



Investigation of an Oil Shale Fire at Windfall Mountain

An Initial Assessment of an In-Situ Formation Fire

Natural Resource Data Series NPS/YUCH/NRDS— 2014/733





ON THIS PAGE

View of formation fire at Windfall Mountain, as seen from the east.
NPS photograph by Jessica Sherwood.

ON THE COVER

Oil shale fire located on an unnamed east ridge of Windfall Mountain, as seen from the southwest.
NPS photograph by Linda Stromquist.

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Abstract

The objective of this project was to conduct a site visit to assess the characteristics and potential hazards of an active oil-shale fire within Yukon-Charley Rivers National Preserve. National Park Service employees from the Yukon-Charley Rivers Administrative Office and the Alaska Regional Office conducted the site work on July 18, 2013.

Procedures employed while on site included the use of an IR Thermal Imaging Scope to safely approach active formation fires to determine the nature of, and hazards posed by gases emitted. Temperature probes were utilized to measure temperatures of the ground where active emissions were occurring. No permissible exposure limits of the monitored gases were exceeded while performing constant direct read monitoring of the emissions onsite. Temperatures recorded in active fissures ranged from 140 to 285 degrees C. Samples of the shale formation were collected for future analysis.

Acknowledgments

The NPS thanks Doyon, Limited, for permitting access to the site for the study purposes, especially Jeff Filut for his enthusiasm and coordination through the permitting process.

This site investigation would not have been possible without the funding and support of the NPS Alaska Region Fire Program Manager, Dan Warthin, and the logistical support provided by James Sullivan, Eastern Area Fire Program Manager. Thanks to Jessica Sherwood for the superb photographic documentation.

Acronyms

AFS: Alaska Fire Service

ARO: Alaska Regional Office of the National Park Service EPA: Environmental Protection Agency

NPS: National Park Service

OSHA: Occupational Safety and Health Administration PEL: Permissible Exposure Limits

STEL: Short Term Exposure Limit TWA: Time Weighted Average

YUCH: Yukon Charley Rivers National Preserve

Acronyms for Gases

CO: Carbon Monoxide, measured in parts per million (ppm) CO₂: Carbon Dioxide, measured in ppm

H₂S: Hydrogen Sulfide, measured in ppm

LEL: Lower Explosive Limit (of Methane), measured as a percentage O₂: Oxygen, measured as a percentage

SO₂: Sulfur dioxide, measure in ppm

VOC: Volatile Organic Carbons, measured in ppm. An assemblage of organic chemicals with high vapor pressures at ambient air conditions. OSHA standards were used to measure these substances.

Introduction and Methods

In late September of 2012, smoke was reported on a ridge north of the Tatunduk River near the confluence with the Yukon River. (Figure 1) By October, the smoke had been reported as a fire, and had been flown over, at which time the fire was reported not as a wildland fire, but some sort of “geologic event”, as it appeared that the ground itself was smoking.

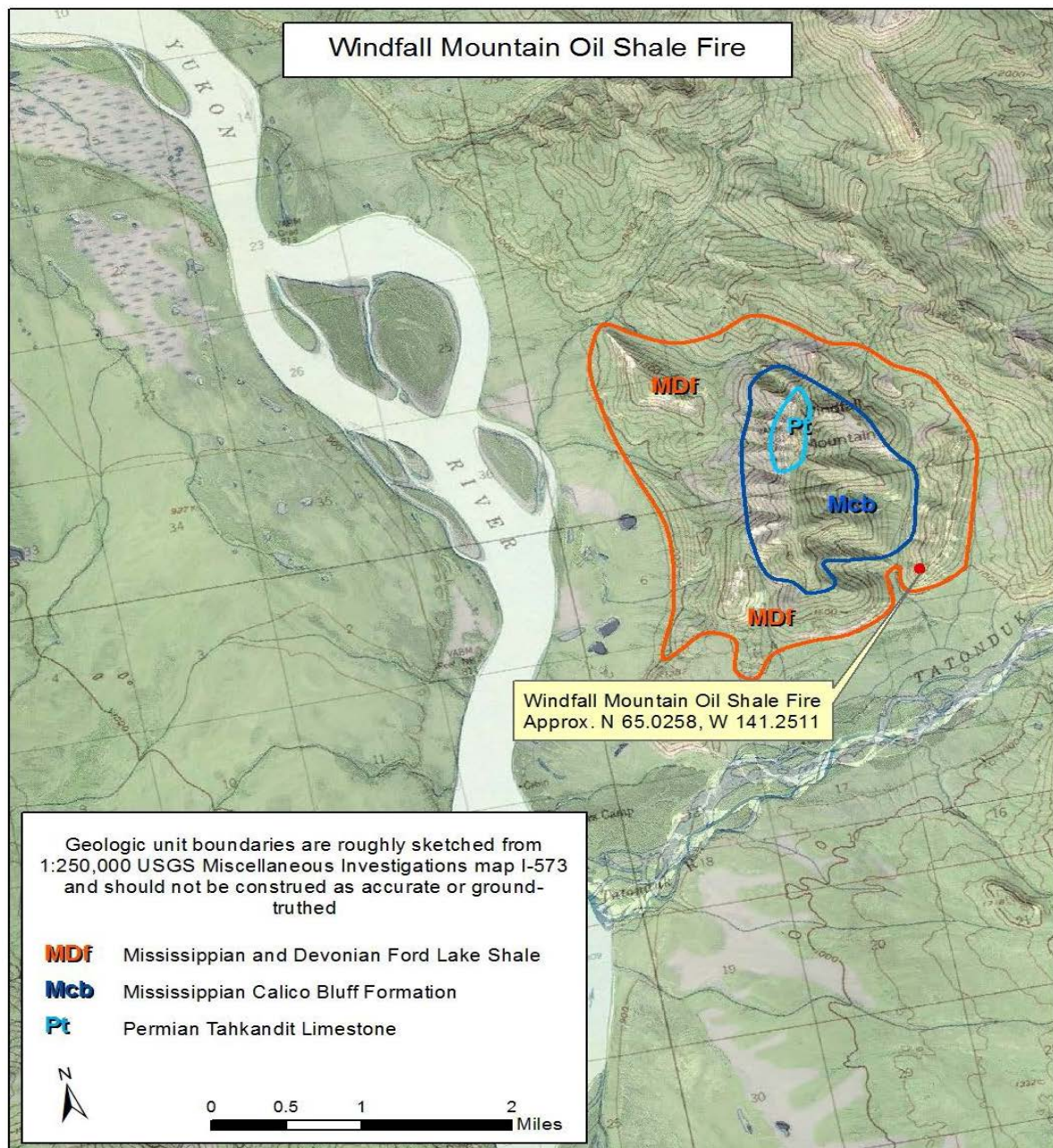


Figure 1. Location of Windfall Mountain Fire

Residents in Eagle, Alaska, upriver from the fire location by approximately 16 miles, began reporting noxious odors associated with the drifts of smoke that emanated from the site down river. Several residents asked the NPS if the fumes posed a health hazard.

In October of 2012, Anchorage Regional Office (ARO) staff coordinated logistics for a site visit, but were unable to complete the trip due to the lack of a viable aviation contract in place. Plans were left to conduct the site visit during the summer fire season, utilizing the fire program helicopter to access the fire.

During the winter of 2012-2013, several aircraft overflew the fire location and took additional photographs of the still-smoldering formation fire. Reports continued from Eagle of the noxious fumes, and heavy smoke associated with the fire.

Background investigation of the existing geologic maps indicated Windfall Mountain was comprised of three geologic units, one which was identified in DOI memos as an oil shale. This unit was mapped at the location of the reported fire, and identified as the Missippian/Devonian Ford Lake Shale. This information provided a working theory that the “ground” involved in the fire was the Ford Lake Shale that had somehow ignited and combustion of the carbonaceous component of the rock was continuing.

Land status records indicated that the site was on Doyon lands, which are encompassed by NPS lands. After coordination with Doyon, the NPS was able to finalize plans to visit the site on July 18, 2013. The goal of the site visit was to ascertain if the fumes from the fire could pose health hazards to residents of Eagle. Additional objectives were to collect data to characterize the nature of the fire and identify formation properties that could determine the possible cause of combustion. When first reported, it was after the usual fire season and did not correspond with any lightning strikes in the area, which are tracked by Alaska Fire Service.

A TEMSCO helicopter on contract to the NPS Alaska Fire Management Program was utilized to perform an aerial reconnaissance of the fire and land onsite for the site survey. This reconnaissance allowed the NPS crew to determine the safest access to the areas of interest and to assess hazards prior to accessing the site on foot.

During the course of the site visit, several active fissures onsite were measured with the temperature probe, and continuous gas monitoring of seven gases, including those most likely to be products of combustion at an oil shale fire were logged and recorded. Photographs of the site were taken while on the ground and include unburned portions of the shale formation in-place, as well as slumped blocks of strongly weathered shale showing sulfur staining and a high degree of fissile fracture. Numerous photographs taken from low altitude reconnaissance flight show the shale unit as a steep ridge, the crest and south face with active combustion of the materials occurring, and slumping along the crest where the formation has experienced structural failure as a result of combustion.

All statements contained in this report are based upon field observations regarding the apparent nature of the site. All photographs used in the report were taken by NPS photographers. Figures were

created in ESRI ArcGIS using a base of 1:63,360 USGS topographic maps, and Google Earth, using Landsat imagery from July 2006.

Findings and Discussion

On July 18th, NPS staff from YUCH Administrative Office and Alaska Regional Office conducted a site visit of the fire located at Windfall Mountain. Aerial reconnaissance revealed the fire location on the south facing slope of a ridge immediately east of Windfall Mountain.

The perimeter of the fire is approximately 1 mile and encloses an active fire area of approximately 22 acres. The crest of the ridge appears to be the only portion of the ridge currently affected by fire, although the downed trees and vegetation succession patterns show evidence of previous fire.



Figure 2. Aerial view of fire as viewed from the west, Tatonduk River in the distance.

The fire is a geologic formation fire of what appears to be a highly fissile shale unit. The landing zone was in an area of shattered-looking finger size shards of light colored shale.



Figure 3. Shattered shale at landing zone

Large in-place blocks of shale along the intact eastern side of the fire-affected zone were observed, in other places, blocks are slumped in different directions near the broad area that has subsided along the crest of the ridge.



Figure 4. Slumped block of weathered black shale.

In-place blocks of shale appear to have nearly horizontal bedding (Figure 5). The shale displays a blocky to fissile cleavage. It is fine grained and dark, almost black in some undisturbed zones, but very light and weathered looking elsewhere. A noticeable yellow staining of the shale was observed. Areas that have clearly been impacted by fire appear baked to a clay brick-red color (Figure 6). There are numerous fissures emitting visible gases present in large cracks and breaks located in the shale.



Figure 5. Horizontal bedding displayed by shale in-place



Figure 6. Horizontal bedding displayed by shale in-place, and brick-red “baked” areas.

Figures 7a and 7b illustrate this ridgeline fire in a comparison of imagery taken seven years apart. Sample locations from the July 18, 2013 site visit are plotted on the Google imagery.



Figure 7a. Image taken 7/18/2013



Figure 7b. Google Imagery dated 7/19/2006.

To address safety concerns while onsite, air monitoring equipment and temperature sensors were utilized during site reconnaissance. An infrared thermal imaging scope was used to plan approaches to active fissures to avoid the hottest areas.



Figure 8. Area of gas monitoring.

The following seven gases were continuously monitored using OSHA monitoring protocols during the approach to hot spots identified by the thermal imaging. These gases were the most likely products of combustion of an oil shale. CO (ppm), VOC (ppm), CO₂ (ppm), Methane measured as LEL(%), O₂(total %), H₂S (ppm), SO₂ (ppm). The air monitors indicated that there were no detectable concentrations of any gases at distances greater than 100 feet from the fire.

Upon approach to active fissures, the concentrations of CO₂ and SO₂ increased. The CO₂ concentration peaked at 780 ppm, the OSHA Short Term Exposure Level (STEL) for CO₂ is the same for all categories at 5000 ppm. VOCs peaked at 0.7 ppm, the OSHA STEL is 25 ppm,

The SO₂ monitor had a one-time momentary peak of 4.2 ppm at a distance of 20 feet from the nearest fissure emitting clouds of water vapor and gases, then recorded a lower peak of 1.4 ppm, and then zero for the duration of the site visit, which was approximately 2 hours. The peak reading was observed when site conditions and changing wind direction blew the visible cloud directly into the monitors.

Sulfur dioxide is a highly toxic, colorless, suffocating, and irritating gas that smells like sulfur. It is much heavier than air, so stratifies at the lowest level in the air column. Sulfur dioxide is produced by fires in the presence of iron pyrite. Sulfur dioxide is extremely irritating to the respiratory system and can be detected at concentrations less than the Permissible Exposure Limits set by OSHA.

OSHA has established Permissible Exposure Limits (PEL) for SO₂ at the following levels:

STEL (Short Term Exposure Limit) = 5.0 ppm, a concentration not to be exceeded during a 15 minute period

TWA (Time Weighted Average) = 2.0 ppm, the concentration considered safe at constant exposure of 8 hours.

In March 2012, EPA set new ambient air quality standards for SO₂. This standard is designed to protect residents from respiratory effects of continuous exposure to SO₂. The standard is set at 75 ppb. Monitoring protocols for ambient air quality differ from OSHA monitoring protocols used onsite.

The fissure that produced the SO₂ peak was measured at 285 degrees C, and was one of the hottest fissures measured. In many places within the perimeter of the fire-affected area, the ground ran between 65-92 degrees C.



Figure 9. This active fissure was measured at 285 degrees C.

Samples of the shale were taken for future analysis to determine the exact nature of the combustible component of the rock. Analysis will help determine the ignition temperature of the shale, the combustible component of the rocks, and provide data that will inform current theories regarding how the current fire may have started. This analysis will include: Petrographic visual inspection, Total

Organic Carbon, Gas Chromatography, bulk sample analysis for iron and sulfur content(to determine pyrite content), and destructive rock evaluation to determine the nature of the carbon component.

Oil shales with a large pyrite component can oxidize in an exothermic reaction that may produce enough heat to allow spontaneous combustion under certain conditions. Further research into AFS records may also reveal previously unreported lightning strikes as an ignition source.

This fire provides an opportunity to study and observe an interesting physical resource phenomenon. A variety of additional studies to fully understand site conditions could include conducting supplementary aerial reconnaissance to assess the rate of fire propagation in the formation, or attempts to quantify and model SO₂ transport. Further action could be required if fire encroachment into vegetated areas results in spreading wildland fire.

The new ambient air quality standards recommend air monitoring for sites that have known SO₂ emission sources. The results of this site investigation indicate that combustion of a fossil fuel in-situ at Windfall Mountain is a known SO₂ emission source. Due to the complex topography and geographic influences, such as thermal effects and forced channeling of air flow, it is not possible to estimate the effects of dispersal affecting the transport of SO₂ upriver to Eagle with the current information. Additionally, the information recorded during the site visit cannot be extrapolated to represent conditions at all times. Air quality monitoring in Eagle should be implemented in accordance with guidelines described in draft technical assistance documents for implementation of the health-based SO₂ standard located at <http://www.epa.gov/air/sulfurdioxide/pdfs/SO2MonitoringTAD.pdf>.

Additional Information

Additional Pictures of the visit can be seen at: W:\YUGA\2013 Tatonduk Fire. Older photographs and associated project documents are also located at this address.

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