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GAMMA-RAY RADIOACTIVITY DATA
PAYETTE NATIONAL FOREST, WEST- CENTRAL IDAHO

By

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INTRODUCTION

Gamma-ray radioactivity data for the Payette National Forest (hereafter referred to as the Forest) consists of aerial spectrometer surveys flown during the U.S. Department of Energy National Uranium Resource Evaluation (NURE) program (ca 1974-1983). NURE surveys that include parts of the Forest are those for the Baker (Geodata International, Inc., 1978), Challis (Geodata International, Inc., 1979), Elk City (EG&G geoMetrics, 1979), and Grangeville (Geodata International, Inc., 1981) 1-degree by 2-degree quadrangles. Aerial gamma-ray data (aeroradioactivity) from these surveys were used to prepare an aeroradioactivity database for the Forest. Other compilations of NURE data that include the Forest are Duval (1995), Duval, Jones, and others (1997) and Phillips, Duval, and Ambroziak (1993).

Aeroradioactivity is the measurement of terrestrial radioactivity with instruments operated in low-flying aircraft. The source of the radioactivity measured is the near-surface rock-and-soil (to 50 cm depth) where the primary gamma-ray emitting isotopes are from the natural radioelements potassium (K), uranium (U), and thorium (Th). NURE aerial systems were quantitatively calibrated at sites of known radioelement concentrations, permitting quantitative reporting of survey data in percent (%) for K and parts per million (ppm) for U and Th (assuming equilibrium in the respective decay series). The near-surface distribution of K, U, and Th generally reflects bedrock lithology and modifications due to weathering, erosion, transportation, ground water movement, and hydrothermal alteration. Common rock types readily discriminated by aeroradioactivity measurements include more radioactive (greater concentrations of radioactive minerals) felsic igneous rocks, arkosic sandstones, most shales, less radioactive (lower concentrations) mafic igneous rocks, (pure) quartzose sandstones, and most limestones.

The Forest aeroradioactivity database - K, U, and Th grids at 3-km cell size - were used to prepare K, U, and Th color and black-and-white maps at 1:100,000- and 1:250,000-scales (some including flight line plots) for use in the assessment and grey-scale maps at 1:1,000,000-scale for inclusion in this report. Subsequent to interpretation (see that section), contour maps were made selectively at 1:24,000-scale that included flight line plots and were used for control and orientation during ground field work (see that section). Grids of the ratios U:Th and K:Th were also prepared and used for map preparation at several scales.

DISCUSSION

K, U, Th, U:Th, and K:Th aeroradioactivity grey-scale contour maps of the Forest are shown (respectively) in figures 1, 2, 3, 4, and 5. The Forest boundary is shown on each map and geographic locations shown on the maps are described in figure titles. Bodies of water, such as Payette Lake and Cascade Reservoir, have no measureable aeroradioactivity. However, the grids used to make figures 1-5 were not masked to show no data for lakes and reservoirs, and any discernable grey-scale values for the areas of water should be ignored.

The near-surface distribution patterns of K, U, and Th as displayed by aeroradioactivity maps are often similar, resulting from common rock-type associations for these elements. However, discontinuities in the patterns can reflect significant mineralogic discontinuities, such as the contrasting properties of felsic and mafic igneous rocks. Th generally has a more consistent distribution pattern than K or U, likely resulting from Th being the least mobile of these elements. For this reason, Th is used as the stable denominator in U:Th and K:Th ratios, thereby highlighting subtle variations in U and K distribution. Of particular interest are variations from the U:Th 0.25 ratio on figure 4. The normal crustal ratio for Th:U is around 1:4 or, in the case of figure 4, 0.25. Values on figure 4 greater than 0.25 suggest relative enrichment of U, values less than 0.25 suggest relative depletion of U.

INTERPRETATION

Natural radioelement distribution for the Payette National Forest as demonstrated in the grey-scale contour maps (figs 1-5) reflects the change in geologic terranes from west to east across the Forest. The accreted terranes and overlying basalts in the western part have generally lower relative concentrations, suture zone rocks in the central part have generally moderate relative concentrations, and the Idaho batholith and intruding and overlying igneous rocks in the eastern part have generally higher relative concentrations.

Accreted terranes, western part of Forest

The southwest part of the Forest west and northwest of Cambridge has relatively low values of 1.0 to 1.2 % K, 0.8 to 1.2 ppm U, and 4 to 6 ppm Th that are associated with Paleozoic and Mesozoic metasedimentary and metavolcanic rocks in the Hitt and

Cuddy Mountains and with Tertiary basalt flows that surround the mountains.

Occurrences of slightly higher concentrations in these parts of the Forest are distinct in the aeroradioactivity maps and may indicate the occurrence of hydrothermal alteration or may indicate radioactive mineral (lithologic) variation not associated with mineral deposits.

These occurrences include:

1) the Mineral district just west of the western boundary of the Forest, where values of 1.2 to 1.8 % K and 1.2 to 1.6 ppm U reflect known hydrothermal alteration;
2) northeast of the Mineral district, within the Forest and southwest of Sturgill Peak, coincident values of 1.4 % K, 1.4 ppm U, and 5 ppm Th may result from an arkosic metasandstone;
3) northwest of Cambridge and north of Brownlee Ranger Station in the Forest where 1.2 to 1.4 % K and 1.2 to 1.4 ppm U possibly indicate rhyolite tuff except for the absence of any Th expression; there may be a porphyry mineral system in this area, as there has been drilling activity (Karen Lund, oral communication, 1998);
4) north of Cambridge in the Forest at Peck Mountain, an occurrence of 1.2 to 1.4 % K has a mostly basalt source. However, this feature could relate to nearby quartz diorite and/or Seven Devils metavolcanic rocks or may relate to hydrothermal alteration known to occur in the area.

Features 1, 3, and 4 also have expression in the U:Th and K:Th ratios, because of relatively lower Th.

Southeast of Cambridge and outside of the Forest, coincident relatively higher values of 1.2 to 2.0 % K, 1.2 to 2.0 ppm U, and

6 to 9 ppm Th are from abundant Tertiary arkosic sandstone.

East and northeast of Cuprum, the northwestern part of the Forest has relatively low and often very uniform values of 0.8 % K, 0.6 to 0.8 ppm U, and 2 to 3 ppm Th, in the Seven Devils accreted terrane of metavolcanic, metasedimentary, and plutonic rocks. Most of this area has distinctly higher U:Th and K:Th values, reflecting the low Th concentrations of these rocks. Southwest of Cuprum, slightly higher K values of 1.0 to 1.2 % likely result from lithologic variation in metavolcanic rocks.

Suture zone

Aeroradioactivity data for the suture zone show the general transition from relatively lower radioactivity rocks to the west to higher radioactivity rocks to the east, and include several possibly unusual geologic phenomena.

Suture zone north of McCall

North of McCall, mostly within the Forest, a sizeable area of non-coincident relatively higher aeroradioactivity features, most prominent in the Th data, occur approximately west and east of Burgdorf and north to the Salmon River Canyon. Metamorphic rocks of varied sedimentary and igneous ancestory constitue the source rocks for these aeroradioactivity features. The non-coincidence of the aeroradioactivity features is notable because in igneous and often in metamorphic rocks, K, U, and Th commonly occur in the same rock types, U and Th often in the same minerals.

The non-coincident features are located as follows (the element not described does not have a specific expression):

1) west of Burgdorf and south to Squaw Point is an area of 1.6 % K and 9 ppm Th, where the geologic source includes quartz monzonitic through gabbroic intrusive rocks and

glacial deposits;

2) northwest of Burgdorf in the Salmon River Canyon is an area of 1.2 ppm U and 10 ppm Th, where the source is gneiss, schist, and quartz monzonitic through gabbroic intrusive rocks;

3) northeast of 2) in the Canyon is an area of 1.6 % K, 0.6 ppm U, and 8 ppm Th, a coincident feature with low U is in biotite gneiss source rocks;

4) northeast of 3) along the north side of the Canyon, outside of the Forest and within the Gospel Hump Wilderness, is an area of 1.4 % K, 2.0 ppm U, and 8 ppm Th, the only coincident feature with all 3 elements with relatively higher values, and with undifferentiated batholithic source rocks;

5) northeast of Burgdorf, an area that includes War Eagle Mountain has values of 1.4 ppm U and 9 ppm Th, has a batholithic source, and could relate to hydrothermal alteration;

6) the Marshall Mountain mining district, approximately enclosed by the previously described features, is a distinct - partially coincident - low of all three radioelements, 0.8 % K, 1.0 ppm U, and 4 to 5 ppm Th, in undifferentiated batholithic rocks. Of course, hydrothermal alteration can result in depletion of radioactive minerals as well as enrichment.

Features 1 through 5 have U:Th and K:Th expression as ratio lows, because of the relatively higher Th. The Marshall Mountain district has relatively moderate ratios due to partially coincident lows of all radioelements.

From the previously described features south to McCall, mostly within the Forest, U (0.8 to 1.0 ppm) and Th (5 to 6 ppm) values are low and featureless, a pattern that continues eastward into the batholith. The K data in this area increase across a relatively a relatively short distance from 0.8 % to the west to 1.4 % to the east where Idaho batholith rocks and their characteristic K signature are more prevalent (see later discussion).

Suture zone south of McCall

South of McCall, the suture zone in and adjacent to Long Valley includes these features:

1) south of McCall, outside of the Forest, coincident relatively higher values of 1.6 ppm U and 8 ppm Th and an offset value of 1.6 % K likely relate to radioactive heavy mineral placers known to occur in Long Valley;
2) east of the previous feature and within the Forest, distinct coincident relative lows of 1.0 % K, 0.6 ppm U, and 3 ppm Th reflect the presence of plagioclase-dominant tonalite and granodiorite at the east side of the suture zone/west side of the batholith.
3) southeast of Donnelly and outside of the Forest, somewhat coincident relatively higher values of 1.8 % K, 1.8 ppm U, and 9 ppm Th occur in the valley, probably related to a heavy mineral placer, and extend to the east to include an upland area where bedrock is sphene-enriched biotite granodiorite, a probable source for the placer;
4) southwest of Cascade and outside of the Forest, coincident relative highs of 1.4 % K, 1.2 ppm U, and 7 ppm Th include alluvium in the valley and a sizeable upland area of hornblende gneiss and quartz diorite;
5) southeast of Cascade and outside of the Forest, relative highs of 2 ppm U and 10 ppm Th include alluvium and the

adjacent (feedstock) biotite granodiorite bedrock of the batholith.

These features, excepting feature 2, lack distinctness in the ratios because of similar expression of the radioelements. Feature 2 is distinct in K:Th because of lower Th.

Heavy mineral placering has occurred historically in Long Valley, and the aeroradioactivity data include four areas of relatively radioactive alluvial deposits, and in three cases, the adjacent bedrock from which much of the detritus probably was derived. However, not all radioactive placers will have an aeroradioactivity signature. Alluvial deposits in valleys can be within the water table and the contained water will absorb gamma-rays, the source of aeroradioactivity measurements, resulting in relative lower aeroradioactivity. Therefore, placers containing appreciable quantities of radioactive minerals can be associated with aeroradioactivity relative highs, dependant on contained water at the time the aeroradioactivity measurement was made.

Idaho batholith and related rocks

East of the suture zone, the Idaho batholith has a regional radioactivity character best expressed in the K data. The K:Th ratio has a variable but distinct pattern of higher values that characterizes the outcrop of the batholith within the Forest.

Northeast of McCall, within the Forest, moderate K values of 1.2 to 2.0 % and low U of 0.8 to 1.0 ppm and low Th of 4 to 6 ppm characterize tonalite and granodiorite of the batholith. An exception to this pattern occurs south and southeast of Warren, where a distinct radioactivity low includes coincident U (0.6 ppm) and Th (5 ppm) lows and an offset K (1.2 %) low. Northeast of Warren, a prominent aeroradioactivity feature that is most evident in the ratios includes the Salmon River Canyon and is partly within the Forest. The feature owes its prominence to relatively low Th of 3 ppm and associated but partly coincident and relatively higher (albeit moderate values) U of 1.4 ppm and K of 1.6 %. It is somewhat prominent in U:Th and especially prominent in K:Th. The feature is within the batholith, may relate to a quartz monzonite roof pendant of the batholith, certainly to rock type(s) of distinct radioactive lithology, and could relate to faulting.

Southeast of McCall, southwest of Yellow Pine, and within the Forest, generally moderate values of 1.4 to 1.8 % K, 1.0 to 1.6 ppm U, and 6 to 8 ppm Th characterize somewhat more felsic rocks of this part of the batholith. Aside from the radioactivity low southeast of McCall (feature 2 in south suture zone section), the Th data define different radioactive lithologies in the batholith in the south-central part of the Forest. East of Donnelly, muscovite-biotite granodiorite and granite is 5 to 6 ppm Th and biotite granodiorite is 7 to 8 ppm Th.

The typical K signature of the batholith disappears in the eastern part of the Forest, reflecting major changes in bedrock. Northeast, east, and southeast of Yellow Pine, varying low to high radioelement values result from the presence of intermediate to mafic Proterozoic metaigneous and quartzitic and carbonate metasedimentary rocks (generally lower values) as roof pendants in the batholith, abundant Tertiary felsic igneous rocks (higher values) intruding and overlying the batholith, and occasional outcrops of batholithic rocks (characteristic K expression).

In the vicinities of Yellow Pine and Big Creek, Proterozoic roof pendants are distinct features as radioactivity lows. Just east of Yellow Pine, a distinct linear north-south low with expression primarily in K (0.8 %) and somewhat in U

(0.8 ppm) is from Proterozoic metasedimentary rocks. Just south of this feature and outside of the Forest, a prominent U relative high of 3 ppm, also expressed in the U:Th ratio, has a probable source of felsic igneous rocks in an area where Challis volcanic rocks (undivided) occur. At and northeast of of Big Creek are two radioactivity features each with coincident lows of the 3 radioelements and each with Late Proterozoic mafic metaigneous source rocks. At Big Creek, the feature has 1.0 % K, 1.4 ppm U, and 7 ppm Th as components; to the northeast, the other feature has 1.0 % K, 0.8 ppm U, and 5 ppm Th components. These coincident component features reflect similar radioelement chemistry for the source rocks.

Further east from Yellow Pine, partly within the Forest, radioactivity increases dramatically as felsic igneous rocks, commonly rhyolites, of the Thunder Mountain cauldron complex, the Van Horn Peak cauldron complex, and the Casto pluton have higher aeroradioactivity. East of Yellow Pine, beginning immediately east of the roof pendant radioactivity low and extending eastward, moderate to high relative concentrations of 2.0 to 2.5 % K, 2.0 to 3.2 ppm U, and 10 to 15 ppm Th indicate the presence of Challis volcanic and associated plutonic rocks. Coinciding 2.0 % K, 2.2 ppm U, and 12 ppm Th grey-scale patterns outline the Thunder Mountain cauldron complex and extend to the southeast outside of the Forest. The 0.16 to 0.19 K:Th ratio occurs across much of the eastern part of the Forest, indicating a common mineralogic residence for these elements in different rocks.

GROUND CHECKING OF AERIAL FEATURES AND GEOCHEMICAL RESULTS

Interpretation as described in the previous section was accomplished at 1:250,000 (mostly) and 1:100,000 (somewhat) scales. Areas of interest in the western part of the Forest with potential for ground checking were selected and K, U, and Th contour maps at 1:24,000-scale that included flight line locations were prepared. The maps were used to select sites for ground checking, using as the primary criteria the need for radioelement concentrations be above (mostly) or below (on occasion) local or regional background for one or more radioelements, and also be within (mostly) the Forest.

The ground work was confined to the western part of the Forest because of relative ease of access and limited time availability. The aeroradioactivity features were located and visted when possible along aerial flight lines, a portable quantitatively calibrated gamma-ray spectrometer was operated to assure positioning relative to the aerial measurement before sampling, and rock-and-soil samples were obtained for geochemical analysis.

Description of table 1

Table 1 includes -a, -b, -c, -d, -e, and -f parts. Table 1a includes the field sample number, the laboratory sample number, sample locations in latitude and longitude, a brief description of the physical sample, and the sample collection date. The field sample number is listed on each part of the table. In parts -c, -d, -e, and -f, a dashed line for an element indicates that element was not detected by that analytical method.

Table 1b includes aerial and ground concentrations in K (%), U (ppm), and Th (ppm), and delayed neutron activation analyses (McKown and McKnight, 1990) for U (ppm) and Th (ppm) and the coefficient of variation (cv) for each radioelement value. The aerial concentrations are ranges of % and ppm because they were derived by extrapolation from contour interval intersections plotted along flight lines on 1:24,000-scale contour maps (described earlier). The ground concentrations are single values of % and ppm as they represent single (most often) measurements at aerial feature locations.

Table 1c includes the 10-element inductively-coupled plasma-atomic emission spectrometry analysis (Motooka, 1990).

Tables 1d, -1e, and -1f include the 40-element inductively coupled plasma-atomic emission spectrometry analysis (Briggs, 1990).

Discussion of field sample sites and geochemical analyses

In the preceeding discussion, the section titled "Suture zone north of McCall" includes the description of a sizeable area of distinctive aeroradioactivity features, most prominent in the Th data, that occur in the area of the Salmon River Canyon east of Riggins and extend south of the Canyon to include Sams Throne and Squaw Point. Reports (Capps, 1940; Reed, 1937) of rare-earth-element (REE) minerals occurring in Burgdorf-area placer deposits east of the Th feature suggests that the Th aeroradioactivity could relate to the bedrock source of the placer deposit REE-minerals. Th and REE often occur in minerals such as zircon, monazite, basnaesite, allanite, apatite, and euxenite (Clark, 1984). Also, in Long and Bear Valleys south of McCall, heavy mineral placers contain significant quantities of monazite and euxenite derived from batholithic rocks to the east (Schmidt and Mackin, 1970). The aeroradioactivity maps of this report (figures 1-5) include some features associated with these placers and their bedrock sources (see discussion on "Suture zone south of McCall"), but do not include any Th features similar to those in and south of the Salmon River Canyon.

Ground investigation of the Salmon River Canyon/Sams Throne/

Squaw Point Th aeroradioactivity feature was confined to those locations by topographic and time constraints. The recommended practice of ground-checking aerial radioactivity data along flight lines was seldom possible because of topographic constraints. However, the portable quantitatively-calibrated gamma-ray spectrometer was used to guide selection of sites for geologic (rock) sample collection, usually on the basis of relatively higher Th values.

For the Salmon River Canyon part of the Th feature, the samples obtained were from outcrops along the south side of the canyon, included 92JP206 and 93JP219 through -224 (table 1), all outside of the Forest. For the Sams Throne part of the feature, the samples obtained were from outcrops about 1.5 mi east of the Throne, included 93JP231 and -232 (table 1), both within the Forest. For the Squaw Point part of the feature, samples 92JP207 and -208 and 93JP231 and -232 (table 1) were obtained at Josephine Lake, all within the Forest.

To aid evaluation of the Th aeroradioactivity feature and its possible REE association, Table 2 was prepared from Table 1a-1f. Table 2 lists those samples with detectable REEs (La, Ce, Nd, Yb), Y, P, and 3 measurements for Th. The dnaa and icp Th values are within a reasonable range of +-50% of the ground (gnd) Th values (with the exception of 93JP222), indicating the sampling sites are within the aerial features, despite ground access precluding sampling along flight lines.

The REE data available are primarily for 'light' REEs, La, Ce, and Nd, and without other evidence are not in themselves evidence for relatively appreciable REE concentrations in bedrock of the Th aeroradioactivity feature. Comparison of these La, Ce, and Nd values with published data (Taylor and McLennan, 1988) indicates the Th feature values are not unusual for similar metaigneous rock types (Taylor and McLennan, 1988, p. 529, 533). However, for the nine samples of table 2, the three with the highest P values - 93JP208, 93JP222, 93JP234 - also have the highest Ce, Nd, and Y values, suggesting the presence of minerals such as apatite, monazite, and sphene. The Th feature and its possible REE association certainly deserves further field investigation, including REE-specific geochemical analysis.

A published report of 94 ppm Th and 29 ppm U (Leinart and Salisbury, 1982, appendix A) for a sample site in the Salmon River Canyon and in the area of the Th aeroradioactivity feature provides further information on the feature, although having no bearing on any REE association.

Other aerial features that were located and sampled are in the western part of the Forest and include several that were discussed in the section on "Accreted terranes, western part of Forest." Feature 1 includes the now inactive Mineral mining district which is located west of the Forest in the Snake River Canyon, and is where samples 92JP201 and 92JP202 were collected along an aerial flight line in an area not affected by mining activities. Analytical results for K (table 1d) and U and Th (table 1b) confirm the aerial anomaly, and indicate the presence of relatively anomalous U possibly related to hydrothermal alternation. The district produced primarily Ag (Livingston, 1923, p. 18) and while the two samples do not have detectable Ag (table 1c), discernable and what may be exploration guide values were obtained for As, Cd, Cu, Mo, Pb, Mo, Pb, Sb, and Zn (table 1c-1f). Feature 2 is within the Forest, is southwest of Sturgill Peak, and is where sample 93JP209 was collected along a flight line on the basis of relatively anomalous aeroradioactivity. Analytical results (table 1b-1f) confirm the aerial feature; however, the paucity of significant non-radioelement values suggests the feature reflects a radioactive lithology not related to mineral deposits.

Three other aerial features in the western part of the Forest, all of slight aeroradioactivity magnitude, were located and sampled along aerial flight lines. All have detectable Ag and other elements of possible exploration significance. They include:

(a) at the west side of the Hitt Mountains at the Forest boundary due east of the Mineral district, samples 92JP203, 93JP212 and 93JP292 were collected on the basis of distinct but subdued K and U concentrations. Detected elements of possible significance for mineral exploration include Ag and As, Cd, Cu, Mo, Pb, Sb, and Zn (table 1c-1f).

(b) on the west side of the Hitt Mountains in the Forest, sample 93JP211 was collected in an area of relatively low-level K. The sample has detectable Ag and As, Cd, Cu, Mo, Pb, Sb, and Zn (table 1c-1f).

(c) in the drainage between the Hitts and the Cuddy Mountains, on the west side of East Brownlee Creek and in the Forest, sample 92JP205 was collected in an area of subdued U. Analytical results (table 1c-1f) include detectable Ag and As, Cu, Mo, Pb and Zn.

In the Snake River Canyon north of the Oxbow, in the Wallowa terrane of very low radioactivity, a subdued K anomaly was located and sampled (93JP218) along a flight line. Analytical results (table 1b-1f) confirm the aeroradioactivity feature, show detectable but low values for Cd, Cu, Mo, Sb, and Zn, probable background values for the host volcaniclastic rocks.

ANALYSIS OF RADIOELEMENT DATA BY NURE AERIAL CONTRACTORS

NURE program procedures included examination of the aerial survey radioelement data to determine the possibility of U deposit occurrences for each 1-degree by 2-degree quadrangle. The radioelement data - U, Th, K and their ratios - were statistically analyzed with surficial geologic data to determine areas along flight lines where radioelement concentrations were one or more standard deviations from the mean per geologic unit. These areas or "anomalies", their associated geologic units, and known U occurrences were published in the NURE GJBX report for each quadrangle.

In the following discussion, the U, Th, and U:Th features discussed are from NURE statistical analysis for each 1-degree by 2-degree quadrangle that includes part of the Forest.

The western part of the Forest (west of 116-degrees W. long) includes parts of two 1-degree by 2-degree quadrangles, Grangeville (to the northwest) and Baker (to the southwest).

Within the Grangeville quadrangle part of the Forest, geologic units with associated U and(or) Th and(or) U:Th anomalies (Geodata International, Inc., 1981) include Paleozoic metavolcanic, metasedimentary, and metamorphic rocks, Mesozoic metavolcanic, metasedimentary, and intrusive igneous rocks, Tertiary extrusive igneous rocks, and Quaternary glacial deposits. There are no known U occurrences within the Grangeville quadrangle part of the Forest; however, one area of statistically anomalous U occurs at the east side of the quadrangle in the French Creek drainage southwest of Burgdorf, where it is associated with glacial deposits. This anomaly possibly reflects the occurrence of U- (and Th-) bearing minerals in placer (gravel) deposits derived from the adjacent Idaho batholith.

Within the Baker quadrangle part of the Forest, geologic units with associated U and(or) Th and(or) U:Th anomalies (Geodata International, Inc., 1978) include Paleozoic and Mesozoic metasedimentary, metavolcanic, and igneous rocks, Tertiary volcanic and sedimentary rocks, and Quaternary glacial and alluvial deposits. Known U occurrnces in the Baker quadrangle part of the Forest are south of McCall in Long Valley in placer deposits adjacent to the Idaho batholith and also in batholithic rocks. NURE statistical anomalies coincide with several of these occurrences.

The eastern part of the Forest (east of 106 W. long) includes parts of two 1-degree by 2-degree quadrangles, Elk City (to the northeast) and Challis (to the southeast).

Within the Elk City quadrangle part of the Forest, geologic units with associated U and(or) Th and(or) U:Th anomalies (EG&G geoMetrics, 1979) include Proterozic metasedimentary and meta-igneous rocks, Mesozoic intrusive igneous rocks, Tertiary volcanic and plutonic rocks, and Quaternary glacial deposits. The southwest part of the quadrangle (northeast of McCall) in the Idaho batholith is notably deficient in NURE statistical anomalies, indicating very uniform radioelement (U and Th) concentrations. There were no known U occurrences in the Elk City quadrangle part of the Forest.

Within the Challis quadrangle part of the Forest, geologic units with associated U and(or) Th and(or) U:Th anomalies (Geodata International, Inc., 1979) include Proterozoic metasedimentary rocks, Cretaceous intrusive igneous rocks, and the Eocene Challis Volcanic Group. Known U occurrences in the Challis quadrangle part of the Forest are sparse and are not significant. Challis Volcanic Group anomalies would seem to have the best potential for U deposits, but while U and Th anomalies in Challis rocks are relatively common, U:Th anomalies are not, suggesting that the U (and the Th) anomalies reflect lithologic variations not significant for U deposits.

NURE procedures culminated in evaluation of the favorability of certain 1-degree by 2-degree quadrangles for the occurrence of U deposits, with procedures and results published in the DOE PGJ/F series. Geological, geochemical, geophysical, and mining data were used, although tight deadlines on occasion resulted in aerial gamma-ray survey and/or geochemical data not being used because of not being available at the time the evaluation was done. A variety of contractors accomplished the evaluations, and approaches varied considerably.

An evaluation was not accomplished for the Grangeville 1-degree by 2-degree quadrangle.

The evaluation of the Baker 1-degree by 2-degree quadrangle (Bernardi and Robins, 1982) utilized the aerial gamma-ray spectrometer survey, but not the stream sediment geochemical survey. However, the contractors accomplished their own geochemical survey. No geologic environment in the Baker quadrangle part of the Forest was found to be favorable for U deposits. The most likely environment, the gravels (placers) of Long Valley, were determined to be unfavorable because they did not meet grade requirements for uraniferous heavy mineral placer deposits (Bernardi and Robins, 1982, p. 20).

The evaluation of the Elk City 1-degree by 2-degree quadrangle (Leinart and Salisbury, 1982) did not utilize the aerial gamma-ray spectrometer data or the stream sediment geochemical data. It did use specially-acquired helicopter-borne total count (total gamma-ray activity) data, truck-borne scintillation-counter (also total count) data, and geochemical data from several sources, including analyses of samples obtained by the the evaluating contractors. All outcrops of Eocene Challis Volcanic Group rocks within the Elk City quadrangle were considered favorable for volcanogenic U deposits, specifically hydroallogenic and hydroauthigenic deposits (Leinart and Salisbury, 1982, p. 6). Outcrops within the Forest include a sizeable area that is east and southeast of Big Creek, is between Big Creek and Yellow Pine, and extends south from the Elk City quadrangle into the Challis quadrangle where it includes the Thunder Mountain caldera. Other occurrences include relatively smaller outcrops north and northwest of Big Creek.

The evaluation of the Challis quadrangle (Wopat, M.A., and others, 1982), which partly utilized NURE aerial gamma-ray spectrometer and geochemical data, did not result in any part the Challis quadrangle part of the Forest being determined favorable for U deposits. As previously discussed, along the quadrangle's northern border with the Elk City quadrangle, from east of Yellow Pine eastward to the southeastern corner of the Forest, Challis Volcanic Group rocks are a continuation of an outcrop evaluated as favorable for volcanogenic U deposits in the Elk City quadrangle. This area in the Challis quadrangle, although containing possibly favorable host rocks, was an "..unevaluated environment.." because of the lack of diagnositic geologic and geophysical data (Wopat and others, 1982, p. 50).

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Titles for aeroradioactivity tables

Table 1a. Sample numbers, locations, and descriptions of rock-and-soil samples from aerial gamma-ray feature and other sites in the Payette National Forest, Idaho.

Table 1b. Aerial K, U, and Th concentrations, ground K, U, and Th concentrations, and delayed neutron activation analyses (dnaa) for U and Th of rock-and-soil samples from aerial gamma-ray feature and other sites in the Payette National Forest, Idaho.

Table 1c. 10-element ICP-AES analyses of rock-and-soil samples from aerial gamma-ray feature and other sites in the Payette National Forest, Idaho.

Table 1d. 40-element ICP-AES analysis (partial list) of rock-and-soil samples from aerial gamma-ray feature and other sites in the Payette National Forest, Idaho. Ag, Au, B, and Bi were not detected or were present in concentrations less than the detection limit.

Table 1e. 40-element ICP-AES analysis (partial list) of rock-and-soil samples from aerial gamma-ray feature and other sites in the Payette National Forest, Idaho. Eu, Ge, and Ho were not detected or were present in concentrations less than detection limits.

Table 1f. 40-element ICP-AES analysis (concluding list) of rock-and-soil samples from aerial gamma-ray feature and other sites in the Payette National Forest, Idaho. Sn, Ta, U, W, and Zr were not detected or were present in concentrations less than detection limits.

Table 2. Geochemical and geophysical data for selected samples in the area of the Th aeroradioactivity feature. All data from table 1a-1f; REE concentrations (ppm) from icp-aes analyses, P concentrations (%) from icp-aes analyses, Th concentrations (ppm) from ground (gnd) measurements, Th concentrations (ppm) from dnaa analyses, Th concentrations (ppm) from icp-aes (icp) analyses. Geographic location of sample: squaw, Squaw Point; canyon, Salmon River Canyon; sams, Sams Throne.

Titles for aeroradioactivity figures

Figure 1. Potassium aeroradioactivity grey-scale contour map of the Payette National Forest, Idaho. Contour interval 0.1 and 0.2 % K. Geographic locations: Bc = Big Creek, Bu = Burgdorf, Ca = Cambridge, Cu = Cuprum, Do = Donnelly, Mc = McCall, Ri = Riggins, Wa = Warren, Ye = Yellowpine.

Figure 2. Uranium aeroradioactivity grey-scale contour map of the Payette National Forest, Idaho. Contour interval 0.2, 0.25, and 0.5 ppm U. Geographic locations: same as for figure 1.

Figure 3. Thorium aeroradioactivity grey-scale contour map of the Payette National Forest, Idaho. Contour interval 1 and 2 ppm Th. Geographic locations: same as for figure 1.

Figure 4. Uranium:Thorium aeroradioactivity grey-scale contour map of the Payette National Forest, Idaho. Contour interval 0.03, 0.08, and 0.19 ppm U per ppm Th. Geographic locations: same as for figure 1.

Figure 5. Potassium:Thorium aeroradioactivity grey-scale contour map of the Payette National Forest, Idaho. Contour interval 0.03, 0.06, and 0.15 % K per ppm Th. Geographic locations: same as for figure 1.

Table 1a. Sample numbers, locations, and descriptions of rock-and-soil samples from aerial gamma-ray features and other sites in the Payette National Forest, Idaho. [do, ditto]

Field Sample Number	Lab Sample Number	Location Latitude	Location Longitude	Sample Description	Date Collected
92JP201	D517393	44 34'00"	117 04'44"	breccia	1 July 92
92JP202	D517394	44 34'01"	117 04'48"	breccia	do
92JP203	D517395	44 34'06"	117 01'37"	greenstone	do
92JP205	D517397	44 43'56"	116 51'08"	greenstone	2 July 92
92JP206	D517398	45 25'22"	116 02'28"	tonalite	3 July 92
92JP207	D517399	45 13'27"	115 58'07"	monzonite	do
92JP208	D517400	45 13'27"	115 58'07"	diorite	do
93JP209	D535005	44 36'43"	116 56'58"	arkose	18 July 93
93JP211	D535006	44 36'34"	117 00'16"	slate	do
93JP212	D535007	44 34'01"	117 01'41"	breccia	do
93JP292	D535008	44 34'01"	117 01'41"	greenstone	do
93JP218	D535009	45 01'59"	116 49'53"	felsite	21 July 93
93JP219	D535010	45 24'05"	116 06'20"	granitic gneiss	23 July 93
93JP220	D535011	45 24'05"	116 06'20"	biotite-hornblende gneiss	do
93JP221	D535012	45 24'05"	116 06'20"	granitic gneiss	do
93JP222	D535013	45 24'11"	116 05'34"	biotite-hornblende gneiss	do
93JP223	D535014	45 24'12"	116 05'28"	granitic gneiss	do
93JP224	D535015	45 24'34"	116 04'47"	granitic gneiss	do
93JP231	D535016	45 18'07"	116 05'55"	tonalite	26 July 93
93JP232	D535017	45 17'50"	116 05'56"	granodiorite	do
93JP233	D535018	45 13'29"	115 58'20"	granodiorite	do
93JP234	D535019	45 13'29"	115 58'20"	granodiorite	do

Table 1b. K, U, and Th concentrations from aerial measurements, K, U, and Th concentrations from ground measurements, and delayed neutron activation analyses (dnaa) for U and Th of rock-and-soil samples from aerial gamma-ray features and other sites in the Payette National Forest, Idaho. [CV, coefficient of variation; do, ditto]

Field Sample Number	Aerial concentrations			Ground concentrations			DNAA			
	K,%	U,ppm	Th,ppm	K,%	U,ppm	Th,ppm	U,ppm	CV	Th,ppm	CV
92JP201	2.0-2.2	2.4-2.6	6-7	4.7	11.2	22.5	13.2	1	20.3	8
92JP202	2.0-2.2	2.4-2.6	6-7	5.3	13.3	23.8	18.8	2	26.5	9
92JP203	1.6-1.8	1.4-1.6	4-5	1.8	0.7	3.8	1.3	6	<2.1	-
92JP205	1.2-1.4	1.4-1.6	5-6	0.5	0.3	2.4	0.6	9	2.0	26
92JP206	1.6-1.8	1.0-1.2	10-12	2.6	2.0	13.7	0.8	7	8.1	8
92JP207	off flight line			5.1	4.5	25.8	0.5	10	4.1	13
92JP208	do			3.5	1.8	23.0	2.1	3	17.4	5
93JP209	1.6-1.8	1.8-2.0	6-7	5.1	4.3	20.3	6.2	2	21.4	5
93JP211	1.6-1.8	1.4-1.6	4-5	2.2	2.3	6.5	3.5	2	4.3	20
93JP212	1.6-1.8	1.4-1.6	4-5	2.0	0.7	3.5	0.9	5	2.8	17
93JP292	do				~do		0.7	6	2.5	19
93JP218	1.2-1.4	0.4-0.6	<2	3.3	0.1	1.9	1.1	5	2.3	23
93JP219	1.4-2.2	1.0-1.6	10->15	2.2	3.0	20.0	2.9	2	18.2	5
93JP220	~do			3.9	2.0	7.9	1.6	4	2.0	29
93JP221	~do			2.6	4.2	19.6	1.7	4	10.3	6
93JP222	~do			3.7	3.1	13.1	1.3	4	4.2	13
93JP223	~do			4.6	7.3	41.7	9.1	1	30.9	4
93JP224	~do			1.2	6.7	40.9	5.0	2	31.7	3
93JP231	off flight line			2.4	1.3	14.6	1.5	4	13.2	5
93JP232	do			2.8	1.3	28.1	0.7	6	18.4	4
93JP233	do			not available			0.8	6	11.8	5
93JP234	do			not available			3.1	2	13.3	6

Table 1c. 10-element ICP-AES analyses of rock-and-soil samples from aerial gamma-ray features and other sites in the Payette National Forest. [all values in ppm; --, not detected or below detection limits]

Field Sample Number	------------- 10-element ICP-AES, ppm ---------------								
	Ag	As	Au	Bi	Cd	Cu	Mo	Pb	Sb	Zn
92JP201	--	88.	--	--	0.094	13.	2.3	17.	2.9	57.
92JP202	--	330.	--	--	.14	20.	120.	97.	13.	26.
92JP203	0.14	3.3	--	--	.17	31.	.68	2.3	--	100.
92JP205	0.093	1.1	--	--	--	6.8	.5	14.	--	41.
92JP206	--	--	--	--	--	7.3	.31	1.9	--	63.
92JP207	--	--	--	--	--	2.1	--	2.5	--	35.
92JP208	--	--	--	--	--	2.1	.088	1.8	--	4.8
93JP209	--	1.1	--	--	.06	7.7	.26	4.4	--	6.3
93JP211	.18	19.	--	--	.89	40.	7.6	7.8	5.	79.
93JP212	.11	9.5	--	--	.24	25.	.17	14.	.85	110.
93JP292	.079	8.2	--	--	.27	24.	.11	11.	1.5	66.
93JP218	--	--	--	--	.054	5.1	.091	.68	--	36.
93JP219	--	--	--	--	--	48.	.38	2.6	--	17.
93JP220	--	--	--	--	--	21.	.51	.82	--	51.
93JP221	--	3.2	--	--	--	7.5	.47	--	--	30.
93JP222	--	--	--	--	--	7.	1.	.95	--	37.
93JP223	--	--	--	--	--	9.5	2.3	1.1	--	6.9
93JP224	--	--	--	--	--	3.	.19	1.4	--	4.7
93JP231	--	--	--	--	--	3.1	--	1.1	--	76.
93JP232	--	--	--	--	--	1.7	--	1.2	--	10.
93JP233	--	--	--	--	--	3.	.063	1.1	--	77.
93JP234	--	--	--	--	--	7.5	--	2.1	--	75.

Table 1d. 40-element ICP-AES analysis (partial list) of rock-and-soil samples from aerial gamma-ray features and other sites in the Payette National Forest. Ag, Au, B, and Bi were not detected or were present in concentrations less than detection limits. [major elements in %; minor in ppm; --, not detected or below detection limits]

Field Sample Number	%								ppm			
	Al	Ca	Fe	K	Mg	Na	P	Ti	Mn	As	Ba	Be
92JP201	6.7	0.05	0.71	5.1	0.06	1.7	0.02	0.12	39.	97.	1200.	1.
92JP202	6.6	0.04	2.3	5.7	0.14	0.39	0.01	0.14	60.	320.	780.	1.
92JP203	7.6	0.86	3.7	1.9	1.5	1.3	0.05	0.29	860.	--	790.	--
92JP205	8.8	2.5	6.8	0.37	2.3	4.8	0.11	0.49	12000.	--	380.	--
92JP206	9.2	3.5	3.3	1.7	1.3	2.8	0.09	0.4	580.	--	1000.	1.
92JP207	7.7	1.8	0.86	2.4	0.18	2.9	0.01	0.08	310.	--	2000.	1.
92JP208	7.9	2.	2.5	2.9	0.6	2.6	0.1	0.37	400.	--	1400.	3.
93JP209	7.	0.1	0.72	5.8	0.13	1.3	0.01	0.14	37.	--	780.	1.
93JP211	7.9	0.1	3.7	2.2	1.3	2.2	0.1	0.4	180.	21.	1200.	1.
93JP212	5.8	3.8	3.6	1.4	1.1	1.6	0.03	0.3	940.	16.	1700.	--
93JP292	8.1	5.1	4.3	2.7	1.1	1.8	0.04	0.39	770.	12.	950.	--
93JP218	6.4	1.5	1.3	1.5	0.54	2.5	0.02	0.13	360.	--	210.	--
93JP219	8.1	6.2	3.3	0.72	1.2	1.3	0.05	0.36	740.	--	280.	2.
93JP220	8.5	2.6	3.4	1.8	1.3	2.8	0.09	0.47	340.	--	430.	2.
93JP221	5.3	1.1	3.5	1.5	0.82	1.5	0.02	0.33	780.	--	300.	1.
93JP222	8.5	4.3	7.1	2.7	1.6	3.4	0.34	1.3	1300.	--	710.	3.
93JP223	6.9	0.58	0.79	2.8	0.1	3.4	0.009	0.08	58.	--	140.	5.
93JP224	7.	0.17	0.43	0.98	0.24	5.	--	0.05	54.	--	58.	3.
93JP231	8.9	2.3	2.7	2.6	0.74	3.	0.09	0.31	330.	--	1500.	3.
93JP232	7.	1.	0.53	4.9	0.12	1.5	0.007	0.05	55.	--	4500.	--
93JP233	8.6	2.9	3.3	2.6	1.	2.5	0.09	0.39	550.	--	1300.	2.
93JP234	10.	4.3	3.6	1.5	1.1	3.5	0.18	0.63	630.	--	450.	3.

Table 1e. 40-element ICP-AES analysis (partial list) of rock-and -soil samples from aerial gamma-ray features and other sites in the Payette National Forest, Idaho. Eu, Ge, and Ho were not detected or were present in concentrations less than detection limits. [all values in ppm; --, not detected or below detection limits]

Field Sample Number	Cd	Ce	Co	Cr	Cu	Ga	La	Li	Mo	Nb
	ppm									
92JP201	--	37.	--	2.	13.	12.	17.	--	--	5.
92JP202	--	28.	--	4.	20.	13.	14.	3.	120.	6.
92JP203	--	11.	13.	9.	41.	14.	5.	33.	--	--
92JP205	--	17.	11.	10.	3.	16.	8.	9.	--	--
92JP206	--	56.	11.	24.	6.	20.	36.	26.	--	12.
92JP207	--	18.	--	2.	5.	16.	13.	21.	--	8.
92JP208	--	130.	4.	2.	3.	21.	82.	32.	--	19.
93JP209	--	36.	--	2.	9.	13.	17.	7.	--	7.
93JP211	--	22.	1.	100.	45.	16.	10.	33.	6.	7.
93JP212	--	12.	15.	14.	34.	11.	5.	24.	--	--
93JP292	--	17.	11.	18.	30.	16.	8.	25.	--	--
93JP218	--	34.	2.	2.	5.	14.	16.	4.	--	4.
93JP219	--	84.	14.	75.	57.	20.	46.	12.	--	13.
93JP220	--	27.	14.	66.	24.	22.	14.	28.	--	20.
93JP221	--	13.	11.	60.	8.	14.	7.	13.	--	14.
93JP222	--	110.	20.	--	5.	28.	56.	12.	--	38.
93JP223	--	45.	2.	1.	11.	24.	27.	10.	--	51.
93JP224	--	68.	--	--	1.	21.	41.	8.	--	36.
93JP231	--	79.	5.	3.	2.	23.	52.	22.	--	15.
93JP232	--	87.	1.	--	1.	11.	66.	6.	--	6.
93JP233	--	88.	8.	9.	3.	21.	53.	32.	--	16.
93JP234	--	120.	9.	4.	9.	28.	67.	32.	--	30.

Table 1f. 40-element ICP-AES analysis (partial list) of rock-and soil samples from aerial gamma-ray features and other sites in the Payette National Forest, Idaho. Sn, Ta, U, W, and Zr were not detected or were present in concentrations less than detection limits. [all values in ppm; --, not detected or below detection limits]

Field Sample Number	Nd	Ni	Pb	Sc	Sr	Th	V	Y	Yb	Zn
	ppm									
92JP201	20.	--	22.	4.	77.	20.	13.	21.	3.	68.
92JP202	15.	--	93.	9.	65.	23.	29.	11.	2.	35.
92JP203	7.	3.	8.	18.	130.	--	140.	15.	2.	120.
92JP205	13.	4.	15.	30.	210.	--	220.	28.	3.	61.
92JP206	23.	6.	11.	9.	710.	7.	84.	9.	--	83.
92JP207	8.	--	20.	--	680.	5.	7.	2.	--	40.
92JP208	52.	--	14.	5.	490.	16.	41.	14.	1.	52.
93JP209	16.	--	9.	5.	82.	18.	14.	19.	3.	16.
93JP211	9.	13.	7.	15.	100.	6.	200.	12.	2.	95.
93JP212	5.	6.	17.	11.	140.	--	170.	12.	1.	130.
93JP292	16.	5.	12.	14.	190.	6.	180.	16.	2.	85.
93JP218	22.	--	--	7.	32.	--	11.	18.	2.	50.
93JP219	38.	33.	--	13.	270.	15.	67.	20.	2.	36.
93JP220	11.	21.	6.	7.	380.	--	74.	7.	--	58.
93JP221	5.	11.	9.	9.	170.	--	50.	17.	2.	34.
93JP222	54.	--	--	14.	510.	4.	170.	39.	3.	91.
93JP223	19.	--	--	--	57.	28.	4.	27.	3.	7.
93JP224	24.	--	--	--	50.	30.	--	21.	2.	4.
93JP231	27.	--	11.	3.	580.	14.	43.	8.	--	84.
93JP232	25.	--	20.	--	570.	18.	10.	--	--	12.
93JP233	32.	3.	10.	16.	550.	9.	64.	16.	1.	80.
93JP234	59.	--	--	8.	760.	11.	81.	23.	2.	84.

Table 2. Geochemical and geophysical data for selected samples in the area of the Th aeroradioactivity feature. All data from table 1a-1f; REE concentrations (ppm) from icp-aes analyses, P concentrations (%) from icp-aes analyses, Th concentrations (ppm) from ground (gnd) measurements, Th concentrations (ppm) from dnaa analyses, Th concentrations (ppm) from icp-aes (icp) analyses. Geographic location of sample: squaw, Squaw Point; canyon, Salmon River Canyon; sams, Sams Throne. [nd, not determined]

Field Sample Number	La	Ce	Nd	Yb	Y	P	gnd Th	dnaa Th	icp Th
92JP208 (squaw)	82	130	52	1	14	0.1	23.0	17.4	16
93JP233 (squaw)	53	88	32	1	16	0.09	nd	11.8	9
93JP234 (squaw)	67	120	59	2	23	0.18	nd	13.3	11
93JP219 (canyon)	46	84	38	2	20	0.05	20.0	18.2	15
93JP222 (canyon)	56	110	54	3	39	0.34	13.1	4.2	4
93JP223 (canyon)	27	45	19	3	27	0.009	41.7	30.9	28
93JP224 (canyon)	41	68	24	2	21	nd	40.9	31.7	30
93JP231 (sams)	52	79	27	nd	8	0.09	14.6	13.2	14
93JP232 (sams)	66	87	25	nd	nd	0.007	28.1	18.4	18

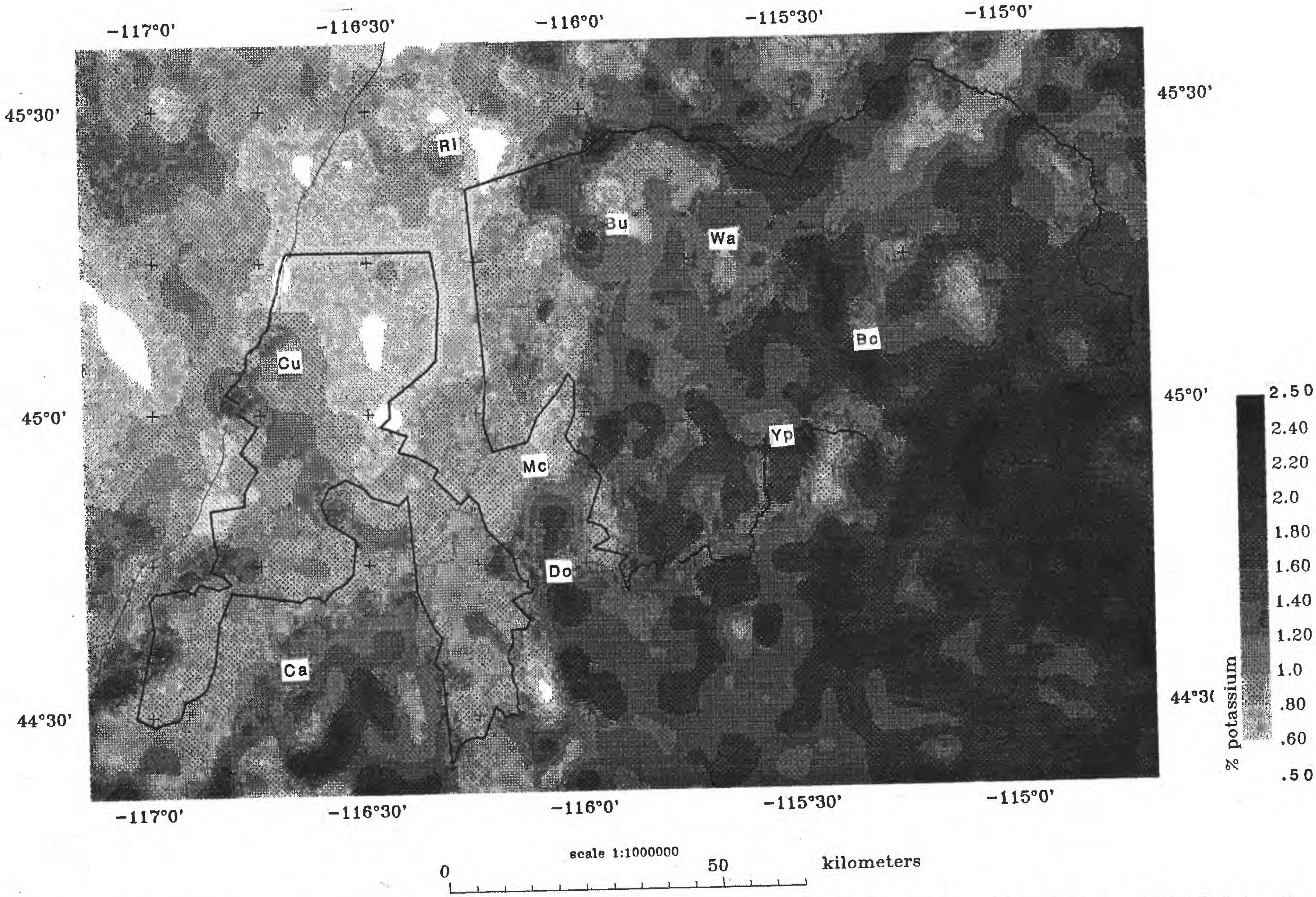

Figure 1. Potassium aeroradioactivity grey-scale contour map of the Payette National Forest, Idaho. Contour interval 0.1 and 0.2 % K. Geographic locations: Bc = Big Creek, Bu = Burgdorf, Ca = Cambridge, Cu = Cuprum, Do = Donnelly, Mc = McCall, Ri = Riggins, Wa = Warren, Ye = Yellowpine.

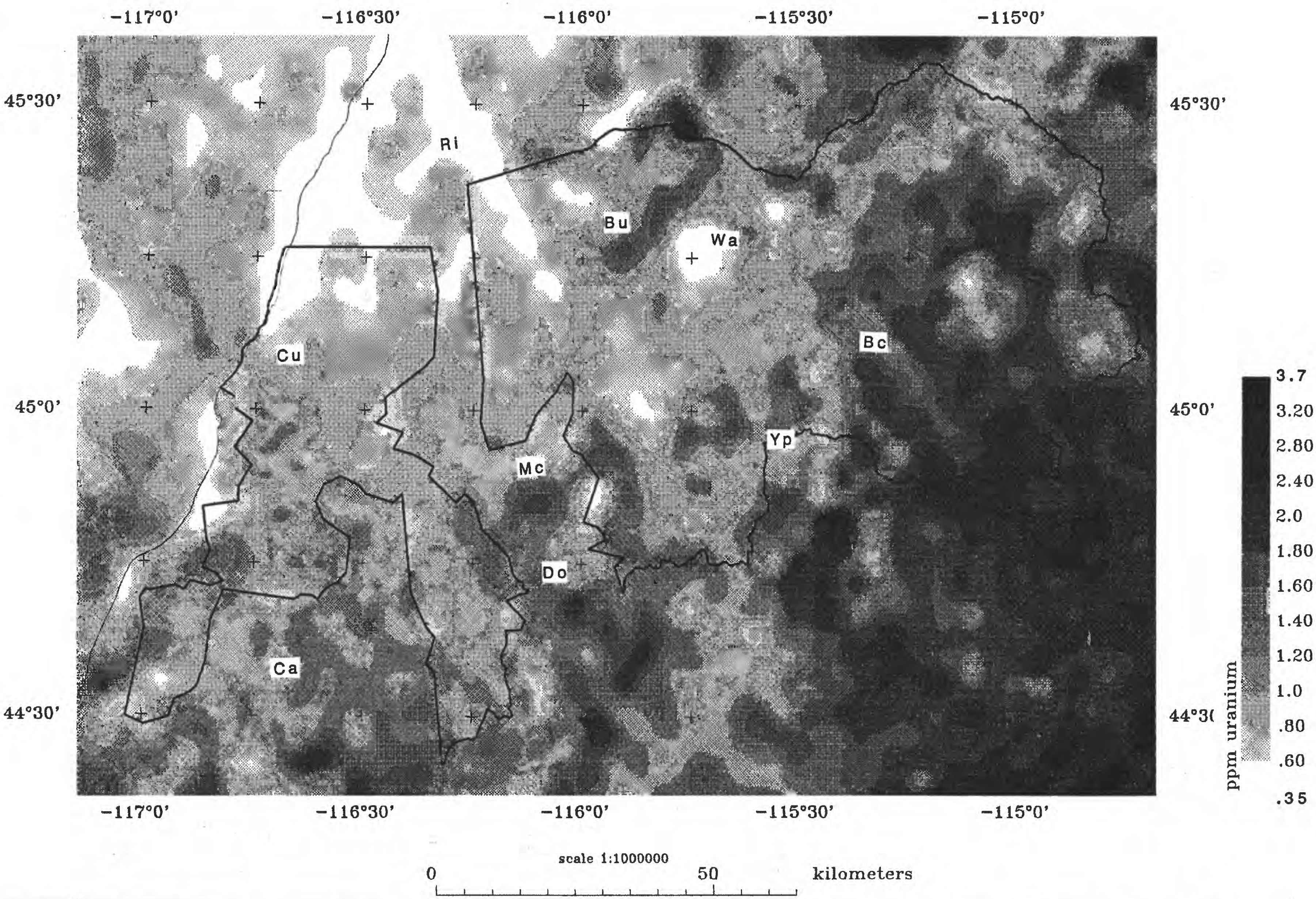

Figure 2. Uranium aeroradioactivity grey-scale contour map of the Payette National Forest, Idaho. Contour interval 0.2, 0.25, and 0.5 ppm U. Geographic locations: Bc = Big Creek, Bu = Burgdorf, Ca = Cambridge, Cu = Cuprum, Do = Donnelly, Mc = McCall, Ri = Riggins, Wa = Warren, Ye = Yellowpine.

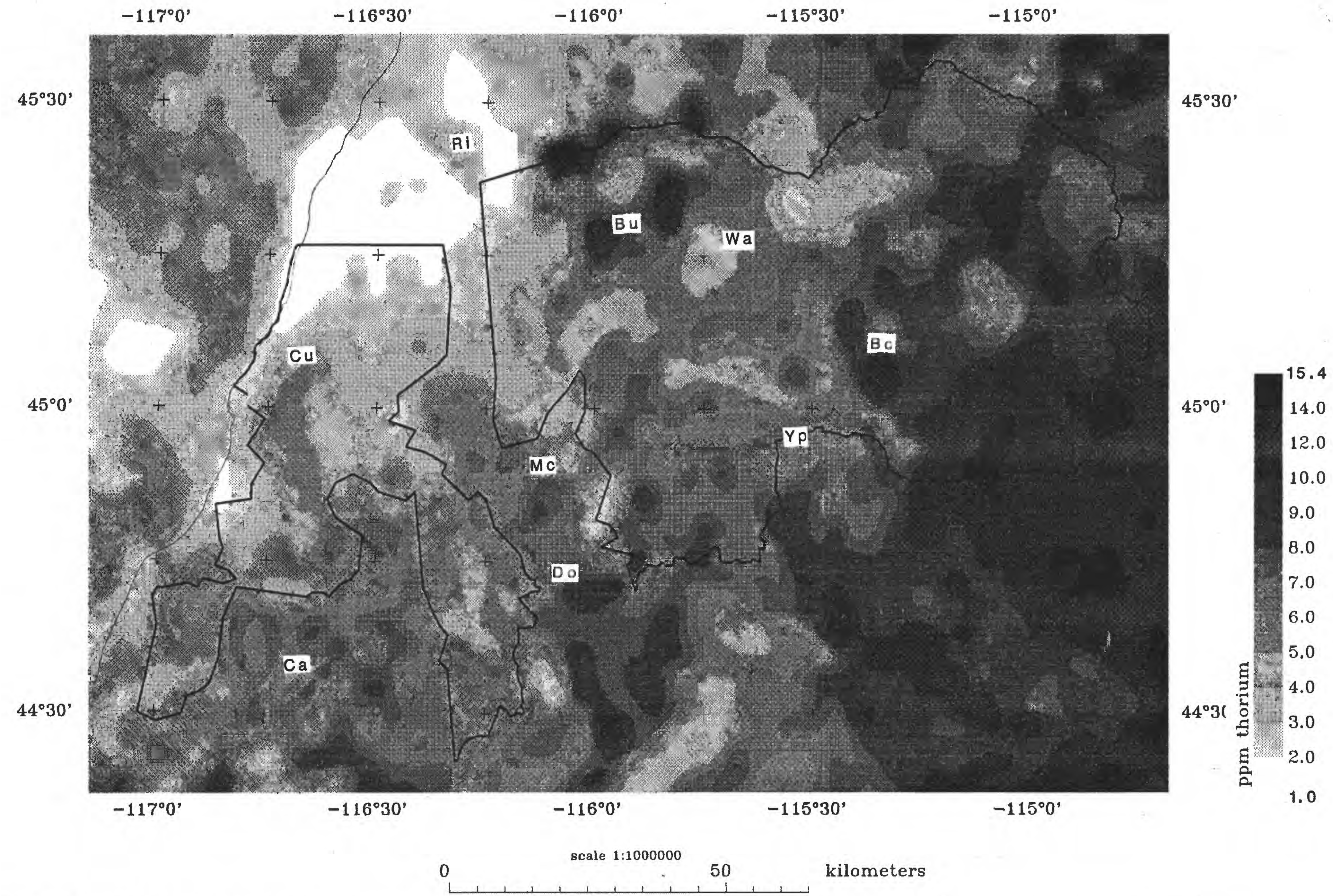

Figure 3. Thorium aeroradioactivity grey-scale contour map of the Payette National Forest, Idaho. Contour interval 1 and 2 ppm Th. Geographic locations: Bc = Big Creek, Bu = Burgdorf, Ca = Cambridge, Cu = Cuprum, Do = Donnelly, Mc = McCall, Ri = Riggins, Wa = Warren, Ye = Yellowpine.

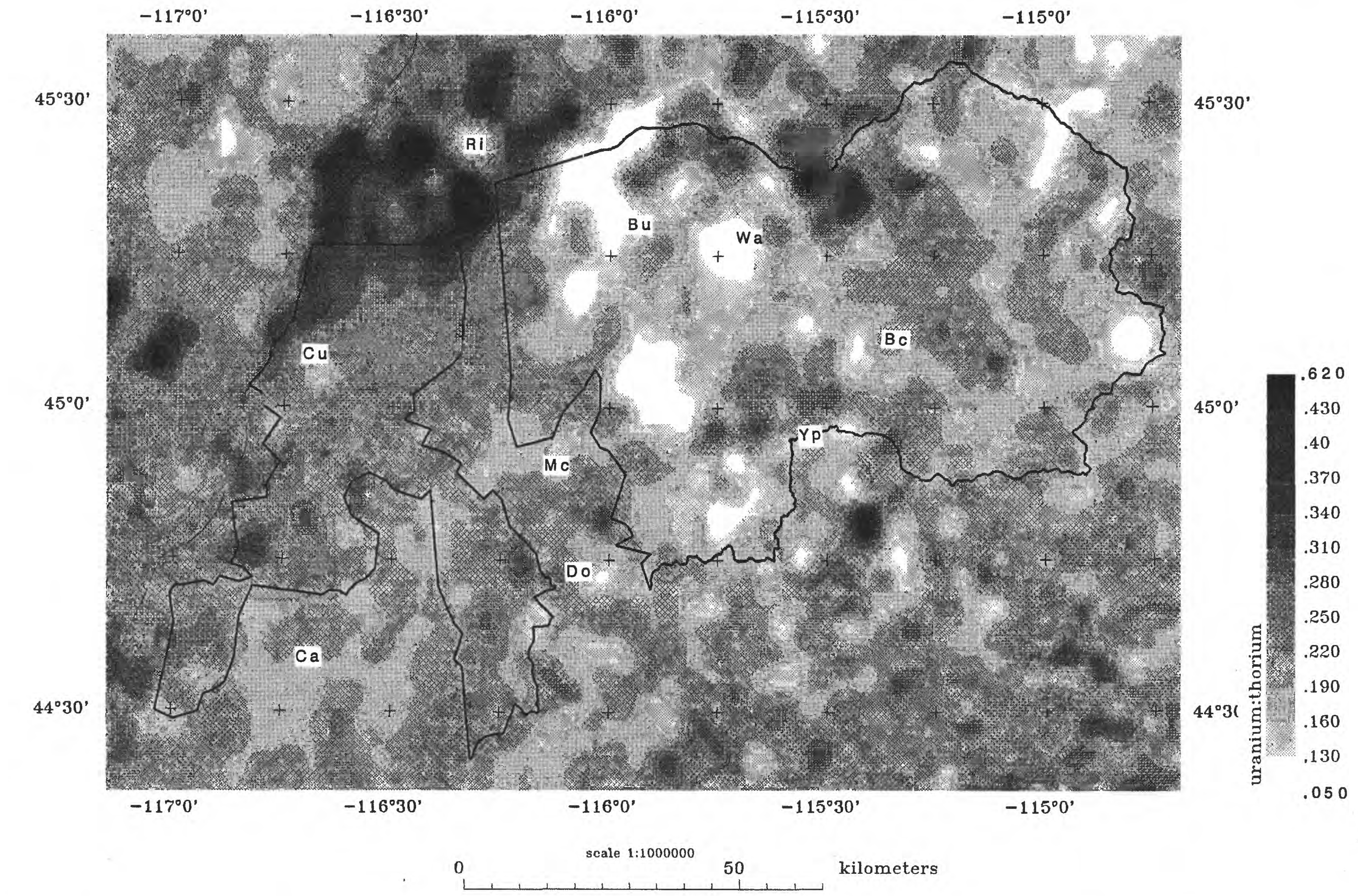

Figure 4. Uranium:Thorium aeroradioactivity grey-scale contour map of the Payette National Forest, Idaho. Contour interval 0.03, 0.08, and 0.19 ppm U per ppm Th. Geographic locations: Bc = Big Creek, Bu = Burgdorf, Ca = Cambridge, Cu = Cuprum, Do = Donnelly, Mc = McCall, Ri = Riggins, Wa = Warren, Ye = Yellowpine.

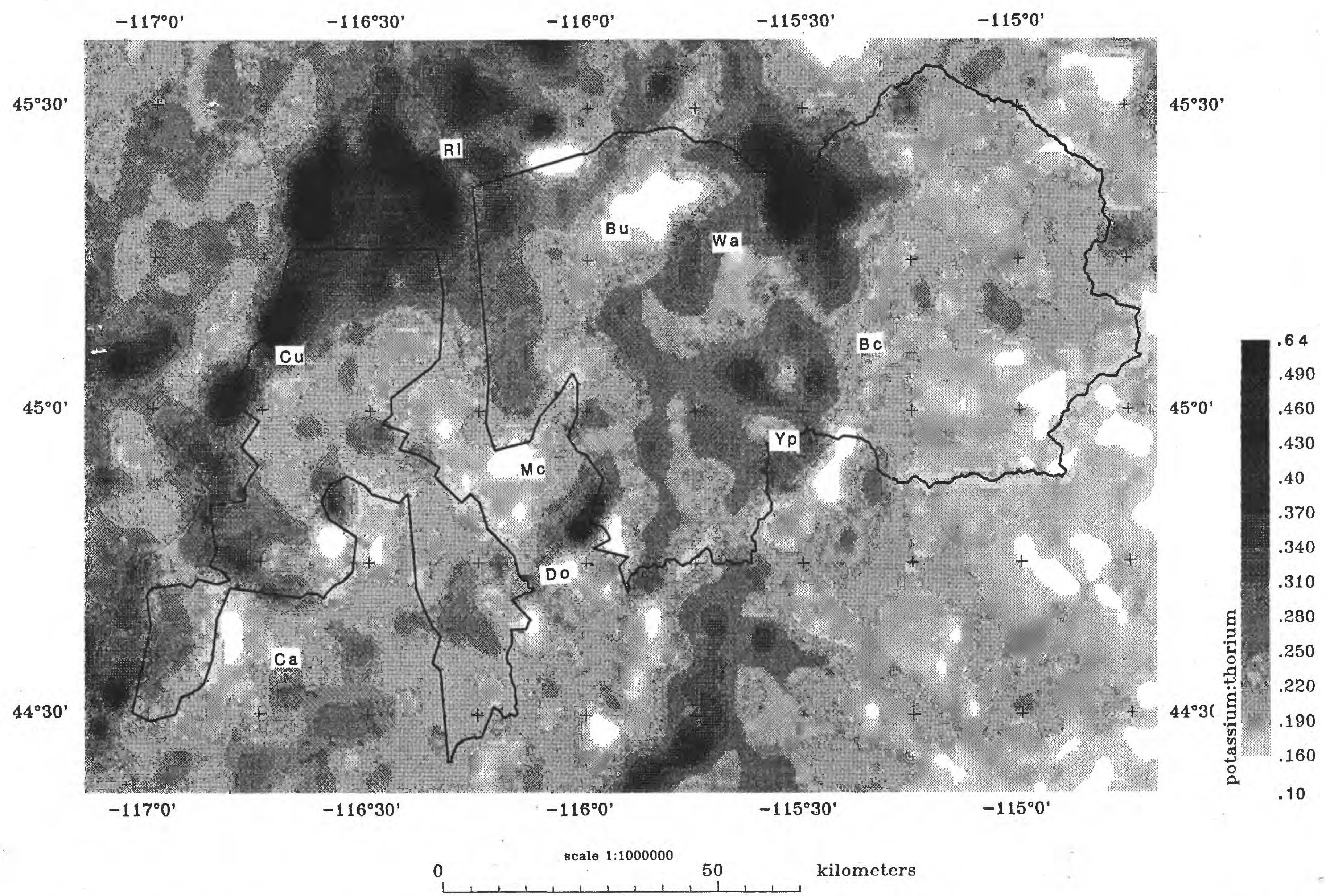

Figure 5. Potassium:Thorium aeroradioactivity grey-scale contour map of the Payette National Forest, Contour interval 0.03, 0.06, and 0.15 % K per ppm Th. Geographic locations: Bc = Big Creek, Bu = Burgdorf, Ca = Cambridge, Cu = Cuprum, Do = Donnelly, Mc = McCall, Ri = Riggins, Wa = Warren, Ye = Yellowpine.