



AUTHORS:

Barry Morkel^{1,2}
Moctar Doucouré^{1,3}
Martin Bentley^{1,3}
Divan Stroebel^{1,3}
Maarten de Wit¹

AFFILIATIONS:

¹Africa Earth Observatory Network (AEON)-Earth Stewardship Science Research Institute (ESSRI), Nelson Mandela University, Port Elizabeth, South Africa

²Department of History and Political Studies, Nelson Mandela University, Port Elizabeth, South Africa

³Department of Geosciences, Nelson Mandela University, Port Elizabeth, South Africa

CORRESPONDENCE TO:

Barry Morkel

EMAIL:

barry.morkel@mandela.ac.za

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Engagement for airborne geophysical survey within a transdisciplinary baseline programme in the Eastern Cape Karoo

The biggest lesson from the recent shale gas boom in the USA – specifically in relation to monitoring and mitigating contamination of water, and community health impacts reported in receiving communities, such as the Marcellus shale regions of Pennsylvania – is the fundamental need for baseline studies prior to any proposed shale gas development.^{1(p.547)} The USA is the largest (shale) gas producer and exporter to the European Union (EU) but it is generally accepted that, in most of the basins and shale plays in the USA in which unconventional oil and gas development has occurred, baseline studies have not been implemented.^{2(p.40)} This phenomenon, along with its environmental monitoring and regulatory implications, led to the establishment of the Karoo Shale Gas Baseline Programme, undertaken by the Africa Earth Observation Network (AEON) – Earth Stewardship Science Research Institute (ESSRI), hereon referred to as AEON, in partnership with the Eastern Cape Provincial Government. The Programme was the first of its kind in South Africa, and produced a transdisciplinary baseline of the Karoo prior to any shale gas development in the Basin.

A report by AEON summarises 4 years of baseline data collection and analyses, and shows that all aspects of life and natural systems in the Karoo could be affected by shale gas development. To provide this data, AEON research teams from Nelson Mandela University conducted groundwater hydrocensus and sampling for chemical analysis, surface water studies and ecosystems analysis, micro-seismicity measurements, and methane gas analysis, socio-economic research, and citizen science.³

As the great shale gas debate⁴ affects all inhabitants of the Karoo, including farmers, landowners and residents in Karoo towns, permission to conduct natural baseline research calls for meaningful consultation involving deliberate engagement with affected communities based on information sharing, and responsiveness to the specific issues raised by local stakeholders in the process. This process requires greater transparency and trust building than has been evident in the overall Karoo shale gas development process to date.³⁻⁶ Difficulties include the application and utilisation of new and/or relatively unfamiliar data gathering methods and technologies, including fixed-wing airborne and unmanned aerial vehicle (UAV or drone) observations within an environment already experiencing considerable uncertainty and trust deficit amongst many stakeholders.

The focus of this Commentary is stakeholder consultation as well as operational and logistical resilience, both in the field and behind the scenes, that have been necessary to conduct an airborne survey in the Karoo.

Landowner suspicions and trust building

Much of our ground and geophysical baseline data sets cover an area near the Eastern Cape Karoo town of Jansenville, a region of the semi-arid Karoo colloquially referred to as the Noorsveld, located 190 km to the north of Port Elizabeth. This area was prioritised mainly due to groundwater and logistical considerations, as well as previous scientific research undertaken by the group, which included studies of black shales from drillholes, deep conductive layer and velocity anomalies.⁷⁻⁹ This led to the deployment of different geophysical methods aimed at better quantifying the deep subsurface, such as magneto-telluric surveys conducted in partnership with the GFZ-Potsdam³, and the application of a novel passive seismic technique (i.e. no induced energy) which was only available through AEON-ESSRI at the time. Airborne data collection was necessary in order to bridge the gap between surface and deep subsurface geophysics.

AEON had developed considerable experience in the area through related baseline studies and field work conducted since mid-2014. These studies were dependent on a productive working relationship with stakeholders, including the local municipality, relevant provincial government departments (through their regional offices located either in Jansenville or Graaff-Reinet) as well as the local business and farming community.

Initial consultations in the survey area primarily focused on providing the local stakeholders of the then Ikwezi Local Municipality (an area now located within the larger Dr Beyers Naude Local Municipality) with an introduction to the Karoo Shale Gas Baseline Research Programme, in order to facilitate initial access to various study sites around the Karoo (see timeline in Figure 1). In Jansenville and across the Noorsveld, prior to commencing with airborne geophysics, the group had already conducted numerous baseline studies, with some still ongoing at the time, including a groundwater survey of 52 boreholes^{3,10}, a magneto-telluric ground survey^{3,8}, surface ecosystems monitoring in water bodies and termite mounds^{3,11-13}, micro-earthquake surveys^{5,9}, as well as a household survey¹³ in and around Jansenville. On implementation of the magneto-telluric survey, a year before commencing preparations for the airborne geophysics, the team convened separate meetings with local farmers' associations, the Ikwezi Municipal Council and senior officials, to inform them in greater detail of the need for the magneto-telluric study and to officially welcome visiting German science collaborators (magneto-telluric survey team) from the GFZ-Potsdam. The team relied heavily on the knowledge and experience of the local farmers' associations (Jansenville, Klipplaat and Waterford) in identifying the many landowners and obtaining their contact details, so as to facilitate direct contact with the individuals involved. Two retired farmworkers, who are familiar with the terrain, assisted the ground team in navigating between the various farms. These contacts proved essential during the roll-out of the magneto-telluric survey in late 2014, because it required extensive interaction with farmers and landowners in gaining access to farms within the study area, and laid a strong foundation for the airborne survey.

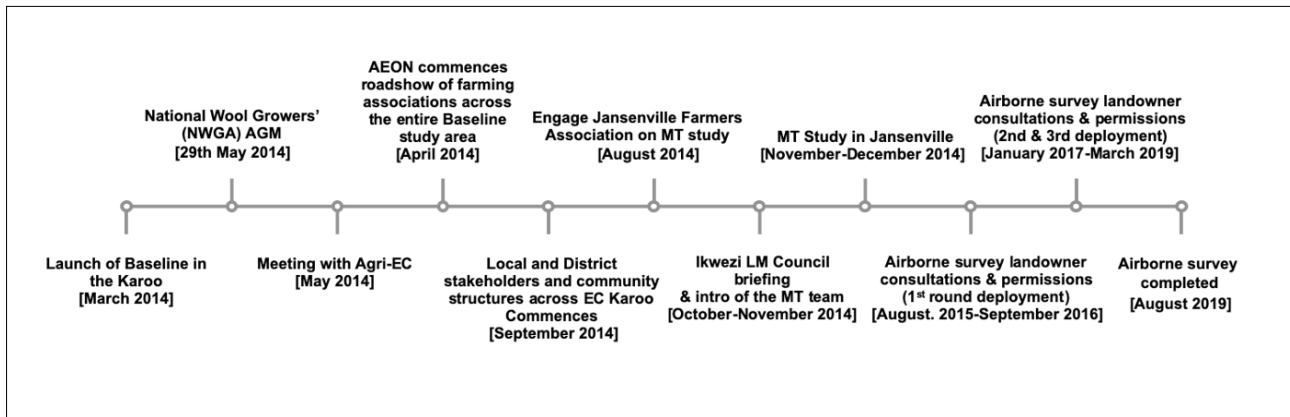


Figure 1: Stakeholder engagement and fieldwork timeline for the Karoo Baseline and Jansenville Airborne Surveys.

Using the same strategies adopted for the smaller magneto-telluric survey, the ground team conducted a farm-to-farm campaign as best as it could. In instances in which the farmer or landowner did not attend our meetings, which were convened with farm associations in the District, the team visited the farm in person or phoned the owner to let them know of the survey and to obtain permission to fly over their property. Owing to the complex nature of landownership, land tenure, land use patterns and agricultural activities in the district, the team encountered a number of unforeseen challenges, and learned lessons along the way. In addition to these difficulties related to contacting landowners, areas to be avoided had to be identified. These ultimately resulted in exclusions and avoidances on the survey flight plan so as to avoid negative impacts on the ground. We had to avoid pre-identified areas related to livestock farming (mainly linked to lambing season), wildlife and game breeding (including for hunting and eco-tourism), as well as chicken and ostrich farms because these were sensitive for a number of farmers and landowners. While these presented difficulties for the permission process, these challenges were overcome by the team undertaking 'ground-truthing' missions and plotting coordinates at specific camps and sites in collaboration with landowners who had identified areas of sensitivity, which were excluded from the survey flight plan. This collaboration between ground teams and landowners ultimately resulted in the survey being successfully flown over 141 land parcels (refer to Box 1).

Operationalising the airborne survey in the Karoo

Survey flying commenced in October 2016 with the use of a gyrocopter. The team decided that a gyrocopter was the platform of choice because it is less invasive, with little disturbance on the ground, whilst maintaining

fuel efficiency. The initial plan was to collect data by flying at an altitude of approximately 40 m, across a grid of N-S flight lines spaced 200 m apart at a speed of 80 km/h. Shortly after commencement, and on review of the initial data collected, flights were suspended owing to strong winds together with the effects of thermal lift during the Karoo's summer months, which had impacted data quality negatively. The survey recommenced in April 2017; this was also cut short after the airborne team experienced a technical malfunction with the aircraft which was left irreparable after an emergency landing.

Given the difficulty in sourcing a replacement gyrocopter, it was then decided to use a fixed-wing Maule Bush aircraft which offered greater stability in the air. However, this new aircraft necessitated further consultation and communication on the ground. An advertisement was published in the local newspaper, the *Graaff-Reinet Advertiser*, and posters were displayed at high visibility sites in Jansenville (library, police stations, shops, municipal offices and local farmers' cooperative). The decision was also taken to re-schedule flying for cooler winter months, thereby ensuring more favourable wind conditions for better data quality.

The first deployment of the fixed-wing aircraft was cut short in 2018 by damage to an essential sensor. The team then finally began the survey again in June 2019. To avoid those areas identified as 'Not allowed' and 'Owner not contactable' (Figure 2), the airborne team had to implement necessary technical measures during planning and the flight itself. Similarly, over farms where it was known that hunting occurred (see Box 1), the height above the ground was increased to 80 m because flying continued during the colder hunting season in the Karoo. While the increase in flight height above ground had the effect of lowering the spatial definition of detectable magnetic features, the gaps in the survey coverage mean that some subtle local structures were unavailable to the interpreter of the geophysical image.

Box 1: Conditions on the ground that make for a dynamic and fluid environment for research teams in the Karoo

The team also liaised with the regional Conservation Management Office of the Provincial Department of Economic Development and Environmental Affairs, located in Graaff-Reinet, in order to better understand the extent and complexities associated with the game breeding and hunting industry in the district due to their economic importance. Compounding the situation was the impact of the prolonged drought experienced in recent years, with a number of farmers raising concerns about flying over certain areas during the harsh summer of the lambing season.

Whilst consultations and preparatory work proved time-consuming, it made a considerable difference in the field, leading initially to the identification of 206 individual land parcels, owned by 115 unique landowners. Based on these initial engagements, our team received permission to fly over 164 of these land parcels; we were denied permission to fly over 15 land parcels, and further excluded another 30 due to the landowner being uncontactable or unidentified by the ground teams (see Figure 2). Subsequent to initial deployments in 2016/2017, and after further adjustments to the survey flight plan, the total final area surveyed included 141 land parcels across approximately 1606 km². It was also important that we maintained communication with the then Ikwezi Local Municipality (now Dr Beyers Naude Local Municipality) during preparations for the airborne survey as we required permission to use the local airstrip. Beyond formal permission by Council, ongoing cooperation and support of the relevant officials in the municipality's technical service division remained critical.

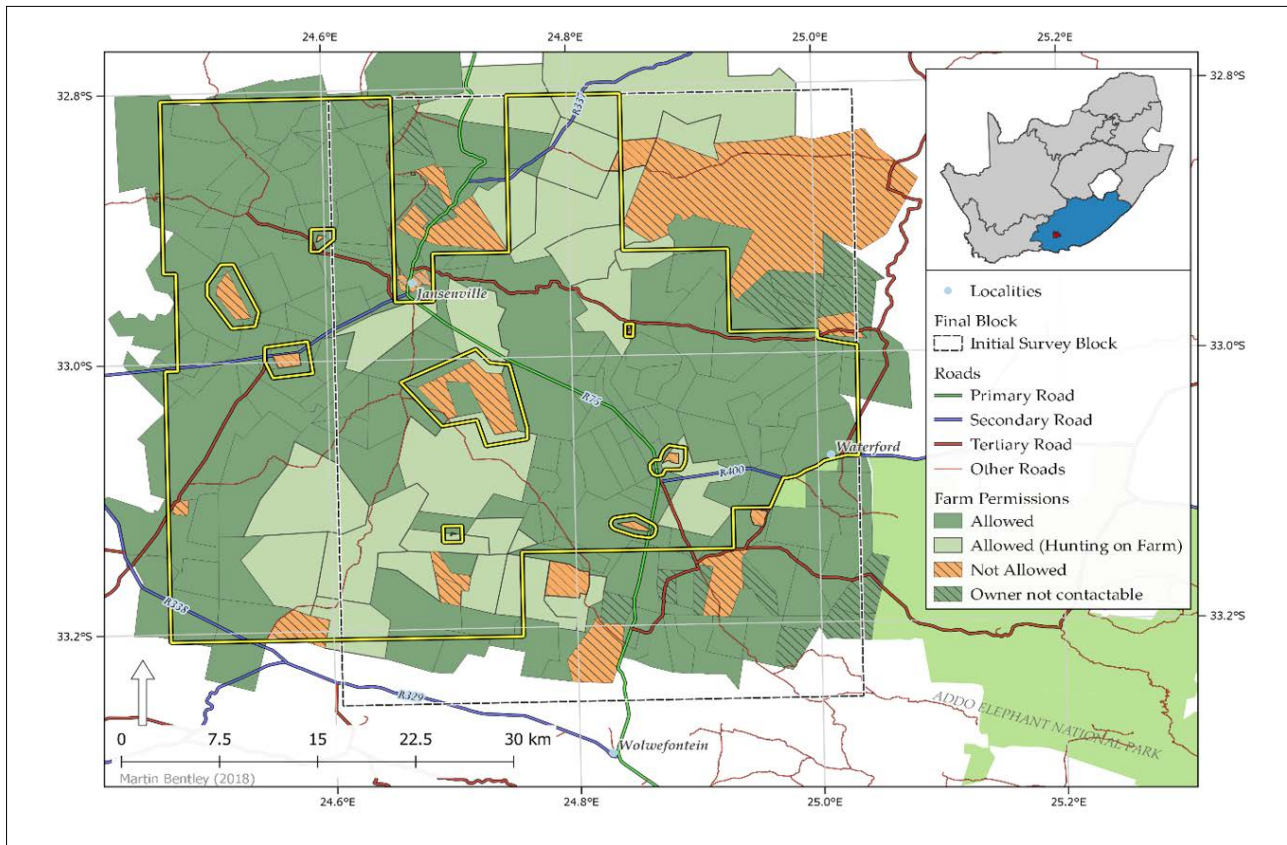


Figure 2: Airborne survey area, showing the coverage obtained during the community consultations and engagements.

Conclusion

The survey, which was eventually concluded in August 2019, has contributed valuable geophysical data to the Karoo baseline study. In addition, the team learnt about negotiating with landowners, farmers and other stakeholders whilst preparing to undertake this airborne survey. In particular, we were aware of the context of distrust that is connected with any research relating to shale gas in the Karoo.

We have shown that permitting for geophysical airborne surveys in the Karoo requires trust building through engagement, and responsiveness to the sensitivities and issues raised by stakeholders in the area. Participatory science, in the form of citizen science, can also prove a significant contribution to trust building. More fundamentally, the operationalisation of airborne surveys in the Karoo as part of the broader natural baseline study has shown that any future exploration for shale gas in the Karoo would require a social licence to operate, which will be reliant on significantly higher levels of consultation and trust building. In the Karoo, where the latter is in short supply, the prevailing trust deficit will only be overcome through honest, open and responsive communication with interested and affected parties moving forward.

During the compilation of this article, one of the authors, AEON Science Director and mentor, Prof. Maarten de Wit, passed away. His passion for science and innovation in fieldwork and data collection through the application of new technologies in the Karoo has been groundbreaking. Similarly, his respect and genuine concern for the people of the Karoo was translated into their inclusion and participation becoming central to the baseline study.

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Competing interests

We declare that there are no competing interests.

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