Pascal, M., Ansdell, K., Annesley, I.R., Jiricka, D., Witt, G., and Brown, A., 2012. Graphite-bearing and graphite-depleted basement rocks in the Dufferin Lake Zone, south-central Athabasca Basin, Saskatchewan; Geological Survey of Canada, Open File 7258, doi:10.4095/291899

P09E-2431

University of Saskatchewan

Graphite-bearing and graphite-depleted basement rocks in the Dufferin Lake Zone, south-central Athabasca Basin, Saskatchewan

Cameco

MARJOLAINE PASCAL[1*], KEVIN ANSDELL[1], IRVINE R. ANNESLEY[1,2], DAN JIRICKA[3], GARY WITT[3] AND AARON BROWN[3]
[1]University of Saskatchewan, Saskatoon, Canada, mjp313@mail.usask.ca, kevin.ansdell@usask.ca
[2]JNR Resources, Saskatoon, Canada, jnrirvine@sasktel.net
[3]Cameco Corporation, Saskatoon, Canada, dan_jiricka@cameco.com, gary_witt@cameco.com, aaron_brown@cameco.com

INTRODUCTION

Unconformity-type uranium deposits (Hoeve and Sibbald, 1978) from the Athabasca Basin (Saskatchewan, Canada) represent the world's largest high-grade uranium ore-bodies. Most of the deposits are located at the unconformity between the sedimentary basin and the underlying Archean to Paleoproterozoic basement. As proposed in the original model (Hoeve & Sibbald, 1978), graphite and/or carbonaceous matter (CM) are often cited as the reducing media for the genesis of these deposits, releasing CH_4 or CO_2 during interaction with oxidized fluids (Annesley and Millar, 2011). The graphite and CM occur in the basement rocks and are often concentrated along ductile to brittle structures which can be identified as electromagnetic (EM) conductors, and potentially could act as a reductant that could trigger deposition of uranium.

The Dufferin Lake Zone (DLZ) is a mineralized occcurence in the south central Athabasca Basin spatially related to an interpreted EM conductor.
The basement rocks contain variable amounts of graphite, either in structures or within pelitic gneisses, but these same rocks immediately below the unconformity appear to have partially to totally lost their graphite. What processes led to the depletion in graphite below the unconformity? Did the graphite or its breakdown products (e.g. CM) act as the reductant for uranium deposition? The aim of this study is to determine the link, if any, between graphite and/or CM and uranium mineralization, and to determine how and why graphite has been lost in the basement rocks, using a variety of geo-analytical methods.

BACKGROUND

The Dufferin Lake Zone straddles the Virgin River Shear Zone, which marks the boundary between the Lloyd Domain (part of the Taltson Magmatic Zone) and the Virgin River Domain (Figs. 1 and 2). This significant crustal structure has been the focus of recent exploration for uranium, which resulted in the discovery of the Centennial deposit to the northwest of the DLZ (Jiricka 2010; Reid et al., 2010, Alexandre et al., 2012). In the DLZ area, the Virgin River Domain consists of quartzite, pelitic and variably graphitic metasedimentary rocks, and deformed granitoids and pegmatites, which have been metamorphosed to upper greenschist to lower amphibolite grade. The basement rocks are overlain by up to 400 metres of the Manitou Falls Formation quartz arenite of the Athabasca Group. The post-Athabasca Dufferin Lake thrust fault has west-over-east displacement of about 250 metres in the DLZ area. Uranium mineralization in the DLZ is hosted mainly in the Manitou Falls sandstones, and is associated with bleaching and clay alteration. Kaolinite alteration also affects the basement rocks.

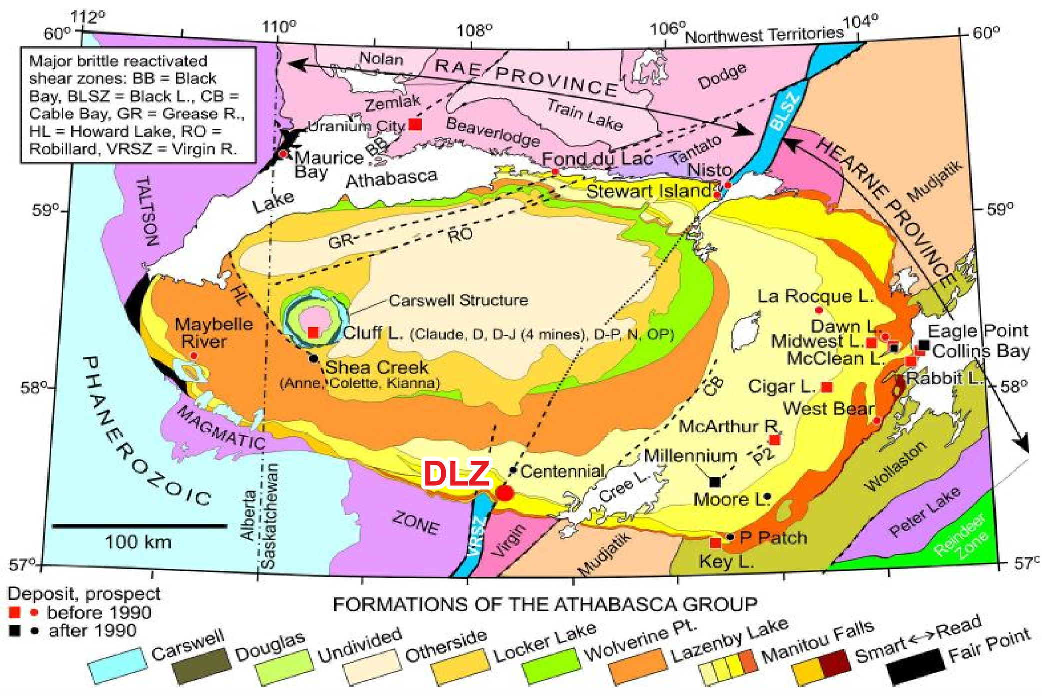

Fig. 1: Geological setting and unconformity-associated uranium occurrences of the Athabasca Basin region of northwestern Canada. Heavy dashed lines are selected major reactivated fault zones. (Jefferson et al. 2007)

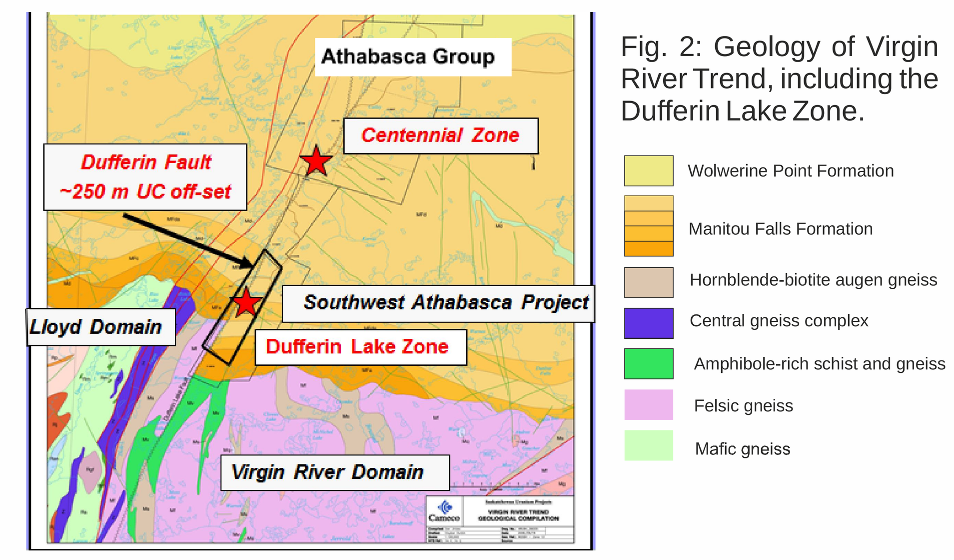

Fig. 2: Geology of Virgin River Trend, including the Dufferin Lake Zone.

GEO-ANALYTICAL METHODS

Twenty four samples of proto-mylonitic to mylonitic graphitic pelitic schist (+/- CM) from the Dufferin Lake Zone, as well as additional drillcore samples to be collected in July 2012 (Figs. 3A, 3B, and 4), are being (will be) analyzed to characterize the textural relationships, crystallinity, and type of CM/graphite using different geo-analytical techniques.

- Location of DDHs for research study:

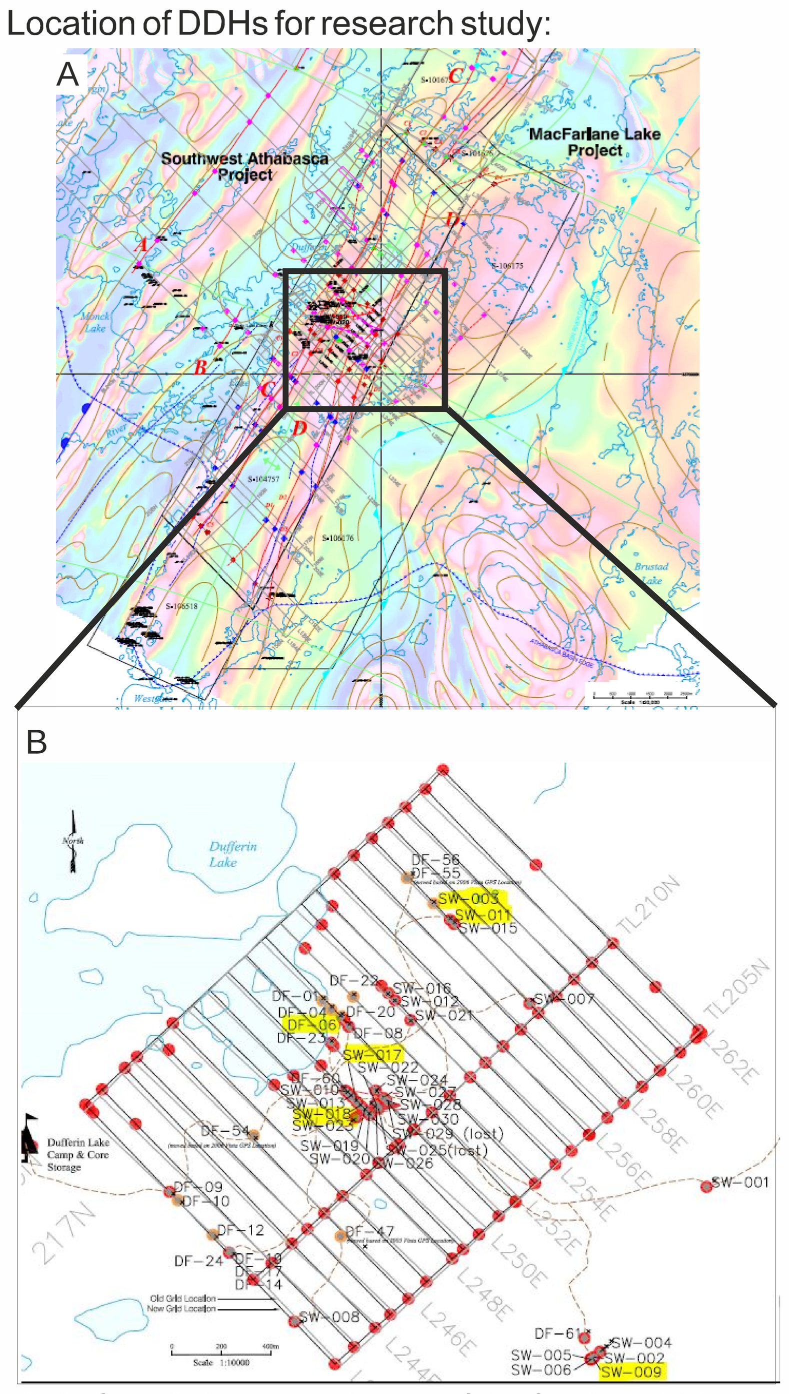

Fig. 3: A. Compilation magnetic map of the Southwest Athabasca project. B. Location of DDHs of Dufferin Lake Zone used in this study (highligted in yellow)

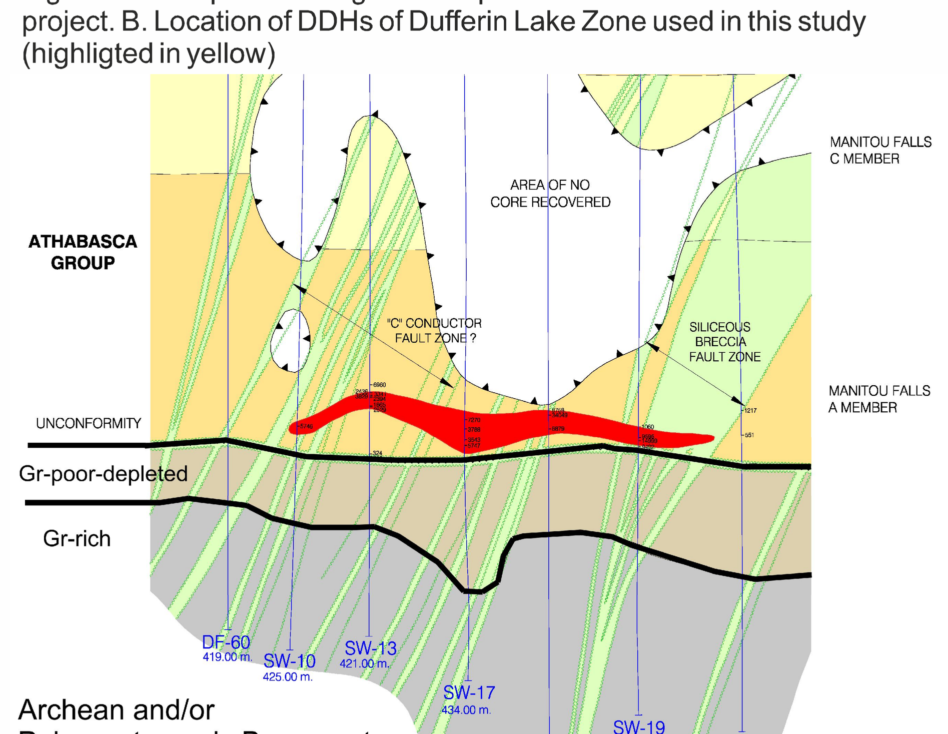

Fig. 4: Geological cross section from the Dufferin Lake Zone, illustrating the presence of graphite-depleted (Gr-poor-depleted) and graphite-rich (Gr-rich) zones. Uranium mineralization is shown in red and fault systems are outlined in green. (Radiometric anomaly: counts/second)

- Petrography:

There is significant hetereogeneity and complexity in the textural and structural relationships and type of CM/graphite observed in the pelitic schist and shear/fault zones at depth (Fig.5).

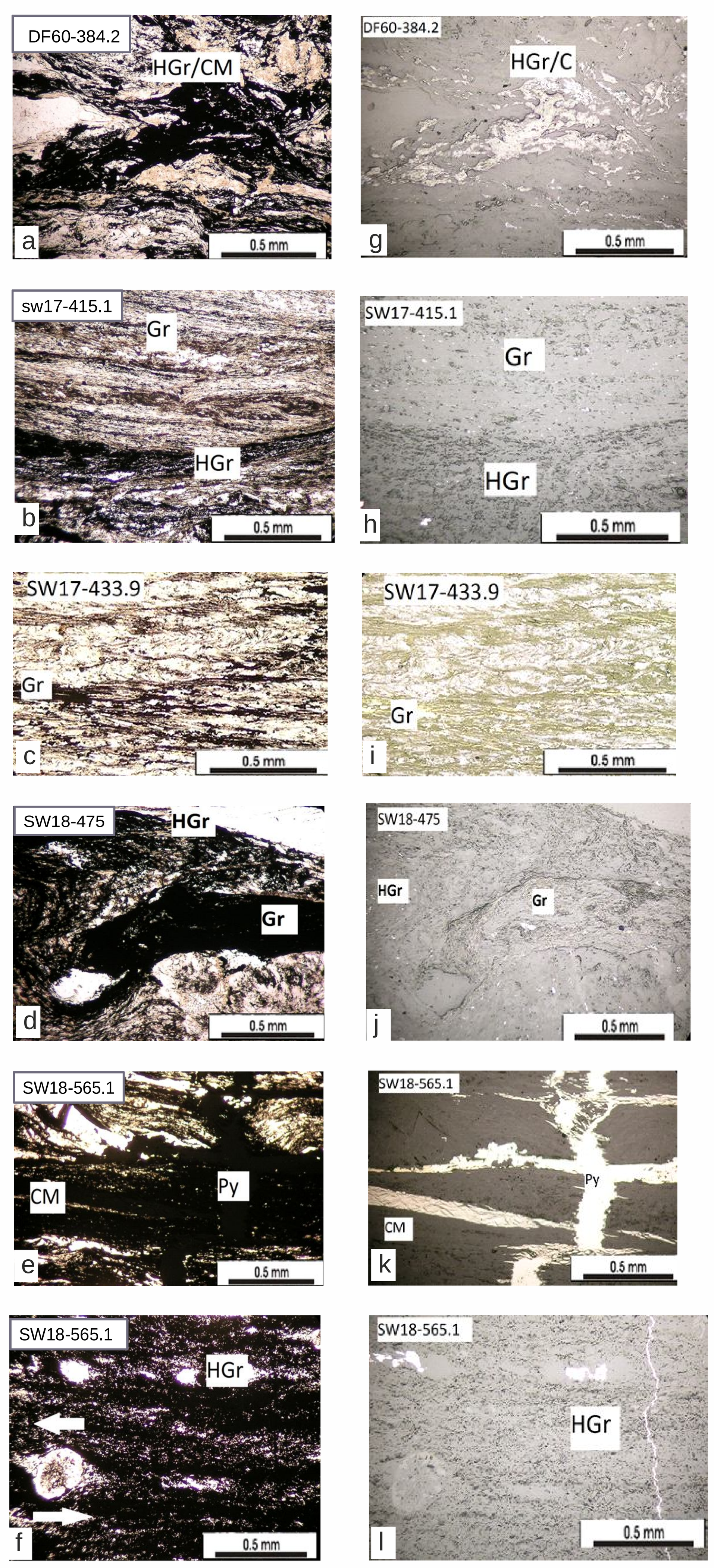

Fig. 5: Photomicrographs of variably deformed graphitic schists (+/-CM) from the Gr-rich part of the Dufferin Lake Zone.
a,b,c,d,e,f: transmitted light;
g,h,j,k: reflected light;
i: transmitted and reflected light.

SUMMARY OF FUTURE RESEARCH WORK

Additional drillcore will be logged and appropriate samples collected from the Dufferin Lake Zone in July 2012 (Figs. 3A, 3B, and 6). This will be followed by further petrographic and geo-analytical analyses so to determine the role of graphite/CM (and its breakdown products) in the uranium mineralizing system at Dufferin Lake. Results from this work will be applicable to other locations in the Athabasca Basin (Figs. 7, 8, and 9).
Ongoing research:

- Field work, including drill core logging and sampling (80-100 samples)

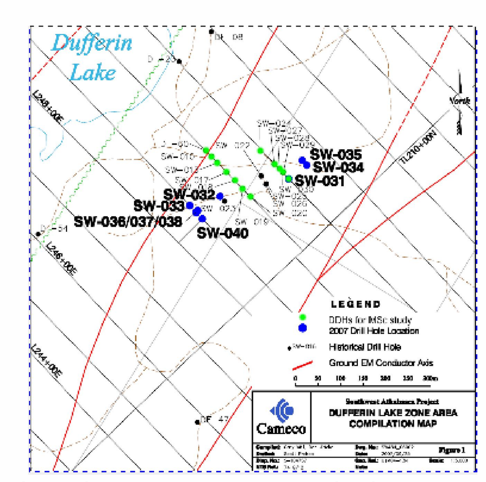

Fig. 6: Dufferin Lake Zone area compilation map showing the DDHs for MSc study.

- Whole-rock Geochemistry (majors, traces, C, S, and B; maybe Pb isotopes)
- SEM imaging
- Raman Spectroscopy
- Carbon isotope composition of Graphite and CM:

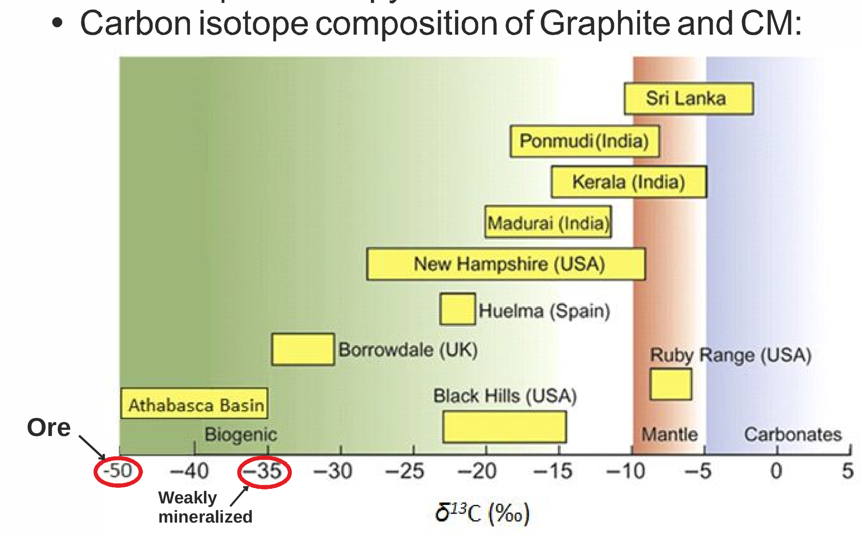

Fig. 7: Ranges of carbon isotopic variations in selected fluid-deposited graphite occurrences. (Modified after Luque et al. 2012, Sangely et al. 2007)

- Fluid Inclusions: microthermometry in combination with carbon speciation:

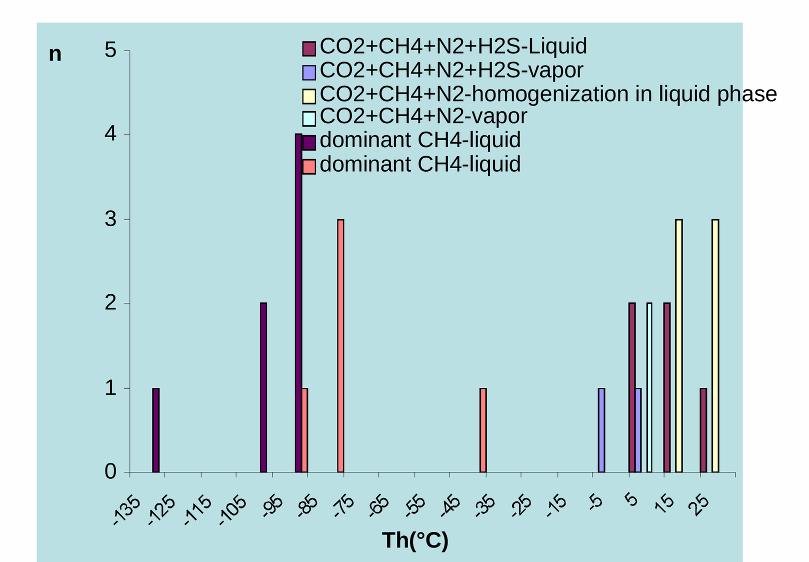

Fig. 8: Different type of carbon as function of the temperature, determined by fluid inclusions. (Modified after D.Derome, M.Cuney, M.Cathelineau, see Annesley and Millar 2011)

- Synchrotron analyses (X-PEEM):

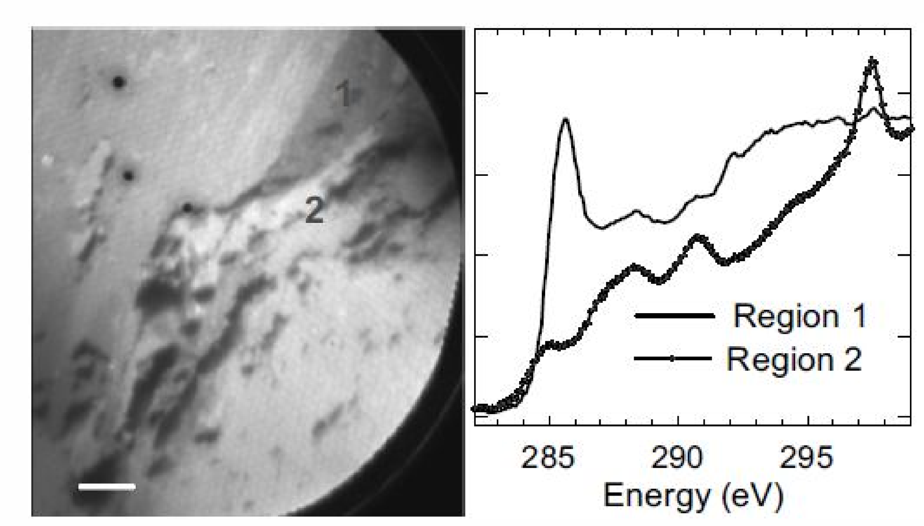

Fig. 9: (left) X-PEEM image of a graphite-sulphide-rich sample ; (right) Extracted NEXAFS spectra showing graphitic domains (Region 1) and mixed organic domains (Region 2). (Lanke et al. 2007)

ACKNOWLEDGEMENT

This work forms part of a Master of Science thesis project by the senior author. The authors acknowledge the financial support of Cameco Corporation, Natural Science and Engineering Research Council of Canada, and the Department of Natural Resources of Canada Targeted Geoscience Initiative Phase 4 (TGI4) Grants program.

REFERENCES

Alexandre, P., Kyser, K., Jiricka, D., and Witt, G., 2012. Formation and evolution of the Centennial unconformity-related Uranium deposit in the South-Central Athabasca Basin, Canada; Econ., Geol., v.107, p. 385-400.
Annesley, I. R. and Millar, R., 2011. Tourmaline- and sulfide-bearing graphitic pelitic gneisses of the Paleoproterozoic Wollaston Group, northern Saskatchewan: new insights into understanding the carbon-sulfur-boron-uranium geochemical system with implications for U/C-type uranium deposits; 25th IAGS, Finland.
Hoeve, J. and Sibbald, T., 1978. On the Genesis of Rabbit Lake and Other Unconformity-type Uranium Deposits in Northern Saskatchewan, Canada; Econ., Geol., v. 73, p. 1450-1473.
Jefferson, C.W., Thomas, D.J., Gandhi, S.S., Ramaekers, P., Delaney, G., Brisban, D., Cutts, C., Portella, P., and Olson, R.A., 2007. Unconformity associated uranium deposits of the Athabasca Basin, Saskatchewan and Alberta, In Mineral Resources of Canada: A synthesis of Major Deposit-types, District Metallogeny, the Evolution of Geological Provinces, and Exploration Methods, W.D. Goodfellow (ed); Mineral Deposits Division of the Geological Association of Canada, p. 273-306.
Jiricka, D., 2010. The Centennial deposit—an atypical unconformity-related uranium deposit—an update; International Association on the Genesis of Ore Deposits (IAGOD), 13th Quadrennial IAGOD Symposium, Adelaide, Australia, Proceedings.
Lanke, U. D., Hitchcock, A. P., Hitchcock, P., Stewart–Ornstein, J., Kaznatcheev, K., Kolmakov, A., Annesley, I., McCready, A., Urquhart, S. G., 2007. CaPeRS and Lox: Prospects for Photoelectron Emission Spectromicroscopy at the Canadian Light Source; Proc. 8th Int. Conf. X-ray Microscopy IPAP Conf. Series 7 p.85-87.
Luque, F.J., E. Crespo-Feo, J.F. Barrenechea, L. Ortega, 2012. Carbon isotopes of graphite: Implications on fluid history; Geosci., Front., v.3, p.197–207.
Reid, K., Ansdell, K., Jiricka, D., Witt, G., and Card, C., 2010. Regional setting and general characteristics of the Centennial unconformity-related uranium deposit, Athabasca Basin, Saskatchewan; GeoCanada 2010, Calgary, Abstract 838.
Sangély, L., Chaussidon, M., Michels, R., Brouand, M., Cuney, M., Huault, V., Landais, P., 2007. Micrometer scale carbon isotopic study of bitumen associated with Athabasca uranium deposits: constraints on the genetic relationship with petroleum source-rocks and the abiogenic origin hypothesis; Earth Planet., Sci., Lett., v. 258, p.378-396.

Natural Resources Canada / Ressources naturelles Canada

Canada

OPEN FILE
DOSSIER PUBLIC
7258
GEOLOGICAL SURVEY OF CANADA
COMMISSION GÉOLOGIQUE DU CANADA
2012
Publications in this series have not been edited; they are released as submitted by the author.
Les publications de cette série ne sont pas révisées; elles sont publiées telles que soumises par l'auteur.

doi:10.4095/291899