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Gary B. Glass, State Geologist

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COLUMBIUM (NIOBium) AND TANTALUM IN WYOMING

by

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This report has not been reviewed for conformity with the editorial standards of the Geological Survey of Wyoming.
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INTRODUCTION

Columbium and tantalum are two closely related metallic elements. They have similar physical and chemical properties and often occur together in nature. Chemists use the term niobium in place of columbium. Columbiun and tantalum are found in the greatest abundance in alkali syenites, alkali granites, carbonatites, pegmatites, and fossil and modern placers. The majority of the world's tantalum production has been as a by-product from modern tin placers in Thailand and Malaysia and modern titanium-bearing black-sand beach placers in Australia. Most of the columbium production has come from pyrochlore-bearing carbonatites in Brazil and as a by-product from southeast Asian tin placers (Cunningham, 1985a, 1985b).

The common columbium- and tantalum-bearing minerals are pyrochlore-microlite (originally spelled mikrolite), columbite-tantalite, euxenite, and samarskite. Pyrochlore-microlite and columbite-tantalite are solid-solution series between columbium-rich (pyrochlore, columbite) and tantalum-rich (microlite, tantalite) end members. All the minerals but the columbite-tantalite series are titanium-bearing, and can contain thorium and rare earths. The composition of the minerals is quite variable, and the radioactive elements in the minerals often destroy their physical structure, producing metamict minerals. The exact mineralogy of columbium-tantalum-bearing minerals is often indecipherable due to this variable composition and structural destruction.

Columbium is used primarily as an alloying agent to produce corrosion resistant and heat tolerant steels. These alloy steels are used for construction (40 percent), transportation (primarily aircraft components) (27 percent), in the oil and gas industry (refinery parts and cracking agents) (11
percent), and in other applications (for example electronic components) (11 percent). Demand for columbium in the United States has been weak recently due to the overall low demand for steel (Table 1). The price of concentrated columbium ore (columbium and pyrochlore) reflects the weakening demand over the last five years (Table 2) (Cunningham, 1986a).

Tantalum is used primarily in alloy steels. Tantalum alloy steels are used in electronic components (63 percent), and in corrosion resistant and heat tolerant alloy steels (primarily aircraft components) (31 percent). Domestic consumption of tantalum had been increasing due to its "high-tech" applications until the recent slump in the electronics industry (Table 1). The price of tantalum ore has fallen significantly in the past five years (Table 2) (Cunningham, 1986b), probably because it is a by-product of increased titanium production. This increase in titanium production has produced surplus tantalum. The price of tantalum ore, however, is higher than that of columbium ore because tantalum is less abundant than columbium.

Table 1. Domestic columbium and tantalum consumption 1981-1985 (in short tons) (Cunningham, 1986a, b).

<table>
<thead>
<tr>
<th>Year</th>
<th>Columbium</th>
<th>Tantalum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>4,059</td>
<td>631</td>
</tr>
<tr>
<td>1982</td>
<td>3,300</td>
<td>530</td>
</tr>
<tr>
<td>1983</td>
<td>2,875</td>
<td>590</td>
</tr>
<tr>
<td>1984</td>
<td>3,835</td>
<td>840</td>
</tr>
<tr>
<td>1985</td>
<td>2,850</td>
<td>600</td>
</tr>
</tbody>
</table>

Table 2. Price of columbium and tantalum ore concentrates 1981-1985 (in U.S. dollars/pound) (Cunningham, 1986a,b).

<table>
<thead>
<tr>
<th>Year</th>
<th>Columbium</th>
<th>Pyrochlore</th>
<th>Tantalum (columbium ore)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>9.83</td>
<td>3.25</td>
<td>81.50</td>
</tr>
<tr>
<td>1982</td>
<td>8.88</td>
<td>3.25</td>
<td>40.90</td>
</tr>
<tr>
<td>1983</td>
<td>6.00</td>
<td>3.25</td>
<td>25.06</td>
</tr>
<tr>
<td>1984</td>
<td>5.50</td>
<td>3.25</td>
<td>30.66</td>
</tr>
<tr>
<td>1985</td>
<td>4.25</td>
<td>3.25</td>
<td>27.00</td>
</tr>
</tbody>
</table>
Production and resources of columbium and tantalum in the United States are limited. Small known reserves are located in modern and Pleistocene titanium-bearing beach placers in Florida and Georgia, pegmatite-derived stream placers in Idaho, carbonatites and carbonatite-related rocks in Colorado and Arkansas, and in pegmatites in South Dakota and New Mexico. The last domestic production of columbium and tantalum was in 1982. The U.S. is now entirely dependent on imports of these elements from foreign countries. These supplies are in turn largely dependent on the production of tin and titanium.

Columbium and tantalum resources in Wyoming have not been adequately assessed. The possible sources of these elements are diverse (see Figures 1 and 2 for locations). Known resources are limited to pegmatites. The total production from pegmatites in Wyoming is around 11,000 pounds of columbium- and tantalum-bearing minerals (Hanley and others, 1950; Houston, 1961; Platt, 1986). Columbium and tantalum are also present in carbonatites and related rocks in the northern Black Hills, and in titanium-bearing, black-sand beach placers of Late Cretaceous age that are scattered throughout Wyoming. Preliminary studies indicate that the concentrations of columbium and tantalum in these occurrences are high enough that further study is warranted (Staatz, 1973; Houston and Murphy, 1962; Welch, 1974; Madsen, 1983).

The alkalic syenites in the Laramie Range anorthosite complex are another possible source of columbium and tantalum. This possible source has not been tested.
Figure 1. Locations of columbium and tantalum occurrences and prospects in Wyoming, exclusive of Mesozoic beach placer locations.

1. Fox Creek area
2. Many Values and Ione prospects
3. Northern Bighorn Mountains
4. Platt pegmatite
5. Big Creek pegmatite area
6. Bear Lodge Mountains
7. Mineral Hill area
8. Bonneville no. 1 and no. 8 claims
9. Beaver Creek allanite prospect
10. Middle Lodgepole Creek area
11. Tie Siding area
12. Rainbow claims
13. East Fork of Wind River
14. Anderson Ridge Quadrangle
15. Ruth prospect
PROSPECTS AND OCCURRENCES
(exclusive of Mesozoic black-sand beach placers)

The Mesozoic beach placers are discussed in a specific section following the information on other prospects and occurrences.

Albany County
Fox Creek area

Orback (1960) reports that two of the Precambrian pegmatites in this area contain traces of columbium. Both these pegmatites are poorly exposed. The pegmatite in Section 13 is cross-cut by a small quartz vein (six to eight inches wide) that contains about one percent columbite. This pegmatite is mapped as 1,300 feet long and up to 200 feet wide. The other columbium-bearing pegmatite (in Section 24) is 2,100 feet long and less than 50 feet wide (Orback, 1960). Although Orback (1960) also mapped a 1,000 feet long, up to 50 feet wide quartz vein that cross-cut the pegmatite in Section 13, he contradictorily noted in his text that all quartz veins are only six to 12 inches wide. The pegmatite in Section 24 is apparently like unmineralized pegmatites in the area while the one in Section 13 is less resistant to erosion and much wider than other unmineralized pegmatites in this area. Therefore, the relative erosional resistance and size of the pegmatites cannot be used as an indication of columbium mineralization.

Many Values (George-Funk Mica, Muscovite) prospect

This prospect is developed in a poorly exposed pegmatite in Precambrian schists and gneisses. The location is from Beckwith (1937). Beckwith estimated that the pegmatite is 600 feet long with a maximum width of 70 feet and an
average width of 40 feet. The pegmatite was exposed in shafts and pits for a length of 140 feet, a width of 15 feet, and a depth of 20 feet in 1942 (Hanley and others, 1950). Minor tantalite and possibly fergusonite were identified in the pegmatite in 1942. Eighty-five pounds of tantalite were produced from the pegmatite (Hanley and others, 1950; Beckwith, 1937, see also Hagner, 1942a).

**Big Horn and Sheridan Counties**

Northern Bighorn Mountains

Sec. 26, T.56N., R.92W.
Secs. 10 and 11, T.55N., R.89W.
Approx. sec. 6, T.55N., R.88W., unsurveyed.
Secs. 31 and 32, T.56N., R.88W., unsurveyed.

Tantalite and tapiolite are present in poorly exposed, Precambrian metamorphosed and unmetamorphosed dikes near Burgess Junction and Medicine Mountain. These minerals were identified through microscopic examinations and confirmed by x-ray diffraction. Traces of columbium are also present in the dikes. The dikes have roughly northeast-southwest and northwest-southeast trends. The dikes vary in composition from quartz diorite to metapyroxenite. The tantalum minerals appear to be concentrated in the more mafic rocks (Harris, 1987b; see also Ross and Heimlich, 1972; Manzer and Heimlich, 1974). One tantalite crystal, taken from a dike south of Medicine Mountain, was peanut sized (John Sans, personal communication, 1984).

Limited analytical data show that the amount of tantalum within the dikes is extremely variable. Concentrations in the rocks analyzed to date vary from less than five ppm to about 2,450 ppm tantalum oxide and from no detectable columbium oxide to about 740 ppm columbium oxide (Harris, 1987b).

**Carbon County**

Platt pegmatite (Platt, Uranium King mine) SW1/4SE1/4SW1/4 sec. 3, T.13N., R.81W.

This zoned pegmatite cross-cuts the foliation of the Precambrian gneissic country rock. The pegmatite is 70 feet wide, 160 feet long, and was mined to a
depth of 75 feet (Houston, 1961a). Rare-earth-bearing minerals ("euxenite", and monazite) and columbite are most abundant in the center of the pegmatite and in gash veins. In order of abundance, these minerals are "euxenite", monazite, and columbite. These minerals are for the most part metamict so that x-ray identifications are suspect. Some crystals of each of these minerals reportedly exceeded three inches in length. The "euxenite" is most probably samarskite or a columbium-rich yttrium-bearing tantalite based on its chemical composition and x-ray pattern. This mine produced the greatest amount of columbium and tantalum in Wyoming (10,000 pounds "euxenite"; 200 pounds columbite) (after Houston, 1961a, 1961b; Platt, 1986).

Samarskite is reported from a granite on the King claims in Section 32 of the same township (Gruner and Knox, 1956). This occurrence probably refers to the Platt pegmatite because (1) there are no granites in Section 32, (2) the claim names are similar, (3) the localities are in the same township, (4) only one digit in the section number is different, and (5) the reported minerals are similar.

Big Creek pegmatite area Approximately sec. 19, T.13N., R.80W. and sec. 22, T.13N., R.81W.

A sketch map by Houston (1961) shows columbium-bearing pegmatites at these locations. This is the only information available on these localities.

**Crook County**

Bear Lodge Mountains Roughly T.52N., R.63W.

The southern portion of these mountains contains Tertiary trachytes, phonolites, and carbonatites which intrude lower Paleozoic sedimentary rocks. These igneous and sedimentary rocks are enriched in rare earths, thorium, uranium, and columbium. Columbium-bearing minerals have not been identified, but concentra-
tions of up to 3,000 ppm elemental columbium have been reported. These rocks have not been analyzed for tantalum (Staatz, 1983; Staatz and others, 1980). This area has only been evaluated for its rare earth, thorium, and uranium potential. These elements apparently occur in a porphyry deposit that is physically similar to porphyry copper deposits. In these porphyry-type mineral deposits, minerals are disseminated in extensive systems of microfractures. The rare earths, uranium, and thorium in the Bear Lodge deposit are concentrated in veins and veinlets that contain manganese and(or) iron oxides. Minor quartz, cristobalite, and sometimes altered trachyte and phonolite, fluorite, and(or) calcite are also present in the veins and veinlets. The columbium concentration apparently has no correlation with the rare earth, thorium, or uranium concentrations (Staatz, 1983; Staatz and others, 1980; Wilmarth and Johnson, 1953). Jenner (1984) described carbonatites south of these previously examined areas. Gold mineralization might be present in this porphyry deposit (Dewitt and others, 1986).

The published information about this district coupled with the common association of columbium and tantalum with silicic alkaline rocks and carbonatites means the Bear Lodge Mountains are an unexplored, potentially economic source of columbium and tantalum. An evaluation of the combined value of gold, thorium, rare earths, strontium, columbium, and tantalum in the Bear Lodge igneous complex and surrounding sedimentary units is needed.

Mineral Hill (Tinton, Negro Hill) area Wyoming and South Dakota

This area encompasses a Tertiary alkaline intrusive complex, with carbonatitic affinities and possibly carbonatites, which was intruded into Precambrian schists and lower Paleozoic sedimentary rocks. The schists contain cassiterite-, spodumene-, and columbium-tantalum-bearing Precambrian pegmatites
as well as barren Precambrian pegmatites that are elongate roughly parallel to the foliation in the schists (Welch, 1974; Smith and Page, 1940). Gold is present in both the Precambrian schists and Tertiary intrusive complex (Norby, 1984; Welch, 1974).

This area encompasses three separate sites of columbium and tantalum mineralization. An alkali intrusive complex underlies Mineral Hill on the western edge of the Tinton mining district in Wyoming. The Mineral Hill area also contains placer deposits. Negro Hill, an area of mineralized pegmatites, straddles the state line within the Tinton mining district.

Mineral Hill intrusive complex, Wyoming  Roughly T.51N., R.60W. and N1/2 T.50N., R.60W.

The Mineral Hill intrusive complex has not been adequately sampled to determine gold, rare earths, columbium, or tantalum contents. The concentrations of rare earths and columbium were low in the single analysis reported. Gold values vary from 0.5 to 10's of ppm (Welch, 1974). Considering the possible presence of carbonatite and a gold- and columbite-tantalite-bearing Precambrian basement, the intrusive complex could contain resources of columbium, tantalum, rare earths, and gold.

Mineral Hill area placers  Approximately center sec. 20, and NW1/4 sec. 28, T.51N., R.60W.

Columbite-tantalite-, gold-, and tin-bearing placers are present in the Mineral Hill area in Wyoming. However, the known placers are upstream from the Federal Fish Genetics Lab (Welch, 1974), and this may preclude production from the placers. Welch (1974) reports the placer one-half mile below the junction of Spotted Tail and Sand Creeks (Section 20) was worked prior to 1960 and contained 1.34 pounds/cubic yard columbite-tantalite as well as gold and tin. The
other placers, above Sand Creek Crossing (Section 28; Section 8 [sic] in the
text of Welch, 1974) is about 2,000 feet long, 300 feet wide, and may be more
than 40 feet thick (Welch, 1974).

Negro Hill pegmatites in Wyoming  E 1/2 S E 1/4 sec. 21, T.51N., R.60W.

A few tin-bearing pegmatites are present in the Wyoming portion of the Negro
Hill area, but all the mining of pegmatites occurred in South Dakota. Columbite-
tantalite is spatially associated with cassiterite and spodumene in the pegma-
tites, but the amounts are apparently inversely proportional. The presence of
columbite or tantalite in the Wyoming portion of this area is not certain. Claim
holders have reported tantalite on their claims in Wyoming, but this was not
confirmed by independent examinations (after Smith and Page, 1940; Johnson,
1938b; Gardner, 1939). Because the abundance of tin and columbite-tantalite are
inversely proportional, the limited amount of tin in the pegmatites located in
Wyoming (Gardner, 1939) implies that the Wyoming pegmatites should be rich in
columbium or tantalum. For this reason a reexamination of the pegmatites in
Wyoming is needed.

Fremont County
Bonneville no. 1 claim (Whippet no. 1 prospect)  Center sec. 28, T.40N., R.93W.

This claim on the southern flank of the Owl Creek Mountains contains tan-
talum- and columbium-bearing pegmatites. In the 1970s feldspar was produced
from a pit on the claim. Beryl and columbium-tantalum-bearing minerals were
being hand-cobbled on the claim in 1986. The pegmatites are concordant with the
foliation in the enclosing Precambrian metamorphic rocks. The sizes of the
pegmatites are uncertain; estimates vary from 50 to 60 feet wide and from 320
to over 500 feet long. The pegmatites contain pyrochlore-microlite, tapiolite,
beryl, and lepidolite. Tantalite crystals up to one by four by four inches in size have been found on this claim (after Harris, 1987a; Hanley and others, 1950; McLaughlin, 1940).

Bonneville no. 8 claim (Whippet no. 8 prospect) SW₁⁄₄SW₁⁄₄SW₁⁄₄ sec. 22 and NW₁⁄₄NW₁⁄₄NW₁⁄₄ sec. 27, T.40N., R.95W.

A tantalum- and columbium-bearing pegmatite is present on this claim on the southern flank of the Owl Creek Mountains. The pegmatite is elongate parallel to the foliation in the adjacent Precambrian metamorphic rocks. The size of the pegmatite is not certain. It is apparently 20 to 30 feet wide at its thickest point and thins to a wedge edge. The pegmatite is at least 400 feet long and might be over 700 feet long. Columbite-tantalite, pyrochlore-microlite, tapiolite, beryl, and petalite are present in the pegmatite (Harris, 1987a; Hanley and others, 1950; McLaughlin, 1942). In 1942, columbium-tantalum-bearing minerals were quite abundant in a 200 feet long, two feet wide zone in the northeastern portion of the pegmatite. At least 250 pounds of tantalum-rich minerals had been removed from this zone prior to 1942 (Hanley and others, 1950).

Reserve estimates in 1942 were 1,375 pounds of tantalite (Hanley and others, 1950; see also Hagner, 1942b). Harris (1987a) reported a zone 50 or more feet long and three feet wide that contained 20 percent tantalum-rich minerals, identified as tapiolite by x-ray diffraction. Kopp (1965) reports some portions of the pegmatite contain 20 to 30 pounds of tantalite per ton of pegmatite. The grade and reserve estimates, however, are not accurate because the entire pegmatite has not been examined in detail or in three dimensions.

Well-formed crystals of several minerals in this pegmatite are suitable for mineral specimens. Aquamarine beryl crystals were being hand-cobbled for this
purpose in 1986. Tapiolite crystals up to one-half by one-quarter inch in size and fan-shaped aggregates of columbite-tantalite crystals up to one inch in diameter are present in the pegmatite. The pegmatite also contains petalite crystals measuring one by three by four inches in size (Harris, 1987a).

**Johnson County**

Beaver Creek allanite prospect (Lyle Ransbottom property) SE1/4SW1/4 sec. 31, T.47N., R.83.W.

Armbrustmacher and Sargent (1982) report 1,000 ppm columbium oxide in a sample of metamorphosed calc-silicate rock from this site in the southern Bighorn Mountains. The sampled unit is a small, Precambrian calc-silicate body that is concordant with the foliation in the enclosing Precambrian quartz-feldspar gneiss. The body is from a few inches to six feet wide and extends for about 3,750 feet across the southern half of Section 31 into the northeast quarter of Section 6 and northwest quarter of Section 5 (T.46N., R.83W.). Columbium-bearing minerals have never been reported at this site. The interest in this property has been for allanite (a uranium-, thorium-, and rare-earth-bearing silicate mineral). The exact origin of the columbium, uranium, thorium, and rare-earth enrichment is not known, but it is thought to be related to regional metamorphism during Precambrian time (Wilson, 1952; Magleby, 1952; Sargent, 1960; Armbrustmacher and Sargent, 1982). The columbium content in the calc-silicate body, based on four samples, varies from 30 to 1,000 ppm elemental columbium and is inversely related to the concentrations of rare-earth elements in the body. No tantalum was found. Columbium and tantalum (if present) might be produced as a by-product to the estimated 18,250 tons of rare earths present in the calc-silicate body (Armbrustmacher and Sargent, 1982).
UNVERIFIED OCCURRENCES
(exclusive of Mesozoic beach placers)

Unknown Location

Eight hundred pounds of samarskite were reportedly shipped to California from an undisclosed location in Wyoming in 1930 (Marzel, 1933).

Albany County

Ione (Funk Mica) prospect  E1/2NE1/4SW1/4 sec. 32, T.13N., R.78W.

Beckwith (1937) reports two pegmatites in Precambrian rocks at this location. A western one is 450 feet long with a maximum width of 25 feet and an eastern one is 800 feet long with a maximum width of 80 feet. He noted workings on the eastern pegmatite and implies tantalite is present in this pegmatite. However, later workers did not report tantalite in place in the pegmatite (Hanley and others, 1950; Hagner, 1942c). This prospect is adjacent to and west of the Many Values prospect (page 5).

Middle Lodgepole Creek area  Sec. 2, T.15N., R.71W.

A 75 feet wide euxenite(?)-bearing pegmatite that cuts Precambrian granite is reported at this location (Wilson, 1961). Euxenite was not seen during an examination in 1978, but high radioactivity is reportedly associated with biotite in this pegmatite. A sample of the pegmatite contained only 50 ppm elemental columbium (Griffin and Warner, 1982).
Tie Siding area  T.12N., R.71W.; T.12N., R.72W.; and T.13N., R.72W.

Many pegmatites are present in the Precambrian Sherman Granite near Tie Siding. Pyrochlore is reported in one pegmatite in this area (Smith, 1954). Smith's (1954) map implies this pegmatite is in the west half of the southwest quarter of Section 29 (T.13N., R.72W.). During an examination in 1978 by Griffin and Warner (1982), columbium- and tantalum-bearing minerals were not noted, but high radioactivity reportedly was associated with biotite. Two pegmatites sampled during the 1978 examination contained more columbium than others in the area. These pegmatites contained 1,000 ppm (SW1/4NE1/4 sec. 6, T.12N., R.71W.) and 200 ppm elemental columbium (SE1/4SW1/4 sec. 2, T.12N., R.72W.) (Griffin and Warner, 1982).

**Big Horn County**

Rainbow claims  Location estimated as T.58N., R.82W., unsurveyed

Parker (1963) reports euxenite in a pegmatite on these claims in the northern Bighorn Mountains. His location is just east of Cookstove Basin where radioactive pegmatites are present. The location given is for the Cookstove Basin.

**Fremont County**

East Fork of Wind River  Mostly sec. 30, T.43N., R.109W.

Ely (1971) reports columbium and tantalum in a pegmatite mined for feldspar. The pegmatite is in Precambrian gneiss and granite.
Anderson Ridge Quadrangle NW1/4Sw1/4 sec. 32, T.29N., R.101W.

El-Etr (1963) reports very minor amounts of columbite in a pegmatite at this site.

Goshen County

Ruth prospect Center sec. 35, T.28N., R.65W.

This columbite(?)-bearing pegmatite is a concordant lens in Precambrian schists and gneisses; the lens is 155 feet long and as much as 80 feet wide (Hanley and others, 1950).

**OCCURRENCES IN MESOZOIC BEACH PLACERS**

Radioactive, titaniferous, black sandstones of Late Cretaceous age are present at many locations in Wyoming (Figure 2 and Table 3). These black sandstones have been interpreted as fossil placers and are known to contain columbium and rare-earth elements. Elemental columbium is present in an unknown opaque mineral that contains cerium and lanthanum. X-ray diffraction patterns from the columbium-bearing opaque mineral do not match those for columbite, tantalite, or euxenite (Houston and Murphy, 1962). Eighteen reliable analyses for columbium have been done on 15 sandstones (Table 3); the results vary from 10 to 126 ppm elemental columbium. These 15 black sandstones were not analyzed for tantalum (Madsen, 1982; Morris and Stanley, 1982; Garrand and others, 1982; Griffin and Milton 1982; Madsen and Reinhart, 1982).

None of the black sandstones have been systematically examined as a source for columbium, tantalum, and rare-earth resources. A systematic sampling
program and chemical analyses are needed to determine the potential value of the black sandstones. Other unreported black sandstones may be found in the rock units shown on Figure 2. Occurrences of columbium, tantalum, and rare earths in these unreported black sandstones of Late Cretaceous age cannot be ruled out either.

Site 25 (Figure 2 and Table 3) is a Late Jurassic titaniferous, black sandstone of uncertain origin. It is not known if this black sandstone contains columbium, tantalum, or rare-earth elements (Houston and Love, 1956). The existence of this Jurassic black sandstone means additional black sandstones that are not Late Cretaceous in age may be present in Wyoming.

The information in Table 3 and on Figure 2 is from Houston and Murphy (1962, 1970); Houston and Love (1956); Dow and Batty (1961); Madsen (1982); Morris and Stanley (1982); Garrand and others, (1982); Griffin and Milton (1982); and Madsen and Reinhart (1982).
Figure 2. Locations of Mesozoic black sandstone (beach placer) deposits and outcrops of their host formations in Wyoming. Numbers refer to listings in Table 3.
<table>
<thead>
<tr>
<th>Area</th>
<th>No.*</th>
<th>Section</th>
<th>T. N. R. W.</th>
<th>Location</th>
<th>Extent (feet)</th>
<th>Thickness (feet)</th>
<th>Columbium content (ppm)</th>
</tr>
</thead>
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<td>900+</td>
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<tr>
<td>Lovell</td>
<td>2</td>
<td>7</td>
<td>55</td>
<td>95</td>
<td>3,000+</td>
<td>4.0</td>
<td>18</td>
</tr>
<tr>
<td>Grass Creek</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Northern segment</td>
<td>8, 9</td>
<td>16</td>
<td>46</td>
<td>98</td>
<td>5,600+</td>
<td>16.0</td>
<td>11</td>
</tr>
<tr>
<td>Southern segment</td>
<td>33, 34</td>
<td>46</td>
<td>98</td>
<td>Unknown</td>
<td>1,600</td>
<td>5.0+</td>
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<tr>
<td>Cottonwood Creek</td>
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<td>89</td>
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<td>Mud Creek</td>
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* = number on Figure 2.
REFERENCES


