Edited transcript of a recording of Andy Smith, interviewed by Chris Eldon Lee at his home in Bradwell, Derbyshire on 15th February 2007.

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Part One

Smith: I am Andy. I was born in Birmingham in 1945.

[00:00:23] Lee: What did you want to do with your life?

Smith: I have always had a bit of a streak for adventure. I like travelling. I enjoy the outdoors. I was in the Boy Scouts. I did a lot of mountaineering and that sort of thing. I went on an exchange visit to France when I was 15. On leaving school I went on VSO to West Africa. I did a year in Nigeria. Having fun, having adventure and having a scientific interest were part of it as well.

[00:00:57] Lee: Can you remember where that scientific bent came from?

Smith: I did well at science at school. I enjoyed it and thought, 'This is what I want to do". There wasn't really any science in our family. My father was an engineer. Maybe I was inspired by one of my physics teachers at school. I just loved Physics.

[00:01:34] Lee: That was your chosen route for a degree?

Smith: Yes. I did an undergraduate degree at Oxford. I did Physics, and did well there. So I decided to do a PhD. I looked around at quite a few of the universities but in the event I stayed at Oxford. I liked Oxford. Did a PhD in theoretical solid state physics. It was fine but when I got to the end of that I thought, "Well I don't really want to do theoretical solid state physics for the rest of my life. I will have a change and do something else". I got interested in the Antarctic, I think, because of the media coverage of the Trans-Antarctic Expedition when I was a schoolboy. When I got to the end of my PhD I thought, "I would love to go to Antarctica". I made some enquiries and I wrote to BAS and said, "I am a qualified Physicist. Have you got any jobs for a physicist in the Antarctic?" They wrote back and said that they had a vacancy for a VLF physicist and would I like to come for an interview. I hadn't a clue what VLF physics was. I had never heard of it. It wasn't something that we had covered in our physics course. I really didn't know what it was but I did find out and went for the interview, and got the job.

[00:03:20] Lee: What do you remember about the interview? Were you asked questions about science or about yourself and your suitability for…

Smith: Probably both. That has certainly been the pattern of BAS interviews since then. I had been involved on the other side of the table quite a lot. There is always somebody who asks you the sort of questions designed to find out if you would be a good chap for the Antarctic, and fit in. Whether you were tolerant of other people and that sort of thing.

[00:03:52] Lee: What sort of questions are we talking about?

Smith: Hard to say really because I never asked those sort of questions. I was involved on the other side of it to see whether you knew the subject. They were the kind of questions like 'how would you cope on your own in a difficult situation?' Questions like 'Have you got a good working knowledge of First Aid? How to fix two stroke engines. How to get out of a crevasse'. All these kind of things. It is not critical because they do train you in all these things, but if you do know about these things in advance you are more likely to be picked for the job. You have got to check when you are recruiting people that they are psychologically stable. Physically that is fine, you just have a medical but how are you going to check whether somebody is going to breakdown under the stress? BAS is generally successful at that, but not always. We don't have anything formal on that side. Chaps who have been there know what it is about and are assessing you.

[00:05:22] Lee: It is almost a sixth sense, is it?

Smith: Well Personnel people like to pride themselves on the fact that they can spot suitable people.

[00:05:34] Lee: You then had to find out about VLF?

Smith: That was quite straightforward really because the way the VLF project came about was though Sheffield University Department of Physics under Professor Tom Kaiser with Ken Bullough. They had bid for the first VLF experiment to fly on a British Satellite, which was Ariel 3 in 1967. They had succeeded in this, and now they wanted to have 'ground truth'. They wanted earth stations on the ground to compare what was being seen on the satellite. So they put three stations out, one in

Sheffield, one in the Faeroes Islands and one in the Antarctic. So that is how the VLF experiment in Sheffield got linked in with the Antarctic. For various reasons, the Antarctic particularly Halley Bay is a very good place for that kind of work. Ariel 3 was then followed by Ariel 4 in 1971/72. They wanted to do the same kind of thing because Ariel 3 was being very successful. Ariel 4 was an enhancement of it. It was going to fly for longer and it had more channels on it. etc.. We are talking about the early 70s now so it was all fairly basic technology. They were building this experiment and they wanted to again have a ground station. It turned out that the local ones like the one on the Faeroes and the one at Bradfield near Sheffield had not been too successful. It was much better, they thought, to just have the one station at Halley Bay, but have more instrumentation there and have somebody there who was running it full time. BAS had agreed to this because by now this was quite a high profile experiment. So they got the go-ahead to recruit somebody. That was me! This was in June, I think, 1970. So before I sailed to the Antarctic in the beginning of 1971, I had about 6 months to learn the job. So I went through all the theory about what VLF was and why it was important, but also the nitty gritty of the instruments. This is what it does and this is all the inside of the instruments and this is what how to mend it when it goes wrong. I had to relearn how to solder, because having done a theoretical PhD, I hadn't had to use a soldering iron very much. So I did a crash course in electronics. I must admit that they did a very good job. We trained pretty well for 6 months.

[00:08:30] Lee: Were you excited by it?

Smith: Oh yes! By that stage I had got in contact with people down at BAS and I had been reading what I could about the Antarctic. I had been on the briefing course because…BAS has a briefing course every year in Cambridge. So I had heard a lot about the Antarctic then. The Antarctic is one of those places, which the more you read about it, the more you find out about it, the more you can't wait to get down there and experience it.

[00:09:08] Lee: So the excitement was more the Antarctic than the work?

Smith: Undoubtedly, and I think that is so for most people. The drive is 'I want to go to the Antarctic.' The next thing is 'What can I do in the Antarctic that some one will pay me to do to go down there'. I was interested in the work but much more I was excited about going down to the place…going to the Antarctic and experiencing that. I think that you will find if you ask most scientists, especially the older ones who have been to the Antarctic, "What was you main thing?" It was, "I was desperate to go to the Antarctic, and I could use my knowledge to get a job with BAS to go down there". Really, that was the case with me. The more I did the work, the more I got interested in it. It is a fascinating subject and I went, as most people do, to Halley Bay. I got the data I was asked to get. I wrote my report. I came back and did a follow up session at Sheffield just being debriefed basically. For most people that is were it stops and they have to go off and get a job. I was very fortunate because I thought 'I would quite like to carry on doing this'. I approached BAS and said I would like to do this a bit further. They extended my contract. I was writing up papers and eventually I got a permanent job. I was there until I retired in November 2005.

[00:10:44] Lee: How many times did you go to the Antarctic in that period?

Smith: About a dozen not counting the time that I wintered. I did two and a half years continuously when I first went. Those were the only two winters, as it is for most people. But I went in the summer, not always to Halley, but mostly.

[00:11:16] Lee: Between the early 70s and 2005, how did the means of getting to the Antarctic improve and develop in that time?

Smith: The first time I went south, it was quite interesting. BAS had a new ship, the *Bransfield*. It was built at Leith. It was launched in early 1970 and it was due to sail in September after being fitted out. I was due to sail on it in October/November, but it was late. It was a question of whether it was going to go or not. It can be too late to get into the Antarctic. BAS was wondering whether they would have to charter a ship as they had done in previous years. In the end we sailed very late from Southampton at the beginning of January 1971. We went straight to Halley Bay, with a quick call into South Georgia. We got in just in time. That was then the pattern for most people who were going south to winter. They would go all the way on the ship, and all the way back if they wanted to. They could opt to come back via South America or via the Antarctic Peninsula. But then it became more of a pattern that you would fly to the Falkland Islands. Obviously it is quite a long time on the ship and it is more difficult to justify paying a research scientist to sit on a ship for three weeks. It is very nice going through the Tropics but you are not doing much work. So you would fly to Port Stanley, and then get on a ship for the last leg. That is the way I have been down mostly, but now there are other options. You fly all the way, which I have done. You fly to the Falklands, then the BAS plane, the Dash 7, into Rothera and then get on the smaller Twin Otter to fly across to Halley. I have done that. It is also possible now to fly in via South Africa. There are getting more options all the time.

[00:14:09] Lee: Lets get back to the work. The whole thing was still in its infancy?

Smith: It was. I ramped up the programme. The '67 one, the VLF Programme at Halley, which had been tied to Ariel 3, was like a pilot with a relative small number of recording tapes and they hadn't had a dedicated person on site. They had one of the geophysicists to do it. So I went South to do a much enhanced ground programme related to Ariel 4 which was launched in August '71. So that is what I meant by that. There was more instrumentation put in and there was a dedicated person to run it and work up the results.

[00:15:10] Lee: What were they hoping to achieve? Was it science purely for the sake of science or could they see a wider application?

Smith: There are wider applications. They were envisaged even then. But it was a relatively unknown subject at that point. The emphasis was more about finding out more about Geospace and VLF waves in Geospace, and how they interacted with the rest of the system. There were applications in view further down the line because VLF had some very important properties, which made it suitable for navigation systems, at least at that time before GPS came along. Also, for submarine communications. Ordinary frequency radio waves can't penetrate the ocean to any depth at all, whereas, because they are low frequency, VLF waves can. So they can be used for submarine communication.

[00:16:24] Lee: You realised that, even in the early days?

Smith: People realised that in the very early days. The Military were doing their own research as well but we weren't directly involved with that. We needed to find out more about the system, about Geospace and how its various parts interact with each other. That was still a relatively new topic. It was starting to be more explored with satellites, but with the VLF programme we had a system that could probe quite distant regions of Geospace using a ground instrument. Most of the exploration of these higher levels of Geospace at a distance of several earth radii had been done by shooting satellites up there, a quite expensive high tech.

complicated business. Here we had a technique where you could sit on the ground with a very simple receiver and pick up these waves, which had come through these very high altitude regions. By analysing the signal you could tell quite a lot about the medium they had passed through. That was really the key to it.

[00:17:41] Lee: Let us back track slightly and get a clear image of what we are talking about. What are Very Low Frequencies and how are they created?

Smith: The whole of the radio spectrum is split into different frequency ranges, like HF [High Frequency], VHF [Very High Frequency] etc., which are the well-known ones. VLF is essentially in the audio frequency range. Usually it is said to be in the 3 kilohertz up to 30 kilohertz. Then there is ELF – Extremely Low Frequency – which is the next decade down, 300 hertz up to 3 kilohertz. But often ELF is included in VLF. They are essentially radio waves, which are in that frequency range. If you turn them into sound you can actually hear them. There is no modulation like as in HF. In the conventional radio HF you have to have a carrier wave at several megahertz. In order to carry information like voice, you have to modulate that signal. With VLF, the information is carried in the carrier wave itself.

[00:19:02] Lee: They make a noise of their own accord, or do you have to do something to them to make a noise?

Smith: You can't go out and hear whistlers. They are electromagnetic signals, but all you have to do is pick them up on an aerial, put them through an ordinary amplifier and then a loudspeaker or headphones. You hear the equivalent of those radio waves.

[00:19:26] Lee: So they do have their own sound properties? You are not applying them? How are they created? Where are they coming from?

Smith: Most of what you hear in the Antarctic are natural. You can generate and transmit VLF radio waves. I have already suggested that there are reasons why you do that. But the most powerful ones are naturally generated. There are essentially two sources. There are waves – we call them emissions – like chorus, which are generated in the magnetosphere itself. This is what we call 'plasma instability', which means that the electrons, which are there, convert some of their energy into electro-magnetic waves by interaction with the Earth's magnetic field. The other main source of the VLF waves that we pick up in the

Antarctic comes from lightning discharges. When you get a lightning flash you also get a pulse of radio energy produced. Part of that is in the VLF range. Part of that escapes up through the ionosphere into the magnetosphere, and travels through this same region and comes down to what we call the conjugate point. This is at the other end of the field line in the opposite hemi-sphere, and is received as a 'Whistler', which is a sound of descending pitch generally. The reason for that is in this propagation path between the two hemispheres, the speed of travel is dependent on the frequency. So the higher frequencies travel faster and get there first. That is why you don't hear a click, you hear a descending note, a whistle.

[00:21:29] Lee: The higher frequencies are the fastest, and a few milliseconds later the lower frequencies catch up?

Smith: Yes. I am over simplifying a bit because actually there is a frequency for minimum travel, and above **and** below that frequency the waves travel slower. It is slightly more complicated than that but that basically that is the idea, yes. It is a dispersive medium, the same principle that light gets split up into different colours, different frequencies in a prism.

[00:22: 04] Lee: When you arrived in the Antarctic for the first time, what did you actually do? Were they actually generating these…

Smith: Of course, the first time you enter Antarctica is when you enter it on a ship. We first of all went to South Georgia and I well remember being on the Monkey Deck, which is right on the top, to get a really good view, everyone up there with their cameras, and we approached South Georgia. It is an absolutely stunning sight. It's a long island, a couple of hundred miles long, I think. Mountains, quite high mountains, glaciers…very, very spectacular. It is an unforgettable sight steaming into South Georgia, with all the bunting flying on the ship because it was the maiden voyage of the ship. The ship was brilliantly painted because we had all been doing that on the passage through the Tropics because they hadn't quite finished it in the shipyard. It was quite an unforgettable sight.

[00:23:09] Lee: Do you remember any teething troubles with the Bransfield?

Smith: Yes. There were a lot of things that they hadn't got fixed. One of the main things was the stabilisers. You go through very rough weather going across the Drake Passage to the Antarctic. They had put in some stabilisers, which weren't the active type where ballast water is pumped from one side to another in response to the way the ship is moving to correct it. This was a passive system, where you rely on the lean of the ship for gravity to move the weight across to bring it back. A good idea in principle but they hadn't got it quite right. In fact, it was tending to make it worse. They also had vibration problems on the propeller and everything was vibrating to bits at the stern end. And it was unfinished! I remember we had to put up lots of cupboards and shelves and knobs and all sorts of things to finish. They had had to leave in a real rush to make the season. I didn't have much experience of ships so I didn't know what was normal and what was not normal. But I do know there was an awful lot of chipping and painting to do.

[00:24:37] Lee: So when you got to Halley, and the scientific side of your quest emerged, at that point what were you actually doing? Were they already generating VLF themselves?

Smith: At first, you do not get on with your programme at all. When the ship gets there it is all hands to unloading the cargo and getting that sorted out. All the things you have to do to keep with the logistics for keeping the station running for the year. You do get a very brief changeover with the people who have been there that winter. You do not really get started with your programme until the ship has gone. Then you open your boxes and start setting things up. There had been a low level VLF programme the previous year, so I took over that. I had to put extra kit on in a new hut. One of the first things I had to do was to put a new aerial up. Before the winter closed in, all the outside work had to be done fairly quickly before it gets too cold and too dark. I had a kit of bits to put a lattice tower up, of 12 meters, or something. We hadn't actually trained to do that because the mast was late. It came as a series of sections and a bag of nuts and bolts. You had to figure out how to do it. I did get a bit of help on that. It is not quite the way you would do it now. No such thing as fancy mast climbing harnesses and hard hats…It was very much 'I think this will work!' [Laughter] Then we got the new recording set-up going ready for the Ariel 4 satellite.

[00:26:43] Lee: So at that stage you were purely receiving VLFs

Smith: Yes. That is all you do. You can't transmit because you need huge power. The Americans do at Siple Station but we have never been able to support the expense. You need huge amounts of power because the wave lengths are very long. To get efficient transmission of a radio signal you need an aerial that is of a comparable size to the wavelength. You can't do that with VLF because the wavelength is 100s of kilometres. The consequence of that is that it is very inefficient to transmit. You need huge amounts of power/input to transmit a small amount of power/output. All the amount of power that you have converted appears as heat and you have to have fancy cooling systems to take the heat away. So we have never transmitted. But nature is a very efficient and powerful transmitter. Those chorus waves for example are very powerful. We were just receiving with a passive instrument. That's what makes it quite attractive to people who fund the programme. You get very good research results out of a very cheap system to actually install. All you need basically is an aerial system. We just used two vertical loops hung from a mast. You plug it in to what is essentially an audio amplifier and some kind of recorder. We just used an audio tape recorder. That is all you need really although there are all sorts of fancy add-ons.

[00:28:38] Lee: What were you recording on?

Smith: A reel-to-reel 'Uher' tape recorder in the early 1970s.

[00:28:55] Lee: They only recorded for 15 minutes!

Smith: That's right. We had some long play tapes, which lasted half an hour. If you wanted to do a long continuous run, which we did, you had to go out to the hut, which was quite some distance off station because you had to be at a quiet site. You would put a tape on…you had a stack of tapes, and you had a little alarm clock, which you would set for 30 minutes. When it went off, you would wake up, take that tape off, label it, put another tape on, and you had about another 20 minutes in which to continue your sleep, until the next tape. We didn't do that very often, but that was the sort of thing that you had to do.

[00:29:38] Lee: That wasn't 24/7? You were only recording at certain times.

Smith: We had a recording programme, where we would record for half an hour twice a day. Of course we had to catch the over flights of the satellite once it had been launched. We got these times coming in on the telex when the satellite would be passing over Halley Bay or close to it. We had to make sure that we were recording at those times.

[00:30:13] Lee: Why?

Smith: The idea was that you wanted to compare the signals received on the satellite with what was received on the ground just underneath and see what the relationship between the two was. Try to work out where these signals had travelled. Ironically in the event we never actually did that.
That is the way that science is! [Laughter] But that was the thinking behind it, the rationale.

[00:30:42] Lee: Would you record because you knew there was activity? How did you know when there was activity before you recorded? Was there a loudspeaker of some sort?

Smith: We must have had some sort of audible warning. Certainly we did have in later times. We had a monitor in the main base and we would listen to it. We had some very crude system because I remember running out some Don-10 telephone wire, which is basically what the Army had used in WW2. It was essentially a couple of copper cores with a steel strengthener to make it strong, so you can put tremendous stress on the telephone cable. You need this in a military situation. We had got miles and miles of the Don-10 stuff so we connected an output of the receiver to one end and we had some headphones at the other. We listened in now and again. Later we had a different system where all the recording kit, except the pre-amplifier, was in one of the main labs. Only the sensitive bits were off-station. So you would have the background signal going on all the time so you could tell if anything unusual was happening.

[00:32:11] Lee: Was this signal at any time displayed visually?

Smith: Not at that time. Later, yes. This experimental work on VLF has two sides; the simple side, which is recording the signals, and the more complicated side, which is analysing the signals that you have recorded. The analysis process is really spectrum analysis, and that has evolved quite a lot over the years. It uses quite complicated, sometimes difficult to use, and expensive techniques. That is the way that you could see the spectrum of the signals. But in the early days we couldn't supply that kit to the Antarctic. We did it back in the lab back in Sheffield or Cambridge. Nowadays they can. They have this moving spectrum, so they can see exactly what is happening at any time

[00:33:16] Lee: So in those early days the tapes were stacked up, brought back to Sheffield, and played back there?

Smith: Exactly. So all they [Base personnel – Transcriber] could do was to listen to it. We sent them some sample tapes down south and said, "This is what some of the things you expect to hear should sound like". They got training in Sheffield before they went and we would play some tapes from the previous year back to them. But you just had to use your ears. There weren't any visual clues as to what was going on. So it was a bit limited, and it was quite time consuming to analyse the data. I remember when I first got back with this pile of tapes, back to Sheffield, the main analysis instrument they had was called a Kay Electric Sonograph. It was a very big heavy beast that sat on the bench. On the top of it, it had a cylinder with a vertical axis that could spin at two speeds, slow and fast. A strip of chemically treated paper would be wrapped round this cylinder and an electrode would scan up and down the cylinder vertically. Around the base of this cylinder was an electromagnetic recording strip. What you would do, you set the cylinder going at the slowest speed. It took two seconds for the cylinder to rotate. You plugged your signal in from the playback tape recorder, and record two seconds of data on the magnetic strip. Then you switched it [the sonograph – transcriber] to payback mode and fast speed. The cylinder whipped round very fast and played back the two seconds of data through a filter which gradually changed frequency whilst the electrode moved up from the bottom to the top of the drum, making its mark on the paper whipping round on the drum. The result was you would get a blackening of the paper according to how strong the signal was at each frequency. You get a two dimensional spectrogram with time along the horizontal axis and frequency along the vertical axis. The blackening of the paper showed how strong the signal was at that time, at that frequency. That is what we used to analyse the tapes. The problem was, it took a couple of minutes to make one of these spectrograms, and that was only two seconds of data. You have a whole pile of tapes, each of 30 minutes. So it was quite a problem to analyse the data using that system. But we did! A large part of my time when I first came back from the Antarctic was using the machine to make stacks and stacks of spectrograms.

[00:35:44] Lee: Was it boring?

Smith: At times, yes! It was also somewhat unpleasant because the chemical paper, when the electrode burned the trace on it, emitted very nasty, and I am sure, highly carcinogenic fumes which were supposed to be sucked out by a pump. But it didn't always work too well, so you got a horrible smell. It would certainly be banned under Health and Safety these days.

[00:37:12] Lee: Ok, so you had got your information on paper, what was the next thing that was done with it? Why were you doing all this?

Smith: Originally, the focus for quite a few years was on the Plasma Pause and the Plasma Sphere. The Plasma Sphere is the region round the Earth, which has a relatively high density of plasma, which are ions and electrons all mixed together. It is relatively cold. Then there is a very sharp boundary called the Plasma Pause, and outside that boundary the plasma has a much lower density. It is very rarefied and very hot. So there is a boundary layer, which is quite interesting physically. It had been discovered in the early days by the Stanford Group, in the early 60s. We focused on that, at least initially. It was a topic of great interest. How does the Plasma Sphere work? What is the shape of the Plasma Pause? We collaborated particularly with the Stanford Group because they had Whistler recordings from their station at Siple, which was at a similar latitude to Halley. So by looking at simultaneous Whistlers from the two stations we could map the surface structure of the Plasma Sphere and the Plasma Pause between the two stations, which was quite a breakthrough. The way we did it was to measure the shape of the Whistler traces on this bit of paper. You would get one of these pieces of paper, 6 inches high by 18 inches long, and it would have a series of black curved traces on it. Each was a Whistler. You needed to check the mathematical shape of the curve of each trace. It would tell you where the Whistler had travelled and what the density of the plasma was along that path. That was what you needed to do because that would tell you where the Plasma Pause was. The signature of the Plasma Pause was a sudden change in the characteristics of the Whistler. As soon as the Whistlers got to the Plasma Pause, the density would drop and the Whistlers would start travelling faster because there was less plasma to slow them up. The Whistlers would appear earlier on the trace. That was how we did it. It was a very tedious business.

[00:40:24] Smith: How do you measure the shape of this thing? Essentially you do it by sticking this spectrogram down on the paper and measuring the two co-ordinates along each bit of the Whistler. You measure the X co-ordinate horizontally and the Y co-ordinate with a ruler, and then say that point on the middle of the trace is so many centimetres from the left-hand side of the paper and so many centimetres from the bottom edge of the paper. That must mean that it is such and such time from the start of the recording and it has such and such a frequency. That is what we did. It gradually got more and more automated. We started by having a digitizer. It was called a D-Mac digitizing table. It was a huge machine connected to a paper tape punch.

You would stick the spectrogram down on the machine and you would have a glass curser with cross hairs on it. You would move the curser to the place where you wanted to record the co-ordinates of, and press a button. The paper punch would write some numbers in [the form of] punched holes on the tape, and that would be your recording. You would do this all along that Whistler trace, and the next dozen on that spectrogram…then the next spectrogram…and the stack of spectrograms. It was a tedious business! I spend six months analysing half an hour of data because that wasn't the end of it. Once you had the paper tape you then had to take it to the main University computer centre. Feed in the tape read the numbers and then get some Fortran program to do some analysis. It was very time consuming! But we did it1

[00:42:35] Lee: Let us talk about how instrumentation developed. I gather that you were partly responsible for improving the recording instrumentation systems. Tell me about the SEAL station.

Smith: That was an interesting experiment. It had it origins in when I was wintering at Halley, I guess, in 1971, when we were doing the Ariel 4 recordings. I thought 'we are looking at one place on the ground and what is going on in Space. To get more information, we really should look at two places on the ground. Can we do that from here now?' I had a spare receiver and I could make up aerials with spare cable. 'Why don't we hop on a sledge and go off someway into the distance and make some extra recordings'. To be quite honest, it was much to get a good excuse to go exploring the Antarctic as to get the data. All the other guys on the station thought that is a good idea for 'if you go off for scientific purposes, that will give us a good chance to go and do it. They [BAS Headquarters – Transcriber] might not let us go if it wasn't for Science.' So we wrote this proposal up. All the expertise was there for going across the hinge zone on to the inland ice because there had been a tractor party for Geology to go to the Shackleton Mountains a year or two before. They had marked all the route out, and the expertise for doing that was still on Base. So we thought that ' we will go part way along that route to the Shackletons.' We went to what they called Depot 200, which was two hundred miles from Cross Roads. This was the first safe place you could put a depot up on the ice shelf above the crevassed hinge zone area. We stayed there for a couple of weeks making the recording. We bought them back and it was interesting to compare them. There are differences when you go that sort of distance. So I had had that experience which was my idea. I thought ' this could be quite a useful technique'. What we were trying to 'get at', which wasn't known in those days, was 'if you get a signal coming down as a Whistler, how close do you have to be to see that Whistler and how far away do you have to be to see different Whistlers?' That was the sort of question that I was trying to answer. So I proposed a follow-up to what I had done in '71, which was to set up an automatic station that would run itself for several months up on the plateau. Because it was unmanned we had to get the data back somehow. We had to have a radio link. We did all the calculations and because of the shape of the way in which the ice rises up from sea level, you could be almost on the edge of the top of this rise and get a direct line of sight back to Base. We planned to put the automatic station at that point. We called it SEAL because it was the 'Sheffield ELF/VLF Antarctic Laboratory'. So at Sheffield we built this insulated box, which had the instrumentation inside it. The aerials were not a problem. We had batteries – NiCads – and a complicated thermostatic system to keep the temperature right inside. Then we had to power it, which is often the problem with these systems. There aren't too many options. It was technologically difficult to use oil because generators with their mechanical bits would never run through the winter. You couldn't do these RPG type things – radio-isotope – things because of the red tape about radio activity. You couldn't use solar panels because you wanted to record data during the winter when there isn't any sun. So it has got to be wind power. There is plenty of wind up there all year. We looked into all types of wind generators. In the end we decided to by one 'off the shelf' from Switzerland. They were using these things in the Swiss Alps in fairly rugged conditions, so it was going to work OK in the Antarctic. It did for a time but then it failed and that was the end of the recordings. But we did get some data. So that was a field station…it was an interesting learning curve.

[00:48:38] Lee: Once the wind generator failed in the middle of winter, it was abandoned?

Smith: Well, you just do not get any more data. Then you go back and sort it out in the summer. We got two stabs at it. We sent a repair party out and we repaired it the next year with improved kit. I think the problem we had was one of the propellers broke off. Metal fatigue. It doesn't work very well with a missing propeller. But interestingly enough we used that technology later on in the AGOs, which came along much later on with much improved systems and so on, and had much more effort spent on them. (The AGOs are a network of six unmanned Antarctic Geophysical Observatories housing instruments to collect data about the earth's ionosphere and magnetosphere at high latitudes, now running in the remote reaches of Antarctica. The AGOs operate all year long, including over the long polar winter. These small trailer-like observatories measure eight-by-eight-by-sixteen feet and provide 50 watts of electrical power to the experiments. They store data to be retrieved later during the Antarctic summer. The AGOs also report on weather and their own status via satellite - Transcriber)

[00:49:18] Lee: What we haven't discussed is, why was Halley a good place to do this?

Smith: Good question. It was fortuitous in a way. There was a station at Halley, set up in the International Geophysical Year (1957 – 58. Transcriber). You can get to Halley whereas it is harder to get any further south in the Weddell Sea because the ice stops you. It was at the right latitude, which was one thing. Physical processes in Geospace map along field lines because the magnetic field controls a lot of the physics and it turns out that the nearer you get to the Poles, the further out into space you are looking along the magnetic field. So going to a high latitude station like Halley, you are mapping at an interesting region near the Plasma Pause. You are also at a very good longitude because you are near to what is called the South Atlantic Anomaly, a region where the magnetic field of the Earth is weaker than anywhere else. That causes increased amplification of VLF signals. It is conjugate to a good active region of thunderstorms so you get lots of Whistlers there. You have got a very radio quiet environment. If you try to do this sort of thing in the Arctic, it is mostly ocean up there and you haven't got any land to put the station on. If you do find somewhere say in Siberia, you have all sorts of problems with… Well Siberia is out anyway for logistic reasons. Most places like in Scandinavia you have big problems with long power lines and Mines and various things. Anytime you get 50 Hertz of power you get a small amount of harmonics, which are multiples of that frequency. Our equipment is so sensitive that it is absolutely wiped out by these harmonics. We just can't deal with it. So that is another reason for going to the Antarctic. Even at Halley our current receivers have to be a couple of kilometres from the main stations power lines. The other thing is, you have all the other instruments at an observatory that give you the extra information that you need. So there are lots of reasons why Halley is very good for this.

[00:52:33] Lee: So it is great for the phenomena but there are added difficulties in trying to operate all the equipment.

Smith: Yes, but that is all part of the game. That is part of the challenge. That is why it is such fun.

[00:52: 43] Lee: Did you have any great successes or devastating failures?

Smith: I can think of a few failures! Things like when the aerials fell down. The aerials are vertical loops of wire, which are suspended on a tower. You raise them up the tower, especially if it is one that you can't climb, on a pulley system. We found out that when the wind blows in the winter, and it flaps the ropes against the mast, at some point they are quite liable to wear through. The aerial falls on the ground and the signal goes away. So we replaced the rope with wire rope and that solved that problem. The SEAL station was a partial failure. We did get finger trouble…staff on the ground not doing quite the right thing. We did get one…it has happened more than once actually. The aerials are two vertical loops; a north-south loop and an east-west loop. At the ends of the loops you have a north plug and a south plug, and an east plug and a west plug. You have to plug them into the receiver. There is a different channel…there is a north-south channel and an east-west channel. You have to plug into the right sockets. If you don't get it right the same signal goes through both loops and both channels so you get exactly the same signal on both channels and you lose a lot of information. One of the most serious failures was the fire in the VLF hut. Nobody was injured fortunately. As I have mentioned to you, you have to have the sensitive instruments well separated from the main base. So it was about a mile away. It was too far to provide power for heating so we decided to have a paraffin heater with a little fuel barrel on top. It worked well for a while but it was in a wooden hut. We don't know how or why, but the hut burnt down. The people on base could see it burning but because it was a mile or so away, by the time they got put there, all they could do was to take pictures of it. I have some pictures of it and there are some on the Web Site. It wrote off the experiment for the rest of the year. We recovered pretty quickly. We sent out a new hut and gear.

[00:56:50] Smith: Successes? Successes on the recording side have just been due to improving technology. We have managed to go to continuous recordings because it is easy to get data and to store data because it has got more reliable. We have improved our documentation. We have improved our spares. We have improved our training. So it is continuous improvement in the system. As far as the analysis side…the output side…probably the two things that I am most proud of is the work we did in the first part of my career on the Plasma Pause. Particularly working with the Stamford Group and Don Carpenter, who had actually discovered the Plasma Pause, with Whistlers. It was a privilege to work with him for many years. He is a great guy and a great friend of mine. Towards the later part of my career we started to look at sub-storms. We discovered or rather rediscovered…people hadn't made much of it before. When you get a sub-storm, which is a fundamental magnetospheric process, one of the things that it does generate is a burst of what we call 'chorus'. 'Chorus' because it does sound like bird-song. We discovered that pretty well every time you got a sub-storm you got one of these 'chorus' bursts. You can tell a lot about sub-storms…not at least just when it occurred, accurately. By looking at these things in a way that other techniques couldn't…in a complementary way to other techniques looking at sub-storms…we made quite a lot out of this. We found out quite a lot about sub-storms. We found out the average rate at which they occur. It is a bit like an earthquake. You build up energy in the system, which on the case of earthquakes is stresses in rocks, but in the case of sub-storms, is magnetic energy in the tail of the magnetosphere stretched out partway from the sun. Then, as in earthquakes, something triggers very suddenly the release of that energy. No one quite knows what that trigger is for a sub-storm so it is very hard to predict exactly when a sub-storm is going to go off. What you can do is predict on average how many sub-storms you are going to get at different times of the year and at different parts of the solar cycle. We could do that with our data. One of the things that we could do with our data is look over a very long length of time because with a continuously recording system we had been recording for years and years. Most of these other systems that other people had been using to record sub-storms they just set them up for 6 months, or satellite experiments for a year or so. They have got a limited data set. We have really something unique, very long, very continuous, very uniform sets of data. I think that is one of the things that where, although you might think that that is pretty mundane, it is a bit like…I wouldn't claim that it is on par with the ozone hole story, but there they discovered the ozone hole in the Antarctic data just because they had been doing this continuous repetitive experiment year after year and they saw the change. That is one of the great strengths of our experiment in that as it has developed we have this very, long run of recordings.

[01:00:49] Lee: What is the value of knowing more about sub-storms and their frequency? How can you use that information?

Smith: Well that is the key process by which electromagnetic energy from the sun via the solar wind enters the Earth's atmosphere. A lot of energy is put in there. You get heating of the upper atmosphere. You get strong electric currents produced. You get the Aurora, but you also get effects on engineering systems. The things that are quoted are induced currents in power lines, which cause transformer failure, extra corrosion in long pipelines, anomalous events in satellites, which in extreme cases can cause failure in communication satellites. There are quite a lot of practical effects of this process. But the main thing is, we wanted to understand it better.

[01:01:57] Lee: When the Aurora Australis appears, that is a busy time for you, is it?

Smith: Where we are, at Halley, you see an Aurora pretty much every night. We are not in the Aurora Zone, but very close to it. It depends on the time of the solar cycle. When I wintered it was very close to the solar maximum and we saw the Aurora pretty much every night that it was clear. Some times it was what they call a quiet arc, which you can see on the horizon around midnight quite away to the South. But at other times it was very active and come overhead. It is an absolutely amazing sight.

[01:02:37] Lee: But were you recording then?

Smith: Yes we were…at times anyway. There is not such a close correspondence between what you see on the VLF and what you see on the Aurora, as you might expect. The field of view is very different. With the Aurora you are only looking a couple of hundred kilometres from the zenith. With the VLF experiment you are looking out to a 1000 km because you gather these VLF waves from a very large area into you receiver. So there is a mismatch between field of view, which makes it so that you are not really looking for detailed correspondence between the Aurora and VLF. Towards the later stages anyway we were running on a more or less routine continuous programme and we wouldn't want to change it when an Aurora came over. Even if we did, it got very automated. Not like when I wintered, but in later stages you would just type up the number of the programme you wanted to record on the computer and it would do it automatically.

[01:04:04] Lee: To a layman, the Aurora would appear to be a very significant event, but it did not have great significance to the sort of work that you were doing.

Smith: No really, in terms of the way we were focused at the time. We were concentrating more on sub-storms and we were concentrating on the Plasma Pause. We have done some work on the Aurora current systems, which are really part of the sub-storm system. You can get a handle on that using the sub-storm chorus events. So we have done some work relating to the Aurora, yes.

Part two

[01:05:17] Lee: How did your VLF research relate to other Antarctic research going on? Does it knit into something else, or does it ‘stand alone’?

Smith: Well, it is never going to be ‘stand alone’ because you are looking at part of a very complex system - Geospace. There are many different aspects of that and you can study it in a variety of ways, using all sorts of radio and optical instruments. This is what we are doing at Halley. We have got active radar experiments probing the system. We’ve got quite a number of passive instruments like aural cameras. We are measuring magnetic fields, electric fields, and that forms part of a system of measurements that tries to get the most information as possible about the system we are studying. Other countries are doing that at other stations in the Antarctic, so that all ties together. So that is one answer to the question. The other answer is there is great advantage in having multipoint measurements of the same quantity, because then you can see how that particular phenomenon is distributed across the Antarctic and how that maps up into the magnetosphere along field lines. So one of the things that we have done, and been doing for quite a time is to compare our VLF measurements with other VLF measurements at other stations, where we are essentially looking at the same thing from a different point. Sometimes the other point has been another BAS station, like Faraday Station. If you do that you get spatial distribution information and that can be very valuable in tying down where these aural systems are, where the current systems are, and comparing that with what the theory says they ought to be.

[01:07:22] Lee: Is there something of a discrepancy between fact and theory?

Smith: Well, theory is always over simplified by its very nature. The reality is generally more variable, more messy, more complex. But you have to try to pick the patterns out.

[01:07:40] Lee: A couple of detailed questions. Does this have any relation to the Van Allen Belt? [The Van Allen belts are a collection of charged particles, gathered in place by Earth's magnetic field. They can wax and wane in response to incoming energy from the sun, sometimes swelling up enough to expose satellites in low-Earth orbit to damaging radiation.]

Smith: Yes it does. The Van Allen Radiation Belt is basically trapped protons and electrons, fairly fast moving protons and electrons, that get trapped in the Earth' magnetic field. It doesn't really affect the protons but as far as the electrons are concerned, they interact very strongly with the VLF waves. You can get processes were you can get either the electrons give up energy to the waves…the electrons get slowed down and the waves get amplified, or the reverse… electrons can get accelerated and the waves can get damped. There is this resonance between the electrons and the waves where these processes are going on. But determining exactly when and where the energy is going to go one way or the other way is not clear but it is quite important because when you get a great enhancement in radiation belts you can get electrons accelerated up to very high energies, which are popularly known as killer electrons which means that they can damage space craft and other systems in space…astronauts and whatever. So in that respect the waves are an important part of the overall picture.

[01:09:19] Lee: So the research that you are doing could assist the space programme in avoiding damage?

Smith: Yes, indeed. Not so much my own work but my colleagues, Richard Horne and Mervin Freeman, have been involved in a project that has been providing information to the space insurance industry where they have been giving them information to quantify the risks to space craft based on measurements on the current wave environment. We need to do a lot more work on that because we are quite a long way to having a really comprehensive picture of what the wave activity is like in the main magnetosphere. That is the on-going goal. There are much better empirical models of the particle distribution…the electrons and protons…but the wave is less well known. The work we can do both on the ground and in space observations means that we can develop that to a much more comprehensive level and get a very good model on what the wave activity is like, and that will then help this kind of risk assessment exercises.

[01:10:43] Lee: You are giving me the impression that you might think that these waves come in cycles so that there can be quiet periods and busy periods and you can launch your shuttle in a quiet period.

Smith: Well there are lots of cycles at work. The whole system undergoes a 24-hour cycle in activity. That is the alternative…where it goes past the sun and there is always a very strong 24-hour cycle. There is an annual cycle. There is a 11 year and 22 year solar cycle. So there are those fixed cycles, but there are also the irregular…you shouldn't really call them cycles…but there are irregular variations in activity…very large solar storms and so on, which are more difficult to predict.

[01:11:28] Lee: You can't spot them, can you?

Smith: You can, and there are ways of doing that sometimes. There are instruments up there that are trying to do that. The problem is, what these corona mass projection…is what they call them…big masses of coronal material thrown out from the sun…

[01:11:50] Lee: Solar flares?

Smith: No they are not solar flares. These are mass, not radiation. If you are looking at the sun, it is quite easy to see then going out from the side…to see one coming directly towards you is not that easy. That is the hard thing. There are people trying to do that…it is quite tricky. There are solar predictions. There are various websites where they will try to predict these things. The next part of the process is trying to model how that particular storm is going to affect the Earth's environment. Where is it going to hit? Which orientation will the Earth be when it's coming towards the side facing the sun? How is that going to spread round the rest of the system? What waves are going to be generated? What current is it going to generate? It is a very complex business, but what you can do is try to learn. Like weather forecasting, you can look at patterns and you can see how things change and how situations, which you have observed in the past, have developed, and then keep on trying to refine your models so you can predict what is going to happen in any particular case. We are a long way from that but we are getting there.

[01:13:04] Lee: That kind of work is rooted in the kind of work that you are doing.

Smith: Yes. Every ones work builds on what has gone on before.

[01:13:10] Lee: I mentioned solar flares before. Perhaps that was a mistake or do solar flares also have a rôle to play?

Smith: Solar flares have a relatively marginal effect. They affect the ionosphere quite a bit, especially the lower layers of the ionosphere. So when you have VLF waves travelling towards your receiver horizontally, coming out of the magnetosphere somewhere else or else they come from a transmitter, they can effectively lower the height of the ionosphere that the waves are reflecting off. You can see that effect and you can work out the strength of the solar flare from the effect. Now I haven't been working on that myself very much but we do have some colleagues in New Zealand who have recently managed to measure the strength of a flare using that technique from their VLF operation, which NASA couldn't actually measure…it was such a large flare that it overloaded their detectors. So that is just one example where you can get a handle on these big flares using the VLF technique, which is difficult to do in other ways.

[01:14:30] Lee: Do you foresee a time when we might be able to predict this kind of activity using very low frequency measuring techniques?

Smith: I think it will probably be not just VLF but it will form an important part of the picture. Just like with ordinary weather forecasting, you wouldn't be able to do much good if you only measured pressures…you have got to measure pressures, temperatures, humidity, wind speeds, all the rest of it, and build up the whole picture in your computer model. But one interesting development, which was just starting to kick off when I retired, was an automatic Whistler detector and analyser which would give you a real time map of the density in the plasma pause. You remember that we talked earlier on about scaling the dispersion shape of these Whistlers using a very tedious method? If you can automate that then what you can do is that you can be constantly recording Whistlers at Halley…and there are Whistlers there all the time…every time you see a Whistler, instead of having to laboriously analyse the shape of this curve, if you can get the computer to do that, put in the appropriate model, then it will tell you what the plasma density profile is in the magnetosphere at that particular instance at that latitude. That is something that our group has been working on with colleagues in Hungary who have been developing the software. We have got the instrumentation, we have got the data, we know a lot about Whistlers at Halley, they are quite complicated, but it is not an insurmountable challenge. If you can do that, it is very interesting, because you can basically map the whole of the plasma sphere by using a few Whistler recordings on the ground. That is an exciting development.

[01:16:30] Lee: Let us move on to a more human scale of things for a bit. You were not alone but you also worked with overseas or foreign collaborators.

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Smith: Yes. I think I mentioned the work I did with Stanford University in the USA. They were one of the pioneering groups in studying Whistlers and applying them to some of these problems like studying the plasma pause. In fact Don Carpenter, who I work quite a bit with, he with a Russian scientist, discovered the plasma pause. I spent a long time working with Don, both at Stanford and elsewhere. We have written quite a lot of papers comparing BAS data with Stanford data from Siple Station mainly, also from Palmer Station. That has been a very fruitful collaboration, and also very enjoyable. It is nice place to work Stanford. I have also worked with colleagues in New Zealand, Hungary, Finland, South Africa, Japan. Quite a lot of countries in the world…anywhere where there is a VLF group. Not every country has them. Little work is done on them in Germany, to give one example, or Canada. The other thing that I have become involved in is, there is an international working party called VERSIM, which is VLF, Elf Remote Sensing of the Ionosphere and Magnetosphere – a VLF Experimenters Club. Almost all people working on VLF are members of that working group. I was co-chairman of the working group for 18 years. That was a good way of keeping that community in contact with each other. We had a Web Site, we had a mailing list, we had a newsletter. We organised sessions at international conferences. We organised joint recording programmes, exchange of data and all that kind of thing. That is still carrying on, though I am not in contact now.

[01:18:56] Lee: Are there any memorable characters that rubbed shoulders with I this kind of work?

Smith: I guess there are. Don Carpenter is quite a character, and the leader of that group, Bob Helliwell is also quite a character, at Stanford.

[01:19:12] Lee: in what respect?

Smith: They both have a tremendous experience with Whistlers. They are both very enthusiastic about that kind of work. They know a lot of people in the USA. They are very talented scientists and very good at getting information out of their data. It is actually an engineering department and they do very good engineering there. They have had a whole load of very talented students there over the years, some of whom come from countries all over the world. It has been very rewarding to work in that group. Currently on the scene these days you have got Graig Rodger who comes from New Zealand, who is a very than life character and very, very dynamic. He is collaborating very closely with the BAS group as well. They are all very nice people, and we enjoy each others company, because we have something in common, we all have enthusiasm for working with VLF data.

[01:20:33] Lee: Would it be fair to say that the UK is playing second fiddle to the USA or is the reverse true?

Smith: I certainly wouldn't agree to the first suggestion. We are at least equal to the USA in terms of what we can do and the sort of quality and quantity of the work that we do, especially with our collaborators. The current BAS crew, lead by Mark Clilvert who took over from me and was one of my PhD students, has developed links with scientists in Finland, New Zealand, South Africa and the USA. That group, with the collaborators, would be easily the equal of any group in the USA and anywhere in the world.

[01:21:30] Lee: So we are 'brand leaders'?

Smith: In this particular area I would say we are, yes. I am proud of that. I mean we have worked at it. There has been a lot of work done over the years. You build on past experience and the work of people who have passed through your group. We have had a succession of very able research students who have contributed over the years. Almost every year we have taken on casual labour, usually Cambridge University undergraduates, for 8 to 10 weeks in the summer. We have given them projects to do. Some haven't done it very well but others have done a brilliant job because they are bright young people. So all that effort has built up to make our group a very important group on the world scene. But you should ask other people that really.

[01:22:30] Lee: Earth is not the only planet to create VLFs? Jupiter and Venus, I think you said?

Smith: Venus doesn't have a magnetic field so the situation is rather different. It has lightning because it has weather systems and you get VLF from lightning.

[01:22:55] Lee: Have you picked up signals from…

Smith: No they are too localised and too weak. You have to be too near the planet. Jupiter is rather different because it has a very strong magnetic field, probably the strongest of any planet in the solar system. It is also very massive and that means although you get the similar kind of waves, Whistler waves, they are not really in the VLF frequency range.

As you go to more massive systems, you get different frequencies of waves. The magnetic field is also very much stronger which means as you increase the magnetic field you basically increase what we call the gyro-frequency. This is the frequency that charged particles gyrate around the field. That affects the frequency of these Whistler waves. If you look at the equivalent kind of waves on a planet like Jupiter you will find that they are quite different frequency ranges. They are not really VLF. Also you would not really see them from Earth. They would probably be trapped in the system, like they are in the Earth. You might get a little bit of leakage but…

[01: 24: 10] Lee: Much of your time in the Antarctic was spent at Halley, 1971 until quite recently.

Smith: Indeed.

[01:24:14] Lee: Tell me a bit about how you think Halley has evolved and changed in those three decades. Are we going from mud-hut to skyscraper?

Smith: I think you almost are. It is quite a good analogy that because when I went there we were living in Halley 2. There has been a successive series of bases, numbered from 1 to… the current one, which is 5, and 6 is being planned and built now. The reason is each time you build one, it has a limited live time because the ice will bury it or move it away…so you have to keep re-building. I was in Halley 2. You could still get down to Halley 1, which was a long way below the ice surface. I have since seen Halley 3, Halley 4, and Halley 5. At each stage you have got more and more technology, more and more confortable living. For example, now-a- days you have flush toilets, in my day it was just a hole in the snow. That is just an example.

[01:25:31] Lee: That was a mile post was it?

Smith: Some people might say so. Because we were underneath the ice, like Halley 1, 2, 3, and 4 were, the pressure of ice gradually built up as the weight of ice above the Base gradually crushed it. Certainly when I was living in Halley 2, it was getting crushed. It was due for replacement. It was replaced by Halley 3 the next year. All the beams were cracking. There was water coming in because as soon as you got a crack in the ceiling heat escapes, melts the snow, the water drips in, hits the floor and refreezes. So you got things like layers of ice on the floor. It was quite cold at times because all the insulation had broken. So you get this quite difficult living in a way. And the fact that because it is a long way underneath the ice surface, every time you wanted to go out you had to go up a series of ladders. You would get togged up and then you would go out of the door and you would into a shaft and go up the first ladder. Up a series of ladders and you would get to the top of the shaft, over the top and then you would be on the surface. Coming back you would have to do the same thing in reverse. Nowadays they don't do that because it is an above the surface Base in Halley 5. So you are above the surface. You have one set of steps to go up to get from the snow surface to the platform and then you are there. Very comfortable. No problems with insulation. No problems with the structure breaking up. We have built on that experience on how to make a comfortable Base. One of the things of course is that when you are under the ice, there are no windows. There is no point in having windows in the hut because you can't see anything. But now with the above surface Base you have got windows. You can look out and that makes a tremendous difference. When you can look out and see the sky and see the stars, the moon, and see the aurora. So I would say that is one of the things that have changed.

[01:27:45] Smith: Technology has changed a lot of course. Communications have changed out of all recognition. Now you have broadband, unlimited E-Mails and phone calls, web access. When I was there, personal messages were 100 words a month to your relatives. Even official communications were done on telex and it was very, very limited. Of course that had the advantage that you weren't supervised too much from back home. You had more autonomy. You were left to get on with it. Essentially you were told what to do at the beginning of the year and left to get on with it. Monthly reports, and that was about it. I think that there is much more close supervision now, and data being set back every day. I am not saying that that is a bad thing. One thing that you can say these days is that we are doing very much more science and good science than we used to. But then, I guess, that is due to the limitations that we had before.

There are things like we had dogs, for example, and we went sledging with dogs. They haven't done that for years. So you had those kinds of opportunities which people wont get now. But they get fun in other ways. Now a days they do a lot of this ski-kiting, which we never did. We did this sky-joring, were you get pulled behind a skidoo. People still like to have fun down there.

[01:29:37] Lee: The lot of the science has evolved too. Looking back does the science of 1972 appear to be a bit Mickey Mouse these days or is that unfair.

Smith: It is different. I don't really know what you mean by 'Mickey Mouse' science. Science is a continual process of building on previous knowledge. To do that, you have got to have that previous knowledge. There was a lot of good work done in the '70s. It was exploring the system, ok, incomplete knowledge. But then, as more work goes on people get more and more idea of what is going on, better and better theories, better and better models, better and better quality data, and understand the system better. But it is a continuous process.

[01:30:26] Lee: I was thinking more of the facilities available to you…more like a school lab than…

Smith: Yes it was simple equipment exactly. So in that way you were more limited in the amount of data you got, in the quality of the data you got. So you had to deal with those limitations. The amount of science you could do was less in those days. No computers of course…every thing had to be done with slide rules and log tables in those days.

[01:31:01] Lee: Pastimes? Did you have any pastimes in the '70s?

Smith: Yes, oh yes!

[01:31:06] Lee: What did you do with it?

Smith: Drinking of course…that has always been popular! I can give you a few examples…things like darts, snooker. People used to rig up a gym and do work outs. Reading was popular, listening to music, playing music. Then the outdoor things like skiing and skijoring. In the summer, people would kick a ball around. All sorts of projects. People would make things. Traditional thing was to make mid-winter presents. Make models. You have very good workshops there. You would have people, who had never seen a lathe or certainly not used one before, would have an opportunity to learn how to use machine tools. People would learn how to cook from the professional chef down there. They might learn how to stick needles in people's arms from the doctor. That sort of thing. You got the chance to develop new skills…that was quite popular. Languages were popular…particularly Spanish. A lot of people learned Spanish, so that they could go home via South America. People would like to get the football results from the radio. They wouldn't care about other happenings in the world really but you could get the BBC World Service with a bit of trouble. As long as people got the football results on a Saturday that was fine!

[01:32:49] Lee: How did they arrive…by the World Service or were they sent out to you specially?

Smith: They are now but they wouldn't be then. You had to rely on someone being able to pick them up on the World Service, which you couldn't always because it would depend very much on the conditions. It was HF then, and so HF is particularly unreliable in the polar regions because of the disturbances to the ionosphere.

[01:33:13] Lee: You talk about the Base cracking up under the weight of ice. I am not clear on this point but I am glad I have got the chance to ask you. Would Halley 2 have been built above the surface of the ice and then would have sunk?

Smith: It doesn't as such sink but snow builds up over the top of it. What happens is…You have some kind of foundation but essentially you build it up on the surface. When there is a blizzard, what happens is the wind picks up snow from the surface, blows it along, and as soon as it meets an obstruction, that obstruction causes the wind speed to drop, and that means that the snow drops out of it. It just builds up…it just drifts up until the roof is completely covered with snow. After that point it then builds up year by year. If you have a completely undisturbed site it will build up by a metre to a metre and a half a year just because of the fact that you have continually snow precipitation dropping and resting on the surface.

[01:34:17] Lee: At some point there would be so much snow it would start to crack…

Smith: Start to crack. The weight of the ice above.

[01:34:20] Lee: Did it crack up people as well?

Smith: [Laughter]

[01:34:24] Lee: Claustrophobia from being so far underground and not having any view?

Smith: [Pause] Yes. There is this thing called 'winteritis', where there is a tendency for people to get a bit depressed in the winter. You know, long hours of darkness and they can't get out, or if they do get out, there is not much to do. One or two people were subject to this but generally not. I think mostly…It varies quite a bit from year to year, I would say. There are some very good years. It is almost always a problem in the winter, if there is going to be a problem. When summer comes along, it is nice and sunny outside and you can do things, but it can be a bit miserable in the winter. Especially if people haven't got enough of interest to do in their work, or in their hobbies, to really make use of the time. Sometimes drink is a problem. So yes there are, just now and again, people who go off the rails just occasionally.

[01:35:33] Lee: You were Base Commander at one point. What years were they?

Smith: Yes. 1972.

[01:35:41} Lee: For one year?

Smith: I wintered for two years but the first year I wasn't Base Commander, no.

[01:35:44] Lee: Was there anything as Commander that you could do to alleviate the risk of winteritis?

Smith: Well we used to organise events. We organised quizzes. We had film shows. We organised dart competitions, fancy dress parties…just something to give people something to do that wasn't work to take their mind of things.

[01:36:10] Lee: Counselling?

Smith: Yes, sort of. It wasn't necessary very often. There was one guy that it was a bit necessary for. No…I hadn't been trained for that at all. By and large, it wasn't a problem. They were a pretty good group. There was a lot of work to do. A lot of the Base Commander's job is doing rotas. Rotas for people being on Night Watch, being on Gash …people took turns on washing up, washing the floors and all that kind of thing. There was the weekly scrub out were everybody turned to, except the Night Man, to scrub out the Base, empty out the rubbish, etc. Every now and again you had to go and dig up fuel drums, dig up food, boxes…you had to chip ice of the tunnels to keep them clear. There was a lot of what we called 'base work', just maintaining the Base, just maintaining what you needed to live, basically.

[01:37:33] Lee: When you were doing your rotas, did you sometimes think when you placing people together, did you consider whether they would get on together for a particular task? Were you creating a rota with a mind to how….?

Smith: Maybe occasionally. I would say, by and large, people did get on with each other...they had to. Most people had the attitude that even if it was not somebody that you would have chosen to be friendly with back here [in the UK – Transcriber], you knew that you had to live with them for the rest of the year. So you just got on with it and did it. Most people are pretty easy and generally very tolerant and easy going, and easy to live with, so it wasn't really a problem

[01:38:14] Lee: So you never found yourself locking up the drinks cabinet?

Smith: I never remember doing that, no.[Laughter].

[01: 38: 23] Lee: Tell me about the reunion…Halley's 50th Anniversary last year.

Smith: Yes 2006. Like many Antarctic stations, it was set up in 1956 for the International Geophysical Year [The 1957-1958 International Geophysical Year (IGY) was an international effort to coordinate the collection of geophysical data from around the world, including the complexity of Earth's oceans and atmosphere, geodesy, geomagnetism, and the role of the sun in Earth processes. It marked the beginning of a new era of scientific discovery at a time when many innovative technologies were appearing, using rockets, radar, and computers - Transcriber] So the 50th Anniversary came…well it was actually 1957, the IGY, but the Advance Party went in, in 1956. That is when Halley was set up. We decided that we aught to mark the occasion. I was quite involved with the 25th Anniversary Reunion in '81. Somebody else organized one for the Millennium in 2001, and at that reunion, people got together and said "well we should do something to mark the 50th". Because I had mentioned this, I some how found myself lumbered with organizing it. So I got together a little group and we had four years to organize it. The first thing we did was to set a date so everybody could have this in their diary four years ahead. Then we had to find a venue. We were aiming for quite a large turnout for the 50th, which we thought would be a unique occasion. We wanted to get a place that could cope with a fairly large number. So we went to this place in Northampton, a big hotel in the middle of town that seemed to have what we wanted. Then we set about trying to 'sell' the event. We tried to contact as many people as possible that had ever been to Halley or had had an interest in it. We did that by circulating publicity in BAS Club Newsletters and anywhere else we could think of. We also set up the ZFIDs web site. You probably realize Z is the code letter for Halley, and FIDs are just people who have been to the Antarctic with BAS. What that does, that is like an unofficial site…it has nothing to do with BAS at all…it is information about the history of Halley, and all the people that have been there. So you have got lists of people, and where appropriate, how to contact them. So it is bringing people together, and just by that Website being out there, we made contact with a lot of people who otherwise we wouldn't have been able to contact. In the end we had nearly 400 people attending the event. That was Halley people and their partners. Yes we had some women who bought their partners along. You have to be careful what you say these days. We had people from all decades.

[01:41:42] Lee: What did you do there?

Smith: It was a weekend... two days. We had an interesting talk from George Hemmen who was actually involved in the logistics of setting up the originally Halley Bay in '56. That was bringing in the past to people's attention. Then Chris Rapley, current Director of BAS, came and talked about the International Pole Year [The International Polar Year is a large scientific programme which focused on the Arctic and the Antarctic from March 2007 to March 2009. IPY, organized through the International Council for Science (ICSU) and the World Meteorological Organization (WMO), was actually the fourth polar year, following those in 1882-3, 1932-3, and 1957-8. In order to have full and equal coverage of both the Arctic and the Antarctic, IPY 2007-8 covered two full annual cycles from March 2007 to March 2009 and involved over 200 projects, with thousands of scientists from over 60 nations examining a wide range of physical, biological and social research topics – Transcriber], which took us into the future. We had some films, which had been taken at Halley over the years. We had a Reunion Dinner with a guest speaker, who was Captain Stuart Lawrence, captain of *RRS Bransfield* for many years, who relieved the station at Halley, year after year…an excellent after-dinner speaker. We had a live video link to Halley. We had an exhibition with some commissioned exhibits but also people just turned up with their own stuff, which was fascinating…photographs, models, lots of stuff that they had brought from their time at Halley. We time-tabled in a fairly generous time for just networking and chatting over coffee and at the bar.

[01:43:08] Lee: Tell me about the video link. What did you do with it? Did it work, first of all?

Smith: Oh it worked. We had a few nail-biting moments but it worked. We had a broadband link between Halley and the hotel, with webcam, microphones and speakers, and a projector at both ends. In Northampton, the webcam pointed at various people and various parts of the room. That picture appeared on one half of the screen, and the other half of the screen showed where the Halley webcam was pointed. So we saw picture of the dinning room and people eating their dinner at Halley, and people eating their dinner in Northampton. There was sound as well so you could talk to people and they could talk to us. There were text messages as well. It was a fine effort by the technical people who put it all together. It was video conferencing, if you like. That was fun…it was a first! We had decided to do this, and put it on the programme and advertised it four years before, when we had no ideas if it would work. We thought "In four years time, the technology would probably let us do it" and it did, just! That was pretty good. Everybody really enjoyed it. I had so many messages after the event saying, "Thank you so very much. We really enjoyed it. It was a fantastic event".

[01:44:45] Lee: You are in a slightly unique position of being in touch with so many ex-Halley people. Is there any thing that ties them in together? Have the majority stayed in science? What was the common denominator?

Smith: Well a lot of them weren't scientists any way when they were there. At least half the stations were technical people and tradesmen, plumbers, electricians, cooks, whatever. Those that were scientists some have stayed in science. They have done a variety of different things. Quite a lot have stayed in science. Some are university professors…very eminent people. One of them is Pete Gibb, who is a BBC Weather Forecaster.

[01:45:38] Lee: Is there something that you can grasp out of the air, which would describe a common denominator for those people?

Smith: I would say that without exception, they would say that Halley is by far the most superior of all the BAS bases. [Laughter].

[01:45:55] Lee: I am not surprised at all to hear that, but is there anything else you could say when you look at those 200 people, "what those 200 people have in common is…"

Smith: That is very difficult because they are a very broad spectrum of characters really. They probably all like to get together for a drink and yarn but beyond that no. They have different skills, different interests. They all obviously had that spark of adventure and wanting to travel, which made them want to go to the Antarctic. That is probably what they had in common. A lot of them are still spread around the world. We had people coming to Northampton from New Zealand, Singapore, Hong Kong, Australia, South Africa, USA, Canada…quite amazing really…Falkland Islands…yes all over the world

[01:46:55] Lee: Just going back briefly to your time as commander of the Base, what we don't really know is how you were selected. Do you know?

Smith: It is rather different now they have somebody who is permanent Base Commander, they call them, and then they have a winter Base Commander. So there are two actually, one is the man 'on the spot' and the one back in Cambridge, who just goes in the summer. Before, there was just one commander and a different one every year. So it had to be some body who was going to be wintering that year and it was normally somebody who had had the experience of living there the previous year. You wouldn't normally choose somebody who was coming to the Antarctic new, because they wouldn't know about it. So that narrows it down to the second year men. I was one of the older ones and I guess people back in Headquarters thought that I was probably the most mature and reliable…who knows. I don 't really know why. They just asked me to do it and I said, "yes" because there was a Base Commander's Bonus. [Laughter]

[01:48:20] Lee: Did you earn that bonus? Was it simply that somebody had to be Base Commander and had to take control, and be responsible…

Smith: Well I was quite fortunate because it was a really good team, apart from this one guy who went to pieces a bit in the winter but recovered again. But apart from that it was a pretty good team. They all supported me and we didn't really have a problem.

[01:48:45] Lee: Did everyone rally round the one guy?

Smith: It was difficult because he sort of withdrew. People did what they could. It wasn't a big deal, really.

[01:48:59] Lee: Did that worry you because you had an individual who wasn't fitting in. Did you feel as Commander that you had to reach out to this guy?

Smith: Yes, we did do that. It wasn't such a big deal really. He was doing his job…just about. He was functioning. He was fulfilling his responsibilities to the others. It was just that the rest of the time he took himself off and didn't socialise.

[01:49:35] Lee: So you had to decide how much to intervene?

Smith: Yes. It worked out in the end…as soon as the sun came back. Getting away from that subject a little bit…it is quite a well known anecdote but I think it one that does bear repeating…is the tractor rescue from the crevasse lead by a guy called Bruce Blackwell, a generator mechanic. A fantastic engineer, a really great guy who sadly died of cancer a few years later. Three or four years before, there had been a tractor expedition going to the mountains south of Halley. One of the tractors had dropped into a crevasse. The crew had managed to get out but they had not managed to salvage the tractor. So they left it there. Bruce, when he was on one of the trips, saw this thing and thought, "that would be an interesting challenge getting that out." So he planned it all out exactly how he was going to do it. Got his team together. Told me about it…and of course I had to give him the 'go-ahead'. I can't remember whether I involved Headquarters or not. One way or another, we managed to agree that he should do it. I went through all the risks with him. He went out with all these winches and things. They had a bit of an epic because they had got the thing nearly all out when it slipped back in again. But in the end they got this huge great tractor out which previously the original team had thrown up their hands and said that that is a 'write off'. They pulled this thing out. They put new batteries in it and everything else worked fine. It started first time. They drove it back to Base using long strings in case it fell into another crevasse. They weren't in any danger…they just had long strings attached to its levers and they just drove it back over the crervasses

[01:52:00] Lee: There was nobody in it? It was being driven by remote control?

Smith: Yes, over the dangerous bits.

[01:52:05] Lee: how do you feel about having to make that decision? We were talking about the days before you had to refer everything back to London. So here you are with these men wanting to do this possibly foolhardy project and you having to say, "OK".

Smith: Well I did, and it worked out alright and we got a congratulatory message from Bunny Fuchs, the Director, saying “Great piece of work”.

[01:52:29] Lee: Did you sit down and weigh up the ‘risk assessment’ as we now would call it, or was it a bit more ‘bravado’ than that?

Smith: I guess I did some sort of unconscious risk assessment. It wasn’t a procedure you went through in a well-defined way, like you would do now.

[01:52:44] Lee: Were there rewards to be had, apart from the bonus, from being Base Commander? Pride?

Smith: Yes…what your people have achieved really and just keeping the Base in a good state…the camaraderie and the fact that you were working together as a good team. You had good morale. Yes.

[01:53:15] Lee: One last thing. One last subject, perhaps one that we may not be able to talk about a great deal…I watched on TV, just the other night a film called ‘The Day after Tomorrow’. It was all about dramatic climate change due to polar air being sucked into tropical areas. We haven’t talked about climate change, and I know that parallel research in the Antarctic began to notice the ozone hole. Is the work that you have been doing and base in the future be doing VLFs will in anyway give us more clues about what is happening to the climate?

Smith: It is possible that it may do. What you can say is that the way we are going at the moment, collecting these long runs of data, we will be able to pick up trends if they exist. Then it will be a matter of seeing if that fits in with the picture of climate change. I know, for example, that there are changes of climate in the upper atmosphere. Martin Jarvis at BAS has done some work on the changing height of the ionosphere using long data series from Faraday. It may well be that we see something similar in the VLF. One thing we know is that one of the sources of VLF is lightning and we expect lightning activity to increase in certain areas if the temperature rises because that gives you enhanced convection. So it may be that we will see something along those lines in the future. If it is there, we will see it in the data because we have these very unique very long runs of recording.

[01:55:23] Lee: And that is data in the long runs and beyond.

Smith: It is in the long-term monitoring and survey programme now, which means that it is an open-ended commitment now to keep that experiment running in that form. We are not the only people using the data. The data is on the web and can be used and has been used by other experimenters.

[01:55:44] Lee: So it could become a diagnostic tool for measuring and monitoring climate change?

Smith: It is possible although it is hard to see…you are not going to learn anything extra about climate change on the ground. You can't do temperature measurements as efficiently with VLF as you can by just having thermometers spread around the surface of the Earth. What you can do possibly is work out the effects of changing atmosphere on these very high levels…high altitude in the atmosphere...in Geospace…which is much more variable anyway so it is harder to pick out a trend. But I don't know. It is early days yet.

[01:56:49] Lee: You have recently retired and I gather that there is still a mountain of data that has been unexploited.

Smith: I would say that we have exploited 10% at the most.

[01:57:00] Lee: What do you plan in your retirement to do with the other 90%?

Smith: I have a few ideas. I have all the data with me. I really want to look at some of the statistics and some of the cycles that might be in there. Some of the periodicity that might be in there which really haven't been fully worked out. I got a few ideas along those lines, which I want to do with the data. I want to see if some of my ideas about where you might get chorus activity maximizing and how that might change with different times of the solar cycle. To see if that is borne out by the data…that is just an example. To see if the data fits with what I think should be in terms of the distribution with local time and frequency.

[01:57:55] Lee: You have some hunches to follow?

Smith: Yes!

The End

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