SCIENTIFIC ADVISORY GROUP FOR EMERGENCIES (SAGE)

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VOLCANIC ASH DISRUPTIONS

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MINUTES of a Meeting held in 35 Great Smith Street on 5 May 2010 at 14:00

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PRESENT

Professor John Beddington
Government's Chief Scientific Advisor
and SAGE Chair

Professor Julia Slingo	Met Office
Dr David Thomson	Met Office
Professor Stephen Mobbs	Natural Environment Research Council (NERC)
Professor Stephen Belcher	University of Reading
Professor Hugh Coe	University of Manchester
Professor Adrian Simmons	European Centre for Medium-Range Weather Forecasts (ECMWF)
Dr Willy Aspinall	University of Bristol
Dr Jennie Gilbert	University of Lancaster
Professor Alex Halliday	University of Oxford
Dr David Kerridge	British Geological Survey
Dr Sue Loughlin	British Geological Survey
Professor Steve Sparks	University of Bristol
Professor Marge Wilson	University of Leeds
Dr. Matt Watson	University Bristol
Professor David Spiegelhalter	University of Cambridge
Professor Brian Collins	Department for Transport and Department for Business, Innovation and Skills
Professor Mark Welland	Ministry of Defence

OBSERVERS

Dr Miles Parker	Defra
Susan Hamilton	Department for Transport
Chris Bradley	Foreign and Commonwealth Office
Ian Williams	Home Office
Dr Hillary Walker	Department for Health
Jeremy Clayton	Government Office For Science
Sarah Brown	Defra
Graham Smith	MOD
Oliver Warren	MOD
Anthony Bedford	MOD
John Tesh	Cabinet Office

BY TELEPHONE

Bob Maynard	Health Protection Agency

SECRETARIAT

Judy Britton (GO-Science)
Miles Elsden (GO-Science)
Chris McFee (GO-Science)
Catherine McCloskey (GO-Science)
Felicity Oswald (Cabinet Office)
Anita Friend (Cabinet Office)

AGENDA ITEM 1: WELCOME AND REVIEW OF MINUTES

Professor Beddington welcomed the group and thanked them for attending at short notice.

Miles Elsden (GO-Science) reviewed the actions.

Action 1 – Confidentiality Agreement and Terms of Reference – This was complete. The secretariat will send copies of the confidentiality agreement back to SAGE members.

ACTION 2: **BRITISH GEOLOGICAL SURVEY**, with the **SAGE SECRETARIAT** to finalise letter to Icelandic Authorities requesting certain information. This had been completed, a letter has been sent, and a copy has also been sent to SAGE members.

ACTION 3: DR MATT WATSON to talk to contacts at the Science and Technology Facilities Council about modelling the agglomeration of volcanic ash particles, and to communicate results to SAGE. Dr Watson told the group that work was progressing well in this area, and that colleagues from Oxford University were making measurements on the amount of Black Carbon in the plume. He said that he was looking at a range of funding sources.

ACTION 4: **MET OFFICE** to form a sub-group to investigate better definitions of particle size distribution and mass at source, and over UK. This had been completed and progress was discussed as part of agenda item 2.

ACTION 5: **BRITISH GEOLOGICAL SURVEY** and **MET OFFICE** to work with **CIVIL CONTINGENCIES SECRETATIAT** and the **GOVERNMENT OFFICE FOR SCIENCE** to investigate lower probability, higher impact Icelandic volcano risks, as part of the National Risk Assessment process. This has been completed, and progress was discussed as part of agenda item 2.

Action 6: DR WILLY ASPINALL to form a sub-group to investigate the likelihood of a Katla eruption as a result of the current volcanic activity, and likely magnitude of this. A paper would be presented at the next meeting of SAGE. This had been completed and was discussed as part of agenda item 3.

ACTION 7: **MET OFFICE**, **CIVIL CONTINGENCIES SECRETARIAT**, **GOVERNMENT OFFICE FOR SCIENCE AND THE BRITISH GEOLOGICAL SURVEY**, on behalf of SAGE,

to develop a range of indicative scenarios considering plausible short- and longer-term impacts. This had been completed and was discussed as part of agenda item 4.

ACTION 8: NATURAL ENVIRONMENT RESEARCH COUNCIL (NERC) and DEPARTMENT FOR TRANSPORT to discuss the timing of the scheduled refurbishment of the NERC research aircraft, and the associated implications on surveillance. This was completed in the discussion during agenda item 5.

ACTION 9: MET OFFICE and the **NERC** to explore options for developing the UK's monitoring capability for volcanic ash and other airborne particulates, and also ways of widening coverage beyond UK borders. This was completed during the discussions during agenda item 6.

ACTION 10: **NATURAL ENVIRONMENT RESEARCH COUNCIL** to liaise with Defence Science and Technology Laboratory (Dstl), through the **MINISTRY OF DEFENCE** Chief Scientific Adviser's office, to organise the chemical analysis of NERC's airborne particulate samples. This had been completed. This work was being coordinated by the Natural History Museum and Professor Mobbs gave an update as part of agenda item 3.

ACTION 11: **NATURAL ENVIRONMENT RESEARCH COUNCIL** to consider possible safety precautions that may be needed to protect research staff from the health impacts of flying through the plume in unpressurized aircraft. This had been completed and Professor Mobbs told the group that appropriate measures were in place.

ACTION 12: **DEPARTMENT OF ENERGY AND CLIMATE CHANGE** to explore the potential for damage to power cables caused by wet ash and the associated impacts. **BRITISH GEOLOGICAL SURVEY or STEVE SPARKS** to provide contact details for Dr David Johnson, working on this issue in New Zealand. [Note: subsequent to this meeting, a draft note was received from DECC and details for Dr Johnson were obtained. This action has been completed.]

ACTION 13: ALL to read and comment on Impact Matrix document, sending comments to [redacted] ideally by close of play 22 April but comments would be welcome after this date. This has been completed. Thanks to all who provided comments.

ACTION 14: DEPARTMENT FOR TRANSPORT to establish an aviation science and engineering subgroup to SAGE to consider volcanic ash effects on aircraft. This was agreed to be

on-going.

AGENDA ITEM 2: SITUATION UPDATES

The British Geological Survey explained that the volcano had recently increased its eruption rate, and the new figure in terms of material erupted was around 50 tonnes per second (previous rate had been 30-40 tonnes per second), and the plume was again visible by satellite. However, some of this increase came from a recalibration of the existing source strength. There had been a slight increase in earthquakes detected under the volcano (previously the trend had been for decreasing numbers). This had been interpreted as recharging of the magma chamber (which was thought to be about 2-3 km deep). The BGS explained that the material erupted recently was pretty coarse, but there was a significant amount of fine grained material which was going higher into the atmosphere. The BGS summarised by saying that the current eruption had not stopped, and could potentially increase.

The group discussed seismic monitoring. There were currently only 5 monitoring stations in place around the volcano, and additional instrumentation was needed to understand whether the seismic activity was due to stress relaxation or related to further magma intrusion. Additional seismic stations would be useful. BGS said they were exploring avenues to procure such equipment on a short timescale. Dr Laughlin also outlined the details of the planned visit to Iceland with academic members of the group to meet with colleagues in Iceland, to explore ways to collaborate fully on all the issues surrounding the behaviour of the volcano.

ACTION 1: BRITISH GEOLOGICAL SURVEY, to investigate deployment timescales, costs and potential sources for additions seismic activity monitoring equipment and to report back to SAGE (including exploring options for assistance from foreign counterparts).

ACTION 2: GO SCIENCE with the BRITISH GEOLOGICAL SURVEY to produce a plan for the Icelandic visit to ensure a collaborative scientific approach and develop current understanding for the consideration of SAGE. This plan should include a brief business case and proposed delegation list.

The group were told that the Italians had a lot of expertise in this area and BGS should ensure they were talking to them as well.

The Met Office also updated the group. They said that no major changes were expected to the

current Northerly flow over the UK and major amounts of ash were not expected over the next couple of days, although the group was told that there could be some problems in Irish airspace.

The rate of emission of Sulphur dioxide was discussed. It was noted that the levels were similar to previous levels although members of the group cautioned that Sulphur dioxide would behave differently to ash and could linger longer than ash. The group agreed that current Sulphur dioxide levels were not a health issue, but could still pose issues in areas such as engine maintenance.

ACTION 3: BRITISH GEOLOGICAL SURVEY, STEVE MOBBS and **OTHER ACADEMIC SAGE MEMBERS** to provide parameters for a scenario where the plume reaches the stratosphere so that the **MET OFFICE** can run their model based on this. This should include estimates for ash, sulphur dioxide and fluoride concentrations and particle size distribution.

ACTION 4: MET OFFICE to work with other relevant parties to enhance capability for modelling and assimilating data on SO_2.

ACTION 5: MET OFFICE to establish a work-stream to continuously improve the NAME model, using the latest data observations.

AGENDA ITEM 3: UPDATE FROM ACTION GROUPS

Dr Willy Aspinall presented his note on Katla eruption probabilities to the group. He had been working closely with other academic members on the group, and he told the group that a more detailed database containing better information on historical volcanic eruptions on Iceland was needed. The group was told that it is difficult to determine exactly when an eruption ceases, which has made it difficult to interpret historical accounts. The group was told that more work was going to be done to assemble a database of past Icelandic activity to inform risk estimates. The group was told that this information would need to include defined dates, timing and VEI levels, interpreted from a risk perspective, rather than a science perspective.

The group was told that a 'typical' Icelandic eruption was about 84 days in duration, but they were cautioned that it was more appropriate to consider the eruption at Eyjafjallajökull could last a hundred days or more, given it had already lasted a month or more. The group was told that historical data would not necessarily improve the level of uncertainty of this figure. However, the group was told that certain Icelandic researchers had worked on this issue for over 30 years, and the

information they held could provide a useful contribution to any risk centred database. The group agreed that it was likely that estimates of duration and eruption size would follow power-law relationships, which meant there would always be large unpredictability when considering longer time scales. The group commented that this was an area where face-to-face contact with colleagues in Iceland would be very helpful.

The group heard that the current probability of an eruption of Katla had been assessed as about 75% in a year, but this assessment was a probability conditioned on Eyjafjallajökull being in eruption and the fact that on the three previous occasions when Eyjafjalajökull had erupted, Katla had erupted too. This inferred association, based on so few cases, could lead to an overestimate of the likelihood of a Katla eruption in the short term. If Katla's eruptions were temporally independent occurrences, the baseline long-term probability was considered to be around 2 - 5% per year for a major Katla eruption, if no other evidence suggesting unrest was available. The group discussed how long it would take for a Katla eruption to break through the glacier above that volcano and hence how much warning time could be given. The group was told that it was likely that it might only take a couple of hours for erupting magma to break through the ice.

The group asked if there was any correlation between the strength of an eruption and the time between eruptions. The group was told that at the moment it is not possible to comment on this, but that this issue would be looked at more formally to see if evidence is available.

Professor Beddington said that he thought it may be appropriate for the risk of a large Katla eruption to be placed into the [redacted]. The group agreed that if this happened, they would need to improve their understanding of the probabilities, particularly what would happen in a 'worst case' eruption, and the extent to which we would get any warning.

Professor Slingo said that plausible scenarios which they could then feed into NAME - for example, what would the potential particle size be in such an eruption -were needed. The group agreed that it would also be important to look at both Sulphur dioxide levels and fluoride levels., The group would need to consider how this could be modelled.

Dr David Thomson gave a presentation on source term modelling for NAME. He described the two main areas of uncertainty: eruption strength and particle size (for example, the proportion of particles less than 100 microns). He said that the consequence of this was that the model was conservative in its estimates of mean concentrations but, the peak levels of ash in the plume were

broadly correct. However, the group was told that the model assumed that all of the particles from the volcano entering the plume (i.e. the source terms) were less than 100 microns. In reality some of the particles were aggregating into particles which were larger than this, and these then fell out of the plume more quickly. The group agreed that this meant there was some over-prediction of mean ash concentrations by the NAME model. Nevertheless, Professor Steve Mobbs cautioned the group that these conservative figures do represent the peak concentrations present in some areas of the plume.

Dr Matt Watson said he was working to get data on particle size from satellite data taken over Iceland.

Some members of the group cautioned that 'particle size' was used to describe actual particle size by geologists, whereas the in the NAME model particle size was used to refer to aggregated particles as well. The group agreed that this term must be defined when used.

Professor Sparks gave a presentation on sample analysis. He discussed source terms and transport processes with the group. He said that initial estimates of mass flux had been too high, and that aggregated ash particles were dominant around Iceland.

The group was told that other aggregates were more loosely bound, and that the total amounts of ash in terms of the total eruptive mass was low (around 0.25%), and that a lot of the eruptive mass had been dumped within 30 miles of the volcano. Particle size distribution was critical, as it determined where the plume moved, and how layers within the plume moved and mixed. It was agreed that many members of the group could contribute to this issue.

The CAA commented that, considering a 'curve' of increasing damage, they had good information for low concentrations, and good information for concentrations likely to cause engine shut-down, but needed more evidence to define this curve more fully to enable the transition between these two regions to be determined with more confidence and thus give us a better understanding of the effect of ash on engines when some ash was present. This was important, as this represented the area where more engine maintenance was required, which had important cost implications.

The group again cautioned that it was necessary to think in terms of ash concentration over time, not just point concentrations. The CAA said that engine temperature was important, e.g. at take off and landing. The group agreed that this was another reason why more information was needed on

source term parameters, and that better information about particles in the vicinity of the volcano (around 100 miles) was needed. The group agreed that nudging techniques could also be used to refine the initial modelling findings.

Dr Matt Watson said that more satellite information was needed to enable parameters to be tuned, and to validate the overall model. The group cautioned that we should aim to get information from other volcanoes so models that were not only relevant for Eyjafjallajökull could be developed. Many members of the group had a lot of expertise in this area and would support the Met Office in using this information.

Professor Simmons presented his review of historical information on weather and wind patterns. He said that North-West weather patterns were more frequent in the 1960s and 1970s, and that such long term weather patterns appeared to be related to changes in the North Atlantic Oscillation. The group agreed that this work was important as it could provide high level indications on trends in weather patterns. Professor Simmons described a Met Office forecasting tool which would be used to take this work forward and which was currently designed to characterise weather patterns in terms of 29 different patterns. The historical work in this area was being put on a firmer footing by the Met Office, and he said it could be used to try to identify what the dominant weather pattern was going to be.

The group was told that in the past 30 years, the majority of large injections of ash into the stratosphere from volcanoes had been in the tropics. This was not representative of more northerly climes as ash falls out of the stratosphere much more quickly at northern latitudes.

Defra described their environmental sampling strategy (rainwater, herbage and air quality), and the Department of Health also confirmed that there were currently no health effects associated with the eruption.

Professor Mobbs briefly outlined the status of the Dornier aircraft and the BAe 146 aircraft to the group. He said that the Dornier had encountered high levels of SO_2, but that these values were not significant in terms of human health. He said that it was possible that there had been some damage to the Dornier's engines due to sulphuric acid from the plume. He said that the BAe 146 had contributed to measuring the particle size distribution, but no problems had been identified with its engines. The BAe's flight path had been initially towards the South West, and it had then turned North to look down onto the plume with its lidar, and it had measured profiles though the plume. He

reminded the group that both of the research aircraft were not dedicated for monitoring volcanic ash plumes, and that they would soon have to return to their programmed research work. He said that there were also problems in ensuring that the aircraft was adequately insured for this type of work.

He outlined the current filter sampling work that was being undertaken. The first collections had not identified sufficient particles for useful analysis, but a small advisory group had been established to examine how to better make the fullest use of existing and future filter samples from research flights.

AGENDA ITEM 4: INDICATIVE SCENARIOS

Professor Beddington thanked all the members of the group for providing useful comments. The group agreed that they would need to consider worst case scenarios in a longer timeframe, and that these scenarios needed to emphasise the pulsatory nature of the eruption. The group was told that it was possible that the last 50 or 60 years had been a period of below-average volcanic activity in Iceland compared with longer term historical trends.

The group discussed what a 'worst case' event should be. The group considered whether a 'every 100 years' figure was appropriate as in floods, but decided an appropriate risk assessment for volcanic activity should consider events with longer average recurrence intervals than this.

Professor Slingo said that the scenarios should consider the meteorological aspects in terms of a few key issues. Work would be undertaken to refine the weather regime analysis and probabilities for each scenario.

The group also discussed eruption probabilities, and how these could be factored into scenarios in terms of particle sizes, trace gas composition, etc. It was also agreed that scenarios should not neglect the eventual destination of the flight - as closures at the final destination would also affect UK flights. However, they agreed it would be much more complex to identify all of the meteorological factors. Dr Sue Loughlin said that a reasonable worst case scenario could be the Laki eruption of 1783. Professor Wilson said she had a Ph.D. student looking at the Laki eruption and that there had been problems across Europe with a sulphuric acid haze. Any realistic worst case scenario should include this. The group also agreed it was important not to forget SO_2 levels as this was also important for health, but they agreed that this would require different models due to its chemistry.

ACTION 6: MET OFFICE to run the NAME models for various weather regimes and volcanic scenarios, including injection of material into the stratosphere (see action 3).

Professor Mobbs reminded the group that within any one eruption which would probably last for several months, there would be a range of weather patterns, and so the probability of a volcanic eruption and the type of eruption was the conditioner in terms of the overall probability. The group agreed.

ACTION 7: GO SCIENCE with **BRITISH GEOLOGICAL SURVEY** and **MET OFFICE** to develop the indicative scenarios on the basis of the latest scientific information and to circulate them to SAGE for comment on the 5th May. This should include a fourth scenario based on historical and geological evidence from the 1783 eruption of Laki in Iceland, reflection of the historic and geological on the frequency of eruptions, temporal clustering and weather regime analysis.

AGENDA ITEM 5: AVIATION SCIENCE WORK

The representative from the CAA discussed current work with the group. He reminded the group that it was not appropriate to consider the effects of volcanic ash by comparing what happened with sand, and that more testing was important. He described the 60nm buffer zone and said that it was established to increase levels of confidence, and that a lot of work was being undertaken on this area.

Professor Beddington said that it would be useful for SAGE to establish a small sub group to offer a peer review function to the CAA and manufacturer's in their work. The group and CAA agreed that this would be helpful.

ACTION 8: BRIAN COLLINS to establish a sub-group to provide a peer review function for the work carried out by the Civil Aviation Authority on safety limits. [Note: it was agreed this superseded action 14 from the previous SAGE (see agenda item 1)].

AGENDA ITEM 6: RESEARCH WORK

Members of the group had worked hard to pull together research teams (including academic contributions from outside SAGE). It was agreed that these groups would be vital in getting the

longer term information that was necessary to support [redacted]

ACTION 9: GO-SCIENCE to produce a paper on how scientific work should be prioritised, setting out a work plan for pulling it all together for circulation around SAGE members.

Professor Welland introduced a paper from the MOD. He said that some satellite imagery was available, and that DSTL were working with the Met Office on this. He advised the group that the MOD's material integrity group had a good capability to analyse data from aircraft, and that they were collating a significant number of samples.

He said that there was also potential for using a C130 for sampling, and that it was important to consider the potential use of this facility alongside the research programme established for the BAe 146. He also reported that the MOD had held with Rolls Royce to carry out tests on the effect of ash ingestion on engines.

ACTION 10: MINISTRY OF DEFENCE to make results of testing undertaken in conjunction with Rolls Royce available to SAGE.

ACTION 11: MINISTRY OF DEFENCE to keep **STEVE MOBBS** informed of research undertaken by Dstl aircraft.

Professor Mobbs outlined research capability. He said that as volcanic ash was non-spherical and it could show up well in polarisation measurements. Doppler measurements had a good capability to show vertical motion of ash particles. He also described mass loading estimates which could be done with a factor of 2 -3 uncertainty, but he said that determining mass loading in terms of particle sizes was difficult and the aggregation size may change over time. The group heard that it was not completely clear how the particles aggregated - evidence suggested that the aggregates may be electrostatically formed.

In terms of trace gases, the group heard that Sulphur Dioxide (SO_2) levels from the eruption were many times normal background level. Carbon Monoxide was 3-4 times normal background levels but it is not clear that this was a hazard. The group agreed that more work needs to be done in future on SO_2.

Professor Slingo outlined some research proposals that the Met Office were working on. There were

research proposals for a range of lidars which offered dual polarisation techniques. The group agreed that funding issues were a matter for discussion with the funding authorities, but that work was progressing in these areas.

In summary, in was clear that the need for information on trace gases will not go away, and more accurate information was needed, particularly more empirical information such as from lidars. There is also a need for better underlying modelling to obtain more information on source terms and trace gases.

Dr Sue Loughlin described some of the proposed work with the Icelandic authorities and the group agreed it was important to link together the research needs of both countries. Professor Beddington said it would be useful for representatives of each community to meet the Icelandic authorities on the forthcoming planned Iceland visit and to establish effective lines of communication.

Professor Beddington thanked everyone for attending at short notice. He said that there had been significant progress in understanding key issues since the first meeting, but that clearly much more work was needed in the short, medium and long term. He said that further meetings of SAGE were clearly needed, and he proposed another meeting in around two weeks – the secretariat would be in touch with a date soon.