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ENERGY MINERALS IN THE CANADIAN CORDILLERA

by

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Summary:

Uranium occurs in most kinds of rocks in the Canadian Cordillera although the number of documented occurrences (Fig. 1) is small (see Bates et al., 1980 for British Columbia; and annual reviews by Indian and Northern Affairs Canada e.g. 1983) especially when compared with adjacent ones in the United States. ~~(Fig. 1).~~ Uranium exploration is young in the Yukon and has been prohibited in B.C. by a seven year moratorium since 1980.

Two uranium provinces are evident. The first contains the Blizzard and associated deposits, surficial deposits and numerous occurrences in syenite, granite, pegmatite and Paleogene volcanic rocks in an area defined by the Okanagan Valley and Highlands region. It borders the Spokane uranium province in northern Washington. The second uranium province is in the eastern Wernecke Mountains, Yukon where 43 groups of high grade U, Cu-U± Au, and Co-Ag± Cu± U occur in extensive megabreccias in Helikian rocks (Bell, 1982).

The most favourable areas for uranium exploration ~~(Bell, in press b)~~ appear to be the two uranium provinces noted above. In addition, the areas containing successor basins characterized by continental felsic volcanism, ~~and~~ clastic deposition and associated late stage granitic intrusions should be considered (Fig. 2).

To date only two areas have been identified with potentially economic deposits: Beaverdell and Clearwater, B.C. Known reserves (less than 2%) and additional and speculative resources (less than 5%) are small relative to the total Canadian endowment (Bates et al., 1980). Deposit sizes and grades are modest in comparison with those of the Athabasca region in Canada or those of the Pine Creek Geosyncline in Australia. The reserves in the Canadian Cordillera are considerable however when compared with those of such nations as Japan, Italy or Mexico.

Thorium is widespread, mainly in igneous rocks but currently is inconsequential as an energy commodity.

Uranium:

<u>Beaverdell area</u>. The largest uranium deposit in the Canadian Cordillera is the Blizzard of Norcen Energy Resources Ltd. (Figs. 3,4), containing about 4000 tonnes U at an average grade of 0.18% U (Sawyer *et al*., 1981; Boyle 1982; Bates *et al*., 1980). Near it are a few smaller deposits (Fig. 3), the largest of which is the Tyee deposit containing 650 tonnes U at an average grade of 0.03% U (*ibidem*). The remainder (PNC Group) containing approximately 1300 tonnes U owned by Power Nuclear Reactor Co. Ltd. Power Nuclear Reactor Company originally discovered this style of mineralization in British Columbia based on a model of similar basal channel deposits in central and western Japan. (Katayama *et al*., 1974).

The following description is mainly of the Blizzard deposit, except where noted and follows descriptions by Sawyer *et al*. (1981), and Boyle (1982). The deposits are contained in silt, sand and gravels within paleovalleys incised into mainly Cretaceous granite and associated gneiss and schist on the west flank of the Omineca Belt. Generally the deposits are overlain and protected by erosional remnants of Pliocene plateau basalts. Locally underlying rocks are Paleogene continental volcanic and sedimentary rocks and Eocene syenitic intrusions (Fig. 3?). The paleovalley sediments are usually only a few tens of metres thick and comprise fluvial and associated overbank deposits. Overall the sequences fine upwards from coarse gravel on the basement to fine sand and silt at the top. In nearby paleovalleys similar sediments are interbedded with lowermost basaltic flows, implying that some of the sediments maybe as young as early Pliocene. The older limit is defined by the Eocene or early Oligocene Coryell intrusions and associated volcanic rocks into which the paleovalleys were incised.

Uranium is found as the yellow minerals saleeite and autunite in oxidized facies of the lower limonitized coarse sediments and in disseminated organic material in the reduced facies of the upper, fine sand and silt. Pitchblende (after ningyoite) and ningyoite (Boyle, 1982) are the only uranium minerals identified in the reduced facies. Ningyoite (Boyle <u>et al</u>., 1981) is also reported in the Tyee deposit where marcasite cements the higher grade zones. Minor mineralization in the form of saleeite or autunite occurs in fractures in underlying regolithic basement granitic rocks and rarely in fractures in overlying plateau basalts. Minor mineralization occurs in the silty matrix and in stoped sedimentary fragments in a basaltic breccia pipe at the north end of the Blizzard deposit.

Interesting aspects of this type of mineralization both in British Columbia and in Japan (Figs. 3, 4) are that the deposits are best developed in the uppermost channels of the paleodrainage and that the best deposits lie on granitoid basement.

Other areas of interest for this type of deposit are the continuations into the Intermontane area characterized by plateau basalts in south and central British Columbia and in southwestern Yukon where similar conditions obtain: fertile felsic igneous basement rocks, late Tertiary fluvial channels and overlying Upper Tertiary basalt.

Clearwater Area. Just south of Clearwater, B.C., Rexspar (owned by Dennison Mines Ltd.), a small deposit of fluorite and uranium-thorium minerals occurs in a sequence of metamorphosed feldspar-porphyritic trachyte and tuff (Preto, 1978; Morton et al., 1978; Bell, in press, a). Stratigraphic tops and ages are not known with certainty in this highly tectonized sequence. It lies on the western margin of the Kootenay (Barkerville?) suspect terrane, immediately adjacent to the Slide Mountain terrane that was accreted in the Jurassic. The trachyte may be older than Early Carboniferous and perhaps related to mid-Devonian granitic intrusion identified to the south. A single K-Ar date on the fluorphlogopite accompanying the mineralization (Morton et al., 1978) suggests mineralization can be no younger than Permian.

The Rexspar deposit includes three zones of sheared dark grey tuffaceous schist with disseminated uraninite, uranian thorite and uranothorianite in a matrix of sercite, albite and quartz; accompanied by abundant coarse pyrite, fluorphlogopite, purple fluorite, celestite and calcite and minor bastnaesite, zircon, monazite and rutile. A fourth zone contains massive and disseminated pale green fluorite and celestite with pyrite, molybdenite and minor galena but only traces of uranium and thorium. Fluorite mineralization both preceded and followed uranium mineralization.

Assuming the section at Rexspar is upright and not overturned, Preto (1978) postulates a syngenetic model wherein the deposition of sulphides, fluorite and uranium was caused by late stage deuteric, volatile-rich fluids generated during the volcanism. He discounts late hydrothermal events because there is no hydrothermal alteration in the schists beneath the trachyte host. On the basis of fluid, inclusion studies Morton et al., (1978) suggests that uranium, thorium and rare earth elements were transported in a early hydrothermal system strongly charged with CO_2. On venting to the surface the sudden drop in P_{CO2} would result in precipitation of the uranium minerals. The lack of hydrothermal alteration in the rocks presently beneath the trachytes is to be expected if the sequence is overturned (Bell, in press).

Extant literature presents no close analogue for the Rexspar deposit. Until structural and stratigraphic problems are resolved it will remain enigmatic.

The deposit contains about 700 tonnes reserves of recoverable uranium at grades of about 0.066 U (Preto 1978, Bates et al., 1980). Additional resources are present in small deposits immediately to the east. Thorium recovery could equal that of uranium. Fluorite and celestite and rare earth elements might also prove economic.

Okanagan 'Young' or surficial Uranium Deposits. In the Okanagan area mainly between Kelowna and Osoyoos there are about 40 occurrences (Culbert et al., 1984) termed 'young' or 'surficial' in that they are forming at present in post-glacial sediments. Because they are so young they have little or no gamma-active daughter products. They occur mainly in closed or cyclically closed alkaline lakes or playas, and to a lesser degree in association with organic-rich swamps in fluviatile systems. Factors important for this environment of uranium deposit are semi-arid climate and areas underlain by felsic igneous rocks. The underlying and adjacent rocks are Cretaceous and Tertiary granite and gneisses and Eocene Marron volcanics. The surficial uranium deposits occur ~~and is~~ immediately west of the Beaverdell deposits. The uranium occurs in concentrations up to a few thousands parts per million, ~~and~~ is very loosely bonded and very easily remobilized. Selenium is commonly anomalous but vanadium is not. How about Mo?

This type or style of deposit was first discovered and described in the area immediately prior to the prohibition of uranium exploration in B.C. in 1980. Subsequently similar deposits were discovered in the U.S.A. and elsewhere. They are almost certainly more widespread in B.C.

The deposits are small - a few tens to a few hundreds of tonnes of uranium with grades in the order of 0.04 ~~.007~~ per cent uranium; the known ones in B.C. aggregate about 800 tonnes uranium (Bates et al., 1980). Despite being small and of low grade, they could eventually prove economic in that they are numerous, near surface (less than 10 m depth), in unconsolidated sediments, contain negligible daughter elements, and very easily mobilized. (Culbert et al., 1984 ~~in press~~).

In addition their removal for commercial purposes could be considered an aspect of environmental improvement.

Wernecke Mountains Area. In the northeastern Wernecke Mountains are more than 40 groups of occurrences of radioactive minerals. A single uraniferous occurrence is also present in the Southern Richardson Mountains. They are all associated with breccias that have the following characteristics (Bell, 1982; ~~in press b~~).

1) The breccia bodies are irregular to elongate in form as much as 20 kms in length and 8 kms wide.

2) They contain kilometre-size blocks of sedimentary rocks, transported upwards as much as 10 kms.

3) The blocks and matrix are of dolomitic sandstone and siltstone, argillite, phyllite, quartzite and dolomite and their altered protoliths with minor jaspilite and very minor greenstone or gabbro fragments.

4) The breccias cut mainly the lower, entirely sedimentary, Wernecke Supergroup; they possibly cut younger Precambrian rocks west of Wernecke but if so represent later remobilization.

5) The breccia bodies contain irregular zones of intense alteration which include carbonatization, hematization, albitization, silicification and chloritization. these may also be rebrecciated and transposted.

6) Mineral~~ization~~ includes: (a) brannerite ± pitchblende ± gold; (b) pitchblende + chalcopyrite + cobaltite ± irrigenite; (c) brannerite + monazite ± pitchblende; (d) chalcopyrite + pyrite + pyrrohotite ± chalcocite ± bornite ± cobaltite; (e) cobaltite +

brannerite; bournonite + chalcopyrite + tetrahedrite + galena + sphalerite + gold; and barite + magnetite. All are accompanied by hematite, hematite + magnetite or siderite.

7) The breccias are widespread west of the Wernecke, but except for one in the southern Richardson Mountains and one in the Ogilvie Mountains do not contain uraniferous minerals. However most do contain copper (Laznicka and Edwards, 1979) and minor cobalt occurrences.

The breccias appear to be intrusive and similar to diapirs although evidence for accompanying evaporites is inconclusive. The intensive local metasomatism and the presence of a few rare-earth element anomalies suggest that deep-seated carbonatites may be involved. At two localities euhedral magnetite-bearing breccia dykes with milled fragments are suggestive of diatremes but the overwhelming bulk of the breccias appear to be of a more passive-intrusive origin.

Breccias of similar size and nature occur in the Copperbelt of Zaire (Lefebvre, 1980) and in South Australia (Dalgarno and Johnson, 1968, Roberts and Hudson, 1982) which are important for copper, cobalt, uranium and perhaps gold. The origins of the breccias are not yet clearly defined. Impressive, however, are similarities, especially with regard to deposits and occurrences (Bell, 1982, in press b). Accordingly the Wernecke area has a high potential for U-Cu-Co$\pm$Au although significant deposits have yet to be defined.

Thorium:

At present the market for thorium is very small. It is used mainly for alloys and for incandescent gas mantles. There is some research on thorium as an energy metal; it is currently used in a small reactor in the Federal Republic of Germany and could be used in a modified CANDU system. Its advantage in reactors is that the plutonium problem may be avoided.

Thorium is identified in the Rexspar deposit and is significant in the Tombstone Mountains in Yukon (Olade and Goodfellow, 1978). Anomalously high concentrations occur in late Cretaceous and early Tertiary granitic plutons in the northern Intermontane Belt, in Carboniferous volcanic complexes in the Pelly Mountains, and along with U, Nb, Ta and REE in Recent placers in the Bugaboo Mountains.

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Figure 1

Lithotectonic terrane map of Canadian Cordillera (after Monger and Berg, 1984, and Monger (in press) with selected groups of uranium occurrences and deposits. Werneckia is a possible suspect terrance made up of Wernecke and Ogilvie Mountains and the Arctic Alaska and Porcupine suspect terranes of Monger and Berg (1984). Deposits and occurrences 1: Beaverdell area (Tyee, Blizzard, PNC deposits); 2: Clearwater area (Rexspar); 3: Okanagan area; 4: Wernecke Mountains; 5: Tombstone Mountains; 6: Pelly Mountains; 7: Bugaboo Mountains.

Figure 2

Spacial and temporal relationships of suspect terrances in Canadian Cordillera (after Monger, in press) with selected groups of uranium occurrences and deposits. Note most deposits developed after terrane accretion. See Figure 1 for legend.

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7: Bugaboo Mountains.

Figure 2

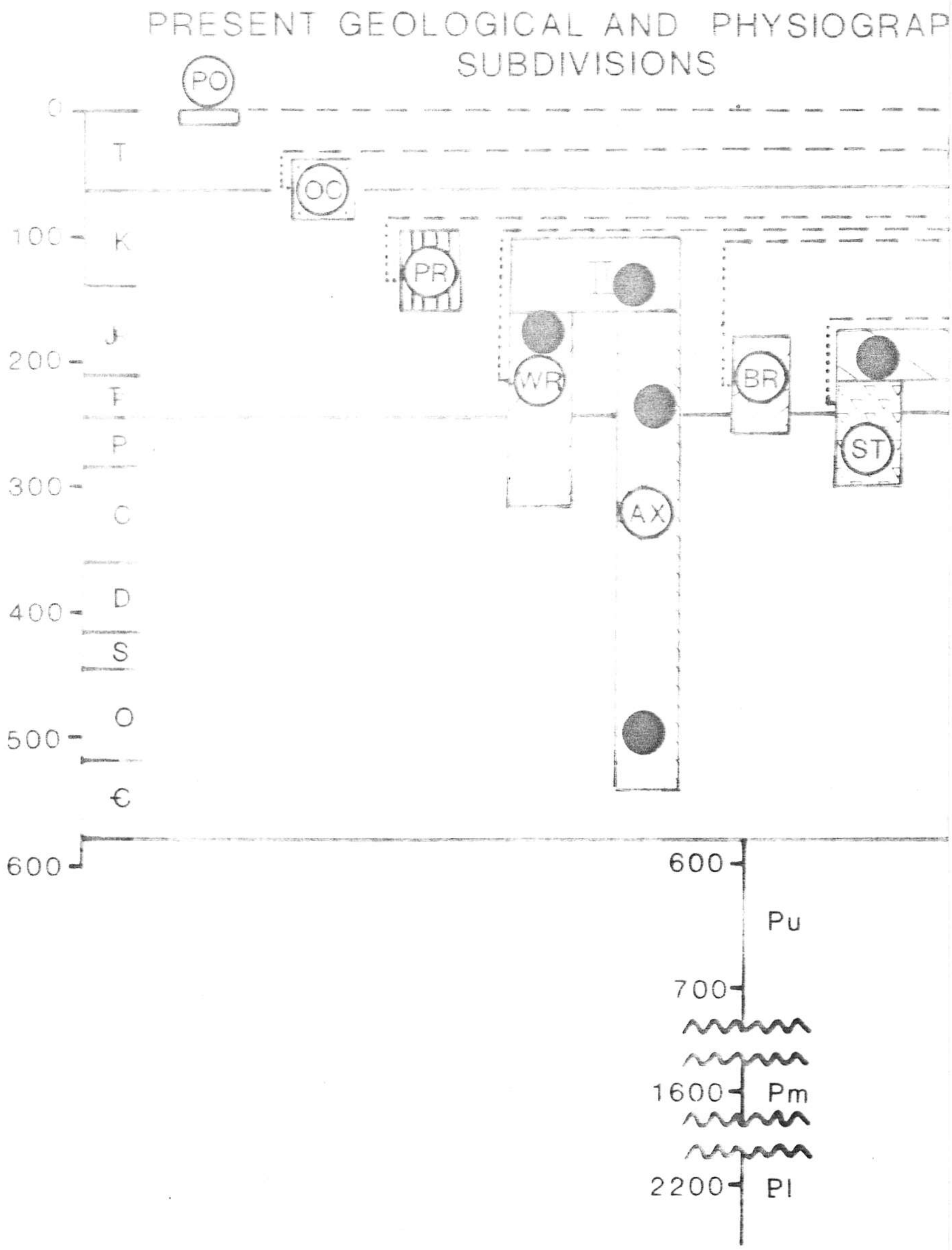
Spatial and temporal relationships of suspect terranes in Canadian Cordillera (after Monger, in press) with selected groups of uranium occurrences and deposits. Note most deposits developed after terrane accretion. See Figure 1 for legend.

Figure 3

Basal channel uranium deposits, pre-Pliocene basement (after Little, 1961, and 1957; and Bayle 1982) and interpreted pre-Pliocene drainage with inset on Tono deposit in Japan (after Katayama et al., 1974). B - Blizzard, T - Tyee and P - PNC deposits.

Figure 2

Plan view of Blizzard Deposits showing sediment thickness, main ore zones, and outline of Plateau Basalt capping (after Noıcen, 1979) and interpreted paleodrainage.



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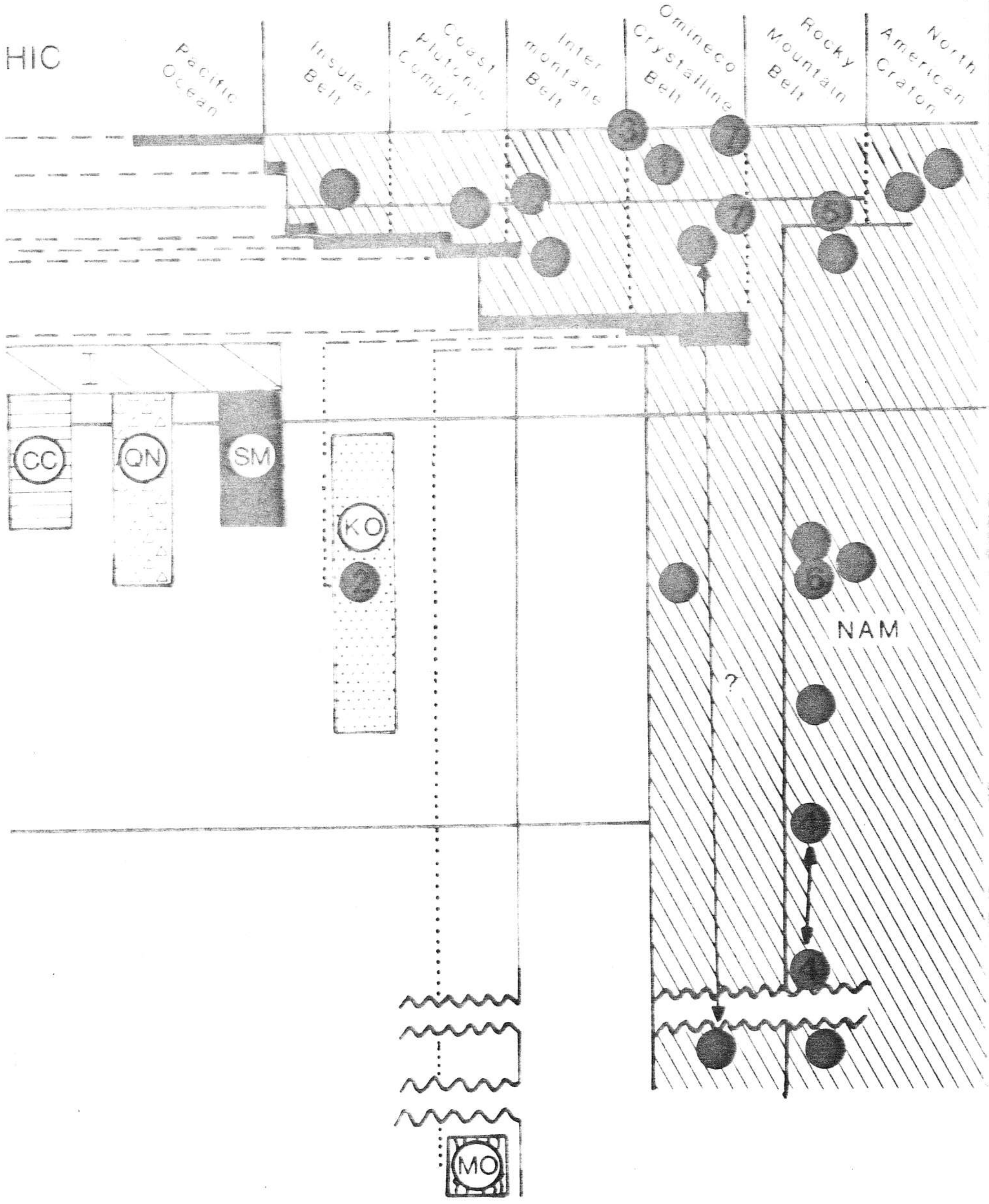
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Figu

SM - Slide Mountain

QN - Quesnellia

CC - Cache Creek

ST - Stikinia

BR - Bridge River

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PR - Pacific Rim
CG - Chugach

OC - Olympic

CA - Cassiar - NAM possibly displaced since mid Paleozoic

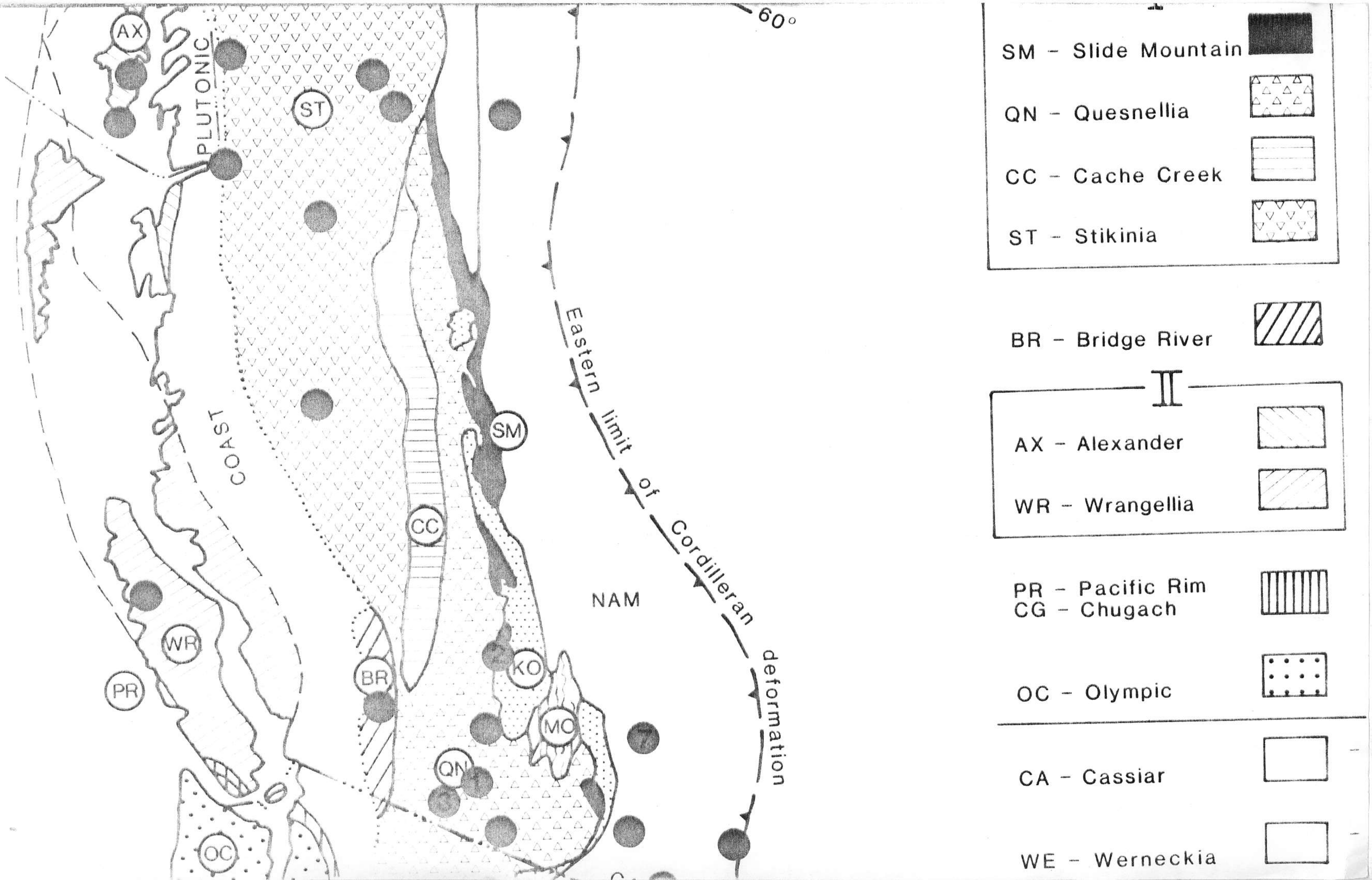
WE - Werneckia - NAM possibly displaced since late Precambrian

NAM - North American Craton

④◯ Uranium and Thorium occurrences and deposits

Figure 1

Bell DNAG



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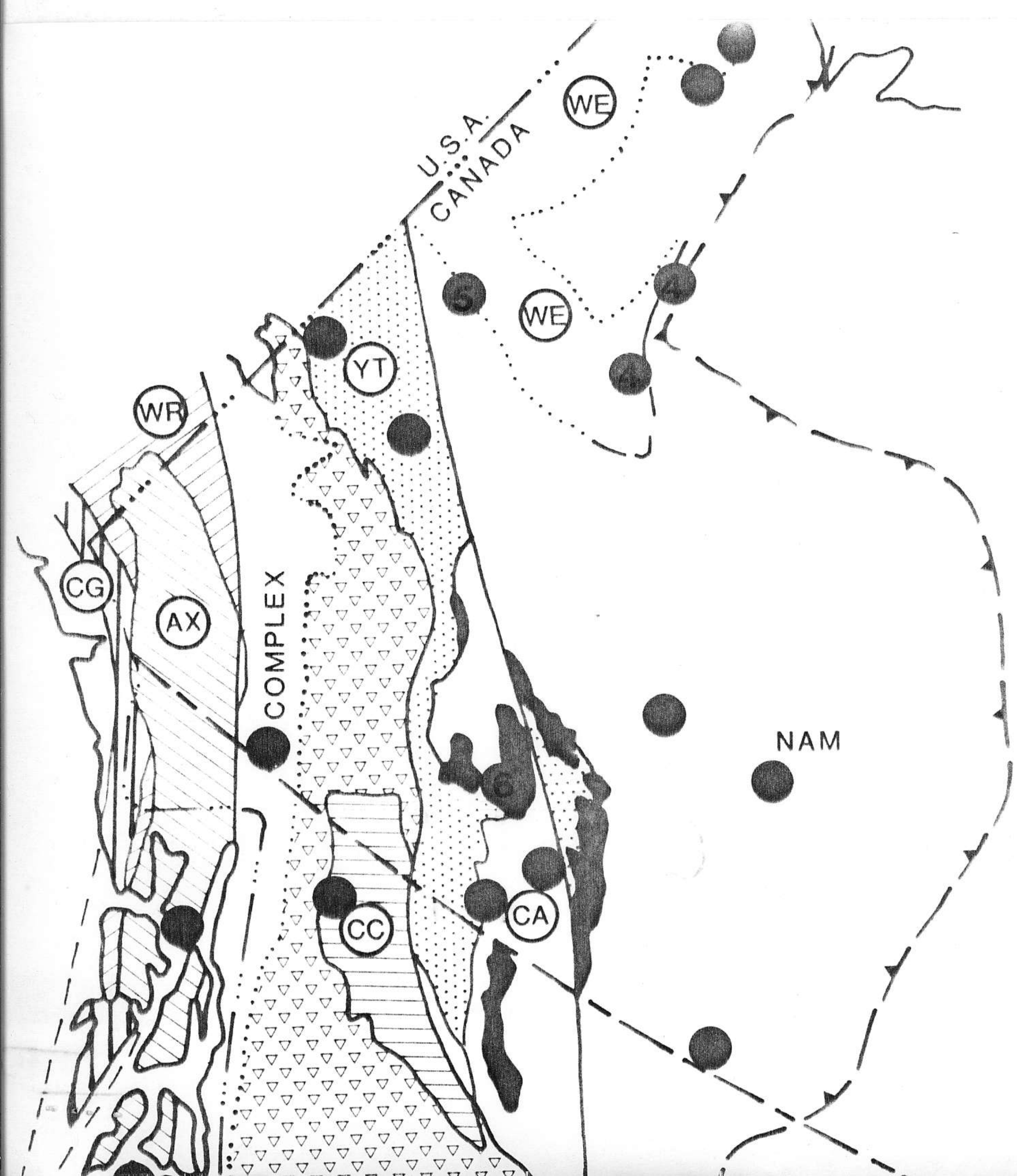
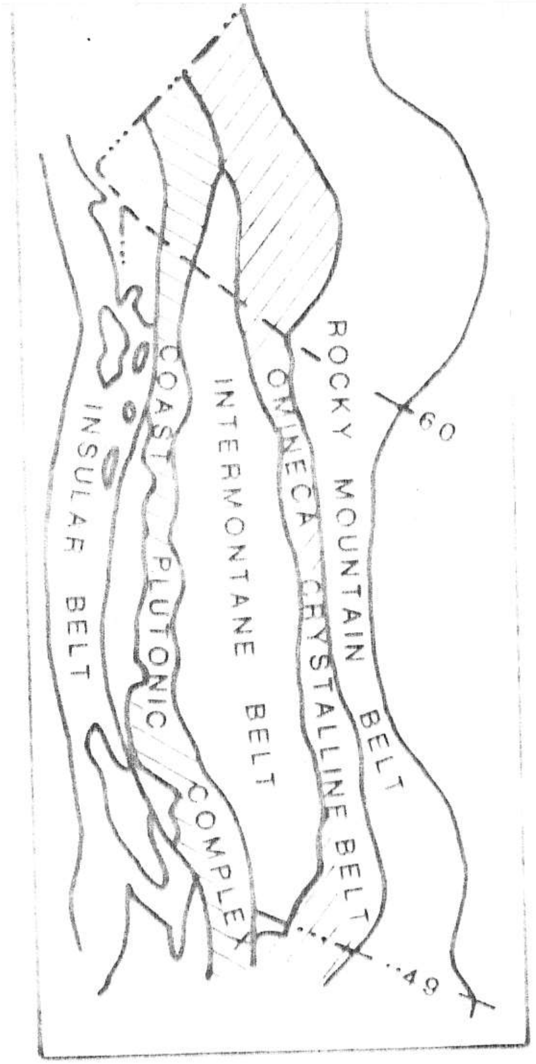
PR - Pacific Rim
CG - Chugach
OC - Olympic
CA - Cassiar
WE - Werneckia





LEGEND

MO - Monashee

KO - Kootenay