Guide to Geochemical Sampling of Stream Sediments for Geologists on Geological Mapping Projects

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Assessment of mineral resource potential from geological mapping can be enhanced by reconnaissance stream sediment geochemistry done during the mapping. Sampling should be planned so that results will be available before the submission of the final manuscript.

For most geologists geochemical sampling by itself can be an unpleasant, exhausting, and boring task if done for long periods of time without a break. It is generally not possible to collect many geochemical samples and pay maximum attention to geological observations the same day. In addition to diversion of attention there is an added burden of equipment and samples in addition to the usual geological field equipment, hammer(s), and rock samples. Some investigators may want to do most of the sampling near the beginning of a project and if fortunate, use a field assistant. Other investigators may alternate geology with geochemical sampling several days at a time. Three days in one week is about enough for most geologists doing geochemical sampling. Combined geologic observation and geochemical sampling would be appropriate at remote stream sites with difficult access, to avoid time-consuming duplicate trips. The sampling schedule should be up to the individual geologist, but it should be remembered that unless a minimum number (about 60 per 7.5′ quadrangle) of samples are collected in a uniform, careful way, and kept from contamination, the effort is a waste of time.

The following comments are intended as a guide to geologists who will collect geochemical samples by themselves or with a field assistant during the course of quadrangle or regional geological mapping.

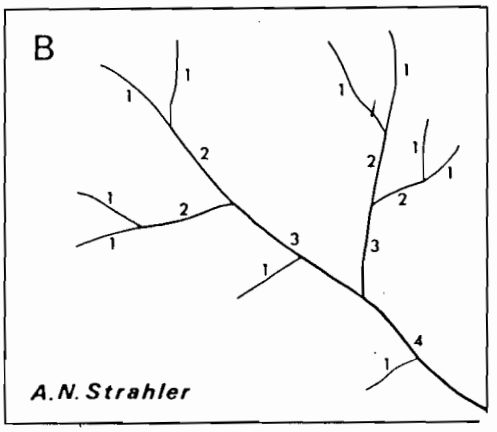


Figure 1

Basis of Geochemical Sampling

Outside of the Coastal Plain sediments and its outliers west of the fall line, stream sediment samples from running water in the headwaters of streams generally reflect the lithology of the sediment source area and the ground water runoff water from that part of the drainage basin. This is true in the Piedmont areas of low relief for the first, second, and third order streams as demonstrated by studies of both heavy and light minerals (Good, Fordham, and Halliday, 1977; Good, 1978; Good, 1981).

First order streams are defined by Strahler (See figure 1) as the headwater springs, small streams or as very small, short side feeder streams to much larger streams. When first order streams join, the stream become second order, and when these join, third order and so forth. Although there might be some question in some cases about designation of stream orders of unequal tributaries, and intermittent drainages, the sampling strategy is basically to sample as many first and second order streams as possible and generally not go beyond third order streams, which might be sampled on one mile intervals. The problem for quadrangle coverage is that from experience in known or potential mineralized zones, the key sample has sometimes been a spring, a gully, an intermittent stream that could very well be omitted on a low density coverage. A diluted anomaly will seldom look impressive in sediment taken from the third order stream a mile or two downstream.

Examples of sampling stations from VDMR surveys are given for several quadrangles. (184 samples) Andersonville and Willis Mountain (155) samples were sampled on density about 3 times suggested for quadrangle mapping because there was a known mineralized zone and the potential for others nearby. (Figures 2,3).

Figure 2

4.

ANDERSONVILLE 7½' QUADRANGLE

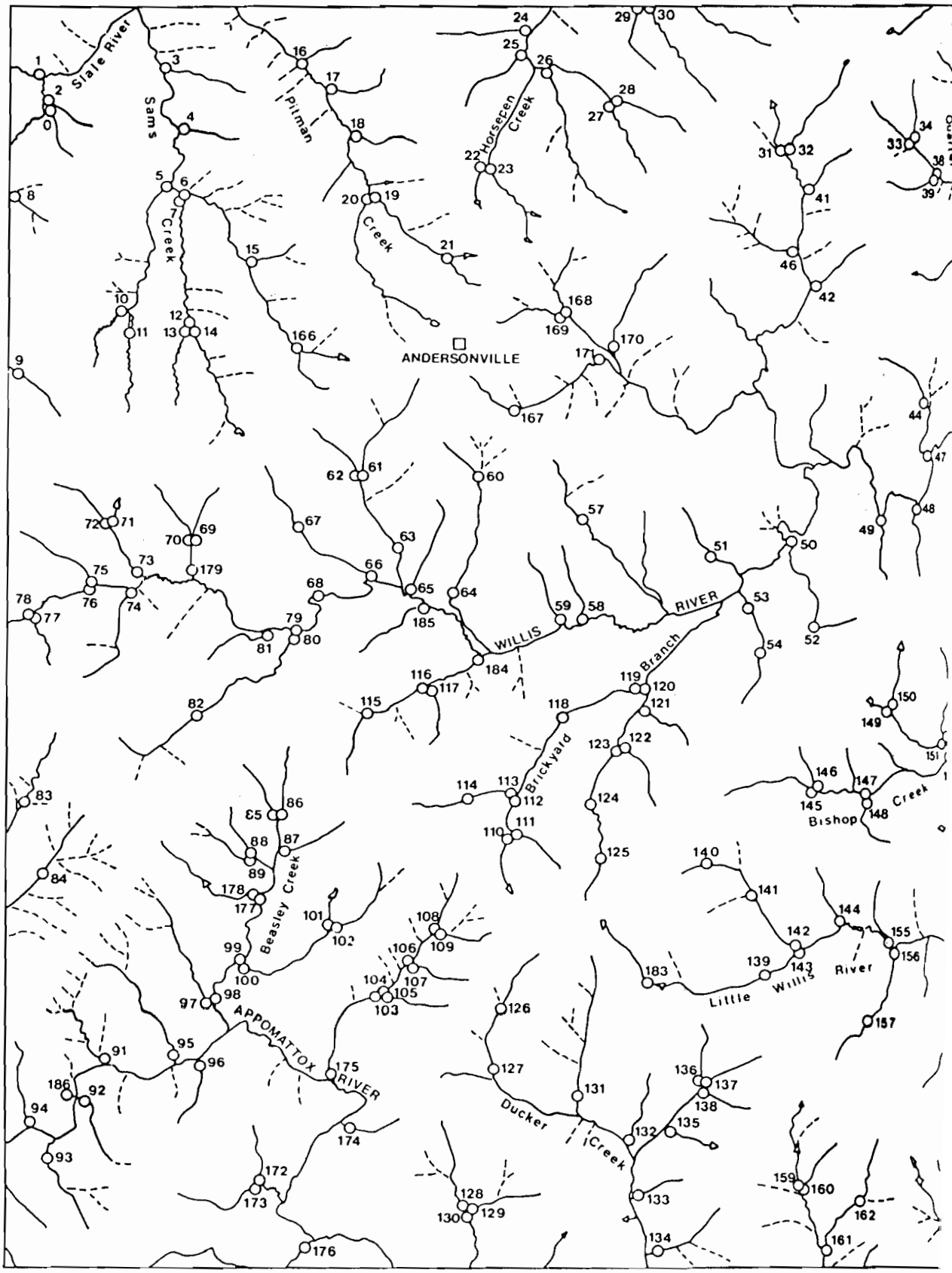
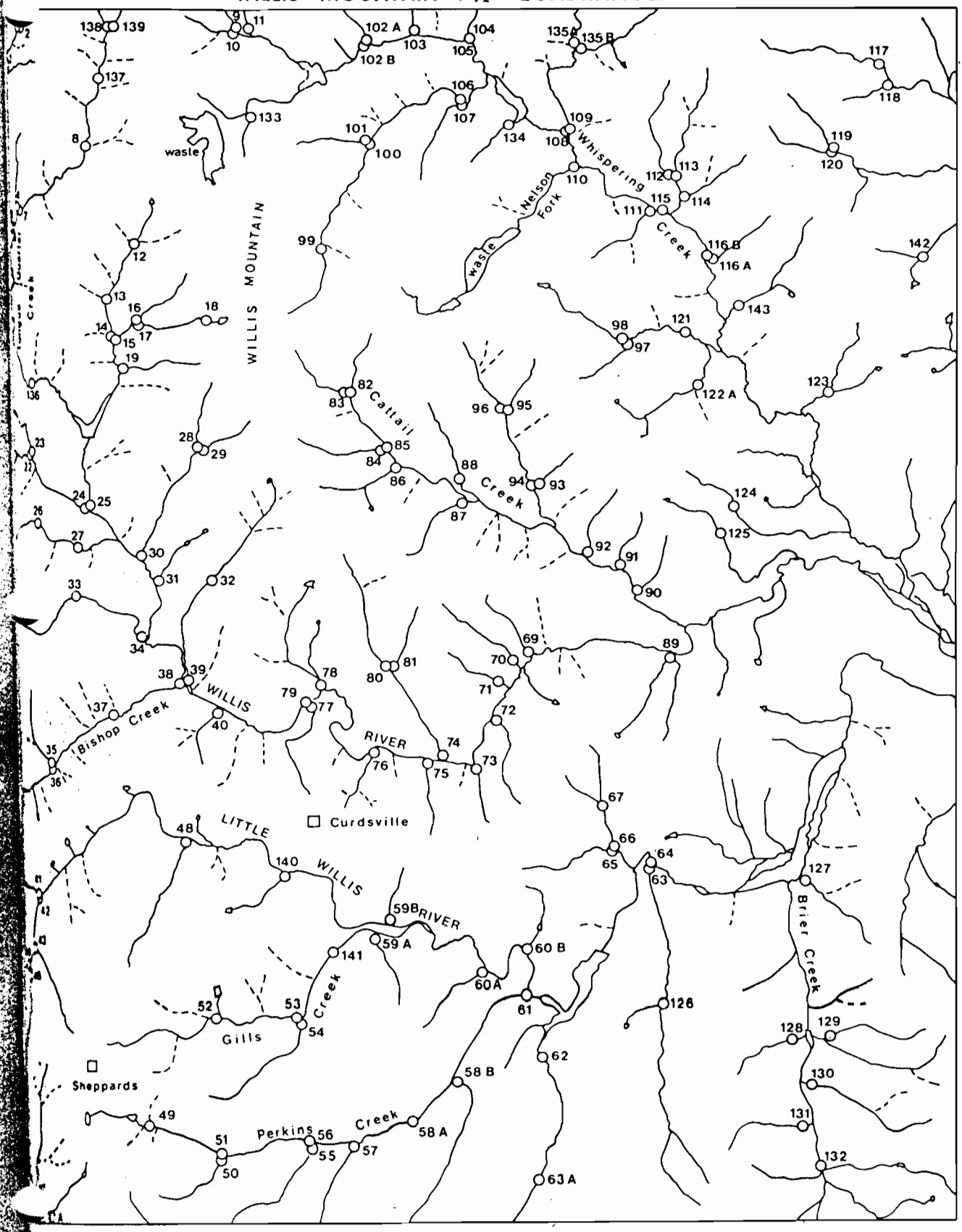


Figure 10. Map of sampling stations in the Andersonville 7.5-minute quadrangle. From Good, 1981 in

Figure 3

WILLIS MOUNTAIN 7½' QUADRANGLE



Map of sampling stations in the Willis Mountain 7.5-minute quadrangle. From Good, 1981 in

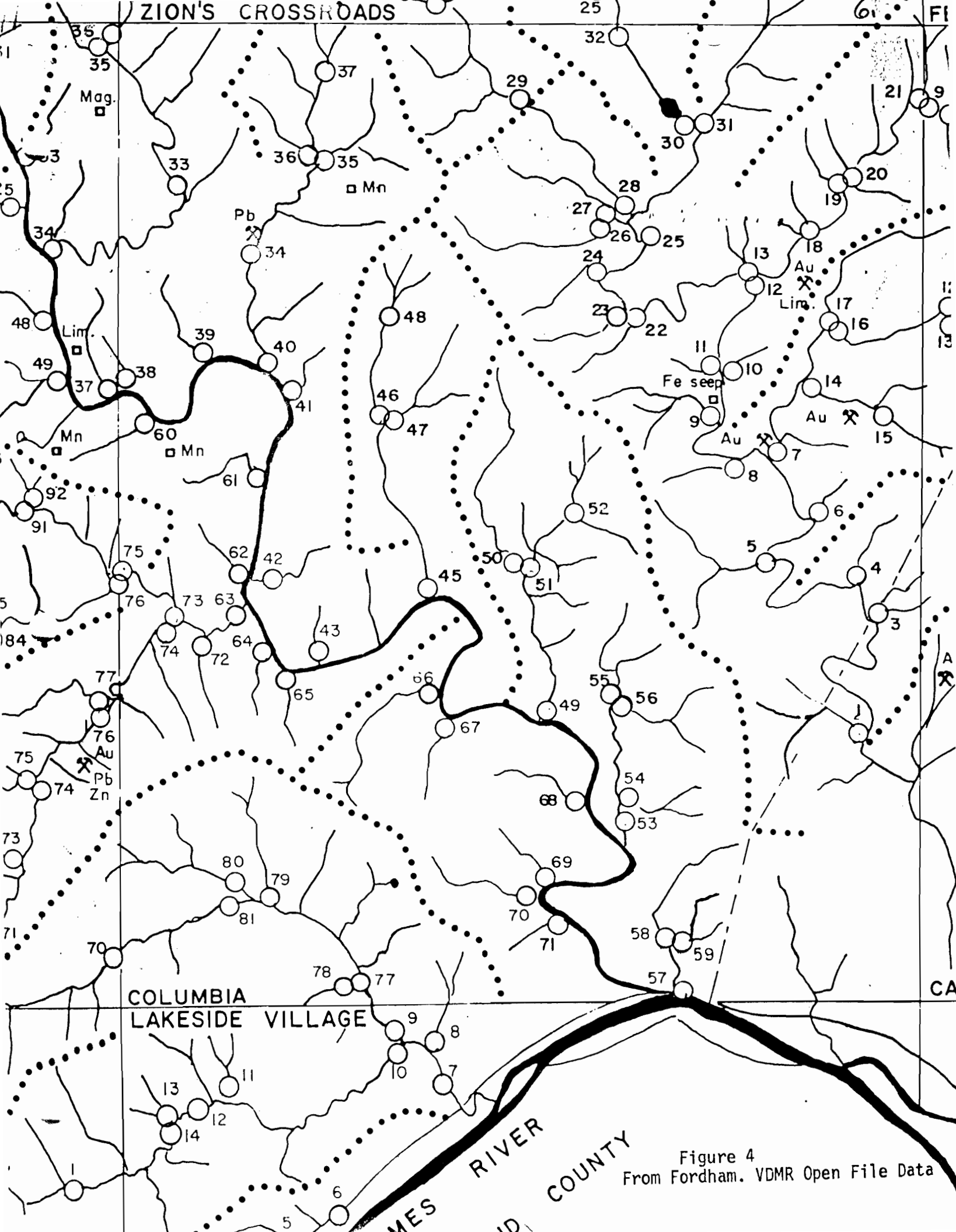
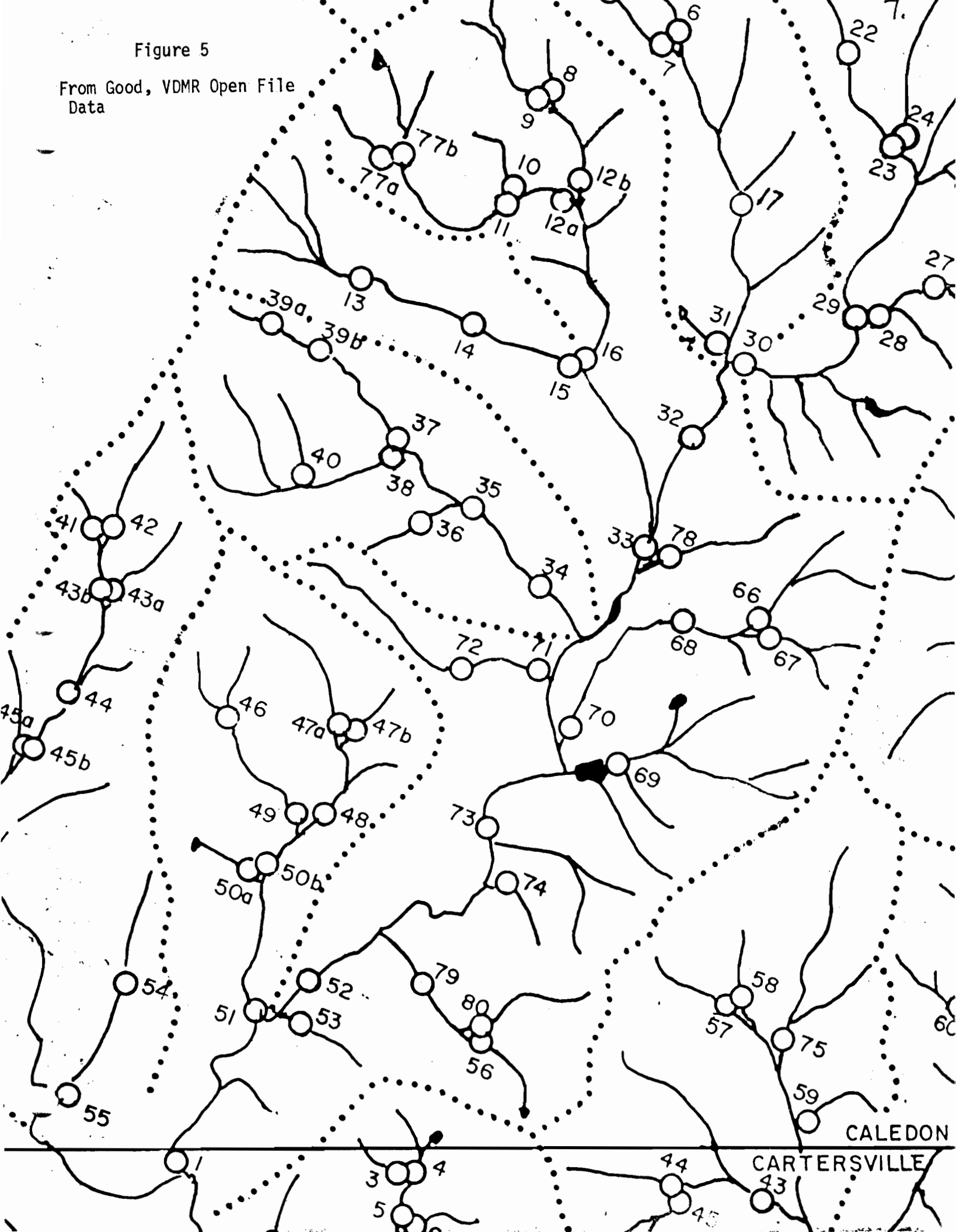


Figure 4
From Fordham. VDMR Open File Data

Figure 5

From Good, VDMR Open File Data



Note that, even so, many first order streams were not sampled. Note also that samples are taken at the junction of streams about 100 feet upstream from the confluence. Sample sites from two county surveys, Fluvanna and Goochland, show density closer to that suggested for quadrangle mapping, 60-75 per quadrangle. (Figures 4,5) The Rocky Mount quadrangle was sampled with an even lower density (40 samples), but the sample sites were selected close to known or potential mineralization and strong anomalies were found.

For statistical purposes, 25-30 samples are required for any significant results in a uniform single sediment population generated from the same parent rock. Most quadrangles have several subpopulations of different lithologies. Some of these markedly show different background metal averages. Experience by the writer, O.M. Fordham, Jr., and other investigators in private industry has shown that most reconnaissance stream sediment anomalies, even close to known mineralization, are commonly very low level, frequently only 1 to 2 standard deviation above an arithmetic mean for all the samples. Metal values in stream sediments are lower in both background and mineralization areas compared to soil geochemistry, which is only useful when a target area is closely pinpointed. Because of the relatively low metal values in sediment chemistry, close control over the statistics must be exercised for any of the data to be useful.

The stream sediment sample should be an integrated sample of metal chemistry from a nearby drainage area, not a point source like stream bank material. The method of analysis, atomic absorption spectrometry, uses a leachate from hot 1:1 HCl digestion and reflects only HCl-soluble metals from the surface oxide and organic coatings of sediment grains. HCl digestion however does not break the silicate bonds, as does a "total digestion" with HF, HNO_3, and $HClO_4$ acids.

"Total attack" releases many ions into solution such as aluminates, calcium sodium and potassium which will cause spuriously high atomic absorption values for some metals such as lead or zinc.

The field geologist should have some idea of what metals will be released and what metals will be slowly attacked or not released at all during the chemical leach of the sediment sample. Hot HCl will attack all metals contained in the iron oxide-manganese oxide coatings because much of the metal content is present in soluble, adsorbed form so that the iron and manganese oxides completely dissolve. Sediment grains usually have very thin, slippery organic films formed from diatom and algal slime, and colloidal or poorly soluble, very fine-grained sediment in the stream may impinge on the slime coating. This fine-grained suspended material from the stream may or may not be attacked by HCl.

In addition to the iron and to a much lesser extent, manganese coatings on sediment grains, HCl will partially attack, or completely dissolve some of the sediment grains themselves. Sediment samples which have been sieved to the fine sand fraction with most of the clay and silt removed, usually consists of quartz with up to 30% or more of a mixture of feldspars, micas, amphiboles (or pyroxenes in the Blue Ridge), magnetite and or ilmenite, limonite, hematite, and depending on the source area, traces of zircon, garnet, staurolite, epidote, zoisite, tourmaline, kyanite, etc. Quartz and fresh amphiboles are unattacked and only cleaned of iron oxide coatings. However, long digestion may partly leach the surface of chlorite, muscovite, and feldspars. Albite is apparently highly resistant to attack, but leaching is said to become more pronounced as the plagioclase becomes more calcic. ~~(cit.~~ (Dolezal and others, 1968). Some of the amphiboles may have been partly altered and therefore subject to limited leaching. In general, the typical sediment will have some metals such as Li, Rb, Sr, Ba and Cr leached from the rock-forming minerals as well as from iron-oxide coatings.

Relatively unstable sulfide grains have been observed in sediment samples taken in headwaters near a sulfide source. Pyrite can be preserved by the oxidized limonitic, or limonitic-hematitic husk. This husk is leached completely by HCl but the acid does not attack the pyrite or chalcopyrite, arsenopyrite. It is interesting to note, however, that pyrrhotite will be attacked by HCl. Hot HCl will dissolve magnetite, limonite, hematite, ankerite, siderite, but not ilmenite. Hot HCl will also dissolve sphalerite, smithsonite, apatite, allanite, cerrussite, galena, scheelite, pyrolusite, scordite, pitchblende (but not uraninite), carnotite, tyuyamite, zeunerite, chrysocolla, and malachite. Other minerals of interest not attacked by HCl are: rutile, tourmaline, leucoxene, garnets, epidote, kyanite, sillimanite, andalusite, monazite, spinel, staurolite, gahnite, fluorite, barite, cassiterite, beryl, topaz, corundum, molybdenite, nickelite, safflorite.

Previous work by the writer (Good, 1981) has shown that because of a large surface area per unit weight and because of metal absorption on clays, the silt-clay (-230 mesh, less than 0.0625 mm, more than 4ϕ fraction of the sediment carries between 2 and about 4 times the metal content in a hot, HCl leachate, compared to the fine sand fraction (-80 to +230 mesh, 0.177-0.0625 mm, 2.5 to 4ϕ Table 1). Because only the bare minimum of samples are used statistically speaking, on the order of about 1 sample per square mile, anomalies are generally very low. An anomaly has been demonstrated to be only 1-2 standard deviations above a quadrangle metal mean in some documented, known mineral deposits. For this reason the samples are screened to eliminate the clays and silts for better statistical control even though the fines have higher values. The metal values are much more erratic with a whole sample or with fines alone. Other research by the writer has shown that the results are not greatly affected by varying amounts of magnetite, since at

least 85% or more of the total metal values were found to be on the iron oxide fraction, not in the magnetite. This observation was based on 20 Piedmont samples, including several anomlous ones.

Sample Collection

Sediment stations should be about 100 feet upstream from stream junctions in running water wherever possible. The sample should be collected from several locations from riffles, underneath cobbles, or gravel bars. Bank material and muds should be avoided. A trowel is essential for the collection of gravel and sand, particulary among cobbles, and angular gravel.

The first step is the collection of 2 mm (-10 mesh) sand by sieving with a stainless steel sieve. Enough material from several locations should be collected, so that the second sieving (-80 to +230 mesh) of fine sand should be about the size of a fist. This fine sand should be bagged in plastic and sealed, then placed in another cloth bag to protect the bag from rupture. The sample station should be marked with flagging tape on a nearby tree or branch. Mesh sizes, screen sizes, and phi units are shown in Table 1 for convenience.

Geologists looking for tin, tantalum, tungsten, and precious metals will need to collect panned concentrates or large 10 pound samples for their analysis. Tin, tunsten, tantalum, and niobium must be analyzed by X-ray fluorescence of their heavy mineral concentrates. Atomic absorption will show traces of silver, but not for assay basis. It is a waste of time to analyse for gold in raw, unconcentrated stream sediment. The material should be panned at the stream site, or a large 10 pound sediment sample should be brought back for treatment with the "gold hound" automatic panner, and special treatment (10 gram sample of panned concentrate) for atomic absorption treatment. The best plan is to standardize a sample size for the automatic panner, and then send the sample to an outside laboratory for analysis.

Table 1

12.

Table 3-2. *Terminology and class intervals for grade scales*

	U.S. Standard sieve mesh	Millimeters		Phi (ϕ) units	Wentworth size class
GRAVEL	Use wire squares	4096		−12	
		1024		−10	Boulder
		256	256	−8	
		64	64	−6	Cobble
		16		−4	Pebble
	5	4	4	−2	
	6	3.36		−1.75	
	7	2.83		−1.5	Granule
	8	2.38		−1.25	
	10	2.00	2	−1.0	
SAND	12	1.68		−0.75	
	14	1.41		−0.5	Very coarse sand
	16	1.19		−0.25	
	18	1.00	1	0.0	
	20	0.84		0.25	
	25	0.71		0.5	Coarse sand
	30	0.59		0.75	
	35	0.50	1/2	1.0	
	40	0.42		1.25	
	45	0.35		1.5	Medium sand
	50	0.30		1.75	
	60	0.25	1/4	2.0	
	70	0.210		2.25	
	80	0.177		2.5	Fine sand
	100	0.149		2.75	
	120	0.125	1/8	3.0	
	140	0.105		3.25	
	170	0.088		3.5	Very fine sand
	200	0.074		3.75	
	230	0.0625	1/16	4.0	
SILT	270	0.053		4.25	
	325	0.044		4.5	Coarse silt
		0.037		4.75	
		0.031	1/32	5.0	
		0.0156	1/64	6.0	Medium silt
	Use	0.0078	1/128	7.0	Fine silt
	pipette	0.0039	1/256	8.0	Very fine silt
MUD	or	0.0020		9.0	
	hydro-	0.00098		10.0	Clay
	meter	0.00049		11.0	
		0.00024		12.0	
		0.00012		13.0	
		0.00006		14.0	