BULLETIN OF THE MINERAL RESEARCH AND EXPLORATION INSTITUTE OF TURKEY

Foreign Edition — April 1975 — Number : 84

CONTENTS

Bu nüshada yazı işlerini fiilen idare edenler - Editors :
Raif AKOL - Sehavet MERSİNOĞLU

Mailing address : Maden Tetkik ve Arama Enstitüsü,
Ankara-Turkey

DISTRIBUTION OF ORDOVICIAN-SILURIAN FORMATIONS IN TURKEY AND IN THE NEIGHBORING COUNTRIES

Adnan KALAFATÇIOĞLU

Mineral Research and Exploration Institute of Turkey

ABSTRACT. — The Ordovician-Silurian formations occurring in Turkey are grouped in two main facies: sedimentary and metamorphic. Sedimentary formations, in general, are fossiliferous. Results obtained from detailed field work and laboratory studies carried out in recent years—although highly controversial as far as the metamorphic formations are concerned —proved valuable, since these studies to a considerable extent clarified the distribution pattern of the Ordovician-Silurian formations and the paleogeography of the country.

In Turkey—which is a part of the Alpine-European-Asian erogenic belt—the nature of the rocks belonging to the metamorphic facies and mainly occurring in Central Anatolia may well indicate to the presence of pre-Caledonian orogeny in the country. In some areas, however, where Ordovician-Silurian fossils are found in the upper parts of the metamorphic rock sequences, sedimentation appears to be continuous.

Although the Ordovician-Silurian formations of Turkey are not reported as very widespread, there still exists a regular distribution pattern throughout the country. Outcrops of Ordovician-Silurian formations are found in the vicinity of İstanbul-Kocaeli, Ereğli, Araç-Tosya in the north; on the Karaburun Peninsula and Sakız Island in the west; in the area between Babadağ, Sultan Dağları, Seydişehir, Hadım and Anamur-Silifke in the south and in extensive areas between Kozan, Feke, Saimbeyli and Sam in the Antitaurus Mountains. The Ordovician-Silurian formations are also exposed in the Amanps Mountains and in the vicinity of Derik, Hazro, Korudağ and Hakkari located along the southeastern fold belt.

NORTH ANATOLIAN REGION

The Ordovician-Silurian formations of this region start to the west of Bosphorus, in the vicinity of Istanbul, and, trending towards east, are locally exposed in the areas between Kocaeli-Sakarya and Bolu-Ereğli. Further to the east they cover large areas between Araç-Tosya, and in the neighborhood of Amasya. During recent studies, Graptolites of Ordovician-Silurian age were found in the upper levels of a vast massif, which is known as the Ilgaz crystalline massif. Further to the east, however, these formations are not exposed, due to overlying younger formations (Fig. 1 and 2).

Although detailed stratigraphical and tectonic study of the Ordovician-Silurian formations occurring in the İstanbul-Kocaeli region has already been carried out, there still exist controversial ideas. F. Baykal and O.Kaya (1965), for example, report that the Silurian formation (including Ordovician), consisting mainly of silts, sandstones, clays and arkosic conglomerates, is composed of the following units (from top to bottom):

5. Coral limestone formation : Silurian
4. Subarkose formation : Silurian
3. Siliceous shale formation : Middle Ordovician-Upper Valentian
2. Orthoquartzite formation : Lower-Middle Ordovician
1. Arkose formation : Lower Ordovician

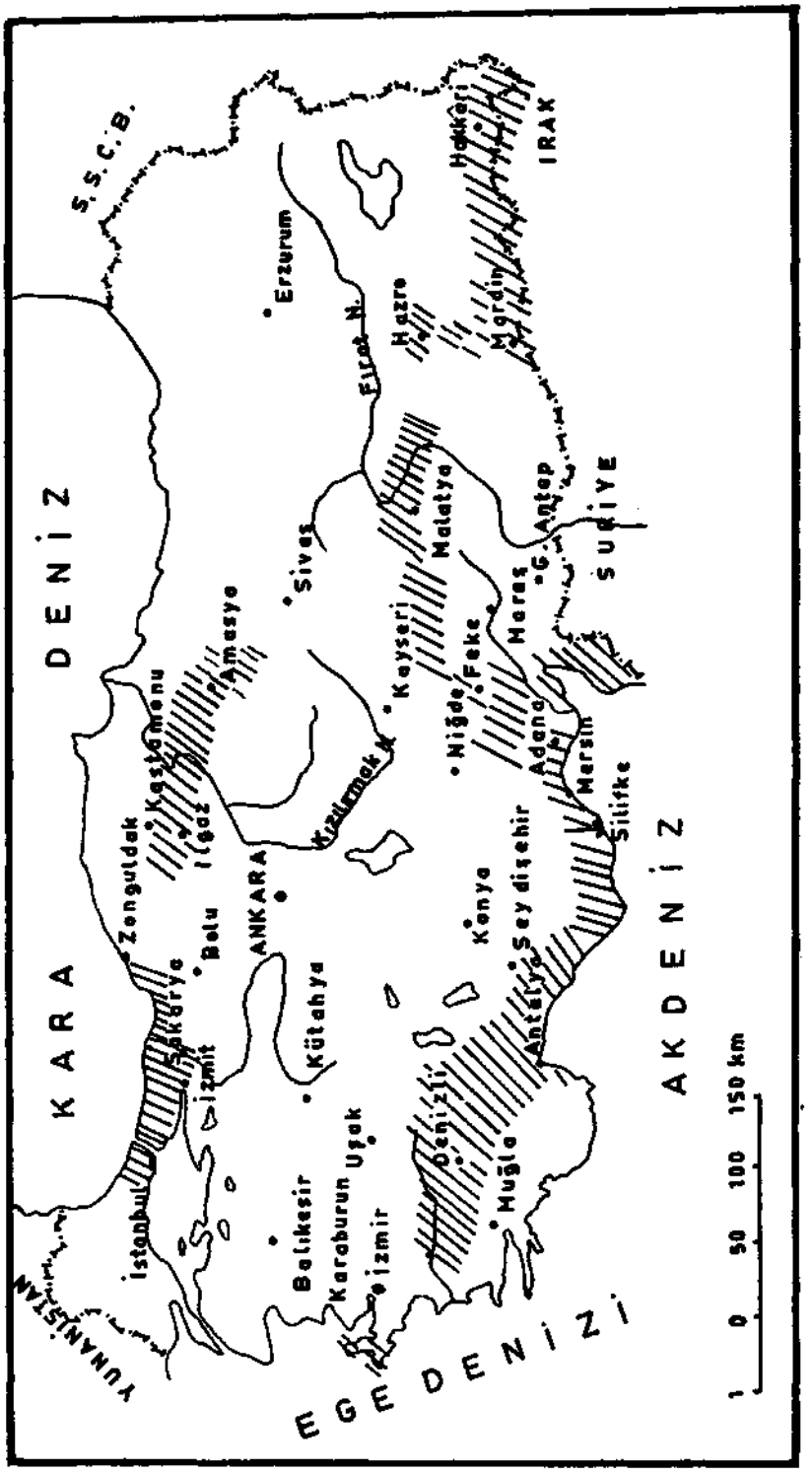

Fig. 1 - Map showing parts of Turkey submerged below the Ordovician-Silurian sea.

It is also reported that only siliceous shales contain fossils.

The following fossils were determined by C. Sayar:

Exconularia istanbulensis Caz. Say.
Exconularia cf. *pyramidata* Hoen.
Archaeconularia fecunda Bar.
Exconularia bohemica Bar.

İ. Yalçınlar, on the other hand, discovered Upper Valentian Graptolites within the same formation.

While several authors, such as F. Baykal and O. Kaya, state that gradual vertical transition between the above units can be seen although harmony between the levels is disturbed due to faulting, erosion and tectonic movements, others, such as I. Ketin, report that the arkose formation is unconformably overlain by quartzites on the eastern part of Bosphorus. It may, thus, be presumed that the conglomerates, arkoses and sandstones occurring in this area are of Ordovician age, whereas the sequence consisting of quartzites, siliceous shale-graywacke, quartzites and Halysites-bearing limestones, in the upper part, are Silurian in age. On the Sedef Island (near Istanbul) a series consisting of arkoses, graywackes, clayey schists and limestones has been known for many years. Paeckelmann determined the following Wenlockian-Ludlovian fossils collected in this area:

Dayia navicula Sow.
Dalmanella elegantula (Dalm.)
Spirifer magnus Kozlowski
Favosites gotlandicus Lamarck
Heliolites barrandei R. Horn.

Among the fossils collected from the Sedef Island, C. Kırağlı (1958) determined *Alveolites lemniscus* Smith of Upper Silurian age.

On the eastern side of the B.osphorus, in the area between Başıbüyük village and Tekkeboyu Tepe, the arkoses are sometimes overlain unconformably by the basal conglomerates and the white-colored thick quartzite beds. These quartzites and basal conglomerates, in turn, are overlain by thin-bedded and green-colored siltstones and sandstones which contain oolitic iron ore.

The following Lower and Middle Silurian fossils were found in this formation:

Halysites sp.
Favosites sp.
Zaphrentis sp.
Meristina furcata Sow.
Plectatrypa imbricata Sow.

On the western side of the Bosphorus, this formation is overlain by the dark-colored sandy limestones.

Towards east, Ordovician-Silurian/ormations occurring in the area between İzmit and Sakarya, show a close resemblance to the Lower Paleozoic of the Istanbul area. E. Altınlı reports that the purple and mauve-colored arkose beds, called by him the "Sopalı Formation", are of Ordovician age. The basal part of this formation, which is up to 1290 meters thick, cannot be seen; it shows a gradual transition with the overlying quartzites. The writer considers that these quartzites are of the same ,age as the quartzites of Çene Formation and reports that they are overlain unconformably by Devonian beds. Based on this, it may be presumed that Ordovician and Silurian

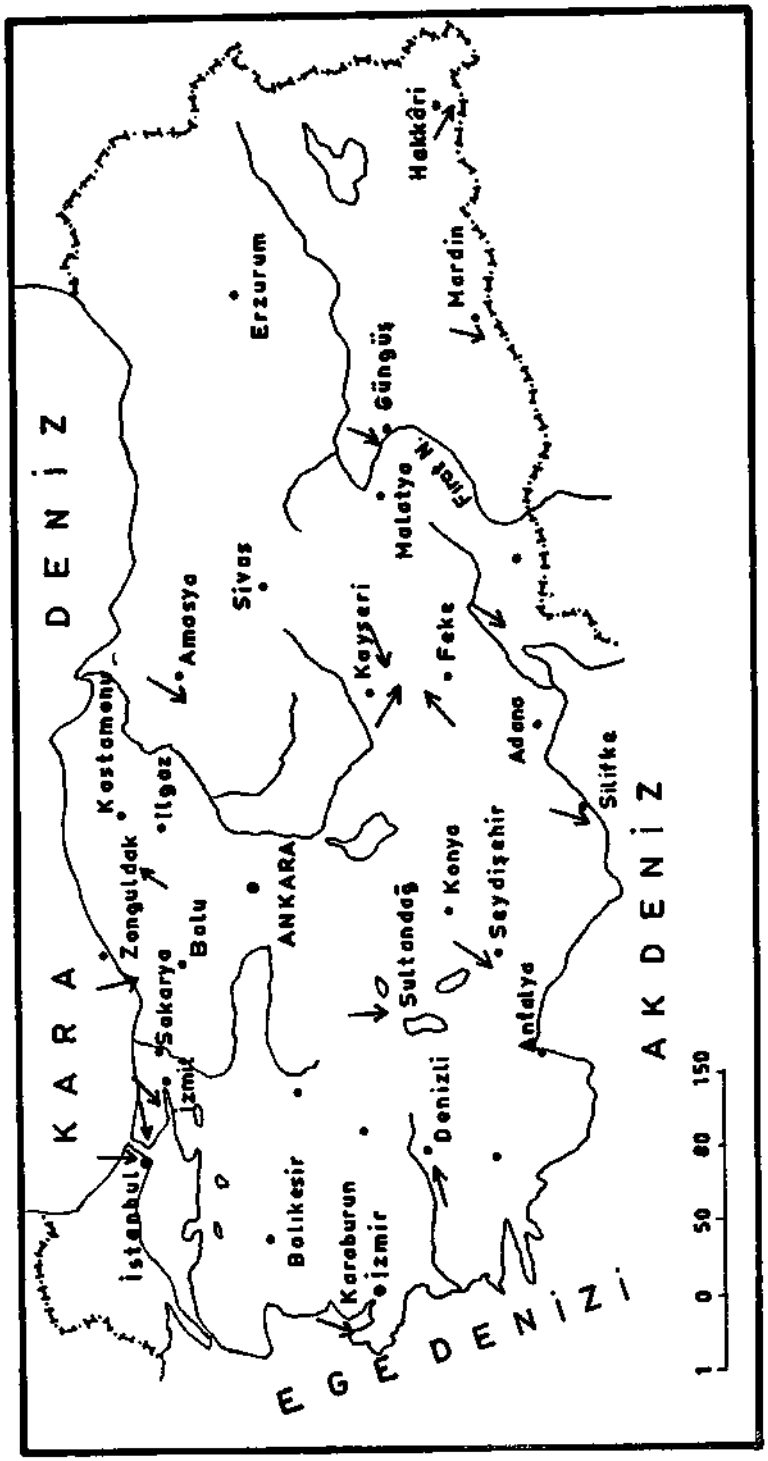

Fig. 2 - Map showing localities where fossiliferous Ordovician-Silurian exposures are observed (⟶)

beds, overlying the quartzites in the Kocaeli region, were most probably eroded. Farther to the east, in the area between Akyakoca, Alaplı and Ereğli, Ordovician-Silurian was not observed. However, to the south of Ereğli, within the shales and blue-colored limestones the following fossils were identified:

Monograptus cf. *armoricanus* Philipot
Orbiculoidea aff. *circe* Billings
Stropheodonta aff. *ivanensis* Barrande
Orthothetina cf. *pencki* Paeckelmann
Monograptus aff. *miloni* Philipot
Monograptus cf. *dubius* Suess
Trimerus sp.

The above fauna indicate an Upper Silurian age. In the basal parts of the limestones, transition to red-colored sandstones and conglomerates was observed (R.Egemen, 1947). Red-colored sandstones and siltstones, belonging to the same formation, can also be seen along the Akçakoca-Düzce road. These red-colored beds were similarly observed along the Ferizli -Adapazarı road. They are separated from the overlying fossiliferous Devonian by a thin quartzite bed. Red and green-colored sandstones are exposed at the core of an anticline located farther to the east, near İnkum (Bartın). These sandstones are thought to be the continuation of a Silurian formation observed in the west (CENTO report, 1966).

Towards east, in the area between Araç, Kastamonu and Tosya, the extension of the Ordovician-Silurian formation overlies the Ilgaz metamorphic massif. During recent studies carried out in the area (personal communication with E. Demirtaşlı and E. Arpat) such fossils as *Monograptus* sp., *Didymograptus* sp., *Dictyonema* sp. were discovered in the green and red-colored shales, siltstones and mudstones (with intercalations of quartzite and sandstone). Based on the fossils discovered in the area, an Ordovician-Silurian age was assigned to this formation. The lower contact of the formation is probably conformable with the Cambrian shales, whereas the upper contact is concordant with the Devonian beds.

The Ordovician-Silurian rocks occurring in the areas described above belong to different facies; therefore the assumption that the unfossiliferous red-colored sandstones and conglomerates are the eastern extension of the arkosic formation is rather doubtful.

According to E. Demirtaşlı (personal communication), the basal conglomerates of the Lower Paleozoic beds occurring in the area between Araç, Kastamonu and Tosya, rest upon the Ilgaz metamorphic massif. Based on this information, it may be presumed that the widespread metamorphic rocks which were previously considered as part of the Mesozoic crystalline massif are actually of Precambrian age. D. Alp (1972), who studied the Amasya area, found such fossils as *Harrisoceras* sp., *Euorthoceras* sp. and *Leurocycloceras* sp. of Middle Silurian age within the phyllite-like graywackes overlying the conglomerates and sandstone which rest discordantly upon these metamorphic rocks. Permo-Carboniferous overlies discordantly this formation.

1. Yalçınlar, who studied the Tokat-Amasya massif, found some Silurian fossils in the upper levels of the metamorphic rocks to the northwest of Tokat. How far the Ordovician-Silurian sea extended towards east cannot be stated definitely because of the presence of younger rocks which cover these formations. However, on the İran-Russian border, in the vicinity of Dzulfa located south of the Caucasus Mountains, the presence of Silurian rocks is known; thus it may be assumed that the sea extended as far as this area,

Although the lower levels of the Devonian rocks occurring to the north of Doğubeyazıt are not exposed, it may be logical to presume that the Silurian sea extended as far as this region, and that a branch of this sea which passed to the south of Caucasus Mountains continued in the eastern direction. The Elburz Range, in the northern part of Iran — considered to be the continuation of the North Anatolian Pontids — is characterized by a continental facies which was formed between Ordovician and Silurian. The Cambrian formations in this area are directly overlain by younger Paleozoic beds. Only in the western part of the Elburz Mountains, in the Talesh area, Silurian outcrops can be encountered. Moreover, in the Elburz Range in the Mubarak Abad area at Alam Kuh fossiliferous Ordovician (Lashkerak formation) is observed.

Based on the above given data, it may be assumed that the Ordovician-Silurian sea occupied very small areas in the northern part of Iran. On the other hand, west of the North Anatolian Range, no Ordovician-Silurian outcrops are encountered on the territory of Greece. Only to the east of Athens Devonian formations consisting of graywackes and slates (the lower part of which is not exposed) cover a very extensive area. Presence of Silurian in this area is highly probable. Moreover, shales of Lower Paleozoic age, intercalated with volcanic tuffs, were observed on the western side of the Argoli Bay.

CENTRAL ANATOLIAN REGION

The Ordovician-Silurian formations occurring in Central Anatolia mainly show a metamorphic facies. Only in the west, north of the Karaburun Peninsula, fossiliferous Ordovician-Silurian formations were observed (Fig.1 and 2). K. Lehnert-Thiel (1969), who carried out detailed studies in the Karaburun Peninsula, observed these formations exposed in a strongly faulted area. The unit consists mainly of sandstones, limestones and quartzites and continues towards the upper levels with red-colored hornstein, conglomerates, diabase-tuffs and graywacke. It is overlain by fossiliferous limestones of Upper Gotlandian age.

According to Höll (1966), the following fossils were found in the limestones which show a color variation ranging from black to white:

Palaeofavosites sp.
Entelophyllum articulatum (Wahlenberg)
Spongophylloides cf. *perfectus* (Wedekind)
Columnaria breviradiata (Weissermel)
Platyorthis cf. *cimex* (Kozlowski)
Leptaena rhomboidalis (Wilckens)
Camarotoechia nucula (Sowerby)

G. Kauffmann (1969), who carried out detailed studies in the Chios Island, located to the west of the Karaburun Peninsula—and which shows similarities to this arae both from stratigraphic and tectonic points of view—found in the vicinity of Kardamila in the northeastern part of the Island, within the siliceous schists and clayey beds such Graptolites as:

Monograptus priodon (Bronn)
Monograptus Sedgwicki Heddein
Diplograptus (Petalograptus) cf. *palmeus* (Barrande)

to which he assigned a Lower Silurian age. Overlying discordantly this formation Upper Silurian-Lower Devonian beds—consisting of quartzites, graywackes, siliceous schists and limestones—suggest the presence of Kaledonian orogeny.

The Lower Silurian formation is unconformably underlain by metamorphic rocks.

No other fossiliferous Ordovician-Silurian exposures were encountered in Central Anatolia. Rocks belonging to a green schist facies which underlie the Carboniferous and Permian beds in Western Anatolia are, most probably, of Lower Paleozoic age. In particular, marble beds, reaching in places a thickness of over 1000 m, and metamorphosed bauxite intercalations (Devonian?) and the underlying sericite-chlorite schists, quartzites and graphite schists almost 1000 m thick, which are widespread in the Menderes massif, are considered to be probably of Silurian age. (Taking into consideration the similarity of these beds with the fossiliferous Ordovician beds observed at Babadağ, south of Denizli.)

Most of the slightly metamorphosed rocks underlying the Permo-Carboniferous formations are Ordovician-Silurian in age. These rocks are exposed in a zone extending NW-SE and are overlain by Devonian and Permo-Carboniferous which outcrop in places. They begin to the north of Bursa-Gemlik and, trending in a SE direction, extend as far as Sultan Dağları and the northern part of Konya, passing through Bozöyük-Bilecik and Afyon-Uşak-Kütahya areas. The possible eastern extension of this area cannot be traced since the area is covered with younger formations.

1. Yalçınlar (1963) reports that in the western extension of the Menderes massif, in the vicinity of Babadağ, Graptolites and Crinoids were collected from the phyllites and intercalations of marble and quartz that overly the gneisses and mica-schists which represent the main constituents of the massif.

Fossils such as *Dictyonema* sp. and *Acanthograptus* sp. were found in the Ordovician-Silurian formation of this area. The author, who reports that the formation is overlain unconformably by Carboniferous beds, points out that the lower contact with the possibly Cambrian formations is conformable. This cannot be true for the entire Menderes massif. In fact, various authors have accepted that the massif is actually a continuous metamorphic series going up to Jurassic, while the stratigraphical relationship between different formations is interpreted in various ways. The only factor that is highly probable is presence of an unconformity between the metamorphic rocks and the overlying limestone series. This fact is valid for the entire Western Turkey. The above-described unconformity can be well observed in the following localities:

1. Going for some 10 km towards north along the Civril-Sivas road;
2. 5 km west of Çal;
3. At Muratdağ and to the north of Saraycık (at Kızıldağ);
4. Some 40-50 km northwest of Saraycık and in the Kocasu Valley, located 30 km to the west of Kütahya;
5. In the near vicinity of the Dağgüney village, on the southern flank of Çalça Tepe situated 8 km to the northeast of Orhaneli;
6. At the intersection of the road between Balya and İvrindi;
7. 20 km to the SSE of Akhisar-and in the bed of the Gördes Stream located 8 km to the NE of Gölmağara;
8. At Dağakçe, along the Orhaneli-Bursa road.

According to L. Dubertret and A. Kalafatçıoğlu (1972), the stratigraphical level of the unconformity changes from one place to another. Transgressive series most probably start with Upper Permian.

Ordovician-Silurian formations are also found in the Sultan Dağları area. İ. Yalçınlar (1959) and H. Haude (1968) report that schist and phyllite occurrences contain Graptolites of Ordovician-

Silurian age. Transition between Ordovician and the overlying Silurian, NE of the Davras Mountain is represented by fine-grained, dark-colored clays and bands of light-colored sandy layers. Remnants of *Monograptus* sp. are found in the Silurian beds.

SOUTHERN ANATOLIAN REGION

Fossiliferous Ordovician-Silurian formations are mainly exposed in Southern Anatolia. Especially recent geological studies carried out in this region suggest that the sedimentary Ordovician-Silurian formations may also be represented in the Taurus Range (Fig. 1, 2).

No outcrops of Lower Paleozoic formations are observed in the area stretching alohg the coastal mountain ranges of Mediterranean as far as the Antalya Bay. In the western part of Southern Anatolia fossiliferous Ordovician beds are observed in the vicinity of Seydişehir., Sandstones, shales and weakly metamorphosed rocks—which were previously know as «Seydişehir schists»— observed here resemble a flysch formation and contain limestones and dolomites. The Ordovician is conformably underlain by red-colored, nodular limestones of Cambrian age, while its upper parts are overlain by Triassic beds.

W.T. Dean and O. Monod (1970), who studied in detail this area, give the following stratigraphic sequence (from top to bottom):

Sobova Formation : Shale, sandstone: gray shales, showing lateral transition into red shales and sandstones (thickness: 20 m).

Sobova limestone; gray and pink-colored detritic limestone, massive and well-bedded shale, sandstone (thickness: 0-10 m).

Seydişehir Formation : Upper graywackes (thickness: 20m).

The thickness of the Seydişehir shales is more than 1000 m.

According to these authors, the Seydişehir shales, consisting of quartzites with alternating silty, micaceous shales and attaining a thickness of some 1000 meters, are characteristically a monotonous series. The following fossils were found in these shales:

Trilobites
Dalmanellid brachiopods
Gastropods *(Lesueurilla* sp.)
Bivalves *(Redonia* cf. *prisca* Thoral)
Graptolites *(Tetragraptus* cf. *reclinatus* Elles & Wood
Didymograptus deflexus Elles & Wood
Didymograptus cf. *nitidus* Hall)

Based on these fossils the series may be assigned a Lower Ordovician age.

The Sobova limestones, located in higher levels, contain the following fossils:

Eodalmanella sp.
Agerina sp.
Carolinites sp.
Illaenus sp.
Niobe sp.
Ampyx sp.
Symphysurus sp.

as well as Ordovician Trilobites.

SE of Seydişehir, near Hadım, N. Özgül (1971) found Trilobites and Brachiopods in the limestone lenses occurring in the alternating shale-sandstone unit located at the lowest level of the autochthonous series, to which he tentatively assigned a Cambrian-Ordovician age.

Further to the south in the Anamur-Ovacık and Silifke areas again fossiliferous Ordovician-Silurian outcrops were encountered. To the NW of Ovacık, clayey schists and shales overlying Cambrian beds contain Ordovician fossils; these in turn are overlain discordantly by the Lower Silurian beds. İ. Yalçınlar (1964), E. Demirtaşlı (1967) and M. Ardos (1968), who studied this area, determined the following fossils:

Strophomena sp.
Didymograptus cf. *uniformis* Elles & Wood
Didymograptus cf. *D. nichohoni* Elles & Wood
Euloma sp.
Nileus sp.
Symphysurus sp.
Obolids
Lingulids

This series attains a thickness of 400-600 m; it is overlain unconformably by arkose conglomerates and Silurian beds. In the uppermost part of the series, which consists of shale, clay and limestone alternations, limestone and quartzites were found. The upper contact of the formation with the Middle Devonian is unconformable. M. Ardos (1968) determined the following fossils in this series:

Monograptus cf. *decipiens* Tornquist
Rastrites sp.
Climacograptus cf. C. *scalaris* Hisinger
Monograptus cf. *spiralis* Geinitz
Monograptus cf. *jaculum* Lapworth
Monograptus cf. *clingani* Carruthers
Monograptus cf. *sedgwicki* Portlock

Towards east in the part of the Taurus Mountain range which is represented here by the Bolkar Mountain, no Silurian fossils were observed in the metamorphic series. However, going further to the east—in the area between Kozan-Feke-Saimbeyli-Sarız and Pınarbaşı—extensive fossiliferous outcrops of Ordovician-Silurian formation are encountered.

For instance, Ordovician is exposed to the south of Pınarbaşı 5 km NE of the Değirmentaşı village in Armutludere. Here the series consists of Cambrian limestones and shales and is overlain conformably by shales and siltstones containing abundant Graptolites and Trilobites. E. Demirtaşlı (1967) and N. Özgül (1973) found in this area such fossils as *Dolerorthis* sp. and *Orthis* sp. Since the formation is covered by basal conglomerates of Lower Silurian age, it should be attributed to Ordovician. Conglomerates and sandstones of Lower Silurian age are overlain by alternations of dark-colored shales and cherts of Lower Silurian. The following fossils were determined by A. Kallioğlu:

Monograptus spiralis (Geinitz)
Monograptus lobiferus (M'Coy)
Monograptus halli (Barrande)
Monograptus convolutus (Hisinger)
Monograptus denticulhtus Tornquist
Monograptus decipiens Tornquist

The formation is overlain conformably by a member consisting of alternating layers of limestones and shales of Upper Silurian - Lower Devonian age.

F. Baykal (1971) found some fossils such as *Monograptus communis* Lap. and *Monograptus lobiferus* M'Coy of Upper Silurian in the arkosic beds in the vicinity of Teke Deresi, between Sarız and Mağara.

On the other hand, İ. Yalçınlar (1964), collected a number of Graptolites occurring within the schist beds of Gedikli, 35 km to the north of Feke, whieh were determined by Dr. Berry as follows:

Monograptus gregarius Lapworth
Climacograptus medius Tornquist
Climacograptus scalaris (Hisinger)
Petalograptus minor Elles
Rastrites cf. *R. approximates* (Perner)

Based on these fossils a Lower Silurian age was assigned to the formation.

F. Baykal reports that the contact between the Upper Silurian series —consisting of limestone, shale, sandstone, fine-grained quartzite and clay alternations—and the overlying Devonian beds, observed SE of the Değirmentaşı village, is slightly discordant.

Ordovician formations occurring in this part of the Taurus Ranges (Hadım, Seydişehir, Saimbeyli-Mağara and Feke-Sarız areas) show facies similarities and contain abundant macrofauna. These formations are mainly composed of sandy detritic material and represent a shallow environment characterized by turbulent flows.

In general, Silurian formations were also developed in a shallow environment.

No exposures of Ordovician-Silurian formations were encountered in the wide area to the east of the Sarız-Kozan line, extending as far as the Binboğa Mountains and the vicinity of Malatya-Çelikhan, because of a large and partly metamorphosed Permo-Carboniferous cover which overlies these series. In contrast, further to the south, in the Amanos Mountains, fossiliferous Ordovician-Silurian beds can be observed in many places.

The Ordovician formations occurring in the Amanos Mountain Range were first found on the Gavur Mountain during construction of a 5-km-long tunnel between Bahçe and Fevzipaşa in the Karasu Valley. This tunnel extends in the NNW-SSE direction. The formation found in this area consists of alternating schists and quartzites, within which a large fragment of Cruziana as well as a pygidium of a Trilobite were discovered 2300 and 750 m (respectively) west of Ayran. This Trilobite was described as an *Acaste* sp.

R. and E. Richter, who studied this specimen later, have determined this fossil as *Dalmanitina* sp. closely resembling *Dalmanella solitaria* and *Dalmanella incerta* Deslongchamp of Ordovician age (L. Dubertret, 1966).

W.T. Dean and R. Krummenacher report that *Dalmanitina* sp. and a fragment of Cruisiana have been collected from the upper part of the formation which has as thickness of 1115 m. According to these authors the Ordovician of Ayran is identical with the Ordovician observed in the vicinity of Mığır Tepe and overlies with a slight unconformity the Cambrian formation. The Ordovician beds of Mığır Tepe are transgressively overlain by Triassic.

In the vicinity of Fevzipaşa-Hasanbeyli, in the dark-colored calcareous shales containing bands of sandstone and mudstone a *Dalmanitina* sp. was found of Ordovician age. According to L Ketin, the basal part of this formation, which is some 1000 m, cannot be seen. These beds are over-

lain discordantly by Devonian. Further to the north in the Maraş Province, 3.5 km west of Eloğlu, the presence of Ordovician-Silurian series was reported by petroleum geologists who studied this area (D. Tuna, 1973).

1. Ketin reports also that in Fevzipaşa, at Nurdağı, he observed again fossiliferous Ordovician and Silurian beds.

SOUTHEASTERN ANATOLIAN REGION

The Ordovician-Silurian outcrops of this region are mostly found in the vicinity of Derik (Bedinan village) as well as at Korudağ, south of Çüngüş, Hazro and to the south of Hakkari (Fig. 1, 2).

The Ordovician formations occurring in the vicinity of Bedinan village (Derik) and at Şeyh Sait Ziyareti were studied by the author of this paper and by C. Teichert and B. Sözeri (CENTO, 1968). The formation observed in this locality consists of green-colored shales containing sometimes sandstone, siltstone and mudstone intercalations. It is as much as 500 m thick and contains abundant fossils. Some fossils collected from the Bozoko village will be determined by T.W. Dean. Although the results of this study are not yet available, it is believed that the age of these fossils is probably Middle-Upper Ordovician. The upper levels of the formation can be well seen at the core of the anticline located near Bedinan (north of Mardin). In this area large rock boulders and gray-colored, medium-grained sandstones are found within the shales. These are thought to be the equivalent of the Silurian-Devonian-aged Dadaş Formation.

Based on the fossils found in this area (such as *Cryptolithus* sp., *Climacograptus* sp., *Lingula* sp., *Diplograptus* sp., *Endoceras* sp. and *Sowerbyella* sp.), a Middle-Upper Ordovician age was assigned to this formation. The lower level of this series is discordant with the Cambrian beds, while the upper level is concordant with the Silurian formation. However, it is impossible to define the boundary of these contacts.

Sandstones overlying these shales are green to gray-colored. The formation is thick to thin-bedded and contains siltstone intercalations in its basal part where it is very thin bedded. The age is probably Upper Ordovician. Overlying these sandstones, with a contact that seems to be conformable, are shales of Lower Silurian age.

Further to the north in the vicinity of Hazro exposures of fossiliferous Devonian formation are observed. Drilling carried out in this area has reached, at 575-and 1700 m-depths, beds of sandstones and shales containing such fossils as *Parachitina luruata, Conochitina claviformis, Desmochitina nodosa* and some Graptolites and Orthoceras. Based on these findings, a Silurian age was assigned to the formation. Thus, it may be concluded that the Hazro region was also covered with the Silurian sea.

Presence of the Silurian formation in the east, in the Hakkari region, was known since many years. According to E. Altınlı (1966), this unit is nearly 1000m thick at the Giri Mountain and consists of gray, red and purple quartzites and secondary psammites, marls and limestones, which are exposed at the core of the middle Büyük Zap antrcline. Only Cruziana was determined from this sequence. This unit is pseudo-conformable with the underlying Cambrian and the overlying Devonian beds.

S. Türkünal (1953) believes that the thick quartzite beds (1000 meters) occurring at the Nekola Mountain, located to the east of Şemdinli, are Cambrian-Silurian in age. Further to the south, in Iraq, the formation consisting of quartzites and siliceous shales contains Cruziana fossils and, since these beds are overlain by Devonian, a Silurian age may be accepted. Further to the east, in Iran,

however, the Cambrian limestones, marls and sandstones occurring in the Kerman-Sagand area, grade into a limestone, shale and schist sequence containing Orthidae which overlies them conformably. An Ordovician age is assigned to this sequence. Going to the south, at Bandar Abbas, in the Gahkum section, a unit consisting of black and green-colored shales and sandstones contains praptolites and is Silurian in age. This formations is overlain unconformably by Carboniferous beds.

Holes drilled in the Kamışlı area in Syrian territory in near vicinity of Nusaybin exposed clay, sand and sandstone beds containing Chitinozoa and Hystrosphaeridae fossils. This series, attaining a thickness of some 500 m, shows a marine origin. Drilling operations carried out in this part of Syria (in Hassetche) and in the vicinity of Jebel Sindjar, in Iraq, have penetrated a formation consisting of sandstones, siltsones and schists. The fact that the detritic Ordovician-Silurian formations in the vicinity of Derik merge into the Ordovician-Silurian to the south of Hakkari, was proved based on the results obtained from drillholes opened between these two localities.

Manuscript received December 6, *1973*

Translated by: Filiz E. DİKMEN

BIBLIOGRAPHY

ABDÜSSELAMOĞLU, Ş. (1963): Nouvelles observations stratigraphiques et paleontologiquies sur les terrains paleozoiques affleurant a l'Est du Bosphore. *M.T.A. Bull.,* no. 60, Ankara.

ALP, D. (1972): Amasya yöresinin jeolojisi. İ*st. Üniv. Fen Fak. Monogr.,* sayı 22, İstanbul.

ALTINLI, E. (1966): Geology of Eastern and Southeastern Anatolia. *M.T.A. Bull.,* no. 66, Ankara.

———(1968): Geologic investigation of the İzmir-Hereke-Kurucadağ area. *M.T.A. Bull.,* no. 71, Ankara.

ARDOS, M. (1968): Les glacis d'Ovacık. *Review Geogr. Inst. Univ. İstanbul,* no. 11, İstanbul.

BAYKAL, F. & KAYA, O. (1965): Note preliminaire sur le Silurien d'İstanbul. *M.T.A. Bull,* no. 64, Ankara.

BAYKAL, F. (1971): Historik jeolojisi. *Karadeniz Teknik Üniv. Yayınl.,* no. 38.

BRINKMANN, R. *et al.* (1970): Geologie der Soma Dağları. *M.T.A. Bull.,* no. 74, Ankara.

CENTO (1966): Report of CENTO stratigraphic working group field meeting (unpublished).

———(1967): Report of CENTO stratigraphic working group field meeting (unpublished).

———(1968): Report of CENTO stratigraphic working group field meeting (unpublished).

DEAN, W.T. & MONOD, O. (1970): The Lower Palaeozoic stratigraphy and faunas of the Taurus Mountains near Beyşehir, Turkey. *Bull. British Museum (Nat. Hist.) Geology,* vol. 19, no. 8, London.

DEMİRTAŞLI, E. (1967): Pınarbaşı-Sarız-Mağara civarının jeolojisi. *M.T.A. Rep.,* no. 1335, Ankara.

DUBERTRET, L. (1966): Liban, Syrie et bordure des pays voisins. *Mem. Museum Nat. Hist. Natur.,* t. VIII, Paris.

———& KALAFATÇIOĞLU, A. (1973): Explanatory text of the Geological Map of Turkey, Izmir Sheet. *M.T.A. Publ.,* Ankara.

EGEMEN, R. (1947): A preliminary note on fossiliferous Upper Silurian beds near Ereğli. *Bull. Geol. Soc. Turkey,* vol. I, no. 1, Ankara.

ERENTÖZ, C. (1966): Contribution a la stratigraphie de la Turquie. *M.T.A. Bull.,* no. 66, Ankara.

FRECH, F. (1916): Geologie Kleinasiens im Bereich der Bagdad-Bahn. *Z. deutsch. geol. Ges.,* Bd. 68.

GHUKASSIAN, H. (1968): Zur Geologie des Gebietes westlich Doganhisar im sudlichem Sultandağ (Türkei). *M.T.A. Rep.* (unpublished), Ankara.

KAUFFMANN, G. (1969): Die Geologie von Nordost-Chios (Agais). Marburg.

HAUDE, H. (1968): Zur Geologie des mittleren Sultandağ sudwestlich von Akşehir (Türkei). *M.T.A. Rep.* (unpublished), Ankara.

HÖLL, R. (1966): Genese und Altersstellung von Vorkommen der Sb-Hg-Formation in der Türkei und auf Chios (Griechenland). *Bayer. Akad. d. Wiss., Math.-Natur-Wiss.K., Abh.,* Neu Folge, H, 127, Munchen.

KETİN. İ. (1959): Über die Tektonik des Çamlıca-Gebietes bei İstanbul. *Bull.Geol.Soc. Turkey,* vol. VII, no. 1, Ankara.

———(1963): Explanatory text of the Geological Map of Turkey, on 1:500,000 scale,—Kayseri Sheet. *M.T.A. Publ.,* Ankara.

LEHNERT-THIEL, K. (1969): Geologisch-Lagerstattkundliche Untersuchungen an dem Zinnobervorkommen Kalecik und den nordostlichen Teil der Halbinsel Karaburun/westl. Türkei. *M.T.A. Bull.,* no. 72, Ankara.

ÖZGÜL, N. (1971): The importance of block movements in structural evolution of the northern part of central Taurus. *Bull. Geol. Soc. Turkey,* vol. XIV, no.l, Ankara.

———METİN, S; GÖĞER, E.; BİNGÖL, İ.;BAYDAR,O. & ERDOĞAN, B. (1973): Cambrian-Tertiary rocks of the Tufanbeyli region, eastern Taurus, Turkey. *Bull. Geol. Soc. Turkey,* vol. XVI, no. 1, Ankara.

PAECKELMANN, W. & SIEVERTS, H. (1932): Obersilürische und devonische Faunen der Prinzeninseln, Bythiniens und Thraziens. *Abh. Preuss. Geol. Landesanst.,* N.F. Heft, P.8, Berlin.

SAYAR, C. (1960): İstanbul boğazında arkozlar içinde bulunan Ordovisiyene ait bazı Conularia'lar (unpublished.)

TOKAY, M. (1952): Contribution a l'etude geologique de la region comprise entre Ereğli, Alaplı, Kızıltepe et Alacaağzı. *M.T.A. Mecm.,* no. 42/43, Ankara.

TOKAY, M. (1954—1955): Filyos çayı ağzı-Amasra-Bartın-Kozcağız-Çaycuma bölgesinin jeolojisi. *M.T.A. Mecm.,* no. 46/47, Ankara.

TUNA, D. (1973): VI. Bölge litostratigrafi birimleri adlamasının açıklayıcı raporu. *T.P.A.O.,* Ankara.

TÜRKÜNAL, S. (1953): Geologie de la region de Hakkari et de Başkale (Turquie). *These, Fac. Sci. Univ. Geneve, M.T.A. Matbaası,* Ankara.

ÜNSALANER-KIRAĞLI, C. (1958): *Alveolites lemniscus* Smith from the Upper Silurian of Sedef Adası (Antirovitha) with remarks on the genera Roseoporella and Kitakamiia. *M.T.A. Bull.,* no. 50, Ankara.

YALÇINLAR, İ. (1959): Sur le terrain du Primaire ancien an Sud d'Akşehir (Turquie). *C.R. Soc. Geol. France,* Paris.

———(1963a): Le massif caledonien de Babadağ et ses couvertures anthracolitiques. *M.T.A. Bull.,* no. 60, Ankara.

———(1963b): Giaptolite series belonging to Silurian found in the Mediterranean region of Turkey. *Publ. Geogr. Inst., Un. İstanbul,* no. 36, İstanbul.

———(1964): Les couches du Paleozoique inferieur dans la Turquie meridionale. *Fac. Geogr. Un. İstanbul,* no. 39, Istanbul.

———(1973): Observations sur la faune du Primaire ancien dans la region mediterraneenne de la Turquie. *Bull. Geol. Soc. Turkey,* vol. XVI, no. 1, Ankara.