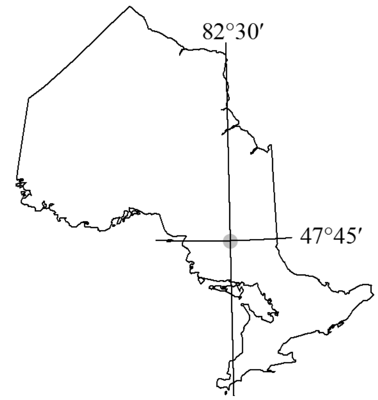
45. The Rundle Intrusive Complex: Investigating Oxidation Processes Related to Gold Mineralization in an Archean Alkalic Intrusive Setting



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INTRODUCTION

This report summarizes data obtained from field mapping, at a scale of 1:1500, of the Rundle intrusive complex in the Swayze area of the southern Abitibi greenstone belt. It was undertaken by the senior author as part of a two-year MSc thesis investigating the processes influencing control of gold mineralization at the Rundle gold deposit and builds upon previous PhD research (Hastie, Lafrance and Kontak 2015; Hastie 2017) on the deposit from 2014 to 2018. The latter work has indicated that gold mineralization predates shearing; gold is associated with intrusive, alkalic syenite-associated(?) rocks; high-grade gold is spatially associated with magnetite and pyrite-bearing rock units; and some of the mafic rock units in the deposit, previously mapped as komatiites, appear to instead be mafic to ultramafic alkalic intrusive rocks, possibly representing the mafic components of a larger alkalic intrusive complex (Hastie, Lafrance and Kontak 2015; Hastie 2017).

The Rundle intrusive complex represents a unique opportunity to examine oxidation–reduction (“redox”) controls on high-grade gold hosted in alkalic intrusive rocks because of its relatively small size (approximately 500 m by 1 km), excellent exposure and good preservation. This becomes particularly important when considering large alkalic complexes that host gold mineralization (e.g., Kirkland Lake), the nature of which could mask evidence of early processes, or the size of which may inhibit the study of broad, small-scale processes. As such, a detailed, integrated study involving field, textural, mineralogical and geochemical relationships, such as this study, will facilitate a characterization of the intrusive complex and the processes responsible both for its formation and the elevated gold contents found within it on the deposit scale. This study will also serve as an essential baseline from which comparative studies at other, larger, related deposits (e.g., Kirkland Lake, Young–Davidson Mine) can be conducted, leading to a more detailed, holistic understanding of the genesis or evolution of alkalic intrusive-hosted gold deposits.

The main objectives of this project are to 1) determine the spatial and temporal relationships of host rocks and how they relate to gold mineralization; 2) examine the mineralogical controls on gold and oxidation-related processes; 3) test whether variations of $\delta^{34}S$ isotope signatures conform with the well-established hypotheses of progressively depleted sulphur isotopic values in association with an increase in fO_2 and gold distribution (Neumayr et al. 2008); and 4) develop an integrated, refined model for gold-mineralizing systems as they relate to the alkalic Rundle intrusive complex.

Summary of Field Work and Other Activities, 2018,
Ontario Geological Survey, Open File Report 6350, p.45-1 to 45-8.

GENERAL GEOLOGY

The Swayze area (Figure 45.1) is considered to be the southwest extension of the Abitibi greenstone belt and is bounded by granitoid rocks to the north, south and east (Nat River granitoid complex, Ramsey–Algoma granitoid complex, and Kenogamissi Batholith, respectively), and to the west by the Kapuskasing Structural Zone. The intrusive and extrusive rocks (ultramafic to felsic in composition), along with chemical and clastic metasedimentary rocks, range in age from *circa* 2739 to 2690 Ma (Heather 2001; van Breemen, Heather and Ayer 2006). It has been previously noted that the alkalic metavolcanic rocks in the central part of the Swayze area have an age of 2670±2 Ma (Ayer, Ketchum and Trowell 2002). These are spatially related to a series of gold deposits, including the Rundle gold deposit. The metavolcanic rocks, which are temporally equivalent to the Timiskaming-type basins (<2669 Ma) found in the Abitibi greenstone belt, are noteworthy because they are commonly found in spatial association with alkalic intrusive rocks and gold deposits. There are also 2 gold-rich shear zones that extend across the southern and central sections of the Swayze area, termed the "Rundle high-strain zone" and the "Ridout high-strain zone", respectively (Heather 2001). Both have been suggested to be the possible west-trending extensions of the Larder–Cadillac deformation zone (Atkinson 2013).

Rundle Deposit

The Rundle gold deposit (Figure 45.2) was discovered by Claude Rundle in 1940 (Love and Roberts 1991). It occurs along the Rundle high-strain zone, within rocks that have intruded a southeast-trending zone of mafic volcanic to ultramafic rocks. During the 2015 field season, 2 gold-bearing zones, termed A-zone south and Main/Shaft zone, were mapped in detail at a scale of 1:20 (Hastie, Lafrance and Kontak 2015). Based on previous field observations (Love and Roberts 1991), A-zone south was interpreted to be composed primarily of komatiitic rocks, although no data (geochemical, textures) were presented to support a komatiite association. Gold mineralization is associated with early pyrite that is found in fractures (Love and Roberts 1991; Hastie, Lafrance and Kontak 2015). At the A-zone south outcrop, these gold-bearing pyrite veins have been folded and deformed during dextral shearing (around the noses of Z-shaped dextral F_2 folds), which suggests that this mineralization predates the shearing (Hastie, Lafrance and Kontak 2015).

RESULTS OF SUMMER FIELD WORK

The goals for the 2018 field season were to perform detailed mapping and sampling on a newly stripped area named the "East zone" (located between A-zone south and Portal zone outcrops; *see* Figure 45.2); to map along transects across the intrusive complex; and to map and collect samples along the shoreline of Parallel Lake.

A total of 200 samples were collected this field season (*see* Figure 45.2) in order to identify the different host rocks, assess their geochemical signatures, obtain sulphide (pyrite) to be used for sulphur isotopic analyses, determine the precious metal content (gold, silver) of the different rock types, and make thin sections for follow-up petrographic study. Results show that at least 12 different rock types were identified (all intrusive rocks, except for komatiites), including various subtypes, ranging from ultramafic to felsic in composition. These results have been used to refine previous maps (Love and Roberts 1991; *see* Figure 45.2).

The study area encompassing the Rundle intrusive complex is composed of mafic and ultramafic volcanic rocks that have been intruded by multiple types of ultramafic to felsic rocks. Previous work by Love and Roberts (1991) indicated that the southeast portion of the study area (*see* Figure 45.2) is dominated by medium- to coarse-grained mafic volcanic rocks. Observations recorded for these rocks as part of the 2018 field season, such as the coarse-grained nature of the amphibole and plagioclase crystals, along with the high magnetic susceptibility of these rocks (compared to that of the fine-grained mafic

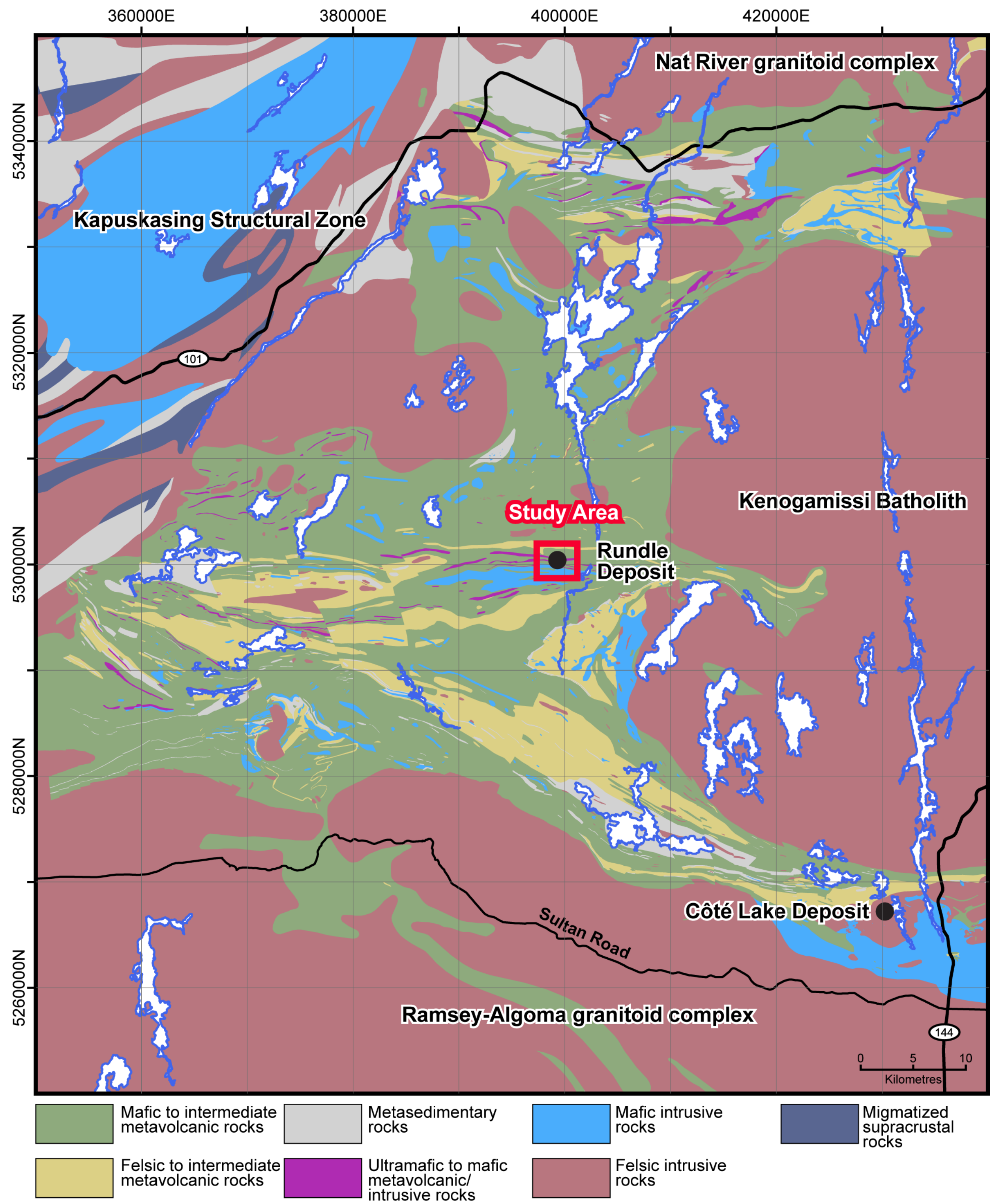

Figure 45.1. Simplified geological map of the Swayze area of the southern Abitibi greenstone belt displaying the area of study (enclosed by red rectangle). Location information provided as Universal Transverse Mercator (UTM) co-ordinates using North American Datum 1983 (NAD83) in Zone 17 (*modified from* Ontario Geological Survey 2011).

volcanic rocks in the area), indicate that these are metagabbroic rocks, with an intrusive origin. Their relationship to the felsic intrusive rocks of the complex is uncertain at this time.

The feldspar porphyries vary in overall colour, ranging from grey to red, suggesting that they may also vary chemically and mineralogically. One operating hypothesis is that the grey feldspar porphyry may represent the least-altered porphyry and that, with time, these rocks become darker red because of progressive oxidation (resulting from the formation of hematite). However, the red feldspar porphyry is anomalous in that it has a black matrix and deep red phenocrysts. Geochemical and petrographic data will be needed to evaluate whether the red feldspar porphyry represents a unit that has been more highly altered or is different unit completely. Further geochemical data will be used to evaluate this unit and its origin. A partial listing of the rock types observed, along with some of their general characteristics and their modes of occurrence, is provided in Table 45.1.

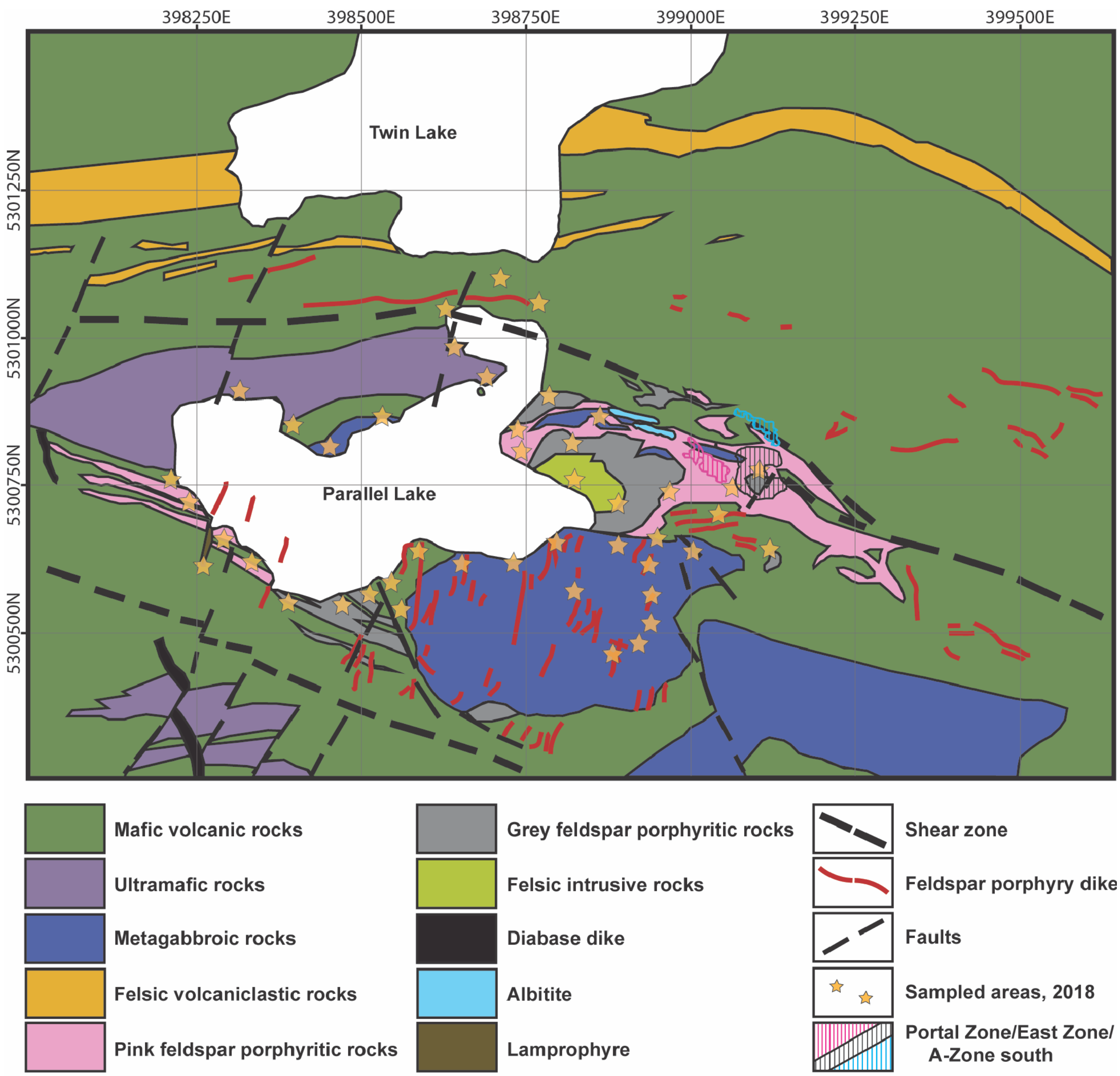

Figure 45.2. Simplified geological map of the Rundle gold deposit, showing important outcrops and sample locations from the 2018 field season (*modified from* Love and Roberts 1991). Location information provided as UTM co-ordinates using NAD83 in Zone 17.

Table 45.1. Descriptions of rock types found at the Rundle intrusive complex, Swayze area, southern Abitibi greenstone belt.

Rock Type	Description
Mafic volcanic rocks	Massive, dark green to black, fine grained, commonly with white calcite and/or epidote veinlets 0.1–2 cm wide. It is composed mainly of plagioclase and pyroxene. These rocks typically contain <4% disseminated subhedral to euhedral pyrite grains that are 1–5 mm in diameter. This rock type is predominantly found at the margins of the intrusive complex. The top direction of the mafic volcanic rocks, indicated by pillowed flows, is to the south, and no evidence for reversals were observed within the study area, consistent with previous observations (Love and Roberts 1991; Heather 2001).
Metagabbroic rocks	Massive, dark green to black, medium to coarse grained, with visible 1–5 mm elongated black amphibole grains (Photo 45.1A). It is composed of plagioclase and pyroxene and it generally has a higher magnetic susceptibility (<50 $\times10^{-3}$ SI) compared to the surrounding mafic volcanic and feldspar porphyry rocks, which typically have a magnetic susceptibility of <10 $\times10^{-3}$ SI. It is mainly found along the outer margins of the complex.
Ultramafic rocks	Dark green to black, coarse-grained unit exhibiting a possible spinifex texture (Photo 45.1B). The crystals range from 3 to 10 mm in length, but this varies with location (larger to smaller when going east to west in the ultramafic unit). This rock type is predominantly located in proximity to the contact between the mafic volcanic and the metagabbroic rocks in the north and south portions of the property.
Metasedimentary rocks	Dark grey to black, very fine grained (resembling chert). It contains <3% disseminated pyrite that is 1–2 mm in diameter. Abundant crosscutting quartz and feldspar veinlets 1–10 mm wide are observed. This rock type is always >2 m wide and has a sharp contact with the grey feldspar porphyry unit.
Mafic feldspar porphyry	Light to dark brown rock with a porphyritic texture, brown matrix, and elongated and strained black and pink phenocrysts. The phenocrysts range from 3 to 8 mm in length and have a weak lineation. This rock type also commonly contains white calcite veinlets 1–4 mm wide. It is mainly found near the contact between mafic volcanic and/or metagabbro and grey feldspar porphyry rock types.
Grey feldspar porphyry	Dark grey rock with a porphyritic texture, grey matrix, and with white and pink feldspar phenocrysts from 1 to 10 mm (Photo 45.1C). Generally contains calcite veinlets that are 1–4 mm wide and it is slightly magnetic (>8 $\times10^{-3}$ SI).
Pink feldspar porphyry	Texturally similar to the grey feldspar porphyry except it has a dark pink matrix with white feldspar phenocrysts, with the phenocrysts ranging from 2 to 10 mm in diameter (*see* Photo 45.1C). Generally contains veinlets of white calcite 2–5 mm wide and it is slightly magnetic (>8 $\times10^{-3}$ SI). Both the pink and grey feldspar porphyry units can be found to the east and west of Parallel Lake.
Red feldspar porphyry	Very dark rock, with a porphyritic texture and black matrix with dark red phenocrysts ranging from 4 to 10 mm (Photo 45.1E). Small (0.5–1 mm), euhedral pyrite grains are disseminated throughout the rock. Generally contains calcite veins that are 1–4 mm wide. This porphyry unit is only found on the very western shoreline of Parallel Lake, between 2 ultramafic rock units on this property. This unit strikes exactly east-west and is 5 m wide.
Silicified and deformed red feldspar porphyry	Very fine-grained rock (resembling chert) that is red and heavily silicified (*see* Photo 45.1E). There are abundant veinlets of crosscutting quartz and feldspar that are 1–12 mm wide. This rock is typically positioned between the pink feldspar porphyry and mafic volcanic units. A higher relative proportion of this unit was found in the newly mapped East zone during the 2018 field season.
Amphibole-bearing feldspar porphyry	Dark grey rock with a porphyritic texture. It has a dark brown matrix with white feldspar phenocrysts that range from 1 to 6 mm, with black amphibole grains that are 1–3 mm long (Photo 45.1D). There are also mafic grains (fragments), and some sulphides (mainly pyrite) that are 1 mm in size, as well as unknown grains with a silvery-metallic lustre that are 1–2 mm in size. This rock weathers to a light cream, which serves to enhance the appearance of the black amphiboles.
Altered felsic rocks	This rock is light beige or creamy yellow with abundant crosscutting quartz veinlets that are 1–3 mm wide (Photo 45.1F). Some fractures are infilled with a black mafic mineral (chlorite?) that is 1 mm wide. There is a large amount of disseminated pyrite throughout the rock, the crystals of which are 0.5–1 mm across. This unit is most abundant on the southwest of the property, near the shoreline of Parallel Lake.
Mafic to ultramafic porphyry	This dark grey rock has a dark green matrix with black phenocrysts of biotite that are 1–3 mm in size, as well as some pink phenocrysts (possibly feldspar) that are 5–8 mm in size. It has a high abundance of pyrite grains that are 1–4 mm in size. This unit was only found in the East zone, is 1 m wide and trends east.

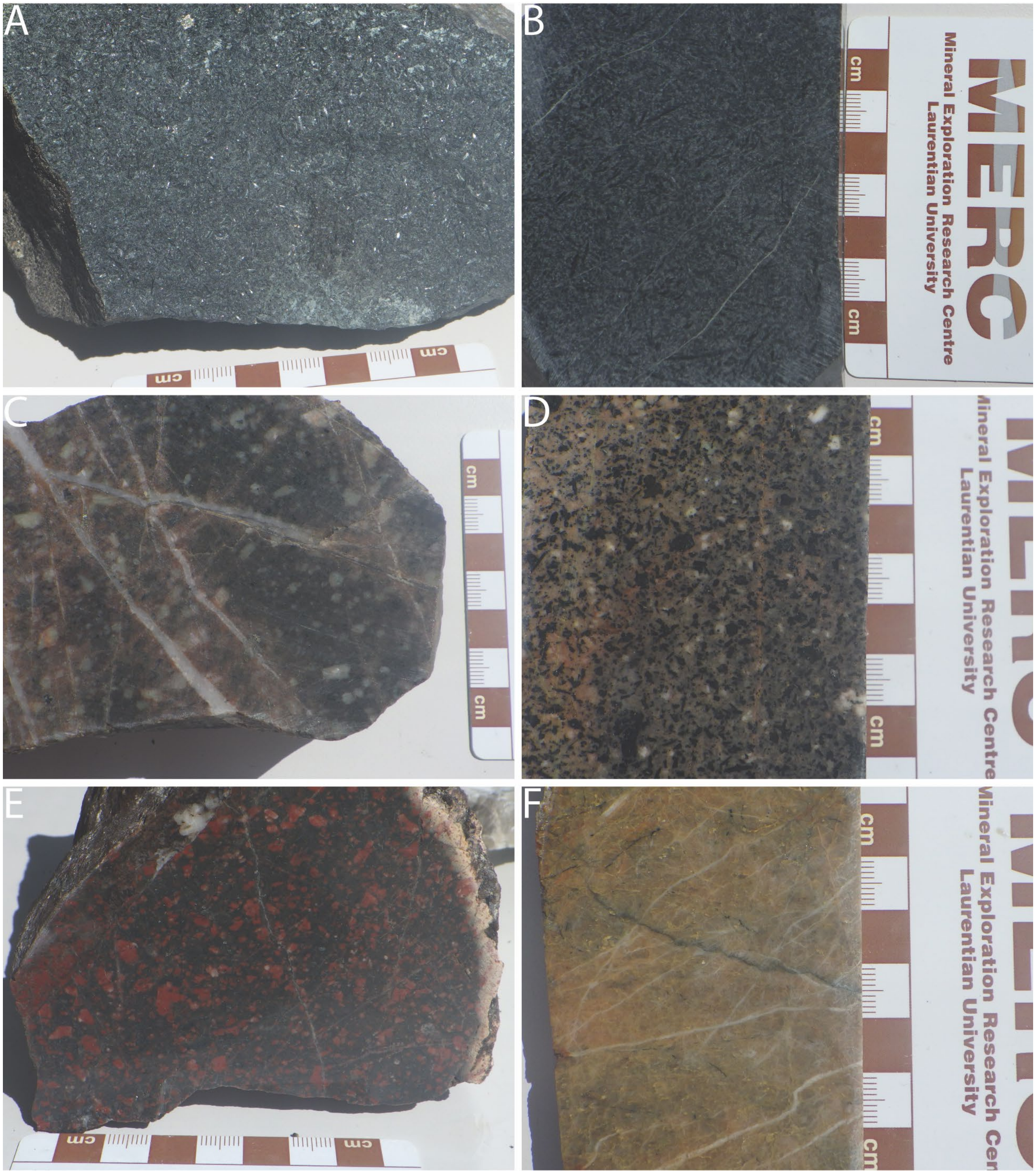

Photo 45.1. Representative hand specimen photos of the dominant rock types at the Rundle gold deposit and associated intrusive complex. **A**) Medium- to coarse-grained metagabbroic unit. **B**) Ultramafic volcanic rock with spinifex texture. **C**) Grey and pink feldspar porphyry with quartz veins and associated hematite alteration. **D**) Amphibole-bearing feldspar porphyry. **E**) Red feldspar porphyry with hematized phenocrysts. **F**) Altered feldspar porphyry with typical quartz-ankerite-sericite alteration.

CONCLUSIONS AND FUTURE WORK

This project will seek to test if the varying conditions of oxidation are preserved within the host rocks, what these states represent (in terms of fO_2), how they vary within rock units and across the intrusive complex, and what relationships to gold mineralization can be discerned. The Rundle intrusive complex is an excellent candidate for use in trying to answer these questions because of its relatively small size, extensive exposure and degree of preservation.

Future work will include the following:

1. sulphur isotopic analyses on pyrite grains in different host rocks from across the complex;
2. interpretation of structural measurements and digitization of detailed deposit-scale maps;
3. detailed petrographic studies incorporating microscopy, scanning electron microscope–electron dispersive spectrometry and electron probe microanalysis to characterize the mineralogy, textures and microstructures, and how these relate to redox conditions and gold mineralization;
4. geochemical analysis on representative samples for identification and interpretation; and
5. follow-up sampling and additional data collection, as warranted, in the 2019 field season.

ACKNOWLEDGMENTS

This work constitutes part of the requirements of an MSc thesis by the senior author in the Harquail School of Earth Sciences at Laurentian University under the co-supervision of Dr. Andrew McDonald and Mr. Evan Hastie. The authors would like to thank the generous funding provided by the Metal Earth Initiative, the Mineral Exploration Research Centre (MERC) at Laurentian University, and the Ontario Geological Survey. This is MERC–Metal Earth publication number MERC-ME-2018-082.

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ISSN 1916-6117 (online)
ISBN 978-1-4868-2715-2 (PDF)
(for entire OFR 6350)

ISSN 0826-9580 (print)
ISBN 978-1-4868-2714-5 (print)
(for entire OFR 6350)