Large volumes of carbon dioxide in sedimentary basins

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Carbon dioxide (CO_2) is encountered in many sedimentary basins around the world in a variety of geological environments (e.g. Southeast Asia, Italy, Eastern Australia). Data on CO_2 occurrences almost invariably come from petroleum exploration activities and are limited by operational and commercial constraints. Where CO_2 is abundant it is effectively a natural 'pollutant' which reduces the worth of the hydrocarbon gas present by diluting it and increasing production costs.

However large volumes of CO_2 are rare with the probability of there being >1% CO_2 being less than 1

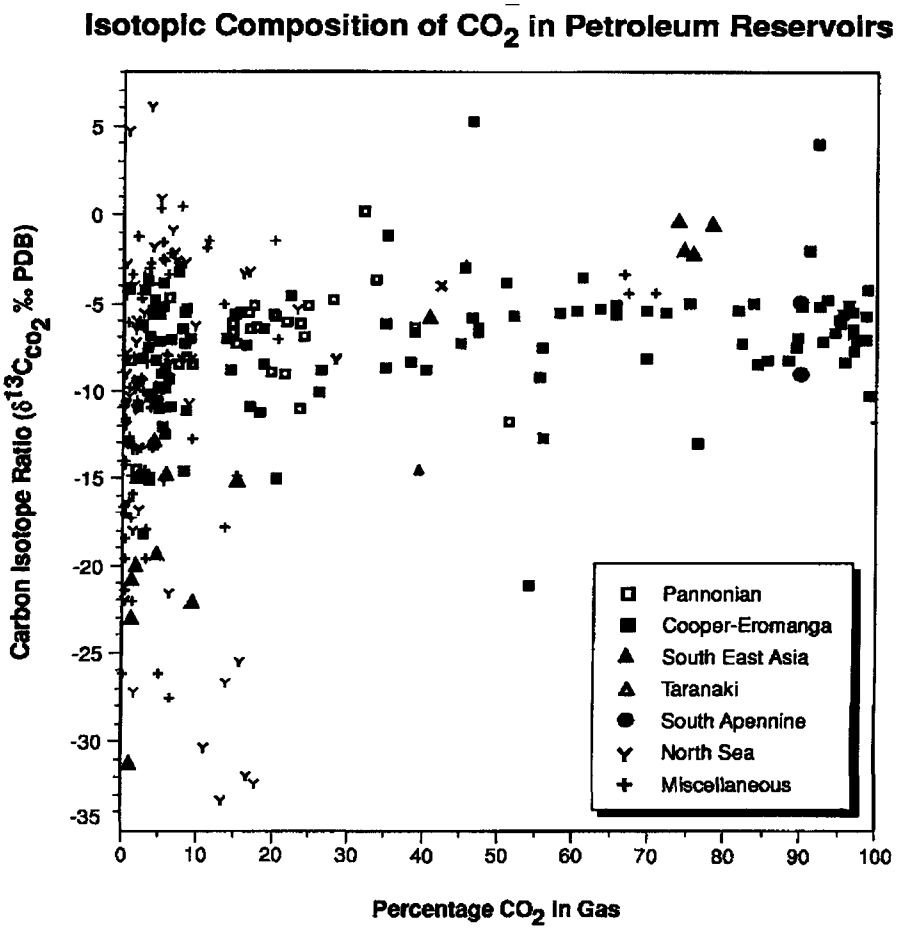

FIG. 1. CO_2 *vs* $\delta^{13}C_{CO_2}$ in petroleum reservoirs (Thrasher and Fleet, 1995).

in 10 and the mean content of such accumulations being about 5%.

High concentrations of CO_2 (arbitrarily >20%) are even rarer and occur in less than one accumulation in a hundred, but when they do occur they are notably high having a mean CO_2 concentration of 50% (Thrasher and Fleet, 1995).

In absolute terms individual large accumulations range from 168 tcf of CO_2 in the Indonesian Natuna d-Alpha field (70% of the 240 tcf of gas is CO_2) to 0.16 tcf of CO_2 in the Miller Field of the North Sea (28% of the 0.57 tcf of gas is CO_2, the gas is associated with 300 million barrels of oil). The tendency for basins to host CO_2-rich accumulations varies. For instance, in the Pannonian Basin in Hungary the majority of gas occurrences contain greater than 20% CO_2 and a significant number more than 90% CO_2, while in the Cooper-Eromanga Basin, Australia most accumulations contain 10–30% CO_2, and in the North Sea only low concentrations of CO_2 (< 5%) are encountered except in some fields in the South Viking Graben where concentrations reach a maximum of 30% CO_2.

Published work suggests seven possible sources of CO_2: (1) magmagenesis/mantle degassing, which gives $\delta^{13}C_{CO_2}$ PDB values of −4 to −7‰ (e.g. Clayton *et al.* 1990; Thrasher and Fleet, 1995); (2) regional metamorphism, which gives $\delta^{13}C_{CO_2}$ PDB values of 0 to −10‰ (e.g. Schoell, 1983; Clayton *et al.*, 1990); (3) contact metamorphism of carbonates, which gives $\delta^{13}C_{CO_2}$ PDB values of −2 to −12‰ (e.g. Schoell, 1983); (4) marine carbonates, which gives $\delta^{13}C_{CO_2}$ PDB values of +2 to −2‰ (e.g. Schoell, 1983); (5) biogenic decay, which gives $\delta^{13}C_{CO_2}$ PDB values of +15 to −30‰ (e.g. Schoell, 1983); (6) breakdown of coaly kerogen type III, which gives $\delta^{13}C_{CO_2}$ PDB values of −10 to −25‰ (e.g. Schoell, 1983); and (7) contact metamorphism of coals, which gives $\delta^{13}C_{CO_2}$ PDB values of −10 to −20‰ (e.g. Schoell, 1983).

In general, although there is significant overlap between CO_2 of different origins, CO_2 from sources external to the petroleum/biogenic system tends to be isotopically heavy ($\delta^{13}C_{CO_2} > -10$‰) while CO_2 from kerogen or petroleum sources tend to be isotopically light ($\delta^{13}C_{CO_2} < -10$‰).

Available data from gas accumulations worldwide (Fig. 1) show that where volumetrically significant CO_2 occurs it is relatively isotopically heavy and thus can be interpreted as coming from outside the petroleum system, i.e. it results from mantle degassing, magmagenesis or metamorphism. The study of Sherwood-Lollar *et al.* (1997) bears this out in concluding that the CO_2 in the Pannonian Basin is predominantly mantle-derived.

Published details suggest that the most common geological circumstances for the occurrence of high concentrations of CO_2 are deep faults close to gas traps, reservoirs close to hot basement and carbonates associated with post-trap igneous activity (Thrasher and Fleet, 1995). Specific case studies of CO_2-rich basins support these conclusions.

References

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