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Targeted Geoscience Initiative 4: Contributions to the Understanding of Precambrian Lode Gold Deposits and Implications for Exploration

Structural and lithological controls on gold mineralization at the Cheminis mine: Implications for the formation of gold deposits along the Larder Lake - Cadillac deformation zone, Ontario

Bruno Lafrance

Laurentian University, Sudbury, Ontario

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TABLE OF CONTENTS

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Bruno Lafrance

Mineral Exploration Research Centre, Department of Earth Sciences, Goodman School of Mines,
Laurentian University, Sudbury, Ontario P3E 2C6
Author's e-mail: blafrance@laurentian.ca

ABSTRACT

The Larder Lake-Cadillac deformation zone (LLCDZ) is a major deformation zone within the southern Abitibi subprovince of the Archean Superior Province. It hosts several gold deposits, including the Cheminis and the giant Kerr Addison – Chesterville deposits in Ontario. The two deposits occur along a strongly deformed band of Fe-rich tholeiitic basalt and komatiite of the Larder Lake Group (ca. 2705 Ma), bounded on both sides by younger, less deformed, Timiskaming turbidite (2680–2670 Ma). Gold was emplaced during D_2 closure of an extensional Timiskaming basin, following the formation of early F_1 folds. D_2 deformation was a progressive compressive deformation event that began with regional F_2 folding and the formation of a regional S_2 cleavage, and ended with the localization of the deformation along the band of older volcanic rocks, the formation of the LLCDZ, and the introduction of gold during south-side-up reverse-slip faulting along the LLCDZ. The presence of weakly deformed syenite dykes suggests a minor magmatic contribution to the gold-bearing hydrothermal fluids. Thus, gold was deposited as hydrothermal fluids flowed upward along the LLCDZ during D_2 south-side-up shearing.

INTRODUCTION

The Larder Lake - Cadillac deformation zone (LLCDZ) can be traced from Val D'Or, Quebec, to Matachewan, Ontario, in the southern Abitibi subprovince of the Archean Superior Province. The deformation zone generally follows the contact between sedimentary and alkaline volcanic rocks of the Timiskaming Group (2680–2670 Ma: Ayer et al., 2005) to the north and older volcanic rocks of the Larder Lake Group (ca. 2705 Ma: Corfu et al., 1989) to the south (Fig. 1). East of Larder Lake, it leaves this contact and is localized along a 100–350 m wide band of ultramafic rocks and Fe-rich tholeiitic basalt of the Larder Lake Group, between two panels of Timiskaming turbidite. The giant Kerr Addison – Chesterville deposit and the smaller satellite Cheminis deposit occur within this band of deformed volcanic rocks. The objectives of the study are to determine the relative chronology and the structural and lithological controls on gold mineralization at the Cheminis mine and highlight implications for the formation of lode gold deposits along the LLCDZ.

RESULTS

The earliest deformation feature in the Timiskaming rocks in the Cheminis mine area is the presence of F_1 folds. These folds, which lack an axial plane cleavage, are refolded by regional F_2 folds with a sericitic and chloritic, axial planar, S_2 cleavage, which strikes east to east-northeast and dips steeply (75–85°) to the south or north. S_2 cleavage becomes more pronounced in the band of Larder Lake volcanic rocks, where it is associated with a strong, steeply plunging, mineral stretching lineation and asymmetrical internal structures (S-C fabrics, asymmetrical strain shadows), suggesting south-side-up movement along S_2 (Ispolatov et al., 2005, 2008). This band of localized shearing and intense deformation represents the LLCDZ. During later dextral trans-current reactivation of the LLCDZ, S_2 cleavage is overprinted by asymmetrical, Z-shaped F_3 folds with an axial planar S_3 slaty/crenulation cleavage.

Gold in the LLCDZ is associated with disseminated pyrite in altered Fe-rich tholeiitic basalt ("flow ore") and with quartz carbonate veins in highly altered fuchsite-carbonate ultramafic schist ("green-carbonate ore") and turbidite (Thompson, 1941; Kishida and Kerrich, 1987; Smith et al., 1993). Fe-rich tholeiitic basalt underwent extensive ankerite alteration (up to 65% of the rock) and sericitization, resulting in sericite largely replacing metamorphic chlorite. Pyrite occurs as small disseminated grains (<1 mm) parallel to S_2

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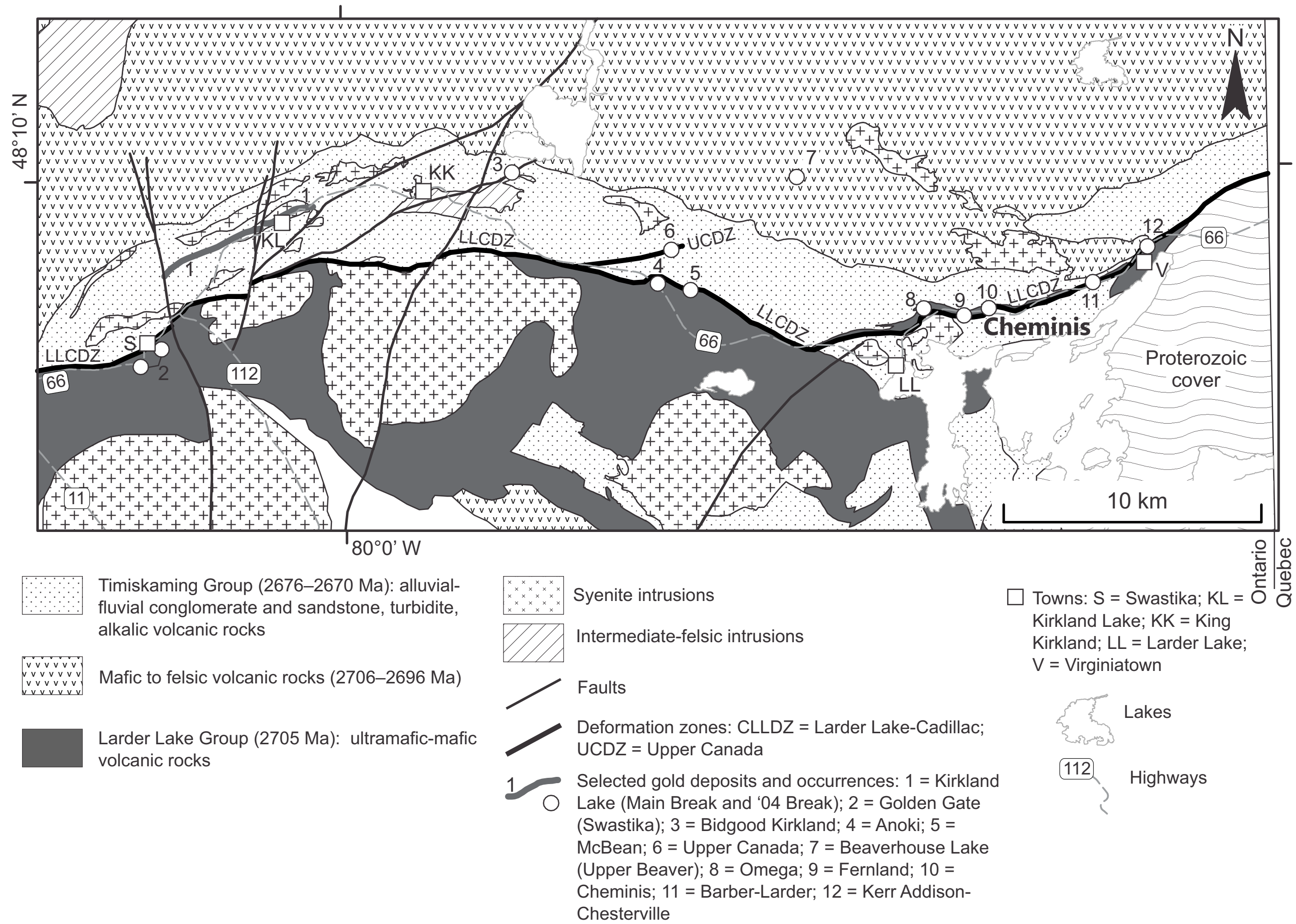

Figure 1. Simplified geological map of the Larder Lake-Cadillac deformation zone from Kirkland Lake to the Ontario – Québec provincial border, showing the location of the Cheminis mine. Modified after Ispolatov et al. (2008).

and as large cubes (up to ≤5 mm) that are surrounded by and truncate S_2 cleavage (Fig. 2a). Strain shadows around pyrite cubes are filled with ankerite, quartz and sericite (Fig. 2b), which also occur as inclusions within the pyrite cubes. Gold grains are present as inclusions within pyrite and along grain boundaries of both disseminated and cube pyrite. Green fuchsitic-carbonate ultramafic schist consists of fuchsite, ferroan dolomite, magnesite, and quartz, replacing all primary and/or metamorphic minerals. Gold is associated with grey quartz-carbonate veins that are boudinaged, folded, and transposed parallel to S_2 cleavage. Syenite dykes are parallel to S_2 in fuchsite-carbonate ultramafic schist, and they are weakly foliated parallel to S_2. Turbidite-hosted mineralization consists of an alteration halo of ankerite, sericite, arsenopyrite and pyrite surrounding fibrous quartz-carbonate veins.

DISCUSSION

The relative chronology of gold mineralization and structural evolution of the LLCDZ can be interpreted from microstructural relationships. In fuchsite-carbonate ultramafic schist, quartz-carbonate veins associated with gold mineralization are folded and transposed parallel to S_2 cleavage, suggesting that mineralization was deposited either before or early during D_2 deformation. In Fe-rich tholeiitic basalt, S_2 cleavage is either truncated by pyrite grains or wraps around pyrite grains that have strain shadows infilled with hydrothermal alteration minerals. These textural relationships and the association of the gold with pyrite suggests that the gold mineralization was emplaced during D_2 deformation.

Syenite dykes are surrounded by rocks with a strong S_2 foliation but are only weakly foliated parallel to S_2. This suggests that the dykes were emplaced either prior to or late during D_2 deformation, as deformation along the LLCDZ became localized in the surrounding weaker ultramafic rocks. The dykes have a similar trace element geochemistry as intramineral albitite dykes at the Kerr-Addison mine (Smith et al., 1993). The latter dykes are interpreted to have been emplaced late during the development of the main foliation along the LLCDZ (Smith et al. 1993). Thus, magmatic fluids may have contributed to the hydrothermal system at Cheminis, as Smith et al. (1993) suggest at Kerr Addison. However, as only three syenite dykes have

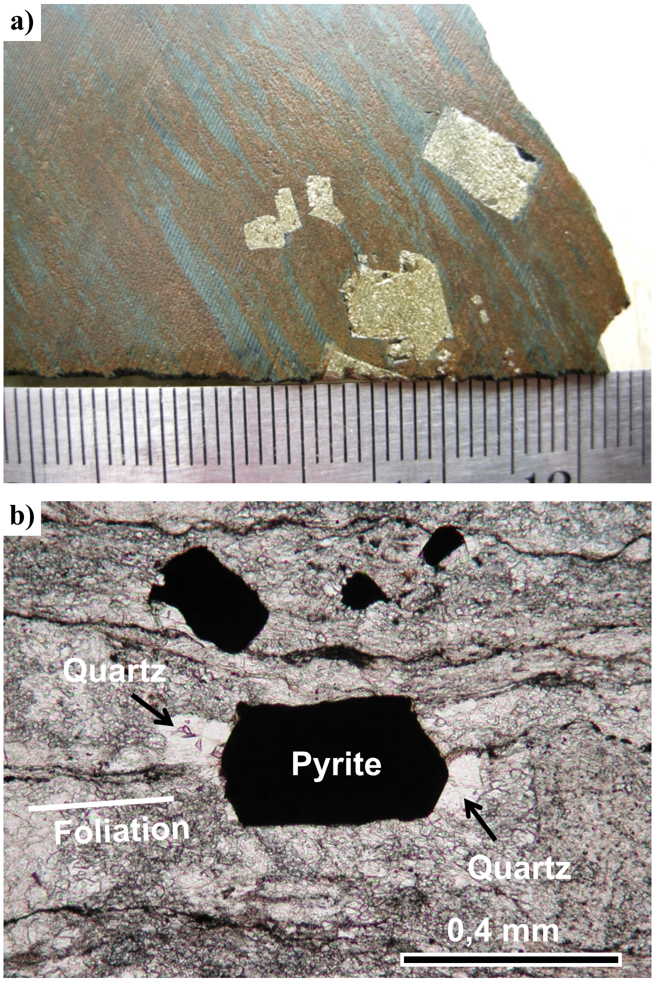

Figure 2. a) Drill core showing a coarse-grained pyrite cube overgrowing S2 foliation in an altered Fe-rich tholeiitic basalt. **b)** Photomicrograph of altered Fe-rich tholeiitic basalt showing a pyrite cube truncating S2 and surrounded by strain shadows filled with quartz. Natural light.

been mapped at Cheminis, this contribution could only have been a minor component of the hydrothermal fluid system.

The migration of hydrothermal fluids and alkaline magmas could have begun before D_2 deformation along an early syn-depositional normal fault that constrains the Timiskaming basin to the south (Dimroth et al., 1982; Cameron, 1993; Mueller et al., 1994; Bleeker, 2012). During the closure and shortening of the Timiskaming basin, the fault was reactivated forming the reverse, south-side-up LLCDZ during D_2 deformation (Bleeker, 2012). The main phase of gold mineralization was emplaced during this contractional D_2 event, as hydrothermal fluids flowed upward along the structure (Card et al., 1989; Hodgson and Hamilton, 1989; Cameron, 1993).

IMPLICATIONS FOR EXPLORATION

The LLCDZ remains an excellent target for new gold discoveries. Within the LLCDZ, detailed mapping of the intensity of ankerite and sericite alteration is warranted, as both are directly associated with gold mineralization (Poulsen et al., 2000; Robert et al., 2005; Dubé and Gosselin, 2007). Slivers of Fe-rich tholeiitic basalt enclosed by more ductile ultramafic schist are favourable targets because the more ductile ultramafic schist was likely less permeable and could have focused or restricted the flow of hydrothermal fluids into the more competent Fe-rich tholeiitic basalt (Ispolatov et al., 2008). Zones with a strong foliation, stretching lineation, and asymmetrical shear sense indicators are also worthy of further study as they represent zones of more intense shear and permeability, which may have acted as channels for the migration of hydrothermal fluids.

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