The University of the Free State Centre for Environmental Management (CEM) has been commissioned by the Water Research Commission (WRC) to undertake a project that will assist with addressing some of these knowledge gaps. The aims are to produce a background review report, develop an interactive vulnerability map and propose provisional screening level monitoring protocols for selected aspects. Together, these will make recommendations as to which areas are vulnerable to unconventional gas mining in South Africa and how hydraulic fracturing activities should be monitored. It will describe important entities that should be monitored for each phase of gas mining and how this monitoring should occur.

The project focuses on a wide array of biophysical and socio-economic aspects for the whole mining process from exploration through to the post mining phase. A number of participants are involved. “The complexity of the problem being studied is such that it requires a wide array of scientists from varying disciplines,” says CEM researcher, Surina Esterhuyse. The main researchers include scientists from the University of the Free State (the CEM and the Department of Sociology, as well as the departments of Physics and Statistics) in association with the University of Pretoria Natural Hazard Centre. Co-workers include independent consultants, as well as scientists from, among others, the Iziko African Museum, the Endangered Wildlife Trust, University of South Africa, the University of Fort Hare and the Technical University of Dresden.

The project spans over two years, but once it started in July 2012, researchers soon realised that their understanding of the issues that are really at stake were limited. Initially, the researchers’ biggest concern was with the impacts of hydraulic fracturing during shale gas mining, says Esterhuys. “As our knowledge base

Various applications for unconventional gas mining have been lodged with the Petroleum Agency of South Africa (PASA). Yet, gaps still exist in the available knowledge on whether economically recoverable quantities of gas exist, and how to manage the possible impacts, should full scale gas mining proceed. Scientists, legislators and regulators are making use of the time available before gas mining applicants start exploration, or possibly mining, in order to develop the necessary strategic plans. Article by Petro Kotzé.

Call for debate on unconventional gas mining to be broadened – Research project sheds new light on debate on unconventional gas harvesting

Stephani Cawood
increased, we realised that shale gas is just one resource in the suite of unconventional resources that may be mined using hydraulic fracturing. We also realised that although (mostly water-related) impacts could be associated with hydraulic fracturing itself, a larger suite of impacts on the biophysical and socio-economic spheres are associated with the unconventional gas mining process. These impacts could be far reaching and would require strategic and regional-scale planning if unconventional gas mining is to be effectively managed.

UNPACKING UNCONVENTIONAL GAS MINING AND FRACKING

Both conventional and unconventional gas resources are natural gas resources. They are differentiated by their degree of permeability and how they are extracted. While conventional gas (CG) is located in permeable rocks and can escape freely after drilling, unconventional gas (UG) is trapped in insufficiently permeable rock formations, such as shale, tight sands and tight coal beds. Resources from these reservoirs may include not only natural gas, but also oil as well as oil and gas condensates. In order to release these resources, a technology called high volume hydraulic fracturing (also known as slickwater fracturing) is applied. Other treatments can include acidising to dissolve carbonate materials in the host rock, as well as gel fracturing or gas fracturing.

High volume hydraulic fracturing involves drilling wells to the depth of the target rock (for instance a shale layer) where temperatures may range from 35 to 140°C. Different sections of the well in the production zone of the target rock are isolated and a mixture of 0.5% to 2% chemical additives and large volumes of proppant (that keep the fracture zones open), as well as large volumes of fluid (usually water) are pumped down the well. The hydraulic pressure used to deliver the fluid into the target formation may range from 10 000 to 15 000 pounds per square inch. This produces fissures in the reservoir and can open cracks in the shale up to 1000 m or more in all directions from the wellbore, which liberates trapped gas and allows the flow of gas into the wellbore and up to the surface.

HOW DOES THE MINING PROCESS WORK?

The process of unconventional oil and gas mining takes place in phases. First, it starts with the exploration phase, during which the presence of oil and gas, as well as the economic viability of extracting the resource is assessed.

Economic viability assessment usually requires in-situ well
Hydraulic fracturing

stimulation by means of hydraulic fracturing. After economic viability has been proven, the mining phase will follow during which oil and gas will be extracted by means of hydraulic fracturing and any other stimulation method that may be required.

In order to mine unconventional gas economically, economies of scale are used. Well densities may be as dense as required to make the venture economically successful. During the mining phase chemicals used for hydraulic fracturing, wastewater and brines from wastewater treatment should be properly managed. A well can be stimulated various times during its lifetime and when wells do not generate gas economically anymore, they are decommissioned during the post mining phase.

During this phase it is important to ensure proper well decommissioning, to perform continuous monitoring of water resources in previous gas mining areas and to ensure the long-term integrity of the decommissioned gas wells. The continuous integrity of decommissioned wells may pose a groundwater contamination risk over the long term.

Hydraulic fracturing itself, says Esterhuyse, as well as the activities associated with the different phases of unconventional oil and gas mining may result in various potential environmental and socio-economic impacts. These are uncertain and can range from positive to negative. Activities can include vegetation clearance during seismic surveys, trucking and storage of chemicals and fluids, wastewater and brine.

The geographic area where unconventional gas mining may be practiced is not limited to only a few concession areas in the Main Karoo basin. Areas may also include Prince Albert and Camaroon.
management, installation of pipelines, gas compression and processing facilities.

Understanding that hydraulic fracturing is just one part of the unconventional gas mining process, and that impacts are associated with the whole mining process is just one of the commonly held misconceptions that the researchers encountered.

**MORE COMMONLY HELD MISCONCEPTIONS**

According to Esterhuyse, some of the most common misguided concepts are that the process only involves impacts related to the extraction of shale gas, when there are actually also differences between these and mining for coalbed methane. “Shale gas may require large volumes of water for fracturing operations while coalbed methane mining may produce large quantities of high salinity water, but may require less fracturing to stimulate gas,” she says.

A second misconception is that environmental concerns are only related to water, when other aspects such as vegetation or socio-economics may also be affected during the process. “For example, if gas mining is not managed properly, it may lead to large scale fragmentation of landscapes and biodiversity and increasing social ills.” Yet, it must also be understood that hydraulic fracturing can be done with gas and gels as well, which may limit the water requirements during fracturing operations.

Esterhuyse further cautions that the geographic area where unconventional gas mining may be practised is not limited to only a few concession areas in the Main Karoo basin. Rather, this mining method may be used anywhere within this basin and sub-basins where unconventional resources may occur.

People also need to understand that impacts from unconventional gas mining may occur on a regional scale and that these may be cumulative in nature, she says.

Lastly, it needs to be understood that unconventional oil and gas mining is fundamentally different from other mining types that have up to this stage been performed in South Africa. “Unconventional oil and gas resources tend to extend across much larger geographic areas and may consequently not be easily managed or regulated on a spatial or temporal scale.”

**PROJECT PROGRESSION**

These insights stemmed from the production of the background review report, one of the first steps of the project. This information, together with the vulnerability map, will serve as a tool to be used by planners and regulators to aid in decision-making before allowing fracturing in certain areas. Esterhuyse cautions that it can, however, not replace local-scale studies that should be executed during exploration and mining licence applications.

Currently, they are in the process of identifying indicators or data sources that can indicate vulnerability for selected aspects. Baseline data on towns or regions that rely heavily on groundwater, regions in South Africa with high water-use demands, groundwater vulnerability and maps...
showing sensitive river reaches will be included. Data sets on areas with special vegetation and demographic, health and socio-economic data (to identify, for example, health impacts) will also be added.

According to Esterhuyse, experts will be used to assist in the development of the vulnerability map throughout the mapping process. “Although this approach requires time and resources and is limited in its application and transferability to other regions outside South Africa, the integration of expert knowledge may significantly increase the usefulness and acceptability of the results,” she says.

The eventual development of this map may take some time and it should be iteratively expanded as new data become available.

The main aim of the screening level monitoring protocol, again, is to identify the most important (screening level) entities or parameters that must be monitored during the different phases of gas extraction (pre-mining, during exploration, during mining and after mining).

These will be relevant for groundwater, surface water, seismicity, vegetation and socio-economic aspects. “In this way it is hoped that the most important entities that should be monitored as allowed by the available time, money and resources of regulatory authorities, could be identified.”

HOW DO WE PROCEED FROM HERE?

There is uncertainty at this stage on whether unconventional gas resources exist and if it would prove economically viable. Now may be the time to link economic benefits with environmental risks and industrial legacy. “We must assess whether proceeding with unconventional gas mining is acceptable on a long term strategic level, by identifying energy generation and job creation alternatives and performing a cost-benefit analyses on all these options.”

Should unconventional gas prove to be economically viable and be a sound strategic energy generation option, proper management of unconventional gas would require a suite of management strategies, Esterhuyse continues.

Firstly, proper management of this activity could only be achieved by strategic planning on a regional scale, in order to avoid unintended long-term negative consequences on a spatial scale (between different geographic regions) and on a temporal scale (like groundwater contamination that is only identified years after the event). Understanding the capacity of a region, and subsequently determining the capacity for development in this region without crossing landscape limits, would be required. A vulnerability map could be a first step to help identify such landscape limits, says Esterhuyse.

Regional strategic environmental assessments as well as integrated catchment management may also prove useful. A transparent and consistent regulatory framework, that regulates unconventional gas mining activities in a coordinated fashion between local and national scale, should also be developed.