PIXEL	1	1	FIRST LINE FIRST PIXEL
C2: CENTER OF PIXEL	1	3800	FIRST LINE LAST PIXEL
C3: CENTER OF PIXEL	3450	1	LAST LINE FIRST PIXEL
C4: CENTER OF PIXEL	3450	3800	LAST LINE LAST PIXEL

CARTOGRAPHIC COORDINATES

C1: X = 502
Y = 4052
C2: X = 577.980
Y = 4052
C3: X = 502
Y = 3983.020
C4: X = 577.980
Y = 3983.020

COORDINATES OF PIXEL : I J

A_0 = 501.980
A_1 = 0.020
B_0 = 4052.020
B_1 = -0.020

I J (PIXELS) ---> X Y (UTM11)

X = A_0 + A_1*I
X = B_0 + B_1*J

IMAGE COORDINATES OF GROUND POINT : X Y

C_0 = -501980
C_1 = 20.00
C_2 = 1000.000
D_0 = 4052020
D_1 = 20.00
D_2 = -1000

X Y (UTM11) ---> I J (PIXELS)

I = (C_0 + C_2*X) / C_1
J = (D_0 + D_2*Y) / D_1

--- I* ---

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Note on DEM of Greenwater supplied by SPOT

--- I* ---

ISTAR 1996 GEOGRAPHIC DIGITAL PRODUCTS

REF : BEATTY JUN 28 1996

ISTAR
ESPACE BEETHOVEN
ROUTE DES LUCIOLES
SOPHIA ANTIPOLIS
06560 VALBONNE
TEL : (33) 93 95 81 23
FAX : (33) 93 95 83 29

--- I* ---

FOR ADDITIONAL INFORMATION PLEASE CONTACT :

SALES DEPARTMENT	M. BEINISH
PRODUCTION DEPARTMENT	M. FLEURY

--- I* ---

DATA STRUCTURE :

1 TAR FILE CONTAINING

FILE :	Entet	INFORMATIONS
FILE :	dem_502_4052_20.bil dem_502_4052_20.hdr	SPOT DEM PANCHROMATIC
FILE :	orthor_502_4052_10.bil orthor_502_4052_10.hdr	ORTHO RIGHT PANCHROMATIC

--- I* ---

FILE : Entet INFORMATIONS

DATA ARE ENCODED IN ASCII

--- I* ---

FILE : dem_502_4052_20.bil SPOT DEM PANCHROMATIC

ZONE : BEATTY COPYRIGHT ISTAR 1996
COMPUTED JUN 28 1996 FROM:

SPOT PANCHROMATIC RIGHT HRV1 JUNE 13 1993 LEVEL 1A K-J=543-277
SPOT PANCHROMATIC LEFT HRV1 MAY 17 1993 LEVEL 1A K-J=543-277

AND FROM 22 GROUND CONTROL POINTS FROM :
38 OF 1/24000 USGS

PIXEL_SIZE: 20.00 METRES
FORMAT: BIL

IMAGE SIZE: 3450 LINES 3800 COLUMNS
IMAGE SIZE:
X AXIS ALONG LINES : 76 KILOMETRES FROM WEST TO EAST
Y AXIS ALONG COLUMNS: 69 KILOMETRES FROM SOUTH TO NORTH

FOR CHECKING PURPOSE:
Z_VALUE AT PIXEL NUMBER 1901 LINE 1727 : 837.500 (METRES)

MINIMUM ALTITUDE : -121.4 METRES
MAXIMUM ALTITUDE : 2033.5 METRES

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Note on DEM of Greenwater supplied by SPOT

ORTHO right Panchromatic

More units of Greenwater DEM

Dear Mike,

Please see Francois' comments below and let me know if you have any questions. My understanding is that your DEM is in meters units, but that to take elevations below sea level into account, ISTAR starts at -10000 as a standard process.

Colleen

Forward Header

Subject: Re: Z units
Author: Francois Zamora at SICORP
Date: 7/15/96 10:05 AM

Colleen,

The DEM has been delivered with the following formula:

Elevation (m) = (Pixel value - 10000) / 10

Mike can load the DEM in ArcInfo and ask during his course how to:

- apply this formula and saving the output file,
- make a 3D visualization with the Orthoimage overlaid _in transparency_ on top of his DEM
- how to integrate his other layers of information

Thanks,

Francois

Reply Separator

Subject: Z units
Author: Colleen Cochran at SICORP
Date: 15/07/1996 08:36

Francois,

Is this something you could help Mike Conway with? Please let me know.

More notes of Greenwater DEM.

I'm working with the DEM data and it looks pretty good. I'm running across one problem, however. The elevation data (Z) are in units that are totally beyond my understanding. I requested and expected elevation data in meters. If you get a chance could you speak with the ISTAR folks and find out what the story is.

I'll be in and out next week -- taking an ARC/INFO course --, but please drop me a line when you get a chance. I'll let you know when the SPOT level 1A images come in.

Again thanks for all your help.

Mike Conway

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Camargo Volcanic Field

An Analog cinder cone field for Yucca Mtn Region. The field is Plio Pleistocene in age and comprises over 300 Km vents. Cinder cones form two major clusters - an older west group and a younger east group.

Jim Luhr & Jorge Aranda are compiling $^{40}Ar/^{39}Ar$ Ages for ≥ 30 vents. In addition, they are sampling a sufficient number of cones in order to characterize the geochemical variation in the field

My role was to put together DEM (DTED) along w/ MSS & Landsat TM scene.

Camargo Volcanic Field Resources

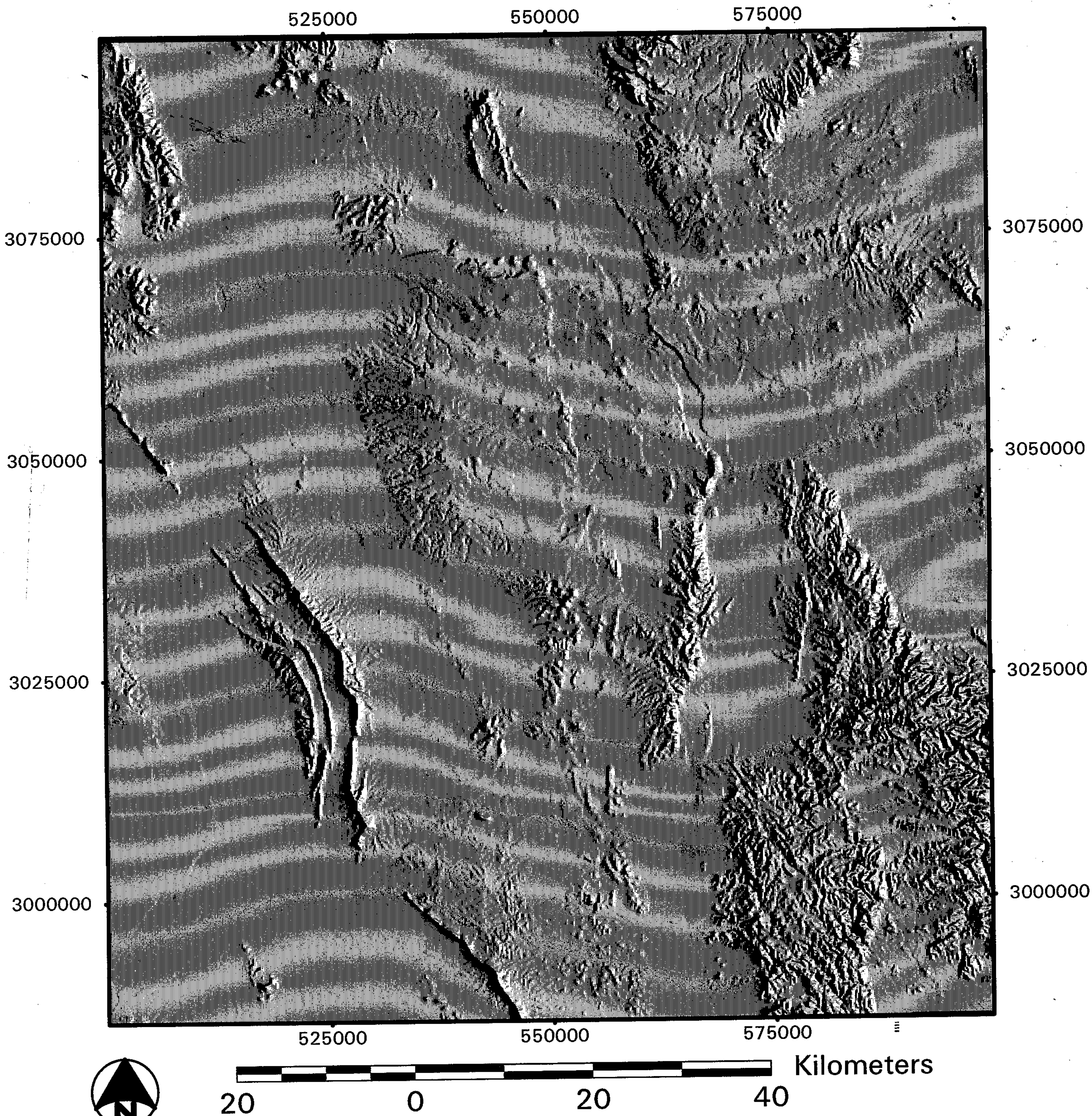
Hard Copy

Aerial Photographs of entire field
Photogeologic map of field
1:50,000 maps of area
1:500,000 (?) geologic map of area

On-line data

Vector coverage of photogeologic map (vent locations and faults)
DTED 93-m ground cell resolution DEM
Landsat-MSS (80-m ground cell resolution)
Landsat-TM (30-m ground cell resolution)
EarthVision model of DTED surface

Camargo Volcanic Field: Digital Shaded Relief DTED 93-m ground cell resolution



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Camargo Volcanic Field Maps

This series consists of 8 maps: 2 digital shaded relief maps from Arc/Info, 2 Landsat TM scenes from ERDAS-Image, 2 vent/fault distribution maps, and 2 slope maps that differ only in the use of color in one.

1) Gray-shaded digital shaded relief map, scale 1:115,000. Scene is illuminated from the west (260 degrees) at an angle of incidence of 40 degrees.

2) Colored digital shaded relief map, scale 175,000.

3) Landsat TM Band 5, scale 1:120,000. High contrast band 5 was used to enhance fault zones and as a base map for labelling fault zones.

4) Landsat TM Bands 7, 4, and 3. This band combination highlights spectral differences between highly oxidized vent facies deposits and neighboring lava flow fields.

5) Vent distribution map with a total of 308 vents. Vent locations digitized from geologic map of Jorge Aranda & Co. Numbers represent internal Arc/Info vent-id number. *In order to correlate with your vent numbering system, we need corresponding vent number from your maps.*

6) Map of faults and vents digitized from Jorge Aranda & Co.'s photogeologic map of Camargo Volcanic Field.

7) Slope Map of Camargo Volcanic Field (gray-scale and color version -- parameters are identical).

Camargo Volcanic Field: Aerial Photos

West 530,000 — East 600,000

(north of 3090000)	R121-20-22 to R121-6-22	
3090000 (North)		
	R121-3-21 to R121-17-21	
3080000		
	R121-20-20 to R121-5-20	
3070000		
	R121-3-19 to R121-17-19	
3060000		
	R120-23-18 to R120-18-18	R120-15-18 to R120-7-18
3050000		
	R120-5-17 to R120-19-17	
3040000 (South)		
	R120-21-16 to R120-6-16	

UTM coordinates are *approximate* and are intended solely to indicate the general order and distribution of air photos.

Making Colored Shaded Relief Maps

This process begins in arc_grid, moves to XV, via gridimage command, and ends up somewhere in usr/people/4dgifts/iristools/imgtools (pbl cglue, blend, or composite or some combination of these and other utilities.

The Process:

What is required are three different images (grids) mapped into hue (or color -- this is driven by elevation of dem), saturation (usally set uniformily at 40 % throughout), intensity (or value and is driven by shaded relieve map).

Processing noisy DEM:

a) use FOCALMEAN (in GRID) to "average" cells (eg., 3x3 default, but uneven averaging (eg. 5x7) works well for averaging grids with noise in certain direciton. FOCALMEAN should be run on original DEM prior to other analysis.

Creating GRIDCOMPOSITE

Let shaded relief drive intensity (value)

Let elevation drive hue (color)

In arc_plot or arc_grid

GRID for hue

hue100 = int (100 * (dem_grid - minimum ele value) / (maximum elev - minimum elev)) use of 100 is optional but is a nice middle of the road value.

GRID for sat

sat40 = con (hue100 == 0, 40, 40)
this produces neutrally and throughly gray grid for processing

GRID -- shaded Relief grid for intensity (this must be normalized)

new_shd_rlf = int (100 * (shd_rlf_grid / 254. 0))
*shd_rlf_grid should consist of values from 0 to 254.

In ARC_PLOT

gridcomposite huegrid satgrid intengrid compgrid
this allows final results to be reviewed.

NEXT
?SCREENSAVE? -- in arc/info ??
Save grids out using gridimage as sunrastor files
Open sunrastors using XV and save as IRIS RGB (normal size files)

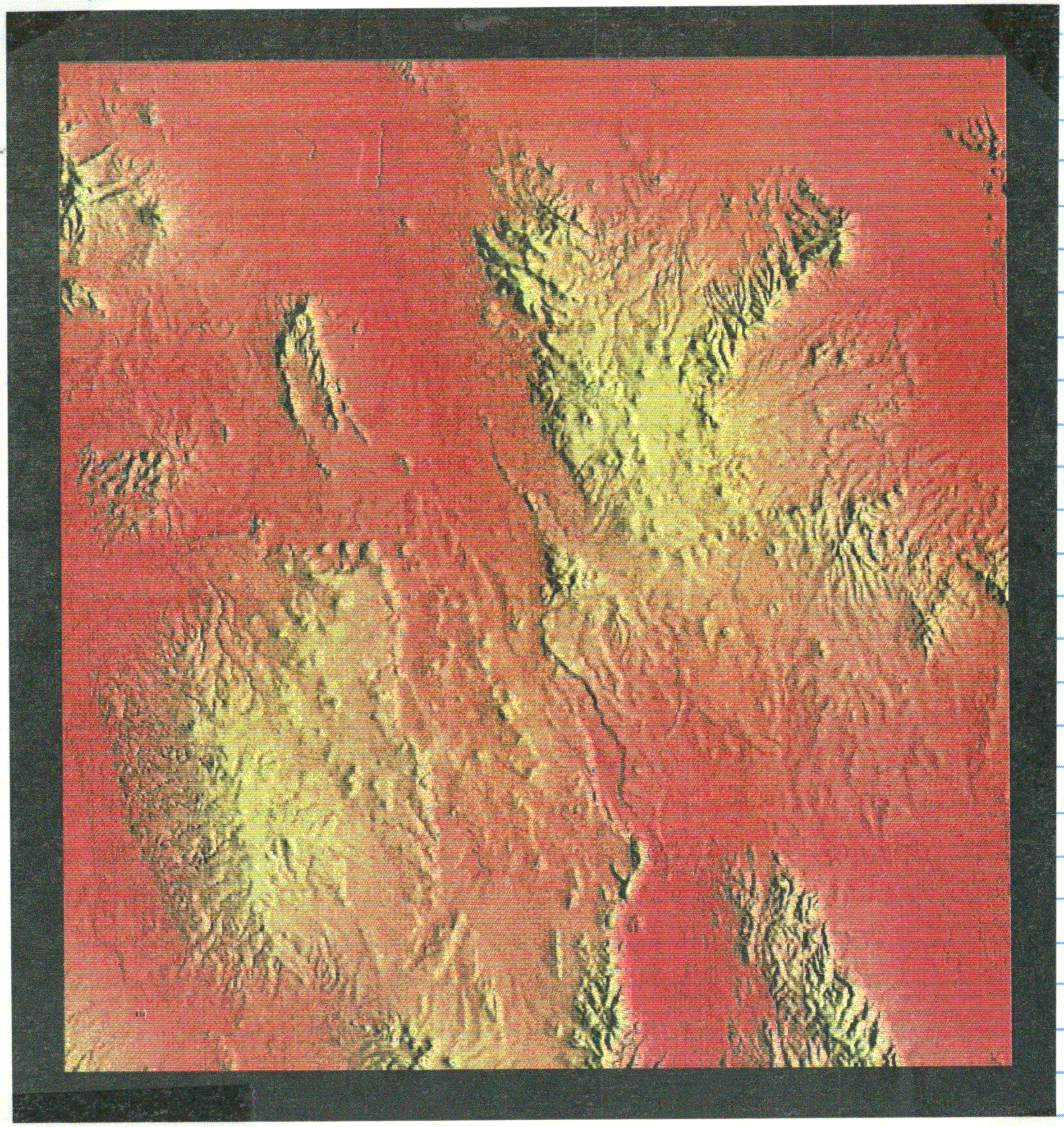
Next
Go Iris/imgtools to determine how to combine three grids.

SAVING and PRINTING GRIDCOM in ARC/INFO

The only way to do this is to save grid, using AML supplied by R. Martin, GRA.metafile . At ARC prompt GRA. file can be used to create *.ps file:

ARC: postscript GRA.metafile new_file.ps

Colored DTED N↑

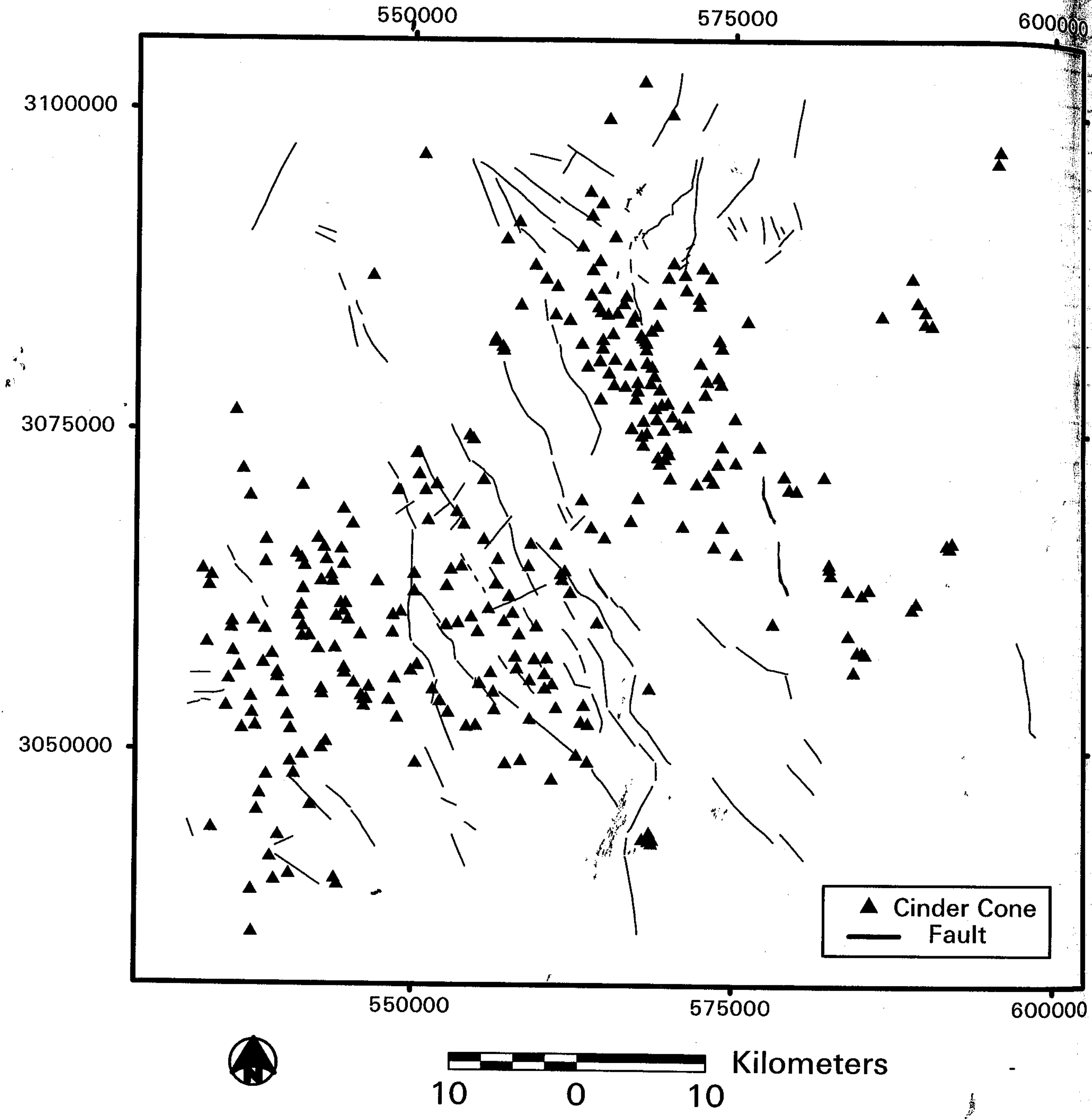


West & East Custer are clear on this image

Plotted by: M.Conway
Plot Date: 07 May 97 08:45:31 Wednesday
MapScale: 175000

N↑

Camargo Volcanic Field



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Camargo Volcanic field

Vents & faults from digitized maps (geologic) of Jorge Aranda; Phuka digitizer.

SW & NE clusters are evident here.
NW trending lineament of vents also observed some of which are colinear w/ ~~vent~~ faults.
~~att~~

I HAVE REVIEWED THIS SCIENTIFIC NOTEBOOK (# 186) AND FIND IT IN COMPLIANCE WITH QAP-001. THERE IS SUFFICIENT INFORMATION REGARDING PROCEDURES USED FOR CONDUCTING STUDIES, SO THAT ANOTHER QUALIFIED INDIVIDUAL COULD REPEAT THIS ACTIVITY. THIS ACTIVITY LARGELY INVOLVED DIGITAL DATA SETS OF REMOTELY SENSED SATELLITE AND AIRBORN DATA FOR ESTAMATING VOLUME OF VOLCANICS IN THE GREENWATER RANGE (CA); AND ANALYSIS OF VOLCANICS AT CARMARGO, MEXICO
SEE P. 85

H. Lawrence McKague
3/5/98

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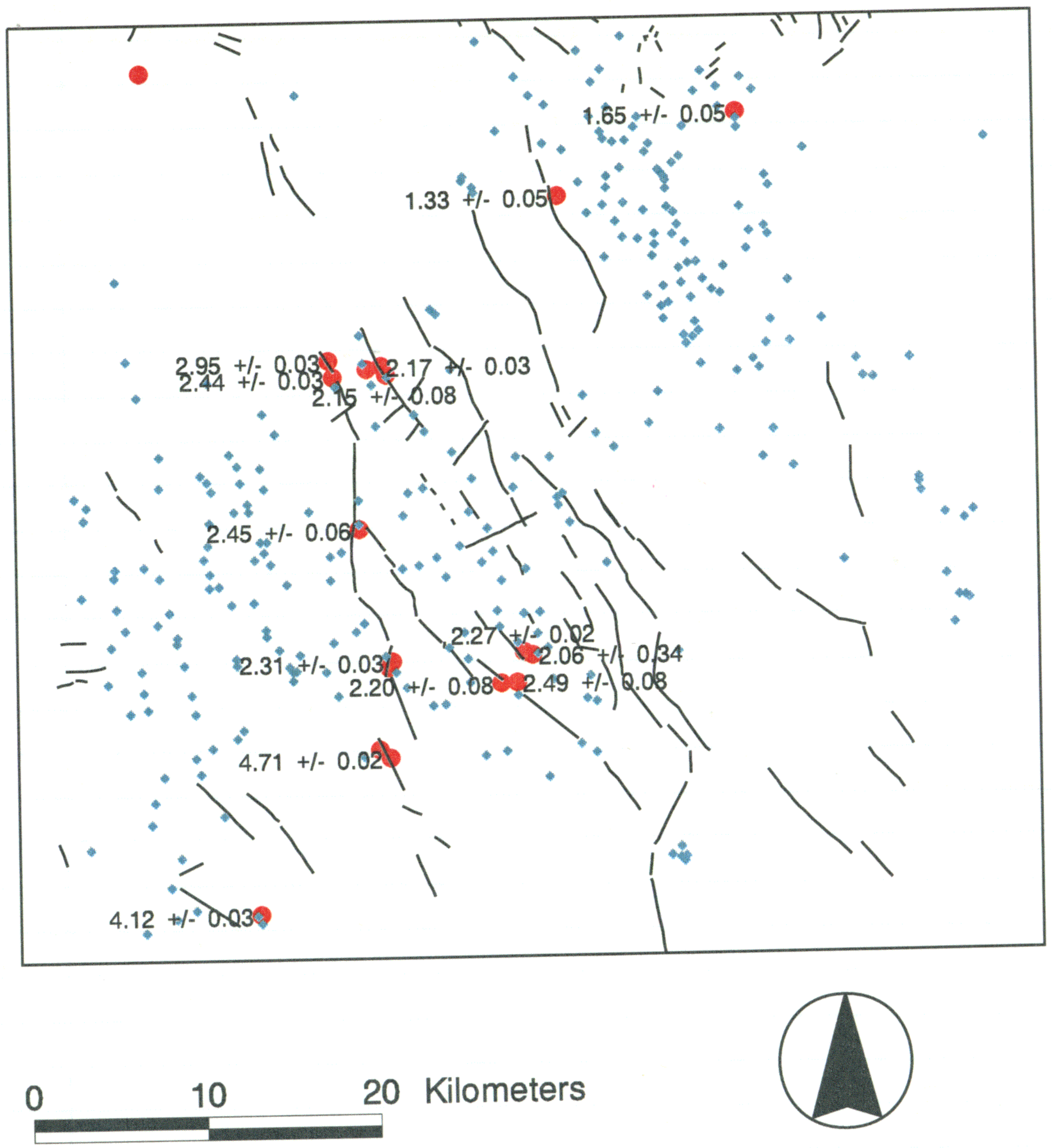
Camargo Volcanic Field:
Vents, Faults, and Ar/Ar Ages



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Camargo Field w/ faults, vent & $^{40}Ar/^{39}Ar$) ages. The latter provided by Jim Luhr.

The former provided by Jorge Aranda.

The data, though preliminary, show that the oldest units are situated in the SW, and the youngest in NE.

PWC

Odd Notes on Erdas 8.2.
Collected over 1 yr. period

this brings out areas of different composition -- less then successful in Saline.

ERDAS Menu

1) Download digital data and inspect header information for array size and projection.

2) Using import of Imagine:
generic binary
BSQ
7 or 4 bands
array size (from header)
block, header, and Trailer are typically 0

3) Produce image file of area of interest
Interpreter
utilities
subset

4) Do contrast stretch
Typically histogram equalization
or std deviation

5) In Interpreter do edge enhancement to sharpen image
Use spectral
3*3 kernel edge enhancement from default library

6) Perform indice rationing
a) composite mineral ration of 7/5 4/3, and 3/2 (?)
this brings out areas of different composition -- less then successful in Saline Range

7) Making a **color table for one band data:** radar, magnetics, gravity
- open raster file with pseudo-color
  - under raster pull-down menu Attributes
    - choose color
      - save if so desired.

8) Radar image enhancement:
Speckle Suppression -- good results
Edge enhancement -- tends to overemphasize edges at expense of clarity

9) Image to Image rectification

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Source image -- image to be rectified
Dest. image -- image to be rectified to (control image)

Within source
- Rastor pulldown
  - GCP menu
    select gnd points in source and dest.
  - Calculate transformation
    - Save transformation .cff file
    - open source image
      - Resample (using .cff file)

Done

10) Interpreter
Resolution Merge
Merging high-resolution data (Slar) with multi-spectral data -- projection must be same but cell size can be different.
Swap Space on order of 6x largest scene required for use
Commonly Princ Comp or Brophy Method used with either NN or CC.
Work well with 12 res. SLAR and 30 m res. TM scene
No results with merge of TM and SPOT -- could be file size (700 mega bytes are too large -- numerous errors reported)

11) Interpreter:
- Topographic Analysis
  - Contour -- allows Dem data to be contoured at sel. interval.

12) Vector
Vector editing enabled
1) able to grab and move all or individual vectors
2) able to manipulate properties of vectors and polygons

13) Map Composer
Can map polygons and vectors onto TM-SLAR image and than delete image leaving UTM correct vector coverage.

To print color symbology assn. with a vector file, you must first edit the vector coverage and save out an evs. file with symbology. Than go into map composer and make map.

14) INFO from DEMONSTRATION

a) Relief tool is robust and using 2nd-3rd button on mouse allows rapid change in az, orientation, and elevation

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b) geolink/unlink to link two scenes in the same projection.

c) Vector Query -- way of extracting info on vectors

d) Feature Extraction -- vector coverage "Region growing properties" * "seed properties" means of quickly and effectively mapping areas with unique spectral characteristics. -- should try on Saline Range.

e) Loading low-resolution image on top of high-res. image in the viewer has the effect of resampling low-res. at the higher resolution.

15) Working with Vectors

a) open attributes and create new column
b) using apple 3 command bring up hidden menu
c) select Formula -- write in new ID code after highlighting column and selecting the arc(s) or polygon(s).
d) SAVE
e) Clear screen
f) **VECTOR ICON -- "build topology"**
This last step must be completed after adding or subtracting vectors.

Vector Symbology editing -- ie changing colors, line widths, etc of indiv. vectors
a) open vector and enable editing
b) open symbology
c) select editing format -- unique etc.
d) under editing select editing or expression
e) do it.
f) save symbology

16) Saving Shaded Relief and vector coveages as IMG. files
a) VIEW go to view to img.
b) Save view to img.
c) proceed from there.

17) Overlaying (draping) img. files (ie. Spot image) on DEM
a) Interpreter
b) Topographic Analysis
C) Shaded Relief
1) Set DEM. img file
2) Ck overlay and set Sat.img file
3) Set AZ, DEM mag., Illumination, etc.

Be forewarned: there are memory limitations and you cannot overlay a whole SPOT scene but must subset it.

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Met Peter Price -- EISYS a distb. for SPOT and knowledable about both ERDAS and SPOT -- a geologist with 15 years experience in remote sensing and 10 years in oil industry -- presently doing remote sensing for industry incld. oil and gas.
a) He recommended getting in touch with SIR-C for multiband radar.
b) He volunteered to give a professional talk some afternoon on topic of our choice
c) He is familiar with the RS lit. and was cordial to the idea of sharing the wealth.

GEO-coding SPOT Level 1A images

Registration advice sought and freely given by Terry Bush (SPOT) and Arman (ERDAS) for geocoding SPOT images in ERDAS.

1) Pick 10 -12 well-distributed GCP from both high and low ground
2) Use 2nd order polynomial to geocode figure
3) Registering to TM scene is ok, but better to register to USGS source

Converting USGS compressed DLG files into format suitable for Erdas.

1) Copy off of CD-rom onto scratch disk
2) unzip* using one of several decomprssion tools in mconway/bin/
3) use rons script in mconway/bin "up2lowxferIRIS.s" to change names and add necessary .dlg suffix.

Loading Imagine - ERDAS *.img files into Arc/Info

1) Prep *.img file -- process, rectify, etc.
2) using **image** in ARC/INFO 7.0 edit simply pull the image in

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ERDAS Log

Started 22 March 1996:

Capabilities:

1) Read in TM bands using IMPORT/BSQ
2) Read in DEM data using IMPORT/DEM
3) Compiling TM bands into 1 scene
4) Image processing of TM: contrast stretch, edge enhancement INDICES, etc
5) Mosaicing DEM data UTILITY/MOSAIC
6) Making SLOPE maps of DEM data
7) INTERPRETER: SHADED RELIEF & CRISP functioning well.
8) Read in SLAR rastor file after saving it out as *.gis file in Arc-Info
9) Generating color table for 1 band data

Remote Sensing Methods

1) Download digital data and inspect header information for array size and projection.

2) Using import of Imagine:
   generic binary
   BSQ
   7 or 4 bands
   array size (from header)
   block, header, and Trailer are typically 0

3) Produce image file of area of interest
   Interpreter
   utilities
   subset

4) Do contrast stretch
   Typically histogram equalization
   or std deviation

5) In Interpreter do edge enhancement to sharpen image
   Use spectral
      3*3 kernel edge enhancement from default library

6) Perform indice rationing
   a) composite mineral ration of 7/5 4/3, and 3/2 (?)

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Final Project Entry 13 June 97

R. Michael Conway 7 Aug 1997

SEE STATEMENT ON PAGE 77

A. L. McKeyne
3/5/98

THIS SCIENTIFIC NOTEBOOK IS TO BE CLOSED OUT AND ARCHIVED EFFECTIVE
3/5/98 A. Lawrence McKeyne