

## Aerosols impact on precipitation

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Changes in rainfall and snowfall regimes and the frequency of extreme weather events are of great importance to life on our planet. Since cloud condensation nuclei and ice nuclei are responsible for the formation of drops and ice in clouds, respectively, any changes in their chemical composition and distribution could influence the amounts and distribution of precipitation on the ground.

The effects of aerosol on clouds have been studied for many years, showing a clear influence on the cloud microphysical properties. However, the impact of the aerosols on rainfall amounts and distribution has been difficult to quantify due to the numerous feedbacks between environmental conditions, dynamics and cloud microphysics (see [1] for a review). For example, measurements downwind of sugarcane fires in Australia showed decrease in precipitation. However, the effects of changes in the background meteorology could not be ruled out as the main causes of these changes. Measurements downwind of large urban areas showed increases in precipitation in some cases [2] and no clear effect of pollution on rainfall in others [3].

Orographic precipitation is believed to be more vulnerable to aerosols impact due to the relatively short time available for precipitation to develop before the clouds get over the mountain top. However, recent analysis, although controversial, could not find such effects [4]. The conclusion of these studies is that if such effects are present, they are overshadowed by other processes (e.g. changes in synoptic conditions, heat island effects, effects of soil moisture etc).

Some recent model simulations on the influence of pollution on precipitation in deep convective clouds show the importance of the cold pools below clouds caused by evaporation of raindrops [5]. This could be one of the reasons for the complex response of precipitation to the various microphysical and meteorological conditions.

- [1] Levin & Cotton (2008) Aerosol pollution impact on precipitation. a scientific review, Springer, 382 pp.  
 [2] Changnon *et al.* (1971) *Bull. Amer. Meteor. Soc.* **52**, 958-968. [3] Jin *et al.* (2005) *J. Geophys. Res.* **110**, D10S20, 10.1029/2004JD005081. [4] Alpert *et al.* (2008) *J. Appl. Meteor. and Climat.* **47**, 933-943. [5] Van den Heever & Cotton (2007). *J. Appl. Meteorol.* **46**, 828-850.

## Vanadium, Nickel, and Uranium associations with petroleum and source rocks

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Black shales with their high metal and organic-carbon contents become source rocks for petroleum (natural gas, crude oil, or tar) when they reach sufficient thermal maturities during burial in sedimentary basins. Various metals have been advocated as indicators of depositional settings for genetic correlation of petroleum with source rocks, sources of radiogenic heat to enhance thermal maturity, and catalysts to explain early natural gas generation.

Vanadium and nickel are especially enriched in petroleum and source rocks through early diagenetic chelation with organic complexes collectively referred to as tetrapyrroles. The proportionality of these two metals in tetrapyrroles is determined by pH, redox potential, and activity of sulfide species of the sediment pore waters during chelation. This proportionality is preserved during thermal maturation and is transferred to expelled oils. In addition, the proportionality is maintained in subsequent secondary migration, thermal cracking, and biodegradation of expelled crude oils. As a result, this proportionality serves as a robust parameter for genetically correlating oils and tars with their source rocks.

Enrichment of uranium in some source rocks has given rise to the idea that its radioactivity serves as a heat source to expedite petroleum generation. Uranium concentrations are enriched like vanadium and nickel during early diagenesis, but occur in authigenic minerals and are not dependent on the preservation of tetrapyrroles. Calculations indicate that the amount of heat generated by radioactive decay of uranium is not sufficient to significantly expedite petroleum generation from uranium-rich source rocks. However, radioactive decay does cause cross-linking damage to the organic matter that results in generation of peculiar condensate-like oils, reduced oil yields, and insoluble organic residues.

Nickel and other transition metals (e.g., Cu, Fe, Co) dispersed as inorganic components in petroleum source rocks have been advocated as catalysts in the generation of methane-rich natural gas at low thermal maturities. However, their catalytic activity is dependent on them occurring as zero-valence metals, which, with the exception of copper, is not likely to occur in sedimentary environments.