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What affects the variety, concentration and $\delta^{34}S$ of volatile organic sulfur compounds in natural gas?

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Volatile organic sulfur compounds (VOSC) are known to occur in petroleum and natural gas reservoirs, where they are typically accompanied by H_2S. Several studies linked the concentrations of VOSC and H_2S, while others suggested VOSC can catalyze in-reservoir processes such as thermochemical sulfate reduction (TSR) and produce H_2S. Hence, VOSC may act as a proxy for the origin of H_2S and natural gas and may be used to identify TSR and fluid migration pathways.

To better understand the processes forming VOSC in natural gas reservoirs, we analyzed, both quantitively and isotopically, gas of high thermal maturity from the Sichuan, Ordos and Tarim basins in China. These samples are suspected to be affected by TSR. Additionally, we analyzed gas samples of low thermal maturity produced directly from a S-rich Cretaceous source rock in Israel. Our results show the VOSC in the Chinese gases are dominated by thiols (~100 ppm) which are followed by sulfides (0-10 ppm) and thiophenes (0-5 ppm). The Israeli low-maturity gases are dominated by CS_2 (0-2 ppm) followed by very low concentrations (<1 ppm) of thiols and thiophenes. Analysis of $\delta^{34}S$ for the VOSC in the gas samples revealed a scatter over a range of 5-30‰ for the high-maturity Chinese samples and a range of <10‰ for the Israeli low-maturity samples. On the other hand, the thiols of most Chinese samples covered a much narrower range of about 6‰ while the Israeli samples lacked such grouping.

Our results demonstrate that high thermal maturity gases contain more VOSC (mainly thiols) than gases formed by early thermal maturation. A similar variety of VOSC was observed in mature gas samples from Alberta (Canada) in which VOSC were reacting with H_2S in the gas phase. It is also in agreement with pyrolysis experiments of pentane and H_2S performed at 360°C. Therefore, we suggest this is the result of H_2S reacting with hydrocarbons in the gas phase to form the large amounts of VOSC identified. These results are a step forward in developing new and useful proxies for natural gas sources and diagenetic pathways.