

Geochemical tracing of methane from unconventional gas production

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There is significant public concern surrounding the exploitation of unconventional gas resources. Many of these concerns relate to potential methane contamination of potable water supplies in shallow aquifers. Public apprehension is predominantly linked to experiences of unconventional gas extraction in the USA where there is strong and growing public dispute around the “fracking” process. Evidence of groundwater contamination by produced gas is equivocal. Some studies have found no direct causality between fracturing and groundwater contamination. However, there is a developing group of work in the USA by individual researchers [1] and by the Environmental Protection Agency [2], which suggests that a degree of contamination of groundwater has occurred.

In such a commercially active sector, a strong suite of evidence is needed to unequivocally detect contamination and allow successful remediation litigation. Simple documentation of elevated methane content in groundwater is not sufficient to enable a legally secure diagnosis. Rival claims can be made that the methane present in the groundwater is from drilling operations which predate shale gas exploration, or that observations of hydrocarbon content, including methane gas, in shallow aquifers are due to natural processes unconnected with unconventional gas exploration. For these reasons, an extremely robust identification of methane source, or multiple methane sources, is needed. In this study we focus on providing the means to make that identification.

Using existing data, we will show how C and H isotopes, radiocarbon (¹⁴C) and noble gases (He Ne Ar Kr Xe) can be used to geochemically “fingerprint” produced gas from coal bed methane and shale gas deposits. This clear “fingerprint” can be used to distinguish any produced gas from other gas sources and provide a robust means for identifying produced methane contamination of shallow groundwaters.

[1] Osborn *et al.*, (2011) *PNAS*, Vol. **108**, No. 20, p8172-8176

[2] EPA (2011) Investigation of groundwater contamination near Pavillion, Wyoming. Environmental Protection Agency, USA.

Volcanostratigraphic controls on the occurrence of massive sulfide (VMS) deposits in the Oman Ophiolite

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The Semail ophiolite in northern Oman is capped by up to 2 km of basaltic–andesitic lavas that host copper-dominant, Cyprus-type, volcanogenic massive sulfide (VMS) deposits. This study identifies the multiple volcanostratigraphic horizons on which the deposits are situated, based on characterization of footwall and hanging-wall lavas from 16 deposits or deposit clusters. Comparison of their field and petrographic features, compositions of igneous clinopyroxenes and whole-rock geochemical signatures permits their classification within a modified version of the established regional volcanostratigraphy.

Four extrusive units host VMS deposits: Geotimes (earliest), Lasail, Alley and Boninitic Alley (latest). The latter was known only at a few localities but the present study reveals its regional extent and significance as a host for VMS deposits. The new results show that VMS deposits sit on or near the Geotimes/Lasail and Geotimes/Alley contacts as well as entirely within the Lasail, Alley and Boninitic Alley Units. The Geotimes and Lasail Units represent Late Cretaceous, ocean spreading ridge and related off-axis volcanic environments respectively. Highest Cu grades tend to occur in deposits lying on or within the Geotimes. The Alley and Boninitic Alley Units represent younger, subduction-related volcanism prior to Coniacian–Santonian obduction of the ophiolite. Highest Au grades occur in deposits within the Boninitic Alley.

In contrast to earlier studies, the new results show that essentially every horizon that marks a hiatus in lava deposition in the Semail ophiolite, i.e. contacts between the four major eruptive units, and umbers and sedimentary chert layers within the units, has exploration potential for Cu–Au VMS deposits.