PS Origin and Enrichment of Diagenetic Calcite in Upper Triassic Xujiahe Sandstones, Northeastern Sichuan Basin*

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Abstract

Calcite is one of the dominant cements in Xujiahe sandstones, northeastern Sichuan Basin. It can be concentrated in certain zones as cements and replacing minerals to form tightly calcite- replaced and cemented intervals and has an obvious damage to the sandstone quality. In this work, we conducted petrology and logging geology to characterize the distribution of tightly calcite- replaced and cemented intervals, and used the geochemical data, including whole rock X-ray diffraction, stable carbon and oxygen isotopes and trace elements, to discuss the formation mechanisms of diagenetic calcite enrichment. The calcite-replaced and cemented intervals are mainly distributed in the west part of the study area usually being observed in the middle of the thick sand body with a thickness of 1~2 m. The occurrence frequency of the calcite-cemented intervals shows a gradually decreasing trend from source rocks of the three member of the Upper Triassic Xujiahe Formation (T_3x^3) to upper and lower formations. The distribution of the calcite-cemented intervals is controlled by both depositional framework and rock component. The depositional framework controls the zone of calcite cements enrichment, while rock component controls the interval of calcite cements enrichment. Diagenetic calcite is mainly formed in eodiagenesis B stage (with temperatures of 60-80°C), corresponding with the main period of organic acid generation. Carbonate minerals are abundant in the T_3x^3 source rock. During the organic acid generation stage, the fluids with abundant Ca^{2+} and organic acids, expelled from the T_3x^3 source rock, flowed into adjacent sandstones, which provide the Ca^{2+} and HCO_3^- source for calcite cementation and replacement, and finally control the distribution of the calcite-cemented intervals. It is noted that not all sandstones adjacent to T_3x^3 formed as tightly calcite-cemented intervals, and calcite cement was selectively concentrated in feldspar or/and carbonate rock fragments abundant layers. It indicates that only sandstones with high alkaline mineral contents can effectively buffer the organic acid, allowing calcite to precipitate as both replacing minerals or cements, and thus finally controlling the location of calcite-cemented intervals.

Origin and enrichment of diagenetic calcite in Upper Triassic Xujiahe sandstones, Northeastern Sichuan Basin

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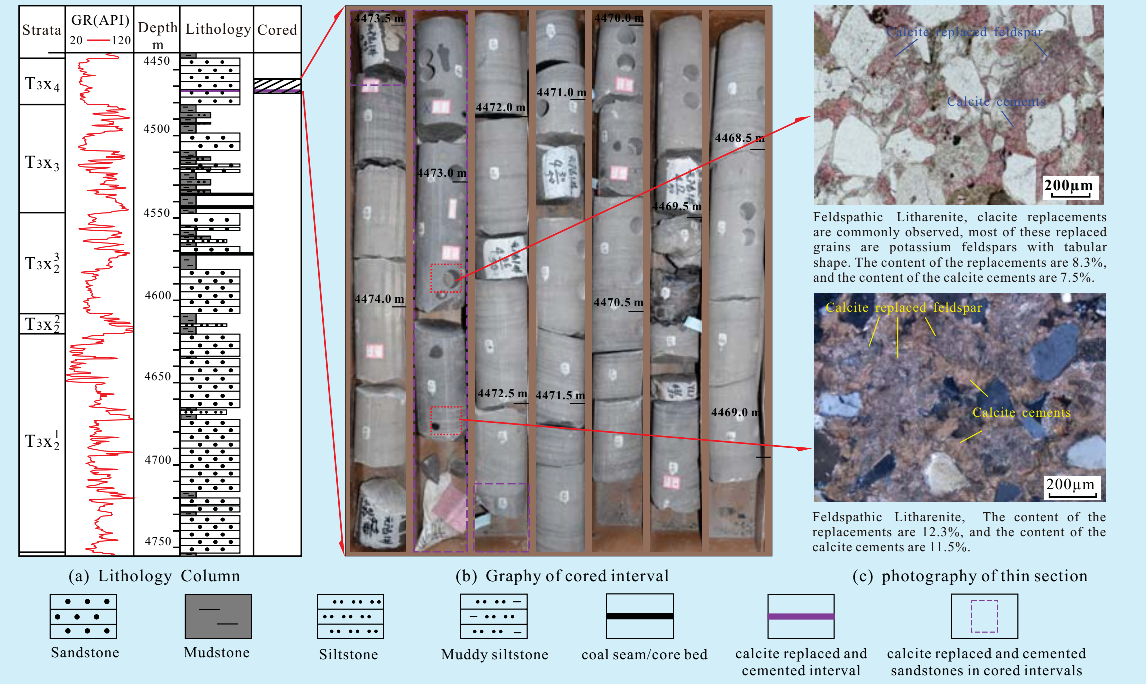
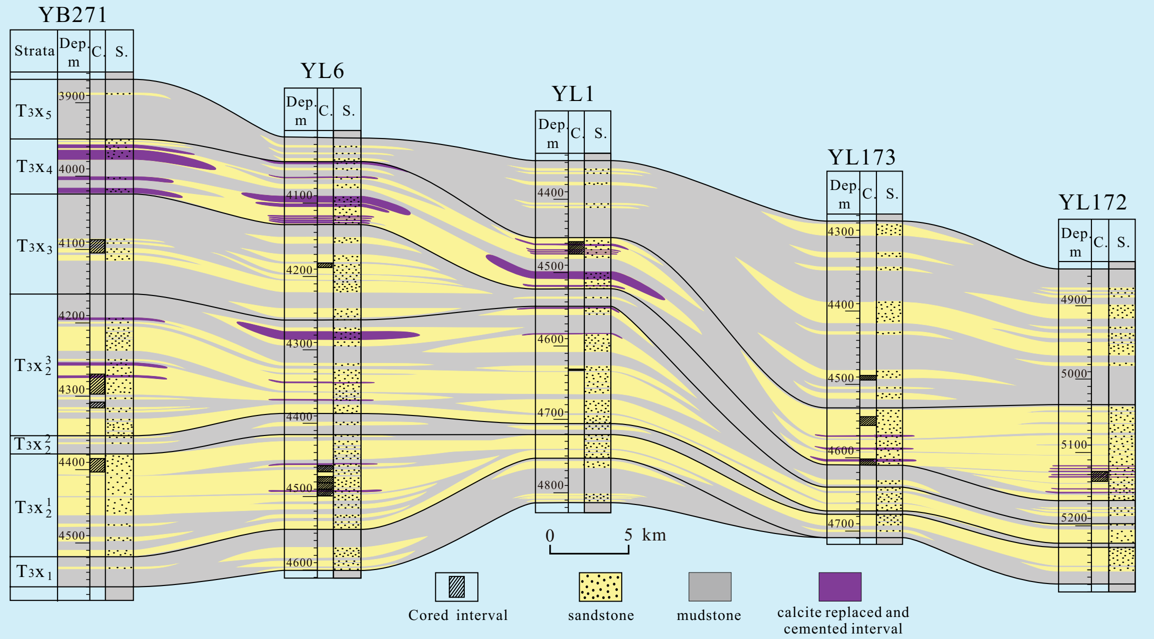
Abstract: Calcite is one of the dominant cements in Xujiahe sandstones, northeastern Sichuan Basin. It can be concentrated in certain zones as cements and replacing minerals to formed tightly calcite-replaced and cemented intervals, and as an obvious damage to the sandstone quality. In this work, we conducted petrology and logging geology to characterize the distribution of tightly calcite-replaced and cemented intervals, and used the geochemical data, including whole rock X-ray diffraction, stable carbon and oxyen isotopes and trace elements, to discuss the formation mechanisms of diagenetic calcite enrichment. The calcite-replaced and cemented intervals are mainly distributed in the west part of the study area usually being observed in the middle of the thick sand body with a thickness of 1~2 m. The occurrence frequence of the calcite-cemented intervals show a gradually decreasing trend from source rocks of the three member of the Upper Triassic Xujiahe Formation (T3x3) to upper and lower formations. The distribution of the calcite-cemented intervals are controlled by both depositional framework and rock component. The depositional framework controls the zone of calcite cements enrichment, while rock component controls the interval of calcite cements enrichment. Diagenetic calcite are mainly formed in eodiagenesis B stage (with temperatures of 60-80°C), corresponding with the main period of organic acid generation. Carbonate minerals are abundant in the T3x3 source rock. During the organic acid generation stage, the fluids with abundant Ca^{2+} and organic acids, expelled from the T3x3 source rock, flowed into adjacent sandstones, which provide the Ca^{2+} and HCO_3^- source for calcite cementation and replacement, and finally control the diatribution of the calcite-cemented intervals. Calcite cement was selectived concentated in feldspar or/and carbonate rock fragments abundant layers. It indicates that only sandstones with high alkaline mineral contents can effectively buffer the organic acid, allowing calcite to precipitate as both replacing minerals or cements, and thus finally controlling the location of calcite-cemented intervals.

Distribution features of calcite-cemented intervals

4. Graphic representing calcite-cemented intervals in well logging lithology, cored interval and thin sections

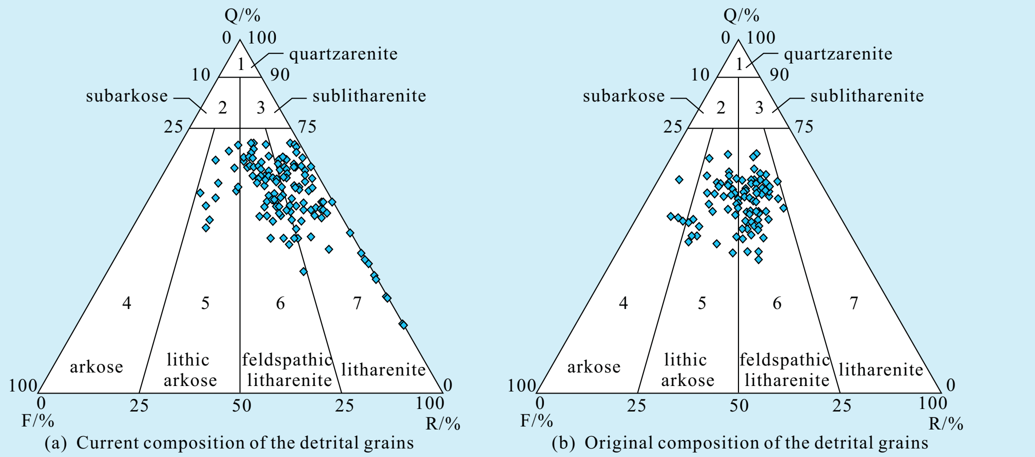


5. Well-tie section of tightly calcite replaced and cemented intervals in Xujiahe Formation, NE Sichuan Basin



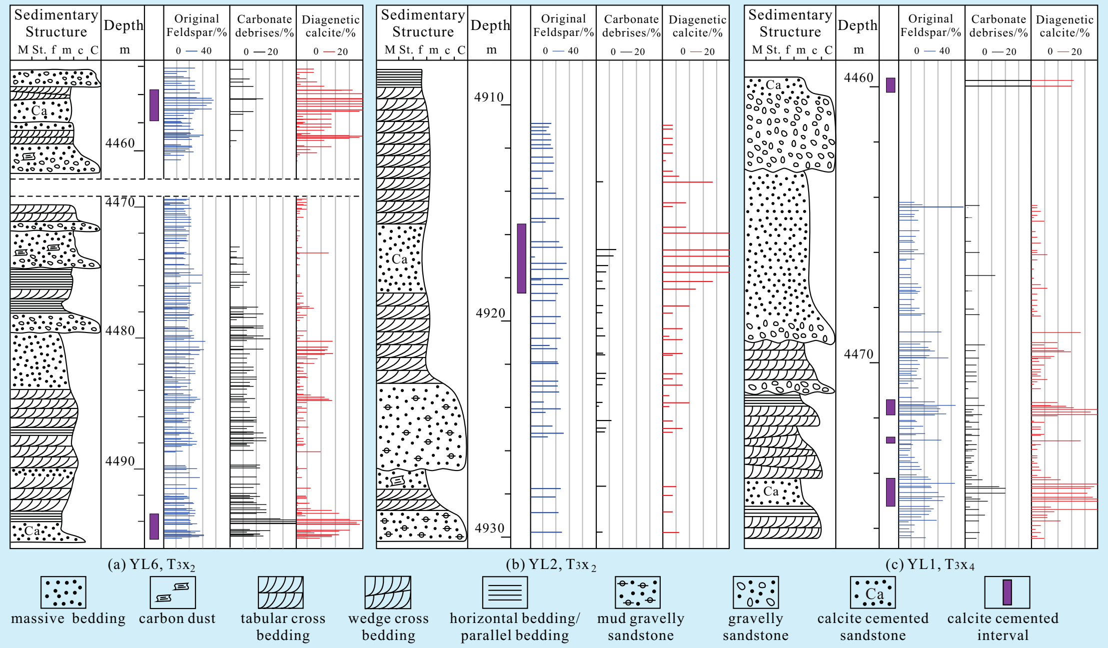
Petrology: detrital component

6. Detrital compositions of tightly calcite replaced and cemented sandstones in the Xujiahe Formation, NE Sichuan Basin



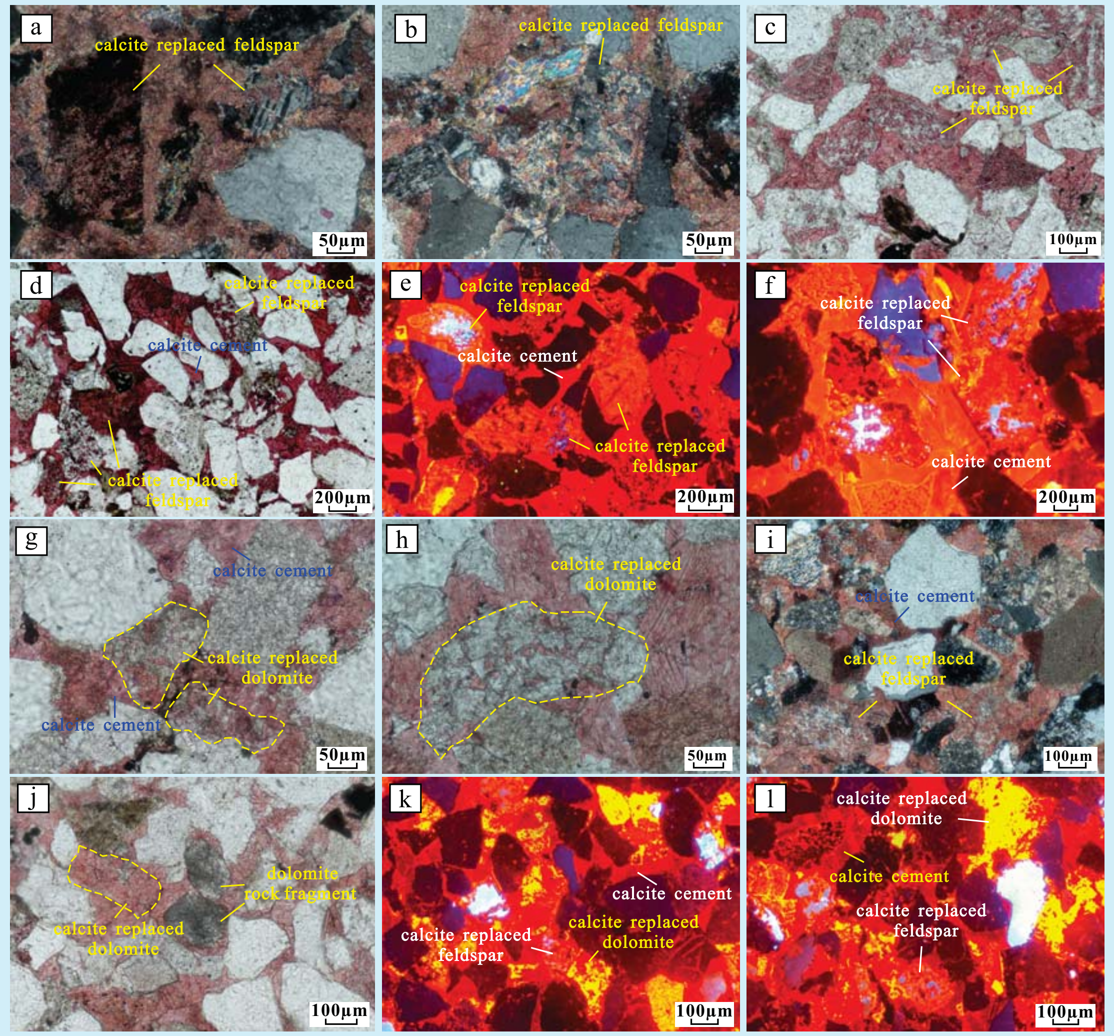
Based on the current detrital composition, tightly calcite replaced and cemented sandstones are mainly feldspathic litharenite and calcarenaceous sandstone. However, current compositions cannot represent the original compositions, due to feldspar easily to be replaced, altered or dissolved. The original composition of sandstone can be restored by residual structure of replaced minerals. It can be seen that the compositions of calcite repalced and cemented sandstones shift to Feldspar end member, and the rock type are mainly lithic arkose and feldspathic litharenite.

7. Content distributions of the diagenetic calcites, original feldspars and carbonate debrises in Xujiahe sandstones, NE Sichuan Basin



Petrology: diagentic minerals and occurrence

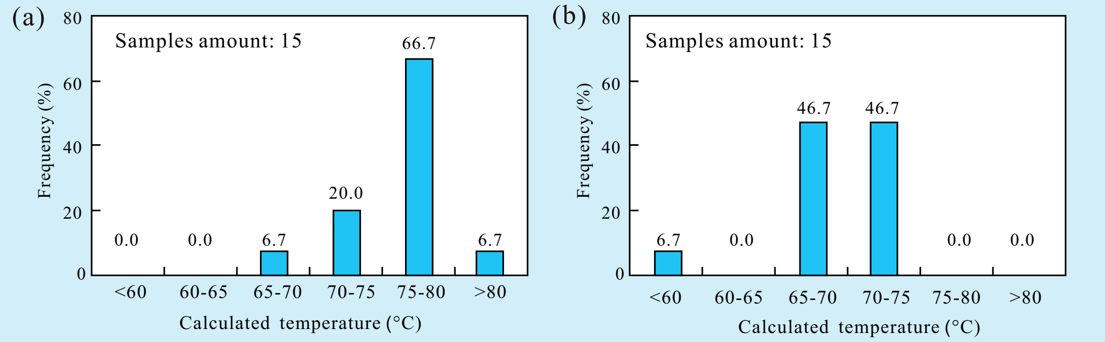
8. Thin section and cathode luminescence characteristics of calcite replaced and cemented sandstones in the Xujiahe Formation



(a) Feldspathic Litharenite, clacite replacements are commonly observed, most of these replaced grains are potassium feldspars with tabular shape, T3x2, 4461.0 m, YL6; (b) Feldspathic Litharenite, calcite replaced feldspar, T3x2, 4461.0 m, YL6; (c) Feldspathic Litharenite, most of the feldspars are replaced by calcite, and the content of the replacements is higher than that of cements, forming a tightly interval dominated by calcite replacements, T3x4, 4768.67 m, YL28; (d) Feldspathic Litharenite, most of the feldspars are replaced by calcite, calcite replacements and cements present as poecilitic texture, T3x4, 4739.20 m, YL176; (e) Feldspathic Litharenite, residual feldspar grains show blue cathode light, T3x4, 4769.67 m, YL28; (f) Feldspathic Litharenite, calcite replaced feldspar, and the residual feldspar grains show blue cathode light, T3x4, 4738.7 m, YL176; (g) Litharenite, carbonate rock fragments present as point to line contact, It can be seem that dolomite rock fragments are raplaced by calcite along grain margin, and calcite cements as calcsparite fill the pore space, T3x4, 4344.42 m, YL1; (h) Litharenite, dolomite rock fragments are raplaced by calcite along grain margin, T3x4, 4344.42 m, YL1; (i) Litharenite, calcite replaced feldspar, and calcite cements as calcsparite fill the pore space, T3x2, 4277.70 m, YB271; (j) Litharenite, dolomite rock fragments are almostly replaced by calcite, T3x2, 4277.7 m, YB271; (k) Litharenite, in cathodoluminescence, dolomite rock fragments present as bright yellow cathode light, calcite replacements present as orange cathode light and distribute along the margin of dolomite rock fragments, T3x4, 4631.88 m, YB16; (l) Litharenite, calcite replaced feldpar and dolomite rock fragments, T3x4, 4631.88 m, YB16.

Formation mechanism of calcite-cemented intervals

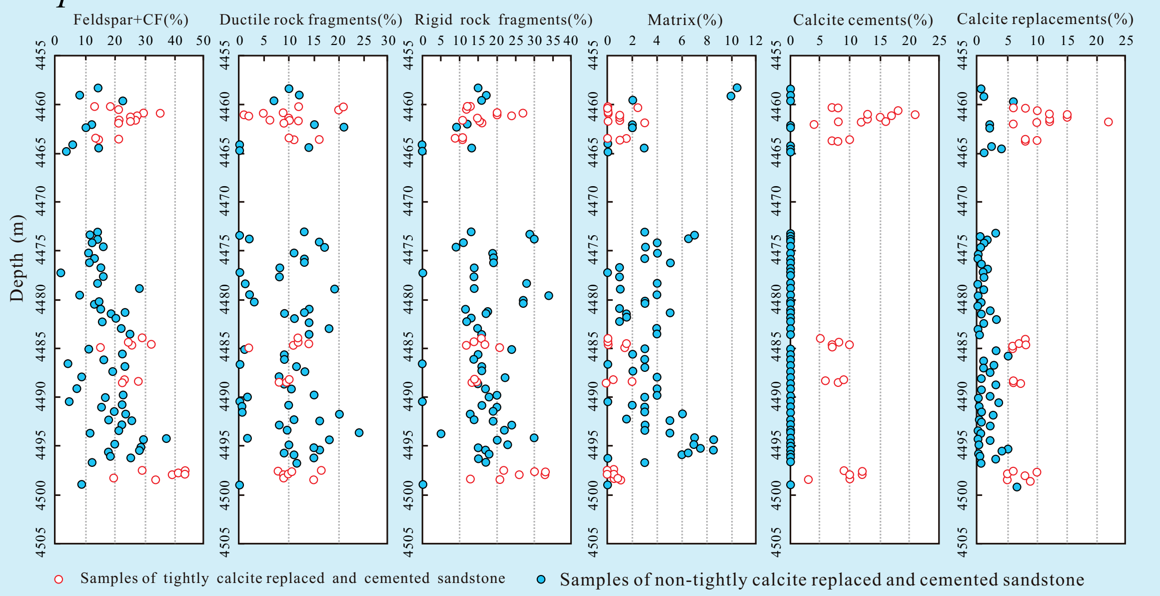
9. Temperature distribution of diagenetic calcites in tightly calcite replaced and cemented sandstones



(a) Calculated temperature with $\delta^{18}O$ composition equal to -5‰ in parent fluid

(b) Calculated temperature with $\delta^{18}O$ composition equal to -6‰ in parent fluid

10. Vertical distribution of rock components in tightly calcite replaced and cemented sandstones versus non-tightly calcite replaced and cemented sandstones

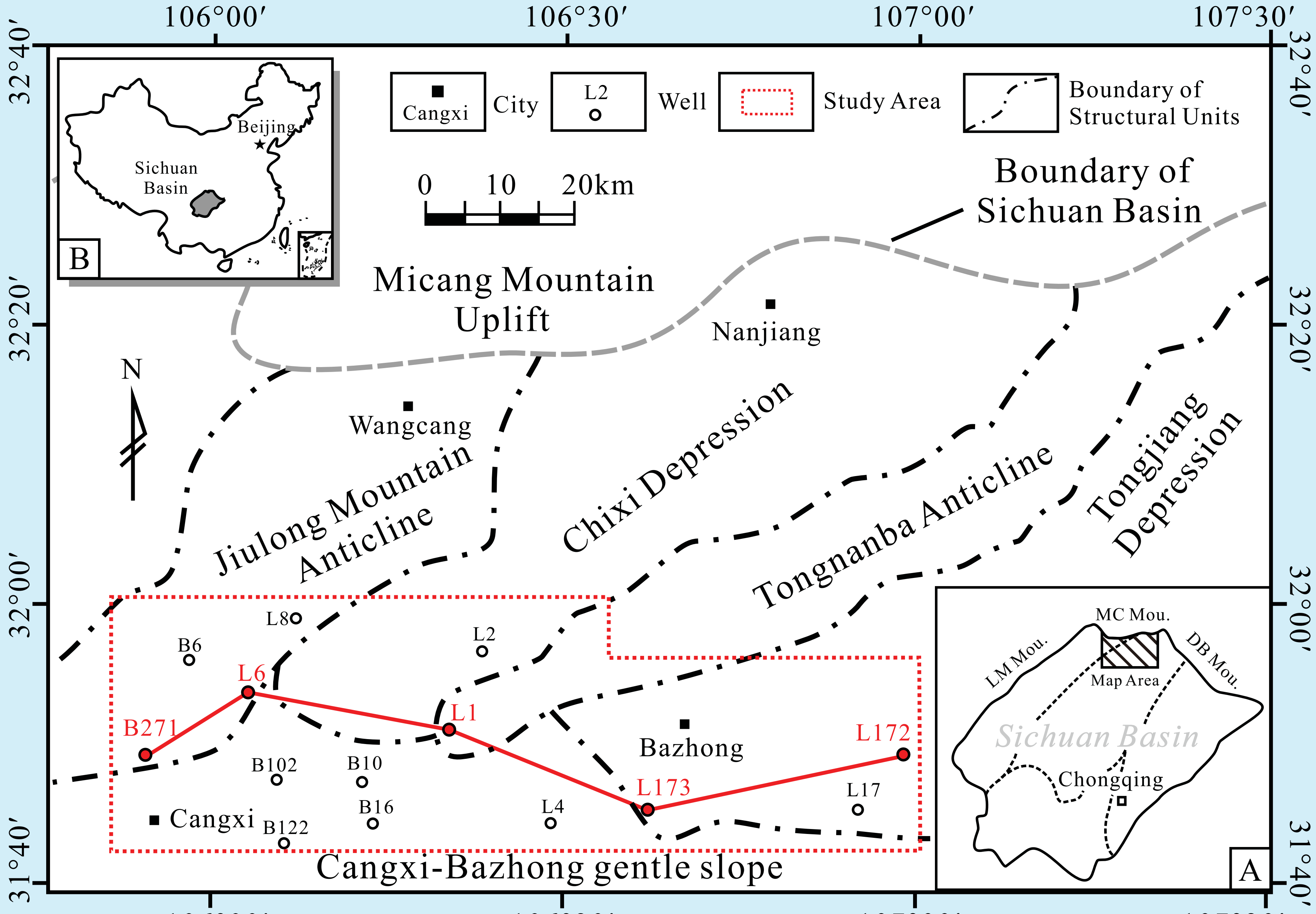


Conclusions

- The distribution of the calcite-cemented intervals are controlled by both depositional framework and rock component
- Calcite cements in feldspar-rich tight intervals form due to the pH-buffering process of the feldspar components

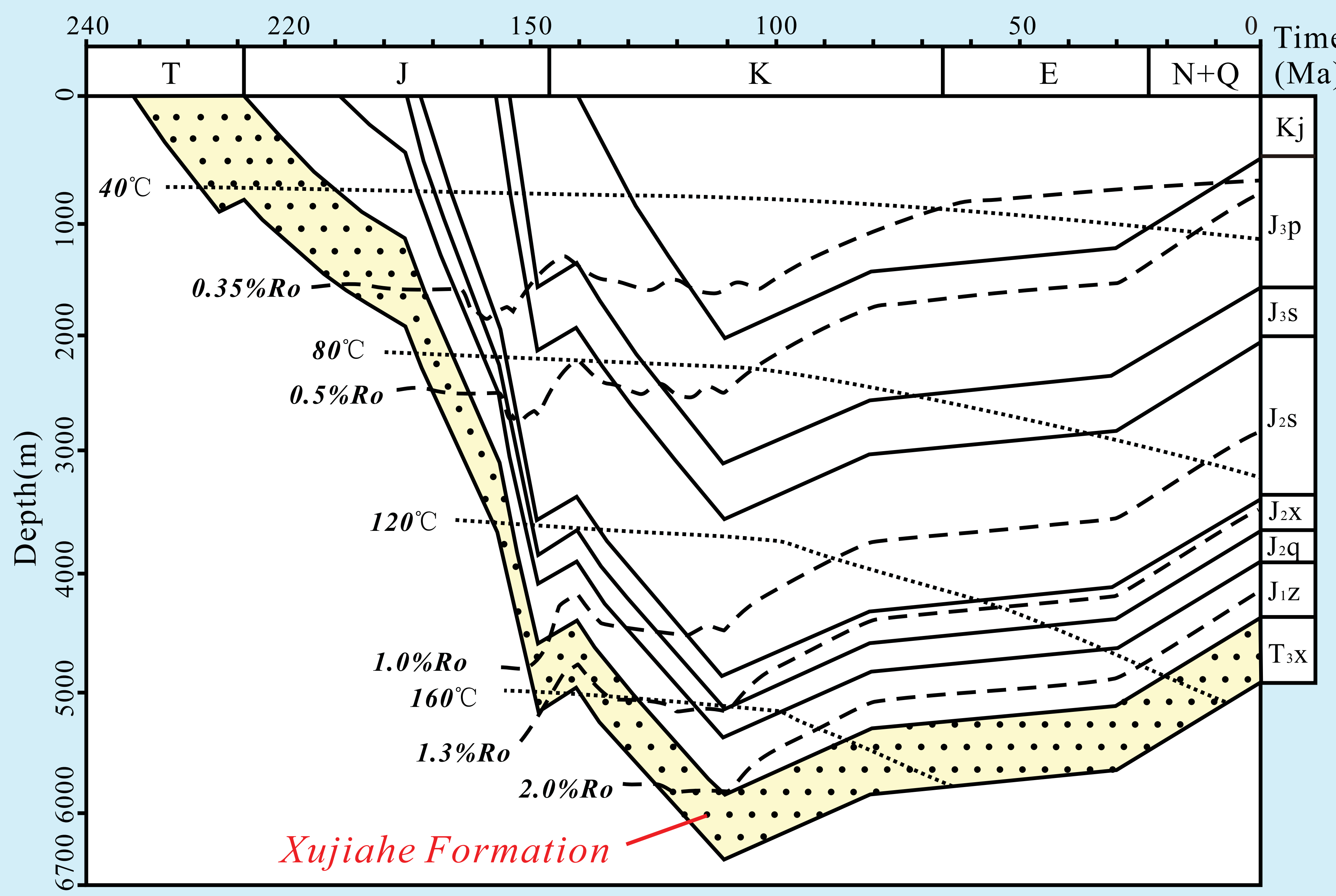
Regional Overview

1. Location of study area in the NE Sichuan Basin



Location map showing the study area fo the NE Sichuan Basin. LM Mou., MC Mou. and DB Mou. around the Sichuan Basin represent the Longmen Mountain thrust faulting belt, Micang Mountain uplift and Daba Mountain uplift, respectively.

2. Burial and thermal history of the Xujiahe Formation in the NE Sichuan Basin



The burial and thermal history show that the maximum burial depth of T3X are reached 5800-6300 m during the period of Middle Crataceous, and the maximum geotempture was 180-220°C with a corresponding vitrinite reflectance (Ro%)≥2.0%.

3. Generalized stratigraphic column of the NE Sichuan Basin