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

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Stream Sediment Geochemical Data for the Casino Porphyry Cu-Au-Mo Deposit, Yukon Territory: additional data in 2021

ABSTRACT

Stream sediment samples were collected at 22 sites in September 2017 around the Casino calc-alkaline porphyry Cu-Au-Mo deposit in west-central Yukon in order to determine if the metal zoning of elements associated with the porphyry copper system is reflected in the geochemical composition of the <177 µm stream sediment fraction. The purpose of this open file is to report stream sediment geochemical data for the Casino deposit that were analyzed in two different years: 1) analyses completed in 2018 and already reported in Open File 8632 (McCurdy et al., 2019), and 2) analyses completed in 2021 and reported here for the first time. Background geological information and stream sediment geochemical maps originally reported in Open File 8632 are not repeated in this new geochemical data reporting.

INTRODUCTION

The Casino porphyry Cu-Au-Mo deposit within the Yukon-Tanana terrane in west-central Yukon (Fig. 1) is one of Canada's largest and highest-grade porphyry deposits. It provides an ideal site for testing modern stream sediment geochemical methods because the deposit has only been minimally disturbed by exploration, is not yet mined, and is known to have metal-rich waters and sediments in creeks draining the deposit (Archer and Main, 1971).

The study area is unique in that the landscape has remained largely unglaciated within the last 200,000 years (Bond and Lipovsky, 2011). Glaciers originating around local peaks in the eastern Dawson Range (glacial maximum at 130,000 BP) have left alpine glacial features and deposits on the east flank of Mount Cockfield and the mountain peak northwest of the Casino deposit, as well as along the Yukon River in the northeast quadrant of the survey area. The surface over much of the area consists of a veneer of frost-shattered weathered bedrock and colluvium mixed with loess. The composition of stream sediments is affected primarily by locally derived material from bedrock entering the drainage systems through periglacial and mass wasting processes.

Samples of stream sediment and water were collected at 22 sites (Fig. 2) around the Casino deposit in September 2017 using a helicopter, truck, and all-terrain vehicles to access sample sites. At each site, two stream water samples, one stream silt sample, one bulk stream sediment sample for indicator minerals and one pebble sample were collected. Samples were collected primarily from fast or moderately fast flowing second- and third-order streams.

This study was carried out as part of the Geological Survey of Canada (GSC) Targeted Geoscience Initiative 5 (TGI-5), a collaborative federal-provincial-territorial geoscience program with a mandate to provide industry with the next generation of geoscience knowledge and innovative techniques that will result in more effective targeting of buried mineral deposits. TGI-5 includes other research activities targeted at porphyry deposits, including studies on porphyry indicator minerals (Plouffe et al., 2017, 2018, 2019; McClenaghan et al., 2018, 2019; Beckett Brown et al., 2019).

The purpose of this open file is to report stream sediment geochemical data for the Casino deposit that were analyzed in two different years: 1) analyses completed in 2018 and already reported in Open File 8632 (McCurdy et al., 2019), 2) analyses completed in 2021 and reported here for the first time, and 3) updated metadata (**Appendix A1**). In additional to geochemical data, Open File 8632 includes other information that is not reported here, specifically details about the bedrock and surficial geology of the Casino deposit area as well as stream sediment geochemical maps. Readers are encouraged to consult Open File 8632 for this relevant information when working with this dataset.

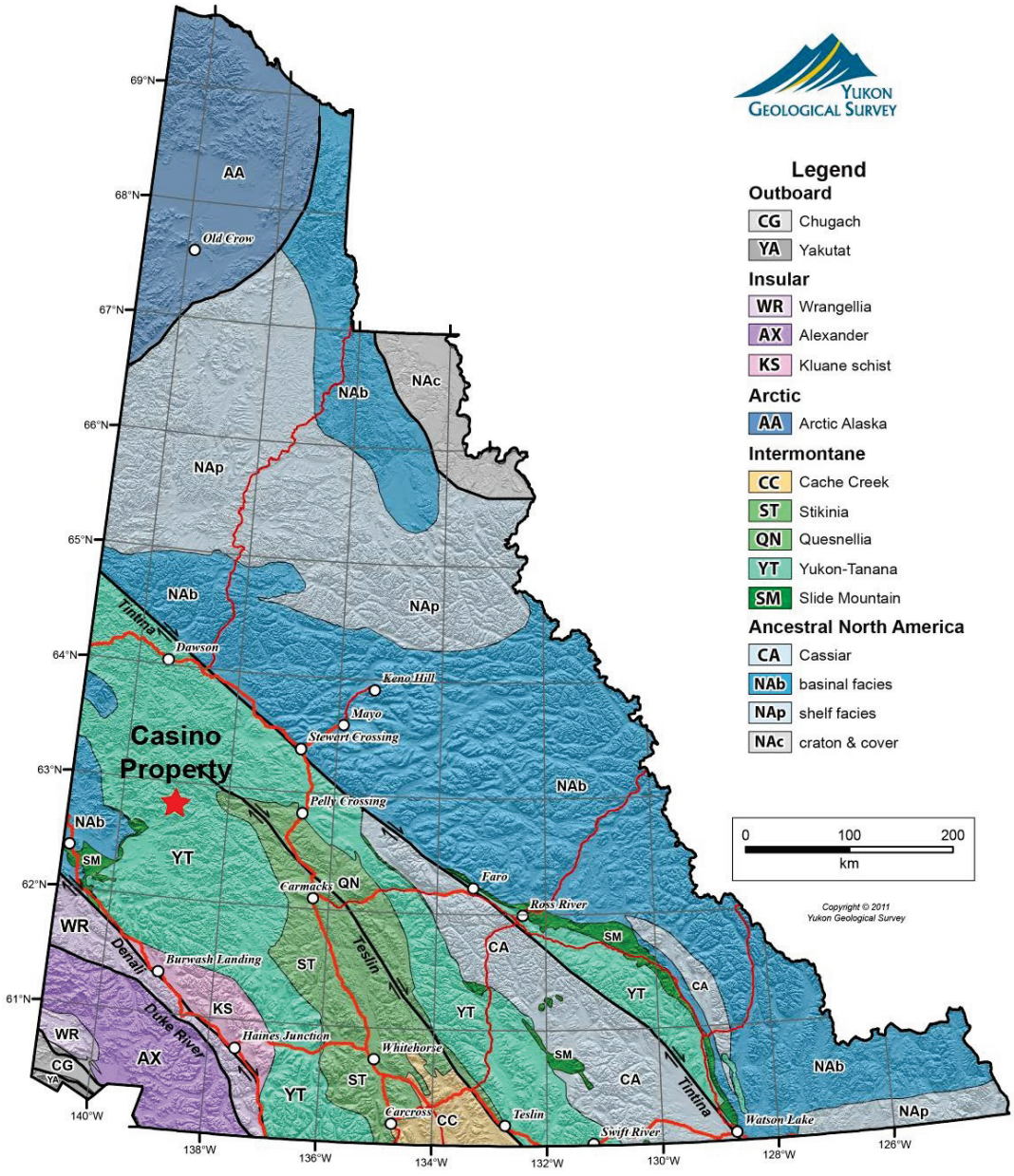

Figure 1. A map of terranes for Yukon Territory showing location of the Casino porphyry Cu-Au-Mo deposit in west central Yukon (map modified from Relf, 2020).

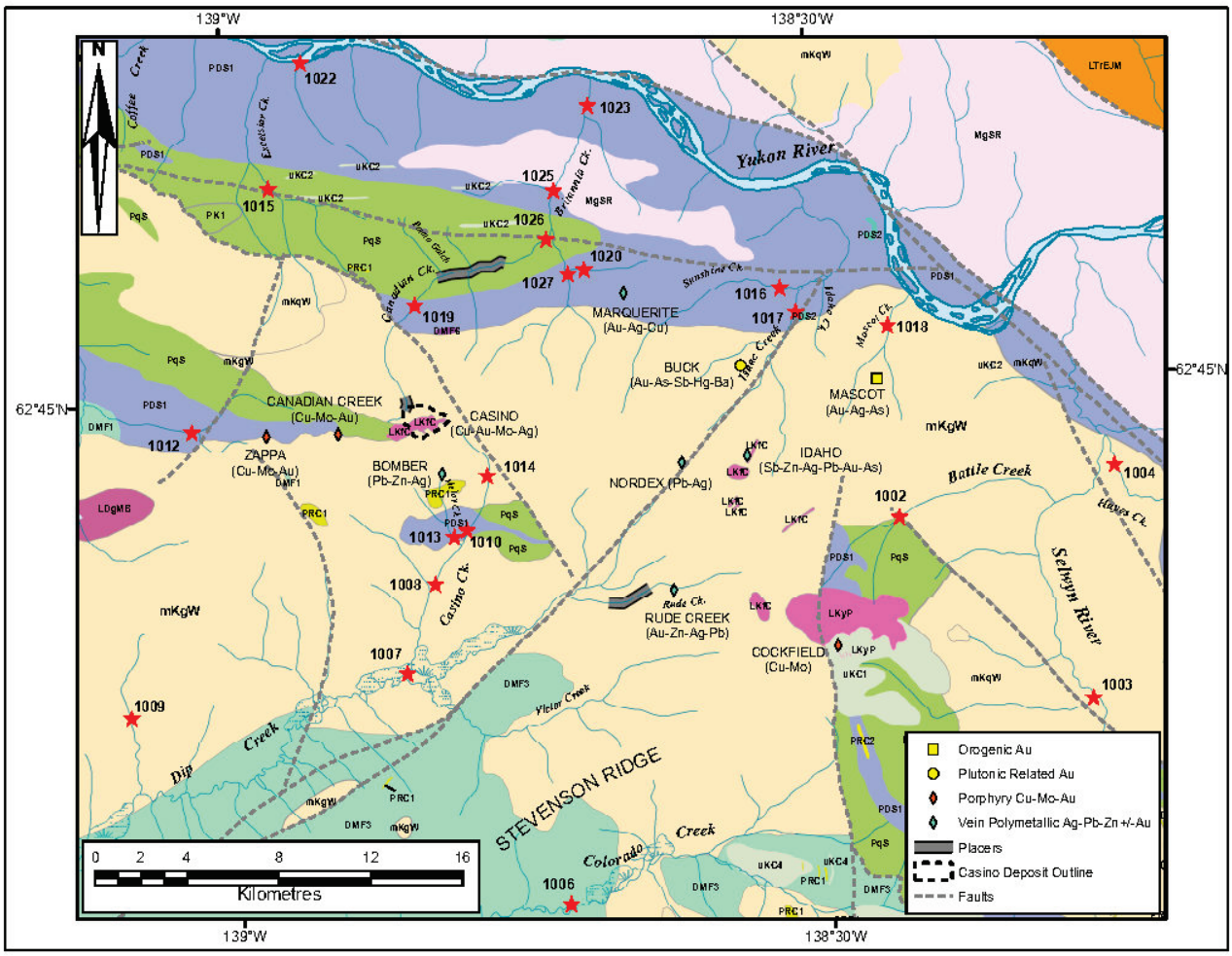

Figure 2a. Map showing the bedrock geology, selected mineral occurrences, and the 2017 stream sediment sample locations (red stars) in the Casino deposit area (geology from Yukon Geological Survey, 2017; mineral occurrences from Yukon Geological Survey, 2018).

Figure 2b. Bedrock geology map legend (Yukon Geological Survey, 2017, 2018).

SAMPLE COLLECTION

Protocols for stream sediment sampling in this study followed those established by the GSC more than 30 years ago by Friske and Hornbrook (1991). At each site, a synthetic cloth bag (18 cm x 32 cm) was two-thirds filled (approximately 1 kg) with silt and fine sand collected from the active stream channel (Fig. 3). This sample is referred to as the silt sample and it was collected after the water samples but before the screened (<1.68 mm) bulk sediment sample was collected. Commonly, the sampler collected fine grained sediment by hand from various points in the active channel while moving upstream, over a distance of 5 to 15 m. If the stream channel was found to consist mainly of clay, coarser material, or organic sediment from which suitable sample material was scarce or absent, moss mat from the stream channel which commonly contains trapped silt may have been added to the sample. Field observations were digitally recorded on a tablet using a standard form developed jointly by the GSC and the Northwest Territories Geological Survey.

SAMPLE PREPARATION

The synthetic cloth bags containing the silt samples were air-dried in the field before being placed into individual plastic bags, taped with electrical tape and shipped to the GSC Sedimentology Laboratory in Ottawa, where they were unpacked and air-dried at temperatures below 40° C. After drying, samples were disaggregated and sieved to recover the <177 µm fraction for geochemical analysis (Girard et al., 2004).

Figure 3. At each site, a stream sediment sample (wet mass 1 kg), two 60 ml filtered water samples, a bulk coarse stream sediment sample screened through a 1.68 mm sieve (wet mass 10-15 kg) and a pebble sample (in synthetic bag beside bulk sample) were collected (NRCan photo 2021-075).

ANALYTICAL METHODS

Instrumental Neutron Activation

In 2018, the <177 µm fraction of the silt samples was analysed by instrumental neutron activation (INA) at Maxxam Analytics (formerly Becquerel Labs), Mississauga, Ontario. See **Appendix A2** for the relevant pages from the Maxxam Analytics lab brochure describing the methods used in 2018. A 30 g aliquot of each sample was encapsulated and packaged for irradiation along with certified reference materials, and both field and analytical duplicates. Samples and quality control insertions were irradiated together with neutron flux monitors in a two-megawatt pool type reactor. After a seven-day decay period, samples were measured with a high-resolution germanium detector. Typical counting time per sample was 500 seconds. Elements determined by INA analysis are listed below in Table 1. The formatted geochemical data are reported in **Appendix B1** in worksheet **'Geochemical data 2018+2021'**. These data were previously published in GSC OF 8632 (McCurdy et al., 2019). An unedited data listing and quality control data as received from Maxxam Analytics are reported in **Appendix B2**; these unedited data have not been reported before.

Aqua Regia Digestion/Inductively Coupled Plasma – Mass Spectrometry and Other Methods

In 2018, aliquots of **0.5 g** of the <177 µm fraction were analysed for 65 elements at Bureau Veritas Commodities Canada (BVCC), Vancouver, using a proprietary 'AQ250 – Ultratrace by ICP Mass Spec.' package with the optional extended packages for rare earth elements (+REE) and precious metals Pt and Pd (+PGM) (Table 2). See **Appendix A3** for the relevant pages from the BVCC lab brochure describing the methods used in 2018. The procedure involves an aqua regia dissolution (HCl:HNO_3, 1:1) followed by inductively coupled plasma - mass spectroscopy (ICP-MS) analysis. The formatted geochemical data are reported in **Appendix B1** in worksheet **'Geochemical data 2018+2021'**. These data were previously published in GSC OF 8632 (McCurdy et al., 2019). An unedited data listing and quality control data as received from BVCC are reported in **Appendix B3** in worksheets **Analytical Data** and **QC Data**; these unedited data files have not been reported before.

In 2021, aliquots of **30 g** of the <177 µm fraction were analysed for 65 elements at Bureau Veritas Commodities Canada (BVCC), Vancouver, using a proprietary 'AQ252 – Ultratrace by ICP Mass Spec.' package with the optional extended packages for rare earth elements (+REE) and precious metals Pt and Pd (+PGM) (Table 2). See **Appendix A4** for the relevant pages from the BVCC lab brochure describing

the methods used in 2021. The procedure involves an aqua regia dissolution ($HCl:HNO_3$, 1:1) followed by inductively coupled plasma - mass spectroscopy (ICP-MS) analysis. These data have not been previously published. The formatted geochemical data are reported in **Appendix B1** in worksheet **'Geochemical data 2018+2021'**. An unedited data listing and quality control data as received from BVCC are reported in **Appendix B4** in worksheets **Analytical Data** and **QC Data**.

Table 1. Elements determined by instrumental neutron activation analysis of the <177 µm fraction of stream silt samples collected around the Casino deposit.

Variable	Detection Limit	Units of Measurement	Variable	Detection Limit	Units of Measurement
Ag	2	ppm	**Ni**	10	ppm
As	0.5	ppm	**Rb**	5	ppm
Au	2	ppb	**Sb**	0.1	ppm
Ba	50	ppm	**Sc**	0.2	ppm
Br	0.5	ppm	**Se**	5	ppm
Cd	5	ppm	**Sm**	0.1	ppm
Ce	5	ppm	**Sn**	100	ppm
Co	5	ppm	**Ta**	0.5	ppm
Cr	20	ppm	**Tb**	0.5	ppm
Cs	0.5	ppm	**Te**	10	ppm
Eu	1	ppm	**Th**	0.2	ppm
Fe	0.2	%	**Ti**	500	ppm
Hf	1	ppm	**U**	0.2	ppm
Ir	50	ppb	**W**	1	ppm
La	2	ppm	**Weight**	0.01	g
Lu	0.2	ppm	**Yb**	2	ppm
Mo	1	ppm	**Zn**	100	ppm
Na	0.02	%	**Zr**	200	ppm

In 2018 at BVCC, lead collection fire assay fusion was used to determine the concentrations of Au, Pt and Pd in a 30 g aliquot of <177 µm stream silt using the FA330 package. The bead resulting from the fusion of the sample was digested in HNO_3 and analysed by ICP-MS. The formatted geochemical data are reported in **Appendix B1** in worksheet **'Geochemical data 2018+2021'**.These data were previously published in GSC OF 8632 (McCurdy et al., 2019). An unedited data listing and quality control data as received from Bureau Veritas are reported in **Appendix B3** in worksheets **Analytical Data** and **QC Data**; these unedited data files have not been reported before.

In 2018 at BVCC, total C and S (BVCC Code TC000 C & S) were determined by igniting 0.1 g of <177 µm sample with a flux in an induction furnace. Released carbon was measured by adsorption in an infrared spectrometric cell. Results are total and attributed to the presence of carbon and sulphur in all forms (Bureau Veritas Minerals, 2017a). In 2018, Loss-on-ignition (LOI) was determined using a 1 g sample using the TG001 package. Each sample, in a tared crucible, was placed into a muffle furnace and ignited to 1000° C for one hour. The oven was then cooled to 100° C and the crucibles transferred to a desiccator followed by cooling to room temperature. The crucibles were re-weighed to determine the loss-on-ignition. The lower limit of detection is indicated as -5.1% to allow for reporting if negative loss on ignition results. Negative LOI results may occur in some samples where a weight gain occurs during ignition, generally due to the oxidation of iron minerals (Bureau Veritas Minerals, 2017b). The formatted geochemical data are reported in **Appendix B1** in worksheet **'Geochemical data 2018+2021'**. These data were previously published in GSC OF 8632 (McCurdy et al., 2019). An unedited data listing and quality control data as received from Bureau Veritas are reported in **Appendix B3** in worksheets **Analytical Data** and **QC Data**; these unedited data files have not been reported before.

Table 2. Variables determined and lower detection limits for the <177 µm fraction of stream sediments by Inductively Coupled Plasma –Mass Spectroscopy (ICP-MS) with a modified *aqua regia* digestion and other methods. Analytical methods other than ICP-MS are in brackets. 'GRAV' is an abbreviation of 'Gravimetric'; 'FA' is 'Fire Assay.'

Element	Detection Limit	Units of Measurement	Element	Detection Limit	Units of Measurement
Au (FA/ICP-MS)	2	ppb	**Mg**	0.01	pct
Pt (FA/ICP-MS)	3	ppb	**Mn**	1	ppm
Pd (FA/ICP-MS	2	ppb	**Mo**	0.01	ppm
Total C (LECO)	0.02	%	**Na**	0.001	%
Total S (LECO)	0.02	%	**Nb**	0.02	ppm
Ag	2	ppb	**Nd**	0.02	ppm
Al	0.01	%	**Ni**	0.1	ppm
As	0.1	ppm	**P**	0.001	%
Au	0.2	ppb	**Pb**	0.01	ppm
B	20	ppm	**Pd**	10	ppb
Ba	0.5	ppm	**Pt**	2	ppb
Be	0.1	ppm	**Pr**	0.02	ppm
Bi	0.02	ppm	**Rb**	0.1	ppm
Ca	0.01	%	**Re**	1	ppb
Cd	0.01	ppm	**S**	0.02	%
Ce	0.1	ppm	**Sb**	0.02	ppm
Co	0.1	ppm	**Sc**	0.1	ppm
Cr	0.5	ppm	**Se**	0.1	ppm
Cs	0.02	ppm	**Sm**	0.02	ppm
Cu	0.01	ppm	**Sn**	0.1	ppm
Dy	0.02	ppm	**Sr**	0.5	ppm
Er	0.02	ppm	**Ta**	0.05	ppm
Eu	0.02	ppm	**Tb**	0.02	ppm
Fe	0.01	%	**Te**	0.02	ppm
Ga	0.1	ppm	**Th**	0.1	ppm
Gd	0.02	ppm	**Ti**	0.001	%
Ge	0.1	ppm	**Tl**	0.02	ppm
Hf	0.02	ppm	**Tm**	0.02	ppm
Hg	5	ppb	**U**	0.1	ppm
Ho	0.02	ppm	**V**	2	ppm
In	0.02	ppm	**W**	0.1	ppm
K	0.01	%	**Y**	0.01	ppm
La	0.5	ppm	**Yb**	0.02	ppm
Li	0.1	ppm	**Zn**	0.1	ppm
LOI (GRAV)	0.1	%	**Zr**	0.1	ppm
Lu	0.02	ppm			

Portable X-Ray Fluorescence

A split of each dry unsieved stream sediment was transferred to a 4-dram vial, covered with a 4 µm Prolene ® film fixed on the vial with a small elastic band. Each sample was shaken 10 times in an up-down motion and read on the pXRF. The sample was shaken again and re-analysed a second time to provide two readings per sample. The shaking motion brings the smaller-sized grains in contact with the Prolene ® film.

The pXRF analyses were conducted in the Inorganic Geochemistry Research Lab at GSC-Ottawa using an Innov-X Delta Premium DP-4000 (serial number 510964) with a Ta tube anode. The analysis was performed in the 3 beam Soil (La, Ce) mode @60 sec per beam. An estimate of the limit of detection (LOD) is provided in **Appendix A5** (manufacturer LOD therefore on the low side). For the pXRF analysis, CONTROL TBLK is a Teflon Block that was used as a 'blank' sample. The low but detectable values reported for S, Cl, K, Ni, etc. in the blank are contaminants in the Teflon block. This blank was analyzed throughout the batch, at the beginning, middle and end of each day. A high value out of the normal range for this blank would indicate contamination of the viewing window of the instrument and was dealt with immediately, until the blank values returned to their expected range. Certified reference materials CANMET TILL-1 to TILL-4 (Lynch, 1996) were analyzed at the beginning of the analysis of a batch each day. TILL-4 was also analyzed in the middle and the end of the batch. Portable XRF analytical data and QA-QC data are reported in **Appendix C – Portable XRF Data** along with the date of analysis. . These data were previously published in GSC OF 8632 (McCurdy et al., 2019).

QUALITY CONTROL FOR GEOCHEMICAL RESULTS FROM COMMERCIAL LABS

Analytical accuracy of elemental determinations was assessed by inserting one of two Canadian Certified Reference Materials (CANMET) STSD-1 or STSD-4 at preselected random positions in a block of 20 consecutive samples. STSD-1 consists of dry sieved -80 mesh (<177 µm) fraction of stream sediment collected from Lavant Creek, about 75 km southwest of Ottawa, ON (NTS map sheet 31-F). STSD-4 is a composite sample comprised of stream sediments collected throughout NTS map sheets 31-F, 93-A, and 93-B. All -80 mesh material was ball-milled and sieved through a 200 mesh (<74 µm) screen prior to homogenisation and bottling (Lynch, 1990; CANMET, 2019).

Field duplicates and prepared analytical duplicates were used to assess site variability and analytical precision. One set of two field duplicates was collected for the first twenty consecutive samples and second set of duplicates was collected for the subsequent samples. A field duplicate sample is a second sample taken at or within a few metres of the first sample. Sample 115J171005 is a field duplicate of routine sample 115J171004 and sample 115J171024 is a field duplicate of routine sample 115J171023.

One analytical duplicate was prepared in the GSC Sedimentology Laboratory for each block of twenty consecutive samples. An analytical duplicate sample is a split from a routine sample after the samples have been prepared for analysis but prior to that analysis. Analytical duplicates were analyzed using the same methods as the routine samples (McCurdy and Garrett, 2016). Sample 115J171001 is an analytical duplicate of routine sample 115J171004 and sample 115J171021 is an analytical duplicate of routine sample 115J171023. Excess <177 µm material was archived for future reference.

Data for CANMET standards, and field and analytical duplicate samples are listed in **Appendix B1** – worksheet **'Geochemical Data 2018+2021'** along with the data for routine samples. Formatted analytical data for all quality control samples are listed in **Appendix B1** worksheet **'Quality Control'**. In this appendix, the means and standard deviations (MEAN ± SD) for control reference standards STSD-1 and STSD-4 for which provisional values have been published by Lynch (1990, 1999) (black font) and Burnham and Schweyer (2004) (blue font) are compared with the values for these elements determined by total and partial methods in routine samples Accepted values in square brackets are derived from published and unpublished data (n > 30) collected from recent projects at the GSC. The lower detection limits (LDL) for each element estimated by the commercial laboratories are also listed.

Internal quality control data reported by the BVCC in 2018 and 2021 for their internal duplicates, reference materials and blanks are reported in **Appendixes B3** and **B4,** worksheet **'QC Data'**.

Control reference materials (CRM) were analyzed by Instrumental Neutron Activation (INA) and aqua regia/ICP-MS (AR). For the 2018 datasets, elements having concentrations at or below detection in both CRMs include Mo (INA), Pd (AR), Ag (INA), Cd (INA), Hf (AR), Ta (AR), W (INA), Re (AR), Ir (INA), Sn (INA), Pt (AR), Se (INA), B (AR), Ge (AR) and Te (INA). Zn (INA) and Zr (INA) are below detection in STSD-4 only. The concentrations of many of the remaining elements analyzed by aqua regia/ICP-MS fall below two standard deviations of the accepted values, however this may be caused by minor changes in the aqua regia digestion used by the commercial laboratory over time, such as a reduced period of heating, reduced acid strength, or both. Accuracy may also be affected by elemental concentrations held within discrete, often refractory, minerals, including spinels, beryl, tourmalines, chromite, zircon, monazite, pyrochlore, scheelite, wolframite, topaz, tantalite and cassiterite (Crock and Lamothe, 2011). Concentrations of a number of elements in CRMs at or just above lower detection limits, can also result in less than satisfactory analytical accuracy. Finally, for some elements, such as Pt and Au, the difficulty of creating homogeneous standard materials can result in reduced accuracy of measurement (Harris, 1982).

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REFERENCES

Archer, A.R., and Main, C.A., 1971. Casino Yukon – a geochemical discovery of an unglaciated Arizona-typed porphyry; *in* Geochemical Exploration: Proceedings, 3rd International Geochemical Exploration Symposium, Toronto, (ed.) R.W. Boyle; Canadian Institute of Mining and Metallurgy, Special Volume 11, p. 67-77.

Beckett-Brown, C. E., McDonald, A. M., and McClenaghan, M. B., 2019. Unravelling tourmaline in mineralized porphyry systems: assessment as a valid indicator mineral; *in* Targeted Geoscience Initiative: 2018 report of activities, (ed.) N. Rogers; Geological Survey of Canada, Open File 8549, p. 345-351.

Bond, J.D. and Lipovsky, P.S., 2011. Surficial geology, soils and permafrost of the northern Dawson Range; *in* Yukon Exploration and Geology 2010, (ed.) K.E. MacFarlane, L.H. Weston, and C. Relf; Yukon Geological Survey, p. 19-32.

Bureau Veritas Minerals, 2017a. Method description for Carbon and Sulphur analysis by Leco, TC000 2017_1; available on request.

Bureau Veritas Minerals, 2017b. Method description for Loss-on-Ignition analysis by muffle furnace ignition, TG001 2017_01; available on request.

Burnham, O.M. and Schweyer, J., 2004. Trace element analysis of geological samples by inductively coupled plasma mass spectrometry at the Geoscience Laboratories: revised capabilities due to improvements to instrumentation; *in* Summary of Field Work and Other Activities 2004; Ontario Geological Survey, Open File Report 6145, p. 54-1 to 54-20.

CANMET, 2019. Stream sediment reference materials STSD- to STSD-4. <https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/mineralsmetals/pdf/mms-smm/tect-tech/ccrmp/cer-cer/stsd-1-eng.pdf> [accessed March 31, 2021]

Crock, J.G. and Lamothe, P.J., 2011. Inorganic chemical analysis of environmental materials – A lecture series; U.S Geological Survey, Open-File Report 2011-1193, 117 p.

Friske, P.W.B. and Hornbrook, E.H.W., 1991. Canada's National Geochemical Reconnaissance programme; Transactions of the Institution of Mining and Metallurgy (Section B: Applied Earth Sciences), v. 100, p. B47-B56.

Girard, I., Klassen, R.A., and Laframboise, R.R., 2004. Sedimentology laboratory manual, Terrain Sciences Division; Geological Survey of Canada, Open File 4823.

Harris, J.F., 1982. Sampling and analytical requirements for effective use of geochemistry in exploration for gold; *in* Precious Metals in the Northern Cordillera, (ed.) A.A. Levinson; Association of Exploration Geochemists and the Cordilleran Section of the Geological Association of Canada, p. 53-67.

Lynch, J. 1990. Provisional values for eight new geochemical lake sediment and stream sediment reference materials LKSD-1, LKSD-2, LKSD-3, LKSD-4, STSD-1, STSD-2, STSD-3, STSD-4; Geostandards Newsletter, v. 14 (1), p. 153-167.

Lynch, J.J., 1999. Additional provisional elemental values for LKSD-1, LKSD-2, LKSD-3, LKSD-4, STSD-1, STDS-2, STSD-3 and STSD-4; Geostandards Newsletter, v. 23 (2), p. 251-260.

McClenaghan, M. B., Beckett-Brown, C. E., McCurdy, M. W., McDonald, A. M., Leybourne, M. I., Chapman, J. B., Plouffe, A., and Ferbey, T., 2018. Mineral markers of porphyry copper mineralization: progress report on the evaluation of tourmaline as an indicator mineral; *in* Targeted Geoscience Initiative: 2017 report of activities, volume 1, (ed.) N. Rogers; Geological Survey of Canada, Open File 8358, p. 69-77.

McClenaghan, M. B., McCurdy, M. W., Garrett, R. G., Beckett-Brown, C. E., Leybourne, M. I., Casselman, S. G., and Pelchat, P., 2019. Mineral and geochemical signatures of porphyry copper mineralization: work in progress for the Casino Cu-Au-Mo-Ag porphyry deposit, Yukon; *in* Targeted Geoscience Initiative: 2018 report of activities, (ed.) N. Rogers; Geological Survey of Canada, Open File 8549, p. 333-344.

McCurdy, M.W. and Garrett, R.G., 2016.Geochemical Data Quality Control for Soil, Till and Lake and Stream Sediment Samples; Geological Survey of Canada, Open File 7944, 35 p.

McCurdy, M.W., McClenaghan, M.B., Garrett, R.G., and Pelchat, P., 2019. The stream sediment geochemical signature of the Casino porphyry Cu-Au-Mo deposit, Yukon: a case study; Geological Survey of Canada, Open File 8632.

Plouffe, A., Ferbey, T., Kobylinski, C.H., Hattori, K., Grenier, A., and McClenaghan, M.B., 2017. Deconvolution of complex spatial-temporal records of porphyry fertility recorded in till minerals; *in* Targeted Geoscience Initiative - 2016 Report of Activities, (ed.) N. Rogers; Geological Survey of Canada, Open File 8199, p. 79-85.

Plouffe, A., Kobylinski, C.H., Hattori, K., Wolfe, L., and Ferbey, T., 2018. Mineral markers of porphyry copper mineralization: Work in progress at the Gibraltar deposit, British Columbia; *in* Targeted Geoscience Initiative - 2017 Report of Activities: Volume 1, (ed.) N. Rogers; Geological Survey of Canada, Open File 8358, p. 59-69.

Plouffe, A., Kjarsgaard, I.M., Kobylinski, C., Hattori, K., Petts, D.C., Venance, K.E., and Ferbey, T., 2019. Discovering the next generation of copper porphyry deposits using mineral markers; *in* Targeted Geoscience

Initiative: 2018 report of activities, (ed.) N. Rogers; Geological Survey of Canada, Open File 8549, p. 321-331.

Relf, C., 2020. Yukon Geological Survey: Planning for the future; *in* Yukon Exploration and Geology Overview 2019, (ed.) K.E. MacFarlane; Yukon Exploration & Geology Overview 2019, Yukon Geological Survey, p. 1–22.

Yukon Geological Survey, 2017. Yukon Geological Survey Integrated Data System – Bedrock geology dataset. <http://data.geology.gov.yk.ca/Compilation/3> [accessed March 31, 2021]

Yukon Geological Survey, 2018. Yukon Geological Survey Integrated Data System (YGSIDS) – Minfile<http://data.geology.gov.yk.ca/Search?q=ygsids#Minfile> [accessed March 31, 2021]