Geospatial Tools and Techniques Behind OSM's Biggest Job – The Dolph Colliery Fire

Location


Unregistered HyperCam 2
Image NASA
© 2008 Tele Atlas
Image © 2008 TerraMetrics
© 2008 Europa Technologies
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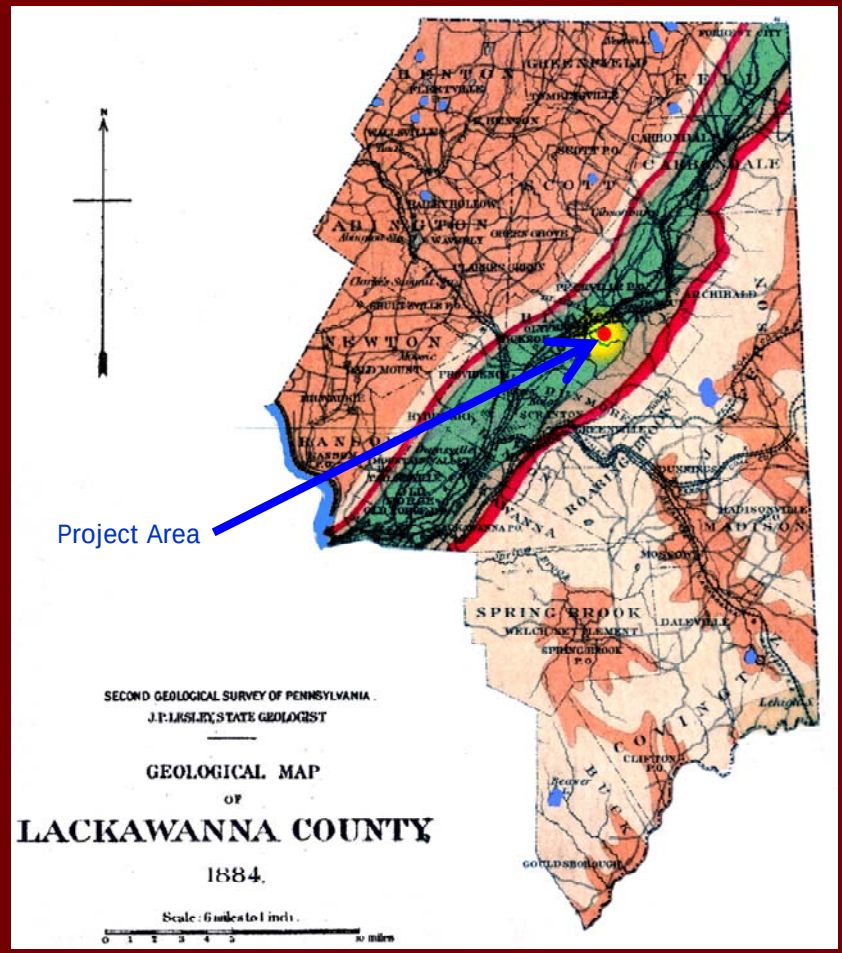
Pointer lat 31.481852° lon -117.208445°
Streaming 100%
Eye alt 9301.98 mi

Surroundings

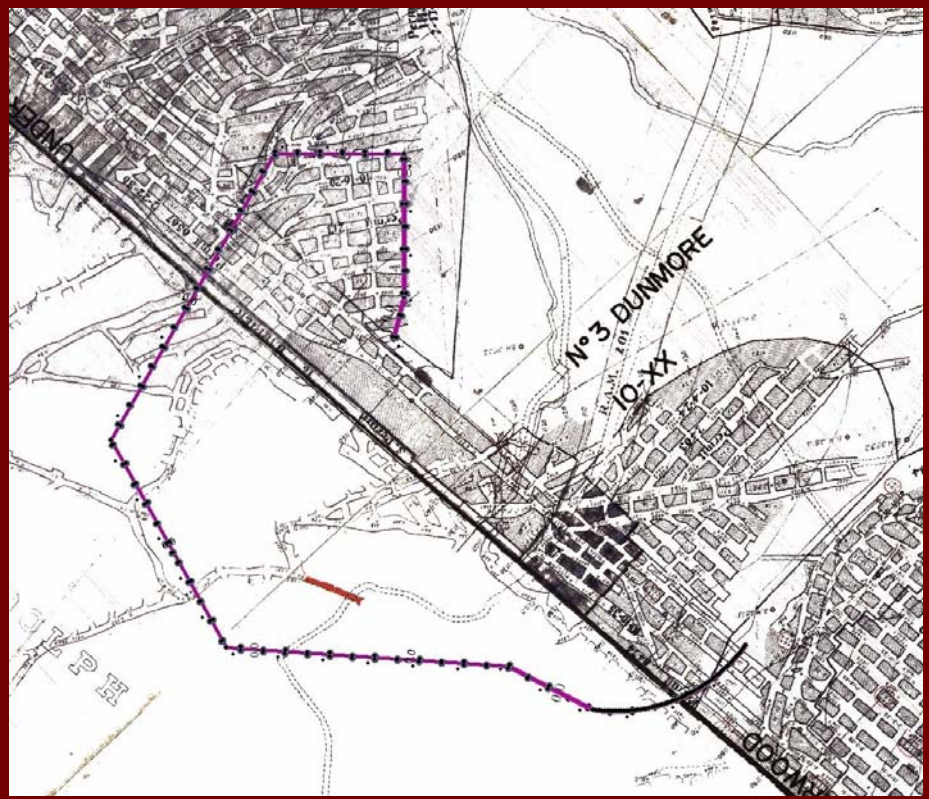
Geologic Setting

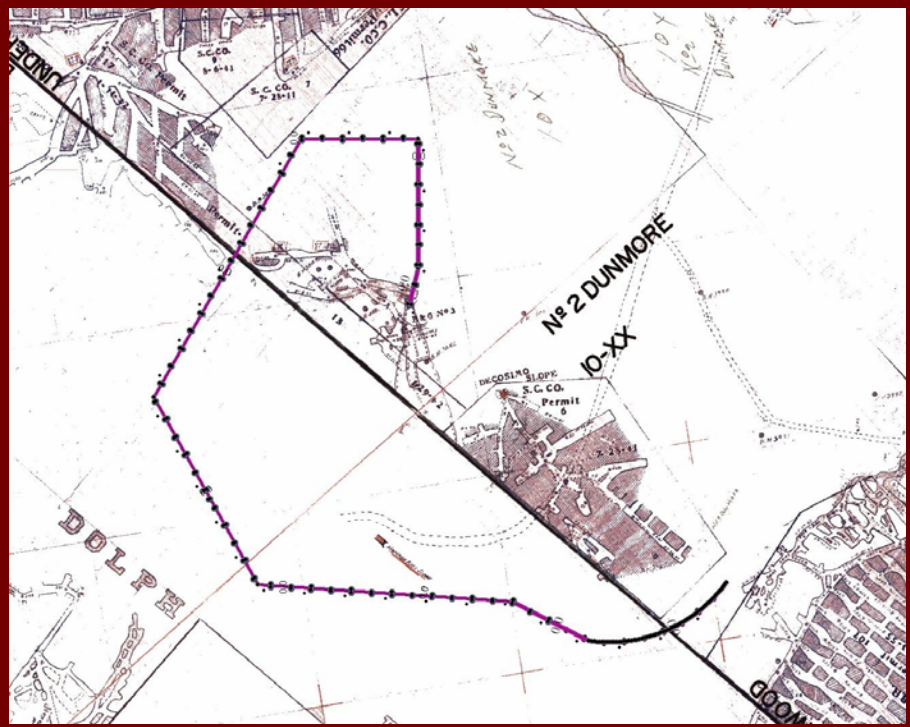
- In the Northern PA anthracite field near the edge of the coal “measures”
- Dip is about 15 NW but a narrow monocline bisects project area and reverses dip to SE, lowering all strata by over 50 feet
- Last glaciation deposited up to 100’ of till and lake sediments creating “subcrop” conditions



Mining

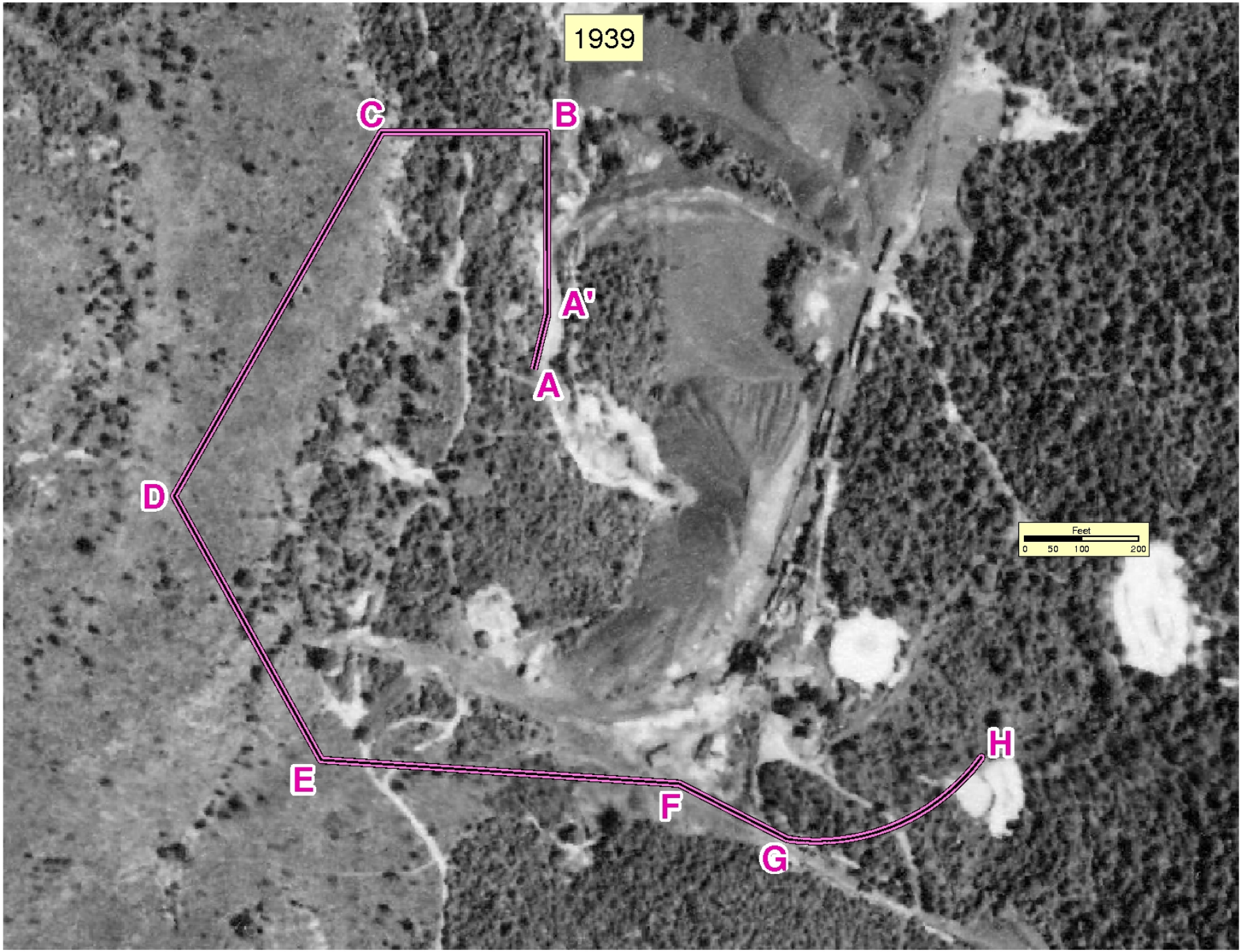
- Surface and UG mines (principally the Underwood and Dolph collieries) were active from 1900 through 1970. Within the project, all mining was on the Dunmore 3 and overlying Dunmore 2





Site Conditions

- The coal was processed nearby and the waste – culm – was backhauled to the site and dumped onto bedrock and glacial material and into strip pits.
- For over 60 years, the site changed little and it became a convenient illegal dump and party place.
- Sewer line construction improved access and dumping and partying increased.
- In mid-2004, open burning started a fire in the culm which OSM isolated with a trench.
- Unfortunately, the fire had already spread into mines in the Dunmore 3.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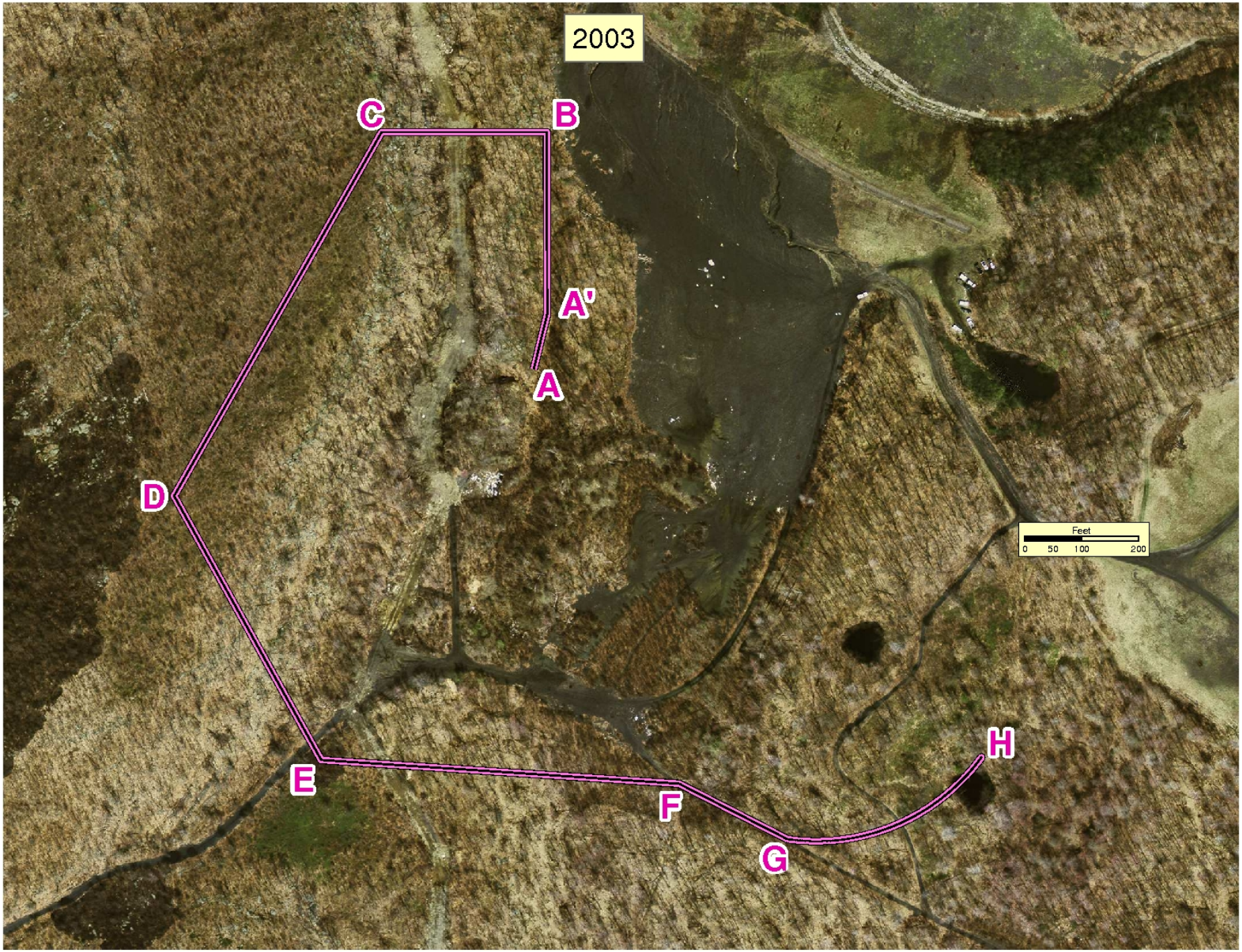
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November 2004


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The Geospatial Journey Begins

- By late 2005, the UG fire is definitely under sewer and serious data collection has begun.
- Fearing another Centralia, OSM decides on a full site characterization because a mine level cutoff trench seems likely.
- Contracts are let for detailed drilling, trench design, sewer relocation; aerial photogrammetry.
- I'm assigned to model the mines, geology, and fire and feed results to design contractor, Project Manager, etc.
- Contacts are cultivated with major players and data sources.
- All available data sources are identified and data accumulation begins.
- A site visit finds complex conditions and a thermal camera reveals high retained heat levels in exposed bedrock and many areas heated by vents.

Thermal Images

Thermal Technique

- If possible, time visit for early morning, low ambient temps, and high humidity
- Tune thermacam to alarm a few degrees above ground ambient
- At anomalies, take thermal image AND regular photo with same FOV
- Map the anomalies.

A Good Base...

Until new surveys and photogrammertry were done, all georeferencing depended on four digital orthophotos:

- Standard USGS DOQQ -1992 and 1999 – good geography but marginal resolution
- 2003 Lackawanna Planning Commission
- 2005 PAMAP

And The Tools

Software/Software group	Major Uses
Adobe Photoshop Elements	cleanup and stitching of mine maps; photographic cleanup and enhancement
Arcmap/Editor/Workstation	High end mapping and plot output; some GIS analysis;principal image georeferencing tool, coverage/shapefile editing; reprojection of vector, grid, lattice and image files; mosaic and merge generation
ArcView GIS	rapid shapefile generation, data exchange, geoprocessing, GPS interface
Autocad Map/Raster Design	drawing and design and data exchange among other programs; principal tool used by A&E and other contractors
Context Programmer's Editor	ASCII data editing and reformatting
CORPSCON	Coordinate and datum conversion
Didger	image warping digitzing, data entry
Earthvision	Geologic modeling, including 2D and 3D structure and stratigraphic modeling, 2D and 3D time/temperature modeling, cross-sections, fence diagrams, area and cut/fill volume calculations, data validation and editing, digitizing tablet interface, VRML creation
GeotiffExamine	GeoTIFF/World File creation and agreement
Ghostgum	DXF creation from PDF documents
GoogleEarth	Climate data access, information exchange
GlobalMapper	Rapid combining of geospatial data, geospatial exchange and conversion
HyperCam	screen animation capture
Irfanview	Image file conversion and photo management
Leica Imagine, mosaic, AutoSync, Photogrammetry Suite	Image analysis, data exchange, reprojection, georeferencing/rectification, topo generation, photomatching, mosaicing, “time travel”

And The Tools (cont'd)

Software/Software group	Major Uses
MicroDEM	digital elevation model conversion, topographic grain, slope, viewshed and watershed analysis
OmniPage Pro	OCR of text scans, especially survey data
OOCalc, Excel, Quattro	Spreadsheets for graphing time and depth temperature data, data reformatting and exchange, analyze fire response to weather conditions.
OpenOffice, MS Office	document and presentation preparation, data exchange
Panavue Image Assembler	panorama, mosaic, and virtual tour creation from photos
PDFCreator	"printing" from any Windows software to create high quality PDF documents
R2V	Heads-up mine and geologic structure digitizing and vectorization; georeferencing, image subsampling, resizing and world file creation
STATGRAPHICS	climatic data plotting and trend analysis
SURVCADD	survey data import/export, baseline and profile and station layout
Topofusion, GPSBabel	GPS data exchange and preparation
Virtual Dub	Editing clipping and conversion of blasting and other movies

Mine Map Data
"The Folio"

- Only known mine maps for site are in the "Folio"
- Folio created by US Bureau of Mines to organize mine maps into a physically manageable, coal-correlated compilation.
- OSM W-B office now has the Folio.
- To reduce wear-and-tear, the PA W-B office in W-B has been systematically scanning the Folio since 2004 – first at 200DPI, 8-bit color; rescanning otherwise as needed.
- Besides preserving original, the digital versions can become part of GIS and mine level details extracted for modeling uses.
- Georeferencing is problematic – features gone, distortion

Folio Problems

- Layout – each Field subdivided into 28”X40” (at 1”=500’) tiles to form Folio borders
- Orientation – Tiles laid out with long side ~parallel to strike; north is anybody’s guess
- Projection – planar; datum NAD27? Any coordinate grids are local and arbitrary
- Creation - for each vein, all mine maps within tile were cut apart and fit together and glued onto paper backing; the glue-ups were then laminated.
- Scans – Pages have yellowed and some delaminated, scratches and other defects diffuse and discolor scan quality; automatic 8-bit color prevents color balancing.

Folio Zoom

Folio Techniques

- Project required four Folio pages for the Dunmore 2 and four for the Dunmore 3; scans ran from great to gross
- Individual georeferencing and merging, didn't work for a lot of reasons: not enough detail for GCPs, extreme color variations, multiple mine map pieces.
- Best results were by reconstruction
- Used a quality image editor to:
  - Crop worthless edges
  - Do fine rotation to keep edges orthogonal
  - Convert to 24-bit color
  - Mask and stitch adjoining pages.
- The 24-bit conversion is vital because every program has its own "idea" about how best to remap the original 8-bit color – no two programs have the same internal palettes.
- When the reconstruction worked; georeferencing focused on getting GCPs for the pertinent mine map pieces as close in to the site area as possible.
- Every imaginable GCP or combination was tried – buildings, shafts, railbeds, property lines (next topic), streams, and roads - nothing every really worked but as in horseshoes and hand grenades – got it close enough.

Property Lines

- Rights-of-entry and other realty issues dictated good parcel outlines
- Only available data were low quality sketch maps and photocopies from DOT and tax maps
- Scanned and got close fits to other base data – good enough for Police Power but not other purposes
- By pure dumb luck, discovered the Planning GIS had a brand new county-wide parcel coverage developed from a complete rework of deed descriptions and tax maps
- Threw away all other maps and incorporated the new
- When overlaid onto the mine maps, discovered that the maps barely showed faint lines that matched parcel geometry – finally, some good GCPs for the mines!

Drillhole Locations

- OSM surveys of over 40 holes used arbitrary origin and orientation but did “capture” new manholes
- Survey was only supplied in hardcopy; nothing digital
- Hiking-grade GPS used by contractor for 25 new, detailed coring locations – caused severe anomalies in early stratigraphic models

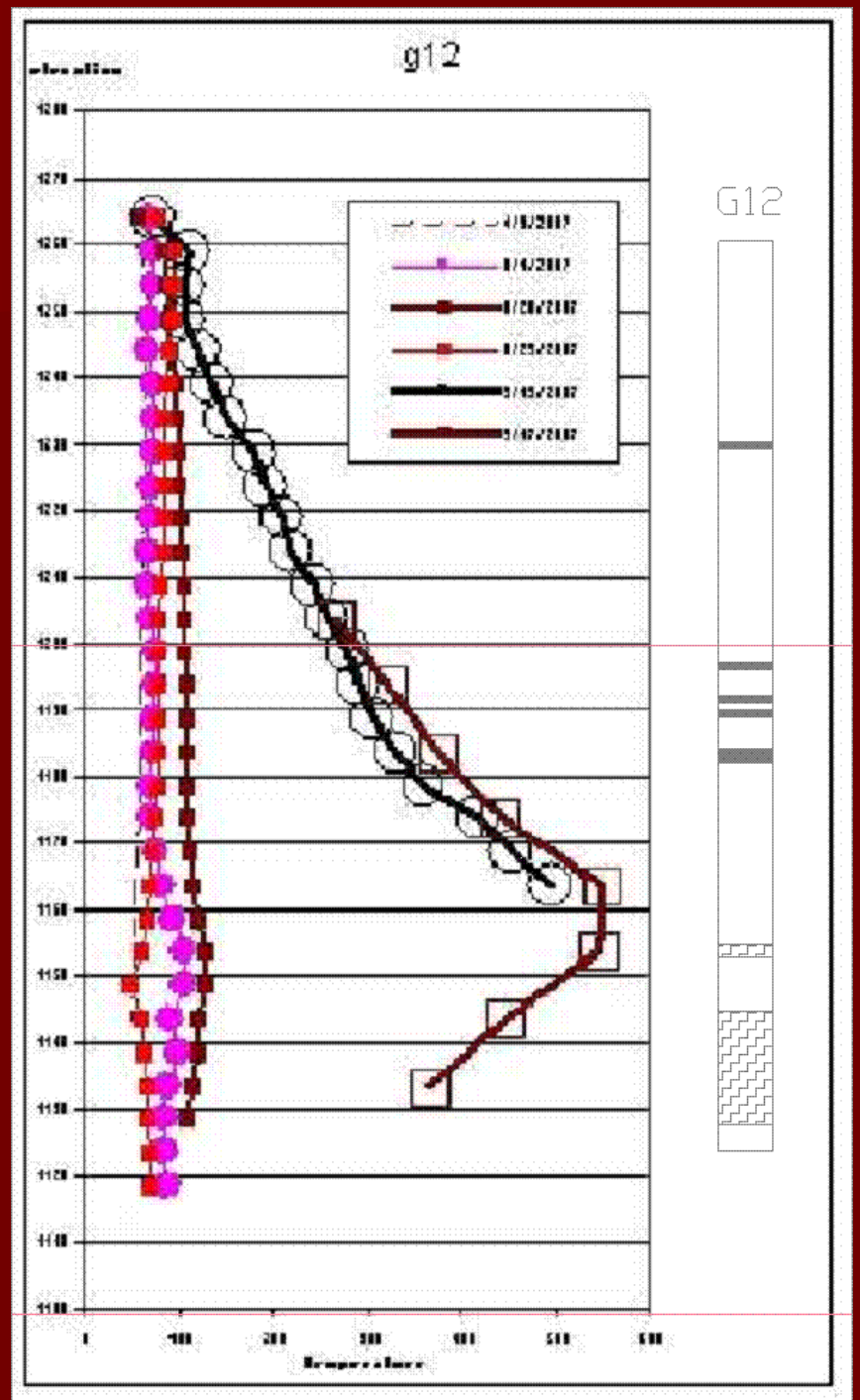
Drillhole Location “Fixes”

- Able to get a printout of OSM survey, scanned and used OCR to convert to spreadsheet and then to drawing
- Had sewer design drawing that had “lost” its coordinate system but did identify existing and planned features
- Used manholes and other features visible on orthoquads to fix design drawing
- Transformed arbitrary OSM XYZ base to “real” coordinates
- “Final” fix was a complete survey of all intact locations months later and after construction started – a bit late

Drill and Thermocouple Data

- None of these data were digital and all were handwritten or unsuitable for OCR
- Date, time, temperature and depth had to be typed into spreadsheets then merged with location information
- The data could then be reformatted and exported for modeling
- Also put data into a drawing as crude graphic logs for correlation – when one hole went “bad,” a paste and match of the temperature against the log was most useful.

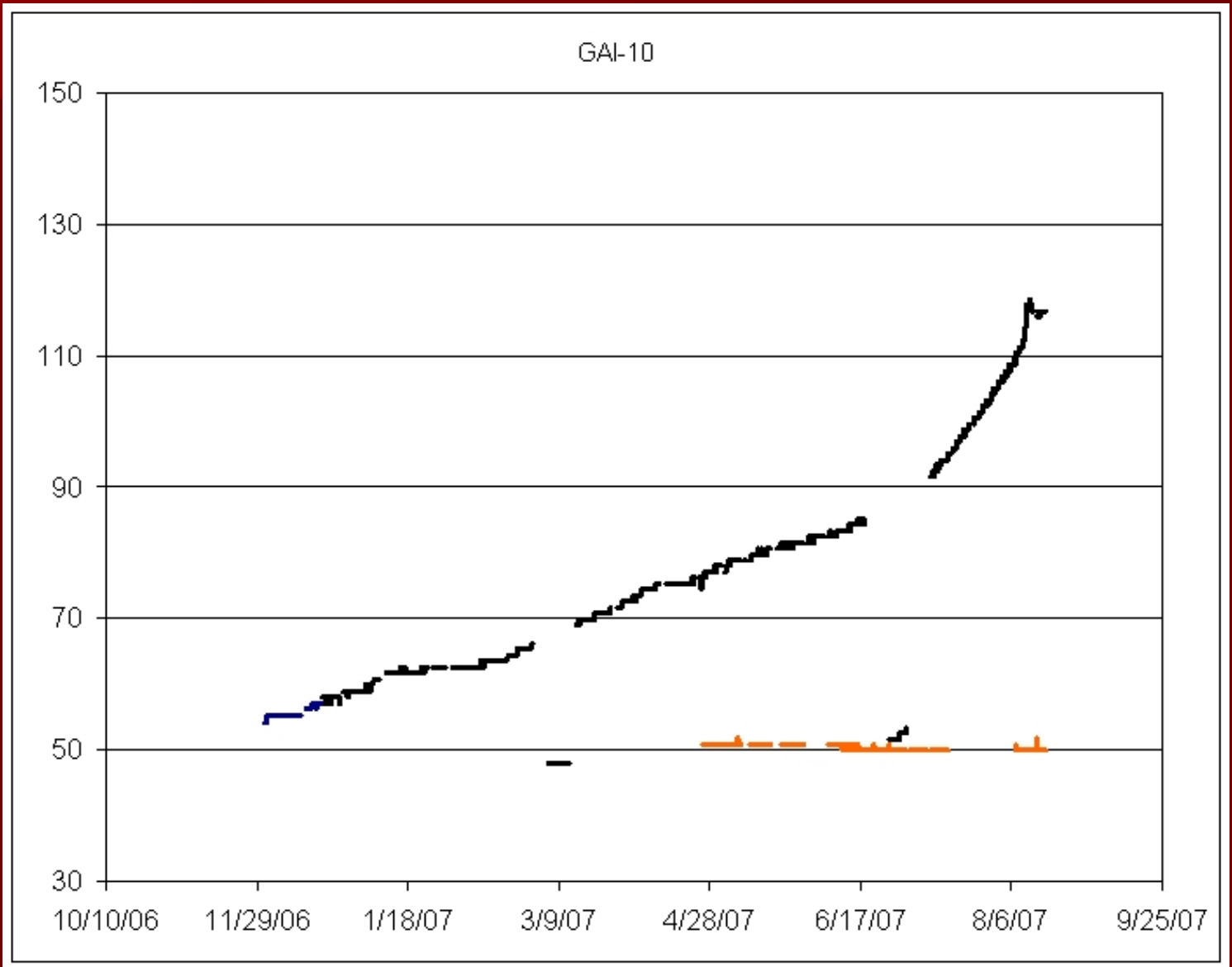
Multiple thermocouple depth-temperature graphs scaled to graphic log



ThermoChron Data

- Thermochrons are inexpensive devices that record temperatures at preset time intervals
- They are installed in lower temperature holes and are periodically downloaded to a PC in spreadsheet format.
- The data are valuable for trend watching and several times alerted us to changes in the fire
- We also could spot Installation problems and during one period, a significant impact climate had on part of the fire.
- Merge location information and the data is ready for modeling

Trend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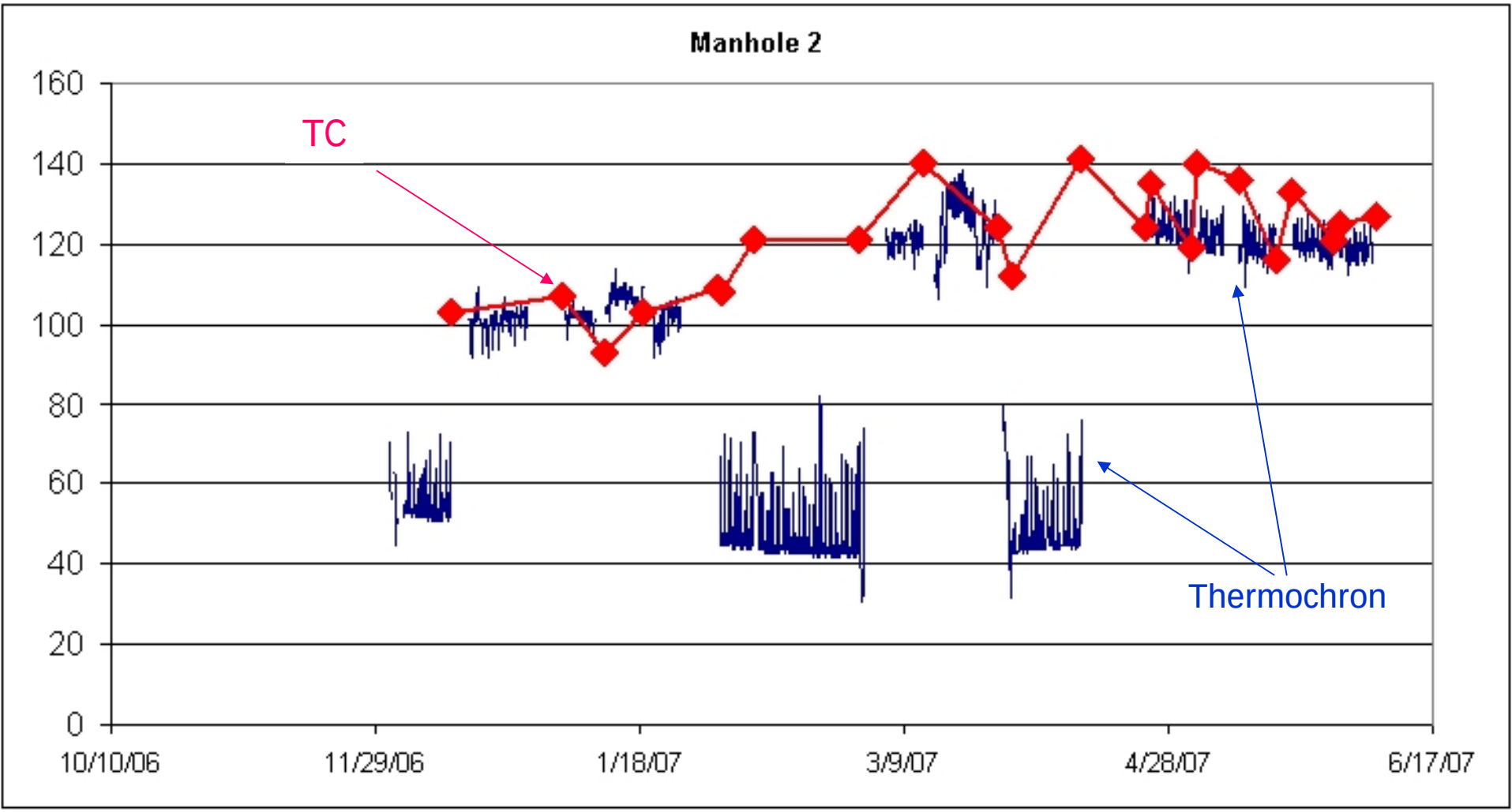
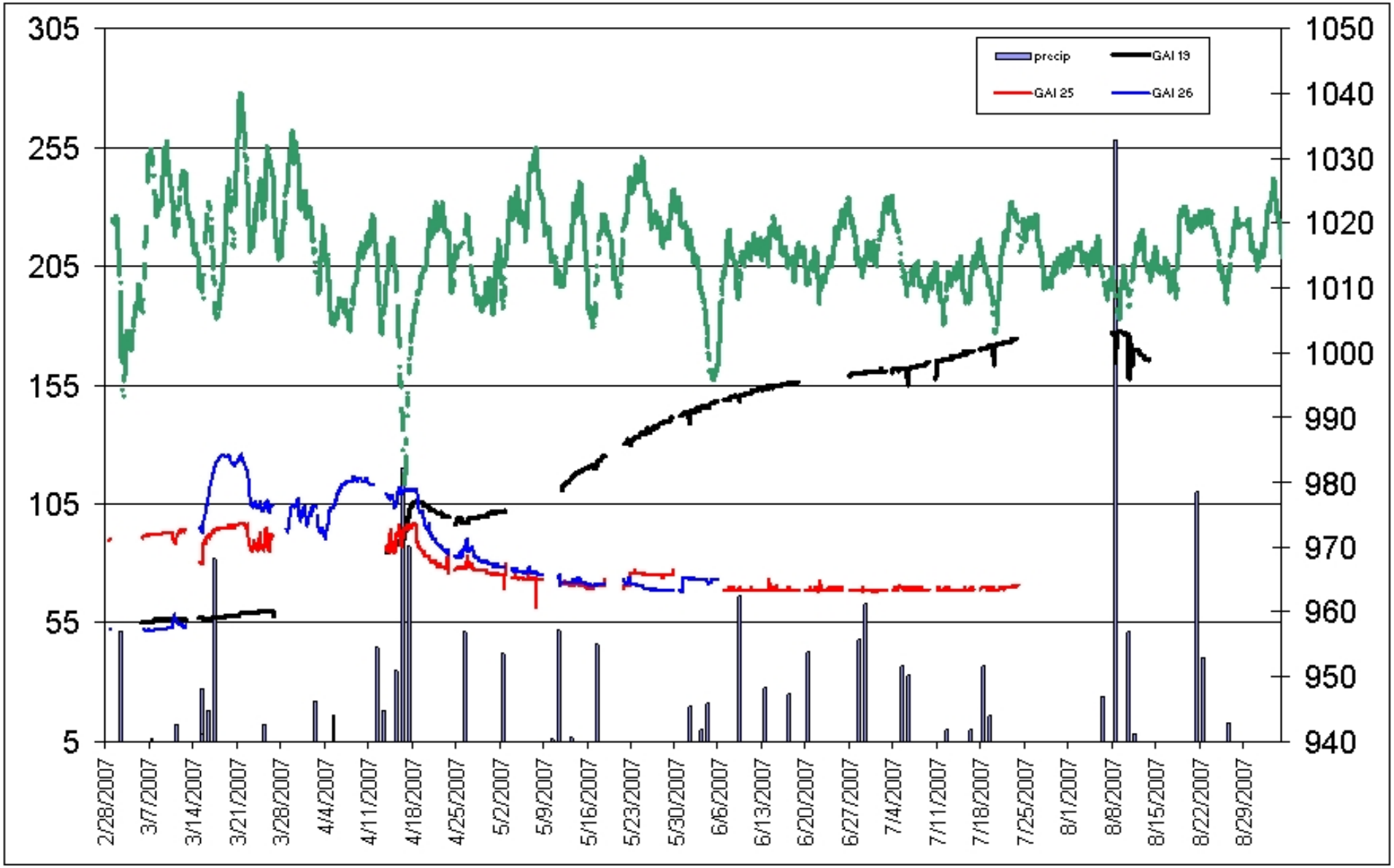
9/25/07

Installation



Climate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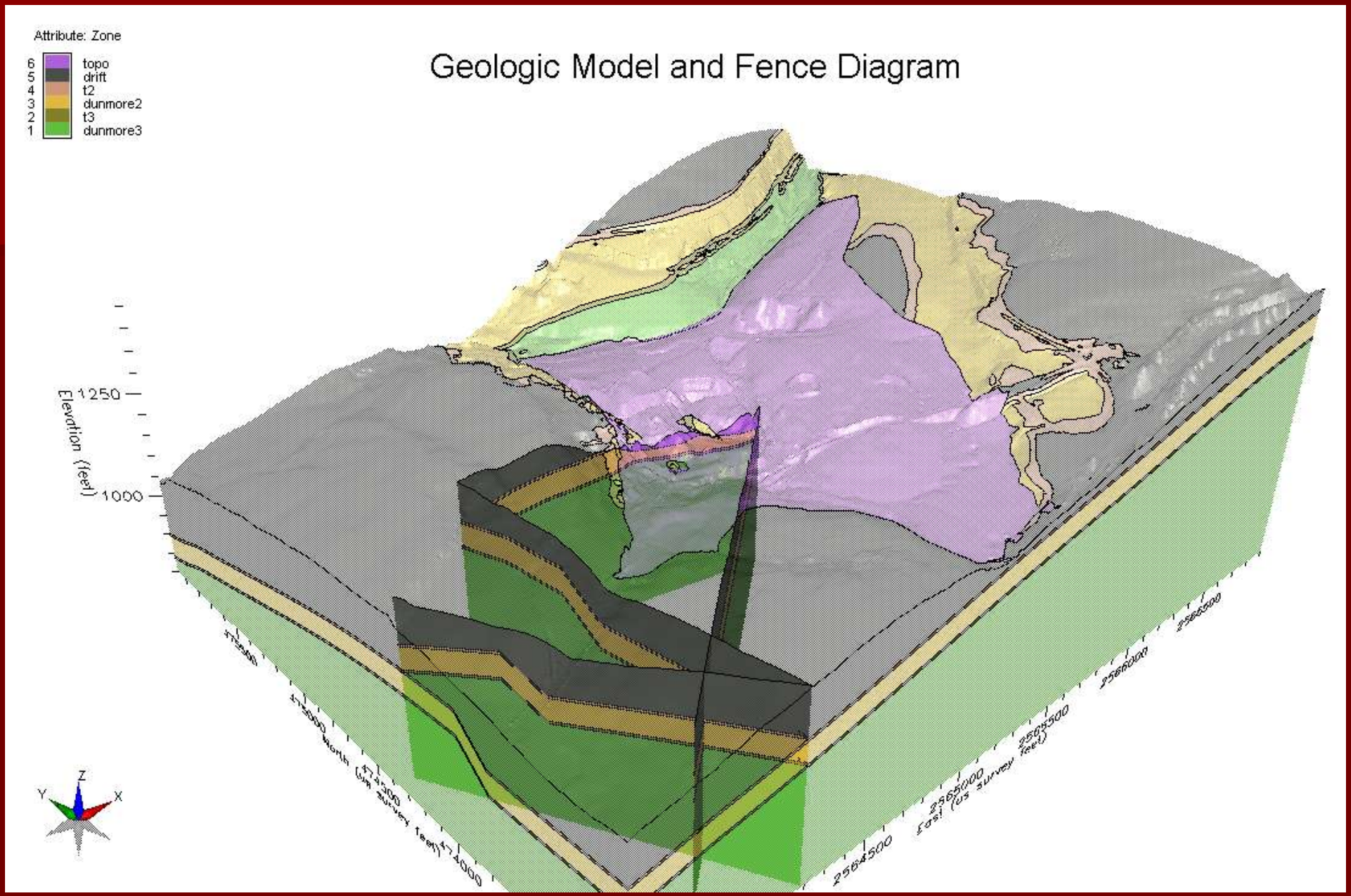
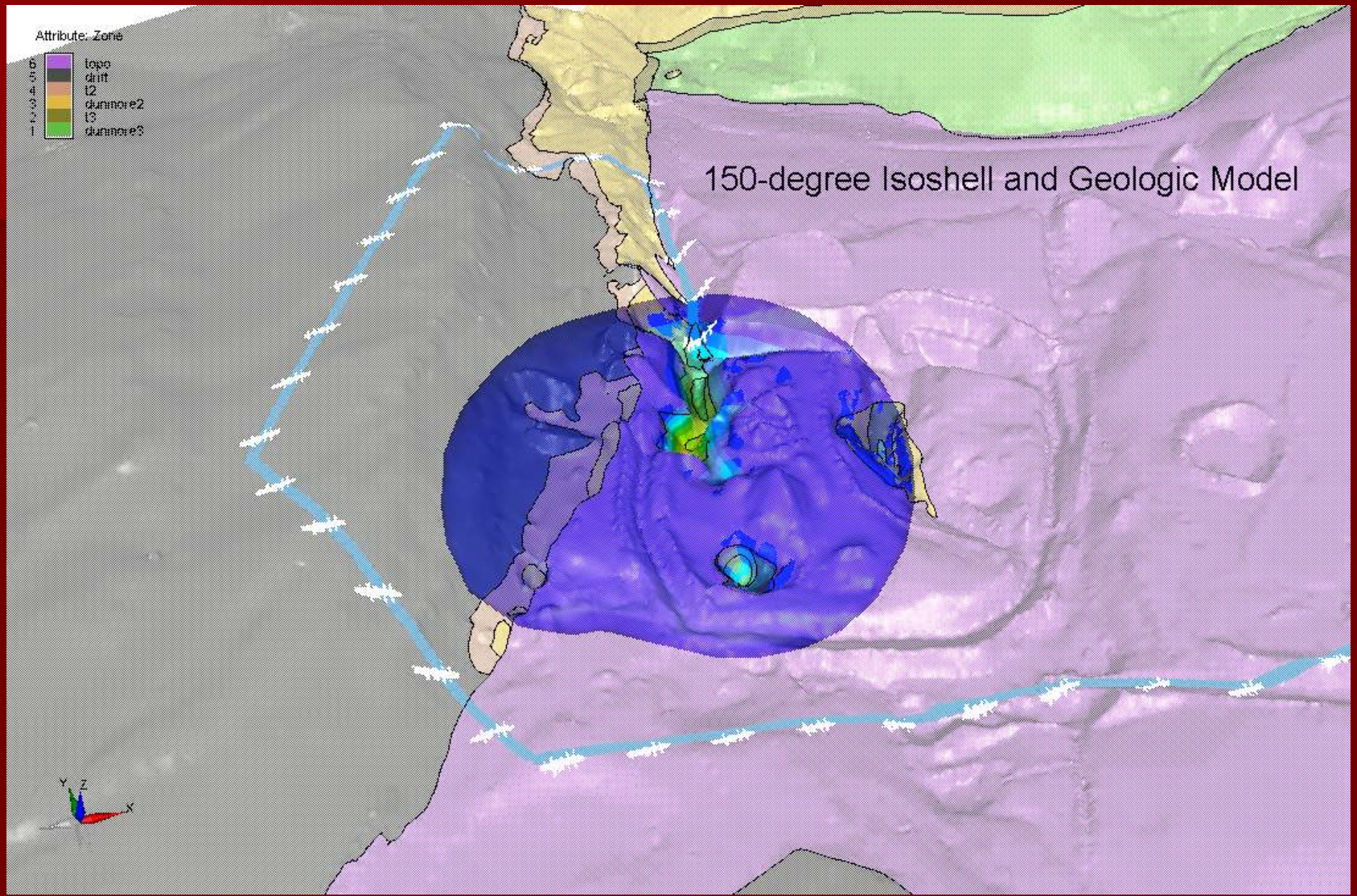
8/29/2007

Modeling

- After formatting, data was processed in EarthVision to generate:
  - 3D Geologic Model
  - Temperature/Depth Models
  - Time/Temperature Models
- Fire growth patterns and model strongly suggested that fire was stalled in high area of monocline
- Maximum 1-year extent of 150-degree isotherm used to locate trench centerline
- Bid package prepared and advertised

Geologic Model and Fence Diagram

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150-degree Isoshell and Geologic Model
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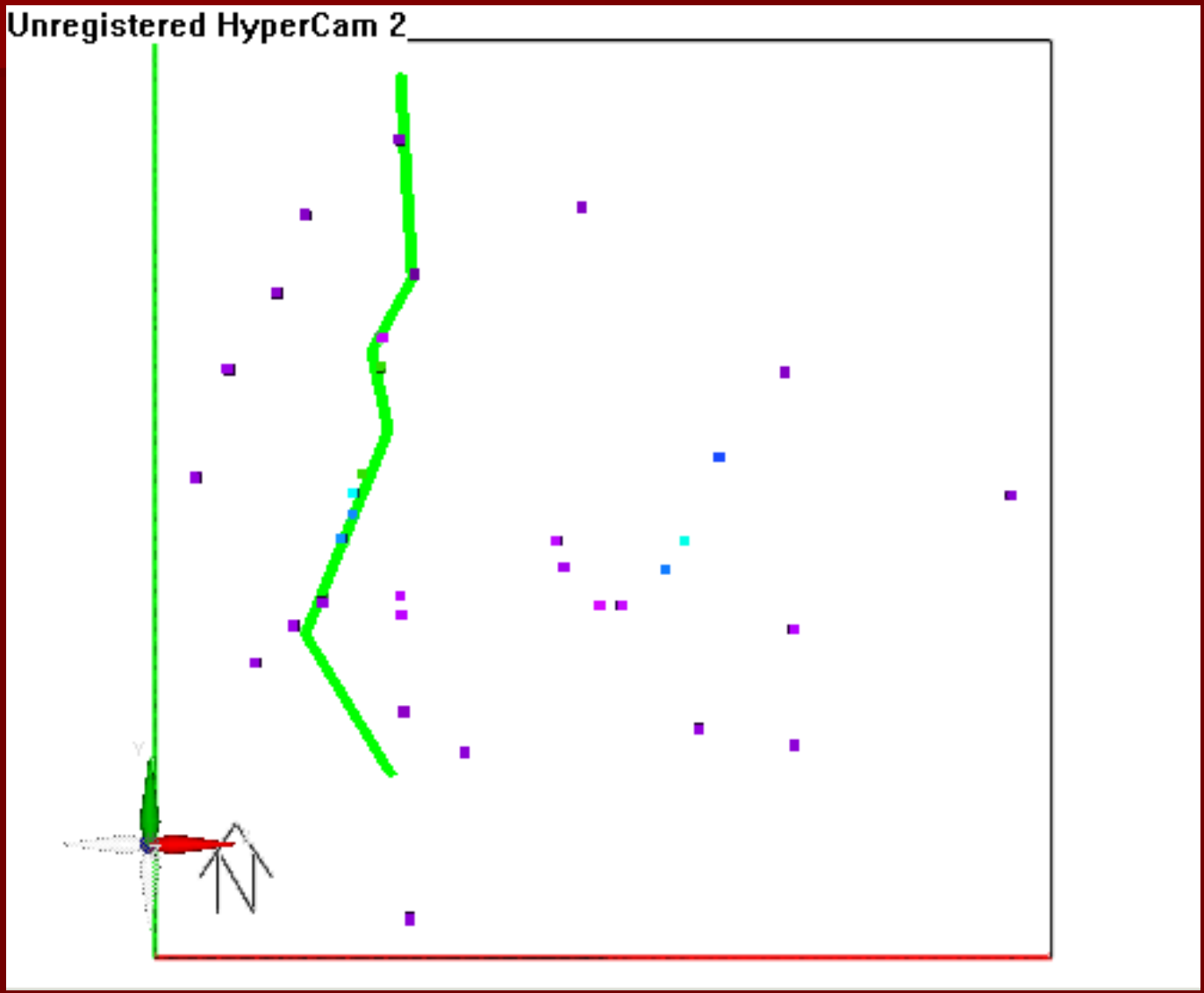
180-day Time/Temperature



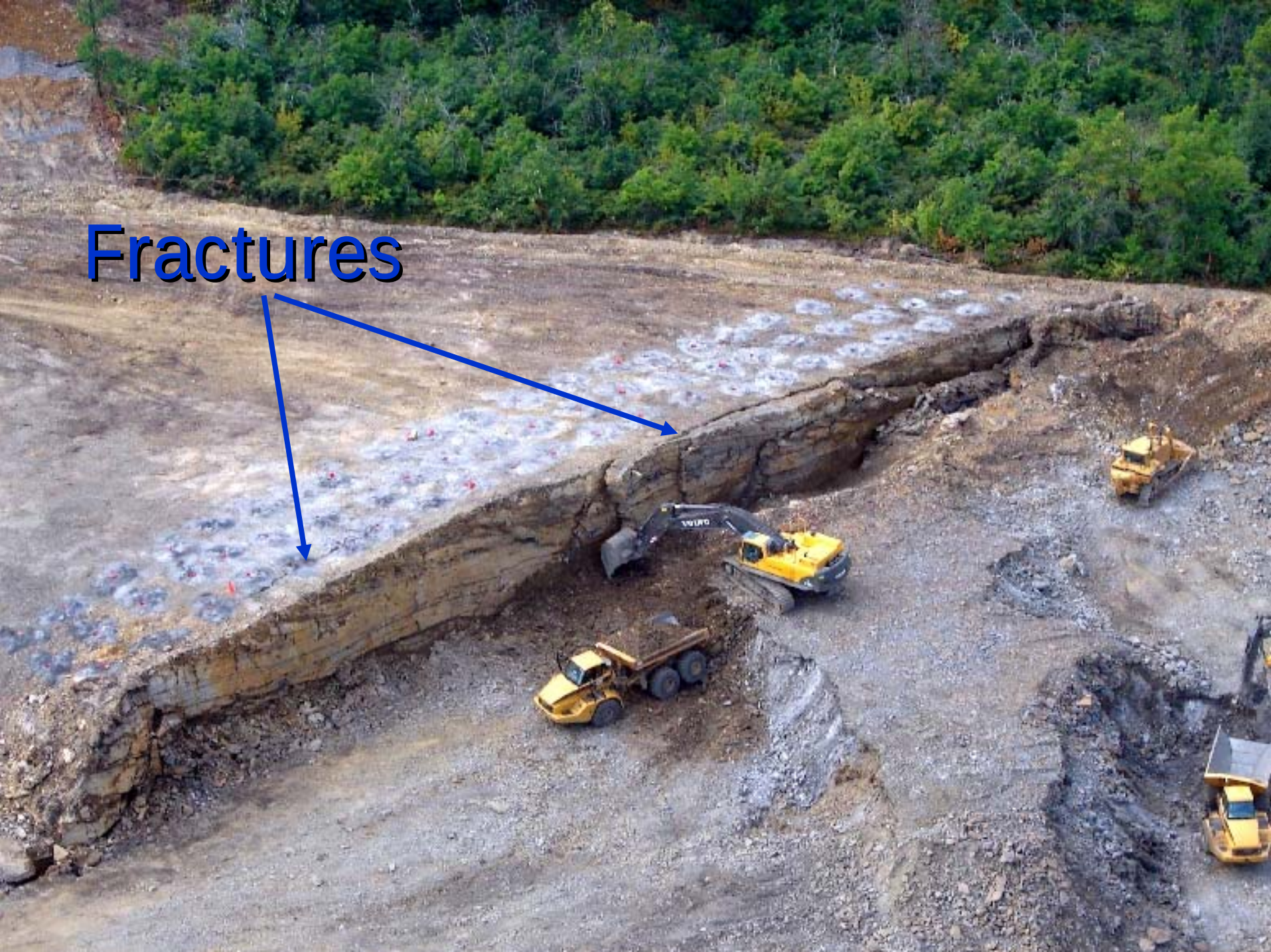
Final Design/Construction

- Spring 2007, the site was flown to yield 2-foot contours and better design volumes; also, the DSM used to backinterpolate more accurate drillhole elevations
- Contract is let and site clearing begins
- Clearing reveals linear fire vents which are staked-out with thermal camera for survey
- As work continues, vents prove to be vertical “mega-joints” which pervade the site
- Joints are controlling the fire and greatly reducing blasting efficiency

Linear Vent

Linear Vent


Fractures


Fractures

Non-metric Aerial Photography

- Almost 4,000 photos were taken on the ground but the job is so big and there are so many sightline obstructions that it's impossible to get the "Big Picture"
- A local pilot was contracted to document the job from the air whenever possible
- Besides obliques, he tries to take near vertical shots over the earthmoving areas
- Drillcaps and other surveyed features have been sprayed with vast quantities of fluorescent paint so they're visible in the pictures
- With these points, we can then rubbersheet the photos to near rectification to generate mosaics and other extremely useful documents (like filling in contours where no survey exists)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Non-metric Aerials (con’td)

- Other non-metric aerials can be taken from lesser platforms
  - RC model airplanes
  - Tethered balloons

There's More!

- This project may be the most documented and instrumented in AML history.
- But, due to the project's pace, data inventory and reduction, photo cataloging, file clean up, modeling, etc. have fallen months behind.
- We plan an extensive post-mortem to identify more techniques and "gotchas" that will be ultimately shared.
- For the present, we're designing a cold side monitoring plan (just in case)

- The single biggest lesson learned is to form a diverse Project Team early and brainstorm, brainstorm, brainstorm!

Lastly, none of our slides have adequately shown the human scale - this will!

Acknowledgements
(in no particular order)

- Chris Murley, Pilot
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- Lackawanna County Planning Department
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- TIPS
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