



**Lecture by
Prof. Avner Vengosh
Duke University, USA**

**A Critical Review of the Risks to Water Resources
from Unconventional Shale Gas Development and
Hydraulic Fracturing in the United States**

1. Welcome and introduction
2. Background to Prof Vengosh visit - current Water Research Commission research project
3. Prof Vengosh presentation
4. Questions and discussion
5. Snacks & drinks

Water Research Commission Project:

***Characterising the chemical composition of deep
and shallow groundwater in an area considered for
shale-gas exploration in the Main Karoo Basin***

Groundwater Africa in collaboration with:

- Stellenbosch University
- Duke University (Prof. Vengosh)
- Ohio State University (Prof. Darrah)
- Private consultants: Dr Gideon Tredoux (hydro-geochemist),
Mr Siep Talma (isotope-geochemist)

Concern

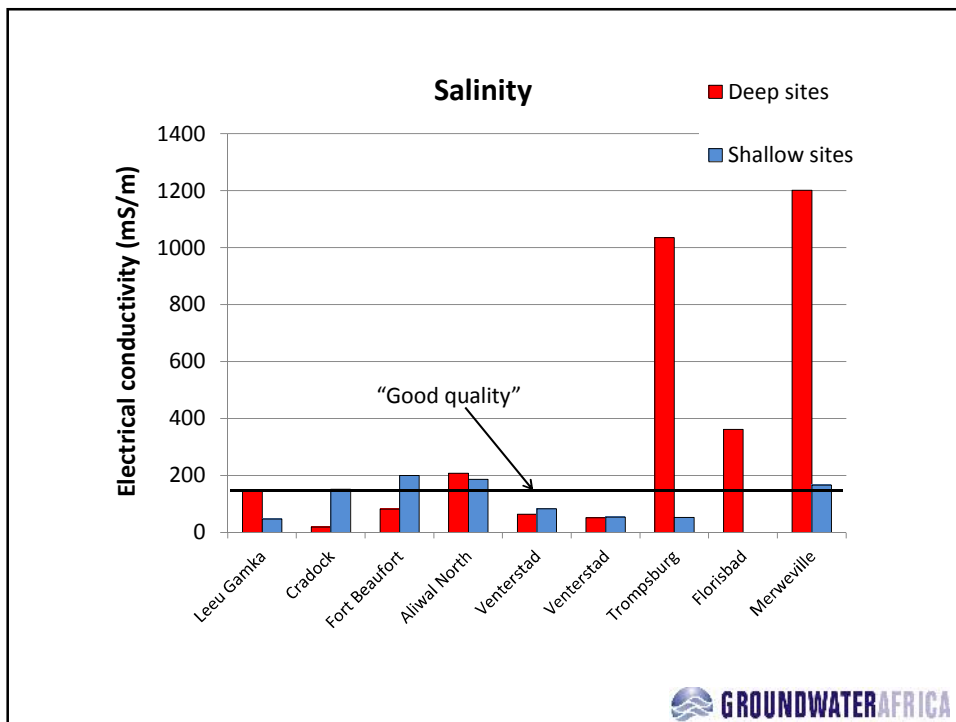
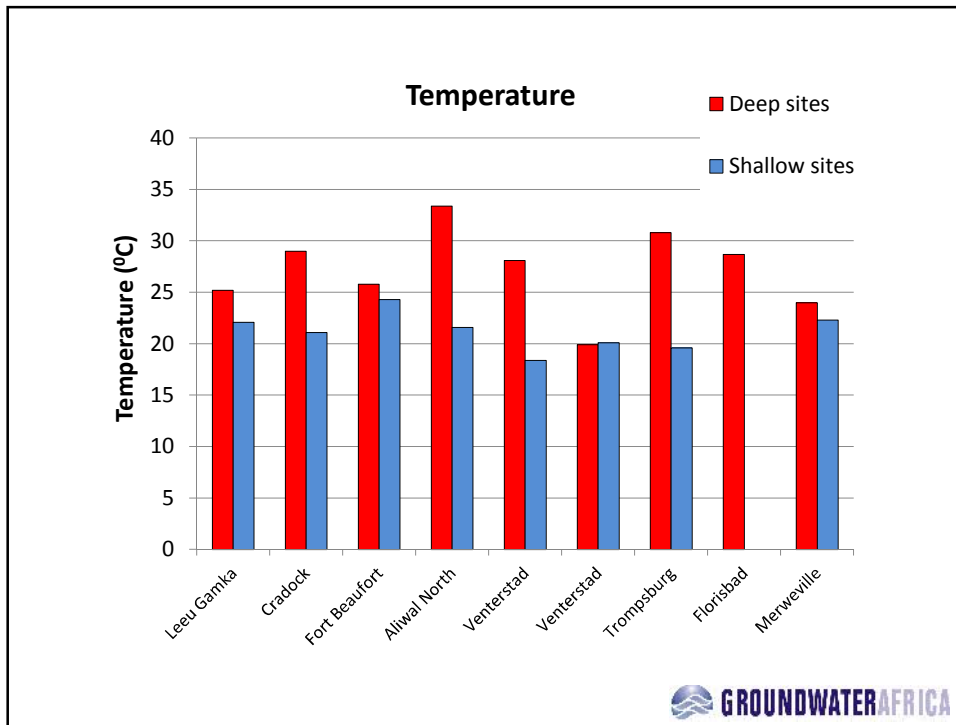
- Shale gas boreholes may encounter groundwater at depth
- This groundwater may be poor quality (eg saline/toxic/radioactive)
- Shale gas operations may open conduits for deep-seated groundwater flow
- Deep exploration, production or decommissioned boreholes may leak and provide conduits for up-ward migration of poor-quality groundwater

Project aims

- Characterise or chemically “fingerprint” shallow (cold) and deep (warm) groundwater
- Identify specific determinands that may distinguish shallow from deep groundwater
- Develop a list of determinands that should be analysed in both shallow and deep boreholes in future shale-gas exploration and development areas

Sampling sites





What we know:

- The main Karoo Basin is intruded with dolerite dykes and sills; is folded along its southern margin; and there is seismic activity
- These can provide possible preferential groundwater flow paths
- The shales are thick & relatively impermeable
- Warm springs show that there is some upward flow of “deep-ish” groundwater.

What we don't know:

- The quality of the deep groundwater
- Whether this water naturally rises from the depths targeted by the shale gas companies
-and if so whether this is a very slow process (geologic-time), or a rapid process (like some spring-flows)



Thank you

- University of Pretoria
- Water Research Commission
- Groundwater Division of the Geological Society of South Africa
- Professor Tom Darrah (Ohio State University)
- Professor Avner Vengosh.....



Prof Avner Vengosh

- **B.Sc.** Hebrew University of Jerusalem
- **M.Sc. Isotope Geology.** Hebrew University Of Jerusalem
- **Ph.D. Environmental Geochemistry.** Australian National University, Research School Of Earth Science, Canberra

- **Current position (since 2005):** Duke University, Durham, NC, USA
Nicholas School Of Environment, Division Of Earth And Ocean Sciences.

- **Associate Editor** of the international journal *Applied Geochemistry*

...the best way to introduce Prof Vengosh is to show a list of published papers for 2013 and 2014.....

Publications - 2014 & 2013

- Vengosh, A.,** Jackson, R.B., Warner, N.R., Darrah, T. H., Knodash, A.J. (2014) A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States. *Environmental Science & Technology*.
- 80) Kravchenko, Y., Rango, T., Akushevich, I., Behailu, A., McCornick, P., Merola, R.B., Paul, C., Weinthal, E., Harrison, C., **Vengosh, A.**, Jeuland, M. (2014). The effect of non-fluoride factors on risk of dental fluorosis: Evidence from rural populations of the Main Ethiopian Rift. *Science of the Total Environment* (in press).
- Knodash, A.J., Warner, N.R., Lahav, O., **Vengosh, A.** (2014) Radium and Barium Removal through Blending Hydraulic Fracturing Fluids with Acid Mine Drainage. *Environmental Science & Technology* (in press).
- Liu, Y.-B., Chen, T.-Y., Mackeebee, W.G., Ruhl, L., **Vengosh, A.**, and Hsu-Kim, H. (2013) Selenium Speciation in Coal Ash Spilled at the Tennessee Valley Authority Kingston Site. *Environmental Science & Technology* (in press; DOI: 10.1021/es4041557)
- Merola, R.B., Kravchenko, J., Rango, T., **Vengosh, A.** (2013) Arsenic exposure of rural populations from the Rift Valley of Ethiopia as monitored by keratin in toenails. *Journal Of Exposure Science And Environmental Epidemiology* (in press; doi: 10.1038/jes.2013.77).
- Warner, N.R., Christie, C.A., Jackson, R.B., **Vengosh, A.** (2013) Impacts of shale gas wastewater disposal on water quality in western Pennsylvania. *Environmental Science & Technology*, 47, 11849–11857 (DOI: 10.1021/es402165b).
- Vinson, D.S., Tagma, T., Bouchaou, L., Dwyer, G.S., Nathaniel R. Warner, N.R., and **Vengosh, A.** (2013) Occurrence and mobilization of radium in brackish to saline groundwater in coastal aquifers as inferred from geochemical and isotopic tracers (Ra, Rn, Sr, S, O, H). *Applied Geochemistry*, 38, 161-175.
- Foster, G.L., Hönisch, B., Paris, G., Gary S. Dwyer, G.S., Rae, J.W.B., Elliott, T., Gaillardet, J., Hemming, N.G., Louvat, P., **Vengosh, A.** (2013) Interlaboratory comparison of boron isotope analyses of boric acid, seawater and marine CaCO₃ by MC-ICPMS and NTIMS. *Chemical Geology*, 358, 1-14.
- Vengosh, A.** Linberg, T.T., Merola, B., Ruhl, L., Warner, N.R., White, Al., Dwyer, G.S., and Di Giulio, R.T. (2013). Isotopic imprints of mountaintop mining contaminants. *Environmental Science & Technology*, 47, 10041–10048 (DOI: 10.1021/es4012959).
- Jackson, R.B., **Vengosh, A.**, Darrah, T.H., Warner, N.R., Down, A., Poreda, R.J., Osborn, S.G., Zhao, K., and Karr, J.D. (2013) Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. *Proceedings of the National Academy of Sciences of United States of America* (June 2013, doi: 10.1073/pnas.1221635110).
- Godebo, T.R., **Vengosh, A.** Dawyer, G., Bianchini, G. (2013) Mobilization of arsenic and other naturally occurring contaminants in groundwater of the Main Ethiopian Rift aquifers. *Water Research*, 47, 5801–5818. 70) Vengosh, A., Warner N.R., Jackson, R.B., Darrah, T.H., (2013). The Effects of Shale Gas Exploration and Hydraulic Fracturing on the Quality of Water Resources in the United States. *Procedia Earth and Planetary Science*, 7, 863–866.
- Warner N.R., Kresse, T.M., Hays, P.D., Down, A., Karr, J.D., Jackson, R.B., **Vengosh, A.** (2013) Geochemical and isotopic variations in shallow groundwater in areas of Fayetteville Shale development, north central Arkansas. *Applied Geochemistry*, 35, 207-220. (<http://dx.doi.org/10.1016/j.apgeochem.2013.04.013>).
- Warner, N.R., Lgourna, Z., Bouchaou, L., Boutaleb, S., Tagma, T., Hsaissoune, M, **Vengosh, A.**, (2013). Integration of geochemical and isotopic tracers for elucidating water sources and salinization of shallow aquifers in the sub-Saharan Drâa Basin, Morocco. *Applied Geochemistry*, 34, 140-151.
- Deonarine, A., Bartov, G., Johnson, T.M, Ruhl, L., **Vengosh, A.**, and Hsu-Kim, H. (2013). Environmental impacts of the Tennessee Valley Authority Kingston coal ash spill. 2. Effect of coal ash on methylmercury in historically contaminated river sediments. *Environmental Science & Technology*, 47(6), 2100-2108. (DOI: 10.1021/es303639d).
- Bartov, G., Deonarine, A., Johnson, T.M., Ruhl, L. **Vengosh, A.** and Hsu-Kim, H. (2013) Environmental impacts of the Tennessee Valley Authority Kingston coal ash spill. 1. Source apportionment using mercury stable isotopes. *Environmental Science & Technology*, 47(6), 2092-2099 (DOI: 10.1021/es303111p).