UNIVERSITY OF ALBERTA

X-Ray Fluorescence Characterization of Volcanic Glass Artifacts from Wilson Butte Cave, Idaho

BY

Jeff Bailey

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Dedicated to my family

ABSTRACT

X-RAY FLUORESCENCE CHARACTERIZATION OF VOLCANIC GLASS ARTIFACTS FROM WILSON BUTTE CAVE, IDAHO

Excavations in 1988 and 1989 at Wilson Butte Cave, Idaho recovered numerous lithic artifacts made from volcanic glasses. A sample of these artifacts was chemically characterized, using non-destructive, energy-dispersive x-ray fluorescence analysis, in an attempt to identify the parent geological source of the raw materials.

In order to achieve this goal, it was first necessary to compile a library of trace element characterizations, or "fingerprints" for geological glass sources in the area surrounding Wilson Butte Cave. Obsidian and ignimbrite samples were collected at seventy-six localities on or near the Snake River Plain in southern Idaho. Chemical and statistical analyses identified thirty chemical types in the sample of source material.

Patterns of volcanic glass use at Wilson Butte Cave changed over time, with an apparent increase in the number of sources being used, and a shift toward more western sources, during the later occupations. Moreover, Big Southern Butte obsidian, the dominant volcanic glass in the artifact sample from Stratum E, Stratum C1, and Facies C2 and C4 of Stratum C, decreased significantly in frequency in the artifact sample from the upper, disturbed stratigraphic zones, while the Brown's Bench and Cannonball Mountain sources were used more intensively. Unfortunately, the upper deposits were completely destroyed prior to the 1988/89 excavations, so it is presently impossible to determine the time at which this apparent shift in lithic resource exploitation occurred.

Acknowledgements

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The field portion of this study could not have been completed without the valuable assistance of my field assistant Ian Franck. Jim Woods of the Herrett Museum, Twin Falls, Idaho was also invaluable in providing locational information for the glass sources. Mark Druss, archaeologist for Idaho Power Co., offered interesting discussions and many useful suggestions about methodology, interpretations, and archaeology in general.

Dr. John D'Auria and Malcolm James of the Department of Chemistry and Biochemistry, Simon Fraser University, provided the equipment and the technical expertise for the analyses.

Finally, thanks are due to my family and friends for their support during the difficult times.

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INTRODUCTION

The archaeological record is, by definition, fragmentary. Interpretation of this record requires the use of multiple lines of evidence, incorporating data from many levels of inquiry, including regions, sites, artifacts, and artifact attributes. In recent years archaeology has found allies in many other disciplines, including the physical sciences, which have stretched the boundaries of archaeological analysis. This study presents an application of scientific methodology to a question of anthropological interest.

Volcanic glass artifacts recovered from Wilson Butte Cave, Idaho, were subjected to x-ray fluorescence analysis in an attempt to identify the geological origin of the raw materials exploited by prehistoric occupants of the cave. X-ray fluorescence (XRF) is a spectroscopic technique of trace element measurement which allows one to characterize chemically, or "fingerprint", certain materials according to their unique suite of trace element compositions. Volcanic glasses such as obsidian and various densely-welded tuffs are well suited to XRF characterization because they exhibit low intra-flow and relatively high inter-flow variation in trace element composition. These features make volcanic glasses very useful in the study of prehistoric patterns of lithic procurement and exchange.

Chapter 1 of this study discusses the development of chemical characterization research, and previous approaches to lithic characterization within the present study area and elsewhere.

Chapter 2 discusses the fundamentals of x-ray fluorescence and its applications to archaeology, as well as the details of the methodology used in this study. Also included in the second chapter are discussions of sampling considerations and data reduction methods. XRF analyses generate large quantities of data which must be reduced by sophisticated statistical means. These are discussed in terms of their assumptions and applications to the data herein.

Chapter 3 presents a general overview of the study area. The geology of the Snake River Plain is briefly described, and the Wilson Butte Cave site and the associated artifacts are discussed in greater detail. The volcanic glasses characterized in this study were collected from 76 localities on or adjacent to the Snake River Plain in southern Idaho. It was hypothesized that most of the volcanic glasses represented in the Wilson Butte artifact assemblages originated within this region of volcanic activity.

Chapter 4 presents the results of the XRF analysis of the geological source samples. Questions about the interpretation of the data are addressed with reference to specific cases.

Chapter 5 considers the results of the artifact characterizations and the reliability of the source attributions derived from statistical manipulation of the data.

The final chapter, Chapter 6, attempts to evaluate the data in terms of prehistoric behaviour. Although a single site provides insufficient data for the formulation of broad hypotheses of regional procurement and exchange, the data raise a number of interesting questions which are considered in this chapter.

CHAPTER ONE

CHARACTERIZATION STUDIES

History of Characterization Studies

Since the 1960s, archaeology has increasingly utilized techniques developed by the physical sciences. This approach ultimately has led to the emergence of archaeometry as a subfield of archaeology. Chemical composition studies have played a leading role in this development.

Pioneering chemical analyses of archaeological materials were conducted as early as A.D. 1800, when the chemist Martin Klaproth studied colour variation in Roman glass and the chemical composition of Greek and Roman coinage (Harbottle 1982:13). In the 1840s, a professor Gobel at the University of Dorpat, Estonia, suggested that chemistry could be valuable to archaeology and prehistory. In perhaps the first scientifically rigorous archaeometric study, Gobel compared the chemical compositions of copper alloy artifacts from prehistoric Greece, Rome, and Europe; concluding that they were all probably of Roman origin (Harbottle 1982:14).

In 1865, French mineralogist M.A. D'Amour remarked that archaeologists should seek the aid of geologists, zoologists, and palaeontologists to help interpret their discoveries. Specifically, he said that principles of chemistry and mineralogy should be used to help interpret the migratory movements of prehistoric peoples (Caley 1951); this topic has received considerable attention in recent years. D'Amour also conducted perhaps the first obsidian characterization study, in which he characterized four obsidian sources and six artifacts, including a Mesoamerican mask (Harbottle 1982). Twenty years later, in 1885, Helm chemically analyzed amber beads found by Schliemann at Mycenae and determined that they were of Baltic origin. This was "one of the first indications by chemical means of the traffic of a material over a great distance in prehistoric times" (Caley 1967:122).

Other early chemical characterization studies employed 'wet chemistry' methods, in which a sample must be put into solution prior to analysis (Harbottle 1982). These methods were slow, labour intensive, destructive to the sample, and relatively insensitive by modern standards. Consequently, wet chemistry methods are rarely used today for the analysis of valuable archaeological materials (atomic absorption spectrophotometry is an exception). Several techniques have been developed recently that are capable of producing elemental composition data quickly and precisely with a minimum of sample preparation.

Modern chemical characterization techniques are based almost universally upon the assumption that all natural materials are impure and contain "a whole suite of trace elements with concentrations ranging from fractions of a percent ... down to parts per billion..." (Harbottle 1982:19). Various spectroscopic techniques differ in their sensitivity to particular trace elements, and, consequently, for the analysis of particular materials.

Volcanic Glass Characterization

During the past twenty years, numerous techniques have been refined specifically for the compositional analysis of volcanic glasses. Atomic absorption spectrophotometry (Michels 1981, 1982a,b, 1983), instrumental neutron activation (Frison et al. 1968; Griffin et al. 1969; Wilmeth 1973), and x-ray fluorescence (Nelson et al. 1975; Sappington 1981; Godfrey-Smith 1985; Hughes 1986; James 1986) have all become popular and reliable means of "fingerprinting" volcanic glasses. Less common techniques include electron microprobe analysis (Merrick and Brown 1984), proton-induced x-ray emission (PIXE) (Nelson et al. 1977) and optical emission spectography (Cann and Renfrew 1964; R.C. Green et al. 1967).

Many early attempts to differentiate obsidian sources concentrated upon the physical characteristics of the rock, such as density, colour, or refraction (Reeves and Ward 1976). However, because obsidian forms only under specific conditions, these physical characteristics rarely display sufficient variability for reliable differentiation (Godfrey-Smith 1985). While certain obsidians may be quite distinctive (some "snowflake" obsidians, for example), most are visually quite similar. Hardness and density likewise vary little. Other volcanic glasses (known variously as ignimbrites, vitrophyres, welded tuffs, opaque volcanic glasses; see Chapter 3 below) may exhibit greater physical variability, simply because the flows often cover vast areas, picking up various materials as they move. Still, the Idaho glass samples have shown that visual inspection is usually insufficient for confident source identification (cf. Bettinger et al. 1984).

For the present study, non-destructive energy-dispersive x-ray fluorescence spectroscopy (XRF) was chosen as the best method of analysis because it has been successfully applied in numerous similar studies (e.g., Nelson et al. 1975; Godfrey-Smith 1985; Hughes 1984,1986; Sappington 1981a,b, 1984; James 1986, 1992). XRF is a rapid technique that allows relatively precise simultaneous measurement of several trace elements with minimal sample preparation. The system used in this study is discussed more fully in Chapter 2, below.

Previous Characterization Studies

Volcanic glass characterization studies are now relatively common throughout the world. Cann and Renfrew (1964) used trace element variations, (particularly Ba and Zr), to distinguish obsidian sources in the Near East. They later applied these methods to the study of obsidian artifacts in the central Mediterranean and Aegean regions (Dixon, Cann and Renfrew 1968) and in the Near East (Renfrew, Dixon and Cann 1968). Wright (1969) also studied prehistoric obsidian exchange networks in the Near East.

In the mid-1960s and early 1970s, obsidian characterization gained popularity worldwide. Green (1962; also R.C. Green et al. 1967) led the way in New Zealand, where research is still very active. Early New Zealand obsidian studies are concisely summarized by Reeves and Ward (1976). Taylor (1976: Part II) presents regional summaries for California, Mesoamerica, the Mediterranean, and the Near East. In Canada, Roscoe Wilmeth (1973) conducted pioneering research, using Instrumental Neutron Activation Analysis (INAA). In 1975, Nelson, D'Auria, and Bennett developed a non-destructive energy-dispersive x-ray fluorescence system, which they applied to artifacts recovered from archaeological sites in British Columbia.

Early work in the United States was concentrated at Berkeley (Weaver and Stross 1965; Heizer et al. 1965), and at the University of Michigan (Griffin 1965; Griffin and Gordus 1966). Since these pioneering works, many advances have been made in the field; and research remains very active, especially in North America.

North American Studies

There are few regions in the world as rich in knappable volcanic glasses as the northwestern United States and neighbouring British Columbia. California, Oregon, Idaho, and Wyoming house numerous sources of high-quality glasses that were extensively used and exchanged by the aboriginal inhabitants of these areas. Washington, Montana, and British Columbia have smaller numbers of sources which were locally important in prehistoric times. Other sources exist in Nevada (Sappington 1981a,b), Utah (Nelson 1984), and the American Southwest (Shackley 1988). Most of these areas have been subjected to at least preliminary characterization studies, and a few have been examined more comprehensively.

Of the North American volcanic regions, California has perhaps been most extensively studied. In terms of sheer numbers of sources and artifacts analyzed, Robert N. Jack's (1976) pilot study remains one of the largest obsidian characterization studies to date. Over 1500 obsidian artifacts from eighteen sources were characterized in this ambitious attempt to determine which California sources were exploited in prehistoric times. Ericson et al. (1976) list an additional fourteen California sources, bringing the total to some forty-two discrete obsidian localities in the state.

Drawing upon Jack's data, Ericson and Kimberlin (1977) and Ericson (1981) performed multiple regression analyses to identify ten regional prehistoric exchange systems in California during Late Horizon times. While Ericson's study was commendable for its anthropological perspective, his interpretations are suspect. Hughes (1986:4) points out that Jack's artifact collection included several tool types that span a number of time periods. This selection effectively eliminates all temporal control from a study in which time-specific cultural reconstruction is the goal.

Ericson and Kimberlin (1977:112) previously used Jack's data to produce a computer-aided contour map (SYMAP) to describe "the distribution of an exchanged item in space...". According to Hughes (1986:4), Ericson used 52 archaeological sites as data points to establish contours on his Late Horizon SYMAP. These supposedly drew upon Jack's source-specific analyses to predict expected obsidian percentages in lithic assemblages at sites located within a particular contour line. However, apparently only ten sites are common to the studies of Ericson and Jack, comprising a collection of only seventy-three artifacts. This limited sample means that Ericson defined a group of ten Late Horizon exchange systems for the entire state of California on the basis of seventy-three artifacts from ten archaeological sites. This problem, combined with the aforementioned lack of temporal control, renders Ericson's interpretations dubious.

Richard E. Hughes (1984, 1986) has vastly expanded on these early studies. Noting that "after nearly fifteen years of endeavour, the anthropological problems on which obsidian source analysis has been focused remain surprisingly few" (1986:1), Hughes echoed Willey and Sabloff's (1974:185) assertion that archaeological theory has not kept pace with the methodological advances made available to the discipline. Specifically, he argued that most obsidian studies had been purely descriptive, largely due to the fact that until relatively recently a limited number of comprehensive regional characterization studies had been completed Such reference studies are absolutely essential before specific questions may be addressed, but the collection and analysis of glass samples and the compilation of a regional source library are extremely time-consuming activities for which few researchers have the time or means.

Hughes (1986) used XRF characterizations to link archaeologically-known obsidian distributions with past human behaviours in what is now northeastern California and south-central Oregon. He found marked diachronic variability in the patterns of obsidian procurement at a number of sites in his study area, and he presented several hypotheses to account for the observed variability. Although no hypothesis was pursued in great detail, Hughes' study marked a significant advance in the application of obsidian research to anthropology. Studies of comparable scope have been initiated elsewhere in the past ten years (e.g., J.P.Green 1982; Reed 1985), as characterization studies have become more and more sophisticated.

Idaho Studies

The first volcanic glass study that considered Idaho sources correlated artifacts from Veratic Rockshelter near the Montana border with an obsidian source about 100 km farther south at Big Southern Butte, Idaho (Wright, Griffin, and

Gordus 1969). Sappington (1981a), however, noted that at the time of the study most of the Idaho sources had not been characterized; and on this basis he judged the Veratic Rockshelter study invalid. In 1975, Gallagher published the first list of Idaho volcanic glass sources (Gallagher 1979: Appendix 1); the list was not exhaustive, nor did it contain locational information for the sources (Sappington 1981a).

These initial studies provided the impetus for more extensive research. Sappington (1981a,b) located and chemically characterised eleven chemically distinct obsidian and "vitrophyre" sources in Idaho, and several others in adjacent states and in British Columbia. Sappington (1981a) also used XRF to assess the importance of the various sources in the local aboriginal economy, as reflected in the stone tool assemblages of a number of Idaho archaeological sites.

Sappington's research at the University of Idaho provided the reference data necessary for studies of broader scope; and other researchers used his characterizations to examine hypotheses about prehistoric exchange, territoriality, and lithic resource procurement. J.P. Green (1982) used source characterizations to correlate archaeological assemblages in an attempt to understand better the development of Archaic settlement-subsistence system in the Great Basin. Stressing a systems approach in which lithic procurement takes place within a broad subsistence strategy rather than as a separate activity, Green examined lithic collections from eight northeast Great Basin sites: Hogup and Danger Caves, and Swallow Shelter in Utah; Brown's Bench, Rock Creek, Garden Creek Gap, Malad Hill, and Weston Canyon, Idaho; and Deer Creek Cave, Nevada. The Hawkins-Malad-Oneida source was shown to have been the primary contributor of obsidian to these sites through time (Green 1982:1).

Reed (1985) applied XRF analyses to the identification of Late Prehistoric Shoshonean subsistence territories in southern Idaho. Although unable to correlate particular projectile point types with specific volcanic glass sources, Reed's research did raise some important questions about access to glass sources in prehistoric times. For example, the Oneida obsidian source near Malad City, southeastern Idaho (also known as the Hawkins-Malad-Oneida or Malad source), was not represented in Reed's sample of small side-notched projectile points, despite the fact that it is known to have been highly-valued prehistorically as a source of toolstone, and traded over great distances (Nelson and Holmes 1979). Given its importance in Fremont assemblages in Utah, Reed suggested that the Oneida source may have been exploited primarily by Fremont populations; and that the Shoshonean activity sphere may not have included the extreme southeastern portion of Idaho during the Late Prehistoric period (Reed 1985:58)

A second interesting aspect of Reed's study concerns the Timber Butte obsidian source northeast of Boise. According to

Sappington's (1984) study of the distribution of debitage produced from Timber Butte obsidian, the source must have been exploited by the Nez Perce during the Late Prehistoric period. Reed's sample of presumed Shoshonean projectile points was dominated by Timber Butte obsidian, suggesting some form of exchange took place between the Nez Perce and the Shoshoni that apparently was not a part of Shoshoni-Fremont interaction (Reed 1985:58).

Another interesting application of obsidian characterization research involved the so-called "F.M.Y." or "90 Group" obsidian (Griffin et al. 1969; Wright and Chaya 1985). Early research of obsidian distribution in archaeological sites covering an area from the American Midwest to Idaho identified two important obsidian sources (Griffin et al. 1969: Table 3.) Using neutron activation analysis, the researchers showed that one obsidian type had a Na/Mn ratio clustering around 150 parts per million (ppm). This source has since been identified as Obsidian Cliff, located in Yellowstone Park, Wyoming (Wright et al. 1986).

A second obsidian type common in the study sample had a Na/Mn ratio clustering around 90 ppm. This obsidian also differed from the 150 group in other elemental ratios (Wright and Chaya 1985). The location of the source of the 90 Group obsidian remained unidentified until recently (Wright and Chaya 1986). Griffin et al. (1969) analyzed a substantial number of source samples to pinpoint the 90 Group origin, but found only one sample with a matching elemental profile. This sample, submitted by the Field Museum in Chicago, was labelled simply as "Yellowstone"; it has since become known as the F.M.Y. (Field Museum Yellowstone) sample. An extensive study by Wright and Chaya (1985) failed to identify the source of the F.M.Y. sample, although they were able to demonstrate that it was not a Yellowstone obsidian; nor did it match the composition of the Teton source located in Jackson Hole, Wyoming, south of Yellowstone. Wright and Chaya believed, on the basis of distribution data for the 90 Group, that the source was located west to north of the Yellowstone Park boundary (1985:240).

Wright and Chaya (1986) eventually concluded that Bear Gulch, Idaho, was the source of the 90 Group obsidian. Bear Gulch is located near Kilgore, in Clark county, Idaho, on the southern face of the Centennial Mountains. The flow is probably associated with nearby Table Mountain (Lawrence Dee, personal communication Oct. 1989). A comparison of raw data for the Bear Gulch and F.M.Y. obsidians tentatively supports this conclusion (Table 1). This comparison should, however, be interpreted with caution because different analytical techniques were used. Moreover, the published data for the F.M.Y. sample consist of only the elements Rb, Sr, and Zr. While these are important elements for identifying obsidian types, interpretations based on only three elements must be seen as tenuous.

These types of studies illustrate the range of applications to which chemical characterization studies may be applied within a systems approach. Taken as supportive evidence in concert with other lines of inquiry, trace element characterisations can provide the archaeologist with a powerful tool for investigating numerous anthropological questions.

Table 1. Comparison of mean data for Bear Gulch and FMY obsidian.

Bear Gulch (ppm)		Rb	Sr	Zr
Wright and Chaya (1986)		159.0	53.4	285.8
["dispersive XRF"]		170.0	58.6	284.0
		161.0	53.7	281.0
	X	163.3	55.2	283.6
Hughes and Nelson (1987)				
[wavelength dispersive XRF n=3]				
	X	171.1	43.7	317.3
[energy-dispersive XRF n=10]				
	X	172.2	44.7	293.6
F.M.Y. [90] (ppm)				
Wright, Chaya, and McDonald (1986)				
['dispersive' XRF; n=?]		146.2	58.4	298.9
"OB 90" (Wright et al. 1986)				
['dispersive' XRF]		167.4	63.2	304.5

Chapter Two

Theory

X-ray fluorescence (XRF) is a spectroscopic technique for determining the elemental composition of a given material. XRF involves the production and measurement of fluorescent radiation lines which are characteristic of the elements present in a sample. Within an x-ray tube, a heated cathode produces electrons which collide with atoms in the anode of the tube. These collisions stop the electrons, causing the emission of a continuous spectrum of broadband (bremsstrahlung) photons (Eisberg and Resnick 1974:46). These high-energy photons are focused on a selectable secondary target. When a photon collides with an atom of the secondary target, an electron is ejected from an inner shell, rendering the atom unstable (Fig. 1). To return the atom to a state of equilibrium, an electron from one of the outer shells moves in to fill the inner shell vacancy. Each such transfer results in a loss in the potential energy of the atom; this energy is released in the form of fluorescent radiation at an energy level lower than that of the x-rays that initially bombarded the target (Tertian and Claisse 1982:4).

The radiation produced in the secondary target is subsequently focused upon the volcanic glass sample. Following the same process that acted upon the secondary target, fluorescent radiation is produced in the sample. Each element present in the sample emits x-rays at characteristic energy levels. It is possible to measure the relative intensities of a number of trace element emissions, and to produce a graphic display (spectrum) that characterizes the sample. Some photons from the secondary target scatter after colliding with the atoms of the sample, and are subsequently not recognizable as characteristic element emissions. These are recorded as Compton and Rayleigh scatter peaks. The Compton peak consists of photons which have lost energy after colliding with an atom, and have reached the detector at an energy level lower than their initial energy. Rayleigh peaks consist of scattered, but otherwise unmodified radiation (Tertian and Claisse 1982:22).

The SFU System

The XRF system used in this study is housed in the Department of Chemistry and Biochemistry, Simon Fraser University, Burnaby, British Columbia. The laboratory is operated under the supervision of Dr. J.M. D'Auria. The Simon Fraser XRF facility is a fully non-destructive energy-dispersive system. It employs an automated x-ray spectrometer with a gold (Au) x-ray tube (Fig. 2).

The selectable secondary target chosen for the glass analysis was silver (Ag). According to Nelson et al. (1975), the elements with characteristic energy lines slightly lower than the energy emitted from the secondary target are most efficiently detected by the system. Under analytical conditions of 40 KeV and 5 mA the silver target emits x-rays at approximately 21 KeV, allowing detection of x-rays in the 3 - 18 KeV range, with maximum detection efficiency in the 13 - 18 KeV range. This feature allows high resolution in the detection of the characteristic energy lines produced by the elements Rubidium (Rb), Strontium (Sr), Yttrium (Y), Zirconium (Zr), and Niobium (Nb). These elements have proven most useful in characterizing volcanic glass sources (Nelson et al. 1975; Godfrey-Smith 1985; James 1986).

Elements ranging between Potassium (K) and Rubidium (Rb) on the atomic weight scale were also detected by the system with somewhat less precision. Of these, only Fe (Ka and Kb) and Zn were considered in this analysis. A thin silver (Ag) filter was placed in the path of the x-ray beam emitted from the secondary target to ensure that the radiation reaching the sample consisted almost exclusively of K-alpha and K-beta rays. This procedure reduces background radiation, and keeps high-energy radiation from producing multiple minor peaks which would make the spectra more difficult to interpret.

The fluorescent radiation emitted from the glass samples was detected using a nitrogen-cooled Silicon-Lithium (Si[Li]) detector. This system is capable of analyzing automatically up to 40 small (<2 cm) or 16 larger (<5 cm) samples. Samples larger than 5 cm in diameter required alteration of the system (discussed below).

Pulse processing equipment used by the SFU system is from the Kevex Corporation. Information from pulse amplifying electronics passed through an ND66 multi-channel pulse height analyzer which stores the data in 512-channel groups. The XRF system is controlled by an IBM XT Personal Computer where the data were stored as spectra on 5 1/4" floppy diskettes.

Following data acquisition, the spectra were transferred into an IBM AT computer where they were loaded into the peak-fitting program GXL. This program is a recently modified version of the MTS program GAMANAL. GXL searches each data file for peaks, and performs an energy calibration for selected peaks in the spectrum. It also fits the selected peaks to a Gaussian curve; and computes the area contained within each peak, as well as the background radiation. Finally, GXL compares the goodness-of-fit of the mathematical shape with the actual data. This comparison allows the operator to adjust the calibration parameters to improve the fit if necessary (Godfrey-Smith 1985). GXL is incapable of calculating steeply rising peaks such as the Compton and Rayleigh scatter peaks. The Compton and Rayleigh peaks were computed separately using the GXL modifier program CRINTEG (created by Andre Mattman 1991).

The numerical data from GXL and CRINTEG, expressed in total photon counts, were imported into spreadsheets in the program LOTUS 1-2-3 Release 2.0. These constituted the raw data of the analysis. The values for each element were also normalized as ratios to the Zr peak at 15.746 KeV to produce relative intensity measures (Appendices 1 and 2). Normalization allows direct comparison of variable samples; and reduces the effects of variable sample size, shape, thickness, and unusually high or low total count measures. The Zr peak was chosen for normalization to ensure comparability with other studies from the SFU facility, and because this peak is consistently well-represented in the source samples (Nelson et al. 1975). Godfrey-Smith (1985) achieved a 98% success rate discriminating obsidian flows using this normalization procedure.

Summary statistics were computed for each collection locality; these included the mean normalized value and standard deviation for each element (Appendix 3). The standard deviation gives an estimate of the distribution of data points within a collection locality. All summary statistics were based on normalized values; raw data were used primarily as a check to help identify sources of unexpected variability and/or error.

To monitor instrumental drift, a standard obsidian sample was included with each analytical run. This standard was from Flow #3 of the Mt. Edziza obsidian source in northwestern British Columbia (Godfrey-Smith 1985). As a further test, five runs of the Edziza standard were compared. In addition, a single Edziza flake was analyzed five times in succession without advancing the chamber (see Tables 3, 4 in Chapter 4 below). Both tests showed that machine error was minimal. A test for operator error was also conducted because there were two primary operators responsible for the peak-fitting stage of the analysis. For all major elemental peaks, the mean inter-operator measurement difference was less than 5%, which is within the range of expected random variation for the system (James 1991, personal communication).

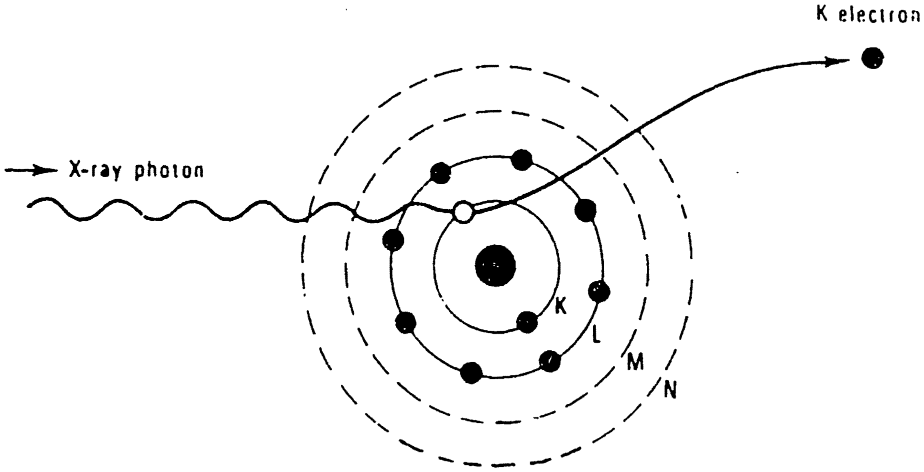


Figure 1. Ejection of a K-shell electron by proton bombardment (Tertian and Claisse 1982:4).

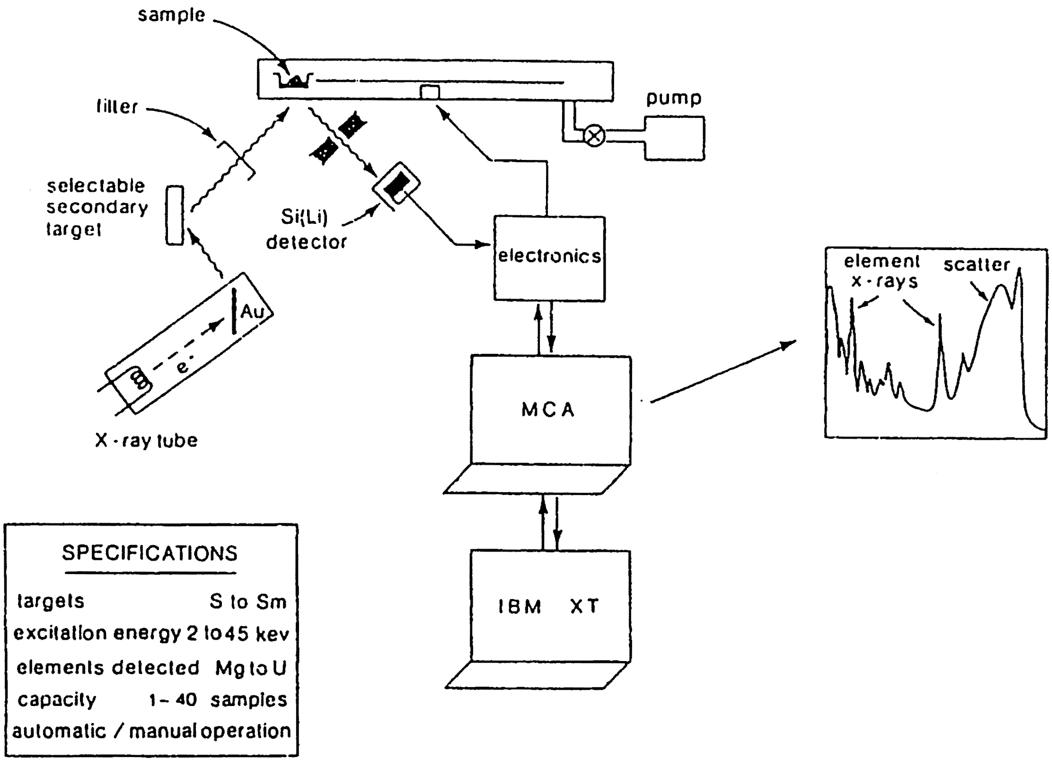


Figure 2. Schematic diagram of the XRF system used in this study. (Adapted from Godfrey-Smith and D'Auria 1987).

Sample Preparation

Source Samples

In virtually all cases, the source samples consisted of cobbles eroded from primary volcanic deposits. It was necessary to cleave flakes from the cobbles for analysis. The flaking was done by hard hammer percussion, using a quartzite hammerstone. Whenever possible (almost always), cortex was removed from the flakes to avoid introducing impurities to the analysis. However, past research using this system has shown that the presence of cortex has no measurable effect on sample characterization (Nelson et al. 1975). Prepared samples measured a maximum of 2 cm in diameter to facilitate their placement in 2 cm plastic sample cups. The samples were at least 1 mm in thickness; this dimension satisfies the infinite thickness criterion of Tertian and Claisse (1982:279). Nelson et al. (1975) explain that x-rays of different energies are differentially transmitted and absorbed by the surrounding glass matrix. As a result, very thin samples will produce a greater response to the low-Z elements in relation to the high-Z elements. This feature has resulted in disproportionately high Fe readings in relation to Zr and Nb values for very thin samples, when compared with thicker samples from the same source (Godfrey-Smith and D'Auria 1987).

Whenever possible, five cobbles were selected at random from each collection locality sample, and three flakes were detached from each cobble. This procedure provided a sample set of 15 flakes from most localities - a number deemed sufficient to test for intra-cobble and intra-flow variability (cf.Sappington 1981a; Hughes 1986)

Samples were placed on 3.6-micron-thick Mylar Spectrofilm screens in the 2 cm cups, and irradiated for 600 seconds in an air path. The spectra were collected using the acquisition program PCA; late in the study, an autosequence program was installed which allowed automatic sequential analyses of up to 40 small samples. Other analytical conditions were unchanged, and no instrumental recalibration was necessary.

Artifacts

Artifact spectra were collected following the same procedure outlined for source samples, with the exception that some artifacts were placed in 5 cm sample cups rather than 2 cm cups. Very large artifacts could not be placed in even the large cups, and special conditions were necessary for their analysis. The sample tray was removed for these analyses; and the samples were laid directly on the machine, above the detector. This setup oriented the large artifacts nearer the detector than those placed in the tray; but because all data were normalized as ratios, the data were directly comparable with those of the smaller samples and no statistical corrections were necessary.

Statistics

XRF analyses generate large sets of numerical data which must be organized in order to characterize a source or artifact. Data reduction of this magnitude demands multivariate statistical analyses (Harbottle 1982, Hughes 1984, Shackley 1988).

Some researchers recommend the use of computer-generated cluster analyses as a first step in XRF data reduction (e.g., Harbottle 1982, Hughes 1986). Clustering programs group variables according to their degree of multivariate similarity (Bowman et al. 1973; Shennan 1988). They provide a quick, general means of illustrating compositional similarities in a sample set. However, clustering programs will create groups from any data, including those which are relatively distantly related. Consequently, the results of cluster analyses must be interpreted with caution; and they should be used only as a preliminary test for covariance in conjunction with more powerful analyses.

Usually, clustering is followed by some form of discriminant analysis. For the present study, clustering was not deemed necessary; and discriminant analysis was used alone. Because the sources of the geologic samples were known in advance, the initial groups (or clusters) of samples were defined on an _a priori_ basis. However, it was necessary to express the group differences in mathematical terms; and to produce a formula by which unknown cases (artifacts) could be correlated with source fingerprints. Discriminant analysis is well suited to these needs.

Discriminant Analysis

Discriminant analysis tests the strength of previously defined groups (sources, in this case), and formulates rules (functions) by which new specimens may be assigned to a source. New attributions are made so that variability within each group is minimized, while inter-group variability is emphasized (Neff and Marcus 1980:145). Each new correlation is assigned a score indicating the Pythagorean distance in multivariate space of that case from the group centroid (Harbottle 1982). Known as the Mahalanobis distance, the squared value of this score provides an estimate of the strength of the group assignment; that is, a case is assigned to the group to which the squared Mahalanobis distance is the shortest (Neff and Marcus 1980).

Discriminant analysis thus serves two purposes for data sets which have been divided into groups on the basis of a priori classification:

1) It sets up rules for the assignment of new specimens to groups;
2) It mathematically describes the distinctness of the *a priori* groups relative to inter-group variability.

Limitations of Discriminant Analysis

Discriminant analysis appears ideally suited to the data and questions of x-ray fluorescence analyses. However, discriminant analyses are dependant upon particular statistical conditions for optimum efficiency (Neff and Marcus 1980; Hughes 1984). Perhaps most important among these is the requirement of multivariate normality. Normality is very difficult to assess in multivariate space; but Hughes (1984:3) points out that by examining the means, ranges, and standard deviations of individual trace elements it is possible to monitor normality indirectly. Elements which are highly variable within a source, and relatively unvarying across sources are generally not good discriminators. Hughes argues that poor discriminators may lead to misclassifications by the discriminant analysis, and therefore these elements should be excluded from statistical treatment. This reasoning was adopted in the present study, with only the best discriminators chosen for peak fitting by the GXL program.

A second requirement of discriminant analysis is equality of group covariance matrices (Hughes 1984:3). Hughes recommends the use of Box's M statistic to assess this condition. However, Neff and Marcus (1980:29,151) note that tests for equality of covariance matrices are highly sensitive to the multivariate normality requirement, and they do not recommend the use of these tests. Since multivariate normality was monitored in this study only by an examination of univariate cohesion, no correction was attempted for equality of group covariance matrices.

SPSS DISCRIMINANT

The discriminant analysis package chosen for this study was SPSSPC Release 3.1. This program offers several useful output options, including summary statistics, classification results tables, first- and second-highest group membership probabilities, and posterior probabilities of group membership.

Classification Results Table

The classification results table tests the performance of the program by calculating the success with which it classifies cases of known group membership. The geologic source samples were subjected to discriminant analysis to test the reliability of the classification procedure (Hughes 1984:4). This test yielded an overall accuracy rating of 82.2% (see Table 5 in Chapter 4 below). However, because the analysis is tested with the same cases that were used to derive the classification functions, these results likely overestimate the accuracy of the analysis (Norusis 1988); and they should be accepted as estimates only.

Two probability statements are provided by SPSS DISCRIMINANT. The value P(G/D), known as the 'posterior probability,' indicates the likelihood that a sample is in fact a member of the group to which it has been assigned by the analysis. This measure assumes that the sample actually belongs to one of the groups in the sampling universe. For volcanic glass studies, this assumption is not necessarily valid, since one cannot be certain that all flows in a region have been sampled. Consequently, the posterior probability value should not be accepted in isolation as a measurement of the reliability of a source attribution (Hughes 1984). Many of the SPSS misclassifications assigned samples to sources with quite similar chemical profiles, but reference to the raw and normalized data allowed the author to resolve most of these discrepancies. This result emphasized the need to assess critically all statistical analyses.

A second probability value, P(D/G), estimates the probability that a case from the assigned group would be as distant from the group centroid as the sample in question. Knoen as the conditional probability, this measure may be interpreted as an approximation of the Mahalanobis D2 value outlined above (Hughes 1984). P(D/G) may be useful for identifying misclassifications made by the discriminant analysis which are not made evident by the P(G/D) value; a high P(D/G) corresponds with a low D2 value, suggesting a close fit with the group centroid. Further checks of the discriminant analysis generally require examination of the raw or normalized source and artifact data.

Chapter Three

The Present Study

Research Goals

The goals of this study were essentially twofold: to compile a library of trace element profiles for southern Idaho volcanic glasses, and to identify the parent sources of the volcanic glass artifacts recovered from the Wilson Butte Cave archaeological site. A related goal was to produce the preliminary data required for obsidian hydration analyses to be conducted as part of a separate study (Gruhn, in preparation) The primary requirement for compiling a source library is to locate and sample as many glass sources as possible. Ideally, every source in the study area should be sampled; but because it is impossible to be certain that all localities have been located, it was necessary to impose a geographic limit upon the study area. Most of the known volcanic glass sources in Idaho are located on or adjacent to the Snake River Plain; and, since Wilson Butte Cave is also located in this physiographic province, it was hypothesized that most or all of the glass artifacts at the site originated from sources on or near the Plain. Consequently, the area contained within and directly adjacent to the Snake River Plain comprises the study area.

Some seventy six localities were visited at which volcanic glass cobbles could easily be collected today and (presumably) in the prehistoric past. Cobbles of various sizes and colours were collected from each locality with the goal of adequately representing physical and chemical variability within the source. No intact bedrock sources were located; all sources consist of eroded "float" material in the form of cobbles of a wide range of shapes and sizes. The quality of the glasses for flintknapping purposes also varied widely, as a function of purity and degree of devitrification. Obsidian and ignimbrite are particularly susceptible to the effects of weathering; they devitrify (loses their glassy quality) over time, becoming crumbly in texture and dull in lustre. Consequently, very old obsidian flows do not yield rocks of quality adequate for flintknapping. Even relatively recent flows may contain spherulitic inclusions or phenocrystic impurities which may adversely affect the flaking quality of the rock. This variation in the quality of the material is probably one of the primary reasons that high-quality glasses were widely traded in prehistoric times; good material was relatively scarce, and it would have been highly valued by flintknappers.

The second goal of the study involved the correlation of the trace element fingerprints of artifacts from Wilson Butte Cave with those in the source library. As noted above, accurate correlations depend upon the completeness of the sampling universe. Since this requirement cannot be assessed directly, it is necessary to assume that all sources in the study area have been sampled. Subsequent examination of the trace element data identifies cases which do not match well with any of the known parent sources; this result may indicate that an unknown source(s) is represented in the collection.

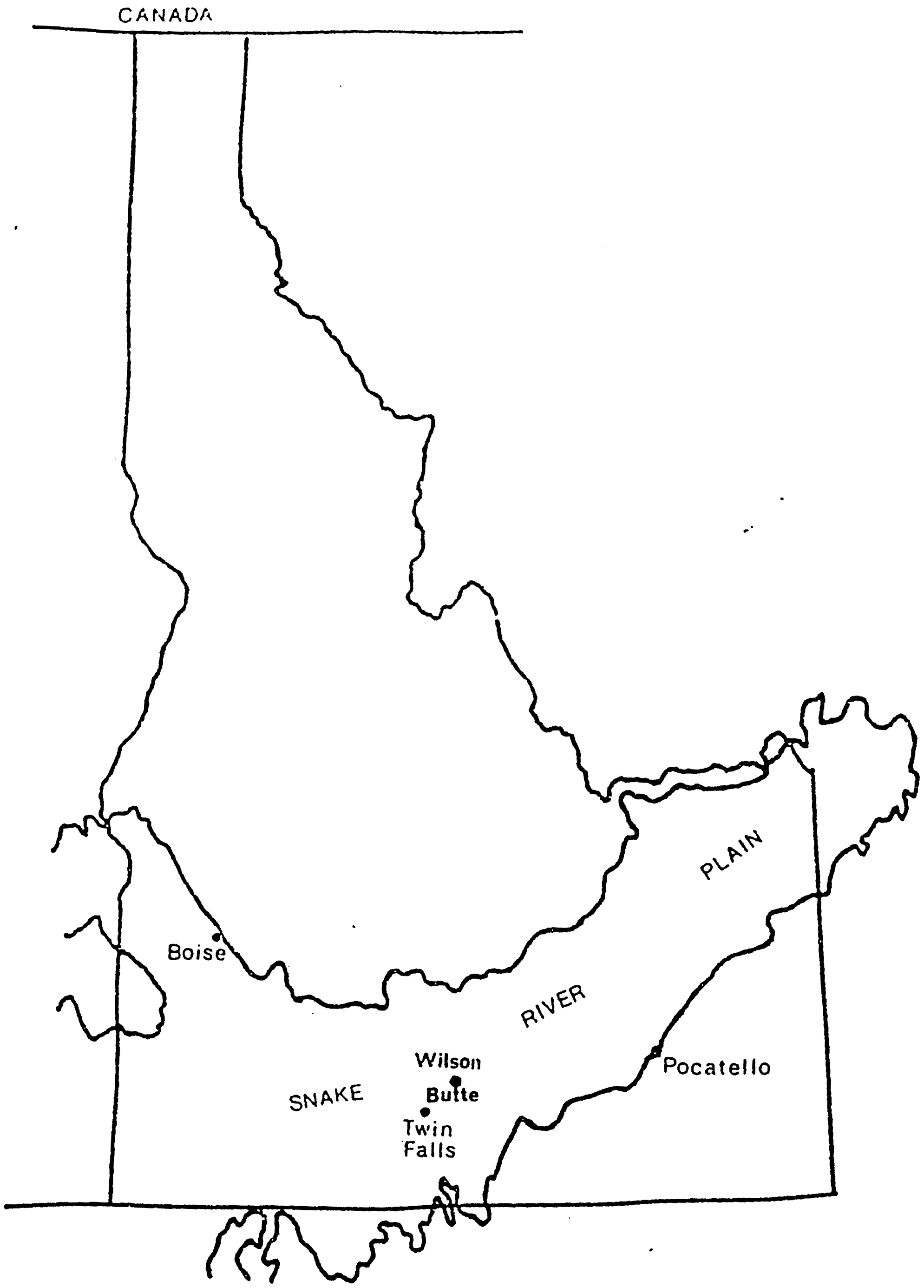
The correlation of artifact and source characterizations for the Wilson Butte Cave collection provides an insight into prehistoric lithic resource exploitation patterns at the site. The limited scope of this study, and the inferred short duration of occupations of the site, dictate that more questions are created by the data than can presently be resolved. This study should be viewed as a part of a process by which hypotheses may be generated about prehistoric population movements, exchange systems, and resource exploitation on the central Snake River Plain.

The Study Area

The Snake River Plain

The Snake River Plain is one of the largest volcanic provinces in the world. It extends some 650 km across southern Idaho from the Idaho/Oregon border northeastward to a point at the Yellowstone Volcano on the Yellowstone Plateau of Wyoming. The Plain forms an arch with a radius of approximately 260 km, and a north-south width varying from 80 km in the west to 200 km in the east-central portion (see Map 1). Greeley and King (1975:1) described the Snake River Plain as a "prominent depression"; and indeed, on first impression it appears quite flat and featureless, especially in contrast with the mountain ranges that surround it (the Timmerman and Bennett Hills to the north, the Cassia Mountains to the south, and the Centennial Mountains in the extreme northeast of the Plain). The Owyhee Uplands border the Plain in the southwest, and the Caribou Hills dominate the southeast. These features add to the illusion of the Plain as a flat area. In fact, the Plain varies in elevation from 760 m at the west end to 1830 m at the northeast end; and it contains a number of significant features, including Wilson Butte (Gruhn 1961:2).

Most of the exposed bedrocks of the Snake River Plain are basalt. This fact led early researchers to believe it to be an extension of the Columbia Plateau, but the two physiographic provinces differ vastly in age and composition (Greeley and King 1975). The Columbia Plateau consists of vast deposits of basalt of Miocene age. The Snake River Plain contains no flows comparable in size to those of the Columbia Plateau. The Snake River basalts are relatively thin deposits of Pliocene/Pleistocene to Holocene age, capping older and much more extensive white rhyolite bedrock deposits (Alt and Hyndman 1989:235). These older deposits had considerable relief, especially in the eastern portion of the Plain, where Big Southern Butte and its neighbours, Middle and Eastern Buttes, rise above the surrounding Plain. Subsequent basaltic lava flows extruded onto the rhyolite bedrock, significantly levelling the topography of the Plain.



Map 1. Extent of the Snake River Plain.

Alt and Hyndman (1989) believe that a meteorite struck the earth some 17 million years ago in what is now southeastern Oregon, producing the volcanic events that formed the Columbia Plateau. They further hypothesize that this catastrophic event created a hotspot in the earth's mantle which remains active today at the Yellowstone Volcano. The hotspot remained stationary; but as the North American lithospheric plate moved over it, a chain of volcanism was created, beginning about 13 million years ago, which formed the Snake River Plain (Alt and Hyndman 1989:33-34). If the suggested timing of the Oregon meteorite is correct, then the continental plate would since have had to move approximately 1.5 inches per year to account for the present location of the hotspot below the Yellowstone Volcano. This analysis conforms closely with many geologists' estimate that the plate moves at a rate of about 2 inches per year (Alt and Hyndman 1989:239).

While the name Snake River Plain conveys a sense of uniformity across the region, the Plain actually consists of two structurally dissimilar segments that join near Twin Falls (Greeley and King 1975:1). The main portion of the Plain forms a virtually straight line following the track of the Yellowstone Hotspot from the southwest corner of Idaho to Yellowstone Park. This is the basalt-capped rhyolite Plain described above. The western part of the Snake River Plain is a northward-projecting Basin and Range valley. It consists of a valley that filled with white rhyolitic ash, subsequent basalt flows, and finally valley-fill sediments (Alt and Hyndman 1989:236-237). The valley-fill sediments cover the majority of the bedrock deposits, making this segment of the Plain appear distinct from the basalt-covered main segment.

Wilson Butte Cave

Wilson Butte Cave (10JE6) sits atop a broad basaltic ridge (Wilson Butte) rising above the Snake River Plain in Jerome County, south-central Idaho (Gruhn 1961:2) (see Map 1). The butte rises gradually some 125 m above the plain to a maximum elevation of 1375 m above sea level (Gruhn 1961:4). The cave is a large "lava blister" that was formed when gases expanded within a cooling subsurface lava flow, forming a lava tube with a relatively flat floor and arched ceiling. The blister solidified as it cooled, forming a bubble of rock that became a cave when a collapse of the east wall occurred during the Late Pleistocene, providing an opening to the inner chamber (Gruhn 1961:20). At the time of the first professional excavation of the cave in 1959, its interior measured 24.2 metres (north-south) by 21.1 metres (east-west) by 4.5 metres high. The opening was 6 metres wide and 2 metres high (Gruhn 1961). Since sediment deposition at the cave is now primarily aeolian in nature (and therefore quite slow), these dimensions have not changed significantly over the past thirty years.

Wilson Butte Cave was initially excavated during the summers of 1959 and 1960 under a project operated jointly by the Idaho State College Museum and the Peabody Museum of Harvard University, under the direction of Ruth Gruhn (Gruhn 1961). Although the cave deposits had been significantly disturbed by relic hunters, it was clear that the site housed a sequence of cultural remains with considerable time depth. Artifacts made from stone, bone, and perishable materials such as leather, wood, and plant fibre were recovered (refer to Gruhn 1961, Chapters 3 - 5 for a detailed description of the site assemblages). Further excavations were undertaken in 1988 and 1989 as a project supported by the University of Alberta and the United States Bureau of Land Management (Gruhn, report in preparation).

Aboriginal Use of Wilson Butte Cave

Gruhn understood Wilson Butte Cave to be a short-term campsite, probably associated with hunting on the butte (1989, personal communication). The site offers a panoramic view of the butte and the plain (and presumably game) below; but because there was no permanent water source nearby, the cave was probably never occupied for long periods of time. After the modern arid climate became established in the region about 5000 years ago, the cave may have been occupied primarily in the winter or spring when snow or runoff water would provide sufficient water for drinking and cooking.

Stratigraphy

Five major strata were identified in the cave, with the deposits reaching a maximum total thickness of three metres near the opening (Fig. 3). The oldest deposit (Stratum E) was a waterlain yellow/brown clay that coated the underlying bedrock floor and accumulated among boulders and in crevices. The clay deposit was generally quite thin, although it reached a maximum thickness of 50 cm among boulders near the front of the cave. The early excavations revealed very little evidence that people occupied the cave at the time the clay was deposited. Large mammal bone fragments were found scattered throughout this stratum; most of the bones were unidentifiable, but horse and camel species were identified, and a concentration of large mammal bones near the mouth of the cave was tentatively identified as Equus sp. (Gruhn 1961:19). The bone concentration provided the first suggested evidence of cultural material in the clay deposit; a modified duck ulna and a small unidentified bone bearing parallel cut marks were recovered during the early excavation. After publication of the Wilson Butte Cave manuscript, a radiocarbon date of 15,000 +/- 800 B.P. (M-1410) was obtained from a collective sample of small mammal bones retrieved from Stratum E (Gruhn 1965). The 1988/89 excavations yielded additional cultural evidence in the clay deposit in the form of six flakes, including two large obsidian flakes found in situ. Both flakes were analyzed as part of the present study.

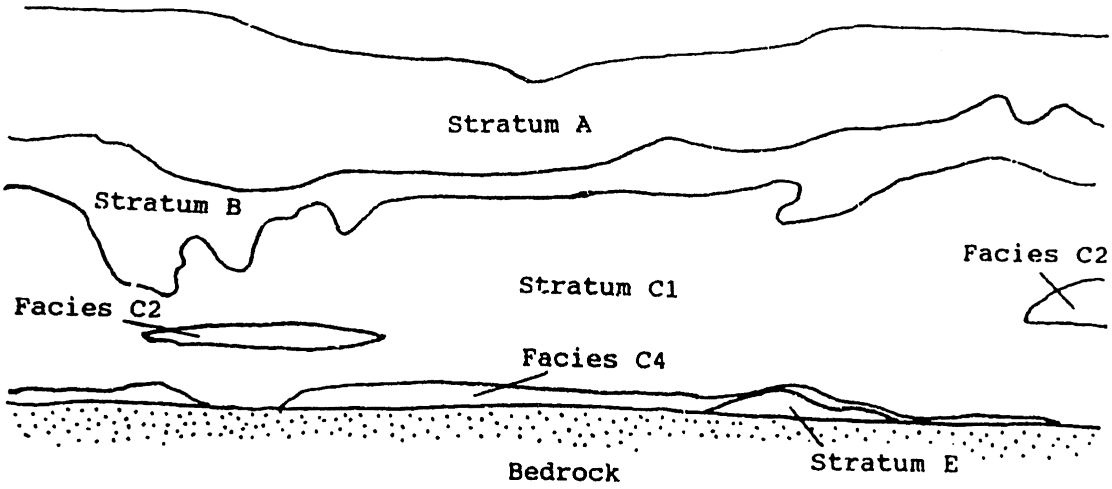


Figure 3. Schematic diagram of the stratigraphy of Wilson Butte Cave. (Adapted from Gruhn 1961: plate 10).

Overlying Stratum E in a highly localized pocket near the front of the cave was Stratum D, a yellow/brown sandy silt. This laminated waterlain deposit accumulated primarily among rocks at the front of the cave, with a maximum thickness of 80 cm. It contained abundant small mammal bones but no cultural material, and it is unlikely that there was any human use of the cave at this time. Chronometric dating of the deposit was not possible, but a time range corresponding to a glacial advance was suggested by severe frost distortion of the laminae in the deposit. Gruhn believed this glacial event predated 11,000 B.P. (1961:48). Stratum D was not encountered in the 1988/89 excavations.

Stratum C consisted of a thick deposit of grey/brown waterlain sand. This sand overlaid Stratum D, where present; and it directly overlaid Stratum E where Stratum D was absent. Stratum C varied in thickness from 50 cm at the rear of the cave, to a maximum of about 2 metres near the cave opening. This deposit contained abundant large mammal bones, including horse and camel, as well as modern bison. Many small mammal and bird species were also represented, and a single human molar was found (Gruhn 1961). A blade, a burinated flake, and a probable wood-working tool were found in association with bone dated at 14,500 +/- 500 B.P. (M-1409) in the lower part of Stratum C. In the 1988/1989 excavations, a number of isolated "rocky zones" incorporated in the middle and lower parts of Stratum C yielded numerous artifacts. Cultural materials were recovered from throughout Stratum C; but few definite features were identified, with the exception of concentrations of lithic material in association with large mammal bones. Finished artifacts, waste flakes, and charcoal comprised the bulk of the cultural remains; and these were scattered widely throughout the thick sand deposit. In 1961, four artifact assemblages were defined from the Stratum C inventory (Wilson Butte Assemblages I-IV; Gruhn 1961: 117-120). Diagnostic projectile point forms are as follows: Assemblage I had no standardized artifacts; a significant portion of Assemblage II were projectile points, featuring long lanceolate points similar to the parallel-flaked point forms common on the Great Plains; Assemblage III included stemmed, concave based projectile points; notable point forms in Assemblage IV included large, broad side-notched forms and stemmed, shouldered points (Gruhn 1961, Plates 33-35).

At first, Stratum C was believed to represent a moist climatic phase extending from about 9,000 years to 7,000 years B.P. A radiocarbon date on charcoal from the upper part of the deposit produced a date of 6,850 B.P.+/- 300 years (M-1087) (Gruhn 1961:27); but the 14,500 B.P. radiocarbon date suggested that Stratum C started accumulating much earlier.

Stratum B was a moderately thick aeolian brown silt deposit. By 1988 this stratum had been completely disturbed by looters, and the lower portions of the deposit had been mixed with upper Stratum C, creating a mottled grey/brown silty sand near their interface. Stratum B represents a long period (possibly up to 6000 years) of slow sedimentation during which human occupation of the cave became more intensive (Gruhn 1961:120). This stratum contained a much greater density of artifacts than did the lower strata; and there were definite occupation areas, including hearths and artifact concentrations. Artifacts from Stratum B comprise Gruhn's Wilson Butte V assemblage, featuring medium-sized lanceolate projectile points (similar to the Humboldt Concave-Base type), medium-to-large corner-notched points, and large side-notched points (Gruhn 1961, Plate 36).

Two radiocarbon dates were obtained from the early excavations of Stratum B: a date of 940 +/- 150 years B.P on charcoal from the upper part of the deposit (M-1144; Gruhn 1961:31); and a date of 2940 +/- 200 years B.P on a piece of sagebrush charcoal from the middle of the stratum (M-1143; Gruhn 1961:32). The most intensive human use of the cave during the deposition of the brown aeolian silt was probably between 2500 and 4000 years B.P. (Gruhn 1961:121). Gruhn suggested that the beginning of Stratum B deposition coincided with the onset of a warm, dry period about 7,000 years ago; the terminal date for the stratum is estimated at about 650 years ago (Gruhn 1961:32).

Stratum A, the uppermost deposit in Wilson Butte Cave, consisted of a matrix of fine, dry, aeolian silt containing concentrations of dry vegetal materials. This stratum was deepest at the rear of the cave, where it reached a maximum thickness of 50 cm. While most of the vegetation was probably brought into the cave by rodents, some of it was likely carried in by human occupants to serve as bedding material (Gruhn 1961:33).

Stratum A held the greatest quantity and variety of cultural material. Artifacts of stone, bone, shell, pottery, wood, plant fibre and animal hide were recovered from this deposit. The artifact assemblage, designated Wilson Butte VI, was sufficiently complete to allow its definition as a distinct phase - the Dietrich Phase (Gruhn 1961:122). Dietrich Phase projectile points are primarily arrow points, including small triangular, corner-notched, and side-notched forms (Gruhn 1961, Plate 37).

Dietrich Phase occupants were apparently bison hunters; very little evidence was found for plant processing. The proposed beginning date for the deposition of Stratum A is about 650 years ago, and a sample of wood from the middle of the deposit yielded a radiocarbon date of 425 +/- 150 years B.P.(M-1088; Gruhn 1961:39). Since no European goods were recovered from Wilson Butte Cave in the 1959/60 excavations, it was assumed that aboriginal use of the site ceased before the onset of the historic period.

It comes as no surprise that the early dates at Wilson Butte Cave were questioned by archaeologists who were unwilling to accept evidence of human presence in the area prior to Clovis times (e.g., Haynes 1969, 1971). In response to these criticisms, further excavation was carried out at the site in 1989 and 1990 to obtain additional radiocarbon dates, and better to assess the extent of historical disturbance of the deposits. These later excavations provided the artifacts that were analyzed in the present study. Details of the 1988/89 excavations will be reported elsewhere (Gruhn, in preparation).

Lithic Artifacts

The excavations of 1959/60 yielded approximately 250 identifiable lithic artifacts, including 106 complete or fragmented projectile points. Raw materials represented in the assemblage included obsidian, ignimbrite, basalt, and other cryptocrystalline silicates such as chalcedony and chert (Gruhn 1961:50). The distribution of raw materials for each stratum, based on waste flake frequencies, showed that ignimbrite was the dominant material in the lower (i.e., earlier) deposits; but, over time, the igneous raw materials all declined in frequency, while chalcedony became more common (Gruhn 1961:51).

The 1988/89 excavations yielded a large number of lithic artifacts, including more than 200 projectile points. Unfortunately, only 29 of these were recovered from the undisturbed lower sand deposits. A total of 135 complete and fragmented projectile points and 105 other lithic items were characterized in the present analysis, including artifacts from both disturbed and undisturbed contexts (see Chapter 5).

To date, raw material frequency distributions have not been computed for the materials collected in 1988 and 1989; however, if we are to assume that the 1959/60 lithic assemblages are representative of the entire site assemblage, then we can expect that these raw material frequencies would be approximately valid for the entire lithic collection.

Gruhn reported that most of the debitage from the early excavations was small and that all cores were virtually expended. She interpreted this fact as an indication that sources of toolstone were not close at hand for the occupants of the cave (1961:51). The present study confirms that while there are numerous sources of flakeable glass within reasonable procurement distance from Wilson Butte Cave, none can be considered "close at hand." The fact that several of these sources were exploited supports the view that prehistoric lithic procurement took place as part of a broader subsistence system, rather than as a separate activity (cf. Hughes 1986). This idea is pursued in greater detail in Chapter 6.

Volcanic Glass Nomenclature

The terms 'obsidian,' 'ignimbrite,' and 'volcanic glass' are commonly used by both archaeologists and geologists. However, the exact meanings of the terms seem to differ among researchers, creating potential difficulties in interpreting other scholars' work. The following discussion does not pretend to resolve this problem, but rather to acknowledge it and to clarify the nomenclature used in the present study.

Obsidian

The meaning of the word obsidian is generally quite well understood; it refers to a non-crystalline igneous glass formed within a cooling magma extrusion. Sometimes described as a "supercooled liquid silica melt" (Hughes 1986:21), there is some disagreement about the details of the formation of obsidian. Alt and Hyndman (1989) argue that it is inconceivable that large obsidian flows could cool sufficiently quickly to preclude crystallization. Instead, they suggest that magma is extremely viscous and that low water content retards the ion movement that would be essential for the formation of crystal structure in rock. Although this issue has little direct relevance for archaeologists, it does have implications for understanding trace element homogeneity in obsidian flows, and for the application of x-ray fluorescence to obsidian samples.

Obsidians from different volcanic events may be quite variable in purity; small phenocrysts, spherulites, or other inclusions are sometimes incorporated into the glassy matrix as the flow cools. Subsequent weathering affects the hardness and texture of the rocks and, consequently, some obsidians are not useful for flintknapping. This fact is important for archaeologists because it helps to explain the wide geographical distribution of certain high-quality obsidians that were valued and exchanged by prehistoric populations.

Ignimbrite

The term 'ignimbrite' has been more troublesome. The word has often been used in the archaeological literature of southern Idaho to describe a rock-type (e.g., Gruhn 1961, Green 1982), but it has not been adequately defined. Archaeologists sometimes use the term ignimbrite in a general way to refer to an array of opaque volcanic rocks which may be quite variable in lustre, hardness, homogeneity, colour, and other physical and chemical qualities. This application has often led to the use of a single term to define a number of rock types, or to the use of a number of names for the same rock type (e.g., ignimbrite, vitrophyre, opaque volcanic glass).

One cause of this confusion seems to be the mixing of relatively precise geological usage of the word ignimbrite, and the more general (if less accurate) archaeological context. In geological terminology, an ignimbrite is "a mappable, sheet-like deposit of relatively nonsorted and nonstratified pyroclastic material of probable nuee ardente origin" (Cook 1962:13). The exact process by which ignimbrite forms is not clearly understood; but it is believed that a 'flowing cloud' of gases, ash, and other particles moves downslope during a volcanic event, melting underlying materials and re-fusing some of them to form rocks. Some materials cool quite quickly, forming relatively glassy rock types, while others may be much coarser. The formative mechanism of ignimbrite deposits has been variously defined as an ash flow, a pyroclastic flow, a sand flow, a tuff flow, and a nuee ardente (Cook 1962). There has been some confusion in the use of these terms, as illustrated by Ross and Smith :

> Usage has not always differentiated between the clouds themselves and the dense ash or block-and-ash-transporting basal part. If so used, this basal portion would constitute the noncloud portion of a glowing cloud, which may or may not even be glowing (1961, cited in Cook 1962:11).

In response to this confusion, many North American geologists have now adopted the simple term 'ash flow' to describe the process by which ignimbrites form (L. Dee Feb. 1991, personal communication).

Thus, an ignimbrite can be understood as a rock unit in which rock types may vary from crumbly, non-welded (sillar) rocks to densely-welded, crystal-poor, vitreous tuffs (Cook 1962; Lawrence Dee pers. comm. Feb. 1991). It is the densely-welded ignimbrite rocks that were of interest to prehistoric flintknappers, and hence to modern archaeologists. These rocks vary significantly in colour and quality; but they all fracture according to a predictable (conchoidal) pattern, and produce sharp, durable edges.

A problem arises when some researchers understand ignimbrites to be rock units, while others use the term to describe a rock type. Sappington (1981a,b) addressed this problem by adopting the term 'vitrophyre' to describe the archaeologically significant components of ignimbrite formations. He suggested that referring to vitrophyre as ignimbrite is akin to calling obsidian lava (pers. comm., Aug. 1989). While the analogy is probably accurate, it can be argued that the term 'vitrophyre' is also extremely vague; it could conceivably describe any vitreous rock, including both ignimbrite and obsidian.

'Welded tuff' is another term which, although technically accurate, encompasses a wide variety of rocks; and more precise descriptors, such as 'densely-welded,' 'crystal-poor,' and 'vitreous' are too cumbersome for common usage. At least one archaeologist has used the term 'opaque volcanic glass' (J. Ross pers. comm., Oct. 1989), but it has not been widely adopted.

Such terminological issues cannot be resolved here, and they would be best tackled in a symposium or similar meeting of archaeologists. For the present study, obsidians and ignimbrites are collectively described as 'volcanic glasses.' For specific reference to opaque, vitreous, ash-flow rocks the term 'ignimbrite' has been adopted because it is technically correct, although imprecise; and because it is generally understood by archaeologists in southern Idaho and other volcanic regions (even though it not always accepted). It is recommended that this term be accepted until a more precise one is introduced and widely accepted by the archaeological community.

Chapter Four

Source Analyses

Trace element analyses of the source samples were very successful. All the geological samples provided sufficient trace element data for analysis, and almost all sources were very well characterized. Homogeneity in trace element composition differed considerably among the glass sources; but all exhibited low intra-source variability in comparison with inter-source variability, thereby making it possible to define thirty statistically discrete chemical groups, or glass sources.

Field Sampling

Bedrock sources of volcanic glass are uncommon or absent in Idaho. Most obsidian and ignimbrite occurs in the form of eroded cobbles on hillsides or in stream beds, and the number of known quarry sites at these secondary (float) localities suggests that they were in fact preferred by prehistoric flintknappers (James 1992). Collecting cobbles would require less energy output than would procurement from a bedrock deposit, and erosional processes would likely help to sort out and remove materials of poor flaking quality (James 1992).

The Idaho glass sources were located primarily from published information; and from directions supplied by archaeologists, geologists, ranchers, landowners, and a number of 'rockhounds' possessing intimate knowledge of the study area. All collection localities were plotted on United States BLM Surface Management Series maps, and on USGS 1:50,000 Topographic Series maps, when available. It was often preferable to use the less-detailed surface management maps when dealing with landowners, as many dirt roads and other local features (including property lines) are included on these maps.

Wherever possible, fifteen cobbles were collected from a given locality. This sample size was deemed sufficient to account for chemical variability within a flow, and to provide an adequate database for statistical analyses and source characterization. Field sampling was essentially random, within broad criteria. A range of cobble sizes was collected, but cobbles ranging from 5 cm to 15 cm in diameter were preferred due to transportation considerations. Moreover, when colour variation was evident at a collection locality, an effort was made to sample a range of cobble colours.

Laboratory Subsampling

The field sample was reduced in the laboratory by the random selection of five cobbles from each locality, and the removal of three flakes from each cobble. In the few cases where smaller sample sizes were collected in the field, three cobbles were subsampled, and five flakes were removed from each for analysis. In only a few cases was it impossible to obtain fifteen flakes for analysis, and the minimum number of samples used to characterize a source was nine. This procedure was designed to control for chemical variability both within a cobble and among cobbles from a collection locality. The number of samples from a given locality was almost always greater than the number of variables used for statistical manipulation, as required for discriminant analysis (Klecka 1980). It should be noted that, although the necessity of this condition has been recently questioned, for volcanic glass characterization it is important that sample sizes be quite large regardless of the statistics employed.

Sources of Variability

Intra-flow Variability

The ideal of chemical homogeneity within a volcanic glass flow is rarely achieved in nature. Recent research has indicated that patterns of variability can be identified, not only in extensive flows, but also in geographically confined deposits (Sappington 1981a; Reed 1989 pers. comm.; James 1992). Variability may be due to horizontal differences in a flow (especially in extensive flows), or the presence of a number of separate flows originating from different volcanic events. In the event of more than one extrusion at a locality over a geologically short time span, flows may be chemically similar because the degree of convective mixing of the parent magma pool has been minimal, preventing significant alteration of the trace element composition of the magma.

Table 2. Idaho volcanic glass sources characterized in this study, and corresponding source names from published sources.

IDAHO VOLCANIC GLASS SOURCES	
OBSIDIAN	OTHER NAMES
Bear Gulch	Camas/Dry Creek (Michels 1983)
Big Southern Butte	
Cannonball Mountain 1	
Cannonball Mountain 2	
Chesterfield	Smith Creek (J.P. Green 1982)
Coal Bank Spring	
Malad	Oneida (Sappington 1981a); Hawkins-Malad-Oneida (HMO) (J.P. Green 1982)
Owyhee 1	
Owyhee 2	
Reynolds	
Timber Butte	
Wedge Butte (Snowflake)	
IGNIMBRITE	
Brown's Bench	
Conant Creek	
Camas Prairie	
Cedar Creek	
Deep Creek	
Dry Creek	
Fish Creek	
Graham Spring	
Jasper Flats 1	
Jasper Flats 2	
Medicine Lodge Canyon	
Murphy Hot Springs	
Ozone	
Picabo Hills	
Pine Mountain	
Reas Pass	
Snake River	Walcott (Sappington 1981a)
Three Creek	
Yale Creek	

In addition to horizontal variation in chemical composition, it has been suggested that a flow may exhibit significant vertical variability. For instance, it has been noted that the upper and lower portions of a flow are often chemically similar, while the central region may be distinct (Reed 1989, pers. comm.; James 1992). The Owyhee, Idaho, obsidian sources illustrate this trend, with two chemical types represented within a very limited area: Owyhee 1 obsidian is apparently restricted in distribution to the north face of the Owyhee Mountains; while Owyhee 2 was collected only on the southern flank, at a location intermediate in elevation to the two Owyhee 1 collection localities. A similar phenomenon was reported at Cannonball Mountain (Reed 1989, pers. comm.), where two obsidian types are also represented. Chemical type 1 was collected over a wide area of Cannonball Mountain and the associated drainages, while the Cannonball Mtn. 2 chemical type was apparently restricted to a ridge at a higher elevation then the Cannonball Mtn. 1 localities. In contrast, Big Southern Butte obsidian shows significant vertical variation in colour, texture, degree of weathering, and purity; but it is chemically quite homogeneous. More research into the mechanisms of volcanic activity might help to explain the causes of chemical variability as a function of elevation.

Colour Variability and Chemical Composition

The source analyses showed clearly that macroscopic variability does not necessarily correspond with trace element variability. For example, obsidian collected from Locality 1 at Big Southern Butte was macroscopically distinct; it was grey/green in colour, with visible lithophysic inclusions. Obsidian collected at Big Southern Butte Locality 4 (Webb Spring) appeared black in colour (dark olive green in thin section) and contained fewer inclusions, but it was chemically indistinguishable from samples collected at other localities on the butte. Cannonball Mountain and Coal Bank Spring obsidian samples provided other examples to support this point; these sources yielded cobbles in an assortment of colours, but each group clustered tightly. The colour variability exhibited at various ignimbrite collection localities (e.g., several Brown's Bench localities) was also shown to be independent of trace element variability.

Interflow Variability

The fundamental requirement of characterization studies is that inter-group differences exceed all other types of variation combined, including instrumental drift, operator inconsistency, and actual variation within any particular group. It is impossible to define distinct groups if this criterion is not met. As noted above, the volcanic glasses analyzed in this study were generally distinct enough that clear group boundaries could be defined.

Interflow Similarity

As more volcanic glass sources are discovered, the probability increases that chemically-overlapping flows will be defined. In cases like this it is important that sufficient samples are analyzed to reveal subtle patterns of variation between the sources, and to meet the statistical requirements of multivariate analyses. The analyst must also be capable of examining other lines of inquiry to support the trace element data; useful types of evidence may include known (or suggested) distributions of particular glass types; sample colour, texture, homogeneity, reflectivity, and other macroscopic characteristics; and the geographic location and extent of the sources in question. In all cases, an adequate sample size is a fundamental requirement.

Statistical Variability

Control experiments were incorporated into the research design to help account for statistical variability and error. Targeted sources of error included variability inherent in the system, inter-operator differences, and true chemical variability within and between flows.

System Variability

A laboratory standard obsidian sample from Mt. Edziza, B.C. was included with each analytical run to provide a point of reference for comparing results from different runs. This procedure can help to identify unexpected variability that might arise from accidental changes in the system settings, or operator error. Unexpected variation in cross-run data for the standards can help to pinpoint sources of unexplained variability in source or artifact data.

To test for consistentcy, the Edziza #3 standard was irradiated five times consecutively without moving the sample. The results were compared with five separate runs of the standard over time, included with the regular runs of source materials. The comparison shows very little variation due to system fluctuations or operator error (Tables 3, 4).

Another check for operator variability monitored the GXL peak-fitting step of the analysis. Several samples from early runs in the project were reanalyzed; and no significant differences were found in the second analyses, indicating both system and operator consistency. This system of checks helped to ensure the consistency and reliability of the x-ray fluorescence analyses, thereby enabling the operator more confidently to attribute observed variability to actual flow variability, rather than system error.

Actual Intraflow Variability

Intrasource variability does exist, and it may be either due to flow variability or the presence of two or more flows at a locality. In the event of two extrusions within a geologically short time span, the flows may be chemically very similar because the degree of convection and mixing in the earth's mantle has been relatively restricted, preventing significant alteration of the trace element composition of the magma pool.

Table 3 Normalized data from the Mt. Edziza Flow #3 Laboratory Standard. Five consecutive runs without moving the sample.

	Fe	FeB	Zn	Rb	Sr	Y	Nb	ZrB
1.	0.365	0.064	0.019	0.100	0	0.106	0.154	0.240
2.	0.374	0.067	0.019	0.097	0	0.100	0.139	0.221
3.	0.384	0.017	0.019	0.103	0	0.114	0.150	0.215
4.	0.417	0.073	0.019	0.103	0	0.101	0.144	0.237
5.	0.394	0.070	0.018	0.113	0	0.110	0.145	0.231
Mean	0.387	0.069	0.019	0.101	0	0.106	0.146	0.229
S.D.	0.020	0.004	0.000	0.003	0	0.006	0.006	0.011

Table 4 Normalized data from the Mt. Edziza Flow #3 Laboratory Standard. Five nonconsecutive runs.

	Fe	FeB	Zn	Rb	Sr	Y	Nb	ZrB
1.	0.394	0.070	0.018	0.113	0	0.110	0.145	0.231
2.	0.295	0.069	0.021	0.107	0	0.111	0.154	0.241
3.	0.384	0.067	0.019	0.099	0	0.105	0.142	0.223
4.	0.389	0.069	0.020	0.105	0	0.105	0.142	0.234
5.	0.289	0.069	0.020	0.105	0	0.105	0.142	0.234
Mean	0.391	0.069	0.020	0.106	0	0.107	0.145	0.233
S.D.	0.005	0.001	0.001	0.005	0	0.003	0.005	0.007

SPSS RESULTS

Thirty chemically-cohesive volcanic glass types were defined on the basis of trace element similarity (Table 2). SPSS discriminant analyses were used to test the strength of these chemical groupings. The statistics program was directed to group the normalized trace element data from the source materials according to covarying trace element composition. Since the actual group membership of each sample was already known, it was possible to monitor directly the success of the SPSS program. Each sample was entered into the analysis as a separate case, thereby comparing the statistical groupings with the known groups. This procedure produced satisfactory results, with the discriminant function analysis even identifying multiple flows within localities, and perhaps even intrusive cobbles (see the discussion of the Cedar Creek and Three Creek ignimbrite samples in Appendix 8). The analysis achieved an success rate of 82.2% (Table 5).

There are examples of overlapping chemical profiles in the Idaho volcanic glass data. The cross-correlation of the Deep Creek and Snake River sources is the most notable example. The statistical overlap of the sources, as indicated by discriminant analysis, is considerable; although it is possible to separate the sources on the basis of patterned differences between the sample sets; however, a single artifact of unknown origin could not be confidently assigned to one group or the other strictly on the basis of trace element data. In this case, the sources are geographically close enough to one another that site locality may not help to identify the artifact origin. Moreover, samples from the two sources do not differ significantly in appearance, hardness, or texture. Hence, even with the sizeable sample sets analyzed in this study, it is not possible at this time to confidently distinguish Snake River ignimbrite from Deep Creek ignimbrite. Nevertheless, the author decided to define the two areas as separate sources, with the hypothesis that they represent two separate, but very closely related events, probably from the same magma pool.

Some misclassifications were made by the discriminant analysis. In most cases, the misattributed cases were assigned to chemically overlapping sources, but some errors were simply mistakes made by the analysis. This fact reinforced the need to validate all statistical results by double checking the raw and normalized data.

A number of localities were consistently correlated with one another, suggesting that they were part of a single chemical type, or source (Table 5). Many of the glass sources were represented by a number of collection localities, and this fact accounted for most of the cross-correlated cases. It was necessary to examine more closely the numerical trace element data to determine the validity of several other correlations.

Table 5. SPSS Classification Results

SOURCE	% CORRECTLY IDENTIFIED	MISCLASSIFICATIONS
Owhyee 1	78%	Owyhee 2 21%
Owyhee 2	100%	
Murphy Hot Springs	93%	Three Creek 7%
Brown's Bench	70%	Picabo Hills 4% Coal Bank Spr. 2% Cedar Creek 2% Camas Prairie 9% Jasper Flats 2 4% Fish Creek 9%
Three Creek	100%	
Ozone	61%	Gibson Ck. 9% Medicine Ldg. 30%
Picabo Hills	93%	Medicine Ldg. 7%
Timber Butte	100%	
Snake River	67%	Deep Creek 33%
Cannonball 1	100%	

Cannonball 2	100%	
Wedge Butte	100%	
Coal Bank Spring	89%	Brown's Bench 6% Three Creek 3% Picabo Hills 2%
Gibson Creek	55%	Ozone 2% Medicine Ldg. 18% Reas Pass 11% Yale Creek 14%
Medicine Lodge Canyon	30%	Ozone 41% Gibson Ck. 12% Reas Pass 6% Yale Creek 6% Dry Creek 5%
Malad	100%	
Deep Creek	68%	Snake River 32%
Chesterfield	100%	
Bear Gulch	99%	Medicine Lodge 1%
Cedar Creek	44%	Camas Prairie 11% J. Flats 2 11% Fish Creek 33%

Camas Prairie	59%	Brown's Bench 3% Cedar Creek 17% J. Flats 2 21%
Dry Creek	78%	Yale Creek 22%
Big Southern Butte	100%	
Jasper Flats 1	100%	
Jasper Flats 2	60%	Cedar Creek 20% Camas Prairie 20%
Reas Pass	80%	Dry Creek 13% Medicine Ldg. 7%
Reynolds	100%	
Conant Creek	100%	
Yale Creek	93%	Ozone 7%
Fish Creek	100%	
Pine Mtn.	61%	Picabo Hills 13% J. Flats 2 10% Camas Pr. 13% Cedar Ck. 3%

After the chemical types were adequately defined, mean values and standard deviations were computed for each element measured in the XRF analysis, to indicate how well the groups clustered (Appendix 3).

Discriminant Analysis

SPSS Source Correlations

Many of the collection localities were combined by the statistical procedures, on the basis of trace element similarities. This result was particularly true of ignimbrite localities that represented a large common flow, such as the Brown's Bench chemical type.

Brown's Bench Ignimbrite

Seven separate collection localities were shown to represent the same chemical source, designated Brown's Bench (Table 6), which covers an area of some 2,000 square kilometers (Sappington 1981a). However, some patterned variability can be identified within the Brown's Bench material, although it is insufficient to warrant the designation of a separate source. For example, it was ultimately judged that the Rock Creek localities represent a patterned variant of the Brown's Bench chemical group with a tendency toward slightly lower Rb and Y values, and slightly higher Sr and Nb values. Macroscopic similarity to Brown's Bench ignimbrite, and geographic location (Rock Creek is located at the east end of the Cassia Mountain Range) were other factors considered in the interpretation of the Rock Creek samples. This patterning should provide increased precision in the source attribution of artifacts made from this widely distributed toolstone.

The identification of the discrete Murphy Hot Spring source establishes a fairly precise western boundary for the Brown's Bench source. The eastern extent appears to lie somewhere in the Cassia Mountains between Rock Creek and Coal Bank Spring, since the Rock Creek locality shows the first signs of patterned variability to the east of Brown's Bench, and Coal Bank Spring is the nearest discrete source in that direction. Moreover, one cobble from the Coal Bank Spring sample (CS1E) correlated with the Cedar Creek Reservoir chemical profile, which is quite similar to that of Brown's Bench. This result may be indicative of human, or some other process of transport, or it may represent actual overlap in the trace element composition of the two sources. All other Coal Bank Spring samples were chemically different from the Cedar Creek Reservoir material, so it is likely that cobble CS1E was intrusive.

The north-south extent of the Brown's Bench source is somewhat unclear at this time. Sappington reported occurrences of Brown's Bench ignimbrite as far north as Roseworth; and the southern boundary is located in Nevada, outside the present study region. In general, it can be said that Brown's Bench ignimbrite is a chemically homogeneous deposit that caps virtually the entire Cassia Mountain range; and it can also be found in cobble form in many of the tributary streams flowing from this range, and from Brown's Bench itself.

Table 6. Comparison of Brown's Bench ignimbrite collection localities. All data are mean values, normalized to the Zr value.

	FeKa	FeKb	Zn	Rb	Sr	Y	Nb	ZrKb
Br. Bench	0.74	0.13	0.009	0.24	0.06	0.15	0.12	0.22
L. Hse. Ck	0.73	0.13	0.010	0.26	0.06	0.16	0.12	0.22
Antelope S.	0.73	0.13	0.008	0.27	0.06	0.15	0.11	0.21
Shoshone B.	0.71	0.13	0.009	0.22	0.07	0.14	0.11	0.22
Three Ck.	0.66	0.12	0.008	0.32	0.03	0.19	0.14	0.23
Rock Creek	0.73	0.13	0.009	0.23	0.08	0.15	0.11	0.21

Deep Creek and Snake River Ignimbrite

Discriminant analysis grouped the Deep Creek ignimbrite localities with the Snake River localities. This result is surprising, given the considerable distance between the collection localities. From a geographic standpoint, one might expect the Deep Creek material to cluster more closely with the nearby Medicine Lodge Canyon or Lava Creek, Cow Creek and Corral Creek ignimbrite samples; but on the basis of physical characteristics, the Deep Creek material more closely resembles the ignimbrite found at the Ozone localities to the east. However, the raw trace element data convincingly argue for the correlation of Deep Creek ignimbrite with the Snake River samples, primarily on the basis of Rubidium values, which clearly differentiate the Snake River and Deep Creek samples from the other nearby ignimbrite sources (Table 7). In cases such as this, the analyst must rely upon experience and common sense to assess the accuracy of the groupings made by the statistical analyses. For the Deep Creek ignimbrite, it was judged unlikely that a single formation would account for the vast distance between the localities; so the Deep Creek and Snake River sources were interpreted to represent separate, but chemically very similar formations. In order to attribute an artifact of unknown origin to one or the other of these sources, it would be necessary to consult other lines of evidence, such as site location, artifact type distribution, or suggested cultural affiliation (see discussion in Chapter 6).

Table 7. Comparison of Deep Creek Ignimbrite with nearby sources. Data are mean values for each source, normalized to the Zr value.

	FeKa	FeKb	Zn	Rb	Sr	Y	Nb	ZrKb
Deep Ck.	0.74	0.13	0.019	0.45	0.06	0.29	0.25	0.22
Snake Riv.	0.76	0.14	0.019	0.46	0.06	0.29	0.24	0.22
Med. Lodge	0.72	0.13	0.014	0.29	0.04	0.21	0.20	0.23
Ozone	0.73	0.13	0.015	0.28	0.03	0.20	0.20	0.22

Bear Gulch Obsidian and Nearby Ignimbrite Sources

The Bear Gulch obsidian samples clustered together very consistently. Interestingly, low-grade Dry Creek ignimbrite samples collected from well within the geographic boundary of the Bear Gulch obsidian source were chemically distinct (Table 8). While the more abundant obsidian was of much higher quality, ignimbrite has been recovered from sites in the area (van Waarden 1977); and it is plausible that the Dry Creek material was exploited locally. Moreover, the Dry Creek chemical profile is quite similar (although distinct from) both the Reas Pass Creek and the Yale Creek ignimbrites. These three source localities form an east-west line along the southern face of the Centennial Mountains. It seems logical to view them as related flows, possibly originating from a common magma flow which changed in trace element composition over time, as a result of convective processes in the earth's mantle.

Table 8. Comparison of Dry Creek ignimbrite with nearby volcanic glasses. All data are mean values, normalized to the Zr value.

	FeKa	FeKb	Zn	Rb	Sr	Y	Nb	ZrKb
Dry Creek	0.70	0.13	0.015	0.33	0.04	0.24	0.23	0.21
Yale Creek	0.75	0.13	0.015	0.32	0.04	0.23	0.21	0.21
Med. Lodge	0.72	0.13	0.014	0.29	0.04	0.21	0.20	0.23
Bear Gulch	0.75	0.13	0.014	0.32	0.09	0.18	0.22	0.22

The Gibson Creek Chemical Type

The Gibson Creek, Graham Spring, and Moody Swamp numerical data could not be confidently differentiated, and this observation was reflected in the SPSS results (see Table 5). It was originally proposed that the Gibson Creek ignimbrite was formed separately from that found at the latter localities, on the basis of geography. Although all are located in the same general area of eastern Idaho, the Gibson Creek material was encountered only in the Caribou Mountain Range, while Graham Spring and Moody Swamp are both situated in the adjacent Snake River Range. Furthermore, since all three source localities represented primary depositional contexts at relatively high elevations, it is difficult to envision a single ash flow that could produce such an extensive formation. This conclusion stands in contrast with the Brown's Bench chemical group, in which the majority of the collection localities lay downslope from the presumed origin of the flow. The processes responsible for the extent of the Gibson Creek source are at present unknown, although it is possible that a number of volcanic vents were actively drawing from the same magma pool at the time of its formation, or that subsequent glacial processes transported float material throughout the area. Further research might clarify this issue.

CHAPTER 5

ARTIFACT CHARACTERIZATION RESULTS

The Wilson Butte Cave artifact collection analyzed in this study consisted of 240 obsidian and ignimbrite specimens. Of these, 133 were obsidian artifacts, comprising 55.4% of the collection, while 107 (44.6%) were ignimbrite artifacts.

Artifact Sampling

All diagnostic projectile points and point fragments from the 1988/89 excavations were selected for analysis. These artifacts were selected for three reasons. First, projectile points were presumably all used for the same or very similar purposes. By controlling for function, questions about function-specific source use, or transhumance are minimized. This consideration is important for a short-term campsite such as Wilson Butte Cave, from which broad questions of settlement and subsistence cannot be directly approached.

A second reason for analyzing all projectile points is that they comprised a relatively large portion of the Wilson Butte assemblage. Analysis of finished artifacts is usually preferable to debitage analysis for preliminary studies of source utilization, because the sheer number of pieces of detritus that can be created from the manufacture of a single artifact dictates that subsampling is an important concern. Moreover, control of function and time is much more difficult to attain with debitage than with diagnostic artifacts, such as projectile points.

A third reason for characterizing the Wilson Butte projectile points is that many of them were subsequently submitted for obsidian hydration dating, a technique that requires knowledge of the material source. Regrettably, the extent of recent disturbance at Wilson Butte Cave precluded stratigraphic temporal control of many of the artifacts. It is hoped that hydration measurements will help to date many of the Wilson Butte stone artifacts which were found in disturbed contexts in 1988/89.

In addition to the projectile points, a selection of flakes was analyzed, spanning the extent of each undisturbed cultural stratum in the site. These specimens were selected to ensure that each stratum was represented in the analyses, with the goal of gaining some insight into temporal patterns of lithic resource utilization. All finished obsidian and ignimbrite tools from the undisturbed strata were included in the sample, as well as all the flakes recovered from the basal clay layer. All sample selections were made by Dr. Alan Bryan, in consultation with the author. Artifact size was not a factor, as it was possible to adapt the measuring apparatus to accommodate large samples, although two flakes (WBC 673, WBC 682) may have been too thin to provide meaningful results (see below).

Analytical Conditions

All analytical procedures were identical to those for the source materials, with the exception of the irradiation time, which was reduced to five minutes for the artifacts. All but one artifact (WBC 651) yielded adequate spectral and numerical data using this procedure (Appendices 7 and 8); unfortunately, this sample was not available for re-analysis, and it was therefore impossible to attribute it confidently to source. The SPSS discriminant analysis did assign the artifact to the Pine Mountain source (see Appendix 4), but the fit was not satisfactory, and the match was considered a misclassification.

Manual Source Assignments

All artifacts were initially assigned to source manually, on the basis of the normalized fluorescent count data. All but three artifacts (WBC 651, WBC 38, and WBC 363) could be correlated with source data, with varying degrees of confidence. The artifacts were then assigned to sources using SPSS discriminant function analysis to test the initial assignments, and to quantify the degree of similarity between the artifact and its source (see Appendix 4). Each artifact was entered as an ungrouped, independent case and matched with the previously defined source groups.

SPSS Discriminant Function Source Assignments

The discriminant analysis output provided probability values for the most probable and second most probable group membership for each artifact (Appendix 4). The conditional probability value (P D/G) is a measure of the fit between a case (artifact) and the group (source) to which it has been assigned. The discriminant program searches for the source profile that best matches the data for an artifact, assigns the artifact to that group, and calculates the probability that the assignment is correct, given the range of variation within that group. A second probability statement, the posterior probability (P G/D), describes the actual fit of the source assignment compared with all other groups in the sample set. The posterior probability does not assume that the assigned group is the correct choice; rather, it quantifies the probability that the correct assignment has been made (Norusis 1988). This statistic must be interpreted with caution, because discriminant analysis assumes that the case must belong to one of the groups in the set, and it will assign the case to the statistically closest group even if the match is very distant.

Comparison of Classification Methods

The degree of agreement between the manual and statistical source assignments was encouragingly high. Of the artifacts assigned to a source by the author, 79.6% corresponded with the primary probability provided by SPSS. Discrepancies centred primarily around the Brown's Bench, Picabo Hills, and Pine Mountain sources, which show substantial overlap in trace element composition. Out of caution, the author tended to lump similar cases into the geographically extensive Brown's Bench chemical group, while the SPSS program tended to separate similar cases into different groups. Further examination of the Brown's Bench, Picabo Hills, and Pine Mountain source assignments resulted in some changes in both the manual and the statistical assignments (see discussion of individual cases below). However, these source assignments should be considered tentative until further sampling is undertaken to better characterize the Picabo Hills and Pine Mountain sources. Both sources are presently known as very restricted areas in which small ignimbrite cobbles are found, and it seems unlikely that either source would have constituted an important part of prehistoric lithic procurement strategies. It is possible, however, that these sources were richer in the past, or that more intensive survey would show that they are more extensive today than is presently recognized.

The Idaho obsidian sources, in contrast with the ignimbrites, are quite distinct from one another; and, consequently, there was only one case in which the manual and statistical source attributions of obsidian artifacts differed. WBC 363 was statistically assigned to the Chesterfield source, when in fact it did not adequately match any of the chemical profiles in the sample set; and ultimately it was classified as an 'unknown.'

The Bear Gulch, Big Southern Butte, Cannonball Mountain 1 and 2, Malad, Timber Butte, and Wedge Butte obsidian sources were all represented in the Wilson Butte Cave assemblage (see Table 9); and all were assigned to source with high posterior probabilities, reflecting the distinctness of these sources. However, many of the conditional probabilities for these sources were quite low. This problem seemed to correlate loosely with sources having high Compton and Rayleigh scatter peak values. Since the Rayleigh value was excluded by the discrimination analysis, it is possible that the conditional probabilities have been consequently affected. In addition, the SPSS discriminant analysis creates extremely exacting rules for calculating the conditional probability. It is possible that statistical intraflow variability exists that is not readily apparent in a variable-by-variable visual examination of the numerical data, and that cases given low conditional probabilities are relative outliers within their groups. Finally, discriminant analysis uses different criteria for defining groups than does a human researcher; cases are combined according to covarying numerical data, without regard to the actual number of counts represented by a variable. For example, the zinc value rarely varies significantly within a source, or even between sources; however, the size of the Zn peak is generally very small. As a result, zinc is generally considered a poor discriminator for obsidian characterization, although it may not be recognized as such by a statistical analysis that is designed to choose discriminators with a minimum of variance. In this study, artifacts that were statistically assigned to a source that matched the manual attribution, were generally accepted as valid if the posterior probability was high, regardless of the conditional probability value. There was a minor discrepancy between the manual and statistical assignment of one Owyhee obsidian artifact; but this was only a difference in flow attribution, with the discriminant analysis identifying it as an Owyhee Flow #2 specimen, while the author assigned it to Owyhee Flow #1. This difference is unimportant, as the collection locales for the two flows were adjacent.

As noted above, there were numerous differences between the manual and statistical source attributions of ignimbrite artifacts. All of the Brown's Bench artifacts identified by statistical means were also so attributed manually, but the discriminant procedure often assigned artifacts to the Pine Mountain and Picabo Hills sources which the author had matched with the chemically-similar Brown's Bench group. Thirty-three artifacts were statistically assigned to the Picabo Hills source; thirty-two of these had been manually identified as Brown's Bench ignimbrites. The other artifact (WBC 651) was misclassified by the discriminant procedure; it did not match with any of the Idaho sources in the study, and it was tentatively labelled an 'unknown,' pending comparison with sources outside the Snake River Plain.

Assessment of Discrepancies

Re-evaluation of the Picabo Hills source assignments resulted in the acceptance of 15 of the 32 identifiable cases. Seventeen artifacts were identified as members of the Brown's Bench chemical group, primarily on the basis of lower Nb values for the Picabo Hills source; five of these were assigned a secondary probability of membership in the Brown's Bench group. Furthermore, artifacts WBC 1 and WBC 1055 were made of red ignimbrite, which was found only at the Brown's Bench localities during field collection for this study.

Although it has been shown that colour is an insufficient criterion for source attribution, it has also been noted in this study that macroscopic features are often useful for assigning artifacts to sources when the trace element data overlap, as is the case with the Pine Mountain/Brown's Bench distinction. It was thus judged that the data were sufficiently similar for these two artifacts that it was useful to consider colour as a selection criterion.

The discriminant analysis assigned eight artifacts to the Pine Mountain ignimbrite source, all of which were manually attributed to the Brown's Bench group. These discrepancies were not unexpected, given the chemical similarity of these sources and the researcher's inability to simultaneously evaluate multivariate similarity. After re-examining the data, only one of the eight Pine Mountain attributions were accepted, on the basis of slight differences in the Rb and Y ranges for the two sources. Seven artifacts were confirmed to best match the Brown's Bench data, based on Rb and Y values, and also due to the fact that they are all made from red ignimbrite. Three of these (431, 856, and 777) had secondary probabilities of membership in the Brown's Bench group.

The single Camas Prairie statistical assignment was also made manually; discriminant analysis assigned one artifact to the Cedar Creek group, which the author identified as a Brown's Bench specimen, probably originating near the Shoshone Basin locality. Two Coal Bank Spring attributions were made by the SPSS program; both (WBC 477) were confirmed by examination of the normalized data.

The similarity of the Deep Creek and Snake River data was illustrated by discrepancies in the manual and statistical analyses. The discriminant analysis assigned seven artifacts to the Deep Creek source, all with secondary probabilities of Snake River membership; four of these had been manually ascribed to the chemically-overlapping Snake River source, one (WBC 38) did not match any of the source data (an unknown), and only one was attributed to the Deep Creek source. In contrast, three artifacts assigned to the Snake River source by the statistical procedure, all with secondary probabilities of Deep Creek membership; and all three were also so assigned manually. It has been shown that the two sources cannot be statistically divided with the information currently available, and all predictions for each source predicted the other source as a second most probable group. For the purposes of comparing the results of manual and discriminant function source attributions, the Snake River and Deep Creek specimens were considered as one.

Four specimens were statistically assigned to chemical group 2 at Jasper Flats. Two of these were manually attributed to the Camas Prairie source, and two to the Brown's Bench group. All four had secondary SPSS probabilities of membership in the Camas Prairie group. WBC 673 (attributed to the Brown's Bench source) and WBC 682 (Camas Prairie) were both very thin flakes, and neither provided fully reliable fluorescent count data. Consequently, these source assignments must be considered tentative.

Finally, the discriminant analysis identified two Three Creeks ignimbrite cases, both of which were manually matched with the Brown's Bench group. On re-examination, the numerical data for artifact WBC 865 was shown to match the Picabo Hills data, while WBC 228C closely conforms to the Brown's Bench profile; the secondary SPSS prediction for this artifact was the Brown's Bench chemical group.

Misclassification Rate

The total measure of agreement between the two source attribution methods before examining discrepancies was 79.6% for the primary SPSS predictions, and 82.5% if matches with secondary predictions are added. After assessing the discrepancies between the two methods and making the changes outlined above, 90.8% of the manual assignments matched the primary SPSS source predictions, with another 2.9% matching the secondary prediction. These results are comparable, or better than those of similar studies elsewhere (Sappington 1981a; James, 1992). The remaining 6.3% of the artifacts were misclassified by the discriminant function procedure, with three artifacts of unknown origin erroneously assigned to sources in the sample set, and only 12 artifacts assigned to incorrect source groups.

Most of the misclassifications apparently occurred because the statistical overlap among the Brown's Bench, Pine Mountain, and Picabo Hills sources is great, making it difficult to distinguish them confidently. The conditional probabilities for artifacts assigned to these sources are generally quite high; but the posterior probabilities are often low, probably because group membership is possible for a number of sources. Despite the low posterior probability values, careful examination of the normalized data shows that the artifacts assigned to the Picabo Hills and Pine Mountain sources probably do belong to those groups. A low posterior probability is often interpreted as a sign that the group attribution is unlikely; but in this case it is interpreted as a division of the probability of group membership among a number of sources.

The number of changes made to the manual source assignment data after comparison with the SPSS results, however, strongly argues for the use of powerful statistical techniques such as discriminant function analysis to identify covarying attributes in a multivariate sample set; and the small number of misclassifications should not be interpreted as a failure of the technique. All discriminant function classifications must be evaluated in terms of the probability of misclassification by chance alone (Norusis 1988), which, in the present study, is extremely high.

Source Distribution Frequencies

A total of 16 volcanic glass sources are represented in the sample of Wilson Butte Cave artifacts. As expected, large, relatively nearby sources comprise the bulk of the collection; the Big Southern Butte source accounts for 59.2% of the obsidian artifacts (32.6% of the total sample), and the Brown's Bench chemical group comprises 70.8% of the ignimbrite artifacts (31.8% of the total collection). Fourteen other sources are represented in smaller proportions (see Table 9).

There is a general pattern indicating the exploitation of an increasing number of volcanic glass sources over time, a phenomenon reported elsewhere, which may suggest increased use of Wilson Butte Cave in later prehistoric times, changes in the movements of the occupants of the site, or other cultural factors. These ideas are addressed in the following chapter.

Table 9. Percentage Distribution of Sources in the total Wilson Butte Cave Artifact Sample.

Source	N	Percent of Sample
Bear Gulch	8	3.3
Big Southern Butte	80	33.3
Brown's Bench	76	31.7
Camas Prairie	3	1.3
Cannonball Mtn. 1	23	9.6
Cannonball Mtn. 2	2	0.8
Coal Bank Spring	2	0.8
Deep Creek	2	0.8
Malad	5	2.1
Owyhee 1	3	1.3
Owyhee 2	1	0.4
Picabo Hills	16	6.7
Pine Mountain	1	0.4
Snake River	7	2.9
Timber Butte	6	2.5
Wedge Butte	2	0.8
Unknown	3	1.3
Total	240	100.0

Chapter Six

Volcanic Glass Source Exploitation at Wilson Butte Cave

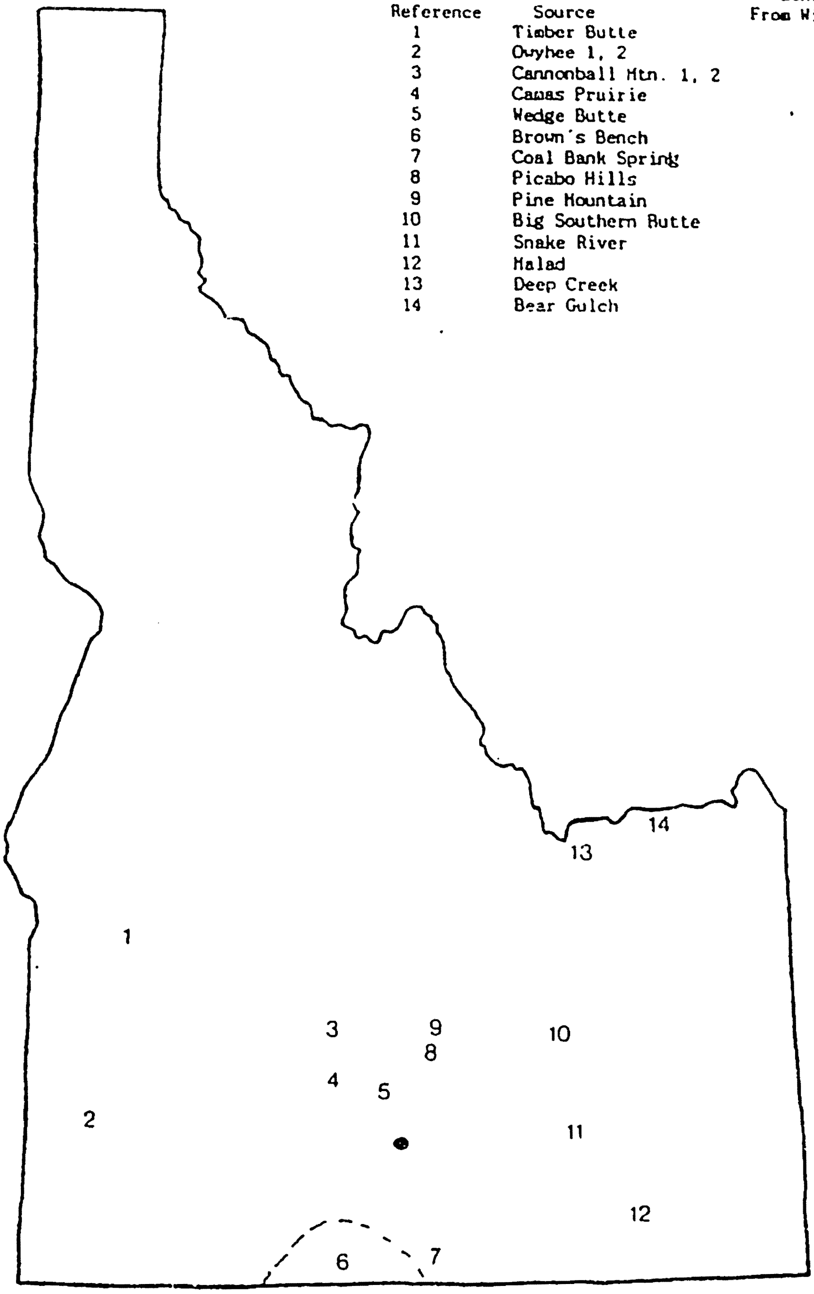
At least sixteen volcanic glass sources were exploited by the prehistoric occupants of Wilson Butte Cave (see Table 10). Geographically, the source localities span virtually the entire Snake River Plain, with the Owyhee and Timber Butte sources located at the southwest and northwest ends of the Plain respectively, the Malad source in the southeastern region, and Bear Gulch at the extreme northeast end of the Plain (Map 2). Broad patterns of gradual diachronic change in lithic resource use were revealed in the course of this study; they are best outlined in a stratum-by-stratum review of source frequencies, presented below.

Source Use By Stratigraphic Zone

Stratum E

Five flakes were analyzed from a yellow clay deposit directly overlying bedrock. Three were made from Big Southern Butte obsidian, while two flakes (WBC 673, WBC 682) were too thin to yield adequate data, although the trace element pattern were similar to the Brown's Bench and Camas Prairie sources respectively. Little more can be said about the flakes

Map Reference	Source	Linear Distance From Wilson Butte Cave
1	Timber Butte	215 km
2	Owyhee 1, 2	195 km
3	Cannonball Mtn. 1, 2	83 km
4	Camas Pruirie	55 km
5	Wedge Butte	35 km
6	Brown's Bench	73 km
7	Coal Bank Spring	68 km
8	Picabo Hills	60 km
9	Pine Mountain	80 km
10	Big Southern Butte	120 km
11	Snake River	113 km
12	Malad	160 km
13	Deep Creek	215 km
14	Bear Gulch	260 km



Map 2. Location of volcanic glass sources identified in the artifact sample from Wilson Butte Cave.

from the yellow clay at present; two have been submitted for obsidian hydration dating to help assess the validity of their stratigraphic position (Gruhn 1992 pers. comm.).

Table 10. Volcanic Glass Sources Identified in the Wilson Butte Cave Artifact Collection.

SPSS #	SOURCE NAME
72	OWYHEE 1
73	OWYHEE 2
75	BROWN'S BENCH
78	PICABO HILLS
79	TIMBER BUTTE
80	SNAKE RIVER
81	CANNONBALL MTN. 1
82	CANNONBALL MTN. 2
83	WEDGE BUTTE
84	COAL BANK SPRING
87	MALAD
88	DEEP CREEK
90	BEAR GULCH
93	CAMAS PRAIRIE
95	BIG SOUTHERN BUTTE
105	PINE MOUNTAIN

Stratum C1

Initial excavations of the thick grey-brown sand deposit in 1959/60 yielded a meagre lithic assemblage of unknown cultural affiliation in the lower part of Stratum C1. Containing few artifacts, none diagnostic, this assemblage was designated Wilson Butte I. This zone was estimated to date to about 8000 B.C. (Gruhn 1961:117), but produced a radiocarbon date on bone of 14,000 B.P. (Gruhn 1965). The sediments and microfauna associated with this assemblage are suggestive of a moist meadowland or parkland environment, possibly near a forest margin. There is evidence of a hunting subsistence, with the fragmented bones of horse and camel species present. Scattered charcoal indicates that hearths may have been present originally, but occupation of the cave was clearly very sporadic at this time, as the cave would have been very cool and damp.

During the 1988/89 excavations, the basal, compact grey sand facies of Stratum C was designated Facies C4 (Gruhn pers. comm. 1992). Two volcanic glass sources are represented in the sample of four artifacts from this basal sand deposit in 1988/89 (see Appendix 5). Three utilized or retouched flakes were made from Big Southern Butte obsidian, while a single projectile point fragment was fashioned from red ignimbrite from Brown's Bench. The small sample size from this zone precludes interpretation at present; but, tentatively, the use of a very restricted number of sources is suggested by samples from the lower sand deposit.

Gruhn's Wilson Butte II assemblage, originally estimated to date to approximately 6000 B.C., was situated in the middle of the grey-brown sand of Stratum C1 (Gruhn 1961:118). By this time, the forest margin had receded, and Wilson Butte was probably covered by moist grassland vegetation. Camel and modern bison were represented in the associated faunal record, but horse had apparently become extinct. Hunting was again the primary activity indicated, with large, parallel-flaked lanceolate projectile points featured in the Wilson Butte II assemblage. Gruhn (1961:119) noted a strong relationship between the Wilson Butte II lanceolates and coeval projectile point types from the Great Plains. Several examples of these Plano-like points were recovered from undisturbed contexts in Stratum C in 1988 and 1989, but the majority of points were stemmed forms reminiscent of the local Haskett type, which is similar in form to Hell Gap points. Knives, scrapers, a blade, and a hammerstone were included in the Wilson Butte II assemblage, supporting the interpretation that hunting was taking place on the butte.

Seventy-three artifacts recovered during the 1988/89 excavations of Stratum C1, the grey-brown sand, were analyzed, with thirteen volcanic glass sources represented (see Appendix 5). Obsidian is more common than ignimbrite in the sample from this zone (71.3% vs 28.7%); and Big Southern Butte obsidian dominates, comprising 61.6% of the inventory. Brown's Bench ignimbrite is the next most common volcanic glass, representing 13.6% of the Stratum C1 sample. The first indication of the use of more distant and varied sources comes from these artifacts, with the Bear Gulch, Camas Prairie, Cannonball Mountain, Deep Creek, Malad, Owyhee, Picabo, Pine Mountain, and Snake River sources represented in minor quantities. A single utilized blade (WBC 651) was made from a volcanic glass not identified in this study. A general intensification in the use of the cave might explain the larger artifact sample and the increase in the number of sources represented in the 1988/89 lithic collection from the undisturbed, portion of Stratum C1.

A facies of coarse sand with abundant rock fragments (now designated C2) was contained within the lower-middle part of Stratum C1. Thirty-one artifacts recovered from this zone in 1988/89 were analyzed; Big Southern Butte obsidian was again the dominant material (64.5%), with Brown's Bench ignimbrite the second most common glass in the collection from this zone (29.1%). Bear Gulch and Cannonball Mountain obsidian were each represented by a single artifact. This distribution resembles that of Stratum E and Facies C4 of Stratum C, with few sources apparently exploited. Again, sampling considerations are germane, as the study collections from these lower strata are quite small; they may present a skewed picture of actual source use during these earliest time periods.

Disturbed Zones

The uppermost three stratigraphic zones at Wilson Butte Cave (Strata A and B, and the upper levels of Stratum C) were destroyed by artifact collectors prior to the 1988/89 excavations. For the purposes of this study, they are combined, and discussed simply as the 'disturbed zones' because accurate distinctions were rendered impossible by the degree of disturbance and mixing of the sediments in many areas. Reference is made, however, to Gruhn's discussions of the strata in terms of the artifact assemblages found within them in 1959/60.

The initial excavations at Wilson Butte Cave in 1959/60 recovered a relatively sparse assemblage from a small occupation area in the upper level of Stratum C, and a separate assemblage at the top of the deposit (Wilson Butte III and IV, respectively). The upper part of Stratum C had been completely destroyed by 1988, but a few projectile point types pertaining to this zone were recovered from disturbed sand deposits.

The megafauna in deposits associated with the Wilson Butte III assemblage indicated a warmer and drier climate (although moister than today), with grasslands on the surrounding plain, and the first indication of xerophytic fauna on the butte. Modern bison, (the only large herbivore associated with the Wilson Butte III assemblage) were certainly being hunted at this time; and large stemmed, indented-base projectile points comprise a relatively large portion of the assemblage, which has been radiocarbon dated at

4890 B.C. +/- 300 years (M-1087). Gruhn (1961:120) interpreted this assemblage as evidence of occasional visits to the site by small groups of bison hunters, with probable cultural relationships with the Great Basin.

The Wilson Butte IV assemblage, situated at the top of the grey-brown sand deposit, probably represents periodic occupation of the cave by bison hunters ca. 4500 B.C. While sediment and faunal evidence suggest a slightly drier climate than that associated with the underlying Wilson Butte III assemblage, the front of the cave, near its opening, was apparently the preferred living area at this time, suggesting that the cave was still somewhat cool and damp.

The Wilson Butte IV lithic assemblage includes large side-notched projectile points, the Northern Side-Notched type, which was a component of the Desert Cultural Tradition of the northern Great Basin, as well as stemmed/shouldered projectile points with apparent southern Great Basin affinities.

Gruhn (1961) defined Stratum B as a temporally - expansive aeolian brown silt deposit, within which she identified the artifact assemblage Wilson Butte V. Although this stratum may represent a depositional history spanning some 6,000 years, the major period of occupation, revealed in the lower-middle portion of the deposit, probably occurred between approximately 2000 B.C. and 500 B.C. (Gruhn 1961:121).

Projectile points were numerous in the Wilson Butte V assemblage. Most were of intermediate size, with corner-notched, stemmed, triangular, and side-notched varieties represented. Knives, scrapers, engraving tools, and a drill provide evidence of hide-, bone-, and wood-working.

A moderate semi-arid climate had developed by this time; and occupation of the cave had become more intensive, although still of short duration, with living areas at the front and back of the cave. Bison and antelope were evidently hunted with atlatls, and the presence of milling stones indicates that plant processing also took place at the site. Cultural traits indicate close ties with both the Great Basin and the northwest Plains.

Artifacts comprising the uppermost Wilson Butte assemblage, found in the dry sand and vegetal material of Stratum A, were sufficiently numerous and distinctive to warrant definition of a separate phase, designated the Dietrich Phase (Gruhn 1961:122). Material from the middle of the deposit has been radiocarbon dated at A.D. 1535 +/- 150 years (M-1088), and the phase likely persisted between about A.D. 1300 and A.D. 1700 (Gruhn 1961:122). Use of the cave during this time period was quite intensive, with large amounts of cultural material deposited, along with numerous shallow hearths.

Small corner- and side-notched projectile points indicate the use of the bow and arrow, and numerous knives and scrapers suggest that dispatched game were processed at the site. Bone and wooden tool comprise an important portion of the Dietrich Phase inventory, and pottery vessels were apparently used for cooking. A number of bone artifacts, including bone gaming pieces, and other incised items, attests to the recreational activities of the Dietrich Phase occupants.

Use of Wilson Butte Cave during the Dietrich Phase remained periodic (likely seasonal), and was probably related to hunting on the butte and the surrounding plain. In 1961 Gruhn proposed, on the basis of lithic, pottery, and perishable artifact styles, that this assemblage represented occupation of the cave by Shoshonean - speaking peoples. While the total inventory of material culture is not present (due to the specialized, short term of occupation), the Dietrich Phase assemblage displays clear affinities with known assemblages of the Great Basin (Gruhn 1961:135). However, relatively close relationships with lithic assemblages of the Great Plains are also evident. Currently there is consideration of the possibility that some of the Late Prehistoric material may represent a Fremont occupation of the site (Gruhn 1992 pers. comm.).

The intensity of occupation and variety of artifact types in the 1988/89 collection from the upper, disturbed zones is reflected in the inventory of volcanic glass sources exploited during the later prehistoric occupations. Sixteen sources are represented in a sample of 127 artifacts from the disturbed zones. Although time resolution is imprecise, with possibly more than 6,000 years represented by these strata, a trend toward an increasing preference for ignimbrite over obsidian emerges (Fig. 4). 58.3% of volcanic glass artifacts from the disturbed zones were fashioned from ignimbrite, with the Brown's Bench source dominating the sample. This source comprises more than 60% of the ignimbrite analyzed from every stratigraphic zone, and 70.3% of the ignimbrite (40.9% of the volcanic glass inventory) from the disturbed zones.

Of the 53 obsidian artifacts (41.7% of the disturbed zone sample), only 9 (17% of the obsidian; 7.1% of the sample) were from the Big Southern Butte source, while Cannonball Mountain (41.5% of the obsidian; 17.3% of the sample) became the primary source of obsidian. This pattern represents the first evidence of a decline in the dominance of the Big Southern Butte source (and of obsidian use in general), with a concomitant rise in the frequency of ignimbrite; and particularly material from the Picabo Hills source, located 60 km north of Wilson Butte Cave (Fig. 4). The Picabo Hills source rises sharply in frequency in the disturbed zones, comprising 20.3% of the ignimbrite, and 11.8% of the entire sample from these deposits.

Six other obsidian sources were represented in the disturbed zone collection, comprising 16.5% of the sample from these zones. An additional obsidian artifact came from a source not characterized in this study. This apparent increase in the number of obsidian sources being utilized is not parallelled in the ignimbrite data, wherein source use appears to become more focused, with only seven of seventy-three artifacts originating at sources other than Brown's Bench or Picabo Hills. Thus, an intensified use of a small number of ignimbrite sources, coupled with an increasing diversity of obsidian source use probably occurred during the time in which the cultural materials in Strata A and B, and upper Stratum C were deposited. Greater quantities and varieties of cultural materials during this time attest to intensified use of Wilson Butte Cave, perhaps associated with a changing transhumant pattern which resulted in a change in lithic procurement strategies.

Better chronological control would facilitate more detailed interpretation of this potentially informative time period, as a significant shift in lithic procurement is indicated here. This economic shift may have resulted from a more general subsistence or settlement pattern shift that necessitated a change in lithic collection strategies. Alternatively, it is possible that high-quality obsidian at Big Southern Butte was becoming scarce by this time, dictating a change in lithic procurement strategies. Recent explorations at the Webb Spring locality on Big Southern Butte identified a lithic reduction site, but a lack of useable lithic material was noted (Truitt 1991). Further research of the distribution of Big Southern Butte obsidian over time might help to clarify this issue.

Patterns of Volcanic Glass Exploitation

The high percentage of Big Southern Butte obsidian in the older Wilson Butte Cave assemblages was not unexpected, as it is a source of high-quality obsidian relatively near Wilson Butte. According to the central assumption of catchment analysis, people exploit their environment in a rational way in order to minimize the effort required to satisfy their needs (Zvelebil 1983). Following this logic, it would be expected that lithic raw materials would be collected as part of a broader subsistence system, and that material sources nearest the areas utilized for subsistence would be most heavily exploited. The data from Wilson Butte Cave are consistent with this pattern, with the relatively nearby Big Southern Butte, Brown's Bench, and Cannonball Mountain sources dominating the analyzed collection. The Brown's Bench ignimbrite localities are also relatively near Wilson Butte, and this proximity is reflected in their frequency in the collection. Although the Wedge Butte source is geographically nearer Wilson Butte, the quality of the stone is much lower;

the rocks contain extremely abundant phenocrystic inclusions that reduce the predictability of the fracture pattern of this toolstone.

It is interesting that Big Southern Butte and Brown's Bench are in diametrically opposite directions from Wilson Butte Cave, and that Brown's Bench lies across the deeply incised Snake River Canyon from the site. Thus, the bulk of the obsidian recovered from the lower levels of the site came from sources to the northeast, while most of the ignimbrite was brought in from the southwest. This distribution is notable because the Snake River ignimbrite source, which was apparently intensively exploited locally, and traded elsewhere (Druss pers. comm. 1989; Godfrey-Smith 1988), is only weakly represented at Wilson Butte Cave, despite its relative proximity to Big Southern Butte and Wilson Butte Cave. Located approximately 110 km to the east of Wilson Butte, the Snake River source comprises only 2.9% of the total analyzed material; and it is absent in Stratum E, and Stratum C Facies C2 and C4. Although substantial chemical overlap between the Snake River and Deep Creek sources confounds this measure somewhat, it is nevertheless known that the Snake River material was used prehistorically as a toolstone; and its relative infrequency at Wilson Butte Cave may indicate that the cave was little used by populations to the southeast of the site. The concordant infrequency of Malad obsidian supports this interpretation, with this extremely high-quality obsidian comprising only 2.1% of the sample collection. If, in fact, people from the southeastern portion of the Snake River Plain were not substantially using Wilson Butte Cave, this conclusion may support Reed's (1985) assertion that the Malad source was controlled, at least in Late Prehistoric times, by Fremont people; and that there was therefore a cultural barrier precluding its use by Shoshonean populations. It is during the later occupation zones that we see more variety in source exploitation at Wilson Butte Cave, and consequently, it is during this time that we might expect to see distant sources such as Malad represented in the collection.

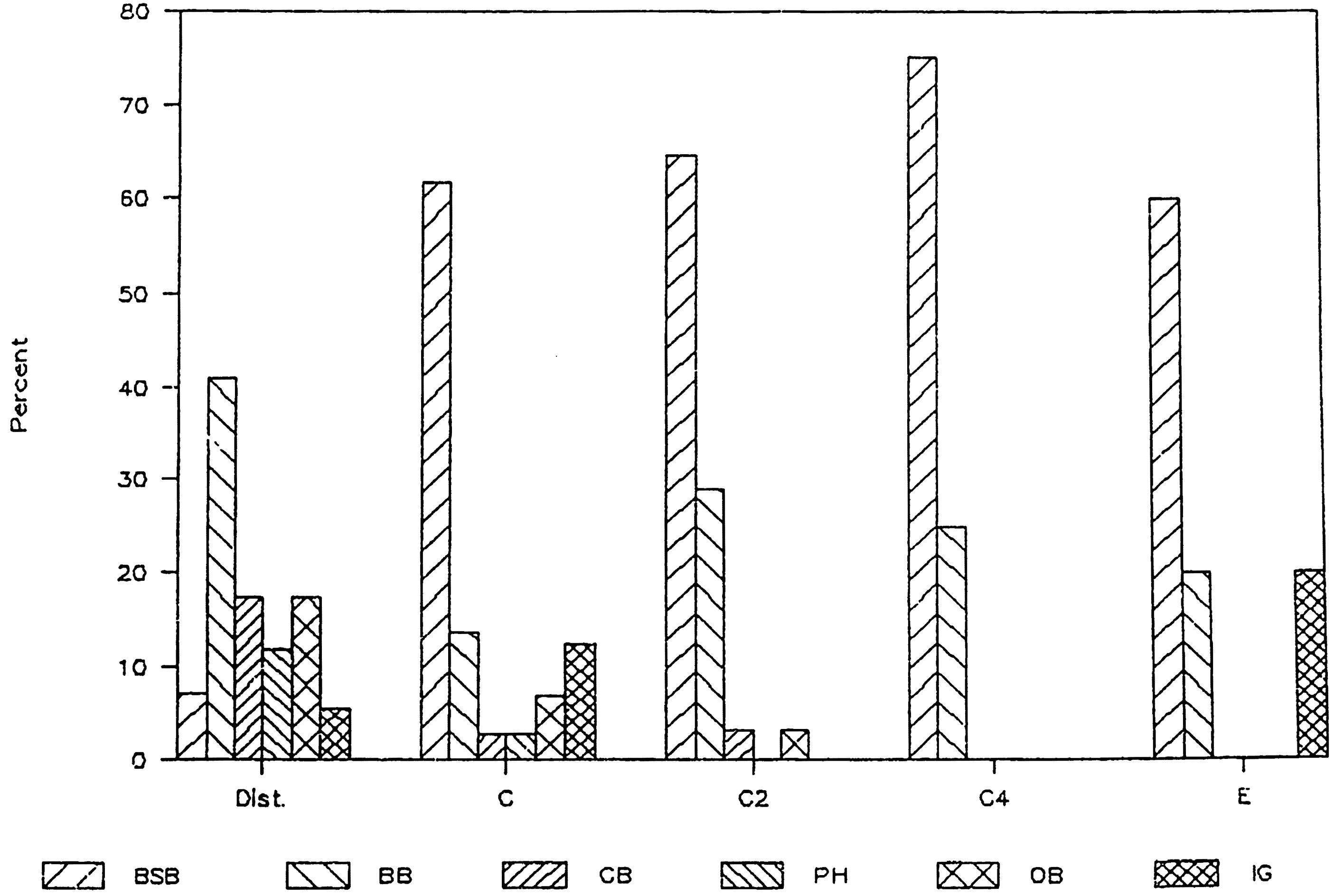
Also of interest is the quantity of Cannonball Mountain obsidian in the sample. Despite the relative proximity of Cannonball Mountain to Wilson Butte, the frequency of this glass in the artifact sample is somewhat surprising because this source has not been identified as a major component in other Idaho sites, and it has not been reported outside the Snake River Plain.

There is a general pattern at Wilson Butte Cave of increasing use of distant sources in the later occupations, represented by collections from the disturbed layers. This pattern parallels the situation at Nightfire Island, California, during the Elko Horizon (3350 - 1750 BP) (Sampson 1985). Bouey and Basgall (1984) also noted a change in the direction of obsidian procurement in the Sierran region of California, beginning about 1500 years ago.

The presence of raw materials from distant locales may be indicative of either population movement or exchange with neighbouring groups. In the case of Wilson Butte Cave, the latter case is more likely; the abundance of high quality volcanic glasses in Idaho, and particularly on the Snake River Plain, would seem to preclude the need for extensive intra-regional exchange of lithic raw materials, although it is known that prehistoric inter-regional exchange of certain Idaho obsidians was extensive. Bear Gulch obsidian, for example, has been identified from archaeological contexts as far north as Edmonton, Alberta (James 1986), and as far east as the Hopewellian mounds of Illinois and Ohio (Wright et al. 1986; Hatch et al. 1990). However, the virtual absence at Wilson Butte Cave of volcanic glass materials from outside the Snake River Plain argues against the use of the cave by groups from more distant areas; and it is more probable that the site was occupied periodically by groups travelling to and from hunting, fishing, and collecting sites near Wilson Butte. Unfortunately, the degree of disturbance at Wilson Butte Cave has made it difficult to obtain good temporal resolution for the upper layers, so the timing of the shift in volcanic glass procurement strategies cannot be accurately determined at this time. Analysis of artifacts recovered in the 1959/60 excavations, previous to much of the destruction of the upper zones, might help to increase our understanding of this problem.

The general pattern of source use at the cave is suggestive of movements between the northeast and the southwest of the site, with the major components including Big Southern Butte, Picabo Hills, Cannonball Mountain, and Brown's Bench, with occasional forays into other areas. Reference to Map 2 shows that these source localities are consistent with a pattern of transhumance that could include the collection of camas roots at Camas Prairie; fishing along the Snake River (possibly near Brown's Bench), where salmon were available until recently (Gruhn 1961:4); and hunting on the plain below Wilson Butte.

An alternative explanation of site use at Wilson Butte Cave has a number of groups from different areas of the Snake River Plain using the site, probably as a short-term shelter associated with hunting activities, and introducing volcanic glass items from sources within their various subsistence-settlement territories. At present, there is no geochemical evidence to suggest use of the cave by people from outside the Intermontane West, with only three analyzed artifacts originating at sources not characterized in this study. However, some evidence from basketry, pottery, gaming pieces and projectile point typology may indicate Late Prehistoric occupation by, or influences from, Fremont populations (Gruhn pers. comm. 1992). Obsidian from the Malad source, previously depicted as a 'Fremont - controlled' source (Reed 1985), is present in the artifact collection from the disturbed deposits of the site; but only in small quantities, probably more indicative of small scale exchange or artifact curation, if access to the source was indeed restricted by Fremont populations.



Legend: BSB Big Southern Butte
BB Brown's Bench
CB Cannonball Mountain
PH Picabo Hills
OB Other Obsidians
IG Other Ignimbrites

Figure 4. Frequency of major sources for each stratigraphic zone.

Conclusion

Contributions to the Study of Idaho Archaeology

The present study successfully attained its three primary goals. First, a substantial number of volcanic glass sources on or near the Snake River Plain were located, sampled, and chemically characterized. While much of this work had been previously completed by R.L. Sappington (1981a,b), a number of previously unreported source areas were analyzed, and excellent resolution was achieved, with the identification of multiple flows at the Owyhee and Cannonball Mountain sources. These data will prove useful to archaeologists interested in examining prehistoric patterns of exchange, both within and outside the study area. Volcanic glasses from Idaho have been reported from sites as distant as central Alberta (James 1986; Godfrey-Smith and D'Auria 1987) and Ohio (Hatch et al 1990); reliable source characterizations provide the first step toward reconstructing the cultural processes responsible for their presence in these areas.

Several of the newly reported source areas require further sampling to provide increased resolution for the correlation of artifacts, but the foundation has been laid for this work to be undertaken. Such sources include Deep Creek, where more intensive sampling might help to distinguish this source from the chemically - similar Snake River source; and the Cedar Creek and Three Creek areas, from which apparently intrusive cobbles were analyzed which may be representative of a source outside the Snake River Plain. Further refinement, through a rigorous sampling strategy, might also strengthen the distinction between the Brown's Bench, Picabo Hills, and Pine Mountain sources; and provide more information about the poorly - characterized Jasper Flats chemical types, where no material of knappable quality was located in the course of this study. It is hoped that these sources will be better characterized in the future, allowing increased confidence in the probabilities of artifact-to-source correlations.

Second, the identification of the parent sources of a sample of obsidian and ignimbrite artifacts from Wilson Butte Cave has supported inferences about the function of the site. It was proposed that the cave was used as a short-term camp for people hunting on and around the butte. The virtual absence, in the lower strata, of distant lithic raw materials supports the notion that in late Pleistocene and early Holocene times the cave was used primarily by local populations. An apparent shift in lithic resource use over time raises interesting questions about resource availability, subsistence and settlement strategies, and population movements. Chemical composition analysis can provide supportive evidence for hypotheses about these and other cultural processes.

Finally, the identification of the parent sources of many of the Wilson Butte Cave artifacts facilitated their dating by the obsidian hydration technique. Results of these analyses, to be reported elsewhere (Gruhn, in preparation), will help to date the occupation events at Wilson Butte Cave more securely, and they may help to clarify the currently controversial projectile point chronology suggested for the Snake River Plain.

This study has demonstrated the usefulness of non-destructive x-ray fluorescence analysis of volcanic glasses for the correlation of stone tools with parent geological sources. It has been shown that adequate results may be obtained by applying the technique semi-quantitatively, using multivariate statistics to quantify the degree of correlation among samples, and to indicate the probability that artifact-to-source correlations are correct. A major limitation of the study is the probability that the Wilson Butte Cave site was occupied only as a temporary campsite; and the deposits were subsequently greatly disturbed by artifact collectors, thereby making it more difficult to interpret the data. A regional study of volcanic glass distribution at primary, long-term habitation sites would provide more valuable insights into prehistoric adaptive processes and exchange on the Snake River Plain.

References Cited

Alt, David D. and Donald W. Hyndman
1989 Roadside Geology of Idaho. Mountain Press Publishing Company, Missoula.

Bettinger, Robert L., Michael G. Delacorte, and Robert J. Jackson
1984 Visual Sourcing of Central Eastern California Obsidians. In Obsidian Studies in the Great Basin, edited by Richard E. Hughes, pp. 63-78. Contributions to the University of California Archaeological Research Facility No.45.

Bouey, Paul D. and Mark E. Basgall
1984 Trans-Sierran Exchange in Prehistoric California: The Concept of Economic Articulation. In Obsidian Studies in the Great Basin, edited by Richard E. Hughes, pp. 135-172. Contributions to the University of California Archaeological Research Facility No.45.

Bowman, H.R., F. Asaro, and I. Perlman
1973 Composition Variations in Obsidian Sources and the Archaeological Implications. Archaeometry 15:123-127.

Caley, E.R.
1951 Early History and Literature of Archaeological Chemistry. Journal of Chemical Education 28:64-66.

1967 The Early History of Chemistry in the Service of Archaeology. Journal of Chemical Education 44:120-123.

Cann, J.R. and C. Renfrew
1964 The Characterization of Obsidian and its Applications to the Mediterranean Region. Proceedings of the Prehistoric Society 33:111-133.

Cook, E.F.
1962 Ignimbrite Bibliography and Review. Idaho Bureau of Mines and Geology Information Circular No. 13. Moscow, Idaho.

Dixon, J.E., J.R. Cann, and C. Renfrew
1968 Obsidian and the Origins of Trade. Scientific American 218:38-46.

Eisberg, Robert and Robert Resnick
1974 Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Other Particles. Wiley, New York.

Ericson, Jonathon E.
1981 Exchange and Production Systems in Californian Prehistory: The Results of Hydration Dating and Chemical Characterization of Obsidian Sources. British Archaeological Reports Series No. 110, Oxford.

Ericson, J.E., J.D. Mackenzie, and R. Berger
1976 Physics and Chemistry of the Hydration Process in Obsidian I: Theoretical Implications. In Advances in Obsidian Glass Studies: Archaeological and Geochemical Perspectives, edited by R.E Taylor, pp.183-217. Noyes Press, New Jersey.

Ericson, J.E. and J. Kimberlin
1977 Obsidian Sources, Chemical Characterization and Hydration Rates in West Mexico. Archaeometry 19(2):157-166.

Frison, G.C., G.A. Wright, J.B. Griffin, and A.A. Gordus
1968 Neutron Activation Analysis of Obsidian: An Example of its Relevance to Northwestern Plains Archaeology. Plains Anthropologist 13:209-217.

Gallagher, Joseph G.
1979 The Archaeology of the Sheepeater Battleground and Redfish Overhang Sites. U.S.D.A. Forest Service, Intermountain Region, Idaho Report No. 5.

Godfrey-Smith, D.I.
1985 X-Ray Fluorescence Characterisation of the Obsidian Flows from the Mount Edziza Volcanic Complex of British Columbia, Canada. Unpublished Master's thesis, Department of Archaeology, Simon Fraser University, Burnaby, B.C.

1988 ASA Obsidian Source Study 1987 Final Report. Report on file at the Archaeological Survey of Alberta, Edmonton, Alberta.

Godfrey-Smith, D.I. and J.M. D'Auria
1987 A Consideration of Semi-Quantitative X-Ray Fluorescence Analysis Used in Obsidian Source Identification. Archaeological Survey of Alberta Occasional Paper No. 31.

Greeley, Ronald and John S. King
1975 Geological Field Guide to the Quaternary Volcanics of the South-Central Snake River Plain, Idaho. Idaho Bureau of Mines and Geology Pamphlet No. 160. Moscow.

Green, James P.
1982 XRF Trace Element Analysis and Hydration Measurement of Archaeological and Source Obsidians from the Northeastern Great Basin. Paper presented at the Great Basin Anthropological Conference, Reno.

Green, R.C.
1962 Obsidian: Its Application to Archaeology. New Zealand Archaeological Association Newsletter 5:8-16.

Green, R.C., R.R. Brooks and R.D. Reeves
1967 Characterizarion of New Zealand Obsidians by Emission Spectroscopy. New Zealand Journal of Science 10:675-682.

Griffin, J.B.
1965 Hopewell and the Dark Black Glass. The Michigan Archaeologist 1(3/4):115-155.

Griffin, J.B. and A.A. Gordus
1966 A Preliminary Study of the Source of Hopewellian Obsidian in the United States. Paper presented at the VII Congress of the Prehistoric and Protohistoric Sciences, Prague.

Griffin, J.B., A.A Gordus, and G.A. Wright
1969 Identification of the Sources of Hopewellian Obsidian in the Midd West. American Antiquity 23:1-14.

Gruhn, Ruth
1961 The Archaeology of Wilson Butte Cave South-Central Idaho. Occasional Papers of the Idaho State College Museum, No. 6, Pocatello.

1965 Two early Radiocarbon Dates from the Lower Levels of Wilson Butte Cave, South-central Idaho. Tebiwa 8:2:57.

Harbottle, Garman
1982 Chemical Characterization in Archaeology. In Contexts for Prehistoric Exchange, edited by Jonathon E. Ericson and Timothy K. Earle, pp. 13-51. Academic Press, New York.

Hatch, J.W., J.W. Michels, C.M. Stevenson, B. Scheetz, and R. Geidel.
1990 Hopewell Obsidian Studies: Behavioral Implications of Recent Sourcing and Dating Research. American Antiquity 55:461-479.

Haynes, C. Vance
1969 A Reply to Bryan. Current Anthropology (10):353-354.

1971 Time, Environment and Early Man. Arctic Anthropology VIII (2):3-14.

Heizer, R.F., H. Williams, and J.A. Graham
1965 Notes on Mesoamerican Obsidians and their Significance in Archaeological Studies. Contributions to the University of California Archaeological Research Facility No.1:94-103.

Hughes, Richard E.
1984 Obsidian Sourcing Studies in the Great Basin: Problems and Prospects. In Obsidian Studies in the Great Basin, edited by Richard E. Hughes, pp. 135-172. Contributions to the University of California Archaeological Research Facility No.45.

1986 Diachronic Variability in Obsidian Procurement Patterns in Northeastern California and Southcentral Oregon. University of California Publications in Anthropology Vol. 17. University of California Press, Berkeley.

Hughes, Richard E. and F.W. Nelson
1987 New Findings on Obsidian Source Utilization in Iowa. Plains Anthropologist 32:313-316.

Jack, R.N.
1976 Prehistoric Obsidian in California I: Geochemical Aspects. In Advances in Obsidian Glass Studies: Archaeological and Geochemical Perspectives, edited by R.E Taylor, pp.183-217. Noyes Press, New Jersey.

James, Malcolm A.
1986 Obsidian Source Analysis for Banff and Jasper National Parks, Alberta. In Eastern Slopes Prehistory: Selected Papers, edited by B. Ronaghan, pp.91-98. Archaeological Survey of Alberta Occasional Paper No.30. Edmonton.

James, Malcolm A. and J.M. D'Auria
1992 An X-Ray Fluorescence Trace Element Characterisation Library of Volcanic Glasses from Northwestern North America. Paper presented at the 45th Annual Northwest Anthropological Meetings, Simon Fraser University, Burnaby, British Columbia.

Klecka, William R.
1980 Discriminant Analysis. Sage University Papers Series No. 19, Beverley Hills, California.

Luessen, Michael J.
1987 Geology of the Massacre Volcanic Complex, Eastern Snake River Plain, Idaho. Unpublished Master's thesis, Department of Geology, Idaho State University, Pocatello.

Mattman, Andre
n.d. CRINTEG: Computer program for the computation of Compton and Rayleigh scatterpeaks. Program written for the x-ray fluorescence laboratory, Department of Chemistry, Simon Fraser University, Burnaby, B.C.

Merrick, H.V. and F.H. Brown
1984 Rapid Chemical Characterization of Obsidian Artifacts by Electron Microprobe Analysis. Archaeometry 26(2):230-236.

Michels, Joseph W.
1981 Hydration Rate Constants for Timber-Squaw Butte Obsidian, Boise County, Idaho. Revised 1984. MOHLAB Technical Report No. 4. State College, Pennsylvania.

1982a Hydration Rate Constants for Hawkins-Malad Obsidian, Oneida County, Idaho. Revised 1985. MOHLAB Technical Report No. 5. State College, Pennsylvania.

1982b Hydration Rate Constants for Big Southern Butte Obsidian, Butte County, Idaho. Revised 1985. MOHLAB Technical Report No. 9. State College, Pennsylvania.

1983 Hydration Rate Constants for Camas-Dry Creek Obsidian, Clark County, Idaho. MOHLAB Technical Report No. 26. State College, Pennsylvania.

Neff, Nancy A. and Leslie F. Marcus
1980 A Survey of Multivariate Methods for Systematics. New York: privately published.

Nelson, D.E., J.M. D'Auria, and R.B. Bennett
1975 Characterization of Pacific Northwest Coast Obsidian by X-Ray Fluorescence Analysis. Archaeometry 17:85-97.

Nelson, Fred W.
1984 X-Ray Fluorescence Analysis of Some Western North American Obsidians. In Obsidian Studies in the Great Basin, edited by Richard E. Hughes, pp.27-62. Contributions to the University of California Archaeological Research Facility No.45.

Nelson, F.W., K.K. Nielsen, N.F. Mangelson, M.W. Hill and R.T. Matheny
1977 Preliminary Studies of the Trace Element Composition of Obsidian Artifacts from Northern Campeche, Mexico. American Antiquity 42:209-225.

Nelson, Fred W. and Richard D. Holmes
1979 Trace Element Analysis of Obsidian Sources and Artifacts from Western Utah. Utah State Historical Society, Division of State History Antiquities Selected Papers No. 15.

Norusis, M.J.
1988 SPSS-X Advanced Statistics Guide, 2nd edition. SPSS Inc., Chicago.

Reed, William G.
1985 An Approach to the Archaeological Identification of Shoshonean Subsistence Territories in Southern

Idaho. Unpublished Master's Thesis, Department of Anthropology, Idaho State University, Pocatello.

Reeves, R.D. and G.K. Ward
1976 Characterization Studies of New Zealand Obsidians: Toward A Regional Prehistory. In Advances in Obsidian Glass Studies: Archaeological and Geochemical Perspectives, edited by R.E. Taylor. Noyes Press, New Jersey.

Renfrew, C.A., J.E. Dixon and J.R. Cann
1968 Further Analysis of Near Eastern Obsidians. Proceedings of the Prehistoric Society 34:319-331.

Sampson, C. Garth
1985 Nightfire Island: Later Holocene Lakemarsh Adaptation Near the Western Edge of the Great Basin. University of Oregon Anthropological Papers No. 33, Eugene.

Sappington, R.L.
1981a A Progress report on the Obsidian and Vitrophyre Sourcing Project. Idaho Archaeologist IV (4):4-17.

1981b Additional Obsidian and Vitrophyre Source Descriptions from Idaho and Adjacent Areas. Idaho Archaeologist V (1):4-8.

Shackley, M. Steven
1988 Sources of Archaeological Obsidian in the Southwest. American Antiquity 53(4):752-772.

Shennan, Steven
1988 Quantifying Archaeology. Edinburgh University Press, Bristol.

Taylor, R.E.
1976 Advances in Obsidian Glass Studies: Archaeological and Geochemical Perspectives. Noyes Press, New Jersey.

Tertian, R. and F. Claisse
1982 Principles of Quantitative X-Ray Fluorescence Analysis. Heyden, London.

Trimble, D.E. and W.J. Carr
1976 The Geology of the Rockland and Arton Quadrangles, Power County, Idaho. United States Geological Survey Bulletin 1399.

Truitt, Lisa
1991 Webb Springs: A Lithic Reduction Site on the Southeastern Snake River Plain. Paper presented at the 44th Annual Northwest Anthropological Meetings, Missoula, Montana.

van Waarden, Catrien
1977 Archaeological Test Excavations, North Camas - West Pete Creek Timber Sale, Targhee National Forest. Archaeological Report No. 14 of the Idaho State Museum of Natural History.

Weaver, J.R. and F.H. Stross
1965 Analysis By X-Ray Fluorescence of Some American Obsidians. Contributions to the University of California Archaeological Research Facility No. 1:94-103.

Willey, Gordon R. and Jeremy A. Sabloff
1974 A History of American Archaeology. Thames and Hudson, London.

Wilmeth, R.
1973 Distribution of Several Types of Obsidian from Archaeological Sites in British Columbia. Canadian Archaeological Association Bulletin 5:28-60.

Wright, Gary A.
1969 Obsidian Analysis and Prehistoric Near Eastern Trade: 7500-3500 B.C.. Ann Arbor: Papers of the Museum of Anthropology, University of Michigan No. 37.

Wright, Gary A., J.B. Griffin, and A.A Gordus
1969 Preliminary Report on Obsidian Samples from Veratic Rockshelter, Idaho. Tebiwa 12 (1):27-30.

Wright, Gary A. and Henry J. Chaya
1985 Obsidian Source Analysis in Western Wyoming: Problems and Prospects. Plains Anthropologist 30 (109):237-241.

Wright, Gary A., Henry Chaya and James McDonald
1986 The Location of the Field Museum Yellowstone (F.M.Y., 90 Group) Obsidian Source. Plains Anthropologist 35(127): 71-74.

Zvelebil, Marek
1983 Site Catchment Analysis and Hunter-Gatherer Resource Use. In Gordon Bronitsky (ed.) Ecological Models in Economic Prehistory, pp.73-114. Arizona State University Anthropological Research Papers No. 29.

APPENDIX ONE

NORMALIZED SOURCE DATA

Group	Flow	FeKa	FeKb	Zn	Rb	Sr	Y	Nb	ZrKb	Com	Ray
Owyhee 1, ID	72	1.487	0.256	0.027	0.962	0.155	0.390	0.130	0.132	11.449	7.766
Owyhee 1, ID	72	2.319	0.366	0.035	0.875	0.151	0.349	0.121	0.108	11.622	7.856
Owyhee 1, ID	72	1.250	0.222	0.021	0.780	0.171	0.293	0.000	0.211	10.630	7.463
Owyhee 1, ID	72	1.209	0.218	0.031	0.821	0.241	0.317	0.086	0.199	10.603	7.225
Owyhee 1, ID	72	1.400	0.241	0.049	0.962	0.152	0.420	0.128	0.133	11.196	7.302
Owyhee 1, ID	72	2.191	0.391	0.040	1.077	0.187	0.389	0.138	0.224	11.978	7.939
Owyhee 1, ID	72	1.093	0.193	0.021	0.843	0.221	0.356	0.055	0.136	10.847	7.704
Owyhee 1, ID	72	1.167	0.215	0.023	0.796	0.191	0.341	0.000	0.240	10.426	7.154
Owyhee 1, ID	72	1.221	0.216	0.047	1.039	0.140	0.378	0.107	0.261	11.907	8.044
Owyhee 1, ID	72	1.231	0.225	0.024	1.098	0.171	0.381	0.108	0.162	12.410	8.575
Owyhee 1, ID	72	1.245	0.227	0.018	0.999	0.148	0.380	0.122	0.161	12.178	8.635
Owyhee 1, ID	72	1.228	0.214	0.027	0.949	0.160	0.377	0.107	0.178	11.480	7.864
Owyhee 1, ID	72	1.113	0.190	0.000	0.893	0.144	0.383	0.108	0.224	11.158	7.843
Owyhee 1, ID	72	1.322	0.226	0.000	1.054	0.175	0.399	0.084	0.253	11.516	7.846
Owyhee 1, ID	72	1.154	0.210	0.022	0.935	0.153	0.375	0.143	0.211	11.034	7.569
Owyhee 1, ID	72	1.261	0.221	0.025	1.008	0.163	0.388	0.079	0.196	11.729	8.035
Owyhee 1, ID	72	1.116	0.189	0.025	0.933	0.138	0.368	0.156	0.194	11.037	7.317
Owyhee 1, ID	72	1.194	0.218	0.020	0.845	0.235	0.339	0.094	0.186	9.649	6.464
Owyhee 1, ID	72	1.090	0.191	0.017	0.848	0.210	0.313	0.073	0.161	10.112	6.878
Owyhee 1, ID	72	1.028	0.179	0.012	0.724	0.194	0.309	0.124	0.253	9.342	6.424
Owyhee 1, ID	72	0.955	0.175	0.012	0.704	0.205	0.316	0.135	0.249	8.987	6.195
Owyhee 1, ID	72	1.006	0.184	0.019	0.851	0.213	0.320	0.127	0.176	9.657	6.630
Owyhee 1, ID	72	1.138	0.212	0.017	0.853	0.235	0.295	0.089	0.277	10.329	6.997
Owyhee 2, ID	73	1.218	0.222	0.019	0.989	0.144	0.404	0.102	0.222	11.203	7.468
Owyhee 2, ID	73	1.227	0.227	0.018	0.950	0.139	0.398	0.106	0.254	10.841	7.470
Owyhee 2, ID	73	1.238	0.238	0.000	1.043	0.170	0.424	0.134	0.257	11.780	7.876
Owyhee 2, ID	73	1.295	0.243	0.017	1.130	0.147	0.385	0.085	0.259	12.963	9.047
Owyhee 2, ID	73	1.240	0.234	0.019	1.025	0.136	0.408	0.108	0.223	11.440	7.691
Owyhee 2, ID	73	1.249	0.212	0.026	1.090	0.184	0.404	0.102	0.252	12.237	8.415
Owyhee 2, ID	73	1.223	0.224	0.016	1.044	0.161	0.379	0.097	0.209	13.026	9.115
Owyhee 2, ID	73	1.275	0.233	0.023	1.052	0.162	0.397	0.092	0.293	12.991	9.325
Owyhee 2, ID	73	1.301	0.228	0.021	0.958	0.140	0.381	0.090	0.246	12.811	8.869
Owyhee 2, ID	73	1.345	0.238	0.000	1.095	0.191	0.455	0.102	0.233	12.599	8.489
Owyhee 2, ID	73	1.398	0.253	0.028	1.141	0.190	0.416	0.097	0.181	12.775	8.699
Owyhee 2, ID	73	1.220	0.218	0.027	1.012	0.162	0.432	0.099	0.202	12.007	8.323
Owyhee 2, ID	73	1.236	0.225	0.031	1.047	0.168	0.452	0.112	0.175	12.022	8.231
Owyhee 2, ID	73	1.363	0.253	0.029	1.133	0.152	0.416	0.101	0.351	12.652	8.614
Owyhee 2, ID	73	1.320	0.231	0.027	1.074	0.184	0.428	0.088	0.284	13.158	8.972
Owyhee 2, ID	73	1.295	0.222	0.026	1.081	0.169	0.421	0.101	0.250	13.304	9.121
Owyhee 2, ID	73	1.355	0.239	0.025	1.099	0.171	0.389	0.086	0.214	12.112	8.308
Owyhee 2, ID	73	1.267	0.233	0.023	1.076	0.167	0.433	0.103	0.223	12.437	8.716
Owyhee 2, ID	73	1.316	0.239	0.025	1.124	0.151	0.404	0.114	0.337	13.079	9.210
Murphy Hot Spr.	74	0.747	0.141	0.010	0.333	0.037	0.203	0.142	0.193	3.450	2.385
Murphy Hot Spr.	74	0.819	0.156	0.016	0.341	0.030	0.190	0.141	0.226	3.623	2.627

Murphy Hot Spr.	74	0.707	0.128	0.009	0.354	0.045	0.192	0.133	0.223	3.745	2.655
Murphy Hot Spr.	74	0.708	0.125	0.011	0.328	0.039	0.187	0.132	0.221	3.519	2.562
Murphy Hot Spr.	74	0.747	0.134	0.011	0.350	0.027	0.199	0.137	0.203	3.556	2.491
Murphy Hot Spr.	74	0.769	0.140	0.011	0.360	0.034	0.197	0.139	0.221	3.875	2.824
Murphy Hot Spr.	74	0.698	0.124	0.014	0.360	0.047	0.202	0.136	0.208	3.782	2.792
Murphy Hot Spr.	74	0.695	0.123	0.008	0.343	0.044	0.190	0.124	0.199	3.522	2.549
Murphy Hot Spr.	74	0.715	0.134	0.008	0.358	0.049	0.190	0.135	0.217	3.779	2.681
Murphy Hot Spr.	74	0.717	0.131	0.011	0.373	0.043	0.204	0.136	0.211	3.982	2.935
Murphy Hot Spr.	74	0.796	0.141	0.010	0.357	0.037	0.205	0.141	0.217	3.944	2.993
Murphy Hot Spr.	74	0.787	0.143	0.014	0.358	0.038	0.209	0.132	0.206	3.746	2.716
Murphy Hot Spr.	74	0.773	0.142	0.011	0.349	0.034	0.203	0.144	0.210	3.862	2.756
Murphy Hot Spr.	74	0.800	0.140	0.011	0.347	0.033	0.206	0.142	0.213	3.622	2.648
Antelope Spring	75	0.730	0.126	0.007	0.257	0.065	0.172	0.111	0.207	2.668	1.849
Antelope Spring	75	0.683	0.121	0.007	0.256	0.067	0.158	0.119	0.216	2.729	2.005
Antelope Spring	75	0.723	0.127	0.009	0.268	0.063	0.157	0.114	0.213	2.637	1.921
Antelope Spring	75	0.734	0.133	0.010	0.261	0.066	0.159	0.119	0.212	2.675	1.937
Antelope Spring	75	0.761	0.132	0.007	0.277	0.058	0.168	0.112	0.209	2.566	1.773
Antelope Spring	75	0.736	0.130	0.008	0.241	0.067	0.154	0.111	0.223	2.623	1.925
Antelope Spring	75	0.723	0.129	0.008	0.263	0.051	0.147	0.108	0.212	2.693	1.846
Antelope Spring	75	0.786	0.134	0.008	0.261	0.049	0.148	0.111	0.222	2.610	1.701
Antelope Spring	75	0.714	0.131	0.011	0.259	0.067	0.150	0.104	0.205	2.685	1.835
Antelope Spring	75	0.731	0.129	0.008	0.263	0.052	0.151	0.107	0.209	2.681	1.782
Antelope Spring	75	0.701	0.128	0.008	0.254	0.053	0.152	0.113	0.214	2.751	1.869
Antelope Spring	75	0.716	0.130	0.009	0.258	0.054	0.145	0.105	0.212	2.642	1.805
Antelope Spring	75	0.734	0.134	0.009	0.263	0.056	0.148	0.107	0.223	2.641	1.820
Antelope Spring	75	0.715	0.134	0.010	0.261	0.093	0.154	0.119	0.218	2.711	1.889
Antelope Spring	75	0.696	0.132	0.007	0.268	0.062	0.154	0.110	0.217	2.652	1.825
Brown's Bench	75	0.928	0.162	0.012	0.237	0.048	0.149	0.104	0.240	2.838	2.028
Brown's Bench	75	0.777	0.139	0.010	0.277	0.059	0.159	0.109	0.201	3.126	2.196
Brown's Bench	75	0.956	0.162	0.009	0.226	0.074	0.152	0.116	0.209	2.899	2.133
Brown's Bench	75	0.692	0.125	0.010	0.228	0.051	0.150	0.114	0.208	2.780	2.028
Brown's Bench	75	0.748	0.138	0.011	0.263	0.062	0.148	0.117	0.217	2.741	1.897
Brown's Bench	75	0.698	0.124	0.009	0.229	0.063	0.153	0.102	0.225	2.680	1.935
Brown's Bench	75	0.685	0.129	0.010	0.255	0.065	0.164	0.112	0.213	2.952	2.177
Brown's Bench	75	0.686	0.118	0.009	0.242	0.065	0.152	0.105	0.215	2.841	2.140
Brown's Bench	75	0.739	0.131	0.009	0.256	0.071	0.149	0.108	0.209	2.882	2.066
Brown's Bench	75	0.668	0.125	0.009	0.226	0.063	0.148	0.107	0.211	2.910	2.165
Brown's Bench	75	0.685	0.124	0.009	0.240	0.071	0.164	0.109	0.236	2.873	2.151
Brown's Bench	75	0.744	0.132	0.010	0.248	0.064	0.160	0.125	0.235	2.869	2.091
Brown's Bench	75	0.742	0.136	0.008	0.278	0.061	0.162	0.129	0.209	3.150	2.274
Brown's Bench	75	0.754	0.137	0.010	0.255	0.066	0.155	0.105	0.243	2.847	2.139
Brown's Bench	75	0.692	0.098	0.010	0.233	0.065	0.156	0.141	0.227	2.769	2.012
Brown's Bench	75	0.782	0.137	0.008	0.267	0.065	0.147	0.106	0.224	2.899	1.985
Brown's Bench	75	0.685	0.127	0.009	0.223	0.062	0.148	0.107	0.235	2.630	1.911
Brown's Bench	75	0.666	0.117	0.009	0.232	0.064	0.148	0.105	0.237	2.798	2.031
Brown's Bench	75	0.710	0.123	0.008	0.234	0.063	0.150	0.111	0.223	2.788	1.981
Brown's Bench	75	0.700	0.126	0.008	0.236	0.063	0.143	0.119	0.226	2.949	2.130
Brown's Bench	75	0.735	0.130	0.009	0.267	0.062	0.172	0.149	0.208	2.893	1.998

Brown's Bench	75	0.696	0.124	0.010	0.263	0.064	0.175	0.143	0.2[illegible]1	2.950	2.087
Brown's Bench	75	0.724	0.127	0.010	0.284	0.064	0.165	0.131	0.2[illegible]1	3.045	2.134
Brown's Bench	75	0.688	0.123	0.007	0.275	0.059	0.167	0.114	0.2[illegible]4	2.863	2.069
Brown's Bench	75	0.667	0.123	0.009	0.246	0.066	0.159	0.107	0.2[illegible]7	2.785	2.028
Brown's Bench	75	0.705	0.130	0.009	0.245	0.066	0.162	0.110	0.2[illegible]0	2.845	2.020
Brown's Bench	75	0.677	0.120	0.010	0.278	0.060	0.171	0.119	0.2[illegible]9	3.191	2.324
Brown's Bench	75	0.727	0.131	0.008	0.268	0.067	0.165	0.123	0.2[illegible]2	3.177	2.368
Brown's Bench	75	0.732	0.131	0.011	0.277	0.067	0.169	0.125	0.215	3.040	2.230
Brown's Bench	75	0.704	0.127	0.008	0.270	0.052	0.166	0.118	0.227	3.137	2.247
Brown's Bench	75	0.722	0.127	0.007	0.269	0.061	0.174	0.115	0.210	3.007	2.133
Brown's Bench	75	0.728	0.127	0.008	0.277	0.072	0.177	0.128	0.205	3.017	2.183
Brown's Bench	75	0.724	0.135	0.012	0.257	0.064	0.171	0.116	0.230	2.987	2.149
Brown's Bench	75	0.726	0.132	0.009	0.243	0.060	0.161	0.118	0.225	2.783	2.024
Brown's Bench	75	0.667	0.122	0.011	0.235	0.068	0.166	0.126	0.209	2.958	2.146
Brown's Bench	75	0.715	0.127	0.010	0.283	0.067	0.166	0.127	0.221	2.995	2.209
Brown's Bench	75	0.719	0.128	0.010	0.252	0.062	0.154	0.127	0.207	2.950	2.176
Idaho Black	75	0.772	0.134	0.011	0.243	0.057	0.146	0.116	0.215	2.773	1.896
Idaho Black	75	0.820	0.149	0.010	0.269	0.066	0.155	0.116	0.190	2.946	2.062
Idaho Black	75	0.716	0.131	0.010	0.247	0.060	0.151	0.095	0.206	2.893	2.100
Idaho Red	75	0.912	0.164	0.013	0.228	0.075	0.166	0.138	0.201	2.400	1.608
Idaho Red	75	0.747	0.131	0.009	0.209	0.062	0.155	0.134	0.168	2.792	1.994
Idaho Red	75	0.772	0.145	0.009	0.218	0.046	0.148	0.136	0.197	2.752	1.919
Little House Ck	75	0.773	0.136	0.011	0.268	0.066	0.158	0.135	0.205	3.092	2.192
Little House Ck	75	0.727	0.126	0.008	0.249	0.067	0.146	0.114	0.224	2.780	2.086
Little House Ck	75	0.707	0.128	0.009	0.246	0.072	0.148	0.120	0.207	2.862	2.088
Little House Ck	75	0.744	0.132	0.009	0.262	0.058	0.161	0.118	0.222	3.170	2.360
Little House Ck	75	0.741	0.139	0.010	0.246	0.069	0.141	0.119	0.230	2.981	2.249
Little House Ck	75	0.755	0.132	0.006	0.298	0.064	0.168	0.114	0.239	3.130	2.261
Little House Ck	75	0.783	0.140	0.010	0.262	0.065	0.154	0.125	0.220	2.965	2.145
Little House Ck	75	0.721	0.132	0.007	0.269	0.067	0.162	0.118	0.221	3.300	2.391
Little House Ck	75	0.722	0.129	0.009	0.250	0.068	0.156	0.103	0.230	3.010	2.269
Little House Ck	75	0.723	0.131	0.011	0.272	0.059	0.153	0.119	0.204	3.045	2.217
Little House Ck	75	0.747	0.131	0.010	0.259	0.064	0.158	0.127	0.221	3.128	2.332
Little House Ck	75	0.705	0.129	0.010	0.256	0.066	0.148	0.130	0.223	3.316	2.343
Little House Ck	75	0.710	0.126	0.012	0.284	0.063	0.166	0.124	0.237	3.328	2.495
Little House Ck	75	0.736	0.128	0.010	0.270	0.063	0.155	0.116	0.231	3.146	2.320
Little House Ck	75	0.697	0.118	0.013	0.257	0.063	0.159	0.127	0.203	3.399	2.482
Murphy Hot Spr.	75	0.893	0.161	0.008	0.265	0.062	0.143	0.101	0.212	2.898	2.160
Oldman Quarry,	75	0.697	0.126	0.009	0.233	0.062	0.147	0.105	0.220	2.469	1.845
Oldman Quarry,	75	0.734	0.130	0.008	0.250	0.066	0.155	0.110	0.209	2.513	1.781
Oldman Quarry,	75	0.734	0.132	0.009	0.256	0.068	0.157	0.115	0.213	2.818	2.046
Oldman Quarry,	75	0.712	0.126	0.009	0.245	0.071	0.153	0.114	0.221	2.582	1.899
Oldman Quarry,	75	0.726	0.130	0.011	0.244	0.067	0.151	0.113	0.212	2.535	1.846
Oldman Quarry,	75	0.708	0.125	0.007	0.249	0.063	0.160	0.121	0.204	2.733	1.996
Oldman Quarry,	75	0.738	0.136	0.008	0.261	0.067	0.157	0.115	0.215	2.646	1.982
Oldman Quarry,	75	0.728	0.132	0.011	0.262	0.064	0.158	0.116	0.211	2.800	1.999
Oldman Quarry,	75	0.722	0.132	0.008	0.267	0.067	0.165	0.114	0.221	2.665	1.982
Oldman Quarry,	75	0.748	0.129	0.008	0.262	0.065	0.161	0.117	0.217	2.785	2.028

Oldman Quarry,	75	0.711	0.130	0.008	0.252	0.067	0.156	0.113	0.218	2.647	1.959
Oldman Quarry,	75	0.733	0.133	0.010	0.259	0.058	0.158	0.118	0.223	2.784	2.012
Oldman Quarry,	75	0.714	0.133	0.008	0.239	0.059	0.142	0.109	0.210	2.611	1.900
Oldman Quarry,	75	0.716	0.128	0.008	0.255	0.062	0.153	0.119	0.220	2.764	2.039
Oldman Quarry,	75	0.720	0.130	0.008	0.252	0.057	0.152	0.108	0.209	2.657	1.931
Shoshone Basin,	75	0.772	0.139	0.010	0.215	0.067	0.140	0.131	0.225	2.192	1.563
Shoshone Basin,	75	0.702	0.122	0.011	0.193	0.060	0.136	0.135	0.223	2.392	1.758
Shoshone Basin,	75	0.714	0.124	0.009	0.187	0.064	0.137	0.122	0.223	2.411	1.837
Shoshone Basin,	75	0.723	0.126	0.011	0.232	0.061	0.147	0.104	0.245	2.590	1.925
Shoshone Basin,	75	0.724	0.131	0.010	0.240	0.063	0.149	0.110	0.242	2.606	1.945
Shoshone Basin,	75	0.724	0.127	0.012	0.230	0.064	0.144	0.102	0.204	2.547	1.893
Shoshone Basin,	75	0.693	0.129	0.007	0.247	0.056	0.165	0.115	0.231	3.018	2.113
Shoshone Basin,	75	0.775	0.133	0.011	0.305	0.060	0.158	0.121	0.226	2.700	1.950
Shoshone Basin,	75	0.802	0.143	0.010	0.260	0.063	0.162	0.111	0.234	2.575	1.839
Shoshone Basin,	75	0.746	0.131	0.009	0.170	0.068	0.117	0.100	0.209	1.971	1.457
Shoshone Basin,	75	0.735	0.130	0.008	0.168	0.071	0.123	0.100	0.237	2.052	1.527
Shoshone Basin,	75	0.775	0.138	0.009	0.162	0.070	0.120	0.104	0.205	1.874	1.396
Shoshone Basin,	75	0.726	0.132	0.011	0.212	0.071	0.138	0.118	0.213	2.245	1.622
Shoshone Basin,	75	0.737	0.135	0.010	0.184	0.067	0.130	0.115	0.236	2.304	1.696
Shoshone Basin,	75	0.732	0.131	0.011	0.192	0.073	0.134	0.114	0.216	2.312	1.725
Shoshone Basin,	75	0.734	0.127	0.008	0.186	0.082	0.127	0.114	0.224	2.309	1.665
Shoshone Basin,	75	0.685	0.127	0.010	0.182	0.061	0.121	0.108	0.232	2.268	1.692
Shoshone Basin,	75	0.730	0.135	0.007	0.198	0.066	0.127	0.106	0.222	2.327	1.728
Shoshone Basin,	75	0.803	0.144	0.008	0.179	0.065	0.129	0.097	0.215	2.088	1.502
Shoshone Basin,	75	0.654	0.116	0.007	0.179	0.065	0.132	0.000	0.225	2.396	1.662
Shoshone Basin,	75	0.782	0.140	0.009	0.163	0.068	0.125	0.106	0.228	2.071	1.551
Shoshone Basin,	75	0.782	0.139	0.009	0.164	0.067	0.117	0.111	0.240	1.975	1.465
Shoshone Basin,	75	0.780	0.140	0.010	0.161	0.074	0.118	0.099	0.227	1.975	1.453
Shoshone Basin,	75	0.740	0.131	0.009	0.165	0.070	0.119	0.115	0.224	2.067	1.518
Shoshone Basin,	75	0.737	0.132	0.011	0.157	0.072	0.116	0.108	0.213	2.046	1.535
Shoshone Basin,	75	0.744	0.136	0.009	0.201	0.060	0.143	0.136	0.230	2.427	1.765
Shoshone Basin,	75	0.731	0.132	0.009	0.207	0.060	0.147	0.130	0.235	2.521	1.857
Shoshone Basin,	75	0.745	0.131	0.008	0.224	0.057	0.150	0.126	0.232	2.516	1.843
Shoshone Basin,	75	0.725	0.131	0.010	0.209	0.061	0.151	0.126	0.231	2.383	1.752
Shoshone Basin,	75	0.838	0.147	0.012	0.211	0.067	0.149	0.133	0.216	2.213	1.602
Shoshone Basin,	75	0.731	0.125	0.010	0.239	0.071	0.146	0.099	0.232	2.630	1.976
Shoshone Basin,	75	0.741	0.131	0.007	0.243	0.070	0.147	0.105	0.226	2.610	1.970
Shoshone Basin,	75	0.730	0.132	0.010	0.262	0.070	0.149	0.105	0.214	2.691	1.973
Shoshone Basin,	75	0.701	0.124	0.008	0.252	0.064	0.143	0.109	0.216	2.627	1.950
Shoshone Basin,	75	0.677	0.120	0.006	0.246	0.065	0.143	0.117	0.242	2.821	2.111
Shoshone Basin,	75	0.724	0.125	0.010	0.238	0.060	0.141	0.106	0.230	2.613	1.932
Shoshone Basin,	75	0.739	0.133	0.008	0.241	0.063	0.148	0.116	0.235	2.588	1.863
Shoshone Basin,	75	0.781	0.137	0.010	0.237	0.058	0.134	0.104	0.234	2.325	1.736
Shoshone Basin,	75	0.755	0.135	0.008	0.239	0.065	0.138	0.103	0.230	2.468	1.811
Shoshone Basin,	75	0.757	0.137	0.010	0.245	0.062	0.148	0.107	0.205	2.486	1.800
Shoshone Basin,	75	0.728	0.133	0.009	0.189	0.074	0.139	0.126	0.222	2.339	1.754
Shoshone Basin,	75	0.711	0.129	0.007	0.185	0.068	0.141	0.124	0.217	2.285	1.682
Shoshone Basin,	75	0.707	0.127	0.009	0.187	0.067	0.135	0.119	0.219	2.311	1.689

Three Ck., ID	75	0.706	0.125	0.009	0.267	0.061	0.158	0.114	(.234	3.090	2.285
Three Ck., ID	75	0.758	0.131	0.012	0.281	0.059	0.156	0.115	(.216	3.137	2.253
Three Ck., ID	75	0.704	0.122	0.000	0.264	0.066	0.158	0.111	(.228	3.284	2.279
Three Ck., ID	75	0.741	0.132	0.008	0.257	0.063	0.138	0.099	(.207	2.810	2.051
Three Ck., ID	75	0.761	0.142	0.006	0.261	0.071	0.137	0.098	(.230	2.673	1.970
Three Ck., ID	75	0.747	0.135	0.011	0.254	0.062	0.142	0.103	(.212	2.886	2.112
Shoshone Basin,	75	0.731	0.127	0.008	0.190	0.070	0.138	0.117	0.211	2.274	1.676
Shoshone Basin,	75	0.736	0.133	0.009	0.183	0.069	0.143	0.127	0.212	2.322	1.721
Three Ck., ID	75	0.706	0.125	0.009	0.267	0.061	0.158	0.114	0.234	3.090	2.285
Three Ck., ID	75	0.758	0.131	0.012	0.281	0.059	0.156	0.115	0.216	3.137	2.253
Three Ck., ID	75	0.704	0.122	0.000	0.264	0.066	0.158	0.111	0.228	3.284	2.279
Three Ck., ID	75	0.741	0.132	0.008	0.257	0.063	0.138	0.099	0.207	2.810	2.051
Three Ck., ID	75	0.761	0.142	0.006	0.261	0.071	0.137	0.098	0.230	2.673	1.970
Three Ck., ID	75	0.747	0.135	0.011	0.254	0.062	0.142	0.103	0.212	2.886	2.112
Three Ck., ID	75	0.721	0.128	0.009	0.230	0.067	0.147	0.107	0.210	2.779	2.106
Three Ck., ID	75	0.753	0.142	0.008	0.231	0.073	0.144	0.108	0.201	2.650	1.934
Three Ck., ID	75	0.680	0.123	0.006	0.247	0.064	0.132	0.095	0.206	2.657	2.047
Youngman Quarry	75	0.759	0.135	0.011	0.264	0.064	0.157	0.110	0.200	2.623	1.870
Youngman Quarry	75	0.732	0.137	0.009	0.259	0.062	0.164	0.118	0.216	2.734	2.031
Youngman Quarry	75	0.730	0.132	0.010	0.251	0.063	0.152	0.117	0.208	2.763	1.985
Youngman Quarry	75	0.755	0.134	0.014	0.262	0.063	0.155	0.116	0.206	2.708	1.891
Youngman Quarry	75	0.720	0.125	0.009	0.242	0.065	0.165	0.112	0.216	2.661	1.923
Youngman Quarry	75	0.734	0.128	0.008	0.262	0.071	0.169	0.114	0.206	2.716	2.002
Youngman Quarry	75	0.742	0.140	0.013	0.264	0.060	0.163	0.120	0.216	2.768	2.078
Youngman Quarry	75	0.729	0.130	0.008	0.250	0.064	0.151	0.123	0.210	2.760	2.025
Youngman Quarry	75	0.743	0.132	0.011	0.269	0.064	0.157	0.120	0.221	2.752	2.018
Youngman Quarry	75	0.727	0.134	0.010	0.250	0.061	0.153	0.115	0.211	2.710	1.989
Youngman Quarry	75	0.741	0.134	0.008	0.254	0.060	0.152	0.115	0.215	2.694	1.953
Youngman Quarry	75	0.720	0.133	0.010	0.243	0.068	0.152	0.107	0.216	2.618	1.905
Youngman Quarry	75	0.721	0.132	0.008	0.238	0.066	0.146	0.107	0.213	2.598	1.889
Youngman Quarry	75	0.717	0.132	0.012	0.241	0.069	0.145	0.112	0.212	2.572	1.865
Youngman Quarry	75	0.727	0.128	0.010	0.239	0.063	0.147	0.113	0.215	2.606	1.888
Three Ck. 2, ID	76	0.614	0.112	0.009	0.320	0.030	0.186	0.148	0.244	3.550	2.597
Three Ck. 2, ID	76	0.691	0.122	0.009	0.329	0.031	0.198	0.138	0.238	3.360	2.465
Three Ck. 2, ID	76	0.675	0.119	0.007	0.325	0.041	0.198	0.133	0.207	3.098	2.151
Flint Hill, ID	77	0.667	0.126	0.014	0.263	0.028	0.202	0.189	0.235	3.946	2.970
Flint Hill, ID	77	0.670	0.122	0.017	0.260	0.030	0.217	0.218	0.222	3.863	2.772
Flint Hill, ID	77	0.686	0.127	0.014	0.267	0.029	0.201	0.205	0.211	3.820	2.586
Flint Hill, ID	77	0.697	0.126	0.014	0.260	0.025	0.192	0.201	0.235	3.663	2.531
Flint Hill, ID	77	0.655	0.119	0.013	0.265	0.027	0.185	0.191	0.244	3.658	2.633
Flint Hill, ID	77	0.730	0.129	0.014	0.288	0.033	0.189	0.216	0.221	3.610	2.479
Flint Hill, ID	77	0.679	0.127	0.012	0.283	0.028	0.204	0.203	0.230	3.772	2.687
Flint Hill, ID	77	0.741	0.138	0.015	0.267	0.030	0.205	0.221	0.224	3.568	2.538
Flint Hill, ID	77	0.695	0.125	0.013	0.260	0.027	0.209	0.208	0.213	3.491	2.380
Flint Hill, ID	77	0.717	0.127	0.013	0.276	0.030	0.211	0.196	0.242	3.887	2.745
Flint Hill, ID	77	0.736	0.131	0.015	0.283	0.030	0.211	0.191	0.231	3.642	2.619
Flint Hill, ID	77	0.674	0.122	0.008	0.270	0.029	0.217	0.181	0.221	3.809	2.835
Flint Hill, ID	77	0.719	0.126	0.014	0.269	0.029	0.199	0.186	0.246	3.931	2.816
Flint Hill, ID	77	0.688	0.121	0.013	0.257	0.030	0.212	0.208	0.227	3.860	2.695
Ozone, ID	77	0.741	0.137	0.017	0.282	0.030	0.202	0.198	0.248	4.316	3.140
Ozone, ID	77	0.737	0.128	0.016	0.277	0.036	0.217	0.208	0.235	4.365	3.151
Ozone, ID	77	0.731	0.127	0.014	0.299	0.030	0.210	0.204	0.224	4.305	3.116
Ozone, ID	77	0.801	0.142	0.018	0.272	0.051	0.202	0.179	0.203	3.791	2.665
Ozone, ID	77	0.748	0.133	0.013	0.294	0.032	0.203	0.205	0.229	4.317	3.100

Ozone, ID	77	0.773	0.130	0.017	0.301	0.032	0.209	0.182	0.213	4.289	3.070
Ozone, ID	77	0.683	0.122	0.018	0.245	0.029	0.181	0.177	0.199	3.866	2.667
Ozone, ID	77	0.685	0.120	0.014	0.290	0.047	0.201	0.190	0.230	3.894	2.801
Ozone, ID	77	0.691	0.122	0.014	0.294	0.035	0.199	0.180	0.219	4.194	2.927
Ozone, ID	77	0.747	0.133	0.018	0.290	0.033	0.216	0.202	0.215	4.257	3.061
Ozone, ID	77	0.736	0.132	0.013	0.290	0.040	0.214	0.218	0.245	4.328	3.176
Ozone, ID	77	0.741	0.129	0.015	0.294	0.022	0.196	0.179	0.202	3.560	2.483
Ozone, ID	77	0.735	0.130	0.015	0.282	0.031	0.212	0.182	0.198	3.585	2.501
Ozone, ID	77	0.687	0.119	0.014	0.283	0.036	0.193	0.185	0.231	3.674	2.630
Ozone, ID	77	0.823	0.158	0.015	0.294	0.039	0.212	0.190	0.209	3.725	2.668
Ozone, ID	77	0.903	0.163	0.040	0.274	0.039	0.200	0.189	0.223	3.367	2.388
Ozone, ID	77	0.775	0.135	0.013	0.279	0.032	0.190	0.183	0.208	3.402	2.376
Ozone, ID	77	0.716	0.121	0.017	0.272	0.029	0.205	0.196	0.205	3.654	2.557
Ozone, ID	77	0.726	0.129	0.017	0.279	0.033	0.203	0.192	0.227	3.707	2.617
Ozone, ID	77	0.742	0.127	0.015	0.277	0.036	0.211	0.204	0.202	3.800	2.665
Ozone, ID	77	0.759	0.134	0.017	0.298	0.029	0.214	0.196	0.198	3.734	2.628
Ozone, ID	77	0.751	0.131	0.014	0.302	0.037	0.210	0.195	0.226	3.738	2.615
Ozone, ID	77	0.741	0.129	0.022	0.290	0.030	0.200	0.211	0.227	4.075	2.876
Ozone, ID	77	0.742	0.134	0.012	0.320	0.031	0.201	0.196	0.218	3.770	2.733
Ozone, ID	77	0.792	0.134	0.013	0.264	0.027	0.190	0.181	0.229	3.478	2.429
Ozone, ID	77	0.749	0.138	0.017	0.321	0.034	0.213	0.196	0.218	3.966	2.851
Ozone, ID	77	0.763	0.137	0.015	0.273	0.028	0.206	0.194	0.228	3.653	2.581
Ozone, ID	77	0.758	0.136	0.015	0.300	0.031	0.206	0.175	0.199	3.567	2.498
Ozone, ID	77	0.703	0.124	0.014	0.291	0.028	0.199	0.180	0.212	3.941	2.665
Ozone, ID	77	0.785	0.135	0.016	0.281	0.031	0.214	0.189	0.196	3.420	2.379
Picabo Hills	78	0.697	0.122	0.009	0.237	0.050	0.174	0.146	0.197	3.124	2.279
Picabo Hills	78	0.726	0.131	0.009	0.249	0.058	0.183	0.158	0.197	2.911	2.036
Picabo Hills	78	0.682	0.122	0.014	0.233	0.053	0.192	0.153	0.229	3.187	2.302
Picabo Hills	78	0.801	0.134	0.009	0.247	0.065	0.161	0.148	0.226	2.865	2.137
Picabo Hills	78	0.677	0.116	0.008	0.232	0.055	0.165	0.148	0.208	3.088	2.285
Picabo Hills	78	0.639	0.103	0.000	0.230	0.044	0.206	0.170	0.223	3.553	2.268
Picabo Hills	78	0.690	0.122	0.008	0.235	0.054	0.165	0.149	0.208	3.063	2.195
Picabo Hills	78	0.722	0.127	0.009	0.235	0.047	0.165	0.147	0.229	2.992	2.142
Picabo Hills	78	0.729	0.125	0.010	0.244	0.054	0.181	0.145	0.221	2.916	2.040
Picabo Hills	78	0.678	0.121	0.014	0.244	0.058	0.177	0.149	0.202	3.101	2.286
Picabo Hills	78	0.632	0.118	0.011	0.221	0.052	0.176	0.175	0.225	3.077	2.122
Picabo Hills	78	0.727	0.127	0.012	0.218	0.058	0.165	0.137	0.187	2.736	1.954
Picabo Hills	78	0.713	0.126	0.009	0.216	0.059	0.174	0.144	0.201	2.811	2.014
Picabo Hills	78	0.755	0.131	0.009	0.227	0.056	0.166	0.138	0.203	2.726	1.928
Timber Butte	79	1.774	0.282	0.085	2.101	0.153	1.084	0.886	0.828	29.482	19.127
Timber Butte	79	2.238	0.346	0.121	2.076	0.177	1.129	0.970	NA	27.262	18.114
Timber Butte	79	1.980	0.375	0.110	2.234	0.160	1.092	0.765	0.126	27.793	18.015
Timber Butte	79	1.592	0.274	0.081	1.956	0.148	1.036	0.827	0.251	23.944	16.331
Timber Butte	79	1.640	0.279	0.099	2.038	0.149	1.093	0.837	0.143	26.699	18.454
Timber Butte	79	1.524	0.257	0.095	2.027	0.129	1.117	0.816	0.206	26.697	18.218
Timber Butte	79	2.012	0.346	0.109	2.021	0.166	0.997	0.831	NA	30.788	20.432
Timber Butte	79	1.548	0.242	0.111	2.031	0.097	1.014	0.929	0.154	27.088	17.745
Timber Butte	79	1.559	0.277	0.087	1.779	0.168	0.951	0.822	0.324	25.298	16.420

American Falls,	80	0.749	0.129	0.016	0.494	0.064	0.293	0.248	0.251	5.495	3.730
American Falls,	80	0.761	0.134	0.022	0.469	0.061	0.285	0.249	0.227	5.411	3.729
American Falls,	80	0.725	0.124	0.022	0.446	0.057	0.286	0.246	0.236	5.408	3.919
American Falls,	80	0.766	0.143	0.000	0.424	0.056	0.289	0.227	0.225	4.952	3.250
American Falls,	80	0.758	0.136	0.018	0.426	0.057	0.282	0.239	0.235	5.342	3.887
American Falls,	80	0.749	0.131	0.019	0.440	0.060	0.288	0.241	0.247	5.666	4.078
American Falls,	80	0.783	0.141	0.022	0.475	0.058	0.286	0.245	0.226	5.362	3.686
American Falls,	80	0.750	0.130	0.021	0.440	0.049	0.283	0.248	0.222	5.231	3.783
American Falls,	80	0.702	0.125	0.019	0.442	0.048	0.297	0.256	0.216	5.885	4.254
American Falls,	80	0.761	0.137	0.016	0.445	0.051	0.288	0.242	0.213	5.489	3.962
American Falls,	80	0.756	0.142	0.021	0.475	0.058	0.307	0.251	0.204	5.335	3.564
American Falls,	80	0.753	0.128	0.021	0.496	0.067	0.304	0.245	0.224	5.419	3.843
American Falls,	80	0.744	0.131	0.020	0.494	0.059	0.295	0.244	0.193	5.408	3.795
American Falls,	80	0.734	0.131	0.018	0.486	0.057	0.305	0.236	0.231	5.521	3.820
American Falls,	80	0.735	0.130	0.021	0.465	0.063	0.316	0.248	0.218	5.672	3.981
Snake River, ID	80	0.756	0.134	0.021	0.460	0.060	0.309	0.246	0.200	5.199	3.606
Snake River, ID	80	0.790	0.145	0.024	0.453	0.084	0.287	0.224	0.184	4.903	3.336
Snake River, ID	80	0.729	0.127	0.016	0.413	0.049	0.280	0.217	0.191	5.777	3.910
Snake River, ID	80	0.744	0.131	0.022	0.452	0.053	0.280	0.234	0.217	5.432	3.854
Snake River, ID	80	0.673	0.124	0.019	0.460	0.067	0.317	0.257	0.217	7.738	5.043
Snake River, ID	80	0.631	0.114	0.018	0.412	0.065	0.285	0.259	0.227	7.944	5.276
Snake River, ID	80	0.642	0.109	0.020	0.441	0.059	0.294	0.259	0.217	8.192	5.454
Snake River, ID	80	0.658	0.128	0.016	0.433	0.058	0.280	0.258	0.212	8.120	5.429
Snake River, ID	80	0.903	0.156	0.032	0.451	0.062	0.312	0.222	0.185	5.427	3.435
Snake River, ID	80	0.826	0.139	0.025	0.461	0.067	0.304	0.266	0.209	6.042	4.072
Snake River, ID	80	0.787	0.143	0.023	0.484	0.061	0.299	0.255	0.188	6.102	4.199
Snake River, ID	80	0.829	0.154	0.019	0.524	0.064	0.277	0.242	0.196	6.072	4.247
Snake River, ID	80	0.721	0.124	0.020	0.453	0.058	0.289	0.243	0.169	5.603	3.846
Snake River, ID	80	0.814	0.149	0.020	0.452	0.092	0.303	0.230	0.143	5.177	3.343
Snake River, ID	80	0.774	0.132	0.025	0.444	0.069	0.298	0.238	0.161	5.431	3.647
Snake River, ID	80	0.774	0.141	0.024	0.458	0.051	0.309	0.238	0.190	5.634	3.719
Walcott, ID	80	0.834	0.153	0.019	0.468	0.052	0.306	0.242	0.185	5.114	3.357
Walcott, ID	80	0.751	0.138	0.019	0.473	0.059	0.296	0.243	0.226	5.483	3.903
Walcott, ID	80	0.777	0.136	0.016	0.440	0.065	0.273	0.237	0.217	5.256	3.594
Walcott, ID	80	0.828	0.156	0.000	0.500	0.055	0.304	0.238	0.175	5.231	3.325
Walcott, ID	80	0.758	0.144	0.016	0.441	0.051	0.307	0.239	0.222	5.085	3.443
Walcott, ID	80	0.787	0.147	0.017	0.454	0.060	0.296	0.249	0.212	5.211	3.622
Walcott, ID	80	0.790	0.140	0.019	0.445	0.059	0.299	0.238	0.189	4.974	3.326
Walcott, ID	80	0.749	0.131	0.018	0.457	0.058	0.278	0.245	0.227	5.547	3.905
Walcott, ID	80	0.749	0.143	0.023	0.481	0.054	0.310	0.252	0.218	5.543	3.886
Walcott, ID	80	0.781	0.137	0.022	0.461	0.054	0.275	0.246	0.224	5.129	3.488
Walcott, ID	80	0.766	0.135	0.015	0.457	0.057	0.300	0.244	0.211	5.264	3.631
Walcott, ID	80	0.841	0.143	0.020	0.465	0.049	0.287	0.244	0.199	5.206	3.566
Walcott, ID	80	0.764	0.136	0.020	0.449	0.060	0.299	0.232	0.235	5.500	3.923
Walcott, ID	80	0.738	0.134	0.018	0.446	0.057	0.281	0.238	0.216	5.542	3.956
Walcott, ID	80	0.758	0.137	0.017	0.469	0.063	0.298	0.238	0.208	5.470	3.836
Walcott, ID	80	0.734	0.130	0.017	0.506	0.062	0.286	0.241	0.226	5.535	4.007
Walcott, ID	80	0.755	0.134	0.019	0.456	0.059	0.284	0.248	0.219	5.940	4.342

Walcott, ID	80	0.796	0.143	0.021	0.464	0.052	0.296	0.235	0.2[illegible]5	5.344	3.805
Walcott, ID	80	0.769	0.132	0.022	0.466	0.056	0.299	0.268	0.2[illegible]4	5.452	3.807
Walcott, ID	80	0.724	0.129	0.017	0.430	0.051	0.270	0.228	0.2[illegible]4	5.371	3.723
Walcott, ID	80	0.771	0.138	0.021	0.457	0.054	0.286	0.253	0.225	5.450	3.853
Walcott, ID	80	0.755	0.121	0.019	0.459	0.064	0.293	0.233	0.228	5.498	3.736
Walcott, ID	80	0.787	0.140	0.016	0.471	0.065	0.306	0.236	0.209	5.446	3.684
Walcott, ID	80	0.729	0.139	0.018	0.504	0.051	0.298	0.238	0.223	6.054	4.184
Walcott, ID	80	0.783	0.145	0.014	0.472	0.057	0.313	0.235	0.207	5.272	3.605
Walcott, ID	80	0.784	0.134	0.018	0.448	0.055	0.288	0.225	0.212	5.550	3.974
Walcott, ID	80	0.741	0.124	0.021	0.456	0.047	0.285	0.248	0.222	5.680	3.873
Walcott, ID	80	0.764	0.141	0.019	0.472	0.056	0.289	0.236	0.194	5.557	3.729
Walcott, ID	80	0.718	0.131	0.022	0.442	0.049	0.285	0.236	0.222	5.303	3.559
Cannonball Mtnl	81	0.462	0.083	0.016	0.168	0.000	0.121	0.136	0.251	1.151	0.861
Cannonball Mtnl	81	0.600	0.102	0.019	0.186	0.000	0.126	0.128	0.232	1.046	0.757
Cannonball Mtnl	81	0.466	0.082	0.015	0.167	0.000	0.120	0.139	0.228	1.116	0.841
Cannonball Mtnl	81	0.469	0.083	0.019	0.171	0.000	0.121	0.134	0.219	1.066	0.769
Cannonball Mtnl	81	0.553	0.099	0.020	0.178	0.000	0.124	0.135	0.211	0.975	0.674
Cannonball Mtnl	81	0.465	0.084	0.016	0.172	0.000	0.119	0.127	0.235	1.169	0.863
Cannonball Mtnl	81	0.474	0.082	0.017	0.177	0.000	0.119	0.131	0.215	1.130	0.821
Cannonball Mtnl	81	0.454	0.080	0.014	0.167	0.000	0.123	0.138	0.222	1.101	0.822
Cannonball Mtnl	81	0.466	0.087	0.017	0.172	0.000	0.122	0.132	0.215	1.121	0.811
Cannonball Mtnl	81	0.469	0.086	0.018	0.188	0.000	0.094	0.094	0.212	1.250	0.885
Cannonball Mtnl	81	0.450	0.078	0.013	0.174	0.000	0.122	0.153	0.243	1.428	1.047
Cannonball Mtnl	81	0.503	0.092	0.016	0.176	0.000	0.118	0.131	0.229	1.399	1.051
Cannonball Mtnl	81	0.544	0.095	0.018	0.179	0.000	0.122	0.142	0.213	1.299	0.952
Cannonball Mtnl	81	0.483	0.084	0.016	0.183	0.000	0.116	0.132	0.211	1.137	0.833
Cannonball Mtnl	81	0.439	0.077	0.015	0.171	0.000	0.114	0.134	0.232	1.190	0.883
Cannonball Mtnl	81	0.463	0.085	0.016	0.172	0.000	0.121	0.134	0.211	1.184	0.894
Cannonball Mtnl	81	0.432	0.078	0.016	0.162	0.000	0.119	0.136	0.233	1.357	0.985
Cannonball Mtnl	81	0.462	0.084	0.016	0.179	0.000	0.118	0.135	0.230	1.218	0.905
Cannonball Mtnl	81	0.452	0.084	0.015	0.174	0.000	0.119	0.133	0.240	1.230	0.903
Cannonball Mtnl	81	0.466	0.082	0.017	0.172	0.000	0.121	0.133	0.212	1.196	0.879
Cannonball Mtnl	81	0.397	0.073	0.017	0.157	0.000	0.107	0.132	0.243	1.516	1.056
Cannonball Mtnl	81	0.511	0.090	0.017	0.176	0.000	0.122	0.139	0.210	1.368	1.018
Cannonball Mtnl	81	0.521	0.098	0.019	0.185	0.000	0.126	0.108	0.223	1.205	0.843
Cannonball Mtnl	81	0.462	0.083	0.016	0.170	0.000	0.123	0.136	0.238	1.265	0.969
Cannonball Mtnl	81	0.454	0.082	0.014	0.187	0.000	0.114	0.132	0.234	1.419	1.044
Cannonball Mtnl	81	0.492	0.088	0.019	0.179	0.000	0.123	0.131	0.233	1.293	0.943
Cannonball Mtnl	81	0.473	0.088	0.016	0.184	0.000	0.121	0.142	0.234	1.293	0.939
Cannonball Mtnl	81	0.540	0.091	0.016	0.180	0.000	0.123	0.138	0.231	1.259	0.938
Cannonball Mtnl	81	0.462	0.082	0.016	0.169	0.000	0.124	0.144	0.234	1.146	0.832
Cannonball Mtnl	81	0.487	0.089	0.018	0.174	0.000	0.122	0.134	0.218	1.251	0.916
Cannonball Mtnl	81	0.480	0.087	0.019	0.169	0.000	0.124	0.132	0.217	1.357	1.001
Cannonball Mtnl	81	0.481	0.088	0.016	0.178	0.000	0.122	0.131	0.230	1.239	0.931
Cannonball Mtnl	81	0.469	0.086	0.017	0.179	0.000	0.126	0.142	0.217	1.227	0.896
Cannonball Mtnl	81	0.525	0.095	0.013	0.192	0.000	0.121	0.131	0.205	1.209	0.857
Cannonball Mtnl	81	0.471	0.081	0.016	0.169	0.000	0.120	0.139	0.227	1.228	0.866
Cannonball Mtnl	81	0.471	0.084	0.018	0.181	0.000	0.125	0.139	0.236	1.191	0.882

Cannonball Mtn1	81	0.464	0.082	0.017	0.179	0.000	0.122	0.139	0.256	1.215	0.886
Cannonball Mtn1	81	0.464	0.082	0.016	0.175	0.000	0.124	0.132	0.231	1.123	0.828
Cannonball Mtn1	81	0.470	0.086	0.017	0.168	0.000	0.118	0.134	0.234	1.155	0.859
Cannonball Mtn1	81	0.454	0.083	0.015	0.177	0.000	0.118	0.135	0.241	1.150	0.814
Cannonball Mtn1	81	0.486	0.086	0.018	0.175	0.000	0.121	0.144	0.237	1.177	0.839
Cannonball Mtn1	81	0.569	0.099	0.022	0.187	0.000	0.127	0.134	0.218	1.156	0.807
Cannonball Mtn1	81	0.491	0.088	0.018	0.180	0.000	0.121	0.129	0.231	1.169	0.855
Cannonball Mtn1	81	0.472	0.085	0.020	0.177	0.000	0.122	0.130	0.227	1.199	0.897
Cannonball Mtn1	81	0.507	0.090	0.021	0.186	0.000	0.119	0.124	0.242	1.217	0.907
Cannonball Mtn1	81	0.508	0.089	0.018	0.184	0.000	0.105	0.125	0.219	1.154	0.840
Cannonball Mtn1	81	0.541	0.098	0.018	0.191	0.000	0.126	0.133	0.229	1.109	0.791
Cannonball Mtn1	81	0.500	0.089	0.016	0.176	0.000	0.122	0.126	0.223	1.133	0.796
Cannonball Mtn1	81	0.508	0.089	0.019	0.177	0.000	0.122	0.129	0.232	1.176	0.886
Cannonball Mtn1	81	0.474	0.086	0.015	0.186	0.000	0.125	0.151	0.220	1.221	0.916
Cannonball Mtn1	81	0.446	0.079	0.017	0.174	0.000	0.123	0.135	0.244	1.208	0.887
Cannonball Mtn1	81	0.503	0.088	0.017	0.176	0.000	0.115	0.134	0.232	1.171	0.857
Cannonball Mtn1	81	0.514	0.092	0.017	0.183	0.000	0.123	0.135	0.215	1.131	0.828
Cannonball Mtn1	81	0.443	0.079	0.015	0.171	0.000	0.123	0.136	0.242	1.224	0.898
Cannonball Mtn1	81	0.487	0.087	0.020	0.176	0.000	0.124	0.133	0.216	1.193	0.906
Cannonball Mtn1	81	0.457	0.082	0.016	0.176	0.000	0.121	0.137	0.247	1.226	0.901
Cannonball Mtn1	81	0.460	0.084	0.017	0.172	0.000	0.122	0.140	0.234	1.178	0.865
Cannonball Mtn1	81	0.461	0.084	0.018	0.173	0.000	0.125	0.130	0.229	1.157	0.843
Cannonball Mtn1	81	0.470	0.085	0.016	0.177	0.000	0.120	0.141	0.225	1.203	0.882
Cannonball Mtn1	81	0.449	0.082	0.020	0.172	0.000	0.125	0.140	0.214	1.169	0.838
Cannonball Mtn1	81	0.472	0.084	0.016	0.175	0.000	0.120	0.137	0.219	1.187	0.879
Cannonball Mtn2	82	1.152	0.204	0.038	0.254	0.000	0.173	0.191	0.226	1.895	1.425
Cannonball Mtn2	82	1.193	0.202	0.040	0.250	0.000	0.164	0.182	0.214	1.820	1.338
Cannonball Mtn2	82	1.273	0.224	0.032	0.266	0.000	0.242	0.200	0.213	1.662	1.191
Cannonball Mtn2	82	1.203	0.210	0.035	0.241	0.000	0.173	0.201	0.235	1.846	1.401
Cannonball Mtn2	82	1.202	0.207	0.031	0.254	0.000	0.174	0.202	0.238	1.883	1.431
Cannonball Mtn2	82	1.182	0.206	0.031	0.263	0.000	0.177	0.199	0.232	1.869	1.437
Cannonball Mtn2	82	1.181	0.213	0.035	0.260	0.000	0.175	0.180	0.272	1.824	1.354
Cannonball Mtn2	82	1.101	0.201	0.031	0.248	0.000	0.179	0.196	0.216	1.781	1.314
Cannonball Mtn2	82	1.183	0.206	0.029	0.256	0.000	0.183	0.192	0.232	1.745	1.297
Cannonball Mtn2	82	1.173	0.213	0.030	0.260	0.000	0.192	0.198	0.210	1.683	1.251
Cannonball Mtn2	82	1.187	0.214	0.032	0.260	0.000	0.183	0.201	0.211	1.729	1.296
Cannonball Mtn2	82	1.137	0.201	0.027	0.247	0.000	0.182	0.187	0.213	1.786	1.370
Cannonball Mtn2	82	1.166	0.215	0.030	0.291	0.000	0.183	0.187	0.229	1.769	1.358
Wedge Butte, ID	83	1.040	0.185	0.070	1.767	0.000	1.213	1.051	0.169	7.923	5.505
Wedge Butte, ID	83	1.353	0.248	0.073	2.116	0.000	1.415	1.173	0.183	8.904	5.932
Wedge Butte, ID	83	1.311	0.238	0.090	2.219	0.000	1.440	1.257	0.191	9.502	6.589
Wedge Butte, ID	83	0.995	0.167	0.069	1.757	0.000	1.270	1.063	0.170	8.429	6.004
Wedge Butte, ID	83	1.315	0.239	0.085	2.192	0.000	1.521	1.187	0.160	9.596	6.363
Wedge Butte, ID	83	0.882	0.156	0.061	1.417	0.000	1.013	0.824	0.180	6.251	4.181
Wedge Butte, ID	83	1.140	0.201	0.077	2.082	0.000	1.410	1.112	0.148	9.351	6.673
Wedge Butte, ID	83	1.375	0.231	0.089	2.088	0.000	1.509	1.257	0.173	9.236	6.245
Wedge Butte, ID	83	1.183	0.226	0.078	1.934	0.000	1.285	1.068	0.164	7.802	5.204
Wedge Butte, ID	83	1.238	0.216	0.077	2.047	0.000	1.447	1.178	0.183	9.130	6.129

Wedge Butte, ID	83	1.158	0.197	0.079	1.942	0.000	1.362	1.133	0.135	8.803	6.026
Wedge Butte, ID	83	1.342	0.228	0.086	2.249	0.000	1.566	1.223	0.153	10.458	7.135
Wedge Butte, ID	83	1.115	0.190	0.071	1.910	0.000	1.326	1.113	0.168	8.792	6.088
Wedge Butte, ID	83	1.161	0.208	0.071	1.909	0.000	1.338	1.044	0.183	8.357	5.668
CoalBank Spring	84	0.696	0.120	0.020	0.249	0.047	0.175	0.026	0.224	2.500	1.768
CoalBank Spring	84	0.898	0.158	0.021	0.294	0.043	0.202	0.131	0.237	2.834	2.002
CoalBank Spring	84	0.680	0.121	0.016	0.277	0.044	0.183	0.152	0.230	2.794	2.052
CoalBank Spring	84	0.749	0.139	0.016	0.269	0.057	0.186	0.141	0.221	2.944	2.138
CoalBank Spring	84	0.852	0.151	0.018	0.295	0.057	0.182	0.128	0.210	2.462	1.752
CoalBank Spring	84	0.874	0.153	0.014	0.239	0.050	0.167	0.117	0.214	2.512	1.840
CoalBank Spring	84	0.676	0.118	0.013	0.250	0.046	0.192	0.120	0.212	2.507	1.789
CoalBank Spring	84	0.705	0.124	0.017	0.289	0.051	0.216	0.134	0.222	2.844	1.996
CoalBank Spring	84	0.785	0.134	0.015	0.267	0.047	0.186	0.136	0.205	2.531	1.824
CoalBank Spring	84	0.687	0.121	0.018	0.258	0.040	0.180	0.151	0.228	2.708	1.962
CoalBank Spring	84	0.727	0.127	0.016	0.237	0.043	0.178	0.143	0.223	2.555	1.881
CoalBank Spring	84	0.670	0.123	0.012	0.245	0.047	0.185	0.130	0.221	2.630	1.922
CoalBank Spring	84	0.721	0.126	0.018	0.295	0.056	0.205	0.152	0.206	2.752	1.948
CoalBank Spring	84	0.735	0.128	0.017	0.315	0.059	0.179	0.123	0.223	2.690	2.010
CoalBank Spring	84	0.696	0.124	0.019	0.296	0.050	0.194	0.149	0.243	2.680	1.965
CoalBank Spring	84	0.885	0.155	0.019	0.326	0.054	0.221	0.164	0.237	2.982	2.153
CoalBank Spring	84	0.787	0.140	0.014	0.300	0.061	0.219	0.145	0.214	2.755	1.965
CoalBank Spring	84	0.807	0.143	0.024	0.322	0.053	0.222	0.151	0.232	3.065	2.219
CoalBank Spring	84	0.707	0.121	0.015	0.312	0.037	0.196	0.133	0.215	2.942	2.198
CoalBank Spring	84	0.737	0.133	0.019	0.308	0.042	0.203	0.138	0.218	2.823	2.073
CoalBank Spring	84	0.714	0.130	0.017	0.331	0.048	0.212	0.140	0.241	3.053	2.296
CoalBank Spring	84	0.711	0.122	0.013	0.273	0.045	0.185	0.093	0.220	2.741	1.946
CoalBank Spring	84	0.802	0.142	0.016	0.285	0.050	0.180	0.125	0.227	2.685	2.001
CoalBank Spring	84	0.706	0.121	0.015	0.290	0.052	0.187	0.135	0.229	2.766	1.947
CoalBank Spring	84	0.667	0.120	0.014	0.280	0.041	0.186	0.127	0.232	2.699	1.972
CoalBank Spring	84	0.701	0.125	0.012	0.310	0.050	0.218	0.133	0.226	2.954	2.184
CoalBank Spring	84	0.645	0.115	0.012	0.288	0.039	0.195	0.141	0.199	2.800	2.065
CoalBank Spring	84	0.669	0.119	0.015	0.310	0.050	0.208	0.158	0.226	3.272	2.374
CoalBank Spring	84	0.704	0.119	0.013	0.326	0.045	0.208	0.148	0.222	2.990	2.249
CoalBank Spring	84	0.706	0.125	0.015	0.330	0.051	0.201	0.150	0.211	3.030	2.217
CoalBank Spring	84	0.684	0.117	0.016	0.297	0.046	0.188	0.129	0.229	2.767	2.048
CoalBank Spring	84	0.662	0.118	0.014	0.293	0.037	0.179	0.136	0.258	2.698	2.030
CoalBank Spring	84	0.664	0.117	0.012	0.262	0.051	0.192	0.149	0.232	2.861	2.048
CoalBank Spring	84	0.687	0.118	0.013	0.276	0.039	0.178	0.150	0.184	2.683	2.022
CoalBank Spring	84	0.670	0.118	0.015	0.271	0.044	0.180	0.094	0.227	2.707	1.989
CoalBank Spring	84	0.670	0.117	0.014	0.266	0.044	0.144	0.127	0.165	2.664	1.933
Gibson Ck., Id	85	0.774	0.138	0.016	0.289	0.042	0.238	0.195	0.211	3.777	2.648
Gibson Ck., Id	85	0.759	0.132	0.015	0.285	0.033	0.222	0.227	0.234	3.974	2.873
Gibson Ck., Id	85	0.720	0.129	0.018	0.317	0.032	0.225	0.202	0.232	4.035	2.765
Gibson Ck., Id	85	0.681	0.126	0.018	0.297	0.033	0.213	0.203	0.228	4.074	2.859
Gibson Ck., Id	85	0.752	0.137	0.013	0.303	0.033	0.225	0.209	0.231	4.039	2.860
Gibson Ck., Id	85	0.761	0.143	0.016	0.289	0.034	0.234	0.227	0.228	3.884	2.754
Gibson Ck., Id	85	0.771	0.131	0.014	0.307	0.032	0.209	0.194	0.219	4.149	2.757
Gibson Ck., Id	85	0.612	0.116	0.013	0.249	0.029	0.179	0.166	0.240	3.544	2.525

Gibson Ck., Id	85	0.740	0.137	0.017	0.298	0.043	0.221	0.220	).224	4.049	2.835
Gibson Ck., Id	85	0.724	0.130	0.014	0.300	0.032	0.227	0.227	).223	3.834	2.663
Gibson Ck., Id	85	0.732	0.127	0.016	0.323	0.025	0.225	0.219	).222	4.203	2.996
Gibson Ck., Id	85	0.703	0.131	0.016	0.317	0.033	0.220	0.203	).223	4.430	3.238
Gibson Ck., Id	85	0.742	0.139	0.017	0.299	0.032	0.221	0.207	).230	4.122	2.952
Gibson Ck., Id	85	0.756	0.135	0.015	0.296	0.033	0.210	0.209	).229	3.959	2.842
Gibson Ck., Id	85	0.699	0.127	0.015	0.284	0.037	0.222	0.208	).222	3.989	2.786
Graham Spring,	85	0.775	0.137	0.017	0.335	0.036	0.229	0.215	0.224	4.584	3.256
Graham Spring,	85	0.769	0.136	0.019	0.347	0.036	0.228	0.217	0.225	4.514	3.136
Graham Spring,	85	0.772	0.135	0.000	0.351	0.047	0.247	0.218	0.234	4.235	2.901
Graham Spring,	85	0.759	0.133	0.012	0.301	0.040	0.250	0.240	0.234	4.136	2.924
Graham Spring,	85	0.741	0.126	0.011	0.332	0.032	0.227	0.222	0.226	4.181	2.964
Graham Spring,	85	0.779	0.137	0.013	0.328	0.037	0.205	0.189	0.250	4.510	3.200
Graham Spring,	85	0.790	0.139	0.014	0.344	0.037	0.246	0.227	0.233	4.643	3.294
Graham Spring,	85	0.783	0.139	0.015	0.334	0.032	0.258	0.214	0.217	4.082	2.833
Graham Spring,	85	0.795	0.146	0.024	0.354	0.030	0.234	0.207	0.213	4.444	3.105
Graham Spring,	85	0.752	0.135	0.000	0.337	0.029	0.232	0.203	0.217	4.772	3.398
Graham Spring,	85	0.832	0.155	0.000	0.342	0.000	0.240	0.229	0.192	4.054	2.662
Graham Spring,	85	0.934	0.166	0.000	0.327	0.000	0.266	0.215	0.216	4.082	2.753
Graham Spring,	85	0.785	0.127	0.016	0.357	0.033	0.244	0.224	0.234	4.219	2.957
Graham Spring,	85	0.807	0.146	0.018	0.358	0.033	0.225	0.226	0.230	4.320	2.979
Graham Spring,	85	0.845	0.173	0.000	0.325	0.000	0.236	0.230	0.213	5.237	3.218
Moody Swamp, ID	85	0.762	0.135	0.015	0.305	0.043	0.216	0.204	0.215	3.989	2.837
Moody Swamp, ID	85	0.788	0.140	0.017	0.331	0.027	0.226	0.193	0.202	3.965	2.730
Moody Swamp, ID	85	0.834	0.144	0.020	0.335	0.041	0.243	0.225	0.224	4.176	2.946
Moody Swamp, ID	85	0.817	0.144	0.020	0.299	0.031	0.235	0.183	0.226	4.456	3.110
Moody Swamp, ID	85	0.737	0.131	0.021	0.290	0.034	0.219	0.206	0.215	3.911	2.759
Moody Swamp, ID	85	0.845	0.154	0.020	0.363	0.042	0.239	0.230	0.218	4.436	2.993
Moody Swamp, ID	85	0.794	0.142	0.022	0.338	0.037	0.232	0.187	0.222	4.402	3.103
Moody Swamp, ID	85	0.854	0.151	0.015	0.316	0.039	0.236	0.213	0.224	4.111	2.878
Moody Swamp, ID	85	0.808	0.147	0.016	0.312	0.036	0.214	0.194	0.264	3.844	2.695
Moody Swamp, ID	85	0.787	0.140	0.017	0.319	0.037	0.225	0.217	0.218	4.286	3.071
Moody Swamp, ID	85	0.768	0.136	0.017	0.309	0.028	0.218	0.202	0.222	4.397	3.059
Moody Swamp, ID	85	0.789	0.135	0.017	0.351	0.042	0.248	0.212	0.206	4.405	3.100
Moody Swamp, ID	85	0.801	0.140	0.018	0.338	0.035	0.223	0.226	0.213	4.168	2.949
Moody Swamp, ID	85	0.792	0.144	0.018	0.355	0.041	0.242	0.204	0.233	4.389	3.098
Corral Ck, ID	86	0.719	0.132	0.012	0.252	0.029	0.198	0.196	0.231	3.655	2.550
Corral Ck, ID	86	0.687	0.119	0.014	0.252	0.033	0.179	0.177	0.224	3.328	2.379
Corral Ck, ID	86	0.673	0.120	0.012	0.254	0.037	0.195	0.197	0.231	3.375	2.290
Corral Ck, ID	86	0.638	0.115	0.011	0.229	0.030	0.193	0.196	0.237	3.423	2.368
Corral Ck, ID	86	0.680	0.121	0.013	0.250	0.038	0.191	0.210	0.236	3.647	2.507
Corral Ck, ID	86	0.700	0.119	0.014	0.261	0.039	0.202	0.201	0.226	3.609	2.514
Corral Ck, ID	86	0.647	0.118	0.015	0.238	0.037	0.193	0.191	0.214	3.367	2.354
Corral Ck, ID	86	0.662	0.118	0.013	0.253	0.028	0.187	0.185	0.251	3.330	2.384
Corral Ck, ID	86	0.694	0.129	0.015	0.243	0.035	0.199	0.203	0.242	3.438	2.447
Corral Ck, ID	86	0.629	0.113	0.013	0.249	0.030	0.188	0.190	0.261	3.458	2.488
Corral Ck, ID	86	0.694	0.125	0.012	0.250	0.038	0.181	0.179	0.239	3.429	2.432
Corral Ck, ID	86	0.639	0.115	0.014	0.248	0.036	0.195	0.192	0.226	3.649	2.603

Corral Ck, ID	86	0.670	0.114	0.012	0.273	0.029	0.192	0.204	0.254	3.613	2.603
Corral Ck, ID	86	0.722	0.132	0.013	0.256	0.033	0.196	0.188	0.256	3.481	2.419
Corral Ck, ID	86	0.680	0.122	0.015	0.249	0.036	0.186	0.190	0.232	3.557	2.495
Cow Creek	86	0.704	0.121	0.014	0.274	0.033	0.195	0.170	0.213	3.497	2.520
Cow Creek	86	0.708	0.129	0.014	0.301	0.033	0.197	0.190	0.208	3.872	2.751
Cow Creek	86	0.717	0.131	0.019	0.307	0.035	0.214	0.204	0.239	4.053	2.906
Cow Creek	86	0.711	0.118	0.015	0.299	0.033	0.200	0.197	0.221	3.667	2.746
Cow Creek	86	0.875	0.152	0.016	0.283	0.038	0.190	0.171	0.199	4.127	2.982
Cow Creek	86	0.736	0.134	0.014	0.286	0.032	0.210	0.179	0.198	3.451	2.545
Cow Creek	86	0.716	0.126	0.015	0.310	0.033	0.212	0.213	0.204	4.280	3.138
Cow Creek	86	0.610	0.109	0.010	0.268	0.030	0.194	0.175	0.229	3.953	2.830
Cow Creek	86	0.755	0.136	0.019	0.305	0.044	0.215	0.216	0.233	4.210	2.955
Cow Creek	86	0.687	0.127	0.011	0.309	0.038	0.232	0.202	0.230	4.348	3.087
Cow Creek	86	0.669	0.124	0.014	0.311	0.042	0.231	0.223	0.226	5.004	3.534
Cow Creek	86	0.725	0.123	0.015	0.303	0.033	0.216	0.198	0.223	4.552	3.203
Cow Creek	86	0.735	0.131	0.011	0.298	0.044	0.226	0.232	0.243	4.094	2.836
Cow Creek	86	0.786	0.132	0.014	0.308	0.034	0.227	0.207	0.219	4.526	3.177
Cow Creek	86	0.769	0.134	0.016	0.321	0.043	0.239	0.183	0.247	3.975	2.717
Lava Ck.,ID	86	0.689	0.127	0.010	0.292	0.039	0.217	0.185	0.245	3.844	2.700
Lava Ck.,ID	86	0.675	0.126	0.013	0.286	0.034	0.207	0.210	0.230	4.129	2.892
Lava Ck.,ID	86	0.730	0.136	0.015	0.313	0.044	0.219	0.194	0.240	4.258	3.164
Lava Ck.,ID	86	0.718	0.134	0.016	0.307	0.042	0.228	0.200	0.231	4.287	3.060
Lava Ck.,ID	86	0.719	0.130	0.014	0.309	0.039	0.228	0.199	0.219	4.317	3.117
Lava Ck.,ID	86	0.741	0.136	0.015	0.311	0.043	0.216	0.202	0.216	4.163	2.810
Medicine Lodge	86	0.739	0.126	0.014	0.296	0.043	0.219	0.215	0.218	4.111	2.876
Medicine Lodge	86	0.794	0.135	0.000	0.274	0.026	0.209	0.198	0.228	4.083	2.791
Medicine Lodge	86	0.731	0.131	0.012	0.279	0.033	0.223	0.233	0.212	3.942	2.754
Medicine Lodge	86	0.726	0.127	0.017	0.302	0.030	0.228	0.215	0.229	3.969	2.819
Medicine Lodge	86	0.724	0.129	0.015	0.310	0.040	0.229	0.209	0.225	4.132	2.883
Medicine Lodge	86	0.724	0.126	0.014	0.304	0.037	0.219	0.198	0.237	4.044	2.847
Medicine Lodge	86	0.773	0.140	0.021	0.309	0.025	0.208	0.205	0.209	3.837	2.629
Medicine Lodge	86	0.701	0.127	0.013	0.296	0.038	0.218	0.201	0.223	4.184	3.060
Medicine Lodge	86	0.700	0.129	0.015	0.298	0.037	0.227	0.212	0.253	4.154	2.924
Medicine Lodge	86	0.839	0.149	0.017	0.286	0.036	0.215	0.200	0.226	4.035	2.823
Medicine Lodge	86	0.703	0.127	0.013	0.294	0.026	0.219	0.199	0.210	4.120	2.927
Medicine Lodge	86	0.753	0.133	0.015	0.309	0.027	0.221	0.208	0.218	3.899	2.633
Medicine Lodge	86	0.726	0.133	0.016	0.294	0.034	0.220	0.197	0.222	3.885	2.778
Medicine Lodge	86	0.725	0.135	0.014	0.290	0.034	0.214	0.196	0.216	3.929	2.787
Medicine Lodge	86	0.695	0.123	0.013	0.275	0.046	0.223	0.224	0.222	4.006	2.797
Medicine Lodge	86	0.716	0.128	0.015	0.296	0.031	0.209	0.221	0.249	3.948	2.775
Medicine Lodge	86	0.744	0.135	0.014	0.267	0.025	0.200	0.193	0.207	3.855	2.767
Medicine Lodge	86	0.760	0.138	0.017	0.299	0.031	0.189	0.187	0.229	3.833	2.740
Medicine Lodge	86	0.748	0.133	0.017	0.290	0.034	0.200	0.187	0.204	4.005	2.869
Medicine Lodge	86	0.756	0.135	0.012	0.307	0.037	0.196	0.194	0.215	3.740	2.617
Medicine Lodge	86	0.744	0.131	0.015	0.291	0.040	0.202	0.187	0.218	3.824	2.671
Medicine Lodge	86	0.774	0.142	0.013	0.284	0.035	0.202	0.190	0.220	3.705	2.645
Medicine Lodge	86	0.731	0.125	0.015	0.322	0.032	0.210	0.184	0.217	4.161	2.915
Medicine Lodge	86	0.690	0.117	0.011	0.291	0.033	0.191	0.174	0.218	4.080	3.033

Medicine Lodge	86	0.686	0.124	0.014	0.256	0.033	0.206	0.189	0.231	[illegible].067	2.917
Medicine Lodge	86	0.752	0.133	0.015	0.277	0.032	0.193	0.175	0.214	[illegible].861	2.726
Medicine Lodge	86	0.815	0.147	0.016	0.296	0.034	0.206	0.207	0.232	[illegible].890	2.685
Medicine Lodge	86	0.685	0.124	0.014	0.268	0.032	0.194	0.184	0.217	[illegible].795	2.704
Medicine Lodge	86	0.732	0.129	0.013	0.295	0.035	0.196	0.186	0.225	[illegible].879	2.750
Medicine Lodge	86	0.739	0.133	0.017	0.280	0.027	0.199	0.199	0.213	3.990	2.841
Malad	87	1.311	0.229	0.000	0.728	0.484	0.398	0.161	0.199	15.347	10.348
Malad	87	1.336	0.247	0.000	0.713	0.441	0.424	0.183	0.234	14.351	9.905
Malad	87	1.547	0.269	0.000	0.741	0.462	0.406	0.179	0.194	13.802	9.250
Malad	87	1.220	0.227	0.019	0.676	0.456	0.383	0.192	0.151	12.867	8.778
Malad	87	1.381	0.269	0.026	0.742	0.524	0.419	0.182	0.244	13.900	92.490
Malad	87	1.347	0.241	0.028	0.738	0.487	0.394	0.163	0.231	14.578	10.105
Malad	87	1.392	0.242	0.000	0.785	0.487	0.441	0.176	0.192	13.788	9.276
Malad	87	1.356	0.238	0.029	0.796	0.442	0.396	0.196	0.149	13.699	9.378
Malad	87	1.263	0.238	0.032	0.746	0.489	0.411	0.208	0.202	13.504	9.440
Malad	87	1.237	0.222	0.021	0.737	0.466	0.419	0.200	0.221	14.559	10.008
Malad	87	1.399	0.237	0.000	0.714	0.465	0.451	0.185	0.240	13.620	9.301
Malad	87	1.344	0.234	0.024	0.696	0.435	0.406	0.204	0.207	13.542	9.313
Malad	87	1.360	0.242	0.032	0.763	0.469	0.389	0.178	0.203	13.934	9.768
Malad	87	1.314	0.202	0.033	0.711	0.467	0.390	0.190	0.201	14.440	10.103
Malad	87	1.322	0.231	0.018	0.743	0.464	0.378	0.200	0.219	14.728	10.329
Malad	87	1.381	0.251	0.000	0.794	0.485	0.395	0.186	0.232	15.646	10.911
Hawkins, ID	87	1.379	0.248	0.014	0.722	0.443	0.407	0.200	0.166	14.275	9.923
Hawkins, ID	87	1.393	0.250	0.000	0.757	0.510	0.432	0.200	0.217	13.652	9.369
Hawkins, ID	87	1.281	0.245	0.036	0.684	0.451	0.445	0.195	0.244	13.834	9.753
Hawkins, ID	87	1.491	0.277	0.000	0.737	0.454	0.405	0.173	0.185	13.082	8.596
Hawkins, ID	87	1.333	0.243	0.022	0.762	0.475	0.432	0.164	0.206	15.084	10.646
Hawkins, ID	87	1.405	0.263	0.028	0.774	0.479	0.434	0.153	0.164	14.954	10.384
Hawkins, ID	87	1.387	0.248	0.074	0.754	0.447	0.400	0.180	0.227	14.686	10.017
Hawkins, ID	87	1.256	0.246	0.000	0.684	0.448	0.409	0.188	0.171	14.193	9.825
Hawkins, ID	87	1.367	0.266	0.038	0.788	0.515	0.421	0.183	0.220	14.749	10.126
Hawkins, ID	87	1.279	0.237	0.059	0.712	0.489	0.423	0.192	0.213	14.099	9.786
Hawkins, ID	87	1.425	0.262	0.019	0.759	0.506	0.440	0.182	0.199	15.317	10.578
Hawkins, ID	87	1.428	0.287	0.032	0.843	0.510	0.458	0.179	0.181	15.602	10.451
Hawkins, ID	87	1.485	0.260	0.000	0.896	0.499	0.414	0.153	0.196	15.186	10.621
Hawkins, ID	87	1.524	0.280	0.053	0.910	0.555	0.416	0.146	0.230	15.832	10.562
Hawkins, ID	87	1.395	0.253	0.051	0.721	0.472	0.410	0.183	0.185	15.284	10.820
Hawkins, ID	87	1.404	0.248	0.000	0.747	0.490	0.397	0.167	0.176	14.461	10.041
Hawkins, ID	87	1.401	0.253	0.000	0.721	0.447	0.418	0.173	0.204	13.960	9.811
Hawkins, ID	87	1.333	0.232	0.000	0.756	0.433	0.393	0.196	0.214	14.191	10.009
Hawkins, ID	87	1.355	0.237	0.000	0.649	0.455	0.409	0.181	0.272	14.065	9.853
Hawkins, ID	87	1.316	0.243	0.000	0.637	0.454	0.399	0.213	0.198	13.460	9.132
Hawkins, ID	87	1.375	0.242	0.031	0.729	0.467	0.423	0.201	0.224	14.231	9.660
Hawkins, ID	87	1.424	0.256	0.000	0.763	0.487	0.432	0.190	0.243	14.633	9.961
Hawkins, ID	87	1.454	0.263	0.000	0.736	0.463	0.400	0.172	0.156	14.503	9.810
Hawkins, ID	87	1.330	0.229	0.000	0.661	0.432	0.408	0.217	0.190	13.817	9.268
Hawkins, ID	87	1.414	0.256	0.000	0.733	0.454	0.431	0.197	0.219	13.951	9.576
Hawkins, ID	87	1.343	0.236	0.000	0.711	0.511	0.412	0.172	0.160	14.197	9.632

Hawkins, ID	87	1.424	0.249	0.000	0.785	0.473	0.376	0.207	[illegible]	14.457	10.078
Hawkins, ID	87	1.361	0.238	0.000	0.768	0.444	0.408	0.161	[illegible]	13.469	9.129
Wright Ck., ID	87	1.346	0.242	0.000	0.734	0.488	0.402	0.174	[illegible]	13.876	9.119
Wright Ck., ID	87	1.333	0.240	0.000	0.673	0.449	0.410	0.169	0.190	12.668	8.657
Wright Ck., ID	87	1.341	0.245	0.027	0.719	0.442	0.390	0.168	0.165	14.638	9.864
Wright Ck., ID	87	1.629	0.282	0.000	0.792	0.513	0.447	0.178	0.183	14.010	8.971
Wright Ck., ID	87	1.456	0.257	0.035	0.778	0.473	0.401	0.153	0.161	14.674	9.955
Wright Ck., ID	87	1.370	0.229	0.020	0.746	0.460	0.382	0.174	0.178	13.132	8.902
Wright Ck., ID	87	1.428	0.267	0.037	0.782	0.459	0.401	0.202	0.159	14.214	9.634
Wright Ck., ID	87	1.467	0.267	0.023	0.742	0.481	0.426	0.159	0.232	14.509	9.945
Wright Ck., ID	87	1.534	0.267	0.000	0.746	0.522	0.455	0.159	0.224	15.427	10.713
Wright Ck., ID	87	1.413	0.265	0.018	0.755	0.493	0.394	0.156	0.161	14.558	9.950
Wright Ck., ID	87	1.296	0.240	0.000	0.689	0.469	0.417	0.227	0.210	13.827	9.611
Wright Ck., ID	87	1.460	0.260	0.000	0.817	0.484	0.420	0.163	0.174	13.558	8.984
Wright Ck., ID	87	1.378	0.252	0.000	0.758	0.487	0.392	0.165	0.179	14.024	9.719
Wright Ck., ID	87	1.406	0.262	0.026	0.754	0.469	0.418	0.206	0.171	13.935	9.948
Wright Ck., ID	87	1.249	0.213	0.000	0.693	0.405	0.389	0.164	0.109	14.076	9.485
Deep Ck., ID	88	0.829	0.142	0.017	0.552	0.070	0.321	0.254	0.213	5.345	3.628
Deep Ck., ID	88	0.762	0.136	0.023	0.451	0.062	0.285	0.242	0.240	5.688	3.889
Deep Ck., ID	88	0.776	0.140	0.022	0.454	0.050	0.287	0.255	0.207	5.838	4.145
Deep Ck., ID	88	0.729	0.132	0.019	0.416	0.057	0.316	0.252	0.198	5.535	3.815
Deep Ck., ID	88	0.766	0.137	0.022	0.527	0.066	0.290	0.246	0.226	5.650	3.900
Deep Ck., ID	88	0.763	0.129	0.020	0.443	0.056	0.298	0.258	0.239	5.764	3.969
Deep Ck., ID	88	0.737	0.132	0.020	0.447	0.061	0.302	0.254	0.223	5.661	3.823
Deep Ck., ID	88	0.719	0.131	0.022	0.431	0.061	0.307	0.237	0.220	5.626	3.942
Deep Ck., ID	88	0.731	0.132	0.021	0.444	0.064	0.290	0.259	0.243	5.850	4.166
Deep Ck., ID	88	0.781	0.133	0.027	0.453	0.063	0.289	0.254	0.213	5.534	3.757
Deep Ck., ID	88	0.769	0.140	0.022	0.430	0.058	0.304	0.238	0.214	5.499	3.768
Deep Ck., ID	88	0.713	0.119	0.018	0.433	0.046	0.285	0.261	0.216	5.701	4.017
Deep Ck., ID	88	0.753	0.133	0.014	0.439	0.058	0.280	0.222	0.214	5.409	3.816
Deep Ck., ID	88	0.662	0.126	0.016	0.439	0.062	0.300	0.257	0.234	5.676	3.955
Deep Ck., ID	88	0.670	0.115	0.015	0.431	0.059	0.292	0.235	0.215	5.770	4.086
Deep Ck., ID	88	0.759	0.133	0.019	0.503	0.060	0.315	0.268	0.213	5.911	4.074
Deep Ck., ID	88	0.757	0.137	0.021	0.441	0.059	0.286	0.257	0.236	5.618	3.860
Deep Ck., ID	88	0.731	0.124	0.019	0.472	0.057	0.288	0.289	0.266	5.974	4.112
Deep Ck., ID	88	0.726	0.131	0.021	0.465	0.068	0.313	0.222	0.217	5.844	4.122
Deep Ck., ID	88	0.832	0.148	0.021	0.451	0.061	0.302	0.236	0.219	5.396	3.625
Deep Ck., ID	88	0.729	0.125	0.022	0.456	0.061	0.289	0.233	0.214	5.868	3.974
Deep Ck., ID	88	0.733	0.128	0.016	0.436	0.062	0.301	0.249	0.232	5.986	4.117
Deep Ck., ID	88	0.774	0.152	0.023	0.478	0.053	0.290	0.246	0.249	5.930	4.070
Deep Ck., ID	88	0.750	0.132	0.023	0.449	0.058	0.286	0.253	0.217	5.705	4.059
Deep Ck., ID	88	0.690	0.118	0.019	0.443	0.050	0.277	0.259	0.224	6.360	4.542
Deep Ck., ID	88	0.733	0.132	0.019	0.461	0.054	0.292	0.261	0.205	5.969	4.224
Deep Ck., ID	88	0.789	0.129	0.000	0.392	0.037	0.297	0.236	0.227	5.136	3.565
Deep Ck., ID	88	0.768	0.133	0.023	0.457	0.066	0.293	0.224	0.204	5.550	3.884
Deep Ck., ID	88	0.699	0.123	0.019	0.411	0.050	0.273	0.252	0.252	5.334	3.750
Deep Ck., ID	88	0.781	0.141	0.022	0.498	0.053	0.291	0.237	0.205	5.642	3.954
Deep Ck., ID	88	0.697	0.123	0.014	0.452	0.052	0.288	0.233	0.212	5.290	3.651

Deep Ck., ID	88	0.705	0.126	0.018	0.438	0.056	0.294	0.236	0.233	5.502	3.776
Deep Ck., ID	88	0.750	0.129	0.020	0.483	0.066	0.310	0.239	0.223	5.795	4.145
Deep Ck., ID	88	0.742	0.134	0.018	0.406	0.049	0.264	0.268	0.221	5.521	3.804
Deep Ck., ID	88	0.730	0.127	0.017	0.467	0.055	0.295	0.252	0.232	5.630	3.862
Deep Ck., ID	88	0.690	0.117	0.019	0.435	0.058	0.303	0.237	0.234	5.607	3.891
Deep Ck., ID	88	0.733	0.127	0.025	0.425	0.051	0.292	0.274	0.233	5.445	3.815
Deep Ck., ID	88	0.743	0.124	0.019	0.425	0.061	0.281	0.247	0.202	5.360	3.645
Deep Ck., ID	88	0.744	0.126	0.021	0.440	0.056	0.275	0.251	0.210	5.749	4.020
Deep Ck., ID	88	0.690	0.116	0.016	0.415	0.044	0.265	0.251	0.211	5.207	3.608
Deep Ck., ID	88	0.716	0.126	0.015	0.501	0.064	0.282	0.257	0.224	5.633	3.991
Chesterfield	89	1.248	0.219	0.015	0.196	0.669	0.107	0.049	0.178	7.448	5.228
Chesterfield	89	1.243	0.213	0.012	0.233	0.684	0.139	0.054	0.185	6.557	4.479
Chesterfield	89	1.231	0.211	0.011	0.202	0.686	0.123	0.055	0.183	6.664	4.629
Chesterfield	89	1.253	0.228	0.011	0.205	0.688	0.131	0.048	0.167	6.315	4.347
Chesterfield	89	1.326	0.241	0.015	0.241	0.666	0.133	0.051	0.161	6.665	4.557
Chesterfield	89	1.242	0.222	0.014	0.216	0.666	0.142	0.046	0.161	6.394	4.501
Chesterfield	89	1.271	0.235	0.021	0.226	0.692	0.127	0.051	0.161	6.226	4.318
Chesterfield	89	1.204	0.212	0.012	0.205	0.672	0.114	0.049	0.149	6.387	4.345
Chesterfield	89	1.252	0.222	0.015	0.272	0.711	0.152	0.051	0.175	7.464	5.138
Chesterfield	89	1.216	0.218	0.017	0.241	0.699	0.131	0.032	0.177	6.908	4.934
Chesterfield	89	1.242	0.218	0.015	0.222	0.696	0.129	0.042	0.178	6.963	4.789
Chesterfield	89	1.262	0.219	0.017	0.186	0.671	0.121	0.051	0.171	6.531	4.567
Chesterfield	89	1.157	0.211	0	0.206	0.665	0.129	0.053	0.182	7.203	4.854
Chesterfield	89	1.251	0.226	0.015	0.208	0.683	0.119	0.047	0.181	6.656	4.658
Chesterfield	89	1.185	0.209	0.018	0.249	0.679	0.135	0.048	0.156	7.078	4.875
Bear Gulch, ID	90	0.793	0.146	0.014	0.319	0.093	0.165	0.222	0.216	3.871	2.729
Bear Gulch, ID	90	0.760	0.138	0.011	0.314	0.094	0.166	0.201	0.214	3.818	2.677
Bear Gulch, ID	90	0.770	0.141	0.016	0.315	0.086	0.166	0.203	0.220	4.043	2.889
Bear Gulch, ID	90	0.688	0.121	0.014	0.309	0.080	0.164	0.216	0.215	4.267	3.074
Bear Gulch, ID	90	0.708	0.127	0.012	0.312	0.094	0.179	0.209	0.219	4.049	2.928
Bear Gulch, ID	90	0.771	0.135	0.010	0.345	0.098	0.178	0.212	0.208	4.190	2.901
Bear Gulch, ID	90	0.790	0.136	0.027	0.335	0.088	0.194	0.205	0.191	4.103	2.638
Bear Gulch, ID	90	0.736	0.127	0.012	0.329	0.085	0.176	0.221	0.218	4.370	3.179
Bear Gulch, ID	90	0.762	0.137	0.011	0.344	0.088	0.182	0.219	0.206	4.312	3.015
Bear Gulch, ID	90	0.742	0.136	0.014	0.327	0.082	0.183	0.217	0.186	4.460	3.202
Bear Gulch, ID	90	0.765	0.136	0.014	0.335	0.089	0.179	0.222	0.204	4.360	2.971
Bear Gulch, ID	90	0.803	0.141	0.012	0.325	0.089	0.179	0.212	0.200	3.900	2.686
Bear Gulch, ID	90	0.731	0.128	0.012	0.341	0.086	0.181	0.217	0.209	4.458	3.244
Bear Gulch, ID	90	0.745	0.133	0.013	0.331	0.098	0.173	0.206	0.185	4.025	2.875
Bear Gulch, ID	90	0.763	0.136	0.014	0.327	0.081	0.172	0.213	0.223	4.168	2.989
Bear Gulch, ID	90	0.735	0.133	0.010	0.313	0.085	0.180	0.215	0.229	4.172	2.913
Bear Gulch, ID	90	0.705	0.128	0.012	0.308	0.081	0.169	0.216	0.231	4.462	3.184
Bear Gulch, ID	90	0.735	0.133	0.011	0.306	0.091	0.169	0.228	0.220	4.252	2.936
Bear Gulch, ID	90	0.711	0.125	0.014	0.308	0.082	0.170	0.229	0.248	4.246	3.056
Bear Gulch, ID	90	0.732	0.140	0.012	0.323	0.086	0.179	0.216	0.220	4.183	2.913
Bear Gulch, ID	90	0.872	0.157	0.017	0.329	0.089	0.167	0.222	0.210	4.013	2.787
Bear Gulch, ID	90	0.760	0.131	0.011	0.308	0.088	0.180	0.217	0.217	4.216	2.880
Bear Gulch, ID	90	0.760	0.143	0.013	0.303	0.077	0.165	0.236	0.239	4.239	2.992

Bear Gulch, ID	90	0.713	0.120	0.012	0.305	0.085	0.170	0.207	0.206	4.267	2.999
Bear Gulch, ID	90	0.682	0.122	0.010	0.309	0.094	0.176	0.239	0.218	4.153	2.928
Bear Gulch, ID	90	0.711	0.125	0.013	0.311	0.092	0.154	0.211	0.243	4.354	3.084
Bear Gulch, ID	90	0.689	0.126	0.012	0.328	0.081	0.179	0.233	0.240	4.218	2.921
Bear Gulch, ID	90	0.696	0.126	0.014	0.295	0.081	0.169	0.208	0.239	4.369	3.157
Bear Gulch, ID	90	0.726	0.128	0.010	0.305	0.077	0.168	0.217	0.244	4.443	3.219
Bear Gulch, ID	90	0.728	0.127	0.012	0.312	0.083	0.177	0.226	0.264	4.311	3.035
Bear Gulch, ID	90	0.679	0.123	0.014	0.296	0.079	0.174	0.243	0.254	4.262	3.029
Bear Gulch, ID	90	0.718	0.128	0.014	0.316	0.087	0.170	0.224	0.229	4.352	3.163
Bear Gulch, ID	90	0.714	0.126	0.012	0.295	0.080	0.177	0.225	0.231	4.003	2.786
Bear Gulch, ID	90	0.792	0.142	0.022	0.296	0.047	0.203	0.191	0.249	4.072	2.903
Bear Gulch, ID	90	0.688	0.122	0.010	0.303	0.086	0.171	0.228	0.252	4.387	3.129
Bear Gulch, ID	90	0.734	0.139	0.013	0.317	0.087	0.176	0.208	0.233	4.187	2.974
Bear Gulch, ID	90	0.684	0.122	0.012	0.308	0.089	0.179	0.236	0.236	4.515	3.230
Bear Gulch, ID	90	0.695	0.123	0.013	0.298	0.090	0.187	0.206	0.228	4.350	3.159
Bear Gulch, ID	90	0.696	0.123	0.014	0.328	0.079	0.188	0.223	0.205	4.471	3.231
Bear Gulch, ID	90	0.711	0.123	0.014	0.347	0.094	0.184	0.206	0.217	4.247	2.982
Bear Gulch, ID	90	0.698	0.127	0.015	0.355	0.083	0.180	0.214	0.214	4.381	3.095
Bear Gulch, ID	90	0.689	0.128	0.011	0.339	0.092	0.177	0.217	0.233	4.434	3.109
Bear Gulch, ID	90	0.732	0.128	0.013	0.339	0.083	0.173	0.221	0.237	4.385	3.081
Bear Gulch, ID	90	0.704	0.122	0.012	0.314	0.077	0.176	0.210	0.243	4.498	3.315
Bear Gulch, ID	90	0.730	0.135	0.015	0.295	0.078	0.167	0.200	0.201	4.525	3.284
Bear Gulch, ID	90	0.700	0.123	0.012	0.293	0.082	0.179	0.221	0.215	4.159	3.068
Bear Gulch, ID	90	0.728	0.123	0.015	0.305	0.087	0.169	0.220	0.205	4.458	3.167
Bear Gulch, ID	90	0.742	0.130	0.016	0.316	0.082	0.173	0.234	0.246	4.374	3.071
Bear Gulch, ID	90	0.775	0.152	0.013	0.287	0.086	0.165	0.226	0.242	4.505	3.201
Bear Gulch, ID	90	0.704	0.122	0.013	0.307	0.089	0.179	0.210	0.223	4.334	3.130
Larkspur Canyon	90	0.699	0.130	0.012	0.316	0.087	0.173	0.213	0.251	4.142	2.920
Larkspur Canyon	90	0.745	0.128	0.013	0.356	0.101	0.187	0.216	0.212	4.235	2.960
Larkspur Canyon	90	0.698	0.124	0.015	0.323	0.084	0.169	0.201	0.244	4.288	2.978
Larkspur Canyon	90	0.742	0.127	0.012	0.339	0.089	0.177	0.211	0.243	4.218	2.961
Larkspur Canyon	90	0.726	0.128	0.011	0.327	0.085	0.166	0.218	0.155	4.468	3.155
Larkspur Canyon	90	0.685	0.123	0.010	0.300	0.088	0.180	0.232	0.249	4.305	3.051
Larkspur Canyon	90	0.710	0.125	0.014	0.293	0.081	0.165	0.216	0.224	4.154	2.967
Larkspur Canyon	90	0.728	0.130	0.015	0.325	0.088	0.180	0.198	0.210	4.189	2.969
Larkspur Canyon	90	0.745	0.130	0.013	0.299	0.084	0.185	0.220	0.240	4.073	2.828
Larkspur Canyon	90	0.752	0.130	0.013	0.310	0.092	0.174	0.210	0.236	4.133	2.898
Larkspur Canyon	90	0.738	0.128	0.010	0.322	0.088	0.174	0.210	0.250	4.079	2.923
Larkspur Canyon	90	0.749	0.136	0.014	0.325	0.086	0.169	0.221	0.239	3.975	2.822
Larkspur Canyon	90	0.694	0.123	0.011	0.327	0.091	0.179	0.212	0.235	4.269	3.090
Larkspur Canyon	90	0.753	0.129	0.011	0.331	0.091	0.173	0.220	0.219	4.324	3.097
Larkspur Canyon	90	0.744	0.139	0.015	0.305	0.087	0.190	0.207	0.207	4.226	2.937
Larkspur Canyon	90	0.796	0.142	0.019	0.359	0.090	0.196	0.214	0.167	4.524	3.143
Larkspur Canyon	90	0.816	0.141	0.011	0.323	0.092	0.187	0.220	0.182	4.000	2.670
Larkspur Canyon	90	1.015	0.174	0.020	0.374	0.097	0.189	0.203	0.197	3.910	2.577
Larkspur Canyon	90	0.855	0.150	0.019	0.352	0.102	0.203	0.184	0.168	4.262	2.830
Larkspur Canyon	90	1.109	0.183	0.030	0.383	0.094	0.225	0.215	0.160	3.844	2.398
Larkspur Canyon	90	0.876	0.156	0.011	0.360	0.078	0.194	0.220	0.192	4.323	2.918

Larkspur Canyon	90	0.821	0.151	0.015	0.337	0.095	0.185	0.194	0.192	3.948	2.727
Larkspur Canyon	90	0.772	0.132	0.018	0.362	0.092	0.203	0.214	0.154	4.646	3.141
Larkspur Canyon	91	0.692	0.125	0.011	0.229	0.071	0.154	0.108	0.243	2.721	2.044
Larkspur Canyon	91	0.703	0.124	0.012	0.239	0.062	0.155	0.117	0.216	2.731	2.023
Cedar Ck 1, ID	91	0.739	0.133	0.009	0.237	0.070	0.158	0.105	0.229	2.635	1.915
Cedar Ck 1, ID	91	0.706	0.115	0.008	0.193	0.060	0.147	0.131	0.212	2.690	2.015
Cedar Ck 1, ID	91	0.678	0.117	0.008	0.198	0.060	0.161	0.138	0.232	2.681	1.937
Cedar Ck 1, ID	91	0.686	0.120	0.012	0.199	0.063	0.158	0.137	0.220	2.791	2.058
Cedar Ck 1, ID	91	0.757	0.141	0.011	0.210	0.065	0.157	0.132	0.212	2.609	1.899
Cedar Ck 1, ID	91	0.673	0.120	0.009	0.204	0.065	0.154	0.126	0.224	2.739	2.034
Cedar Ck 1, ID	91	0.686	0.120	0.011	0.211	0.066	0.155	0.136	0.229	2.737	1.975
Cedar Ck 2, ID	92	0.690	0.125	0.011	0.193	0.066	0.134	0.120	0.215	2.435	1.828
Cedar Ck 2, ID	92	0.709	0.129	0.011	0.186	0.070	0.138	0.118	0.223	2.416	1.752
Cedar Ck 2, ID	92	0.692	0.122	0.009	0.174	0.067	0.133	0.141	0.236	2.492	1.874
Cedar Ck 2, ID	92	0.685	0.122	0.011	0.163	0.069	0.125	0.103	0.227	2.222	1.661
Cedar Ck 2, ID	92	0.672	0.121	0.007	0.154	0.064	0.122	0.124	0.231	2.271	1.741
Cedar Ck 2, ID	92	0.705	0.129	0.010	0.155	0.071	0.123	0.101	0.227	2.157	1.599
CoalBank Spring	92	0.758	0.133	0.010	0.155	0.075	0.122	0.099	0.225	1.990	1.481
CoalBank Spring	92	0.691	0.125	0.009	0.142	0.079	0.117	0.099	0.231	2.048	1.559
CoalBank Spring	92	0.753	0.139	0.008	0.142	0.070	0.116	0.097	0.222	1.899	1.393
Camas Prairie,	93	0.744	0.132	0.009	0.166	0.070	0.115	0.109	0.230	1.959	1.412
Camas Prairie,	93	0.739	0.128	0.011	0.163	0.069	0.117	0.000	0.215	2.002	1.449
Camas Prairie,	93	0.724	0.130	0.010	0.161	0.067	0.114	0.111	0.240	2.081	1.559
Camas Prairie,	93	0.777	0.136	0.008	0.158	0.069	0.116	0.101	0.203	1.934	1.353
Camas Prairie,	93	0.738	0.130	0.011	0.172	0.071	0.115	0.076	0.233	2.017	1.441
Camas Prairie,	93	0.778	0.137	0.011	0.162	0.068	0.119	0.108	0.232	1.968	1.469
Camas Prairie,	93	0.706	0.124	0.009	0.169	0.071	0.128	0.110	0.220	1.968	1.472
Camas Prairie,	93	0.735	0.131	0.011	0.156	0.068	0.123	0.108	0.214	1.987	1.414
Camas Prairie,	93	0.750	0.135	0.010	0.161	0.068	0.118	0.107	0.217	2.107	1.565
Camas Prairie,	93	0.742	0.133	0.010	0.173	0.070	0.123	0.112	0.227	2.150	1.579
Camas Prairie,	93	0.707	0.123	0.007	0.174	0.070	0.125	0.112	0.232	2.172	1.593
Camas Prairie,	93	0.694	0.124	0.010	0.177	0.071	0.122	0.117	0.230	2.239	1.700
Camas Prairie,	93	0.692	0.118	0.011	0.167	0.074	0.124	0.117	0.214	2.221	1.583
Camas Prairie,	93	0.771	0.135	0.013	0.177	0.052	0.127	0.117	0.219	2.170	1.555
Camas Prairie,	93	0.757	0.139	0.009	0.164	0.069	0.136	0.109	0.218	2.138	1.526
Camas Prairie,	93	0.725	0.126	0.009	0.188	0.070	0.126	0.114	0.217	2.128	1.546
Camas Prairie,	93	0.721	0.127	0.009	0.175	0.065	0.123	0.090	0.218	2.189	1.625
Camas Prairie,	93	0.717	0.126	0.009	0.182	0.073	0.127	0.111	0.209	2.138	1.617
Camas Prairie,	93	0.716	0.129	0.008	0.171	0.070	0.131	0.119	0.231	2.185	1.627
Camas Prairie,	93	0.735	0.129	0.009	0.173	0.068	0.127	0.117	0.235	2.204	1.628
Camas Prairie,	93	0.757	0.138	0.010	0.176	0.072	0.130	0.120	0.228	2.187	1.558
Camas Prairie,	93	0.759	0.131	0.010	0.195	0.074	0.130	0.116	0.219	2.143	1.458
Camas Prairie,	93	0.742	0.136	0.011	0.184	0.068	0.093	0.117	0.211	2.197	1.590
Camas Prairie,	93	0.730	0.132	0.008	0.197	0.068	0.129	0.118	0.215	2.232	1.675
Camas Prairie,	93	0.717	0.126	0.009	0.194	0.063	0.128	0.116	0.223	2.241	1.642
Camas Prairie,	93	0.773	0.132	0.000	0.179	0.061	0.123	0.107	0.202	2.069	1.425
Camas Prairie,	93	0.987	0.170	0.012	0.260	0.086	0.178	0.165	0.239	3.058	2.255
Camas Prairie,	93	0.727	0.129	0.010	0.171	0.061	0.129	0.126	0.253	2.225	1.645

Camas Prairie,	93	0.742	0.129	0.009	0.189	0.062	0.131	0.120	0.217	2.238	1.628
Camas Prairie,	93	0.700	0.122	0.011	0.154	0.069	0.128	0.112	0.224	2.166	1.605
Flattop Butte,	93	0.759	0.134	0.009	0.169	0.065	0.129	0.107	0.203	2.395	1.728
Flattop Butte,	93	0.707	0.126	0.010	0.170	0.065	0.130	0.119	0.216	2.417	1.821
Flattop Butte,	93	0.666	0.123	0.010	0.162	0.069	0.127	0.120	0.216	2.412	1.722
Flattop Butte,	93	0.801	0.143	0.010	0.165	0.073	0.129	0.103	0.227	2.306	1.677
Flattop Butte,	93	0.720	0.128	0.007	0.171	0.080	0.126	0.120	0.222	2.568	1.913
Flattop Butte,	93	0.759	0.136	0.010	0.164	0.069	0.123	0.119	0.213	2.411	1.766
Flattop Butte,	93	0.764	0.139	0.004	0.167	0.070	0.122	0.105	0.226	2.304	1.711
Flattop Butte,	93	0.757	0.139	0.009	0.168	0.072	0.127	0.115	0.204	2.281	1.672
Flattop Butte,	93	0.741	0.136	0.009	0.180	0.072	0.127	0.116	0.203	2.368	1.740
Dry Ck., ID	94	0.745	0.131	0.013	0.344	0.049	0.236	0.211	0.212	4.177	2.930
Dry Ck., ID	94	0.723	0.131	0.015	0.329	0.048	0.242	0.217	0.245	4.414	3.118
Dry Ck., ID	94	0.669	0.120	0.016	0.352	0.038	0.237	0.222	0.000	4.475	3.222
Dry Ck., ID	94	0.681	0.122	0.013	0.341	0.032	0.235	0.244	0.239	4.230	2.988
Dry Ck., ID	94	0.697	0.120	0.017	0.317	0.039	0.239	0.232	0.225	4.114	2.879
Dry Ck., ID	94	0.678	0.124	0.016	0.328	0.036	0.221	0.217	0.228	4.165	2.841
Dry Ck., ID	94	0.680	0.127	0.013	0.309	0.046	0.233	0.246	0.229	4.249	3.022
Dry Ck., ID	94	0.697	0.123	0.015	0.299	0.039	0.236	0.245	0.239	4.325	3.140
Dry Ck., ID	94	0.695	0.125	0.014	0.330	0.039	0.240	0.225	0.243	4.270	2.990
Big Southern B.	95	0.751	0.134	0.069	0.515	0.000	0.661	1.172	0.197	4.344	2.975
Big Southern B.	95	0.773	0.133	0.070	0.513	0.000	0.682	1.183	0.206	4.348	3.072
Big Southern B.	95	0.821	0.145	0.075	0.536	0.000	0.690	1.184	0.188	4.275	2.939
Big Southern B.	95	0.758	0.137	0.072	0.514	0.000	0.660	1.191	0.201	4.238	2.962
Big Southern B.	95	0.768	0.145	0.068	0.536	0.000	0.677	1.187	0.237	4.437	3.139
Big Southern B.	95	0.766	0.134	0.072	0.524	0.000	0.676	1.195	0.197	4.464	3.102
Big Southern B.	95	0.780	0.149	0.076	0.532	0.000	0.672	1.203	0.216	4.623	3.272
Big Southern B.	95	0.825	0.149	0.074	0.520	0.000	0.686	1.152	0.190	4.213	2.916
Big Southern B.	95	0.782	0.153	0.072	0.492	0.000	0.661	1.198	0.201	4.535	3.142
Big Southern B.	95	0.800	0.138	0.067	0.513	0.000	0.649	1.156	0.204	4.390	3.120
Big Southern B.	95	0.954	0.160	0.067	0.510	0.000	0.661	1.140	0.178	4.276	2.975
Big Southern B.	95	0.760	0.149	0.068	0.550	0.000	0.687	1.195	0.204	4.418	3.052
Big Southern B.	95	1.002	0.170	0.082	0.514	0.000	0.677	1.233	0.218	4.395	3.090
Big Southern B.	95	0.828	0.146	0.071	0.518	0.000	0.675	1.146	0.239	4.375	3.142
Big Southern B.	95	0.748	0.138	0.068	0.500	0.000	0.655	1.193	0.196	4.257	2.925
Big Southern B.	95	0.777	0.142	0.068	0.518	0.000	0.674	1.191	0.200	4.410	3.068
Big Southern B.	95	0.820	0.148	0.071	0.522	0.000	0.662	1.163	0.196	4.099	2.766
Big Southern B.	95	0.775	0.145	0.071	0.518	0.000	0.674	1.169	0.195	4.127	2.827
Big Southern B.	95	0.740	0.129	0.065	0.470	0.000	0.656	1.178	0.196	4.061	2.822
Big Southern B.	95	0.728	0.129	0.065	0.483	0.000	0.649	1.177	0.204	4.068	2.838
Big Southern B.	95	0.775	0.131	0.069	0.495	0.000	0.661	1.221	0.208	4.292	2.973
Big Southern B.	95	0.762	0.140	0.074	0.511	0.000	0.680	1.200	0.193	4.425	3.076
Big Southern B.	95	0.736	0.132	0.068	0.488	0.000	0.661	1.228	0.201	4.215	2.996
Big Southern B.	95	0.747	0.133	0.068	0.518	0.000	0.643	1.163	0.207	4.154	2.884
Big Southern B.	95	0.783	0.135	0.071	0.547	0.000	0.700	1.263	0.206	4.653	3.200
Big Southern B.	95	0.741	0.134	0.068	0.501	0.000	0.665	1.223	0.194	4.272	2.964
Big Southern B.	95	0.736	0.133	0.068	0.517	0.000	0.678	1.205	0.190	4.688	3.325
Big Southern B.	95	0.706	0.128	0.062	0.448	0.000	0.619	1.152	0.191	4.211	3.063

Big Southern B.	95	0.768	0.138	0.067	0.488	0.000	0.661	1.168	0.189	3.835	2.611
Big Southern B.	95	0.798	0.149	0.069	0.519	0.000	0.673	1.207	0.201	4.224	2.955
Big Southern B.	95	0.762	0.135	0.071	0.514	0.000	0.657	1.170	0.201	4.243	3.023
Big Southern B.	95	0.784	0.141	0.073	0.520	0.000	0.674	1.223	0.201	4.645	3.271
Big Southern B.	95	0.761	0.135	0.069	0.507	0.000	0.658	1.189	0.197	4.348	3.018
Big Southern B.	95	0.775	0.143	0.065	0.502	0.000	0.670	1.185	0.199	4.232	2.946
Big Southern B.	95	0.841	0.150	0.071	0.522	0.000	0.659	1.169	0.195	3.991	2.733
Big Southern B.	95	0.755	0.133	0.068	0.510	0.000	0.643	1.172	0.222	4.280	3.102
Big Southern B.	95	0.743	0.132	0.067	0.492	0.000	0.656	1.169	0.197	4.131	2.927
Big Southern B.	95	0.786	0.148	0.071	0.534	0.000	0.676	1.195	0.194	4.434	2.998
Big Southern B.	95	0.752	0.133	0.071	0.474	0.000	0.647	1.182	0.192	4.007	2.898
Big Southern B.	95	0.792	0.145	0.076	0.535	0.000	0.664	1.228	0.211	4.492	3.169
Big Southern B.	95	0.741	0.128	0.072	0.497	0.000	0.662	1.212	0.205	4.217	3.001
Big Southern B.	95	0.851	0.147	0.077	0.559	0.000	0.708	1.235	0.189	4.511	3.049
Big Southern B.	95	0.772	0.136	0.067	0.510	0.000	0.663	1.240	0.206	4.614	3.191
Big Southern B.	95	0.785	0.151	0.067	0.483	0.000	0.666	1.224	0.174	4.078	2.844
Big Southern B.	95	0.775	0.140	0.075	0.549	0.000	0.692	1.186	0.198	4.565	3.122
Big Southern B.	95	1.106	0.185	0.067	0.568	0.000	0.672	1.246	0.194	4.737	3.273
Big Southern B.	95	0.856	0.148	0.075	0.543	0.000	0.695	1.255	0.203	4.995	3.486
Big Southern B.	95	0.910	0.157	0.074	0.584	0.000	0.684	1.261	0.203	4.709	3.243
Big Southern B.	95	0.850	0.156	0.074	0.528	0.000	0.676	1.200	0.193	4.566	2.964
Big Southern B.	95	0.788	0.141	0.075	0.521	0.000	0.659	1.244	0.205	4.613	3.168
Big Southern B.	95	0.910	0.164	0.076	0.528	0.000	0.672	1.215	0.188	4.412	3.053
Big Southern B.	95	0.964	0.175	0.073	0.534	0.000	0.690	1.190	0.188	4.225	2.896
Big Southern B.	95	0.883	0.157	0.077	0.521	0.000	0.654	1.244	0.198	4.533	3.278
Big Southern B.	95	0.857	0.151	0.070	0.556	0.000	0.684	1.261	0.212	4.483	3.066
Big Southern B.	95	0.739	0.133	0.066	0.481	0.000	0.662	1.214	0.201	4.242	3.004
Big Southern B.	95	0.762	0.135	0.066	0.536	0.000	0.668	1.246	0.219	4.823	3.410
Big Southern B.	95	0.952	0.171	0.067	0.503	0.000	0.662	1.209	0.207	4.545	3.260
Jasper Flats 1,	96	0.773	0.136	0.009	0.146	0.102	0.117	0.096	0.215	1.939	1.428
Jasper Flats 1,	96	0.778	0.140	0.010	0.151	0.091	0.116	0.096	0.214	2.121	1.578
Jasper Flats 1,	96	0.723	0.131	0.009	0.140	0.096	0.112	0.100	0.210	1.981	1.494
Jasper Flats 1,	96	0.753	0.135	0.009	0.146	0.094	0.112	0.098	0.208	1.821	1.350
Jasper Flats 1,	96	0.785	0.139	0.008	0.146	0.108	0.111	0.090	0.216	1.945	1.443
Jasper Flats 1,	96	0.754	0.134	0.008	0.151	0.088	0.123	0.105	0.221	1.927	1.437
Jasper Flats 1,	96	0.727	0.130	0.008	0.148	0.096	0.114	0.100	0.219	1.950	1.505
Jasper Flats 1,	96	0.758	0.136	0.009	0.147	0.103	0.120	0.104	0.211	1.911	1.422
Jasper Flats 1,	96	0.788	0.140	0.010	0.153	0.097	0.117	0.098	0.225	1.922	1.437
Jasper Flats 1,	96	0.780	0.138	0.008	0.150	0.092	0.113	0.107	0.214	1.941	1.455
Jasper Flats 1,	96	0.717	0.128	0.009	0.145	0.089	0.110	0.098	0.211	1.899	1.473
Jasper Flats 2,	97	0.749	0.127	0.011	0.173	0.071	0.129	0.120	0.209	2.143	1.549
Jasper Flats 2,	97	0.727	0.132	0.009	0.180	0.069	0.134	0.120	0.231	2.266	1.696
Jasper Flats 2,	97	0.761	0.135	0.011	0.173	0.067	0.130	0.117	0.217	2.058	1.519
Jasper Flats 2,	97	0.748	0.134	0.010	0.171	0.072	0.130	0.112	0.207	2.180	1.569
Jasper Flats 2,	97	0.746	0.137	0.010	0.176	0.070	0.146	0.112	0.210	2.209	1.579
Reas Pass Ck.,	98	0.741	0.138	0.011	0.336	0.033	0.230	0.216	0.229	5.000	3.593
Reas Pass Ck.,	98	0.757	0.129	0.016	0.359	0.035	0.232	0.235	0.223	4.789	3.342
Reas Pass Ck.,	98	0.736	0.128	0.019	0.368	0.032	0.237	0.213	0.217	5.011	3.401

Reas Pass Ck.,	98	0.729	0.133	0.017	0.317	0.037	0.239	0.224	0.194	4.477	3.065
Reas Pass Ck.,	98	0.743	0.129	0.017	0.363	0.036	0.239	0.213	0.213	4.780	3.314
Reas Pass Ck.,	98	0.737	0.127	0.017	0.324	0.041	0.244	0.219	0.199	5.660	2.950
Reas Pass Ck.,	98	0.761	0.138	0.012	0.340	0.044	0.236	0.227	0.198	4.489	3.050
Reas Pass Ck.,	98	0.713	0.124	0.017	0.310	0.034	0.217	0.207	0.222	3.986	2.799
Reas Pass Ck.,	98	0.794	0.150	0.017	0.371	0.037	0.240	0.237	0.228	4.944	3.435
Reas Pass Ck.,	98	0.745	0.128	0.016	0.308	0.035	0.241	0.232	0.214	4.467	3.077
Reas Pass Ck.,	98	0.789	0.138	0.017	0.345	0.035	0.239	0.220	0.202	4.652	3.298
Reas Pass Ck.,	98	0.807	0.144	0.018	0.350	0.040	0.241	0.235	0.230	4.700	3.288
Reas Pass Ck.,	98	0.695	0.121	0.011	0.309	0.036	0.232	0.206	0.224	4.427	3.142
Reas Pass Ck.,	98	0.774	0.137	0.018	0.349	0.041	0.232	0.222	0.215	4.745	3.450
Reas Pass Ck.,	98	0.757	0.135	0.016	0.348	0.041	0.236	0.203	0.221	4.666	3.306
Rock Ck., ID	99	0.822	0.149	0.009	0.221	0.070	0.138	0.107	0.214	2.314	1.708
Rock Ck., ID	99	0.731	0.131	0.008	0.254	0.067	0.149	0.111	0.216	2.703	2.000
Rock Ck., ID	99	0.712	0.123	0.010	0.236	0.058	0.144	0.110	0.204	2.588	1.895
Rock Ck., ID	99	0.748	0.136	0.007	0.300	0.061	0.185	0.153	0.227	3.034	2.200
Rock Ck., ID	99	0.701	0.124	0.008	0.239	0.061	0.148	0.109	0.224	2.673	2.008
Rock Ck., ID	99	0.727	0.133	0.008	0.241	0.068	0.155	0.116	0.217	2.765	2.097
Rock Ck., ID	99	0.711	0.128	0.011	0.307	0.065	0.189	0.154	0.200	2.971	2.161
Rock Ck., ID	99	0.707	0.129	0.010	0.242	0.068	0.154	0.106	0.212	2.582	1.932
Rock Ck., ID	99	0.723	0.126	0.009	0.237	0.069	0.151	0.114	0.215	2.605	1.924
Rock Ck., ID	99	0.709	0.130	0.011	0.302	0.060	0.184	0.146	0.215	3.134	2.273
Rock Ck., ID	99	0.686	0.120	0.008	0.236	0.061	0.150	0.107	0.220	2.578	1.932
Rock Ck., ID	99	0.720	0.129	0.009	0.211	0.069	0.130	0.100	0.213	2.446	1.851
Rock Ck., ID	99	0.683	0.121	0.010	0.246	0.065	0.148	0.114	0.217	2.540	1.894
Rock Ck., ID	99	0.753	0.128	0.000	0.291	0.060	0.198	0.150	0.196	3.107	2.165
Rock Ck., ID	99	0.735	0.133	0.009	0.241	0.064	0.154	0.114	0.224	2.650	1.941
Rock Ck., ID	99	0.698	0.123	0.011	0.177	0.068	0.149	0.118	0.207	2.305	1.621
Rock Ck., ID	99	0.712	0.130	0.010	0.178	0.067	0.137	0.125	0.235	2.302	1.702
Rock Ck., ID	99	0.720	0.130	0.010	0.179	0.066	0.134	0.123	0.220	2.295	1.736
Rock Ck., ID	99	0.728	0.132	0.010	0.178	0.064	0.136	0.119	0.216	2.167	1.572
Rock Ck., ID	99	0.710	0.127	0.010	0.187	0.068	0.140	0.121	0.225	2.292	1.687
Rock Ck., ID	99	1.064	0.129	0.013	0.237	0.427	0.147	0.113	0.213	2.611	1.891
Rock Ck., ID	99	0.733	0.134	0.008	0.237	0.066	0.143	0.105	0.222	2.446	1.817
Rock Ck., ID	99	0.754	0.135	0.008	0.237	0.063	0.146	0.107	0.206	2.466	1.767
Rock Ck., ID	99	0.731	0.133	0.009	0.242	0.068	0.164	0.116	0.211	2.634	1.972
Rock Ck., ID	99	0.701	0.127	0.009	0.190	0.073	0.134	0.130	0.210	2.292	1.670
Rock Ck., ID	99	0.691	0.124	0.008	0.182	0.062	0.137	0.114	0.213	2.262	1.628
Rock Ck., ID	99	0.725	0.129	0.010	0.191	0.068	0.139	0.123	0.220	2.385	1.747
Rock Ck., ID	99	0.723	0.126	0.009	0.193	0.071	0.142	0.123	0.221	2.349	1.771
Rock Ck., ID	99	0.717	0.126	0.008	0.193	0.068	0.143	0.122	0.215	2.213	1.615
Rock Ck., ID	99	0.674	0.119	0.009	0.251	0.065	0.159	0.117	0.221	2.766	2.073
Reynolds, ID	100	0.949	0.167	0.063	0.981	0	0.701	0.307	0.201	7.873	5.464
Reynolds, ID	100	1.008	0.179	0.043	0.731	0	0.569	0.262	0.213	7.448	5.228
Reynolds, ID	100	0.973	0.169	0.069	0.973	0	0.726	0.313	0.198	8.371	5.641
Reynolds, ID	100	0.984	0.158	0.068	1.012	0	0.735	0.307	0.216	8.226	5.652
Reynolds, ID	100	1.016	0.177	0.063	0.986	0	0.716	0.321	0.214	8.557	5.966
Reynolds, ID	100	1.021	0.169	0.064	0.975	0	0.705	0.311	0.179	7.191	4.938

Reynolds, ID	100	1.105	0.187	0.061	0.989	0	0.706	0.325	0.188	8.451	5.684
Reynolds, ID	100	0.961	0.171	0.633	0.971	0	0.722	0.321	0.209	8.208	5.556
Reynolds, ID	100	0.886	0.149	0.067	0.971	0	0.711	0.268	0.181	8.461	5.841
Reynolds, ID	100	1.429	0.234	0.063	0.937	0	0.711	0.299	0.193	8.377	5.889
Conant	101	1.001	0.184	0.032	0.491	0.066	0.414	0.406	0.198	6.362	4.297
Conant	101	0.969	0.178	0.029	0.511	0.046	0.394	0.379	0.189	5.898	4.055
Conant	101	0.948	0.165	0.036	0.483	0.059	0.395	0.370	0.182	6.141	4.126
Conant	101	1.163	0.200	0.046	0.510	0.069	0.401	0.378	0.211	6.258	4.389
Conant	101	1.044	0.185	0.032	0.523	0.058	0.423	0.410	0.190	6.183	4.264
Conant	101	1.039	0.186	0.031	0.492	0.059	0.405	0.378	0.219	6.255	4.396
Conant	101	1.027	0.186	0.037	0.522	0.053	0.414	0.399	0.177	6.297	4.358
Conant	101	1.015	0.186	0.034	0.523	0.075	0.413	0.377	0.193	6.188	4.265
Conant	101	0.937	0.159	0.032	0.498	0.070	0.420	0.405	0.215	6.754	4.816
Conant	101	0.961	0.173	0.033	0.491	0.059	0.414	0.387	0.208	6.381	4.470
Conant	101	0.994	0.180	0.039	0.526	0.075	0.418	0.387	0.224	6.691	4.776
Conant	101	0.964	0.175	0.031	0.518	0.064	0.401	0.386	0.225	6.484	4.553
Conant	101	0.987	0.174	0.034	0.509	0.075	0.414	0.384	0.201	6.716	4.935
Conant	101	0.936	0.162	0.036	0.509	0.061	0.391	0.390	0.207	6.572	4.576
Conant	101	0.973	0.175	0.031	0.516	0.053	0.395	0.399	0.204	6.513	4.615
Yale Ck., ID	103	0.783	0.131	0.014	0.320	0.036	0.240	0.210	0.200	4.084	2.792
Yale Ck., ID	103	0.733	0.131	0.018	0.323	0.057	0.233	0.209	0.202	4.102	2.892
Yale Ck., ID	103	0.769	0.137	0.015	0.325	0.041	0.238	0.221	0.208	4.335	3.130
Yale Ck., ID	103	0.850	0.150	0.015	0.338	0.040	0.248	0.208	0.201	3.660	2.500
Yale Ck., ID	103	0.749	0.130	0.012	0.332	0.046	0.235	0.220	0.198	4.171	2.960
Yale Ck., ID	103	0.705	0.128	0.012	0.312	0.052	0.229	0.202	0.218	4.160	2.935
Yale Ck., ID	103	0.764	0.133	0.014	0.357	0.050	0.234	0.210	0.214	4.183	3.012
Yale Ck., ID	103	0.737	0.132	0.018	0.328	0.039	0.231	0.220	0.211	4.225	3.077
Yale Ck., ID	103	0.732	0.129	0.018	0.318	0.042	0.225	0.212	0.210	4.066	2.900
Yale Ck., ID	103	0.724	0.132	0.017	0.316	0.041	0.238	0.223	0.214	4.247	3.013
Yale Ck., ID	103	0.739	0.136	0.014	0.317	0.044	0.239	0.215	0.212	4.297	3.180
Yale Ck., ID	103	0.707	0.121	0.013	0.296	0.033	0.217	0.204	0.199	3.650	2.556
Yale Ck., ID	103	0.727	0.130	0.013	0.332	0.042	0.236	0.212	0.207	4.178	2.986
Yale Ck., ID	103	0.716	0.132	0.013	0.311	0.052	0.221	0.210	0.207	4.050	2.964
Yale Ck., ID	103	0.748	0.138	0.018	0.311	0.039	0.229	0.220	0.204	4.071	2.901
Fish Ck., ID	104	0.871	0.161	0.017	0.512	0.016	0.350	0.278	0.200	5.268	3.576
Fish Ck., ID	104	0.828	0.146	0.020	0.495	0.027	0.328	0.288	0.219	5.636	3.930
Fish Ck., ID	104	0.896	0.153	0.024	0.515	0.017	0.353	0.282	0.191	5.426	3.768
Fish Ck., ID	104	0.861	0.161	0.019	0.504	0.015	0.342	0.291	0.206	5.719	4.078
Fish Ck., ID	104	0.871	0.162	0.023	0.522	0.017	0.341	0.293	0.206	5.737	4.022
Fish Ck., ID	104	0.892	0.162	0.023	0.508	0.007	0.339	0.291	0.180	4.906	3.322
Fish Ck., ID	104	0.883	0.159	0.022	0.504	0.006	0.356	0.288	0.197	5.148	3.432
Fish Ck., ID	104	0.826	0.150	0.021	0.525	0.005	0.357	0.294	0.212	5.517	3.938
Fish Ck., ID	104	0.816	0.143	0.023	0.496	0.006	0.345	0.292	0.197	5.421	3.718
Fish Ck., ID	104	0.852	0.145	0.025	0.512	0.011	0.336	0.283	0.210	5.295	3.651
Fish Ck., ID	104	0.84[illegible]	0.152	0.025	0.509	0.015	0.358	0.302	0.206	5.610	3.882
Fish Ck., ID	104	0.864	0.153	0.023	0.482	0.018	0.362	0.286	0.198	5.642	3.921
Fish Ck., ID	104	0.871	0.150	0.020	0.483	0.010	0.339	0.285	0.192	4.885	3.363
Fish Ck., ID	104	0.850	0.155	0.021	0.508	0.016	0.340	0.303	0.211	5.545	3.951

Fish Ck., ID	104	0.863	0.157	0.022	0.507	0.010	0.341	0.289	0.210	5.330	3.651
Fish Ck., ID	104	0.842	0.154	0.025	0.502	0.012	0.333	0.294	0.211	5.760	4.135
Fish Ck., ID	104	0.824	0.149	0.023	0.485	0.006	0.342	0.291	0.207	5.529	4.005
Fish Ck., ID	104	0.859	0.156	0.024	0.517	0.005	0.340	0.277	0.215	5.400	3.884
Fish Ck., ID	104	0.838	0.145	0.021	0.504	0.009	0.351	0.277	0.205	5.282	3.498
Fish Ck., ID	104	0.854	0.152	0.023	0.511	0.008	0.346	0.300	0.217	5.405	3.777
Fish Ck., ID	104	0.860	0.155	0.025	0.518	0.006	0.347	0.296	0.229	5.844	4.297
Fish Ck., ID	104	0.849	0.151	0.021	0.511	0.020	0.356	0.288	0.202	5.543	3.810
Fish Ck., ID	104	0.912	0.168	0.023	0.499	0.008	0.352	0.279	0.187	5.109	3.343
Fish Ck., ID	104	0.827	0.155	0.025	0.504	0.005	0.357	0.302	0.214	5.338	3.671
Fish Ck., ID	104	0.862	0.153	0.023	0.516	0.005	0.356	0.292	0.219	5.367	3.697
Fish Ck., ID	104	0.858	0.151	0.021	0.497	0.007	0.357	0.293	0.212	5.470	3.811
Fish Ck., ID	104	0.871	0.159	0.025	0.519	0.008	0.329	0.302	0.208	5.402	3.844
Fish Ck., ID	104	0.863	0.153	0.029	0.515	0.006	0.353	0.293	0.212	5.650	3.986
Pine Mtn., ID	105	0.648	0.115	0.006	0.241	0.064	0.161	0.144	0.215	2.933	2.142
Pine Mtn., ID	105	0.650	0.116	0.007	0.227	0.062	0.163	0.136	0.218	2.927	2.125
Pine Mtn., ID	105	0.671	0.122	0.010	0.235	0.065	0.161	0.143	0.214	2.867	2.131
Pine Mtn., ID	105	0.684	0.125	0.012	0.215	0.072	0.153	0.133	0.211	2.751	1.996
Pine Mtn., ID	105	0.667	0.117	0.009	0.197	0.066	0.149	0.120	0.204	2.792	2.020
Pine Mtn., ID	105	0.678	0.127	0.011	0.199	0.073	0.150	0.129	0.226	2.729	1.962
Pine Mtn., ID	105	0.677	0.115	0.008	0.177	0.068	0.130	0.134	0.228	2.563	1.926
Pine Mtn., ID	105	0.678	0.122	0.008	0.178	0.072	0.143	0.120	0.236	2.548	1.883
Pine Mtn., ID	105	0.748	0.135	0.009	0.176	0.069	0.145	0.121	0.208	2.397	1.736
Pine Mtn., ID	105	0.613	0.109	0.010	0.172	0.059	0.130	0.101	0.234	2.217	1.581
Pine Mtn., ID	105	0.695	0.123	0.009	0.186	0.071	0.139	0.118	0.214	2.460	1.771
Pine Mtn., ID	105	0.658	0.117	0.009	0.194	0.066	0.145	0.119	0.230	2.622	1.937
Pine Mtn., ID	105	0.631	0.110	0.008	0.205	0.067	0.139	0.110	0.225	2.823	2.097
Pine Mtn., ID	105	0.692	0.125	0.010	0.206	0.061	0.141	0.123	0.219	2.808	2.016
Pine Mtn., ID	105	0.658	0.117	0.008	0.207	0.064	0.159	0.137	0.230	2.842	2.108
Pine Mtn., ID	105	0.710	0.123	0.009	0.176	0.070	0.143	0.118	0.215	2.580	1.846
Pine Mtn, ID	105	0.733	0.129	0.007	0.185	0.062	0.132	0.103	0.219	2.527	1.825
Pine Mtn, ID	105	0.791	0.142	0.010	0.197	0.071	0.147	0.119	0.205	2.262	1.597
Pine Mtn, ID	105	0.655	0.121	0.010	0.190	0.068	0.131	0.122	0.227	2.485	1.812
Pine Mtn, ID	105	0.743	0.129	0.008	0.185	0.071	0.128	0.115	0.210	2.158	1.592
Pine Mtn, ID	105	0.698	0.124	0.008	0.186	0.068	0.132	0.121	0.219	2.292	1.734
Pine Mtn, ID	105	0.772	0.140	0.010	0.184	0.067	0.124	0.111	0.219	2.098	1.485
Pine Mtn, ID	105	0.681	0.121	0.007	0.184	0.066	0.133	0.115	0.217	2.298	1.651
Pine Mtn, ID	105	0.691	0.128	0.008	0.175	0.065	0.123	0.105	0.202	2.114	1.534
Pine Mtn, ID	105	0.754	0.137	0.010	0.202	0.064	0.136	0.117	0.216	2.436	1.797
Pine Mtn, ID	105	0.757	0.133	0.009	0.174	0.064	0.131	0.128	0.219	2.248	1.597
Pine Mtn, ID	105	0.693	0.126	0.008	0.186	0.069	0.141	0.113	0.210	2.362	1.718
Pine Mtn, ID	105	0.703	0.126	0.009	0.198	0.071	0.137	0.120	0.224	2.352	1.706
Pine Mtn, ID	105	0.680	0.125	0.008	0.220	0.069	0.151	0.126	0.213	2.676	1.924
Pine Mtn, ID	105	0.681	0.121	0.009	0.192	0.072	0.139	0.112	0.216	2.309	1.712

APPENDIX TWO

NORMALIZED ARTIFACT DATA

Normalized Artifact Data

	FeKa	FeKb	Zn	Rb	Sr	Y	Zr	Nb	ZrKb	Com.	Ray.
wbc867	0.830	0.150	0.072	0.494	-0.000	0.663	1.000	1.143	0.216	4.454	3.838
wbc583	0.755	0.132	0.007	0.261	0.062	0.158	1.000	0.114	0.213	3.656	3.446
wbc1189	0.749	0.133	0.069	0.487	-0.000	0.652	1.000	1.161	0.190	4.760	3.923
wbc128	0.941	0.160	0.078	0.512	-0.000	0.670	1.000	1.240	0.217	4.783	4.283
wbc674	0.780	0.139	0.067	0.472	-0.000	0.627	1.000	1.162	0.219	4.589	3.864
wbc48	1.143	0.185	0.064	1.657	0.122	0.878	1.000	0.708	0.166	27.399	22.771
wbc343	0.804	0.133	-0.000	0.231	0.075	0.148	1.000	0.097	0.220	3.153	2.934
wbc327	0.790	0.131	0.013	0.247	0.060	0.169	1.000	0.146	0.212	3.581	3.581
wbc120	0.714	0.124	0.010	0.257	0.060	0.178	1.000	0.151	0.219	3.786	3.390
wbc60	0.736	0.132	0.002	0.245	0.057	0.173	1.000	0.147	0.223	3.593	3.254
wbc799	0.735	0.131	0.014	0.294	0.091	0.165	1.000	0.207	0.231	4.843	3.847
wbc572	0.684	0.124	0.013	0.263	0.063	0.172	1.000	0.146	0.224	3.803	3.010
wbc345	0.734	0.127	0.018	0.409	0.056	0.291	1.000	0.247	0.213	6.097	4.763
wbc647	0.717	0.121	0.067	0.481	-0.000	0.645	1.000	1.193	0.205	0.000	0.000
wbc134	0.824	0.143	0.079	0.508	-0.000	0.667	1.000	1.224	0.195	0.000	0.000
wbc133	1.170	0.203	0.055	0.425	-0.000	0.603	1.000	1.055	0.204	0.000	0.000
wbc165	0.847	0.150	0.076	0.497	0.004	0.673	1.000	1.182	0.199	4.715	4.089
wbc1186	0.752	0.128	0.070	0.480	-0.000	0.679	1.000	1.208	0.202	4.691	3.435
wbc1193	0.747	0.130	0.069	0.455	-0.000	0.623	1.000	1.115	0.205	4.696	4.147
wbc226	0.802	0.146	0.074	0.504	-0.000	0.662	1.000	1.182	0.197	4.923	4.167
wbc480	0.642	0.112	-0.000	0.257	0.055	0.144	1.000	0.115	0.214	3.628	3.383
wbc736	0.748	0.133	0.072	0.499	-0.000	0.669	1.000	1.188	0.192	5.000	3.998
wbc349	0.763	0.139	0.010	0.157	0.074	0.123	1.000	0.102	0.216	2.589	2.316
wbc520	0.828	0.137	-0.000	0.237	0.074	0.168	1.000	0.144	0.200	3.234	2.920
wbc1082	2.181	0.338	0.039	0.670	0.489	0.411	1.000	0.128	0.174	16.661	12.430
wbc453	0.996	0.184	0.002	0.233	0.005	0.175	1.000	0.197	0.234	2.099	1.729
wbc17	0.703	0.129	0.013	0.319	0.096	0.173	1.000	0.200	0.215	4.770	3.733
wbc533	0.705	0.129	0.059	0.252	0.056	0.163	1.000	0.132	0.206	3.335	2.592
wbc590	0.614	0.108	0.008	0.193	0.058	0.140	1.000	0.123	0.225	3.246	2.382
wbc1051	0.631	0.115	0.006	0.231	0.068	0.148	1.000	0.108	0.228	3.551	2.636
wbc26	0.670	0.126	0.014	0.248	0.075	0.158	1.000	0.111	0.223	3.267	2.375
wbc840	0.408	0.073	0.015	0.162	-0.000	0.114	1.000	0.126	0.224	1.332	0.990
wbc330	1.349	0.234	0.025	0.896	0.199	0.344	1.000	0.055	0.303	11.747	10.298
wbc45	1.546	0.248	0.113	1.994	0.202	1.087	1.000	0.835	0.161	31.484	26.451
wbc1171	0.671	0.114	0.008	0.255	0.059	0.170	1.000	0.142	0.209	3.342	2.733
wbc1165	0.920	0.165	0.083	0.530	-0.000	0.677	1.000	1.183	0.216	4.806	4.243
wbc631	0.792	0.138	0.065	0.494	-0.000	0.665	1.000	1.184	0.211	4.944	4.273
wbc589	0.833	0.138	0.007	0.272	0.066	0.162	1.000	0.111	0.211	2.776	1.767

wbc156a	0.864	0.160	0.083	0.525	-0.000	0.688	1.000	1.155	0.235	3.941	2.618
wbc156b	0.817	0.155	0.073	0.538	-0.000	0.684	1.000	1.164	0.194	4.074	2.794
wbc156c	1.026	0.183	-0.000	0.838	0.072	0.283	1.000	0.101	0.233	9.749	6.408
wbc156d	0.745	0.139	0.022	0.426	0.065	0.293	1.000	0.283	0.233	5.208	3.562
wbc156e	0.835	0.150	0.072	0.531	-0.000	0.673	1.000	1.131	0.190	4.005	2.771
wbc156f	0.917	0.162	0.085	0.540	-0.000	0.696	1.000	1.207	0.194	4.193	2.595
wbc673	1.059	0.181	0.015	0.260	0.077	0.162	1.000	0.138	0.205	2.531	1.778
wbc682	0.800	0.140	0.010	0.154	0.070	0.122	1.000	0.102	0.211	2.101	1.482
wbc540	0.450	0.080	0.017	0.167	-0.000	0.116	1.000	0.124	0.215	1.246	1.021
wbc363	1.382	0.252	0.031	0.514	0.866	0.262	1.000	0.101	0.158	13.587	10.242
wbc582	1.306	0.252	0.101	1.164	0.118	0.446	1.000	0.105	0.194	14.819	11.268
wbc999	0.707	0.125	0.016	0.226	0.064	0.152	1.000	0.110	0.209	3.138	2.490
wbc577	0.624	0.111	0.058	0.411	-0.000	0.547	1.000	0.962	0.201	3.790	2.867
wbc1157	0.685	0.121	0.012	0.215	0.066	0.149	1.000	0.132	0.213	2.958	2.282
wbc369	0.861	0.143	0.028	0.403	0.069	0.311	1.000	0.247	0.207	6.686	5.140
wbc188	0.675	0.120	0.008	0.227	0.058	0.137	1.000	0.095	0.208	2.944	2.316
wbc1045	1.377	0.236	-0.000	0.702	0.491	0.440	1.000	0.163	0.167	15.639	11.869
wbc865	0.736	0.011	-0.000	0.255	0.060	0.174	1.000	0.141	0.230	3.405	2.771
wbc995	0.685	0.122	0.009	0.264	0.079	0.157	1.000	0.112	0.200	3.250	2.585
wbc581	0.456	0.082	0.016	0.179	-0.000	0.110	1.000	0.124	0.228	1.296	1.012
wbc350	0.670	0.157	0.030	0.974	0.140	0.386	1.000	0.069	0.255	0.000	0.000
wbc54	0.454	0.067	0.015	0.171	-0.000	0.118	1.000	0.125	0.235	1.304	1.016
wbc24	0.712	0.126	0.013	0.417	0.055	0.291	1.000	0.248	0.207	5.952	4.549
wbc477	0.650	0.113	0.016	0.236	0.040	0.176	1.000	0.125	0.224	2.949	2.316
wbc957	0.694	0.126	0.010	0.235	0.069	0.150	1.000	0.108	0.227	3.033	2.353
wbc117	0.660	0.118	0.010	0.193	0.051	0.144	1.000	0.130	0.212	3.045	2.330
wbc339	0.677	0.126	0.010	0.247	0.066	0.159	1.000	0.111	0.219	3.161	2.589
wbc29	0.442	0.081	0.017	0.164	-0.000	0.116	1.000	0.115	0.224	1.290	1.019
wbc1106	0.740	0.129	0.013	0.256	0.065	0.172	1.000	0.144	0.208	3.486	2.859
wbc660	0.685	0.128	0.009	0.261	0.063	0.152	1.000	0.102	0.217	3.258	2.597
wbc611	0.627	0.110	0.007	0.267	0.070	0.155	1.000	0.132	0.218	3.548	2.840
wbc486	0.435	0.075	0.016	0.174	-0.000	0.112	1.000	0.125	0.232	1.305	1.026
wbc1168	0.711	0.123	0.007	0.207	0.057	0.134	1.000	0.106	0.214	2.923	2.297
wbc42	0.691	0.118	0.013	0.229	0.065	0.148	1.000	0.113	0.233	3.044	2.389
wbc281	0.677	0.121	0.009	0.252	0.066	0.157	1.000	0.111	0.221	3.321	2.583
wbc1174	0.600	0.106	0.007	0.237	0.061	0.147	1.000	0.110	0.209	3.372	2.546
wbc801	0.733	0.134	0.010	0.238	0.067	0.147	1.000	0.101	0.220	3.086	2.431

wbc241d	0.811	0.147	0.069	0.495	-0.000	0.666	1.000	1.099	0.199	3.725	2.515
wbc241e	1.371	0.238	0.101	0.584	-0.000	0.682	1.000	1.098	0.182	3.598	2.325
wbc231a	0.915	0.160	0.082	0.565	-0.000	0.714	1.000	1.188	0.202	4.056	2.762
wbc231b	0.882	0.157	0.076	0.539	-0.000	0.679	1.000	1.188	0.221	3.862	2.637
wbc231c	1.039	0.183	0.095	0.600	-0.000	0.698	1.000	1.133	0.178	3.654	2.420
wbc398	0.736	0.139	0.069	0.467	-0.000	0.649	1.000	1.181	0.195	4.399	3.205
wbc116	0.735	0.134	0.068	0.458	-0.000	0.657	1.000	1.201	0.191	4.322	2.925
wbc651	0.619	0.112	0.015	0.138	0.031	0.133	1.000	0.088	0.199	2.942	2.231
wbc669	0.665	0.109	0.063	0.445	-0.000	0.650	1.000	1.112	0.190	4.673	3.229
wbc180	0.651	0.111	0.009	0.220	0.058	0.133	1.000	0.109	0.217	3.058	2.438
wbc172	0.661	0.115	0.010	0.196	0.072	0.147	1.000	0.126	0.228	3.207	2.523
wbc221	0.756	0.130	0.064	0.479	-0.000	0.645	1.000	1.169	0.189	4.178	3.170
wbc445	0.792	0.133	0.070	0.502	-0.000	0.662	1.000	1.187	0.197	4.211	3.364
wbc854	0.720	0.124	0.067	0.492	-0.000	0.658	1.000	1.221	0.201	4.371	2.979
wbc446	0.741	0.136	0.069	0.500	-0.000	0.669	1.000	1.222	0.211	4.371	3.275
wbc770	0.738	0.136	0.072	0.515	-0.000	0.685	1.000	1.210	0.189	4.198	3.026
wbc136	0.749	0.136	0.018	0.436	0.078	0.326	1.000	0.254	0.235	5.996	4.618
wbc671	0.758	0.135	0.061	0.475	-0.000	0.648	1.000	1.157	0.212	4.338	3.347
wbc182	0.759	0.139	0.024	0.450	0.060	0.284	1.000	0.247	0.213	6.086	4.612
wbc225	0.665	0.125	0.009	0.213	0.070	0.148	1.000	0.136	0.241	3.027	2.297
wbc367	0.651	0.120	0.026	0.254	0.068	0.167	1.000	0.115	0.202	3.141	2.413
wbc677	0.636	0.122	0.057	0.469	-0.000	0.683	1.000	1.207	0.216	4.824	3.279
wbc644	0.766	0.147	0.075	0.505	-0.000	0.691	1.000	1.220	0.189	4.379	3.220
wbc127	0.763	0.146	0.085	0.500	-0.000	0.697	1.000	1.220	0.199	4.472	3.101
wbc439	0.757	0.150	0.076	0.520	-0.000	0.681	1.000	1.238	0.125	4.932	3.780
wbc851	0.715	0.123	0.017	0.424	0.062	0.303	1.000	0.243	0.215	6.611	5.079
wbc905	0.708	0.122	0.011	0.237	0.057	0.170	1.000	0.137	0.209	3.383	2.655
wbc859	1.071	0.189	0.077	1.726	-0.000	1.297	1.000	1.045	0.188	9.007	6.676
wbc1218	0.677	0.118	0.010	0.282	0.066	0.191	1.000	0.148	0.208	3.685	2.833
wbc228a	0.723	0.132	0.007	0.194	0.071	0.150	1.000	0.127	0.212	2.828	2.052
wbc228b	0.593	0.096	0.027	0.223	0.059	0.160	1.000	0.108	0.206	3.449	2.359
wbc228c	0.599	0.101	0.003	0.264	0.061	0.152	1.000	0.115	0.204	3.302	2.493
wbc397	0.767	0.127	0.067	0.504	-0.000	0.672	1.000	1.208	0.188	4.430	3.265
wbc224	0.708	0.128	0.068	0.465	-0.000	0.619	1.000	1.149	0.189	4.280	3.068
wbc431	0.616	0.116	0.010	0.228	0.056	0.146	1.000	0.125	0.209	3.023	2.312
wbc1096	0.631	0.109	0.011	0.228	0.066	0.151	1.000	0.110	0.207	3.394	2.598

wbc407	0.756	0.132	0.008	0.262	0.063	0.187	1.000	0.158	0.208	2.370	2.068
wbc395	0.815	0.143	0.011	0.161	0.075	0.130	1.000	0.112	0.221	2.118	1.574
wbc410	1.235	0.238	0.107	2.048	-0.000	1.403	1.000	1.084	0.177	8.169	5.563
wbc366	0.799	0.148	-0.000	0.280	0.049	0.153	1.000	0.123	0.200	2.748	1.877
wbc443	0.708	0.126	0.011	0.253	0.060	0.153	1.000	0.122	0.219	2.682	1.908
wbc341	0.757	0.138	0.009	0.251	0.068	0.155	1.000	0.133	0.214	2.713	1.971
wbc342	0.749	0.138	0.013	0.242	0.071	0.143	1.000	0.105	0.219	2.701	1.942
wbc473	0.498	0.091	0.016	0.173	-0.000	0.121	1.000	0.124	0.235	1.166	0.861
wbc464	0.732	0.127	0.011	0.251	0.060	0.170	1.000	0.132	0.226	3.079	2.220
wbc699	0.870	0.155	-0.000	0.262	0.066	0.168	1.000	0.146	0.211	2.850	1.982
wbc381	0.952	0.167	0.026	0.447	0.062	0.292	1.000	0.253	0.234	5.496	3.848
wbc291	1.815	0.347	0.128	2.422	0.189	1.229	1.000	0.938	0.261	30.430	20.497
wbc541	0.458	0.082	0.017	0.177	-0.000	0.118	1.000	0.136	0.237	1.168	0.877
wbc416	0.754	0.131	0.009	0.252	0.067	0.166	1.000	0.121	0.227	2.991	2.197
wbc38	1.362	0.244	0.020	0.550	0.118	0.346	1.000	0.284	0.444	6.412	4.739
wbc107	0.818	0.145	0.009	0.154	0.069	0.130	1.000	0.100	0.214	2.099	1.517
wbc187	0.483	0.088	0.017	0.173	-0.000	0.121	1.000	0.146	0.230	1.082	0.792
wbc43	0.826	0.139	0.011	0.243	0.060	0.170	1.000	0.161	0.223	2.856	2.028
wbc32	0.474	0.081	0.017	0.169	-0.000	0.120	1.000	0.127	0.223	1.108	0.803
wbc58	0.762	0.142	0.010	0.280	0.057	0.168	1.000	0.132	0.202	2.850	2.124
wbc55	0.681	0.121	0.014	0.248	0.059	0.173	1.000	0.159	0.222	2.921	2.118
wbc842	0.805	0.144	0.010	0.361	0.063	0.163	1.000	0.220	0.230	4.330	3.070
wbc798	0.432	0.075	0.015	0.173	-0.000	0.115	1.000	0.126	0.230	1.150	0.837
wbc10	0.781	0.139	0.013	0.222	0.067	0.157	1.000	0.139	0.227	2.821	2.003
wbc703	0.690	0.124	0.008	0.208	0.062	0.131	1.000	0.097	0.225	2.400	1.758
wbc793	0.837	0.137	0.014	0.343	0.090	0.182	1.000	0.188	0.208	4.145	2.902
wbc832	0.860	0.153	0.076	0.537	-0.000	0.676	1.000	1.210	0.195	4.150	2.870
wbc947	1.087	0.189	0.013	0.242	-0.000	0.173	1.000	0.198	0.226	1.741	1.296
wbc731	0.776	0.134	0.008	0.267	0.063	0.162	1.000	0.115	0.222	2.804	2.049
wbc912	0.553	0.102	0.020	0.186	-0.000	0.123	1.000	0.128	0.209	0.984	0.638
wbc740	0.848	0.145	0.009	0.254	0.061	0.154	1.000	0.114	0.219	2.993	2.147
wbc911	0.750	0.133	0.012	0.238	0.065	0.179	1.000	0.143	0.209	2.762	1.986
wbc935	0.476	0.088	0.017	0.187	-0.000	0.115	1.000	0.119	0.224	1.140	0.812
wbc1011	0.711	0.130	0.010	0.239	0.067	0.148	1.000	0.111	0.221	3.041	2.356
wbc871	0.701	0.122	0.012	0.237	0.063	0.160	1.000	0.129	0.231	2.910	2.101
wbc931	1.584	0.272	0.115	2.124	0.154	1.142	1.000	0.924	0.171	27.005	17.546
wbc735	0.710	0.124	0.011	0.245	0.057	0.180	1.000	0.146	0.218	3.255	2.372
wbc1141	0.732	0.125	0.011	0.259	0.057	0.183	1.000	0.147	0.224	3.057	2.144
wbc760	0.473	0.086	0.017	0.194	-0.000	0.122	1.000	0.136	0.226	1.147	0.840
wbc1023	0.738	0.139	0.010	0.263	0.060	0.189	1.000	0.138	0.207	2.866	2.043
wbc794	0.492	0.089	0.016	0.176	-0.000	0.123	1.000	0.134	0.233	1.094	0.800
wbc1119	0.756	0.136	0.013	0.258	0.070	0.153	1.000	0.120	0.226	3.047	2.285

wbc1024	0.874	0.160	0.014	0.279	0.070	0.165	1.000	0.131	0.199	2.892	1.842
wbc640	0.753	0.131	-0.000	0.225	0.059	0.161	1.000	0.127	0.169	3.134	1.986
wbc1209	0.760	0.137	0.067	0.534	-0.000	0.676	1.000	1.246	0.207	4.836	3.560
wbc1217	0.692	0.121	0.009	0.242	0.064	0.144	1.000	0.115	0.237	3.150	2.481
wbc795	0.469	0.082	0.016	0.174	-0.000	0.121	1.000	0.125	0.218	1.214	0.914
wbc105	0.890	0.152	0.020	0.323	0.101	0.164	1.000	0.190	0.178	4.001	2.607
wbc992	0.702	0.125	0.007	0.240	0.068	0.143	1.000	0.107	0.209	2.935	2.278
wbc580	1.413	0.234	0.029	0.625	0.432	0.383	1.000	-0.000	0.162	15.301	10.886
wbc681	0.737	0.139	0.072	0.527	-0.000	0.668	1.000	1.256	0.209	4.931	3.617
wbc168	0.706	0.125	0.010	0.250	0.066	0.166	1.000	0.148	0.200	3.423	2.714
wbc1190	0.795	0.140	0.068	0.501	-0.000	0.678	1.000	1.247	0.210	4.714	3.594
wbc1182	0.771	0.144	0.002	0.523	-0.000	0.672	1.000	1.217	0.201	4.691	3.511
wbc130	0.791	0.152	0.069	0.524	-0.000	0.690	1.000	1.228	0.189	4.625	3.208
wbc1025	0.707	0.130	0.012	0.258	0.054	0.175	1.000	0.149	0.215	3.472	2.674
wbc750	0.723	0.129	0.011	0.277	0.069	0.156	1.000	0.116	0.217	3.497	2.719
wbc1124	0.883	0.153	0.079	0.558	-0.000	0.685	1.000	1.252	0.212	4.850	3.773
wbc1172	0.786	0.131	0.070	0.532	-0.000	0.667	1.000	1.262	0.200	4.693	3.467
wbc649	0.759	0.134	0.065	0.494	-0.000	0.667	1.000	1.189	0.195	4.574	3.398
wbc156	0.766	0.140	0.071	0.518	-0.000	0.675	1.000	1.211	0.196	5.470	3.633
wbc242a	0.748	0.132	0.063	0.478	-0.000	0.644	1.000	1.140	0.183	4.476	2.881
wbc242b	0.695	0.123	0.009	0.225	0.063	0.148	1.000	0.100	0.209	3.051	2.289
wbc242c	0.791	0.147	0.069	0.500	-0.000	0.666	1.000	1.238	0.200	4.753	3.502
wbc1197	0.752	0.133	0.072	0.478	-0.000	0.642	1.000	1.177	0.199	4.472	3.387
wbc1210	0.771	0.135	0.077	0.483	-0.000	0.680	1.000	1.196	0.219	4.347	3.101
wbc830	0.746	0.132	0.012	0.336	0.080	0.168	1.000	0.221	0.207	4.849	3.760
wbc1	0.604	0.110	0.006	0.215	0.069	0.152	1.000	0.139	0.192	3.162	2.222
wbc52	0.781	0.149	0.063	0.476	-0.000	0.674	1.000	1.227	0.212	4.551	3.090
wbc219	0.752	0.136	0.068	0.500	-0.000	0.670	1.000	1.240	0.183	4.723	3.206
wbc813	0.692	0.128	0.063	0.489	-0.000	0.668	1.000	1.191	0.188	5.302	3.871
wbc222	0.677	0.116	0.008	0.220	0.066	0.156	1.000	0.134	0.225	3.103	2.354
wbc113	0.801	0.154	0.076	0.520	-0.000	0.675	1.000	1.257	0.210	4.640	3.418
wbc110	0.640	0.118	0.008	0.240	0.062	0.149	1.000	0.109	0.199	2.815	2.238
wbc650	0.795	0.133	0.069	0.517	-0.000	0.652	1.000	1.213	0.190	4.518	3.430
wbc111	0.679	0.121	0.014	0.317	0.092	0.179	1.000	0.231	0.198	4.386	3.165
wbc103	0.554	0.101	0.009	0.233	0.053	0.174	1.000	0.166	0.256	3.254	2.550
wbc545	0.722	0.127	0.013	0.214	0.058	0.167	1.000	0.147	0.224	2.764	2.014
wbc614	0.462	0.080	0.017	0.180	-0.000	0.118	1.000	0.122	0.226	1.202	0.892
wbc685	1.477	0.233	-0.000	0.674	0.489	0.434	1.000	0.153	0.143	14.066	9.605
wbc496	0.716	0.126	0.012	0.256	0.057	0.176	1.000	0.149	0.223	3.207	2.304
wbc502	0.776	0.132	0.009	0.239	0.067	0.156	1.000	0.103	0.199	2.662	1.840
wbc310	0.749	0.130	0.022	0.207	-0.000	0.107	1.000	0.128	0.185	1.075	0.686
wbc193	1.520	0.305	0.158	2.100	0.148	1.048	1.000	0.817	0.084	27.520	18.484

wbc1012	0.759	0.128	0.008	0.278	0.058	0.163	1.000	0.118	0.242	3.036	2.152
wbc805	0.950	0.171	-0.000	0.287	0.075	0.187	1.000	0.145	0.196	2.750	1.788
wbc856	0.526	0.096	0.007	0.147	0.039	0.104	1.000	0.092	0.137	1.660	1.168
wbc956	0.798	0.148	0.013	0.292	0.048	0.169	1.000	0.152	0.217	3.050	2.142
wbc549	0.731	0.133	0.008	0.231	0.058	0.149	1.000	0.116	0.226	2.655	1.920
wbc203	0.882	0.159	0.020	0.277	0.061	0.179	1.000	0.148	0.230	2.909	2.014
wbc913	0.485	0.089	0.017	0.179	-0.000	0.121	1.000	0.137	0.229	1.139	0.841
wbc844	0.775	0.141	0.020	0.487	0.048	0.303	1.000	0.248	0.229	5.714	3.971
wbc852	0.778	0.141	0.010	0.304	0.064	0.190	1.000	0.120	0.214	2.953	2.073
wbc1216	0.524	0.093	0.017	0.181	-0.000	0.119	1.000	0.128	0.219	1.089	0.767
wbc777	0.667	0.120	0.005	0.242	0.096	0.152	1.000	0.140	0.218	3.178	2.086
wbc382	0.640	0.114	-0.000	0.226	0.058	0.151	1.000	0.115	0.220	2.850	2.047
wbc841	1.874	0.322	0.161	1.933	0.307	1.814	1.000	0.772	0.236	25.971	17.850
wbc587	1.825	0.321	-0.000	0.734	0.522	0.429	1.000	0.187	0.106	12.390	7.593
wbc629	0.476	0.086	0.017	0.171	-0.000	0.125	1.000	0.142	0.236	1.115	0.842
wbc1211	0.828	0.145	0.075	0.527	-0.000	0.667	1.000	1.174	0.204	4.259	2.971
wbc537	0.665	0.119	0.008	0.272	0.057	0.188	1.000	0.151	0.214	3.414	2.427
wbc1160	0.838	0.152	0.071	0.519	-0.000	0.682	1.000	1.177	0.202	4.225	2.975
wbc1055	0.718	0.127	0.011	0.200	0.056	0.160	1.000	0.154	0.230	2.516	1.757
wbc630	0.719	0.130	0.008	0.265	0.064	0.153	1.000	0.126	0.219	2.897	2.089
wbc37	0.735	0.122	-0.000	0.296	0.080	0.179	1.000	0.207	0.210	4.065	2.757
wbc1184	0.501	0.087	0.018	0.191	-0.000	0.121	1.000	0.127	0.232	1.130	0.823
wbc132	0.718	0.128	0.063	0.459	-0.000	0.628	1.000	1.114	0.198	3.841	2.664
wbc135	0.723	0.137	0.064	0.482	-0.000	0.647	1.000	1.142	0.211	4.180	2.918
wbc1198	0.715	0.127	0.010	0.244	0.064	0.156	1.000	0.109	0.211	2.733	2.014
wbc771	0.732	0.136	0.074	0.487	-0.000	0.662	1.000	1.182	0.200	3.624	2.771
wbc643	0.765	0.136	0.065	0.504	-0.000	0.661	1.000	1.208	0.197	4.043	2.767
wbc388	0.707	0.123	0.010	0.149	0.069	0.120	1.000	0.115	0.222	1.965	1.452
wbc1180	0.873	0.130	0.081	0.475	-0.000	0.660	1.000	1.159	0.205	4.511	2.961
wbc781	0.872	0.157	0.078	0.503	-0.000	0.646	1.000	1.147	0.205	3.768	2.618
wbc280	0.765	0.140	0.070	0.511	-0.000	0.674	1.000	1.149	0.214	4.161	2.922
wbc1185	0.528	0.094	0.018	0.179	-0.000	0.123	1.000	0.132	0.207	1.026	0.682
wbc158a	1.040	0.195	0.089	0.541	-0.000	0.698	1.000	1.143	0.168	3.192	2.460
wbc158b	0.899	0.161	0.080	0.537	-0.000	0.678	1.000	1.128	0.199	3.840	2.656
wbc158c	1.059	0.193	0.087	0.539	-0.000	0.668	1.000	1.110	0.188	3.410	2.298
wbc157a	0.755	0.140	0.066	0.460	-0.000	0.655	1.000	1.155	0.203	3.873	2.703
wbc157b	0.802	0.148	0.071	0.514	-0.000	0.668	1.000	1.122	0.181	3.948	2.739
wbc157c	0.945	0.172	0.082	0.581	-0.000	0.704	1.000	1.185	0.187	3.995	2.590
wbc157d	0.832	0.147	0.068	0.491	-0.000	0.646	1.000	1.132	0.197	3.731	2.526
wbc241a	0.957	0.175	0.089	0.563	-0.000	0.687	1.000	1.104	0.196	3.614	2.407
wbc241b	1.040	0.188	0.096	0.598	-0.000	0.718	1.000	1.151	0.182	3.899	2.595
wbc241c	0.954	0.169	0.081	0.535	-0.000	0.686	1.000	1.084	0.182	3.520	2.332

APPENDIX THREE

NORMALIZED SOURCE MEANS AND STANDARD DEVIATIONS

Source Means and Standard Deviations

SOURCE\FLOW NO.	FEKAZR	FEKBZR	ZNZR	RBZR	SRZR	YZR	NBZR	ZRKBZR	α MZR	RAYZR
Owyhee 1 (72)										
N=19										
Mean	1.293	0.228	0.026	0.912	0.182	0.356	0.111	0.189	10.923	7.443
S.D.	0.362	0.057	0.011	0.108	0.035	0.035	0.027	0.048	1.008	0.708
Owyhee 2 (73)										
N=17										
Mean	1.282	0.232	0.024	1.061	0.161	0.409	0.099	0.246	12.415	8.564
S.D.	0.059	0.011	0.005	0.059	0.017	0.021	0.009	0.049	0.728	0.589
Murphy Hot Springs (74)										
N=14										
Mean	0.748	0.136	0.011	0.351	0.038	0.198	0.137	0.212	3.715	2.687
S.D.	0.042	0.009	0.002	0.012	0.007	0.007	0.005	0.009	0.169	0.167
Brown's Bench (75)										
N=194										
Mean	0.735	0.131	0.009	0.242	0.064	0.151	0.115	0.219	2.701	1.961
S.D.	0.047	0.008	0.001	0.032	0.027	0.013	0.011	0.011	0.289	0.211
Three Creek (76)										
N=3										
Mean	0.656	0.118	0.008	0.325	0.034	0.194	0.139	0.229	3.336	2.404
S.D.	0.041	0.005	0.001	0.005	0.006	0.007	0.008	0.019	0.223	0.229
Ozone (77)										
N=44										
Mean	0.732	0.131	0.015	0.281	0.032	0.204	0.195	0.221	3.824	2.711
S.D.	0.047	0.009	0.004	0.016	0.005	0.009	0.012	0.014	0.274	0.229
Picabo Hills (78)										
N=13										
Mean	0.711	0.125	0.011	0.233	0.055	0.173	0.149	0.211	2.969	2.132
S.D.	0.042	0.005	0.002	0.011	0.004	0.009	0.009	0.014	0.153	0.131
Timber Butte (79)										
N=9										
Mean	1.661	0.284	0.095	2.024	0.143	1.055	0.841	0.289	26.715	17.759
S.D.	0.256	0.046	0.014	0.121	0.024	0.061	0.063	0.249	2.036	1.261
Snake River (80)										
N=58										
Mean	0.758	0.135	0.019	0.459	0.059	0.293	0.243	0.219	5.642	3.892
S.D.	0.045	0.009	0.003	0.021	0.008	0.011	0.011	0.019	0.697	0.452

Cannonball Mtn. 1 (81)
N=61

Mean	0.481	0.086	0.017	0.176	0	0.121	0.134	0.228	1.207	0.883
S.D.	0.035	0.006	0.002	0.007	0	0.005	0.008	0.011	0.094	0.073

Cannonball Mtn. 2 (82)
N=13

Mean	1.179	0.209	0.032	0.258	0	0.183	0.193	0.226	1.792	1.343
S.D.	0.039	0.007	0.004	0.012	0	0.019	0.008	0.017	0.074	0.074

Wedge Butte (83)
N=14

Mean	1.186	0.209	0.077	1.973	0	1.365	1.121	0.169	8.752	5.982
S.D.	0.147	0.028	0.008	0.223	0	0.144	0.112	0.016	1.002	0.713

Coal Bank Spring (84)
N=36

Mean	0.726	0.128	0.016	0.287	0.048	0.192	0.133	0.221	2.774	2.021
S.D.	0.067	0.012	0.003	0.026	0.006	0.017	0.024	0.016	0.184	0.147

Gibson Creek (85)
N=44

Mean	0.766	0.137	0.017	0.318	0.035	0.227	0.211	0.225	4.171	2.933
S.D.	0.052	0.011	0.006	0.025	0.011	0.015	0.015	0.012	0.298	0.197

Medicine Lodge (86)
N=66

Mean	0.718	0.128	0.014	0.285	0.035	0.207	0.197	0.226	3.905	2.765
S.D.	0.047	0.008	0.003	0.023	0.005	0.015	0.014	0.014	0.327	0.241

Malad (87)
N=59

Mean	1.365	0.249	0.031	0.751	0.475	0.411	0.182	0.197	14.392	12.779
S.D.	0.078	0.017	0.018	0.051	0.027	0.019	0.018	0.031	0.689	0.782

Deep Creek (88)
N=41

Mean	0.739	0.131	0.019	0.451	0.058	0.292	0.249	0.223	5.659	3.931
S.D.	0.037	0.008	0.004	0.032	0.007	0.013	0.014	0.015	0.214	0.199

Chesterfield (89)
N=15

Mean	1.239	0.221	0.014	0.221	0.682	0.129	0.048	0.171	6.764	4.681
S.D.	0.039	0.009	0.005	0.023	0.014	0.011	0.006	0.011	0.397	0.282

Bear Gulch (90)
N=73

Mean	0.747	0.133	0.014	0.322	0.087	0.178	0.216	0.219	4.243	2.987
S.D.	0.069	0.012	0.004	0.021	0.007	0.011	0.011	0.025	0.184	0.177

Cedar Creek (92)										
N=9										
Mean	0.706	0.127	0.009	0.163	0.071	0.125	0.111	0.226	2.214	1.654
S.D.	0.031	0.006	0.001	0.018	0.005	0.008	0.015	0.006	0.209	0.161
Camas Prairie (93)										
N=39										
Mean	0.743	0.132	0.009	0.174	0.069	0.126	0.111	0.221	2.209	1.614
S.D.	0.049	0.008	0.002	0.018	0.005	0.011	0.022	0.011	0.201	0.159
Dry Creek (94)										
N=9										
Mean	0.696	0.125	0.015	0.328	0.041	0.235	0.229	0.207	4.269	3.014
S.D.	0.024	0.004	0.001	0.017	0.006	0.006	0.013	0.078	0.118	0.126
Big Southern Butte (95)										
N=57										
Mean	0.803	0.144	0.071	0.516	0	0.668	1.201	0.201	4.368	3.045
S.D.	0.076	0.012	0.004	0.025	0	0.015	0.032	0.011	0.226	0.167
Jasper Flats 1 (96)										
N=11										
Mean	0.758	0.135	0.009	0.148	0.096	0.115	0.099	0.215	1.942	1.457
S.D.	0.026	0.004	0.001	0.004	0.006	0.004	0.005	0.005	0.072	0.057
Jasper Flats 2 (97)										
N=5										
Mean	0.746	0.133	0.011	0.175	0.069	0.134	0.116	0.215	2.171	1.582
S.D.	0.012	0.004	0.001	0.003	0.002	0.007	0.004	0.009	0.078	0.067
Reas Pass (98)										
N=15										
Mean	0.752	0.133	0.016	0.339	0.037	0.236	0.221	0.215	4.719	3.234
S.D.	0.031	0.008	0.003	0.021	0.004	0.007	0.011	0.012	0.369	0.214
Reynolds (100)										
N=10										
Mean	1.033	0.176	0.119	0.953	0	0.701	0.303	0.199	8.116	5.586
S.D.	0.151	0.023	0.181	0.081	0	0.047	0.022	0.014	0.464	0.313
Conant Creek (101)										
N=15										
Mean	0.997	0.178	0.034	0.508	0.063	0.408	0.389	0.203	6.379	4.459
S.D.	0.056	0.011	0.004	0.014	0.009	0.011	0.012	0.015	0.242	0.253

Yale Creek (103)										
N=15										
Mean	0.745	0.133	0.015	0.322	0.044	0.233	0.213	0.207	4.099	2.919
S.D.	0.036	0.006	0.002	0.014	0.007	0.008	0.006	0.006	0.199	0.187
Fish Creek (104)										
N=28										
Mean	0.858	0.154	0.023	0.506	0.011	0.347	0.291	0.206	5.435	3.784
S.D.	0.022	0.006	0.002	0.011	0.006	0.009	0.008	0.011	0.237	0.246
Pine Mtn. (105)										
N=31										
Mean	0.693	0.124	0.009	0.195	0.067	0.141	0.121	0.218	2.512	1.829
S.D.	0.042	0.008	0.001	0.018	0.004	0.011	0.269	0.031	0.251	0.192

APPENDIX FOUR

SPSS SOURCE ASSIGNMENTS FOR ARTIFACTS

SPSS ARTIFACT-SOURCE ATTRIBUTIONS

Cat. Number	SPSS Number	Most Probable Source	P(D/G)	P(G/D)	Second Most Probable Source	P(G/D)
WBC 799	1062	Bear Gulch	0.8183	1.0000	Reas Pass	0.0000
WBC 17	1078	Bear Gulch	0.8881	1.0000	Dry Creek	0.0000
WBC 105	1099	Bear Gulch	0.4934	1.0000	Picabo Hills	0.0000
WBC 830	1118	Bear Gulch	0.8964	1.0000	Reas Pass	0.0000
WBC 111	1127	Bear Gulch	0.9538	1.0000	Dry Creek	0.0000
WBC 842	1157	Bear Gulch	0.4055	1.0000	Medicine Lodge	0.0000
WBC 793	1161	Bear Gulch	0.3923	0.9995	Picabo Hills	0.0002
WBC 37	1198	Bear Gulch	0.8514	0.9970	Dry Creek	0.0009
WBC 677	1289	Big Southern Butte	0.0545	1.0000	Conant Creek	0.0000
WBC 644	1290	Big Southern Butte	0.5309	1.0000	Conant Creek	0.0000
WBC 127	1291	Big Southern Butte	0.3317	1.0000	Conant Creek	0.0000
WBC 439	1292	Big Southern Butte	0.0027	1.0000	Conant Creek	0.0000
WBC 1173	1293	Big Southern Butte	0.3726	1.0000	Conant Creek	0.0000
WBC 1102	1294	Big Southern Butte	0.1174	1.0000	Conant Creek	0.0000
WBC 221	1279	Big Southern Butte	0.9173	1.0000	Conant Creek	0.0000
WBC 445	1280	Big Southern Butte	0.9321	1.0000	Conant Creek	0.0000
WBC 854	1281	Big Southern Butte	0.8317	1.0000	Conant Creek	0.0000
WBC 446	1282	Big Southern Butte	0.9654	1.0000	Conant Creek	0.0000
WBC 770	1283	Big Southern Butte	0.9632	1.0000	Conant Creek	0.0000
WBC 671	1285	Big Southern Butte	0.7460	1.0000	Conant Creek	0.0000
WBC 669	1276	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 398	1273	Big Southern Butte	0.8888	1.0000	Conant Creek	0.0000
WBC 116	1274	Big Southern Butte	0.9010	1.0000	Conant Creek	0.0000
WBC 397	1269	Big Southern Butte	0.8180	1.0000	Conant Creek	0.0000
WBC 224	1270	Big Southern Butte	0.4476	1.0000	Conant Creek	0.0000
WBC 577	1237	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 156E	1229	Big Southern Butte	0.0204	1.0000	Conant Creek	0.0000

WBC 156F	1230	Big Southern Butte	0.8302	1.0000	Conant Creek	0.0000
WBC 158A	1210	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 158B	1211	Big Southern Butte	0.0018	1.0000	Conant Creek	0.0000
WBC 158C	1212	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 157A	1213	Big Southern Butte	0.4984	1.0000	Conant Creek	0.0000
WBC 157B	1214	Big Southern Butte	0.0071	1.0000	Conant Creek	0.0000
WBC 157C	1215	Big Southern Butte	0.1559	1.0000	Conant Creek	0.0000
WBC 157D	1216	Big Southern Butte	0.0945	1.0000	Conant Creek	0.0000
WBC 241A	1217	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 241B	1218	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 241C	1219	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 241D	1220	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 241E	1221	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 231A	1222	Big Southern Butte	0.1445	1.0000	Conant Creek	0.0000
WBC 231B	1223	Big Southern Butte	0.6821	1.0000	Conant Creek	0.0000
WBC 231C	1224	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 156A	1225	Big Southern Butte	0.0261	1.0000	Conant Creek	0.0000
WBC 156B	1226	Big Southern Butte	0.3338	1.0000	Conant Creek	0.0000
WBC 1180	1206	Big Southern Butte	0.0002	1.0000	Conant Creek	0.0000
WBC 781	1207	Big Southern Butte	0.2538	1.0000	Conant Creek	0.0000
WBC 280	1208	Big Southern Butte	0.2263	1.0000	Conant Creek	0.0000
WBC 771	1203	Big Southern Butte	0.8487	1.0000	Conant Creek	0.0000
WBC 643	1204	Big Southern Butte	0.9964	1.0000	Conant Creek	0.0000
WBC 132	1200	Big Southern Butte	0.0202	1.0000	Conant Creek	0.0000
WBC 135	1201	Big Southern Butte	0.3229	1.0000	Conant Creek	0.0000
WBC 1160	1195	Big Southern Butte	0.8686	1.0000	Conant Creek	0.0000
WBC 1211	1193	Big Southern Butte	0.9387	1.0000	Conant Creek	0.0000
WBC 832	1162	Big Southern Butte	0.9939	1.0000	Conant Creek	0.0000
WBC 650	1126	Big Southern Butte	0.7066	1.0000	Conant Creek	0.0000
WBC 113	1124	Big Southern Butte	0.0560	1.0000	Conant Creek	0.0000
WBC 52	1120	Big Southern Butte	0.2835	1.0000	Conant Creek	0.0000
WBC 219	1121	Big Southern Butte	0.4396	1.0000	Conant Creek	0.0000
WBC 813	1122	Big Southern Butte	0.1221	1.0000	Conant Creek	0.0000
WBC 242C	1115	Big Southern Butte	0.4295	1.0000	Conant Creek	0.0000
WBC 1197	1116	Big Southern Butte	0.9635	1.0000	Conant Creek	0.0000
WBC 1210	1117	Big Southern Butte	0.7955	1.0000	Conant Creek	0.0000

WBC 158A	1210	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 158B	1211	Big Southern Butte	0.0018	1.0000	Conant Creek	0.0000
WBC 158C	1212	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 157A	1213	Big Southern Butte	0.4984	1.0000	Conant Creek	0.0000
WBC 157B	1214	Big Southern Butte	0.0071	1.0000	Conant Creek	0.0000
WBC 157C	1215	Big Southern Butte	0.1559	1.0000	Conant Creek	0.0000
WBC 157D	1216	Big Southern Butte	0.0945	1.0000	Conant Creek	0.0000
WBC 241A	1217	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 241B	1218	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 241C	1219	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 241D	1220	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 241E	1221	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 231A	1222	Big Southern Butte	0.1445	1.0000	Conant Creek	0.0000
WBC 231B	1223	Big Southern Butte	0.6821	1.0000	Conant Creek	0.0000
WBC 231C	1224	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 156A	1225	Big Southern Butte	0.0261	1.0000	Conant Creek	0.0000
WBC 156B	1226	Big Southern Butte	0.3338	1.0000	Conant Creek	0.0000
WBC 1180	1206	Big Southern Butte	0.0002	1.0000	Conant Creek	0.0000
WBC 781	1207	Big Southern Butte	0.2538	1.0000	Conant Creek	0.0000
WBC 280	1208	Big Southern Butte	0.2263	1.0000	Conant Creek	0.0000
WBC 771	1203	Big Southern Butte	0.8487	1.0000	Conant Creek	0.0000
WBC 643	1204	Big Southern Butte	0.9964	1.0000	Conant Creek	0.0000
WBC 132	1200	Big Southern Butte	0.0202	1.0000	Conant Creek	0.0000
WBC 135	1201	Big Southern Butte	0.3229	1.0000	Conant Creek	0.0000
WBC 1160	1195	Big Southern Butte	0.8686	1.0000	Conant Creek	0.0000
WBC 1211	1193	Big Southern Butte	0.9387	1.0000	Conant Creek	0.0000
WBC 832	1162	Big Southern Butte	0.9939	1.0000	Conant Creek	0.0000
WBC 650	1126	Big Southern Butte	0.7066	1.0000	Conant Creek	0.0000
WBC 113	1124	Big Southern Butte	0.0560	1.0000	Conant Creek	0.0000
WBC 52	1120	Big Southern Butte	0.2835	1.0000	Conant Creek	0.0000
WBC 219	1121	Big Southern Butte	0.4396	1.0000	Conant Creek	0.0000
WBC 813	1122	Big Southern Butte	0.1221	1.0000	Conant Creek	0.0000
WBC 242C	1115	Big Southern Butte	0.4295	1.0000	Conant Creek	0.0000
WBC 1197	1116	Big Southern Butte	0.9635	1.0000	Conant Creek	0.0000
WBC 1210	1117	Big Southern Butte	0.7955	1.0000	Conant Creek	0.0000

WBC 1124	1109	Big Southern Butte	0.4380	1.0000	Conant Creek	0.0000
WBC 1172	1110	Big Southern Butte	0.0405	1.0000	Conant Creek	0.0000
WBC 649	1111	Big Southern Butte	0.9796	1.0000	Conant Creek	0.0000
WBC 156	1112	Big Southern Butte	0.2846	1.0000	Conant Creek	0.0000
WBC 242A	1113	Big Southern Butte	0.2470	1.0000	Conant Creek	0.0000
WBC 1190	1104	Big Southern Butte	0.4721	1.0000	Conant Creek	0.0000
WBC 1182	1105	Big Southern Butte	0.0288	1.0000	Conant Creek	0.0000
WBC 130	1106	Big Southern Butte	0.5378	1.0000	Conant Creek	0.0000
WBC 681	1102	Big Southern Butte	0.0613	1.0000	Conant Creek	0.0000
WBC 1209	1096	Big Southern Butte	0.5225	1.0000	Conant Creek	0.0000
WBC 1165	1087	Big Southern Butte	0.6640	1.0000	Conant Creek	0.0000
WBC 631	1088	Big Southern Butte	0.7320	1.0000	Conant Creek	0.0000
WBC 128	1089	Big Southern Butte	0.0004	1.0000	Conant Creek	0.0000
WBC 134	1090	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 674	1091	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 736	1073	Big Southern Butte	0.7035	1.0000	Conant Creek	0.0000
WBC 647	1065	Big Southern Butte	0.5589	1.0000	Conant Creek	0.0000
WBC 133	1067	Big Southern Butte	0.0000	1.0000	Conant Creek	0.0000
WBC 165	1068	Big Southern Butte	0.8191	1.0000	Conant Creek	0.0000
WBC 1186	1069	Big Southern Butte	0.5899	1.0000	Conant Creek	0.0000
WBC 1193	1070	Big Southern Butte	0.0051	1.0000	Conant Creek	0.0000
WBC 226	1071	Big Southern Butte	0.8762	1.0000	Conant Creek	0.0000
WBC 867	1052	Big Southern Butte	0.1622	1.0000	Conant Creek	0.0000
WBC 1189	1054	Big Southern Butte	0.5761	1.0000	Conant Creek	0.0000
WBC 583	1053	Brown's Bench	0.6462	0.4931	Picabo Hills	0.1933
WBC 343	1058	Brown's Bench	0.5642	0.6291	Pine Mountain	0.1426
WBC 480	1072	Brown's Bench	0.2892	0.2814	Murphy Hot Spr.	0.2789
WBC 1051	1081	Brown's Bench	0.4424	0.4021	Pine Mountain	0.3160
WBC 26	1082	Brown's Bench	0.8210	0.5421	Pine Mountain	0.2855
WBC 589	1092	Brown's Bench	0.7764	0.6629	Coal Bank Spr	0.2000
WBC 1024	1093	Brown's Bench	0.7122	0.5452	Jasper Flats 2	0.1359
WBC 1217	1097	Brown's Bench	0.9683	0.6111	Pine Mountain	0.2011
WBC 992	1100	Brown's Bench	0.9978	0.6560	Pine Mountain	0.1925
WBC 750	1108	Brown's Bench	0.8685	0.6788	Murphy Hot Spr	0.1018
WBC 242B	1114	Brown's Bench	0.9571	0.5144	Pine Mountain	0.2504

WBC	110	1125	Brown's Bench	0.9677	0.5835	Pine Mountain	0.2354
WBC	502	1133	Brown's Bench	0.9680	0.5797	Pine Mountain	0.1255
WBC	366	1139	Brown's Bench	0.7614	0.7442	Pine Mountain	0.0622
WBC	443	1140	Brown's Bench	0.9999	0.6069	Pine Mountain	0.1618
WBC	341	1141	Brown's Bench	0.9964	0.4344	Pine Mountain	0.2298
WBC	342	1142	Brown's Bench	0.9978	0.5863	Pine Mountain	0.1415
WBC	699	1145	Brown's Bench	0.7452	0.3073	Jasper Flats 2	0.1893
WBC	416	1149	Brown's Bench	0.9970	0.5012	Pine Mountain	0.1686
WBC	58	1155	Brown's Bench	0.9594	0.6125	Pine Mountain	0.1201
WBC	703	1160	Brown's Bench	0.9981	0.4352	Pine Mountain	0.1855
WBC	731	1164	Brown's Bench	0.9957	0.6465	Coal Bank Spr	0.1706
WBC	740	1166	Brown's Bench	0.9119	0.6263	Camas Prairie	0.1159
WBC	1011	1169	Brown's Bench	0.9952	0.5475	Pine Mountain	0.2435
WBC	871	1170	Brown's Bench	0.9936	0.3223	Pine Mountain	0.2494
WBC	1119	1177	Brown's Bench	0.9988	0.6343	Pine Mountain	0.1734
WBC	1012	1178	Brown's Bench	0.8481	0.4769	Coal Bank Spr	0.3073
WBC	805	1179	Brown's Bench	0.2008	0.3368	Jasper Flats 2	0.3081
WBC	956	1181	Brown's Bench	0.6145	0.4756	Picabo Hills	0.1815
WBC	549	1182	Brown's Bench	0.9999	0.4437	Pine Mountain	0.2094
WBC	203	1183	Brown's Bench	0.5889	0.3605	Jasper Flats 2	0.1617
WBC	382	1189	Brown's Bench	0.9745	0.3969	Pine Mountain	0.2813
WBC	630	1197	Brown's Bench	0.9975	0.6725	Pine Mountain	0.1604
WBC	1198	1202	Brown's Bench	0.9999	0.5914	Pine Mountain	0.1640
WBC	999	1236	Brown's Bench	0.9527	0.3826	Pine Mountain	0.2899
WBC	188	1240	Brown's Bench	0.9555	0.6514	Pine Mountain	0.1879
WBC	995	1243	Brown's Bench	0.8683	0.6903	Pine Mountain	0.1796
WBC	957	1249	Brown's Bench	0.9935	0.5391	Pine Mountain	0.2544
WBC	339	1251	Brown's Bench	0.9457	0.5387	Pine Mountain	0.2414
WBC	660	1254	Brown's Bench	0.8785	0.7052	Pine Mountain	0.1156
WBC	611	1255	Brown's Bench	0.4208	0.3838	Picabo Hills	0.2835
WBC	1168	1257	Brown's Bench	0.9552	0.3904	Pine Mountain	0.2816
WBC	42	1258	Brown's Bench	0.9555	0.4859	Pine Mountain	0.2448
WBC	281	1259	Brown's Bench	0.9121	0.5599	Pine Mountain	0.1810
WBC	1174	1260	Brown's Bench	0.4604	0.3668	Picabo Hills	0.2410
WBC	801	1261	Brown's Bench	0.9824	0.6221	Pine Mountain	0.1868
WBC	180	1277	Brown's Bench	0.7859	0.5106	Pine Mountain	0.2625

WBC 367	1288	Brown's Bench	0.7736	0.4445	Pine Mountain	0.2360
WBC 388	1205	Camas Prairie	0.9992	0.2730	Jasper Flats 2	0.2718
WBC 840	1083	Cannonball Mtn. 1	0.9967	1.0000	Three Creek	0.0000
WBC 795	1098	Cannonball Mtn. 1	0.9999	1.0000	Coal Bank Spr	0.0000
WBC 614	1130	Cannonball Mtn. 1	0.9997	1.0000	Coal Bank Spr	0.0000
WBC 310	1134	Cannonball Mtn. 1	0.0376	1.0000	Camas Prairie	0.0000
WBC 473	1143	Cannonball Mtn. 1	0.9998	1.0000	Coal Bank Spr	0.0000
WBC 541	1148	Cannonball Mtn. 1	1.0000	1.0000	Coal Bank Spr	0.0000
WBC 187	1152	Cannonball Mtn. 1	0.9998	1.0000	Coal Bank Spr	0.0000
WBC 32	1154	Cannonball Mtn. 1	0.9996	1.0000	Coal Bank Spr	0.0000
WBC 798	1158	Cannonball Mtn. 1	0.9991	1.0000	Three Creek	0.0000
WBC 912	1165	Cannonball Mtn. 1	0.9831	1.0000	Coal Bank Spr	0.0000
WBC 935	1168	Cannonball Mtn. 1	0.9987	1.0000	Coal Bank Spr	0.0000
WBC 760	1174	Cannonball Mtn. 1	0.9999	1.0000	Coal Bank Spr	0.0000
WBC 794	1176	Cannonball Mtn. 1	1.0000	1.0000	Coal Bank Spr	0.0000
WBC 913	1184	Cannonball Mtn. 1	1.0000	1.0000	Coal Bank Spr	0.0000
WBC 1216	1187	Cannonball Mtn. 1	0.9999	1.0000	Coal Bank Spr	0.0000
WBC 629	1192	Cannonball Mtn. 1	1.0000	1.0000	Coal Bank Spr	0.0000
WBC 1184	1199	Cannonball Mtn. 1	0.9993	1.0000	Coal Bank Spr	0.0000
WBC 1185	1209	Cannonball Mtn. 1	0.9994	1.0000	Coal Bank Spr	0.0000
WBC 540	1233	Cannonball Mtn. 1	0.9999	1.0000	Coal Bank Spr	0.0000
WBC 581	1244	Cannonball Mtn. 1	0.9998	1.0000	Three Creek	0.0000
WBC 54	1246	Cannonball Mtn. 1	0.4545	1.0000	Three Creek	0.0000
WBC 29	1252	Cannonball Mtn. 1	0.9966	1.0000	Coal Bank Spr	0.0000
WBC 486	1256	Cannonball Mtn. 1	0.9974	1.0000	Three Creek	0.0000
WBC 453	1077	Cannonball Mtn. 2	0.2105	1.0000	Ozone	0.0000
WBC 947	1163	Cannonball Mtn. 2	0.9204	1.0000	Jasper Flats 2	0.0000
WBC 349	1074	Cedar Creek	0.9703	0.3084	Jasper Flats 2	0.2307
WBC 363	1234	Chesterfield	0.0000	1.0000	Malad	0.0000
WBC 477	1248	Coal Bank Spring	0.9134	0.5402	Picabo Hills	0.2694

WBC 852	1186	Coal Bank Spring	0.9540	0.5731	Brown's Bench	0.2937
WBC 345	1064	Deep Creek	0.7027	0.6583	Snake River	0.3391
WBC 38	1150	Deep Creek	0.0000	0.3970	Snake River	0.2994
WBC 156D	1228	Deep Creek	0.3121	0.5900	Snake River	0.3604
WBC 369	1239	Deep Creek	0.0008	0.6789	Snake River	0.3202
WBC 24	1247	Deep Creek	0.9057	0.6014	Snake River	0.3966
WBC 851	1262	Deep Creek	0.1229	0.6648	Snake River	0.3351
WBC 136	1284	Deep Creek	0.1563	0.5610	Snake River	0.4390
WBC 395	1137	Jasper Flats 2	0.9966	0.3439	Camas Prairie	0.2725
WBC 107	1151	Jasper Flats 2	0.9742	0.3718	Camas Prairie	0.2742
WBC 673	1231	Jasper Flats 2	0.0384	0.4099	Camas Prairie	0.3995
WBC 682	1232	Jasper Flats 2	0.9967	0.3159	Camas Prairie	0.3118
WBC 1045	1241	Malad	0.0000	1.0000	Chesterfield	0.0000
WBC 587	1191	Malad	0.0000	1.0000	Chesterfield	0.0000
WBC 685	1131	Malad	0.0000	1.0000	Chesterfield	0.0000
WBC 580	1101	Malad	0.0000	1.0000	Owyhee 1	0.0000
WBC 1082	1076	Malad	0.0000	1.0000	Chesterfield	0.0000
WBC 156C	1227	Owyhee 1	0.0000	1.0000	Owyhee 2	0.0000
WBC 350	1245	Owyhee 1	0.0000	1.0000	Owyhee 2	0.0000
WBC 330	1084	Owyhee 2	0.0001	0.7442	Owyhee 1	0.2558
WBC 582	1235	Owyhee 2	0.0000	1.0000	Owyhee 1	0.0000
WBC 327	1059	Picabo Hills	0.7994	0.8140	Pine Mountain	0.0595
WBC 120	1060	Picabo Hills	0.8873	0.6992	Medicine Lodge	0.1093
WBC 60	1061	Picabo Hills	0.9411	0.7274	Ozone	0.0698
WBC 572	1063	Picabo Hills	0.7622	0.6684	Medicine Lodge	0.0774
WBC 520	1075	Picabo Hills	0.7740	0.6269	Pine Mountain	0.1559
WBC 533	1079	Picabo Hills	0.3184	0.4286	Brown's Bench	0.0238
WBC 590	1080	Picabo Hills	0.7926	0.5149	Pine Mountain	0.3299
WBC 1171	1086	Picabo Hills	0.9605	0.7324	Brown's Bench	0.0810
WBC 640	1094	Picabo Hills	0.8936	0.6345	Pine Mountain	0.1789

WBC 168	1103	Picabo Hills	0.9722	0.7238	Pine Mountain	0.1414
WBC 1025	1107	Picabo Hills	0.9620	0.6984	Pine Mountain	0.0832
WBC 1	1119	Picabo Hills	0.7397	0.5760	Pine Mountain	0.3241
WBC 222	1123	Picabo Hills	0.9855	0.4942	Pine Mountain	0.2770
WBC 103	1128	Picabo Hills	0.5886	0.6017	Medicine Lodge	0.1960
WBC 545	1129	Picabo Hills	0.9997	0.5705	Pine Mountain	0.2056
WBC 496	1132	Picabo Hills	0.9998	0.7032	Pine Mountain	0.0999
WBC 407	1136	Picabo Hills	0.9977	0.6942	Pine Mountain	0.1011
WBC 464	1144	Picabo Hills	0.9897	0.3647	Brown's Bench	0.2750
WBC 43	1153	Picabo Hills	0.8780	0.5756	Pine Mountain	0.1320
WBC 55	1156	Picabo Hills	0.9981	0.7055	Pine Mountain	0.1440
WBC 911	1167	Picabo Hills	0.9973	0.4866	Pine Mountain	0.2020
WBC 735	1172	Picabo Hills	0.9996	0.8135	Pine Mountain	0.0651
WBC 1141	1173	Picabo Hills	0.9972	0.6072	Coal Bank Spr	0.0000
WBC 1023	1175	Picabo Hills	0.8104	0.3687	Brown's Bench	0.2093
WBC 537	1194	Picabo Hills	0.9792	0.7356	Coal Bank Spr	0.0607
WBC 1055	1196	Picabo Hills	0.9769	0.4231	Pine Mountain	0.2332
WBC 117	1250	Picabo Hills	0.9768	0.5464	Pine Mountain	0.2810
WBC 1106	1253	Picabo Hills	0.9838	0.7321	Pine Mountain	0.1093
WBC 905	1263	Picabo Hills	0.9888	0.8056	Pine Mountain	0.0820
WBC 1218	1265	Picabo Hills	0.8251	0.7458	Coal Bank Spr	0.0442
WBC 228B	1267	Picabo Hills	0.0646	0.5333	Coal Bank Spr	0.1481
WBC 1096	1272	Picabo Hills	0.5039	0.3615	Brown's Bench	0.2972
WBC 651	1275	Picabo Hills	0.0389	0.4714	Pine Mountain	0.3054
WBC 172	1278	Pine Mountain	0.8630	0.3990	Picabo Hills	0.3743
WBC 431	1271	Pine Mountain	0.8600	0.3749	Brown's Bench	0.2833
WBC 225	1287	Pine Mountain	0.9176	0.4548	Picabo Hills	0.1525
WBC 228A	1266	Pine Mountain	0.9880	0.3572	Cedar Creek	0.1784
WBC 1157	1238	Pine Mountain	0.9968	0.3744	Picabo Hills	0.2934
WBC 856	1180	Pine Mountain	0.0128	0.4448	Brown's Bench	0.1336
WBC 777	1188	Pine Mountain	0.4617	0.5067	Brown's Bench	0.2343
WBC 10	1159	Pine Mountain	0.9868	0.2607	Jasper Flats 2	0.1748

WBC 182	1286	Snake River	0.9581	0.5491	Deep Creek	0.4500
WBC 844	1185	Snake River	0.9957	0.5760	Deep Creek	0.4228
WBC 381	1146	Snake River	0.2995	0.4730	Deep Creek	0.3988
WBC 228C	1268	Three Creek	0.3659	0.5056	Brown's Bench	0.2164
WBC 865	1242	Three Creek	0.0000	0.9691	Coal Bank Spr	0.0309
WBC 45	1085	Timber Butte	0.0000	1.0000	Malad	0.0000
WBC 193	1135	Timber Butte	0.0000	1.0000	Owyhee 2	0.0000
WBC 291	1147	Timber Butte	0.0000	1.0000	Malad	0.0000
WBC 931	1171	Timber Butte	0.0000	1.0000	Owyhee 2	0.0000
WBC 841	1190	Timber Butte	0.0000	1.0000	Reynolds	0.0000
WBC 48	1057	Timber Butte	0.0000	1.0000	Malad	0.0000
WBC 859	1264	Wedge Butte	0.0000	1.0000	Reynolds	0.0000
WBC 410	1138	Wedge Butte	0.0001	1.0000	Reynolds	0.0000

APPENDIX FIVE

SOURCE REPRESENTATION IN EACH STRATIGRAPHIC ZONE

Wilson Butte Cave Artifacts By Stratigraphic Zone

Cat No	Zone	Artifact	Source
17	Disturbed Zones	Broad Concave-Based Point	Bear Gulch
799	Disturbed Zones	Biface	Bear Gulch
793	Disturbed Zones	Small Corner-Notched Point	Bear Gulch
842	Disturbed Zones	Corner-Notched Point Base	Bear Gulch
1160	Disturbed Zones	Corner-Notched Point Frag	Big Southern Butte
832	Disturbed Zones	Indented Point Base	Big Southern Butte
1165	Disturbed Zones	Large Retouched Flake	Big Southern Butte
867	Disturbed Zones	Thick Retouched Flake	Big Southern Butte
631	Disturbed Zones	Thick Retouched Flake	Big Southern Butte
577	Disturbed Zones	Stem Fragment	Big Southern Butte
1211	Disturbed Zones	Retouched Flake	Big Southern Butte
1102	Disturbed Zones	Gatecliff Split-Stem Point	Big Southern Butte
133	Disturbed Zones	Thick Flake Scraper	Big Southern Butte
349	Disturbed Zones	Ovate Biface	Brown's Bench
1171	Disturbed Zones	Large Biface Fragment	Brown's Bench
549	Disturbed Zones	Corner-Notched Point Frag	Brown's Bench
957	Disturbed Zones	Side-Notched Point Base	Brown's Bench
1217	Disturbed Zones	Point Tip	Brown's Bench
1055	Disturbed Zones	Projectile Point Tip	Brown's Bench
856	Disturbed Zones	Corner-Notched Projectile Pt.	Brown's Bench
583	Disturbed Zones	Stemmed Point	Brown's Bench
533	Disturbed Zones	Base of Stemmed Point	Brown's Bench
117	Disturbed Zones	Stemmed Point, Indented Base	Brown's Bench
590	Disturbed Zones	Humboldt Concave-Base Point	Brown's Bench
343	Disturbed Zones	Long 'Waisted' Point	Brown's Bench
777	Disturbed Zones	Biface Frag	Brown's Bench
1051	Disturbed Zones	Large Side-Notched Point	Brown's Bench
1174	Disturbed Zones	Large Triangular Point	Brown's Bench
464	Disturbed Zones	Small Corner-Notched Point	Brown's Bench
203	Disturbed Zones	Small Side/Basal-Notched Pt.	Brown's Bench

731	Disturbed Zones	Small Side-Notched Point	Brown's Bench
26	Disturbed Zones	Gatecliff Split-Stem Point	Brown's Bench
366	Disturbed Zones	Small Corner-Notched Point	Brown's Bench
120	Disturbed Zones	Large 'Waisted' Point	Brown's Bench
188	Disturbed Zones	Large Side/Basal-Notched Pt.	Brown's Bench
339	Disturbed Zones	Eastgate Expanding Stem Point	Brown's Bench
60	Disturbed Zones	Broad Concave-Based Point	Brown's Bench
1157	Disturbed Zones	Small 'Waisted' Point	Brown's Bench
1023	Disturbed Zones	Small Corner-Notched Point	Brown's Bench
443	Disturbed Zones	Side\Basal-Notched Point Base	Brown's Bench
480	Disturbed Zones	Corner-Notched Point	Brown's Bench
502	Disturbed Zones	Small Corner-Notched Pt. Frag	Brown's Bench
341	Disturbed Zones	Small Corner-Notched Point	Brown's Bench
342	Disturbed Zones	Small Side-Notched Point	Brown's Bench
699	Disturbed Zones	Corner-Notched Point Frag	Brown's Bench
416	Disturbed Zones	Stubby Corner-Notched Point	Brown's Bench
58	Disturbed Zones	Small Corner-Notched Point	Brown's Bench
703	Disturbed Zones	Notched Point Base Frag	Brown's Bench
740	Disturbed Zones	Small Corner-Notched Pt. Frag	Brown's Bench
1011	Disturbed Zones	Corner-Notched Point	Brown's Bench
1012	Disturbed Zones	Corner-Notched Point	Brown's Bench
1119	Disturbed Zones	Corner-Notched Point	Brown's Bench
871	Disturbed Zones	Corner-Notched Point Frag	Brown's Bench
956	Disturbed Zones	Corner-Notched Point Frag	Brown's Bench
382	Disturbed Zones	Stemmed/Indented Base Frag	Brown's Bench
999	Disturbed Zones	Projectile Point Frag	Brown's Bench
995	Disturbed Zones	Projectile Point Frag	Brown's Bench
660	Disturbed Zones	Corner/Basal-Notched Point	Brown's Bench
611	Disturbed Zones	Side-Notched Point	Brown's Bench
1168	Disturbed Zones	Corner-Notched Point Frag	Brown's Bench
42	Disturbed Zones	Corner-Notched Point	Brown's Bench
281	Disturbed Zones	Biface Frag (Drill?)	Brown's Bench
801	Disturbed Zones	Projectile Point Frag	Brown's Bench
395	Disturbed Zones	Small Corner-Notched Point	Brown's Bench
805	Disturbed Zones	Corner-Notched Point Frag	Brown's Bench
107	Disturbed Zones	Small Corner-Notched Pt Base	Camas Prairie

840	Disturbed Zones	Corner-Notched Point	Cannonball Mtn. 1
581	Disturbed Zones	Medium Side-Notched Point	Cannonball Mtn. 1
541	Disturbed Zones	Small Corner-Notched Point	Cannonball Mtn. 1
187	Disturbed Zones	Small Side/Basal-Notched Pt	Cannonball Mtn. 1
614	Disturbed Zones	Side-Notched Point Base	Cannonball Mtn. 1
310	Disturbed Zones	Large Side-Notched Point Base	Cannonball Mtn. 1
473	Disturbed Zones	Small Side-Notched Point	Cannonball Mtn. 1
32	Disturbed Zones	Corner-Notched Projectile Pt	Cannonball Mtn. 1
798	Disturbed Zones	Small Corner-Notched Point	Cannonball Mtn. 1
912	Disturbed Zones	Small Corner-Notched Point	Cannonball Mtn. 1
935	Disturbed Zones	Projectile Point Tip	Cannonball Mtn. 1
760	Disturbed Zones	Corner-Notched Point Frag	Cannonball Mtn. 1
794	Disturbed Zones	Small Corner-Notched Point	Cannonball Mtn. 1
913	Disturbed Zones	Concave Point Base Frag	Cannonball Mtn. 1
540	Disturbed Zones	Corner-Notched Projectile Pt	Cannonball Mtn. 1
29	Disturbed Zones	Corner-Notched Projectile Pt	Cannonball Mtn. 1
54	Disturbed Zones	Corner-Notched Point Frag	Cannonball Mtn. 1
486	Disturbed Zones	Corner-Notched Projectile Pt	Cannonball Mtn. 1
1216	Disturbed Zones	Small Corner-Notched Point	Cannonball Mtn. 1
629	Disturbed Zones	Biface Frag	Cannonball Mtn. 1
453	Disturbed Zones	Projectile Point Frag	Cannonball Mtn. 2
947	Disturbed Zones	Biface Frag	Cannonball Mtn. 2
477	Disturbed Zones	Corner-Notched Projectile Pt	Coal Bank Spring
852	Disturbed Zones	Corner-Notched Point Frag	Coal Bank Spring
851	Disturbed Zones	Notched Biface Frag	Deep Creek
587	Disturbed Zones	Stemmed Point Base	Malad
685	Disturbed Zones	Corner-Notched Point Frag	Malad
1082	Disturbed Zones	Biface Frag	Malad
1045	Disturbed Zones	Medium Corner-Notched Point	Malad
350	Disturbed Zones	Large Corner-Notched Point	Owyhee 1
330	Disturbed Zones	Ovate Biface	Owyhee 1
582	Disturbed Zones	Corner-Notched Projectile Pt	Owyhee 2
327	Disturbed Zones	Corner-Notched Projectile Pt	Picabo Hills
572	Disturbed Zones	Side-Notched Projectile Pt	Picabo Hills
520	Disturbed Zones	Biface	Picabo Hills
545	Disturbed Zones	Small Corner-Notched Point	Picabo Hills

496	Disturbed Zones	Projectile Point Frag	Picabo Hills
55	Disturbed Zones	Small Corner-Notched Pt Frag	Picabo Hills
735	Disturbed Zones	Small Corner-Notched Pt	Picabo Hills
1141	Disturbed Zones	Small Corner-Notched Pt	Picabo Hills
537	Disturbed Zones	Small Triangular Pt Frag	Picabo Hills
1106	Disturbed Zones	Thick Biface Frag	Picabo Hills
865	Disturbed Zones	Large Corner-Notched Point	Picabo Hills
407	Disturbed Zones	Corner-Notched Point Frag	Picabo Hills
911	Disturbed Zones	Small Corner-Notched Pt Frag	Picabo Hills
905	Disturbed Zones	Corner-Notched Point Frag	Picabo Hills
1218	Disturbed Zones	Large Flake	Picabo Hills
381	Disturbed Zones	Stubby Corner-Notched Point	Snake River
369	Disturbed Zones	Base of Stemmed Point	Snake River
345	Disturbed Zones	Small Stemmed Point	Snake River
24	Disturbed Zones	Stemmed/Indented Base Pt.	Snake River
844	Disturbed Zones	Small Corner-Notched Point	Snake River
45	Disturbed Zones	Corner-Notched Projectile Pt	Timber Butte
931	Disturbed Zones	Projectile Point Frag	Timber Butte
48	Disturbed Zones	Corner-Notched Projectile Pt	Timber Butte
291	Disturbed Zones	Small Side-Notched Point	Timber Butte
193	Disturbed Zones	Small Corner-Notched Pt Base	Timber Butte
841	Disturbed Zones	Corner-Notched Point Frag	Timber Butte
410	Disturbed Zones	Large Side-Notched Point Base	Wedge Butte
859	Disturbed Zones	Projectile Point Frag	Wedge Butte
363	Disturbed Zones	Small Corner-Notched Pt Frag	Unknown obsidian
105	Stratum C	Broad Point Midsection	Bear Gulch
37	Stratum C	Square Stemmed Point Base	Bear Gulch
830	Stratum C	Biface Fragment	Bear Gulch
158A	Stratum C	Flake	Big Southern Butte
158B	Stratum C	Flake	Big Southern Butte
158C	Stratum C	Flake	Big Southern Butte
157A	Stratum C	Flake	Big Southern Butte
157B	Stratum C	Flake	Big Southern Butte
157C	Stratum C	Flake	Big Southern Butte
157D	Stratum C	Flake	Big Southern Butte

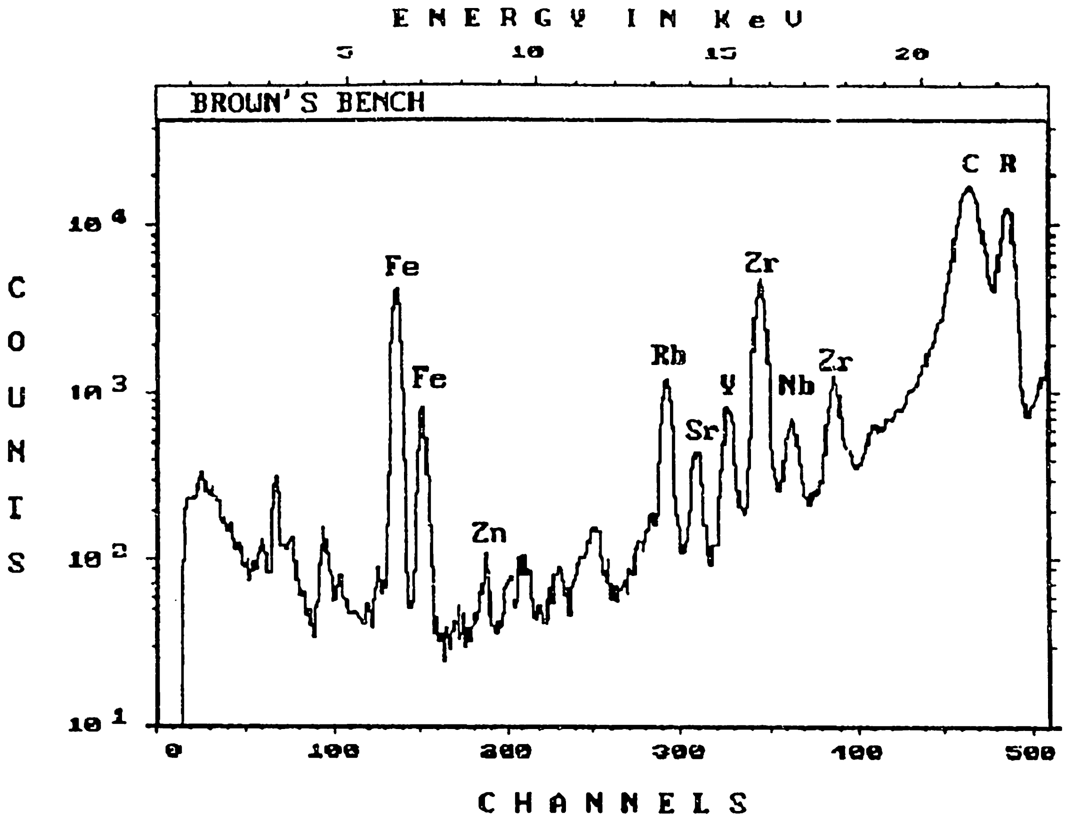
231A	Stratum C	Flake	Big Southern Butte
231B	Stratum C	Flake	Big Southern Butte
231C	Stratum C	Flake	Big Southern Butte
643	Stratum C	Biface Fragment	Big Southern Butte
1197	Stratum C	Thick Biface Fragment	Big Southern Butte
1210	Stratum C	Biface Fragment	Big Southern Butte
644	Stratum C	Flake	Big Southern Butte
127	Stratum C	Utilized Flake	Big Southern Butte
439	Stratum C	Retouched Flake	Big Southern Butte
1173	Stratum C	Utilized Flake	Big Southern Butte
671	Stratum C	Utilized Flake	Big Southern Butte
770	Stratum C	Notched Flake	Big Southern Butte
398	Stratum C	Utilized Flake	Big Southern Butte
677	Stratum C	Utilized Flake	Big Southern Butte
781	Stratum C	Utilized Flake	Big Southern Butte
771	Stratum C	Biface Tip	Big Southern Butte
135	Stratum C	Stemmed Point Fragment	Big Southern Butte
132	Stratum C	Stemmed Point Base	Big Southern Butte
116	Stratum C	Retouched Flake	Big Southern Butte
1193	Stratum C	Utilized Flake	Big Southern Butte
674	Stratum C	Stemmed Point	Big Southern Butte
130	Stratum C	"Fluted" Flake Scraper	Big Southern Butte
134	Stratum C	Alberta Point Tip	Big Southern Butte
128	Stratum C	Thick Flake Scraper	Big Southern Butte
165	Stratum C	Utilized Cortical Flake	Big Southern Butte
1189	Stratum C	Utilized Flake	Big Southern Butte
736	Stratum C	Utilized Flake	Big Southern Butte
1186	Stratum C	Large Utilized Flake	Big Southern Butte
226	Stratum C	Large Utilized Flake	Big Southern Butte
280	Stratum C	Small Multiple Graver	Big Southern Butte
1180	Stratum C	Biface Fragment	Big Southern Butte
1172	Stratum C	Point Fragment	Big Southern Butte
1209	Stratum C	Thick Point Tip (?)	Big Southern Butte
1124	Stratum C	Thick Point Tip	Big Southern Butte
681	Stratum C	Stemmed Shouldered Point	Big Southern Butte
1182	Stratum C	Large Side-Notched Point	Big Southern Butte

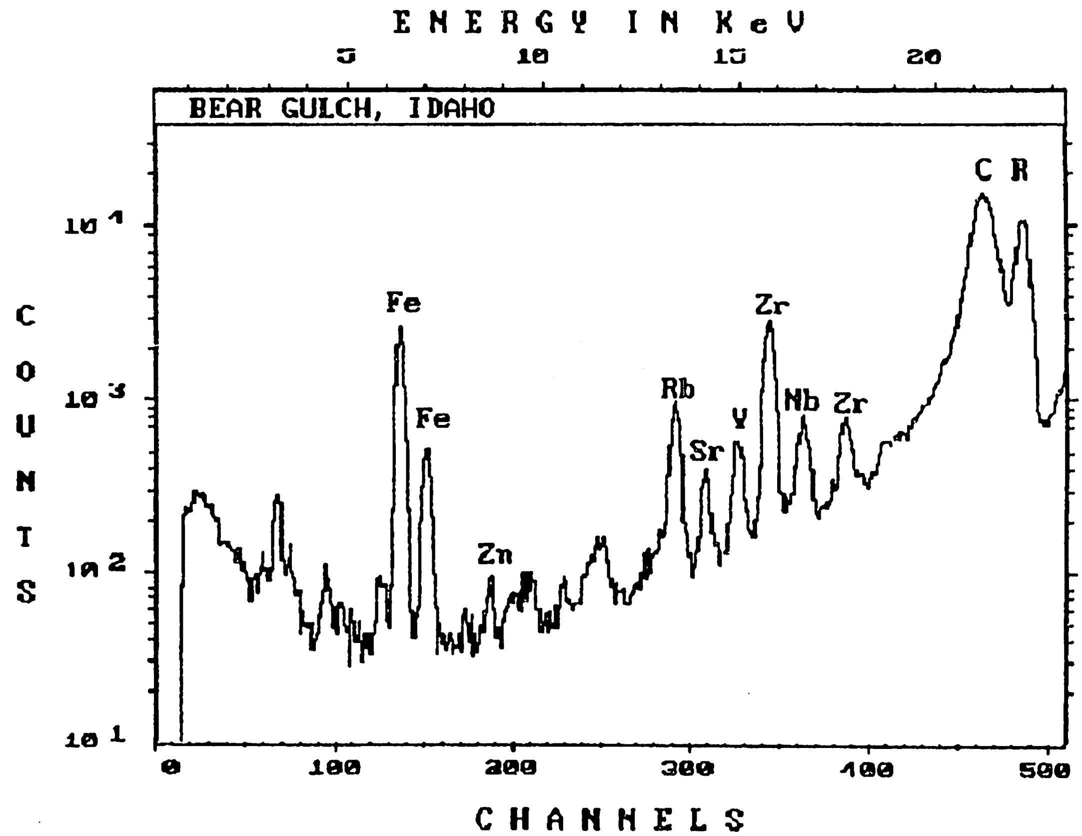
1190	Stratum C	Short Shouldered Point	Big Southern Butte
647	Stratum C	Large Biface Tip	Big Southern Butte
1025	Stratum C	Corner-Notched Point	Brown's Bench
992	Stratum C	Alberta Point Base	Brown's Bench
750	Stratum C	Stemmed Point Base	Brown's Bench
172	Stratum C	Utilized Flake	Brown's Bench
367	Stratum C	Biface Tip	Brown's Bench
1024	Stratum C	Utilized Flake	Brown's Bench
630	Stratum C	Corner-Notched Point	Brown's Bench
589	Stratum C	Retouched Split Pebble	Brown's Bench
1198	Stratum C	Stemmed Point Base	Brown's Bench
225	Stratum C	Utilized Flake	Brown's Bench
228B	Stratum C	Flake	Brown's Bench
228C	Stratum C	Flake	Brown's Bench
10	Stratum C	Corner-Notched Projectile Pt	Brown's Bench
388	Stratum C	Utilized Flake	Camas Prairie
1185	Stratum C	Retouched Flake	Cannonball Mtn. 1
1184	Stratum C	Stemmed Point Base	Cannonball Mtn. 1
156D	Stratum C	Flake	Deep Creek
580	Stratum C	Leaf-Shaped Point	Malad
156C	Stratum C	Flake	Owyhee 1
43	Stratum C	Corner-Notched Point Frag	Picabo Hills
228A	Stratum C	Flake	Pine Mountain
136	Stratum C	Retouched Flake	Snake River
182	Stratum C	Retouched Flake	Snake River
651	Stratum C	Utilized Blade	Unknown Ignimbrite
38	Stratum C	Small Corner-Notched Point	Unknown Ignimbrite
111	Facies C2	Blade Graver	Bear Gulch
241A	Facies C2	Flake	Big Southern Butte
241B	Facies C2	Flake	Big Southern Butte
241C	Facies C2	Flake	Big Southern Butte
241D	Facies C2	Flake	Big Southern Butte
241E	Facies C2	Flake	Big Southern Butte
156A	Facies C2	Flake	Big Southern Butte
156B	Facies C2	Flake	Big Southern Butte

156E	Facies C2	Flake	Big Southern Butte
156F	Facies C2	Flake	Big Southern Butte
156G	Facies C2	Flake	Big Southern Butte
669	Facies C2	Stemmed Point Base	Big Southern Butte
242A	Facies C2	Flake	Big Southern Butte
242C	Facies C2	Flake	Big Southern Butte
113	Facies C2	Utilized Flake	Big Southern Butte
649	Facies C2	Thick Point Tip	Big Southern Butte
650	Facies C2	Flake	Big Southern Butte
397	Facies C2	Utilized Flake	Big Southern Butte
224	Facies C2	Thick Flake Scraper	Big Southern Butte
221	Facies C2	Biface Fragment	Big Southern Butte
640	Facies C2	Retouched Flake	Brown's Bench
180	Facies C2	Split Pebble Scraper	Brown's Bench
242B	Facies C2	Flake	Brown's Bench
110	Facies C2	Small Thick Core	Brown's Bench
1096	Facies C2	Utilized Flake	Brown's Bench
168	Facies C2	Fluted" Point Fragment	Brown's Bench
103	Facies C2	Biface Fragment	Brown's Bench
222	Facies C2	Biface Fragment	Brown's Bench
431	Facies C2	Retouched Flake	Brown's Bench
795	Facies C2	Stemmed Point Base	Cannonball Mtn. 1
813	Facies C4	Retouched Flake	Big Southern Butte
52	Facies C4	Flake Burin	Big Southern Butte
219	Facies C4	Retouched Flake	Big Southern Butte
1	Facies C4	Stemmed Point Base	Brown's Bench
854	Stratum E	Flake	Big Southern Butte
445	Stratum E	Flake	Big Southern Butte
446	Stratum E	Flake	Big Southern Butte
673	Stratum E	Flake	Brown's Bench (?)
682	Stratum E	Flake	Camas Prairie (?)

APPENDIX SIX

SOURCE CHARACTERIZATION SPECTRA


ENERGY IN KeV
5
10
15
20
BROWN'S BENCH
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
BEAR GULCH, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
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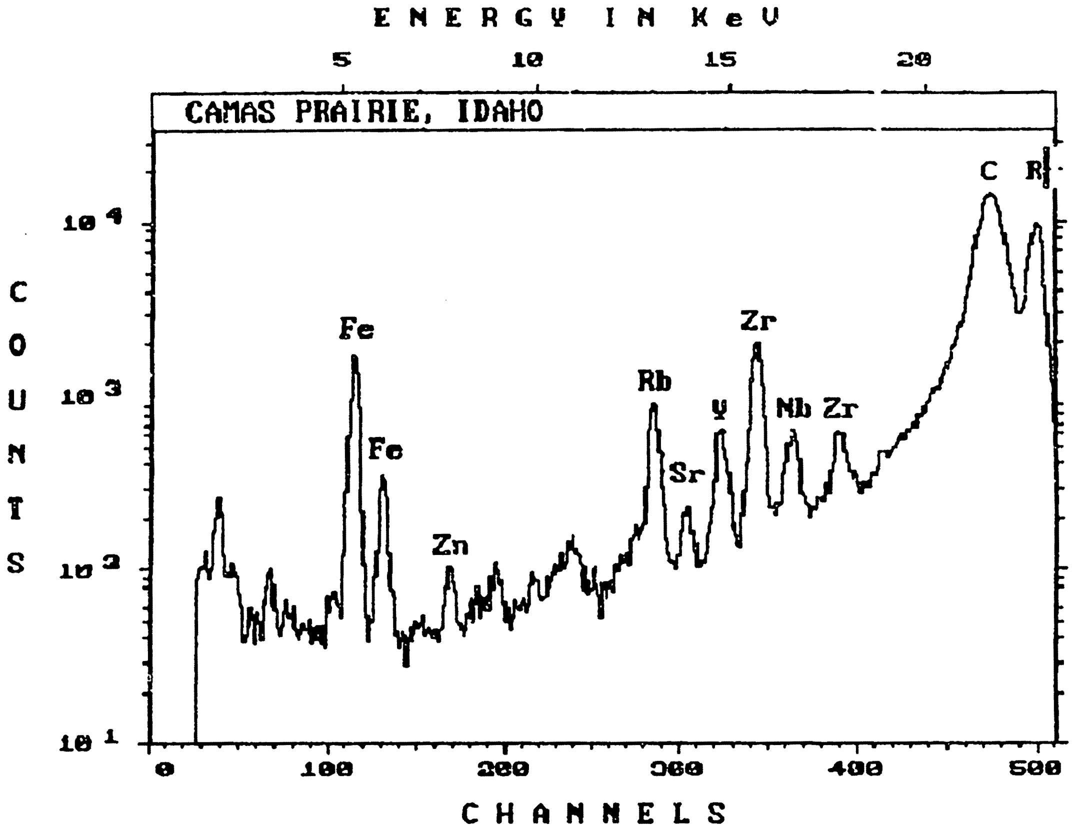
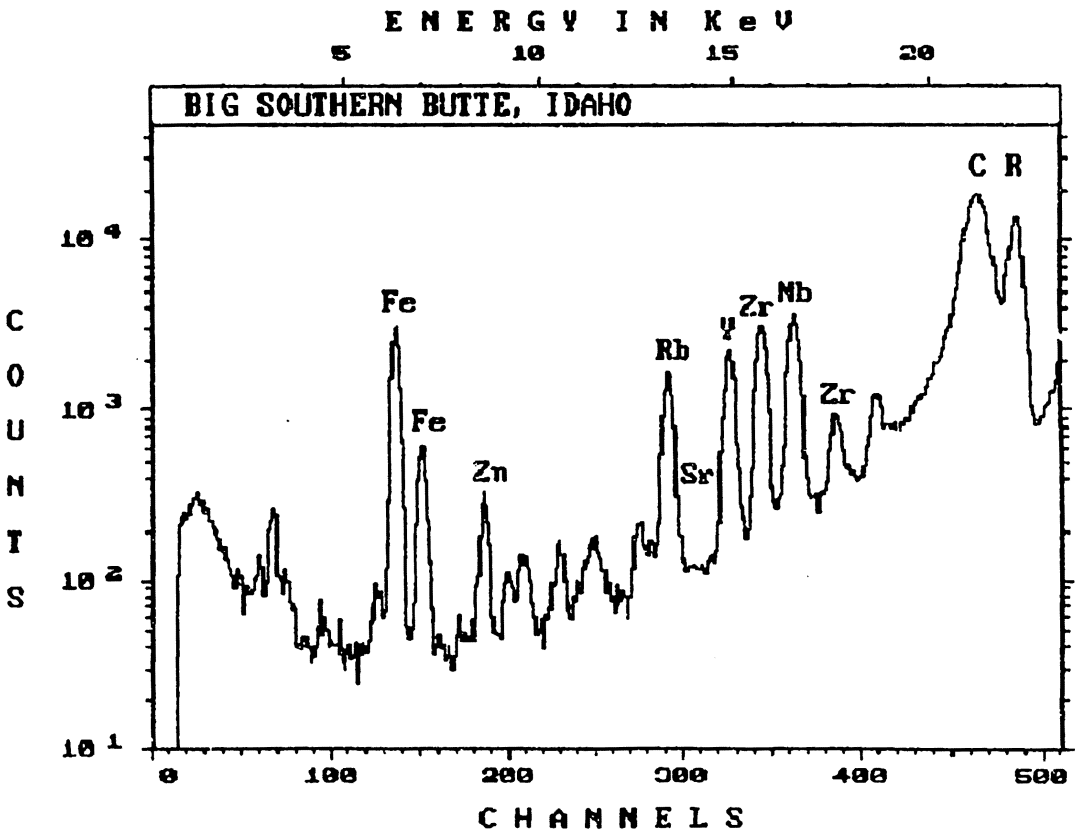
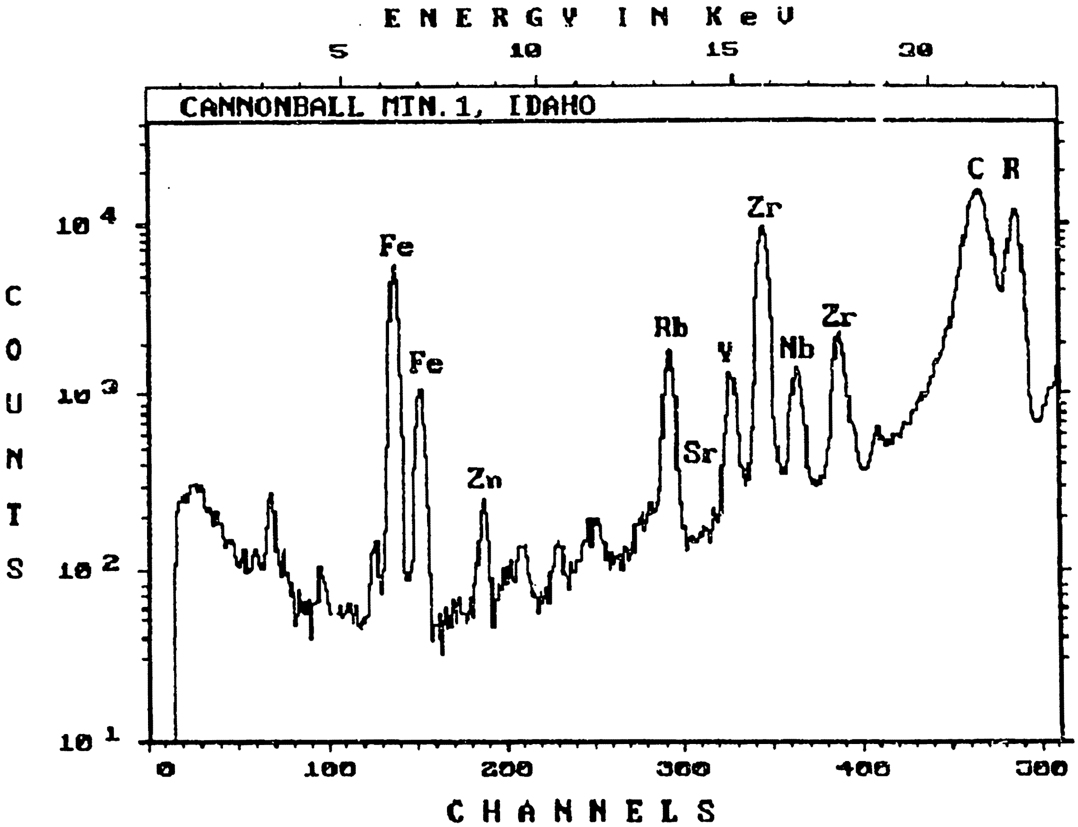
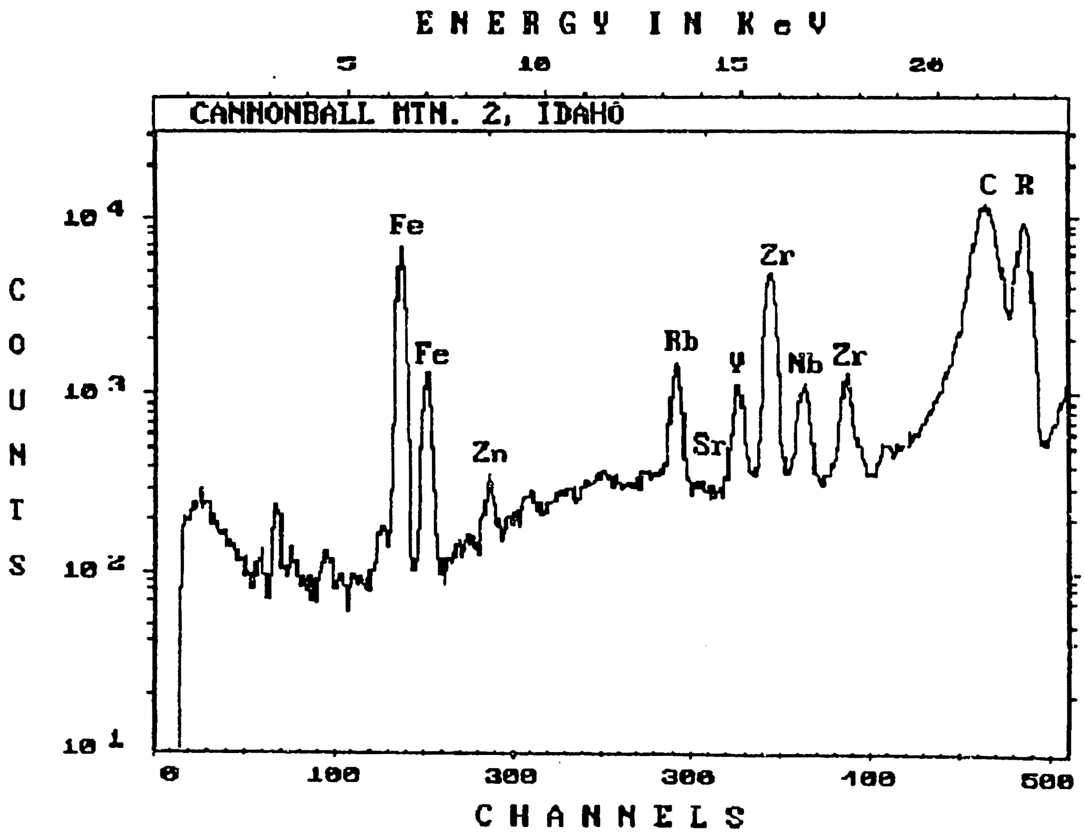
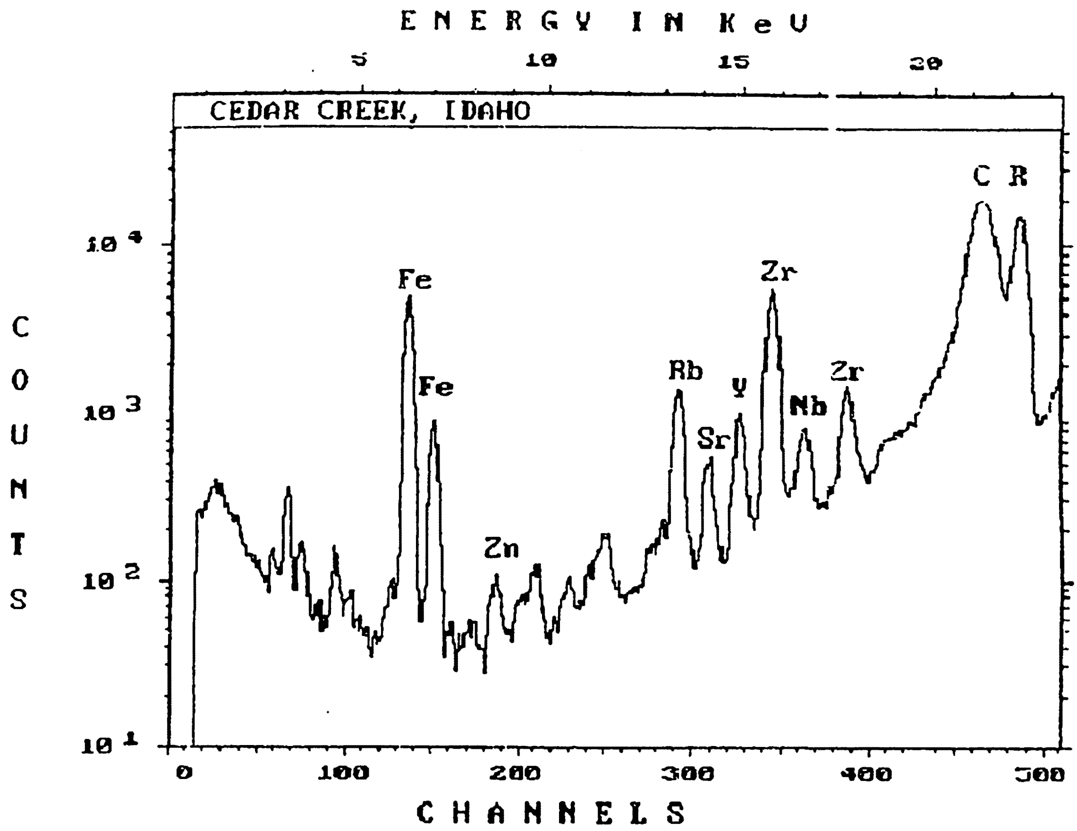
200
300
400
500
CHANNELS

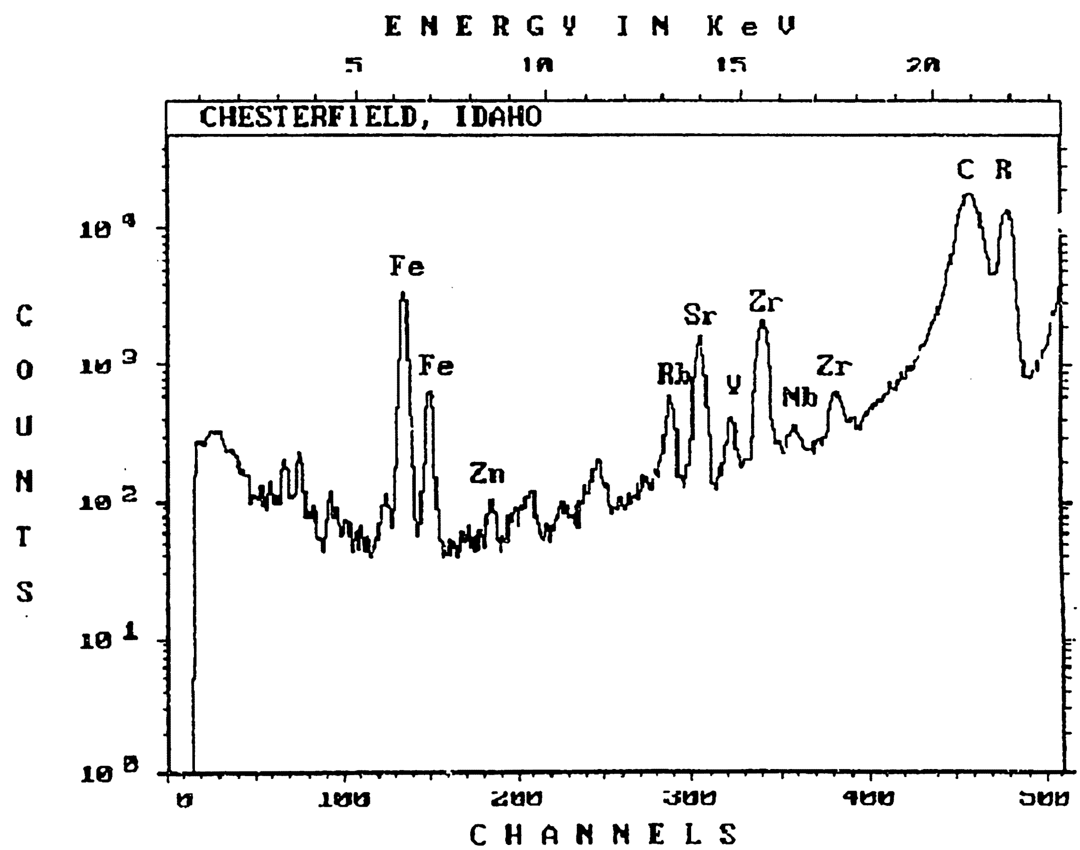

ENERGY IN KeV
5
10
15
20
CAMAS PRAIRIE, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS

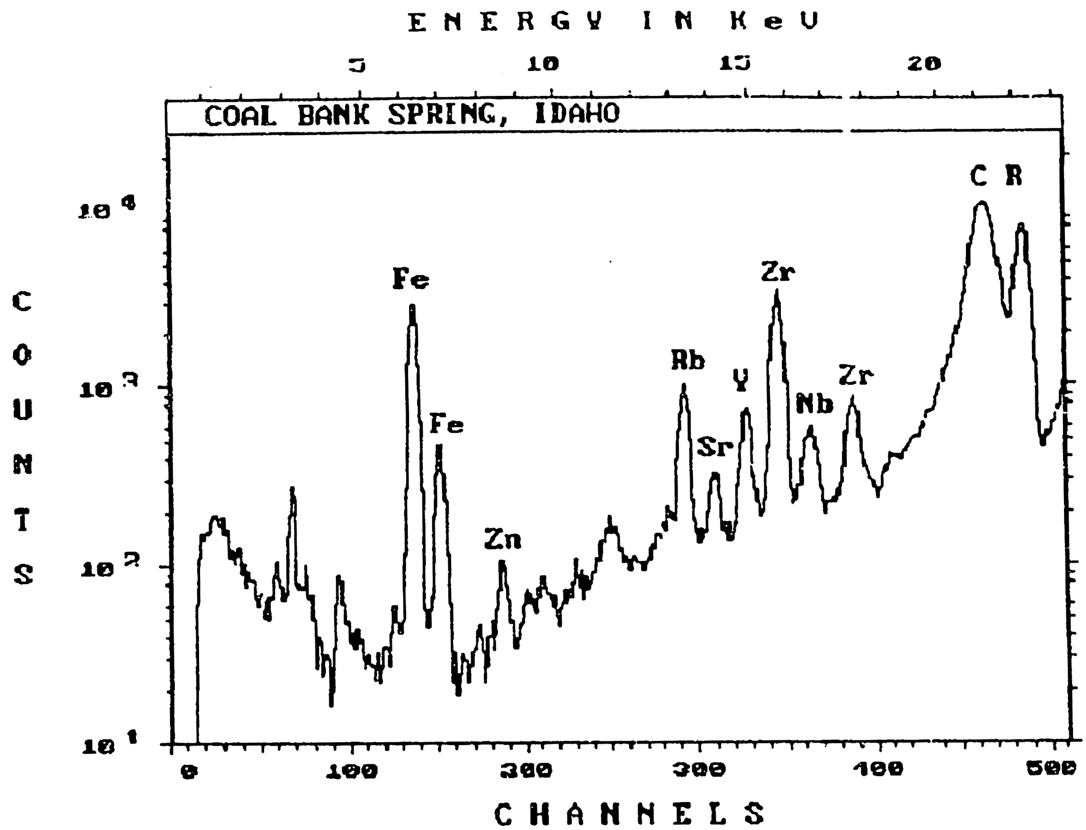

ENERGY IN KeV
5
10
15
20
BIG SOUTHERN BUTTE, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS

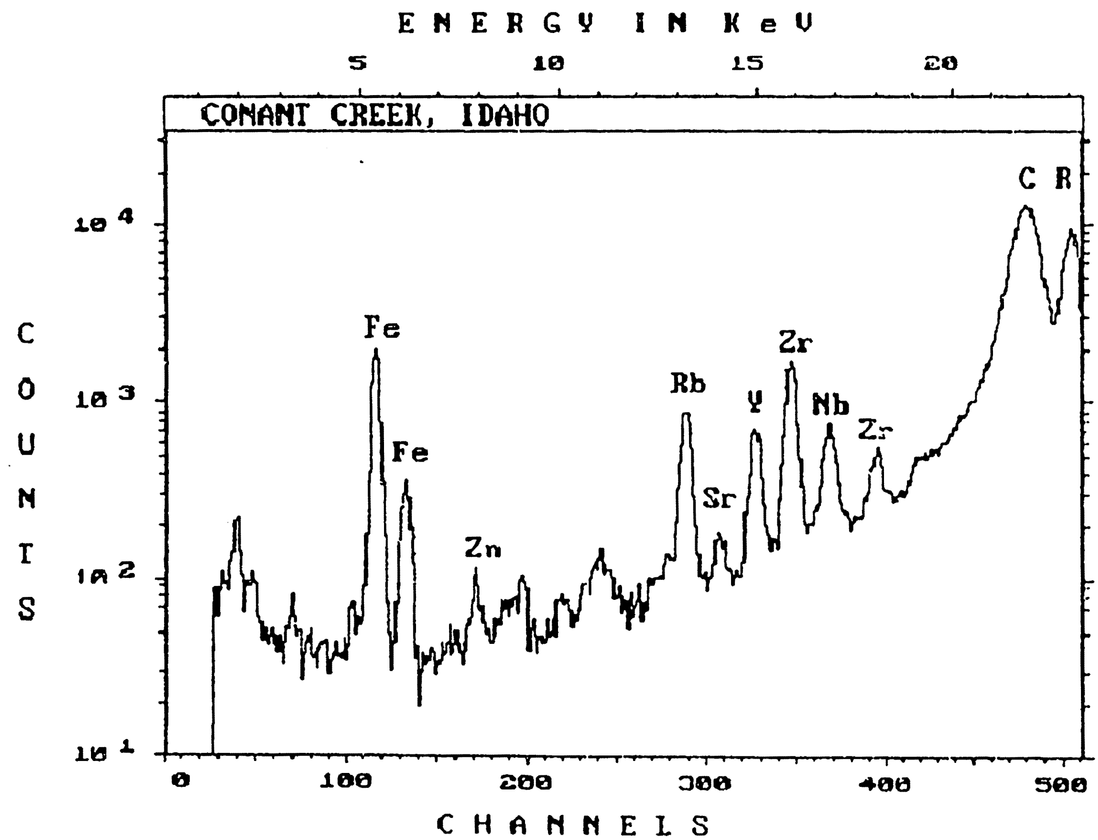

ENERGY IN KeV
5
10
15
20
CANNONBALL MTN. 1, IDAHO
C R
Zr
Fe
Fe
Rb
Y
Nb
Zr
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS

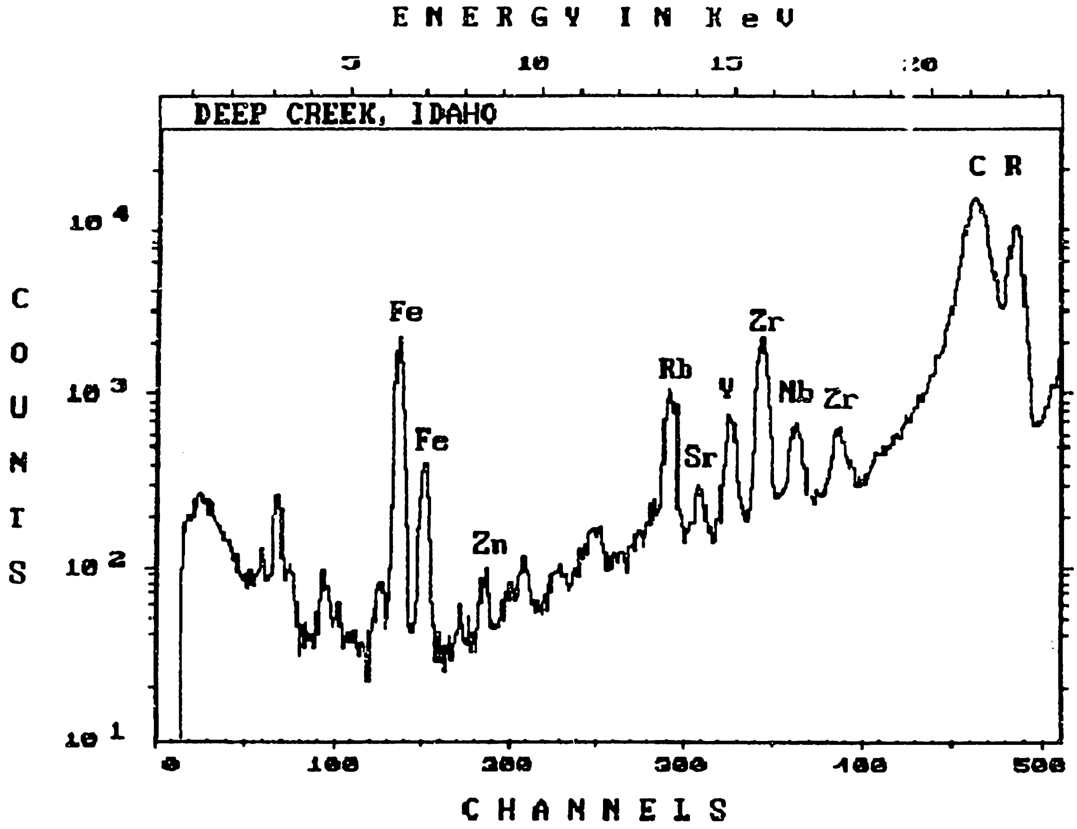

ENERGY IN KeV
5
10
15
20
CANNONBALL MTN. 2, IDAHO
C R
Fe
Zr
Fe
Rb
Y
Nb
Zr
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
CEDAR CREEK, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS

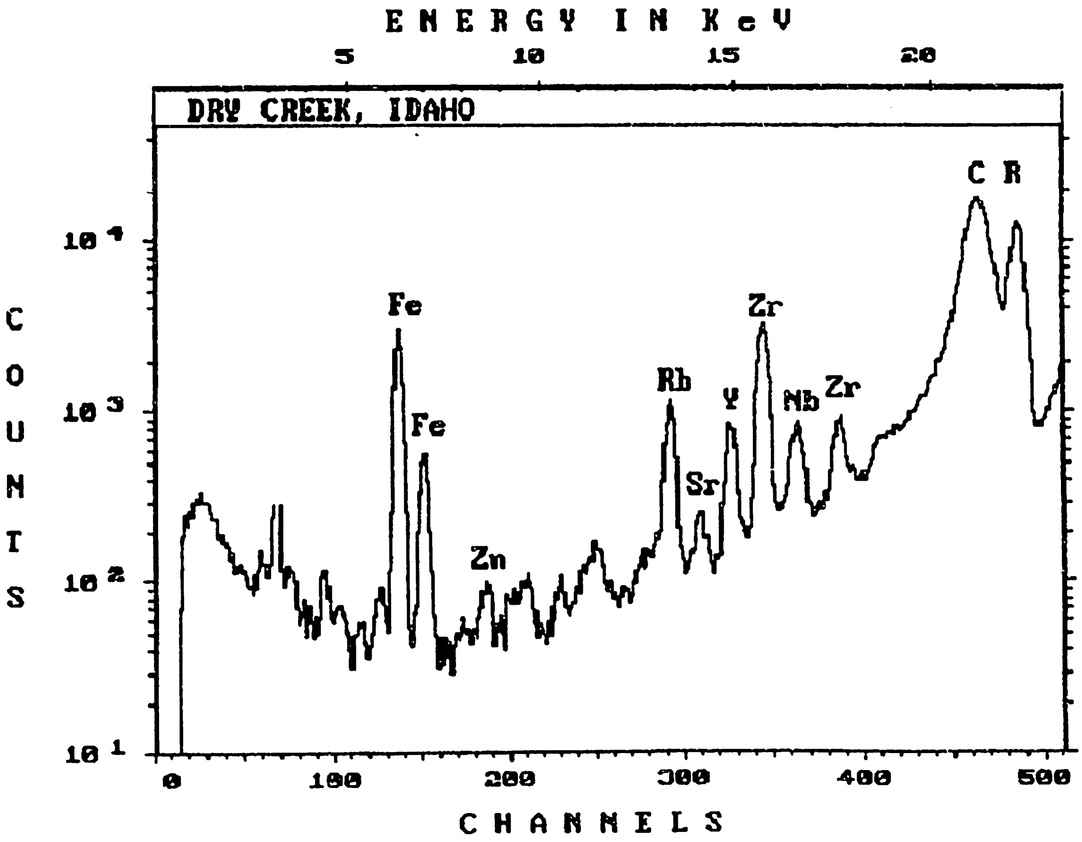

ENERGY IN KeV
5
10
15
20
CHESTERFIELD, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
10 0
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
COAL BANK SPRING, IDAHO
C R
Fe
Zr
Rb
Y
Zr
Fe
Nb
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS

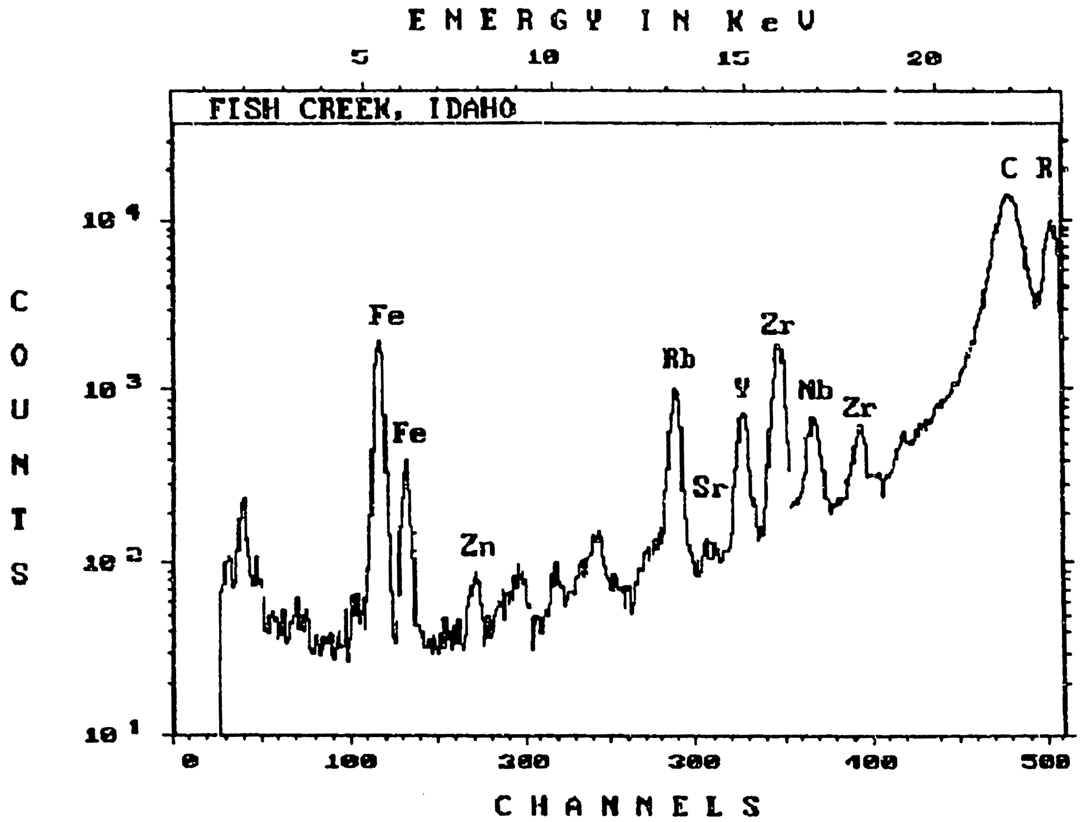

ENERGY IN KeV
5
10
15
20
CONANT CREEK, IDAHO
C R
Fe
Zr
Rb
Y
Nb
Fe
Zr
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS

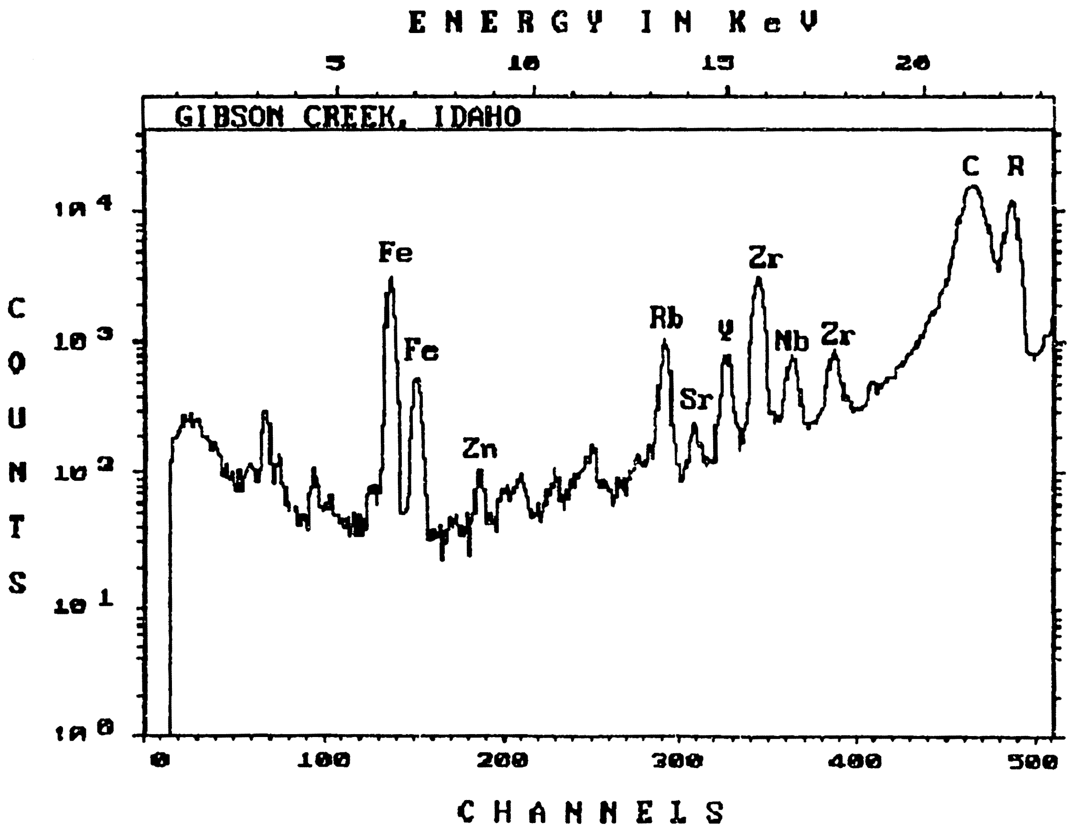


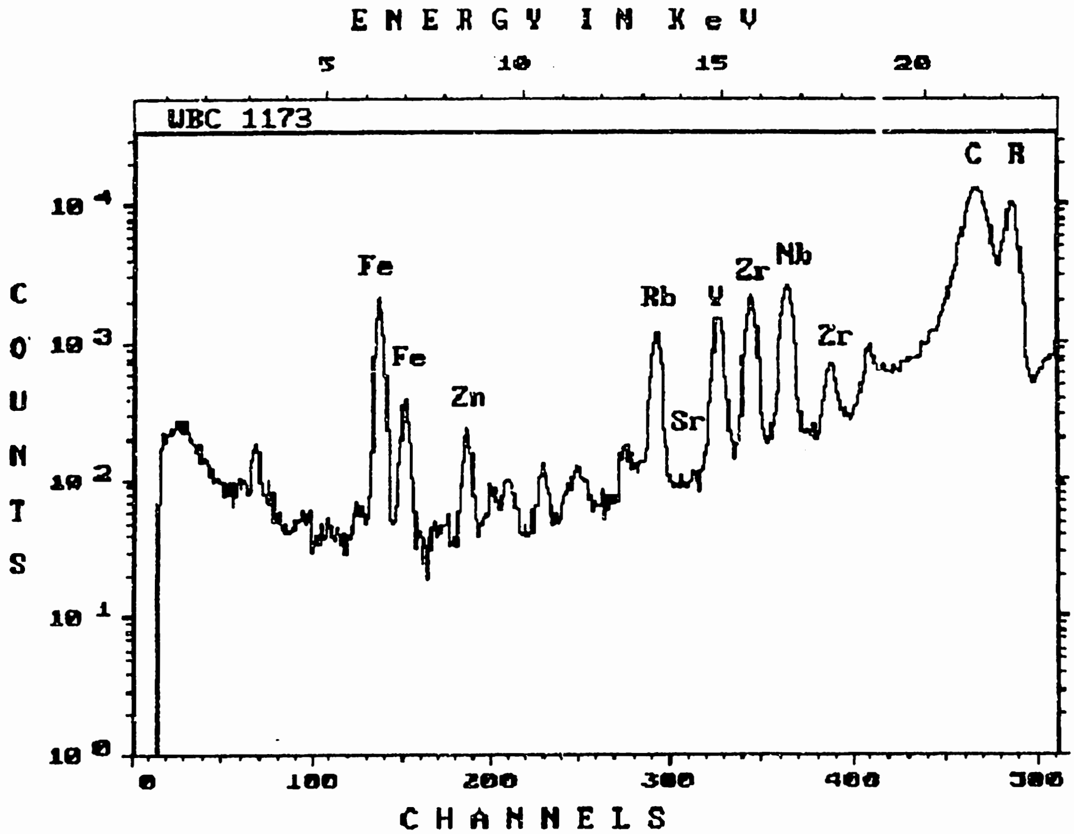
ENERGY IN KeV
5
10
15
20
DEEP CREEK, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS



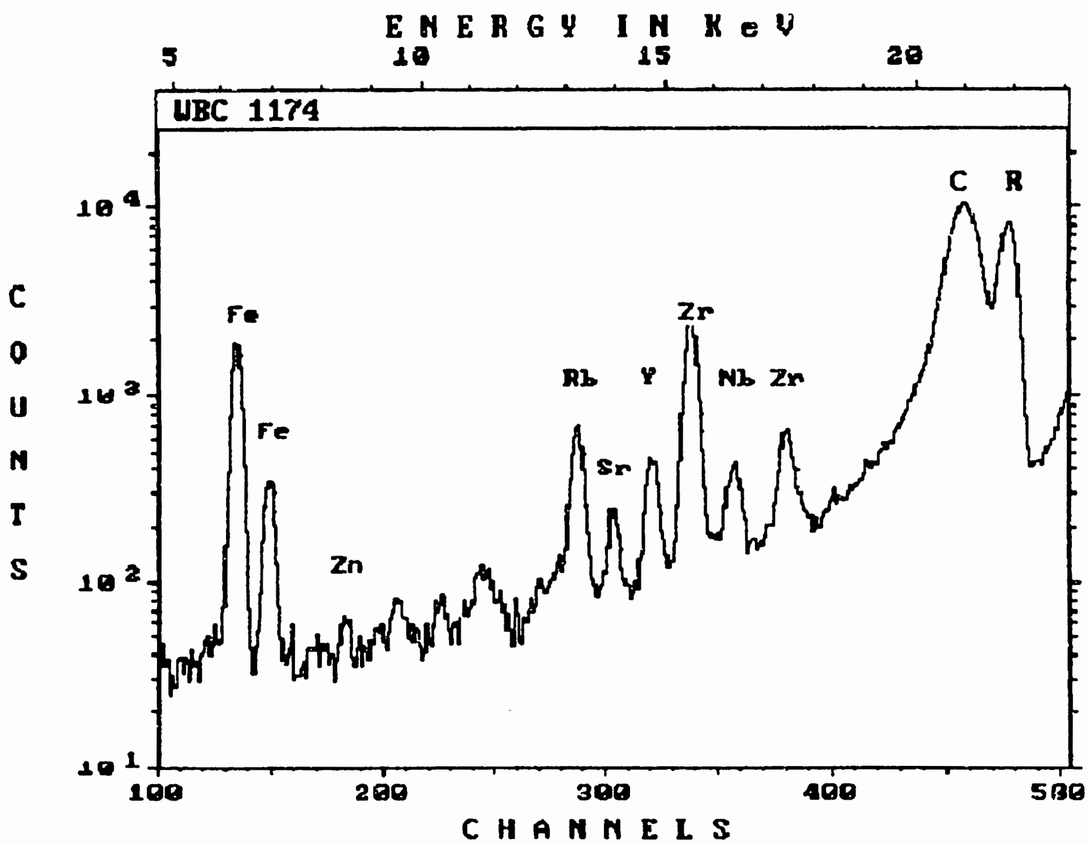
ENERGY IN KeV
5
10
15
20
DRY CREEK, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
FISH CREEK, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 1
10 2
10 3
10 4
0
100
200
300
400
500
CHANNELS

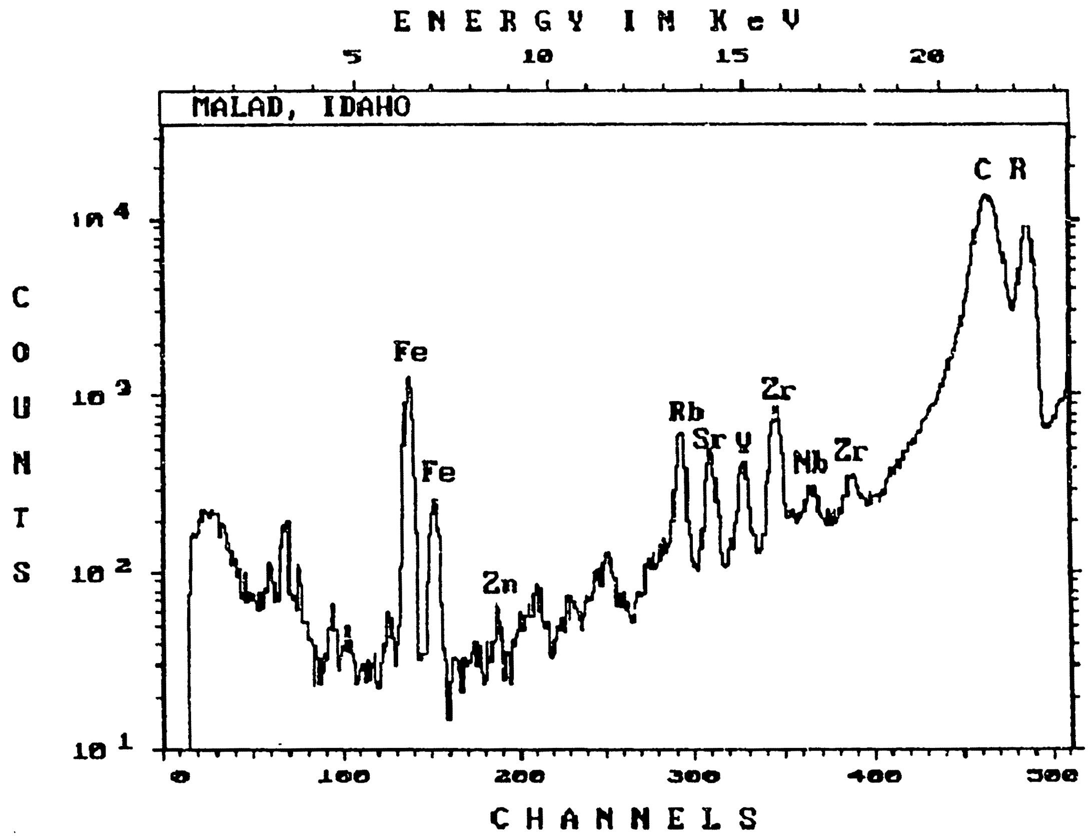

ENERGY IN KeV
5
10
15
20
GIBSON CREEK, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 0
10 1
10 2
10 3
10 4
0
100
200
300
400
500
CHANNELS

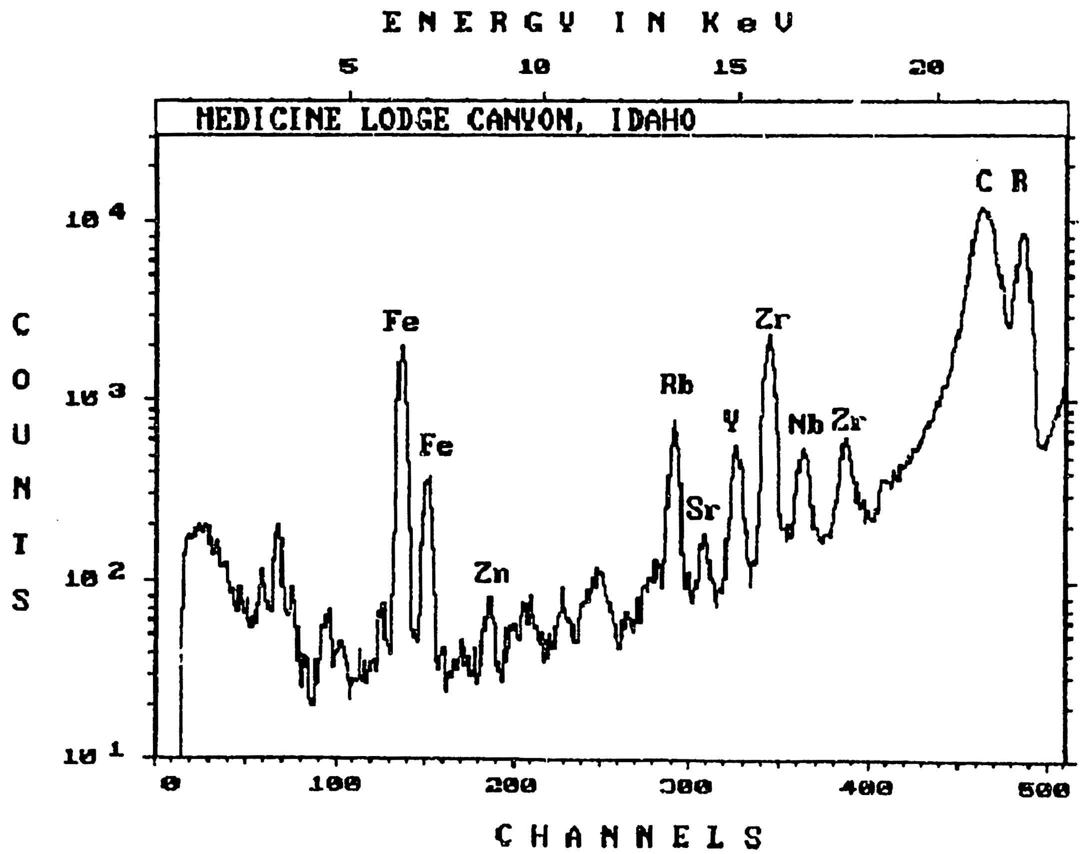


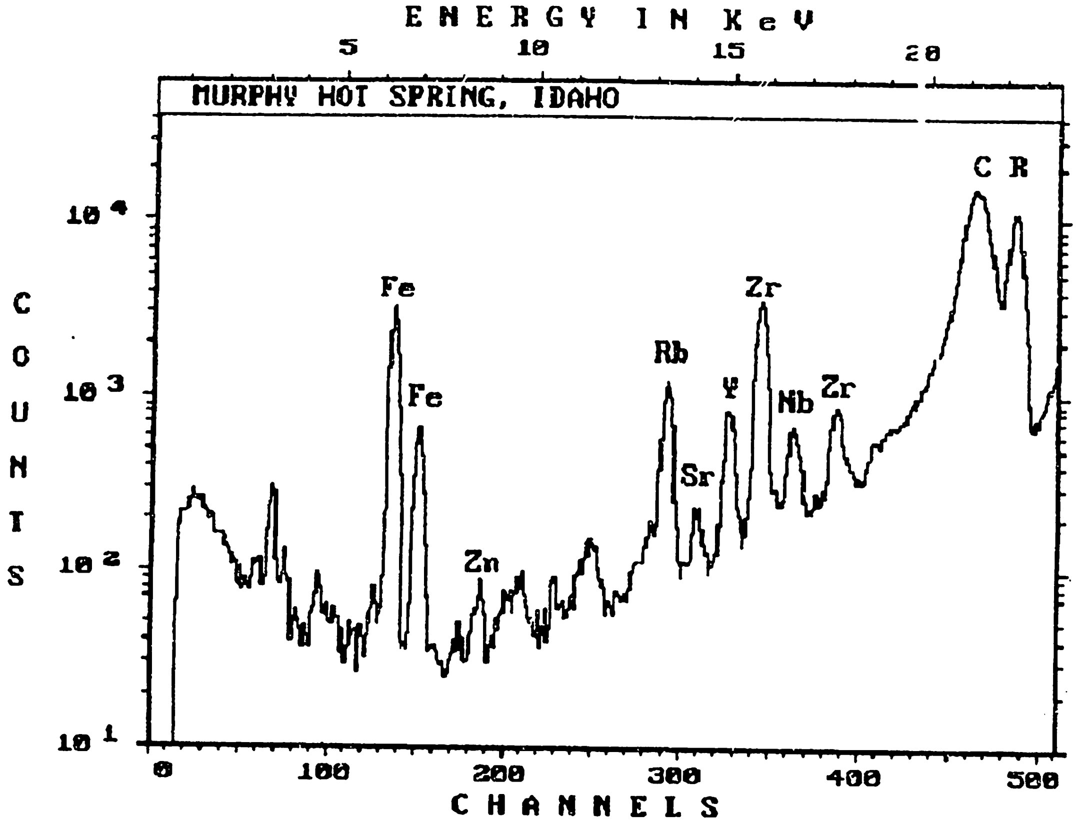
ENERGY IN KeV
5
10
15
20
UBC 1173
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
10^0
0
100
200
300
400
500
CHANNELS

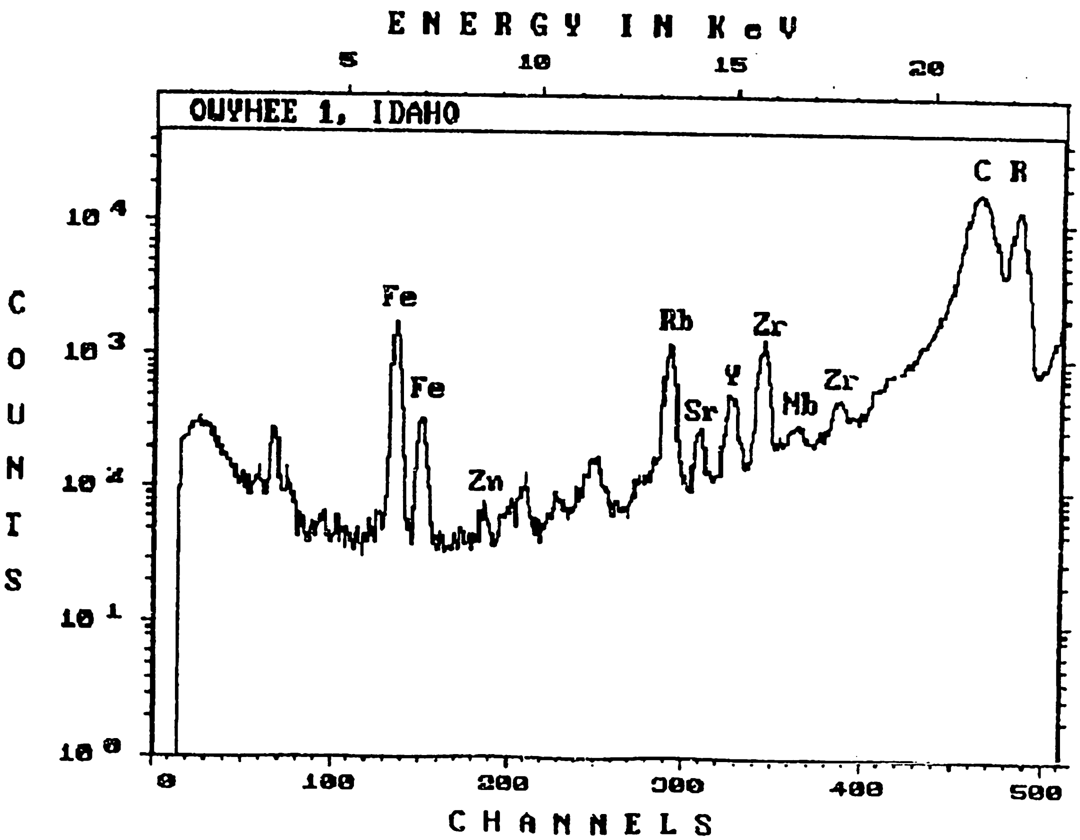


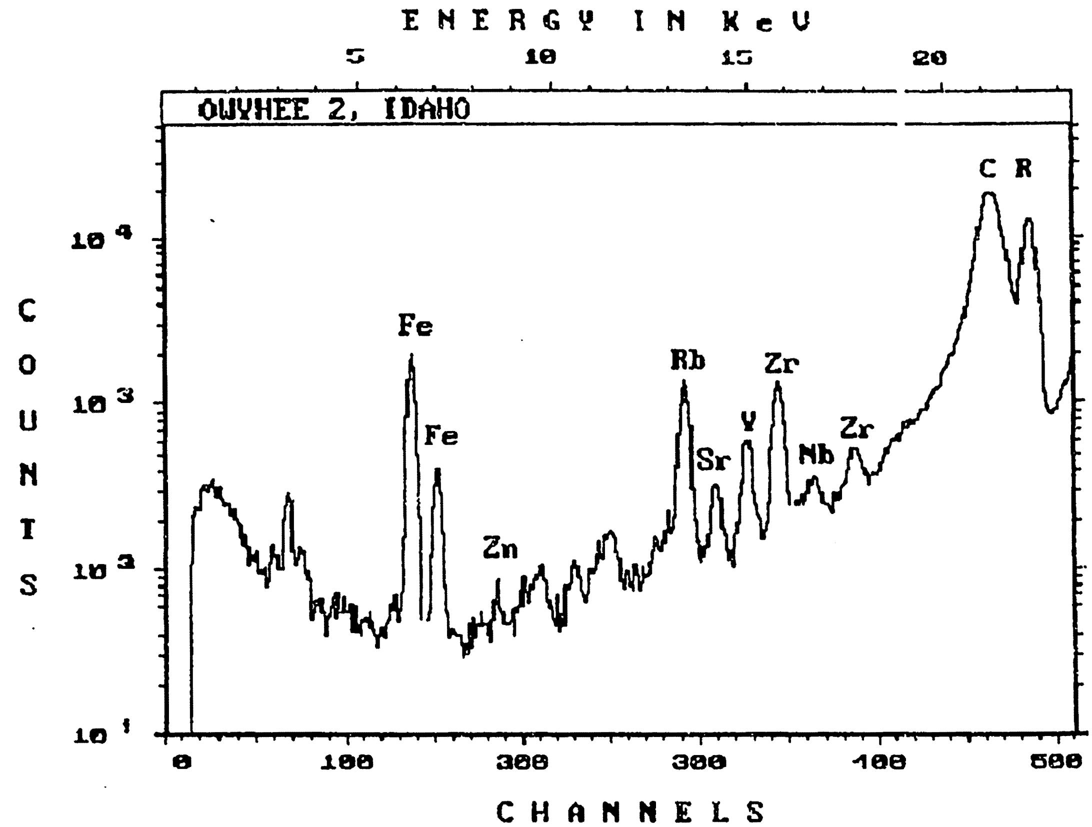
ENERGY IN KeV
5
10
15
20
UBC 1174
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
100
200
300
400
500
CHANNELS

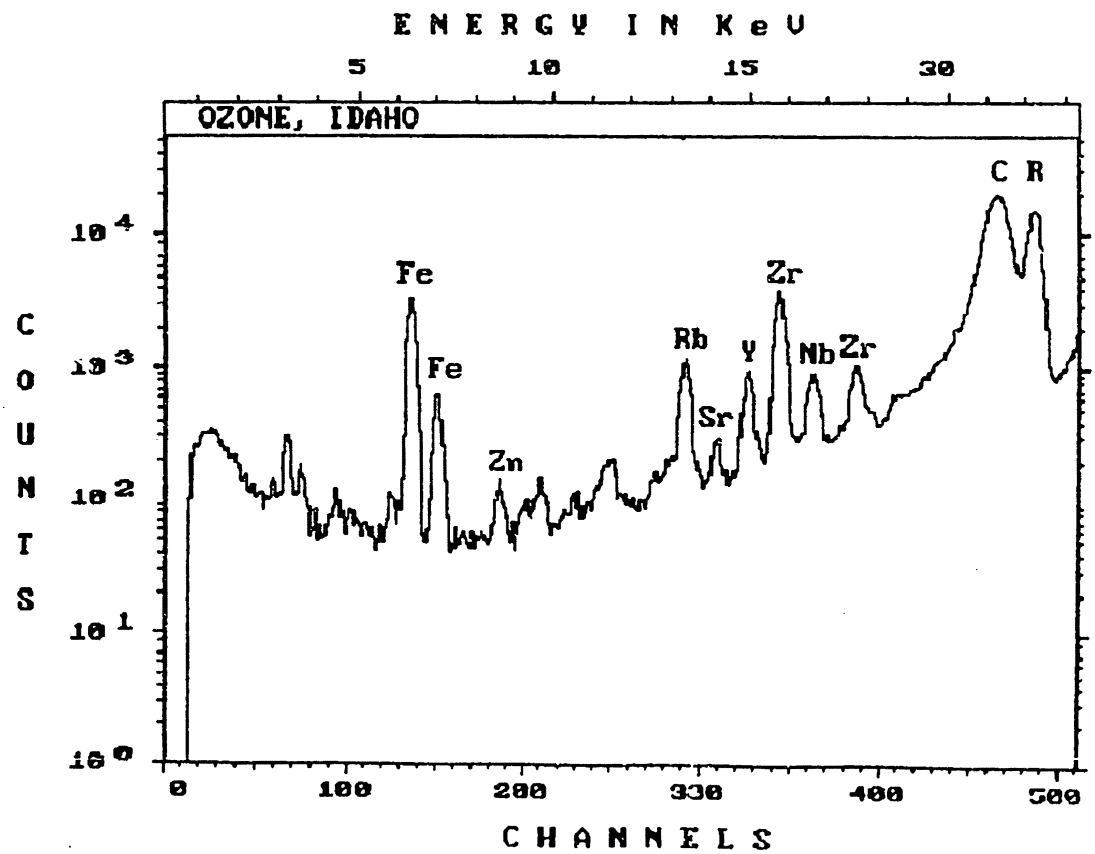

ENERGY IN KeV
5
10
15
20
MALAD, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS

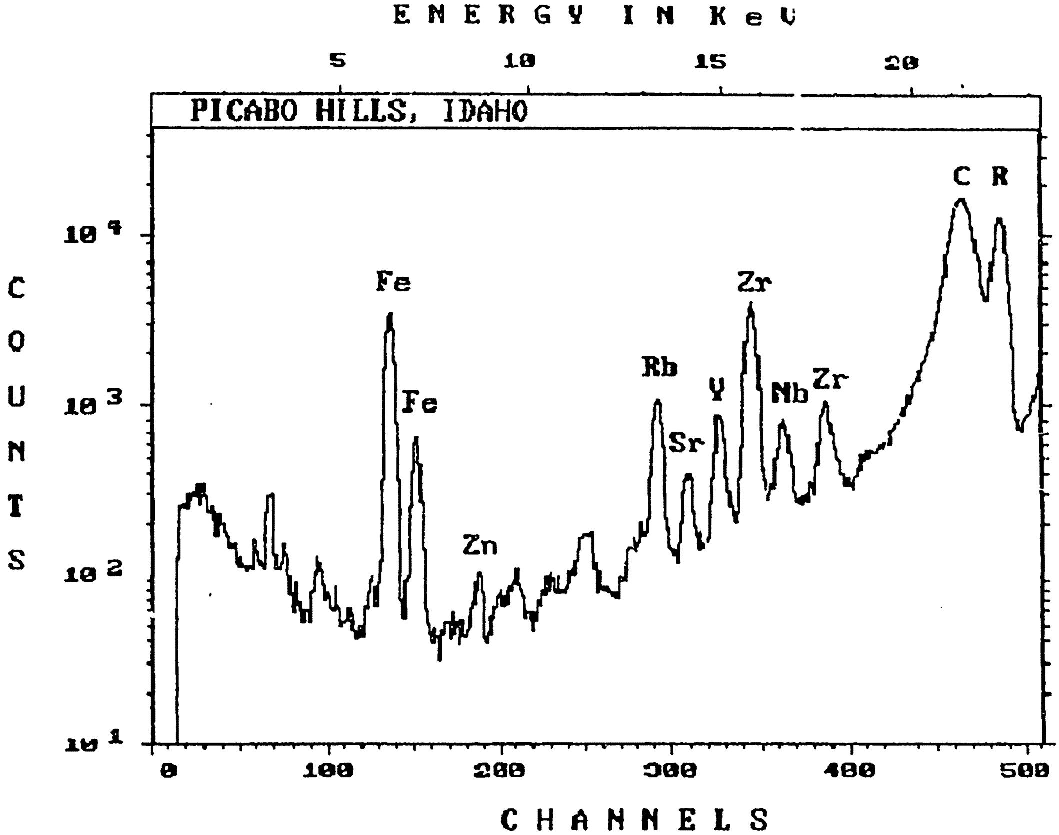

ENERGY IN KeV
5
10
15
20
MEDICINE LODGE CANYON, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS

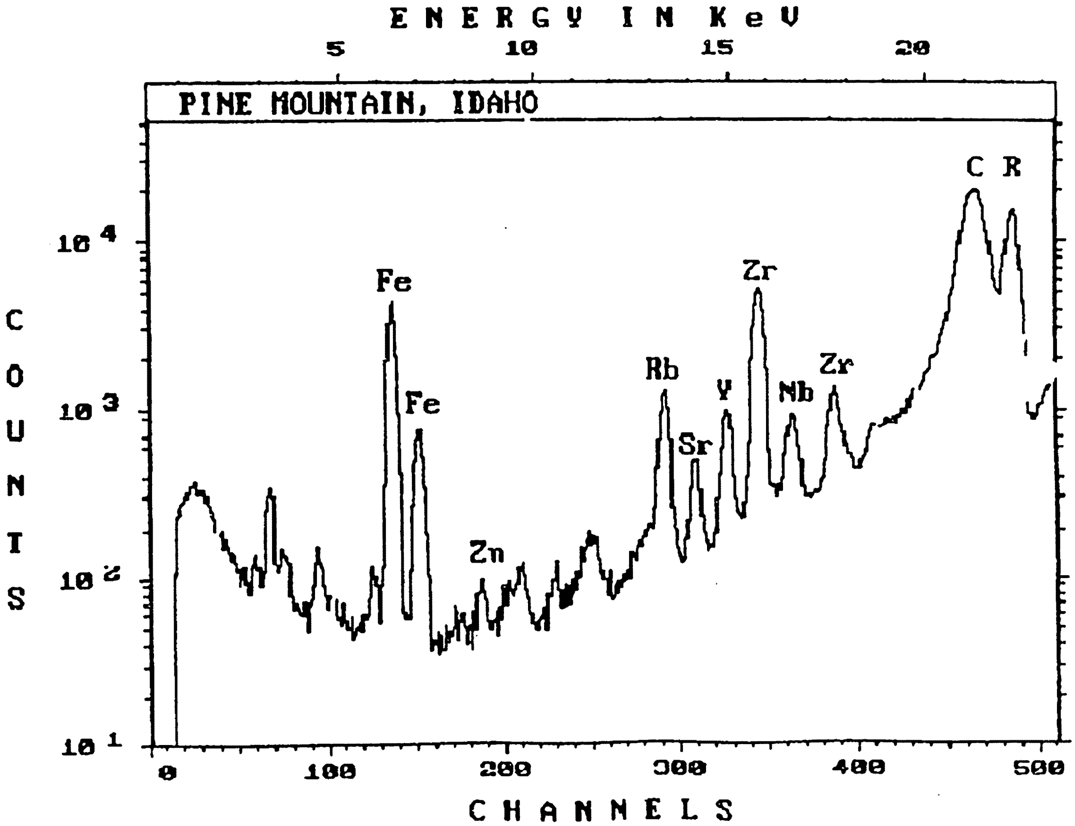

ENERGY IN KeV
5
10
15
20
MURPHY HOT SPRING, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS

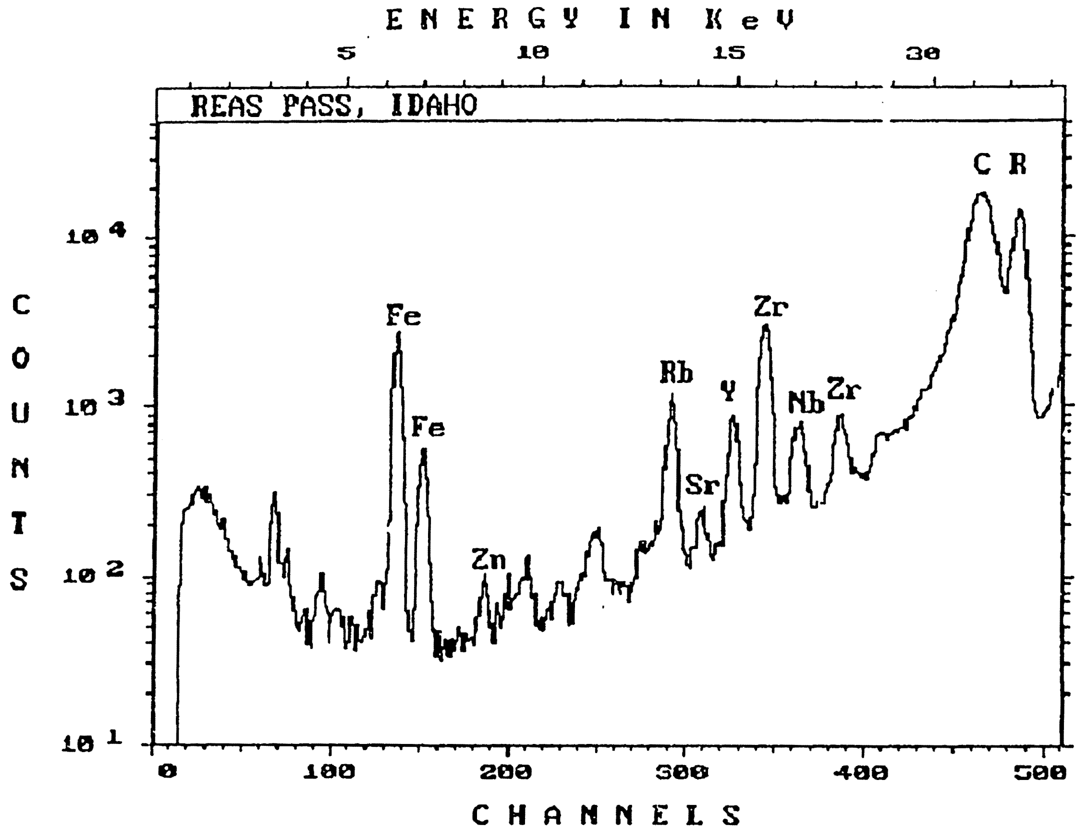

ENERGY IN KeV
5
10
15
20
OWYHEE 1, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
10 0
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
OWYHEE 2, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS


ENERGY IN KeV
OZONE, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS


ENERGY IN KeV
5
10
15
20
PICABO HILLS, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
PINE MOUNTAIN, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
REAS PASS, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
0
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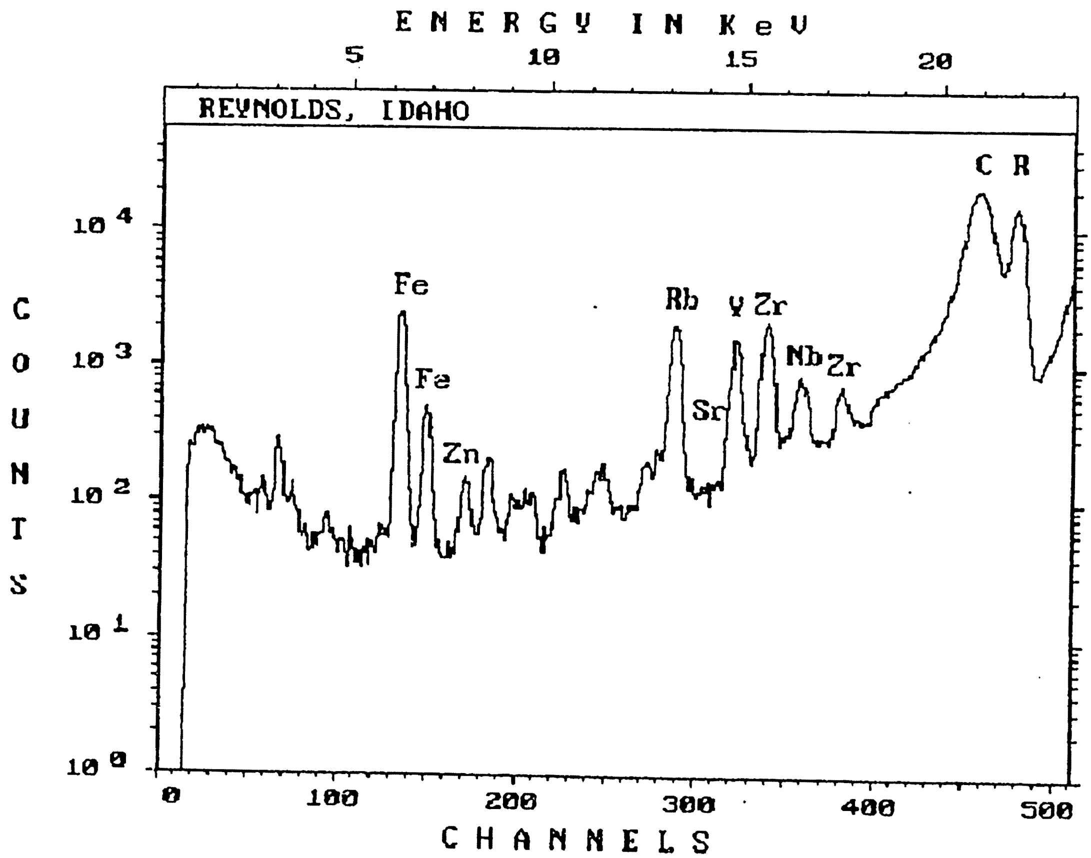
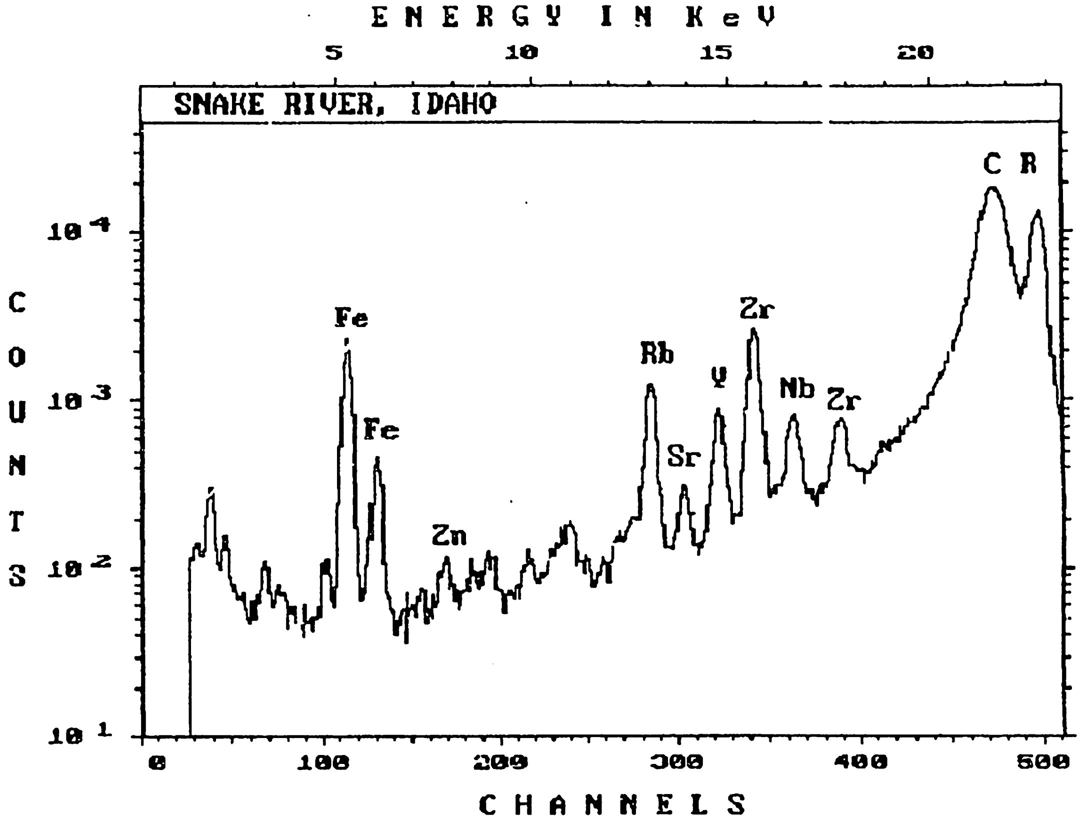
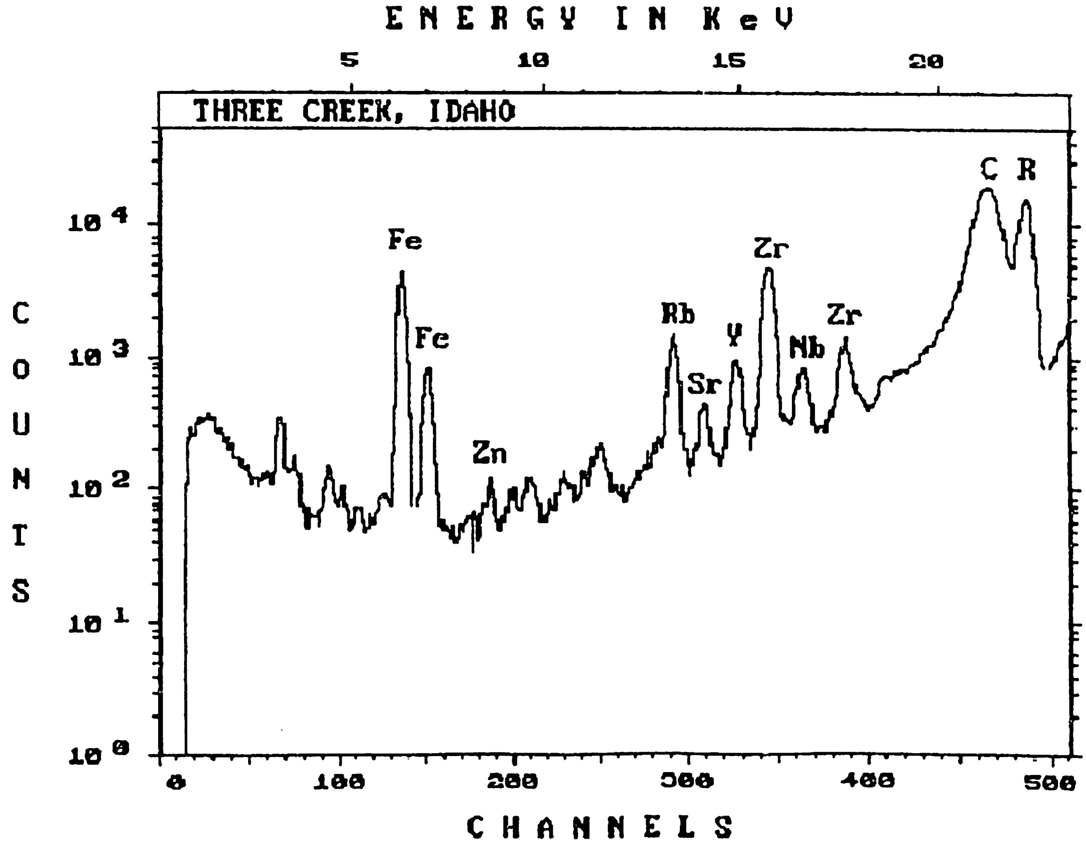
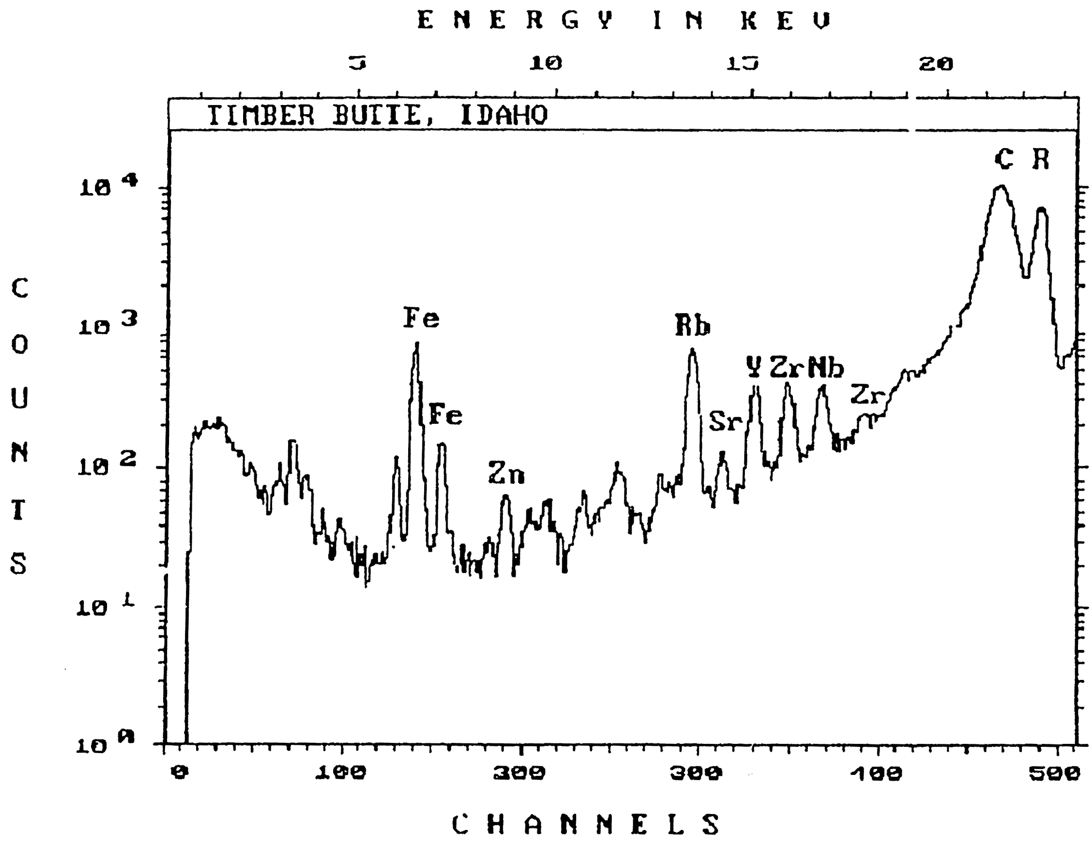
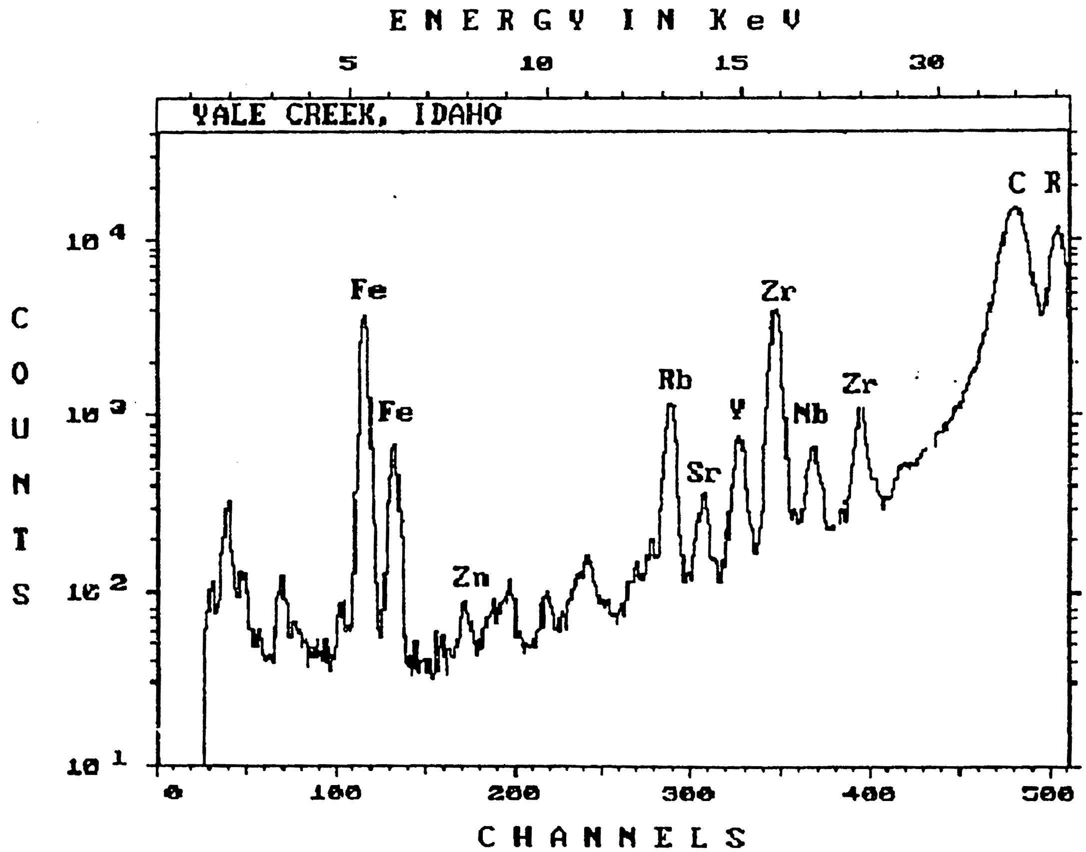
200
300
400
500
CHANNELS

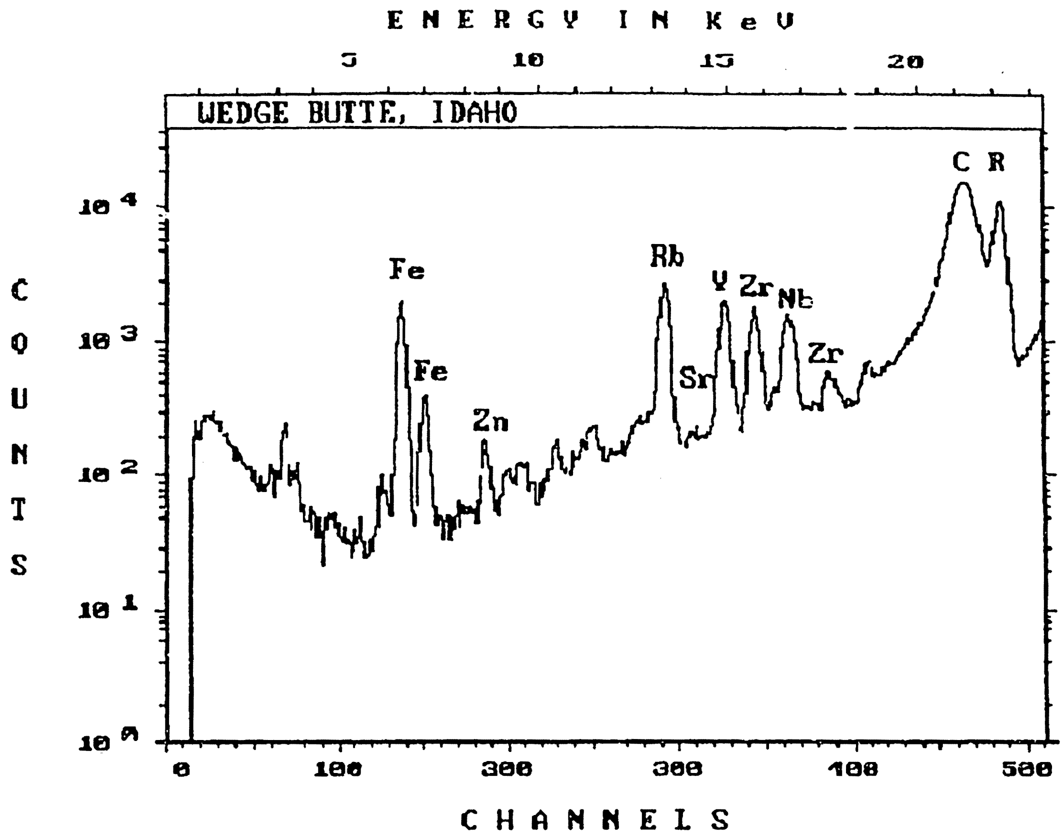

ENERGY IN KeV
5
10
15
20
REYNOLDS, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
10^0
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
SNAKE RIVER, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
0
100
200
300
400
500


ENERGY IN KeV
5
10
15
20
THREE CREEK, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
0
100
200
300
400
500

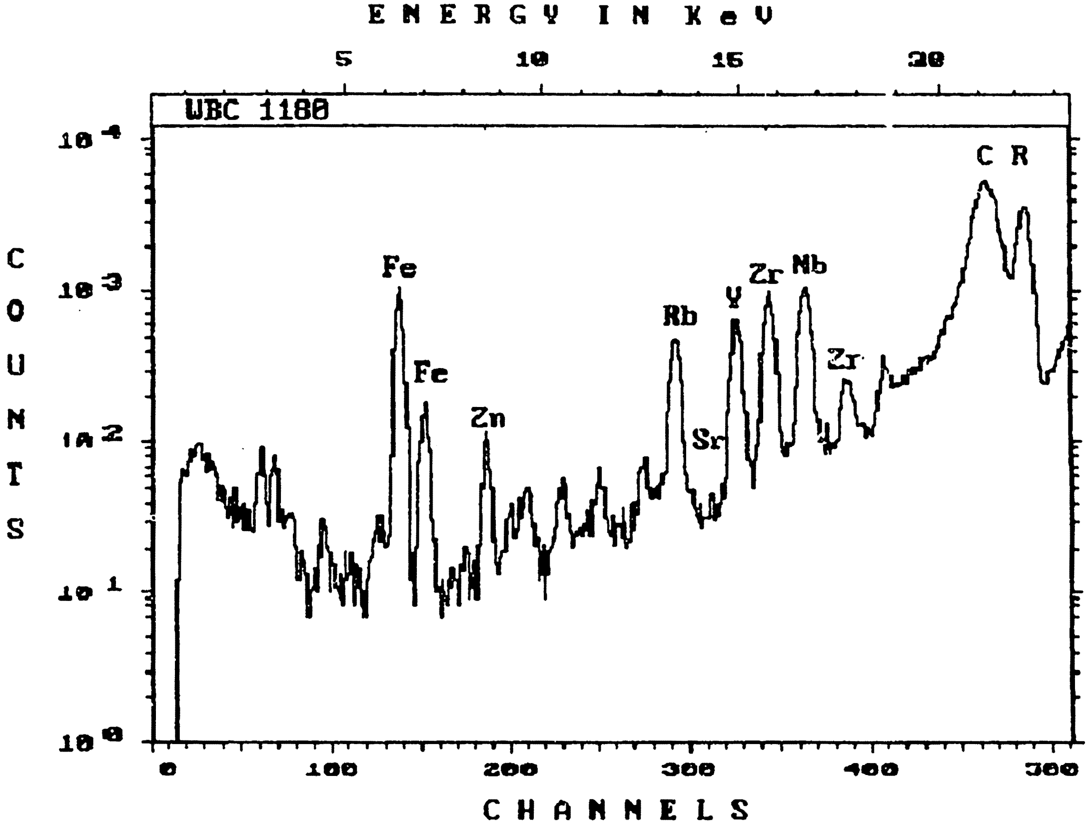

ENERGY IN KEV
5
10
15
20
TIMBER BUTTE, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y Zr Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
10 0
0
100
200
300
400
500
CHANNELS

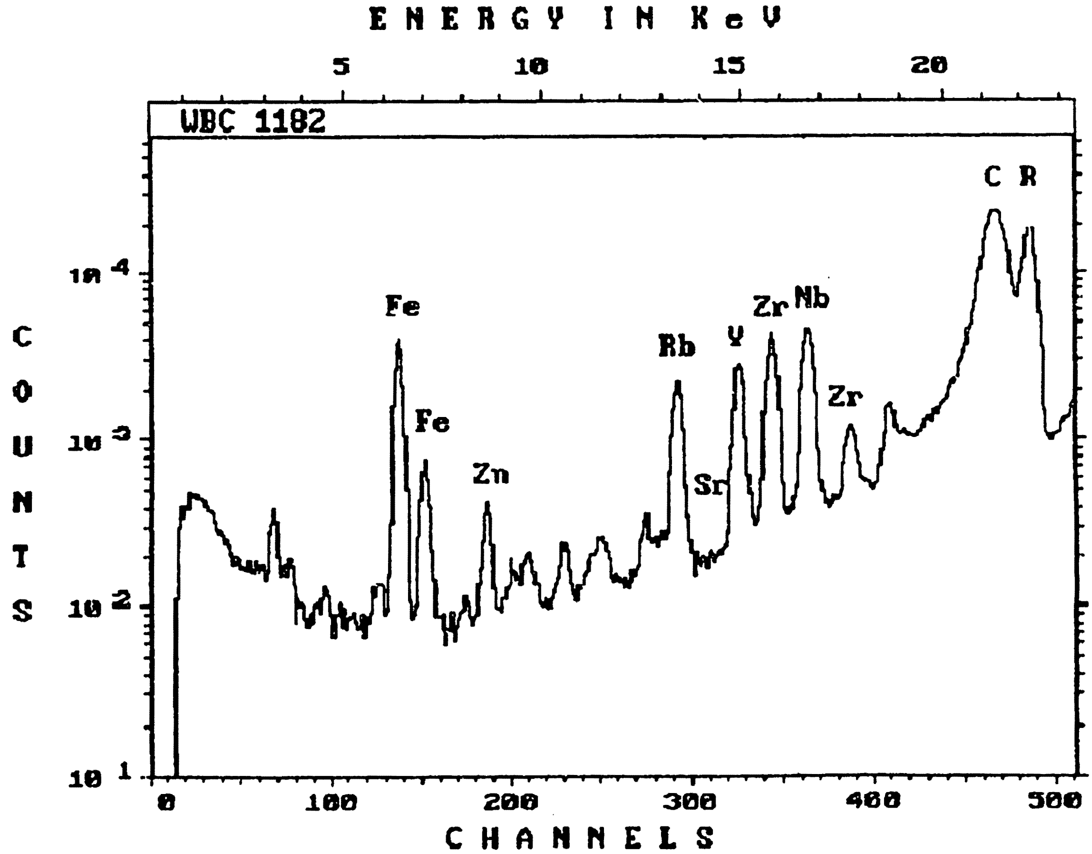

ENERGY IN KeV
5
10
15
20
YALE CREEK, IDAHO
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WEDGE BUTTE, IDAHO
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
10 0
0
100
200
300
400
500
CHANNELS

APPENDIX SEVEN

ARTIFACT CHARACTERIZATION SPECTRA


ENERGY IN KeV
5
10
15
20
UBC 1180
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
0
100
200
300
400
500


ENERGY IN KeV
5
10
15
20
UBC 1182
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
0
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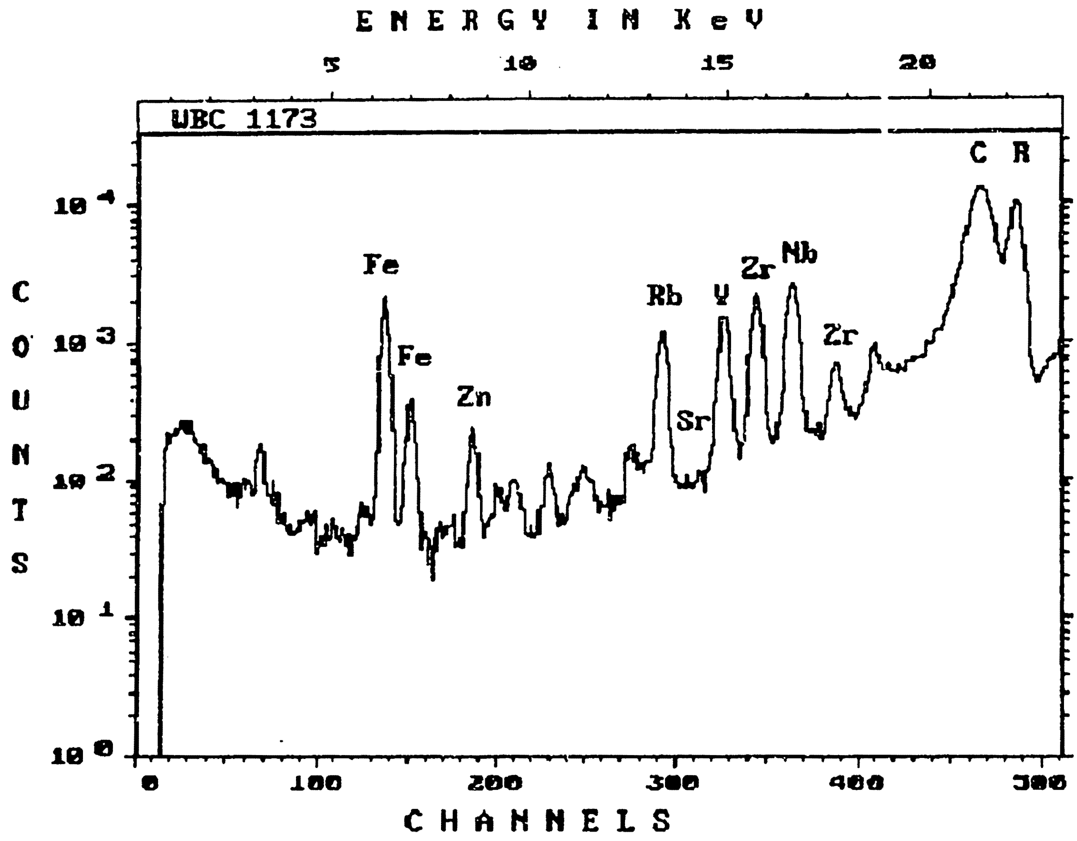
200
300
400
500


ENERGY IN KeV
5
10
15
20
UBC 1173
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
10^0
0
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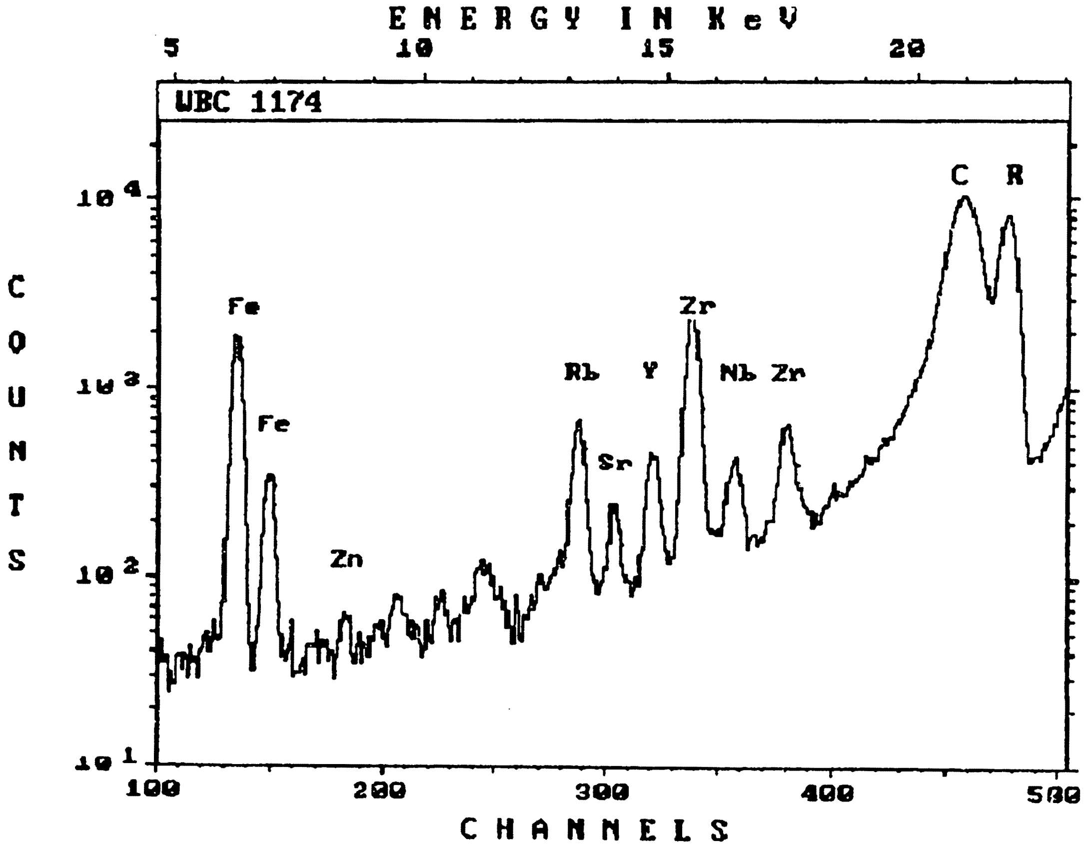
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 1174
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10^3
10^2
10^1
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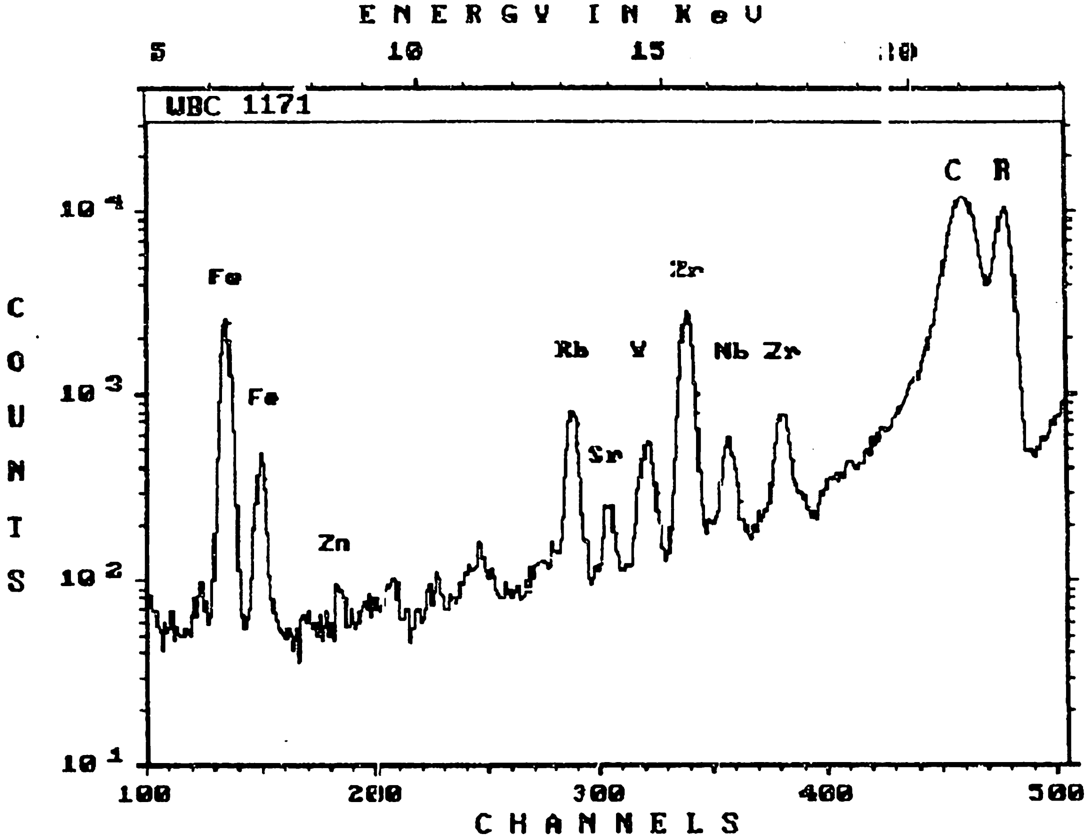
200
300
400
500
CHANNELS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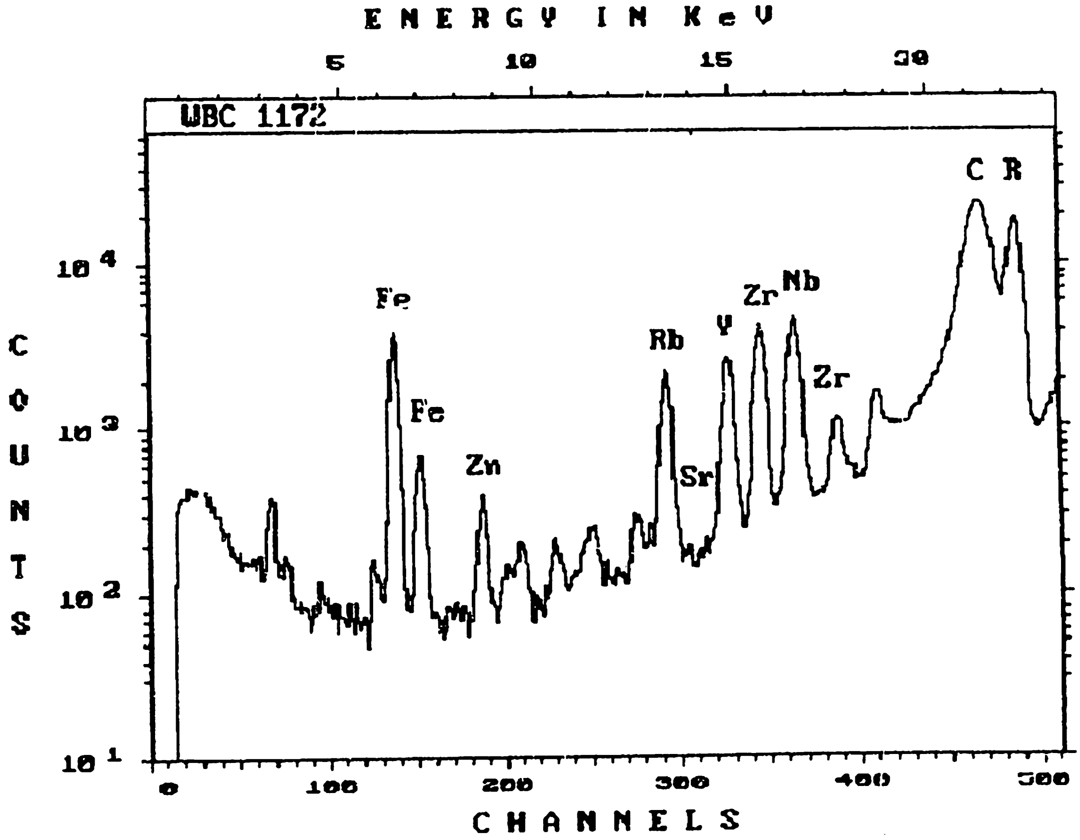
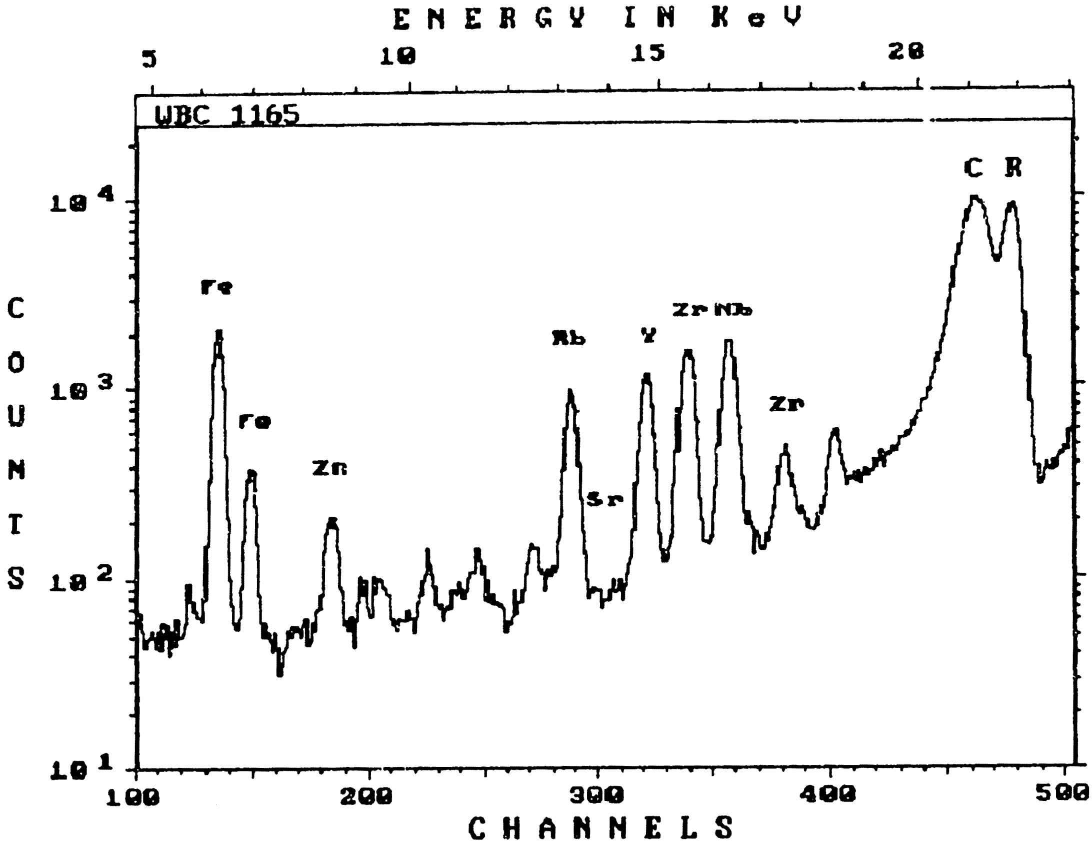
UBC 1171
C R
Fe
Fe
Zn
Rb
Y
Sr
Zr
Nb Zr
COUNTS
CHANNELS


ENERGY IN KeV
UBC 1172
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 1165
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10^3
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10^1
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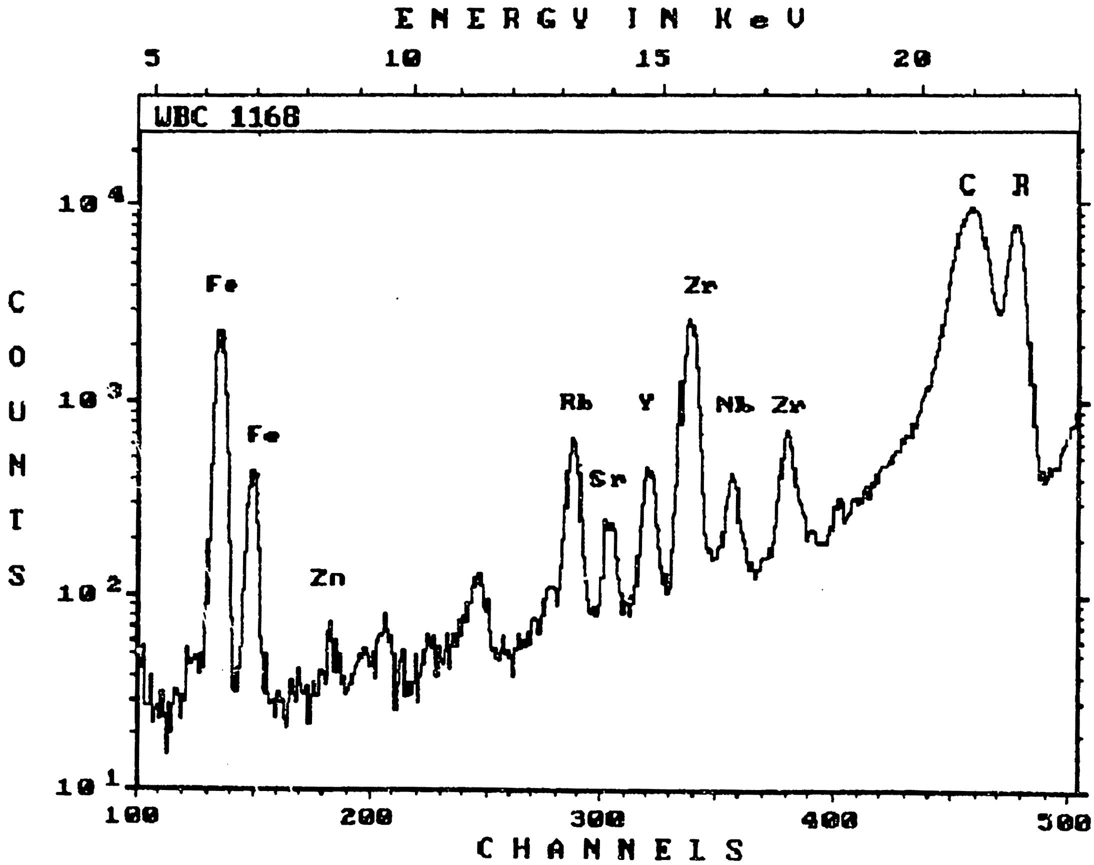
200
300
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 1168
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10^1
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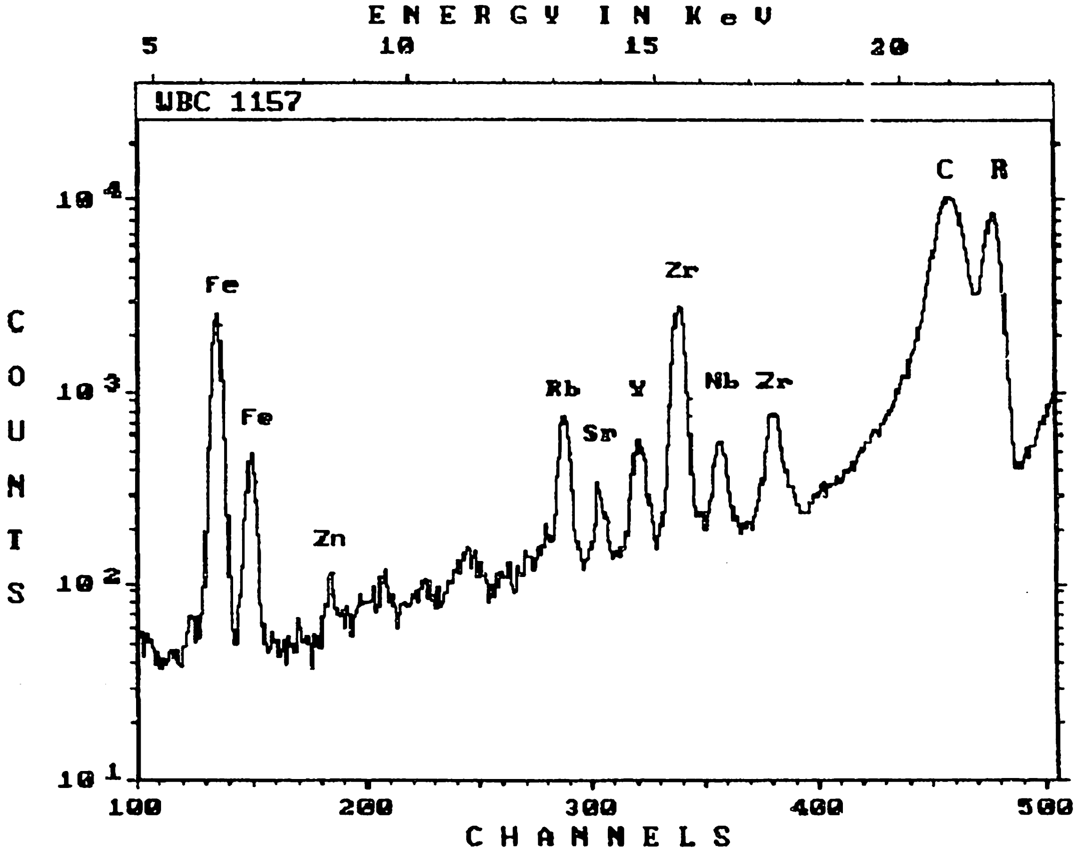
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1157
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 2
10 1
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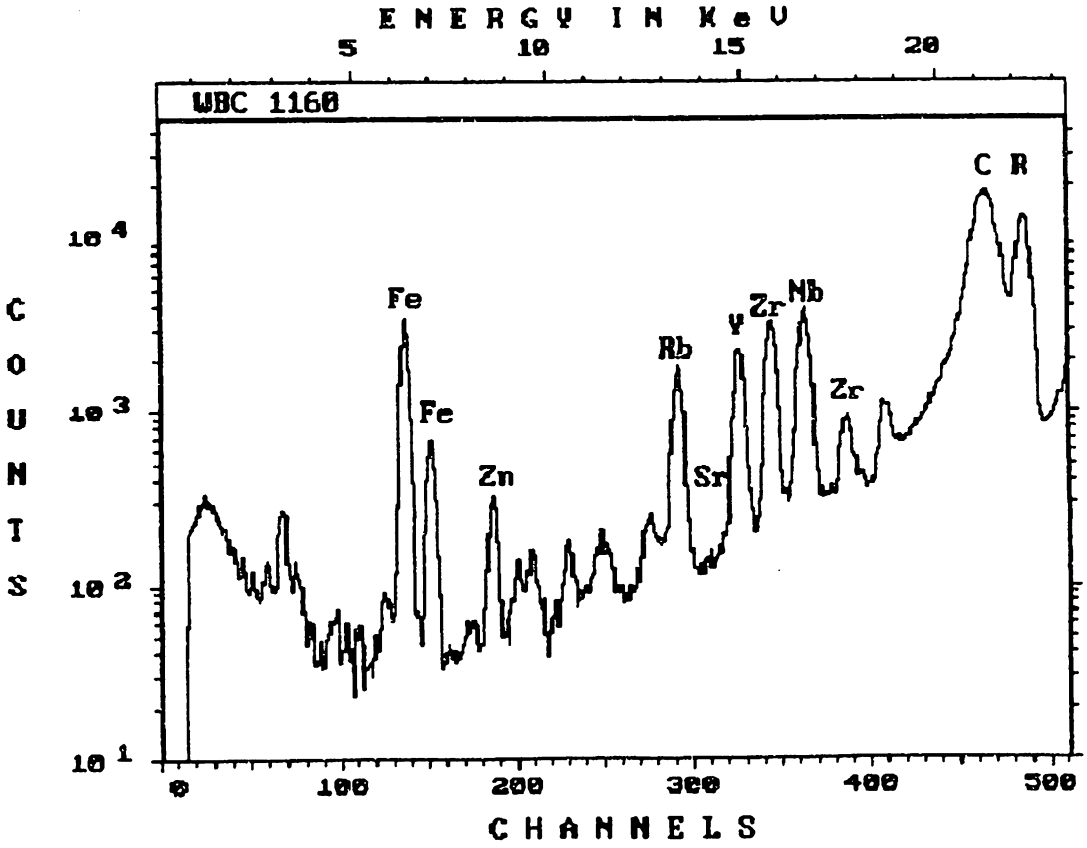
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1160
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
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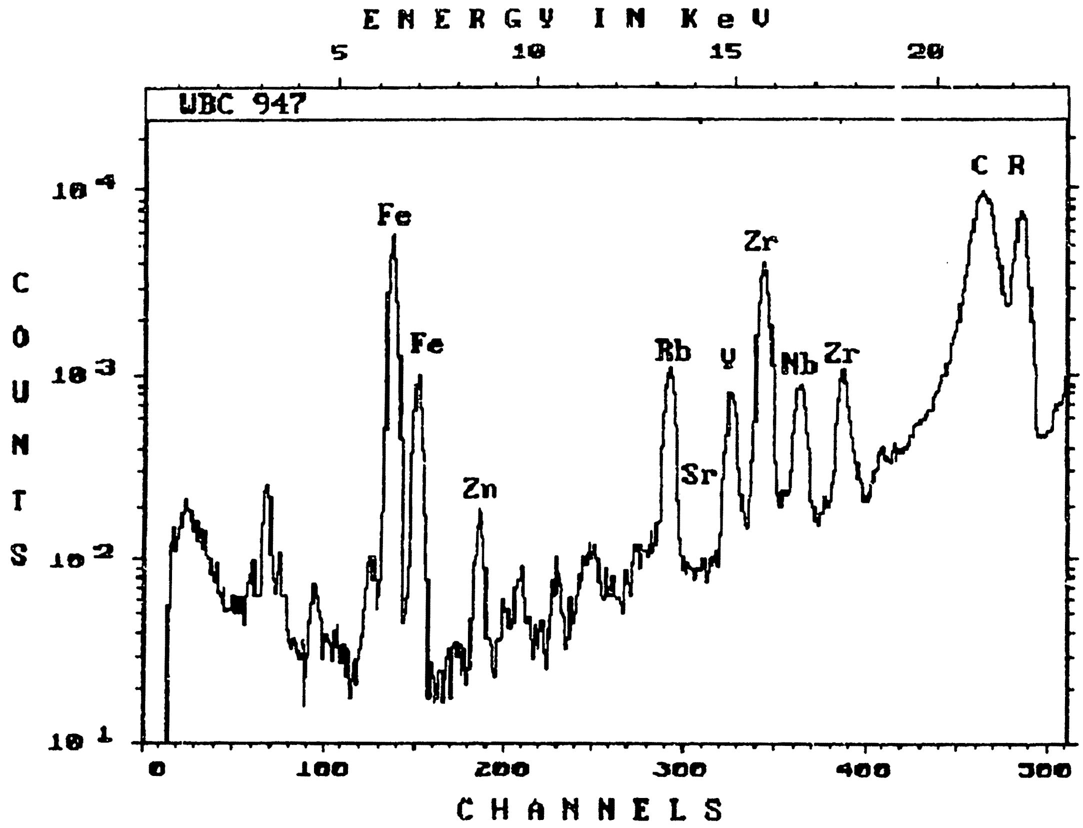
CHANNELS


ENERGY IN KeV
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10
15
20
UBC 947
COUNTS
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10 3
10 2
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Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
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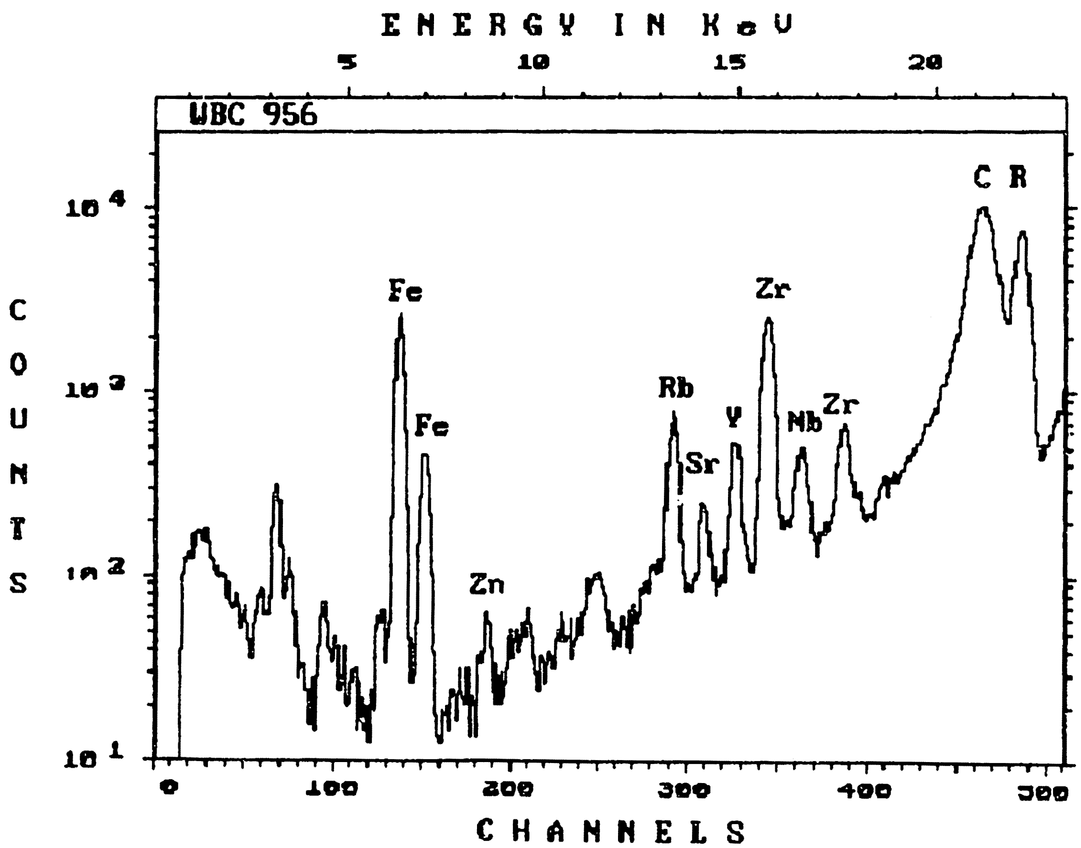
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 956
COUNTS
10 4
10 3
10 2
10 1
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Rb
Sr
Y
Zr
Nb
Zr
C
R
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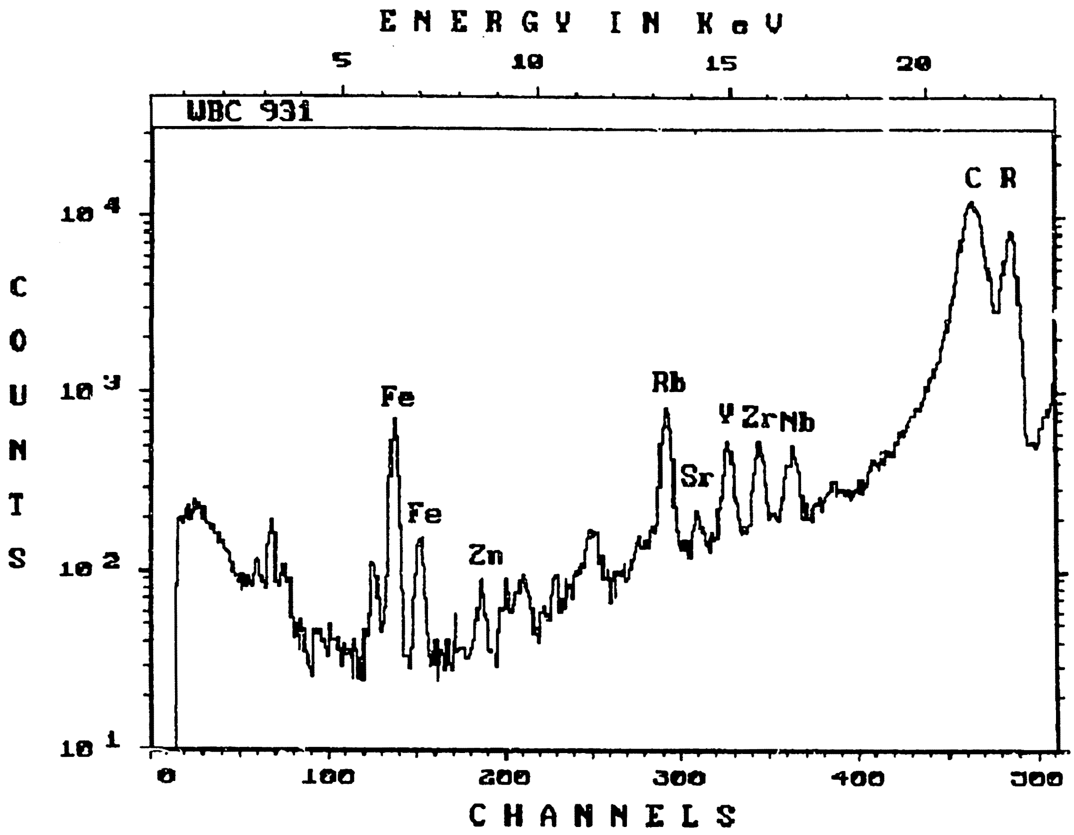
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 931
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
COUNTS
10^4
10^3
10^2
10^1
0
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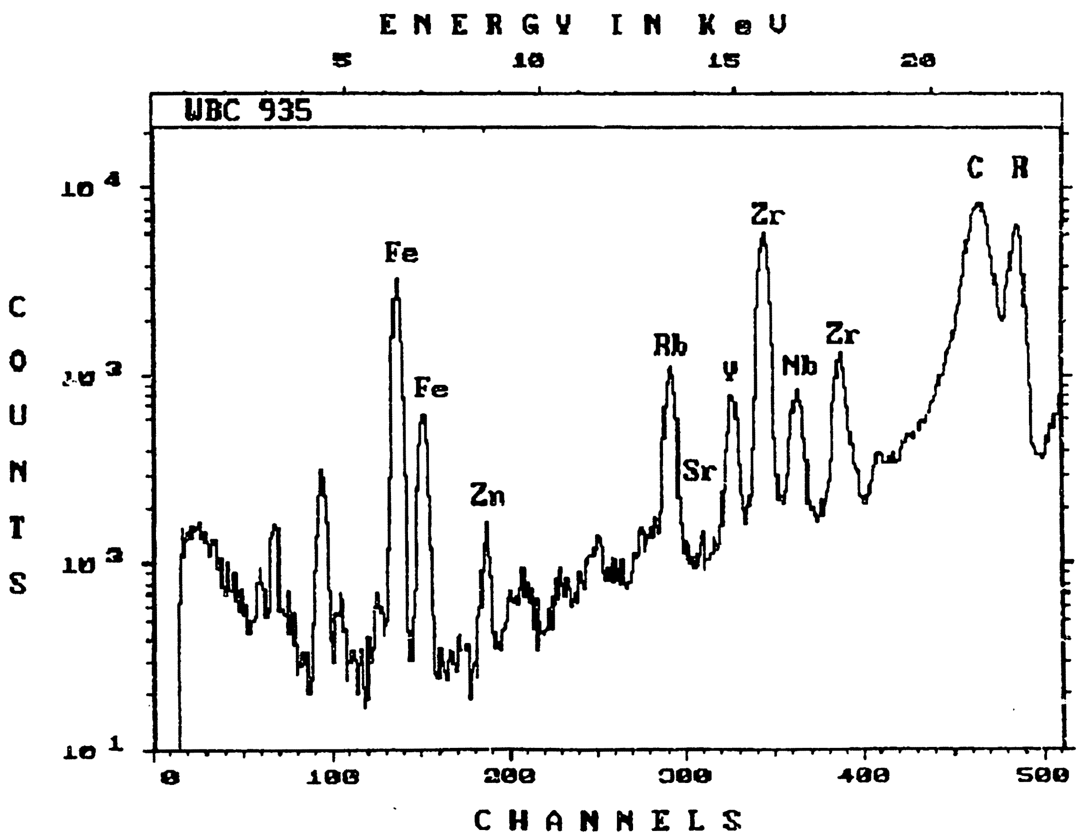
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 935
C R
Zr
Fe
Fe
Rb
Y
Nb
Zr
Sr
Zn
COUNTS
10^4
10^3
10^2
10^1
0
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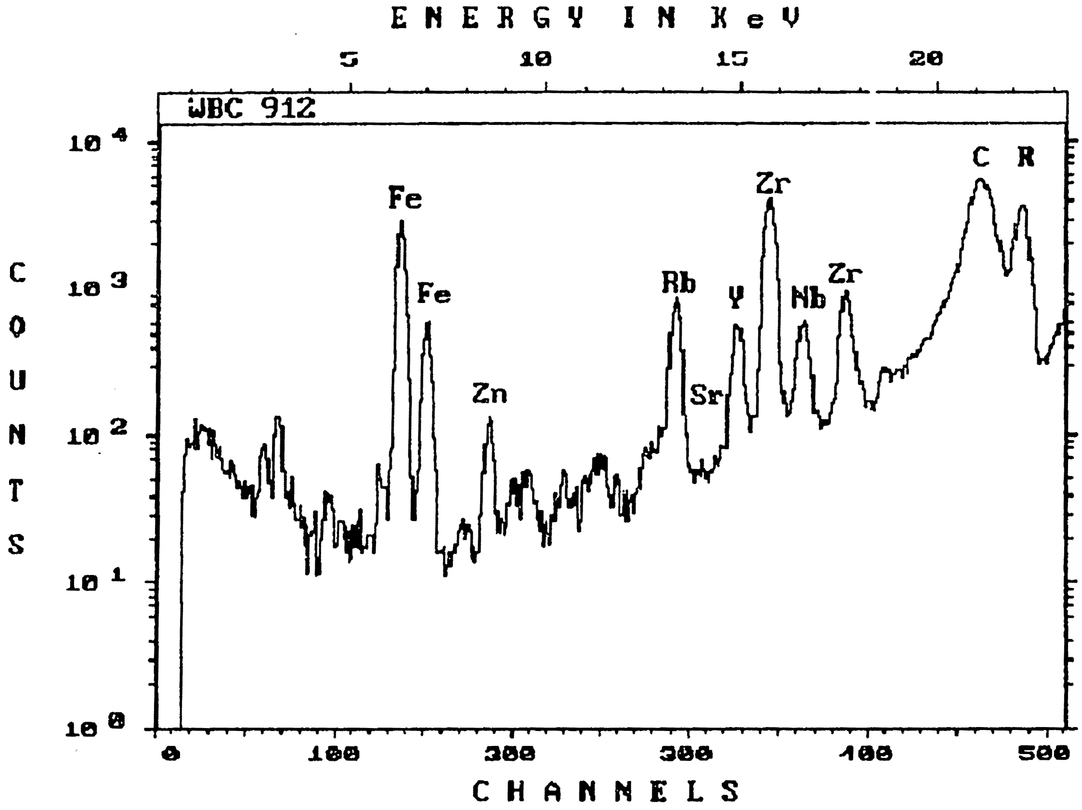
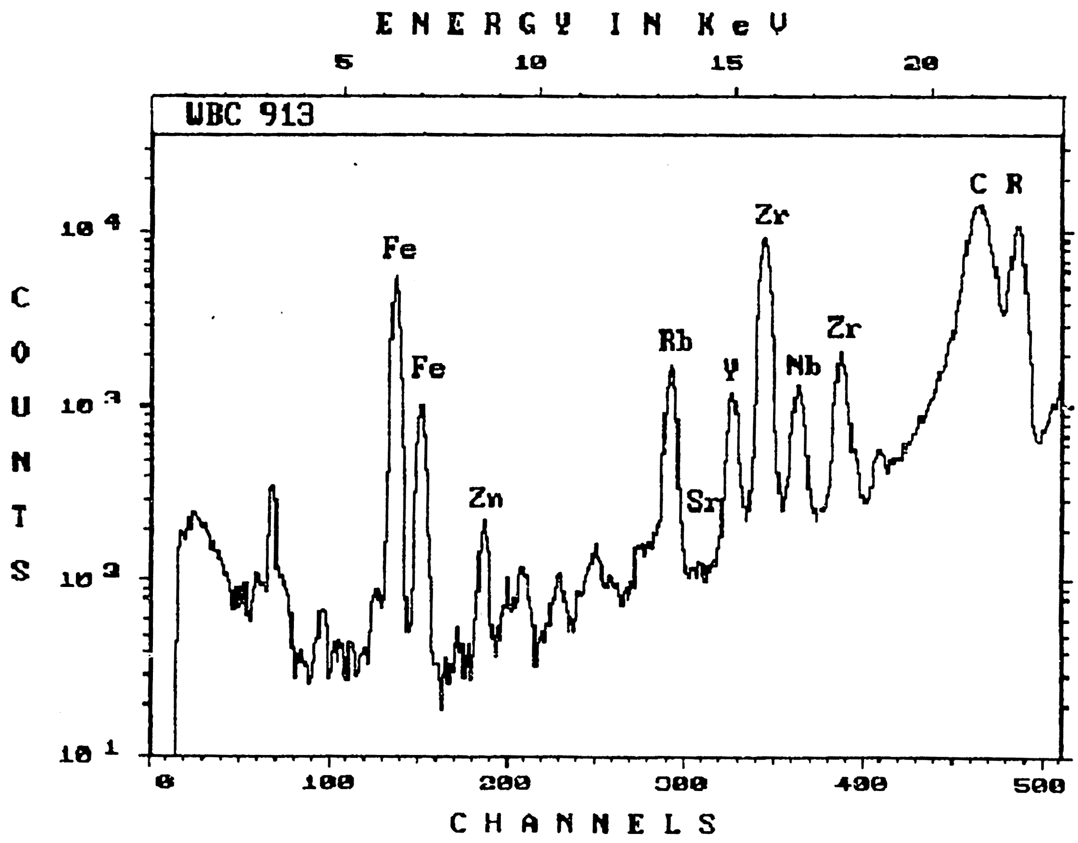
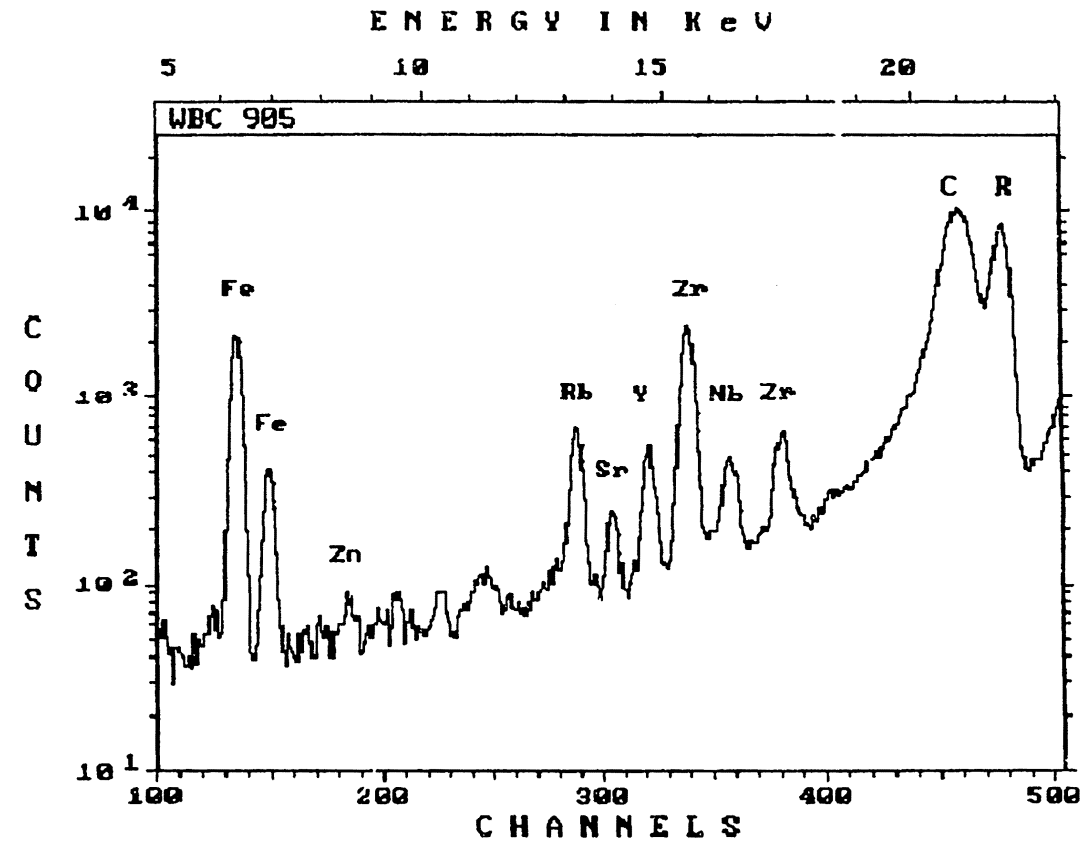
200
300
400
500
CHANNELS


ENERGY IN KeV
WBC 912
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C R
COUNTS
CHANNELS


ENERGY IN KeV
WBC 913
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C R
COUNTS
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 905
COUNTS
10^1
10^2
10^3
10^4
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Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
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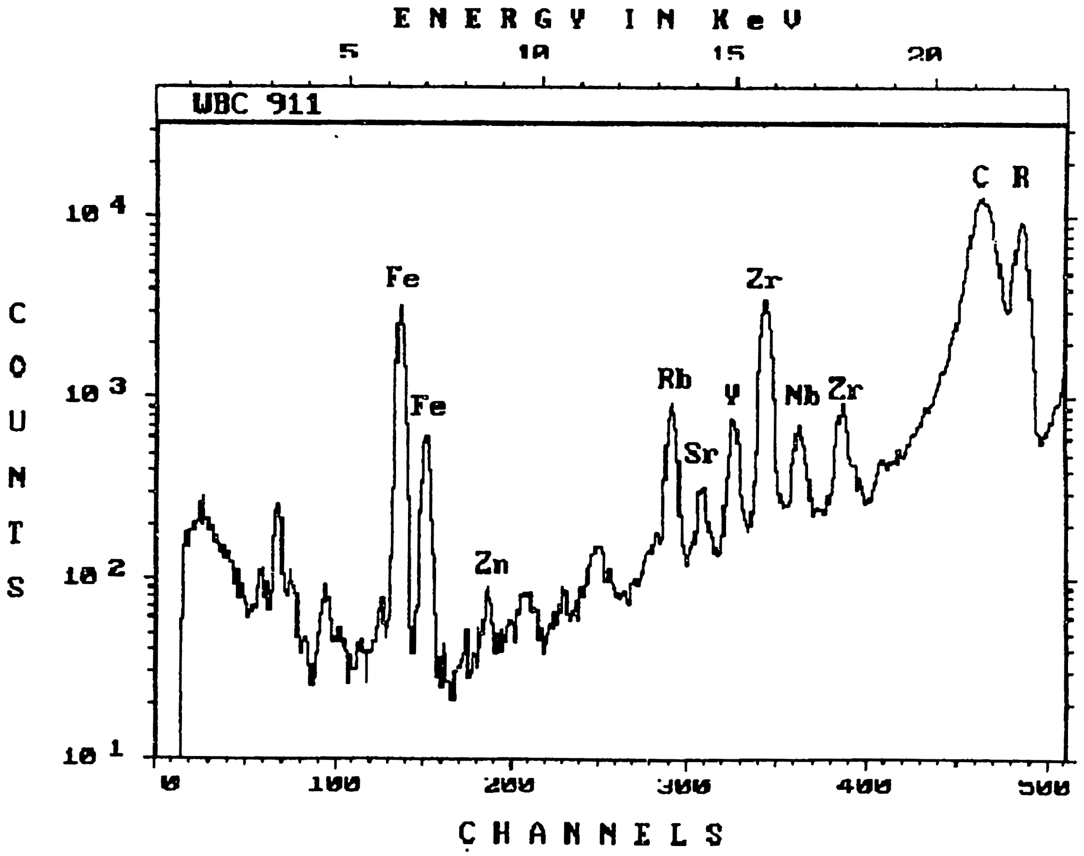
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 911
COUNTS
10^1
10^2
10^3
10^4
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
0
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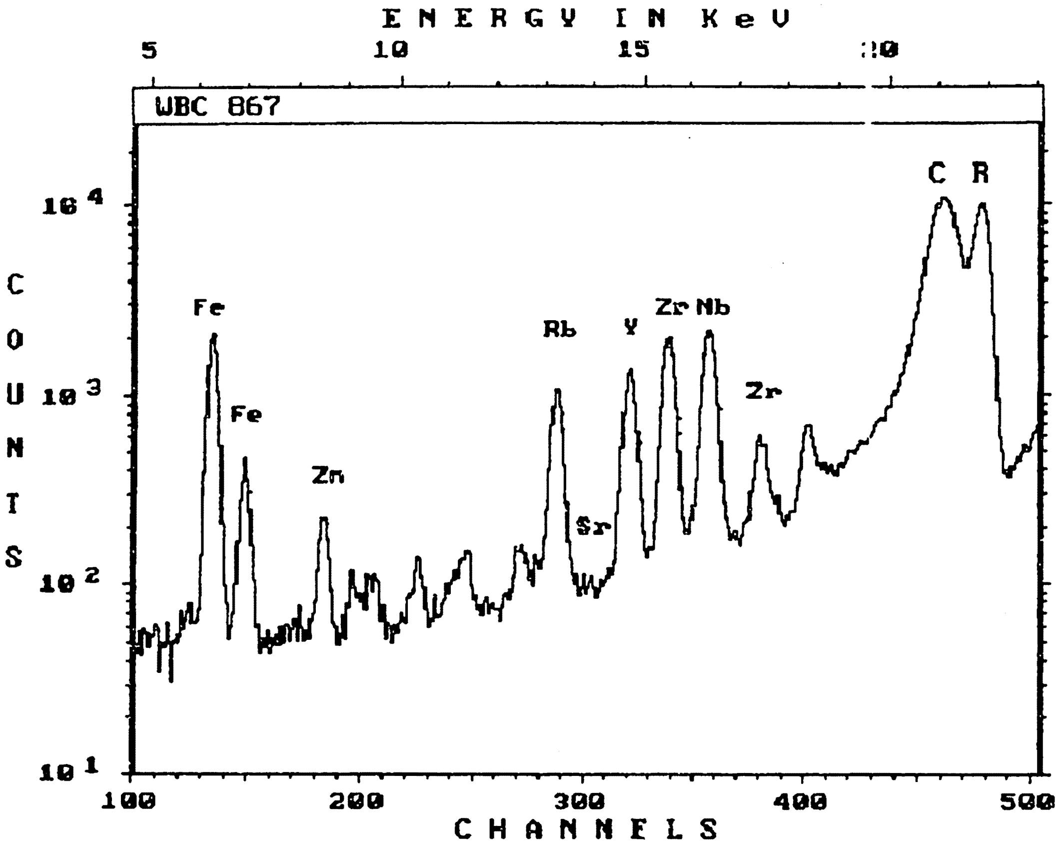
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 867
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr Nb
Zr
COUNTS
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10^3
10^2
10^1
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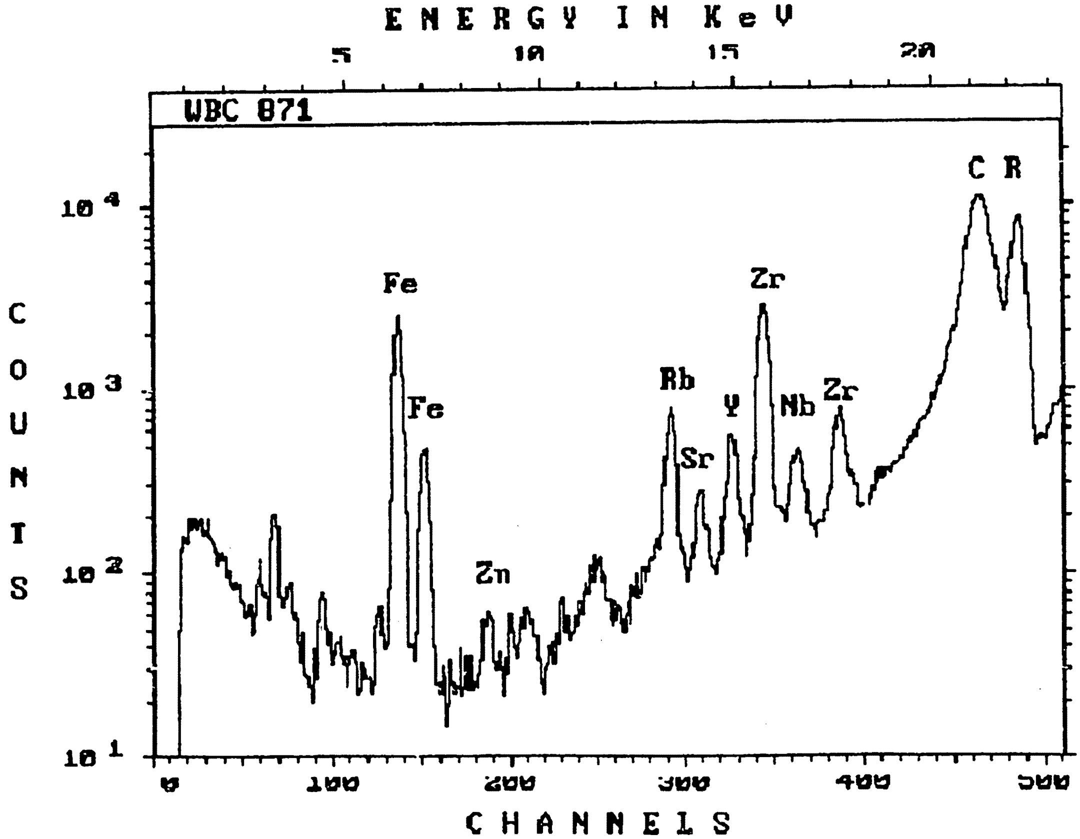
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 871
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
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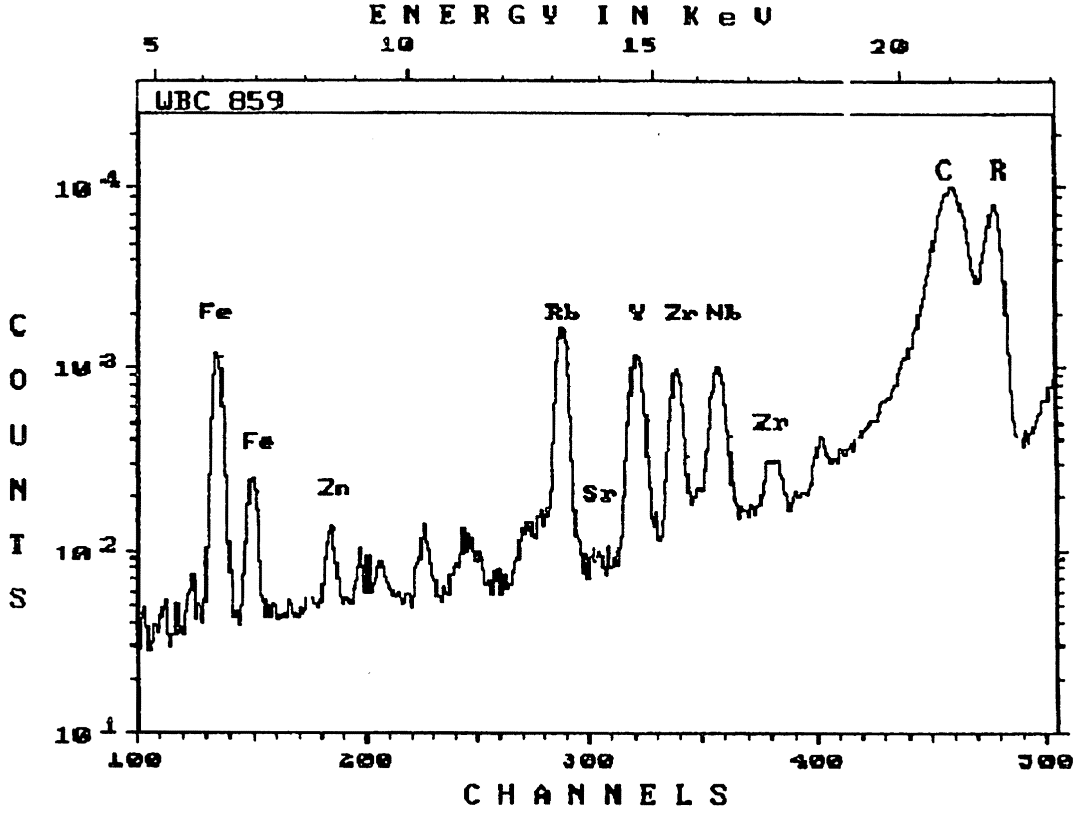
200
300
400
500
CHANNELS


ENERGY IN KeV
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15
20
WBC 859
C
R
Fe
Rb
Y
Zr
Nb
Fe
Zr
Zn
Sr
10^4
10^3
10^2
10^1
COUNTS
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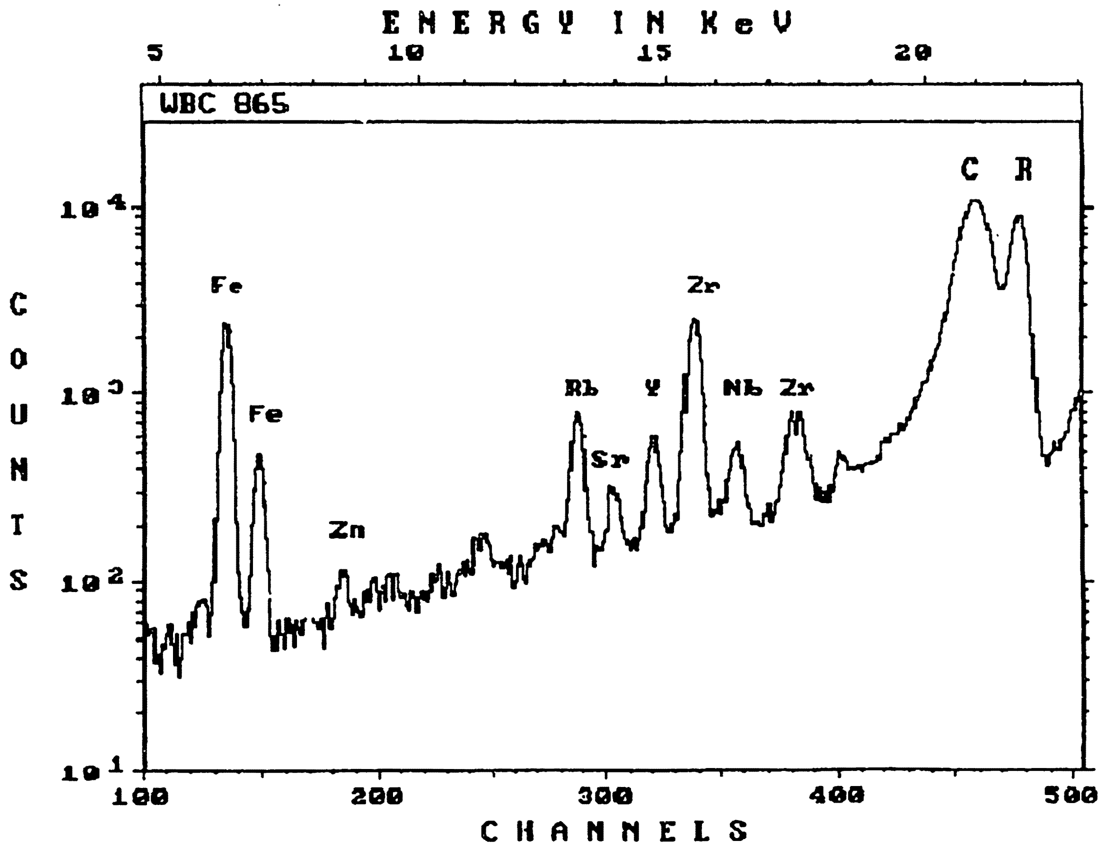
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 865
C
R
Fe
Zr
Rb
Y
Nb
Zr
Fe
Sr
Zn
10^4
10^3
10^2
10^1
COUNTS
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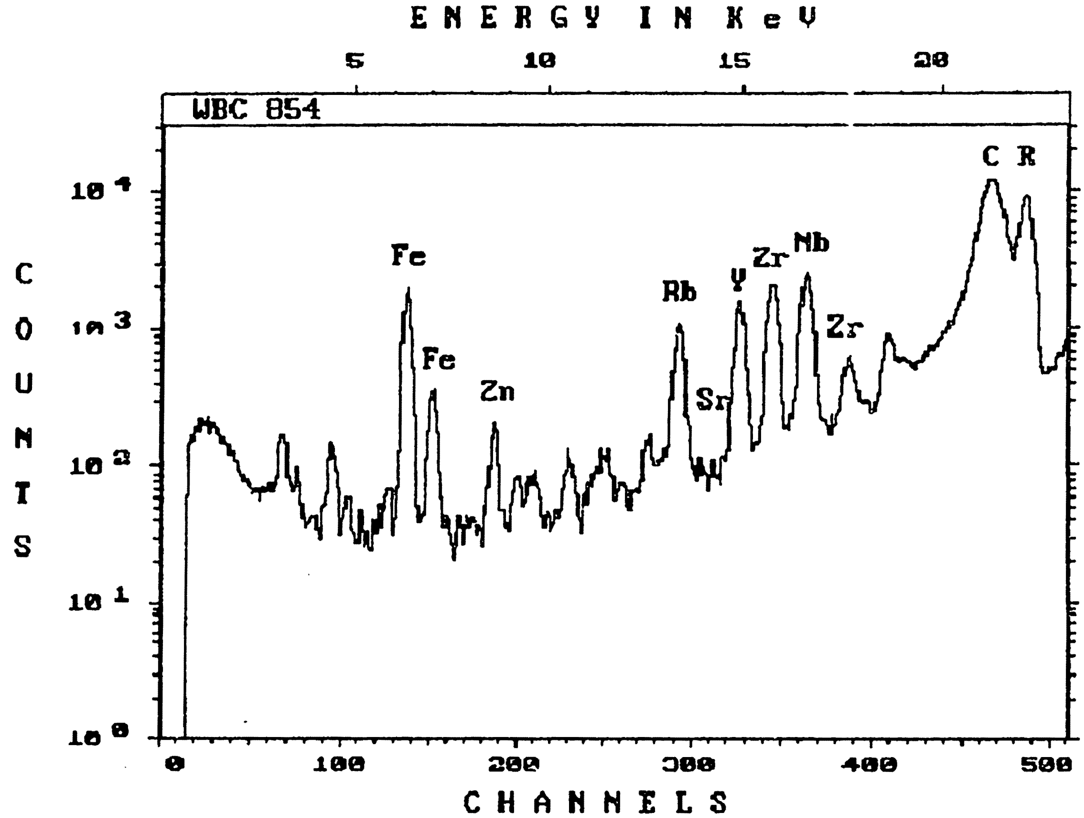
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 854
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
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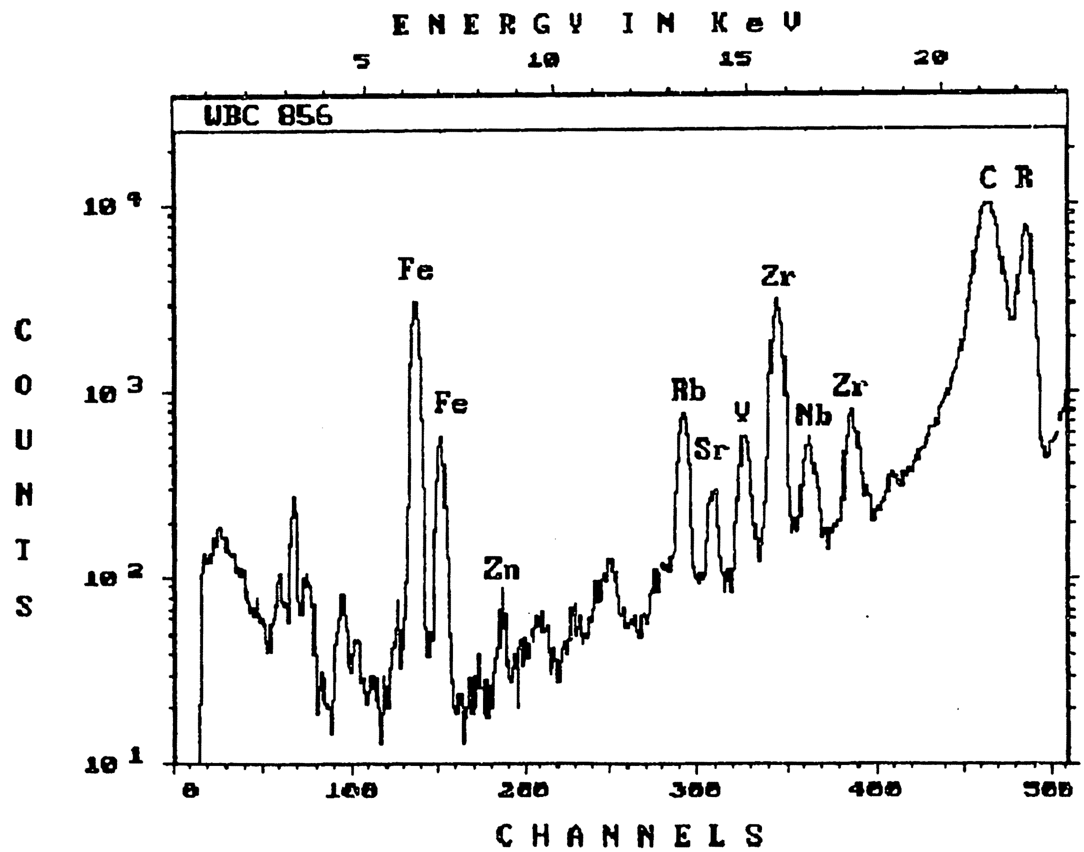
300
400
500


ENERGY IN KeV
5
10
15
20
WBC 856
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
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200
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400
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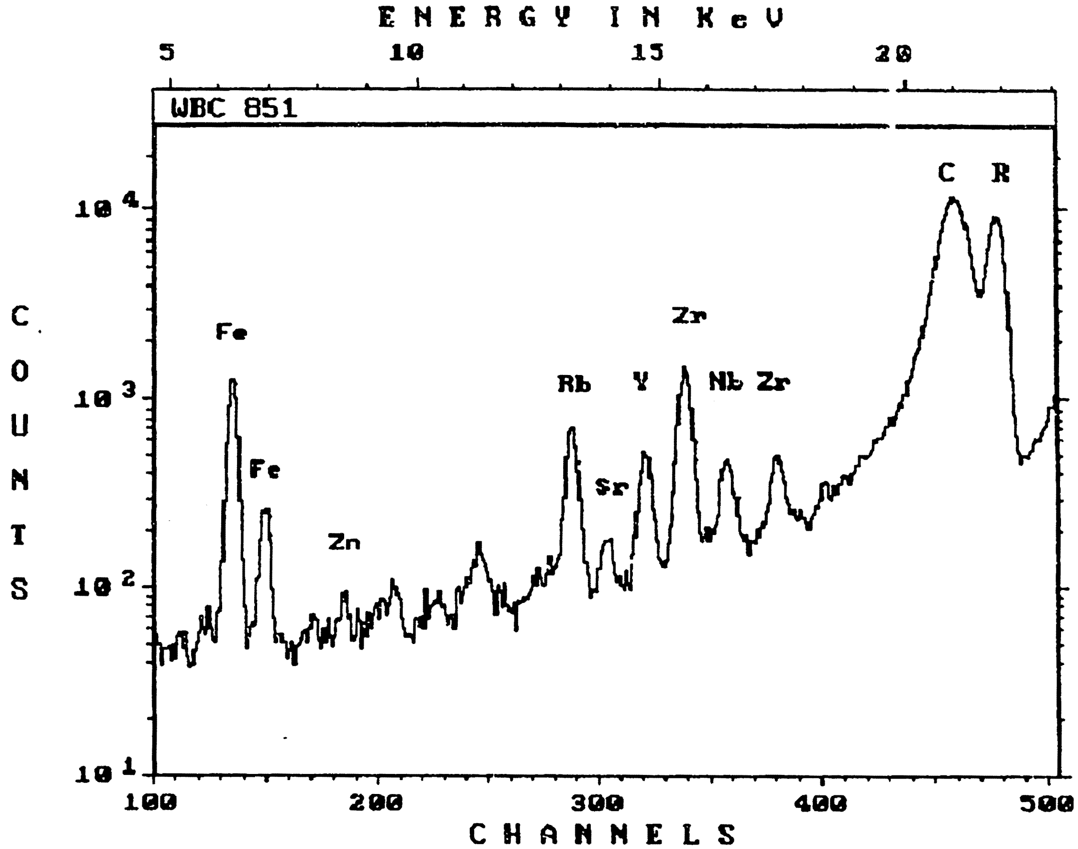

ENERGY IN KeV
5
10
15
20
WBC 851
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
10^4
10^3
10^2
10^1
COUNTS
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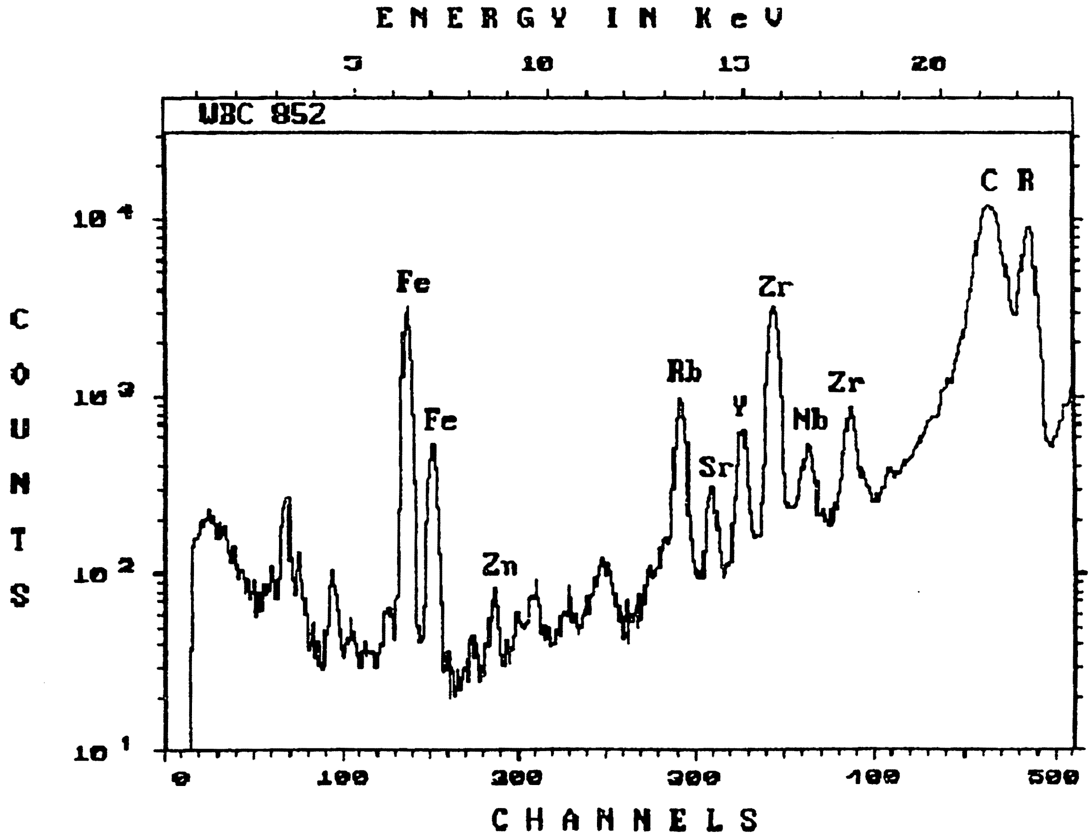
200
300
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 852
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
10^4
10^3
10^2
10^1
COUNTS
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200
300
400
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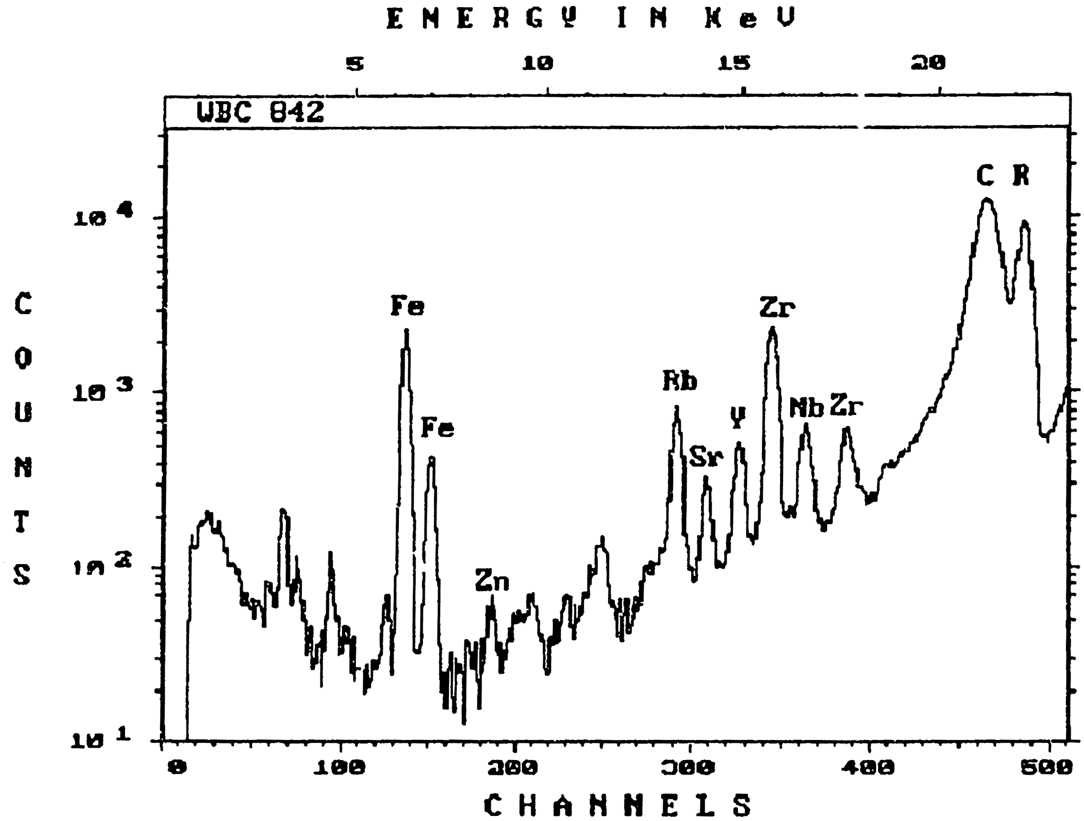
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 842
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb Zr
COUNTS
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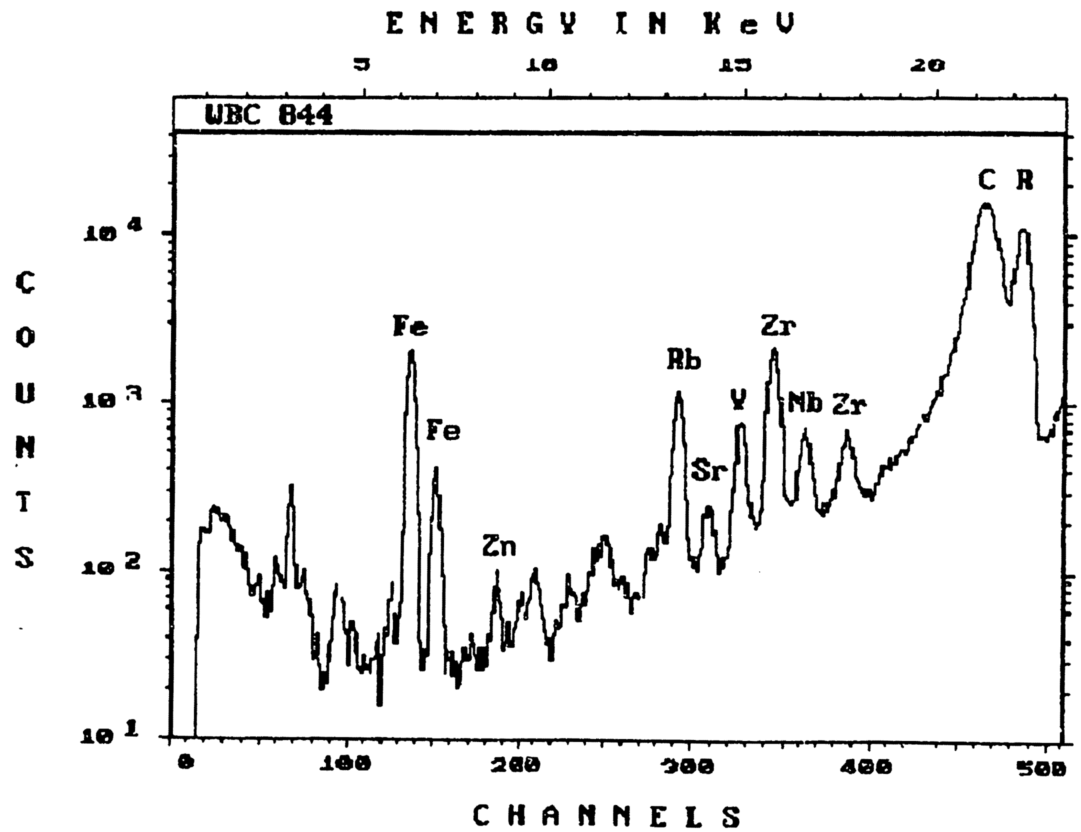
CHANNELS


ENERGY IN KeV
5
10
15
20
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Fe
Zn
Rb
Sr
Y
Zr
Nb Zr
COUNTS
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10^3
10^2
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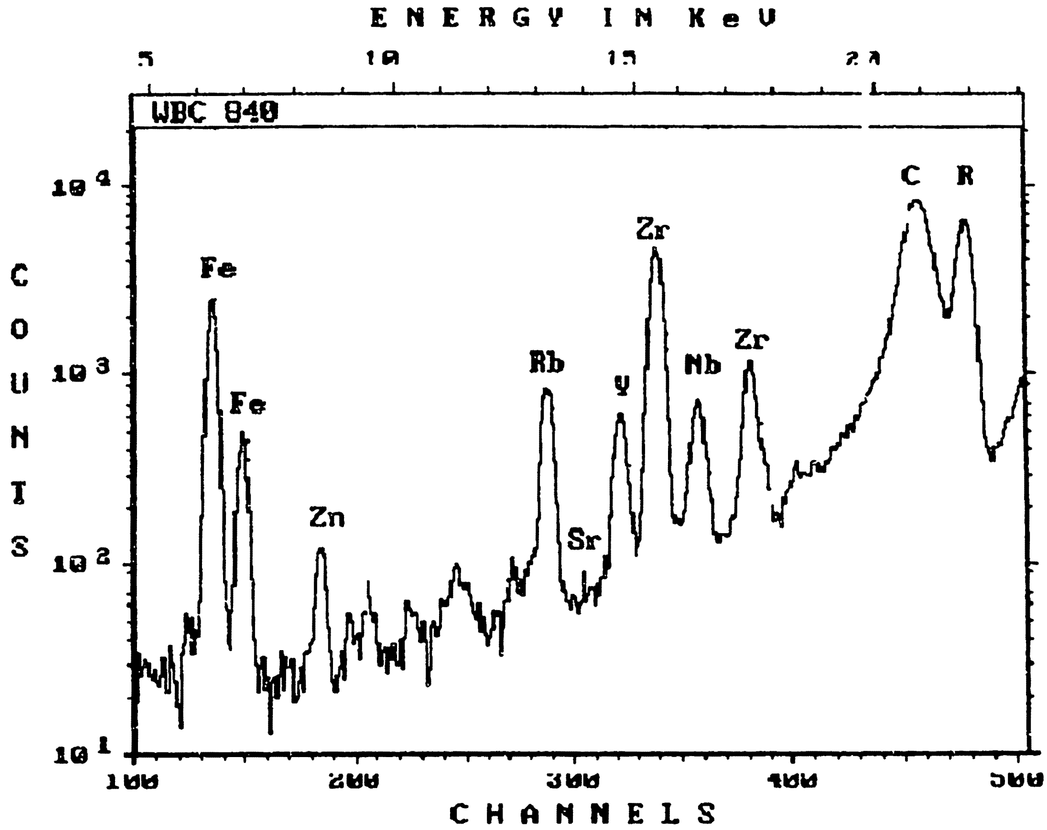
CHANNELS


ENERGY IN KeV
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CHANNELS
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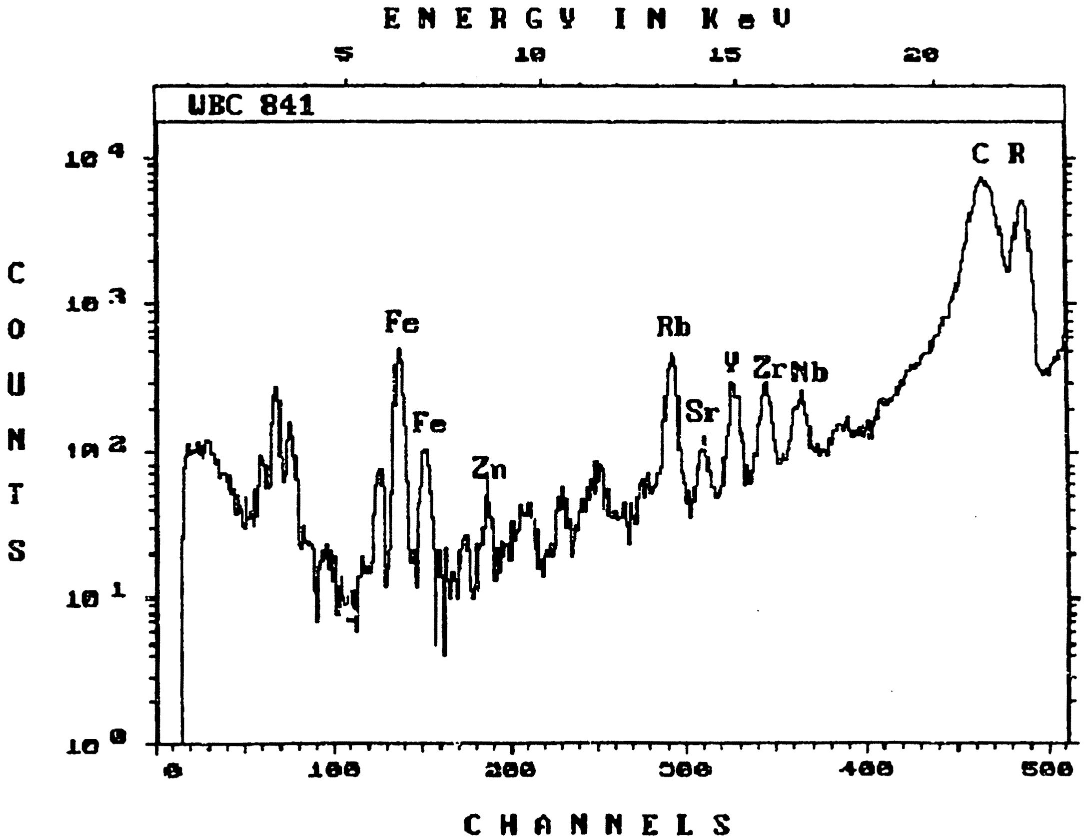
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R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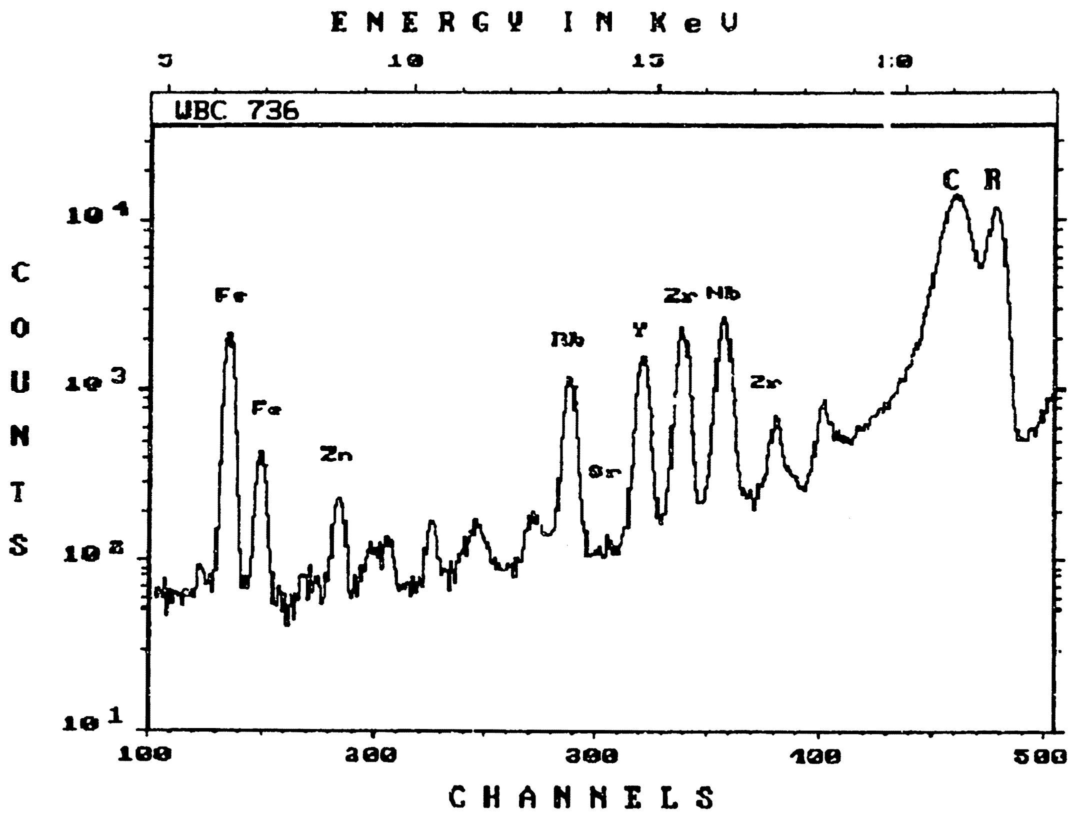
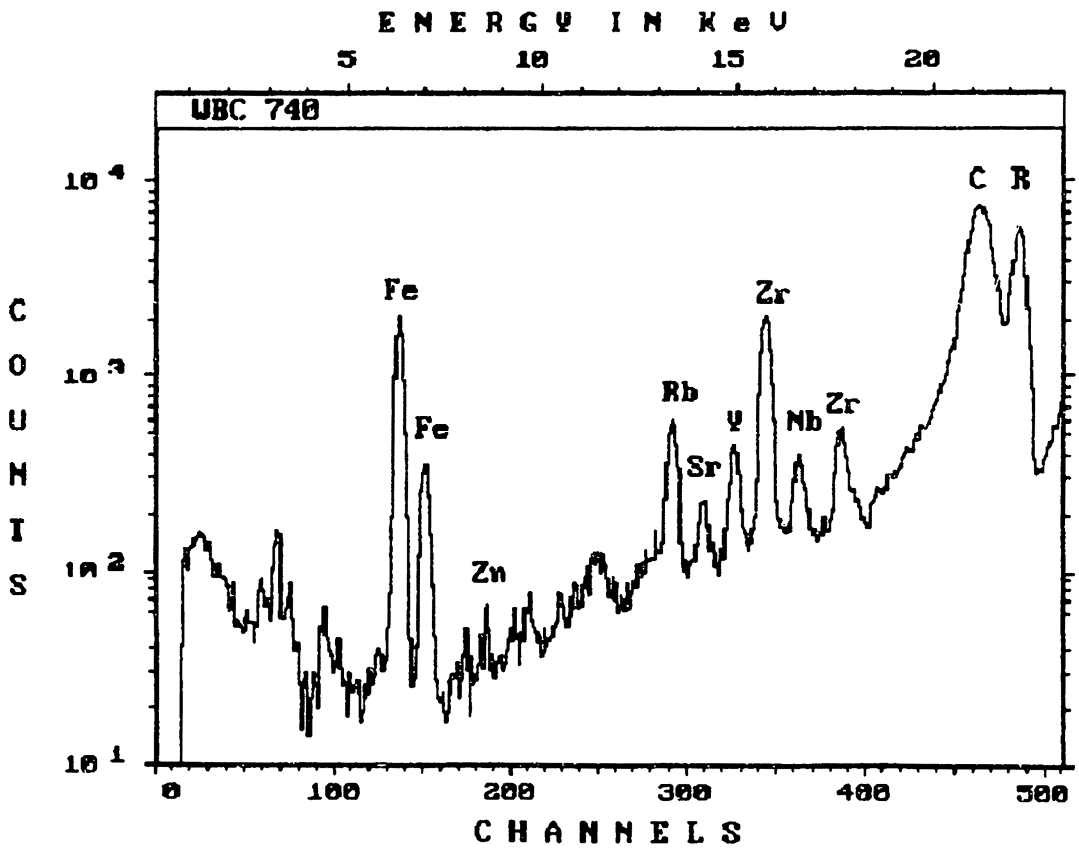
Fe
Zn
Rb
Sr
Y
Zr
Nb
C
R


ENERGY IN KeV
UBC 736
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr Nb
Zr
COUNTS
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 740
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
0
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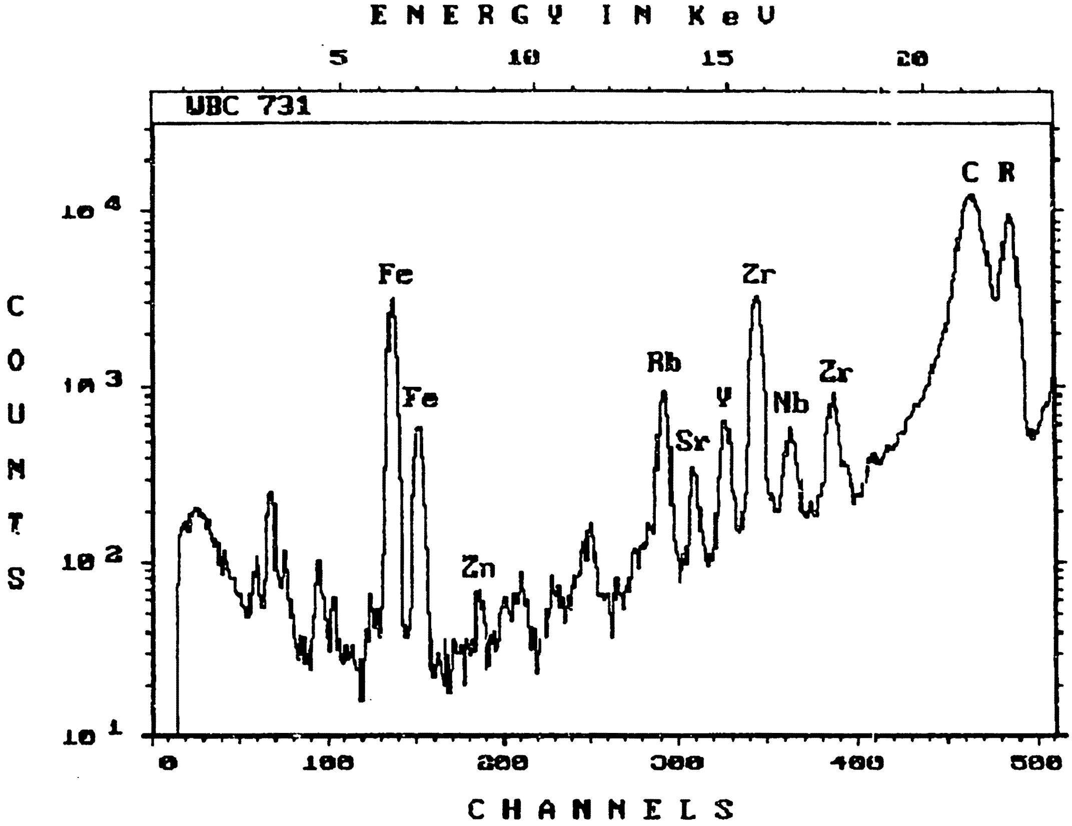
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 731
COUNTS
10 1
10 2
10 3
10 4
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
0
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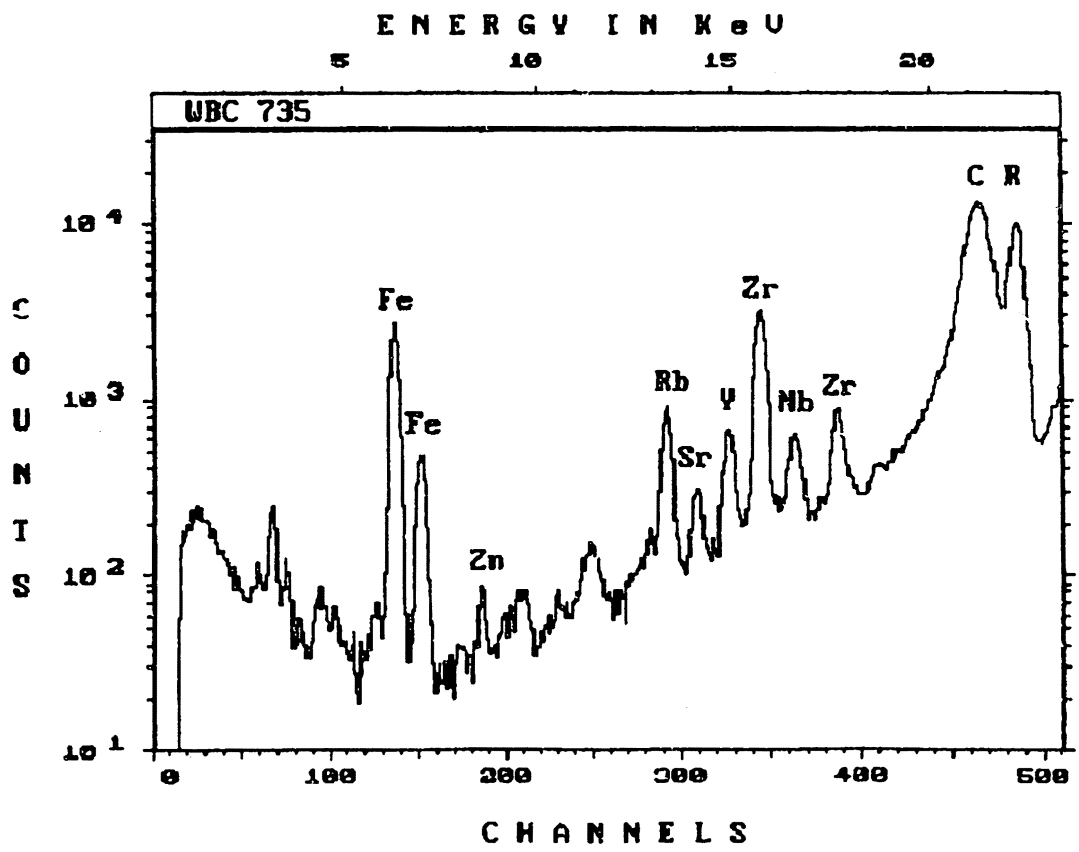
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 735
COUNTS
10 1
10 2
10 3
10 4
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
0
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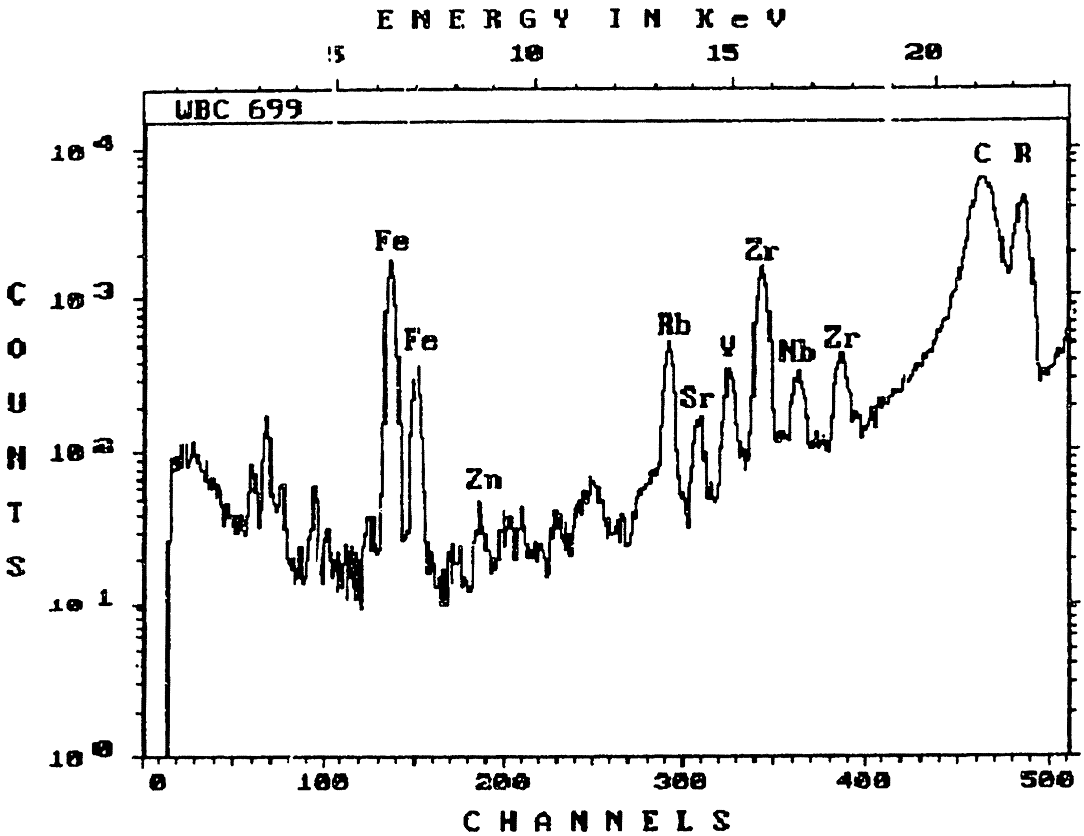
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 699
COUNTS
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10^3
10^2
10^1
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Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
0
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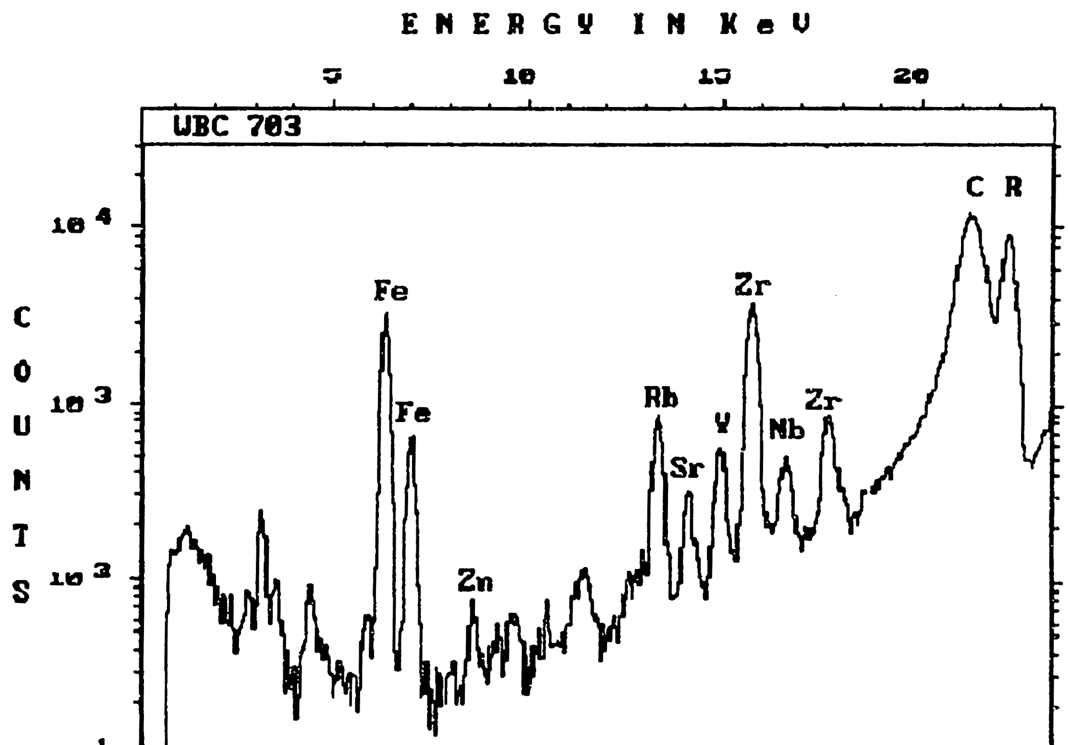
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 703
COUNTS
10^4
10^3
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Rb
Sr
Y
Zr
Nb
Zr
C
R
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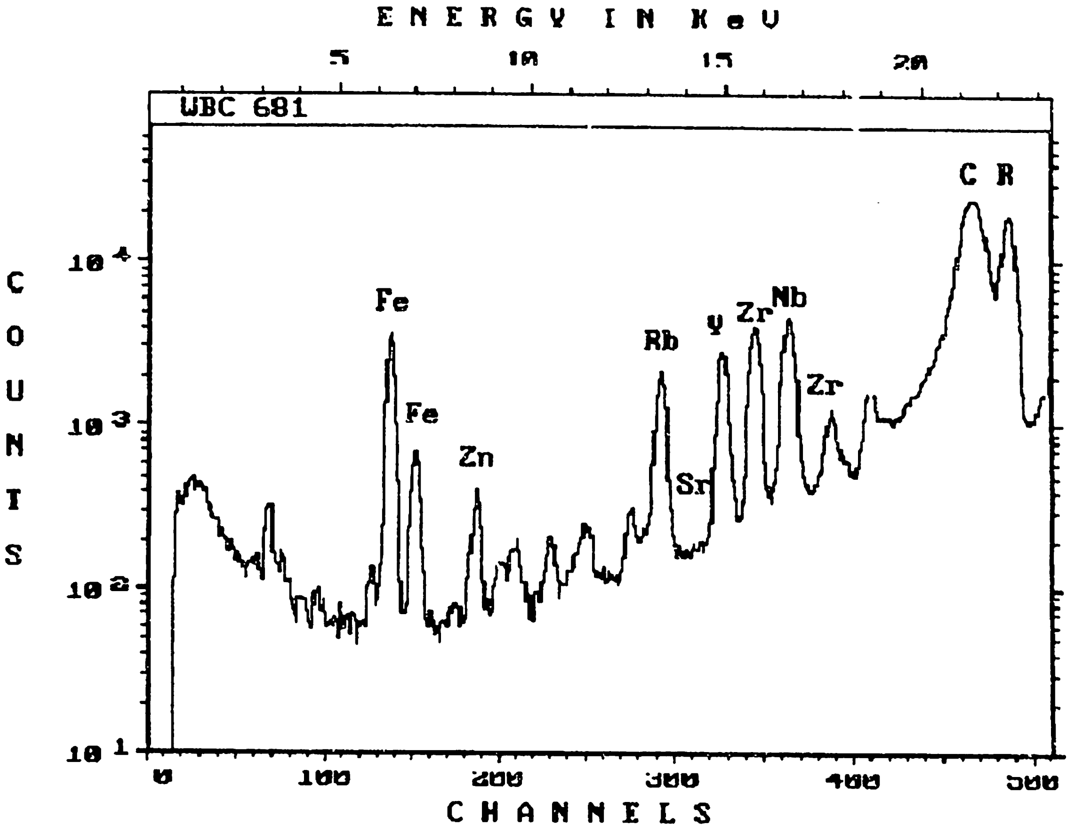
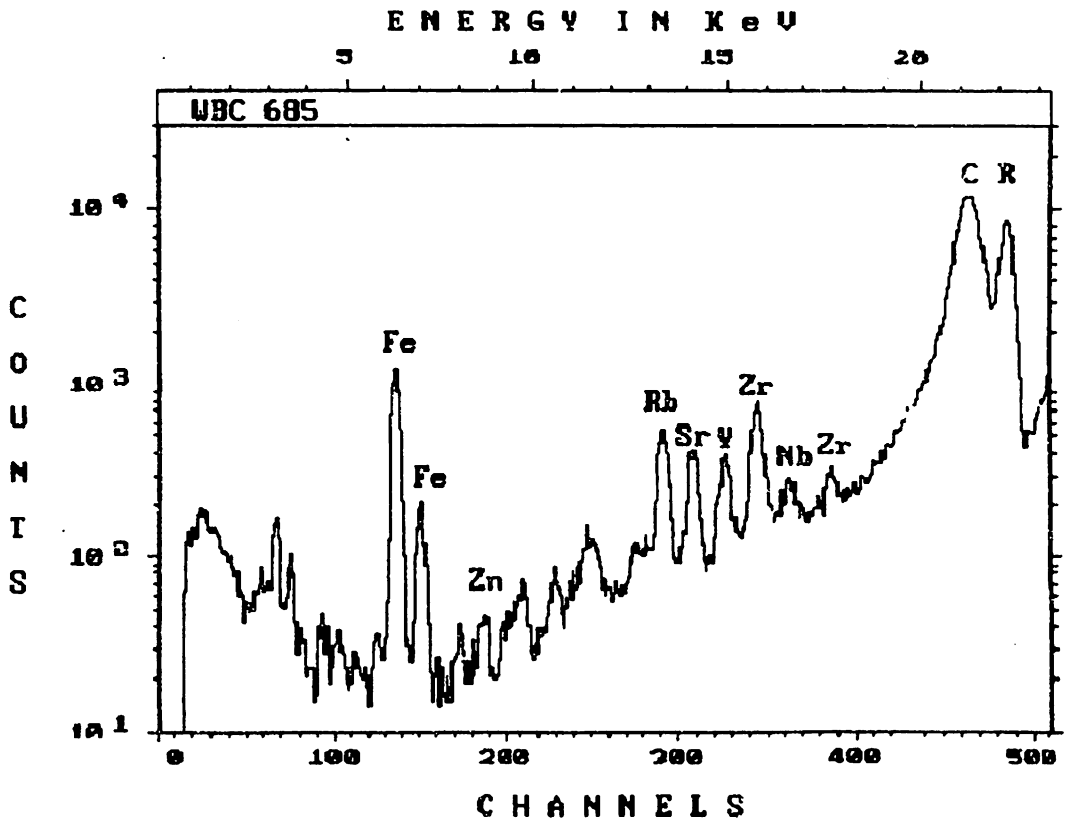
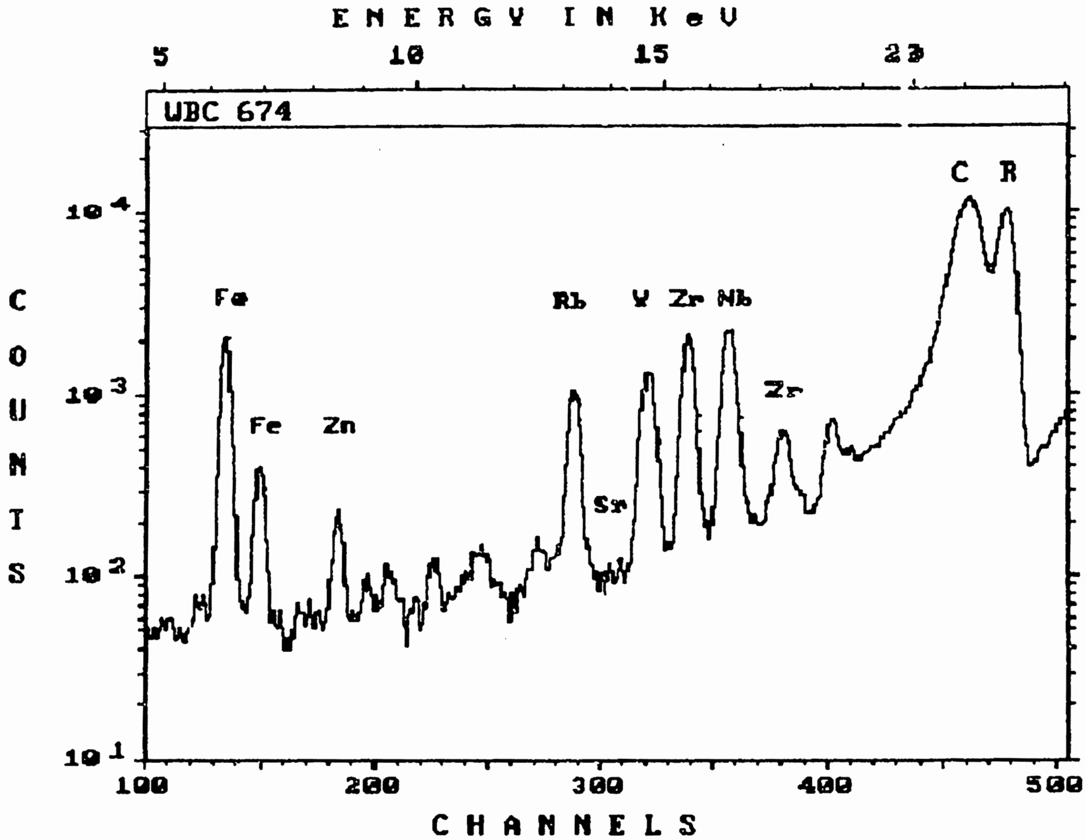
300
400
500
CHANNELS



E N E R G Y I N K e V
5
10
15
20
WBC 681
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C O U N T S
10 4
10 3
10 2
10 1
0
100
200
300
400
500
C H A N N E L S



E N E R G Y I N K e V
5
10
15
20
WBC 685
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C O U N T S
10 4
10 3
10 2
10 1
0
100
200
300
400
500
C H A N N E L S


ENERGY IN KeV
5
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15
20
UBC 674
C
R
Fe
Rb
Y
Zr
Nb
Fe
Zn
Zr
Sr
COUNTS
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10^2
10^1
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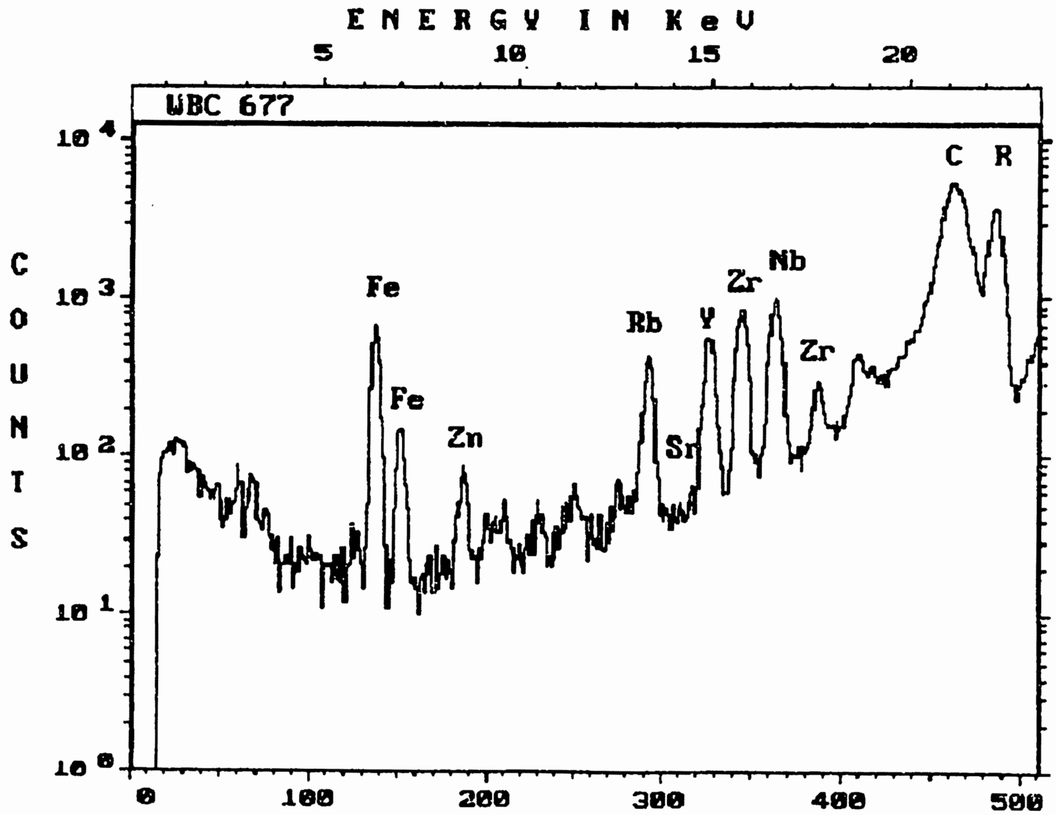
200
300
400
500
CHANNELS


ENERGY IN KeV
5
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15
20
UBC 677
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R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
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10^1
10^0
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200
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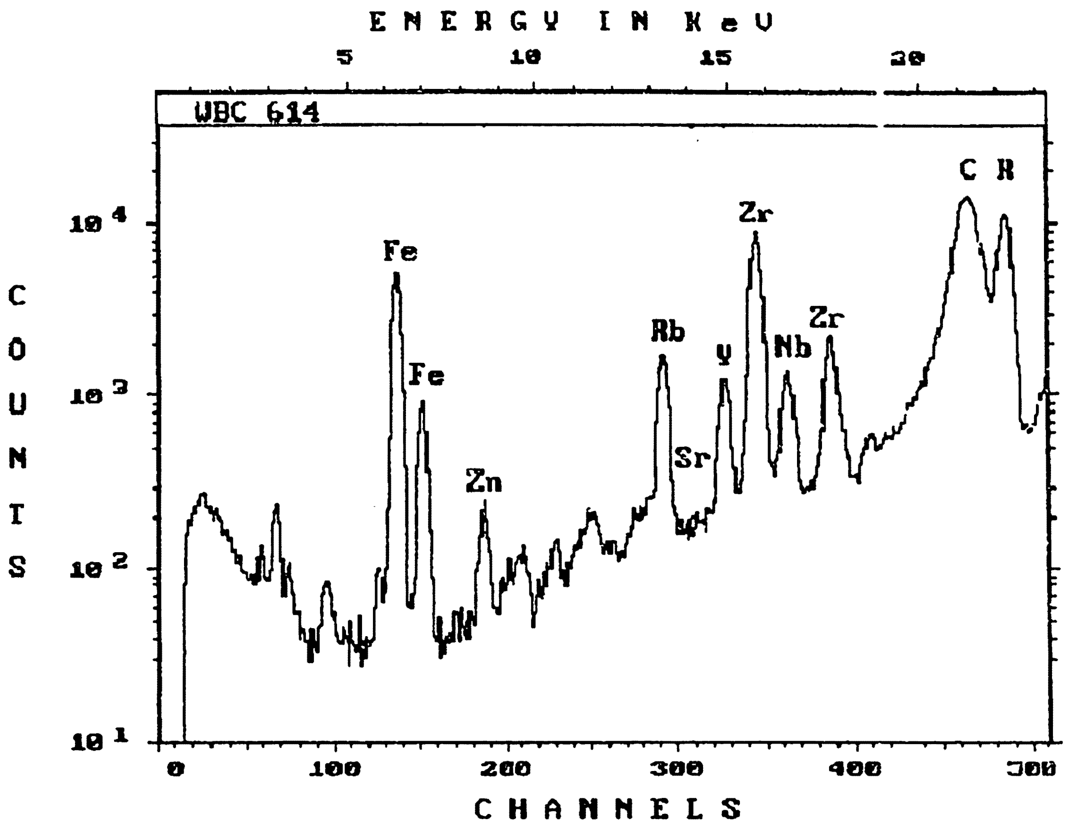
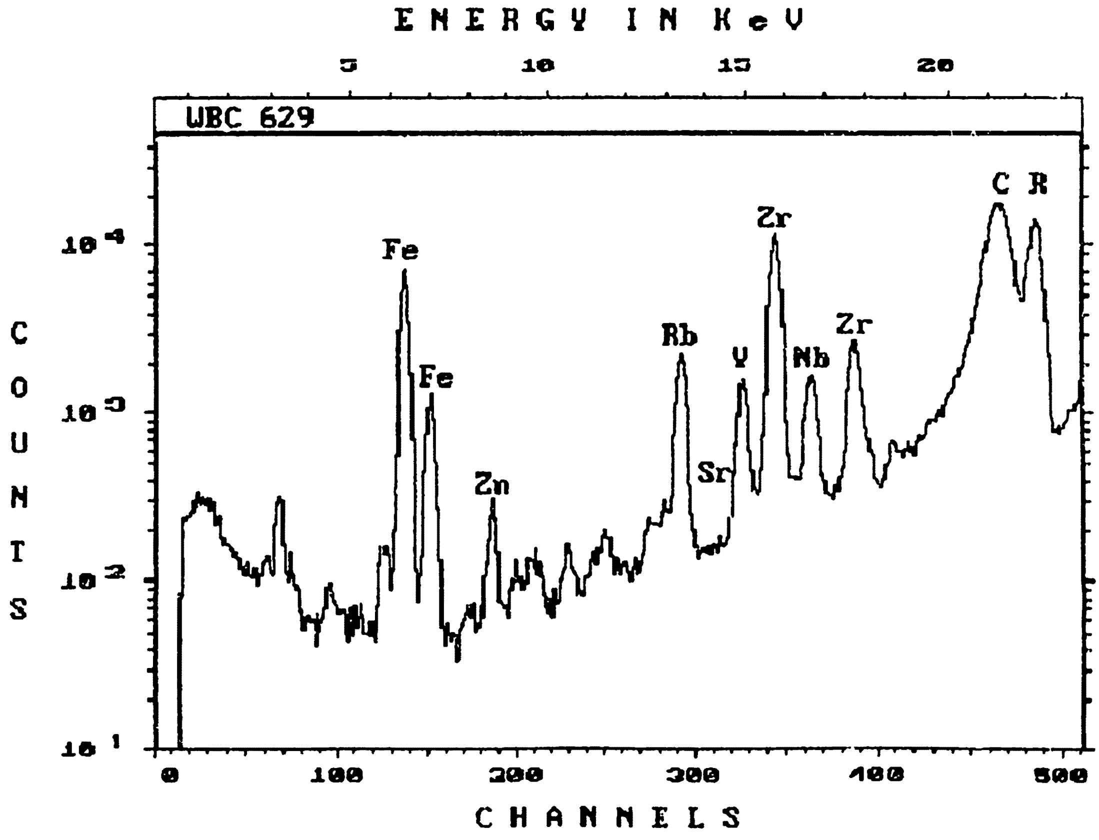
400
500


ENERGY IN KeV
5
10
15
20
WBC 614
COUNTS
10⁴
10³
10²
10¹
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C R
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 629
COUNTS
10⁴
10³
10²
10¹
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Zn
Rb
Sr
Y
Zr
Nb
Zr
C R
0
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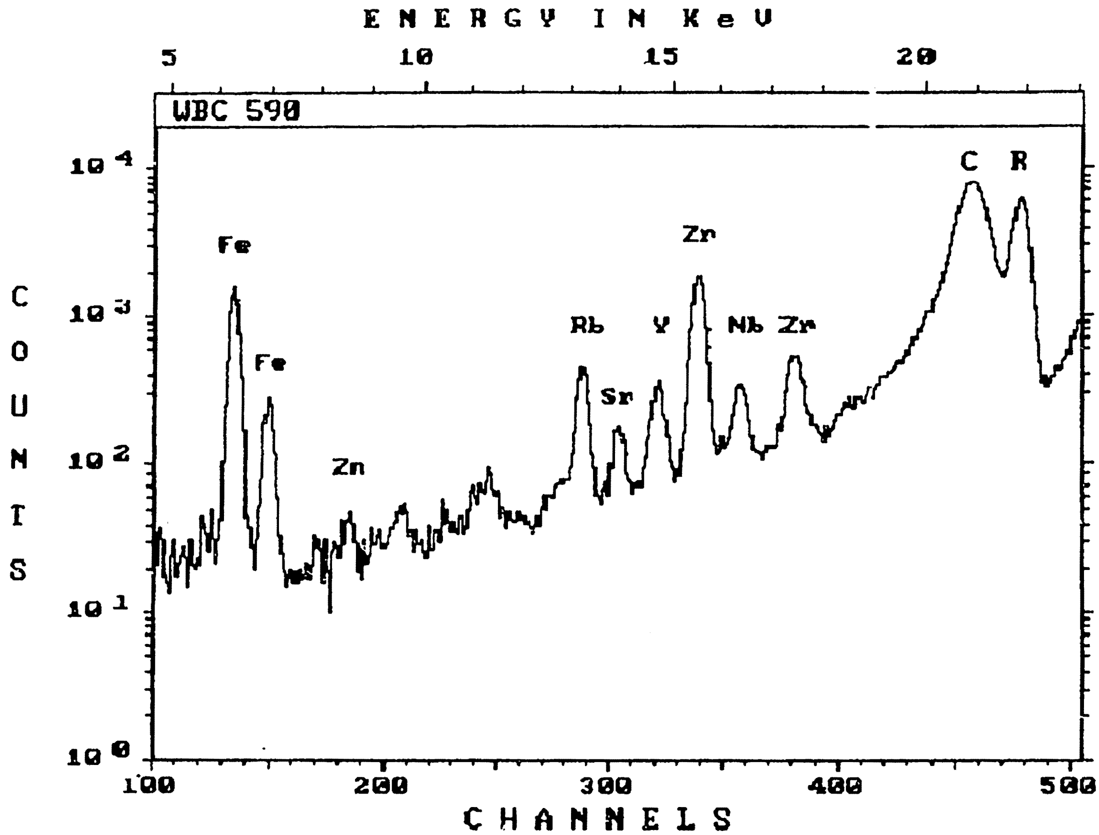
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 590
C
R
Fe
Zr
Rb
Y
Nb
Zr
Fe
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
10 0
100
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300
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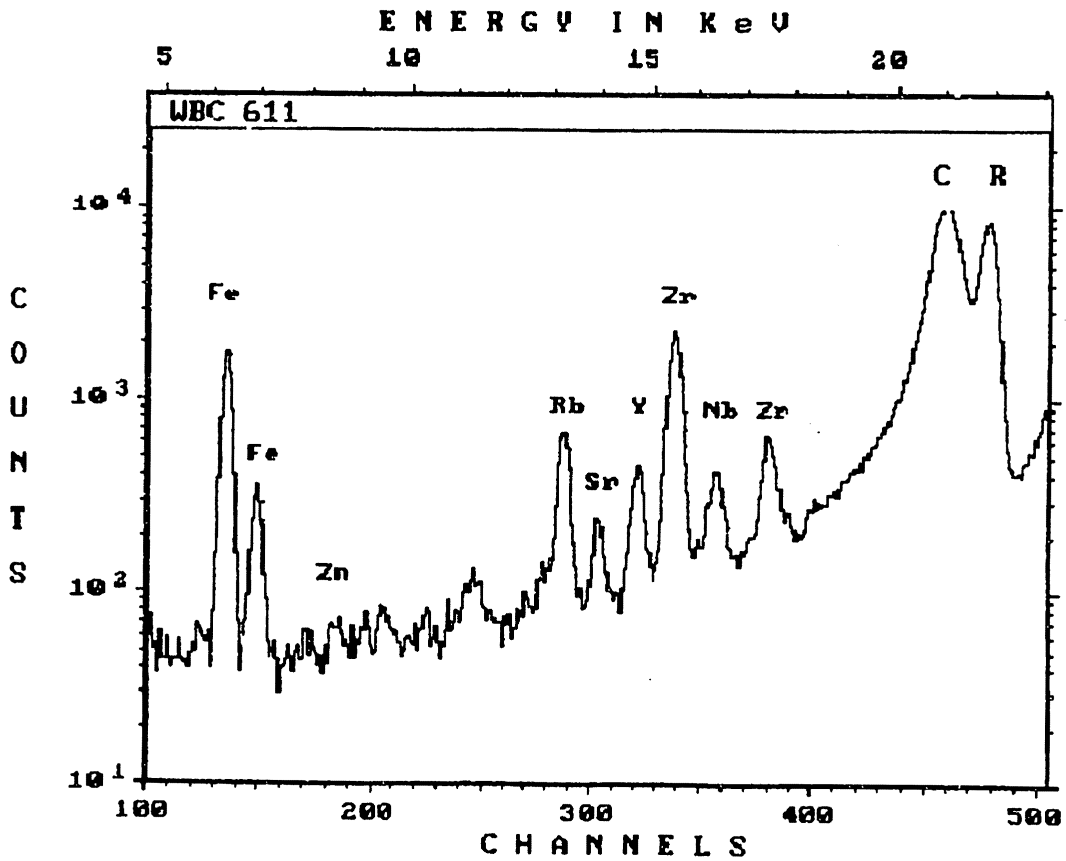
CHANNELS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R
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Zr
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Sr
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10 1
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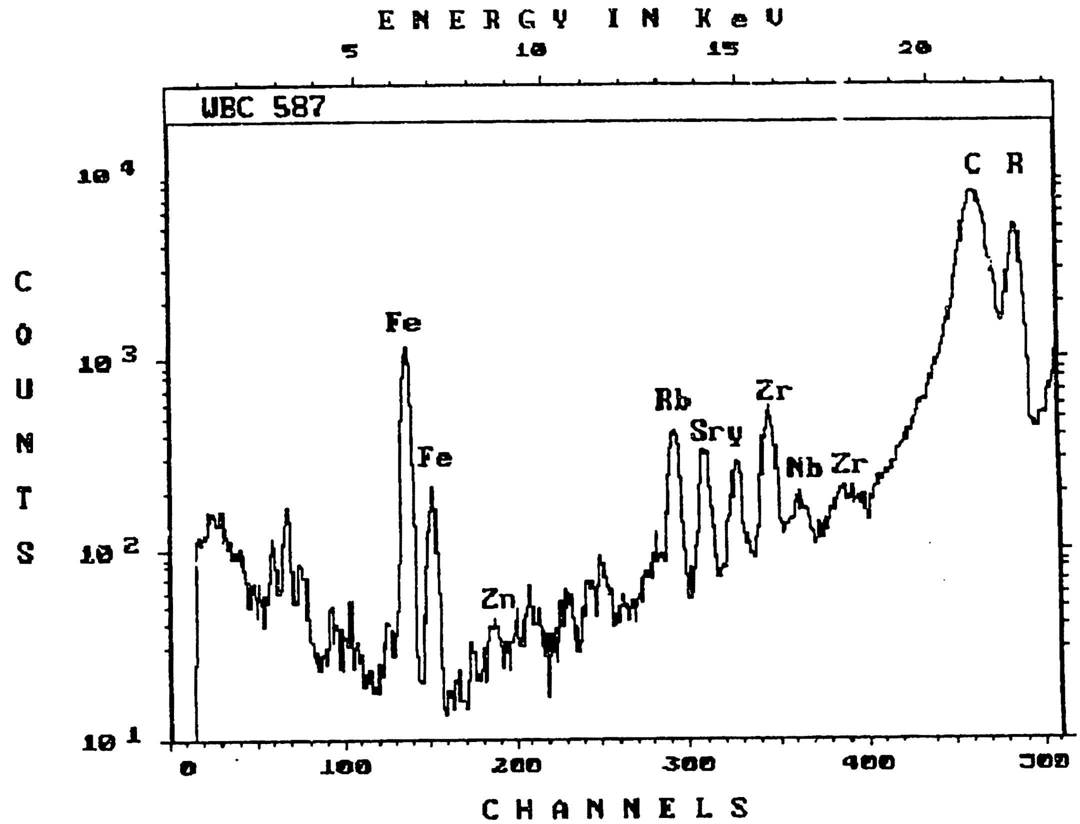
CHANNELS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Nb
Zr
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R
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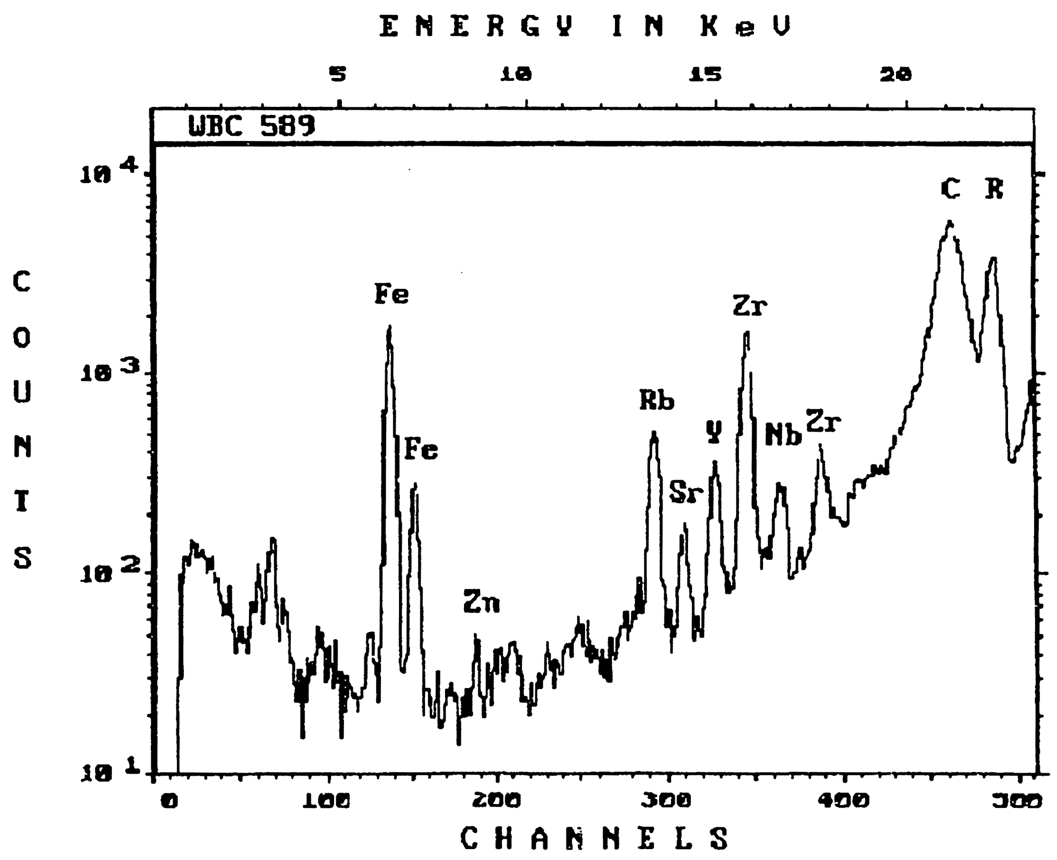
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10 1
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Y
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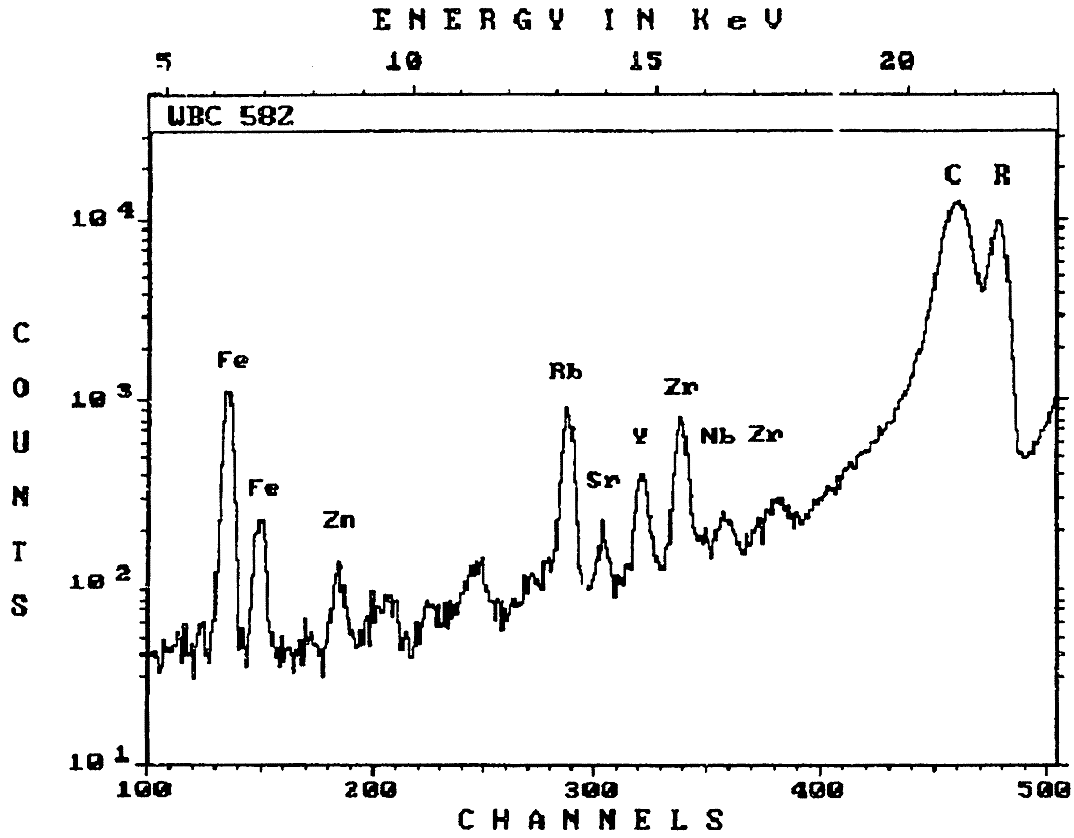
CHANNELS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Fe
Rb
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Fe
Zn
COUNTS
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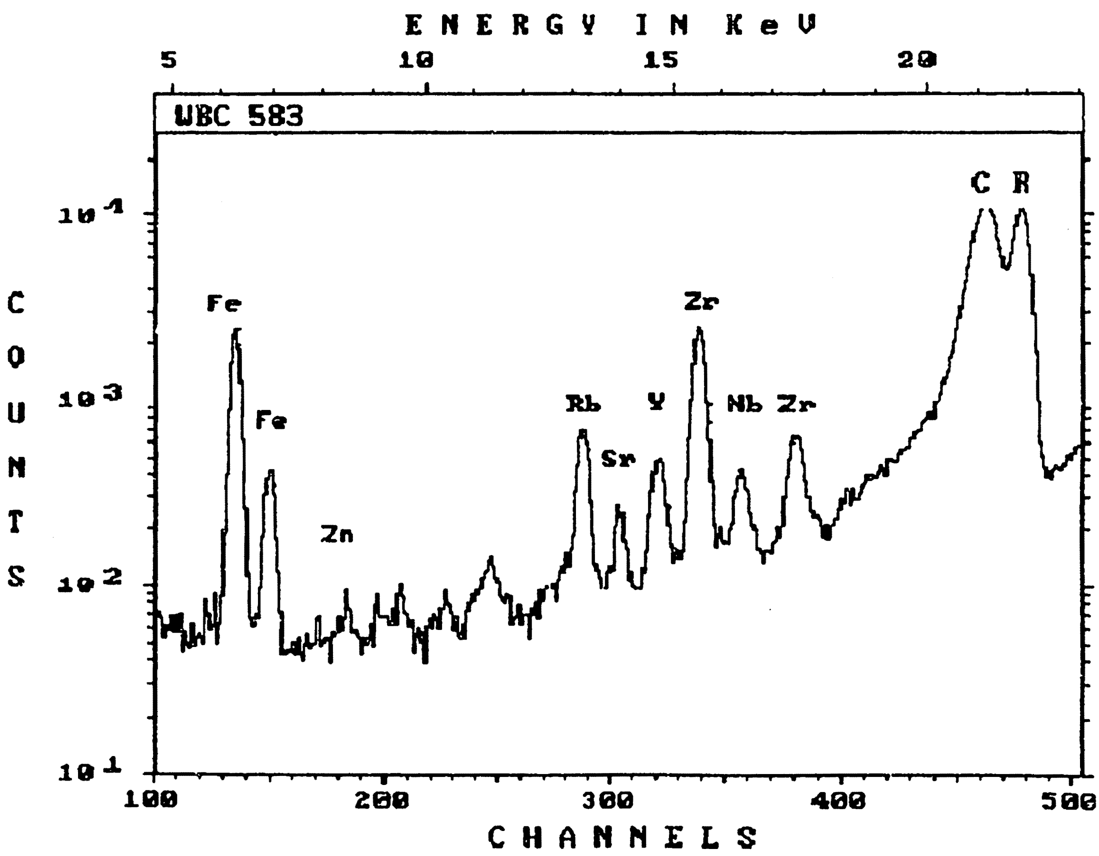
CHANNELS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UBC 583
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Fe
Zr
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Fe
Zn
COUNTS
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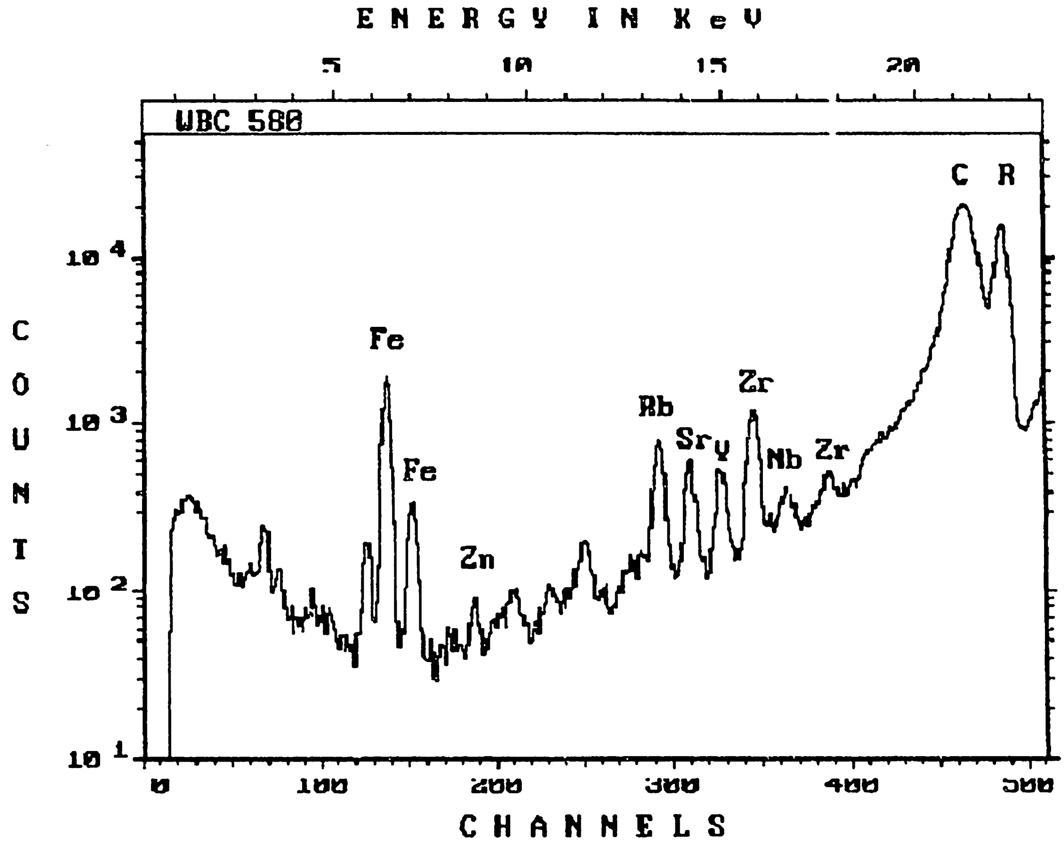
CHANNELS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Sr
Y
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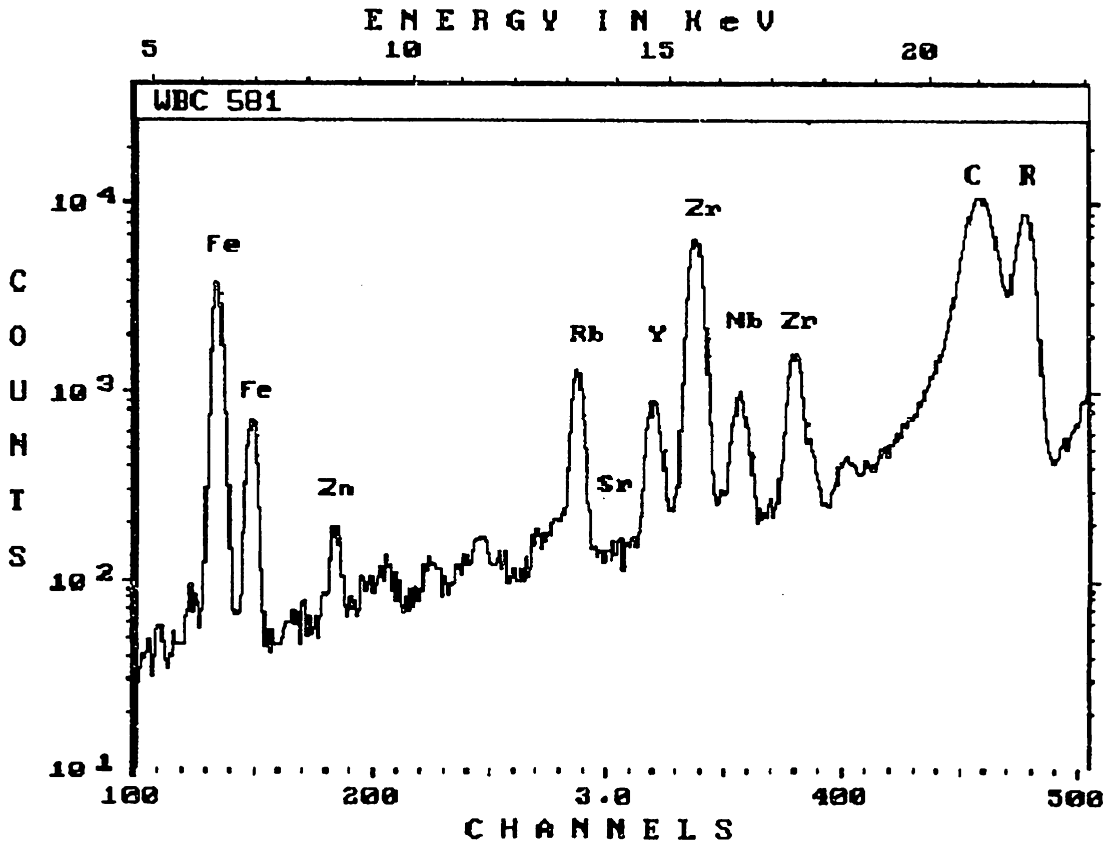
COUNTS
CHANNELS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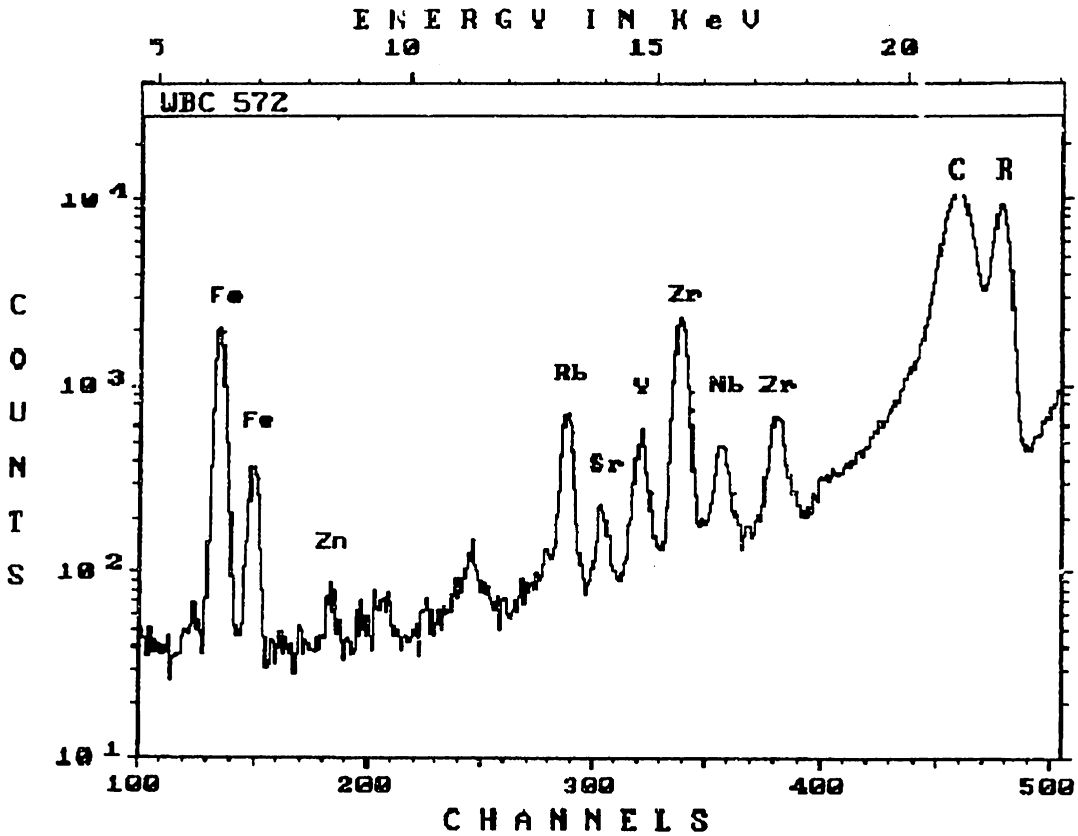
Y
Zr
Nb
Zr
COUNTS
CHANNELS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Nb
Zr
COUNTS
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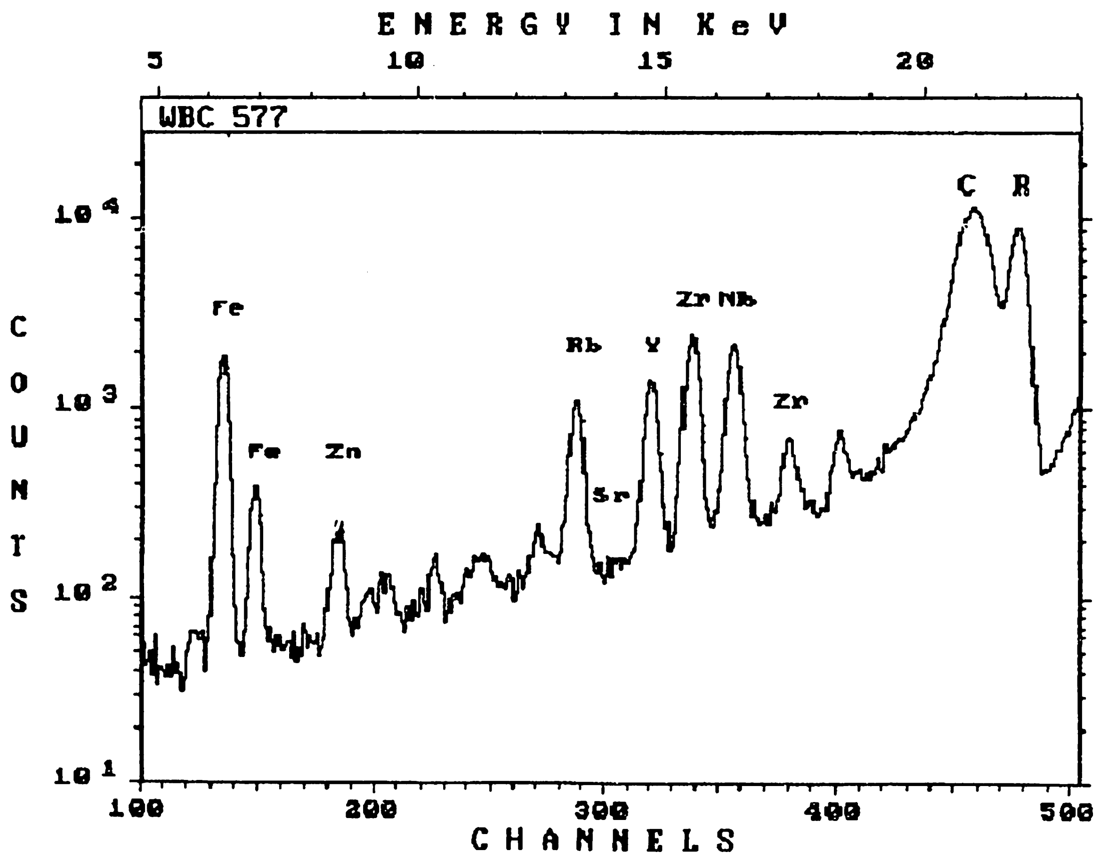
ENERGY IN KeV
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15
20
WBC 577
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr Nb
Zr
COUNTS
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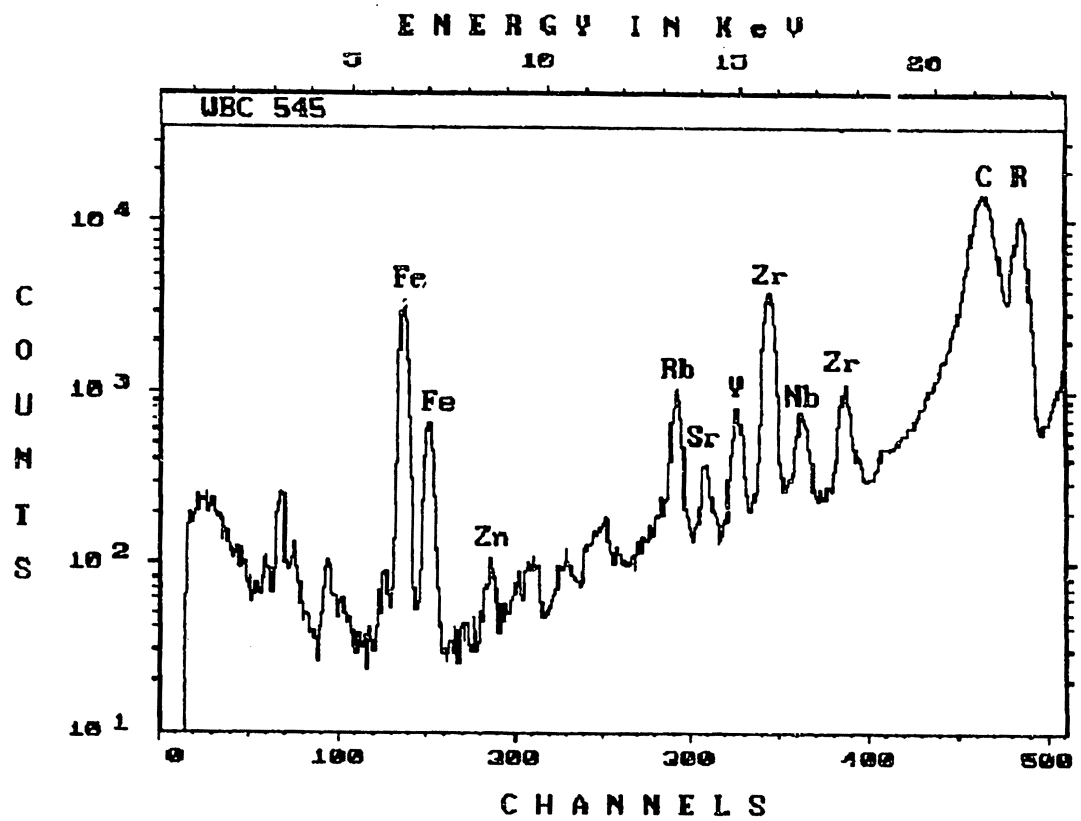
CHANNELS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20
WBC 545
COUNTS
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10 2
10 3
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Rb
Sr
Y
Zr
Nb
Zr
C R
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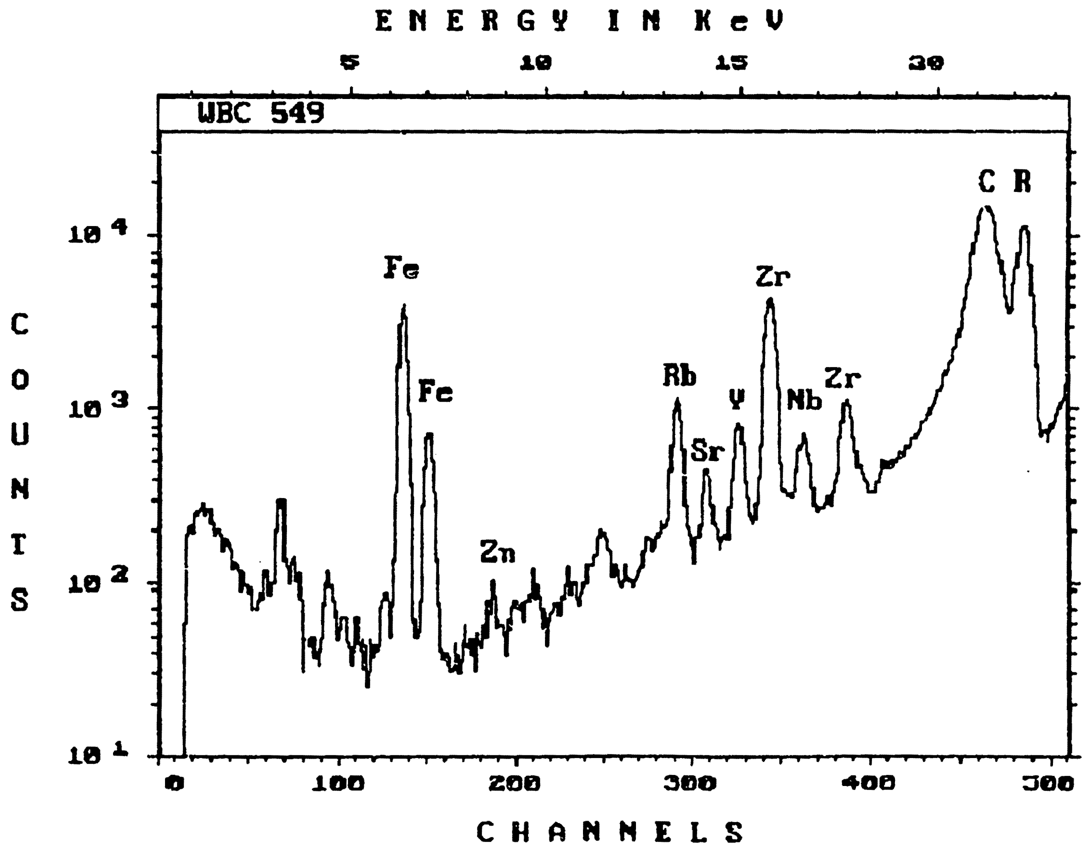
CHANNELS


ENERGY IN KeV
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15
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WBC 549
COUNTS
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10 3
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Sr
Y
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Nb
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C R
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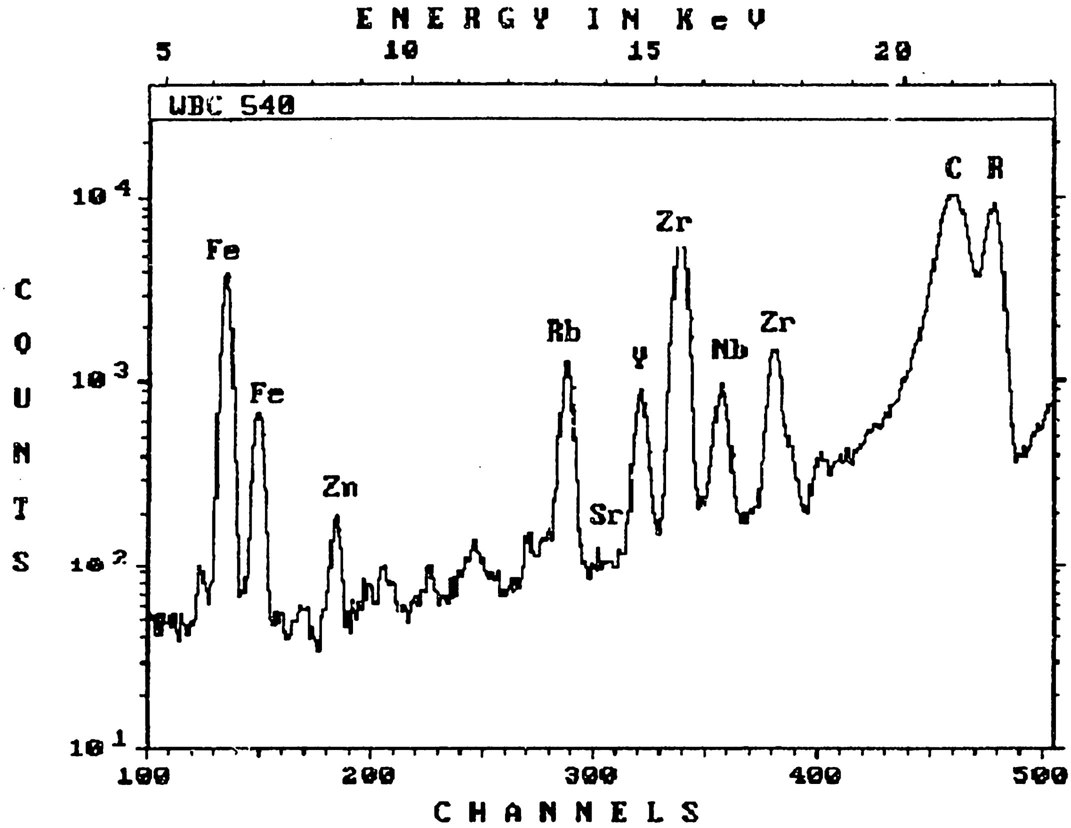
CHANNELS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15
20
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Fe
Fe
Zn
Rb
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Nb
Zr
COUNTS
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10^1
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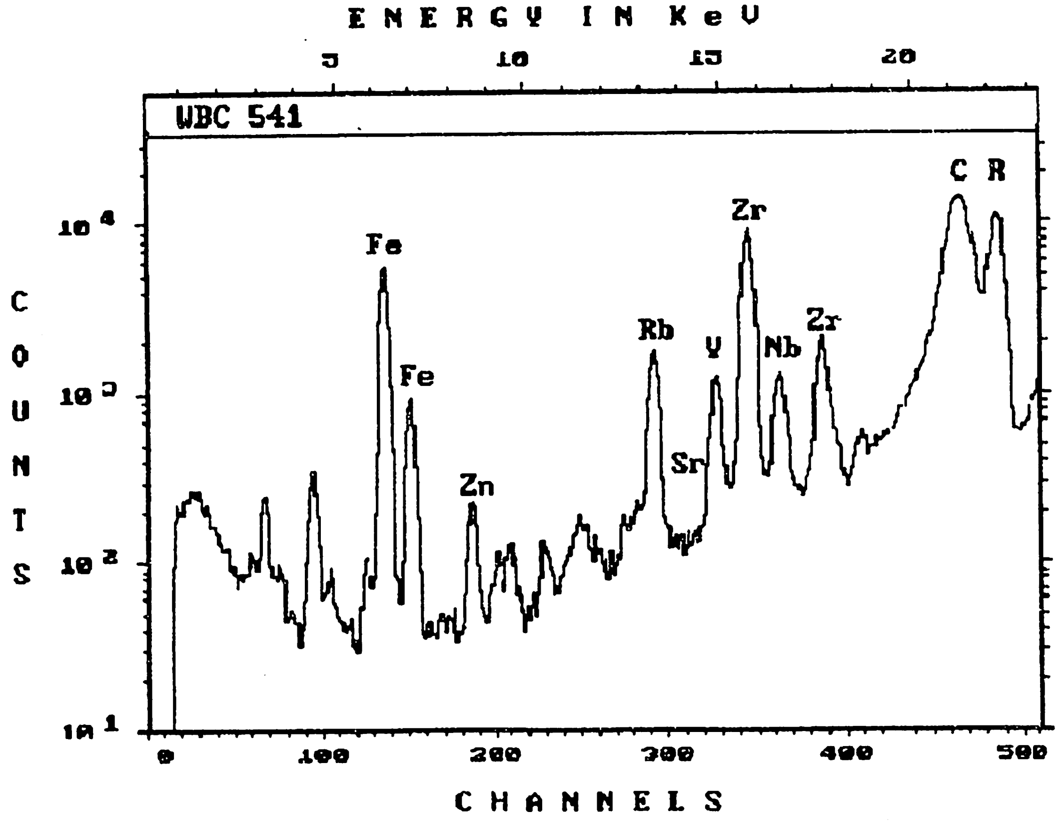
CHANNELS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Fe
Fe
Zn
Rb
Sr
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Nb
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COUNTS
10^4
10^3
10^2
10^1
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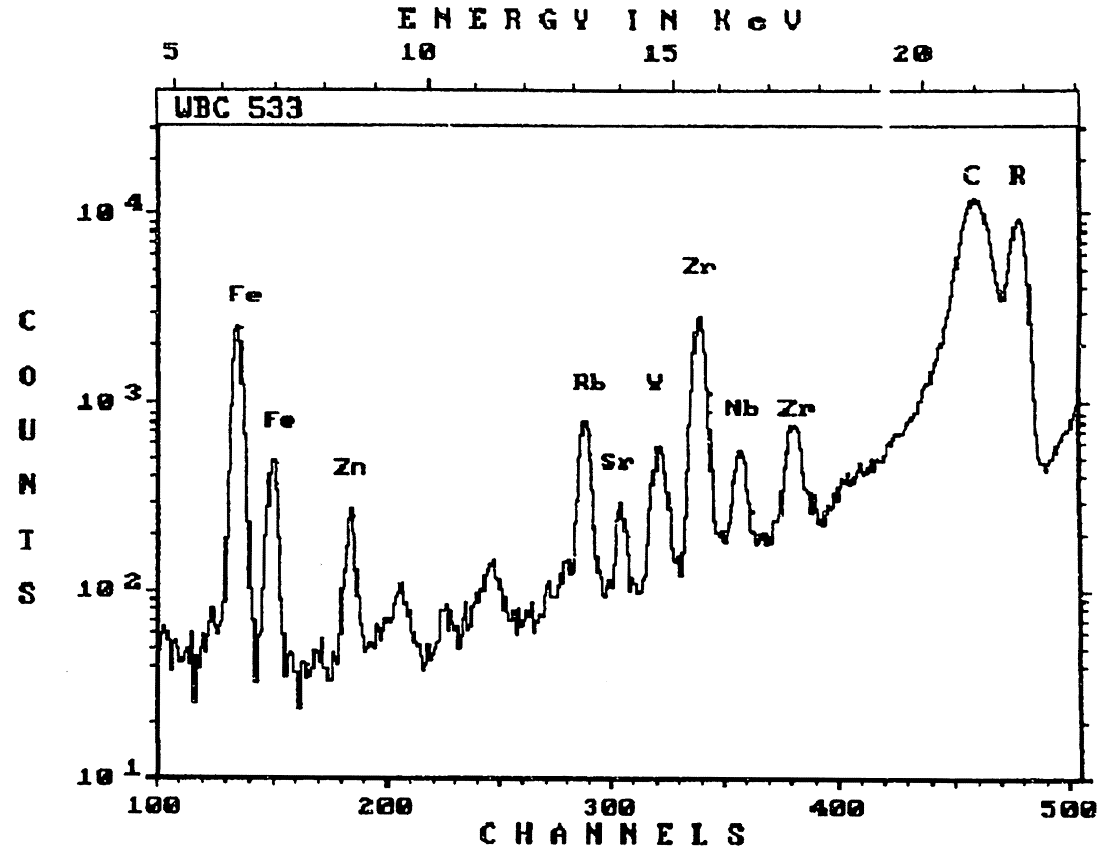
CHANNELS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C R
Fe
Zr
Fe
Rb
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Nb
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N
T
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10 1
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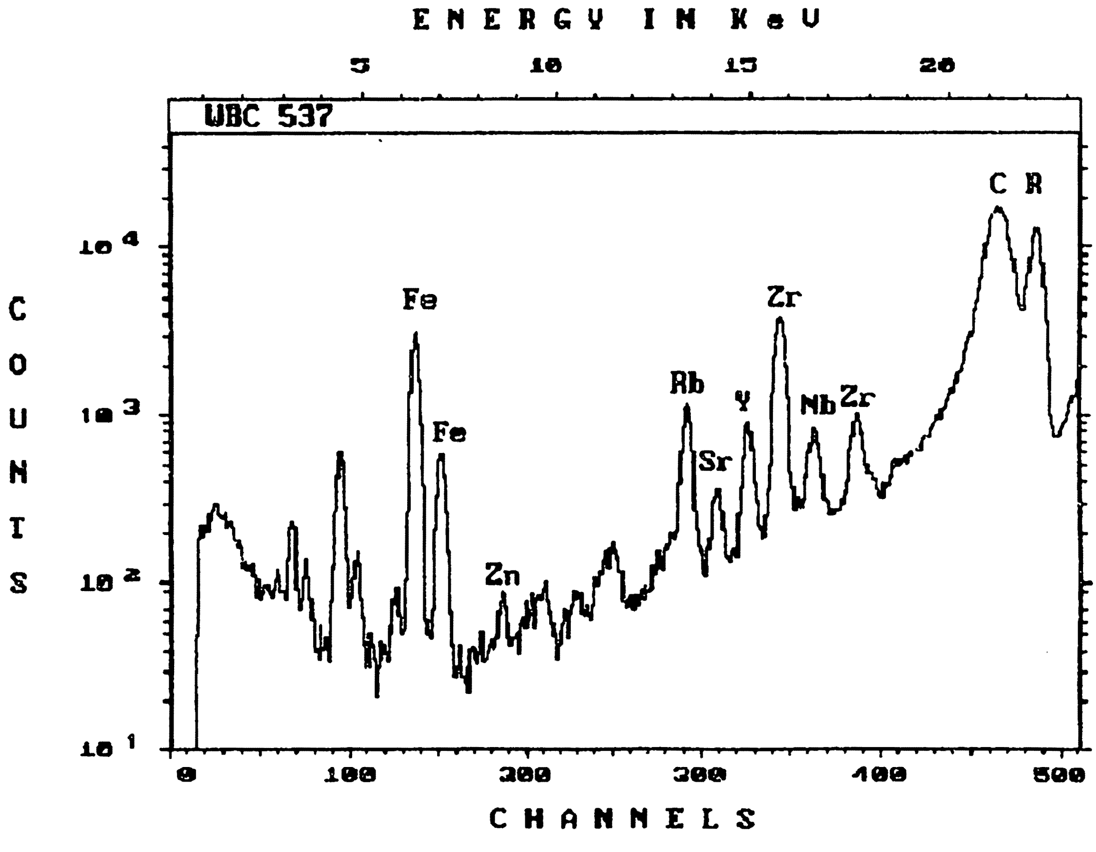
CHANNELS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Zr
Rb
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Nb
Zr
Fe
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T
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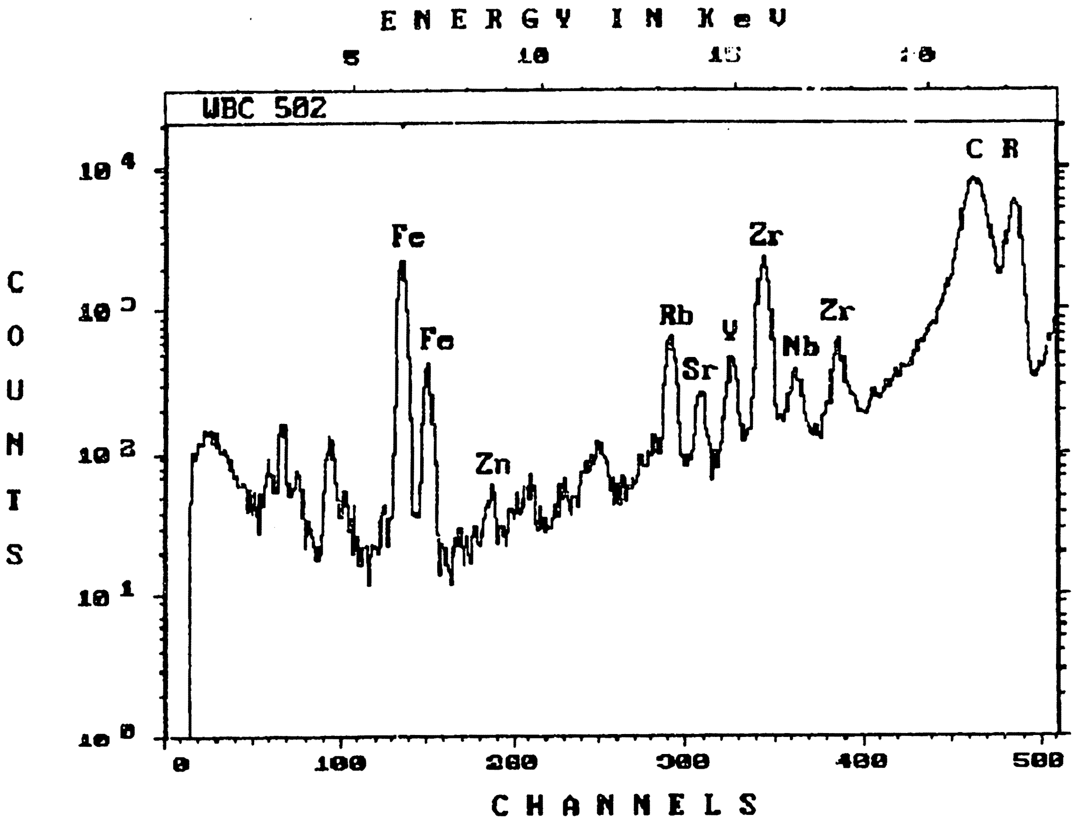
CHANNELS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C R
Fe
Fe
Zn
Rb
Sr
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Nb
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COUNTS
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10 2
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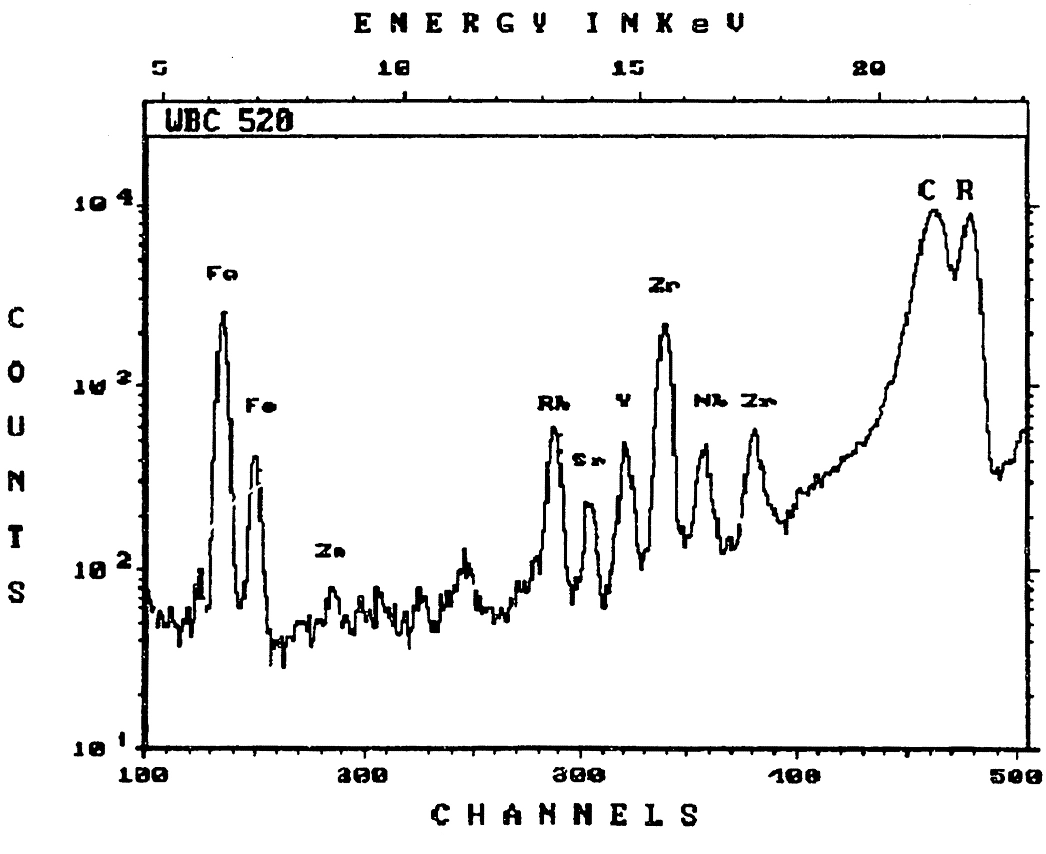
CHANNELS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Fe
Fe
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Nb
Zr
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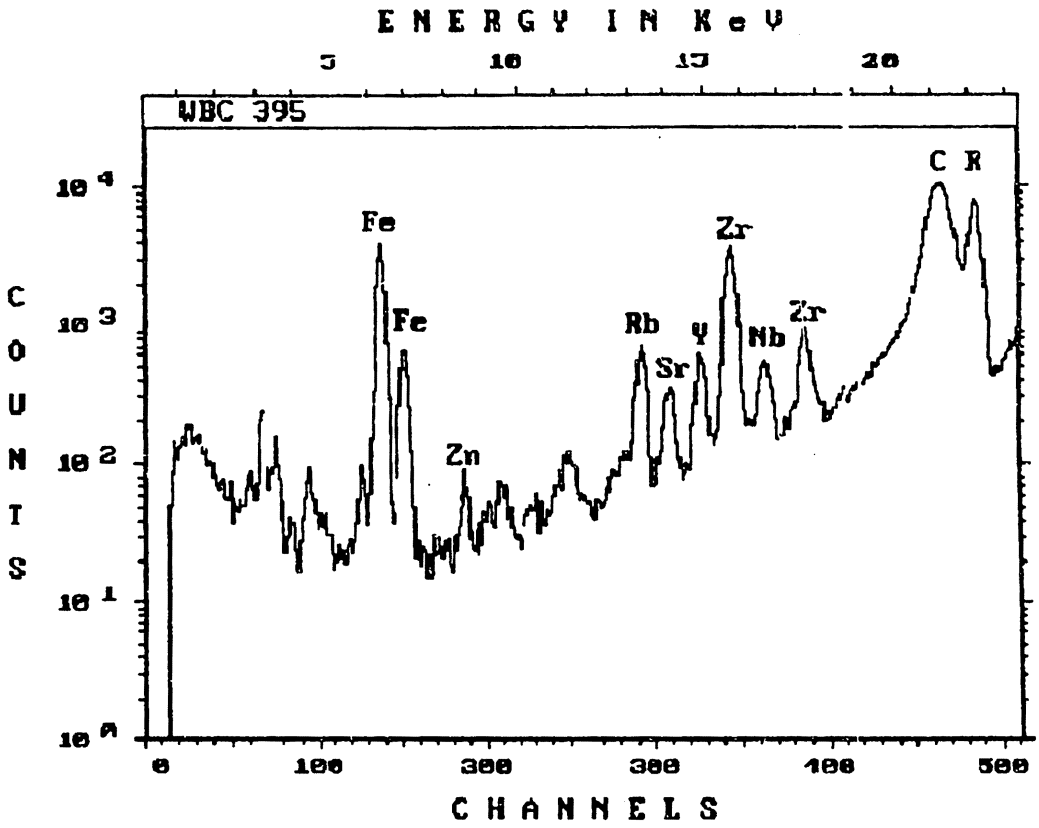
CHANNELS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Zr
Rb
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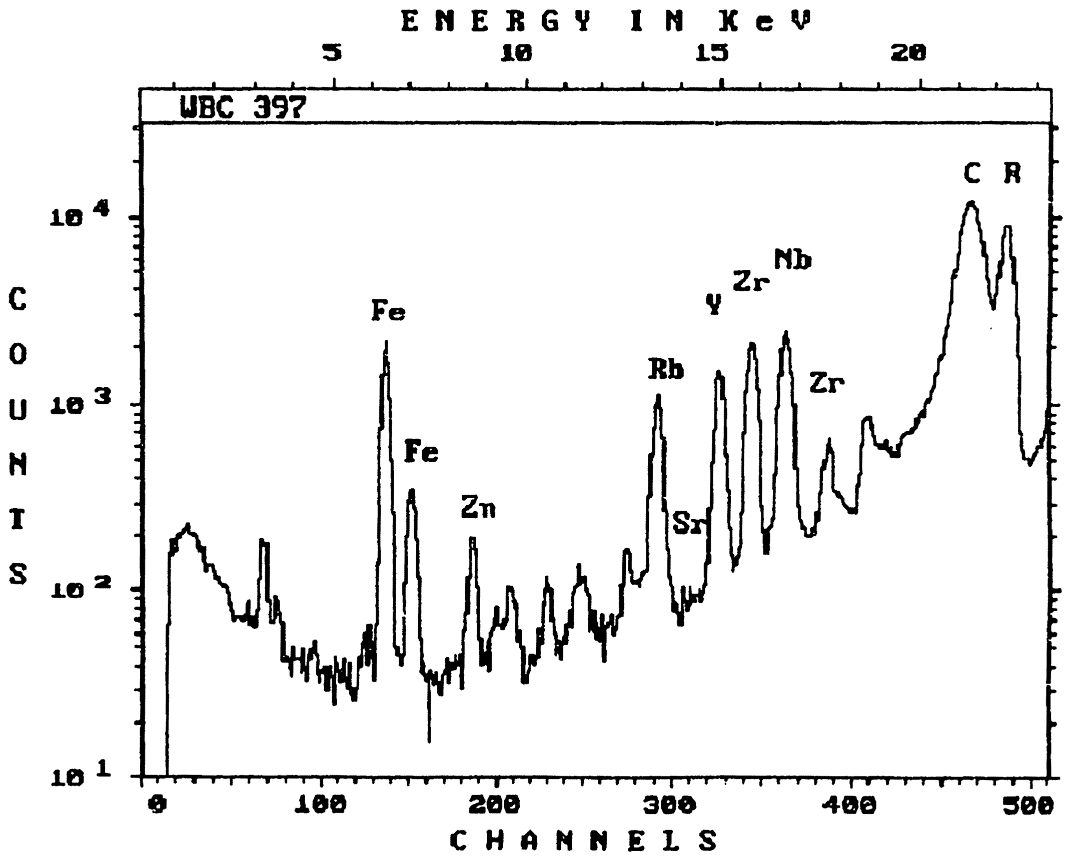
CHANNELS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Sr
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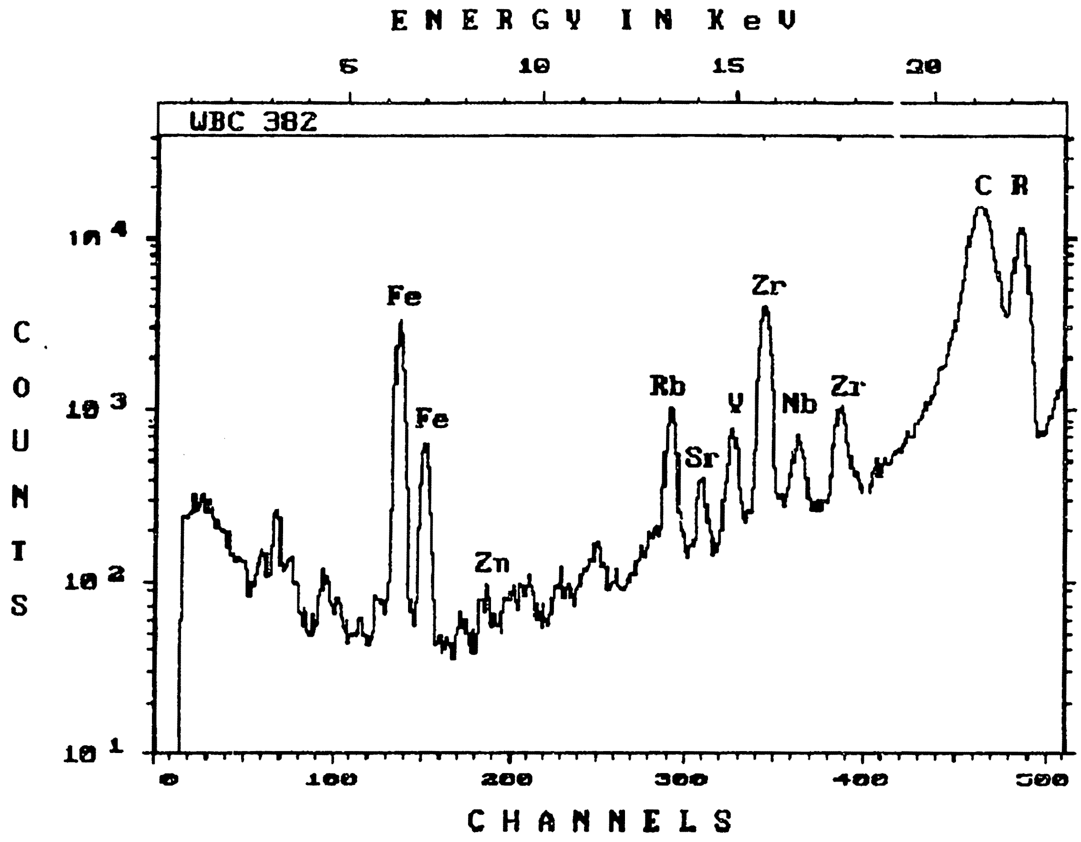
CHANNELS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Zn
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COUNTS
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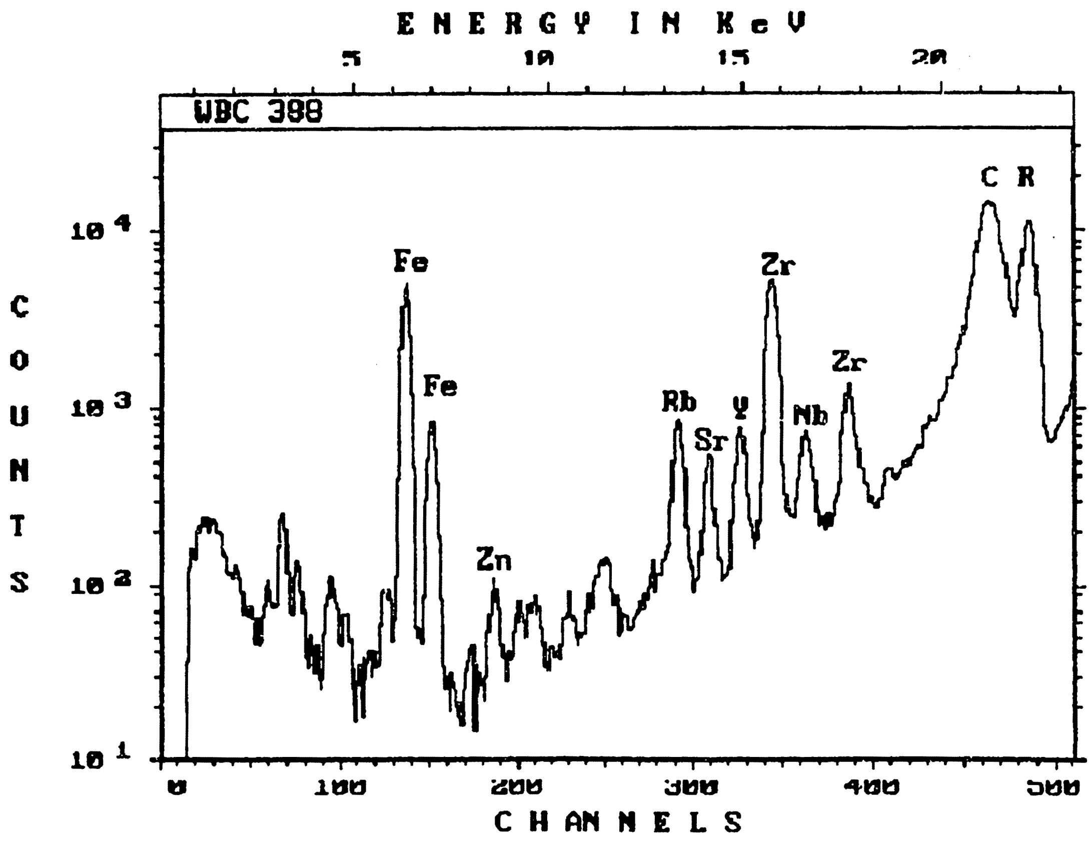
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Fe
Fe
Zn
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Sr
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Nb
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COUNTS
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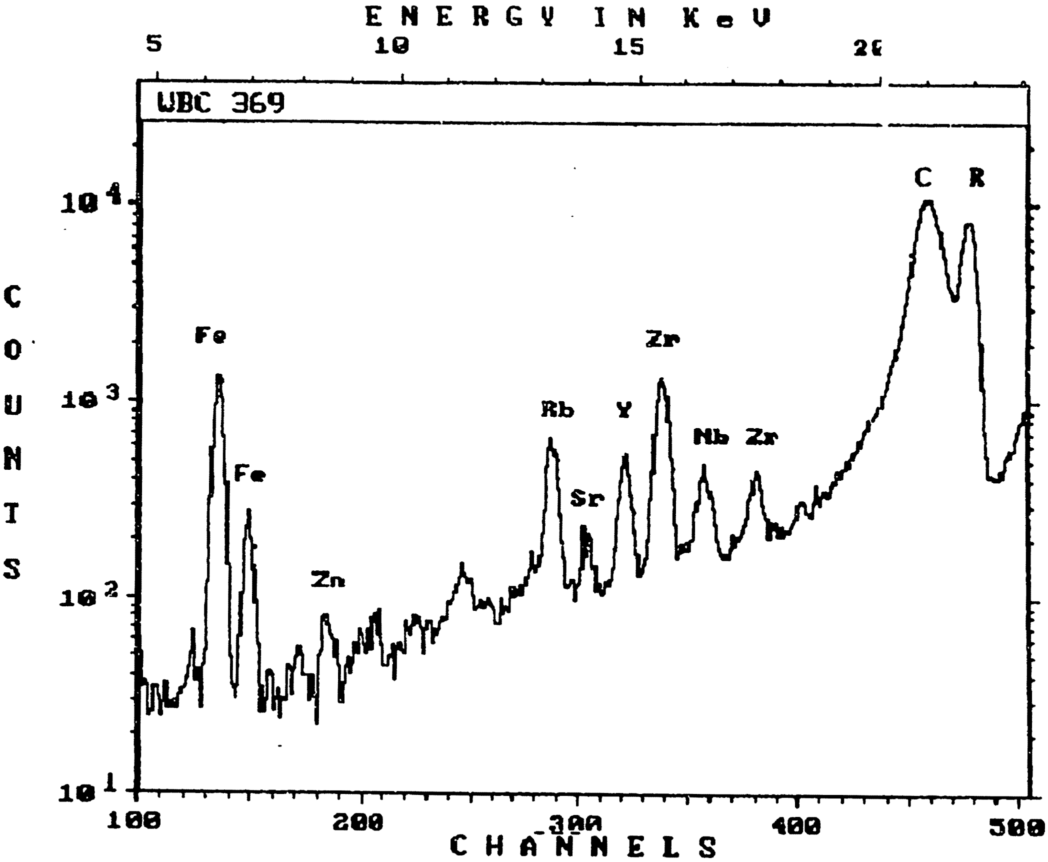

ENERGY IN KeV
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R
Fe
Fe
Zn
Rb
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COUNTS
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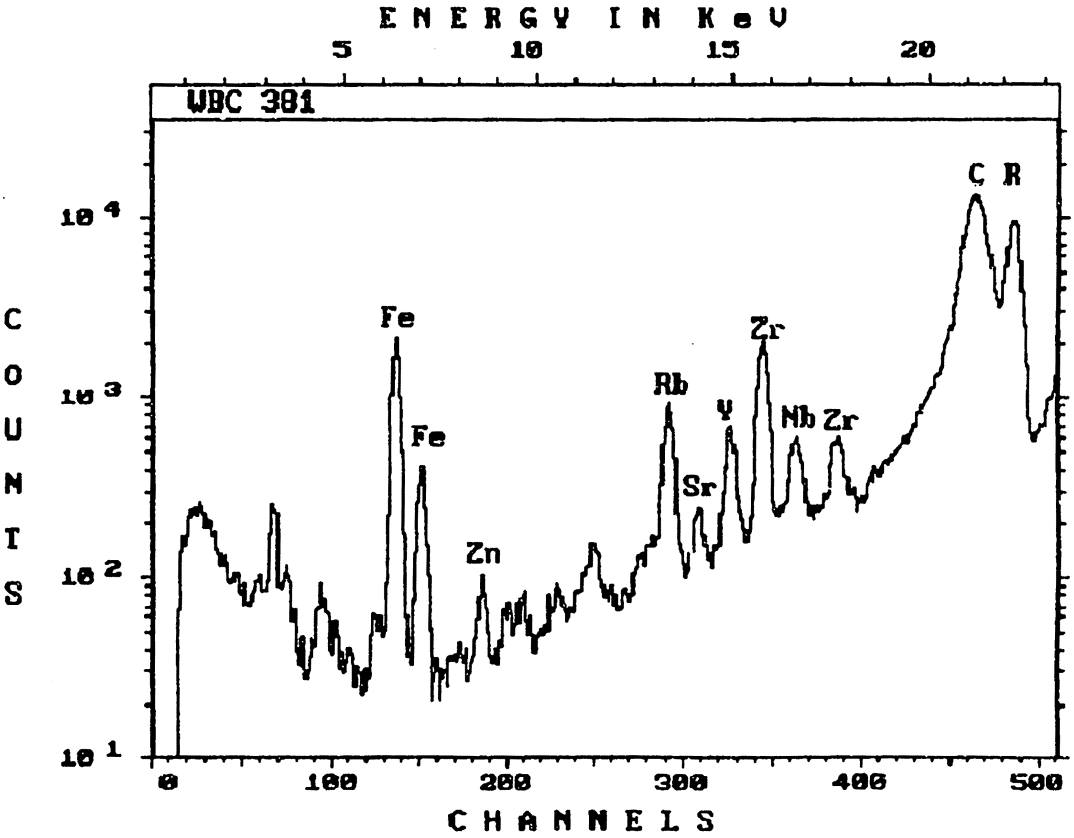
CHANNELS



ENERGY IN KeV
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Fe
Zn
Rb
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COUNTS
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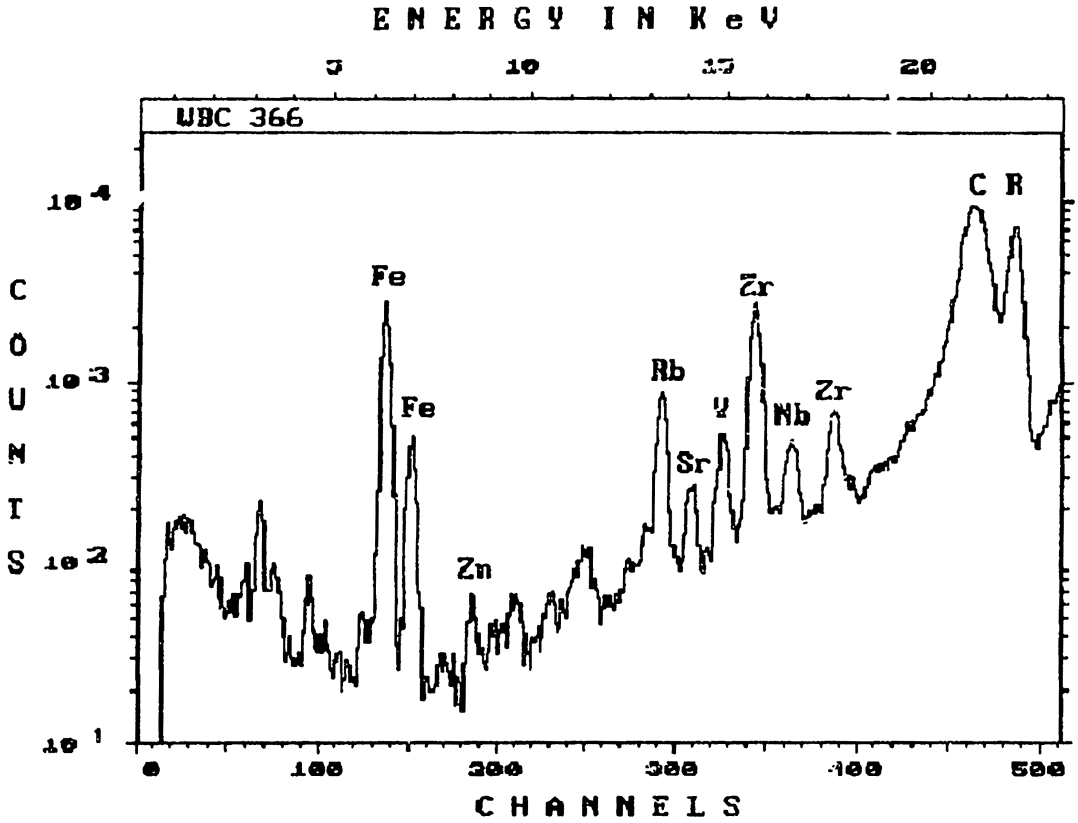
CHANNELS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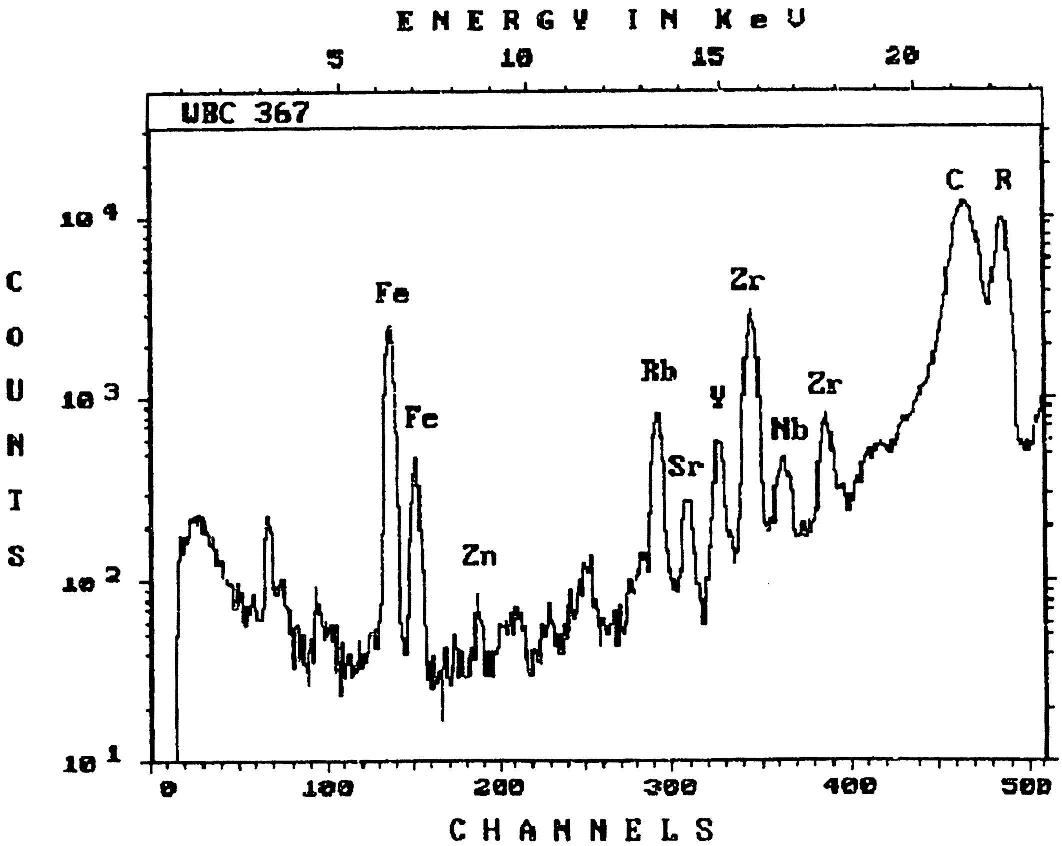
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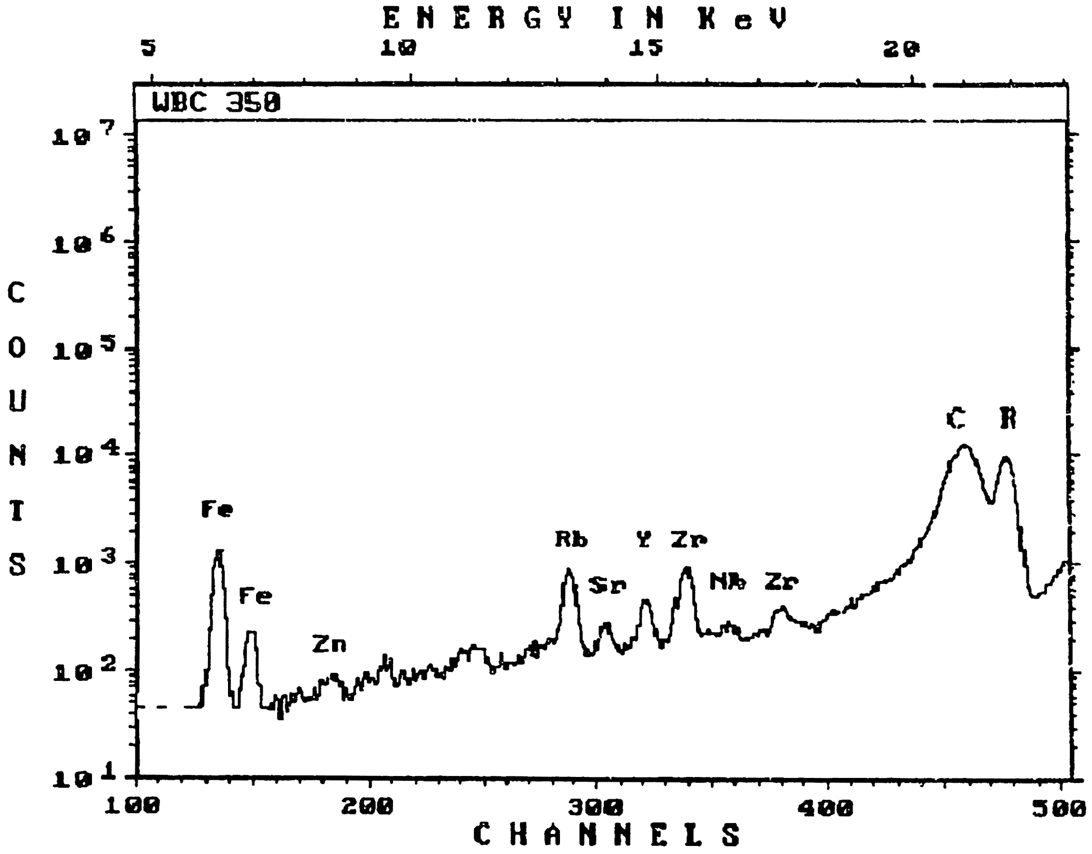
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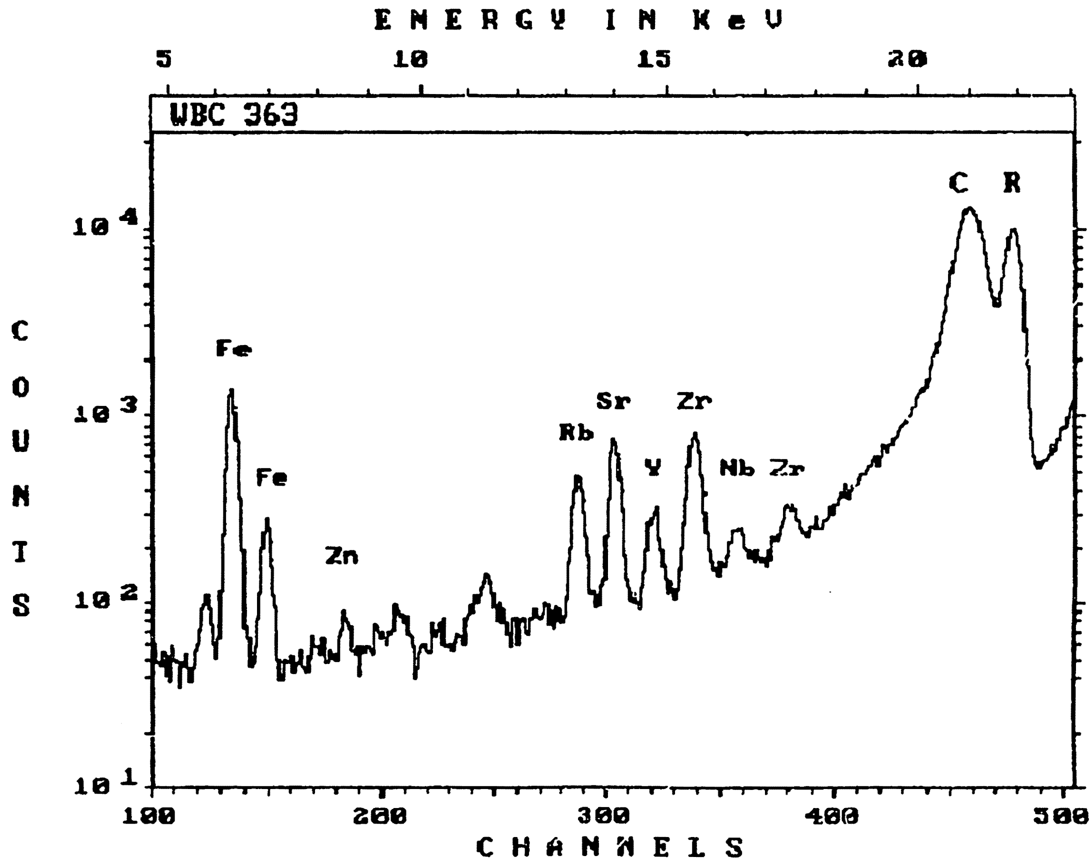
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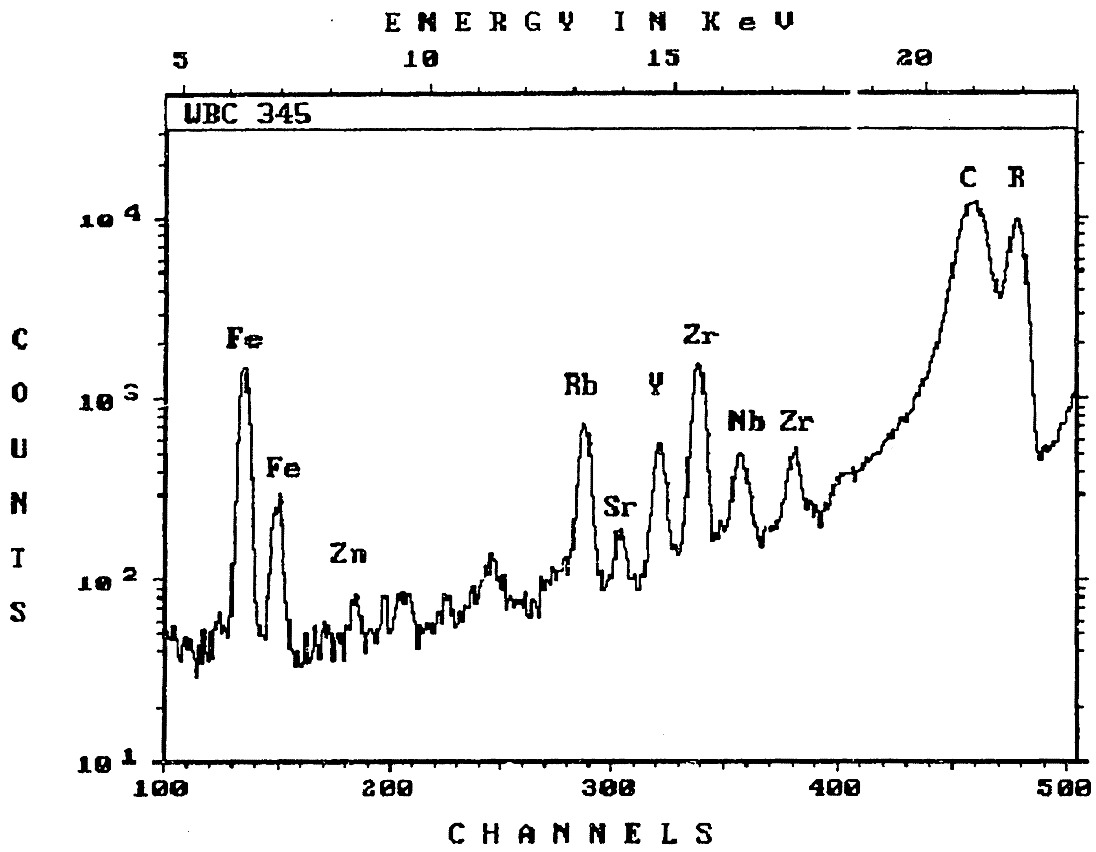
ENERGY IN KeV
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20
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Fe
Zn
Rb
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Zr
COUNTS
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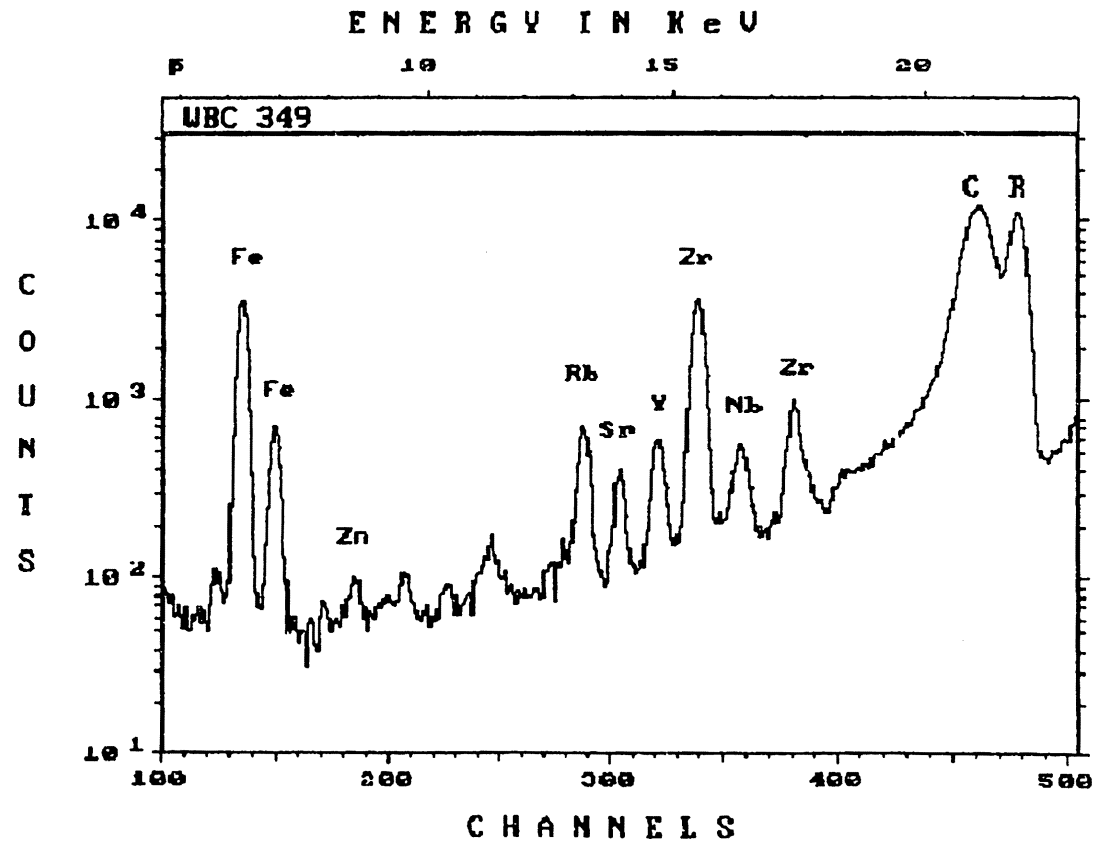
CHANNELS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COUNTS
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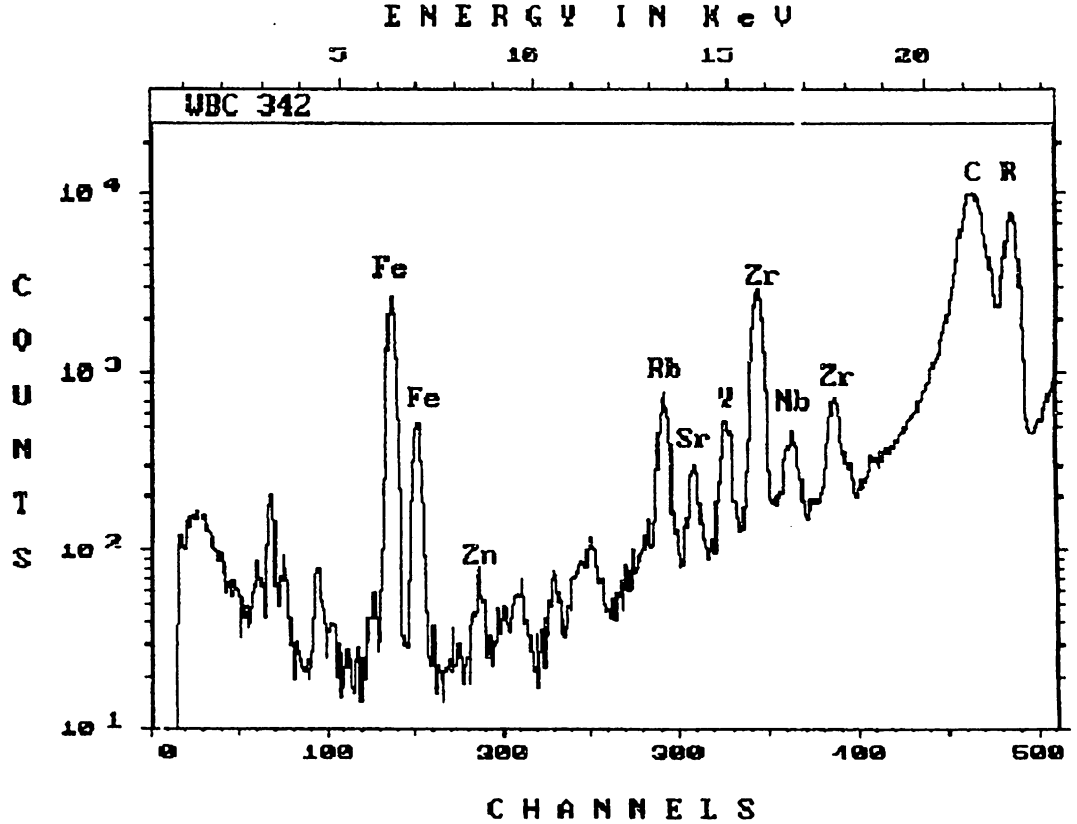
CHANNELS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Rb
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10¹
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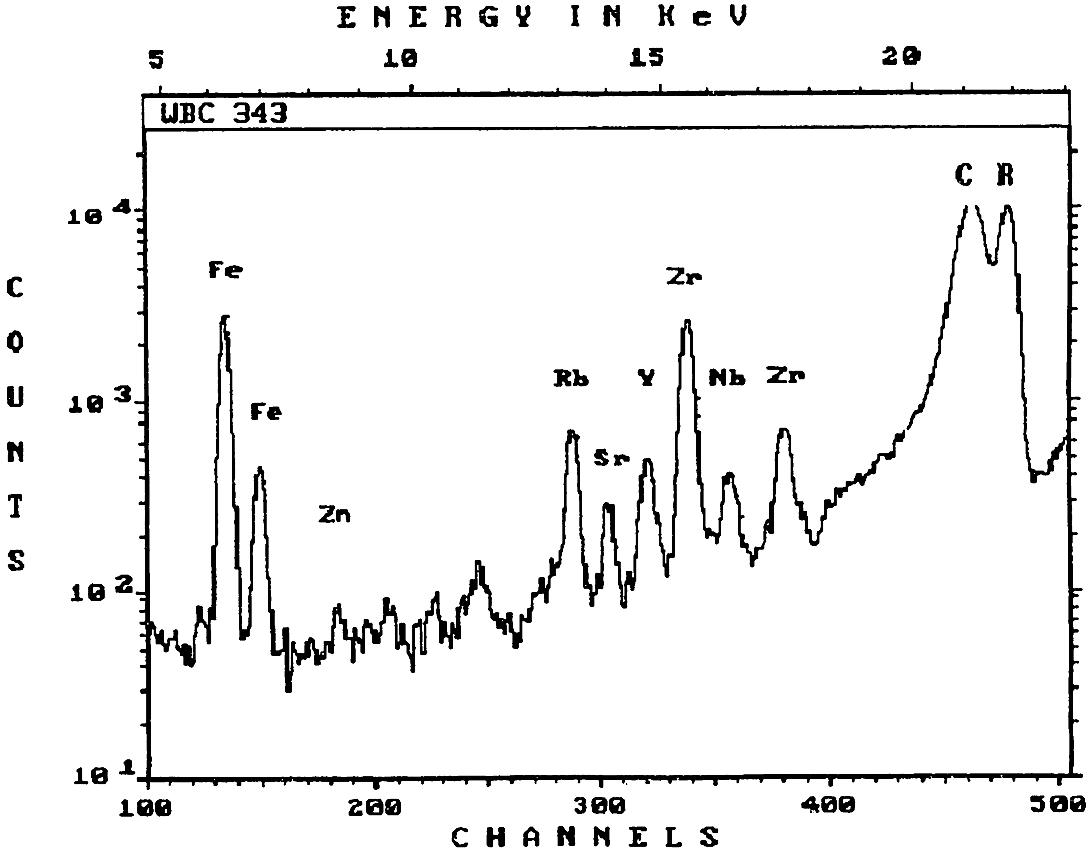
CHANNELS


ENERGY IN KeV
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COUNTS
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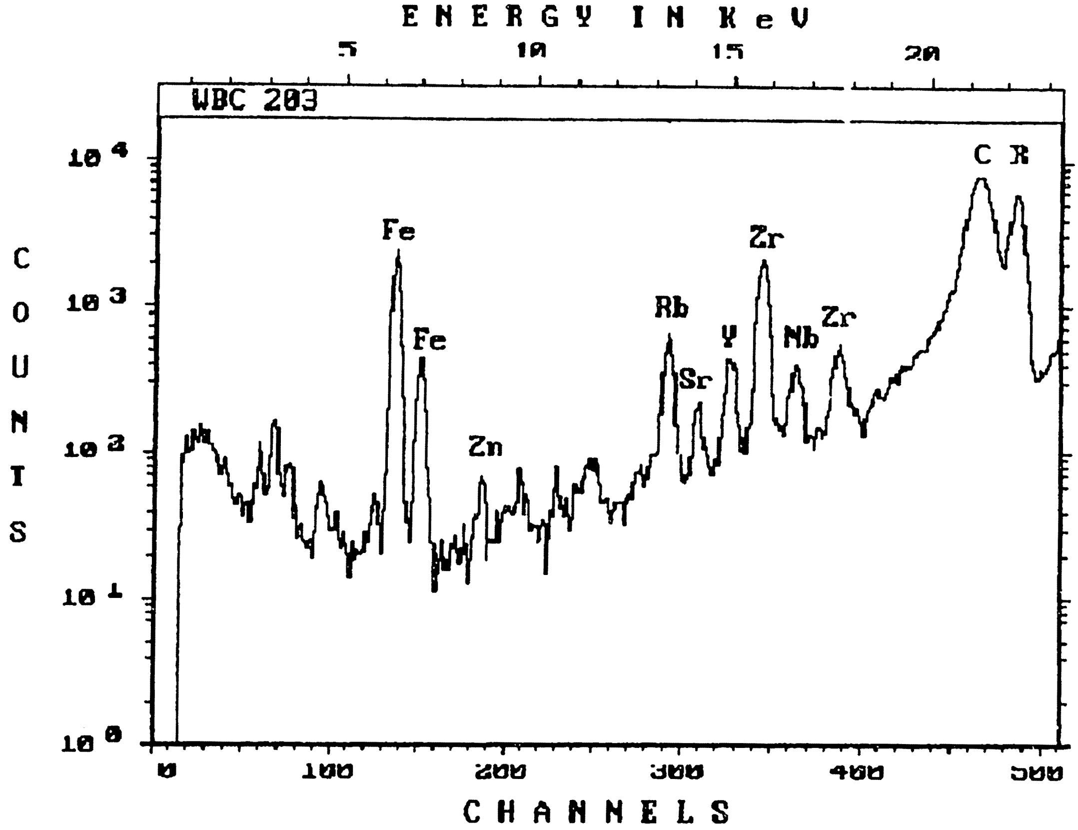
CHANNELS


ENERGY IN KeV
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WBC 203
COUNTS
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Y
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Nb
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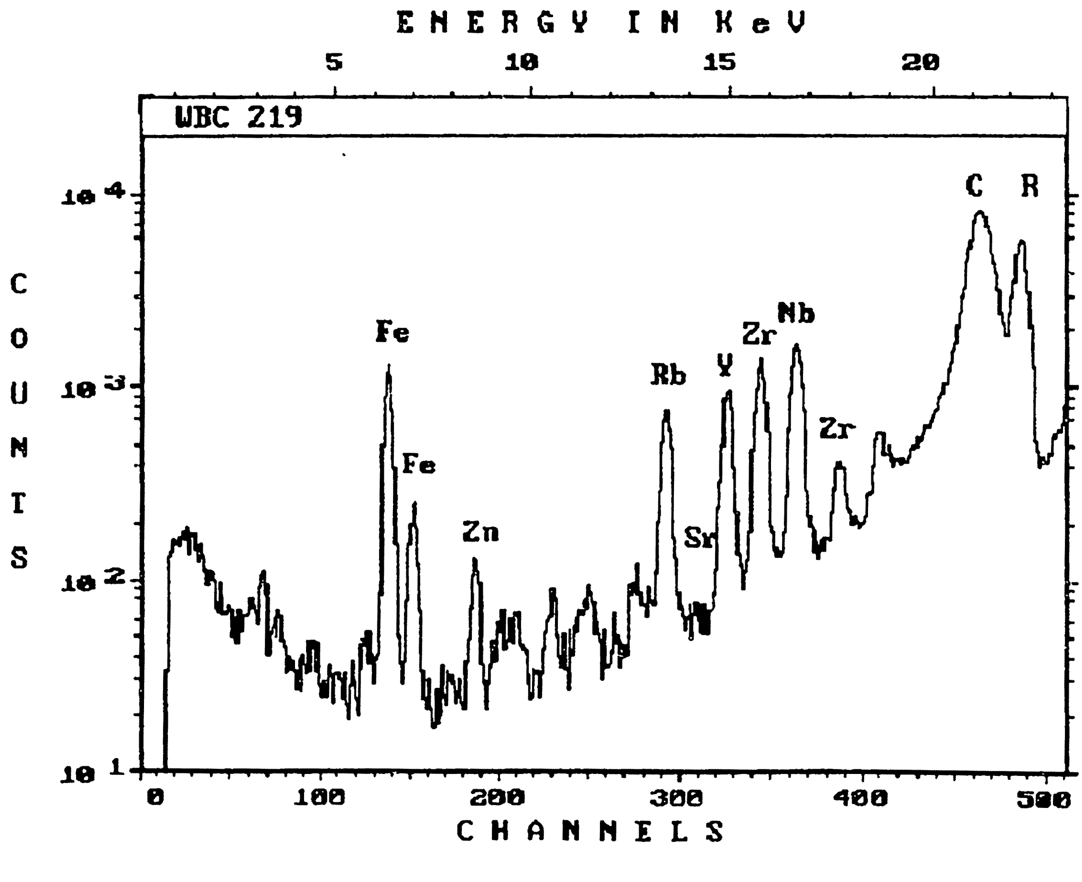
CHANNELS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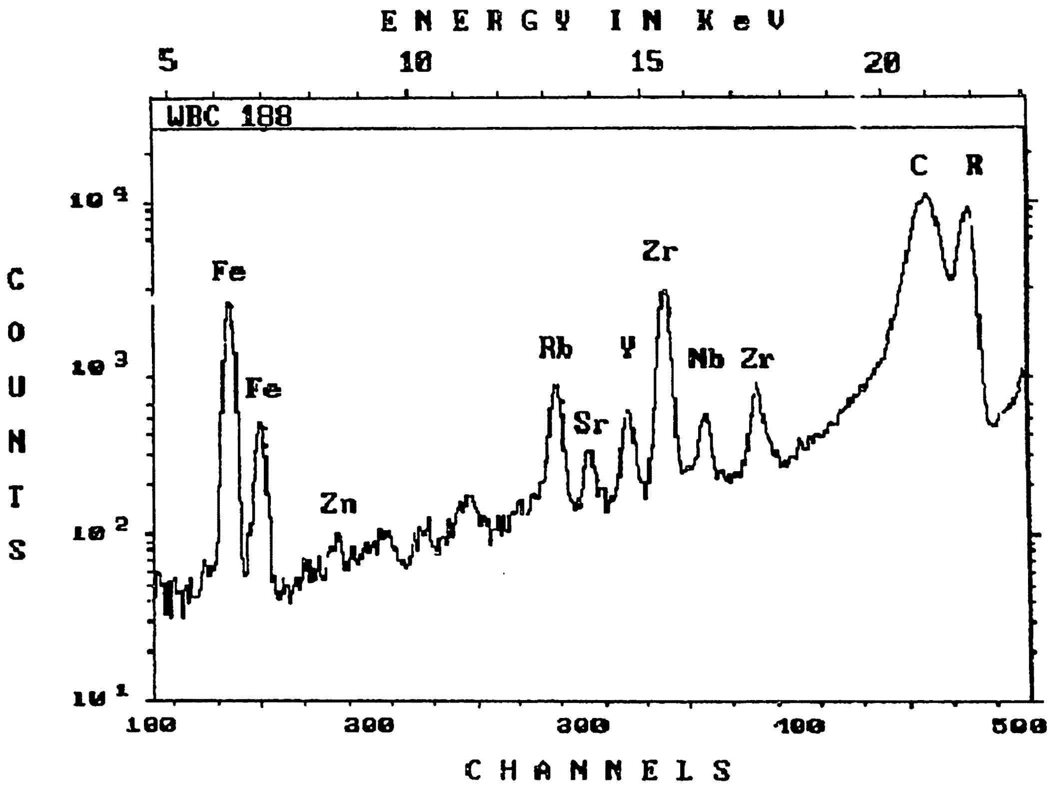
CHANNELS



E N E R G Y I N K e V
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WBC 188
C R
Fe
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Zn
Rb
Sr
Y
Zr
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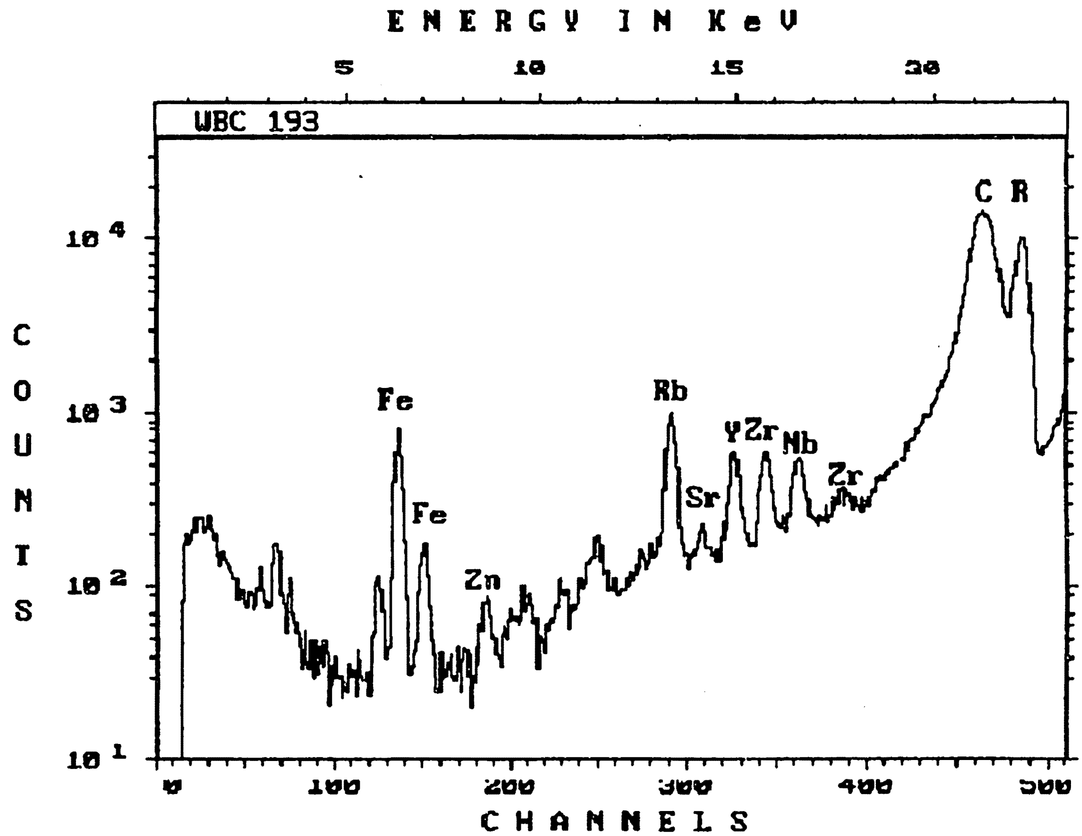
C H A N N E L S



E N E R G Y I N K e V
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C R
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Rb
Sr
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Zr
Nb
Zr
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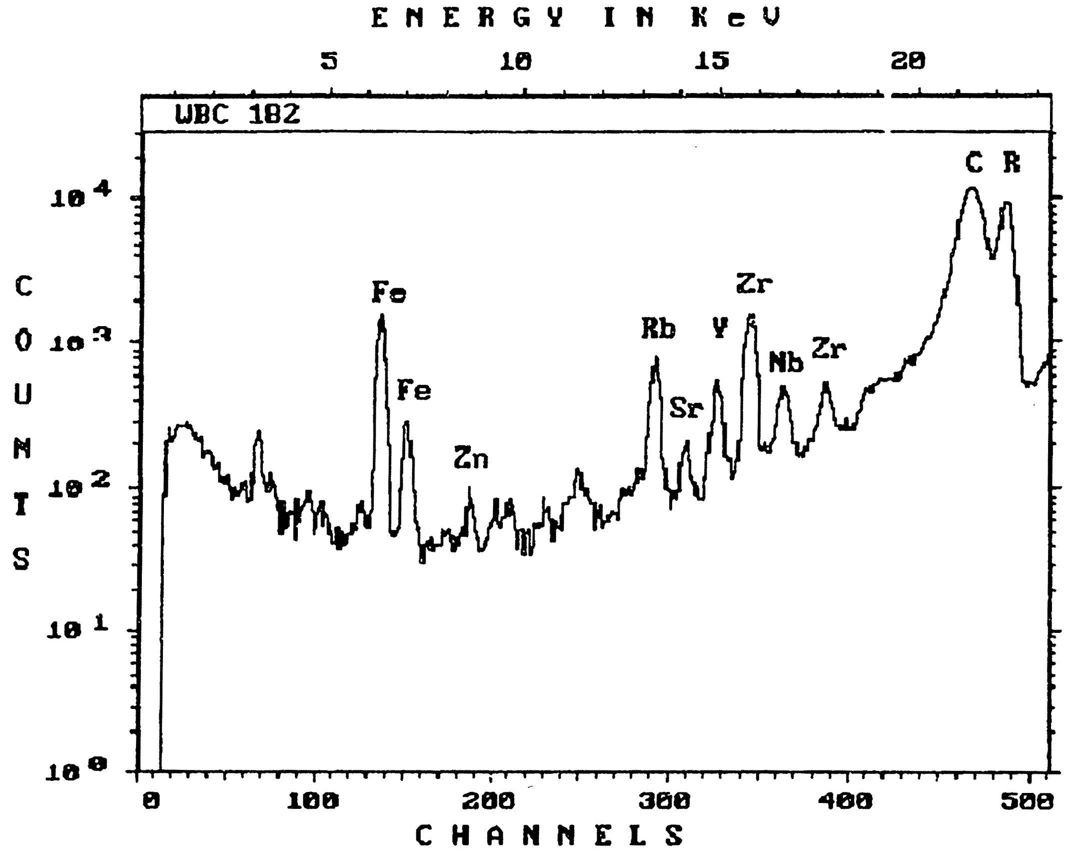
C H A N N E L S


ENERGY IN KeV
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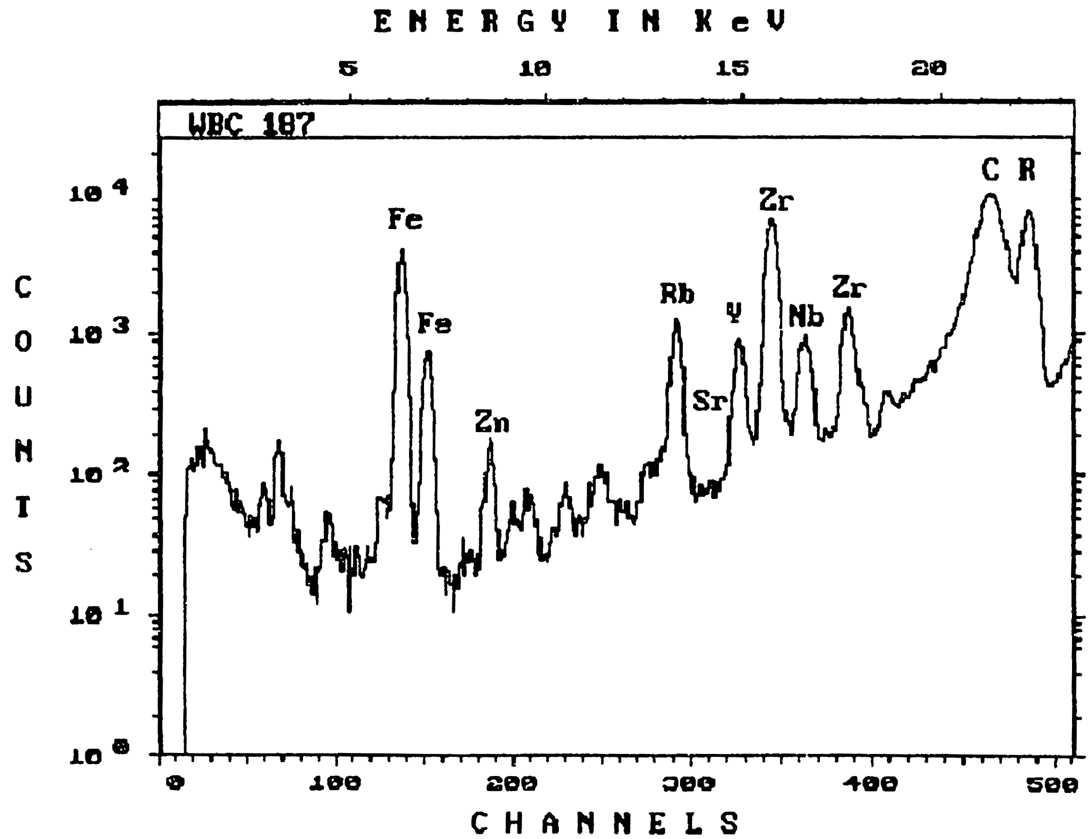
CHANNELS


ENERGY IN KeV
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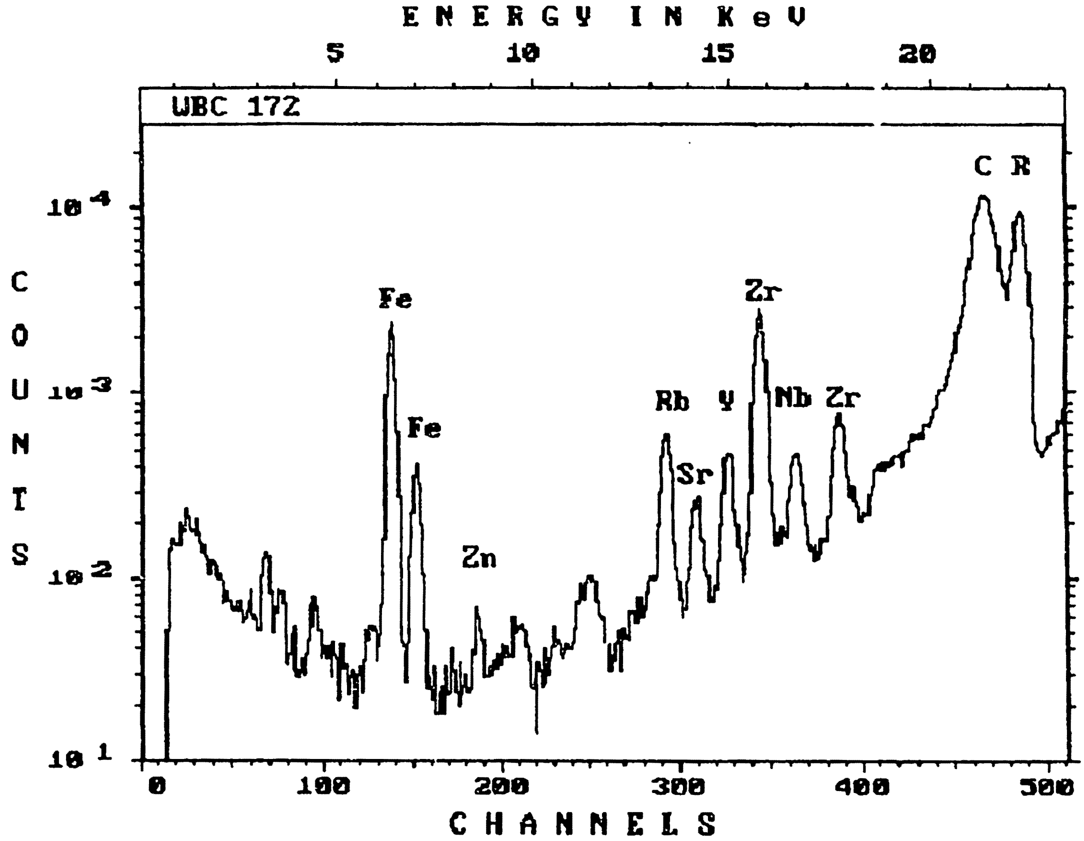
CHANNELS


ENERGY IN KeV
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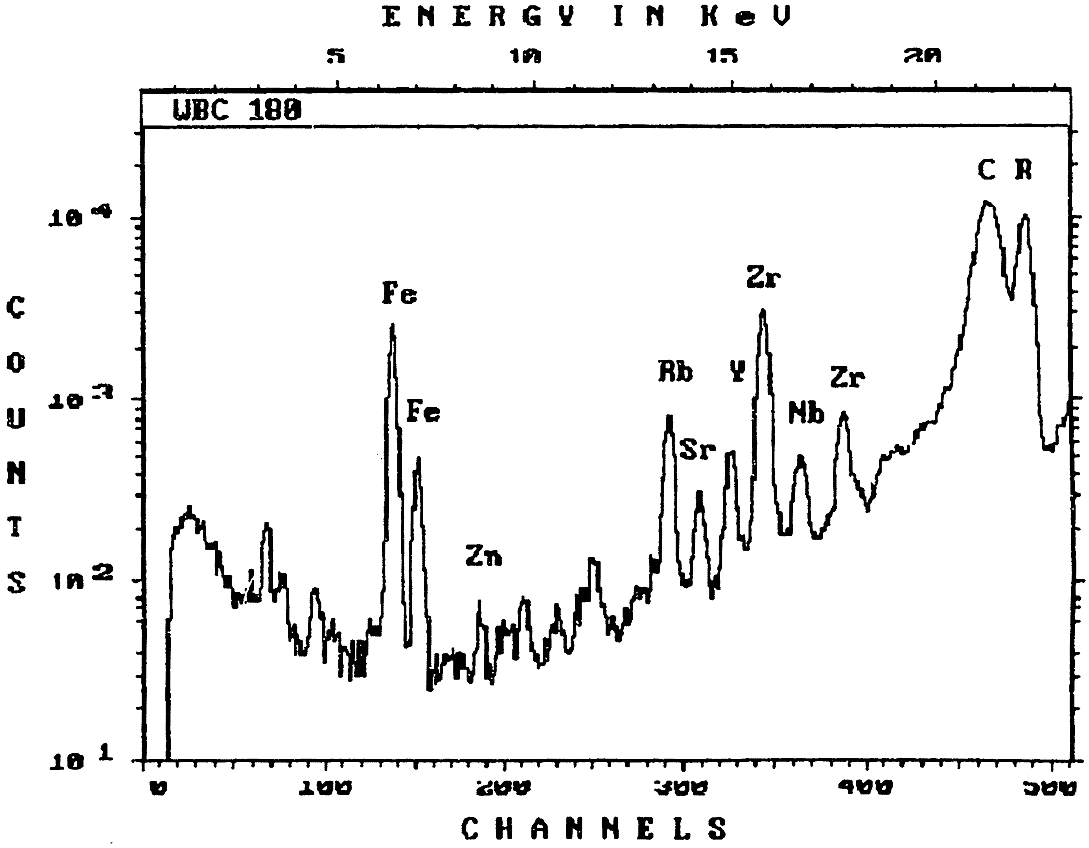
CHANNELS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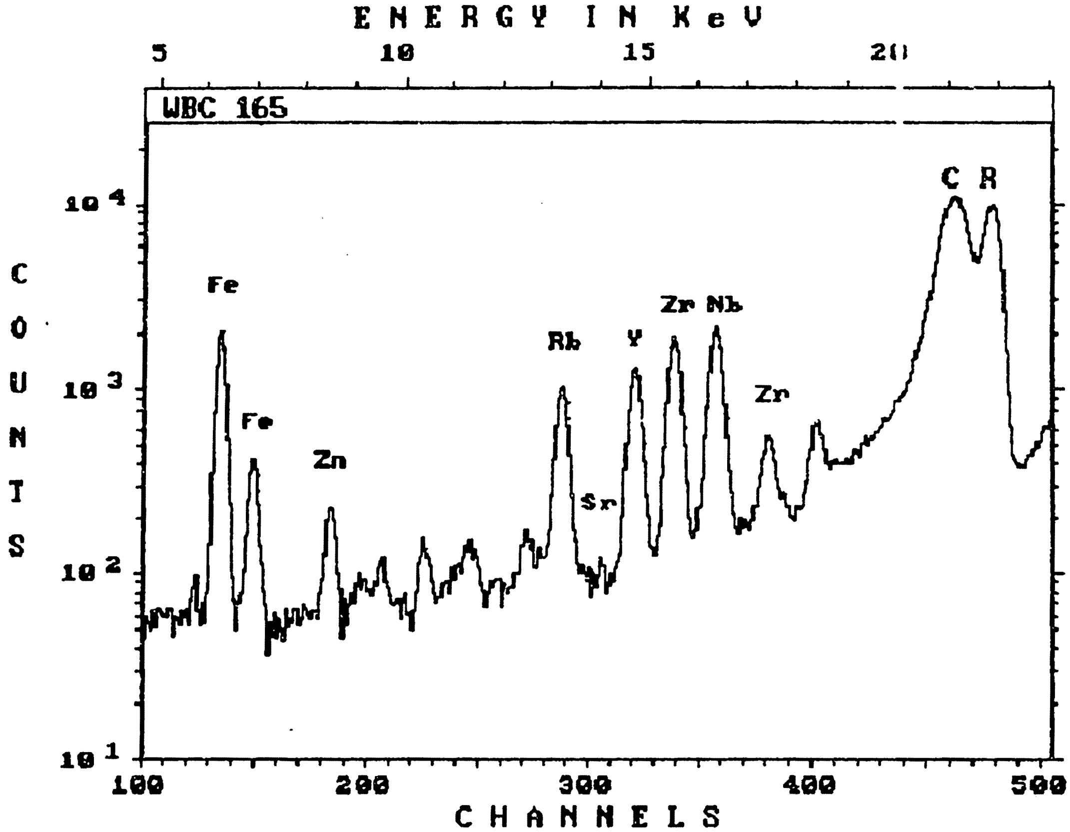
CHANNELS


ENERGY IN KeV
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Zr Nb
Zr
COUNTS
10 4
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10 1
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200
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400
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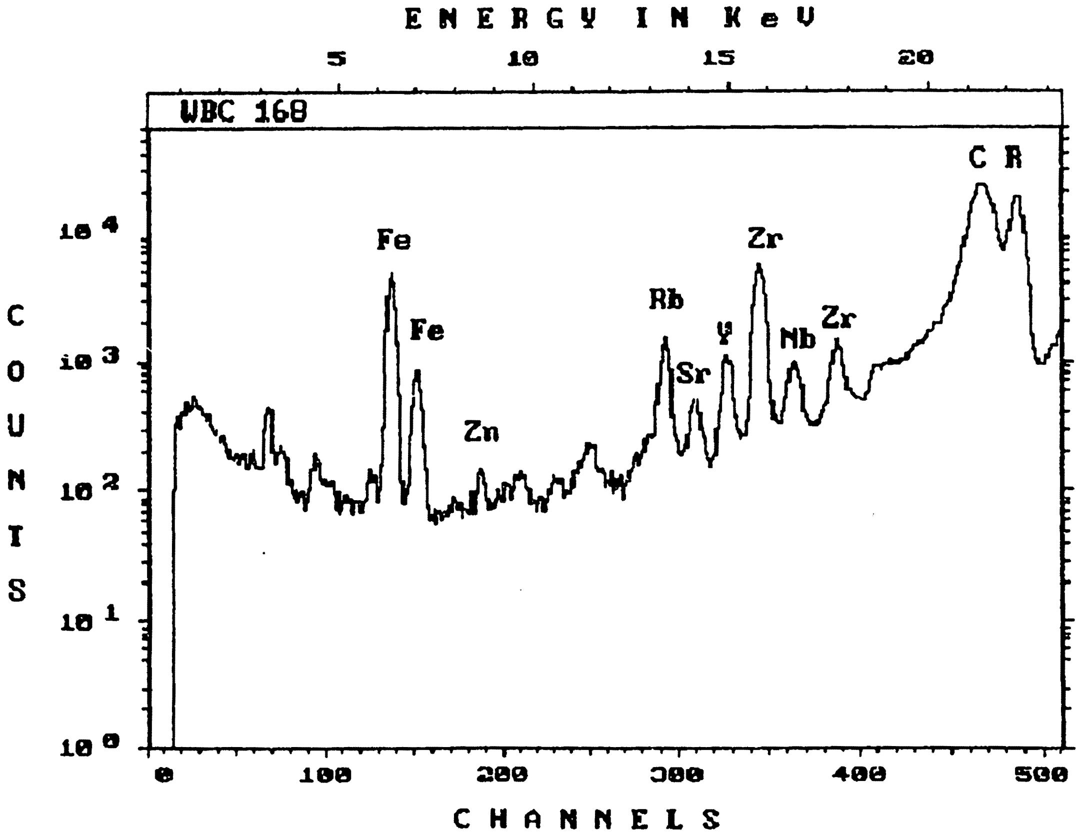
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 168
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
10 0
0
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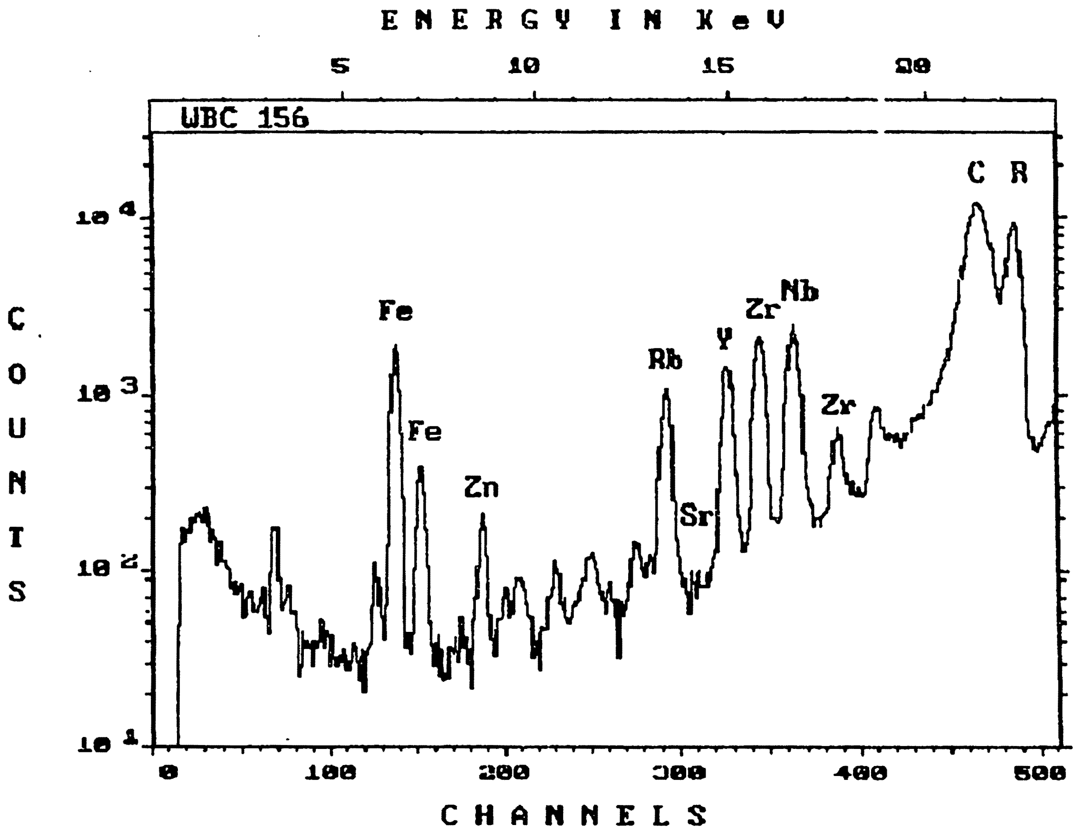
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 156
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
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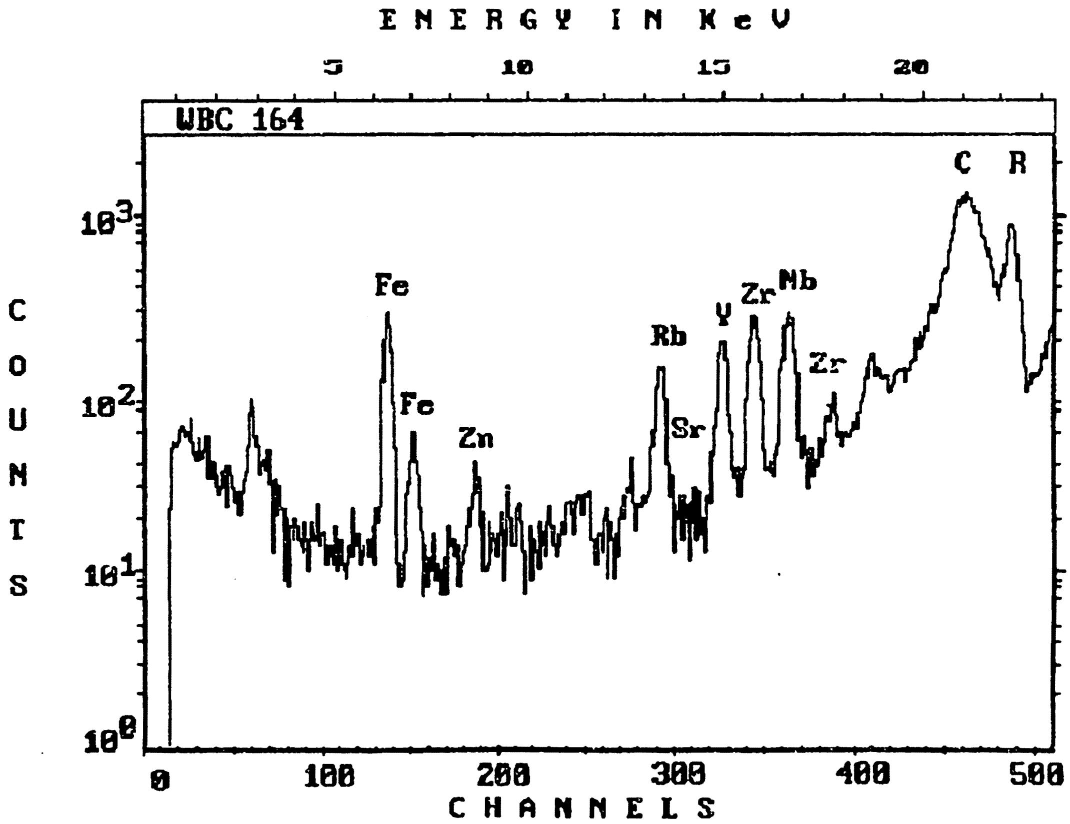
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 164
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10²
10¹
10⁰
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200
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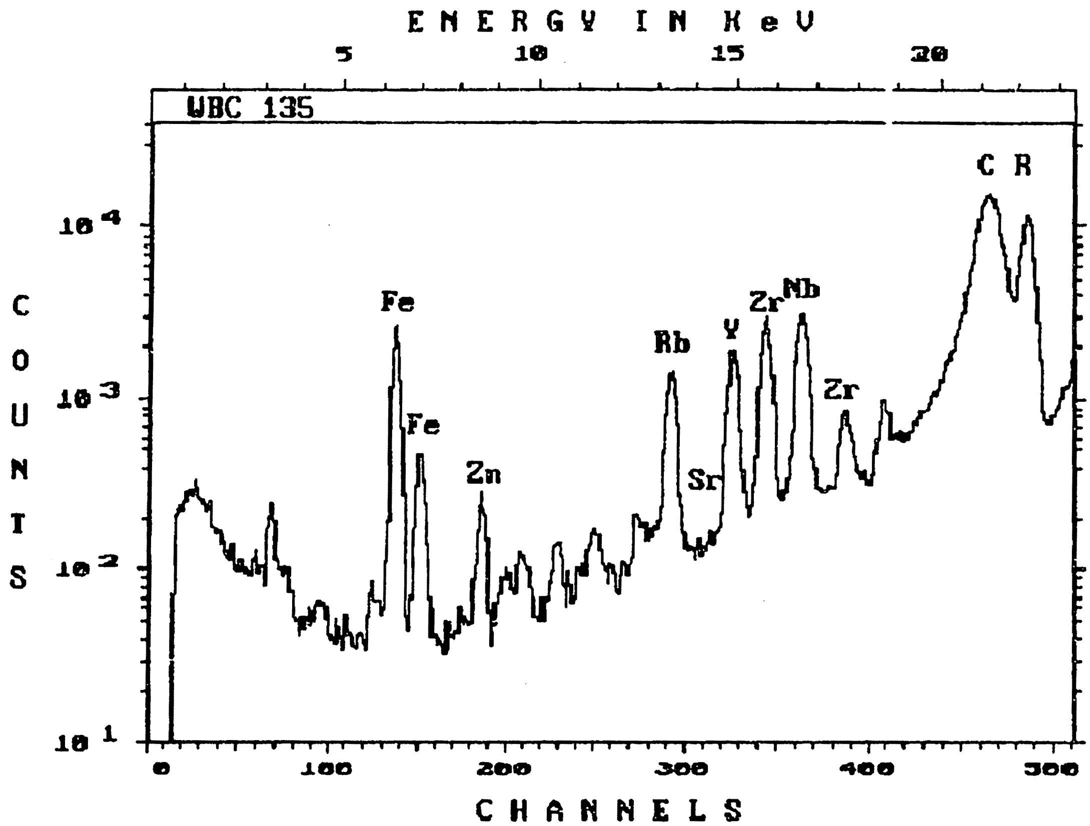
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 135
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
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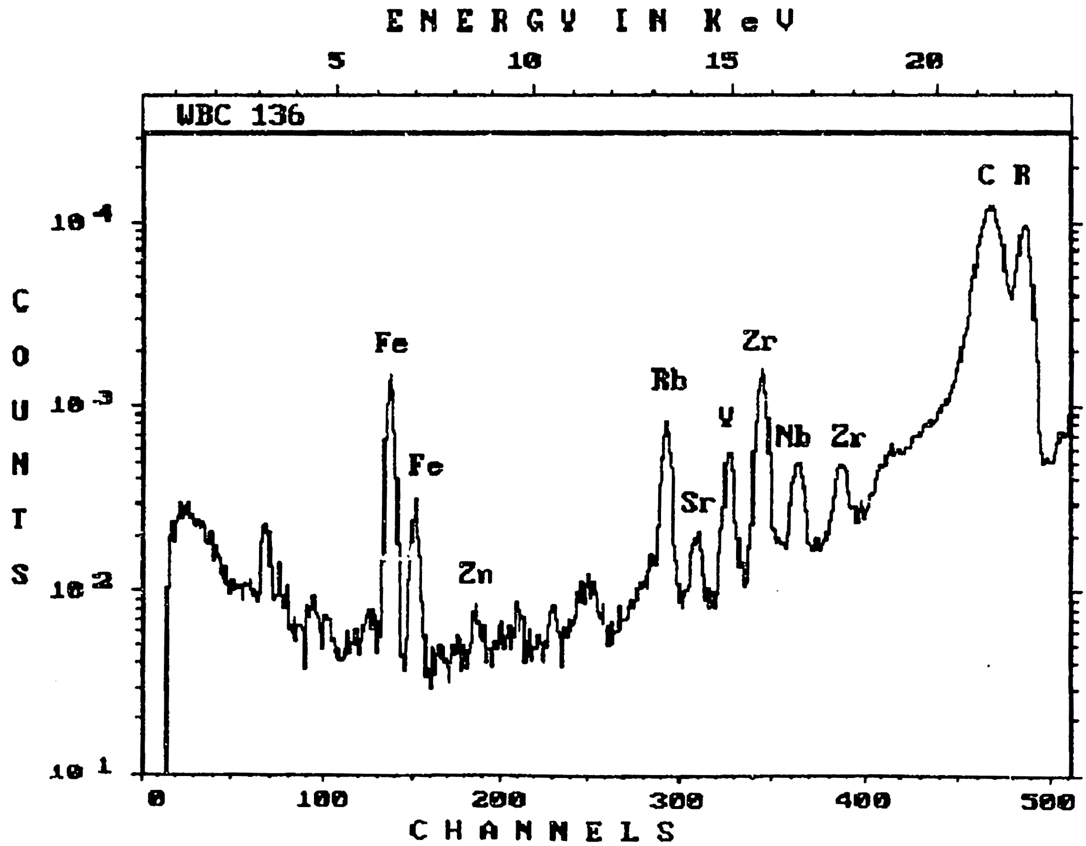
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 136
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
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200
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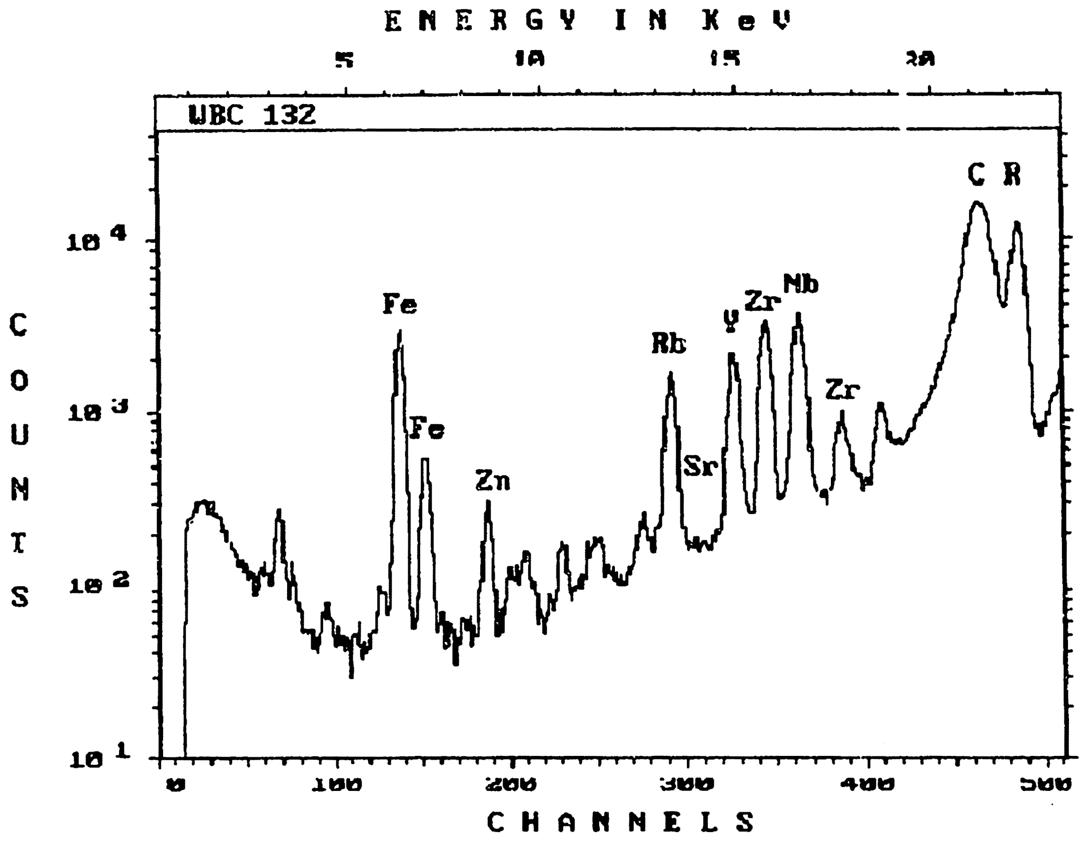
500
CHANNELS


ENERGY IN KeV
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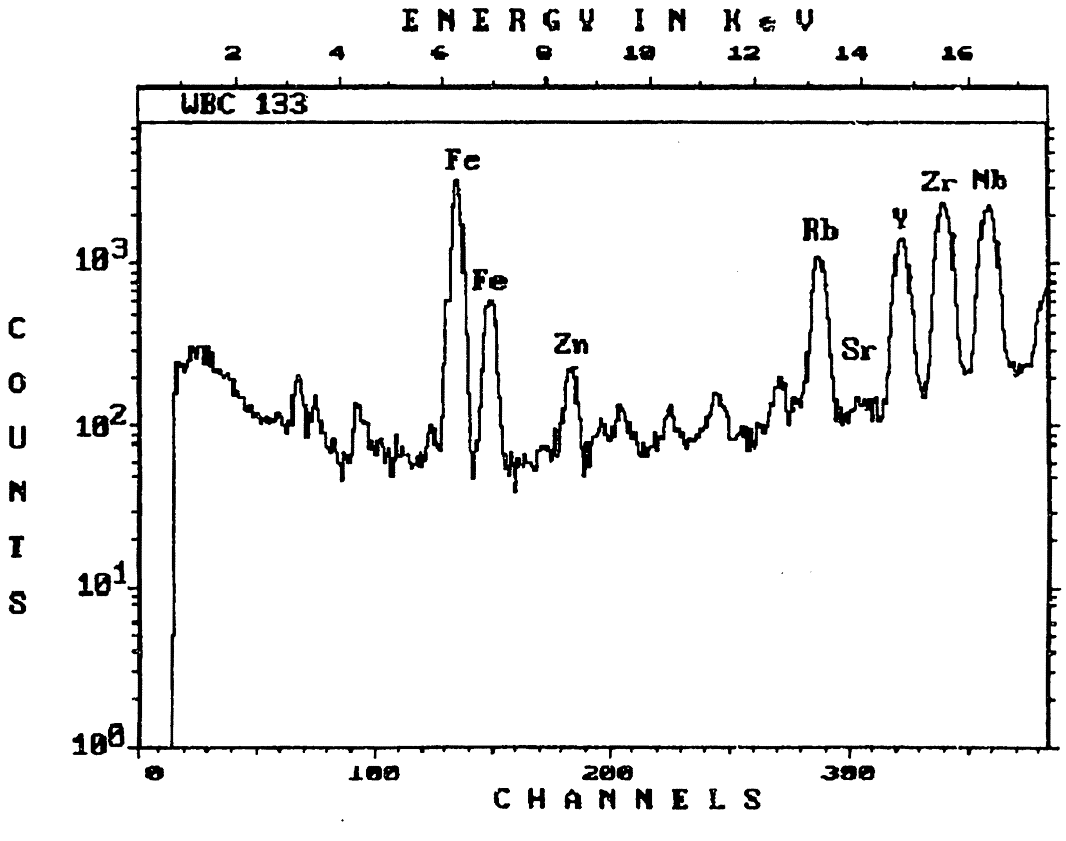
20
WBC 132
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS


ENERGY IN KeV
2
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6
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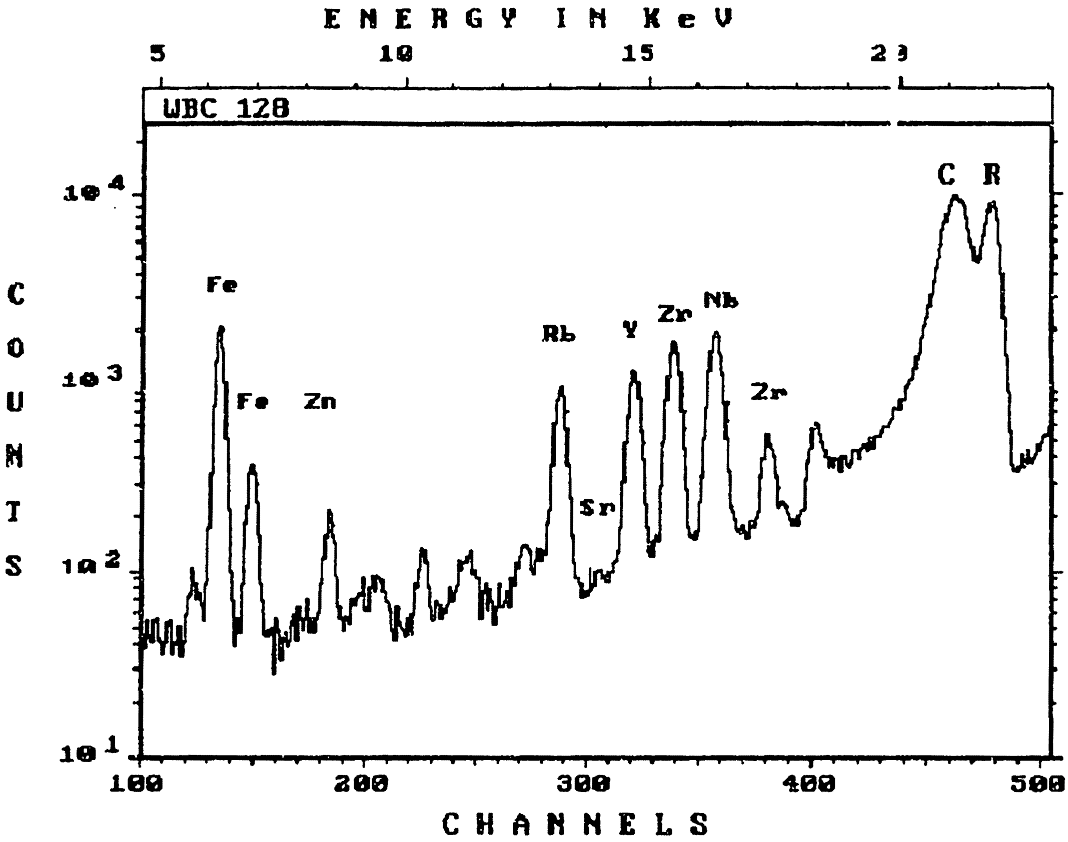
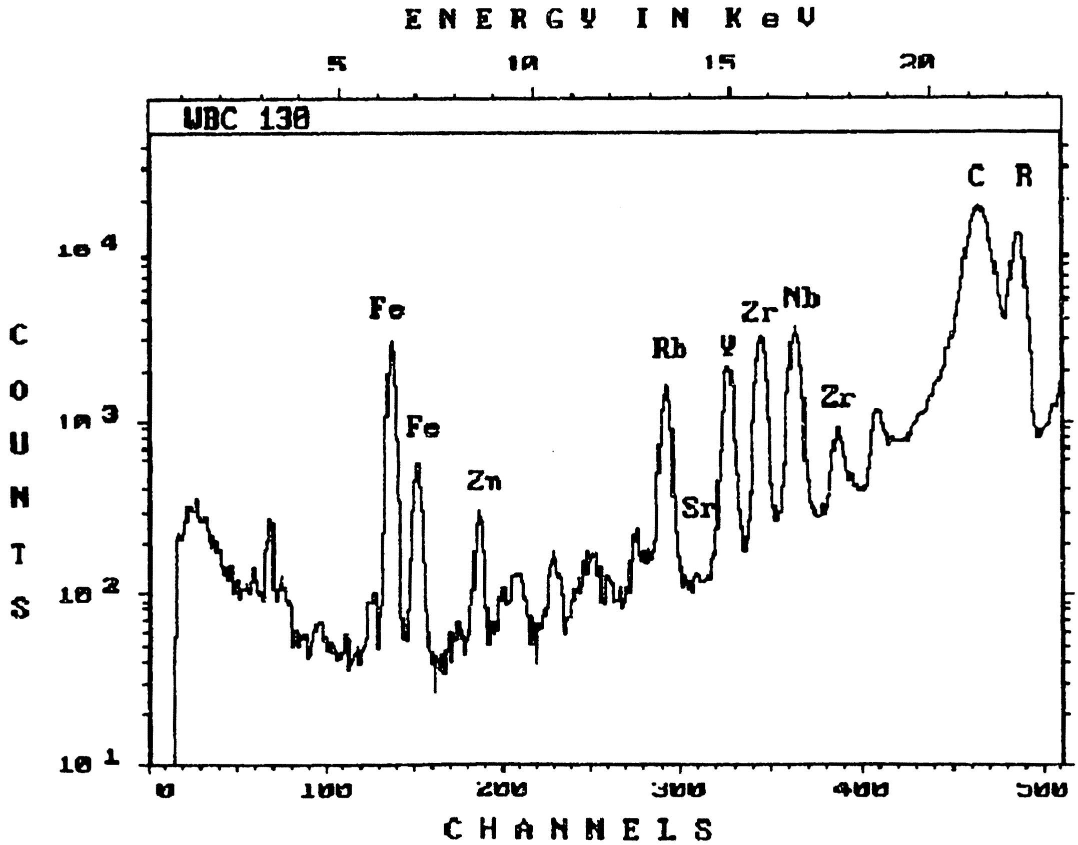
10
12
14
16
WBC 133
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
COUNTS
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 128
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 130
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
0
100
200
300
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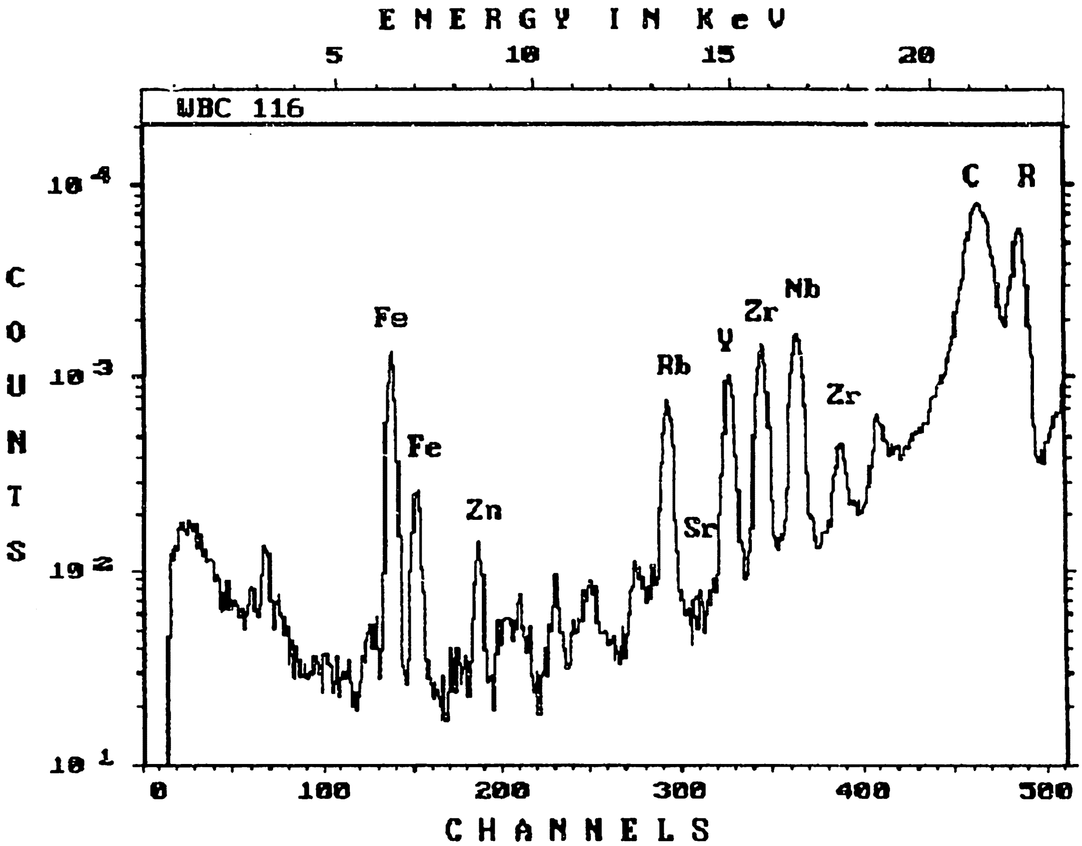
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 116
COUNTS
10 4
10 3
10 2
10 1
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
0
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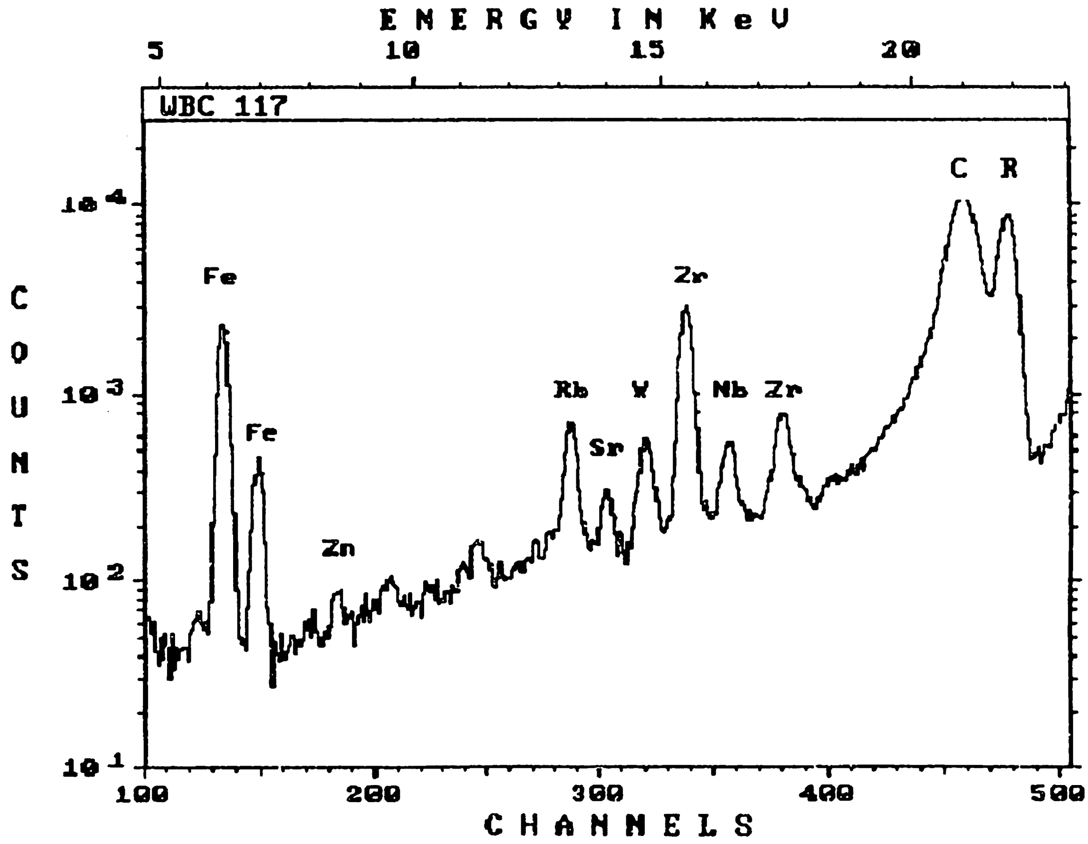
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 117
COUNTS
10 4
10 3
10 2
10 1
C
R
Fe
Fe
Zn
Rb
Sr
W
Zr
Nb
Zr
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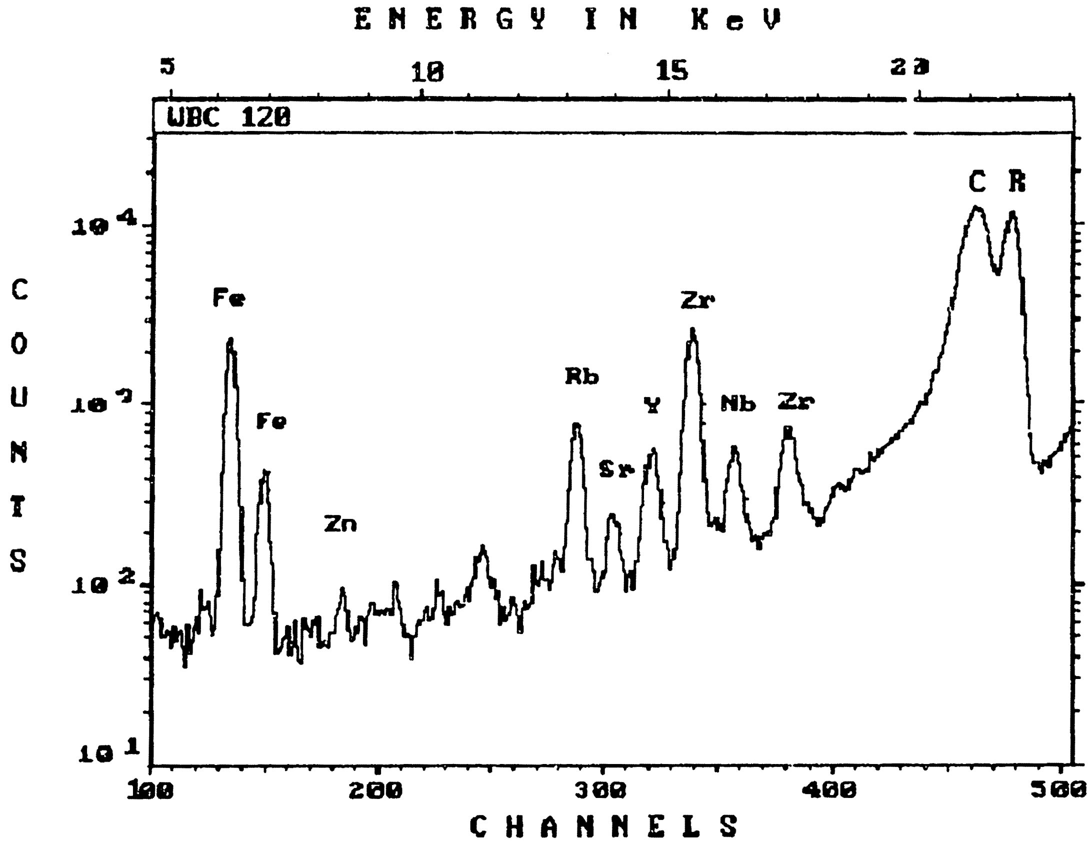
200
300
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 120
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
100
200
300
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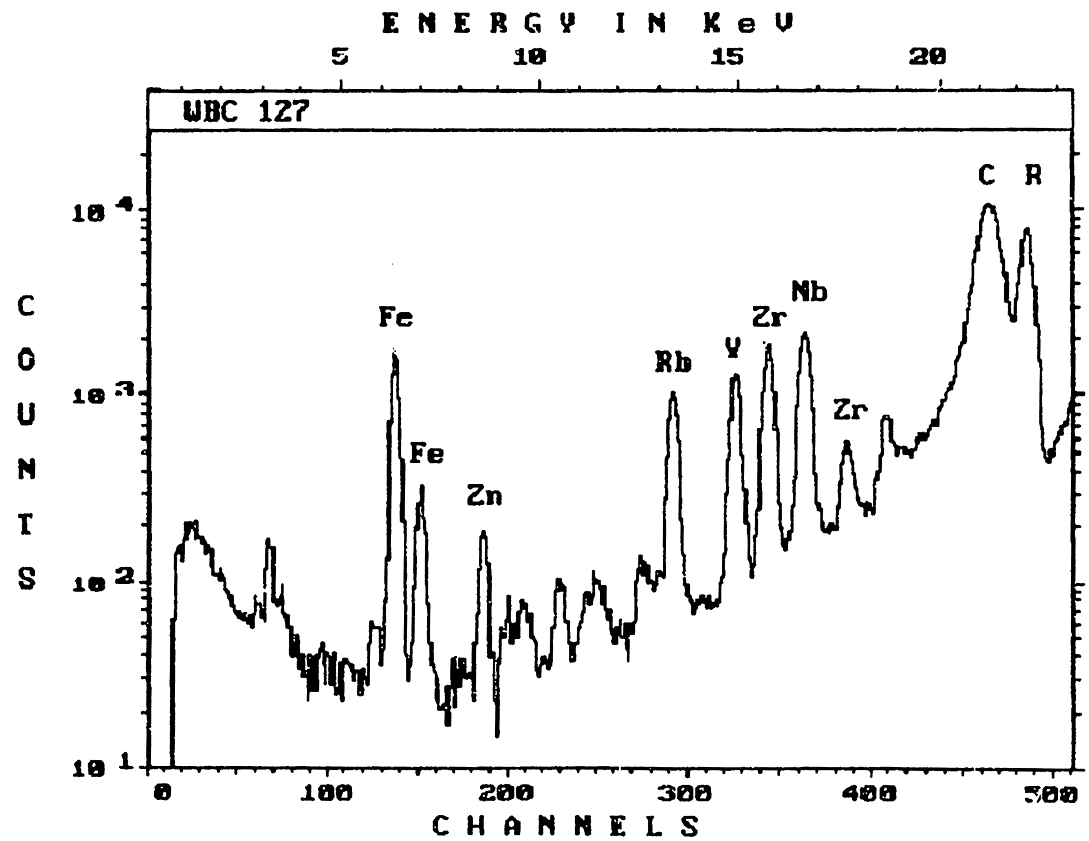
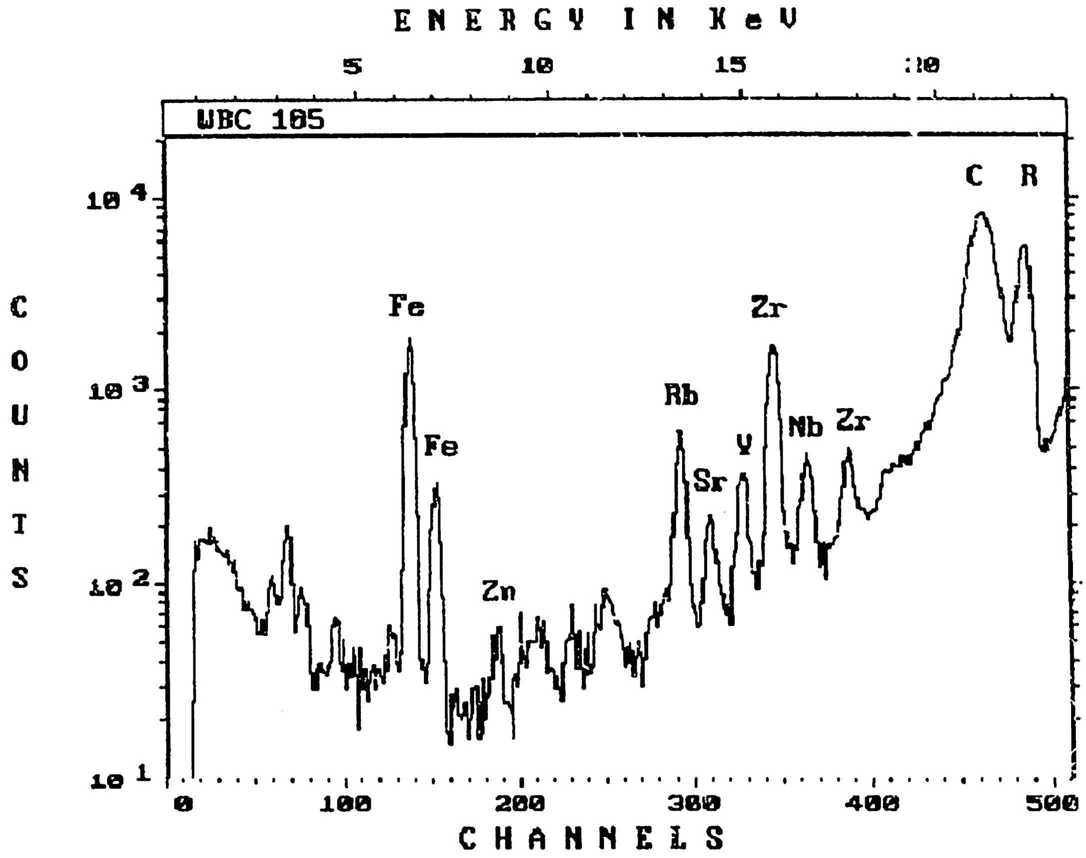
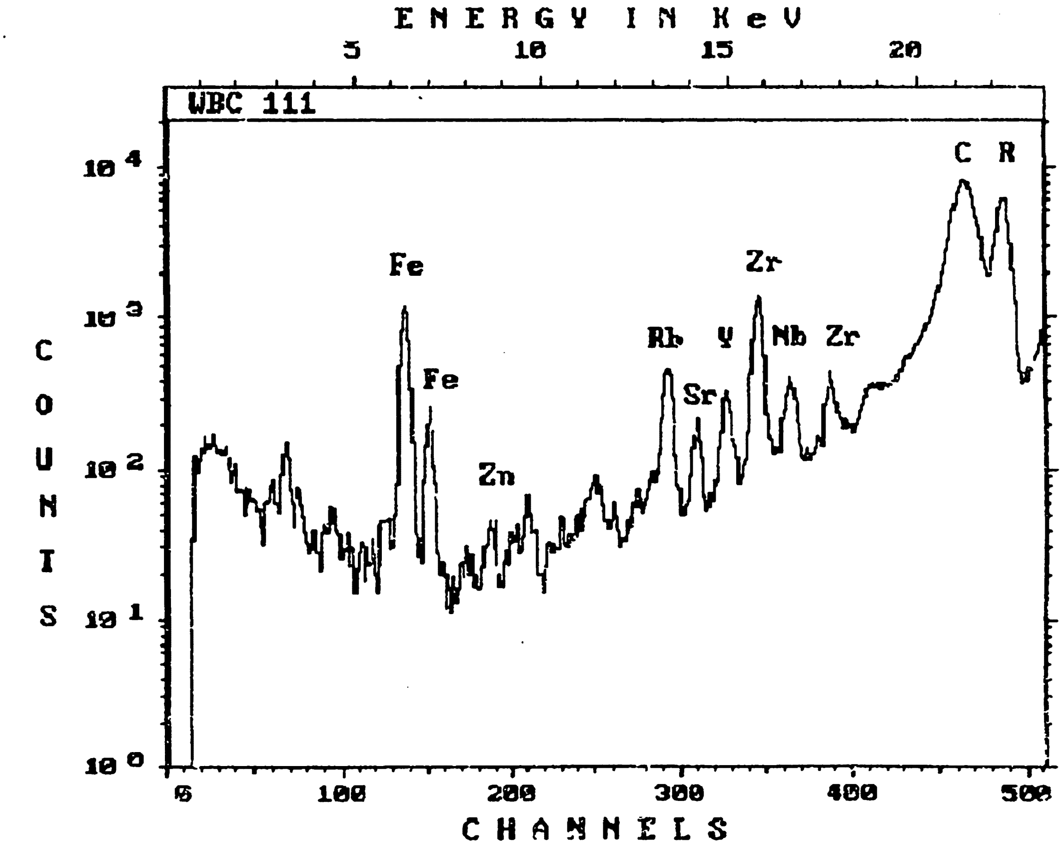
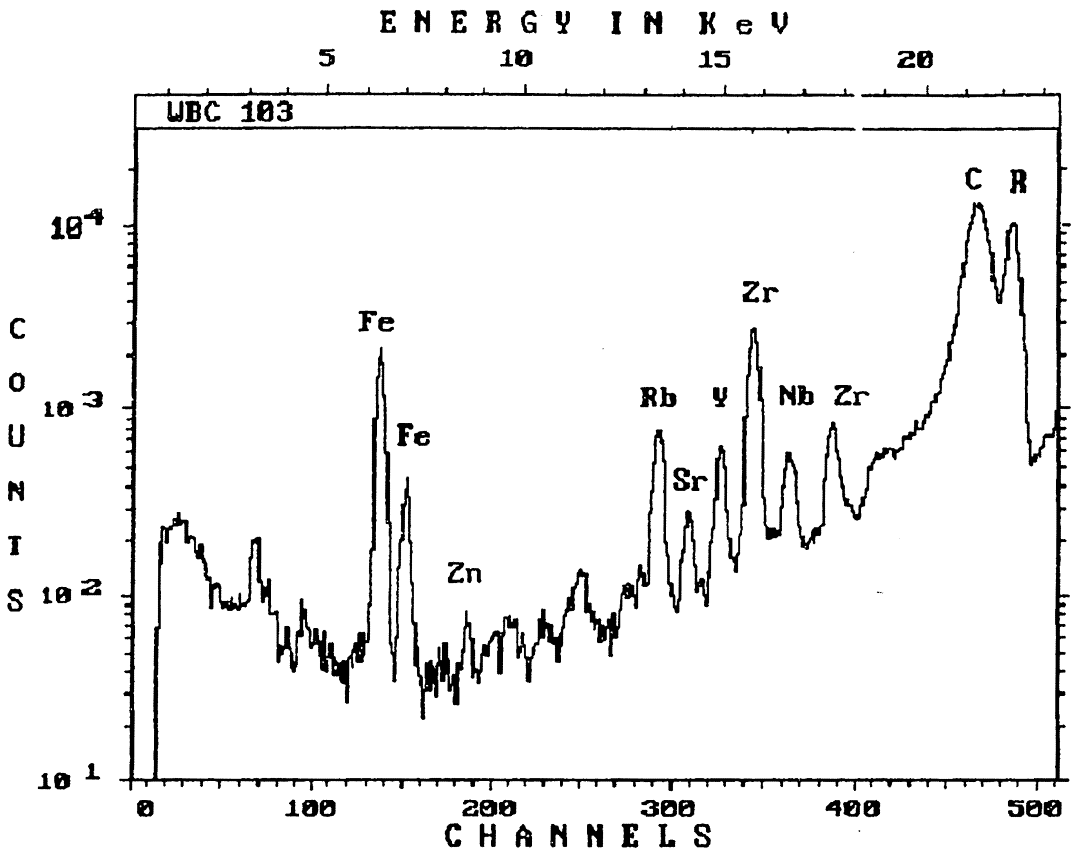
500
CHANNELS

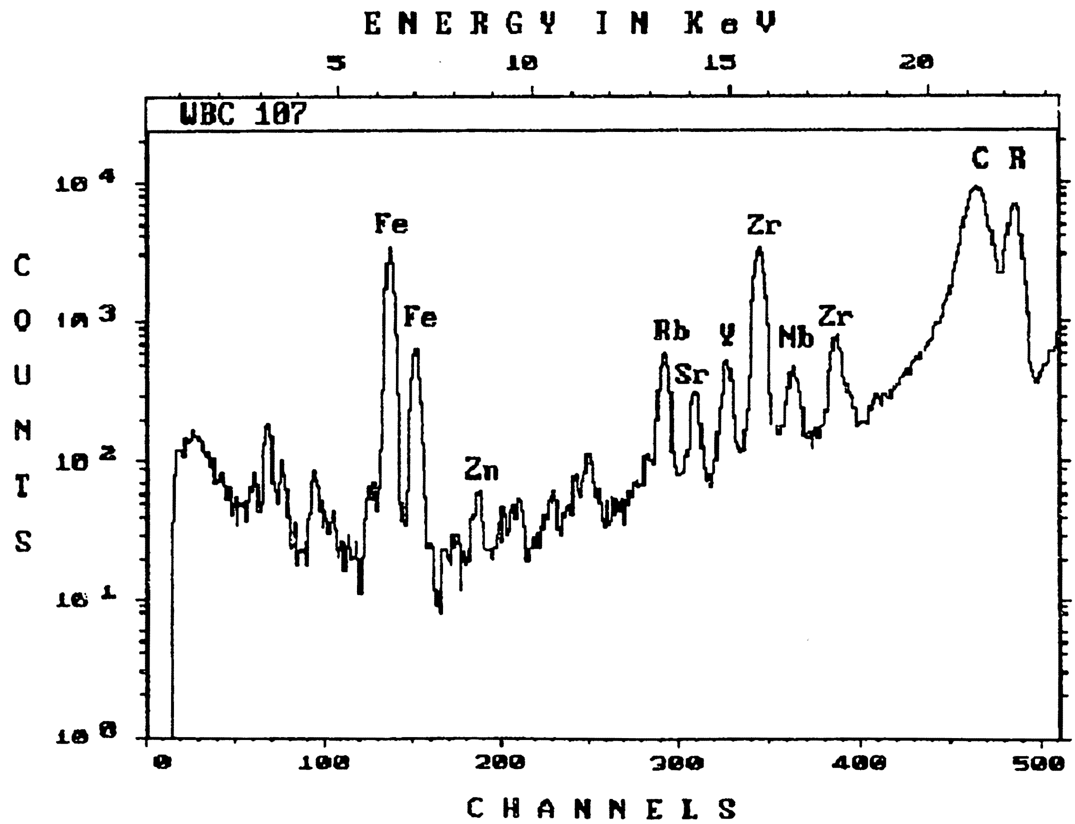


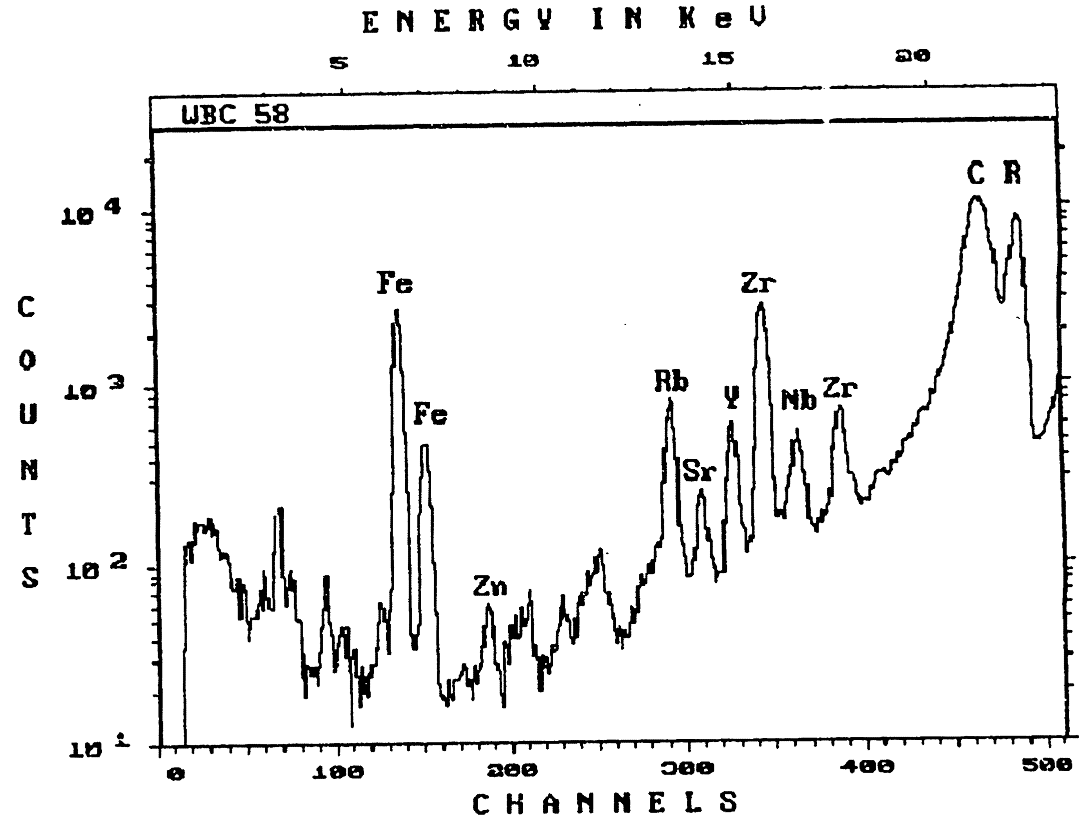
ENERGY IN KeV
5
10
15
20
WBC 127
C R
Fe
Fe
Zn
Rb
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 105
C
R
Fe
Zr
Rb
Fe
Y
Nb
Zr
Sr
Zn
COUNTS
10^4
10^3
10^2
10^1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 111
C
R
Fe
Zr
Rb
Y
Nb
Zr
Fe
Sr
Zn
COUNTS
10^4
10^3
10^2
10^1
10^0
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 103
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 107
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
10^0
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 58
COUNTS
10^4
10^3
10^2
10^1
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
0
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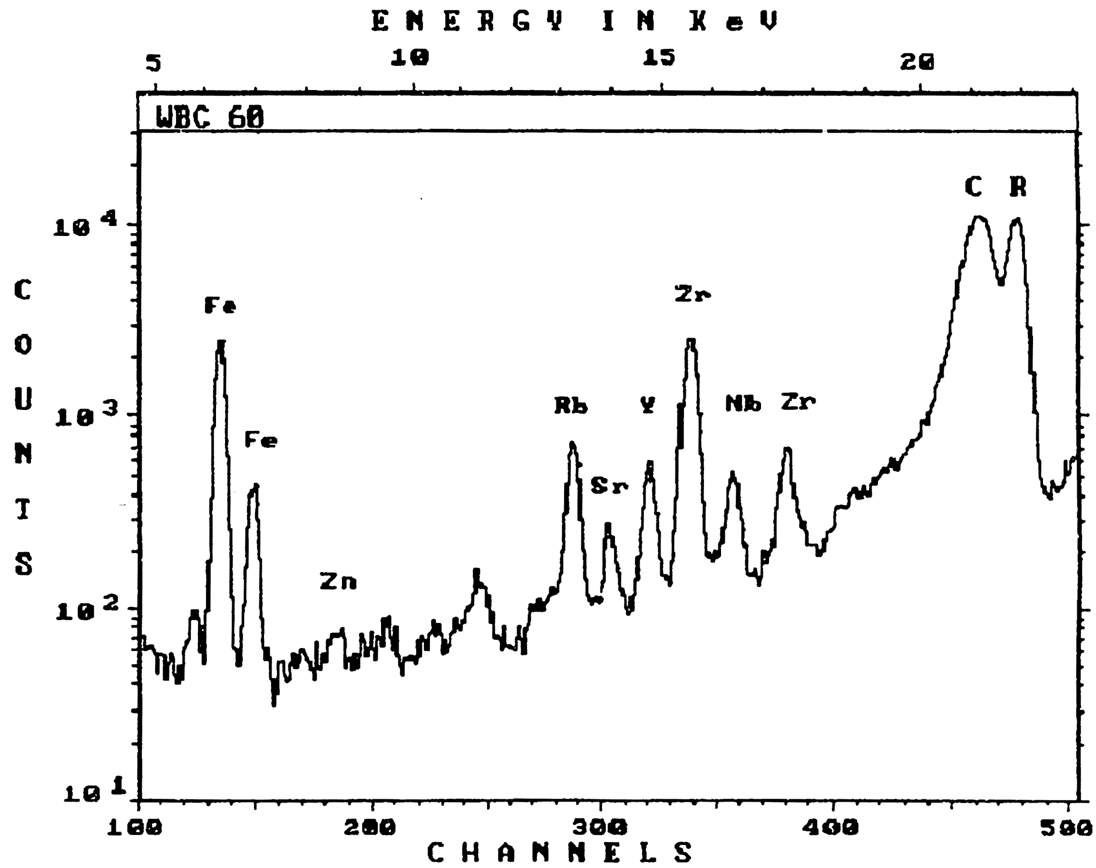
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 60
COUNTS
10^4
10^3
10^2
10^1
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
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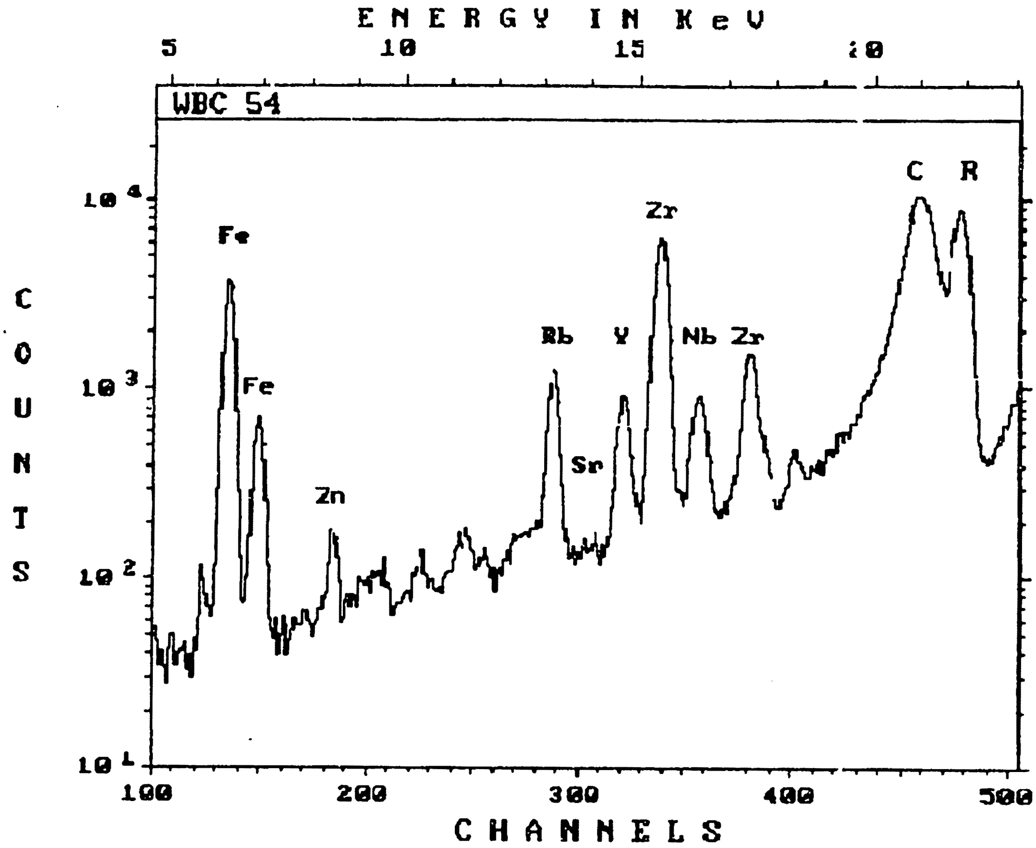
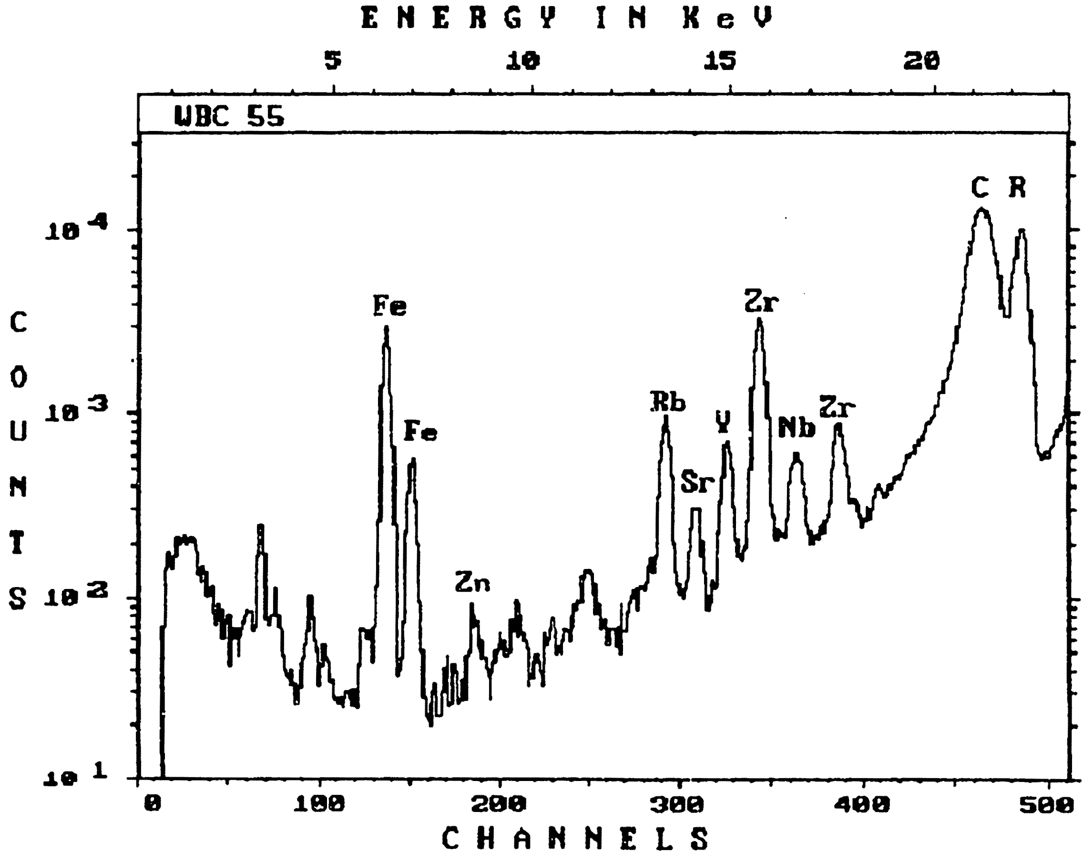
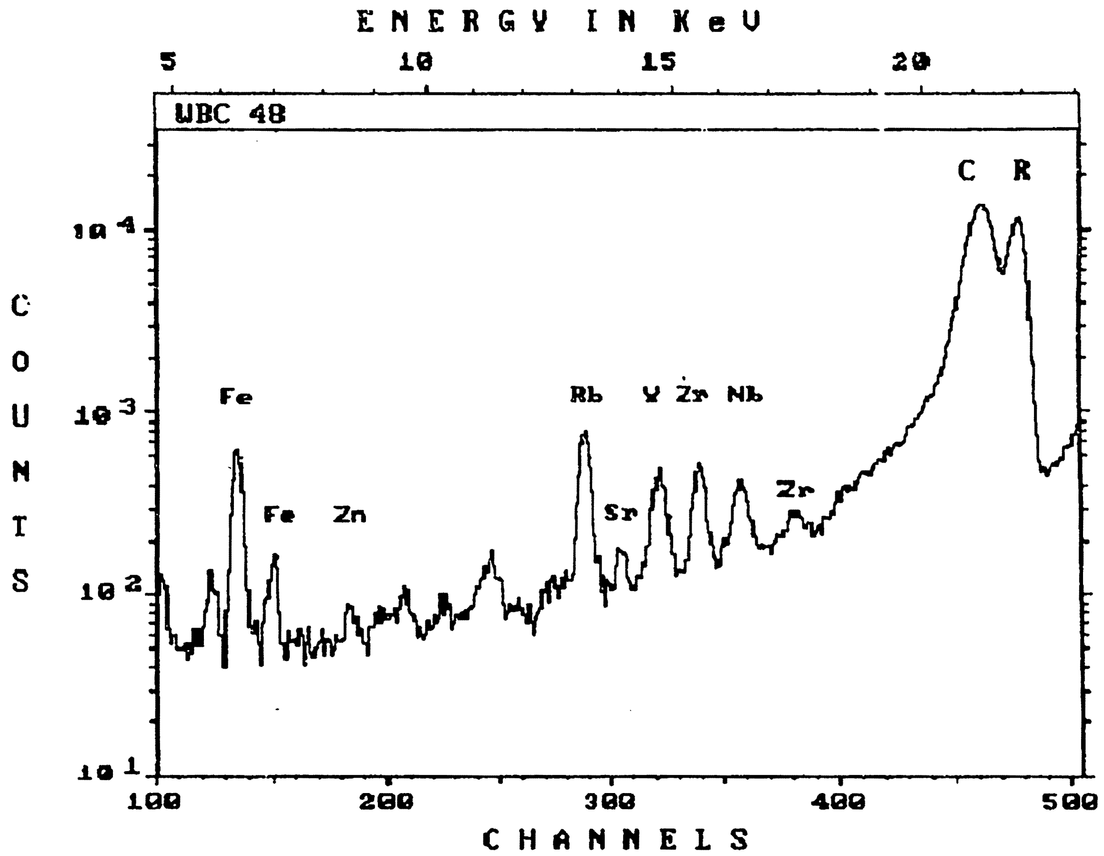
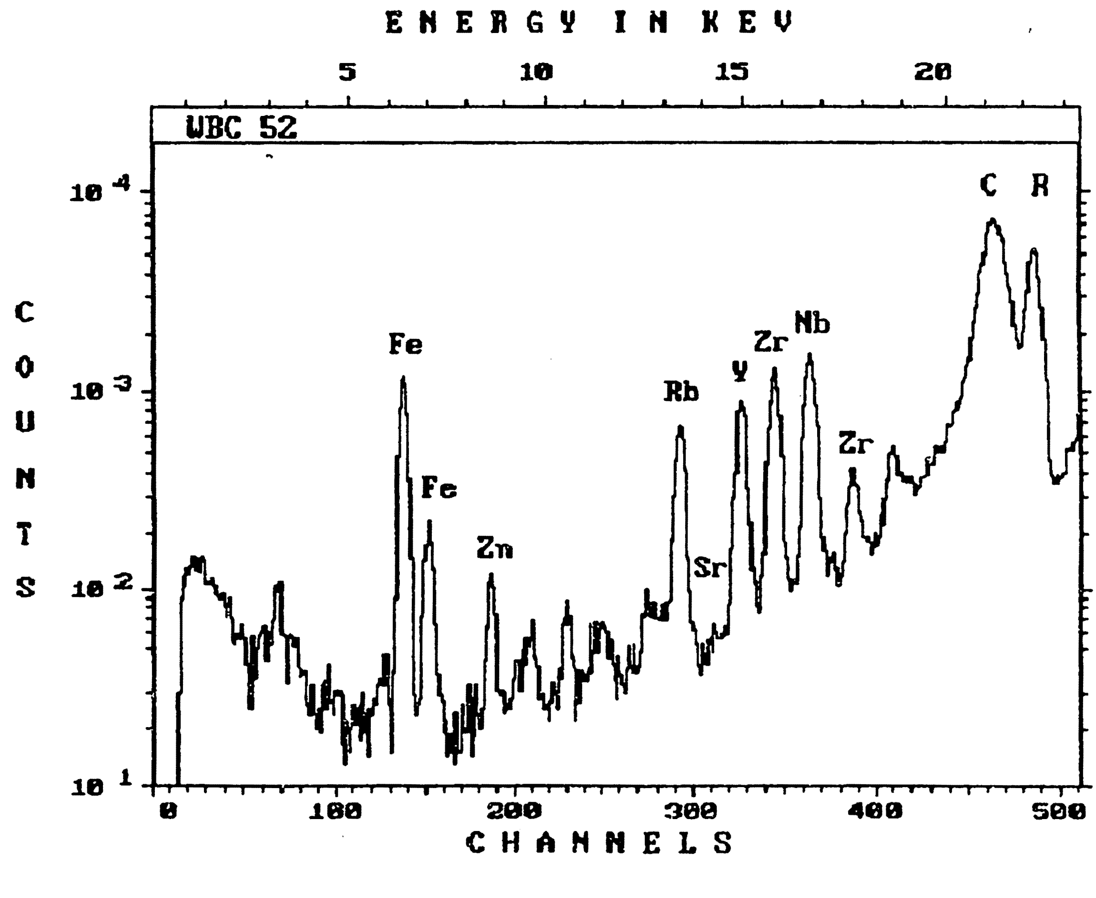
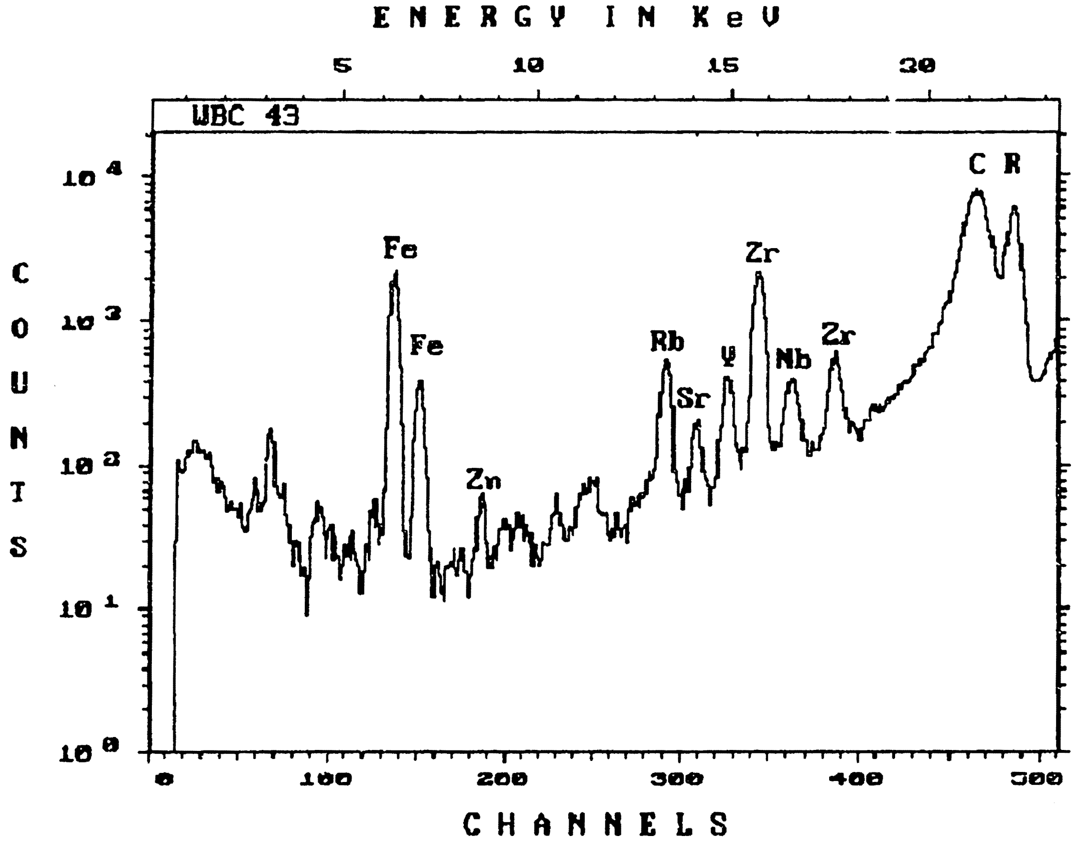
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 54
C
R
Zr
Fe
Rb
Y
Nb
Zr
Fe
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 55
C
R
Fe
Zr
Rb
Y
Nb
Zr
Fe
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
WBC 48
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS


ENERGY IN KEV
WBC 52
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 43
COUNTS
10^4
10^3
10^2
10^1
10^0
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
0
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200
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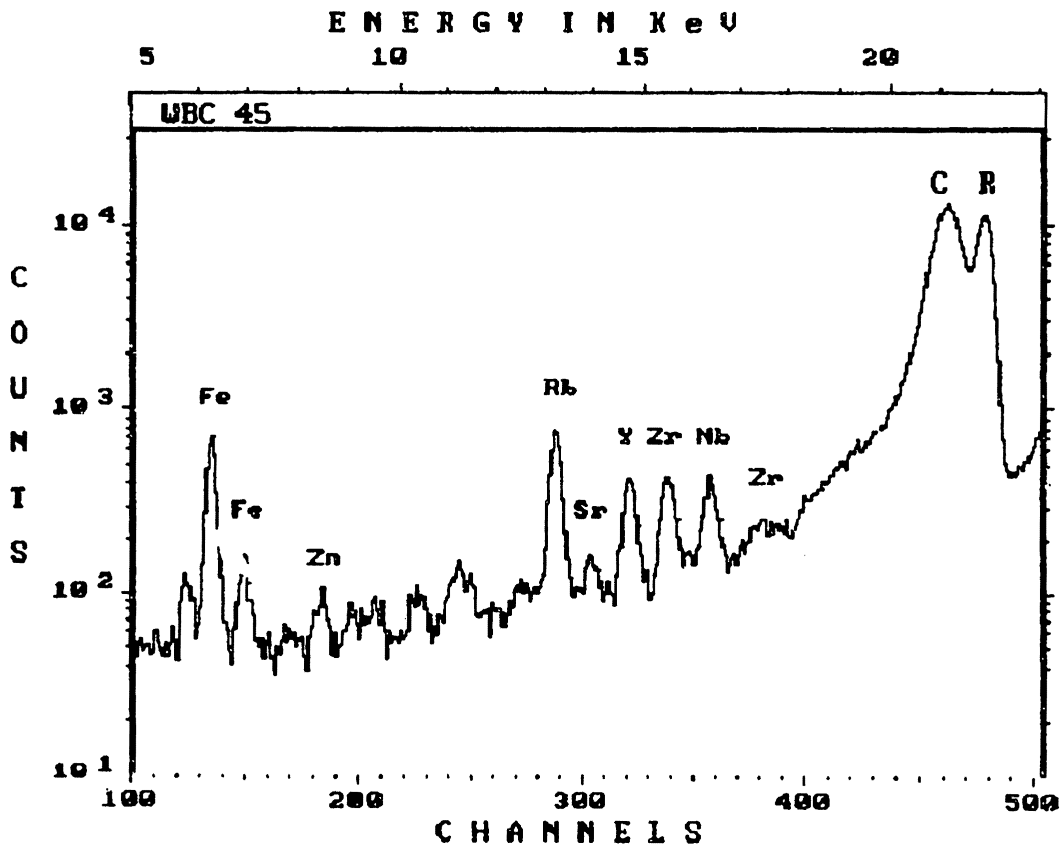
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 45
COUNTS
10^4
10^3
10^2
10^1
C R
Fe
Fe
Zn
Rb
Sr
Y Zr Nb
Zr
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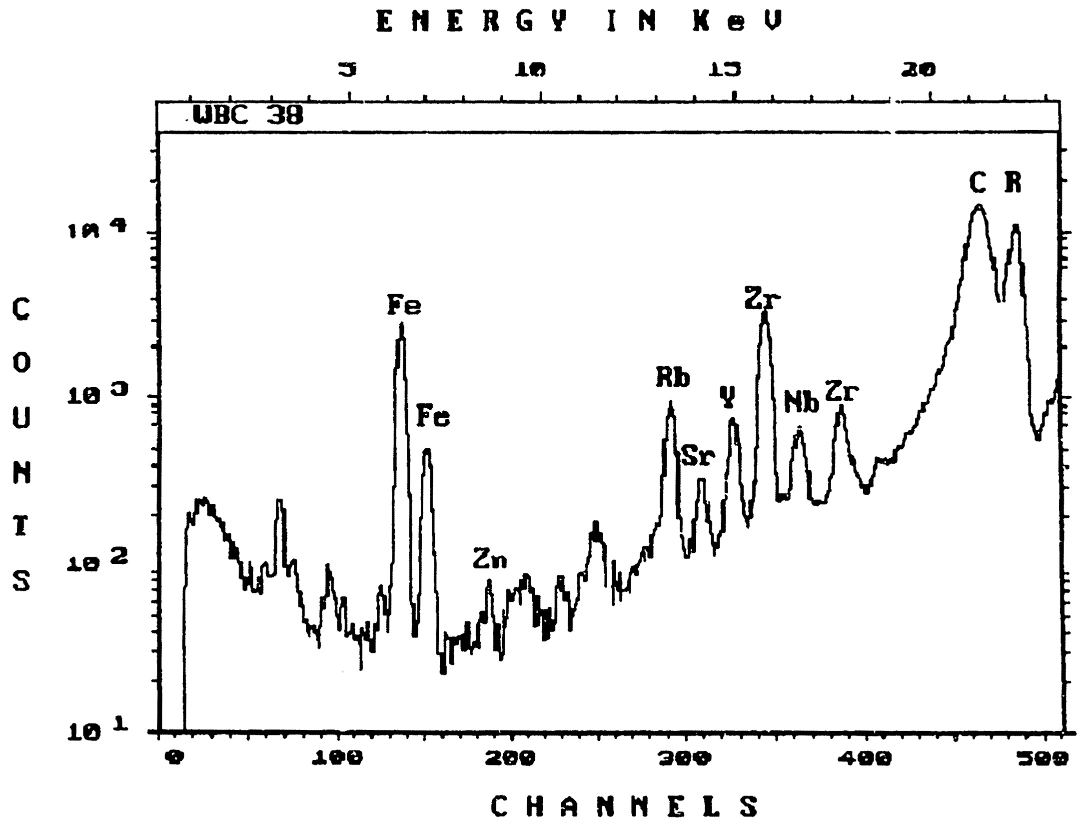
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 38
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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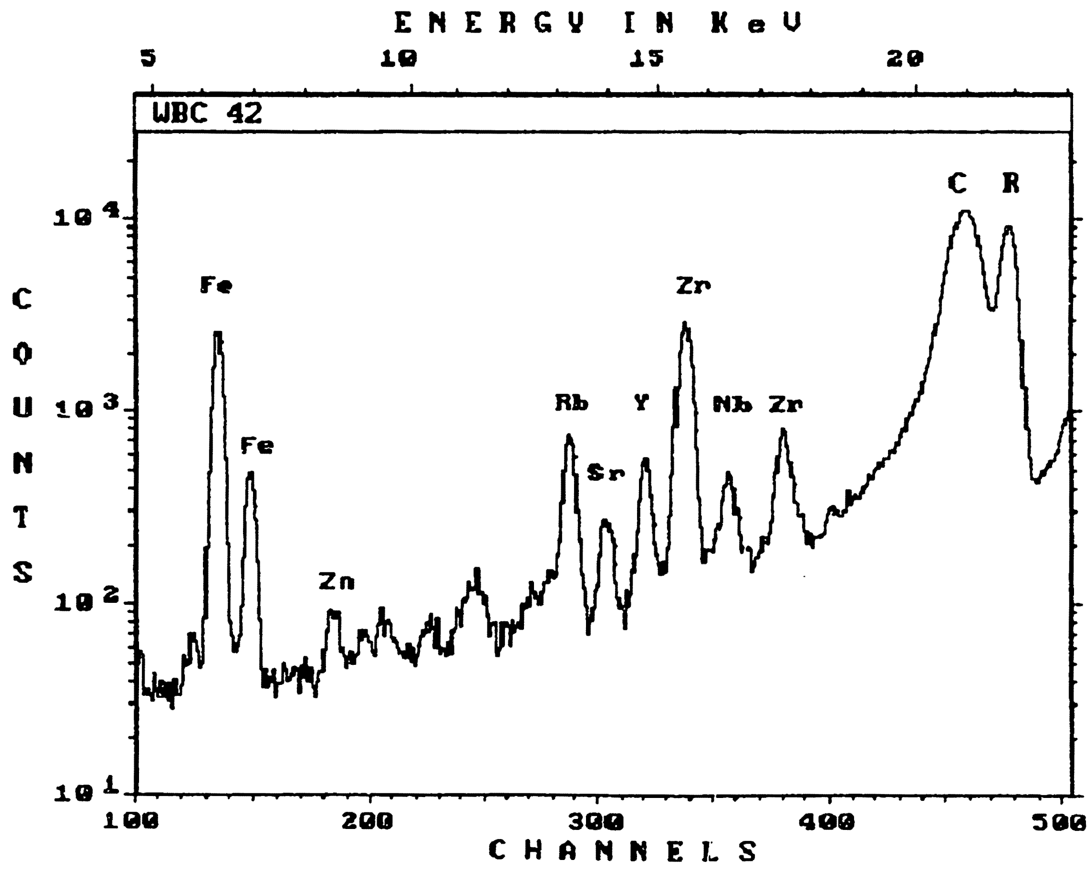
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 42
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10^3
10^2
10^1
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300
400
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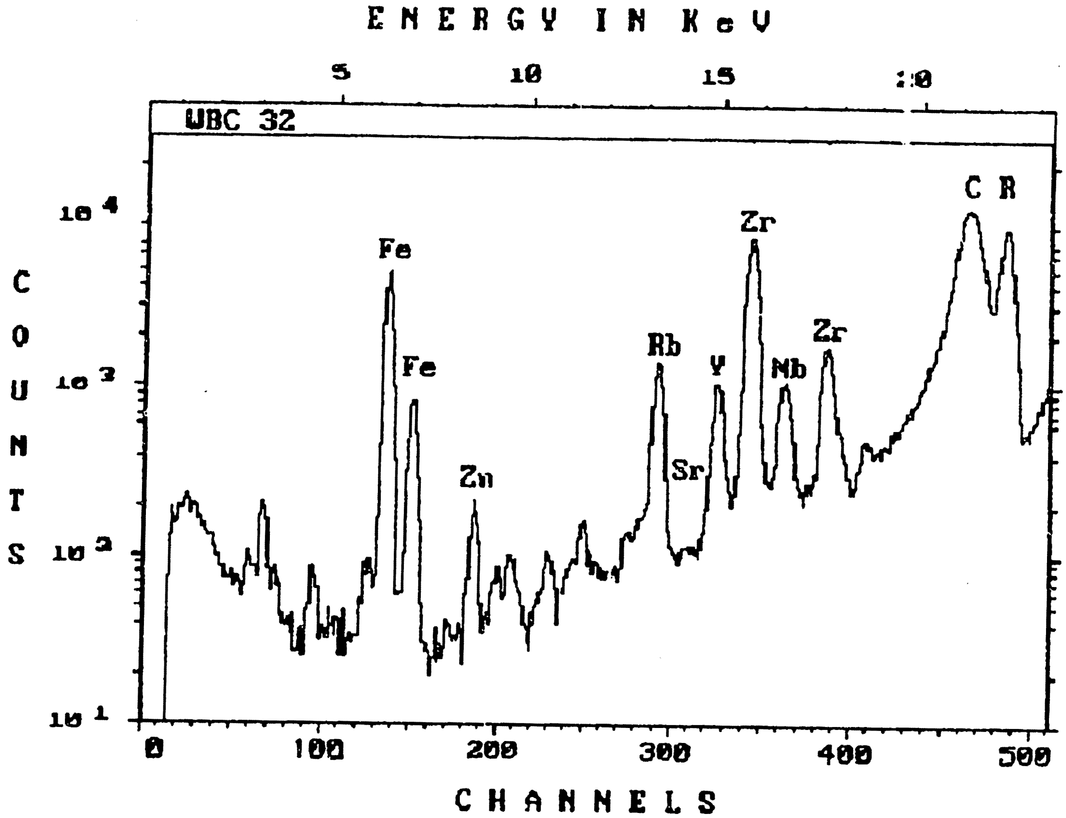
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 32
10^4
10^3
10^2
10^1
COUNTS
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Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C R
0
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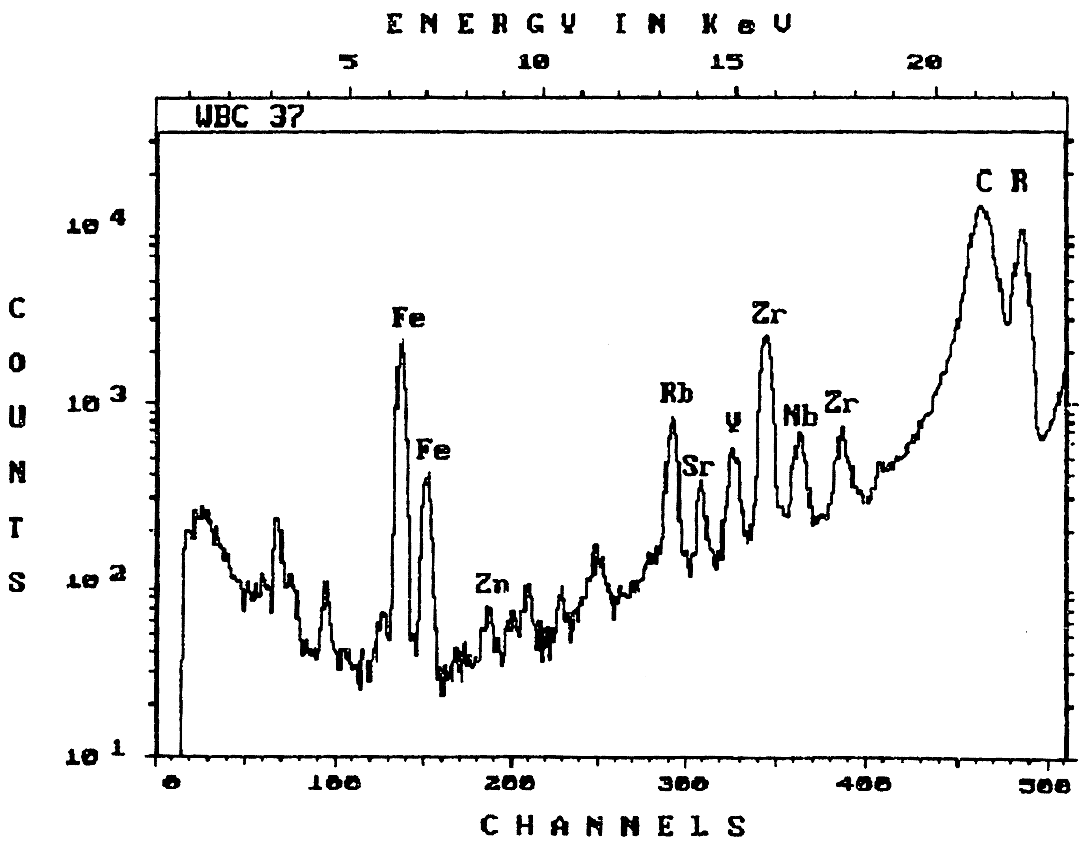
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 37
10^4
10^3
10^2
10^1
COUNTS
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Rb
Sr
Y
Zr
Nb
Zr
C R
0
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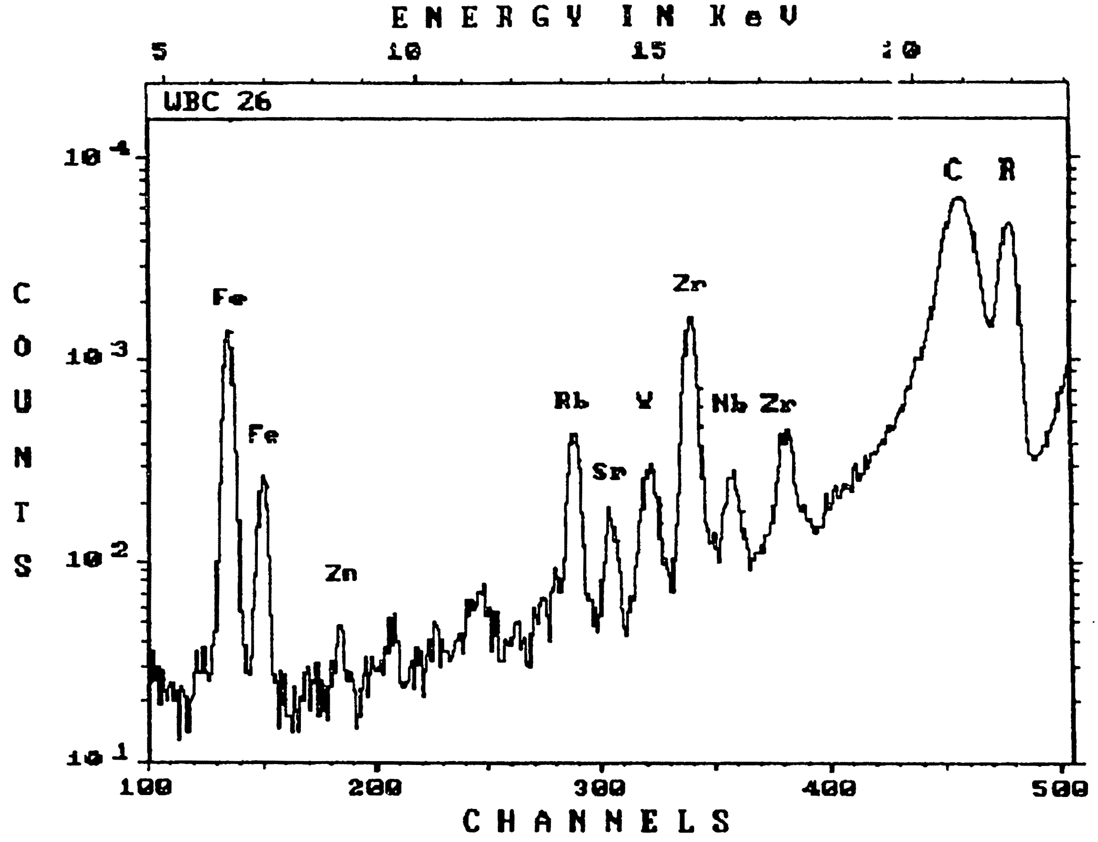
400
500
CHANNELS


ENERGY IN KeV
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10
15
20
WBC 26
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10^3
10^2
10^1
COUNTS
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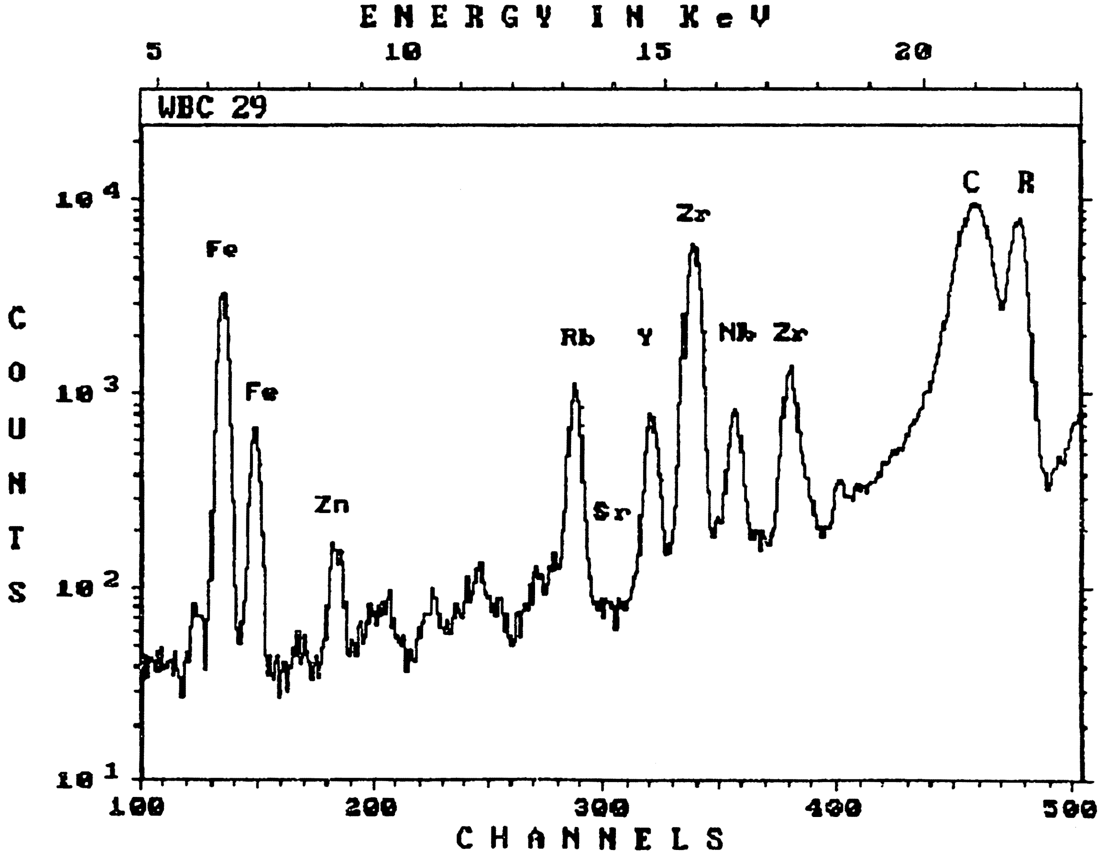
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 29
10^4
10^3
10^2
10^1
COUNTS
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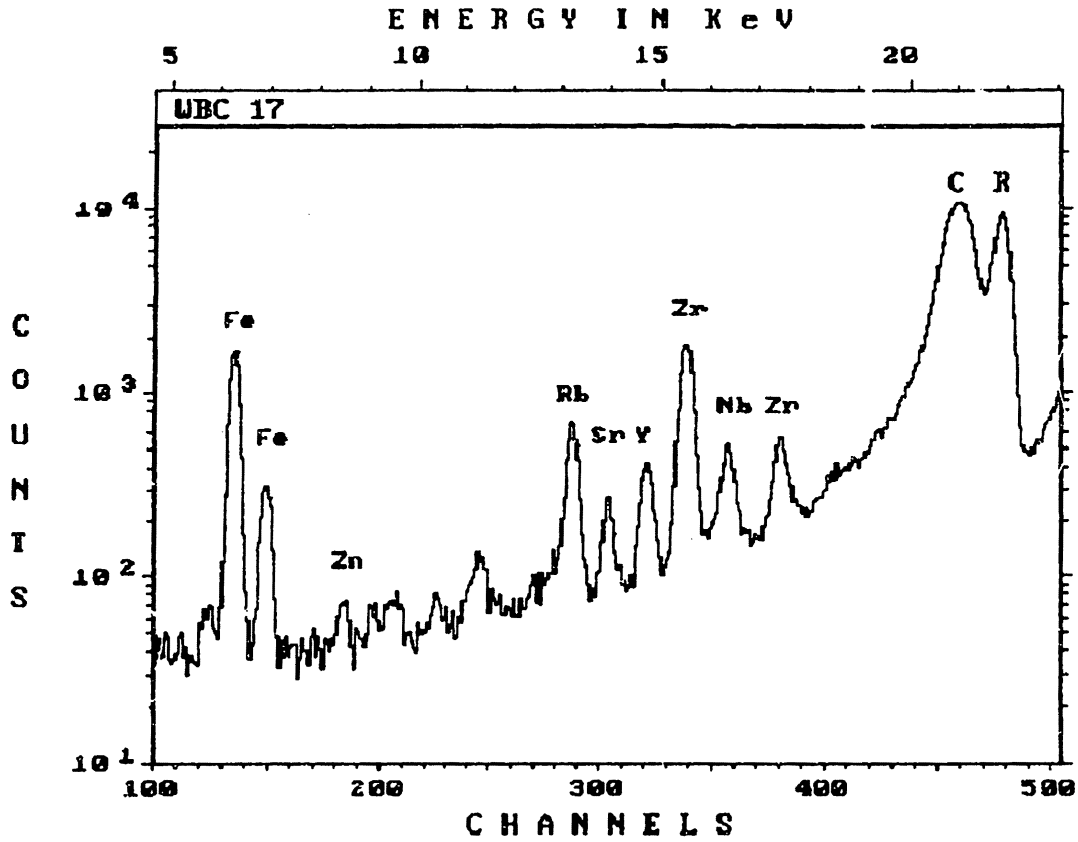
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 17
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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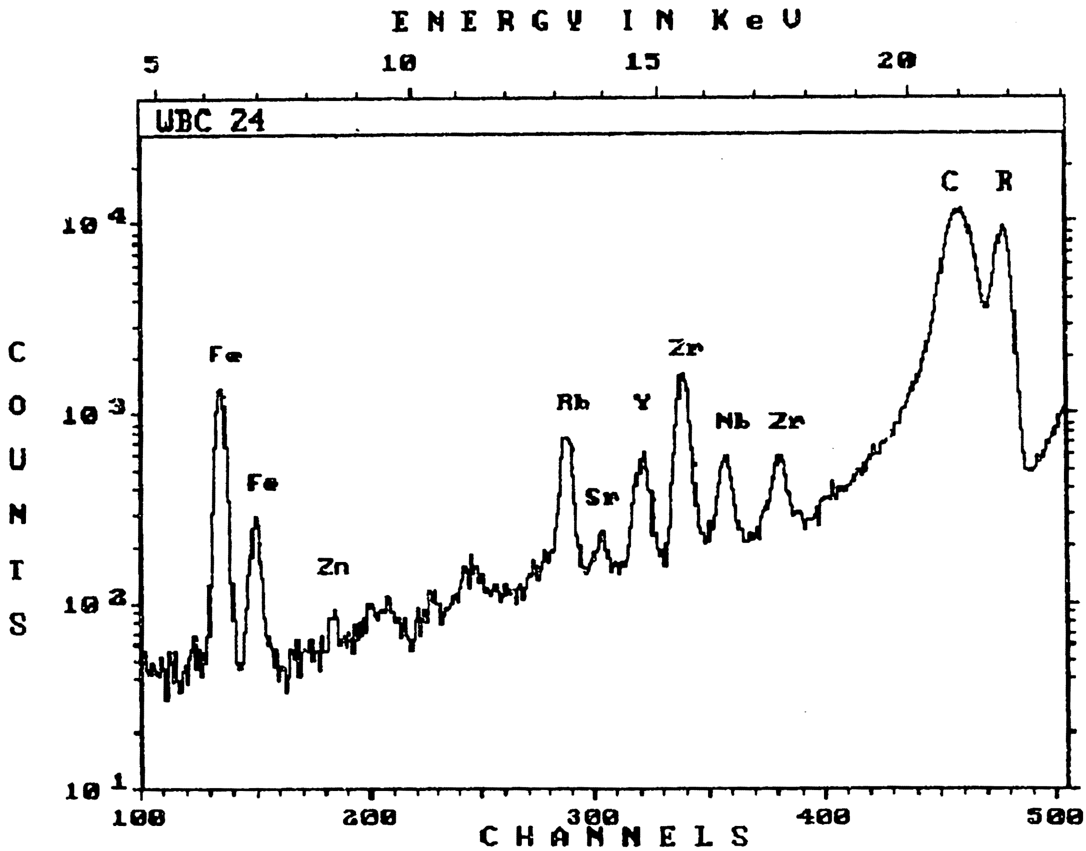
10 3
10 2
10 1
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 24
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
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200
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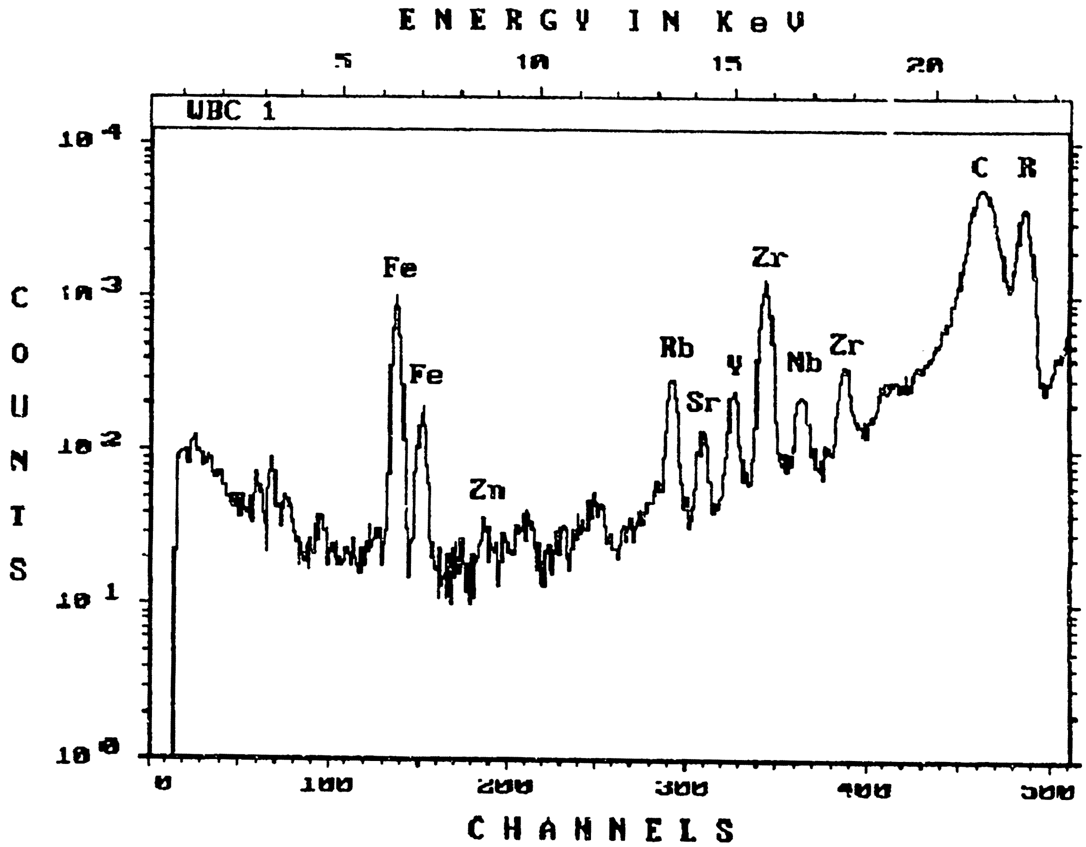
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1
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Fe
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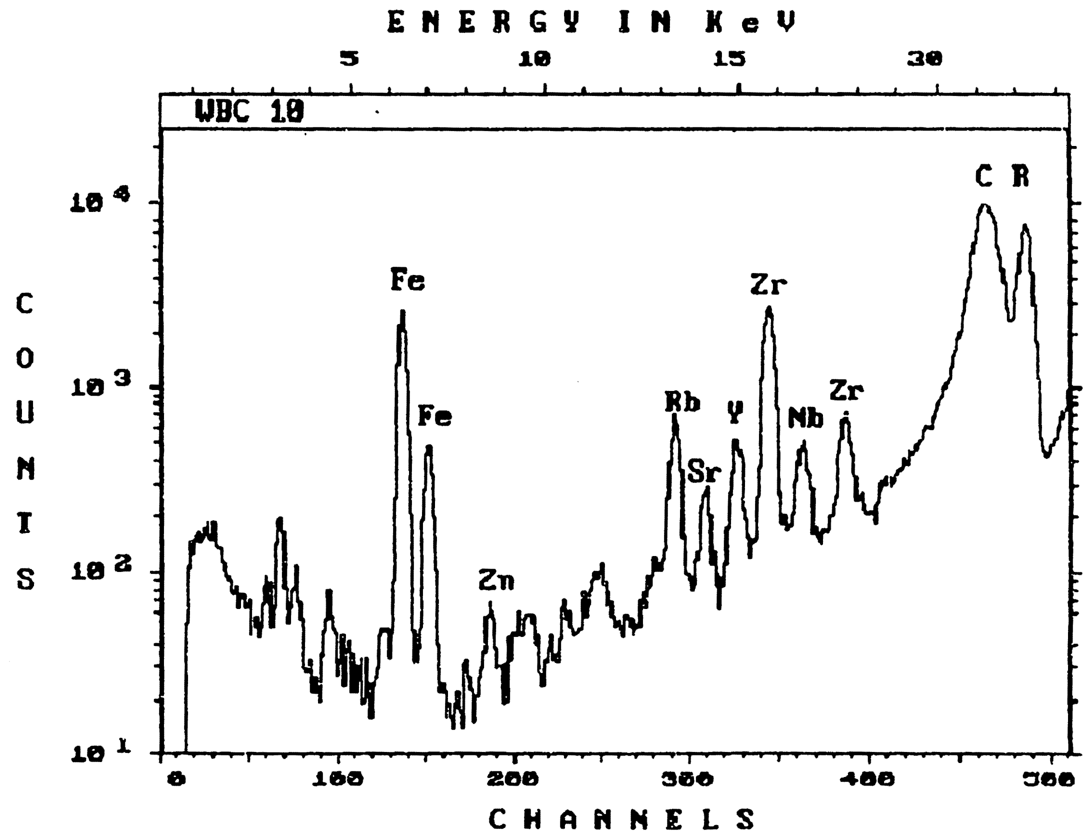
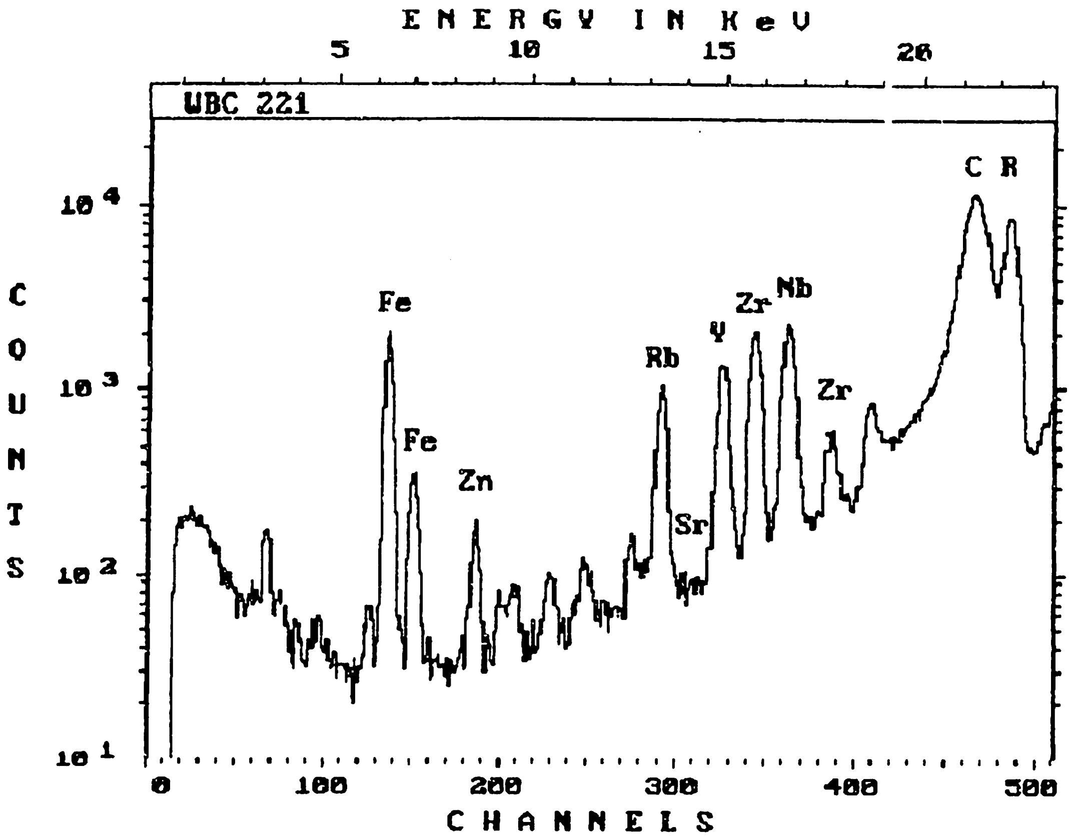
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
0
100
200
300
400
500


ENERGY IN KeV
5
10
15
20
WBC 10
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
0
100
200
300
400
500


ENERGY IN KeV
5
10
15
20
WBC 221
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
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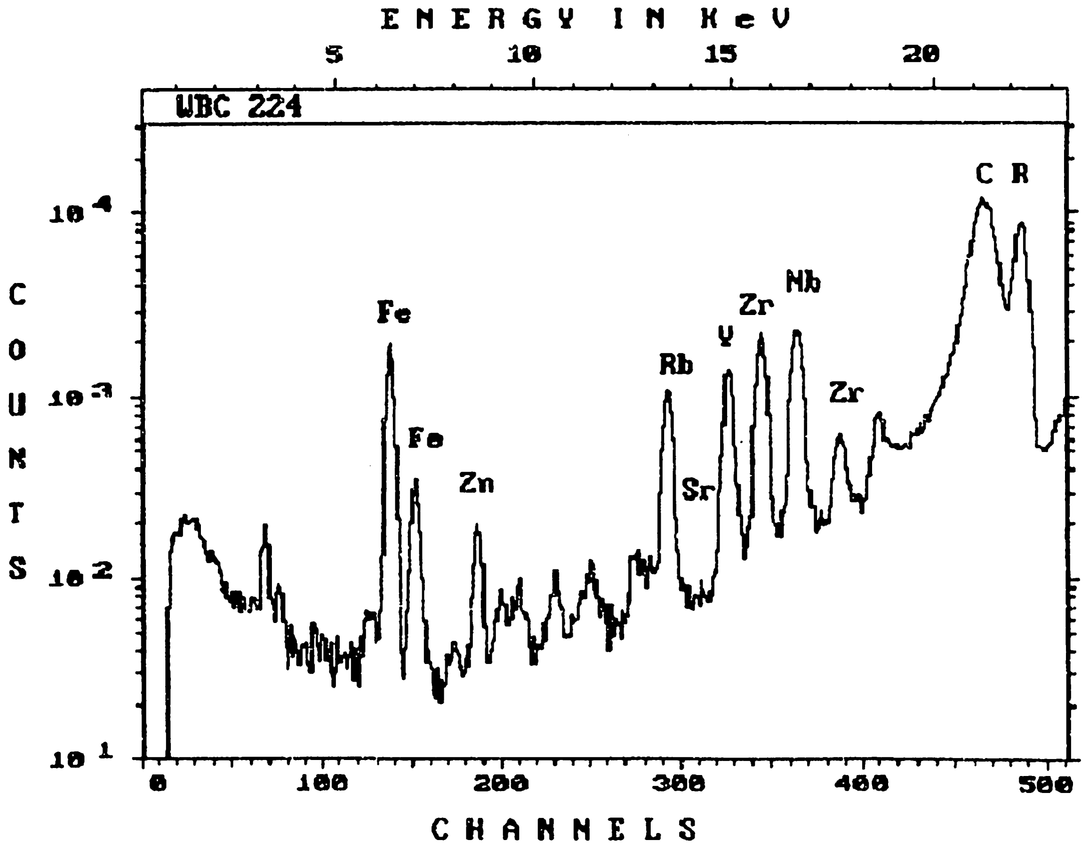
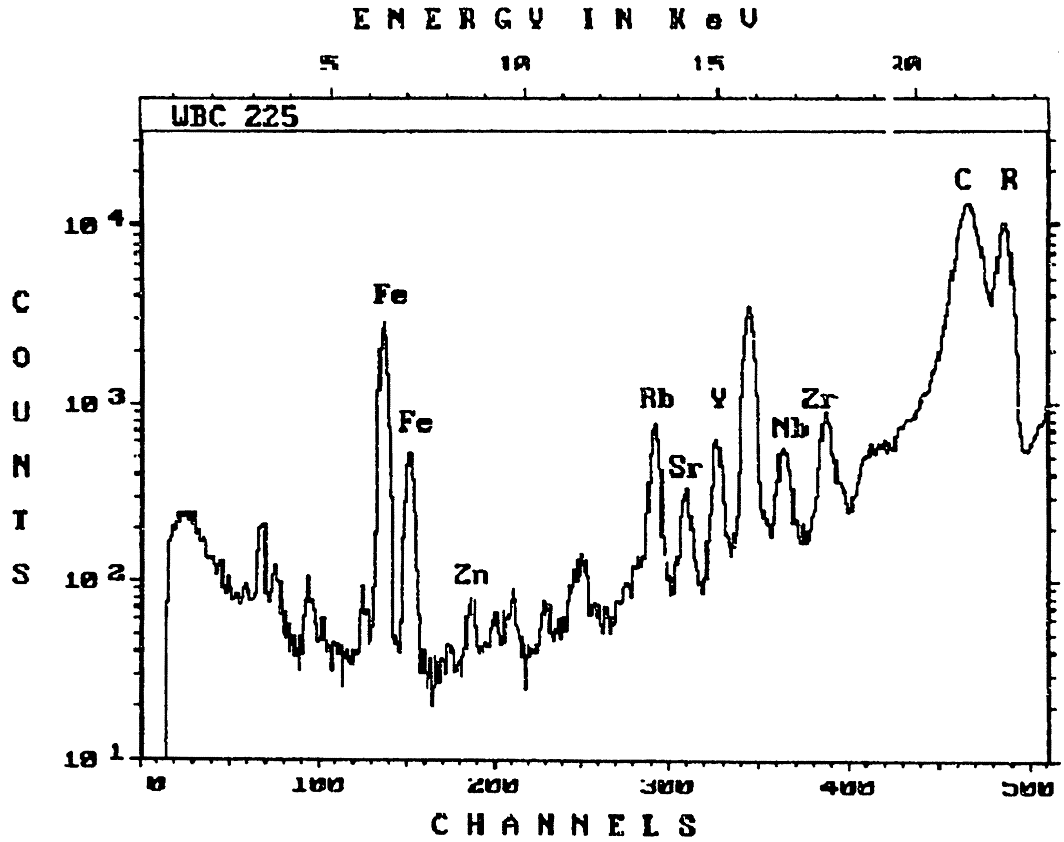
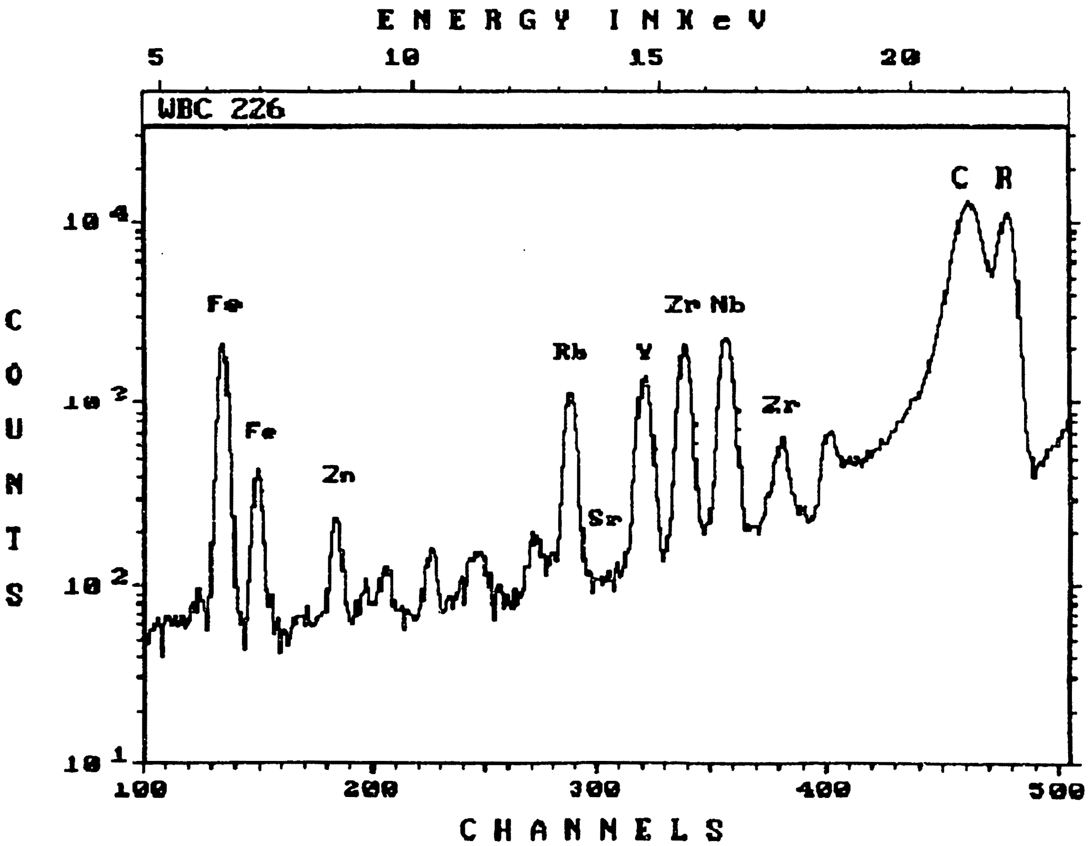
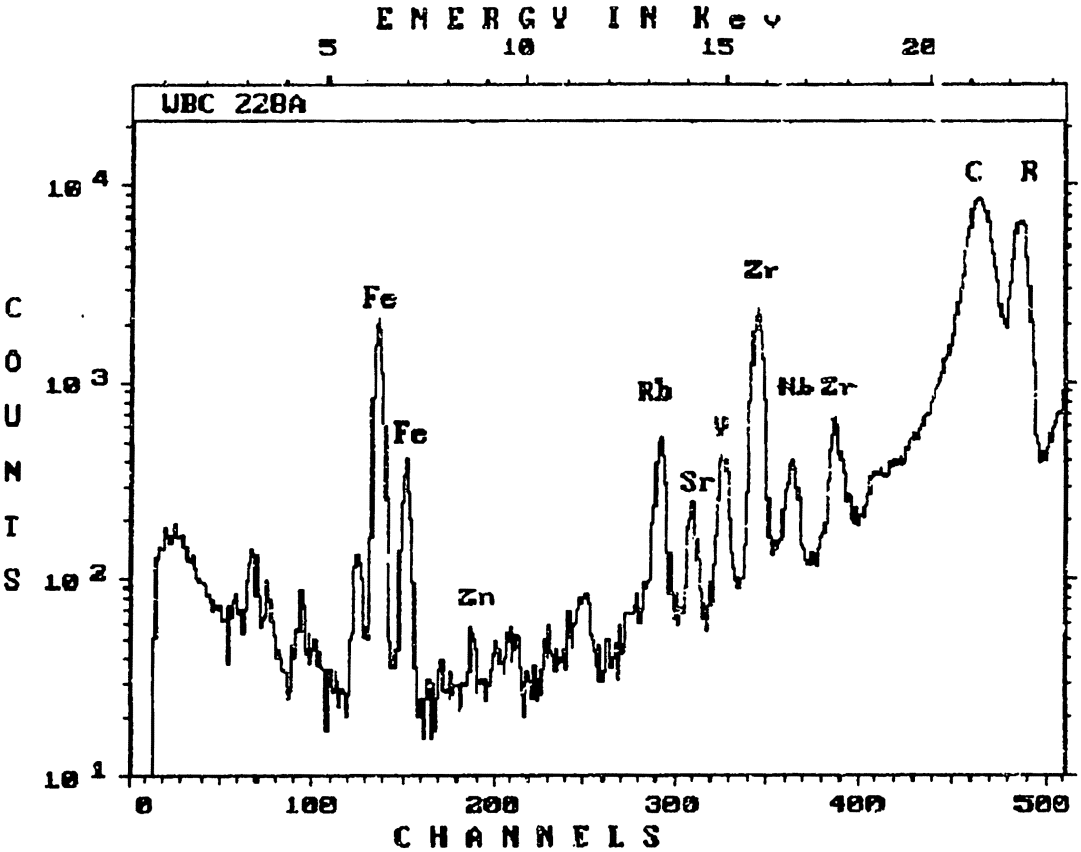
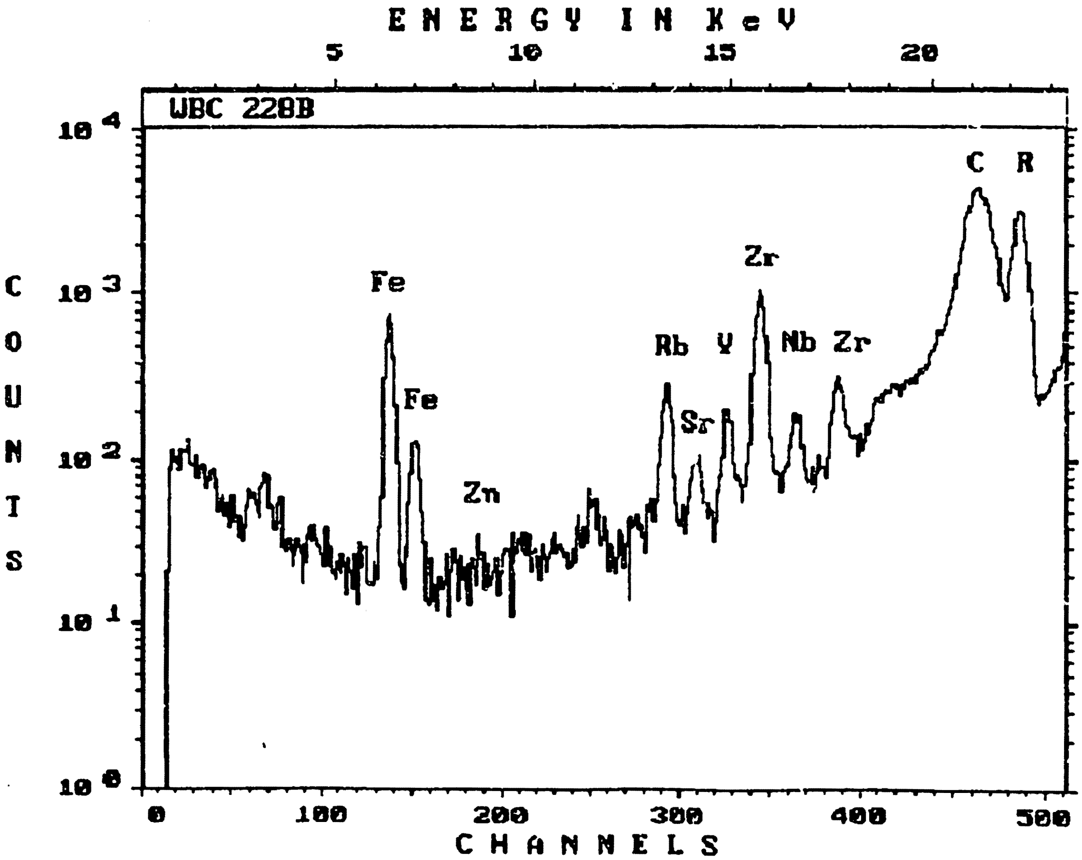
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 224
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 225
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
COUNTS
10 4
10 3
10 2
10 1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 226
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
100
200
300
400
500
CHANNELS


ENERGY IN Kev
5
10
15
20
WBC 228A
C
O
U
N
T
S
10^4
10^3
10^2
10^1
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 228B
C
O
U
N
T
S
10^4
10^3
10^2
10^1
10^0
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
0
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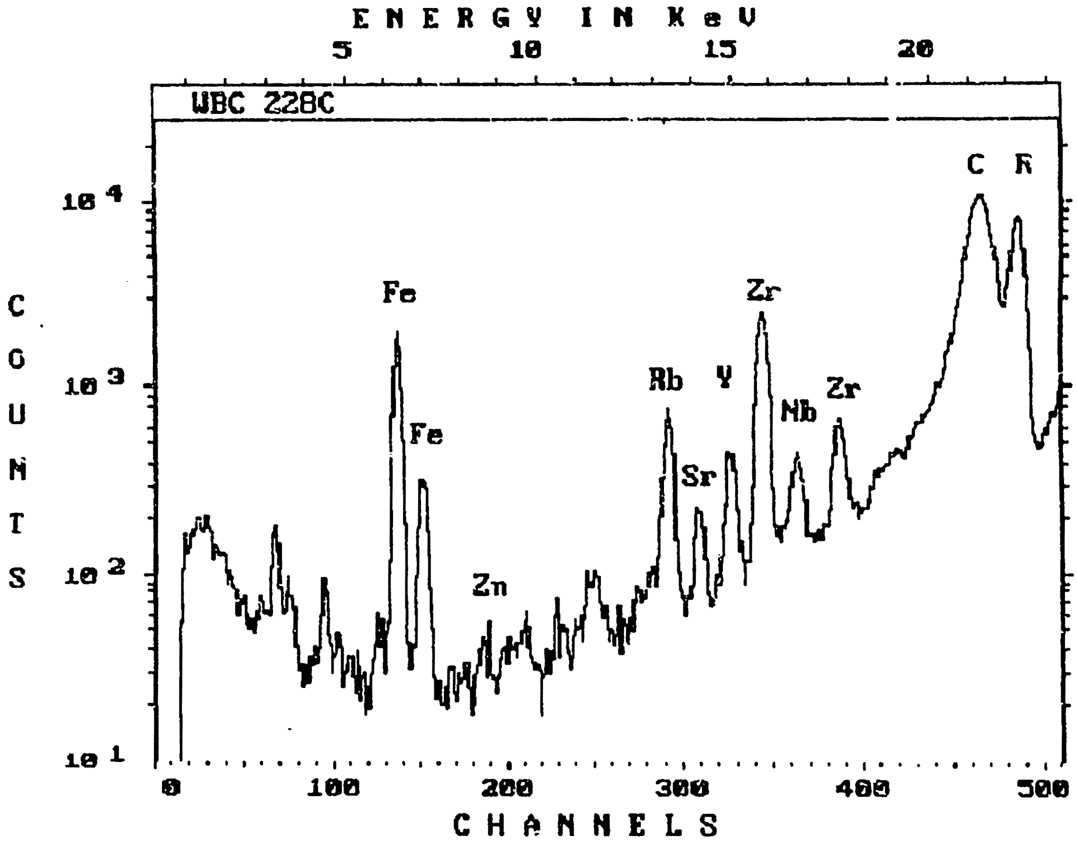
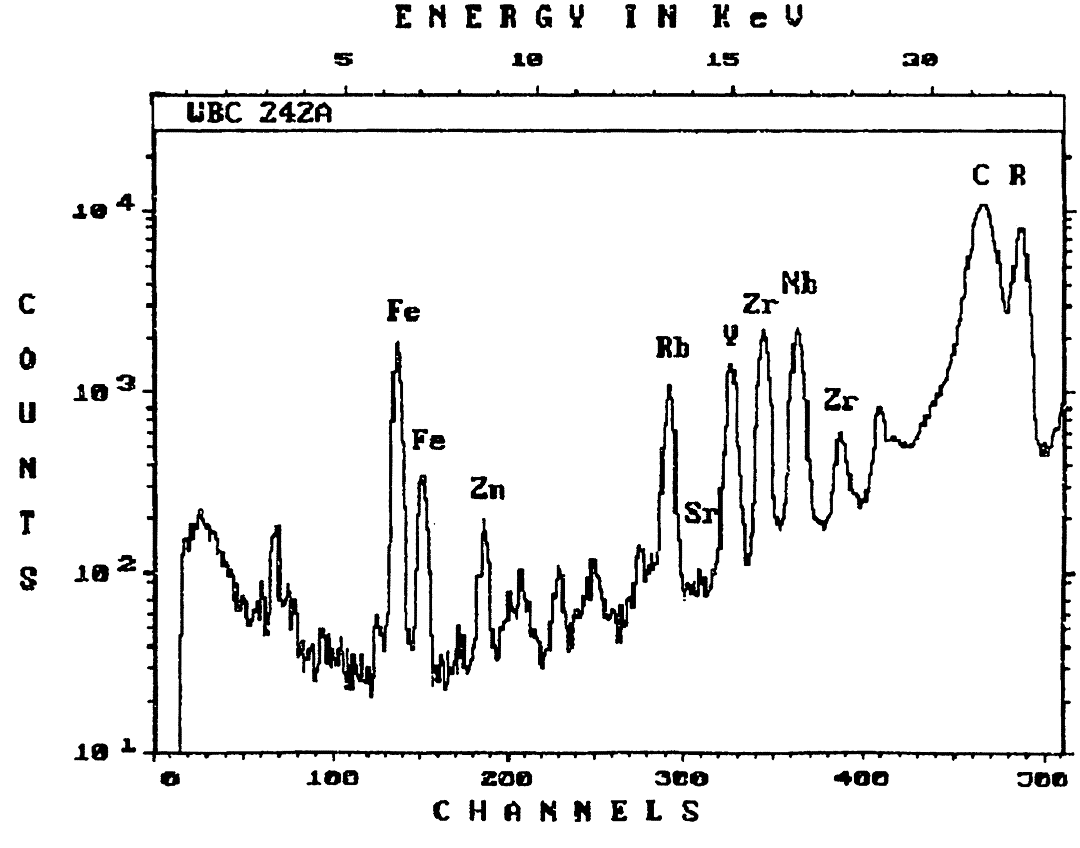
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 228C
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 242A
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
0
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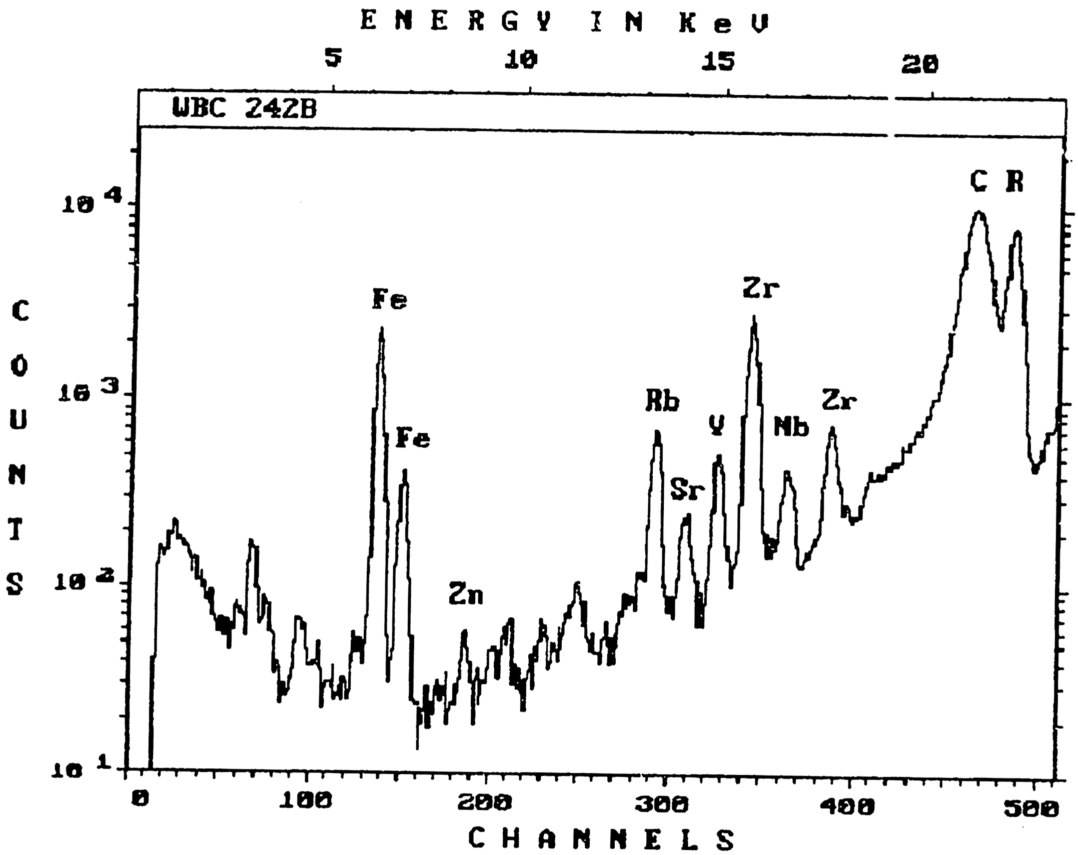
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 242B
C R
Fe
Fe
Zr
Rb
Y
Nb
Zr
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
0
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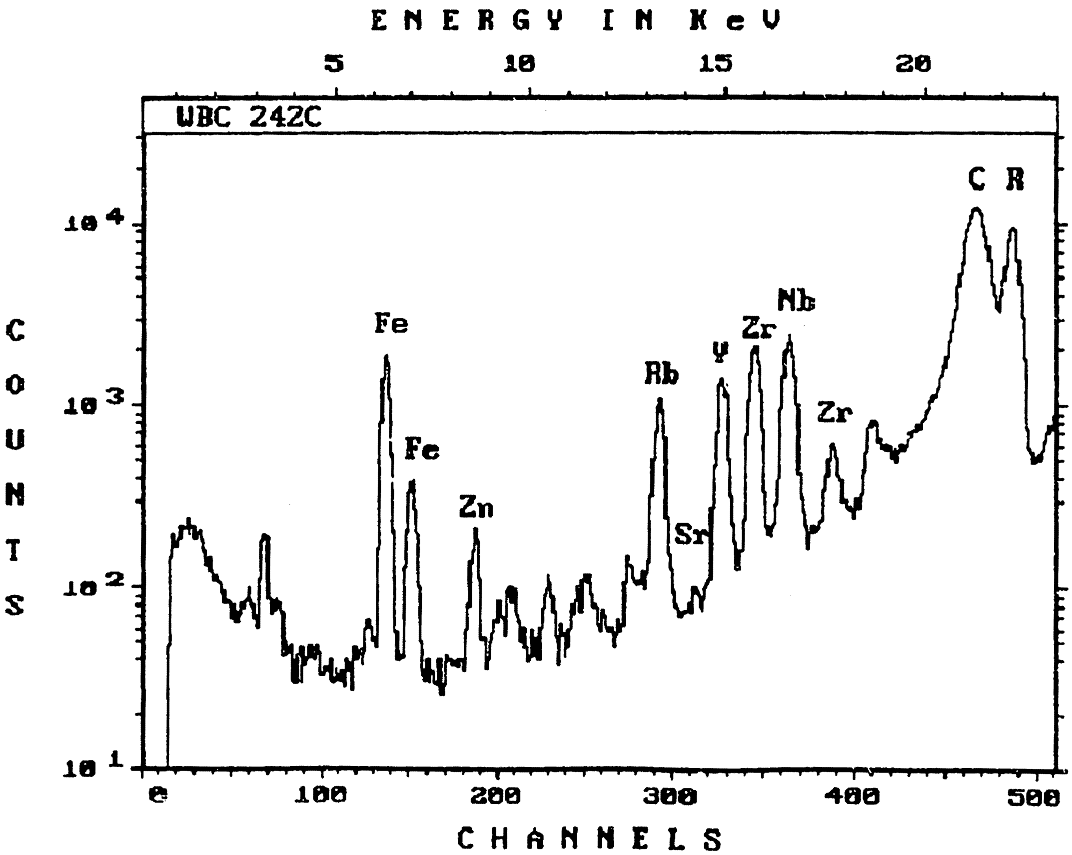
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 242C
C R
Nb
Fe
Zr
Y
Rb
Zr
Fe
Zn
Sr
COUNTS
10 4
10 3
10 2
10 1
0
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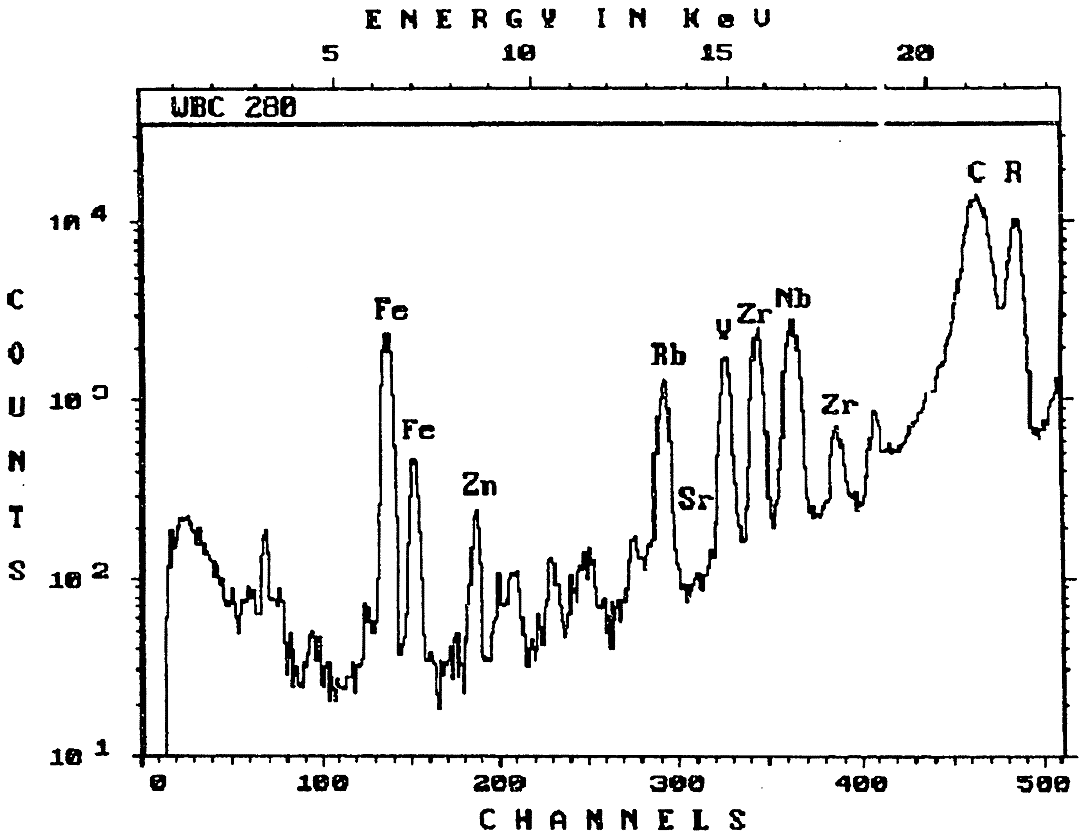
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 280
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
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200
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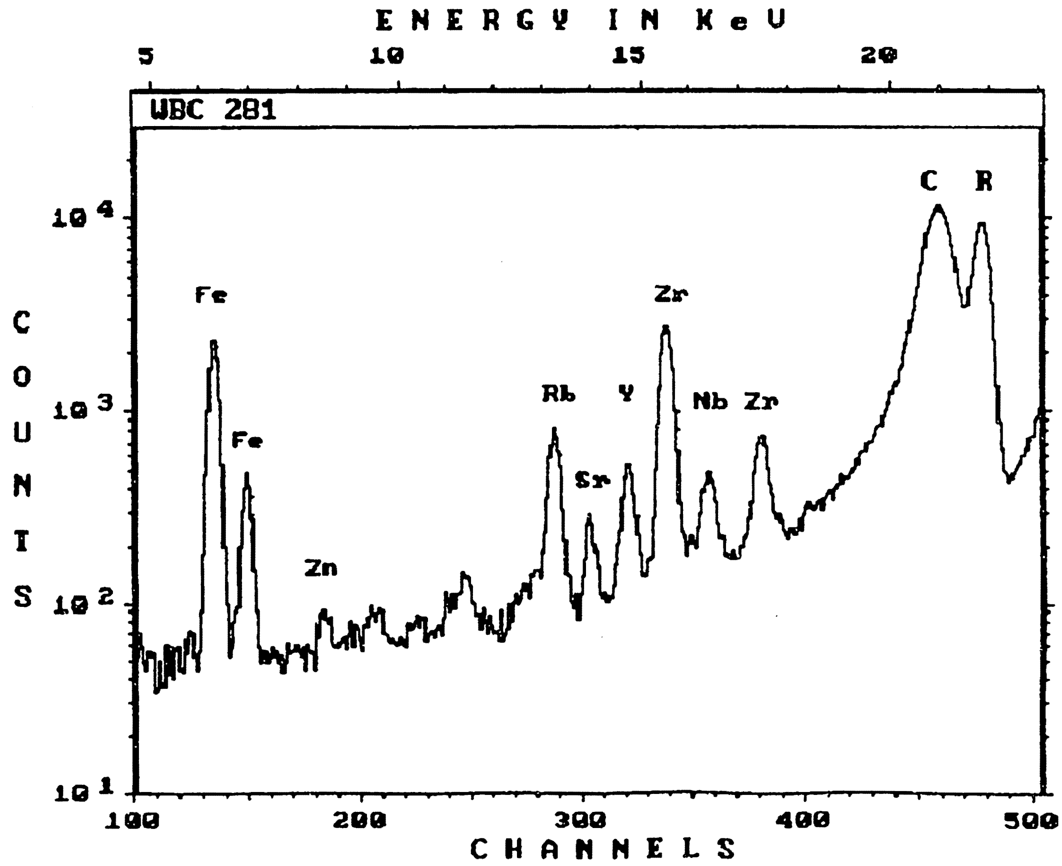
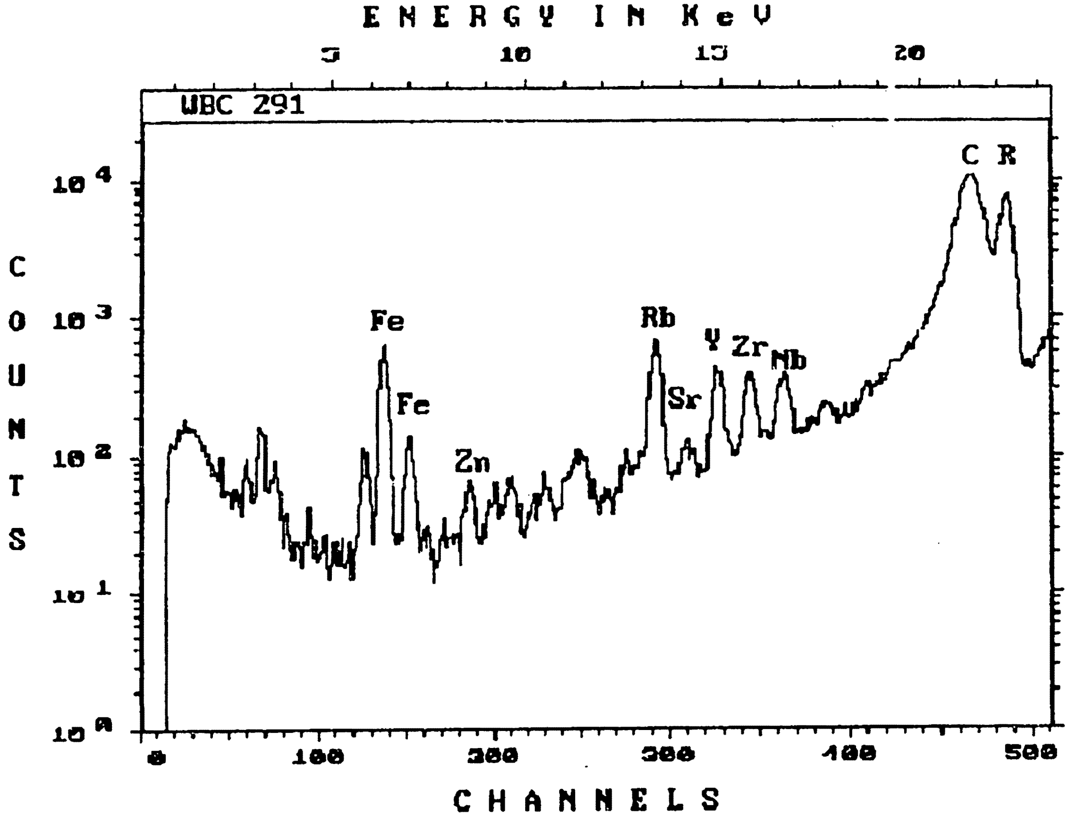
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 281
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 291
COUNTS
10 4
10 3
10 2
10 1
10 0
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
C
R
0
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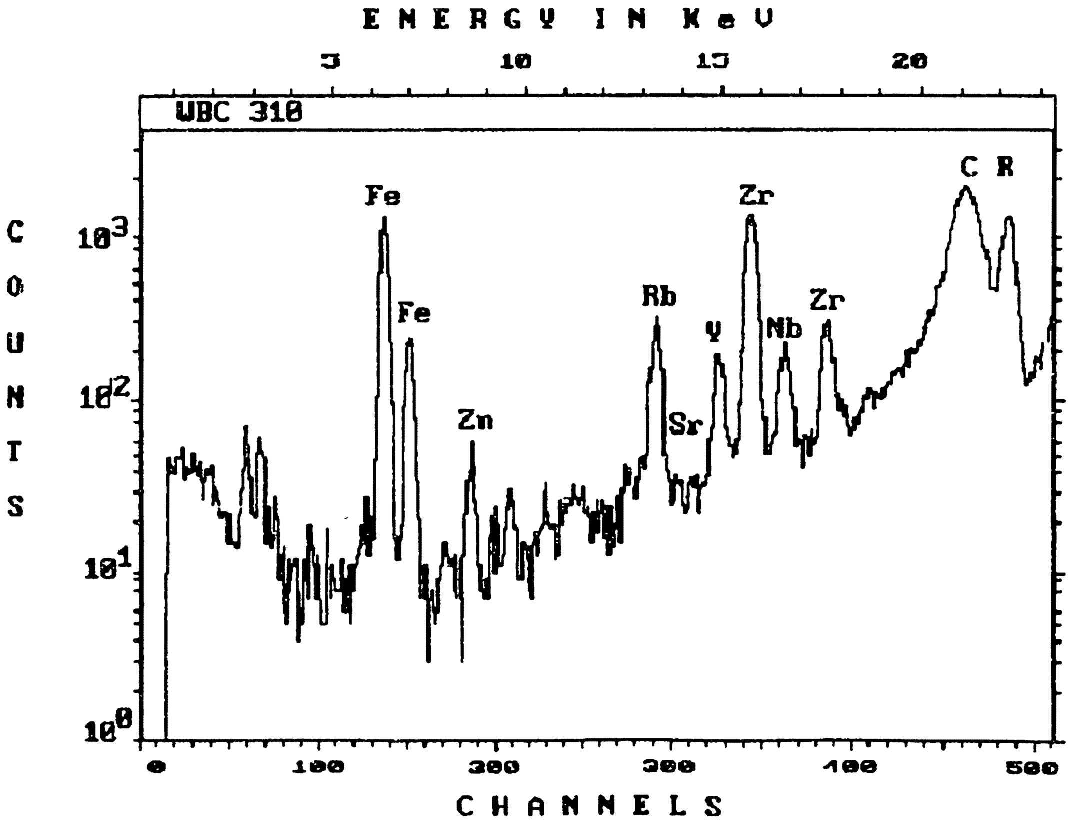
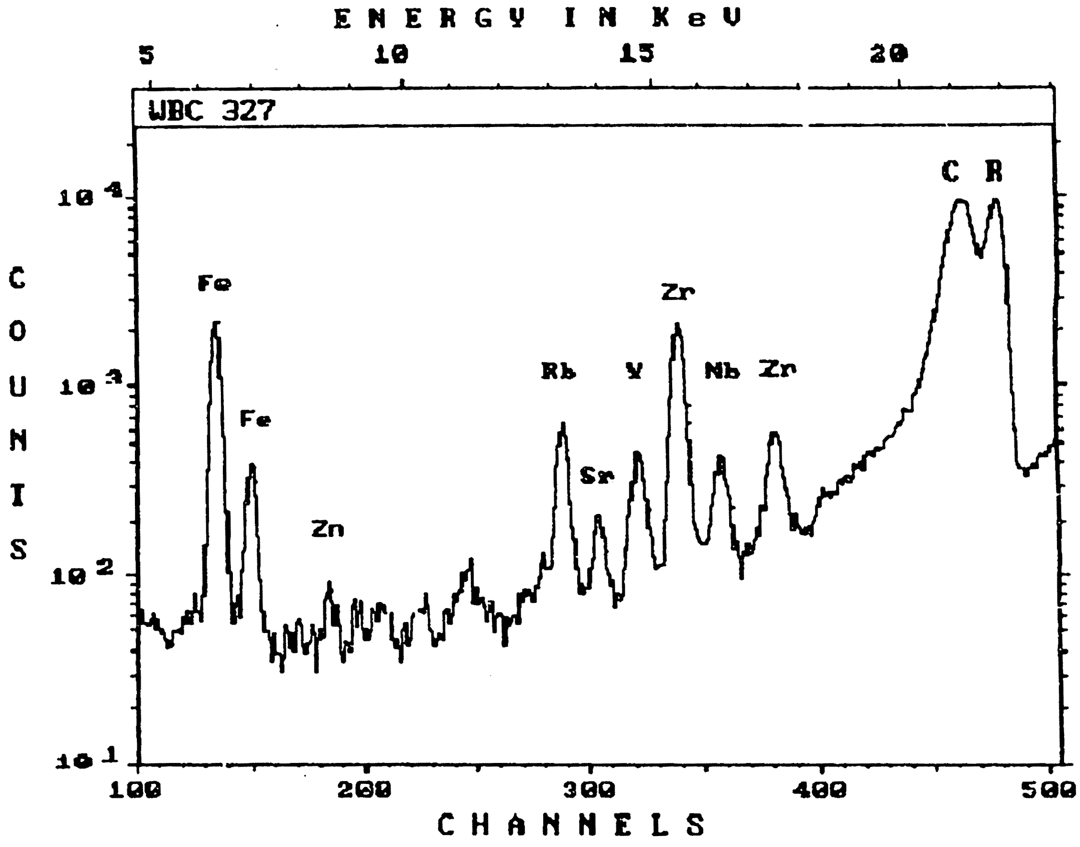
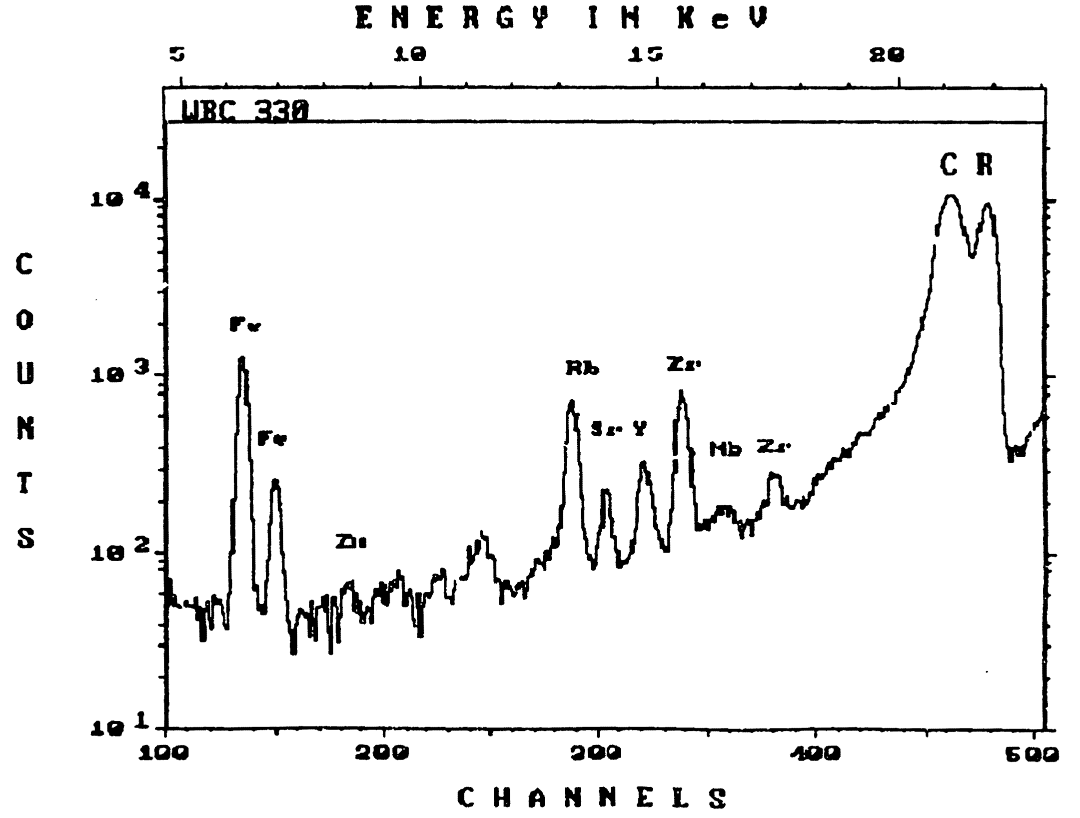
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 310
COUNTS
10³
10²
10¹
10⁰
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
R
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 327
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
100
200
300
400
500


ENERGY IN KeV
5
10
15
20
WBC 330
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Fe
Fe
Rb
Sr Y
Zr
Nb
Zr
COUNTS
CHANNELS
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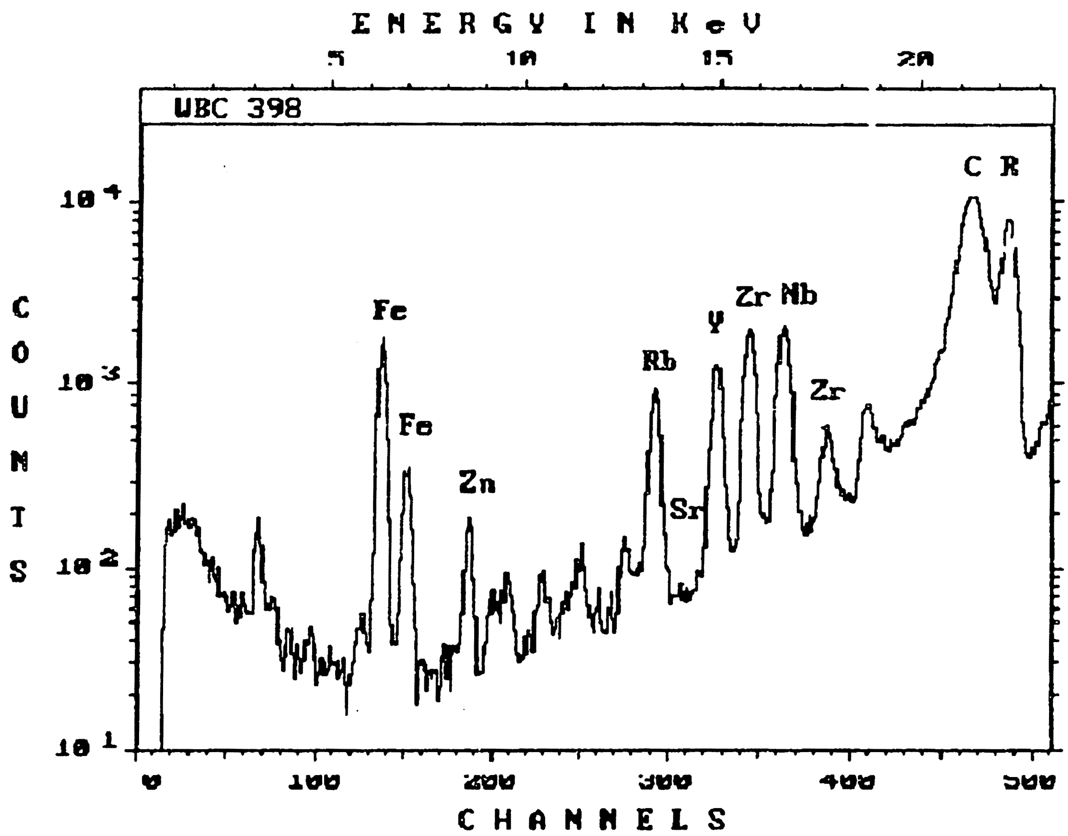
300
400
500


ENERGY IN KeV
5
10
15
20
UBC 398
10 4
10 3
10 2
10 1
COUNTS
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
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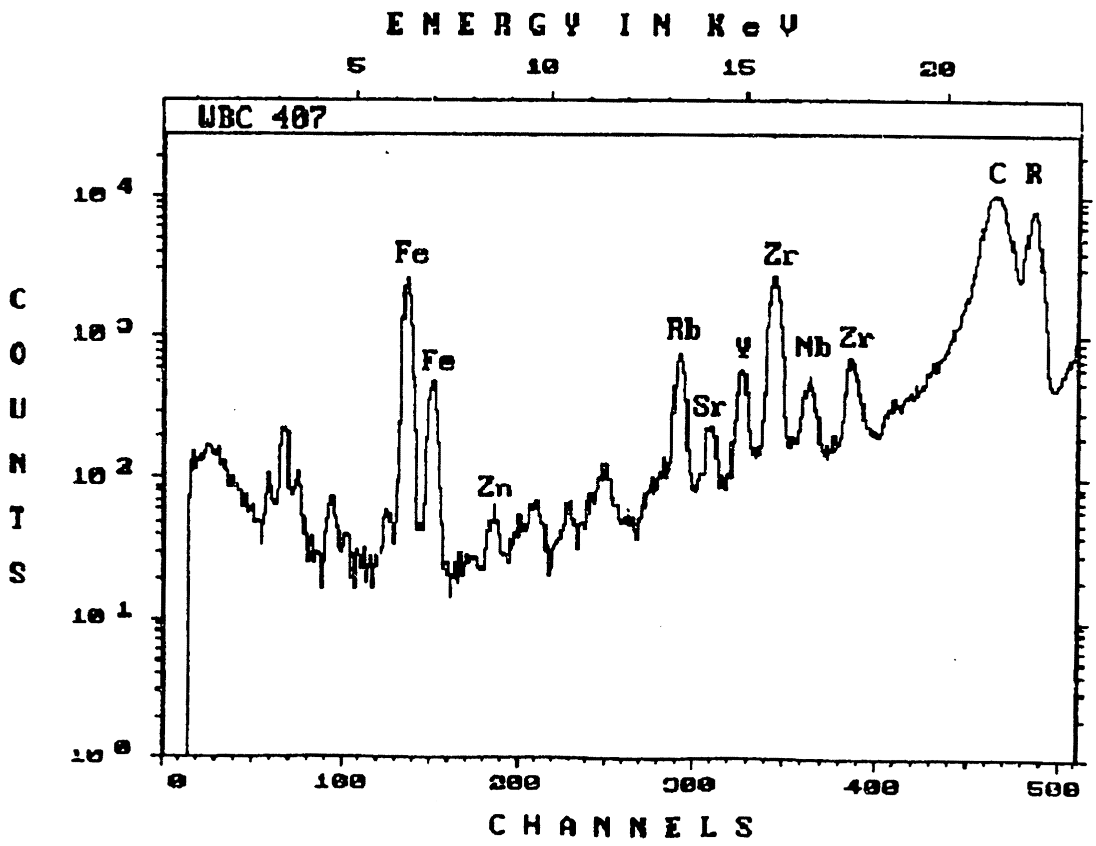
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 407
10 4
10 3
10 2
10 1
10 0
COUNTS
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
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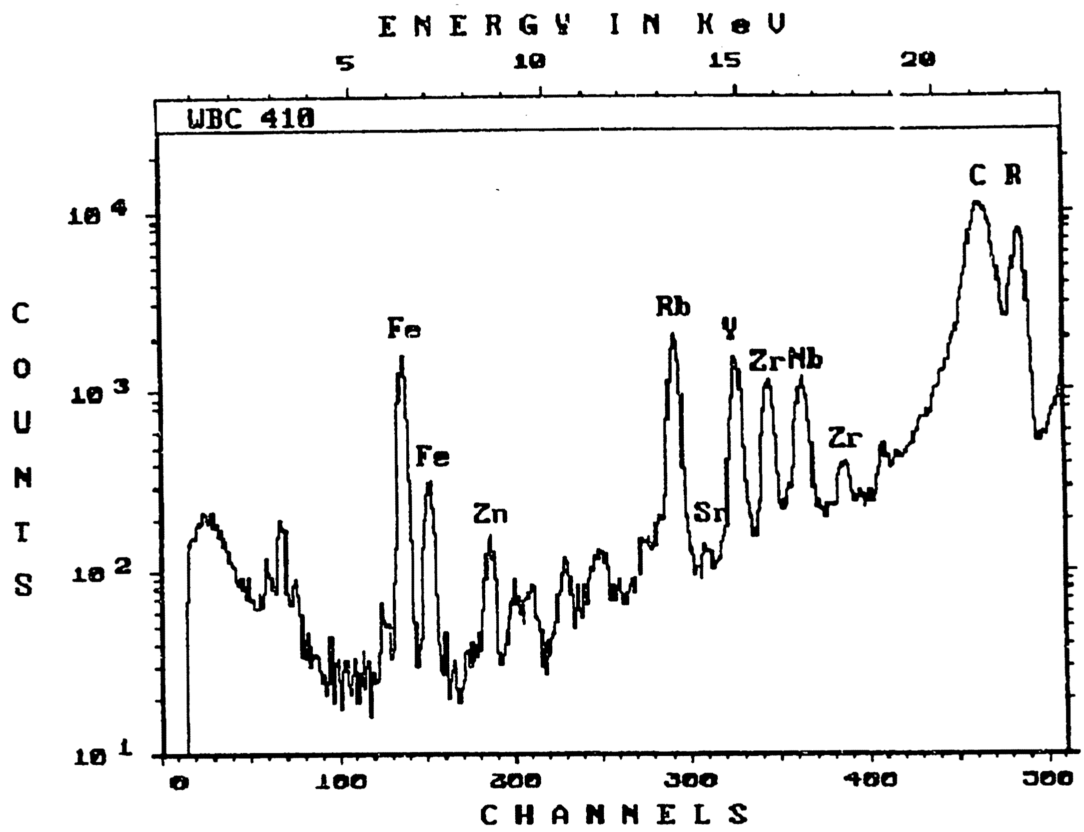
200
300
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 410
C R
Rb
Y
Fe
Zr
Nb
Fe
Zr
Zn
Sr
COUNTS
10 4
10 3
10 2
10 1
0
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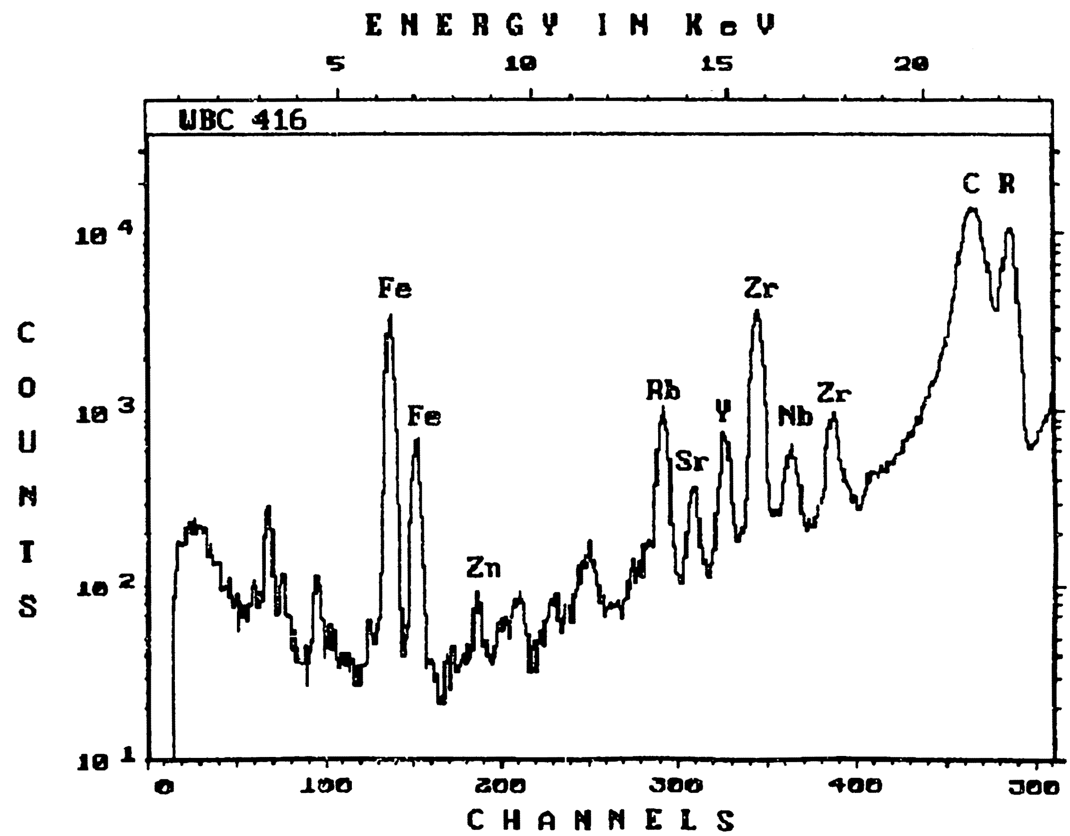
300
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 416
C R
Fe
Zr
Rb
Y
Nb
Zr
Fe
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
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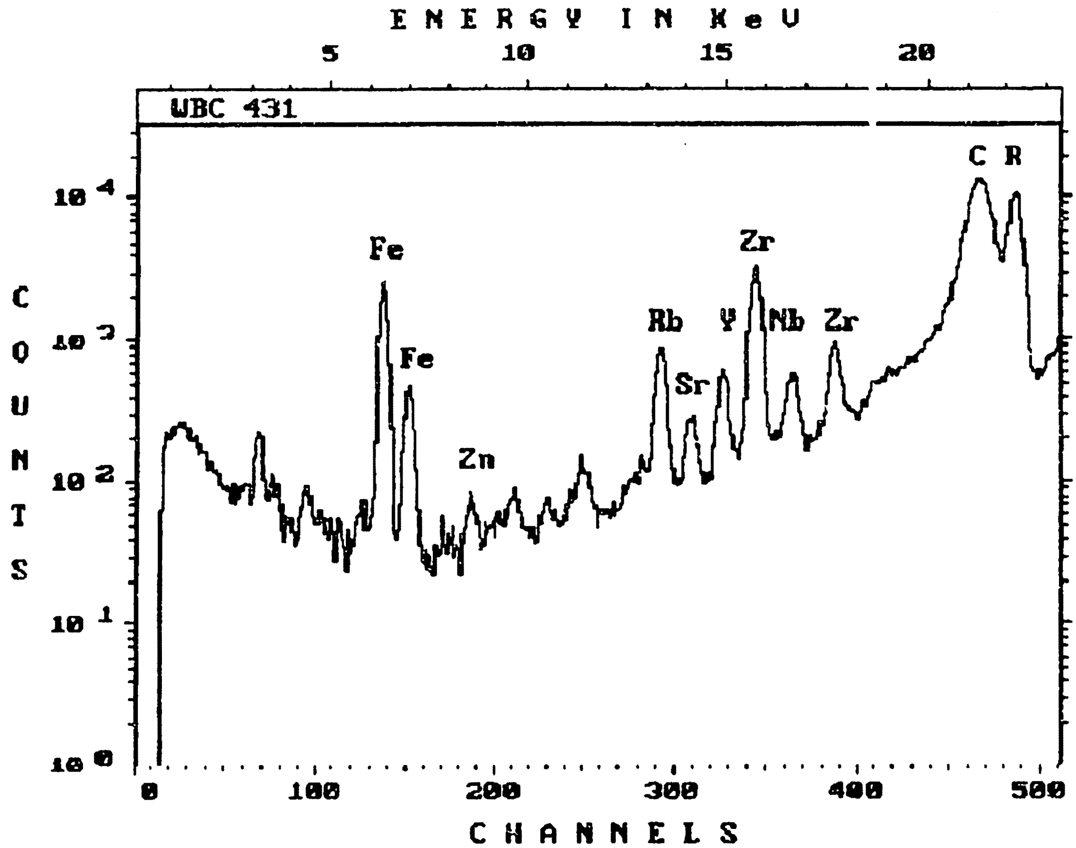
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 431
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
10 0
0
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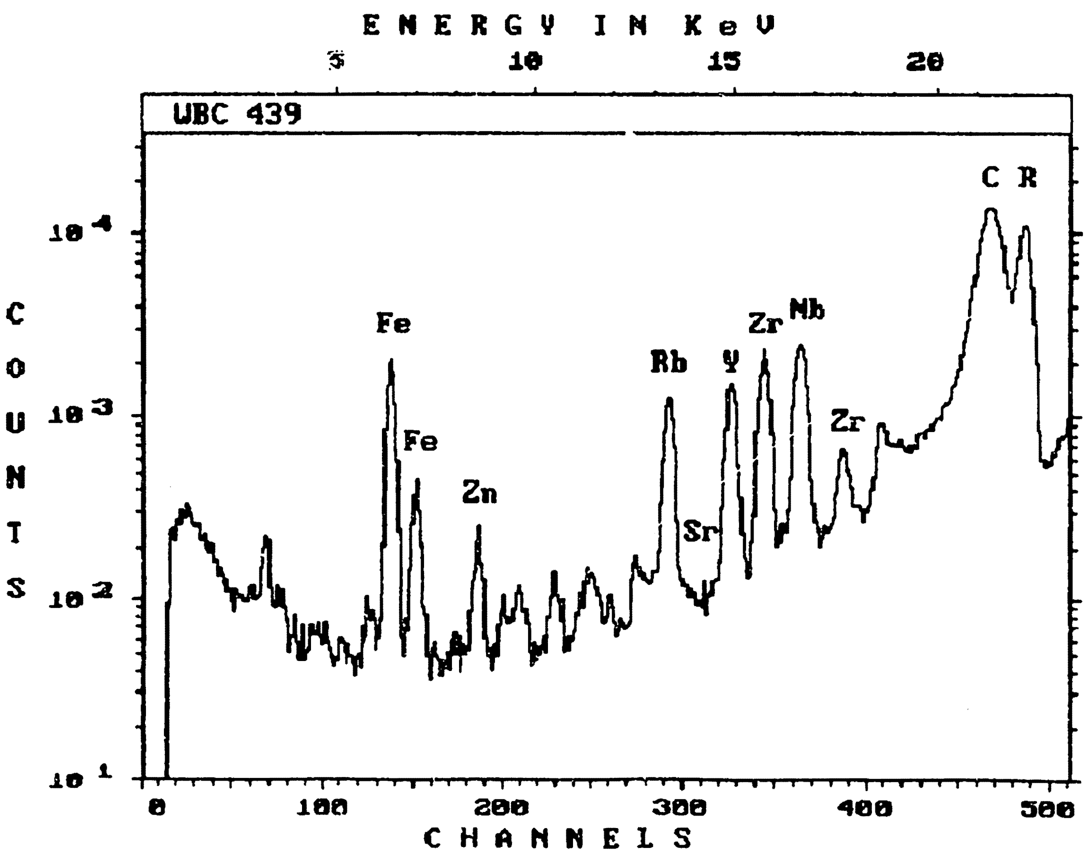
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 439
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 3
10 2
10 1
0
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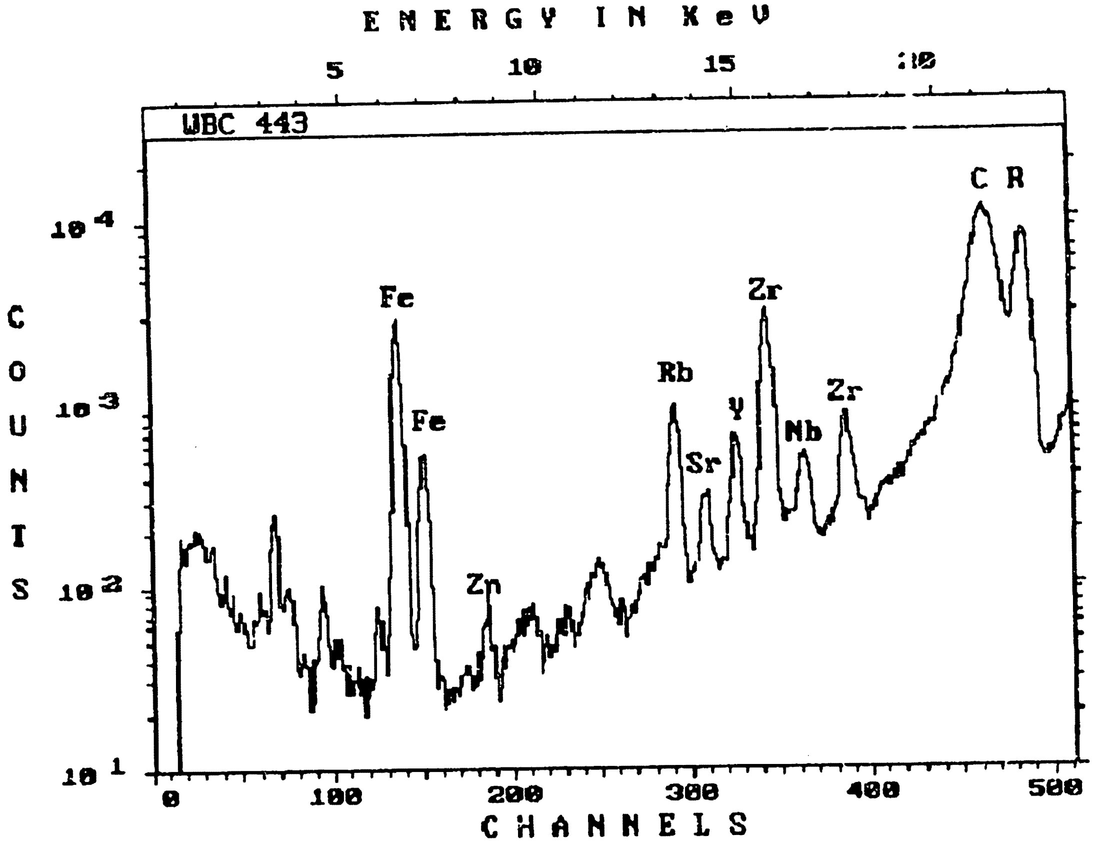
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 443
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
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200
300
400
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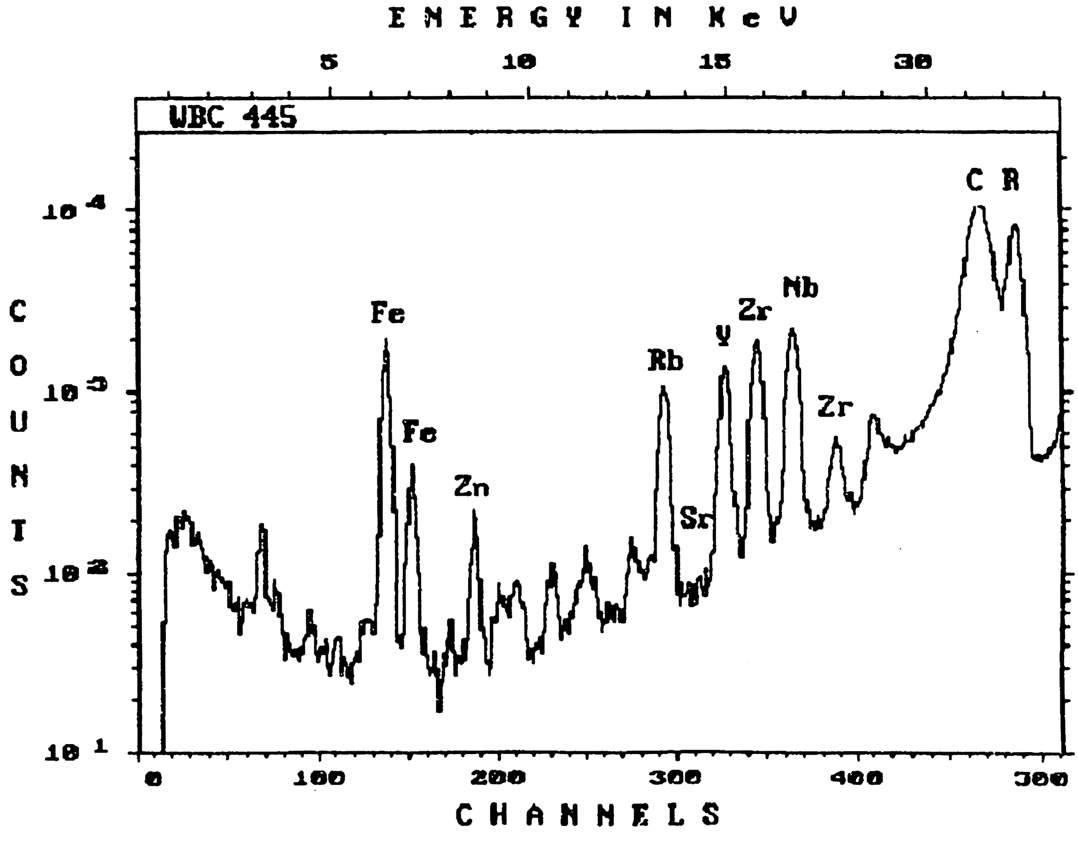
ENERGY IN KeV
5
10
15
20
WBC 445
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
CHANNELS
0
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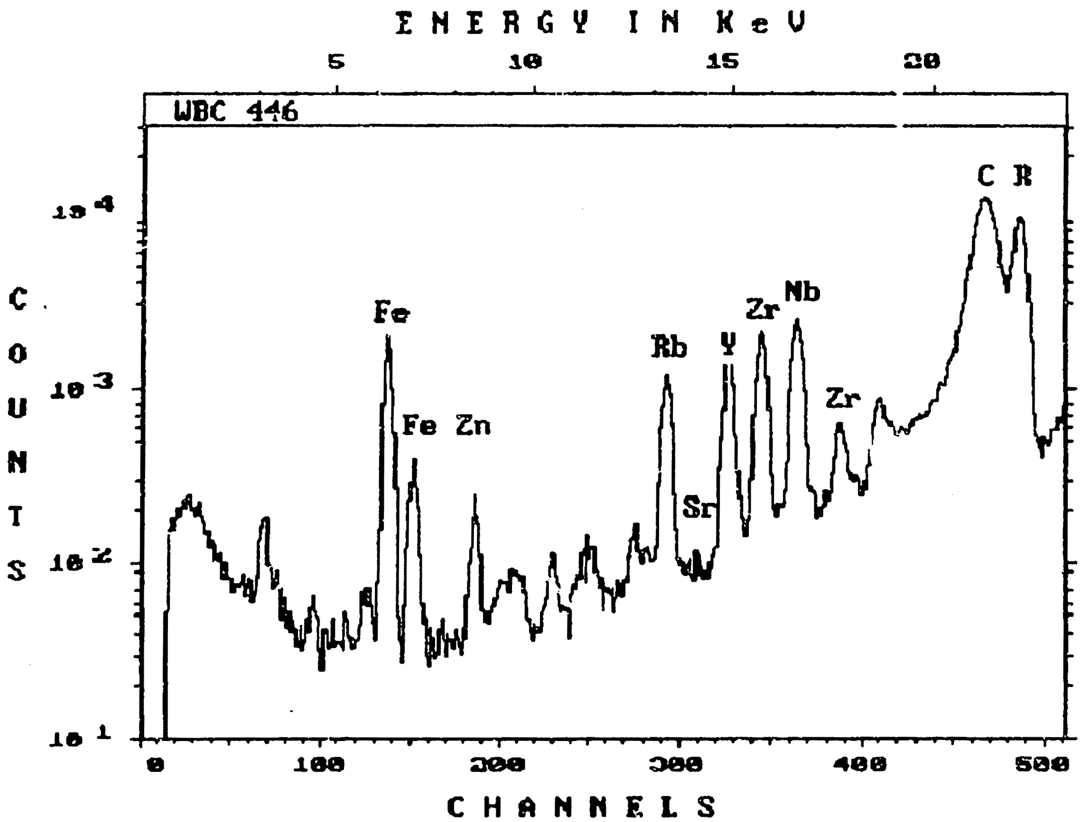
200
300
400
500


ENERGY IN KeV
5
10
15
20
WBC 446
C
R
Fe
Rb
Y
Zr
Nb
Fe
Zn
Zr
Sr
10^4
10^3
10^2
10^1
COUNTS
0
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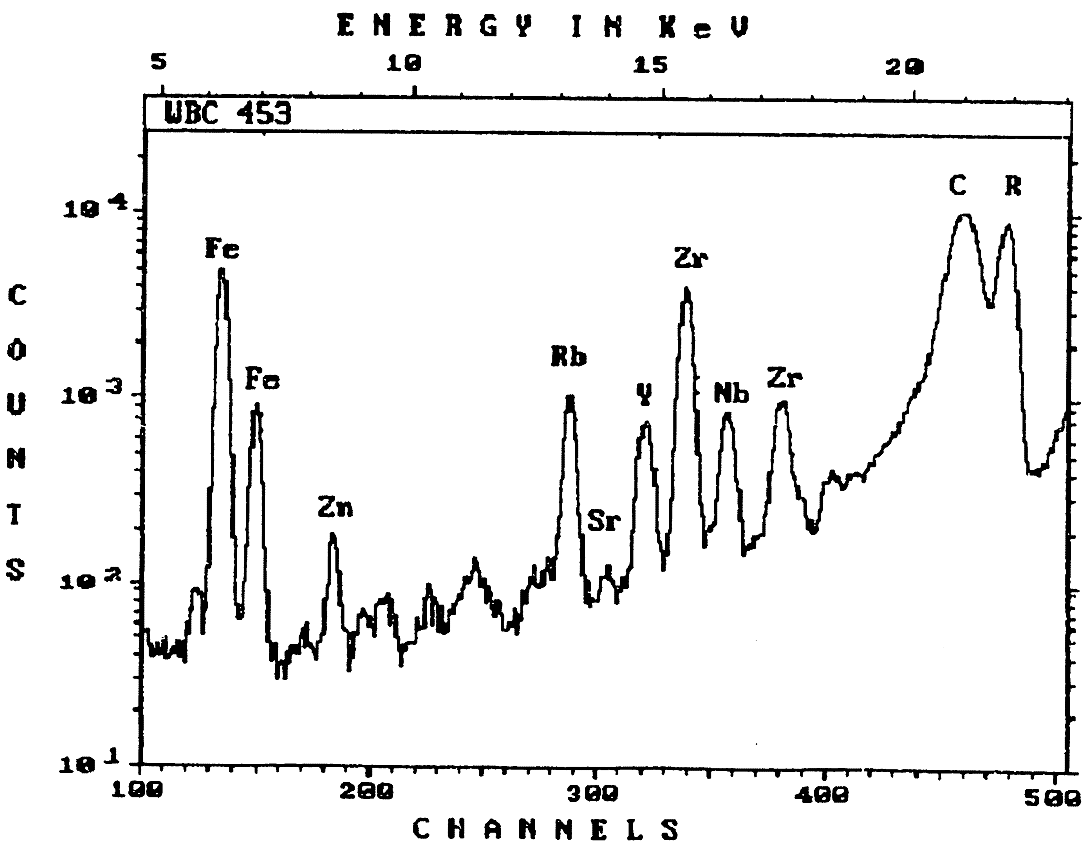
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 453
C
R
Fe
Zr
Fe
Rb
Y
Nb
Zr
Zn
Sr
10^4
10^3
10^2
10^1
COUNTS
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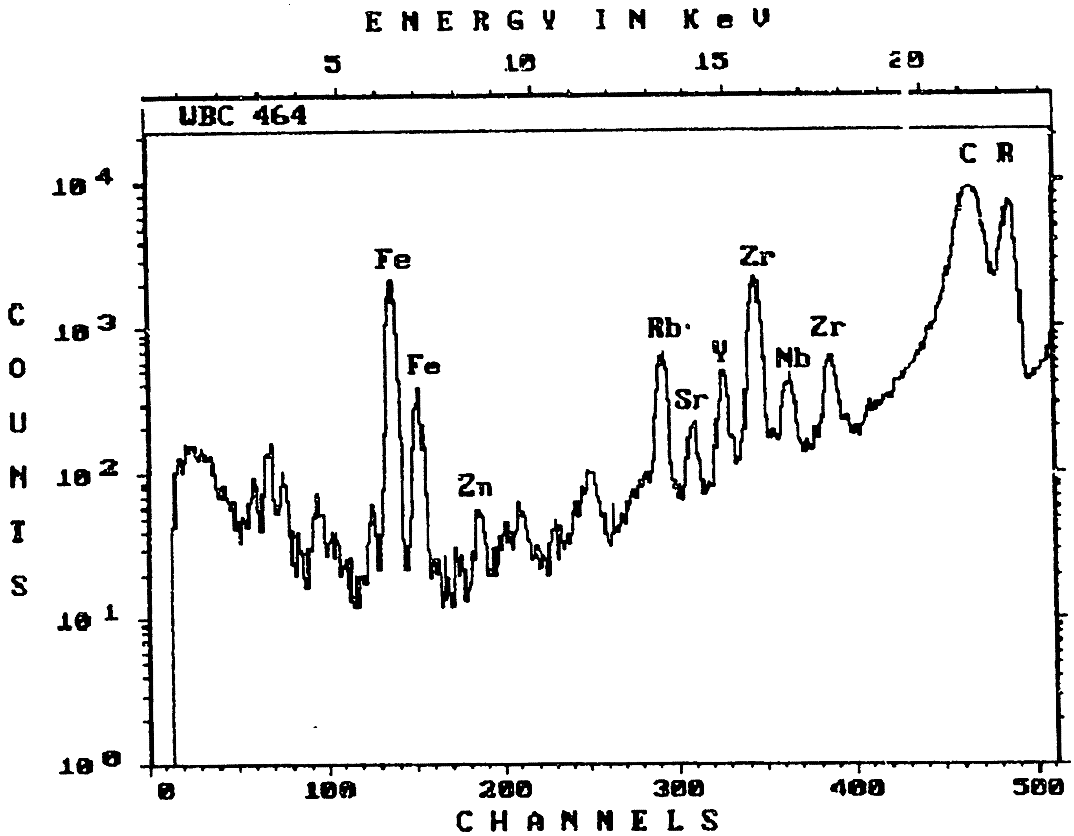
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 464
C R
10 4
Fe
Zr
COUNTS
10 3
Rb·
Y
Zr
Fe
Nb
Sr
10 2
Zn
10 1
10 0
0
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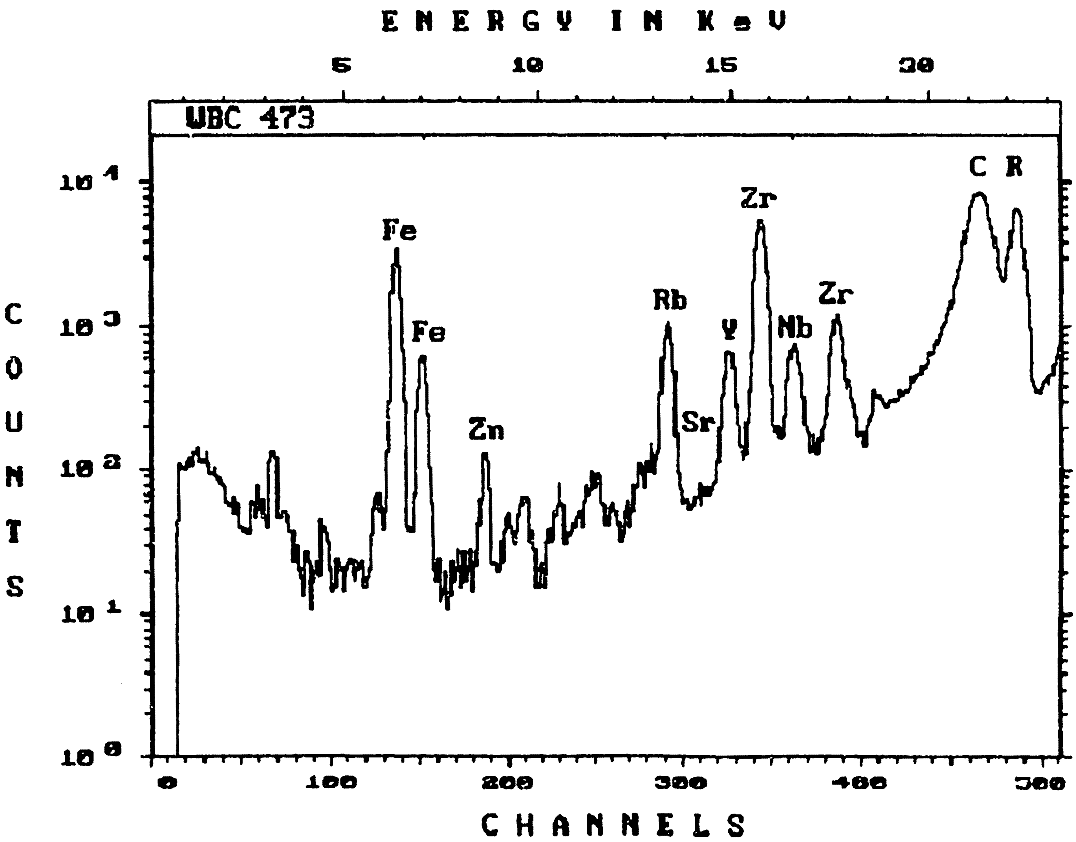
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 473
C R
10 4
Zr
Fe
COUNTS
10 3
Rb
Zr
Y
Nb
Fe
Zn
Sr
10 2
10 1
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200
300
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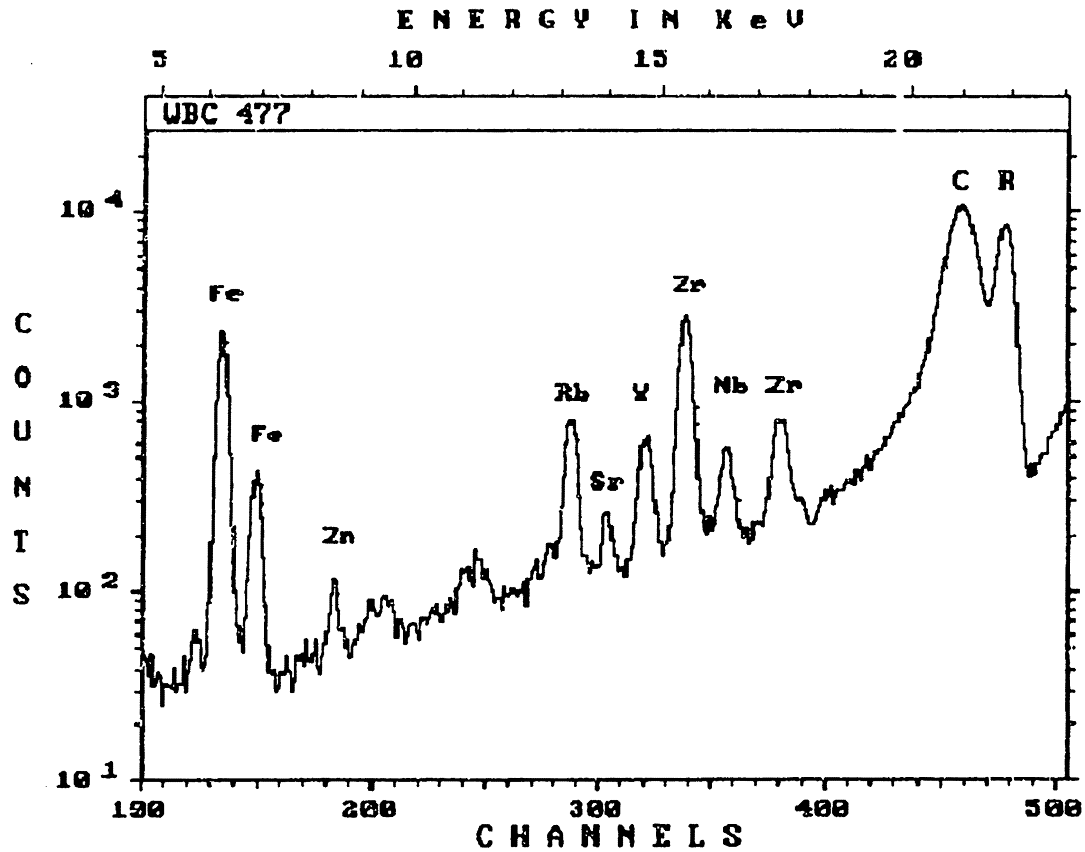
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 477
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
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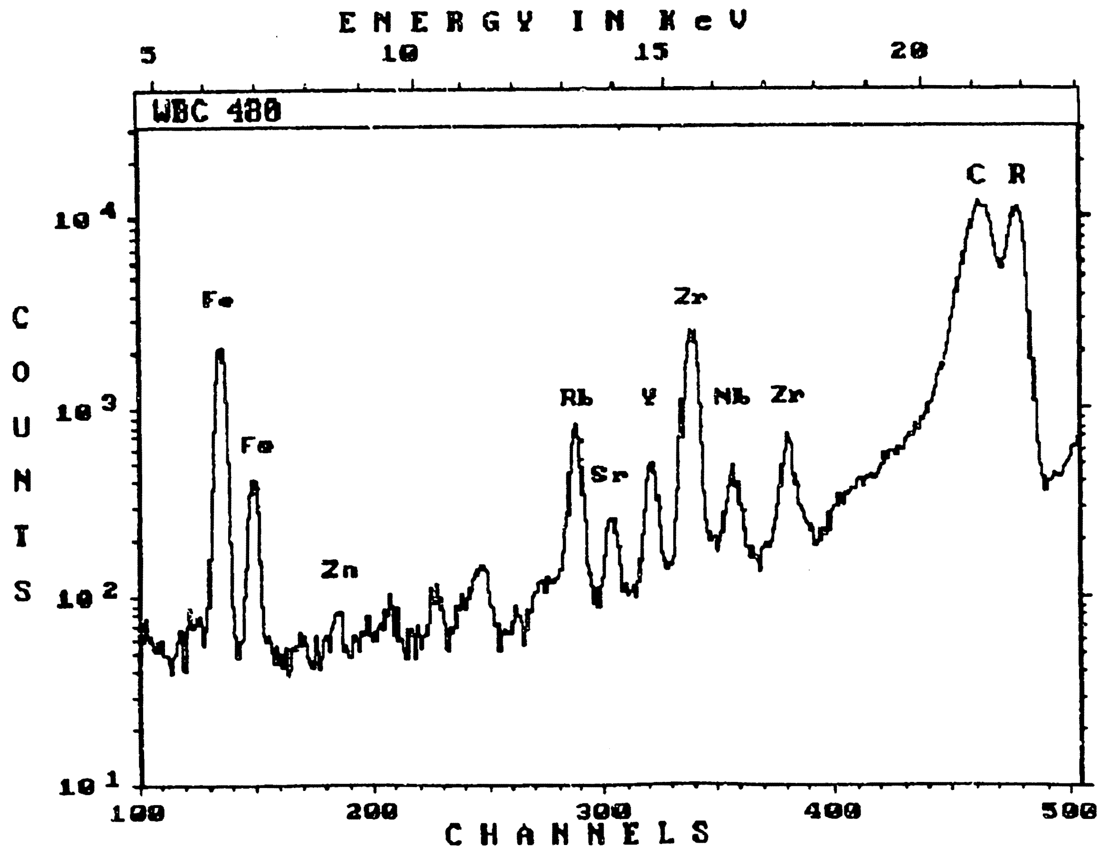
500
CHANNELS


ENERGY IN KeV
5
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15
20
WBC 480
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 2
10 1
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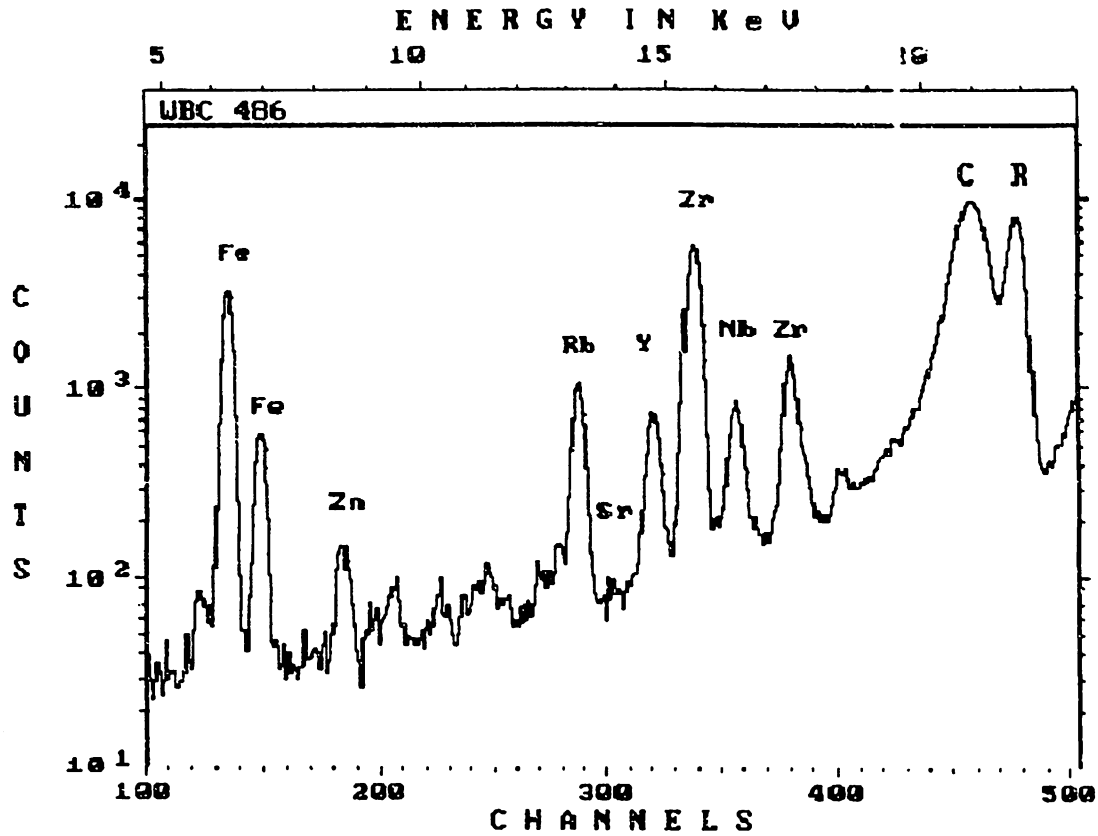
500
CHANNELS


ENERGY IN KeV
5
10
15
WBC 486
C R
Zr
Fe
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Rb
Y
Nb
Zr
Zn
Sr
COUNTS
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10 3
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10 1
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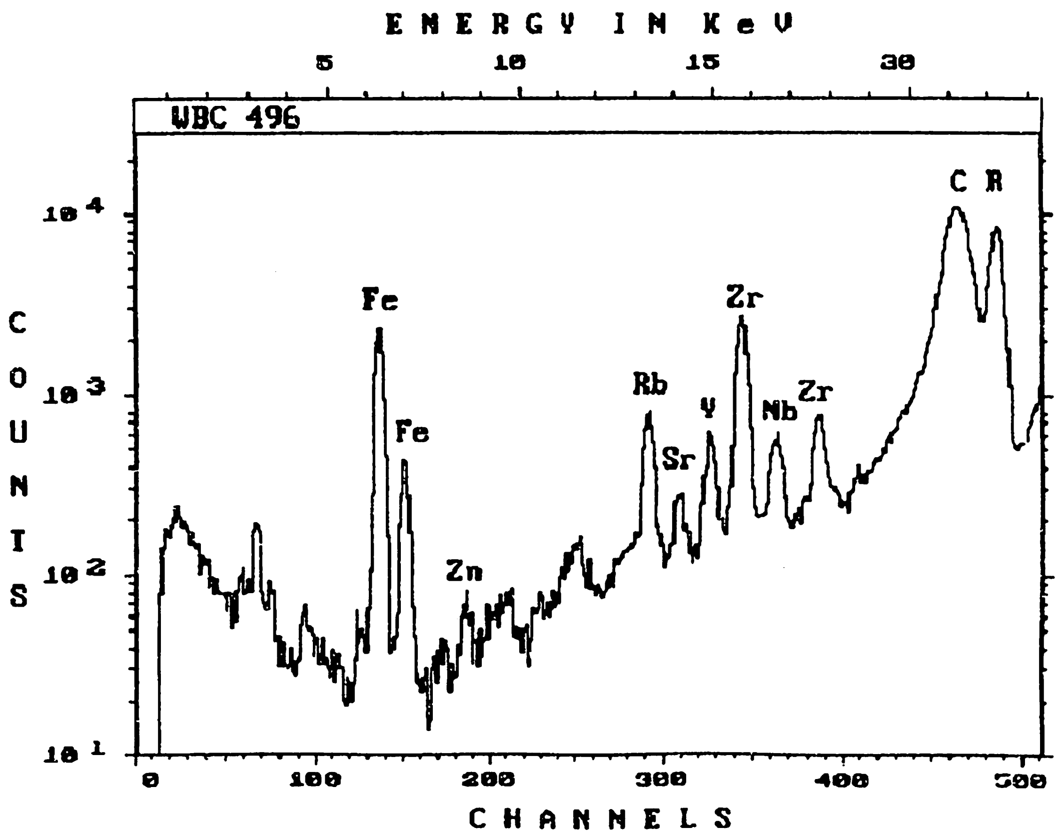
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 496
C R
Fe
Zr
Fe
Rb
Y
Nb
Zr
Sr
Zn
COUNTS
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10 2
10 1
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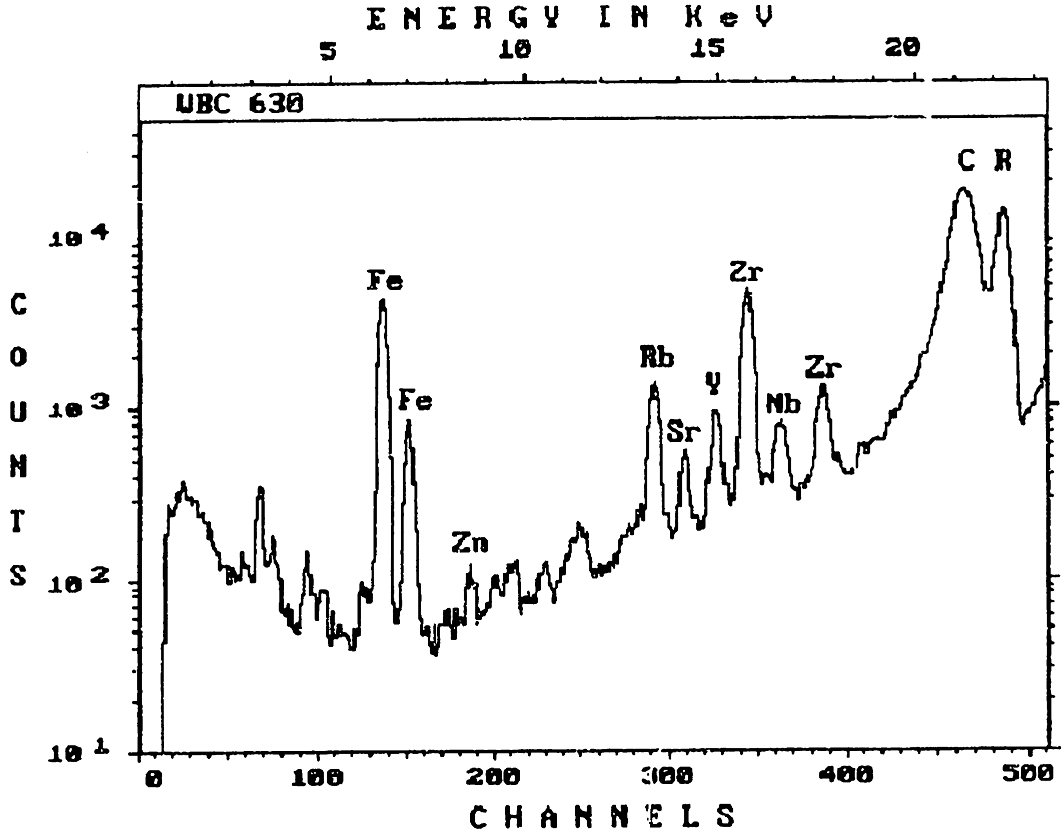
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 630
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10^3
10^2
10^1
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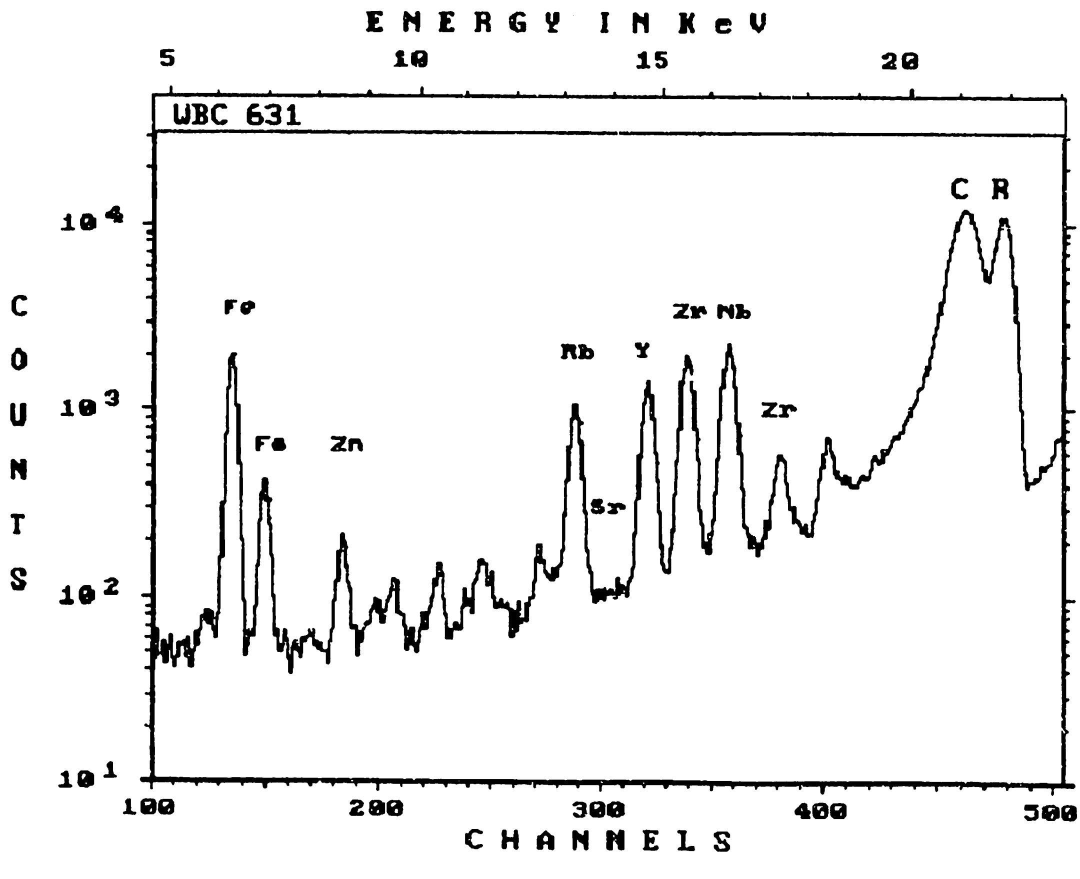
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 631
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr Nb
Zr
COUNTS
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10^3
10^2
10^1
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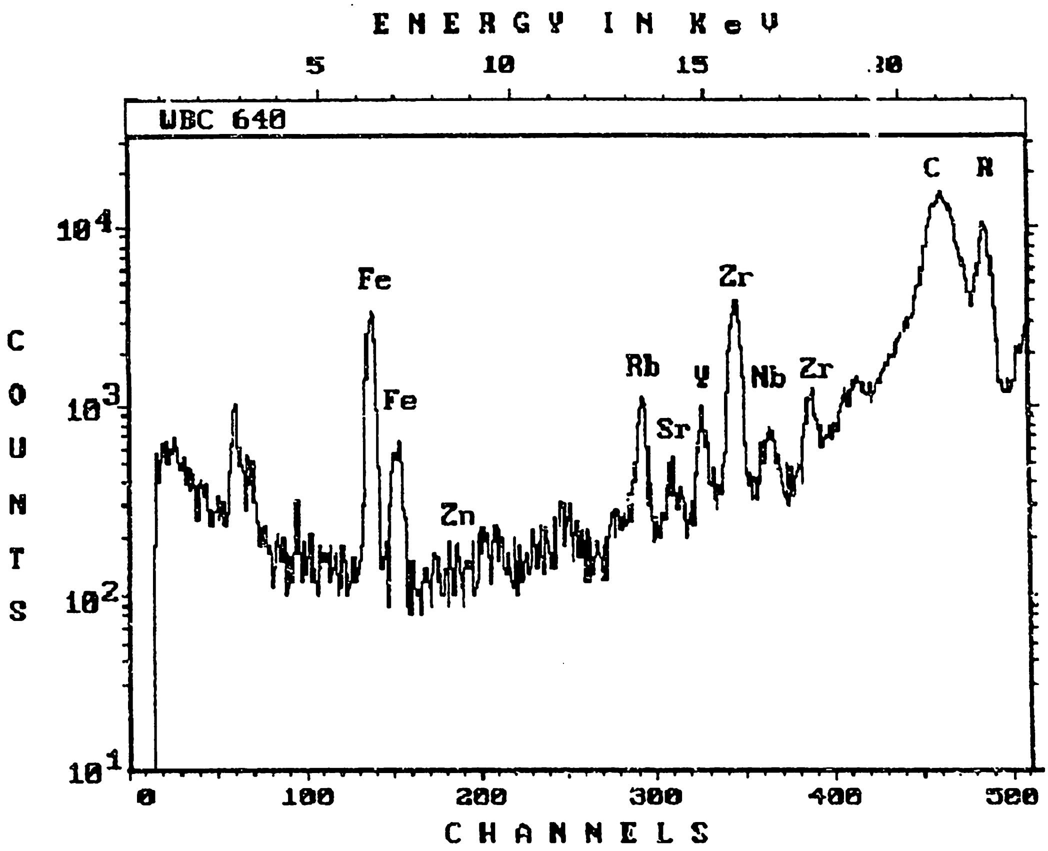
300
400
500
CHANNELS


ENERGY IN KeV
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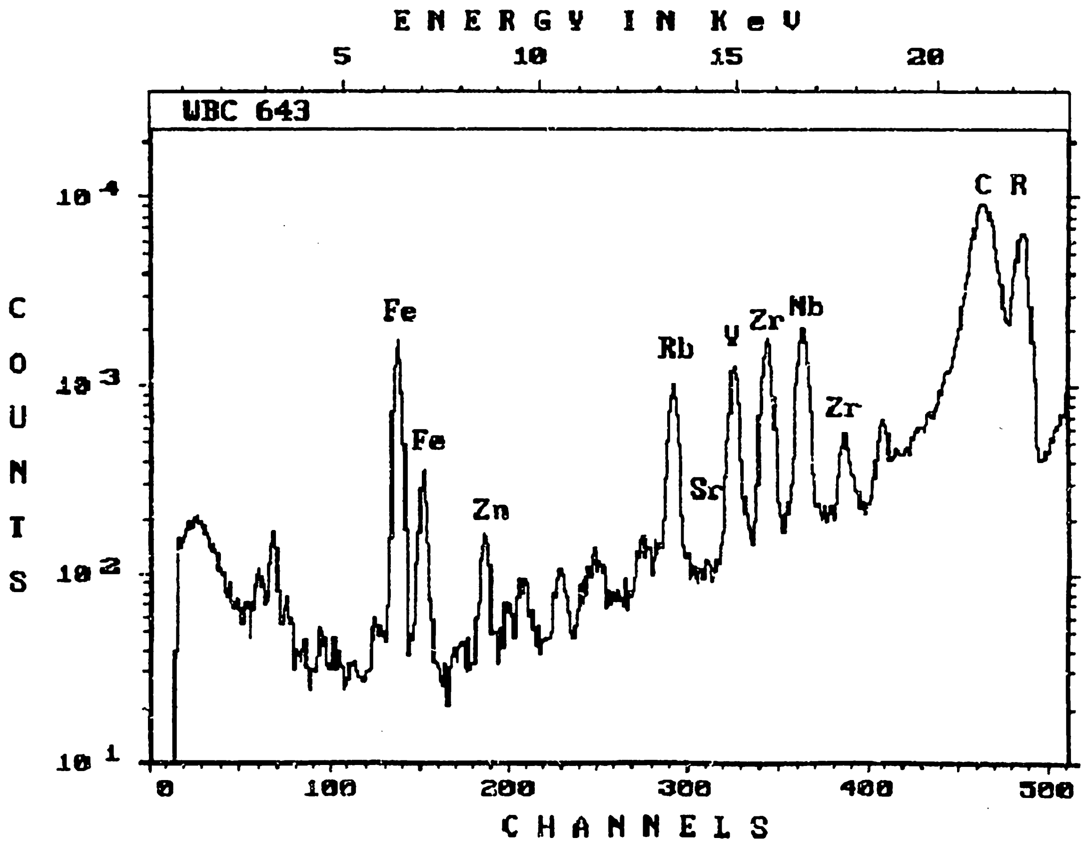
10
15
20
WBC 640
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 643
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
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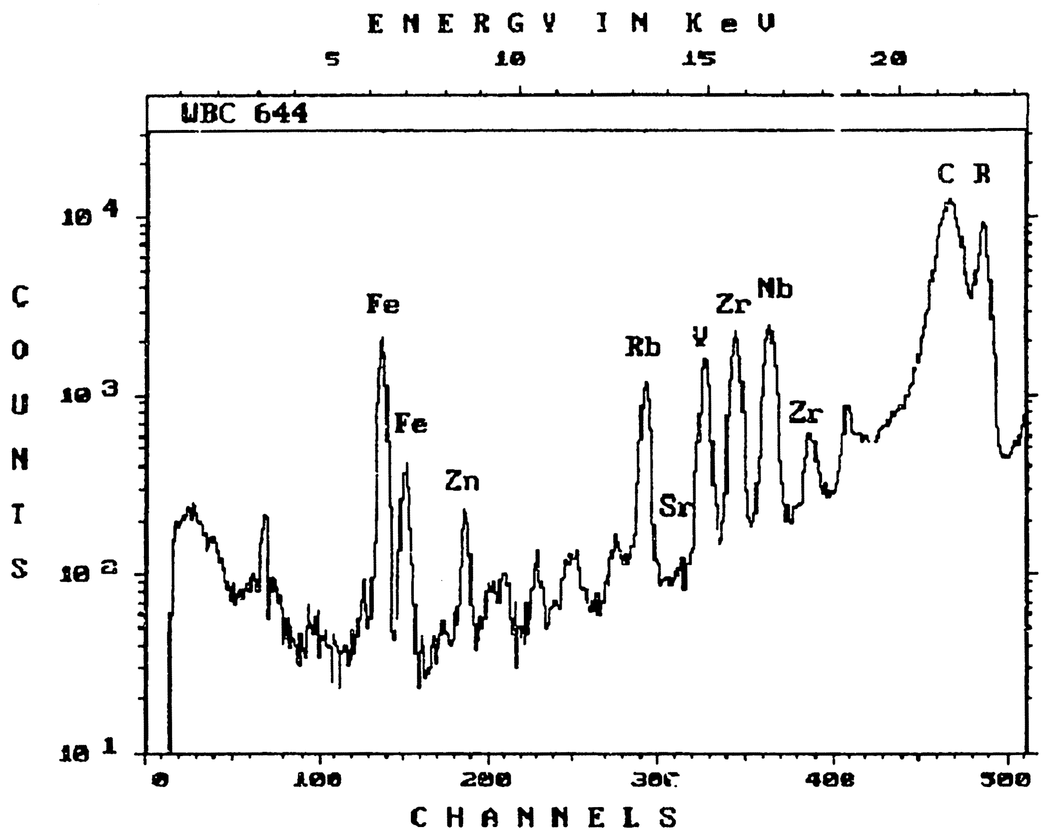
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 644
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
O
U
N
T
S
10 4
10 3
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10 1
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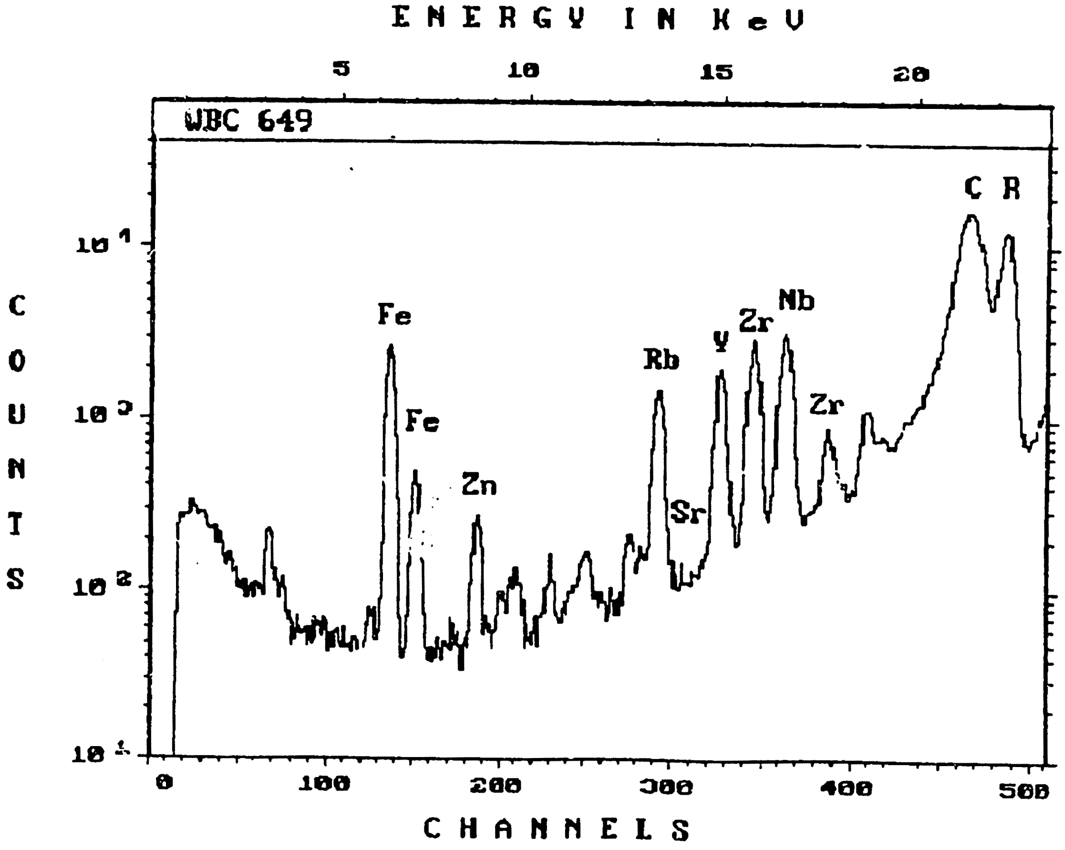
200
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 649
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
O
U
N
T
S
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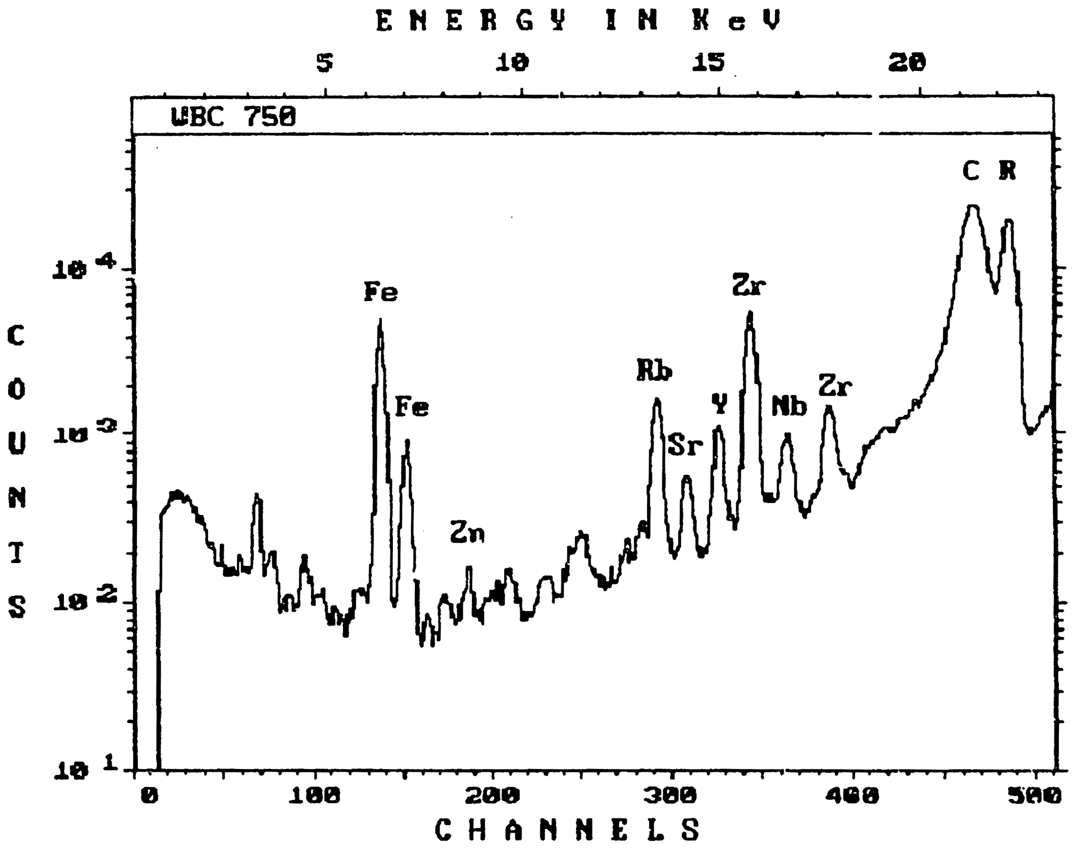
300
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 750
C R
Fe
Zr
Fe
Rb
Sr
Y
Nb
Zr
Zn
10 4
10 3
10 2
10 1
COUNTS
0
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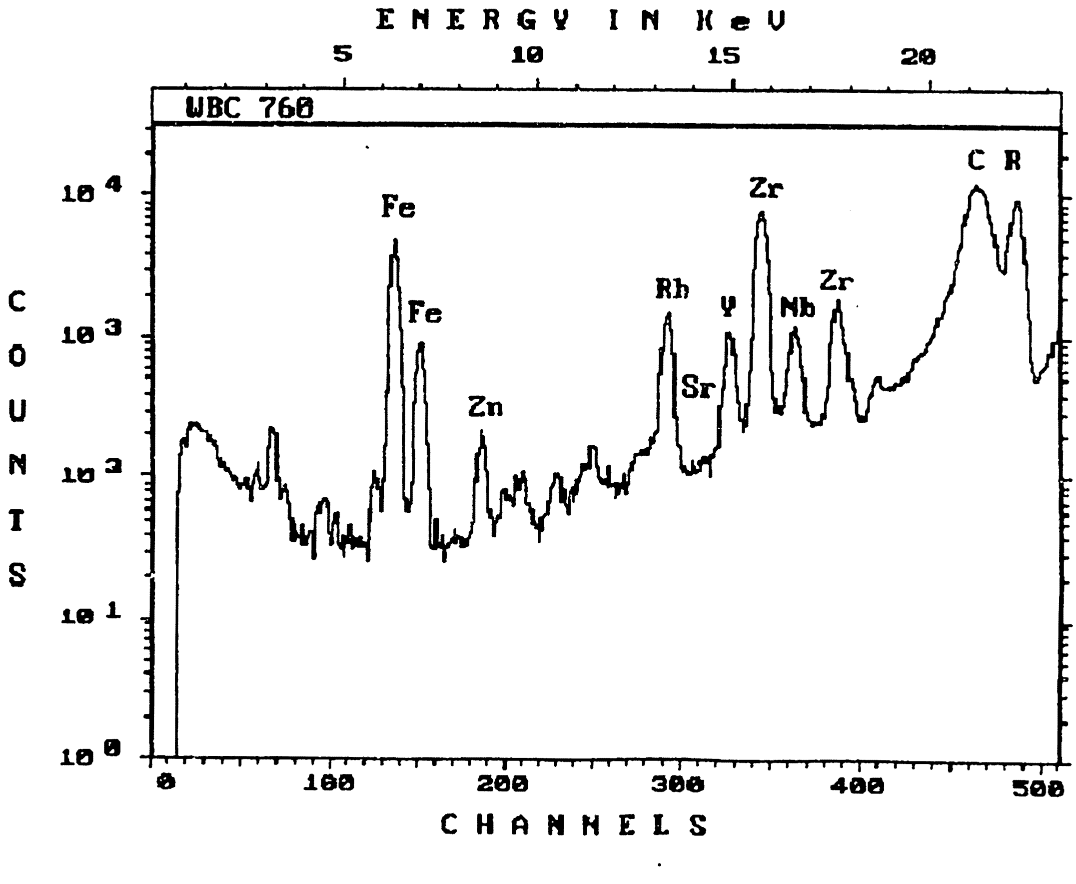
200
300
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 760
C R
Fe
Zr
Fe
Rh
Y
Nb
Zr
Sr
Zn
10 4
10 3
10 2
10 1
10 0
COUNTS
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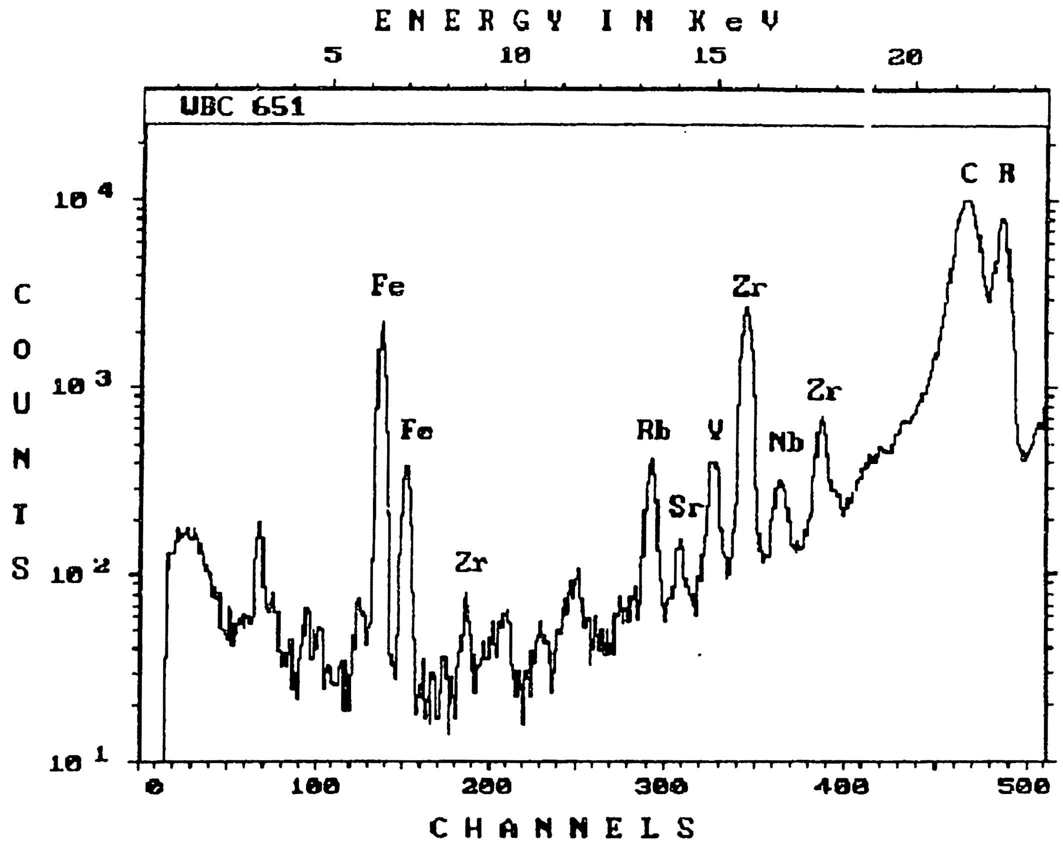
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 651
C R
Fe
Fe
Zr
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
0
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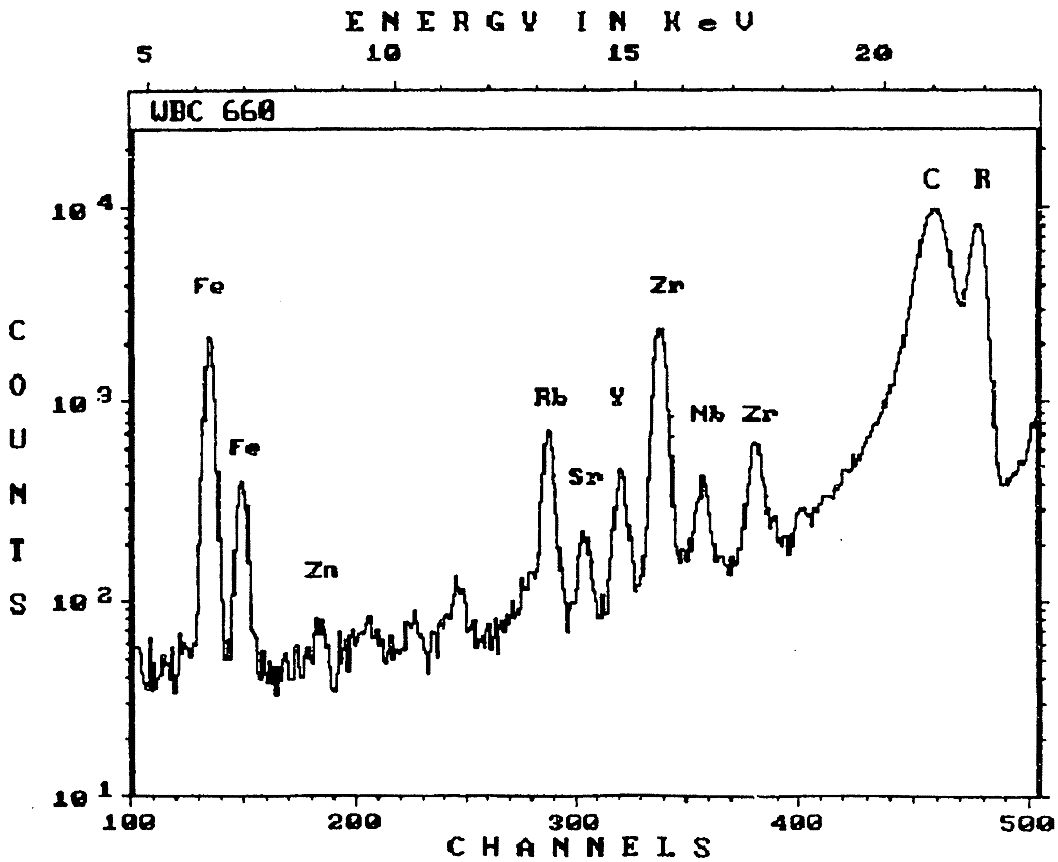
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 660
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb Zr
COUNTS
10^4
10^3
10^2
10^1
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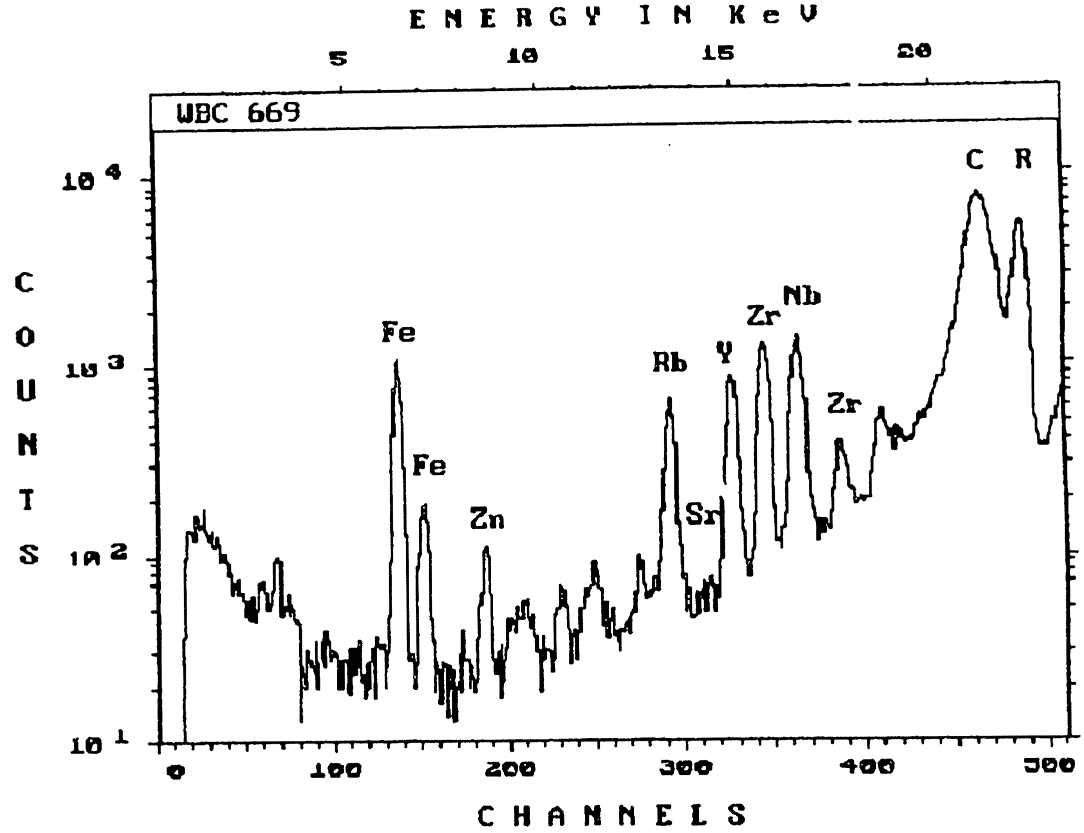
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 669
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
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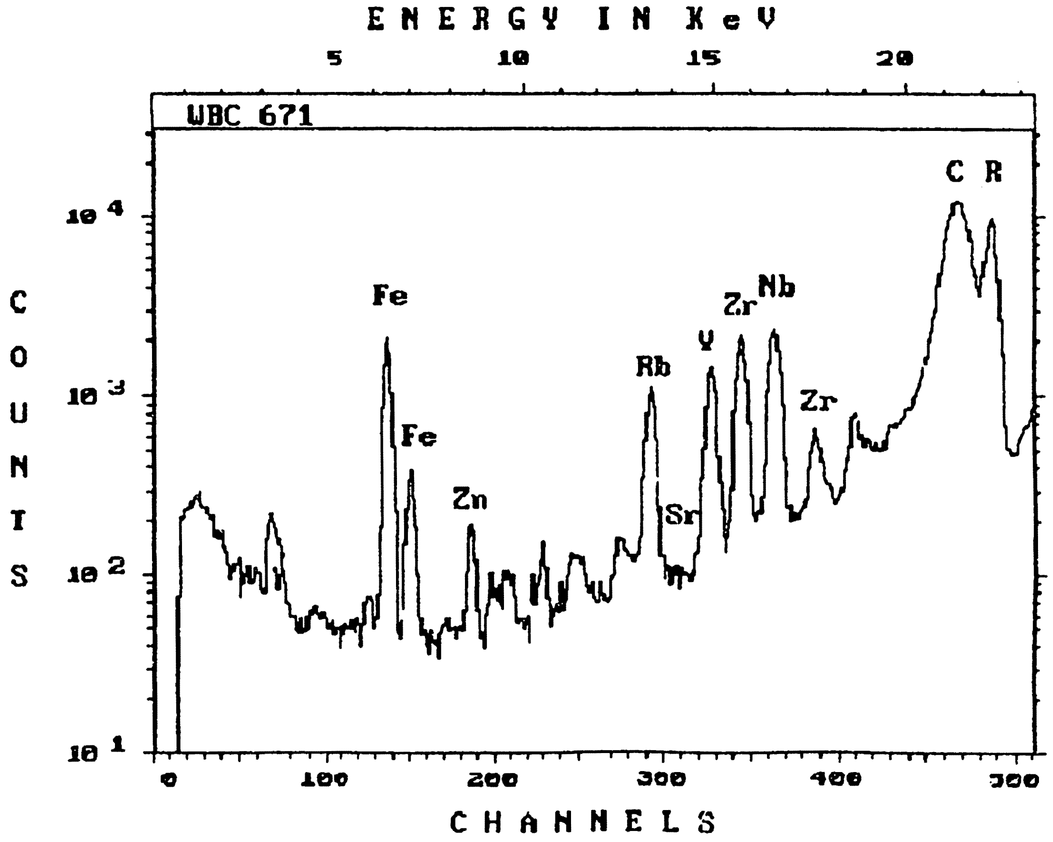
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 671
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
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300
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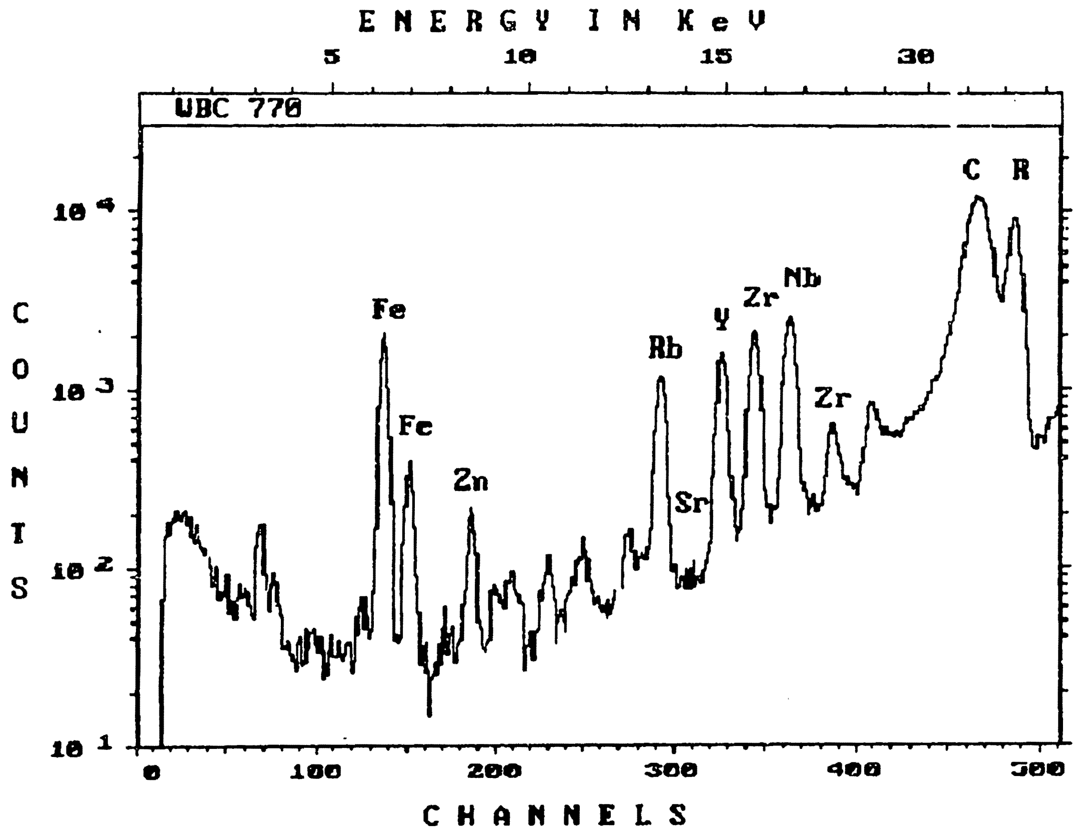
500
CHANNELS


ENERGY IN KeV
5
10
15
30
WBC 770
C R
Nb
Zr
Y
Fe
Rb
Fe
Zr
Zn
Sr
COUNTS
10 4
10 3
10 2
10 1
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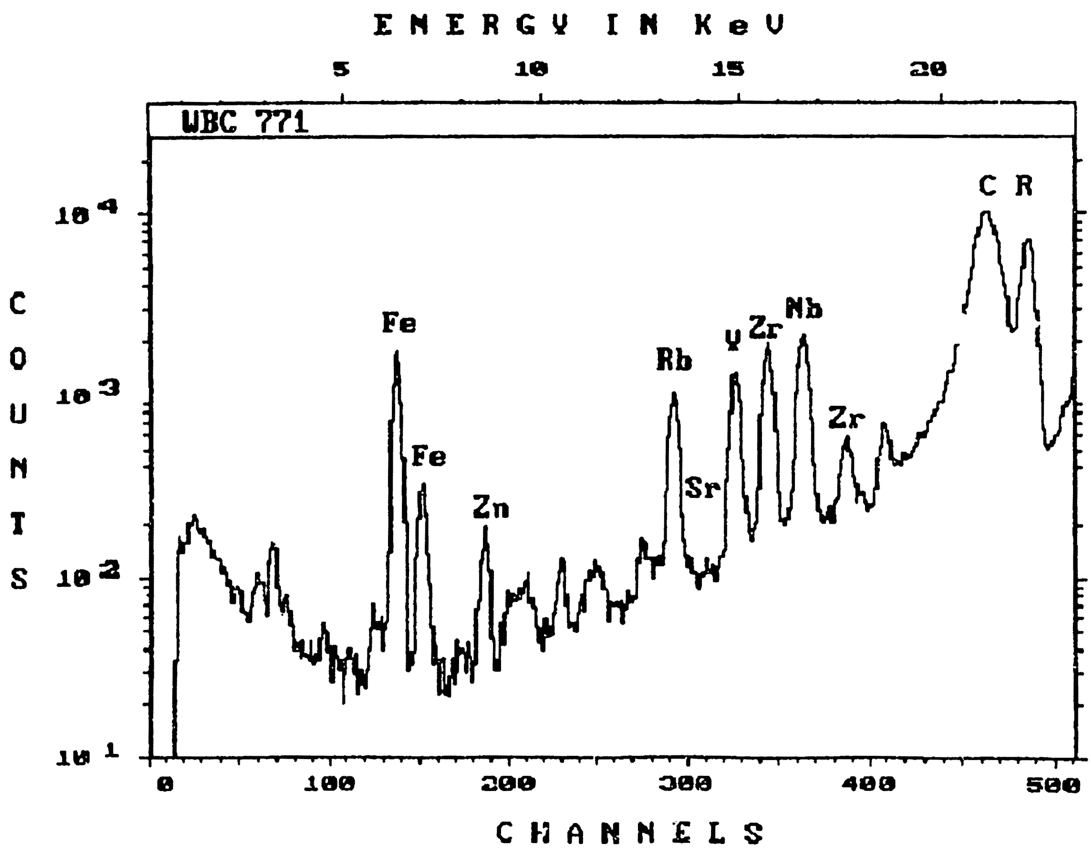
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 771
C R
Nb
Y Zr
Fe
Rb
Zr
Fe
Sr
Zn
COUNTS
10 4
10 3
10 2
10 1
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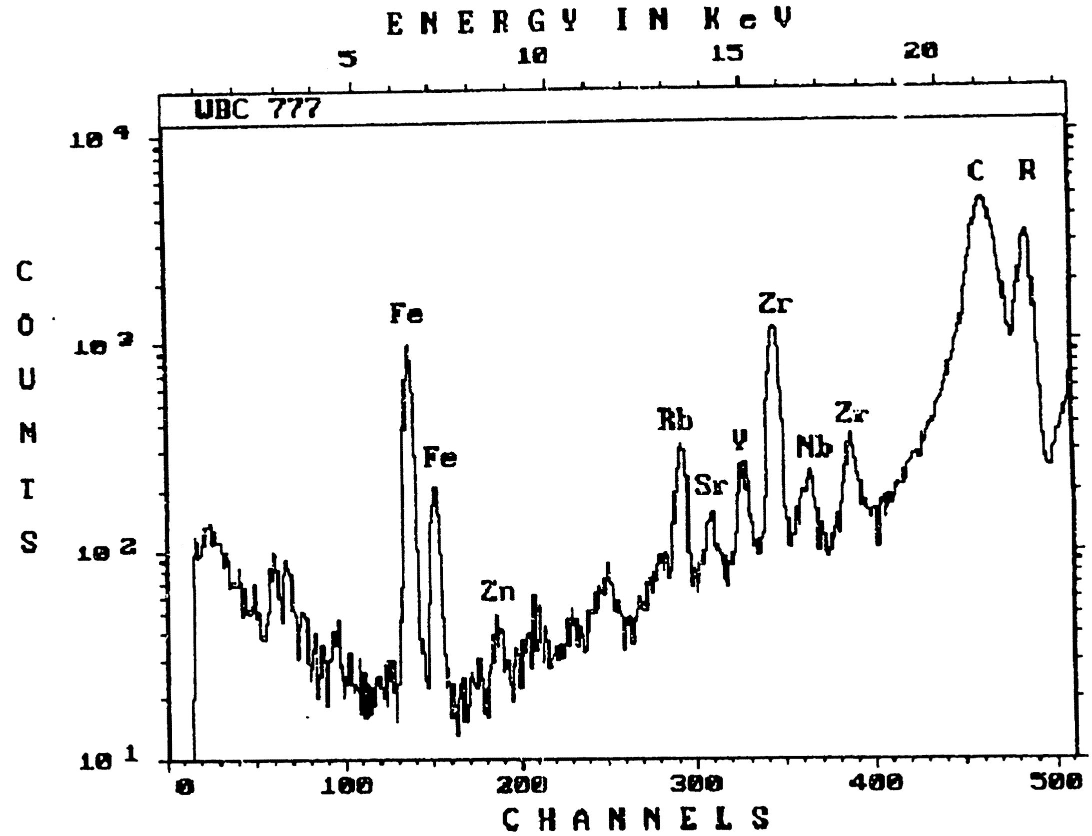
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 777
10 4
10 3
10 2
10 1
COUNTS
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Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
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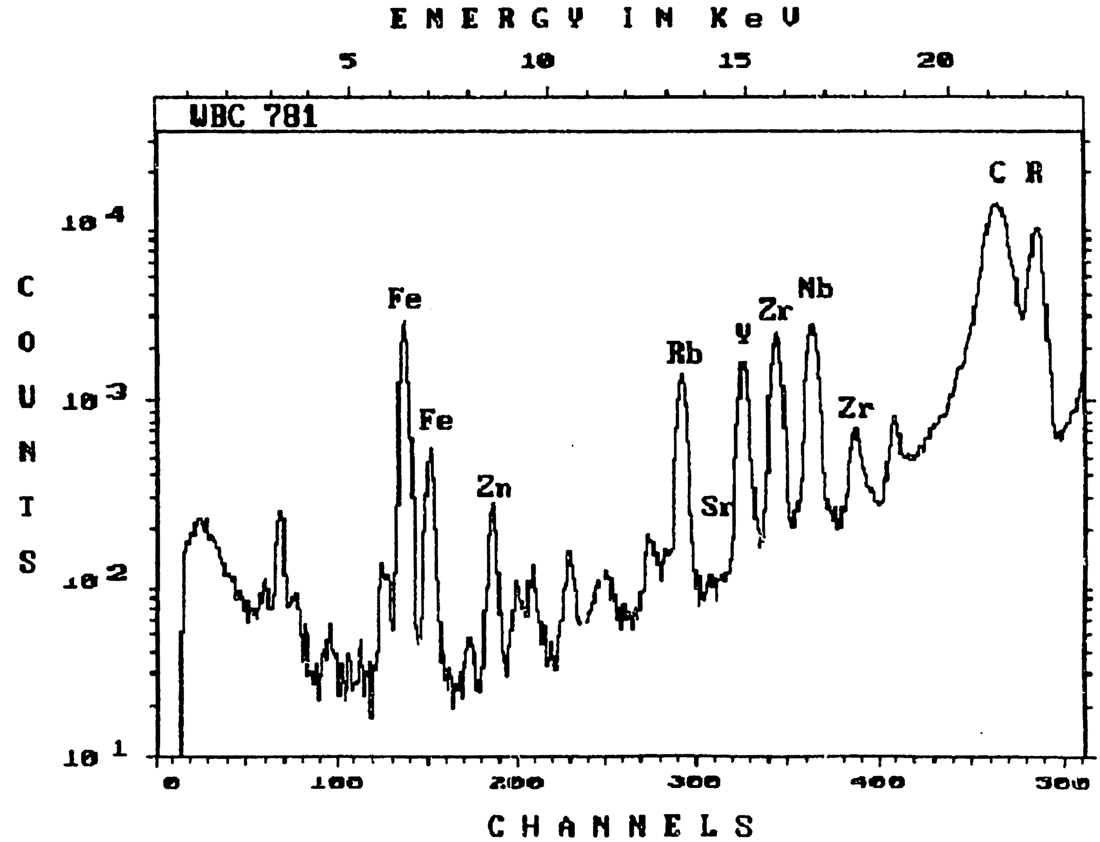
CHANNELS


ENERGY IN KeV
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15
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WBC 781
10 4
10 3
10 2
10 1
COUNTS
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Fe
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Rb
Sr
Y
Zr
Nb
Zr
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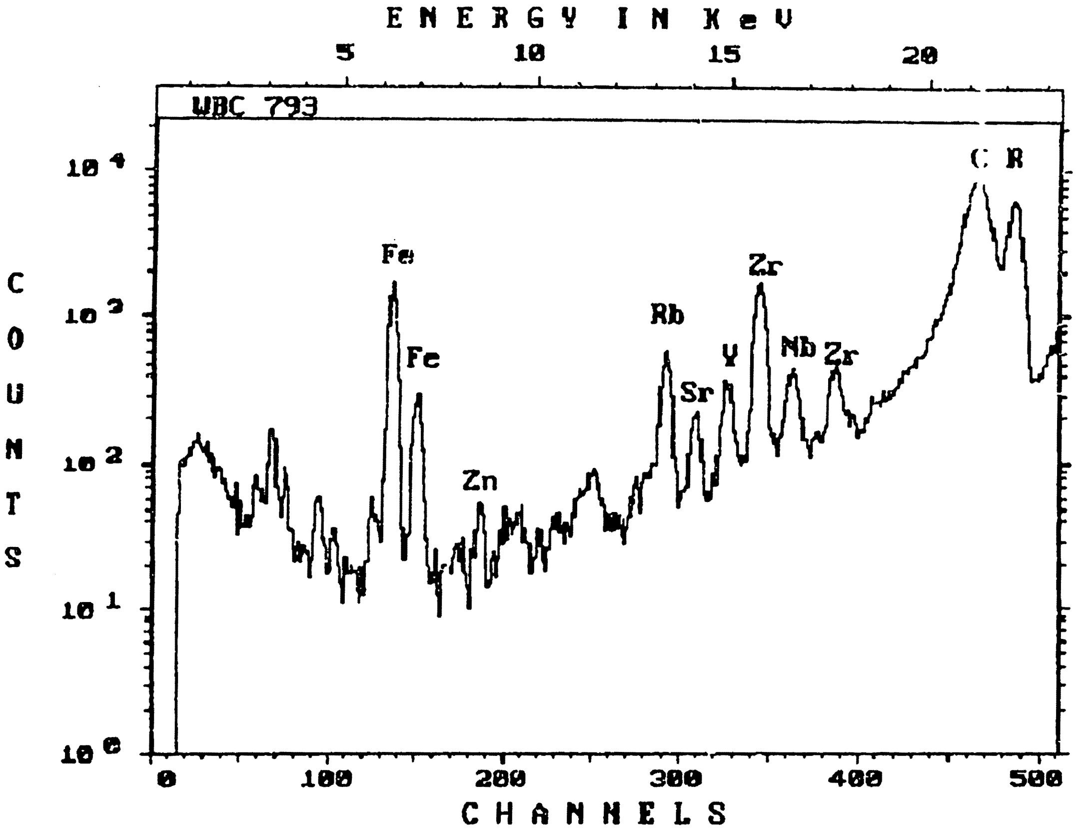
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 793
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10^3
10^2
10^1
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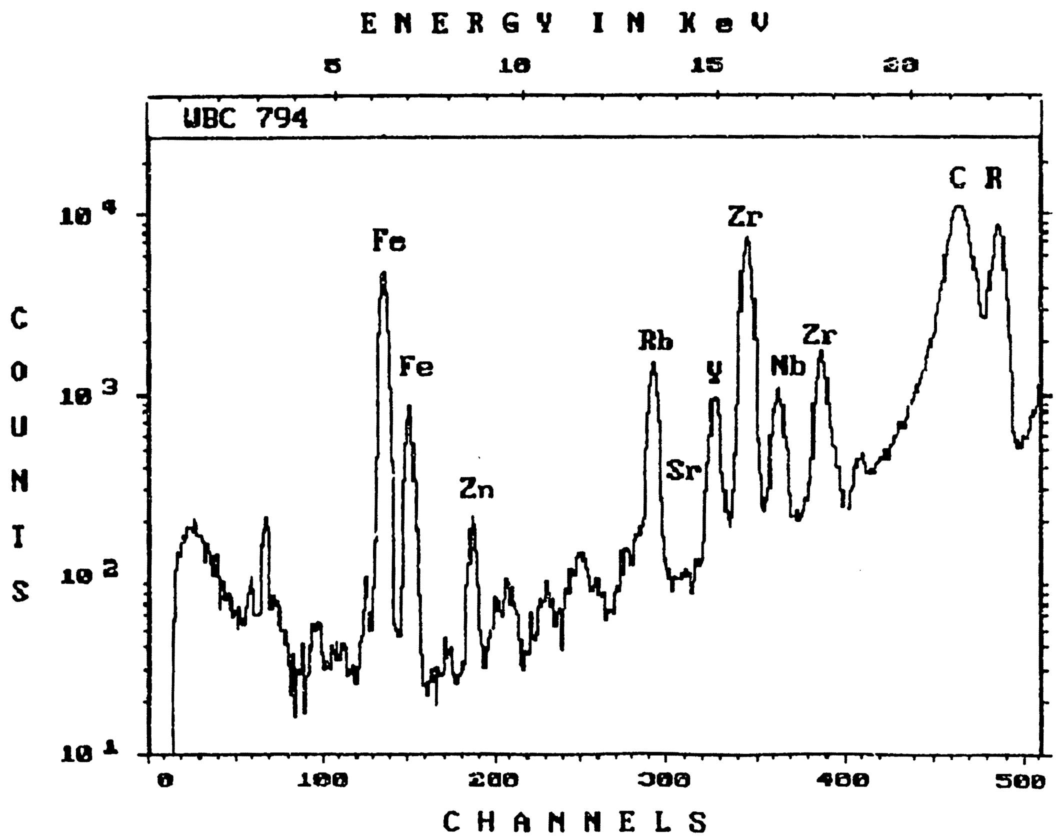
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 794
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
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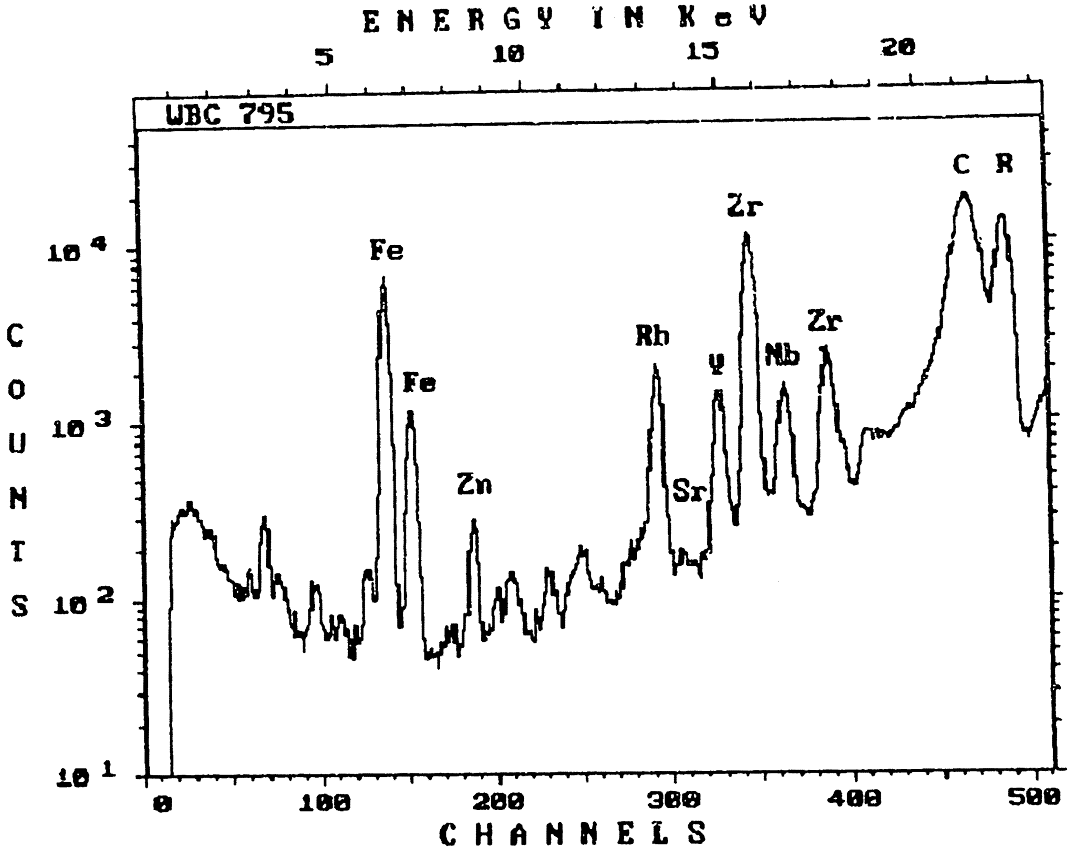
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 795
C R
Zr
Fe
Fe
Zn
Rb
Sr
Y
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
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400
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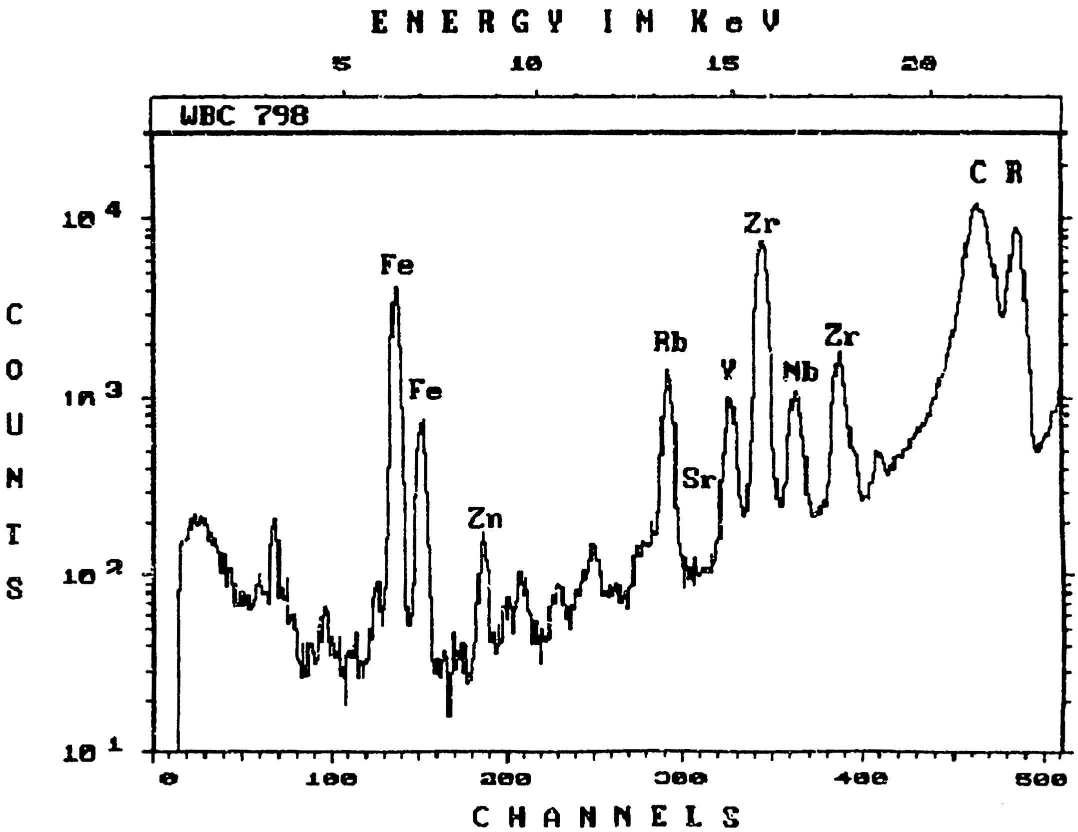
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 798
C R
Zr
Fe
Fe
Zn
Rb
Sr
Y
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
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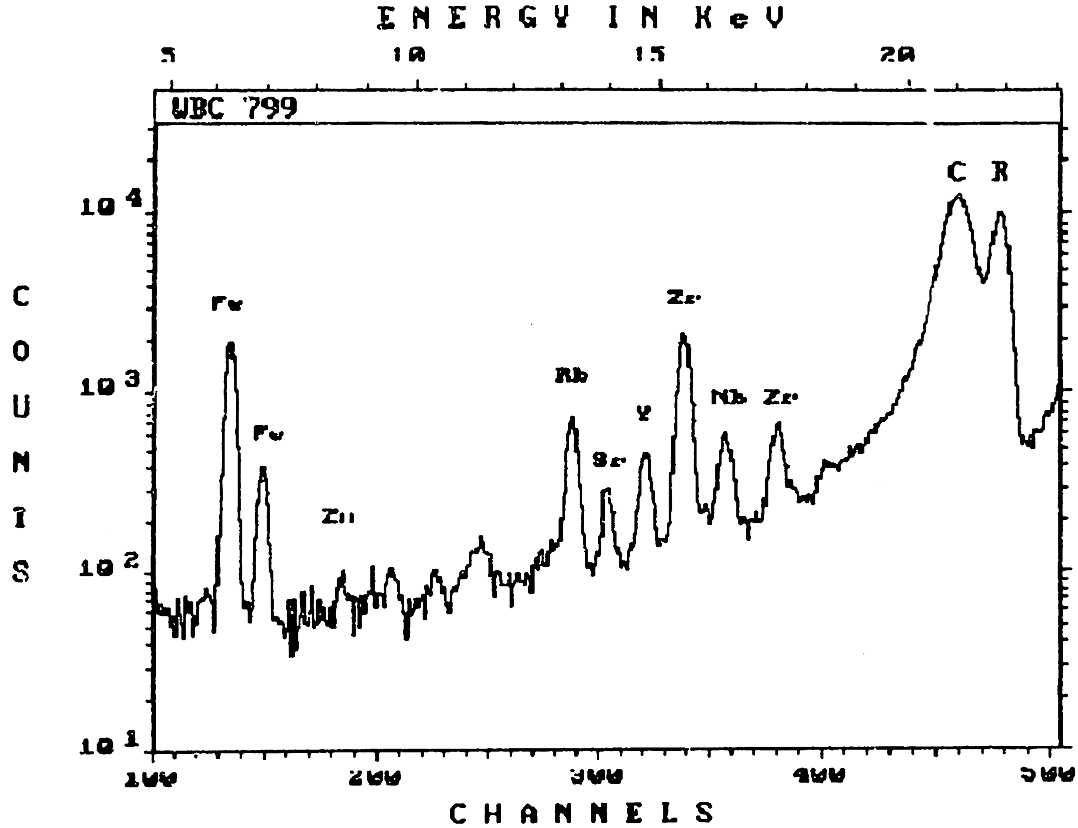
CHANNELS



ENERGY IN KeV
5
10
15
20
UBC 799
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COUNTS
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
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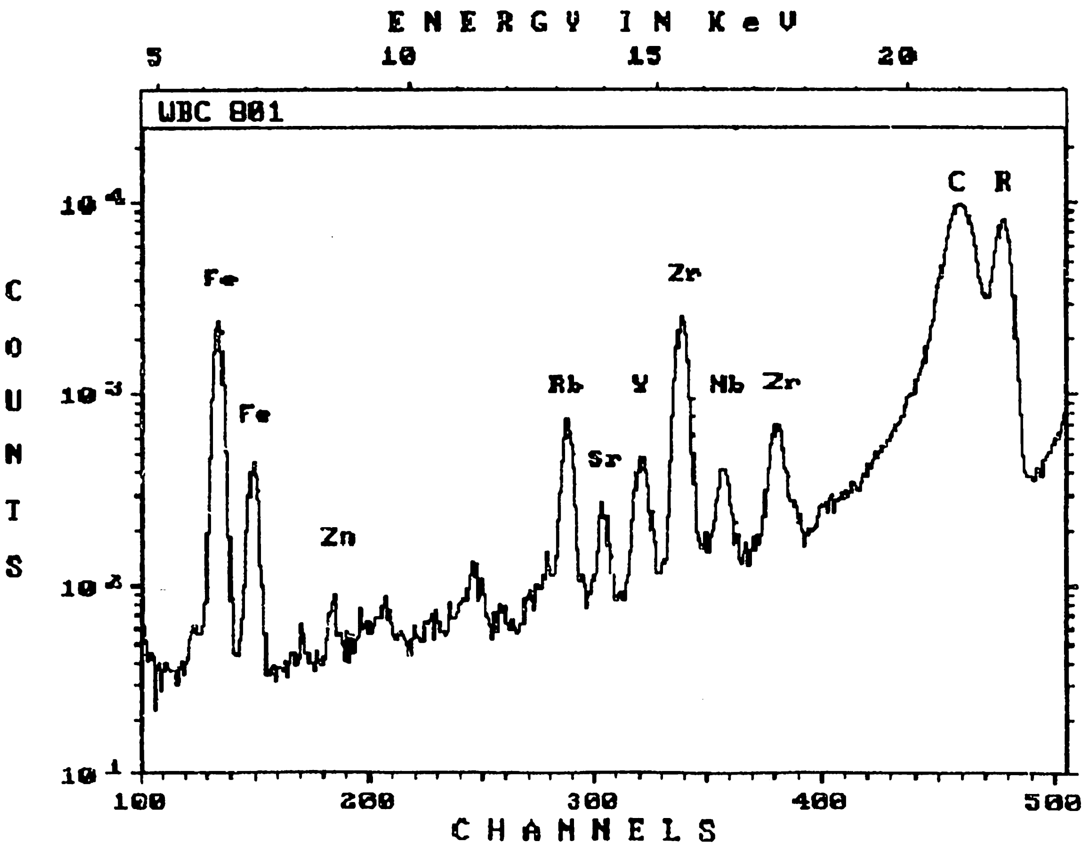
CHANNELS



ENERGY IN KeV
5
10
15
20
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COUNTS
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
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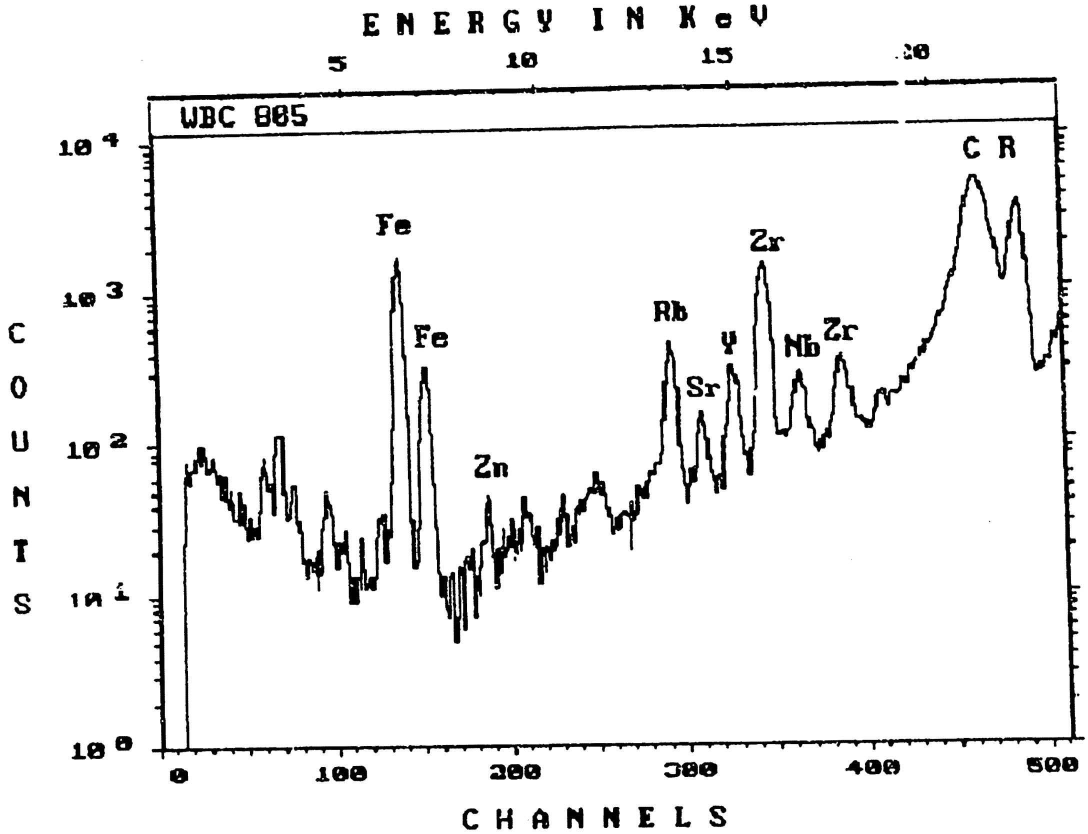
CHANNELS


ENERGY IN KeV
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10
15
20
WBC 805
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
O
U
N
T
S
10 4
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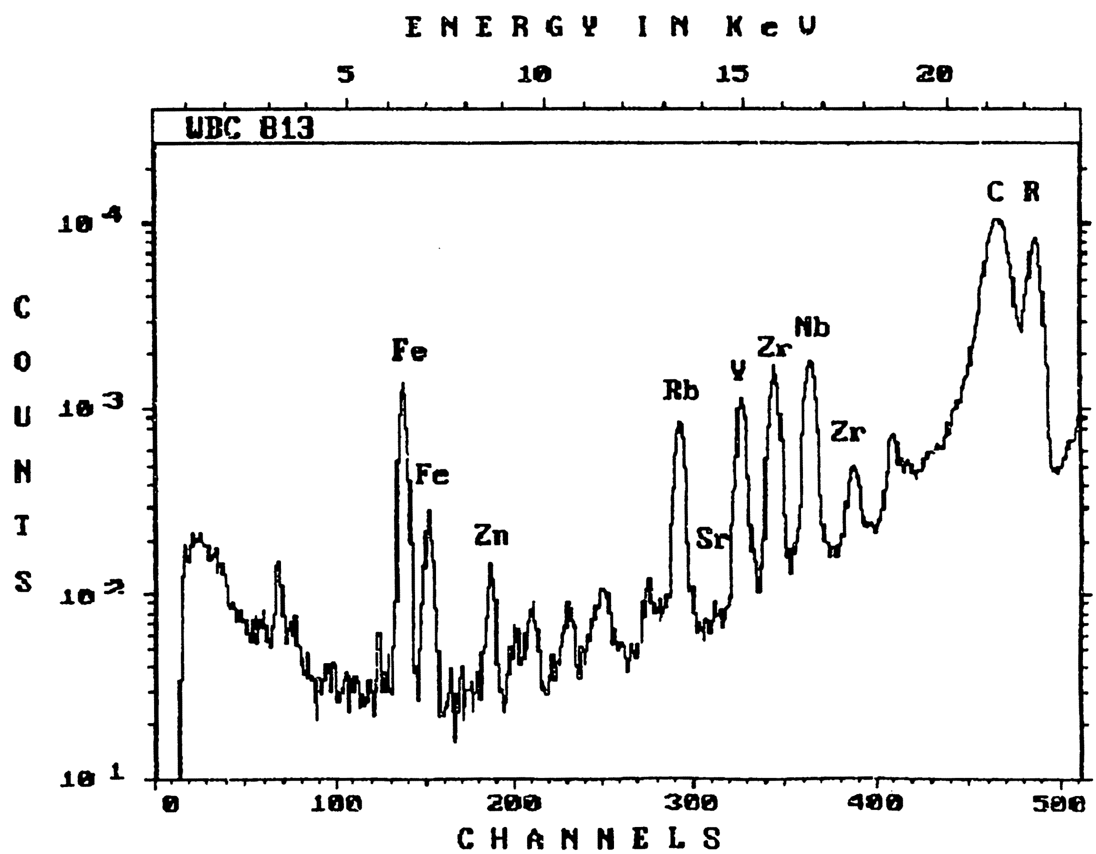
CHANNELS


ENERGY IN KeV
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15
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WBC 813
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
C
O
U
N
T
S
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400
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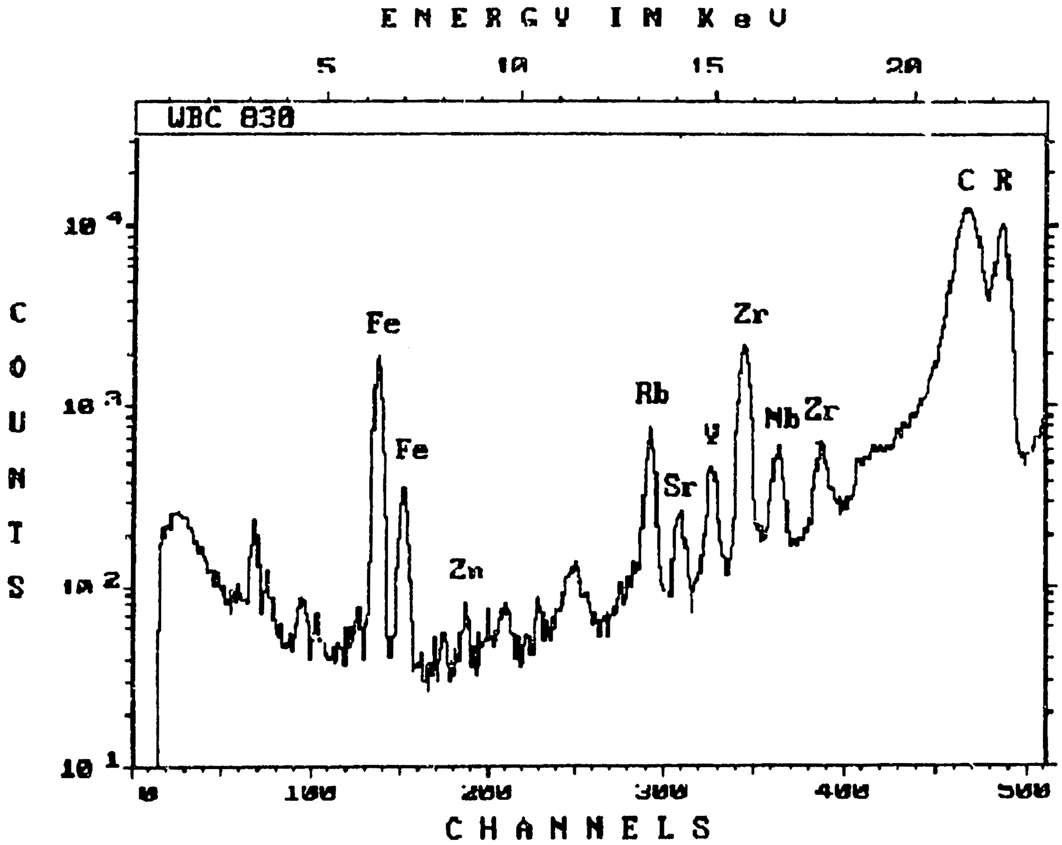
CHANNELS



ENERGY IN KeV
5
10
15
20
UBC 830
C R
Fe
Zr
Rb
Nb
Zr
Y
Fe
Sr
Zn
COUNTS
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10 3
10 2
10 1
0
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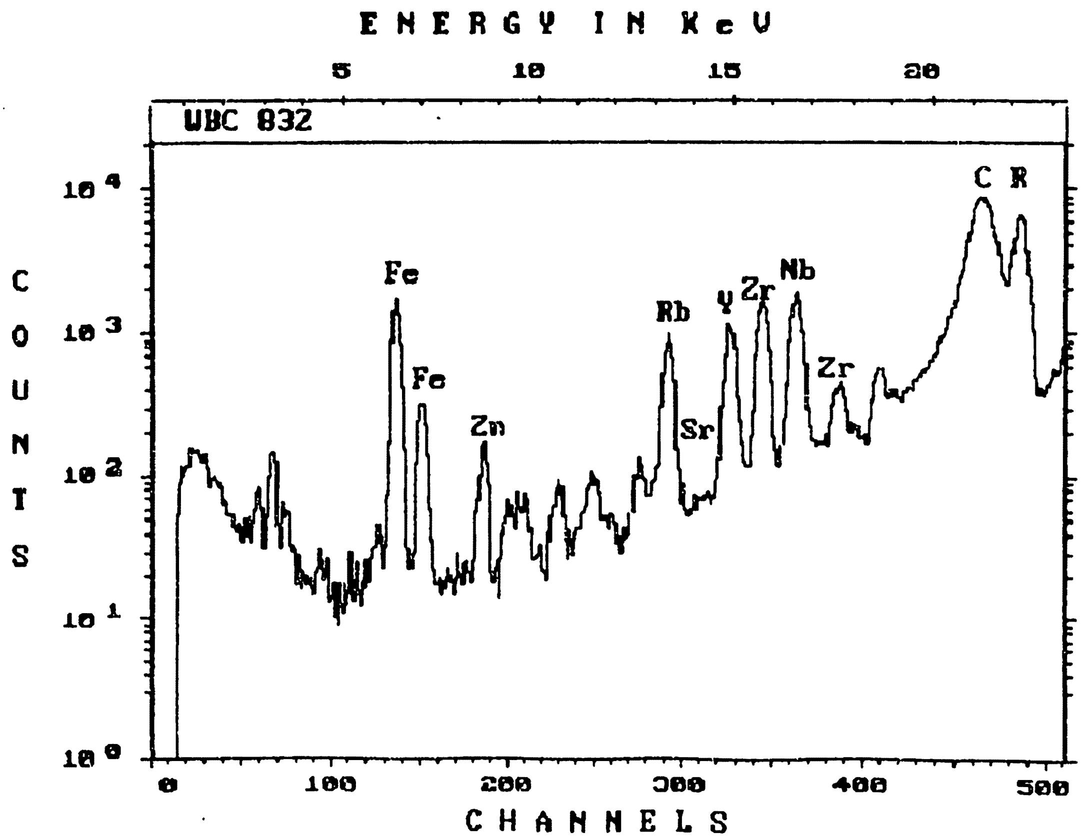
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
UBC 832
C R
Fe
Nb
Y
Zr
Rb
Fe
Zr
Zn
Sr
COUNTS
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10 2
10 1
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400
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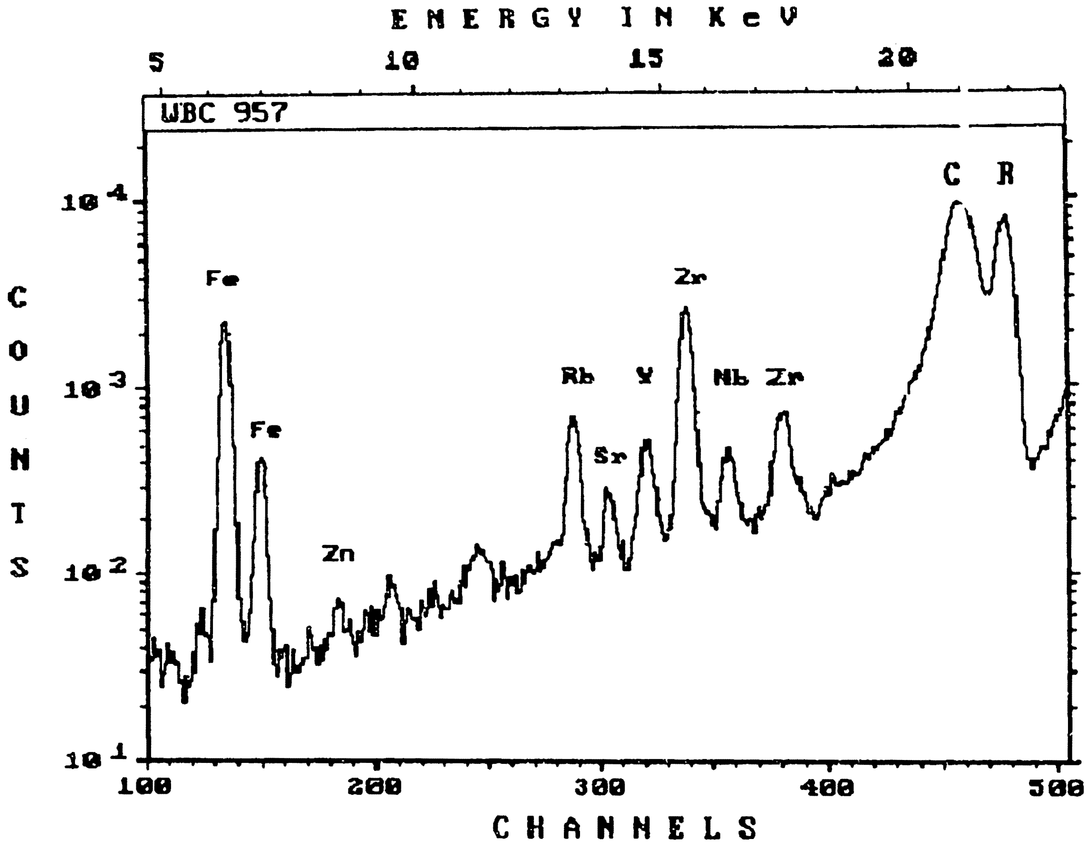
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 957
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10^3
10^2
10^1
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300
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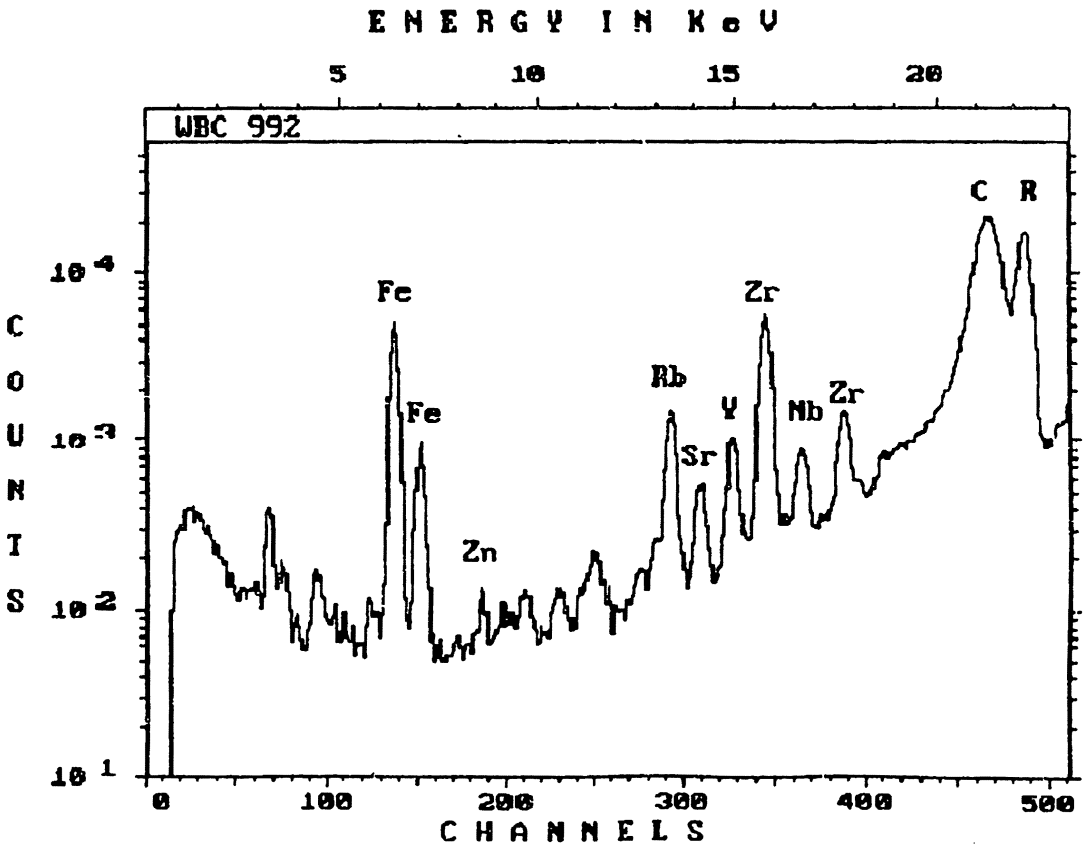
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 992
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
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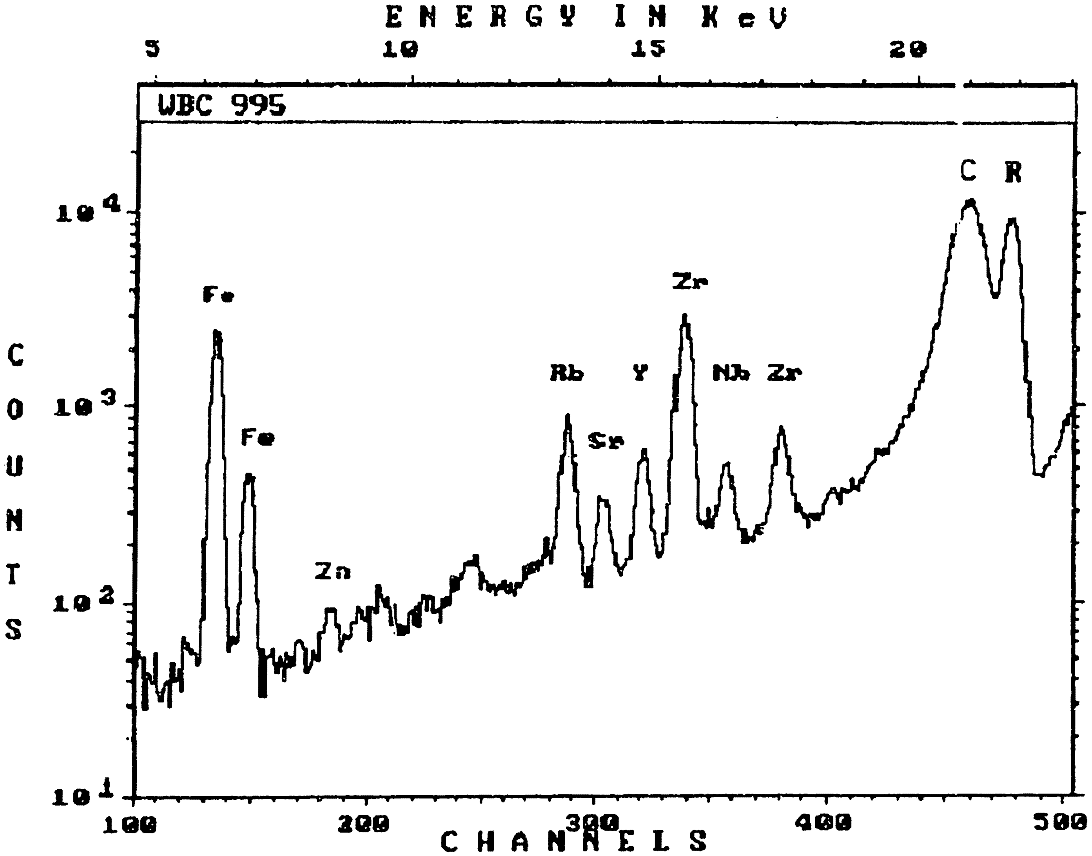
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 995
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10^3
10^2
10^1
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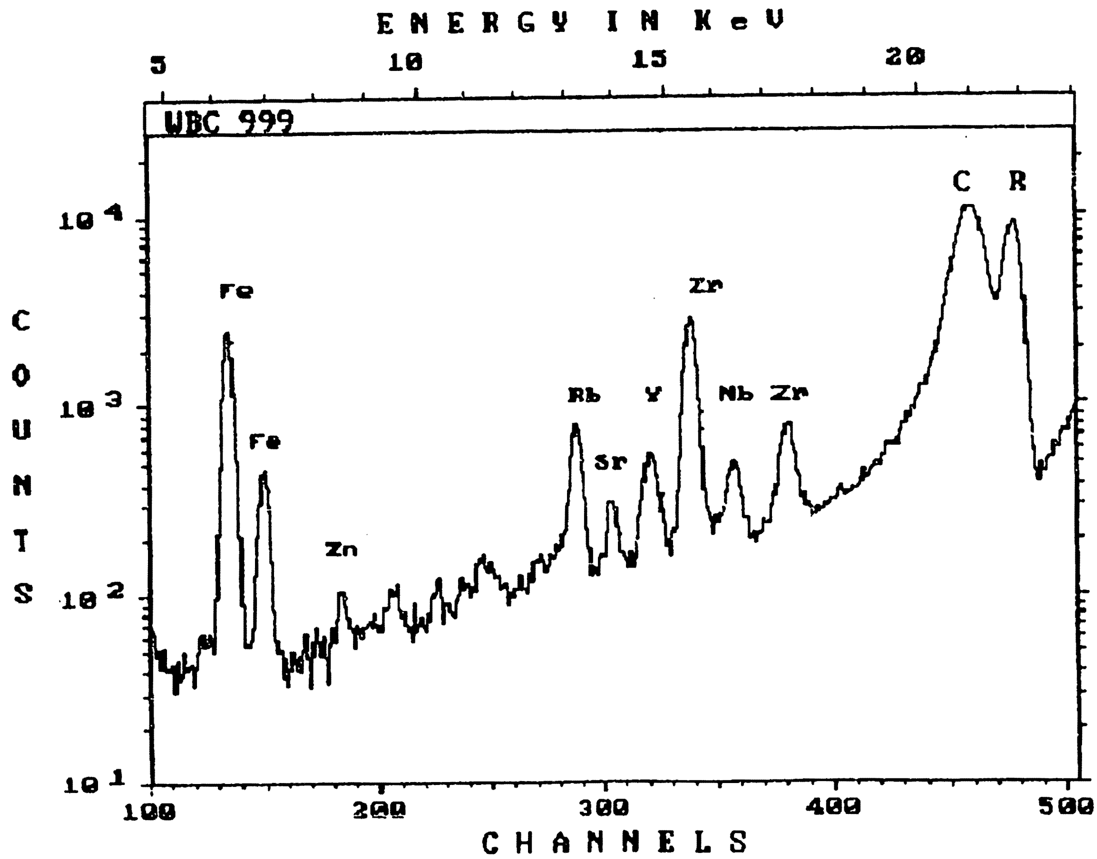
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 999
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10^3
10^2
10^1
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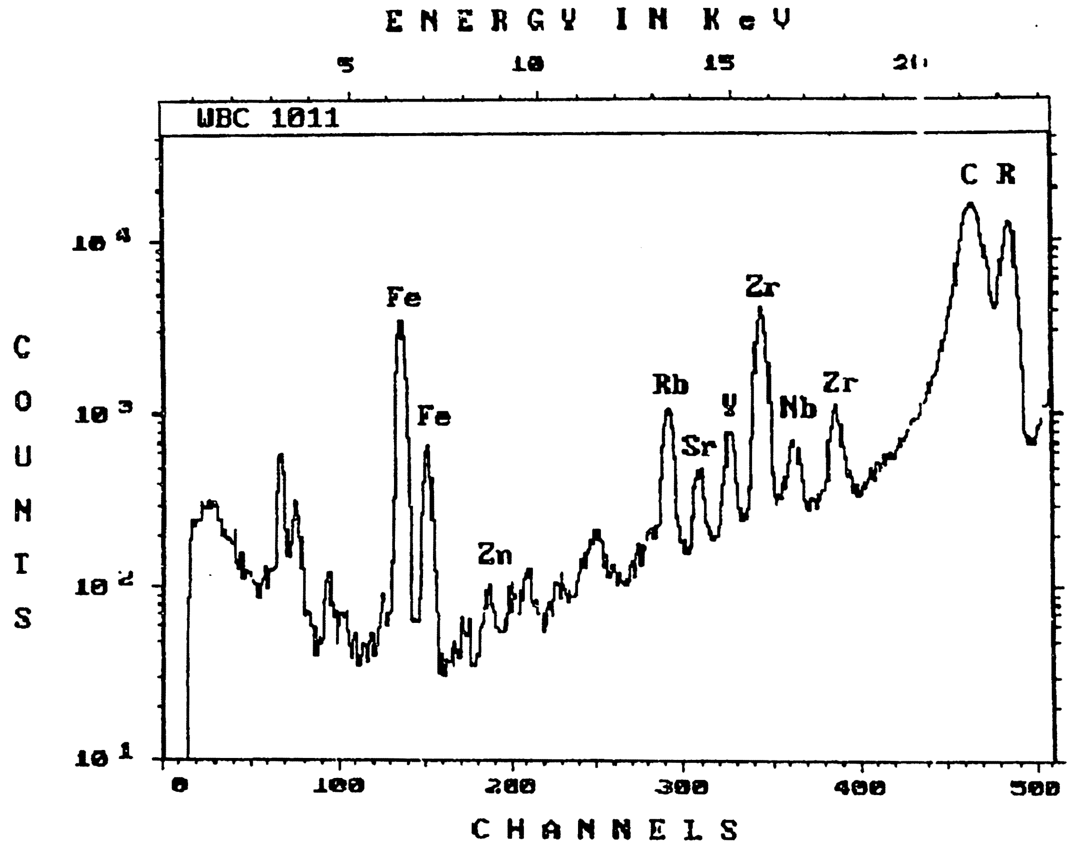
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1011
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
0
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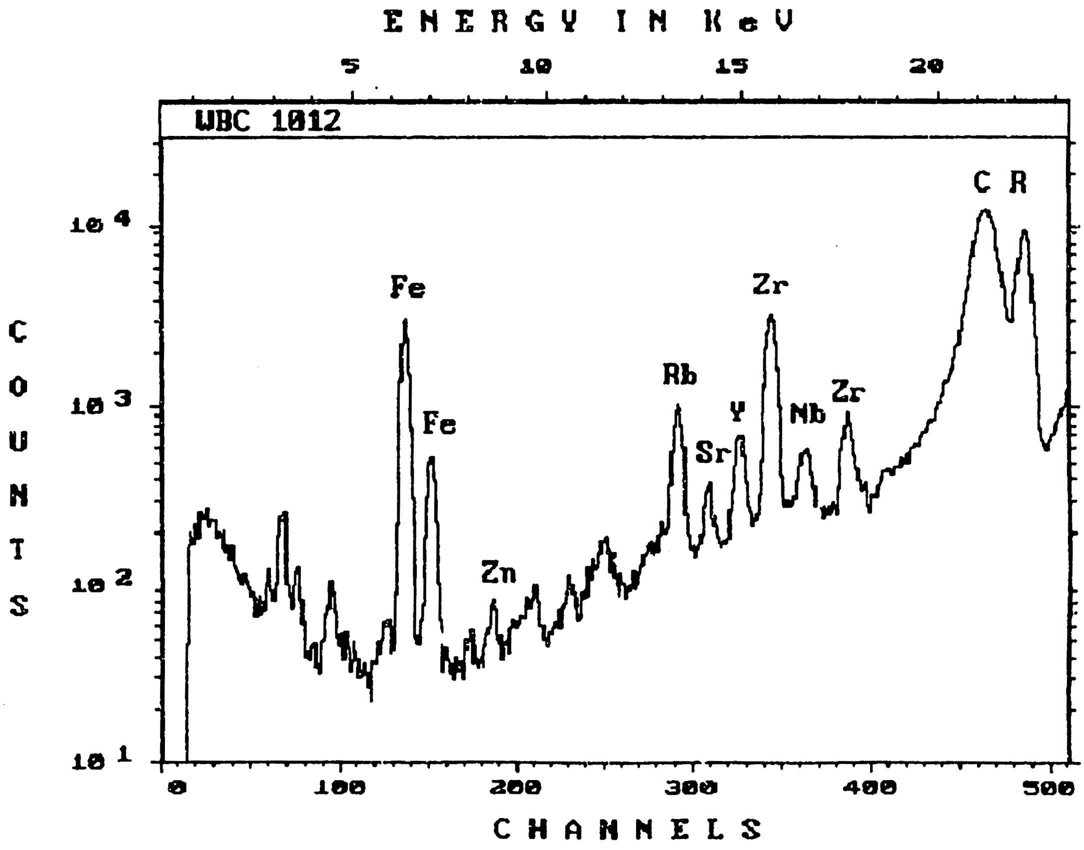
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1012
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 3
10 2
10 1
0
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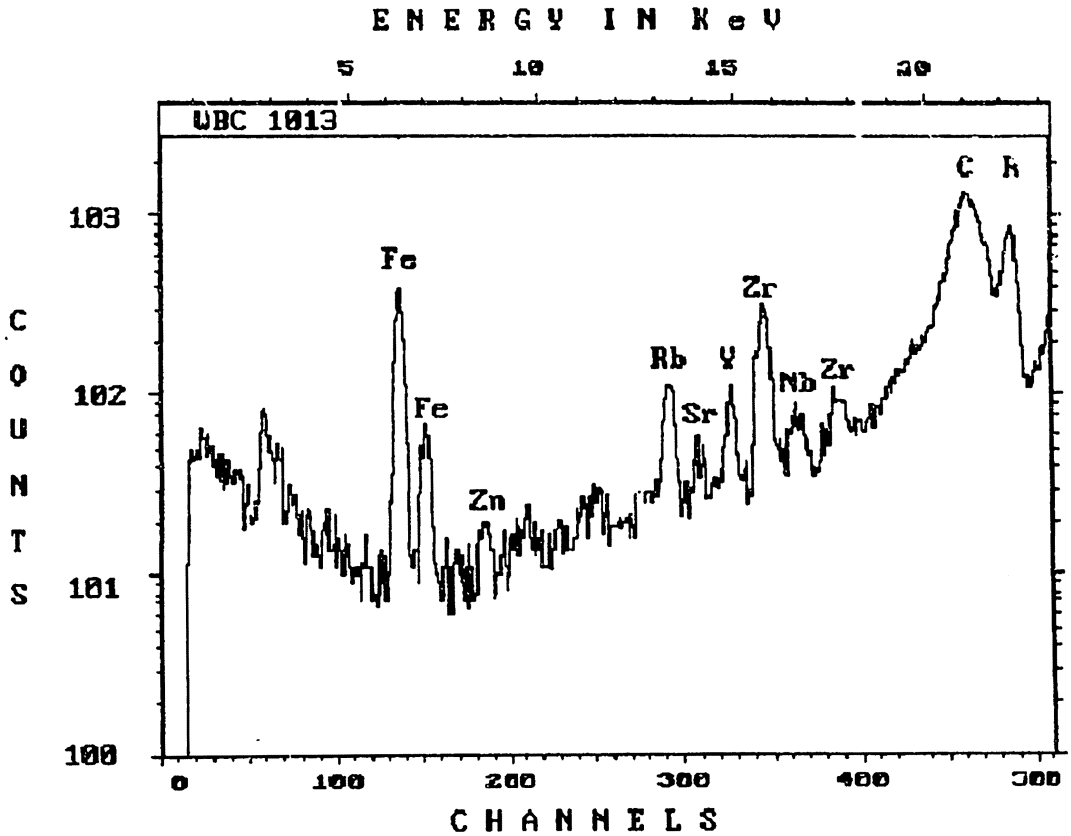
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1013
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
103
102
101
100
0
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200
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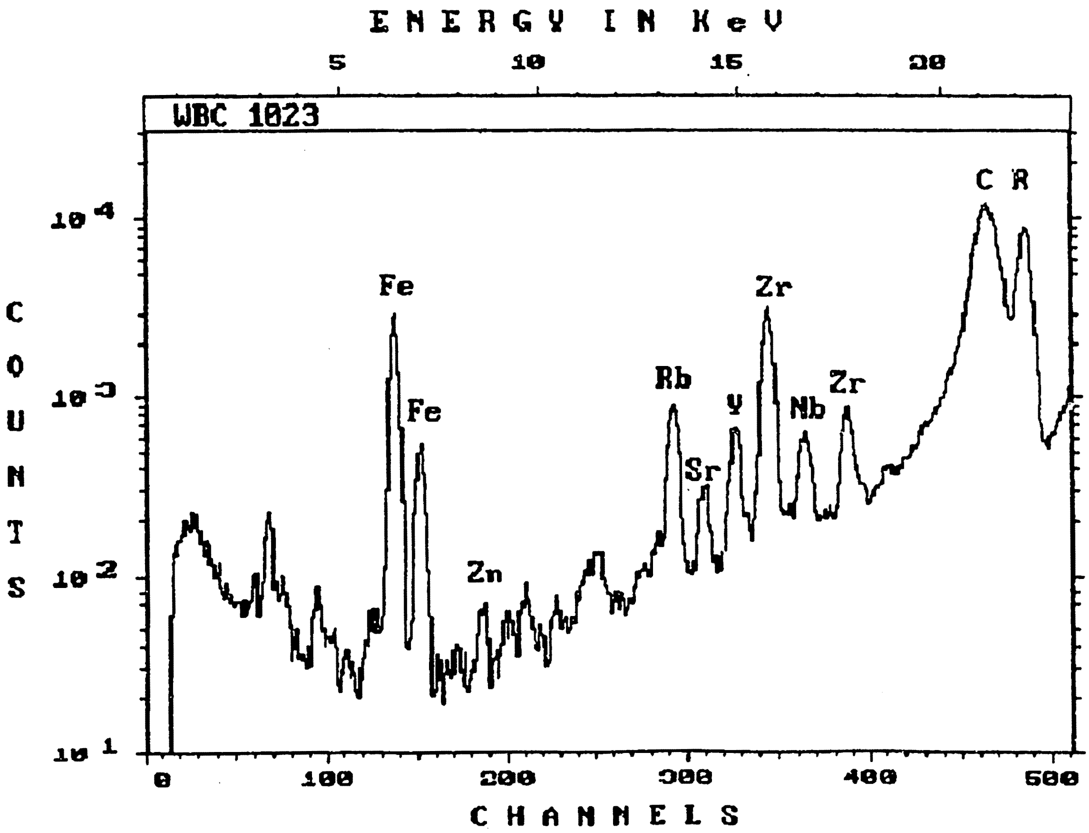
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1023
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 2
10 1
0
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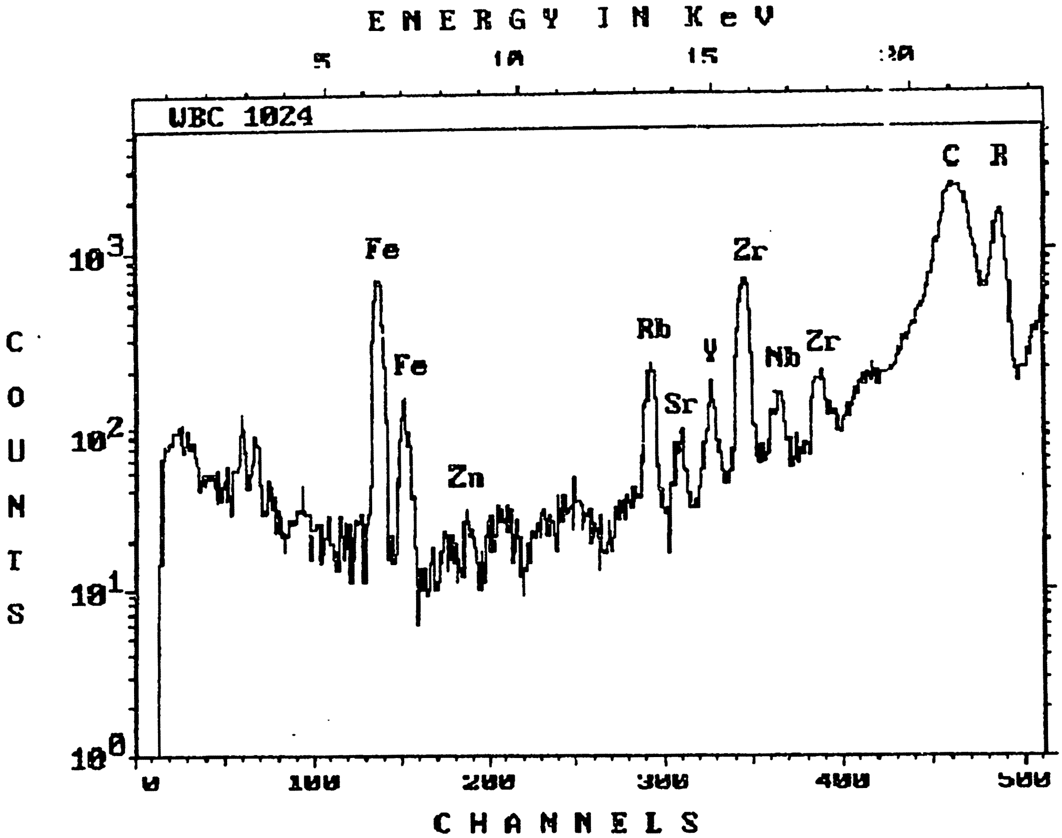
CHANNELS


ENERGY IN KeV
UBC 1024
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
10^3
10^2
10^1
10^0
COUNTS
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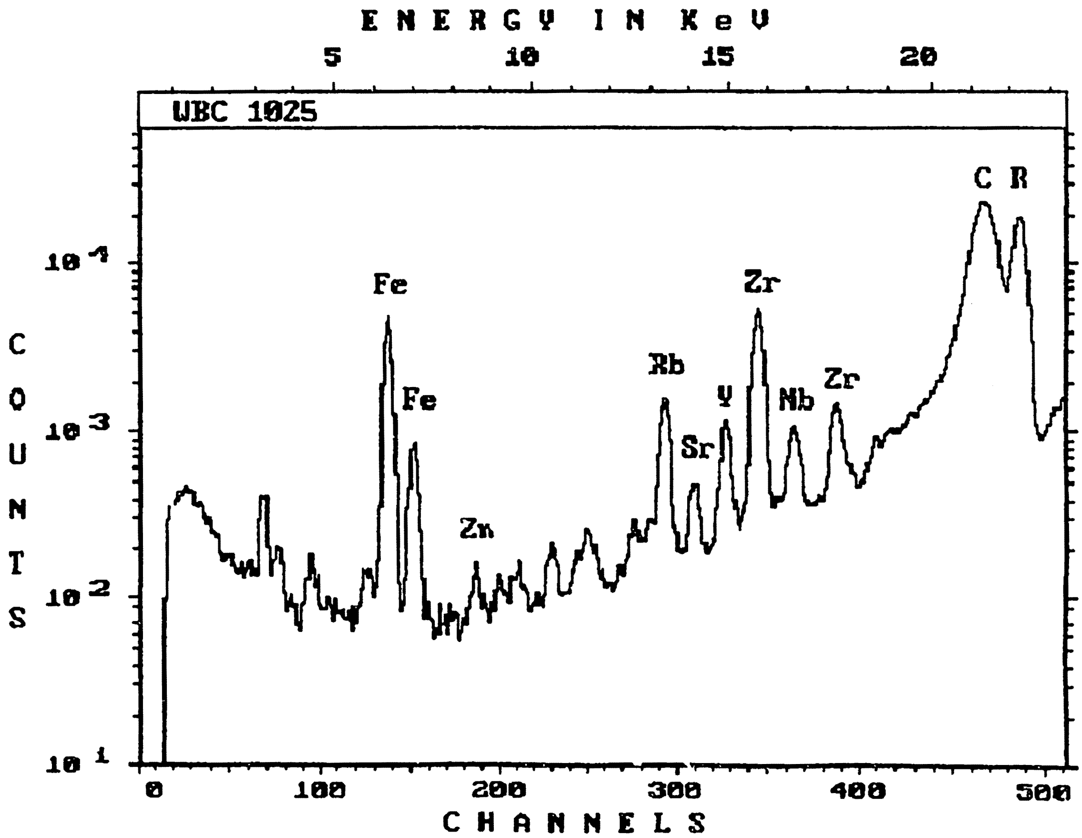
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 1025
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Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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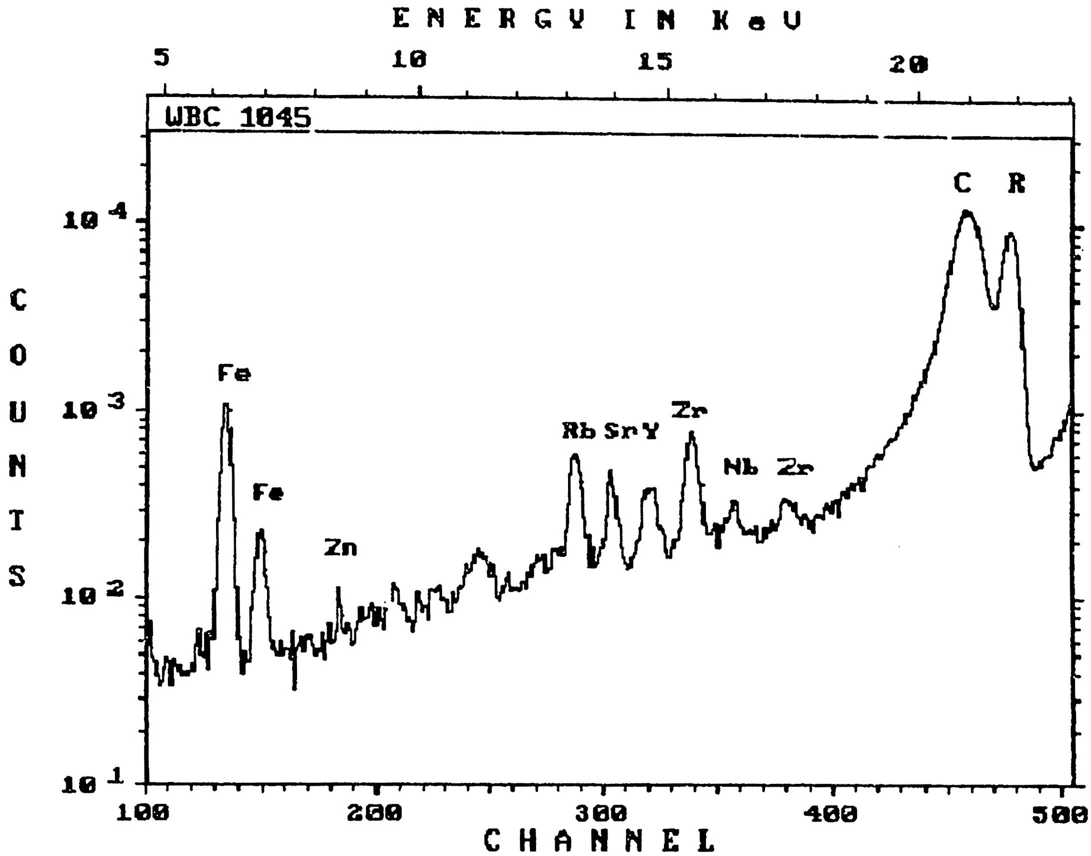
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1045
C
R
10 4
COUNTS
Fe
10 3
Rb Sr Y
Zr
Nb
Zr
Fe
Zn
10 2
10 1
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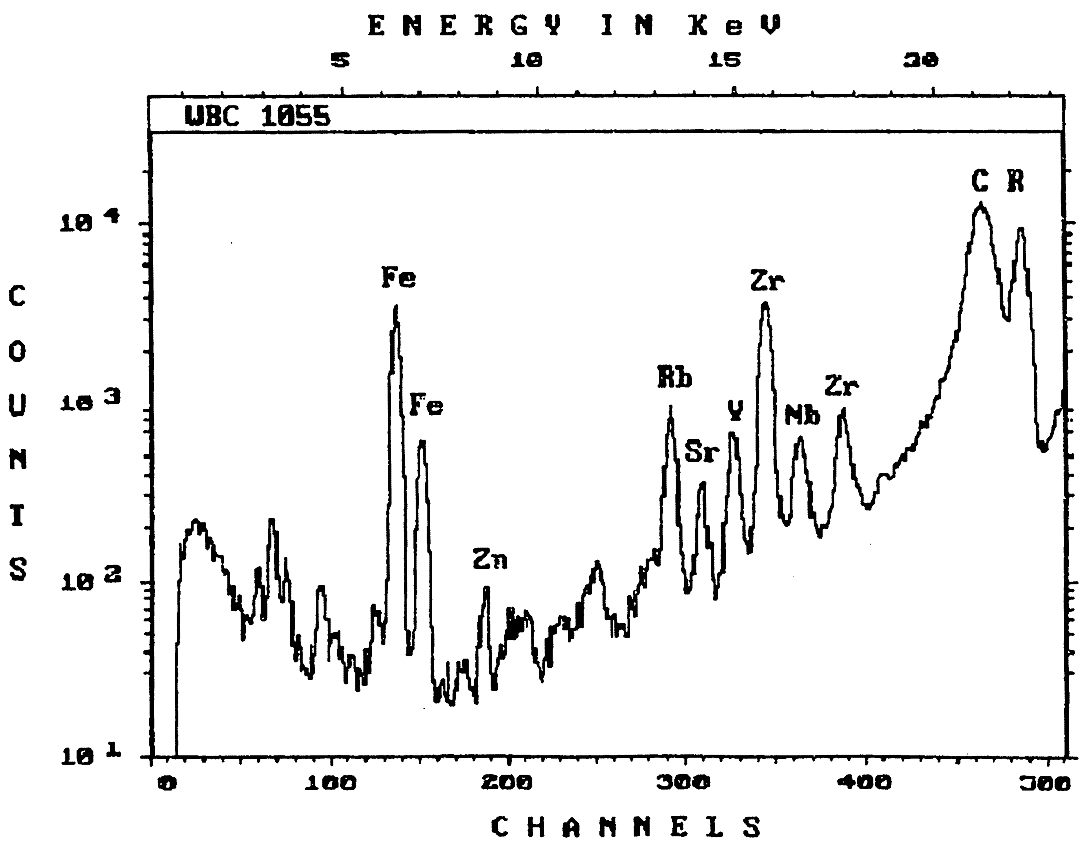
500
CHANNEL


ENERGY IN KeV
5
10
15
20
WBC 1055
C R
10 4
Fe
Zr
COUNTS
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Zr
10 3
Fe
Sr
Y
Nb
Zn
10 2
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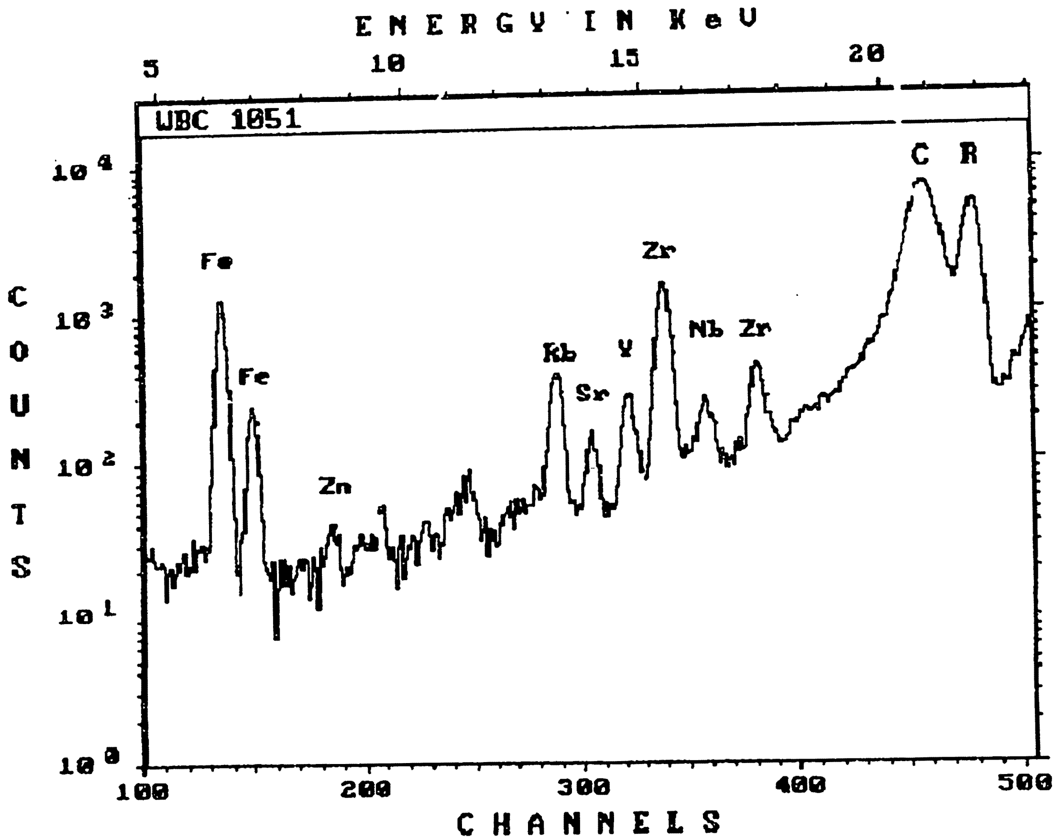
CHANNELS


ENERGY IN KeV
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Zn
Rb
Sr
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Nb
Zr
COUNTS
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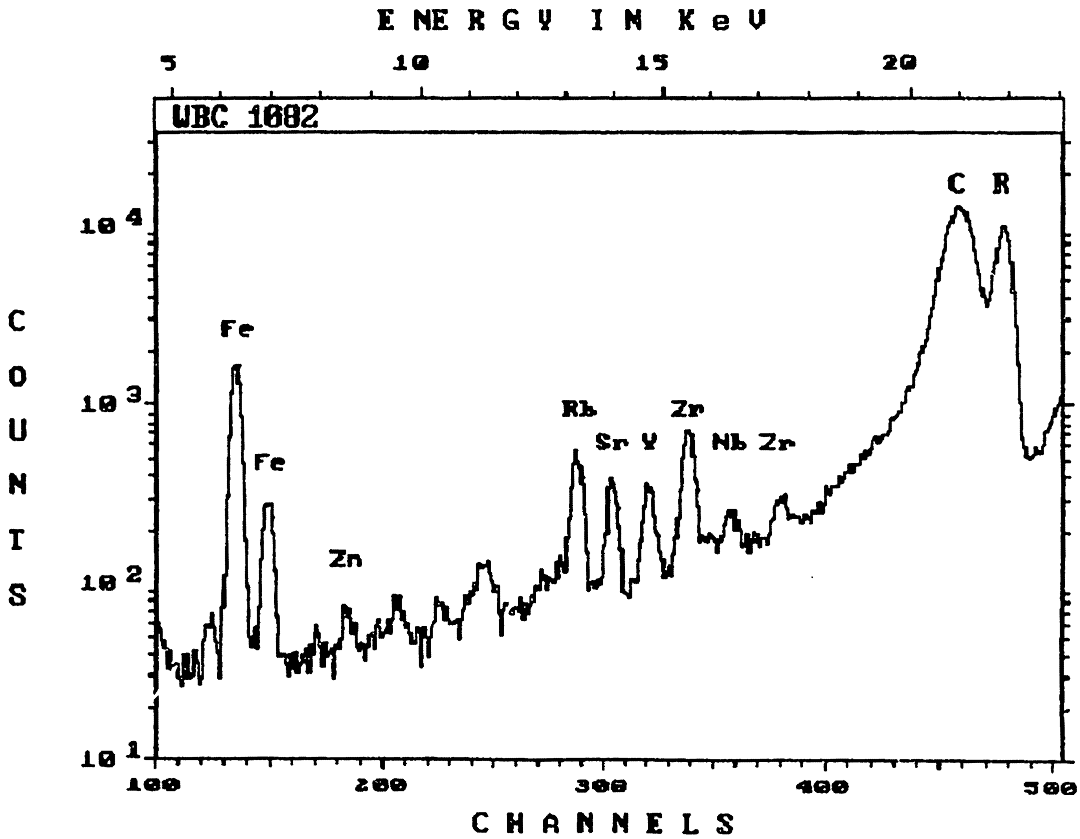
ENERGY IN KeV
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Nb
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COUNTS
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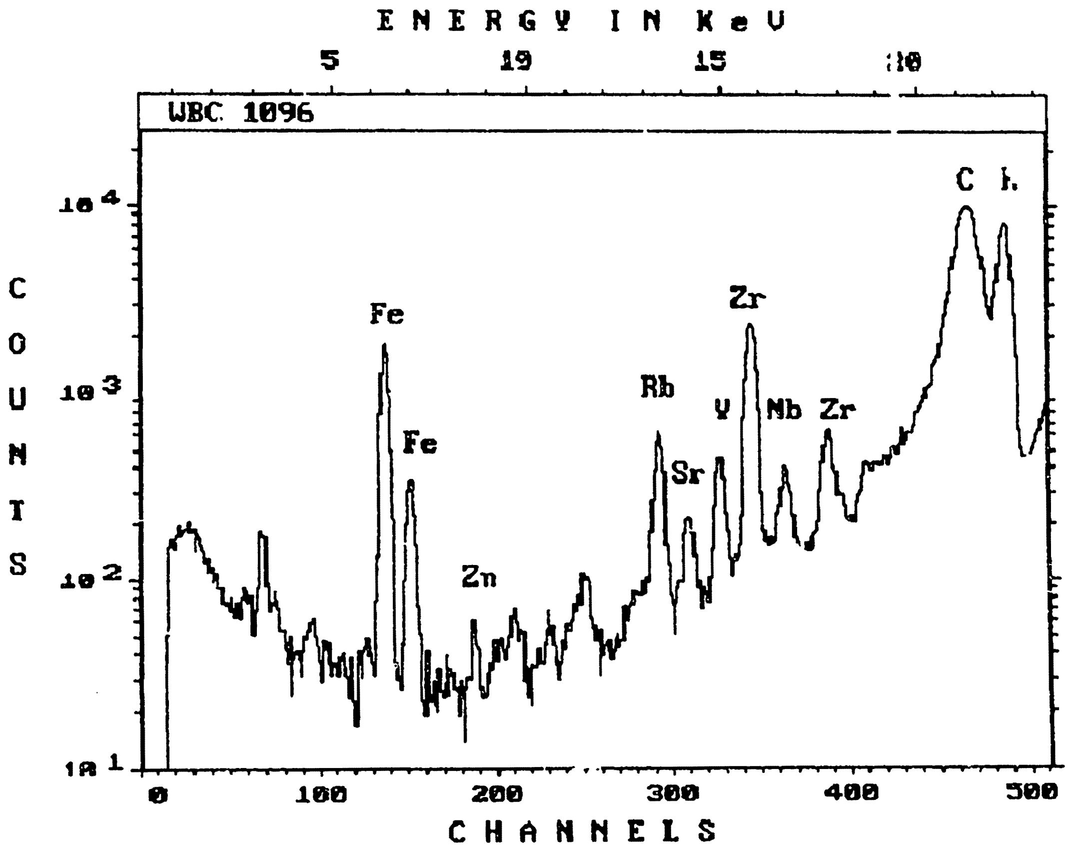
CHANNELS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Zn
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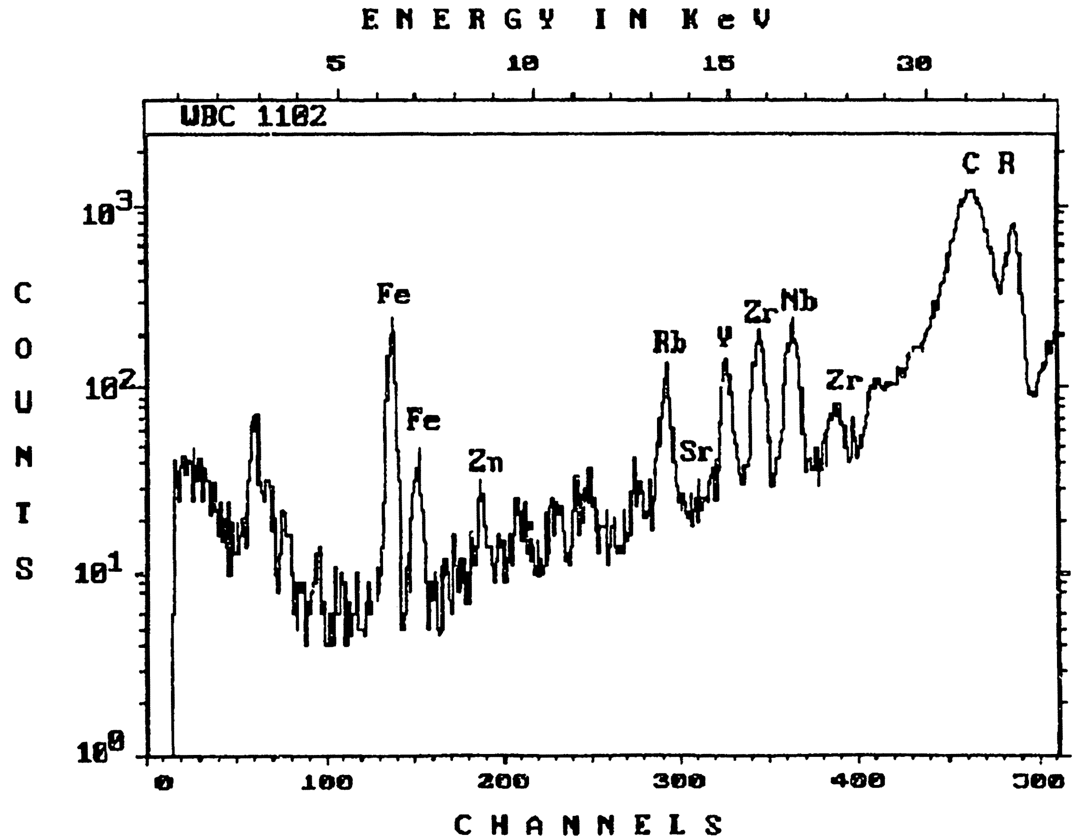
Y
Zr
Nb
Zr


ENERGY IN KeV
WBC 1102
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CHANNELS
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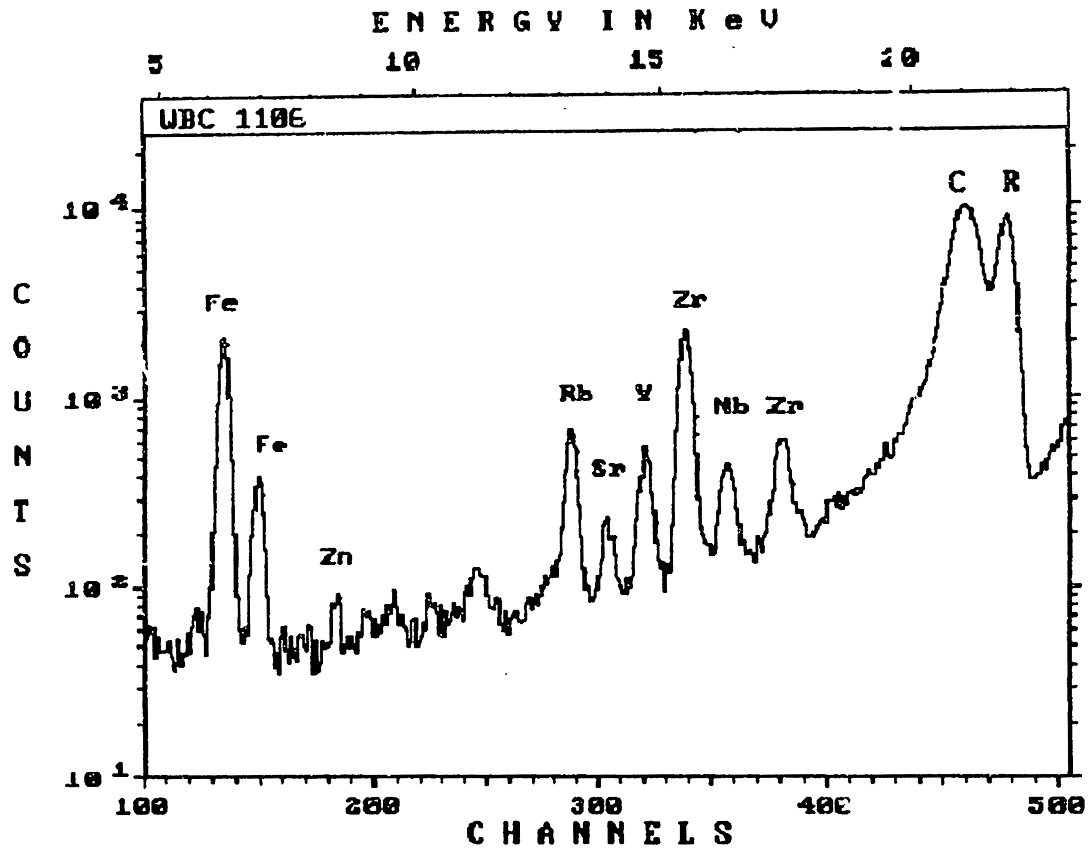
Zn
Rb
Sr
Y
Zr
Nb
Zr
C R


ENERGY IN KeV
5
10
15
20
WBC 1106
C
R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 2
10 1
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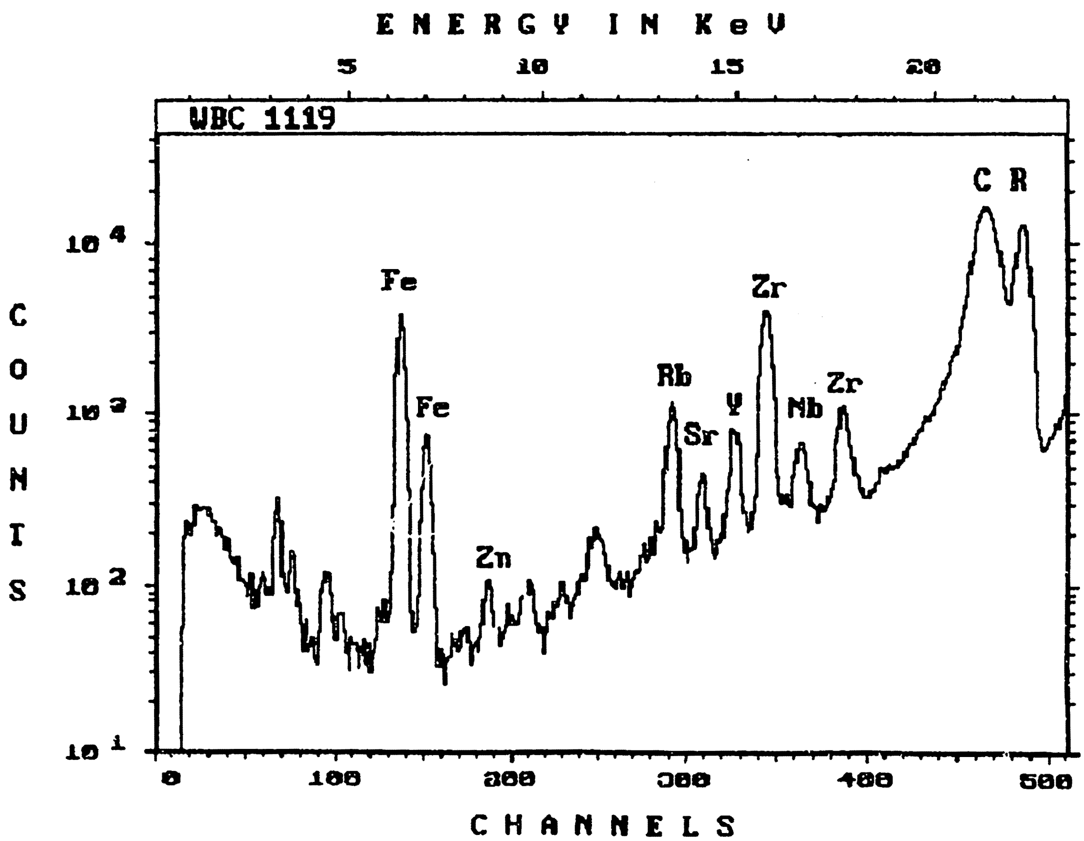
500
CHANNELS


ENERGY IN KeV
5
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15
20
WBC 1119
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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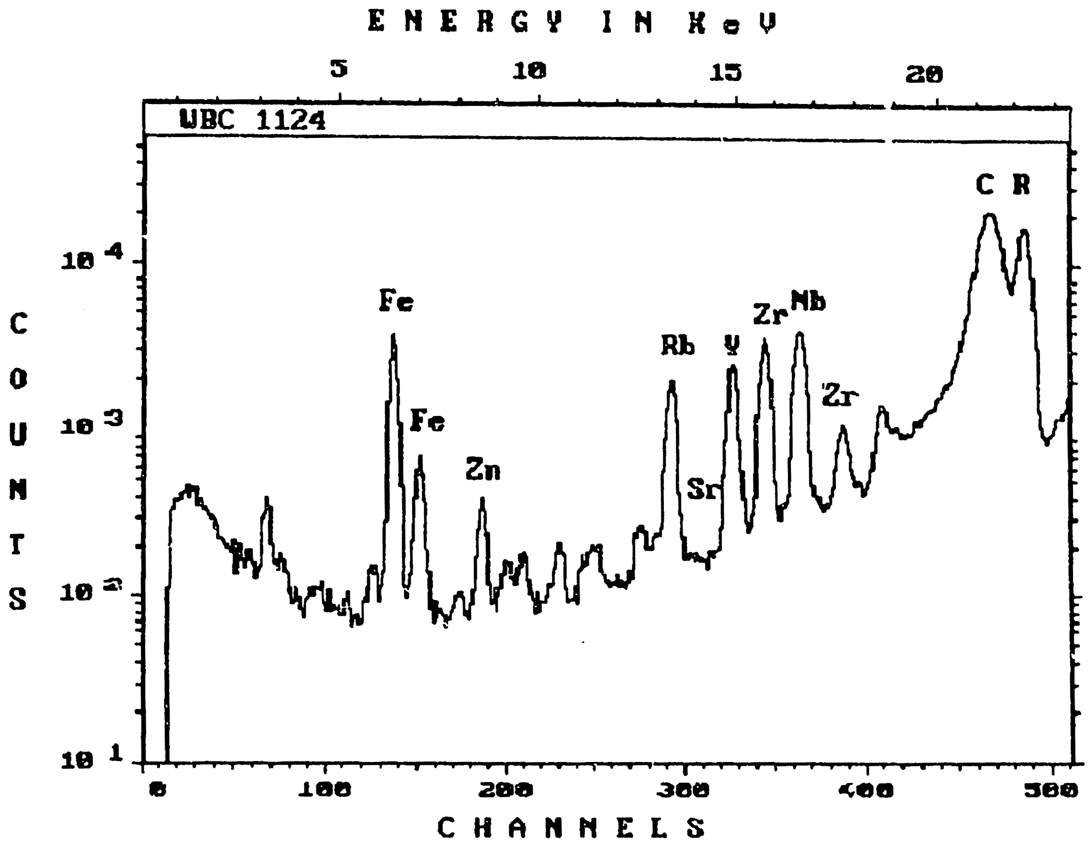
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1124
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 1
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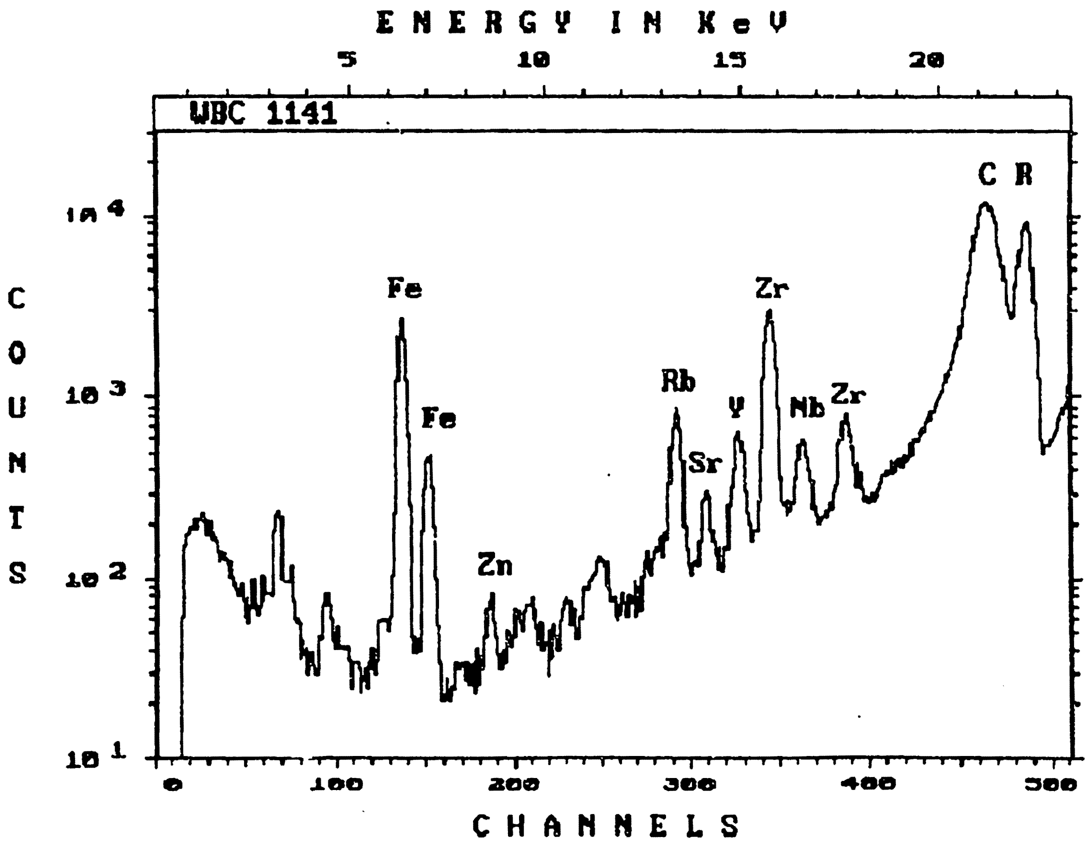
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1141
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 1
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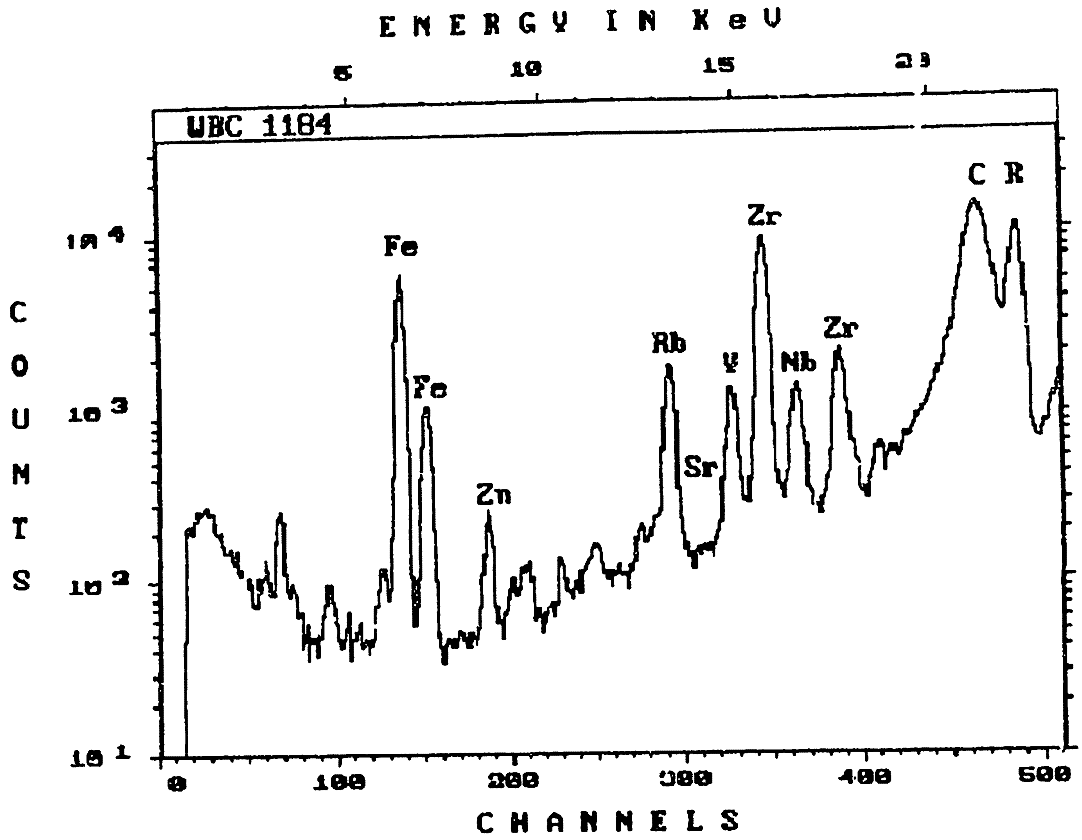
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 1184
C R
Zr
Fe
Fe
Rb
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Y
Nb
Zr
Zn
COUNTS
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10 1
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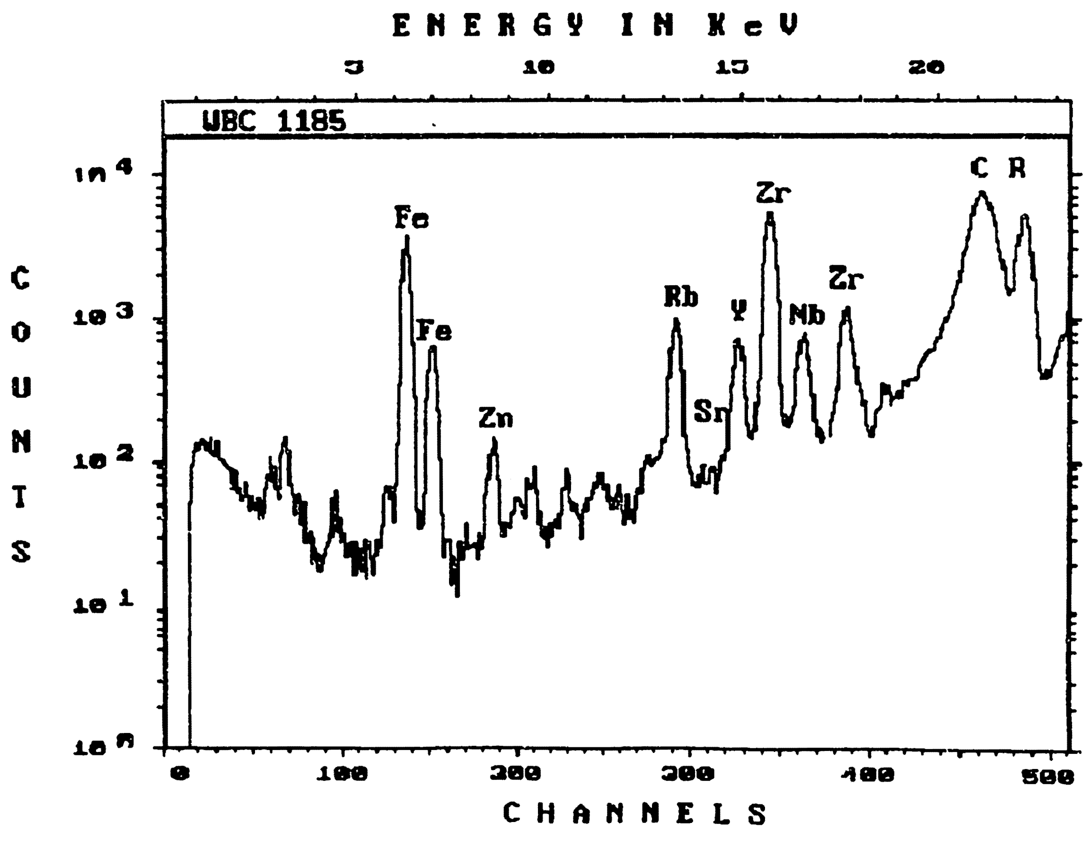
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 1185
C R
Zr
Fe
Fe
Rb
Y
Nb
Zr
Sr
Zn
COUNTS
10 4
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10 2
10 1
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0
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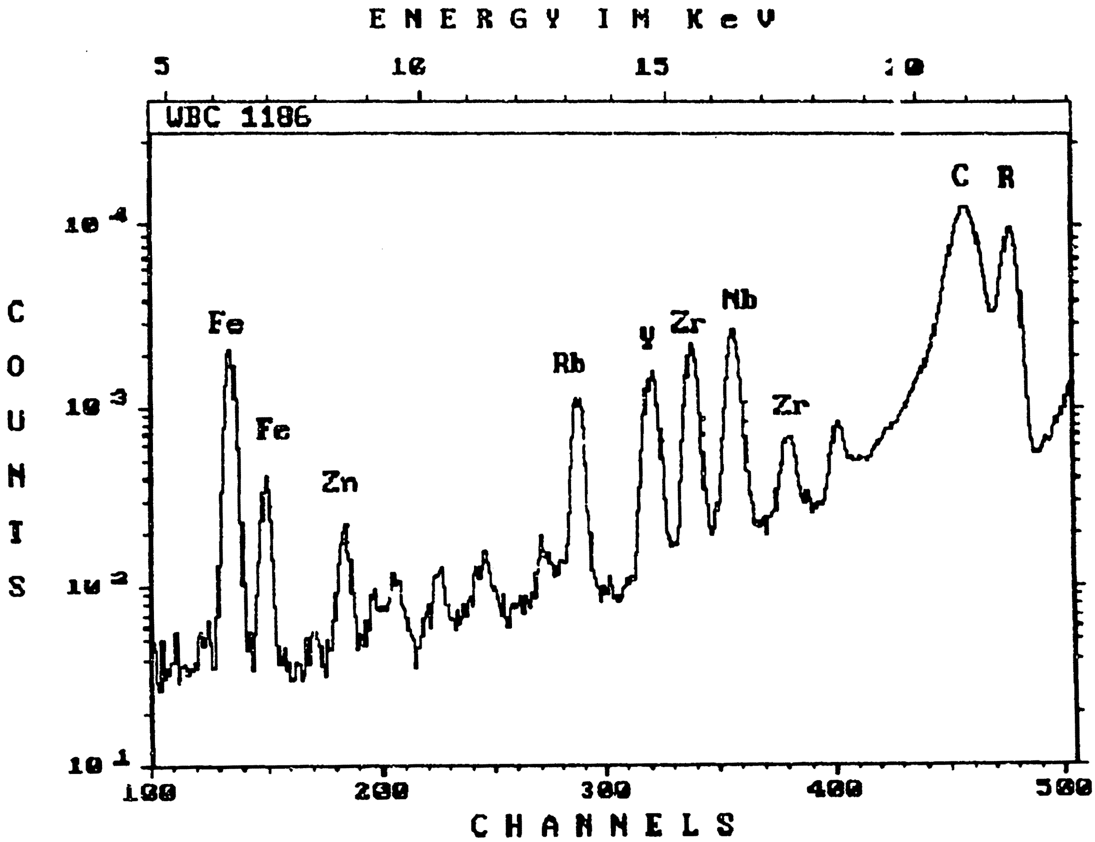
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 1186
C R
10^4
Fe
Fe
Zn
Rb
Y
Zr
Nb
Zr
10^3
10^2
10^1
COUNTS
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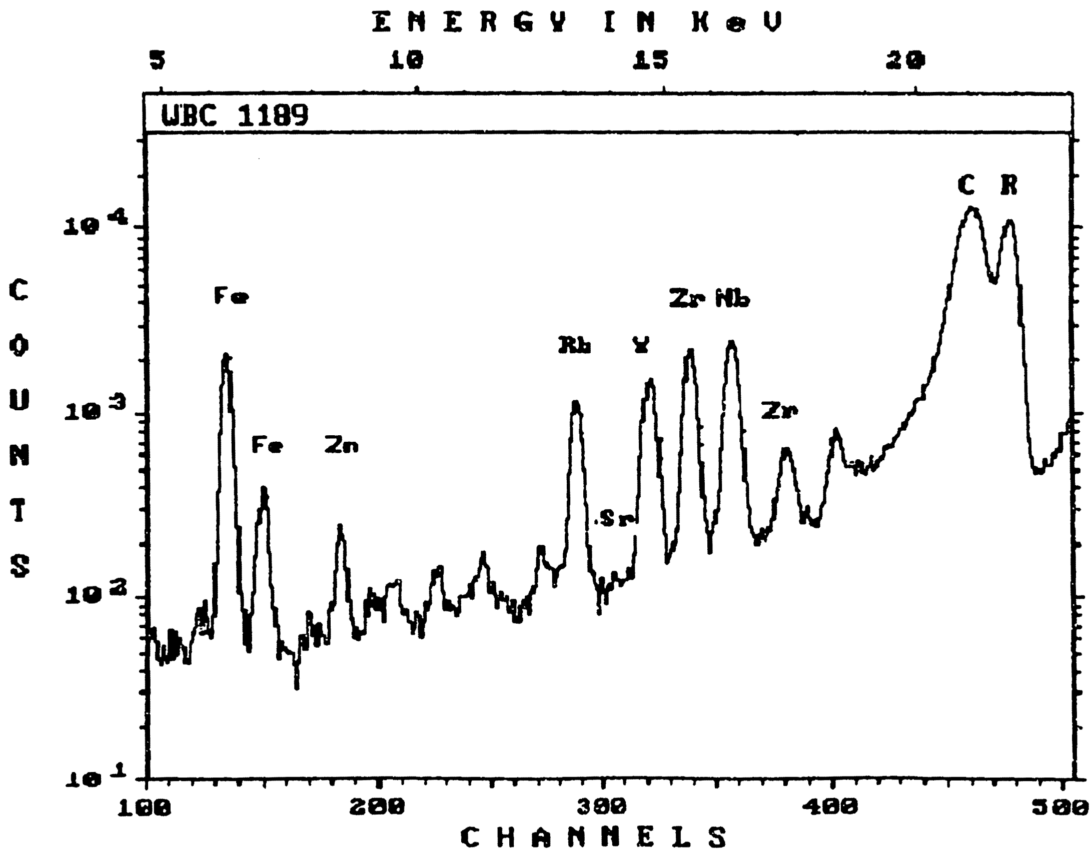
200
300
400
500
CHANNELS


ENERGY IN KeV
5
10
15
20
UBC 1189
C R
10^4
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
10^3
10^2
10^1
COUNTS
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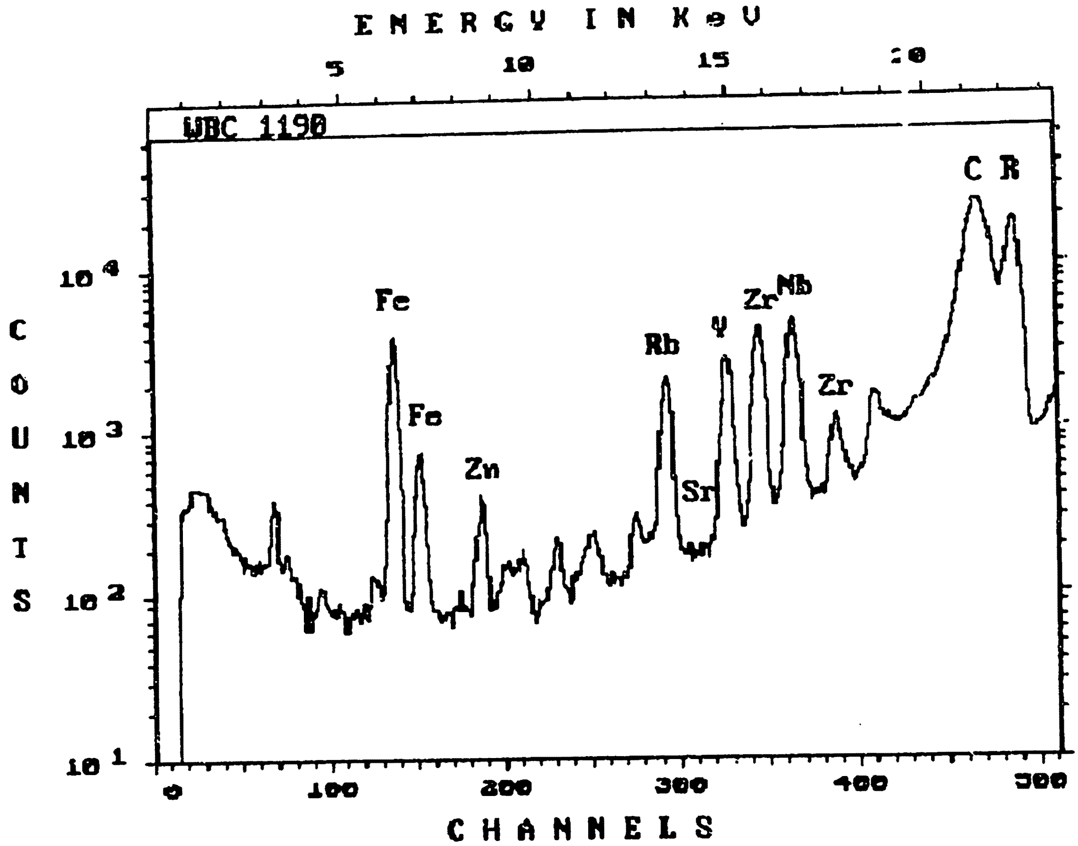
400
500
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 1190
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
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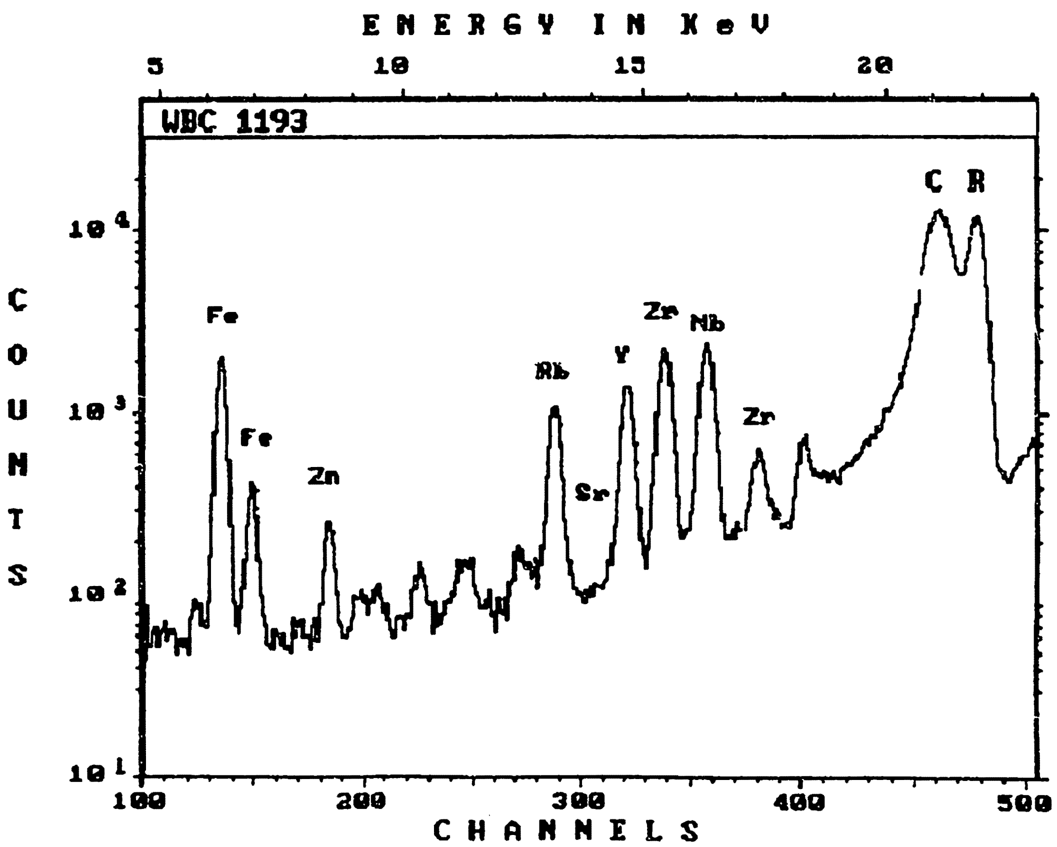
CHANNELS



ENERGY IN KeV
5
10
15
20
WBC 1193
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10 4
10 3
10 2
10 1
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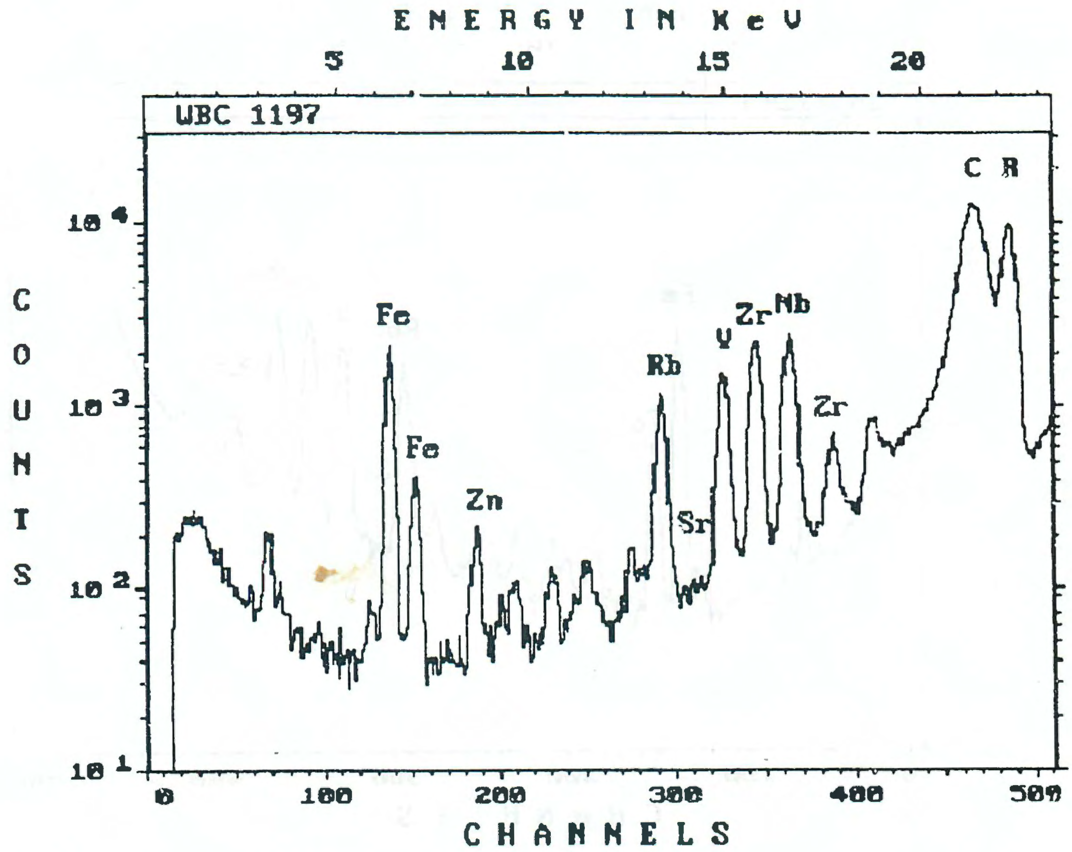
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1197
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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300
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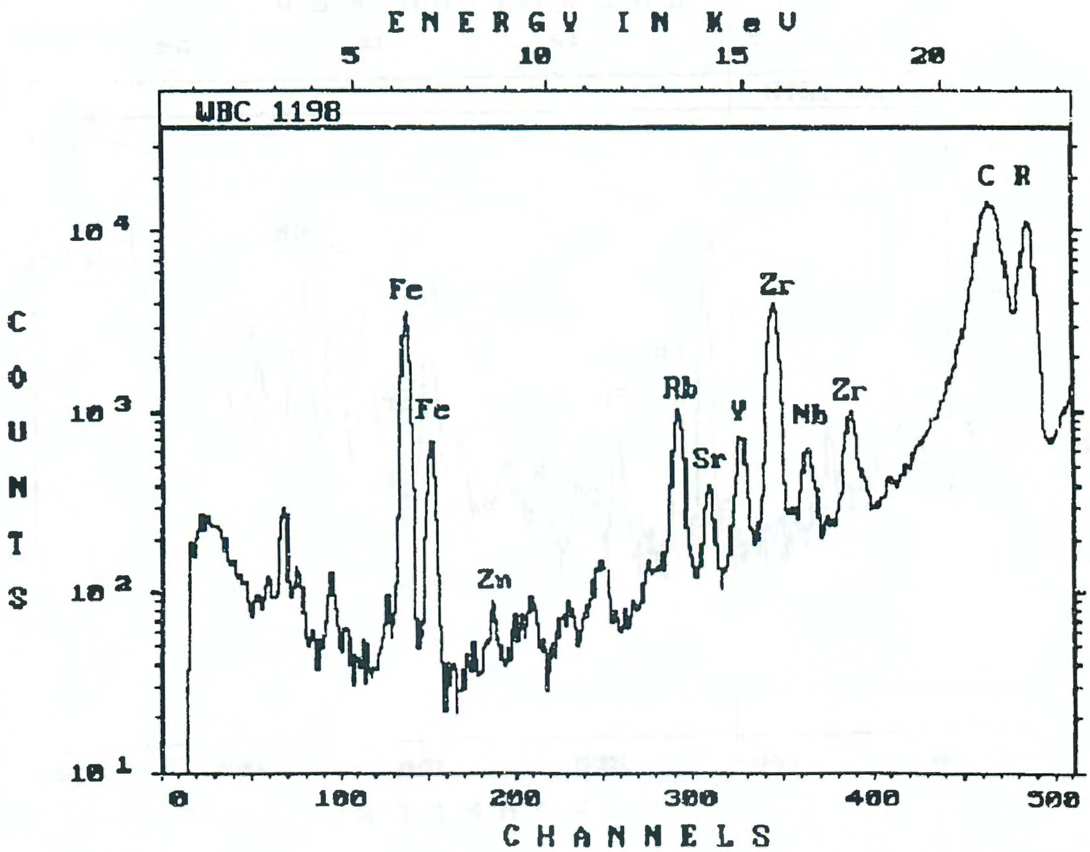
500
CHANNELS


ENERGY IN KeV
5
10
15
20
WBC 1198
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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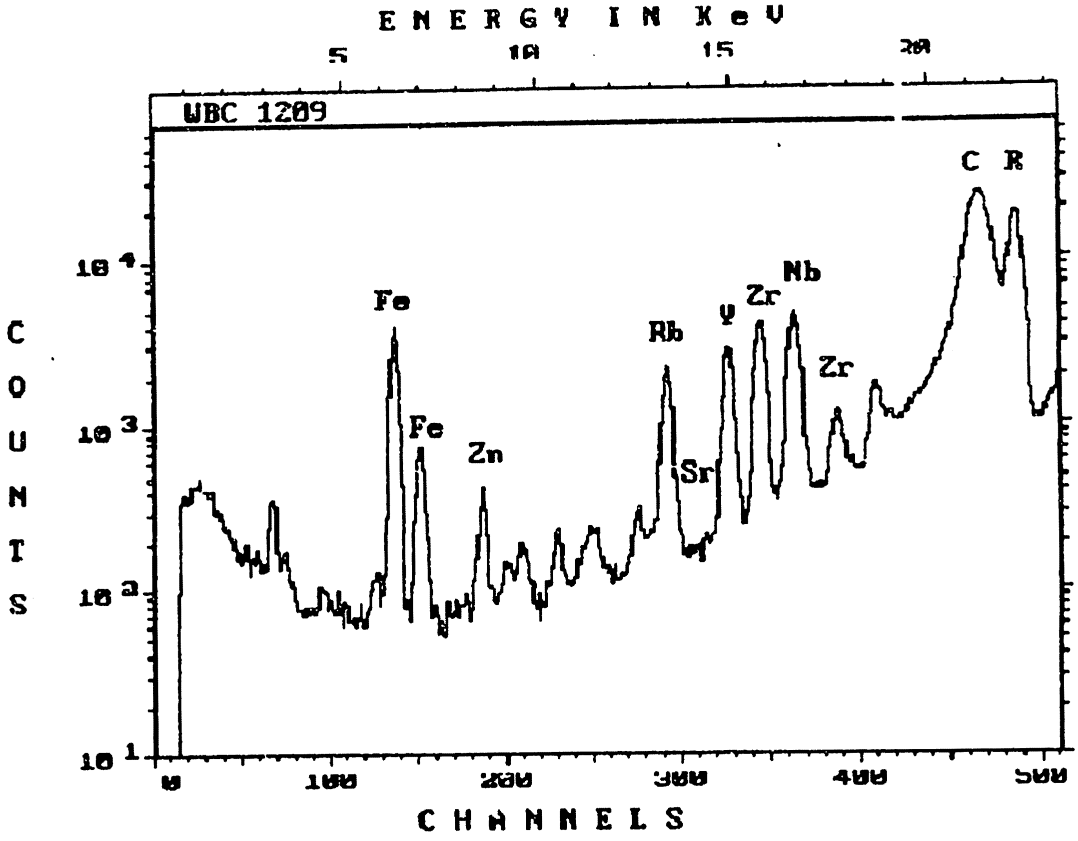
500
CHANNELS


ENERGY IN KeV
WBC 1209
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Fe
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Rb
Sr
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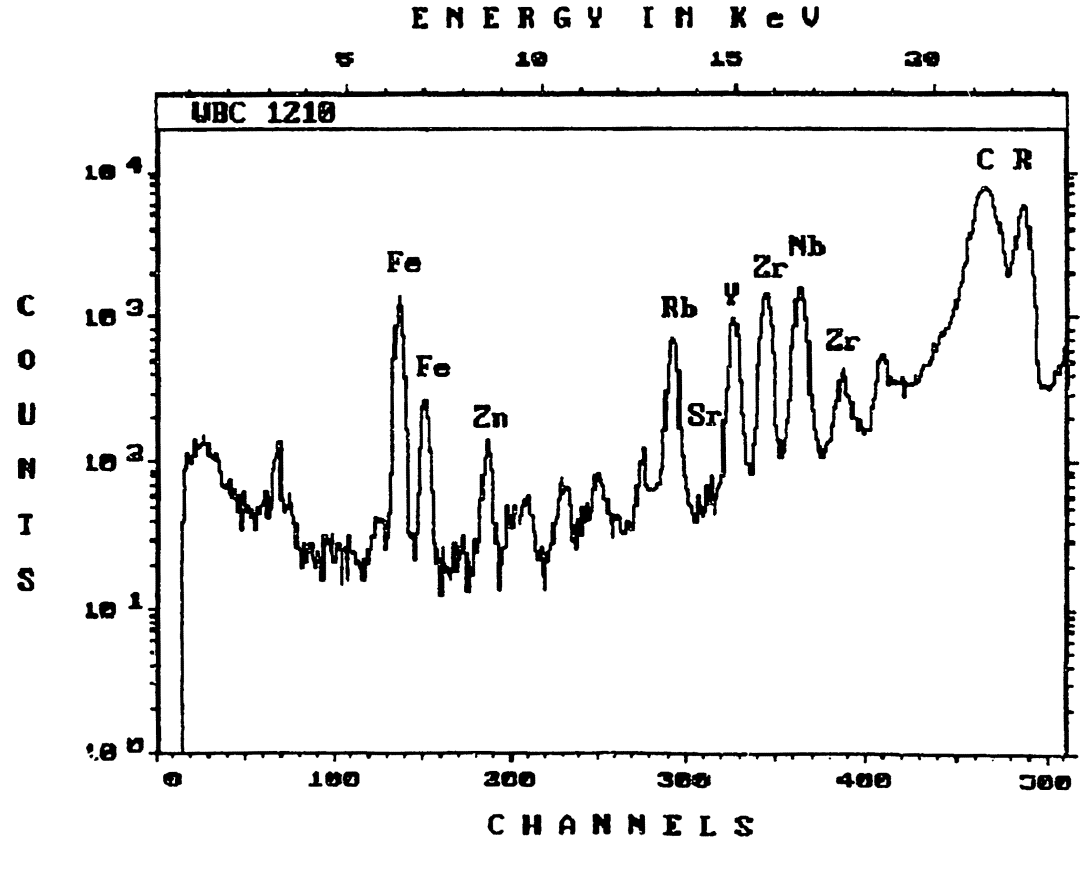
Nb
Zr
COUNTS
CHANNELS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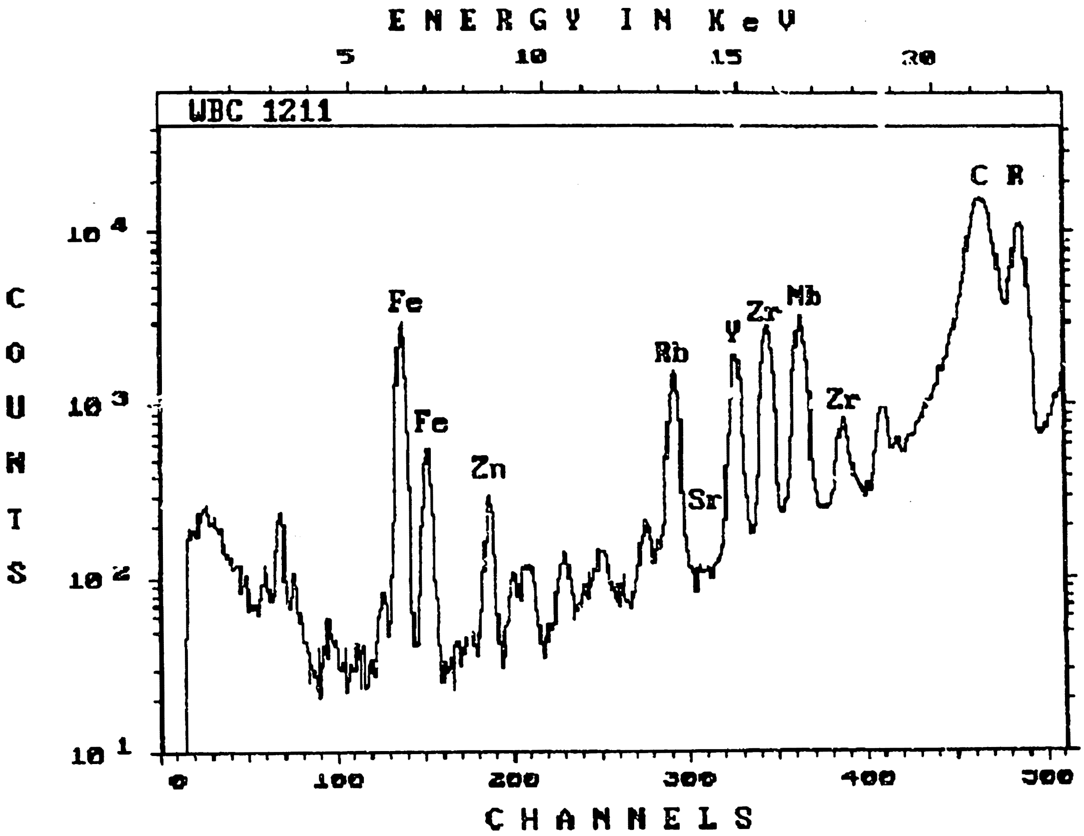
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R
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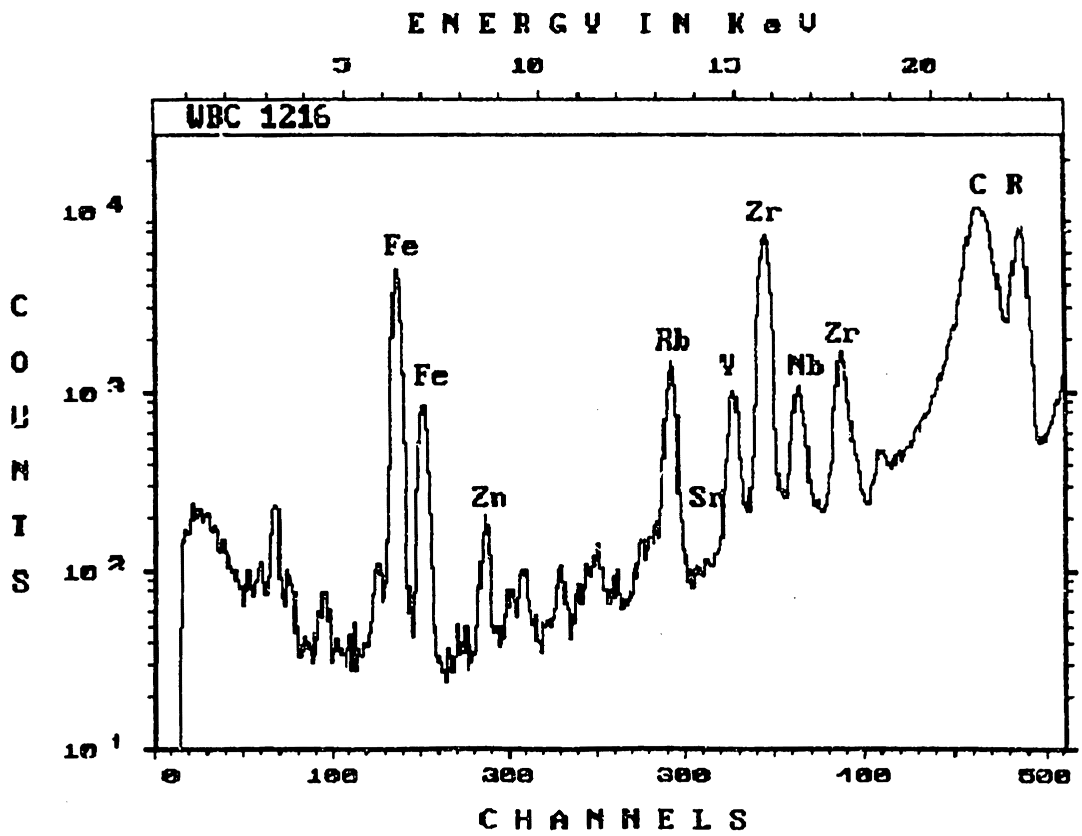
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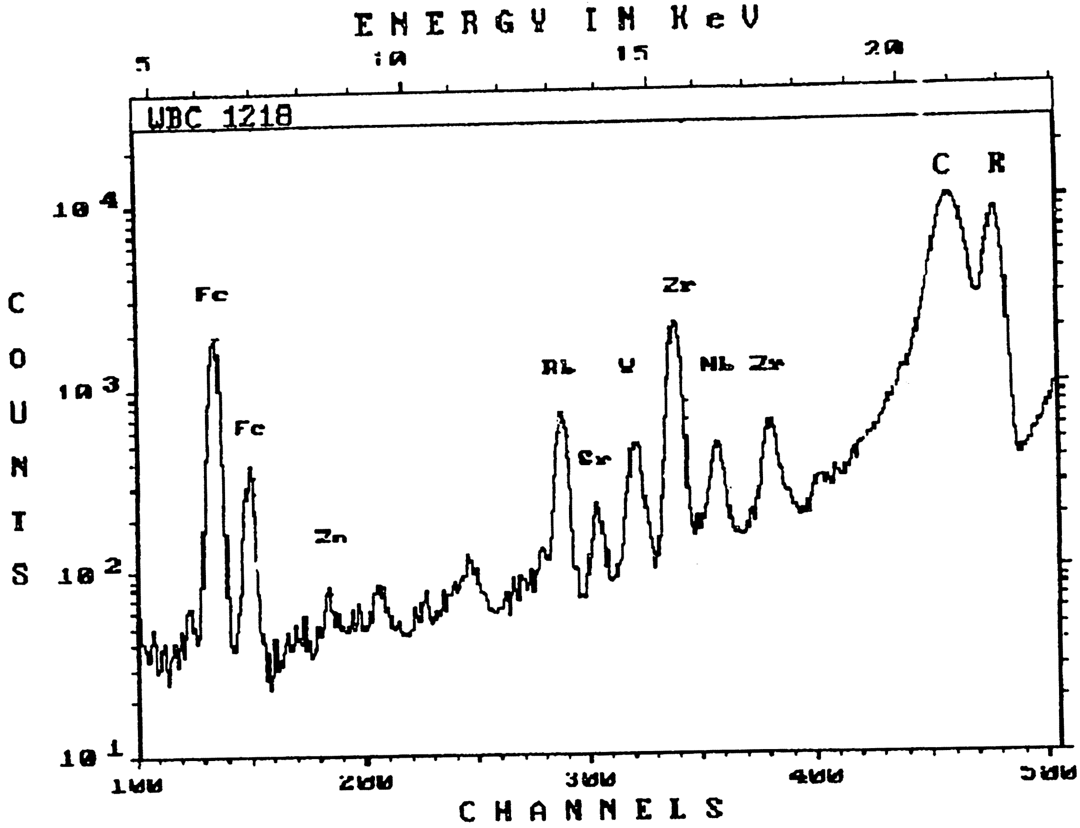
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Nb Zr
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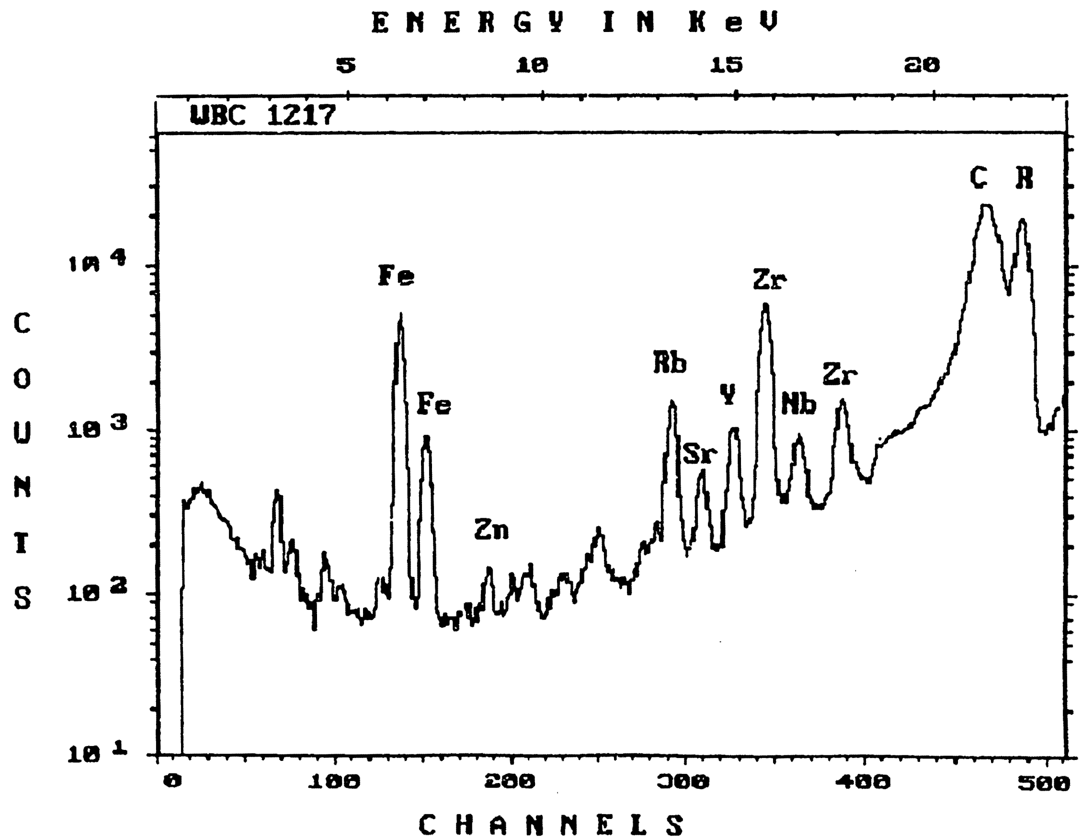
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COUNTS
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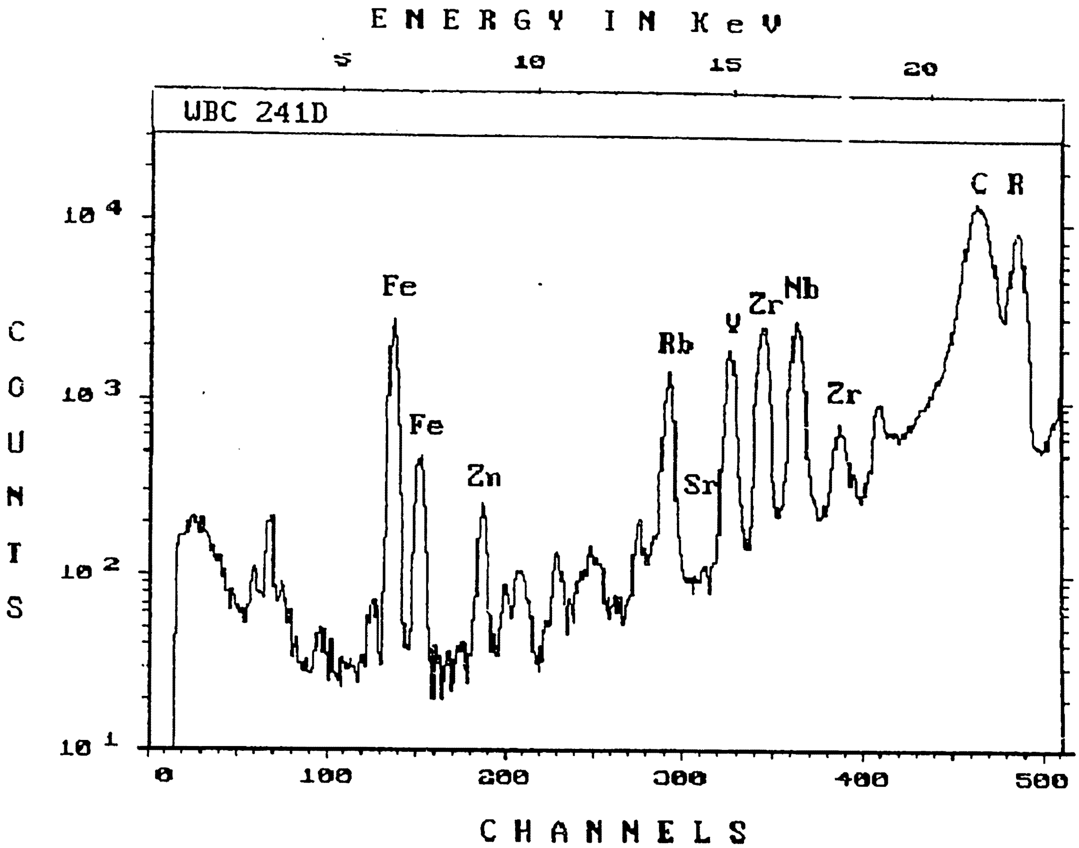
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Fe
Zn
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COUNTS
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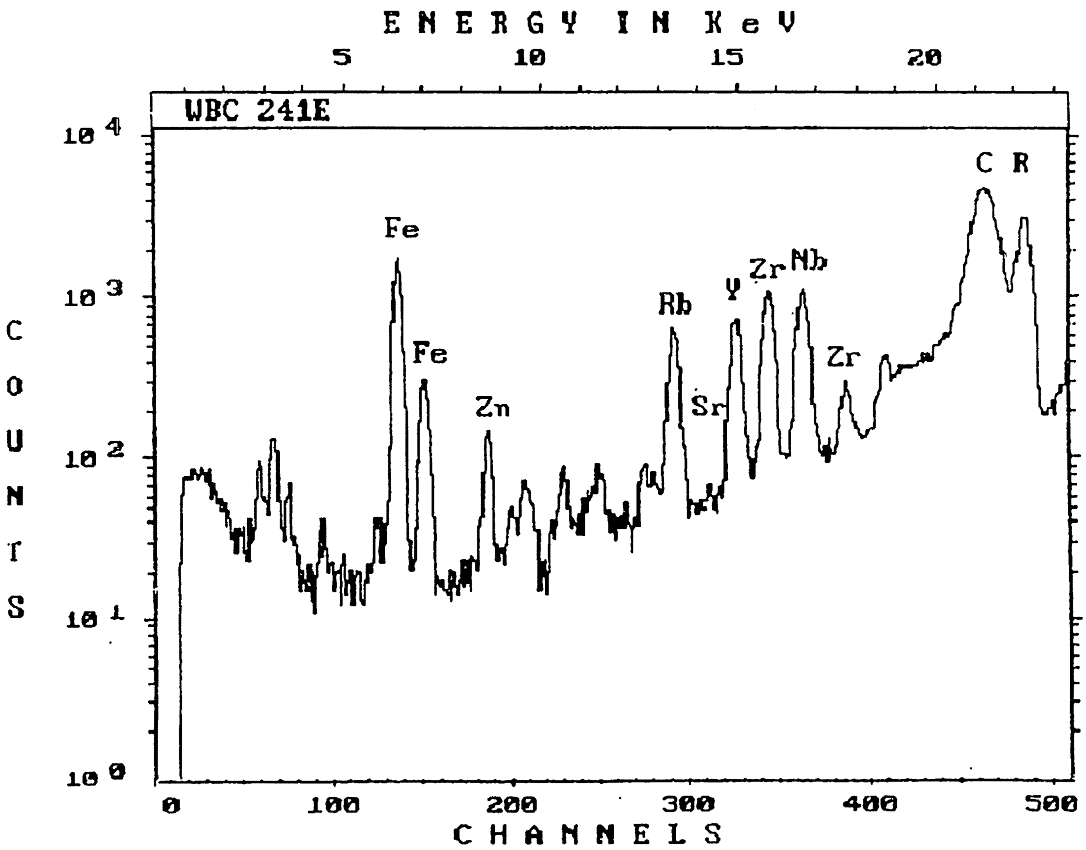
CHANNELS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COUNTS
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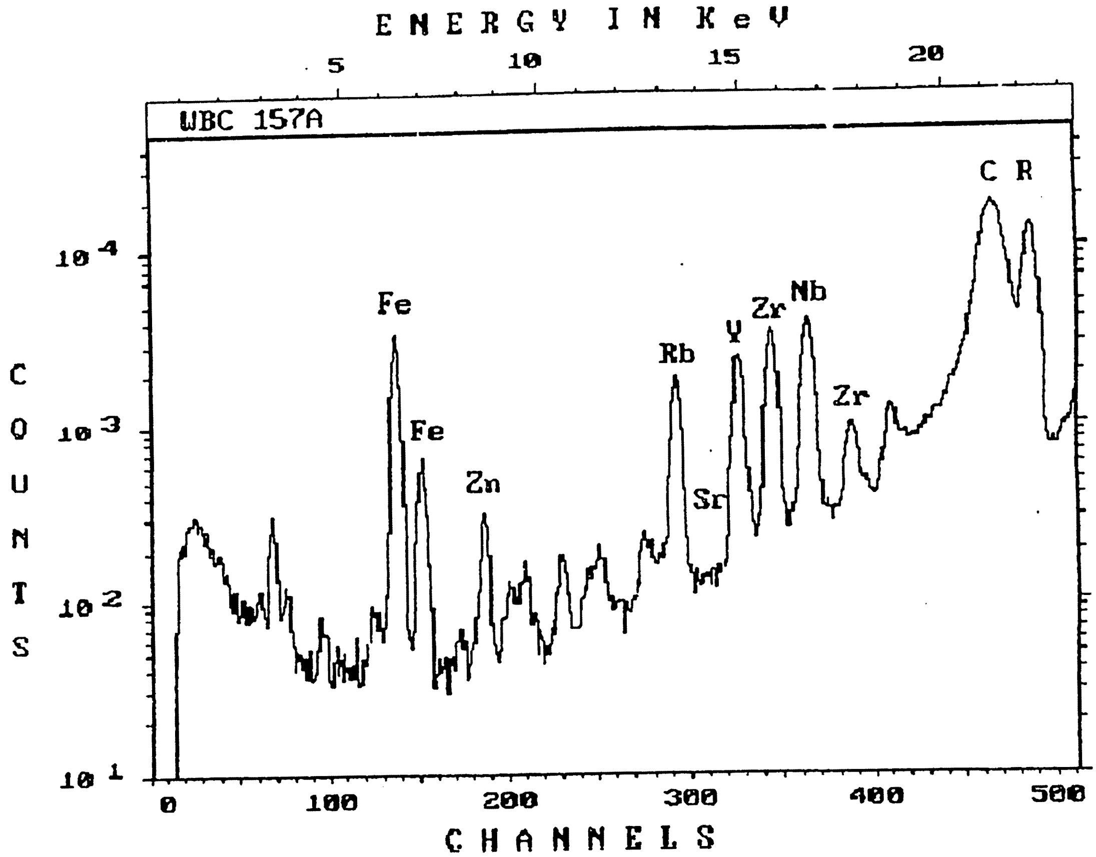

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C R
Fe
Fe
Zn
Rb
Sr
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Nb
Zr
COUNTS
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10 2
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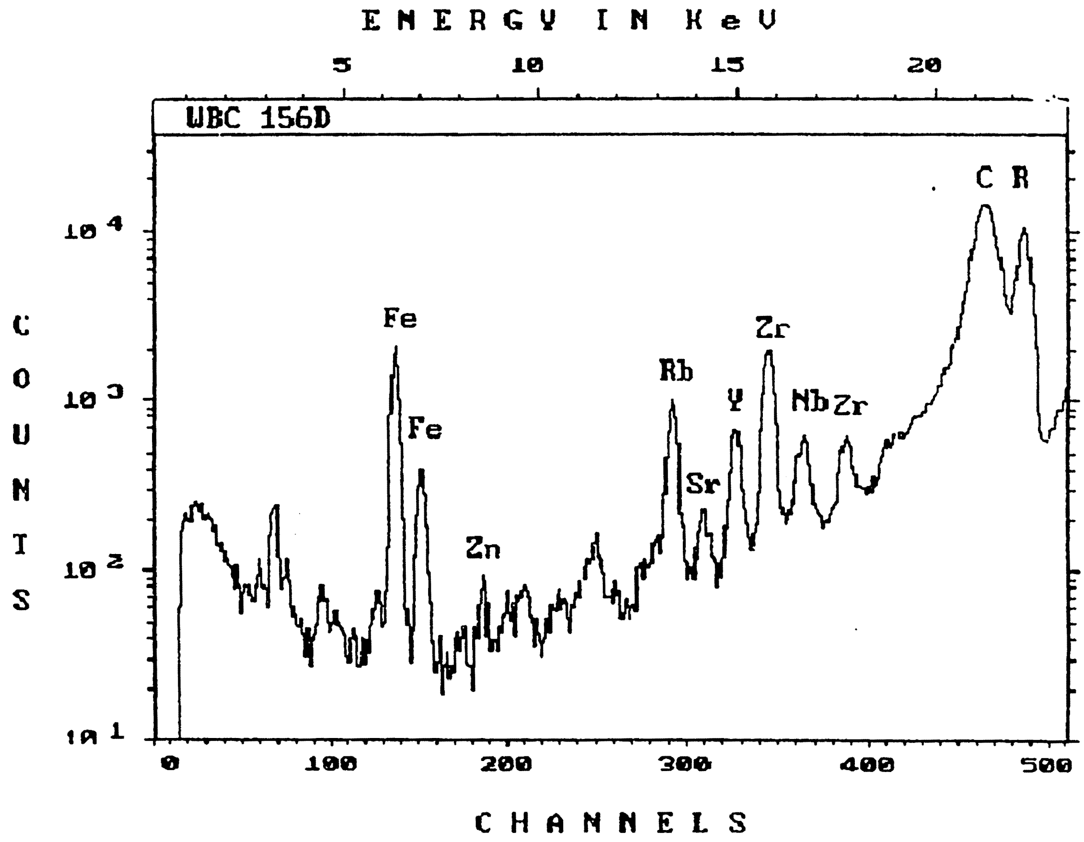
CHANNELS



ENERGY IN KeV
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Fe
Zn
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Nb
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COUNTS
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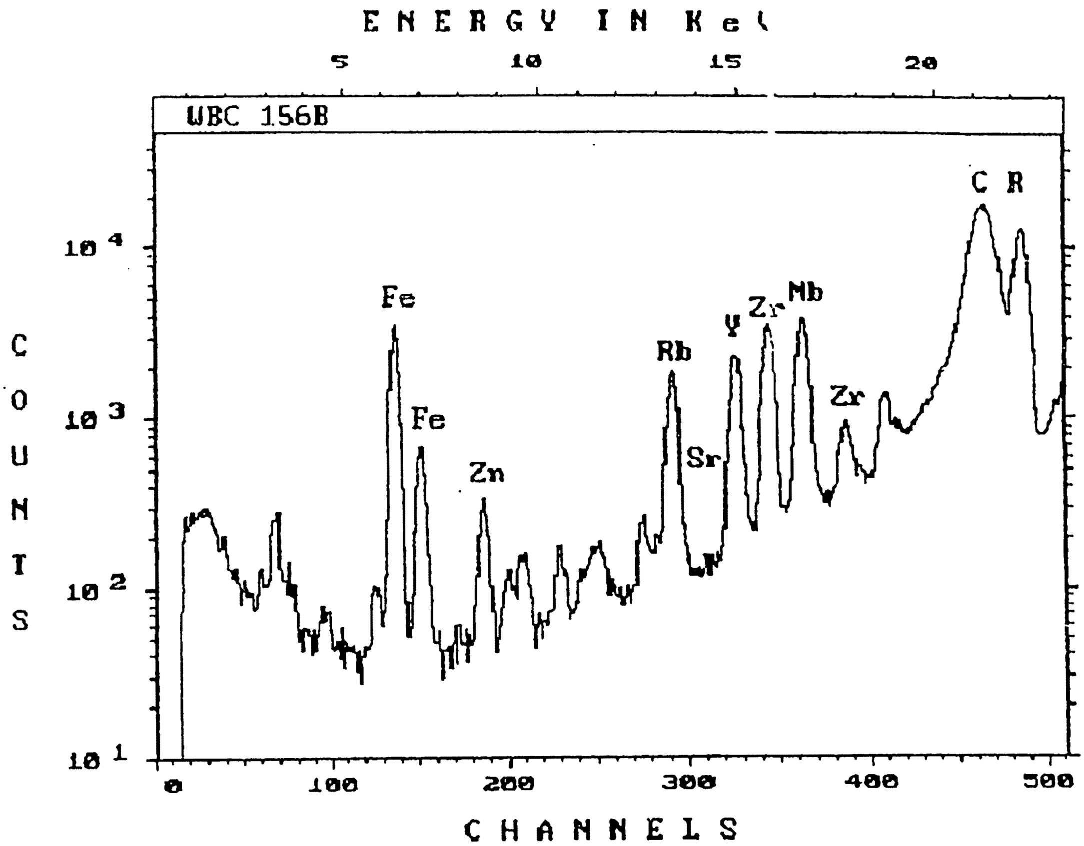
CHANNELS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Zn
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COUNTS
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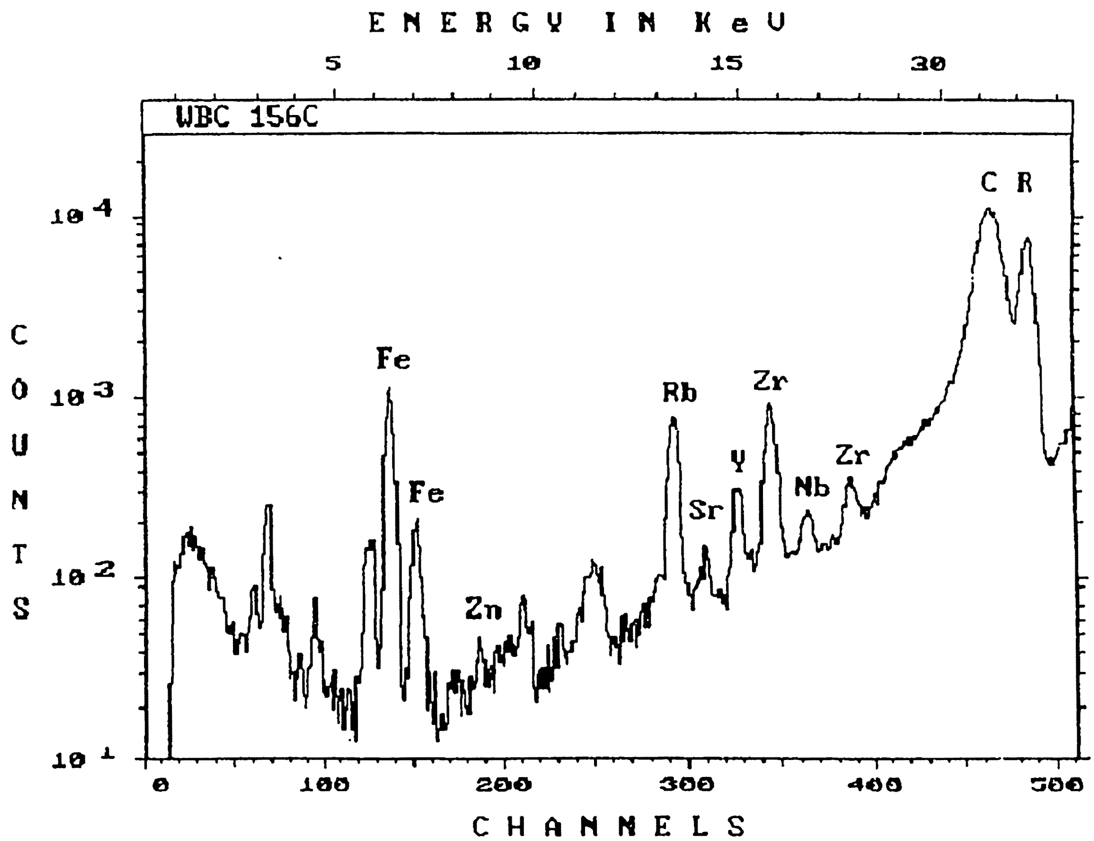
CHANNELS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Fe
Zn
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Zr
COUNTS
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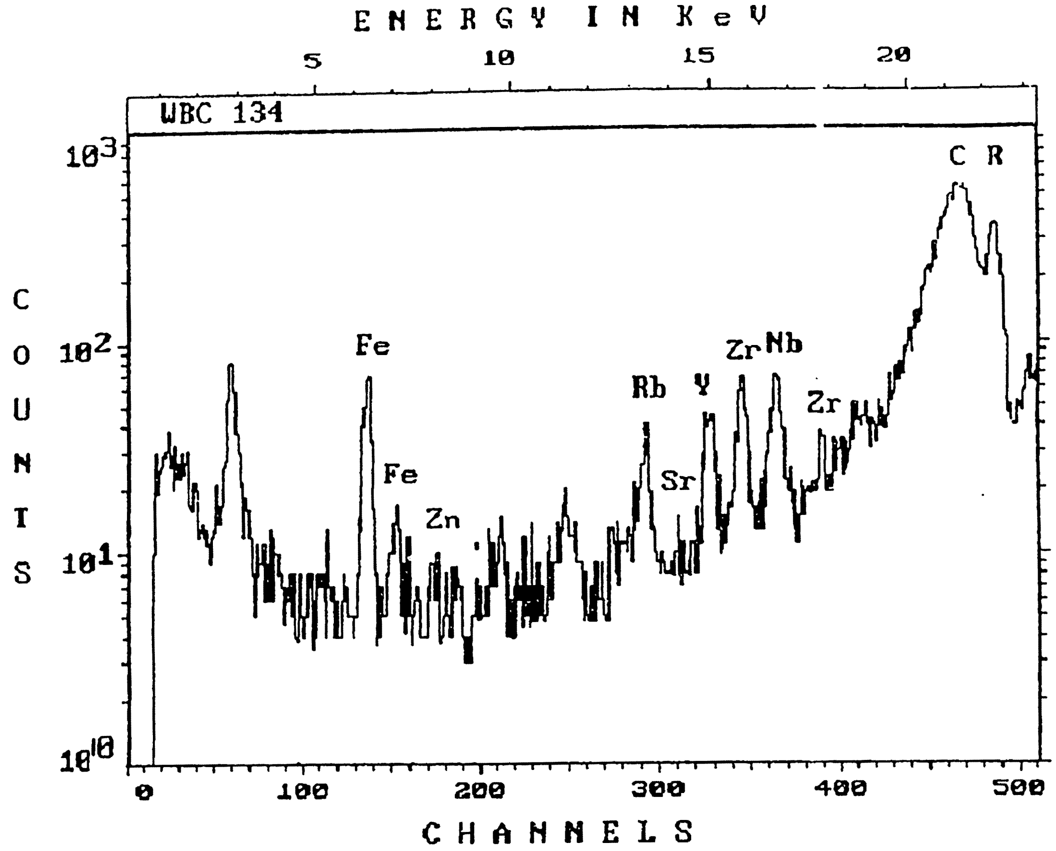
CHANNELS



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15
20
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C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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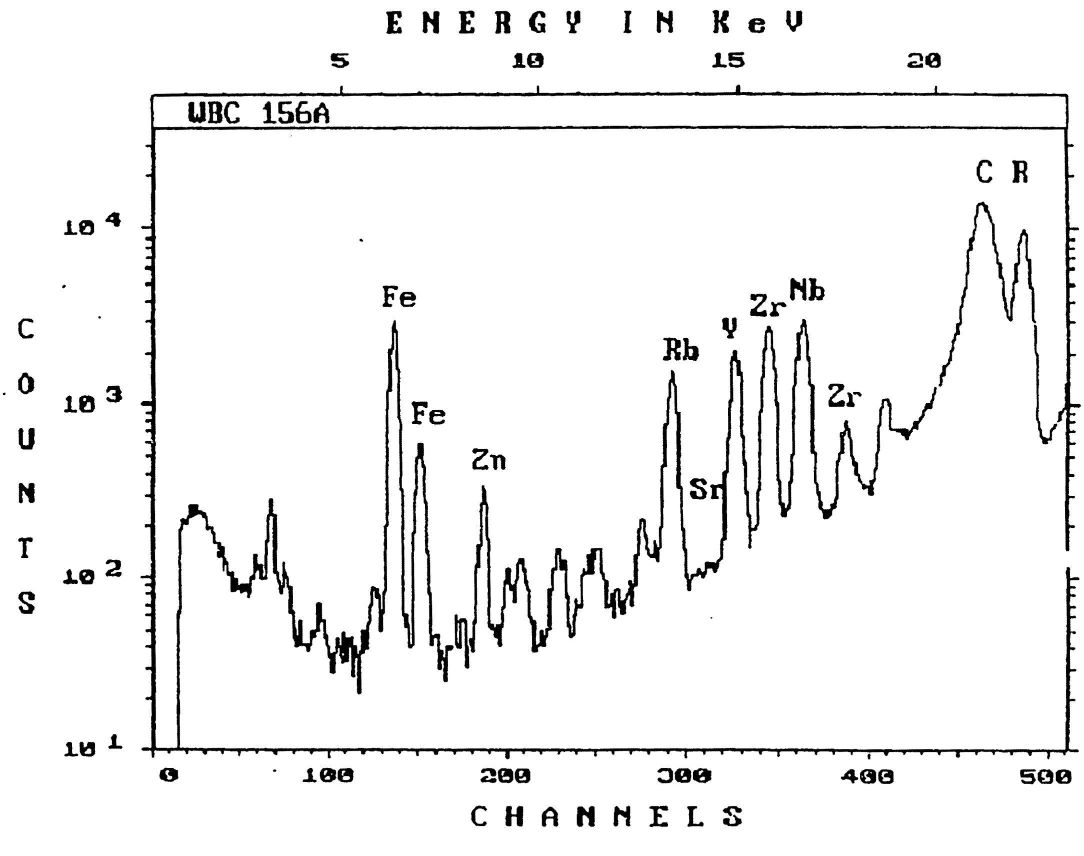
500
CHANNELS



ENERGY IN KeV
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10
15
20
WBC 156A
C R
Fe
Fe
Zn
Rb
Sr
Y
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Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
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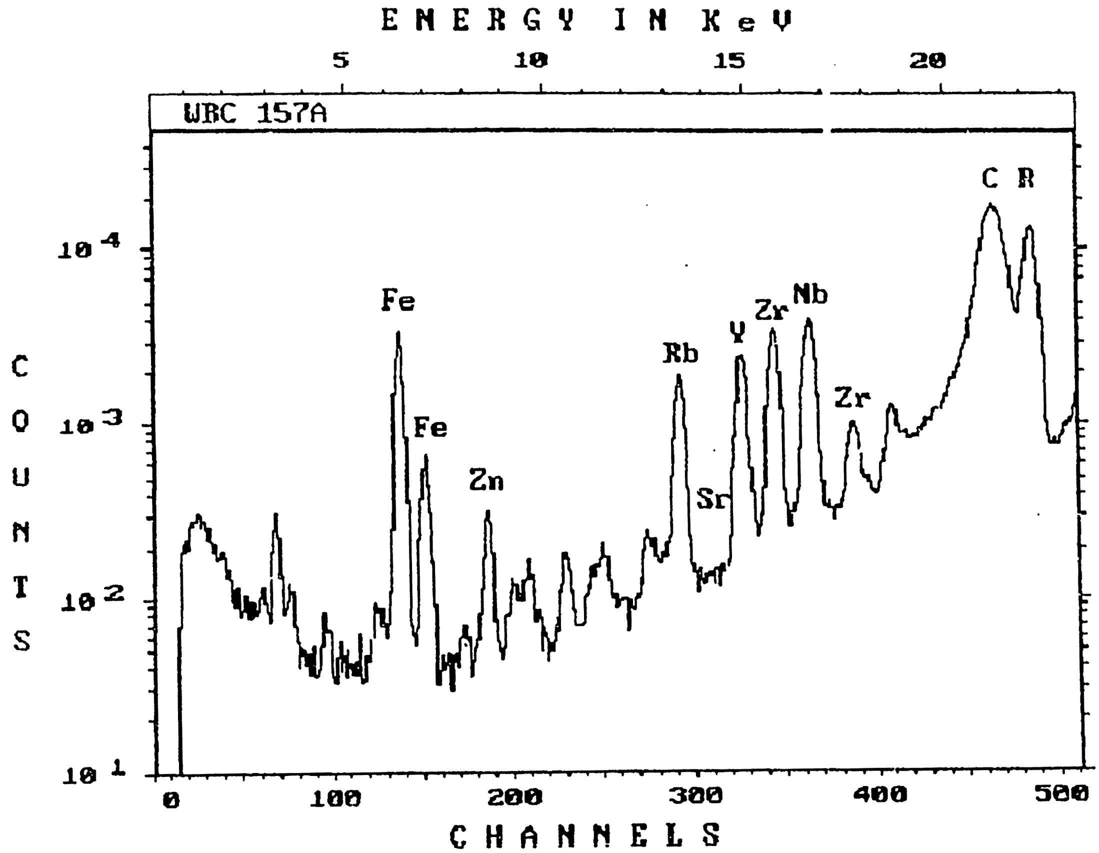
500
CHANNELS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Fe
Zn
Rb
Sr
Y
Zr
Nb
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T
S
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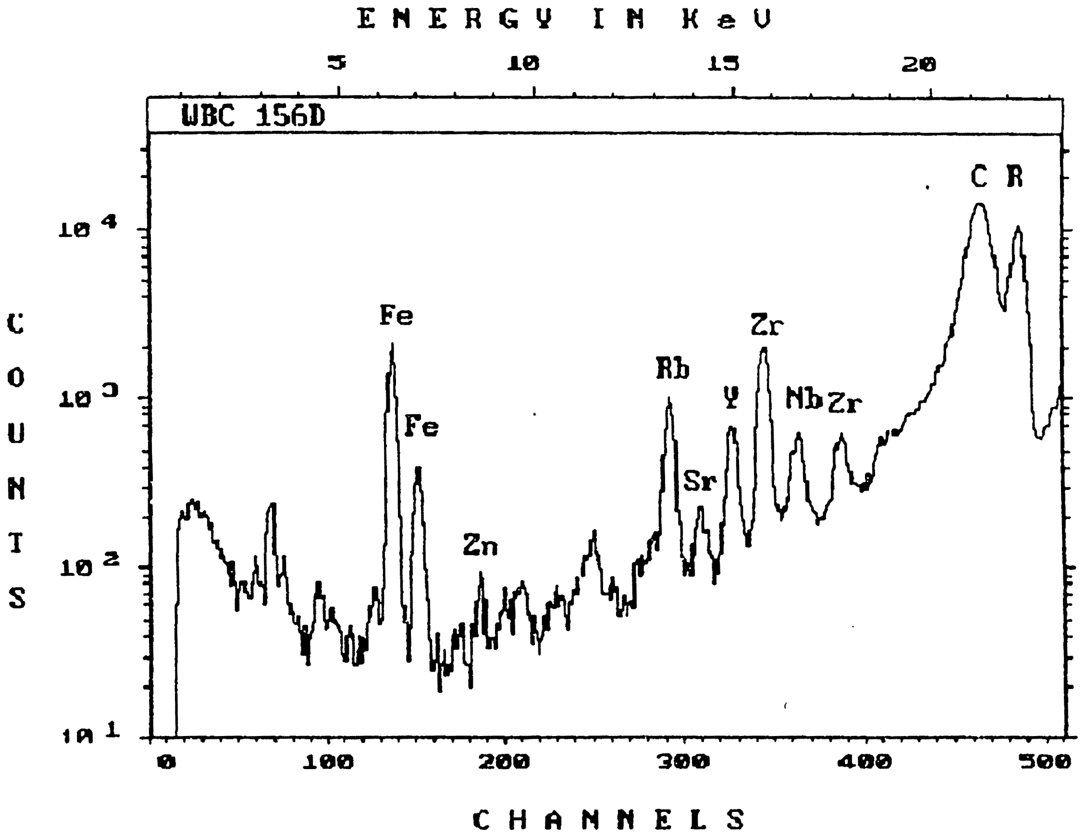
CHANNELS


ENERGY IN KeV
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15
20
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C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
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C
O
U
N
T
S
10 4
10 3
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10 1
0
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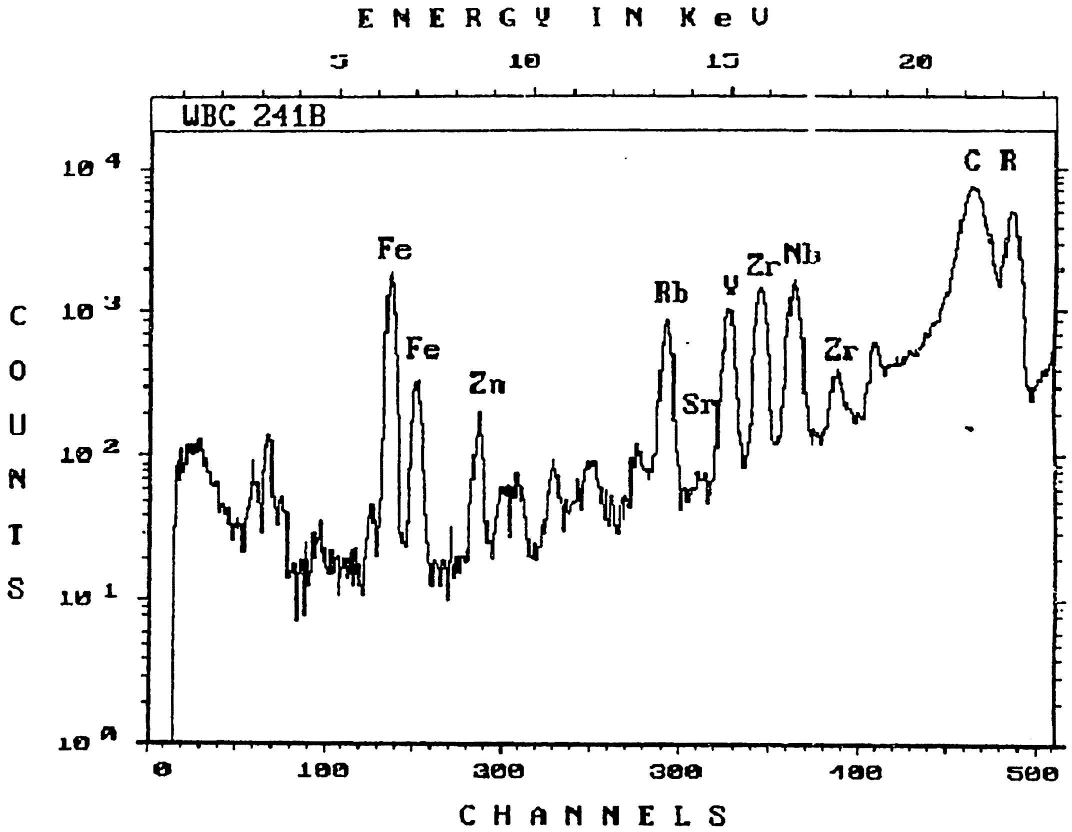
500
CHANNELS


ENERGY IN KeV
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15
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C R
Fe
Fe
Zn
Rb
Sr
Y
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Nb
Zr
COUNTS
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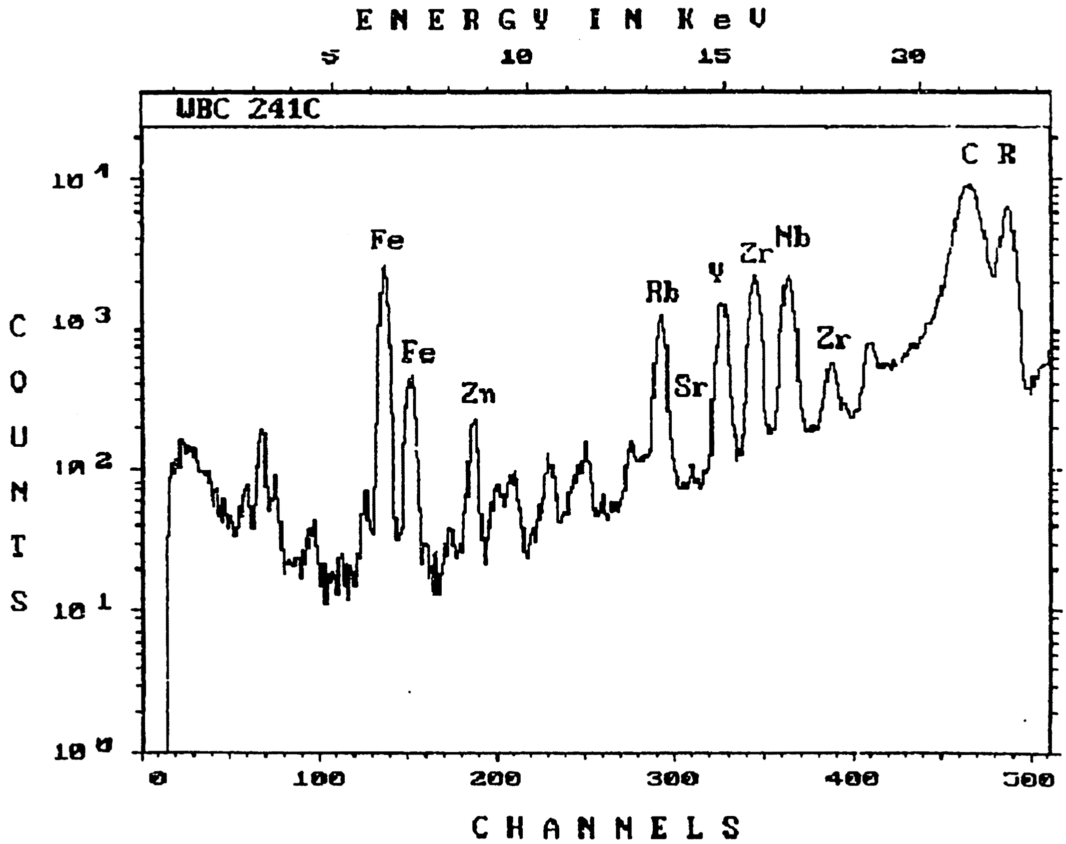
10^3
10^2
10^1
10^0
0
100
200
300
400
500
CHANNELS


ENERGY IN KeV
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15
20
WBC 241C
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
10^4
10^3
10^2
10^1
10^0
0
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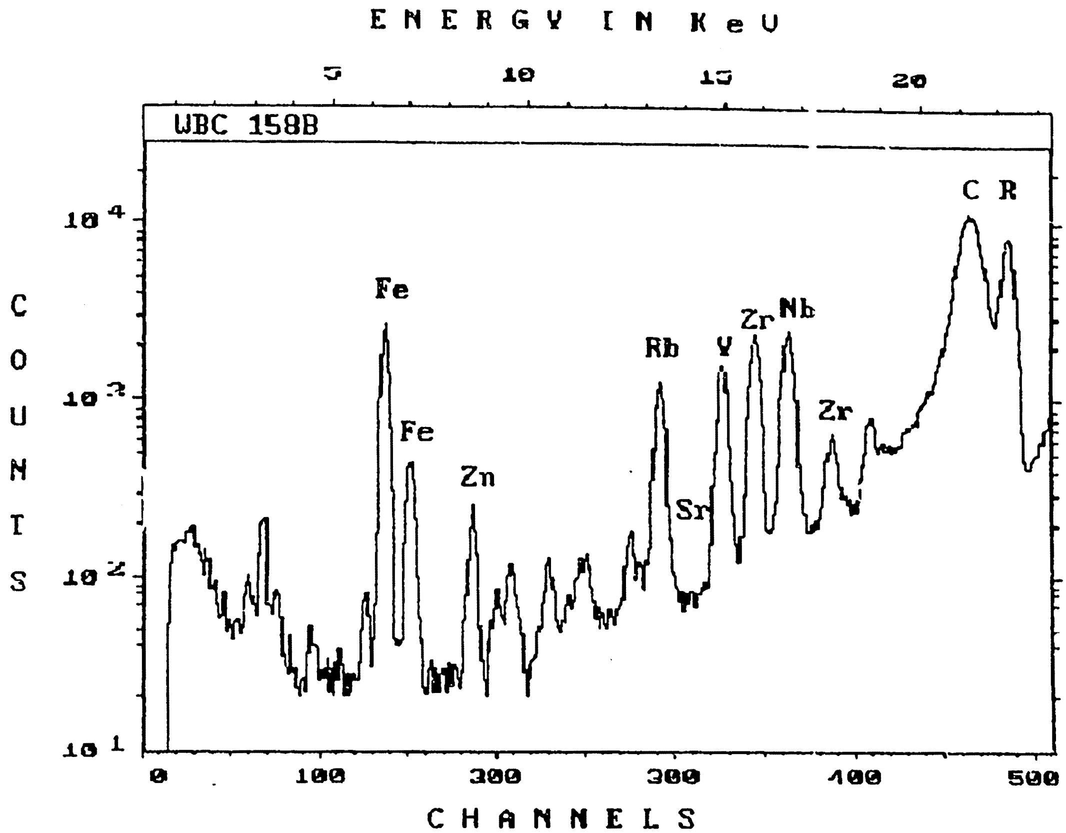
200
300
400
500
CHANNELS


ENERGY IN KeV
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C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 3
10 2
10 1
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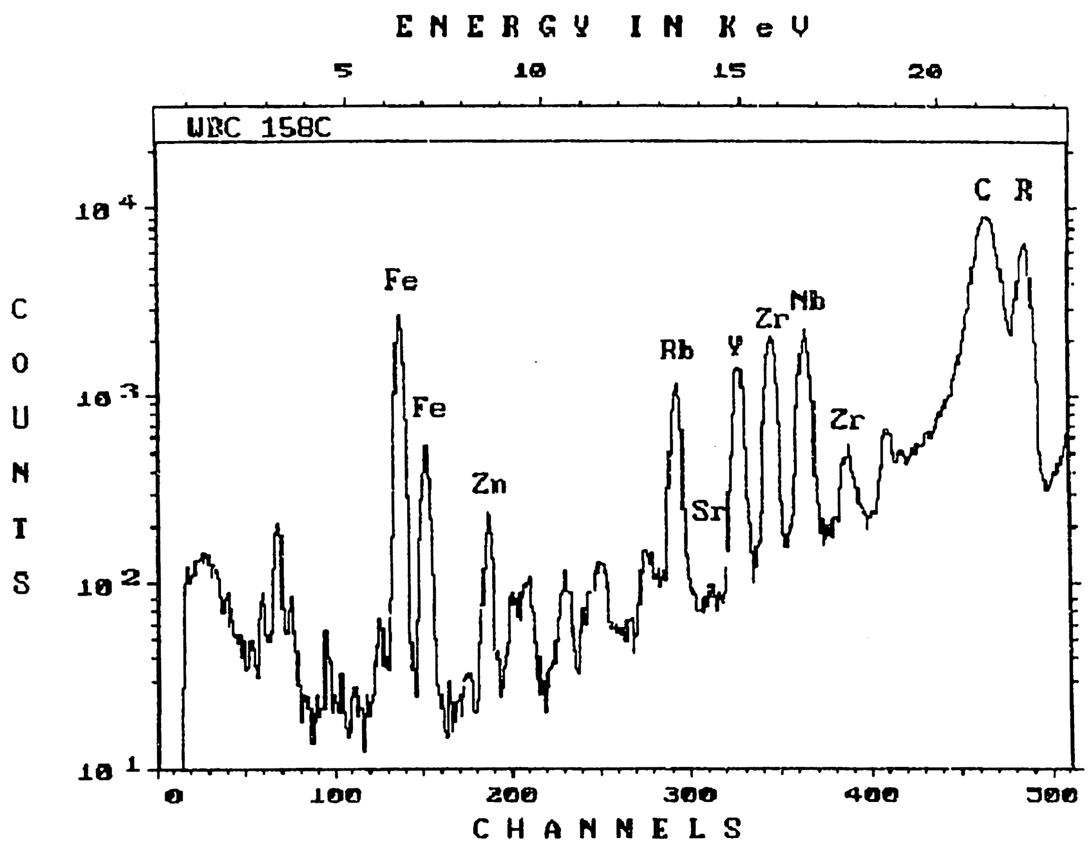
500
CHANNELS


ENERGY IN KeV
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20
WBC 158C
C R
Fe
Fe
Zn
Rb
Sr
Y
Zr
Nb
Zr
COUNTS
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10 3
10 2
10 1
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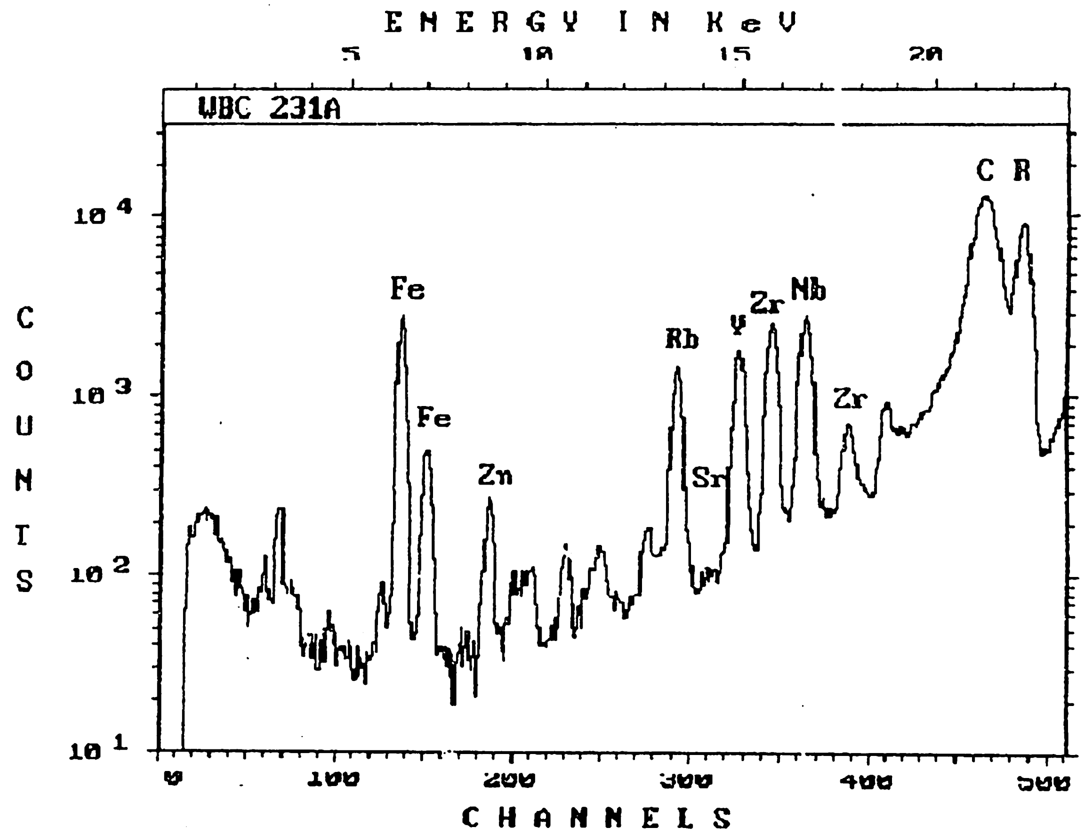
CHANNELS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Fe
Zn
Rb
Y
Zr
Nb
Sr
Zr
COUNTS
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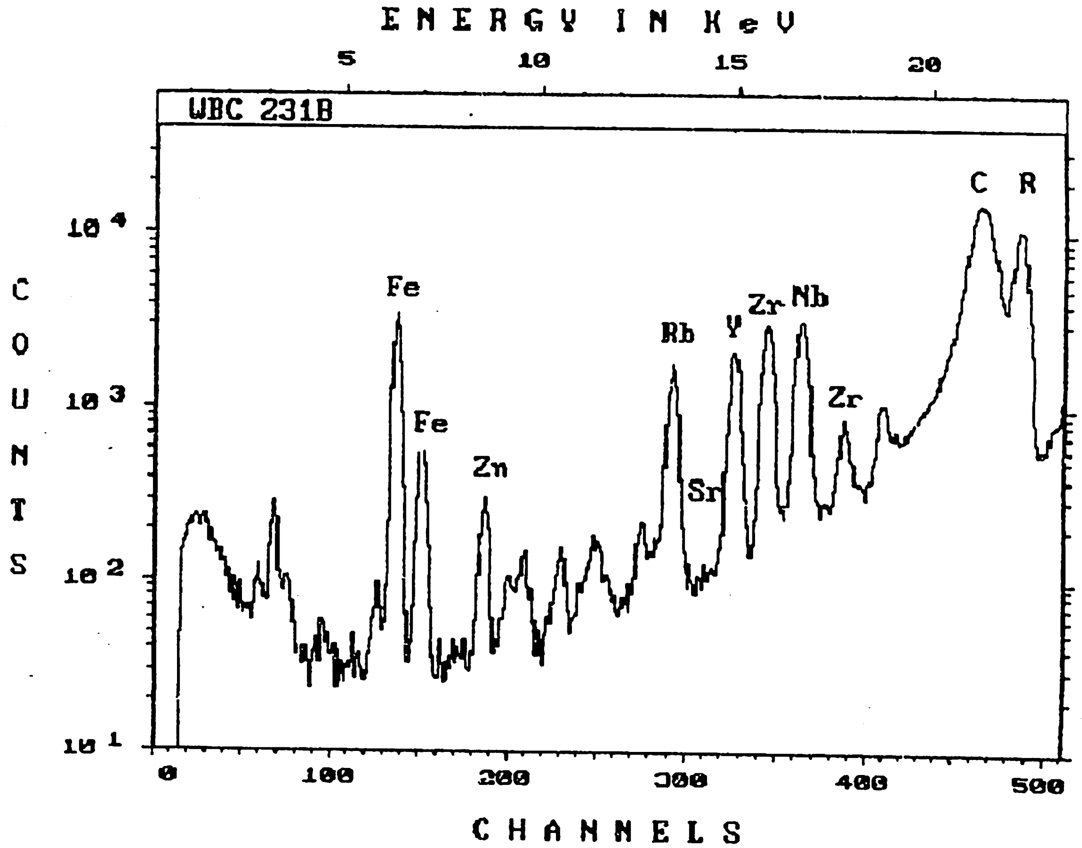
CHANNELS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C R
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Fe
Zn
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COUNTS
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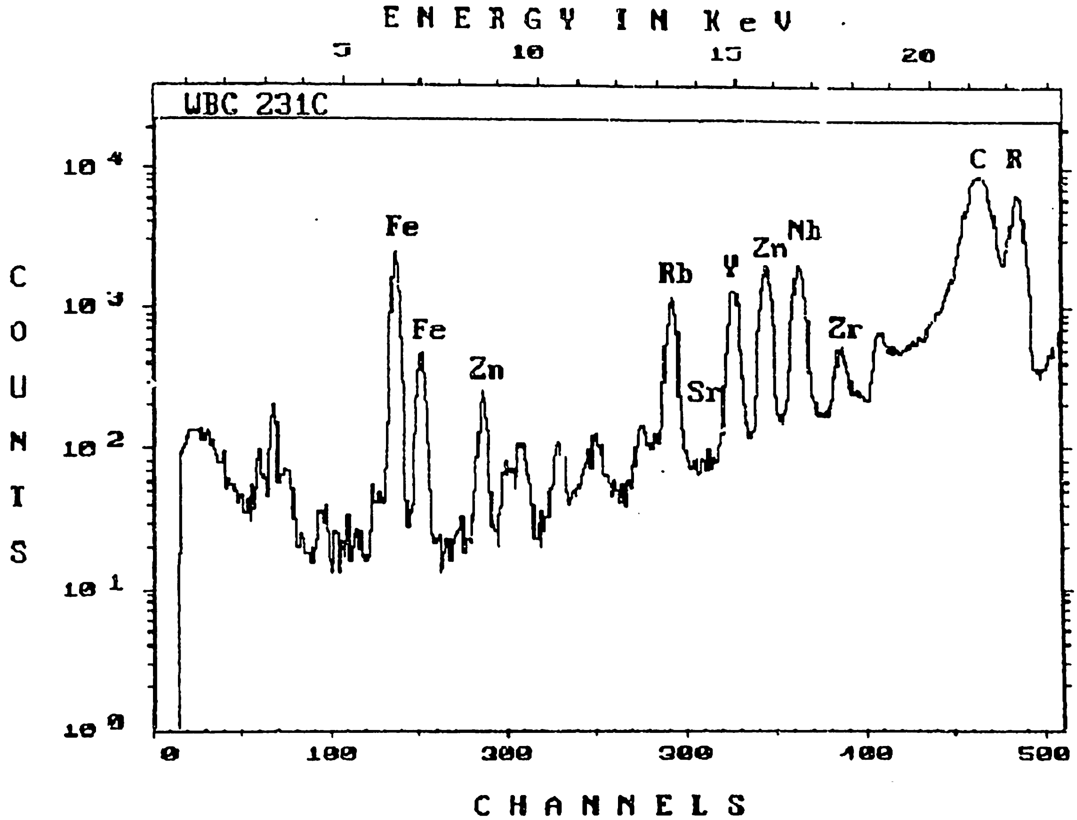
CHANNELS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15
20
WBC 231C
COUNTS
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Rb
Sr
Y
Zn
Nb
Zr
C
R
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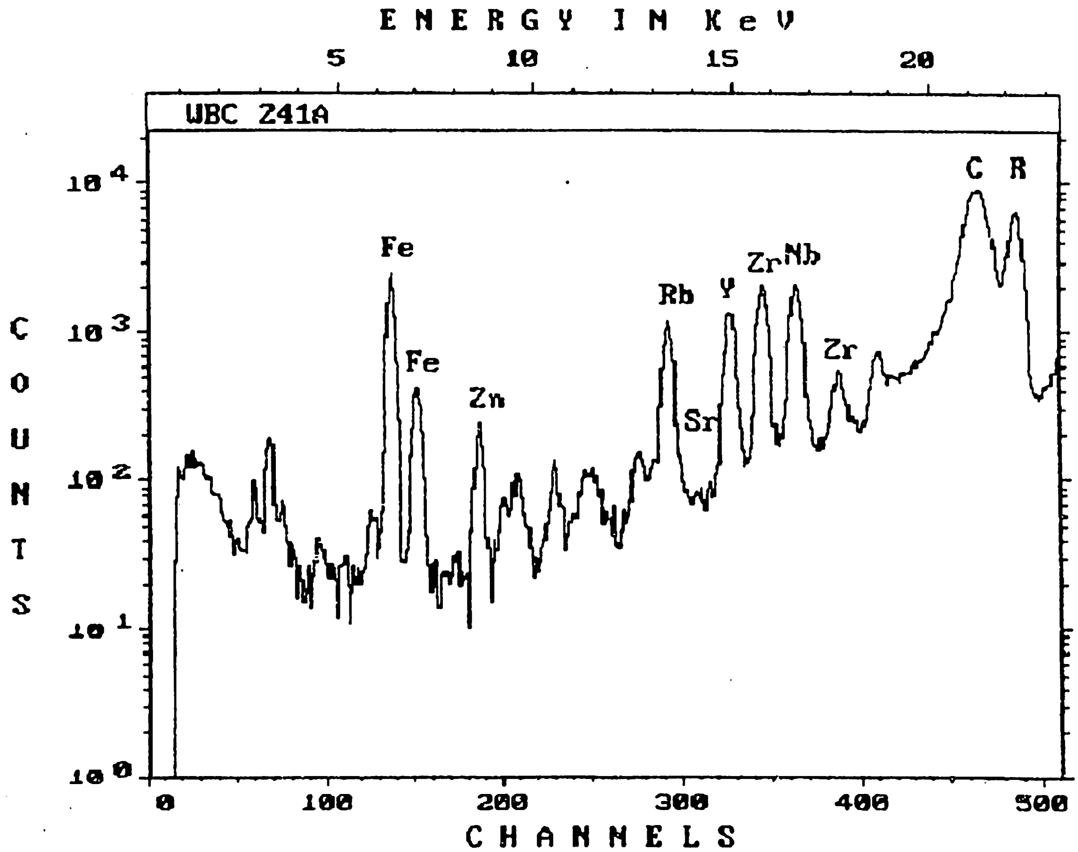
CHANNELS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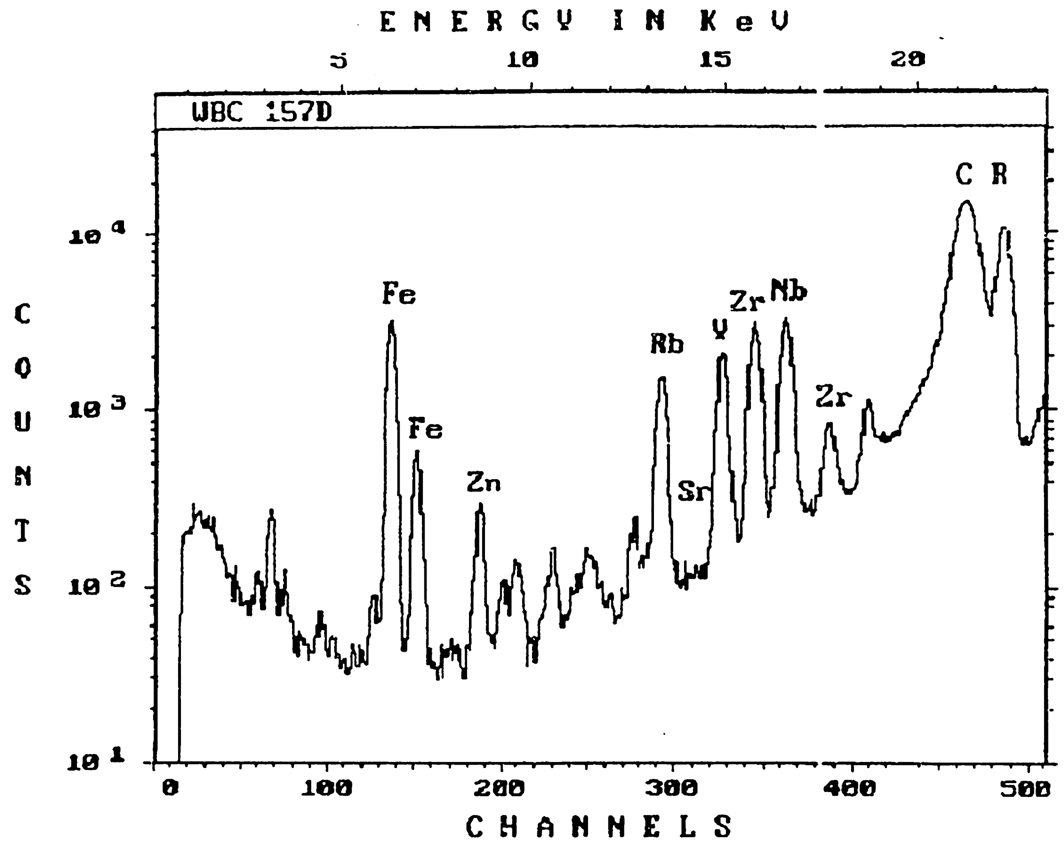
CHANNELS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Fe
Zn
Rb
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Y
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Nb
Zr
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10 2
10 1
COUNTS
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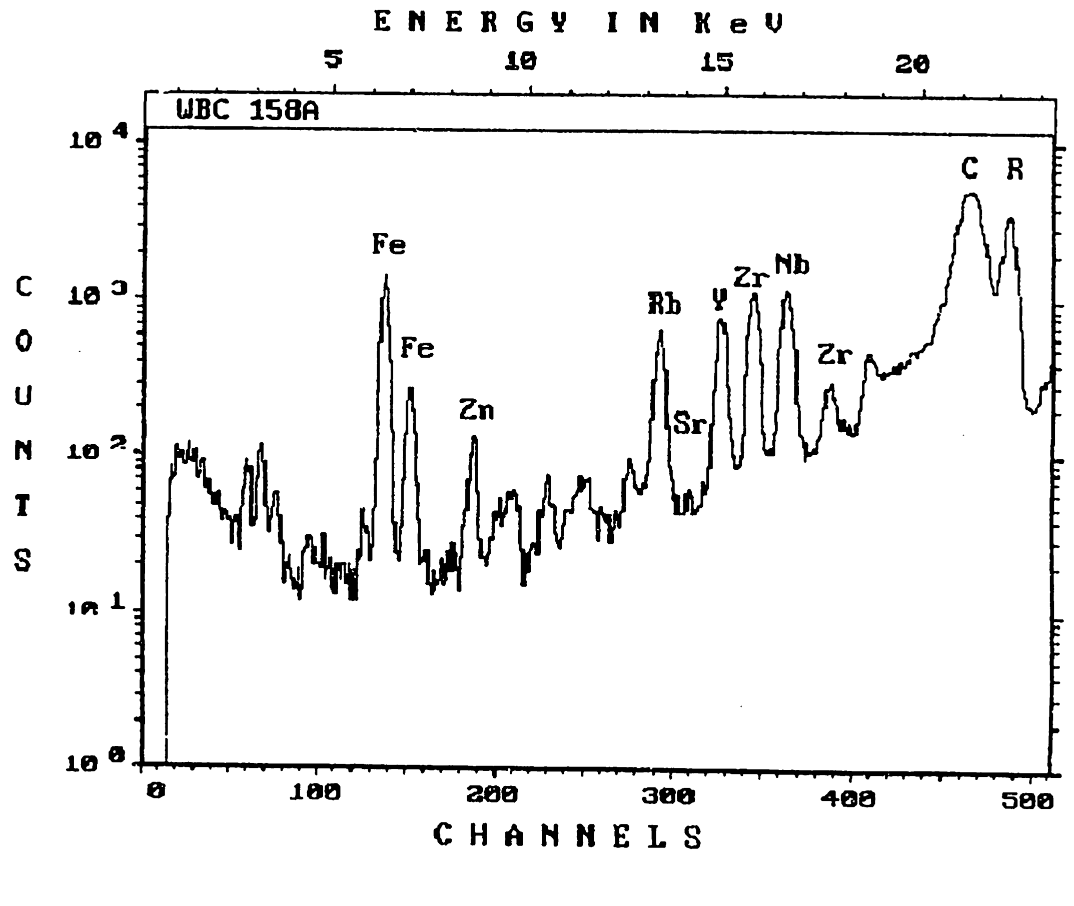
500
CHANNELS


ENERGY IN KeV
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Zn
Rb
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10 1
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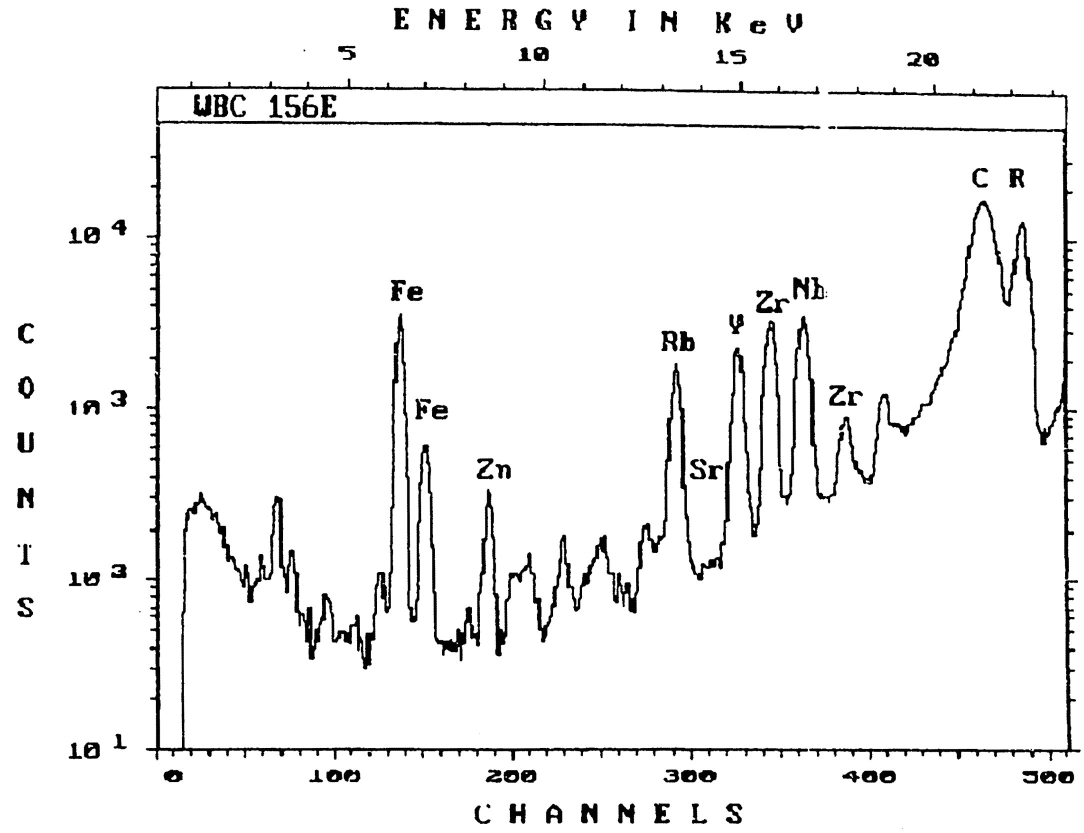
CHANNELS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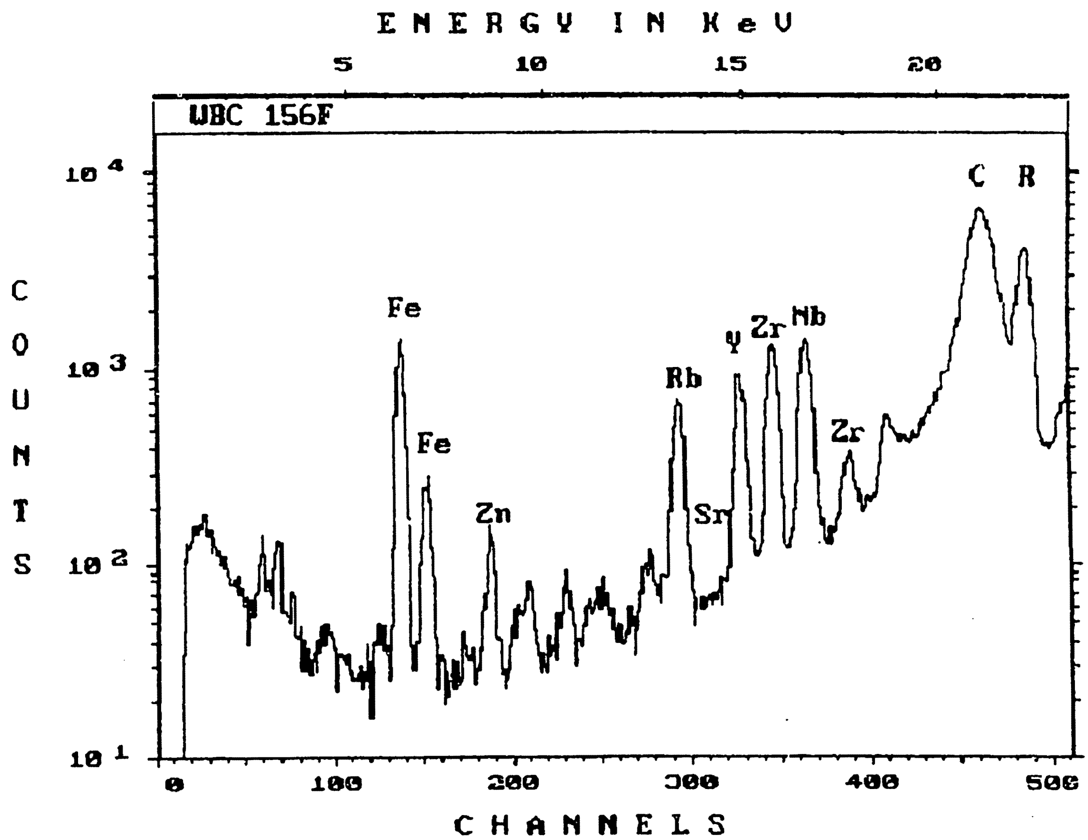
CHANNELS


ENERGY IN KeV
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Zn
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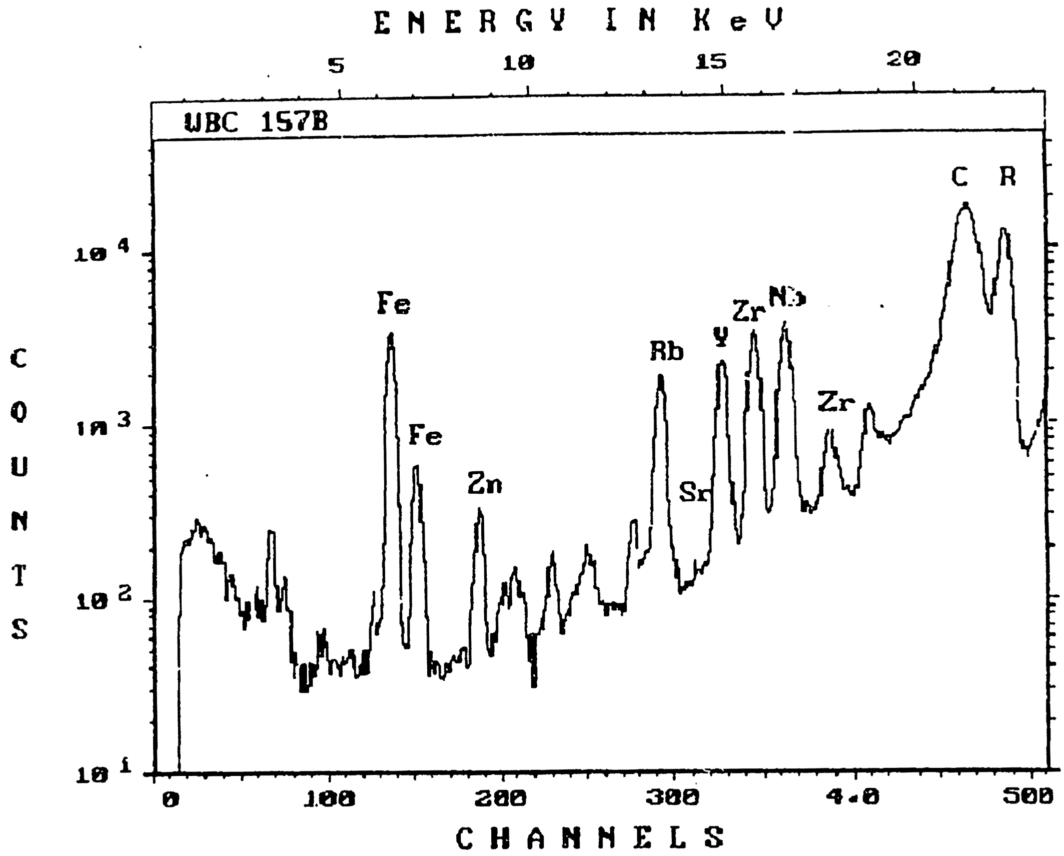
CHANNELS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Zn
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Nb
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COUNTS
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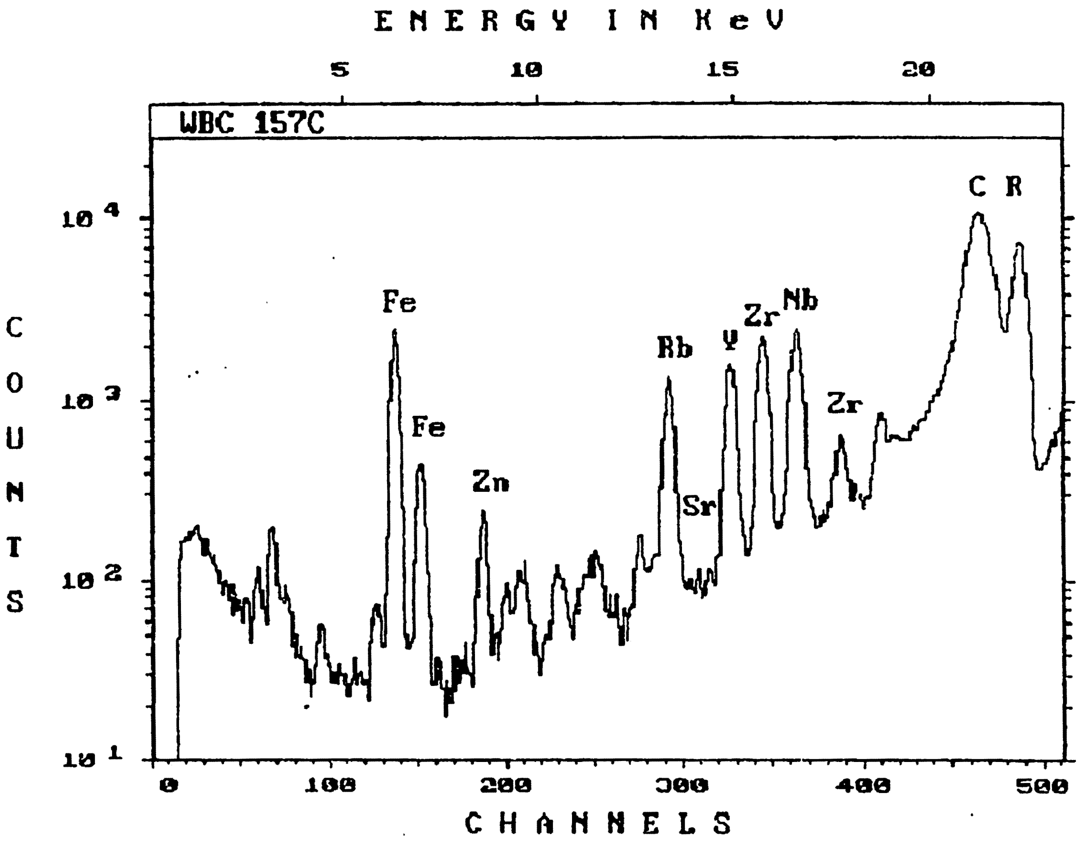
CHANNELS


ENERGY IN KeV
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20
WBC 157C
C R
Fe
Fe
Zn
Rb
Sr
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Zr
Nb
Zr
COUNTS
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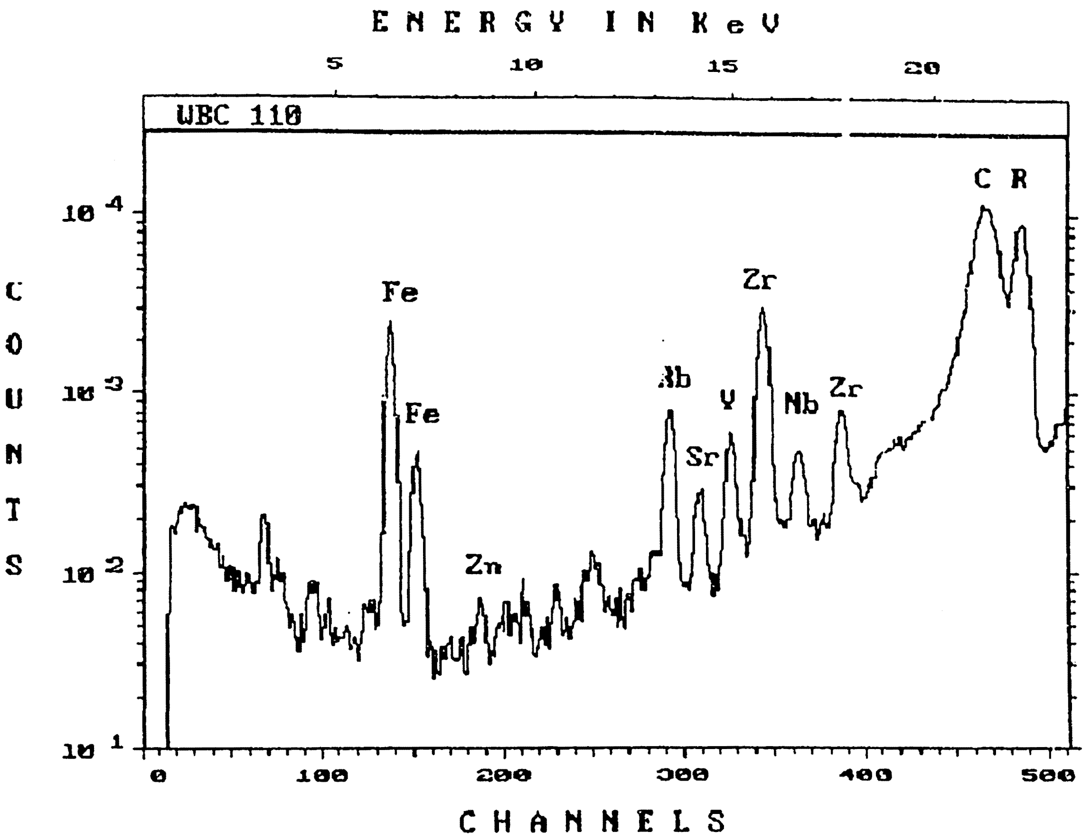
CHANNELS



ENERGY IN KeV
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20
UBC 110
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Fe
Zr
Fe
Nb
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Nb
Zr
Sr
Zn
COUNTS
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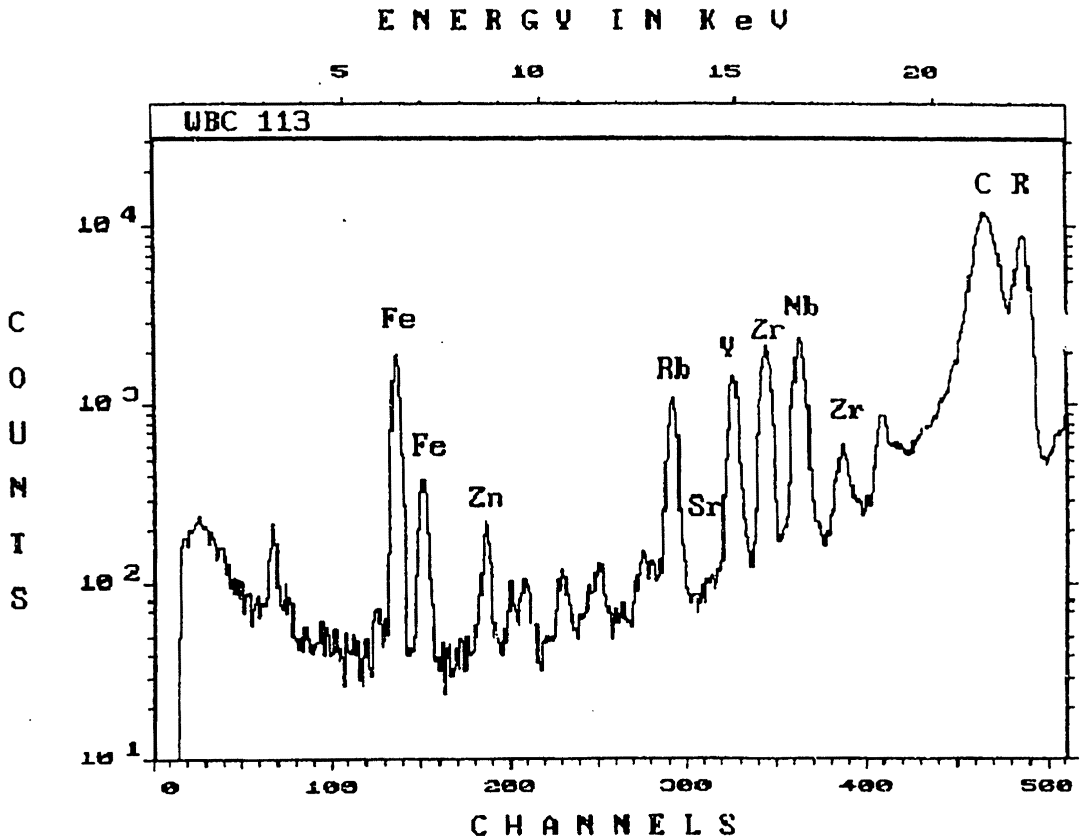
CHANNELS



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20
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Fe
Nb
Y
Zr
Rb
Fe
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Zn
Sr
COUNTS
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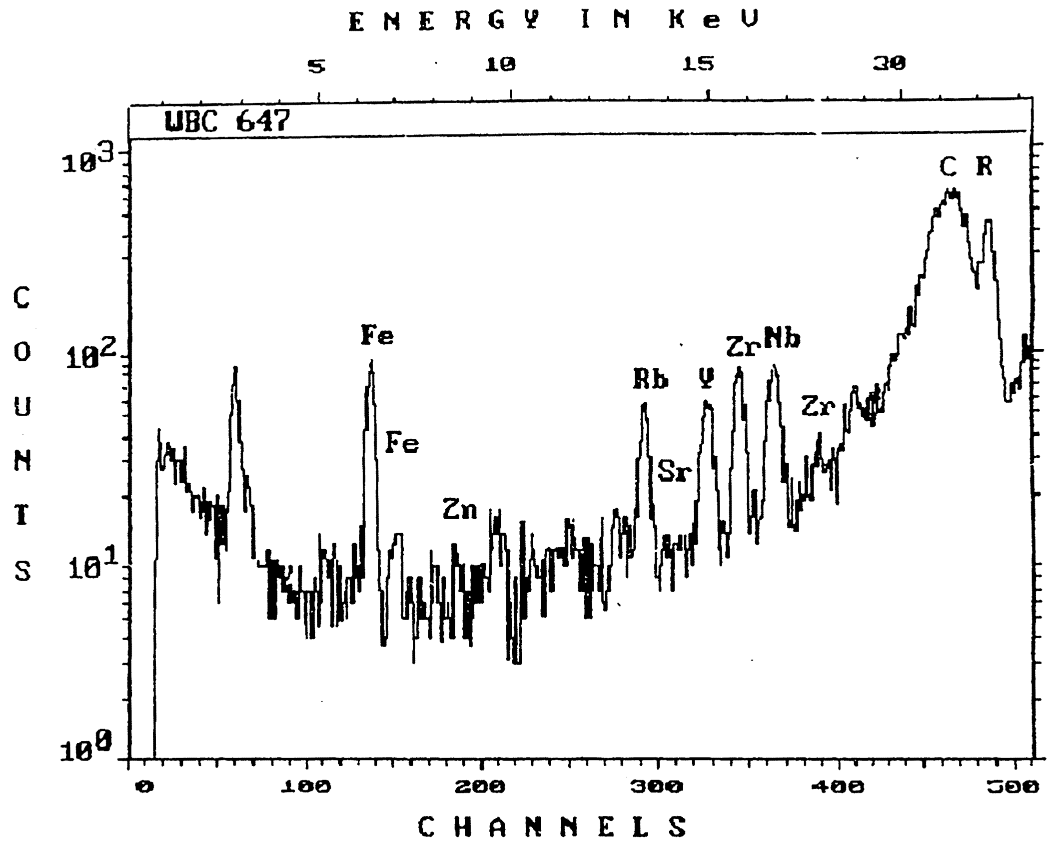
CHANNELS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15
20
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Fe
Zr Nb
Rb
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Fe
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Zn
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400
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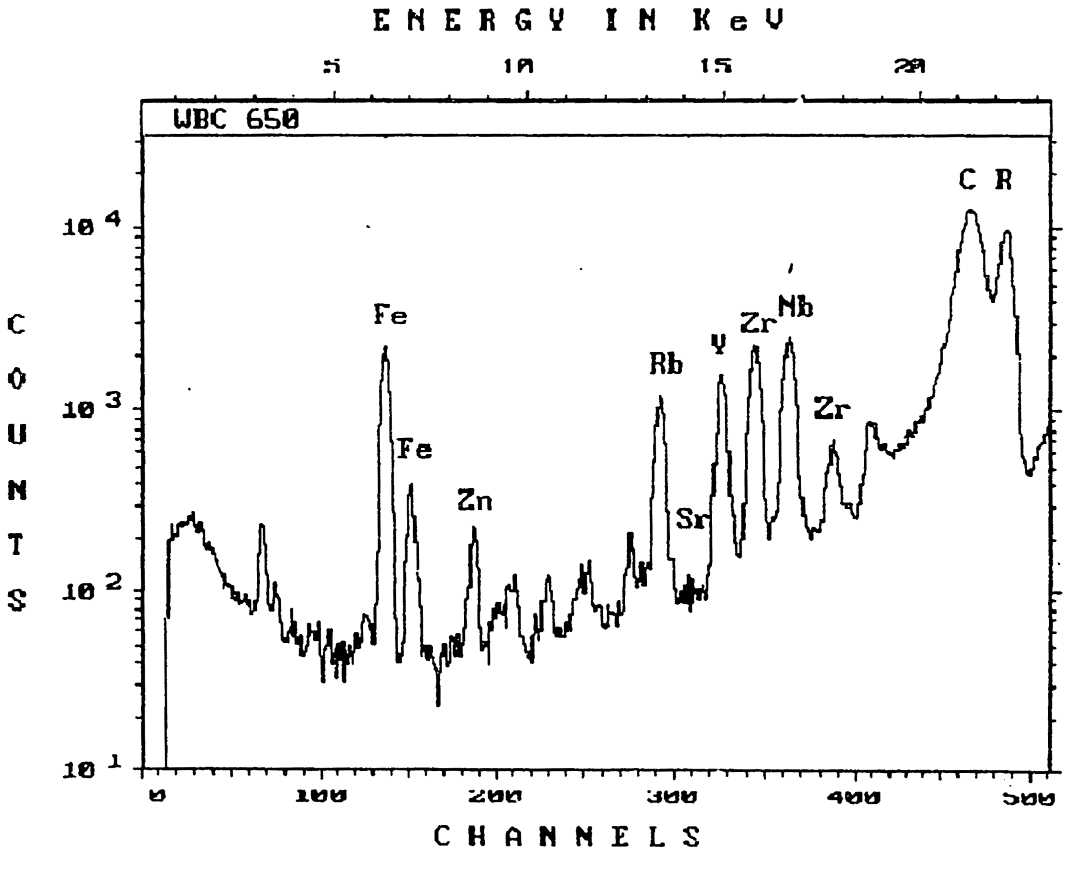
CHANNELS


ENERGY IN KeV
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Fe
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Y
Rb
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Sr
COUNTS
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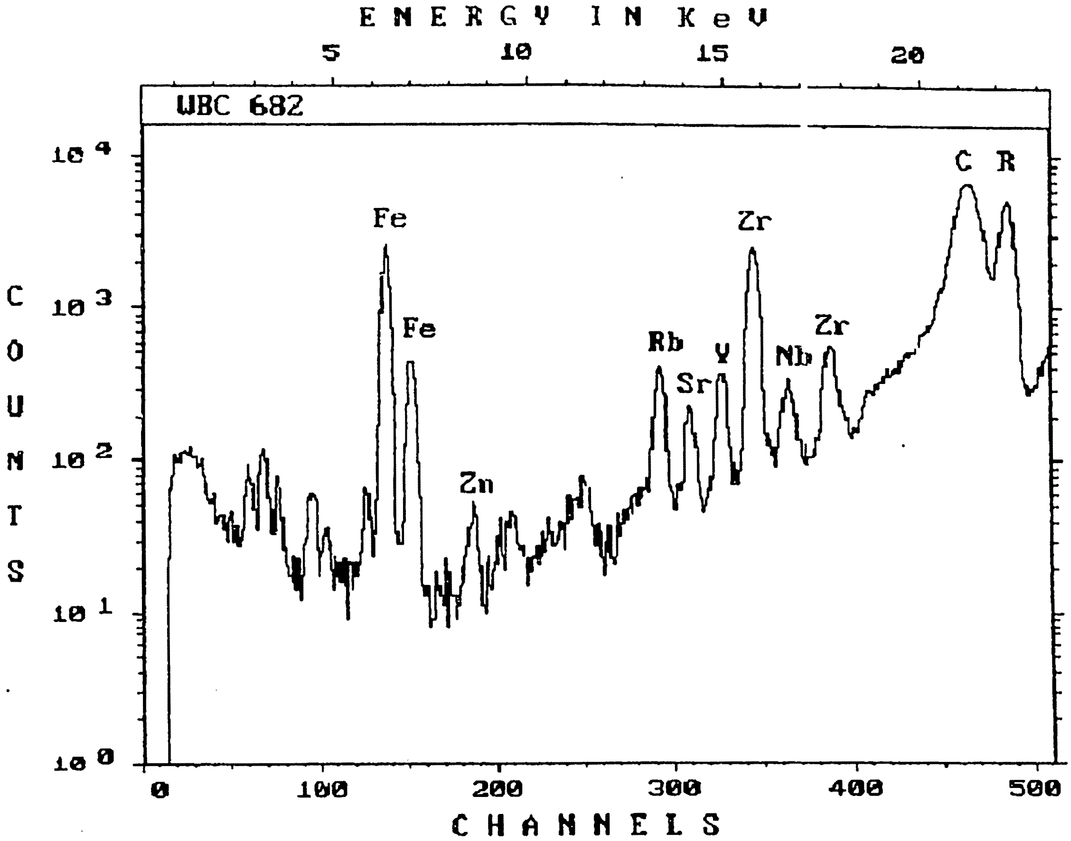
CHANNELS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Fe
Rb
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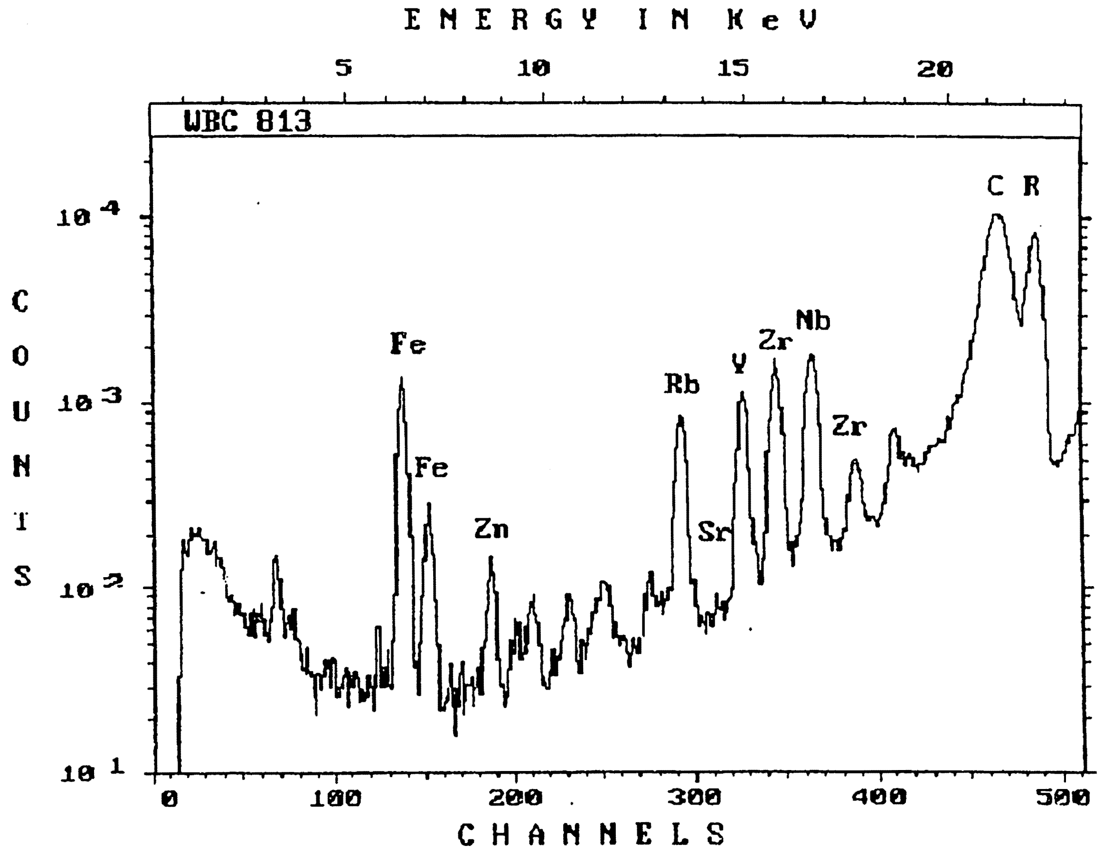
CHANNELS


ENERGY IN KeV
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15
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WBC 813
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Zr
Nb
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Rb
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Sr
Zn
COUNTS
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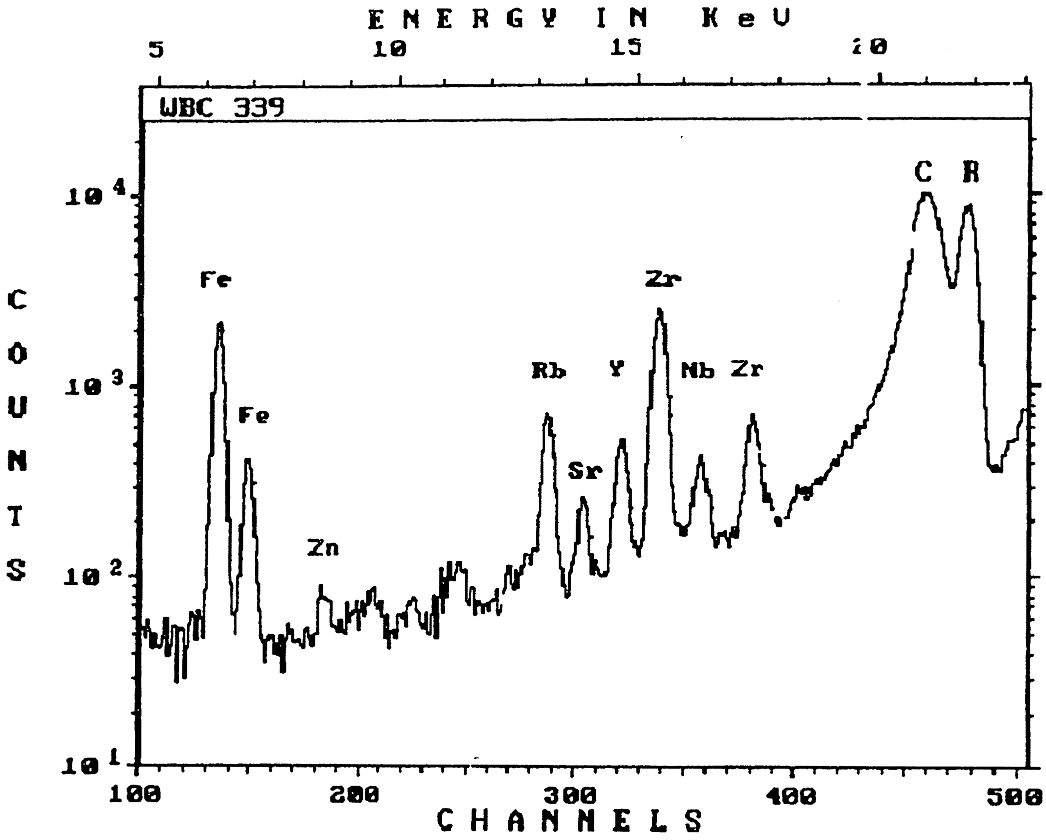
CHANNELS


ENERGY IN KeV
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15
20
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C R
Fe
Zr
Fe
Rb
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Zr
Sr
Zn
COUNTS
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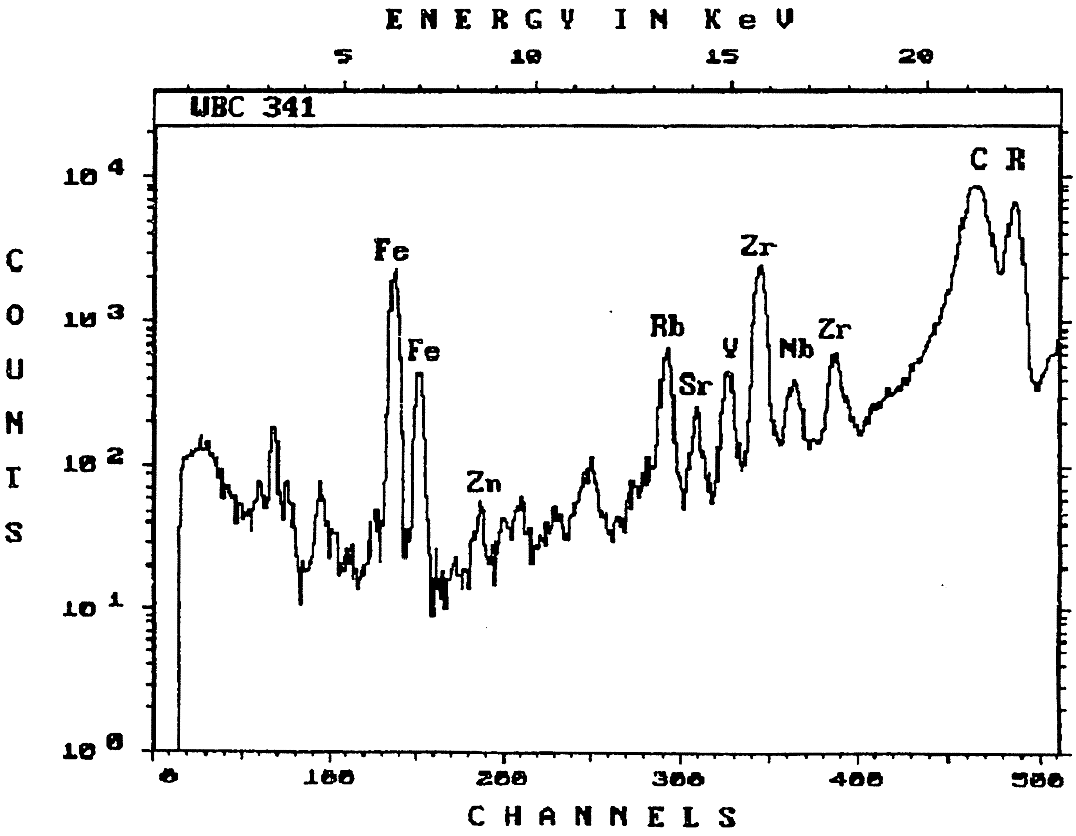
CHANNELS


ENERGY IN KeV
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15
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Zr
Fe
Rb
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Nb
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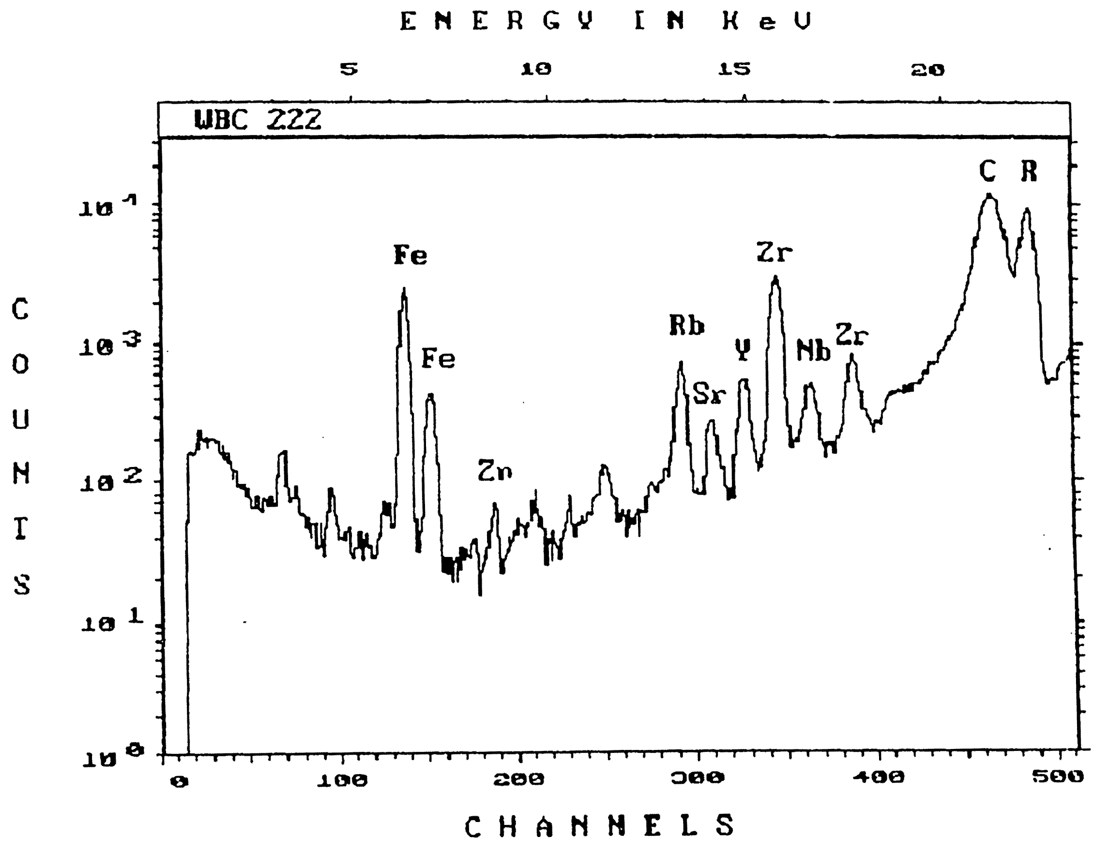
CHANNELS



ENERGY IN KeV
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15
20
WBC 222
C
R
Fe
Fe
Zr
Rb
Sr
Y
Nb
Zr
Zn
COUNTS
10 4
10 3
10 2
10 1
10 0
0
100
200
300
400
500
CHANNELS

APPENDIX EIGHT

SOURCE LOCATIONS

APPENDIX 8

SOURCE LOCATIONS

All map references for the source locations, unless otherwise specified, are Bureau of Land Management Surface Management Status 1:100,000-scale Maps (1985), which were compiled from USGS 1:24,000-scale topographic maps dated 1968-1971. All map legal descriptions refer to the Boise Baseline and Boise Meridian.

IGNIMBRITE SOURCES

Brown's Bench Chemical Group, Ignimbrite, Owyhee, Twin Falls and Cassia Counties.

Ignimbrite of good flaking quality is reported over a 2000 square-kilometer area in extreme south-central Idaho (Sappington 1981a). Cobbles were collected at seven localities between Little House Creek (T15S R12E NW1/4 NW1/4 section 23) and Rock Creek (T13S R19E NW1/4 NE1/4 section 17); Sappington (1981a) observed material as far north as Roseworth. Ignimbrite cobbles in a range of sizes are available at many locations in this area. Colour variation is significant, varying from black, to grey, to brick red; but all are chemically comparable. Cobbles range in size from pebbles to about 30 cm in diameter, with particularly abundant deposits in the Shoshone Basin area, and on Brown's Bench itself.
193 samples were analyzed from these localities, and the source is very well characterized.

Camas Prairie Ignimbrite, Gooding County.

Localities: T3S R15E NW1/4 section 2; S1/2 section 11.
T2S R15E SW1/4 section 35. Fairfield Quadrangle.

Small black ignimbrite cobbles were collected from low hillsides and roadcuts. Flakes of brick red ignimbrite were observed, but only very small unworked pebbles were found. Sappington (1981a) reported two chemical types here; one obsidian and one "vitrophyre', or ignimbrite. No obsidian was found at Camas Prairie in the course of this study. Thirty-nine samples were analyzed, providing an adequate characterization of the source. However, significant overlap with the Brown's Bench chemical type makes discrimination of the Camas Prairie type difficult.

Cedar Creek Ignimbrite, Owyhee County.

Locality: T14S R13E S1/2 SE1/4 section 14. Rogerson Quadrangle.

Fifteen cobbles of black and red ignimbrite were collected from the shore of Cedar Creek Reservoir, at the northern base of Brown's Bench. The cobbles, ranging from 10 cm to 20 cm in diameter, were megascopically identical to those found on Brown's Bench, and at surrounding localities. However, samples analyzed from a single cobble yielded data that did not match any of the source profiles in this study. For the purposes of this thesis, the cobble was tentatively designated a separate chemical type, "Cedar Creek", although it is possible that the rock was transported to the area by natural or cultural means. However, one cobble from the Coal Bank Spring source had a chemical composition similar to the Cedar Creek sample, so it is possible that a separate source is indicated. Further sampling, and comparison with Nevada ignimbrite data might clarify the nature of this poorly-characterized chemical type.

Conant Creek Ignimbrite, Fremont Country.

Locality: T8N R45E NW1/4 SW1/4 section 24. Ashton Quadrangle.

Abundant rounded ignimbrite cobbles were noted in Conant Creek bed and on the first terrace above the creek, near Buggy Spring. Black and grey cobbles of moderate flaking quality were collected. The primary source of this ignimbrite was not located; but it may lie in the Conant Pass area of Wyoming, from which samples were previously reported (Sappington 1981a). 15 Conant Creek samples were analyzed in the present study, providing an adequate chemical fingerprint.

Deep Creek Ignimbrite, Clark County.

Localities: T11N R33E N1/2 NE1/4 section 29
NE1/4 SE1/4 section 20
center NW1/4 section 27. Ashton Quadrangle.

Cobbles of high-quality, black ignimbrite to 15 cm in diameter occur on a north-south trending ridge northwest of Dubois. Cobbles are visible in road cuts and along streams, suggesting the source is largely buried; however, abundant debitage throughout the area indicates that the material was accessible in prehistoric times. 39 samples were analyzed, yielding a very good chemical profile, but it was not possible to differentiate confidently between the Deep Creek and Snake River chemical types. Further sampling might determine the relationship between these two material types.

Dry Creek Ignimbrite, Clark County.

Locality: T13N R40E N1/2 SW1/4 section 9. Ashton Quadrangle.

Cobbles of low-grade, partially devitrified ignimbrite were collected from the bed of Dry Creek for comparison with the nearby Bear Gulch obsidian. The Dry Creek ignimbrite showed a different chemical composition than the obsidian, and it is possible that higher quality ignimbrite exists in the area. Cobbles at the Dry Creek locality ranged from 5 cm to 60 cm in diameter. 9 samples were analyzed, providing an adequate characterization.

Fish Creek Ignimbrite, Fremont County.

T12N R45E sections 29 and 32.

Cobbles of low- to medium-grade red and black ignimbrite visible in the hillsides adjacent to Fish Creek Road. All samples were quite brittle and contained abundant phenocrysts but all were flakeable; red cobbles, where present, were of higher quality than black cobbles. Cobbles ranged widely in size, from pebbles to boulders. This source is adequately characterized.

Gibson Creek Chemical Group, Madison, Teton, and Bonneville Counties.

Localities:	Gibson Creek:	T1N R42E N edge NW1/4 section 20. Palisades Quadrangle.
	Moody Swamp:	T4N R42E section 13. Rexburg Quadrangle.
	Graham Spring:	T5N R43E section 21. Rexburg Quadrangle.

Angular cobbles of light grey to black, brittle ignimbrite were collected over a wide area of eastern Idaho. The material was of moderate flaking quality; and very abundant at the collection localities, where it was found eroding out of hillsides, in road cuts, and in an area cleared by logging (near Graham Spring). The three localities sampled in this study were chemically indistinguishable, and they were therefore combined to form the Gibson Creek Chemical Group.

The processes responsible for the formation of these rocks are not presently clear; but it is likely that a number of volcanic vents, associated with a single magma pool, produced the spatially-distinct, but chemically similar ignimbrite deposits.

A total of 44 samples was analyzed from the three localities, and the chemical type has been well characterized.

Jasper Flats Ignimbrite Types 1 and 2, Blaine County.

Locality: T1N R20E section 31.

Small cobbles of somewhat crumbly, partially devitrified black ignimbrite were analyzed from Jasper Flats in an attempt to trace the source of the small Picabo Hills cobbles submitted by Dr. Mark Druss. Two distinct chemical types were identified in the Jasper Flats material; but, at present, it is not known whether flakeable ignimbrite is present in this area. Further survey is strongly recommended for the Jasper Flats area.

Medicine Lodge Canyon, Clark County.

Locality: NW 1/4 SE 1/4 NW 1/4 sec.18 T11N R34E, Dubois Quadrangle.

Ignimbrite cobbles were found on hillsides and exposed on dirt roads atop the bench on the west side of Medicine lodge Canyon. All samples were black, fairly brittle ignimbrite in cobble form, to a maximum diameter of 12 cm. Lithic scatters containing substantial amounts of ignimbrite were found along the bench, particularly near water sources.

Corral Creek Locality: NW 1/4 sec.33 T13N R35E, Dubois Quadrangle.

Ignimbrite pebbles and cobbles to 60 cm in diameter were collected from a slope directly to the north of Corral Creek. All samples contained phenocrystic inclusions, and all were of moderate flaking quality. Colour ranged from grey to black, with banding or colour grading evident in some samples.

Cow Creek Locality:

Most ignimbrite cobbles at this locality were small, although two samples measuring approximately 25 cm in diameter were collected. The samples were visually identical to the Corral Creek material.

Lava Creek Locality: LEGALS?? Same as Cow Creek.

Black and grey ignimbrite cobbles were collected along Lava Creek Road, near its crossing of Lava Creek. This locality is directly east of Cow Creek, on the opposite face of the hill separating the two creeks.

The Medicine Lodge Canyon source has been well characterized.

Murphy Hot Spring Ignimbrite, Owyhee County.

Locality 1: SW 1/4 NW 1/4 sec.24 T16S R9E.
Locality 2: W 1/2 SE 1/4 sec.27 T16S R9E.
Sheep Creek Quadrangle.

Both collection areas are located on a hill directly west of the settlement of Murphy Hot Springs. Locality 1, on the eastern face of the hill, produced small (< 5 cm) pebbles of black ignimbrite; a number of flakes and chunks and a single biface were also recorded at the locality.

Locality 2, located at the top of the same hill, consisted of a much more dense concentration of cobbles; most were in the 5-10 cm size range. Samples were invariably black in colour, but flaking quality varied significantly. Five samples were analyzed from Murphy Hot Springs Locality 1, and 10 samples from Locality 2. Flakes from one cobble grouped within the Browns Bench chemical type; this cobble was probably intrusive. The source is well characterized.

Ozone Ignimbrite, Bonneville County.

Locality: Center sec.36 T1N R39E. Palisades Quadrangle.

Very dark brown to black ignimbrite with visible phenocrystic inclusions was found eroding from a gentle slope on the north side of Rock Creek. Cobbles were also exposed in a ploughed field adjacent to the creek. Virtually all cobbles were located on the north side of the creek, although this distribution may be a function of agricultural disturbance. Cobbles ranged in size from 5 cm to 40 cm, and the average size collected was approximately 10 cm. There was no evidence of transport or redeposition of the material, so Flint Hill is assumed to be a primary source.

A local landowner indicated that the material was abundant throughout the area. The Idaho Falls District of the Bureau of Land Management lists an "obsidian" quarry site near this locality (site 10-BV-78, center N 1/2 SW 1/4 sec.32 T1N R40E;

Richard Hill pers. comm. 1989) which is probably another exposure of the same deposit. The source is well characterized.

Picabo Hills Ignimbrite, Blaine County.

Locality: W 1/2 sec 24 T1S R20E. Fairfield Quadrangle.

The Picabo samples were kindly submitted by Dr. Mark Druss, who collected them as a raw material sample near site 10-BN-183 (BLM IMACS data on file at the Shoshone District Office, United States Bureau of Land Management). He suggested that the primary exposure might be at nearby Jasper Flats, but the only material recovered there was extremely friable. Thus, the precise origin of the Picabo Hills ignimbrite remains unknown. However, the lithic scatter at site 10-BN-183 contained numerous cortical and secondary flakes of black ignimbrite; this find supports the suggestion that the raw material was close at hand.

All Picabo Hills samples were smaller than 10 cm in diameter, and all were black with few visible phenocrysts. Fifteen flakes were analyzed, representing five cobbles. The chemical type is well characterized, although the location of the primary source should be more accurately determined.

Pine Mountain Ignimbrite, Blaine County

Locality: S 1/2 SW 1/4 sec.12 T1N R22E. Craters of the Moon Quadrangle.

Small ignimbrite cobbles were collected from a small exposure at the base of Pine Mountain. One cobble was chocolate brown in colour; all others were black. The largest cobble measured approximately 15 cm in diameter but most were smaller, and some flakes were present. The ignimbrite is apparently eroding out of Pine Mountain, rather than the adjacent Timber Butte, on which no cobbles were found. 15 flakes, representing five cobbles, were analyzed, producing a good chemical profile for this source.

Reas Pass Ignimbrite, Fremont County.

Locality: sec.2 T14N R45E Hebgen Lake, Mont., Id., Wyo. Quadrangle.

Cobbles of friable phenocrystic black ignimbrite were found in the gravels of Reas Pass Creek, approximately 2 km downstream from Reas Pass in the Centennial Mountains. Some cobbles were quite large, and the average size was about 25-30 cm in diameter. Most cobbles had smooth water-worn outer surfaces, but the mass of the rocks and the smallness of the stream suggest that little or no water transport had taken place. Scattered debitage noted along the banks of the creek support the notion that this locality was exploited prehistorically.

Sappington (1981a) reported the collection of obsidian from Reas Pass in the center of sec.2 T14N R45E. However, his analyses grouped the Reas Pass material with samples from Bear Gulch, Spring Creek, and a number of Montana sites to comprise the "Centennial" source. The present study considers the Reas Pass ignimbrite to be different from Bear Gulch obsidian.

Snake River Ignimbrite, Power and Bonneville Counties

Locality 1: NW 1/4 sec.6 T8S R31E.
Locality 2: NW 1/4 NW 1/4 SW 1/4 sec.32 T8S R30E
Locality 3: SW 1/4 sec.29 T8S R30E
All Pocatello Quadrangle.

This source has previously been identified as the Walcott Source (Sappington 1981a).

Cobbles of a rather brittle black ignimbrite were collected at the American Falls Sanitary Landfill site in Power County, and at two other localities near Massacre Rocks Park (see legal descriptions above). Ignimbrite cobbles were found eroding out of the hillside and in roadways; size varied from small flakes to large cobbles, to about 40 cm.

Sappington (1981a) reported that this source has been identified at several localities between Neely (approximately 7 km southwest of American Falls) and Ammon, some 115 linear km to the northeast. Luessen (1987) notes a 12 m-thick ignimbrite deposit northeast of the Rock Creek townsite, in the NW 1/4 NE 1/4 Sw 1/4 of an unspecified section of T9S R30E. It is not clear whether the deposit contains rock suitable for flintknapping. Sappington identified the American Falls ignimbrite as part of the Walcott Tuff Formation of Middle Pliocene age (cf. Trimble and Carr 1976). Greeley and King referred to an "upper dark obsidian welded tuffs" (1975:35) in this formation, which probably corresponds to the ignimbrite samples collected.

A total of 45 flakes were analyzed from the American Falls localities (15 flakes from each locality). The source is well characterized.

Three Creek Ignimbrite, Owyhee County.

Locality: T16S R11E center N1/2 section 10. Sheep Creek Quadrangle.

As with the Cedar Creek collection locality, Three Creek ignimbrite was collected as part of the Brown's Bench sampling strategy. 12 samples were analyzed, representing four cobbles; nine samples matched the Brown's Bench chemical profile, but the samples from a single cobble failed to conform to any of the source fingerprints in this study. Further sampling is required to determine the validity of this chemical type.

Yale Creek Ignimbrite, Fremont County.

Localities: T13N R42E NW1/4 NE1/4 section 1
T14N R42E SE1/4 section 36. Ashton Quadrangle.

Small, rounded cobbles of black ignimbrite were collected from in and adjacent to Yale Creek. Ranging in size from 3 to 8 cm in diameter, the cobbles were of moderate flaking quality. 15 samples were analyzed, providing a good chemical profile, but further survey should be undertaken to locate the primary source of this material.

OBSIDIAN SOURCES

Bear Gulch Obsidian, Clark County.

Locality 1: NE 1/4 NW 1/4 sec.16 and E 1/2 SW 1/4 sec.9 T13N R38E. Ashton Quadrangle.

Cobbles to 10 cm in diameter were exposed along West Camas Creek and Bear Gulch Road. Cortex was smooth due to weathering, but not rounded by transport; this is a primary source.

Locality 2: SW 1/4 NW 1/4 sec.15 T13N R38E. Ashton Quadrangle.

Located at the junction of Bear Gulch Road Spur No. 4 and Camas Creek Road, cobbles were especially abundant near the East Fork of West Camas Creek, where they were exposed by erosional processes. Cobbles were also observed in the road cut, and eroding from the dirt road itself. Cobbles were larger than those at Locality 1. This location is just west of

Sappington's Spring Creek locality (1981a).

Locality 3: center of south boundary sec.36 T13N R38E. Ashton Quadrangle.

Cobbles to 20 cm in diameter were found on both sides of the Kilgore road, approximately 1.5 km west of Kilgore. A private gravel pit has exposed many cobbles.

Locality 4: NE 1/4 NE 1/4 sec.22 T13N R38E. Ashton Quadrangle.

Most cobbles at this locality were 3-5 cm in diameter; but a few reached 20 cm, and many were elongated. An extensive archaeological site lies on the surface at this locality; lithics observed at the site included flakes, retouched flakes, scrapers, and bifaces.

The Bear Gulch source has been very well characterized by the analysis of 50 samples. This source is also known as the Camas/Dry Creek (Michels 1983) and the Centennial Source (Sappington 1981a). The former name was not adopted because a physically and chemically different volcanic glass (ignimbrite?) was collected from the Dry Creek locality; the latter name was judged too general, in light of Hughes and Nelson's (1987) evidence that obsidian from the Centennial Valley of Montana differed chemically from obsidian on the south (Idaho) face of the Centennial Mountains. As noted in Chapter 1, Bear Gulch obsidian is equivalent to the FMY 90 group obsidian.

Big Southern Butte Obsidian, Butte County

Big Southern Butte is a large lava dome rising some 760 m above the Snake River Plain. It is the youngest of a series of such features in the area, dated at approximately 300,000 years old. A total of 57 flakes were analyzed, producing an excellent characterization for the Big Southern Butte source.

Localities 1, 2, and 3 were located at various points along the road leading to a lookout station at the top of Big Southern Butte. All three localities are in the northern 1/2 sec.23 T1N R29E, Craters of the Moon Quadrangle.

The obsidian at locality 1 ranged in colour from black to grey to a milky grey/green. No rounded cobbles were observed at this locality; instead the obsidian occurred in amorphous forms containing large spherulitic lithophysae and bands of coarse-grained material (Lawrence Dee 1989 pers. comm.). Locality 1 was littered with flakes and chunks of this obsidian. Locality 2 contained similar obsidian; but fewer artifacts were found, and some rounded cobbles were collected.

At Locality 3, located on the west side of the butte just below the lookout station, obsidian occurred in a number of forms. Small pebbles and tabular pieces of grey and green phenocrystic obsidian of average flaking quality were fairly abundant. A small bedded seam of similar material was sampled from the slope of the butte, as was a large weathered boulder (measuring approximately 60 cm in diameter; the outer surface was very friable, but harder rock was found within). Some small cobbles in the 5 cm range were eroding out of the bank about 15 m downslope from the boulder.

Locality 4, located in the vicinity of Webb Spring, is probably the best known collection locale for Big Southern Butte obsidian. Artifactual material was abundant, consisting primarily of debris from early stages of lithic reduction (Truitt 1991). Only one sizable cobble was found, although others are probably present; however, rockhounds and archaeologists have apparently collected obsidian from this location for several decades (B. Robert Butler 1989, pers. comm.), and it is likely that much of the source has been exhausted. Sappington (1981a), however, reported that samples from Webb Spring were submitted to him, and that some cobbles up to 50 cm in diameter had been observed on the butte; the precise location of these large cobbles is unclear from his description.

Cannonball Mountain Obsidian, Camas County.

Cannonball Mountain samples were provided by William G. Reed, Boise National Forest archaeologist. Reed sampled 32 localities on and near Cannonball Mountain during a 1983 survey project for the Bureau of Land Management. A total of 77 samples were analyzed from six localities. Subsampling of Reed's large sample was based primarily upon the quantity of material available from individual localities. Cobbles were preferred over flakes; although some flakes were analyzed, and a range of macroscopically variable samples was selected.

Two chemically-distinct obsidian types were represented in the Cannonball Mountain samples. Localities 1-4 and Locality 6 clustered closely, comprising the Cannonball Mountain 1 chemical type. Locality 5 samples clustered closely together, but they were quite distinct from the other Cannonball flakes. The 15 samples from Locality 5 define the Cannonball Mountain 2 chemical type.

Locality 1: N 1/2 NW 1/4 sec.19 T1N R15E, at the confluence of Big Deer and Little Deer Creeks. Fairfield Quadrangle.

Ten samples were analyzed, consisting of opaque black obsidian with a dark brown tinge on thin edges. Most of the flakes had sandy inclusions, which sometimes occurred in bands.

Locality 2: N 1/2 sec.12 T1N R14E. Fairfield Quadrangle.

Three flakes were cleaved from each of five small cobbles (averaging approximately 5 cm in diameter). The obsidian varied in colour from black to black/grey banded. Thin flakes held before a light source showed a grey matrix with black speckles. A lithic quarry site (temporary number 050-83-12) was found at Locality 2 (report on file at the Shoshone District Office of the United States Bureau of Land Management).

Locality 3: sec.14 T1N R14E

Samples from this locality consisted primarily of decortication flakes from a associated quarry site (temporary number 050-83-13-2), recorded by Reed (1983; report on file at the Shoshone District Office of the United States Bureau of Land Management). Fifteen flakes were analyzed.

Locality 4: Elk Creek: T1N R14E section not given.

Locality 6: SE 1/4 sec.14 T1N R14E. Fairfield Quadrangle.

Fifteen cobbles were analyzed from this collection area. One cobble (CB6-A) was an opaque black obsidian with abundant phenocrysts that was visually similar to the Locality 1 samples. This cobble may have been brought to Locality 6 from elsewhere, as all other samples from this area consisted of small pebbles of opaque blue/grey obsidian with a slightly grainy texture. However,all samples from Locality 6 were chemically consistent; and, despite the range of visual characteristics, the Locality 6 flakes all correlated very closely with those from Localities 1-4.

Cannonball Mountain 2

Locality 5: SW 1/4 SW 1/4 sec.6; NW 1/4 NW 1/4 sec.7 T1N R15E. Fairfield Quadrangle.

Fifteen flakes were analyzed from Locality 5. The chemical fingerprint for this locality is quite distinct from that of the other Cannonball Mountain samples. Further analysis is required before the nature of the volcanic events at Cannonball Mountain can be understood, but it is clear that two discrete events deposited obsidian on the mountain.

Chesterfield Obsidian, Caribou County.

Chesterfield obsidian samples were provided by R.L Sappington. He reported collection areas in sec.9 and sec.10 T6S R38E, and over a broad area in T6S R37E and R38E (1981a). Although the source was exploited locally (Green 1982), the obsidian is of only moderate quality; and it was probably not a highly valued raw material if other sources were available. Sappington suggested that the bedrock source for the Chesterfield float material may be associated with Miocene-Pliocene rhyolite flows in the area (1981a:14), but he noted that further investigation of the area is required before the extent of the source can be delineated. Fifteen samples were analyzed, and the chemical type is adequately characterized. Chesterfield obsidian is sometimes known as Smith Creek obsidian (Green 1982).

Coal Bank Spring Obsidian, Cassia County.

Locality: T16S R12E NW1/4 NE1/4 section 18 Oakley Quadrangle.

Cobbles of green, grey, and green/grey banded obsidian with a sugary texture were collected from this geologically-complex area, which contains cliffs of ash and pumice, as well as abundant metamorphic rock types (Lawrence Dee, pers. comm. 1989). Most obsidian occurred in blocky, angular form to 25 cm in diameter, but ropy extruded forms are not uncommon. Quantities of debitage were noted in the area. 39 samples were analyzed from this well-characterized source; samples from one cobble matched the suggested Cedar Creek chemical type.

Malad Obsidian, Oneida County.

Localities: T12S R35E NW1/4 section 4 (Hess Pumice Mine)
T11S R35E SE1/4 SE1/4 section 26 (Wright Creek)
T11S R35E center section 9; NE1/4 SW1/4 section 16. All Malad City Quadrangle

This high-quality obsidian can be found scattered throughout the area near Daniels, southeastern Idaho, north of Malad City. Cobbles ranging in size from 8-15 cm were collected from the overburden at the Hess Pumice Mine; one sample had mahogany-coloured streaks, similar to those of the well-known Glass Buttes obsidian from Oregon. Elongated cobbles with little or no cortex were collected from the section 9 and 16 localities, where the glass was very abundant. Fifty-nine samples of Malad obsidian were analyzed, producing a very distinctive, well-characterized chemical profile.

Owyhee Obsidian, Owyhee County.

Owyhee 1

Locality 1: NE 1/4 NE 1/4 sec.1 T5S R1W, and Nw 1/4 NW 1/4 sec.6 T5S R1E. Both in Murphy Quadrangle.

Cobbles of high-quality obsidian were collected from the banks and bed of Brown Creek. Maximum cobble size was approximately 10 cm in diameter. Owyhee obsidian is black in colour, visually homogeneous, and extremely translucent.

Locality 2: SE 1/4 SW 1/4; and N 1/2 SE 1/4 sec.30 T5S R1W. Murphy Quadrangle.

This locality is approximately 12 km upstream from Locality 1, also along Browns Creek. Cobbles were slightly larger and more abundant here, suggesting this locality is nearer the primary source.

Locality 3: NW 1/4 sec.22 T6S R2W. Murphy Quadrangle.

Located at the summit of Toy Pass between Oreana and Triangle, this may be the primary source of the Owyhee obsidian. Cobbles were generally quite small, with the largest piece observed measuring approximately 12 cm in diameter; but the material was extremely abundant. An adjacent hillside did not have exposures of obsidian, nor did the slopes below the pass. It appeared that the road had cut into the deposit, or that erosion associated with vehicular traffic had resulted in exposure only at the road level.

Owyhee 2

Locality 4: east-central sec.6 T7S R2W. Murphy Quadrangle.

Located about half-way between Locality 3 and Triangle, this locality contained the largest cobbles found at the Owyhee source (up to 20 cm in diameter). This is the only Owyhee locality on the south face of the hills. The obsidian was visually identical to that found at the other Owyhee localities, but it was chemically distinct; it was found in road cut exposures over an area of approximately 0.6 km.

A total of 37 flakes were analyzed from the Owyhee sample. Localities 1 and 2 were combined to produce 15 flakes; twelve flakes were run from Locality 3, and ten were run from Locality 4.

Sappington reported that the Owyhee obsidian occurs on both slopes of the Owyhee mountain range over an area of some 1600 km². The obsidian is apparently Pliocene or older in age (Sappington 1981a:14), and it is apparently associated with silicic volcanics approximately 13.8 million years old (Bennett 1976: Fig.4).

Reynolds Obsidian, Owyhee County.

Locality: Several sections in the northeastern corner of T3S R4W. Murphy Quadrangle.

Reynolds obsidian samples were provided by R.L. Sappington. This material was used locally, but it was apparently not important outside the range of its availability (Sappington 1981b:5). The author was able to locate only very small pebbles of Reynolds obsidian (<2 cm), and those submitted by Sappington were no larger. However, the fact that this chemical type is represented at archaeological sites in the Reynolds Creek area indicates that larger cobbles were available in the past. Fifteen flakes were analyzed; and while the geographical extent of the source is poorly understood, the Reynolds obsidian chemical type is well characterized.

Timber Butte Obsidian, Gem and Boise Counties.

Locality: SE 1/4 sec.6 T8N R2E. Weiser Quadrangle.

The Timber Butte samples were provided by R.L. Sappington. The obsidian is black, sometimes with grey banding, macroscopically homogeneous, and highly translucent. According to Sappington (1981a), Timber Butte obsidian may be collected at a number of locations on Timber Butte and along Squaw Valley in streambeds over a distance of over 16 km². Fifteen Timber Butte samples were analyzed, and data from four additional samples from the Simon Fraser University obsidian library were added. The source is chemically distinct, and it is very well characterized.

Wedge Butte (Snowflake) Obsidian, Blaine County.

Locality: SW 1/4 SW 1/4 sec.14 T2S R18E. Fairfield Quadrangle.

Wedge Butte obsidian is quite distinctive in appearance, having abundant inclusions. The material is of moderate flaking quality. A small exposure was located on a finger extending northward near the base of Wedge Butte. Most cobbles measured approximately 3-4 cm in diameter, but there were numerous decortication flakes in an associated lithic scatter which attested to the presence of larger cobbles in the past. 15 samples were analyzed, and the source is well characterized.