UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

AN ASSESSMENT OF METAL ENDOWMENTS IN REVETT-TYPE SEDIMENT HOSTED CU DEPOSITS IN THE KOOTENAI NATIONAL FOREST, MONTANA AND IDAHO

by

G. T. Spanski(1) and G.E. McKelvey(2)

Open-File Report 90-470

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

(1) U.S. Geological Survey, Denver, CO 80225
(2) U.S. Geological Survey, Tucson, AZ 85705

1990

CONTENTS

ILLUSTRATIONS

TABLES

APPENDIX

INTRODUCTION

This study was undertaken by the U.S. Geological Survey (USGS) in response to a request from the Northern Region of the U.S. Forest Service (USFS) to perform a quantitative assessment of the mineral endowment for copper and silver resources occurring within the Revett Formation on lands in the Kootenai National Forest (KNF) and portions of the Kaniksu National Forest administered by the Kootenai Forest management. Results of the study are to be used by the USFS in future land-use planning activities and by the U.S. Bureau of Mines (USBM) as input to a potential minerals supply analysis to develop economic projections related to the future development of as yet undiscovered deposits (U.S.B.M., 1990).

The study area encompasses approximately 2.3 million acres of Federal forest lands located in Lincoln and Sanders Counties in extreme northwestern Montana and in portions of Bonner and Boundary Counties in Idaho. Principle physiographic features are the northwest trending Purcell and Cabinet Mountains and Bitteroot Range. Major drainages crossing the area generally from east to west are the Kootenai and Clark Fork Rivers. Local relief reaches 5,000 ft. in the vicinity of the Cabinet Mountains and 3,000 ft. is common elsewhere. With the exception of the Cabinet Mountains Wilderness which covers 94,274 acres of the Cabinet Mountains Range, forest lands are open to mineral entry.

The forest lands have been of prospective interest for copper, silver, gold, lead, and zinc since the 1880's. Early prospecting targets and mines were developed on vein and placer type mineralization. In the early 1960's the first "ore grade", stratabound, disseminated argentiferous copper mineralization was discovered hosted in quartzites of the Revett Formation. The Troy mine near Spar Lake (fig. 1) currently produces from this original Revett discovery. Rigorous surface exploration and drilling during the succeeding 25 years has shown that similar

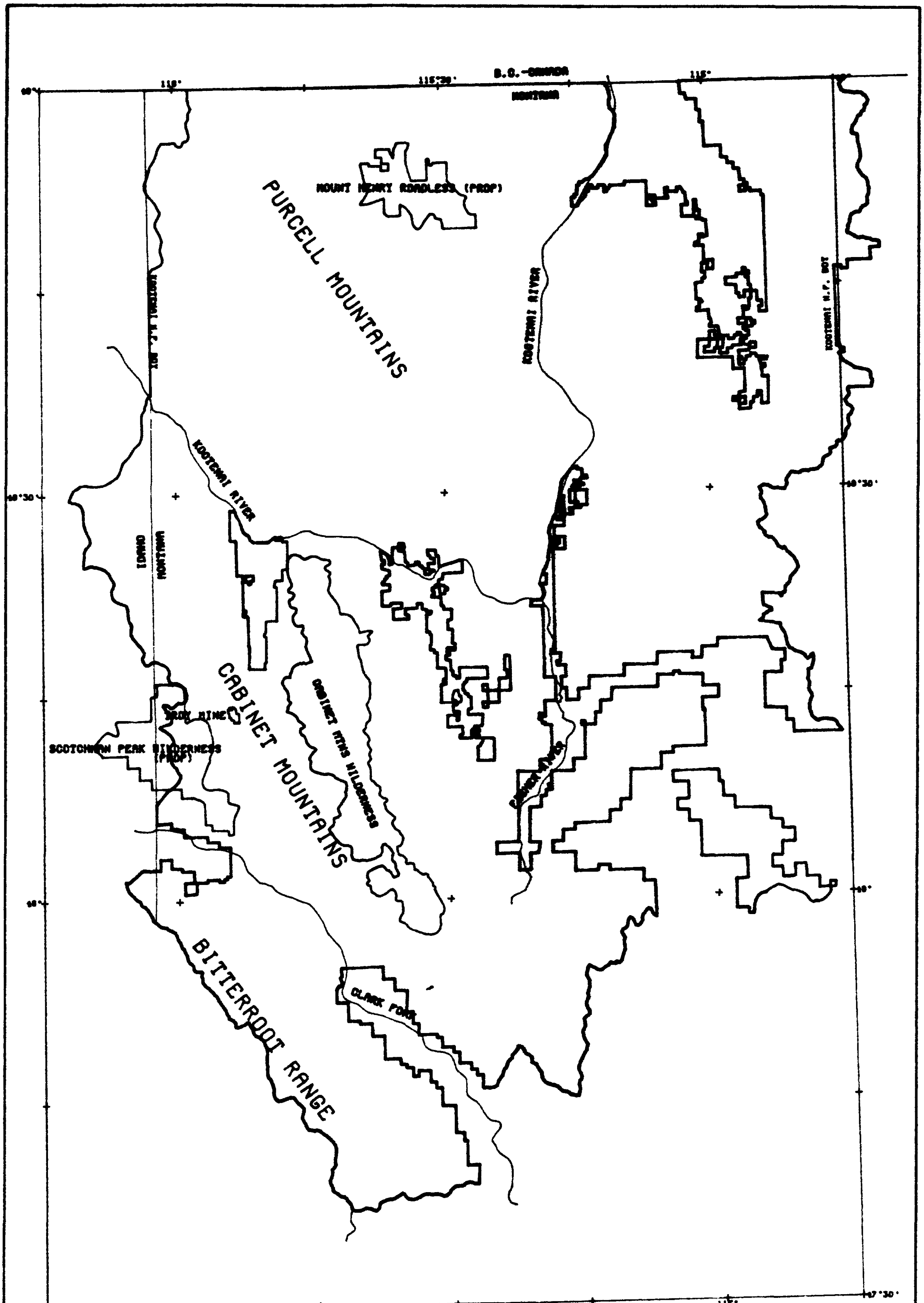

FIGURE 1.–Map showing the boundaries of the Kootenai N.F. and portions of the Kaniksu N.F. included in the assessment with the location of the Troy Mine and areas designated as wilderness or proposed for wilderness or roadless area designation. Scale approx. 1:800,000

stratabound copper-silver mineralization in quartzites of the Revett Formation occurs at many locations in the southwestern third of the study area. Locations of these additional occurrences are shown in figure 2. The latter area falls within a continuous north trending zone of mineralization known as the "western Montana copper sulfide belt" which extends from the Coeur d'Alene District on the south to near the Canadian border on the north. It has become a promising exploration target area for copper and silver deposits hosted in Revett quartzites which hereafter are simply referred to as Revett-type deposits.

The USFS request specifically limited the scope of this joint USGS-USBM investigation to evaluating the potential future economic impacts attributable to the mining of copper-silver from deposits of the Revett-type. Primary USGS responsibilities include (1) identification of favorable areas for Revett-type mineralization; (2) estimation of the probable number of deposits that remain to be discovered; and (3) estimation of the probable endowment of copper and silver contained in both undiscovered deposits and known but incompletely explored deposits.

An assessment team composed of USGS economic geologists with the assistance of other USGS specialists and in conjunction with personnel from the USBM, USFS and the Montana Bureau of Mines and Geology, performed the reviews of published reports and data contained in the files of Federal agencies and conducted the analyses required to select permissive terranes and make estimates of deposits. Metal endowments were estimated using the Mark3 Simulator computer software developed by the USGS. The assessment methodology used follows closely that described by Singer (1984), Drew and others (1986), Singer and Cox (1988), and by Root and others (in press), to which the reader is referred for more specific details on the procedure.

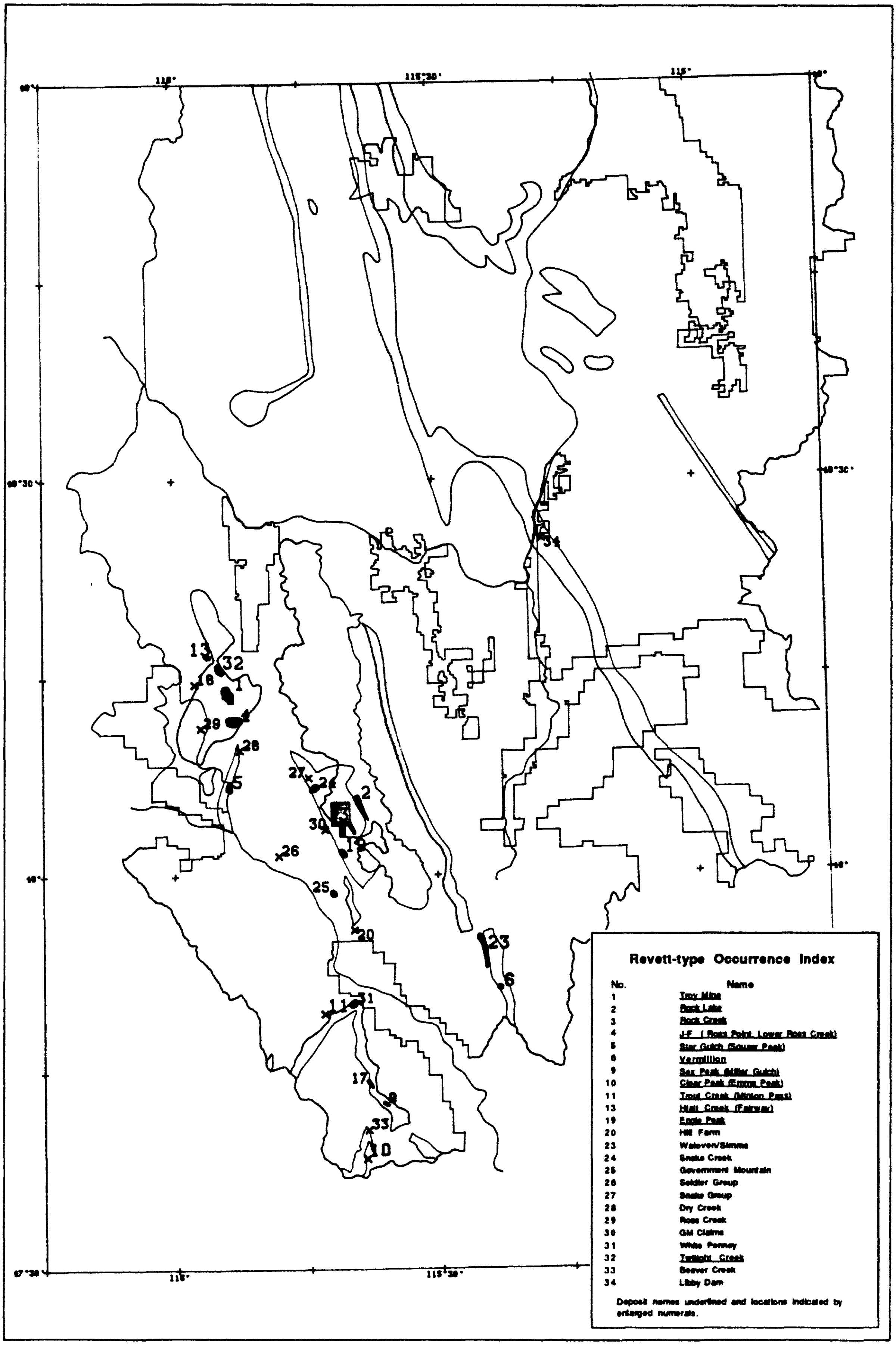

FIGURE 2.--Shows the approximate locations of 26 identified Revett-type mineral occurrences and deposits and the approximate areal extent of Revett Formation bedrock exposure. Scale approx. 1:800,000. ⬭-Area of deposit. x-Location of deposit.

GEOLOGIC REVIEW

The mineral resource assessment process begins with a thorough examination of all available information bearing on the geology of the Revett Formation and the character of known Revett-type mineral occurrences. The data is then analyzed in order to identify those geologic attributes that appear to be spatially or genetically related to the mineralization and can be used to identify permissive host terranes. This study benefitted greatly from the extensive volume of published studies on both the geology of the region and the Revett-type deposits, as well as, geochemical and geophysical data contained in various USGS data base systems. An extended listing of published materials examined during the course of the assessment can be found in the reference section of the report.

Geologic Analysis

The study area lies entirely within the Belt Basin; an area geologically defined by surficial exposure of Proterozoic age rocks belonging to the Belt Supergroup. The Belt Supergroup consists of a +35,000 foot thick section of generally fine-grained metasedimentary argillites, siltites, quartzites and carbonates deposited between 1,685 and 850 m.y. ago in an epicratonic re-entrant seaway lying along the western edge of the Precambrian North American craton (Harrison, 1972). The section has been subdivided from oldest to youngest into four major divisions which are the Lower Belt (Prichard Fm.), the Ravalli Group, the Middle Belt Carbonate (Wallace or Helena Fm.) and the Missoula Group. The name Revett Formation is applied to an interbedded sequence of quartzites, argillites and siltites that occurs near the middle of the Ravalli Group and includes all rocks between the first and last appearances of prominent well-sorted, quartzite units in the Ravalli Group. In turn, the Revett has been informally divided into a lower, a middle and an upper member. Quartzite units occur with greatest frequency in the lower and upper members, whereas argillites and siltites are dominant in the middle member and occur interlayered with quartzites in the other members.

The Revett Formation has been recognized (Harrison, 1972; White et al, 1984; Winston, 1986) as being representative of deposition in a fluviodeltaic environment in which sediment spread to the north and east across the study area to the Belt seaway from a source area in central Idaho. Cross-bedded and flat laminated, very fine- to medium-grained, well sorted quartzite units represent sedimentation in stream and tidal channels and in prograding, high-energy beach, bar and nearshore slope environments. The finer grained siltites and argillites represent sedimentation on tidal flats and floodplains. The wedge shaped geometry of the Revett is clearly demonstrated in an isopach map reconstruction by Harrison (1972). It shows the general thinning that occurs from a +2,200 foot thickness at the southwest edge of the area to a near zero thickness at the northeast boundary. The thinning is affected by the pinching out of individual quartzite units or through their lateral transition into siltite or argillite. In a measured section at the Troy mine, the Revett exceeds 1,800 feet in thickness of which 650 feet (36%) are well sorted quartzites occurring in nine named beds. Each named bed is a composite of many thinner quartzite units ranging in thickness from less than a half meter to rarely over 1 meter. Minor intervening fine grained non-quartzite units occur within these predominately quartzite beds. The Troy mine section is generally accepted as being representative of the Revett Formation in that part of the study area lying within the "western Montana copper sulfide belt", although large local variations in quartzite thickness may occur.

Hayes and Einaudi (1986) provide the most detailed petrologic descriptions for both the Revett Formation and the Revett-type deposits and insights concerning the genesis of the deposits. They describe the Revett quartzites as having been relatively immature sandstone deposits containing up to 10% detrital feldspars, some lithic clasts, a diverse assemblage of heavy minerals and minor clay. In some areas, ferric iron oxide grain coatings developed in early diagenesis to yield red beds, but in other areas, clay, pyrite and titanium oxides were early cements instead. Well preserved primary textures suggest a sediment possessing high initial porosity with excellent permeability. Superimposed on this simple mineralogy is a complex, zoned suite of authigenic minerals introduced during a period of post depositional diagenesis and altered by a succeeding period of weak burial metamorphism. The latter events occurred in response to burial of the Revett sediments beneath a minimum of 15,000 feet of post Revett, Belt age deposition (Harrison, 1972). The following is a listing of relationships and associations they observed and conclusions they drew that were found to be helpful to the assessment process:

(1) copper sulfide and native silver mineralization developed during the middle stage of diagenesis as an intergranular cement;

(2) "ore grade" mineralization occurs only in the coarser grain quartzite facies where argentiferous chalcocite, bornite and digenite are the predominant sulfides with native silver;

(3) quartzites deposited in subtidal channel environments serve as the most favorable hosts for mineralization that reaches "ore grade" concentrations;

(4) "ore grade" mineralization can occur in more than one quartzite unit in vertically stacked sequences of quartzites and argillites; and "ore grade" zones can cut gently across quartzite units within the area of a deposit;

(5) authigenic K-feldspar overgrowths on detrital K-feldspar developed contemporaneously with the sulfides; and

(6) certain lavender colored quartzites are the simple burial metamorphic equivalent of red bed sandstones that have not been exposed to the copper sulfide mineralizing solutions.

Several alternative explanations for the genesis of the Revett-type deposits have been offered by other investigators. Harrison (1972) draws attention to the coincidence of the "western Montana copper sulfide belt" with an apparent regional dome of uplift that developed during early Missoula time. He suggests that the permeable Revett sandstone units near the crest of the dome served as stratigraphic traps into which copper bearing solutions migrated from deeper regions of the basin. He also notes the favored association between anomalous copper sulfide mineralization and the chlorite rich, green facies of the Revett where Fe occurs in the reduced state, as opposed to the lavender and purple facies in which Fe is oxidized. Lange and Sherry (1983) emphasize the importance of hypothesized syndepositional basement controlled faults in providing access for copper-silver bearing solution to the Revett sediments. In support of their hypothesis, they call attention to the close spatial association of mineralization with northwest striking faults at the Spar Lake, Rock Creek, Emma Peak, Ross Point (J-F) and Minton Pass deposits. Hayes and others (1989) suggest that the faults forming the graben to the east of the Spar Lake deposit are likely conduits for the long-distance transport of deep basinal fluids. At the Spar Lake, Star Gulch, Minton Pass, Rock Lake and Rock Creek occurrences, repetition of zones of mineralization occurs at different stratigraphic intervals along cross cutting faults. At Spar Lake, Rock Creek and Rock Lake the mineralization is found in higher stratigraphic intervals in down thrown blocks such that its elevation may have been maintained across faults at the time of ore genesis, suggesting pre- or syn-ore fault offset. All of the above relationships and associations were taken into consideration in formulating criteria to be used to identify permissive host terrane for Revett-type mineralization and estimate the degree of favorability as reflected in the number of deposits estimated.

Two important tectonic events are cited as playing significant roles in determining the size and distribution of Revett-type mineral occurrences. The first of these events was the subsidence of the Belt Basin which led to the eventual accumulation of a maximum of 20 km. of sediment (Harrison et al., 1980). There is general agreement that the conditions generated in the deeper portions of the sediment pile by sediment loading were conducive to the development of the Revett-type deposits and that the number, sizes and sites of occurrences were all firmly established before the close of the Proterozoic.

The second event began in the Cretaceous and continued into the early Tertiary and was the intense crustal compression that resulted in the development of the Rocky Mountain fold and thrust belt. Within the study area which lies entirely within the western half of the fold and thrust belt, the Belt Supergroup sequence underwent an east-west foreshortening affected through the development of north trending openfolds and a complex of major and minor east-vergent thrust faults. Harrison and others (1980) describe the thrust faults as listric, with a steep near surface attitude flattening to the west at depth. Price (1984) describes the end product as an imbricated stack of thrust slices of Belt Supergroup rocks overthrust to the east. Subsequent erosion of the thrust slices in the study area has exposed the Revett Formation in a series of subparallel, northwesterly striking outcrops. The approximate bedrock exposure pattern of the Revett Formation is shown in the map in figure 3 compiled by J.W. Whipple and based on recent field investigations and previously published mapping by Earhart, 1981; Harrison and Jobin, 1963; Harrison and others, 1983; Johns, 1970; and Wells and others, 1981b. Revett rocks occur in outcrop or under shallow cover in over 258,000 acres of forest lands. Areas known or believed to be underlain by the projected subsurface extensions of the Revett

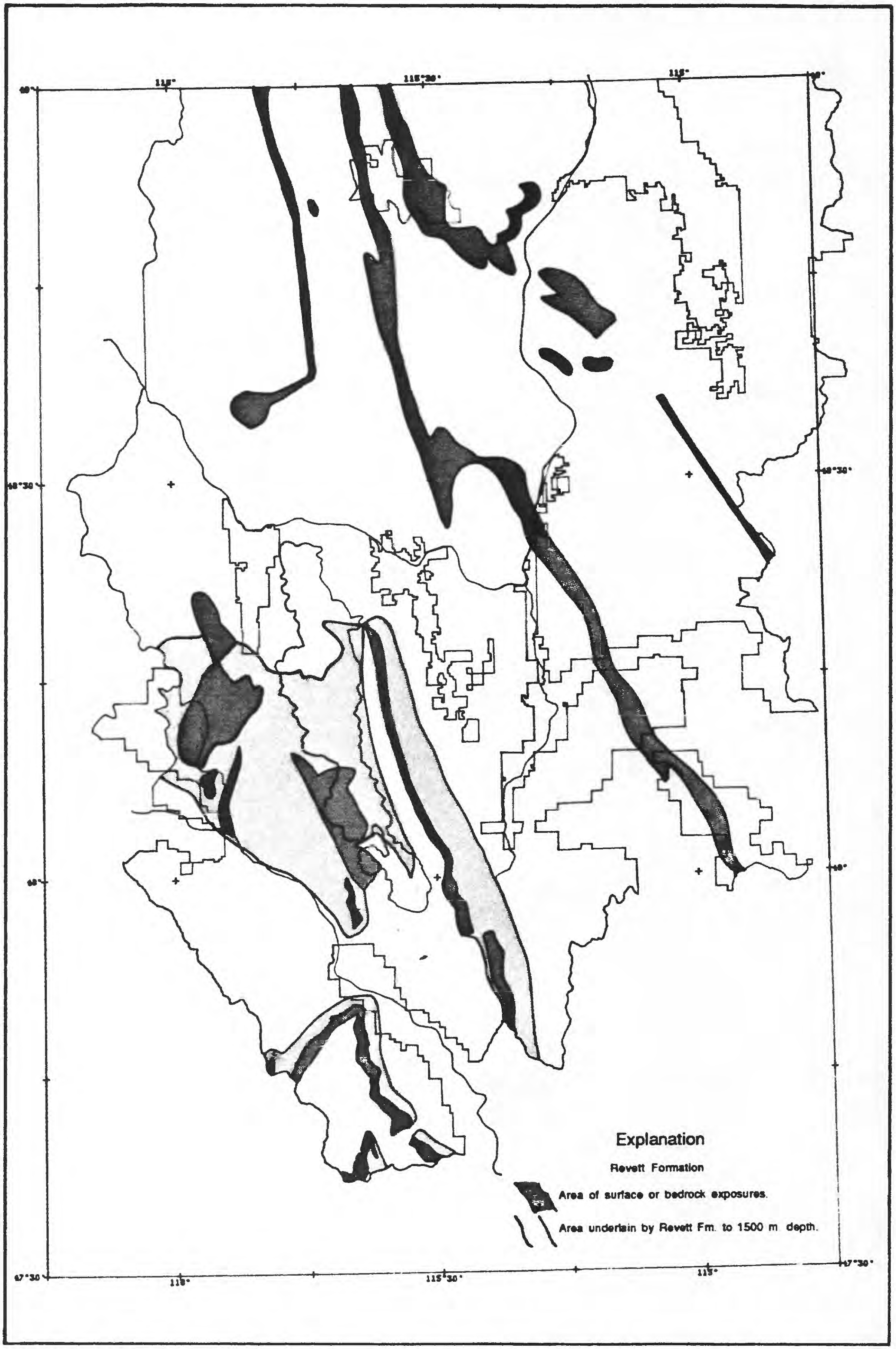

FIGURE 3.--Shows area of the Kootenai-Kaniksu N.F. interpreted to be underlain by the Revett Formation projected to depths of 1,500 meters. Scale approx. 1:800,000

Formation from surface outcrops to a cut-off depth 1,500 meters are also shown for the area south of the Kootenai River and west of the Fisher River; where some subsurface control is available. The latter area comprises an additional 260,000 acres of forest lands. However, because of the imprecision associated with the projections of both fault planes and the Revett Formation, the position of the cut-off boundaries must be considered speculative. It is also possible, due to the nature and complexity of the thrust faulting, that additional, totally concealed thrust slices containing Revett strata may occur within the study area at depths of less than 1,500 meters of the surface.

Harrison and others (1980) call attention to copper-silver sulfide mineralization along bedding plane shears that occurs in close spatial association with existing Revett-type occurrences. They suggest that if the shears are related in origin to the second tectonic event then it is possible that some remobilization of sulfides in Revett-type occurrences has taken place. Therefore, copper sulfide occurrences in veins and shears may be indicative of the presence of Revett-type mineralization in near proximity.

Geochemical Analysis

The study area has been covered in whole or part by five recent geochemical surveys. As part of the National Uranium Resource Evaluation (NURE) project, approximately 760 soil and stream sediment samples were collected from widely scattered sites throughout the entire study area. An additional 1,208 rock, soil and stream samples were collected as part of the Cabinet Mountains Wilderness study (Wells and others, 1981a), 208 soil, stream and sedimentary rock samples were collected for the Scotchman Peak Wilderness study area (Grimes and Earhart, 1981), and 160 rock and stream sediment samples within the Mount Henry Roadless Area (Seims and others, 1984). Leach and others (1986a,b) in their reconnaissance scale study of the Wallace 1°x2° quadrangle analyzed 159 samples collected from that portion of the study area that lay south of the 48th parallel.

Harrison (1972) observed that anomalously high amounts of copper (100 ppm) are scattered throughout thousands of square miles of the Belt terrane and can occur in almost all formations. Wells and others (1981) clearly identify an anomalous Cu+Ag±Pb geochemical signature associated with the Revett-type deposit partially exposed at Rock Creek and Rock Lake in the Cabinet Mountains Wilderness area. In the Scotchman Peak Wilderness study area the coincidence of copper and silver anomalies was used to identify Revett-type mineralization which could be traced to mineralized outcrops in the lower member of the Revett Formation in the vicinity of Star Gulch. The Cu+Ag±Pb geochemical signature element group was also used by Leach (1986) to identify anomalies related to stratabound copper-silver mineralization in the Wallace 1°x2° quadrangle. Although anomalies indicative of stratabound deposits could be found related to almost all Belt formations, excluding the Prichard and Pilcher Formations, Revett Formation outcrops were successfully ranked for their potential as hosts for Revett-type mineralization based on proximity to signature anomalies. Seims and others (1984) in their reconnaissance scale geochemical survey of the Mount Henry Roadless study area found only very weak evidence of any anomalous copper or silver values and none specifically related to Revett Formation outcrops.

The value of the regional NURE geochemical data is largely negated by the insensitive analytical limit of detection used for Ag of 2 ppm and 5 ppm in the Kalispell and Wallace quadrangles. Sites of reported anomalous Ag or Cu values are shown in figure 4, along with results of a rank sum analysis using a 4Cu+Pb-Zn suite. As a result of the insensitive limit of detection applied in the analysis for Ag, Ag was detected at only 14 sample sites and made the use of the Cu+Ag±Pb geochemical

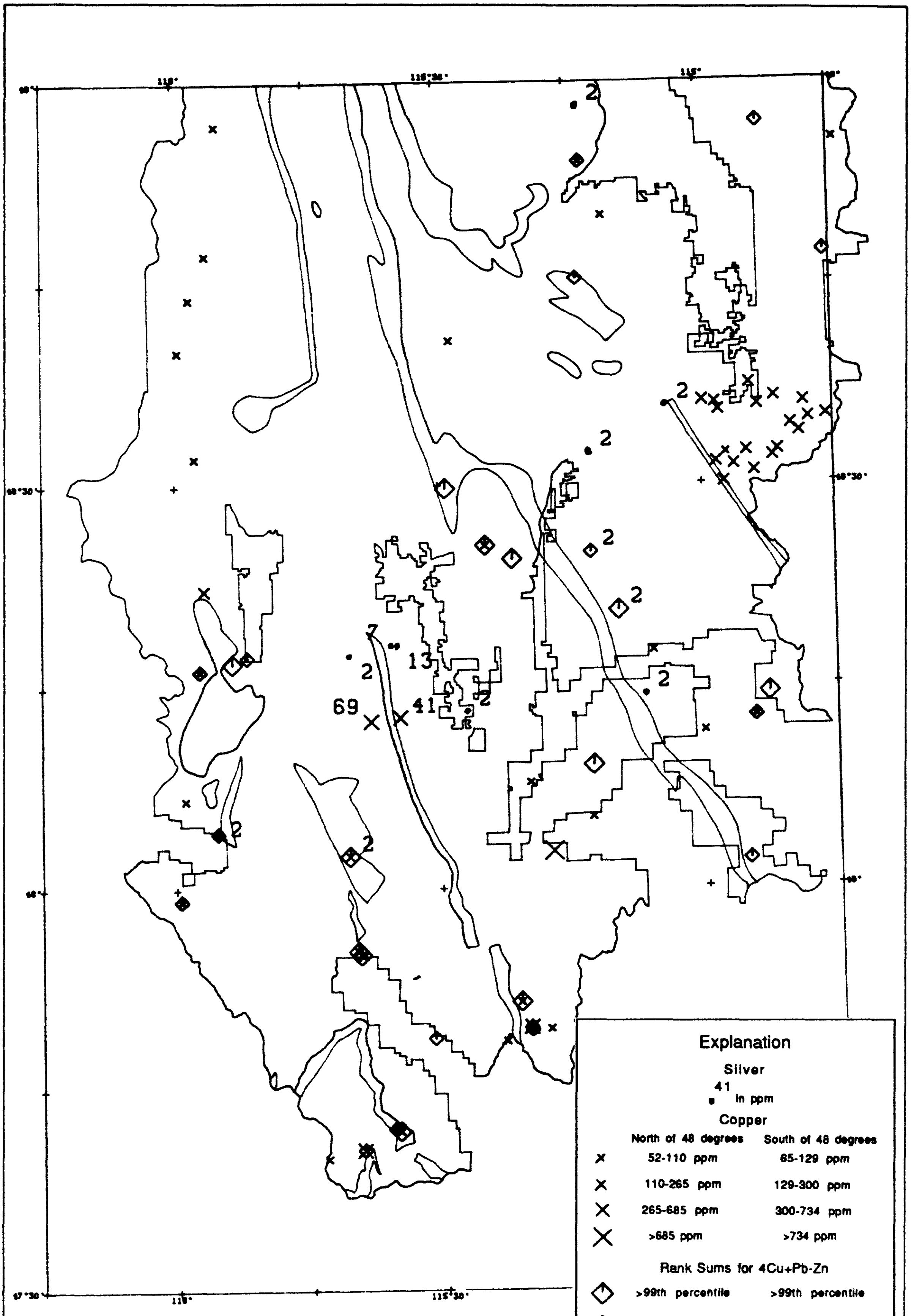

FIGURE 4.--Shows NURE sample sites with anomalous levels of Cu or Ag and sites with ranked sum values for the 4 Cu+Pb-Zn geochemical signature group in the two highest percentile divisions. Scale approx. 1:800,000

signature suite ineffectual. In place of the latter signature suite, a 4Cu+Pb-Zn suite was substituted. The inclusion of Zn as a negative factor was intended to discriminate between responses attributable to polymetallic veins containing Zn, which are prevalent in the area, and those from Revett-type mineralization which have no Zn. The results show that several sites at which Cu and Ag were present were not highlighted in the rank sum analysis suggesting that Zn was probably present and that the response is indicative of polymetallic vein rather than Revett-type mineralization in the area. The elimination of many of the low level Cu anomalous values suggests that they are also produced by non-Revett-type mineralization. The rank sum method also generates high values at sites where Cu is not present in anomalous quantities suggesting a sample site geochemistry which is compatible with Revett-type mineralization but weak. Revett-type mineralization is known to occur in subeconomic amounts in other formations within the Belt Supergroup. Such occurrences may be responsible for producing the responses at sample sites where Revett rock is now known in the site drainage. The latter may apply to many of the rank sum values in the northeastern portion of the area.

With the exception of the NURE data, each of the latter geochemical surveys was conducted in support of a mineral resource appraisal. In each the end product of the appraisal process was the identification of areas permissive for mineralization of a specified type. Results pertaining to stratabound deposits contained in these appraisals are shown in figure 5 and were considered in the current assessment.

Geophysical Analysis

The NURE project also provides complete aero-radiometric coverage for the study area. East-west flight lines were flown on a three mile spacing over the region south of latitude 48° N and on a 6 mile spacing north of that line. North-south

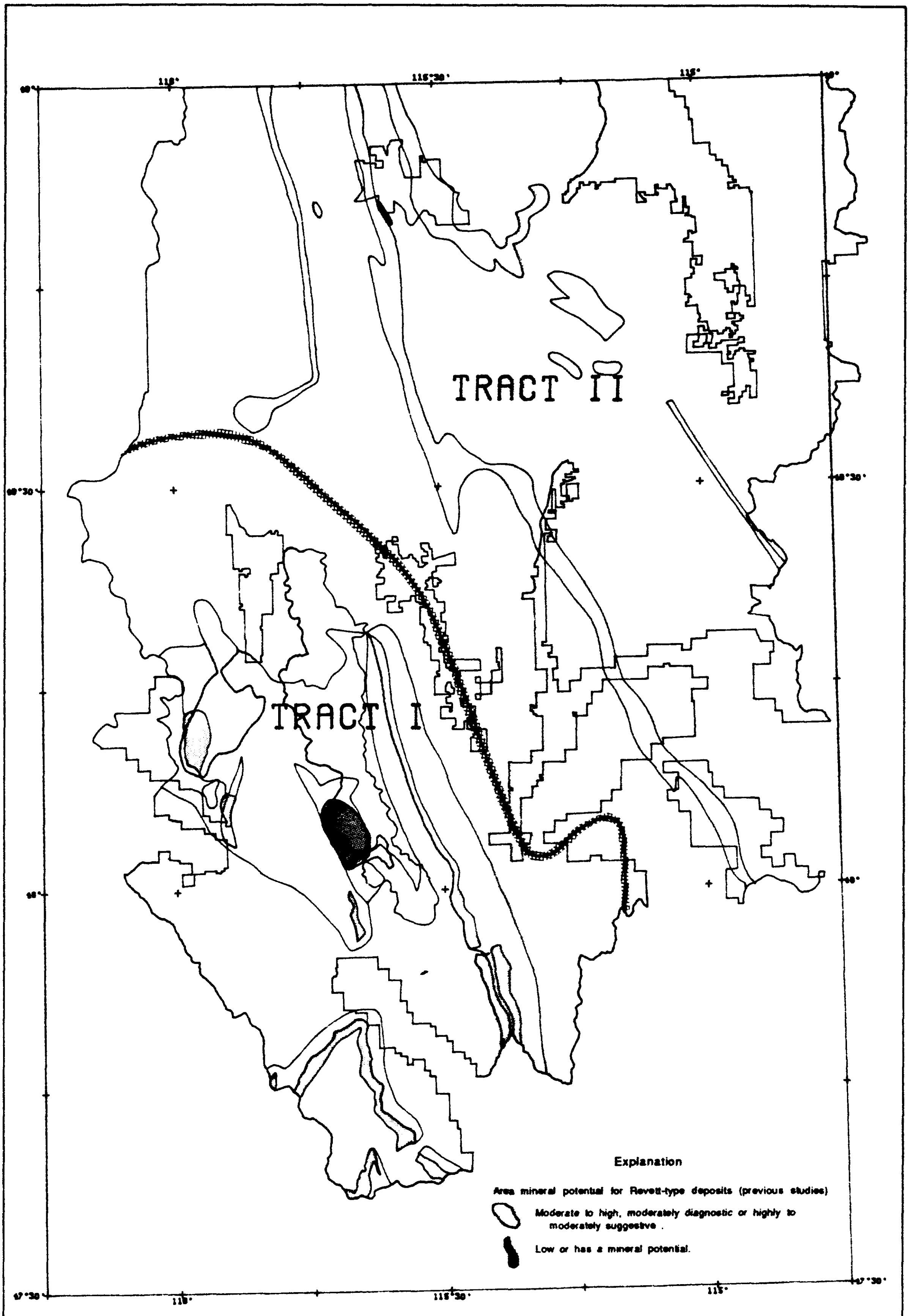

FIGURE 5.--Shows area assessed for their potential for hosting sediment-hosted Cu deposits as in prior studies and the areal extent of Tracts I and II delineated for this study. Scale approx. 1:800,000

flight lines were flown on 12 mile and 18 mile spacings in the respective areas. It was anticipated that the potassium aero-radiometric response over outcrop areas of the Revett Formation might reflect a subtle increase in potassium levels occurring in areas where authigenic K-feldspar overgrowth on detrital feldspars were prevalent. It was also anticipated that a subtle decrease in potassium aero-radioactivity coupled with subtly higher magnetic response would be found in areas of low copper, the albite zone of Hayes (in prep.). However, these relationships were not evident in conventionally contoured maps of the data.

MINERAL RESOURCE ASSESSMENT

The assessment process is a three-part procedure. It consists of the identification of a permissive host terrane for a specified type of mineral deposit, the probabilistic estimation of the number of deposits of the specified type that may be present within the terrane, and the selection of appropriate grade and tonnage models based on well-explored deposits (Singer and Cox, 1988). This study is concerned with only one type of deposit, the Revett-type; a stratabound copper-silver sulfide mineralization found in the Revett Formation. Based on a study of the Revett-type deposit at Spar Lake, the deposits have been classified by Cox (1986) as belonging to the more broadly defined sediment-hosted Cu deposit model; a description of which is found in USGS Bulletin 1693.

Tract Delineation

The term tract, as applied in this study, refers to a geographic area which encompasses one or more occurrences of the permissive host terrane for Revett-type deposits, the Revett Formation, which have been determined to possess similar degrees of favorability for the existence of these deposits. The determination of favorability and delineation of boundaries is based on a consideration of the following geologic attributes.

(1) Presence of the Revett Formation within 1,500 meters of the surface.

(2) Number of quartzite units present in the Revett section, their thickness, average detrital grain size, and inferred environments of deposition.

(3) Presence of authigenic K-feldspar overgrowths on detrital K-feldspars.

(4) Proximity to faults which were probably present in middle Proterozoic Belt time.

(5) Presence of mineral phases in the Revett Formation containing Fe in its +2 state of oxidation.

(6) Presence of known occurrences and deposits of the Revett-type.

(7) Presence of favorable rank sum signature suite geochemistry for Revett-type mineralization.

Based on a thorough review utilizing the latter attributes, two tracts were delineated (see figure 5). The area designated as Tract I contains approximately 90,000 acres of Revett exposures and 260,000 acres interpreted to be underlain by concealed Revett rock that were deposited in the middle regions of the fluviodeltaic complex where stream and tidal channels were common sites for sandstone deposition. The frequency of quartzite occurrence is high; detrital grain-size and sorting favor a high initial sediment porosity and permeability. Proterozoic age faults are inferred to be present and show permissive evidence of movement during Belt time. Chlorite-bearing reduced Fe is a dominant mineral phase present in argillites and siltites interlayered with quartzites. The area coincides with the apex of the early Missoula doming inferred by Harrison (1972), and 25 known Revett-type occurrences and deposits are located within the tract.

Tract II includes 147,000 acres of exposed Revett rocks that were deposited toward the distal regions of the fluviodeltaic wedge where marine environments were more common. Quartzites are fewer in number and thinner. Grain-size is generally finer, authigenic mica content is greater, and sorting is poorer suggesting lesser primary sediment permeability. Rocks are dominantly lavender- or purple-gray in color due to the presence of minerals containing $Fe^{(+3)}$. Most of the area is positioned over the flanks of Harrison's (1972) early Missoula dome, and the area contains only one known occurrence of Revett-type mineralization.

The areas of Revett outcrop and areas underlain by Revett to depths of 1,500 meters in Tract I are assigned an uniformly high value as potential hosts for Revett-type mineralization without regard to depth. Tract I also includes all Revett outcrops that have been assigned a "high" or moderate potential in prior appraisal efforts for the occurrence of stratabound copper-silver deposits (see figure 5). The Revett Formation in Tract II has been treated as having almost no potential for the occurrence of these deposits. Only a small area which was designated as having a "low" potential for stratabound deposits in the Mount Henry Roadless Area report, is included in this tract.

Grade and Tonnage Models

Grade and tonnage models are an extension of the application of deposit modeling wherein the assumption is made that the cumulative tonnage and grade distribution curves constructed using production and reserve data for all known deposits is statistically representative of tonnage and grade distribution for all deposits belonging to the given model. Cox (1986) has identified the Revett-type deposits as examples of the sediment-hosted Cu deposit model (30b) based on a data from the Spar Lake deposit. However, a comparison of reported Cu grade data for proven Revett-type deposits with the global Cu grade model shown that the Revett-type deposits are consistently low, clustering on the low grade tail of the global curve. It is also observed that the Revett-type deposits are consistently Ag bearing averaging nearly 67 grams per tonne, whereas only 11 of 57 deposits in the global model have reported Ag. For these reasons it was felt that the global models for 30b were inappropriate for this study.

It is believed that the consistently low grades of Revett-type deposits reflect a mining policy in the United States that emphasizes metal recovery, improved industry efficiencies in the mining and processing of low grade ores, and the high Ag values that run in these deposits. In order to achieve better agreement in grades, a modified subset of mines was selected, consisting of 6 proven Revett-type deposits and 6 other western U.S. and Canadian deposits. The grade and tonage data for the 12 deposits is tabulated in table 1 and the grade and tonnage models are displayed in figures 6, 7, and 8. The models are used in both the estimation of undiscovered deposits and in the estimation of metal endowments.

Estimation of Undiscovered Deposits

The term deposit as used in this report refers to a Revett-type occurrence that has a Cu grade and ore tonnage that falls within the model ranges. Of the 26 known occurrences shown in figure 2, twelve are sufficiently explored to be known to meet or exceed the minimum model standards for a deposit. Based on the distribution of the known deposits, knowledge concerning the exploration history, geology and tectonics of the region, the characteristics and genesis of the Revett-type mineralization, and the grade and tonnage distribution model adopted for this study, the assessment team developed consensus subjective estimates for the

TABLE 1: Grade and Tonnage Data for the Sediment-hosted Cu Deposit Model

Name	Country	Tonnes x 10^6	Cu grade %	Ag grade g/t
Big Horn Yarrow Cr	CNAL	5.	1.5	6.8
Creta	USOK	14.6	2.3	34.
Crowell	USTX	1.622	0.94	0.
Eagle Creek	USMT	15.	0.47	16.
J-F	USMT	14.	0.4	45.
Mangum	USOK	36.74	1.1	0.
Nacimiento	USNM	20.	0.67	0.
Pintada Stauber	USNM	0.111	4.5	1.09
Rock Creek	USMT	147.	0.68	57.
Rock Lake	USMT	127.	0.8	69.
Snowstorm	USMT	0.8136	3.	154.
Spar Lake Troy	USMT	58.	0.74	58.

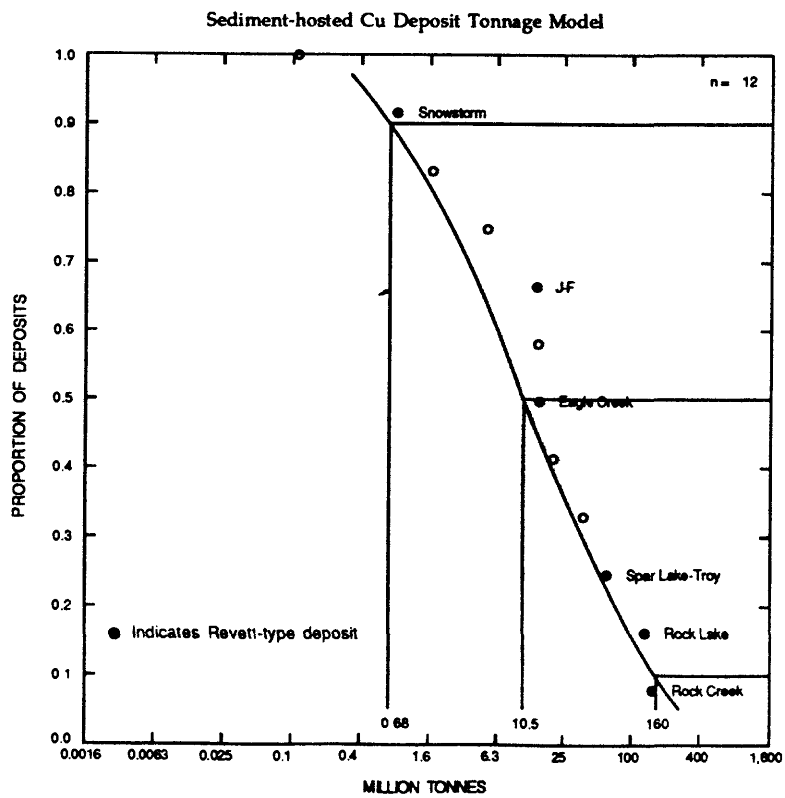

FIGURE 6.--Shows the frequency distribution plot of tonnages for the 12 deposits in Table 1 and a lognormal approximation of the distribution preserving the mean and standard deviation of the observed values.

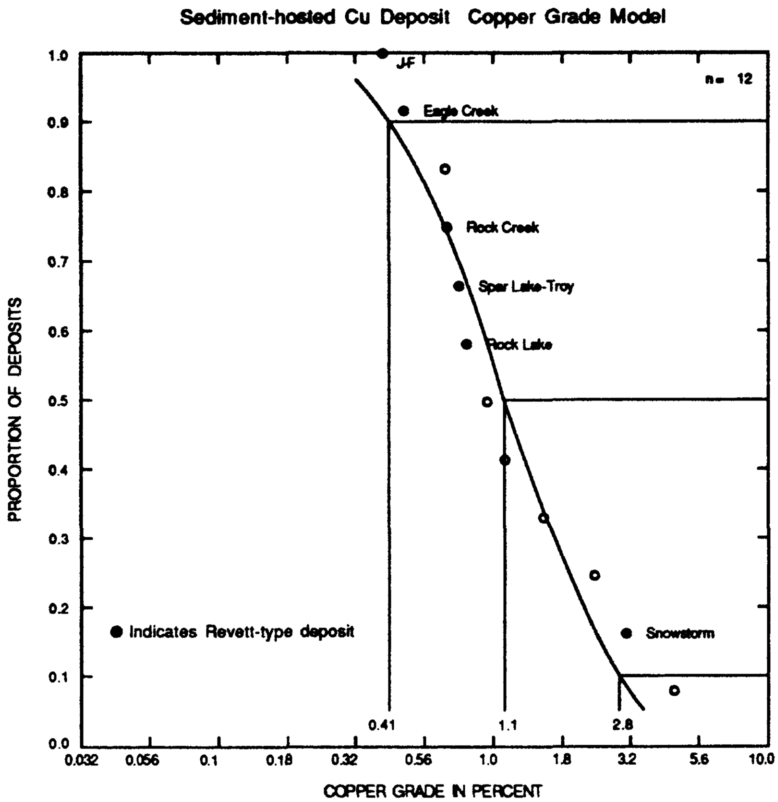

FIGURE 7.–Shows the frequency distribution plot of the Cu grades for the 12 deposits in Table 1 and a lognormal approximation of the distribution preserving the mean and standard deviation of the observed values.

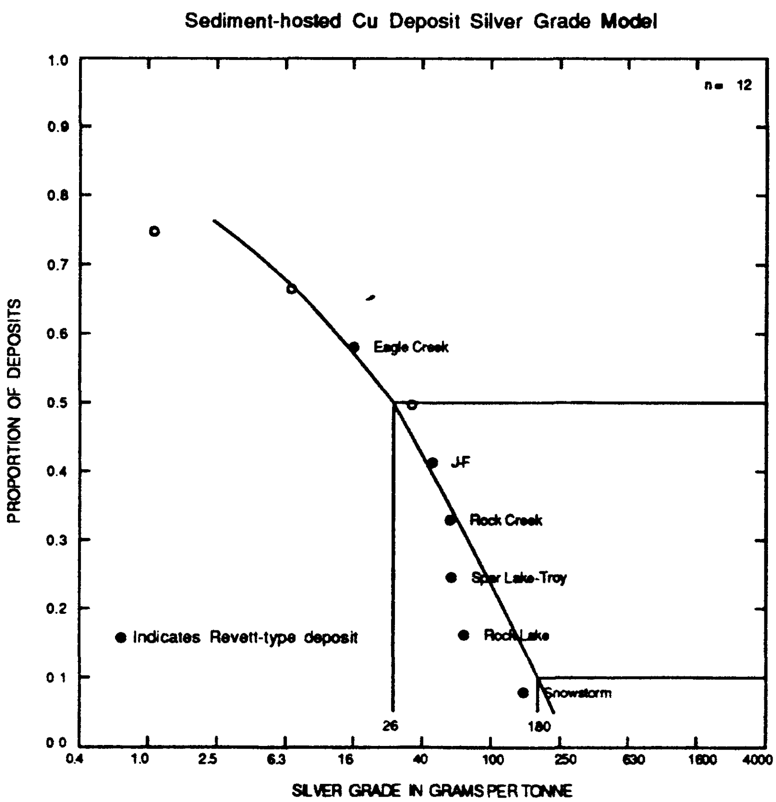

FIGURE 8.–Shows the frequency distribution plot of Ag grades for the 12 deposits in Table 1 and a lognormal approximation of the distribution.

expected number of undiscovered deposits for each tract (see table 2). Values were

TABLE 2: Estimated Number of Undiscovered Revett-Type Deposits

Tract No.	Deposit Probability Level		
	.9	.5	.1
I	25	50	85
II	0	0	3

estimated at three levels of probability for each tract to reflect the uncertainty that is inherently associated with incomplete information. These are the minimum number of deposits that are expected to exist in the tracts at the indicated levels of probability. In fact, there is some fixed but unknown number of deposits in each tract. By this it is meant that approximately half of the estimated deposits should have greater than the indicated median tonnage or median Cu grade. It is also assumed that the undiscovered deposits will occur uniformly distributed throughout the 1,500 meter depth interval and that most will have no surface expression.

Metal Endowment Simulations

A metal endowment is arrived at by summing the products of metal grades times deposit tonnages for all known deposits in an area that contain the metal. The process becomes more complex where the number, size or grades of the deposits are not definitively known. The USGS has developed an approach for estimating metal endowments, where the latter conditions apply, which is based on the concept of the mineral deposit model. By combining the information from the cumulative grade and tonnage curves with the subjective estimations of the numbers of undiscovered deposits using the Monte Carlo techniques embodied in the USGS Mark3 Simulator

(Drew et al., 1986; Root et al., in press), probabilistic estimates of metal endowments associated with undiscovered deposits can be calculated.

Estimated Cu and Ag endowments have been calculated for deposits in three categories: (1) identified deposits that lack announced grade and tonnage estimates, (2) unidentified deposits in Tract I and, (3) unidentified deposits in Tract II. A summary of results in tonnes of metal are reported in tables 3, 4 and 5 as endowment values given at 3 levels of probability and a mean value. Complete results of the 3 simulation runs are contained in Appendix A. The endowment values are the minimum estimated quantities of metal that are expected to be present with the indicated degree of certainty. For example in table 3, it may be

TABLE 3: Estimated Metal Endowments for 9 Identified Revett-Type Deposits
(in thousand metric tons of metal)

Metal	Endowment Values			Mean Endowment
	90%	50%	10%	
Cu	1,300	2,400	4,300	2,700
Ag	3.2	13	35	17

stated that there is a 90% certainty that the 9 identified deposits will contain at least 1.3 million metric tonnes of Cu, a 50 % certainty that the Cu endowment will equal or exceed 2.4 million tonnes, and only a 10% certainty of it equalling or exceeding 4.3 million tonnes. The mean endowment is a best point estimate of the endowment and in the latter case of the 9 identified deposits it is equal to 2.7 million tonnes. The results in table 3 are the estimated metal endowments for 9 of the 12 identified Revett-type occurrences that preliminary exploration has shown contain sufficient quantities of Cu and Ag mineralization to achieve deposit status, but whose total extent is still unknown. The remaining 3 deposits, excluded from the endowment simulation, are the Spar Lake, Rock Creek and Rock Lake deposits, for which reported grades and tonnages have been confirmed by development and exploration drilling. Combining the proven metal endowments with the estimated mean endowments for the 9 identified deposits yields a total mean Cu endowment of 5.1 million tonnes and a Ag endowment of 38,000 tonnes for all of the identified deposits in the study area.

It should be noted that the assessment team believes the Ag endowments may be underestimated in the deposit simulations. This perception arises from the fact, that in all known Revett-type occurrences observed to date, Cu is accompanied by Ag and in a grade ratio of Cu to Ag ranging from 89 to 195 for individual deposits. However, the model used to estimate the Ag endowments contains 3 (25%) deposits that have no reported Ag. In the iterative simulation process, this will result in every fourth mine simulated having no Ag. If, in fact, it is found that the proportion of undiscovered deposits containing Ag does exceed 75%, then it is very probable the Ag endowments has been underestimated. The degree of that underestimation cannot be determined from information now available.

Tables 4 and 5 contain the estimated metal endowments for undiscovered Revett-type deposits that are expected to be present in the areas of Tract I and II respectively. The much larger endowment estimates for Tract I reflect the much higher mineralization expectations given the more favorable geology that is found in this tract.

TABLE 4: Estimated Metal Endowments in Undiscovered Revett-Type Deposits in Tract I
(in thousand metric tons of metal)

Metal	Endowment Values			Mean Endowment
	90%	50%	10%	
Cu	6,300	15,000	25,000	15,000
Ag	32	90	165	95

TABLE 5: Estimated Metal Endowments in Undiscovered Revett-Type Deposits in Tract II
(in thousand metric tons of metal)

Metal	Endowment Values			Mean Endowment
	90%	50%	10%	
Cu	0	0	900	280
Ag	0	0	5.5	1.7

CONCLUSIONS

This assessment has separated the Kootenai Forest lands into two regions, within which the potential for occurrence of Revett-type stratabound copper-silver sulfide mineralization to depths of 1,500 meters is predicted to be distinctly different. In the southwestern one third of the area (Tract I) the number of undiscovered deposits is predicted to range from 25 with a 90% certainty to as many as 85 with a 10% certainty. These numbers are in addition to 12 deposits already identified within Tract I. Using cumulative grade and tonnage curves constructed with data from a selected subset of known deposits belonging to the sediment-hosted Cu deposit model of which the Revett-type deposits are a member; estimated Cu and Ag endowments were calculated using Monte Carlo simulation techniques. A total mean Cu endowment of 20.1 million tonnes is estimated for Tract I and includes 2.4 million tonnes of proven Cu in 3 identified deposits, 2.7 million tonnes of estimated Cu in an additional 9 partially explored deposits and 15 million tonnes of Cu in undiscovered deposits. The total mean Ag endowment of 133,000+ tonnes in these same three categories breaks down into 21,000 tonnes of proven Ag and 17,000 and 95,000 tonnes in the identified and undiscovered deposit groups.

Occurrences of the Revett Formation in the remaining area of the forest (Tract II) were assessed as having a much lower potential. The predictions of numbers of undiscovered deposits reflect this low potential, ranging from 0 deposits at the 90% and 50% certainty levels to 3 deposits at the 10% certainty level. There are no identified Revett-type deposits in Tract II, therefore the mean Cu and Ag endowments are attributable entirely to metal in undiscovered deposits. Results of the simulations give very modest mean endowments of 280,000 tonnes for Cu and 1,700 tonnes of Ag, which are approximately equivalent to half the present proven resource at the Spar Lake deposit.

ACKNOWLEDGEMENTS

The authors wish to thank those who graciously gave of their time and expertise to the assessment effort. J. Whipple prepared the map of the Revett Formation; T. Hayes contributed detailed information on the genesis of the Cu and Ag mineralization; C. Smith processed and analyzed the NURE geochemical data and D. Kleinkopf provided a summarization of the geophysical data. Thanks are also extended to T. Gunther and B. Gosling of the Bureau of Mines, and R. McCulloch of the Montana Bureau of Mines and Geology for their enlightened contributions to the assessment discussions. Robert Thompson, U.S. Forest Service, provided invaluable incites concerning the geology of the area and the past and present exploration activities in the Kootenai Forest. W. D. Menzie was instrumental in leading the assessment discussions and D. Singer provided critical comments concerning the development of the grade and tonnage models used in this study and on the theory behind their proper application. D. Root patiently explained the output capabilities of the Mark3 Simulator and performed repeated runs to determine metal endowments. However, the authors assume full responsibility for the content of the report and its accuracy.

REFERENCES

Balla, J.C., 1982, Geology of the Troy Deposit Northwestern Montana [abs.], in Symposium on the Genesis of Rocky Mountain Ore Deposits: Denver Region Exploration Geologists Society, Denver, Colorado, p. 29.

Banister, D.P., Weldin, R.D., Zilka, N.T., and Schmauch, S.W., 1981, Economic Appraisal of the Cabinet Mountains Wilderness, Lincoln and Sanders Counties, Montana: U.S. Geological Survey Bulletin 1501-D, p. 53-77.

Chesson, S., Wallace, R.R., and Griffith, T., 1984, Map Showing Mineral Occurrence Data for the Wallace 1°x2° Quadrangle, Montana and Idaho: U.S. Geological Survey MF-1354-F, scale 1:250,000.

Clark, A.L., 1971, Stratabound copper sulfides in the Precambrian Belt Supergroup, northern Idaho and northwestern Montana, U.S.A. [abs.], in Proceedings, International Mineralogical Association General Meeting, 7th International Association on the Genesis of Ore Deposits, Tokyo-Kyoto Meeting, 1970, Proceedings, p. 261-267.

Cox, D.P., 1986, Descriptive Model of Sediment-Hosted Cu, in Mineral Deposit Models, ed., Cox, D.P. and Singer, D.A., U.S. Geological Survey Bulletin 1693, p. 205.

Drew, L.J., Bliss, J.D., Bowen, R. W., Bridges, N.J., Cox, D.P., DeYoung, Jr., J.C., Houghton, J.C., Ludington, S., Menzie, W.D., Page, N.J., Root, D.H., and Singer, D.A., 1986, Quantitative Estimation of Undiscovered Mineral Resources--A Case Study of U.S. Forest Service Wilderness Tracts in the Pacific Mountain System: Economic Geology, v. 81, pp 80-88.

Earhart, R.L., 1981, Geology of the Scotchman Peak Wilderness Study Area, Lincoln and Sanders Counties, Montana and Bonner County, Idaho: U.S. Geological Survey Bulletin 1467-A, p. A1-A14.

Garlick, W.G., 1987, Genesis of the Spar Lake Stratabound Copper-Silver Deposit, Montana: Part I. Controls Inherited from Sedimentation and Preore Diagenesis--A Discussion: Economic Geology, v. 82, p. 1967-1968.

Grimes, D.J., and Earhart, R.L., 1981, A Geological and Geochemical Evaluation of the Mineral Resources of the Scotchman Peak Wilderness Study Area, Lincoln and Sanders Counties, Montana, and Bonner County, Idaho: U.S. Geological Survey Bulletin 1467, P. C1-C24.

Hamilton, J.M. and Balla, J., 1983, Belt-Purcell Supergroup: Troy (Spar Lake), in Stratabound Base Metal Deposits in Southeastern British Columbia and Northwestern Montana, Field Trip Guidebook: Geological Association of Canada, p. 25-31.

Harrison, J.E. and Jobin, D.A., 1963, Geology of the Clark Fork Quadrangle Idaho-Montana: U.S. Geological Survey Bulletin 1141-K, 38 pp.

Harrison, J.E., 1973, Precambrian Belt Basin of Northwestern United States: Its Geometry, Sedimentation, and Copper Occurrences: Geological Society of America Bulletin, v. 83, p. 1215-1240.

Harrison, J.E., Kleinkopf, M.D., and Wells, J.D., 1980, Phanerozoic thrusting in Proterozoic Belt rocks, northwestern United States: Geology, v. 8, p. 407-411.

Harrison, J.E., Cressman, E.R., and Whipple, J.W., 1983, Preliminary Geologic and Structural Maps of the Kalispell 1°x2° Quadrangle, Montana: U.S. Geological Survey Open File Report 83-502., scale 1:250,000.

Harrison, J.E., Domenico, J.A., and Leach, D.L., 1986, Resource Appraisal Map for Stratabound Copper-Silver Deposits in the Wallace 1°x2° Quadrangle, Montana and Idaho: U.S. Geological Survey I-1509-F, scale 1:250,000.

Hayes, T.S., 1984, The relations between stratabound copper-silver ore and Revett Formation sedimentary facies at Spar Lake, Montana [abs.], in The Belt: Abstracts with Summaries, Belt Symposium II, 1983, S.W. Hobbs (ed.): Montana Bureau of Mines and Geol. Spec. Pub. 90, p. 63-64.

Hayes, T.S., and Einaudi, M.T., 1986, Genesis of the Spar Lake Stratabound Copper-Silver Deposit, Montana: Part I, Controls Inherited from Sedimentation and Preore Diagenesis: Economic Geology, v. 81, p. 1899-1931.

Hayes, T.S., Rye, R.O., Whelan, J.F., and Landis, G.P., 1989, Geology and Sulphur-isotope Geothermometry of the Spar Lake Stratabound Cu-Ag Deposit in the Belt Supergroup Montana, in Sediment-hosted Stratiform Copper Deposits, eds., Boyle, R.W., Brown, A.C., Jefferson, C.W., Jowett, E.C., and Kirkhom, R.V.: Geological Association of Canada Special Paper 36, p. 315-338.

Johns, W.M., 1970, Geology and Mineral Deposits of Lincoln and Flathead Counties, Montana; Montana Bureau of Mines and Geology, Bulletin 79, 182 pp.

Lange, I.M., 1975, Revett sulfide deposits and sandstone-type red-bed copper deposits of the southwestern United States: Northwest Geology, v. 4, p. 59-76.

Lange, I.M. and Sherry, R.A., 1983, Genesis of sandstone (Revett) type of copper-silver occurrences in the Belt Supergroup of northwestern Montana and northeastern Idaho: Geology, v. 11, p. 643-646.

______1986, Nonmassive Sulfide Deposits in the Late Precambrian Belt Supergroup of Western Montana in Belt Supergroup: A Guide to Proterozoic Rocks of Western Montana and Adjacent Areas (ed.), Roberts, S.M., 1986: Montana Bureau of Mines and Geology, Special Pub. 94, p. 269-278.

Leach, D.L., 1986, Application of Geochemical Data to the Mineral Resource Appraisal of the Wallace 1°x2° Quadrangle, Montana and Idaho: in U.S. Geological Survey I-1509 B, C, D, 5 pp.

Leach, D.L. and Domenico, J.A., 1986a, Geochemical Map Showing Distribution of Samples of Nonmagnetic Heavy-Mineral Concentrates That Contain Anomalous Concentrations of Antimony, Arsenic, Copper, Lead, Silver, and Zinc in the Wallace 1°x2° Quadrangle, Montana and Idaho: U.S. Geological Survey I-1509-B, scale 1:250,000.

Leach, D.L. and Hopkins, D.M., 1986b, Geochemical Map Showing Distribution of Stream-Sediment Samples That Contain Anomalous Concentrations of Antimony, Bismuth, Cadium, Copper, Lead, Silver, and Zinc in the Wallace 1°x2° Quadrangle, Montana and Idaho: U.S. Geological Survey, I-1509-C, scale 1:250,000.

Mosier, D.L., Singer, D.A., and Cox, D.P., 1986, Grade and Tonnage Model of Sediment-Hosted Cu in Mineral Deposit Models, ed. Cox, D.P. and Singer, D.A., U.S. Geological Survey Bulletin 1693, p. 206-208.

Price, R.A., 1984, Tectonic Evolution of the Purcell (Belt) Rocks of the Southeastern Canadian Cordillera and Adjacent Parts of the United States in "The Belt" Abstracts and Summaries, Belt Symposium II, 1983, ed. Hobbs, W., Montana Bureau of Mines and Geology Special Pub. 90, pp. 47-48.

Root, D.H., Menzie, W.D., and Scott, W.A., in press, Computer Simulation in Quantitative Resource Estimation.

Rye, R.O., Whelan, J.F., Hayes, T.S. and Harrison, J.E., 1984, The Origin of the copper-silver mineralization in the Ravalli Group as indicated by preliminary stable isotope studies [abs.], in The Belt: Abstracts with Summaries, Belt Symposium II, 1983, Hobbs, S.W., (ed): Montana Bureau of Mines and Geological Special Pub. 90, p. 104-107.

Siems, D.F., Leinz, R.W., VanLoenen, R.E., Wadsworth, G.A. and McDougal, C.M., 1984, Reconnaissance Geochemical Map of the Mount Henry Roadless Area, Lincoln County, Montana: U.S. Geological Survey MF-1534-B, scale 1:50,000.

Singer, D.A., 1984, Mineral Resource Assessments of Large Regions: New and in the Future in Vol. 2, U.S.-Japan Joint Seminar on Resources of the 1990's, ed. by Geol. Survey of Japan.

Singer, D.A. and Cox, D.P., 1988, Applications of Mineral Deposit Models to Resource Assessments, in U.S. Geological Survey Yearbook 1987, p. 55-57.

U.S. Bureau of Mines, 1990, The Potential Supply of Minerals from Undiscovered Copper-Silver Deposits in the Kootenai National Forest: U.S.B.M. Open-File Rept. 24-90, 34 p.

VanLoenen, R.E., Siems, D.F., Bankey, V. and Conyac, M.D., 1983, Mineral Resource Potential Map of the Mount Henry Roadless Area, Lincoln County, Montana: U.S. Geological Survey MF-1534-D, scale 1:50,000.

Wells, J.D., Domenico, J.A., Frisken, J.G. and Hopkins, R.T., 1981a, Geochemical Survey of the Cabinet Mountains Wilderness, Lincoln and Sanders Counties, Montana: U.S. Geological Survey Bulletin 1501-C, 27 p.

Wells, J.D., Lindsey, D.A., and VanLoenen, R.E., 1981b, Geology of the Cabinet Mountains Wilderness, Lincoln and Sanders Counties, Montana: U.S. Geological Survey Bulletin 1501-A, 19 pp.

White, B.G., Mauk, J. and Winston, D., 1984, Stratigraphy of the Revett Formation in "The Belt" abstracts and summaries, Belt Symposium II, 1983, ed., Hobbs, W., Montana Bureau of Mines and Geological Special Pub. 90, p. 16-17.

Winston, D., 1986, Sedimentology of the Ravalli Group, Middle Belt Carbonate and Missoula Group, Middle Proterozoic Belt Supergroup, Montana, Idaho and Washington in Belt Supergroup: A Guide to Proterozoic Rocks of Western Montana and Adjacent Areas, Roberts, S.M. (ed.), 1986: Montana Bureau of Mines and Geology special Pub. 94, p. 85-124.

Zilka, N.T., 1981, Economic Appraisal of the Scotchman Peak Wilderness Study Area, Lincoln and Sanders Counties, Montana and Bonner County, Idaho: U.S. Geological Survey Bulletin 1467-D, p. D1-D26.

APPENDIX A

RESULTS OF METAL ENDOWMENT SIMULATION RUNS

In the Kootenai National Forest study, copper and silver endowments are estimated for Revett-type sediment-hosted Cu deposits in three categories. The first run estimates metal endowments and deposit size for a suite of 9 identified deposits whose locations are known but extent of mineralizations is not fully known. Runs 2 and 3 estimate endowments and deposit sizes for the undiscovered Revett-type deposits estimated to be present within the ares of Tract I and II respectively. For each metal and ore tonnage, values are reported for each tenth percentile and a mean value is given. The Mark3 output also provides a tabulation of the actual and theoretical frequencies of deposit occurrences used in the simulation run and the values at the 10th, 50th, and 90th percentile of the frequency distribution curves of the grade and tonnage values used in the run. The latter is standard output from the Mark3 Simulator.

The detailed operation of the Mark3 Simulator is covered in Drew and others, (1986) and Root and others, (in press). In brief, the Mark3 applies Monte Carlo simulation methodologies to information concerning the number of deposits of a given deposit type that may be present in an area and historical information concerning the size and metal grades that have been shown to be associated with deposits of the same type. In the current study, the number of deposits have been estimated by an assessment team composed of highly experienced economic geologists. The historical grade and tonnage data is obtained from a 12 deposit subset of deposits extracted in part from the global sediment-hosted Cu deposit data set and supplemented with data for several recently proven deposits from the northwestern Montana region. For all simulation runs in this study, the empirical option is used in which the grade and tonnage distributions for the 12 deposit model are approximated by 10 segment piecewise linear distribution curves. The latter approximation requires segregation of the three non-silver bearing deposits into a suite separate from the nine silver bearing deposits.

PIECEWISE LINEAR DISTRIBUTIONS

KOOTENAI ASSESSMENT MODEL

Suite I. Copper with Silver (9 Deposits)
Conditional Probability = 0.75

Probability	Ore Metric Tons	Cu Grade %	Ag Grade %
1	55500	0.200	0.00005450
0.9	155400	0.389	0.00015260
0.8	1081100	0.494	0.00085895
0.7	6000000	0.598	0.00184960
0.6	10165000	0.760	0.00300860
0.5	14522000	0.950	0.00396390
0.4	18878000	1.271	0.00485570
0.3	46400000	1.952	0.00601400
0.2	84592000	2.726	0.00750840
0.1	143080000	3.780	0.01000700
0	198060000	5.939	0.02148500

Suite II. Copper Only (3 Deposits)
Conditional Probability = 0.25

Probability	Ore Metric Tons	Cu Grade %
1	811000	0.335
0.9	1297600	0.509
0.8	1784200	0.606
0.7	2270800	0.693
0.6	14000000	0.779
0.5	19425000	0.866
0.4	23311000	0.952
0.3	27196000	1.064
0.2	33066000	1.217
0.1	44088000	1.369
0	55393000	1.625

During the course of the simulation, values are selected from the two models in accordance with the frequency they represent in the original deposit model; values will be selected from the curves in Suite 1 75% of the time and Suite 2 25% of the time. Results of the simulations are as follows.

RUN 1: IDENTIFIED REVETT-TYPE DEPOSITS (9)

NUMBER OF DEPOSITS PER SIMULATION

NUMBER	FREQUENCY	THEORETICAL FREQUENCY
0	0	0.0133
1	0	0.0133
2	0	0.0133
3	0	0.0133
4	0	0.0133
5	0	0.0133
6	0	0.0133
7	0	0.2067
8	0	0.4000
9	4999	0.3000
	4999	1.0000

MEAN NUMBER OF DEPOSITS 9.000

SORTED SIMULATION RESULTS FOR COPPER
ORDER OF OCCURRENCE

RANK	TONNES CU
1	3.29342E+05
500	1.31404E+06
1000	1.65590E+06
1500	1.90179E+06
2000	2.15250E+06
2500	2.41889E+06
3000	2.71309E+06
3500	3.04942E+06
4000	3.54503E+06
4500	4.34506E+06
4999	9.64618E+06

CU GRADE %, DISTRIBUTIONS AT THREE PROBABILITIES

	PROB	%	PROB	%	PROB	%
SUITE 1	90%=	0.38545	50%=	0.94937	10%=	3.75877
SUITE 2	90%=	0.51702	50%=	0.86819	10%=	1.37233

EXPECTED MEAN COPPER METAL TONNAGE = 2.66932E+06

SORTED SIMULATION RESULTS FOR SILVER
ORDER OF OCCURRENCE

RANK	TONNES AG
1	2.43944E+01
500	3.22252E+03
1000	5.54128E+03
1500	8.00453E+03
2000	1.06232E+04
2500	1.33960E+04
3000	1.68545E+04
3500	2.07242E+04
4000	2.65117E+04
4500	3.54439E+04
4999	1.10056E+05

AG GRADE %, DISTRIBUTIONS AT THREE PROBABILITIES

	PROB	%	PROB	%	PROB	%
SUITE 1	90%=	0.00015	50%=	0.00396	10%=	0.01006
SUITE 2	90%=	0.00000	50%=	0.00000	10%=	0.00000

EXPECTED MEAN SILVER METAL TONNAGE = 1.68737E+04

SORTED SIMULATION RESULTS FOR TONNES
ORDER OF OCCURENCE

RANK	TONNES ORE
1	2.77354E+07
500	1.45701E+08
1000	1.97812E+08
1500	2.44129E+08
2000	2.80994E+08
2500	3.19259E+08
3000	3.57655E+08
3500	4.00727E+08
4000	4.56131E+08
4500	5.36844E+08
4999	8.83735E+08

ORE TONNAGE, TONNES, DISTRIBUTION AT THREE PROBABILITIES

	PROB	TONNES	PROB	TONNES	PROB	TONNES
SUITE 1	90%=	154696.46875	50%	14633710.00000	10%=	144226240.00000
SUITE 2	90%=	1286490.00000	50%	19263492.00000	10%=	44134432.00000

EXPECTED MEAN ORE TONNAGE = 3.33108E+08

RUN 2: UNDISCOVERED REVETT-TYPE DEPOSITS IN TRACT I (25-50-85)
NUMBER OF DEPOSITS PER SIMULATION

NUMBER	FREQUENCY	THEORETICAL FREQUENCY
0	18	0.0039
1	19	0.0039
2	18	0.0039
3	14	0.0039
4	11	0.0039
5	15	0.0039
6	16	0.0039
7	23	0.0039
8	19	0.0039
9	17	0.0039
10	15	0.0039
11	20	0.0039
12	9	0.0039
13	20	0.0039
14	23	0.0039
15	19	0.0039
16	27	0.0039
17	16	0.0039
18	20	0.0039
19	21	0.0039
20	16	0.0039
21	20	0.0039
22	16	0.0039
23	31	0.0039
24	20	0.0039
25	63	0.0100
26	80	0.0160
27	86	0.0160
28	70	0.0160
29	89	0.0160
30	82	0.0160
31	86	0.0160
32	77	0.0160
33	84	0.0160
34	84	0.0160
35	72	0.0160
36	64	0.0160
37	78	0.0160
38	64	0.0160
39	70	0.0160
40	81	0.0160

NUMBER	FREQUENCY	THEORETICAL FREQUENCY
41	76	0.0160
42	85	0.0160
43	82	0.0160
44	78	0.0160
45	71	0.0160
46	88	0.0160
47	81	0.0160
48	87	0.0160
49	81	0.0160
50	81	0.0137
51	49	0.0114
52	59	0.0114
53	64	0.0114
54	69	0.0114
55	68	0.0114
56	46	0.0114
57	47	0.0114
58	61	0.0114
59	45	0.0114
60	59	0.0114
61	73	0.0114
62	71	0.0114
63	56	0.0114
64	56	0.0114
65	63	0.0114
66	58	0.0114
67	57	0.0114
68	67	0.0114
69	45	0.0114
70	67	0.0114
71	51	0.0114
72	48	0.0114
73	55	0.0114
74	51	0.0114
75	53	0.0114
76	65	0.0114
77	68	0.0114
78	50	0.0114
79	50	0.0114
80	65	0.0114
81	59	0.0114
82	56	0.0114
83	53	0.0114

NUMBER	FREQUENCY	THEORETICAL FREQUENCY
84	54	0.0114
85	538	0.1057
	4999	1.0000

MEAN NUMBER OF DEPOSITS 52.047

SORTED SIMULATION RESULTS FOR COPPER
ORDER OF OCCURRENCE

RANK	TONNES CU
1	0.00000E-01
500	6.28991E+06
1000	8.78061E+06
1500	1.07799E+07
2000	1.28559E+07
2500	1.51000E+07
3000	1.72356E+07
3500	1.96951E+07
4000	2.22092E+07
4500	2.53669E+07
4999	4.48528E+07

CU GRADE %, DISTRIBUTIONS AT THREE PROBABILITIES

	PROB	%	PROB	%	PROB	%
SUITE 1	90%=	0.39033	50%=	0.95538	10%=	3.81189
SUITE 2	90%=	0.50947	50%=	0.86478	10%-	1.36656

EXPECTED MEAN COPPER METAL TONNAGE = 1.54339E+07

SORTED SIMULATION RESULTS FOR SILVER
ORDER OF OCCURRENCE

RANK	TONNES AG
1	0.00000E-01
500	3.16195E+04
1000	4.92353E+04
1500	6.34489E+04
2000	7.72090E+04
2500	9.05385E+04
3000	1.05393E+05
3500	1.21789E+05
4000	1.40633E+05
4500	1.65814E+05
4999	3.09144E+05

AG GRADE %, DISTRIBUTIONS AT THREE PROBABILITIES

	PROB	%	PROB	%	PROB	%
SUITE 1	90%=	0.00015	50%=	0.00394	10%=	0.00999
SUITE 2	90%=	0.00000	50%=	0.00000	10%-	0.00000

EXPECTED MEAN SILVER METAL TONNAGE = 9.58469E+04

SORTED SIMULATION RESULTS FOR TONNES
ORDER OF OCCURRENCE

RANK	TONNES ORE
1	0.00000E-01
500	7.95193E+08
1000	1.09176E+09
1500	1.35362E+09
2000	1.60424E+09
2500	1.86385E+09
3000	2.13544E+09
3500	2.44571E+09
4000	2.75829E+09
4500	3.12133E+09
4999	4.89946E+09

ORE TONNAGE, TONNES, DISTRIBUTIONS AT THREE PROBABILITIES

	PROB	TONNES	PROB	TONNES	PROB	TONNES
SUITE 1	90%=	152876.93750	50%	14421168.00000	10%=	143356544.00000
SUITE 2	90%=	1296031.75000	50%	19138440.00000	10%=	43990320.00000

EXPECTED MEAN ORE TONNAGE = 1.91091E+09

RUN 3: UNDISCOVERED REVETT-TYPE DEPOSITS IN TRACT II (0-0-3)
NUMBER OF DEPOSITS PER SIMULATION

NUMBER	FREQUENCY	THEORETICAL FREQUENCY
0	2846	0.5667
1	644	0.1333
2	671	0.1333
3	838	0.1667
	4999	1.000

MEAN NUMBER OF DEPOSITS 0.900

SORTED SIMULATION RESULTS FOR COPPER
ORDER OF OCCURRENCE

RANK	TONNES CU
1	0.00000E-01
500	0.00000E-01
1000	0.00000E-01
1500	0.00000E-01
2000	0.00000E-01
2500	0.00000E-01
3000	2.07781E+04
3500	2.24479E+05
4000	4.97425E+05
4500	8.97867E+05
4999	6.99057E+06

CU GRADES %, DISTRIBUTIONS AT THREE PROBABILITIES

	PROB	%	PROB	%	PROB	%
SUITE 1	90%=	0.39247	50%=	0.95346	10%=	3.82374
SUITE 2	90%=	0.49789	50%=	0.86044	10%-	1.37576

EXPECTED MEAN COPPER METAL TONNAGE = 2.75868E+05

SORTED SIMULATION RESULTS FOR SILVER
ORDER OF OCCURRENCE

RANK	TONNES AG
1	0.00000E-01
500	0.00000E-01
1000	0.00000E-01
1500	0.00000E-01
2000	0.00000E-01
2500	0.00000E-01
3000	0.00000E-01
3500	1.75239E+02
4000	1.35669E+03
4500	5.49172E+03
4999	5.06026E+04

AG GRADES %, DISTRIBUTIONS AT THREE PROBABILITIES

	PROB	%	PROB	%	PROB	%
SUITE 1	90%=	0.00015	50%=	0.00397	10%=	0.00990
SUITE 2	90%=	0.00000	50%=	0.00000	10%-	0.00000

EXPECTED MEAN SILVER METAL TONNAGE = 1.66770E+03

SORTED SIMULATION RESULTS FOR TONNES
ORDER OF OCCURRENCE

RANK	TONNES ORE
1	0.00000E-01
500	0.00000E-01
1000	0.00000E-01
1500	0.00000E-01
2000	0.00000E-01
2500	0.00000E-01
3000	1.59398E+06
3500	2.19274E+07
4000	5.42812E+07
4500	1.29092E+08
4999	4.64728E+08

ORE TONNAGE, TONNES, DISTRIBUTION AT THREE PROBABILITIES

	PROB	TONNES	PROB	TONNES	PROB	TONNES
SUITE 1	90%=	148970.15625	50%	14970460.00000	10%=	140670912.00000
SUITE 2	90%=	1327988.25000	50%	19404668.00000	10%=	43197560.00000

EXPECTED MEAN ORE TONNAGE = 3.35522E+07