Now, compare the areas of the clipped isopachs with original fall areas, to calculate the amount of tephra that fell in the Fortymile Drainage system. Remember that polys 15–16 are in the aggrading fan and shouldn't be counted as part of the remobilized surface. Calculations in Excel spreadsheet TOLBCLIP.XLS:

TOLBCLIP.XLS: area of tolbachik falls in fortymile drainage. BHill 1/2/01									
Clip Coverage					**Original**	**Original**		**% in**	**Tephra in**
Poly#	**cm**	**Area km2**	**Sum km2**	**Sum m2**	**area m2**	**tephra m3**		**40-mile**	**40-mile**
9	200	11.91	11.91	1.191E+07	1.191E+07	2.382E+07		100.0%	2.38E+07
8	150	16.949	16.949	1.695E+07	1.732E+07	2.599E+07		97.8%	2.54E+07
7	100	21.68	21.68	2.168E+07	2.645E+07	2.645E+07		82.0%	2.17E+07
10	50	15.078	27.645	2.765E+07	4.967E+07	2.484E+07		55.7%	1.38E+07
6	50	12.567							
12	30	1.117	20.664	2.066E+07	6.337E+07	1.901E+07		32.6%	6.20E+06
11	30	0.649							
5	30	18.898							
13	10	2.147	63.639	6.364E+07	2.409E+08	2.409E+07		26.4%	6.36E+06
4	10	61.492							
15	*5*	*0.481*							
14	5	2.474	40.402	4.040E+07	5.364E+08	2.682E+07		7.5%	2.02E+06
3	5	37.928							
16	*1*	*33.545*							
2	1	59.885	59.885	5.989E+07	1.005E+09	1.005E+07		6.0%	5.99E+05
1	0	0							
						1.811E+08		55.2%	9.993E+07
Ital = In aggrading fan									
					Area of Fortymile depositonal basin (m2):			1.355E+08	
					Uniform thickness of tephra in depo (m):			7.38E-01	

This demonstrates that, had the 1975 Tolbachik eruption occurred through the proposed repository site at Yucca Mountain, Nevada, and had experienced the same windfield as in Kamchatka (not unreasonable), then about 55% of the tephra fall would have fallen within the Fortymile Wash drainage basin. If all this material was remobilzed and deposited with a uniform thickness in the southern, depositional part of the basin, the remobilized deposit would be around 70 cm thick. This assumes that all tephra moves without dilution/bulking, which is not reasonable, nor is that all surfaces in the drainage are instantaneously capable of remobilization. This does demonstrate, however, that an initial deposit thickness of around 1-5 cm at the critical group could be increased significantly due to fluvial remobilization. The rate of deposition is, however, unknown at this time.

Next step is to divide the Fortymile Wash drainage basin into slope categories, and determine what amount of tephra falls on steep, moderate, and shallow slope surfaces.

Project: Construct a 30-m Digital Elevation Model (DEM) for area around YM. This DEM will be used for surface analyses associated with remobilization of tephra models. Primary goal is to produce a slope map for the YM area, which encompasses the Fortymile Wash drainage basin. Work will be conducted using Arc/Info 7.2 and 8.0.

a) From extent of Fortymile Wash system, determine that these 7.5" quads are needed to construct a 30-m DEM. The USGS provides 30-m DEMs for download at edcwww.cr.usgs.gov/Webglis/glisbin/glismain.pl. The 30-m DEMS correspond to 7.5' topographic map names:

	116° 52.5	116° 45'	116° 37.5'	116° 30'	116° 22.5'	116° 15'
37° 15'	Tolicha Pk	Black Mtn	Trail Ridge	Silent Butte **PM**	Dead Horse Flat **PM**	Quartet Dome
37° 7.5'	Springdale NE **Sl Bu**	Thirsty Cyn NW **Sl Bu**	Thirsty Cyn **TM - RW**	Scrugham Peak **BM**	Ammonia Tanks **BM**	Ranier Mesa
37°	Springdale	Thirsty Cyn SW	Thirsty Cyn SE **RW**	Timber Mtn **BM**	Buckboard Mesa **BM**	Tippipah Spring
36° 52.5'	Beatty	Beatty Mtn	E of Beatty Mtn	Pinnacles Ridge	Topopah Spring	Mine Mtn MALDONADO 19
36° 45'	Gold Center	Carrara Cyn	Crater Flat **CF**	Busted Butte	Jackass Flat	Skull Mtn
36° 37.5'	E of Chloride	Ashton	Big Dune **CF - LW**	Amargosa Vly **Aeromag**	Striped Hills	Specter Rng NW
36° 30'	Nevares Pk	Lees Camp	Leeland **Aeromag**	S. of Amargosa V **Aeromag**	Skeleton Hills	Spector Rng SW
36° 22.5'	Furnace Creek	Echo Canyon	E of Echo Cyn	Franklin Well	Devils Hole	Amargosa Flat
36° 15'	Devils Golf Cors	Ryan	E. of Ryan	Death Vly Jnct	Bole Spring	High Peak

DEMs downloaded are compressed with gzip. Uncompress with GZIP -D *.GZ. To recompress the tar files, use GZIP -F *.TAR, to force an overwrite of the tar file.

Listing of DEM files downloaded for DEM project:

```
-rw-r--r--   1 bhill    sunuser    101348 Jan 28  1998 amarflat_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     67889 Dec 15  1998 amarvaly_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    167245 Jan 28  1998 amontank_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     74004 Dec 15  1998 ashton_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    172809 Jan 29  1998 beatty_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    183329 Dec 15  1998 beattymtn_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     86460 Dec 15  1998 bigdune_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    142620 Jul 27  1998 blackmtn_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     99075 Jan 28  1998 bolesp_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    153389 Dec 15  1998 buckmesa_75dem.tar.gz
-rwxr-xr-x   1 bhill    sunuser    160826 Dec 22 13:20 bustbu_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    155125 Dec 15  1998 carrara_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    115069 Aug  3  1998 cratflat_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    162387 Jul 27  1998 deadhorse_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    131900 Jul  8  1998 devilgolf_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     73786 Jan 28  1998 devlhole_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     72022 Jul  8  1998 dvjunction_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    190617 Jul  8  1998 e_chloride_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    156784 Jul  8  1998 e_ryan_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    177043 Aug  3  1998 ebeatymtn_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    218658 Jul  8  1998 echocyn_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    154671 Jul  8  1998 eechocyn_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     57154 Jul  8  1998 frankwell_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    151824 Dec 29 09:33 frenchlk_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    178240 Jul  8  1998 furnaceck_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     67607 Jan 29  1998 goldctr_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    148042 Jan 28  1998 highpk_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    155106 Dec 29 09:37 horsesp_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    105929 Dec 15  1998 jackass_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    118734 Dec 29 09:36 lastchance_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     51253 Jan 28  1998 leeland_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    180463 Jul  8  1998 leescamp_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    169930 Dec 29 09:33 mercury_ne_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    110271 Dec 29 09:35 mercury_se_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    180044 Dec  4  1998 minemtn_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    170452 Dec 29 09:36 mtschader_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    226369 Dec 29 09:36 mtstirling_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    197056 Jul  8  1998 nevarespk_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    131495 Dec 29 09:35 niaviwash_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    203450 Dec 29 09:28 oaksp_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    187138 Dec 29 09:28 oakspbu_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    224955 Dec 29 09:29 paiuteridge_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    152867 Dec 29 09:32 plutovaly_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    159499 Dec 29 09:34 pointrocks_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    186727 Jul 27  1998 quartdome_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    259620 Aug  3  1998 raniermesa_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    198872 Jul  8  1998 ryan_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     66046 Jan 28  1998 samarvaly_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    127543 Jan 28  1998 scrugpeak_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    151610 Jul 27  1998 silntbu_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    135920 Jan 28  1998 skelhils_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    136736 Jul 27  1998 skulmtn_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    141305 Jan 28  1998 spectnw_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    115783 Jul 27  1998 springdale_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser     99370 Jan 29  1998 springdale_ne_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    128440 Dec 15  1998 striphill_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    150946 Dec 15  1998 thirsty_nw_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    119324 Dec 15  1998 thirsty_sw_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    169970 Dec 15  1998 thirstycyn.tar.gz
-rw-r--r--   1 bhill    sunuser    155450 Jul 27  1998 thirstyse_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    183156 Dec 15  1998 timbrmtn_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    244719 Aug  3  1998 tippisp_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    138346 Jul 27  1998 tolichapk_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser    212175 Dec 15  1998 topospr_75dem.tar.gz
```

```
-rw-r--r--   1 bhill    sunuser   202713 Dec 15  1998 topsprnw_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser   141522 Jul 27  1998 trailridge_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser   216278 Dec 29 09:37 wheelerwell_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser   198907 Dec 29 09:35 willowpk_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser   116853 Dec 29 09:28 yuccaflat_75dem.tar.gz
-rw-r--r--   1 bhill    sunuser   174835 Dec 29 09:29 yuccalake_75dem.tar.gz
```

b) Unfortunately, the SDTS uses common prefixes for 7.5' DEMS along common longitudes. When the .tar file is uncompressed (> tar -xvf *.tar), about 10 files with a common prefix (1229, 1228 etc, but not regular for each latitude!) are uncompressed. Have to manually untar each file, do step C, then erase the SDTS files so as not to get confused or run out of disk space fast.

c) RUNNING ARC 8.0, create a DEM using
Arc> stdsimport file# outname /* where file# is the common prefix from the uncompressed tar file

d) Check vertical units and datum using DESCRIBE. Sometimes vertical units are shown as meters, but by looking at extent can tell that they actually are in feet. To convert feet to meters, run GRID:
GRID> New_DEM = Old_DEM * 0.3048 /* converts the Z values to meters.

e) Once the individual DEMs are created, combine using
GRID> New_DEM = MERGE (DEM1, DEM2, ... DEMn). /* Merge priority is first in = upper layer.

An easy way to do this is with an AML, which creates YM32DEM:

```
&if [show program] ne GRID &then
  &return AML must be run from GRID.

ym32dem = merge (amarflat, amarvaly, ammoniatank, bigdune, buckboard, bustedbu, cratflat, deadhorse,
devilshole, e_echocyn, ebeattymtn, franklinwell, jackass, leeland, minemtn, quartetdome, rainiermesa,
s_amarvaly, scrughampk, silentbu, skeleton, skullmtn, spectnw, striphills, thirsty_se, thirstycyn,
timbermtn, tippipahsp, topopasp, topopasp_nw, trailridge)

&return
```

f) Note that Spector Range SW does not have a USGS DEM or 7.5' DLG available. Clip part of the existing 3-arc-second DEM in /gis/pub1/usgs/dems/ym, and merge into large DEM

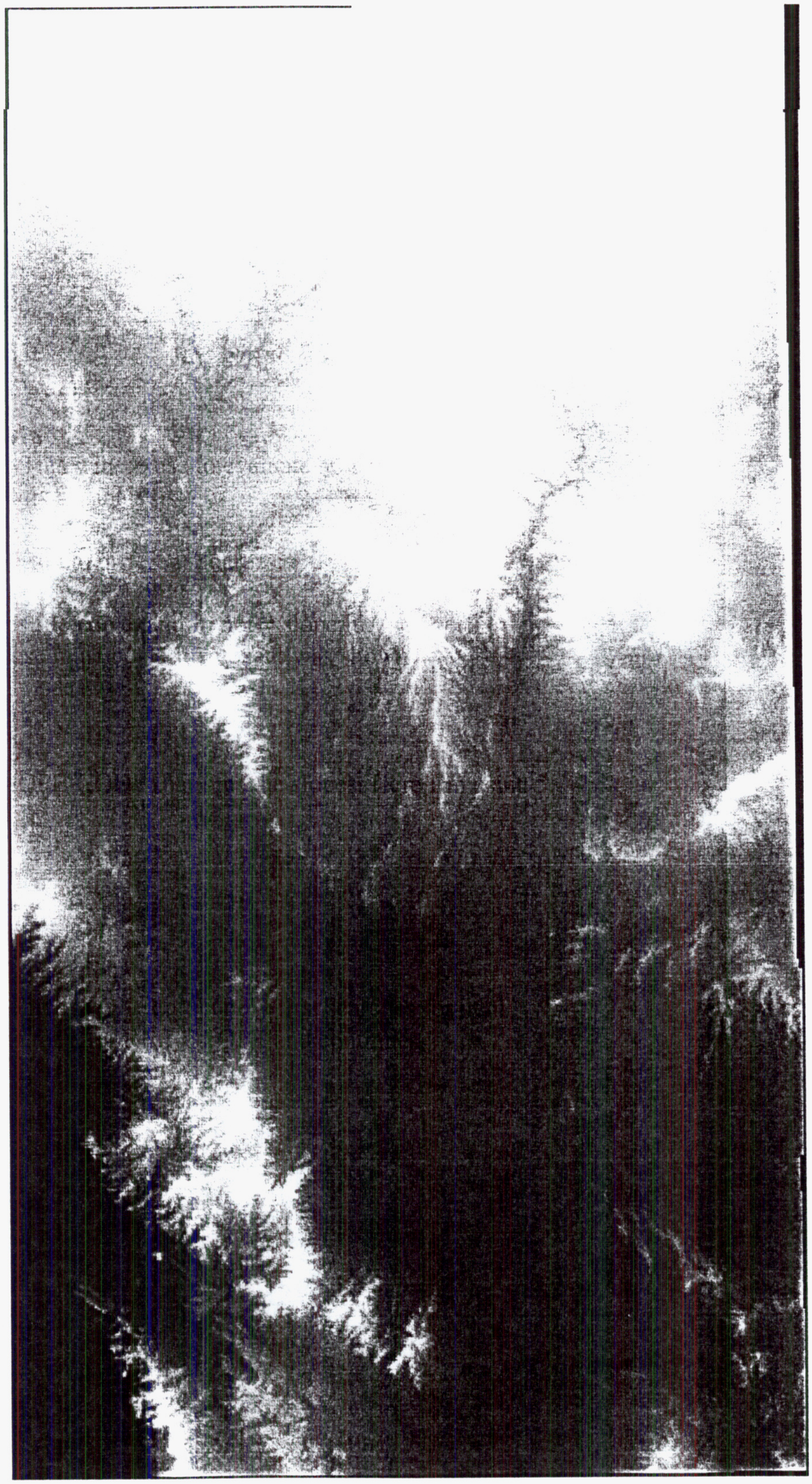
g) To display the DEM:
GRID> gridpaint fn value linear nowrap gray

There likely will be thin black lines from edge mismatch, and some very light lines due to erroneously high values.

h) Correct erroneously high Z values by:
GRID> New_DEM = setnull (Old_DEM > 10000, OldDEM)

i) Correct null values by:
GRID> New_DEM = con (isnull (Old_DEM), focalmean (Old_DEM, rectangle, 2, 2), Old_DEM)

Once all values are corrected, use GRIDP to display final DEM:



Additional GRID tricks:

To clip a grid:

GRID> gridp Old_DEM
GRID> setwindow * /* define the box that you want to clip down from the Old_DEM
GRID> New_DEM = Old_DEM

PROJECT: Construct a slope map for the YM DEM. This will be use to evaluate how much tephra-fall is deposited on different slope angles. Use Arc/Info 7.2 for this analysis.

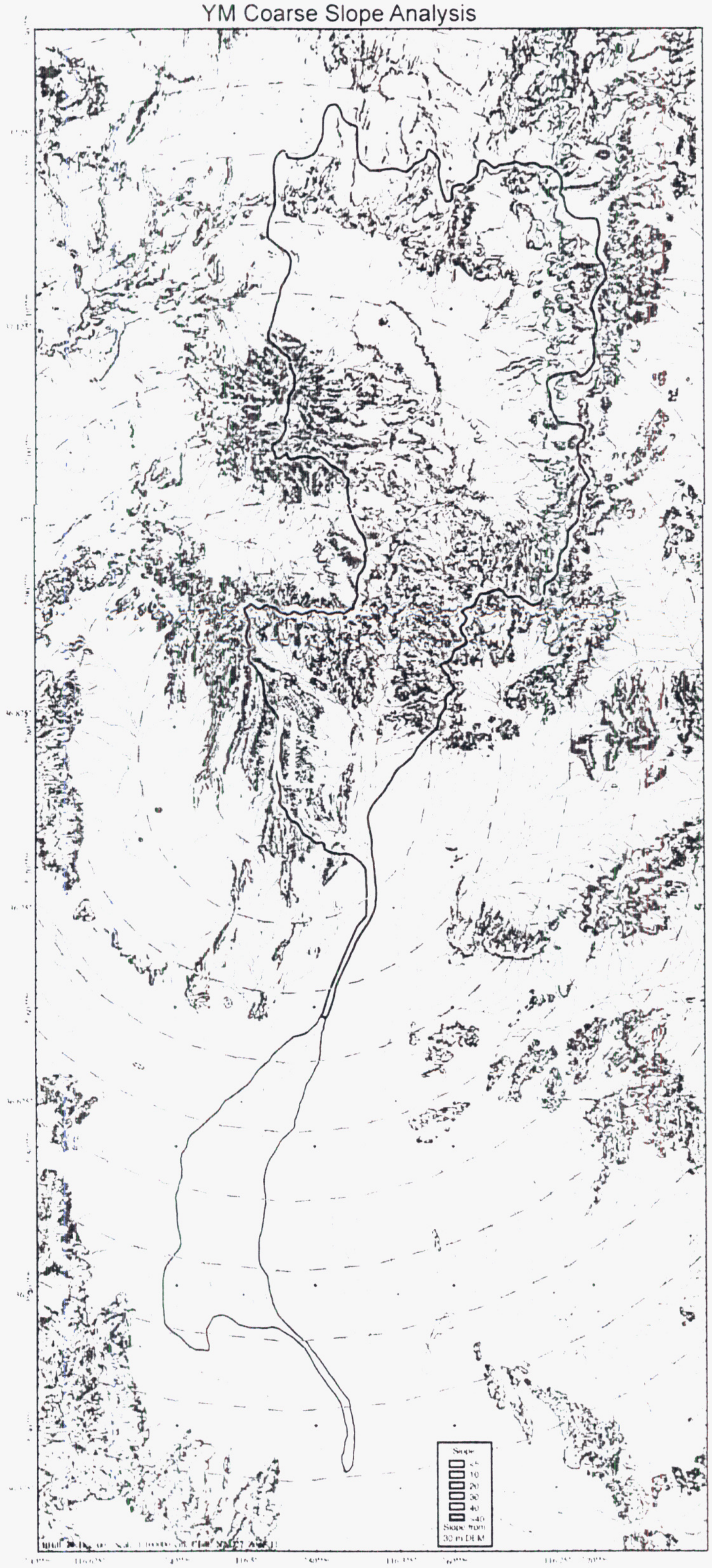
1) Define a look-up table in INFO, which bins the slopes into different degrees:

INFO> Define YMSLOPE.LUT /* Remember, all caps file name, and fn not = slope.lut
ITEM> DEGREE_SLOPE ....., 4,5, B /* These must be defined exactly as shown
ITEM> SLOPE-CODE ...., 4,5, B
ITEM> <cr>
INFO> ADD
for each DEGREE_SLOPE (enter), enter a SLOPE-CODE that bins the slopes. Here I'm using 5, 10, 20, 30, 40, and 50
<cr> item to end
INFO> Q STOP

2) To generate a polygon coverage with slope attributes:
ARC> latticepoly YM54DEM out_fn slope YMSLOPE.LUT
- NOTE: will get error "% slope not found", which is OK. Latticepoly first searches for item PERCENT_SLOPE, give error if not found, then looks for DEGREE_SLOPE and continues.

3) Print the slope map, convert to TIFF using Illustrator and Photoshop:

YM Coarse Slope Analysis



Project: Evaluate the amount of 1975 Tolbachik tephra falls, which, if deposited in the Fortymile Wash drainage basin, would be deposited on surfaces with moderate to high remobilization potential. This analysis assumes that tephra falls deposited on slopes 5–35° will be readily remobilized during flooding events. Slopes >35° are likely beyond the angle of repose for the tephra, resulting in slumping of material into drainages. Slopes <5° are assumed to have a low remobilization potential. This observation must be tempered, however, with the observation that tephra from the 80 ka Lathrop Wells volcano is removed from bedrock surfaces having slopes <5°.

1) Create a new slope map that bins slopes as <=5, 5–35, and >35°

INFO> Make look-up table YMSLOPE3.LUT same as YMSLOPE.LUT above.

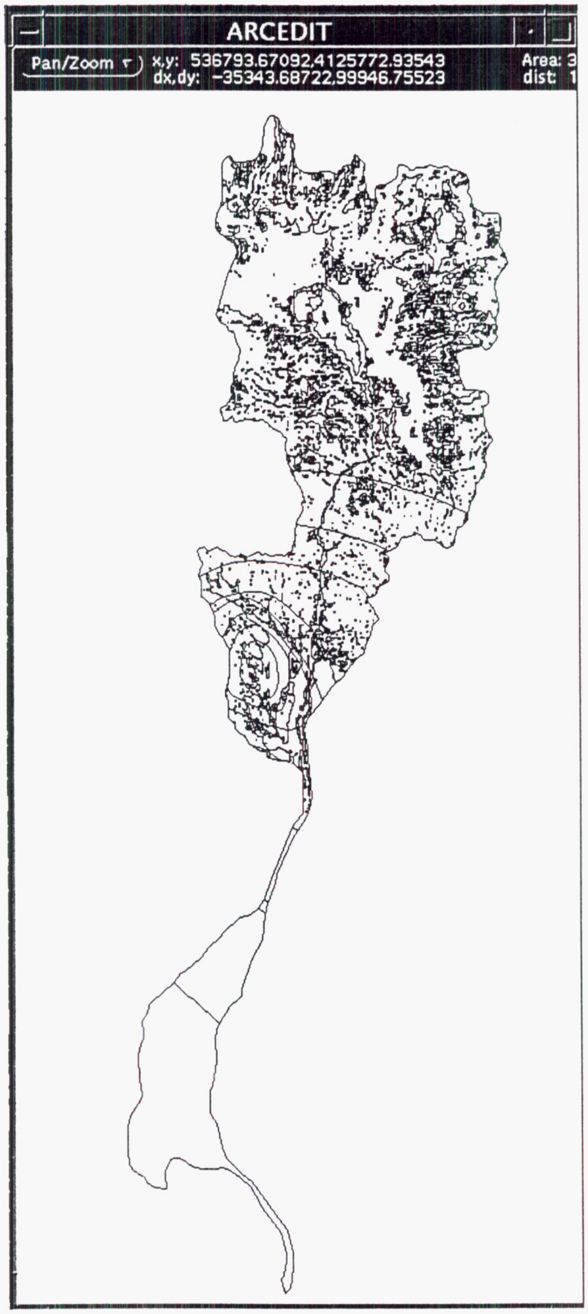
ARC> latticepoly fortymile_dem forty_slope3x SLOPE YMSLOPE3.LUT /* fortymile_dem is a clipped grid from ym54dem, that samples only the area immediately around the Fortymile system.

2) Clip the slope map with fortymile extent:

ARC> clip forty_slope3x fortymile fortyslop_clip POLY

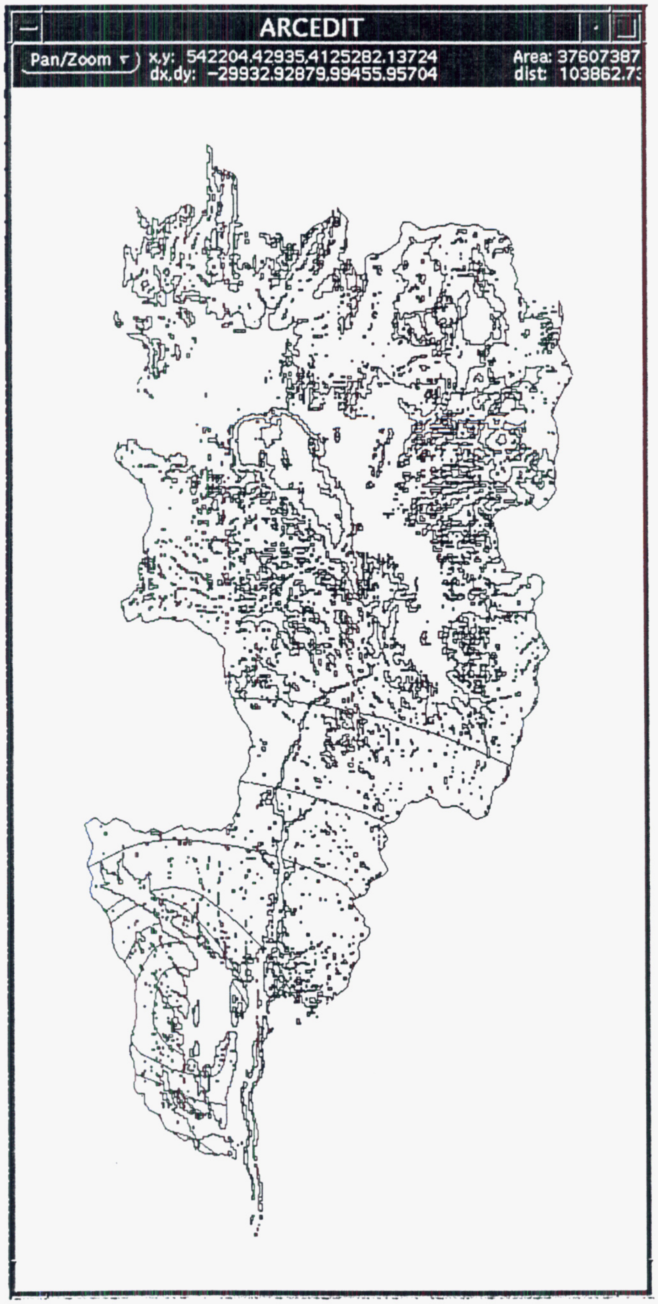
3) Now, intersect the tolbon and fortyslope clipped coverages into a single poly coverage:

ARC> intersect tolbisoclip fortyslop_clip tolb40slope POLY # JOIN



4) To evaluate the amount of tephra on 5–35° slopes

```
AE> edit tolb40_int
AE> de poly; ef poly
AE> sel for SLOPE-CODE = 35
AE> nsel; delete        /* this inverts the selection and deletes all polys not= to 35° slope
AE> save tolb40_35      /* save to new coverage
```



5) To get the numerical data out of the PAT file

TABLES> SELECT TOLB40_35.PAT

TABLES> UNLOAD TOLB40_35.TXT AREA TOLBISOCLIP-ID SLOPE-CODE DELIMITED INIT

/* this outputs the area, isopach thickness, and slope code for each poly in a comma delimited text file.

6) Read the text file into Excel as delimited text.

Sum up the areas of interest per thickness, and compare with original mass. Determine that 33% of the original deposit is on a remobilization slope (5–35°), or that 59% of the basin impacted by this eruption represents a remobilization surface.

Moving that mass downstream and depositing it uniformly on the Fortymile fan give a bulk thickness of 44 cm, versus an original depositional thickness of around 4 cm.

TOLBCLIP.XLS: area of tolbachik falls in fortymile drainage. BHill 1/2/01													
												SLOPE	Volume
Clip Coverage						**Original**	**Original**		**% in**	**Tephra in**		**area in**	**in 40-mile**
Poly#	**cm**	**Area km2**	**Sum km2**	**Sum m2**		**area m2**	**tephra m3**		**40-mile**	**40-mile**		**40-mile**	**Slope 5-35**
9	200	11.91	11.91	1.191E+07		1.191E+07	2.382E+07		100.0%	2.38E+07		5.93E+06	1.19E+07
8	150	16.949	16.949	1.695E+07		1.732E+07	2.599E+07		97.8%	2.54E+07		1.10E+07	1.66E+07
7	100	21.68	21.68	2.168E+07		2.645E+07	2.645E+07		82.0%	2.17E+07		1.20E+07	1.20E+07
10	50	15.078	27.645	2.765E+07		4.967E+07	2.484E+07		55.7%	1.38E+07		1.60E+07	8.00E+06
6	50	12.567											
12	30	1.117	20.664	2.066E+07		6.337E+07	1.901E+07		32.6%	6.20E+06		1.16E+07	3.49E+06
11	30	0.649											
5	30	18.898											
13	10	2.147	63.639	6.364E+07		2.409E+08	2.409E+07		26.4%	6.36E+06		5.16E+07	5.16E+06
4	10	61.492											
15	*5*	*0.481*											
14	5	2.474	40.402	4.040E+07		5.364E+08	2.682E+07		7.5%	2.02E+06		3.51E+07	1.75E+06
3	5	37.928											
16	*1*	*33.545*											
2	1	59.885	59.885	5.989E+07		1.005E+09	1.005E+07		6.0%	5.99E+05		5.44E+07	5.44E+05
1	0	0											
							1.811E+08		55.2%	9.993E+07		Remob:	5.94E+07
												% of Erupt	33%
Ital = In aggrading fan												% of 40mile	59%
					Area of Fortymile depositonal basin (m2):				1.355E+08				a/a
					Uniform thickness of tephra in depo (m):				7.38E-01				4.38E-01

Project: Construct a useable, shaded relief topographic map from YMR DEM. Nonspecialists often have a difficult time visualizing contour lines on maps, and do not understand scale of elevation changes. Shaded relief maps can help viewers think in 3D space. Arc*, however, does not provide direct utilities for display of shaded relief maps, except for gray scale.

By using a relatively detailed binning of elevation heights, and constructing a gradational color map for those elevations, a colored shaded relief map can be constructed from a DEM.

1) Determine elevation range of DEM, and decide how to bin elevation increments. For the Death Valley to YM region, elevation ranges from -100m to 2500m. Using the Excel spreadsheet TOPO_COLOR.XLS, make a table in the following format:

Elevation By 10m		Relate
-100	-90 :	1
-90	-80 :	2
-80	-70 :	3
-70	-60 :	4
-60	-50 :	5
-50	-40 :	6
-40	-30 :	7
-30	-20 :	8
-20	-10 :	9
-10	0 :	10
0	10 :	11
10	20 :	12

Note that the elevation must be in ascending order; I've tried using this technique in descending order (should make a more logical legend), but the reclassification doesn't work that way.

Copy this range and save as flat text file. Edit in TE to remove ^M and tabs, save as YMR_ELEV.LUT

Relate	Red	Green	Blue	Begin/end
1	200	225	225	b
2	201	225	224	
3	202	225	223	
4	203	225	221	
5	204	225	220	
6	205	226	219	
7	206	226	218	
8	207	226	217	
9	208	226	215	
10	209	226	214	
11	210	226	213	
12	211	226	212	

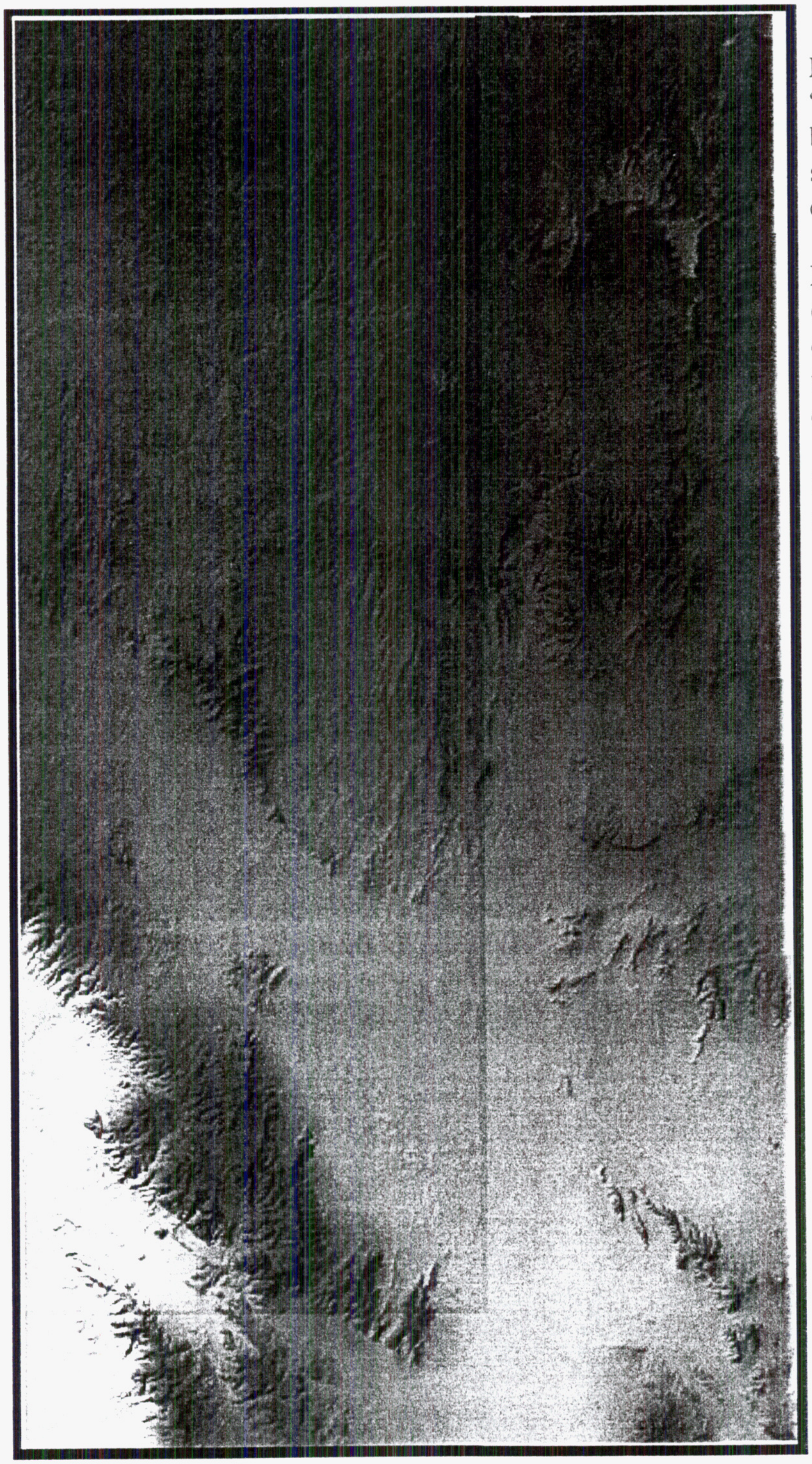
Using the same spreadsheet assign a RGB color to each relate item. Note that in TOPO_COLOR.XLS there are endpoints that represent the start and stop colors. Use the Excel SERIES command to create a regular RGB gradation between the endpoints.

Copy this range and save as flat text file. Edit in TE to remove ^M and tabs, save as YMR_COLOR.LUT

2) Use the RELIEF.AML to create a shaded relief map (HILL) and composite RGB maps that use the LUT's in step 1 to bin and color the shaded relief map. This AML is a series of GRID commands and is a macro, not a computer program.

```
/* relief.aml: creates "painted relief"
 /* jeffery s. nighbert
 /* bureau of land management
 /* 1515sw 5th ave
 /* portland oregon 97208
 /* phone 503-952-6399 email: jnighber@or.blm.gov
 /*
 /* assumptions:
 /* you're in grid and your window and mapextent are set
 /*
 /* needs two look-up tables
 /* elev.lut - classifies elevation into bins
 /* color.lut - colormap from YMCOLOR.XLS
 /*
 /* to run:
 /* &r relief <elev_map>
 /*
 /* arg definitions
 /* elev_map -- an elevation map with Z values in meters
 /*
 &echo &on
 &args elev_map
 /* kill off some maps

 &if [exists hill -grid] &then; kill hill all
 &if [exists illum -grid] &then; kill illum all
 &if [exists slice -grid] &then; kill slice all
 &if [exists red -grid] &then; kill red all
 &if [exists green -grid] &then; kill green all
 &if [exists blue -grid] &then; kill blue all

 /* The creation of illumination values
 /* create a hillshade map then divide by 255

 hill = hillshade(%elev_map%,315,65,#,1)

 illum = float(hill) / 255

 /*The assignment of color to elevation values
 /* reclassify elevation using elevation.lut

 slice = reclass(%elev_map%,ymr_elev.lut)

 /* Creating the painted relief backdrop
 /* use color2(X) commands at the same time use other functions
 /* int reduces the size of final grids
 /* con(isnull(),255 takes care of nulls in the map and assigns them "white"

red = int(con(isnull(color2red(slice,ymr_color.lut,nowrap) *
illum),255,(color2red(slice,ymr_color.lut,nowrap) * illum)))

green = int(con(isnull(color2green(slice,ymr_color.lut,nowrap) *
illum),255,(color2green(slice,ymr_color.lut,nowrap) * illum)))
```

```
blue = int(con(isnull(color2blue(slice,ymr_color.lut,nowrap) *
illum),255,(color2blue(slice,ymr_color.lut,nowrap) * illum)))

/* use "gridcomposite rgb red green blue" to display the results

gridcomposite rgb red green blue
```



Note that white areas represent "null" values in the DEM, caused by latitude divergence along a straight grid (geographic coordinate feature).

Lowest elevations are in blue gray (Death Valley), going from tans to orange to brown to olives and finally light greens at highest elevations on Pahute Mesa.

Note that this is a low-res version used for printing.

Contrast this with a typical shaded relief DEM. Note that you cannot really tell elevation differences between YM, Timber Mtn, or Pahute Mesa. In addition , Death Valley looks the same as Crater Flat:

Project: Integrate polygon files into shaded DEMs. Although the shaded DEM image can be used for a backdrop in plots, overlays of arcs and polygons are opaque and thus obliterate the topographic information. By blending the polygons with the shaded DEM, topographic information can be preserved for clarity.

1) Compile all relevant basalt into a single ARC coverage, YMRALLBAS. This combines the appropriate basalt from coverages FS95_BED (Frizzell and Shulters, 1990, geologic map of YMR), BURIED (Amargosa Desert and Crater Flat buried anomalies), DAY_DIKES (Solitario Canyon dikes from Day, Potter et al 1998 geol. map of YM, USGS I-2627), and YMRBAS50, which is a miscellaneous edit file that corrects some problems with Frizzell and Shulters boundaries, and contains basalt outside their map boundaries.

2) During GET, need to have the same items in the PATs. Use ADDITEM in AE, and DROPITEM in ARC to remove excess items. Preserve AGE information.

3) Create new item in YMRALLBAS.PAT, = VALUE = 4,5,B
- VALUE will be used to assign unique shades to specific age ranges.

4) sel all, calc value = 1002; Select for age <2, calc VALUE = 1001; age > 6, calc VALUE = 1003; sel age = 0, calc value = 0. Bins ages for shading.

5) Modify YMR_COLOR.LUT to YMR_COLORb.LUT by adding new RGB lookup colors at end, for basalt VALUEs. These colors are red for quaternary, green for Pliocene, and blue for Miocene: Note that you need to assign the secondary colors significantly above the values used in the elevation classifications:

...
249 149 170 108
250 150 172 109
251 152 174 111
252 154 175 113
253 155 177 114
254 157 179 116
255 159 180 118
256 160 182 119
257 162 184 121
258 164 186 123
259 165 187 124
260 167 189 126
1001 240 128 128
1002 150 250 150
1003 100 200 240

6) Convert YMRALLBAS to a grid:

```
GRID> bas_grid = polygrid(../YMRALLBAS, value, #, #, 15)
        /* gives a 15x15m grid
```

7) Now get rid of the null values in BAS_GRID, which will mess up the shading if not corrected

GRID> BAS_GRID0 = con(isnull(BAS_GRID), 0, BAS_GRID)

8) Blend the basalt grid with the YMR classified DEM, accounting for age VALUES

GRID> ELEV_BAS = con(BAS_GRID0 > 1000, BAS_GRID0, YM54_CLASS)

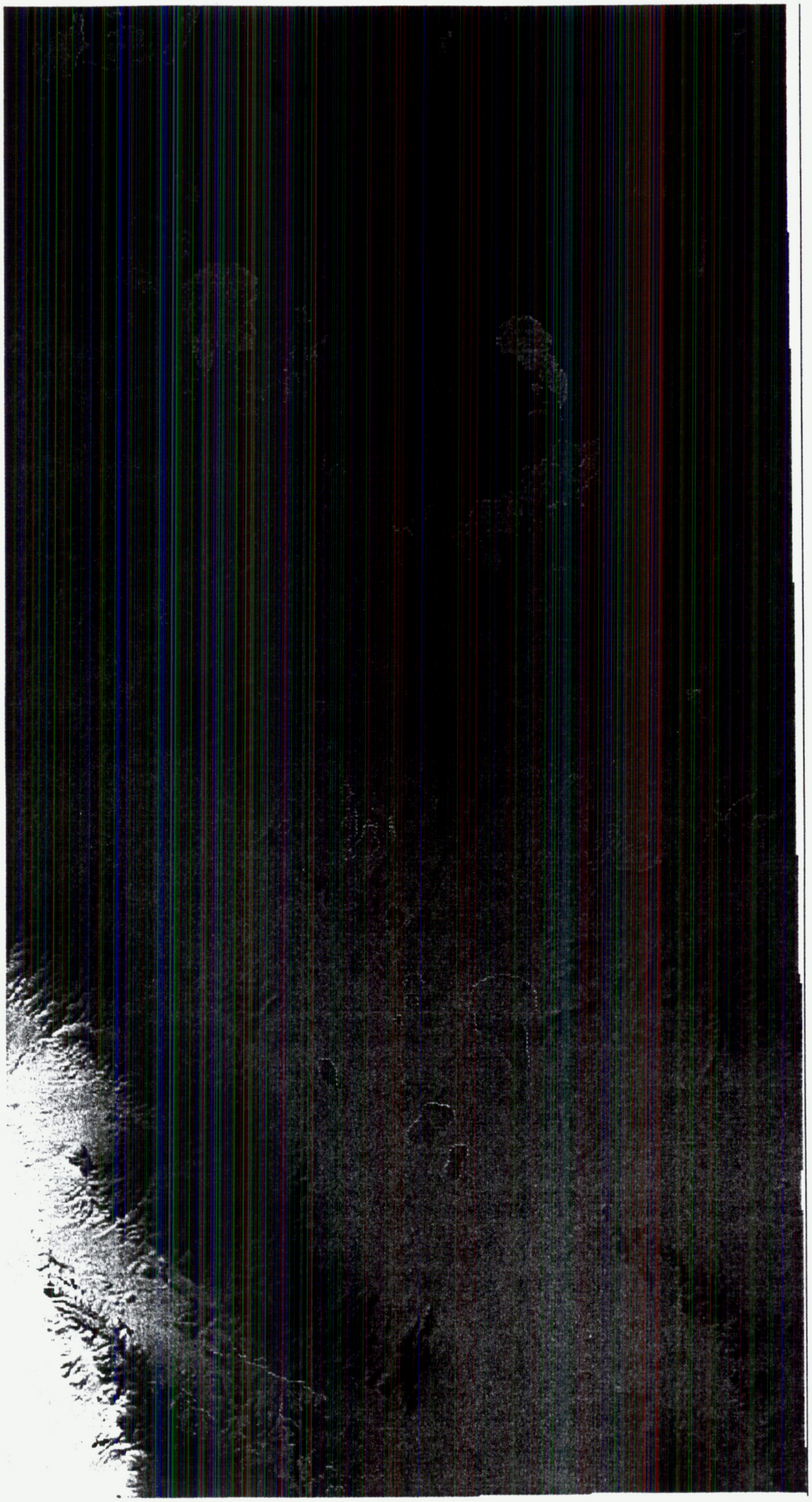
9) Clip ELEV_BAS so that only area of shaded DEM is of interest

GRID> gridp ELEV_BAS value linear nowrap gray
GRID> setwindow *
GRID> ELEV_BASALT = ELEV_BAS

10) To blend, run this command macro (BASCOLOR.AML). Basically, take ELEV_BAS and convert it to R,G, or B channels, and multiply it by the grid in YM54_SHADE for a composite:

```
bas54_red = int(con(isnull(color2red(ELEV_BASALT,YMR_COLORB.LUT,nowrap) *
YM54_SHADE),255,(color2red(ELEV_BASALT,YMR_COLORB.LUT,nowrap) * YM54_SHADE)))

bas54_green = int(con(isnull(color2green(ELEV_BASALT,YMR_COLORB.LUT,nowrap) *
YM54_SHADE),255,(color2green(ELEV_BASALT,YMR_COLORB.LUT,nowrap) * YM54_SHADE)))

bas54_blue = int(con(isnull(color2blue(ELEV_BASALT,YMR_COLORB.LUT,nowrap) *
YM54_SHADE),255,(color2blue(ELEV_BASALT,YMR_COLORB.LUT,nowrap) * YM54_SHADE)))

/* use "gridcomposite rgb red green blue" to display the results

gridcomposite rgb bas54_red bas54_green bas54_blue
```

This grid is displayed on the next page



Project: Estimate the solidus and liquidus for YMR basalt, based on existing literature. No direct measurements have been made, but these temperatures are needed for waste package disruption calculations.

Knutson and Green (1975, CMP 52:121–132) performed crystallization experiments on Hawaiite basalts similar in composition to YMR basalt. The advantage to these data are that they controlled H_2O content in addition to pressure, but did not evaluate the solidus or 1 atm conditions. YMR basalt has about 2 wt% H_2O in the melt, as documented previously.

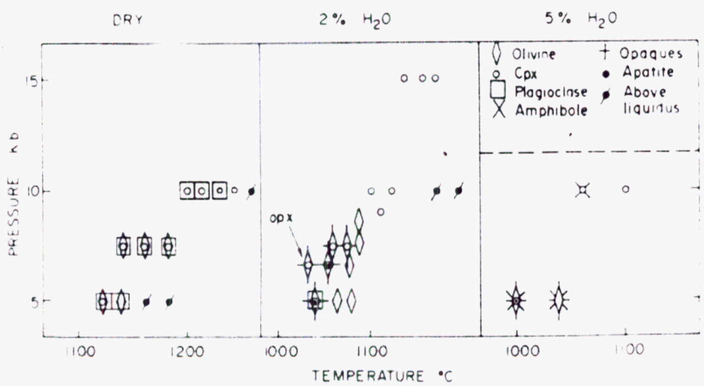


Fig. 1. Experimentally determined phase relationships for the Mt. Baldy hawaiite

From their figure 1, can see that the liquidus was not reached at 5 kbar, but is about 50C above the first crystallization at 10 kbar runs. Anhydrous 5 kbar has the liquidus at 1160C, and about 1250C for 10 kbar. Addition of H_2O will depress the liquidus, so liquidus for 2 wt% H_2O at 5 kbar should be about 1100C.

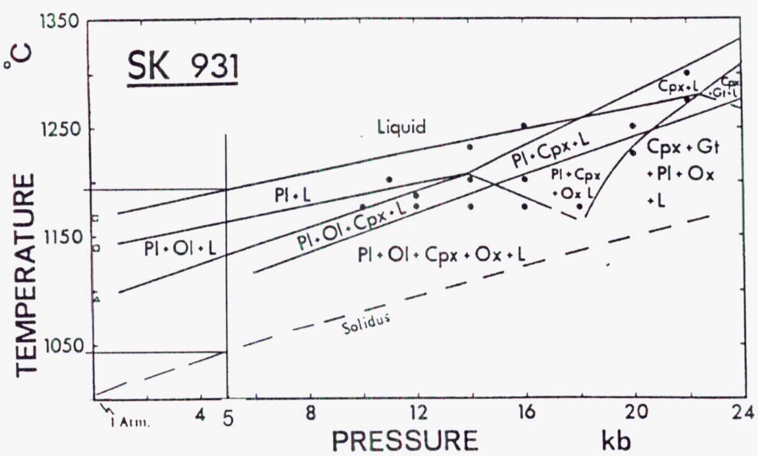


Fig. 6. Interpretation of melting experiments on near-aphyric hawaiite SK 931. Symbols as in Fig. 4

For 1 atm conditions, Thompson (1974, CMP 45:317–341) analyzed a hawaiite very similar to the YMR hawaiite basalts. His anhydrous melts have a liquidus also around 1200C, with the solidus at 1050C. This gives a crystallization interval of 150C. Thus, with the 2% H_2O liquidus for YMR basalt at around 1100C, the solidus should be around 950C.

Based on experience in basaltic experimental petrology, I would estimate an uncertainty of ±50C for these numbers. If these values are truly significant to performance, then the DOE will need to provide a suitable experimental basis for basalt crystallization in order to evaluate a range of thermal and mechanical stresses associated with basalt emplacement into repository drifts.

Entries into Scientific Notebook No. 88 for the period 9/01/00 to 3/31/01 (pp. 347–369) have been made by Brittain E. Hill. No original text entered into this Scientific Notebook has been removed.

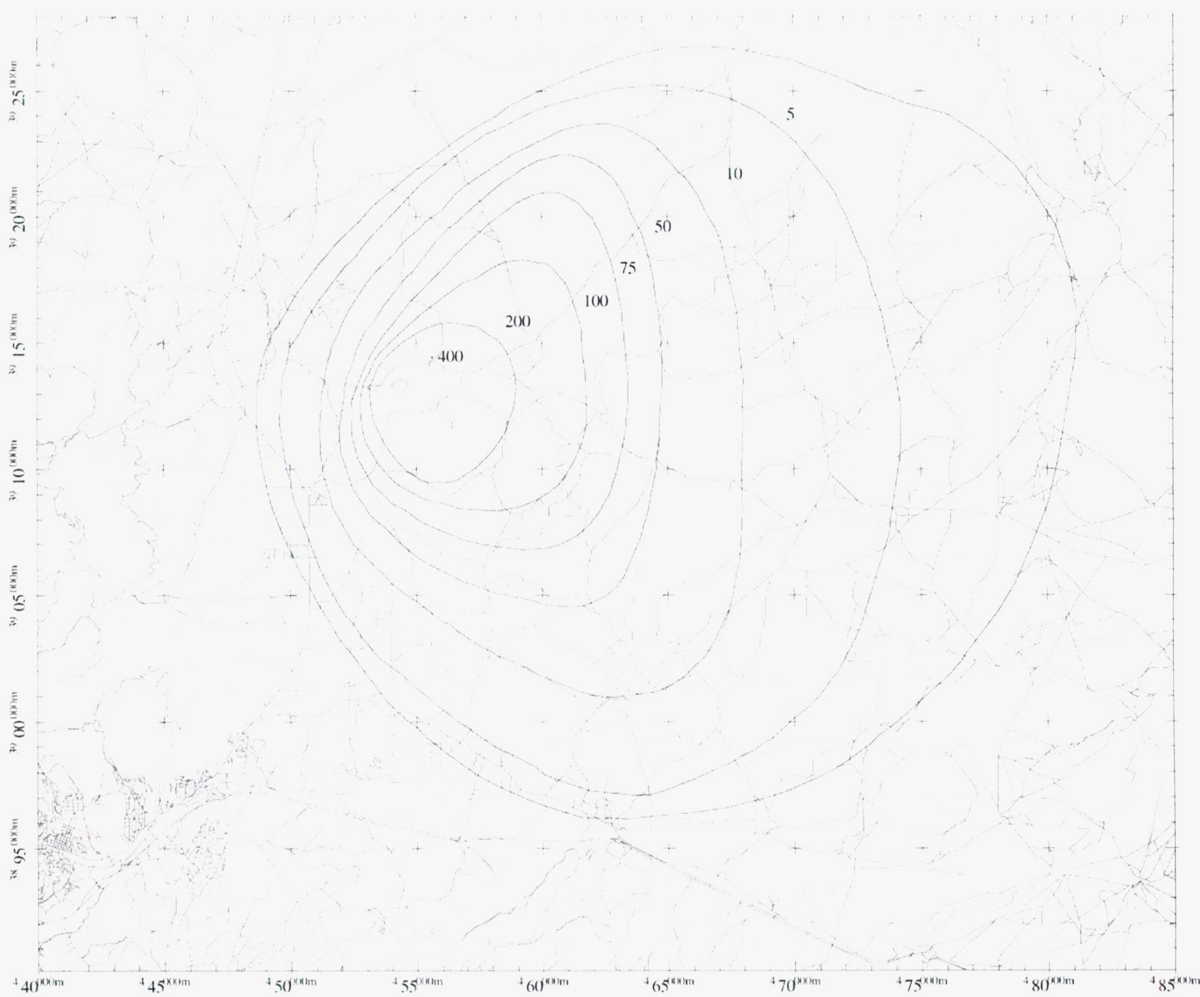
Brittain E. Hill [signature]

I HAVE REVIEWED THIS SCIENTIFIC NOTEBOOK, E 88, AND FIND IT IN COMPLIANCE WITH QAP-001. THERE IS SUFFICIENT INFORMATION REGARDIN THE PROCEDURES USED FOR CONDUCTING RESEARCH AND ACQUIRING AND ANALYZING THE DATA SO THAT ANOTHER QUALIFIED SCIENTIST COULD REPEAT THE ACTIVITIES RECORDED IN THIS SCIENTIFIC NOTEBOOK H. L. McKague 03/20/01

Project: Evaluate the possibility of using Sunset Crater, AZ, as an analog to remobilization of YMR tephra. First need to determine where the fall deposits are, then look at availability of accessible drainages. Thus, need to construct a GIS for this area. Use same basic procedure for creating slope-maps as for YMR, in last quarter's section of this notebook.

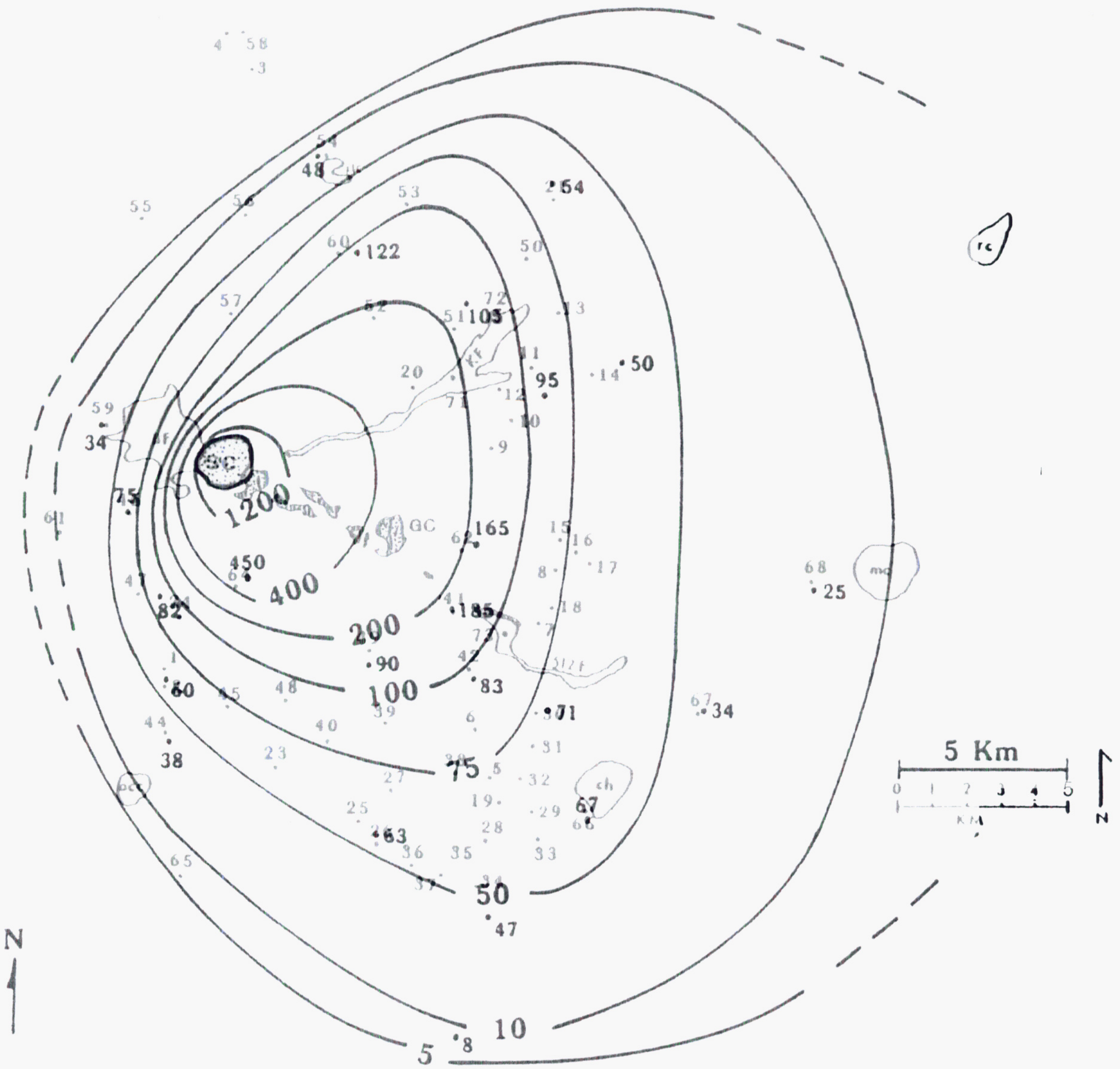
(1) Need stable topographic base for all maps.

- Using http://edcwww.cr.usgs.gov/Webglis, download 1:100,000 scale digital line graphics (DLG) for the Flagstaff 30'x60' quadrangle
- Uncompress and tar -xvf a single packed file into multiple SDTS files with common prefix
- Unlike simple DEMS, these SDTS files contain multiple layers. If you use SDTSIMPORT command in Arc/Info, will only get the first layer. Need to run SDTS2COV.AML (attached electronically), which combines all appropriate layers into a theme coverage.
- Unpack and combine coverages for Flagstaff topography (FLAG100CONT), hydrology (FLAG100HYDR), and roads+trails (FLAG100ROAD). These files are backed up electronically as part of BHill GIS backups.
- Using the SUNMAP.AML (attached electronically), construct a simple topographic base map from these coverages (ignore isopachs):



BHill 16 Apr 01 Scale 1:198950 cm, CI=50, NAD27 Zone 12

(2) Register the isopach map from Amos (1983, Sunset Crater Arizona: Evidence for a large magnitude strombolian eruption. MS thesis, Tempe, AZ: Arizona State University). Unfortunately, his isopach map on p. 64 has no geographic features to register. Need to overlay his sample location map (p. 53) onto sample locations on the isopach map. This is done using Adobe Photoshop, with the locations be a secondary transparent layer. Then the isopach map is sized in Photoshop until the location points match as closely as possible the location on the underlying map:

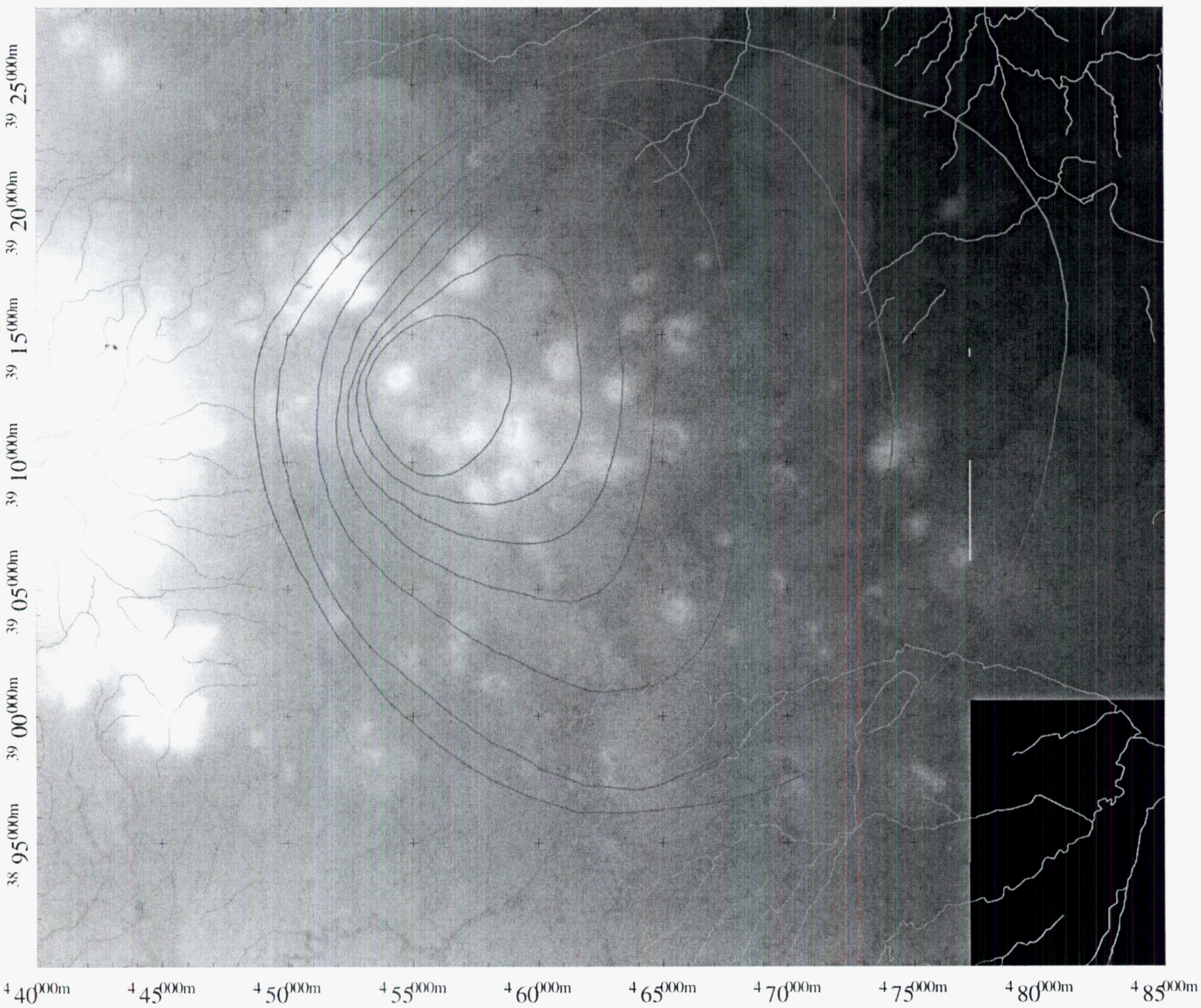


(3) In Arc/Info, use the REGISTER command to warp the TIF image to the FLAG100CONT locations of these cinder cones (gray, labeled areas on TIF image).

(4) Using Arc/Edit, trace the isopach arcs onto a new coverage. Add labels for isopach thickness. Build arcs and polygons. Plot as above to confirm general location of isopachs with cinder cones.

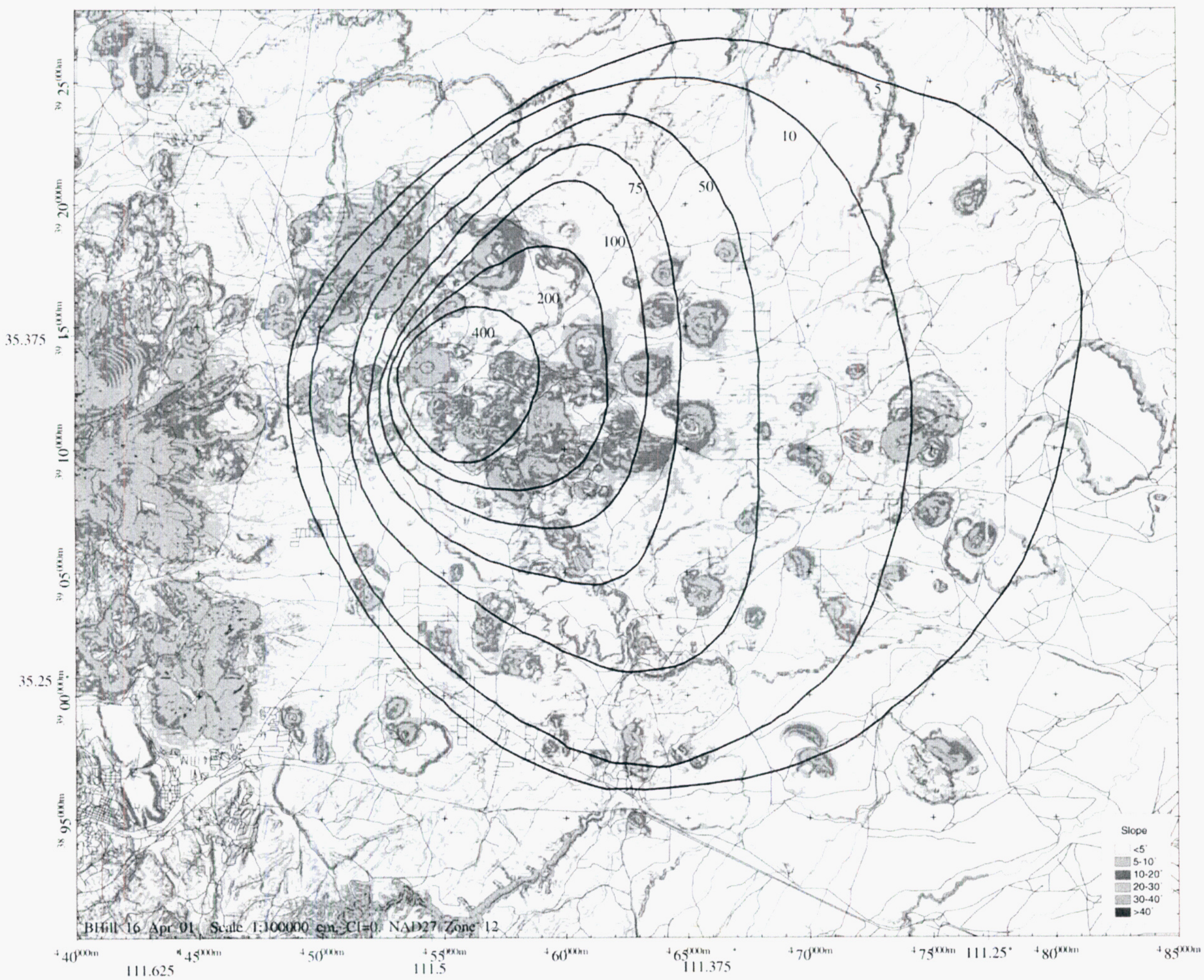
(5) Construct DEM of isopach area and nearby downgradient areas. Again, Download 7.5' DEM SDTS files from http://edcwww.cr.usgs.gov/Webglis, for the 14 quadrangles surrounding Flagstaff. These quads are copied onto the accompanying CD-ROM Flagstaff DEMs. Using procedures outlined in last quarter's section on YMR DEMS, combine and edit the 7.5' quads into a single DEM (FLAG14DEM):

Also shown are drainages and Sunset Crater Isopachs.
Lower right quadrangle has no DEM information available from the USGS, but is not needed for this study.



(6) Calculate slope map. Define a look-up table in INFO, which bins the slopes into different degrees:
INFO> Define SUNSET.LUT /* Remember, all caps file name, and fn not = slope.lut
ITEM> DEGREE_SLOPE ....., 4,5, B /* These must be defined exactly as shown
ITEM> SLOPE-CODE ...., 4,5, B
ITEM> <cr>
INFO> ADD
for each DEGREE_SLOPE (enter), enter a SLOPE-CODE that bins the slopes. Here I'm using 5, 10, 20, 30, 40, and 50
<cr> item to end
INFO> Q STOP
- Generate a polygon coverage with slope attributes:
ARC> latticepoly FLAG14DEM out_fn slope SUNSET.LUT
- *NOTE*: will get error "% slope not found", which is OK. Latticepoly first searches for item PERCENT_SLOPE, give error if not found, then looks for DEGREE_SLOPE and continues.

(7) Plot relevant features onto slope map:
Areas in southern part look favorable for 0.5 m deposits and throughgoing drainages. End Project.



Project: Perform simplified calculations to scope how removal rate may affect net accumulation processes at Fortymile Wash, NV. Following a volcanic eruption, tephra is distributed over a relatively large area (100–1000 km2) based on analog data. As shown on pages 357–361 of this notebook, using a 1975 Tolbachik eruption gives analog approach to evaluating how much tephra can move off of steep (i.e., >5°) bedrock surfaces and flow into Fortymile drainage. For the example 1.8e8 m3 original eruption directed to SE, about 6e7 m3 would fall on remobilized surfaces (about 1/3 of deposit volume). In the given example (p. 361), having all this tephra move instantaneously down the Fortymile drainage and be deposited uniformly in the depositional basin (south of Hwy 95) gives a deposit 44 cm thick.

Realistically, the tephra deposit will move down the hillsides and through the Fortymile drainage system at some rate, rather than instantaneously. In addition, although mass is accumulating at the depositional system, mass also is being removed from erosion (wind and water), in addition to mixing with soil and leaching through irrigation and rainwater. We currently model removal as a simple exponential function (i.e., ASHREMOVE in the TPA 4.0 code), which also accounts for geochemical effects and radioactive decay.

In this scoping calculation, I'm just concerned with tephra mass and not radionuclide concentration. Thus, for any given year following the eruption of M_0, the mass of tephra M_i removed from the hillside and input into the depositional point is

$$M_i = M_0\left(\exp^{-\lambda_i t} - \exp^{-\lambda_i t+1}\right)$$

and the mass of tephra removed from the depositional point is

$$M_r = (M_0 + M_i)\left(\exp^{-\lambda_r t_1} - \exp^{-\lambda_r t_2}\right)$$

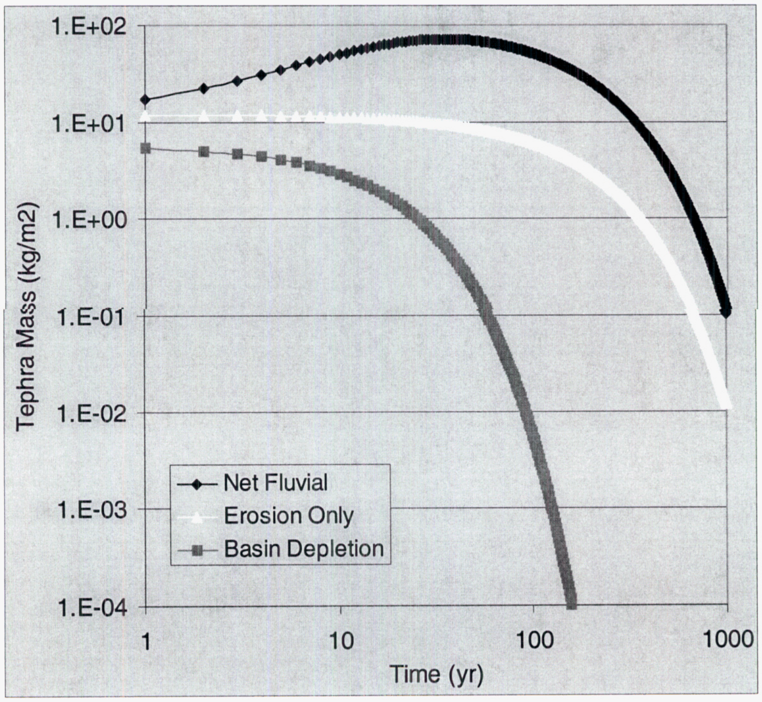
For any year, there is an influx of new tephra (M_i). Thus, the deposit ages like a 1-yr-old deposit after each influx, even if it is 100 years after the eruption. Using t=100 would give a much lower removal rate, corresponding to a deposit that has appreciably aged *in situ* without any influx of new mass. So, although we use a half-life of 100 yrs for the distal (i.e., slopes <5°) deposit, the time of "decay" is continuously reset each year by the influx of new mass M_i. In addition, when doing the actual calculations in spreadsheet REMOBIL.XLS (attached)*, note that the mass tracking is the original mass (M0) plus the net change in mass given the previous years influx and erosion.

For the first example, I assume the removal half-life from bedrock surfaces is 10 yrs, based on appreciable erosion of the Paricutin, Mexico fall deposits on older, less permeable surfaces (eg., Segerstrom, USGS, 1950). The *in situ* deposit at the critical group location erodes more slowly, at 100 yr half life. This is still very short, considering, for example, that the 1000-yr-old Sunset Crater fall deposits are still only about 50% eroded from steeper surfaces (i.e., half-life may be on order of 1000 yr, as assumed in current TPA modeling).

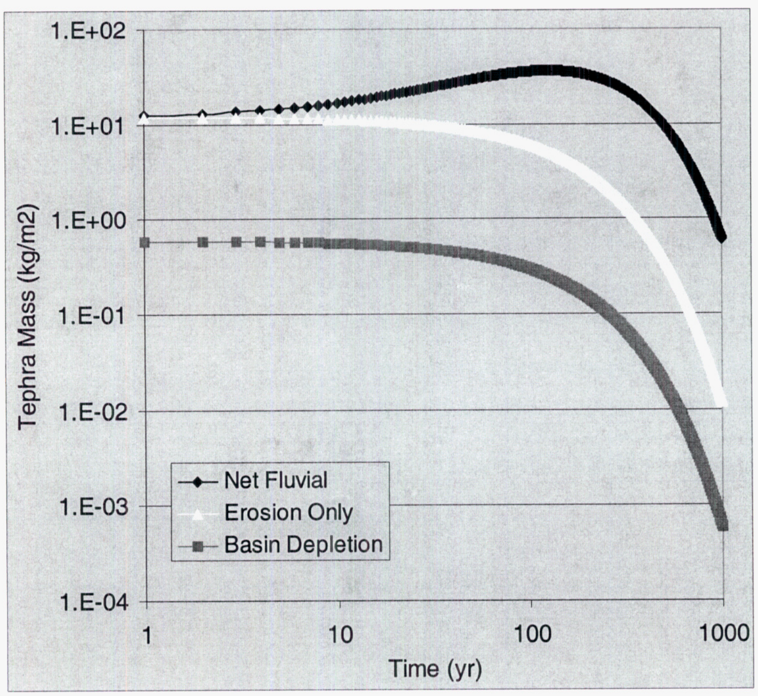
Applying these half-lives to the two equations above gives:

* IN ATTACHED HIGH DENSITY DISK

B. Hill
10/12/01



For a typical deposit with 1200 kg/m3 density, an initial 1-cm-thick fall (i.e., yellow triangles) receives a small amount of mass each year from a rapidly decaying fall deposit up-gradient (purple squares) and also erodes in situ. After about 100 years, the net effects of accumulation versus erosion have peaked, giving about a factor of 6x increase in tephra mass per unit area in the depositional system. Again, this model assumes uniform deposition throughout a very large depositional basin - in reality, the actual depo system is more narrowly constrained and sedimentation is more exponential towards source, rather than uniform.



Using the same assumptions as before, but increasing the tephra half-life to 100 yr extends the period of peak accumulation to several hundred years after the eruption, and reduced the magnitude of the peak to about 3x the initial deposit thickness.

Both of these simplified examples demonstrate that the net accumulation of tephra in the Fortymile drainage system may result in deposit thicknesses that significantly exceed original depositional thicknesses. For scenarios where the tephra plume is directed away from the critical group, fluvial remoblization could still result in an appreciable dose. Thus, we need to continue requiring the DOE to evaluate this process, using realistic models and assumptions.

Entries into Scientific Notebook No. 88 for the period 4/01/00 to 9/30/01 (pp. 370–375) have been made by Brittain E. Hill. No original text entered into this Scientific Notebook has been removed.

Brittain E. Hill [signature] 9/18/01

375 A

NOT IN SCIENTIFIC NOTEBOOK /HLMcK

I have reviewed scientific notebook 88E and find it in compliance with QAP-001. There is sufficient information regarding procedure used for conducting the research and acquiring and analyzing the data so that another qualified scientist could repeat the activity or activities recorded in this scientific notebook

H. Lawrence McKague 04/03/02

H. Lawrence McKague
GLGP Element Manager

H. L. McKague

Continuation of Field Volcanism Research Project - Scientific Notebook #E88, Started June 10, 1993 - Brittain Hill. WP8.0 file FELDVOL10.NOT

April 8, 2002

Project: Evaluation of geophysical information used to detect and characterize buried volcanic features in the Yucca Mountain region. New information from the U.S. Geological Survey and CNWRA indicates the DOE may have missed about half of the existing basaltic volcanoes in the Yucca Mountain region during site characterization. Additional volcanoes also may be present but undetected within approximately 20 km of the proposed repository site. Without direct information on the age and composition of these potential volcanoes, effects on probability models and risk calculations are highly speculative. The risk significance of this uncertainty ranges from potentially negligible, to a potential order of magnitude increase in igneous event probability. This uncertainty can be reduced through direct drilling of likely basalt locations. The range of uncertainty in these interpretations and associated new information clearly exceeds the uncertainties and information considered by DOE during probability model development in 1995.

Entries in this section of notebook E88 detail the data process steps used to create geophysical anomaly maps and interpret these maps. The details of these interpretations and relevance to probability models are discussed in IM 01420.461.215 "Evaluation of Geophysical Information Used to Detect and Characterize Buried Volcanic Features in the Yucca Mountain Region."

Data processing was performed using the Oasis MONTAJ™ software from Geosoft Inc. Data grids were generated using a standard minimum curvature algorithm that constructs the smoothest possible surface between the data points and grid nodes. A grid-node spacing of 100 m was selected for consistency with the original data processing technique (Blakely et al., 2000; O'Leary et al., 2002). The contouring algorithm used to prepare the maps contains a histogram stretching routine to equalize the relative areas of each contour interval. Thus, maps in this report have contour intervals that are irregular. Anomaly names used herein are consistent with the named anomalies in O'Leary et al. (2002).

The Blakely et al. (2000) data were downloaded from the USGS:
ftp://geopubs/wr.usgs.gov/pub/open-file/of00-188/data

and decompressed using the standard UNIX gzip utility. Files are contained in the main directory of the E88 CD-ROM for this reporting period.
amargosa.xyz: Magnetic field measurements every 10th point along survey flightlines, ASCII xyz format
amargosa.grd: 100-m grid of magnetic anomaly, in Geosoft gxf grid exchange format
amargosa.info: Text file describing the data.

An image of the original USGS grid file, displayed using MONTAJ with a default colormap (COLOUR.LUT) and histogram stretch on contour interval (i.e., equivalent to all processing used in this report), is shown on the next page.

Throughout this section of notebook E88, I refer to the accompanying data CD-ROM. This CD contains the MONTAJ grid and support files used to create the images in this section, along with the georeferenced TIFF formatted image files that result from this grid processing.

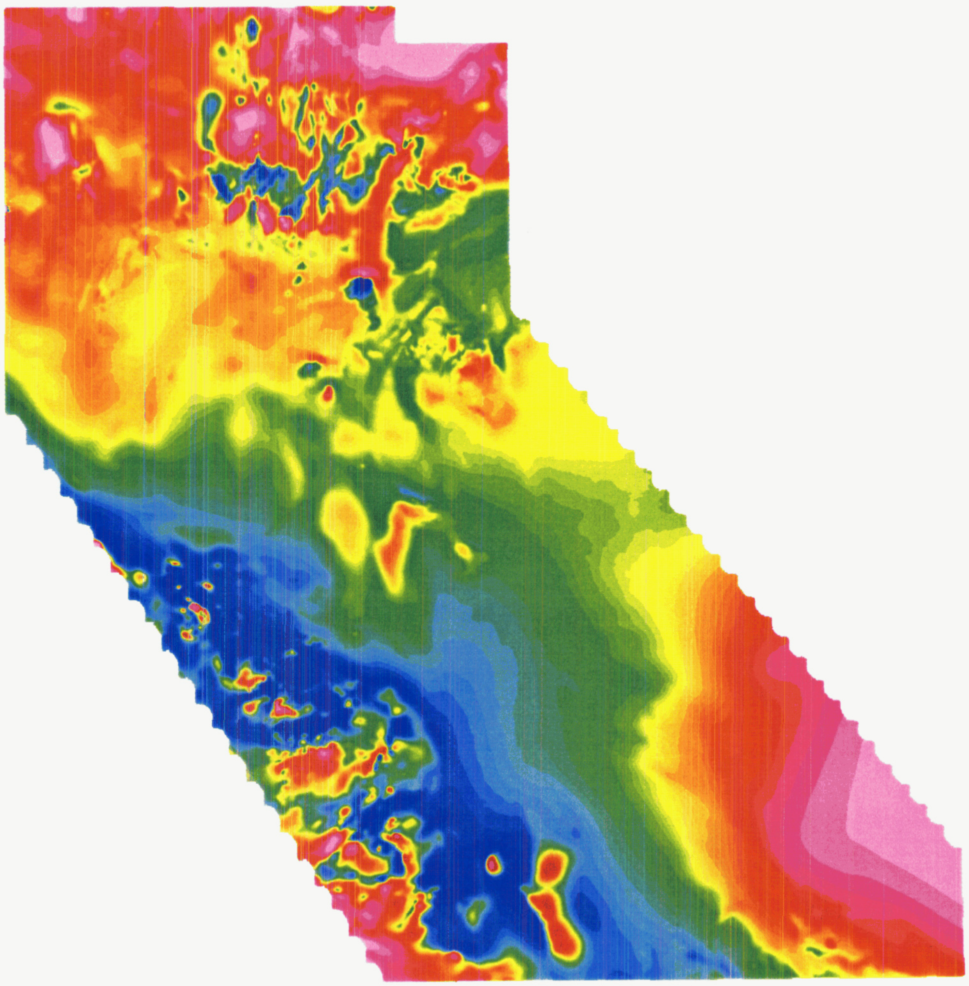
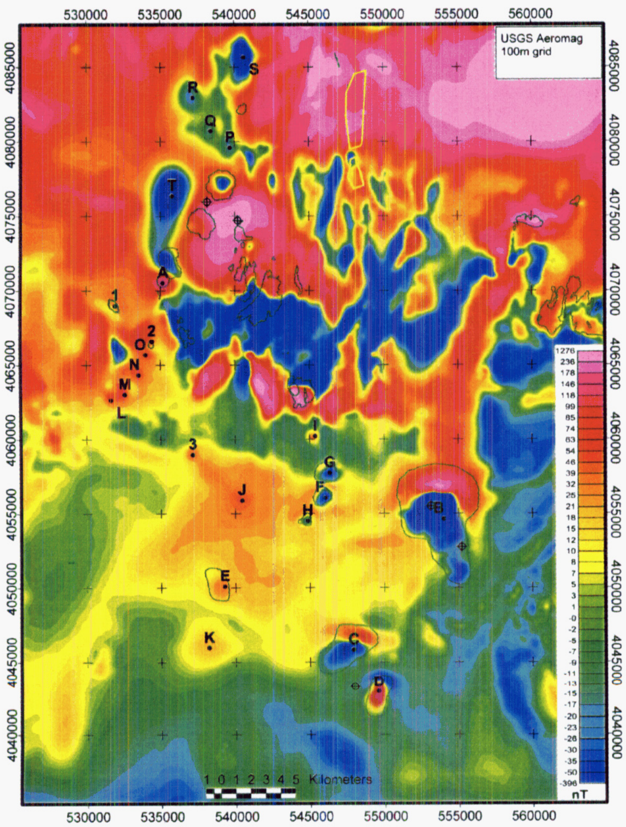


Image AMAR1.JPG of the USGS Amargosa Desert survey, original data from Blakely et al. (2000). The remainder of this notebook focuses on analysis of the upper half of this survey, which is localized on the proposed Yucca Mountain repository site.

Using MONTAJ, the original xyz data file was clipped to the region of interest around Yucca Mountain. This clipping allows for quicker processing, and contouring of anomaly amplitudes constrained by the area of interest rather than the entire, original survey. The clipped data are referred to as the Yucca Mountain Region (YMR) survey.

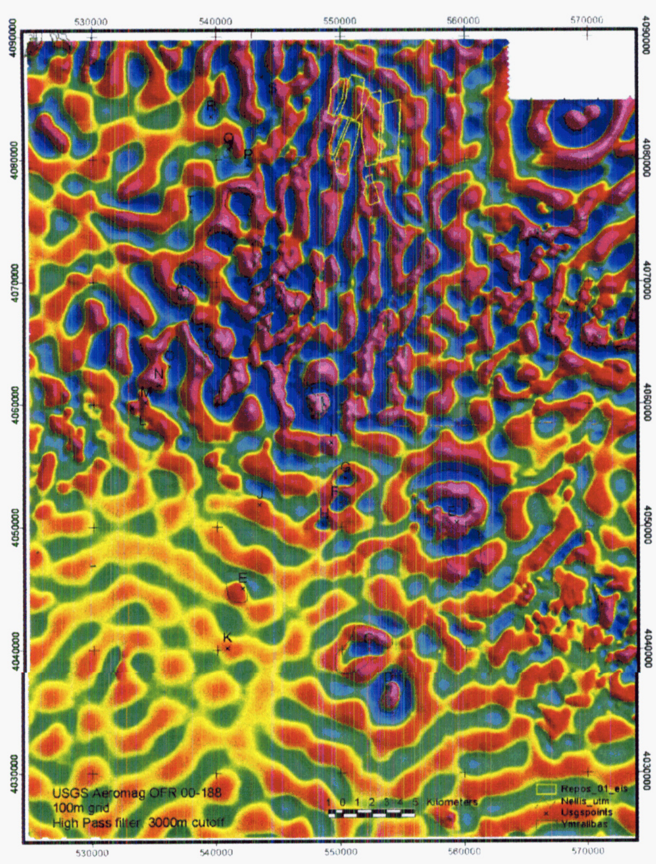
To conduct mag processing in MONTAJ, goto GX => load menu. At dialog box, select Magmap. to add to the menu bar. Under MAGMAP there are four subheadings (i) prepare grid, (ii) forward fft, (iii) define filter, and (iv) apply filter. Under Define filter select d:/geosoft/program/magmap.omn, select type, and then apply filter following the different popups.



For clarity, many of the following figures are shown with UTM coordinates (NAD27, Zone 11) and outlines from Arc/Info GIS coverages located in /IO/home/bhill/arcstuff/ymregion. These coverages show the outline of the repository site used in the DOE TSPA-SR, along with outlines of surface (dark green) and buried (lighter green) basalts, drill holes (crossed circles), and general centers of anomalies from O'Leary et al. (2002).

The base image for this figure is cd/cf_100/cf_100_base.tif

Note that this grid and contour plot is generally consistent with the USGS figure on the preceding page. The intensity and peak-to-peak strength of some anomalies are more pronounced, due to a contour range controlled by this region of interest.

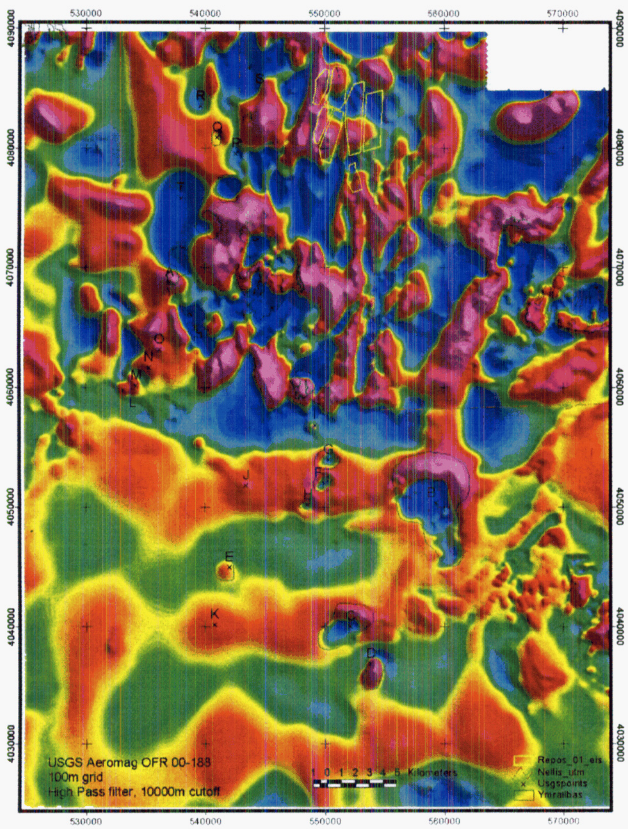


MONTAJ contains numerous tools to process magnetic data, using well-accepted Fast Fourier Transformations. A high-pass filter removes the magnetic component of larger scale features from the anomaly data, leaving only the contribution from smaller scale features. There is no general rule to select the cutoff wavelength for high-pass filtering. I selected several different wavelengths to see which size feature gave the most useful information in identifying unique anomalies that may represent buried basalt.

This image uses a 3000 m cutoff wavelength, enhancing anomalies with wavelengths less than 3 km

The base image for this figure is cd/cf_100/cf100_hip3k.tif

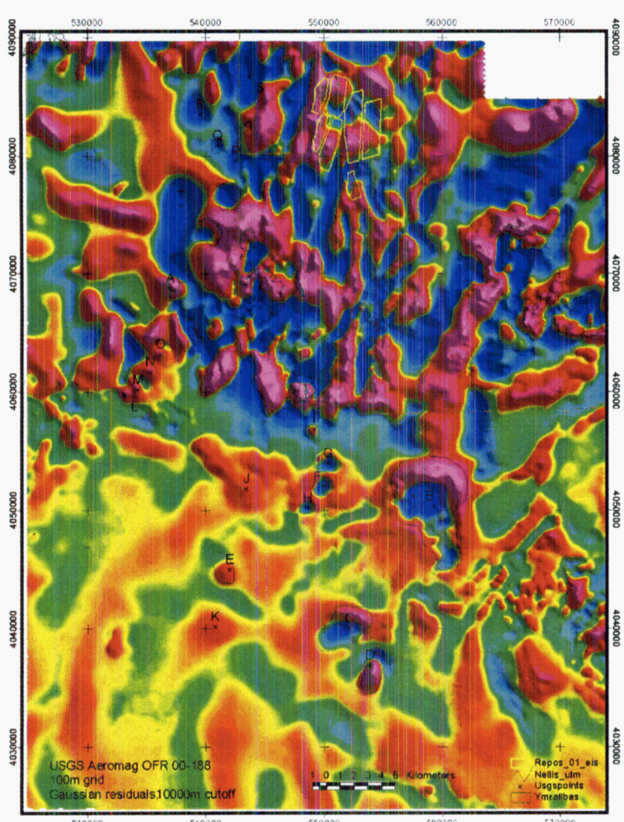
Note that anomaly patterns in the Amargosa Desert and Crater Flat basin appear fairly uniform, but known basaltic volcanoes do not appear to have characteristic anomalies.



This image uses a 10,000 m cutoff wavelength, enhancing anomalies with wavelengths less than 10 km

The base image for this figure is cd/cf_100/cf100_hip10k.tif

Note that anomaly patterns in the Amargosa Desert and Crater Flat basin appear very similar to the original base figure, although some anomalies in the Amargosa Desert are enhanced by high-pass filtering.

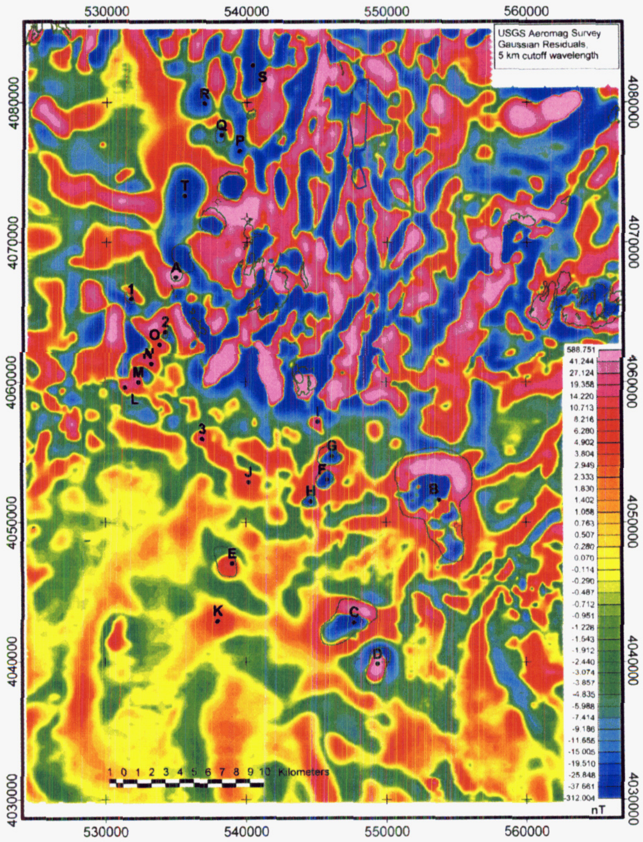


A FFT method similar to high-pass filtering is a Gaussian residual filter, The magnetic component of the long wavelength feature is removed from the total-field anomaly by using a Gaussian function to interpolate the average signal of the regional feature across the survey region. The coherence of the resulting map is a direct function of the wavelength selected for the regional feature.

This image also uses a 10,000 m cutoff wavelength, enhancing anomalies with wavelengths less than 10 km

The base image for this figure is cd/cf_100/cf100_resid10k.tif

I chose to use the Gaussian residual rather than the high-pass filter as there is less signal attenuation with the residual filter, and it enhances the dipole characteristics of known basaltic features.

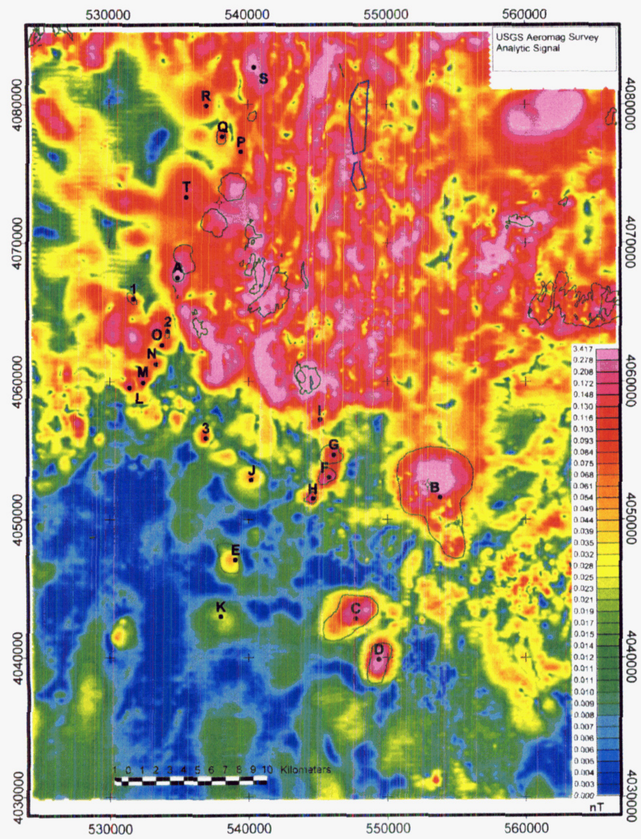


April 9, 2002: Continuation of project.

This image uses a 5,000 m cutoff wavelength, enhancing anomalies with wavelengths less than 5 km

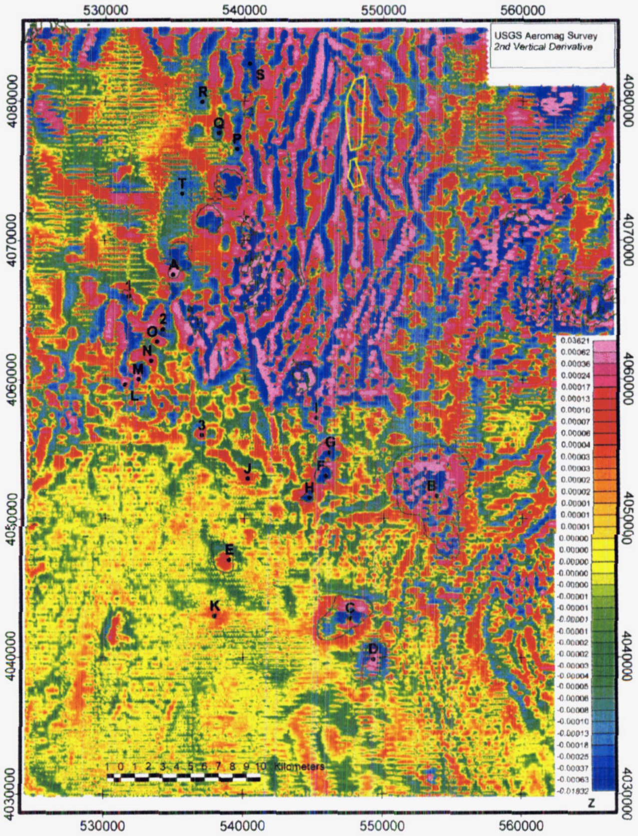
The base image for this figure is cd/cf_100/cf100_resid5k.tif

Thus, a 3km cutoff produces many small, nonunique anomalies whereas a 10km cutoff gives only small differences from the original map. I use the 5km cutoff residual to enhance the character of anomalies that may represent buried basalt.



An analytic signal filter is used to calculate the absolute strength of an anomaly from the magnetic field's three mutually orthogonal spatial (x, y, z) derivative terms. This filter provides a simple comparison of the anomaly strength between features with normal and reverse remnant magnetization, and often is used to delineate the edges of source bodies. The analytic signal map illustrates the complexities and limitations to anomaly interpretations in the Crater Flat basin, due to the abundance of high remnant magnetization tuffs. Note that known basaltic features in the Crater Flat basin also are not particularly well defined by application of the analytic signal filter. Identified anomalies, however, generally have higher analytic signal strengths than surrounding rock

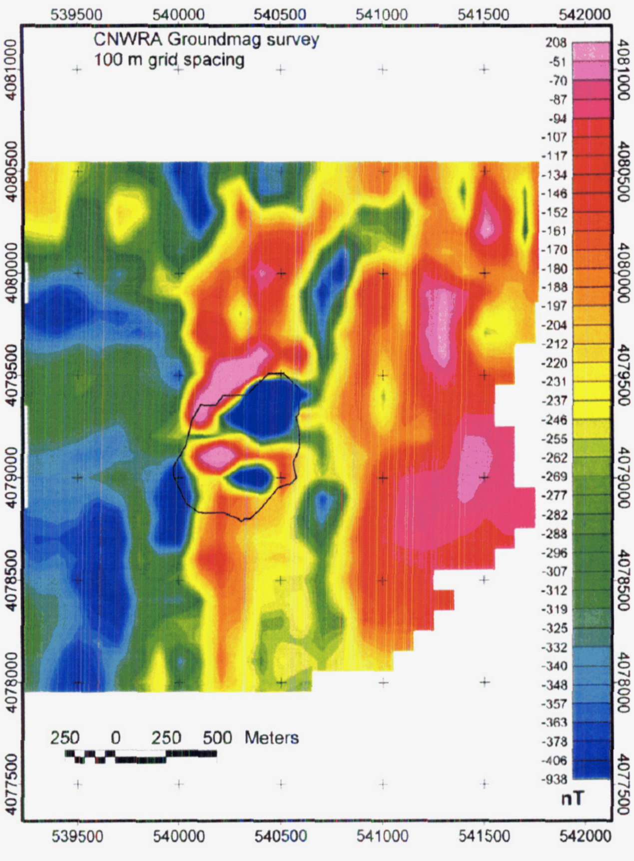
The base image for this figure is cd/cf_100/cf100_analytic_flat.tif



The second vertical derivative calculates the gradient in the magnetic anomaly field, emphasizing steep gradients and attenuating longer wavelength features. This calculation enhances shallow local anomalies in a manner similar to a high-pass filter, without the need to define cutoff wavelengths for the background features.

This enhances the definition of most identified anomalies. In addition, this filter emphasizes the complex, north-northeast-trending structural grain within the Crater Flat basin due to faulting of welded ignimbrite deposits. The abundant, steep magnetic gradients in Crater Flat basin clearly obscure the anomaly characteristics of known basaltic features.

The base image for this figure is cd/cf_100/cf100_2derv_vert.tif

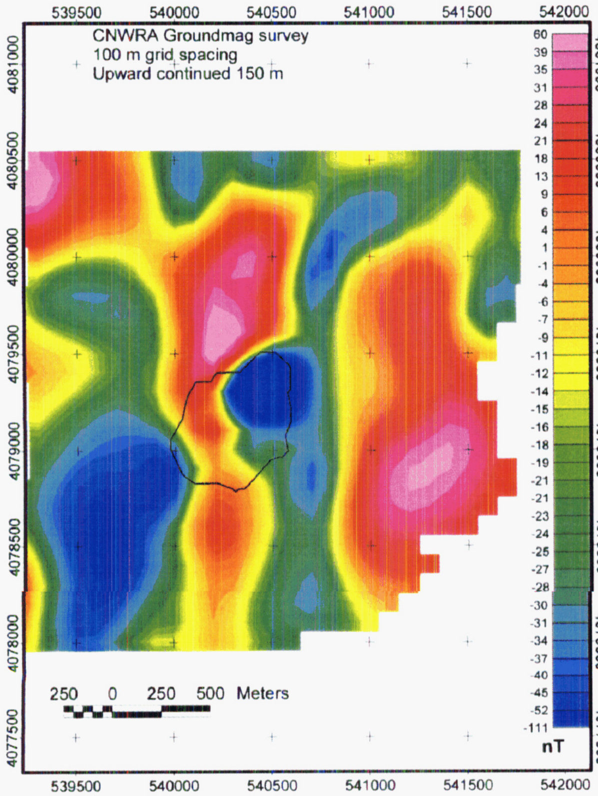


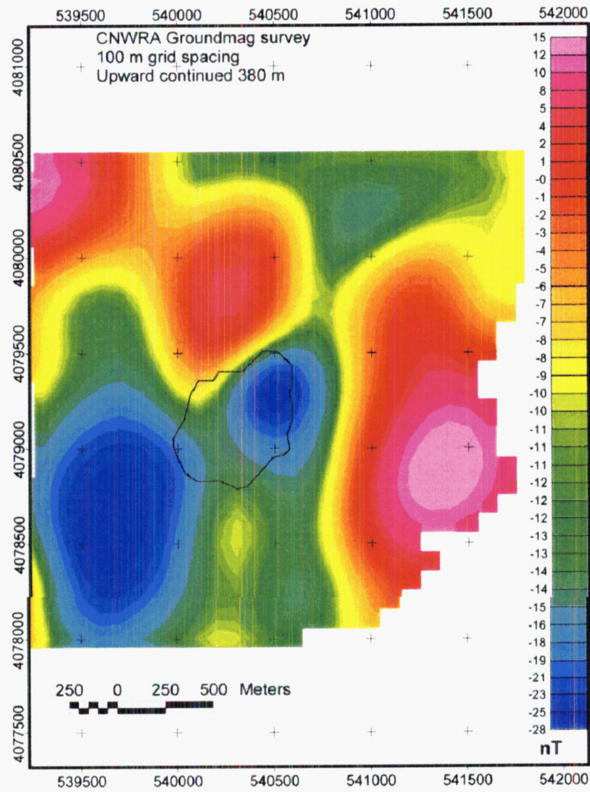
April 11, 2002: Continuation of project.

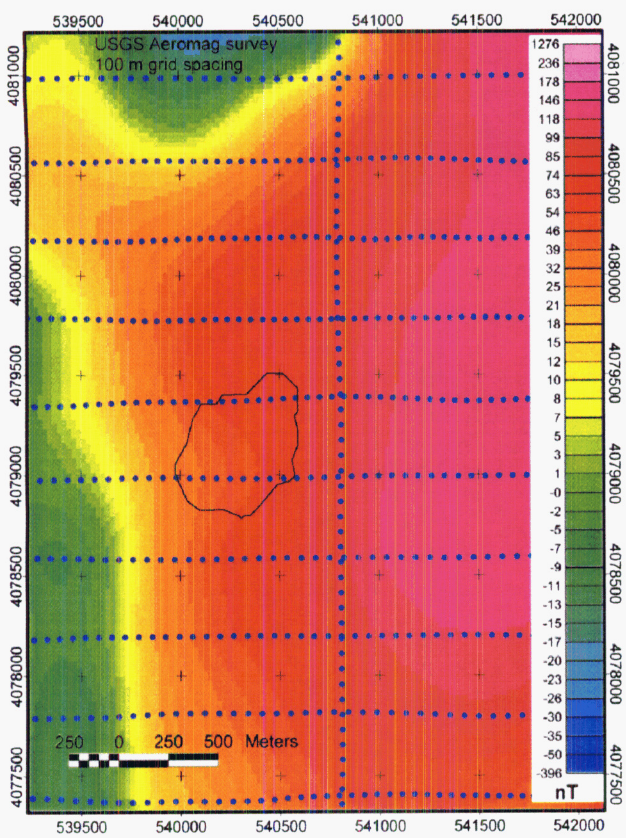
Analysis of ground magnetic survey data (Magsino et al., 1998; Connor et al., 2000) provides useful information on the resolution capabilities of the YMR survey.

A ground magnetic survey over the 1 Ma Northern Cone volcano examined the possible controls of shallow subsurface structure on the localization of basaltic magma (Magsino et al., 1998). These survey data are averaged onto a minimum curvature grid with 100 m node spacings and contoured using a histogram stretching algorithm identical to the processing methods used on the YMR survey. Note high peak to peak signal over outlined outcrops of basalt.

The base image for this figure is cd/ncone/ncone100_flat.tif







Upward continuing the ground mag data to 150 m (upper left) estimates expected resolution if YMR survey was flown at nominal altitude. Upward continuing to actual flight altitude of 380 m AGL (Upper right) further attenuates the anomaly amplitude and resolution.

In comparison, the base YMR survey has even lower resolution due to 400-m-wide flightline spacing, in addition to signal attenuation due to 380 m survey altitude. This indicates buried basalt of size of Northern Cone (i.e., about 0.5 km^2) would likely be undetectable in the YMR survey.

The base images for these figurse are
cd/ncone/ncone100_up15_flat.tif
cd/ncone/ncone100_up38_flat.tif
cd/cf_100/cf_100_base.tif