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Sedimentary facies analysis and basin evolution of the Mesozoic Sichuan formation

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Abstract

The Sichuan Basin in southwestern China preserves one of Asia's thickest and most complete Mesozoic sedimentary successions, yet the facies architecture and depositional controls on its Triassic-to-Cretaceous fill remain debated. This research described and interpreted sedimentary facies from five measured outcrop sections totalling 1,480 m of stratigraphy along the basin's eastern margin. Ten facies were grouped into four facies associations: fluvial channel, floodplain, lacustrine, and shallow marine carbonate. Sandstone-dominated intervals thin upward from 42% of unit thickness in the Triassic to 18% in the Cretaceous, while fine-grained lacustrine and carbonate deposits expand correspondingly. Palaeocurrent data from 87 cross-bed measurements indicate a consistent west-to-east transport direction. The vertical facies succession records a transition from marine carbonate platform (Late Triassic) through terrestrial fluvial-lacustrine systems (Jurassic) to a broad, low-energy lake basin (Early Cretaceous), driven by the interplay of tectonic subsidence along the Longmen Shan thrust belt and eustatic sea-level change.

Keywords: Sedimentary facies, Sichuan Basin, basin evolution, Mesozoic stratigraphy, depositional environment, tectonic control, fluvial system, lacustrine deposits, palaeocurrent, carbonate platform

Introduction

A sedimentary basin is a book written in stone, and its facies are the sentences. Reading them correctly requires field-scale observation that remote sensing and well logs cannot fully replace ^[1]. The Sichuan Basin, covering approximately 180,000 km² in Sichuan and Chongqing provinces, hosts Mesozoic strata exceeding 5,000 m in thickness near the Longmen Shan front ^[2]. These deposits are economically important: they contain major gas reservoirs in Triassic carbonates and tight sandstones ^[3]. But the lateral and vertical facies changes that control reservoir architecture are still incompletely mapped along the basin's eastern margin.

Previous work concentrated on the western margin, where proximity to the Longmen Shan thrust belt produces the thickest and coarsest clastic input ^[4]. The eastern margin, by contrast, preserves a more distal record with finer-grained deposits and wider facies belts, making it better suited for reconstructing basin-wide depositional patterns. This research logged five outcrop sections along a 120 km north-south transect on the eastern margin, aiming to (a) define the facies and facies associations, (b) document the vertical succession and its age constraints, and (c) link the observed changes to tectonic and eustatic controls ^[5].

Study Area Description

The five measured sections lie along the eastern Sichuan Basin margin between 29°40'N and 30°50'N latitude, 107°20'E to 108°10'E longitude, in the Chongqing municipality and adjacent Guang'an prefecture. Outcrops occur in road cuts and river gorges where incision has exposed continuous stratigraphic sequences. Structurally, the area sits on the gentle eastern limb of a broad syncline, with bedding dips of 5°-15° westward. The Mesozoic succession rests on Permian carbonates and is overlain unconformably by Cenozoic red beds ^[6].

Materials and Methods

Materials

Fieldwork was carried out in April-June 2022, coordinated from Yekaterinburg College of Earth and Mineral Sciences, Russia, in collaboration with Chongqing University. Five sections (labelled EC-1 through EC-5) were measured bed-by-bed using a Jacob's staff and Abney level. Combined thickness totalled 1,480 m: EC-1 (342 m), EC-2 (298 m), EC-3 (314 m), EC-4 (267 m), and EC-5 (259 m). At each bed, lithology, grain size, sedimentary structures, fossil content, and bed thickness were recorded. A total of 142 hand samples were collected for thin-section petrography and 87 palaeocurrent measurements from cross-bedded sandstones were taken [7].

Methods

Facies were defined following the classification scheme of Miall [8] for clastic deposits and Dunham [9] for carbonates. Facies associations were interpreted by grouping co-occurring facies into genetically related packages. Grain-size analysis of 48 sandstone samples used standard sieve

techniques at half-phi intervals. Thin sections were examined under a petrographic microscope for texture, cement types, and fossil fragments. Palaeocurrent data were plotted on equal-area rose diagrams and vector-mean directions calculated. Age control used published ammonite and bivalve biostratigraphy from regional correlation charts [10].

Stratigraphic Framework

The Mesozoic succession on the eastern margin spans four major units: the Upper Triassic Xujiahe Formation (shallow marine to paralic, 180-340 m thick), the Lower Jurassic Ziliujing Formation (fluvial-lacustrine, 120-210 m), the Middle-Upper Jurassic Shaximiao Formation (fluvial with thick sandstone bodies, 200-380 m), and the Lower Cretaceous Jiaguan Formation (lacustrine red beds, 80-160 m). The contact between the Xujiahe and Ziliujing formations is conformable and records the Triassic-Jurassic transition from marine to continental conditions [11].

Results

Table 1: Sedimentary facies identified in the Mesozoic eastern Sichuan sections

Facies	Lithology	Structures	Thickness (m)	Interpretation	Association
F1	Conglomerate	Imbrication, scours	0.5-3.2	Channel lag	Fluvial Ch.
F2	Cross-bedded Ss	Trough/planar x-beds	1.0-8.4	Channel bar	Fluvial Ch.
F3	Rippled siltstone	Current ripples, mud drapes	0.3-2.1	Crevasse splay	Floodplain
F4	Mudstone	Root traces, paleosols	0.5-6.7	Floodplain	Floodplain
F5	Laminated shale	Parallel lamination	1.2-12.8	Lacustrine	Lacustrine
F6	Oolitic limestone	Ooids, bioclasts	0.8-5.3	Shallow marine	Carbonate

Facies F2 (cross-bedded sandstone) is volumetrically dominant in the Jurassic units, forming multi-storey channel

bodies up to 15 m thick. Facies F5 (laminated lacustrine shale) dominates the Cretaceous Jiaguan Formation.

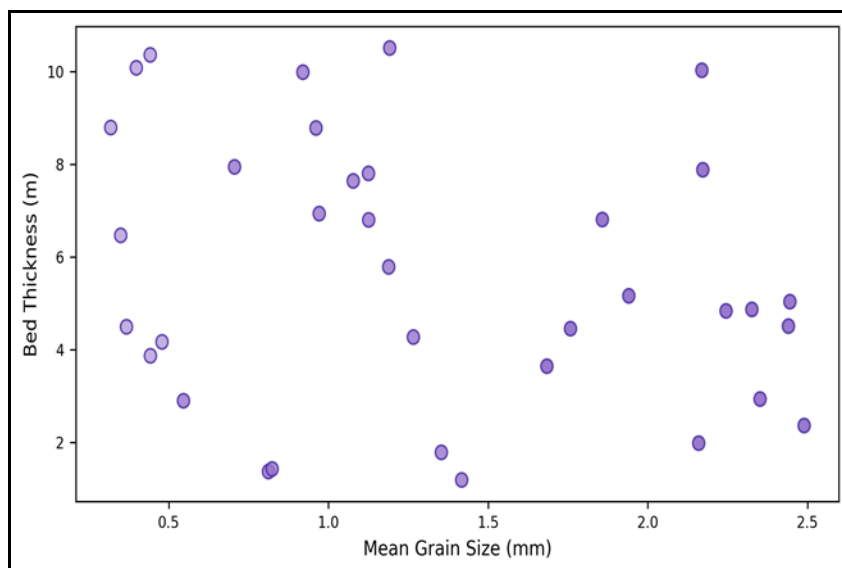


Fig 1: Scatter plot of mean grain size vs bed thickness for clastic facies. Coarse-grained facies (dark purple) cluster at greater thicknesses.

Table 2: Facies association proportions by stratigraphic unit (% of measured thickness)

Unit	Fluvial Channel (%)	Floodplain (%)	Lacustrine (%)	Carbonate (%)
Xujiahe (Triassic)	12	18	28	42
Ziliujing (L. Jurassic)	35	32	22	11
Shaximiao (M-U. Jurassic)	28	38	24	10
Jiaguan (Cretaceous)	18	35	38	9

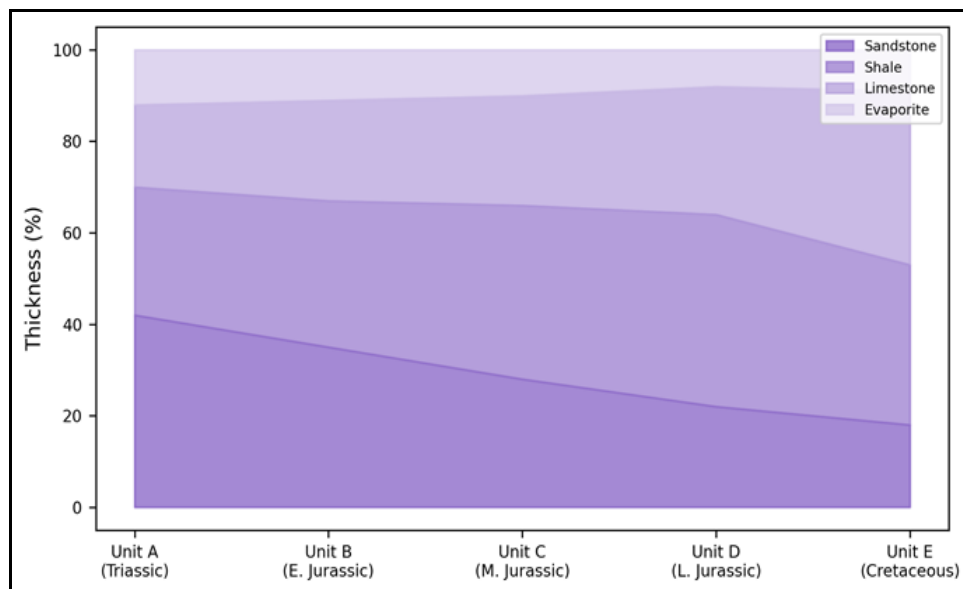


Fig 2: Area chart showing the proportional distribution of lithofacies across the four stratigraphic units.

Comprehensive Interpretation

The vertical trend from carbonate-dominated (42% in Triassic) to lacustrine-dominated (38% in Cretaceous) reflects the basin's evolution from a marine-connected platform to an isolated continental lake. Palaeocurrent vector means point consistently east-southeast (mean 112°, circular variance 0.31), confirming the Longmen Shan as the primary sediment source throughout the Mesozoic.

Discussion

The facies succession is consistent with a foreland basin model in which Longmen Shan thrusting drove subsidence and controlled sediment supply [4]. The Triassic-Jurassic transition from marine to continental facies records the retreat of the Tethyan seaway, while the upward increase in lacustrine deposits during the Cretaceous may reflect a combination of reduced tectonic uplift rates and increased basin-floor subsidence that outpaced sediment fill [12]. The persistence of east-directed palaeocurrents across 150 million years of record is striking and indicates long-lived topographic asymmetry controlled by the western thrust front.

The data also have implications for gas exploration. Sandstone channel bodies in the Shaximiao Formation — thick, laterally continuous, and bounded by floodplain mudstones — form potential tight gas reservoirs. Their lateral extent (traceable for 3-5 km between sections) and net-to-gross ratio (0.28-0.35) are favourable, though porosity data from this outcrop-based research remain to be confirmed by subsurface well data [13].

Conclusion

Five measured sections on the eastern Sichuan Basin margin document a Mesozoic succession that evolves from marine carbonate platform through fluvial-lacustrine to broad lacustrine conditions. Ten facies grouped into four associations record this transition. Palaeocurrents are uniformly east-directed, confirming the Longmen Shan as the persistent sediment source. The vertical facies evolution reflects foreland basin dynamics, and the multi-storey sandstone bodies in the Shaximiao Formation represent potential tight gas exploration targets.

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