

**METHODS OF ROCK, SOIL, STREAM SEDIMENTS, VEGETATION AND VAPOUR**  
**SAMPLING**

*Sampling* is the process of taking a small portion of an object such that consistency of the portion shall be a representative of the entire property of the object under assessment.

**Sampling equipments**

Samples are collected by various suitable and convenient methods and means without compromising quality and reproducibility.

Conventional sampling tools are-

1. hammer and chisel
2. Sampling buckets
3. Boxes/large sacks
4. Sample bags
5. Wax, twine, seals, linen shipping tags
6. Measuring tape
7. Pencils, note books,
8. Spades, shovels, and mechanized loaders are preferred to signify large volumes of sample material.

The other supporting tools are compass, Global Positioning System, hand-held X-ray fluorescence (XRF) analyzer, and camera. The various drilling tools are for ultimate primary and authentic support in mineral exploration and investment decisions.

**Methods of sampling**

Experience and judgement are required in selecting the method of sampling best adopted to a given set of geological conditions. Generally there are two sampling methods-

- i. Surface sampling
- ii. Underground sampling

**The common methods of surface sampling are -**

1. Channel sampling
2. Groove and chip sampling
3. Muck sampling, dump sampling and grab sampling
4. Bulk sampling
5. Car sampling and chute sampling

## Channel sampling

Channel sampling is suitable for uniformly distributed mineralization in the form of veins, stringers, and disseminations. Sampling is performed by the cutting of channels across a mineralized body in fresh surface exposures or underground mine workings, such as the mine face, walls, and roof. The area is cleaned to remove dust, dirt, slime, and soluble salts by any of three processes. These are washing with a hose pipe (air/water) or scrubbing with a stiff brush or by chipping of the outer part of rocks to smoothen the sampling face. A linear horizontal channel is cut between two marked lines at a uniform width and depth (Fig. 1). The width is between 5 and 10 cm at a depth of 1-2 mm. Sample length varies depending on variation in mineralization. The length is preferred at a uniform unit between 1 and 2 m within mineralization to promote statistical applications.

The standard tools are hammer and a sharp pointed end chisel made of drill steel, or pneumatic hammer with a pointed/chisel bit (Fig. 2). While the sampler cuts the channel, a second person collects chips, fragments, and fines in a clean box, sack, or on a canvas sheet spread on the floor. A sample of 1 m length will weigh ~1-2 kg.

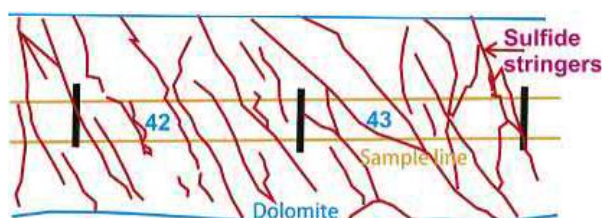


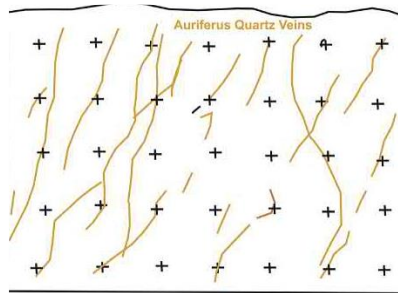
Figure1-Schematic presentation of channel sampling of mineral exposure at surface and underground mine cross-cut wall at 1 m intervals.



Figure 2- Channel sample cut by pneumatic drill machine for exploration of platinum-group elements at open pit bench face, Boula-Nausahi chromite mine, Orissa, India.

## Groove and chip sampling

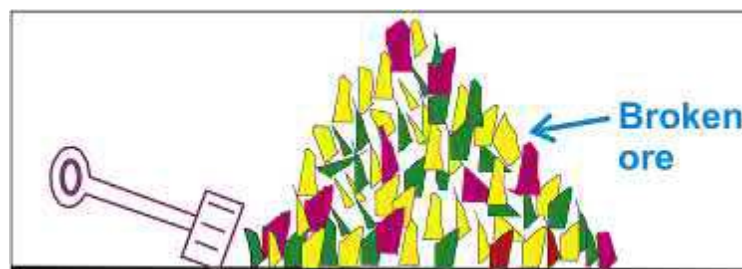
Channel sampling may not be representative in the case of mineralization that is irregularly distributed or disseminated, and is not easily recognized by eye. Chipping fragments of ~1-2 cm by 1-2 cm size covering the entire surface exposure, underground mine face, walls, and roof in a regular grid interval of 25 cm x 25 cm (Fig. 3) will be a better alternative. The area is cleaned before sample cutting. The sampler chips off fragments by hammer and a pointed chisel. The chips are collected in a clean box or satchel or on a canvas sheet spread on the floor. The weight of samples from a 3 m x 3 m area is between 1 and 2 kg. Channel sampling is laborious, tedious, time consuming, and expensive compared to chip sampling. Chip sampling is preferred due to low cost, faster identification of mineralized contacts, and quick evaluation of grade of the area.



**Figure 3-** Chip sampling (+) of wall/face in irregular vein-type deposits such as auriferous quartz veins.

### **Muck sampling, dump sampling and grab sampling**

**Muck sample** is composed of a few handheld spades or mechanized shovels full of mineralized fragments and fines collected from the mine face or stope drawpoints (Fig. 4). These samples collected from mine production are useful to compare with drill estimates, as well as cuttings/ sludge sample values of jackhammer and long hole drills. The grades rarely match on a day-to-day basis. However, the average production grade over a period of a week, fortnight, month, quarter, or year can be comparable depending on heterogeneity of the deposit. It also helps to indicate the intrinsic external mining dilution.



**Figure 4-** Muck sampling collected from all sides using a handheld spade or mechanized shovel depending on the volume of the sample.

**Dump sampling** is generally carried to whenever and wherever old workings exist in the exploratory area. Sampling of dump material is warranted at times to examine suitability of the dump material afresh either for beneficiation studies or to re-examine its grade and marketability.

**Grab sampling** is performed at any stage of exploration, and more so during mine production for a quick approximation of run-of-mine grade. The samples are randomly picked up from loose broken material from outcrops, pits, trenches, mine workings, stope drawpoints, mine cars, load shipments, and all types of stockpiles. Good care should be taken to avoid inclusion of any foreign objects like wood, iron pieces, nails, masonry, and plastics.

### **Bulk Sampling**

A bulk sample comprises a large volume of material (100-1000 tonnes) representing all metal grades and mineral distributions of an entire ore body. Samples are collected from different parts of stockpiles generated from surface trial pits, underground cross-cuts, and run-of-mine ore of regular production. The best collection equipment is shovels to handle huge volumes. Total material is mixed thoroughly to reduce heterogeneity. Samples are used for developing beneficiation flowsheets for optimum reagent consumption and maximizing recovery efficiency.

## Car sampling and Chute sampling

A car sample comprises a handful of broken pieces picked up randomly from ore chute as the mine car is loaded or every 5th/10th/15th moving mine car from an underground mine (Fig. 5), or dumpers/trucks from a surface mine, or aerial ropeway tubs that transport ore to integrated or third-party beneficiation plants and smelters. The sample values are compared between run-of-mine and mill head grade for valuation, grade control, and reconciliation. The method is suitable for valuation of metal grade, penalty components, and moisture content of ore/concentrate being shipped for integrated or third-party smelters.



Figure 5- Car sample in underground mine by collecting a handful of ore randomly from mine cars.

### The important underground sampling methods are -

1. Face sampling
  - Regular channel or groove sampling
  - Pick sampling
2. Grab sampling
  - Muck sampling
  - Car / chute sampling
3. Bulk sampling
4. Drill sampling
  - Percussion/Churn drill samples
  - Diamond drill samples
  - Percussive Cum Rotary Drilling
  - Diamond drills

### Face sampling

The sampling of exposed surfaces of ore and waste whether they be faces in stopes or faces, backs and ribs in development headings. It includes what is termed as bolt/ ring samples.

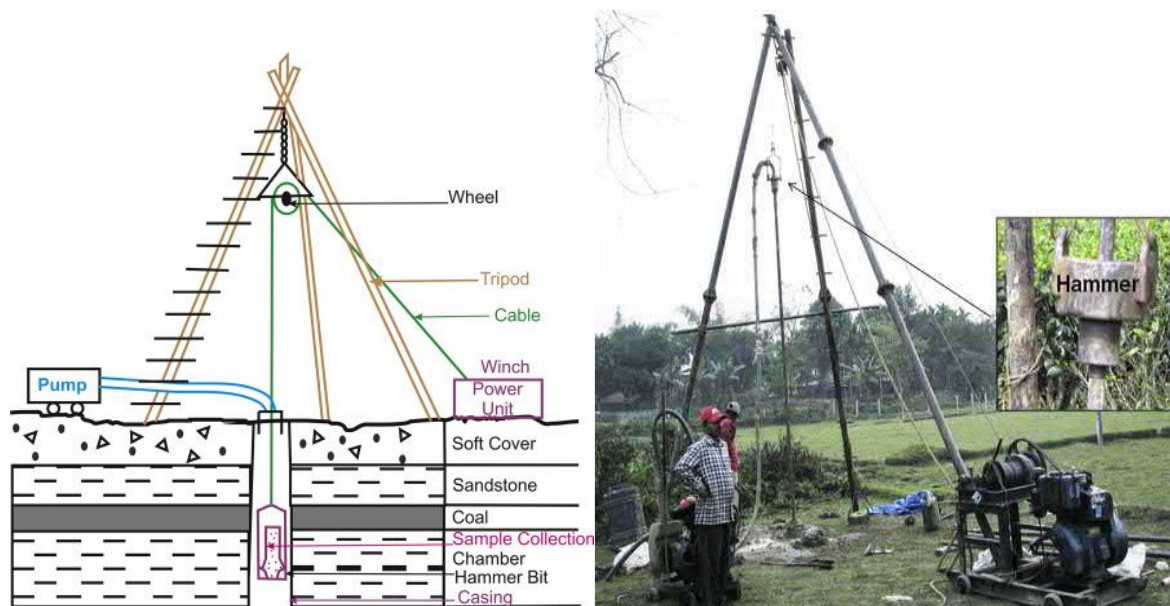
Face samples are taken by

- a) cutting grooves or channels of uniform depth and width across the face or
- b) picking of small pieces all over the face at random.

## Percussion or churn drilling

The percussion or churn drill digs a vertical hole using the principle of a freely falling chisel bit hanging by a cable to which percussive motion is imparted by power units. The power units work by manual lift and drop, compressed air, and electrically driven winches. A tungsten carbide bit fitted in a hammer is lifted a few meters up and allowed to drop (Fig. 6) to hit the bottom of the hole. The process continues in succession. The churning motion of the bit crushes and scrapes the ground to dig a hole. The rock cuttings produce mud or slurry brought about by lowering water. The crushed material is removed from the hole bottom at regular intervals to form a sample.

Churn drilling is suitable for soft and medium formation. The cutting bit is required to be re-sharpened frequently in hard formations resulting in low progress at high labour cost. The capacity of the churn drill is limited to relatively short holes of 10-50 m.



**Figure 6-** Percussion drilling in operation for rock quality and quick target test for mineral occurrences at low cost and reduced time (The hammer is detailed in the inset).

## Diamond drill core sampling

Diamond drill core sampling cuts/splits the core along its length into two identical halves or mirror images with respect to mineral distribution as observed during logging. One half is grinded, reduced, and sent to the laboratory for chemical analysis. The other half is preserved in the core boxes as a primary record for future check studies. The second half can also be used as a composite sample for metallurgical test works during the initial stage of exploration to develop a laboratory-scale beneficiation process flow diagram.

## Percussive Cum Rotary Drilling

The percussive cum rotary drill uses an integral or detachable tungsten carbide bit that penetrates the ground due to the resultant action of both percussive and rotary motions, e.g., jackhammer (Fig. 7) and wagon drills. The percussive action produces a vertical impact on the drill rod to break rock particles. The rotational motion exerts a force on the bit head to penetrate into the rocks. The drill depth is limited to 6 m. Drills are compressed air driven. Water is injected through hollow steel drill rods to cool the bit head from excessive heating. The returning water flushes out cutting material from

the hole for free movement of bit and rods. The cuttings serve as samples to understand the metal content of the advancing face.

These drills are used primarily for the development of tunnels, advanced mining faces, and for breaking big boulders in construction areas. They have limited use in mineral exploration. Samples are used to estimate approximate metal content of big rock exposures and mine blast quality in advance for grade control and scheduling. They provide information about the roof and floor of the coal seam, including the thickness of coal bands within.



**Figure7-** Jackhammer drilling in rich sulfide mineralization for multipurpose use as underground mine face development and sample source for ore continuity and grade control.

### **Diamond drills**

Diamond drills, surface and underground, are most versatile tools, and extensively used in mineral exploration, at dam sites, for other foundation tests, drainage of mine workings, underground mine ventilation, oil structure investigations, and oil/gas well drilling (Heinz, 2009). The extreme hardness of diamond enables it to cut all types of rocks and minerals found in Earth's crust.

**Core-** is the best and most authentic sample, is a cylindrical piece of one or multiple pieces of rock cut (Fig. 8) with advancement of the bit. The core represents the subsurface geology of the section passing through in general, and serves as samples for petrology and precise chemical properties for grade assessment. The core provides physical and accurate records of formations through which the drilling continues.



**Figure 8-** Standard drill core showing stratiform sphalerite and galena in calc-silicate host rock with the red pencil line marked for splitting into two near-identical halves at Rajpura-Dariba Mine, India.

## **Sample reduction for chemical analysis**

Analytical laboratories require a few grams (~5 g) of homogeneous fines at ~100 mesh size for chemical analysis. Sample reduction is done by progressive grinding of fragment size and gradual reduction of quantity at stages. Samples can be prepared manually by mortar and pestle or by relatively faster by using a succession of mini-crusher (jaw crusher), grinding roll crusher and pulverizing disc/ball/rod pulverizer/mill. The final samples change to relatively homogeneous after each stage of crushing, grinding, and pulverizing. The sample quantity is further reduced by coning and quartering.

Two identical samples of 50 g each are prepared: one part is sent to an analytical laboratory and the duplicate is preserved at the exploration department for future reference. Laboratory chemists/technicians further grind the material, mix thoroughly, and reduce to ~5 g for analysis and to preserve the remainder for reference.

## **Analytical instruments**

*Atomic absorption spectrometry (AAS)*-is a widely accepted, rapid, precise, and commonly used method for quantitative determination of a large number of samples for multi-elemental analysis.

*X-ray Fluorescence*- It is used as a nondestructive test to detect elemental/chemical analysis ranging between Mg and U. Typical applications are detection of minerals, including precious metals in exploration and mining projects, alloy in industrial locations and scrap markets, environmental remediation, and lead paint identification.

*Inductively Coupled Plasma-Atomic Emission Spectrometry*- Inductively coupled plasma-atomic emission spectrometry (ICP-AES) works on an optical emission method excited by inductively coupled plasma. It is a promising emission technique that has been successfully used as a powerful tool for fast multi-elemental analysis since 1975.

*Instrumental Neutron Activation Analysis*- The method is suitable for the detection of trace elements and rare earth elements with a high level of accuracy.

*Scanning Electron Microscope (SEM)*- Detailed knowledge of the physical nature of the surfaces of solids is significant in geology, chemistry, and material science. Finer surface information at considerably higher resolution is obtained by scanning electron microprobe.

## SOIL SAMPLING

Soil samples are a widely used geochemical sampling medium. In general, soil sampling is recommended in the following situations:

- Areas of residual soil over any bedrock are generally suitable.
- Areas with soil developed on in situ regolith.
- Areas with soil developed over transported regolith that is less than 5 metres thick.
- Areas where soil geochemical methods have a proven record of success, some of which can be in areas of thick transported regolith but where geochemical indicators have reached surface.

### **Sampling Program**

After a block is delineated for detailed investigation, soil sampling is carried out in grid pattern to delineate the mineralized zone if it is concealed. It is a useful tool for base metal, manganese, chromite and to lesser extent for iron in covered terrain.

Parameters that need to be considered are:

- Sample spacing
- Soil horizon to be sampled
- Soil fraction to be sampled and analysed (generally either bulk or a particular size fraction)
- Method of sample digestion and analysis

There is no substitute for a well-executed orientation program which will answer questions relating to the above mentioned parameters and optimise the signal to background ratio for the target and pathfinder elements.

### **Sample Spacing**

Sampling density and patterns are determined by the style of target sought, the topography of the exploration area and the prospective geology. Soil samples are typically collected on a rectangular pattern, generally with closer spacing of sample sites along more widely spaced sample lines. Theoretically, the sampling lines are oriented normal, or at high angle, to the expected longer dimension of the target, but the orientation of geochemical dispersion patterns are generally not well known, if at all, before sampling. The optimum spacing between sampling lines and sample sites will depend on the purpose of the survey and the expected size of the dispersion halo to be detected. Generally the aim is to obtain at least two (2) samples from the anomaly on a sampling line. Common sample spacings for reconnaissance soil sampling are 400m by 400m or 200m by 400m. For detailed anomaly detection, samples are commonly collected at 100m intervals on 200m spaced lines with infill sampling down to 50m on 100m spaced lines.

Stream sediment samples are usually taken from sites within a stream and are typically active sediments within the actual channel profile. Alternatively, 'overbank sediments' collected adjacent to, but just outside the main channel, have been shown to be extremely effective in defining mineralisation trends and centres.

### **Soil Horizon to be Sampled**

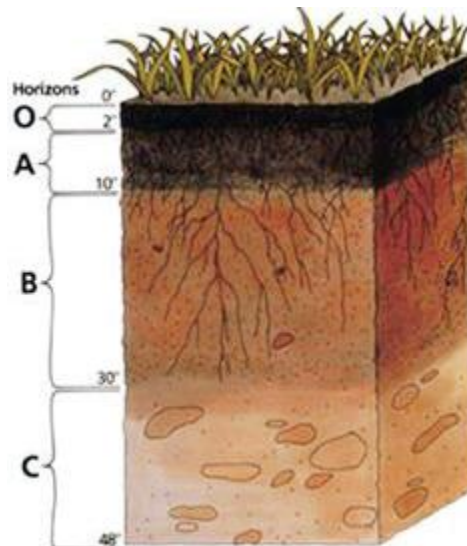
Elements can accumulate in different forms within a soil profile. Traditionally 'B Horizon' soils have represented visual positions where elements have concentrated as minerals such as silicates, iron oxy hydroxides and carbonate crusts to name a few. This 'pre-concentration' can represent an ideal sample



material for collection given the analytical methods now available. As analytical technology has advanced, becoming increasingly sensitive, there are now other equally relevant positions within a profile that can be sampled. Many soil sampling programs have taken shallow soil samples (10-20cm depth) due to speed and ease of sampling. The near surface layer (<50cm) of many soils can have a large component of windblown dust or be partly eroded and disturbed by agricultural activities. Near surface samples may have advantages in areas of deep transported or leached regolith where the target and pathfinder elements have been taken up by deep-rooted vegetation to be deposited and accumulated in the humus component of the upper soil layer (although in some areas this has been eroded away). The near-surface zone of the soil may also contain ferruginous lag fragments which retain a geochemical signature from their source.

In very shallow soils (e.g. skeletal soils on bedrock rises) it is probably best to sample as close to the base of the soil profile as possible. For deeper colluvial and alluvial soils (particularly where they have been ploughed) sampling below the plough hard pan (about 50cm) will give a less disturbed or contaminated clay-rich sample.

As with most sampling methods, it is important to be as consistent as possible in terms of type of material collected (but not necessarily the depth of sampling).



### Soil Fraction

Traditionally, selective size fractions have been used to enhance the signal to noise ratio of elements and soil geochemical surveys have targeted the finer fraction (<120 micron), clay-rich B horizon, in the belief that cations present will be largely adsorbed onto clays. This will be influenced by the type of clays in the soil, for example kaolinite and illite have very low cation exchange capacities, whereas smectites have high cation exchange capacities. Coarser fractions can often cause a dilutive effect on these fine fractions, reducing the signal to noise ratio, hence the preference for sieving.

In deeply weathered regolith, most of the cations are probably hosted in iron and manganese oxides/hydroxides, carbonates and residual rock and quartz grains (as occluded particles of other host minerals). The coarser fraction (up to 2-3mm) will target these soil components and a number of studies have shown that the 0.1-0.2mm fraction generally gives a stronger response for most target and pathfinder elements.

Selection of the most appropriate fraction will depend upon the target commodity and deposit type, the regolith of the sampling site and the nature of the cover present. The initial orientation program conducted can allow analysis of several fractions to determine which provides the best response.

## **Method of Sample Digestion and Analysis**

The sample digestion method will depend to some extent on the elements being targeted and their host phase/phases. Both from an economic and information gathering perspective it is logical to analyse for a wide range of pathfinder and target elements, which can be analysed using combination ICP Mass Spectrometer and ICP Atomic Emission Spectrometer techniques.

A strong acid digestion is most suitable for all round multielement detection where the target and pathfinder elements are both weakly and strongly bound in ferruginous and weathered lithic components. Aqua regia is commonly used because it will dissolve elemental gold, as well as breakdown iron and manganese oxides/hydroxides, carbonates, sulfates, sulfides and many clays (**ALS method TL42-PKG or TL-43PKG**).

Solutions obtained from acid digestions or others (partial leach and selective extractions) are typically analysed using a combination of ICP Mass Spectrometry and ICP Atomic Emission Spectrometry.

## **STREAM SEDIMENT SAMPLING**

The stream sediment survey is most widely practiced in all reconnaissance, prospecting, and detailed surveys of drainage basins. Many minerals, particularly sulfides, are unstable in stream/weathering environments, and greatly disperse as a result of oxidation and other chemical reactions. Stream sediment surveys are very useful for mineral exploration because of greater dispersion in the stream environment. Greater dispersion means greater ability to detect an ore body from a greater distance.

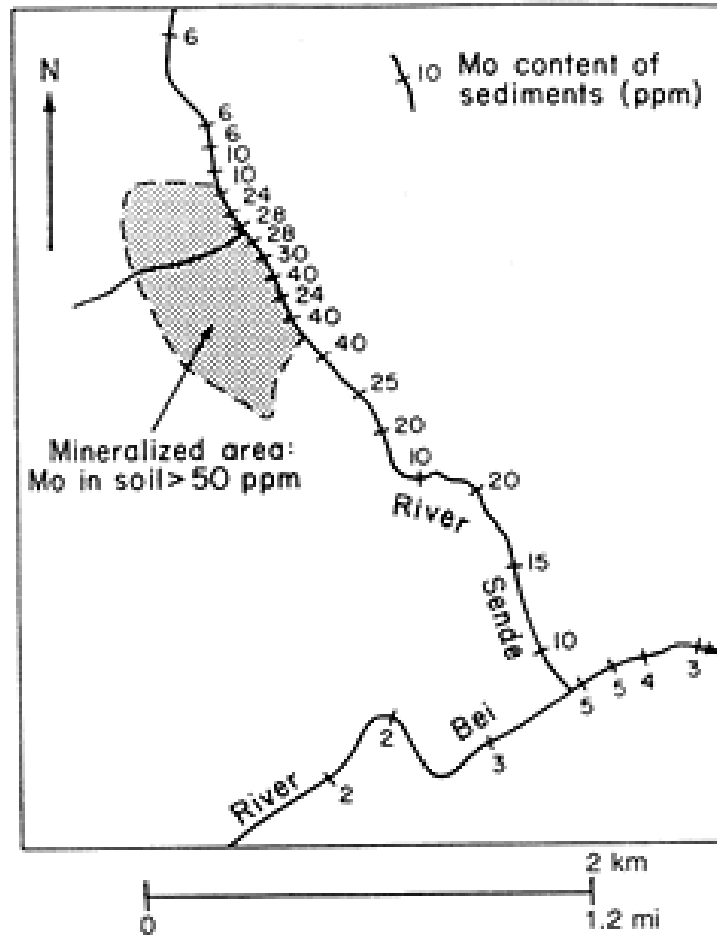
A drainage basin is an area with a network of streams like the branches of a tree: smaller streams join together leading into larger and larger streams.

Mechanical erosion leads to the breakdown of host rocks containing ore minerals. Consequently, tiny grains of the minerals occur in the suspended load of the stream. Turbulence of the water keeps the particles in suspension. Turbulence is greatest in steeper areas where the stream water flows faster. Downstream where the topography is gentler the stream waters move slower, thereby decreasing turbulence. This causes the suspended load to drop out, resulting in deposition of the mineral grains in the stream sediments. Heavy minerals, like ore minerals, tend to drop out first because less turbulence is needed to keep them in suspension.

Studies have shown that the preferred material to collect for a stream sediment sample is the –100 mesh size fraction, which corresponds with silt size. About ½ to 1 cup of this size material is sufficient in most cases. If gravel or organic material is mixed with the silt, then a larger sample needs to be collected. Steep areas may lack the hydrologic conditions which allow silt and fine grained sediments to settle, which can make sample collection very difficult. The downstream sides of large boulders are sometimes the best place to look in these areas. Moss growing on boulders within the stream can act as a filter, trapping finer grained sediments, and can be collected to provide samples from these more difficult areas. The material needs to be collected from the active stream channel, not dried up side channels.

A single sample taken at the mouth of a large drainage basin may be a good way to quickly evaluate potential of a large area, but it provides little detail of the location of a source of mineralization. By sampling the entire stream network of an area, the location of mineralization can be narrowed down considerably. This can be done by collecting samples at close spacing (approximately ¼-mile spacing is common) and by sampling both sides of every stream fork. In this manner, if an anomaly occurs on one side and not on the other, only the fork with the anomaly needs to be considered in locating the source. The trail of anomalies forms a path upstream towards the source. Generally the values will

increase upstream towards the source and reach a maximum value in close proximity to the source, and then drop to background values further upstream from the source.



**Figure 1-** Stream sediment anomaly pattern (It is assumed that the values will decrease downstream from the source, so following the “path” of increasing values upstream, may lead to mineralization).

### Pan concentrate survey

Another type of survey which relies on collection of alluvium is the “pan concentrate” survey. In a pan concentrate survey, coarse materials (generally pebble-sized) are collected and screened to ¼ inch or smaller and placed in a gold pan. The screened material is then panned using a standardized method, down to a volume size of approximately ½ cup. This will be further processed in a laboratory setting and then analyzed.

Pan concentrate samples give an indication of the types of heavy minerals present in an area. Due to inherent inconsistencies in sample collection and panning methods, results from these surveys are difficult to evaluate statistically. To help remedy this problem, special methods are sometimes employed in the field which use screening and collection of specified volume of material, and minimize or eliminate the use of actual panning of the materials (ie, concentration of heavy minerals).

## **Laboratory analysis**

A wide range of techniques may be used, but the most common are emission spectrography and atomic absorption spectrophotometry. The latter technique is particularly suitable for routine geochemical analysis since it permits a large number of samples to be analyzed relatively quickly and inexpensively to an adequate standard of precision. Sample digestion prior to atomic absorption analysis frequently involves a hot mineral acid or mixture of acids; one of the most common digestion agents is a mixture of nitric and perchloric acids.

Other geochemical analytical procedures include x-ray fluorescence spectrography, chromatography, and polarography. Gas chromatography is frequently used for analytical determination of hydrocarbons.

## **VEGETATION SURVEY**

A vegetation survey can broadly be grouped as-

- (1) Geobotany
- (2) Biogeochemistry.

### **Geobotany**

Plants usually respond to the geological environment in which they grow, and may show characteristic changes with respect to form, size, color, growth rate, and toxic effects. Geobotany uses these environmental variations. It includes a survey to recognize the presence or absence of specific plant populations in a location, and is critically associated with particular elements.

Examples-

- Alamine violet thrives only on zinc-rich soils in the zinc district of Central and Western Europe.
- *Viola calaminaria* sp. acts as an indicator plant for base metal prospecting.
- Prolific growth of *Impatiens balsamia* and *Nyctanthes arbor-tristis* (Seuli in Bengali) in rainy seasons, exactly over the outcrops of zinc-lead deposits at Zawar, and *Leucas aspera* in the ancient mine dump of Rajpura-Dariba zinc-lead-silver deposit, India, are location-specific indicator plants.

Sometimes the normal growth of certain plants suffers from malformation or odd coloring caused by the excess presence of certain harmful toxic trace elements on or near the mineralization. The dwarfing of plants and the total absence of sal (*Shorea robusta*) over Kansa nickel deposit, India, are significant. In contrast, the same species is plentiful in the rest of the valley. Bryophyte moss has been a good indicator of uranium mineralization in the Siwalik sandstone of Himachal Pradesh, India.

### **Biogeochemical**

Biogeochemistry encompasses the collection and chemical analysis of whole plants, selected parts, and humus. The mobilized elements dissolve and enrich in soils during chemical weathering. As plants and trees grow, these dissolved elements, including metals, from soil are extracted by roots that act as a sampling agent. The elements migrate to various parts of the tree, such as roots, trunk, stem, and finally to leaves. The cycle is complete with leaves falling to the ground enriching the humus in metals).

Anomalies indicating buried mineralization can be detected by judicious selection of appropriate parts of plants (roots, bark, twigs, needles, and leaves) and subject to analysis. The widely distributed plants of the same species, ages, and parts should be sampled from location to location and values compared for signs of anomaly.

The samples should be washed thoroughly and dried before burning. The quantity should be large enough to generate adequate ash for trace element analysis.

- *Artemisia* (sagebrush) accumulates high copper in British Columbia and Pb, Zn, and Ba in Kazakhstan.
- *Curatella americana* L. is known to be a potentially reliable indicator tree for epithermal gold-quartz veins in Costa Rica.
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### **General Methodology for Geobotanical Studies**

In planning a geobotanical study, the sampling procedures adopted should take into account the potential differences in metal uptake by different plant species and plant parts. In addition, the stages of maturity and seasonal cycles should be considered, as recommended by Thornton (1986).

Normally, a brief reconnaissance survey where transects and sampling plots are established on the geobotanical units map should be undertaken in order to identify locations for collecting samples. Transects should be established in a direction perpendicular to the general strike of the lithological units. The data used in geobotanical sampling research should be collected during two field seasons that should be selected to coincide with the driest time (months) of the year when vegetation is most stressed, and mineral concentrations in the subsurface are at their highest (Cole, 1983; Lyon et al., 1982). In both cases the sampling period should take as short a time as possible in order to minimise climatic variations that might influence element uptake by plants.

Sampling should be during the same time of day to avoid any diurnal climatic impacts on the vegetation. Wet seasons should be avoided since leaching of elements from plant leaves may occur (Brooks, 1983), and concentrations in the subsurface may be diluted by the excess water available in the soil due to heavy rainfall. A second reason for the dry season being ideal for geobotanical studies is that the atmosphere is relatively cloud-free. As a result, conditions for collection of spectral data are ideal and cloud free satellite imagery is easily selectable (Odhiambo, 1993). Finally, fieldwork is not impeded by impassable roads, which can occur during wet seasons in most tropical environments.

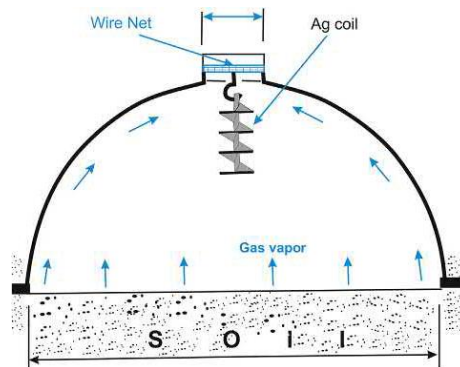
Geobotanical samples should be separated (where applicable) into twigs and leaves; the reason being that the two plant parts (organs) are known to concentrate different amounts of trace elements. In addition, each sample should be split several times to provide replicates. This enables repeated determinations to test the repeatability of analytical results obtained. Standard plant material should be used (or prepared) with which to compare the results from the analyses.

Sample preparation in geobotanical trace element analysis is of utmost importance, since, for example, the ashing technique pre-concentrates the elements in plant material. The concentration levels so obtained are usually much higher (sometimes by a factor of about 20 fold) than the values obtained for the same samples when the material has simply been dried and then digested (Odhiambo, 1993).

It is recommended that only a few soil samples may be collected from selected sample sites (from soil sampling pits) in order to determine the soil pH and Eh, soil organic matter content and soil texture, since these physicochemical factors control uptake mineral elements by plants.

### VAPOUR SURVEY

Vapour surveys (atmgeochemical) help in locating buried deposits through detection of halos of mercury, helium, nitrogen, sulfur dioxide, hydrogen sulfide, hydrocarbon, radon, methane, and other gases and volatile elements, often at a considerable distance from the source of mineralization. The vapors can be detected from air, soils, and groundwater (Fig. 1). Volatile elements are released through oxidation of ore deposits. Samples from shallow depth of soil are collected and analyzed by mass spectrometry.



**Figure 1-** Vapour sampling instrument collecting subsurface metal elements from mineralization located at depth.

The common types of anomalies are as follows:

- Mercury (Hg) vapor anomalies are determined over structurally controlled mineralization in arid terrain. Hg anomalies are associated with concealed deep-seated high temperature geothermal systems, zinc-lead sulfide assemblages, hydrocarbon gas, and oil fields. Hg gas from soil can be sampled by precipitation of Hg as amalgam on extra pure noble metal foils (Ag) in a couple of hours and analyzed to suggest deep-seated sulfide mineralization.
- Helium (He) anomalies are produced by radioactive decay and are found over oil reservoirs, hot springs, porphyry copper, and uranium deposits. SO<sub>2</sub>, CO<sub>2</sub>, and CS<sub>2</sub> are commonly found in soil over copper deposits and their wall rocks.