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BASAL-TYPE GOLD-URANIUM DEPOSITS, OKANAGAN REGION, BRITISH COLUMBIA

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INTRODUCTION AND HISTORY

Epigenetic uranium mineralisation in poorly consolidated Tertiary stream channel deposits, known as "Basal-type uranium deposits" have been recognised in B.C. since 1968. However, a provincial government moratorium on uranium mining imposed in 1980 and the low price of uranium have rendered these deposits uninteresting to the mining industry. Re-evaluation of these deposits with respect to gold placer creeks in the Okanagan region suggests that Tertiary palaeochannels could be targets for gold exploration.

Despite the recognition of the Fuki uranium occurrence (Fig. 1) by Japanese geologists using car-bourne scintillometer surveys in 1968, exploration for uranium deposits in the Okanagan did not accelerate until the mid-1970s as a result of the sharp increase in the price of uranium. Subsequently, two groups of deposits were found in the Kelowna-Beaverdell area as well as several prospects in the region north of Kelowna (Fig. 1). In contrast, placer gold has been known in creeks in the Okanagan since the 1870s and mining is still carried on at a very small scale by prospectors.

REGIONAL GEOLOGY

The regional geology may be divided into three elements when considering Tertiary channel gravel deposits: 1) basement rocks on which the gravels were deposited, 2) the gravels and 3) overlying basalt and Pleistocene and recent deposits.

Basement geology (Jones 1959, Okulitch and Woodsworth 1977)

Monashee group gneisses, metasediments, and metavolcanics of the Shuswap metamorphic complex form the Proterozoic basement. These rocks are overlain by Permo-Pennsylvanian volcanic and sedimentary rocks of the Anarchist group. This package is intruded by Jura-Cretaceous Nelson and Valhalla granodioritic to granitic stocks and batholiths. Eocene conglomerates and shales of the Kettle River formation were deposited unconformably on the pre-Tertiary rocks. This formation grades into volcanics of the Marron formation.

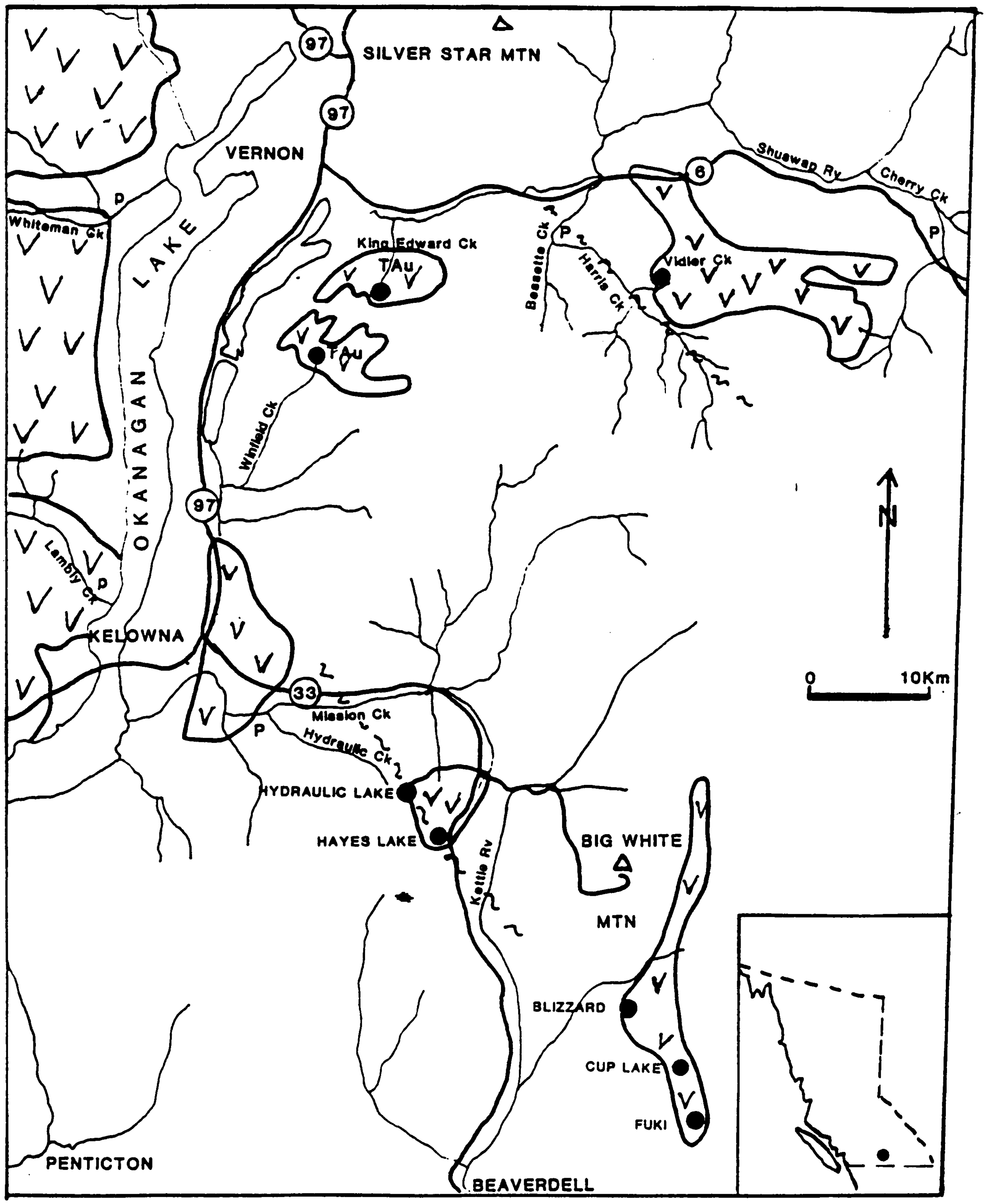


Fig. 1. Economic geology of the Okanagan Highlands. Basal uranium deposits and showings (●), historical gold placers (P) and auriferous Tertiary gravels (TAu) are shown. Subcrops of plateau basalts are indicated by "V" pattern.

Subsequently, the Eocene rocks were folded, tilted and intruded by the Coryell intrusives of ca. 45 Ma which are granitic and syenitic stocks.

Channel gravels

Channel gravels known as "the Plateau Basalt formation" infill valleys in the basement developed on an upland plateau (Tilkov 1984). The gravels consist of poorly-sorted cobble deposits interbedded with dirty sands, thin muds and silts. Clasts are derived from the local basement. The age of the gravels is not well known though Church and Seusser (1983) dated felsic tuffs interbedded with unconsolidated uraniferous gravels at Harris Creek (Fig. 1) at 48.3 Ma (K/Ar). Rouse (pers. comm. 1986) used palynology to obtain a mid-Miocene date for gravels in the Kelowna-Beaverdell area (Fig. 1). This age is corrobarated by palaeoclimate information from a floral abundance of conifers. These data suggest cool, wet conditions coincident with the world-wide mid-Miocene cooling.

Post-channel deposits

The channel deposits were subsequently covered by a thin veneer of olivine basalts and interbedded volcanic breccias of debated age: 20.4-14.9 Ma by K/Ar (Church and Seusser 1983) and 5 Ma by K/Ar (Christopher 1978). The uncertainty of age of the overlying basalts is of lesser importance than the resultant uncertainty for the age of the underlying channel deposits.

Much of the Okanagan is mantled by thick glacial drift. Glaciation and recent erosion have dissected the basalt plateau so that only remnant cappings remain.

BASAL URANIUM DEPOSITS AND GOLD PLACER CREEKS

The locations of the Kelowna-Beaverdell uranium deposits and nearby showings as well as placer creeks catalogued by Barlee (1970), and Church and Seusser (1983) are shown in Fig. 1. Three of the placer-bearing creeks are of particular interest: King Edward Creek, Harris Creek, and Mission Creek. King Edward Creek drains an area of plateau basalt overlying auriferous Tertiary channel gravels that were tested for uranium mineralisation in 1979 by Bangwest Resources Ltd. of Vancouver. The same company drilled the area of plateau basalt around Vidler Creek which drains into Harris Creek. The main gold placer deposits occur a few kilometres downstream along Harris Creek at its confluence with Bessette Creek. Stream sediment geochemistry for Harris Creek (Day and Fletcher 1986) has delineated a gold dispersion train that may originate in the unconsolidated gravels. Mission Creek had productive placers close to its confluence with Hydraulic Creek. Both streams drain the area of the Hydraulic Lake and Hayes Lake uranium deposits. Many of the small placer creeks draining into the west side of Okanagan Lake have areas of plateau basalts in their drainage basins. Even the reknowned Monashee or Cherry Creek placers could have received gold from erosion of channel gravels (Fig 1.).

In summary, these data suggest that Tertiary channel gravels in the Okanagan region could be auriferous.

DEPOSIT GEOLOGY

The geology of five basal uranium deposits in the Kelowna-Beaverdell area was delineated by diamond and rotary drilling. The gravels of the Fuki deposit are exposed in a road cut but otherwise no outcrops of the gravels are seen at the other deposits. The channel gravels are typically carbonaceous and contain abundant pyrite and/or marcasite. Uranium mineralisation ideally occurs as a lens at the base of the channel (Fig. 2) though at the Fuki deposit it is localised beneath a thin layer of mudstone (Fig. 3). In plan, the deposits are long and sinuous.

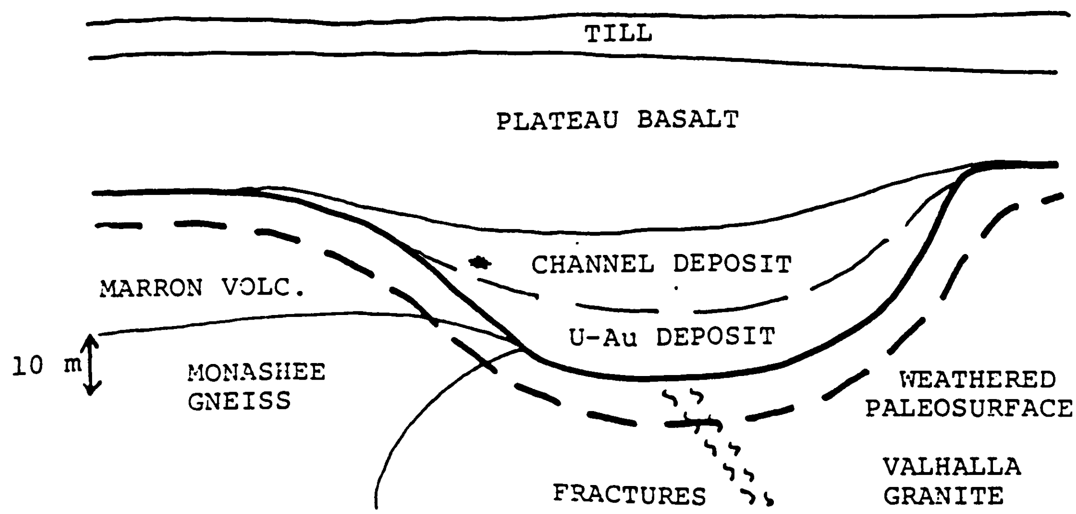


Fig. 2. Cross-section of an idealised basal uranium deposit. (Modified from McMillan 1978)

Uranium minerals are finely disseminated in the sandy matrix and also coat the larger clasts. Mineralisation may also occur in the surrounding volcanic rocks as at the Cup Lake and Blizzard deposits (Fig. 4). Uranium minerals are usually low temperature oxidised and reduced phases (Table 1)

Table 1: Uranium minerals

Mineral	Chemical formula	Oxidation state of uranium
Autunite	$Ca(UO_2)_2(PO_4)_2.10\text{-}12H_2O$	VI
Saleeite	$Mg(UO_2)_2(PO_4)_2.10\text{-}12H_2O$	VI
Coffinite	$(U(SiO_4))_{1-X}(OH)_{4X}$	IV - VI
Ningyoite	$(U,Ca,Ce)_2(PO_4)_2.2H_2O$	IV - VI

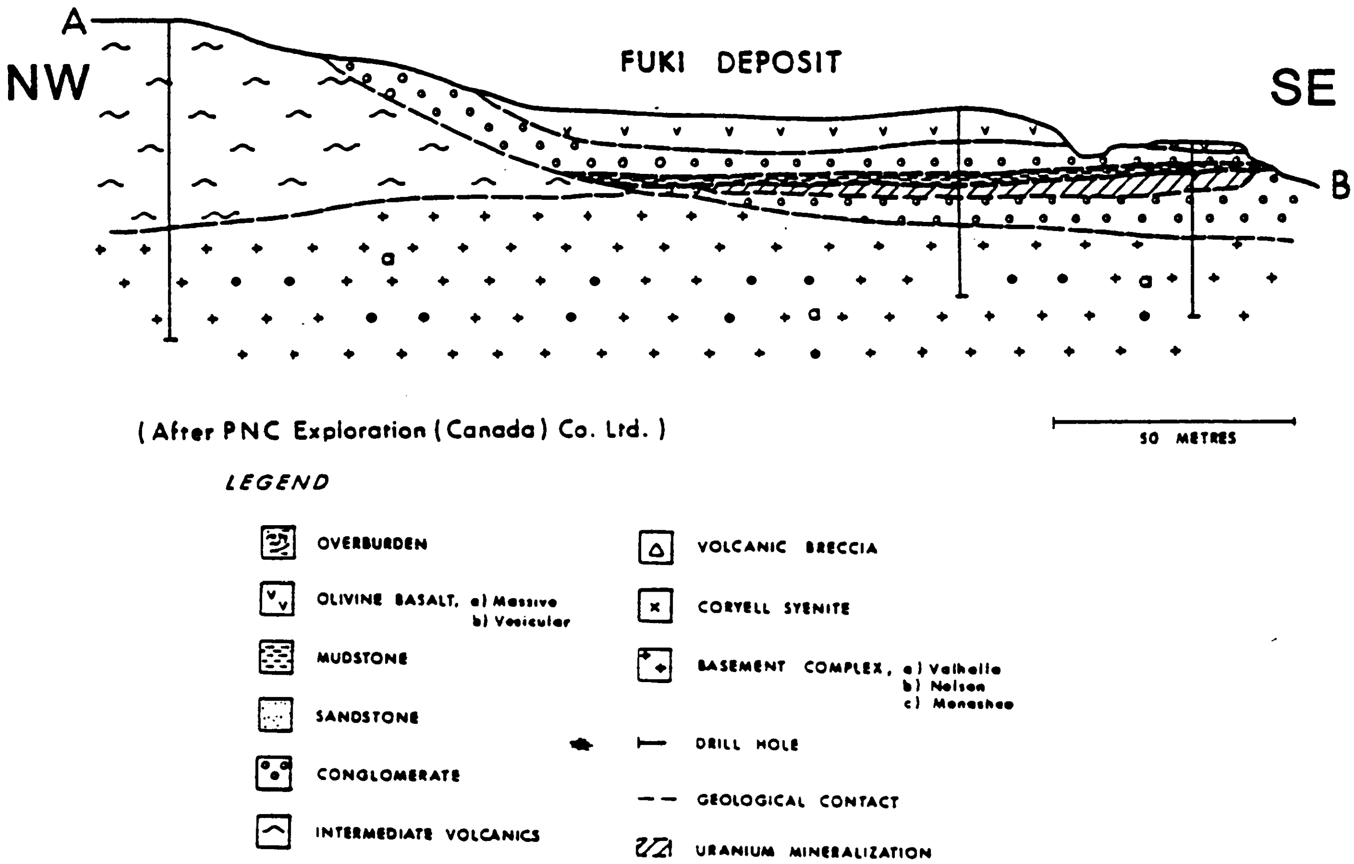


Fig. 3. Cross-section of the Fuki deposit (from Sawyer <u>et al</u>. 1981).

but uraninite has been found (Sawyer et al. 1981).

Gold associated with uranium minerals in the gravels was not recorded during exploration in the late 1970s. Norcen Energy Resources Ltd. of Toronto had anomolous gold values in the volcanic breccia at the Blizzard deposit (Godwin, pers. comm. 1986).

The deposits typically grade 0.5-2 Mt of 0.02-0.05% U_3O_8 (Tilkov 1984) which is lower than similar deposits at Sherwood, Washington (13 Mt, 0.09% U_3O_8) and Ningyo-Toge, Japan (4.5 Mt, 0.05% U_3O_8).

GENETIC ASPECTS

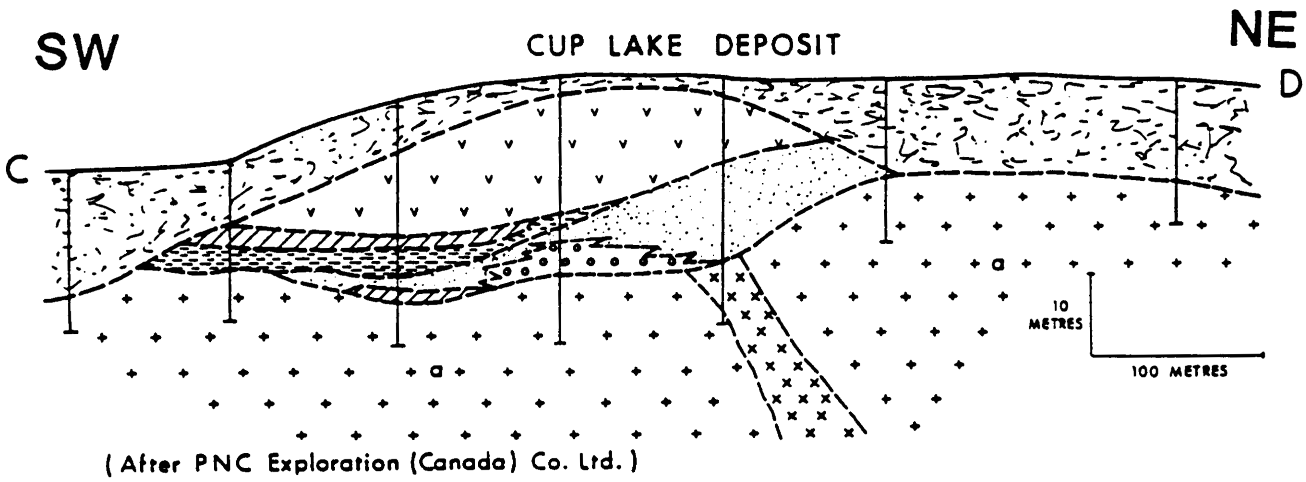
Although the co-occurrence of gold and uranium in these deposits has yet to be proven, diagenetic rather than syngenetic mechanisms such as those recently suggested for the Witwatersrand gold-uranium deposits may be involved (Reimer 1984). The formation of the uranium mineralisation in general appears to be similar to that of the "roll-front" type uranium deposits of the southwestern United States. The gold may originate via a number of routes:

1) Mechanical concentration in palaeo-placers.

2) Accretion of large particles by surficial chemical processes prior to burial.

3) Remobilisation and concentration by groundwaters after the plateau basalts were emplaced.

The first process would produce small hydraulically controlled gold concentrations. The second process appears to be most active in tropical environments (Reimer 1984, Webster and Mann 1984). Therefore, if the gravels are of Eocene age then gold concentrations might form prior to burial. The third process is favoured over the previous two because gold and uranium could be transported and precipitated by similar processes. Lack of hydraulic equivalence of gold, uraninite and quartz particles and evidence of replacement of carbon by gold and uraninite has



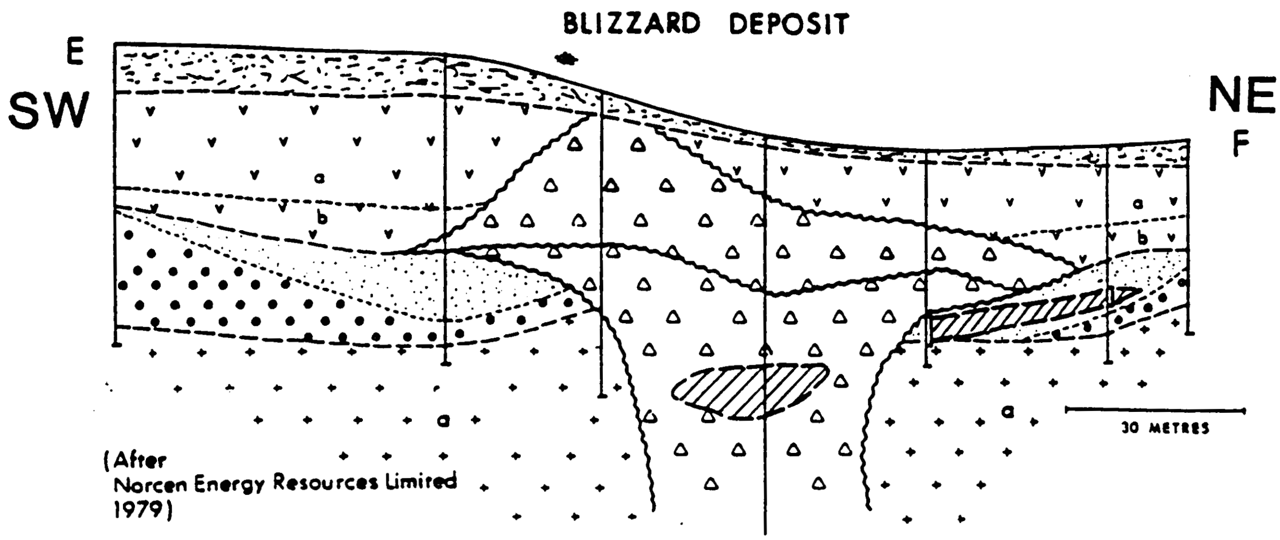


Fig. 4. Cross-sections of the Cup Lake and Blizzard deposits. See Fig. 3 for legend. (from Sawyer <u>et al</u>. 1981).

been used to suggest a similar diagenetic or epigenetic origin for the Witwatersrand deposits (Reimer 1984).

Source of metals

Uranium was probably leached from granitic basement rocks which have elevated uranium contents (up to 18 ppm, Sawyer et al. 1981). Gold could be derived from weathering of local lode gold occurrences and high background rocks in the Intermontane or Omineca belts.

Transport of metals

Gold is not chemically transported far in cool, nearly neutral pH groundwaters (Boyle 1979), hence there must be a series of processes by which gold is concentrated. Gold mobilised from the basement rocks would be dispersed throughout drainage networks as fine particles and colloids. After emplacement of the plateau basalts, the gold could be re-mobilised by cool, oxidised, neutral to weakly alkaline groundwater perhaps as aurothiosulphate, aurocyanide or gold organic complexes (Boyle 1979):

$$4Au + 8CN^- + O_2 + 2H_2O = 4[Au(CN)_2]^- + 4OH^-$$

$$4Au + 4S_2O_3^= + O_2 + 2H_2O = 4[Au(S_2O_3)]^- + 4OH^-$$

Doi et al. (1975) have shown that for Japanese basal uranium deposits uranium is leached and transported by weakly alkaline carbonated oxidising groundwaters produced by weathering granitic rocks:

$$2UO_2 + 4CO_3^= + 2H_2O + O_2 = 2UO_2(CO_3)_2^= + 4OH^-$$

Concentrations of roughly 1 ppb uranium as uranyl carbonate complexes are apparently sufficient to form economic uranium mineralisation. The solutions would be transported to the gravels via fractures in the basement.

Hence, both gold and uranium can be mobilised by oxidising, weakly alkaline groundwaters.

Precipitation of minerals

Both uranium minerals and native gold can be precipitated as a result of asorption and reduction by carbonaceous matter (decreased Eh) or by significantly lowering pH. Iron sulphides may have been produced by reduction of sulphate to sulphide. Elevated concentrations of gold and uranium can be produced by re-solution and precipitation by oxidising groundwater.

Preservation of deposits

A capping of resistant basalt not only acts as an impermeable barrier to groundwater solutions but also protects the deposits from erosion and surficial leaching.

EXPLORATION PARAMETERS

Regional scale

1. *Regional granitic and gneissic bodies with high background uranium concentrations*. Three main intrusions in the Okanagan and the Monashee gneissic complex have up to 18ppm uranium.

2. *Regionally elevated background gold concentrations and gold sources as indicated by known vein-type occurrences* (eg Carmi occurrence, near Beaverdell).

3. *Multiple igneous intrusion and brittle deformation to produce extensive fracture systems*. Northwest trending regional faults appear to have acted as a focus for uraniferous groundwaters at the Hydraulic Lake and Hayes Lake deposits and the Vidler Creek occurrence (Fig. 1).

4. *Definition of regional palaeochannel systems*. Auriferous palaeochannel systems should be identified by defining the regional palaeoslope and extending known auriferous channels. There might be a facies relationship between gold and uranium occurrences similar to that seen in the Witwatersrand supergroup. Uranium mineralisation occurs further downslope than the gold mineralisation (Pretorius 1981).

5. *Age of the palaeochannel gravels*. Different chemistries of mobilisation, transport and precipitation of gold will be involved depending on the climate. The Eocene (tropical climate) gravel deposits in the north half of the area might have been favourably affected by surficial chemical concentration processes.

Property scale

6. *Thickest sections of plateau basalts*. Plateau basalts cap the gravels and are likely to be thickest along the axes of ancient valleys.

7. *Stream sediment gold and uranium anomolies and historical placer activity.* Stream sediment anomolies for gold would be enhanced by heavy mineral concentration. Secondary uranium minerals would be in the moderate to light mineral fraction (S.G.<3.3).

8. *Uraniferous and auriferous springwaters.* Seeps from uranium showings are known to uraniferous. Gold concentrations might be elevated in the water (Boyle 1979).

9. *Carbonaceous and iron sulphide rich horizons in gravels.* Carbonaceous material provides a reducing environment for gold and uranium precipitation.

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