Geochemical characteristics and distribution of heavy oil degraded gas in China

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There is much shallow gas in heavy oil reservoirs in China. It's mainly biogenic gas that generated from the biodegradation process of crude oil under aerobic conditions and also called as heavy oil degraded gas. CH_4 is the main production, which shows a great exploration potential for CH_4 produced by biodegradation in petroliferous Basins in China. Lots of heavy oil degraded gas has been found in the west slope of Song Liao Basin, Bohai Bay Basin and the northwest margin of Jungar Basin [1]. Its burial depths generally range from 200m to 1000m.

The shallow gas is mainly dry gas, methane is the main component, with only a little heavy hydrocarbons(C_2+) and relatively high content of N_2. Methane carbon isotope is characterized by high negative values ranging from -75‰ to -50‰; Ethane carbon isotope is heavy, with the numbers ranging from -35‰ to -55‰, which is possibly due to the mixture of thermalgenetic gas; And CO_2 bears very heavy carbon isotope, some is up to +15‰~+20‰. On the whole, the methane of crude oil degraded gas are rich in light carbon isotope, the main reason is that methane bacteria select $^{12}CO_2$ as carbon source, and the thermodynamic carbon isotope exchange reactions are also favor for methane rich in ^{12}C, while the more ^{13}C remain in the remnant carbon dioxide [2,3]. The carbon isotopic fractionation is obvious in the biodegradation process of crude oil.

The reservoir was in an open environment during the formation period of heavy oil. Surface water containing oxygen and microbes infiltrated into the oil pool so that crude oil was densified by oxidation, water washing and aerobic degradation. Once free oxygen was consumed out, N_2 became enriched and anaerobic degradation producing CH_4 started. So heavy oil degraded gas always bears high content of N_2.

[1] Zhu G Y *et al*. (2008) *Science in China* (D)**51**(supp.) 80-89. [2] Larter S *et al*. (2003) *Organic Geochemistry* **34**, 601-613. [3] Röling *et al*. (2003) *Res.Microbiol* **154**, 321-328.

Magma mingling origin of mafic microgranular enclaves in Guposhan granite pluton, South China

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The mafic microgranular enclaves (MMEs) are widely distributed in the central part (Lisong district) of the A-type Guposhan granite batholith, western Nanling Mountains, South China. The MMEs are dioritic to gabbroic in chemical composition, characteristic of variable sizes, oval to irregular shapes, fine-grained dark biotite-rich margins, frequently with felsic halos and back-veining. The xenocrysts of K-feldspar are unevenly spreaded in MMEs, sometimes straddling the granite-enclave boundaries. The corroded margins and rapakivi-like texture are not rare. Under the microscope, the MMEs often possess diabasic texture. The oscillatory zoned phenocrysts of plagioclase, alignment of elongate laths of twinned plagioclase and acicular apatite are very common.

Chemically, all the MMEs, the Lisong hosting granite and the Guposhan major phase granite are enriched in alkalies, LILEs and HFSEs, showing obvious A-type granite features according to the classification of Whalen *et al* (1987) and Eby (1992). In the major and trace elements geochemistry, the Lisong hosting granite is transitional between the MMEs and the Guposhan major phase granite.

The single grain zircon SHRIMP U-Pb dating reveals coeval isotopic ages of a large enclave (4.5 m across) and its hosting granite (162±2 and 162±3 Ma, respectively), which excludes the possibility of the restite of melted metamorphic rocks in the lower crust and the entrapped pieces of country rocks in the shallower depth. Their significant difference in chemistry and texture excludes the possibility of co-magmatic segregations and/or cumulate of earlier stage crystallization for the MMEs.

The I_{Sr} values of MMEs and hosting granite are 0.70473 and 0.70664~0.70742, respectively. Their $\varepsilon Nd(t)$ values are +1.94 and -1.72 ~ -3.07, respectively. Their zircon $\varepsilon Hf(t)$ values are in the range of +2.6~+7.4 and -3.7 ~ +0.3, respectively. While the I_{Sr} and $\varepsilon Nd(t)$ values of most S-type high-K calc-alkaline granites in Nanling Mountains region are in the range of 0.710~0.722 and -9.0~-12.0, respectively.

All these integrated geologo-geochemical data demonstrate that the Lisong hosting granite is the mixing product of the Guposhan granite melt with the intermediate-basic magmatic melt, the Lisong MMEs are the remnants of incomplete mingling from the intermediate-mafic magma, and the mafic components of these rocks were derived from the depleted mantle end-member.