Project Title: Metallogenic evolution of Mesoproterozoic sedimentary rocks in Idaho and Montana

Statement of Problem

The project region is mainly known as the Belt-Purcell basin (Ross, 1963), best defined in western Montana but extending into adjacent Idaho and British Columbia. The basin was the depocenter for as much as 50,000 feet of mostly clastic sedimentary rocks known as the Belt-Purcell Supergroup. Similar sedimentary rocks in adjacent east-central Idaho, known mainly as the Lemhi Group (Ruppel, 1975), have been correlated with the Belt for a number of years, but the actual correlations are complex and sometimes convoluted (Winston et al., 1999). Rocks from the Belt and Lemhi Groups maintain their stratigraphic integrity in western Montana and east-central Idaho, respectively; however, correlations become exceedingly tenuous across the Idaho-Montana state line in the vicinity of Salmon, Idaho (eg. Winston et al., 1999; Tysdal et al., 2003). Correlations have been based mainly on reconnaissance data, are characteristically speculative, and much debated. Only recently has an effort been made, supported mostly by the USGS and state universities, to understand the sedimentology, stratigraphy, paleogeography, and most recently age of deposition of the Belt-Purcell Supergroup and Lemhi Group, in an attempt to base correlations of the two Groups of Mesoproterozoic strata in a more rigorous fashion.

Closely tied to this new study of Mesoproterozoic geologic framework, is an understanding of the nature of the basement directly underlying these strata and how this basement influenced sedimentation and mineralization. The main difficulty in assessing the influence of the basement on metallogeny is the fact that thick clastic sequences blanket the crystalline rocks and as such mask most indications of the character (fabric and composition) of crystalline basement beneath the northern Cordillera. Consequently, much of the basement structure must be interpreted from high quality aeromagnetic data and from geographically limited exposures in the southwesternmost part of Montana.

There are at least three major issues regarding the metallogenesis of the Mesoproterozoic rocks of the northern U.S. Cordillera that can be reasonably investigated, given the Goals and Funding levels outlined in the Geologic Discipline Prospectus for FY04:

1. The contribution of the crystalline basement to mineral deposits in the overlying cover rocks needs to be evaluated. Specifically, what is the relationship between the Paleoproterozoic accretionary tectonic development of the basement rocks and Mesoproterozoic and younger mineralization in the overlying Belt and younger sedimentary rocks?

2. How significant is the northwest-trending Mesoproterozoic strike-slip fault system to syngenetic mineralization in Belt-age rocks? How do we characterize the north-west-trending Clearwater zone and what can it tell us about the fundamental relationship between Belt-Purcell and Lemhi Group rocks-are they really the same age?

3. When did the major mineral deposits in the Mesoproterozoic basins form, how can they be characterized, and what is their relationship to younger magmatic and tectonic events?

The answers to each one of the above questions requires, in addition to basic research, a viable synthesis of preexisting data, much of which will be drawn from products of the preceding Headwaters Project.

Objectives

The objectives of this Project are twofold: To understand the processes of base and precious metal mineralization in the large Mesoproterozoic basins in the northern U.S. Cordillera and to enhance the prediction of potential for undiscovered mineral deposits in this basin.

A major emphasis of this Project will be to refine the known Mesoproterozoic geologic framework of the region, both in terms of stratigraphy and sedimentalogy as well as tectonics of basin development. The Mesoproterozoic deposits in this region host important syngenetic stratabound as well as younger epigenetic mineral deposits; the integration of stratigraphic, tectonic, magmatic, and geochronologic studies will assist in the development of mineral deposit models that will further enhance our ability to predict potential for undiscovered deposits.

Key to the success of this Project and the accomplishment of the proposed objectives is the synthesis of as much previously accumulated geologic knowledge as possible-stratigraphic, structural, tectonic, geochronologic-that has been obtained, in large part, by the Headwaters Project.

Relevance and Impact

Exploration for undiscovered mineral deposits in the Mesoproterozic rocks of the northwest U.S. has generally followed traditional programs that require extensive geochemical analysis of stream sediments. Little attention has been paid to prediction of the location of mineral deposits based on tectonic controls or deposit type. It is the intention of the Project to provide greater insight into tectonic controls of mineral deposition and to enhance our knowledge of the mineral deposit models that pertain to metallogeny within the Mesoproterozic basins.

The proposed multidisciplinary study of metallogeny in the northern Cordillera will result in new interpretations of the crustal evolution that have direct applicability to new interpretations of mineral resource and environmental assessments in the region. Impacts include: 1) Precambrian basement map, tectonic analysis, and characterization of Paleoproterozoic mineral deposits, 2) palinspastic and tectonic reconstruction of Mesoproterozoic rift basins and characterization of related sediment-hosted deposit types, 3) characterization of timing of orogenesis, composition, and magnetic patterns of the crystalline basement terranes give data for recognition of related Laurentian basement fragments now amalgamated into crust of other continents aiding a global understanding of plate tectonics and paleoclimate (Rodinia reconstructions and Snowball Earth events), 4) tectonic map and analysis of Mesozoic arc-continent oblique collisional zones and translation structures and the characterizition of related mineral deposit types, 5) model for genesis of very different magmatic systems that resulted in different types of mineral deposits (Atlanta, Boulder, Challis systems) or near total lack of mineral deposits despite same compositions and sequences of magmatism (Bitterroot and Kaniksu batholiths), 6) integrated tectonic model of northern U.S. Cordillera, and 7) process-oriented crustal evolution and tectonic setting analyses of mineral deposits with emphasis on Butte, Coeur d'-Alene, Montana-Idaho porphyry belt, and sediment-hosted deposits (Blackbird, Spar Lake, etc) for future resource assessments.

Strategy and Approach

Strategy: Integration of magnetic, geologic-map, and metals distribution data with interpreted basement geology and later plate tectonic overprints

Expand interpretation of magnetic anomaly maps. Aeromagnetic maps are a major tool for interpreting the fabric of crystalline basement. In the northern Cordillera, basement is covered by thick sequences of sedimentary rocks that are non-magnetic thus allowing imaging of magnetic signature of the basement. Variation in magnetite causes unique magnetic signatures of different basement terranes and linear anomalies that delimit structures penetrating and deforming the basement. Tectonic interpretation of the magnetic map of Montana (and southern Cordillera) is complete but interpretation of maps from Idaho and northeastern Washington must be completed and regionally synthesized. Interpretations of regional basement geology gained from the magnetic maps must be corroborated using evidence that is interpreted from: 1) available geologic mapping of limited basement exposures, 2) newly compiled maps of Phanerozoic features giving evidence of basement structure, and 3) the very limited U-Pb isotopic analyses of zircon cores and isotopic tracer studies of magmatic source terranes. Reactivation/rejuvenation during overprinting plate interactions Interpretation of influences of basement fabric and chemistry on more recent deformation, magmatism, and mineral deposit formation will be based on: 1) evidence from newly compiled digital geologic map datasets for the region on topics such as localization of depocenters for large Mesoproterozoic basins, setting of Mesoproterozoic sediment-hosted deposits in palinspastically restored Mesoproterozoic basins, and location and offsets of Phanerozoic plutonic and continental margin belts. 2) targeted topical studies to interpret and fill gaps in the data on topics such as proposed Paleoproterozoic, Mesoproterozoic, and Mesozoic collisional belts including some isotopic dating of critical rocks in orogenic belts and in mineral deposits and structural analysis to answer critical questions regarding collison geometry and sequence of events. Analysis of metal occurrence data Digital layering and analysis of metal occurrences, basement terranes, orogenic belts, and structures with respect to time slices (in so far as possible), will help determine temporal patterns of metal occurrence and deposit type and what influence rejuvenation has on crustal metal recycling, recurrent leakage along structures, and deposit types.

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