

# Characterization of a Coalbed Fire Near Durango, CO

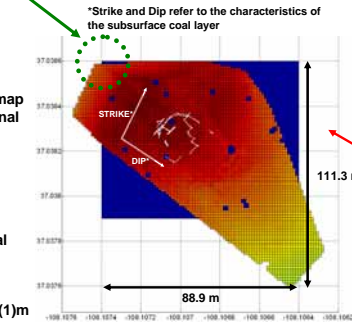
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## Coalbed Fire Characterization and Results

### Surface Characteristics:

- Possible point of O<sub>2</sub> influx where the coal is believed to intersect the surface
- Surface contour map created using a handheld GPS device
- Fissures superposed on the contour map show distinct patterns that are orthogonal in nature
- Fissures found where the elevation is highest in the region
- Surface temperatures away from the fissures do not show significant thermal anomaly
- Distance to the top of coal O(10)m, overburden is sandstone and topsoil O(1)m



- Fissure formation seems to follow pre-existing fracture set found in the sandstone overlaying the coal



Wet Top-soil (~130 °C)  
Vents (200-500 °C)  
Fissures (200-1200 °C)  
Sulfur & Sal-Ammoniac present  
Thermally altered reddish sandstones

- The direction of fire propagation is first detected when moisture driven off due to heat wets the surface soil
- Small vents appear as the hot exhaust from the combustion zone penetrates through the loosened surface

- The vents eventually connect, and form a surface fissure

- Surface fissures located with a GPS system to observe pattern and propagation

- Surface fissures' systematic perpendicular pattern supports pre-existing fracture hypothesis

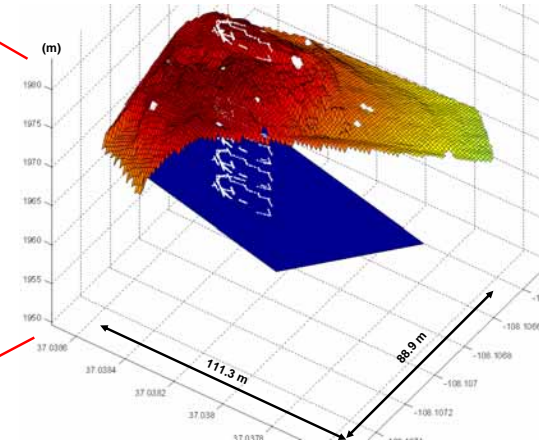
### Results and Discussions:

- The depth to the top of the coal is ~O(10) m, while the fissure width is ~O(0.1) m. This high aspect ratio suggests that adequate O<sub>2</sub> supply to the combustion region may not be taking place through the fissures
- Conceptual geological model suggests that coal plane could intersect the surface NW of the coalbed fire
- Pre-existing sandstone fractures are main conduits for releasing hot combustion gases at temperatures that can exceed 1000 °C
- Hot regions show signs of dehydration, which seem to give rise to a sharp measurement contrast in the electromagnetic readings
- Well-log data and sample GPS data seem to be consistent, helping us visualize the general depth to the top of the burning coal layer as well as its strike and dip

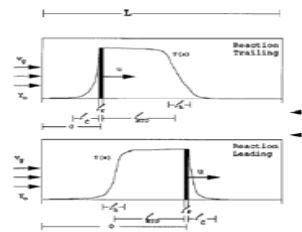
### Abstract

Subsurface coalbed fires occur worldwide, such as in China, India, Indonesia, Australia, and the United States. In one estimate, a coalbed fire in China is reported to be emitting as much as ~700 Mt / CO<sub>2</sub> a year, a value comparable to the annual U.S. transportation sector emissions. In yet another coalbed fire in Centralia, PA, an entire town above the fire was displaced. Although coalbed fires have significant societal impacts, they remain poorly characterized.

In this research project, we explore an early stage coalbed fire found in Durango, CO. We begin by first constructing a detailed local surface and subsurface model using GPS measurements, well-log data, core samples, and subsurface resistivity readings. We use this model to understand the boundary conditions governing the physical process and to adapt existing analytical models. We will then construct a numerical model to understand combustion front propagation speed and direction. This knowledge will help us investigate various methods to stall the advancement of such a combustion front, ultimately leading to extinction of the coalbed fire.

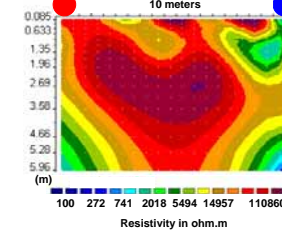
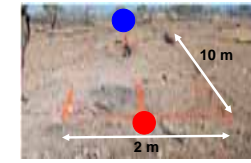


### Analytical and Numerical Models:



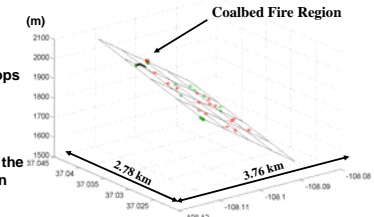
- Currently in the process of evaluating available analytical models
- Models depend strongly on boundary conditions
- The analytical model will be compared against numerical results
- Numerical model will be used to forecast the migration velocity and the direction of the combustion front

### Subsurface Characteristics:



- To construct the subsurface coal layer, we used:
  - 1) Well log data
  - 2) GPS data of nearby coal outcrops
- Strike: NE 29.5°
- Dip: 10.2°
- Strike and Dip calculated based on the fitted plane → similar in orientation to the fissures

- Ohm-mapper allows for mobile, easy to set up electro-magnetic resistivity measurements
- No previous attempt has been made to image the subsurface using EM methods
- EM readings show significant contrasts in resistivity
- High resistivity could be due to dehydration of rocks near the fissure, where hot exhaust gases escape
- coal: 500 -1500 ohm.m
- sandstone: 10 ~ 1000 ohm.m
- water: 3~ 100 ohm.m
- soil: 1 ~ 10 ohm.m
- dry gravel: 600 ~ 10,000 ohm.m
- air: very large 10<sup>4</sup> ~ 10<sup>10</sup> ohm.m



### Conclusions and Future Work:

- Conclusion:**
  - The surface fissures follow a discernable orthogonal pattern, supporting the idea that the exhaust gases are escaping through preexisting sandstone fractures
  - GPS data, in conjunction with well-log data from the region have been used to propose a sloping coal layer. The depth to the coal layer is ~O(10) meters
  - The contour map of the surface with the fissures overlaid indicates that the distance spanned by surface fissures is fairly small scale
- Future Work:**
  - Core samples will be obtained from the area to more accurately model top of coal formation in the region near the coal fire
  - Further physical observations will be made at the coalbed fire site to help construct a more robust numerical model of the phenomenon
  - The modeling will be approached from two sides:
    - 1) Coal combustion and reaction chemistry to model quantities of coal consumed and combustion gases produced
    - 2) Using rock mechanics to model subsurface activities based on fissure characteristics and data at the surface