



A Mesozoic orogenic plateau across South China[☆]

Mark B. Allen^{a,*}, Shuguang Song^b, Chao Wang^b, Renyu Zeng^c, Yang Chu^d, Alex Copley^e

^a Department of Earth Sciences, Durham University, Durham DH1 3LE, UK

^b MOE Key Laboratory of Orogenic Belts and Crustal Evolution, School of Earth and Space Sciences, Peking University, Beijing 100871, China

^c Jiangxi Provincial Key Laboratory of Genesis and Prospect for Strategic Minerals, East China University of Technology, Nanchang 330013, Jiangxi, China

^d State Key Laboratory of Lithospheric and Environmental Coevolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China

^e Department of Earth Sciences, University of Cambridge, Cambridge, UK

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ABSTRACT

The South China Block (SCB) underwent intense magmatism, deformation and mineralisation in the Mesozoic. These events were the combined result of Triassic collisions along three plate margins, and subduction of the Paleo-Pacific Ocean from the east. Beyond this framework there are gaps in our understanding. We propose that growth of an orogenic plateau controlled the Mesozoic tectonic and magmatic evolution of South China. The plateau was similar to the modern Central Andes, but >1000 km across. Thickening was the result of compressional stresses generated at the Paleo-Pacific convergent margin, and continental collisions at other margins. Retroarc, compressional deformation migrated westwards through the Jurassic and Cretaceous, thickening crust as far as the Sichuan Basin. Structures are convex towards the foreland, consistent with the influence of gravitational flow. Two sets of folds occur in the Eastern Yangtze Fold Zone. One set of folds is roughly concentric, convex towards the plate interior. The other set is radial and contains nine long wavelength folds (~100 km). Folding may be the result of constrictional strain, producing two sets of structures simultaneously. We find little evidence for Triassic or Jurassic extension, which is commonly inferred from pluton geochemistry. Regional extension began in the Early Cretaceous at ~135 Ma and was oriented WNW-ESE. Extension was plausibly triggered by a change in the regional force balance, itself related to plate reorganization. Extension in the interior was contemporary with thrusting to the west, in the East Sichuan fold-and-thrust belt, and to east, in the Southeast Coast Magmatic Belt; this configuration is difficult to explain solely by Paleo-Pacific plate rollback or foundering mechanisms. Permian and Mesozoic magmatism took place within regions affected by progressive crustal thickening from the Permian to the Early Cretaceous. A ~700 km wide magmatic belt was in existence by the Late Triassic, ~60 Myr after initial Paleo-Pacific subduction. Magmatism includes I-, S- and A-type granites. Different compositions were broadly contemporary, with a tendency for A-type intrusions to postdate other types. Magmatism continued through the Jurassic and Cretaceous, with lulls inland at 200–180 Ma and 115–100 Ma. There were lateral shifts in the focus of magmatism over time, with a pronounced move to the southeast in the Early Cretaceous. A-type granites may result from high temperature crustal melting, generated in thickened crust by radiogenic heating. We propose that thick, hot, lower crust of orogenic plateaus is a productive tectonic setting for the generation of A-type granites, without needing extensional strain and crustal thinning, in regions dehydrated by prior melt extraction during orogeny. Within-plate signatures in rare Jurassic mafic rocks may relate to lithospheric drips. Topographic plateau relicts are distributed across South China, including the Wu Shan and Xuefengshan ranges. Scattered surfaces at 1500–2000 m altitude may be remnants of an extensive plateau, and consistent with an original crustal thickness of ~45–50 km. Plateau development took place between the Late Triassic and Early Cretaceous. The minimum age is constrained by Lower Cretaceous *syn*-rift strata which disrupt the plateau remnant surfaces, and by ~135 Ma extensional core complexes.

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* Corresponding author.

E-mail address: m.b.allen@durham.ac.uk (M.B. Allen).

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1. Introduction

Orogenic plateaus are generated by plate convergence, either during continental collision (Iranian plateau), during oceanic subduction (Central Andean Plateau), or sequentially as collision follows subduction (Tibetan Plateau). These settings represent limits to continental deformation, as they contain the thickest and highest elevation crust on Earth (Hatzfeld and Molnar, 2010). Therefore understanding the operation and evolution of orogenic plateaus is a major goal for tectonic studies. However, whereas modern plateaus are distinctive because of their high elevations, low relief and thick crust, ancient plateaus are overprinted

and destroyed by later events and processes, especially extension and erosion (Dewey, 1988). This destruction makes recognition of ancient plateaus difficult, and risks that their existence is overlooked in favor of regional interpretations involving arcs and collisions, but not the existence of a broad, hot, region of low strain crust with lateral plateau growth.

This paper proposes that large parts of the South China Block (SCB, Figs. 1 and 2) formed an orogenic plateau in the Mesozoic era. This plateau was the result of deformation and magmatism caused by subduction of the Paleo-Pacific Plate, acting on regions also affected by shortening resulting from collisions at the other margins of the SCB. Paleo-Pacific and then Pacific Plate subduction under east Eurasia has been a first order feature of global tectonics since the Permian, with influence over elemental cycling, mineralisation and climate change via carbon fluxes (Fig. 1). The SCB records the effects of this subduction in the form of voluminous magmatism from the Permian to the Cenozoic (Zhou et al., 2006; Li and Li, 2007; Wang et al., 2013). World-class metal deposits are associated with some of these magmatic rocks (Mao et al., 2013). The SCB was also deformed through the Mesozoic era, with crustal shortening and thickening in the form of fold-and-thrust belts (Chu et al., 2012a; Li et al., 2012a; Zhang et al., 2013; Dong et al., 2018). Shortening was interspersed with periods of extensional deformation in the Cretaceous (Li et al., 2014a).

We envisage a similar but larger plateau than the modern Central Andean Plateau, which contains the Central Volcanic Zone of the Andes (Armijo et al., 2015; Ducea et al., 2026). There are also comparisons with the older Nevadaplano and Lhasaplano orogenic plateaus (DeCelles, 2004; Kapp et al., 2007), which likewise developed above oceanic subduction zones. Further insights come from the modern Iranian and Tibetan plateaus (Hatzfeld and Molnar, 2010). The orogenic plateau model has implications for understanding the setting of different magma suites and patterns of deformation, mineralisation and sedimentation in the SCB. It also re-interprets the SCB as an example of a tectonic setting that can be hard to recognise in the geological record, due to the low-strain nature of plateau interiors, albeit one that can have major implications for crustal evolution and composition. An important

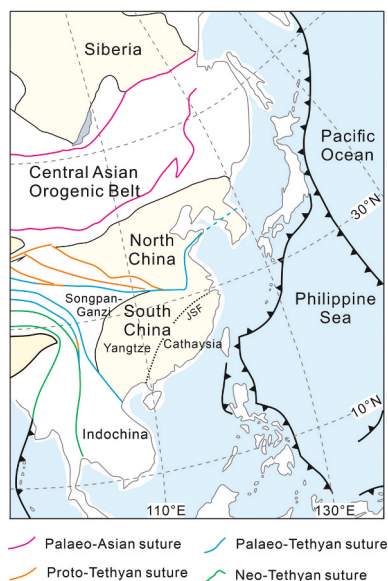


Fig. 1. Main tectonic units of east Asia. JSF - Jiangshan-Shaoxing Fault. From Wang et al. (2024).

aspect of an orogenic plateau is that thickened crust produces a buoyancy force which resists further compressional deformation, such that compressional strains required to accommodate plate convergence are achieved at the lower elevation margins of the plateau (Molnar and Lyon-Caen, 1988). This behaviour leads to lateral plateau growth, and low rates of strain in the plateau interior. Changes in the regional force balance can lead to the scenario where extension in the plateau interior occurs at the same time as folding and thrusting at the plateau margins (Wimpenny et al., 2018). Plateau geomorphology is not an incidental feature of the tectonics. Low relief plateau interiors with internal drainage lead to low exhumation rates, and preserve the crustal thickness (Sobel et al., 2003). As well as accommodating plate convergence via marginal fold-and-thrust belts, the creation of a wide region of thick crust creates a site for crustal heating and the generation of metamorphic and granitic rocks.

The following sections review the geology of the SCB and adjacent areas (Fig. 3), using the extensive datasets that have been published over recent decades. These datasets permit an overview of the magmatism, deformation and basin evolution (Fig. 4). There is also an analysis of the present geomorphology: one of the surprising findings of our study is that scattered relict plateau surfaces exist across South China, which appear to date from the Mesozoic era.

2. South China basement and Paleozoic-Triassic cover sequences

Collision and amalgamation of the Yangtze and Cathaysia blocks to form the SCB took place by ~ 0.8 Ga (Cawood et al., 2018; Shu et al., 2021). The suture between the Yangtze and Cathaysia blocks is along the Jiangshan-Shaoxing Fault (Figs. 1 and 3), although the southern trace of this structure is uncertain. Proterozoic igneous and metamorphic rocks related to the collision are exposed in the east of the Yangtze Block and to a lesser extent in Cathaysia, collectively known as the Jiangnan orogenic belt (Fig. 3). The original extent of this belt is uncertain because of the widespread younger cover sequences.

An Early Paleozoic compressional episode deformed large parts of the SCB, known as the Wuyi-Yunkai orogen, or the Kwangsi orogeny (Wang et al., 2023). Intense deformation, metamorphism and magmatism took place in the Ordovician and Silurian, sealed by a Middle-Late Devonian unconformity (Charvet et al., 2010; Chen et al., 2014). The

causes of this orogeny are enigmatic. It has been described as an intra-continental orogeny (Faure et al., 2009), and related to suturing events elsewhere within Gondwana, such as the Kuunga orogen (Xu et al., 2016). Alternatively, there was an Early Paleozoic orogenic belt within South China, related to subduction and closure of an oceanic plate (Zhang et al., 2016). Cambrian plagiogranite along the Zhenghe-Dapu (or Zhenghe-Dabu) Fault (Fig. 3) has been interpreted as an ophiolitic fragment (Li et al., 2022a). Early Paleozoic granitoids within West Cathaysia and the Yangtze Block have calc-alkali and shoshonitic chemistries, consistent with an arc setting related to subduction and subsequent closure of an ocean between East and West Cathaysia (Zhang et al., 2015a, 2015b; He et al., 2023). Both undeformed and deformed plutons occur (e.g. Guan et al., 2014; Shu et al., 2015).

The extent of Early Paleozoic deformation decreased towards the west of the SCB (Chu et al., 2012a). Stable, platform conditions for sedimentation persisted from Middle Devonian to Early-Middle Triassic times across much of the block. Facies alternated between clastic sedimentary rocks and carbonates. These sequences provide markers for Late Triassic and younger strain across the SCB. By the Early Permian a Cathaysian Highland was established in what are now coastal regions of South China; this timing coincides with the development of the first arc along this margin, in response to Paleo-Pacific subduction (Li et al., 2012c; Hu et al., 2015).

3. Late Paleozoic and Mesozoic plate margins

The SCB was affected by three collisions during the Triassic period, at its south, west and north margins (Fig. 2). The southern and northern events involved collisions with the Indochina and North China blocks, respectively. The western event was somewhat different, as the SCB converged with a giant accretionary complex, the Songpan-Ganzi Zone (Fig. 3).

Collision of the SCB and Indochina closed the Ailaoshan (Song Ma) branch of the Paleo-Tethys (Figs. 2 and 3). Initial collision was Late Permian to Early Triassic, ~ 255 – 247 Ma (Faure et al., 2016), based on combined stratigraphic, magmatic and metamorphic evidence from the collision zone. It is likely that there was bivergent subduction before initial collision. There is a well-established arc within Indochina, and models commonly depict a single subduction zone, under Indochina (e.

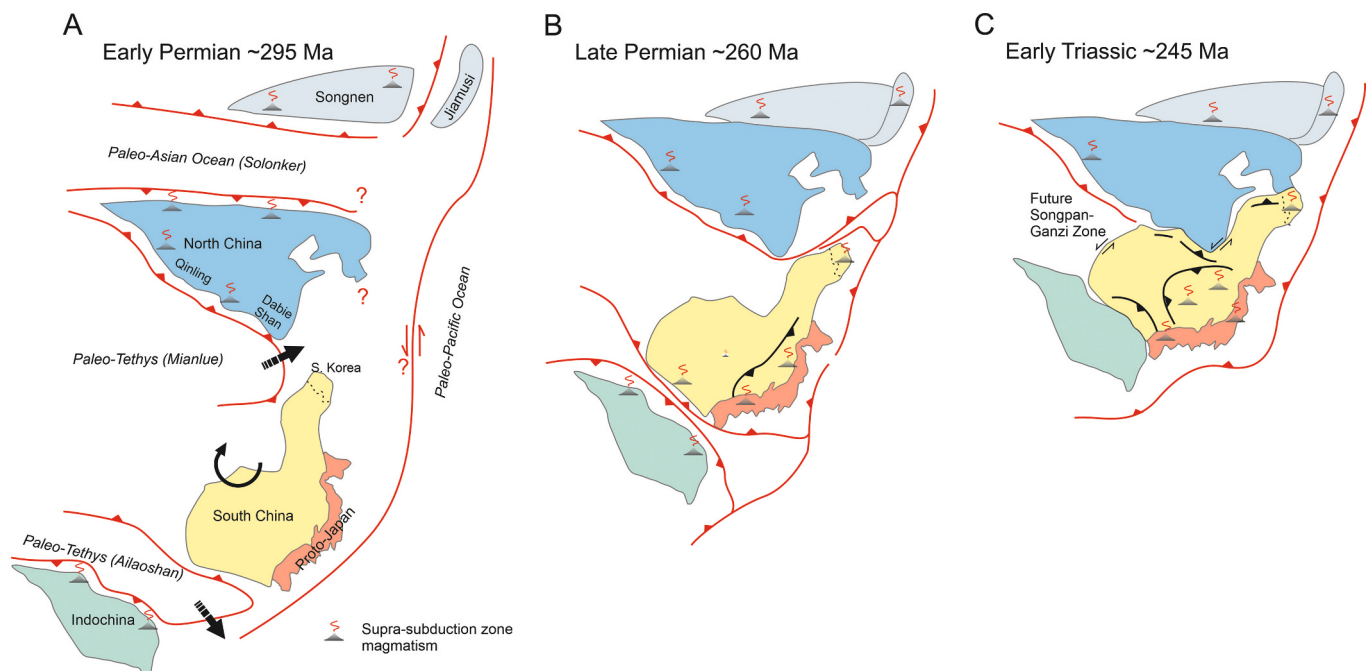


Fig. 2. Summary reconstructions for the tectonic assembly of east Asian continental blocks from the Early Permian to Early Triassic. From Allen et al. (2025).

g., Metcalfe, 2021). However, evidence for a Late Permian-Triassic arc, accretionary complex and associated forearc basin have been identified within the southwest SCB (Xia et al., 2020; Xu et al., 2022), implying a subduction zone under the SCB as well. This arc seems to be restricted in time to the Late Permian-Triassic and in space to the proximity of the Ailaoshan Suture (Xu et al., 2022); Paleozoic-Triassic magmatism is not widespread within the southwest SCB. The eastern continuation of the Ailaoshan Suture may run through Hainan Island (He et al., 2018), although details are obscured by abundant Mesozoic granitic plutons (Dilek and Tang, 2021). Four other suture zones have been identified to the south of the Ailaoshan Suture, and interpreted as the trace of sub-parallel back-arc basins that closed at approximately the same time in the Early-Late Triassic (Wang et al., 2018a). We speculate that this collective set of sutures was produced by orogen-parallel strike-slip shear and repetition during ocean closure and collision, derived from a much simpler subduction system (Faure et al., 2014). There are potential similarities with the multiple sutures mapped across the Central China Orogenic Belt, which may also originate by strike-slip repetition (Allen et al., 2023).

The Youjiang (Nanpanjiang) Basin in the southwest of the SCB (Fig. 3) records the amalgamation of Indochina with the SCB. It is conventionally regarded as a foreland basin, thickening and deepening to the southwest (e.g. Yang et al., 2021), although Duan et al. (2020), interpreted pre-Norian extension on sedimentological grounds, before latest Triassic thrusting and foreland basin development.

Collision of the northern margin of the SCB with the southern side of the NCB created a Triassic orogenic belt along the Qinling-Dabie Shan Orogen (Figs. 2 and 3), including ultra-high-pressure (UHP) metamorphic rocks. There is a range of published ages for the metamorphism

of the continental protoliths in the Dabie Shan UHP belt, but the earliest, at 245 Ma, place the initial collision in the Early Triassic (Hacker et al., 1998). Subduction polarity is typically interpreted as northwards, with Paleozoic arc magmatism developed within the various tectonic units of the Qinling. These units represent arcs and microcontinental slivers that welded to each other and to the southern margin of the NCB before closure of the Mianlue branch of the Paleo-Tethys. Jahn and Chen (2007) interpreted southwards subduction, at least at the eastern part of the orogen exposed in the Dabie Shan, based on the Sr-Nd-Pb isotope signatures of Cretaceous granitoids exposed in this region, and their similarity to the basement characteristics of the NCB. Overall, the lack of arc magmatism along the northern side of the SCB indicates that it was a passive continental margin before collision with the NCB.

The basement of the western margin of the SCB is exposed in the Longmen Shan (Fig. 3), where nappes with Precambrian basement cores were thrust to the southeast and over the Sichuan Basin in the Late Triassic-Early Jurassic (Fig. 4; Chen et al., 1995; Yong et al., 2003; Yan et al., 2018). This margin of the SCB was a passive margin before the collision. To the west, the Songpan-Ganzi Zone is a huge accumulation of Triassic flysch, which is the infill of an irregular region between the SCB, the Qiangtang Block, and the western continuation of the North China Block (NCB) (Jian et al., 2019).

The final, southeastern, margin of the SCB has been an oceanic subduction zone related to the subduction of the Paleo-Pacific Plate and then the modern Pacific Plate (Li and Li, 2007) (Fig. 2). The time of initial subduction has long been debated, with suggestions of Permian initiation (e.g., Li and Li, 2007; Hu et al., 2015), but also the Jurassic, e.g., Dong et al. (2015), Li et al. (2025). The distribution of pre-Jurassic magmatism along the eastern side of South China strongly indicates a

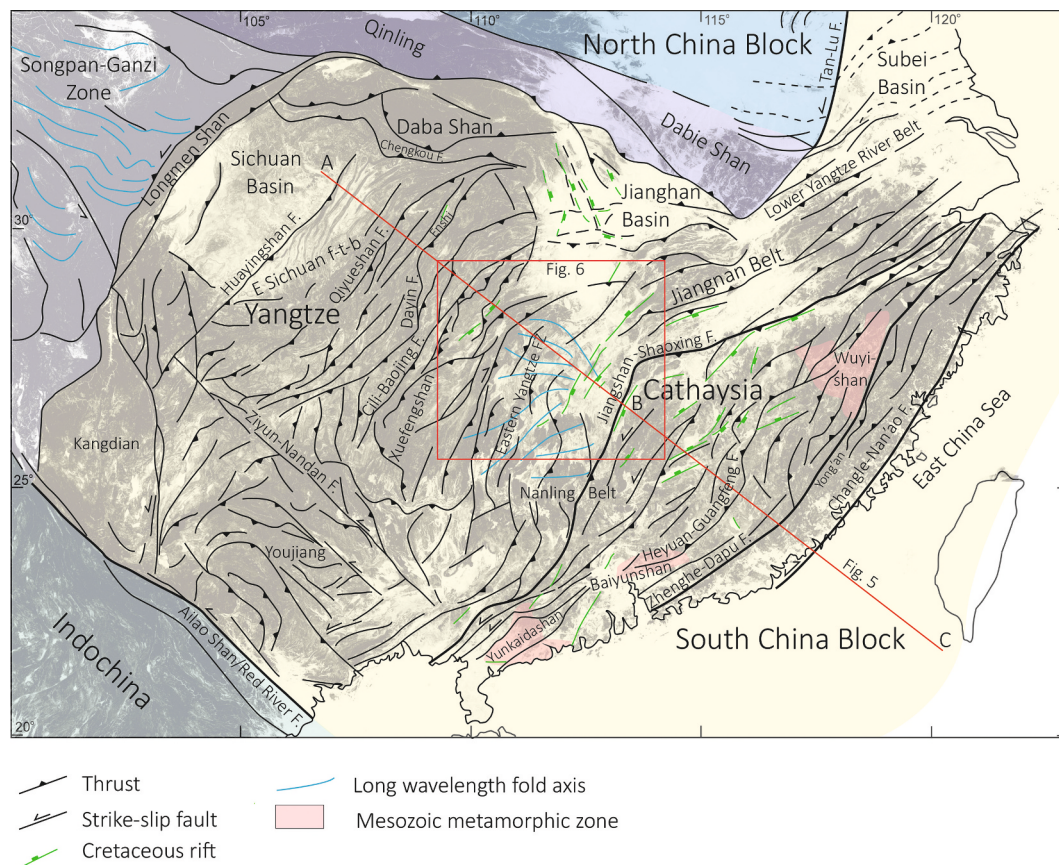


Fig. 3. Regional tectonic map of South China, highlighting the main tectonic units. Most of the structures shown in the South China Block are Mesozoic in age. Some have Paleozoic or Precambrian origins; some have been active in the Cenozoic as the result of the India-Asia collision, especially in the west. Background shading is topographic slope (dark tone = high slope). Compiled from many sources, including Li et al. (2001), Li et al. (2012a), Li et al. (2014a), Li et al. (2017a), Wu et al. (2020), Chu et al. (2024) and Zhang et al. (2025).

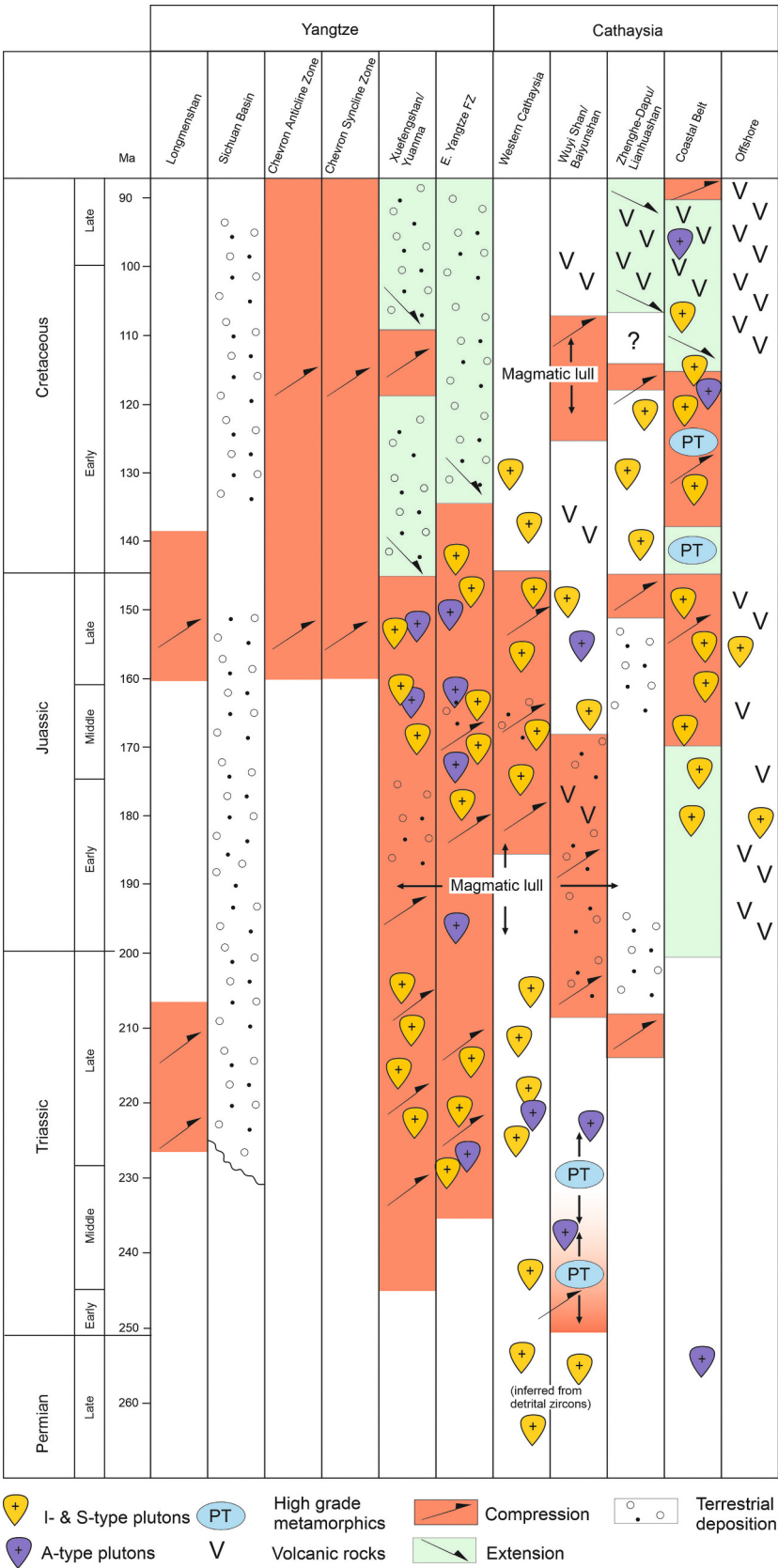


Fig. 4. Tectonostratigraphic charts for the Mesozoic geology of the SCB along the zones intersected by the section line of Fig. 5.

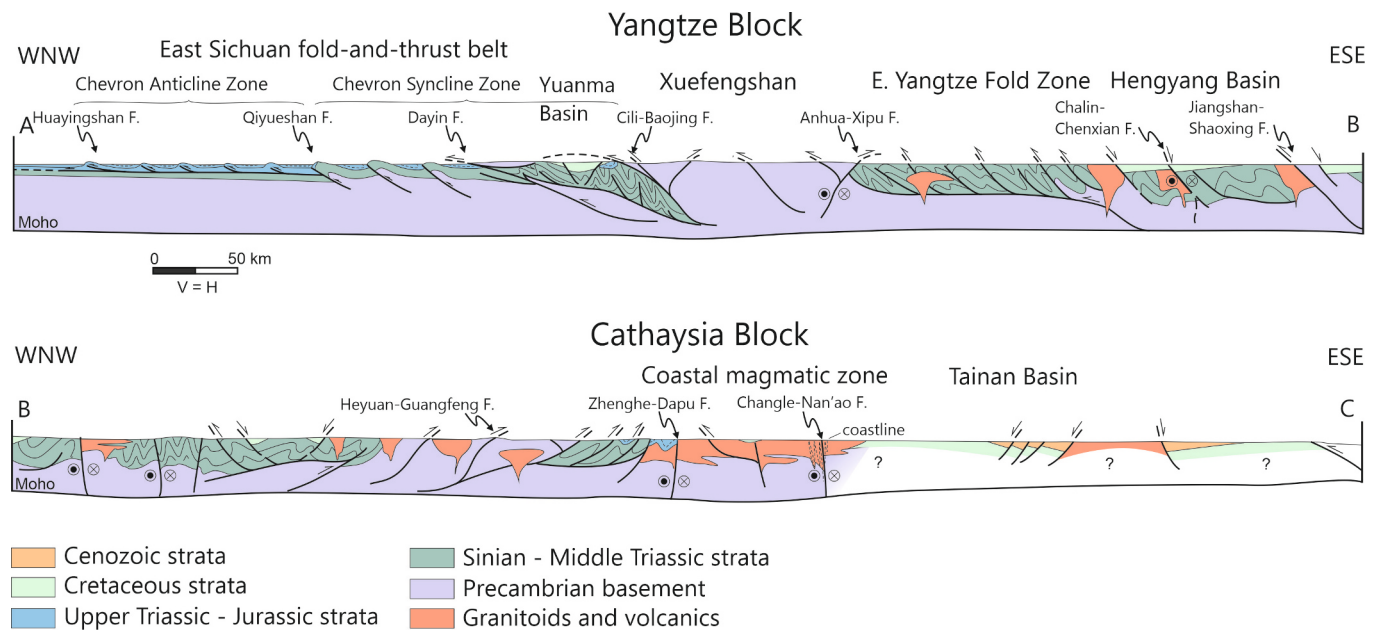


Fig. 5. Regional tectonic cross-section for South China. The cross-section is schematic but true scale. Sources include Bureau of Geology and Mineral Resources of Fujian Province (1985), Bureau of Geology and Mineral Resources of Hunan Province (1988), Chen (1999), Li et al. (2001), Yan et al. (2003), Chu et al. (2012a), Li et al. (2012b), Li et al. (2013), Li et al. (2018a), Dilek and Tang (2021), Cao et al. (2022) and Feng et al. (2023). Section line shown on Fig. 3.

cause related to an arc along this margin. Initial subduction may have been related to the late stages of convergence along the other plate margins of the SCB. In this scenario, subduction zones of the closing Paleo-Tethyan oceans migrated eastwards to affect the Paleo-Pacific Plate (Fig. 2), in an example of subduction invasion (Allen et al., 2025). An important model of Paleo-Pacific subduction under the SCB suggests that a westward migration of magmatism was caused by advance of a flat slab under the continental margin, beginning in the Permian, followed by a trenchward retreat from the Early Jurassic at ~200 Ma (Li and Li, 2007), with localised foundering of the flat slab to explain co-eval I-type and A-type granitoid magmatism within the interior of the SCB (Li et al., 2007). This model has been extremely influential in our understanding of Eurasian tectonic, magmatic evolution and metallogeny (Goldfarb et al., 2021). However, more recent geochronology data give a different picture of the distribution of magmatism over time (Wang et al., 2013; Li et al., 2019; Li et al., 2023a, 2023b). Magmatism was already present far inland of the modern coastline by the Late Triassic (~230 Ma; Wang et al., 2013). The ideas of slab foundering and Jurassic-Cretaceous trenchward migration of magmatism persist, albeit with increasing complexity required to account for the detail in the growing geochemical and geochronological datasets (Li et al., 2019; Dilek and Tang, 2021; Zhang et al., 2022a; Li et al., 2023a; Wu et al., 2023).

4. Deformation in space and time

On the largest scale, there is bivergent thrusting across the SCB (Fig. 5), with the dividing line between mainly WNW- and mainly ESE-vergent structures at the Jiangshan-Shaoxing Fault (Chen, 1999; Xu et al., 2011; Faure et al., 2009; Charvet et al., 2010). This is not an exact distinction: structures in each of these two areas have contrasting transport directions, but it serves as a starting point for descriptions of the regional structure. This account begins with structures west of the Jiangshan-Shaoxing Fault, and then describes structures to its east.

4.1. Compressional deformation, west of the Jiangshan-Shaoxing Fault

An element of the fold-and-thrust belt across the SCB, west of the

Jiangshan-Shaoxing Fault, is that the overall structure is arcuate: individual thrusts and folds are convex outwards, away from the interior of the SCB (Fig. 3). This convexity can be traced around the SCB, including sub-surface structures underneath the Cretaceous and Cenozoic strata of the Jiangshan Basin (Wu et al., 2020). In the north, structures face opposing folds and thrusts originating in the Qinling-Dabie Shan Orogen. In the south, folds and thrusts swing in orientation to face structures of the Youjiang Basin across the Ziyun-Nandan (Ziyun-Luodian) Fault (Li et al., 2017a) (Fig. 3).

Moving west from the Jiangshan-Shaoxing Fault, the structural units consist of the Eastern Yangtze Fold Zone, the Xuefengshan Belt, the Chevron Syncline Zone and the Chevron Anticline Zone (Yan et al., 2003; Cao et al., 2022) (Figs. 4 and 5). These belts are separated from each other by the Anhua-Xupu, Cili-Baojing and Qiyueshan faults, respectively (Figs. 3, 5 and 6). The Chevron Syncline Zone and the Chevron Anticline Zone collectively form the East Sichuan fold-and-thrust belt. The Huayingshan Fault separates the Chevron Anticline Zone from the interior of the Sichuan Basin (Fig. 5).

The Eastern Yangtze Fold Zone contains domal structures, where Neoproterozoic and Lower Paleozoic strata or Lower Paleozoic and Triassic intrusive rocks are exposed as a result of fold superposition (Fig. 6). Conventionally, NNE or NE-trending folds are interpreted to postdate and deform E-W or WNW-ESE trending folds (e.g. Li et al., 2016), but Zheng et al. (2021) interpreted the NNE/NE folds as the earlier set, based on paleostress analysis of calcite twins. These superposed folds are described in more detail in a later section. Structures of the Eastern Yangtze Fold Zone are broadly convex towards the interior of the SCB, and continue along strike to the northeast past the Dabie Shan and southeastern NCB into the Lower Yangtze River Belt (Fig. 3). In this region the faults close to the Jiangshan-Shaoxing Fault are thrusts directed towards the northwest (Xiao and He, 2005). The strike-slip Tan-Lu Fault is the boundary between the eastern side of the NCB and the northern promontory of the SCB (Fig. 3). Structures of the Lower Yangtze River Belt continue to the northeast under the Cenozoic rift and post-rift stratigraphy of the Subei Basin.

The Xuefengshan Belt exposes Precambrian basement, and is bounded by faults so that it represents a large-scale pop-up structure (Fig. 5; Li et al., 2012b; Li et al., 2018a). The Cili-Baojing Fault separates the

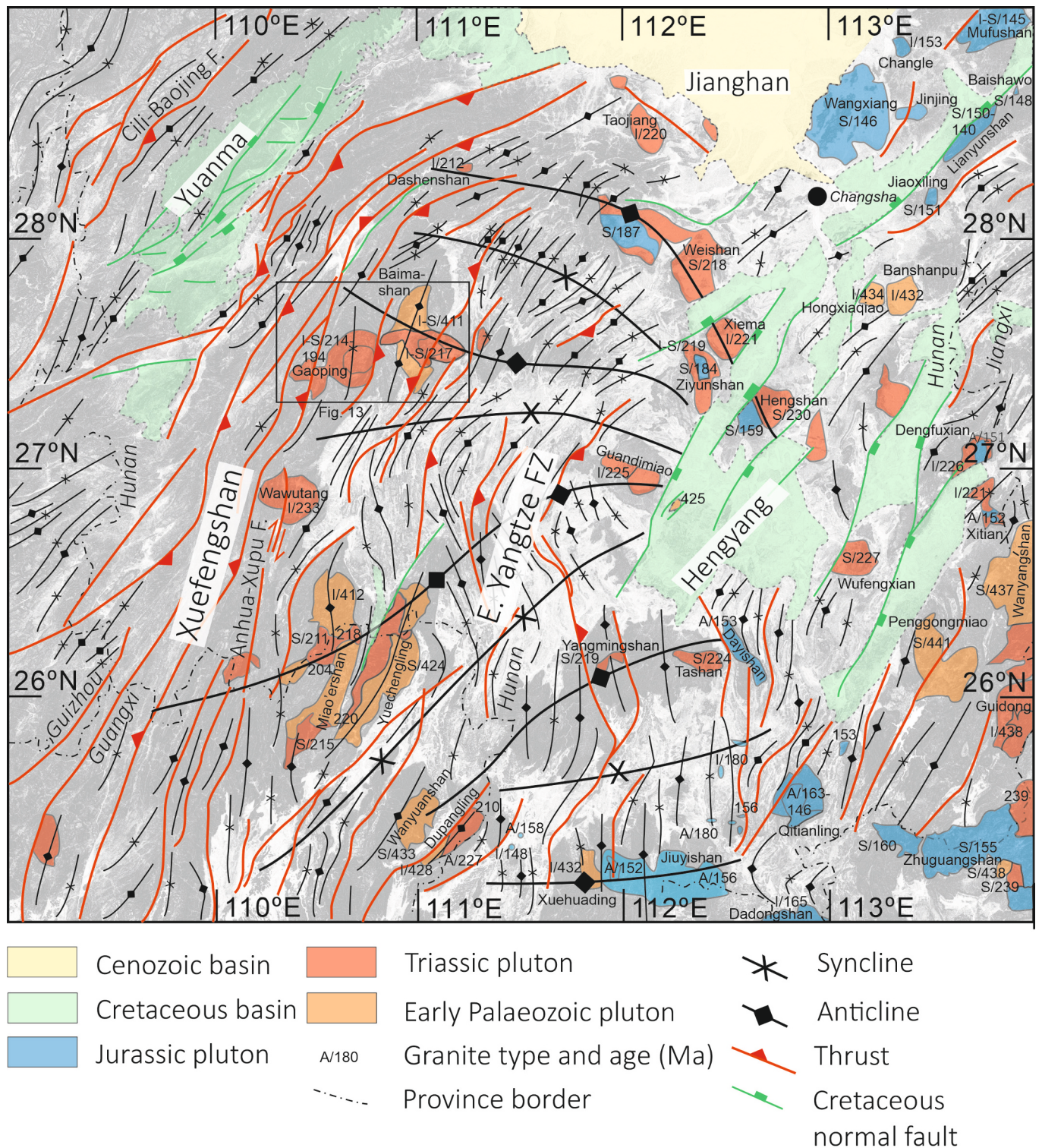


Fig. 6. Structural map of central/southern Hunan Province and adjacent areas, highlighting superposed fold patterns, different pluton generations, and Cretaceous rift basins. Background shading is topographic slope (dark tone = high slope). Geology from Bureau of Geology and Mineral Resources of Hunan Province (1988), supplemented by local maps in references listed in Table S1, Li et al. (2012b), Li et al. (2016) and Chu et al. (2012a). Data sources for pluton ages listed in Table S1.

Xuefengshan Belt from the Chevron Syncline Zone to the west (Figs. 3 and 5): both regions involve the basement, but the Chevron Syncline Zone also involves strata as young as Triassic in age. Middle and lower crustal shear zones are imaged on deep seismic sections, dipping east and flattening at depth (Li et al., 2018a). Yan et al. (2003) described nappes of basement, implying largescale overthrusting; this geometry is

included in Fig. 5, but this interpretation has not been universally adopted in other papers on the region (e.g. Li et al., 2012b; Bai et al., 2014). Middle and Late Jurassic deformation affected the Jurassic stage of the Yuanma Basin, which has the appearance of a piggyback basin above the Cili-Baojing Fault (Fig. 5). The eastern boundary to the Xuefengshan Belt is the Anhua-Xupu Fault, which is noted as a left-

lateral strike-slip or oblique-slip fault (Dilek and Tang, 2021), but offsets a ~194 Ma granite in a right-lateral sense (Fig. 6; Li et al., 2012a). Monazite U–Th–Pb ages of shear zones in schists indicate thrusting from 243 to 226 Ma (Chu et al., 2012b), i.e. from Early to Late Triassic. Ar–Ar ages of *syn*-kinematic micas are in the range 216–195 Ma (Wang et al., 2005a). Therefore the Xuefengshan was a zone of prolonged sinistral transpression from at least the Middle Triassic to Early Jurassic (244–195 Ma), characterised by top-to-WNW-thrusts and top-to-ESE-back-thrusts, with a range-parallel element of sinistral strike-slip. Yan et al. (2003) estimated ~20% shortening across the region, similar to the East Sichuan fold-and-thrust belt to the west. Later deformation in the Jurassic has been inferred from unconformities in intramontane basin deposits (Jin et al., 2009). The age of the post-194 Ma dextral slip on the Anhua-Xupu Fault (Fig. 6) does not seem to be well-constrained.

The Chevron Syncline Zone is interpreted as being deformed by thrusts which root into the Precambrian basement of the region (Gu et al., 2021; Feng et al., 2023) (Fig. 5). The Qiyueshan Fault at the western margin of the zone has a throw in the order of ~1 km or more; it is not everywhere emergent (Li et al., 2020a). Cambrian–Triassic strata are tilted in its footwall towards the WNW, effectively in a monocline at the edge of the Triassic–Jurassic strata exposed in the Chevron Anticline Zone.

Deformation is thin-skinned in the outer, Chevron Anticline Zone (Yan et al., 2009; Li et al., 2018a; Feng et al., 2023) (Fig. 5). Long, cylindrical anticlines are preserved in the present-day topography. These folds overlie thrusts, which are typically blind. The main detachment is along Cambrian evaporites and shales, at depths as great as 9 km (Gu et al., 2021). These strata are duplexed (Li et al., 2018a). Other detachment levels are present, including Sinian, Silurian and Triassic strata (Yan et al., 2009; Li et al., 2015a). These include Lower Triassic gypsum of the Jialingjiang Formation. Balanced cross-sections suggest 12–18% shortening (Gu et al., 2021). Yan et al. (2003) calculated at least 18–21% shortening across both thin- and thick-skinned zones of deformation between the Xuefengshan and the foreland.

Whereas the folds at the eastern margin of the Sichuan Basin are convex towards the basin interior, the faults in this region are distinctly more linear (e.g. the Huayingshan Fault), and in places seem to cross-cut and so post-date the folding (e.g., Yan et al., 2009; Li et al., 2019). The youngest deformed strata in the East Sichuan fold-and-thrust belt are Middle Jurassic, whereas Cretaceous strata to the northwest are flat-lying and show little or no deformation, thereby constraining the deformation as mainly Late Jurassic or younger in age (Li et al., 2018a). The stratigraphic age constraints are supported by a growing set of thermochronology data, which collectively show younger exhumation towards the west, from Early Jurassic (~190 Ma) in the Xuefengshan to mid Cretaceous (120–90 Ma) in the East Sichuan fold-and-thrust belt (Shi et al., 2016; Feng et al., 2023).

Thrusts and folds in the Daba Shan range, at the south side of the Qinling orogen, record convergence of the NCB and the northern side of the SCB (Li et al., 2007) (Fig. 3). The adjacent northeast Sichuan Basin preserves sediment derived from the uplifted ranges. Structures are convex southwards and verge in the same general direction. Precambrian basement is exposed in the north, but the bulk of the region exposes Paleozoic to Middle Triassic strata. There are rarer exposures of Neoproterozoic phyllites and schists in the hangingwalls of major south-directed thrusts such as the Chengkou Fault (Li et al., 2015b). Ramps and detachments are interpreted to dip northwards (Li et al., 2007). Compressional deformation is recorded in three stages: late Middle Triassic, Late Triassic to Early Jurassic and Late Jurassic to Early Cretaceous (Li et al., 2014b), although thermochronological data indicate two pulses, broadly between 235 and 225 Ma (Late Triassic) and 165 to 135 Ma (Late Jurassic to Early Cretaceous) (Li et al., 2015b). The adjacent part of the Sichuan Basin underwent rapid subsidence in the Late Jurassic to Early Cretaceous in particular (Liu et al., 2006), indicating also major deformation and uplift of the Daba Shan through this time interval.

The Youjiang fold-and-thrust belt is a deformed region at the southwest margin of the SCB, between the Ailaoshan suture zone and the Ziyun–Nandan Fault (Fig. 3). Structures are commonly convex to the north or northeast in map view, and expose Permian–Middle Triassic strata (Qiu et al., 2016). There are also NW–SE fold axes parallel to the Ziyun–Nandan Fault. Thrusts predominantly dip south, and are interpreted as thick-skinned and involving Precambrian basement by Yang et al. (2021), although Precambrian rocks are not exposed. Li et al. (2017a) placed a major decollement horizon in the Cambrian, thereby detaching the sedimentary cover from Precambrian basement. Type 1 refolded folds in the Long'an area were interpreted by Li et al. (2017a) as the result of northeast-vergent structures overprinting an earlier phase of northwest-vergent deformation, all in the Early–Middle Triassic. This is the opposite sequence of events commonly interpreted for the Eastern Yangtze Fold Zone, which is described in the next section.

4.2. Superposed deformation in the Eastern Yangtze Fold Zone

Several regions of the SCB have been identified as containing superposed fold patterns, taken to indicate two distinct periods of deformation, of different stress orientations. Most studies have focussed on examples in Hunan and Jiangxi provinces and adjacent areas, loosely corresponding with the Eastern Yangtze Fold Zone (Fig. 6). These regions are complicated by the pre-Devonian Kwangsi deformation; Mesozoic deformation is easier to map in Devonian to Triassic strata. Hunan Province in particular contains multiple examples of superposed folds. Trains of fold axes are conventionally categorised as belonging to one of two sets. One set is described as aligned N–S to NE–SW and the other WNW–ESE (Shi et al., 2015). Folding affects Neoproterozoic to Middle Triassic strata. The fold sets are typically interpreted in terms of an early, Late Triassic set with WNW–ESE alignment, refolded by the N–S to NE–SW, folds such that there are type 1 fold interference, dome-and-basin patterns (Li et al., 2016). Li et al. (2023b) described refolded folds in Jiangxi Province as the result of Middle–Late Triassic NE–SW shortening followed by Middle–Late Jurassic ~E–W shortening.

The folds in central Hunan were interpreted by Zheng et al. (2021) to be the result of earlier deformation producing the NE–NNE structures, with an overprint by the WNW trending folds, based on calcite twinning analysis and a review of the fold patterns at the regional map scale; the deflection of the NE–NNE fold trends is clear in this area. Li et al. (2021) suggested that Middle–Late Triassic convergence from multiple plate boundaries at the margins of the SCB formed NW or WNW-trending folds in the interior of the SCB, and NE or ENE-trending folds in the interior of Cathaysia.

We provide a re-examination and re-interpretation of the folds in Hunan and adjacent areas. Fold orientations were analysed from provincial scale geology maps (Bureau of Geology and Mineral Resources of Hunan Province, 1988) and other published sources (e.g. Wang et al., 2005b; Li et al., 2016; Chu et al., 2012a) and are summarised in Fig. 6. Overall, there is one fold set that is convex westwards, towards the interior of the SCB. Collectively, these folds are concentric, with a decreasing arc length in folds developed in the east. More than ten anticline/syncline pairs of this set are present east of the Precambrian outcrops in the Xuefengshan Belt. Individual folds are more than 50 km in length. The folds in this set are relatively high amplitude, short wavelength structures, with wavelengths of 10–20 km, down to kilometre scale folds and much smaller, parasitic structures (Wang et al., 2005b). Amplitudes are typically on a scale which involves either the Neoproterozoic to Carboniferous stratigraphy, or the Devonian to Triassic successions, depending on the relationship with the second fold set. Some anticlines are breached by thrust faults, which are parallel to the fold traces. The majority of the folds are not visibly faulted in this way at present exposure levels. The structures of the other fold set consist of longer wavelength regions (~100 km) where either Neoproterozoic-cored anticlines or Triassic-cored synclines are concentrated. There are at least nine of these broad zones in all,

consisting of both anticlinal and synclinal domains (Fig. 6). The combination of the two fold set axes resembles a wheel and spokes in map view. The “spokes”, i.e., the axes of the longer wavelength fold set, are radial in map view and converge at $\sim 27^\circ$ N 114° E, although the structure in this area is obscured by Cretaceous rift basin strata. The two fold sets have no consistent overprinting relationships; locally one set or the other appears to be older (as noted in Li et al., 2021, their Fig. 6b). We conclude that the folds developed more or less synchronously, following Li et al. (2021).

Timing of deformation is constrained by the regional stratigraphy to be roughly Late Triassic to Late Jurassic (Fig. 4). Middle Triassic strata are deformed and exposed in the syncline cores. Upper Triassic strata are rare, but overlie folds unconformably, albeit with some tilting and folding themselves, indicating later deformation. Lower and Middle Jurassic clastic strata are preserved in scattered outliers, and are also faulted and folded. Lower Cretaceous strata were deposited in rift basins, which trend NE-SW and postdate the folding.

Chu and Lin (2018) described deformation fabrics in Neoproterozoic conglomerates within the Xuefengshan Belt, indicating an arcuate pattern to the strain trajectories; this deformation is consistent with the kinematics indicated by the concentric folds within the Eastern Yangtze Fold Zone. Chu and Lin (2018) considered the deformation within the conglomerates to be 245–225 Ma in age, i.e., mainly Middle Triassic. If correct, these ages indicate slightly earlier deformation in the Xuefengshan Belt than in both the zones to the west and east.

Both I- and S-type granites intruded into the Eastern Yangtze Fold Zone (Wang et al., 2007a; Tang et al., 2022), with a cluster of Late Triassic ages at ~ 225 –217 Ma (Chu et al., 2012c). These granites are mapped as cross-cutting folds, and are concentrated along the anticlinal zones of the radial fold set. They are commonly inferred to have been emplaced in an extensional setting (e.g. Gao et al., 2017), but there does not seem to be direct evidence for extension at this time. Late Jurassic (~ 150 Ma) compressional deformation is interpreted for the emplacement of the Dayunshan (Mufushan) pluton (Fig. 6) at the northern side of the superposed fold region (Ji et al., 2018).

Our interpretation of the two fold sets is that the concentric set records the main compressional deformation arising from the Paleo-Pacific subduction zone margin to the east of the SCB. This set passes outwards to the structures of the Xuefengshan Belt and the East Sichuan fold-and-thrust belt. All of these belts are consistent with a folds and thrusts at the margins of a developing orogenic plateau in the SCB, growing outwards over time and “frozen” at the eastern margin of the Sichuan Basin. The radial folds are more unusual structures in an orogenic belt. In our model, the Late Triassic magmatism that post-dated folding took place within an orogenic plateau that was undergoing little active strain at the time, but heating as a result of the previous crustal thickening and the continued subduction from the Paleo-Pacific subduction zone to the east. We develop these ideas for the interactions of deformation and magmatism in the Discussion section.

4.3. Compressional deformation and metamorphism, east of the Jiangshan-Shaoxing Fault

Mesozoic deformation to the east of the Jiangshan-Shaoxing Fault is less well-understood than to its west, partly because of concealment or overprinting by Jurassic-Cretaceous plutons and volcanic rocks, especially east of the Zhenghe-Dapu Fault (e.g. Cao et al., 2021). Structural vergence in folded and thrust regions is variable within the eastern SCB (Figs. 3 and 5). Chen (1999) recorded large scale thrusting towards the ESE in Fujian Province, with shortening estimated on the order of 40%. The Heyuan-Guangfeng Fault appears to be a major structure with this slip sense (Fig. 3) but there are few specific details known. Other studies have reported the opposite sense of transport in different areas, e.g. the Yong'an Basin (Li et al., 2021) and on both sides of the Zhenghe-Dapu Fault (Zhou et al., 1996). Wang et al. (2007a) and Li et al. (2017b) interpreted Late Permian to Middle Triassic, northwestwards-directed

thrusting in the Shiwandashan and Yunkaidashan regions, at the southern side of the SCB (Fig. 3).

Basement is involved in some of these thrust systems, but the relationships to Permian-Triassic metamorphism in the same regions is not well-understood. Permian-Triassic ages for metamorphism are reported from areas previously known as Paleozoic or even Precambrian basement exposures, specifically the Wuyishan, Baiyunshan and Yunkaidashan massifs (Fig. 3; Yang et al., 2010; Li et al., 2022b; Zhao et al., 2023). Middle Permian zircon, rutile and titanite U-Pb ages recorded from the Wuyishan were interpreted by Zhao et al. (2023) as evidence for metamorphism produced by the collisions at the northern and southern margins of the SCB. However, the general orientation of the metamorphic belts within the eastern SCB is NE-SW (Fig. 3), i.e. parallel to the Paleo-Pacific continental margin. It is therefore more likely that the metamorphism is a result of the Andean-type margin developed at this plate boundary since Permian times (Li and Li, 2007; Hu et al., 2015). The Badu complex within the northeastern Wuyishan contains Triassic eclogite and granulite facies metamorphic rocks, associated with peak metamorphism at ~ 251 –235 Ma and retrograde amphibolite metamorphism between ~ 235 and ~ 221 Ma (Fig. 4; Li et al., 2022b).

There is evidence that compressional deformation within the southeastern SCB continued from Triassic times, and covered most periods from the Early Jurassic to the early part of the Early Cretaceous (~ 135 Ma). Early-Middle Jurassic thrusting was intense on either side of the Jiangshan-Shaoxing Fault in Zhejiang Province (Suo et al., 2019). There was widespread compressional deformation within the southeastern SCB in the Late Jurassic, with a common stratigraphic gap and angular unconformity between Middle Jurassic and Early Cretaceous successions (Li and Li, 2015). Li et al. (2020b) described Late Jurassic thrusting along the southwestern section of the Zhenghe-Dapu Fault (Lianhuashan Fault Zone). Coastal regions of South China also underwent extensive Early Cretaceous compressional deformation, including NW-directed thrusting between ~ 130 and 105 Ma along the Changle-Nan'ao Fault (Li and Li, 2015; Wei et al., 2015). These events are distinctive for deforming and metamorphosing Middle and Late Jurassic granites, producing a suite of granite gneisses that do not have counterparts in the western part of the orogenic belt (Cui et al., 2013).

There are several NE-trending shear zones east of the Jiangshan-Shaoxing Fault (Figs. 3 and 5), but no clear picture as to whether sinistral and dextral faults operated at the same time in different regions, or whether there was reversal in the slip sense, parallel to the plate margin to the east. Different papers record either dextral or sinistral slip on sub-parallel, range parallel faults and shear zones, with overlapping Ar-Ar ages of syn-kinematic minerals (e.g. Wang et al., 2007b; Zhang and Cai, 2009; Xu et al., 2011; Shu et al., 2015; Li et al., 2017b; Cochelin et al., 2022; Huang et al., 2024).

In the south of the SCB, in the Yunkaidashan and Meizhou regions, Wang et al. (2021) reported two stage Triassic-Early Jurassic deformation, with top-to-the-north and dextral-oblique thrusting on $\sim$ WNW-trending structures at ~ 250 –225 Ma followed by NE-trending sinistral transpression at 230–190 Ma. Huang et al. (2024) found muscovite $^{40}\text{Ar}/^{39}\text{Ar}$ plateau ages of 249–246 Ma for granitic mylonites with sinistral shear sense along the NE-SW trending Rongxian shear zone, at the boundary between the Yunkaidashan and Shiwandashan regions. This result indicates that sinistral and dextral shear in the Yunkaidashan overlapped in time in the Early Triassic. The NE-SW-trending Hepu-Hetai dextral shear zone was active from 213 to 195 Ma, based on Ar-Ar muscovite ages (Zhang and Cai, 2009). Similarly, the Guangning-Bobai Fault on the north side of the Yunkai Massif was active with dextral slip in the Late Jurassic (193–187 Ma) (Cai, 2013). The Changle-Nan'ao Fault (Fig. 3) appears to have had a complex, polyphase history of oblique slip between the Jurassic and Cretaceous (Shi and Zhang, 2010; Xu et al., 2017), involving Early-Middle Jurassic dextral thrusting, Late Jurassic sinistral thrusting, and Early Cretaceous dextral extension. The coastal strip east of the Changle-Nan'ao Fault is known as the Pingtan-Dongshan metamorphic belt, where pre-Silurian schists and

migmatitic granitoids were thrust obliquely (sinistral) to the northwest across the Changle-Nan'ao Fault (Chen et al., 2002). Further northeast, Li et al. (2017b) reported activity from 245 to 228 Ma on NE-SW dextral faults in the east Wuyishan and Chencai regions of NE Cathaysia. Shi et al. (2015) found ages of ~230 Ma for sinistral NE-SW trending shear on the Jiangshan-Shaoxing and Zhenghe-Dapu faults. We provide an explanation for these apparently contradictory data in the Discussion section.

4.4. Extensional deformation across the SCB

Triassic and/or Jurassic extension is commonly claimed across South China (e.g. Jiang et al., 2009; Wang and Shu, 2012; Liu et al., 2020), but this interpretation relies heavily on inference from the within-plate signature of basalts or the presence of A-type granites. Structural evidence for extension is very sparse for these periods: there are no regional sets of rift basins and metamorphic core complexes of Triassic-Jurassic age, of the kind prevalent in the Cretaceous (Figs. 3 and 4). For this reason, we question tectonic models which involve major Triassic-Jurassic extension, until and unless clear evidence becomes available. There are very localised and rare examples of Late Triassic extension, notably the Pingxiang Basin, Jiangxi, and the Quzhou region of Zhejiang (Shu et al., 2009). Similarly, there are rare examples of Early-Middle Jurassic extension, notably the Dongkeng rift basin in southern Jiangxi (Shu et al., 2009; Wang and Shu, 2012), located at the eastern end of the Nanling Belt of bimodal and within-plate volcanism (Fig. 3).

In contrast, there was widespread Early Cretaceous extension across South China, which was coincident with extension across the NCB and the CAO to the north (Figs. 3 to 5). Rifts within South China were commonly oriented NE-SW, indicating NW-SE extension (Li et al., 2020b). These basins are filled with non-marine clastic sedimentary rocks, typically red beds.

Low angle extensional detachments and exhumed domes are present in several places, notably the Dayunshan (Mufushan), Hengshan, Hongzhen, Lushan, Wugongshan and Yuechengling domes (Lin et al., 2000; Li et al., 2013, 2014a, 2014b, 2014c; Chu et al., 2024). Geochronology and thermochronology studies of the sheared rocks associated with these domes reveal a pattern of deformation beginning within the Early Cretaceous with a second, Late Cretaceous, pulse of exhumation in most examples (Chu et al., 2024). Stretching lineations associated with the extensional shear trend WNW-ESE or northwest-southeast (Li et al., 2023a). U-Pb ages of metamorphic zircons and Ar-Ar ages of synkinematic minerals reveal exhumation ages as summarised in Table 1.

The stratigraphy in rift basins provides evidence for the timing of regional extension. The timing of initial extension varies in age from the Early Cretaceous (e.g., Hengyang and Yuanma basins, Li et al., 2012b)

(Fig. 6) to the Late Cretaceous (e.g., Enshi Basin, Zhang et al., 2025) (Fig. 4). There is consistency between the timing of extension indicated by the syn-rift stratigraphy (albeit imprecise) and the constraints provided by Ar-Ar ages on exhumed rocks in metamorphic core complexes. Thermochronology data also record both Early and Late Cretaceous exhumation across South China (Wu et al., 2023), consistent with the structural and stratigraphic records of both Early and Late Cretaceous rifting. Based on stratigraphic constraints, there is a general younging in the age of initial extension, outwards from the interior of the SCB westwards towards the Sichuan Basin to the west, the Lower Yangtze River Belt to the northeast (Xu et al., 2021), and offshore in the East China Sea (Zhu et al., 2019). Overall, extension affected the SCB to the east of the Yuanma and Jiangnan basins (Fig. 3). Western rifts lack volcanic rocks, but these become more prevalent eastwards (Chen et al., 2005; Li et al., 2023a), dominated by tuffs and rhyolites (Liu et al., 2012a). Overall sections are several kilometres in thickness. Large areas of the coastal provinces contain Cretaceous volcanic rocks, for which the structural setting is unclear: they are mapped as blanketing the underlying geology across much of Fujian and Zhejiang provinces (e.g., Bureau of Geology and Mineral Resources of Fujian Province, 1985), but information is sparse on local fault controls (if any).

The two phases of Cretaceous extension were separated by a phase of compressional deformation, roughly at 120–110 Ma, marked by inversion of the rift basins and production of folds, thrusts and angular unconformities (Li and Li, 2015). The second phase of rifting was followed by a second, more minor phase of compressional deformation and inversion in the Late Cretaceous, beginning at ~85 Ma (Li et al., 2014a). Extension renewed for a third phase at the end of the Cretaceous and continued through the early part of the Cenozoic. This phase of extension was focussed on what is now the offshore region of the SCB, leading to the formation of basins on the continental margin such as the East China Sea Basin (Zhu et al., 2019). This third phase of extension is not recorded by thermochronology data from the inland metamorphic core complexes (Table 1), but was associated with uplift in the coastal Changle-Nan'ao Belt (Ding et al., 2023). In summary, Li et al. (2014a, 2014b, 2014c) interpreted six phases of Cretaceous deformation in South China, with related stress fields of: (1) earliest Cretaceous (147–137 Ma) E–W compression; (2) Early Cretaceous (136–118 Ma) NW–SE extension; (3) subsequent NW–SE transpression (117–108 Ma); (4) Middle–Late Cretaceous (107–86 Ma) WNW–ESE extension; (5) WNW–ESE compression (85–? Ma); and (6) latest Cretaceous N–S extension.

5. Distribution and composition of Permian-Mesozoic magmatism

5.1. Overall magmatic evolution

South China contains a huge amount of Mesozoic magmatic rocks, estimated by Zhou et al. (2006) as presently covering ~220,000 km² in area (Fig. 7). These are predominantly plutons inland, with large areas of Cretaceous volcanic rocks near the coast (Figs. 7 and 8). Magma compositions are predominantly felsic, and there are representatives of I-, S- and A-type granites across most time periods and regions (Wang et al., 2013). There does not seem to be a consistent and overall trend in compositions: different chemistries are commonly found in close proximity, and intruded at approximately the same time (e.g. Wang et al., 2007a). Within this framework it is possible to pick out details of more local variations, especially now that the coverage of ages and compositions is so comprehensive (Fig. 9). The volume of magmatism rose through the Late Permian and Early-Middle Triassic to reach a peak in the Late Triassic (~225 Ma; Jiang et al., 2015) (Fig. 9). An Early Jurassic lull at ~200 Ma was followed by peaks in productivity in the Late Jurassic (~160 Ma) and Early Cretaceous (~135 Ma) (Li et al., 2021). Another major lull at ~110 Ma was followed by a rise in activity peaking at ~100 Ma (Figs. 8 and 9).

Table 1

Summary of deformation (exhumation) ages of Cretaceous extensional complexes in the SCB. The Lianhuashan deformation is unusual in being solely Late Cretaceous in age (Li et al., 2020b). The early phase of deformation at Yuechengling is associated with high angle normal faulting, and the later phase with detachment faulting (Chu et al., 2019).

Location	Age (Ma)	Dating method	Reference
Dayunshan	132–95	Monazite U–Th–Pb; ⁴⁰ Ar/ ³⁹ Ar	Ji et al. (2018)
Hengshan	136–97	⁴⁰ Ar/ ³⁹ Ar; zircon U–Pb	Li et al. (2013)
Hongzhen	129–126	⁴⁰ Ar/ ³⁹ Ar	Zhu et al. (2010)
Lianhuashan (Zhenghe-Dapu)	100–96	⁴⁰ Ar/ ³⁹ Ar	Li et al. (2020b)
Lushan	140–114	⁴⁰ Ar/ ³⁹ Ar	Yang et al. (2022)
Wugongshan	132	⁴⁰ Ar/ ³⁹ Ar	Faure et al. (1996); Shu et al. (1998)
Yuechengling	140–120; 99–87	⁴⁰ Ar/ ³⁹ Ar	Chu et al. (2019)

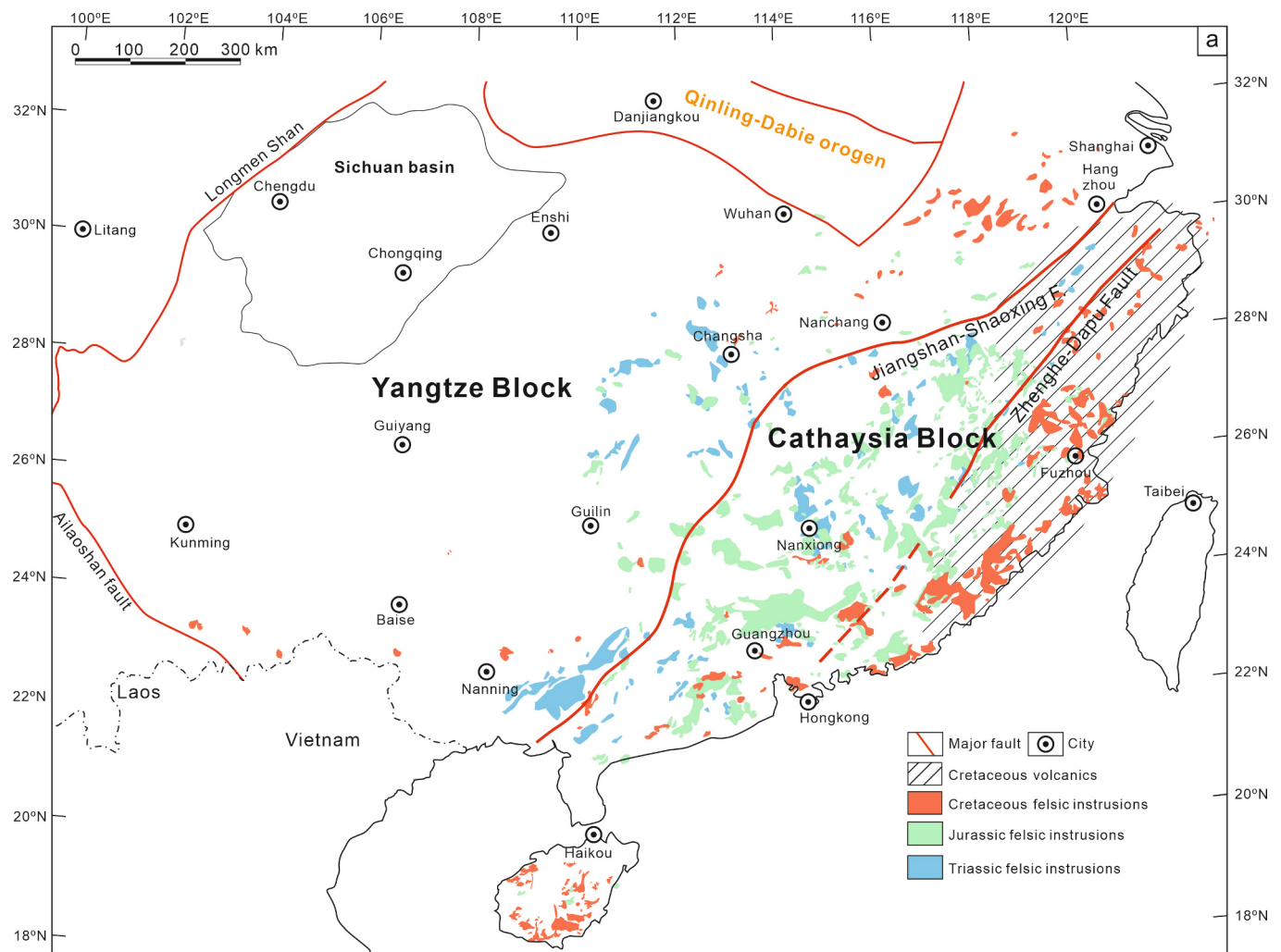


Fig. 7. Mesozoic intrusions and volcanic rocks of the SCB. Modified from Hu and Zhou (2012), Deng et al. (2017).

Permian igneous centres are sparse, but their presence indicates that Paleo-Pacific subduction had begun by this time (Li and Li, 2007). This conclusion is reinforced by the record of Permian detrital zircons in sedimentary rocks from South China, indicating the presence of an arc in the east, in the region of the modern coastline (Hu et al., 2015). There was a well-established magmatic zone along South China by 240 Ma, i. e., Early Triassic times (Wang et al., 2013; Gao et al., 2017; Cai et al., 2017) (Fig. 9). All of I-, S- and A-type granites are present in the Triassic (Wang et al., 2007a; Gao et al., 2017) (Fig. 10). There are no clear trends or patterns in composition except for a concentration of the A-type magmatism in the east and south. A-type centres are located within and adjacent to the Wuyishan (Cai et al., 2017), and form a vaguely NE-SW trending belt (Fig. 10). Middle Triassic felsic volcanics with A-type chemistry are present in the Youjiang Basin, on the south side of the SCB (Gan et al., 2021), but volcanic rocks are rare by comparison with later periods, especially the Cretaceous. Most Triassic granites across the SCB have signatures of reworked Proterozoic basement (e.g., Gao et al., 2017; Cai et al., 2015; Song et al., 2016) (Fig. 12), with $\epsilon\text{Nd}(t)$ commonly < -10 . Gao et al. (2017) summarised high $^{87}\text{Sr}/^{86}\text{Sr}_i$ ratios from 0.7101 to 0.7325, $\epsilon\text{Nd}(t)$ values from -11.3 to -6.4 , with two-stage Nd model ages in the range 1.7 to 2.0 Ga.

Late Triassic plutons are found in Hunan Province and adjacent areas (Fig. 6), within the Eastern Yangtze Fold Zone and the Xuefengshan (Chu et al., 2012c; Gao et al., 2017). S- and I-type plutons overlap in ages within this region (Wang et al., 2005a, 2005b, 2005c; Wang et al., 2007a, 2007b) (Fig. 11), which represents the westernmost extent of

Mesozoic magmatism within the SCB (Xi et al., 2025). Rock types include biotite- and hornblende-bearing I-type granite (Tang et al., 2022). There appears to be a spatial shift over time (Figs. 9 and 11); younger Triassic magmatism occurred further northwest (Gao et al., 2017). This shift, or the lack of a shift, has been debated since the groundbreaking proposal by Li and Li (2007) that magmatism migrated westwards across the SCB in the Triassic, focussed in a narrow zone at any given time interval. This migration model was challenged on the basis of a wider spread of ages, as more data became available (Wang et al., 2013). But, the reported Early and Middle Triassic ages for plutons in western Hunan (Wang et al., 2007a) are not supported by the numerous analyses which have been carried out in the last 20 years (e.g., Fu et al., 2015) (Fig. 11). It now seems that magmatism reached its western limit in the SCB by ~ 230 Ma (Chu et al., 2012c), which indicates a western migration over time (Fig. 8), following the start of arc magmatism at ~ 280 Ma, but not reaching its limit by as late as ~ 200 Ma as envisaged by Li and Li (2007).

There was an Early Jurassic lull in magmatism, inland (Zhou et al., 2006; Liu et al., 2020; Bai et al., 2025) (Figs. 8 and 9). This lull took place at the same time as a switch to OIB-like basaltic magmatism and A-type granitic plutons in the Nanling Belt (Ningyuan-Fankeng Igneous Zone (NFIZ)) and a pulse of magmatism in the East China Sea (Wang et al., 2003; Gan et al., 2017; Li et al., 2018a, 2018b; Kong et al., 2018; Xu et al., 2023; Zhu et al., 2025). Therefore the Early Jurassic was not a time of a switch-off magmatism, but rather a re-focus to i) arc magmatism in areas now offshore in the East China Sea; ii) within-plate

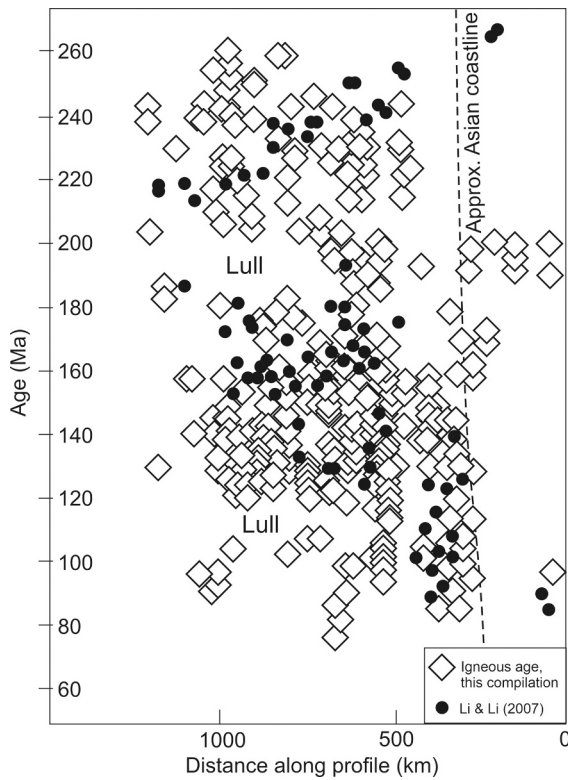


Fig. 8. Space time distribution of Permian and Mesozoic magmatism across the South China Block. Data are projected onto the section line shown in Fig. 3. Data used in the Li and Li (2007) study are highlighted for comparison. $N = 362$. Data points from Li and Li (2015), Xu et al. (2017), Li et al. (2021), Xu et al. (2023) and Zhu et al. (2025). Samples from the southwest margin of the SCB (near the Ailaoshan Fault) are not included.

signatures and an WNW-ESE alignment in the Nanling Belt. The tempo of magmatism picked up in the Middle Jurassic (Fig. 9). Early-Middle Jurassic magmatism in the Nanling Belt ranged from alkali, OIB-like basalts to A-type granites (Ye et al., 2013; Song et al., 2017), distributed in an east-west trending zone. These rocks are very variable in composition. This Early-Middle Jurassic magmatism is commonly attributed to a phase of extension (e.g., Zhou et al., 2006; Wang et al., 2003; Ye et al., 2013; Li et al., 2018b), but independent evidence of extension is lacking. The same issue applies to Late Jurassic magmatism: an extensional tectonic setting is commonly claimed for igneous complexes of this age, but this interpretation is not based on any independent structural evidence (e.g. Bai et al., 2025). In eastern Fujian, Late Jurassic andesites, dacites and rhyolites were derived from subduction-modified mantle during compressional deformation (Li et al., 2009).

The Late Jurassic saw a renewal of magmatism across the Eastern Yangtze Fold Zone (Fig. 6), although there are individual intrusions in this region that date to ~ 185 Ma, i.e. within the Early Jurassic (Fig. 11). Late Jurassic plutons include I-, S- and A-type granites (Jiang et al., 2009; Kong et al., 2018; Liang et al., 2023; Wan et al., 2024). Intrusions are commonly focussed within or adjacent to Triassic plutons, which were intruded 50–80 million years earlier. These Late Jurassic plutons are more widespread and over a wider area than the Early Jurassic (Fig. 6). Derivation was largely from crustal melting of Proterozoic source rocks (Song et al., 2016; Li et al., 2021; Wan et al., 2024); plutons typically have $\epsilon\text{Nd}(t)$ in the range of -10 to -6 , i.e., similar to Triassic granitoids. Late Jurassic mafic dykes in coastal regions of eastern Guangdong display arc-like chemistry, indicating derivation from subduction-modified lithospheric mantle (Yan et al., 2021).

There was an intensification of Cretaceous magmatism in the coastal regions of Zhejiang and Fujian provinces, and an overall shift northeast

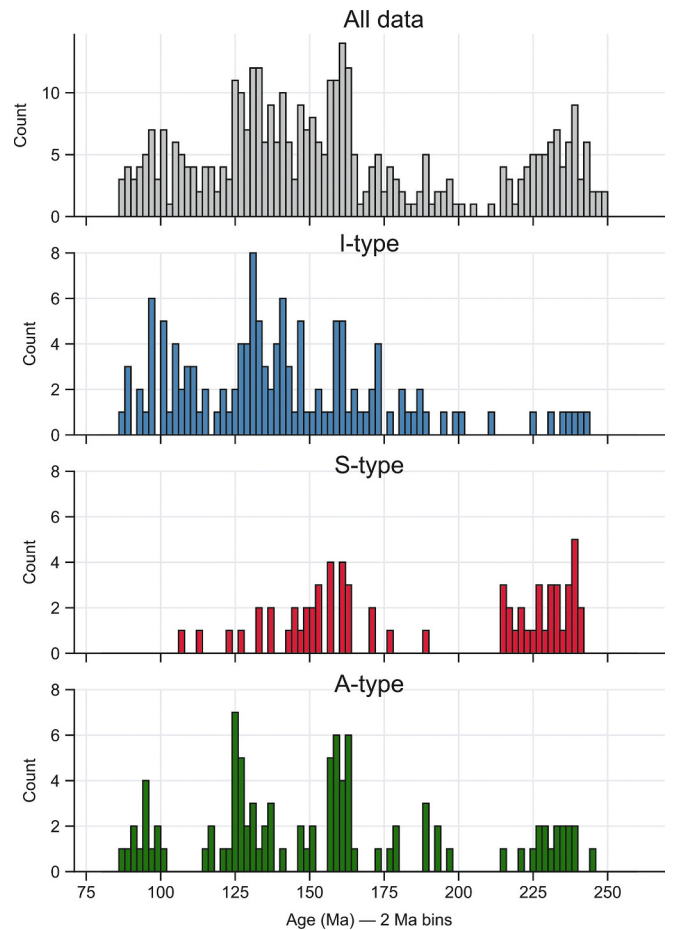


Fig. 9. Age data for Mesozoic magmatism of the SCB. From Li et al. (2021).

from Jurassic centers (Cui et al., 2013; Cao et al., 2021) (Figs. 8 and 9). Magmatic rocks are largely in the ~ 200 km wide zone between the Zhenghe-Dapu Fault and the Changle-Nan'ao Fault, known by various names such as the Southeast China Coastal Complex (Shu et al., 2015) or the Southeast Coast Magmatic Belt (Chen et al., 2008). Most of these rocks are granitic with subduction chemistry (e.g. Yu et al., 2001; Liu et al., 2012b; Li et al., 2021), but basic and intermediate compositions are also present (Chen et al., 2005). Both intrusive and extensive volcanic rocks occur, the latter in accumulations several km thick in units such as the Shimaoshan Group (Li et al., 2018c). Pyroclastic deposits are common (Liu et al., 2014). Li et al. (2014c) showed there was a mantle contribution to the granitic magmas, on the basis of higher $\epsilon\text{Nd}(t)$ values in the granitoids than the SCB metamorphic basement: generally -6 to -2.5 for the granites and ~ -12 for the basement (Fig. 12). Early Cretaceous magmatism diminished to produce a second regional lull at around 110 Ma (Figs. 8 and 9). Like the Early Jurassic lull, the coastal and offshore regions of the SCB do not record a drop-off in magmatism (Fig. 8); on the contrary, recent work shows that magmatism flared up in the East China Sea at this time (Hu et al., 2025).

The Pingtan-Dongshan metamorphic belt along the coast contains calc-alkaline, I-type, granitic plutons of various ages from 187 to 100 Ma, derived from Neoproterozoic and older basement (Liu et al., 2012b). Subduction-modified mantle sources produced Early Cretaceous basaltic tholeiites in Fujian Province (Li et al., 2009). The coastal province also contains Late Cretaceous basalt lavas formed between 101 and 76 Ma, with geochemical signatures indicating derivation from subduction-modified mantle (Chen et al., 2008; Li et al., 2017a, 2017b), e.g. La/Nb ratios >2 . Heat and magma from this mafic magmatism may have contributed to lower crustal melting which produced the granites in the same area (Jiang et al., 2006; Chen et al., 2017).

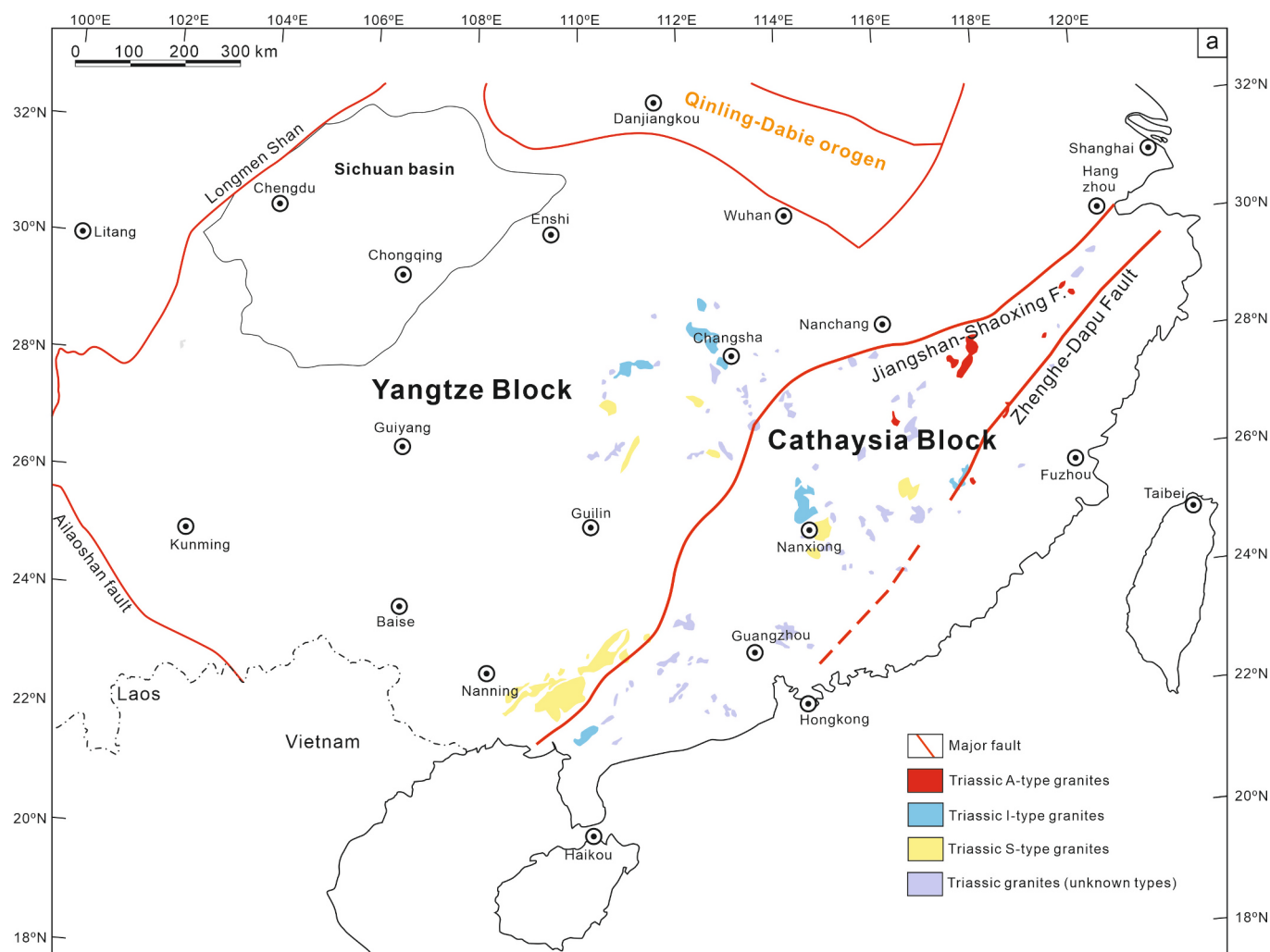


Fig. 10. Triassic granite distribution in the SCB. From Gan et al. (2017).

Within-plate signatures have been identified in intrusive and volcanic mafic rocks in the interior of the SCB, distinguished by positive Nb-Ta spikes in primitive mantle-normalized spider diagrams and positive $\epsilon\text{Nd}(t)$ values (Chen et al., 2005; Qi et al., 2016; Wang and Yan, 2021) (Fig. 12). These rocks are commonly associated with arc-like rocks in the same areas at the same time (e.g., Wang and Yan, 2021), although there is an overall pattern of within-plate signatures west of the Wuyishan and Baiyunshan massifs and arc-like chemistries to the east (Chen et al., 2005).

Recent dating has also revealed widespread but scattered Cretaceous magmatism in the interior of the continent to the west (e.g., Su et al., 2018; Wang and Yan, 2021), and in the southwest of the SCB in Yunnan Province (Cheng et al., 2016). Regionally, Cretaceous magmatism was not focussed in a narrow band for each time interval, migrating eastwards across the SCB, as originally envisaged by Li and Li (2007). The Cretaceous flare-up in coastal provinces was contemporary with continued but sporadic magmatism in the continental interior.

Early Cretaceous (147–136 Ma) granitoids are commonly sheared and include migmatite zones, but younger intrusive rocks are undeformed (Cui et al., 2013). Wei et al. (2023a, 2023b) described granites intruded between 130 and 105 Ma as emplaced during a NW-SE shortening regime, which they attributed to collision of the eastern margin of the SCB with the Dangerous Grounds-West Philippines Block. The timing of this compressional-setting magmatism is important, as it overlaps with the Early Cretaceous rifting and metamorphic core complex formation in the interior of the SCB.

Whereas Cretaceous dykes are relatively abundant and commonly trend NE-SW over large distances of the SCB (Chen et al., 2021), earlier Mesozoic dykes are rarer, have a variety of orientations, and more commonly occur as swarms associated with individual plutons (e.g., Wang et al., 2015a; Zhang et al., 2018) – even if the dykes are 10s of millions of years after the previous intrusion in the same area. Given that dyke orientation relates to the regional stress field, these patterns are consistent with the NW-SE extension in the Cretaceous, but lower and less consistent differential stress orientations earlier in the Mesozoic.

In many areas there is a broad overlap between the different types of granitic magmatism, but no discernible progression in chemistry over time (e.g., Kong et al., 2018). There are some indications of an age progression from I- or S-type to A-type (oldest to youngest) in individual cases. Examples include the Dengfuxian and Xitian plutons, which were originally contiguous but are now separated by a Cretaceous rift basin (Liang et al., 2023) (Fig. 6): these both involve a Late Triassic I-type pluton (226–221 Ma), intruded by a Late Jurassic A-type pluton (152–151 Ma). Similar age relationships are found between the Late Triassic S-type Tashan pluton (224 Ma; Song et al., 2017) and the adjacent A-type Dayishan pluton (153 Ma; Lu et al., 2021).

Gan et al. (2017) summarised the Mesozoic A-type magmatism across the southeastern SCB as falling into three age ranges: 229–215 Ma, 197–152 Ma, and 135–92 Ma. This division seems to be robust, although the age range can be extended back at least as far as the ~233 Ma Miantuwo and Pingtian plutons of northern Guangdong and southern Jiangxi provinces (Sun et al., 2017). This age distribution means that

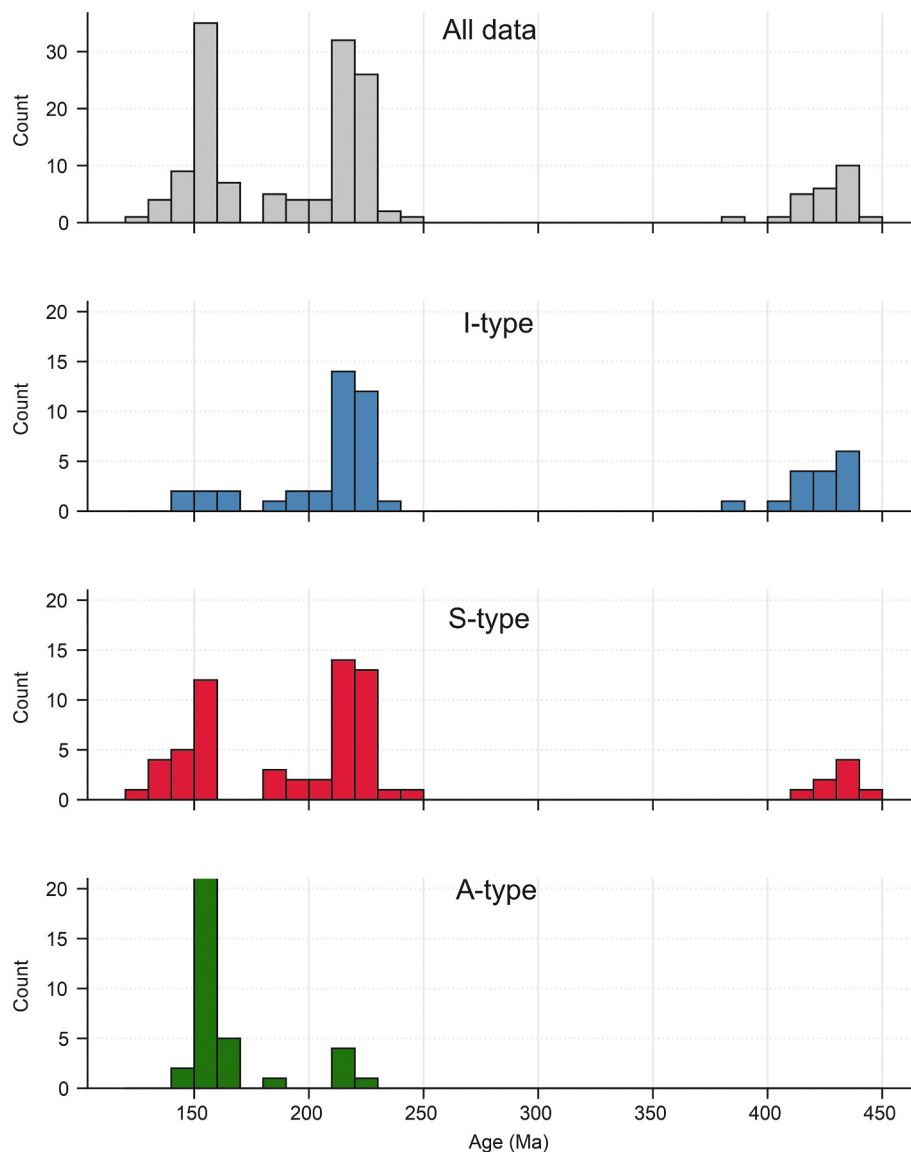


Fig. 11. Age data for plutons shown on Fig. 6, Hunan Province and adjacent areas. Data sources for pluton ages listed in Table S1.

A-type magmatism did not appear until ~50 million years after the start of arc magmatism in the SCB.

Source characteristics are reflected in $\epsilon\text{Nd}(t)$ compositions (Fig. 12), which show a considerable range from 5 to -15 at any part of the Triassic to Cretaceous time interval. Positive $\epsilon\text{Nd}(t)$ values are typical of OIB-like Jurassic and Cretaceous volcanic rocks and dykes from the Yangtze Block, i.e., the interior of the Mesozoic SCB. Similar $\epsilon\text{Nd}(t)$ values are also found in Triassic basalts, andesites and adakites from Borneo and the southern South China Sea (Burton-Johnson et al., 2020; Wei et al., 2022; Wang et al., 2025); these studies indicate depleted mantle sources for rocks of this age along the southeast margin of the SCB, which is not typically exposed or sampled further north. The Early-Middle Jurassic rocks of the Nanling Belt are represented in the positive $\epsilon\text{Nd}(t)$ datapoints, but are not distinctive. Highly negative $\epsilon\text{Nd}(t)$ values represent melts derived from Proterozoic basement. Rocks in the range of $\epsilon\text{Nd}(t) = 0$ to -5 are either directly derived from subduction-modified mantle or a mixture of such melts and basement melts.

5.2. Adakites

Adakitic magmatism has attracted great attention in orogenic belts worldwide, as its distinctive signatures of high Sr/Y and La/Yb ratios,

high Mg#, and high Na_2O and silica contents are understood to derive from specific tectonic regimes such as the melting of subducting oceanic crust or lower crustal melting in the roots of mountain belts (Castillo, 2012). Triassic adakites in the SCB are rare, although there are individual reports from marginal regions, such as the Yanba pluton at the southern side of the Qinling orogenic belt (Qin et al., 2010). Jurassic examples include Middle Jurassic (170 Ma) Dexing porphyries, which host large copper deposits (Zhang et al., 2021), and are interpreted to result from melting of Neoproterozoic subduction-modified lithosphere. The Late Jurassic (160 Ma) Tangquan pluton from central Fujian was interpreted by Wang et al. (2015b) as the result of melting Proterozoic lower continental crust at a depth of ~40 km. Cretaceous adakites are concentrated in the northeast of the SCB, in the Lower Yangtze River Belt and adjacent areas (Wang et al., 2012), interpreted as formed from melting thick lower crust during early stage extension at ~135 Ma. Adakites also occur in the adjacent eastern part of the Qinling-Dabie Shan orogen (e.g. Zhao et al., 2012).

5.3. Composite plutons

Many of the Mesozoic plutons in the SCB are composite intrusions, with repeated phases of activity. This is distinctly the case in Hunan

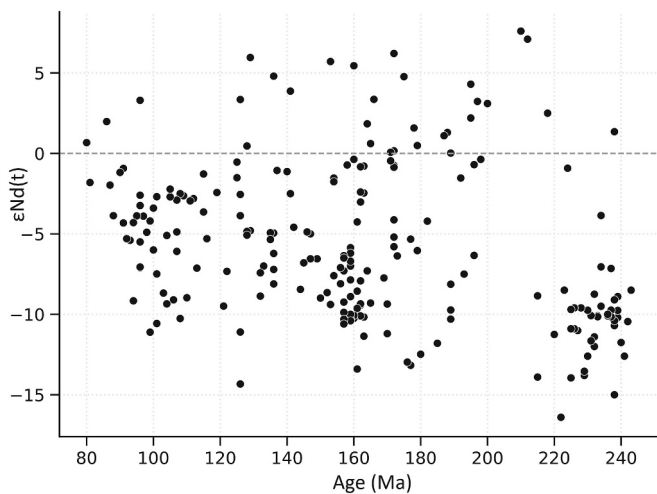


Fig. 12. $\epsilon\text{Nd}(t)$ for Mesozoic magmatic rocks of South China. Data from Li et al. (2021), with additional data for offshore regions and Cretaceous mafic rocks (Chen et al., 2005; Wang et al., 2005c; Wei et al., 2022). Note the shift towards less negative values over time.

Province, where several Mesozoic intrusions occur in the same locality as older plutons, of Early Paleozoic or Mesozoic ages (Ding et al., 2006; Wang et al., 2007a) (Fig. 6). One of the best-studied examples is the composite Baimashan pluton (Fig. 13), which was intruded into western Hunan in a series of distinct phases (e.g., Zhang et al., 2015a, 2015b; Yang et al., 2015). The Shuiche unit is end Silurian - Early Devonian, with published ages of 418–411 Ma (Tang et al., 2022; Chu et al., 2012c), and a north-south orientation. It cross-cuts folded Lower Paleozoic strata, which are themselves folded with NNE fold axes. The Mesozoic Gaoping pluton consists of the nested Xiaoshajiang, Longtan and Longcanwan units, which collectively have an ENE orientation, i.e.

roughly orthogonal to both the Shuiche unit and the local fold axes (Fig. 13). The Gaoping units are largely Late Triassic in age (Chu et al., 2012c; Fu et al., 2015), at 217–209 Ma, but older and younger ages are also recorded. Wang et al. (2007a, 2007b) recorded 241 ± 3 Ma from the Gaoping unit, but this age seems to be too old, in the light of the numerous other analyses (see discussion in Fu et al., 2015). Chen et al. (2007) produced an age of 176.7 ± 1.7 Ma for zircon rims in the Longtan unit, which is distinctly younger than any other published age from the pluton, but consistent with plutons intruded in the same region (Fig. 6). Whereas Baimashan illustrates the case of multiple pluton phases 10s and even 100 s of millions of years apart, there are also many examples of multiple nested intrusions where the intervals between pulses of magma are only a few million years apart, and close enough to consider all magmatism at the site as phases of the same centre. An example is the mid Cretaceous Jiahuashan body from the Lower Yangtze region (Wang et al., 2018b).

6. Mesozoic crustal thickness and paleoaltimetry

Sedimentary rocks provide a crude constraint on crustal thickness, in that marine depositional environments imply crustal thickness of ~ 35 km or less, and certainly not thickened crust. Locally emergent areas within the future Xuefengshan and Eastern Yangtze fold-and-thrust belts in the Late Permian were transgressed by carbonates in the Early Triassic (Shao et al., 2020; Song et al., 2016) (Fig. 14). Shallow-marine carbonate deposition continued across most of the SCB in the Middle Triassic (Tong and Liu, 2000). On this basis, near-average crustal thickness can be interpreted for most of the SCB until the Middle Triassic (Fig. 14). Within the Lower Yangtze River Belt and eastern Cathaysia, the Middle to Late Permian witnessed a transition to non-marine sedimentation as deposition took place adjacent to the growing arc along the eastern side of the SCB (Zhang et al., 2022b). By the Late Triassic shallow marine environments had shrunk in area to a curved fringe across the SCB, convex to the west (Pang et al., 2016; Shao et al., 2020).

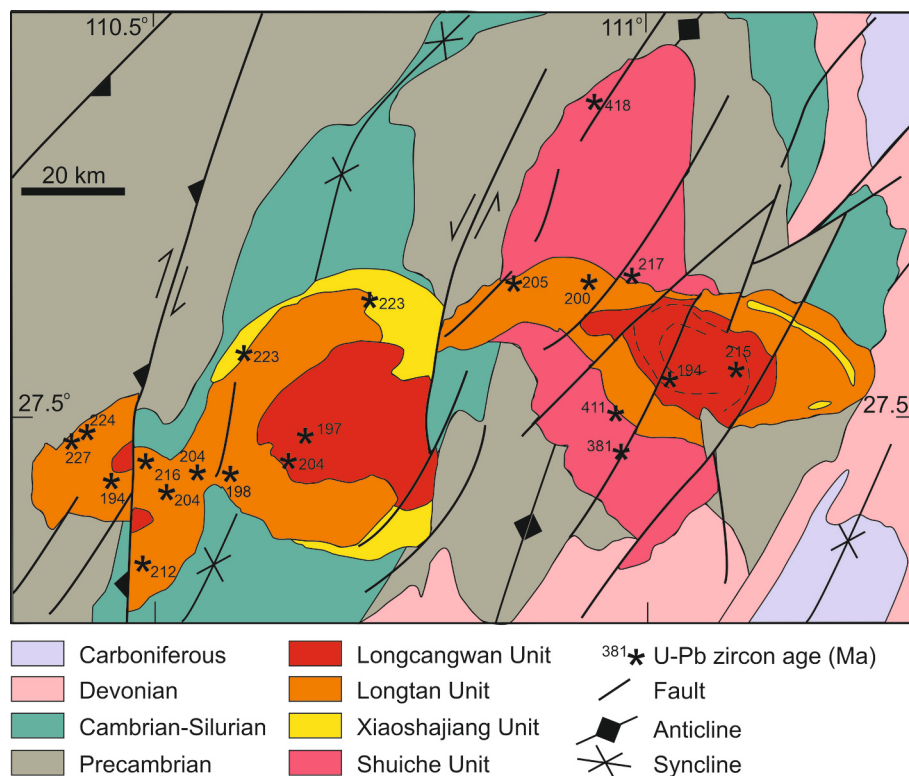


Fig. 13. Examples of composite plutons: the Baimashan intrusions of Hunan Province. Adapted from Chen et al. (2007), Zhang et al. (2015a, 2015b) and Tang et al. (2022). Location shown on Fig. 6.

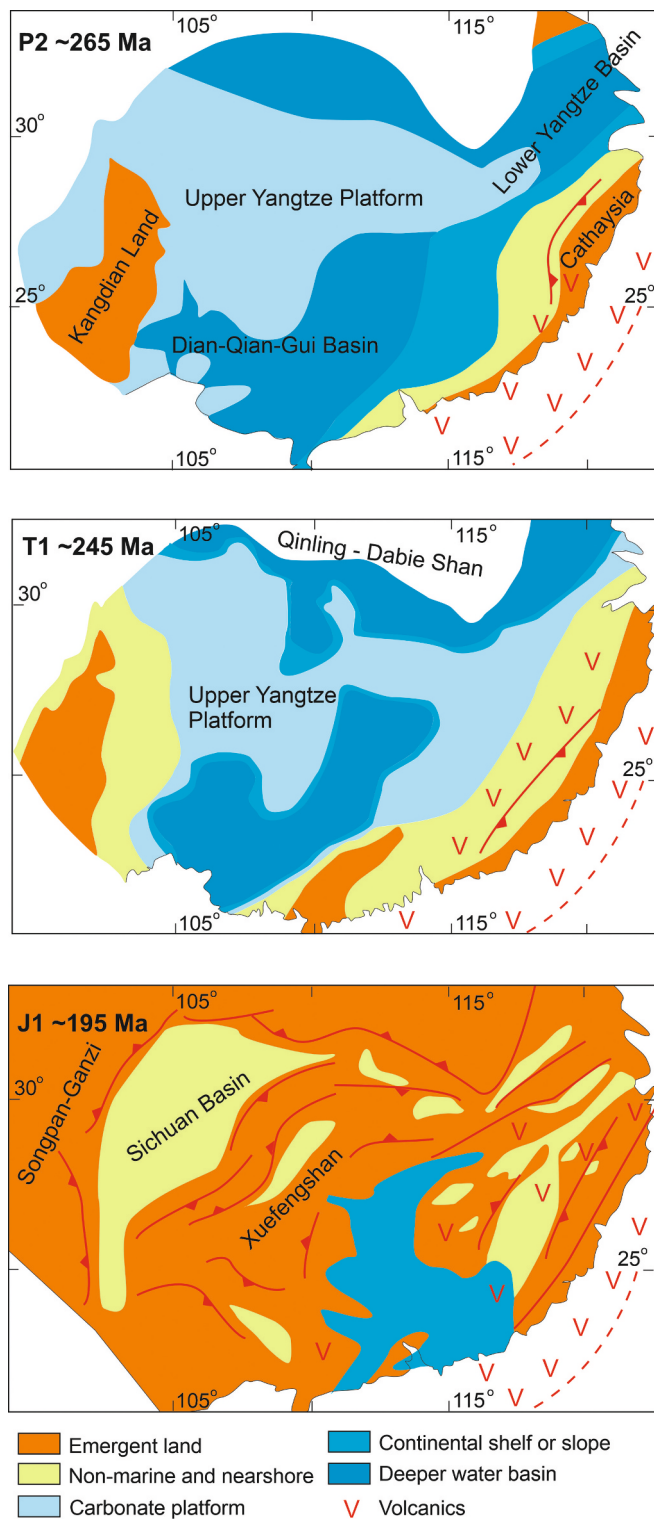


Fig. 14. Paleogeographic reconstructions for the SCB. a) Late Permian, ~265 Ma, derived from Zhang et al. (2022a, 2022b). b) Early Triassic, ~245 Ma, derived from Song et al. (2016). c) Early Jurassic, ~195 Ma, derived from Pang et al. (2014).

Late Triassic to Cretaceous magmatism across the SCB permits the use of geochemical proxies for crustal thickness, based on observed correlations between parameters such as Sr/Y ratio and La/Yb ratio and crustal thickness in modern orogens (Chapman et al., 2015; Hu et al., 2017). These approaches are in the early stages of being applied to the SCB (Li et al., 2024). Available results indicate crust of at least 50 km

thick by the Late Jurassic (~160 Ma), followed by thinning to under 30 km in the Early Cretaceous (~125 Ma) and renewed crustal thickening to ~50 km in the mid Cretaceous (~105 Ma) (Li et al., 2024). These estimates for crustal thickness are in line with the very rough estimate of ~45 km for the Late Triassic crustal thickness (Chu et al., 2020), which was derived by adding the present crustal thickness (35–40 km) to a representative value of regional exhumation since the peak of crustal thickening (5–10 km). Assuming standard relationships between crustal thickness and surface elevation apply, via isostasy, the regional elevation across much of South China would have been at least ~1.5–2 km above sea level between the Late Triassic and the Early Cretaceous.

7. Stratigraphy and paleogeographic reconstructions

Depositional environments have been used to reconstruct paleogeography across South China from the Permian through the Mesozoic (Pang et al., 2016; Zhang et al., 2022a). Previous studies are synthesised in Fig. 14. Middle Permian, Guadalupian, times saw a marine basin across much of the southwestern SCB, west of highlands in the present-day coastal region (Zhang et al., 2022b). This basin linked to the northeast to the Lower Yangtze Basin. Much of the interior of the SCB underwent carbonate deposition within the Upper Yangtze Platform. Conditions were similar in the Late Permian and Early Triassic (Dai et al., 2019; Shao et al., 2020). The Great Bank of Guizhou was an isolated carbonate platform from the Late Permian to Middle Triassic, overwhelmed by clastic turbidites in the Late Triassic (Lehrmann et al., 1998). This change is representative of a regional Late Triassic shift across the SCB, with destruction of the previous carbonate platform, and either an influx of clastic sediments or uplift (e.g. Kong et al., 2022). Upper Triassic to Middle Jurassic clastic sedimentary rocks are preserved in numerous small basins across the interior of the SCB (Shu et al., 2009), with no clear evidence as to the original basin configuration (Xu, 2023). More regional Upper Triassic and younger strata are preserved within the Sichuan, Xichang and Chuxiong basins, overlying the Yangtze Block (Fig. 14). These three basins were unified from Late Triassic to Early Cenozoic times (Deng et al., 2018), as the Paleo-Yangtze Basin. There is an unconformity between Upper Triassic continental clastics and underlying strata across most places in the SCB where the Triassic rocks are preserved (Jin et al., 2009). A notable exception is the Sichuan Basin, where the contact is a disconformity (Xu, 2023).

There are angular unconformities within the Jurassic and Cretaceous non-marine clastic successions of the eastern SCB, especially east of the Jiangshan-Shaoxing Fault. These features are linked to compressional deformation in the Jurassic and alternating phases of extensional and compressional deformation in the Cretaceous (Li and Li, 2015). Shallow marine conditions across parts of the southern SCB in the Early Jurassic produced an important stratigraphic unit (Pang et al., 2014; Fig. 14); these marine sedimentary rocks imply that compressional deformation and crustal thickening had not affected this area by this time. Surface uplift in this area must be a later event.

8. Plateau remnants

Extant plateaus on Earth are easy to identify and define through their combination of high elevations and low relief. This is an obstacle to identifying ancient orogenic plateaus, where these topographic features have not survived erosion and tectonic overprinting over millions of years. At first sight modern South China does not contain a topographic plateau, although much of the landscape is rugged, and even mountainous. Closer inspection of digital elevation data reveals several isolated low relief surfaces at elevations of ~1000 m–2000 m within South China, which we propose to be relicts of a much more extensive plateau across the region (Fig. 15a).

The Wu Shan is located in western Hubei Province, where folded and thrust strata of Neoproterozoic to Middle Jurassic age are truncated by an erosion surface at surface elevations of 2000 m (Fig. 15b). The surface

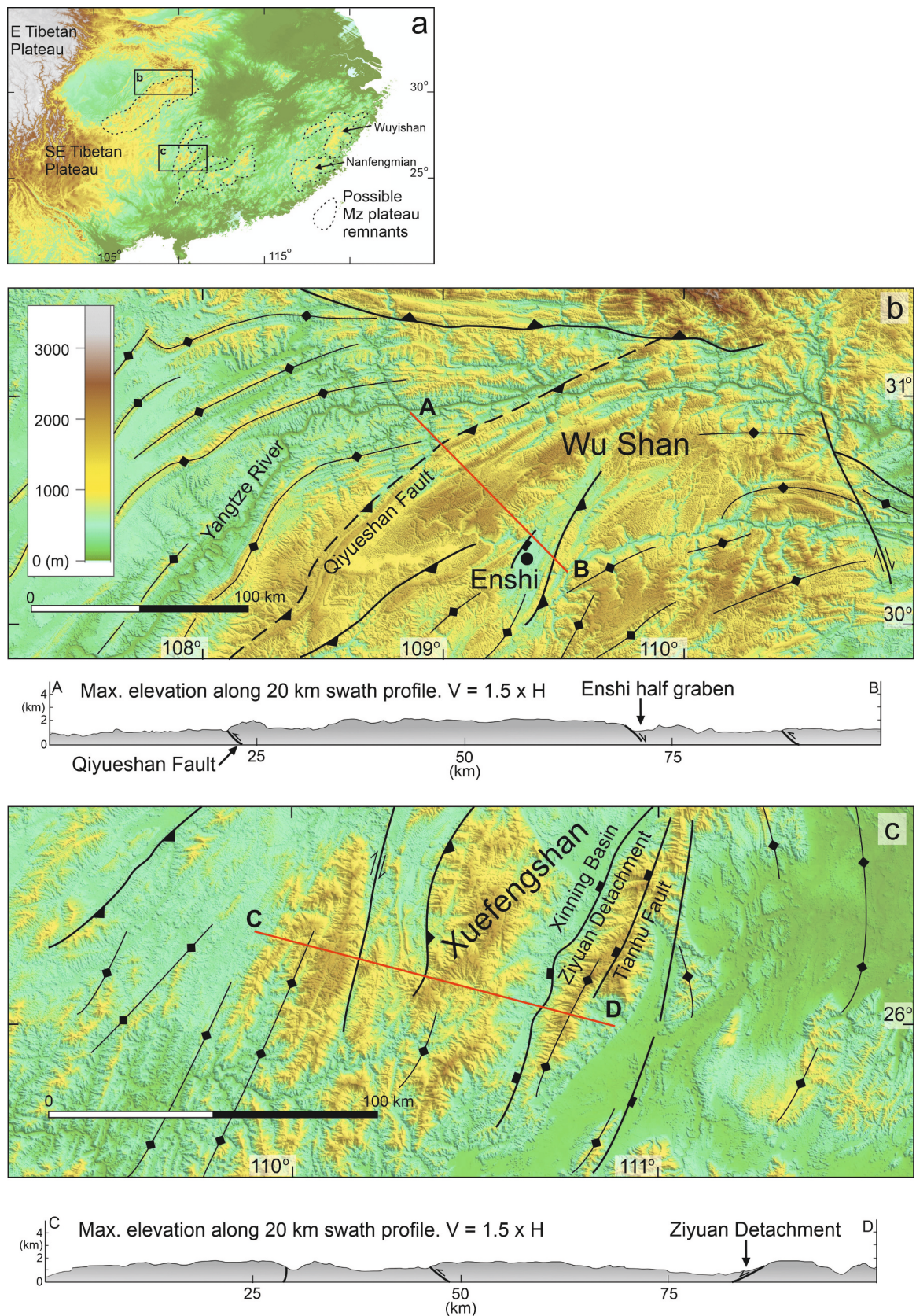


Fig. 15. Topographic analysis of plateau areas within South China. Data are derived from SRTM topography (Jarvis et al., 2008). a) Location map of regions with possible Mesozoic plateau remnants. b) topographic map and cross-section of the Wu Shan, where a plateau with a regional elevation of ~2000 m lies to the south of the Yangtze River. c) topographic map and cross-section of the southern Xuefengshan, where three separate massifs appear to be relicts of a wider plateau landscape.

is best expressed in regions of Lower Triassic carbonate outcrop, but it is developed across all folded strata, across an area of $\sim 20,000 \text{ km}^2$. The maximum age of the plateau surface is constrained by the folded Middle Jurassic strata it truncates. The minimum age is constrained by Upper Cretaceous clastics within a half-graben at Enshi (Zhang et al., 2025): this feature forms a topographic low, which is sunk into the plateau surface. The western margin of the Wu Shan plateau is formed by the Qiyueshan Fault. Regional topography slopes westwards towards the interior of the Sichuan Basin and there is no trace of the relict plateau surface west of the Wu Shan. The anticlinal crests of the fold-and-thrust belt west of the Qiyueshan Fault are coincident with topographic highs (Fig. 15b), indicating that relative relief has been preserved in this area since the Jurassic-Cretaceous formation of these folds. The Wu Shan appears to mark the limit of plateau growth in the Mesozoic. The anticlines west of the Qiyueshan Fault represent the fold-and-thrust belt that was not integrated into the orogenic plateau by the time compressional deformation ended.

The southern part of the Xuefengshan preserves a similar topography to the Wu Shan to its north (Fig. 15c): a regional low-relief surface at $\sim 1750 \text{ m}$, developed in a region that exposes deformed Precambrian basement, and Precambrian-Paleozoic strata (e.g., Chu et al., 2012a). The plateau is traceable within a region of three elongate topographic ridges. The plateau surface is disrupted by the topographic low of the Xinning Basin, adjacent to the Ziyuan Detachment (Fig. 15c). The slip on this detachment fault is dated at 100–85 Ma (Chu et al., 2019), although the stratigraphy of the basin fill has been reported as Lower Cretaceous (Wang et al., 2018b), and there are Early Cretaceous ages (140–120 Ma) for extensional slip on the nearby Tianhu Fault (Fig. 15c; Table 1; Chu et al., 2019). Therefore it appears that plateau development was at least pre-Late Cretaceous in age and may well be older. The plateau relict examples described in Fig. 15b and c are far inland, and at upstream sections of the regional drainage systems.

Eastern South China contains large areas of uplands, at surface

elevations of $>1000 \text{ m}$, with individual peaks above 2000 m . We have not identified plateau remnants as clear-cut as the three examples noted above, but there are regions where the highest elevations have distinctly low relief. The Nanfengmian area on the Hunan/Jiangxi borderlands is one example, where elevations are at $\sim 1000 \text{ m}$ for an area of $\sim 200 \times 100 \text{ km}$ (Fig. 15a). Another example is the Wuyishan, where relief on the regional scale ($>100 \text{ km}$) is comparable to the eastern Tibetan Plateau, albeit with elevations around 1000 m rather than the 4000 m present in eastern Tibet. While further work is needed to define the location, timing and correlations of these relict plateau surfaces, they provide important markers for the past existence of a regional topographic plateau across much of the SCB. The possible reduction in elevation of these surfaces since formation, by either Cretaceous extension or lower-crustal flow (e.g. McKenzie et al., 2000), means that they represent a lower bound on the possible elevation of such a plateau. Present-day elevations are indicative of crustal thickness of $45\text{--}50 \text{ km}$, consistent with geochemical estimates (Li et al., 2024).

9. Magmatic models

To further investigate the idea that crustal thickening and heat production was responsible for much of the Mesozoic felsic magmatism across South China, we have run one-dimensional numerical models of the type developed in Copley and Weller (2022) (Fig. 16). The presence of two pulses of magmatism does not in itself uniquely constrain the thermal models. We instead make use of independently-estimated parameters regarding the geology and evolution of the SCB, and show that these parameters result in an evolution of the temperature structure that is consistent with the observed magmatism. The model set-up includes an initial phase of crustal thickening for 30 Myr , followed by a 20 Myr period of no thickening to correspond to the Early Jurassic magmatic lull, and then a renewed phase of thickening for 30 Myr . Full parameters are given in the caption to Fig. 16, and the method is explained in detail

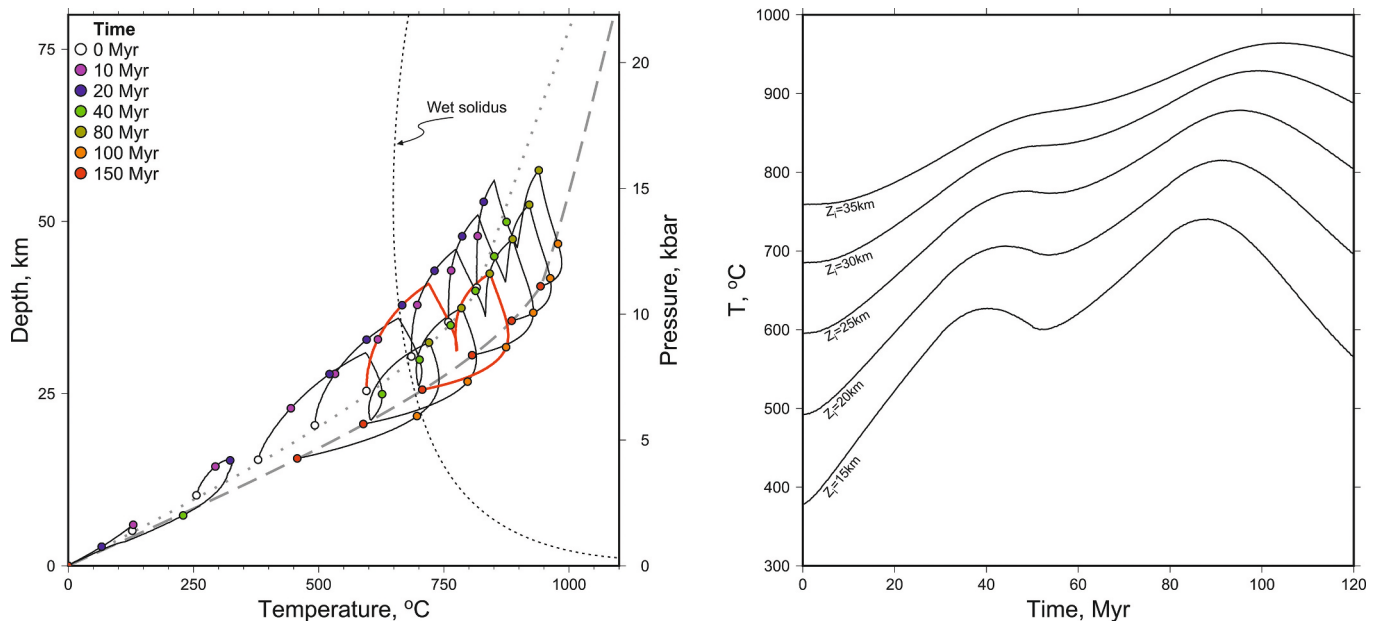


Fig. 16. a) Model result from thickening of initially 40 km thick crust, at a rate of 1 mm/year for 30 Myr , followed by a pause for 20 Myr , and then renewed crustal thickening at 1 mm/yr for another 30 Myr . For consistency with the geological observations, thickening occurs above a mid-crustal detachment horizon, located at an initial depth of 15 km . The initial lithosphere thickness is 150 km . The rate of crustal radiogenic heating is $1\text{e-}6 \text{ W/m}^3$, and the erosion coefficient is $1.5/\text{s}$ (as defined in Copley and Weller, 2022). There is no mantle heat production. The grey dotted and dashed lines show the initial geotherm and the geotherm after 150 Myr . The lines track rocks initially located at 5 km depth intervals from 5 to 40 km , with the deepest point representing the Moho. The colored circles indicate times since the start of the model run. One PT loop is highlighted in red for illustration. b) Temperature through time for various depth levels within the crust (labelled with the depth before thickening begins). Through most of the crust the temperature is constant, or slightly decreases, during the crustal thickening pause, but increases to the highest values attained during the second phase of thickening, $>80 \text{ Myr}$ after the model start. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

in Copley and Weller (2022). Results show peak temperatures are achieved ~ 100 Myr after the beginning of the model, and reach $\sim 900^\circ\text{C}$ for regions near the base of the crust (Fig. 16a). Imposing a pause in crustal thickening leads to a pause or even a reversal in temperature through most of the crust (Fig. 16b), lasting ~ 20 Myr. This finding is consistent with the magmatic lull in the SCB. We interpret these modeling results to show that Mesozoic crustal thickening across South China was capable of producing lower crustal temperatures above the solidus for a variety of protoliths, leading to production of I- and S-type granites and even higher temperature A-type granites. The latter would be favored at later stages of the tectonic evolution, during higher temperatures and after the extraction of other granite types from the lower crust. The model is consistent with recent studies of the Central Andean plateau, which focus on the generation of S-type granites as the result of melting of the thick crust and without additional inputs via arcs or other mantle sources (Ducea et al., 2026). The maximum crustal thicknesses achieved in the model (~ 60 km) are consistent with the bounds on the thickness of the SCB discussed above.

10. Discussion: a plateau model for Mesozoic South China

The concept of a Mesozoic orogenic plateau across South China has previously been suggested (Chu et al., 2020) to explain the wide region of thickened crust and protracted deformation and exhumation, but the model has not been applied to explain the patterns of deformation, magmatism and sedimentation observed across the region.

10.1. A Mesozoic orogenic plateau in the SCB

We propose that many of the features and processes of the Mesozoic geology of the SCB (Fig. 18) are best explained by an orogenic plateau model, and summarise the geology of the Central Andes at the end of this section, to reinforce the comparison. The 1300 km wide region between the modern coast and the Sichuan Basin was intensely deformed by Mesozoic thrusting (Fig. 3), leading to thickened crust (Chu et al., 2020; Li et al., 2024). Initial Mesozoic deformation was diachronous across this vast region, associated with Permian-Triassic high grade metamorphism in the east (Wuyishan; Zhao et al., 2023), Triassic ductile shear in the Xuefengshan (Chu et al., 2012b), Early Jurassic exhumation in the Chevron Syncline Zone (Feng et al., 2023) and mid Cretaceous exhumation in the Chevron Anticline Zone (Shi et al., 2016).

The resultant structures are convex towards the forelands in map view (Fig. 3), especially between the Qingling-Dabie Shan Orogen and the Ziyun-Nandan Fault. The overall along-strike:across-strike aspect ratio of the SCB is roughly 1.2:1, i.e., comparing the NE-SW distance between the Subei Basin and the Ziyun-Nandan Fault to the NW-SE distance between the Sichuan Basin and the modern coastline. This is a low ratio compared to many active fold-and-thrust belts worldwide, such as the Zagros (comparable ratio is 4:1) and the Greater Caucasus (8:1). It is similar to the present Tibetan Plateau value of $\sim 1.5:1$ (including the marginal Himalaya and Qilian Shan fold-and-thrust belts). The deformed part of the Mesozoic SCB had the dimensions (and, as discussed above, crustal thickness) for gravitational flow to be an important factor in its development. Such a process results in arcuate-shaped fold-thrust belts in map view (Copley, 2012), as observed in the SCB. Deformation and surface uplift cannot have proceeded from east to west in a perfectly regular fashion: the Early Jurassic marine embayment in southern China (Fig. 14) lies between the Xuefengshan and regions to the east. This gulf was deformed and exhumed after areas to the west had already been deformed in the Late Triassic. A dry continental interior (Li et al., 2024) would have caused inefficient erosion, especially if internal drainage developed, and so promoted formation of high, low relief landscapes and plateau formation.

Magmatism developed across a broad region, previously thickened by crustal shortening (Wang et al., 2007a), as well as the subduction of the Paleo-Pacific Plate (Fig. 17). The exact distribution of magmatism

caused by these different processes over time remains to be deciphered, but it is notable how much of the Mesozoic magmatism in the interior of the SCB was derived from Proterozoic crustal sources, without significant juvenile inputs (Wang et al., 2013; Li et al., 2021; Liu et al., 2025). Most of the plutons are undeformed and cross-cut earlier Mesozoic compressional structures (Fig. 6), suggesting that they were emplaced during low strain (Liu et al., 2018). The coastal region is the exception, where Jurassic granites are themselves sheared and transformed into gneiss complexes (Cui et al., 2013; Wei et al., 2015). Early Cretaceous (130–105 Ma) plutons in the coastal region were emplaced during NW-SE directed shortening (Wei et al., 2023a). Therefore Early Cretaceous compressional deformation at the east of the Sichuan Basin and in coastal regions took place at the same time as extension began in the interior of the SCB (Fig. 17d). This scenario is hard to explain by a subduction rollback model alone, but is consistent with a reduction in the boundary force leading to extension in the plateau interior, at the same time as marginal regions continued to undergo thrusting. A key consideration is the buoyancy force produced by thickened and elevated crust, which promotes extension if and when the boundary force is reduced. It is feasible that Early Cretaceous extension within east Asia was triggered by slab rollback of the Paleo-Pacific Plate (Fig. 17d), which began at a time of plate re-organization and convergence vector change to more oblique subduction, at ~ 135 Ma (Mao et al., 2010). There was a rapid change in the azimuth of subduction at this time, with a $\sim 45^\circ$ clockwise rotation of the Izanagi/Asia convergence vector, caused by the start of Pacific Plate spreading (Torsvik et al., 2019). The common timing of extension within the SCB, NCB and regions further north implies a continental-scale mechanism, not local to a particular region (Dong et al., 2018). This is a major distinction from the Central Andes, where localised late Cenozoic extension has been attributed to a reduction in the shear strength of the basal thrust in the retroarc fold-and-thrust belt (Wimpenny et al., 2018).

The next two sections concern specific aspects of the Mesozoic deformation, which we believe are not adequately accounted for by existing models. We then summarise implications for the magmatic evolution of the SCB.

10.2. Superposed folding

Both sets of shear zones and folds in the cover sequences of the Eastern Yangtze Fold Zone may have formed at approximately the same time through the Middle-Late Triassic and into the Early Jurassic (Fig. 6). This model is consistent with the apparently synchronous timings and mutually cross-cutting relationships (Li et al., 2021). The SCB structures relate to convergence imposed by the Paleo-Pacific subduction zone, the Tethyan collisions to the south of the SCB, and possibly the Paleo-Tethyan collision between the SCB and the NCB. The collisions that mark the boundaries of the SCB on its northern and southern sides are Triassic, and so the right age to have generated Late Triassic compressional deformation across the continental interior. There was also post-Triassic convergence across the southwestern SCB, north of the Ailaoshan suture. This deformation is consistent with the post-Triassic Tethyan evolution of SE Asia, where post-Triassic collisions (Metcalf, 2021) could have reactivated structures within the Eurasian continental interior.

10.3. Synchronous sinistral and dextral shear

Via individual studies on local areas, there is now evidence that both dextral and sinistral shear operated on $\sim$ NE-SW trending zones within the eastern part of the SCB in the Triassic. This shear took place predominantly east of the Jiangshan-Shaoxing Fault (Fig. 3). Previous models have emphasised local geometries to explain the dominance of one shear sense or the other (e.g. Wang et al., 2007b; Zhang and Cai, 2009). Wang et al. (2021) suggested at least two phases of deformation, but the data on timing indicates an overlap in ages along the

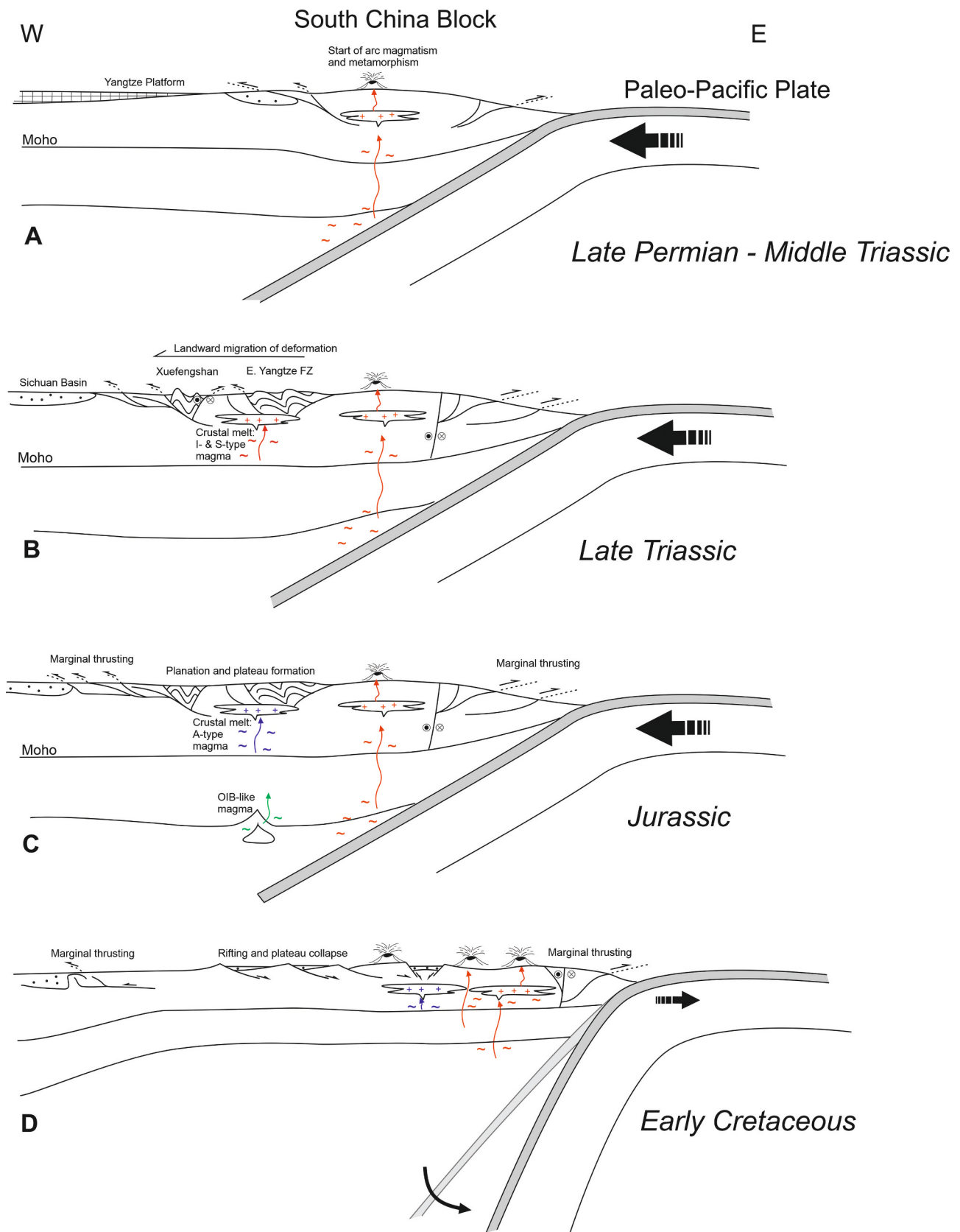


Fig. 17. Schematic cross-sections for the Mesozoic tectonic evolution of South China. a) Initiation of Paleo-Pacific subduction in the Permian. b) Late Triassic retroarc deformation migrated westwards across South China, accompanied by crustal thickening and I- and S-type granite magmatism. c) Planation and plateau formation during the Jurassic, with localised within plate magmatism caused by lithospheric instability at the base of the thickened crust. d) first regional extension in the Early Cretaceous at ~135 Ma, caused by reduction in stress at the Paleo-Pacific plate boundary.

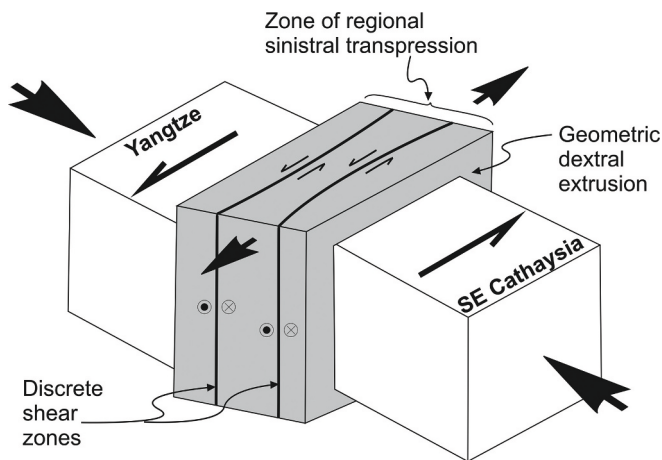


Fig. 18. Sketch to explain the operation of coeval sinistral and dextral shear during overall sinistral transpression. Modified from Jones et al. (1997).

eastern side of the SCB (Huang et al., 2024). Cui et al. (2019) related alternating phases of shear to changes in subduction azimuth at the Paleo-Pacific margin. Cochelin et al. (2022) described synchronous dextral and sinistral senses of slip on different margins of anatectic gneiss domes in the Yunkaidashan. None of these studies and

explanations covers the apparent synchronicity of dextral and sinistral slip along the length of the eastern SCB. Synchronous and parallel strike-slip shear of both senses has been recorded in other orogens, e.g. the Cenozoic evolution of Yunnan, to the west of the SCB (Zhang et al., 2010). The explanation may be the operation of transpression, i.e. oblique convergent deformation, with lateral extrusion (Jones et al., 1997). In this scenario overall shortening across a region is achieved by lateral extrusion as well as vertical thickening (Fig. 18). In the case of the SCB, we speculate that the overall transpressional sense was sinistral, on the balance of the distribution of individual sheared locations. On the larger scale, Late Triassic sinistral transpression took place along parallel to the west side of the SCB, in the Longmen Shan (Chen et al., 1995). Fold trains in the eastern part of the Songpan-Ganzi Zone record this shear, as they curve into parallelism with the northwest-southwest trending thrusts of the Longmen Shan (Dirks et al., 1994). Likewise, Mesozoic shear along the Tan Lu Fault was sinistral (Peng et al., 2022), with Ar-Ar ages of adjacent mylonites in the range of 245–218 Ma (Lu et al., 2022). There is therefore evidence of Triassic sinistral shear on both the west and east sides of the SCB, indicating that its margins with the Songpan-Ganzi Zone and the NCB consisted of strike-slip/transpressional zones (Longmen Shan, Tan Lu Fault), alternating with head-on convergence (Dabie Shan, Sulu) (Fig. 19).

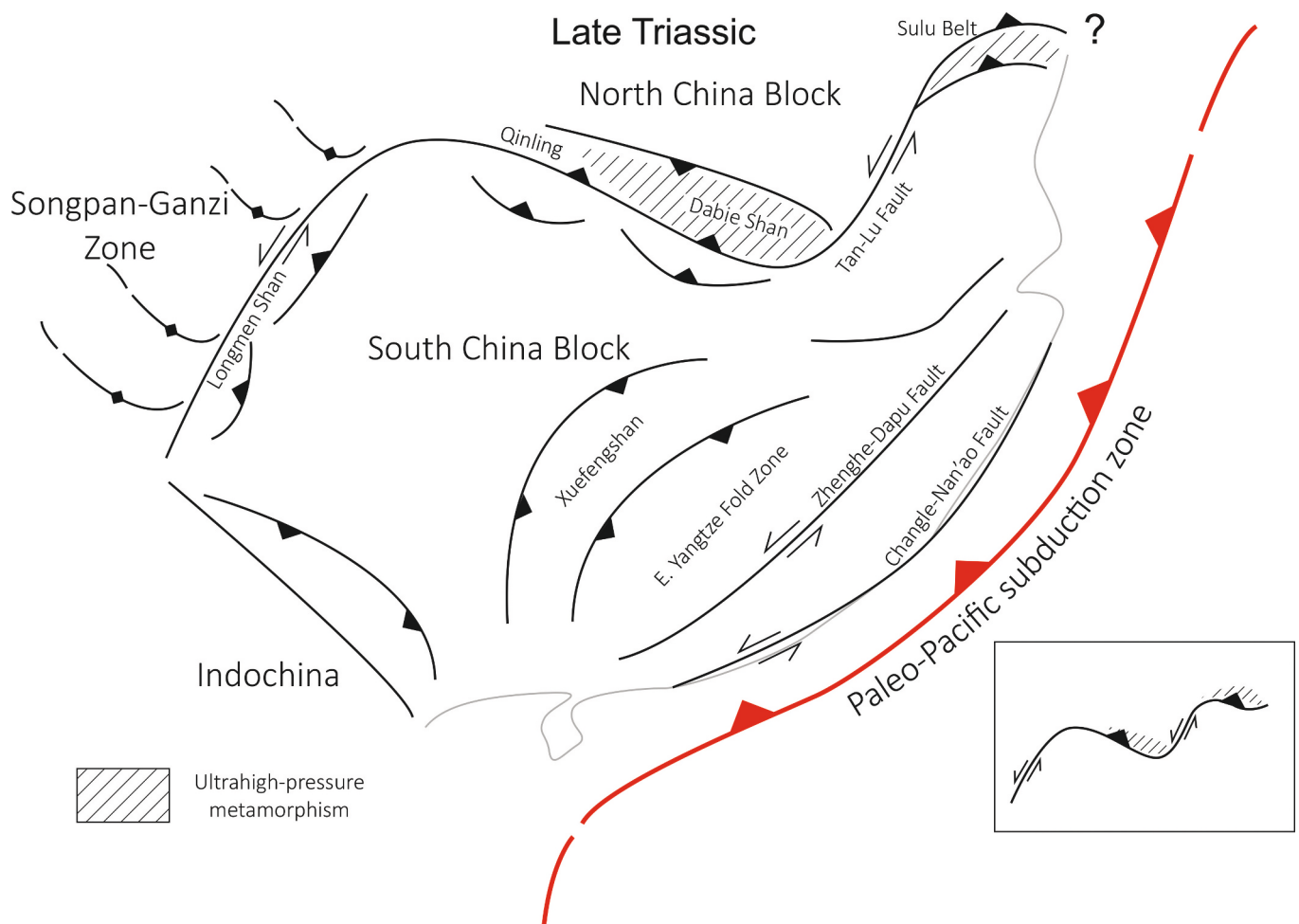


Fig. 19. Sketch of the Triassic tectonics of the SCB, to illustrate the combination of sinistral shear and transpression along the Tan Lu Fault and within the Longmen Shan, at the same time as orthogonal convergence and (ultra)high pressure metamorphism within the Qinling-Dabie Shan and Sulu regions. In this model, the (ultra) high pressure metamorphism is focussed within regions of more orthogonal convergence, and strike-slip concentrated in regions with more oblique convergence (see inset for a reduction to the simplest form).

10.4. Magmatism

Li and Li (2007) produced a landmark paper and model for the Mesozoic magmatic evolution of the SCB. In the Li and Li (2007) model, flat slab subduction of the Paleo-Pacific Plate controlled the distribution of magmatism in the overriding SCB, with arc magmatism taking place above the downward track of the subducting slab. Lateral migration of the point at which the slab descended controlled a westward wave of magmatism from ~260–200 Ma. The start of slab rollback at ~200 Ma led to slab retreat under the continent, with eastward migration of magmatism as a consequence. Areas ahead of or behind the magmatic front lacked magmatism, based on the apparent distribution of magmatic ages across the SCB.

Instead of a wave of magmatism advancing landwards and then retreating, it appears that magmatism was present inland by the Late Permian - Early Triassic (~230 Ma; Chu et al., 2012c), and persisted across the South China Block through much of the rest of the Mesozoic, with a lull at ~200–180 Ma (Early Jurassic) and also at ~115–105 Ma (Fig. 8). An alternative hypothesis for the regional tectonic setting is that Permian-Cretaceous magmatism took place in an orogenic plateau behind an active Andean-type arc, somewhat resembling the modern Central Andes but much wider, at >1000 km (Fig. 17). In this interpretation, magmatism took place within regions affected by Triassic crustal thickening as a result of the ocean closures to the south and north of the South China Block, to produce a very broad magmatic zone by 230 Ma (Fig. 17b). Crustal heating in the aftermath of crustal thickening was sufficient to generate crustal melts (e.g. Fu et al., 2015), without major additional inputs of mantle-derived magma and heat (Wang et al., 2007a).

Magmatism persisted across many parts of this broad belt through the Jurassic and in the Cretaceous (Figs. 7 and 8). There was not a void in magmatism east of a westward-migrating front, as depicted in Li and Li (2007): the more recent geochronology data fill that gap, including Early Jurassic ages from rocks in the East China and South China seas, and Taiwan (Fig. 8). Nor was there a progressive eastwards shutdown of magmatism after 200 Ma. There is a definite concentration of Cretaceous magmatism in the coastal regions of Zhejiang and Fujian provinces, but recent dating has revealed widespread if scattered Cretaceous magmatism in the interior of the continent to the west. Early Cretaceous magmatism was synchronous with rifting, and this phase is consistent with extension across the orogenic plateau, west of the active arc.

A-type granites are a widespread feature of the SCB in the Mesozoic (Figs. 6 and 10), and have been identified across regions and time periods without clear spatial or temporal progressions in their distribution. Compositions resemble A₂ A-type granites worldwide, with high silica, alkalis, Zr, Nb, Ce, Y, FeO^T/MgO, REE (except Eu), and Ga/Al ratios. Their sources are reasonably well modeled and understood, as melts of lower crust under relatively hot and anhydrous conditions (Eby, 1992). Different specific lower crustal compositions have been proposed for different plutons, with both meta-igneous and meta-sedimentary sources.

A very common interpretation of the SCB A-type plutons is that they were generated during extension (e.g., Fu et al., 2010; Gao et al., 2017; Liang et al., 2023). This view is consistent with a global consensus on the setting for such magmatism, but in the SCB it is not supported by independent evidence for extension in the Triassic or Jurassic periods. There is no issue for the Cretaceous, where A-type granites overlap in time with episodes of regional extension, which are documented by rift basins and metamorphic core complexes (Figs. 5 and 6). An orogenic plateau offers an alternative setting for Mesozoic A-type magmatism in the SCB (Fig. 16). Thickened continental crust produces heating in the middle and lower crust following the original thickening event, via the radioactive decay and heat production of elements concentrated in the crust (e.g. U, K, Th; McKenzie and Priestley, 2008). Temperatures of 900° C are modeled for the lower crust 60 million years after rapid threefold thickening of the crust. Simultaneously, progressive

metamorphism dehydrates the lower crust, and produces the anhydrous source regions identified as the origins of A-type magmas (Fig. 17c). In this model, extensional strain is not required for the production of granitic melt from the lower crust. The key factor in determining the composition of the melt is the composition of the available metamorphic rock. If the source region is dominated by metaigneous rocks, I-type melts result. If the source is metasedimentary, S-type granites are produced. A-type granites are produced from refractory lower crust, which has undergone a previous episode of melting and so is relatively anhydrous.

The earliest Indosinian A-type granites are Triassic in age, and so 10s of millions of years later than the onset of arc magmatism in the Permian (Fig. 18). These Triassic intrusions are limited in extent, and do not have the wide distribution of I- and S-type counterparts (Fig. 8). For example, A-type Triassic granites are rare in Hunan Province, in contrast to the widespread occurrence of other types. A-type granites do appear in Hunan by the Jurassic (~180 Ma), and range through this period into the Early Cretaceous (Fig. 6). We interpret this westward spread of A-type migration over time as the result of the time required for the lower crust to heat sufficiently for the higher temperature, A-type melts to appear (Figs. 16 and 17).

Plutons in the SCB are commonly composite (Figs. 6 and 13). Paleozoic intrusions may act as focal points for magmatism in one or more Mesozoic period. Mesozoic plutons commonly contain more than one phase of intrusion, with either 10s of millions of years between phases or a few million years between pulses of different composition. A-type granites are typically younger than I- or S-type granites in the same locality (Wang et al., 2018b) (Fig. 11). This pattern is consistent with a scenario where initial crustal heating produces the I-type or S-type granites, depending on the nature of the source region, and subsequent heating produces A-type granites with their higher melt temperatures and refractory sources (e.g., Cai et al., 2015, 2017).

There were clearly factors which favored the repeated generation and intrusion of magmas at the same localities, with 10s and even 100 s of millions of years between melt generation phases. What is not currently understood is whether the overlap of intrusions is because older granites promote later melting in the same place, possibly through higher heat flows, or if the control is more structural, with later melts preferentially guided by pre-existing networks of granite. This is a subject for future research, especially considering the world-class mineralisation associated with magmatism in the SCB.

10.5. Central Andean analogue

The Central Andes orogenic plateau provides a modern analogue for the Mesozoic magmatism and deformation across the SCB. We provide a brief summary of the salient features of the Central Andes (Fig. 20). Oceanic subduction under the western side of South America has generated a magmatic arc since at least the Early Jurassic, with more scattered relicts of Paleozoic arc rocks. In the Central Andes, Cenozoic compressional deformation across the plate boundary has shortened and thickened the crust. This shortening and magmatic additions combine to produce the present-day thicknesses of ~60–70 km. Active thrusting takes place at the western and eastern margins of the plateau (Devlin et al., 2012). The eastern, retroarc, fold-and-thrust belt deforms strata of the Brazilian Shield, producing elongate anticlines and synclines (McQuarrie et al., 2005). These folds are individually and collectively convex towards the foreland in map view (Fig. 20). The western zone of thrusting is far narrower (Armijo et al., 2015; Martinez et al., 2021), but also seismogenic. Between the two compressional belts there is little internal active deformation of the high plateau, at elevations of ~4000 m (Devlin et al., 2012), but there has been localised late Cenozoic extension in regions such as the South Peruvian Altiplano (Wimpenny et al., 2020) and northeastern Chile (Tibaldi and Bonali, 2018).

Magmatism is active across >200 km width in the Central Andes, in contrast to northern and southern sectors of the Andean arc where

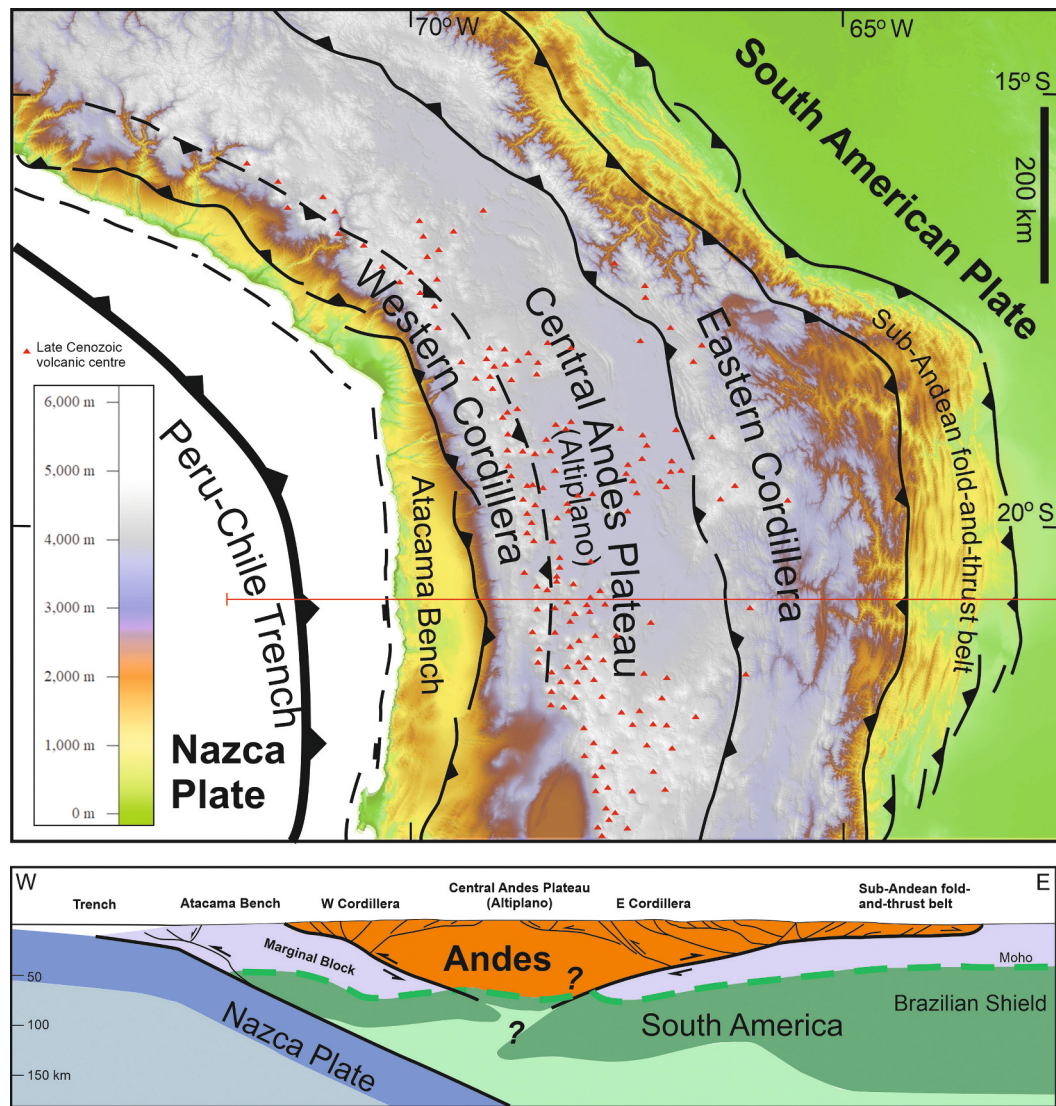


Fig. 20. Summary tectonic map of the Central Andes. After [Armijo et al. \(2015\)](#), with late Cenozoic volcanic centers added after [Bertin et al. \(2025\)](#) and our own observations.

magmatism is commonly confined to a linear chain of arc volcanoes ([Fig. 20](#)). Compositions range from rare medium-K to high-K calc-alkaline mafic rocks, through andesites, to dacites and rhyolites with extensive crustal contamination ([Blum-Oeste and Wörner, 2016](#); [Ducea et al., 2026](#)). Voluminous ignimbrites are common, and provide evidence of extensive crustal melting. It is not clear how these volcanic compositions relate to plutons at depth, as these are not exposed. There are mafic centres in the eastern part of the plateau with within-plate geochemical signatures ([Davidson and de Silva, 1992](#); [Hoke and Lamb, 2007](#)).

Much of the plateau is internally drained, with an arid climate because of the rain shadow effect produced by the marginal fold-and-thrust belts. Rivers flow into the lake basins in the plateau interior ([Sobel et al., 2003](#)). This aspect is important, because external drainage allows erosion to keep pace with compressional deformation, such that a dynamic equilibrium can be established where a fold-and-thrust belt maintains a steady-state profile, whilst exhuming deeper rocks. With internal drainage, a region is more likely to achieve a crustal thickness and consequent surface elevation at which the buoyancy force associated with gravitational potential energy contrasts balances the far-field compressive stresses ([Molnar and Lyon-Caen, 1988](#)). In this scenario further convergence is accommodated at the margins of the plateau in

lower elevation areas. In this scenario it is easier for further convergence to be accommodated at the margins of the plateau in lower elevation areas. The Zagros fold-and-thrust belt illustrates this process well, where major ($M > 5$) thrust earthquakes are predominantly in regions below the 1250 m regional elevation contour ([Nissen et al., 2011](#)). The surface uplift history of the Central Andean Plateau is debated. Evidence for rapid regional surface uplift ([Garzione et al., 2006](#)) is interpreted to be driven by removal of the lower lithosphere, but data for more gradual and diachronous surface uplift ([Scott et al., 2018](#)) do not indicate a catastrophic event. Diachronous surface uplift is consistent with a process of gradual broadening of the area of crust at sufficient thickness and surface elevation to resist further crustal shortening in that region, such that continued convergence is accommodated in marginal, lower elevation regions ([Molnar and Lyon-Caen, 1988](#)). [Ducea et al. \(2013\)](#) invoked localised mantle lithosphere drips to trigger isolated mafic volcanic centres, without the need for an extensional event. A similar scenario was modeled by [Kaislaniemi et al. \(2014\)](#) to account for magmatism across the Iranian Plateau in the aftermath of the Arabia-Eurasia collision.

To summarise, the Central Andean Plateau consists of a low strain, internally-drained centre, flanked by active fold-and-thrust belts ([Fig. 20](#)). Magmatism is present across a much wider region than in the

Andes to the north and south. East of the arc front, magmatism includes individual mafic centres. Crustal melting is commonplace across the plateau as a result of thickening and warming of the lower crust beyond its solidus (Ducea et al., 2026). These features of the Central Andes have a strong resemblance to the Mesozoic geology of South China. Important differences relate to scale (but we note that the Andean story has not finished, and that the plateau is still growing), and the lack of exposure of A-type granites in the Andes. The lack of A-type granites may relate to exposure level, or simply time, given that the Andean plateau has not been in existence for the protracted period envisaged for the Mesozoic South China Plateau.

11. Conclusions

Our analysis of the deformation, magmatism and basin evolution across South China has produced four main sets of conclusions which relate to the existence of an orogenic plateau in the Mesozoic era. The present-day dimensions of the region interpreted as this plateau are 1200×1700 km (Fig. 3).

1. Much of the extensive granitic magmatism relates to melting of thickened crust (~ 50 km or greater), without major mantle inputs. Regional extension did not occur until the Early Cretaceous at ~ 135 Ma (Fig. 17d), and cannot have been a significant driver for magmatism before this time. Mesozoic crustal heating was a consequence of radiogenic heating in thickened crust; the variety of I-, S- and A-type plutons reflecting different sources (meta-igneous, meta-sedimentary and refractory), rather than fundamental differences in tectonic setting. The Early Jurassic lull in magmatism (~ 200 – 180 Ma; Cao et al., 2021) may have been a time during which the crust reheated after Triassic production of granites, with melting intensifying in the Middle Jurassic. We suggest that the relative increase in the proportion of A-type granites from the Middle Jurassic onwards (Fig. 11) was the result of second stage melting of refractory crust, following initial production of I-type or S-type granites. Orogenic plateaus are a plausible setting for the generation of the A₂ subtype of the A-type granites worldwide; extension should not be invoked as a mechanism unless there is independent structural evidence.
2. Superposed fold patterns in the Eastern Yangtze Fold Zone (Fig. 6) have previously been interpreted as the result of two separate phases of deformation (e.g., Shi et al., 2015), with distinct origins in the marginal collisions (Triassic) and Paleo-Pacific convergence (Jurassic). Our regional analysis of the fold patterns suggest that both sets of folds are roughly contemporary, following Li et al. (2021), as indicated by mutually cross-cutting relationships. There is a concentric set of folds and thrusts, convex westwards, and a radial set of long wavelength folds (~ 100 km scale). Collectively, the folds are consistent with constrictional deformation and the synchronous operation of stresses originating at both the Paleo-Pacific plate boundary and one or both of the collision zones at the north and south margins of the SCB. The long wavelength anticlinoria appear to have a control on the location of Mesozoic plutons in the Eastern Yangtze Fold Zone, especially where the anticlinoria coincide with Early Paleozoic granites. The influence of Early Paleozoic structures on Mesozoic deformation remains to be deciphered in full and on the regional scale. There are implications for the world-class resources of critical elements in South China, in that hydrothermal systems associated with younger plutons may have operated on areas already mineralised by earlier generations of plutons. Repeated mobilisation and precipitation of ore elements between the Early Paleozoic and the Cretaceous enhanced the prospects of mineralisation on the regional scale. Future exploration should incorporate the implications of the plateau model for the generation of magmatic and hydrothermal systems with potential mineralisation.
3. Both dextral and sinistral strike-slip faults have previously been identified in the east of the SCB, mainly east of the Jiangshan-

Shaoxing Fault (Fig. 3), and generally striking northeast-southwest. Available constraints on the timing of these structures indicates that dextral and sinistral shear may have operated at the same time in sub-parallel zones. The causes of this strike-slip deformation are enigmatic. Strain partitioning would be an explanation, whereby oblique plate convergence is achieved by the spatial separation of strain onto dip-slip and strike-slip components, but this mechanism is hard to reconcile with the co-existence of contemporary dextral and sinistral faults. Another explanation is lateral extrusion across different sectors of the southeastern SCB during compression (or transpression), whereby along-strike lengthening of crustal blocks causes both dextral and sinistral slip with respect to adjacent blocks that have undergone lower strain (Jones et al., 1997) (Fig. 19).

4. Topographic plateau remnants occur within the SCB, notably in the Wu Shan, Dalou Shan and Xuefengshan regions (Fig. 15). These relict plateau surfaces are at ~ 1500 – 2000 m above sea level and have distinctly low relief over $10s$ – $1000s$ km² of area. Their maximum age is constrained by Middle Jurassic strata, which are folded and peneplained. A minimum age is provided by the (?) Upper Cretaceous syn-rift strata of the Enshi Basin (Zhang et al., 2025), which lie in a topographic depression within the Wu Shan plateau remnant. We propose that the original plateau surface was much wider in extent, on a scale comparable to the modern Tibetan Plateau (>1 M km²). Plateau erosion occurred from the Late Cretaceous and through the Cenozoic, following the Late Cretaceous establishment of the eastward-flowing Yangtze River (Wang et al., 2018c).

By viewing the Mesozoic tectonic evolution of the SCB as the growth of an orogenic plateau during Paleo-Pacific subduction, it is possible to give contexts for individual episodes of deformation, magmatism, and deposition, which better fit the data than existing models.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.earscirev.2026.105672>.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

References

- Allen, M.B., Song, S., Wang, C., Zeng, R., Wen, T., 2023. An oblique subduction model for closure of the Proto-Tethys and Palaeo-Tethys oceans and creation of the Central China Orogenic Belt. *Earth Sci. Rev.* 240, 104385.
- Allen, M.B., Song, S., Wang, C., 2025. An invasion model for the start of Paleo-Pacific subduction. *Geology* 53, 488–492.
- Armijo, R., Lacassin, R., Coudurier-Curveur, A., Carrizo, D., 2015. Coupled tectonic evolution of Andean orogeny and global climate. *Earth Sci. Rev.* 143, 1–35.
- Bai, D.Y., Xiong, X.L., Yang, J., Zhong, X., Jia, P.Y., Huang, W.Y., 2014. Geological structure characteristics of the middle segment of the Xuefeng orogen. *Geol. China* 41, 399–418.

- Bai, T., Qian, X., Gan, C., Wang, Y., 2025. Late Jurassic high-silica granites in the interior and coastal South China and their tectonic implication. *Lithos* 498–499, 107971.
- Bertin, D., Bustos, E., Grosse, P., Báez, W., 2025. The Central Andes of South America: a review of its tectono-magmatic evolution. *J. S. Am. Earth Sci.* 158, 105503.
- Blum-Oeste, M., Wörner, G., 2016. Central Andean magmatism can be constrained by three ubiquitous end-members. *Terra Nova* 28, 434–440.
- Bureau of Geology and Mineral Resources of Fujian Province, 1985. Regional Geology of Fujian Province. Geological Publishing House, Beijing.
- Bureau of Geology and Mineral Resources of Hunan Province, 1988. Regional Geology of Hunan Province. Geological Publishing House, Beijing.
- Burton-Johnson, A., Macpherson, C., Millar, I., Whitehouse, M.J., Ottley, C., Nowell, G., 2020. A Triassic to Jurassic arc in north Borneo: geochronology, geochemistry, and genesis of the Segama Valley Felsic Intrusions and the Sabah ophiolite. *Gondwana Res.* 84, 229–244.
- Cai, J.-X., 2013. An early Jurassic dextral strike-slip system in southern South China and its tectonic significance. *J. Geodyn.* 63, 27–44.
- Cai, Y., Lu, J., Ma, D., Huang, H., Zhang, H., Zhang, R., 2015. The late Triassic Dengfuxian A-type granite, Hunan Province: age, petrogenesis, and implications for understanding the late Indosinian tectonic transition in South China. *Int. Geol. Rev.* 57, 428–445.
- Cai, D., Zhao, J., Tang, Y., Zhang, H., Liu, Y., Lv, Z., 2017. Geochemistry, petrogenesis and tectonic significance of the late Triassic A-type granite in Fujian, South China. *Acta Geochim.* 36, 166–180.
- Cao, X., Flament, N., Li, S., Müller, R.D., 2021. Spatio-temporal evolution and dynamic origin of Jurassic-Cretaceous magmatism in the South China Block. *Earth Sci. Rev.* 217, 103605.
- Cao, K., Tian, Y., van der Beek, P., Wang, G., Shen, T., Reiners, P., Berner, M., Husson, L., 2022. Southwestward growth of plateau surfaces in eastern Tibet. *Earth Sci. Rev.* 232, 104160.
- Castillo, P.R., 2012. Adakite petrogenesis. *Lithos* 134, 304–316.
- Cawood, P.A., Zhao, G., Yao, J., Wang, W., Xu, Y., Wang, Y., 2018. Reconstructing South China in Phanerozoic and Precambrian supercontinents. *Earth Sci. Rev.* 186, 173–194.
- Chapman, J.B., Ducea, M.N., DeCelles, P.G., Profeta, L., 2015. Tracking changes in crustal thickness during orogenic evolution with Sr/Y: an example from the North American Cordillera. *Geology* 43, 919–922.
- Charvet, J., Shu, L., Faure, M., Choulet, F., Wang, B., Lu, H., Le Breton, N., 2010. Structural development of the Lower Paleozoic belt of South China: genesis of an intracontinental orogen. *J. Asian Earth Sci.* 39, 309–330.
- Chen, A., 1999. Mirror-image thrusting in the South China Orogenic Belt: tectonic evidence from western Fujian, southeastern China. *Tectonophysics* 305, 497–519.
- Chen, S.F., Wilson, C., Worley, B., 1995. Tectonic transition from the Songpan-Garzê fold belt to the Sichuan Basin, south-western China. *Basin Res.* 7, 235–253.
- Chen, W.-S., Yang, H.-C., Wang, X., Huang, H., 2002. Tectonic setting and exhumation history of the Pingtan–Dongshan Metamorphic Belt along the coastal area, Fujian Province, Southeast China. *J. Asian Earth Sci.* 20, 829–840.
- Chen, W., Chen, P., Xu, X., Zhang, M., 2005. Geochemical characteristics of Cretaceous basaltic rocks in South China and constraints on Pacific plate subduction. *Sci. China Ser. D Earth Sci.* 48, 2104–2117.
- Chen, W., Chen, P., Huang, H., Ding, X., Sun, T., 2007. Chronological and geochemical studies of granite and enclave in Baimashan pluton, Hunan, South China. *Sci. China Ser. D Earth Sci.* 50, 1606–1627.
- Chen, C.-H., Lee, C.-Y., Shinjo, R., 2008. Was there Jurassic paleo-Pacific subduction in South China?: Constraints from $^{40}\text{Ar}/^{39}\text{Ar}$ dating, elemental and Sr–Nd–Pb isotopic geochemistry of the Mesozoic basalts. *Lithos* 106, 83–92.
- Chen, X., Fan, J., Chen, Q., Tang, L., Hou, X., 2014. Toward a stepwise Kwangsi orogeny. *Sci. China Earth Sci.* 57, 379–387.
- Chen, J.-Y., Yang, J.-H., Ji, W.-Q., 2017. Ages and petrogenesis of Jurassic and Cretaceous intrusive rocks in the Matsui Islands: implications for lower crust modification beneath southeastern China. *J. Asian Earth Sci.* 150, 14–24.
- Chen, X., Liu, S., Feng, C., Xu, J., Zhao, H., Feng, G., Coulson, I.M., Sun, J., Fan, Y., 2021. Zircon U–Pb Age, Geochemical, and Sr–Nd–Pb–Hf Isotopic Constraints on the Time Frame and Origin of Early Cretaceous Mafic Dykes in the Wuling Mountain Gravity Lineament, South China. *Acta Geol. Sin. Eng. Ed.* 95, 419–438.
- Cheng, Y., Mao, J., Liu, P., 2016. Geodynamic setting of Late Cretaceous Sn–W mineralization in southeastern Yunnan and northeastern Vietnam. *Solid Earth Sci.* 1, 79–88.
- Chu, Y., Lin, W., 2018. Strain analysis of the Xuefengshan Belt, South China: from internal strain variation to formation of the orogenic curvature. *J. Struct. Geol.* 116, 131–145.
- Chu, Y., Faure, M., Lin, W., Wang, Q., 2012a. Early Mesozoic tectonics of the South China block: insights from the Xuefengshan intracontinental orogen. *J. Asian Earth Sci.* 61, 199–220.
- Chu, Y., Faure, M., Lin, W., Wang, Q., Ji, W., 2012b. Tectonics of the Middle Triassic intracontinental Xuefengshan Belt, South China: new insights from structural and chronological constraints on the basal décollement zone. *Int. J. Earth Sci.* 101, 2125–2150.
- Chu, Y., Lin, W., Faure, M., Wang, Q., Ji, W., 2012c. Phanerozoic tectonothermal events of the Xuefengshan Belt, central South China: implications from U–Pb age and Lu–Hf determinations of granites. *Lithos* 150, 243–255.
- Chu, Y., Lin, W., Faure, M., Xue, Z., Ji, W., Feng, Z., 2019. Cretaceous episodic extension in the South China block, east Asia: evidence from the Yuechengling massif of central South China. *Tectonics* 38, 3675–3702.
- Chu, Y., Lin, W., Faure, M., Allen, M.B., Feng, Z., 2020. Cretaceous exhumation of the Triassic intracontinental Xuefengshan Belt: delayed unroofing of an orogenic plateau across the South China Block? *Tectonophysics* 793, 228592.
- Chu, Y., Liu, T., Lin, W., Meng, L., Feng, Z., Wei, W., Ji, W., Xue, Z., 2024. Lithospheric reworking and thinning by cyclical continental extension: a synthesis of Cretaceous extensional domes in the South China Block. *Comp. Rend. Géosci.* 356, 137–162.
- Cochelin, B., Wang, B., Liu, J., Lu, S., Shu, L., Gumiaux, C., Chen, Y., Song, F., 2022. Early Mesozoic anatexis-induced strain partitioning and gneiss doming in the Yunkai Massif, South China: a response to contrasted dynamics of Paleo-Pacific and Paleotethys subductions? *Tectonics* 41, e2022TC007457.
- Copley, A., 2012. The formation of mountain range curvature by gravitational spreading. *Earth Planet. Sci. Lett.* 351, 208–214.
- Copley, A., Weller, O., 2022. The controls on the thermal evolution of continental mountain ranges. *J. Met. Geol.* 40, 1235–1270.
- Cui, J., Zhang, Y., Dong, S., Jahn, B.-m., Xu, X., Ma, L., 2013. Zircon U–Pb geochronology of the Mesozoic metamorphic rocks and granulites in the coastal tectonic zone of SE China: constraints on the timing of Late Mesozoic orogeny. *J. Asian Earth Sci.* 62, 237–252.
- Cui, X., Dai, L., Li, S., Guo, L., Suo, Y., 2019. Control of strike-slip and pull-apart processes to tectonic transition of the southern East China Sea Shelf Basin. *Geol. J.* 54, 850–861.
- Dai, X., Song, H., Brayard, A., Ware, D., 2019. A new Griesbachian–Dienerian (Induan, Early Triassic) ammonoid fauna from Gujiao, south China. *J. Paleontol.* 93, 48–71.
- Davidson, J.P., de Silva, S.L., 1992. Volcanic rocks from the Bolivian Altiplano: insights into crustal structure, contamination, and magma genesis in the central Andes. *Geology* 20, 1127–1130.
- DeCelles, P.G., 2004. Late Jurassic to Eocene evolution of the Cordilleran thrust belt and foreland basin system, western USA. *Am. J. Sci.* 304, 105–168.
- Deng, J., Wang, Q.F., Li, G.J., 2017. Tectonic evolution, superimposed orogeny, and composite metallogenic system in China. *Gondwana Res.* 50, 216–266.
- Deng, B., Liu, S., Jiang, L., Zhao, G., Huang, R., Li, Z., Li, J., Jansa, L., 2018. Tectonic uplift of the Xichang Basin (SE Tibetan Plateau) revealed by structural geology and thermochronology data. *Basin Res.* 30, 75–96.
- Devlin, S., Isacks, B., Pritchard, M., Barnhart, W., Lohman, R., 2012. Depths and focal mechanisms of crustal earthquakes in the central Andes determined from teleseismic waveform analysis and InSAR. *Tectonics* 31, TC2002. <https://doi.org/10.1029/2011TC002914>.
- Dewey, J.F., 1988. Extensional collapse of orogens. *Tectonics* 7, 1123–1139.
- Dilek, Y., Tang, L., 2021. Magmatic record of the Mesozoic geology of Hainan Island and its implications for the Mesozoic tectonomagmatic evolution of SE China: effects of slab geometry and dynamics in continental tectonics. *Geol. Mag.* 158, 118–142.
- Ding, X., Chen, P., Chen, W., Huang, H., Zhou, X., 2006. Single zircon LA-ICPMS U–Pb dating of Weishan granite (Hunan, South China) and its petrogenetic significance. *Sci. China Ser. D Earth Sci.* 49, 816–827.
- Ding, R., Seward, D., Zou, H., 2023. Late Cretaceous–Paleogene rift initiation of the southwestern East China Sea Basin: implications from a fission-track study of the Changlè–Nan’ao Belt. *J. Asian Earth Sci.* 256, 105824.
- Dirks, P., Wilson, C., Chen, S., Luo, Z., Liu, S., 1994. Tectonic evolution of the NE margin of the Tibetan Plateau; evidence from the central Longmen Mountains, Sichuan Province, China. *J. SE Asian Earth Sci.* 9, 181–192.
- Dong, S., Zhang, Y., Zhang, F., Cui, J., Chen, X., Zhang, S., Miao, L., Li, J., Shi, W., Li, Z., Huang, S., Li, H., 2015. Late Jurassic–Early Cretaceous continental convergence and intracontinental orogenesis in East Asia: a synthesis of the Yanshan Revolution. *J. Asian Earth Sci.* 114, 750–770.
- Dong, S., Zhang, Y., Li, H., Shi, W., Xue, H., Li, J., Huang, S., Wang, Y., 2018. The Yanshan orogeny and late Mesozoic multi-plate convergence in East Asia—commemorating 90th years of the “Yanshan Orogeny”. *Sci. China Earth Sci.* 61, 1888–1909.
- Duan, L., Meng, Q.-R., Wu, G.-L., Yang, Z., Wang, J., Zhan, R., 2020. Nanpanjiang basin: a window on the tectonic development of south China during Triassic assembly of the southeastern and eastern Asia. *Gondwana Res.* 78, 189–209.
- Ducea, M., Seclaman, A., Murray, K., Jianu, D., Schoenbohm, L., 2013. Mantle-drip magmatism beneath the Altiplano–Puna plateau, central Andes. *Geology* 41, 915–918.
- Ducea, M.N., DeCelles, P.G., Chapman, J.B., Delph, J.R., Carrapa, B., Petrescu, L., Ward, K.M., Rossel, P., 2026. The role of crustal magmatism in the formation and the evolution of orogenic plateaus. *Geol. Soc. Am. Bull.* <https://doi.org/10.1130/B38190.1>.
- Eby, G.N., 1992. Chemical subdivision of the A-type granulites: petrogenetic and tectonic implications. *Geology* 20, 641–644.
- Faure, M., Sun, Y., Shu, L., Monié, P., Charvet, J., 1996. Extensional tectonics within a subduction-type orogen. The case study of the Wugongshan dome (Jiangxi Province, southeastern China). *Tectonophysics* 263, 77–106.
- Faure, M., Shu, L., Wang, B., Charvet, J., Choulet, F., Monié, P., 2009. Intracontinental subduction: a possible mechanism for the Early Palaeozoic Orogen of SE China. *Terra Nova* 21, 360–368.
- Faure, M., Lepvrier, C., Nguyen, V.V., Vu, T.V., Lin, W., Chen, Z., 2014. The South China block–Indochina collision: where, when, and how? *J. Asian Earth Sci.* 79, 260–274.
- Faure, M., Lin, W., Chu, Y., Lepvrier, C., 2016. Triassic tectonics of the Ailaoshan belt (SW China): Early Triassic collision between the South China and Indochina blocks, and Middle Triassic intracontinental shearing. *Tectonophysics* 683, 27–42.
- Feng, Q., Qiu, N., Wu, H., Koyi, H., 2023. Thermo-Kinematic Constraints on Restoration of the Eastern Sichuan Fold-and-Thrust Belt, South China. *Tectonics* 42, e2022TC007630.
- Fu, L., Wei, J., Li, Y., Tan, J., Li, S., Li, H., 2010. LA-ICP-MS zircon U–Pb dating of the Kunlunuan A-type granites in Guangxi Province, South China and its geological significance. *Chin. J. Geochem.* 29, 223–232.

- Fu, S., Hu, R., Bi, X., Chen, Y., Yang, J., Huang, Y., 2015. Origin of Triassic granites in central Hunan Province, South China: constraints from zircon U–Pb ages and Hf and O isotopes. *Int. Geol. Rev.* 57, 97–111.
- Gan, C., Wang, Y., Zhang, Y., Qian, X., Zhang, J., 2017. The earliest Jurassic A-type granite in the Nanling Range of southeastern South China: petrogenesis and geological implications. *Int. Geol. Rev.* 59, 274–292.
- Gan, C., Zhang, Y., Qian, X., Zhang, A., 2021. The assembly of the South China and Indochina blocks: constraints from the Triassic felsic volcanics in the Youjiang Basin. *Bulletin* 133, 2097–2112.
- Gao, P., Zheng, Y.-F., Zhao, Z.-F., 2017. Triassic granites in South China: a geochemical perspective on their characteristics, petrogenesis, and tectonic significance. *Earth Sci. Rev.* 173, 266–294.
- Garzone, C.N., Molnar, P., Libarkin, J.C., MacFadden, B.J., 2006. Rapid late Miocene rise of the Bolivian Altiplano: evidence for removal of mantle lithosphere. *Earth Planet. Sci. Lett.* 241, 543–556.
- Goldfarb, R.J., Mao, J.-W., Qiu, K.-F., Goryachev, N., 2021. The great Yanshanian metallogenic event of eastern Asia: consequences from one hundred million years of plate margin geodynamics. *Gondwana Res.* 100, 223–250.
- Gu, Z., Wang, X., Nunns, A., Zhang, B., Jiang, H., Fu, L., Zhai, X., 2021. Structural styles and evolution of a thin-skinned fold-and-thrust belt with multiple detachments in the eastern Sichuan Basin, South China. *J. Struct. Geol.* 142, 104191.
- Guan, Y., Yuan, C., Sun, M., Wilde, S., Long, X., Huang, X., Wang, Q., 2014. I-type granitoids in the eastern Yangtze Block: implications for the Early Paleozoic intracontinental orogeny in South China. *Lithos* 206, 34–51.
- Hacker, B.R., Ratschbacher, L., Webb, L., Ireland, T., Walker, D., Shuwen, D., 1998. U/Pb zircon ages constrain the architecture of the ultrahigh-pressure Qinling–Dabie Orogen, China. *Earth Planet. Sci. Lett.* 161, 215–230.
- Hatzfeld, D., Molnar, P., 2010. Comparisons of the kinematics and deep structures of the Zagros and Himalaya and of the Iranian and Tibetan plateaus and geodynamic implications. *Rev. Geophys.* 48, RG2005. <https://doi.org/10.1029/2009RG000304>.
- He, H., Wang, Y., Qian, X., Zhang, Y., 2018. The Bangxi–Chenxing tectonic zone in Hainan Island (South China) as the eastern extension of the Song Ma–Ailaoshan zone: evidence of late Paleozoic and Triassic igneous rocks. *J. Asian Earth Sci.* 164, 274–291.
- He, H., Wang, T., Sui, Q., Duan, X., Ren, X., Hou, D., Xie, Y., Liu, S., Feng, P., Zhang, H., 2023. Geochronology and Petrogenesis of the Early Paleozoic Jilongjie Granites in the Central South China Block: implication for Post-Kinematic Lithospheric Delamination. *Minerals* 13, 734.
- Hoke, L., Lamb, S., 2007. Cenozoic behind-arc volcanism in the Bolivian Andes, South America: implications for mantle melt generation and lithospheric structure. *J. Geol. Soc. Lond.* 164, 795–814.
- Hu, R.Z., Zhou, M.F., 2012. Multiple Mesozoic mineralization events in South China—an introduction to the thematic issue. *Mineral. Deposita* 47, 579–588.
- Hu, L., Cawood, P.A., Du, Y., Yang, J., Jiao, L., 2015. Late Paleozoic to early Mesozoic provenance record of paleo-Pacific subduction beneath South China. *Tectonics* 34, 986–1008.
- Hu, F., Ducea, M.N., Liu, S., Chapman, J.B., 2017. Quantifying crustal thickness in continental collisional belts: global perspective and a geologic application. *Sci. Rep.* 7, 7058.
- Hu, L., Li, N., Fu, X., Tang, X., Feng, K., Zhu, W., Xu, X., 2025. Unveiling the ~110 Ma continental arc in South China: geochemical and isotopic insights from offshore magmatic records in the East China Sea Basin. *Gondwana Res.* 143, 239–255.
- Huang, W., Li, S., Xin, L., Feng, Z., Zhang, H., Geng, J., Liu, K., Shi, C., 2024. The influence of the closure of the east Paleo-Tethys Ocean on southern South China: evidences from kinematics and $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology of the Rongxian Ductile Shear Zone in Southeastern Guangxi. *Acta Geol. Sin. Eng.* 98, 1125–1140.
- Jahn, B.-M., Chen, B., 2007. Dabiehan UHP metamorphic terrane: Sr–Nd–Pb isotopic constraint to pre-metamorphic subduction polarity. *Int. Geol. Rev.* 49, 14–29.
- Jarvis, A., Reuter, H.I., Nelson, A., Guevara, E., 2008. Hole-Filled SRTM for the Globe Version 4. available from the CGIAR-CSI SRTM 90m Database. International Centre for Tropical Agriculture (CIAT). <http://srtm.csi.cgiar.org>.
- Ji, W., Faure, M., Lin, W., Chen, Y., Chu, Y., Xue, Z., 2018. Multiple emplacement and exhumation history of the Late Mesozoic Dayunshan–Mufushan batholith in southeast China and its tectonic significance: 1. Structural analysis and geochronological constraints. *J. Geophys. Res. Solid Earth* 123, 689–710.
- Jian, X., Weislogel, A., Pullen, A., 2019. Triassic sedimentary filling and closure of the eastern paleo-Tethys Ocean: new insights from detrital zircon geochronology of Songpan–Ganzi, Yidun, and west Qinling flysch in eastern Tibet. *Tectonics* 38, 767–787.
- Jiang, Y.-H., Jiang, S.-Y., Zhao, K.-D., Ling, H.-F., 2006. Petrogenesis of Late Jurassic Qianlishan granites and mafic dykes, Southeast China: implications for a back-arc extension setting. *Geol. Mag.* 143, 457–474.
- Jiang, Y.-H., Jiang, S.-Y., Dai, B.-Z., Liao, S.-Y., Zhao, K.-D., Ling, H.-F., 2009. Middle to late Jurassic felsic and mafic magmatism in southern Hunan province, southeast China: implications for a continental arc to rifting. *Lithos* 107, 185–204.
- Jiang, X.-Y., Li, X.-H., Collins, W., Huang, H.-Q., 2015. U–Pb age and Hf–O isotopes of detrital zircons from Hainan Island: implications for Mesozoic subduction models. *Lithos* 239, 60–70.
- Jin, C., Li, S., Wang, Y., Zhang, G., Liu, L., Wang, J., 2009. Diachronous and progressive deformation during the Indosinian–Yanshanian movements of the Xuefeng Mountain intracontinental composite tectonic system. *Oil Gas Geol.* 30, 598–607.
- Jones, R.R., Holdsworth, R.E., Bailey, W., 1997. Lateral extrusion in transpression zones: the importance of boundary conditions. *J. Struct. Geol.* 19, 1201–1217.
- Kaislaniemi, L., Van Hunen, J., Allen, M., Neill, I., 2014. Sublithospheric small-scale convection—a mechanism for collision zone magmatism. *Geology* 42, 291–294.
- Kapp, P., DeCelles, P., Leier, A., Fabijanic, J., He, S., Pullen, A., Gehrels, G., Ding, L., 2007. The Gangdese retroarc thrust belt revealed. *GSA Today* 17, 4.
- Kong, H., Li, H., Wu, Q.-H., Xi, X.-S., Dick, J.M., Gabo-Ratio, J.A.S., 2018. Co-development of Jurassic I-type and A-type granites in southern Hunan, South China: dual control by plate subduction and intraplate mantle upwelling. *Geochemistry* 78, 500–520.
- Kong, J.-T., Xu, Z.-J., Tao, G.-Z., Cheng, R.-H., Wang, L.-L., 2022. U–Pb geochronology of Upper Triassic–Lower Jurassic detrital sequences from SE margin of the South China Block: implications for Palaeo-Pacific subduction and tectonic evolution. *Geol. Mag.* 159, 833–852.
- Lehrmann, D.J., Jiayong, W., Enos, P., 1998. Controls on facies architecture of a large Triassic carbonate platform; the Great Bank of Guizhou, Nanpanjiang Basin, South China. *J. Sediment. Res.* 68, 311–326.
- Li, Z.-X., Li, X.-H., 2007. Formation of the 1300-km-wide intracontinental orogen and postorogenic magmatic province in Mesozoic South China: a flat-slab subduction model. *Geology* 35, 179–182.
- Li, P., Li, H., 2015. Geochronological, sedimentary, structural, and metallogenic characteristics of Southeast China during the Mesozoic: a general review. *Int. J. Geosci.* 6, 1032.
- Li, X.-H., Li, Z.-X., Li, W.-X., Liu, Y., Yuan, C., Wei, G., Qi, C., 2007. U–Pb zircon, geochemical and Sr–Nd–Hf isotopic constraints on age and origin of Jurassic I- and A-type granites from central Guangdong, SE China: a major igneous event in response to foundering of a subducted flat-slab? *Lithos* 96, 186–204.
- Li, L.M., Sun, M., Xing, G.F., Zhao, G.C., Zhou, M.F., Wong, J., Chen, R., 2009. Two late Mesozoic volcanic events in Fujian Province: constraints on the tectonic evolution of southeastern China. *Int. Geol. Rev.* 51, 216–251.
- Li, J., Zhang, Y., Dong, S., Li, H., 2012a. Late Mesozoic–Early Cenozoic deformation history of the Yuanma Basin, central South China. *Tectonophysics* 570, 163–183.
- Li, S., Santosh, M., Zhao, G., Zhang, G., Jin, C., 2012b. Intracontinental deformation in a frontier of super-convergence: a perspective on the tectonic milieu of the South China Block. *J. Asian Earth Sci.* 49, 313–329.
- Li, X.-H., Li, Z.-X., He, B., Li, W.-X., Li, Q.-L., Gao, Y., Wang, X.-C., 2012c. The Early Permian active continental margin and crustal growth of the Cathaysia Block: in situ U–Pb, Lu–Hf and O isotope analyses of detrital zircons. *Chem. Geol.* 328, 195–207.
- Li, J., Zhang, Y., Dong, S., Su, J., Li, Y., Cui, J., Shi, W., 2013. The Hengshan low-angle normal fault zone: Structural and geochronological constraints on the Late Mesozoic crustal extension in South China. *Tectonophysics* 606, 97–115.
- Li, J., Zhang, Y., Dong, S., Johnston, S.T., 2014a. Cretaceous tectonic evolution of South China: a preliminary synthesis. *Earth Sci. Rev.* 134, 98–136.
- Li, W., Liu, S., Qian, T., Dou, G., Gao, T., 2014b. Analysis of structural deformation in the North Dabashan thrust belt, South Qinling, central China. *Int. Geol. Rev.* 56, 1276–1294.
- Li, Z., Qiu, J.-S., Yang, X.-M., 2014c. A review of the geochronology and geochemistry of Late Yanshanian (Cretaceous) plutons along the Fujian coastal area of southeastern China: implications for magma evolution related to slab break-off and rollback in the Cretaceous. *Earth Sci. Rev.* 128, 232–248.
- Li, C., He, D., Sun, Y., He, J., Jiang, Z., 2015a. Structural characteristic and origin of intra-continental fold belt in the eastern Sichuan basin, South China Block. *J. Asian Earth Sci.* 111, 206–221.
- Li, J., Dong, S., Yin, A., Zhang, Y., Shi, W., 2015b. Mesozoic tectonic evolution of the Daba Shan Thrust Belt in the southern Qinling orogen, central China: constraints from surface geology and reflection seismology. *Tectonics* 34, 1545–1575.
- Li, Y., Dong, S., Zhang, Y., Li, J., Su, J., Han, B., 2016. Episodic Mesozoic constructional events of central South China: constraints from lines of evidence of superimposed folds, fault kinematic analysis, and magma geochronology. *Int. Geol. Rev.* 58, 1076–1107.
- Li, J., Zhang, Y., Zhao, G., Johnston, S.T., Dong, S., Koppers, A., Miggins, D.P., Sun, H., Wang, W., Xin, Y., 2017a. New insights into Phanerozoic tectonics of South China: Early Paleozoic sinistral and Triassic dextral transpression in the east Wuyishan and Chencai domains, NE Cathaysia. *Tectonics* 36, 819–853.
- Li, J., Zhao, G., Johnston, S.T., Dong, S., Zhang, Y., Xin, Y., Wang, W., Sun, H., Yu, Y., 2017b. Permo-Triassic structural evolution of the Shiwandashan and Youjiang structural belts, South China. *J. Struct. Geol.* 100, 24–44.
- Li, J., Dong, S., Cawood, P.A., Zhao, G., Johnston, S.T., Zhang, Y., Xin, Y., 2018a. An Andean-type retro-arc foreland system beneath northwest South China revealed by SINOPROBE profiling. *Earth Planet. Sci. Lett.* 490, 170–179.
- Li, X.-Y., Li, S.-Z., Suo, Y.-H., Dai, L.-M., Guo, L.-L., Ge, F.-J., Lin, P.-J., 2018b. Late Cretaceous basalts and rhyolites from Shimaoshan Group in eastern Fujian Province, SE China: age, petrogenesis, and tectonic implications. *Int. Geol. Rev.* 60, 1721–1743.
- Li, X.-Y., Li, S.-Z., Suo, Y.-H., Dai, L.-M., Guo, L.-L., Ge, F.-J., Lin, P.-J., 2018c. Late Cretaceous basalts and rhyolites from Shimaoshan Group in eastern Fujian Province, SE China: age, petrogenesis, and tectonic implications. *Int. Geol. Rev.* 60, 1721–1743.
- Li, S., Suo, Y., Li, X., Zhou, J., Santosh, M., Wang, P., Wang, G., Guo, L., Yu, S., Lan, H., 2019. Mesozoic tectono-magmatic response in the East Asian ocean-continent connection zone to subduction of the Paleo-Pacific Plate. *Earth Sci. Rev.* 192, 91–137.
- Li, J., Cawood, P.A., Ratschbacher, L., Zhang, Y., Dong, S., Xin, Y., Yang, H., Zhang, P., 2020a. Building Southeast China in the late Mesozoic: insights from alternating episodes of shortening and extension along the Lianhuashan fault zone. *Earth Sci. Rev.* 201, 103056.
- Li, S., Li, Y., He, Z., Chen, K., Zhou, Y., Yan, D., 2020b. Differential deformation on two sides of Qiyeshan Fault along the eastern margin of Sichuan Basin, China, and its influence on shale gas preservation. *Mar. Pet. Geol.* 121, 104602.

- Li, C., Wang, Z., Lü, Q., Tan, Y., Li, L., Tao, T., 2021. Mesozoic tectonic evolution of the eastern South China Block: a review on the synthesis of the regional deformation and magmatism. *Ore Geol. Rev.* 131, 104028.
- Li, L., Lin, S., Xing, G., Xiao, F., Xiao, W., 2022a. Identification of ca. 520 Ma mid-ocean-ridge-type ophiolite suite in the inner Cathaysia block, South China: evidence from shearing-type oceanic plagiogranite. *Geol. Soc. Am. Bull.* 134, 1701–1720.
- Li, J., Zhang, Y., Ratschbacher, L., Zhao, G., Dong, S., Xin, Y., Lü, F., 2022b. Polyphase deformation in the Badu complex: Insights into Triassic intraplate orogeny in South China. *J. Struct. Geol.* 154, 104475.
- Li, C., Wang, Z., Tan, Y., Li, L., 2023a. Differential fold interference patterns in an intracontinental orogen: insights from superposed buckle folding in southern Jiangxi Province, South China Block. *J. Struct. Geol.* 167, 104801.
- Li, J., Dong, S., Cawood, P.A., Thybo, H., Clift, P.D., Johnston, S.T., Zhao, G., Zhang, Y., 2023b. Cretaceous long-distance lithospheric extension and surface response in South China. *Earth Sci. Rev.* 243, 104496.
- Li, J., Dong, S., Zhao, G., Cawood, P.A., Johnston, S.T., Zhang, J., Xin, Y., Wang, J., 2024. Cretaceous coastal mountain building and potential impacts on climate change in East Asia. *Sci. Adv.* 10, eads0587.
- Li, S., Zheng, Y.-F., Suo, Y., 2025. Reconstructing the framework of the Paleo-Pacific Plate: a synthetic review. *J. Struct. Geol.* 199, 105505.
- Li, J.W., Zhou, M.F., Li, X.F., Fu, Z.R., Li, Z.J., 2001. The Hunan-Jiangxi strike-slip fault system in southern China: southern termination of the Tan-Lu fault. *J. Geodynamics* 32, 333–354.
- Liang, C., Luo, B., Xu, X., Chen, J., Xu, Y., 2023. Geochronology, petrogenesis and tectonic implications of Late Triassic and Late Jurassic granitoids in the South China Block. *J. Asian Earth Sci.* 250, 105651.
- Lin, W., Faure, M., Monié, P., Schärer, U., Zhang, L., Sun, Y., 2000. Tectonics of SE China: new insights from the Lushan massif (Jiangxi Province). *Tectonics* 19, 852–871.
- Liu, X.C., Hu, G.H., Hu, F.F., Wang, H., Wang, Y., 2025. Genetic links of crustal radiogenic heating to peraluminous granites. *Lithos* 504, 108028.
- Liu, S., Li, Z., Liu, S., Luo, Y., Xu, G., Dai, G., Jong, C., Yong, Z., 2006. Formation and Evolution of Dabashan Foreland Basin and Fold-and-Thrust Belt, Sichuan, China. Geological House, Beijing, pp. 1–248.
- Liu, L., Xu, X., Xia, Y., 2014. Cretaceous Pacific plate movement beneath SE China: Evidence from episodic volcanism and related intrusions. *Tectonophysics* 614, 170–184.
- Liu, L., Xu, X., Zou, H., 2012a. Episodic eruptions of the Late Mesozoic volcanic sequences in southeastern Zhejiang, SE China: Petrogenesis and implications for the geodynamics of paleo-Pacific subduction. *Lithos* 154, 166–180.
- Liu, Q., Yu, J.-H., Wang, Q., Su, B., Zhou, M.-F., Xu, H., Cui, X., 2012b. Ages and geochemistry of granites in the Pingtan–Dongshan Metamorphic Belt, Coastal South China: new constraints on Late Mesozoic magmatic evolution. *Lithos* 150, 268–286.
- Liu, H., Martelet, G., Wang, B., Erdmann, S., Chen, Y., Faure, M., Huang, F., Scaillet, B., le Breton, N., Shu, L., 2018. Incremental emplacement of the Late Jurassic midcrustal, lopolith-like Qitianling pluton, South China, revealed by AMS and Bouguer gravity data. *J. Geophys. Res. Solid Earth* 123, 9249–9268.
- Liu, J.-X., Wang, S., Wang, X.-L., Du, D.-H., Xing, G.-F., Fu, J.-M., Chen, X., Sun, Z.-M., 2020. Refining the spatio-temporal distributions of Mesozoic granitoids and volcanic rocks in SE China. *J. Asian Earth Sci.* 201, 104503.
- Mao, J., Xie, G., Pirajno, F., Ye, H., Wang, Y., Li, Y., Xiang, J., Zhao, H., 2010. Late Jurassic–Early Cretaceous granitoid magmatism in Eastern Qinling, central-eastern China: SHRIMP zircon U–Pb ages and tectonic implications. *Aust. J. Earth Sci.* 57, 51–78.
- Lu, Y., Cao, J., Fu, J., Yang, X., Yang, Q., Guo, J., Cheng, S., Qin, Z., Zhang, Z., Zhang, T., 2021. Petrogenesis of the granite related to the Dashunlong Sn polymetallic deposit, Dayishan ore field, South China. *Ore Geol. Rev.* 139, 104478.
- Lu, Y., Zhu, G., Yin, H., Su, N., Wu, X., Zhang, S., Xie, C., 2022. Superposition of two orthogonal transpressions: an example from the oblique convergent margin adjoining the Tan-Lu Fault Zone, eastern China. *Tectonophysics* 836, 229415.
- Mao, J., Cheng, Y., Chen, M., Pirajno, F., 2013. Major types and time-space distribution of Mesozoic ore deposits in South China and their geodynamic settings. *Mineral. Deposita* 48, 267–294.
- Martinez, F., Fuentes, G., Perroud, S., Bascuñán, S., 2021. Buried thrust belt front of the western Central Andes of northern Chile: style, age, and relationship with basement heterogeneities. *J. Struct. Geol.* 147, 104337.
- McKenzie, D., Priestley, K., 2008. The influence of lithospheric thickness variations on continental evolution. *Lithos* 102, 1–11.
- McKenzie, D., Nimmo, F., Jackson, J.A., Gans, P., Miller, E., 2000. Characteristics and consequences of flow in the lower crust. *J. Geophys. Res. Solid Earth* 105, 11029–11046.
- McQuarrie, N., Horton, B.K., Zandt, G., Beck, S., DeCelles, P.G., 2005. Lithospheric evolution of the Andean fold–thrust belt, Bolivia, and the origin of the central Andean plateau. *Tectonophysics* 399, 15–37.
- Metcalfe, I., 2021. Multiple Tethyan ocean basins and orogenic belts in Asia. *Gondwana Res.* 100, 87–130.
- Molnar, P., Lyon-Caen, H., 1988. Some simple physical aspects of the support, structure, and evolution of mountain belts. In: Clark, S.P., Burchfiel, B.C., Suppe, J. (Eds.), *Processes in Continental Lithospheric Deformation*, GSA Special Paper, pp. 179–207.
- Nissen, E., Tatar, M., Jackson, J.A., Allen, M.B., 2011. New views on earthquake faulting in the Zagros fold-and-thrust belt of Iran. *Geophys. J. Int.* 186, 928–944.
- Pang, C.-J., Krapez, B., Li, Z.-X., Xu, Y.-G., Liu, H.-Q., Cao, J., 2014. Stratigraphic evolution of a Late Triassic to Early Jurassic intracontinental basin in southeastern South China: a consequence of flat-slab subduction? *Sediment. Geol.* 302, 44–63.
- Pang, C.-J., Li, Z.-X., Xu, Y.-G., Wen, S.-N., Krapez, B., 2016. Climatic and tectonic controls on late Triassic to Middle Jurassic sedimentation in northeastern Guangdong province, South China. *Tectonophysics* 677, 68–87.
- Peng, P., Mitchell, R.N., Chen, Y., 2022. Earth's one-of-a-kind fault: the Tanlu fault. *Terra Nova* 34, 381–394.
- Qi, Y., Hu, R., Liu, S., Coulson, I.M., Qi, H., Tian, J., Zhu, J., 2016. Petrogenesis and geodynamic setting of Early Cretaceous mafic–ultramafic intrusions, South China: A case study from the Gan–Hang tectonic belt. *Lithos* 258, 149–162.
- Qin, J.-F., Lai, S.-C., Diwu, C.-R., Ju, Y.-J., Li, Y.-F., 2010. Magma mixing origin for the post-collisional adakitic monzogranite of the Triassic Yangba pluton, Northwestern margin of the South China block: geochemistry, Sr–Nd isotopic, zircon U–Pb dating and Hf isotopic evidences. *Contrib. Mineral. Petrol.* 159, 389–409.
- Qiu, L., Yan, D.-P., Tang, S.-L., Wang, Q., Yang, W.-X., Tang, X., Wang, J., 2016. Mesozoic geology of southwestern China: Indosinian foreland overthrusting and subsequent deformation. *J. Asian Earth Sci.* 122, 91–105.
- Scott, E.M., Allen, M.B., Macpherson, C.G., McCaffrey, K.J., Davidson, J.P., Saville, C., Ducea, M.N., 2018. Andean surface uplift constrained by radiogenic isotopes of arc lavas. *Nat. Commun.* 9, 969.
- Shao, L., Wang, X., Wang, D., Li, M., Wang, S., Li, Y., Shao, K., Zhang, C., Gao, C., Dong, D., 2020. Sequence stratigraphy, paleogeography, and coal accumulation regularity of major coal-accumulating periods in China. *Int. J. Coal Sci. Technol.* 7, 240–262.
- Shi, J., Zhang, S., 2010. Characters of the Mesozoic tectonic activity and geotectonic setting of the Changle–Nan’ao fault zone. *J. Jilin Univ. (Earth Sci. Ed.)* 40, 1333–1343.
- Shi, W., Dong, S., Zhang, Y., Huang, S., 2015. The typical large-scale superposed folds in the central South China: implications for Mesozoic intracontinental deformation of the South China Block. *Tectonophysics* 664, 50–66.
- Shi, H., Shi, X., Glasmacher, U.A., Yang, X., Stockli, D.F., 2016. The evolution of eastern Sichuan basin, Yangtze block since Cretaceous: constraints from low temperature thermochronology. *J. Asian Earth Sci.* 116, 208–221.
- Shu, L., Sun, Y., Wang, D., Faure, M., Monié, P., Charvet, J., 1998. Mesozoic doming extensional tectonics of Wugongshan, South China. *Sci. China Ser. D Earth Sci.* 41, 601–608.
- Shu, L., Zhou, X., Deng, P., Wang, B., Jiang, S., Yu, J., Zhao, X., 2009. Mesozoic tectonic evolution of the Southeast China Block: new insights from basin analysis. *J. Asian Earth Sci.* 34, 376–391.
- Shu, L., Wang, B., Cawood, P.A., Santosh, M., Xu, Z., 2015. Early Paleozoic and Early Mesozoic intraplate tectonic and magmatic events in the Cathaysia Block, South China. *Tectonics* 34, 1600–1621.
- Shu, L., Yao, J., Wang, B., Faure, M., Charvet, J., Chen, Y., 2021. Neoproterozoic plate tectonic process and Phanerozoic geodynamic evolution of the South China Block. *Earth Sci. Rev.* 216, 103596.
- Sobel, E.R., Hilley, G.E., Strecker, M.R., 2003. Formation of internally drained contractional basins by aridity-limited bedrock incision. *J. Geophys. Res. Solid Earth* 108 (B7), 2344. <https://doi.org/10.1029/2002JB001883>.
- Song, M., Shu, L., Santosh, M., 2016. Early Mesozoic granites in the Nanling Belt, South China: implications for intracontinental tectonics associated with stress regime transformation. *Tectonophysics* 676, 148–169.
- Song, M., Shu, L., Santosh, M., 2017. Early Mesozoic intracontinental orogeny and stress transmission in South China: evidence from Triassic peraluminous granites. *J. Geol. Soc. Lond.* 174, 591–607.
- Su, J., Dong, S., Zhang, Y., Ma, L., Chen, X., 2018. Geochronology, geochemistry, and tectonic implications of Jishou Cretaceous diabase, western Xuefengshan tectonic zone in South China. *Geol. J.* 53, 1186–1199.
- Sun, L.-Q., Ling, H.-F., Shen, W.-Z., Wang, K.-X., Huang, G.-L., 2017. Petrogenesis of two Triassic A-type intrusions in the interior of South China and their implications for tectonic transition. *Lithos* 284, 642–653.
- Suo, Y., Li, S., Jin, C., Zhang, Y., Zhou, J., Li, X., Wang, P., Liu, Z., Wang, X., Somerville, I., 2019. Eastward tectonic migration and transition of the Jurassic–Cretaceous Andean-type continental margin along Southeast China. *Earth Sci. Rev.* 196, 102884.
- Tang, Y., Wang, Q., Yang, Y.L., Zhou, Y.L., Cui, X.d., Zou, H., 2022. Petrogenesis and geodynamic implications of the Baimashan granitic complex in central Hunan, South China. *Geol. J.* 57, 4718–4745.
- Tibaldi, A., Bonali, F., 2018. Contemporary recent extension and compression in the central Andes. *J. Struct. Geol.* 107, 73–92.
- Tong, J., Liu, Z., 2000. Middle Triassic stratigraphy and sedimentary paleogeography of South China. *J. Earth Sci.* 11, 264–270.
- Torsvik, T.H., Steinberger, B., Shephard, G.E., Doubrovine, P.V., Gaina, C., Domeier, M., Conrad, C.P., Sager, W.W., 2019. Pacific–Panthalassic reconstructions: overview, errata and the way forward. *Geochim. Geophys. Geosyst.* 20, 3659–3689.
- Wang, D., Shu, L., 2012. Late Mesozoic basin and range tectonics and related magmatism in Southeast China. *Geosci. Front.* 3, 109–124.
- Wang, S., Yan, J., 2021. Coexisting Early Cretaceous arc-type and OIB-type mafic magmatic rocks in the eastern Jiangnan Orogen, South China Block: implications for paleo-Pacific plate subduction. *Lithos* 400, 106421.
- Wang, Y., Fan, W., Guo, F., Peng, T., Li, C., 2003. Geochemistry of Mesozoic mafic rocks adjacent to the Chenzhou–Linwu fault, South China: implications for the lithospheric boundary between the Yangtze and Cathaysia blocks. *Int. Geol. Rev.* 45, 263–286.
- Wang, Y., Fan, W., Liang, X., Peng, T., Shi, Y., 2005a. SHRIMP zircon U–Pb geochronology of Indosinian granites in Hunan Province and its petrogenetic implications. *Chin. Sci. Bull.* 50, 1395–1403.
- Wang, Y., Fan, W., Peng, T., Guo, F., 2005b. Elemental and Sr–Nd isotopic systematics of the early Mesozoic volcanic sequence in southern Jiangxi Province, South China: petrogenesis and tectonic implications. *Int. J. Earth Sci.* 94, 53–65.
- Wang, Y., Zhang, Y., Fan, W., Peng, T., 2005c. Structural signatures and $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology of the Indosinian Xuefengshan tectonic belt, South China Block. *J. Struct. Geol.* 27, 985–998.

- Wan, L., Jin, W., Kusky, T., Tian, Y., Wang, J., Ke, X., Long, W., Yang, J., Sun, X., Chen, C., 2024. Late Jurassic granitoids in Mufushan complex and their significance for the Mesozoic tectonic evolution of eastern South China. *Lithos* 482, 107707.
- Wang, Y., Fan, W., Cawood, P.A., Ji, S., Peng, T., Chen, X., 2007a. Indosinian high-strain deformation for the Yunkaidashan tectonic belt, south China: kinematics and $^{40}\text{Ar}/^{39}\text{Ar}$ geochronological constraints. *Tectonics* 26, TC6008. <https://doi.org/10.1029/2007TC002099>.
- Wang, Y., Fan, W., Sun, M., Liang, X., Zhang, Y., Peng, T., 2007b. Geochronological, geochemical and geothermal constraints on petrogenesis of the Indosinian peraluminous granites in the South China Block: a case study in the Hunan Province. *Lithos* 96, 475–502.
- Wang, X.L., Shu, X.J., Xu, X., Tang, M., Gaschnig, R., 2012. Petrogenesis of the Early Cretaceous adakite-like porphyries and associated basaltic andesites in the eastern Jiangnan orogen, southern China. *J. Asian Earth Sci.* 61, 243–256.
- Wang, Y., Fan, W., Zhang, G., Zhang, Y., 2013. Phanerozoic tectonics of the South China Block: key observations and controversies. *Gondwana Res.* 23, 1273–1305.
- Wang, G.-C., Jiang, Y.-H., Liu, Z., Ni, C.-Y., Qing, L., Zhang, Q., 2015a. Elemental and Sr-Nd-Hf isotopic constraints on the origin of Late Jurassic adakitic granodiorite in central Fujian province, southeast China. *Mineral. Petrol.* 109, 501–518.
- Wang, L.-X., Ma, C.-Q., Lai, Z.-X., Marks, M.A., Zhang, C., Zhong, Y.-F., 2015b. Early Jurassic mafic dykes from the Xiazhuang ore district (South China): implications for tectonic evolution and uranium metallogenesis. *Lithos* 239, 71–85.
- Wang, L.-X., Ma, C.-Q., Zhang, C., Zhu, Y.-X., Marks, M.A., 2018a. Halogen geochemistry of I- and A-type granites from Jiuhuashan region (South China): insights into the elevated fluorine in A-type granite. *Chem. Geol.* 478, 164–182.
- Wang, Y., Zhang, J., Zhang, B., Zhao, H., 2018b. Cenozoic exhumation history of South China: a case study from the Xuefeng Mt. Range. *J. Asian Earth Sci.* 151, 173–189.
- Wang, P., Zheng, H., Liu, S., Hoke, G., 2018c. Late Cretaceous drainage reorganization of the middle Yangtze River. *Lithosphere* 10, 392–405.
- Wang, Y., Wang, Y., Zhang, Y., Cawood, P.A., Qian, X., Gan, C., Zhang, F., Zhang, P., 2021. Triassic two-stage intra-continental orogenesis of the South China Block, driven by Paleotethyan closure and interactions with adjoining blocks. *J. Asian Earth Sci.* 206, 104648.
- Wang, L.-J., Lin, S.-F., Xiao, W.-J., 2023. Yangtze and Cathaysia blocks of South China: their separate positions in Gondwana until early Paleozoic juxtaposition. *Geology* 51, 723–727.
- Wang, C., Song, S., Zhao, G., Allen, M.B., Su, L., Ackerman, L., Sláma, J., Zhang, D., Wen, T., Feng, D., Strnad, L., 2024. Tracing DUPAL anomaly evolution in the Tethyan-Indian oceanic mantle. *Geochim. Cosmochim. Acta* 368, 50–63.
- Wang, Y., Yang, J., Liu, X., Yu, H., Li, Z., Li, T., Xu, Z., Yuan, Y., 2025. Late Jurassic to Early Cretaceous mafic to felsic magmatism reveals the coupled processes of crustal growth and thinning in Southeast China. *Geochemistry* 85, 126314.
- Wei, W., Faure, M., Chen, Y., Ji, W., Lin, W., Wang, Q., Yan, Q., Hou, Q., 2015. Back-thrusting response of continental collision: Early Cretaceous NW-directed thrusting in the Changle-Nan'ao belt (Southeast China). *J. Asian Earth Sci.* 100, 98–114.
- Wei, W., Liu, C.Z., Hou, Y.F., Deng, C.L., Yan, W., Li, X.H., Chung, S.L., Mitchell, R.N., 2022. Discovery of a hidden Triassic Arc in the Southern South China Sea: evidence for the breakaway of a ribbon continent with implications for the evolution of the Western Pacific margin. *Terra Nova* 34, 12–19.
- Wei, J., Le, W., Yang, T., Kusky, T., Jing, W., Xianzhong, K., Jie, Y., Wenguo, L., 2023a. Petrogenesis of early Cretaceous granites in Mufushan complex, northeastern Hunan Province: insights on middle-late Mesozoic tectonic evolution of eastern South China. *Lithos* 456, 107296.
- Wei, W., Lin, W., Chen, Y., Faure, M., Ji, W., Hou, Q., Yan, Q., Wang, Q., 2023b. Tectonic controls on magmatic tempo in an active continental margin: insights from the Early Cretaceous syn-tectonic magmatism in the Changle-Nan'ao Belt, South China. *J. Geophys. Res.* Solid Earth 128, e2022JB025973.
- Wimpenny, S., Copley, A., Benavente, C., Aguirre, E., 2018. Extension and dynamics of the Andes inferred from the 2016 Parí (Huarichancara) earthquake. *J. Geophys. Res.* Solid Earth 123, 8198–8228.
- Wimpenny, S., Benavente, C., Copley, A., Garcia, B., Rosell, L., O'Kane, A., Aguirre, E., 2020. Observations and dynamical implications of active normal faulting in South Peru. *Geophys. J. Int.* 222, 27–53.
- Wu, L., Mei, L., Paton, D.A., Liu, Y., Shen, C., Liu, Z., Luo, J., Min, C., Li, M., Wen, H., 2020. Basement structures have crucial influence on rift development: insights from the Jiangnan Basin, Central China. *Tectonics* 39, e2019TC005671.
- Wu, J., Li, H., Danišik, M., Yonezu, K., Zheng, H., Li, Z., 2023. Low-Temperature thermochronological perspective on geodynamic evolution of the Cathaysia Block since early Mesozoic. *Tectonics* 42, e2022TC007662.
- Xi, Z., Zhang, Y., Liu, Z., Li, H., Liu, F., 2025. Petrogenesis and geodynamics of the Dashenshan I-type granite and its implications for the Triassic tectonic evolution of the South China Block. *Acta Geochim.* 44, 673–699.
- Xia, X.-P., Xu, J., Huang, C., Long, X., Zhou, M., 2020. Subduction polarity of the Ailaoshan Ocean (eastern Paleotethys): constraints from detrital zircon U-Pb and Hf-O isotopes for the Longtan Formation. *Bulletin* 132, 987–996.
- Xiao, W., He, H., 2005. Early Mesozoic thrust tectonics of the northwest Zhejiang region (Southeast China). *Geol. Soc. Am. Bull.* 117, 945–961.
- Xu, X., 2023. Late Triassic to middle Jurassic tectonic evolution of the South China block: geodynamic transition from the paleo-Tethys to the paleo-Pacific regimes. *Earth Sci. Rev.* 241, 104404.
- Xu, X., Zhang, Y., Shu, L., Jia, D., 2011. La-ICP-MS U-Pb and $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology of the sheared metamorphic rocks in the Wuyishan: constraints on the timing of Early Paleozoic and Early Mesozoic tectono-thermal events in SE China. *Tectonophysics* 501, 71–86.
- Xu, Y.-J., Cawood, P.A., Du, Y.-S., 2016. Intraplate orogenesis in response to Gondwana assembly: Kwangsi orogeny, South China. *Am. J. Sci.* 316, 329–362.
- Xu, C., Zhang, L., Shi, H., Brix, M.R., Huhma, H., Chen, L., Zhang, M., Zhou, Z., 2017. Tracing an early Jurassic magmatic arc from South to East China Seas. *Tectonics* 36, 466–492.
- Xu, X., Zaza, A.V., Chen, L., Zhu, W., Yin, A., Fu, X., Gao, S., Xu, X., Kuang, X., Zhang, F., 2021. Late Cretaceous to early Cenozoic extension in the Lower Yangtze region (East China) driven by Izanagi-Pacific plate subduction. *Earth Sci. Rev.* 221, 103790.
- Xu, J., Xia, X.-P., Wang, Q., Spencer, C.J., He, B., Lai, C.-K., 2022. Low- $\delta^{18}\text{O}$ A-type granites in SW China: evidence for the interaction between the subducted Paleotethyan slab and the Emeishan mantle plume. *Bulletin* 134, 81–93.
- Xu, C., Deng, Y., Barnes, C.G., Shi, H., Pascal, C., Li, Y., Gao, S., Jiang, D., Xie, J., Ma, C., 2023. Offshore-onshore tectonomagmatic correlations: towards a Late Mesozoic non-Andean-type Cathaysian continental margin. *Earth Sci. Rev.* 240, 104382.
- Yan, D.-P., Zhou, M.-F., Song, H.-L., Wang, X.-W., Malpas, J., 2003. Origin and tectonic significance of a Mesozoic multi-layer over-thrust system within the Yangtze Block (South China). *Tectonophysics* 361, 239–254.
- Yan, D.-P., Zhang, B., Zhou, M.-F., Wei, G., Song, H.-L., Liu, S.-F., 2009. Constraints on the depth, geometry and kinematics of blind detachment faults provided by fault-propagation folds: an example from the Mesozoic fold belt of South China. *J. Struct. Geol.* 31, 150–162.
- Yan, D.-P., Qiu, L., Wells, M.L., Zhou, M.-F., Meng, X., Lu, S., Zhang, S., Wang, Y., Li, S.-B., 2018. Structural and geochronological constraints on the Early Mesozoic North Longmen Shan Thrust Belt: foreland fold-thrust propagation of the SW Qinling Orogenic Belt, Northeastern Tibetan Plateau. *Tectonics* 37, 4595–4624.
- Yan, Q.-H., Wang, H., Wu, Y., Chi, G., 2021. Simultaneous development of arc-like and OIB-like mafic dikes in eastern Guangdong, SE China: implications for late Jurassic–early Cretaceous tectonic setting and deep geodynamic processes of South China. *Lithos* 388, 106021.
- Yang, D.-S., Li, X.-H., Li, W.-X., Liang, X.-Q., Long, W.-G., Xiong, X.-L., 2010. U-Pb and ^{40}Ar – ^{39}Ar geochronology of the Baiyunshan gneiss (central Guangdong, South China): constraints on the timing of early Palaeozoic and Mesozoic tectonothermal events in the Wuyun (Wuyi-Yunkai) Orogen. *Geol. Mag.* 147, 481–496.
- Yang, J., Bai, D., Wang, X., He, J., 2015. Zircon SHRIMP U-Pb dating and geochemistry of Caledonian Baimashan pluton and its tectonic significance. *Geol. Miner. Resour. South China* 31, 48–56.
- Yang, W.X., Yan, D.P., Qiu, L., Wells, M.L., Dong, J.M., Gao, T., Zhang, Z., Mu, H., Wang, X., Wang, F., 2021. Formation and forward propagation of the Indosinian foreland fold-thrust belt and Nanpanjiang foreland basin in SW China. *Tectonics* 40, e2020TC006552.
- Yang, F., Song, C., Ren, S., Ji, M., 2022. The Mesozoic tectonic transition from compression to extension in the South China block: insight from structural deformation of the Lushan massif, SE China. *Minerals* 12, 1531.
- Ye, H.-M., Mao, J.-R., Zhao, X.-L., Liu, K., Chen, D.-D., 2013. Revisiting Early-Middle Jurassic igneous activity in the Nanling Mountains, South China: geochemistry and implications for regional geodynamics. *J. Asian Earth Sci.* 72, 108–117.
- Yong, L., Allen, P.A., Densmore, A.L., Qiang, X., 2003. Evolution of the Longmen Shan foreland basin (western Sichuan, China) during the Late Triassic Indosinian orogeny. *Basin Res.* 15, 117–138.
- Yu, Y., Xu, B., Chen, J., Dong, C., 2001. Nd isotopic systematics of the Late Mesozoic volcanic rocks from southeastern Zhejiang Province, China: implications for stratigraphic study. *Geol. J. China Univ.* 7, 62.
- Zhang, K.-J., Cai, J.-X., 2009. NE-SW-trending Hepu-Hetai dextral shear zone in southern China: penetration of the Yunkai Promontory of South China into Indochina. *J. Struct. Geol.* 31, 737–748.
- Zhang, X., Zhang, H., Wilde, S.A., Yang, Y., Chen, H., 2010. Late Permian to Early Triassic mafic to felsic intrusive rocks from North Liaoning, North China: petrogenesis and implications for Phanerozoic continental crustal growth. *Lithos* 117, 283–306.
- Zhang, G., Guo, A., Wang, Y., Li, S., Dong, Y., Liu, S., He, D., Cheng, S., Lu, R., Yao, A., 2013. Tectonics of South China continent and its implications. *Sci. China Earth Sci.* 56, 1804–1828.
- Zhang, C.-L., Santosh, M., Zhu, Q.-B., Chen, X.-Y., Huang, W.-C., 2015a. The Gondwana connection of South China: evidence from monazite and zircon geochronology in the Cathaysia Block. *Gondwana Res.* 28, 1137–1151.
- Zhang, Y., Zhang, J., Wang, Y., 2015b. Zircon SHRIMP U-Pb Dating on the Baimashan Granitic Composite Batholith from Hunan Province, South China. *Acta Geol. Sin. Eng. Ed.* 89, 1–17.
- Zhang, C.-L., Zhu, Q.-B., Chen, X.-Y., Ye, H.-M., 2016. Ordovician arc-related mafic intrusions in South China: implications for plate subduction along the southeastern margin of South China in the Early Paleozoic. *J. Geol.* 124, 743–767.
- Zhang, D., Zhao, K.-D., Chen, W., Jiang, S.-Y., 2018. Early Jurassic mafic dykes from the Aigao uranium ore deposit in South China: geochronology, petrogenesis and relationship with uranium mineralization. *Lithos* 308, 118–133.
- Zhang, L., Chen, Z., Wang, F., Zhou, T., 2021. Whole-rock and biotite geochemistry of granites from the Miao'ershan batholith, South China: Implications for the sources of granite-hosted uranium ores. *Ore Geol. Rev.* 129, 103930.
- Zhang, B., Yao, S., Ma, A., Hu, W., Liu, B., Yang, W., 2022a. New geochemical constraints on the development of active continental margin in Southeast China during the Middle Permian and its tectonic implications. *Gondwana Res.* 103, 458–472.
- Zhang, W., Zhang, F.-Q., Dilek, Y., Zhu, K.-Y., Wu, H.-X., Chen, D.-X., Chen, H.-L., 2022b. Basin response to the Jurassic geodynamic turnover from flat subduction to normal subduction in South China. *GSA Bull.* 134, 1681–1700.
- Zhang, Q., Qiu, L., Yan, D.P., Li, M., Yang, T., Zhou, Z., Ariser, S., Yang, B., Wang, M., Zhao, X., 2025. Impact of slab rollback on the surface of overriding plate: Late Cretaceous extension and topographic evolution to the west of the Xuefeng orogen in the South China block. *Tectonics* 44, e2024TC008354.

- Zhao, H.-X., Jiang, S.-Y., Frimmel, H.E., Dai, B.-Z., Ma, L., 2012. Geochemistry, geochronology and Sr–Nd–Hf isotopes of two Mesozoic granitoids in the Xiaoqinling gold district: implication for large-scale lithospheric thinning in the North China Craton. *Chem. Geol.* 294, 173–189.
- Zhao, L., Tang, H., Mitchell, R., Li, Q., Zhou, X., Zhai, M., 2023. The joining of North and South China during the Permian: coherent metamorphic evidence from East Asia orogenesis. *Tectonics* 42, e2023TC007916.
- Zheng, J., Shan, Y., Hu, S., 2021. Paleostress analysis from calcite twins at the Longshan Dome (Central Hunan, South China): Mesozoic mega-fold superimposition in the reworked continent. *Geosciences* 11, 456.
- Zhou, Z., Lao, Q., Chen, H., Ding, S., Liao, Z., 1996. Early Mesozoic orogeny in Fujian, Southeast China. *Geol. Soc. Lond. Spec. Publ.* 106, 549–556.
- Zhou, X., Sun, T., Shen, W., Shu, L., Niu, Y., 2006. Petrogenesis of Mesozoic granitoids and volcanic rocks in South China: a response to tectonic evolution. *Episodes* 29, 26–33.
- Zhu, W.-G., Zhong, H., Li, X.-H., He, D.-F., Song, X.-Y., Ren, T., Chen, Z.-Q., Sun, H.-S., Liao, J.-Q., 2010. The early Jurassic mafic–ultramafic intrusion and A-type granite from northeastern Guangdong, SE China: age, origin, and tectonic significance. *Lithos* 119, 313–329.
- Zhu, W., Zhong, K., Fu, X., Chen, C., Zhang, M., Gao, S., 2019. The formation and evolution of the East China Sea Shelf Basin: a new view. *Earth Sci. Rev.* 190, 89–111.
- Zhu, S., Han, Y., Wang, Z., Ma, S., Liang, K., Zhang, L., Yao, Y., Tang, J., Xu, Z., Yang, C., 2025. Spatiotemporal distribution and mechanism of Mesozoic magmatism in the Taiwan Strait and its adjacent areas: insights from seismic, geochemical, and geochronological data. *Int. Geol. Rev.* 67, 440–471.