Representing multiple water quality variables spatially—a comparison of groundwater and surface water in South Africa

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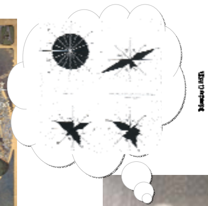
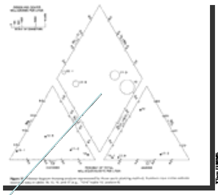
The most common ways of representing water quality on maps are point symbols and areal shading. Point symbols communicate one or more quality indicators at sites, while areal shading interpolates, and sometimes extrapolates, the information from many sites to produce a theoretical picture of water quality type distribution.

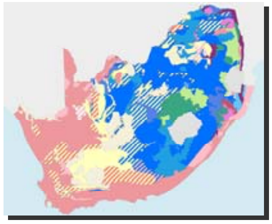
Surprisingly, commonly-available geographical information systems do not provide simple built-in methods, such as the 1932 Maucha diagram, for symbolising multiple variables at point locations. Users must develop their own scripts, a time-consuming process. This would appear to be a business opportunity for companies like Esri®, though as yet they have shown little interest.

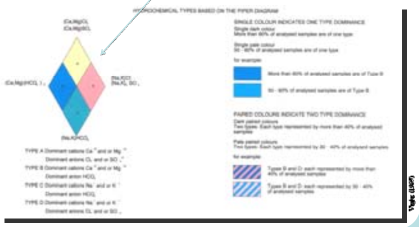


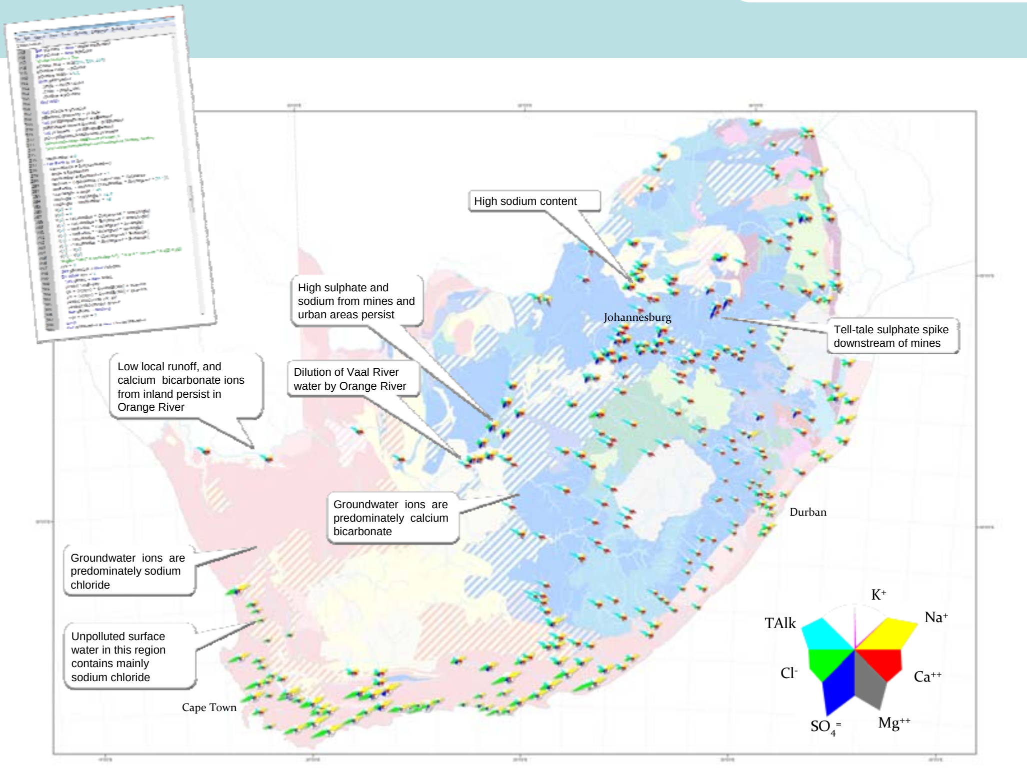
(That's *Maucha*, not Mucha...)

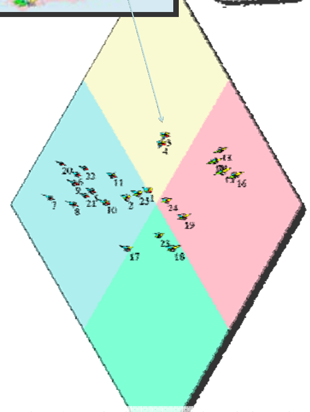
Hill or Piper ternary diagrams show the major ion composition of multiple samples in "ion space" (Hem 1985). Polygon shading to show multiple variables, although a little more complex than point symbolisation, is also feasible, as shown on the ingenious maps of South African groundwater chemistry that use colour coding in combination with a Piper diagram key (Vegter 1995).











Mapping of Maucha (1932) radial symbols to the Piper ternary graph, showing clustering of Maucha symbol shapes on a Piper diagram according to the ionic makeup of each water quality sample. The colours of the shaded lozenges represent the shaded groundwater regions on the map. Map and Piper diagram after Vegter (1995). *Colour mismatches arise from the peculiarities of different software.*

Using the human visual system's effortless ability to separate areal and point data (Ware 2008), we can represent surface water and groundwater chemistry on the same map sheet or computer display. Showing the data in this way is a powerful means for suggesting where links between land use, surface water and groundwater chemistry may occur. Indicator ions show the effect of human activity on general surface water chemistry, for example sulphate suggests mining, while sodium chloride is a sign of sewage effluent (Silberbauer 2009).

For those familiar with only the areal or the point representation, a "Rosetta Stone" graphs the Maucha and Piper diagrams in ionic dimensions, clarifying the relationship between the two symbolic methods.

Conclusion

The effects of geology, urbanisation, industry and mining leave discernable "fingerprints" on the gross ionic composition of surface waters.

Specialists from different backgrounds learn to visualise their data in vastly different ways. A "Rosetta Stone" approach can help different disciplines to match their interpretations and can potentially trigger new insights into system functioning.

Acknowledgements

The staff of the Department of Water Affairs' Resource Quality Services and their predecessors have worked for decades to build up the WMS, a comprehensive database of South Africa's river, dam, lake and groundwater chemistry.
Prof Jenny Day, Freshwater Research Unit, University of Cape Town, first prompted the author to automate the generation of Maucha diagrams in the late 1980s.

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