Last update: April 4, 2019

Synthesis of Soil Geochemical Characteristics and Organic Carbon Degradation from Arctic Polygon Tundra, Barrow, Alaska

NGEE Arctic Record_ID: NGA166

Review and follow the current NGEE Data and Fair-Use Policies prior to using these data (http://ngee-arctic.ornl.gov/content/ngee-arctic-data-management-policies-and-plans).

Summary:

This is a synthesis data product that reports (1) the results of soil geochemical characterization and (2) organic carbon degradation in low temperature soil incubations on cores collected on the NGEE Arctic Study Area near Utqiaġvik (Barrow), Alaska. The study area consists of thaw lakes, drained thaw lake basins and interstitial tundra with a polygonal landscape of microtopographic features created by ice wedges. Integrated geochemical and organic carbon degradation data from 9 individual soil cores collected in April 2012 and April 2013 are included in the synthesis product.

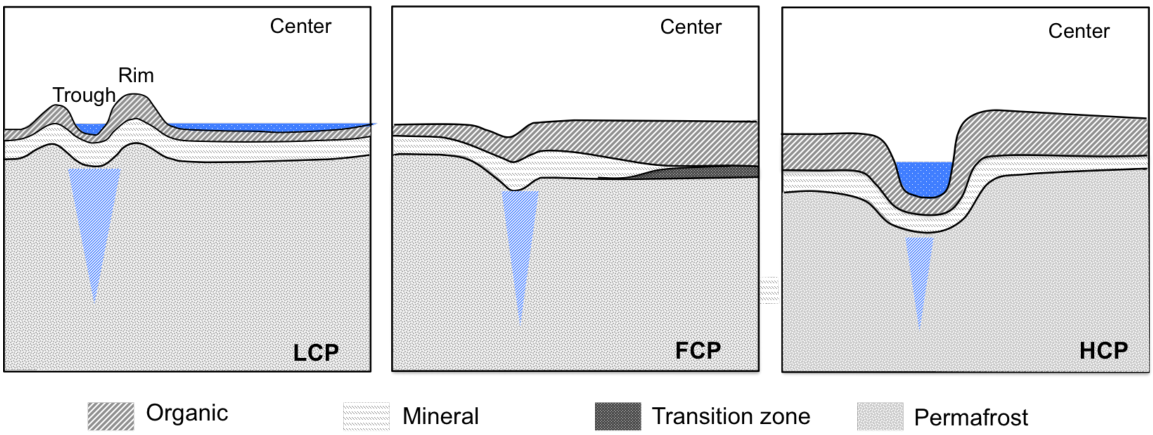

Figure 1. Schematic diagrams of different polygon types (LCP – low-centered polygon; FCP – flat-centered polygon; HCP – high-centered polygon) and features. The cross section represents the relative landscape positions of soil profile, including organic, mineral, transition zone and permafrost. Zheng et al. (2018, in review)

Please use this citation to reference the data:

Zheng, J., RoyChowdhury, T., Herndon, E.M., Yang, Z., Gu, B., Wullschleger, S., Graham, D. 2018. Synthesis of Soil Geochemical Characteristics and Organic Carbon Degradation in Arctic Polygon Tundra, Barrow, Alaska. Next Generation Ecosystem Experiments Arctic Data Collection, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, USA. Dataset accessed on [date] at https://doi.org/10.5440/1440029

Please use this citation for the related publication:

Zheng, J., Thornton, P. E., Painter, S. L., Gu, B., Wullschleger, S. D., and Graham, D. E.: Modeling anaerobic soil organic carbon decomposition in Arctic polygon tundra: insights into soil geochemical influences on carbon mineralization, Biogeosciences, 16, 663-680, https://doi.org/10.5194/bg-16-663-2019, 2019.

Related NGEE Arctic Datasets

Herndon, E., Yang, Z., and B., G.: Soil Organic Carbon Degradation during Incubation, Barrow, Alaska, 2012. Next Generation Ecosystem Experiments Arctic Data Collection, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, USA. Data set accessed at http://dx.doi.org/10.5440/1168992, 2016.

Roy Chowdhury, T., and Graham, D., Soil Physicochemical Characteristics from Ice Wedge Polygons, Barrow, Alaska, Ver.3. Next Generation Ecosystem Experiments Arctic Data Collection, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, USA. Dataset accessed at http://dx.doi.org/10.5440/1109232, 2014.

Roy Chowdhury, T., Graham, D., and Wullschleger, S., CO2 and CH4 Production in Low-Temperature Soil Incubations from Low and High Centered Polygons, Barrow, Alaska. Next Generation Ecosystem Experiments Arctic Data Collection, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, USA. Dataset accessed at http://dx.doi.org/10.5440/1237703 , 2016.

Zheng, J., Roy Chowdhury, T., and Graham, D.: CO2 and CH4 Production and CH4 Oxidation in Low Temperature Soil Incubations from Flat- and High-Centered Polygons, Barrow, Alaska, 2012. Next Generation Ecosystem Experiments Arctic Data Collection, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, USA. Dataset accessed at http://dx.doi.org/10.5440/1288688, 2016.

Zheng, J., and Graham, D.: Soil Organic Carbon Degradation in Low Temperature Soil Incubations from Flat- and High-Centered Polygons, Barrow, Alaska, 2012-2013. Next Generation Ecosystem Experiments Arctic Data Collection, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee, USA. Dataset accessed at http://dx.doi.org/10.5440/1393836, 2017.

Data Characteristics

This data archive contains 9 files representing 9 individual soil cores included in the synthesis study.

- A complete list of soil cores is summarized in Table 1 for quick reference.
- Core locations are provided in Table 2.
- Data are provided in comma-separated files, named by Core ID, e.g., NGADG0001.csv.

User Notes:

- For certain measured or calculated values, -9999 is used when the value is either not available or applicable.
- **Measurements** listed across the row on **Incubation_Time**, **Day 0**, of each incubation series, are pre-incubation characterizations.
- **CO_2 and CH_4 production rates** listed across the row on **Incubation_Time**, **Day 0**, of each incubation series, are derived from daily gas production for that entire incubation series and are summarized in each **Day 0** row.

Table 1. Summary of soil cores included in the synthesis study

Core_ID	Type	Soil_Layer	Depth	Incubation	Collection Date
NGADG0001	HCP-Center	Organic	10-30 cm	Oxic	2012-04-13
		Permafrost	50-70 cm	Anoxic	
NGADG0003	FCP-Center	Organic	8-28 cm	Oxic	2012-04-13
		Transition	38-48 cm	Anoxic	
		Permafrost	48-68 cm	Anoxic	
NGADG0005	LCP-Rim	Organic	0-8 cm	Anoxic	2012-04-12
		Mineral	8-42 cm	Anoxic	
NGADG0009	LCP-Trough	Organic	0-19 cm	Anoxic	2012-04-12
		Mineral	25-69 cm	Anoxic	
NGADG0017	LCP-Center	Organic	0-22 cm	Anoxic	2012-04-13
		Mineral	22-54 cm	Anoxic	
NGADG0043	HCP-Center	Organic	10-20 cm	Oxic	2013-04-16
		Mineral	20-50 cm	Anoxic	
NGADG0048	HCP-Trough	Organic	10-30 cm	Anoxic	2013-04-16
		Mineral	30-50 cm	Anoxic	
NGADG0071	HCP-Trough	Organic	8-20 cm	Anoxic	2013-04-17
		Mineral	22-45 cm	Anoxic	
NGADG0073	LCP-Center	Mineral	15-40 cm	Anoxic	2013-04-17
		Permafrost	55-82 cm	Anoxic	

Table 2. Description of geographic coordinates

Region	Locale	Administrative_area	Site	Area	Object_ID	Easting_m	Northing_m	Longtitude	Latitude	Elevation_m
North Slope	Barrow	BEO	Intensive Site 1	Area B	**NGADG0001**	585787.386	7910247.311	-156.6049957	71.2792969	5.5999999
North Slope	Barrow	BEO	Intensive Site 1	Area C	**NGADG0003**	585958.488	7910335.587	-156.6000061	71.2799988	4.8899999
North Slope	Barrow	BEO	Intensive Site 1	Area A	**NGADG0005**	585566.096	7910494.188	-156.6109924	71.281601	5.2600002
North Slope	Barrow	BEO	Intensive Site 1	Area A	**NGADG0009**	585563.144	7910496.304	-156.6109924	71.281601	5.1100001
North Slope	Barrow	BEO	Intensive Site 1	Area A	**NGADG0017**	585572.967	7910489.012	-156.6100006	71.2815018	5.1399999
North Slope	Barrow	BEO	Intensive Site 1	Area B	**NGADG0043**	585790.0056	7910246.805	-156.6049957	71.2792969	5.5799999
North Slope	Barrow	BEO	Intensive Site 1	Area B	**NGADG0048**	585783.026	7910245.21	-156.6049957	71.2792969	5.1399999
North Slope	Barrow	BEO	Intensive Site 1	Area A	**NGADG0071**	585573.8618	7910489.754	-156.6100006	71.281601	5.1500001
North Slope	Barrow	BEO	Intensive Site 1	Area A	**NGADG0073**	585573.8618	7910489.754	-156.6100006	71.281601	5.1500001

Last update: April 4, 2019

Data Dictionary

Column Name	Unit/Format	Description
Core_ID		NGEE Arctic sample identifier
Soil_layer		Organic, Mineral, Transition or Permafrost
Polygon Type		LCP – low-centered polygon; FCP – flat-centered polygon; HCP – high-centered polygon
Microtopography		Center, Rim or Trough
Upper_depth_of_soil_layer	cm	Upper depth of soil layer
Lower_depth_of_soil_layer	cm	Lower depth of soil layer
Moisture	gH2O g^{-1} soil	Moisture of designated soil layer
SOC	%	Total organic carbon content of designated soil layer
C_N_ratio		C/N ratio of designated soil layer
Headspace		Anoxic or Oxic
Incubation_Temperature		-2, 4 or 8 degree C
Incubation_Time	Day	See important **Incubation_Time, Day 0, notes above.**
CO2_1	µmol g^{-1} dwt	CO_2 production of replicated incubation 1
CO2_1_Rate	µmol g^{-1} dwt day^{-1}	Maximum CO_2 production rate estimated from curve fitting
CO2_1_Fit		Curve fitting for replicated incubation 1, possible values include linear, hyperbolic, or sigmoidal.
CO2_2	µmol g^{-1} dwt	CO_2 production of replicated incubation 2
CO2_2_Rate	µmol g^{-1} dwt day^{-1}	Maximum CO_2 production rate estimated from curve fitting
CO2_2_Fit		Curve fitting for replicated incubation 2, possible values include linear, hyperbolic, or sigmoidal.
CO2_3	µmol g^{-1} dwt	CO_2 production of replicated incubation 3
CO2_3_Rate	µmol g^{-1} dwt day^{-1}	Maximum CO_2 production rate estimated from curve fitting
CO2_3_Fit		Curve fitting for replicated incubation 3, possible values include linear, hyperbolic, or sigmoidal.
CH4_1	µmol g^{-1} dwt	CH_4 production of replicated incubation 1
CH4_1_Rate	µmol g^{-1} dwt day^{-1}	Maximum CH_4 production rate estimated from curve fitting
CH4_1_Fit		Curve fitting for replicated incubation 1, possible values include linear, hyperbolic, or sigmoidal.
CH4_2	µmol g^{-1} dwt	CH_4 production of replicated incubation 2
CH4_2_Rate	µmol g^{-1} dwt day^{-1}	Maximum CH_4 production rate estimated from curve fitting
CH4_2_Fit		Curve fitting for replicated incubation 2, possible values include linear, hyperbolic, or sigmoidal.
CH4_3	µmol g^{-1} dwt	CH_4 production of replicated incubation 3
CH4_3_Rate	µmol g^{-1} dwt day^{-1}	Maximum CH_4 production rate estimated from curve fitting
CH4_3_Fit		Curve fitting for replicated incubation 3, possible values include linear, hyperbolic, or sigmoidal.
WEOC	µmol g^{-1} dwt	Water-extractable organic carbon
TOAC	µmol g^{-1} dwt	Total organic acid carbon, calculated as the sum of organic carbon from organic acids (including Formate, Acetate, Propionate, and Butyrate)
Formate	µmol g^{-1} dwt	Formic acid (HCOOH)
Acetate	µmol g^{-1} dwt	Acetic acid (CH3COOH)
Propionate	µmol g^{-1} dwt	Propionic acid (CH3CH2COOH)
Butyrate	µmol g^{-1} dwt	Butyric acid (CH3CH2CH2COOH)

Column Name	Unit/Format	Description
Fe_II	μmol g^{-1} dwt	Dissolved Ferrous iron
pH		Soil pH

Methods

Details of and additional references for sampling, analysis, and incubation methods are provided in Zheng et al. (2018, in review).

Sampling: Soil cores were collected in Site 1 from both active layer and permafrost (if present) of different microtopographic features (rim, trough, and center) of low-centered polygons (Area A), high-centered polygons (Area B), and flat-centered polygons (Area C). LCPs are characterized by narrow, saturated rims, raised rims, and wet, sometimes saturated centers (Figure 1). FCPs represent transitional polygons with melting ice wedges, minimal rims, moderately dry centers, and disconnected rims, while HCPs have well drained centers and low, saturated rims.

Soil Analyses: Details and comprehensive analysis results on soil cores collected from ice-wedge polygons during field expeditions are synthesized in the dataset. Reported soil geochemical characteristics include water content, pH, organic carbon content, and C/N ratio. Additional reported analytes include dissolved organic carbon, low molecular weight organic acids (such as acetate, formate, etc), extractable Fe(II) content, and total Fe content.

Soil Incubations: Incubations were conducted on each soil layer, including organic, mineral, cryoturbated transition zone (if identified) and permafrost. The period of anoxic incubation in these studies ranged from 45 to 90 days with an average of approximately 60 days at field-relevant temperatures of -2, +4 and +8 °C. Cumulative CO_2 and CH_4 production are reported at different time intervals during incubations. Changes in exchangeable Fe(II), water extractable organic carbon (WEOC), low molecular weight organic acids, and pH of soil microcosms during incubation are also reported.

CO_2 and CH_4 production rates were estimated using individual curve fitting for each microcosm. CO_2 production generally followed linear or hyperbolic curves with immediate CO_2 release for all LCP, FCP and HCP trough samples. CO_2 production from HCP center samples experienced time lags for approximately 10 days for the mineral layer, and 45 days for the permafrost. CH_4 production was also associated with varying time lags before reaching maximum rates, following the sigmoidal shape. The rate of gas production estimated from hyperbolic curve fitting predicts a continuously decreasing rate, while sigmoidal curve fitting with an initial delay predicts a maximum rate after the lag time. Here, we used the derivatives of nonlinear curve fitting to calculate initial rates of gas production. For hyperbolic fittings, the maximum rate is calculated at day 0. For sigmoidal fittings, the maximum rate is calculated by setting the third derivative to zero. The temperature dependence using conventional Q_{10} can be calculated by taking the ratio of maximum production rates at 8 and -2°C based on triplicate measurements.

These controlled incubations provided critical information on anaerobic SOM decomposition processes across a gradient of soil with fine-scale variability in thermal and hydrological regimes. The results facilitate benchmarking and parameterization for fine-scale anaerobic SOM decomposition models.

References

Zheng, J., Thornton, P. E., Painter, S. L., Gu, B., Wullschleger, S. D., and Graham, D. E.: Modeling anaerobic soil organic carbon decomposition in Arctic polygon tundra: insights into soil geochemical influences on carbon mineralization, Biogeosciences Discuss., https://doi.org/10.5194/bg-2018-63, in review, 2018.

Last update: April 4, 2019

Disclaimer of Liability

Data Center Contact: support@ngee-arctic.ornl.