



UNCONFORMITY-ASSOCIATED U

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IDENTIFICATION

SYNONYMS: Unconformity-veins, unconformity-type uranium, unconformity U.

COMMODITIES (BYPRODUCTS): U (Au, Ni).

EXAMPLES (British Columbia - Canada/International): None in British Columbia; *Rabbit Lake, Key Lake, Cluff Lake, Midwest Lake, McClean Lake, McArthur River, Cigar Lake and Maurice Bay in the Athabasca uranium district (Saskatchewan, Canada), Lone Gull (Kiggavik) and Boomerang Lake, Thelon Basin district (Northwest Territories, Canada), Jabiluka, Ranger, Koongarra and Nabarlek, Alligator River district (Northern Territory, Australia).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Uranium minerals, generally pitchblende and coffinite, occur as fracture and breccia fillings and disseminations in elongate, prismatic-shaped or tabular zones hosted by sedimentary/metasedimentary rocks located below, above or across a major continental unconformity.

TECTONIC SETTING: Intracratonic sedimentary basins.

GEOLOGICAL SETTING/DEPOSITIONAL ENVIRONMENT: Structurally-prepared and porous zones within chemically favourable reduced or otherwise reactive strata.

AGE OF MINERALIZATION: Mid-Proterozoic, however, there is potential for younger deposits.

HOST/ ASSOCIATED ROCK TYPES: Shelf facies metasedimentary (amphibolite or granulite facies) rocks of Early Proterozoic age (graphitic or sulphide-rich metapelites, calcsilicate rocks and metapsammites), regolith and overlying continental sandstones of Middle Proterozoic age. The Early Proterozoic hostrocks in many cases are retrograded amphibolite-facies metamorphic rocks on the flanks of Archean gneiss domes. The overlying continental sandstones are well sorted fluvial quartz-rich psammites; generally with a clay or siliceous matrix and red or pale in colour. Dikes and sills, commonly diabases and lamprophyres, occur in some districts.

DEPOSIT FORM: Orebodies may be tabular, pencil shaped or irregular in shape extending up to few kilometres in length. Most deposits have a limited depth potential below the unconformity of less than a 100 m, however, the Jabiluka and Eagle Point deposits are concordant within the Lower Proterozoic host rocks and extend for several hundred metres below the unconformity.

TEXTURE/STRUCTURE: Most deposits fill pore space or voids in breccias and vein stockworks. Some Saskatchewan deposits are exceptionally rich with areas of "massive" pitchblende/coffinite. Features such as drusy textures, crustification banding, colloform, botryoidal and dendritic textures are present in some deposits.

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ORE MINERALOGY (Principal and *subordinate*): Pitchblende (Th-poor uraninite), coffinite, uranophane, thucolite, brannerite, iron sulphides, *native gold*, *Co-Ni arsenides and sulpharsenides*, *selenides*, *tellurides*, *vanadinates*, *jordesite (amorphous molybdenite)*, *vanadates*, *chalcopyrite*, *galena*, *sphalerite*, *native Ag and PGE*. Some deposits are “simple” with only pitchblende and coffinite, while others are “complex” and contain Co-Ni arsenides and other metallic minerals.

GANGUE MINERALOGY: Carbonates (calcite, dolomite, magnesite and siderite), chalcedonic quartz, sericite (illite) chlorite and dravite (tourmaline).

ALTERATION: Chloritization, hematization, kaolinization, illitization and silicification. In most cases hematization is due to oxidation of ferrous iron bearing minerals in the wallrocks caused by oxidizing mineralizing fluids, however, the intense brick-red hematite adjacent to some high grade uranium ores is probably due to loss of electrons during radioactive disintegration of U and its daughter products. An interesting feature of the clay alteration zone is the presence of pseudomorphs of high grade metamorphic minerals, such as cordierite and garnet, in the retrograded basement wallrock.

WEATHERING: Uranium is highly soluble in the +6 valence state above the water table. It will re-precipitate as uraninite and coffinite below the water table in the +4 valence state in the presence of a reducing agents such as humic material or carbonaceous “trash”. Some U phosphates, vanadates, sulphates, silicates and arsenates are semi-stable under oxidizing conditions, consequently autunite, torbernite, carnotite, zippeite, uranophane, uranospinite and numerous other secondary minerals may be found in the near-surface zone of oxidation, particularly in arid environments.

ORE CONTROLS: A pronounced control related to a mid-Proterozoic unconformity and to favourable stratigraphic horizons within Lower Proterozoic hostrocks - these strata are commonly graphitic. Local and regional fault zones that intersect the unconformity may be important features. Generally found close to basement granitic rocks with a high U clark.

GENETIC MODEL: The exceptionally rich ore grades which characterize this type of deposit point to a complex and probably polygenetic origin.

- Some form of very early pre-concentration of U in the Archean basement rocks seems to have been important.
- The hostrocks are commonly Lower Proterozoic in age, and are comprised of metamorphosed rocks derived from marginal marine and near-shore facies sedimentary rocks which may have concentrated U by syngenetic and diagenetic processes.
- Although the behaviour of U under metamorphic and ultrametamorphic conditions is poorly known, it is possible that U could have been mobilized in the vicinity of Archean gneiss domes and anatectic granites and precipitated in pegmatites and stratabound deposits as non-refractory, soluble uraninite.
- Supergene enrichment in paleo regoliths, that now underlie the unconformity, may have been an important process in the additional concentration of U.
- Typically the overlying quartz-rich fluvial sandstones have undergone little deformation, but are affected by normal and reverse faults that are probably re-activated basement faults. In Saskatchewan, these faults carry ore in several deposits and in others appear to have facilitated the transport of U within the cover sandstones.
- Hydrothermal/diagenetic concentration of U through mixing of oxidized basinal and reduced basement fluids appear to have resulted in exceptional concentrations of U and Ni. There is a possibility that radiogenic heat developed in these extremely rich deposits may have been instrumental in heating formation fluids and in remobilizing the metals upwards above the deposit.

- Diabase dikes occur in faults near some deposits and some researchers have suggested that the dikes might have provided the thermal energy that remobilized and further upgraded U concentrations. Recent age dates of the Mackenzie dikes in the Athabasca district do not support this interpretation.

ASSOCIATED DEPOSIT TYPES: Sandstone-hosted U deposits (D05) are found in associated supracrustal quartz-rich arenites. Stratabound disseminated or skarn deposits, such as the Duddridge Lake and Burbidge Lake deposits (Saskatchewan) and pegmatitic occurrences are commonly present in the metamorphosed basement rocks. In arid or semi-arid environments surficial deposits may be present in the overburden. The deposits have affinities to "Classical" U veins (I15).

COMMENTS: Virtually all the known unconformity-associated uranium deposits are found in the Athabasca Basin, Alligator River district and Thelon Basin. In British Columbia favourable target areas for this style of mineralization might be found within strongly metamorphosed shelf-facies Proterozoic strata near gneiss domes, particularly in plateau areas near the Cretaceous-Tertiary paleosurface. The Midnite mine, located 100 km south of Osoyoos, British Columbia, may be an unconformity-associated U deposit. The ore comprises fracture-controlled and disseminated U and alteration minerals (pitchblende, coffinite as well as autunite and other secondary minerals) within metamorphosed shelf-facies pelitic and calcareous rocks of the Precambrian Togo Formation. Production and reserves prior to closing at the Midnite mine are estimated at approximately 3.9 Mt grading 0.12% U.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: U, Ni, Co, As, Pb and Cu are good pathfinder elements which can be utilized in standard stream silt, lake bottom sediment and soil surveys. Stream and lake bottom water samples can be analyzed for U and Ra. In addition, the inert gases He and Ra can often be detected above a U-rich source in soil and soil gas surveys, as well as in groundwater and springs. In Saskatchewan, lithogeochemical signatures have been documented in Athabasca Group quartz arenites for several hundred metres directly above the deposits and in glacially dispersed boulders located "down ice" - the signature includes boron (dravite) and low, but anomalous U as well as K and/or Mg clay mineral alteration (illite and chlorite).

GEOPHYSICAL SIGNATURE: During early phases of exploration of the Athabasca Basin, airborne and ground radiometric surveys detected near surface uranium deposits and their glacial dispersions. Currently, deeply penetrating ground and airborne electromagnetic surveys are used to map the graphitic argillites associated with most deposits. The complete spectrum of modern techniques (gravity, magnetic, magneto-telluric, electromagnetic, VLF-EM, induced polarization, resistivity) can be utilized to map various aspects of structure as well as hostrock and alteration mineral assemblages in the search for deep targets.

OTHER EXPLORATION GUIDES: Standard techniques using sensitive gamma ray scintillometers to detect mineralization directly in bedrock or in float trains in glacial till, frost boils, talus or other debris derived from U mineralization remain the most effective prospecting methods.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: Individual deposits are generally small, but can be exceedingly high-grade, up to several percent U. The median size for 36 Saskatchewan and Australian deposits is 260 000 t grading 0.42% U (Grauch and Mosier, 1986). Some deposits are exceptionally high grade such as the Key Lake Gaertner-Deilmann deposits (2.5 Mt @ 2.3% U), Cigar Lake deposits (900 000 t @ 12.2% U) and McArthur River (1.4 Mt @12.7% U).

ECONOMIC LIMITATIONS: Since the early 1980s, average ore grades have generally risen to exceed 0.25% U. Problems related to the pervasively clay-altered wallrocks and presence of radon gas and other potentially dangerous elements associated with some high-grade uranium deposits in Saskatchewan have resulted in exceptionally high mining costs in some cases.

IMPORTANCE: The Rabbit Lake mine, opened in 1975, was the first major producer of unconformity-type ore. Since then the proportion of the world's production to come from unconformity-type deposits has increased to 33% and is expected to rise in the future.

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