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Stratigraphic Distribution of Uranium Clusters in the Rocky Mountain and Intermontane Basins Uranium Province

By

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ABSTRACT

The Rocky Mountain and Intermontane Basins Uranium Province (RMIBUP) is defined by the extent of the Laramide uplifts and intermontane Tertiary basins in the southern Rocky Mountains region. Uranium clusters in the RMIBUP are distributed in nearly 75 stratigraphic units that range in age from Quaternary to Proterozoic except for Devonian and Silurian. The most important units containing large-size clusters number about 15 and are Tertiary, Cretaceous, Mississippian, and Proterozoic in ages. Important uranium-bearing units containing intermediate-size clusters number about 25 stratigraphic units and are more widely distributed in the geologic section. Minor uranium-bearing units contain insignificant-size clusters and are the most widely distributed. Roll-front sandstone uranium deposits in the Wyoming Basins and vein uranium deposits in Colorado are the main types of uranium deposits.

INTRODUCTION

This preliminary report on the stratigraphic distribution of uranium deposits in the Rocky Mountain and Intermontane Basins Uranium Province (RMIBUP) is being published before completion of the comprehensive report on the Province for comments by readers. Your comments are solicited and should be sent to the author at the address listed on the title page or phoned: 303 236-1520, FAXed: 303 236-0459, or e-mailed: wfinch@sedproc.cr.usgs.gov.

Definitions

A uranium cluster is defined as the group of all of the uranium deposits (properties) within an area of about 25 square miles (about 65 square kilometers). A cluster commonly consists of more than one deposit. In order to distinguish major, important, and minor uranium-bearing units, the size of a cluster was determined by totalling the production, if any, and the amount of uranium in rock using a cutoff of about 0.03 percent U_3O_8. Major uranium-bearing units contain one or more clusters with a size greater than 500 short tons of U_3O_8. Important uranium-bearing units contain deposit clusters with sizes 1-500 short tons. Minor uranium-bearing units contain clusters of less than 1 short ton of U_3O_8.

A uranium province is defined as a large geologically and tectonically distinct region where substantial uranium concentrations occur in clusters and the uranium is economically recovered for itself or as a by-product of another commodity, such as gold and phosphate. The province can be defined geologically as a structural or tectonic unit, such as a very large prominent basin, a group of interrelated basins, organic belt, geo-physiographic province, or granitic massif.

The most abundant type of uranium deposit in the RMIBUP is the roll-front sandstone uranium deposit, which occurs mainly in Tertiary basin sedimentary rocks. These deposits were formed by oxidizing uranium-bearing ground waters that entered the host sandstone from the edges of the basins. Two possible sources of the uranium were 1) uraniferous Precambrian granite masses surrounding the basins or 2) overlying volcanic ash sediments. Several major uranium deposits occur as veins in Precambrian metamorphic and Lower Paleozoic sedimentary rocks outside Tertiary basins in the central part of the RMIBUP. These deposits formed mainly in Tertiary time. Minor types of deposits include surficial and pegmatite.

Acknowledgments

Discussions were very helpful concerning the stratigraphy in certain parts of the stratigraphic chart (Table 1), particularly with R.B. O'Sullivan for the Jurassic and Triassic sections, P.K. Sims for the Precambrian section in the northern part, and J.C. Reed, Jr. for the central and southern parts. George Garcia prepared a computerized copy of Table 1. Figure 1 was prepared by R.B. Taylor using the RMIBUP database in GSMAP System 9 (Selner and Taylor, 1993) and the PrintAPLOT program.

DESCRIPTION OF THE ROCKY MOUNTAIN AND INTERMONTANE BASINS URANIUM PROVINCE

The outline of the Rocky Mountain and Intermontane Basins Uranium Province (RMIBUP) shown in Figure 1 is a modification of the Rocky Mountain structural province, which is a reactivated craton characterized by uplifts of the basement and reverse faulting, that is defined by Bayer (1983). The RMIBUP is essentially defined by the extent of the Laramide uplifts and basins where uranium host basinal sedimentary and fractured rocks formed and by the distribution of roll-front sandstone and vein uranium deposits, respectively. The Laramide fluvial-lacustrine basins acquired their individuality in the latest Cretaceous to Eocene (Gries, 1983). The southern part of the western boundary is coincident with the Colorado Plateau Uranium Province (CPUP) and the northern edge of this boundary is with the Phanerozoic western Cordilleran of North America. The Rocky Mountain front as shown by Bayer (1983) forms the eastern and northern boundaries of the RMIBUP. The intermontane Powder River Basin lies between the Black Hills and Bighorn Mountains and extends into Montana and is included in the RMIBUP; however, the Williston Basin in the western Dakotas, Crawford Basin in northwestern Nebraska (DeGraw, 1971), and Denver Basin in eastern Colorado are not intermontane basins and lie outside of the RMIBUP. Large roll-front uranium deposits in the Chadron Formation, White River Group, are in the Crawford Basin. The RMIBUP boundary that excludes the large Crow Butte and related uranium deposits in this Basin is drawn on the northern edge of the Black Hills domain in the Trans-Hudson orogeny in contact with the Central Plains orogeny in the Precambrian basement (Sims and others, 1991, fig. 2). In the Denver Basin, clusters of large roll-front uranium deposits in Weld County, Colorado are in the Cretaceous Fox Hills Formation. The southern tip of the RMIBUP is in contact with the Basin and Range Uranium Province (BRUP) (Figure 1). The southernmost part of the RMIBUP includes Tertiary volcanic rocks and their uranium clusters in the Rio Grande rift, which might more properly belong in the BRUP, but for convenience is included in the RMIBUP.

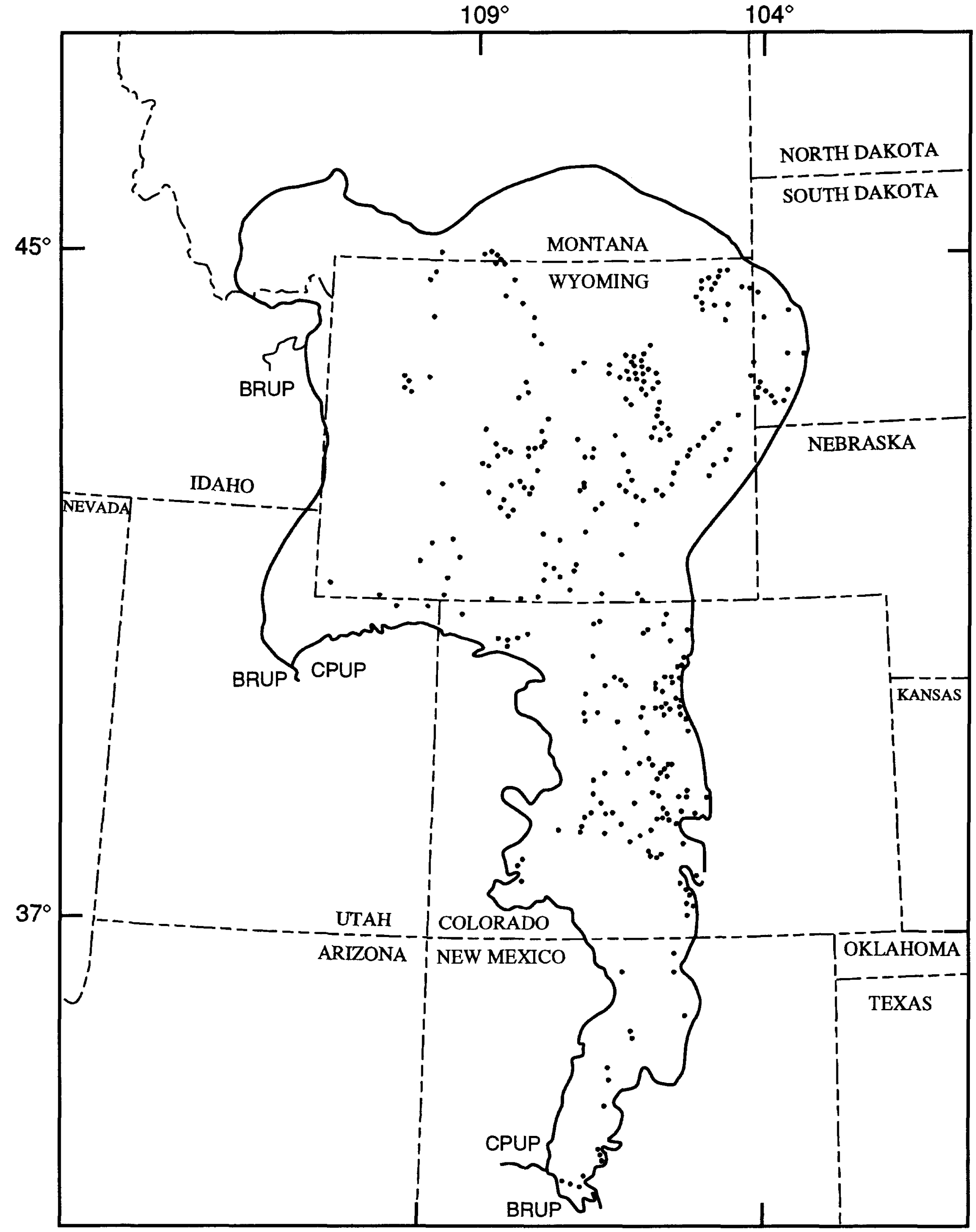

Figure 1. Map showing the outline of the Rocky Mountains and Intermontane Basins Uranium Province and locations of uranium clusters within the Province. Scale approximately 1:7,500,000. Adjacent uranium provinces labeled are the Colorado Plateau Uranium Province (CPUP) and Basin and Range Uranium Provence (BRUP).

STRATIGRAPHIC DISTRIBUTION

The stratigraphic units are compiled in three columns in Table 1: 1) northern part, 2) central part, and 3) southern part of the RMIBUP. The northern part is subdivided roughly into three areas: north, central, and south. The north area includes Montana and northern Wyoming; the central area includes central Wyoming and South Dakota; and the south area includes southern Wyoming. The Central part in subdivided into two areas: northern Colorado and southern Colorado. Note that stratigraphic units to the east in the High Plains region are excluded. The units in the Colorado Plateau adjacent to the west are shown by Finch (1991). Some of the stratigraphic units in the southern part of the RMIBUP in New Mexico are imperfectly subdivided into the north area and south area. Major unconformities and hiatuses are shown in critical parts of the column. The age in MA for boundaries between systems and series following Harland and others (1990), Bralower and others (1990), and Obradovich (1993) are given along the left side of Table 1. Note that numerical ages are reported for some Precambrian units. Dominant lithologies and depositional environments are given for most units in Table 1.

Uranium deposits in the Rocky Mountain and Intermontane Basins Uranium Province (RMIBUP, Figure 1) are distributed in sedimentary, igneous, and metamorphic host rocks and in rocks that range in age from Holocene to Lower Proterozoic, with notable absences in rocks of Devonian, Silurian, and Archean ages (Table 1). Uranium concentrations with a grade of 0.03 or more percent U_3O_8 occur in 74 stratigraphic units, depending upon how one considers to equate Groups, Formations, Members, and undifferentiated rocks.

Major uranium-bearing units contain clusters with 500 short tons or more of U_3O_8 in production plus reserves and total 14 stratigraphic units. They are limited to Tertiary, Cretaceous, Mississippian, and Precambrian age rocks. The Tertiary Wyoming basins are the most important uranium resource in the RMIBUP. The most productive areas and basins with very large uranium reserves are (1) the Eocene Wasatch Formation in the Powder River Basin, Campbell, Converse, and Johnson Counties (Hausel and others, 1990); (2) the Eocene Wind River Formation in the Gas Hills District (Zeller and others, 1957; King and others, 1965; Anderson, 1969) in the Wind River

Basin , Natrona and Fremont Counties, and in Shirley Basin (Harshman, 1972), Carbon County; and (3) the Eocene Battlesprings Formation in the Green Mountain (Crooks Gap) District (Klingmuller, 1989), Fremont County, and in the Sweetwater Mine area (Sherborne and others, 1980), Sweetwater County, both in the Great Divide Basin. These Eocene host formations are equivalent units in adjacent basins. The second most productive units are the Early Cretaceous Inyan Kara Group divided into two Formations, Fall River and Lakota Formations, in the Black Hills region of South Dakota and Wyoming (Robinson and Gott, 1958; Robinson and others, 1964). The largest deposits are in the Fall River Formation in the Hauber-New Haven mine area, Crook County, Wyoming (Hausel and others, 1990). Roll-front uranium deposits occur in these Tertiary and Cretaceous continental fluvial sandstone formations. Other major uranium-bearing stratigraphic units that contain roll-front deposits but with smaller resources are as follows: (1) the Miocene Browns Park Formation along the Wyoming and Colorado border (Vine and Prichard, 1959); (2) the Eocene Tepee Trail Formation in the Copper Mountain District, Wyoming (Yellich and others, 1978); (3) the Eocene Sand Butte Bed (Roehler, 1992) of the Laney Member of the Green River Formation at the Ogle project (Staub and others, 1986) in Bison Basin, Fremont County, Wyoming; (4) the Eocene Galisteo Formation in the Hagan Basin, New Mexico (Chenoweth, 1979; Moore, 1979); (5) the Late Cretaceous Lance and Fox Hills Formations in the Oshoto mine area in east central Powder River Basin (Stoick and others, 1981), and (6) Upper Cretaceous Teapot Sandstone Member of the Mesaverde Group in the Nine Mile Lake area (Staub and others, 1986), Natrona County, in southern Wyoming. The Mississippi Leadville Limestone is the major host in the large vein uranium deposits in the Pitch Mine cluster, Saguache County, Colorado (Nash, 1988). Many uranium deposits occur as veins in Early Proterozoic metasedimentary and metavolcanic rocks in the Central City District, Colorado; the largest is the Schwartzwalder (Ludwig and others, 1985; Wallace and Karlson, 1985; Wallace and Whelan, 1986).

Important uranium-bearing units are intermediate size clusters (1-500 short tons U_3O_8 in production plus reserves) occur in 23 stratigraphic units. Their age distribution is wider than for major units; they include the major units ages plus Permian, Ordovician, and Cambrian. The more important and interesting units include (1) the Late Cretaceous Laramie Formation at the Old Lyden Coal Mine, Jefferson County, Colorado (Sims and Sheridan, 1964); (2) several vein uranium deposits in the Brushy Basin Member of the Upper Jurassic Morrison Formation (part of the uranium occurs in the Salt Wash Member of the Morrison Formation and in Precambrian schist) in the Los Oches area in Colorado (Olson, 1988); (3) the Mississippian Madison Limestone that contains the cavern-filling type uranium deposits in the Pryor Mountains in Carbon County, Montana (Hart, 1958) and the Little Mountain area, Big Horn County, Wyoming (McEldowney and others, 1977); (4) the Ordovician Harding Sandstone at the Little Indian mine in close association with the Pitch mine noted above in the Leadville Limestone; (5) a vein deposit in the Cambrian Flathead Formation and undifferentiated Precambrian at the Silver Cliff mine, Niobrara County, Wyoming (Wilmarth and Johnson, 1954); and (6) the Middle Proterozoic Silver Plume Granite and associated biotite gneiss at the Fairday Mine in the Jamestown Mining District, Boulder County, Colorado (Sims and Sheridan, 1964).

Minor uranium-bearing units consist of clusters of occurrences of uranium with sample assays equal to or greater than 0.03 percent U_3O_8 or production plus reserves less than 1 short ton U_3O_8. They are widespread both stratigrahically and geographically in most Systems and Series that contain major and important uranium concentrations (Table 1). They occur in 37 different units. Many of these minor occurrences are associated with vein structures, particularly in Tertiary volcanic rocks, in formations with lithologies not generally considered to be favorable of major deposits such as marine limestone, and in Precambrian igneous, metasedimentary, and metavolcanic rocks. Many such minor occurrences are most likely surficial deposits of uranium related to water transport of uranium to the earth's surface in outcrops and at fracture exposures. Two occurrences of the quartz-pebble conglomerate type of uranium deposit with a grade of greater than 0.03 percent U_3O_8 occur at Savory Creek in the Middle Proterozoic Magnolia Formation and at the Carrico Ranch in the Late Archean Deep Gulch Conglomerate at the base of the Jack Creek Quartzite in the Phantom Lake Metamorphic Suite, both in Carbon County, Wyoming (Karlstrom and others, 1981; Houston and Karlstrom, 1987). The Magnolia is equivalent to the Matienda Formation that contains the large quartz-pebble conglomerate deposits in the Blind River-Elliot Lake Uranium Province in Ontario, Canada (Houston and others, 1992). Pegmatites commonly contain sporadic radioactive minerals but rarely form distinct uranium deposits and are mostly excluded from this compilation. The only production recorded was from the Uranium King in Carbon County, Wyoming (Houston, 1961). Holocene peat deposits contain surficial deposits of uranium recently studied in Colorado (Owen and others, 1992).

DISCUSSION

The generalize stratigraphic sections in Table 1 cover a large area in which the plotting of rock units of such areal extent and diversity as well as the mixed nature of sedimentary, igneous, and metamorphic host rocks have never before been attempted in this region, particularly for the purpose of describing the distribution of mineral deposits. The starting point is a list of reported host units for known uranium deposits, and the columns were built around these host units. Selection of stratigraphic units was arbitrary, but with the idea of showing the local stratigraphic relations as reasonably as possible. The way of showing the stratigraphic distribution of uranium deposits in this report is similar to that used for the Colorado Plateau originally by Fred Peterson in Granger and Finch (1988, Table II) and later modified in Finch (1991).

The information in this report will be useful for further geologic, genetic, and resource studies of uranium deposits in the RMIBUP. New exploration targets may be identified from the information. Additional information on the uranium clusters will become available upon completion of the ongoing research.

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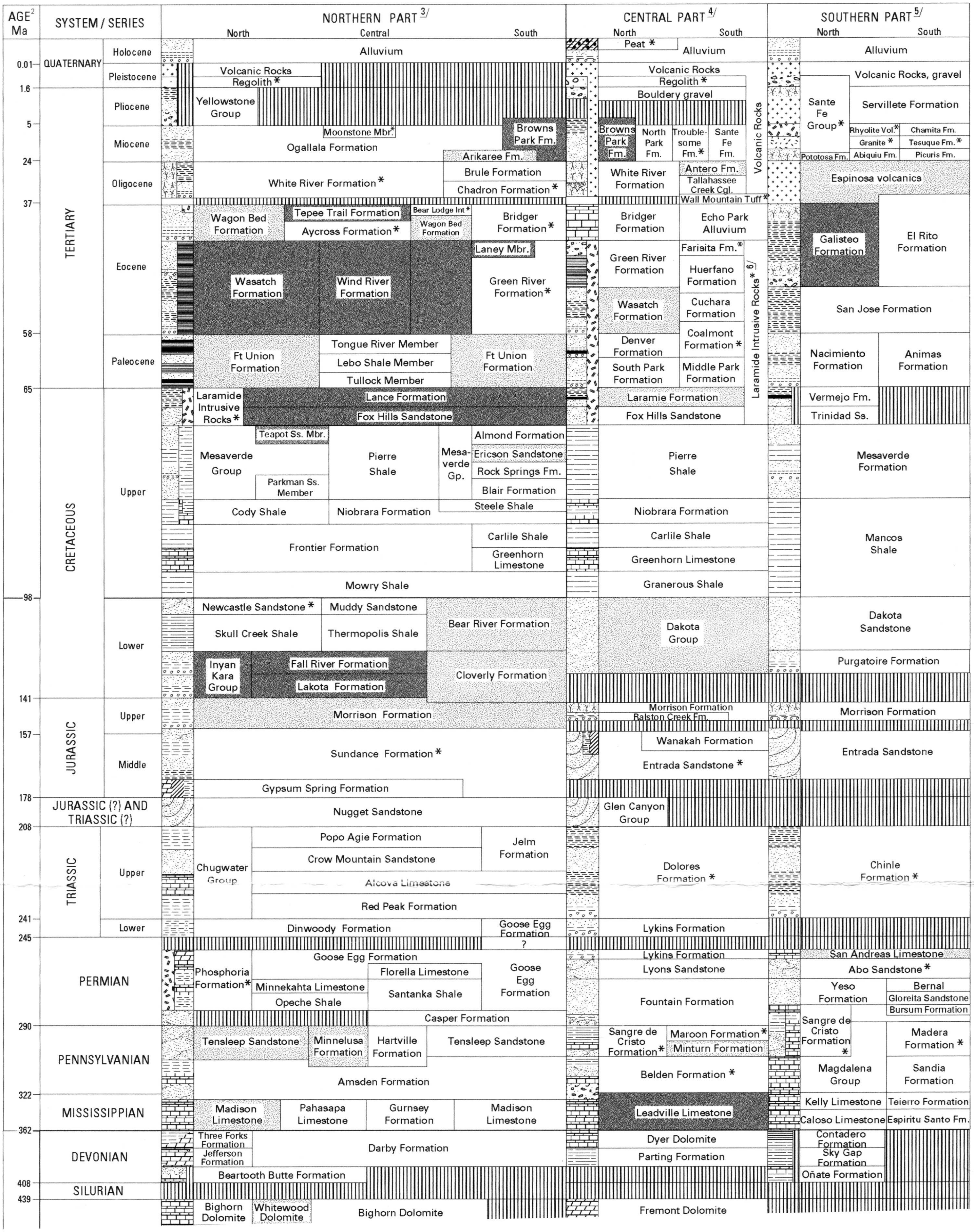
TABLE 1. Generalized stratigraphic units in selected parts of the Rocky Mountain and Intermontane Basins Uranium Province showing uranium host and adjoining units, and their dominant lithologies and depositional environments [1/]

(Thicknesses of units are schematic)



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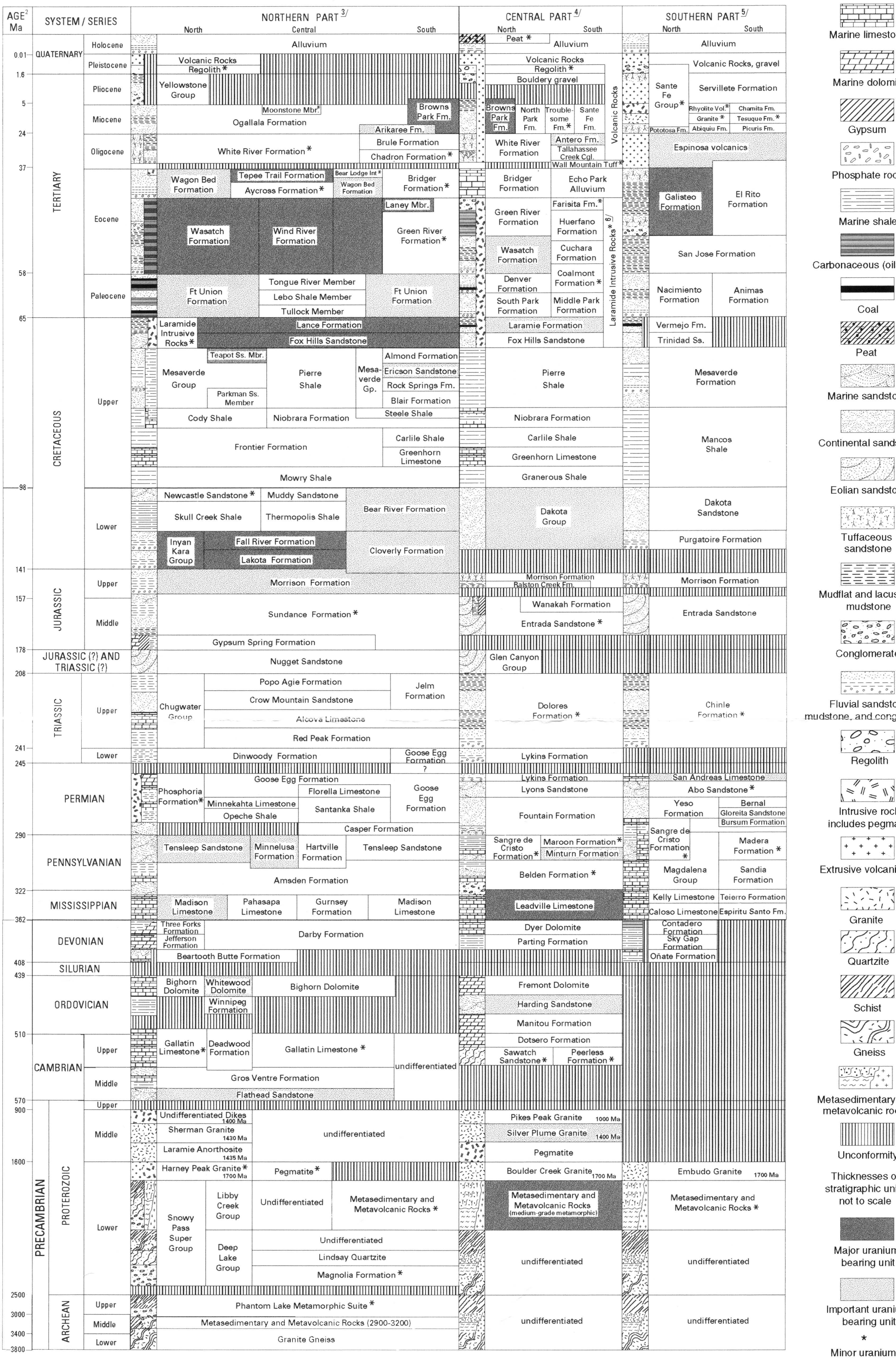

1. Barrs, 1979 (Devonian); Foster, 1979 (Ordovician); Lockman-Balk, 1979 (Cambrian); Reed, in press (Precambrian); Robinson, 1979 (Tertiary).
2. After Hartland and others, 1990; Bralower and others, 1990; Obradovich, 1993.
3. Denson and others, 1991 (Tertiary); Dewitt and others, 1989 (K-J, etc. Black Hills area); Love, Christiansen, and Ver Pleog, 1993; Love and Christiansen, 1985; Pipiringos and O'Sullivan, 1978; (Tr, J); Staatz, 1983 (Bear Lodge intrusives). Precambrian: Houston and others, 1992; Houston and Karlstrom, 1987; Houston and Karlstrom, 1979; Karlstrom and others, 1981; Sims and others, 1991.
4. Epis and Chapin, 1968 (Miocene, Oligocene); Tweto, 1979.
5 Asher-Bolinder, 1988 (Popotosa); Baltz, 1983 (Santa Fe Group); Bauer, 1984 (Pc); Bauer and Williams, 1989 (Pc); Hawley, 1978 (Santa Fe Group); Ingersoll and Kelley, 1979 (Hagan Basin area), Moore, 1979 (Galisteo Formation); Osburn and Lockman-Balk, 1983 (C).
6. Tweto, 1979 (granodiorite, 40-72? Ma).