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Consultative Workshop on the Shale Gas Science Action Plan for South Africa

14 – 15 MARCH 2019

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Academy of Science of South Africa (ASSAf)
PO Box 72135, Lynnwood Ridge, Pretoria, South Africa, 0040
Tel: +27 12 349 6600 • Fax: +27 86 576 9520
E-mail: admin@assaf.org.za

The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science and scholarship for the benefit of society, with a mandate encompassing all scholarly disciplines that use an open-minded and evidence-based approach to build knowledge. ASSAf thus adopted in its name the term 'science' in the singular as reflecting a common way of enquiring rather than an aggregation of different disciplines. Its Members are elected on the basis of a combination of two principal criteria, academic excellence and significant contributions to society.

The Parliament of South Africa passed the Academy of Science of South Africa Act *(No 67 of 2001)*, which came into force on 15 May 2002. This made ASSAf the only academy of science in South Africa officially recognised by government and representing the country in the international community of science academies and elsewhere.

This report reflects the proceedings of the Consultative Workshop on the Shale Gas Science Action Plan for South Africa held on 14 – 15 March 2019 in Pretoria, Gauteng, South Africa, unless otherwise stated.

Views expressed are those of the individuals and not necessarily those of the Academy nor a consensus view of the Academy based on an in-depth evidence-based study.

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DAY 1

SESSION 1: INTRODUCTION AND CONTEXT
Programme Facilitator: Ms Nadia Algera, Academy of Science of South Africa (ASSAf)

Welcome Remarks (Mr Trueman Goba, President: South African Academy of Engineering (SAAE))

Mr Goba welcomed participants to the consultative workshop on behalf of ASSAf and SAAE.

The Department of Science and Technology (DST) commissioned ASSAf, working jointly with the SAAE, to undertake a study, which culminated in the development of the ASSAf/SAAE Science Action Plan (SAP), a national research programme for an emerging shale gas industry in South Africa. Examples of how the shale gas industry has helped grow other economies have been well documented, but this resource has not yet been exploited in South Africa. ASSAf and SAAE, being the most highly respected institutions of their kind in science and engineering in South Africa, have the capability to resolve some of South Africa's more challenging developmental problems and should be called upon more often to help resolve the country's socio-economic challenges.

At the time that the National Development Plan (NDP) was drafted, it was understood that the technically recoverable shale gas resources in the country could constitute as much as the fifth largest reserve globally and that such a large reserve could contribute significantly to the energy mix given how the Integrated Resources Plan would be implemented. The energy reality was well documented, but so were imperatives to stimulate and maintain economic growth, reduce unemployment, promote social equity and maintain environmental stability.

The aim of the workshop was to help unpack and finalise some of the key areas of the SAP, facilitate the sharing of experiences on the process of shale gas quantification, the use of alternative technologies and lessons learnt globally, and discuss scenarios related to the implementation of a shale gas industry and aspects related to the shale gas extraction value chain.

The workshop was an important milestone towards advancing the shale gas debate and the SAP to exploit what could become a potentially valuable resource for the country in the future. It was anticipated that South African research would lead to a wide scope of benefits that would become available for future generations.

Mr Goba wished participants well with their deliberations.

Perspectives of the Department of Science and Technology (DST) (Mr Mmboneni Muofhe, Deputy Director-General, Technology Innovation, DST)

The study done by the ASSAf/SAAE group had culminated in the report, *South Africa's Technical Readiness to Support the Shale Gas Industry,* which was crucial to inform the work done by the Council for Scientific and Industrial Research (CSIR) relating to a strategic environmental impact assessment and the decisions about the future of the shale gas industry in South Africa.

Studies commissioned by the DST were essential in order to ensure that important decisions made by government were made based on scientific evidence. Although some professions were in disrepute globally because they have been found to have provided wrong information, this should not be the case with science, technology and engineering professions. For numerous reasons, hydraulic fracturing (fracking) was a sensitive matter and brought conflict among scientific professions and communities. Decision-makers could not afford to be misinformed. The overarching issue was to ensure that the environment was treated delicately and sustainably.

The engagements at this workshop were expected to guide the way to developing a research and development (R&D) programme that would provide scientific evidence in various areas and scientific baselines to inform and guide decisions going forward.

The ASSAf report, as well as the report of the workshop that took place in Port Elizabeth, were presented to the Executive Committee of the DST and the permission was given for this workshop and further engagements on the topic to take place. The DST supported all efforts to make sure that decision-making was based on scientific evidence and, as a matter of urgency, looked forward to beginning to unpack and prioritise research programmes, and engaging with its stakeholders. However, the mandate for implementation rested with government as a whole and not only the DST.

On the Science Action Plan (Prof Cyril O'Connor, ASSAf/SAAE)

Prof O'Connor acknowledged the presence of two distinguished international guests, Dr Azra Tutunca and Prof Fikri Kuchuk, and looked forward to their contributions. He also acknowledged Ms Algera, ASSAf Programme Officer and members of the ASSAf/SAAE panel – Prof Maarten de Wit, Dr Mike Shand, Mr Mthozami Xiphu and Mr Stefan Hrabar – as well as Mr Stephanus de Lange and Prof Meagan Mauter who were not present at the workshop.

The panel, commissioned by ASSAf on behalf of the DST, began working on a technical (engineering, scientific) investigation of South Africa's readiness to support the shale gas industry in 2014 and published its report in October 2016, after being endorsed by Cabinet in September 2016. In August 2017, ASSAf in partnership with SAAE, hosted a conference in Port Elizabeth that brought together a wide spectrum of interested parties related to the shale gas industry in South Africa in mature and robust discussions. The panel was subsequently requested by the DST to draw up a SAP and the drafting began in November 2017.

Prior to the ASSAf study, reports on the potential shale gas in the Karoo region were estimated to be between 19 and 23 trillion cubic feet (Tcf). A recent paper, in fact, estimated the amount of exploitable gas in different regions to be from 10 – 50 Tcf to as high as 65 – 400 Tcf. Even a relatively modest yield of 5 Tcf of economically recoverable gas represented a potentially significant resource for the South African energy economy and could support a 1 000 – 2 000 megawatt (MW) combined cycle gas turbine supplying electricity into the national grid for 20 to 30 years.

The SAP proposed six flagship research programmes divided into ten topics. The research outcomes would be used to strengthen policymaking, minimise negative environmental impacts and support the emergence of a shale gas industry. The SAP covered research in a variety of areas including geology, gas value chain, social science, induced seismicity and water and waste, and proposed the following phased approach over 35 years:

- Exploration Phase 1 (seismic surveys and the drilling of stratigraphic wells, but no hydraulic fracturing activities).
- Exploration Phase 2 (seismic surveys, vertical drilling, horizontal drilling plus hydraulic fracturing).
- Commencement of meaningful production (installing surface equipment, setting up the well pad and beginning production drilling).
- Full decommissioning (suspending or abandoning gas-flow and disconnecting or removing surface equipment).

The phased approach to exploration would provide sufficient opportunity for ongoing baseline data collection processes and post-closure monitoring would continue to trace legacy impacts over at least 50 years.

The research programme would address the following questions:

- What are the composition and the scale of shale gas deposits in the Karoo Basin and how can it be safely extracted, governed and used, given that such usage will be subject to market forces?
- What regional social, environmental and economic baseline trends should be monitored before, during and after hydraulic fracturing, potentially at scale?
- What scientific, governance and engineering management actions can be employed to mitigate future risks and to enhance benefits?

The six flagship programmes identified were:
Flagship 1: Geology, gas resources, seismicity, exploration technology/engineering and electromagnetic interference (EMI).
Flagship 2: Potential gas utilisation, energy security and macro-economic benefits.
Flagship 3: Water quality and availability; and waste management.
Flagship 4: Biodiversity, air quality, greenhouse gases (GHGs) and human health.
Flagship 5: Social fabric, local economics, regional development and governance capacity.
Flagship 6: Skills development and integrated decision-making support systems.

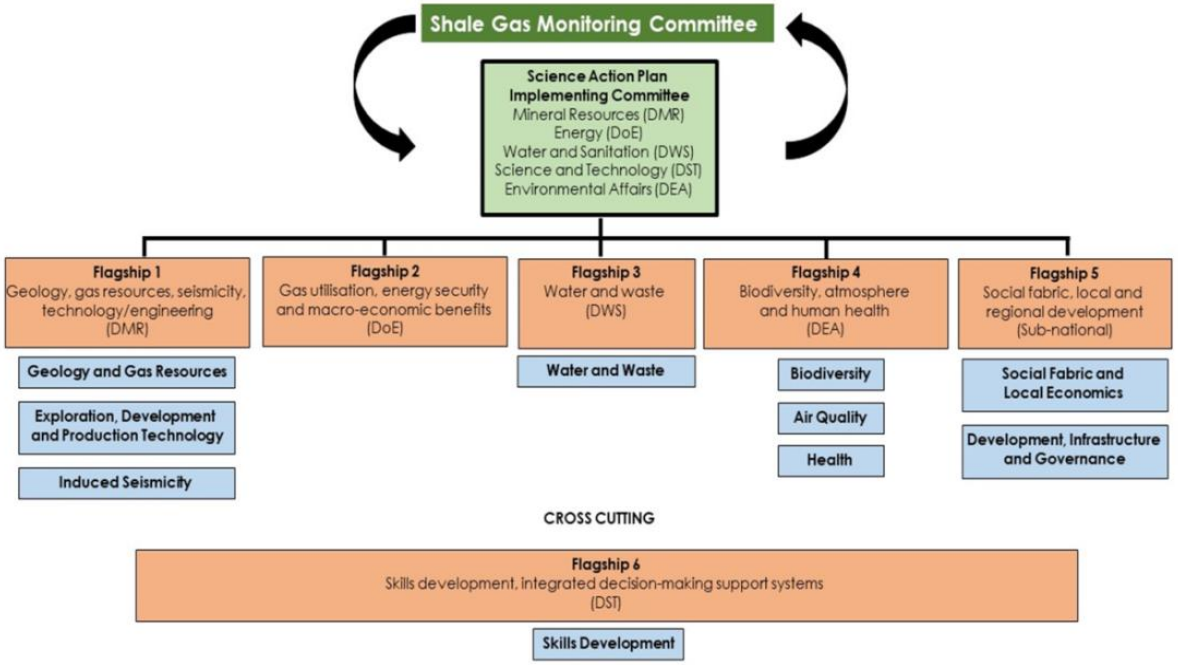
The ten research topics were:
Topic 1: Geology and Gas Resources
Topic 2: Exploration, Development and Production Technology and Electromagnetic Interference
Topic 3: Induced Seismicity
Topic 4: Water and Waste
Topic 5: Biodiversity
Topic 6: Air Quality and Green House Gases
Topic 7: Health
Topic 8: Social Fabric and Local Economics
Topic 9: Development, Infrastructure and Governance
Topic 10: Skills Development.

Proposals encompassed in the SAP were:

- Appointment of a suitably resourced secretariat to initiate and manage (coordinate) the SAP over an initial period of around ten years.
- Appointment of appropriate persons from government departments and the non-government sector to co-chair the flagship programmes.
- Reconvening the Hydraulic Fracturing Monitoring Committee (HFMC).
- Involving the private sector with a view to participation in and co-funding many of the

SAP tasks, especially those that relate to exploration drilling activities and skills development.
- Initiating (as a matter of urgency) the work to be undertaken on the 22 priority research tasks (0 – 2 years).

The following governance model for implementation of the SAP was proposed:



Discussion

Fikri Kuchuk (Emeritus Fellow, Cambridge, US): The United States of America (USA) has 100 years' experience in shale exploration and production. Wells were commercial in a local and not global sense. Shale formation fracturing started in the 1980s, but it was not very successful because maintaining conductivity in long fractures is difficult. The SAP plans for stratigraphic wells in the exploration phase, but I suggest that first, fracture vertically a vertical or short-radius horizontal well before going drill a horizontal well and fracture. It is necessary to perform a production test should be done after fracking. I emphasise that commercial success depends on the country's (or the company's) efficient application of current fracturing technology.

Cyril O'Connor (ASSAf/SAAE): This sounds like a very sensible and logical proposal.

Mike Shand (Aurecon): My understanding is that the formation is about 30m thick. A vertical well will not succeed. A horizontal well will be necessary to make an informed decision on the volume of gas that can be extracted.

Azra Tutuncu (Colorado School of Mines, USA): Vertical wells are definitely needed but fracturing is critical to gather information about the future field development. Horizontal wells are also necessary because unlike the commercial reservoirs, these potentially have large natural fractured networks. Understanding the characteristics of these is equally critical to

understanding the reservoir characteristics. This goes hand in hand with future success of hydraulic fracturing design and execution. I suggest to pilot one or two (or a few) lateral wells in a small area. This will enable you to obtain detailed information about local heterogeneity and anisotropy in the field from which you can expand. We go through the same process of learning about the characteristics of the reservoir and finding suitable methodologies and technologies for each individual new basin. Research is an essential aspect and will continue for a long period of time.

Bob Scholes (University of the Witwatersrand): The SAP should not be conflated with the gas development plan and should not be presented as a done deal. The research plan is informed by the realities of gas development, but is not the decision basis on which to go into gas development. In addition, the SAP deeply undermines the credibility of the scientists who say they are providing objective information. It should be understood that the scientists are working to understand what the underlying issues are, and these will go into a decision process that has many other inputs. To some degree, the shale gas discussion has been overtaken by the recent discovery of a fairly large gas reserve offshore. The issues this raises are technically different and challenging, but there are some overlaps and it is necessary to be aware of these areas of overlap when developing the shale gas research plan and try to develop the synergies.

Cyril O'Connor (ASSAf/SAAE): This workshop has excluded any reference to gas utilisation because it is not part of the SAP. I am hoping colleagues from the Petroleum Agency South Africa (PASA) and PetroSA will add to the issues raised by Prof Scholes.

Perspectives from PetroSA (Mr Thomas K Nyanat, Manager: Onshore and Unconventional Shale Gas Resource, PetroSA)

PetroSA was fully supportive of the SAP for shale gas and of the view that a significant shale gas resource would be a game changer in government's efforts to achieve its transformation agenda by providing cleaner energy solutions to support the future economy of the nation. The application of expertise, skills and research played a pivotal role in assisting government in achieving its aspirations and goals. The SAP could play a significant role towards a roadmap for a shale gas resource venture that was technically robust, economically attractive, commercially viable, organisationally supported across the country, and politically and socially accepted by the people of South Africa.

PetroSA was convinced that, in the longer term, a significant shale gas resource would support the NDP by attracting foreign direct investment and economic benefits, creating opportunities for employment, and contributing to infrastructure development and the plan for cleaner energy.

PetroSA has initiated internal technical studies, integrating published data into a regional 3-D basin scale geological model, with the objective of:

- Looking at the various aspects of shale gas expertise required to support an industry.
- Developing an in-house integrated workflow to evaluate the economic and commercial viability of future shale gas resource ventures.
- Identifying gaps in terms of skills and competencies.

SESSION 2: SYNTHESIS OF TECHNICAL WORK DONE IN SOUTH AFRICA (KAROO)
Facilitator: Mr Niall Kramer, South African Oil and Gas Alliance (SAOGA)

Assessing Formation of Unconventional Gas in South Africa

Karoo Deep Drilling (KDD) and Geo-Environmental Baseline Programme (Mr Ngqondi Nxokwana, Council for Geoscience (CGS))

The KDD programme was designed to study geologically the impacts that could be brought about by possible shale gas exploration in the Karoo. The CGS was conducting a five-year geo-environmental baseline study that would culminate in the drilling of a deep vertical research borehole near Beaufort West in the Western Cape. This study was coupled with a wide range of multi-disciplinary geo-scientific investigations to better understand the impact any geo-resource exploration activities could have on the Karoo environment. The programme was being conducted in three phases, namely:

- Phase 1: Baseline studies
- Phase 2: Drilling
- Phase 3: Borehole results analysis and gas potential.

The study was located in an area earmarked as a shale gas 'sweet spot' outside the shale gas license application blocks. Products of the regional baseline studies done in Phase 1 included a seismic monitoring system (adding to the existing national seismic monitoring network), geophysics surveys, geological mapping and hydrocensus to monitor groundwater as part of the municipality's network of boreholes.

Drilling five shallow observation boreholes (designed to set up a monitoring system for shallow aquifers) and two monitoring boreholes was complete. The boreholes intersected good groundwater and because the area was in the midst of a drought crisis, the boreholes have been handed over to the local municipality. This initiative contributed to building trust with the local community. The two monitoring holes targeted deeper structures (dolerites) and their role on semi-deep ground water systems and would monitor the proposed deep borehole. This phase of the programme provided a good opportunity to train young geoscientists and gain a better understanding of the geology, and to develop a geological and hydrogeological model of the study area.

An ultra-deep vertical stratigraphic core borehole to the depth of 3 500m would be drilled to intersect the Ecca Group sediments. This borehole was necessary in order to acquire fresh core for the carbonaceous Whitehill and Prince Albert formations and to understand the hydrocarbon potential and deep groundwater.

Health and safety practices, as well as on-going stakeholder engagement and community outreach, were crucial elements of the KDD programme. The programme was intended to establish an environmental baseline and effective environmental monitoring systems, as well as to build capacity in terms of developing future scientists and augment and strengthen the regulatory framework for shale gas development in South Africa.

Questioning the Existence of an Economically Viable Shale Gas Resource in the Southern Main Karoo Basin Based on Results of the Centre for Integrated Mineral and Energy Research (CIMERA)-Karoo Research Initiative (KARIN) Drilling Project (Prof Nic Beukes, University of Johannesburg)

In the last eight years or so there have been discussions, assessments of environmental impacts and many reports about shale gas in South Africa. Starting in 2011, several highly varied best speculative or inferred estimates of shale gas resource in the southern main Karoo basin have been made, with estimates of 450 Tcf and later between 19 and 23 Tcf. This wide variation was because it was difficult to relate the Karoo geology to any other area where shale gas exploration took place. The Karoo was full of dolerites and compression that formed the southern Cape folded mountain belt.

The assumption remained that South Africa does have an economic shale gas resource and thus should prepare for developing this resource. However, the awarding of exploration permits (even for initial phase one assessment of the potential of the succession for economically exploiting shale gas) continued to be delayed. In addition, the basic question of whether the Whitehill formation really contained an economically extractable resource of shale gas remained unresolved and fostered continued speculation, which hindered proper well-founded decision-making and policy development for the future.

The CIMERA-KARIN Drilling Project drilled two deep cores and investigated another core near Colesberg and has done the first true desorbed gas measurements on site followed by adsorbed gas measurements on vacuum-sealed core pieces in the laboratory. The main target was the shale gas or Whitehill formation. The project proved to be cost effective and took 21 months to complete. The results were published in two main papers and a number of students were still working on various aspects of the project. The main geological findings regarding shale gas indicated that the rocks were over mature and almost up to anthracite grade of metamorphism with only dead carbon remaining. Very little to no desorbed or adsorbed gas was detected. It was concluded that the shale gas potential might be much lower than initially estimated (possibly around 13 Tcf), noting that sweet spots were not targeted and that small resources of natural gas in the Karoo were possible. This raised the relevant and important question of whether South Africa has an economically viable shale gas resource. The main concern was that an economically viable gas resource should be concentrated in a very small area (900 km^2 and not over the vast 70 000 – 90 000 km^2 as required for the calculation that was done in 2016.

The following steps needed to be taken:

- The public would have to be convinced about the need for first-phase exploration based on the fact that initial true shale gas measurements combined with over-maturity of organic matter indicated that chances were rather slim that an economically viable shale gas resource was actually present. This would avoid unnecessary environmental concerns and legal battles that would merely delay the whole issue further.
- An urgent drive would have to be made to issue licences to interested companies in order for them to be able to properly evaluate shale gas resource potential through first-phase exploration under regulations as prescribed in the ASSAF 2016 Report.

The CGS core was perhaps the only hope to further investigate the shale gas potential of the southern Karoo basin in the near future because Shell had withdrawn from exploration in the Karoo due to the lack of clear and supportive legislative and regulatory framework, as well as competitive commercial terms.

South Africa urgently required new economic initiatives and sustained economic growth. A shale gas industry would contribute towards reaching that goal.

Unconventional Shale Gas Development with Possible Technically Recoverable Volumes in the Karoo Basin (Prof Maarten de Wit, Nelson Mandela University (NMU))

Prof De Wit presented a summary of the Africa Earth Observatory Network (AEON)-Earth Stewardship Science Research Institute (ESSRI) transdisciplinary baseline report across the south-eastern Karoo. ESSRI, a unit of NMU, had 40 Masters and PhD students working on the project, which looked at the potential for shale gas and aimed to establish the current baseline.

Two potential shale gas reservoirs with technically recoverable resource were found and ESSRI was the first to use non-inducive seismic-measuring methods (natural seismic noise), which proved to be very successful. Ecosystem services and social sciences were some of the areas incorporated in the project.

The long-term aim was to have a large project for South Africa and Africa using advanced technology to develop Cradock, a town in the Karoo, into a high-technical centre with an Earth Stewardship Science and Technology Hub, offering among others, earth stewardship science, earth exploration science, citizen science and technology zones, controlled drilling laboratories, a geothermal energy test site and a science and technology education and training centre. The hub would require long-term investment into a new way of doing science in South Africa. The centre has attracted huge interest globally and in South Africa and similarities between Pennsylvania and the Karoo would be useful in informing future expectations with respect to the environment.

The full report was available at http://aeon.org.za/gaas-award.

Questions

Niall Kramer (SAOGA): Is enough being done to enable policymakers adequately to understand what researchers were telling them, is there a wider benefit to the research for the electorate and what can be done to advance action, particularly policy action?

Maarten de Wit (NMU): The plan to set up an Earth Stewardship Science and Technology Hub and drilling centre in Cradock was presented to the DST two years ago, but no response has been received. The way forward is to deal with overseas investors and people who are interested in investing in the project but are able to see a bigger picture, and to persuade government that the hub is a good thing to do.

Ngqonodi Nxokwana (CGS): CGS is part of the HFMC and is able to interact with government and policymakers and disseminate information from the research through this mechanism. In terms of science benefitting the community, the CGS is involved in trying to resolve the water problem in Beaufort West. Science should not be limited to the communities in which it takes place.

Niall Kramer (SAOGA): More should be done to communicate the benefits of science to policymakers, as well as communities.

Nic Beukes (University of Johannesburg): South Africa requires new economic incentives and new energy sources. All the research and information needed is already available. Researchers ought to convince government that in order to understand fully the shale gas

potential, it is necessary for it to be explored and this could be done by giving licences to people who could do the exploration and investigation. If a shale gas industry develops in South Africa, the South African people would develop the relevant skills and knowledge.

Maarten de Wit (NMU): The importance of baseline studies must be emphasised, particularly in order to avoid negative impacts in the longer term.

The three speakers were asked to project ten years into the future and consider what they would like to have happened and what they would present to this group. They responded as follows:

- **Ngqonodi Nxokwana**: In ten years' time I would like to see well-coordinated scientific research that informs decisions and provides a very good understanding of the geology and environmental situation in the Karoo from which the right decisions are made.
- **Nic Beukes**: In ten years' time I would like to see that a number of very good holes have been drilled, mainly by big companies, to evaluate the situation and provide an understanding of all the deep groundwater systems (deeper than 1 500 m), which cannot be predicted from working in the shallow areas. This information is essential in order to monitor and work with the environmental systems.
- **Maarten de Wit**: Deep drilling and the water issue are extremely important. My vision for ten years is that there is more good science and a community that understands what is being done, and that there is a trust relationship between scientists and communities. People will know how to answer questions about shale gas in a transdisciplinary way.

Discussion

Moctar Doucoure (NMU): Scientists are not equipped to make the connection with policymakers. This forum provides a unique opportunity. Government representatives in the room should be asked whether government was doing enough to bring all the research into policymaking.

Lindiwe Mekwe (PASA):

- PASA was responsible for the regulation of shale gas. The discussion on shale gas started in 2010 when applications were received from Shell and processed together with applications from another two companies. The public raised concerns and opposed the applications and a moratorium was imposed on the applications. Cabinet adopted the specific concerns raised. The directive that came out of the process was that scientific evidence was required in order to ensure that shale gas was correctly regulated. The moratorium was lifted, and the application process could continue on condition that no hydraulic fracturing is allowed to take place. The regulation was implemented but it was challenged in court and the entire process came to a halt. On intervention of the Department of Mineral Resources (DMR), the three interested companies were instructed to consult thoroughly with interested and affected parties and to augment the environmental programme. The Minister ensured that the consultations took place. There was a strong view that science should precede any decision about shale gas. This is where the DST became involved and ASSAf was asked to conduct a study and advise government on the matter.
- PASA would like to see the development of the shale gas industry, but the concerns raised about the need for scientific evidence have to be addressed. National Treasury has agreed to fund the research around shale gas. CGS was continuing with its study and a directive was issued to PASA to make sure that a baseline study was done before

applications are considered. Since 2010, numerous studies have been conducted, but there was a concern that none of the academic institutions involved approached PASA about the reports that they produced. Perhaps the DST should coordinate the work and consolidate the various reports for presentation to government in order for the appropriate department to take further steps in terms of legislation and a regulatory framework. It is essential for all parties concerned to work together rather than competing for attention.

Cyril O'Connor (ASSAf/SAAE):

- Ms Mekwe's intervention is critically important and speaks to many of the issues that came up during the ASSAf study. One of the main recommendations of the study was the need for a 'one-stop-shop' for processing applications for licences. The panel thought that PASA would be an appropriate body to act as the 'one-stop-shop' and coordinate all the issues relating to licenses. Mr Xosa (DST) and I made a presentation to the cluster of Directors-General, but I was confused as to who owned the ASSAf report.
- Profs Beukes and De Wit's positions are not mutually exclusive. The idea of going ahead is good and skills development could go parallel with that.

Somila Xosa (DST):

- The public sector has to follow certain protocols and processes in terms of any intervention to be put in place. The DST has responded in a number of ways. It has commissioned studies and has convened local and international people to discuss the matter and determine the best way forward. Cabinet gave the following recommendations:
  - Establish a HFMC
  - Develop a regulatory framework
  - Ensure co-existence between shale gas and astronomy research activities
  - Ensure that independent research is done.
- The DST has ensured that independent research is enabled and undertaken. The ASSAf study ironed out some of the key aspects and then the DST went to the South African public and got guidance to develop a SAP, which has been done and approved by the DST executive. Within the HFMC, DST has been given the responsibility of all the science, engineering and technology aspects. It is necessary to show the public which aspects have been identified and how they are being addressed. Although much is being done there are still gaps and it is necessary to agree on how to proceed. There is a clause in the technical regulations that accommodates all the work that will take place. A lot of money is involved in funding the shale gas action plan. A single approach cannot be taken. A synthesis process is necessary in order for everyone to agree on the way forward and the priorities. This forum is part of that process. Various government departments are represented at the workshop in order to ensure that the matter is taken forward. It must be appreciated that not everyone agrees to proceed with shale gas exploration. Government is clear on its approach to present science-based evidence and participants at this workshop are assisting government to determine the way forward.

Nic Beukes (University of Johannesburg): Scientists can do interesting work, drill more holes, get sample material and train a lot of students, but this will not create the industry in South Africa. Only the industry can do what is required.

Namisha Muthraparsad (Department of Water and Sanitation (DWS)):

- DWS has the mandate to manage water resources in the country and I am responsible for the development of regulation for the department. Data get presented at

conferences but never comes to us through government protocols and the HFMC does not analyse reports. If specialists in DWS do not have access to the data, I will not know what is happening. How the information is addressed with the department needs to work better.
- There are valid reasons the application process involves many different departments. The process is complex.
- Baseline monitoring is crucial.

Mike Shand (Aurecon): The second report implies that the exploratory phase is divorced from the production phase. It is clear that these need to link, particularly the trial hydraulic, which has to be linked to be a production phase, but prior to the actual production. Collapsing periods and having longer periods will avoid having to redo all the permitting.

Bob Scholes (University of the Witwatersrand):
- Getting the knowledge into the decision-making domain is an incredibly important process. This differs from public outreach activities. When pushing the science into a deeply technical decision-making domain there is the expectation that government should have a receiving capacity. The knowledge cannot be simplified to the point where the policy decision about whether or not to do fracking is being made by the scientist. The information has to be presented clearly and appropriately and address the policy question. At the same time, the receiving environment has to be capable of dealing with that information.
- This discussion is disciplinarily very imbalanced. The problem is being constructed from a geophysics and engineering perspective, where social and ecological factors would be a barrier as impervious as dolerite. There is a tendency to brush off the other disciplines as obstacles that have to be circumvented. The history of such developments in South Africa is that most that have not gone ahead, failed for not paying attention to those issues. Social sciences and ecological sciences in South Africa have not engaged with this kind of problem. Attention must be paid to these issues as they are clearly as important as issues about where drilling should take place.

Somila Xosa (DST): The focus of this workshop is on one of a number of focal areas identified in the SAP. This focal area (exploration, development and production technology) is one of the areas in which South Africa needs to ensure it has sufficient/latest know how and capabilities. The intention is to tie up with national activities so that key challenges in this particular area can be unpacked and discussed.

SESSION 3: SHALE GAS PRE-PRODUCTION
Facilitator: Mr Somila Xosa, DST

Optimisation of Hydraulic Fracturing and Production in Unconventional Oil and Gas Reservoirs (Dr Azra Tufuncu, Unconventional Natural Gas and Oil Institute (UNGI), Colorado School of Mines, USA)

UNGI's research focused on coupled integrated multiscale measurements and modelling.

The following points were made in relation to shale reservoir exploration and development:
- Coupling horizontal wells and multistage fracturing were key in ensuring economically viable production. Some of the reasons for this were:

    - Horizontal wells (no fractures) increased the contact area, improved access to formation and reduced the number of horizontal wells.
    - The addition of (a limited number of) fractures further increased the contact area.
    - The environmental footprint was significantly reduced.
- Effectiveness of fracturing operations strongly depended on production rates, drainage area and recovery efficiency, as well as knowledge of the *in-situ* stress state, formation characteristics and anisotropy influence on the design and execution of the operations.
- The main challenges included:
    - Reservoir and fracture characterisation/ sweet spot identification,
    - Up-scaling core heterogeneity and anisotropy to field scale,
    - Hydraulic fracturing coupled with existing natural fractures in geomechanics/flow modelling for permeability.
    - Environmental issues (water use, air pollution, environmental footprint).
    - Adequate infrastructure.

The following aspects were being studied at UNGI as understanding them was necessary in order to properly design operations and production:

- Anisotropy and microporosity in shale.
- Shale maturity and kerogen type and distribution, and clay composition.
- Direction dependent mechanical properties of shale.
- Hydraulic fracturing in naturally fractured formations.
- Incorporation of stress alteration for hydraulic fracturing optimisation.
- Shale-fluid interactions.
- Geohazard risk evaluation and monitoring.

The following conclusions were drawn from UNGI's research:

- There was no doubt that a combination of horizontal drilling and hydraulic fracturing and understanding the nanoscale characteristics were key for economically viable production.
- Geomechanical, petrophysical and geochemical properties of the formation made a difference to production.
- Natural fracture characterisation and fluid and proppant selection were essential for successful developments in shale reservoirs.
- Water use, air pollution and environmental footprint issues required proper regulation for sustainable production.
- Technically excellent and responsible engineering/science would bring prosperity to shale developments.

Discussion

Cyril O'Connor (ASSAf/SAAE): How much of the fundamental research is done in real time on site and how much is done in the laboratory with feedback to the operator in terms of what is happening during the hydraulic fracturing process?

Moctar Doucoure (NMU): At which stages are these studies conducted (pre-, during or post-production)? Are the different conclusions you have come up with typical of fracking waves or are there significant differences?

Thomas Nyanat (PetroSA): Could you give a brief idea of what the geohazard risk evaluation and monitoring involves? Is this done at the beginning and the end of the drilling, before reclamation? Of all the different aspects, what is specifically representative of fracking?

Responses, **Azra Tutunca**:

- Some companies allow consortia at the university to go the sites and collect data. We start with an internet research in order to get general information about what has been done in the specific area. In the USA, the location of almost all unconventional resources has been very well established. Initially, our geologists collect outcrop samples and do some tests. Simultaneously, we use cores collected from wells (vertical as well as horizontal) because outcrop samples and real reservoir conditions are sometimes significantly different.
- There needs to be a seismic network and each region has to be investigated for earthquakes. A valuable addition would be to have microseismic stations placed in several areas. Good work has been done in water quality. Setting reference data is very critical as this is a base to start. South Africa has the advantage of learning from the USA's negative experiences and should definitely start with a network and do microseismic monitoring before and during hydraulic fracturing. This would provide important information, which can be assessed and lessons learnt. Monitoring is essential in order to better understand the reservoir.
- There is huge variation within all properties and in all directions, even within a small area. We try to understand everything and model each fracture network for each well and to include some predictive statistical models to be able to generate a bigger scale and have a better general understanding of the basin. Each unconventional well has to be studied on its own. It is important to understand the fracture network and heterogeneity and anisotropy in the reservoir before applying other things.

Mike Shand (Aurecon): Should the regulations specify that the information gained by the developer should be made available to the authority?

Response, **Azra Tutunca**: In the USA, service companies put the general information onto a database. In some case they do withhold proprietary information. One by one, states are making it mandatory to release the information. The Colorado Oil and Gas Conservation Commission has a very good database of all the information. The more transparent the operation, the less the concern and resistance there will be.

Niall Kramer (SAOGA): Is there any experience in the USA of collaborative stakeholder education engagement through industry and government talk to communities?

Response, **Azra Tutunca**: UNGI shares its work internationally through the US Department of State. Also, every state has industry funding to create an educational programme for policymakers and regulators. Education starts at preschool. Engineers and scientists must be equipped and prepared to answer any questions and work closely with government and local communities. Our regulators teach us scientists many things.

SESSION 4: RESERVOIR ENGINEERING ASPECT OF UNCONVENTIONAL RESERVOIRS
Facilitator: Mr Sbusiso Mkhize, PetroSA

Unconventional Shale Oil and Gas Reservoirs (Dr Fikri Kuchuk, Emeritus Fellow, Cambridge, Massachusetts, USA)

The USA currently produced around 11.4 million barrels of crude oil per day, with six million or more barrels per day having been added over the last ten or so years due to shale oil production. This involved huge operations and the substantial increase in shale resource development brought with it increased impact due to the sheer number of wells, surface disturbance, service intensity, truck traffic, required resources, water produced, air emissions and noise. The environmental aspect of unconventional shale resource development has become very important. The current technology could play a role in reducing the impact and had to be developed where necessary to help minimise potential negative impacts. Long horizontal wells have shown to be the better option in environmentally sensitive areas where the oil was otherwise inaccessible.

Unconventional shale resource development involved several steps: basin characterisation, geological and reservoir modelling, fracture network modelling, drilling and completion design, stimulation design, fracturing operation, microseismic monitoring, and numerical simulation and forecasting. Integrated technologies were used as a workflow for shale development and production optimisation.

In terms of the characteristics of gas shales, it was important to note that although it was thought that the production well life was short (this had not yet been fully established), the reservoir pressure is currently very difficult to determine and it had to be accepted that gas shales were heterogeneous.

A developed multiscale model for gas flow in shale formations should address gas diffusion and desorption in sub-nanopores kerogen, as well as gas desorption in shale pores. A model of gas flow in multi-scale medium should take cognisance of:

- Macroscopic scale shale matrix medium.
- Equivalent medium for matrix and vugs, and secondary and tertiary fractures.
- Macroscopic scale explicitly modeled major natural and multiple hydraulic fractures with horizontal well.
- The horizontal well in these fractured shale systems can intersect one or more fractures.

In conclusion, success in developing shale gas reservoirs required a very efficient integrated system.

Discussion

Sbusiso Mkhize (PetroSA): Petroleum engineering is a scarce discipline in South Africa. What is your advice to the team working on the SAP in terms of developing this discipline and building the necessary capacity?

Response, **Fikri Kuchuk**: I notice that geoscience, especially reservoir engineering, is weak in the shale gas discussion. Inclusion of reservoir and production engineering capabilities in the discussion is essential. This will help when talking to the authorities. In the USA, the petroleum sector is being combined with the Earth Science group.

Cyril O'Connor (ASSAf/SAAE): A consultant who was approached as part of the study emphasised the importance of developing a field development model, but I wondered how

this can be done when there is so much heterogeneity. What has to be done to find out how much gas there is in the Beaufort West region, for example? What is your advice? Please explain your point about having to do fracturing as part of the exploratory phase.

Response, **Fikri Kuchuk**: In many shale formations or reservoirs, one out of three wells is productive. The more wells that are drilled, heterogeneity can be better understood. Density logs are very valuable in indicating how much organic matter there is. Sonics logs, stress directions and geomechanics also helps. Vertical wells are poor indicators of fractures and faults. Horizontal wells provide lots of knowledge about heterogeneity. In any shale development, especially when heterogeneity and fractures are expected, horizontal wells are essential.

Unknown person: What is the status of research on waterless fracking?

Response, **Fikri Kuchuk**: Work is being done on using foam in fracturing. This reduces water usage by more than 20%. There has not yet been any commercial success. Advancements in water use reduction have been made in chemistry and the work is ongoing.

DAY 2

Welcome (Prof Cyril O'Connor, ASSAf/SAAE)

Prof O'Connor welcomed participants to the second day of the workshop and thanked those who presented during the first day's proceedings and contributed to the discussions.

Attendance by an important policymaking audience with participation from people who are key decision-makers in various sectors of the industry presented a unique opportunity for the round-table discussions to contribute to assisting the DST, as well as the ASSAf panel to develop a rigorous and robust methodology for the way forward in terms of implementing the SAP.

Day 1 had focused on Flagship 1 of the proposed governance model for the implementation of the SAP. Round Table 1 would review the current status of the SAP as it related to Flagship 1 and Round Table 2 would focus on brainstorming how to take the SAP forward.

Perspectives of the DMR (Mr Andries Moatshe, Acting Deputy Director-General: Mineral Policy and Promotion, DMR)

DMR was of the view that the shale gas project would be able to provide a sizeable investment in the country but was aware of the complexity of this challenging project. Many communities have borne the brunt of the impact of development on the environment. Government relied on scientists for guidance, but has experienced that they struggle to agree on the basics and tend to work in silos and would therefore provide a platform for engagement in order to come to some agreement. With regard to the shale gas project, scientists should take cognisance of the work government was doing to facilitate and promote scientists' ideas. An investment in the project by organised business would be facilitated by government.

The NDP indicated that by 2030 South Africa should have an energy sector that promoted economic growth and development, social equity and environmental sustainability, and

recognised the substitution of coal with gas resources (of which shale gas is one) as a means to reduce carbon emissions and as a major contributor to the energy mix. Information to date showed that a sizeable amount of shale gas was available for exploitation. The DMR took guidance from the report which was approved by Cabinet and which made the following recommendations with regard to enabling development of shale gas through hydraulic fracturing:

- Allow exploration other than hydraulic fracturing to proceed under the existing regulatory framework.
- Constitute a monitoring committee to ensure comprehensive and coordinated augmentation of the regulatory framework and supervision of operations.
- Augment the current regulatory framework and establish the appropriate regulations, controls and co-ordination systems.
- Define buffer zones around Square Kilometre Array (SKA) installations (to be established by notice in the *Government Gazette*).

Progress made in terms of the recommendations was as follows:

- The HFMC has been constituted and was chaired by the DMR Director-General.
- Regulations for Petroleum Exploration and Production were gazetted and promulgated in 2015, but were challenged on technical, as well las administrative grounds. A Supreme Court of Appeal decision was awaited.
- After promulgation of the regulations, several companies applied for licenses to do exploration. The applications have been put on hold awaiting the Court's decision.
- The Regulations for Petroleum Exploration and Production (2015) included provisions for the protection and coexistence of the SKA and shale gas development.
- A sub-committee looking at licensing, taking into consideration protection of and coexistence with the SKA, has been established comprising DMR, DST and PASA.
- The DST commissioned ASSAf to conduct an assessment of the technical readiness of South Africa to support the shale gas industry. The report was published in October 2016.
- The CGS/PASA Karoo Deep Drilling and Geo-Environmental Baseline Programme was underway.
- Department of Environmental Affairs (DEA) and the CSIR carried out a Strategic Environmental Assessment.

The DMR initiated a process for the separation of petroleum provisions from the Mineral and Petroleum Resources Development Act (MPRDA) and developed a Petroleum Bill that addressed specific issues relating to the petroleum sector and provided the necessary legislative certainty. In addition, a moratorium has been imposed on the granting of new permits pending the publication of a notice in the *Government Gazette* for a more strategic system of applications by invitation in specified areas.

SESSION 5: ROUND-TABLE DISCUSSIONS

Purpose and Way Forward (Mr Somila Xosa, Director: Transport Fuels, DST)

Government's decision to begin exploring the shale gas space was based on the following considerations:

- Establishment of a shale gas multi-department monitoring committee to oversee what government was doing. The HFMC has been set up by the DMR.
- Development of a regulatory framework to address how the shale gas resource development would be approached. Regulations were developed through an

interactive process involving numerous government departments. However, some had disputed the consultation processes and taken the matter to court.
- Engagement between the DST and DMR to develop a framework for co-existence that ensured that shale gas activities would not impact on the SKA programme. This work was ongoing.
- Conduct independent research to assist in clarifying whether or not to proceed with shale gas activities.

Tasks relating to the above were assigned to specific leaders within government. The DMR was leading on regulatory matters and the DMR Director-General chaired the HFMC, which had given the DST the responsibility of assisting government to shape the research aspect in order to provide a clearer understanding of whether or not to go ahead with shale gas activities anticipating that policy would be influenced by the research outcomes. The research identified key areas of focus that needed to be addressed and this led to the development of the SAP. It became evident that some focus areas identified in the SAP were already being attended to and people and processes were in place, while more clarity was required in other focus areas. One of these areas was identified in the SAP as Flagship 1. This consultative workshop aimed to unpack and gain a better sense of what was taking place in the areas grouped under Flagship 1. The discussions on Day 1 of the workshop provided more clarity with regard to quantifying the resource and skills, location, recoverability, safety, as well as technical capability requirements. Discussions on Day 2 were aimed at identifying any gaps in the SAP in preparation for the HFMC to take the plan to government in order to determine how it would be taken forward.

Round Table 1 (Facilitator: Mr Mthozami Xiphu, SAOGA)
Review the Current Status of the SAP as it Relates to Flagship 1 (Geology, Gas Resources, Seismicity, Exploration Technology/Engineering and EMI)

Context

Ten topics (areas of focus/research) were identified within the six Flagship programmes. The following three topics were part of Flagship 1:
Topic 1: Geology and Gas Resources
Topic 2: Exploration, Development and Production Technology and Electromagnetic Interference
Topic 3: Induced Seismicity.

The key research tasks in Flagship 1 were identified as:
- Task 1: Measure gas resource and test recoverability.
- Task 2: Develop inventory of primary technologies, processes, practices and specifications used in safe hydraulic fracturing and gas extraction plus a gap analysis of what technology was not currently available.
- Task 3: Monitor progress of technology used during seismic surveys and deep vertical drilling in Phase I Exploration and then during horizontal drilling and hydraulic stimulation undertaken during Phase II Exploration.
- Task 4: Analyse data from existing seismic and GPS stations; deploy additional stations if necessary. Integrate and interpret existing geological and geophysical data. Assess seismic hazard and identify faults.
- Task 5: Monitor seismic activity during hydraulic fracturing.
- Task 6: Undertake risk analyses of existing buildings in region.

- Task 7: Given the unique challenges of the area under discussion, determine the gas need in South Africa across end-user sectors, identify sectors for fuel switching and determine tipping points which made gas a financially feasible option. Quantify the economic advantage of indigenous gas over other energy resources and over imported sources of gas.

Sub-tasks identified under Task 1 were:
- Drill deep boreholes in high prospective areas.
- Test for gas and groundwater.
- Develop Bayesian basin models of the Karoo Basin.
- Establish shale gas research laboratory co-funded by industry.
- Undertake core analysis of existing borehole data.
- Undertake magnetic and seismic surveys.
- Determine location of high probability gas reserves.
- If deep borehole results were positive, undertake horizontal drilling and Exploration Phase II hydraulic fracturing co-funded by industry.

Participants were asked to reflect on the seven tasks in the context of the input provided through presentations and discussions during the proceedings on Day 1 and indicate whether any of the sub-tasks were already done or being done as a means to consolidate the information.

Discussion

Mike Shand (Aurecon): The international speakers indicated in their presentations on Day 1 that the resource could not be determined unless horizontal drilling and trial fracking are done. In this case, it will be necessary to review how this is done. The only way would be via the concessionaire who undertakes the work.

Stefan Hrabar (Mirlem): Phase 1 should include a pilot drilling with horizontal drilling as well. This is necessary to ensure that all the information is gathered.

Ray Durrheim (University of the Witwatersrand): Some parallel processes with overlapping goals that are happening have not been mentioned. One of the activities in our research group is at our reflection seismic research centre. The original focus was on the hard rock environment using technology adapted from the oil industry to search for gold and platinum, but in the last five years, the focus has moved to the oil and gas industry. For example, we are working on datasets from the Orange River basin and the Zululand basin, and supervising students from the University of the Western Cape and employees from organisations such as PetroSA. Through Operation Phakisa (marine economy), colleagues from NMU have been through the exercise of identifying skill gaps. Operation Phakisa tried to recruit Research Chairs (I hold a Chair in Petroleum Geoscience) and has not been successful in getting credible applications in the last while. When Total announced its discovery, I was contacted by the National Research Foundation (NRF) about what can be done to develop expertise in this area. There was a meeting with the DST and the South African International Maritime Institute to coordinate Operation Phakisa and it was decided to set up a community of practice in Petroleum Geoscience (as a complementary initiative). I was asked to coordinate/convene this body. I have been talking to others about this. The scope of the study is the whole value chain and it is not confined to South Africa.

Mthozami Xiphu (SAOGA): It is becoming clear that there is a need for concerted coordination of shale gas-related activities. More must be done (by the DMR, DST and PASA) to address the lack of coordination.

Fikri Kuchuk (Emeritus Fellow, Cambridge, US):

- The shale gas industry has been going on for a hundred year in the USA, and the technology has been maturing during the last 20 years. Many of the sub-tasks listed are commercially available. It is important to discover and use the services that are commercially available through companies that are managing the projects and through universities and accelerate the process. Start doing the work and then develop the project and task in parallel. If you wait to complete all the tasks before drilling, it will take 15 years before starting to drill the first well.
- Undertaking magnetic and seismic surveys has nothing to do with gas. Seismic studies are only needed to asses basin and structure before drilling.

Stephanie Scheiber-Enslin (University of the Witwatersrand): In terms of magnetic and seismic surveys not being a necessity, I looked at the Soekor seismic data and it shows the complicated interconnected network on sills, but the dykes are seen on the seismics. Regional data from a high-resolution survey done in the Western Karoo missed a whole dyke swarm because of low resolution. An aero-mag is desperately needed to map the dykes.

Mthozami Xiphu (SAOGA):

- The CGS can contribute a lot to induced seismicity, even before fracking.
- We need to know what is being done or what has already been done, but we cannot waste time. Proper coordination is necessary in order to accelerate the process.

Moctar Doucoure (NMU): Some of the tasks are in the wrong order. One of these relates to induced seismicity. We have done a background study of the seismicity that exists today in a natural background. In terms of sub-task 1, drilling deep boreholes in high-prospective areas, the work done so far has avoided prospective areas. Companies have a sense of where these areas are and that is why they took licenses. We should be drilling there so that we have a high prospect and know what the resource could be. We seem to be avoiding the real challenge.

Reinhard Meyer (Geological Society of South Africa (GSSA)): Groundwater (focus area of Flagship 3 and linked to waste) ought to be given a much bigger emphasis in Flagship 1. I make a plea for groundwater research during the first phase of the SAP. South Africa's aquifers are mainly in (deep) fractured hard rock and we do not understand anything of fractured hard rock hydrogeology in this country. This is an opportunity to study fractured hard rock aquifers in the Karoo in great detail.

Niall Kramer (SAOGA):

- Integration is always the missing piece as is commerciality. People pursue their own interests and research areas with tunnel vision. The question is being asked about what has been drilled so far and where the data is, but the data is not being integrated. This is the first piece. The other piece on integration is unless government departments are better integrated with an eye on commerciality, nothing will happen. It is the license applicants (if they are still interested) and not the taxpayer that will underwrite this. I proposed to the HFMC that an active pursuit of the big companies is necessary. They have large amounts of data. The key issue is feeding upwards to DMR and the need to issue licenses. Unless

licenses are issued, there is no certainty that companies will be interested in doing anything around shale, especially since the offshore yield has started to look very promising.

- The idea of having ten core drills across the Karoo to get more data from different areas, done on a research basis, bringing in the commercial companies is good because it de-risks everyone. ASSAf has the kind of stature that would attract interest from commercial companies.

Cyril O'Connor (ASSAf/SAAE): I support the point that industry players need to be around the table. There are some constraints within government concerning the extent to which information is put into the public domain.

Nic Beukes (University of Johannesburg): I would like to support Mr Kramer's proposition. When drilling for the KARIN Project, with limited budget, we specifically decided on two areas. The Eastern Cape province, where no drilling had taken place and nothing was known, to learn more about the Karoo sequence in that area and we know it would have a lot of dolerites. The other area had no dolerites and we only drilled 700 m but found interesting things. At that time, around 2015, CGS was planning its drill core, which has not yet happened. They want to drill 3.5 kms deep but the Whitehill in that area is 2.5 kms. It took us three months to drill to 2.5 kms. South African companies have the ability to drill that deep. Instead of spending money to go to 3.5 kms, it would be helpful to go to 2.5 kms and drill a few deflections to get a much bigger intersection of the succession and do orientated core, fractures and so on from the same core. I also think that scientists (such as myself and Prof De Wit) have the capability to oversee these type of projects. Drilling for science is not commercial at all and only has to do with research. No exploration license is needed. Drilling could be done in areas around certain Karoo towns where there is no concession and the information can become available immediately for everybody. If funding was made available, possibly from a consortium of companies, scientists would be able to drill four of five very good wells that would lead companies to become more interested in shale gas in the Karoo. Scientists cannot do anything more because they have no new material to work with. This is a big problem for science and geology.

Ngqondi Nxokwana (CGS): The 3.5 kms depth that is proposed to be drilled in Beaufort West is because we anticipate that the Whitehill might be between 2.5 to 3 kms. Decisions will be made about how far to drill below that. The target is to try to understand if there is shale gas and understand how this will impact the shallow water.

Thomas Nyanat (PetroSA): Are all the activities under task 1 connected to the CGS deep borehole in Beaufort West? If so, a question can be developed around what is feasible.

Ngqondi Nxokwana (CGS): The Beaufort West borehole is sited specifically as it is intended to drill all the way down to possibly 3.5 kms and understand the shallow and semi-deep aquifers, as well as the fractured aquifers, and try to understand the gas potential. It addresses certain but not all the aspects of the activities under task 1.

Cyril O'Connor (ASSAf/SAAE): The point has been made that government is responsible for managing the whole process (regulation, legislation and so on). However, money is a problem. Second, the high prospectivity area is a proxy for Beaufort West. There is no point focusing on the good science. This prompts the discussion about engaging with industry with care, caution and due diligence. In my opinion, this is the only way this will be affordable.

Thomas Nyanat (PetroSA): I personally support the location in Beaufort West for the same reason that the KARIN wells were drilled, to be able to exclude the area we are not interested in. I am convinced that operators are very interested in the data and would be interested in working with scientists. It is very important to get the drilling right and do it safely in order to gain the confidence of the public.

Stephanie Scheiber-Enslin (University of the Witwatersrand): I always thought that the sweet spot was further east and was surprised at the focus on Beaufort West. If companies were involved, it could not be open to everyone as the matter is sensitive. Care needs to be taken about how the three companies already involved are treated.

Maarten de Wit (NMU):

- The ASSAf report was very clear that there were areas that should not be undergoing this kind of exploration, particularly in the beginning. These included the area where the SKA is, all areas where the shale gas is above 1 500 m, and in potential UNESCO World Heritage sites, such as Graaff Reinet.
- We have been working with communities in the Karoo for almost six years. The people do not like scientists at all. It takes a very long time to talk with the communities to help them understand what science is about. Part of the baseline study is about how to get people to trust each other. Trust building, particularly in the Karoo communities, is part of a very lengthy process.

Mthozami Xiphu (SAOGA): It is important to remember that we are looking after the interests of government. Government is the licensing authority and monitoring authority. These roles are essential and need to be well documented and protected. This mind frame will be helpful in coordinating the information. The operators have their own end goals and can be engaged at a later stage.

Mokone Roberts (*Journal of Energy in Southern Africa*): Looking at the complexity of implementing this project, I sense that a desk needs to be set up, comprising a project management team with trusted knowledge, expertise and experience in projects of this size internationally, with no conflict of interest, but with sufficient authority to coordinate all tasks and activities. This will ensure that nothing gets lost and that decisions are made correctly.

Mike Shand (Aurecon): This idea ties in with the proposal to have a 'one-stop-shop', which is particularly for applications, whereas Mr Roberts' idea would be for implementing and/or approval process with links into all the government departments or there will be massive delays in pursuing the exploratory phase.

Lindiwe Mekwe (PASA): From the regulator point of view, a well-coordinated effort is needed to draw on all the research that has been done and develop one consolidated report that looks at the concerns raised and how they could be addressed. In terms of the tasks that need to be done, it is not clear whether they are the responsibility of science or business. Developing an inventory of primary technologies (Task 2) is a concern as it seems to go beyond a baseline study and because one of the legislative requirements for licenses is that the relevant companies have to be able to show what technology they will use, which has to be within the parameters of the baseline study. Is this task aimed at developing best practice?

Moctar Doucoure (NMU): At the risk of government representatives thinking that scientists cannot agree on anything, the point is that NMU has done a baseline report that shows where possible sweet spots are. It would be good to bring together different data and look at it carefully before making a pronouncement on the definite well. The comments made by Ms Mekwe (PASA) are fundamental to this workshop. Government should be looking at the baseline. This is core to monitoring issues. Skills development comes with baseline studies. The NMU report spells out and demonstrates how all this can be done.

Azra Tutunca (Colorado School of Mines, US): Everyone has good intentions and good work is going on. What I am hearing, especially from government's perspective, is that reference data is critical and has to be established, but trust must be shown to companies who invest and make it happen. Government, industry and academia collaboration is extremely important for things to be accomplished in good time. If you want to do everything on your own and not allow companies to be involved it will take forever. In the USA, some things have been done wrong but when there is no baseline, collaboration with well-established companies helps us to establish the reference state. We ask companies to provide water tests before they do anything at all in a local area. During operations and five years afterwards, they have to report back on the water from the same locations. This monitoring allows for any significant variation to be identified. The companies' reputations are at stake. There are many advantages to collaborating with companies.

Niall Kramer (SAOGA): ASSAf should not underestimate the degree of trust that it can develop with communities. Scientists are trusted more than explorers and politicians. This is a marketing opportunity for SA Inc to work together with the explorers and establish the baseline and do all the other studies. Exploring companies have different interests. It is important that the licenses are issued so that those who are not interested are flushed out and those blocks are reallocated and can go to new players who can become partners. They are not only interested in the geology but they also want to know what the geology can yield. For them the sweet spot is not just the place with the most gas, but one that is close to rail, roads, infrastructure and power. From their point of view, it is not about science in a vacuum.

Round Table 2 (Facilitator: Prof Cyril O'Connor. ASSAf/SAAE)
Taking the SAP Forward

Context

Dr Maserumule provided the context in which the DST operated in terms of implementing the SAP.

All DST programmes required funds, human resources and a scope, and most lasted ten years. To some extent, the SAP provided the scope of what should be done, allowing some flexibility, and was a good starting point. The funding aspect was always difficult. Although the DST had never received a reduction in baseline, increases were mostly below the inflation rate. Three possible options for funding were:

- DST funds different activities and about 60% of these funds go towards knowledge generation in relation to blue skies research activities, which is usually done by policy instruments, such as the Centres of Excellence. Knowledge generation from the shale gas would fall under this category of funding. Creating a new Centre of Excellence or using existing ones such as CRIMERA, and increasing their funds could be considered. Surpluses from the 2018/19 financial year were available and should be pursued aggressively.

- Funding through the South African Research Chairs Initiative (SARChI), particularly to female Research Chairs, could be pursued. There were also joint research chairs with other countries.
- Funding for innovation and economic development could be relevant if there was incremental innovation in relation to existing technologies (or tools) proven elsewhere and adapted for South Africa's needs. Around R100 million was spent on high infrastructure on an annual basis. A project could be scoped around this with the private sector and a proposal submitted to the DST.
- Co-funding for DST projects from other government departments was possible.

In terms of the human resource aspect, there were funds for a secretariat. Involvement of various departments would increase the likelihood of the DST's support. The scope of the project should be no less than ten years.

Purpose

Prof O'Connor explained that the purpose of the Round Table was to build on Round Table 1 by sharing thoughts about an implementation methodology for SAP. He highlighted the following in this regard:

- The HFMC had been established and met on a monthly basis.
- Each of the six Flagships had a government department associated with it, ensuring a distribution of responsibilities across key departments.
- Each Flagship would have two co-chairs: one from the relevant government department and the other from outside government domain. The 12 chairs needed to be identified and would form the co-ordinating group managing the Flagships.
- The ten topics, forming the next tier of activity, were identified as broad areas that were subsets of the Flagships.
- An inventory analysis of who was doing what around the country needed to be done (mainly to avoid undue duplication of effort), but also to assess the potential contribution from industrial partners. The coordinating group under the auspices of the SAP would be tasked with this exercise, possibly within six months but a maximum of 12 months.
- A gap analysis needed to be done.

Discussion

Maarten de Wit (NMU): I want to emphasise the need to find a way to get communities to understand the shale gas project and set up something such as a shale gas laboratory within a community centre, where high-level science was being done at the same time as a talking with the community and building trust, and where companies could invest and universities were involved, such as a controlled fracking site, which would be the next step of a baseline study.

Fikri Kuchuk (Emeritus Fellow, Cambridge, US): Community leaders should be taken to fracturing sites, possibly in other countries, in order to educate and inform them so their experiences can be shared with communities.

Cyril O'Connor (ASSAf/SAAE): Associated with the SAP activity is another activity to see how to implement the proposal elaborated on by Prof De Wit to develop a research centre in the Karoo. This is clearly a project that has to be undertaken. The DST would want to engage with PASA, PetroSA and other players who can participate in this exercise.

Mike Shand (Aurecon): The need for the one-stop-shop idea and a review of the regulations and the National Water Act as it applies specifically, or a general review in order to facilitate the process, gaining experience from international partners who have the knowledge, should not be forgotten.

Cyril O'Connor (ASSAf/SAAE): The ASSAf report only touched briefly on the domain of regulations, which is very important in the implementation of the SAP. Ms Mekwa explained that PASA played a role in Flagship 1 in terms of ensuring the baseline study is conducted and also in the other Flagships in terms of reviewing the regulatory framework.

Ray Durrheim (University of the Witwatersrand): Much could be learnt from the second Operation Phakisa, which has to do with mining, has six themes and is run by a government partnership with the Minerals Council of South Africa.

Stefan Hrabar (Mirlem): Progress on the three-point plan for Operation Phakisa has been slow. SAOGA has a committee for shale gas that is not represented at this workshop.

Niall Kramer (SAOGA): This is correct. The committee comprised Karoo shale gas drillers as a representative body primarily in the shaping the Petroleum Development Act, putting the companies' position into the new legislation. In terms of Prof Durrheim's suggestion to look at mining as well, the Karoo shale gas companies have been clear that they wanted petroleum legislation to be separate from that of mining.

Mthozami Xiphu (SAOGA): Unfortunately, Operation Phakisa was oceans economy oriented. Onshore oil and gas exploration fell through the crack between the Mining Phakisa and the Phakisa for offshore oil and gas exploration. In terms of the emphasis on public education, PASA under Operation Phakisa already has a work group that is leading on public education and interacts indirectly with every application and when issues arise. The shale gas aspect should be included in this work group as it would be the best entity to lead this process.

Cyril O'Connor (ASSAf/SAAE): There is evidence of a wealth of experience within the government domain in terms of systems and processes that work and do not work. These should be shared across departments. Members of the ASSAf panel would urge the process beyond this workshop to move ahead and were available to assist in whatever way possible.

Closure and Vote of Thanks (Dr Rebecca Maserumule, Chief Director: Hydrogen and Energy, DST)

A vote of thanks was offered to:

- Prof O'Connor and the ASSAf/SAAE team for having steered the process and ensuring that it was taken forward, for their integrity and professionalism, and diplomacy with regards to how their recommendations were communicated to government. The report, *South Africa's Technical Readiness to Support the Shale Gas Industry* was the first to be taken by ASSAf to Cabinet.
- Ms Algera and the ASSAf team for their steadfast support and for always delivering on DST projects.
- The end of the financial year is a very busy time for government hence I want to extend a special thanks to government colleagues, who despite working under pressure of reporting deadlines, still took time to participate in the workshop.

- The DMR and the HFMC under its leadership, for their steerage and guidance, as well as ensuring that all of government was coming together for the good of the country
- Local speakers from academia, industry and government, for their thoughtful words and fruitful discussions that would help move things forward in the right direction.
- The DST team, led by Mr Xosa who has been part of this project since the beginning, for his efforts, persistence and dedication to the shale gas project.

Special thanks and tokens of appreciation were offered to the international speakers: Prof Tutunca for her insight and passion, and for sharing her knowledge, and Dr Kuchuk for his words of wisdom and consistent advice to stick to the task.

ANNEXURE A: ACRONYMS

AEON	Africa Earth Observatory Network
ASSAf	Academy of Science of South Africa
CGS	Council for Geoscience
CIMERA	Centre for Integrated Mineral and Energy Research
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DMR	Department of Mineral Resources
DST	Department of Science and Technology
DWS	Department of Water and Sanitation
EMI	Electromagnetic interference
ESSRI	Earth Stewardship Science Research Institute
GHG	Greenhouse gas
GSSA	Geological Society of South Africa
HFMC	Hydraulic Fracturing Monitoring Committee
KARIN	Karoo Research Initiative
KDD	Karoo Deep Drilling
MPRDA	Mineral and Petroleum Resources Development Act
MW	Megawatt
NDP	National Development Plan
NMU	Nelson Mandela University
NRF	National Research Foundation
PASA	Petroleum Agency South Africa
R&D	Research and development
SAAE	South African Academy of Engineering
SAOGA	South African Oil and Gas Alliance
SAP	Science Action Plan
SARChI	South African Research Chairs Initiative
SKA	Square Kilometre Array
Tcf	Trillion cubic feet
UNGI	Unconventional Natural Gas and Oil Institute
USA	United States of America

ANNEXURE B: LIST OF PARTICIPANTS

Name	Surname	Affiliation
Nadia	Algera	ASSAf
Nyeleti	Baloyi	National Treasury
Nic	Beukes	University of Johannesburg
Vhongani	Chabalala	South African Bureau of Standards (SABS)
Steve	Clark	Stellenbosch University
Michiel	de Kock	University of Johannesburg
Maarten	de Wit	NMU
Moctar	Doucoure	NMU
Ray	Durrheim	University of the Witwatersrand
Surina	Esterhuyse	University of the Free State
Trueman	Goba	SAAE
Stefan	Hrabar	Mirlem
Sean	Johnson	PASA
Niall	Kramer	SAOGA
Fikri	Kuchuk	Emeritus Fellow, Cambridge, US
Tebogo	Mabotha	ASSAf
Tumi	Mailula	DST
Rebecca	Maserumule	DST
Alistair	McMaster	Department of Economic Development, Environmental Affairs and Tourism (Eastern Cape)
Lindiwe	Mekwe	PASA
Reinhard	Meyer	GSSA
Sbusiso	Mkhize	PetroSA
Andries	Moatshe	DMR
Maketele	Monyemangene	DST
Kurt	Morais	Shell
Mmboneni	Muofhe	DST
Namisha	Muthraparsad	DWS
Jali	Nhlanhla	DMR
Ngqondi	Nxokwana	CGS
Thomas	Nyanat	PetroSA
Cyril	O'Connor	University of Cape Town (ASSAf/SAAE)
Bob	Pullen	SAAE
Mokone	Roberts	Journal of Energy in Southern Africa
Stephanie	Scheiber-Enslin	University of the Witwatersrand
Bob	Scholes	University of the Witwatersrand
Mike	Shand	Aurecon
Ian	Shendelana	ASSAf
Khuthala	Somdaka	Coega Development Corporation

Name	Surname	Affiliation
Saleem	Soobader	PetroSA
Francis	Tsehloane	PetroSA
Azra	Tutuncu	Colorado School of Mines, US
Nicola	Wagner	University of Johannesburg
Mthozami	Xiphu	SAOGA
Somila	Xosa	DST