Geochemical study of natural gas pools combining He, Ne and Ar isotopic tracers and major elements

A. Battani — Université Paris Sud, 91405 Orsay Cedex, France

A. Prinzhofer — Institut français du pétrole, 1 et 4, avenue de Bois-Preau, 92852 Rueil-Malmaison Cedex, France

P. Sarda — Université Paris Sud, 91405 Orsay Cedex, France

Samples from 20 CO_2,N_2-enriched natural gas wells have been collected using the copper tube technique (Weiss, 1969). In the aim to constrain the origin and migration of gas, He, Ne and Ar concentrations and He and Ar isotopic compositions have been determined using a VG 5400 mass spectrometer.

Major element analyses show that CH_4 is the main component, but that CO_2 an N_2 can be relatively high for some of the wells, reaching maximum values of 69% and 23% respectively. Maturity indicators clearly correlate with depth of pool indicating that gas accumulation is 'near the kitchen', so that gas migration has been very short.

$^3He/^4He$ isotope ratios are generally very low, i.e. of 0.02–0.05 × Ra, a range typical of continental helium, indicating no admixture of mantle helium. Therefore, a mantle origin for CO_2 and N_2 can be discarded. Argon isotope ratios are low, generally between 296 and 500 (with one exception reaching 800) which indicates that argon is dominated by the atmospheric component.

He and Ar concentrations exhibit systematic variations. The atmospheric isotopes, ^{36}Ar and ^{20}Ne, or total ^{40}Ar, show no clear correlation with depth of pool, while the radiogenic isotopes, ^4He or radiogenic ^{40}Ar ($^{40}Ar^*$), decrease with depth of the pool. N_2 also decreases with depth, and radiogenic isotopes do positively correlate with N_2, indicating that N_2 cannot be thermogenically cogenetic with present hydrocarbons. At basin scale, values of the $^4He/^{40}Ar^*$ ratio are centered around 4.5 , as expected for continental radiogenic gases. Altogether, N_2 and radiogenic rare gases appear to have been diluted by hydrocarbons, the amounts of which increase with depth.

$CH_4/^{36}Ar$ ratios are typically one order of magnitude lower than expected if methane had dissolved into water and then degassed (Ballentine *et al.*, 1991). Mixing diagrams for the different rare gas isotopes indicate a second stage in the gas story, where gas has equilibrated with subsurface water, thereby mixing with variable amounts of atmospheric rare gases.

References

Weiss, R.F. (1968) *Deep-sea research*, **15**, 595–699.

Ballentine, C.J., O'Nions, R.K., Oxburgh, E.R., Horvath, F. and Deak, J. (1991) *Earth Planet. Sci. Lett.*, **105**, 229–46.