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COIMBRA

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PRELIMINARY MINERAL PROSPECTING ON THE CULOCAU RIVER BASIN

BARIQUE-NATARBORA (EAST TIMOR)

Dissertation in the scope of the Master of Geoscience, advisors by Doctor João António Mendes Serra Pratas and Doctor Fernando Antunes Gaspar Pita, and presented to the Department of Earth Sciences of the Faculty of Science and Technology of the University of Coimbra

September 2019

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Master in Geoscience

Scientific Advisors

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Abstract

The prospecting by conducting geochemical surveys and panned heavy mineral concentrates sample (Stream sediment or drainage surveys), are based on the concept that fluvial and chemical processes carry metals and minerals from within a drainage catchment (watershed) to a site of mineral either base metals or precious metals accumulation. This technique has been commonly applied for precious metals, gems and other dense minerals with economic importance which can be identified in the field. More recently, multi-elemental chemical analysis of heavy minerals has become widely used. This study is to evaluate and identify sub-basins that may be anomalous for some minerals with economic interest through chemical analysis of the stream sediments or panned concentrates, to locate the primary mineral deposits that may be present on the study area, to predict the geochemical environment of the geological formations present in the study area and their relationships and to establish the regional mineralogical and metallogenic characteristics by studying the heavy minerals present in panned concentrates and also with geochemical analysis of the fine fraction of stream sediments.

The prospecting method was conducted with field observations for watershed as catchment area of materials, sample collection referred to watershed determination. Then, chemical analysis of X-ray fluorescence (XRF) and inductively coupled plasma mass spectrometry (ICP-MS) were applied for those collected sample that represented each of watersheds.Furthermore, the data were resulted from chemical analyses then applied with statistical data to classify thresholds values that separate the defined value ranges from the background and the anomalous values

There have been two basins are considered to have mineralization anomaly with the watersheds. Therefore, it is recommended that a detailed geological and geochemical study could be carried out in areas upstream, principally from sites of anomalous values of metals. This is necessary to confirm the presence or otherwise of the different suspected metallic mineralizations in the area.

Keywords: Barique-Narabora (Timor); geochemical prospecting; sediments; anomaly, mineralizations.

Resumo

A prospecção através da realização de levantamentos geoquímicos e amostras de concentrados de minerais pesados de bateia, baseia-se no conceito de que, numa dada bacia de drenagem, processos químicos e fluviais transportam minerais e metais, comuns ou preciosos, podendo levar à sua deposição e acumulação. Essa técnica tem sido comumente aplicada a metais preciosos, gemas e outros minerais densos com importância económica. Mais recentemente, a análise química multi-elementar de minerais pesados tornou-se amplamente utilizada.

Este estudo visa avaliar e identificar sub-bacias que possam conter concentrações anómalas de alguns minerais com potencial interesse económico. Sua relação com as formações geológicas presentes na área de estudo.

O método de prospecção foi conduzido com observações de campo da bacia hidrográfica da área de captação do material, coleta de 32 amostras de sedimentos em linhas de água, com posterior concentração em bateia no campo, sendo depois em laboratório submetidas a separação magnética e análise química.

Os dados resultantes de análises químicas e seu tratamento estatístico, permitiu identificar as zonas com concentrações de alguns dos elementos químicos. Houve duas bacias hidrográficas com concentrações anómalas de mineralização. Recomenda-se que um estudo geológico e geoquímico detalhado possa ser realizado em áreas a montante, principalmente a partir de locais com valores anómalos de metais. Isso é necessário para confirmar a presença ou não das diferentes mineralizações metálicas suspeitas na área.

Palavras-chave: Barique-Narabora (Timor); prospecção geoquímica; sedimentos; anomalia, mineralizações.

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Chapter I Introduction

1.1. Background

Prospecting is an important tool and is defined as a branch of geological science which on its application is search for minerals or ores that can lead to the location of mineral deposit on surface or underneath the earth´s crust. The prospecting by conducting geochemical surveys and panned heavy mineral concentrates sample (Stream sediment or drainage surveys), are based on the concept that fluvial and chemical processes carry metals and minerals from within a drainage catchment (watershed) to a site of mineral either base metals or precious metals accumulation. Surveys based on chemical sample of stream sediment analysis have long been used for prospecting programs throughout the world. The underlying premise is that stream sediments are composite products of erosion and weathering and thus represent the source catchment area of the stream drainage network. The source for the minerals either base metals or precious metals can be weathered bedrock, transported sediment or previous fluvial deposits. Determining just what constitutes an anomaly for different elements is critical and relies on estimating geochemical background.

Panned heavy mineral concentrates and drainage water samples are often collected at the same time as stream sediment samples. Various ore minerals are dispersed on the surficial environment as detrital grains, mechanically and chemically resistant, with greater densities that most of the rock-forming minerals. Inspection and analysis of these grains in heavy mineral panned concentrates provide valuable information on the mineralization and bedrock geology, complementary to that derived from the fine fraction stream sediment samples. This technique has been commonly applied for precious metals, gems and other dense minerals with economic importance which can be identified in the field. More recently, multi-elemental chemical analysis of heavy minerals has become widely used.

The study was conducted at *Barique* and *Abat Oan Villages, Barique/Natarbora Subdistrict, Manatuto Municipality* which located to 64 km the East of Dili, the national capital of Timor Leste. Referred to geological map reference (Audley Charles, 1968), the research area was over laid by some eruptive rock units such as basic tuffs (Barique Formation) and metamorphosed basic and ultrabasic eruptive rocks in which gabbroic and doleritic types predominate (Lolotoe Formation) that that is geologically interested to conduct a prospecting assignment on the site.

1.2. Objectives

- To evaluate and identify sub-basins that may be anomalous for some minerals with economic interest through chemical analysis of the stream sediments or panned concentrates.
- To locate the primary mineral deposits that may be present on the study area.
- To predict the geochemical environment of the geological formations present in the study area and their relationships
- To establish the regional mineralogical and metallogenic characteristics by studying the heavy minerals present in panned concentrates and also with geochemical analysis of the fine fraction of stream sediments.

1.3 Methodology

The present work is contemplated of several stages:

The first phase is consisted of bibliographic research of studies on the thematic topic.

The second phase consisted of field work and field data information. Describe the fieldwork: 32 waterline samples of fine grade material for chemical analysis were collected and as well, 32 waterline samples that were subjected to bulk concentration which sieving to eliminate material with greater than approximately 2 mm and eliminating the lowest density material.

Third phase laboratory work on *Departamento de Ciências da Terra (*DCT) – Faculdade de Ciências e Tecnologia da Universidade de Coimbra: magnetic separation and XRF for panned concentrates, while ICP-MS chemical analysis for fine fractions grade, was run by Actlabs laboratory, Canada.

1.4. Organization of work

This dissertation is divided into five chapters, as follows:

This first chapter: Introduction, provides slight introduction to the work theme, the objectives of the dissertation, methodology and how it is organized.

The second chapter: The study area and geological setting, providing information regarding the where area the study was taken place and describing its regional geology .

The third chapter: Methodology, describes methods that used in the study, initiated from bibliographic research of studies, field work and laboratory phase.

The fourth chapter: explaining the results obtained from analyses and discussion.

The fifth chapter: Conclusion, resumes all the results of the research and analysis and provides suggestions and predictions for the future as well.

Chapter II Study area and Regional Geology

2.1 Study Area

Administratively, the research area is part of *Barique* and *Abat-Oan Villages, Barique/Natarbora Subdistrict, Manatuto Municipality* (Fig. 2.1). *The width of research area covers more or less* 25 km^2 with coordinate boundaries between *126° 1' 35.75" E - 126° 4' 19.64" E and 8° 51' 38.30" S - 8° 54' 20" S.* The basemap was produced with scale of 1:12.500 to compare and find out the real distances and width between the real site and map which practically make it easier to conduct field observation and sampling correctly.

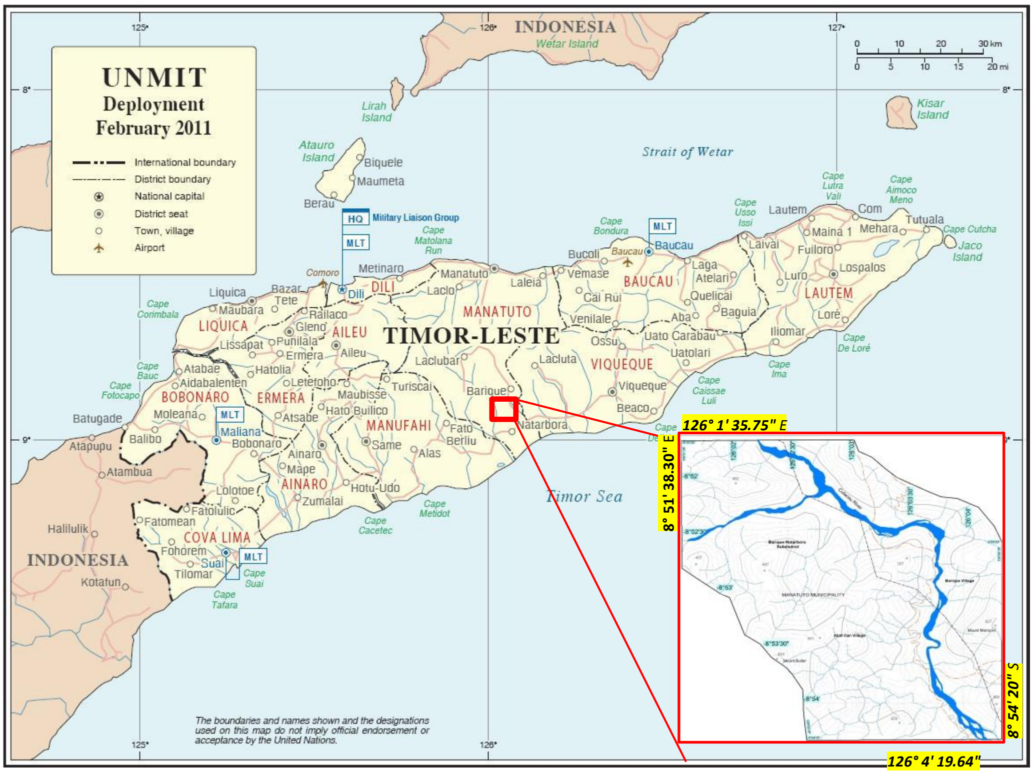


Figure 2.1. The area of study is located at *Barique and Abat Oan* Villages *(Suco) - Barique/Natarbora* Subdistrict*, Manatuto Municipality*

2.2 Regional Geology

Timor is located at the collisional margin between the oceanic Banda volcanic arc and the Australian continental margin (Fig. 2.2). Early mapping documented structural deformation of Australian-affinity strata below allochthonous material with affinity to the Banda arc (Audley-Charles, 1968). Using the early mapping of Audley-Charles (1968) as a base, subsequent interpretations of mapped relationships suggest duplexing of Permian–

Jurassic Australian sedimentary strata below an overthrust oceanic Banda forearc klippe, with Cretaceous and younger Australian strata deformed at the front of the Banda klippe (Carter et al., 1976; Harris, 1991, 2006; Zobell, 2007).

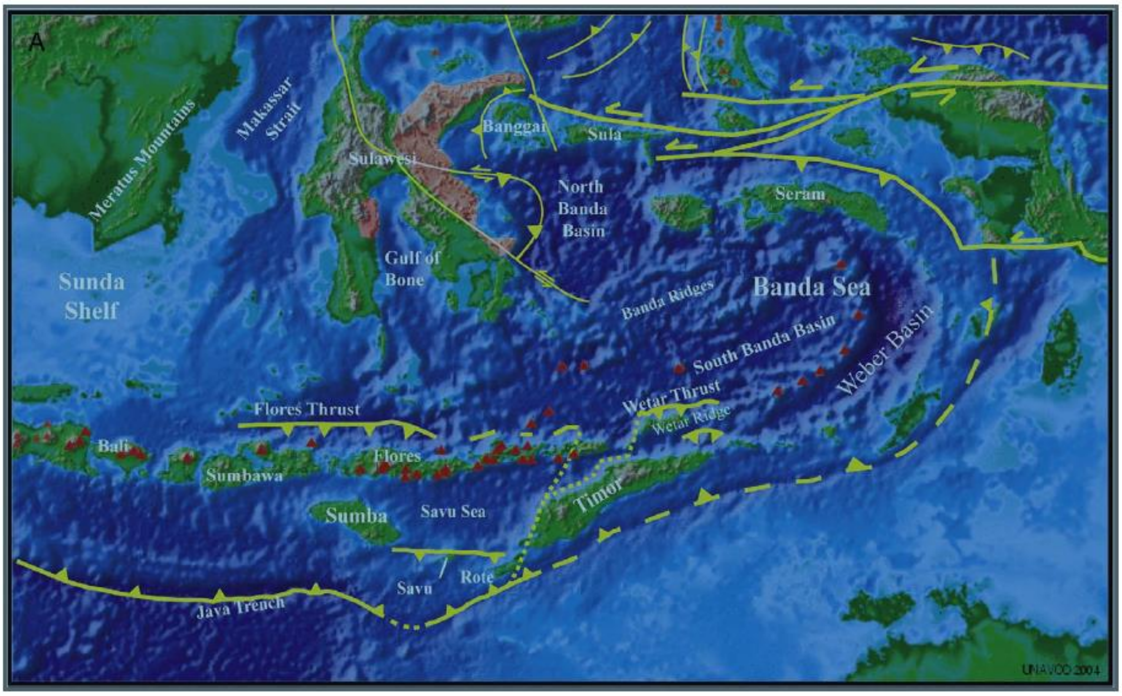


Figure 2.2. Digital elevation model of the Banda Arc region. Active faults are shown in yellow, red triangles are active volcanoes, pink areas are regions of mafic and ultramafic rocks. The Makassar Strait, Gulf of Bone and Banda Sea occupy a region that was formerly the Cretaceous to Paleogene Great Indonesian Arc. Arc fragments, known as the Banda Terrane (Harris, 2006) are found in Sulawesi, the Banda Ridges, Sumba, Savu, Rote, Timor, and the volcanic islands around Flores and Wetar (Standley, C.E., and Harris, R. (2009)

However, the locations of duplex faults and the stratigraphy involved in duplexing have not been documented in detail. This is a key element of our study, since it is essential information to determine the amount of shortening and continental subduction. To place the amount of continental subduction in its plate kinematic context, it is imperative to know the age of collision, which is debated. Stratigraphic constraints require orogenesis at Timor after 9.8 Ma, the ages of youngest Australian passive margin strata within the thrust belt on Timor- Leste (Keep and Haig, 2010), and before 5.6–5.2 Ma, the oldest synorogenic sediments deposited on a tectonic mélange that formed during orogenesis (Harris et al., 1998; Haig and McCartain, 2007). 40Ar/39Ar thermochronology suggests earliest exhumation of under plated Australian continental material at 7.13 ± 0.25 Ma (Tate et al., 2015) or ca. 7.5–8 Ma (Berry and McDougall, 1986). Some debate remains over whether these cooling ages reflect processes within the Banda forearc or initial collision between the Banda forearc and the distal-most Australian margin. Detrital zircon ages of ca. 290 Ma have been used to argue that these units with 40Ar/39Ar ages >7 Ma belong to fragments of the Sula Spur (a continental ribbon that rifted off Australia in the Mesozoic) that were incorporated within the Banda forearc before Banda-Australia collision (Ely et al., 2014). However, because similar detrital zircon peaks of 254–358 Ma have been found within other Australian-affinity units of the Gondwana Sequence (Zobell, 2007), a derivation from the Sula Spur is not required. The continuation of volcanism at Wetar until 3 Ma (Abbott and Chamalaun, 1981) or even 2.4 Ma (Herrington et al., 2011) and at Ataúro until 3.3 Ma (Ely et al., 2011) has been used as an argument against initial collision of the distal Australian margin with the Banda arc before 4 Ma (Audley-Charles, 2011). However, He, Pb, and Sr isotopic signals from Banda arc volcanics demonstrate contamination of the magma source with continental material, supporting subduction of continental material to depths of magma generation from 5 to 2.4 Ma (Elburg et al., 2004; Herrington et al., 2011) and therefore initial collision of the Banda forearc and Australian margin even earlier. Thermochronologic and sedimentologic observations also constrain the age of emergence and the rate of continued deformation on Timor. The emergence of Timor-Leste above water is suggested to be shortly before 4.45 Ma by Nguyen et al. (2013) as indicated by increased clastic input and increased mangrove and lowland rainforest pollen in synorogenic deposits.

Tate et al. (2015) use low-temperature thermochronology to document an extremely heterogeneous history of exhumation across the map area of this paper, with apatite and zircon (U-Th)/He ages ranging from 1.5 to 5.5 Ma with larger exhumation magnitudes and faster exhumation rates in the hinterland slate belt compared to the more foreland fold-thrust belt in the south and east. Continued rapid uplift on Timor and the Banda arc is also evident, with Quaternary coral terraces uplifted up to 700 m on Ataúro (Ely et al., 2011) and with similar coral terraces present on the north coast of Timor-Leste (Audley-Charles, 1968; Cox, 2009). Significant debate remains as to the active mode of deformation on Timor today, with various interpretations spanning active duplexing of Australian strata (Tate et al., 2015), arc-parallel extrusion along transtensional faults (Duffy et al., 2013), and extension driven by slab breakoff and isostatic rebound (Keep and Haig, 2010). Plate reconstructions and GPS measurements both indicate that Australia is moving north relative to the Sunda arc and South Banda arc at ~7 cm/yr (Nugroho et al., 2009; Spakman and Hall, 2010; Seton et al., 2012). Modern convergence is oblique, with ~53 mm/yr of convergence perpendicular to the Timor Trough (the deformation front of the Timor orogen) (Nugroho et al., 2009). Along the trend of Timor this convergence is partitioned between the Timor Trough and the Wetar Thrust, with ~20 mm/yr of convergence partitioned between Australia and Timor and ~33 mm/yr of convergence accommodated between Wetar and the Sunda block (Nugroho et al., 2009). It appears, therefore, that plate boundary reorganization may be under way at Timor. Another argument to that end comes from seismological observations that a seismic gap exists in the downgoing slab below Wetar that may indicate ongoing or recent slab breakoff (McCaffrey et al., 1985; Sandiford, 2008; Ely and Sandiford, 2010). We note, however, that such a seismic gap does not uniquely indicate slab breakoff, since a similar seismic gap below Taiwan is attributed to the subduction of continental material that would lack the water content necessary for typical slab dehydration earthquakes (Chen et al., 2004). In addition, seismic tomography does not image a gap in the slab below Wetar (Spakman and Hall, 2010).

2.3 Regional Stratigraphy

The study area refers to the regional geology map (Audley Charles, 1968) (Fig. 2.3), is overlaid by two formations that consist of Lolotoe complex and Barique formations that which are derived from Banda Terrane group (Charles 1968 and Harris 2006).

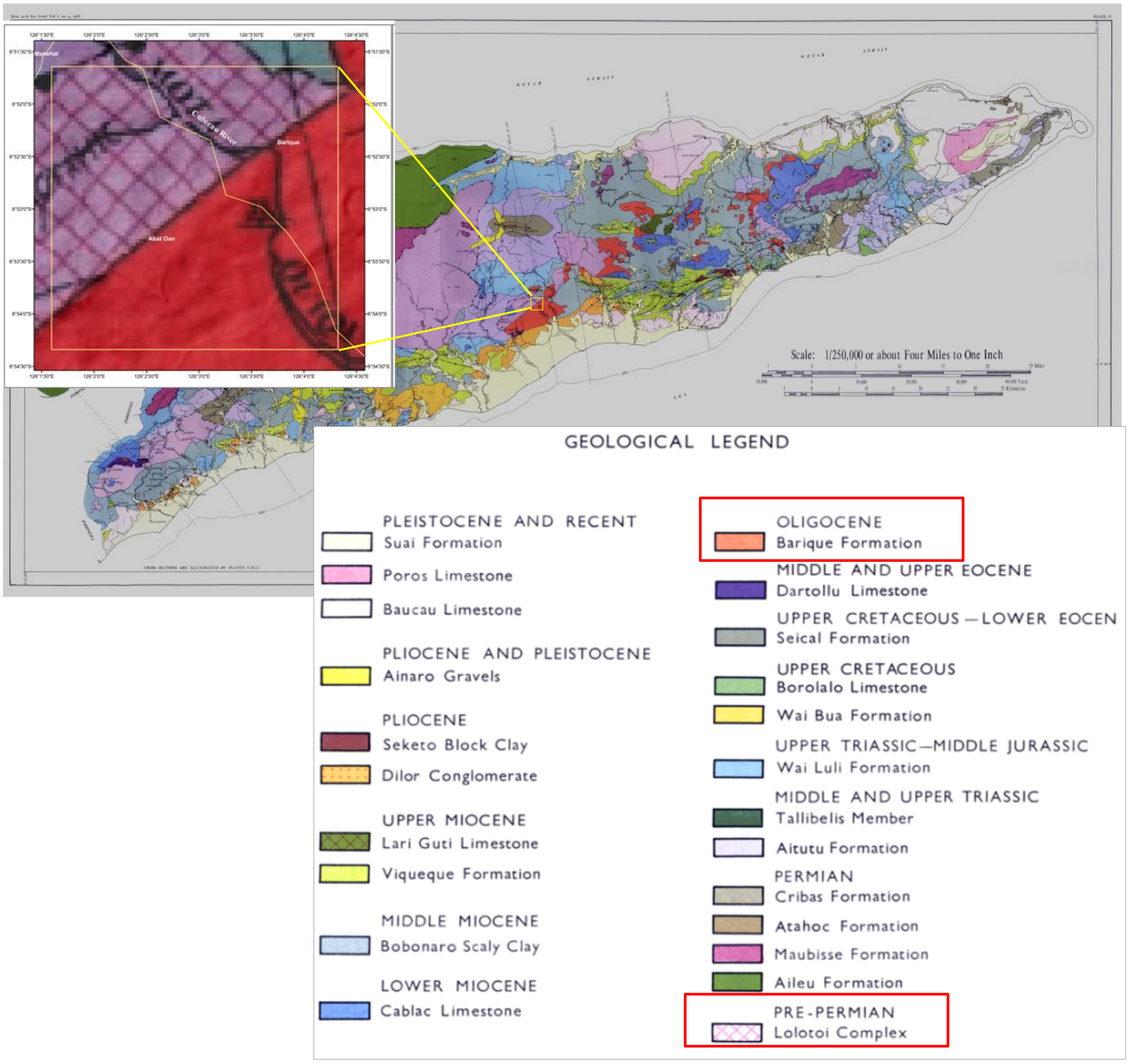


Figure 2.3. Geological Map of Portuguese Timor (Audley Charles,1968)

2.3.1 Lolotoi Complex

Allochthonous units on Timor derived from the Banda forearc (Asian affinity) can be divided into metamorphic forearc basement and the overlying sedimentary and volcanic cover units (Harris, 2006) (Fig.2.4). The metamorphic forearc basement, known in East Timor as the Lolotoi Complex (Audley-Charles, 1968), was described by Standley and Harris (2009) to contain greenschist to amphibolite-facies metasediments and meta-igneous units including graphitic phyllite, garnet-bearing quartz-mica schist, and amphibolite gneiss.

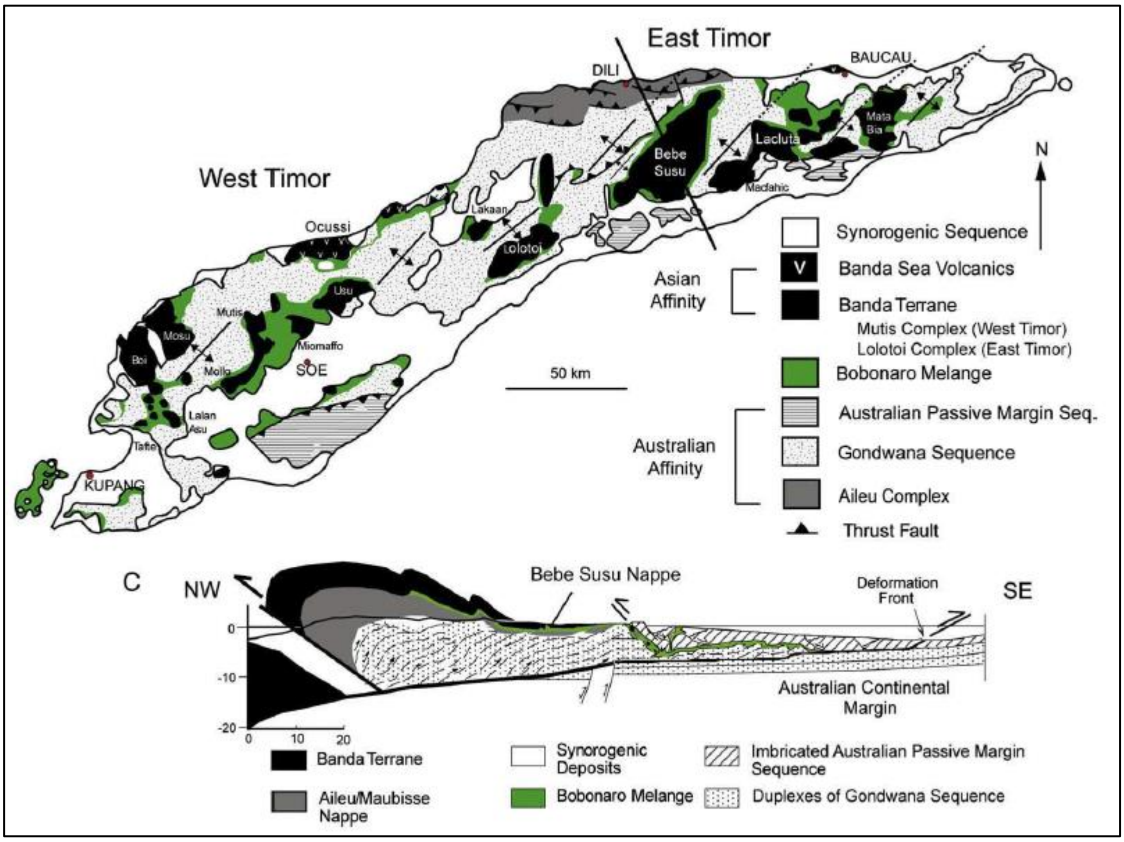


Figure 2.4. Generalized geologic map of Timor taken mostly from Audley-Charles (1968) and Harris et al. (2000) showing various Banda Terrane massifs interpreted as structurally overlying Australian affinity Gondwana Sequence units.

Although some authors have suggested that the Lolotoi Complex is Australian basement (Charlton, 2002) or more strongly metamorphosed Aileu Complex (Kaneko et al., 2007), young detrital zircons (<40 Ma) found within the Lolotoi Complex (Harris, 2006; Standley and Harris, 2009) confirm earlier hypotheses (Audley-Charles, 1968) that the Lolotoi Complex is the allochthonous forearc of the Banda volcanic arc and is of Asian affinity. Previous thermochronologic studies suggest cooling of the Mutis Complex (the Lolotoi Complex equivalent in West Timor) through hornblende and mica $^{40}Ar/^{39}Ar$ closure between 31 and 38 Ma (Harris, 2006) and cooling of the Lolotoi Complex at the town of Laclubar through zircon (U-Th)/He closure at 25.7 ± 1.5 Ma (Tate et al., 2014). This cooling history, coupled with the presence of unmetamorphosed sedimentary units deposited unconformably on the metamorphic Lolotoi Complex prior to the Miocene (Audley-Charles, 1968), suggests significant exhumation in this portion of the Banda forearc prior to collision at Timor.

2.3.2 Barique Formation

Grunau (1953, 1956, 1957A) and Gageonnet & Lemoine (1958) did not distinguish this formation, but grouped part of it with the Dartollu Limestone , part with the overthrust rocks of Permian age (Maubisse Formation in this *Memoir),* part with the overthrust crystalline rocks (Lolotoi Complex in this *Memoir),* and part with what are now recognized as exotic blocks in the Bobonaro Scaly Clay (Audley-Charles 1965A). In all instances they regarded these eruptive rocks as allochthonous. The stratigraphical unity of these rocks was first recognized by I. B. Freytag (unpublished report dated 1959) in central eastern Timor, who called them the *Barique Volcanics,* and showed that they were autochthonous. The author has found Freytag's interpretation to be correct throughout eastern Timor. The composition of the larger clastic particles is variable, and includes Eocene limestones that can be matched locally as well as eruptive rocks resembling those found at higher levels in the Barique Formation. The matrix of the basal conglomerates is tuffaceous. The type-section is composed of a series of tufts with an occasional lava. Basic tufts predominate and consist largely of fragments of basalts and serpentinites; zeolites are common. The acid (possibly mostly dacitic) tufts are composed mainly of feldspar laths with quartz, pumice and glass, which is usually considerably altered. Some tufts contain Foraminifera, and some contain large rounded quartz grains probably derived from sedimentary non-volcanic rocks. A few crystal tufts have been found, Interbedded with the tufts are some foraminiferal quartz-sandstones containing less than 25 per cent of igneous rock-fragments. The greatest development of sandstones is found south of Mt Cablac, where they are about 20m thick. The principal lavas in the type-locality are basalts varying in composition and texture. *Thickness.* The formation is estimated to be about 300m thick in the type-locality, elsewhere it is less. *Stratigraphical position.* In the type-locality the formation is faulted near the base, which is not exposed. North-east of the type-locality, around Lacluta village, the Barique Formation is unconformable on the Lolotoi Complex, which was overthrust to its present position during the Lower Eocene. The youngest rocks on which the Barique Formation rests are the Middle and Upper Eocene Dartollu Limestone near Fehuc Reen, where the contact is unconformable. The base of this formation is everywhere unconformable and generally rests on the Dartollu Limestone or the Lolotoi Complex, but in places it rests on the Aitutu Formation or the Wai Luli Formation. The Barique Formation is usually overlain unconformably by the Lower Miocene Cablac Limestone, but in places is overlain by younger formations. Thus, from its stratigraphical relations the Barique Formation must have been erupted and deposited during the time-interval between late Tb (Upper Eocene) and early Te (Lower Miocene).

2.4 Previous Study

2.4.1 Metallogeny and mineral potential of Timor Island and adjacent areas

The orogenic history of Timor plays a critical role in defining the location of its metallic minerals occurrences, notably copper, gold, silver, chromite, manganese and a number of important non-metallic minerals such as limestone, marble, bentonite and phosphate. The northern edge of Timor-Leste is located near the Inner Banda Arc, the site of a Miocene subduction zone. Oceanic rocks of the Eurasian plate were thrust onto Timor-Leste by tectonic processes, which are poorly understood. Consequently, the northern edge of Timor Island is host to a number of important mineral occurrences, e.g. copper, chromite, gold, silver and manganese. One of the potentially richest copper zones is the north edge of Oecussi district was explored by a multinational company in the 1980s. The base metals are concentrated in ultramafic rocks, which are parts of an ophiolite suite. Large parts of Timor-Leste are underlain by cratonic rocks derived from Northwest Australia. These rocks too are notably endowed with a wide variety of economic mineral occurrences. Precious metals such as gold and silver were also deposited in and adjacent to volcanic centers in the Inner Banda Arc as a result of epithermal activity. One of the islands of this Arc, Atauro, belongs to Timor-Leste. Atauro has a number of gold and silver occurrences. Some important copper occurrences are also located in southern Baucau and north central Viqueque districts. Less significant deposits of chromite, manganese and iron sand deposits occur in Manatuto, Baucau and Lautern districts andon Atauro Island of Dili district. The widespread occurrences of limestone and marl, especially in the eastern and western coastal areas of Timor-Leste, are important and are amongst the few minerals that have been exploited for many years. House foundation materials almost always consist of rock walls made of local rocks cemented with lime made from marl. Important phosphate and bentonite occurrences are located in central Baucau district although these have not yet been exploited. There is a potential for the development of ornamental stones from the numerous good quality marble occurrences in Manatuto district east of Dili. Argillic alteration has resulted in the development of a red to white clay complex in the Aileu

Formation. The alteration has changed phyllites and schists to kaolin in a number of places near Aileu town. The alteration zone occurs over a wide belt beginning a few kilometers east of Dili and extending eastward to include much of Aileu district. This belt contains an almost unlimited amount of clay, including some possibly high grade kaolin deposits. Moreover, the argillic alteration may be a guide to the occurrence of base and precious metals beneath the cover. River valleys throughout the country include a wide range of sand and gravel deposits some of which have already been used to make concrete blocks. Every major town exploits its own local sand and gravel deposits creating a rather lucrative small scale mining industry for a large number of entrepreneurs. None of these non-metallic mineral deposits have been evaluated for their technical characteristics. The most attractive mineral potential of Timor-Leste is in base metals, mainly copper, and associated gold and silver. This potential is in the occurrence of so-called Cyprus type volcanogenic massive sulfides related to ophiolite sequences. This style of mineralization can be observed in outcrop in the Ossu area of the Viqueque District. Geological reasoning and extrapolation allow for the conclusion that similar mineralization will be found in other locations where ophiolite sequences are found in the territory. Chromite, vein gold and certain non-metallic minerals are also found and may have potential. Timor Island is a part of the non-volcanic outer Banda arc. It occupies a suture or collision zone between the Asian and the Australian plates. Formed by mechanical accretion of under thrust or collided Australian continental margin material, the island is covered by several autochtonous sequences. Ophiolites, the so-called Banda terrane, and a clay mélange are the main overlying sequences. Two other important aspects of the geology and geologic evolution that influence the metallogeny are the Australian northwest shelf and the active tectonics and the continuing uplift of the territory. Ophiolite is a stratified group of three separate rock types. The lowermost member consist of peridotites and dunites, above which are layered to massive gabbros that in turn are source to and overlain by a volcanic member composed of sheeted dikes and pillow basalts. While the individual basic to ultrabasic rocks of this sequence have been mapped by the Allied Mining Corp. (1937.), the recognition of these rocks as an ophiolite series was first clearly mentioned by van Bemmelen (1947). “Schist-Ophiolite Complex is probably widely distributed and it forms the overthrust unit of theNorth Coast Schist-Manufahi Diabase Complex.” Van Bemmelen based his descriptions on the earlier work of Dutch geologists, particularly that of de Roever (1940) and the Allied Mining Corp. (1937). A geological sketch by van Bemmelen clearly shows that large areas in Timor-Leste are underlain by ophiolites. Possibly the best and most complete description of the ophiolitic rocks, though not under the term ophiolite, is found in the annotation to the geologic map of the Kupang – Atambua Quadrangle in West Timor (Rosidi, 1978). In this annotation, the Manamas Formation (Tmm.) corresponds to the upper section of the accepted ophiolite sequence, while the Ultra Basic Unit (UB) forms the lower part and completes the sequence. Ore deposits in ophiolites (Coleman, 1977; Cox and Singer, 1986) include massive sulfides as stratabound bodies in the pillow lavas, mainly as copper-bearing massive pyrite lenses with some gold and silver. At times, these lenses also carry lead and zinc values. These Cyprus Type volcanogenic massive sulfides are usually between 500,000 tons and a few million tons in size, though larger deposits exist. They account for significant ancient and modern mining in Cyprus, Oman, Turkey, Greece, the Philippines and elsewhere and, with copper grades between 1 per cent and 10 per cent, are attractive exploration targets. Manganese and manganese-iron-silica formations overly this type sulphide deposits. They are mostly low grade accumulations of manganese oxides and silicates. Chromite occurs in ophiolites, in podiform chromite deposits and as schlieren. Ophioliterelated chromite deposits include some of the most important deposits in the world, such as those in the Islamic Republic of Iran, Greece, Turkey, the Philippines and New Caledonia.

Nickel deposits can form secondary concentrations in laterite weathering profiles on the dunites and peridotites of ophiolitic sequences. Most notable are the examples from New Caledonia where huge lateritic nickel concentrations exist. The ultrabasic rocks of Timor-Leste contain approximately 2000 ppm Ni (Harris, 2000) and could, therefore, in theory also be the source rock for the formation of concentrations of lateritic nickel. Field observations however seem to indicate the absence of deep laterite weathering profiles, probably due to the constant uprising of the island, and, therefore, no evidence exists for the occurrence of this type of mineral concentration. The occurrence of platinum group minerals (PGMs) related to ophiolites has been reported from Oman where platinum group minerals have been found in the Samail ophiolite (BRGM, 1995) and from the Islamic Republic of Iran. No indication exists that these may also occur in Timor-Leste, but excluding the possibility is, as always in exploration, risky.

The Bobonaro Mélange (Harris, 2000), and the Bobonaro Scaly Clay (Charles, 1968) or the Sonnebait Series by the older Dutch workers, covers large parts of Timor island and about 60 per cent of the territory of Timor-Leste. The unit consists of soft scaly clay with exotic blocks and lenses of rocks of all ages and sizes in it, sometimes dominating the landscape as abrupt outcrops as in Laleia, where a huge knoll of limestone with no apparent roots and surrounded by mélange stands towering over the city.

The clay itself has probably been derived from the sub-marine weathering of volcanic ash material and has been structurally interpreted as marking the collision suture between the Australian lower plate and the Asian upper plate (Harris and others, 2000). Much of the clay in the mélange is bentonitic in nature with a dominance of smectite clay minerals. Raised beaches, reefs and alluvial terraces including the occurrence of raised reef material at altitudes of 500 metres and more above, clearly indicate that the recent and probably ongoing tectonic movements cause continuous uplift of the island. One of the consequences of this uplift is the likely absence of any thick accumulations of deep tropical weathering, and thus the probable absence of large nickel laterites. The upliftresults in aggressive erosion and the possible formation of concentrations of mineral sands. Large concentrations of ordinary sand and gravel will result, though these concentrations may be 'bouldery' and unsorted (ESCAP, UN (2003).

2.4.2. Metallic mineral occurrences of Timor Leste.

Several copper, copper-gold and gold occurrences have been reported all associated with a suite of basic to ultrabasic rocks. The geological setting in all areas is dominated by ultrabasic units, with extensive serpentinite alteration, and intrusive diorite/diabase rocks. These basic/ultra basic units are in many places covered by more recent marine sediments and, therefore, their total extent in each individual area is unknown. Some of these areas are already on record as having either copper or copper/gold indications (Vemasse/Ossuala and Virac, both in the Baucau District). Other ophiolite localities are in Covalima, Manufahi, Manatuto and Lautem districts. Gold has been observed in quartz veins that occur as lenticular bodies in shales and schists. Quartz–calcite veins occur in altered diabase and at the contact between diabase and black shales. They are mineralized with disseminated chalcopyrite, pyrite and gold.

Chromite occurrences are reported from Baucau, Manatuto and Manufahi districts. Typically these chromite deposits occur in highly deformed dunite and harzburgite units of ophiolite complexes. Chromite occurs in the Hili Manu subdistrict of Manatuto district. The occurrences are located south of the village of Behada at km 53 on the main coastal road (ESCAP, UN (2003).

CHAPTER III. METHODOLOGY

The following methodology stages were conducted in the prospecting mineral from earliest step to finish;

3.1 Preliminary Study

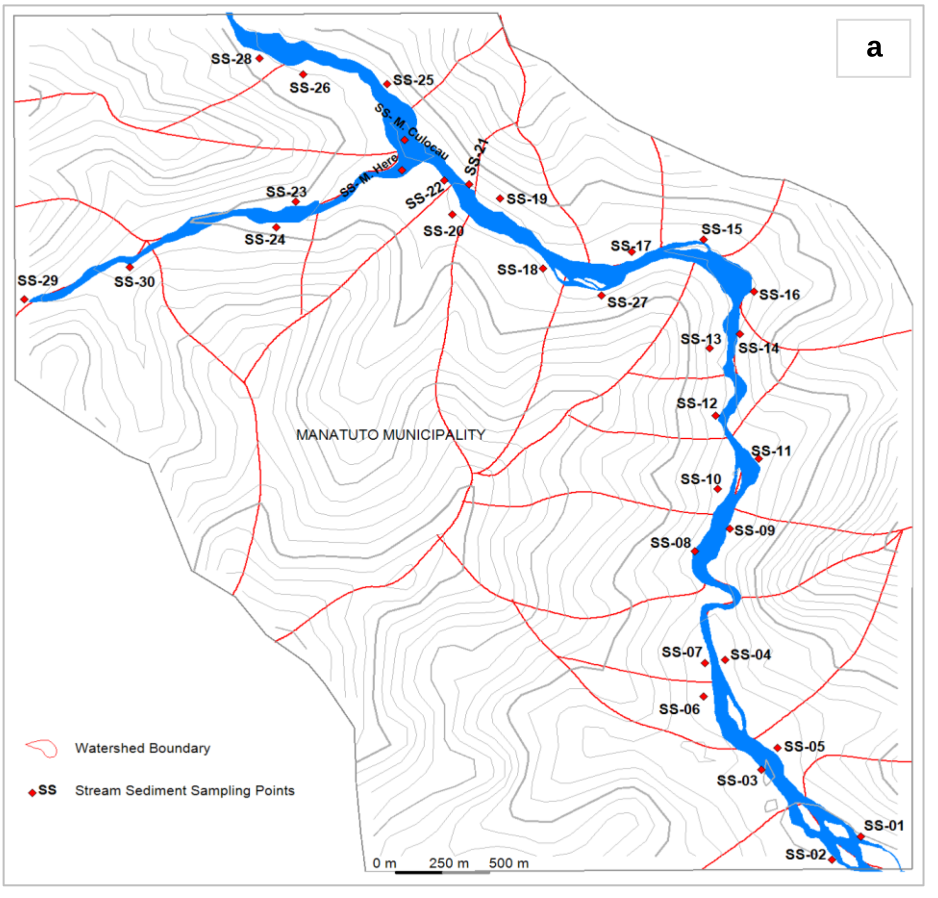
This was including revision of some publications by previous researchers who have done investigations on the research area and expected to gain better understanding about regional geology and other related informations such as accessibility and geographical conditions of the study area.

3.2 Time Frame and Field Work

The field work was conducted during more less a couple of weeks, dated 5 – 22 March 2019. It was conducted by a Geologist (João Paulo) and assisted by a driver and two local guides.

3.3. Site selection

The sampling points were collected base of the catchment area or watershed (fig.3.1a). There were 32 total of samples collected from site which divided into 30 watersheds that collected from each tributary within each watershed and 2 additional samples that collected from two main rivers i.e. Culocau and Here rivers. The watershed boundaries were determined referring to catchment area that interpreted manually by contour lines basemap and the 3D of Digital elevation model (DEM) image (fig 3.1.a-b)



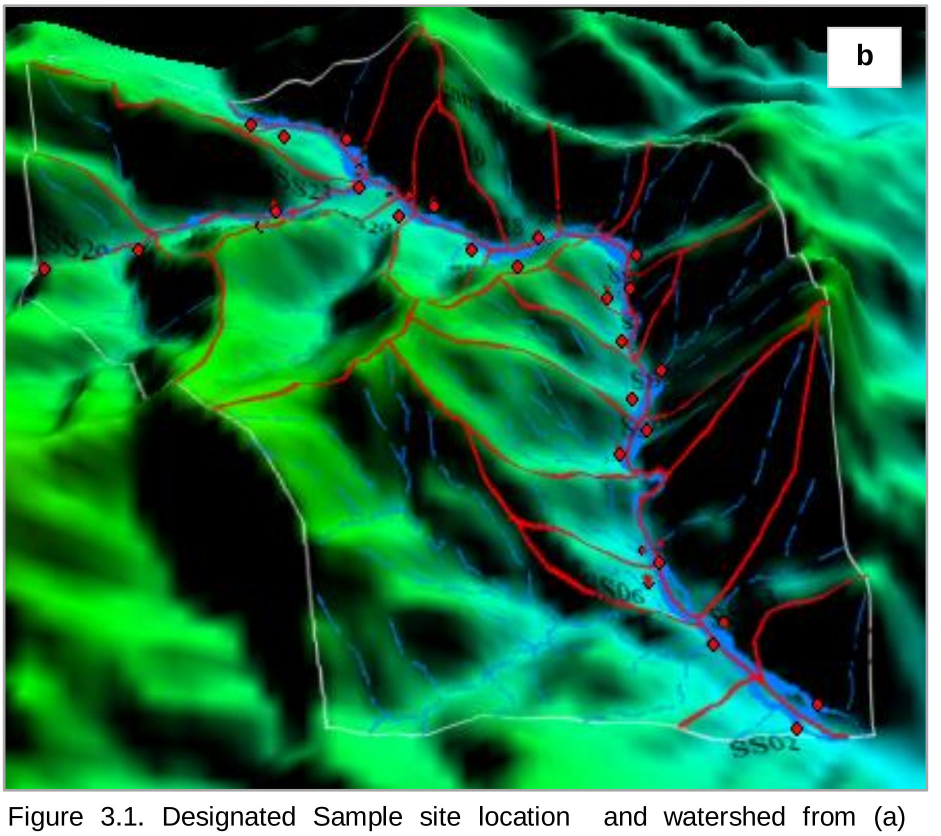


Figure 3.1. Designated Sample site location and watershed from (a) Topography map, b).3-D DEM image.

3.4 Sample collection

In this study, two sets of samples were collected from tributaries within watershed which are fine fraction for chemical analysis only with <180 microns in size and coarser material <2mm in size is for panned concentrates, which was subjected to gravity separation operation in pan until collected about 5-10kg sample. Then, concentrating in pan allowed to have a product with about more less 300g, which was later treated in the laboratory (magnetic separation and XRF).

For fine fraction (<180 µm), the material was wet sieved in 180 micron sieve and the undersize was collected. The sieve of 2mm was placed on the top of the fine sieve (180 µm) and both were mounted on the top of the pan (Fig. 3.2).

Collected sediments from several points on the stream bed to produce a representative composite sample (Pratas, J.A. (2015). The top 10-20cm of the sediment was discharged.

- Loaded coarse sediment into the top sieve with the minimum input of water. Remove large clasts by hand and rub the material through the top sieve. Removed the top sieve and continue careful rubbing and shaking until an adequate fine material (normally about 150-200g) was passed through the lower (fine) sieve into the pan beneath. No coarse particles should be allowed to enter the fine fraction sample
- Left sample to settle for a fixed time, generally about 10 to 15 minutes. During that period panned-concentrate and water samples may be collected and site data were recorded.
- Decanted the excess water leaving a final volume of 200 to 250 ml. Homogenized this by gentle agitation with stirring and carefully decant into a clean numbered plastic bag (fig 3.3) using a clean funnel. Place the sealed bag in a thin plastic bag and secure with a loose knot for transportation in an upright position.
- Two general sampling campaign were collected from the two main rivers i.e. Here and Culocau rivers.

Figure 3.2. The sieve of 2mm was placed on the top of the fine sieve (180 µm) and both were mounted on the top of the pan.

Figure 3.3 Fine Fractions < 180 microns about 150-200g in plastic bags after decanted excess water.

While for panned concentrate, the sieve of 2mm was placed on the top of the pan.

- Reaped the sediments from various locations of the stream to produce a representative composite sample (usually 5). At harvest discard 10 to 20 cm to avoid false anomalies caused by materials with high coating Mn and Fe- oxides or with reduced amount of heavy minerals. Crop as close to the bedrock as possible.

- Sieved the sediments on screen, remove the large clastic and rub the material to promote disaggregation (fig 3.4). Did not let coarse particles with the fine fraction. The material should be removed from the side as close to bedrock as possible.
- Then, continued to do this until filling the pan up to the mark with under 2mm sediment (about 5 liters).
- Washed the sediments to remove the clay fraction and organic material with plenty of water until the water coming out will become clear.
- Started panning process washing vigorously the sediments with water to promote the sinking of the heavier minerals. The panning is performed with circulatory movements and back and forth, causing water to come out from the front. When the water is directed to the front drags a surface layer of light sediment that overflow out by regular intervals, especially during the early stages of concentration, shaked vigorously with circulatory movements, remaining sediments in order to promote settling of the dense mineral grains at the base of pan.
- Continued to panning thoroughly until to obtain a final concentrate which should have about 150 ml.
- Transfer the material to a plastic bag, properly labelled, and place this in a plastic bag to be carried to the laboratory (figure 3.5).
- Two general sampling campaign were collected from the two main rivers i.e. Here and Culocau rivers.

Figure 3.4. Sieve the sediments on screen, remove the large clastic and rub the material to promote disaggregation

Figure 3.5 Transfer the pan concentrate to a plastic bag

3.5 Field observations

In the field should be used a logbook and a sampling map. The approximate location of each sample was inferred from the map, indicating the number of the respective sampling site. In the field book, the following observations were recorded at each sampling site:

- Coordinates using GPS;
- Description of the place taking into account the variability of local characteristics;
- Coordinates of the sample site;
- Identity of collectors;
- Date;
- Catchment geology from map;
- Characteristics of clasts and geology of the bedrock;
- Heavy minerals observed with the naked eye;
- Presence of minerals with an interest in fraction under 2 mm;
- Presence of traces of contaminating materials;
- Land use;
- Possible contaminations;
- Color and composition of sediments;
- Precipitates on stream;

- Weather conditions;
- Stream-flow conditions.

3.6 Sample preparation

There were two types of samples as fine fractions <180 microns for chemical analysis and panned concentrates <2mm for heavy mineral analysis.

Chemical samples <180 microns with total of 32 samples were sent to Actlabs Laboratory-Canada as both for preparation and ICP-MS analysis at once. While, the same total of 32 panned concentrate samples <2mm were brought to Laboratory DCT- Coimbra University to be subjected to magnetic separator and XRF separation operations.

Magnetic separation is a process that separates particles according to their magnetic susceptibility. What defines the magnetic susceptibility, or magnetization, of a material is its behavior when subjected to a magnetic field. The magnetic susceptibility of a mineral represents the mineral's response to an external magnetic field. Materials have magnetic susceptibility that can be positive (paramagnetic) or negative (diamagnetic). Paramagnetic materials when subjected to a magnetic field tend to be attracted to the higher intensity field zone, while diamagnetic materials when subjected to a magnetic field tend to be repelled to the lower intensity zone. Within paramagnetic materials are considered ferromagnetic materials which have a high susceptibility, such as magnetite. Galopim de Carvalho (2005) presents a table with the most common sedimentary minerals organized by decreasing magnetic susceptibility as a function of the parameters used in the Frantz separator.

The field separation concentrate was subjected to magnetic separation at the Geophysics, Geotechnics and Ore Treatment Laboratory of the Earth Sciences Department of the University of Coimbra. The equipment used was a Frantz separator, which has an electromagnet with two elongated poles. It allows to separate mineral particles according to their magnetic susceptibility. A vibrating, inclined rail parallel to the poles allows materials to cross the magnetic field. Mineral particles are discharged with an adjustable flow rate at the upper end of the rail sliding to its lower end. The separator allows you to adjust the front slope of the slope as well as a normal lateral slope to the tilt. The frontal inclination of the gutter was 15º, while the lateral inclination was 12º.

In a first phase the sample was passed with a natural strong magnet to withdraw ferromagnetic fraction. The remaining sample was separated with the aid of a Franz magnetic separator, adjusted to different champ intensities (0.3A, 0.5A, 1A, and maximum intensity in this case study preparation was 1.5A) (Fig. 3.6). Once you separate the different fractions of each sample were weighed and labeled for quantifying heavy minerals.

Figure 3.6. Frantz magnetic separator (Laboratory DCT-Coimbra University, 2019)

X-Ray Fluorescence (XRF) is a lab-based technique used for bulk chemical analysis of rock, mineral, sediment, and fluid samples. The technique depends on the fundamental principles of x-ray interactions with solid materials, similar to XRD analysis. XRF analysis is one of the most commonly used techniques for major and trace element analysis, due to the relative ease and low cost of sample preparation (fig.3.7)

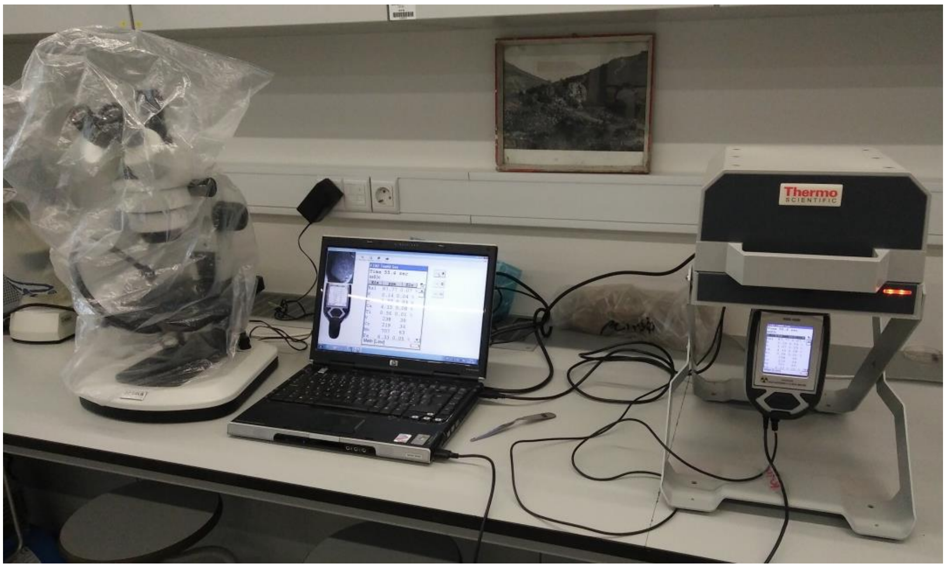


Figure 3.7. X-Ray Fluorescence (Laboratory DCT-Coimbra University, 2019)

The ICP-MS of the GI department is a model Xseries I from Thermo Fisher Scientific.
ICP-MS (inductively coupled plasma-mass-spectrometry) is a technique to determine low-concentrations (range: ppb = parts per billion = µg/l) and ultra-low-concentrations of elements (range: ptt = parts per trillion = ng/l). Atomic elements are lead through a plasma source where they become ionized. Then, these ions are sorted on account of their mass. The advantages of the ICP-MS technique above AAS (Atomic Absorption Spectroscopy) or ICP-OES (inductively coupled plasma optical emission spectrometry) are: extremely low detection limits, a large linear range and possibilities to detect isotope composition of elements

The ICP-MS technique has a multi-element character and a high sample throughput, like ICP-OES, but it allows one to perform more sensitive measurements (fig 3.8). Disadvantages and weaknesses of the ICP-MS detection are the occurrence of spectral and non-spectral interferences and the high costs.

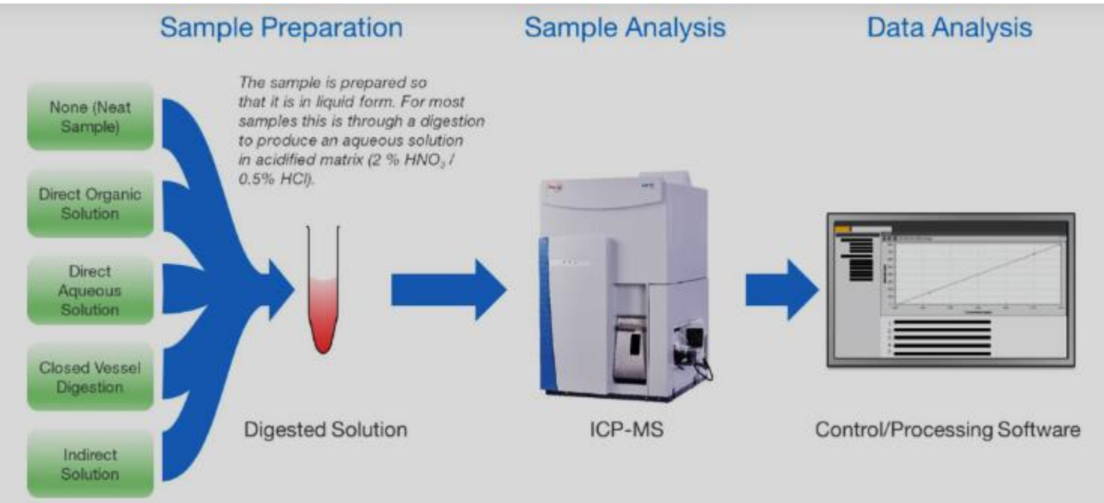


Figure 3.8. The ICP-MS workflow includes sample preparation and introduction, data acquisition and processing, and experimental analysis (source: Thermo Fisher Scientific, 2019)

3.7 Geochemistry Statistical Prospection

The common present problem in interpreting data generated in geochemical prospecting campaigns (in various sampling means) is the determination of thresholds, values that separate the defined value ranges from the background and the anomalous values. In addition to the most commonly used statistics measures, such as variance and standard deviation, other measures express the variability of attributes, some of which are commented below. The coefficient of variation (CV) is the result of dividing the standard deviation by the arithmetic mean (averages).

$$CV = \frac{Stdev.P}{Averages} \times 100$$

and its value shows how much larger (or smaller) the standard deviation is from the mean. This is a useful quantity for comparing different unit distributions. In general, when CV>1 it is advisable to do logarithmic transformation of the data. The coefficient of variation gives an idea of the regularity or homogeneity of the samples being studied. High values, in practice greater than about one, represent samples with great heterogeneity, and values below about 0.4 reflect sample homogeneity. Among the latter would be sedimentary layer thicknesses and principal oxide contents in rocks, as well as several cases of soils in so-called high-grade mineral deposits. Measure levels decrease or the geological complexity of the process of formation of the accumulation studied increases the value of the CV (ie the heterogeneity) tends to increase in the case of metallic elements and Rare elements in nature. Another measure of variability is Median Absolute Deviation (MAD),

$$MAD = Median\ (|X - Median\ of\ original\ data|)$$

which is a measure less affected by extreme values, since the median is not influenced by the extreme data as the average; For this reason, data with extreme valueshave a more stable estimate of variability than measures using mean, variance and standard deviation. In the determination of the MAD, the concept of the median is used twice, once directly on the original data and once on the differences between them and the respective median, that is, on the residuals obtained from the median of the data. Standard deviation is a useful measure for normally distributed data, and deviations from normality deviate it from the best condition for representing data variability. Using the median and the MAD does not require the data to fit any distribution model. Some authors propose to set the threshold value to twice the value of the MAD (Median Absolute Deviation) from the median. The MAD approach is best applied when data contains less than 10% of outliers. Usually the method (median ± 2 MAD) gives the lowest threshold, identifying the highest number of outliers, followed by the boxplot. The threshold set by the boxplot is in many cases close (but lower) than that obtained from logtransformed data using the rule (mean ± 2 standard deviations). Thus, by using the rule (median ± 2 MAD) the lowest threshold is obtained, using the boxplot it is higher and applying the classic rule (mean padrão standard deviations) the threshold is even higher.

3.7.1 Modified z score test

This test has been used more extensively than the test that considers as outlier simply the values that exceed the sum of the arithmetic mean with three standard deviations, or the average minus three standard deviations, since both the mean and the standard deviation are, already, affected by the presence of the outlier. The modified z-score test uses robust estimators such as the median, which ensures that the values used to define an outlier affected by it were not used. Through an example (table below) we will set up a check for the presence of an outlier with this test.

1st step - calculates the median of raw data.
2nd step - determine the column with the values of the absolute deviations, defined by:

$$|Xi - Xm|$$

3rd step - the arithmetic mean of the absolute deviations (MAD) is determined, values that appear in the column created in the previous step.
Step 4 - Calculates the modified z values or each observation, generating column three of the previous table; this value is represented by z * i, which is worth:

$$z * i = 0.6745 (Xi - Xm) / MAD$$

5th step - outliers are considered values of $|z * i| > 3.5$, ie, in the case studied, the values larger than 3.5 are considered outliers.

3.7.2 Pearson's correlation coefficient

The correlation coefficient that applied in this case is Pearson's correlation coefficient (r), that is a measure of the strength of the association between the two variables critical value for Pearson´s **r** (table 3.1). For this samples data were consisted of 32 stream sediment samples and obtained an r of 30. To see how likely an r of this size is to have occurred by chance, see (table 4.5) and the way to define critical value as follow:

Table 3.1 Critical Value for Pearson´s **r**

	Level of Significance for a One-Tailed Test					
	.10	.05	.025	.01	.005	.0005
	Level of Significance for a Two-Tailed Test					
df	.20	.10	.05	.02	.01	.001
1	0.951	0.988	0.997	0.9995	0.9999	0.99999
2	0.800	0.900	0.950	0.980	0.990	0.999
3	0.687	0.805	0.878	0.934	0.959	0.991
4	0.608	0.729	0.811	0.882	0.917	0.974
5	0.551	0.669	0.755	0.833	0.875	0.951
6	0.507	0.621	0.707	0.789	0.834	0.925
7	0.472	0.582	0.666	0.750	0.798	0.898
8	0.443	0.549	0.632	0.715	0.765	0.872
9	0.419	0.521	0.602	0.685	0.735	0.847
10	0.398	0.497	0.576	0.658	0.708	0.823
11	0.380	0.476	0.553	0.634	0.684	0.801
12	0.365	0.457	0.532	0.612	0.661	0.780
13	0.351	0.441	0.514	0.592	0.641	0.760
14	0.338	0.426	0.497	0.574	0.623	0.742
15	0.327	0.412	0.482	0.558	0.606	0.725
16	0.317	0.400	0.468	0.542	0.590	0.708
17	0.308	0.389	0.456	0.529	0.575	0.693
18	0.299	0.378	0.444	0.515	0.561	0.679
19	0.291	0.369	0.433	0.503	0.549	0.665
20	0.284	0.360	0.423	0.492	0.537	0.652
21	0.277	0.352	0.413	0.482	0.526	0.640
22	0.271	0.344	0.404	0.472	0.515	0.629
23	0.265	0.337	0.396	0.462	0.505	0.618
24	0.260	0.330	0.388	0.453	0.496	0.607
25	0.255	0.323	0.381	0.445	0.487	0.597
26	0.250	0.317	0.374	0.437	0.479	0.588
27	0.245	0.311	0.367	0.430	0.471	0.579
28	0.241	0.306	0.361	0.423	0.463	0.570
29	0.237	0.301	0.355	0.416	0.456	0.562
30	0.233	0.296	0.349	0.409	0.449	0.554
40	0.202	0.257	0.304	0.358	0.393	0.490
60	0.165	0.211	0.250	0.295	0.325	0.408
120	0.117	0.150	0.178	0.210	0.232	0.294
∞	0.057	0.073	0.087	0.103	0.114	0.146

Adapted from Appendix 2 (Critical Values of *t*) using the square root of $[t^2/(t^2 + df)]$
Note: Critical values for Infinite *df* actually calculated for *df* = 500.

To use the chart of critical values for Pearson's r, note that the formula for degrees of freedom is N – 2. Find the appropriate row of values using the degrees of freedom; identify the critical value of r by identifying the appropriate column depending on whether alpha was set at .05, .01, or .001.

For this samples data were consisted of 32 stream sediment samples, N value= 32 and obtained an r of 30. To see how likely an r of this size is to have occurred by chance, use the table. It shoud be 32-2 = 30 **degrees of freedom (df).** Obtaining r with **critical significance level (α)** which was set from α=0.5 (95%), α=0.2 (98%), α=0.1 (99%) and α= 0.01 (99.99%) as the result is highlighted with red boxes on table 4.5 above. For details, the results for level of significance as follows:

Total of samples size N = 32

Degrees of freedom (df) = (N-2)
= 32-2
= 30

α=0.5 for critical value (r) = 0.349

α=0.2, for critical value (r) = 0.409

α=0.1 for critical value (r) = 0.449

α=0.01 for critical value (r) = 0.554

Refers to the data above, **r critical value** with df=30 is larger than **0.349 for** α= 0.01 (99.99%)**, 0.409 for** α=0.2 (98%) and **0.449 for** α= 0.1 (99%) but NOT equal to or larger than **0.554 for** α= 0.01 (99.99%). Thus, can be considered that an **r critical** values for this 32 samples (df=30) are likely to occur by chance with a **p<0.01**.

Chapter IV Results and Discussion

The results will consist of lithology observation and laboratory result of pan concentrates and geochemical analysis.

4.1 Lithology Unit

Base on the Lithological field observation from 63 selected outcrops, the lithology type is divided into 4 units, i.e: Green schist, Black Phyllite, Metabasic, and alluvial deposit. The lithology types are classified according to texture and mineral compositions by megascopic (included by loupe) only. It can be seen on the Lithology map below :

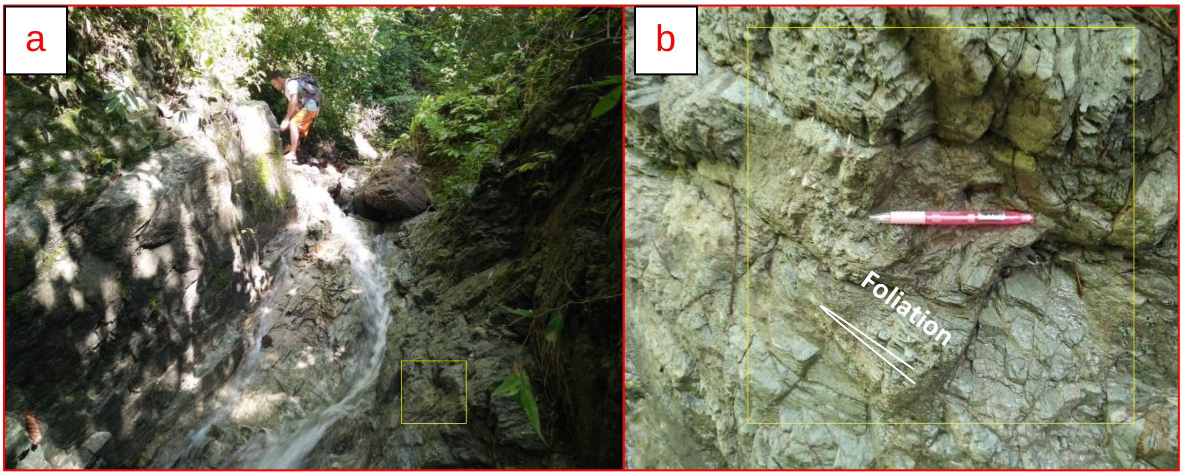


Figure 4.1. a - b) Outcrop R106, Green Schist with foliation direction N50E/32, Brownish green weathered and green fresh color, foliated texture, schistose structure, medium to coarse grained, there mostly mica and chlorite minerals and quartz vein.

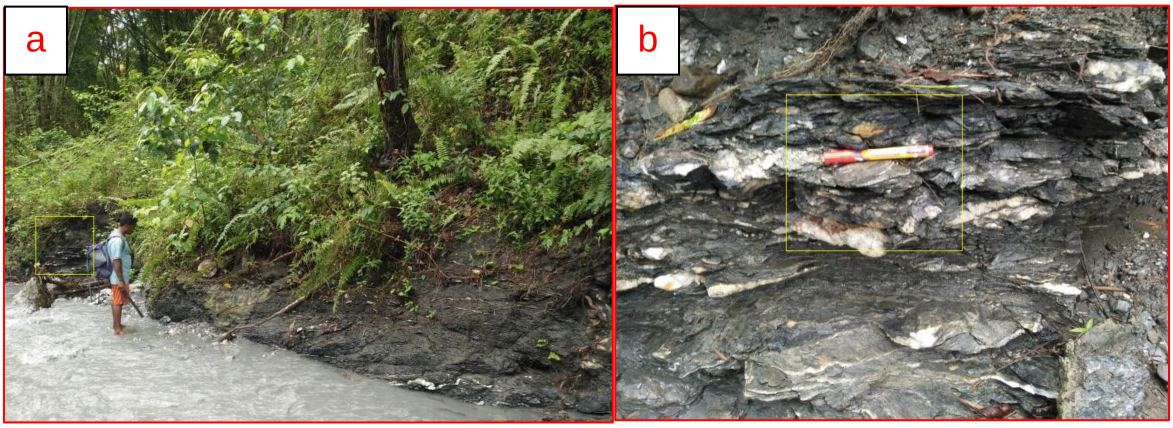


Figure 4.2.a-b) Outcrop R51, It has blackish grey weathered and blackish gray fresh color, foliated texture, homoblastic, lepidoblastic, hipidioblastik, phyllitic structure. Fractures are filled with quartz veins.The mineral composition is dominated by mediun grain muscovite, graphite and quartz.

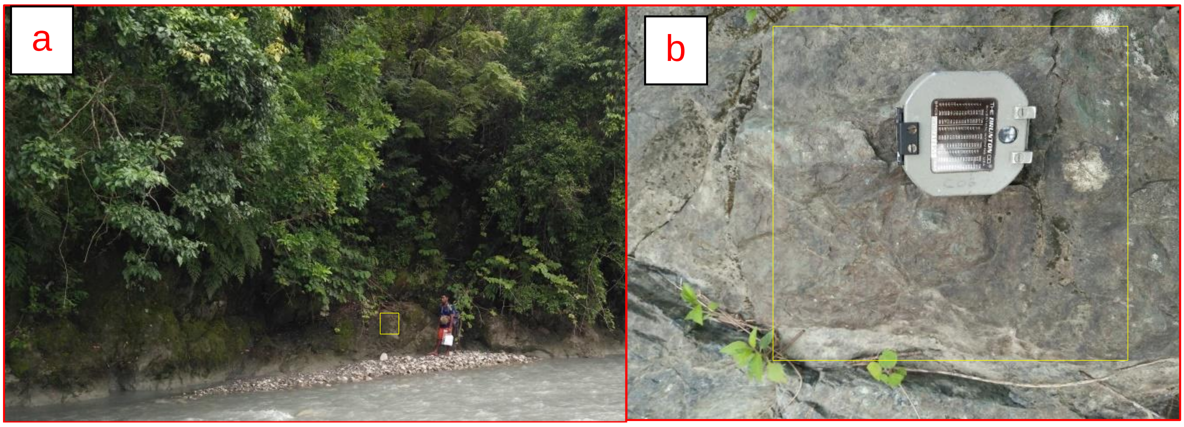


Figure 4.3a-b) Outcrop R84, has showh brownish green weathered and green fresh color, fine grain (aphanitic),there mostly mica and chlorite minerals following with amphibole, epidote, plagioclas and quartz.

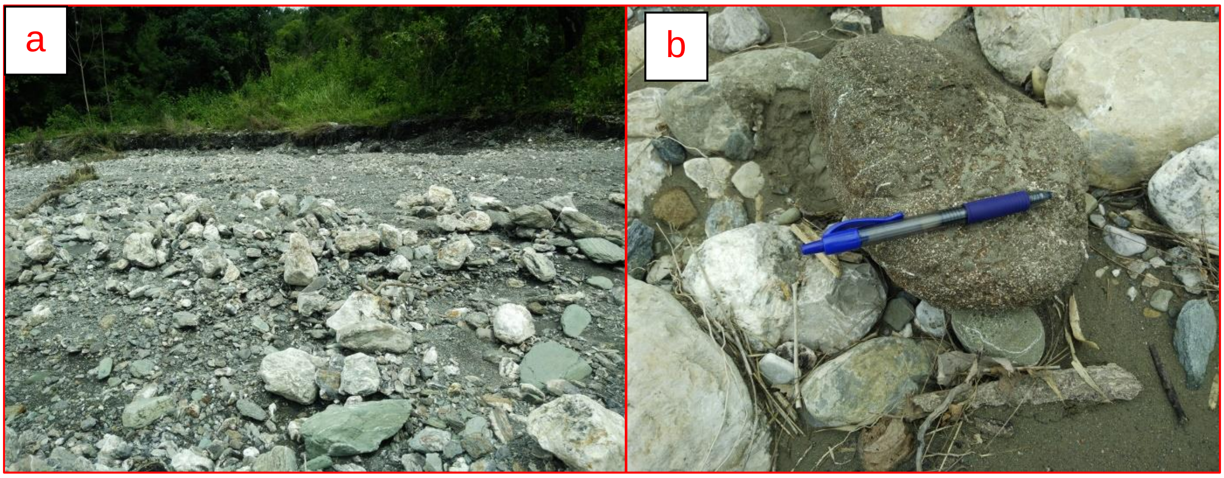
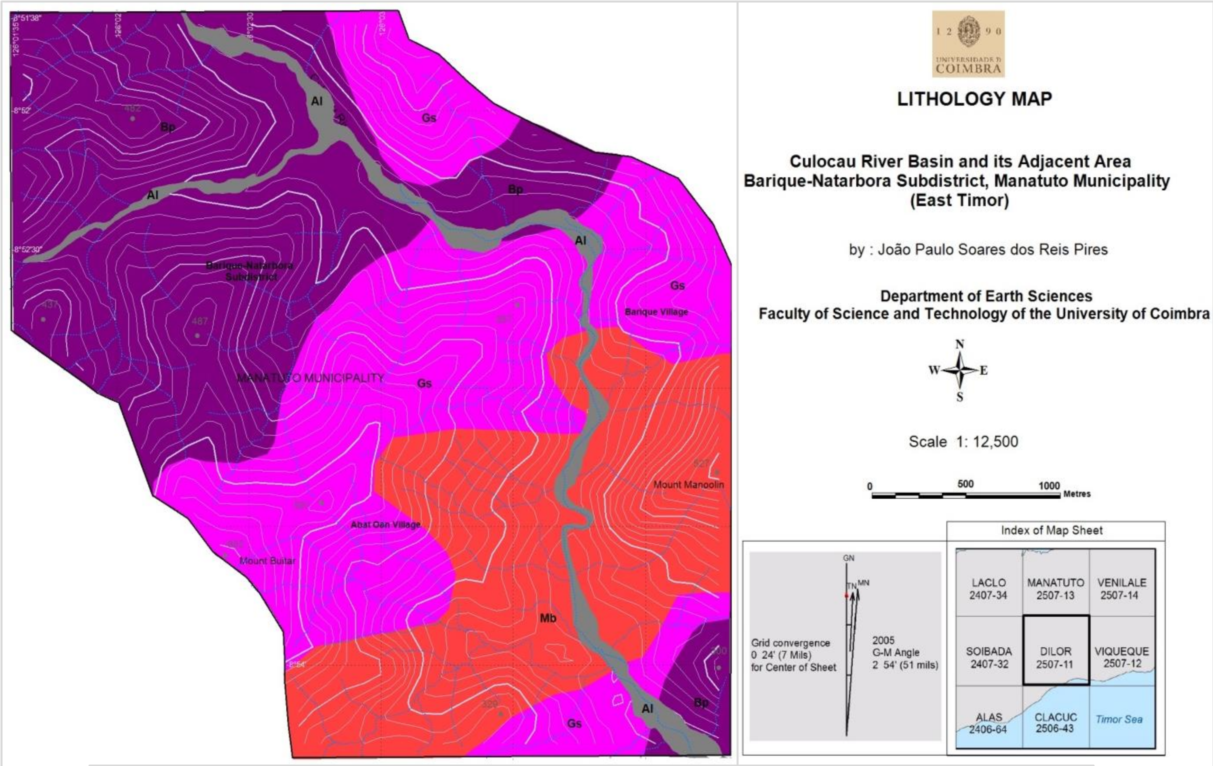


Figure 4.4a. Culocau river, alluvial deposit, loose material with various sizes from gravel to boulder that consist of rock fragments; green schist, black phyllites, metabasic, quartz, b). Limestone boulder that probably considered as exotic block with the basin due to deformation affection.

According to type of lithology found, a simplified of lithology map is performed on figure 4.5 below;



Al **ALLUVIAL DEPOSIT**

Loose material with with various sizes from gravel to boulder that consist of rocks; green schist, black phyllites, metabasic, limestone and quartz fragments.

Mb **METABASIC**

The outcrop performs brownish green weathered and green fresh color, fine grain (aphanitic), there mostly mica and chlorite minerals following with amphibole, epidote, plagioclas and quartz.

Bp **BLACK PHYLLITE**

It has blackish grey weathered and blackish gray fresh color, foliated texture, homoblastic, lepidoblastic, hipidioblastik, phyllitic structure. Fractures are filled with quartz veins.The mineral composition is dominated by muscovite, graphite and quartz. Several outcrops is intercalated with green schist.

Gs **GREEN SCHIST**

Brownish green weathered and green fresh color, foliated texture, homoblastic, lepidoblastic, hipidioblastik, schistose structure, medium to coarse grained, there mostly mica and chlorite minerals following with amphibole, epidote, plagioclase and quartz. There also some outcrops are intercalated with black phyllite.

Figure 4.5 Simplified lithology Map of Culocau River Basin and its adjacent area, classified by megascopic (included by loupe) observation.

4.2 Pan concentrates

There were the total of 32 panned concentrates samples that carried out in the field. Those samples were transported for prerparation and then separate on the magnetic separator in the *DCT's Mineral Treatment and Sample Preparation laboratory*. Figure 4.6, shows both geochemical stream sediment and pan concentrate sample are overlied with rock sample point.

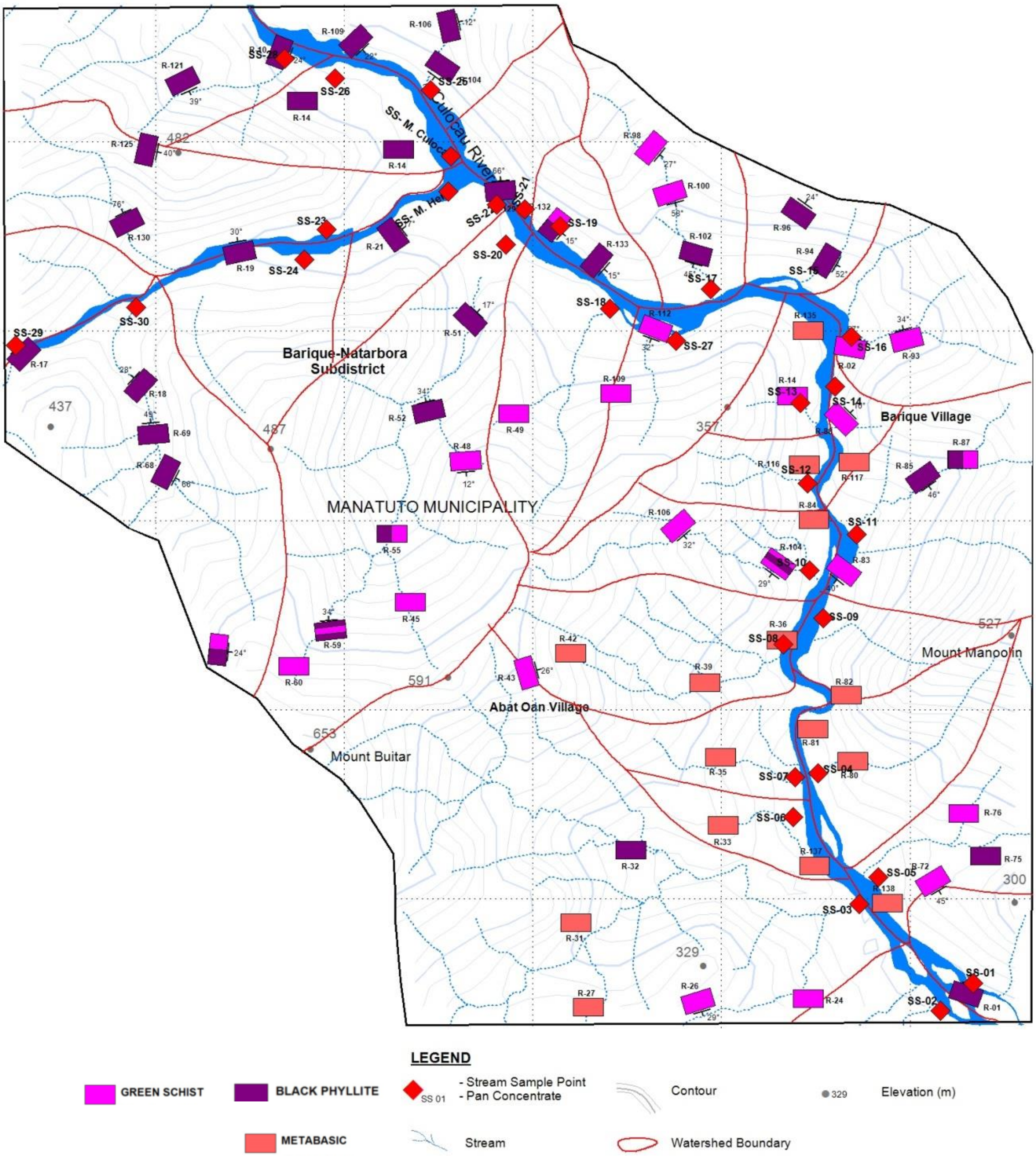


Figure 4.6. Trajectory Map, showing geochemical stream sediment and pan concentrate sample are overlied with rock sample point.

Those concentrates have a weight of approximately 300 grams for each sample that derived from approximately 5 kg of each panned concentrates from 32 samples collection. Although the material has a relatively small grade of less than 2 mm, because it has been not possible to separate the grade greater than 0.7 mm. it was being magnetically separated only if the particle size smaller than 0.7 mm. However, binocular observation of some particle quantities larger than 0.7 mm did not show the presence of magnetic or heavy minerals. In table 4.1, it represents the percentage of material from each of these two sizes (<07and >0.7 mm) from the total of 32 sample collections. Note that these values only represent a percentage of material in each of these two sizes, being approximately 50% (Table 4.1).

Tabel 4.1 – Contribution (%) of panned concentrate particle <0.7 and > 0.7 mm

Size (mm)	SS01	SS02	SS03	SS04	SS05	SS06	SS07	SS08	SS09	SS10	SS11
<0.7	55.4	47.8	54.7	55.6	62.3	40.3	59.7	69.1	50.1	56.3	42.7
>0.7	44.6	52.2	45.3	44.4	37.7	49.7	40.3	30.9	49.9	43.7	57.3

Size (mm)	SS12	SS13	SS14	SS15	SS16	SS17	SS18	SS19	SS20	SS21	SS22
<0.7	45.5	43.1	35.7	65.6	63.6	28.5	49.5	42.8	50.7	34.1	47.0
>0.7	54.5	56.9	64.3	34.4	36.4	71.5	50.5	57.2	49.3	65.9	53.0

Size (mm)	SS23	SS24	SS25	SS26	SS27	SS28	SS29	SS30	Culocau	Here
<0.7	37.8	65.8	56.6	44.2	39.5	42.8	42.9	60.7	56.4	47.7
>0.7	62.2	34.2	43.4	45.8	60.5	57.2	57.1	39.3	43.6	52.3

The magnetic separation of the particle <0.7 mm from the 32 samples, under field strength of 0.3A, 0.5A, 1A and 1.5A, led to the results presented in table 4.2. In addition to show the percentage of attracted material at each of the field strengths, the percentage of un attracted material and the cumulative percentage of attracted material at field strength 0.5A are also presented. The 32 samples have slightly different results. The amount of material not attracted was maximum in sample 15 (25.72%) and minimum in sample 11 (4.09%). The amount of cumulative material attracted to field strength of 0.5A was maximum in sample 23 (51.17%) and minimum in samples 17 (15.5%).

Table 4.2 – Magnetic data (%) of 32 samples with magnitude 03.A, 0.5A, 1A, 1.5 A, Magnetic (attracted material) and Non magnetic (non attracted).

Field strength (A)	SS01	SS02	SS03	SS04	SS05	SS06	SS07	SS08	SS09	SS10	SS11
0.3 M	1,65	6,43	6,04	0,90	3,18	3,37	2,10	1,48	5,01	2,44	3,39
0.5 M	30,58	35,80	23,82	33,29	14,64	19,33	39,41	31,88	29,15	42,22	43,92
1.0 M	46,67	39,91	57,78	55,26	65,79	60,72	47,48	53,20	41,91	40,94	43,51
1.5 M	6,82	7,01	1,03	3,45	6,17	5,48	4,81	7,81	16,87	5,34	5,08
1.5 Nm	14,28	10,85	11,33	7,11	10,21	11,10	6,19	5,63	7,06	9,06	4,09
<0.5 M	32,22	42,23	29,86	34,18	17,83	22,69	41,51	33,36	34,17	44,66	47,31

	SS12	SS13	SS14	SS15	SS16	SS17	SS18	SS19	SS20	SS21	SS22
0.3 M	5,70	6,32	1,87	1,49	6,88	2,39	3,82	5,98	7,12	3,36	1,20
0.5 M	29,89	29,84	31,12	36,64	41,64	12,90	37,69	25,16	42,06	39,66	22,14
1.0 M	41,17	35,06	54,12	29,67	40,97	50,81	39,73	45,46	34,66	33,55	47,89
1.5 M	15,21	15,47	6,55	6,48	3,88	13,44	7,57	8,68	7,19	3,54	13,67
1.5 Nm	8,04	13,31	6,34	25,72	6,63	20,45	11,19	14,72	8,98	19,88	15,09
<0.5 M	35,58	36,16	32,99	38,13	48,52	15,29	41,51	31,14	49,17	43,02	23,34

	SS23	SS24	SS25	SS26	SS27	SS28	SS29	SS30	Culoc	Here
0.3 M	2,06	1,06	4,62	4,41	2,31	1,26	1,01	3,78	1,38	5,30
0.5 M	49,11	21,76	31,39	35,18	39,07	18,86	42,39	39,42	34,72	22,31
1.0 M	35,80	48,14	45,30	38,39	42,24	47,38	37,14	37,59	39,82	41,76
1.5 M	3,16	14,86	7,56	8,78	9,44	19,84	5,32	8,53	10,29	11,99
1.5 Nm	9,86	14,18	11,13	13,25	6,94	12,66	14,14	10,68	13,79	18,65
<0.5 M	51,17	22,82	36,01	39,58	41,38	20,12	43,40	43,20	36,10	27,61

Binocular observation was not able for the identification and quantification of the main minerals present in each of the magnetic particle accumulation. However, chemical analysis of the 32 samples by XRF was performed, the results of which are presented in table 4.3. In this case, only elements whose measurement was possible / significant are shown.

Higher Si contents are observed, followed by Fe and Al. In general, samples with higher Fe content also have higher Ti and Cr levels, in the case of samples 9, 23 and 27.

Table 4.3 – XRF chemical analysis results for the <0.7 mm fraction of the pan concentrate.

Samples	Si (%)	Al (%)	Ca (%)	K (%)	Fe (%)	Ti (%)	Mg (%)	P ppm	S ppm	Mn ppm	V ppm
SS01	16,51	3,60	4,80	1,25	5,05	0,45	0,58	697	2196	653	164
SS02	16,93	3,79	3,37	1,23	5,80	0,52	0,48	595	231	880	177

SS03	15,02	3,92	4,15	1,11	6,29	0,56	0,81	816	1229	720	225
SS04	13,48	3,88	7,71	1,16	5,49	0,45	0,75	791	792	553	210
SS05	18,27	5,01	1,55	1,56	5,45	0,51	0,62	1072	830	569	216
SS06	16,46	4,41	0,99	1,42	5,28	0,54	0,41	1066	345	712	199
SS07	16,56	4,71	2,98	1,17	6,23	0,55	0,95	882	513	806	226
SS08	17,20	5,50	1,06	1,49	6,78	0,67	0,77	955	1511	1050	266
SS09	14,82	3,82	4,11	0,67	7,38	0,70	1,36	817	310	1409	282
SS10	18,07	5,71	1,20	1,56	7,19	0,80	0,79	1274	1186	1708	308
SS11	16,93	5,63	1,20	1,56	6,75	0,69	0,76	1193	1205	1210	285
SS12	17,66	5,29	1,68	1,33	7,23	0,76	0,59	943	554	1565	298
SS13	16,13	4,25	2,93	1,35	6,30	0,64	0,84	1238	756	1476	261
SS14	17,71	4,65	2,58	1,13	6,34	0,76	0,72	1022	254	1160	276
SS15	13,80	3,75	12,08	1,10	4,59	0,44	0,88	831	540	887	139
SS16	17,87	5,73	1,17	1,47	6,90	0,65	0,51	1154	1680	1036	274
SS17	19,86	4,75	0,65	1,69	5,05	0,51	0,62	993	260	944	196
SS18	16,58	5,05	4,18	1,65	6,00	0,57	0,86	1137	327	1436	224
SS19	18,93	5,84	0,82	2,26	5,79	0,65	0,97	923	208	757	219
SS20	18,46	5,68	1,47	1,84	6,65	0,59	1,01	1143	3058	889	217
SS21	14,02	3,98	9,72	1,62	4,35	0,45	0,85	920	495	768	155
SS22	16,69	5,35	1,08	2,09	5,94	0,72	0,65	1379	865	1177	230
SS23	15,25	6,96	1,35	3,13	6,89	0,89	0,99	1105	145	583	282
SS24	16,68	5,28	2,69	2,05	5,91	0,65	0,73	1086	901	642	216
SS25	17,89	4,00	3,14	1,40	4,82	0,50	0,75	782	674	1046	157
SS26	15,70	4,53	4,63	1,39	6,07	0,66	0,50	1187	534	1565	243
SS27	17,75	5,69	0,72	2,00	6,97	0,79	0,71	1382	1484	1603	292
SS28	13,42	4,51	8,74	1,79	5,29	0,52	0,70	868	819	645	168
SS29	15,93	5,85	2,63	2,24	6,73	0,65	1,08	908	1207	643	212
SS30	17,43	6,71	1,53	2,42	7,00	0,71	0,92	1215	2458	624	229
Culocau	19,00	4,43	5,13	1,43	4,85	0,49	0,48	778	942	1028	165
Here	17,18	5,49	2,47	2,03	5,85	0,69	0,70	1443	1018	635	215

Table 4.3 – XRF chemical analysis results for the <0.7 mm fraction of the pan concentrate. *(continued)*

Samples	Cr	Ni	Cu	Zn	As	Sr	Zr	Nb	Ba	Pb
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SS01	129	64,0	62,0	82,7	14,0	233,2	175,0	9,4	240,3	11,3
SS02	155	58,6	72,5	90,1	19,3	178,8	168,5	8,8	323,8	12,8
SS03	196	72,1	89,4	93,9	13,2	160,8	138,4	6,2	250,5	13,9
SS04	172	66,1	78,6	89,8	17,3	114,6	142,8	7,6	499,5	16,7
SS05	106	43,7	71,3	96,3	26,4	194,4	174,4	7,8	481,5	19,8
SS06	120	63,0	84,7	103,9	20,0	160,0	168,1	7,2	401,2	18,0
SS07	375	86,7	73,1	89,0	15,8	146,2	128,5	6,3	403,4	13,3
SS08	230	93,2	104,5	114,1	23,6	159,6	188,3	8,1	497,6	22,9
SS09	263	79,2	94,7	105,2	10,4	186,1	115,3	5,5	248,4	11,9
SS10	153	82,7	96,9	112,1	24,4	155,9	187,2	8,3	543,3	15,8
SS11	205	69,7	98,7	120,7	25,1	183,7	200,8	8,5	430,8	16,2
SS12	169	91,3	99,9	112,7	28,3	162,8	198,3	9,0	471,0	16,0
SS13	177	73,3	101,1	115,4	31,3	133,7	168,9	6,7	339,3	16,7
SS14	157	79,4	98,7	92,0	16,2	175,0	162,0	5,9	323,5	14,8
SS15	133	75,6	75,8	85,4	19,4	177,1	152,6	8,6	361,1	11,2
SS16	149	90,8	105,3	119,0	27,3	183,1	201,7	9,4	716,7	22,4
SS17	*125*	75,4	80,3	92,6	14,7	96,2	168,9	9,3	285,0	14,5
SS18	177	99,3	124,1	105,6	22,8	155,6	173,7	8,4	583,3	19,2
SS19	176	109,2	79,2	101,7	23,4	105,3	201,4	11,7	482,6	18,2
SS20	168	108,6	99,4	105,9	36,3	175,9	187,2	10,2	584,0	18,6
SS21	142	68,9	83,7	81,0	15,7	136,1	161,2	8,7	287,6	11,7
SS22	162	99,2	105,7	106,5	19,8	135,0	258,9	12,4	313,2	14,5
SS23	229	113,0	88,7	127,2	27,4	98,5	353,1	19,0	542,4	15,7
SS24	146	79,1	85,7	97,7	24,4	160,8	224,6	10,4	314,0	12,6
SS25	*112*	53,7	*66,0*	89,2	13,7	158,9	185,9	11,6	191,1	15,1
SS26	172	77,0	105,8	115,5	27,4	137,2	170,9	6,7	367,2	17,4
SS27	157	126,6	111,0	116,1	38,2	111,7	211,2	11,4	633,2	22,5
SS28	*143*	92,7	92,0	90,1	18,9	156,6	167,1	9,0	413,8	14,2
SS29	186	91,5	90,4	109,4	35,4	153,8	217,1	11,3	225,2	12,4
SS30	167	104,1	97,5	125,0	42,9	166,1	249,4	13,3	449,2	14,7
Culocau	156	56,1	*57,8*	91,1	15,9	243,0	186,0	14,2	463,3	17,3
Here	187	106,3	*68,6*	99,6	29,3	157,2	276,2	13,0	442,6	14,3

The results of magnetic separation will certainly be conditioned by the mineralogical composition of the sample. In the face of mineralogical nonidentification, we will try to interpret the results of magnetic separation with the chemical composition data by XRF (Table 4.3).

It is observed that the samples with the highest percentage of material attracted to field strength 0.5A, (for example from samples 11 and 23), also generally have the highest Fe, Ti, Mg, Cr, Ni, Zn and Zr contents. These are constituent elements of some magnetic minerals, such as magnetite, ilmenite probably.

Samples with a lower percentage of material attracted at 0.5A field strength (eg samples 5 and 17) have a higher Si content and low Cr and As, Fe and Ti contents.

On the other hand, the samples with the highest percentage of material in the fraction not attracted for field strength 1.5A (samples 15, 17 and 21), the Fe, Ti, Cr, Zr content is lower and the content is higher Si. Samples with the lowest percentage of unattracted material at field strength 1.5A (eg sample 11) generally also have the highest Fe, Ti, Mg and Zr contents.

Note that the chemical analysis by XRF of all results of 32 samples obtained in magnetic separation was also performed, and are presented in the annex. However, they were not considered in the present discussion because, due to the small amount of material of some fractions, some values needed to be confirmed / validated, and it is necessary to obtain particle with larger amount of material.

4.2 Geochemical analyses

The results obtained for the watershed sediment geochemistry samples give the ICP-MS values summarized in the table 4.4 that has been analised at Actlabs laboratory-Canada. It consisted of 32 samples collected base on watershed or catchment area within the study area. It was comprised of 30 Samples from watershed and other 2 samples were taken from main rivers of Culocau and Here. There have been some statistic data such as minumun, maximun, averages, MAD and Z critics used to define the anomaly of elements and the correlation to each other to figure out the relationships between two and more elements.

Table 4.4 Statistical chemical data of ICP MS (32 samples).

Analyte Element	Unit	min	Max	Average	Median	StdDev	CV	MAD	-z(crit)	med-2MAD	med+2MAD	z(crit)	B+Z	B+2z	B+3z
Ag	ppm	0.05	0.40	0.12	0.11	0.07	0.58	0.03		0.06	0.14	0.20	0.30	0.51	0.71
Al	%	5.13	11.50	8.72	8.86	1.10	0.13	0.54	6.03	7.88	9.84	11.40	20.25	31.65	43.05
As	ppm	3.8	67.0	21.2	20.3	12.7	0.60	6.4		8.0	31.8	50.8	70.7	121.4	172.2
Au	ppb	< 2	25	10	10	8	0.75	8		-3	15	17	23	40	58
Ba	ppm	91	653	420	431	124	0.30	81		269	593	851	1282	2134	2985
Be	ppm	0.8	2.8	1.8	1.9	0.4	0.20	0.2	1.1	1.7	2.1	2.4	4.3	6.7	9.2
Bi	ppm	0.2	0.9	0.4	0.4	0.2	0.41	0.1		0.3	0.5	0.9	1.3	2.2	3.1
Ca	%	0.5	13.9	2.7	2.1	2.4	0.88	1.0		0.2	4.0	7.0	9.1	16.1	23.0
Cd	ppm	< 0.1	0.3	0.1	< 0.1	0.1	0.53	0.0		0.1	0.1	0.3	0.4	0.8	1.1
Ce	ppm	24.5	131.0	58.8	56.8	19.8	0.34	8.9		37.7	69.9	95.6	149.4	244.9	340.5
Co	ppm	14.5	53.8	24.5	23.7	7.7	0.32	3.6		16.6	30.6	41.8	65.4	107.1	148.9
Cr	ppm	53	280	117	105	45	0.39	18		69	137	191	293	484	675
Cs	ppm	1.39	12.00	5.04	4.87	1.79	0.35	0.86		3.17	6.53	9.21	14.06	23.27	32.48
Cu	ppm	40.8	137.0	77.5	72.2	23.0	0.30	13.1		47.6	93.6	130.3	200.9	331.1	461.4
Dy	ppm	2.0	5.4	4.0	4.2	0.9	0.24	0.7		2.8	5.6	7.8	12.0	19.9	27.7
Er	ppm	0.8	2.6	1.8	2.0	0.5	0.31	0.5		1.1	2.9	4.3	6.2	10.5	14.8
Eu	ppm	0.89	2.28	1.24	1.16	0.25	0.20	0.11		0.94	1.38	1.73	2.89	4.62	6.35
Fe	%	3.44	6.72	5.53	5.59	0.81	0.15	0.59		4.42	6.76	8.63	14.22	22.84	31.47
Ga	ppm	12.0	30.5	21.1	21.3	3.1	0.14	1.7	12.4	18.5	24.1	28.5	49.8	78.3	106.8
Gd	ppm	2.8	7.1	4.7	4.7	0.8	0.17	0.5		3.7	5.7	7.3	12.0	19.3	26.6
Ge	ppm	< 0.1	0.5	0.2	0.2	0.1	0.54	0.1		0.0	0.4	0.7	0.9	1.6	2.4
Hf	ppm	0.5	2.5	1.3	1.3	0.5	0.39	0.4		0.5	2.1	3.3	4.6	7.9	11.2
Hg	ppb	20	230	83	75	53	0.63	25		10	130	196	266	461	657
Ho	ppm	0.3	1.1	0.7	0.8	0.2	0.30	0.2		0.4	1.2	1.8	2.6	4.5	6.3
K	%	0.46	3.56	1.69	1.63	0.55	0.33	0.25		1.13	2.09	2.86	4.47	7.32	10.18
La	ppm	10.8	70.4	28.3	26.8	11.1	0.39	5.8		15.1	38.3	56.8	83.5	140.3	197.1
Li	ppm	15.2	82.3	54.6	55.8	14.4	0.26	8.8		38.3	73.3	101.2	157.0	258.2	359.4
Lu	ppm	< 0.05	0.21	0.13	0.13	0.03	0.25	0.02		0.09	0.17	0.23	0.36	0.60	0.83
Mg	%	0.94	2.79	1.73	1.72	0.41	0.23	0.21		1.30	2.14	2.80	4.52	7.32	10.13
Mn	ppm	535	1810	1037	1000	336	0.32	275		451	1549	2424	3423	5847	8271

Table 4.4 Statistical of ICP MS chemical data (32 samples)

(Continued)

Na	%	1.01	1.78	1.40	1.42	0.21	0.15	0.17		1.08	1.76	2.30	3.72	6.02	8.33
Nb	ppm	< 0.1	10.8	1.5	0.6	2.6	1.70	0.4		-0.1	1.1	3.7	4.2	7.8	11.5
Nd	ppm	14.5	68.1	28.7	27.1	9.8	0.34	4.3	4.7	19.0	34.6	47.0	73.8	120.9	167.9
Ni	ppm	30.3	157.0	70.9	65.1	25.8	0.36	17.3		30.0	98.8	153.7	218.1	371.7	525.4
P	%	0.042	0.117	0.080	0.079	0.019	0.24	0.012	0.017	0.055	0.103	0.141	0.220	0.362	0.503
Pb	ppm	4.8	29.0	18.8	18.6	5.1	0.27	3.4	1.0	11.8	25.4	36.2	54.8	91.1	127.3
Pr	ppm	3.1	16.1	6.8	6.5	2.4	0.35	1.1	1.0	4.1	8.1	11.2	17.3	28.5	39.8
Rb	ppm	21	174	86	82	28	0.32	14	12	55	109	152	234	386	538
S	%	0.02	1.78	0.25	0.15	0.36	1.46	0.10		-0.07	0.32	0.62	0.74	1.36	1.98
Sb	ppm	< 0.1	2.0	0.8	0.8	0.4	0.50	0.2		0.4	1.2	1.8	2.6	4.5	6.3
Sc	ppm	12.1	26.1	17.9	17.7	3.2	0.18	2.3	5.7	13.1	22.3	29.6	47.2	76.8	106.4
Se	ppm	< 0.1	1.7	0.3	< 0.1	0.4	1.44	0.0		-0.1	0.2	0.6	0.7	1.4	2.0
Sm	ppm	3.5	12.6	6.0	5.6	1.7	0.28	0.7	2.2	4.5	6.7	8.5	14.1	22.5	31.0
Sn	ppm	< 1	4	2	2	1	0.58	1		0	4	8	10	17	25
Sr	ppm	94.9	248.0	161.2	161.0	33.8	0.21	20.0	57.2	121.0	201.0	264.8	425.8	690.6	955.3
Tb	ppm	0.4	0.8	0.6	0.6	0.1	0.17	0.1		0.4	0.8	1.1	1.7	2.8	4.0
Th	ppm	2.1	20.8	9.6	9.7	3.2	0.33	1.5	1.9	7.2	12.2	16.2	25.9	42.1	58.3
Ti	%	0.1	0.5	0.3	0.3	0.1	0.40	0.1		0.1	0.4	0.6	0.8		
Tl	ppm	0.07	0.80	0.43	0.44	0.13	0.30	0.07	0.10	0.32	0.56	0.75	1.19	1.94	2.69
Tm	ppm	0.1	0.4	0.3	0.3	0.1	0.31	0.1		0.1	0.5	0.8	1.1	1.9	2.8
U	ppm	0.4	2.2	1.2	1.3	0.4	0.36	0.3		0.7	1.9	2.8	4.1	6.9	9.7
V	ppm	34	156	103	102	29	0.29	20		62	142	206	308	514	719
Y	ppm	7.6	24.1	17.2	19.3	5.0	0.29	3.0	3.7	13.3	25.3	34.8	54.1	88.9	123.7
Yb	ppm	0.8	2.6	1.7	1.9	0.5	0.30	0.4		1.1	2.7	4.0	5.9	9.9	13.8
Zn	ppm	73	134	112	114	14	0.13	11	57	92	136	171	285	456	627
Zr	ppm	18	88	47	45	18	0.39	12		21	69	107	151	258	365

Also for these samples chemical analyzes were performed by XRF in the DCT Laboratory. However the results obtained by these two methods were slightly different. This discussion considers only the results obtained by ICP performed in the Canadian Laboratory (Table 4.4). Nevertheless, considering only the mean values obtained by the two processes of the 32 samples, we can observe the similarity of the mean values of some elements obtained by ICP and XRF. For example, the Fe, Cu, Pb, Zn and As content determined by ICP (5.53%, 77.5ppm, 18.8ppm, 112 ppm and 21.2ppb respectively) are similar to those obtained by XRF (respectively 6.0%, 88.8ppm, 17.7ppm, 102.4 and 23.1ppm). However for other elements, such as for Ti, Mg, Cr and S the content determined by ICP (0.26%, 1.73%, 117ppm, and 0.25% respectively) presents values different from those obtained by XRF (respectively 0.62% 0.76%, 172ppm and 0.094%).

4.2.1 Anomaly classification

Basicly, geochemical anomalies have been identified by setting threshold values, which mark the upper and lower limits of normal variation for a particular population of data. Values within the threshold values are referred to as background values and those above or below as anomalies. In mineral exploration interest is generally in positive anomalies, on the assumption that ore deposits and their weathering have increased element abundances above normal crustal levels. However, negative anomalies can also be important, for example where they reflect depletion in some elements during host rock alteration accompanying ore formation.

Statistical methods have been widely applied to interpret geochemical data sets and define anomalies. For this study case of 32 samples, the definition of anomalies was based on the methodology to define the threshold value (z (crit). The background was defined as the median of values below the Threshold. The background population was divided as a function of median and median deviation: -z (crit), med-2MAD; med-2MAD to med + 2MAD; and med + 2MAD to z (crit). The anomaly was divided based on multiples of z (crit) incremented by the background. The anomaly elements on the table is a highlighted yellow color resulted from Background + Z values which both taken from sum of median and z (crit). The description of elements below is just described elements wich considered as anomaly.

Table 4.5 Anomaly Calculation

Background values	Elements	-z(crit)	med-2MAD	med+2MAD	z(crit)	B+z	B+2z	B+3z
0.1	Ag		0.06	0.14	0.20	0.30	0.51	
8.855	Al	6.31	7.88	9.84	11.40	20.25		
19.9	As			31.80	50.77	70.67		
9.5	Au			15.00	17.24	23.24	40.49	
431	Ba		269.00	593.00	851.31			
1.9	Be	1.28	1.70	2.10	2.42	4.32		
0.35	Bi		0.25	0.45	0.91			
2.1	Ca			3.98	6.98	9.08	16.06	
0.09	Cd			0.11	0.34			
53.8	Ce		37.70	69.90	95.57	149.37		
23.6	Co		16.60	30.60	41.76	65.36		
102.5	Cr		68.50	136.50	190.71	293.21		
4.85	Cs		3.17	6.53	9.21	14.06		
70.6	Cu		47.60	93.60	130.27	200.87		
4.2	Dy		2.80	5.60				

1.95	Er		1.05	2.85				
1.16	Eu		0.94	1.38	1.73	2.89		
5.59	Fe		4.42	6.76				
21.25	Ga	13.99	18.45	24.05	28.51	49.76		
4.7	Gd		3.70	5.70	7.29			
0.2	Ge			0.40	0.72			
1.25	Hf			2.05	3.33			
70	Hg			130.00	195.67	265.67		
0.8	Ho		0.40	1.20				
1.61	K		1.13	2.09	2.86	4.47		
26.7	La		15.10	38.30	56.80	83.50		
55.8	Li		38.30	73.30	101.20			
0.13	Lu		0.09	0.17	0.23			
1.715	Mg		1.30	2.14	2.80			
999.5	Mn			1548.50	2423.89			
1.42	Na		1.08	1.76	2.30			
0.5	Nb			1.10	3.66	4.16	7.81	11.47
26.8	Nd		19.00	34.60	47.04	73.84		
64.4	Ni			98.80	153.65	218.05		
0.079	P		0.06	0.10	0.14			
18.6	Pb		11.80	25.40	36.24			
6.05	Pr		4.05	8.05	11.24	17.29		
82	Rb		55.00	109.00	152.05	234.05		
0.125	S			0.32	0.62	0.74	1.36	1.98
0.8	Sb		0.40	1.20	1.84	2.64		
17.65	Sc		13.05	22.25	29.58			
0.08	Se			0.22	0.64	0.72	1.37	2.01
5.6	Sm		4.50	6.70	8.45	14.05		
2	Sn			4.20	7.71			
161	Sr		121.00	201.00	264.78			
0.6	Tb			0.80				
9.7	Th	2.24	7.20	12.20	16.19	25.89		
0.25	Ti		0.12	0.38	0.59			
0.44	Tl	0.13	0.32	0.56	0.75	1.19		
0.3	Tm			0.50				
1.25	U		0.65	1.85	2.81			
102	V		62.00	142.00	205.78			
19.25	Y		13.25	25.25				
1.9	Yb		1.10	2.70				
114	Zn		92.00	136.00				
44.5	Zr		20.50	68.50	106.77			

Table 4.5 above shows, there are 28 elements have performed anomaly values larger than each elements threshold, those are [Ag, Al, As, Au,Be,Ca,Ce, Co, Cr, Cs, Cu, Eu, Ga, Hg, K, La, Nb, Nd, Ni, Pr, Rb, S, Sb, Se, Sm, Th and Tl]. Ag has two samples indicating anomaly that have values larger than threshold (z (crit)= 0.20 ppm) which are performed by sample of SS 20 (0.34 ppm) and SS 30 (0.40ppm), see on table 4.4 ICP-MS data. It means that the rest samples have values under threshold owned by Ag. Al performs only one anomaly indicated with sample SS 23 (11.5%) compare its threshold 11.40%. As has 2 anomalies from samples SS 20 (51 ppm) and SS 30 (67 ppm) larger than threshold 50.77 ppm.

Au is indicated by 7 anomalies that have values larger than its threshold (17.24 ppb) which its values are ranged from 19 ppb to 25 ppb as the highest. Those are SS 02 (19 ppb), SS 18 (21ppb), SS 20 (22 ppb), SS 26 (23 ppb), SS 27 (23 ppb), SS 29 (25 ppb) and SS 30 (20 ppb).

From anomalies above, on basin SS 20 and SS 30 are likely considered as sulphides ore deposits which have shown Ag, Au, and Cu in the watershed and some pathfinder associated elements such As, S, Sb and Se are also found although Zn is not presented.

While, SS 23 sample has indicated a group of rare earth elements (REE) such as Ce, Eu, La, Nd, Pr, Sc, Sm which often associated with thorium (Th) and Ce often associated with K and Rb as well. Although Be and Nb values have shown anomaly values, those are considered as formational in earth crust. In this case, Nb threshold value is 3.66 ppm and it should be said that the Nb anomaly must formational because the threshold values are low compared to world averages of Nb is 20 ppm and also, Be threshold values is 2.42 ppm which lower than world averages 3 ppm (Pendias & Mukherjee, 2007).
For details, can be seen on the table 4.6 below.

Table 4.6 Table base on z score value

Analyte Element	< (-Z)	> Z	> B+Z	> B+2z
Ag			ss20, ss30	
Al	ss15	ss23		
As		ss20, ss30		
Au		ss2, ss18, ss20, ss30	ss26, ss27, ss29	
Be	ss9, ss15	ss23		
Ca			ss15	
Ce		ss23, M.Here		
Co		ss30		
Cr		ss3, ss7		
Cs		ss23		

Cu		ss20, ss30		
Eu		ss23		
Ga	ss15	ss23		
Hg		ss3, ss4, ss5		
K		ss23		
La		ss23		
Nb			ss24, ss29	ss20, ss30
Nd		ss23		
Ni		ss30		
Pr		ss23		
Rb		ss23		
S		ss20	ss30	
Sb		ss20		
Se		ss21, ss22	ss20, ss30	
Sm		ss23, M.Here		
Th		ss23		
Tl	ss9	ss23		

4.2.2. Correlation coefficient

Correlation is a technique for investigating the relationship between two quantitative, continuous variables, for example, in this case is the relationship between ores elements with their associated mineral from geochemical stream sediment sample. Table 4.7 is performed only those element that have been observed on catchment basin (watershed) SS 23 that has various of elements found and the two others i.e SS 20 and SS 20 are the principal basins that considered in this data as anomaly for mineralization such Ag, Au and Cu, etc.

Table 4.7 Correlations of ICP-MS chemical data

	Ag	*Al*	*As*	*Au*	*Be*	*Ca*	*Ce*	*Co*	*Cr*	*Cs*	*Cu*	*Eu*	*Ga*	*Hg*	*K*	*La*	*Nb*	*Nd*	*Ni*	*Pr*	*Rb*	*S*	*Sb*	*Se*	*Sm*	*Th*	*Tl*
Ag	1																										
Al	0.291	1																									
As	0.896	0.483	1																								
Au	0.546	0.128	0.570	1																							
Be	0.315	0.726	0.499	0.188	1																						
Ca	-0.266	-0.770	-0.392	-0.196	-0.675	1																					
Ce	0.393	0.594	0.538	0.287	0.778	-0.423	1																				
Co	0.714	0.377	0.766	0.397	0.116	-0.206	0.277	1																			
Cr	-0.067	0.200	-0.092	-0.065	-0.137	-0.006	0.029	0.195	1																		
Cs	0.302	0.547	0.393	0.205	0.769	-0.433	0.857	0.141	0.041	1																	
Cu	0.713	0.432	0.791	0.554	0.243	-0.427	0.207	0.728	-0.110	0.051	1																
Eu	0.349	0.608	0.504	0.177	0.600	-0.358	0.847	0.528	0.247	0.709	0.263	1															
Ga	0.209	0.957	0.442	0.106	0.729	-0.685	0.622	0.401	0.161	0.566	0.383	0.674	1														
Hg	-0.258	0.082	-0.257	-0.255	0.158	-0.160	-0.260	-0.416	0.154	-0.175	-0.290	-0.290	-0.019	1													
K	0.431	0.678	0.559	0.321	0.817	-0.492	0.889	0.263	-0.006	0.937	0.246	0.742	0.676	-0.205	1												
La	0.371	0.537	0.485	0.252	0.738	-0.365	0.992	0.244	0.055	0.876	0.128	0.848	0.565	-0.267	0.883	1											
Nb	0.928	0.173	0.801	0.513	0.162	-0.115	0.325	0.702	-0.015	0.259	0.544	0.303	0.111	-0.336	0.349	0.324	1										
Nd	0.365	0.624	0.511	0.230	0.763	-0.413	0.991	0.291	0.087	0.865	0.182	0.878	0.649	-0.230	0.890	0.988	0.306	1									
Ni	0.772	0.449	0.768	0.509	0.288	-0.308	0.530	0.804	0.435	0.452	0.605	0.638	0.412	-0.362	0.538	0.520	0.744	0.531	1								
Pr	0.378	0.601	0.514	0.255	0.762	-0.412	0.996	0.274	0.063	0.870	0.178	0.861	0.625	-0.244	0.892	0.994	0.322	0.997	0.528	1							
Rb	0.444	0.581	0.517	0.327	0.787	-0.450	0.882	0.202	-0.009	0.943	0.163	0.710	0.571	-0.187	0.978	0.893	0.378	0.873	0.530	0.884	1						
S	0.934	0.240	0.859	0.420	0.233	-0.188	0.268	0.740	0.010	0.130	0.712	0.296	0.163	-0.109	0.264	0.238	0.842	0.253	0.722	0.254	0.259	1					
Sb	0.638	0.427	0.688	0.420	0.534	-0.551	0.372	0.370	-0.260	0.272	0.683	0.184	0.364	0.085	0.403	0.306	0.419	0.334	0.379	0.347	0.377	0.611	1				
Se	0.749	0.096	0.606	0.411	0.068	-0.114	0.227	0.563	0.091	0.081	0.585	0.284	0.006	-0.238	0.206	0.213	0.659	0.219	0.604	0.222	0.210	0.733	0.496	1			
Sm	0.366	0.646	0.523	0.276	0.777	-0.437	0.960	0.343	0.092	0.840	0.209	0.887	0.681	-0.201	0.864	0.952	0.290	0.967	0.534	0.964	0.839	0.271	0.342	0.250	1		
Th	0.394	0.626	0.508	0.272	0.869	-0.503	0.952	0.187	-0.034	0.899	0.163	0.766	0.638	-0.096	0.914	0.948	0.306	0.939	0.460	0.949	0.924	0.254	0.422	0.178	0.922	1	
Tl	0.453	0.633	0.565	0.352	0.881	-0.564	0.879	0.198	-0.042	0.917	0.236	0.683	0.617	-0.049	0.949	0.871	0.353	0.864	0.500	0.874	0.964	0.305	0.495	0.201	0.835	0.950	1

r critical Values for significance levels		
	0.807	Very Significant
99.99%	0.554	Significant
99%	0.449	Moderated significant

r critical Values for significance levels		
98%	0.409	Poor Significant
95%	0.349	Very Poor Significant

The correlation coefficient that applied in this case is Pearson's correlation coefficient (r), that is a measure of the strength of the association between the two variables critical value for Pearson´s r (table 4.5). For this samples data were consisted of 32 stream sediment samples and obtained an r of 30. To see how likely an r of this size is to have occurred by chance, see (table 4.5) and the way to define critical value as follow:

As shown on table 4.4.2, derived from 32 stream sediment samples from ICP-MS analyses result; elemental silver (Ag) showed very significant relationship (> 0.807) with arsenic (As) , tellurium (Te and Ti (titanium) with r critical value range between 0.80-0.89. Followed by cobalt (Co) and copper (Cu) that have a significant level (>0.554) with the average critical values about 0.713. Then, a moderated significant level (>0.449) is indicated from gold (Au), bismuth (Bi), thallium (Tl) with critical values ranged from 0.45-0.54 . Zn has showed poor significant relationship (>0.409) and iron (Fe) and thorium (Th) with critical values 0.35 -0.39 performing very poor signifint relationship (> 0.349).

4.2.3. Anomaly map on watershed

It is described base according to basins that have been discovered by ICP-MS results derived from 32 samples. Base on the threshold (z critic value) application to each element and then comparing to world standard threshold (Pendia & Mukherjee, 2007). There are two basins i.e SS 20 and SS 30 considered to have mineralization anomaly. Therefore, only elements such as Ag, As, Au, Co, Cu, Eu, Nb, Ni, S, Sb, and Se that were obtained from those two basins, their anomaly maps are performed as below:

a. **Ag (in ppm)**

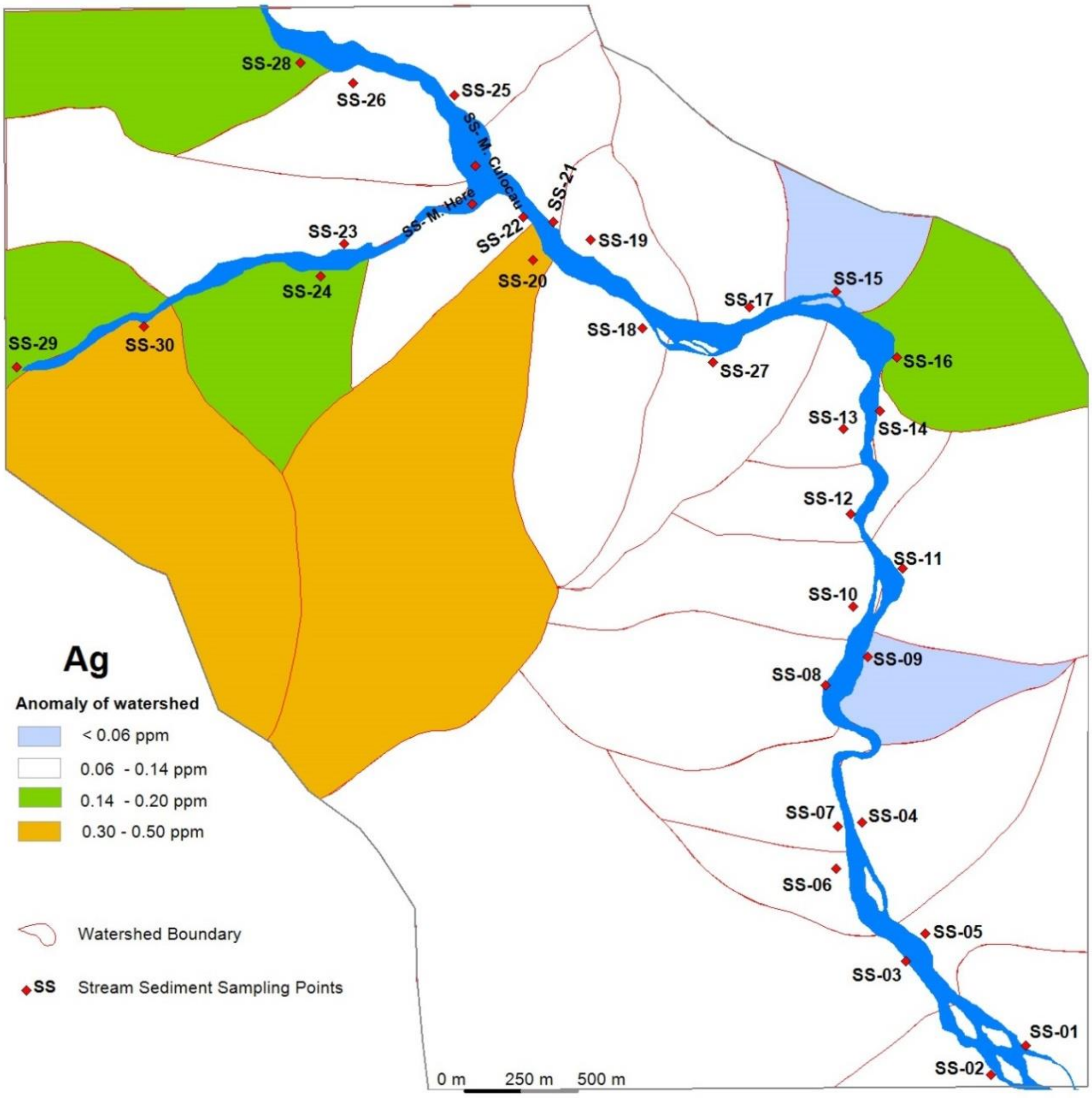


Figure 4.8 Anomaly map of Ag in ppm

World average standard threshold of Ag values is 0.06 ppm (Pendias & Mukherjee, 2007). Threshold from Z (critic) of Ag has its values 0.20 ppm.

The anomaly of Ag showing on figure 4.8, have indicated values > 0.06, which it has the highest values on basins SS20 and SS 30 with values 0.30-0.50 ppm.

b. **As (in ppm**)

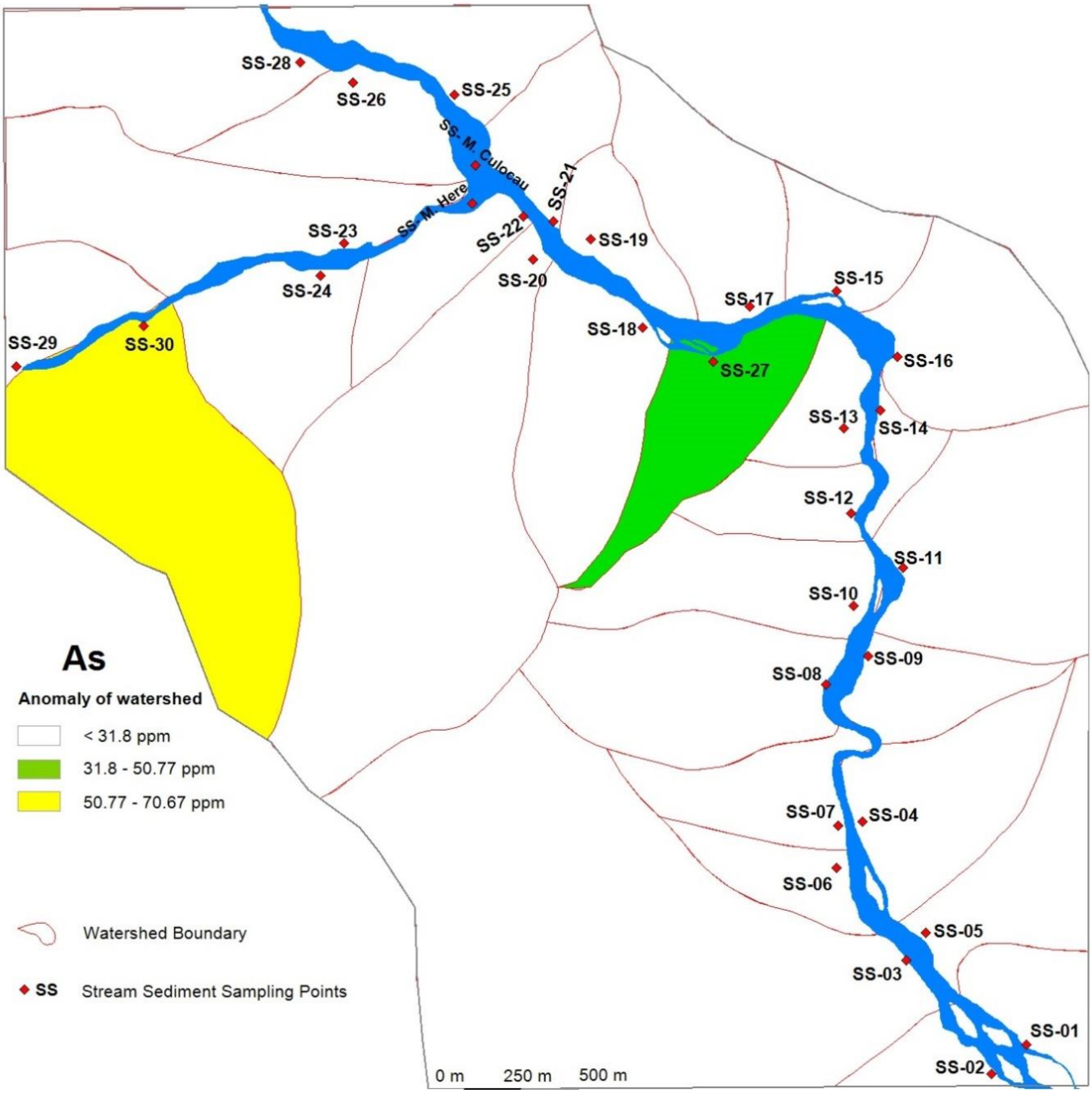


Figure 4.9 Anomaly map of As in ppm

World average standard threshold of As values is 1.8 ppm (Pendias & Mukherjee, 2007). Threshold from Z (critic) of As has its values 50.77 ppm. The anomaly of As showing on figure 4.9, have indicated values > 1.8, which it has the highest values on basin SS 30 with values 50.77-70.67 ppm, that can be considered as mineral anomaly.

c. **Au (in ppb**)

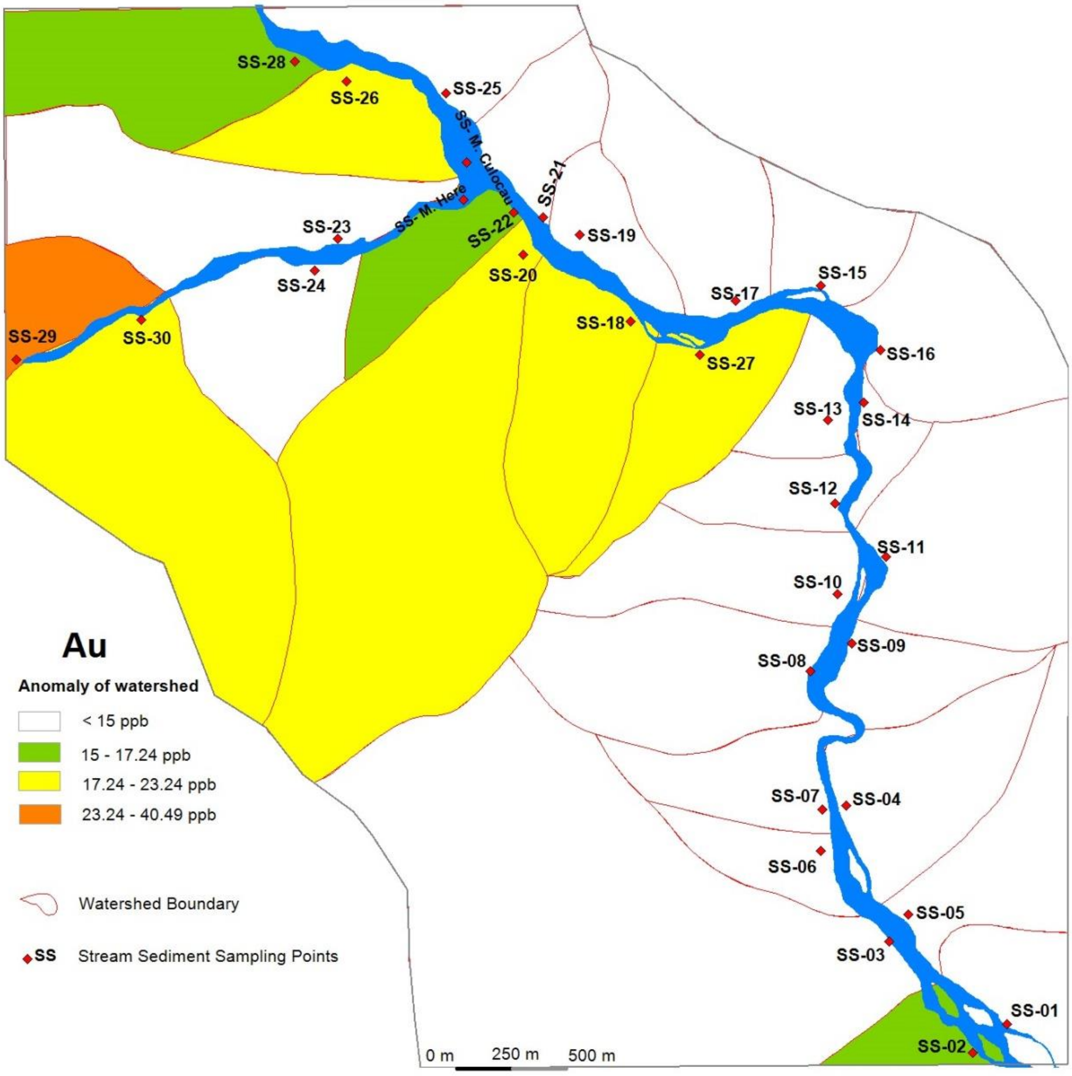


Figure 4.10 Anomaly map of Au in ppb

World average standard threshold of Au values is 0.004 ppm that is similar 4 ppb (Pendias & Mukherjee, 2007). Threshold from Z (critic) of Au has its values 17.24 ppb.

The anomaly of Au showing on figure 4.10, have indicated values > 1.8, which it has the highest values on basin SS 29 with values 23-40.49 ppb, but it has a small basin only and considered as mineralization of Au and Ag., tha can be a pathfinder of mineralization type. Base on anomaly calculation table, only basin SS20 and SS30 are considered as potential anomaly.

d. **Co (in ppm)**

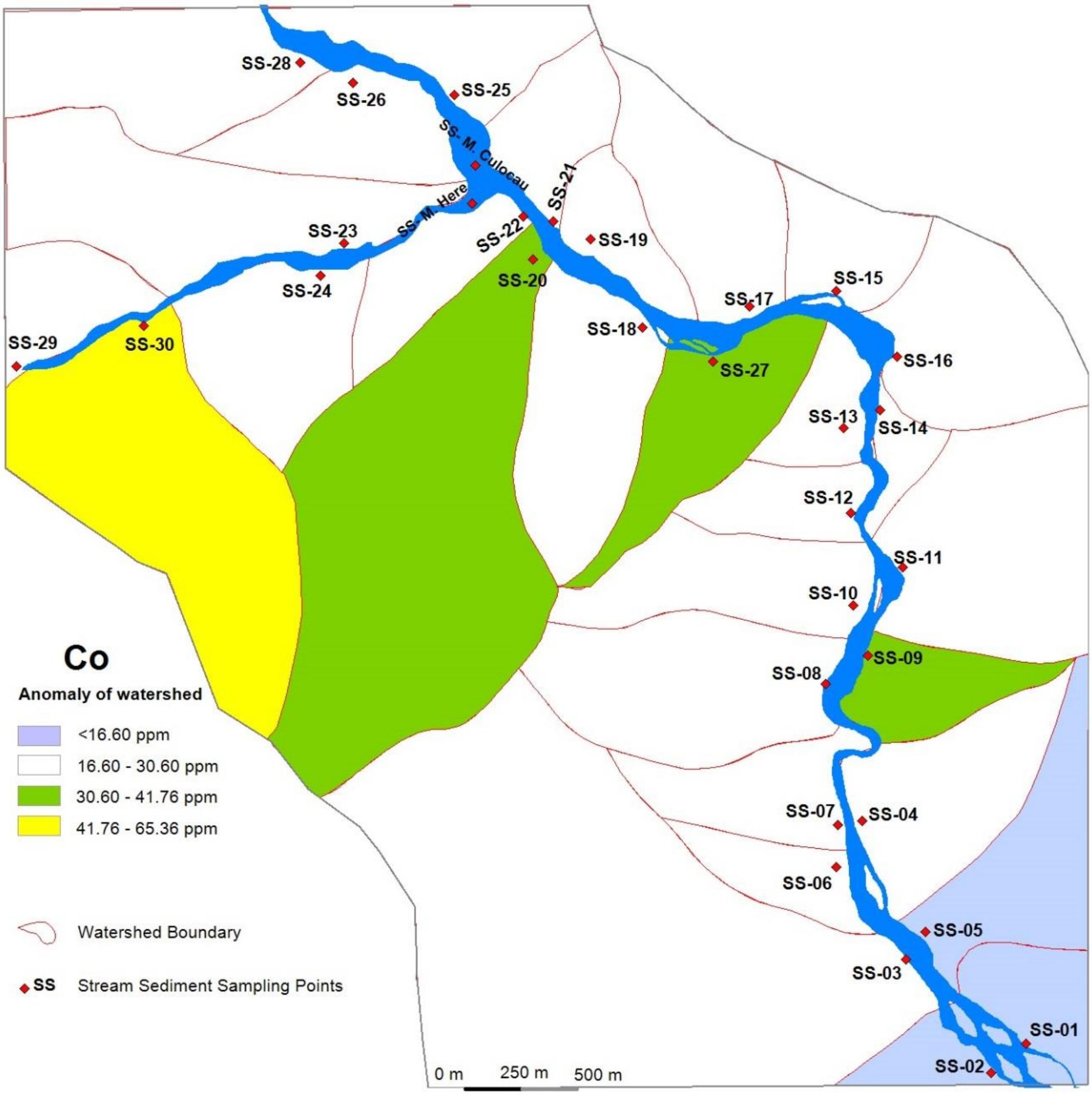


Figure 4.11 Anomaly map of Co in ppm

World average standard threshold of Co values is 10 ppm (Pendias & Mukherjee, 2007).

Threshold from Z (critic) of Co has its values 41.76 ppm.

e. **Cu (in ppm)**

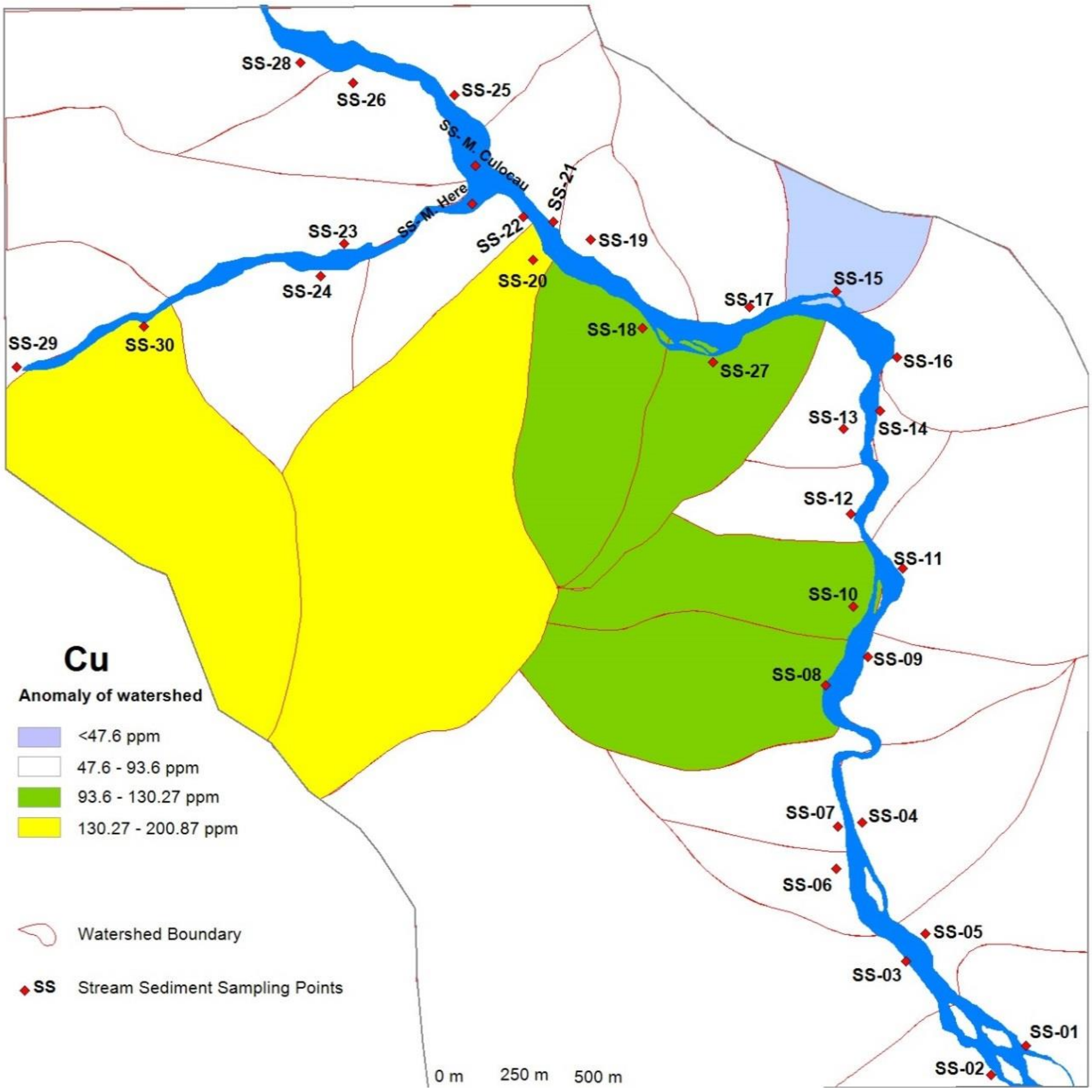


Figure 4.12 Anomaly map of Cu in ppm

World average standard threshold of Cu values is 55 ppm (Pendias & Mukherjee, 2007).

Threshold from Z (critic) of Cu has its values 130.27 ppm.

f. **Eu (in ppm)**

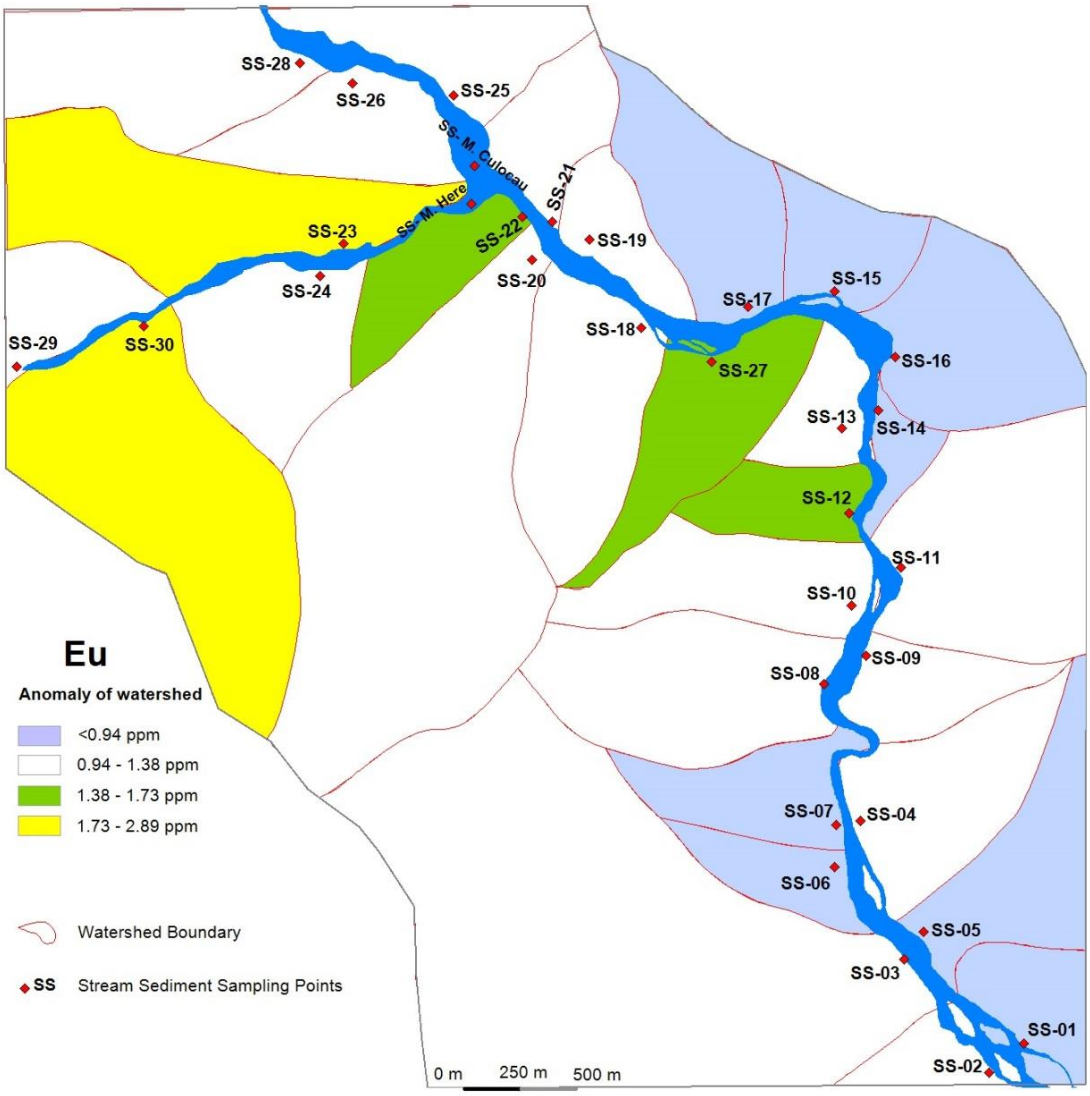


Figure 4.13 Anomaly map of Eu in ppm

World average standard threshold of Eu values is 1.2 ppm (Pendias & Mukherjee, 2007).

Threshold from Z (critic) of Eu has its values 1.73 ppm.

g. **Ni (in ppm)**

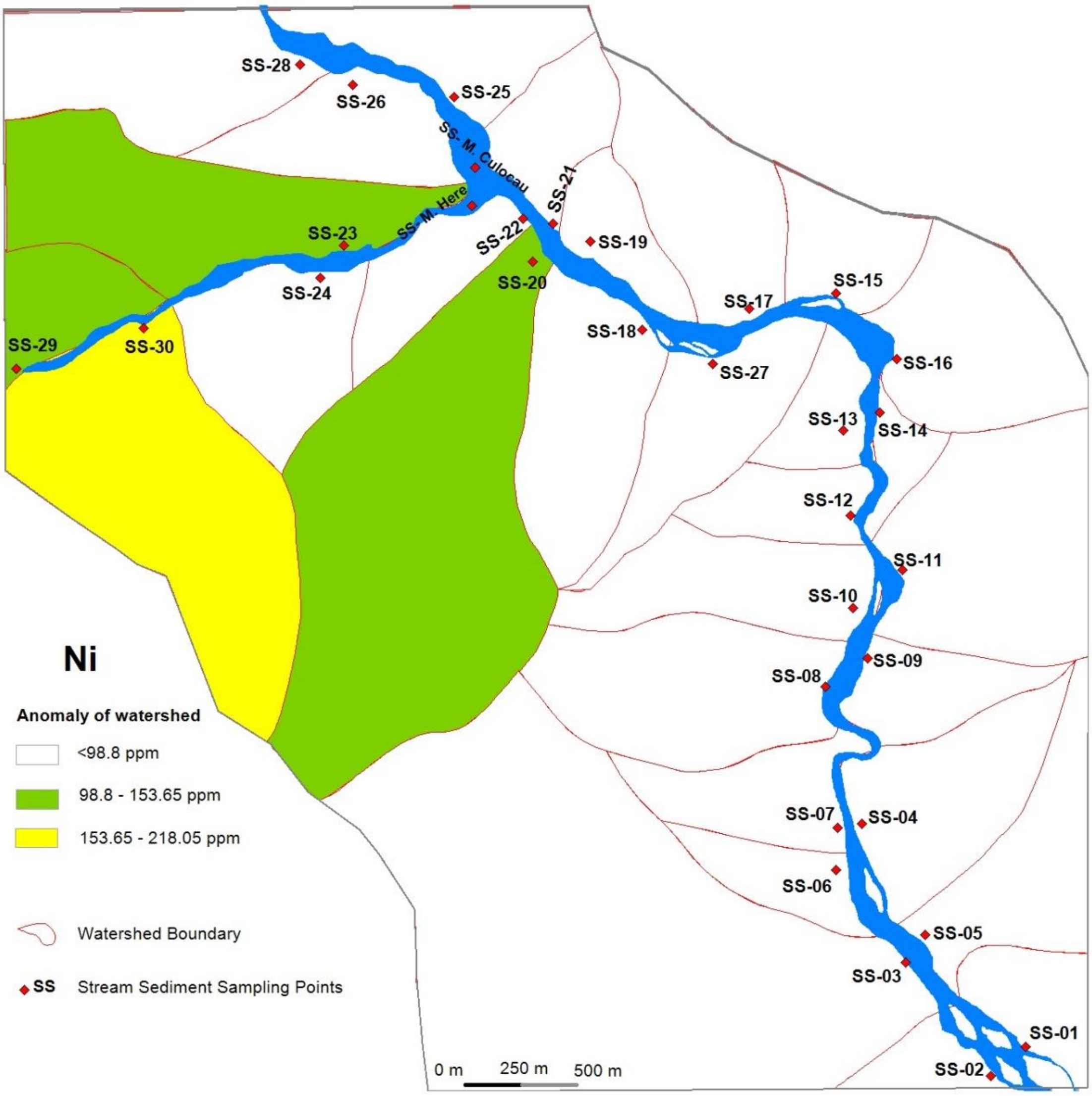


Figure 4.14 Anomaly map of Ni in ppm

World average standard threshold of Ni values is 20 ppm (Pendias & Mukherjee, 2007).

Threshold from Z (critic) of Ni, has its values 153.65 ppm.

h. **S (in %**)

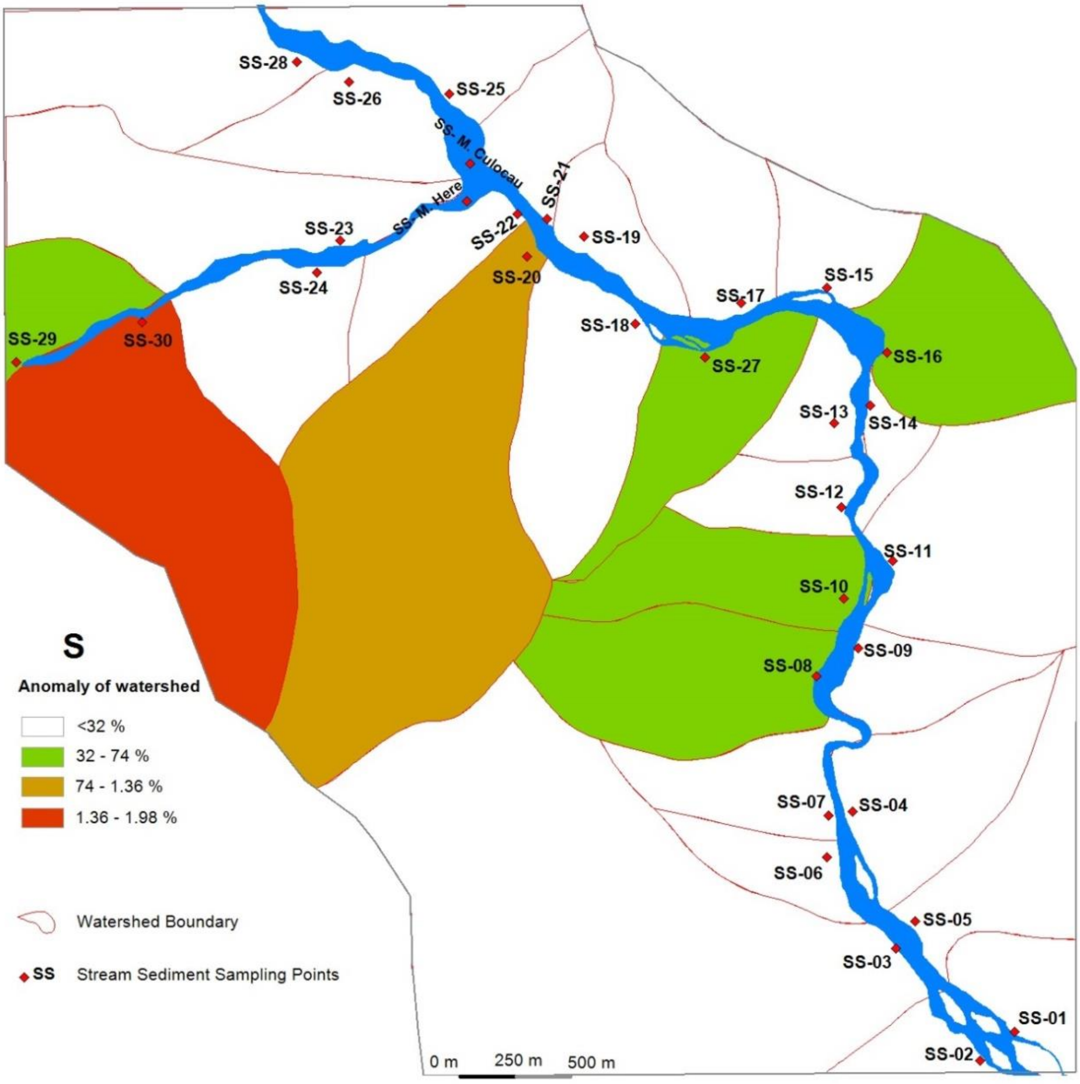


Figure 4.15 Anomaly map of S in Percent (%)

Threshold from Z (critic) of S has its values 0.62%.

i. **Sb (in ppm)**

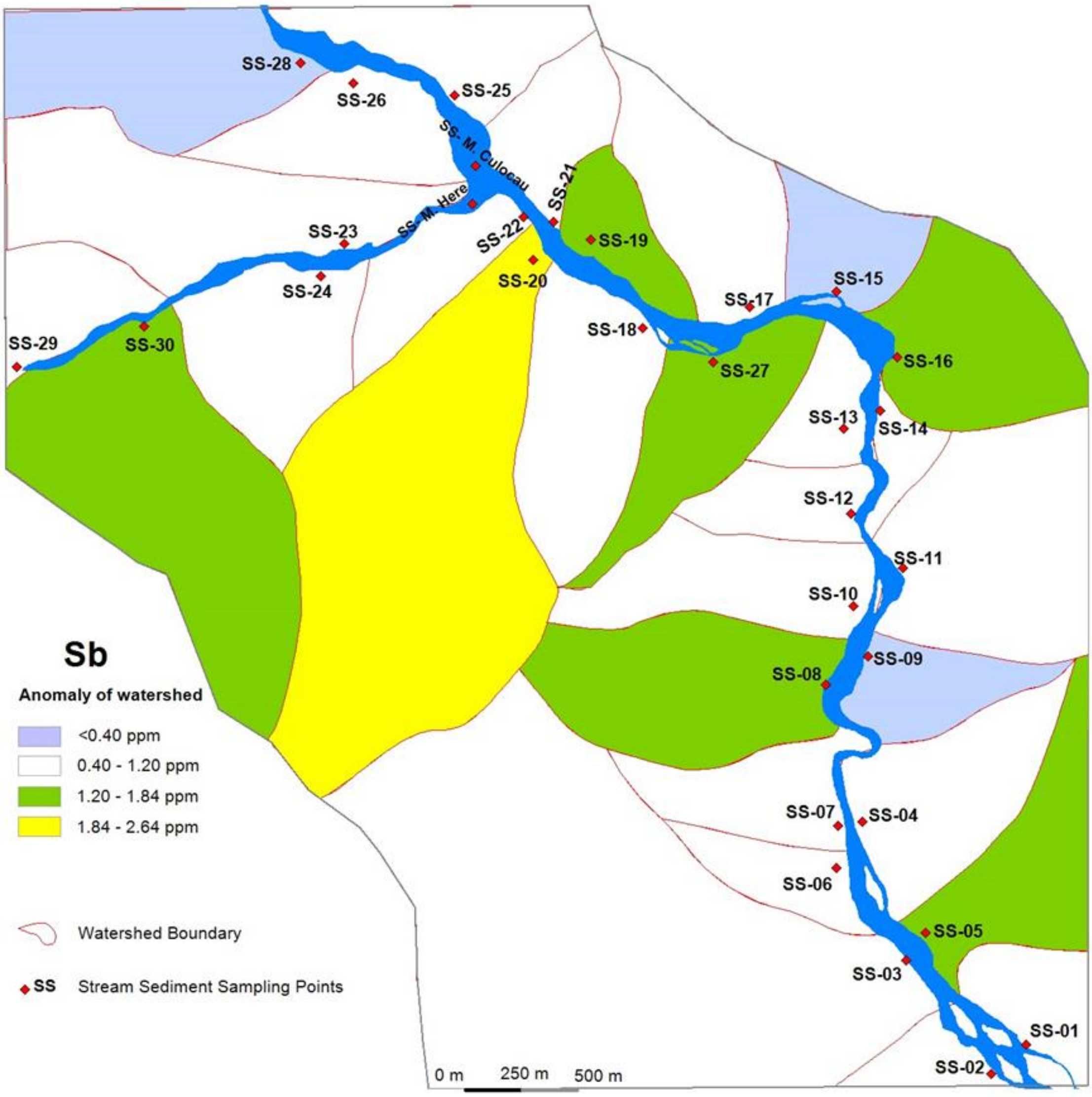


Figure 4.16 Anomaly map of Sb in ppm

World average standard threshold of Sb values is 0.2 ppm (Pendias & Mukherjee, 2007). Threshold from Z (critic) of Sb has its values 1.84 ppm.

j. **Se (in ppm)**

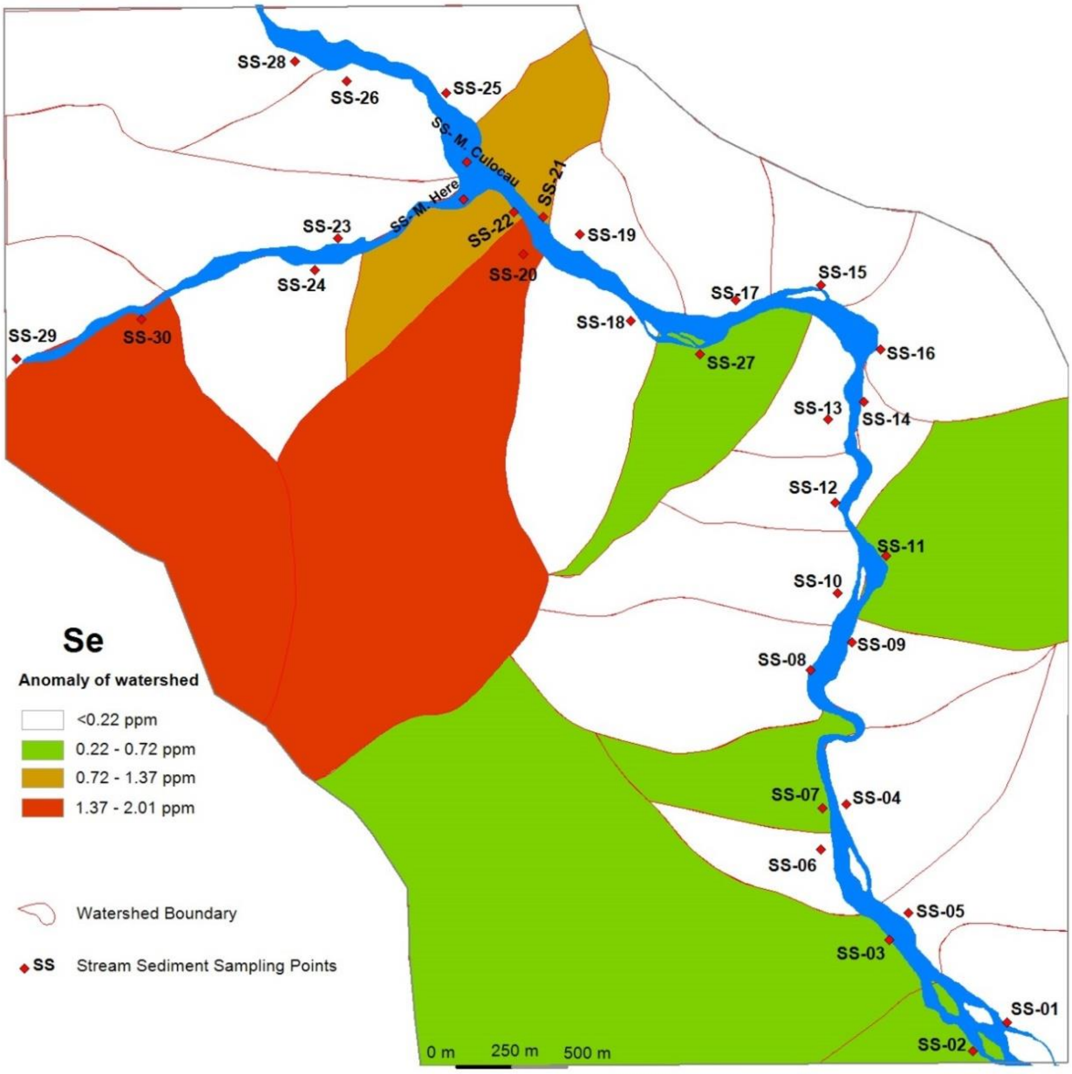


Figure 4.17 Anomaly map of Se in ppm

World average standard threshold of Se values is 0.02 ppm (Pendias & Mukherjee, 2007). Threshold from Z (critic) of Se has its values 0.64 ppm.

Chapter IV Conclusions

- Results obtained by these two methods i.e XRF and ICP-MS were slightly different, but considering only the mean values obtained by the two processes of the 32 samples, we can observe the similarity of the mean values of some elements obtained by ICP and XRF suach as example, the Fe, Cu, Pb, Zn and As content are similar to those obtained by XRF (respectively 6.0%, 88.8ppm, 17.7ppm, 102.4 and 23.1ppm).

- There have been two basins i.e SS 20 and SS 30 considered to have mineralization anomaly, mostly for ores Ag, Au, Cu which associated with As, Co, Eu, Nb, Ni, S, Sb, and Se.

- The anomaly of basin SS 20 and SS 30 are likely considered as sulphide ore deposit which have shown Ag, Au, and Cu in the watershed and some pathfinder associated elements such As, S, Sb and Se are also found although Zn is not presented.

- Quartz veins occur the disseminated ores bearing of Ag, Au, and Cu with probably black phyllite unit if reffered to mineralization on basin SS 20 & SS 30 (as shown on lithology map).

- Therefore, it is recommended that a detailed geological and geochemical study could be carried out in areas upstream of SS 20 and SS30 basins that indicate mineralization anomalous such sulphide ore deposit, perhaps vein of quartz vein with gold bearing or others ores have been completely weathered and residual as placer deposit during sedimentary processes.

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Appendix

I. ICP-MS data

Analyte Symbol	Unit Symbol	Samples ID																
		SS 01	SS 02	SS 03	SS 04	SS 05	SS 06	SS 07	SS 08	SS 09	SS 10	SS 11	SS 12	SS 13	SS 14	SS 15	SS 16	SS 17
Ag	ppm	0.08	0.09	0.08	0.09	0.11	0.09	0.09	0.12	0.05	0.12	0.1	0.07	0.08	0.08	0.05	0.15	0.08
Al	%	7.73	8.1	5.13	9.05	8.65	8.48	8.75	7.76	7.85	8.81	8.89	8.69	7.1	10.1	11.5	7.16	9.19
As	ppm	10.4	3.8	6.2	21.5	11.7	21.7	10.8	12.1	14.2	13.7	15.5	10.9	10.7	20.6	25.4	13.4	19.8
Au	ppb	< 2	19	2	12	< 2	< 2	6	12	< 2	7	< 2	8	< 2	< 2	< 2	13	12
Ba	ppm	470	91	157	403	433	456	267	328	561	511	483	549	387	429	476	653	592
Be	ppm	1.7	0.8	0.8	1.8	1.5	1.9	1.4	1.6	1.5	1.9	1.9	1.5	1.8	1.9	2.8	1.9	2.2
Bi	ppm	0.5	0.2	0.2	0.3	0.3	0.3	0.2	0.6	0.3	0.4	0.4	0.3	0.3	0.4	0.3	0.4	0.4
Br	ppm	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.3	< 0.5	< 0.5	5.3	< 0.5	< 0.5	< 0.5	7.3	5.8	20.6	< 0.5	10.8
Ca	%	3.78	4.87	13.9	2.1	3.19	2.46	3.04	0.5	3.11	3.04	0.7	3.13	2.8	1.41	1.15	4.6	1.36
Cd	ppm	0.1	< 0.1	0.1	0.2	< 0.1	< 0.1	0.1	0.1	0.3	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.3	< 0.1	< 0.1
Ce	ppm	51.1	24.5	30.2	53	35.4	47.3	37.1	50.4	48.8	45.2	48.4	36.8	58.9	62.7	131	67.6	50.2
Ce	ppm	56	27	32	59	40	49	56	57	51	45	50	39	63	73	150	68	56
Co	ppm	15.5	16.2	23.8	19.5	14.5	16.6	22.4	22.1	36.5	24.2	22.5	24.8	26.1	27.1	17.1	23.6	20
Cr	ppm	85	139	234	103	57	53	280	122	170	80	138	84	102	87	93	89	97
Cs	ppm	5.32	3.69	3.3	4.18	5.2	6.23	4.51	4.69	1.39	4.01	3.8	4.01	4.45	2.95	2.02	4.09	5.32
Cu	ppm	48.6	65.4	69.7	54.1	58.7	67.3	59.5	97.2	68.2	114	85.8	75.2	74.3	79	40.8	90.1	68.9
Dy	ppm	3.7	4.1	4.5	5.1	4.6	4.2	4.5	4.7	4.7	5.2	4.8	5.4	4.8	5	2.6	5	2.9
Er	ppm	1.8	1.9	2.4	2.6	2.2	2.1	2.2	2.3	2.3	2.3	2.2	2.5	2.2	2.4	1.3	2.4	1.3
Eu	ppm	0.9	1.1	1.1	1	0.9	0.9	0.9	1	1.3	1.2	1.3	1.5	1	0.9	0.6	1	0.9
Eu	ppm	1.12	1.15	1.06	1.15	1.1	1.01	1.07	1.18	1.41	1.3	1.33	1.32	1.13	1.16	0.89	1.29	0.93
Fe	%	4.2	4.92	6.07	5.36	5.13	4.66	5.52	6.3	6.53	6.63	6.36	6.53	5.71	5.76	3.44	6.02	4.55
Ga	ppm	17.7	18.1	19.5	20.7	21.7	21.1	20.5	23.9	20.4	23.2	24.3	23.6	21.5	21.2	12	23.4	17.6
Gd	ppm	4.5	4.6	4	4.7	4.6	4.2	4.2	5.3	4	5.2	5.3	5.1	4.8	4.6	2.8	5.3	3.5
Ge	ppm	0.1	< 0.1	< 0.1	0.2	0.3	0.2	0.2	0.3	0.3	0.4	0.3	0.1	0.1	0.3	0.1	0.4	< 0.1
Hf	ppm	1.5	1.8	2	1.7	2.5	1.9	1.5	1.9	1.1	0.8	1.3	0.8	0.7	0.9	0.5	2	1.2
Hg	ppb	100	120	200	230	220	100	140	100	40	70	90	60	50	40	40	130	80
Ho	ppm	0.7	0.8	0.9	1	0.9	0.9	0.9	0.9	0.9	1	0.9	1.1	0.9	1	0.5	1	0.5
K	%	1.51	1.35	1.18	1.51	1.85	1.69	1.22	1.72	0.46	1.59	1.61	1.49	1.51	1.13	0.7	1.69	1.41
La	ppm	24.9	23	15.9	20.6	24.1	22.9	17.1	26.9	10.8	23.7	29.5	23.7	19.7	16.2	14.5	27.2	24.5
La	ppm	23.4	21.2	16.5	19.2	23.6	20.9	16.2	25.1	10.1	22.1	27.9	22.6	18	15.4	13.1	24.3	22.5
Li	ppm	50.1	49.5	46	37.1	58.7	76.6	47.5	78.5	15.2	66.9	74.3	65	59.8	44.8	21.3	82.3	48.5
Lu	ppm	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2
Lu	ppm	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2
Mg	%	1.27	1.61	2.27	1.67	1.06	0.94	2.38	1.93	2.79	1.76	1.61	1.59	1.71	1.64	1.52	1.39	1.51
Mn	ppm	863	1120	889	700	620	760	861	1110	1310	1810	1170	1490	1620	1250	640	979	1050
Na	%	1.41	1.39	1.74	1.78	1.59	1.22	1.65	1.42	1.78	1.44	1.59	1.33	1.19	1.46	1.01	1.26	1.15
Nb	ppm	0.7	0.7	0.1	0.5	0.2	< 0.1	0.2	0.8	0.4	0.3	0.1	0.1	0.1	0.7	0.1	0.8	0.3
Nd	ppm	25.8	24.5	18.8	22.3	25.8	23.8	19.6	28.4	14.5	26.8	29.9	25.6	21.9	19.7	15.2	29.5	23.7
Nd	ppm	19	14	13	17	24	15	17	16	11	15	24	16	15	15	10	22	19

Ni	ppm	42.4	63.1	77.1	46.8	34.4	30.3	91.5	81	68.5	61.6	64	58.7	62.8	46.1	35.6	50.5	65.8
P	%	0.063	0.069	0.067	0.068	0.08	0.076	0.067	0.084	0.05	0.091	0.08	0.07	0.079	0.06	0.042	0.091	0.068
Pb	ppm	13.1	15.4	14.4	19.9	22.1	21.4	15.8	20.7	4.8	21.9	20.2	19.5	17.7	15.1	17.2	27.5	16.7
Pr	ppm	6	5.8	4.2	5.2	6	5.8	4.4	6.8	3.1	6.1	7.2	5.9	5.1	4.4	3.5	6.9	5.7
Rb	ppm	72.1	67.7	59.9	82.9	96.7	83.9	66.1	81.6	21	73	78.1	73.2	70.6	53.5	37.8	82	80.4
S	%	0.11	0.06	0.2	0.24	0.19	0.03	0.28	0.33	0.02	0.4	0.14	0.05	0.03	0.02	0.06	0.42	0.02
Sb	ppm	0.4	0.4	0.4	0.9	1.2	0.9	0.6	1.2	< 0.1	0.8	0.8	0.5	0.8	0.6	< 0.1	1.2	0.6
Sc	ppm	13.5	15.4	21.4	18.4	15.1	14.8	19.7	19.9	26.1	20	20.4	21.3	20	21.9	12.1	17.5	14.9
Se	ppm	< 0.1	0.4	0.4	< 0.1	0.1	< 0.1	0.3	< 0.1	< 0.1	0.2	0.6	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sm	ppm	5.1	4.8	4.1	5.6	5.6	5.6	4.6	5.4	4	5.8	6.4	5.6	4.8	4.2	3.5	5.8	5.3
Sm	ppm	4.9	4.6	4.2	4.7	5.3	4.5	4.1	5.5	3.6	5.4	6.3	5.7	4.7	4.6	3.2	5.5	4.7
Sn	ppm	< 1	< 1	< 1	2	2	4	2	2	< 1	3	< 1	< 1	< 1	2	< 1	4	< 1
Sr	ppm	230	190	165	119	203	163	154	165	198	156	195	172	139	181	181	181	94.9
Tb	ppm	0.6	0.6	0.6	0.7	0.7	0.6	0.6	0.7	0.6	0.8	0.8	0.8	0.7	0.7	0.4	0.8	0.5
Tb	ppm	0.6	0.6	0.6	0.7	0.7	0.6	0.6	0.7	0.6	0.8	0.8	0.8	0.7	0.7	0.4	0.8	0.5
Th	ppm	7.9	7.6	6.3	8.8	10.3	9.5	6.2	10.1	2.1	8.1	10.6	8.6	6.6	6.3	3.9	10.4	9.3
Ti	%	0.11	0.2	0.23	0.18	0.25	0.16	0.2	0.31	0.25	0.29	0.25	0.14	0.15	0.18	0.1	0.37	0.2
Tl	ppm	0.36	0.34	0.31	0.44	0.49	0.43	0.35	0.44	0.07	0.38	0.4	0.38	0.35	0.27	0.15	0.45	0.43
Tm	ppm	0.3	0.3	0.3	0.4	0.4	0.3	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.2	0.3	0.2
U	ppm	1.3	1.3	1.1	1.5	1.8	1.7	1.3	1.3	0.4	0.7	1.2	0.8	0.6	0.8	0.6	1.3	1.1
V	ppm	63	88	125	100	112	91	102	144	80	108	141	82	73	66	34	128	78
Y	ppm	16.3	19	21.3	23.9	21	20.1	21.5	20.7	22.3	22.1	21.2	24.1	21.9	22.2	11.8	21.7	12.4
Yb	ppm	1.7	1.9	2.3	2.6	2.4	2.3	2.3	2.2	2.2	2	2	2.2	2	2.1	1.2	2.3	1.3
Yb	ppm	2.2	2.5	2.7	2.8	2.7	2.5	2.7	2.8	2.5	3	2.9	3.4	2.7	2.8	1.5	2.6	2.5
Zn	ppm	91.8	94.5	126	115	116	119	99.1	132	103	125	118	114	119	94.6	73	134	103
Zr	ppm	55	64	75	53	77	63	47	64	39	24	45	25	22	31	18	59	44

I. ICP-MS data [continued]

Analyte Symbol	Unit Symbol	Samples ID														
		SS 18	SS 19	SS 20	SS 21	SS 22	SS 23	SS 24	SS 25	SS 26	SS 27	SS 28	SS 29	SS 30	SS Here	SS Culocau
Ag	ppm	0.11	0.13	0.34	0.12	0.13	0.1	0.17	0.09	0.11	0.13	0.16	0.2	0.4	0.12	0.1
Al	%	8.91	8.47	9.92	9.36	7.51	9.33	8.98	9.11	9.44	9.83	8.25	8.88	9.66	8.83	9.5
As	ppm	24.9	22.1	21.1	22.6	13.7	31	21.6	14.9	39.7	26.3	20	25.2	36.1	51	67
Au	ppb	21	5	22	14	17	4	5	7	23	23	16	25	20	11	11
Ba	ppm	449	463	504	534	318	394	389	425	593	532	283	349	409	316	245
Be	ppm	2	1.8	1.8	2	1.6	2	1.9	1.9	1.9	2.1	1.6	1.8	1.9	1.7	2.2
Bi	ppm	0.4	0.7	0.4	0.7	0.3	0.3	0.5	0.3	0.5	0.9	0.3	0.3	0.3	0.6	0.7
Br	ppm	< 0.5	< 0.5	< 0.5	20.5	< 0.5	< 0.5	< 0.5	1.8	8.1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Ca	%	2.02	3.6	1.24	1.51	5.46	2.13	0.84	0.95	0.81	1.18	4.67	2.35	1.92	1.79	1.56
Cd	ppm	< 0.1	< 0.1	0.1	< 0.1	0.1	< 0.1	< 0.1	0.2	0.2	0.1	0.1	< 0.1	0.1	< 0.1	0.1
Ce	ppm	61.3	49.9	60.3	54.6	60.5	95.9	64.6	78.3	71.6	60.9	52	72	70.6	69.7	80
Ce	ppm	75	55	64	60	67	99	70	92	79	59	56	82	80	71	90
Co	ppm	24.5	23.2	37.3	20	22.4	28.9	24.2	17.1	26.7	35.7	23.9	30.5	53.8	24.5	18
Cr	ppm	106	107	98	95	139	180	126	101	106	112	98	134	121	133	86
Cs	ppm	5.36	6.67	4.89	5.57	6.34	12	5.99	4.39	4.76	5.44	6.38	6.65	6.51	6.35	4.85
Cu	ppm	101	79.4	133	68.5	72.9	56.3	67.2	56.8	87.9	122	83.4	76.5	137	71.5	50.6
Dy	ppm	3.9	2.8	3.5	2	3.5	2.9	2.6	4.2	4.9	4.3	2.5	2.6	3.4	3.3	4.3
Er	ppm	1.7	1.2	1.5	0.8	1.4	0.9	1	2	2.3	1.8	0.9	1	1.3	1.2	2
Eu	ppm	1.3	1.3	1.3	1.2	1.5	2.8	1.3	1.2	1	1.5	1.2	1.2	2	1.8	1.1
Eu	ppm	1.23	1.16	1.32	1.05	1.42	2.28	1.25	1.09	1.13	1.46	0.97	1.27	1.51	1.65	1.14
Fe	%	5.89	5.14	6.08	4.39	5.47	6.19	5.55	4.38	5.63	6.41	5.21	6.16	6.72	5.38	4.52
Ga	ppm	21.2	21.7	20.2	17.4	21.8	30.5	21.3	16.8	21.9	23.9	20.1	23.2	22.9	21.9	19
Gd	ppm	4.8	4.1	4.9	3.6	5.3	7.1	4.6	4.7	4.9	5.6	3.9	4.3	5.6	5.8	5
Ge	ppm	< 0.1	0.2	< 0.1	0.4	0.3	0.2	0.4	< 0.1	0.2	0.3	0.5	0.4	0.2	0.2	0.1
Hf	ppm	1	1	1.5	1	1.1	1.5	1.5	2.2	0.8	0.8	0.6	1.1	1.3	1.1	2.3
Hg Hg	ppb ppb	90 90	60 60	50 50	20 20	30 30	70 70	80 80	100 100	80 80	60 60	20 20	20 20	40 40	50 50	90 90
Ho	ppm	0.7	0.5	0.6	0.3	0.6	0.4	0.5	0.8	1	0.8	0.4	0.4	0.5	0.5	0.8
K	%	1.65	2.3	1.81	1.9	2.18	3.56	1.75	1.23	1.51	2.07	2.09	2.43	2.32	2.21	1.43
La	ppm	29.5	32.5	33.6	30.9	39.4	70.4	36.1	30	21.5	32.6	26.7	35.7	39.7	48.9	34.2
La	ppm	29.1	29.5	28.8	27	38.3	61.2	34.1	26.9	19.7	31.3	24.5	29.8	37	41	28.6
Li	ppm	62.1	51.4	60.8	44.2	56.2	67.1	51.1	41.1	60.1	66.9	46	56	58.2	55.6	47.7
Lu	ppm	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.1	0.1	0.2	0.2	0.3
Lu	ppm	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.1	0.1	0.2	0.2	0.3
Mg	%	1.72	1.96	1.92	1.5	1.75	2.43	1.81	1.08	1.6	2.08	1.77	2.13	1.96	1.86	1.09
Mn	ppm	1360	810	1020	886	1160	535	707	1240	1570	1600	705	711	675	706	1260

Na	%	1.54	1.42	1.34	1.04	1.5	1.25	1.55	1.13	1.16	1.62	1.26	1.48	1.43	1.62	1.05
Nb	ppm	0.5	0.3	8.8	2.1	0.8	1	4.9	0.5	0.6	1.2	2.3	7.6	10.8	0.6	1.1
Nd	ppm	29.9	31.5	33.8	29.6	37.5	68.1	35.2	27.3	22.9	34.9	24.3	33.7	38.9	45.9	29.8
Nd	ppm	27	23	21	25	39	58	27	20	18	24	18	27	31	34	27
Ni	ppm	72.7	83.7	116	60.6	85	103	81.6	51.3	64.4	86.7	83.1	105	157	86.1	51.8
P	%	0.096	0.085	0.099	0.066	0.113	0.111	0.093	0.066	0.079	0.117	0.071	0.088	0.112	0.113	0.052
Pb	ppm	24	22.1	28.2	14.8	17.2	14.7	14.6	19.5	19.6	28.6	15.8	14.1	29	14.3	20.1
Pr	ppm	7.1	7.5	8.2	7	9.1	16.1	8.5	6.8	5.4	8.3	6	8.3	9.2	11	7.5
Rb	ppm	84.1	118	92.9	102	115	174	99	74.4	69.5	95.5	115	124	118	114	85.6
S	%	0.07	0.15	1.29	0.05	0.05	0.07	0.24	0.08	0.03	0.4	0.22	0.39	1.78	0.27	0.22
Sb	ppm	1.1	1.3	2	0.6	0.9	0.7	0.7	0.8	0.8	1.5	0.4	0.6	1.4	0.6	0.9
Sc	ppm	18.5	16.9	15.8	14.9	17.8	24.5	16.7	13.4	19.6	19.7	15.8	19	16.8	17.1	14.1
Se	ppm	< 0.1	< 0.1	1.7	1	1	< 0.1	< 0.1	< 0.1	< 0.1	0.5	< 0.1	< 0.1	1.6	0.1	< 0.1
Sm	ppm	6.3	5.8	6.8	5.5	8.2	12.6	6	5.6	6	6.9	5	6.8	8.2	9	6.1
Sm	ppm	6.6	6.2	6.4	5.6	8.1	12.4	7.1	5.3	5.1	7.3	5	6.4	8	8.6	5.8
Sn	ppm	1	< 1	2	2	4	< 1	2	< 1	< 1	2	1	2	2	2	2
Sr	ppm	152	107	177	135	140	97.1	162	165	142	116	159	152	160	158	248
Tb	ppm	0.6	0.5	0.6	0.4	0.6	0.6	0.5	0.7	0.7	0.7	0.5	0.5	0.6	0.7	0.7
Tb	ppm	0.6	0.5	0.6	0.4	0.6	0.6	0.5	0.7	0.7	0.7	0.5	0.5	0.6	0.7	0.7
Th	ppm	9.9	11.1	9.9	9.4	12.4	20.8	11.6	10	9.1	10.4	9.2	11.5	13.7	13.1	11.3
Ti	%	0.22	0.16	0.48	0.29	0.29	0.25	0.36	0.27	0.1	0.36	0.34	0.46	0.5	0.27	0.26
Tl	ppm	0.45	0.52	0.44	0.46	0.51	0.8	0.5	0.41	0.36	0.53	0.49	0.54	0.6	0.52	0.44
Tm	ppm	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.1	0.1	0.2	0.2	0.3
U	ppm	1	1.3	1.1	0.9	1.3	2.2	1.3	1.8	0.7	0.9	0.8	1.1	1.9	1.4	2.1
V	ppm	111	85	155	93	109	115	120	83	62	133	106	154	156	102	82
Y	ppm	15.8	11	13.8	7.6	14.3	9.9	10.5	19.5	21.7	18.3	9	9.5	12.2	12.1	20.1
Yb	ppm	1.5	1.2	1.4	0.8	1.3	1.1	1.1	1.9	1.9	1.6	0.8	0.9	1.2	1.1	2
Yb	ppm	3.2	3	2.8	2.8	3.2	4.4	3.3	2.3	2.7	3.4	2.5	3	3.4	3.5	2.4
Zn	ppm	114	106	130	90.1	115	128	110	97.5	114	132	103	119	125	109	100
Zr	ppm	37	35	52	38	42	52	52	87	28	28	22	41	48	38	88

II. XRF Chemical data – SS 01

Type	Sample Codes		SS-01				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	12.86	15.84	11.90	5.81	2.68
TestAllGeo	CaO	(%)	3.39	5.03	5.99	23.03	21.08
TestAllGeo	Cr2O3	(%)	0.10	0.06	0.03	na	na
TestAllGeo	Fe2O3	(%)	41.94	21.84	10.08	4.29	0.94
TestAllGeo	K2O	(%)	0.99	3.23	2.51	0.98	0.48
TestAllGeo	MgO	(%)	5.98	1.95	1.93	0.63	na
TestAllGeo	MnO	(%)	0.89	0.30	0.14	0.10	0.06
TestAllGeo	P2O5	(%)	na	0.41	0.46	0.18	0.27
TestAllGeo	SO2	(%)	0.09	0.05	0.22	0.38	0.44
TestAllGeo	SiO2	(%)	25.51	49.24	64.81	64.18	73.80
TestAllGeo	TiO2	(%)	8.12	1.98	1.89	0.40	0.26
TestAllGeo	V2O3	(%)	0.13	0.07	0.04	0.01	0.01
TestAllGeo	Ag	(ppm)	13.35569	na	na	na	na
TestAllGeo	As	(ppm)	59.0251	45.22548	24.97829	13.94439	11.69809
TestAllGeo	Ba	(ppm)	60.05577	930.8874	772.3776	na	3693.349
TestAllGeo	Cu	(ppm)	215.9863	134.7487	143.9499	57.45284	72.69008
TestAllGeo	Nb	(ppm)	55.67979	18.05737	15.96562	7.253538	4.80379
TestAllGeo	Ni	(ppm)	123.3801	203.4294	128.1062	na	na
TestAllGeo	Pb	(ppm)	51.97113	34.73151	26.67774	9.675722	11.86454
TestAllGeo	Sn	(ppm)	15.40051	21.15848	18.51415	na	na
TestAllGeo	Sr	(ppm)	90.28518	300.4904	320.7991	380.3382	382.3407
TestAllGeo	Zn	(ppm)	328.4349	231.4638	140.0593	47.27914	32.94938
TestAllGeo	Zr	(ppm)	1466.203	330.5218	308.337	114.5181	624.8963
TestAllGeo	Rb	(ppm)	12.43985	60.21489	43.70362	25.60155	13.44618
TestAllGeo	Te	(ppm)	na	72.67409	75.4469	na	18.87094
TestAllGeo	Th	(ppm)	na	5.31232	12.2182	na	2.697556
TestAllGeo	U	(ppm)	na	na	14.22715	na	4.873598
TestAllGeo	W	(ppm)	na	na	na	na	30.39726

III. XRF Chemical data – SS 02

Type	Sample Codes		SS-02				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	11.62	12.09	13.02	7.79	4.26
TestAllGeo	CaO	(%)	6.34	9.87	6.03	11.03	11.10
TestAllGeo	Cr2O3	(%)	0.70	0.06	0.05	0.01	na
TestAllGeo	Fe2O3	(%)	35.79	19.75	13.79	4.68	1.11
TestAllGeo	K2O	(%)	1.10	1.69	2.13	1.01	0.55
TestAllGeo	MgO	(%)	3.51	2.33	2.28	0.71	na
TestAllGeo	MnO	(%)	0.74	0.33	0.17	0.07	0.02
TestAllGeo	P2O5	(%)	0.39	0.42	0.27	na	0.47
TestAllGeo	SO2	(%)	0.08	0.28	0.12	0.12	0.44
TestAllGeo	SiO2	(%)	31.85	50.69	60.33	73.92	81.71
TestAllGeo	TiO2	(%)	7.74	2.37	1.78	0.66	0.32
TestAllGeo	V2O3	(%)	0.15	0.07	0.05	0.02	0.01
TestAllGeo	Ag	(ppm)	na	na	na	na	na
TestAllGeo	As	(ppm)	63.91371	29.49888	26.18731	25.72698	10.54546
TestAllGeo	Ba	(ppm)	333.2211	3027.901	677.9931		2219.739
TestAllGeo	Cu	(ppm)	331.6997	356.1931	183.8411	255.5271	75.2258
TestAllGeo	Nb	(ppm)	75.9442	13.26772	13.92387	17.23278	5.367568
TestAllGeo	Ni	(ppm)	176.0238	163.0389	144.7344	na	na
TestAllGeo	Pb	(ppm)	46.60238	14.11674	15.45037	11.12909	4.162111
TestAllGeo	Sn	(ppm)	na	na	9.297738	na	na
TestAllGeo	Sr	(ppm)	142.3651	338.6105	274.1681	298.4371	278.8448
TestAllGeo	Zn	(ppm)	303.764	222.8924	188.2031	84.3519	69.20778
TestAllGeo	Zr	(ppm)	541.8324	611.4501	328.5021	7207.322	304.8106
TestAllGeo	Rb	(ppm)	18.51564	29.64011	40.78014	32.60986	15.15491
TestAllGeo	Te	(ppm)	na	na	46.66231	na	na
TestAllGeo	Th	(ppm)	na	na	11.70894	na	na
TestAllGeo	U	(ppm)	na	na	6.165048	6.171669	na
TestAllGeo	W	(ppm)	188.0526	na	na	121.4405	118.2878

IV. XRF Chemical data – SS 03

Type	Sample Codes		SS-03				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	9.86	11.93	12.55	12.69	8.47
TestAllGeo	CaO	(%)	7.54	10.63	10.40	9.09	10.36
TestAllGeo	Cr2O3	(%)	0.72	0.07	0.04	0.04	na
TestAllGeo	Fe2O3	(%)	33.33	25.78	13.96	12.93	3.31
TestAllGeo	K2O	(%)	0.83	0.91	2.42	1.78	1.15
TestAllGeo	MgO	(%)	4.73	4.04	2.80	3.23	1.55
TestAllGeo	MnO	(%)	0.42	0.37	0.16	0.10	0.03
TestAllGeo	P2O5	(%)	0.24	0.45	0.29	0.29	0.17
TestAllGeo	SO2	(%)	0.31	0.06	0.10	0.93	0.17
TestAllGeo	SiO2	(%)	37.91	43.70	56.92	57.67	74.33
TestAllGeo	TiO2	(%)	4.01	1.99	1.35	1.22	0.44
TestAllGeo	V2O3	(%)	0.11	0.09	0.05	0.04	0.02
TestAllGeo	Ag	(ppm)	na	na	na	na	2.302414
TestAllGeo	As	(ppm)	51.08108	31.38435	23.27089	29.671	13.87226
TestAllGeo	Ba	(ppm)	171.5761	501.2445	1018.877	na	396.5531
TestAllGeo	Cu	(ppm)	166.6289	178.6673	133.7851	175.7644	60.7687
TestAllGeo	Nb	(ppm)	10.49655	9.76911	9.737581	7.508437	3.460659
TestAllGeo	Ni	(ppm)	246.7603	200.0047	128.3645	na	na
TestAllGeo	Pb	(ppm)	na	10.96748	20.01634	16.2331	7.482626
TestAllGeo	Sn	(ppm)	na	na	23.48825	na	na
TestAllGeo	Sr	(ppm)	159.7504	202.7388	288.8338	249.3322	195.563
TestAllGeo	Zn	(ppm)	247.6077	236.9184	196.6952	104.0198	40.60793
TestAllGeo	Zr	(ppm)	157.6285	163.6442	237.986	124.8032	69.57452
TestAllGeo	Rb	(ppm)	10.49038	14.18329	38.58518	36.97234	34.87665
TestAllGeo	Te	(ppm)	na	125.7629	118.3277	na	na
TestAllGeo	Th	(ppm)	na	na	10.38436	na	na
TestAllGeo	U	(ppm)	na	na	8.630806	na	na
TestAllGeo	W	(ppm)	na	na	26.58093	179.1948	na

V. XRF Chemical data – SS 04

Type	Sample Codes		SS-04				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	14.70	13.70	14.95	10.34	4.92
TestAllGeo	CaO	(%)	2.89	8.27	5.48	6.54	13.85
TestAllGeo	Cr2O3	(%)	0.14	0.06	0.03	0.01	na
TestAllGeo	Fe2O3	(%)	42.30	22.05	10.91	4.55	na
TestAllGeo	K2O	(%)	1.13	1.84	2.97	1.89	0.88
TestAllGeo	MgO	(%)	5.15	3.59	1.27	na	na
TestAllGeo	MnO	(%)	0.34	0.27	0.09	0.02	0.00
TestAllGeo	P2O5	(%)	0.33	0.31	0.38	0.25	0.32
TestAllGeo	SO2	(%)	0.24	0.10	0.09	0.08	0.14
TestAllGeo	SiO2	(%)	30.94	48.09	62.48	75.51	78.57
TestAllGeo	TiO2	(%)	1.75	1.65	1.31	0.82	0.30
TestAllGeo	V2O3	(%)	0.09	0.07	0.05	0.02	0.01
TestAllGeo	Ag	(ppm)	11.50331	na	na	na	na
TestAllGeo	As	(ppm)	53.15773	23.9362	22.21225	17.56435	9.312211
TestAllGeo	Ba	(ppm)	na	980.0027	902.598	na	1211.037
TestAllGeo	Cu	(ppm)	280.1441	187.9452	90.45636	74.18906	54.14558
TestAllGeo	Nb	(ppm)	8.761992	10.03982	13.60308	9.277646	2.971169
TestAllGeo	Ni	(ppm)	98.21924	255.1367	111.5556	na	na
TestAllGeo	Pb	(ppm)	44.21368	22.9591	23.42459	15.37812	9.09614
TestAllGeo	Sn	(ppm)	na	23.89109	na	na	na
TestAllGeo	Sr	(ppm)	69.09214	202.1371	190.5929	135.7724	82.58984
TestAllGeo	Zn	(ppm)	470.2253	229.948	150.4301	60.34117	24.76196
TestAllGeo	Zr	(ppm)	na	208.8164	275.5978	121.1269	228.8278
TestAllGeo	Rb	(ppm)	18.54002	25.48604	58.58588	57.60503	23.70915
TestAllGeo	Te	(ppm)	na	117.1689	49.70291	na	na
TestAllGeo	Th	(ppm)	na	na	15.28579	na	na
TestAllGeo	U	(ppm)	na	3.970777	9.274769	na	na
TestAllGeo	W	(ppm)	na	na	na	39.2015	na

VI. XRF Chemical data – SS 05

Type	Sample Codes		SS-05				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	14.06	16.19	14.50	10.46	5.85
TestAllGeo	CaO	(%)	1.95	2.78	2.87	5.07	4.39
TestAllGeo	Cr2O3	(%)	0.07	0.05	0.03	0.01	na
TestAllGeo	Fe2O3	(%)	40.29	25.50	12.31	6.07	1.22
TestAllGeo	K2O	(%)	1.71	2.57	2.79	2.07	1.18
TestAllGeo	MgO	(%)	2.79	2.32	1.24	1.21	na
TestAllGeo	MnO	(%)	0.42	0.23	0.11	0.03	0.00
TestAllGeo	P2O5	(%)	0.23	0.43	0.35	0.29	0.23
TestAllGeo	SO2	(%)	0.39	0.31	0.06	0.33	0.19
TestAllGeo	SiO2	(%)	38.40	48.53	65.10	74.35	86.55
TestAllGeo	TiO2	(%)	1.01	1.53	1.39	0.69	0.36
TestAllGeo	V2O3	(%)	0.07	0.07	0.05	0.02	0.01
TestAllGeo	Ag	(ppm)	10.68609	na	na	na	na
TestAllGeo	As	(ppm)	102.6066	73.33893	25.89962	16.80406	11.99411
TestAllGeo	Ba	(ppm)	411.5592	843.4954	1054.331	na	439.3986
TestAllGeo	Cu	(ppm)	198.4209	199.3678	98.25013	70.77941	29.04687
TestAllGeo	Nb	(ppm)	10.25736	14.11359	10.74603	6.697062	na
TestAllGeo	Ni	(ppm)	125.5875	100.0743	108.3157	na	na
TestAllGeo	Pb	(ppm)	31.25068	53.69365	21.96953	16.28276	10.87467
TestAllGeo	Sn	(ppm)	13.47964	na	17.61055	na	na
TestAllGeo	Sr	(ppm)	173.8925	204.3211	305.5783	220.343	116.9315
TestAllGeo	Zn	(ppm)	320.6115	271.3258	145.7655	70.49509	25.03397
TestAllGeo	Zr	(ppm)	162.7628	207.5872	272.8143	155.1044	68.89894
TestAllGeo	Rb	(ppm)	34.77308	47.67787	55.48762	33.17103	35.40786
TestAllGeo	Te	(ppm)	na	96.07634	76.64269	na	na
TestAllGeo	Th	(ppm)	6.711067	7.348668	14.96064	2.995836	na
TestAllGeo	U	(ppm)	na	na	16.64868	5.371052	na
TestAllGeo	W	(ppm)	na	na	24.44722	na	na

VII. XRF Chemical data – SS 06

Type	Sample Codes		SS-06				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	16.52	16.92	15.08	10.14	5.96
TestAllGeo	CaO	(%)	1.14	1.84	1.12	0.76	0.56
TestAllGeo	Cr2O3	(%)	0.07	0.05	0.03	na	na
TestAllGeo	Fe2O3	(%)	22.07	25.03	12.77	5.48	1.65
TestAllGeo	K2O	(%)	2.99	2.66	3.07	1.98	1.15
TestAllGeo	MgO	(%)	1.90	2.15	1.59	na	na
TestAllGeo	MnO	(%)	0.13	0.23	0.13	0.03	0.02
TestAllGeo	P2O5	(%)	0.40	0.43	0.38	0.25	0.25
TestAllGeo	SO2	(%)	na	0.07	na	0.08	na
TestAllGeo	SiO2	(%)	53.26	49.05	64.23	80.62	90.05
TestAllGeo	TiO2	(%)	1.46	1.52	1.55	0.68	0.36
TestAllGeo	V2O3	(%)	0.06	0.08	0.05	0.02	0.01
TestAllGeo	Ag	(ppm)	10.32649	na	na	na	1.755887
TestAllGeo	As	(ppm)	55.17954	72.15628	34.53559	15.83904	11.91973
TestAllGeo	Ba	(ppm)	370.5765	1000.264	1127.43	na	172.1167
TestAllGeo	Cu	(ppm)	108.0552	229.575	123.1644	48.57924	37.87161
TestAllGeo	Nb	(ppm)	14.24058	14.38017	12.21005	6.714505	na
TestAllGeo	Ni	(ppm)	na	122.1831	129.7716	na	na
TestAllGeo	Pb	(ppm)	39.50935	64.12368	26.92525	11.733	5.633303
TestAllGeo	Sn	(ppm)	12.21712	na	16.14434	na	na
TestAllGeo	Sr	(ppm)	157.5559	198.3739	326.6458	129.909	59.23394
TestAllGeo	Zn	(ppm)	257.7191	323.6511	165.7685	62.82351	23.17013
TestAllGeo	Zr	(ppm)	224.3089	253.7476	317.6765	125.3573	45.36039
TestAllGeo	Rb	(ppm)	58.90273	52.21143	57.78492	38.99244	23.76463
TestAllGeo	Te	(ppm)	na	117.589	80.93537	na	na
TestAllGeo	Th	(ppm)	11.74773	9.304838	16.92013	1.688806	1.664972
TestAllGeo	U	(ppm)	5.981213	15.12388	20.6792	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

VIII. XRF Chemical data – SS 07

Type	Sample Codes		SS-07				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	9.59	12.30	14.39	10.49	6.31
TestAllGeo	CaO	(%)	5.89	9.28	5.44	11.75	12.21
TestAllGeo	Cr2O3	(%)	2.36	0.09	0.03	0.02	na
TestAllGeo	Fe2O3	(%)	34.17	22.45	12.81	5.78	1.33
TestAllGeo	K2O	(%)	0.88	1.62	2.71	1.31	0.90
TestAllGeo	MgO	(%)	7.14	3.98	1.85	1.66	na
TestAllGeo	MnO	(%)	0.55	0.27	0.09	0.04	0.00
TestAllGeo	P2O5	(%)	0.23	0.29	0.31	0.13	0.15
TestAllGeo	SO2	(%)	0.18	0.19	0.33	0.47	0.24
TestAllGeo	SiO2	(%)	32.21	47.43	60.93	67.79	78.63
TestAllGeo	TiO2	(%)	6.63	2.02	1.06	0.58	0.21
TestAllGeo	V2O3	(%)	0.15	0.08	0.04	0.02	0.01
TestAllGeo	Ag	(ppm)	8.406116	3.762463	na	na	na
TestAllGeo	As	(ppm)	38.4875	30.30525	26.43864	13.37401	9.822547
TestAllGeo	Ba	(ppm)	110.7803	194.5648	na	na	1080.584
TestAllGeo	Cu	(ppm)	153.7122	151.903	97.5614	60.88212	100.808
TestAllGeo	Nb	(ppm)	17.57874	12.34104	12.44093	8.116478	3.738946
TestAllGeo	Ni	(ppm)	753.1999	167.0697	na	na	na
TestAllGeo	Pb	(ppm)	17.96125	17.4083	15.55755	8.433956	9.5304
TestAllGeo	Sn	(ppm)	11.73445	11.55898	na	na	na
TestAllGeo	Sr	(ppm)	64.30859	321.7039	252.3926	201.4996	132.3316
TestAllGeo	Zn	(ppm)	412.4345	192.1007	125.7364	50.35198	54.5863
TestAllGeo	Zr	(ppm)	125.5581	235.5563	210.9748	84.84188	38.4518
TestAllGeo	Rb	(ppm)	14.75559	36.6932	43.91951	48.58065	22.71484
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	na	3.668383	na	na
TestAllGeo	U	(ppm)	na	na	na	na	na
TestAllGeo	W	(ppm)	50.9583	na	na	70.50619	na

IX. XRF Chemical data – SS 08

Type	Sample Codes		SS-08				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	12.18	17.81	15.67	12.64	6.63
TestAllGeo	CaO	(%)	2.75	3.14	2.49	3.05	2.39
TestAllGeo	Cr2O3	(%)	0.24	0.05	0.03	0.02	na
TestAllGeo	Fe2O3	(%)	35.82	24.84	12.83	9.44	2.29
TestAllGeo	K2O	(%)	1.11	2.54	2.83	2.10	0.95
TestAllGeo	MgO	(%)	8.16	3.09	1.58	0.91	0.34
TestAllGeo	MnO	(%)	0.54	0.40	0.15	0.08	0.01
TestAllGeo	P2O5	(%)	0.25	0.35	0.29	0.28	0.23
TestAllGeo	SO2	(%)	0.33	0.28	0.28	1.66	0.95
TestAllGeo	SiO2	(%)	34.75	45.70	62.79	68.51	85.84
TestAllGeo	TiO2	(%)	3.77	1.72	1.53	1.28	0.43
TestAllGeo	V2O3	(%)	0.10	0.09	0.05	0.04	0.01
TestAllGeo	Ag	(ppm)	8.180449	12.08488	na	na	na
TestAllGeo	As	(ppm)	40.57216	45.53322	30.73855	40.92849	13.8232
TestAllGeo	Ba	(ppm)		166.5044	713.3861	na	na
TestAllGeo	Cu	(ppm)	179.5915	171.7986	116.7858	120.7865	63.22286
TestAllGeo	Nb	(ppm)	9.530319	15.44714	12.30921	8.716207	3.257354
TestAllGeo	Ni	(ppm)	658.5987	na	134.6344	na	na
TestAllGeo	Pb	(ppm)	5.957889	26.4196	22.34763	22.3633	16.48454
TestAllGeo	Sn	(ppm)	na	na	na	na	na
TestAllGeo	Sr	(ppm)	83.18882	186.403	265.7927	228.7315	104.2224
TestAllGeo	Zn	(ppm)	203.4484	314.0485	144.1763	140.0354	86.71693
TestAllGeo	Zr	(ppm)	160.9671	231.9112	272.9651	182.3406	49.17872
TestAllGeo	Rb	(ppm)	13.18863	43.87581	47.0533	32.03321	22.34681
TestAllGeo	Te	(ppm)	na	na	55.71766	na	na
TestAllGeo	Th	(ppm)	na	2.996889	11.42713	2.082352	na
TestAllGeo	U	(ppm)	na	4.408627	12.8114	6.162394	na
TestAllGeo	W	(ppm)	97.91921	na	na	na	22.54073

X. XRF Chemical data – SS 09

Type	Sample Codes		SS-09				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	10.37	11.29	11.69	11.66	9.24
TestAllGeo	CaO	(%)	9.14	15.22	12.07	11.07	12.19
TestAllGeo	Cr2O3	(%)	0.11	0.08	0.06	0.05	na
TestAllGeo	Fe2O3	(%)	34.86	23.15	16.81	15.40	3.98
TestAllGeo	K2O	(%)	0.37	0.29	0.53	0.45	0.44
TestAllGeo	MgO	(%)	4.16	3.83	3.63	3.14	0.72
TestAllGeo	MnO	(%)	0.39	0.29	0.24	0.21	0.05
TestAllGeo	P2O5	(%)	0.22	0.21	0.19	0.18	0.12
TestAllGeo	SO2	(%)	na	na	na	na	na
TestAllGeo	SiO2	(%)	37.88	43.76	52.83	56.28	72.91
TestAllGeo	TiO2	(%)	2.38	1.80	1.89	1.50	0.33
TestAllGeo	V2O3	(%)	0.12	0.09	0.06	0.05	0.01
TestAllGeo	Ag	(ppm)	7.844416	4.349859	2.932591	na	na
TestAllGeo	As	(ppm)	18.98206	17.50963	14.18909	10.83407	7.684303
TestAllGeo	Ba	(ppm)	na	na	na	na	na
TestAllGeo	Cu	(ppm)	231.0333	130.4514	112.7287	129.8568	49.53402
TestAllGeo	Nb	(ppm)	12.02041	8.678185	8.619041	9.718355	2.838134
TestAllGeo	Ni	(ppm)	49.57716	na	91.86082	62.07471	na
TestAllGeo	Pb	(ppm)	na	na	na	na	na
TestAllGeo	Sn	(ppm)	19.99904	na	na	na	na
TestAllGeo	Sr	(ppm)	194.3484	317.4115	352.1281	291.6449	170.0433
TestAllGeo	Zn	(ppm)	344.3942	168.1993	149.999	156.2809	48.36129
TestAllGeo	Zr	(ppm)	135.0295	126.9478	169.9501	155.3291	48.68751
TestAllGeo	Rb	(ppm)	na	na	9.890725	7.168796	7.020019
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	na	na	na	na
TestAllGeo	U	(ppm)	na	na	na	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XI. XRF Chemical data – SS 10

Type	Sample Codes		SS-10				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	9.55	16.17	13.70	7.12	2.84
TestAllGeo	CaO	(%)	5.17	5.25	3.12	1.15	0.94
TestAllGeo	Cr2O3	(%)	0.09	0.05	0.03	na	na
TestAllGeo	Fe2O3	(%)	31.22	25.87	15.00	9.78	3.55
TestAllGeo	K2O	(%)	0.69	2.18	2.51	0.97	0.41
TestAllGeo	MgO	(%)	5.00	3.13	1.63	na	na
TestAllGeo	MnO	(%)	1.11	0.52	0.25	0.09	0.04
TestAllGeo	P2O5	(%)	0.36	0.50	0.76	0.34	0.20
TestAllGeo	SO2	(%)	0.39	0.17	0.92	2.91	3.15
TestAllGeo	SiO2	(%)	26.07	43.15	60.04	77.01	88.39
TestAllGeo	TiO2	(%)	20.13	2.89	1.98	0.61	0.47
TestAllGeo	V2O3	(%)	0.23	0.12	0.06	0.02	0.01
TestAllGeo	Ag	(ppm)	na	na	na	na	na
TestAllGeo	As	(ppm)	64.04686	39.4091	41.52473	35.24012	18.63216
TestAllGeo	Ba	(ppm)	380.2544	556.2068	507.8283	na	1633.307
TestAllGeo	Cu	(ppm)	251.2039	200.8657	132.4804	90.60883	65.32855
TestAllGeo	Nb	(ppm)	16.00695	12.35662	11.16126	6.38934	2.460526
TestAllGeo	Ni	(ppm)	149.97	120.0019	125.5428	na	na
TestAllGeo	Pb	(ppm)	na	10.58142	34.79705	24.39883	26.44282
TestAllGeo	Sn	(ppm)	na	16.03268	na	na	na
TestAllGeo	Sr	(ppm)	77.5166	191.6928	238.8148	99.5436	109.8858
TestAllGeo	Zn	(ppm)	256.6919	255.0121	148.0659	247.6324	30.96239
TestAllGeo	Zr	(ppm)	408.1996	210.5622	233.4618	58.71356	30.81286
TestAllGeo	Rb	(ppm)	13.08498	37.54304	38.41037	24.32367	7.55111
TestAllGeo	Te	(ppm)	115.6529	na	na	na	na
TestAllGeo	Th	(ppm)	na	na	5.742103	na	na
TestAllGeo	U	(ppm)	na	na	7.448953	na	na
TestAllGeo	W	(ppm)	59.94577	54.37072	na	49.46159	na

XII. XRF Chemical data – SS 11

Type	Sample Codes		SS-11				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	12.28	16.00	14.14	5.42	7.81
TestAllGeo	CaO	(%)	5.58	4.42	3.29	4.71	5.37
TestAllGeo	Cr2O3	(%)	1.25	0.05	0.02	na	na
TestAllGeo	Fe2O3	(%)	35.16	21.72	11.36	1.93	4.72
TestAllGeo	K2O	(%)	0.61	2.18	2.49	0.49	0.91
TestAllGeo	MgO	(%)	5.29	2.20	1.86		0.51
TestAllGeo	MnO	(%)	0.73	0.34	0.11	0.02	0.04
TestAllGeo	P2O5	(%)	0.21	0.35	0.33	na	0.18
TestAllGeo	SO2	(%)	0.07	0.14	0.13	0.67	0.26
TestAllGeo	SiO2	(%)	29.21	50.67	65.03	86.57	80.01
TestAllGeo	TiO2	(%)	9.42	1.86	1.18	0.18	0.32
TestAllGeo	V2O3	(%)	0.19	0.07	0.04	0.01	0.01
TestAllGeo	Ag	(ppm)	10.99448	6.192714	na	na	na
TestAllGeo	As	(ppm)	39.70627	45.12683	27.12263	19.03215	9.642141
TestAllGeo	Ba	(ppm)	na	294.5283	208.4425	416.6988	na
TestAllGeo	Cu	(ppm)	200.0928	194.0812	114.156	32.18498	56.71955
TestAllGeo	Nb	(ppm)	13.53387	12.60528	9.994677	4.828059	4.246046
TestAllGeo	Ni	(ppm)	274.1956	102.1046	na	na	na
TestAllGeo	Pb	(ppm)	na	15.98259	17.57109	129.7613	21.76531
TestAllGeo	Sn	(ppm)	11.18131	na	na	na	na
TestAllGeo	Sr	(ppm)	70.56448	306.3128	349.0005	106.8789	195.7799
TestAllGeo	Zn	(ppm)	298.0839	205.5744	125.1206	19.55788	43.28022
TestAllGeo	Zr	(ppm)	97.84881	279.5141	232.7107	25.31185	58.02957
TestAllGeo	Rb	(ppm)	6.483021	37.244	39.3325	12.22313	24.71228
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	na	na	na	na
TestAllGeo	U	(ppm)	na	na	na	na	na
TestAllGeo	W	(ppm)	na	na	na	43.23858	50.91228

XIII. XRF Chemical data – SS 12

Type	Sample Codes		SS-12				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	13.65	15.64	16.83	13.38	3.55
TestAllGeo	CaO	(%)	5.26	5.84	2.59	2.92	2.17
TestAllGeo	Cr2O3	(%)	0.12	0.06	0.04	0.03	na
TestAllGeo	Fe2O3	(%)	27.93	26.35	15.25	14.88	1.25
TestAllGeo	K2O	(%)	1.46	1.86	3.15	2.12	0.47
TestAllGeo	MgO	(%)	2.60	3.13	1.97	na	na
TestAllGeo	MnO	(%)	0.55	0.46	0.24	0.22	0.03
TestAllGeo	P2O5	(%)	0.35	0.40	0.47	0.32	0.22
TestAllGeo	SO2	(%)	0.06	na	na	0.04	0.05
TestAllGeo	SiO2	(%)	42.23	43.78	58.40	64.69	92.05
TestAllGeo	TiO2	(%)	5.67	2.37	1.66	1.38	0.21
TestAllGeo	V2O3	(%)	0.13	0.10	0.07	0.04	0.01
TestAllGeo	Ag	(ppm)	9.829277	na	na	na	na
TestAllGeo	As	(ppm)	45.8905	50.06245	42.16192	34.30141	9.369235
TestAllGeo	Ba	(ppm)	143.0959	580.333	na	na	na
TestAllGeo	Cu	(ppm)	136.5258	176.114	121.2685	97.83622	22.63891
TestAllGeo	Nb	(ppm)	12.22746	13.79059	13.95485	14.01646	2.816983
TestAllGeo	Ni	(ppm)	na	156.408	na	na	na
TestAllGeo	Pb	(ppm)	27.07147	12.20774	20.2245	19.24375	6.152109
TestAllGeo	Sn	(ppm)	17.41683	na	na	na	na
TestAllGeo	Sr	(ppm)	154.0288	193.1064	270.5261	204.3158	39.93623
TestAllGeo	Zn	(ppm)	254.4759	266.9404	154.0891	138.8849	23.91822
TestAllGeo	Zr	(ppm)	235.6293	228.3981	323.54	194.2279	24.7732
TestAllGeo	Rb	(ppm)	25.94596	28.20311	49.71393	29.66904	8.686915
TestAllGeo	Te	(ppm)	na	103.6878	na	na	na
TestAllGeo	Th	(ppm)	na	na	13.391	na	na
TestAllGeo	U	(ppm)	na	na	8.27783	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XIV.XRF Chemical data – SS 13

Type	Sample Codes		SS-13				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	15.62	16.70	15.60	12.44	4.37
TestAllGeo	CaO	(%)	3.10	4.56	3.31	2.07	6.02
TestAllGeo	Cr2O3	(%)	0.07	0.06	0.04	0.03	na
TestAllGeo	Fe2O3	(%)	29.80	22.36	16.27	11.11	2.51
TestAllGeo	K2O	(%)	2.40	2.68	2.88	2.41	0.74
TestAllGeo	MgO	(%)	3.21	2.57	2.27	1.19	na
TestAllGeo	MnO	(%)	0.65	0.50	0.32	0.20	0.05
TestAllGeo	P2O5	(%)	0.37	0.36	0.38	0.34	0.23
TestAllGeo	SO2	(%)	0.01	na	na	na	0.04
TestAllGeo	SiO2	(%)	41.57	48.23	57.11	69.24	85.81
TestAllGeo	TiO2	(%)	3.09	1.88	1.74	1.33	0.24
TestAllGeo	V2O3	(%)	0.10	0.09	0.07	0.05	0.01
TestAllGeo	Ag	(ppm)	5.634869	6.032236	na	na	na
TestAllGeo	As	(ppm)	63.97783	80.59381	39.99534	29.88518	12.85208
TestAllGeo	Ba	(ppm)	475.0082	434.5022	784.7731	266.1293	na
TestAllGeo	Cu	(ppm)	159.5914	149.9282	131.2709	93.7891	43.88153
TestAllGeo	Nb	(ppm)	10.30413	10.6363	10.14169	6.016789	na
TestAllGeo	Ni	(ppm)	118.7948	147.3424	120.4183	86.23548	na
TestAllGeo	Pb	(ppm)	25.60519	20.63143	19.04798	16.72752	10.2649
TestAllGeo	Sn	(ppm)	10.55321	na	4.531117	na	na
TestAllGeo	Sr	(ppm)	128.8737	252.7654	228.2428	174.359	57.01021
TestAllGeo	Zn	(ppm)	337.2117	237.1702	197.6271	125.1149	39.4736
TestAllGeo	Zr	(ppm)	227.0814	262.8299	266.9002	207.9562	34.97668
TestAllGeo	Rb	(ppm)	40.40455	38.83285	43.12278	32.98861	14.6916
TestAllGeo	Te	(ppm)	na	na	32.46964	na	na
TestAllGeo	Th	(ppm)	na	na	9.226003	4.37677	na
TestAllGeo	U	(ppm)	na	na	14.07014	7.487399	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XV. XRF Chemical data – SS 14

Type	Sample Codes		SS-14				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	12.95	13.54	14.34	10.25	4.45
TestAllGeo	CaO	(%)	2.84	8.70	6.34	3.25	1.96
TestAllGeo	Cr2O3	(%)	0.44	0.05	0.03	na	na
TestAllGeo	Fe2O3	(%)	24.75	23.78	13.13	5.25	1.09
TestAllGeo	K2O	(%)	1.56	1.24	2.10	1.22	0.48
TestAllGeo	MgO	(%)	2.02	3.23	2.13	na	na
TestAllGeo	MnO	(%)	0.49	0.33	0.18	0.05	0.02
TestAllGeo	P2O5	(%)	0.36	0.40	0.27	0.25	0.22
TestAllGeo	SO2	(%)	0.04	na	na	0.07	na
TestAllGeo	SiO2	(%)	46.34	46.14	60.22	79.15	91.57
TestAllGeo	TiO2	(%)	9.08	2.48	1.22	0.54	0.20
TestAllGeo	V2O3	(%)	0.14	0.10	0.05	0.02	0.01
TestAllGeo	Ag	(ppm)	8.711188	4.528935	na	na	na
TestAllGeo	As	(ppm)	33.10761	26.7514	24.71223	10.47511	7.840626
TestAllGeo	Ba	(ppm)	162.1859	200.7976	265.9767	na	na
TestAllGeo	Cu	(ppm)	102.4942	145.5965	131.4547	49.08194	32.97504
TestAllGeo	Nb	(ppm)	11.37713	8.187349	5.934169	3.277736	na
TestAllGeo	Ni	(ppm)	na	na	67.94424	na	na
TestAllGeo	Pb	(ppm)	31.61211	11.36337	15.40195	2.565925	na
TestAllGeo	Sn	(ppm)	na	na	na	na	na
TestAllGeo	Sr	(ppm)	131.099	271.7783	344.1653	130.8595	38.5458
TestAllGeo	Zn	(ppm)	180.646	193.7411	123.2984	45.82769	12.68997
TestAllGeo	Zr	(ppm)	225.9629	181.417	215.4618	74.83915	19.66125
TestAllGeo	Rb	(ppm)	32.86483	14.48508	27.63735	24.6558	6.457765
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	na	na	na	na
TestAllGeo	U	(ppm)	na	na	na	na	na
TestAllGeo	W	(ppm)	na	na	na	27.5768	na

XVI. XRF Chemical data – SS 15

Type	Sample Codes		SS-15				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	12.22	16.83	13.30	6.41	11.05
TestAllGeo	CaO	(%)	5.13	6.12	10.15	21.03	8.18
TestAllGeo	Cr2O3	(%)	0.22	0.05	0.02	0.01	-0.02
TestAllGeo	Fe2O3	(%)	33.93	20.86	10.55	4.10	12.42
TestAllGeo	K2O	(%)	1.52	3.11	2.35	1.23	1.85
TestAllGeo	MgO	(%)	4.25	3.20	1.54	na	2.52
TestAllGeo	MnO	(%)	0.67	0.33	0.12	0.11	0.21
TestAllGeo	P2O5	(%)	0.46	0.40	0.28	0.22	0.32
TestAllGeo	SO2	(%)	0.10	0.16	0.07	0.13	0.06
TestAllGeo	SiO2	(%)	37.81	46.99	60.78	66.30	63.40
TestAllGeo	TiO2	(%)	3.58	1.89	0.81	0.44	1.21
TestAllGeo	V2O3	(%)	0.11	0.06	0.02	0.01	0.04
TestAllGeo	Ag	(ppm)	13.20319	na	na	na	8.454629
TestAllGeo	As	(ppm)	40.83793	31.33679	22.58083	12.56424	22.5019
TestAllGeo	Ba	(ppm)	86.49041	216.6901	na	78.7105	na
TestAllGeo	Cu	(ppm)	163.755	142.2084	103.8034	50.04691	86.45895
TestAllGeo	Nb	(ppm)	43.00507	13.38491	14.2595	6.201482	13.74266
TestAllGeo	Ni	(ppm)	128.474	137.5977	na	na	91.19799
TestAllGeo	Pb	(ppm)	15.01688	6.247938	6.389027	12.96199	na
TestAllGeo	Sn	(ppm)	na	na	na	na	7.471985
TestAllGeo	Sr	(ppm)	153.206	319.8604	222.9919	352.1336	215.5626
TestAllGeo	Zn	(ppm)	352.6946	226.6818	127.0293	77.33906	137.7671
TestAllGeo	Zr	(ppm)	265.3712	298.0725	163.9765	86.90933	169.665
TestAllGeo	Rb	(ppm)	17.33599	47.24884	33.12109	26.91766	27.84861
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	2.9826	3.597843	na	na
TestAllGeo	U	(ppm)	na	8.412182	na	2.789086	na
TestAllGeo	W	(ppm)	na	71.15292	72.3795	na	na

XVII. XRF Chemical data – SS 16

Type	Sample Codes		SS-16				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	16.71	18.18	15.49	7.56	3.48
TestAllGeo	CaO	(%)	2.23	2.82	1.65	3.94	3.52
TestAllGeo	Cr2O3	(%)	0.10	0.05	0.03	na	na
TestAllGeo	Fe2O3	(%)	38.76	20.92	12.44	8.68	4.27
TestAllGeo	K2O	(%)	1.56	2.82	2.68	1.05	0.54
TestAllGeo	MgO	(%)	2.40	2.52	1.25	na	na
TestAllGeo	MnO	(%)	0.51	0.28	0.13	0.06	0.03
TestAllGeo	P2O5	(%)	0.42	0.38	0.36	0.26	0.24
TestAllGeo	SO2	(%)	1.04	0.43	0.68	3.24	4.25
TestAllGeo	SiO2	(%)	34.86	50.58	63.79	74.79	83.47
TestAllGeo	TiO2	(%)	1.33	1.79	1.44	0.39	0.18
TestAllGeo	V2O3	(%)	0.09	0.07	0.05	0.02	0.02
TestAllGeo	Ag	(ppm)	2.852262	na	na	na	na
TestAllGeo	As	(ppm)	77.69073	40.99343	38.63479	49.5377	35.66446
TestAllGeo	Ba	(ppm)	535.0079	524.2919	713.9602	375.4287	3752.147
TestAllGeo	Cu	(ppm)	251.6944	133.7584	149.7574	109.3944	61.23791
TestAllGeo	Nb	(ppm)	9.555898	14.91958	11.47574	6.922911	na
TestAllGeo	Ni	(ppm)	197.1233	109.2509	88.66213	na	42.40858
TestAllGeo	Pb	(ppm)	31.10466	20.93065	35.60618	51.71774	116.6202
TestAllGeo	Sn	(ppm)	na	na	na	na	na
TestAllGeo	Sr	(ppm)	131.1956	314.8035	284.5795	146.9976	253.2585
TestAllGeo	Zn	(ppm)	304.0968	218.7238	144.2555	99.73597	36.86524
TestAllGeo	Zr	(ppm)	181.7753	320.6528	280.4082	79.40936	29.26667
TestAllGeo	Rb	(ppm)	23.14425	49.97123	48.81208	35.89369	14.04428
TestAllGeo	Te	(ppm)	90.24259	na	15.99448	na	na
TestAllGeo	Th	(ppm)	na	8.566381	10.60407	na	na
TestAllGeo	U	(ppm)	na	12.04004	18.62007	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XVIII. XRF Chemical data – SS 17

Type	Sample Codes		SS-17				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	16.42	18.34	14.97	5.89	2.77
TestAllGeo	CaO	(%)	0.72	1.21	0.87	0.47	0.17
TestAllGeo	Cr2O3	(%)	0.05	0.07	0.04	0.01	na
TestAllGeo	Fe2O3	(%)	24.43	27.33	14.07	5.16	1.68
TestAllGeo	K2O	(%)	3.46	3.96	3.87	1.12	0.55
TestAllGeo	MgO	(%)	2.66	3.52	1.98	na	na
TestAllGeo	MnO	(%)	0.32	0.38	0.16	0.05	0.02
TestAllGeo	P2O5	(%)	0.28	0.43	0.29	0.26	0.21
TestAllGeo	SO2	(%)	0.02	na	na	0.06	0.05
TestAllGeo	SiO2	(%)	49.93	43.09	62.21	86.23	93.96
TestAllGeo	TiO2	(%)	1.63	1.59	1.50	0.74	0.16
TestAllGeo	V2O3	(%)	0.07	0.07	0.05	0.01	0.01
TestAllGeo	Ag	(ppm)	5.229559	na	na	na	2.778472
TestAllGeo	As	(ppm)	35.91425	52.02505	24.98551	10.17167	7.890544
TestAllGeo	Ba	(ppm)	391.1018	849.925	363.9926	na	na
TestAllGeo	Cu	(ppm)	163.7809	218.1369	90.69104	30.0793	22.26998
TestAllGeo	Nb	(ppm)	15.75221	15.46219	13.25157	na	na
TestAllGeo	Ni	(ppm)	109.0371	165.4014	91.61456	na	na
TestAllGeo	Pb	(ppm)	43.82255	36.38973	17.26187	6.932685	3.178155
TestAllGeo	Sn	(ppm)	na	na	na	na	na
TestAllGeo	Sr	(ppm)	126.5954	108.96	156.8273	66.36198	31.5353
TestAllGeo	Zn	(ppm)	248.9157	315.8286	178.1558	56.90191	17.61609
TestAllGeo	Zr	(ppm)	216.271	225.2964	281.4328	94.28151	20.50042
TestAllGeo	Rb	(ppm)	65.32525	77.24785	66.81334	22.21336	8.953129
TestAllGeo	Te	(ppm)	na	85.49856	na	na	na
TestAllGeo	Th	(ppm)	na	na	5.143557	na	na
TestAllGeo	U	(ppm)	10.67331	8.784906	15.77031	na	na
TestAllGeo	W	(ppm)	57.50268	na	na	na	na

XIX. XRF Chemical data – SS 18

Type	Sample Codes		SS-18				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	15.80	17.72	11.31	5.76	3.16
TestAllGeo	CaO	(%)	3.07	2.29	2.89	4.77	5.99
TestAllGeo	Cr2O3	(%)	0.11	0.05	0.02	na	na
TestAllGeo	Fe2O3	(%)	35.44	20.89	9.20	3.98	0.87
TestAllGeo	K2O	(%)	1.90	3.70	2.22	1.01	0.69
TestAllGeo	MgO	(%)	3.82	2.99	1.63	na	na
TestAllGeo	MnO	(%)	0.69	0.40	0.13	0.05	0.03
TestAllGeo	P2O5	(%)	0.45	0.41	0.42	0.38	0.20
TestAllGeo	SO2	(%)	0.04	na	na	0.03	0.06
TestAllGeo	SiO2	(%)	35.83	49.82	71.81	83.49	88.86
TestAllGeo	TiO2	(%)	2.77	1.68	0.89	0.50	0.13
TestAllGeo	V2O3	(%)	0.10	0.06	0.03	0.01	0.01
TestAllGeo	Ag	(ppm)	3.748593	na	na	na	na
TestAllGeo	As	(ppm)	49.42748	39.18874	23.06603	14.61643	10.18582
TestAllGeo	Ba	(ppm)	285.8757	981.3567	na	na	na
TestAllGeo	Cu	(ppm)	163.9444	132.4166	74.07872	43.59436	32.62215
TestAllGeo	Nb	(ppm)	17.00124	15.4832	6.441928	9.763204	na
TestAllGeo	Ni	(ppm)	190.4989	184.0418	na	na	na
TestAllGeo	Pb	(ppm)	21.78395	16.1476	9.357865	5.259589	2.391349
TestAllGeo	Sn	(ppm)	na	12.28992	na	na	na
TestAllGeo	Sr	(ppm)	140.008	259.7345	171.6153	126.7773	95.77603
TestAllGeo	Zn	(ppm)	364.2478	230.7671	104.6523	39.75752	15.60304
TestAllGeo	Zr	(ppm)	204.3113	304.8719	155.3858	63.13953	18.81531
TestAllGeo	Rb	(ppm)	28.29777	64.48041	43.29981	19.39678	6.94504
TestAllGeo	Te	(ppm)	na	41.06687	na	na	na
TestAllGeo	Th	(ppm)	na	6.282277	2.360525	na	na
TestAllGeo	U	(ppm)	na	14.65531	3.196016	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XX. XRF Chemical data – SS 19

Type	Sample Codes		SS-19				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	12.44	19.32	14.36	5.35	1.99
TestAllGeo	CaO	(%)	1.60	1.88	0.97	2.96	2.15
TestAllGeo	Cr2O3	(%)	0.03	0.06	0.04	na	na
TestAllGeo	Fe2O3	(%)	15.68	21.17	12.58	4.77	0.64
TestAllGeo	K2O	(%)	2.81	4.81	4.24	0.99	0.34
TestAllGeo	MgO	(%)	2.93	3.00	0.84	na	na
TestAllGeo	MnO	(%)	0.16	0.24	0.11	0.05	0.00
TestAllGeo	P2O5	(%)	0.32	0.37	0.41	0.20	0.17
TestAllGeo	SO2	(%)	0.29	na	na	na	na
TestAllGeo	SiO2	(%)	62.54	47.22	65.09	85.25	94.47
TestAllGeo	TiO2	(%)	1.15	1.87	1.32	0.44	0.23
TestAllGeo	V2O3	(%)	0.04	0.06	0.04	0.01	0.00
TestAllGeo	Ag	(ppm)	na	4.2418	na	na	na
TestAllGeo	As	(ppm)	37.10221	46.08781	30.81469	13.312	7.485602
TestAllGeo	Ba	(ppm)	279.3409	378.0807	na	na	na
TestAllGeo	Cu	(ppm)	96.23933	121.9022	98.63839	33.11362	21.6285
TestAllGeo	Nb	(ppm)	11.28752	19.19598	18.04021	4.134756	2.487008
TestAllGeo	Ni	(ppm)	124.2526	131.7912	na	na	na
TestAllGeo	Pb	(ppm)	22.16043	17.91314	11.60351	10.05478	na
TestAllGeo	Sn	(ppm)	na	8.833336	na	na	na
TestAllGeo	Sr	(ppm)	160.4092	175.2333	165.3819	178.4499	114.3924
TestAllGeo	Zn	(ppm)	158.0199	243.181	137.3582	40.86508	10.21805
TestAllGeo	Zr	(ppm)	296.8217	314.7269	280.8751	48.39473	79.94009
TestAllGeo	Rb	(ppm)	50.85092	92.25467	68.37113	18.97742	3.779972
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	2.646318	4.023044	na	na
TestAllGeo	U	(ppm)	11.94233	16.91936	6.835344	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XXI. XRF Chemical data – SS 20

Type	Sample Codes		SS-20				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	13.60	17.36	11.64	6.55	3.33
TestAllGeo	CaO	(%)	10.87	6.24	1.92	1.85	2.83
TestAllGeo	Cr2O3	(%)	0.08	0.05	0.03	0.02	na
TestAllGeo	Fe2O3	(%)	35.36	20.30	12.48	20.47	11.84
TestAllGeo	K2O	(%)	1.55	3.78	2.49	0.91	0.42
TestAllGeo	MgO	(%)	5.49	1.91	0.73	na	na
TestAllGeo	MnO	(%)	0.61	0.32	0.09	0.02	0.03
TestAllGeo	P2O5	(%)	0.34	0.38	0.27	0.25	0.51
TestAllGeo	SO2	(%)	1.71	0.55	1.73	15.63	11.81
TestAllGeo	SiO2	(%)	28.16	47.38	67.58	53.67	68.86
TestAllGeo	TiO2	(%)	2.14	1.68	1.02	0.63	0.36
TestAllGeo	V2O3	(%)	0.08	0.06	0.03	0.01	0.01
TestAllGeo	Ag	(ppm)	3.679357	na	na	na	na
TestAllGeo	As	(ppm)	112.3786	56.7714	63.98946	265.6345	168.6115
TestAllGeo	Ba	(ppm)	308.5968	1038.887	na	262.2669	1545.717
TestAllGeo	Cu	(ppm)	378.5959	143.209	155.1832	427.136	217.5083
TestAllGeo	Nb	(ppm)	13.79315	15.45062	8.91909	5.100108	na
TestAllGeo	Ni	(ppm)	316.5695	209.4832	75.37335	210.472	101.2282
TestAllGeo	Pb	(ppm)	34.39955	17.67944	23.76215	100.559	122.1172
TestAllGeo	Sn	(ppm)	na	18.02979	na	na	na
TestAllGeo	Sr	(ppm)	322.9274	428.9977	197.9521	85.5718	163.587
TestAllGeo	Zn	(ppm)	332.9559	225.8291	128.343	326.1297	84.30943
TestAllGeo	Zr	(ppm)	189.7663	336.8757	184.4932	56.30518	646.1179
TestAllGeo	Rb	(ppm)	21.13348	66.90994	39.20161	9.499448	10.95018
TestAllGeo	Te	(ppm)	46.20183	88.14366	na	na	na
TestAllGeo	Th	(ppm)	na	8.181906	na	na	na
TestAllGeo	U	(ppm)	na	10.55727	10.27958	na	na
TestAllGeo	W	(ppm)	na	na	na	na	28.15863

XXII. XRF Chemical data – SS 21

Type	Sample Codes		SS-21				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	16.06	18.23	11.15	5.14	2.44
TestAllGeo	CaO	(%)	1.40	1.17	2.82	3.32	3.37
TestAllGeo	Cr2O3	(%)	0.07	0.04	0.03	na	na
TestAllGeo	Fe2O3	(%)	35.77	20.79	9.43	4.16	0.92
TestAllGeo	K2O	(%)	2.70	4.87	2.99	0.99	0.45
TestAllGeo	MgO	(%)	3.17	2.96	1.31	0.92	na
TestAllGeo	MnO	(%)	0.48	0.25	0.10	0.03	0.02
TestAllGeo	P2O5	(%)	0.20	0.26	0.47	0.36	0.16
TestAllGeo	SO2	(%)	0.07	0.10	0.22	0.03	0.05
TestAllGeo	SiO2	(%)	38.58	49.35	69.67	84.27	92.50
TestAllGeo	TiO2	(%)	1.42	1.92	1.79	0.77	0.17
TestAllGeo	V2O3	(%)	0.07	0.06	0.03	0.01	0.00
TestAllGeo	Ag	(ppm)	2.936471	6.052419	na	na	na
TestAllGeo	As	(ppm)	58.29478	34.30167	26.03295	10.78235	9.608966
TestAllGeo	Ba	(ppm)	453.7246	626.3997	292.9624	na	na
TestAllGeo	Cu	(ppm)	194.0142	142.0797	89.43362	47.57339	30.64642
TestAllGeo	Nb	(ppm)	11.62023	20.74405	12.58893	5.630867	na
TestAllGeo	Ni	(ppm)	207.4651	169.5846	95.72978	na	na
TestAllGeo	Pb	(ppm)	27.71832	14.84857	12.42549	3.56442	na
TestAllGeo	Sn	(ppm)	na	8.878514	na	na	na
TestAllGeo	Sr	(ppm)	77.84247	161.7624	115.4196	72.81484	49.01279
TestAllGeo	Zn	(ppm)	387.875	235.0231	102.5691	36.06947	15.62953
TestAllGeo	Zr	(ppm)	193.3835	359.0887	711.5	412.9984	15.36012
TestAllGeo	Rb	(ppm)	50.43022	95.54983	45.59973	17.06773	6.392871
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	7.454284	7.864185	na	na
TestAllGeo	U	(ppm)	na	18.72897	5.736007	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XXIII. XRF Chemical data – SS 22

Type	Sample Codes		SS-22				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	13.10	19.53	15.53	7.91	3.78
TestAllGeo	CaO	(%)	2.52	2.88	1.26	1.01	3.80
TestAllGeo	Cr2O3	(%)	0.41	0.06	0.03	0.01	na
TestAllGeo	Fe2O3	(%)	31.70	25.44	11.98	4.86	1.08
TestAllGeo	K2O	(%)	1.92	4.06	3.95	1.58	0.77
TestAllGeo	MgO	(%)	3.23	3.70	1.80	0.38	na
TestAllGeo	MnO	(%)	0.50	0.32	0.11	0.03	0.02
TestAllGeo	P2O5	(%)	0.39	0.32	0.43	0.31	0.68
TestAllGeo	SO2	(%)	0.11	0.04	0.04	0.10	0.20
TestAllGeo	SiO2	(%)	43.54	42.00	63.28	83.09	89.41
TestAllGeo	TiO2	(%)	2.51	1.59	1.55	0.73	0.32
TestAllGeo	V2O3	(%)	0.08	0.07	0.05	0.01	0.01
TestAllGeo	Ag	(ppm)	8.820888	9.383671	na	na	na
TestAllGeo	As	(ppm)	43.57677	36.98809	23.0998	12.40448	11.03648
TestAllGeo	Ba	(ppm)	92.19464	360.4586	432.5134	na	211.0899
TestAllGeo	Cu	(ppm)	136.6899	86.32805	70.08075	32.99517	35.15092
TestAllGeo	Nb	(ppm)	24.06545	17.37718	11.97532	na	na
TestAllGeo	Ni	(ppm)	121.0089	98.44918	97.69713	na	na
TestAllGeo	Pb	(ppm)	8.483236	na	6.904605	9.79434	na
TestAllGeo	Sn	(ppm)	10.05505	na	na	na	na
TestAllGeo	Sr	(ppm)	132.4685	189.5099	180.8559	115.4694	92.37163
TestAllGeo	Zn	(ppm)	279.3535	266.4766	137.21	53.76828	15.91291
TestAllGeo	Zr	(ppm)	179.6466	259.6653	244.718	105.6423	102.1672
TestAllGeo	Rb	(ppm)	34.91969	75.07817	59.61971	26.59418	12.00732
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	na	8.58567	na	na
TestAllGeo	U	(ppm)	na	13.80913	6.165298	na	na
TestAllGeo	W	(ppm)	203.4238	na	na	na	na

XXIV. XRF Chemical data – SS 23

Type	Sample Codes		SS-23				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	17.20	20.38	15.64	7.33	3.80
TestAllGeo	CaO	(%)	1.11	0.67	1.32	3.36	10.77
TestAllGeo	Cr2O3	(%)	0.08	0.06	0.04	0.01	na
TestAllGeo	Fe2O3	(%)	34.82	19.56	11.43	5.36	2.27
TestAllGeo	K2O	(%)	2.87	5.90	4.41	1.24	0.65
TestAllGeo	MgO	(%)	4.54	2.96	2.08	na	na
TestAllGeo	MnO	(%)	0.20	0.12	0.04	0.03	0.01
TestAllGeo	P2O5	(%)	0.19	0.35	0.36	0.34	0.34
TestAllGeo	SO2	(%)	0.42	0.02	0.20	0.48	0.57
TestAllGeo	SiO2	(%)	37.16	47.78	62.61	81.10	80.76
TestAllGeo	TiO2	(%)	1.35	2.14	1.82	0.74	0.33
TestAllGeo	V2O3	(%)	0.06	0.06	0.05	0.01	0.01
TestAllGeo	Ag	(ppm)	5.677564	na	na	na	na
TestAllGeo	As	(ppm)	167.9661	42.25523	35.21777	26.16012	15.70704
TestAllGeo	Ba	(ppm)	189.1525	441.75	na	na	na
TestAllGeo	Cu	(ppm)	309.6583	111.4595	88.31132	69.41476	84.86253
TestAllGeo	Nb	(ppm)	13.92004	22.49597	16.17141	7.595469	na
TestAllGeo	Ni	(ppm)	287.8132	158.1134	na	na	na
TestAllGeo	Pb	(ppm)	15.33511	7.257128	15.85478	10.39894	5.231935
TestAllGeo	Sn	(ppm)	na	12.91769	na	na	na
TestAllGeo	Sr	(ppm)	65.17837	141.8711	143.7001	92.77964	101.315
TestAllGeo	Zn	(ppm)	409.2737	239.3302	137.0019	59.93573	49.61769
TestAllGeo	Zr	(ppm)	156.003	419.1923	317.1448	232.2403	77.41263
TestAllGeo	Rb	(ppm)	50.76392	109.2988	68.14937	28.84365	14.91417
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	5.071793	13.45247	7.114741	na
TestAllGeo	U	(ppm)	4.807665	21.21984	11.92453	na	na
TestAllGeo	W	(ppm)	46.23668	na	na	na	na

XXV. XRF Chemical data – SS 24

Type	Sample Codes		SS-24				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	10.73	19.16	15.31	6.83	3.16
TestAllGeo	CaO	(%)	3.08	4.91	1.77	3.34	13.91
TestAllGeo	Cr2O3	(%)	0.18	0.06	0.04	0.01	na
TestAllGeo	Fe2O3	(%)	48.20	23.74	14.11	5.07	1.08
TestAllGeo	K2O	(%)	1.52	4.24	3.58	1.21	0.61
TestAllGeo	MgO	(%)	2.50	3.64	2.36	0.35	na
TestAllGeo	MnO	(%)	0.23	0.30	0.11	0.03	0.03
TestAllGeo	P2O5	(%)	0.20	0.38	0.36	0.27	0.36
TestAllGeo	SO2	(%)	1.77	0.23	0.96	0.25	0.24
TestAllGeo	SiO2	(%)	30.51	41.58	59.82	82.26	80.40
TestAllGeo	TiO2	(%)	1.84	1.69	1.52	0.37	0.20
TestAllGeo	V2O3	(%)	0.07	0.07	0.05	0.01	0.01
TestAllGeo	Ag	(ppm)	10.51229	10.57257	na	na	na
TestAllGeo	As	(ppm)	294.5681	39.96361	38.8006	15.03823	9.431946
TestAllGeo	Ba	(ppm)	206.8427	346.6838	738.4812	na	173.0073
TestAllGeo	Cu	(ppm)	510.5891	112.2079	130.6115	47.49095	43.77185
TestAllGeo	Nb	(ppm)	15.90395	18.47078	11.77439	2.768612	na
TestAllGeo	Ni	(ppm)	527.4363	na	198.8316	na	na
TestAllGeo	Pb	(ppm)	21.18675	5.544157	18.71148	9.809036	105.751
TestAllGeo	Sn	(ppm)	na	30.38833	20.96484	na	na
TestAllGeo	Sr	(ppm)	96.18282	213.4395	196.6214	131.6023	190.5452
TestAllGeo	Zn	(ppm)	286.7048	271.7979	146.9475	50.85955	14.82555
TestAllGeo	Zr	(ppm)	138.4666	278.6357	267.6166	66.17725	133.954
TestAllGeo	Rb	(ppm)	28.07127	87.9981	58.72257	25.73477	10.73675
TestAllGeo	Te	(ppm)	na	na	71.78936	na	na
TestAllGeo	Th	(ppm)	na	3.132061	9.677484	na	na
TestAllGeo	U	(ppm)	na	4.53626	15.58513	na	na
TestAllGeo	W	(ppm)	265.3889	na	na	na	na

XXVI. XRF Chemical data – SS 25

Type	Sample Codes		SS-25				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	12.72	17.90	13.86	7.38	3.16
TestAllGeo	CaO	(%)	4.42	2.96	4.86	18.38	18.92
TestAllGeo	Cr2O3	(%)	0.09	0.06	0.02	na	na
TestAllGeo	Fe2O3	(%)	29.64	19.74	9.04	3.86	0.82
TestAllGeo	K2O	(%)	1.55	3.13	2.64	1.65	0.61
TestAllGeo	MgO	(%)	3.95	2.26	1.82	1.30	1.15
TestAllGeo	MnO	(%)	0.68	0.27	0.11	0.12	0.06
TestAllGeo	P2O5	(%)	0.29	0.41	0.25	0.26	0.12
TestAllGeo	SO2	(%)	1.48	0.06	0.05	0.44	0.22
TestAllGeo	SiO2	(%)	39.40	50.66	67.01	66.79	74.79
TestAllGeo	TiO2	(%)	5.69	2.49	0.90	0.24	0.13
TestAllGeo	V2O3	(%)	0.09	0.06	0.04	0.01	0.01
TestAllGeo	Ag	(ppm)	11.01988	na	na	na	na
TestAllGeo	As	(ppm)	78.45876	22.51611	12.11777	11.12518	9.150897
TestAllGeo	Ba	(ppm)	109.6689	370.4333	249.6049	195.7343	1051.986
TestAllGeo	Cu	(ppm)	239.2408	243.579	61.41361	49.32544	54.67037
TestAllGeo	Nb	(ppm)	37.52145	22.27129	8.632398	3.159838	na
TestAllGeo	Ni	(ppm)	228.1209	171.0373	77.10057	na	na
TestAllGeo	Pb	(ppm)	24.61719	24.88268	18.50981	7.270111	na
TestAllGeo	Sn	(ppm)	na	na	na	na	na
TestAllGeo	Sr	(ppm)	124.4045	239.659	204.8764	165.9294	149.7927
TestAllGeo	Zn	(ppm)	264.2825	225.7898	102.0136	42.10927	28.26056
TestAllGeo	Zr	(ppm)	191.0179	355.8556	210.8196	54.50784	46.2392
TestAllGeo	Rb	(ppm)	26.82295	68.07082	59.33352	50.62823	15.34942
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	24.0247	9.305202	na	na
TestAllGeo	U	(ppm)	na	9.807915	16.13893	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XXVII. XRF Chemical data – SS 26

Type	Sample Codes		SS-26				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	3.14	16.72	12.43	6.55	3.23
TestAllGeo	CaO	(%)	17.59	2.26	2.78	4.75	4.38
TestAllGeo	Cr2O3	(%)	na	0.09	0.02	0.01	na
TestAllGeo	Fe2O3	(%)	0.93	34.94	9.84	7.16	2.07
TestAllGeo	K2O	(%)	0.64	1.90	2.64	1.13	0.48
TestAllGeo	MgO	(%)	na	4.58	1.69	na	na
TestAllGeo	MnO	(%)	0.06	0.60	0.11	0.06	0.03
TestAllGeo	P2O5	(%)	0.26	0.33	0.36	0.23	0.21
TestAllGeo	SO2	(%)	0.45	0.54	0.24	1.83	1.30
TestAllGeo	SiO2	(%)	76.79	35.12	68.72	77.89	88.15
TestAllGeo	TiO2	(%)	0.15	3.04	1.12	0.40	0.14
TestAllGeo	V2O3	(%)	0.01	0.10	0.04	0.01	0.01
TestAllGeo	Ag	(ppm)	na	3.267304	na	4.373286	na
TestAllGeo	As	(ppm)	13.08044	69.96648	23.49817	57.32868	14.51734
TestAllGeo	Ba	(ppm)	739.3484	163.0573	202.8604	na	na
TestAllGeo	Cu	(ppm)	40.34782	285.6096	102.8678	182.7972	68.61881
TestAllGeo	Nb	(ppm)	na	29.20468	7.838506	3.441465	na
TestAllGeo	Ni	(ppm)	na	236.6985	66.66557	na	na
TestAllGeo	Pb	(ppm)	5.861619	11.3558	15.09799	28.8149	16.40634
TestAllGeo	Sn	(ppm)	na	na	na	na	na
TestAllGeo	Sr	(ppm)	154.9924	91.34523	173.6262	141.3388	110.1841
TestAllGeo	Zn	(ppm)	20.5853	475.908	120.5173	103.4572	58.8674
TestAllGeo	Zr	(ppm)	61.04487	1041.706	187.0724	53.79316	20.13673
TestAllGeo	Rb	(ppm)	14.33726	30.47224	37.54414	21.55184	7.040972
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	na	8.093098	na	na
TestAllGeo	U	(ppm)	na	5.123727	na	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XXVIII. XRF Chemical data – SS 27

Type	Sample Codes		SS-27				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	16.36	18.01	14.94	6.26	2.20
TestAllGeo	CaO	(%)	0.94	1.72	1.24	2.36	1.20
TestAllGeo	Cr2O3	(%)	0.08	0.05	0.03	na	na
TestAllGeo	Fe2O3	(%)	42.33	23.84	13.48	8.12	4.95
TestAllGeo	K2O	(%)	1.18	3.19	3.21	1.01	0.29
TestAllGeo	MgO	(%)	5.88	4.74	1.55	0.85	na
TestAllGeo	MnO	(%)	0.83	0.52	0.22	0.09	0.03
TestAllGeo	P2O5	(%)	0.30	0.43	0.45	0.25	0.22
TestAllGeo	SO2	(%)	2.09	0.32	0.63	3.50	5.55
TestAllGeo	SiO2	(%)	28.45	45.37	62.86	77.22	85.14
TestAllGeo	TiO2	(%)	1.46	1.75	1.34	0.34	0.41
TestAllGeo	V2O3	(%)	0.09	0.08	0.05	0.01	0.01
TestAllGeo	Ag	(ppm)	7.275292	4.095029	na	na	na
TestAllGeo	As	(ppm)	110.2793	54.08385	48.13557	63.52257	53.37637
TestAllGeo	Ba	(ppm)	154.4224	446.9595	212.6182	na	na
TestAllGeo	Cu	(ppm)	491.3217	250.8661	96.10768	69.75272	85.22332
TestAllGeo	Nb	(ppm)	11.3322	13.71758	9.641844	3.123436	4.21033
TestAllGeo	Ni	(ppm)	422.6067	123.9677	125.246	na	na
TestAllGeo	Pb	(ppm)	27.82962	6.575918	15.8093	23.13852	21.28195
TestAllGeo	Sn	(ppm)	na	na	na	na	na
TestAllGeo	Sr	(ppm)	43.9277	116.0132	172.6704	130.6028	70.8796
TestAllGeo	Zn	(ppm)	497.8292	271.1623	142.8862	65.60767	33.28274
TestAllGeo	Zr	(ppm)	141.4947	227.0656	217.7262	45.58752	12.95392
TestAllGeo	Rb	(ppm)	14.24531	50.4888	45.13088	18.02433	4.017132
TestAllGeo	Te	(ppm)	na	35.9432	na	na	na
TestAllGeo	Th	(ppm)	na	na	7.284404	na	na
TestAllGeo	U	(ppm)	na	na	12.23735	na	na
TestAllGeo	W	(ppm)	256.259	na	na	na	na

XXIX. XRF Chemical data – SS 28

Type	Sample Codes		SS-28				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	13.94	20.60	15.95	9.63	3.10
TestAllGeo	CaO	(%)	2.16	2.86	1.73	3.67	4.58
TestAllGeo	Cr2O3	(%)	0.07	0.06	0.04	0.02	na
TestAllGeo	Fe2O3	(%)	25.76	22.54	12.59	7.20	0.98
TestAllGeo	K2O	(%)	2.64	4.90	4.18	2.09	0.45
TestAllGeo	MgO	(%)	2.49	3.02	2.16	0.48	na
TestAllGeo	MnO	(%)	0.29	0.23	0.08	0.05	0.01
TestAllGeo	P2O5	(%)	na	0.30	0.28	0.23	0.21
TestAllGeo	SO2	(%)	0.59	0.05	na	0.07	0.13
TestAllGeo	SiO2	(%)	49.18	43.32	61.46	75.72	90.17
TestAllGeo	TiO2	(%)	2.81	2.08	1.49	0.81	0.44
TestAllGeo	V2O3	(%)	0.06	0.07	0.05	0.02	0.01
TestAllGeo	Ag	(ppm)	9.263098	na	na	na	na
TestAllGeo	As	(ppm)	55.48465	34.6208	19.12252	15.55744	7.631429
TestAllGeo	Ba	(ppm)	na	370.2105	108.2614	na	na
TestAllGeo	Cu	(ppm)	306.9809	104.8098	67.16857	40.70809	25.53996
TestAllGeo	Nb	(ppm)	17.08862	17.9091	13.91345	7.946332	6.045491
TestAllGeo	Ni	(ppm)	132.5207	na	na	na	na
TestAllGeo	Pb	(ppm)	31.19873	7.53702	10.72843	11.05507	5.462073
TestAllGeo	Sn	(ppm)	na	12.93284	na	na	na
TestAllGeo	Sr	(ppm)	105.1655	146.6879	204.5983	161.7757	104.5089
TestAllGeo	Zn	(ppm)	254.0226	275.6599	145.295	68.25264	12.7114
TestAllGeo	Zr	(ppm)	1747.564	254.8226	248.2259	109.2075	112.2632
TestAllGeo	Rb	(ppm)	55.81883	99.51961	72.40471	48.37639	7.340409
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	4.284591	10.63504	7.871702	na	na
TestAllGeo	U	(ppm)	6.549694	23.20337	17.85335	na	na
TestAllGeo	W	(ppm)	188.3792	na	na	na	na

XXX. XRF Chemical data – SS 29

Type	Sample Codes		SS-29				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	14.89	20.38	14.06	7.47	4.38
TestAllGeo	CaO	(%)	3.07	3.58	2.72	7.51	6.27
TestAllGeo	Cr2O3	(%)	0.06	0.06	0.03	0.01	0.01
TestAllGeo	Fe2O3	(%)	40.23	19.74	9.94	4.10	1.96
TestAllGeo	K2O	(%)	1.50	4.84	3.21	1.52	0.88
TestAllGeo	MgO	(%)	3.92	3.04	2.05	1.16	na
TestAllGeo	MnO	(%)	0.29	0.19	0.06	0.03	0.03
TestAllGeo	P2O5	(%)	0.19	0.41	0.29	0.26	0.87
TestAllGeo	SO2	(%)	1.31	0.18	0.33	0.33	0.05
TestAllGeo	SiO2	(%)	32.80	45.46	66.12	77.94	84.35
TestAllGeo	TiO2	(%)	1.68	2.07	1.15	0.44	1.18
TestAllGeo	V2O3	(%)	0.07	0.06	0.03	0.01	0.01
TestAllGeo	Ag	(ppm)	12.73192	na	na	na	na
TestAllGeo	As	(ppm)	112.5229	50.07901	32.88666	22.46014	14.30225
TestAllGeo	Ba	(ppm)	na	524.6617	na	na	na
TestAllGeo	Cu	(ppm)	421.7811	91.04756	57.2776	28.87099	39.19867
TestAllGeo	Nb	(ppm)	15.36235	19.48584	12.06519	4.181918	3.450156
TestAllGeo	Ni	(ppm)	398.2764	175.5744	na	na	na
TestAllGeo	Pb	(ppm)	18.3996	15.3538	12.20556	9.844175	9.668494
TestAllGeo	Sn	(ppm)	na	na	na	na	na
TestAllGeo	Sr	(ppm)	110.3728	263.8824	180.0249	192.8692	134.6251
TestAllGeo	Zn	(ppm)	381.779	227.3003	110.2024	41.55422	29.7204
TestAllGeo	Zr	(ppm)	130.1707	361.5325	205.7481	77.28491	192.1229
TestAllGeo	Rb	(ppm)	25.34519	88.48902	44.01742	31.20701	15.88145
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	12.71501	6.898314	na	2.458218
TestAllGeo	U	(ppm)	na	22.57649	10.71339	na	na
TestAllGeo	W	(ppm)	234.1932	na	na	na	na

XXXI. XRF Chemical data – SS 30

Type	Sample Codes		SS-30				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	15.42	19.24	13.61	6.78	3.87
TestAllGeo	CaO	(%)	11.46	3.89	2.19	3.50	6.08
TestAllGeo	Cr2O3	(%)	0.06	0.05	0.03	0.01	na
TestAllGeo	Fe2O3	(%)	32.52	17.90	10.63	8.10	5.71
TestAllGeo	K2O	(%)	1.99	4.64	2.96	1.15	0.63
TestAllGeo	MgO	(%)	3.88	2.62	1.36	0.34	na
TestAllGeo	MnO	(%)	0.47	0.18	0.05	0.02	0.02
TestAllGeo	P2O5	(%)	0.36	0.41	0.38	0.27	0.31
TestAllGeo	SO2	(%)	0.93	0.29	0.83	4.75	4.73
TestAllGeo	SiO2	(%)	31.12	48.84	66.74	74.65	76.37
TestAllGeo	TiO2	(%)	1.72	1.88	1.17	0.43	2.27
TestAllGeo	V2O3	(%)	0.07	0.06	0.04	0.01	0.02
TestAllGeo	Ag	(ppm)	12.08776	na	na	na	na
TestAllGeo	As	(ppm)	120.0414	38.22162	24.12312	49.00845	36.40249
TestAllGeo	Ba	(ppm)	na	480.4325	na	na	na
TestAllGeo	Cu	(ppm)	306.7968	132.261	114.2655	95.07345	167.644
TestAllGeo	Nb	(ppm)	15.76511	17.33735	9.191349	3.26905	5.950562
TestAllGeo	Ni	(ppm)	144.0812	119.2855	66.04932	53.75111	na
TestAllGeo	Pb	(ppm)	34.1383	15.29945	16.23321	23.77207	13.34868
TestAllGeo	Sn	(ppm)	14.68697	na	na	na	na
TestAllGeo	Sr	(ppm)	336.5259	298.0518	182.0715	156.0475	160.6236
TestAllGeo	Zn	(ppm)	437.2996	211.685	133.0374	61.35703	65.0387
TestAllGeo	Zr	(ppm)	200.0309	357.637	199.7037	68.54363	104.1608
TestAllGeo	Rb	(ppm)	31.01922	83.49026	41.5853	20.83833	12.57904
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	14.44587	na	2.09706	na
TestAllGeo	U	(ppm)	na	21.61304	15.82091	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XXXII. XRF Chemical data – SS Here

Type	Sample Codes		SS-Here				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	14.30	17.72	11.40	6.32	2.82
TestAllGeo	CaO	(%)	2.85	4.50	1.93	3.50	14.97
TestAllGeo	Cr2O3	(%)	0.37	0.06	0.03	na	na
TestAllGeo	Fe2O3	(%)	44.75	21.40	9.41	4.03	0.79
TestAllGeo	K2O	(%)	1.38	4.42	2.47	1.36	0.61
TestAllGeo	MgO	(%)	5.29	2.16	2.02	0.53	na
TestAllGeo	MnO	(%)	0.43	0.26	0.06	0.02	0.03
TestAllGeo	P2O5	(%)	0.20	0.31	0.27	0.15	0.24
TestAllGeo	SO2	(%)	0.66	0.09	0.15	0.15	0.19
TestAllGeo	SiO2	(%)	27.80	47.20	71.28	83.62	80.13
TestAllGeo	TiO2	(%)	1.90	1.82	0.95	0.30	0.22
TestAllGeo	V2O3	(%)	0.08	0.05	0.02	0.01	0.01
TestAllGeo	Ag	(ppm)	5.113186	7.585507	na	na	na
TestAllGeo	As	(ppm)	112.3436	38.19567	22.50572	13.3606	9.973954
TestAllGeo	Ba	(ppm)	102.385	779.8745	na	na	na
TestAllGeo	Cu	(ppm)	280.9249	87.52709	52.26019	34.33171	24.88243
TestAllGeo	Nb	(ppm)	12.40961	20.10841	7.204339	3.260146	na
TestAllGeo	Ni	(ppm)	352.8451	146.7949	48.60986	na	na
TestAllGeo	Pb	(ppm)	13.67884	13.23637	9.259715	8.500512	2.956355
TestAllGeo	Sn	(ppm)	23.93998	16.20437	na	na	na
TestAllGeo	Sr	(ppm)	110.0148	335.0997	178.4199	143.1438	209.9601
TestAllGeo	Zn	(ppm)	422.2674	223.6901	106.0237	38.54915	16.04986
TestAllGeo	Zr	(ppm)	131.2046	357.3726	176.4716	60.93611	22.6211
TestAllGeo	Rb	(ppm)	19.28408	86.79912	36.06064	26.23272	10.12722
TestAllGeo	Te	(ppm)	na	36.70979	na	na	na
TestAllGeo	Th	(ppm)	na	7.340923	3.252541	na	na
TestAllGeo	U	(ppm)	na	na	na	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na

XXXIII. XRF Chemical data – Culocau

Type	Sample Codes		SS-32 Culocau				
	Element	Unit	Field Strength				
			0.3A	0.5A	1A	1.5A	1.5Nm
TestAllGeo	Al2O3	(%)	12.07	16.75	12.41	6.22	3.77
TestAllGeo	CaO	(%)	4.01	3.26	8.80	33.36	34.47
TestAllGeo	Cr2O3	(%)	0.20	0.06	0.03	na	na
TestAllGeo	Fe2O3	(%)	35.35	20.82	10.45	4.44	1.24
TestAllGeo	K2O	(%)	1.61	3.56	2.57	1.13	0.64
TestAllGeo	MgO	(%)	3.48	2.17	2.11	1.01	na
TestAllGeo	MnO	(%)	1.61	0.36	0.19	0.22	0.09
TestAllGeo	P2O5	(%)	0.38	0.33	0.22	0.22	0.22
TestAllGeo	SO2	(%)	0.39	0.22	0.27	0.14	0.49
TestAllGeo	SiO2	(%)	35.11	50.47	61.82	52.98	58.87
TestAllGeo	TiO2	(%)	5.68	1.95	1.09	0.39	0.21
TestAllGeo	V2O3	(%)	0.11	0.05	0.04	0.01	0.01
TestAllGeo	Ag	(ppm)	9.20952	3.83668	na	na	na
TestAllGeo	As	(ppm)	68.92526	39.03268	20.95828	12.57964	9.802523
TestAllGeo	Ba	(ppm)	348.6594	510.2376	138.8448	na	2073.177
TestAllGeo	Cu	(ppm)	176.968	98.90221	71.30543	65.0157	41.62832
TestAllGeo	Nb	(ppm)	71.04339	25.72727	15.74398	15.29104	5.315486
TestAllGeo	Ni	(ppm)	145.2826	160.8622	54.97153	na	25.11546
TestAllGeo	Pb	(ppm)	30.27016	27.80963	28.47364	12.70171	9.771426
TestAllGeo	Sn	(ppm)	na	na	na	na	na
TestAllGeo	Sr	(ppm)	166.3394	268.1604	315.001	566.9396	587.4403
TestAllGeo	Zn	(ppm)	329.8924	239.2456	125.0775	55.87905	32.21012
TestAllGeo	Zr	(ppm)	302.7816	368.9732	243.8394	122.5556	53.15482
TestAllGeo	Rb	(ppm)	23.50723	70.60754	55.08655	46.08869	18.13726
TestAllGeo	Te	(ppm)	na	na	na	na	na
TestAllGeo	Th	(ppm)	na	14.71409	9.870288	4.318908	1.899613
TestAllGeo	U	(ppm)	na	14.45642	6.068391	na	na
TestAllGeo	W	(ppm)	na	na	na	na	na