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GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7792

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2015

Canada

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2015

doi:10.4095/296461

This publication is available for free download through GEOSCAN (http://geoscan.nrcan.gc.ca/).

Recommended citation
Wright, D.M., Potter, E.G., and Comeau, J-S., 2015. Athabasca Basin Uranium Geochemistry Database v.2; Geological Survey of Canada, Open File 7792, 1 .zip file. doi:10.4095/296461

Publications in this series have not been edited; they are released as submitted by the author.

Overview

The **A**thabasca Basin **U**ranium **G**eochemistry Database (AUG) represents the compilation of several Saskatchewan Geological Survey Data Files and drill core geochemistry extracted from Mineral Assessment reports submitted to the Saskatchewan Mineral Assessment Database for the period 2000 to 2011 for the Athabasca Basin of northern Saskatchewan and Alberta (Figure 1). This revised version (2) of the database supersedes Open File 7495 (Wright et al., 2013), incorporating an addition year of publically available data. The primary purpose of this compilation is to produce a dataset from which further academic, government, and industrial research related to unconformity-associated uranium deposits may proceed.

The AUG is stored in the Microsoft Access™ 2010 database accompanying this summary (Ath_Basin_lithgeoch2015.mdb). During compilation, the metadata associated with the data has been standardized to assist with sorting, summarizing, and querying the dataset, described in detail in the following sections four sections: 2) Original Data Sources; 3) Geographic Distribution; 4) Sample Descriptions; 5) Analytical Laboratories; and 6) Analytical Results. To create a single shape file [AthBasinGeochem] in the database, coordinates from UTM NAD83 Zone 12 were projected to Zone 13 coordinates to create the ESRI® shapefile. Due to the limitations of the shapefile format, the column headers have been truncated to 10 characters in the shapefiles and the included ArcMap™ 10.1 document.

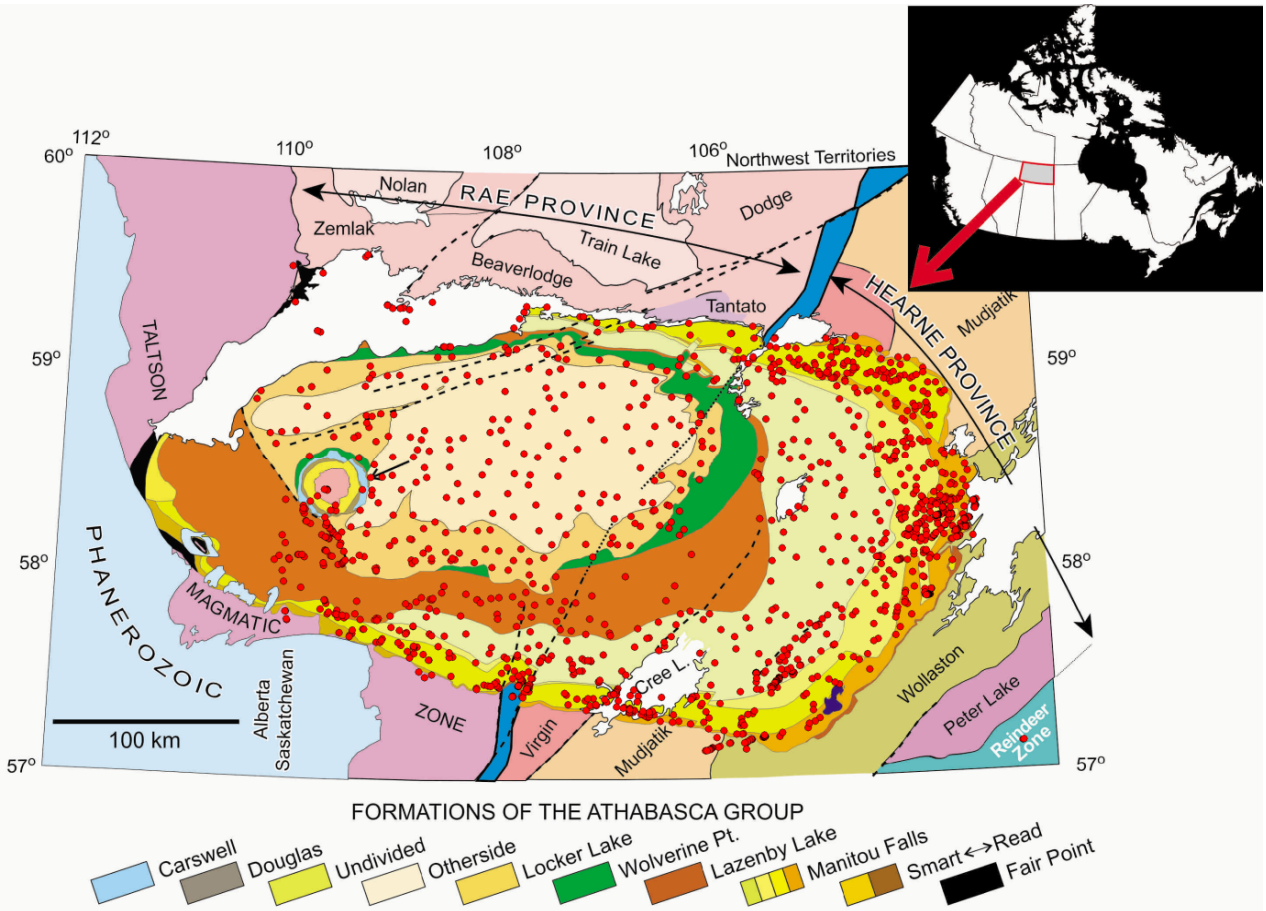

Figure 1: *Location Map of the Athabasca Basin and the geographic distribution of samples (red) within the AUG database (map modified after Jefferson et al., 2007)*

Original Data Sources

Saskatchewan Geological Survey Data File publications and Mineral Assessment Reports submitted to the Saskatchewan Mineral Assessment Database (SMAD) are the primary sources of information contained within the AUG database.

Column: DATASET

- **SGS_DF:** Six separate surface and diamond drill core geochemistry Data Files from the Athabasca Basin have been published by the Saskatchewan Geological Survey (Table 1).
- **SGS_MAD**: The Saskatchewan Mineral Assessment Database was queried to identify Mineral Assessment reports containing geochemical data submitted for uranium exploration or development within the Athabasca Basin between 2000 and 2011. This range of dates was used to encompass the adoption of multi-element geochemical analysis as a common method (~2000) to the date at which the assessment reports would become public (i.e. assessment reports submitted in 2010 would be no longer confidential as of 2013). One additional assessment report was also obtained from the government of Alberta for the western Athabasca Basin and is cited as a source in Card et al., (2011).
- **GSC_GeoScan:** A single open file report published by the Earth Sciences Sector of Natural Resources Canada contained multi-element geochemical data from drill holes within the Athabasca Basin. The report was downloaded from GEOSCAN and is included in the database.

Column: REPORT_ID

- The specific Assessment Report file number, SGS Data File Report number or GSC Open File Report number from which the original data were extracted.

Column: YEAR_FROM

- The year within which the work reported in the Assessment Report was started.

Column: YEAR_TO

- The year within which the work reported in the Assessment Report was completed.

Column: COMPANY

- The company primarily responsible for submitting the Assessment Report. A tabulation of the companies represented in the database is presented in Table 2.

Column: CONFIDENTIAL_DATE

- The date at which the submitted assessment report became confidential.

Column: OFF_CONFIDENTIAL_DATE

- The date at which the submitted assessment report would be no longer confidential.

Table 1: *Summary of SGS Data Files included in the AUG compilation*

SGS Data File	Description	Reference
Data File Report 24	Industry Drillcore Data	Uravan Minerals Inc., 2010
Data File Report 29	Geochemical Analyses: Athabasca Group Outcrops	Card et al., 2011
Data File Report 30	Geochemical Analyses: Athabasca Group Outcrops (Supplementary to DF 29)	Card and Bosman, 2012
Data File Report 31	Geochemical Analyses: Athabasca Group Drillholes (Supplementary to DF 24, 29, & 30)	Bosman and Card, 2012
Data File Report 32	Geochemical Analyses: Athabasca Group Drillholes (Supplementary to DF 24, 29, 30, & 31)	Bosman and Card, 2013
Data File Report 33	Geochemical Analyses of Athabasca Group Drillholes in Saskatchewan (NTS 64L, 74F to 74K, and 74N to 74P) – Supplementary to Data File Reports 24, 29, 30, 31, and 32	Bosman and Card, 2013

Table 2: *Company representation within AUG Dataset.*

Column: COMPANY	Sample Count (n)	Proportion of AUG Dataset (n = 40,378)
AREVA RESOURCES CANADA INC.	5042	12.49%
CAMECO CORP.	12609	31.23%
CANALASKA URANIUM	1878	4.65%
CLARK LLOYD (OPTIONED TO NUINSCO RESOURCES)	380	0.94%
DEJOUR ENTERPRISES LTD	724	1.79%
DENISON MINES	6848	16.96%
ESO URANIUM CORP	380	0.94%
FISSION ENERGY CORP	450	1.11%
FORUM URANIUM CORP	978	2.42%
HATHOR EXPLORATION LTD.	128	0.32%
JNR RESOURCES INC.	271	0.67%
KODIAK EXPLORATION LTD (NOW OWNED BY ARGONAUT GOLD)	144	0.36%
PHELPS DODGE CORPORATION - LEDERHOUSE M	25	0.06%
PITCHSTONE EXPLORATION LTD	465	1.15%
SGS	1466	3.63%
SGS-Uravan	955	2.37%
TITAN URANIUM INC.	923	2.29%
TRIEX MINERALS CORPORATION	247	0.61%
UEM INC.	2029	5.03%
UEX CORP.	4044	10.02%
URANERZ EXPLORATION AND MINING LIMITED	392	0.97%

Geographic Distribution

The geographic location of each sample is described in both absolute and relative terms within the AUG dataset.

Absolute Geographic Distribution

The UTM coordinates of individual samples/drill holes were extracted from each assessment report or data file, and tabulated according to datum, zone, easting and northing. To facilitate spatial modeling, the data were converted and compiled into the NAD83 datum. The following conversion parameters were followed:

- WGS84 data were copied directly to NAD83, assuming no shifts (not precisely accurate, but at the scale of the current compilation, likely acceptable)
- NAD27 data were converted to NAD83 using the NTv2 National Transformation software provided by Natural Resources Canada: (http://geoapps.nrcan.gc.ca/applications/0/NTv2%20National)

Column: E_NAD83Z13

- UTM NAD83 Zone 13 Easting value.

Column: N_NAD83Z13

- UTM NAD83 Zone 13 Northing value.

Column: E_NAD83Z12

- UTM NAD83 Zone 12 Easting value, missing for samples with coordinates originally in Zone 13.

Column: N_NAD83Z12

- UTM NAD83 Zone 12 Northing value, missing for samples with coordinates originally in Zone 13.

Column: Sample_Elevation

- Sample elevation calculated from the DDH_ELEV collar elevation, the AZIMUTH, DIP, DDH_FROM and DDH_TO values using pbEncom™ Discover™ (3D) software with MapInfo® Professional.

Column: DDH_SAMPID

- The original sample label or drill hole label with which the sample is associated.

Column: DDH_FROM

- For samples collected from drill core, the depth within the drill hole at which the sample interval begins.

Column: DDH_TO

- For samples collected from drill core, the depth within the drill hole at which the sample interval ends.

Column: DDH_ELEV

- Where available, the drill collar elevation has been added to new and existing assessment reports included in this edition of the database. For reports that did not include elevation measurements, the elevation was determined from a digital elevation model (DEM).

Column: DDH_from_DEM

- Whether the elevation was taken directly from the assessment report or from the DEM. A value of 1 indicates that the data was extracted from the DEM.

Column: AZIMUTH

- The median orientation of the drill hole with respect to the horizontal plane. For statistical and modelling purposes, an azimuth of 0 degrees has been chosen for drill logs with a 90 degrees dip.

Column: DIP

- The median dip angle of the drill hole. A dip angle of 90 indicates vertical drilling whereas a dip angle of 0 refers to the horizontal plane.

Relative Geographic Distribution

Where possible, the spatial distribution of each sample from submitted Assessment Reports was also categorized according to their relative position within the Athabasca Basin. The individual samples within the SGS Data Files were not assigned to specific regions due to the regional nature of the dataset.

Column: GEN_AREA

- For most Assessment Report files, a general area of the Athabasca Basin was identified within the report.

Column: DEP_AREA

- For some areas, a spatial association with the sampling completed and a known deposit area or area of interest was identified (Table 3).

Column: REL_GEOG_DIST

- The spatial distribution of each sample from submitted Assessment Reports was also categorized according to their relative position within the Athabasca Basin (Table 4).

Sample Descriptions

Sample descriptions within the AUG dataset range from very detailed to non-existent, often without any standard format or content between or even within the same report. In an attempt at standardization, several summary columns were added to the database to facilitate rapid sorting of the data in future, summarized from the original sample descriptions.

Column: LITHOLOGY_BASIC

- Several types of description are applied to each sample, depending on their basic lithology or purpose as described within the respective source reports (Table 3). Unknown samples were most commonly those for which either a sample lithology label was not provided, or the labels provided were insufficient to accurately define the actual sample lithology.
- Samples collected for the purposes of monitoring quality control (QAQC) were not well represented in original Assessment Report files. As they represented only a very small proportion of the original sample data population, their value was considered minimal within the context of the compilation and were excluded.

Column: BASEMENT_CODES

- Of a total of 14,656 Basement samples (Table 3), 5,324 were labeled with enough information to identify the likely basement source material (Table 4).

- This column was added to facilitate the interpretation of geochemical variations relative to primary basement host rock.

Column: FORMATION

- Of a total of 19,847 sandstone samples (Table 3), 11,436 were labeled with enough information to identify the likely stratigraphic formation from which these samples were collected (Column: Formation; Table 5).

Column: STRATORDER

- In addition to the basic Sandstone Formation labels, an additional column containing the formation labels with a numeric prefix is also included to assist with sorting the data based on stratigraphic order (Table 5).

Table 3: *Column: LITHOLOGY_BASIC Statistics*

Column: LITHOLOGY_BASIC	Sample Count (n)	Proportion of AUG Dataset (n = 40,378)
Basement	14,656	36.30%
Sandstone	19,847	49.15%
Unknown	5,875	14.55%

Table 4: *Column: BASEMENT_CODES Statistics*

Column: BASEMENT_CODES	Description	Sample Count (n)	Proportion of Coded Samples (n = 5,324)
PELT	Pelite	2,923	54.90%
ARKS	Arkose	833	15.65%
QZIT	Quartzite	422	7.93%
GRAN	Granite	235	4.41%
PEGM	Pegmatite	215	4.04%
CALC	Calc-Silicate	139	2.61%
PSAM	Psammite	97	1.82%
MARB	Marble	57	1.07%
MYLN	Mylonite	51	0.96%
AMPH	Amphibolite	27	0.51%
MDYK	Mafic Dyke	24	0.45%
FXPO	Feldspar Porphyry	6	0.11%
ANAT	Anatexite	27	0.51%
CLPL	Calc-pelite	81	1.52%
CLSP	Calc-semi-pelite	3	0.06%
GRDT		6	0.11%
GRGN		10	0.19%
MCGR		7	0.13%
MGPE	Moderate GF Metapelite	37	0.70%
MGRN	Microgranite	11	0.21%
SGPE		19	0.36%
SMPL	Semi-pelite	38	0.71%
SYEN		6	0.11%
TONL		4	0.08%
WGPE		65	1.22%
WGPL		1	0.02%

Table 5: *Column: FORMATION Statistics*

Column: FORMATION	Column: STRATORDER	Formation Description	Sample Count (n)	Proportion of Coded Samples (n=11,430)
O	01_O	Otherside	107	0.94%
LL	02_LL	Locker Lake (undivided)	133	1.16%
W	03_W	Wolverine Point (undivided)	129	1.13%
LZ	04_LZ	Lazenby Lake (undivided)	248	2.17%
MFd	05_MFd	Manitou Falls, Dunlop Member	1,519	13.29%
MFc	06_MFc	Manitou Falls, Collins Member	2,242	19.62%
MFw	07_MFw	Manitou Falls, Warnes Member	75	0.66%
MFr	08_MFr	Manitou Falls, Raibl Member	114	1.00%
MFb	09_MFb	Manitou Falls, Bird Member	2,944	25.76%
MFa/RD	10_MFa/RD/SMT	Manitou Falls, "A" Member / Read / Smart	3,914	34.24%
FP	11_FP	Fair Point	5	0.04%

5. Analytical Laboratories

Column: ANALYTICAL_LABORATORY

- Six analytical laboratories are represented in the AUG dataset, summarized in Table 6.
    - The SRC (Saskatchewan Research Council – GeoAnalytical Laboratory) is the most common commercial laboratory used for the analysis of geochemical samples from the Athabasca Basin region.

Column: PARTIAL_DIGESTION

- Partial digestion attempts to focus the digestion of the sample to the more labile components of the sample, assumed to more likely represent the proportion of the sample associated with alteration and mineralization.
- The most common partial digest analysis method employed in the Athabasca Basin is the SRC Partial digest, comprising a 9:1 mixture of HNO_3:HCl; This digest was designed to more particularly focus on uranium than the similar Aqua Regia partial digest (3:1 HCl:HNO_3). Final analysis of the digestion product is most commonly completed by ICP-OES techniques, yet ICP-MS techniques may also be used, providing lower detection limits.

Column: TOTAL_DIGESTION

- Total digestion attempts to fully digest samples, providing a relatively complete geochemical signature. Total digestion methods usually rely on a combination of three to four different acids, usually including hydrofluoric acid (HF). These techniques are typically effective, but incomplete digestion of the sample is still possible due to the presence of highly resistate minerals. In addition, elements that may volatilize during total digestion may be under-represented in the dataset, including elements such as As, Se, and Te. The most common total digest method employed in the Athabasca Basin is the three-acid digest provided by the SRC (Table 6). The authors are not aware of published comparisons of the effectiveness of this digest relative to more common four-acid digest combinations. Final analysis of the digestion product is most commonly completed by ICP-OES techniques, yet ICP-MS techniques may also be used.

- A major difference is observed in the reporting of major element data between the data provided by the SRC versus that of other laboratories: Major element data reported by the SRC and NTEL are commonly reported as oxide values, whereas other laboratories report these elements in the elemental form. This difference has not always been respected in the datasets reported to the SGS MAD. As a result, mixtures of oxide and elemental data are possible within the major element data present. All reasonable attempts have been made to respect the oxide vs. elemental reporting of the major elements in the compiled AUG dataset.

Column: BORON_DIGESTION

- A sodium peroxide fusion digest has been commonly applied to enhance the extraction of boron. Boron is of interest due to its role as a component of dravite/magnesiofoitite alteration in the sandstones of the Athabasca Basin (REFS). Analysis of the digestion product is typically by ICP-OES techniques.

Column: ALT_DIGESTION

- Prior to commercial access to ICP technology, partial digest uranium analysis was completed using fluorimetry (most commonly at the SRC). As the detection limits available via ICP-OES analysis were commonly higher than those available via fluorimetry, the use of the latter as the primary method for uranium determination was continued.

Table 6: *Analytical Laboratories represented in the AUG dataset.*

Analytical Laboratory	Sample Count (n)	Proportion of AUG Dataset (n = 40,378)	Partial Digest	Total Digest	Additional Digests
SRC Saskatoon, SK	36,350	90.02%	SRC Partial: 9-1 HNO_3:HCl	$HF/HNO_3/HClO_4$	B: Na_2O_2 Fusion; U(p): Fluorimetry
NTEL Darwin, NT, Australia	1,343	3.33%	2% HNO_3 or $HClO_4$	$HCl/HF/HNO_3/HClO_4$	
Loring Laboratories Calgary, AB	1,196	2.96%	Aqua Regia: 3-1 HCl/HNO_3	N/A	
ACME Laboratories Vancouver, BC	1,489	3.69%	Aqua Regia: 3-1 HCl/HNO_3	$HNO_3/HClO_4/HF/HCl$	B: Na_2O_2 Fusion

Analytical Results

The analytical results for each sample are listed in individual columns using standardized labels indicating the element determined, the digest used, and the units used to measure the element. Data below detection have been handled in a variety of ways within the various Assessment Reports compiled, including preserving the original detection limit values (using "<" and "-" prefixes or "0" values), modification of the detection limit values, or deletion. Where identified in the original data, the absolute value of the original detection limit has been preserved in the AUG dataset, identified as the negative value of the absolute value.

Column: Element_Digest_Unit

- Element Labels:
    - Trace Elements (e.g. Ag through Zr)
        - Some lead isotope data is present, with the specific isotopes identified according to their isotopic number (e.g. ^{206}Pb = Pb206)

    - Major Element Oxides (e.g. Al_2O_3 through TiO_2)
    - Major Elements (e.g. Al through Ti – not reported as Oxides)
- Digest Labels:
    - p = Partial Digest (laboratory specific)
    - t = Total Digest (laboratory specific)
        - Note: includes Boron by Na_2O_2 fusion digestion.
- Unit Labels:
    - ppm = parts per million
    - pct = Percent.
- Sample Column Header Examples:
    - Ag_p_ppm = Silver by Partial Digest, reported in parts per million.
    - Al2O3_t_pct = Aluminum Oxide by Total Digest, reported in percent.

Acknowledgments

The AUG database plus associated GIS files benefitted from constructive reviews and technical assistance by Lesley Chorlton and Beth Hillary of the Geological Survey of Canada.

References

The references for the individual assessment reports are included in the database as a separate table.

Bosman, S.A. and Card, C.D., 2012. Geochemical Analyses of Athabasca Group Drillcores in Saskatchewan (NTS 64L, 74F to 74K, and 74N to 74P) – Supplementary to Data File Reports 24, 29, and 30; Saskatchewan Ministry of Energy and Resources Data File Report 31 (digital).

Bosman, S.A. and Card, C.D., 2013. Geochemical Analyses of Athabasca Group Drillcores in Saskatchewan (NTS 64L, 74F to 74K, and 74N to 74P) – Supplementary to Data File Reports 24, 29, 30, and 31; Saskatchewan Ministry of Energy and Resources Data File Report 32 (digital).

Bosman, S.A. and Card, C.D., 2013. Geochemical Analyses of Athabasca Group Drillholes in Saskatchewan (NTS 64L, 74F to 74K, and 74N to 74P) – Supplementary to Data File Reports 24, 29, 30, 31, and 32; Saskatchewan Ministry of Energy and Resources Data File Report 33 (digital).

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Uravan Minerals Inc., 2010. Industry Drillcore Data – Regina Subsurface Core Facility – Uravan Minerals, Athabasca Basin (NTS 64L, 74F to 74K, and 74N to 74P); Saskatchewan Ministry of Energy and Resources Data File Report 24 (digital).

Appendices

Access 2010 Database: Ath_Basin_lithgeoch2015.mdb
ArcGIS ArcMap 10.1 document: AthBasin_lithogeoch_2015.mxd