as a result of that a fine-grained sedimentation was interrupted by a sandy-shaly deposition. The Rybie sandstones, the Szydłowiec sandstones, the Gorzeń beds and the Czerwin sandstones are the effect of this sedimentation. At the end of Paleocene sedimentary conditions changes and are deposited muddy sediments called as green or variegated shales, which pass in to in marly shales with the Middle Eocene. The marly complex passes upwards into Globigerina Marls representing uppermost part of the Eocene.

The movement of Inner Carpathian terranes during Eocene-Oligocene led to the development of Outer Carpathian accretionary prism. This prism overrode the ridges, including the Sub-Silesian ridge. The ridge basement rocks and part of its depositional cover from olistostroms and exotic pebbles within Menilitic-Krosno flysch. The Oligocene begins in the Sub-Silesian realm with brown, bituminous shales (Menilite Beds) which grades upward into a complex of thick and medium bedded, calcareous sandstones and marly shales (Krosno Beds).

Finally, during the Miocene time the Outer Carpathian nappes were detached from the basement and thrust northward onto North European platform with its Miocene cover. The Subsilesian realm forms the present-day Subsilesian Nappe. The Outer Carpathian allochtonous rocks have been Overthrust onto the platform for a distance of 50 to more than 100 km.

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Phanerozoic Palaeogeography of Southeast Asia

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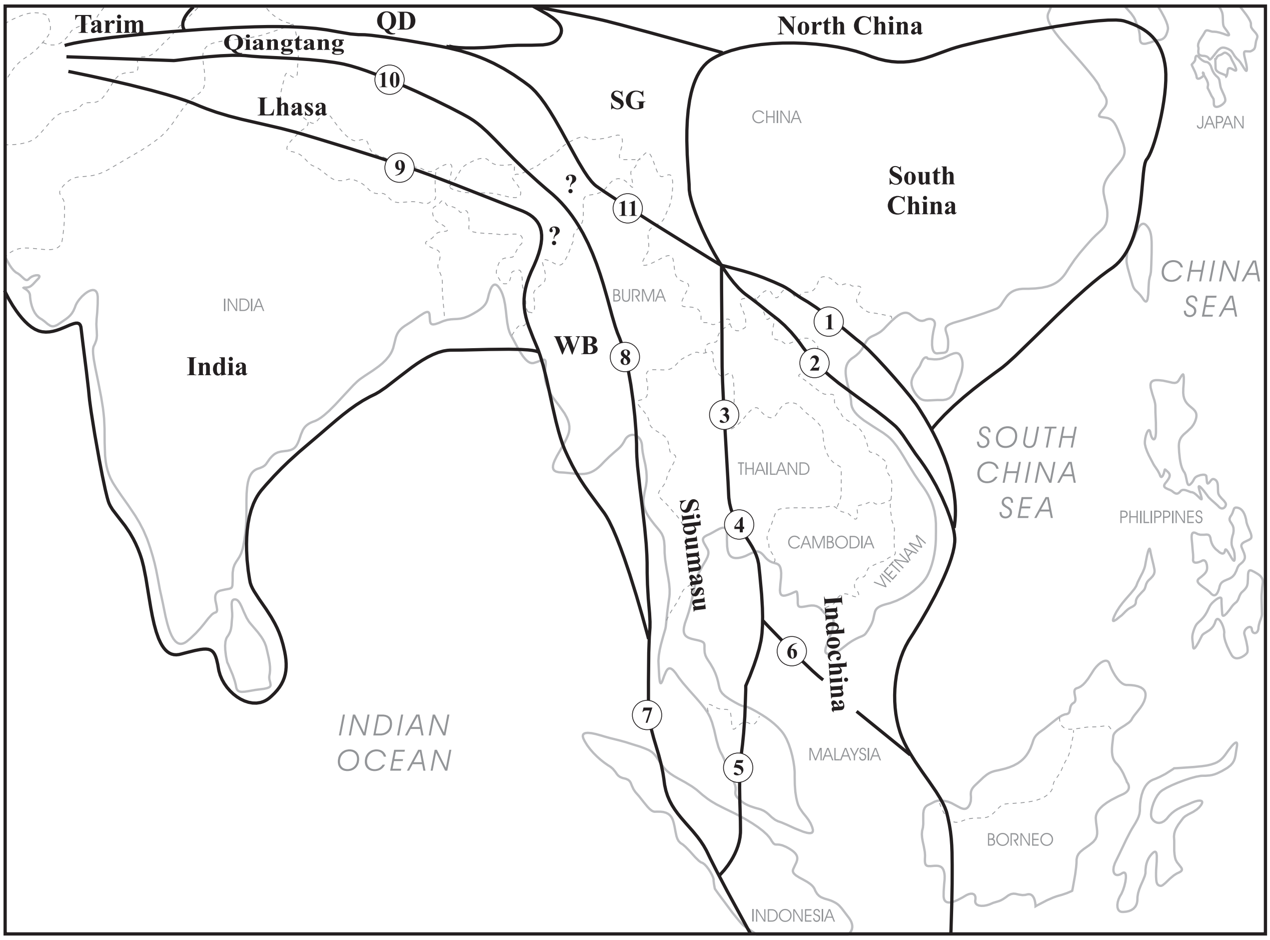
Methodology

Thirty two time interval maps have been presented, which depict the global plate tectonic configuration as well as palaeogeography and lithofacies for South-East Asia region (Fig. 1) from Cambrian to Neogene. The presented maps were primarily generated as Intergraph™ design files and CorelDraw™ files using computer software and databases. The plate tectonic model used to create palaeocontinental base maps is based on Plates and PALEOMAP tectonic reconstruction programs. These programs take tectonic features in the form of digitised data files and assemble those features in accordance with user specified rotation criteria. The detail information about the database, including the palaeopoles used can be found in the Plates homepage:

- http://www.ig.utexas.edu/research/projects/plates/plates.htm.

Plates maintains an up-to-date oceanic magnetic and tectonic database, continuously adding new palaeomagnetic, hot spot, geological, and geophysical data to extend the span and accuracy of global plate reconstructions. Plates' reconstructions are built around a comprehensive database of finite-difference poles of rotation, derived both from extensive plate motion research at UTIG, using the Plates interactive plate modeling software, and from published studies. Updated plate motion models are in turn



■ **Fig. 1.** Main plates, terranes and of Southeast Asia. Partially from Mecalfe, (1998). WB – Weast Burma, SG – Songpan Ganzi accretionary complex. QD – Quidam terrane. Sutures and major strike-slip faults: 1 – Red River zone, 2 – Song Ma, 3 – Nan-Uttaradit, 4 – Sra Kaeo, 5 – Raub Bentong, Three Pagodas, 7 – Woyla, 8 - Shan boundary, 9 – Indus Yarlung Zangbo, 10 – Banggong, 11 – Ailaoshan.

margin connected to South China Sea by extended continental crust (Fan 2000). The Indochina proper is separated from the plate southern part by the Three Pagodas Fault of NE-SW orientation.

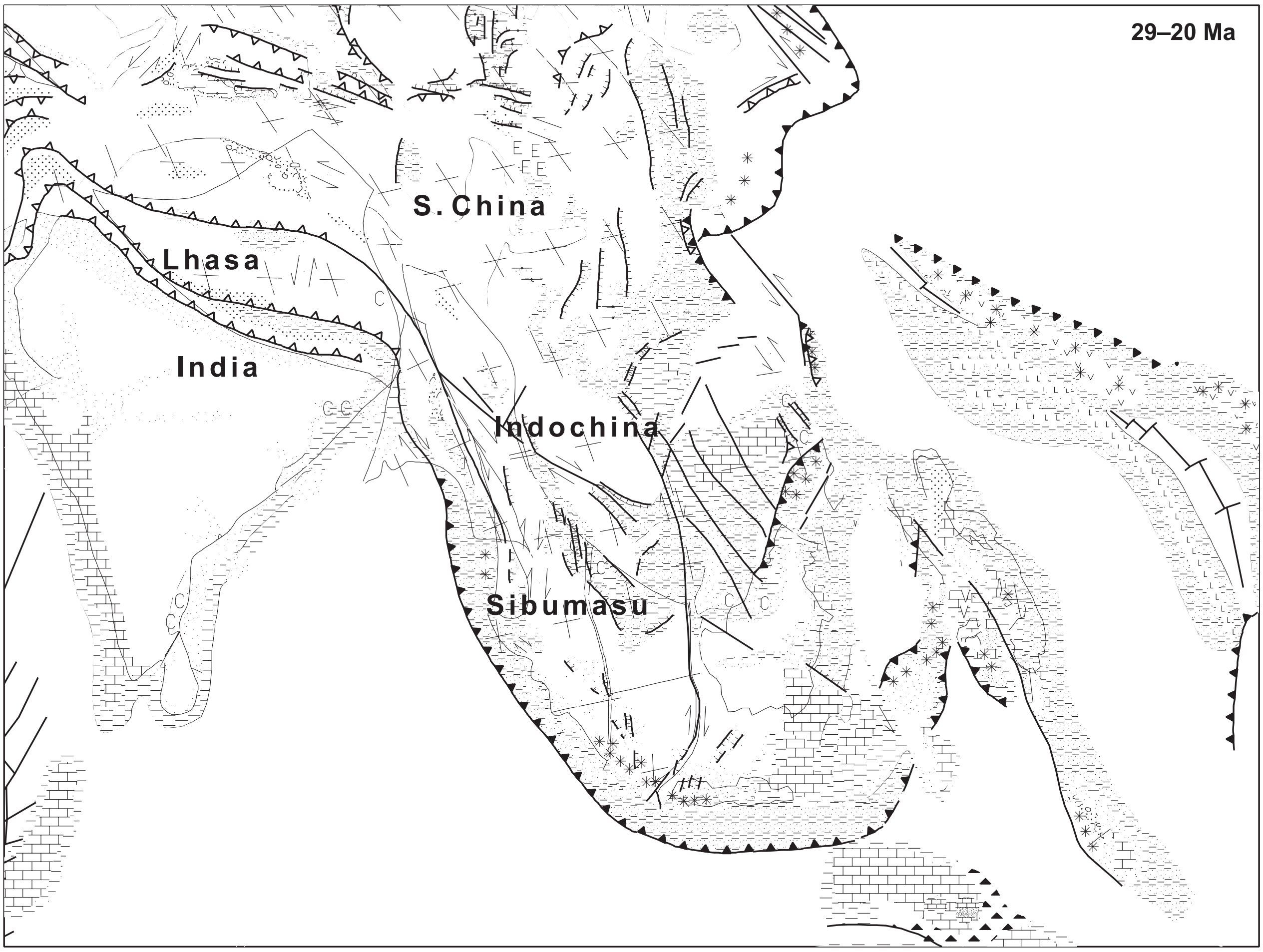
The South China plate includes southern part of China and northeastern fragment of Vietnam. It is separated from North China by Quingling-Dabie suture, from Indochina by Song Ma suture, from Sibumasu terrane by Ailaoshan suture, from Songpan-Ganzi accretionary complex by Longmenshan suture (Fig. 1) (Nie *et al.* 1990, Metcalfe 1998). The southeastern margin of South China is a passive margin connected to South China Sea by extended continental crust. To the east, the South China plate is bordered by the Taiwan foldbelt and the Okinawa trough passive margin. The Sibumasu terrane is bordered to the east by Raub-Bentong, Sra Kaeo and Nan-Uttaradit sutures, to the northeast by the Ailaoshan suture, (Fig. 1) (Nie *et al.* 1990, Metcalfe 1998, 2000), to the west its northern part is separated from the West Burma by the Shan suture. The Qiantang terrane is bounded on the south by the Bangong-Nuijang suture and to the north by the Lungmu-Yushu Zone. The Lhasa plate is bounded on the North by Lungmu-Yushu Zone and on the south by Indus Yarlung-Zangbo suture (Nie *et al.* 1990, Metcalfe 2002).

Outline of Geodynamic Evolution

The major South-East Asia plates originated during the Proterozoic as parts of Gondwana. They were detached during Palaeozoic time and drifted northward. The carbonate platforms were developed during the Devonian – Late Palaeozoic. The carbonate deposits were karstified later giving beautiful landscapes. The Palaeozoic history of detachment and collision is quite speculative. The equivalent of Caledonian orogeny followed by the formation of the Palaeotethys Ocean is quite possible. Climate record indicates major differences between Sibumasu, Indochina and South China during the Late Palaeozoic.

During Triassic time, as a result of the Indosinian orogeny and closure of the Palaeotethys Ocean, the South-East Asian plates joined the Asian continent. Strong tectonic deformations, metamorphism and magmatic intrusion and extrusion events were associated with the orogeny. The territory of South China was uplifted with mountains and intermountain basins with red beds, coals and volcanics. In the Indochina plate, during Jurassic and Cretaceous, terrestrial clastic sedimentation prevailed with red beds.

The onset of the collision of India with Asia occurred near the Palaeocene-Eocene boundary (e.g. Gaetani and Garzanti 1991). Pull-apart basins and strike-slip faulting occurred in China. Indo-



■ **Fig. 2.** Plate tectonic and lithofacies map of Southeast Asia during Late Tejas I.–Chattian–Aquitanian – 29–20 Ma.

china perhaps initiated the movement southeastwards, with respect to South China along the left-lateral Red River Fault (Lee and Lawver 1994, Golonka 2002), the main stage of this movement occurred, however, at a later time (fig. 2). The Red River Fault Zone in Yunnan, China and North Vietnam, up to 20 km wide, is one of the main strike-slip fault zones in SE Asia that separates the South China and Indochina blocks. The fault zone activity occurred in two phases: sinistral ductile shear active in 27–16 Ma, followed by exhumation and uplift from a depth of 20–25 km, and dextral, predominantly brittle shear active in Plio-Quaternary times. The Late Miocene change of the sense of motion is commonly related to the history of collision between India and Eurasia (e.g. Tapponnier et al. 1990). The opening of the South –East Asia basinal zones occurred as a result of complex tectonics during Palaeogene-Neogene time.

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Lithospheric Structure of the Carpathian Mountains, Pannonian basin and Eastern Alps Based on Seismic Data

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The network of seismic refraction profiles in the Central Europe covered now the area from the East European craton (EEC), along and across the Trans-European suture zone (TESZ) region in Poland to the Bohemian massif, and through the Carpathians and Eastern Alps to the Pannonian basin. The resulting seismic velocity models show strong variations in crustal and lower lithospheric structure (*Brueckl et al.,* submitted; *Grad et al.* 2006; *Środa et al.* 2006). In the Pannonian basin crustal structure is relatively simple. Beneath the sedimentary layer, two almost homogeneous crustal layers are observed with velocities 6.1–6.2 km/s in the depth interval 5–18 km, and 6.3–6.6 km/s in the lower crust. In this area, the Moho lies at depths of only 24–25 km.

In the Eastern Alps crustal thickness varies between 40 and 50 km. The most complicated structure is observed in the transition from the Pannonian basin to the EEC, which includes the Carpathians and the TESZ. In this area, the sedimentary cover with low velocities (Vp<5.5 km/s) reaches a depth of ~20 km, and the Moho deepens to ~50 km. Further to the northeast, the crustal structure of the EEC is typical for cratonic areas, with a thin sedimentary cover and a three-layer crystalline crust with velocities of 6.0–6.4 km/s, 6.5–6.7 km/s and 6.7–7.0 km/s, respectively. The depth of the Moho for the EEC varies between 42 and 48 km. Beneath the Moho lower lithospheric reflectors were found at depths of ~15 km beneath the Moho and at several deeper intervals.

The longest profile CEL05 (1420 km) shows clear crustal thickening from the Pannonian basin to the TESZ region, together with the configuration of the lower lithospheric reflectors. This result suggests northward subduction of mantle underlying Carpathian-Pannonian plate toward the north under the European plate. *Książkiewicz* (1977) postulated that subduction of the Pannonian lithosphere under the East European craton occurred during the Jurassic–Early (Lower) Cretaceous. In their paleogeographic reconstruction of the circum-Carpathian area *Golonka et al.* (2003) also proposed that north-northwestward subduction of the Meliata-Halstatt Ocean crust was completed by the end of the Jurassic, ~140 Ma ago and that the location of this closure corresponds to the Mid-Hungarian line. The northward subduction however conflicts with strong geological evidence for southward subduction, and we present three tectonic models for the CEL05 area, that are to not totaly mutually exclusive, to explain the lithospheric structure of the area: (1) northward “old” subduction of the Pannonian lithosphere under the East European craton in the Jurassic - Lower Cretaceous, (2) a collisional zone containing a “crocodile” structure where Carpatho-Pannonian upper crust is obducting over the crystalline crust of the EEC and the Carpathian-Pannonian mantle lithosphere is underthrusting cratonic lower crust, and (3) lithosphere thinning due to the effects of Neogene extension and heating with the slab associated with “young” subduction southward in the Miocene having been either detached and/or rolled-back to the east. In the last case, the northwestward dipping in the lithosphere can be interpreted as being due to isotherms that could represent the lithosphere/asthenosphere boundary in the Pannonian region.

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