National Uranium Resource Evaluation

EVALUATION OF SELECTED GEOCHEMICAL ANOMALIES IN COLORADO AND THE SOUTHEASTERN U.S.

FINAL REPORT

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TABLE OF CONTENTS

Section 1. Introduction

1.1 Objective and Scope	11
1.2 Uranium - The Exploration Problem	12
1.3 Rationale for Techniques Employed	13

Section 2. Methods of Investigation

2.1 Introduction	15
2.2 Procedures	15
Sampling	15
Sample Preparation	15
Analysis	16
Total Analysis, Sediment, Oxalic Acid Residues	16
Preparation of Oxalic Acid Residues	16
Partitioning Calculations	16

Section 3. Results

3.1 Tallahassee Creek Area	19
Discussion	24
3.2 Southeastern U.S.	24
CHA Area, Charlotte 1° x 2° Sheet	26
SPF Area, Spartanburg 1° x 2° Sheet	26
GRA Area, Greenville 1° x 2° Sheet	26
GRB Area, Greenville 1° x 2° Sheet	32
GRC Area, Greenville 1° x 2° Sheet	32
GRD Area, Greenville 1° x 2° Sheet	37

Section 4. Comparisons with Published HSSR Data

4.1 Comparison with SRL Analyses	45
4.2 Comparison of Uraniferous Occurrences with SRL Data	45

Section 5. Conclusions and Recommendations

5.1 Conclusions	53
5.2 Recommendations	54

TABLE OF CONTENTS (Continued)

	Page
<u>References</u>	57
<u>Appendices</u>	59
Appendix A. - Analyses, Tallahassee Creek Area;	60
Analysis of Boulder Coatings	
Analysis of minus 80-mesh sediment	61
Appendix B - Stream sediment analyses, southeastern U.S.	65
Appendix C - Uranium Assays	72
Appendix D - Uranium Assays	73

ILLUSTRATIONS

	Page
Figure 1. Map showing sample location sites and known uranium occurrences, Tallahassee Creek area, Colorado.	20
Figure 2. Uranium concentrations (ppm) in minus 80-mesh sediment, Tallahassee Creek area, Colorado. A - total U (ppm), heavy minerals removed. B - total U (ppm).	21
Figure 3. Uranium concentrations (ppm) in oxalic acid residues of minus 80-mesh sediment, Tallahassee Creek area, Colorado.	22
Figure 4. Uranium in oxalic acid residues of boulder coatings, Tallahassee Creek area, Colorado. A - uranium concentrations (ppm) in oxalic acid residues. B - U x Fe/Mn in oxalic acid residues.	23
Figure 5. Map showing locations of 63 sites anomalous for residual uranium (UR) and the locations of areas included in the present study in the southeastern U.S. Map adapted from Koch and other, 1979.	25
Figure 6. Histograms of total uranium concentrations in sediment and oxalic acid residues for all sites sampled in the southeastern U.S.	27
Figure 7. Map showing locations of drainages surveyed in evaluation of residual uranium anomalies near Greenville, S.C. Seven-character code for HSSR sites sampled by SRL and GRA- and GRB-sample numbers presented in Appendix B are also shown. Cross-hatched pattern indicates drainages in which one or more samples contains over 50 ppm U in oxalic acid residues.	28
Figure 8. Map showing total uranium (ppm)/uranium (ppm) in oxalic acid residue for two drainages upstream from SRL sites SCGV072 and SCGV132. Location of profile shown in Figure 9 is also indicated.	30
Figure 9. Profile along road north of Hampton Heights, S.C. (see Figure 8) showing distribution of lithologies, equivalent uranium (ppm), assays (U_3O_8) of samples (black squares) and equivalent U/equivalent Th ratios.	31

ILLUSTRATIONS (Continued)

Page

- Figure 10. Map showing total U (ppm)/U(ppm) in oxalic acid residues for two drainages (GRB area) near Fountain Inn, S.C. The location of uraniferous occurrence identified by radiometric survey is also shown. This area is shown in greater detail in Figure 11. 33
- Figure 11. Map showing sample sites and assays for uranium occurrence near Fountain Inn, S.C.. 34
- Figure 12. Geologic map of Greenville, S.C. area taken from Hatcher (1978). F - older Ordovician (?) granites of the Inner Piedmont; H - young (?) granites of the Inner Piedmont; 7 - sillimanite schist, muscovite and biotite schist; 8 - migmatitic biotite gneiss; J - biotite hornblende granodiorite. 35
- Figure 13. Map showing drainages surveyed in evaluation of residual uranium anomalies (UR) near Smeltzer Mountain, S.C. (GRC area). Seven-character code for HSSR sites sampled by SRL and GRC-sample numbers presented in Appendix B are also shown. Drainage west of Smeltzer Mountain containing over 50 ppm U in oxalic acid residues shown by cross-hatched pattern. 36
- Figure 14. Geologic map of GRC area, adapted from Hatcher (1978). 6 - mainly schists and quartzites (Chauga River and Plor Mountain Formations); stippled pattern - quartzofeldspathic gneiss. Drainages surveyed are also outlines. Cross-hatched pattern is drainage west of Smeltzer Mountain containing over 50 ppm uranium in oxalic acid residue. 38
- Figure 15. Map showing total U (ppm)/U (ppm) in oxalic acid residues for drainages west of Smeltzer Mountain (GRC area). Location of radiometric anomaly (stippled pattern) on the western slope of Smeltzer Mountain is also shown. 39
- Figure 16. Map showing drainages surveyed in evaluation of residual uranium (UR) anomalies near Clarkesville, Ga. (GRD area). Seven-character code for HSSR sites sampled by SRL and SRD-sample numbers presented in Appendix B are also shown. Drainage above sample site GAHA015 (cross-hatched pattern) contains over 50 ppm U in oxalic acid residues. 40

ILLUSTRATIONS (Continued)

Page

- Figure 17. Map showing total U(ppm)/U(ppm) in oxalic acid residues for drainages upstream from site GAHA015 on Ben Tatum Branch (GRD area). Location of radiometric anomalies and selected uranium assay values is also shown. 41
- Figure 18. Geologic map of GRD area, adapted from Hatcher (1978). 2 - metasedimentary rocks of the Tallulah Falls Fm.; 4 - Tallulah Falls quartzite - schist member; stippled pattern - Wolf Creek granitic gneiss and related granites. Drainages surveyed are also outlined. Cross-hatched pattern indicates drainage containing over 50 ppm U in oxalic acid residue (Ben Tatum Branch). 43
- Figure 19. Areal distribution of uranium concentrations in stream sediment for the Greenville 1° x 2° sheet (after Ferguson, 1978). X-symbol indicates locations of drainages containing over 50 ppm U in oxalic acid residues of sediment. 47
- Figure 20. Areal distribution of log U/log Ce in stream sediment for the Greenville 1° x 2° sheet (after Ferguson, 1978). X-symbol indicates locations of drainages containing over 50 ppm U in oxalic acid residues. 48
- Figure 21. Areal distribution of uranium concentrations in groundwater for the Greenville 1° x 2° sheet (after Ferguson, 1978). X-symbol indicates locations of drainages containing over 50 ppm U in oxalic acid residues. 49
- Figure 22. Areal distribution of log[U/Conductivity x 1000] in groundwater for the Greenville 1° x 2° sheet (after Ferguson, 1978). X-symbol indicates locations of drainages containing over 50 ppm U in oxalic acid residues. 50

TABLES

	Page
Table 1. Comparison of Uranium Analyses for Samples Collected at or near same sites.	46

SECTION 1. INTRODUCTION

1.1 Objective and Scope

Under a previous BFEC subcontract (#78-211-E), various methods for enhancing and displaying HSSR data were developed (Koch and others, 1979). The present contract has two major objectives: 1. Determining the applicability of HSSR data in uranium resource assessment; and, 2. Evaluation of selected HSSR geochemical anomalies identified under subcontract #78-211-E and reported in Koch and others (1979). This report deals exclusively with item 2 (above). A separate report by G. S. Koch, R. J. Howarth, and J. H. Schuenemeyer will summarize studies related to item 1.

Anomalous HSSR sample sites which were evaluated in the present study are located in the Tallahassee Creek area, Fremont County, Colorado. HSSR surveys conducted in this area are described by Shannon (1979). Evaluations were also made in portions of North Carolina and South Carolina where the Savannah River Laboratory (SRL) has described geochemical surveys on the Charlotte (Heffner and Ferguson, 1978), Spartanburg (Heffner and Ferguson, 1977); and Greenville (Ferguson, 1978) 1° x 2° NIMS areas.

Anomalies were identified from the HSSR data by the following procedures:

1. Calculating residual uranium values (UR) from multi-element data published by SRL and LASL.
2. Designation of HSSR sample sites to specific geological units delineated on published geologic maps.
3. Identification of anomalies by analysis of the frequency distribution of residual uranium (UR) values in the various geological units which comprise the study areas.

Residual uranium (UR) values are those that remain after the uranium present in resistate minerals is accounted for. The resistate minerals include monazite, xenotime, allanite, and zircon. Factors involved in the development of equations for UR, as well as the application of these procedures to HSSR data in the Tallahassee Creek area, Colorado, and the southeastern U.S. are described by Koch and others (1979).

In the evaluation of anomalous HSSR sample sites, several sampling media and analytical procedures were employed in the present study. In follow-up stream surveys, the uranium content of oxalic acid residues of fine stream sediment has proven to be an effective guide to uranium mineralization. Known uranium occurrences in the Tallahassee Creek area are defined much better by uranium concentrations in oxalic acid residues than by "total" analysis of sediment. In the southeastern U.S., two areas containing approximately .01% U in saprolite were discovered in

drainage basins in which oxalic acid residues were found to contain high concentrations of U. On the basis of information available at the present time, these areas represent excellent targets for continued exploration. In the Tallahassee Creek area, boulder coatings were also determined to be a useful sampling medium.

Ground radiometric surveys were also utilized in follow-up surveys of anomalous HSSR sample sites. Reconnaissance surveys served to locate uraniferous zones in several areas.

The major contributions of the present study are as follows:

1. Identification of areas containing potentially exploitable uranium mineralization.
2. The development of cost-effective geochemical procedures which have broad applicability in the search for uranium.

This study also demonstrates the utility of the HSSR data base in uranium exploration. All of the data which was utilized in the report was taken from published reports released by Bendix Field Engineering Corporation. Identification of specific uraniferous occurrences in areas lacking previous reports of uranium mineralization indicates the value of acquiring HSSR data in most regions of the U.S.

1.2 Uranium - The Exploration Problem

The nature of the occurrence of uranium and its daughter isotopes creates considerable difficulties in exploration. There are many documented cases where significant anomalies have no relationship to uranium mineralization. In some areas, stream sediment commonly contains several hundred ppm U represented entirely by resistate, accessory minerals (Price and Ferguson, 1980) whereas values of 10 ppm or less are known to occur downstream from known uraninite deposits (Tallahassee Creek area, this report). Ground waters locally exceed 500 ppb U in some areas, but have no known association with uranium mineralization. Near some uranium deposits, ground water contains less than 10 ppb U (Langmuir and Chatham, 1980). Significant radiometric anomalies arising from gamma-ray emissions from Bi-214 may not reflect uranium mineralization in some areas because of disequilibrium. Alternatively, high-grade uranium deposits may lack corresponding radiometric anomalies because of disequilibrium (Hambleton-Jones, 1978).

In recent years considerable emphasis has been placed on development of more effective exploration procedures. At present, there is no general agreement on optimum procedures and no single method appears to be universally effective. The problem does not appear to be related to analytical precision, accuracy, or detection limits. Most analytical systems can provide values of much greater precision and accuracy than that required to delineate legitimate anomalies. The problem appears to be that the anomalies

arise from factors other than uranium mineralization.

1.3 Rationale for Techniques Employed

The procedures utilized in this study are based on differences in the geochemical properties of the principal ore minerals of uranium, uraninite and coffinite, and those of uraniferous, resistate accessory minerals such as monazite, xenotime, zircon, and allanite. Under the oxidizing conditions which characterize most areas of the earth's crust, the contained uranium in uraninite and coffinite is readily oxidized from +4 to +6 resulting in soluble complexes such as the uranyl ion, or dicarbonate and tr carbonate anions (Hambleton-Jones, 1978). The soluble uranium species tend to be carried away in ground water, eventually emerging to the earth's surface in springs and streams. In the process of soil formation, small quantities of soluble uranium may be scavenged by iron oxides or organic matter, or coprecipitated by phosphate, arsenate, or vanadate complexes (Bradshaw, 1980). As soil erodes, this uranium is incorporated into stream sediment as well as uranium from resistate heavy minerals which are concentrated in the streams by processes of weathering and erosion. Soluble uranium introduced into the stream environment in groundwater is also scavenged in varying degrees by iron oxides and organic matter (Rose, 1977; Langmuir, 1978). In summary, introduction of soluble uranium in the environment may result in higher concentrations of uranium in iron oxides and organic matter.

Based on these considerations, pure iron oxide from stream sediment would be a much better sample than sized sediment which consists mainly of common minerals such as quartz, feldspar, clays, etc., and accessory minerals, as well as minute quantities of iron oxides. Although mechanical separation of pure iron oxide is extremely difficult due to the occurrence of iron oxides as thin "wispy" coatings on clastic grains, chemical separations are quite effective. A technique developed by Alminas and Mosier (1976) utilizes a 3% oxalic acid solution that preferentially leaches iron and manganese oxides from stream sediment with little or no effect on common silicate minerals and most accessory minerals. When evaporated to dryness and heated in a furnace, the oxalate is volatilized leaving a residue consisting mainly of iron oxides. A high concentration of U in the oxalic acid residue is direct evidence for soluble uranium in the environment. Because resistate uraniferous minerals are unaffected by the oxalic acid, the complexities introduced by the presence of uranium in these phases is eliminated.

Coatings of Fe-Mn oxides on large boulders can also be analyzed by a modification of this procedure. Unlike sediment where some of the contained iron oxide was probably derived by erosion of soil, boulder coatings represent iron and contained metals introduced into the stream environment in solution (Carpenter and Hayes, 1979; Whitney, 1975).

Certain types of organic matter constitute viable sampling media in geochemical exploration for uranium due to the ability of certain organisms

to scavenge dissolved uranium from stream water. Whitehead and Brooks (1969) used aquatic bryophytes (mosses and liverworts) to delineate uranium mineralization in New Zealand. The present writer, together with T. T. Chao and F. N. Ward of the U. S. Geological Survey have also determined that aquatic bryophytes served to define areas of uranium mineralization near Kenosha Pass, Colorado (Carpenter and others, 1980).

In this study, primary emphasis has been placed on uranium concentrations in oxalic acid residues of stream sediment. In the Tallahassee Creek area, boulder coatings were also analyzed. Moss and other organic media were not considered.

SECTION 2. METHODS OF INVESTIGATION

2.1 Introduction

In our statistical analysis of HSSR data using equations for residual uranium (UR), 63 anomalous sites (out of a total of 5197 sites) were identified in the southeastern U.S. and 7 anomalous sites (out of 311 sites) in the Tallahassee Creek area (Koch and others, 1979). These sites were located first on topographic maps at a scale of 1:250,000, and subsequently on quadrangle maps at scales of either 1:62,500 or 1:24,000.

In the southeastern U.S. evaluations were made in 6 areas where at least two or more adjacent HSSR sites were anomalous. Twenty-six HSSR sites occurred in these 6 "clusters". The remaining 37 sites represent isolated anomalies and were not included in the present study.

A total of 170 follow-up stream sediment samples were collected in the 6 areas. The initial HSSR sampling sites were resampled in each area as well as a number of sites upstream from the initial site. A "total" uranium analysis, and analysis of U and Fe in the oxalic acid residue, was obtained for each sediment sample.

In the Tallahassee Creek area, 22 sites were sampled on major streams. Analyses were performed on the following materials:

1. Boulder coatings - oxalic acid residues (Fe, Mn, U).
2. Minus 80-mesh sediment - (total U, Th).
3. Minus 80-mesh sediment - heavy minerals removed (total U, Th, Fe).
4. Minus 80-mesh sediment - oxalic acid residues (U, Fe).

2.2 Procedures

Sampling

All samples were collected from flowing streams. Sediment and boulders were collected from mid-stream sites and placed in olefin bags for storage and transport. For boulders, attempts were made to collect samples containing the greatest abundance of coating on the surface. Three or four boulders weighing approximately 2 lbs. each were collected at each site.

Sample Preparation

Stream sediment samples were dried in the olefin bags under infrared

lamps at a temperature of 65° C for a period of 3-4 days. They were subsequently screened to either minus 80-mesh (Tallahassee Creek samples) or minus 100-mesh (southeastern U.S. samples) in stainless steel screens utilizing a Ro-Tap machine for a 3-minute period.

In one experiment with the Tallahassee Creek samples, heavy minerals were removed from minus 80-mesh sediment in tetrabromoethane and the "light" fraction submitted for analysis.

Boulder coatings were washed in distilled water to remove sediment and some of the organic material which adhered to the surface. All of the boulders from each site were placed in a 2 l beaker and immersed in 3% oxalic acid solution for a 30-minute period. A filtered 500 ml sample of the solution was submitted for analysis for Fe, Mn, and U.

Analysis

All analyses were performed by Skyline Labs, Inc. in their laboratory at Wheat Ridge, Colorado. Procedures utilized for analysis of sediment and boulder coatings are summarized below.

Total analysis, sediment, oxalic acid residues.

A 0.2 gm sample is digested in a mixture of hydrofluoric, nitric, and perchloric acid in a teflon beaker and evaporated to dryness. The precipitate is redissolved in nitric acid. Prior to extraction of uranium with MIBK (methylisobutyl ketone), aluminum nitrate is added to the solution. A 1 ml aliquot of the MIBK extract is mixed with sodium fluoride, potassium carbonate, and sodium carbonate and placed in a furnace where the mixture fuses into a solid disk. The disk is placed in a fluorimeter for uranium analysis. Iron and manganese are analyzed by AA procedures on another split of the sample. This is determined by XRF (X-ray fluorescence) analysis on yet another split.

Preparation of oxalic acid residues.

For sediment, a 5 gm sample is dissolved in 3% oxalic acid and boiled for 5 minutes. This solution is filtered through No. 41 Whatman filter paper and evaporated to dryness. The precipitate is placed in a muffle furnace and heated at 450° C for ½ hour. This volatilizes the oxalate leaving a residue consisting mainly of iron and manganese oxides and contained metals. The residue is quantitatively recovered and weighed. A fraction is analyzed by the same procedures noted above for sediment.

The 500 ml oxalic acid solution extracts of the boulder coatings were treated identically to those described for stream sediment extracts.

Partitioning calculations

Knowing total uranium (ppm), U (ppm) in oxalic acid residue, the weight

of the oxalic acid residue, and the bulk sample weight, the % of the total uranium in the sample represented by that in the oxalic acid residue can be determined by the equation given below.

$$\begin{array}{l} \text{\% total U in} \\ \text{oxalic acid residue} \end{array} = \frac{[\text{U (ppm) in oxalic acid residue}] \times [\text{wt. of residue}]}{[\text{total U (ppm) in sample}] \times [\text{initial sample wt.} \\ \text{prior to digestion} \\ \text{with oxalic acid.}]}$$

SECTION 3. RESULTS

3.1 Tallahassee Creek Area

Analytical data for the Tallahassee Creek area is summarized in Appendix A. The location of sampling sites in relation to known uranium occurrences is shown in Figure 1. Information presented on the size and outline of the deposits is taken mainly from Nelson-Moore and others (1978). The dominant ore minerals are uraninite and coffinite. Major occurrences are located along Middle Tallahassee Creek. Most of the shallow deposits in this area occur in the Tallahassee Creek conglomerate (Oligocene). Mineralization also occurs in a stratigraphically lower unit, the Echo Park Alluvium (Eocene). A buried deposit in the Echo Park Alluvium recently discovered by Cyprus Mines (Hansen lease) is reported to contain 13.6 million kilograms of U_3O_8 . Other rock types present in the study area include Precambrian granodiorite plutons, Precambrian metasedimentary rocks, rhyolitic ash flow tuffs (Oligocene), and Tertiary andesites. For further information on geology and mineralization in the area, the reader is referred to Shannon (1979).

Figure 2 shows the distribution of uranium in minus 80-mesh sediment samples. In 2A, results are shown for a fraction in which heavy minerals have been removed. Both media show virtually the same range of concentration, less than 2 ppm to 7 ppm. Although higher values occur in the vicinity of known mineralization, the total spread of values is low. In this area, uraniferous heavy minerals do not appear to be particularly abundant in the sediment.

Figure 3 illustrates uranium concentrations in oxalic acid residues. In this media, values range from 11 - 75 ppm. Highest values are located near mineralized areas along Middle Tallahassee Creek.

Relationships for oxalic acid residues of boulder coatings are shown in Figure 4A and 4B. Concentrations of uranium range from 5 to 60 ppm. Higher values again reflect the mineralized areas. In Figure 4B, the factor $(U) \times (Fe/Mn)$ appears to magnify the contrast between mineralized and unmineralized areas. Values for this factor range from 0.8 to 164.5. Groundwater passing through a mineralized zone will not only dissolve uranium, but also iron, manganese, and other metals. If the groundwater is more acid than adjacent areas, iron may be more copiously precipitated than manganese where the water emerges into a stream. Because the factor is multiplicative, contrast between mineralized and unmineralized areas is enhanced.

U/Fe ratios in oxalic acid extracts of sediment also define mineralization quite well. However, iron concentration is relatively constant, ranging from 22.5% to 33%. Consequently, the ratios provide essentially the same pattern as U concentrations in the oxalic acid residues.

Figure 1. Map showing sample location sites and known uranium occurrences, Tallahassee Creek area, Colorado.

A

B

Figure 2. Uranium concentrations (ppm) in minus 80-mesh sediment, Tallahassee Creek area, Colorado. A - total U (ppm), heavy minerals removed. B - total U (ppm).

Figure 3. Uranium concentrations (ppm) in oxalic acid residues of minus 80-mesh sediment, Tallahassee Creek area, Colorado.

A

B

Figure 4. Uranium in oxalic acid residues of boulder coatings, Tallahassee Creek area, Colorado. A - U (ppm) in oxalic acid residues. B-U x Fe/Mn in oxalic acid residues.

Discussion

Previously, Shannon (1979) described a geochemical survey involving 311 sites in the study area. Most of the sites were along small, dry tributaries of the principal streams. Minus 100-mesh samples were analyzed by neutron activation for U and consequently represent a total analysis. Values above 12 ppm in the minor drainages are generally associated with uranium mineralization. However, insufficient samples were collected along the principal streams to determine if mineralization is reflected in the analysis of these sediments.

The present study suggests that "total" analysis of uranium in sediment along the major drainages may provide weak anomalies. However, if the samples were collected in a regional survey, there is some question as to how anomalous the values would appear. Perhaps they would tend to blend in with background.

U concentrations in oxalic acid extracts of sediment and/or boulder coatings provide much more pronounced anomalies near mineralization. In a regional survey, the anomalies along Middle Tallahassee Creed would probably remain intact in these media.

The question of whether stream sediment geochemistry can be effective if samples are limited to major drainages is an important one. In the present study, only 22 sites were sampled. Shannon (1979) reports analyses at 311 sites in approximately the same area. Most of the sites reported by Shannon were on dry streams less than 0.25 miles in length with drainage areas of less than 0.1 sq. miles. Both surveys defined the main area of mineralization. However, in the present study, the sample requirement was less than 10% of that reported by Shannon. Furthermore, indicated anomaly/background ratios from the oxalic acid residues of sediment and boulder coatings are generally greater than those present in total analysis reported by Shannon.

The degree to which past mining activities has served to accentuate anomalies by acceleration of the rate of weathering is not known with certainty. The largest known deposit in the area is the Hansen lease, but it is known to be buried and is probably unweathered. It does not provide a geochemical anomaly in any of the media employed.

3.2 Southeastern U.S.

Analytical results for stream sediment analyses from the southeastern U.S. are summarized in Appendix B. Chemical assays of rock and saprolite samples are presented in Appendices C and D. The six areas, or "clusters", included in the present evaluation are shown in Figure 5. They represent 26 sites in which residual uranium (UR) values calculated from published HSSR data were determined to be anomalous. The areas were selected on the basis of proximity of anomalous sites to one another rather than the intensity of individual anomalies.

Figure 5. Map showing locations of 63 sites anomalous for residual uranium (UR) and the locations of areas included in the present study in the southeastern U.S. (CHA, SPF, GRA, GRB, GRC, and GRD). Map adapted from Koch and others (1979).

Total uranium was analyzed in the minus 100-mesh fraction of 170 samples. In addition, uranium and iron were determined for oxalic acid residues as well as the weight of the oxalic acid residue obtained from a 5 gm sample.

Figure 6 is a histogram which summarizes the distribution of values in the two fractions. For total uranium analysis, values range from less than 2 ppm to 95 ppm. The U concentration is less than 20 ppm for 80.5% of the samples. In the oxalic acid residues, values range from less than 2 ppm to 220 ppm U. Only 67% of the samples contain less than 20 ppm U. Twenty-five samples contained over 50 ppm U in the oxalic acid residues. Follow-up exploration was concentrated in these drainages which include portions of GRA, GRB, GRC, and GRD which are shown on the geologic map in Figure 5.

Inspection of the data in Appendix B shows that there is no close relationship between uranium concentrations in the two fractions. Sample GRA-37A contains the highest concentration of total U (95 ppm), but contains only 8 ppm in the oxalic acid residue. On the other hand, sample GRB-10A contains the highest concentration of uranium in the oxalic acid residue (220 ppm) but contains only 14 ppm total U. Because past experience has shown that uraniferous accessory minerals unrelated to uranium mineralization commonly account for high total uranium concentrations in sediment, emphasis has been placed on analytical results for the oxalic acid residues.

Relationships for individual anomalous areas are discussed below:

CHA Area, Charlotte 1° x 2° Sheet

Thirty-one samples collected from this area contain less than 20 ppm U in oxalic acid residues. The reasons for the high UR values is not clear. One explanation is that U-Th-RE relationships for accessory minerals are different than those assumed in the equation for UR. Most of the area is included in the Oak Hill and Cornover pegmatite districts. It is possible that monazite, xenotime, or zircon derived from pegmatites are compositionally different from the same minerals derived from other rock types.

SPF Area, Spartanburg 1° x 2° Sheet

This area is located near Winnsboro, S.C. For both total U and U in oxalic acid residues, the 30 samples collected from this area contained less than 15 ppm. High UR values determined for this area may indicate compositionally unique accessory minerals derived from the Winnsboro granitic pluton.

GRA Area, Greenville 1° x 2° Sheet

This area is located northeast of Greenville, S.C. and consists of 6 drainages in which UR values were determined to be anomalous (Figure 7). The 7-character SRL site numbers are shown as well as GRA-sample numbers. Drainages shown with a cross-hatched pattern contain over 50 ppm U in oxalic acid residues.

Figure 6. Histograms of total uranium concentrations in sediment and oxalic acid residues for all sites sampled in the southeastern U.S.

Figure 7. Map showing locations of drainages surveyed in evaluation of residual uranium anomalies near Greenville, S.C. Seven-character code for HSSR sites sampled by SRL and GRA- and GRB- sample numbers presented in Appendix B are also shown. Cross-hatched pattern indicates drainages in which one or more samples contains over 50 ppm U in oxalic acid residues.

Detailed relationships for samples collected upstream from sites SCGV072 (GRA- 13-18) and SCGV132 (GRA- 6-12) are shown in Figure 8. Although total U values are generally less than 30 ppm, all of the values in the southern drainage exceed 70 ppm in oxalic acid residues.

A radiometric survey of the anomalous drainage reveals intense anomalies along a road north of Hampton Heights. A 3600 ft. profile along this road is shown in Figure 9. Equivalent U determined from 2-minute counts on a 4-channel gamma ray spectrometer exceeds 20 ppm along two portions of the traverse. Ratios of eU/eTh exceed 6/1 at several localities along the traverse. Only near the northern limit are ratios in the 0.1 to 0.3 range which are normal for most average rocks in the earth's crust. Chemical assays taken at selected sites are typically double the indicated U concentrations from radiometric measurements. At 1100N and 2600N, chemical assays indicate .0070% and .0085% U_3O_8 (70 and 85 ppm U_3O_8) compared to eU values of 20 and 33 ppm U, respectively. In our initial evaluation of the anomaly, three additional samples were submitted for assay, but their exact location along the profile is not known. These contained 65, 75, and 110 ppm U (Appendix D).

The dominant rock type, which is well exposed in roadcuts along the profile, is mica schist. Small pegmatitic stringers, generally less than 3 cm in thickness, are locally present. Feldspathic and sillimanite-bearing mica schists are also present. In general, the foliation of these rocks display a large angle with respect to the profile suggesting that a significant stratigraphic thickness may be represented.

Some other relationships noted for the occurrence are as follows:

1. Concentrations of heavy minerals in ditches along the profile do not show enhanced radioactivity. In other areas where high radioactivity is due to monazite, heavy mineral concentrations show elevated gamma ray intensities.
2. Radioactivity diminishes away from exposures along the road.

It appears likely that the A and B horizons are leached of U and radioactive daughter isotopes. Elevated values of U in oxalic residues of stream sediment support the hypothesis that U is being mobilized by weathering. Relatively low concentrations of total U in stream sediment suggest that uraniferous accessory minerals are not abundant in the drainage. This is further supported by the lack of radioactivity of heavy mineral concentrations in ditches. The higher chemical assays for U vs. eU determined radiometrically, suggest that certain daughter isotopes have been leached from saprolite more thoroughly than U.

Although the material sampled contains sufficient relict minerals and texture to determine its lithology, it disaggregates readily when struck with a hammer. None of the samples collected is fresh. If U has been leached from the saprolite, which appears likely, higher concentrations might be expected in unweathered rock at depth.

Figure 8. Map showing total uranium (ppm)/uranium (ppm) in oxalic acid residue for two drainages upstream from SRL sites SCGV072 and SCGV132. Location of profile shown in Figure 9 is also indicated.

Figure 9. Profile along road north of Hampton Heights, S.C. (see Figure 8) showing distribution of lithologies, equivalent uranium (ppm), assays (U_{3O8}) of samples (black squares) and equivalent U/equivalent Th ratios.

Regional geological relationships are discussed below in the section on the GRB area.

GRB Area, Greenville 1° x 2° Sheet

Sediment in two adjacent streams near Fountain Inn, S.C. contained anomalous UR values (Figure 7). In follow-up surveys, extremely high U concentrations were identified in the southern stream where 3 samples exceed 100 ppm U (Figure 10). One sample, GRB-10A, contains 220 ppm U in oxalic acid residues. This is the highest value obtained in the entire study area.

A radiometric survey of the area revealed an intense anomaly in a recently excavated roadcut. This locality is identified in Figure 10. Relationships for this occurrence are shown in Figure 11. Equivalent U values determined at 8 localities range from 9.9 to 52.6 ppm. Two samples collected for assay contain .0075% and .0095% U_3O_8 (75 ppm and 95 ppm U_3O_8). The 95 ppm sample was taken with a pick about .5 m below the level of the ditch next to the road. Equivalent U values for these samples are 47.3 and 52.6 ppm, respectively. Ratios for eU/eTh are quite anomalous, generally exceeding a value of 2.0.

Overall relationships are similar to those determined for GRA. The anomaly is associated with muscovite mica schist which locally contains sillimanite. Chemical assays vs. eU are about 2:1 and quite high eU/eTh characterize the occurrence.

Geological relationships for the area, which includes GRA and GRB, are shown in Figure 12. The geological map is adapted from Hatcher (1978). Most of the drainages which contain over 50 ppm U in oxalic acid residues are near the contact between mica schist and metagranite.

Because the uraniferous occurrences at GRA and GRB are so similar, yet separated by a distance of 20 miles, additional occurrences of uraniferous mica schist might be expected elsewhere in the area. The contact zone between metagranite and mica schist would deserve the highest priority.

Detailed evaluations of the most uraniferous occurrences identified at GRA and GRB are warranted. Shallow drilling is essential to establish whether or not uranium has been leached. If it has, ore-grade mineralization may exist in fresh rock at depth.

GRC Area, Greenville 1° x 2° Sheet

This area is located in a mountainous section of South Carolina in the north-central portion of the Greenville sheet. Three streams contain anomalous UR values (Figure 13). Follow-up sampling of these anomalies revealed a drainage near Smeltzer Mountain which contains over 50 ppm U in oxalic acid residues of sediment.

Two drainages containing samples GRC 1-19 are along strike from a

Figure 10. Map showing total U (ppm)/U (ppm) in oxalic acid residues for two drainages (GRB) area near Fountain Inn, S.C. The location of uraniferous occurrence identified by radiometric survey is also shown. This area is shown in greater detail in Figure 11.

Figure 11. Maps showing sample sites and assays for uranium occurrence near Fountain Inn, S.C.

Figure 12. Geologic map of Greenville, S.C. area taken from Hatcher (1978). F - older Ordovician (?) granites of the Inner Piedmont; H - young (?) granites of the Inner Piedmont; 7 - sillimanite schist, muscovite and biotite schist; 8 - migmatitic biotite gneiss; J - biotite hornblende granodiorite.

Figure 13. Map showing drainages surveyed in evaluation of residual uranium anomalies (UR) near Smeltzer Mountain, S.C. (GRC area). Seven-character code for HSSR sites sampled by SRL and GRC-sample numbers presented in Appendix B are also shown. Drainage west of Smeltzer Mountain containing over 50 ppm uranium in oxalic acid residue shown by cross-hatched pattern.

throrite (ThO_2) occurrence which is located near Persimmon Mountain on the Tamassee quadrangle (personal communication, Van Price, 1980). In the equation for UR, a mineral high in Th that lacks rare earths is not accounted for. The effect of this is to generate artificially high UR values. This may explain why samples collected upstream from SRL sites SCOC125 and SCOC091 are not anomalous for uranium in oxalic acid extracts. SCOC125 is also reported to contain 191 ppm Th which is quite high for this area (Ferguson, 1978).

The locations of these drainages relative to geologic units mapped in the area are shown in Figure 14. The anomaly near Smeltzer Mountain is located mainly in the Henderson gneiss and to a lesser extent in quartzites of the Chauga River and Poor Mountain Formations. The other drainages are in the Brevard Fault Zone and associated rocks are mainly cataclastites.

Relationships for stream sediment near Smeltzer Mountain are shown in Figure 15. Total U values are extremely low (less than 7 ppm). However, in oxalic acid residues, U concentrations exceed 75 ppm on the western slope of Smeltzer Mountain.

A limited radiometric survey on the western slope of Smeltzer Mountain revealed a prominent anomaly. Over the area shown by the stipled pattern, eU values were in the 8-16 ppm range, and eTh values were in the 23-67 ppm range. Samples were not submitted for chemical analysis. Although indicated eU/eTh ratios are not particularly favorable, anomalous U concentrations in oxalic acid residues suggest that U is mobile. The low total U concentrations in stream sediment suggest that uraniferous heavy minerals are not abundant in the sediment. High eTh in the radioactive zone, however, suggests that either a Th-rich mineral accompanies a U-rich mineral that is soluble, or that U and Th both occur in a single phase which is susceptible to weathering.

Further evaluation of this anomaly is warranted. The extent of the radiometric zone on the western slope of Smeltzer Mountain should be determined. Chemical analyses should be made to determine the state of equilibrium in the U and Th decay series. Detailed stream sediment surveys along strike from this occurrence are also warranted.

GRD Area, Greenville 1° x 2° Sheet

Five drainages north of Clarkesville, Ga. were anomalous for UR (Figure 15). Follow-up stream sediment surveys revealed a small anomaly on Ben Tatum Creek upstream from SRL site GAHA105. Analyses of stream sediment from this drainage is shown in Figure 17. Site GRD-16A contains 55 ppm U in oxalic acid residues. Total U concentrations are less than 7 ppm in all samples.

A radiometric survey yielded two small, but intense anomalies in the drainage. The anomalies were confined to an area recently excavated for 5 large chicken barns (locality indicated by cross in Figure 17). Both occurred in saprolite derived from biotite gneiss and are separated

Figure 14. Geologic map of GRC area, adapted from Hatcher (1978). 6 - mainly schists and quartzites (Chauga River and Poor Mountain Formations); stippled pattern - quartzofeldspathic gneiss. Drainages surveyed are also outlined. Cross-hatched pattern is drainage west of Smeltzer Mountain containing over 50 ppm U in oxalic acid residue.

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

Figure 15. Map showing total U (ppm)/ U (ppm) in oxalic acid residues for drainages west of Smeltzer Mountain (GRC area). Location of radiometric anomaly (stippled pattern) on the western slope of Smeltzer Mountain is also shown.

Figure 16. Map showing drainages surveyed in evaluation of residual uranium (UR) anomalies near Clarkesville, Ga. (GRD area). Seven-character code for HSSR sites sampled by SRL and GRD-sample numbers presented in Appendix B are also shown. Drainage above sample site GAHA015 (cross-hatched pattern) contains over 50 ppm U in oxalic acid residues.

Figure 17. Map showing total U (ppm)/U (ppm) in oxalic acid residues for drainages upstream from site GAHA015 on Ben Tatum Branch (GRD area). Location of radiometric anomalies and selected uranium assay values is also shown.

by about 500 ft. At one locality, chemical assays of 38 and 34 ppm U correspond with eU determinations of 45 and 28 ppm U, respectively. Equivalent Th concentrations were 54 and 63 ppm at these sites.

At the second radioactive anomaly, the following results were obtained: 1) AC-C contained 7 ppm U on assay, 7 ppm eU, and 80 ppm eTh; 2) AC-D contained 27 ppm U on assay, 14 ppm eU, and 89 ppm eTh; and 3) AC-E contained 5 ppm U on assay, 3 ppm eU, and 122 ppm eTh.

Based on this data, one radiometric anomaly results from both U and Th, while the other is due mainly to Th. In general eU and chemical U are similar, suggesting that the isotopes in the U-decay series are essentially in equilibrium.

The anomalies could not be traced outside the excavated areas. Both were less than 100 ft. in length, and ranged in thickness from 5 to 60 ft.

Resistate accessory minerals may account for most of the U and Th identified in the radioactive zones. Daughter isotopes in the resistate phases might be expected to remain in equilibrium because of the chemical stability of the host phases. Some soluble uranium-bearing mineral is probably also present in the drainage to account for the modest anomaly (55 ppm U in the oxalic acid residue of sample GRD-16A).

Figure 18 shows the location of the drainages investigated in relation to geologic units determined for the area. Three out of four drainages, including the one containing Ben Tatum Branch (cross-hatched pattern) occur near the contact between the Wolf Creek granitic gneiss and meta-sedimentary rocks.

Figure 18. Geologic map of GRD area, adapted from Hatcher (1978). 2 - metasedimentary rocks of the Tallulah Falls Fm.; 4 - Tallulah Falls quartzite-schist member; stippled pattern - Wolf Creek granitic gneiss and related granites. Drainages surveyed are also outlined. Cross-hatched pattern indicates drainage containing over 50 ppm U in oxalic acid residue (Ben Tatum Branch).

SECTION 4. COMPARISONS WITH PUBLISHED HSSR DATA

In follow-up surveys described in this report, a number of sites which were sampled by SRL were also sampled in the present study and analyzed by Skyline Labs, Inc. The minus 100-mesh fraction was analyzed by both laboratories. A comparison of the results is described.

A comparison is also made between the locations of drainages containing sediment with over 50 ppm U in oxalic acid residues and geochemical maps previously prepared by SRL for the Greenville 1° x 2° Sheet.

4.1 Comparison with SRL Analyses

Table 1 summarizes the results of analyses for U collected on the same streams at or near the sites reported by SRL. With one exception, SRL analyses (neutron activation) are higher than those made by Skyline Labs (fluorimetry). Although different analytical procedures may account for some of the discrepancies, differences in sampling and sample preparation may also account for the dissimilar results. One of the follow-factors is most likely involved:

1. In sampling and/or sample preparation, SRL tended to concentrate uraniferous heavy minerals (monazite, xenotime, etc.) to a greater degree than in the present investigation.
2. In analysis, the hydrofluoric-nitric-perchloric acid mixture used by Skyline Labs does not dissolve certain refractory minerals such as monazite, xenotime, and zircon. Because SRL uses neutron activation, sample digestion is not a factor.

In the present investigation, HSSR data from SRL was used to select anomalous areas, whereas data from Skyline Labs was used in the evaluation of these areas.

4.2 Comparison of Uraniferous Occurrences with SRL Data

Four uraniferous occurrences with associated radioactivity were located in drainages on the Greenville 1° x 2° Sheet where oxalic acid residues of sediment contain over 50 ppm U. Two additional drainages contain over 50 ppm U in oxalic acid residues.

These six localities have been plotted (X symbols) on maps prepared by Ferguson (1978) and are shown in Figures 19-22. A rating system was

Table 1. Comparison of Uranium Analyses for Samples Collected at or near the same sites.

Present Study		SRL Study	
Sample #	U(ppm)	Sample #	U(ppm)
CHA-8	3	NCCL044	65
CHA-21	16	NCCL049	83
CHA-22	14	NCBK060	124
CHA-14	12	NCCL048	88
SPF-28	2	SCFA044	54
SPF-30	3	SCFA041	51
GRA-17	13	SCGU072	83
GRA-10	18	SCGU132	51
GRA-5	11	SCGU085	88
GRA-23	80	SCSP053	87
GRA-31	65	SCSP076	98
GRA-38	95	SCGU079	68
GRB-7	28	SCLU005	75
GRB-15	34	SCLU006	51
GRD-6	-2	GAHA060	46
GRC-22	3	SCOC103	45
GRC-8	-2	SCOC125	63
GRC-19	-2	SCOC091	22
GRD-13	6	GAHA015	28

GREENVILLE 1°x2° Sheet
 Uranium In Sediments
 1401 Values Above D. L.

Uranium concentration - p.p.m.				
+ < 0.9	• 2.1- 2.8	○ 6.1- 8.9	⊙ 18.7- 29.1	● 57.2- 86.5
x 0.9- 1.6	○ 2.8- 4.1	⊙ 8.9- 13.0	● 29.1- 39.5	◆ 86.5- 131.3
• 1.6- 2.1	○ 4.1- 6.1	⊙ 13.0- 18.7	● 39.5- 57.2	★ > 131.3

Figure 19. Areal distribution of uranium concentrations in stream sediment for the Greenville 1° x 2° sheet (after Ferguson, 1978). X-symbol indicates locations of drainages containing over 50 ppm U in oxalic acid residues of sediment.

Figure 20. Areal distribution of $\log U/\log C_e$ in stream sediment for the Greenville 1° x 2° sheet (after Ferguson, 1978). X-symbol indicates locations of drainages containing over 50 ppm U in oxalic acid residues.

Figure 21. Areal distribution of uranium concentrations in groundwater for the Greenville 1° x 2° sheet (after Ferguson, 1978). X-symbol indicates locations of drainages containing over 50 ppm U in oxalic acid residues.

GREENVILLE 1°x2° Sheet
Ux1000/Cond. In Ground Water
712 Values Above D.L.

Figure 22. Areal distribution of $\log(U/\text{Conductivity} \times 1000)$ in groundwater for the Greenville 1° x 2° sheet (after Ferguson, 1978). X-symbol indicates locations of drainages containing over 50 ppm U in oxalic acid residues.

devised to compare the six localities with selected parameters (uranium in sediment, Figure 19: $\log U/\log Ce$ in sediment, Figure 20: U in groundwater, Figure 21; and, $\log (U/\text{conductivity} \times 1000)$ in groundwater, Figure 22). For each parameter, SRL reports 15 class intervals with separate symbols. Each locality is rated 1 - 15 depending on the nearest symbol on the map. A perfect score would be 90, the worst possible score is 6. Scores for the various parameters are as follows: U in stream sediment - 73; $\log U/Ce$ in stream sediment - 77; U in groundwater - 51; $\log (U/\text{conductivity} \times 1000)$ in groundwater - 54.

Stream sediment parameters rate highest with respect to the six localities. The average concentration of U in stream sediment on the Greenville sheet is 10 ppm, whereas the average U concentration in sediment associated with the 6 localities is about 40 ppm. For $\log U/\log Ce$ in sediment, the mean value for the Greenville sheet is .46 compared with an average value of .63 for the 6 localities. The apparent relationship is not surprising since the streams were selected for follow-up survey on the basis of high UR values which in turn depend on sites with high uranium concentration as well as high U/Ce ratios.

Scores for groundwater are distinctly lower. The average U and $\log (U/\text{conductivity} \times 1000)$ in groundwater is about the same for the six localities as for the average of all groundwater sites on the Greenville sheet. Unlike stream sediment, some of the groundwater sites are from different watersheds than the identified uraniferous localities. This would tend to make a positive comparison less likely.

5a

SECTION 5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study demonstrates the utility of HSSR geochemical data from stream sediment in exploration for uranium. In the southeastern U.S., four uraniferous occurrences and associated radiometric anomalies were identified in areas where uranium mineralization has not been previously reported. At two localities, assays of about .01% have been obtained from saprolite. There is some evidence which suggests that uranium may have been leached at these localities and that higher grades of U are likely at depth.

In determining anomalies from HSSR data, it is essential that elements other than uranium be utilized in the evaluation. Uraniferous resistate heavy minerals such as monazite, xenotime, zircon, and allanite are widespread and can create "anomalies" which may be more intense than those arising from uranium mineralization. Ce, Y, Hf, Zr, Dy, and Th as well as other rare earths can be used in regression equations with uranium, or mineralogical models can be developed, to remove the affects of these minerals. Many of these techniques are discussed by Koch and others (1979). Even simple ratios such as U/Ce or U/(Ce + Th + Hf) are more likely to reflect mineralization than the highest uranium values. Pathfinder elements should also be considered in anomaly selection. Common pathfinder elements for U include Se, Mo, V, As, and Ni.

The process of anomaly selection should also take into account variations in background over the region being considered. We have found that geological stratification of data into lithologic units followed by an analysis of the frequency distribution of various parameters is an effective means of accomplishing this. Computer-based cartographic techniques such as picture-frame filters or Kolmogorov-Smirnov filters can also be used for this purpose. These techniques have also been discussed in Koch and others (1979).

Having determined an area to be anomalous, cost-effective follow-up procedures are necessary for continued evaluation. Two procedures which have proven to be effective in this study involve analysis of boulder coatings and oxalic acid residues of sediment. Aquatic moss may also prove to be an effective sampling medium. Detailed sampling and analysis of material collected upstream from anomalous HSSR sites serve to delimit those portions of the drainage likely to contain mineralization.

Radiometric surveys and/or soil grids can be used to identify near-surface uraniferous zones in these areas. Radon in soil gas should also be considered at this stage. In mountainous or desert areas where soils are thin and poorly developed, radiometric surveys are probably more cost-effective. In the southeastern U.S. where the effects of weathering may extend to depths of 100 ft. or more, it appears likely that uraninite

mineralization will be thoroughly leached from the upper portion of the soil profile. In the present study, radiometric surveys were made throughout several drainage basins where oxalic acid residues of sediment contained anomalous concentrations of U. However, all radiometric anomalies were confined to roadcuts or other excavations where the A and B soil horizons had been removed. This may be a coincidence, but it strongly suggests that in areas of thick soil cover, radiometric surveys or standard soil geochemical surveys utilizing the A or B soil horizons may not be effective. Shallow drilling to the C horizon (saprolite) or bedrock may be required to delineate uraniferous zones by radioactivity or geochemistry. In general, the depths required will range from 5 - 20 ft.

Boulder coatings and oxalic acid residues can be used in fairly large streams in the Front Range of Colorado. Based on results in the Tallahassee Creek area, sample spacings along these streams should be $\frac{1}{2}$ mile or less. This can result in much lower costs/unit area surveyed because uniform sampling of smaller drainages may require 10 times the number of samples. The formations which contain uranium mineralization in the Tallahassee Creek area are widespread and the geochemical techniques described here may be well-suited for reconnaissance exploration in this area.

5.2 Recommendations

Sufficient success has been achieved with the analysis of oxalic acid residue of sediment to warrant its use on a larger scale. Re-analysis of previously collected samples on two 10 x 20 sheets is recommended. One sheet should be selected from the eastern U.S. and one from the western U.S. The Pueblo and Charlotte sheets would be representative as well as having some potential for uranium mineralization. Based on costs required for this type of analysis in this study (about 10\$/sample) total analytical costs for this project (about 3000 samples) would be about \$30,000. By combining the new analyses of partial digestions with previous analyses of the same samples by neutron activation, a considerable amount of useful information can be derived. It might also be desirable to analyze for pathfinder elements in the oxalic acid residues.

Optimum statistical treatment of published HSSR data is difficult to achieve because of difficulties in acquiring readable data tapes and editing these tapes for various computer programs. If this task was performed as a part of the HSSR program, the utility of HSSR data in uranium exploration would be enhanced considerably.

The portion of the Inner Piedmont near Greenville, South Carolina warrants additional investigation. Drilling of uraniferous occurrences at GRA and GRB and determining the nature of the uranium occurrence here deserves high priority. If favorable results are obtained, the following activities would be warranted:

1. Detailed airborne radiometric and magnetic surveys of the Williamston, Fountain Inn, Greenville, and Greer 15-minute quadrangles with flight-line spacings of $\frac{1}{4}$ mile.

2. Detailed stream sediment geochemical coverage of these quads.
3. Detailed geologic mapping of these quads.

Additional reconnaissance exploration is also recommended in the vicinity of Smeltzer Mountain, South Carolina (GRC area). Radiometric surveys are warranted on the western slope of the mountain. Samples of rock and saprolite from the most radioactive areas should be analyzed for U and Th. Identification of U and Th-bearing phases should also be made.

In our analysis of geochemical data reported by Koch and others (1979), 63 anomalous stream sediment sites were identified in the Winston-Salem, Charlotte, Spartanburg, and Greenville 1° x 2° sheets. Only 26 of these were included in the present study. The remaining 37 sites should be evaluated in a similar manner.

REFERENCES

- Alminas, H.V., and Mosier, E.M., 1976, Oxalic acid leaching of rock, soil, and stream sediment as an anomaly-accentuation technique: U.S. Geol. Survey, Open File Report 76-275, 25 p.
- Bradshaw, P.M.D., and Lett, R.E.W., 1980, Geochemical exploration for uranium using soils: Journal of Geochemical Exploration, (in press).
- Carpenter, R.S., and Hayes, W.B., 1979, Fe-Mn oxide coatings in routine geochemical surveys; in Proceedings of the Seventh International Exploration Geochemistry Symposium, J.R. Watterson and P.K. Theobald, Ed.: Association of Exploration Geochemists, Toronto, p. 277-282.
- Carpenter, R.H., Chao, T.T., Sanzolone, R.F., and Ward, F.N., 1980, Selective sampling and partial digestions in geochemical exploration for uranium in stream environments: Abstracts with program, 8th International Geochemical Exploration Symposium, Hannover, 1980, p. 131.
- Ferguson, R.B., 1978, Savannah River Laboratory hydro-geochemical and stream sediment reconnaissance, preliminary raw data release Greenville 1° x 2° NTMS area, Georgia, North Carolina, and South Carolina: GJBX-58(78), United States Dept. of Energy, Grand Junction, Colorado.
- Hambleton-Jones, B.B., 1978, Theory and practice of geochemical prospecting for uranium: Min. Sci. and Engineering, vol. 10, No.3, p. 182-197.
- Heffner, J.D., and Ferguson, R.B., 1977, Preliminary Raw Data Release, Spartanburg 1° x 2° NTMS Area, North Carolina and South Carolina: GJBX-9(78), United States Department of Energy, Grand Junction, Colorado. 29 p.
- Heffner, J.D., and Ferguson, R.B., 1978, Preliminary Raw Data Release, Charlotte 1° x 2° NTMS Area, North Carolina and South Carolina: GJBX-9(78), United States Department of Energy, Grand Junction, Colorado. 29 p.
- Koch, George S., Jr., Howarth, R.J., Carpenter, R.H., and Schuenemeyer, J.H., 1979, Development of Data Enhancement and Display Techniques for Stream-Sediment Data Collected in the National Uranium Resource Evaluation Program of the United States Department of Energy: GJBX-28(80), United States Department of Energy, Grand Junction, Colorado, 283 p.

REFERENCES (Continued)

- Langmuir, D., 1978, Uranium solution-mineral equilibria at low temperatures with application to sedimentary ore deposits: *Geochim et Cosmochim Acta*, vol. 42, p. 547-570.
- Langmuir, D., and Chatham, J.R., 1980, Groundwater prospecting for sandstone-type uranium deposits: a preliminary comparison of the merits of mineral-solution equilibria, and single-element tracer methods: *Journal of Geochemical Exploration*, vol. 13, (in press).
- Nelson-Moore, J.L., Collins, D.B., and Hornbaker, A.X., 1978, Radioactive occurrences of Colorado and Bibliography: Bull. 40, Colorado Geological Survey, Denver, Colorado, 1054 p.
- Price, Van and Ferguson, R.B., 1980, Stream sediment geochemical surveys for uranium: *Journal of Geochemical Exploration*, vol. 13 (in press).
- Rose, A.W., 1977, Geochemical Exploration for Uranium; in *Symposium on hydrogeochemical and stream sediment reconnaissance for uranium in the United States*: DOE-GJO Document No. GJBX077(77), pp. 303-352.
- Shannon, S.S., 1979, Detailed uranium hydrogeochemical and stream sediment reconnaissance of the Tallahassee Creek, Badger Creek, Castle Rock Gulch, and Buffalo Gulch areas in the northwestern part of the Pueblo NTMS quadrangle Colorado: Los Alamos Scientific Laboratory, Internal Report, LA-7593-MS, 109 p.
- Whitehead, N.E., and Brooks, R.R., 1969, Aquatic bryophytes as indicators of uranium mineralization. *Bryologist*, vol. 72, p. 501-507.
- Whitney, P.R., 1975, Relationship of manganese - iron oxides to grain size in stream sediments: *Jour. Geochem. Expl.*, vol. 4, pp. 251-263.

APPENDIX A

SKYLINE LABS, INC.

Analyses, Tallahassee Creek Area
Analysis of Boulder Coatings

SPECIALISTS IN EXPLORATION GEOCHEMISTRY

12890 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL.: (303) 424-7718

REPORT OF ANALYSIS

JOB NO. MOX 005
DECEMBER 27, 1979

R. H. Carpenter
Department of Geology
University of Georgia
Athens, Georgia 30602

Analysis of 19 Solution Residues

ITEM	SAMPLE NUMBER	Fe (%)	Mn (%)	U (ppm)
1	TAL-1	3.2	21.2	18.
2	TAL-2	2.4	54.	24.
3	TAL-4	7.4	47.8	5.
4	TAL-NO NUMBER	5.2	41.6	10.
5	TAL-6	6.2	44.	19.
6	TAL-7	9999.	9999.	36.
7	TAL-9	4.8	41.6	12.
8	TAL-10	20.	25.6	48.
9	TAL-11	17.	6.2	60.
10	TAL-12	13.5	10.2	42.
11	TAL-13	17.5	14.	18.
12	TAL-14	21.5	14.6	16.
13	TAL-15	12.5	11.2	34.
14	TAL-16	17.	14.	40.
15	TAL-17	23.	13.	44.
16	TAL-19	9999.	9999.	32.
17	TAL-20	12.	22.8	11.
18	TAL-21	19.5	11.	5.
19	TAL-22	6.6	47.	9.

E: 9999 = Insufficient sample for analysis.

APPENDIX A (CONTINUED)
Analyses, Tallahassee Creek Area
Analysis of Boulder Coatings

JOB NO. MOX 005
DECEMBER 26, 1979
Page 2

ITEM	SAMPLE NUMBER	WEIGHT of residue (g)
------	---------------	-----------------------------

1	TAL-1	.1534
2	TAL-2	.3076
3	TAL-4	.6483
4	TAL-NO NUMBER	.2035
5	TAL-6	.2857
6	TAL-7	.1157
7	TAL-9	.233
8	TAL-10	.1793
9	TAL-11	.1961
10	TAL-12	.1465
11	TAL-13	.276
12	TAL-14	.2826
13	TAL-15	.1976
14	TAL-16	.3069
15	TAL-17	.2729
16	TAL-19	.1253
17	TAL-20	.2167
18	TAL-21	.2122
19	TAL-22	.5449

Gordon H. VanSickle
Manager

APPENDIX A (CONTINUED)
Analyses, Tallahassee Creek Area
Analysis of minus 80-mesh sediment

JOB NO. MOX 004
JANUARY 9, 1980
Page 3

ITEM	SAMPLE NUMBER	U* (ppm)	Fe* (%)	Oxalic Acid Residue (g)	Fe (%)
1	TAL-01C	0.	0.	0.	1.2
2	TAL-02C	0.	0.	0.	2.1
3	TAL-03C	0.	0.	0.	3.
4	TAL-04C	0.	0.	0.	3.6
5	TAL-05C	0.	0.	0.	3.6
6	TAL-06C	0.	0.	0.	3.7
7	TAL-07C	0.	0.	0.	4.6
8	TAL-08C	0.	0.	0.	4.5
9	TAL-09C	0.	0.	0.	2.8
10	TAL-10C	0.	0.	0.	3.7
11	TAL-11C	0.	0.	0.	3.6
12	TAL-12C	0.	0.	0.	3.7
13	TAL-13C	0.	0.	0.	3.7
14	TAL-14C	0.	0.	0.	3.6
15	TAL-15C	0.	0.	0.	4.1
16	TAL-16C	0.	0.	0.	4.2
17	TAL-17C	0.	0.	0.	5.6
18	TAL-18C	0.	0.	0.	4.4
19	TAL-19C	0.	0.	0.	5.4
20	TAL-20C	0.	0.	0.	5.6
21	TAL-21C	0.	0.	0.	6.4
22	TAL-22C	0.	0.	0.	3.6
45	TAL-01AB-OX	30.	24.5	.0888	0.
46	TAL-02AB-OX	22.	23.	.1795	0.
47	TAL-03AB-OX	36.	27.	.2173	0.
48	TAL-04AB-OX	17.	30.5	.2456	0.
49	TAL-05AB-OX	24.	26.5	.2152	0.
50	TAL-06AB-OX	30.	20.5	.1451	0.
51	TAL-07AB-OX	24.	26.	.1387	0.
52	TAL-08AB-OX	15.	26.	.1693	0.

TAL-XXC - Analysis of sediment, heavy minerals removed.
TAL-XXXX-OX - Analysis of oxalic acid residue

APPENDIX A (CONTINUED)

Analyses, Tallahassee Creek Area
Analysis of minus 80-mesh sediment

JOB NO. MOX 004
JANUARY 9, 1980

Page 4

ITEM	SAMPLE NUMBER	U* (ppm)	Fe* (%)	Oxalic Acid Residue (g)	Fe (%)
53	TAL-09AB-OX	70.	27.5	.0932	0.
54	TAL-10AB-OX	38.	28.5	.1265	0.
55	TAL-11AB-OX	44.	29.	.1194	0.
56	TAL-12AB-OX	44.	28.	.1327	0.
57	TAL-13AB-OX	55.	27.5	.1153	0.
58	TAL-14AB-OX	15.	26.	.1437	0.
59	TAL-15AB-OX	40.	28.5	.1646	0.
60	TAL-16AB-OX	48.	29.	.1801	0.
61	TAL-17AB-OX	44.	29.5	.1868	0.
62	TAL-18AB-OX	75.	29.	.177	0.
63	TAL-19AB-OX	65.	32.	.2255	0.
64	TAL-20AB-OX	32.	33.	.2342	0.
65	TAL-21AB-OX	11.	30.	.1688	0.
66	TAL-22AB-OX	36.	22.5	.1548	0.

TAL-XXX-OX - Analysis of oxalic acid residue

NOTES: * = Samples run on leachate
0 = Analysis not requested.

Gordon H. VanSickle
Manager

APPENDIX A (CONTINUED)

Analyses, Tallahassee Creek Area

SKYLINE LABS, INC. Analysis of minus 80-mesh sediment

SPECIALISTS IN EXPLORATION GEOCHEMISTRY

12090 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL.: (303) 424-7718

REPORT OF ANALYSIS

JOB NO. MOX 004
JANUARY 9, 1980
SHIPMENT NO. 1

R. H. Carpenter
Department of Geology
The University of Georgia
Athens, Georgia 30602

Analysis of 44 Pulp Samples

ITEM	SAMPLE NUMBER	U (ppm)	Th (ppm)
1	TAL-01C	<2.	<50.
2	TAL-02C	3.	<50.
3	TAL-03C	5.	<50.
4	TAL-04C	2.	50.
5	TAL-05C	3.	<50.
6	TAL-06C	4.	70.
7	TAL-07C	3.	<50.
8	TAL-08C	3.	<50.
9	TAL-09C	4.	<50.
10	TAL-10C	3.	<50.
11	TAL-11C	2.	<50.
12	TAL-12C	7.	<50.
13	TAL-13C	4.	<50.
14	TAL-14C	3.	<50.
15	TAL-15C	3.	<50.
16	TAL-16C	4.	<50.
17	TAL-17C	3.	<50.
18	TAL-18C	4.	<50.
19	TAL-19C	6.	<50.
20	TAL-20C	4.	<50.
21	TAL-21C	<2.	<50.
22	TAL-22C	3.	<50.
23	TAL-01AB-80	3.	<50.
24	TAL-02AB-80	3.	<50.
25	TAL-03AB-80	4.	<50.

TAL-XXC - Analysis of sediment, heavy minerals removed

TAL-XXXX-80 - Total analysis, minus 80 mesh sediment

APPENDIX A (CONTINUED)
Analyses, Tallahassee Creek Area
Analysis of minus 80-mesh sediment

JOB NO. MOX 004
JANUARY 9, 1980

Page 2

ITEM	SAMPLE NUMBER	U (ppm)	Th (ppm)
26	TAL-04AB-80	3.	<50.
27	TAL-05AB-80	3.	55.
28	TAL-06AB-80	4.	<50.
29	TAL-07AB-80	3.	<50.
30	TAL-08AB-80	3.	<50.
31	TAL-09AB-80	5.	<50.
32	TAL-10AB-80	2.	<50.
33	TAL-11AB-80	3.	<50.
34	TAL-12AB-80	2.	<50.
35	TAL-13AB-80	3.	<50.
36	TAL-14AB-80	<2.	<50.
37	TAL-15AB-80	2.	<50.
38	TAL-16AB-80	3.	<50.
39	TAL-17AB-80	3.	<50.
40	TAL-18AB-80	4.	<50.
41	TAL-19AB-80	4.	<50.
42	TAL-20AB-80	3.	<50.
43	TAL-21AB-80	<2.	<50.
44	TAL-22AB-80	2.	<50.

TAL-XXXX-80 Total analysis, minus 80-mesh sediment

APPENDIX B

SKYLINE LABS, INC. Stream sediment analyses, southeastern U.S.

SPECIALISTS IN EXPLORATION GEOCHEMISTRY

12090 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL.: (303) 424-7718

REPORT OF ANALYSIS

JOB NO. MOX 008

MARCH 20, 1980

SHIPMENT NO. 3

University of Georgia
Attn: R. H. Carpenter
Department of Geology
Athens, Georgia 30602

Analysis of 31 Pulp and 31 Oxalic Acid Residue Samples

ITEM	SAMPLE NO.	U (ppm)	Oxalic Acid Residue (g)	U* (ppm)	Fe* (%)
1	CHA-01A	26.	.1612	13.	28.3
2	CHA-02A	13.	.1748	14.	20.
3	CHA-03A	5.	.2687	17.	30.7
4	CHA-04A	5.	.2704	11.	32.
5	CHA-05A	5.	.185	13.	26.
6	CHA-06A	8.	.2314	10.	29.8
7	CHA-07A	6.	.2243	10.	30.3
8	CHA-08A	3.	.1829	8.	33.3
9	CHA-09A	44.	.1401	10.	26.
10	CHA-10A	8.	.1732	10.	27.3
11	CHA-11A	7.	.1545	10.	26.3
12	CHA-12A	11.	.1001	10.	26.3
13	CHA-13A	9.	.1074	11.	27.8
14	CHA-14A	12.	.1324	5.	28.7
15	CHA-15A	5.	.1682	8.	25.3
16	CHA-16A	5.	.2678	17.	25.7
17	CHA-17A	11.	.1434	13.	23.3
18	CHA-18A	20.	.1949	10.	26.
19	CHA-19A	20.	.0723	16.	23.
20	CHA-20A	7.	.1159	15.	22.7

APPENDIX B (CONTINUED)

Stream sediment analyses, southeastern U.S.

JOB NO. MOX 008

MARCH 20, 1980

PAGE 2

ITEM	SAMPLE NO.	U (ppm)	Oxalic Acid Residue (g)	U* (ppm)	Fe* (%)
21	CHA-21A	16.	.137	12.	22.
22	CHA-22A	14.	.2298	13.	28.
23	CHA-23A	8.	.2969	12.	28.8
24	CHA-24A	17.	.1876	11.	26.7
25	CHA-25A	22.	.2841	14.	28.
26	CHA-26A	90.	.1231	13.	26.7
27	CHA-27A	19.	.2946	13.	28.
28	CHA-28A	26.	.2768	12.	28.2
29	CHA-29A	20.	.3553	11.	28.7
30	CHA-30A	20.	.2095	7.	25.3
31	CHA-31A	34.	.4	14.	34.7

Gordon H. VanSickle
Manager

NOTES:

Weight of oxalic acid residue from 5 grams of sample.

*Analyses run on oxalic acid residue. Values represent metal content of residues.

APPENDIX B (CONTINUED)

Stream sediment analyses, southeastern U.S.

SKYLINE LABS, INC.

SPECIALISTS IN EXPLORATION GEOCHEMISTRY

12090 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL.: (303) 424-7718

REPORT OF ANALYSIS

JOB NO. MOX 007

MARCH 19, 1980

SHIPMENT NO. 2

University of Georgia
Attn: R. H. Carpenter
Department of Geology
Athens, Georgia 30602

Analysis of 139 Sediment Pulp and 139 Oxalic Acid Residue Samples

ITEM	SAMPLE NUMBER	U (ppm)	Oxalic Acid Residue. (g)	U* (ppm)	Fe* (%)
1	GRA-01A	60.	.1517	60.	29.3
2	GRA-03A	7.	.0981	70.	28.7
3	GRA-04A	9.	.0975	75.	30.3
4	GRA-05A	11.	.0032	60.	29.
5	GRA-06A	8.	.0835	70.	27.3
6	GRA-07A	32.	.0725	150.	26.7
7	GRA-08A	12.	.0896	90.	27.3
8	GRA-09A	17.	.1078	120.	23.3
9	GRA-10A	18.	.1647	85.	23.3
10	GRA-11A	10.	.1896	70.	23.7
11	GRA-12A	11.	.0907	95.	23.
12	GRA-13A	7.	.1891	19.	25.3
13	GRA-14A	9.	.1623	22.	30.3
14	GRA-15A	11.	.1605	19.	30.3
15	GRA-16A	28.	.1481	14.	29.
16	GRA-17A	13.	.1143	20.	29.7
17	GRA-18A	22.	.1413	17.	23.8
18	GRA-19A	50.	.0849	32.	26.3
19	GRA-20A	70.	.0426	22.	25.
20	GRA-21A	42.	.0982	40.	25.
21	GRA-22A	26.	.0877	38.	26.3
22	GRA-23A	80.	.1305	44.	24.
23	GRA-24A	32.	.2447	20.	25.7
24	GRA-25A	22.	.1863	30.	23.3
25	GRA-26A	90.	.0467	22.	24.

APPENDIX B (CONTINUED)

Stream sediment analyses, southeastern U.S.

JOB NO. MOX 007

MARCH 19, 1980

Page 2

ITEM	SAMPLE NUMBER	U (ppm)	Oxalic Acid Residue (g)	U* (ppm)	Fe* (%)
26	GRA-27A	20.	.1097	75.	27.3
27	GRA-28A	13.	.3058	24.	26.3
28	GRA-29A	65.	.1425	60.	27.
29	GRA-30A	24.	.1526	50.	27.
30	GRA-31A	65.	.1552	14.	26.3
31	GRA-32A	17.	.2952	6.	30.2
32	GRA-33A	9.	.2663	11.	28.
33	GRA-34A	10.	.1925	10.	28.7
34	GRA-35A	28.	.1862	10.	30.3
35	GRA-36A	8.	.1467	22.	29.
36	GRA-37A	5.	.1467	14.	30.
37	GRA-38A	95.	.0678	8.	26.7
38	GRA-39A	10.	.1553	8.	29.7
39	GRB-01A	13.	.0881	38.	34.7
40	GRB-02A	17.	.039	I/S	32.7
41	GRB-03A	42.	.0326	I/S	34.7
42	GRB-04A	60.	.041	24.	24.
43	GRB-05A	12.	.0665	50.	28.7
44	GRB-06A	10.	.0616	18.	27.3
45	GRB-07A	28.	.0467	38.	24.7
46	GRB-08A	11.	.0663	32.	33.7
47	GRB-09A	12.	.081	32.	27.7
48	GRB-10A	14.	.0631	220.	26.
49	GRB-11A	14.	.1624	70.	23.3
50	GRB-12A	14.	.0756	70.	18.
51	GRB-13A	38.	.0284	44.	34.7
52	GRB-14A	21.	.0735	110.	28.3
53	GRB-15A	34.	.0563	105.	28.3
54	GRC-01A	3.	.1	13.	22.
55	GRC-02A	<2.	.1126	10.	20.

SKYLINE LABS, INC.

SPECIALISTS IN EXPLORATION GEOCHEMISTRY

APPENDIX B (CONTINUED)

Stream sediment analyses, southeastern U.S.

JOB NO. MOX 007

MARCH 19, 1980

Page 3

ITEM	SAMPLE NUMBER	U (ppm)	Oxalic Acid Residue (g)	U* (ppm)	Fe* (%)
56	GRC-03A	3.	.107	4.	21.
57	GRC-04A	2.	.1101	8.	20.
58	GRC-05A	3.	.0805	12.	20.7
59	GRC-06A	<2.	.1122	8.	21.
60	GRC-07A	<2.	.1216	11.	24.
61	GRC-08A	<2.	.1106	10.	21.7
62	GRC-09A	<2.	.0872	12.	21.
63	GRC-12A	<2.	.1452	8.	26.7
64	GRC-13A	<2.	.1138	12.	26.3
65	GRC-14A	3.	.167	7.	20.7
66	GRC-15A	2.	.1608	6.	23.7
67	GRC-16A	<2.	.2541	7.	22.7
68	GRC-17A	<2.	.3389	16.	22.3
69	GRC-18A	<2.	.0566	10.	23.3
70	GRC-19A	<2.	.099	9.	25.
71	GRC-20A	<2.	.0278	20.	22.7
72	GRC-21A	2.	.0275	12.	22.3
73	GRC-22A	3.	.0146	46.	18.5
74	GRC-23A	3.	.0219	40.	20.
75	GRC-24A	7.	.0156	90.	20.7
76	GRC-25A	4.	.043	60.	16.7
77	GRC-26A	7.	.0174	130.	23.7
78	GRC-27A	2.	.0272	44.	18.5
79	GRC-28A	4.	.0227	75.	22.3
80	GRC-29A	3.	.0321	52.	22.7
81	GRD-01A	<2.	.0497	38.	23.7
82	GRD-02A	3.	.159	13.	26.7
83	GRD-03A	<2.	.0392	32.	18.7
84	GRD-04A	<2.	.1183	12.	23.3
85	GRD-05A	<2.	.0443	28.	27.

SKYLINE LABS, INC.

SPECIALISTS IN EXPLORATION GEOCHEMISTRY

APPENDIX B (CONTINUED)

Stream sediment analyses, southeastern U.S.

JOB NO. MOX 007

MARCH 19, 1980

Page 4

ITEM	SAMPLE NUMBER	U (ppm)	Oxalic Acid Residue (g)	U* (ppm)	Fe* (%)
86	GRD-06A	<2.	.0538	20.	17.7
87	GRD-07A	<2.	.156	11.	24.2
88	GRD-08A	<2.	.1235	14.	25.3
89	GRD-09A	<2.	.1734	10.	23.8
90	GRD-10A	<2.	.165	8.	26.
91	GRD-11A	4.	.1306	11.	22.3
92	GRD-12A	<2.	.1696	9.	25.
93	GRD-13A	6.	.207	34.	25.
94	GRD-14A	<2.	.1239	9.	24.
95	GRD-15A	7.	.3086	38.	25.7
96	GRD-16A	3.	.1423	55.	26.
97	GRD-17A	4.	.0597	26.	23.7
98	GRD-18A	3.	.0558	20.	26.8
99	GRD-19A	4.	.2112	8.	26.
100	GRD-20A	6.	.3162	9.	27.
101	GRD-21A	4.	.2557	5.	26.3
102	GRD-22A	7.	.2167	8.	26.
103	GRD-23A	<2.	.2037	5.	30.3
104	GRD-24A	4.	.2622	5.	27.
105	GRD-25A	7.	.1892	7.	25.
106	GRD-26A	<2.	.1867	<2.	33.3
107	GRD-27A	<2.	.0975	<2.	31.2
108	GRD-28A	<2.	.1521	<2.	23.3
109	GRD-29A	<2.	.0837	<2.	23.3
110	GRD-30A	4.	.2587	<2.	24.
111	GRD-31A	4.	.1274	<2.	22.3
112	SPF-01A	6.	.0761	4.	29.3
113	SPF-02A	12.	.1141	3.	28.
114	SPF-03A	4.	.0696	2.	28.7
115	SPF-04A	5.	.1757	3.	36.7

SKYLINE LABS, INC.

SPECIALISTS IN EXPLORATION GEOCHEMISTRY

APPENDIX B (CONTINUED)

Stream sediment analyses, southeastern U.S.

JOB NO. MOX 007

MARCH 19, 1980

Page 5

ITEM	SAMPLE NUMBER	U (ppm)	Oxalic Acid Residue (g)	U* (ppm)	Fe* (%)
116	SPF-05A	4.	.0849	2.	37.
117	SPF-05B	9.	.096	2.	40.
118	SPF-06A	4.	.1595	6.	32.7
119	SPF-07A	11.	.2258	4.	45.
120	SPF-7(+1)	15.	.2154	10.	57.7
121	SPF-08A	5.	.0933	2.	29.
122	SPF-09A	4.	.1312	2.	40.3
123	SPF-10A	4.	.1417	<2.	40.
124	SPF-11A	5.	.1926	2.	33.3
125	SPF-12A	7.	.1584	3.	39.
126	SPF-13A	3.	.146	2.	39.
127	SPF-14A	<2.	.0462	<2.	35.3
128	SPF-15A	5.	.5831	2.	44.
129	SPF-16A	4.	.624	3.	54.
130	SPF-17A	4.	.2724	4.	38.7
131	SPF-18A	<2.	.117	2.	38.3
132	SPF-19A	<2.	.118	<2.	36.
133	SPF-20A	2.	.1	3.	32.7
134	SPF-23A	<2.	.124	<2.	40.
135	SPF-25A	<2.	.1591	<2.	37.
136	SPF-26A	<2.	.0998	2.	36.
137	SPF-27A	3.	.1996	2.	37.
138	SPF-28A	2.	.1563	2.	39.7
139	SPF-30A	3.	.3655	2.	39.

NOTES:

I/S = Insufficient sample for analysis

Weight of oxalic acid residue from 5 grams
of sample.

*Analyses run on oxalic acid residue. Values
represent metal content of residue.

Gordon H. VanSickle
Gordon H. VanSickle
Manager

SKYLINE LABS, INC.
SPECIALISTS IN EXPLORATION GEOCHEMISTRY

SKYLINE LABS, INC.

SPECIALISTS IN EXPLORATION GEOCHEMISTRY

12090 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL.: (303) 424-7718

APPENDIX C

Uranium Assays

REPORT OF ANALYSIS

JOB NO. MOX 010
JUNE 11, 1980
SHIPMENT NO. 5

University of Georgia
Attn: R. H. Carpenter
Department of Geology
Athens, Georgia 30602

Analysis of 9 Rock Chip Samples

ITEM	SAMPLE NUMBER	U308 (%)
1	GRA-2 1100N	.0070
2	GRA-2 1200N	.0034
3	GRA-2 2224N	.0024
4	GRA-2 2566N	.0048
5	GRA-2 2585N	.0030
6	GRA-2 2600N	.0085
7	GRA-2 2670N	.0044
8	GRBB-2	.0075
9	GRBB-3	.0095

Item 1-7 Samples collected along profile shown in figure 9.

Item 8-9 Samples collected at localities shown in figure 11.

Gordon H. VanSickle
Manager

APPENDIX D

SKYLINE LABS, INC.

Uranium Assays

SPECIALISTS IN EXPLORATION GEOCHEMISTRY

2090 WEST 50TH PLACE • WHEAT RIDGE, COLORADO 80033 • TEL.: (303) 424-7718

REPORT OF ANALYSIS

JOB NO. MOX 009

MAY 7, 1980

SHIPMENT NO. 4

University of Georgia

Attn: R. H. Carpenter

Department of Geology

Athens, Georgia 30602

Analysis of 14 Rock Samples

ITEM	SAMPLE NO.	U (ppm)
1	AC-A	38.
2	AC-B	34.
3	AC-C	7.
4	AC-D	24.
5	AC-E	5.
6	GRA-2-1	65.
7	GRA-2-2	75.
8	GRA-2-3	110.
9	GRA-3-1	11.
10	GRA-3-2	11.
11	GRA-3-3	<2.
12	GRB-1	50.
13	GRB-2	<2.
14	GRB-3	5.

Items 1-5. Assays of biotite gneiss saprolite, GRD Area,
at site shown on figure 17.

Items 6-8 Assays of muscovite schist along road north of Hampton Heights, S.C. (GRA Area) Gordon H. VanSickle
Manager

Items 9-11 Assays of saprolite from area east
of Greenville, S.C.

Items 12-14 Assays of muscovite schist from radiometric anomaly
at GRB. GRB-2 and GRB-3 collected from outcrop
near bridge east of main anomaly.