Structural Architecture of the Kirkland Lake Mining District

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The Kirkland Lake mining district in the Abitibi greenstone belt, northeastern Ontario hosts Macassa mine, one of the world's highest-grade gold mines (18.4 g/t Au). Gold is primarily hosted along semi-brittle faults and quartz veins that cross-cut volcanic and sedimentary rocks of the Timiskaming assemblage (2676 Ma– 2670 Ma), as well as co-genetic intrusions. These are separated from older volcanic rocks of the Larder Lake Group (2705 Ma) by the Larder Lake-Cadillac deformation zone (LLCDZ), a 200-800 m wide ductile shear zone extending over 250 km across Ontario and Quebec, hosting numerous world-class gold deposits.

The South Mine Complex (SMC) is Macassa's most active zone, with gold localized along narrow, east-northeast trending, shallowly-dipping (0-30°) faults filled with quartz veins, hydrothermal breccia, and sericite-pyrite alteration. These faults lie between the reverse, south-side-up Main Break and the reverse, north-side-up Amalgamated Break. This study focuses on surface mapping of a 2.3 km-wide Timiskaming panel between the Amalgamated Break and the LLCDZ, plus underground structural mapping in the SMC. The panel's structure is dominated by east-northeast-trending, F3 folds with a regional axial planar S3 cleavage, which intensifies in iron-carbonatized LS tectonites along the LLCDZ.

The Timiskaming rocks young towards the LLCDZ and Larder Lake Group, suggesting that the LLCDZ originated as a north-directed thrust fault prior to S3 formation. This thrusting may coincide with the formation of the Amalgamated Break, which evolved from a brittle fault to a ductile shear zone through clay alteration during fluid flow along the fault. Gold within the mineralized AK zone, located in the study area, is controlled by brittle fractures predating regional foliation and the LLCDZ, indicating early gold deposition during a brittle deformation event. This project aims to investigate the relative timing of the semi-brittle faults and ductile LLCDZ and constrain the structural controls on gold mineralization.