The Elemental Analysis of Bog Oak Samples of Archaeological Interest By ICP-MS

by

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Abstract

The archaeological samples in question are Bog Oak that are over 3000 years old and have been excavated fro Garry Bog, Co. Antrim. These trees along with others have been used to build a tree ring chronology that can aid archaeological dating and also track climate changes. Climate changes can be tracked because the width of a tree ring depends on the growing conditions prevalent that year. It was noted in the chronology that in some years of the 11^{th} century B.C. the growth rings were extremely small, denoting very bad growing conditions. This is attributed to the massive eruption of Mt. Hekla in Iceland. The aim of the project was to determine whether chemical data that track the change in growth rings could be gathered from these samples. The samples were divided up into different sections corresponding to separate time periods. Samples were then processed into liquid form and analysed using ICP-MS. The concentrations of several elements were determined. Initial results indicated that the concentrations of a range of elements were elevated in the years following the eruption. However further work only shows this pattern for copper. The data can be said to be inconclusive but can also be seen as a basis for further work.

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Appendix B Raw Data for Q1921, Q 2030 and Q1932.

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Appendix D Raw Data for Q9779.

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the degree of MSc.is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text.

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CHAPTER 1 Tree Anatomy, Growth and Plant Nutrition

INTRODUCTION

Dendrochronology is the science of dating wood by analysing the patterns of annual growth rings within a species [1]. One can overlap earlier patterns of growth on a younger tree with the later growth years of an older tree and repeat this process so that one compiles a pattern of growth (or chronology) for the past few centuries or even several millennia. Wood samples of the same species (normally more than 100 growth rings) can then be matched with the master chronology for that species and it can be determined when that tree grew and was cut [2](Figure 1).

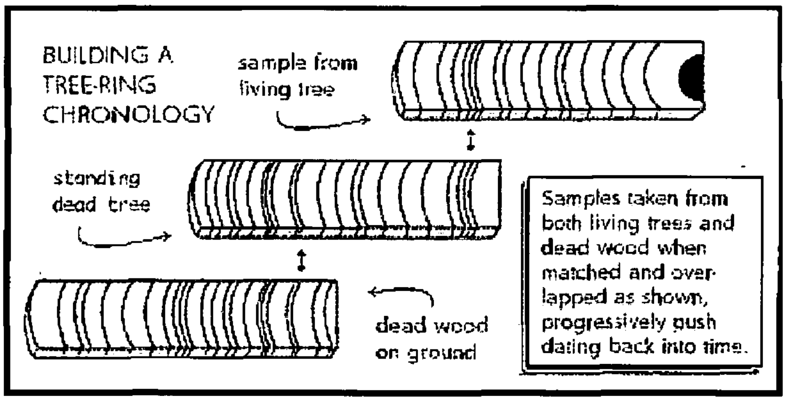


Figure 1 Basics of dendrochronology [3]

Obviously this method is very useful for the dating of archaeological samples. Significant narrowing of the rings during a particular period of time can also point to environmental disturbances such as drought or raised water levels since the growth ring will be narrower in years of hardship for the tree, and this pattern can persist for a few years. When a catastrophic natural event occurs, such as a huge volcanic eruption, the resulting climate change can be traced in the dendrochronological record and historic dates can be independently verified.

Each bog oak sample analysed during the course of the project was cut in cross-section. Thus one is able to identify individual growth rings (corresponding to specific dates) and estimate the growth conditions prevalent over the life of the tree. This is the means whereby dendrochronologists can identify dates where climate ([4], [5] and [6]) and environmental changes ([7],[8]) including volcanic eruption could have occurred, affecting the growth of the tree. The aim of the project was to discover whether anomalous concentrations of various elements could accumulate in the tissues of the tree, which would be associated with global environmental catastrophes.

As the tree grows it draws nutrients in the form of water and minerals from the soil, transports these through the stem of the tree and uses them to form new tissue. However minerals transported through the vascular tissue during one growth season may not remain static in that growth ring when the tree adds another ring the following year. It appears that some elements are more mobile than others across rings. Therefore if we want to see definitive elevated levels of an element during one period it must be relatively immobile in the wood tissue. It's therefore useful to describe the manner in which wood tissue develops, and how this development affects the structure of the vascular vessels that carry these minerals through the stem of the plant.

1.1 TREE ANATOMY

Oak trees are members of a class of plants called dicotyledons. These are characterised by their leaves having a radial structure and their vascular bundles are also arranged in an organised fashion. These bundles are clustered together as shown in figure 2.

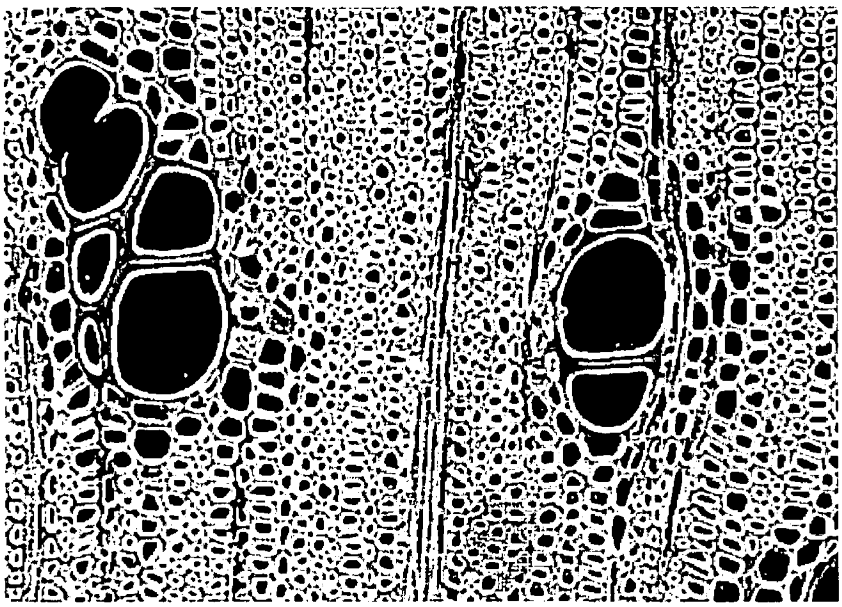


Figure 2 Cross-section of vascular system of oak [9]

They are angiosperms, which means that they use fruit to transport their seeds to the ground. For example oak trees produce acorns, which fall to the ground and germinate if conditions are right.

1.1.1 DERMAL MATERIAL

The stem of all plants is covered with dermal tissue, which is used to protect the inside of the plant from the environment. In trees this is known as bark and is made up of cork tissue. There is a layer of cells behind this called the cork cambium, which produces new cork cells all the time. Cambium cells can be of different types but all produce new cells for the maintenance of the tree. Cells with this function are called embryonic or meristematic tissue.

1.1.2 GROUND MATERIAL

Within the stem the majority of material is made up of ground tissue of which there are three types: Parenchyma are non-specialised chloroplasts, which perform photosynthesis or store the products of photosynthesis. The collenchyma form thicker primary walls that support the plant. Sclerenchyma form thick secondary walls and are rich in lignins. These calls are normally non-living and support mature regions of the plant. They basically make up what we call wood.

1.1.3 VASCULAR MATERIAL

The two elements of vascular bundles are xylem and phloem. The xylem carry water and minerals up the plant towards the leaves to aid photosynthesis. They are made up of tracheids and vessel elements. Tracheids are elongated with tapered ends.

Figure 3 Tracheids [10]

Vessel elements are non-living tubular cells which fit together to form a type of pipeline for nutrients (figure 4). Therefore the xylem is most influential in transporting the elements that we are hoping to find in the tree [11].

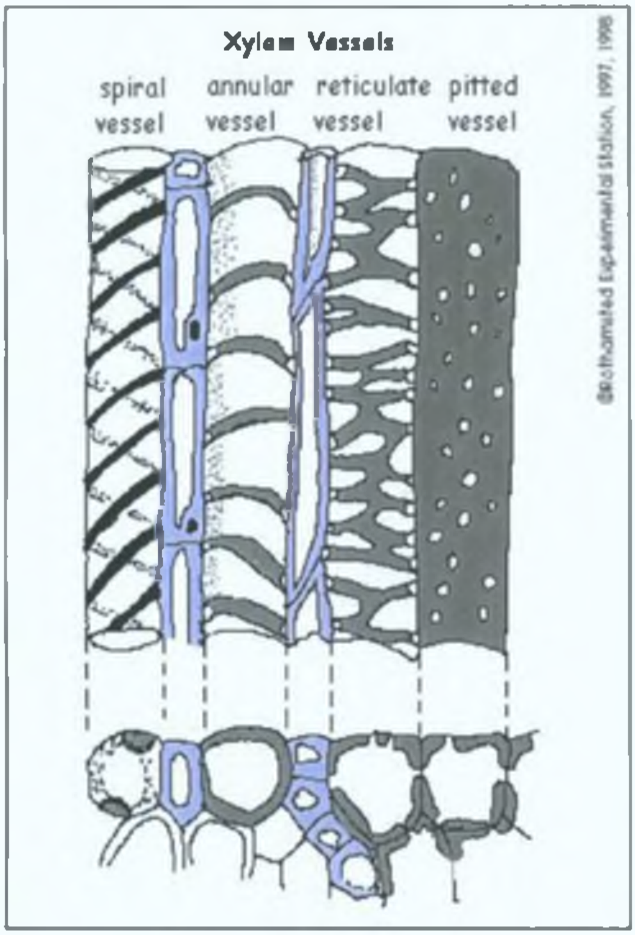


Figure 4 Xylem cell system [12]

The ray parenchymas intersect the sieve-tube cells laterally. This could afford a route for some elements to migrate across rings to accumulate towards the outer edges of the tree.

The phloem carry the products of photosynthesis down the plant from the leaves for storage or use in building new tissues. The tissues are made up of sieve-tube cells with a companion cell for each sieve-tube cell. There are channels in the end wall of the sieve-tube cells and as they have no nucleus the companion cells control both cells.

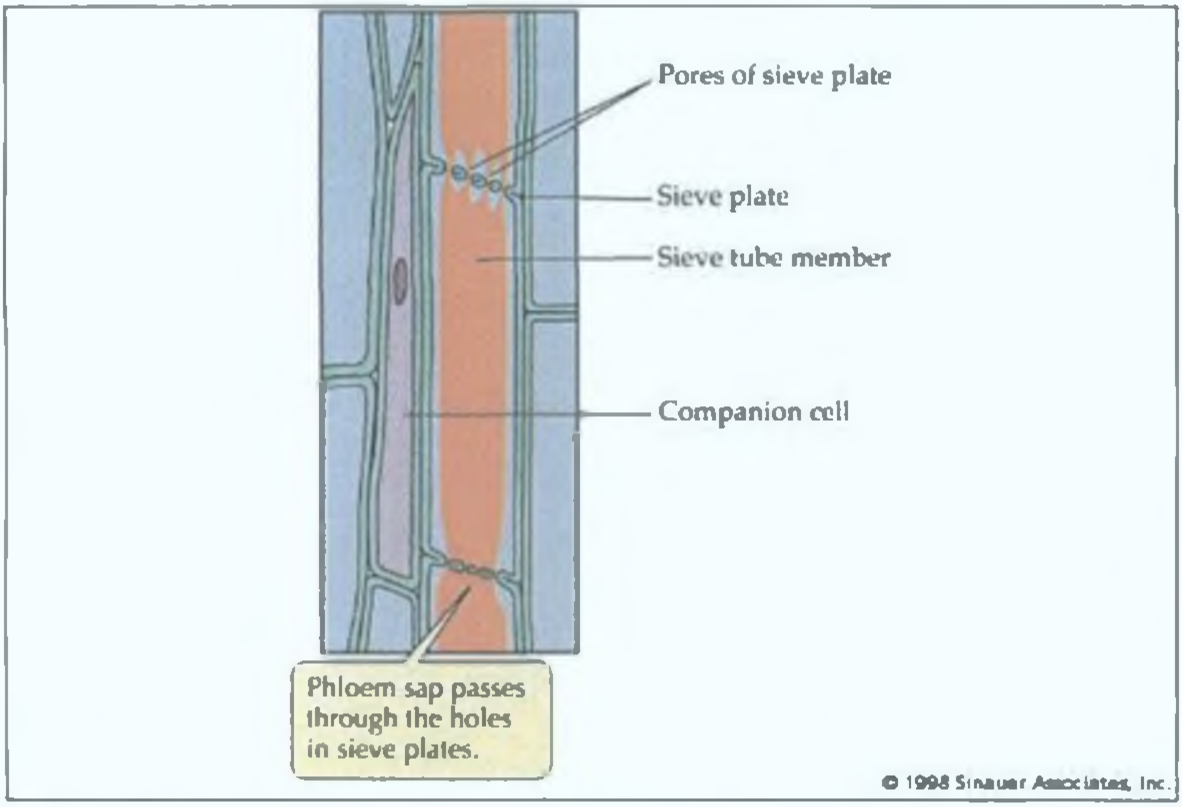


Figure 5 Phloem cell system [13]

This diagram of phloem cells represents a sieve-tube element with sieve plates at each end.

1.2 GROWTH

Of course all this only provides background to elucidate the process that we are interested in, namely the yearly growth of the tree [14]. Primary growth involves the lengthening of the trunk of the tree, while secondary growth increases the diameter of the tree. This process of widening also takes place in the root of the tree. The sources of this new tissue are the lateral meristems:

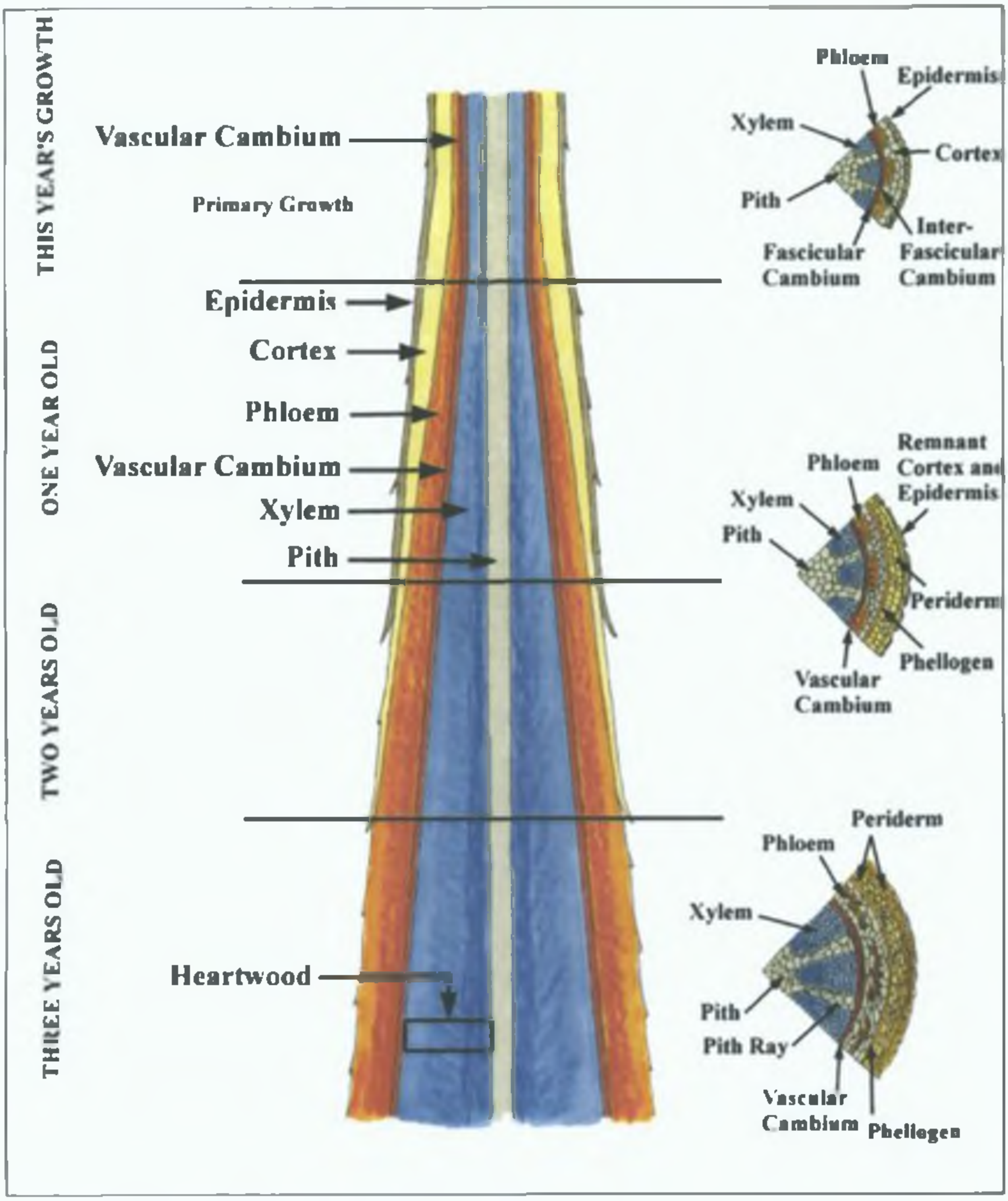


Figure 6 Division and growth of cambium [15]

When vascular cambium produces new xylem and phloem each year, the xylem builds up increasing the girth of the tree. Notice in figure 6 how the vascular cambium gradually becomes shifted away from the centre as secondary xylem builds up.

1.2.1 VASCULAR CAMBIUM

These cells produce secondary vascular tissue. They are located between the xylem and phloem of the vascular bundle. They join to form a ring of meristematic cells and the way in which their division proceeds is shown below (Figure 7). They divide in a plane parallel to the surface of the plant.

The wood of trees in seasonal climates like our own produce secondary xylem i.e. growth rings. A growth ring is made up of a layer of spring growth, and a layer of summer growth. In spring there is usually more rainfall so the xylem vessels are larger than in the summer layer. As a mature tree grows only the most recently formed layer of xylem transports water. This tissue is known as sapwood. The older wood (heartwood) becomes plugged with resins and gums strengthening the structure of the tree.

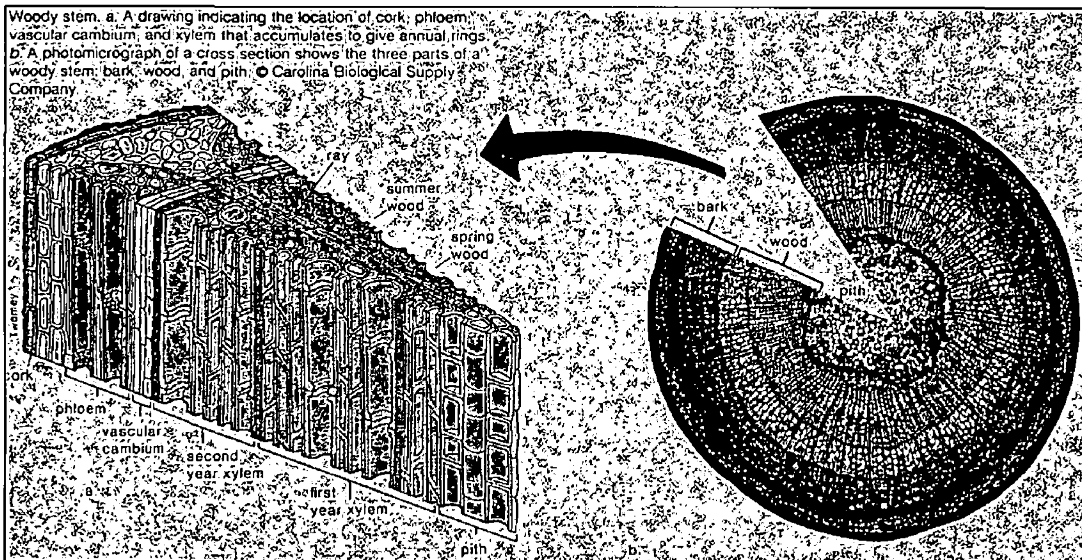


Figure 7 The elements of the vascular system [20]

1.3 PLANT NUTRITION

1.3.1 MINERAL TRANSLOCATION

The process of translocation of minerals through the tree in the direction of root to leaf using the xylem would be the mechanism most relevant when describing the process of a tree absorbing anomalous levels of any element from the surrounding soil.

The translocation of all chemicals within trees takes place using four mechanisms [16]:

- Xylem
- through phloem or ray parenchyma
- through cell walls
- through the intercellular spaces

The xylem carry aqueous solutions from the roots, but these solutions can also travel laterally via the other mechanisms. When these solutions travel via these alternative mechanisms the concentrations of some elements can become localised in the cell walls [17]. Metals and inorganic nutrients are carried in the sap, and metals are almost entirely in the form of chelates. Different metals will chelate with specific ligands so not all elements will be as laterally mobile in the tissues of these plants. Table 1 clusters the radial mobilities of elements in tree xylem [18] into three classes; low, medium and high. From the table we note that the elements Cu and Pb have moderate and low mobility respectively. These elements will merit a closer look as we consider the effect of the atmospheric deposition of heavy metals on trees. Although we have so far described the anatomical processes involved in the uptake of elements we must also describe the physiological effects the uptake of too much or too little of a given element can have.

High Mobility	Moderate Mobility	Low Mobility
As	Ca	Fe
K	Sr	Mo
Na	Mn	Ni
Mg	Zn	Sn
P	Rb	Sb
N	Cu	Ba
S	Mo	Al
Cl		Pb
B		Cd

Table 1 Mobility of elements in the stem [17]

1.3.2 THE ESSENTIAL MINERAL ELEMENTS

It has been known since the early nineteenth century that plants obtain elements essential to their nutrition from the soil via their root system. There are fifteen elements that are necessary for the normal growth and development of the plant [17].

The major ones are:

C, H, O, N, P, K, Ca, S, Mg and Fe. These are present as soluble salts in soil or water. Analysis of sap in cell vacuoles demonstrated that the concentration of inorganic salts within cells can be much greater than the environment and that this process is selective [19].

But there are also trace elements that are necessary:

Mn, Zn, B, Cu and Mo. These are also known as micronutrients. These elements occur in concentrations ranging from <1 to a few hundred ppm. They're usually constituents of enzymes or enzyme activators.

1.3.3 OCCURRENCE OF THE ELEMENTS

1.3.3.1 Nitrogen

The two major ionic forms absorbed by plants from soils are nitrate (NO_3^-) and ammonium (NH_4^+). Nitrogen is present in many important compounds in the plant and plants suffer very retarded growth as a result of nitrogen deficiency [20].

1.3.3.2 Phosphorus

Phosphorus is present in the soil in organic and inorganic forms. Organic phosphorus however is in an unusable form to the plant, though it may decompose and be released in an inorganic utilisable form. Soluble phosphorus in the soil is present as phosphate ions: e.g. $H_2PO_4^-$ and HPO_4^{2-}. Lower pH levels, around 2-4 such as those found in peat bogs favour the $H_2PO_4^-$ form, while higher pHs around 5-6 favour the HPO_4^{2-} ion in soil solution.

The availability of phosphorus to the plant is determined by four main factors:

1. pH of the soil solution: In acid soils around pH 2-4 only the $H_2PO_4^-$ ion is present in the solution and this is the ion with which plants can most readily absorb phosphorus.
2. Dissolved aluminium and iron: at low pHs such as levels present in peat bogs, soluble Al and Fe can precipitate phosphate and iron as aluminium and iron phosphates, making phosphorus unavailable to the plant.
3. Available calcium: Calcium reacts with all three forms of the phosphate ion (to form monocalcium phosphate, dicalcium phosphate and tricalcium phosphate) but only the mono form permits sufficient phosphorus nutrition to the plant, and this is under acid conditions. In alkaline conditions most of the calcium is bound up in insoluble dicalcium phosphate and tricalcium phosphate.
4. Anion exchange: The anion $H_2PO_4^-$ can replace a hydroxyl anion on the surface of a soil micelle under mild acid conditions making the phosphate ion unavailable to the plant.

Thus the optimal conditions for phosphorus nutrition are at pH 6-7, because in acid soils phosphorus can be bound up in aluminium and iron phosphates while in alkaline soils it can be bound up in insoluble calcium phosphate salts.

1.3.3.3 Calcium

Calcium is the most important exchange cation in soils because it is the most active. Calcium is thought to be adsorbed onto the surface of clay micelles (discs with an enveloping layer of negative charges). This attracts cations, which become adsorbed onto the surface of the micelle. As the hydrogen ion concentration increases, more H^+ ions become adsorbed onto the micelle and so Ca^{2+}ions are released.

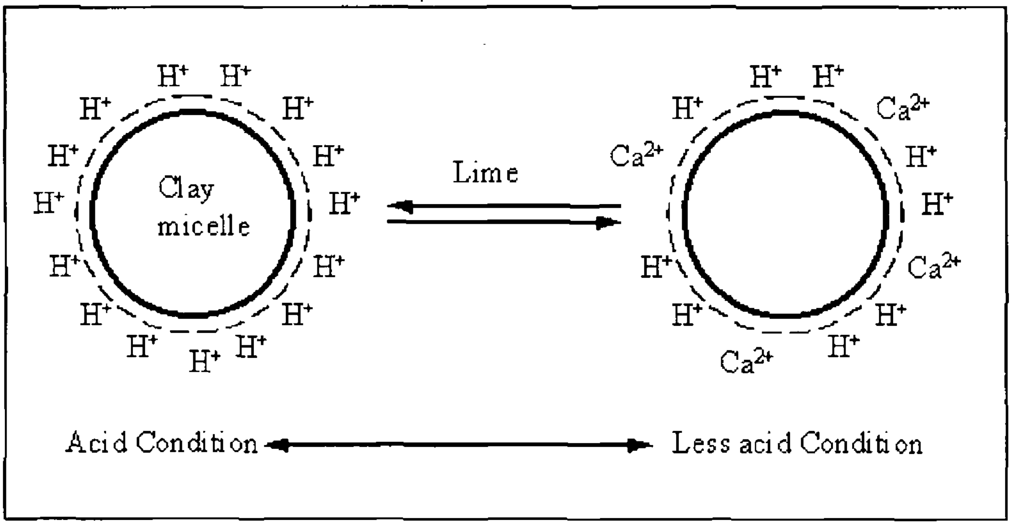


Figure 8 The uptake of Ca from the soil solution [17]

1.3.3.4 Potassium

Most of the potassium present in the soil is in a non-exchangeable form and can't be utilised by plants. But these non-exchangeable forms are minerals like biotite, muscovite, and illite, which can release potassium in a useable form through natural processes like weathering and leaching. Potassium ions are released from the lattice by these processes, making this potassium available in a form that the plant can ingest, and the gaps in the ion lattice are filled by calcium, magnesium or hydronium ions. Wiklander [21]has dealt with potassium fixation and release mechanisms.

1.3.3.5 Magnesium

Magnesium in the soil exists as minerals and in water soluble, exchangeable and fixed form. Magnesium is an exchangeable cation but is not as abundant as calcium so less is available to the plant via cation exchange. Most soil magnesium is found in magnesium silicates, which in themselves are unavailable to the plant but can weather to release magnesium. Fixed magnesium is supplied through the minerals magnesite ($MgCO_3$), olivine ($(MgFe)_2SiO_4$) and dolomite ($MgCO_3.CaCO_3$).

1.3.3.6 Iron

Iron supply in the soil comes from minerals, hydrated oxides (e.g. $Fe_2O_3.3H_2O$) and FeS. The amount of iron available to the plant is controlled by the pH of the soil. Acid soils allow the iron to be dissolved in the soil and remain available to the plant for uptake through the soil.

1.3.3.3.7 Sulphur [23]

Sulphur in the soil is predominantly in the organic fraction, which is unusable for plant nutrition. It is also found in inorganic form in minerals and in soluble form as the sulphate ion, which is in the form that plants absorb to fulfil their sulphur requirements. The sulphate ion is weakly adsorbed onto the soil micelle but this adsorption becomes stronger under more acid conditions. The process of release of sulphate ions from these micelles is known as anion exchange and takes place most efficiently in alkaline soils. Thus low pH retards sulphur uptake in a growing plant.

Sulphur can also reach the soil through precipitation. The burning of fossil fuels releases sulphur dioxide into the atmosphere where it combines with clouds and falls as acid rain. This can be absorbed through the soil by plants.

Organic sulphur can also be liberated to the plant via biological oxidation. Micro organisms can also oxidise sulphide minerals such as FeS and FeS_2. Chemical oxidation to elemental sulphur can also occur if the soil is moist and well aerated with the elemental sulphur then biologically oxidised to sulphate but the necessary conditions are not present in peat bogs. Thus it's possible that plants grown on peat bogs may be sulphur deficient.

1.3.3.8 Manganese

Manganese can exist in the soil in the monovalent, bivalent, trivalent and/or tetravalent form. The bivalent form can be dissolved in the soil solution or be adsorbed onto the surface of the soil colloids as an exchangeable cation. The exchangeable ion is the most important because very little manganese will be dissolved in the soil water and it is the Mn^{2+} form that is absorbed and utilised by the plant. A lot of the manganese present will be bound up in insoluble trivalent and tetravalent compounds and can't be absorbed by the plant. But poorly aerated and acid soils, such as the conditions present in peat bogs, favour the presence of Mn^{2+} ions. Also, under these conditions the trivalent and tetravalent forms may be reduced to Mn^{2+}.

Bivalent cations may also be biologically oxidised to the Mn^{3+} and Mn^{4+} forms by microorganisms but this process occurs mainly in neutral or alkaline soils. There is also evidence that higher valence forms may also be biologically reduced to Mn^{2+} making more manganese available to the plant [22].

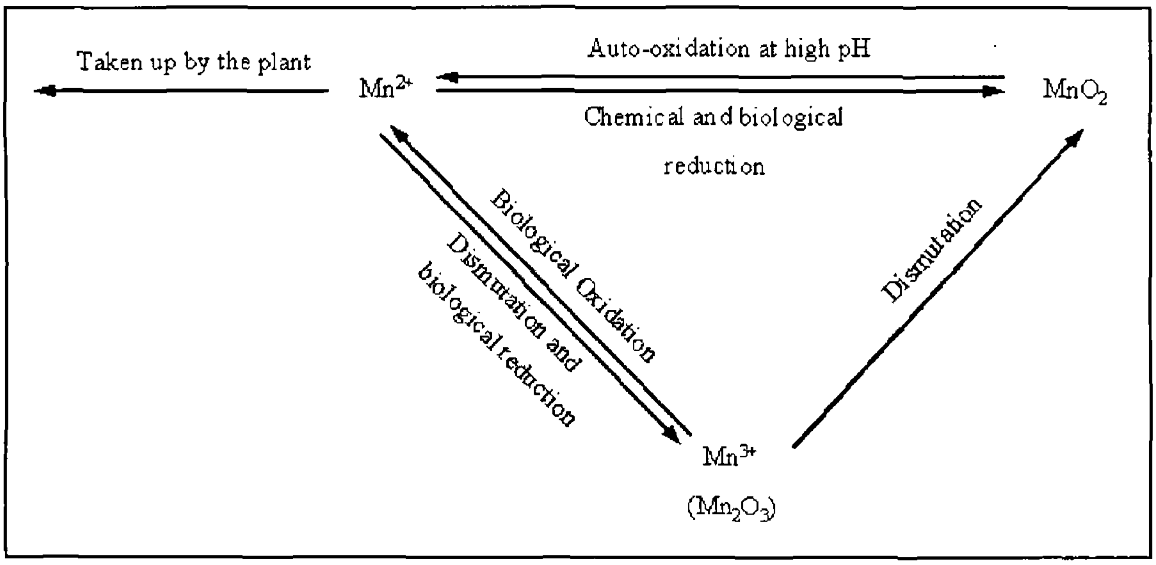


Figure 9 The Mn cycle [17].

1.3.3.9 Copper

Very little copper is dissolved in the soil solution, probably only about 0.01ppm in ordinary soil. Natural deposits of copper sulphide probably originate from rock such as chalcopyrite ($CuFeS_2$). Cu^{2+} is adsorbed very strongly onto the surface of the soil colloids and organic material of the soil and is relatively exchangeable. The biological use of copper is in a protein important for photosynthesis (plastocyanin) and as a component of enzymes such as phenolases, laccase and ascorbic oxidase. Severe copper deficiency causes plants to lose their leaves while an excess of copper available to the plant also has toxic effects. Cu^{2+} is the form of the element most readily available to the plant. Perhaps the availability of Cu^{2+} to the plant could be increased with a lowering of soil pH in the same manner as Ca^{2+} becomes more available as the hydrogen ion concentration in the soil increases.

1.3.3.10 Zinc

Zinc is released to the plant by weathering of the ferromagnesian minerals such as magnetite, biotite and hornblende. Concentrations of zinc in the soil are believed to be quite low but its availability is strongly determined by soil pH. Zinc, like iron and magnesium is most available in acid soils. This is thought to be due to acids dissolving ZnS and $ZnCO_3$ and weathering of minerals containing zinc.

1.3.3.11 Boron

Boron is present in the soil as boric acid, calcium or magnesium silicates, and as a constituent of silicates. The dissolved boron content of the soil of the soil is very low and its availability is determined by pH in the same manner as that of zinc.

1.3.3.12 Molybdenum

Molybdenum unlike all other trace elements becomes more available with increasing pH. It is present in soils in three forms, as molybdate ions (MoO_4^- or $HOMoO_4^-$), adsorbed to soil particles in an exchangeable form, and in a non-exchangeable form bound to soil minerals. Only very low concentrations of molybdenum are dissolved in the soil solution. An interesting relationship has been fund between the concentrations of molybdenum and sulphur in tree-rings of red cedar (juniperus virginiana L.). a study undertaken by Guyette et al[23] revealed that a decrease in the concentration of Mo in heartwood rings, starting in 1860, coincided with an increase in sulphur concentrations. This was probably due too an increase in soil sulphates after industrialisation and promoted by atmospheric deposition. Unfortunately there seems to have been no further studies in other species.

1.3.3.13 Aluminium

Aluminium is chiefly known for its toxic effects at high levels. An example of this, which is pertinent to the field of dendrochemistry and dendrochronology, is that frosts or droughts can cause necrosis of the root systems of trees and reduce nutrient uptake. This results in losses of base cations such as K^+ and Ca^{2+}, which are essential for nutrition. These base cations are replaced by Al^{3+} and a vicious cycle of decline can occur [24].

1.3.3.14 Nickel

There is recent evidence to suggest that nickel Ni^{2+} is an important part of the enzyme urease, which is used by the plant to catalyse the breakdown of urea (using H_2O) to NH_4^+ and CO_2. see also [25]

1.3.3.15 Chlorine

Chlorine is one of the most available elements to plants because it is so soluble and is distributed by wind and deposited by precipitation. Chlorine is absorbed from soils as the Cl^- ion and most of it remains in this form in the plant. It is essential for nearly every aspect of plant nutrition [17].

CHAPTER 2 The Effect of Volcanic Eruptions on Climate and Tree Growth

Explosive volcanic eruptions eject huge quantities of fine silicate ash and sulphur gases into the troposphere and stratosphere. Volcanic ash settles out due to gravity within weeks. Sulphur gases form aerosols, fine particles, which remain in the stratosphere for many years. These particles reflect sunlight and cause the surface temperature of the earth to drop. For example the eruption of Mt. Pinatubo in the Philippines in 1991 had already cooled the earth's surface by 0.5°C by 1993 [26]. A study by R.B. Stothers [27] examined the climate change caused by volcanic aerosols from an eruption around AD 536. Historical accounts had described dimming of the sun for over a year in the eastern Mediterranean and the failure of crops. There were also very cold winters in the Middle East and snowfalls in Mesopotamia. Stothers [27] calculated that the sun was one-tenth of its normal brightness and attributed the "dry fog" to an eruption in the southern hemisphere. Obviously this decrease in the amount of sunlight reaching trees would reduce photosynthesis and inhibit growth ([28], [29]). This "dry fog" remained for over a year and took about another year to fully decay. Large volcanic eruptions also have a warming effect on winter in Eurasia and North America in the year following the eruption no matter which hemisphere the eruption occurs in. Warming of the stratosphere brings warm maritime winds to continental landmasses in winter, because the sea is warmer than the land. This happens in mid-latitudes but doesn't happen in the southern hemisphere due to the absence of a mid-latitude continental land mass.

2.1 THE COMPOSITION OF VOLCANIC GAS AND ASH EMISSIONS

Volcanic gases analysed at fumaroles (volcanic vents) have been found to be composed of H_2O, CO_2, SO_2, H_2S, HCl, S_2 and HF ([30], [31]). But at these high temperatures other trace elements exist in the gaseous phase such as As, Sb, Se, Hg and Te but these are not thought to be dispersed very far as gases in eruptions because they readily revert to solid or liquid form outside the elevated temperature of the fumarole plume. When sulphur dioxide reaches the atmosphere it gets converted to sulphuric acid. Mt. Pinatubo released 15 to 20 mega tonnes of sulphur dioxide that was converted into sulphuric acid within a month [32]. HCl and HF are the dominant species of chlorine and fluorine present in volcanic gases, although there are many more gases that contain these elements [33]. Although volcanic emissions are a very significant part of global Cl and F emissions, they do not exceed industrial emissions.

Volcanic ash can be distributed after an eruption by wind and will usually be deposited in a layer of even depth over a given site, depending on the distance from the eruption. Lighter minerals in the ash and smaller particles will be deposited further away from the eruption site [34]. A study by *Gulchard et al* [35] has even indicated that this pattern persists even in the deposition of ash in marine sediments. An ash layer was recovered from a deep-sea sediment core from the southern Black Sea and analysed using x-ray spectrometry. The ash contained glass shards made up of minerals, which were superheated at the time of the Santorini eruption in 1650 BC. The relative concentration of minerals was characteristic of the geology of the Santorini area and so the source of the ash could be traced. Another study by Vasquez et al [36] shows that the composition of ash can be a fingerprint of where it came from.

Both these studies have revealed that volcanic ash contains the following minerals: SiO_2, TiO_2, AL_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, F, Cl and S. The halogens and sulphur were present only in ppm concentrations and by far the most abundant minerals were SiO_2 and AL_2O_3. Unfortunately the spread of volcanic ash is closely related to wind direction at the time of eruption and it's not easy to evaluate how much ash from a given volcano would reach Irish latitudes.

2.2 HEAVY METALS

Concentrations of heavy metals in our environment have increased over the past two hundred years. This has been due to increasing industrialisation such as activities like smelting and petroleum refining. These processes cause deposition of heavy metals and allow greater amounts to be absorbed by trees, whether through their roots, bark or foliage. Elevated levels then show up in the tree rings of species affected [37].

The heavy metals are elements such as Co, Cu, Zn, Cd and Pb. Excessive levels of these elements in an ecosystem have been linked to decreased growth in trees [38]. These metals are distributed everywhere throughout the tree but there is evidence that they reach the tree rings (in the xylem) via the root system [39]. It has also been discovered that metal flux increases with pH for Co, Cu, Zn, Cd and Pb and there is greater transport of these metals to the above ground wood. In the study by Jordan et al [40], levels of xylem trace metals were analysed for a particular site since 1866 and found to have increased steadily. This coincided with a significant decrease in growth. After analysing the climate (specifically drought) data over the same period and removing their effects it was still found that increased levels of heavy metals such as Cu, Cd, Zn, Al and Pb in the xylem were significantly related to reduced growth. However this study failed to reveal the cause of this relationship, as there was no correlation between higher levels of these metals in soil or bark and increased levels in the xylem (other than Zn).

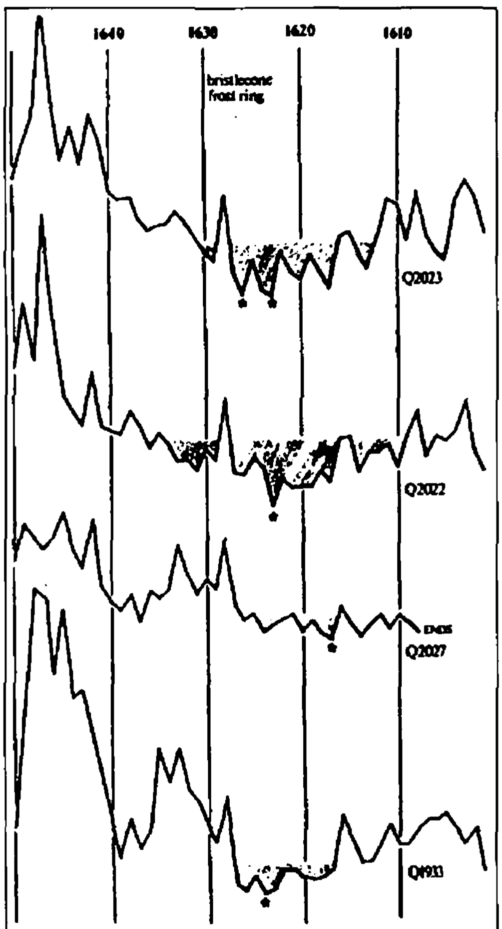
There is also evidence that reduced growth could be caused by competition between cations for binding sites in the roots and that increased levels of Al could lead to Ca deficiency. Another study also showed levels of lead and zinc in tree-rings could trace the industrial development of an area, with levels of lead correlating strongly with distance from site of pollution [38]. This study is important because it establishes that these elements remain in the rings for significant periods of time. Pb and Cd are bound to the lower part of the tree but Cu and Zn are distributed evenly on the vertical axis to at least five metres [41]

2.3 HISTORIC ERUPTIONS

2.3.1 SANTORINI [42]

There have been several eruptions in the last few millennia big enough to cause climatic disturbance in these latitudes. For example the explosive eruption of Santorini is thought to have wiped out the Minoan civilization. The exact date of this eruption was in question until the use of dendrochronology settled the argument. It was first noticed that bristlecone pines near the upper tree line had been damaged by severe frosts apparently caused by the dust veil from a violent volcanic eruption ([43], see also [44]). A significant frost ring was found for 1626 BC, which dated the eruption to one or two years previously. Hammer et al revised their ice-core dating of Santorini to 1645 BC with an error of ± twenty years, which would bring their date within range of figures produced using dendrochronology [45]. There was also ^{14}C evidence for a seventeenth century BC eruption.

The Belfast oak tree-ring chronology for the 1620s BC (figure 10) showed some trees putting on narrow bands of rings. The diagram shows the ring pattern s of four trees



Four trees from Garry Bog, Co. Antrim, Northern Ireland, showing curtailment of growth (the shaded areas are rings <0.5 mm wide), associated with the narrowest rings in the lifetime of each tree (marked by asterisks). All the trees have more than 220 rings. The shaded square marks the American bristlecone pine frost ring dates for the eruption of Thera[1].

Figure 10 Some examples from the Belfast Oak Tree-Ring Chronology[46]

The diagram plots the annual ring of four trees against the year of growth. After 1628 BC the rings are narrower than at any time in the previous century and in each tree one ring is the narrowest of its entire lifetime. However some trees in the Irish bog oak record don't contain such obviously narrow patterns and other trees have narrow bands at dates when no volcanic events have been suggested.

Irish bog oaks are thought to have been extremely sensitive to changes in water levels in the bog and any increase in precipitation could also cause a reduction in growth [47]. Therefore some of the oaks surveyed with narrow rings at dates outside any known volcanic events were probably affected by localised flooding caused by something like a landslide. The data shown above also shows that while adverse weather conditions only lasted about two to three years it took about a decade for Irish bog oak growth to recover. This suggests that the initial trigger of flooding had long lasting consequences.

In theory the narrowest ring, or band of rings of equal width, should correspond to the year in which the tree suffered the worst growth conditions of its life. In Irish oak the width of the early wood (put on in spring) in each ring is approximately equal, because this depends on the food reserves of the previous year. The overall ring-width is a minimum when there's no summer growth and the ring is only made up of the spring vessels. There's also a rare condition where spring vessels are reduced and damaged. When this occurs along with no summer growth the tree puts on its narrowest ring.

2.3.2 HEKLA 3 [48]

The polar ice-sheets have been building up for thousands of years. Every year the winter snowfall turns to ice and forms a layer. This layer is covered by the following winter snowfall, which also eventually becomes ice. Each layer corresponds to a year's snowfall and if one samples a core drilled from the ice sheet one can date a layer in much the same way as one dates tree rings. These layers are invaluable because they contain atmospheric data locked away in the ice.

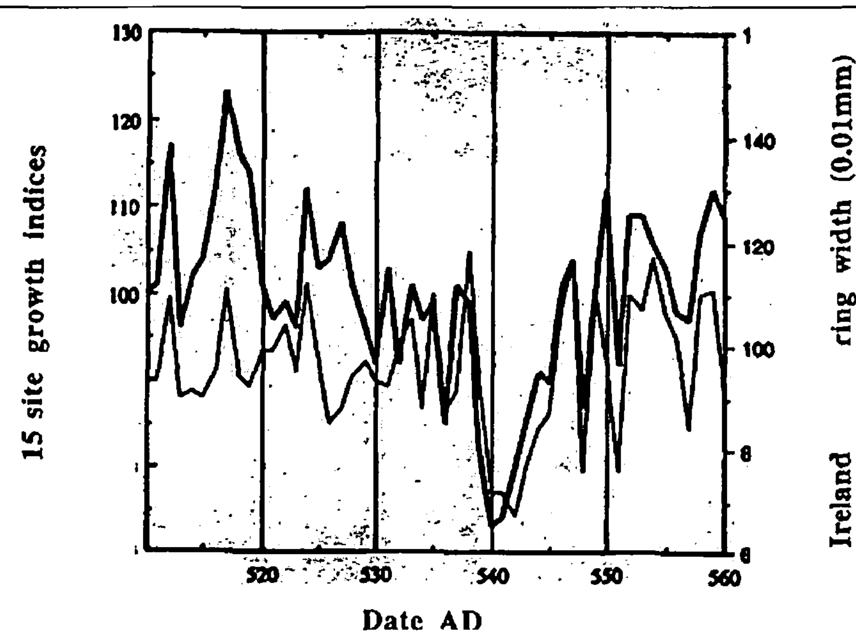
The Crête ice core of 1980 showed that there had been a huge eruption of Hekla in Iceland and it was bigger than previously realized. The ice-core data gave the eruption a date range of 1100 ± 50 BC and these dates correlate with Chinese historical texts which tell of a dimmed sun, crop failure and famine around this time.

Another cluster of narrow rings showed up in Irish oak from 1159 BC and total recovery didn't happen until 1140 BC. Forty-three percent of trees on six sites laid down their narrowest rings during this period. These types of clusters are very rare and usually coincide with volcanic eruptions.

Some work on samples of this period had been undertaken in D.C.U. and in the State Laboratory using non-destructive surface techniques. XRF analysis was performed on Q8001. Although this technique is not very sensitive the data gave the first indications that there were differences in the elemental compositions of the regions with narrower growth rings.

2.3.3 THE AD 536 DUST-VEIL EVENT [34]

This event is the last of the most significant post-glacial eruptions to show up in the Irish oak chronology. Like Hekla 3 it is thought that the volcanic fallout changed climate and significantly influenced human populations around this time. The event is believed to have been the southern hemisphere eruption of Rabaul and perhaps this accounts for the delay in adverse effects on growth. Historical evidence dates the eruption to AD 536 and although there's a narrow ring in the Irish chronology at that date, the narrowest one occurs in AD 540 [49]. Reduction in growth also occurred in European oaks and a comparison with the Irish scenario is shown in figure 11.

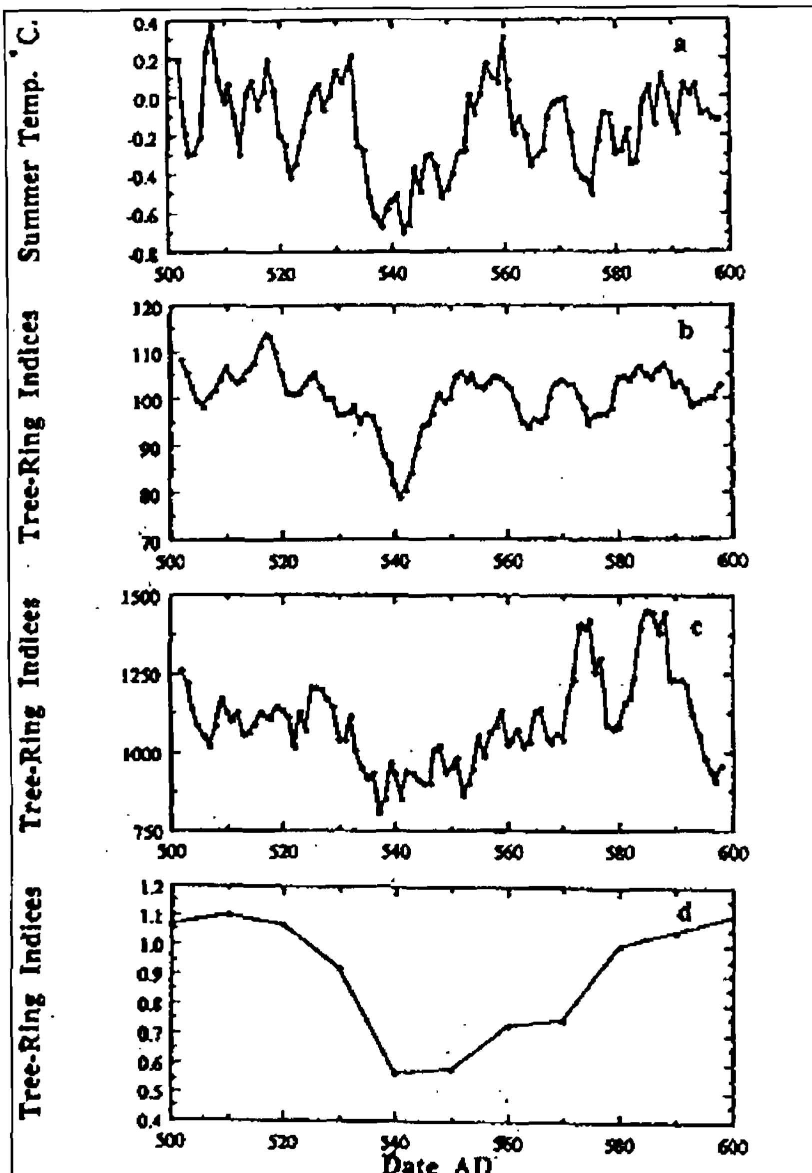


The narrow-ring event at AD 540. Ring-width indices for : European oak chronologies (heavy lines) plotted with a mean Irish oak chronology which shows narrowest rings in AD 540 to 542.

Figure 11 The AD 540 Narrow-Ring event [34]

There is evidence that crops failed and that famine resulted in Ireland and Britain at the time [50]. Archaeological data also suggests a population collapse around this time and perhaps people were driven to conflict due to scarcity of food, as evidenced by the construction of forts around this time [49]. There may also have been an outbreak of plague.

Furthermore there's also corroborative evidence from Scandinavian pines that AD 536 had the second coldest summer of the previous 1500 years, and data from US bristlecone pine and foxtail pines indicate that from AD 536 to AD 541 the second, third and fourth coldest years in the previous two millennia occurred.



(a) Five-point smoothed Fennoscandinavian temperatures reconstructed from pine ring-width and density measurements (Briffa *et al.*, 1990); (b) five-point smoothed mean of 15 European oak chronologies; (c) five-point smoothed mean of western US bristlecone pine (International Tree-Ring Data Bank); (d) decadal means of western US foxtail pine (Scuderi, 1990). All show notable growth reduction associated with the AD 536–546 event.

Figure 12 Correlation of chronologies across Northern Hemisphere with respect to the AD536 event [51], [52].

Due to the clear evidence for decline in growth due to this eruption, samples from these dates would be ideal for the study of elemental anomalies in Irish bog oak tree rings but unfortunately there are no dendrochronological dates in the Irish chronology between 95 BC and the mid sixth century AD. Thus the samples that we analysed refer only to the Hekla 3 eruption.

CHAPTER 3 The Instrument [53]

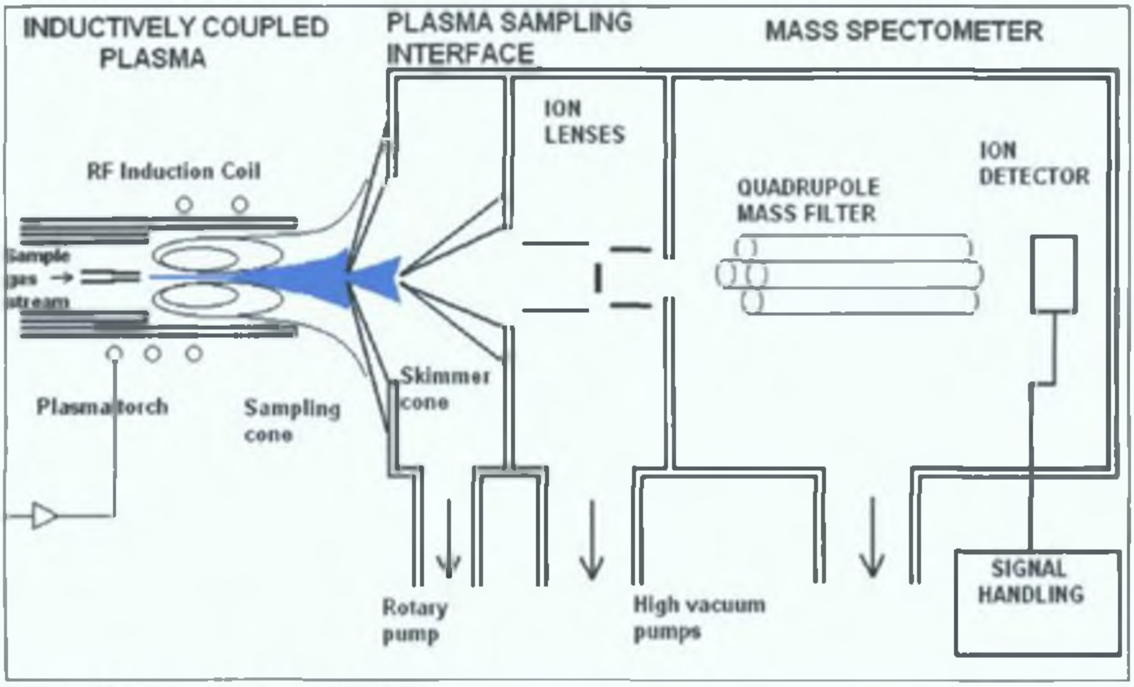


Figure 13 Layout of an ICP-MS instrument

3.1 ION SOURCE

Inductively coupled mass spectroscopy has been used as an atomisation and excitation source for optical emission spectroscopy for more than twenty years. Because many of the most intense lines in ICP optical emission spectra are attributable to singly charged ions, this suggests that the ICP would be an efficient ionisation source for mass spectroscopy.

In fact it can be calculated that all the metals in the ICP would be over 90% ionised. However even some elements with quite high ionisation potentials exhibit much lower ionisation efficiencies (e.g. P, As, Hg and I).

The ICP-MS system that was employed during this project was a Varian UltraMass. In such instruments the ion source typically operates at 760 torr (atmospheric pressure).

However the mass spectrometer operates at very low pressures (typically 5×10^{-6} torr), so efficient ion-transfer from the ICP to the spectrometer can be a challenge. The high temperature of the plasma (6,000-10,000K) and high power radio frequency currents (1.1-1.5kW) also add to the difficulties involved.

In the first stage of the sampling process ions are removed from the plasma through a small hole in the tip of a water-cooled metal cone (figure 13). This is called the sampler cone. The sampler cone is earthed and partially insulated from the plasma by a cooler layer of gas next to the cone. This can result in a potential difference developing between the plasma and the cone, which can give rise to a secondary discharge between the plasma and the sampler cone. This in turn can result in ion energies becoming unsuitable for efficient sampling and mass analysis due to voltage swings in the plasma.

The solution to this problem is to ground the induction coil, either at the front of the torch (front grounded), centre (centre grounded) or rear (rear grounded). The Varian UltraMass uses a configuration called the Turner interlaced induction coils. While all other systems use only one coil to maintain the plasma, this system uses two. One is "front grounded", the other is "rear grounded". Each coil is connected so that the magnetic field of one reinforces the other while the axial electric fields of the two coils cancel.

3.2 INTERFACE AND VACUUM SYSTEM

Although the hole in the sampler cone is very small it obviously constitutes a very large leak in a high vacuum system. The pressure is therefore reduced in three stages, a process known as differential pumping. This removes the need for a large vacuum pump to maintain a high vacuum. The first stage produces a beam of particles from an atmospheric pressure source using two coaxial cones separated by a well-defined distance, with the space between them kept at a pressure of 2 torr. The second cone is usually referred to as the skimmer cone. This allows the majority of the gas entering the hole in the sampler cone to be removed while passing a beam of gas and ions from the plasma into the second stage of the vacuum system. The plasma entering the interface undergoes rapid expansion and cooling which allows no time for significant recombination of ions and electrons. Therefore the composition of the sampled beam is representative of that of the plasma.

A turbomolecular pump is used to keep the second stage at a pressure of around 5×10^{-5} torr. At this stage ions are guided by electrostatic ion lenses. The neutral gases diffuse from the beam and are removed from the system by the vacuum pump.

The third and final stage of the vacuum system, which contains the mass analyser and the detector, is kept at a pressure of 5×10^{-6} torr by a smaller turbomolecular pump.

3.3 ION OPTICS

Ions entering the second stage of the vacuum stage from the back of the skimmer cone must be focussed into the third stage containing the mass analyser. This is achieved using an ion lens assembly consisting of a stack of ion lens elements. These are basically conductive tubes with appropriate DC currents applied.

The first ion optics element is the extraction lens, a small cylinder located directly behind the skimmer cone. Ions captured by the extraction lens are directed through the hole in the gate valve that separates the first and second stage of the vacuum system. These are then focussed into the mass analyser by the main lens stack in front of the quadrupole assembly.

Within the lens stack is a disc shaped element called a photon stop which blocks the direct path between the extraction lens and the mass filter. This prevents light from the plasma entering mass filter, where it could possibly reach the detector and contribute to background noise. This is relatively improbable due to the way that the detector is mounted. Therefore the main function of the photon stop is to prevent the transmission of high-energy on-axis ions and high-energy neutral atoms and molecules. If these ions entered the mass filter a significant amount could pass through without being sorted and contribute to background noise. Also, neutral species that happened to ionise on the way through would add to these effects. With the correct voltages selected, the ions emerging from the optics can undergo effective mass filtering.

3.4 MASS ANALYSER

3.4.1 QUADRUPOLE MASS FILTER

The ions are separated at this stage by their mass to charge ratio (m/z). A quadrupole consists of four conductive rods arranged so that they are parallel and their axes lie at the corner of a square. In the Varian UltraMass the rods are nominally 220mm long and 9mm in diameter. For the efficient mass filtering the geometry of the system must be correct to within a few microns. Opposite pairs of rods are electrically connected. DC and radio frequency potentials are applied so that one pair has the potential:

$$P=U+V\cos(2\pi ft) \qquad (1)$$

where U is a dc potential and Vcos (2πft) is a radio frequency potential of fixed frequency f and maximum amplitude V, and t is the time the ion spends in the quadrupole. The potential of the opposite pair is equal in magnitude but opposite in sign. Ions entering the array interact with the electrical fields of the rods so that they begin to oscillate in a direction transverse to the direction of their motion. The frequency f of the DC potential applied to the rods is fixed, so the only way to adjust the oscillatory motion of the ions is to adjust U and V. We can change these values so that only ions having a certain m/z will be transmitted to the detector. Ions that have different m/z will have unstable paths through the quadrupole and will collide with the rods.

To have good mass filtering there are several requirements placed on the quadrupole. The rods must be sufficiently long and the frequency high enough to allow ions following unstable paths to collide with the rods. The velocity of the ion on the longitudinal axis must be suitable. If the velocity is too low, the ion will be lost, and if it is too high the ion will pass through too quickly to allow mass filtering. In theory any ion travelling perfectly on-axis down the middle of the quadrupole will pass through. In reality the number of these ions is very small, though unfiltered ions do contribute significantly to the background noise in ICP-MS.

The mass spectrum of the sample is scanned by electronically controlling the DC and radio frequency voltages supplied to the rods. If U and V are varied with time so that their ratio remains the same but the absolute magnitude of the potential increases, ions of increasing m/z will pass through the quadrupole in rapid succession. The relationship between the DC signal applied and the mass-to-charge ratio of the ion that are transmitted is calibrated using reference solution containing isotopes of known mass.

3.4.2 RESOLUTION

The resolution of a mass spectrometer is really a quantitative measure of its ability to separate ions of similar mass. The narrower the peaks produced, the better the resolution achieved. Resolution is usually quoted as the peak width in a.m.u.s at a named fraction of the peak maximum, usually 5%. Obviously the smaller the value, the better the resolution. Resolution is adjusted by changing the ratio of the DC potential U to the maximum RF potential V.

As is the case with a lot of analytical instrumentation, increasing the resolution gives a corresponding decrease in sensitivity. This is because the efficiency of ion transmission decreases. There is also a limiting resolution for any given quadrupole system where any attempt to further changes in the DC/RF ratio decreases ion transmission without any increase in resolution.

3.4.3 ABUNDANCE SENSITIVITY

When small amounts of an analyte are present with a species that has an atomic mass within one atomic mass unit of the analyte one needs good resolution. However one needs another quantity rather than just resolution to evaluate the performance of the spectrometer. For example a peak having a narrow width at 5% peak maximum could have a sufficiently wide base to contribute to the signal at one a.m.u. on either side.

The parameter used to evaluate performance in this case is abundance sensitivity. This is a measure of the signal at one a.m.u. above and below a peak at mass m resulting from the "tails" of that peak. It is normally expressed as a ratio e.g. signal at (m-1)/signal at m. Obviously the smaller the ratio, the less "tailing" has occurred. Since the mass peaks produced by a quadrupole mass spectrometer, it is normal to quote two abundance sensitivities. The ratio for m+1 is normally five times lower than that for m-1.

3.4.4 FRINGE RODS

The electric fields at the entrance and exit to the quadrupole overlap slightly (or fringe). These fields retard the efficient transmission of ions. Therefore a set of very short quadrupole rods is placed at the entrance and exit to the main rods. These are capacitively coupled to the main rods so that the short rods carry the RF frequency potentials but no DC component. This reduces the fringing effects of the fields and allows more efficient ion transmission.

3.5 DETECTOR

Ions emerging from the quadrupole are detected using an electron multiplier. An ion from the quadrupole collides with an electrode maintained at high negative potential (dynode) resulting in the release of a pulse of electrons. These are then accelerated towards another electrode where this pulse is amplified. This process is repeated many times so that a measurable current is produced.

In the Varian UltraMass the multiplication process is carried out using a series of separate dynodes ranging from around –2kV to near ground potential. A chain of resistors of equal resistance is connected in parallel with the multiplier. Each link of the chain is connected to an intermediate dynode to provide a stepwise reduction in potential. This type of detector is called a discrete dynode electron multiplier (DDEM) (figure 14).

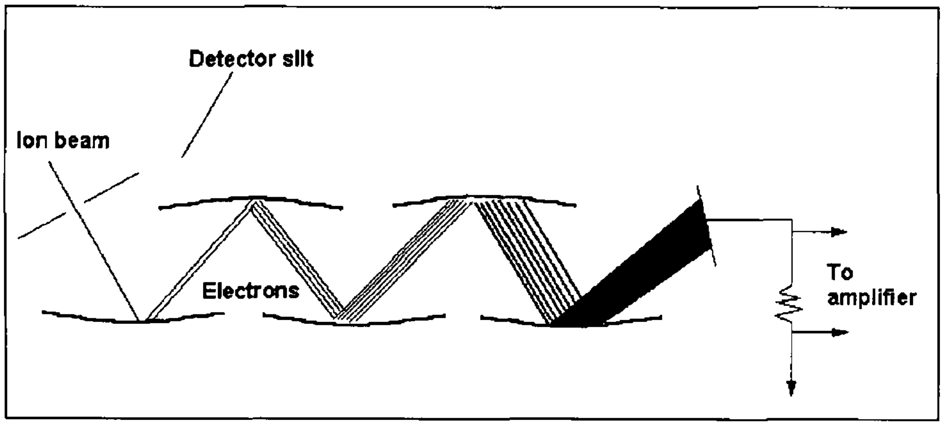


Figure 14 Schematic of a DDEM

Each ion arriving at the detector collides with an electrode at high negative potential to emit a pulse of electrons, which accelerate towards another surface, amplifying the pulse. The process is repeated many times (as in figure 14) so that a small amount of ions reaching the detector result in a measurable pulse in current.

3.5.1 DETECTOR ELECTRONICS

The pulses of electric current that come from the multiplier enter a preamplifier/discriminator module. This component produces an amplified output pulse for every input pulse above a certain pre-set threshold. This therefore discriminates between pulses arising from ion detection and those originating from background noise. The relevant pulses are then sent to pulse counting electronics. The software then represents these as counts per second, which is the method for measuring instrument response. The instrument software uses counts per second to calculate the concentration of analyte in the sample. The instrument response is calibrated with solutions of known concentration.

3.6 INTERFERENCES

The sources of interference that occur in ICP-MS are divided into spectroscopic and non-spectroscopic effects. Non-spectroscopic effects are also known as matrix effects. Spectroscopic interferences can be separated into four types;

3.6.1 ISOBARIC OVERLAP

This occurs when two elements have isotopes of virtually the same atomic mass. The difference is normally so low that the quadrupole mass analyser cannot resolve it. However most elements in the periodic table have one, two or even three isotopes free from isobaric overlap. The exception to this is Indium but this element was not relevant to our study. As a rule of thumb isotopes with odd masses have no overlap and many with even masses are not. There are no isobaric peak interferences below 36m/z. The most abundant (and therefore most sensitive) isotope for Ti (^{48}Ti, 73.7% abundant) overlaps with ^{48}Ca. The degree to which this interference affects the analysis is dependent on the sample matrix and the relative proportions of the elements present.

Ba, La and Ce have an isotope at 138m/z with ^{138}Ba the most abundant. The measurement of ultra trace levels of Ba in a sample would necessitate selection of this isotope. But the concentration of Ba in most samples is much greater than that of either La or Ce and the relative abundance of the138 isotopes of these elements are not very abundant. Therefore ^{138}Ba can be used without correction to the data. But there's a more serious problem with the overlap of ^{204}Pb and ^{204}Hg. ^{204}Pb is the only non-radiogenic isotope of lead so all other isotopes of lead are ratioed back to ^{204}Pb. Therefore accurate measurement of ^{204}Pb is very important. Also mercury is a common contaminant in the acids used for dissolving the analyte. A correction is thus required to account for the contribution of ^{204}Hg to the 204m/z peak for lead. This is done by measuring the amount of ^{201}Hg (12.2% abundant) present and then working out the contribution of ^{204}Hg to the ^{204}Pb peak:

$$^{204}Pb = 204_{integral} - (201_{integral} / 12.2) \times 6.8) \qquad (2)$$

This principle can be used to correct for any isobaric overlap by substitution of the appropriate factor values. However there's a need for another easily measurable isotope of the interfering element available to correct this phenomenon against. There's always a certain degree of error involved in the measurement when corrections are used. Obviously, different matrices present their own problems with regard to isobaric overlap but there are also a number of overlaps with the plasma gas Ar, and with impurities present in it such as Kr and Xe. The majority of ions in the in the plasma are ^{40}Ar (99.6%), therefore correction for the overlap of this isotope with ^{40}K(0.01%) and ^{40}Ca(96.9%) can't be made. This is because the peak at 40m/z is always saturated. Although levels of Kr and Xe are low, levels of Kr can vary depending on the purity of the argon and the liquid level of the argon in the tank. Kr has an isobaric overlap with ^{84}Sr and ^{88}Sr, which can cause problems with measurements of Sr isotope ratios. Kr also has an isobaric overlap with the three most abundant isotopes of Se.

3.6.2 POLYATOMIC IONS

Polyatomic ions are formed when one or species combine briefly in the plasma stream. The major contributors are argon, oxygen and hydrogen and these may combine with each other or with elements from the analyte. Elements such as N, S and Cl, which are present in the acids used for sample preparation also become involved. Fast ion molecule reactions can occur even though the composition of the gas extracted from the plasma stabilises about 1μs after leaving the plasma. The nature of the acid and sample matrix is the most important factor in limiting the formation of polyatomic ions. The formation of polyatomic ion peaks is also only significant up to 82m/z.

Deionised water is considered the ideal matrix. It has polyatomic ion peaks at 80 m/z (for $^{40}Ar^{40}Ar$), the small $^{40}Ar^{36}Ar$ peak at 76m/z and peaks of equal size for $^{40}Ar^{16}O$ and $^{40}Ar^{1}H_2$ at 56 and 42m/z, respectively. There are also small peaks at 57m/z($^{40}Ar^{16}O^{1}H$) and 44m/z ($^{12}C^{16}O_2$).

This is obviously a very simple plot with very few interfering polyatomic ion molecules. Matrices of this simplicity are rare but this plot demonstrates the need to choose the right solvent for the acid digestion step involved in processing our wood samples. The polyatomic ion peaks in the mass spectrum for HNO_3 are identical to those for deionised water and so HNO_3 is considered an ideal matrix. The most significant interferences from polyatomic ion peaks come from the isotopes of H, C, N, O, S, Cl and Ar. Therefore the digestion method for our wood samples used nitric acid as the primary acid in the digestion step. Our method also involved the use of a small amount of 50: 50 HCl: water v/v, and hydrochloric acid is definitely not considered an ideal matrix. But the amount of

HCl used in the digestion mixture did not introduce any significant interferences into the analysis because due to the use of a small amount of a small amount of high purity acid. The effect of polyatomic ion interferences in complex matrices can be minimised by modifying the operating conditions of the ICP. One can modify several conditions but the most important are RF forward power and nebuliser flow rate. The goal of the analyst is to set the instrument up so that the analyte response is at a maximum while keeping the sensitivity to ArO^+, ClO^+ and $ArAr^+$ at a minimum. By choosing an appropriate nebuliser flow rate it's possible to achieve this at several different RF power settings, a very useful feature for multi-element analysis. Limiting the amount of water vapour reaching the plasma stream can also reduce polyatomic ion interferences. This is because many of these interferences are caused by ions that contain O and H.

3.6.3 REFRACTORY OXIDES

Another common but less serious source of interference is the formation of refractory oxide ions. They occur 16, 32 or 48 mass units above the molecular ion peak and result from incomplete dissociation or recombination in the plasma tail. Usually the relative level of oxides can be predicted from the monoxide bond strength of the element involved. Those with the highest bond strength will give the highest yield of refractory oxides (MO^+). The levels of oxide species are quoted with respect to the elemental peak (MO^+/M^+). Table 2 presents bond strengths and levels of oxide species typically formed, given as the ratio of the oxide ion (MO^+) to the elemental ion M^+. As one can see the levels of oxides don't go above 1.3 % even for Ce. Plasma operating conditions influence the formation of oxide ions. For example, the nebuliser gas flow rate controls the position along the axis where dissociation is complete. This point is usually kept well ahead of the position at which ions are extracted, but if the flow rate is increased this reduces the amount of time the ions spend in the plasma and moves the point at which full dissociation occurs further along the axis. Therefore at the sampling point full dissociation may not have been achieved.

Element	Bond strength (kJ/mol)	MO^+/M^+
Co	368	1.7×10^{-5}
Pb	409	1.2×10^{-5}
Fe	427	1.1×10^{-5}
Cr	512	3.6×10^{-5}
Al	563	1.1×10^{-5}
P	607	3.7×10^{-3}
Mo	619	9.5×10^{-4}
Ti	760	1.8×10^{-3}
Ce	795	1.3×10^{-2}
Si	799	1.5×10^{-3}

Table 2 Relationship between bond strength and formation of metal oxides

3.6.4 DOUBLY CHARGED IONS

Most ions produced in the ICP are singly charged but multiply charged species can also occur. The second ionisation energy of an element, along with the condition of the plasma equilibrium determines the extent of formation of doubly charged ions. Only elements with second ionisation energies lower than the first ionisation energy of argon will undergo a significant amount of 2+ formation. These include alkaline earths, some transition metals and the rare earth elements. Once again, nebuliser flow rate is the deciding factor in the formation of these species. At low flow rates the temperature of the plasma increases. This produces higher yields of doubly charged ions. The formation of these species has two effects. The presence of these species results in a small loss of signal and therefore a reduction in sensitivity for the singly charged species but more importantly they create a number of isotopic overlaps at one half the mass of the parent element. Therefore sometimes an alternative isotope can be selected to get around this problem. However, if there are none available, one has to make do with interference corrections.

3.6.5 NON-SPECTROSCOPIC INTERFERENCES

This group of interferences encompass physical effects resulting from solids in a solution, and analyte suppression or enhancement effects. Physical effects are well studied and understood but analyte suppression or enhancement effects are more complex and tend to be instrument specific. Therefore this discussion will be restricted to the former. A high concentration of dissolved solids present in a solution is not conducive to obtaining good results. These solids cause a high signal drift over a short period of time. Basically the signal decreases rapidly at the beginning of a run. This is because these solids probably become deposited on the aperture of the sampling cone, reducing the diameter of the sampling aperture. This reduction in diameter would also affect the extraction process as well as the number of ions entering the ICP-MS.

However there is something the analyst can do to alleviate this problem. In most cases the decrease in signal occurs during the first twenty minutes of the run. Therefore we can prime the system to avoid a reduction in signal. A solution of similar composition to the unknown solution should be aspirated for approximately twenty minutes prior to the start of the run, and signal loss is reduced during the beginning of the run. Thus quantitative determination can be made as soon as a steady state is reached.

3.7 INSTRUMENT PARAMETERS

Standard operating conditions were used for most metals analysed. Cool plasma conditions were used to measure Ca, Mg, K and Na. They were also used to measure Fe due to interference from ArO under normal conditions. Typical standard and cool plasma operating condition used are summarised in Table 3.

Calibration was carried out using working standards prepared from pre-mixed Merck multi-element standard IV for ICP. Standards were in the range 10-500ppb for normal operating conditions and 50-1000ppb for cool plasma conditions. The ICP-MS software used linear calibration curves to calculate individual element concentrations.

A preparation blank (Milli-Q water/1% v/v Aristar Grade HNO_3) and two different quality control standards representing low and high level concentrations of trace elements were analysed with each set of samples. The quality control standards were purchased from Promochem UK and a 10% dilution with Milli-Q water was carried out on each standard before analysis. The certified values were entered into the analytical method and any result outside ± 10% was automatically flagged.

On analysis, five replicate determinations were made of each sample and the ICP-MS software reported a mean concentration. Calculation of element concentrations were based on prior calibration equations and correction for internal standard and dilution was carried out automatically by the instrument software.

	Normal Conditions	**Cool Plasma Conditions** (Fe, Ca, Mg, K & Na)
RF Power:	1.28kW	0.7kW
Plasma flow:	17.0 L/min	18.0 L/min
Auxiliary flow:	1.05 L/min	1.00 L/min
Nebuliser flow:	0.95 L/min	1.22 L/min
Sample uptake:	1ml/min	0.8ml/min

Table 3 ICP-MS operating conditions

3.8 SAMPLE PREPARATION

The fundamentals of the following wet digestion method are described by Hall [55]. This method of preparing the wood for digestion is followed (most notably the use of a scalpel cleaned in acetone). The relevant sample size (10-100mg wood) was adopted but it was felt at this stage that H_2SO_4 might more easily digest the extremely hard bog oak.

3.8.1 Q8001A

- Circa 50mg of wood shavings were removed from each region of the sample using a scalpel, which had been washed in acetone. The sample from each region represented a cross-section through the wood.
- The dark brown shavings were transferred to a glass vial and 2ml conc. analar H_2SO_4 was added.
- The sample was boiled in H_2SO_4 for 20 min with the periodic addition of 32% analar hydrogen peroxide until the wood dissolved. While boiling, copious amounts of brown gases evolved from the solution. About 1ml in total was added.
- The vial and the light brown digest were allowed to cool down and the digest transferred to a polycarbonate vial.
- The sample was then diluted to 14ml with deionised water to form a colourless solution. This provided enough volume to aspirate through the instrument.
- All glassware had been pre-washed in nitric acid for 24 hours.

Following the promising results obtained from the study of Q8001A, it was not noted that sulphuric acid exhibits strong matrix suppression effects (see page 54) and the sample preparation procedure was changed to a dry ash. The final ashing temperature is typically 575 ± 25°C [56]. The method was developed and refined based on factors mentioned by Jorhem [54]. The most advantageous feature of a dry ash procedure is the ability to determine very low concentrations of elements because one can dissolve a large amount of ash in a small amount of acid. Thus 500mg of wood can be dissolved in 10ml with a dry ash while only 50mg of wood was dissolved in 14 ml using a wet digestion.

3.8.2 Q1921, Q2030 AND Q1932

- Circa 0.5g of drilled sample was weighed into an acid-washed porcelain basin.
- The sample was ashed at 550° C for two hours in a muffle furnace.
- The resultant ash was allowed to cool then 5 mL of concentrated analar HCl was added. The solution was covered with a clock glass and heated on a steam bath for fifteen minutes.
- One mL HNO_3 was added and the solution was evaporated to dryness and heated for a further hour to dehydrate silica.
- One mL HCl was then added to dissolve the residue.
- The solution was made up to 10 mL with 18M water.

The dry ash procedure used above was very simple and it was deemed unsuitable to proceed with this method. The results obtained from the analysis were very erratic and this thought to be due to inconsistent heating during the ashing procedure. If the temperature is ramped too quickly hot spots can arise. This results in violent ignition of the sample and the possibility of losing some material [54]. Thus an ashing procedure with a slower ramp was employed.

3.8.3 Q8001B AND Q9779

- 0.5g of a sample of drill dust from each section was ashed in an acid washed crucible. A manual temperature program was used as a sharp increase in temperature in the oven might cause a violent ignition of the wood resulting in a loss of elements e.g. Cd and Pb which are more volatile around 500°C. Therefore the following temperature program was followed;
- One hour at 150°C, one hour at 250°C, one hour at 400°C and then overnight at 550°C.
- 2mL of Aristar (Merck Suprapur) grade HCl was added to the crucible to dissolve the dust and the resultant yellow solution was boiled on a hot plate for 15 mins.
- 1mL of Aristar (Merck Suprapur) grade HNO_3 was added and the solution was allowed to evaporate to dryness using a low heat on hot plate.
- The dark brown residue was heated for a further hour to dehydrate silica.

  1mL of 1+1 HCl (50:50 HCl: water v/v) was added to dissolve the residue. Some Milli-Q water (18 M) was added and the solution transferred to a polycarbonate vial. The solution was then made up to 10mL using Milli-Q water.

Chapter 4 Experimental & Results

The methods used for sampling and sample processing evolved and were refined during the course of the project. This was a consequence of trying to eliminate any interference effects from chemicals used during the digestion procedure and to reduce the amount of particulate present in the digest. As mentioned before, ICP instruments react adversely to solutions with a high degree of dissolved solids. Though it is possible to reduce the effect of these solids it is also wise to try to eliminate them as much as possible. The first analysis carried out on our bog oak samples involved the use of a H_2SO_4 digestion step, which although yielded interesting results, was deemed unsuitable because the sulphuric acid exhibited strong matrix suppression effects. Sulphuric acid also gives more polyatomic ion peaks, restricting the choice of isotope to be used for a given element. Also, using only a wet digestion step would not eliminate the organic species present in wood, leading to a higher probability of refractory oxides being formed. The precision for the results obtained was also quite poor so it was decided to pursue a dry ash stage followed by an acid digestion step using nitric acid and a small amount of hydrochloric acid. Nitric acid has polyatomic ion peaks identical to deionised water and is considered an ideal matrix.

The following is the data from the first sample of bog oak analysed using the sulphuric acid digestion method. This sample was collected from Garry Bog in Co. Antrim, as where all subsequent samples.

4.1 Q8001A

The sample (Figure 15) was divided up into six regions corresponding to different time periods. The section of most interest was section B as it corresponded to the time period attributed to the eruption. However section D was also an area of very low growth, preceding the occurrence of the volcanic event.

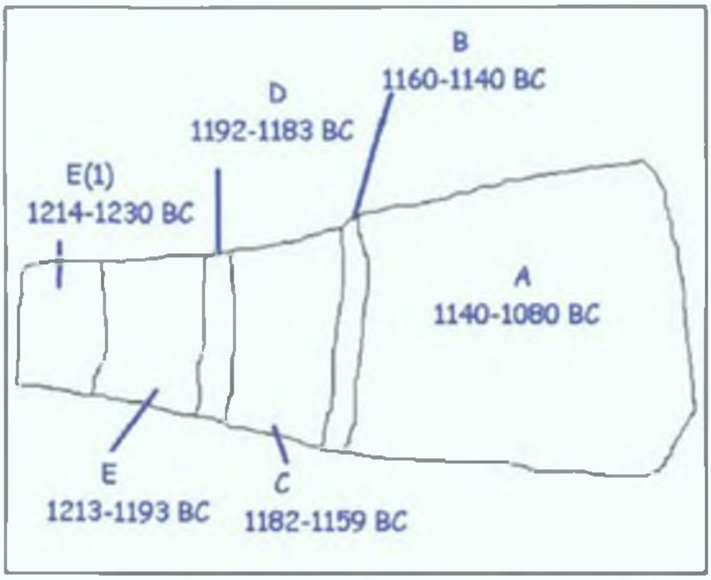


Figure 15 Outline diagram of how Q8001A was divided up

Section	Dates	Comments
A	1140-1080 BC	Relatively wide, normal growth rings
B	1160-1140 BC	Region of interest straddling eruption, almost no early growth
C	1182-1159 BC	Relatively wide, normal growth rings
D	1192-1183 BC	Very narrow growth rings, also of interest
E	1213-1193 BC	Heartwood
E (1)	1214-1230 BC	Heartwood

Table 4 Description of sections and dates for Q8001

There was a strong increase in concentration for nearly every element investigated in these samples within the time period during which the eruption of Hekla 3 took place. This was a very striking pattern, as can be seen below:

4.1.1 PLOTS SHOWING ELEMENTAL PATTERNS FOR Q8001A

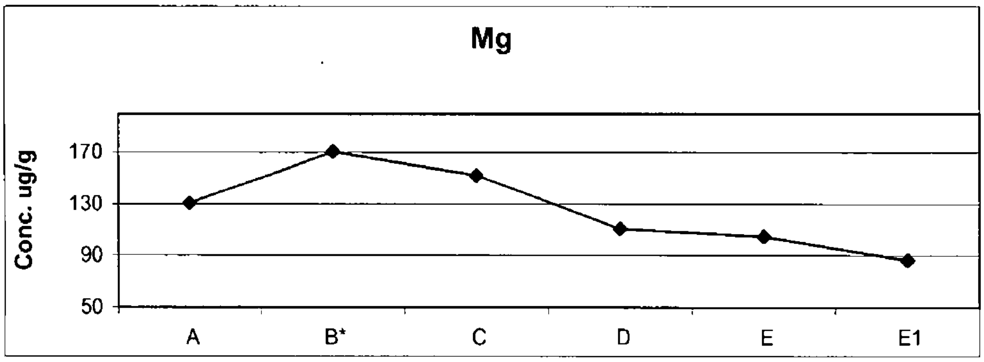


Figure 16 Uptake pattern for Mg (region A being the most recent growth)

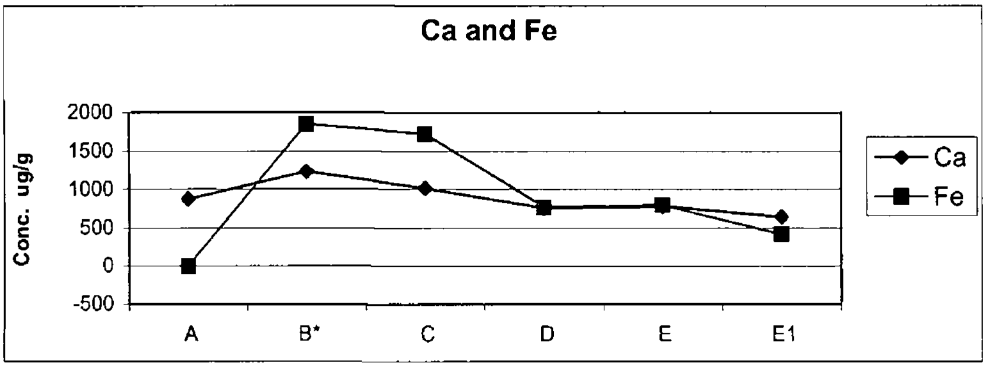


Figure 17 Comparison of uptake patterns for Ca and Fe

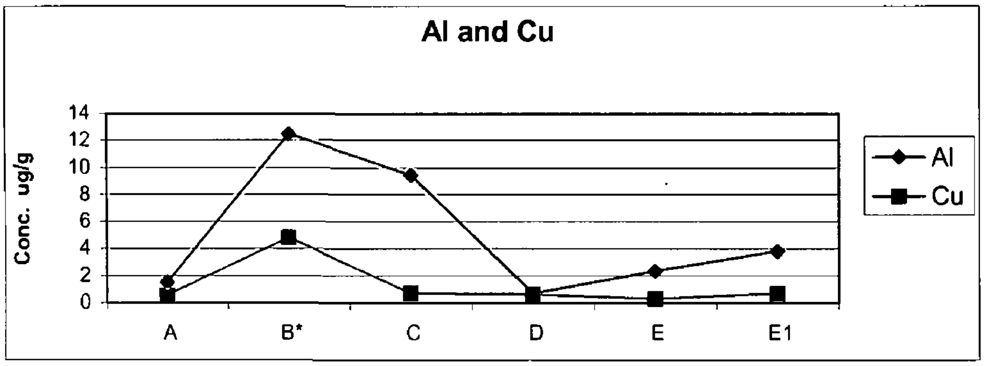


Figure 18 Comparison of uptake patterns for Al and Cu

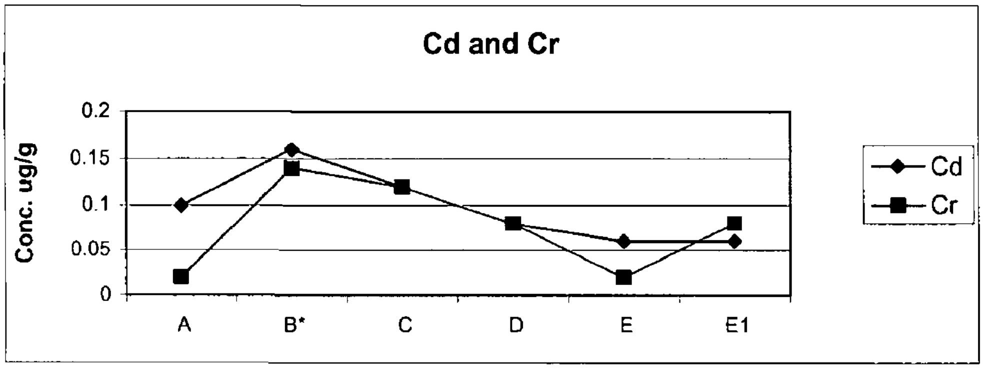


Figure 19 Comparison of uptake patterns for Cr and Cd

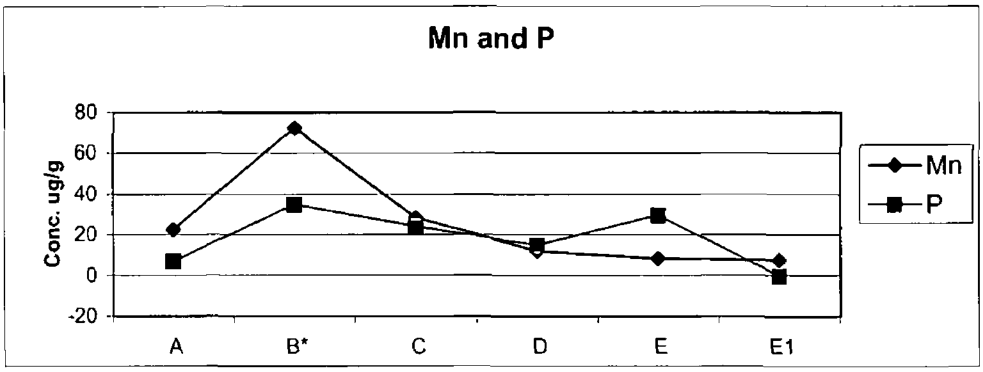


Figure 20 Comparison of uptake patterns for Mn and P

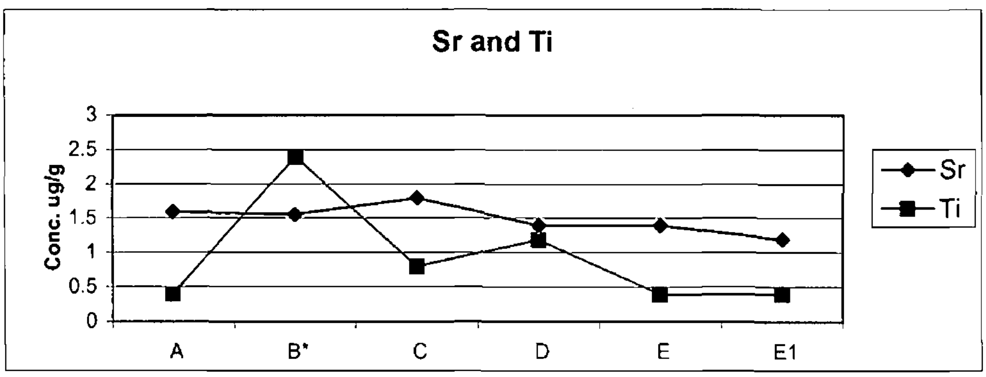


Figure 21 Comparison of uptake patterns for Sr and Ti

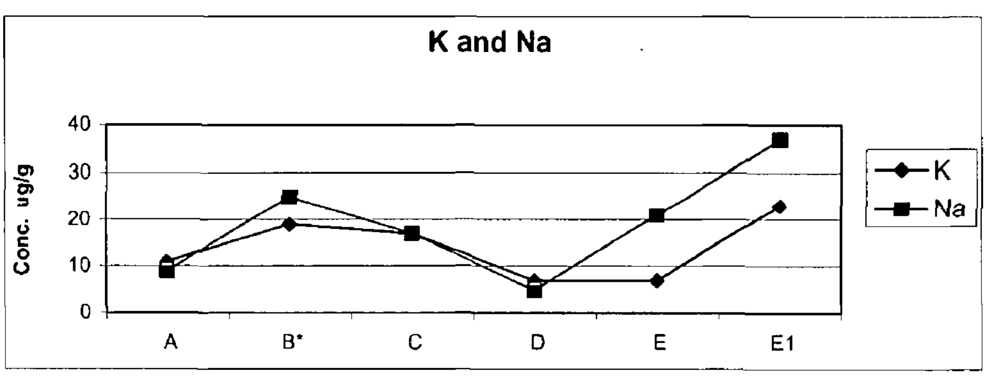


Figure 22 Comparison of uptake patterns for K and Na

The plots detailed above show some anomalous increases in the concentrations of certain elements during the period of growth with the narrowest rings (Table 4). A lot of these elements would not easily translocate in the tree (see Table 1) so elevated levels of these elements such as Cu, Fe,Sr, Mn and Cd could be seen as real evidence that something unusual was going on.

4.2 Q2030, Q 1932 AND 1921

Following these encouraging trends from the first tree sampled, it was decided to see if the same trends hold true for a broader sample of bog oak of this age. We wanted to see if all these elements were really as immobile in the plant tissue as the results implied. Research suggested, as mentioned in chapter 1, that not all elements are equally mobile laterally, or for that matter axially in the trunk of the tree. If some elements are more mobile than others, we might expect some to accumulate in the outer edges of the trunk in the sapwood. If a significant increase in the uptake of these elements occurred in one year we would not be able to quantify as these elements would migrate radially through the tree making it appear that the increase occurred in the last years of the tree's life. The only way to determine the true uptake of these elements in any given year would be to sample the ring in the year of its growth. Clearly this is impossible therefore we are more interested in the heavy, and less mobile elements e.g. Cu (figure 18) which might show a spike in concentration in a given time period because they tend to be trapped in those growth rings.

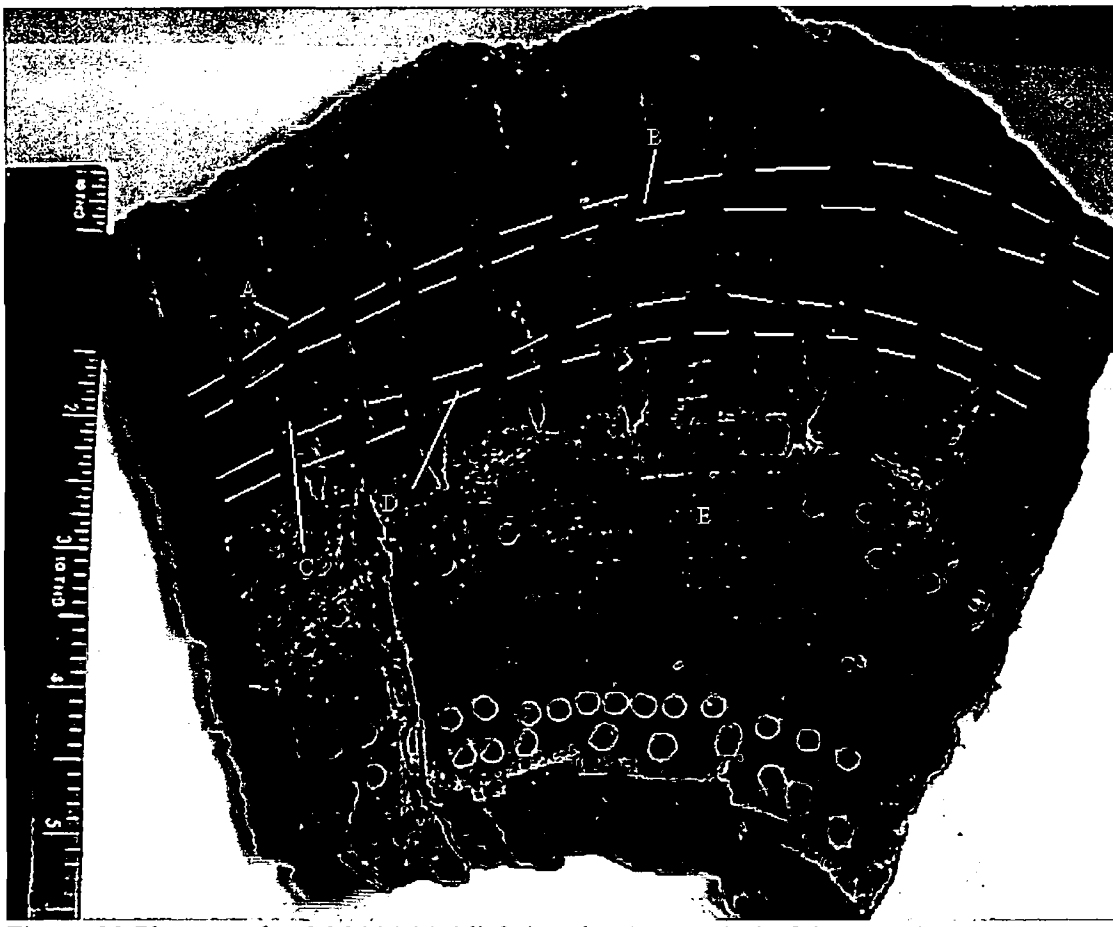


Figure 23 Photograph of Q2030 highlighting the time period of the eruption.

Three trees taken from Garry Bog in Co. Antrim were selected and sampled. The samples corresponded to the same time periods as those analysed for the first sample.

Section	Dates	Comments
A	1140-1060 BC	Relatively wide, normal growth rings
B	1160-1140 BC	Region of interest straddling eruption, almost no early year growth
C	1182-1159 BC	Relatively wide, normal growth rings
D	1192-1183 BC	Relatively wide, normal growth rings
E	1213-1193 BC	Heartwood

Table 5 Description of Q2030

4.2.1 PLOTS SHOWING ELEMENTAL PATTERNS IN Q2030, Q1932 AND Q1921

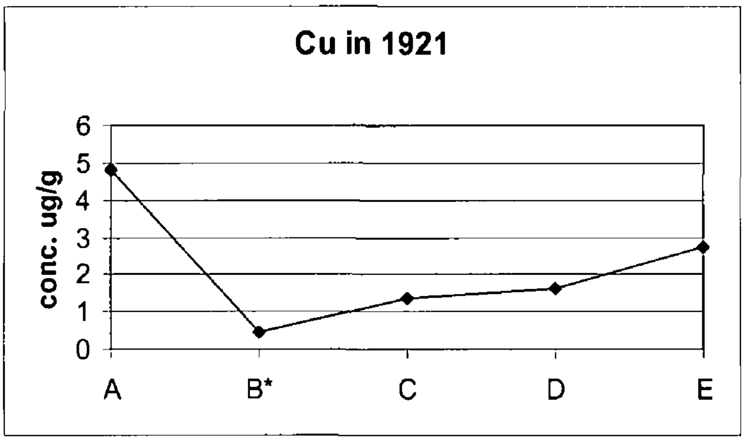


Figure 24

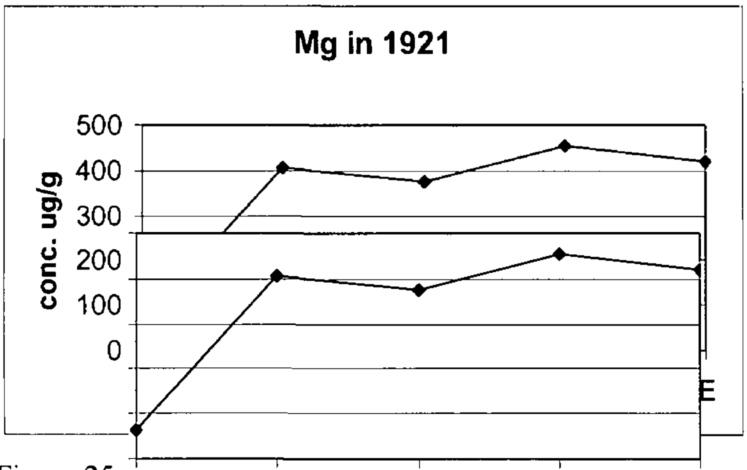


Figure 25

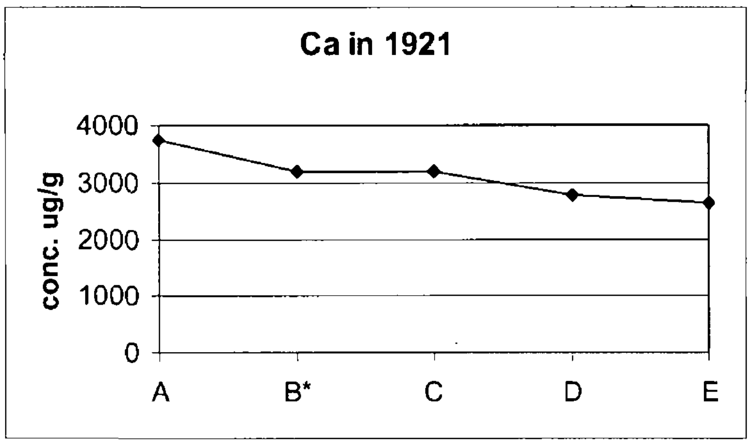


Figure 26

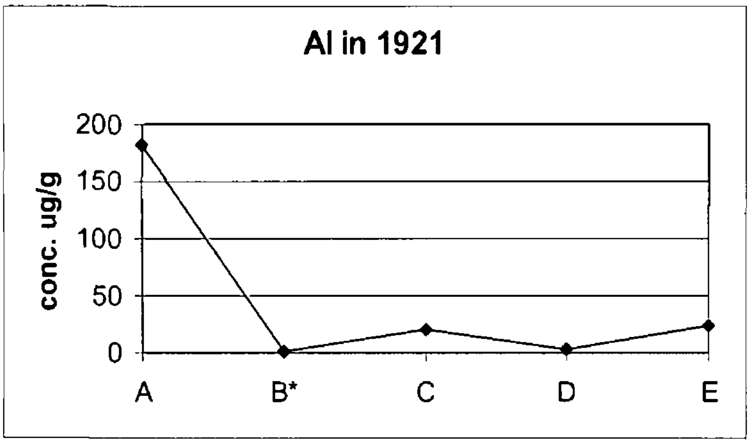


Figure 27

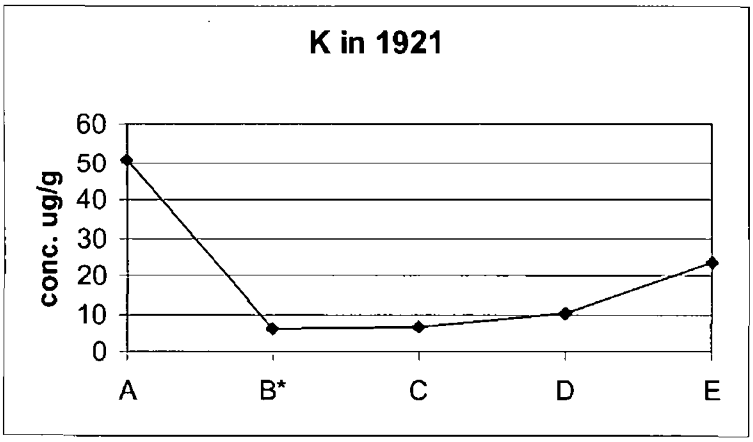


Figure 28

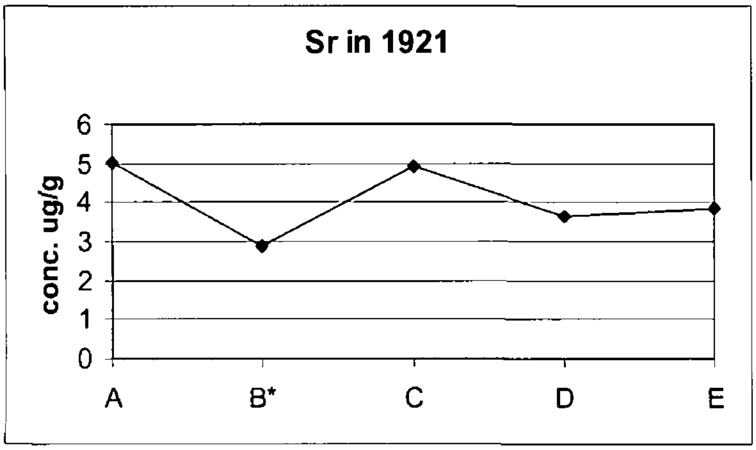


Figure 29

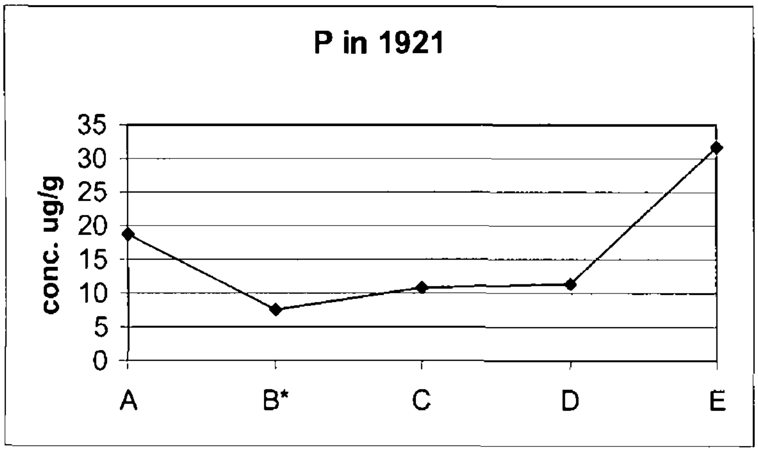


Figure 30

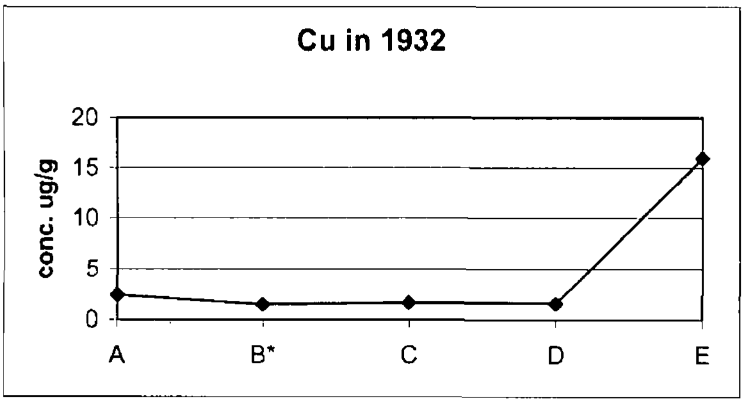


Figure 31

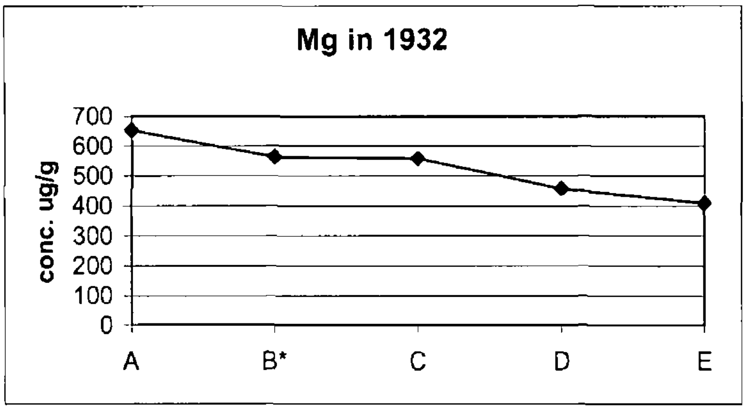


Figure 32

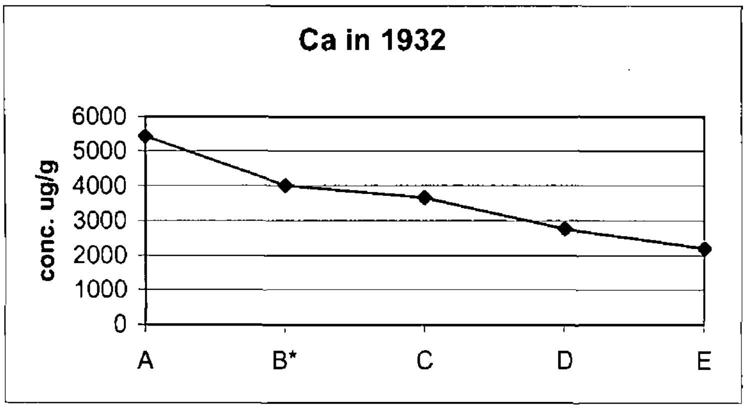


Figure 33

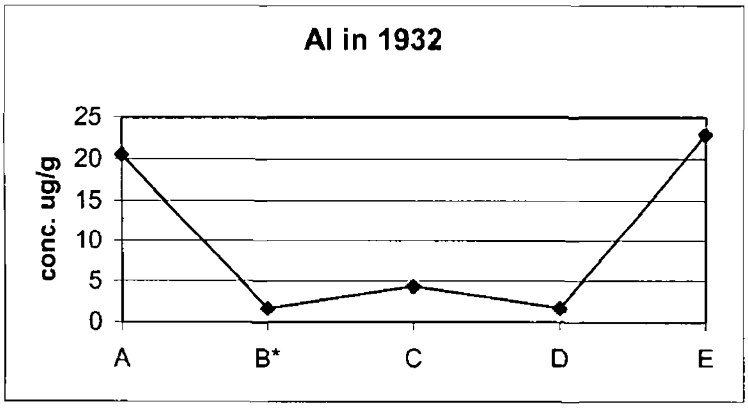


Figure 34

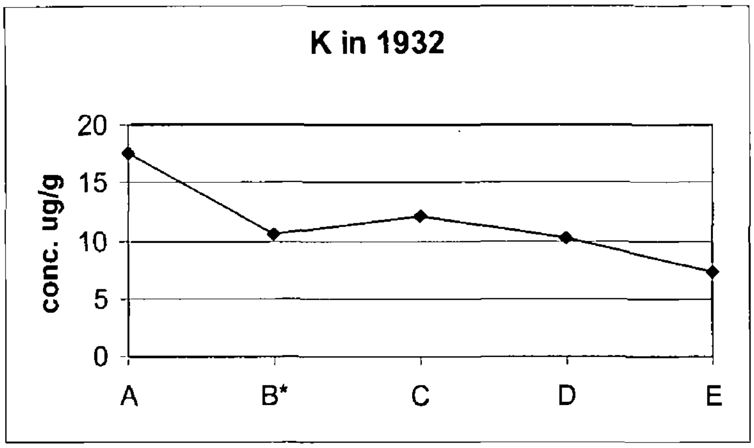


Figure 35

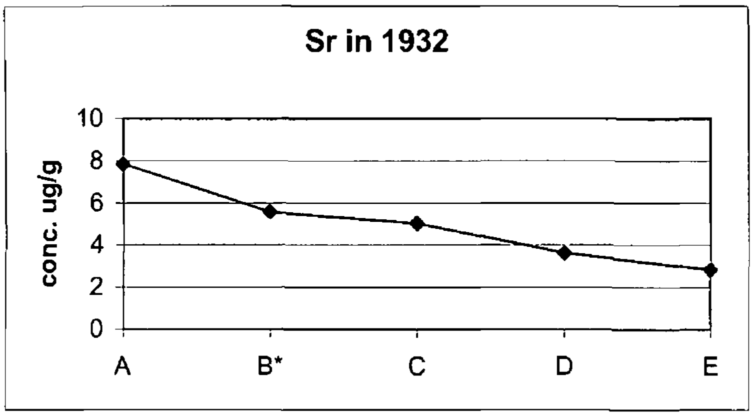


Figure 36

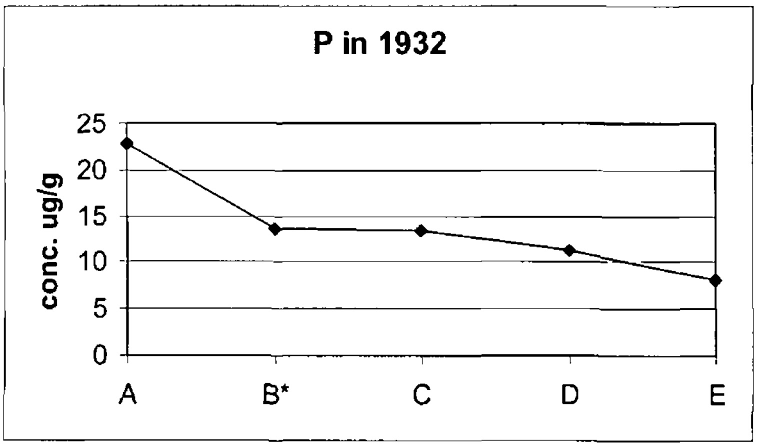


Figure 37

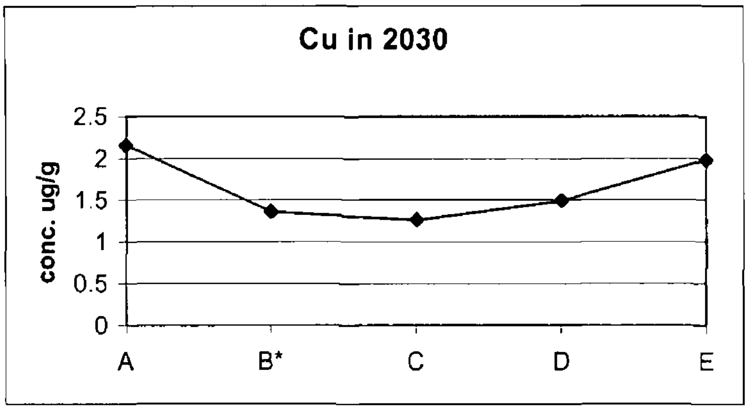


Figure 38

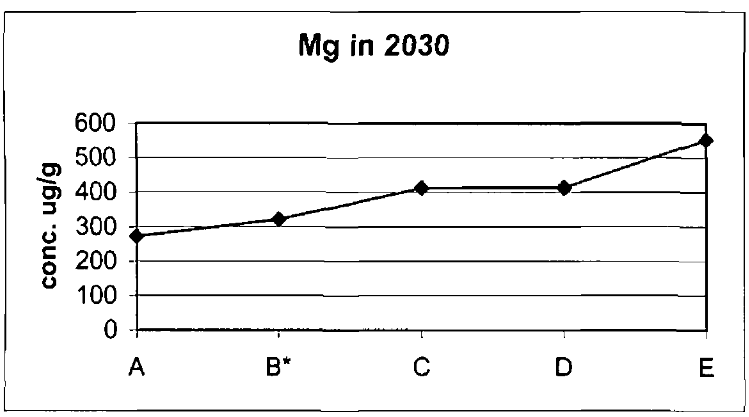


Figure 39

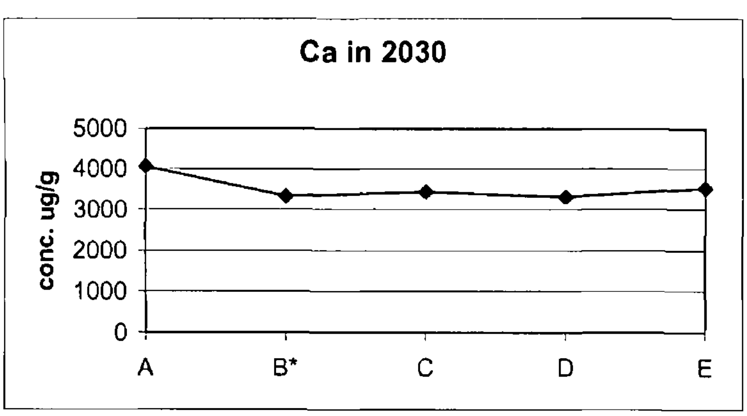


Figure 40

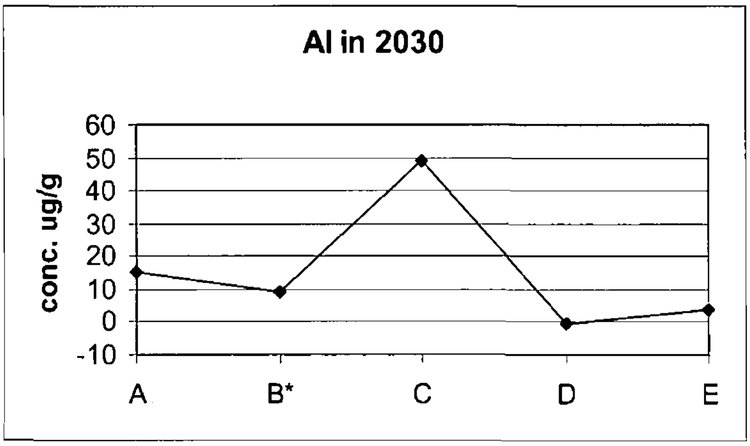


Figure 41

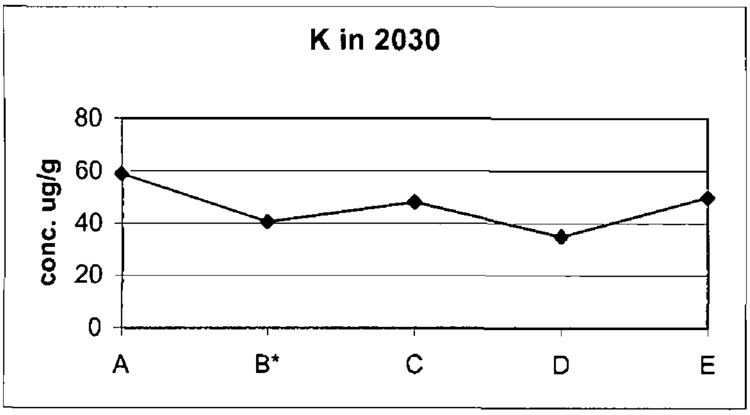


Figure 42

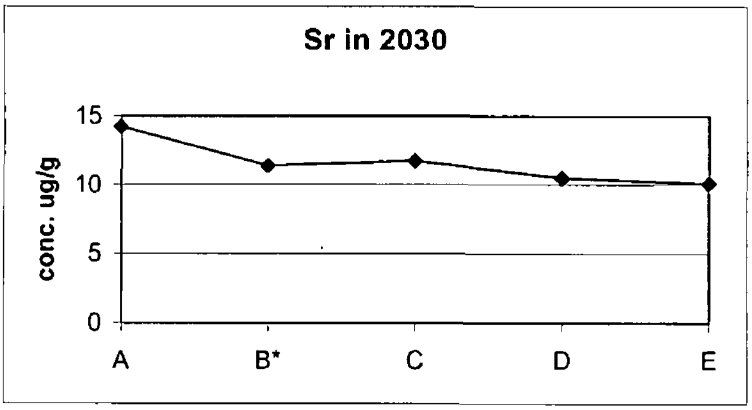


Figure 43

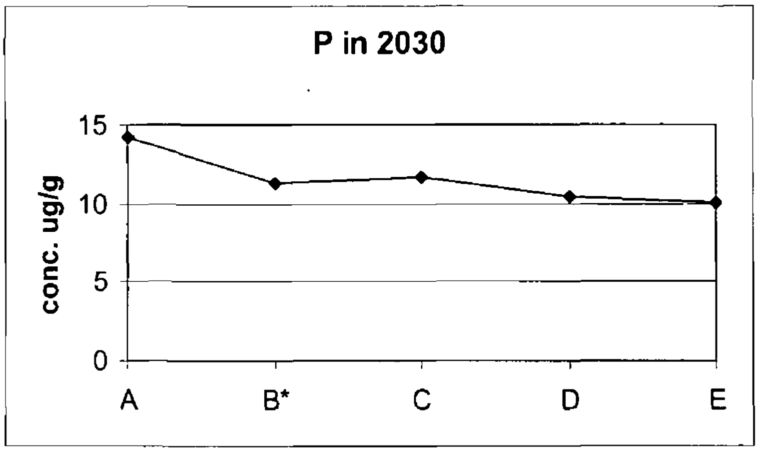


Figure 44

As one can see from the results detailed above (figures 24-44) the pattern of elemental uptake shown in sample Q8001 was not repeated when a broader sample of trees was analysed. Is this because a broader sample shows that there is no increase in elemental uptake correlating with reduced growth rings? Or could it be due to the fact that the sample preparation for these trees is so different to that of the first tree? One must note that the ashing procedure of two hours at 550° C may be quite harsh. It is known that Pb and Cr are volatile above 400° C and this is the reason why these elements aren't included. It was my opinion that a sharp rise in temperature may have resulted in the material catching fire quickly rather than a slower degradation and ashing effect. This could perhaps result in the sudden loss of material from the crucible and this could explain the randomness of the results. Vaporisation or sublimation of some elements may also take place [17], [54].

After all if there were bias in the results obtained from Q8001 due to the sampling procedure this bias would affect every section of the tree, not just section B. This bias would affect the accurate quantitation of elements present but would not affect the pattern.

Therefore it was decided to proceed with a slower programmed rise in temperature for the next samples to be analysed. In this way it was hoped that any sudden ignition of the sample could be avoided.

4.3 Q8001B

Since there was more material from Q8001 available it was decided to analyse this using the programmed ashing method to determine whether the results obtained would be comparable to the wet digestion method.

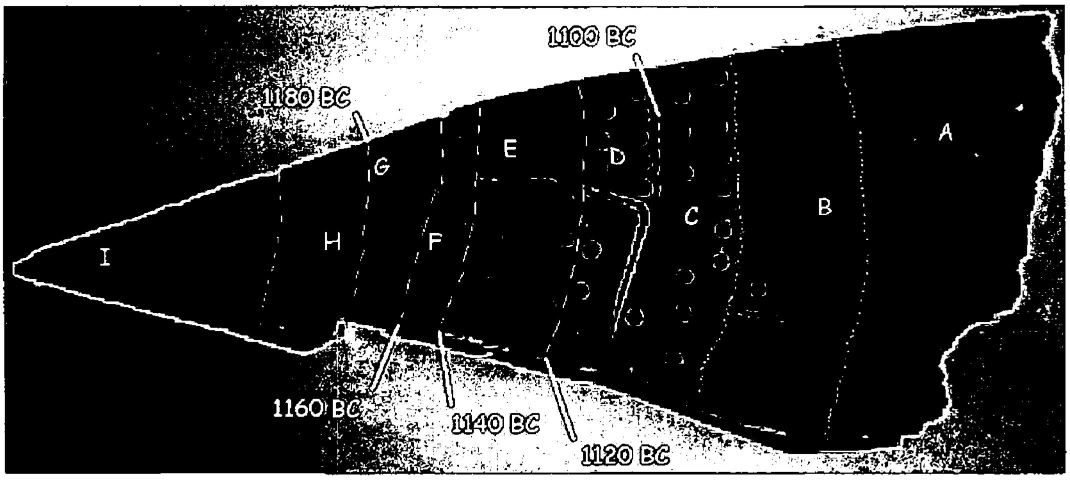


Figure 45 Sectional diagram of Q8001

Section	Dates	Comments
A B C D E	1140-1060 BC	Relatively wide, normal growth rings
F	1160-1140 BC	Region of interest straddling eruption, almost no early year growth
G	1183-1160 BC	Relatively wide, normal growth rings
H	1192-1183 BC	Relatively narrow growth rings, noteworthy but not of primary interest
I	1210- ca.1195 BC	Relatively wide, normal growth rings

Table 6 Descriptions and dates for Q8001

4.3.1 PLOTS SHOWING ELEMENTAL PATTERNS ACROSS SECTIONS IN Q8001B

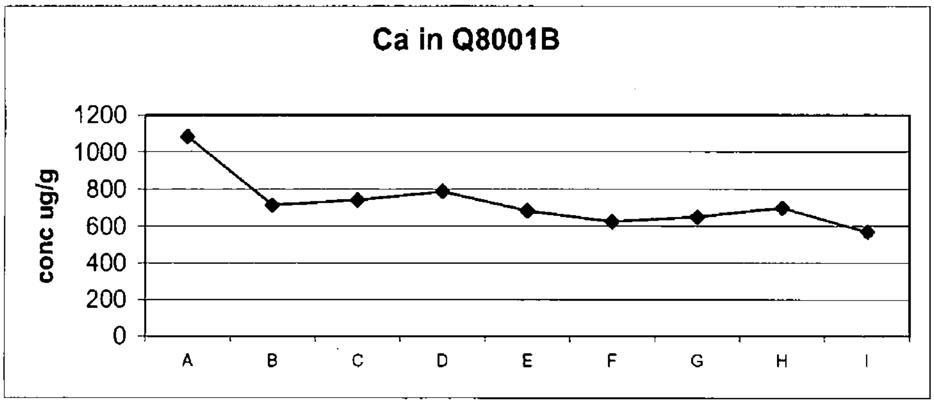


Figure 46

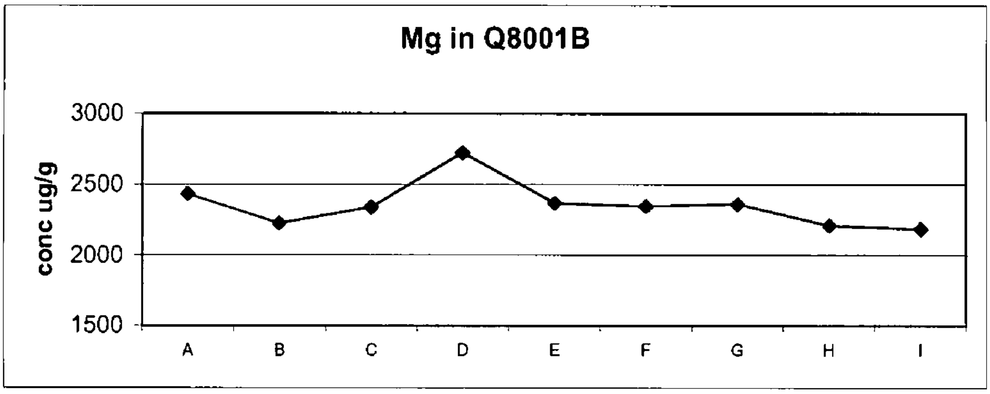


Figure 47

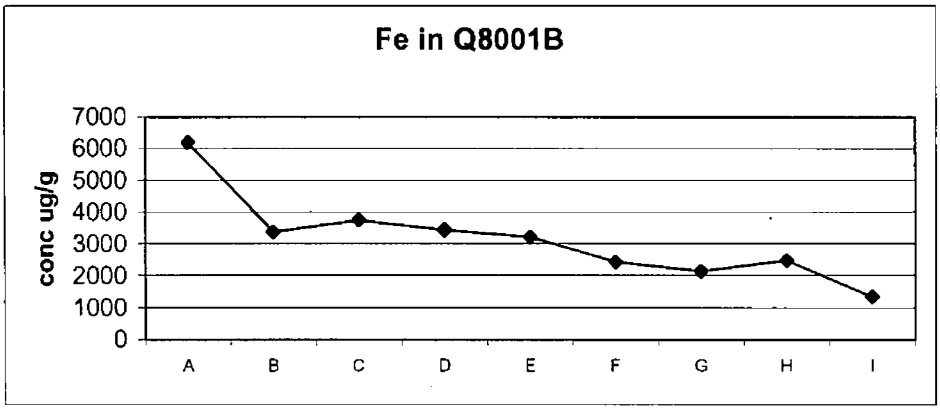


Figure 48

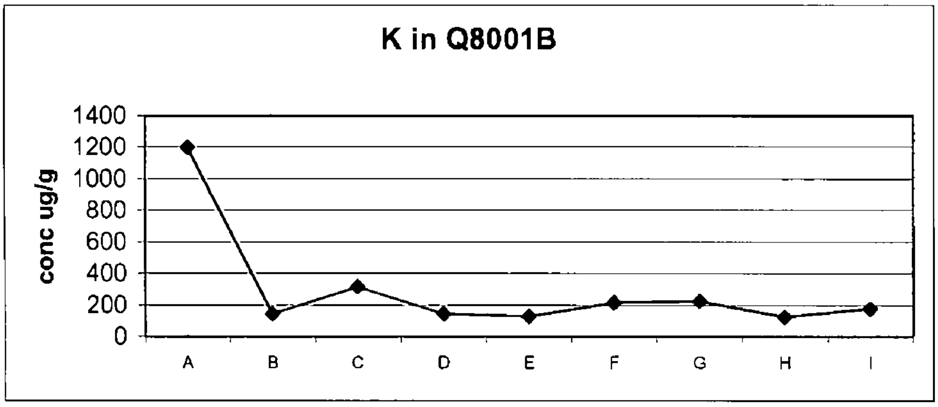


Figure 49

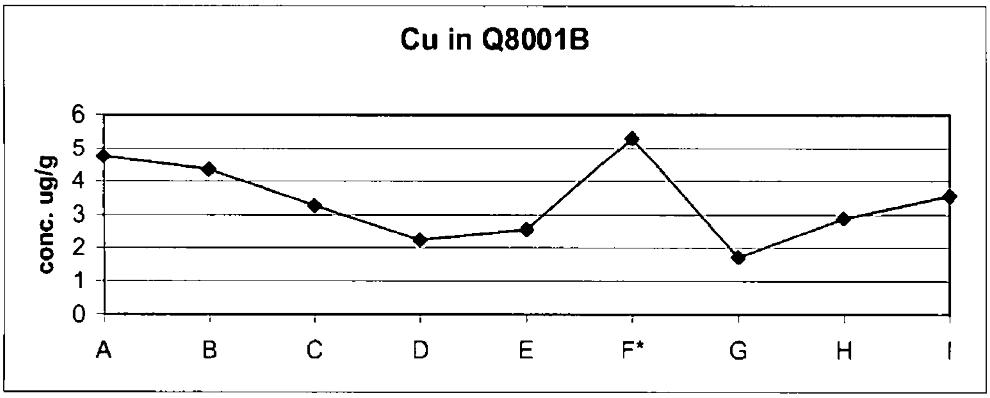


Figure 50

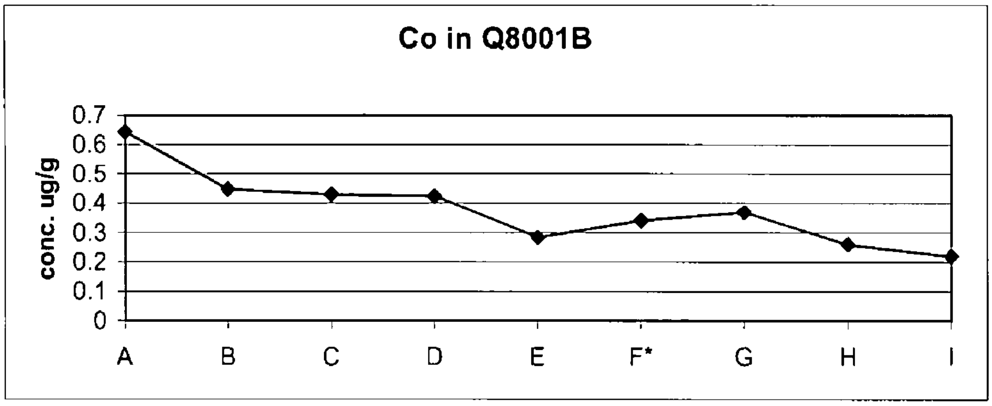


Figure 51

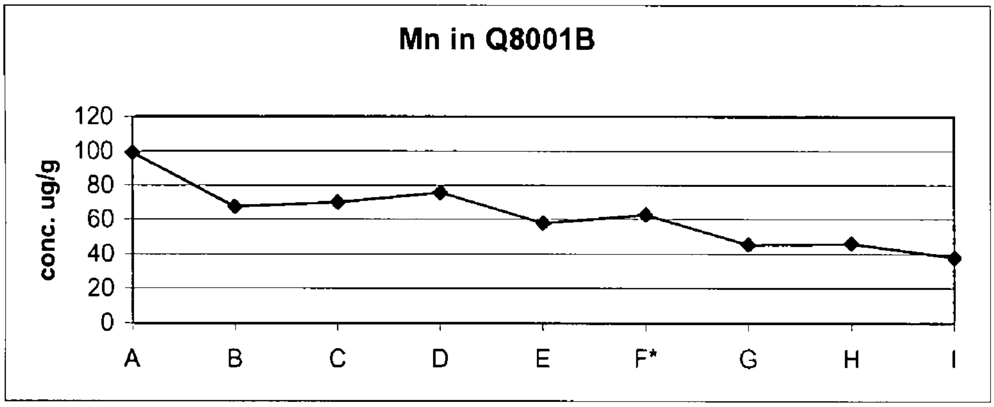


Figure 52

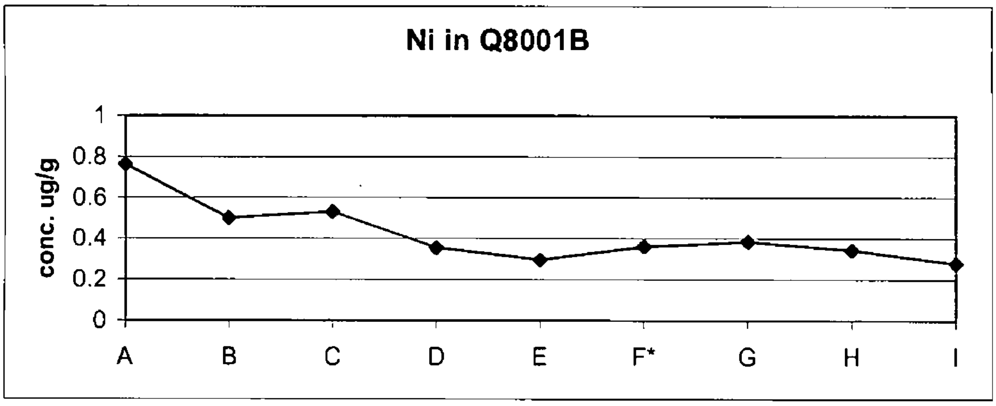


Figure 53

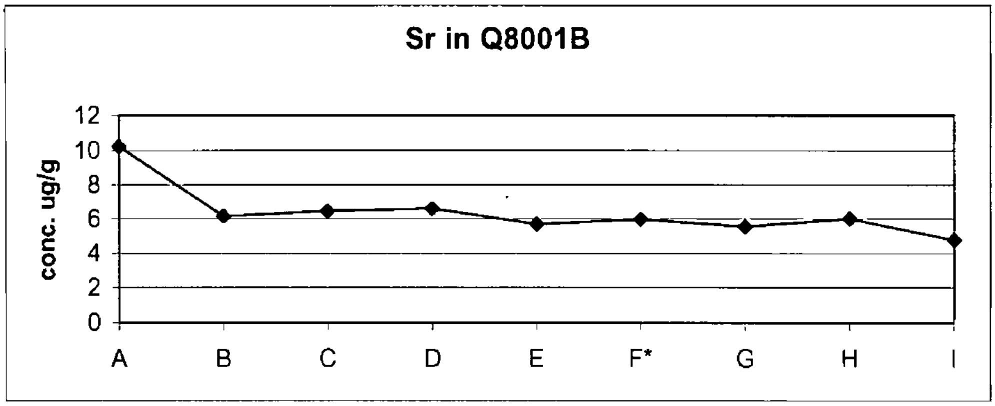


Figure 54

Yet again the pattern of increased uptake for all elements in the region with the narrowest rings fails to appear. Note that the level of elemental uptake in almost all cases is greatest in section A, which is the latest year of growth of the tree. The only exceptions are Mg (figure 47) and Cu (figure 50). In the case of Cu the region that is most elevated is that with the narrowest growth rings. This is a very important result as it is the only element that follows the pattern in Q8001A (figure 18).

One can definitely say the variability in results using the fast ashing procedure is not present here. The overriding pattern is that of a slow rise in elemental concentrations peaking in the last years of the tree's life.

4.4 Q9779

Figure 55 Cross-sectional diagram of Q9779

Section	Dates	Comments
A1 A2 A3 A4	1140-1060 BC	Relatively wide, normal growth rings
B	1160-1140 BC	Region of interest straddling eruption, almost no early year growth
C	1183-1160 BC	Relatively wide, normal growth rings
D	1192-1183 BC	Relatively narrow growth rings, noteworthy but not of primary interest
E	1210- ca.1195 BC	Relatively wide, normal growth rings
F	Not sampled	Heartwood

Table 7 Description of sections and dates for Q9779.

The slow ashing procedure used for the previous sample was once again used. Since this method is thought to avoid ignition of the sample in the crucible it was deemed appropriate to prepare samples in this manner in order to determine if this slow rise in elemental concentrations toward the end of the life of the tree was reproducible. We were also interested in leaning the elevated level of Cu in the narrowest rings would occur again. If this sample showed the same pattern as the previous one (using the same sample preparation) we would at least have two sets of data that were telling the same story.

4.4.1 PLOTS SHOWING ELEMENTAL PATTERNS IN Q9779

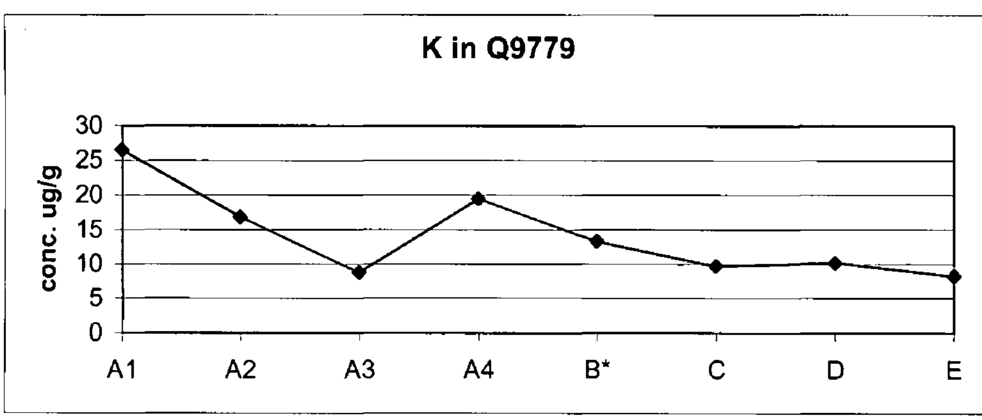


Figure 56

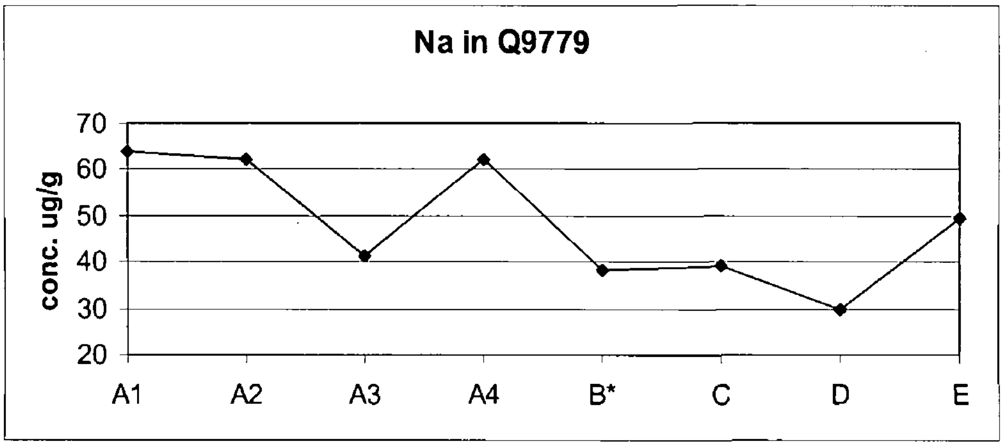


Figure 57

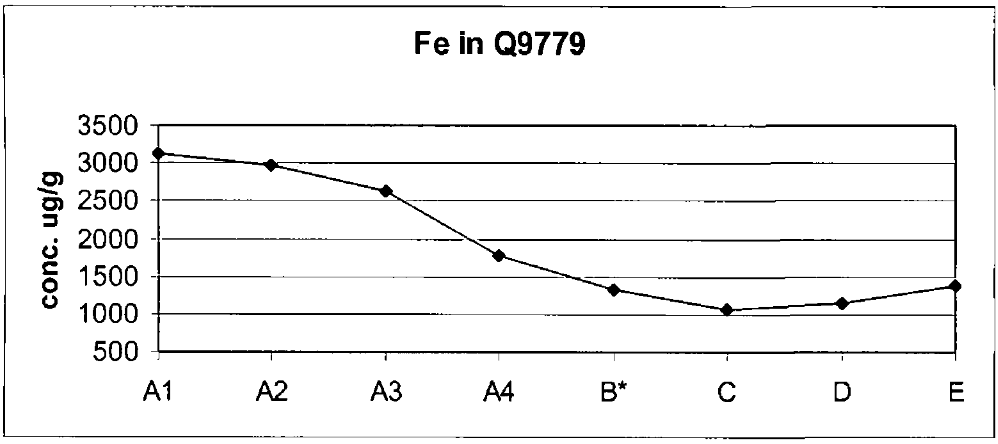


Figure 58

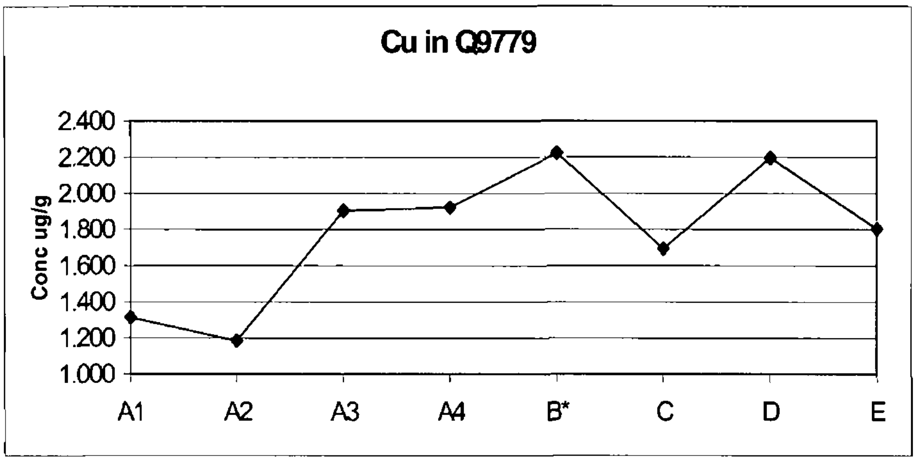


Figure 59

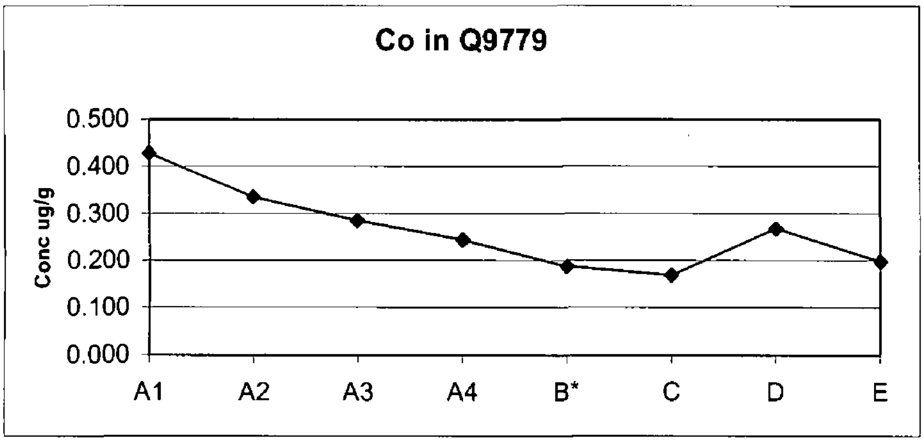


Figure 60

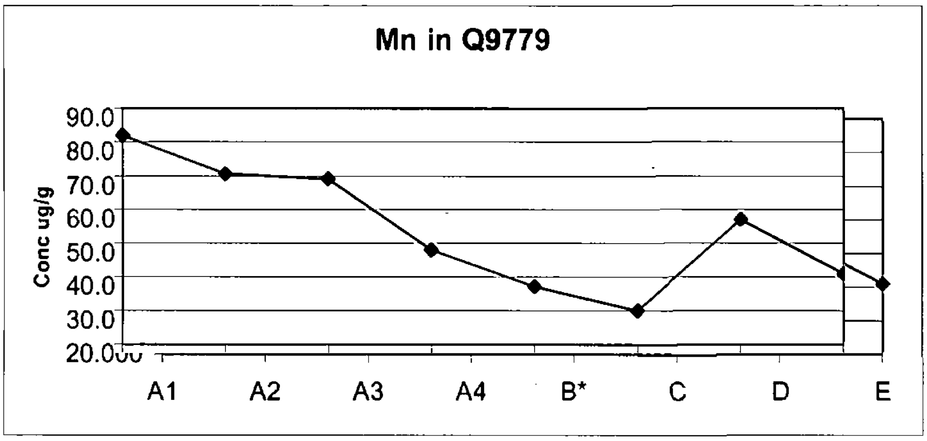


Figure 61

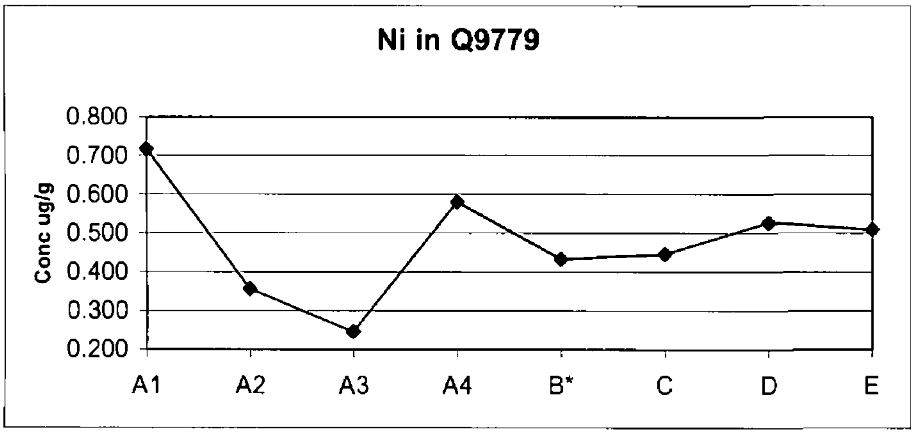


Figure 62

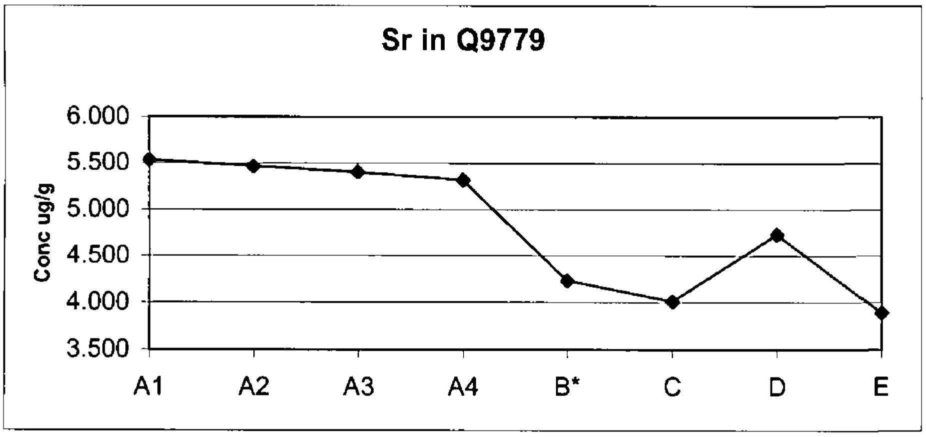


Figure 63

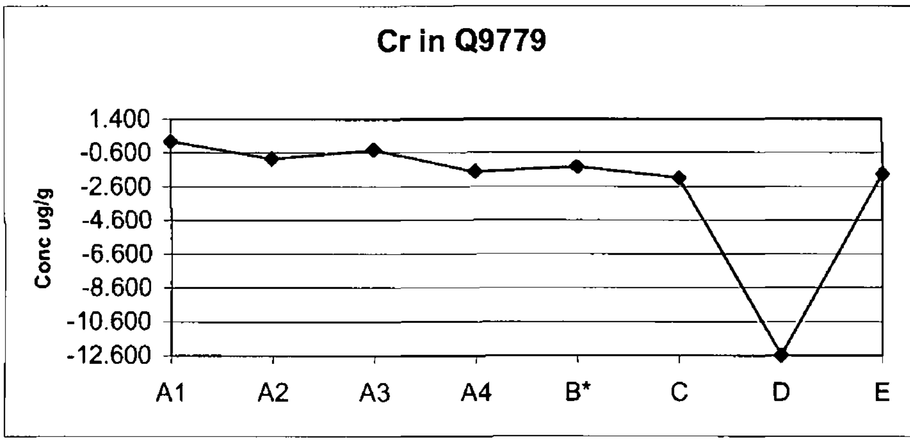


Figure 64

As one can see from the data presented above, the definite patterns observed in Q8001a with respect to the region of interest (B) are not repeated in these samples. There is however the same general trend as Q8001b with concentrations of elements rising towards the end of the life of the tree. There also elevated levels of copper present in the region with the narrowest growth rings (B) (figure 59). The earliest sections of wood are section E, while section A1 is the sapwood located at the edge of the tree corresponding to the last growth years of the tree.

For the first time we have two separate samples prepared in the same way that exhibit the same characteristics in the way they have absorbed a variety of elements throughout their lifetimes.

4.5 DISCUSSION

During the course of the research project four different sets of results were generated. The initial sample (Q8001A) exhibited some very exciting patterns of elemental uptake which led one to believe that a catastrophic volcanic eruption would not just leave an impressive record in the growth of Irish oak trees but also a very dramatic chemical record within the tree rings themselves. The theory was that acid rain deposition might lower the pH of the soil solution and make a range of metal and mineral ions much more available to these trees. The trees would be forced to take in these elements because they were present in the soil solution.

Obviously with normal growing conditions a tree would take up roughly the same amount of each element every year if it grew rings of equal width every year. Some elements might be more mobile [55], [17] in the vascular tissues (Table 1) and migrate with each new ring towards the outside of the tree. These include akali and alkaline earth metals [55]. This would lead to a build up of certain elements in the outermost ring of the tree. Therefore if one were to analyse each ring one would see a roughly baseline concentration with an upward slope in concentration in the last years of growth (e.g. figure 58). Also, less mobile elements might stay in situ in the ring they were absorbed in. For example according to Hall [55] Fe, Cu, Zn and Ni form strong complexes with amino acids in the xylem and will not translocate. The tree would absorb a similar amount of these elements for its own nutrition in each subsequent year of growth, so that if one were to analyse each ring, the concentration of these elements would remain reasonably constant.

This is actually the general pattern of uptake that we see in Q8001B and Q9779. Most of the elements seem to accumulate in the outer rings, except copper. If copper were absorbed in excess in one growth year (due to conditions outlined above) it would remain in that ring and when one analyses the uptake of copper during the lifetime of the tree one sees a spike in the growth period where the tree was under the most stress (figures 24, 50 and 59). However when one views the results for Fe and Ni the levels of these elements are not elevated in the region with the narrowest rings. They follow the same trend of gradual increase that other elements show throughout the life of the tree. However these elements are not capable of translocation. A comprehensive explanation for the uptake pattern of elements is not easy to give. While some of the physiological factors have been mentioned, uptake is also a function of the relative availability of elements over the lifetime of the tree. The amount of a given element that is even detected could depend on the height up the trunk of the tree at which the sample is taken. One study indicates that while Cu and Zn are evenly distributed along the axis of the tree up to 5m, Cd and Pb are bound in the lower parts of the tree [41]. There is no reason why this is not the case for other elements. This could explain some of the variability in the results, as there was no control over the height at which samples were taken.

The issue of contamination is relevant to the accurate quantitation of the levels of different elements present in the wood.. Contamination due to the digestion methods employed would affect all samples and would not influence the patterns obtained.

Platinum is regarded as the best crucible material [54] but porcelain crucibles were used in this project. Elements may or may not have been retained in the surface of the crucibles but no study of this was made. In any case platinum crucibles would have been prohibitively expensive. Another factor was the lack of information on atmospheric contamination both in the laboratory and where the furnace was located. The furnace was in almost constant use and it was impossible to know what type of samples other users were placing in the furnace. The material lining the furnace was also not taken into account. It is known that unsuitable materials may contaminate samples [54]. Finally although a temperature program was initiated for the last two samples, the furnace was not programmable. The user could not set or accurately measure the heating rate. A heating rate of no more than 1°C/ min is normally used [54], [56]. The temperature program consisted of the user setting a target temperature, then returning to the furnace after a given time and setting the temperature for the next step. Even though great care was taken, the lack of electronic controls may have resulted in hot spots or self-ignition. Incomplete ashing can also prevent complete liberation of elements from the carbonaceous residue [54].

The patterns in Q1921, Q1932 and Q2030 make little or no sense (e.g. figure 39). The concentration of each element varies greatly across the life of each tree. As previously mentioned, this is most likely due to an aggressive digestion method. One must therefore concentrate on the results obtained for Q8001A, Q8001B and Q9779. When one reviews the data for Q8001A we note that Cu and Fe follow the appropriate pattern that would occur if a tree absorbed a large amount of these elements in a given growth period. These elements remain in the rings that they were originally absorbed in. However it seems that this tree absorbed abnormal quantities of other elements, some of which also remained in situ. These include Mn, P, Sr , Cd, Cr, Ca, Mg and Al (figures 20, 21, 19, 16 and 18 respectively). There is little or no information in the literature about how the concentrations of these elements in trees would vary due to increased environmental exposure. This is because most workers are concerned with environmental pollution in recent times and concentrate on Cd, Pb , Zn and Cu as indicators of industrial activity. Consequently there is very little backup for the results obtained with Q8001A though there is no way to discount them due to sampling procedures or digestion methods as this would affect all samples in this data set.

The data presented above each represent the mean of five determinations. Therefore the %RSD for each element would be different in each sample. The ICP-MS software does not normally report this data but the worst case scenario is detailed below.

Element	Wet Digestion	Dry Ash [57]
Fe	0.5%	5%
Na	0.8%	10%
Mg	0.5%	12%
K	6%	13%
Ca	0.6%	9%
Co	Not measured	13%
Cu	0.7%	11%
Sr	0.4%	1%
Mn	0.3%	8%
Ni	8%	6%
Cr	25%	6%

Table 8 Typical worst case %RSDs for a variety of elements.

As one can see from the table above the data for the wet digestion was much more precise than that for the dry ash procedure, for all elements except Cr. Therefore one has more confidence in the likely accuracy of these results. This does not mean that the data for the dry ash procedure is not accurate, rather that it is less precise than the wet digestion. The data from the final dry ash are broadly similar to each other so this suggests that a real trend in elemental uptake is emerging. Unfortunately only two trees were analysed using this sample preparation procedure.

The main problem with Q8001A is that the analysis was never repeated using the same wet digestion method. Unfortunately this was due to the limited time available, the small amount of material and the large amount of effort needed to generate a small number of samples. The sulphuric acid used in the digestion is also known to exhibit matrix suppression effects and this is the reason why the sample preparation was changed to a dry ashing procedure. As the pattern was never reproduced for all elements with the dry ash we can't determine if the wet digestion result was an outlier or representative of the composition of the tree rings. There are many influences on the composition of the wood:

- How static is the element in the ring?
- How high can an element penetrate up the trunk of the tree?
- How is the retention of an element in a ring affected by what happens to the tree during subsequent growth or after death?
- How effective is the digest for each element?

These influences were outside the scope of this study but the data obtained were very interesting. Samples prepared using the revised ashing procedure were very similar in uptake pattern. Q8001B and Q9779 seem to suggest that Cu could be a chemical marker of environmental stress when narrow growth rings are present (figure 50, figure 59). No other elements in these data sets exhibit an increase in concentration in the years with the narrowest growth rings.

The behaviour of most of the elements can be explained in terms of the physiology of oak trees. The elevated level of copper seems to be indicative of the stressful conditions and this pattern is present in Q8001A, Q8001B and Q9779, which gives great scope for further work on this matter. As things stand, the results obtained using the dry ashing procedure would be the most promising for further investigation. As a result of the very labour intensive nature of sample preparation there were some opportunities for further work that could not be exploited. These are detailed below.

4.6 FURTHER WORK

- Although the concentrations of different elements are quantified in the graphs shown, one cannot evaluate the effectiveness of these sample preparation methods due to the lack of a suitable certified reference material. The actual percentage recovery of the digestion method could not be measured. The only CRM available was Beech leaf but when a wet digestion was performed on this reference material it did not digest in the same way as a hardwood sample. Thereafter the use of this material was abandoned. It is not known whether a CRM for the investigation of hardwoods exists but if so it would be an invaluable tool for the further investigation of these results.
- There was no control over the height on the trunk at which the samples were taken. If it were possible in the future to take note of the approximate height on the trunk at which samples are taken one could evaluate whether height is a factor for the distribution of other elements other than Cd and Pb [41].
- Part of the problem in evaluating trees of this time period is that their growth patterns are so unusual. If a researcher were to investigate bog Oak where the growth patterns were normal, in tandem with the anomalous trees, they could attribute any unusual elemental uptake solely to the environment. There may be chemical changes that occur in a tree when it is buried under peat, which may cause it to absorb certain elements. The patterns we have observed could be due to this but we have no way of knowing unless we had 'normal' bog Oak to compare them to. All the modes of elemental uptake and translocation described above

refer exclusively to Oak trees that grow in normal well drained soils. There is no literature on how, if at all, lower pH and waterlogged soil conditions would affect these processes.

- Harju et al [56] have written an interesting paper on the use thick target Particle induced X-ray emission (ttPIXE) in the analysis of trace elements in trunk wood. The advantage of this method is that it avoids the use of acids to dissolve the sample, hence eliminating another potential source of contamination. The sample is analysed as a dry ash in pellet form. If the researcher could implement the measures mentioned above with regard to CRMs and better choice of samples this method could be usefully applied to the analysis of ancient bog Oak.

- New surface analysis techniques are being developed that could potentially lead to much faster assays, ideally on solid samples. Laser ablation ICP-MS has potential, as the sample is "ablated" in situ using a laser [58]. The technique is powerful enough to ablate metal samples so there would no problem analysing the hard bog oak samples. The laser is focussed beneath the surface of the material and a plasma is induced above the surface. The volatilised surface material is then drawn into an ICP-MS system. This technique produces very sensitive elemental maps as a function of ablation depth and surface distribution. This would make it possible to analyse individual tree rings, thus tracking more accurately the changes in elemental composition. The advantage of this technique is primarily its speed. There would be no time consuming sampling using drills or scalpels. Both dry ashing and wet digestion are also time consuming and these would be eliminated This would allow the worker to gather a large amount of data on a year by year basis, thus more precisely isolating any environmental effects. One would also be able to collect data on a larger number of trees. Obviously the greater the sample size the more confidence one can have in the validity of data, so this is definitely a technique with great promise.

REFERENCES

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1 **Baillie**, M. and Pilcher, J. 1988. Make a date with a tree. In New Scientist, 17 March 1988, p. 48-51.

2 **Becker**, Bernd 1993. An 11,000 Year German oak and pine dendrochronology for radiocarbon calibration. In Radiocarbon vol. 35, no. 1 , 1993 p. 201-213.

3 http://www.sonic.net/bristlecone/dendro.html

4 **Cook**, E. R., Johnson, A. H., Blasing, T. J., 1987. Forest decline: modelling the effect of climate in tree rings. Tree Physiol., 3: 27-40.

5 **Cook**, E. R., Kairiukstis, L. A. (eds.), 1990. Methods of Dendrochronology. Applications in the Environmental Sciences. Kluwer Academic Publishers, Dordrecht, Boston, London: 394.

6 **Hughes**, M. K., Kelly, P. M., Pilcher, J. R., Lamarche, V. C., 1982. Climate from Tree Rings. Cambridge University Press, Cambridge.

7 **Fritts**, H. C., Swetnam, T. W., 1989. Dendroecology: a tool for evaluating variations in past and present environments. Advances in Ecology Research, 19: 111-188.

8 **Schweingruber**, F. H. (eds.): Tree Rings and Environment. Proceedings of the International Dendrochronological Symposium. Ystad, South Sweden, 3-9 September 1990, Lunqua Report, Lund University: 104-108.

9 http:www.britannica.com/eb/article?eu=79788

10 http://www.emunix.emich.edu/~ghannan/anatomy/xylem/ptracheid.html

---

11 **Connor** et al 1990. Effects of tree age on secondary xylem and phloem anatomy in stems of Great Basin bristlecone pine(pinus longaeva). In American Journal of Botany, 77(8): 1070-1077.

12 http://www.iacr.bbsrc.ac.uk/notebook/courses/guide/xylem.htm

13http://gened.emc.maricopa.edu/bio/bio181/BIOBK/BioBookPLANTANAT.html#Phloem from **Purves** et al., Life: The Science of Biology, 4th Edition, Sinauer Associates.

14 **Shashkin**, A. V. Vaganov, E. A., Fritts, H. C., 1994. A model of cambial activity and tree-ring formation in conifers. [In print.]

15 http://www.puc.edu/Faculty/Gilbert_Muth/art0062.jpg.

16 **Thornley**, J. H. M., 1976. Mathematical Models in Plant Physiology. Academic Press, London, New York, San Francisco.

17 **Leopold**, Kriedeman, Plant Growth and Development 2nd Ed. Pg. 444.

18 **Devlin**, Robert M., Plant physiology 3rd Ed., Nostramo 1975.

19 **Street**, H.E. & W. Cockburn, Plant metabolism, Ch. 7 pg. 12.

20 **Salisbury** and Ross, Plant Physiology 4th Ed., Wadsworth Publishing Co 1992. 120-135.

21 **Wiklander**, L. 1958. The Soil. In W. Ruhland, ed., Encyclopaedia of plant physiology. 4; 118. Berlin: Springer.

22 **Quastel**, J.H. 1963. Microbial activities of soil as they affect plant nutrition. In F.C. Steward, ed., Plant Physiology. New York: Academic Press.

23 **Guyette** et al 1989. Long-Term Relationships between Molybdenum and Sulfur Concentrations in Redcedar Tree-rings. In Journal of Environmental Quality 18:385-389 (1989).

24 **Cote** et al. 1995. Application of Leaf, Soil and Tree-Ring Chemistry to Determine the Nutritional Status of Sugar Maple on Sites of Different Levels of Decline. In Water, Air and Soil Pollution 83:363-375.

25 **Gabbrielli**, R., Mattioni, C., Vergnano, O., Accumulation Mechanisms and Heavy-Metal Tolerance of a Nickel Hyperaccumulator, Journal of Plant Nutrition 14: (10) 1067-1080. (1991)

26 **Science** 23rd September 1994, pg. 19. Pinatubo warms winters in the North.

27 **Stothers**, R.B., 1984. Mystery Cloud of ad 536. In Nature vol 307: p. 344-345, 26 January 1984.

28 **Schweingruber**, F.H. 1987. Flächenhafte dendroclimatische Temperatur-rekonstruktionen für Europa. In Naturwissenschaften 74, 205 –212(1987).

Schweingruber, F. H., 1983. Der Jahrring. Standort, Methodik, Zeit und Klima in der Dendrochronologie. Bern: 234.

29 **Yamaguchi**, D. K., 1986. Tree-ring evidence for a two-year interval between recent prehistoric explosive eruptions of Mount St. Helens. Geology, 13: 554-557.

30 **Bichler** et al 1995. Determination and Speciation of Minor and Trace Elements in Volcanic Exhalations by NAA. In Journal of Radioanalytical and Nuclear Chemistry Articles vol. 192, (2) (1995), 183-194.

31 **Kienast**, F., Luxmoore, R. J., 1988. Tree-ring analysis and conifer growth responses to increased atmospheric CO2 levels. Oecologia, 76: 487-495.

32 **Brasseur** et al 1992. In Science vol. 257:1239-1241, 28 August 1992.

33 **Symonds** et al 1988. Contribution of Cl- and F-bearing gases to the atmosphere by volcanoes. In Nature vol. 334: 415-418, 4 August 1988.

34 **Vazquez** et al 1994. Inorganic analysis and electron microscopy of the emission of the Hudson Volcano in Argentina(August 1991). In Analusis 22:347-349(1994).

35 **Gulchard** et al 1993. Tephra from the Minoan eruption of Santorini in sediments of the Black Sea. Nature vol. 363 17 June 1993.

36 **Vazquez** et al 1994. Inorganic analysis and electron microscopy of the emission of the Hudson Volcano in Argentina(August 1991). In Analusis 22:347-349(1994).

37 **Latimer** et al 1996. Dendrochronology and Heavy Metal Deposition in Tree Rings of Baldcypress. In Journal of Environmental Quality 25: 1411-1419 (1996).

38 **Symeonides** C., Journal of Environmental Quality 8 (1979) 482.

39 **Robitaille** G., Environmental Pollution B2 (1981) 193.

40 **Jordan** et al 1989.Time series modelling of relationships between climate and radial growth of loblolly pine In Journal of Environmental Quality 19: 504-508 (1990).

41 **Queirolo** et al 1991. Study of the Radial and Axial Distribution Of Heavy Metals in Oak Growth Rings by Stripping Voltammetry. In Electroanalysis 3: 325-329.

42 **Kuniholm** et al 1996. Anatolian tree rings and the absolute chronology of the eastern Mediterranean, 2220-718 BC. In Nature, vol. 381, 27 June 1996.

43 **Lamarche**, V.C., Hirschboek, K. K., 1984. Frost rings in trees as records of major volcanic eruptions. Nature, 307: 121-126.

44 **Lamarche**, V. C., Hirschboek, K. K., 1984. Frost rings in trees as records of major volcanic eruptions. Nature, 307: 121-126.

45 **Hammer** et al. In Nature, vol. 328, pp. 517-519 (1987).

46 **Baillie** et al 1988. Irish tree rings, Santorini and volcanic dust veils. In Nature, vol.332, pp.344-346, 24 March 1988.

47 Technology Ireland, May 1989.

48 **Baillie**, M.G.L.1989. Hekla 3: how big was it? In Endeavour, New Series, vol. 13, no. 2, 1989.

49 **Baillie**, M.G.L. Patrick, Comets and Christianity. In Emania, p. 69-78.

50 **Baillie**, M.G.L., Dendrochronology raises questions about the nature of the AD 536 dust-veil event. In The Holocene, 4,2, (1984) 212-217.

51 **Briffa**, K. R., Bartholin, T. S., Eckstein, D., Jones, P. D., Karlen, W., Schweingruber, F. H., Zetterberg, J., 1990. A 1400--year tree-ring record of summer temperatures in Fennoscandia. Nature, 346: 434-439.

52 **Scuderi**, L. A., 1990. Tree-ring evidence for climatically effective volcanic eruptions. Quaternary Research, 34: 67--85.

53 **Jarvis**, K.E., Gray A.L., Houk., R.S, Blackie, Inductively Coupled Mass Spectrometry New York.

54 **Jorhem**, Lars, 1995. Dry Ashing, Sources of Error, and Performance Evaluation in AAS. Mikrochimica Acta 119, 211-218(1995).

55 **Hall**, G.S. 1990. Sample Preparation Methods of Tree Rings for PIXE-PIGE Multielemental Analysis. Nuclear Instruments and Methods in Physics Research B49 (1990) 60-64 North-Holland.

56 **Harju** et al 1997. Analysis of trace elements in trunk wood by thick-target PIXE using dry ashing for preconcentration. Fresenius Journal of Analytical Chemistry (1997) 358: 523-528.

57 **O'Connor**, Fionnuala, Central Fisheries Board. Personal communication.

58 **Russo**, R.E., "Laser Ablation", focal point, Applied Spectroscopy, 49, No. 9 (1995).

Appendix A

Raw Data for Q8001A

Raw Data for Q8001A

Concentrations in ppm

Element	A	B*	C	D	E	E1
Al	0.0076	0.0625	0.0472	0.0035	0.0118	0.0192
Ca	4.385	6.165	5.085	3.795	3.925	3.235
Cd	0.0005	0.0008	0.0006	0.0004	0.0003	0.0003
Cr	0.0001	0.0007	0.0006	0.0004	0.0001	0.0004
Cu	0.0028	0.0242	0.0036	0.0033	0.0016	0.0035
Fe	-0.01275	9.25475	8.62635	3.86445	4.01225	2.12835
Ir	-0.0015	0.0055	0.0005	-0.0055	0.0045	0.0005
K	0.055	0.095	0.085	0.035	0.035	0.115
Mg	0.655	0.855	0.765	0.555	0.525	0.435
Mn	0.113	0.362	0.1431	0.0607	0.042	0.0381
Na	0.045	0.125	0.085	0.025	0.105	0.185
Ni	0.0006	0.0014	0.0005	0.0012	-0.0005	0.0005
P	0.036	0.176	0.122	0.075	0.149	-0.001
Sr	0.008	0.0078	0.009	0.007	0.007	0.006
Ti	0.002	0.012	0.004	0.006	0.002	0.002
Zn	-0.0113	-0.0067	-0.0087	-0.0117	0.0397	0.1306

Appendix B

Raw Data for Q1921, Q 2030 and Q1932

Raw Data for Q1921, Q2030 and Q1932

Sample	Element	conc	Units	RSD
blank1	Al 396.152	0.08	mg/L	1.26
blank2	Al 396.152	0.06	mg/L	1.58
1921a1	Al 396.152	9.492	mg/L	0.64
1921a2	Al 396.152	5.344	mg/L	0.31
1921b1	Al 396.152	0.533	mg/L	0.27
1921b2	Al 396.152	0.19	mg/L	0.47
blank1	Ca 317.933	0.381	mg/L	0.4
blank2	Ca 317.933	0.339	mg/L	0.39
1921a1	Ca 317.933	192.737	mg/L	0.13
1921a2	Ca 317.933	225.278	mg/L	0.14
1921b1	Ca 317.933	159.591	mg/L	0.02
1921b2	Ca 317.933	163.341	mg/L	0.33
blank1	Cd 228.802	0.002	mg/L	37.61
blank2	Cd 228.802	0.001	mg/L	54.14
1921a1	Cd 228.802	-0.003	mg/L	19.22
1921a2	Cd 228.802	-0.003	mg/L	8.81
1921b1	Cd 228.802	-0.001	mg/L	50.56
1921b2	Cd 228.802	-0.002	mg/L	29.75
blank1	Cr 267.716	0.003	mg/L	10.72
blank2	Cr 267.716	0.005	mg/L	5.38
1921a1	Cr 267.716	0.028	mg/L	0.26
1921a2	Cr 267.716	0.01	mg/L	2.65
1921b1	Cr 267.716	0.002	mg/L	24.12
1921b2	Cr 267.716	0.001	mg/L	20.1
blank1	Cu 324.754	0.001	mg/L	14.2

blank2	Cu 324.754	0.001	mg/L	24.04
1921a1	Cu 324.754	0.248	mg/L	0.49
1921a2	Cu 324.754	0.092	mg/L	1.3
1921b1	Cu 324.754	0.026	mg/L	0.24
1921b2	Cu 324.754	0.027	mg/L	1.78
blank1	Fe 259.940	0.387	mg/L	6
blank2	Fe 259.940	0.245	mg/L	0.44
1921a1	Fe 259.940	423.836	mg/L	0.07
1921a2	Fe 259.940	448.364	mg/L	0.06
1921b1	Fe 259.940	306.459	mg/L	0.07
1921b2	Fe 259.940	310.714	mg/L	0.2
blank1	K 766.491	0.072	mg/L	0.33
blank2	K 766.491	0.07	mg/L	0.36
1921a1	K 766.491	2.717	mg/L	0.68
1921a2	K 766.491	3.205	mg/L	0.34
1921b1	K 766.491	0.526	mg/L	0.12
1921b2	K 766.491	0.448	mg/L	0.16
blank1	Mg 279.079	0.219	mg/L	1.35
blank2	Mg 279.079	0.224	mg/L	0.79
1921a1	Mg 279.079	27.534	mg/L	0.14
1921a2	Mg 279.079	29.154	mg/L	0.2
1921b1	Mg 279.079	20.507	mg/L	0.15
1921b2	Mg 279.079	21.293	mg/L	0.29
blank1	Mn 257.610	0.007	mg/L	1.22
blank2	Mn 257.610	0.003	mg/L	0.94
1921a1	Mn 257.610	3.586	mg/L	0.27
1921a2	Mn 257.610	3.689	mg/L	0.09
1921b1	Mn 257.610	2.517	mg/L	0.05

1921b2	Mn 257.610	2.577	mg/L	0.12
blank1	Na 589.592	0.722	mg/L	0.67
blank2	Na 589.592	0.657	mg/L	0.6
1921a1	Na 589.592	9.217	mg/L	0.33
1921a2	Na 589.592	8.264	mg/L	0.43
1921b1	Na 589.592	4.399	mg/L	0.5
1921b2	Na 589.592	4.755	mg/L	0.82
blank1	Ni 231.604	0.015	mg/L	3.93
blank2	Ni 231.604	0.016	mg/L	0.44
1921a1	Ni 231.604	0.081	mg/L	1.69
1921a2	Ni 231.604	0.057	mg/L	1.61
1921b1	Ni 231.604	0.031	mg/L	4.83
1921b2	Ni 231.604	0.031	mg/L	2.95
blank1	P 178.221	-0.006	mg/L	261.7
blank2	P 178.221	-0.002	mg/L	324.4
1921a1	P 178.221	1.506	mg/L	0.76
1921a2	P 178.221	1.48	mg/L	4
1921b1	P 178.221	0.599	mg/L	7.81
1921b2	P 178.221	0.495	mg/L	5.4
blank1	Sr 407.771	0.001	mg/L	0.57
blank2	Sr 407.771	0.004	mg/L	0.38
1921a1	Sr 407.771	0.342	mg/L	0.17
1921a2	Sr 407.771	0.407	mg/L	0.17
1921b1	Sr 407.771	0.275	mg/L	0.08
1921b2	Sr 407.771	0.28	mg/L	0.4
blank1	Ti 336.121	0.001	mg/L	36.81
blank2	Ti 336.121	0.001	mg/L	35.74
1921a1	Ti 336.121	0.304	mg/L	0.14

1921a2	Ti 336.121	0.182	mg/L	0.56
1921b1	Ti 336.121	0.023	mg/L	7.18
1921b2	Ti 336.121	0.007	mg/L	0.85
blank1	Zn 213.856	0.017	mg/L	2.83
blank2	Zn 213.856	0.091	mg/L	0.15
1921a1	Zn 213.856	0.275	mg/L	0.39
1921a2	Zn 213.856	0.179	mg/L	0.32
1921b1	Zn 213.856	0.083	mg/L	0.35
1921b2	Zn 213.856	0.096	mg/L	0.59
1921c1	Al 396.152	0.4	mg/L	0.39
1921c2	Al 396.152	1.969	mg/L	0.18
1921d1	Al 396.152	0.354	mg/L	0.75
1921d2	Al 396.152	18.124	mg/L	0.18
1921e1	Al 396.152	2.145	mg/L	0.05
1921e2	Al 396.152	0.672	mg/L	0.62
1932a1	Al 396.152	1.762	mg/L	0.35
1932a2	Al 396.152	0.619	mg/L	0.17
1932b1	Al 396.152	0.321	mg/L	0.35
1932b2	Al 396.152	0.134	mg/L	0.3
1932c1	Al 396.152	0.358	mg/L	0.33
1932c2	Al 396.152	0.368	mg/L	0.58
1932d1	Al 396.152	0.186	mg/L	0.88
1932d2	Al 396.152	0.275	mg/L	0.83
1932e1	Al 396.152	2.511	mg/L	0.29
1932e2	Al 396.152	0.109	mg/L	0.71
2030a1	Al 396.152	0.872	mg/L	0.35
2030a2	Al 396.152	0.991	mg/L	0.43
2030b1	Al 396.152	0.228	mg/L	1.1

2030b2	Al 396.152	0.995	mg/L	0.25
2030c1	Al 396.152	4.968	mg/L	0.34
2030c2	Al 396.152	0.306	mg/L	0.67
2030d1	Al 396.152	0.121	mg/L	1.46
2030d2	Al 396.152	0.143	mg/L	0.77
2030e1	Al 396.152	0.539	mg/L	0.12
2030e2	Al 396.152	0.135	mg/L	0.21
1921c1	Ca 317.933	155.06	mg/L	0.47
1921c2	Ca 317.933	170.962	mg/L	0.08
1921d1	Ca 317.933	145.491	mg/L	0.21
1921d2	Ca 317.933	145.432	mg/L	0.23
1921e1	Ca 317.933	127.356	mg/L	0.17
1921e2	Ca 317.933	142.318	mg/L	0.28
1932a1	Ca 317.933	273.893	mg/L	0.12
1932a2	Ca 317.933	280.177	mg/L	0.4
1932b1	Ca 317.933	227.249	mg/L	0.23
1932b2	Ca 317.933	184.338	mg/L	0.35
1932c1	Ca 317.933	209.788	mg/L	0.22
1932c2	Ca 317.933	166.235	mg/L	0.13
1932d1	Ca 317.933	143.983	mg/L	0.37
1932d2	Ca 317.933	139.518	mg/L	0.2
1932e1	Ca 317.933	94.838	mg/L	0.2
1932e2	Ca 317.933	132.091	mg/L	0.12
2030a1	Ca 317.933	206.376	mg/L	0.38
2030a2	Ca 317.933	209.166	mg/L	0.34
2030b1	Ca 317.933	174.103	mg/L	0.3
2030b2	Ca 317.933	166.889	mg/L	0.23
2030c1	Ca 317.933	173.522	mg/L	0.34

2030c2	Ca 317.933	178.773	mg/L	0.14
2030d1	Ca 317.933	166.733	mg/L	0.58
2030d2	Ca 317.933	171.998	mg/L	0.23
2030e1	Ca 317.933	206.663	mg/L	0.42
2030e2	Ca 317.933	154.677	mg/L	0.11
1921c1	Cd 228.802	-0.001	mg/L	26.54
1921c2	Cd 228.802	0	mg/L	435.6
1921d1	Cd 228.802	-0.002	mg/L	25.02
1921d2	Cd 228.802	-0.001	mg/L	87.61
1921e1	Cd 228.802	-0.001	mg/L	33.16
1921e2	Cd 228.802	-0.001	mg/L	28.99
1932a1	Cd 228.802	-0.003	mg/L	38.65
1932a2	Cd 228.802	-0.002	mg/L	11.73
1932b1	Cd 228.802	-0.001	mg/L	195.4
1932b2	Cd 228.802	-0.001	mg/L	64.55
1932c1	Cd 228.802	-0.001	mg/L	25.32
1932c2	Cd 228.802	-0.001	mg/L	83.1
1932d1	Cd 228.802	0.001	mg/L	17.43
1932d2	Cd 228.802	0	mg/L	2166
1932e1	Cd 228.802	0	mg/L	399.1
1932e2	Cd 228.802	0	mg/L	1046
2030a1	Cd 228.802	-0.001	mg/L	69.44
2030a2	Cd 228.802	0	mg/L	43.87
2030b1	Cd 228.802	0	mg/L	161
2030b2	Cd 228.802	0.001	mg/L	61.44
2030c1	Cd 228.802	0	mg/L	471.6
2030c2	Cd 228.802	0	mg/L	121.3
2030d1	Cd 228.802	0	mg/L	215.1

2030d2	Cd 228.802	-0.001	mg/L	122.8
2030e1	Cd 228.802	-0.001	mg/L	89.07
2030e2	Cd 228.802	-0.001	mg/L	57.12
1921c1	Cr 267.716	0.019	mg/L	0.77
1921c2	Cr 267.716	0.042	mg/L	1.77
1921d1	Cr 267.716	0.175	mg/L	0.35
1921d2	Cr 267.716	0.088	mg/L	0.63
1921e1	Cr 267.716	0.003	mg/L	16.27
1921e2	Cr 267.716	0.009	mg/L	2.22
1932a1	Cr 267.716	2.85	mg/L	0.15
1932a2	Cr 267.716	0.032	mg/L	0.94
1932b1	Cr 267.716	0.022	mg/L	0.71
1932b2	Cr 267.716	0.013	mg/L	1.99
1932c1	Cr 267.716	0.016	mg/L	0.87
1932c2	Cr 267.716	0.088	mg/L	0.52
1932d1	Cr 267.716	0.163	mg/L	0.73
1932d2	Cr 267.716	0.041	mg/L	0.55
1932e1	Cr 267.716	0.603	mg/L	0.12
1932e2	Cr 267.716	0.027	mg/L	0.71
2030a1	Cr 267.716	0.025	mg/L	2.06
2030a2	Cr 267.716	0.016	mg/L	2.04
2030b1	Cr 267.716	0.05	mg/L	0.97
2030b2	Cr 267.716	0.092	mg/L	0.71
2030c1	Cr 267.716	0.035	mg/L	1.95
2030c2	Cr 267.716	0.015	mg/L	1.83
2030d1	Cr 267.716	0.011	mg/L	3.61
2030d2	Cr 267.716	0.022	mg/L	2.19
2030e1	Cr 267.716	0.021	mg/L	1.27

2030e2	Cr 267.716	0.044	mg/L	1.07
1921c1	Cu 324.754	0.083	mg/L	0.21
1921c2	Cu 324.754	0.063	mg/L	0.31
1921d1	Cu 324.754	0.099	mg/L	0.3
1921d2	Cu 324.754	0.107	mg/L	0.2
1921e1	Cu 324.754	0.104	mg/L	0.18
1921e2	Cu 324.754	0.18	mg/L	0.62
1932a1	Cu 324.754	0.154	mg/L	0.44
1932a2	Cu 324.754	0.102	mg/L	0.11
1932b1	Cu 324.754	0.077	mg/L	0.05
1932b2	Cu 324.754	0.08	mg/L	0.05
1932c1	Cu 324.754	0.077	mg/L	0.34
1932c2	Cu 324.754	0.099	mg/L	0.63
1932d1	Cu 324.754	0.083	mg/L	0.25
1932d2	Cu 324.754	0.088	mg/L	0.14
1932e1	Cu 324.754	0.471	mg/L	0.18
1932e2	Cu 324.754	1.161	mg/L	0.2
2030a1	Cu 324.754	0.067	mg/L	0.36
2030a2	Cu 324.754	0.157	mg/L	0.2
2030b1	Cu 324.754	0.067	mg/L	0.3
2030b2	Cu 324.754	0.076	mg/L	0.35
2030c1	Cu 324.754	0.071	mg/L	0.15
2030c2	Cu 324.754	0.062	mg/L	0.27
2030d1	Cu 324.754	0.089	mg/L	0.69
2030d2	Cu 324.754	0.067	mg/L	0.13
2030e1	Cu 324.754	0.147	mg/L	0.28
2030e2	Cu 324.754	0.059	mg/L	0.31
1921c1	Fe 259.940	328.268	mg/L	0.47

1921c2	Fe 259.940	368.848	mg/L	0.04
1921d1	Fe 259.940	313.036	mg/L	0.18
1921d2	Fe 259.940	298.662	mg/L	0.15
1921e1	Fe 259.940	302.162	mg/L	0.17
1921e2	Fe 259.940	170.022	mg/L	0.15
1932a1	Fe 259.940	688.309	mg/L	0.16
1932a2	Fe 259.940	692.752	mg/L	0.35
1932b1	Fe 259.940	285.466	mg/L	0.19
1932b2	Fe 259.940	229.512	mg/L	0.22
1932c1	Fe 259.940	229.257	mg/L	0.18
1932c2	Fe 259.940	170.257	mg/L	0.1
1932d1	Fe 259.940	141.782	mg/L	0.3
1932d2	Fe 259.940	134.131	mg/L	0.16
1932e1	Fe 259.940	88.949	mg/L	0.19
1932e2	Fe 259.940	119.533	mg/L	0.08
2030a1	Fe 259.940	192:098	mg/L	0.38
2030a2	Fe 259.940	197.269	mg/L	0.27
2030b1	Fe 259.940	141.606	mg/L	0.29
2030b2	Fe 259.940	150.902	mg/L	0.16
2030c1	Fe 259.940	136.334	mg/L	0.35
2030c2	Fe 259.940	140.468	mg/L	0.09
2030d1	Fe 259.940	118.411	mg/L	0.53
2030d2	Fe 259.940	131.816	mg/L	0.06
2030e1	Fe 259.940	75.281	mg/L	0.44
2030e2	Fe 259.940	50.619	mg/L	0.23
1921c1	K 766.491	0.399	mg/L	2.56
1921c2	K 766.491	0.564	mg/L	3.16
1921d1	K 766.491	0.841	mg/L	1.79

1921d2	K 766.491	0.554	mg/L	6.41
1921e1	K 766.491	1.75	mg/L	1.05
1921e2	K 766.491	0.952	mg/L	0.55
1932a1	K 766.491	1.152	mg/L	0.49
1932a2	K 766.491	0.931	mg/L	1.93
1932b1	K 766.491	0.634	mg/L	2.67
1932b2	K 766.491	0.726	mg/L	1.88
1932c1	K 766.491	0.672	mg/L	2.26
1932c2	K 766.491	0.842	mg/L	0.96
1932d1	K 766.491	0.519	mg/L	2.89
1932d2	K 766.491	0.805	mg/L	2.19
1932e1	K 766.491	0.408	mg/L	2.09
1932e2	K 766.491	0.632	mg/L	1.19
2030a1	K 766.491	3.225	mg/L	0.51
2030a2	K 766.491	3.08	mg/L	0.51
2030b1	K 766.491	2.171	mg/L	0.19
2030b2	K 766.491	2.273	mg/L	0.44
2030c1	K 766.491	2.652	mg/L	0.12
2030c2	K 766.491	2.539	mg/L	0.55
2030d1	K 766.491	2.013	mg/L	0.17
2030d2	K 766.491	1.846	mg/L	0.5
2030e1	K 766.491	3.184	mg/L	0.48
2030e2	K 766.491	2.192	mg/L	1.29
1921c1	Mg 279.079	18.376	mg/L	0.43
1921c2	Mg 279.079	21.109	mg/L	0.2
1921d1	Mg 279.079	17.551	mg/L	0.31
1921d2	Mg 279.079	18.595	mg/L	0.3
1921e1	Mg 279.079	18.724	mg/L	0.2

1921e2	Mg 279.079	24.848	mg/L	0.45
1932a1	Mg 279.079	33.744	mg/L	0.32
1932a2	Mg 279.079	33.813	mg/L	0.13
1932b1	Mg 279.079	31.153	mg/L	0.21
1932b2	Mg 279.079	27.134	mg/L	0.28
1932c1	Mg 279.079	31.07	mg/L	0.19
1932c2	Mg 279.079	26.769	mg/L	0.32
1932d1	Mg 279.079	23.757	mg/L	0.19
1932d2	Mg 279.079	23.759	mg/L	0.28
1932e1	Mg 279.079	19.225	mg/L	0.28
1932e2	Mg 279.079	23.4	mg/L	0.24
2030a1	Mg 279.079	14.83	mg/L	0.23
2030a2	Mg 279.079	13.938	mg/L	0.2
2030b1	Mg 279.079	17.33	mg/L	0.34
2030b2	Mg 279.079	16.476	mg/L	0.12
2030c1	Mg 279.079	22.641	mg/L	0.36
2030c2	Mg 279.079	20.403	mg/L	0.12
2030d1	Mg 279.079	21.766	mg/L	0.08
2030d2	Mg 279.079	21.374	mg/L	0.13
2030e1	Mg 279.079	32.004	mg/L	0.07
2030e2	Mg 279.079	25.173	mg/L	0.34
1921c1	Mn 257.610	2.481	mg/L	0.2
1921c2	Mn 257.610	2.719	mg/L	0.13
1921d1	Mn 257.610	2.523	mg/L	0.06
1921d2	Mn 257.610	2.636	mg/L	0.07
1921e1	Mn 257.610	2.367	mg/L	0.15
1921e2	Mn 257.610	2.733	mg/L	0.35
1932a1	Mn 257.610	6.031	mg/L	0.13

1932a2	Mn 257.610	5.872	mg/L	0.06
1932b1	Mn 257.610	2.968	mg/L	0.06
1932b2	Mn 257.610	2.4	mg/L	0.06
1932c1	Mn 257.610	2.565	mg/L	0.21
1932c2	Mn 257.610	2.109	mg/L	0.05
1932d1	Mn 257.610	1.863	mg/L	0.16
1932d2	Mn 257.610	1.784	mg/L	0.13
1932e1	Mn 257.610	1.395	mg/L	0.17
1932e2	Mn 257.610	1.722	mg/L	0.14
2030a1	Mn 257.610	3.36	mg/L	0.17
2030a2	Mn 257.610	3.234	mg/L	0.25
2030b1	Mn 257.610	3.636	mg/L	0.13
2030b2	Mn 257.610	3.501	mg/L	0.25
2030c1	Mn 257.610	3.83	mg/L	0.14
2030c2	Mn 257.610	4.153	mg/L	0.04
2030d1	Mn 257.610	4.073	mg/L	0.06
2030d2	Mn 257.610	4.14	mg/L	0.12
2030e1	Mn 257.610	4.956	mg/L	0.3
2030e2	Mn 257.610	3.863	mg/L	0.06
1921c1	Na 589.592	3.883	mg/L	0.43
1921c2	Na 589.592	4.074	mg/L	0.11
1921d1	Na 589.592	3.442	mg/L	0.16
1921d2	Na 589.592	4.05	mg/L	0.12
1921e1	Na 589.592	3.654	mg/L	0.33
1921e2	Na 589.592	4.416	mg/L	0.16
1932a1	Na 589.592	4.87	mg/L	0.29
1932a2	Na 589.592	5.045	mg/L	0.36
1932b1	Na 589.592	4.417	mg/L	0.34

1932b2	Na 589.592	3.955	mg/L	0.04
1932c1	Na 589.592	4.407	mg/L	0.29
1932c2	Na 589.592	3.821	mg/L	0.37
1932d1	Na 589.592	3.255	mg/L	0.46
1932d2	Na 589.592	5.448	mg/L	0.13
1932e1	Na 589.592	3.148	mg/L	0.45
1932e2	Na 589.592	3.666	mg/L	0.14
2030a1	Na 589.592	4.865	mg/L	0.43
2030a2	Na 589.592	5.196	mg/L	0.44
2030b1	Na 589.592	3.231	mg/L	0.25
2030b2	Na 589.592	3.508	mg/L	0.2
2030c1	Na 589.592	26.881	mg/L	0.4
2030c2	Na 589.592	4.958	mg/L	0.1
2030d1	Na 589.592	3.864	mg/L	0.72
2030d2	Na 589.592	4.207	mg/L	0.2
2030e1	Na 589.592	4.564	mg/L	0.14
2030e2	Na 589.592	3.992	mg/L	0.27
1921c1	Ni 231.604	0.031	mg/L	4.08
1921c2	Ni 231.604	0.041	mg/L	4.38
1921d1	Ni 231.604	0.064	mg/L	1.14
1921d2	Ni 231.604	0.028	mg/L	4.8
1921e1	Ni 231.604	0.034	mg/L	2.73
1921e2	Ni 231.604	0.031	mg/L	3.25
1932a1	Ni 231.604	1.999	mg/L	0.11
1932a2	Ni 231.604	0.041	mg/L	1.37
1932b1	Ni 231.604	0.022	mg/L	2.85
1932b2	Ni 231.604	0.019	mg/L	6.26
1932c1	Ni 231.604	0.02	mg/L	5.78

1932c2	Ni 231.604	0.035	mg/L	1.84
1932d1	Ni 231.604	0.067	mg/L	0.89
1932d2	Ni 231.604	0.026	mg/L	2.68
1932e1	Ni 231.604	0.444	mg/L	0.28
1932e2	Ni 231.604	0.026	mg/L	2.31
2030a1	Ni 231.604	0.045	mg/L	3.01
2030a2	Ni 231.604	0.069	mg/L	0.81
2030b1	Ni 231.604	0.019	mg/L	6.74
2030b2	Ni 231.604	0.157	mg/L	0.73
2030c1	Ni 231.604	0.044	mg/L	0.38
2030c2	Ni 231.604	0.016	mg/L	3.94
2030d1	Ni 231.604	0.013	mg/L	7.59
2030d2	Ni 231.604	0.021	mg/L	0.25
2030e1	Ni 231.604	0.028	mg/L	0.14
2030e2	Ni 231.604	0.027	mg/L	4.11
1921c1	P 178.221	0.516	mg/L	7.16
1921c2	P 178.221	0.578	mg/L	4.11
1921d1	P 178.221	0.521	mg/L	3.81
1921d2	P 178.221	0.536	mg/L	5.6
1921e1	P 178.221	1.413	mg/L	2.71
1921e2	P 178.221	1.819	mg/L	2.91
1932a1	P 178.221	1.153	mg/L	3.23
1932a2	P 178.221	1.161	mg/L	3.19
1932b1	P 178.221	0.703	mg/L	2.05
1932b2	P 178.221	0.663	mg/L	11.8
1932c1	P 178.221	0.73	mg/L	3.98
1932c2	P 178.221	0.628	mg/L	3.52
1932d1	P 178.221	0.577	mg/L	2.22

1932d2	P 178.221	0.568	mg/L	3.65
1932e1	P 178.221	0.283	mg/L	0.59
1932e2	P 178.221	0.532	mg/L	9.03
2030a1	P 178.221	0.52	mg/L	2.26
2030a2	P 178.221	0.599	mg/L	4.72
2030b1	P 178.221	0.336	mg/L	7.67
2030b2	P 178.221	0.373	mg/L	2.78
2030c1	P 178.221	0.308	mg/L	8.69
2030c2	P 178.221	0.281	mg/L	13.28
2030d1	P 178.221	0.3	mg/L	7.21
2030d2	P 178.221	0.287	mg/L	7.8
2030e1	P 178.221	0.537	mg/L	2.17
2030e2	P 178.221	0.393	mg/L	10.24
1921c1	Sr 407.771	0.245	mg/L	0.15
1921c2	Sr 407.771	0.266	mg/L	0.06
1921d1	Sr 407.771	0.23	mg/L	0.12
1921d2	Sr 407.771	0.23	mg/L	0.1
1921e1	Sr 407.771	0.199	mg/L	0.21
1921e2	Sr 407.771	0.203	mg/L	0.12
1932a1	Sr 407.771	0.4	mg/L	0.17
1932a2	Sr 407.771	0.412	mg/L	0.2
1932b1	Sr 407.771	0.319	mg/L	0.1
1932b2	Sr 407.771	0.263	mg/L	0.19
1932c1	Sr 407.771	0.294	mg/L	0.4
1932c2	Sr 407.771	0.232	mg/L	0.06
1932d1	Sr 407.771	0.195	mg/L	0.16
1932d2	Sr 407.771	0.187	mg/L	0.18
1932e1	Sr 407.771	0.125	mg/L	0.25

1932e2	Sr 407.771	0.175	mg/L	0.15
2030a1	Sr 407.771	0.732	mg/L	0.08
2030a2	Sr 407.771	0.731	mg/L	0.04
2030b1	Sr 407.771	0.598	mg/L	0.2
2030b2	Sr 407.771	0.572	mg/L	0.15
2030c1	Sr 407.771	0.616	mg/L	0.35
2030c2	Sr 407.771	0.591	mg/L	0.15
2030d1	Sr 407.771	0.532	mg/L	0.08
2030d2	Sr 407.771	0.549	mg/L	0.19
2030e1	Sr 407.771	0.604	mg/L	0.15
2030e2	Sr 407.771	0.436	mg/L	0.06
1921c1	Ti 336.121	0.006	mg/L	5.2
1921c2	Ti 336.121	0.068	mg/L	0.39
1921d1	Ti 336.121	0.011	mg/L	0.41
1921d2	Ti 336.121	0.007	mg/L	2.79
1921e1	Ti 336.121	0.071	mg/L	0.88
1921e2	Ti 336.121	0.021	mg/L	0.96
1932a1	Ti 336.121	-0.001	mg/L	11.77
1932a2	Ti 336.121	0.01	mg/L	0.91
1932b1	Ti 336.121	0.001	mg/L	20.47
1932b2	Ti 336.121	0.004	mg/L	3.75
1932c1	Ti 336.121	0	mg/L	20.43
1932c2	Ti 336.121	0.002	mg/L	12.72
1932d1	Ti 336.121	0.001	mg/L	21.16
1932d2	Ti 336.121	0.005	mg/L	2.15
1932e1	Ti 336.121	0	mg/L	837.1
1932e2	Ti 336.121	0	mg/L	24.12
2030a1	Ti 336.121	0.008	mg/L	1.59

2030a2	Ti 336.121	0.02	mg/L	1.43
2030b1	Ti 336.121	-0.001	mg/L	19.14
2030b2	Ti 336.121	0.013	mg/L	3.28
2030c1	Ti 336.121	0.01	mg/L	0.47
2030c2	Ti 336.121	-0.001	mg/L	8.91
2030d1	Ti 336.121	-0.001	mg/L	25.14
2030d2	Ti 336.121	-0.002	mg/L	5.8
2030e1	Ti 336.121	0.01	mg/L	2.08
2030e2	Ti 336.121	0.002	mg/L	19.91
1921c1	Zn 213.856	0.096	mg/L	0.14
1921c2	Zn 213.856	0.117	mg/L	0.22
1921d1	Zn 213.856	0.069	mg/L	0.27
1921d2	Zn 213.856	0.096	mg/L	0.22
1921e1	Zn 213.856	0.097	mg/L	0.11
1921e2	Zn 213.856	0.159	mg/L	0.07
1932a1	Zn 213.856	0.17	mg/L	0.21
1932a2	Zn 213.856	0.134	mg/L	0.14
1932b1	Zn 213.856	0.068	mg/L	0.52
1932b2	Zn 213.856	0.059	mg/L	0.51
1932c1	Zn 213.856	0.068	mg/L	0.22
1932c2	Zn 213.856	0.121	mg/L	0.48
1932d1	Zn 213.856	0.1	mg/L	0.06
1932d2	Zn 213.856	0.076	mg/L	0.33
1932e1	Zn 213.856	0.334	mg/L	0.37
1932e2	Zn 213.856	0.178	mg/L	0.06
2030a1	Zn 213.856	0.128	mg/L	0.35
2030a2	Zn 213.856	0.21	mg/L	0.16
2030b1	Zn 213.856	0.051	mg/L	0.32

2030b2	Zn 213.856	0.12	mg/L	0.34
2030c1	Zn 213.856	0.446	mg/L	0.31
2030c2	Zn 213.856	0.057	mg/L	0.4
2030d1	Zn 213.856	0.037	mg/L	0.53
2030d2	Zn 213.856	0.046	mg/L	0.08
2030e1	Zn 213.856	0.208	mg/L	0.14
2030e2	Zn 213.856	0.039	mg/L	1.02

Appendix C

Raw Data for Q8001B

Raw Data for Q8001B

Cool Plasma

Label	Type	Element	Flags	Sol'n Conc	Units	Corr Conc	Units	c/s
Blank	BLK	Ca		0	ppb	0	ppb	1931
Blank	BLK	Fe		0	ppb	0	ppb	451.9436
Blank	BLK	K		0	ppb	0	ppb	4185
Blank	BLK	Li		0	ppb	0	ppb	-5.6259
Blank	BLK	Mg		0	ppb	0	ppb	565
Blank	BLK	Na		0	ppb	0	ppb	9227
50ppb	STD	Ca			ppb		ppb	
50ppb	STD	Fe		50	ppb	50	ppb	2041.768
50ppb	STD	K			ppb		ppb	
50ppb	STD	Li		50	ppb	50	ppb	-4629.42
50ppb	STD	Mg			ppb		ppb	
50ppb	STD	Na			ppb		ppb	
100ppb	STD	Ca		100	ppb	100	ppb	2879
100ppb	STD	Fe		100	ppb	100	ppb	3539.002
100ppb	STD	K		100	ppb	100	ppb	54667
100ppb	STD	Li		100	ppb	100	ppb	-9129.05
100ppb	STD	Mg		100	ppb	100	ppb	21597
100ppb	STD	Na		100	ppb	100	ppb	127117
500ppb	STD	Ca		500	ppb	500	ppb	6127
500ppb	STD	Fe		500	ppb	500	ppb	14565.09
500ppb	STD	K		500	ppb	500	ppb	268486
500ppb	STD	Li		500	ppb	500	ppb	-40499
500ppb	STD	Mg		500	ppb	500	ppb	108792

500ppb	STD	Na	500	ppb	500	ppb	628002
1000ppb	STD	Ca	1000	ppb	1000	ppb	9958
1000ppb	STD	Fe		ppb		ppb	
1000ppb	STD	K	1000	ppb	1000	ppb	559770
1000ppb	STD	Li	1000	ppb	1000	ppb	-68718.2
1000ppb	STD	Mg	1000	ppb	1000	ppb	220241
1000ppb	STD	Na	1000	ppb	1000	ppb	1290679
Blank 1	SAM	Ca	-9.0001754	ppb	-90.001754	ppb	1858
Blank 1	SAM	Fe	15.7664794	ppb	157.664794	ppb	899.0973
Blank 1	SAM	K	15.0155963	ppb	150.15596	ppb	12441
Blank 1	SAM	Li		ppb		ppb	-125.206
Blank 1	SAM	Mg	7.17474556	ppb	71.7474517	ppb	2136
Blank 1	SAM	Na	34.3557357	ppb	343.557373	ppb	52925
Blank 2	SAM	Ca	-33.781482	ppb	-337.81481	ppb	1657
Blank 2	SAM	Fe	31.0016479	ppb	310.016479	ppb	1331.182
Blank 2	SAM	K	21.7740707	ppb	217.740707	ppb	16157
Blank 2	SAM	Li		ppb		ppb	-19.2674
Blank 2	SAM	Mg	15.6282501	ppb	156.282501	ppb	3987
Blank 2	SAM	Na	88.012886	ppb	880.128845	ppb	121173
Blank 3	SAM	Ca	-45.617328	ppb	-456.17327	ppb	1561
Blank 3	SAM	Fe	24.4145526	ppb	244.145523	ppb	1144.365
Blank 3	SAM	K	0.58927488	ppb	5.89274883	ppb	4509
Blank 3	SAM	Li		ppb		ppb	-22.56
Blank 3	SAM	Mg	2.53011394	ppb	25.3011398	ppb	1119
Blank 3	SAM	Na	21.8605251	ppb	218.605255	ppb	37032
Blank 4	SAM	Ca	-41.795337	ppb	-417.95336	ppb	1592
Blank 4	SAM	Fe	19.8933754	ppb	198.933746	ppb	1016.14
Blank 4	SAM	K	0.24189369	ppb	2.41893697	ppb	4318

Blank 4	SAM	Li		ppb		ppb	-9.71499
Blank 4	SAM	Mg	2.99138021	ppb	29.9138031	ppb	1220
Blank 4	SAM	Na	20.8172264	ppb	208.172271	ppb	35705
Blank 5	SAM	Ca	-11.712557	ppb	-117.12557	ppb	1836
Blank 5	SAM	Fe	10.996521	ppb	109.96521	ppb	763.8163
Blank 5	SAM	K	0.61109984	ppb	6.11099815	ppb	4521
Blank 5	SAM	Li		ppb		ppb	-22.3654
Blank 5	SAM	Mg	3.16035914	ppb	31.6035919	ppb	1257
Blank 5	SAM	Na	18.5128498	ppb	185.128494	ppb	32774
Blank	BLK	Ca	0	ppb	0	ppb	1695
Blank	BLK	Fe	0	ppb	0	ppb	392.7464
Blank	BLK	K	0	ppb	0	ppb	3376
Blank	BLK	Li	0	ppb	0	ppb	-4.02419
Blank	BLK	Mg	0	ppb	0	ppb	519
Blank	BLK	Na	0	ppb	0	ppb	8660
Blank 8	SAM	Ca	-5.0548934	ppb	-50.548934	ppb	1654
Blank 8	SAM	Fe	6.88504696	ppb	68.8504715	ppb	588.0134
Blank 8	SAM	K	4.80331755	ppb	48.0331764	ppb	6017
Blank 8	SAM	Li		ppb		ppb	-161.629
Blank 8	SAM	Mg	2.03231192	ppb	20.3231201	ppb	964
Blank 8	SAM	Na	25.1523799	ppb	251.523803	ppb	40652
Blank 7	SAM	Ca	-0.1232902	ppb	-1.2329025	ppb	1694
Blank 7	SAM	Fe	8.22441959	ppb	82.244194	ppb	625.9995
Blank 7	SAM	K	3.17553663	ppb	31.7553672	ppb	5122
Blank 7	SAM	Li		ppb		ppb	-114.752
Blank 7	SAM	Mg	1.95467293	ppb	19.54673	ppb	947
Blank 7	SAM	Na	19.6457748	ppb	196.457748	ppb	33648
Blank 6	SAM	Ca	8.75359535	ppb	87.5359497	ppb	1766

Blank 6	SAM	Fe		9.79372025	ppb	97.9372024	ppb	670.5065
Blank 6	SAM	K		2.0606432	ppb	20.6064319	ppb	4509
Blank 6	SAM	Li			ppb		ppb	-11.52
Blank 6	SAM	Mg		2.41137218	ppb	24.1137218	ppb	1047
Blank 6	SAM	Na		18.7227668	ppb	187.227661	ppb	32474
50ppb std check	MSA	Ca		72.3712768	ppb	72.3712768	ppb	2282
50ppb std check	MSA	Fe		63.4469337	ppb	63.4469337	ppb	2192.167
50ppb std check	MSA	K		37.1552352	ppb	37.1552352	ppb	23805
50ppb std check	MSA	Li			ppb		ppb	-4230.17
50ppb std check	MSA	Mg		43.9162025	ppb	43.9162025	ppb	10135
50ppb std check	MSA	Na		58.9373283	ppb	58.9373283	ppb	83624
A1	SAM	Ca	x	7108.65966	ppb	71086.5937	ppb	59353
A1	SAM	Fe	x	12057.5507	ppb	120575.507	ppb	342357.4
A1	SAM	K		196.770523	ppb	1967.7052	ppb	111566
A1	SAM	Li			ppb		ppb	-1298.71
A1	SAM	Mg		533.927124	ppb	5339.27148	ppb	117429
A1	SAM	Na		280.950012	ppb	2809.5	ppb	366008
A2	SAM	Ca	x	7145.64697	ppb	71456.4687	ppb	59653
A2	SAM	Fe	x	10588.165	ppb	105881.648	ppb	300684.1
A2	SAM	K		82.471199	ppb	824.711975	ppb	48721
A2	SAM	Li			ppb		ppb	-704.261
A2	SAM	Mg		653.573242	ppb	6535.73242	ppb	143627
A2	SAM	Na		163.264831	ppb	1632.64831	ppb	216321
Blank	BLK	Ca		0	ppb	0	ppb	1656
Blank	BLK	Fe		0	ppb	0	ppb	1471.084
Blank	BLK	K		0	ppb	0	ppb	3352
Blank	BLK	Li		0	ppb	0	ppb	-5.7153
Blank	BLK	Mg		0	ppb	0	ppb	724

Blank	BLK	Na		0	ppb	0	ppb	8170
100ppb	RSP	Ca		100	ppb	100	ppb	2533
100ppb	RSP	Fe		100	ppb	100	ppb	2946.077
100ppb	RSP	K		100	ppb	100	ppb	45666
100ppb	RSP	Li		100	ppb	100	ppb	-8674.09
100ppb	RSP	Mg		100	ppb	100	ppb	18970
100ppb	RSP	Na		100	ppb	100	ppb	114219
B1	SAM	Ca	x	5417.88134	ppb	54178.8125	ppb	42309
B1	SAM	Fe			ppb		ppb	172866.8
B1	SAM	K		70.1635665	ppb	701.635681	ppb	35688
B1	SAM	Li			ppb		ppb	-559.867
B1	SAM	Mg		643.064392	ppb	6430.64404	ppb	122879
B1	SAM	Na		81.4448089	ppb	814.44812	ppb	101357
B2	SAM	Ca	x	4888.26074	ppb	48882.6093	ppb	38335
B2	SAM	Fe			ppb		ppb	178896.6
B2	SAM	K		29.5400409	ppb	295.400421	ppb	16966
B2	SAM	Li			ppb		ppb	-413.589
B2	SAM	Mg		606.21936	ppb	6062.19335	ppb	115880
B2	SAM	Na		83.6350402	ppb	836.350402	ppb	103863
C1	SAM	Ca	x	4836.81787	ppb	48368.1796	ppb	37949
C1	SAM	Fe			ppb		ppb	177133.7
C1	SAM	K		61.5102882	ppb	615.102905	ppb	31700
C1	SAM	Li			ppb		ppb	-396.618
C1	SAM	Mg		598.670349	ppb	5986.70361	ppb	114446
C1	SAM	Na		92.2797088	ppb	922.797119	ppb	113754
C2	SAM	Ca	x	5421.47949	ppb	54214.7968	ppb	42336
C2	SAM	Fe			ppb		ppb	198694.4
C2	SAM	K		35.0036697	ppb	350.036682	ppb	19484

C2	SAM	Li			ppb		ppb	-355.306
C2	SAM	Mg		639.77948	ppb	6397.79492	ppb	122255
C2	SAM	Na		80.5201263	ppb	805.201293	ppb	100299
SW1	QCS	Ca		-9.9953527	ppb	-9.9953527	ppb	1581
SW1	QCS	Fe			ppb		ppb	3258.619
SW1	QCS	K		1.5102005	ppb	1.5102005	ppb	4048
SW1	QCS	Li			ppb		ppb	0.6911
SW1	QCS	Mg		-2.5163505	ppb	-2.5163505	ppb	246
SW1	QCS	Na		-5.2404637	ppb	-5.2404637	ppb	2174
SW1	QCS	Ca		257.880096	ppb	257.880096	ppb	3591
SW1	QCS	Fe			ppb		ppb	559.9716
SW1	QCS	K		20.899786	ppb	20.899786	ppb	12984
SW1	QCS	Li			ppb		ppb	-3.008
SW1	QCS	Mg		41.7935295	ppb	41.7935295	ppb	8663
SW1	QCS	Na		192.371154	ppb	192.371154	ppb	228276
SW2	QCS	Ca	x	1032.32006	ppb	1032.32006	ppb	9402
SW2	QCS	Fe			ppb		ppb	730.1404
SW2	QCS	K		100.931732	ppb	100.931732	ppb	49868
SW2	QCS	Li			ppb		ppb	-1.3332
SW2	QCS	Mg		213.242279	ppb	213.242279	ppb	41231
SW2	QCS	Na	x	955.13916	ppb	955.13916	ppb	1101015
D1	SAM	Ca	x	5742.39697	ppb	57423.9687	ppb	44744
D1	SAM	Fe			ppb		ppb	177278.7
D1	SAM	K		60.7942504	ppb	607.942504	ppb	31370
D1	SAM	Li			ppb		ppb	-398.508
D1	SAM	Mg		780.310791	ppb	7803.10791	ppb	148950
D1	SAM	Na		90.6890335	ppb	906.890319	ppb	111934
Blank	BLK	Ca		0	ppb	0	ppb	1879

Blank	BLK	Fe		0	ppb	0	ppb	1118.281
Blank	BLK	K		0	ppb	0	ppb	3403
Blank	BLK	Li		0	ppb	0	ppb	-5.3332
Blank	BLK	Mg		0	ppb	0	ppb	829
Blank	BLK	Na		0	ppb	0	ppb	8745
D2	SAM	Ca	x	5394.69189	ppb	53946.9179	ppb	42358
D2	SAM	Fe			ppb		ppb	174505
D2	SAM	K		38.481903	ppb	384.81903	ppb	21138
D2	SAM	Li			ppb		ppb	-413.587
D2	SAM	Mg		707.789367	ppb	7077.89355	ppb	135279
D2	SAM	Na		66.6533508	ppb	666.533508	ppb	85008
E1	SAM	Ca	x	4526.02929	ppb	45260.2929	ppb	35840
E1	SAM	Fe			ppb		ppb	144333.3
E1	SAM	K		23.1998043	ppb	231.998046	ppb	14095
E1	SAM	Li			ppb		ppb	-407.402
E1	SAM	Mg		605.729797	ppb	6057.29785	ppb	115892
E1	SAM	Na		67.3927459	ppb	673.92749	ppb	85854
E2	SAM	Ca	x	5249.69287	ppb	52496.9296	ppb	41270
E2	SAM	Fe			ppb		ppb	188363.5
E2	SAM	K		34.6564979	ppb	346.564971	ppb	19375
E2	SAM	Li			ppb		ppb	-399.205
E2	SAM	Mg		684.436767	ppb	6844.36767	ppb	130843
E2	SAM	Na		72.525711	ppb	725.25708	ppb	91727
50ppb std check	MSA	Ca	x	5244.62841	ppb	5244.62841	ppb	41232
50ppb std check	MSA	Fe			ppb		ppb	184139.4
50ppb std check	MSA	K		78.9882583	ppb	78.9882583	ppb	39806
50ppb std check	MSA	Li			ppb		ppb	-5425.88
50ppb std check	MSA	Mg		720.976562	ppb	720.976562	ppb	137784

50ppb std check	MSA	Na		117.867599	ppb	117.867599	ppb	143606
F1	SAM	Ca	x	4957.96142	ppb	49579.6132	ppb	39081
F1	SAM	Fe			ppb		ppb	121502.7
F1	SAM	K		18.165802	ppb	181.65802	ppb	11775
F1	SAM	Li			ppb		ppb	-213.928
F1	SAM	Mg		694.312683	ppb	6943.12695	ppb	132719
F1	SAM	Na		46.9159584	ppb	469.159576	ppb	62425
F2	SAM	Ca	x	4144.87304	ppb	41448.7304	ppb	32980
F2	SAM	Fe			ppb		ppb	115279.3
F2	SAM	K		34.3613967	ppb	343.613952	ppb	19239
F2	SAM	Li			ppb		ppb	-350.491
F2	SAM	Mg		586.446533	ppb	5864.46533	ppb	112229
F2	SAM	Na		61.8813438	ppb	618.813415	ppb	79548
Blank	BLK	Ca		0	ppb	0	ppb	1901
Blank	BLK	Fe		0	ppb	0	ppb	830.9717
Blank	BLK	K		0	ppb	0	ppb	3424
Blank	BLK	Li		0	ppb	0	ppb	-4.57709
Blank	BLK	Mg		0	ppb	0	ppb	798
Blank	BLK	Na		0	ppb	0	ppb	8540
100ppb	RSP	Ca		100	ppb	100	ppb	2636
100ppb	RSP	Fe		100	ppb	100	ppb	2969.541
100ppb	RSP	K		100	ppb	100	ppb	46963
100ppb	RSP	Li		100	ppb	100	ppb	-8495.9
100ppb	RSP	Mg		100	ppb	100	ppb	18916
100ppb	RSP	Na		100	ppb	100	ppb	113568
G1	SAM	Ca	x	5376.11572	ppb	53761.1562	ppb	35709
G1	SAM	Fe			ppb		ppb	114138
G1	SAM	K		29.5946025	ppb	295.946014	ppb	17458

G1	SAM	Li			ppb		ppb	-352.337
G1	SAM	Mg		642.746032	ppb	6427.46044	ppb	122036
G1	SAM	Na		57.0291252	ppb	570.291259	ppb	73163
G2	SAM	Ca	x	5723.89062	ppb	57238.9062	ppb	37896
G2	SAM	Fe			ppb		ppb	108480
G2	SAM	K		43.0781326	ppb	430.781311	ppb	23852
G2	SAM	Li			ppb		ppb	-510.835
G2	SAM	Mg		656.768615	ppb	6567.68603	ppb	124681
G2	SAM	Na		77.6537933	ppb	776.537963	ppb	96534
H1	SAM	Ca	x	5495.06201	ppb	54950.621	ppb	36457
H1	SAM	Fe			ppb		ppb	104253.2
H1	SAM	K		29.1665191	ppb	291.665191	ppb	17255
H1	SAM	Li			ppb		ppb	-460.627
H1	SAM	Mg		567.008483	ppb	5670.08496	ppb	107750
H1	SAM	Na		61.2421302	ppb	612.421325	ppb	77937
H2	SAM	Ca	x	6612.64746	ppb	66126.4765	ppb	43485
H2	SAM	Fe			ppb		ppb	159528.2
H2	SAM	K		21.5116519	ppb	215.116516	ppb	13625
H2	SAM	Li			ppb		ppb	-286.16
H2	SAM	Mg		673.982666	ppb	6739.82666	ppb	127928
H2	SAM	Na		73.8608474	ppb	738.608459	ppb	92236
I1	SAM	Ca	x	5569.95996	ppb	55699.6015	ppb	36928
I1	SAM	Fe			ppb		ppb	77696.36
I1	SAM	K		45.6213188	ppb	456.213195	ppb	25058
I1	SAM	Li			ppb		ppb	-514.575
I1	SAM	Mg		665.638	ppb	6656.37988	ppb	126354
I1	SAM	Na		145.238372	ppb	1452.38378	ppb	173118
I2	SAM	Ca	x	4179.33837	ppb	41793.3828	ppb	28183

I2	SAM	Fe			ppb		ppb	64825.35
I2	SAM	K		16.6614608	ppb	166.614608	ppb	11325
I2	SAM	Li			ppb		ppb	-442.595
I2	SAM	Mg		539.297424	ppb	5392.97412	ppb	102523
I2	SAM	Na		63.2603797	ppb	632.60382	ppb	80224
50ppb std check	MSA	Ca	x	4360.62011	ppb	4360.62011	ppb	29323
50ppb std check	MSA	Fe			ppb		ppb	66858.53
50ppb std check	MSA	K		61.4582481	ppb	61.4582481	ppb	32568
50ppb std check	MSA	Li			ppb		ppb	-4738.62
50ppb std check	MSA	Mg		599.459106	ppb	599.459106	ppb	113871
50ppb std check	MSA	Na		109.186019	ppb	109.186019	ppb	132265
SW1	QCS	Ca		224.216842	ppb	224.216842	ppb	3311
SW1	QCS	Fe			ppb		ppb	756.2955
SW1	QCS	K		17.2962036	ppb	17.2962036	ppb	11626
SW1	QCS	Li			ppb		ppb	-9.64199
SW1	QCS	Mg		34.4545974	ppb	34.4545974	ppb	7297
SW1	QCS	Na		157.87738	ppb	157.87738	ppb	187440
SW2	QCS	Ca		253.953414	ppb	253.953414	ppb	3498
SW2	QCS	Fe			ppb		ppb	496.1407
SW2	QCS	K		4.61189938	ppb	4.61189938	ppb	5611
SW2	QCS	Li			ppb		ppb	-4.13789
SW2	QCS	Mg		4.10337877	ppb	4.10337877	ppb	1572
SW2	QCS	Na		9.73209476	ppb	9.73209476	ppb	19568
Preparation Blank	PRB	Ca		109.087059	ppb	109.087059	ppb	2587
Preparation Blank	PRB	Fe			ppb		ppb	3678.577
Preparation Blank	PRB	K		8.00281525	ppb	8.00281525	ppb	7219
Preparation Blank	PRB	Li			ppb		ppb	-1.9024
Preparation Blank	PRB	Mg		3.9549365	ppb	3.9549365	ppb	1544

Preparation Blank	PRB	Na	26.6679515	ppb	26.6679515	ppb	38759

Hot Plasma

Label	Type	Element	Flags	Sol'n Conc	Units	Corr Conc	Units	c/s
Blank	BLK	Ag		0	ppb	0	ppb	76.66666
Blank	BLK	Al		0	ppb	0	ppb	3116.666
Blank	BLK	As		0	ppb	0	ppb	3047.527
Blank	BLK	B		0	ppb	0	ppb	8296.667
Blank	BLK	Ba		0	ppb	0	ppb	26.66666
Blank	BLK	Bi		0	ppb	0	ppb	60
Blank	BLK	Cd		0	ppb	0	ppb	10
Blank	BLK	Co		0	ppb	0	ppb	283.3333
Blank	BLK	Cr		0	ppb	0	ppb	353.3333
Blank	BLK	Cu		0	ppb	0	ppb	496.6666
Blank	BLK	Fe		0	ppb	0	ppb	5346.666
Blank	BLK	Ga		0	ppb	0	ppb	316.6666
Blank	BLK	Ir		0	ppb	0	ppb	40
Blank	BLK	Mg		0	ppb	0	ppb	1380
Blank	BLK	Mn		0	ppb	0	ppb	923.3333
Blank	BLK	Ni		0	ppb	0	ppb	1073.333
Blank	BLK	Pb		0	ppb	0	ppb	206.6666
Blank	BLK	Sr		0	ppb	0	ppb	103.3333
Blank	BLK	Ti		0	ppb	0	ppb	23.33333
Blank	BLK	Tl		0	ppb	0	ppb	23.33333
Blank	BLK	V		0	ppb	0	ppb	1479.279
Blank	BLK	Zn		0	ppb	0	ppb	80
Blank	BLK	(Rh)			ppb		ppb	1686380
Blank	BLK	(Sc)			ppb		ppb	1388146
Blank	BLK	(Tb)			ppb		ppb	1650743

Blank	BLK	(Y)		ppb		ppb	1932350
10ppb	STD	Ag	10	ppb	10	ppb	52023.33
10ppb	STD	Al	10	ppb	10	ppb	76626.66
10ppb	STD	As	10	ppb	10	ppb	13319.38
10ppb	STD	B	10	ppb	10	ppb	20836.66
10ppb	STD	Ba	10	ppb	10	ppb	12386.66
10ppb	STD	Bi	10	ppb	10	ppb	60946.66
10ppb	STD	Cd	10	ppb	10	ppb	10506.66
10ppb	STD	Co	10	ppb	10	ppb	108900
10ppb	STD	Cr	10	ppb	10	ppb	9956.667
10ppb	STD	Cu	10	ppb	10	ppb	53933.33
10ppb	STD	Fe	10	ppb	10	ppb	8943.333
10ppb	STD	Ga	10	ppb	10	ppb	55546.66
10ppb	STD	Ir	10	ppb	10	ppb	47176.66
10ppb	STD	Mg	10	ppb	10	ppb	16846.66
10ppb	STD	Mn	10	ppb	10	ppb	119423.3
10ppb	STD	Ni	10	ppb	10	ppb	24950
10ppb	STD	Pb	10	ppb	10	ppb	68170
10ppb	STD	Sr	10	ppb	10	ppb	120156.6
10ppb	STD	Ti	10	ppb	10	ppb	5256.666
10ppb	STD	Tl	10	ppb	10	ppb	52606.66
10ppb	STD	V	10	ppb	10	ppb	94712.18
10ppb	STD	Zn	10	ppb	10	ppb	11770
10ppb	STD	(Rh)	1.07023728	ppb	1.07023728	ppb	1804826
10ppb	STD	(Sc)	1.05716503	ppb	1.05716503	ppb	1467500
10ppb	STD	(Tb)	1.02717769	ppb	1.02717769	ppb	1695606
10ppb	STD	(Y)	1.06359792	ppb	1.06359792	ppb	2055243
50ppb	STD	Ag	50	ppb	50	ppb	193473.3

50ppb	STD	Al	50	ppb	50	ppb	342243.3
50ppb	STD	As	50	ppb	50	ppb	53291.45
50ppb	STD	B	50	ppb	50	ppb	67416.66
50ppb	STD	Ba	50	ppb	50	ppb	62620
50ppb	STD	Bi	50	ppb	50	ppb	320400
50ppb	STD	Cd	50	ppb	50	ppb	54440
50ppb	STD	Co	50	ppb	50	ppb	532530
50ppb	STD	Cr	50	ppb	50	ppb	49556.66
50ppb	STD	Cu	50	ppb	50	ppb	266186.6
50ppb	STD	Fe	50	ppb	50	ppb	19253.33
50ppb	STD	Ga	50	ppb	50	ppb	272283.3
50ppb	STD	Ir	50	ppb	50	ppb	243213.3
50ppb	STD	Mg	50	ppb	50	ppb	76020
50ppb	STD	Mn	50	ppb	50	ppb	588600
50ppb	STD	Ni	50	ppb	50	ppb	123280
50ppb	STD	Pb	50	ppb	50	ppb	367160
50ppb	STD	Sr	50	ppb	50	ppb	595053.3
50ppb	STD	Ti	50	ppb	50	ppb	25630
50ppb	STD	Tl	50	ppb	50	ppb	276396.6
50ppb	STD	V	50	ppb	50	ppb	458049.6
50ppb	STD	Zn	50	ppb	50	ppb	57310
50ppb	STD	(Rh)	1.10058224	ppb	1.10058224	ppb	1856000
50ppb	STD	(Sc)	0.99939972	ppb	0.99939972	ppb	1387313
50ppb	STD	(Tb)	1.08042634	ppb	1.08042634	ppb	1783506
50ppb	STD	(Y)	1.07759118	ppb	1.07759118	ppb	2082283
100ppb	STD	Ag	100	ppb	100	ppb	310903.3
100ppb	STD	Al	100	ppb	100	ppb	624316.6
100ppb	STD	As	100	ppb	100	ppb	103756.7

100ppb	STD	B	100	ppb	100	ppb	112090
100ppb	STD	Ba	100	ppb	100	ppb	126950
100ppb	STD	Bi	100	ppb	100	ppb	658203.3
100ppb	STD	Cd	100	ppb	100	ppb	110306.6
100ppb	STD	Co	100	ppb	100	ppb	1035066
100ppb	STD	Cr	100	ppb	100	ppb	95486.66
100ppb	STD	Cu	100	ppb	100	ppb	513203.3
100ppb	STD	Fe	100	ppb	100	ppb	32080
100ppb	STD	Ga	100	ppb	100	ppb	529280
100ppb	STD	Ir	100	ppb	100	ppb	502363.3
100ppb	STD	Mg	100	ppb	100	ppb	142256.6
100ppb	STD	Mn	100	ppb	100	ppb	1134576
100ppb	STD	Ni	100	ppb	100	ppb	239630
100ppb	STD	Pb	100	ppb	100	ppb	752543.3
100ppb	STD	Sr	100	ppb	100	ppb	1167076
100ppb	STD	Ti	100	ppb	100	ppb	49496.66
100ppb	STD	Tl	100	ppb	100	ppb	567350
100ppb	STD	V	100	ppb	100	ppb	860938
100ppb	STD	Zn	100	ppb	100	ppb	114840
100ppb	STD	(Rh)	1.09160054	ppb	1.09160054	ppb	1840853
100ppb	STD	(Sc)	0.97653949	ppb	0.97653949	ppb	1355580
100ppb	STD	(Tb)	1.09823656	ppb	1.09823656	ppb	1812906
100ppb	STD	(Y)	1.06460178	ppb	1.06460178	ppb	2057183
500ppb	STD	Ag	500	ppb	500	ppb	782600
500ppb	STD	Al		ppb		ppb	
500ppb	STD	As		ppb		ppb	
500ppb	STD	B	500	ppb	500	ppb	466573.3
500ppb	STD	Ba	500	ppb	500	ppb	623166.6

500ppb	STD	Bi			ppb		ppb	
500ppb	STD	Cd		500	ppb	500	ppb	539493.3
500ppb	STD	Co			ppb		ppb	
500ppb	STD	Cr		500	ppb	500	ppb	456233.3
500ppb	STD	Cu		500	ppb	500	ppb	2381833
500ppb	STD	Fe		500	ppb	500	ppb	128946.6
500ppb	STD	Ga		500	ppb	500	ppb	2483196
500ppb	STD	Ir		500	ppb	500	ppb	2362580
500ppb	STD	Mg		500	ppb	500	ppb	637416.6
500ppb	STD	Mn			ppb		ppb	
500ppb	STD	Ni		500	ppb	500	ppb	1130916
500ppb	STD	Pb		500	ppb	500	ppb	3697740
500ppb	STD	Sr			ppb		ppb	
500ppb	STD	Ti		500	ppb	500	ppb	236450
500ppb	STD	Tl		500	ppb	500	ppb	2656160
500ppb	STD	V			ppb		ppb	
500ppb	STD	Zn		500	ppb	500	ppb	565253.3
500ppb	STD	(Rh)		1.09519601	ppb	1.09519601	ppb	1846916
500ppb	STD	(Sc)		0.92864591	ppb	0.92864591	ppb	1289096
500ppb	STD	(Tb)		1.12411582	ppb	1.12411582	ppb	1855626
500ppb	STD	(Y)		1.06615603	ppb	1.06615603	ppb	2060186
Blank 1	SAM	Ag			ppb		ppb	3960
Blank 1	SAM	Al	x	128.159271	ppb	3844.77807	ppb	627310
Blank 1	SAM	As		-0.2300564	ppb	-6.9016923	ppb	2958.66
Blank 1	SAM	B			ppb		ppb	14220
Blank 1	SAM	Ba		0.10536679	ppb	3.16100359	ppb	176.6666
Blank 1	SAM	Bi		0.92687088	ppb	27.8061256	ppb	5810
Blank 1	SAM	Cd		0.01457174	ppb	0.43715218	ppb	26.66666

Blank 1	SAM	Co		0.05229091	ppb	1.56872725	ppb	633.3333
Blank 1	SAM	Cr		8.33370209	ppb	250.011062	ppb	6450
Blank 1	SAM	Cu		0.58634162	ppb	17.5902481	ppb	2650
Blank 1	SAM	Fe		27.2525005	ppb	817.575012	ppb	9550
Blank 1	SAM	Ga		-2.8726506	ppb	-86.179519	ppb	636.6666
Blank 1	SAM	Ir		-3.0515613	ppb	-91.546844	ppb	723.3333
Blank 1	SAM	Mg		6.88770676	ppb	206.631195	ppb	8196.667
Blank 1	SAM	Mn		0.48770314	ppb	14.6310939	ppb	4983.333
Blank 1	SAM	Ni		0.90390766	ppb	27.1172294	ppb	2473.333
Blank 1	SAM	Pb		0.15725793	ppb	4.71773767	ppb	1526.666
Blank 1	SAM	Sr		0.09031043	ppb	2.70931292	ppb	1143.333
Blank 1	SAM	Ti		1.04121625	ppb	31.2364883	ppb	376.6666
Blank 1	SAM	Tl		-3.391689	ppb	-101.75067	ppb	216.6666
Blank 1	SAM	V		-0.4836562	ppb	-14.509685	ppb	272.6651
Blank 1	SAM	Zn		5.447299	ppb	163.418975	ppb	5063.333
Blank 1	SAM	(Rh)		1.08994806	ppb	32.6984405	ppb	1838066
Blank 1	SAM	(Sc)		0.75593603	ppb	22.6780815	ppb	1049350
Blank 1	SAM	(Tb)		1.22793162	ppb	36.8379478	ppb	2027000
Blank 1	SAM	(Y)		1.0455128	ppb	31.3653831	ppb	2020296
Blank 2	SAM	Ag			ppb		ppb	2376.666
Blank 2	SAM	Al	x	304.115844	ppb	9123.47558	ppb	1448953
Blank 2	SAM	As		-0.3037029	ppb	-9.1110887	ppb	2860.304
Blank 2	SAM	B			ppb		ppb	9506.667
Blank 2	SAM	Ba		0.16591935	ppb	4.97758055	ppb	260
Blank 2	SAM	Bi		0.50684065	ppb	15.2052192	ppb	2743.333
Blank 2	SAM	Cd		0.02134928	ppb	0.64047843	ppb	33.33333
Blank 2	SAM	Co		0.26698348	ppb	8.00950432	ppb	2296.666
Blank 2	SAM	Cr		9.39315319	ppb	281.794586	ppb	7060

Blank 2	SAM	Cu		1.81564629	ppb	54.469387	ppb	7240
Blank 2	SAM	Fe		49.1128578	ppb	1473.38574	ppb	13630
Blank 2	SAM	Ga		-2.8950667	ppb	-86.852005	ppb	523.3333
Blank 2	SAM	Ir		-3.1445417	ppb	-94.33625	ppb	246.6666
Blank 2	SAM	Mg		21.9209556	ppb	657.628662	ppb	23230
Blank 2	SAM	Mn		0.87635338	ppb	26.2906017	ppb	8200
Blank 2	SAM	Ni		1.24683154	ppb	37.4049453	ppb	3030
Blank 2	SAM	Pb		0.28788278	ppb	8.63648319	ppb	2600
Blank 2	SAM	Sr		0.12649052	ppb	3.79471564	ppb	1543.333
Blank 2	SAM	Ti		1.20103443	ppb	36.0310325	ppb	426.6666
Blank 2	SAM	Tl		-3.4159202	ppb	-102.4776	ppb	76.66666
Blank 2	SAM	V		-0.4608353	ppb	-13.825059	ppb	416.7132
Blank 2	SAM	Zn		21.9042205	ppb	657.126586	ppb	19680
Blank 2	SAM	(Rh)		1.07294321	ppb	32.1882972	ppb	1809390
Blank 2	SAM	(Sc)		0.73739809	ppb	22.1219425	ppb	1023616
Blank 2	SAM	(Tb)		1.23519099	ppb	37.0557289	ppb	2038983
Blank 2	SAM	(Y)		1.03579926	ppb	31.0739784	ppb	2001526
A1	SAM	Ag			ppb		ppb	2976.666
A1	SAM	Al	x	436.213073	ppb	13086.3925	ppb	2179656
A1	SAM	As		-0.4451362	ppb	-13.354087	ppb	2805.772
A1	SAM	B			ppb		ppb	10263.33
A1	SAM	Ba		40.6192245	ppb	1218.57678	ppb	56130
A1	SAM	Bi		0.43841675	ppb	13.152502	ppb	2253.333
A1	SAM	Cd		0.17304388	ppb	5.19131613	ppb	200
A1	SAM	Co		4.06731844	ppb	122.019554	ppb	33590
A1	SAM	Cr		67.0897293	ppb	2012.69189	ppb	51220
A1	SAM	Cu		9.03534698	ppb	271.060424	ppb	36280
A1	SAM	Fe	x	15786.9433	ppb	473608.312	ppb	3270636

A1	SAM	Ga		-2.8213317	ppb	-84.639953	ppb	903.3333
A1	SAM	Ir		-3.1404526	ppb	-94.213577	ppb	270
A1	SAM	Mg	x	598.774597	ppb	17963.2382	ppb	637716.6
A1	SAM	Mn	x	177.036377	ppb	5311.0913	ppb	1594390
A1	SAM	Ni		5.75423336	ppb	172.626998	ppb	11666.66
A1	SAM	Pb		0.57877487	ppb	17.3632469	ppb	5000
A1	SAM	Sr		24.3854637	ppb	731.563903	ppb	285610
A1	SAM	Ti		5.33482122	ppb	160.044632	ppb	2076.666
A1	SAM	Tl		-3.4160018	ppb	-102.48005	ppb	76.66666
A1	SAM	V		45.4139137	ppb	1362.41735	ppb	313764.2
A1	SAM	Zn		29.6119403	ppb	888.358215	ppb	27896.66
A1	SAM	(Rh)		1.099841	ppb	32.9952316	ppb	1854750
A1	SAM	(Sc)		0.77378476	ppb	23.2135429	ppb	1074126
A1	SAM	(Tb)		1.24359131	ppb	37.3077392	ppb	2052850
A1	SAM	(Y)		1.06618023	ppb	31.9854068	ppb	2060233
B1	SAM	Ag			ppb		ppb	1610
B1	SAM	Al		31.8794746	ppb	956.384216	ppb	158173.3
B1	SAM	As		-0.3652658	ppb	-10.957974	ppb	2926.325
B1	SAM	B			ppb		ppb	9203.333
B1	SAM	Ba		17.4186763	ppb	522.560302	ppb	24646.66
B1	SAM	Bi		0.33008868	ppb	9.90266037	ppb	1480
B1	SAM	Cd		0.03525776	ppb	1.0577327	ppb	50
B1	SAM	Co		0.83736306	ppb	25.1208915	ppb	6940
B1	SAM	Cr		17.9481868	ppb	538.445617	ppb	13616.66
B1	SAM	Cu		10.4153986	ppb	312.461944	ppb	40900
B1	SAM	Fe	x	7423.52099	ppb	222705.625	ppb	1508493
B1	SAM	Ga		-2.9270885	ppb	-87.812652	ppb	386.6666
B1	SAM	Ir		-3.1596193	ppb	-94.788581	ppb	173.3333

B1	SAM	Mg	x	587.10675	ppb	17613.2031	ppb	612250
B1	SAM	Mn	x	119.514244	ppb	3585.42724	ppb	1054476
B1	SAM	Ni		2.05079412	ppb	61.5238227	ppb	4596.666
B1	SAM	Pb		0.21759836	ppb	6.52795076	ppb	2086.666
B1	SAM	Sr		10.8859815	ppb	326.579437	ppb	129560
B1	SAM	Ti		1.43720591	ppb	43.1161766	ppb	530
B1	SAM	Tl		-3.4185864	ppb	-102.55759	ppb	63.33333
B1	SAM	V		5.95065212	ppb	178.519561	ppb	43315.1
B1	SAM	Zn		6.95606375	ppb	208.681915	ppb	6463.333
B1	SAM	(Rh)		1.12024963	ppb	33.6074905	ppb	1889166
B1	SAM	(Sc)		0.7578066	ppb	22.7341976	ppb	1051946
B1	SAM	(Tb)		1.27159882	ppb	38.1479644	ppb	2099083
B1	SAM	(Y)		1.08319235	ppb	32.4957695	ppb	2093106
D1	SAM	Ag			ppb		ppb	1473.333
D1	SAM	Al		11.1300745	ppb	333.902221	ppb	56280
D1	SAM	As		0.01157245	ppb	0.34717342	ppb	3299.52
D1	SAM	B			ppb		ppb	8140
D1	SAM	Ba		15.5108861	ppb	465.326599	ppb	21830
D1	SAM	Bi		0.38553381	ppb	11.5660142	ppb	1893.333
D1	SAM	Cd		0.01104352	ppb	0.33130544	ppb	23.33333
D1	SAM	Co		0.66421533	ppb	19.9264602	ppb	5503.333
D1	SAM	Cr		15.0182638	ppb	450.547912	ppb	11346.66
D1	SAM	Cu		6.10942268	ppb	183.282684	ppb	23940
D1	SAM	Fe	x	7482.15234	ppb	224464.562	ppb	1507526
D1	SAM	Ga		-2.929702	ppb	-87.891059	ppb	373.3333
D1	SAM	Ir		-3.17089	ppb	-95.126701	ppb	113.3333
D1	SAM	Mg	x	693.532836	ppb	20805.9843	ppb	717070
D1	SAM	Mn	x	130.832138	ppb	3924.96411	ppb	1144393

D1	SAM	Ni		1.73821604	ppb	52.1464805	ppb	3983.333
D1	SAM	Pb		0.15135019	ppb	4.54050541	ppb	1523.333
D1	SAM	Sr		11.2016429	ppb	336.049285	ppb	133110
D1	SAM	Ti		1.5356319	ppb	46.0689582	ppb	563.3333
D1	SAM	Tl		-3.4196503	ppb	-102.5895	ppb	56.66666
D1	SAM	V		3.00586581	ppb	90.1759719	ppb	23415.38
D1	SAM	Zn		11.5796947	ppb	347.390838	ppb	10633.33
D1	SAM	(Rh)		1.1245054	ppb	33.7351608	ppb	1896343
D1	SAM	(Sc)		0.75141674	ppb	22.5425014	ppb	1043076
D1	SAM	(Tb)		1.26492703	ppb	37.9478111	ppb	2088070
D1	SAM	(Y)		1.08119988	ppb	32.435997	ppb	2089256
F1	SAM	Ag			ppb		ppb	1203.333
F1	SAM	Al		10.3512582	ppb	310.53775	ppb	50180
F1	SAM	As		-0.6666322	ppb	-19.998968	ppb	2559.836
F1	SAM	B			ppb		ppb	8200
F1	SAM	Ba		15.2026071	ppb	456.078216	ppb	21400
F1	SAM	Bi		0.2311859	ppb	6.93557692	ppb	723.3333
F1	SAM	Cd		0.01125461	ppb	0.33763817	ppb	23.33333
F1	SAM	Co		0.54669309	ppb	16.400793	ppb	4366.666
F1	SAM	Cr		11.085267	ppb	332.558013	ppb	8066.666
F1	SAM	Cu		14.1100692	ppb	423.302063	ppb	52383.33
F1	SAM	Fe	x	5534.24609	ppb	166027.375	ppb	1066600
F1	SAM	Ga		-2.9414882	ppb	-88.244644	ppb	306.6666
F1	SAM	Ir		-3.173361	ppb	-95.200828	ppb	100
F1	SAM	Mg	x	666.550659	ppb	19996.5195	ppb	658463.3
F1	SAM	Mn		107.383232	ppb	3221.49707	ppb	897893.3
F1	SAM	Ni		1.53626788	ppb	46.0880355	ppb	3456.666
F1	SAM	Pb		0.1747275	ppb	5.2418251	ppb	1716.666

F1	SAM	Sr		10.2642841	ppb	307.928527	ppb	119280
F1	SAM	Ti		1.51477134	ppb	45.4431419	ppb	530
F1	SAM	Tl		-3.4213409	ppb	-102.64022	ppb	46.66666
F1	SAM	V		-0.2852597	ppb	-8.5577917	ppb	1517.149
F1	SAM	Zn		7.16781092	ppb	215.034332	ppb	6310
F1	SAM	(Rh)		1.10253322	ppb	33.0759964	ppb	1859290
F1	SAM	(Sc)		0.71801496	ppb	21.5404491	ppb	996710
F1	SAM	(Tb)		1.2647655	ppb	37.9429664	ppb	2087803
F1	SAM	(Y)		1.05733263	ppb	31.7199783	ppb	2043136
D2	SAM	Ag			ppb		ppb	1126.666
D2	SAM	Al		3.8583343	ppb	115.75003	ppb	22093.33
D2	SAM	As		-0.1106724	ppb	-3.3201739	ppb	3244.368
D2	SAM	B			ppb		ppb	7753.333
D2	SAM	Ba		14.7548294	ppb	442.644897	ppb	20460
D2	SAM	Bi		0.17446458	ppb	5.23393726	ppb	290
D2	SAM	Cd		0.02287569	ppb	0.68627059	ppb	36.66666
D2	SAM	Co		0.96376377	ppb	28.9129123	ppb	8283.333
D2	SAM	Cr		9.92332172	ppb	297.699646	ppb	7963.333
D2	SAM	Cu		4.72348118	ppb	141.704437	ppb	19530
D2	SAM	Fe	x	7281.63964	ppb	218449.187	ppb	1540436
D2	SAM	Ga		-2.9129948	ppb	-87.389846	ppb	466.6666
D2	SAM	Ir		-3.1698801	ppb	-95.096405	ppb	116.6666
D2	SAM	Mg	x	633.793823	ppb	19013.8144	ppb	688056.6
D2	SAM	Mn	x	126.031692	ppb	3780.95068	ppb	1157610
D2	SAM	Ni		1.65033066	ppb	49.5099182	ppb	4016.666
D2	SAM	Pb		0.14000557	ppb	4.20016718	ppb	1406.666
D2	SAM	Sr		11.3732481	ppb	341.197448	ppb	137756.6
D2	SAM	Ti		1.09458697	ppb	32.8376083	ppb	413.3333

D2	SAM	Tl		-3.4206304	ppb	-102.61891	ppb	50
D2	SAM	V		1.35064232	ppb	40.519268	ppb	13053.72
D2	SAM	Zn		1.29462469	ppb	38.8387413	ppb	1303.333
D2	SAM	(Rh)		1.1418047	ppb	34.2541427	ppb	1925516
D2	SAM	(Sc)		0.78889596	ppb	23.6668796	ppb	1095103
D2	SAM	(Tb)		1.24603057	ppb	37.3809166	ppb	2056876
D2	SAM	(Y)		1.10232449	ppb	33.0697326	ppb	2130076
F2	SAM	Ag			ppb		ppb	946.6666
F2	SAM	Al		6.56582928	ppb	196.974884	ppb	34433.33
F2	SAM	As		-0.6186156	ppb	-18.558469	ppb	2680.826
F2	SAM	B			ppb		ppb	7296.666
F2	SAM	Ba		13.4540519	ppb	403.621551	ppb	19020
F2	SAM	Bi		0.19395508	ppb	5.81865215	ppb	443.3333
F2	SAM	Cd		0.01372242	ppb	0.41167259	ppb	26.66666
F2	SAM	Co		0.71225625	ppb	21.3676872	ppb	5930
F2	SAM	Cr		8.69223118	ppb	260.766937	ppb	6726.666
F2	SAM	Cu		5.75340939	ppb	172.602279	ppb	22756.66
F2	SAM	Fe	x	5195.92822	ppb	155877.843	ppb	1056793
F2	SAM	Ga		-2.9308307	ppb	-87.924919	ppb	370
F2	SAM	Ir		-3.1791112	ppb	-95.373336	ppb	70
F2	SAM	Mg	x	574.079162	ppb	17222.375	ppb	598446.6
F2	SAM	Mn		90.4510879	ppb	2713.53271	ppb	798040
F2	SAM	Ni		1.78095031	ppb	53.4285087	ppb	4093.333
F2	SAM	Pb		0.18078932	ppb	5.42367983	ppb	1776.666
F2	SAM	Sr		8.70024872	ppb	261.007446	ppb	104196.6
F2	SAM	Ti		1.39485073	ppb	41.84552	ppb	513.3333
F2	SAM	Tl		-3.4241676	ppb	-102.72502	ppb	30
F2	SAM	V		-0.2731886	ppb	-8.1956596	ppb	1701.639

F2	SAM	Zn	1.92221534	ppb	57.6664619	ppb	1830
F2	SAM	(Rh)	1.13620293	ppb	34.0860862	ppb	1916070
F2	SAM	(Sc)	0.75763851	ppb	22.7291545	ppb	1051713
F2	SAM	(Tb)	1.27010655	ppb	38.1031951	ppb	2096620
F2	SAM	(Y)	1.08950758	ppb	32.6852264	ppb	2105310
Blank 5	SAM	Ag		ppb		ppb	590
Blank 5	SAM	Al	3.55839229	ppb	106.75177	ppb	17343.33
Blank 5	SAM	As	-0.1811733	ppb	-5.4351992	ppb	2933.03
Blank 5	SAM	B		ppb		ppb	3683.333
Blank 5	SAM	Ba	0.1361611	ppb	4.08483315	ppb	226.6666
Blank 5	SAM	Bi	0.17793159	ppb	5.33794785	ppb	323.3333
Blank 5	SAM	Cd	0.00552918	ppb	0.16587549	ppb	16.66666
Blank 5	SAM	Co	0.03370431	ppb	1.01112938	ppb	426.6666
Blank 5	SAM	Cr	11.3731727	ppb	341.19519	ppb	7663.333
Blank 5	SAM	Cu	2.0479784	ppb	61.4393539	ppb	7326.666
Blank 5	SAM	Fe	33.9399871	ppb	1018.19958	ppb	9600
Blank 5	SAM	Ga	-2.9469008	ppb	-88.407028	ppb	270
Blank 5	SAM	Ir	-3.1728792	ppb	-95.186378	ppb	103.3333
Blank 5	SAM	Mg	3.65499854	ppb	109.649955	ppb	4260
Blank 5	SAM	Mn	0.5456571	ppb	16.3697128	ppb	4840
Blank 5	SAM	Ni	1.02734685	ppb	30.8204059	ppb	2376.666
Blank 5	SAM	Pb	0.16270949	ppb	4.88128471	ppb	1630
Blank 5	SAM	Sr	0.12365902	ppb	3.70977068	ppb	1490
Blank 5	SAM	Ti	0.746306	ppb	22.3891792	ppb	230
Blank 5	SAM	Tl	-3.4241738	ppb	-102.72521	ppb	30
Blank 5	SAM	V	-0.7786429	ppb	-23.359289	ppb	-1494.53
Blank 5	SAM	Zn	0.74213481	ppb	22.2640438	ppb	653.3333
Blank 5	SAM	(Rh)	1.08224523	ppb	32.4673576	ppb	1825076

Blank 5	SAM	(Sc)	0.66538841	ppb	19.9616527	ppb	923656.6
Blank 5	SAM	(Tb)	1.27478123	ppb	38.2434387	ppb	2104336
Blank 5	SAM	(Y)	1.01962721	ppb	30.5888156	ppb	1970276
Blank 6	SAM	Ag		ppb		ppb	730
Blank 6	SAM	Al	2.70673823	ppb	81.2021484	ppb	14500
Blank 6	SAM	As	-0.7218085	ppb	-21.654256	ppb	2481.041
Blank 6	SAM	B		ppb		ppb	4063.333
Blank 6	SAM	Ba	0.19339092	ppb	5.80172777	ppb	306.6666
Blank 6	SAM	Bi	0.17570359	ppb	5.27110767	ppb	303.3333
Blank 6	SAM	Cd	0.01098242	ppb	0.32947275	ppb	23.33333
Blank 6	SAM	Co	0.02769531	ppb	0.83085924	ppb	406.6666
Blank 6	SAM	Cr	10.6041164	ppb	318.123504	ppb	7583.333
Blank 6	SAM	Cu	2.0691936	ppb	62.0758094	ppb	7840
Blank 6	SAM	Fe	24.7893848	ppb	743.681518	ppb	8440
Blank 6	SAM	Ga	-2.9304809	ppb	-87.914428	ppb	356.6666
Blank 6	SAM	Ir	-3.1791405	ppb	-95.374214	ppb	70
Blank 6	SAM	Mg	3.15830922	ppb	94.7492752	ppb	4030
Blank 6	SAM	Mn	0.430621	ppb	12.9186296	ppb	4183.333
Blank 6	SAM	Ni	1.18583834	ppb	35.5751495	ppb	2790
Blank 6	SAM	Pb	0.13083218	ppb	3.92496538	ppb	1356.666
Blank 6	SAM	Sr	0.09568138	ppb	2.8704412	ppb	1210
Blank 6	SAM	Ti	0.78062099	ppb	23.4186306	ppb	256.6666
Blank 6	SAM	Tl	-3.4252386	ppb	-102.75715	ppb	23.33333
Blank 6	SAM	V	-0.6086463	ppb	-18.259389	ppb	-519.281
Blank 6	SAM	Zn	0.71653986	ppb	21.4961967	ppb	670
Blank 6	SAM	(Rh)	1.10752618	ppb	33.2257843	ppb	1867710
Blank 6	SAM	(Sc)	0.70467097	ppb	21.140129	ppb	978186.6
Blank 6	SAM	(Tb)	1.26850331	ppb	38.0550994	ppb	2093973

Blank 6	SAM	(Y)	1.04892313	ppb	31.4676933	ppb	2026886
50ppb spike	MSA	Ag		ppb		ppb	201110
50ppb spike	MSA	Al	50.7867965	ppb	50.7867965	ppb	234593.3
50ppb spike	MSA	As	41.2337379	ppb	41.2337379	ppb	43198.35
50ppb spike	MSA	B		ppb		ppb	35800
50ppb spike	MSA	Ba	48.1441497	ppb	48.1441497	ppb	67153.33
50ppb spike	MSA	Bi	51.1003074	ppb	51.1003074	ppb	383066.6
50ppb spike	MSA	Cd	50.4899368	ppb	50.4899368	ppb	54370
50ppb spike	MSA	Co	55.0500907	ppb	55.0500907	ppb	414310
50ppb spike	MSA	Cr	60.9328918	ppb	60.9328918	ppb	42676.66
50ppb spike	MSA	Cu	60.0895538	ppb	60.0895538	ppb	219223.3
50ppb spike	MSA	Fe	90.8665084	ppb	90.8665084	ppb	21030
50ppb spike	MSA	Ga	47.0351448	ppb	47.0351448	ppb	239686.6
50ppb spike	MSA	Ir	51.6861763	ppb	51.6861763	ppb	288280
50ppb spike	MSA	Mg	52.9892616	ppb	52.9892616	ppb	52616.66
50ppb spike	MSA	Mn	55.0232772	ppb	55.0232772	ppb	454866.6
50ppb spike	MSA	Ni	55.6197929	ppb	55.6197929	ppb	96786.66
50ppb spike	MSA	Pb	52.2323646	ppb	52.2323646	ppb	432176.6
50ppb spike	MSA	Sr	49.5773162	ppb	49.5773162	ppb	562063.3
50ppb spike	MSA	Ti	49.7612457	ppb	49.7612457	ppb	17956.66
50ppb spike	MSA	Tl	50.9423522	ppb	50.9423522	ppb	321003.3
50ppb spike	MSA	V	50.9443817	ppb	50.9443817	ppb	322291.2
50ppb spike	MSA	Zn	70.5503463	ppb	70.5503463	ppb	60856.66
50ppb spike	MSA	(Rh)	1.09168363	ppb	1.09168363	ppb	1840993
50ppb spike	MSA	(Sc)	0.70936072	ppb	0.70936072	ppb	984696.6
50ppb spike	MSA	(Tb)	1.25466502	ppb	1.25466502	ppb	2071130
50ppb spike	MSA	(Y)	1.03226125	ppb	1.03226125	ppb	1994690
Blank	BLK	Ag	0	ppb	0	ppb	620

Blank	BLK	Al	0	ppb	0	ppb	2316.666
Blank	BLK	As	0	ppb	0	ppb	2751.186
Blank	BLK	B	0	ppb	0	ppb	4896.666
Blank	BLK	Ba	0	ppb	0	ppb	23.33333
Blank	BLK	Bi	0	ppb	0	ppb	703.3333
Blank	BLK	Cd	0	ppb	0	ppb	13.33333
Blank	BLK	Co	0	ppb	0	ppb	456.6666
Blank	BLK	Cr	0	ppb	0	ppb	576.6666
Blank	BLK	Cu	0	ppb	0	ppb	573.3333
Blank	BLK	Fe	0	ppb	0	ppb	6253.333
Blank	BLK	Ga	0	ppb	0	ppb	396.6666
Blank	BLK	Ir	0	ppb	0	ppb	83.33333
Blank	BLK	Mg	0	ppb	0	ppb	920
Blank	BLK	Mn	0	ppb	0	ppb	1383.333
Blank	BLK	Ni	0	ppb	0	ppb	696.6666
Blank	BLK	Pb	0	ppb	0	ppb	153.3333
Blank	BLK	Sr	0	ppb	0	ppb	163.3333
Blank	BLK	Ti	0	ppb	0	ppb	53.33333
Blank	BLK	Tl	0	ppb	0	ppb	166.6666
Blank	BLK	V	0	ppb	0	ppb	879.9077
Blank	BLK	Zn	0	ppb	0	ppb	113.3333
Blank	BLK	(Rh)	1.07555628	ppb	1.07555628	ppb	1813796
Blank	BLK	(Sc)	0.78044832	ppb	0.78044832	ppb	1083376
Blank	BLK	(Tb)	1.15236771	ppb	1.15236771	ppb	1902263
Blank	BLK	(Y)	1.02593386	ppb	1.02593386	ppb	1982463
100ppb	RSP	Ag	100	ppb	100	ppb	270870
100ppb	RSP	Al	100	ppb	100	ppb	472580
100ppb	RSP	As	100	ppb	100	ppb	90253.64

100ppb	RSP	B	100	ppb	100	ppb	78490
100ppb	RSP	Ba	100	ppb	100	ppb	128620
100ppb	RSP	Bi	100	ppb	100	ppb	706640
100ppb	RSP	Cd	100	ppb	100	ppb	108293.3
100ppb	RSP	Co	100	ppb	100	ppb	872593.3
100ppb	RSP	Cr	100	ppb	100	ppb	80680
100ppb	RSP	Cu	100	ppb	100	ppb	451776.6
100ppb	RSP	Fe	100	ppb	100	ppb	27240
100ppb	RSP	Ga	100	ppb	100	ppb	499370
100ppb	RSP	Ir	100	ppb	100	ppb	537183.3
100ppb	RSP	Mg	100	ppb	100	ppb	103456.6
100ppb	RSP	Mn	100	ppb	100	ppb	969893.3
100ppb	RSP	Ni	100	ppb	100	ppb	202433.3
100ppb	RSP	Pb	100	ppb	100	ppb	803976.6
100ppb	RSP	Sr	100	ppb	100	ppb	1110560
100ppb	RSP	Ti	100	ppb	100	ppb	39756.66
100ppb	RSP	Tl	100	ppb	100	ppb	599540
100ppb	RSP	V	100	ppb	100	ppb	697633.8
100ppb	RSP	Zn	100	ppb	100	ppb	104513.3
100ppb	RSP	(Rh)	1.06441414	ppb	1.06441414	ppb	1795006
100ppb	RSP	(Sc)	0.76626873	ppb	0.76626873	ppb	1063693
100ppb	RSP	(Tb)	1.14986372	ppb	1.14986372	ppb	1898130
100ppb	RSP	(Y)	1.00734508	ppb	1.00734508	ppb	1946543
G2	SAM	Ag		ppb		ppb	860
G2	SAM	Al	8.95893097	ppb	268.767944	ppb	40546.66
G2	SAM	As	-0.0191127	ppb	-0.5733826	ppb	2642.653
G2	SAM	B		ppb		ppb	8693.333
G2	SAM	Ba	12.7097282	ppb	381.291839	ppb	16640

G2	SAM	Bi		0.11777723	ppb	3.53331685	ppb	533.3333
G2	SAM	Cd		0.1532162	ppb	4.59648609	ppb	170
G2	SAM	Co		0.43181679	ppb	12.954504	ppb	3830
G2	SAM	Cr		10.8564186	ppb	325.692565	ppb	8476.667
G2	SAM	Cu		5.19399977	ppb	155.819992	ppb	21266.66
G2	SAM	Fe	x	4331.64404	ppb	129949.32	ppb	811553.3
G2	SAM	Ga		-2.9239056	ppb	-87.71717	ppb	446.6666
G2	SAM	Ir		-3.1879901	ppb	-95.639709	ppb	60
G2	SAM	Mg	x	773.396911	ppb	23201.9082	ppb	682226.6
G2	SAM	Mn		74.7216949	ppb	2241.65087	ppb	659590
G2	SAM	Ni		1.76178253	ppb	52.8534774	ppb	3810
G2	SAM	Pb		0.21727313	ppb	6.51819372	ppb	1940
G2	SAM	Sr		9.50830936	ppb	285.249267	ppb	105113.3
G2	SAM	Ti		1.03828931	ppb	31.1486797	ppb	393.3333
G2	SAM	Tl		-3.4505908	ppb	-103.51772	ppb	23.33333
G2	SAM	V		0.35198441	ppb	10.5595321	ppb	5273.737
G2	SAM	Zn		26.3234462	ppb	789.703369	ppb	25833.33
G2	SAM	(Rh)		1.0143503	ppb	30.4305095	ppb	1710580
G2	SAM	(Sc)		0.69396847	ppb	20.8190536	ppb	963330
G2	SAM	(Tb)		1.21518993	ppb	36.4556961	ppb	2005966
G2	SAM	(Y)		0.99914443	ppb	29.9743328	ppb	1930696
H2	SAM	Ag			ppb		ppb	353.3333
H2	SAM	Al		5.78580236	ppb	173.574066	ppb	32676.66
H2	SAM	As		0.09454215	ppb	2.83626437	ppb	3185.203
H2	SAM	B			ppb		ppb	8310
H2	SAM	Ba		16.2888717	ppb	488.666137	ppb	22160
H2	SAM	Bi		0.08965593	ppb	2.68967795	ppb	336.6666
H2	SAM	Cd		-0.0035379	ppb	-0.106139	ppb	10

H2	SAM	Co		0.49046475	ppb	14.7139425	ppb	5176.666
H2	SAM	Cr		10.1395216	ppb	304.185638	ppb	9590
H2	SAM	Cu		6.77028084	ppb	203.108429	ppb	33336.66
H2	SAM	Fe	x	6659.854	ppb	199795.625	ppb	1504063
H2	SAM	Ga		-2.8899352	ppb	-86.698059	ppb	690
H2	SAM	Ir		-3.1909894	ppb	-95.729682	ppb	46.66666
H2	SAM	Mg	x	765.636779	ppb	22969.1035	ppb	819606.6
H2	SAM	Mn		82.9318695	ppb	2487.95605	ppb	883783.3
H2	SAM	Ni		1.64696574	ppb	49.4089736	ppb	4373.333
H2	SAM	Pb		0.19269839	ppb	5.7809515	ppb	1806.666
H2	SAM	Sr		11.4991798	ppb	344.975402	ppb	146443.3
H2	SAM	Ti		1.04476666	ppb	31.3430004	ppb	466.6666
H2	SAM	Tl		-3.450808	ppb	-103.52423	ppb	23.33333
H2	SAM	V		1.04365122	ppb	31.3095359	ppb	11649.67
H2	SAM	Zn		3.06437087	ppb	91.9311294	ppb	3753.333
H2	SAM	(Rh)		1.15757418	ppb	34.7272262	ppb	1952110
H2	SAM	(Sc)		0.83959192	ppb	25.1877574	ppb	1165476
H2	SAM	(Tb)		1.263659	ppb	37.9097709	ppb	2085976
H2	SAM	(Y)		1.15204287	ppb	34.5612869	ppb	2226150
C1	SAM	Ag			ppb		ppb	253.3333
C1	SAM	Al		9.7198801	ppb	291.596405	ppb	52396.66
C1	SAM	As		-0.2554119	ppb	-7.6623587	ppb	2795.838
C1	SAM	B			ppb		ppb	6906.666
C1	SAM	Ba		17.2996139	ppb	518.988403	ppb	23900
C1	SAM	Bi		0.59370393	ppb	17.8111171	ppb	4310
C1	SAM	Cd		0.01068191	ppb	0.32045737	ppb	26.66666
C1	SAM	Co		0.82604951	ppb	24.7814846	ppb	8253.333
C1	SAM	Cr		12.1487541	ppb	364.462616	ppb	11176.66

C1	SAM	Cu		4.4646349	ppb	133.939041	ppb	21846.66
C1	SAM	Fe	x	7538.28076	ppb	226148.421	ppb	1673910
C1	SAM	Ga		-2.8774831	ppb	-86.324493	ppb	746.6666
C1	SAM	Ir		-3.1899128	ppb	-95.697387	ppb	53.33333
C1	SAM	Mg	x	664.617492	ppb	19938.5253	ppb	700303.3
C1	SAM	Mn	x	113.863342	ppb	3415.90039	ppb	1192923
C1	SAM	Ni		1.76167417	ppb	52.8502235	ppb	4553.333
C1	SAM	Pb		0.13985401	ppb	4.19562054	ppb	1376.666
C1	SAM	Sr		10.3928098	ppb	311.784301	ppb	130546.6
C1	SAM	Ti		1.42037964	ppb	42.6113891	ppb	620
C1	SAM	Tl		-3.4508252	ppb	-103.52475	ppb	23.33333
C1	SAM	V		2.09463882	ppb	62.8391647	ppb	19406.41
C1	SAM	Zn		3.27302003	ppb	98.1905975	ppb	3926.666
C1	SAM	(Rh)		1.16358113	ppb	34.9074325	ppb	1962240
C1	SAM	(Sc)		0.82592863	ppb	24.7778587	ppb	1146510
C1	SAM	(Tb)		1.28366208	ppb	38.5098609	ppb	2118996
C1	SAM	(Y)		1.13625729	ppb	34.0877189	ppb	2195646
E1	SAM	Ag			ppb		ppb	253.3333
E1	SAM	Al		3.97132683	ppb	119.139801	ppb	22246.66
E1	SAM	As		-0.1692916	ppb	-5.0787487	ppb	2870.708
E1	SAM	B			ppb		ppb	6793.333
E1	SAM	Ba		15.0384779	ppb	451.154327	ppb	21120
E1	SAM	Bi		0.13707627	ppb	4.112288	ppb	726.6666
E1	SAM	Cd		0.00160248	ppb	0.04807432	ppb	16.66666
E1	SAM	Co		0.58190835	ppb	17.4572506	ppb	5803.333
E1	SAM	Cr		11.0352993	ppb	331.05899	ppb	9940
E1	SAM	Cu		5.83324909	ppb	174.997467	ppb	27603.33
E1	SAM	Fe	x	6014.99072	ppb	180449.718	ppb	1301386

E1	SAM	Ga		-2.890825	ppb	-86.724754	ppb	673.3333
E1	SAM	Ir		-3.18949	ppb	-95.6847	ppb	56.66666
E1	SAM	Mg	x	638.047058	ppb	19141.4121	ppb	654646.6
E1	SAM	Mn		92.3434143	ppb	2770.30249	ppb	942053.3
E1	SAM	Ni		1.51641858	ppb	45.4925575	ppb	3916.666
E1	SAM	Pb		0.08706249	ppb	2.61187482	ppb	936.6666
E1	SAM	Sr		9.17412758	ppb	275.223815	ppb	115030
E1	SAM	Ti		1.18244946	ppb	35.473484	ppb	503.3333
E1	SAM	Tl		-3.4504301	ppb	-103.5129	ppb	26.66666
E1	SAM	V		1.47499549	ppb	44.2498664	ppb	14337.77
E1	SAM	Zn		4.23308706	ppb	126.992614	ppb	4910
E1	SAM	(Rh)		1.1694082	ppb	35.0822448	ppb	1972066
E1	SAM	(Sc)		0.80397129	ppb	24.1191387	ppb	1116030
E1	SAM	(Tb)		1.30465055	ppb	39.1395149	ppb	2153643
E1	SAM	(Y)		1.13382316	ppb	34.0146942	ppb	2190943
Blank 7	SAM	Ag			ppb		ppb	133.3333
Blank 7	SAM	Al		2.01111293	ppb	60.3333892	ppb	10993.33
Blank 7	SAM	As		-0.936174	ppb	-28.08522	ppb	2000.469
Blank 7	SAM	B			ppb		ppb	3040
Blank 7	SAM	Ba		0.07917048	ppb	2.37511444	ppb	136.6666
Blank 7	SAM	Bi		0.11347223	ppb	3.40416694	ppb	536.6666
Blank 7	SAM	Cd		0.00816848	ppb	0.24505441	ppb	23.33333
Blank 7	SAM	Co		0.19629094	ppb	5.88872814	ppb	2000
Blank 7	SAM	Cr		11.8704023	ppb	356.11206	ppb	9396.667
Blank 7	SAM	Cu		0.30497029	ppb	9.14910889	ppb	1770
Blank 7	SAM	Fe		15.3197603	ppb	459.592804	ppb	8596.667
Blank 7	SAM	Ga		-2.9171769	ppb	-87.515312	ppb	506.6666
Blank 7	SAM	Ir		-3.1870276	ppb	-95.610832	ppb	70

Blank 7	SAM	Mg	2.41219139	ppb	72.3657379	ppb	3020
Blank 7	SAM	Mn	0.28850663	ppb	8.65519905	ppb	3853.333
Blank 7	SAM	Ni	1.00214255	ppb	30.0642757	ppb	2503.333
Blank 7	SAM	Pb	0.04618827	ppb	1.38564801	ppb	576.6666
Blank 7	SAM	Sr	0.5868178	ppb	17.6045341	ppb	7123.333
Blank 7	SAM	Ti	0.79935348	ppb	23.9806041	ppb	303.3333
Blank 7	SAM	Tl	-3.4525225	ppb	-103.57567	ppb	13.33333
Blank 7	SAM	V	-0.7457333	ppb	-22.372001	ppb	-1709.04
Blank 7	SAM	Zn	0.38492653	ppb	11.5477962	ppb	486.6666
Blank 7	SAM	(Rh)	1.12775683	ppb	33.8327064	ppb	1901826
Blank 7	SAM	(Sc)	0.7101171	ppb	21.3035125	ppb	985746.6
Blank 7	SAM	(Tb)	1.30139959	ppb	39.0419883	ppb	2148276
Blank 7	SAM	(Y)	1.07259893	ppb	32.177967	ppb	2072636
SW1	QCS	Ag		ppb		ppb	263.3333
SW1	QCS	Al	5.57086754	ppb	5.57086754	ppb	31626.66
SW1	QCS	As	1.17177558	ppb	1.17177558	ppb	4038.133
SW1	QCS	B		ppb		ppb	7923.333
SW1	QCS	Ba	5.30442381	ppb	5.30442381	ppb	6883.333
SW1	QCS	Bi	0.05120724	ppb	0.05120724	ppb	36.66666
SW1	QCS	Cd	0.07242766	ppb	0.07242766	ppb	96.66666
SW1	QCS	Co	0.21401998	ppb	0.21401998	ppb	2540
SW1	QCS	Cr	0.24709994	ppb	0.24709994	ppb	840
SW1	QCS	Cu	2.11736441	ppb	2.11736441	ppb	10863.33
SW1	QCS	Fe	7.52416754	ppb	7.52416754	ppb	8426.667
SW1	QCS	Ga	-2.8629567	ppb	-2.8629567	ppb	790
SW1	QCS	Ir	-3.1860101	ppb	-3.1860101	ppb	70
SW1	QCS	Mg	43.4500083	ppb	43.4500083	ppb	47530
SW1	QCS	Mn	1.05662096	ppb	1.05662096	ppb	12736.66

SW1	QCS	Ni	1.01320863	ppb	1.01320863	ppb	2983.333
SW1	QCS	Pb	0.53027499	ppb	0.53027499	ppb	4450
SW1	QCS	Sr	5.18467712	ppb	5.18467712	ppb	62730
SW1	QCS	Ti	0.07882764	ppb	0.07882764	ppb	43.33333
SW1	QCS	Tl	-3.448251	ppb	-3.448251	ppb	36.66666
SW1	QCS	V	0.73095894	ppb	0.73095894	ppb	9285.645
SW1	QCS	Zn	2.1235745	ppb	2.1235745	ppb	2636.666
SW1	QCS	(Rh)	1.14041114	ppb	1.14041114	ppb	1923166
SW1	QCS	(Sc)	0.84034592	ppb	0.84034592	ppb	1166523
SW1	QCS	(Tb)	1.2029469	ppb	1.2029469	ppb	1985756
SW1	QCS	(Y)	1.09266603	ppb	1.09266603	ppb	2111413
SW2	QCS	Ag		ppb		ppb	183.3333
SW2	QCS	Al	26.3149356	ppb	26.3149356	ppb	137950
SW2	QCS	As	5.09335232	ppb	5.09335232	ppb	7745.614
SW2	QCS	B		ppb		ppb	3433.333
SW2	QCS	Ba	26.1566047	ppb	26.1566047	ppb	33923.33
SW2	QCS	Bi	0.05204786	ppb	0.05204786	ppb	43.33333
SW2	QCS	Cd	0.30658412	ppb	0.30658412	ppb	360
SW2	QCS	Co	1.06129861	ppb	1.06129861	ppb	10480
SW2	QCS	Cr	0.82925117	ppb	0.82925117	ppb	1333.333
SW2	QCS	Cu	10.7938852	ppb	10.7938852	ppb	52030
SW2	QCS	Fe	15.094964	ppb	15.094964	ppb	9973.333
SW2	QCS	Ga	-2.8725881	ppb	-2.8725881	ppb	740
SW2	QCS	Ir	-3.1886522	ppb	-3.1886522	ppb	56.66666
SW2	QCS	Mg	215.433517	ppb	215.433517	ppb	228060
SW2	QCS	Mn	5.16325331	ppb	5.16325331	ppb	55563.33
SW2	QCS	Ni	5.20522785	ppb	5.20522785	ppb	12030
SW2	QCS	Pb	2.6709795	ppb	2.6709795	ppb	21813.33

SW2	QCS	Sr	25.9460868	ppb	25.9460868	ppb	312876.6
SW2	QCS	Ti	0.08816316	ppb	0.08816316	ppb	46.66666
SW2	QCS	Tl	-3.4523234	ppb	-3.4523234	ppb	13.33333
SW2	QCS	V	4.93935966	ppb	4.93935966	ppb	40887.01
SW2	QCS	Zn	9.16444874	ppb	9.16444874	ppb	10800
SW2	QCS	(Rh)	1.13535106	ppb	1.13535106	ppb	1914633
SW2	QCS	(Sc)	0.82722288	ppb	0.82722288	ppb	1148306
SW2	QCS	(Tb)	1.20546901	ppb	1.20546901	ppb	1989920
SW2	QCS	(Y)	1.09146202	ppb	1.09146202	ppb	2109086
Blank 8	SAM	Ag		ppb		ppb	166.6666
Blank 8	SAM	Al	2.34378695	ppb	70.3136062	ppb	12830
Blank 8	SAM	As	-0.3409781	ppb	-10.229343	ppb	2535.53
Blank 8	SAM	B		ppb		ppb	2976.666
Blank 8	SAM	Ba	0.06451372	ppb	1.93541157	ppb	113.3333
Blank 8	SAM	Bi	0.66899264	ppb	20.0697784	ppb	4856.666
Blank 8	SAM	Cd	0.0026867	ppb	0.08060111	ppb	16.66666
Blank 8	SAM	Co	0.01559543	ppb	0.46786284	ppb	556.6666
Blank 8	SAM	Cr	9.55741119	ppb	286.722351	ppb	7896.666
Blank 8	SAM	Cu	1.26287246	ppb	37.8861732	ppb	5850
Blank 8	SAM	Fe	12.5921239	ppb	377.763732	ppb	8316.667
Blank 8	SAM	Ga	-2.8955116	ppb	-86.865348	ppb	610
Blank 8	SAM	Ir	-3.190989	ppb	-95.729667	ppb	46.66666
Blank 8	SAM	Mg	2.48220921	ppb	74.466278	ppb	3173.333
Blank 8	SAM	Mn	0.24205892	ppb	7.26176739	ppb	3536.666
Blank 8	SAM	Ni	1.0040884	ppb	30.122652	ppb	2576.666
Blank 8	SAM	Pb	0.04227591	ppb	1.26827717	ppb	530
Blank 8	SAM	Sr	0.0695699	ppb	2.08709693	ppb	983.3333
Blank 8	SAM	Ti	0.87472206	ppb	26.241661	ppb	340

Blank 8	SAM	Tl		-3.4502639	ppb	-103.50791	ppb	26.66666
Blank 8	SAM	V		-0.5027314	ppb	-15.081943	ppb	-145.446
Blank 8	SAM	Zn		0.43751779	ppb	13.125534	ppb	556.6666
Blank 8	SAM	(Rh)		1.12383533	ppb	33.7150611	ppb	1895213
Blank 8	SAM	(Sc)		0.73074412	ppb	21.9223232	ppb	1014380
Blank 8	SAM	(Tb)		1.27029634	ppb	38.1088905	ppb	2096933
Blank 8	SAM	(Y)		1.06279051	ppb	31.8837146	ppb	2053683
G1	SAM	Ag			ppb		ppb	286.6666
G1	SAM	Al		15.9911661	ppb	479.734985	ppb	78666.66
G1	SAM	As		-0.2878125	ppb	-8.6343774	ppb	2703.587
G1	SAM	B			ppb		ppb	5213.333
G1	SAM	Ba		12.6237068	ppb	378.711212	ppb	17700
G1	SAM	Bi		2.76601839	ppb	82.9805526	ppb	21730
G1	SAM	Cd		0.00762906	ppb	0.22887188	ppb	23.33333
G1	SAM	Co		0.86769575	ppb	26.0308723	ppb	8033.333
G1	SAM	Cr		11.4190797	ppb	342.572387	ppb	9803.333
G1	SAM	Cu		3.10206103	ppb	93.0618286	ppb	14276.66
G1	SAM	Fe	x	4629.53808	ppb	138886.14	ppb	957746.6
G1	SAM	Ga		-2.8876504	ppb	-86.629516	ppb	676.6666
G1	SAM	Ir		-3.1918208	ppb	-95.754623	ppb	43.33333
G1	SAM	Mg	x	607.541015	ppb	18226.2304	ppb	595130
G1	SAM	Mn		81.9974823	ppb	2459.92456	ppb	798823.3
G1	SAM	Ni		1.56816375	ppb	47.0449142	ppb	3843.333
G1	SAM	Pb		0.21609929	ppb	6.48297882	ppb	2066.666
G1	SAM	Sr		9.6681118	ppb	290.043365	ppb	118766.6
G1	SAM	Ti		1.05522847	ppb	31.6568546	ppb	430
G1	SAM	Tl		-3.4525342	ppb	-103.57602	ppb	13.33333
G1	SAM	V		0.04380083	ppb	1.31402504	ppb	3673.711

G1	SAM	Zn		5.28020334	ppb	158.406097	ppb	5820
G1	SAM	(Rh)		1.1614939	ppb	34.8448181	ppb	1958720
G1	SAM	(Sc)		0.7675966	ppb	23.0278987	ppb	1065536
G1	SAM	(Tb)		1.30200124	ppb	39.0600357	ppb	2149270
G1	SAM	(Y)		1.11088049	ppb	33.326416	ppb	2146610
I1	SAM	Ag			ppb		ppb	206.6666
I1	SAM	Al		15.5544366	ppb	466.633087	ppb	78913.33
I1	SAM	As		-0.1679005	ppb	-5.0370168	ppb	2861.872
I1	SAM	B			ppb		ppb	5476.666
I1	SAM	Ba		13.9228086	ppb	417.684265	ppb	19426.66
I1	SAM	Bi		0.22365938	ppb	6.70978165	ppb	1410
I1	SAM	Cd		0.0215435	ppb	0.64630502	ppb	40
I1	SAM	Co		0.41983163	ppb	12.5949487	ppb	4246.666
I1	SAM	Cr		10.6254406	ppb	318.763214	ppb	9436.667
I1	SAM	Cu		6.06927443	ppb	182.078231	ppb	28230
I1	SAM	Fe	x	3375.11035	ppb	101253.312	ppb	721070
I1	SAM	Ga		-2.8898177	ppb	-86.694534	ppb	676.6666
I1	SAM	Ir		-3.1888387	ppb	-95.665161	ppb	60
I1	SAM	Mg	x	670.578613	ppb	20117.3593	ppb	676810
I1	SAM	Mn		69.6154098	ppb	2088.4624	ppb	698973.3
I1	SAM	Ni		1.68962538	ppb	50.6887626	ppb	4210
I1	SAM	Pb		0.26425228	ppb	7.92756844	ppb	2473.333
I1	SAM	Sr		9.45431423	ppb	283.629425	ppb	118070
I1	SAM	Ti		1.55977571	ppb	46.7932701	ppb	650
I1	SAM	Tl		-3.4508814	ppb	-103.52644	ppb	23.33333
I1	SAM	V		-0.1864774	ppb	-5.5943226	ppb	2126.256
I1	SAM	Zn		5.71607161	ppb	171.482147	ppb	6483.333
I1	SAM	(Rh)		1.18030334	ppb	35.4090995	ppb	1990440

I1	SAM	(Sc)		0.79092753	ppb	23.7278251	ppb	1097923
I1	SAM	(Tb)		1.29614127	ppb	38.8842392	ppb	2139596
I1	SAM	(Y)		1.12925541	ppb	33.8776626	ppb	2182116
H1	SAM	Ag			ppb		ppb	203.3333
H1	SAM	Al		6.23902178	ppb	187.170654	ppb	33543.33
H1	SAM	As		-0.243579	ppb	-7.3073716	ppb	2815.579
H1	SAM	B			ppb		ppb	5736.666
H1	SAM	Ba		13.8969373	ppb	416.908111	ppb	19456.66
H1	SAM	Bi		2.18478155	ppb	65.5434494	ppb	17066.66
H1	SAM	Cd		0.00717416	ppb	0.21522479	ppb	23.33333
H1	SAM	Co		0.46035346	ppb	13.8106041	ppb	4676.666
H1	SAM	Cr		9.84235191	ppb	295.270568	ppb	8913.333
H1	SAM	Cu		5.62717915	ppb	168.815368	ppb	26596.66
H1	SAM	Fe	x	4590.73925	ppb	137722.171	ppb	992953.3
H1	SAM	Ga		-2.87909	ppb	-86.372703	ppb	740
H1	SAM	Ir		-3.1846506	ppb	-95.53952	ppb	83.33333
H1	SAM	Mg	x	577.855285	ppb	17335.6582	ppb	592096.6
H1	SAM	Mn		78.4863357	ppb	2354.59008	ppb	799436.6
H1	SAM	Ni		1.56185365	ppb	46.8556098	ppb	4003.333
H1	SAM	Pb		0.20200899	ppb	6.06026983	ppb	1940
H1	SAM	Sr		9.69244957	ppb	290.773498	ppb	122303.3
H1	SAM	Ti		1.85648811	ppb	55.6946449	ppb	783.3333
H1	SAM	Tl		-3.4492774	ppb	-103.47832	ppb	33.33333
H1	SAM	V		0.20539124	ppb	6.16173744	ppb	5033.048
H1	SAM	Zn		8.34409142	ppb	250.322738	ppb	9546.667
H1	SAM	(Rh)		1.19448364	ppb	35.8345108	ppb	2014353
H1	SAM	(Sc)		0.80260491	ppb	24.0781478	ppb	1114133
H1	SAM	(Tb)		1.30042422	ppb	39.0127258	ppb	2146666

H1	SAM	(Y)		1.14103556	ppb	34.2310676	ppb	2204880
I2	SAM	Ag			ppb		ppb	306.6666
I2	SAM	Al		11.0087728	ppb	330.263183	ppb	57183.33
I2	SAM	As		-0.1924678	ppb	-5.7740359	ppb	2847.67
I2	SAM	B			ppb		ppb	4910
I2	SAM	Ba		11.4242801	ppb	342.728393	ppb	15730
I2	SAM	Bi		0.13497874	ppb	4.04936218	ppb	696.6666
I2	SAM	Cd		0.01308022	ppb	0.39240667	ppb	30
I2	SAM	Co		0.37913203	ppb	11.3739604	ppb	3923.333
I2	SAM	Cr		10.0829877	ppb	302.489624	ppb	9086.667
I2	SAM	Cu		8.46666336	ppb	253.999908	ppb	39580
I2	SAM	Fe	x	2831.47583	ppb	84944.2734	ppb	612770
I2	SAM	Ga		-2.8719623	ppb	-86.158866	ppb	770
I2	SAM	Ir		-3.1898524	ppb	-95.695571	ppb	53.33333
I2	SAM	Mg	x	542.084411	ppb	16262.5322	ppb	553556.6
I2	SAM	Mn		61.1864013	ppb	1835.59204	ppb	621366.6
I2	SAM	Ni		1.28965282	ppb	38.6895828	ppb	3420
I2	SAM	Pb		0.16043547	ppb	4.8130641	ppb	1550
I2	SAM	Sr		7.0561161	ppb	211.683486	ppb	88390
I2	SAM	Ti		1.50818193	ppb	45.2454567	ppb	636.6666
I2	SAM	Tl		-3.4519372	ppb	-103.55811	ppb	16.66666
I2	SAM	V		0.37951463	ppb	11.3854389	ppb	6273.844
I2	SAM	Zn		5.92045021	ppb	177.61351	ppb	6786.666
I2	SAM	(Rh)		1.18739951	ppb	35.6219863	ppb	2002406
I2	SAM	(Sc)		0.79984343	ppb	23.9953022	ppb	1110300
I2	SAM	(Tb)		1.27852094	ppb	38.3556289	ppb	2110510
I2	SAM	(Y)		1.13236737	ppb	33.9710197	ppb	2188130
50ppb spike	MSA	Ag			ppb		ppb	205090

50ppb spike	MSA	Al		56.3816261	ppb	56.3816261	ppb	260686.6
50ppb spike	MSA	As		45.7519645	ppb	45.7519645	ppb	45643.02
50ppb spike	MSA	B			ppb		ppb	35456.66
50ppb spike	MSA	Ba		62.5098953	ppb	62.5098953	ppb	84926.66
50ppb spike	MSA	Bi		49.1447258	ppb	49.1447258	ppb	380646.6
50ppb spike	MSA	Cd		51.1609458	ppb	51.1609458	ppb	57566.66
50ppb spike	MSA	Co		51.9375152	ppb	51.9375152	ppb	436286.6
50ppb spike	MSA	Cr		58.3752403	ppb	58.3752403	ppb	45846.66
50ppb spike	MSA	Cu		59.7799987	ppb	59.7799987	ppb	254170
50ppb spike	MSA	Fe	x	2920.46606	ppb	2920.46606	ppb	581966.6
50ppb spike	MSA	Ga		47.4706001	ppb	47.4706001	ppb	251890
50ppb spike	MSA	Ir		50.8793373	ppb	50.8793373	ppb	292106.6
50ppb spike	MSA	Mg	x	593.156677	ppb	593.156677	ppb	557753.3
50ppb spike	MSA	Mn	x	110.144081	ppb	110.144081	ppb	1029246
50ppb spike	MSA	Ni		52.694477	ppb	52.694477	ppb	102473.3
50ppb spike	MSA	Pb		50.7179603	ppb	50.7179603	ppb	431066.6
50ppb spike	MSA	Sr		56.1357574	ppb	56.1357574	ppb	668840
50ppb spike	MSA	Ti		49.5459098	ppb	49.5459098	ppb	19016.66
50ppb spike	MSA	Tl		51.098011	ppb	51.098011	ppb	327216.6
50ppb spike	MSA	V		49.9253082	ppb	49.9253082	ppb	338689.6
50ppb spike	MSA	Zn		54.8973197	ppb	54.8973197	ppb	57070
50ppb spike	MSA	(Rh)		1.13307393	ppb	1.13307393	ppb	1910793
50ppb spike	MSA	(Sc)		0.73668969	ppb	0.73668969	ppb	1022633
50ppb spike	MSA	(Tb)		1.26329958	ppb	1.26329958	ppb	2085383
50ppb spike	MSA	(Y)		1.07873321	ppb	1.07873321	ppb	2084490
Blank	BLK	Ag		0	ppb	0	ppb	363.3333
Blank	BLK	Al		0	ppb	0	ppb	2136.666
Blank	BLK	As		0	ppb	0	ppb	3304.758

Blank	BLK	B	0	ppb	0	ppb	3646.666
Blank	BLK	Ba	0	ppb	0	ppb	46.66666
Blank	BLK	Bi	0	ppb	0	ppb	673.3333
Blank	BLK	Cd	0	ppb	0	ppb	13.33333
Blank	BLK	Co	0	ppb	0	ppb	640
Blank	BLK	Cr	0	ppb	0	ppb	636.6666
Blank	BLK	Cu	0	ppb	0	ppb	456.6666
Blank	BLK	Fe	0	ppb	0	ppb	8023.333
Blank	BLK	Ga	0	ppb	0	ppb	836.6666
Blank	BLK	Ir	0	ppb	0	ppb	110
Blank	BLK	Mg	0	ppb	0	ppb	860
Blank	BLK	Mn	0	ppb	0	ppb	1703.333
Blank	BLK	Ni	0	ppb	0	ppb	730
Blank	BLK	Pb	0	ppb	0	ppb	186.6666
Blank	BLK	Sr	0	ppb	0	ppb	196.6666
Blank	BLK	Ti	0	ppb	0	ppb	63.33333
Blank	BLK	Tl	0	ppb	0	ppb	236.6666
Blank	BLK	V	0	ppb	0	ppb	963.3671
Blank	BLK	Zn	0	ppb	0	ppb	116.6666
Blank	BLK	(Rh)	1.1152488	ppb	1.1152488	ppb	1880733
Blank	BLK	(Sc)	0.80421859	ppb	0.80421859	ppb	1116373
Blank	BLK	(Tb)	1.15936649	ppb	1.15936649	ppb	1913816
Blank	BLK	(Y)	1.0576086	ppb	1.0576086	ppb	2043670
100ppb	RSP	Ag	100	ppb	100	ppb	248056.6
100ppb	RSP	Al	100	ppb	100	ppb	456510
100ppb	RSP	As	100	ppb	100	ppb	89157.51
100ppb	RSP	B	100	ppb	100	ppb	74086.66
100ppb	RSP	Ba	100	ppb	100	ppb	132100

100ppb	RSP	Bi	100	ppb	100	ppb	707273.3
100ppb	RSP	Cd	100	ppb	100	ppb	110593.3
100ppb	RSP	Co	100	ppb	100	ppb	872430
100ppb	RSP	Cr	100	ppb	100	ppb	77253.33
100ppb	RSP	Cu	100	ppb	100	ppb	441270
100ppb	RSP	Fe	100	ppb	100	ppb	28056.66
100ppb	RSP	Ga	100	ppb	100	ppb	497596.6
100ppb	RSP	Ir	100	ppb	100	ppb	543600
100ppb	RSP	Mg	100	ppb	100	ppb	98773.33
100ppb	RSP	Mn	100	ppb	100	ppb	952916.6
100ppb	RSP	Ni	100	ppb	100	ppb	198320
100ppb	RSP	Pb	100	ppb	100	ppb	816376.6
100ppb	RSP	Sr	100	ppb	100	ppb	1117046
100ppb	RSP	Ti	100	ppb	100	ppb	39056.66
100ppb	RSP	Tl	100	ppb	100	ppb	606996.6
100ppb	RSP	V	100	ppb	100	ppb	684529
100ppb	RSP	Zn	100	ppb	100	ppb	104020
100ppb	RSP	(Rh)	1.07401848	ppb	1.07401848	ppb	1811203
100ppb	RSP	(Sc)	0.74695039	ppb	0.74695039	ppb	1036876
100ppb	RSP	(Tb)	1.1574825	ppb	1.1574825	ppb	1910706
100ppb	RSP	(Y)	1.01330328	ppb	1.01330328	ppb	1958056
A2	SAM	Ag		ppb		ppb	546.6666
A2	SAM	Al	30.3412056	ppb	910.236145	ppb	149383.3
A2	SAM	As		ppb		ppb	2951.98
A2	SAM	B		ppb		ppb	8506.667
A2	SAM	Ba	34.4236755	ppb	1032.7102	ppb	47680
A2	SAM	Bi	1.07126606	ppb	32.1379814	ppb	7866.666
A2	SAM	Cd	0.0139675	ppb	0.41902503	ppb	30

A2	SAM	Co		1.15606868	ppb	34.6820602	ppb	11243.33
A2	SAM	Cr		12.3268671	ppb	369.805999	ppb	10653.33
A2	SAM	Cu		6.26289463	ppb	187.88684	ppb	28910
A2	SAM	Fe	x	13515.7539	ppb	405472.625	ppb	2862586
A2	SAM	Ga		-2.9360642	ppb	-88.081924	ppb	876.6666
A2	SAM	Ir		-3.1654586	ppb	-94.96376	ppb	213.3333
A2	SAM	Mg	x	765.358032	ppb	22960.7402	ppb	752943.3
A2	SAM	Mn	x	166.269668	ppb	4988.08984	ppb	1673836
A2	SAM	Ni		2.25956511	ppb	67.7869567	ppb	5400
A2	SAM	Pb		0.23721494	ppb	7.11644793	ppb	2230
A2	SAM	Sr		18.1386795	ppb	544.1604	ppb	222096.6
A2	SAM	Ti		1.0636065	ppb	31.9081955	ppb	456.6666
A2	SAM	Tl		-3.4524524	ppb	-103.57357	ppb	86.66666
A2	SAM	V		3.69120145	ppb	110.736045	ppb	30204.18
A2	SAM	Zn		8.23169136	ppb	246.950744	ppb	9443.333
A2	SAM	(Rh)		1.15566683	ppb	34.6700058	ppb	1948893
A2	SAM	(Sc)		0.7877962	ppb	23.6338863	ppb	1093576
A2	SAM	(Tb)		1.26337624	ppb	37.901287	ppb	2085510
A2	SAM	(Y)		1.1085794	ppb	33.2573814	ppb	2142163
B2	SAM	Ag			ppb		ppb	393.3333
B2	SAM	Al		6.11257124	ppb	183.377136	ppb	30430
B2	SAM	As			ppb		ppb	3031.321
B2	SAM	B			ppb		ppb	6180
B2	SAM	Ba		16.8724727	ppb	506.174194	ppb	23346.66
B2	SAM	Bi		0.55068678	ppb	16.5206031	ppb	3843.333
B2	SAM	Cd		0.02282592	ppb	0.68477744	ppb	40
B2	SAM	Co		0.88166136	ppb	26.4498405	ppb	8360
B2	SAM	Cr		12.3743553	ppb	371.230651	ppb	10243.33

B2	SAM	Cu			6.12409735	ppb	183.722915	ppb	27070
B2	SAM	Fe		x	8086.125	ppb	242583.75	ppb	1642286
B2	SAM	Ga			-2.9512994	ppb	-88.538986	ppb	783.3333
B2	SAM	Ir			-3.1844799	ppb	-95.5344	ppb	110
B2	SAM	Mg		x	618.573486	ppb	18557.205	ppb	583120
B2	SAM	Mn		x	114.32238	ppb	3429.67138	ppb	1101550
B2	SAM	Ni	Ø		1.66446924	ppb	49.9340782	ppb	3990
B2	SAM	Pb			0.18965767	ppb	5.68973017	ppb	1823.333
B2	SAM	Sr			10.5229349	ppb	315.688049	ppb	126646.6
B2	SAM	Ti			1.13447618	ppb	34.0342865	ppb	463.3333
B2	SAM	Tl			-3.4613978	ppb	-103.84193	ppb	33.33333
B2	SAM	V			2.98748732	ppb	89.6246185	ppb	24044.53
B2	SAM	Zn			4.99657393	ppb	149.897216	ppb	5523.333
B2	SAM	(Rh)			1.14163077	ppb	34.2489242	ppb	1925223
B2	SAM	(Sc)			0.75373161	ppb	22.611948	ppb	1046290
B2	SAM	(Tb)			1.25897622	ppb	37.7692871	ppb	2078246
B2	SAM	(Y)			1.08831561	ppb	32.6494674	ppb	2103006
C2	SAM	Ag				ppb		ppb	303.3333
C2	SAM	Al			50.7359161	ppb	1522.07751	ppb	241166.6
C2	SAM	As				ppb		ppb	2962.832
C2	SAM	B				ppb		ppb	5916.666
C2	SAM	Ba			18.5091953	ppb	555.275878	ppb	25573.33
C2	SAM	Bi			0.83053738	ppb	24.9161205	ppb	5983.333
C2	SAM	Cd			0.01684672	ppb	0.50540161	ppb	33.33333
C2	SAM	Co			0.72371787	ppb	21.7115364	ppb	7066.666
C2	SAM	Cr			10.8340539	ppb	325.021606	ppb	9163.333
C2	SAM	Cu			7.56041193	ppb	226.812362	ppb	33770
C2	SAM	Fe		x	8757.61621	ppb	262728.5	ppb	1802053

C2	SAM	Ga		-2.9436447	ppb	-88.309341	ppb	833.3333
C2	SAM	Ir		-3.1943295	ppb	-95.829887	ppb	56.66666
C2	SAM	Mg	x	635.848327	ppb	19075.4492	ppb	607540
C2	SAM	Mn	x	119.505943	ppb	3585.17822	ppb	1166986
C2	SAM	Ni		1.91820443	ppb	57.5461311	ppb	4556.666
C2	SAM	Pb		0.26042187	ppb	7.8126564	ppb	2423.333
C2	SAM	Sr		11.4660587	ppb	343.98175	ppb	140190
C2	SAM	Ti		1.08388531	ppb	32.5165596	ppb	450
C2	SAM	Tl		-3.4597458	ppb	-103.79237	ppb	43.33333
C2	SAM	V		2.14298391	ppb	64.2895202	ppb	18449.68
C2	SAM	Zn		8.35664463	ppb	250.69934	ppb	9290
C2	SAM	(Rh)		1.1580683	ppb	34.7420501	ppb	1952943
C2	SAM	(Sc)		0.76392508	ppb	22.9177513	ppb	1060440
C2	SAM	(Tb)		1.25708413	ppb	37.7125244	ppb	2075123
C2	SAM	(Y)		1.10590219	ppb	33.1770668	ppb	2136990
Blank 3	SAM	Ag			ppb		ppb	266.6666
Blank 3	SAM	Al		3.54769874	ppb	106.430961	ppb	15553.33
Blank 3	SAM	As			ppb		ppb	2477.698
Blank 3	SAM	B			ppb		ppb	2383.333
Blank 3	SAM	Ba		0.06345508	ppb	1.90365219	ppb	143.3333
Blank 3	SAM	Bi		1.32626295	ppb	39.7878875	ppb	10176.66
Blank 3	SAM	Cd		0.00926995	ppb	0.27809855	ppb	23.33333
Blank 3	SAM	Co		0.02273885	ppb	0.68216556	ppb	673.3333
Blank 3	SAM	Cr		13.0813541	ppb	392.440612	ppb	9076.667
Blank 3	SAM	Cu		0.46668771	ppb	14.0006313	ppb	2066.666
Blank 3	SAM	Fe		41.9347572	ppb	1258.04272	ppb	13446.66
Blank 3	SAM	Ga		-2.9679012	ppb	-89.037033	ppb	656.6666
Blank 3	SAM	Ir		-3.1906077	ppb	-95.718231	ppb	80

Blank 3	SAM	Mg	3.34408998	ppb	100.3227	ppb	3323.333
Blank 3	SAM	Mn	0.27335739	ppb	8.20072174	ppb	3553.333
Blank 3	SAM	Ni	0.98052633	ppb	29.4157905	ppb	2213.333
Blank 3	SAM	Pb	0.12918399	ppb	3.87551975	ppb	1356.666
Blank 3	SAM	Sr	0.04521924	ppb	1.35657716	ppb	700
Blank 3	SAM	Ti	0.65363646	ppb	19.6090927	ppb	230
Blank 3	SAM	Tl	-3.4632258	ppb	-103.89677	ppb	23.33333
Blank 3	SAM	V	-0.88103	ppb	-26.430902	ppb	-2299.77
Blank 3	SAM	Zn	4.66742182	ppb	140.022659	ppb	4346.666
Blank 3	SAM	(Rh)	1.09594917	ppb	32.8784751	ppb	1848186
Blank 3	SAM	(Sc)	0.63372988	ppb	19.0118961	ppb	879710
Blank 3	SAM	(Tb)	1.30724943	ppb	39.2174835	ppb	2157933
Blank 3	SAM	(Y)	1.02071059	ppb	30.6213169	ppb	1972370
Blank 4	SAM	Ag		ppb		ppb	200
Blank 4	SAM	Al	11.6751966	ppb	350.255889	ppb	48833.33
Blank 4	SAM	As		ppb		ppb	2296.851
Blank 4	SAM	B		ppb		ppb	2416.666
Blank 4	SAM	Ba	0.10285987	ppb	3.08579612	ppb	196.6666
Blank 4	SAM	Bi	0.89316505	ppb	26.7949523	ppb	6643.333
Blank 4	SAM	Cd	0.01256798	ppb	0.37703928	ppb	26.66666
Blank 4	SAM	Co	0.00891554	ppb	0.26746625	ppb	586.6666
Blank 4	SAM	Cr	11.9666528	ppb	358.999572	ppb	8603.333
Blank 4	SAM	Cu	0.20609596	ppb	6.18287897	ppb	1146.666
Blank 4	SAM	Fe	36.3808021	ppb	1091.42407	ppb	12906.66
Blank 4	SAM	Ga	-2.9685368	ppb	-89.056106	ppb	653.3333
Blank 4	SAM	Ir	-3.1916663	ppb	-95.749992	ppb	73.33333
Blank 4	SAM	Mg	3.71066427	ppb	111.319931	ppb	3723.333
Blank 4	SAM	Mn	0.37701228	ppb	11.3103685	ppb	4536.666

Blank 4	SAM	Ni		0.83495224	ppb	25.0485668	ppb	2033.333
Blank 4	SAM	Pb		0.12745592	ppb	3.82367754	ppb	1323.333
Blank 4	SAM	Sr		0.05080487	ppb	1.5241462	ppb	766.6666
Blank 4	SAM	Ti		0.76796699	ppb	23.039009	ppb	276.6666
Blank 4	SAM	Tl		-3.4636824	ppb	-103.91046	ppb	20
Blank 4	SAM	V		-0.8300039	ppb	-24.900117	ppb	-2038.99
Blank 4	SAM	Zn		3.17434096	ppb	95.2302322	ppb	3080
Blank 4	SAM	(Rh)		1.09764314	ppb	32.9292945	ppb	1851043
Blank 4	SAM	(Sc)		0.6540159	ppb	19.6204776	ppb	907870
Blank 4	SAM	(Tb)		1.29167056	ppb	38.7501182	ppb	2132216
Blank 4	SAM	(Y)		1.0217576	ppb	30.652729	ppb	1974393
E2	SAM	Ag			ppb		ppb	466.6666
E2	SAM	Al		6.11048603	ppb	183.314575	ppb	31336.66
E2	SAM	As			ppb		ppb	2905.181
E2	SAM	B			ppb		ppb	4963.333
E2	SAM	Ba		16.3094139	ppb	489.282409	ppb	22620
E2	SAM	Bi		0.09118873	ppb	2.73566198	ppb	313.3333
E2	SAM	Cd		0.01660149	ppb	0.49804458	ppb	33.33333
E2	SAM	Co		0.52349418	ppb	15.7048254	ppb	5366.666
E2	SAM	Cr		10.9845762	ppb	329.537292	ppb	9436.667
E2	SAM	Cu		5.74343348	ppb	172.303009	ppb	26186.66
E2	SAM	Fe	x	8087.54541	ppb	242626.359	ppb	1692483
E2	SAM	Ga		-2.9114937	ppb	-87.34481	ppb	1000
E2	SAM	Ir		-3.1943521	ppb	-95.830566	ppb	56.66666
E2	SAM	Mg	x	697.017822	ppb	20910.5351	ppb	676670
E2	SAM	Mn		106.558784	ppb	3196.76342	ppb	1058080
E2	SAM	Ni		1.60851884	ppb	48.2555656	ppb	3996.666
E2	SAM	Pb		0.16131036	ppb	4.83931065	ppb	1583.333

E2	SAM	Sr		10.8106746	ppb	324.320251	ppb	132733.3
E2	SAM	Ti		0.97487015	ppb	29.2461051	ppb	413.3333
E2	SAM	Tl		-3.4630656	ppb	-103.89196	ppb	23.33333
E2	SAM	V		0.90129769	ppb	27.0389308	ppb	9900.709
E2	SAM	Zn		3.97532439	ppb	119.259735	ppb	4553.333
E2	SAM	(Rh)		1.16216385	ppb	34.8649139	ppb	1959850
E2	SAM	(Sc)		0.77660143	ppb	23.2980423	ppb	1078036
E2	SAM	(Tb)		1.26152658	ppb	37.8457984	ppb	2082456
E2	SAM	(Y)		1.11060631	ppb	33.3181877	ppb	2146080
50ppb spike	MSA	Ag			ppb		ppb	220443.3
50ppb spike	MSA	Al		52.1830787	ppb	52.1830787	ppb	244823.3
50ppb spike	MSA	As			ppb		ppb	47975.78
50ppb spike	MSA	B			ppb		ppb	37263.33
50ppb spike	MSA	Ba		66.9777603	ppb	66.9777603	ppb	90830
50ppb spike	MSA	Bi		48.9703483	ppb	48.9703483	ppb	368910
50ppb spike	MSA	Cd		50.7273559	ppb	50.7273559	ppb	57940
50ppb spike	MSA	Co		50.3060836	ppb	50.3060836	ppb	443796.6
50ppb spike	MSA	Cr		58.1246643	ppb	58.1246643	ppb	45926.66
50ppb spike	MSA	Cu		56.2055244	ppb	56.2055244	ppb	245126.6
50ppb spike	MSA	Fe	x	8163.49755	ppb	8163.49755	ppb	1659060
50ppb spike	MSA	Ga		47.9236831	ppb	47.9236831	ppb	253400
50ppb spike	MSA	Ir		50.3019981	ppb	50.3019981	ppb	284213.3
50ppb spike	MSA	Mg	x	737.83905	ppb	737.83905	ppb	695850
50ppb spike	MSA	Mn	x	153.519149	ppb	153.519149	ppb	1479730
50ppb spike	MSA	Ni		51.5106926	ppb	51.5106926	ppb	103093.3
50ppb spike	MSA	Pb		49.5542907	ppb	49.5542907	ppb	415680
50ppb spike	MSA	Sr		59.7375717	ppb	59.7375717	ppb	715606.6
50ppb spike	MSA	Ti		48.8488502	ppb	48.8488502	ppb	19350

50ppb spike	MSA	Tl	49.4069671	ppb	49.4069671	ppb	312016.6
50ppb spike	MSA	V	50.0710868	ppb	50.0710868	ppb	350062.1
50ppb spike	MSA	Zn	51.588684	ppb	51.588684	ppb	56066.66
50ppb spike	MSA	(Rh)	1.13650346	ppb	1.13650346	ppb	1916576
50ppb spike	MSA	(Sc)	0.75421906	ppb	0.75421906	ppb	1046966
50ppb spike	MSA	(Tb)	1.23585129	ppb	1.23585129	ppb	2040073
50ppb spike	MSA	(Y)	1.08467412	ppb	1.08467412	ppb	2095970
Preparation Blank	PRB	Ag		ppb		ppb	163.3333
Preparation Blank	PRB	Al	0.38729638	ppb	0.38729638	ppb	4230
Preparation Blank	PRB	As		ppb		ppb	2923.385
Preparation Blank	PRB	B		ppb		ppb	4063.333
Preparation Blank	PRB	Ba	-0.0237676	ppb	-0.0237676	ppb	16.66666
Preparation Blank	PRB	Bi	0.07344385	ppb	0.07344385	ppb	163.3333
Preparation Blank	PRB	Cd	0.00342326	ppb	0.00342326	ppb	16.66666
Preparation Blank	PRB	Co	0.03256796	ppb	0.03256796	ppb	986.6666
Preparation Blank	PRB	Cr	1.23141479	ppb	1.23141479	ppb	1730
Preparation Blank	PRB	Cu	0.00950102	ppb	0.00950102	ppb	523.3333
Preparation Blank	PRB	Fe	8.46426582	ppb	8.46426582	ppb	10270
Preparation Blank	PRB	Ga	-2.8641901	ppb	-2.8641901	ppb	1183.333
Preparation Blank	PRB	Ir	-3.1816053	ppb	-3.1816053	ppb	116.6666
Preparation Blank	PRB	Mg	-0.1773547	ppb	-0.1773547	ppb	706.6666
Preparation Blank	PRB	Mn	0.15092775	ppb	0.15092775	ppb	3393.333
Preparation Blank	PRB	Ni	0.85420573	ppb	0.85420573	ppb	2646.666
Preparation Blank	PRB	Pb	-0.0035221	ppb	-0.0035221	ppb	160
Preparation Blank	PRB	Sr	-0.0002487	ppb	-0.0002487	ppb	193.3333
Preparation Blank	PRB	Ti	0.05036383	ppb	0.05036383	ppb	40
Preparation Blank	PRB	Tl	-3.4561281	ppb	-3.4561281	ppb	60
Preparation Blank	PRB	V	-0.425524	ppb	-0.425524	ppb	495.5551

Preparation Blank	PRB	Zn	-0.0215019	ppb	-0.0215019	ppb	96.66666
Preparation Blank	PRB	(Rh)	1.09369385	ppb	1.09369385	ppb	1844383
Preparation Blank	PRB	(Sc)	0.83938301	ppb	0.83938301	ppb	1165186
Preparation Blank	PRB	(Tb)	1.17010915	ppb	1.17010915	ppb	1931550
Preparation Blank	PRB	(Y)	1.05596471	ppb	1.05596471	ppb	2040493
SW1	QCS	Ag		ppb		ppb	486.6666
SW1	QCS	Al	5.59415865	ppb	5.59415865	ppb	30860
SW1	QCS	As		ppb		ppb	4053.549
SW1	QCS	B		ppb		ppb	8090
SW1	QCS	Ba	5.02963543	ppb	5.02963543	ppb	6546.666
SW1	QCS	Bi	0.06948253	ppb	0.06948253	ppb	136.6666
SW1	QCS	Cd	0.06773059	ppb	0.06773059	ppb	90
SW1	QCS	Co	0.24182057	ppb	0.24182057	ppb	3006.666
SW1	QCS	Cr	-0.112796	ppb	-0.112796	ppb	560
SW1	QCS	Cu	2.02472687	ppb	2.02472687	ppb	10176.66
SW1	QCS	Fe	3.46527052	ppb	3.46527052	ppb	9056.667
SW1	QCS	Ga	-2.8771114	ppb	-2.8771114	ppb	1130
SW1	QCS	Ir	-3.1843464	ppb	-3.1843464	ppb	103.3333
SW1	QCS	Mg	44.362503	ppb	44.362503	ppb	46880
SW1	QCS	Mn	1.05473757	ppb	1.05473757	ppb	12940
SW1	QCS	Ni	0.95445979	ppb	0.95445979	ppb	2843.333
SW1	QCS	Pb	0.52753627	ppb	0.52753627	ppb	4403.333
SW1	QCS	Sr	5.15903759	ppb	5.15903759	ppb	61056.66
SW1	QCS	Ti	0.05249262	ppb	0.05249262	ppb	40
SW1	QCS	Tl	-3.4586267	ppb	-3.4586267	ppb	46.66666
SW1	QCS	V	0.72366524	ppb	0.72366524	ppb	9235.365
SW1	QCS	Zn	1.84053159	ppb	1.84053159	ppb	2320
SW1	QCS	(Rh)	1.11675107	ppb	1.11675107	ppb	1883266

SW1	QCS	(Sc)	0.83026773	ppb	0.83026773	ppb	1152533
SW1	QCS	(Tb)	1.17847717	ppb	1.17847717	ppb	1945363
SW1	QCS	(Y)	1.06844509	ppb	1.06844509	ppb	2064610
SW2	QCS	Ag		ppb		ppb	326.6666
SW2	QCS	Al	26.1182003	ppb	26.1182003	ppb	133606.6
SW2	QCS	As		ppb		ppb	7876.325
SW2	QCS	B		ppb		ppb	3353.333
SW2	QCS	Ba	25.8286151	ppb	25.8286151	ppb	33543.33
SW2	QCS	Bi	0.06301281	ppb	0.06301281	ppb	90
SW2	QCS	Cd	0.30046558	ppb	0.30046558	ppb	350
SW2	QCS	Co	1.01651978	ppb	1.01651978	ppb	10333.33
SW2	QCS	Cr	0.71243632	ppb	0.71243632	ppb	1246.666
SW2	QCS	Cu	10.7584753	ppb	10.7584753	ppb	51120
SW2	QCS	Fe	13.1323766	ppb	13.1323766	ppb	11010
SW2	QCS	Ga	-2.8828804	ppb	-2.8828804	ppb	1100
SW2	QCS	Ir	-3.1897335	ppb	-3.1897335	ppb	76.66666
SW2	QCS	Mg	221.428909	ppb	221.428909	ppb	226436.6
SW2	QCS	Mn	5.14452934	ppb	5.14452934	ppb	55300
SW2	QCS	Ni	5.15894938	ppb	5.15894938	ppb	11833.33
SW2	QCS	Pb	2.65366912	ppb	2.65366912	ppb	21476.66
SW2	QCS	Sr	25.906332	ppb	25.906332	ppb	305373.3
SW2	QCS	Ti	0.03916132	ppb	0.03916132	ppb	33.33333
SW2	QCS	Tl	-3.4581031	ppb	-3.4581031	ppb	50
SW2	QCS	V	4.91475391	ppb	4.91475391	ppb	40458.87
SW2	QCS	Zn	9.01725578	ppb	9.01725578	ppb	10700
SW2	QCS	(Rh)	1.11617589	ppb	1.11617589	ppb	1882296
SW2	QCS	(Sc)	0.81565595	ppb	0.81565595	ppb	1132250
SW2	QCS	(Tb)	1.18232393	ppb	1.18232393	ppb	1951713

SW2	QCS	(Y)	1.06711864	ppb	1.06711864	ppb	2062046

APPENDIX D

RAW DATA FOR Q9779

RAW DATA FOR Q9779

Cool Plasma

UltraMass ICP-MS

Result Export from 991124c.RAT

Description: Cav/Erne Oct99, Ger DCU cool

Label	Type	Element	Flags	Sol'n Conc	Units	Corr Conc	Units	c/s
Blank	BLK	Ca		0	ppb	0	ppb	4
Blank	BLK	Fe		0	ppb	0	ppb	13.98588
Blank	BLK	K		0	ppb	0	ppb	153
Blank	BLK	Mg		0	ppb	0	ppb	41
Blank	BLK	Na		0	ppb	0	ppb	3316
Blank	BLK	(Li)			ppb		ppb	2833246
50ppb	STD	Ca			ppb		ppb	
50ppb	STD	Fe		50	ppb	50	ppb	207.8292
50ppb	STD	K			ppb		ppb	
50ppb	STD	Mg			ppb		ppb	
50ppb	STD	Na			ppb		ppb	
50ppb	STD	(Li)		0.968352	ppb	0.968352	ppb	2743580
100ppb	STD	Ca		100	ppb	100	ppb	73
100ppb	STD	Fe		100	ppb	100	ppb	341.5882
100ppb	STD	K		100	ppb	100	ppb	12924
100ppb	STD	Mg		100	ppb	100	ppb	8336
100ppb	STD	Na		100	ppb	100	ppb	80430
100ppb	STD	(Li)		0.949692	ppb	0.949692	ppb	2690710
500ppb	STD	Ca		500	ppb	500	ppb	288
500ppb	STD	Fe		500	ppb	500	ppb	1303.452

500ppb	STD	K	500 ppb	500 ppb	55612
500ppb	STD	Mg	500 ppb	500 ppb	33945
500ppb	STD	Na	500 ppb	500 ppb	331895
500ppb	STD	(Li)	0.830384 ppb	0.830384 ppb	2352682
1000ppb	STD	Ca	1000 ppb	1000 ppb	397
1000ppb	STD	Fe	ppb	ppb	
1000ppb	STD	K	1000 ppb	1000 ppb	95818
1000ppb	STD	Mg	1000 ppb	1000 ppb	59385
1000ppb	STD	Na	1000 ppb	1000 ppb	559361
1000ppb	STD	(Li)	0.745654 ppb	0.745654 ppb	2112621
Blank	BLK	Ca	0 ppb	0 ppb	2
Blank	BLK	Fe	0 ppb	0 ppb	23.12673
Blank	BLK	K	0 ppb	0 ppb	138
Blank	BLK	Mg	0 ppb	0 ppb	37
Blank	BLK	Na	0 ppb	0 ppb	3156
Blank	BLK	(Li)	0.952269 ppb	0.952269 ppb	2698012
Blank	BLK	Ca	0 ppb	0 ppb	3
Blank	BLK	Fe	0 ppb	0 ppb	8.81686
Blank	BLK	K	0 ppb	0 ppb	151
Blank	BLK	Mg	0 ppb	0 ppb	63
Blank	BLK	Na	0 ppb	0 ppb	3320
Blank	BLK	(Li)	1.003139 ppb	1.003139 ppb	2842139
100ppb	RSP	Ca	100 ppb	100 ppb	100
100ppb	RSP	Fe	100 ppb	100 ppb	381.4754
100ppb	RSP	K	100 ppb	100 ppb	12427
100ppb	RSP	Mg	100 ppb	100 ppb	8172
100ppb	RSP	Na	100 ppb	100 ppb	78578
100ppb	RSP	(Li)	0.941962 ppb	0.941962 ppb	2668809

SW1	SAM	Ca	216.5302 ppb	2165.302 ppb	167
SW1	SAM	Fe	12.09855 ppb	120.9855 ppb	44.84503
SW1	SAM	K	22.75599 ppb	227.5599 ppb	2868
SW1	SAM	Mg	45.07617 ppb	450.7617 ppb	3456
SW1	SAM	Na	216.1506 ppb	2161.506 ppb	156762
SW1	SAM	(Li)	0.954624 ppb	9.54624 ppb	2704684
Blank	BLK	Ca	0 ppb	0 ppb	3
Blank	BLK	Fe	0 ppb	0 ppb	20.07038
Blank	BLK	K	0 ppb	0 ppb	152
Blank	BLK	Mg	0 ppb	0 ppb	54
Blank	BLK	Na	0 ppb	0 ppb	3270
Blank	BLK	(Li)	0.971052 ppb	0.971052 ppb	2751230
Blank	BLK	Ca	0 ppb	0 ppb	4
Blank	BLK	Fe	0 ppb	0 ppb	16.56333
Blank	BLK	K	0 ppb	0 ppb	155
Blank	BLK	Mg	0 ppb	0 ppb	52
Blank	BLK	Na	0 ppb	0 ppb	3372
Blank	BLK	(Li)	1.003176 ppb	1.003176 ppb	2842245
100ppb	RSP	Ca	100 ppb	100 ppb	77
100ppb	RSP	Fe	100 ppb	100 ppb	336.9261
100ppb	RSP	K	100 ppb	100 ppb	12906
100ppb	RSP	Mg	100 ppb	100 ppb	8280
100ppb	RSP	Na	100 ppb	100 ppb	81426
100ppb	RSP	(Li)	0.950663 ppb	0.950663 ppb	2693463
Prep blank	SAM	Ca	-1.59576 ppb	-15.9576 ppb	3
Prep blank	SAM	Fe	2.118184 ppb	21.18184 ppb	21.98588
Prep blank	SAM	K	0.717708 ppb	7.177085 ppb	242
Prep blank	SAM	Mg	0.027881 ppb	0.278809 ppb	53

Prep blank	SAM	Na		0.259251 ppb	2.592506 ppb	3488
Prep blank	SAM	(Li)		0.980124 ppb	9.801241 ppb	2776932
Ger DCU Blank7	SAM	Ca		7.785888 ppb	77.85888 ppb	5
Ger DCU Blank7	SAM	Fe		-4.82504 ppb	-48.2504 ppb	4.21124
Ger DCU Blank7	SAM	K		3.58169 ppb	35.81689 ppb	353
Ger DCU Blank7	SAM	Mg		1.024638 ppb	10.24638 ppb	76
Ger DCU Blank7	SAM	Na		6.650517 ppb	66.50517 ppb	4830
Ger DCU Blank7	SAM	(Li)		0.571775 ppb	5.717748 ppb	1619978
Ger DCU Blank8	SAM	Ca		67.80264 ppb	678.0264 ppb	25
Ger DCU Blank8	SAM	Fe		-2.49229 ppb	-24.9229 ppb	10.18307
Ger DCU Blank8	SAM	K		5.511186 ppb	55.11186 ppb	489
Ger DCU Blank8	SAM	Mg		1.354598 ppb	13.54598 ppb	90
Ger DCU Blank8	SAM	Na		9.536066 ppb	95.36066 ppb	6017
Ger DCU Blank8	SAM	(Li)		0.564593 ppb	5.645926 ppb	1599629
Blank	BLK	Ca		0 ppb	0 ppb	1
Blank	BLK	Fe		0 ppb	0 ppb	17.90136
Blank	BLK	K		0 ppb	0 ppb	140
Blank	BLK	Mg		0 ppb	0 ppb	42
Blank	BLK	Na		0 ppb	0 ppb	2519
Blank	BLK	(Li)		0.86384 ppb	0.86384 ppb	2447472
Ger DCU D1	SAM	Ca	x	14165.02 ppb	141650.2 ppb	4294
Ger DCU D1	SAM	Fe	x	5241.941 ppb	52419.41 ppb	13435.93
Ger DCU D1	SAM	K		62.61452 ppb	626.1451 ppb	4211
Ger DCU D1	SAM	Mg	x	1651.614 ppb	16516.14 ppb	67016
Ger DCU D1	SAM	Na		168.907 ppb	1689.07 ppb	67757
Ger DCU D1	SAM	(Li)		0.511274 ppb	5.112739 ppb	1448564
Ger DCU D2	SAM	Ca	x	10866.63 ppb	108666.3 ppb	3500
Ger DCU D2	SAM	Fe	x	4566.996 ppb	45669.96 ppb	11708.07

Ger DCU D2	SAM	K		35.60493ppb	356.0493ppb	2582
Ger DCU D2	SAM	Mg	x	1299.496ppb	12994.96ppb	56111
Ger DCU D2	SAM	Na		106.2955ppb	1062.955ppb	46020
Ger DCU D2	SAM	(Li)		0.54446ppb	5.444596ppb	1542588
Ger DCU Prep blank	SAM	Ca		-2.98367ppb	-29.8367ppb	2
Ger DCU Prep blank	SAM	Fe		0.165059ppb	1.650586ppb	16.98588
Ger DCU Prep blank	SAM	K		0.633094ppb	6.330945ppb	213
Ger DCU Prep blank	SAM	Mg		0.389078ppb	3.890782ppb	74
Ger DCU Prep blank	SAM	Na		0.750182ppb	7.50182ppb	3541
Ger DCU Prep blank	SAM	(Li)		0.901238ppb	9.012383ppb	2553429
SW2	SAM	Ca	x	1252.227ppb	12522.27ppb	659
SW2	SAM	Fe		8.874338ppb	88.74338ppb	39.28162
SW2	SAM	K		101.1236ppb	1011.237ppb	11664
SW2	SAM	Mg		216.3404ppb	2163.404ppb	15206
SW2	SAM	Na		967.204ppb	9672.04ppb	656286
SW2	SAM	(Li)		0.883177ppb	8.83177ppb	2502257
Blank	BLK	Ca		0ppb	0ppb	1
Blank	BLK	Fe		0ppb	0ppb	15.84503
Blank	BLK	K		0ppb	0ppb	165
Blank	BLK	Mg		0ppb	0ppb	32
Blank	BLK	Na		0ppb	0ppb	2940
Blank	BLK	(Li)		0.919056ppb	0.919056ppb	2603912
100ppb	RSP	Ca		100ppb	100ppb	74
100ppb	RSP	Fe		100ppb	100ppb	360.6871
100ppb	RSP	K		100ppb	100ppb	12127
100ppb	RSP	Mg		100ppb	100ppb	7407
100ppb	RSP	Na		100ppb	100ppb	74434
100ppb	RSP	(Li)		0.894536ppb	0.894536ppb	2534439

C72	SAM	Ca	x	12384.96 ppb	123849.6 ppb	6944
C72	SAM	Fe		-1.29824 ppb	-12.9824 ppb	12.26758
C72	SAM	K		242.6102 ppb	2426.102 ppb	28015
C72	SAM	Mg		639.3684 ppb	6393.684 ppb	43124
C72	SAM	Na	x	1135.341 ppb	11353.41 ppb	756006
C72	SAM	(Li)		0.89242 ppb	8.924197 ppb	2528444
C73	SAM	Ca	x	9281.595 ppb	92815.95 ppb	5489
C73	SAM	Fe		-1.71225 ppb	-17.1225 ppb	11.12673
C73	SAM	K		233.8446 ppb	2338.446 ppb	28472
C73	SAM	Mg		640.561 ppb	6405.61 ppb	45556
C73	SAM	Na	x	1081.677 ppb	10816.77 ppb	759760
C73	SAM	(Li)		0.940601 ppb	9.406011 ppb	2664954
C74	SAM	Ca	x	11855.13 ppb	118551.3 ppb	6969
C74	SAM	Fe		1.865593 ppb	18.65593 ppb	20.98588
C74	SAM	K		247.375 ppb	2473.75 ppb	29939
C74	SAM	Mg		625.2242 ppb	6252.242 ppb	44218
C74	SAM	Na	x	1102.622 ppb	11026.22 ppb	769816
C74	SAM	(Li)		0.935237 ppb	9.352368 ppb	2649756
C75	SAM	Ca	x	7891.378 ppb	78913.78 ppb	4761
C75	SAM	Fe		-0.25045 ppb	-2.50446 ppb	15.1549
C75	SAM	K		256.9389 ppb	2569.389 ppb	31893
C75	SAM	Mg		557.1672 ppb	5571.672 ppb	40435
C75	SAM	Na		1020.777 ppb	10207.77 ppb	731528
C75	SAM	(Li)		0.959549 ppb	9.595494 ppb	2718639
C76	SAM	Ca	x	11160.98 ppb	111609.8 ppb	6660
C76	SAM	Fe		1.967821 ppb	19.67821 ppb	21.26758
C76	SAM	K		266.7893 ppb	2667.893 ppb	32763
C76	SAM	Mg		561.9471 ppb	5619.472 ppb	40353

C76	SAM	Na	x	1074.34 ppb	10743.4 ppb	761740
C76	SAM	(Li)		0.949785 ppb	9.497853 ppb	2690975
Blank	BLK	Ca		0 ppb	0 ppb	4
Blank	BLK	Fe		0 ppb	0 ppb	17.04221
Blank	BLK	K		0 ppb	0 ppb	138
Blank	BLK	Mg		0 ppb	0 ppb	57
Blank	BLK	Na		0 ppb	0 ppb	3456
Blank	BLK	(Li)		0.984101 ppb	0.984101 ppb	2788201
C77	SAM	Ca	x	11871.4 ppb	118714 ppb	6925
C77	SAM	Fe		-0.65423 ppb	-6.54232 ppb	14.04221
C77	SAM	K		268.3089 ppb	2683.089 ppb	32198
C77	SAM	Mg		571.0604 ppb	5710.604 ppb	40074
C77	SAM	Na	x	1142.103 ppb	11421.03 ppb	790955
C77	SAM	(Li)		0.927782 ppb	9.277821 ppb	2628634
C78	SAM	Ca	x	11790.07 ppb	117900.7 ppb	7245
C78	SAM	Fe		-2.82138 ppb	-28.2138 ppb	8.07039
C78	SAM	K		237.9198 ppb	2379.198 ppb	30099
C78	SAM	Mg		585.6427 ppb	5856.427 ppb	43288
C78	SAM	Na		1046.962 ppb	10469.62 ppb	764252
C78	SAM	(Li)		0.977601 ppb	9.776005 ppb	2769782
C79	SAM	Ca	x	11079.93 ppb	110799.3 ppb	6982
C79	SAM	Fe		-1.12958 ppb	-11.2958 ppb	12.73234
C79	SAM	K		253.9862 ppb	2539.862 ppb	32931
C79	SAM	Mg		601.1282 ppb	6011.282 ppb	45570
C79	SAM	Na	x	1091.72 ppb	10917.2 ppb	817009
C79	SAM	(Li)		1.002591 ppb	10.02591 ppb	2840585
prep blank 1	SAM	Ca		7.573405 ppb	75.73405 ppb	6
prep blank 1	SAM	Fe		2.156929 ppb	21.56929 ppb	21.78868

prep blank 1	SAM	K	0.897579 ppb	8.975787 ppb	302
prep blank 1	SAM	Mg	0.423235 ppb	4.232347 ppb	68
prep blank 1	SAM	Na	1.658547 ppb	16.58547 ppb	4537
prep blank 1	SAM	(Li)	1.024051 ppb	10.24051 ppb	2901388

Blank7	Ca	77.85888 ppb
Blank7	Fe	-48.2504 ppb
Blank7	K	35.81689 ppb
Blank7	Mg	10.24638 ppb
Blank7	Na	66.50517 ppb
Blank7	(Li)	5.717748 ppb
Blank8	Ca	678.0264 ppb
Blank8	Fe	-24.9229 ppb
Blank8	K	55.11186 ppb
Blank8	Mg	13.54598 ppb
Blank8	Na	95.36066 ppb
Blank8	(Li)	5.645926 ppb
D1	Ca	141650.2 ppb
D1	Fe	52419.41 ppb
D1	K	626.1451 ppb
D1	Mg	16516.14 ppb
D1	Na	1689.07 ppb
D1	(Li)	5.112739 ppb
D2	Ca	108666.3 ppb
D2	Fe	45669.96 ppb
D2	K	356.0493 ppb
D2	Mg	12994.96 ppb

D2	Na	1062.955 ppb
D2	(Li)	5.444596 ppb
Prep blank	Ca	-29.8367 ppb
Prep blank	Fe	1.650586 ppb
Prep blank	K	6.330945 ppb
Prep blank	Mg	3.890782 ppb
Prep blank	Na	7.50182 ppb
Prep blank	(Li)	9.012383 ppb

Hot Plasma

Label	Type	Element	Flags	Sol'n Conc	Units	Corr Conc	Units	c/s
Blank	BLK	Ag		0	ppb	0	ppb	34
Blank	BLK	Al		0	ppb	0	ppb	1052
Blank	BLK	As		0	ppb	0	ppb	1542.805
Blank	BLK	Ba		0	ppb	0	ppb	14
Blank	BLK	Cd		0	ppb	0	ppb	26
Blank	BLK	Co		0	ppb	0	ppb	468
Blank	BLK	Cr		0	ppb	0	ppb	214
Blank	BLK	Cu		0	ppb	0	ppb	178
Blank	BLK	Fe		0	ppb	0	ppb	5298
Blank	BLK	Mg		0	ppb	0	ppb	276
Blank	BLK	Mn		0	ppb	0	ppb	1182
Blank	BLK	Ni		0	ppb	0	ppb	314
Blank	BLK	Pb		0	ppb	0	ppb	158
Blank	BLK	Sr		0	ppb	0	ppb	60
Blank	BLK	Ti		0	ppb	0	ppb	10
Blank	BLK	Tl		0	ppb	0	ppb	2
Blank	BLK	V		0	ppb	0	ppb	597.4578
Blank	BLK	Zn		0	ppb	0	ppb	48
Blank	BLK	(Rh)			ppb		ppb	402864
Blank	BLK	(Sc)			ppb		ppb	303464
Blank	BLK	(Tb)			ppb		ppb	570252
Blank	BLK	(Y)			ppb		ppb	420546
10ppb	STD	Ag			ppb		ppb	
10ppb	STD	Al		10	ppb	10	ppb	15276
10ppb	STD	As		10	ppb	10	ppb	1563.136

10ppb	STD	Ba	10	ppb	10	ppb	3368
10ppb	STD	Cd	10	ppb	10	ppb	2178
10ppb	STD	Co	10	ppb	10	ppb	25148
10ppb	STD	Cr	10	ppb	10	ppb	2596
10ppb	STD	Cu	10	ppb	10	ppb	11430
10ppb	STD	Fe	10	ppb	10	ppb	6020
10ppb	STD	Mg	10	ppb	10	ppb	3254
10ppb	STD	Mn	10	ppb	10	ppb	29254
10ppb	STD	Ni	10	ppb	10	ppb	5746
10ppb	STD	Pb	10	ppb	10	ppb	26696
10ppb	STD	Sr	10	ppb	10	ppb	25870
10ppb	STD	Ti	10	ppb	10	ppb	1116
10ppb	STD	Tl	10	ppb	10	ppb	20272
10ppb	STD	V	10	ppb	10	ppb	19282.99
10ppb	STD	Zn	10	ppb	10	ppb	2220
10ppb	STD	(Rh)	0.97637415	ppb	0.97637415	ppb	393346
10ppb	STD	(Sc)	0.96005458	ppb	0.96005458	ppb	291342
10ppb	STD	(Tb)	0.98385978	ppb	0.98385978	ppb	561048
10ppb	STD	(Y)	0.97895116	ppb	0.97895116	ppb	411694
50ppb	STD	Ag	50	ppb	50	ppb	49918
50ppb	STD	Al	50	ppb	50	ppb	71010
50ppb	STD	As	50	ppb	50	ppb	1487.999
50ppb	STD	Ba	50	ppb	50	ppb	17004
50ppb	STD	Cd	50	ppb	50	ppb	10992
50ppb	STD	Co	50	ppb	50	ppb	122048
50ppb	STD	Cr	50	ppb	50	ppb	11630
50ppb	STD	Cu	50	ppb	50	ppb	56044

50ppb	STD	Fe		50	ppb	50	ppb	8028
50ppb	STD	Mg		50	ppb	50	ppb	15340
50ppb	STD	Mn		50	ppb	50	ppb	138272
50ppb	STD	Ni		50	ppb	50	ppb	26926
50ppb	STD	Pb		50	ppb	50	ppb	131922
50ppb	STD	Sr		50	ppb	50	ppb	128108
50ppb	STD	Ti		50	ppb	50	ppb	5480
50ppb	STD	Tl		50	ppb	50	ppb	99410
50ppb	STD	V		50	ppb	50	ppb	95689.6
50ppb	STD	Zn		50	ppb	50	ppb	11614
50ppb	STD	(Rh)		0.96556652	ppb	0.96556652	ppb	388992
50ppb	STD	(Sc)		0.94102103	ppb	0.94102103	ppb	285566
50ppb	STD	(Tb)		0.98460329	ppb	0.98460329	ppb	561472
50ppb	STD	(Y)		0.98005927	ppb	0.98005927	ppb	412160
100ppb	STD	Ag	eo	100	ppb	100	ppb	56047.5
100ppb	STD	Al		100	ppb	100	ppb	139072
100ppb	STD	As		100	ppb	100	ppb	1495.983
100ppb	STD	Ba		100	ppb	100	ppb	34110
100ppb	STD	Cd		100	ppb	100	ppb	21490
100ppb	STD	Co		100	ppb	100	ppb	240162
100ppb	STD	Cr		100	ppb	100	ppb	23180
100ppb	STD	Cu		100	ppb	100	ppb	111836
100ppb	STD	Fe		100	ppb	100	ppb	10870
100ppb	STD	Mg		100	ppb	100	ppb	30236
100ppb	STD	Mn		100	ppb	100	ppb	274570
100ppb	STD	Ni		100	ppb	100	ppb	52722
100ppb	STD	Pb		100	ppb	100	ppb	261072

100ppb	STD	Sr	100	ppb	100	ppb	254550
100ppb	STD	Ti	100	ppb	100	ppb	11192
100ppb	STD	Tl	100	ppb	100	ppb	197490
100ppb	STD	V	100	ppb	100	ppb	186261.7
100ppb	STD	Zn	100	ppb	100	ppb	22704
100ppb	STD	(Rh)	0.95168096	ppb	0.95168096	ppb	383398
100ppb	STD	(Sc)	0.9099465	ppb	0.9099465	ppb	276136
100ppb	STD	(Tb)	0.96849465	ppb	0.96849465	ppb	552286
100ppb	STD	(Y)	0.95905322	ppb	0.95905322	ppb	403326
500ppb	STD	Ag	500	ppb	500	ppb	106780
500ppb	STD	Al		ppb		ppb	
500ppb	STD	As		ppb		ppb	
500ppb	STD	Ba	500	ppb	500	ppb	167854
500ppb	STD	Cd	500	ppb	500	ppb	106292
500ppb	STD	Co		ppb		ppb	
500ppb	STD	Cr	500	ppb	500	ppb	111422
500ppb	STD	Cu	500	ppb	500	ppb	536268
500ppb	STD	Fe	500	ppb	500	ppb	34452
500ppb	STD	Mg	500	ppb	500	ppb	146390
500ppb	STD	Mn		ppb		ppb	
500ppb	STD	Ni	500	ppb	500	ppb	253638
500ppb	STD	Pb	500	ppb	500	ppb	1274902
500ppb	STD	Sr		ppb		ppb	
500ppb	STD	Ti	500	ppb	500	ppb	53182
500ppb	STD	Tl	500	ppb	500	ppb	957374
500ppb	STD	V	500	ppb	500	ppb	898725.1
500ppb	STD	Zn	500	ppb	500	ppb	110664

500ppb	STD	(Rh)	0.95925176	ppb	0.95925176	ppb	386448
500ppb	STD	(Sc)	0.92063642	ppb	0.92063642	ppb	279380
500ppb	STD	(Tb)	0.97411323	ppb	0.97411323	ppb	555490
500ppb	STD	(Y)	0.97527498	ppb	0.97527498	ppb	410148
Blank 1	SAM	Ag		ppb		ppb	672
Blank 1	SAM	Al	3.19461942	ppb	31.9461937	ppb	5612
Blank 1	SAM	As		ppb		ppb	1551.257
Blank 1	SAM	Ba	0.06383711	ppb	0.63837111	ppb	36
Blank 1	SAM	Cd	0.03860681	ppb	0.38606811	ppb	34
Blank 1	SAM	Co	0.01721599	ppb	0.17215991	ppb	490
Blank 1	SAM	Cr	30.4834671	ppb	304.834655	ppb	7246
Blank 1	SAM	Cu	0.2905885	ppb	2.90588498	ppb	498
Blank 1	SAM	Fe		ppb		ppb	5096
Blank 1	SAM	Mg	1.48484206	ppb	14.8484211	ppb	716
Blank 1	SAM	Mn	0.10472983	ppb	1.04729831	ppb	1426
Blank 1	SAM	Ni	2.29597521	ppb	22.9597511	ppb	1508
Blank 1	SAM	Pb	0.26864538	ppb	2.68645382	ppb	860
Blank 1	SAM	Sr	0.06964669	ppb	0.69646686	ppb	244
Blank 1	SAM	Ti	1.51584888	ppb	15.1584892	ppb	346
Blank 1	SAM	Tl	-1.2496715	ppb	-12.496715	ppb	174
Blank 1	SAM	V	-2.5088219	ppb	-25.088218	ppb	-953.262
Blank 1	SAM	Zn	0.43357787	ppb	4.33577871	ppb	146
Blank 1	SAM	(Rh)	0.99357599	ppb	9.93575954	ppb	400276
Blank 1	SAM	(Sc)	0.95500618	ppb	9.55006218	ppb	289810
Blank 1	SAM	(Tb)	0.99937922	ppb	9.99379253	ppb	569898
Blank 1	SAM	(Y)	0.99859709	ppb	9.9859705	ppb	419956
Blank 2	SAM	Ag		ppb		ppb	332

Blank 2	SAM	Al	2.97036052	ppb	29.7036056	ppb	5300
Blank 2	SAM	As		ppb		ppb	1360.817
Blank 2	SAM	Ba	0.02283739	ppb	0.22837394	ppb	22
Blank 2	SAM	Cd	3.48902178	ppb	34.8902168	ppb	802
Blank 2	SAM	Co	0.03452652	ppb	0.34526524	ppb	534
Blank 2	SAM	Cr	32.2866287	ppb	322.866272	ppb	7680
Blank 2	SAM	Cu	0.83993828	ppb	8.39938259	ppb	1110
Blank 2	SAM	Fe		ppb		ppb	5364
Blank 2	SAM	Mg	2.22949862	ppb	22.2949867	ppb	942
Blank 2	SAM	Mn	0.09086655	ppb	0.90866554	ppb	1392
Blank 2	SAM	Ni	2.49597454	ppb	24.9597454	ppb	1624
Blank 2	SAM	Pb	0.22114044	ppb	2.21140432	ppb	746
Blank 2	SAM	Sr	0.05346088	ppb	0.53460878	ppb	202
Blank 2	SAM	Ti	0.40414265	ppb	4.04142666	ppb	228
Blank 2	SAM	Tl	-1.3143391	ppb	-13.143391	ppb	48
Blank 2	SAM	V	-2.7621569	ppb	-27.62157	ppb	-1407.28
Blank 2	SAM	Zn	1.00656307	ppb	10.0656309	ppb	278
Blank 2	SAM	(Rh)	1.00257659	ppb	10.0257663	ppb	403902
Blank 2	SAM	(Sc)	0.95691085	ppb	9.56910896	ppb	290388
Blank 2	SAM	(Tb)	1.0112021	ppb	10.1120204	ppb	576640
Blank 2	SAM	(Y)	1.00585902	ppb	10.0585899	ppb	423010
Blank 3	SAM	Ag		ppb		ppb	220
Blank 3	SAM	Al	2.3630197	ppb	23.6301975	ppb	4390
Blank 3	SAM	As		ppb		ppb	1588.714
Blank 3	SAM	Ba	0.06215291	ppb	0.6215291	ppb	36
Blank 3	SAM	Cd	0.0354974	ppb	0.35497397	ppb	34
Blank 3	SAM	Co	-0.0047917	ppb	-0.047917	ppb	432

Blank 3	SAM	Cr	35.0732498	ppb	350.732482	ppb	8258
Blank 3	SAM	Cu	0.44486031	ppb	4.44860315	ppb	678
Blank 3	SAM	Fe		ppb		ppb	5840
Blank 3	SAM	Mg	3.64574552	ppb	36.4574546	ppb	1362
Blank 3	SAM	Mn	0.25793162	ppb	2.57931614	ppb	1852
Blank 3	SAM	Ni	1.96245754	ppb	19.6245746	ppb	1352
Blank 3	SAM	Pb	0.26794732	ppb	2.67947316	ppb	870
Blank 3	SAM	Sr	0.06474464	ppb	0.64744645	ppb	234
Blank 3	SAM	Ti	1.1578418	ppb	11.5784177	ppb	308
Blank 3	SAM	Tl	-1.314354	ppb	-13.14354	ppb	48
Blank 3	SAM	V	-2.0773334	ppb	-20.773334	ppb	-179.955
Blank 3	SAM	Zn	1.18854332	ppb	11.8854332	ppb	322
Blank 3	SAM	(Rh)	1.00462687	ppb	10.0462684	ppb	404728
Blank 3	SAM	(Sc)	0.9491142	ppb	9.49114227	ppb	288022
Blank 3	SAM	(Tb)	1.01045847	ppb	10.1045846	ppb	576216
Blank 3	SAM	(Y)	1.01272631	ppb	10.127263	ppb	425898
Blank 4	SAM	Ag		ppb		ppb	200
Blank 4	SAM	Al	2.61175847	ppb	26.1175842	ppb	4758
Blank 4	SAM	As		ppb		ppb	1696.096
Blank 4	SAM	Ba	0.03948614	ppb	0.39486143	ppb	28
Blank 4	SAM	Cd	-0.0443668	ppb	-0.4436686	ppb	16
Blank 4	SAM	Co	0.02599679	ppb	0.25996795	ppb	510
Blank 4	SAM	Cr	36.1067695	ppb	361.067688	ppb	8516
Blank 4	SAM	Cu	0.82882929	ppb	8.28829288	ppb	1100
Blank 4	SAM	Fe		ppb		ppb	5510
Blank 4	SAM	Mg	2.85966563	ppb	28.5966568	ppb	1128
Blank 4	SAM	Mn	0.20706008	ppb	2.07060075	ppb	1712

Blank 4	SAM	Ni	2.01519203	ppb	20.1519203	ppb	1374
Blank 4	SAM	Pb	0.22677329	ppb	2.26773286	ppb	766
Blank 4	SAM	Sr	0.07064517	ppb	0.70645165	ppb	248
Blank 4	SAM	Ti	1.04478693	ppb	10.4478693	ppb	296
Blank 4	SAM	Tl	-1.3244767	ppb	-13.244767	ppb	28
Blank 4	SAM	V	-2.5506391	ppb	-25.506391	ppb	-1028.2
Blank 4	SAM	Zn	0.89644778	ppb	8.96447754	ppb	254
Blank 4	SAM	(Rh)	0.99589938	ppb	9.95899391	ppb	401212
Blank 4	SAM	(Sc)	0.95175707	ppb	9.5175705	ppb	288824
Blank 4	SAM	(Tb)	1.01993859	ppb	10.1993856	ppb	581622
Blank 4	SAM	(Y)	1.00779939	ppb	10.0779933	ppb	423826
Blank 5	SAM	Ag		ppb		ppb	124
Blank 5	SAM	Al	2.64293885	ppb	26.429388	ppb	4770
Blank 5	SAM	As		ppb		ppb	1282.895
Blank 5	SAM	Ba	0.06280363	ppb	0.62803626	ppb	36
Blank 5	SAM	Cd	-0.0717556	ppb	-0.7175561	ppb	10
Blank 5	SAM	Co	0.00299718	ppb	0.02997184	ppb	450
Blank 5	SAM	Cr	39.3064079	ppb	393.064086	ppb	9198
Blank 5	SAM	Cu	0.3835246	ppb	3.83524609	ppb	608
Blank 5	SAM	Fe		ppb		ppb	5386
Blank 5	SAM	Mg	1.10865402	ppb	11.0865402	ppb	594
Blank 5	SAM	Mn	0.07109136	ppb	0.7109136	ppb	1320
Blank 5	SAM	Ni	2.06174421	ppb	20.617443	ppb	1404
Blank 5	SAM	Pb	0.20183617	ppb	2.01836157	ppb	692
Blank 5	SAM	Sr	0.03953736	ppb	0.39537355	ppb	166
Blank 5	SAM	Ti	1.27089667	ppb	12.7089672	ppb	320
Blank 5	SAM	Tl	-1.3242256	ppb	-13.242256	ppb	28

Blank 5	SAM	V	-2.5099299	ppb	-25.099298	ppb	-955.248
Blank 5	SAM	Zn	0.84828824	ppb	8.4828825	ppb	242
Blank 5	SAM	(Rh)	0.98757893	ppb	9.87578964	ppb	397860
Blank 5	SAM	(Sc)	0.94581234	ppb	9.45812321	ppb	287020
Blank 5	SAM	(Tb)	1.0082525	ppb	10.0825252	ppb	574958
Blank 5	SAM	(Y)	1.00994897	ppb	10.0994892	ppb	424730
Blank 6	SAM	Ag		ppb		ppb	118
Blank 6	SAM	Al	2.62132859	ppb	26.2132854	ppb	4798
Blank 6	SAM	As		ppb		ppb	1217.158
Blank 6	SAM	Ba	0.07379414	ppb	0.73794138	ppb	40
Blank 6	SAM	Cd	-0.0436165	ppb	-0.4361655	ppb	16
Blank 6	SAM	Co	-0.0067231	ppb	-0.0672313	ppb	432
Blank 6	SAM	Cr	38.1006279	ppb	381.006286	ppb	9024
Blank 6	SAM	Cu	0.55566382	ppb	5.55663824	ppb	800
Blank 6	SAM	Fe		ppb		ppb	5180
Blank 6	SAM	Mg	1.06055367	ppb	10.6055364	ppb	586
Blank 6	SAM	Mn	0.03355978	ppb	0.33559784	ppb	1228
Blank 6	SAM	Ni	1.81845248	ppb	18.1845245	ppb	1276
Blank 6	SAM	Pb	0.24919415	ppb	2.49194145	ppb	820
Blank 6	SAM	Sr	0.08129484	ppb	0.81294841	ppb	278
Blank 6	SAM	Ti	1.74195862	ppb	17.4195861	ppb	370
Blank 6	SAM	Tl	-1.3242813	ppb	-13.242813	ppb	28
Blank 6	SAM	V	-2.3908369	ppb	-23.908369	ppb	-741.811
Blank 6	SAM	Zn	0.68500328	ppb	6.85003281	ppb	206
Blank 6	SAM	(Rh)	0.99456394	ppb	9.94563961	ppb	400674
Blank 6	SAM	(Sc)	0.95738536	ppb	9.57385349	ppb	290532
Blank 6	SAM	(Tb)	1.01145816	ppb	10.114582	ppb	576786

Blank 6	SAM	(Y)		1.01274061	ppb	10.1274061	ppb	425904
A1 1	SAM	Ag			ppb		ppb	230
A1 1	SAM	Al		9.63385677	ppb	96.3385696	ppb	15836
A1 1	SAM	As			ppb		ppb	1552.366
A1 1	SAM	Ba		39.5961074	ppb	395.961059	ppb	14282
A1 1	SAM	Cd		0.01518218	ppb	0.15182179	ppb	30
A1 1	SAM	Co		2.10261703	ppb	21.0261707	ppb	6072
A1 1	SAM	Cr		30.9471225	ppb	309.471221	ppb	7814
A1 1	SAM	Cu		5.66690683	ppb	56.6690673	ppb	6746
A1 1	SAM	Fe			ppb		ppb	1361758
A1 1	SAM	Mg	x	1571.3103	ppb	15713.1035	ppb	506858
A1 1	SAM	Mn	x	355.587554	ppb	3555.87548	ppb	1078120
A1 1	SAM	Ni		5.6590395	ppb	56.590393	ppb	3424
A1 1	SAM	Pb		0.75360399	ppb	7.53603983	ppb	2228
A1 1	SAM	Sr		21.676815	ppb	216.768158	ppb	60292
A1 1	SAM	Ti		1.47816384	ppb	14.7816381	ppb	342
A1 1	SAM	Tl		-1.3287472	ppb	-13.287472	ppb	20
A1 1	SAM	V		-1.3929325	ppb	-13.929325	ppb	1046.617
A1 1	SAM	Zn		8.87267399	ppb	88.7267379	ppb	2168
A1 1	SAM	(Rh)		1.01476431	ppb	10.147643	ppb	408812
A1 1	SAM	(Sc)		1.01433444	ppb	10.1433448	ppb	307814
A1 1	SAM	(Tb)		1.04479074	ppb	10.4479074	ppb	595794
A1 1	SAM	(Y)		1.05032027	ppb	10.5032024	ppb	441708
A1 2	SAM	Ag			ppb		ppb	92
A1 2	SAM	Al		17.2673549	ppb	172.673553	ppb	27546
A1 2	SAM	As			ppb		ppb	1401.402
A1 2	SAM	Ba		60.0961685	ppb	600.961669	ppb	21118

A1 2	SAM	Cd		-0.0015063	ppb	-0.0150635	ppb	26
A1 2	SAM	Co		1.69017315	ppb	16.9017314	ppb	4972
A1 2	SAM	Cr		32.5624618	ppb	325.624633	ppb	8210
A1 2	SAM	Cu		6.91879177	ppb	69.1879196	ppb	8198
A1 2	SAM	Fe			ppb		ppb	1735990
A1 2	SAM	Mg	x	2038.53796	ppb	20385.3789	ppb	657334
A1 2	SAM	Mn	x	358.605194	ppb	3586.052	ppb	1087012
A1 2	SAM	Ni		5.38247013	ppb	53.8246994	ppb	3274
A1 2	SAM	Pb		0.74468946	ppb	7.44689465	ppb	2148
A1 2	SAM	Sr		26.585886	ppb	265.858856	ppb	73936
A1 2	SAM	Ti		3.06093216	ppb	30.6093215	ppb	510
A1 2	SAM	Tl		-1.3273332	ppb	-13.273332	ppb	22
A1 2	SAM	V		1.85602665	ppb	18.5602664	ppb	6869.351
A1 2	SAM	Zn		4.06567383	ppb	40.6567382	ppb	1022
A1 2	SAM	(Rh)		1.00748146	ppb	10.0748148	ppb	405878
A1 2	SAM	(Sc)		1.01422906	ppb	10.1422901	ppb	307782
A1 2	SAM	(Tb)		1.01821303	ppb	10.1821308	ppb	580638
A1 2	SAM	(Y)		1.0505724	ppb	10.5057239	ppb	441814
A2 1	SAM	Ag			ppb		ppb	108
A2 1	SAM	Al		12.1258955	ppb	121.258956	ppb	20262
A2 1	SAM	As			ppb		ppb	1670.359
A2 1	SAM	Ba		51.7210121	ppb	517.210144	ppb	18582
A2 1	SAM	Cd		-0.0478373	ppb	-0.478373	ppb	16
A2 1	SAM	Co		1.74878705	ppb	17.4878711	ppb	5284
A2 1	SAM	Cr		27.2975597	ppb	272.975585	ppb	7134
A2 1	SAM	Cu		5.49535751	ppb	54.9535751	ppb	6632
A2 1	SAM	Fe			ppb		ppb	1744710

A2 1	SAM	Mg	x	1540.55651	ppb	15405.5654	ppb	512266
A2 1	SAM	Mn	x	314.391815	ppb	3143.91821	ppb	982820
A2 1	SAM	Ni		4.6470809	ppb	46.4708099	ppb	2908
A2 1	SAM	Pb		0.71682698	ppb	7.16826963	ppb	2120
A2 1	SAM	Sr		25.4742794	ppb	254.742797	ppb	71712
A2 1	SAM	Ti		1.74195862	ppb	17.4195861	ppb	370
A2 1	SAM	Tl		-1.3277266	ppb	-13.277265	ppb	22
A2 1	SAM	V		-1.3407349	ppb	-13.407349	ppb	1140.164
A2 1	SAM	Zn		1.62918067	ppb	16.2918071	ppb	444
A2 1	SAM	(Rh)		1.03291929	ppb	10.3291931	ppb	416126
A2 1	SAM	(Sc)		1.04602194	ppb	10.4602193	ppb	317430
A2 1	SAM	(Tb)		1.04107308	ppb	10.4107303	ppb	593674
A2 1	SAM	(Y)		1.06343186	ppb	10.6343183	ppb	447222
A2 2	SAM	Ag			ppb		ppb	106
A2 2	SAM	Al		8.9435606	ppb	89.4356079	ppb	15062
A2 2	SAM	As			ppb		ppb	1778.17
A2 2	SAM	Ba		49.7519378	ppb	497.519378	ppb	17694
A2 2	SAM	Cd		0.03160425	ppb	0.31604245	ppb	34
A2 2	SAM	Co		1.33611012	ppb	13.3611011	ppb	4104
A2 2	SAM	Cr		27.0790309	ppb	270.790313	ppb	6998
A2 2	SAM	Cu		6.29602194	ppb	62.9602203	ppb	7504
A2 2	SAM	Fe			ppb		ppb	1485256
A2 2	SAM	Mg	x	1899.81567	ppb	18998.1562	ppb	624326
A2 2	SAM	Mn	x	321.76242	ppb	3217.62426	ppb	994152
A2 2	SAM	Ni		3.389498	ppb	33.8949813	ppb	2192
A2 2	SAM	Pb		0.53580225	ppb	5.35802269	ppb	1610
A2 2	SAM	Sr		23.9063644	ppb	239.063644	ppb	66748

A2 2	SAM	Ti	3.04208946	ppb	30.4208946	ppb	508
A2 2	SAM	Tl	-1.3295117	ppb	-13.295117	ppb	18
A2 2	SAM	V	-1.6451752	ppb	-16.451751	ppb	594.5516
A2 2	SAM	Zn	4.06687212	ppb	40.6687202	ppb	1026
A2 2	SAM	(Rh)	1.03016901	ppb	10.3016901	ppb	415018
A2 2	SAM	(Sc)	1.0336448	ppb	10.3364477	ppb	313674
A2 2	SAM	(Tb)	1.03068817	ppb	10.3068819	ppb	587752
A2 2	SAM	(Y)	1.0545814	ppb	10.5458145	ppb	443500
SW1	SAM	Ag		ppb		ppb	154
SW1	SAM	Al	4.66451025	ppb	46.6451034	ppb	7806
SW1	SAM	As		ppb		ppb	1775.91
SW1	SAM	Ba	4.82702684	ppb	48.2702674	ppb	1658
SW1	SAM	Cd	-0.0349343	ppb	-0.3493436	ppb	18
SW1	SAM	Co	0.18990181	ppb	1.89901817	ppb	930
SW1	SAM	Cr	0.60004717	ppb	6.00047159	ppb	346
SW1	SAM	Cu	2.12366343	ppb	21.2366333	ppb	2520
SW1	SAM	Fe		ppb		ppb	5872
SW1	SAM	Mg	37.5971183	ppb	375.971191	ppb	11776
SW1	SAM	Mn	1.03837109	ppb	10.3837108	ppb	4124
SW1	SAM	Ni	1.10214448	ppb	11.0214443	ppb	888
SW1	SAM	Pb	0.4831996	ppb	4.83199596	ppb	1406
SW1	SAM	Sr	4.81404066	ppb	48.1404075	ppb	12798
SW1	SAM	Ti	-1.630845	ppb	-16.30845	ppb	12
SW1	SAM	Tl	-1.3332772	ppb	-13.332772	ppb	10
SW1	SAM	V	-0.5287004	ppb	-5.2870039	ppb	2595.48
SW1	SAM	Zn	2.36894011	ppb	23.6894016	ppb	586
SW1	SAM	(Rh)	0.99005127	ppb	9.9005127	ppb	398856

SW1	SAM	(Sc)	0.96307307	ppb	9.63073063	ppb	292258
SW1	SAM	(Tb)	0.98706537	ppb	9.87065411	ppb	562876
SW1	SAM	(Y)	1.0004946	ppb	10.0049457	ppb	420754
Blank	BLK	Ag	0	ppb	0	ppb	92
Blank	BLK	Al	0	ppb	0	ppb	860
Blank	BLK	As	0	ppb	0	ppb	1646.359
Blank	BLK	Ba	0	ppb	0	ppb	14
Blank	BLK	Cd	0	ppb	0	ppb	16
Blank	BLK	Co	0	ppb	0	ppb	484
Blank	BLK	Cr	0	ppb	0	ppb	212
Blank	BLK	Cu	0	ppb	0	ppb	122
Blank	BLK	Fe	0	ppb	0	ppb	5880
Blank	BLK	Mg	0	ppb	0	ppb	232
Blank	BLK	Mn	0	ppb	0	ppb	1272
Blank	BLK	Ni	0	ppb	0	ppb	370
Blank	BLK	Pb	0	ppb	0	ppb	184
Blank	BLK	Sr	0	ppb	0	ppb	52
Blank	BLK	Ti	0	ppb	0	ppb	22
Blank	BLK	Tl	0	ppb	0	ppb	12
Blank	BLK	V	0	ppb	0	ppb	692.6444
Blank	BLK	Zn	0	ppb	0	ppb	38
Blank	BLK	(Rh)	0.96784025	ppb	0.96784025	ppb	389908
Blank	BLK	(Sc)	0.9460628	ppb	0.9460628	ppb	287096
Blank	BLK	(Tb)	0.95989138	ppb	0.95989138	ppb	547380
Blank	BLK	(Y)	0.96560186	ppb	0.96560186	ppb	406080
100ppb	RSP	Ag	100	ppb	100	ppb	55996
100ppb	RSP	Al	100	ppb	100	ppb	136272

100ppb	RSP	As	100	ppb	100	ppb	1560.526
100ppb	RSP	Ba	100	ppb	100	ppb	33692
100ppb	RSP	Cd	100	ppb	100	ppb	21312
100ppb	RSP	Co	100	ppb	100	ppb	237282
100ppb	RSP	Cr	100	ppb	100	ppb	22894
100ppb	RSP	Cu	100	ppb	100	ppb	110130
100ppb	RSP	Fe	100	ppb	100	ppb	11360
100ppb	RSP	Mg	100	ppb	100	ppb	28764
100ppb	RSP	Mn	100	ppb	100	ppb	276372
100ppb	RSP	Ni	100	ppb	100	ppb	51784
100ppb	RSP	Pb	100	ppb	100	ppb	251712
100ppb	RSP	Sr	100	ppb	100	ppb	252890
100ppb	RSP	Ti	100	ppb	100	ppb	10852
100ppb	RSP	Tl	100	ppb	100	ppb	190756
100ppb	RSP	V	100	ppb	100	ppb	186697.1
100ppb	RSP	Zn	100	ppb	100	ppb	22768
100ppb	RSP	(Rh)	0.97891599	ppb	0.97891599	ppb	394370
100ppb	RSP	(Sc)	0.95871669	ppb	0.95871669	ppb	290936
100ppb	RSP	(Tb)	0.99419206	ppb	0.99419206	ppb	566940
100ppb	RSP	(Y)	0.99185818	ppb	0.99185818	ppb	417122
A3 1	SAM	Ag		ppb		ppb	120
A3 1	SAM	Al	71.8033065	ppb	718.033081	ppb	108738
A3 1	SAM	As		ppb		ppb	1738.453
A3 1	SAM	Ba	50.0238418	ppb	500.238403	ppb	17422
A3 1	SAM	Cd	0.01090018	ppb	0.10900178	ppb	20
A3 1	SAM	Co	1.25470412	ppb	12.5470409	ppb	3840
A3 1	SAM	Cr	30.7636966	ppb	307.636962	ppb	7680

A3 1	SAM	Cu		10.2566328	ppb	102.56633	ppb	11766
A3 1	SAM	Fe			ppb		ppb	1250388
A3 1	SAM	Mg	x	2017.28552	ppb	20172.8554	ppb	618164
A3 1	SAM	Mn	x	281.020141	ppb	2810.20141	ppb	856248
A3 1	SAM	Ni		3.7541995	ppb	37.541996	ppb	2416
A3 1	SAM	Pb		0.54062545	ppb	5.40625477	ppb	1596
A3 1	SAM	Sr		23.5958042	ppb	235.958038	ppb	64798
A3 1	SAM	Ti		3.07785368	ppb	30.7785377	ppb	508
A3 1	SAM	Tl		-1.3348618	ppb	-13.348618	ppb	18
A3 1	SAM	V		-1.7651084	ppb	-17.651084	ppb	474.3966
A3 1	SAM	Zn		4.14102745	ppb	41.4102745	ppb	1028
A3 1	SAM	(Rh)		1.05819833	ppb	10.5819835	ppb	426310
A3 1	SAM	(Sc)		1.06709194	ppb	10.6709194	ppb	323824
A3 1	SAM	(Tb)		1.04856455	ppb	10.4856452	ppb	597946
A3 1	SAM	(Y)		1.07973921	ppb	10.7973918	ppb	454080
A3 2	SAM	Ag			ppb		ppb	74
A3 2	SAM	Al		9.48268795	ppb	94.8268814	ppb	15362
A3 2	SAM	As			ppb		ppb	1607.857
A3 2	SAM	Ba		45.144989	ppb	451.44989	ppb	15662
A3 2	SAM	Cd		0.01147933	ppb	0.11479329	ppb	20
A3 2	SAM	Co		1.12977588	ppb	11.297759	ppb	3548
A3 2	SAM	Cr		28.5613441	ppb	285.613433	ppb	7228
A3 2	SAM	Cu		6.33905029	ppb	63.3905029	ppb	7432
A3 2	SAM	Fe			ppb		ppb	1220798
A3 2	SAM	Mg	x	1673.78418	ppb	16737.8418	ppb	518136
A3 2	SAM	Mn	x	285.372924	ppb	2853.72924	ppb	878578
A3 2	SAM	Ni		3.02734447	ppb	30.2734451	ppb	2058

A3 2	SAM	Pb		0.42873833	ppb	4.28738308	ppb	1302
A3 2	SAM	Sr		20.6074142	ppb	206.074142	ppb	57428
A3 2	SAM	Ti		2.90275955	ppb	29.0275955	ppb	490
A3 2	SAM	Tl		-1.3379758	ppb	-13.379758	ppb	12
A3 2	SAM	V		-1.7642223	ppb	-17.642223	ppb	475.9875
A3 2	SAM	Zn		1.79115951	ppb	17.9115943	ppb	476
A3 2	SAM	(Rh)		1.07118535	ppb	10.711853	ppb	431542
A3 2	SAM	(Sc)		1.07863212	ppb	10.7863216	ppb	327326
A3 2	SAM	(Tb)		1.04445398	ppb	10.44454	ppb	595602
A3 2	SAM	(Y)		1.09606087	ppb	10.9606084	ppb	460944
A4 1	SAM	Ag			ppb		ppb	158
A4 1	SAM	Al		14.4079608	ppb	144.079605	ppb	22218
A4 1	SAM	As			ppb		ppb	1612.334
A4 1	SAM	Ba		36.9189033	ppb	369.189025	ppb	12534
A4 1	SAM	Cd		0.06778155	ppb	0.67781544	ppb	32
A4 1	SAM	Co		1.21148133	ppb	12.1148128	ppb	3664
A4 1	SAM	Cr		27.2841796	ppb	272.841796	ppb	6724
A4 1	SAM	Cu		7.76424599	ppb	77.642456	ppb	8658
A4 1	SAM	Fe			ppb		ppb	785496
A4 1	SAM	Mg	x	1984.50817	ppb	19845.082	ppb	598014
A4 1	SAM	Mn	x	204.507949	ppb	2045.07946	ppb	613178
A4 1	SAM	Ni		4.14295769	ppb	41.4295768	ppb	2542
A4 1	SAM	Pb		1.1877538	ppb	11.8775377	ppb	3182
A4 1	SAM	Sr		21.9774379	ppb	219.774383	ppb	58470
A4 1	SAM	Ti		4.69261074	ppb	46.9261093	ppb	674
A4 1	SAM	Tl		-1.3326042	ppb	-13.326043	ppb	22
A4 1	SAM	V		-1.6311368	ppb	-16.311368	ppb	714.9382

A4 1	SAM	Zn		6.71929598	ppb	67.1929626	ppb	1592
A4 1	SAM	(Rh)		1.03588307	ppb	10.3588304	ppb	417320
A4 1	SAM	(Sc)		1.04956102	ppb	10.4956102	ppb	318504
A4 1	SAM	(Tb)		1.02180088	ppb	10.218009	ppb	582684
A4 1	SAM	(Y)		1.04630172	ppb	10.4630174	ppb	440018
A4 2	SAM	Ag			ppb		ppb	60
A4 2	SAM	Al		22.5140228	ppb	225.140228	ppb	34306
A4 2	SAM	As			ppb		ppb	1993.45
A4 2	SAM	Ba		43.6781463	ppb	436.781463	ppb	14754
A4 2	SAM	Cd		0.13117924	ppb	1.31179237	ppb	46
A4 2	SAM	Co		0.83775783	ppb	8.37757874	ppb	2712
A4 2	SAM	Cr		29.7900047	ppb	297.900054	ppb	7350
A4 2	SAM	Cu		9.62310696	ppb	96.2310714	ppb	10870
A4 2	SAM	Fe			ppb		ppb	911622
A4 2	SAM	Mg	x	2142.33862	ppb	21423.3867	ppb	647868
A4 2	SAM	Mn	x	197.535293	ppb	1975.3529	ppb	594410
A4 2	SAM	Ni		4.70902681	ppb	47.0902671	ppb	2878
A4 2	SAM	Pb		2.19591665	ppb	21.9591674	ppb	5690
A4 2	SAM	Sr		22.5634822	ppb	225.634826	ppb	60968
A4 2	SAM	Ti		6.69646549	ppb	66.964653	ppb	880
A4 2	SAM	Tl		-1.3399119	ppb	-13.399119	ppb	8
A4 2	SAM	V		-2.4682664	ppb	-24.682664	ppb	-788.101
A4 2	SAM	Zn		3.98953962	ppb	39.8953971	ppb	976
A4 2	SAM	(Rh)		1.03237319	ppb	10.3237323	ppb	415906
A4 2	SAM	(Sc)		1.05340338	ppb	10.5340337	ppb	319670
A4 2	SAM	(Tb)		1.0168767	ppb	10.1687669	ppb	579876
A4 2	SAM	(Y)		1.0624522	ppb	10.6245222	ppb	446810

B1	SAM	Ag			ppb		ppb	82
B1	SAM	Al		14.5921697	ppb	145.921691	ppb	22524
B1	SAM	As			ppb		ppb	1509.93
B1	SAM	Ba		32.1796112	ppb	321.796112	ppb	10872
B1	SAM	Cd		0.00481267	ppb	0.04812669	ppb	18
B1	SAM	Co		0.47739545	ppb	4.77395439	ppb	1772
B1	SAM	Cr		28.3806247	ppb	283.806243	ppb	6996
B1	SAM	Cu		6.97773218	ppb	69.7773208	ppb	7830
B1	SAM	Fe			ppb		ppb	602578
B1	SAM	Mg	x	1820.11499	ppb	18201.1503	ppb	549148
B1	SAM	Mn	x	140.628387	ppb	1406.28393	ppb	422546
B1	SAM	Ni		3.37624764	ppb	33.7624778	ppb	2154
B1	SAM	Pb		1.68315804	ppb	16.8315811	ppb	4412
B1	SAM	Sr		17.6402568	ppb	176.402572	ppb	47148
B1	SAM	Ti		7.47466135	ppb	74.7466125	ppb	960
B1	SAM	Tl		-1.332427	ppb	-13.32427	ppb	22
B1	SAM	V		-1.8484813	ppb	-18.484813	ppb	324.7032
B1	SAM	Zn		2.70429063	ppb	27.0429058	ppb	668
B1	SAM	(Rh)		1.03442848	ppb	10.344285	ppb	416734
B1	SAM	(Sc)		1.05064857	ppb	10.5064859	ppb	318834
B1	SAM	(Tb)		1.0171994	ppb	10.1719942	ppb	580060
B1	SAM	(Y)		1.05073404	ppb	10.5073404	ppb	441882
B2	SAM	Ag			ppb		ppb	72
B2	SAM	Al		10.3852796	ppb	103.852798	ppb	16206
B2	SAM	As			ppb		ppb	1836.373
B2	SAM	Ba		25.0388031	ppb	250.388031	ppb	8508
B2	SAM	Cd		0.0847545	ppb	0.84754497	ppb	36

B2	SAM	Co		0.96840656	ppb	9.68406582	ppb	3022
B2	SAM	Cr		32.5046958	ppb	325.046966	ppb	7928
B2	SAM	Cu		11.0850076	ppb	110.850074	ppb	12382
B2	SAM	Fe			ppb		ppb	421132
B2	SAM	Mg	x	1296.80322	ppb	12968.0322	ppb	389010
B2	SAM	Mn	x	138.137863	ppb	1381.37866	ppb	412582
B2	SAM	Ni		3.8646369	ppb	38.6463699	ppb	2410
B2	SAM	Pb		0.52699912	ppb	5.26999092	ppb	1522
B2	SAM	Sr		13.9902324	ppb	139.902328	ppb	37468
B2	SAM	Ti		6.01554394	ppb	60.1554412	ppb	810
B2	SAM	Tl		-1.3357273	ppb	-13.357273	ppb	16
B2	SAM	V		-1.2917435	ppb	-12.917434	ppb	1324.308
B2	SAM	Zn		2.86515141	ppb	28.651514	ppb	706
B2	SAM	(Rh)		1.04386091	ppb	10.4386091	ppb	420534
B2	SAM	(Sc)		1.04451931	ppb	10.4451932	ppb	316974
B2	SAM	(Tb)		1.02262509	ppb	10.2262506	ppb	583154
B2	SAM	(Y)		1.05230343	ppb	10.5230341	ppb	442542
C1	SAM	Ag			ppb		ppb	58
C1	SAM	Al		10.3958358	ppb	103.958358	ppb	16468
C1	SAM	As			ppb		ppb	1667.842
C1	SAM	Ba		27.688507	ppb	276.88507	ppb	9324
C1	SAM	Cd		0.09294149	ppb	0.92941493	ppb	38
C1	SAM	Co		0.59480393	ppb	5.94803905	ppb	2090
C1	SAM	Cr		23.8229389	ppb	238.229385	ppb	5960
C1	SAM	Cu		6.38971853	ppb	63.8971862	ppb	7164
C1	SAM	Fe			ppb		ppb	519844
C1	SAM	Mg	x	1529.96606	ppb	15299.6601	ppb	465706

C1	SAM	Mn	x	135.741241	ppb	1357.41235	ppb	411550
C1	SAM	Ni		2.7065928	ppb	27.0659275	ppb	1804
C1	SAM	Pb		0.82822877	ppb	8.2822876	ppb	2258
C1	SAM	Sr		14.844634	ppb	148.446334	ppb	39622
C1	SAM	Ti		4.80934	ppb	48.093399	ppb	686
C1	SAM	Tl		-1.3388787	ppb	-13.388787	ppb	10
C1	SAM	V		-0.2855621	ppb	-2.8556208	ppb	3130.875
C1	SAM	Zn		3.21018529	ppb	32.1018524	ppb	784
C1	SAM	(Rh)		1.04323053	ppb	10.4323053	ppb	420280
C1	SAM	(Sc)		1.0602839	ppb	10.6028385	ppb	321758
C1	SAM	(Tb)		1.01360106	ppb	10.1360111	ppb	578008
C1	SAM	(Y)		1.04913616	ppb	10.4913616	ppb	441210
C2	SAM	Ag			ppb		ppb	76
C2	SAM	Al		12.9409008	ppb	129.409011	ppb	20384
C2	SAM	As			ppb		ppb	1551.15
C2	SAM	Ba		33.161045	ppb	331.610443	ppb	11360
C2	SAM	Cd		0.04887071	ppb	0.4887071	ppb	28
C2	SAM	Co		0.85457987	ppb	8.5457983	ppb	2790
C2	SAM	Cr		28.6799736	ppb	286.799743	ppb	7176
C2	SAM	Cu		9.0949316	ppb	90.9493179	ppb	10326
C2	SAM	Fe			ppb		ppb	453234
C2	SAM	Mg	x	1696.76672	ppb	16967.6679	ppb	519972
C2	SAM	Mn	x	126.108306	ppb	1261.083	ppb	384954
C2	SAM	Ni		4.80266619	ppb	48.0266609	ppb	2940
C2	SAM	Pb		1.14528263	ppb	11.4528265	ppb	3104
C2	SAM	Sr		19.2052688	ppb	192.052688	ppb	52146
C2	SAM	Ti		10.217803	ppb	102.178031	ppb	1242

C2	SAM	Tl		-1.3368356	ppb	-13.368356	ppb	14
C2	SAM	V		-1.2625073	ppb	-12.625073	ppb	1376.801
C2	SAM	Zn		3.94595623	ppb	39.4595642	ppb	970
C2	SAM	(Rh)		1.03596747	ppb	10.3596744	ppb	417354
C2	SAM	(Sc)		1.06703925	ppb	10.6703929	ppb	323808
C2	SAM	(Tb)		1.03099334	ppb	10.3099336	ppb	587926
C2	SAM	(Y)		1.06777382	ppb	10.6777381	ppb	449048
E1	SAM	Ag			ppb		ppb	64
E1	SAM	Al		17.7820377	ppb	177.820373	ppb	28448
E1	SAM	As			ppb		ppb	1822.26
E1	SAM	Ba		32.5435791	ppb	325.435791	ppb	11148
E1	SAM	Cd		0.08950544	ppb	0.8950544	ppb	38
E1	SAM	Co		1.11161363	ppb	11.1161365	ppb	3560
E1	SAM	Cr		30.260292	ppb	302.602905	ppb	7768
E1	SAM	Cu		9.13921833	ppb	91.3921814	ppb	10446
E1	SAM	Fe			ppb		ppb	869170
E1	SAM	Mg	x	1769.80285	ppb	17698.0293	ppb	557744
E1	SAM	Mn	x	223.997283	ppb	2239.9729	ppb	702146
E1	SAM	Ni		4.94770384	ppb	49.4770393	ppb	3038
E1	SAM	Pb		0.53609461	ppb	5.36094618	ppb	1558
E1	SAM	Sr		17.7006855	ppb	177.006851	ppb	48374
E1	SAM	Ti		6.94937897	ppb	69.4937896	ppb	906
E1	SAM	Tl		-1.3368485	ppb	-13.368484	ppb	14
E1	SAM	V		-2.1934123	ppb	-21.934123	ppb	-294.609
E1	SAM	Zn	x	755.94403	ppb	7559.44043	ppb	179062
E1	SAM	(Rh)		1.06538188	ppb	10.653819	ppb	429204
E1	SAM	(Sc)		1.0975734	ppb	10.9757337	ppb	333074

E1	SAM	(Tb)		1.03094423	ppb	10.3094425	ppb	587898
E1	SAM	(Y)		1.07456493	ppb	10.7456493	ppb	451904
E2	SAM	Ag			ppb		ppb	66
E2	SAM	Al		8.83767223	ppb	88.3767242	ppb	14472
E2	SAM	As			ppb		ppb	1748.079
E2	SAM	Ba		31.1890316	ppb	311.890319	ppb	10714
E2	SAM	Cd		-0.0154715	ppb	-0.1547152	ppb	14
E2	SAM	Co		0.64240825	ppb	6.42408276	ppb	2268
E2	SAM	Cr		31.1236591	ppb	311.236602	ppb	7892
E2	SAM	Cu		7.63745594	ppb	76.3745575	ppb	8696
E2	SAM	Fe			ppb		ppb	450864
E2	SAM	Mg	x	1668.14233	ppb	16681.4238	ppb	519564
E2	SAM	Mn	x	138.593017	ppb	1385.93017	ppb	429932
E2	SAM	Ni		3.45326495	ppb	34.5326499	ppb	2232
E2	SAM	Pb		0.70840287	ppb	7.08402872	ppb	1998
E2	SAM	Sr		16.4842758	ppb	164.842758	ppb	44780
E2	SAM	Ti		9.92597961	ppb	99.2597961	ppb	1212
E2	SAM	Tl		-1.3411045	ppb	-13.411045	ppb	6
E2	SAM	V		-2.4840693	ppb	-24.840694	ppb	-816.475
E2	SAM	Zn		3.50781679	ppb	35.0781669	ppb	868
E2	SAM	(Rh)		1.0625273	ppb	10.6252727	ppb	428054
E2	SAM	(Sc)		1.08457017	ppb	10.8457012	ppb	329128
E2	SAM	(Tb)		1.0335536	ppb	10.335536	ppb	589386
E2	SAM	(Y)		1.0679878	ppb	10.6798782	ppb	449138
Prep blank	SAM	Ag			ppb		ppb	56
Prep blank	SAM	Al		0.66005367	ppb	6.60053682	ppb	1872
Prep blank	SAM	As			ppb		ppb	1693.46

Prep blank	SAM	Ba	0.03028606	ppb	0.30286059	ppb	24
Prep blank	SAM	Cd	0.0233481	ppb	0.23348099	ppb	22
Prep blank	SAM	Co	0.02030346	ppb	0.20303458	ppb	572
Prep blank	SAM	Cr	0.52070183	ppb	5.20701838	ppb	348
Prep blank	SAM	Cu	0.03721523	ppb	0.37215233	ppb	168
Prep blank	SAM	Fe		ppb		ppb	6608
Prep blank	SAM	Mg	0.43408361	ppb	4.34083605	ppb	376
Prep blank	SAM	Mn	0.03132973	ppb	0.31329727	ppb	1464
Prep blank	SAM	Ni	-0.1134383	ppb	-1.1343834	ppb	332
Prep blank	SAM	Pb	-0.0338706	ppb	-0.3387066	ppb	106
Prep blank	SAM	Sr	0.00055372	ppb	0.00553719	ppb	56
Prep blank	SAM	Ti	-1.8053267	ppb	-18.053266	ppb	6
Prep blank	SAM	Tl	-1.3397151	ppb	-13.39715	ppb	8
Prep blank	SAM	V	-1.7078484	ppb	-17.078483	ppb	577.2052
Prep blank	SAM	Zn	0.14500234	ppb	1.45002341	ppb	72
Prep blank	SAM	(Rh)	1.01033103	ppb	10.1033105	ppb	407026
Prep blank	SAM	(Sc)	1.01908624	ppb	10.1908626	ppb	309256
Prep blank	SAM	(Tb)	0.97897071	ppb	9.78970718	ppb	558260
Prep blank	SAM	(Y)	1.01571763	ppb	10.157176	ppb	427156
SW2	SAM	Ag		ppb		ppb	34
SW2	SAM	Al	24.743864	ppb	247.438644	ppb	35968
SW2	SAM	As		ppb		ppb	2757.908
SW2	SAM	Ba	26.0249767	ppb	260.249755	ppb	8418
SW2	SAM	Cd	0.29016191	ppb	2.90161896	ppb	78
SW2	SAM	Co	1.04549491	ppb	10.4549493	ppb	3104
SW2	SAM	Cr	1.38570201	ppb	13.8570203	ppb	542
SW2	SAM	Cu	11.4004945	ppb	114.004943	ppb	12180

SW2	SAM	Fe		ppb		ppb	7016
SW2	SAM	Mg	205.925628	ppb	2059.25634	ppb	59752
SW2	SAM	Mn	4.96507215	ppb	49.6507225	ppb	15602
SW2	SAM	Ni	5.40560532	ppb	54.0560531	ppb	3074
SW2	SAM	Pb	2.54166985	ppb	25.4166984	ppb	6272
SW2	SAM	Sr	24.8076572	ppb	248.076568	ppb	63526
SW2	SAM	Ti	-1.6496874	ppb	-16.496873	ppb	22
SW2	SAM	Tl	-1.3408734	ppb	-13.408735	ppb	6
SW2	SAM	V	4.1436882	ppb	41.436882	ppb	11083.45
SW2	SAM	Zn	10.2299938	ppb	102.299942	ppb	2310
SW2	SAM	(Rh)	0.99528378	ppb	9.95283794	ppb	400964
SW2	SAM	(Sc)	1.00748682	ppb	10.0748682	ppb	305736
SW2	SAM	(Tb)	0.97296631	ppb	9.7296629	ppb	554836
SW2	SAM	(Y)	1.00692439	ppb	10.0692443	ppb	423458