

Multi-scale Mineral Chemistry Vectors to Au-Bi-Cu Mineralization in the World-class Tennant Creek IOCG Province

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The accelerating global demand for critical raw materials has intensified the need for advanced exploration tools capable of detecting mineral systems in historically productive yet underexplored provinces. One such province is the Tennant Creek mineral field in Australia, which, despite significant past production of gold, copper, and bismuth, presents substantial exploration challenges.

Au-Bi-Cu mineralization is typically hosted within magnetite-hematite-chlorite-quartz bodies known locally as ironstones. These bodies are surrounded by narrow, chlorite-rich alteration haloes that produce only weak geochemical signatures, making mineralization difficult to predict. This study integrates detailed ore mineralogy with multi-scale mineral chemistry to assess the use of ore and alteration minerals as vectors to Au-Bi-Cu mineralization in this atypical IOCG province.

Detailed ore-zone mineralogical study across major deposits reveals a diverse assemblage of bismuth-bearing phases spatially and texturally linked to Au-Cu mineralization. These include native bismuth and bismuthinite, as well as complex Bi-Se-Te sulphosalts occurring as intergrowths with chalcopyrite and chlorite, and locally as inclusions within native gold. Textural relationships indicate early Au-Bi-Cu mineralization followed by late-stage copper remobilization forming Bi-Cu sulphosalts. Thermodynamic considerations suggest a bismuth-collector model for gold in some deposits, providing insights into the uncommon bismuth and gold enrichment observed at Tennant Creek and supporting the use of bismuth minerals as indicators for gold mineralization.

Alteration mineral chemistry provides complementary exploration vectors. Systematic variations in chlorite chemistry enable precise targeting of high-grade zones within ironstone bodies. At the deposit scale, chlorite chemistry vectors extend up to 1.5 km from mineralization, well beyond previously recognized exploration footprints. At the province scale, chlorite chemistry effectively discriminates mineralized from barren ironstones and highlights fluid pathways associated with fertile systems.

These findings highlight the potential of multi-scale mineral chemistry to guide the next generation of discoveries at Tennant Creek and other IOCG provinces globally.