RESUMED **[4.33 pm]**

COMMISSIONER: We will start now and wind our way through it.

DR VAN GEET: Okay.

COMMISSIONER: Working back to topic 16, high-level waste storage and disposal and I welcome Dr Maarten Van Geet from ONDRAF/NIRAS. Counsel.

MR JACOBI: ONDRAF/NIRAS is the Belgian national agency for radioactive waste and enriched fissile material. It is a public body set up under law to carry out radioactive waste management in Belgium. It is charged with the collection, transport, processing conditioning, storing and disposal of radioactive waste and with the decommissioning of nuclear facilities. Dr Maarten Van Geet has been the coordinator of research, development and demonstration with ODRAF/NIRAS since 2008. Previously he was employed by the Belgian Nuclear Research Centre SCKCEN which conducts research on problems of societal concerns such as the safety of nuclear installations, radiation protection, safe treatment and the disposal of radioactive waste and nuclear non-proliferation. There he held positions as project leader, clay barrier characterisation and as a scientific collaborator geological disposal. Dr Van Geet obtained his doctorate in geology from the University of Leuven in 2001 and the Commission calls Dr Maarten Van Geet.

COMMISSIONER: Good morning, Dr Van Geet and thank you very much for joining us. Counsel assisting has given us a brief overview of the responsibilities of ANDRAF/NIRAS is there anything in addition you would like to add to the functions that you are currently performing?

DR VAN GEET: Well indeed ANDRAF/NIRAS is (indistinct) to public body and it was founded in 1980 by Belgian Law and it is charged with the management, including the disposal of all the nuclear waste that is present on Belgian territory, so we also do the interim storage, we find (indistinct) qualification of installations that are used for (indistinct) to waste. Inventorying the wastes, including legacy waste and avoid future legacy waste and also (indistinct) dismantling plants. It is a (indistinct) to develop a final solution for the management of radioactive waste, so the development of disposal facilities.

COMMISSIONER: Whilst we are talking about waste, it would be useful if we could classify what it is that you intend to manage and just an approximation of the volumes?

DR VAN GEET: So we collect our waste in three (indistinct) actually we have the short-lived low-level waste, which we call the A waste which amounted to volumes of about 70,000 cubic metres. Next we have – we also have the low and (indistinct) level waste, short lived and long lived which we call the B waste. This amounted to about 11,000 cubic metres and then finally we have the high-level waste, which also emits heat, which amounted to 600 or 4,500 cubic metres. The 600 cubic metres is if we would reprocess all the spent fuel, however if we stop the reprocessing then we would come up with about 4,500 cubic metres. In slide 1 that I have provided, you can see these different categories that I just mentioned, category A, B and C waste. After the final commission of the waste, making it ready for disposal facility, this category A waste which amounted to 26,000 millilitres for category A, about 4,500 to 5,000 millilitres for category B and 2,000 to 3,000 super containers for the category C waste.

COMMISSIONER: That might be a good time for us to just explore briefly the concept that you have in mind for the disposal of spent fuel and particularly what are the key elements of that concept? I think you - -

DR VAN GEET: Well, the final objective of disposal facility is to guarantee the safety for humans and the environment now and in the future. Now the radioactivity of these kind of wastes lasts for quite a long time, 10,000, 200,000 years for this B and C waste, so you can't count on an active system. You can't count on humans to continuously take care of this kind of waste. That is why we want to develop a passive system; a system where we do not need human intervention. This doesn't mean that we cannot control, monitor the disposal as long as we want but we do not count on it for the safety – the eventual safety. In line with international practice, we therefore recommend geological disposal for this low level (indistinct) or high-level waste. This is based on three safety functions, which I have indicated on my second slide. First of all, we want to guarantee this passive safety by isolating the waste. So we want to reduce the likelihood of inadvertent human intrusion, or human actions close to the facility and their possible consequences. This safety function should last for at least about one million years.

Next we also want to contain the waste. That is the second safety function. We want to prevent (indistinct) dispersion from the waste forms during the thermal phase. This is especially the case for this C waste, the high-level waste, which emits heat for several hundreds to (indistinct) So we want the containment of this waste during, let's say about 5,000 years. And this is done by several impermeable engineered barriers. Finally, we know that these engineered barriers might corrode, might get lost eventually, so we want – we want to retain the radio nuclide for as long as possible in the whole system, which is also the (indistinct) And therefore we also count on limiting the release from the waste forms, so we won't get liquids in to the disposal facility but always solidified waste et cetera. We want to limit the water flow because that eventually what is needed to have a dispersion of the radionuclide. So if we limit the water flow there will be less dispersion of radionuclides and eventually we want to (indistinct) the migration of radionuclides, so that it goes very slowly and only small tiny fractions of radionuclides might get in to the (indistinct) So that is the overall system as we develop it.

COMMISSIONER: And the role of your particular geology and clay in that process, can you walk us through what that does and how you manage that?

DR VAN GEET: Certainly. This clay is actually – this natural barrier is the main barrier in our system. And it has several functions. First of all, of course, it is that the clay is present at depth so that we can isolate the waste from the biosphere. In the third slide that I have provided, you can see two pictures of two possible (indistinct) layers present in Belgium. The top one is the boom clay and right from it you see that the location of the boom clay here in Belgium, so you see it's mostly in the north east of Belgium. Where this clay layer dips towards north east, so the further we go to the north east, the deeper the clay is present. So it's present from the surface up to depths of about 400 metres. Underneath, you can see on the left side, the picture of this encasing clay, a second clay layer which is a potential (indistinct) It is more present towards the north west of Belgium and again it is dipping towards the north, northeast. This clay layer is present from the surface up to depths of about 600 metres more or less. So that is the first importance of this clay. It provides the depth at which the disposal facility would be.

Next is also to have a slow transport of water. I had mentioned this is also a safety function and I have illustrated that on the fourth slide that I have provided. On the left, you can see that the picture of this boom clay and you can see several layers, so there is differences in mineralogy et cetera. However, on the right side, I won't go in to the details of everything but the grey bulk – this grey layer, that corresponds with the boom clay and the different dots that you see on the right side are measurements of diffusion on hydraulic conductivity et cetera. So although there is a difference in mineralogy, you can see that the most important transport parameters are very homogenous and they are very (indistinct) they have very low hydraulic conductivity and a very low diffusion which assures the show movement of water and radionuclides.

MR JACOBI: Dr Van Geet, can I just hold you up there and just take you to the table and I was just perhaps wondering whether you might just offer us just a brief interpretation of what we are looking at. As I understand it, the Y axis indicates the layers which we're actually seeing in the photograph on the left. And I am just interested to understand, what is it we are looking at with the – particularly the blue dots and the red dots as we move outwards?

DR VAN GEET: So the blue dots are the hydraulic conductivities. Towards (indistinct) so that the grey layer is the whole thickness of the clay.

MR JACOBI: Yes.

DR VAN GEET: So the different layers you see in the picture, you can't see them on the right graph, they are hidden let's say in to – because they are too small to visualise in this picture. So – but you see that throughout this whole thickness of the clay layer, which is about 100 metres thick, where the constant more or less constant hydraulic conductivity only at the very bottom and the (indistinct) very bottom there is a slow increase of hydraulic conductivity. So those are the blue dots. Then the red dots are the diffusion coefficients of iodine and then the – on the right side the white dots, those are the diffusion coefficients of (indistinct) water.

MR JACOBI: Right.

DR VAN GEET: So – and again, in all these cases, you see that there are very constants throughout the thickness of the boom clay, so throughout this

100 metres of thickness we have very constant values and those are also very low - - -

MR JACOBI: Yes. So - - -

DR VAN GEET: - - - hydraulic conductivities are of the order of 10 minus 12 metre per second.

MR JACOBI: Yes. So perhaps if I can give my lay interpretation. As we move up and down, what we are seeing is that there is consistency in the properties in terms of the movement that materials – as one goes through the depth of the clay and as we move left to right what we are seeing is very, very low movement of particular materials through the clay. Is that right?

DR VAN GEET: That's correct. That's a good way to interpret it. A (indistinct) importance aspect of these clays is the fixation of heavy metals. As mentioned, we want to also to retard the transport of radionuclides. Now many of you probably know that clays have this property to fix heavy metals and most of radionuclides are heavy metals. Actually clays are also used in pharmaceuticals whenever there is an intoxication with heavy metals, people are treated with clays for instance, to absorb those radionuclides and in that way try to evacuate these heavy metals. So this is a very good property of clays and we here thickness of about 100 metres of these clays where a continuous fixation of a lot of those radionuclides can take place. Finally, there is also – last but least, there is also a buffering of chemical changes by clay. So if there is some oxygen or high pH materials that are introduced in to the system, in to these clays, these clays can adapt quite well all these changes and they will not be disturbed for large areas. So it's only at the small scale that they will have some small changes, so the majority of this clay layer will be – will have its original properties throughout the time of several hundred thousands of years.

And then finally, that's the next slide, the fifth slide, as we will excavate in this boom clay, you will create some fractures. You can't avoid it. During the excavation you create some disturbances, some fractures. However, this clay has a very unique opportunity for property that it's self-sealing. So that means whenever there is some water in the neighbourhood, fractures will self-seal. They will seal itself and that's what you clearly see on this picture, that was an artificial fracture we made in the clay. On the left side you see it and on the right side, you see the result after four hours of water, that runs through this fracture. So the original fracture is no longer visible. So then again, this low hydraulic conductivity is restored very rapidly in these clay layers. So I think those are the most important characteristics of the clay which hold importance for geological repository facility.

COMMISSIONER: If we could move then from the geological barriers and talk about the engineered barrier system and if you could work us through the proposal that Belgium has developed.

DR VAN GEET: Well, I – the next slide then, slide 6, on the left side you can see how such repository might look like. It would consistent of several shafts that go to the mid-plane of the grey layer, where we would have several galleries. At central – in the central position we have an access gallery and perpendicular to it, we would have several disposal galleries. Now important for the clays that we consider, these are (indistinct) clays compared to other types of clays considered worldwide. These clays are not that strong, which means that very fast after excavation, we do have to put a liner, otherwise the clay would come down and would close the original hole or tunnel. That's what you saw in the picture before; this sealing capacity is so strong in this – in (indistinct) clays that you have to put a liner. So in practice we will put a concrete liner to keep open the galleries. For the amount of waste that we have in Belgium, we would need a footprint of a geological repository of about three square kilometres and it would need about 30 kilometres of galleries to dispose all of the B and C waste. Within these galleries - - -

MR JACOBI: Can I just pick you up on the footprint? Is that a footprint as taken at the surface?

DR VAN GEET: Could you repeat your question, I didn't hear it very well?

MR JACOBI: Sorry, you gave an estimate of about three square kilometres as the footprint. Is that the footprint as taken at the surface?

DR VAN GEET: Yes, that's correct. So that's also at the (indistinct) distance of the galleries. So the eventual – the real surface of course much more but taking in to (indistinct) all the clay that is in between all these galleries, you would add up with about three square kilometres. On the surface the – the real surface installations are much smaller of course. So it's – the whole repository at the bottom, at the underground, that would fit with three square kilometres.

So within these galleries we would put the different waste types. As mentioned before, the engineered barrier system has its main goal in containing the waste during at least the thermal phase, which lasts several hundreds of thousands of years. In our case we propose an engineered barrier system that consists of first of all three centimetres of carbon steel which would be surrounded with about 70 centimetres of concrete which is surrounded again by six millimetres of stainless steel. The whole system is called a supercontainer.

The stainless steel would retard potential aggressive species that might be present immediately after a disposal. The concrete dictates the conditions near the carbon steel, so high gauge which guarantees very low corrosion rates, especially in the absence of oxygen, which is the case in a backfilled geological disposal system. Based on our current knowledge, this supercontainer system would last for several tens to hundreds of thousands of years. Although, we only aim for it during - the thermal phase should last only several thousands of years. So that's in a nutshell the engineered barrier system.

MR JACOBI: We've heard about the KBS concept which uses copper canisters. I'm just wondering perhaps whether you could pick up - and what's the reason for selecting a carbon steel system as opposed to a copper system in relation to your geology?

DR VAN GEET: In our system, in this case we do have pyrite present. This pyrite produces quite a lot of sulphates, sulphur, ions, and these are very corrosive towards copper. So that's the reason we can't use a copper system. So we did have a special group of corrosionists that sit together and, together with them, we have developed this supercontainer design in order to have a system which would certainly contain the waste during several thousands of years and which would be compatible with our natural barrier, these encasing clays.

Another thing is very different to other systems is that we use quite a lot of concrete or it might seem to be a lot of concrete. However, as mentioned before, we do need a liner in these clay layers, otherwise the tunnels would creep very fastly and the tunnel wouldn't be open any more. So we already have to concrete liners because other materials are too expensive. So we use concrete liners already and then we add almost - just we doubled the amount of concrete. It's not that we are exaggerating the amount of concrete, it's just doubling by using these concrete supercontainers.

The advantage is of course that use a system which is well known already for decades, even centuries. We have evidence of the use of carbon steel in high pH concretes. This is of course an additional argument that you can use in explaining that very low corrosion rates will take place in these systems.

MR JACOBI: I just wonder if perhaps we can pick up - we understand that an underground laboratory was developed in Belgium. I'm just wondering whether perhaps you can give a sense of the history of that and its purpose.

DR VAN GEET: So the research on geological disposal actually started already in the 70s, together with the start-up of the first nuclear reactors in Belgium. At that time underground was not created yet. It was the Belgium Research Centre on Nuclear Energy that launched the research. From the early days on it was clear that poorly indurated clays are present in Belgium and our potential host spots for geological disposal. But it became clear that excavating galleries in such clay layer would be a first of a kind, certainly at such depths. Therefore, already in the early 80s an underground research laboratory was constructed. Underneath the Belgium Research Centre there's boom clay that's present at a depth of 200 to 300 metres, more or less.

So the underground laboratory was excavated at 225 metres undersurface. After the creation of (indistinct) in the early 80s, the management and steering of the R&D was gradually taken over by SEK but of course SEK remained and still remains an important partner in the development of the geological disposal facility. In 89 Belgium (indistinct) published a first safety assessment and feasibility interim report and in 2001 we published the second safety and feasibility interim report. Those reports confirmed that poorly indurated clays are good candidates for potential host spots for geological disposal.

In 2011 then (indistinct) published its waste plan and transmitted it to the government in order to ask for a decision in principle on geological disposal with these poorly indurated clays. However, the decision is still pending. But it doesn't mean that the research is not going on. We continue our research also in the underground laboratory. There I can illustrate to you that we use this underground laboratory also to demonstrate the possibility to develop such a underground repository.

The next slide, so slide 7, illustrates the current underground laboratory that we have underneath the Belgium Research Centre. So it consists of two shafts that are now created, one access gallery and perpendicular to it is the main gallery. Actually, if you look at the picture on the left, which is how an underground disposal facility looks like, you see that all components that are present in the disposal facility are already present in the underground laboratory as well. So we do have shafts, we do have an access gallery, and perpendicular to it we have those disposal galleries. So the crossing between an access gallery and a disposal gallery has been demonstrated, actually.

This was not so easy so in the early days the researchers thought that this poorly indurated clay would behave as toothpaste. So whenever you would make a hole in it, that it would come out again like toothpaste. So that's why in the beginning they froze the clay and excavated all this material manually.

In the next slide, slide 8, you can see some pictures on how this clay was frozen was excavated manually. During the years we have made quite a lot of progress and we tested stepwise the possibility of excavating all this clay. First of all, we could demonstrate that we can excavate in this clay without freezing it but then we still did it manually. That was the late 80s. Then in the early 2000s - and that is seen on the next slides, slide 9 and 10 - you can see that we have excavated the gallery actually with industrial techniques.

On slide number 10 then you can see that we used this tunnel boring machine. That's the one that we have used to excavate the perpendicular gallery but which was also used to excavate the second part of the underground laboratory with an industrial technique. These industrial techniques allow us to excavate galleries at the rate of two to three metres in the underground laboratory but the (indistinct) maker is actually the shaft which is not that big, it's quite limited. So we assume that in a real repository then we would have a larger shaft, we can excavate galleries at the rate of about 10 metres a day.

MR JACOBI: Can I just pick up on an issue raised earlier, which is that a proposal was put forward I think in about 2011 for a decision. I'm just interested in what is the process or the time frame for a policy decision in Belgium; that is, when is there a necessity for a decision to be made?

DR VAN GEET: That's a difficult question actually. This is purely political. So we have quite a lot of work behind us. We have been working on geological disposal with poorly indurated clays for more than 40 years. So we believe that we certainly have all the information needed to have this policy decision. There were some political problems last year so it took a while. The government felt that we had to create a new government so (indistinct) This is one of the reasons why our proposal of 2011 was not accepted yet. Now it's again on the table. The government has clearly stated that it would make a decision dealing with this at this point of sitting, but we are still waiting. It's difficult for me to answer on this.

MR JACOBI: I think that's fine, Maarten.

DR VAN GEET: Yes?

MR JACOBI: In terms of the work that's now being undertaken in terms of developing a safety case, I'm interested to pick up on what the task is now in terms of integrating information into a safety case.

DR VAN GEET: Well, it's important that we - and you built actually our proposal. So we had made this proposal to the government and we want to continue to confirm that geological disposal is the good way forward and that it is feasible and safe to do this in these (indistinct) so that's why we propose to have a next safety case and what we want to do in this next safety case is to integrate the remarks we received during former safety cases. For instance, during this safety and feasible entry report in 2001 there were some remarks, for instance, on the engineered barriers, that they were not that optimal. So that's why we came up with the supercontainer I explained earlier. So this is one of the points that we want to include now in our next safety case.

Next to that of course we want to integrate all new RP&D results. Since 2001 we have continued not only in the new engineered barrier systems, but continued our research on the geological host rock, et cetera. We want to integrate all this information. We have also further developed our methodology to develop such safety cases. So we want to apply this methodology so that the time that we would like to have or that we need to develop a licence application that we can use this methodology and that we have discussed it with our regulator and they agree on this methodology.

The next step is also to incorporate already the currently existing draft regulations. So the regulator is still working on it, but at least some basics are present already, and of course also international regulations are present. So we want to clearly demonstrate that we meet those regulations. Another regulator puts quite a lot of effort or accent on the demonstration of robustness and the optimisation of the system. So these items we would like to incorporate in our next safety case.

And finally, of course all this would help us and confirm importation of a poorly underrated case as potential host rock and not only in the neighbourhood of this underground research, laboratory, but in a wider zone which I have illustrated earlier on when I explained to you these (indistinct) and (indistinct) present in the northeast and northwest of Belgium.

MR JACOBI: Already in evidence today we've had some discussion about reference cases and also the testing of those with other scenarios that are thought to be less plausible. I'm interested to understand what the reference case is that's been used for the purposes of your safety analyses and which other scenarios you as a proponent are considering.

DR VAN GEET: Okay. I think a good slide to illustrate a little bit is slide number 13. Within a safety case, actually we want to clearly tell people that we have confidence in the long-term safety, and then we have tried in our methodology, safety assessment methodology to break this up in several statements. Why do we have confidence in the safety? First of all, because the system is known. This means that all the components can be characterised and are well known.

So that is what you see on the left side of this slide. Where we have this branch, the system is known and it can be characterised. Of course these are only the top statements that we illustrate. There's a further breaking down in small pieces where we illustrate that the waste is characterised, that the engineered barrier system can be characterised, and the natural barrier can be characterised.

Next to that, it can not only be characterised, its evolution can be bound. We clearly state here that we do not have a prediction of the evolution. This is very difficult over times of ten thousands, hundred thousands of years. It's not one prediction of the evolution, but its evolution can be bound. We have a clear view in which direction it goes, although it can still be several evolutions that are possible, but it can clearly be bound, and that is what's helpful in further illustrating that safety can be guaranteed.

So once we have this basic information, we can check then if the safety functions can be relied upon based of course on this basic knowledge. So can we rely on the isolation, on the containment and on the retardation and no transport? Once we can illustrate that - we go to the right side of the slide - we can perform calculations in order to illustrate that the system meets the requirements, first of all, radiological requirements, but also environmental requirements; and maybe conditions that come out from stakeholder involvement, consultations of different stakeholders, also these have to be taken into account.

So this is how we work. We have broken down this system in several statements and for each of the statements, we try to have all the arguments, several arguments (indistinct) of evidence, that we can guarantee these statements. And actually, based on all the knowledge we have, our reference case today is that we broadly accept that the safety functions can be relied upon.

So we do have all the arguments now that the safety functions can be relied upon and then that makes the reference scenario. So we can isolate a way for several hundred thousand years up to 1 million years. We can contain the waste during at least the thermal phase, and then there's a slow transport of water and a good retardation of radio nuclides, and that's our current reference case.

MR JACOBI: To what extent, for the purposes of your processes with your regulator, are there specific other scenarios that you're required to analyse, that is, scenarios that might address things such as unexpected failure of a container or intrusion or some extreme climatic outcome?

DR VAN GEET: So unexplained - we have all these statements where we have good arguments (indistinct) of evidence, et cetera, however for each of these statements there are still some uncertainties. Some of these uncertainties are just ranges and parameters and these lead to different cases which might still be reference scenarios, so you still count on the different safety functions, but some parameters have to be changed and then you come up with different cases within the reference scenario. However, there might also be some arguments or open uncertainties where we try to challenge does this put into question the safety function.

An illustration is given on the next slide actually, on slide number 14. Maybe this helps. So the people that perform this basic research and the people that perform safety assessments, they interact with each other and they try to look at the different arguments that we give for a specific safety statement. So there are several arguments (indistinct) present, but there are also some questions. This is research. There might be some questions, and based on these questions we try to challenge would this put into question the overarching safety function.

So the example that is given in the slide is the evolution of the (indistinct) can be bound. There are some issues on potential of aggressive species. So we ask our researchers to put this into question, the containment that we rely upon during several thousands of years. We can continue our research, but we can also do some bounding safety assessment characterisations, and based on all this information, we can then look if we really have a threat on this safety function or not.

So if there is a potential of a certain safety function that might be put into question, then we will do some alternative or altered scenarios where the whole safety function or part of the safety function is not present in the safety assessment. So these kind of evaluations are performed. Next to that we of course also have the calculations of (indistinct) this is a very specific amount of cases that we have to do and are regulated (indistinct) independent of the risk or the potential we will have to do deterministic analysis of (indistinct) scenario. So those are the different cases. Another example that I might give, I'm not sure if you are interested in a little bit more detail about this climate changes for instance. The arguments we use and how we – how we inform people on - - -

MR JACOBI: I am interested in picking up on that if – if you are happy to go in to it.

MR VAN GEET: Mm. Then I would propose to go to slide number 15. So this is a typical example of how we take into account the evolution of the boom clay in this assessment period of one million years. In the slides you see actually the (indistinct) of the boom clay which the geologist have (indistinct) based on all the properties and all the knowledge we have of this boom clay. So at the location of the underground laboratory, we have (indistinct) this (indistinct) history, so the slide shows in the X-axis, the time evolution. We go from the past about two or three million years ago towards the present zero and even the future plus one million years. In the Y-axis you see the depth of the boom clay. So what you see in yellow is at 30 million years, the boom clay was present at the surface. Actually there was a sea in its current position where this clay layer was deposited during several million of years. Then gradually above it, sands were deposited in this sea and the boom clay got at great depths.

This lasted for several million years and then about 27 million years ago, there was some erosion of the sands that overlie this boom clay, so there was some erosion and the (indistinct) of the boom clay again towards 60 metres depth. Then there was a quiet period for several tens of million years until nearly 10 million years ago and then again there were depositions of several sand layers above the boom clay in this sea. So that the boom clay got very deeper and deeper and got at its current position of depth in that area of (indistinct) where (indistinct) laboratory is located. So the top of the boom clay is at about 190 metres depth of 290 metres depth. If you look now at the assessment period which is about one million years, you see that it's only a small tiny fraction compared with geological history. I made this an animation - - -

MR JACOBI: Yes.

MR VAN GEET: - - - this slide so - - -

MR JACOBI: If we pick that up - - -

MR VAN GEET: Then you have seen this assessment area of one million years. Now next to that, you also have these different climate changes. In modern Europe we had, in the last two million years, about 10 Ice Ages. So the timeframe is also illustrated on the slides, this two million years. During all these Ice Ages, there was no specific interaction with the boom clay which caused dramatic changes of its characteristic. Actually its characteristic always the same as in its very early days. So climate changes, as we know them for the last two million years, do not have a major impact on the boom clay properties. Finally, there might be some erosion that is correct; we have seen that in this period in geological history in the area of 27 to 25 million years ago, there was uplift of the boom clay. So this can happen, although the general geological history in Belgium is rather to have a continuous deepening of the clay layers. But there might be some erosion. However, if you have a look at it and you would try to have the mid-plane of the boom clay up to the surface in one million year, that is what's illustrated when you (indistinct) line, then you see that you need very unrealistically steep evolutions, which it's not possible from a geological point of view. If we take the steepest - - -

MR JACOBI: Deepening.

MR VAN GEET: - - - deepening of the boom clay and we extrapolate that towards the future then the mid-plane of the boom clay can only come at the surface after seven million years. But then you need the continuous uplift which is again not really corresponding with the overall knowledge we have – geological knowledge we have of the area of Belgium and the Netherlands. So you see that we have several arguments here to illustrate that it is very reasonable to assume that the isolation of the repository during one million years is very likely and is the most likely evolution of the system. This does not mean that we can still do some what if scenarios. What would happen if, for instance, part of the sand layers would be eroded? What would happen if permafrost would come and part of the clay layer would be frozen? What would be the impact then on safety? So all those scenarios will also be taken in to account eventually; but first of all we focus all the knowledge we have, the arguments we have, to illustrate that our reference scenario is the most likely one.

MR JACOBI: I think perhaps if we can pick up and move on from the clay and just come quickly back to the carbon steel. You made a reference to – I think we've done the lines of reasoning with respect to the geology. I just wanted to pick up what are the sorts of lines of reasoning you have available to you with respect to the carbon steel and the concrete system that you are proposing?

MR VAN GEET: Well, as mentioned, this is a very old system which is used certainly several decades by modern man but also former archaeological relics are available where carbon steel is conserved within high (indistinct) countries. So this illustrates that this system really has low corrosion rates and that's what we aim for. So next to that it's a very well (indistinct) system, it's not only for geological disposal that we use it, it's also an (indistinct) system that we use it and we do have some geological remnants that illustrate this also on very long terms.

MR JACOBI: And I just want to just pick up with respect to the underground rock laboratory, where – what presently is the focus of the research and development in seeking to further demonstrate or prove the safety concept?

MR VAN GEET: Okay. So R and D is really very important for us to set up all the argumentation. So for all these statements we don't arguments, we don't settle arguments; we don't (indistinct) of evidence. So this R and D is continuing. We want to evaluate the moment, challenge the moment and come up with intermediate conclusions. In that respect the underground laboratory is first also very important and also international collaboration. We do not do this on our own. We have several colleagues working abroad, also working on clay, which – with whom we collaborate. First of all to check if they have the same observations that would strengthen of course our argumentation but in some cases they also have different observations and then we need to explain the need to know why there are differences. And also this helps us in strengthening our argumentation for different statements we make.

The underground laboratories of course very helpful in having several arguments. Most of our research is first performed in on surface laboratory but then we try to upscale this. The underground laboratory helps us to work at intermediate scales of (indistinct) scale and also helps us to work in more representative conditions. That is really very important. And in some cases we really have to go to very large scales. There we have a very important example now which is the impact of the (indistinct) face on the properties of the clay. We have tested it of course first in the laboratory and then we did several tests in the underground laboratory at about metre scales. But now we try to upscale this at really decametre scale. So in this gallery which is perpendicular to the access gallery of the underground laboratory, we have – this gallery is about 40 metres long and we call it a (indistinct) gallery. Where we have installed a 30 metre long heater experiment, this experiment allows us to test all our former tests on heating and the impact on the clay. So we will heat this gallery, this part of the gallery, 30 metres, for about 10 years at temperatures which are representative for a real disposal facility.

We have started that, the heating in November 2014 and so we are running already about one year and a half and up to now, I can confirm you that all the results, all the data correspond with what we predicted on the evolution of temperature of course but also the properties of the clay with respect to poor water pressure for instance, total pressures within the clay. So this is a very important tool for us, this underground laboratory and we are convinced that it will continue to be in order to confirm our results and we think that even during the expectation of an underground facility, it might still be important to have this underground laboratory to continue tests and further optimise the system. Another point may be which is very important of this underground laboratory is to have stakeholder involvement. It is important that our people are aware of what we are doing, that they know what we do, that they know how we are doing it and there the underground laboratory is very helpful to illustrate this. It's not just 40 years of research on paper, no, we actually did something concrete and we are very serious about it. So that helps to inform the people on what we are doing and why we are doing this.

MR JACOBI: Can I just come in terms of the current state of the safety analysis that has been undertaken, what is the output in terms of from the reference case, what is the prediction, or perhaps prediction is the wrong word but what is the assessment as against the regulatory limit that is fixed?

MR VAN GEET: Okay. So indeed, prediction is the wrong word. I want to stress this very firmly, we do an assessment of a potential evolution or potential evolutions, with conservative assumptions. We always use conservative assumptions. And then we try to estimate what might be, or assess what might be the potential affects of humans and/or the environment. In our reference case, we use many conservative assumptions and amongst them is the fact that we assume that a family lives in (indistinct) just above the repository and is extracting drinking water just above the repository. This family uses this drinking water – this water for drinking, for irrigation and also for drinking water for the cattle. So there is no input of water or food from abroad, so they only use this slightly contaminated water let's say. In this case, the reference scenario leads to potential doses which are 10 times lower than the regulatory limits.

Now these regulatory limits is already 10 times – more than 10 times below the natural average background in Belgium. The real (indistinct) including medical applications and air travel for instance is in (indistinct) natural background. So we have a natural background of about two, four, five millisieverts in Belgium, the real mean average is about 4.5 millisieverts. Regulatory limit is about 0.1 millisieverts and what we assess is 0.01 millisievert, considering several conservative assumptions of course. So we are well below regulatory limits and certainly very below background levels.

COMMISSIONER: Dr Van Geet, thank you very much for your time. I think that's a very useful explanation of how Belgium has gone about the process of thinking how to store their spent fuel and nuclear waste and I appreciate the time that you have devoted to our visit to Belgium as well as today's presentation.

MR VAN GEET: It was my pleasure.

COMMISSIONER: Thank you.

MR VAN GEET: I hope it helps you further.

COMMISSIONER: Thank you. It will. We will adjourn until tomorrow afternoon when we will talk to the regulator in Switzerland.

MATTER ADJOURNED AT 5.24 PM UNTIL TUESDAY, 5 APRIL 2016