KHWARZIMIC SCIENCE SOCIETY

A SCIENCE ODYSSEY:
PAKISTAN'S NUCLEAR EMERGENCE

Speech delivered by Dr. Samar Mubarakmand
On Monday, November 30 1998

The Vice Chancellor Punjab University, President Khwarzimic Society, members of the audience, office bearers of the Interact Club.

I feel honoured to be able to come and address this audience on a topic which has become quite popular, it seems to me, especially in Lahore. The President of the Khwarzimic Science Society has just said that he was not very happy initially with the nuclear weapons programme and the detonation of the nuclear weapon because it can hold hostage several generations of Pakistan. Let me say that this is a moral issue. Anything we do for the defence of the country is a matter of pride, it is not a matter of shame. Weapons are developed so that they are not used. So that they will establish a fair and honourable deterrent, in the sub-continent with your neighbours. We have not forgotten the discourse from across the border. We have not forgotten the belligerence we heard in the fifteen days between the Indian and the Pakistani tests. I am very sure, had we not detonated the weapons, this belligerence, this aggression would have increased. Who knows they would have pursued some misadventures into Azad Kashmir, into our province of Sind and even across our borders of Punjab. The nuclear detonation has established a deterrent beyond all doubt. Now let me address myself to the topic of today.

Yes, it was on odyssey – the nuclear programme of Pakistan. At the time of partition of India, there were hardly any scientists or engineers in our country who would undertake this programme. There were hardly any establishments or institutions where research in sciences, such as chemistry and physics were being undertaken. Therefore these institutions had to be developed by some pioneers.

One of the pioneers of science, physics and I would say, the true father of the Pakistani nuclear programme was Dr. Rafi Muhammad Chaudhary. He migrated to Pakistan from Aligarh University and established the Physics Department at the Government College Lahore and was also the pioneer setting up the High Tension laboratories. There an atomic accelerator was set up and real high level research was possible. One of his early students was Dr. Tahir Hussain who was my teacher and of course, the present Chairman of the PAEC was one of his early students. Similarly the tradition of physics was set up in the Physics Department of the Punjab University. We know the name of Dr. Majeed Mian, Dr. Baseer Pal and some others. The two departments in the GC and the Punjab University had a very healthy competition. This produced a team of physicists that has now lead Pakistan's nuclear programme.

In 1955, the Atomic Energy Commission (PAEC) was established and its first chairman was Dr. Nazir Ahmed. He had a small office in Karachi Sadr at the top of the post office and the labs were in the West Wharf. The labs were mostly concentrating in fundamental research in high energy physics and there were less than ten people working there. It was in the early years of the PAEC to train and recruit manpower to initiate Pakistan's nuclear programme.

In 1961, PAEC set up a Mineral Centre at Lahore on the campus close by and a similar multidisciplinary Centre was set up in Dhakka. So with these two centres the research work started.

The first thing that was to be undertaken was the search for Uranium. This continued for about 3 years from 1960 to 1963. Uranium deposits were discovered in the Dera Ghazi Khan district and the first ever national award was given to PAEC's Mr. K. Aslam who was a geologist who discovered Uranium. Mining of Uranium began in the same year.

The next landmark was the establishment of the PINSTECH – Pakistan Institute of Nuclear Science and Technology at Nilore near Islamabad. The principal facility there was a 5 MW research reactor. Now with the establishment of the PINSTECH, The Lahore Centre and with the manpower we set abroad for their Ph.D.'s in the early 60's started coming back and the research programme started gaining momentum.

At this time, our Chairman Mr. Usmani was a man of great vision and he envisaged that the atomic programme had to split up into 2 branches: one was the peaceful usage of atomic energy. Under this area we set up the agricultural research centres in Tando Jam and nuclear medicine centres in different parts of the country. We also concentrated on the application of radioisotopes to industry and started training industrialists in the peaceful usage of radioisotopes. Of course nobody in the world would expect PAEC just to do research in agriculture and medicine and industry and therefore we had to think about the nuclear weapons programme in parallel with the peaceful programme.

1971 marked the establishment of the KANNUP, which was commissioned the same year and connected to the national grid. In 1972, the scientists of the country were collected in Multan by the then Prime Minister, Zulfiqar Ali Bhutto and a conference was called and at the Multan conference, we really swore to make nuclear weapons.

How would we set about this job. The first thing to do was to refine the uranium we had discovered. The discovery of uranium and its refinement is a massive, manpower-intensive job. 10,000 tons of uranium ore has to be recovered and dug up from the ground to produce enriched uranium for one bomb. So you can imagine the effort that goes into the huge refinement process. The refinement plant was established in a series of smaller plants. The Chemical plant complex CPC was established in Dera Ghazi Khan and it looks more or less like the chemical complex at Kala Shah Kaku.

From the CPC we get 2 products:

1. One is uranium dioxide which is a metallic powder and which is the input to the Karachi KANNUP reactor. We all know that after the Indian explosion in 1974, the Canadians stopped the supply of fuel for the research reactor. The Canadians said that the streets of Karachi would go dark. We took this as a challenge and we thought that we must be able to make our own reactor fuel. So from the CPC near DG Khan, came uranium dioxide to make fuel for the Karachi reactor.
2. We also started making uranium hexaflouride which came from the same campus. So the CPC was branching down into 2 products. You are sending uranium dioxide to the Karachi reactor. This is a peaceful use of uranium, a part of the nuclear fuel cycle and we are also making uranium hexaflouride from the same chemical facility, which is now the input material for the enrichment plant at Kahuta.

So in the early days of about 1976, the establishment of the infrastructure for nuclear technology had begun and this was an effort that was started in parallel at different facilities.

One facility was the establishment of the enrichment plant at Kahuta which of course was the responsibility of the PAEC and this was started by some scientist from the PAEC.

The second was to set up the Uranium Metals laboratory UML, so that ultimately when we get enriched uranium hexaflouride from the plant at Kahuta, we convert it back to the metal and give it the right shape to be used in a bomb.

Then the 3rd facility that was to be set up was the design of the bomb. The critical thrust was to set up a theoretical physics group that could work on the design of the bomb. At that time, the responsibility was entrusted to Dr. Riazzuddin, who was in the Physics Department of the Quaid-e-Azam University and then in Dharan (SA). He was a Member Technical of the PAEC in those days and was a theoretical physicist and he set up the group. Dr. Masud who is with us today, was a student of Dr. Riazzuddin and now Dr. masud heads the team that is the design team. I will come to the capabilities of this group, but I must say that our design was a pure indigenous process. Nobody in the world would come and help you to design nuclear weapons, or to fabricate them or even test them. It has to be a purely Pakistani effort and our scientists on the theoretical side were so capable, they studied they literature that was available and they worked so hard, developed computer codes, acquired powerful computers to design this system and came up with the design that was to be manufactured.

The 4th facility that was set up in those days was a manufacturing facility for the bomb. So at the PAEC, the finest experimental physicists, engineers and electronics people, chemical engineers formed a team to manufacture these weapons.

We had to develop our own explosive plants. The explosive used in a nuclear bomb is a very special type of explosive. It is not to be purchased from anywhere in the world, nobody would sell it to you. So we had to put up our own plant for this and we had to have chemical engineers that would operate this plant and make the explosives. Then the

explosive had to be given the right shape according to the design that was delivered by our design team. The explosive had to be machined. The machining of the explosive is an awesome task. You know explosives are so difficult materials to handle. Its machining is a very dangerous process. We have a dedicated team of people, mechanical engineers who were not afraid of this and who did this job, which of course is done by remote control. These pioneers risk their lives to machine the explosives.

So when a bomb is made, it has to be detonated and the detonation is not from one point. It is from several points on the surface of the bomb and the trick lies in this that you should be able to detonate the bomb from several points at the same time. This is called simultaneity and the simultaneity has to be of the order of 50 ns (nanosecond). A ns is 1/1000 of a micro second us and I repeat 1 us is one-millionth of a second. So you can imagine, in 50 ns, you have to detonate the bomb at several points so that the implosion takes place in a simultaneous fashion.

This was a challenge for our electronics people because they had to develop the trigger mechanism. I mention this because I want to tell you the dimension of the problem and of course the whole journey to the end, and this is a part of the journey.

Then there was the question that you have made the bomb, you put the electronics in it, the bomb has got explosives, it has metallic uranium which comes from Dr. Khalil Qureshi, out top metallurgist and he converts the gas from Kahuta into metal and then he does the coating and machining. So that is one part. Then you have to have a holding system that holds everything, the bits and pieces in such a way that we get a very rugged device. The device has to be rugged so that if you want to have deliverable weapons, you do not have problems. You can put them on aircraft or missile. All the facilities for explosives and chemical manufacture, explosive machining and electronics transfer the product to the manufacturing facility and Dr. Mansoor Beg is the Director of that facility.

All these things had to be started at the same time in parallel.

Suppose you had a bomb, what to do with it. You have to have a facility, a site where you can test the bomb and you would also like that when the bomb is detonated, you can do the diagnostics or the measurement on it. There can be 2 approaches; either to detonate a bomb and sit back and clap or to treat it as a scientific experiment – try to get the maximum scientific data from the nuclear detonation. We chose to do the latter and for that we had established another Directorate – the Diagnostics Directorate.

They are really smart people. They are trained very thoroughly in capturing the yield of the device. They measure the number of neutrons produced in the device, the efficiency of the nuclear bomb: how much uranium produces how much power – this is the efficiency. One must remember that the phenomenon is a single shot phenomenon. It is a very fast process. You press the button and everything is finished within a us. The bomb goes to maximum power, stays there for some time and comes down to zero power in less than a us. So in this time, one must do all the measurements and if you miss the data, it is the end of it, it is finished and would not repeat. So it is a single shot event and our

Diagnostics Directorate has the capability of measuring what is the yield of the device. They cannot only measure the yield of the devices that they themselves detonate but also of the devices that are exploded across our border.

The diagnostic people are not only responsible for diagnostics of the device but also for detonating the device. The detonation of a device is not done by sitting close to it. It is a very sophisticated process. This expertise was established over the years by a dedicated team of people and when we did the experiments, the detonation at Chagi, we were able to detonate the first 5 devices from a distance of about 15 km and the last detonation on the 30th, we were able to do from a distance of 45 km.

This was not the first time we were doing these experiments. We had performed so many cold tests before. We had practices the remote control detonations of the cold test over the years. So we knew what we were doing. We were very professional and very well trained. We had a team of 300-400 people who were responsible for developing the detonation procedure. So this is a massive programme.

This is in short, what I want to say. There are 5-6 different disciplines that have to be dealt with. Each discipline in itself contains electrical engineers, electronics people, physicists, chemical engineers, metallurgists and so on.

This entire infrastructure came into being by 1980. By 1976, we selected the sites in Chagi and Kharan and our geologists went to work on these sites. In Kharan there is a desert and we went for a vertical shaft. It is like a vertical well that is 300-400 feet deep and at the bottom of the well you have a horizontal tunnel which is 700 feet long. You do the detonation at the end of this tunnel. So this was an L-shaped configuration. In Chagi, where we had the mountain range, the Ras-Koh range, we went for an underground horizontal tunnel. The overburden available was about 400 feet. That was the height of the mountain available for containment.

The designing of the tunnels is also a very intricate thing. It is not just blasting a hole into a mountain. Again there is a lot of science. I shall tell you why. If you have a straight tunnel and you put the bomb at the end of the tunnel, you plug the tunnel with concrete and explode the bomb, the concrete is really going to blow out and so all the radioactivity is going to leak out through the mouth of the tunnel. We did not want this to happen. The tunnel is not designed safe but is designed in the form a double-S shape and when we detonate the bomb, the pressures are very great. They move the mountain outward and you use the force of the bomb to seal the tunnel. When the rock expands under the explosion, the rock moves in the direction so that it seals the tunnel. So the tunnel collapses inward by the force of the tunnel. This is how you seal the tunnel through the force of the bomb. Dr. Mansoor Beg is an expert in this. Apart from the manufacturing things, he is the one who does all the calculations and gives it to the geologists who do this work. So in 1976, we selected the sites for the atomic tests. In 1980-81, both the sites were complete and the shafts were all made.

Why were doing all this so keenly in a parallel effort in 1975 and 76? The PAEC was told by that whenever you were ready, you would detonate the bomb. So we were all very enthusiastic. We were running day and night concentrating on our effort. But history has proved, it did not happen that time. The mandate was withdrawn from us when we were ready.

By the end of 1980, the Kahuta plant was completed and Dr A Q khan was made incharge of the plant. First he was working as a scientist within the plant and later on he became the incharge. The plant was commissioned in 1980 and it started t function, first at a slow pace and then gradually picked up speed. All the uranium hexaflouride gas it needed was provided by the PAEC from the CPC at DG Khan. It is still done the same way. After enrichment, the uranium hexaflouride is sent to the UML where it is converted into metal and bombs are being manufactured.

In March 1983, we crossed a milestones. The first nuclear bomb had been manufactured. In March 1983 we went for a cold test. We were very apprehensive. It was the first biggest event in our lifetime and it was conducted. A cold test is the actual detonation of a complete nuclear bomb except instead of enriched uranium, in the middle of the bomb, you put natural uranium. So it will not go into fission. It will not acquire full power, but it is a complete bomb in all respects. What does it do? It produces a high flux of neutrons when the detonation takes place and one has to have the capability of measuring these neutrons. The diagnostics Department has this capability and they measured neutrons from these cold tests very successfully. When we saw these neutrons on our recorders we were very happy. We thought that we had achieved the objective of our lifetime. I remember that the people were very happy for several days. If you have a cold test and you detect neutrons you can be more tan 100 % sure that if you put enriched uranium in the same bomb, it is bound to give you fission. So the test was successful and we were very happy.

Now we had a choice. What would we do next? Where do we go from here. Do we stop, should we go for a hot test, a proper hot test like we had in may this year and when we had positive results from that, we would carry out further work. That was one way of doing it. The second choice was that since our cold tests were successful, so we believe our theoretical physicists. Okay, your design is fine and we go ahead and we develop more modern designs, which are smaller and more rugged and which are being capable of delivery by aircraft and missile. For every country in the world which produces this bomb, the first one is very large and very unwieldy and not suitable for deliverable weapons. So the miniaturisation or the quantisation of the weapon, should we do it now or wait for a hot test? We went to the Government and said we are ready and we want to do a hot test. The then President said no, it is not the right time and so we had to abide by that decision.

We decided to keep on working on better and better designs and since 1983, over the last 15 years, I must really confess and congratulate our theoretical physicists, lead by Dr. Masud, in that they designed one sample after the other. After every 18 months or 2 years

or so, we would have a new design and would perform a cold test on that. The success rate in every cold test was 100 percent. Sometimes we started thinking that our diagnostic people are giving us positive results all the time. At least we should fail some time. Maybe our electronics are faulty and giving us detected neutrons. Probably they are spurious counts but the success was so consistent that we started disbelieving our diagnostic people. Anyway, one design after the other kept coming out, we manufactured the bombs, tested them and were successful.

We came through a series of 4 or 5 designs and then we came up with a model which we would say, and our generation of people in the PAEC would claim that is the state-of-the-art. The real last word in nuclear fission design and here of course, the concept was different from earlier designs. It was very small, compact, high yield and small size. So you could see the efficiency was tremendous and we were all very proud of it. When the cold test was successful on it, we were all very happy and this was the last thing we did in the earlier part of the 1990's.

Now, I think that the rest is all history and very recent history. It is all the memory of the people. Now we had all these designs available with us. I would not tell you what we were doing beyond that. Then you also have to weaponise so that they become deliverable weapons. I would not also tell you what we did about that but you can draw your own conclusions.

We had spent our lifetimes on the project and still there was no chance of a hot test. And on the morning of the 11th of May, this year, one of our friends, in the Armed Services, phoned me and he said, "Have you heard the news today?" I said. "What?" He said, "The Indians have conducted the explosion in Pokhran." So I said, "Congratulations." I was genuinely happy. He said, "You are congratulating us on the Indian tests?" I said, "Yes, because now we would get a chance to do our own tests."

It is always happening like that. Indians are always trying to do things first and we follow suit. Although as scientists, we would have liked that the Government had allowed us to do the tests in the normal way. Anyway, these were political decisions.

When the Indians conducted the tests on the 11th May, within 2 days, they conducted another test. They claim that they conducted 5 tests in all: 3 on the 11 and 2 on the 13th. Several people have queried on this. We have though about what were those tests. The claims were that they conducted 5 tests. We have our capability of detecting nuclear tests, measuring their yields and so on. They claimed that of the 3 tests on the first day, one was a fission device, one was a fusion device and the third was a low-yield device. We have detected only one explosion on that day and the yield of that explosion according to our measurement, and you know we are the ones whose measurements are the most reliable, and the yield was the same as the 1974 Pokhran test. So I think the first test was a repeat of the 1974 test and the yield was the same. We did not detect a thermonuclear or a smaller test. We can detect smaller, sub-kiloton tests which are of the order of 0.5 – 1.0 kiloton but we could not detect that. So our estimates were such that they had conducted only 1 test on that day. Later on, when international data started coming in from all over

the world, it was also said that on the 11th of May they had conducted only one test. Of course, the yield they presented had a greater error in it. They would give a wide range of yield. They said it could be between 10-25 kiloton or 10-40 kiloton. This is because the further the station is, the greater the error margin. On the 13th of May, they said they conducted 2 tests but we did not detect any tests at all and our capability, as I have said, is between 0.5 and 1.0 kiloton sensitivity levels.

After these Indian tests, as we expected very quickly, the Prime Minister was at it. He called me and said, "Are you ready for it?" I said, "Yes, definitely." He said, "OK! Get yourselves ready." I told my colleagues that we have to be ready and we started packing. There we went on the 20th of May and we conducted the first 5 tests on the 28th of May.

One test was a huge explosion, a large device. The others were sub-kiloton tests. On the 30th of May, we had an L-shaped shaft in the Kharan desert and it was tested on the latest of our models. In all, we conducted 6 tests and the results are that the results were successful to the hilt, to the last detail. The yield was always as predicted by our theoretical physicists.

I can assure you that if you give them the specifications, we want this much yield; this much size and they would be out with 2 months and Dr. Beg would be out with an actual bomb or so I perhaps a year. This capability is now with us and it is a tribute to thousands of our scientists, engineers, geologists, metallurgists and theoretical physicists who have really spent more than 2 decades in this programme and it is also a tribute to the vital link in the chain at KRL, who are successfully doing the enrichment of uranium.

Very smoothly, this process is going on and we got so much data from the 6 tests, it gives us so much confidence in our design capability that as I have said, we can design any specification weapon we want.

Maybe we acquired this capability from some other country. Somebody came to us and gave us some knowledge or transferred us some technology. I can swear to you that nobody in the world, no matter how friendly he is to Pakistan has ever helped Pakistan. This I can say on oath. This is an indigenous technology and this should be really hammered in because this gives you pride. You have done it. Pakistan has done it. It is not borrowed technology. You know we are a generation of scientists that has lived under embargoes. Right from the mid-70's, since India exploded the bomb, embargoes were also levied on Pakistan. I sometimes tell my colleagues that we are an embargoed nation. We have learned to live under embargoes. No one would give us literature, hardware, components, technology. For everything we have to struggle. We had worked under these adverse circumstances and inspite of this adversity, my colleagues took it up as a challenge. OK, you cannot do it for us, we shall show you how to do it. The nation of Pakistani's works best when it is handicapped. When you are facing a challenge, you show your best. I firmly believe that the young people of this nation are capable of reaching the skies.

The last thing I want to say is that the PAEC has proved that this country is an island of excellence and to substantiate my statement let me say that if you take the statistics of Pakistan and compare it would the rest of the world, they are dismal. Our life expectancy is 122nd in the world; in the literacy rate we are the 162nd and in per capita income we are the 122nd. The access to health services gives us a ranking of 148 and in clean drinking water we are 114th in the world. In the OHD, we are 139th in the world, almost the last and of course and in nuclear weapons we are the 7th in the world. The PAEC works with a certain tradition of excellence. What is this tradition?

One is tremendous team spirit. Nobody works I our organization for money or fame. We do not believe that sensitive work can be done by publicising it. It should be done quietly and so it there is no lust for fame in this organization. There is honesty, dedication. The work is dangerous: we are working with explosives, atom bombs and we are rubbing our shoulders with nuclear weapons. Who can pay you to do this? Who can pay people to work in explosive plants and do explosive machining? Only the people who are dedicated, who put into their head that we are going to make Pakistan a nuclear state, they are able to do it. Only a purpose, motivation and a high philosophy in life could do this.

When a large number of people work together for a large period of time intelligently, they achieve an objective. If one person works hard for a long period of time, he will only achieve a small objective. In our organization, there are 15-20 Directorates, each dedicated to part of the nuclear weapons programme. Each Directorate has 700-800 people and their work is over 25 years, consistent, without greed, publicity and without quarreling with each other.

I can tell you this, the miracle of teamwork I saw in Chagi. We were there for about 10 days. The PM had told me, “Dr. Sahib, please do not fail, we cannot afford to fail. IF WE FAIL WE CANNOT SURVIVE. This is an hour of crisis for Pakistan.”

He was dead sure that if we failed, they would have attacked our nuclear facilities immediately and we could not afford to fail. There was a tremendous burden of responsibility when he said that to me. I came back to my team and said, “This is a responsibility. Let us all share it. You are a team and nobody let me down.”

They worked as a team. There were technical difficulties during these 10 days. We took collective decisions and solved the problems. This is not a miracle. This is something you achieve after you work for a lifetime. So team spirit was very much there. There was so much responsibility on the shoulders of a few. One would expect us to become tense, abusive, quarreling with each other and bad-tempered, but you would be surprised to find us there all smiling and in good spirits, cheered up and relaxed.

We all believed that we had worked very hard and God will give us success and success he gave us.