Mineralogical, Elemental, and Organic Signatures of Prairie-type Mineralizing Processes in the Western Canada Sedimentary Basin

Hugh J. Abercrombie
Geological Survey of Canada, Calgary, 3303 - 33rd Street NW, Calgary, AB T2L 2A7

Glen R. De Paoli
Consulting Geologist, Calgary, AB

ABSTRACT

In the Western Canada Sedimentary Basin (WCSB), mineralogical and geochemical indicators of metallic element mobility and enrichment consistent with Prairie-type mineralization have been observed at three locations that share similar geological and geochemical characteristics. Key factors for localization of Prairie-type mineralization are: i) proximity to regions of brine flow and discharge from the Prairie Formation or other salt-evaporites, and ii) proximity to major redox boundaries or unconformities. Brine discharge and metal contents may be influenced by deep-seated structural features such as the Peace River–Athabasca Arch in the Fort MacKay region of northeastern Alberta and the Churchill-Superior boundary zone in central Manitoba. Major redox boundaries are controlled by stratigraphic or unconformable contacts between strata of contrasting redox potential, by diagenesis and maturation of organic material, by migration and alteration of hydrocarbons, or by a combination of these factors. Prairie-type mineralization has been observed in the WCSB rocks ranging in age from Precambrian to Cretaceous, but is most commonly observed near the pre-Cretaceous unconformity.

The nature of Prairie-type mineralization varies across the WCSB. In the best studied area, the Fort MacKay region of northeastern Alberta, petrographic analysis has documented up to three mineralizing events. These comprise earliest formed Cu (±Au-Ag) mineralization, succeeding Pb-Zn mineralization, and latest and demonstrably syn- or post-Lower Cretaceous Ni (±PGM) mineralization. A wide variety of micron-sized (<1 to 30 μm), disseminated mineralization consisting of native metals and metal alloys or intergrowths with associated sulphide, oxide, carbonate, chloride, and phosphate minerals are observed. Silicification of Upper Devonian limestones and deposition of microquartz cements in Lower Cretaceous sandstones are spatially related to Prairie-type mineralization in Manitoba and Alberta, respectively. In northeastern Alberta, intense microbially facilitated reduction signaled by pyrrhotite growth in Upper Devonian limestones has preconditioned these rocks to low redox potentials in paleo-upflow regions. In both regions marcasite is common and is interpreted to signal oxidation of pre-existing sulphides by oxidized, metal-bearing brines originating from the Prairie Formation or other salt evaporites. Establishing the lithostratigraphic and structural architecture of the eastern margin of the WCSB will assist in the interpretation of existing multi-element geochemical data and will contribute to the discovery of new and potentially economic Prairie-type deposits.