Osiris cluster Carlin-type gold, east-central Yukon

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Coulter, A.B., Lane, J. and Steiner, A., 2018. Osiris cluster Carlin-type gold, east-central Yukon. *In:* Yukon Exploration and Geology Overview 2017, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 65-74.

ABSTRACT

The Nadaleen trend is located in east-central Yukon, 400 km north-northeast of Whitehorse. Carlin-style gold mineralization was discovered on the property in 2010 and exploration has been ongoing since. The Nadaleen trend is a 25 km long trend of gold mineralization focused into two major clusters, from west to east: the Anubis cluster and the Osiris cluster. Four significant zones of gold mineralization have been identified in the Osiris cluster and are known as the Conrad, Osiris, Sunrise and Ibis zones. Gold mineralization is most commonly hosted in structurally controlled, decarbonatized and silicified silty limestone. Many characteristics of the Carlin-style deposits of Nevada are shared with the Osiris cluster, such as: decarbonatization, silicification, gold hosted within arsenian pyrite, spatial association with realgar, orpiment, calcite and fluorite and elevated As, Tl, Hg and Sb trace element geochemistry.

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INTRODUCTION

The Nadaleen trend is a 25-km-long cluster of recently discovered Carlin-style gold occurrences located in east-central Yukon. It is centered at 64°12′64″ N latitude and 132°54′94″ W longitude, 400 km north-northeast of Whitehorse and 180 km east-northeast of Mayo (Fig. 1). Exploration by ATAC Resources Limited (ATAC) started in 2007 on the western part of the Rackla Gold property with the discovery of the Tiger gold deposit (Fig. 2). Results from diamond drilling between 2008 and 2010 led to the release of a measured and indicated resource of 485,700 ounces gold at an average grade of 2.66 g/t and an additional inferred resource of 188,500 ounces gold at an average grade of 1.81 g/t (Ghaffari *et al.*, 2016).

Continued reconnaissance soil sampling and prospecting by ATAC between 2008 and 2010 focused along a 15-km-long ridge system of Paleozoic carbonate rocks near the Tiger deposit, which resulted in the identification of nine gold exploration targets known as the Rau trend (Fig. 2). In 2009, ATAC identified an area ~100 km east of the Tiger deposit where five of six stream-sediment samples in a government stream-sediment database were highly anomalous in arsenic (Héon, 2003). Follow-up stream-sediment sampling identified several anomalous areas; one 2 km long tributary returned a stream-sediment gold value of 1.78 g/t. Subsequent prospecting in the headwaters of this creek in 2010 revealed gold mineralization across a widespread area and grid soil sampling returned values up to 18.2 g/t gold. The core of the gold and arsenic geochemical anomaly covers an area of approximately 3.5 by 2 km that defines the Osiris cluster.

Follow-up drill testing by ATAC late in the summer of 2010 resulted in the discoveries of Osiris and Conrad. Further drilling, prospecting, and soil sampling in 2011 resulted in the discovery of Ibis. In 2012, Sunrise was discovered through trenching and drilling; soil sampling and prospecting 10 km to the west revealed the Anubis cluster mineralization. An alignment of the Carlin-style gold prospects, together with several gold and arsenic occurrences, collectively comprise the Nadaleen trend (Fig. 2), named for its proximity to the headwaters of the Nadaleen River. Exploration to date has identified abundant gold mineralization within the Nadaleen trend, although the full potential of this region is far from being determined.

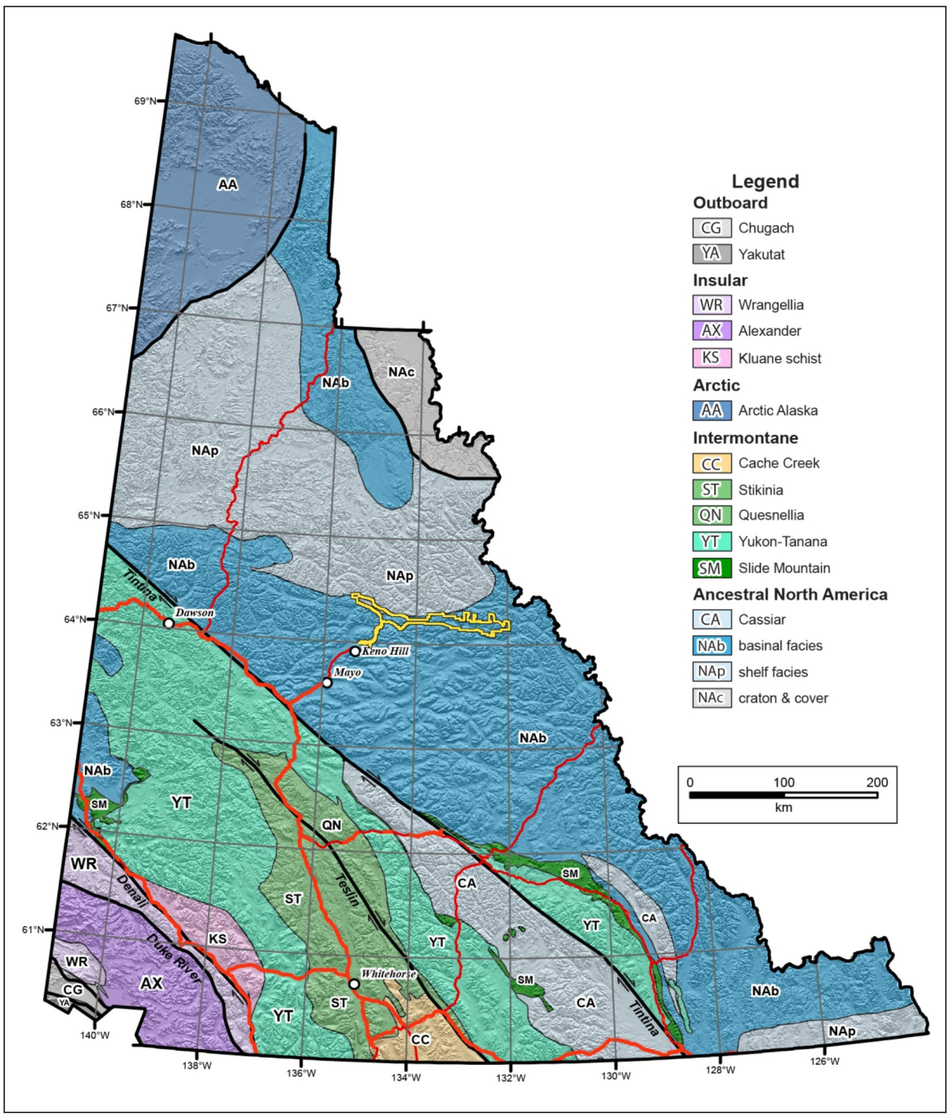

Figure 1. *Rackla Gold property location highlighted in yellow on Yukon terrane map (modified from Colpron and Nelson, 2011).*

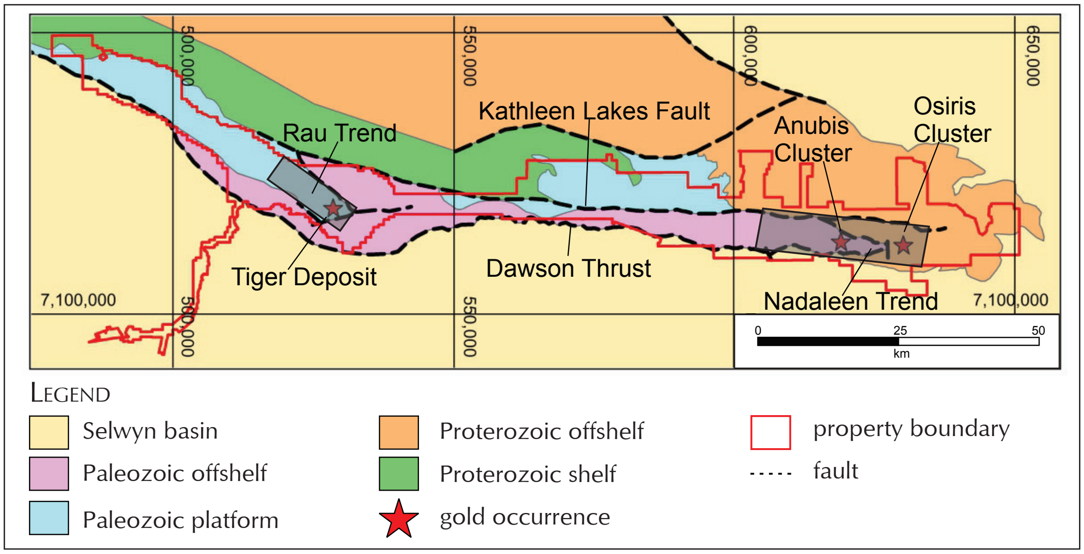

Figure 2. *Summary of major facies domains, major structures and mineral occurrences in the Rackla Gold property after Colpron et al. (2013). Coordinates are displayed in UTM NAD83.*

REGIONAL GEOLOGY

The Rackla Gold property (Property) is situated on the boundary between the deep water clastic rocks of the Selwyn basin to the south and shallower water shelf strata of the Ogilvie platform to the north (Fig. 2). The Dawson fault juxtaposes rocks of Selwyn basin against rocks of Ogilvie platform and marks a crustal break that dates back to late Neoproterozoic rifting and reactivated as a north directed thrust in the Cretaceous (Abbott, 1997). The eastern part of the Property contains the Nadaleen trend which hosts numerous Carlin-style gold prospects and is the focus of this paper (Fig. 2).

In the southern part of the Property, Selwyn basin strata in the hanging wall of the Dawson fault consist of Neoproterozoic-Cambrian Hyland Group, which is further subdivided into lower coarse clastic sedimentary rocks of the Yusezyu Formation, carbonate rocks of the Algae Formation, and an upper mudstone comprising the Narchilla Formation (Gordey and Anderson, 1993; Abbott, 1997; Roots, 2003). In the western two-thirds of the Property, these rocks were thrust northward over Paleozoic shelf and slope rocks deposited along the southern edge of the Ogilvie platform (Fig. 2).

In the eastern part of the Property, the Dawson fault loses stratigraphic displacement and coeval Neoproterozoic rocks of the Hyland Group and upper parts of the Windermere Supergroup are juxtaposed across the fault. The carbonate rocks of the Algae Formation and mudstone of the Narchilla Formation provide ties between the two successions; they are lateral equivalent of the Risky and Ingta formations of the Mackenzie Mountains (Moynihan, 2014, 2016). Strata of the Windermere Supergroup include fine-grained clastic and carbonate sequences that can be correlated in part with strata described elsewhere in the Mackenzie Mountains (e.g., Narbonne and Aiken, 1995). In the Nadaleen area, Windermere strata beneath the Algae/Risky formation are assigned to the Nadaleen, Gametrail, and Blueflower formations (Moynihan, 2014, 2016).

DEPOSIT GEOLOGY

The Nadaleen trend is located near the eastern end of the Dawson fault, where coeval siliciclastic and carbonate rocks of the upper Windermere Supergroup and Hyland Group are juxtaposed, and where Paleozoic platform to slope facies carbonate rocks end (Fig. 2; Colpron *et al.*, 2013). The Nadaleen trend hosts two major clusters of Carlin-style gold mineralization known as the Osiris and Anubis (Fig. 2). The more easterly Osiris cluster occurs mostly within the Windermere rocks and the more westerly Anubis cluster is mainly hosted within Paleozoic carbonate rocks. The Paleozoic rocks terminate to the east towards the Osiris cluster across a series of north-trending faults. The Osiris cluster hosts 4 significant zones of Carlin-style gold mineralization discovered to date: the Conrad, Osiris, Sunrise and Ibis zones (Fig. 3).

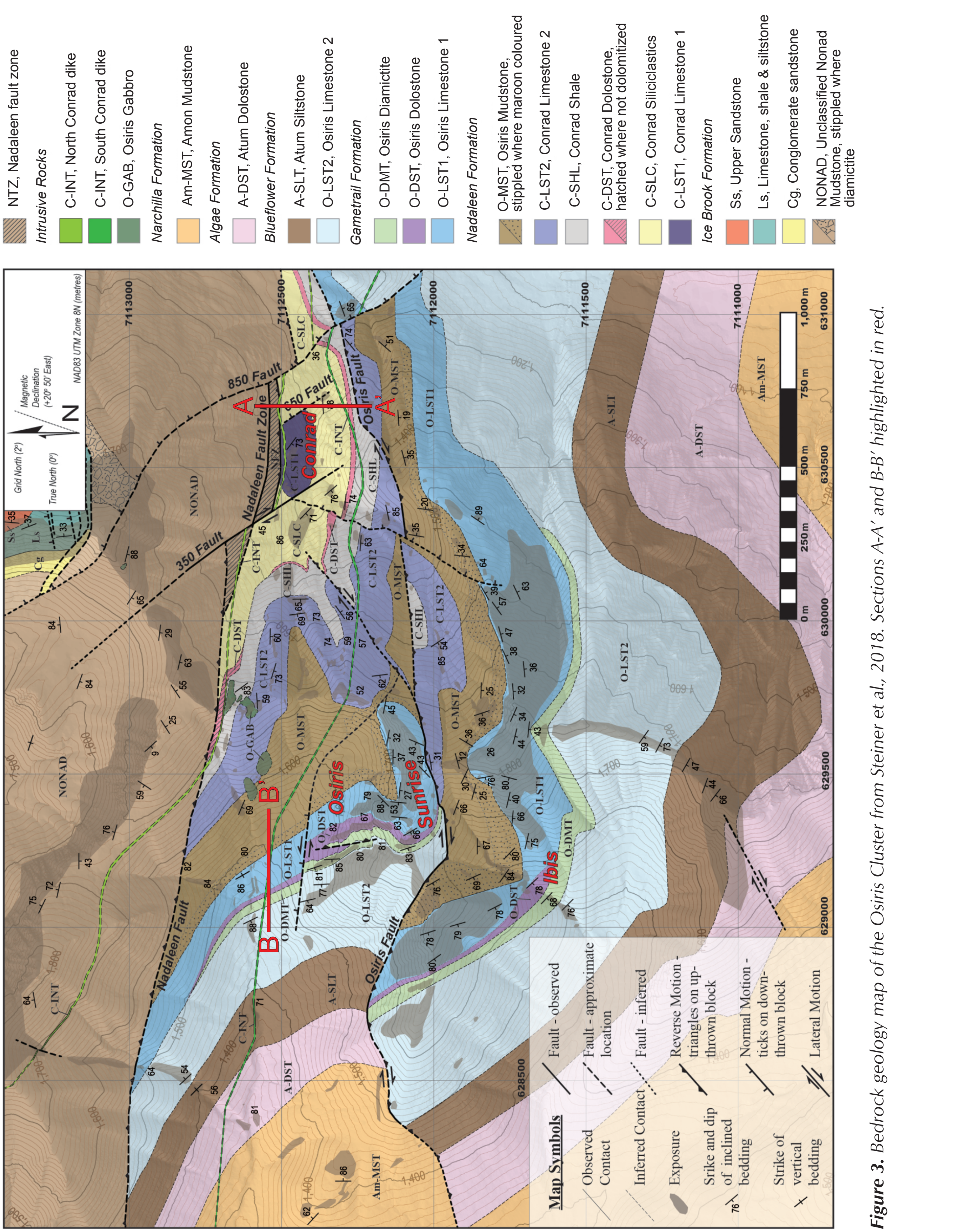

Figure 3. Bedrock geology map of the Osiris Cluster from Steiner et al., 2018. Sections A-A' and B-B' highlighted in red.

The geology of the Osiris cluster consists of a southward and westward-younging sequence of Neoproterozoic to Cambrian slope facies sedimentary rocks that are part of the Windermere Supergroup. The local geologic units, as described below and observed in the stratigraphic column (Fig. 4), have been correlated with the more regional Formations and map units by Colpron *et al.* (2013) and Moynihan (2016). From oldest to youngest, these include:

NONAD: The North of Nadaleen mudstone is part of the upper Ice Brook Formation and is a light teal-green to maroon and brown mudstone with minor interbedded quartz pebble conglomerate. The mudstone displays distinctive rusty brown weathering.

C-LST1: The Conrad limestone 1 is part of the lower Nadaleen Formation and is a light grey, silty laminated clastic limestone with cone-in-cone and beef calcite, and wispy, fine quartz sand layers (Fig. 5A).

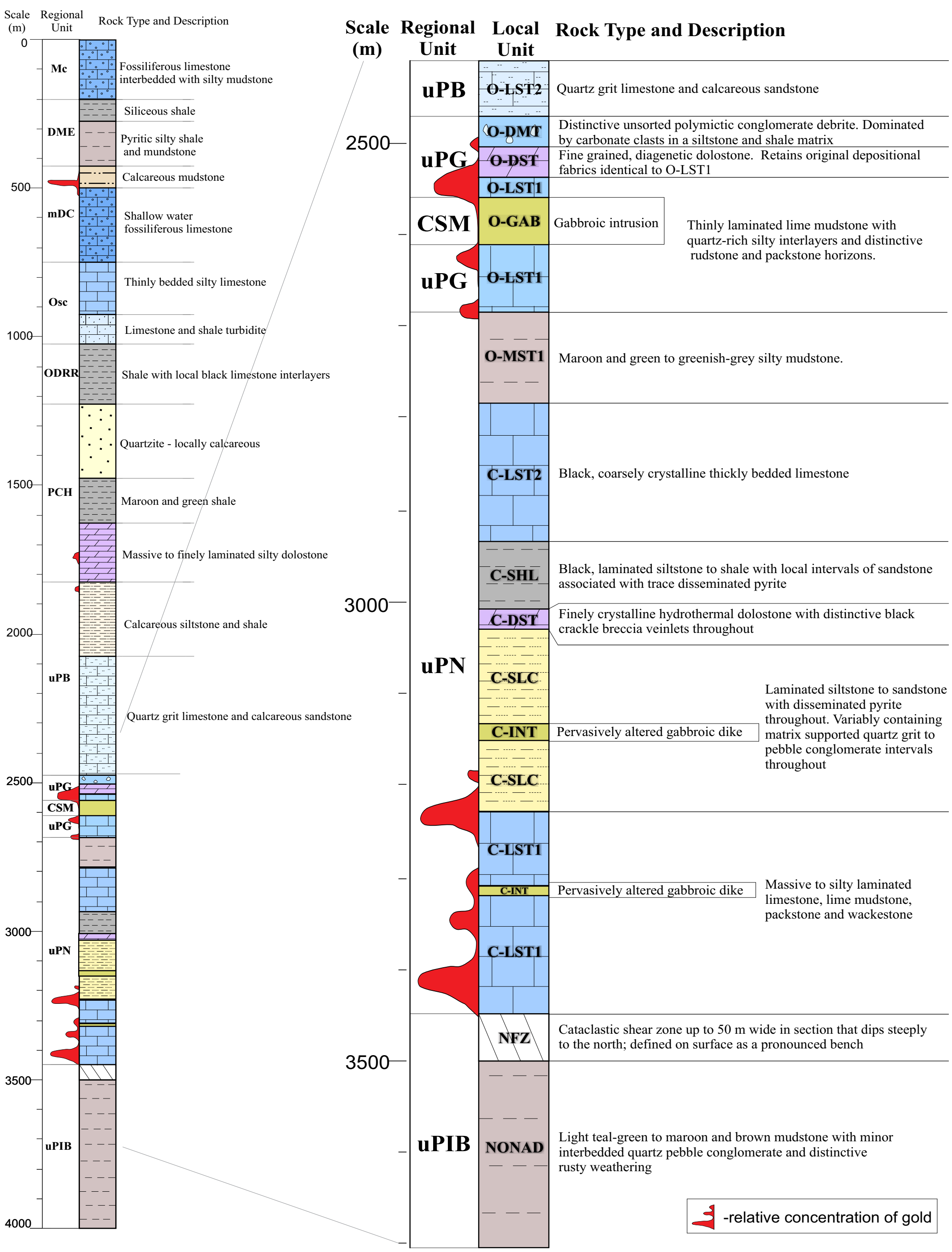

Figure 4. *Stratigraphic section of the local and regional stratigraphy and detailed section of Osiris cluster stratigraphy on the right. Regional unit abbreviations from oldest to youngest: uPIB = Ice Brook Fm, uPN = Nadaleen Fm, uPG = Gametrail Fm, CSM = Cambrian-Silurian Marmot Fm, uPB = Blueflower Fm, PCH = Hyland Group, ODRR = Road River Group, Osc = Ordovician-Silurian carbonate, mDC = Middle Devonian carbonate, DME = Earn Group and Mc = Mississippian carbonate.*

C-SLC: The Conrad siliciclastic unit is part of the Nadaleen Formation and is a grey-green pyritic siltstone and mudstone, poorly sorted matrix-supported quartz pebble conglomerate with lesser grey, well sorted, weakly calcareous sandstone. The conglomerate, informally referred to as 'starry night', consists of rounded quartz pebbles floating in a mix of sand and silt with sporadic larger clasts that appear to be rip up clasts of matrix material (Fig. 5B).

C-DST: The Conrad dolostone is part of the Nadaleen Formation and is a finely crystalline hydrothermal dolostone with distinct black crackle breccia veinlets in the Conrad area. Farther to the west, nearer to the Nadaleen fault, it is a non to partially dolomitized limestone.

C-SHL: The Conrad shale is part of the Nadaleen Formation and is a black, laminated siltstone to shale with local intervals of sandstone associated with trace disseminated pyrite.

C-LST2: The Conrad limestone (2) is part of the Nadaleen Formation and is a dark, crystalline lime mudstone, calc-arenite, and lensoidal pebble to boulder conglomerate. It is interpreted as debris flows with lesser interbedded siltstone and grey to black shale. Clast composition of the conglomerate is dominated by limestone and lesser dolostone.

O-MST: The Osiris mudstone is part of the upper Nadaleen Formation and is a finely laminated maroon and green to greenish-grey siltstone. This unit can be subdivided into an overlying maroon and green siltstone and a lower greenish-grey siltstone (Fig. 5C).

O-LST1: The Osiris limestone (1) is part of the lower Gametrail Formation and is a well-bedded, tan and grey limestone with primary sedimentary structures. Monolithic, intraclast rudstone layers, averaging 0.5 to 2 m thick, are common throughout the unit. They consist of randomly oriented to imbricated, tabular to equant clasts in a carbonate mudstone matrix. Clast composition is almost exclusively the same as the enclosing carbonate mudstone (Fig. 5D).

O-DST: The Osiris dolostone is part of the middle Gametrail Formation and is a fine-grained diagenetic dolostone. The dolostone retains many of the original depositional fabrics identical to O-LST1 (*see* above for further description; Fig. 5E).

O-DMT: The Osiris diamictite is part of the upper Gametrail Formation and is a limestone pebble to boulder conglomerate, predominantly matrix supported debrite. Clasts vary from centimetre to metre-scale and comprise limestone that is similar to O-LST1. Matrix composition is variable comprising non to weakly calcareous green siltstone and shale and/or crystalline limestone. The bottom of the unit is consistently marked with a non-calcareous siltstone horizon that is approximately 5 m in true thickness (Fig. 5F).

O-LST2: The Osiris limestone (2) is part of the lower Blueflower Formation and is a very dark grey-black, coarsely crystalline limestone. The base of the unit is often associated with beds of polymictic floatstone containing clasts of orange-weathering dolostone, limestone, rounded quartz pebbles, and minor shale (Fig. 5G).

O-GAB: The 465.6 ± 4.4 Ma (Tucker, 2015) Osiris gabbro has a slight rusty coating on weathered surfaces and dark grey-green on fresh surfaces. The gabbro is composed of medium to coarse-grained amphibole, plagioclase and clinopyroxene.

C-INT: The 74.4 ± 1.0 Ma (Tucker, 2015) Conrad gabbroic dikes dip approximately 60° to the north, 2 subparallel dikes trend roughly east-west and are up to 20 m in true thickness. The dikes are generally competent in drill core, pale beige grey in colour and pervasively altered. The gabbro dikes are composed of coarse plagioclase, clinopyroxene, and abundant secondary carbonate and pyrite (Fig. 5H).

ALTERATION AND MINERALIZATION

Carlin-style gold mineralization in the Nadaleen trend is most commonly hosted in structurally controlled, decarbonatized and silicified silty limestone. Gold mineralization is less commonly found within siliciclastic and mafic intrusive rocks but can occur within structural corridors and immediately adjacent to mineralized limestone. Gold deposition occurs in a variety of settings including fold hinges, stylolites, fault zones, and along lithologic contacts. Decarbonatization occurs contemporaneously with silicification and is the primary alteration associated with gold deposition (Fig. 6A). Gold is found within the rims of sooty arsenian pyrite (Tucker, 2015) and is spatially associated with post-ore realgar and orpiment in hand sample (Fig. 6B-F). Although less common, illite, fluorite (Fig. 6B) and stibnite occur in the vicinity of gold mineralization and can therefore also be good indicators. Intense calcite flooding and chaotic calcite veining can also be a good indicator of mineralization although its temporal relationship to mineralization is complex due to many generations of veining and re-dissolution.

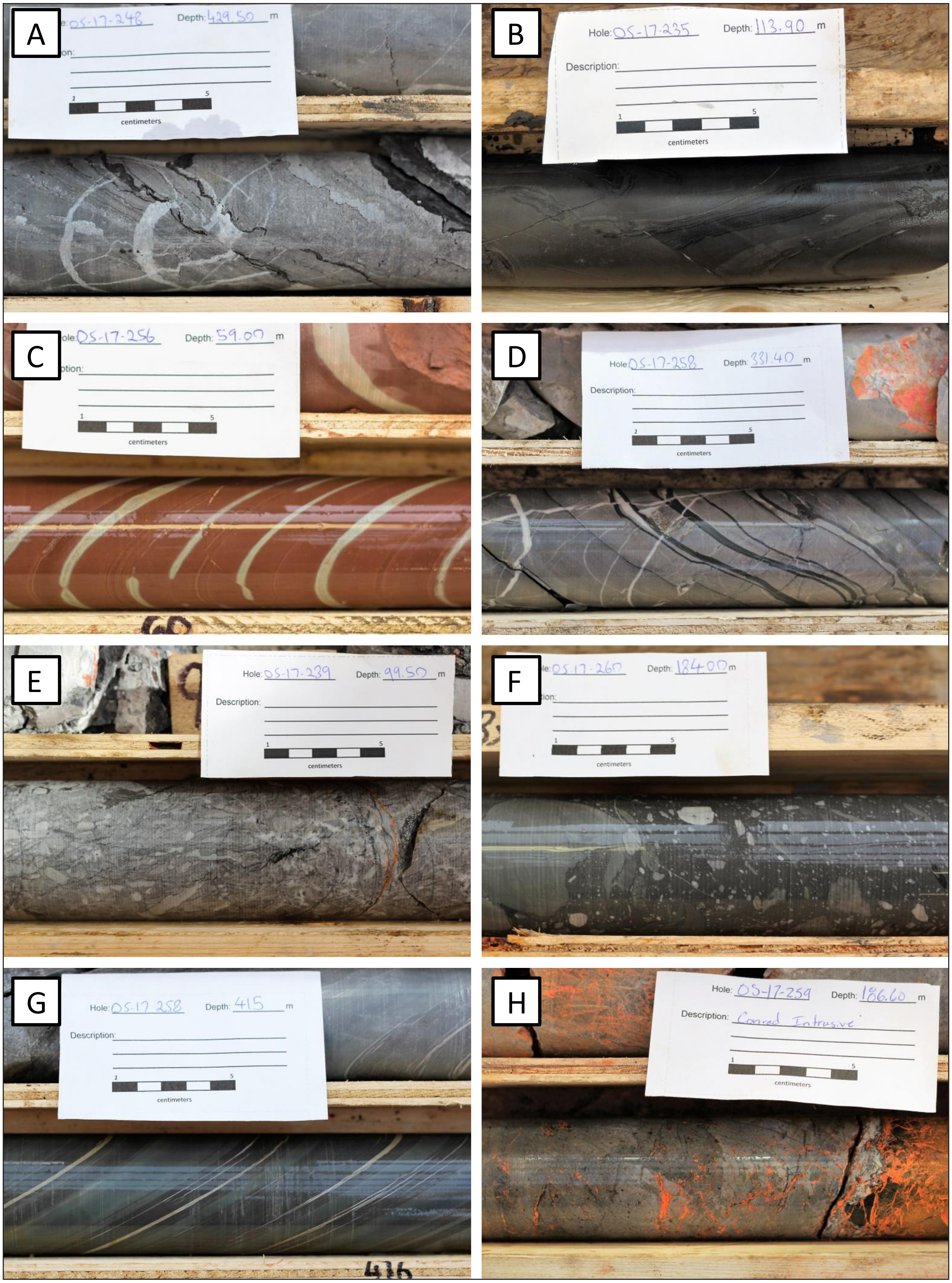

Figure 5. *Representative rock samples from the Osiris cluster from oldest to youngest:* ***(A)*** *C-LST1;* ***(B)*** *C-SLC;* ***(C)*** *O-MST1;* ***(D)*** *O-LST1;* ***(E)*** *O-DST with typical debrite textures;* ***(F)*** *O-DMT;* ***(G)*** *O-LST2; and* ***(H)*** *C-INT.*

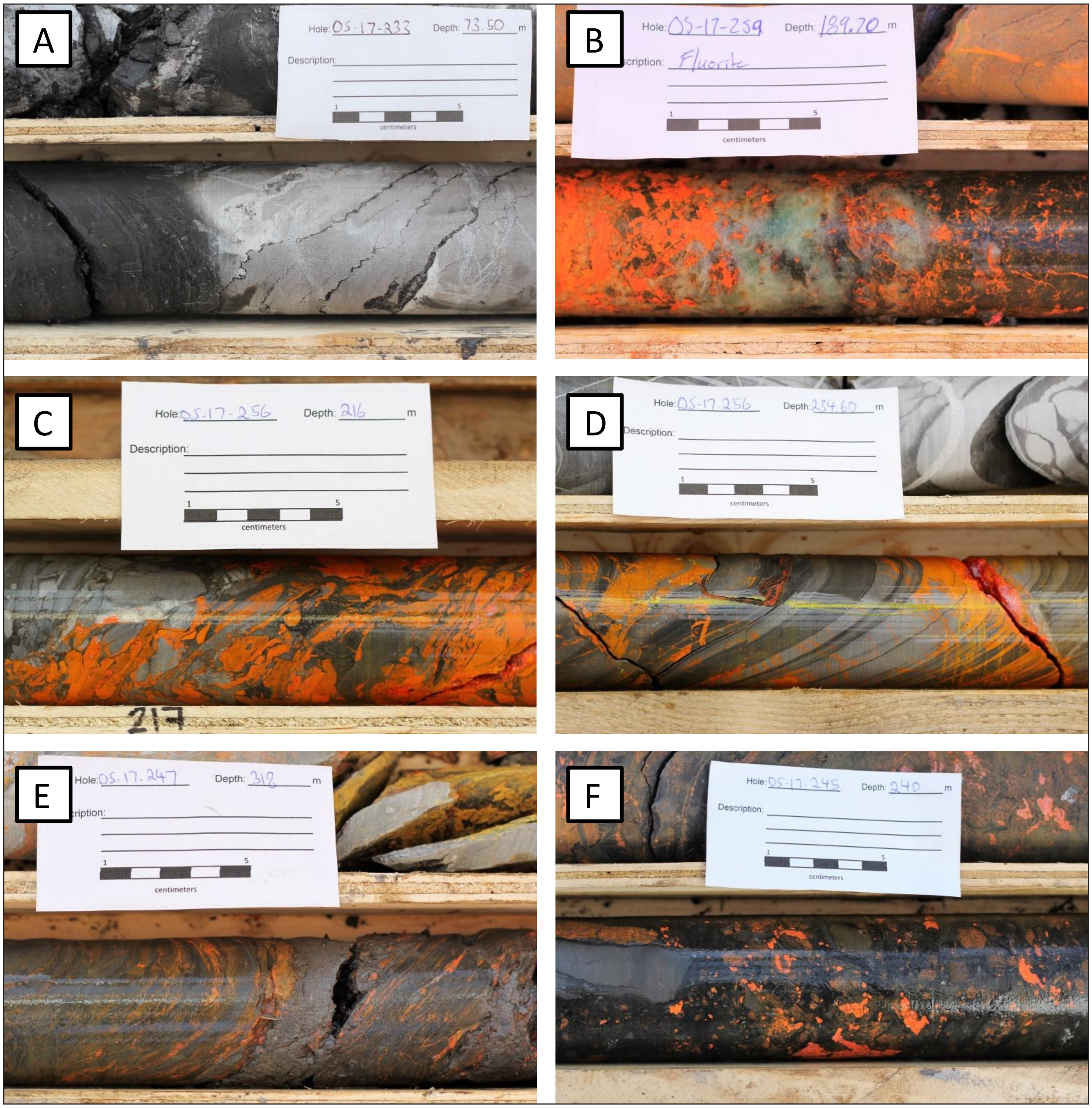

Figure 6. *Representative alteration and mineralization styles from the Osiris cluster.* **(A)** *Black decarbonatization, silicification and stylolitic seams of C-LST1;* **(B)** *Massive realgar, fluorite and decarbonatization and silicification of C-LST1;* **(C)** *realgar preferentially replacing debrite in O-LST1;* **(D)** *realgar intruding along joint and preferentially replacing limestone beds in O-LST1;* **(E)** *sheared, decarbonatized, silicified and patchy realgar replacement of O-LST1 with black sooty seams; and* **(F)** *decarbonatization, silicification, brecciation and preferential realgar replacement of C-LST1.*

DIAMOND DRILL CORE IN YGS CORE COLLECTION

Core from two holes drilled on the Osiris and Conrad have been donated by ATAC Resources Ltd. to the YGS core collection. Drill hole OS-12-130 is from the central-eastern part of Conrad and displays a conformable contact between C-LST1 and C-SLC (Figs. 3 and 7). This hole does not intersect the Nadaleen fault zone or NONAD unit as they are farther to the north (Fig. 7). The hole displays typical contact style mineralization between these units, massive realgar replacement, limestone decarbonatization, gold-bearing stylolitic seams and a complex assembly of calcite veining.

Drill hole OS-11-088 is from the northwestern part of Osiris and displays the entire stratigraphic sequence of Osiris, from oldest to youngest: O-MST1, O-LST1, O-DST, O-DMT and O-LST2 (Figs. 3 and 8). The hole displays typical contact style mineralization at the lithological boundary between the O-MST and O-LST1 units with massive and disseminated realgar replacement and limestone decarbonatization.

Available data for each diamond drill hole includes digital data in the form of pdf files and jpeg images of core photographs. The pdf files include collar survey, lithology, assay and geochemical data.

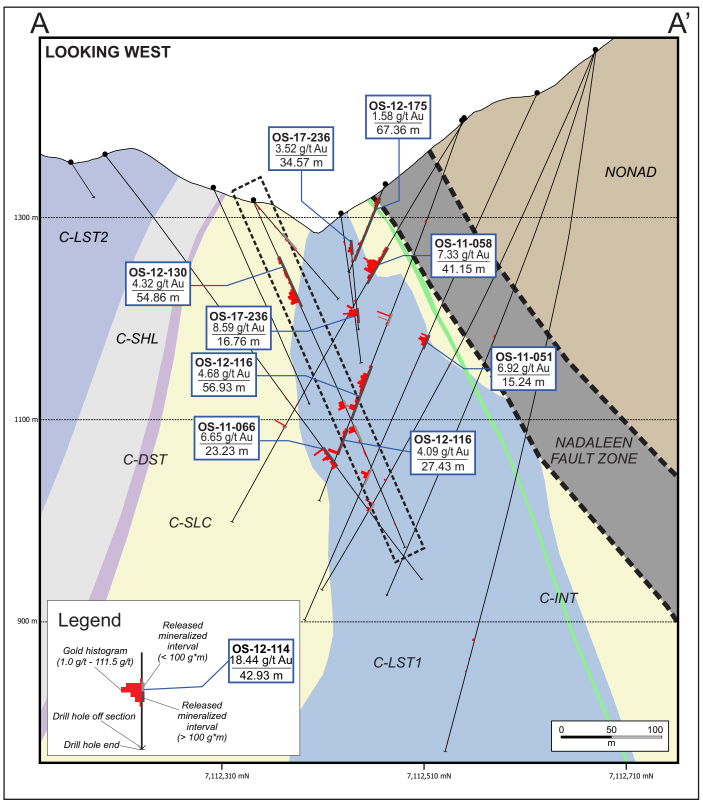

Figure 7. *A-A' Conrad 50 m-wide cross section looking west highlighting donated drill hole OS-12-130. See Figure 3 for section location.*

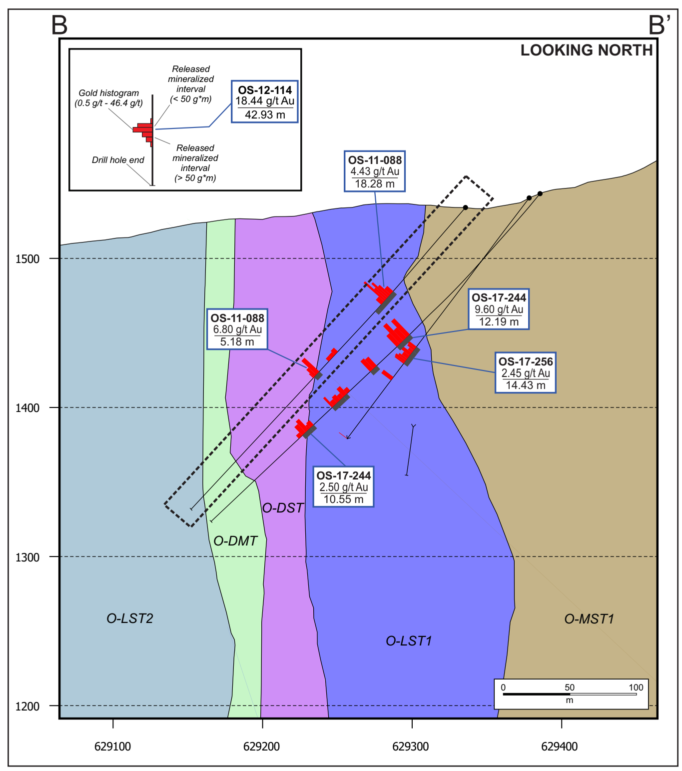

Figure 8. *B-B' Osiris 50 m-wide cross section looking north highlighting donated drill hole OS-11-088. See Figure 3 for section location.*

Table 1. *Drill core donated to YGS library.*

Hole No.	Easting (m)*	Northing (m)*	Year drilled	Length (m)	Area	Mineralization style
OS-11-088	629336	7112445	2011	273.4	North Osiris	Contact and disseminated
OS-12-130	630650.51	7112341.04	2012	374.29	Central Conrad	Contact

*UTM NAD83, Zone 8

ACKNOWLEDGEMENTS

The authors would like to thank ATAC Resources Limited for the permission to publish this paper and for the donation of core from two diamond drill holes, accompanying data and photographs to the Yukon Geological Survey H.S. Bostock core library.

REFERENCES

Abbott, G., 1997. Geology of the Upper Hart River Area, Eastern Ogilvie Mountains, Yukon Territory (116A/10, 116A/11). Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Bulletin 9, p. 1-92.

Colpron, M. and Nelson, J.L., 2011. A Digital Atlas of Terranes for the Northern Cordillera. Yukon Geological Survey, www.geology.gov.yk.ca/bedrock_terrane.html, *also British Columbia Geological Survey, BC GeoFile 2011-11*.

Colpron, M., Moynihan, D., Israel, S. and Abbott, G., 2013. Geological map of the Rackla belt, east-central Yukon (NTS 106C/1-4, 106D/1). Yukon Geological Survey, Open File 2013-13, 1:50 000 scale, 5 maps and legend.

Ghaffari, H., Huang, J., Giroux, G., Martin, C., Hafez, S.A., Bomtraeger, B., Boye, E. and Dumala, M., 2016. Technical Report and preliminary Economic Assessment for the Tiger Deposit, Rackla Gold Project, Yukon, Canada.

Gordey, S.P., and Anderson, R.G., 1993. Evolution of the northern Cordilleran miogeocline, Nahanni map area (105I), Yukon and Northwestern Territories. Geologial Survey of Canada, Memoir 428, 214 p.

Héon, D. (compiler), 2003. Yukon Regional Geochemical Database 2003 - Stream sediment analyses. Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, http://ygspub.gov.yk.ca/Databases/yukon_regional_geochemical_2003.zip, [accessed October, 2017].

Moynihan, D., 2014. Bedrock Geology of NTS 106B/04, Eastern Rackla Belt. *In:* Yukon Exploration and Geology 2013, K.E. MacFarlane, M.G. Nordling and P.J. Sack (eds.), Yukon Geological Survey, p. 147-167.

Moynihan, D., 2016, Bedrock geology compilation of the eastern Rackla belt, east-central Yukon. Yukon Geological Survey Open File 2016-2, 1:75 000 scale.

Narbonne, G.M. and Aitken, J.D., 1995. Neoproterozoic of the Mackenzie Mountains, northwestern Canada. Precambrian Research, vol. 73, p. 101-121.

Roots, C.F., 2003. Bedrock geology of Lansing Range map area (NTS 105N), central Yukon. Yukon Geological Survey, Geoscience Map 2003-1, scale 1:250 000.

Steiner, A., Hickey, K. and Coulter, A.B., 2018. The structural framework for Carlin-type gold mineralization in the Nadaleen trend Yukon. *In:* Yukon Exploration and Geology 2017, K.E. MacFarlane (ed.), Yukon Geological Survey.

Tucker, M.J., 2015. Geology, mineralization and geochronology of the Conrad zone Carlin-type gold prospect, east-central Yukon Territory, Canada. Unpublished MSc thesis, University of British Columbia, 235 p.