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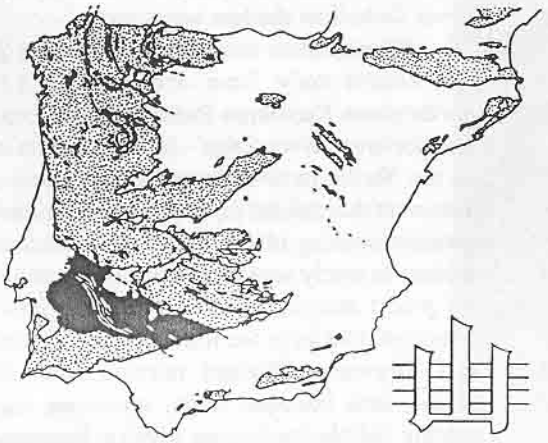

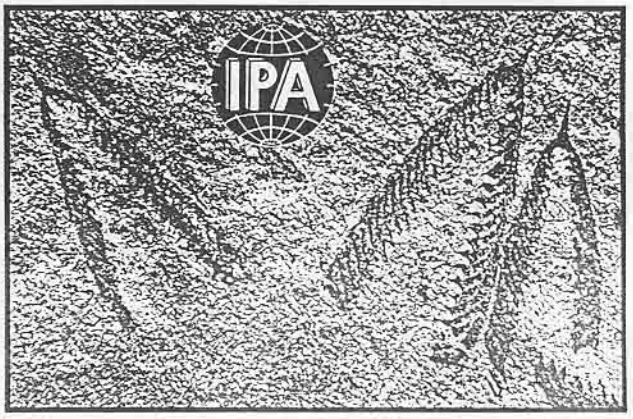

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Facial development and thermal alteration of Silurian rocks in Turkey

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The Silurian of the Istanbul area consists of shallow water sediments (Llandovery greywackes, sandstones, shales, Wenlock to Prídolí marls and limestones: Haas, 1968) that continue despite a slight deepening in the Prídolí until the Lower Devonian. This indicates that the Istanbul Zone was in Caledonian time a shelf area. The Silurian conodonts have the same Conodont Alteration Index as the Middle and Upper Devonian pelagic deposits (CAI around 4), indicating a Hercynian thermal alteration of the Istanbul Zone (Fig. 1).

The Silurian of the Zonguldak Zone consists mainly of deep water black and gray graptolitic shales and mudstones with conodonts (CAI= 5) and paleopsychrospheric ostracods indicating deposition at or close to the margin of an ocean. Different Wenlock to Prídolí horizons are unconformably overlain by Devonian siliciclastic rocks, followed by shallow-water dolomites and limestones with *Icriodus*-dominated conodont famas (CAI around 2) of late Early to Late Devonian age. The deep water Arenig to Prídolí and the post-Silurian / pre-Emsian disconformity, connected with a distinct thermal alteration, indicate a Caledonian event, whereas no Hercynian event is present in this area. A position north of the Istanbul Zone is assumed for the Zonguldak Zone that had its cantinuation in the Moesian Platform.

In the Sakarya Composite Terrane south of the Istanbul Zone (Fig. 1) both earliest Devonian granodiorites (Camlik granodiorite) and Hercynian metamorphic rocks in high-grade amphibolite facies to granulite facies are present (Okay *et al.*, 1996). The age of the Camlik granodiorite (if in future confirmed) indicates a Caledonian event. The Camlik granodiorite intruded Silurian shaly-silty rocks and does not show Hercynian metamorphism (Okay *et al.*, 1996). Unmetamorphic pelagic Silurian limestones with numerous well preserved radiolarians were found in the Upper Triassic turbidite-olistostrome unit of the Karakaya Complex in NW-Turkey (Kozur & Kaya, in prep.), where the youngest unmetamorphic Hercynian pelagic rocks are very rare Bashkirian pink cherty limestones (Okay & Mostler, 1994; Kozur, 1997c) beside Bashkirian shallow water limestones. Moscovian to lower Dzhulfian rocks are only represented by shallow water limestones; reports on Lower Permian red radiolarites (Okay & Mostler, 1994) are based on misidentification of radiolarians from uppermost Permian (Dorashamian) red radiolarites (Kozur, 1997c). In the surroundings of Ankara, the Karakaya Complex contains blocks of Silurian lydites and grey pelagic limestones, Devonian pelagic limestones, Upper Carboniferous and Permian shallow water limestones. Thus, there are three different basements in the Sakarya Composite Terrane: Hercynian high-grade metamorphic rocks, Caledonian granodiorites in an area without Hercynian metamorphism, and unmetamorphic to low-grade metamorphic, mostly pelagic Silurian to Bashkirian rocks, all partly overlain by Moscovian to lower Dzhulfian shallow water rocks.

Silurian rocks from the Izmir-Ankara Zone (Fig. 1) are known only from the Kalecik Limestone in northeastern Karaburun Peninsula (Bornova Melange of the Bornova Flysch Zone - BFZ) from the marginal part of the Vardar-Izmir-Ankara Ocean, where rocks of the basement that existed prior to the Late Triassic rifting and Jurassic opening of the Vardar-Izmir-Ankara Ocean are present as portly very large olistoliths and blocks). Kozur (in press) recognized three different facies of Silurian limestone blocks in the Kalecik area: basinal, slope, arid reef limestones. Basinal micritic nautiloid limestone blocks with abundant large, orthocone nautiloids, and pelagic radiolarian-bearing micritic limestones contain a rich Silurian conodont fauna that consists mostly of coniform conodonts, e.g., *Dapsilodus obliquicostatus* (Branson & Mehl). The slope facies of the same age is represented by crinoidal limestones and reef-debris limestones. The crinoid limestone contains the same Silurian conodont fauna as the basinal limestone. In the old mercury ore quarry at Kalecik, there are hydrothermally strongly altered limestones with patches of fewer altered dark crinoidal limestone that contains a Silurian conodont fauna. Surprisingly, no Early Devonian conodonts were found, but Lower Devonian macrofaunas have been previously reported. The low-temperature hydrothemal mercury ores within the Kalecik Limestone represent probably a late Caledonian hydrothermal activity because younger limestones of similar facies are not hydrothermally altered. The CAI varies between 3 and 6. This indicates no or insignificant Caledonian regional metamorphic thermal alteration, the higher alteration values are caused the hydrothenmal alteration.

Silurian deep-sea rocks are common in the Karaburun Zone (Fig. 1), where these rocks were assigned previously to the assumed Triassic Karareis "Formation" (e.g., Erdogan *et al.*, 1995) that contains additionally a very thick, slightly metamorphic siliciclastic undated pre-Wenlock (?Ordovician)

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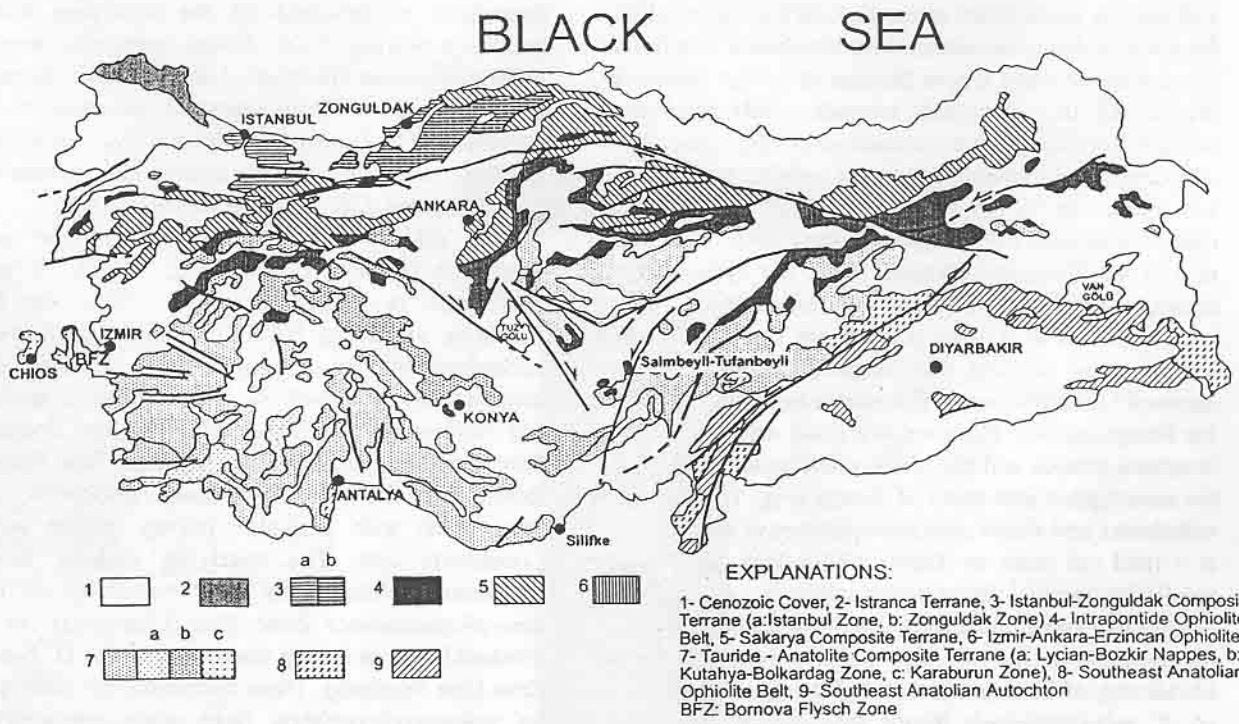

Figure 1. Tectonic units with studied Silurian rocks in Turkey (after Göncüoglu, 1997).

sequence, as well as pelagic Upper Devonian to Lower Carboniferous rocks, including an upper Famennian to middle Visean siliciclastic flysch. According to Kozur (1997a, 1997b and in press), the Lower-Middle Silurian Consists of a deep-sea sequence with shales and dark radiolarites. Ludlow and Prídolí (and Lochkovian-Pragian) are represented by siliciclastic deep-sea turbidites (with numerous distal turtiditic dark radiolarites), olistostromes and keratophyre tuffs. The olistoliths consist mostly of rocks of the siliciclastic turbidites, and subordinately of Silurian and earliest Devonian pelagic limestones. The Late Silurian-Pragian turbidite-olistostrome unit is metamorphic but has a distinct cleavage and a thermal alteration (CAI 4-5). The radiolarites from the matrix contain well preserved Silurian Muellerisphaerida (Kozur, 1997b). Some of these radiolarites yielded a poor conodont fauna consisting exclusively of coniform conodonts, mostly long-ranging Silurian-Early Devonian species but partly with the Silurian *Dapsilodus obliquicostatus* (Branson & Mehl). The youngest fossils from the matrix are Lochkovian-Pragian conodonts and the radiolarian *Eoalbaillella lilaensis* Feng & Liu, probably of the same age (Kozur, 1997b). The limestone olistoliths of the Late Silurian to Pragian turbidite-olistostrome Unit have contemporaneous Late Silurian-Pragian conodont faunas, but most limestone olistoliths yielded pelagic lower Devonian (mostly Lochkovian, rarely Pragian: Kozur, 1997a, and in press). These limestones have not the facies and macrofauna of the Kalecik Limestone from the Bornova Melange, and were not transported from this area and perhaps even not from this (northern) side into the Caledonian Karaburun Ocean.

Late Silurian microfaunas (conodonts, some ostracods, detritus of graptolites and few well preserved Muellerisphaerida) were found also in a dark-grey, micritic, keratophyre tuffite-bearing limestone olistolith from the upper Famennian-lower Visean turbidite-olistostrome Unit (with *Palmatolepis* sp. in the surrounding matrix: Kozur, 1997b, and in press). At the Fatih College Campus several limestone inclusions in a thick keratophyre-keratophyre tuff sequence yielded only ostracods (Bairdiidae, Bairdiocrypprididae, early Tricorninidae, Pachydomellidae, Primitiopsidae and Thlipsuridae) with Silurian to Silurian - Early Devonian species. These data indicate a strong Silurian keratophyre volcanism on a carbonate shelf and slope adjacent to the ocean (Kozur, 1997a, 1997b, and in press). Until now, rocks of the Upper Silurian to Pragian siliciclastic turbidites were not found in the upper Famennian to lower Visean turbidite-olistostrome Unit, but only Silurian and Lower Devonian basinal limestones, upper Frasnian and lower Famennian basinal and slope limestones. This indicates, that the Caledonian Upper Silurian-Pragian siliciclastic turbidites were not the source area of the Hercynian Upper Famennian to Lower Visean siliciclastic turbidites. The Caledonian and Hercynian siliciclastic turbidite - olistostrome units were juxtaposed by Hercynian or/and younger crustal shortening.

The Bozdag Limestone of the Kütahya-Bolkardag Zone (Fig. 1) corresponds to the different basinal, slope and shallow water facies of the Kalecik Limestone of the Bornova Melange in northeastern Karaburun Peninsula. It contains the same Upper Silurian to Lower Devonian macrofossils (e.g.. nautiloids, crinoids, corals) and Upper Silurian conodonts, and contains even the same low-temperature hydrothermal mercury ores as the Kalecik Limestone. As in the Bornova Melange, no younger limestone contains these hydrothermal ores. Therefore, also in the Kütahya-Bolkardag Zone the hydrothermal activity is regarded as a late Caledonian event.

Özcan *et al.* (1990) pointed out that the Bozdag Limestone is overlain with angular unconformity by assumed Carboniferous siliciclastic deep-sea turbidites of the Hercynian Belt. However, we could not confirm this structural relation and age of the siliciclastic turbidites in the investigated area north of Konya (Fig. 1). Deep-sea radiolarites and shales with intercalations of altered tuffs at a road cut close to Bilecik (Yükselen) contain the muellerisphaerids *Sannemannisphaera rarispinosa* Kozur (also known from the basal Wenlock of Hungary), *Papinochium* n. sp. A (also known from the upper Llandovery of Greenland), and *Papinochium* n. sp. B ex gr. *P. robustispinosum* Kozur that indicate an upper Llandovery to earliest Wenlock age. The next younger fossils were derived from siliciclastic deep-sea turbidites and olistostromes (the matrix consists of distal turbiditic radiolarites and graded siliciclastic beds around the village Ardiçli. The olistoliths consist of radiolarites, pelagic, partly cherty or silicified limestones, crinoidal limestones, and sandstones. The limestones are often metasomatically changed into dolomite or magnesite. The sequence is anchimetamorphic (CAI 5-6). The radiolarites of the matrix yielded only very few conodonts of Late Silurian to Early Devonian age. The limestone olistoliths contain rich conodont faunas of the same age. As shown above, the Silurian to Lower Devonian sequence of the Kütahya-Bolkardag Zone is identical with that of the Karaburun Zone. Thus, also in the Kütahya-Bolkardag Zone a Caledonian ocean was present, and a Late Silurian to Pragian closure of this ocean can be observed. The Bozdag Limestone is a carbonate shelf and slope sequence that is contemporaneous with the siliciclastic turbidite-olistostrome Unit. If present the Carboniferous and Permian of the Kütahya-Bolkardag Zone consists of shallow water deposits (mainly limestones) with algae, foraminifers and conodonts (Kozur & Ekmeçi, in prep.).

The Silurian of the southern Tauride-Anatolide Composite Terrane (Fig. 1) represents a shallow to moderately deep Perigondwana shelf sequence that unconformably overlays the Arenig upper Seydisehir Formation (in the Silifke area, the Silurian overlays siliciclastic rocks of Caradoc-Ashgill age that unconformably overlay the Seydisehir Formation. The Silurian begins in the Silifke area with coarse-grained rocks that contain granitic and metamorphic pebbles from a crystalline basement (Göncüoglu, 1997), overlain by a grey shale-sandstone interbedding. A distinct deepening is indicated by the overlying Wenlock graptolite-bearing black shales with rare nautiloid-bearing limestone interlayers. Late Silurian is represented by an alternation of black limestone and shale. A similar development is known from the Antalya nappes where, however, dolomites may be additionally present in the Lower Silurian (Göncüoglu & Kozur, in prep.).

A different development was found in the Saimbeyli-Tufanbeyli area (Fig. 1), as shown by Göncüoglu & Kozur (in press). Then, the Upper Cambrian to Arenig Seydisehir Formation is overlain unconformably by a coarse lower Silurian quartz conglomerate, followed by cross-laminated sandstones and violet-gray, silty shales (Halit Yaylasi Formation). This fonnation is overlain by the Puscu Tepe Formation (black graptolite shales with some radiolarites in their lower part) with graptolite- proven middle and late Llandovery age. The overlying nodular nautiloid limestone yielded at its base conodonts of the *P. amorphognathoides* Zone (late Llandovery to basal Wenlock), and at its top conodonts of the *O. bohemica* Zone (late Wenlock). These conodonts are accompanied by paleopsychrospheric deep water ostracods that indicate that this sequence was deposited close to the margin of an ocean (Göncüoglu & Kozur, in press). The deep water conditions continued in the Upper Silurian with black shales, dark siltstones and thin-bedded limestones. All Silurian conodonts have a CAI 5. As the Late Devonian and younger conodonts from the same area are thermally unaltered a distinct Caledonian thermal alteration is present. The Silurian of this area is transitional between the Caledonian oceanic development in the Kütahya-Bolkardag and Karaburun Zones and the Perigondwana shelf development.

In Southeast Anatolian Autochton (Fig. 1), Silurian is either missing or Upper Silurian to Lower Devonian dark shales of an restricted marine environment follow after a Lower-Middle Silurian regional stratigraphic gap (Göncüoglu, 1997).

References

Erdogan, B., Güngör, T., Özer, S. & Altiner, D. 1995. Stratigraphy and deformational style of Karaburun Belt and Izmir-Ankara Zone. *Excursion Guide, International Earth Sciences Colloquium on the Aegean region, IESCA 1995*, Izmir, 1-31.

Göncüoglu, M.C. 1997. Distribution of Lower Paleozoic rocks in the Alpine terranes of Turkey: Paleogeographic constraints. *In*: Göncüoglu, M.C. & Derman, A.S. (eds.), *Early Paleozoic evolution in NW Gondwana. Turkish Association of Petroleu Geologists, Special Publication*, 3, 13-23.

Haas, W. 1968. Das Alt-Paläozoikum von Bithynien (Nordwest-Türkei). *Neues Jahrbuch für Geologie und*

Paläontologie, Abhandlungen, **131**, 178-242.

Kozur, H. 1997a. New stratigraphic results on the Paleozoic of the western parts of the Karaburun peninsula. western Turkey. *In*: Piskin, Ö., Ergün, M., Savascin, M.Y. & Tarcan, G. (eds.), *Proceedings of an International Earth Sciences Colloquium on the Aegean region, IESCA 1995*, Izmir, 1, 289-307.

Kozur, H. 1997b. First discovery of Muellerisphaerida (inc. sedis) and Eoalbaillella (Radiolaria) in Turkey and the age of the siliciclastic sequence (clastic series) in Karaburun Peninsula. *Freiberger Forschungshefte*, C **466**, 33-59.

Kozur. H. 1997c. Pelagic Permian and Triassic of the Western Tethys and its paleogeographic and stratigraphic significance. *487 Berg- und Hüttenmannischer Tag, Kolloquium 1. Stratigraphie, Sedimentation und Beckenentwicklung im Karbon and Perm*, Freiberg, 21-25.

Okay, A.I. & Mostler, H. 1994. Carboniferous and Permian radiolarite blocks from the Karakaya Complex in northwest Turkey. *Turkish Journal of Earth Sciences*, **3**, 23-28.

Okay. A.I., Satir, M., Maluski, H., Siyako, M., Metker, R. & Akyüz, S. 1996. Paleo- and Neo-Tethyan events in northwest Turkey: Geological and geochronological constraints. *In*: Yin, A. & Harrison, M. (eds), *Tectonics of Asia*, Cambridge University Press, 420-441.

Özcan, A., Göncüoglu, M.C., Turan. N., Uysal, S., Sentürk, K. & Isik, A. 1990. Late Paleozoic evolution of the Kütahya-Bolkardag Belt. *METU Journal of Applied Sciences*, **21**, 211-220.