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Investigating the causes of the helium-poor conditions in Anyue Gas Field, Sichuan Basin, China

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Sichuan Basin is a significant source of natural gas production in China. As the first natural gas field in China to realize the industrial use of helium, the Weiyuan gas field in the basin boasts a high concentration of helium. The old uplift belt of the Leshan-Longnvsi paleo-uplift contains the Anyue and Weiyuan gas fields, but the former has a much lower helium level than the latter. This study examines the constraints of helium accumulation conditions in Anyue gas field in conjunction with the regional geological background in order to investigate the reasons behind the helium-poor condition in Anyue gas field. It does this by methodically analyzing and comparing the gas composition and nitrogen and noble gas isotope characteristics of natural gas samples in Anyue gas field and Weiyuan gas field. Helium-containing samples (He>0.05%) make up just 12.5% of the natural gas in the Anyue gas field, which has a helium concentration of 0.012% to 0.089%. These samples are concentrated in the Dengying Formation Section Second near the west side of the Gaoshiti block. The nitrogen isotope characteristics and helium-nitrogen coupling enrichment trends of helium-containing and poor helium samples differ; the former resembles the Weiyuan gas field and may have an intermediate-acidic metamorphic rock as its helium source, while the latter may have mud shale from the Qiongzhusi Formation as its helium-nitrogen source. The primary factor limiting the enrichment of helium gas in the Anyue gas field is the helium source condition. Furthermore, the Anyue gas field contains an enormous amount of natural gas resources, and a significant volume of hydrocarbon gas in the gas reservoir seriously dilutes helium gas. The comparatively mild structural traps and high reservoir pressure limit the precipitation and enrichment of helium through formation water, and the evidence of noble gas isotopes indicates that the gas-water interaction in the Anyue gas field is substantially weaker than that in the Weiyuan gas field. The two points mentioned above are also important factors.