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Research paper

U–Pb zircon geochronology of basal granite by LA-ICP-MS in Yitong Basin, Northeast China: Implications for origin of limestone

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A B S T R A C T

Massive deposits of limestone were encountered for the first time by wells drilled into the bedrocks of Yitong Basin, Northeast China. U–Pb zircon dating analyses with LA-ICP-MS were then employed to determine the geological ages of the deposits and analyze the impact of a later magmatic intrusion upon the hydrocarbon generation and preservation environment in the deposits. Analyses of 6 granite samples taking from the limestone shows that the basement of the Yitong Basin contains numerous zircons of magmatic origin and these zircons are characterized in CL images as light color, clear oscillatory zoning and intact crystalline form, In terms of REE (rare earth elements) content and its distributive pattern, the zircons are shown with mild loss of Eu, high Th/U ratio and left-slanting distributive curves. Concordia plots based on U–Pb dating of 61 zircons of magmatic origin showed concentrated data points along the Concordia line, indicating no obvious Pb loss. The crystallization ages of 6 granite samples were dated as 220 Ma, 192 Ma, 261 Ma, 185 Ma, 270 Ma and 273 Ma, respectively. Based on the understanding, we inferred that the limestone of sedimentary genesis imbedded with the Permian formations of the basin was formed during deposition in the Permian era. The magma activity was the most active during the Jurassic. Magmatic intrusion was thought to be originated from deeper parent rocks below the Permian layers. It cut through the Permian limestone from the bottom up and released great amount of heat to bake the limestone. This accelerated hydrocarbon generation in the limestone and increased its KTG (kerogen to gas) rate to 0.9 or more during 190 Ma and 185 Ma. Early hydrocarbon generation and poor preservation are the two hydrocarbon-related features of the limestone. In terms of reservoir lithology, the limestone went through thermal contact metamorphism with the heat and volatile components from magmatic activities. It is also observed that contact metamorphism of the limestone was the most active near the eruption points of magma.

1. Introduction

Yitong Basin sets in the Jiamusi-Yitong faulted area of the west part of northern Tanlu Fault Zone. It has been considered as one of the most promising basins for oil and gas exploration and development off Songliao Basin in Northeastern China (Guo and He, 2009; Jiang et al., 2009; Li et al., 2009). Oil and gas exploration activities into the bedrocks of the basin had been intensified during the last couple years as many wells drilled there had yielded with positive results. Among them, Well Chang-37 was tested with gas anomaly from 19 layers of a total thickness of 56 m in the bedrocks and the maximum instantaneous gas flow rate once reached 25 600 m^3/h. However, all previous studies concerning the basin had failed to explain how the bedrock structure was formed, leaving a blank to be filled. Another well Chang-27 was the first exploratory well that ever penetrated the buried-hill bedrocks of the basin. It ran down 230 m below the granite bedrocks and bumped into a 600-m-thick limestone with argillite and quartzite at the bottom. Data gathered from the well also verified the complexity of the bedrock structures.

Previous studies enlighteningly suggested a sedimentary origin for the massive deposits of limestone based on electronic logging and seismic data analyses (Miao et al., 2011). Logging data show that the limestone under the intrusive granites has a rather low apparent resistivity that can be matched to sediments, thus indicating a sedimentary origin for the limestone. Apart from that, the facts that the Cenozoic strata overlying the bedrocks, intrusive

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granites dominates the strata between the top of bedrocks and the top of low-resistivity formation, angular unconformity between the intrusive rocks and low-resistivity formation and a moderate-continuous reflectance from the low-resistivity formation, all infer a sedimentary origin for the limestone. The limestone bears great significance as it hits right at the possibility of the existence of a hydrocarbon-bearing assemblage in the bedrocks of the basin. However, what had drawn more attention was whether the limestone had appropriate conditions for hydrocarbon generation and accumulation as well as whether it makes good pooling–sealing relationship with overlaying granites.

There are two basic types of geologic dating: absolute dating and relative dating (Demetsopoullos et al., 1983; Barendregt, 1984; Zech et al., 2003). But both have constrains in dating limestones. Relative dating is not practical as paleotology fossils are rare in the stones and a few such fossils indeed found there are mostly globoids and filiform fossils of low-disparity that have no stratigraphic significance. Absolute dating of the stones is also unsuitable because isotopes such as Rb, Sr, Pb, U, Sm and Nd, are less developed. Another two isotopes C and O with their short half-life period could not be measured after ages of decaying. Another fact makes the dating difficult is that it is the first time that limestones are encountered by a well (Chang-27) in the region and a comparison with adjacent wells is not possible.

Therefore, we decided to date the limestone through isotopic analyses of its overlying and underlying granites. Furthermore, we analyzed the impact of later magmatic intrusion upon the hydrocarbon generation and accumulation capacity of the limestone.

2. Samples and methods

2.1. Sampling

Yitong basin is a Tertiary strike-slip basin with oil and gas potentials developed on Hercynian fold basement. The NE-trending basin has an area of 3400 km^2 with 300 km long by 10–20 km wide. It contains three first-order tectonic units: Chaluhe fault depression, Luxiang fault depression and Moliqing fault depression (Fig. 1). The basin is defined by nearly upright slip-strike faults in the northwest and typical listic normal faults in the southeast.

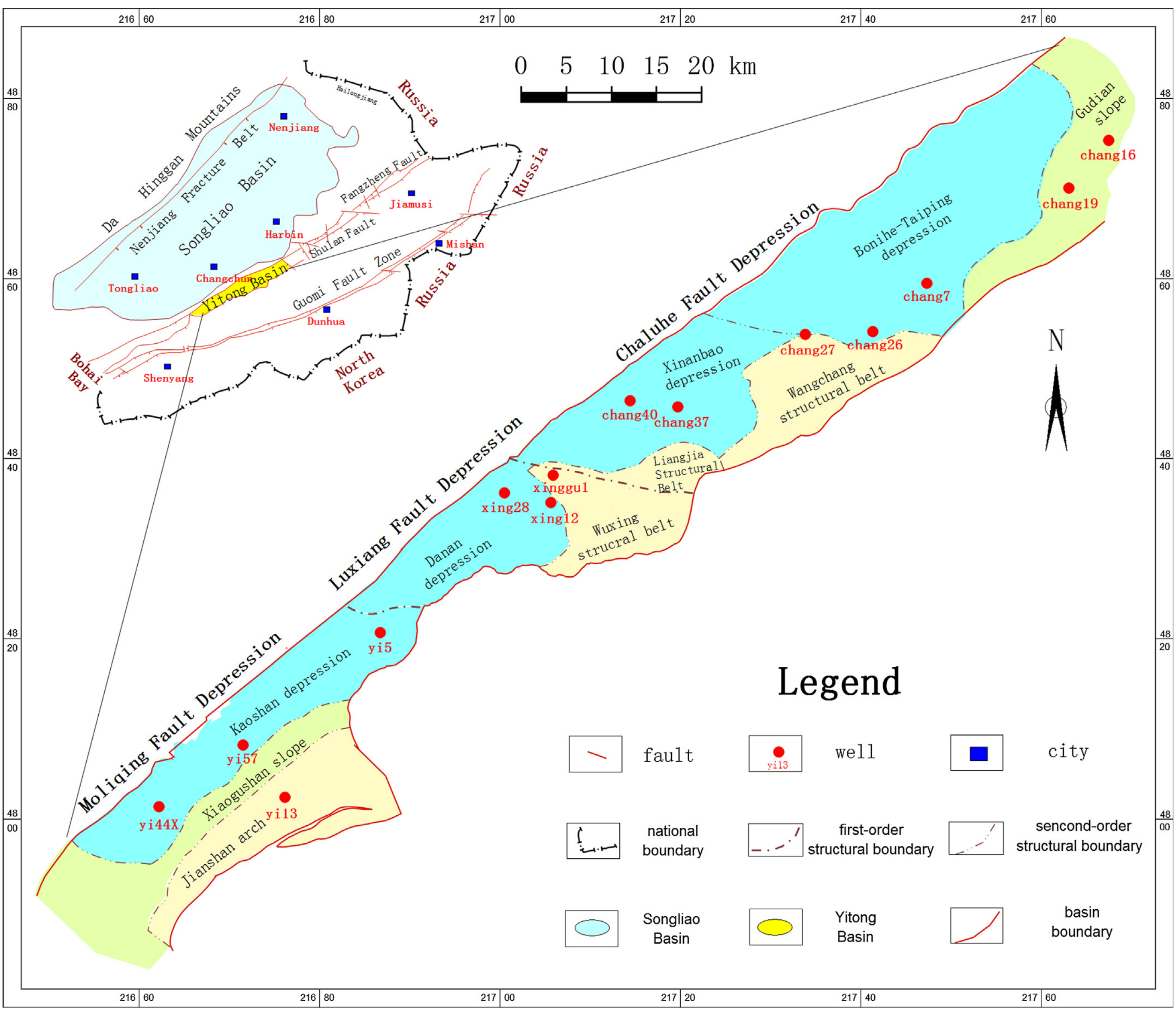

Figure 1. Tectonic units division and position in Yitong Basin.