1. ACCELERATOR

1.1 OPERATIONAL SUMMARY

S Chopra

The 15 UD Pelletron accelerator performed quite well, from April 2010 to March 2011, with very few problems. The last beam cycle in the month of October 2010 finished on 3rd October and the chains were put OFF on 4th October. Pneumatic high pressure testing of SF_6 storage tank is mandatory and it has to be done once in every five years. This testing, for all five SF_6 storage tanks, was started after the beam runs were over and it lasted for around two months. Thereafter, the only scheduled tank opening maintenance was carried out. The accelerator was back in operation for users from 10th February 2011 onwards. The detail of this maintenance is mentioned in maintenance section. The operational summary of the accelerator from 1st April 2010 to 31st March 2011 is given below.

Total No. of Chain Hours	=	5751 Hrs.
Total Beam utilization	=	3228 Hrs.
Machine breakdown	=	0132 Hrs.
Accelerator Conditioning	=	0755 Hrs.
Beam Change Time	=	0012 Hrs.
Tank opening maintenance	=	1248 Hrs.
Beam tuning time	=	367 Hrs.
Experimental setup time	=	406 Hrs.
Accelerator set up time after maintenance	=	48 Hrs.

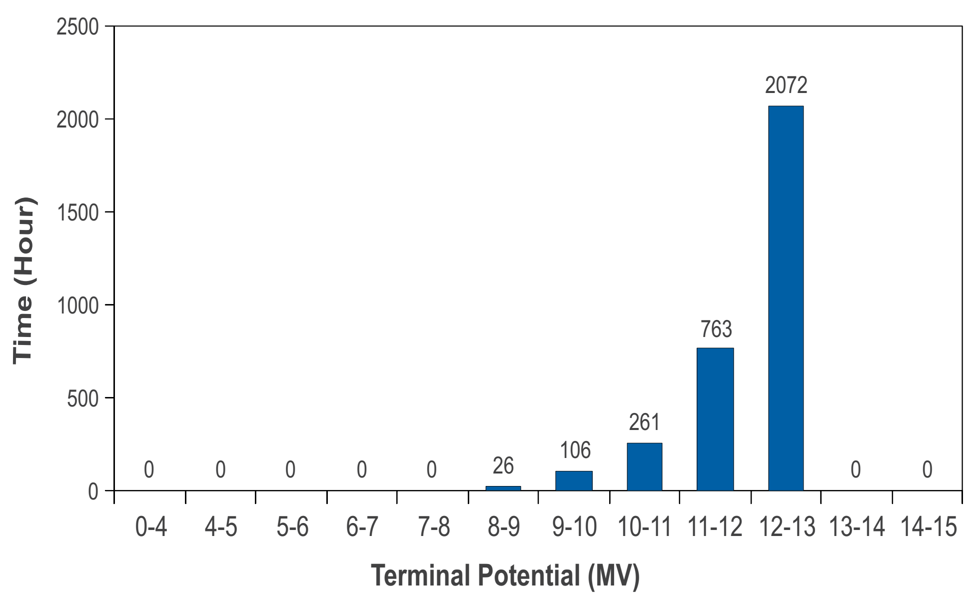

Fig. 1. Terminal Potential vs. Hour Graph

A total number of 719 shifts were used for experiment during the mentioned period. Out of these 719 shifts, 165 shifts were used for pulsed beam users. The machine up time for this period is 97.70% and the beam utilization is 56.13%. The voltage distribution graph of the Terminal Potential used for different experiments during above mentioned period is shown in figure 1.

^{16}O, 6^+, 89.3 MeV pulsed beam was delivered to user at maximum terminal potential of 12.77 MV and ^{28}Si, 8^+, 84 MeV dc beam at minimum terminal potential of 9.34 MV. Maximum terminal voltage achieved during conditioning in this year was 13.86 MV.

Accelerator performance (Chain hours utilization), in the form of Pi-chart, is shown below in figure 2.

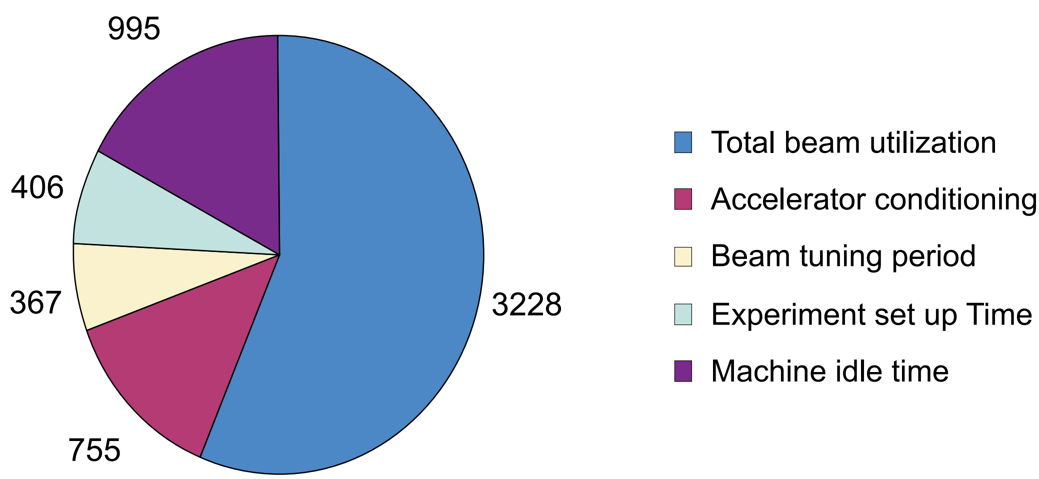

Fig. 2. Accelerator performance, in the form of Pi-chart

The total duration of beam run for mentioned period was 4197 hrs. Duration of run time in percentage for different ions is shown in table 1.

Table 1 : Duration of run time in percentage for different ions

Beam delivered	Utilization (%age of total time)		Beam delivered	Utilization (%age of total time)
^{7}Li	1.29%		^{30}Si	2.71%
^{12}C	5.21%		^{31}P	0.77%
^{16}O	31.52%		^{58}Ni	4.62%
^{18}O	2.06%		^{79}Br	0.12%
^{19}F	11.74%		^{107}Ag	16.47%
^{27}Al	1.91%		^{127}I	0.12%
^{28}Si	14.20%		^{197}Au	7.26%

Pi- chart in figure 3 shows the distribution of delivered beam species during beam run from 1st April 2010 to 31st March 2011.

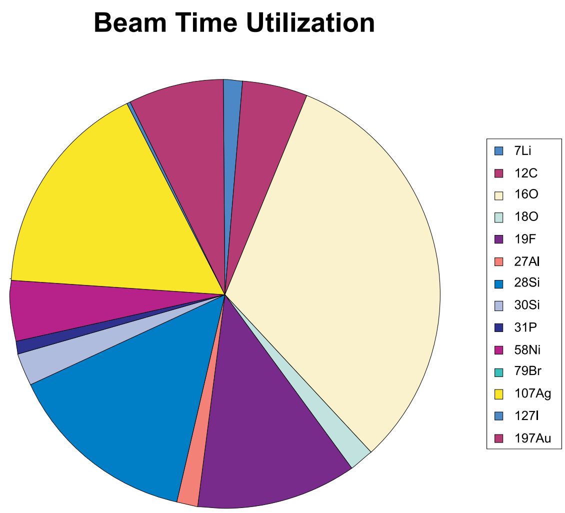

Fig.3. Distribution of delivered beam species

1.2 MAINTENANCE AND DEVELOPMENT ACTIVITIES

S Chopra, R Joshi, S Gargari, M Sota, S Ojha, K Devarani, Pankaj Kumar, V P Patel, R P Sharma, J Prasad, R Kumar, M P Singh, N S Panwar, S Mohan, Suraj Kumar, Pranav Singh, P Barua and A Kothari

There was only one scheduled tank opening maintenance during above mentioned period. Maintenance of Pelletron and associated components were performed during tank opening period. This scheduled maintenance was from 11th December 2010 to 31st January 2011. During this maintenance, routine maintenance jobs like checking of resistor network inside tank, HV breakdown test of CSP gaps, foil stripper change, maintenance of all ion pumps and sublimator pumps, CAMAC maintenance, ion source routine maintenance etc. were carried out. Apart from this, few major maintenance works were also performed, which are listed below.

Major maintenance jobs during scheduled tank openings:

The major maintenance jobs carried out are listed below:

1. Charging system maintenance

After the major maintenance of charging system #2, which was performed during July 2008 maintenance, the condition of both charging system was extremely good.

During this maintenance, routine check up of both the charging systems was done. Both the charging systems were quite clean with no or little idler dust. A small amount of black dust from terminal pulley in case of both the chains was observed. The idler wheels in unit #22 for both the chains were adjusted. Tightening of all nuts and bolts of both the charging system, on terminal as well as motor end, was assured. Both the charging systems ran for two overnights and their performance was satisfactory. Pulleys of both charging systems on terminal and motor side were oiled and full charging system was cleaned thoroughly.

2. Maintenance of Rotating parts inside accelerator tank

All the rotating parts, such as charging chain motors, rotating shaft motors, rotating shafts and blower motor, play important role for the operation of accelerator. Thorough maintenance of all these rotating parts was also performed. Separator boxes are used for mounting of these rotating shafts. It contains bearings and a rubber coupler. In this maintenance, fine black and metal dust was observed in unit #27, 28 and 29 due to severe damage of separator box between unit #27 and 28. Three separator boxes, one in high energy side and two in low energy side, were replaced by new assemblies (NEC make), as all of them were beyond repair. Apart from this, eleven separator box assemblies were opened and bearings of all of these separator boxes were changed. After maintenance, all of them were installed back. Out of these eleven separator boxes, eight boxes were in low energy side and three were in high energy side of machine. Cracked rubber coupler between RS-1 and unit #1 was replaced by new one. Also, the alternator in low energy dead section was replaced by new alternator due to bad bearings. The performance of both rotating shafts was satisfactory after their maintenance. All five motors were greased for smooth performance.

3. Replacement of Column Support Posts

During March 2009 tank opening maintenance, it was noticed that six equipotential rings, in unit #26, came out from their mountings. This caused severe damage to the corresponding Column Support Post (CSP) electrodes. Total number of five CSP gaps were shorted in this unit. In this maintenance all four CSP were replaced by new CSP in unit #26. After replacement work, all CSPs were tested and all CSP resistors were mounted. The distribution of these resistors was done in three column support posts.

4. Replacement of equipotential rings screws

Three hoop screws, in P-2, P-3 and P-4, of 3^{rd} ring in unit #16 were replaced by new screws. Threads of all these screws were damaged. A hoop screw in unit #13 (17^{th} ring) on P-1 side, was replaced by new screw as the slot of this screw was quite broad.

5. *Corona probe maintenance*

The condition of corona probe was found to be bad. Mushroom head of corona probe was taken out. Corona probe head could not be taken out as the top of one of the bolts holding corona probe head was sheared. Portion of probe head, near damaged screw, was ground by grinder and the corona probe head was taken out. Two new threaded hole of metric dimension were made to hold the probe head. Mushroom head and corona probe head was properly cleaned, to remove all the spark marks on them, by scotch brite and alcohol. All seven needles of corona probe were replaced by new needles before the corona probe was installed back.

6. *Stripper foil loading in terminal and High Energy Dead Section (HEDS)*

IUAC 15 UD accelerator facility has four stripper foil assemblies. Those are in HV terminal, in High Energy Dead Section (HEDS), in post acceleration section before analyzer magnet and one is after analyzer magnet. Stripper foils were loaded in all these stripper foil assemblies. In high voltage terminal, 106 number of Laser Plasma ablated (LPA) foil strippers and 60 IUAC made stripper foils were loaded. Both 50 position foil stripper assemblies, before and after analyzer magnet, and foil stripper assembly in HEDS were loaded by IUAC made stripper foils of thickness ~10 $\mu g/cm^2$ whereas ~4 $\mu g/cm^2$ thickness stripper foils were loaded in terminal area.

7. *Replacement of Pendulum valve*

During routine operation of accelerator, vacuum of post acceleration area (03 area) was going bad, to the order of 10^{-5} T, whenever pendulum valve (BLV 03-1) was closed. A leak was detected in the bellow of pendulum valve in closed condition. Therefore pendulum valve was kept open permanently for routine operation of accelerator. A turbo pump, of 250 l/s capacity, was also installed at the upper port of BLV 03-1 to take care of this leak. This temporary remedy held the vacuum of 03 area in the order of 10^{-7} T. This leaky pendulum valve was replaced by a drift tube of proper length during tank opening maintenance.

8. *Replacement of in tank ion pumps*

Two numbers of ion pumps inside tank, one in terminal (IP T-1) and another in HEDS (IP D-2), were replaced by new ion pumps of capacity 80 l/s. Ion pump T-1 got operated in atmosphere accidentally and was damaged. This pump was megger tested and was showing almost short at 5 kV. Therefore, this ion pump was replaced by new ruggedised ion pump. A simple arrangement was designed and installed to support this newly installed IP T-1.

During normal operation of accelerator, IP D-2, had undergone lots of vacuum accidents due to leaky BLV 03-1. Megger testing of IP D-2 was done. It was showing almost short at 5 kV and it could be due to many vacuum accidents during normal operation. Hence this ion pump was replaced by a new one. Physical dimensions of new ion pump is different from old one, hence a new supporting sheet had to be installed and a new HV cable of bigger lengthy has to be made for this new ion pump. An aluminum plate of ~6.5 mm thick, with proper dimension, was placed under IP D-2 for its support. A new conduit of required length was installed and a HV cable, for new ion pump (IP D-2), was made and installed through this conduit.

Maintenance of other beam line components outside tank

1. Replacement of Beam Profile Monitor (BPM)

During regular operation, in the month of June 2010, the BPM in pre-acceleration area (BPM #2) stopped operating. This caused difficulty in tuning of beam through injector magnet. Proper investigation suggested that the BPM wire was not rotating. Hence the BPM #2 was replaced by a new BPM assembly to solve the problem.

2. Maintenance of Vacuum related components

Routine maintenance of all ion pumps and sublimator pumps along with their controller was done. During the replacement of pendulum valve, sublimator pump in post acceleration section (SP 03-1) was opened from the beam line. The inner surface of this pump was properly cleaned to remove Ti layer and all three Ti cartridges were also replaced by new one. After maintenance it was installed back.

Turbo pump TP 01-1 installed after ion source deck was replaced by new turbo pump as this turbo pump was loading its controller and stopped working.

3. Fluctuations in charging current of chain #2

Charging system #2 performance was tested after December 2010 tank opening maintenance. The terminal was shorted with the help of shorting rods for its testing. This testing was done as fluctuations from 22 μA to as low as 4 μA was observed in charging current of chain #2. This led to beam instability. Testing was done from CPS of 2 kV to 12 kV and the maximum charging current at 12 kV CPS was ~28 μA. Its performance was satisfactory and there were no charging current fluctuations. The problem was further investigated by shorting the units in High Energy Section (HES) in groups. When unit #22 was shorted, the problem of charging current fluctuation in chain #2 disappeared. Therefore unit #22 was shorted, with other units live in HES, for routine operation of Pelletron accelerator.

4. Fluctuations in Triode valve grid voltage

Although the terminal voltage was stable, still fluctuation of ~2 V was noticed in triode valve grid voltage in GVM mode, without beam. The reason for this was investigated and found a ripple of 800 mv (p-p) in -24 Vdc supply in corona probe controller. This ripple was responsible for the fluctuation in triode grid voltage which led to the fluctuation in corona probe current. The ripple was reduced to 400 mv (p-p) after replacing the related control card in corona probe controller. Now, triode valve grid voltage fluctuation reduced to ~0.3 V.

1.3 ION SOURCE ACTIVITIES

S Chopra, R Joshi, S Gargari, M Sota, S Ojha, K Devarani, Pankaj Kumar, V P Patel, J Prasad, R Kumar, M P Singh, N S Panwar, S Mohan, Suraj Kumar and Pranav Singh

The ion source operation was satisfactory from April 2010 to March 2011. The source was opened twice in this duration for routine maintenance.

Maintenance work

Routine maintenance

Routine maintenance work for ion source was carried only once, in June 2010. All the electrical connections of ion source were removed. The source was removed from line and taken out from deck for maintenance. The source was dismantled and all of its parts were cleaned. After cleaning of all the parts, the source was assembled again and the alignment was done with the help of alignment jig.

Breakdown maintenance

During the reported period the ion source breakdown maintenance was performed for four times, the details of which are mentioned below.

1. Ion source operational problem

The ion source could not be operated in both local and remote mode. The problem was investigated and found that fuse of 24 Vdc supply in local control console was blowing off. Initially, in order to deliver the beam to user in time, this power supply was replaced by a lab power supply. Later a new power supply was developed and installed in the local control console. This power supply is working satisfactorily since then.

2. Ionizer problem

There was no current through the ionizer. The ionizer filament was showing open when measured with multi meter. The MC-SNICS was opened to look into the problem. Deposition of carbon layer was found in the return path of ionizer filament. This layer was cleaned and the filament was connected back. This solved the problem and the beam was delivered to user.

3. Tripping of extractor power supply

During one of the operation, it was noticed that the extractor power supply was tripping whenever the filament current increases. The cause for this problem was investigated which showed that the problem was inside source. The MC-SNICS was opened and the ionizer was changed to solve the problem. During this maintenance, 5 gm. of fresh cesium was also loaded in cesium reservoir.

4. No beam from ion source

After the maintenance mentioned in sr. no. 3, there was no current through cathode, hence no sputtering of cathode material. The reason for this problem could be lack of cesium supply or no supply to cathode. Cathode power supply and other control signals related to cathode were checked and all of them were fine. The source was opened for further investigation. The HV supply connected to cathode wheel is through a sliding contact on cathode wheel. There was an insulation layer on this contact which was not making contact with cathode wheel. This insulating layer was cleaned for proper connection and problem was solved.

5. No extractor voltage

During routine operation of ion source, suddenly beam reduced to very low value. The reason was the absence of extractor voltage. The problem was analyzed and the reason for absence of extractor voltage was the breakdown in extractor power supply. This faulty power supply was replaced by new one to solve the problem.

General Purpose Tube (GP tube) conditioning

All five General purpose tubes were cleaned thoroughly with alcohol and then conditioned. During conditioning X-ray activity was monitored as well as electron current was also monitored in FC 01-1. After proper conditioning, now the General purpose tube is holding upto 330 kV.

1.4 BEAM PULSING SYSTEM

R Joshi, M Sota and A Sarkar

Operation

1314 hours of beam time was used for pulsed beam runs using multi harmonic buncher (MHB) along with low energy chopper and traveling wave deflector. 68 hours of total pulsed beam time was utilized by LINAC group for facility testing and 668 hours of pulsed beam was delivered to users, after boosting beam energies using LINAC. Energies of ^{16}O, ^{19}F and ^{30}Si were boosted by using LINAC.

For remaining 578 hours, pulsed beam from Pelletron, was utilized by users to perform experiments in different experimental lines. The beam bunched for these 578 hours were ^{16}O, ^{18}O, ^{19}F and ^{28}Si. Only once, during LINAC run, instability in pulsed beam was observed due to instability in Pelletron accelerator. To solve this problem the unit #26 and 28 were shorted and accelerator was conditioned for higher terminal potential.

Maintenance

Routine maintenance of chopper was carried out. In this maintenance, tuning of output of 100 W, 4 M Hz. amplifier for 50 Ω pure resistive load, was done for maximum power transfer. Thereafter, 50 Ω pure resistive load was disconnected and chopper tank circuit was connected at the output of chopper amplifier. Now, chopper tank circuit was tuned according to output of chopper amplifier for maximum power transfer and minimum reflected power.

Once a breakdown maintenance was done for Traveling Wave Deflector (TWD). Switching amplifier of TWD has two banks and each bank contains 6 nos. of switching channels. Three channels in one bank and one channel in another bank were not working properly. The deflection voltages in these channels were not canceling out totally for the proper selection of beam particles. Tetrode valves of all these channels were replaced to solve the problem.

1.5 DEVELOPMENT ACTIVITIES

S Chopra, R Joshi, S Gargari, M Sota, S Ojha, K Devarani, V P Patel, R P Sharma, J Prasad, R Kumar, M P Singh, N S Panwar, S Mohan, Suraj Kumar and Pranav Singh

Few modifications and development work were also carried out in July 2008 scheduled maintenance. Those are mentioned below.

1. Testing of stripper foils

The performance of stripper foils installed in post acceleration section, before analyzer magnet and after analyzer magnet was tested. The performance test of stripper foils for both positions (before and after analyzer magnet) was done with ^{107}Ag and ^{58}Ni beams. Charge state distribution for both the beams was studied for stripper foil after analyzer magnet. The similar study for stripper foil before analyzer magnet could not be done as no higher charge states were observed by using these stripper foils. During December 2010 tank opening maintenance, stripper foil assembly before analyzer magnet was opened and noted that all the stripper foils in this assembly were broken. A new lot of 25 stripper foils (10 $\mu g/cm^2$ thickness) was loaded in this assembly and its performance will be studied.

2. Phase correction for High Energy Sweeper (HES)

A prototype circuit for phase correction of HES was developed and tested with beam. Now the final design of this circuit is under process. It will be ready for use whenever High Energy Sweeper will be used for rejection of dark current from bunched beam.

3. New Facility at IUAC

A new facility has been installed at IUAC. This new facility had been inaugurated and dedicated to nation by Smt. Vibha Puri Das, Secretary, MHRD on 1st March 2011. This facility is now open for the users for their experiments. The details of this facility are mentioned in the next section separately.

1.6 INSTALLATION OF 1.7 MV PELLETRON FACILITY AT IUAC

Apart from 15 UD Pelletron accelerator, a new 1.7MV Pelletron accelerator facility was installed at IUAC. This facility has a 1.7 MV tandem accelerator (Model 5SDH-2). The ion source for this accelerator is an RF ion source, and is used for accelerating protons and alpha beams for use in research. Presently, this Pelletron will be used for RBS and channeling experiments.

1.6.1 Installation of RBS facility with 1.7 MV Pelletron

A dedicated facility for RBS and channeling measurements is installed at IUAC. This facility is installed along with 1.7 MV pelletron accelerator. RBS is non- destructive componental analysis technique widely utilised by material scientists. The technique has vast application in the field of semiconductor and telecommunication industry. It is ideally used for thin film composition analysis, determination of areal composition in atoms/cm^2 and determination of film density if thickness is known. RBS measurements are quantitative in nature and do not require any reference standard. The RBS facility to be installed is EAG make (Evans Analytical Group. Helium ions accelerated by the 1.7MV pelletron accelerator will be used as backscattering element which will be capable of detecting element from Boron to Uranium.

1.7 ACCELERATOR MASS SPECTROMETRY (AMS)

Pankaj Kumar, Archna Bohra, Sunil Ojha, S. Gargari, R. Joshi, G. S. Roonwal and S.Chopra

The AMS facility for ^{10}Be and ^{26}Al measurements is in operation. A new clean chemistry laboratory has been developed and initial calibrations are done. The lab is being used by various user groups for chemical processing of geological samples prior to the AMS measurements.

1.7.1 ^{26}Al AMS measurements

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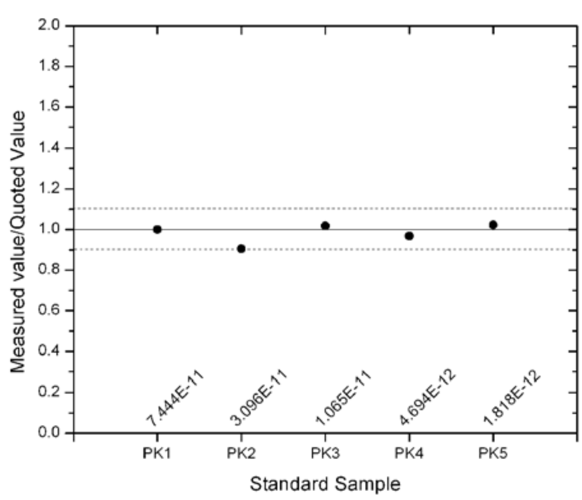

Fig.1. Ratio of measured to quoted value for ^{26}Al measurement has been plotted for various concentrated standard samples. The ratio is close to one within ±10% for all the samples.

^{26}Al ($T_{1/2}$=0.72Ma) measurements have been carried out with the standard samples. The sequential measurement technique is used for ^{26}Al measurements. Initially, measurements have been carried out using standard samples procured from University of California, USA. Standards of various concentrations of $^{26}Al/^{27}Al$ ratio show good agreement between quoted and measured value as shown in fig.1. ^{26}Al extraction from the natural geological samples is in progress and measurements will be tried soon.

1.7.2 AMS Chemistry laboratory activities: Anion and cation exchange column calibration

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Separation of ^{10}Be and ^{26}Al from other matrix elements is essential to increases ionization efficiency and to minimize the interferences during AMS measurement. Column chromatography with cation and anion exchange columns is used to separate ^{10}Be and ^{26}Al from other elements present in the geological sample matrix. Poly-propylene columns of 20 ml volume filled with 15ml AG 1-X8 200-400 mesh chloride form resin is used as cation exchange column. For anion exchange, 10ml poly-propylene columns filled with 2ml AG MP-50 100-200 mesh hydrogen form resin is used.

Columns are first calibrated using standard elemental solution of various elements to establish the procedure. With the calibration our aim is to know the yield of the columns for Be and Al elements and to know that which volume need to be collected for Be and Al elements while we pass the standard elemental solution through the columns. With the calibration we can also know that presence of neighboring elements in the collected solution, which may create interferences (e.g. B in case of Be and Mg in case of Al) during the AMS measurement. The elemental study of the drained solution from the columns is done by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). Standard elemental solution was prepared with elements Al, B, Ca, Fe, Mg, Na, Rb, K, Sr, Ti (1000 ppm), Be (100ppm) and Mn (10ppm).

Anion exchange column calibration:

After the loading the anion exchange resin into the poly-propylene column, resin is washed repeatedly first with pure water (MQ grade) and then with 1.2 N HCl. For calibrating anion exchange column, the resin is conditioned with 6 N HCl. The dried elemental solution is loaded to column by picking it using 6N and 1.2 N HCl and drained solution is collected in separate vials after each loading. The collected solutions are analyzed for elemental analysis using ICP-AES. Fig.2 shows the elemental concentration in different vials. The yield for Be and Al for anion column is 86% and 95% respectively.

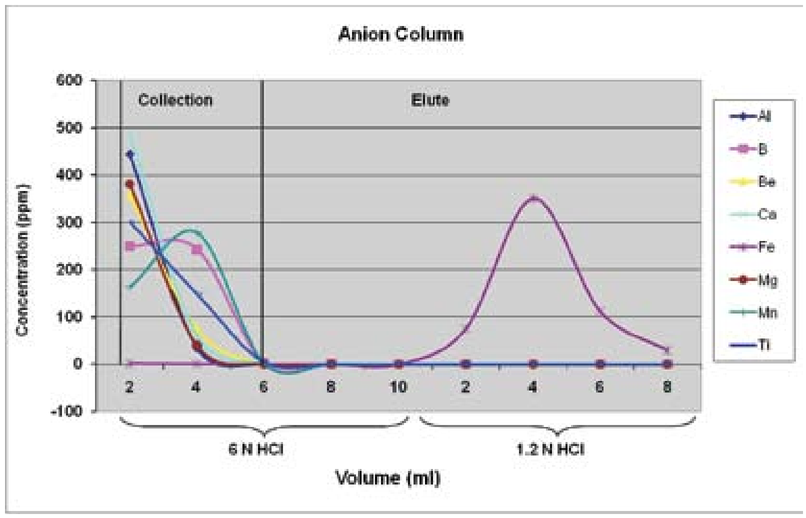

Fig.2. Concentration of different elements after passing through the anion exchange column along with different volume of 6N and 1.2N HCl.

From above figure it is clear that except Fe all other elements are eluted in 6 N HCl and when 1.2N HCl is used Fe is also eluted. The reason is that in strong HCl, Fe^{3+} forms a range of anionic Cl^- complexes such as $FeCl_4^-$, $FeCl_5^{2-}$ and $FeCl_6^{3-}$, which bind tightly to the anion exchange resin and form a brown band at the top of the resin column. In week HCl it gets eluted and can come out of the column. Al and Be do not form strong Cl^- complexes and are eluted from the column with the higher normality HCl. In geological samples only Fe is separated using anion exchange column and other elements are separated using cation exchange column.

Cation exchange column calibration:

After loading the cation exchange resin into the poly-propylene column the resin is washed with 15ml 1N HCl, and then stripped by filling 45ml of 4N HCl. After stripping the resin is conditioned first with 15ml 1.2 N HCl and then by 15ml 0.2M H_2SO_4 containing a trace of 2% H_2O_2. Dried elemental solution is picked up with 0.2 M H_2SO_4 and loaded in cation exchange column and drained solution is collected in the vial. After this gradually other acids of various concentrations are added to the columns and drained solutions are collected. Finally the elemental analysis is done using ICP-AES with the solution collected in vials at different stages. Fig.3 shows the elemental concentration in different vials. The yield for Be and Al for cation exchange column is 84% and 98% respectively.

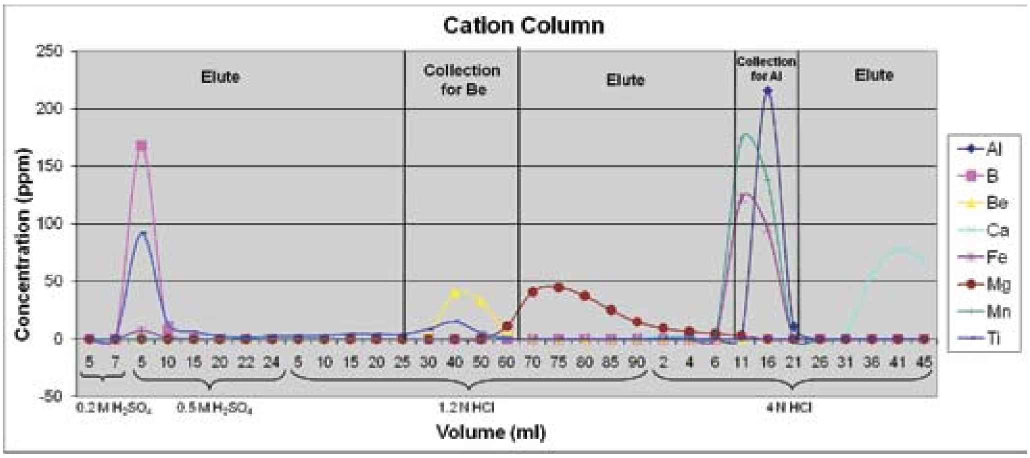

Fig. 3. Concentration of different elements after passing through the cation exchange column along with different concentration of H_2SO_4 and HCl.

For Be separation from matrix, drained solution between 25 to 65ml (with 1.2N HCl) is collected. During Be collection region boron is removed almost completely (B concentration is negligible). For Al separation, the drained solution between 10 to 22ml (with 4N HCl) is collected. During Al collection region Mg concentration is only 8%, but since Mg does not form elemental negative ion in the ion source during ^{26}Al measurement therefore it does not create any interferences. Fe and Mn are seen in Al collection region, but during actual sample processing Fe is already removed by the anion exchange column and Mn is almost negligible in the ^{26}Al containing geological samples such as quartz.