while the relics of first compressional steep foliations are preserved in both regions. In addition, the entirely discordant northern contacts of BBTC with respect to the host rock foliations contrast with the southern intrusion margins that show fabrics perfectly coherent with the host rock. The BBTC intrusions show systematic transition from the dominant magmatic fabric in their northern and central parts to the MT subsolidus deformation terminating in LT mylonites in the south. The latter fabrics are developed in conjunction with E-W trending foliation and subhorizontal stretching lineation. The progressive decrease of deformation temperature is confirmed by quartz c-axis fabric patterns that suggest transition from the activity of prism <a> slip system towards the rhomb <a+c> and the basal <a> slip systems. AMS study reveals bimodal fabric pattern with the central-northern margins showing NW-SE trending foliations and lineations, low intensity (P parameter) and the southern parts with steep E-W trending magnetic foliation, horizontal lineation and high intensity (P parameter). The AMS within the central and northern parts is consistent with the AMS fabrics in southern migmatites. Telescoped ^{40}Ar-^{39}Ar cooling and U-Pb crystallization ages (~328–325 Ma) of BBTC and migmatites in the south proved that the exhumation occurred during a short period of time and that the intrusions of granitoids were coeval with the ductile thinning of southern domain. In contrast, the granulites to the north show cooling path related to compressional exhumation (~335–330 Ma) followed by reheating (~325 Ma) during intrusion of northern granite sheet (Thannenkirch pluton) of the BBTC. Based on our structural study, we suggest that the preexisting E-W trending compressive fabrics structurally controlled the distribution and the emplacement of the granitic magmas. The SSW-NNE extensional traction operated along steep mechanical anisotropy at high angles which generated oblique transtensional regime. The internal fabric within individual plutons is therefore interpreted in terms of partitioning of transtensional deformation, with pure shear dominated area in their northern and central parts and wrench dominated domains along their southern margins. To asses realistically the obtained AMS pattern we compare two numerical models of AMS fabrics in transtension with respect to originally isotropic and pre-deformational intrusion-related fabrics. It is the latter model which returns more realistical fabric data. The asymmetrical microstructural and geochronology patterns are further discussed using thermal 1D modeling which indicates the sequences of individual intrusion from north to south and their mutual thermal interferences leading to successive reheating of southern margins of northerly intrusions that can accommodate prolongated viscous deformation compared to granite northern regions that are cooled down almost instantaneously.

Caledonian Orogeny in Southeast Asia: Questions and Problems

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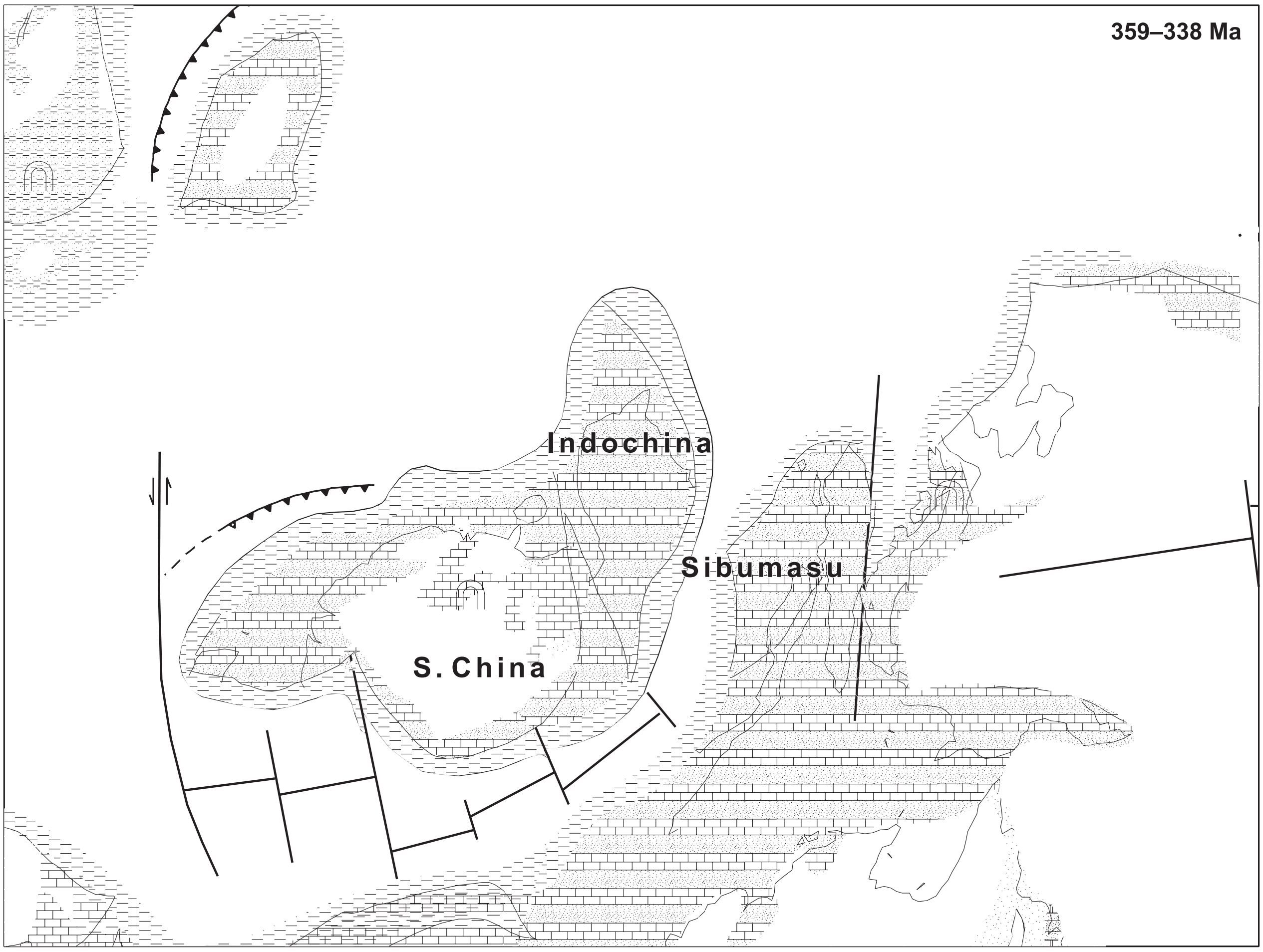
Avalonia probably started to drift from Gondwana and move towards Baltica in the late Tremadocian and was in a drift stage by the Llanvirnian (McKerrow *et al*. 1991, Torsvik *et al*. 1996, Golonka 2002). Between Gondwana, Baltica, Avalonia and Laurentia, a large longitudinal oceanic unit, known as the Rheic Ocean (McKerrow *et al*. 1991, Golonka 2002) was formed. Traditionally the continent of Avalonia consists of northwestern and possibly southern Poland, and their foredeep, terranes in northern Germany, the Ardennes of Belgium and northern France, England, Wales, southeastern Ireland, the Avalon Peninsula of eastern Newfoundland, much of Nova Scotia, southern New Brunswick and some coastal parts of New England. The Brunovistulicum terrane, some accreted terranes in the basement of East Carpathians parts of the Scythian platform, parts of Kazakhstan and Southern Mongolia terrane could constitute the eastern extension of the Avalonia (Paul *et al*. 2003a, b). The Turkmen (Zonenshain *et al*. 1990) and Solonker (Sengör and Natalin, 1996) oceans in Asia could constitute the eastern parts of this Rheic Ocean. Relationship of eastern peri-Gondwana terranes and Avalonia plates remain unknown and speculative. On presented maps the South China and Southeast Asia plates remain attached to Gondwana according to the previously published global paleoreconstructions (Golonka 2002). The alternative reconstructions (Paul et al. 2003a, b) suggest the possibility of extension of Rheic toward the easternmost part of Gondwana. It is not impossible that South China and Indochina plates were rifted from Gondwana in Ordovician. The uplift and volcanic rocks (Fig. 9) support such a possibility. According to Shouxin and Yongyi (1991) the Ordovician conformably overlies the Cambrian over most of the South China plate. The northern part of the plate (Yangzi Platform was covered with carbonates and mixed carbonate/clastic facies. The southern part of the plate is partially uplifted and partially covered by deep water synorogenic clastic deposits – more than 4000 m of weakly metamorphosed flysch, sandstones and graptolitic shales. Similar rocks formed on the margins of Indochina plate. They are known as Pa Ham formation (Ordovician-Silurian).

Late Siluruian was the time of the major development of the Caledonian orogeny and final closure of the Iapetus. The collision between Baltica and Greenland continued, marked by nappes in Norway and Greenland. After the complete closure of the Iapetus Ocean, the continents of Baltic, Avalonia, and Laurentia formed the continent of Laurussia (P. Ziegler 1989). It is quite possible, that at that time several microplates rifted away from the Gondwana margin to arrive at Laurussia and Kazakhstan at the Devonian-Permian time (Golonka 2002). The exact time and the nature of rifting of these terranes and their relationship to Southeast Asia and Chinese plates remain speculative. Accor-



■ **Fig. 1.** Plate tectonic and lithofacies map of Southeast Asia during Kaskaskia III time – latest Devonian–Early Carboniferous – 359–338 Ma

ding to Shouxin and Yongyi (1991) following orogenic movements (Guanxi orogenic episodes), the Late Silurian was a time of regression within South China plate.

This was the time of the final phase of the Caledonian orogeny, transpressional collision of Gondwana and Laurentia and formation of the Oldredia supercontinent, which included all major plates. Most of Oldredia was located between the South Pole and the Equator. According to Golonka (2002) collision of South and North America occurred during Early Devonian time. The Caledonian orogeny was concluded in Europe and North America. A late stage of thrust related deformation occurred in northern Scandinavia, eclogites formed about 410 Ma in Norway, in an over-deepened root of Baltica, which had developed in the ductile lower crust, as a response to extreme crustal shortening (Golonka 2000, 2002). The peak of orogenic process occurred during this time within Southeast Asia and South China. In Northern Vietnam deep water Ordovician and Silurian synorogenic deposits were replaced by continental Early Devonian red beds (Tran Van Tri 1979, Tran Due Luong and Nguyen Xuan Bao (Eds.) 1988, Phan Cu Tien 1989). This red beds can be observed in Mai Chu area. The important unconformity is visible between Early Paleozoic rocks and Middle-Late Devonian carbonate deposits in North Vietnam. The similar unconformity exists in the adjacent part of China. According to Leloup et al. (1995), within Yangtzi paraplatform south of Kunming, the lowermost sediments are folded (schistosed Proterozoic shales, carbonates and volcanoclastics). These sediments are covered by Lower Devonian conglomerates and sandstones followed by Upper Devonian, Carboniferous and Permian shallow-water carbonates. Perhaps the Late Silurian – Early Devonian was time of accretion of terranes to South China plate in the collisional process. The paleogeography of this event is unknown and will be a subject of future research. Perhaps these events were related to the global Caledonian orogenic process and closing of extension of Iapetus Ocean (see Paul et al. 2003a, b). This orogenic process is, according to Leloup et al. (1995) well established in Guangzi province where metamorphic Siluro-Ordovician schists are covered by Lower Devonian Old Red sandstones. The orogenic process was perhaps also related to the onset of rifting of South China, Tarim, and Indochina from Gondwana that happened, according to Metcalfe (1998), during this time leading to the future development of new generation of oceanic realms (Fig. 1).

In the western part of South China plate (Shouxin and Yongyi 1991) and in Indochina (Tran Van Tri 1979, Tran Due Luong and Nguyen Xuan Bao (Eds.) 1988, Phan Cu Tien 1989, Brookfield 1996) the previous synorogenic and postorogenic facies were replaced by shallow water carbonates. The mixed character of this carbonates is changing upward leading to the deposition of pure limestone and dolomites.

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Comparative, Velocity-Dependent Gravity Modeling of the Density Section Along Three Carpathian DSS Profiles

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Difficulties arisen during gravity modeling along the three Carpathian DSS profiles (CEL 01, CEL 04, CEL 05) crossing boundary of the orogen, were a reason of searching for a modifications of the simplest method of constant layer densities applied at the beginning. The problem was resolved by taking more extensive advantage of the structural information contained in the velocity distribution in the cross section. A stable and convincing results were obtained by using a modified concept of the density field, where density is a function of p-wave velocity in each layer and the density satisfies limitations for