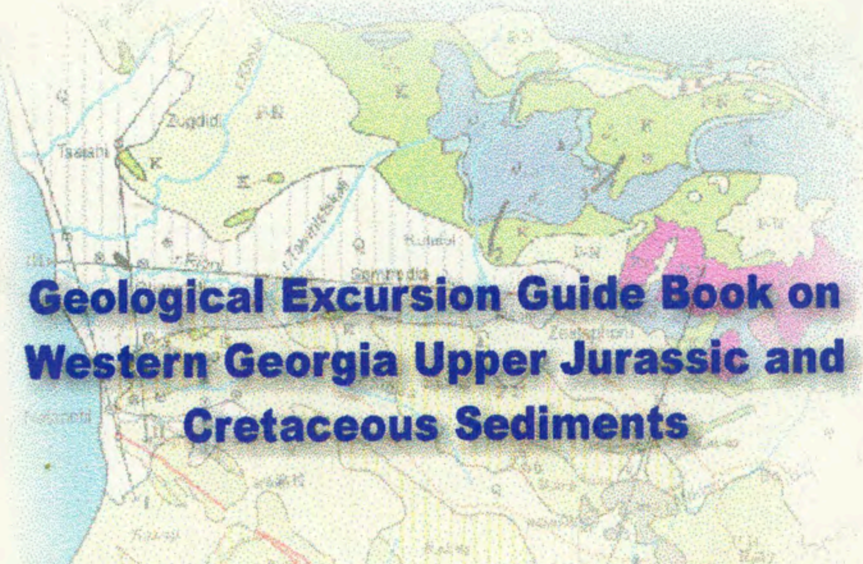

Geological Excursion Guide Book on Western Georgia Upper Jurassic and Cretaceous Sediments

OIL AND GAS COMPANY
SAKNAVTOBI

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Part 1
General Information About Geology of Georgia*

* This part is prepared on base of article by Sh.Adamia, K.Akhvlediani, V.Kulasonia, A.Nairn, D.Papava and D.Pattor Geology of the Republic of Georgia: a review" in International Geology Review, 1992, 34, #5, pp.447-476

Introduction

The Republic of Georgia encompasses part of the Alpine Himalayan fold belt; it extends from the northern slope of the Greater Caucasus to the Lesser Caucasus in the south, a geologically complex zone sandwiched between two lithospheric plates, the Afro-Arabian (Gondwana) and the Eurasian plates. More specifically it consists of the Greater Caucasus Range to the north and the Transcaucasus to the south (Fig.1). The sutured boundary (the Sevan-Akera zone) lying between the Transcaucasus and the Lesser Caucasus to the south is effectively the northern margin of Gondwana. The northern boundary, between the Caucasus Mountains (*sensu stricto*) and the Scythian Platform, the southerly projection of the Russian Platform, is less clearly defined due to the superposition or partial superposition of the

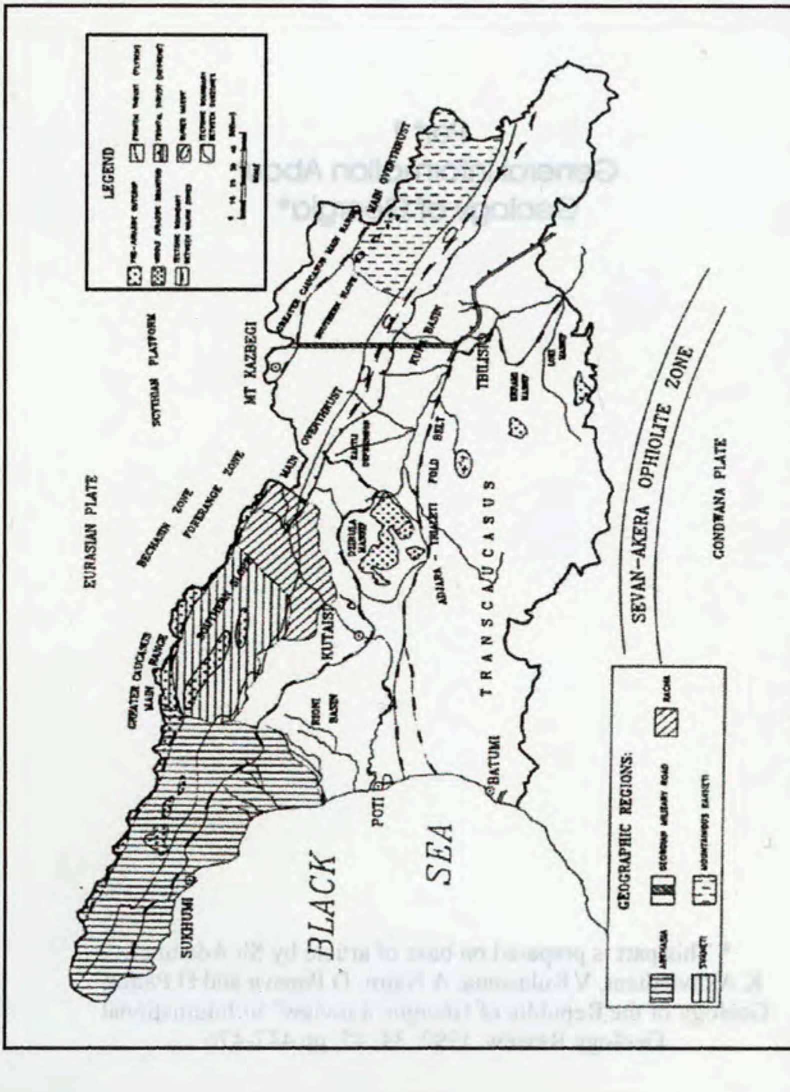


FIGURE 1. The principal geographic and geological regions of Georgia.

Alpine tectonic edifice over the Hercynian and older rocks of the Scythian Platform. One consequence of this has been that the pre-Mesozoic, or more specifically the pre-Jurassic, geological history of the Georgian region is known only in broad outline. Even until quite recently all the metamorphic rocks of the Caucasus were regarded as Precambrian, as the occurrence of a Hercynian metamorphosed suite which includes granites and lower Paleozoic rocks had not been recognized.

The geological, structural and stratigraphic history of the Republic of Georgia is consistent with the observed depositional sequences and lithologies. It is basically the history of the evolution of the Caucasus Mountains and is most easily described in terms of the Greater Caucasus and the Transcaucasian regions. Basin development is discussed here in the context of plate tectonics, and particular attention has been directed toward igneous activity and its relationship to the tectonic processes of an active margin. A general outline of the regional structure is presented, followed by a review of Paleozoic and Triassic history. The description of the less deformed and better exposed Jurassic, Cretaceous, and Cenozoic sections which follows is presented in greater detail.

Structural Outline of the Greater Caucasus Region

The Caucasian Alpine Province lies across the junction of the Eurasian and Gondwana plates. In the deep seismic and geological profile (Fig. 2) across the Caucasian province, four broad zones (Fig. 3) are clearly indicated. These are the Iranian subplate in the south followed sequentially by the Transcaucasian median mass, the Greater Caucasian folded zone and to the north the Scythian (Precaucasian) Platform in the north. Certain features of the seismic profile have been interpreted as indicating the existence of relicts of an older Hercynian suture under the Greater Caucasus range (Adamia et al., 1990). However, the persistence of a trough, the Dizi trough, from Devonian to the early Liassic seems to rule out a purely collisional hypothesis for its origin and favor a collisional event passing to a translational episode. South of the Transcaucasus, traces of a younger ocean floor have completely disappeared, but its former presence is marked by the line of the Sevan-Akera suture, and relicts of it are preserved in the southern Caspian and central Black Sea (Zonenshain and Le Pichon, 1986). South of the suture lies the Lesser Caucasus (Fig. 3), with the exposed rocks indicating that it was part of the old Gondwana Mesozoic carbonate province.

Parts of the Hercynian basement are exposed in Transcaucasia and the Greater Caucasus, and these show enough similarity that it is permissible to regard them as having been a single unit prior to separation during the Mesozoic. The Scythian basement, the southern margin of Eurasia, is buried under a thick sedimentary succession and is nowhere exposed. It is in the Greater Caucasus that the younger Alpine edifice, which overrides the southern Eurasian margin, is so spectacularly developed, and is coincident with the second suture to have formed in the same region. The present tectonic zonation is illustrated in Figure 1. Within the intracontinental folded structure of the Greater Caucasus and Transcaucasus, the several terranes or continental and island-arc fragments which accreted to the Eurasian margin during the Phanerozoic can be recognized through the analysis of facies, paleo-biogeography, magmatic evolution, and paleomagnetic data. Some are classified as European, Tethyan, or Gondwanan, the origin of others remains suspect.

Hercynian accretion, which marked the end of Paleotethys, is the oldest event documented by radiometrically dated late Paleozoic granites. Thus in mid-Carboniferous, the Greater Caucasus composite terrane (part of the extensive Paleozoic island-arc system of Northern Tethys) collided with the European Platform closing Paleotethys with the metamorphism and folding of the East

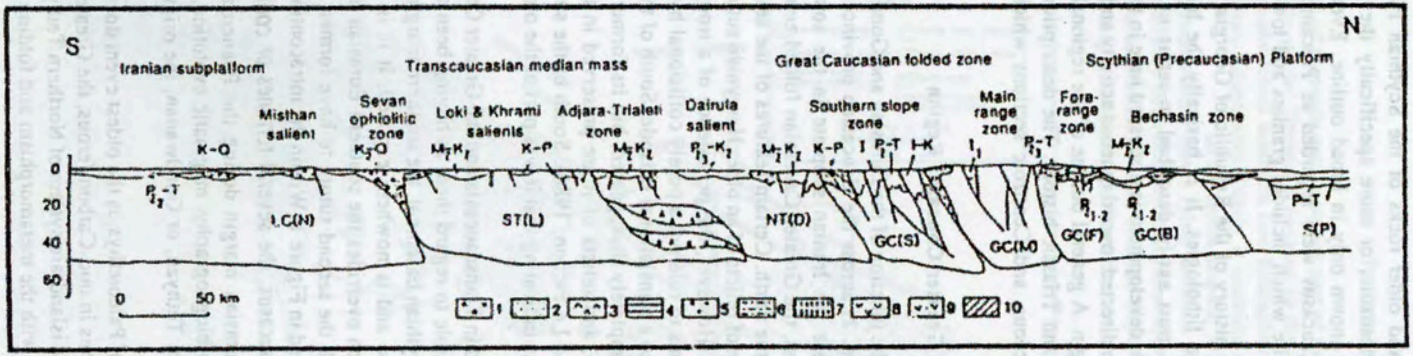
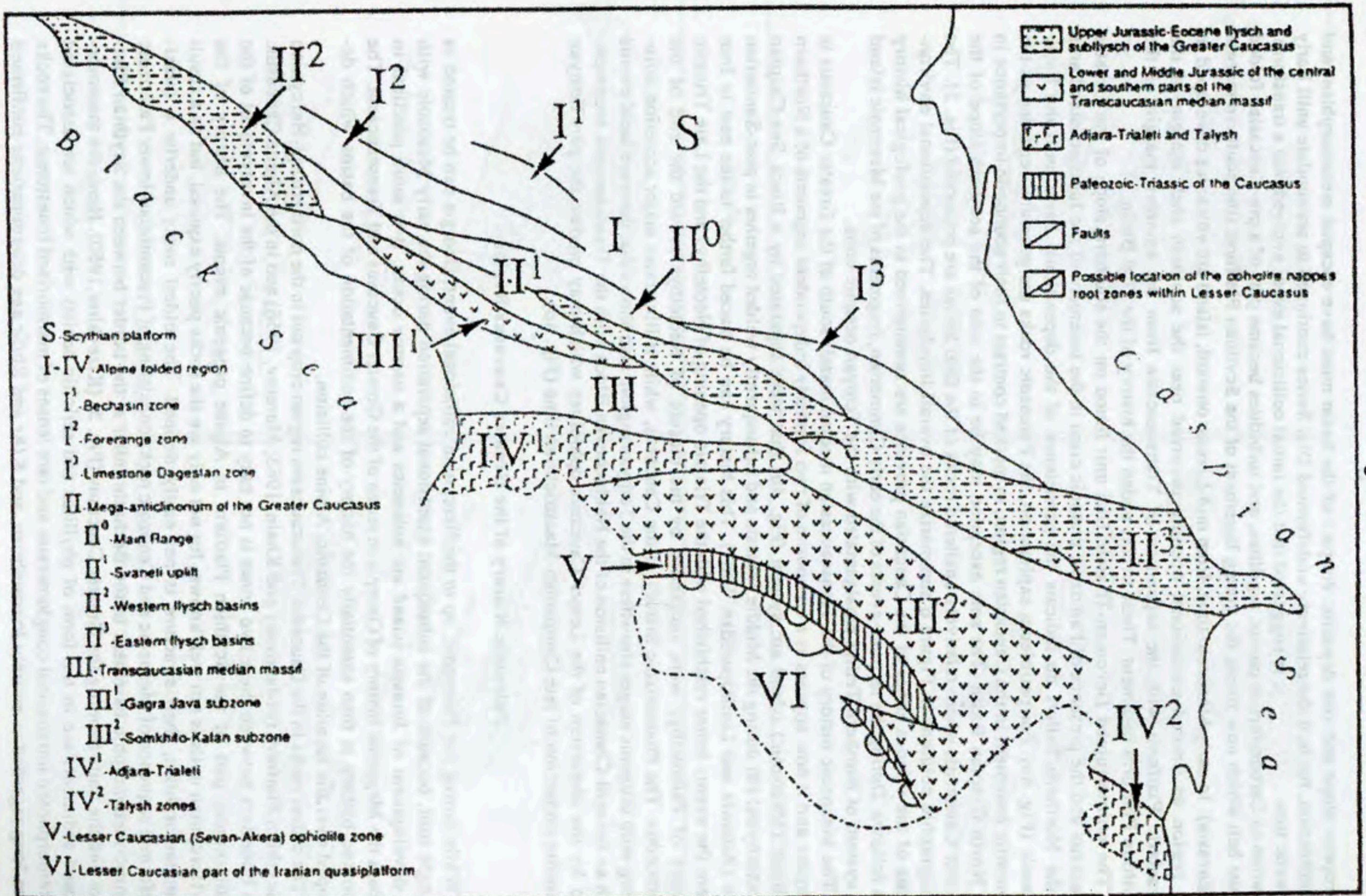


FIGURE 2. Geological-geophysical profile across the Caucasus. Principal tectonic units: LC(N), Lesser Caucasus (Nakhichevan); SAT(L), Southern Transcaucasus (Loki); NT(D), Northern Transcaucasus (Dzirula); GC, Greater Caucasus, (S-Southern slope, M-Main range, F-Forerange, B-Bechasin, S(P)-Scythian (Precaucasian) Platform). 1) Ophiolite nappes of the Lesser Caucasus (Vedi, Mishkan, Sevan); 2) Adjara-Trialeti overthrust nappe; 3) high-velocity inliers in the crust of the Transcaucasus; 4) pre-Alpine tectonic slices of the Dzirula Massif; 5) nappes in the Transcaucasus molasse deposits; 6) frontal overthrust nappes in the flysch zone of the Greater Caucasus; 7) pre-Alpine tectonic slices and nappes in the Main Range; 8) pre-Alpine ophiolitic nappes of the Forerange and Bechasin; 9) parautochthon (nappes ?) of the Forerange; 10) overthrusts in the sedimentary cover of the Scythian Platform.


Upper Jurassic-Eocene flysch and subflysch of the Greater Caucasus
Lower and Middle Jurassic of the central and southern parts of the Transcaucasian median massif
Adjara-Trialeti and Talysh
Paleozoic-Triassic of the Caucasus
Faults
Possible location of the ophiolite nappes root zones within Lesser Caucasus
S-Scythian platform
I-IV-Alpine folded region
I¹-Bechasin zone
I²-Forerange zone
I³-Limestone Dagestan zone
II-Mega-anticlinorium of the Greater Caucasus
II⁰-Main Range
II¹-Svaneti uplift
II²-Western flysch basins
II³-Eastern flysch basins
III-Transcaucasian median massif
III¹-Gagra Java subzone
III²-Somkhito-Kalan subzone
IV¹-Adjara-Trialeti
IV²-Talysh zones
V-Lesser Caucasian (Sevan-Akera) ophiolite zone
VI-Lesser Caucasian part of the Iranian quasiplatform
Black Sea
Caspian Sea
S
I
I¹
I²
I³
II⁰
II¹
II²
II³
III
III¹
III²
IV¹
IV²
V
VI

European slope and rise deposits. As part of the basin must have escaped metamorphism and compression, for in it the relatively undeformed Dizi Series continued to accumulate until Early Jurassic time it is suggested that the initial collisional event evolved into a transform. Silurian to Carboniferous cherts, argillites, and turbidites became part of a pre-Caucasian folded thrust belt which now forms the young basement of the Scythian Platform (the southern margin of Eurasia). In early Mesozoic time, from mid-Liassic onward, island arc volcanics developed in the region as limited extensional opening occurred near the southern shelf margin of the Eurasiatic Platform with the separation of Transcaucasia from the southern margin of the Scythian Platform basement. These events ended the history of the Dizi Basin.

The uninterrupted Devonian-Triassic Dizi unit found on the southern slope of the Greater Caucasus and the presence of Paleozoic cratonic crust in the basement of the Jurassic island arcs of the Northern Tethys do indicate the persistence of the depositional basin until the Early Jurassic (Fig. 4a). For petroleum exploration, the Paleozoic rocks are generally regarded as the economic basement in the Caucasian region, in marked contrast to their economic importance in the North Caspian Basin. The sole exception may be in the area of the southern slope of the Greater Caucasus, where relatively unaltered rocks of the Dizi Series are preserved (Fig. 5). The stratigraphic columns in Figure 6 summarize the overall lithofacies. The depositional environments of the various zones of the Caucasian province are summarized in the geological history that follows. During the tectonic events of the early Cimmerian, fragments of the Mesozoic island arc system of Northern Tethys amalgamated with the Tethyan oceanic units.

The Mesozoic history of the Transcaucasian median massif south of the Greater Caucasus is complex and it now appears as a composite of two formerly independent segments of a Northern Tethyan (Mesozoic) island arc system (Fig. 4b) that were separated by a Black Sea-Caspian (Neotethyan) rift during the Middle Jurassic and subsequently welded together in post-Santonian time (Adamia and Lordkipanidze, 1987). This history can be traced farther to the east in Iran where the events better established with the Triassic opening of Neotethys and the Late Triassic closure of Paleotethys were succeeded by the closure of Neotethys toward the end of the Cretaceous. The Phanerozoic history of the Caucasus, while it illustrates major accretion coinciding with orogenic stages elsewhere in the Tethyan region, also shows that there are local events such as the mid-Coniacian collision of the Nakhichevan Block with the Transcaucasus accompanied by the obduction of the Lesser Caucasus ophiolites which may predate the pan-Tethyan ophiolite obduction of late Campanian-Maastrichtian time (Fig. 4d).

Paleozoic History of the Greater Caucasus Region

While during the Paleozoic, up to the Hercynian collisional event, Georgia can be treated as a single unit, because of the subsequent extensional separation during the early Mesozoic with the development of Jurassic island arc volcanics and a narrow ocean, it is more practical to discuss the Mesozoic history of Georgia in terms of the Greater Caucasus and Transcaucasia. The Cenozoic history is then essentially the history of the sedimentation of the basins which developed over the location of the Cenozoic, Alpine collision.

The oldest rocks in the Caucasus-Transcaucasus region crop out in the northern epi-Hercynian or Scythian Platform (Milanovsky and Khain, 1963; Muratov, 1956) and in the Alpine Caucasus. The boundary between these two zones is not easy to define because of the involvement of the southernmost part of the Scythian Platform in Alpine orogenic events. The history of the pre-Hercynian units is not well known, for not only are the rocks poorly exposed, but as a result of metamorphism, their structure is not easily defined. The oldest rocks underlie a quasi-platformal sequence of Mesozoic and Cenozoic rocks consisting of Precambrian-lower Paleozoic granitic-metamorphic basement in the Bechasin inlier at the border between the Scythian Platform and the units forming the Greater Caucasus (Fig. 3) (Kizevalter,1960). Here, the metamorphosed sediments are in the form of phyllites and sericitic schists with which are associated metamorphosed intrabasinal conglomerates and rare lenses of marmorized limestones. The rocks were long regarded as entirely Precambrian, and K/Ar and Rb/Sr age determinations confirmed

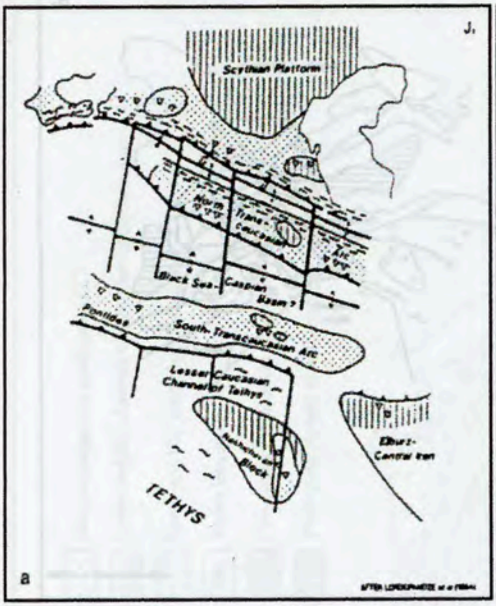


Fig. 4a

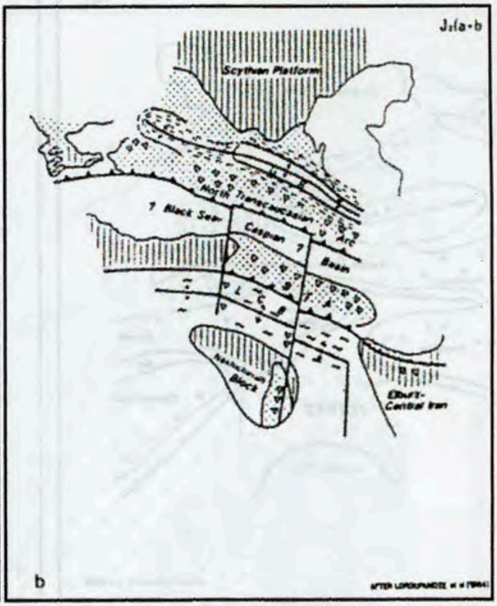


Fig. 4b

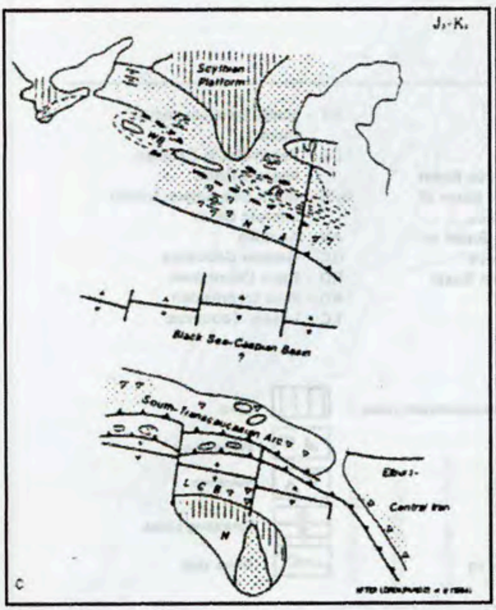


Fig. 4c

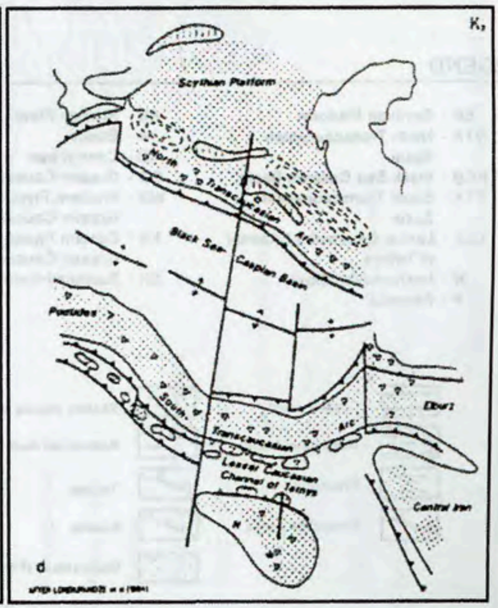


Fig. 4d

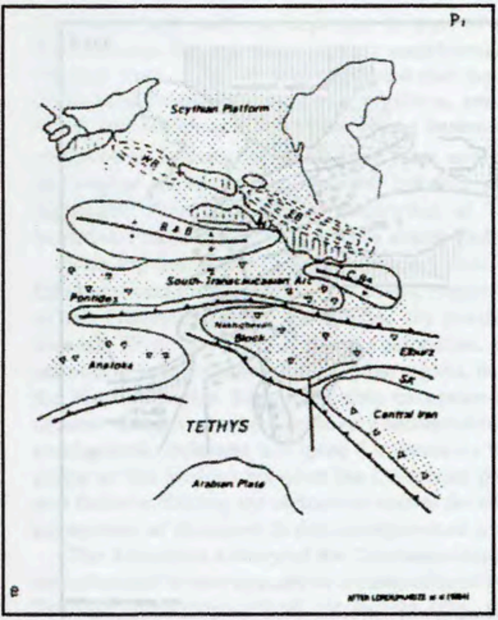


Fig. 4e

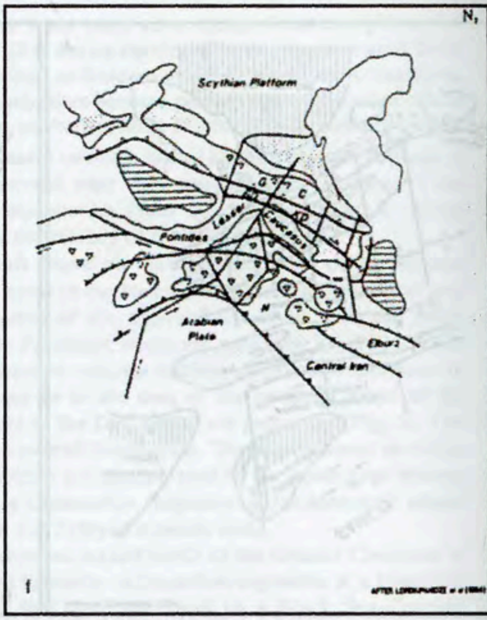


Fig. 4f

LEGEND

SP - Scythian Platform
NTA - North Transcaucasian Basin
BCB - Black Sea-Caspian Basin
STA - South Transcaucasian Basin
LCB - Lesser Caucasian Channel of Tethys
N - Nakhichevan Block
P - Pontides

AB - Arabian Plate
A - Elburz
CI - Central Iran
GB - Greater Caucasus Basin
WB - Western Flysch Basin of Greater Caucasus
EB - Eastern Flysch Basin of Greater Caucasus
SK - Saidabad-Karast Basin

NT - North Transcaucasian Block
TCB - Talish-South Caspian Interarc Basin
BAB - Black Sea Adjara-Trialeti Interarc Basin
AN - Anatolia
GC - Greater Caucasus
RD - Rioni Depression
KD - Kura Depression
LC - Lesser Caucasus

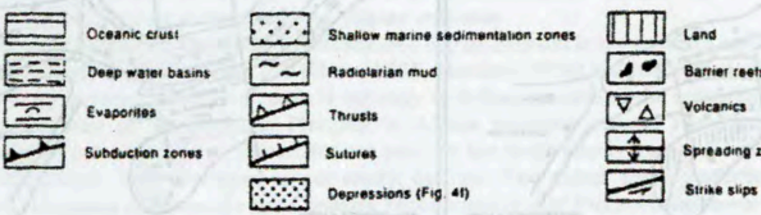


FIGURE 4. Plate reconstructions of the Caucasus (after Lordkipanidze et al.,1984): a) Early Jurassic; b) Bajocian-Bathonian; c) Late Jurassic; d) Late Cretaceous; e) Mid-Eocene; f) Pliocene.

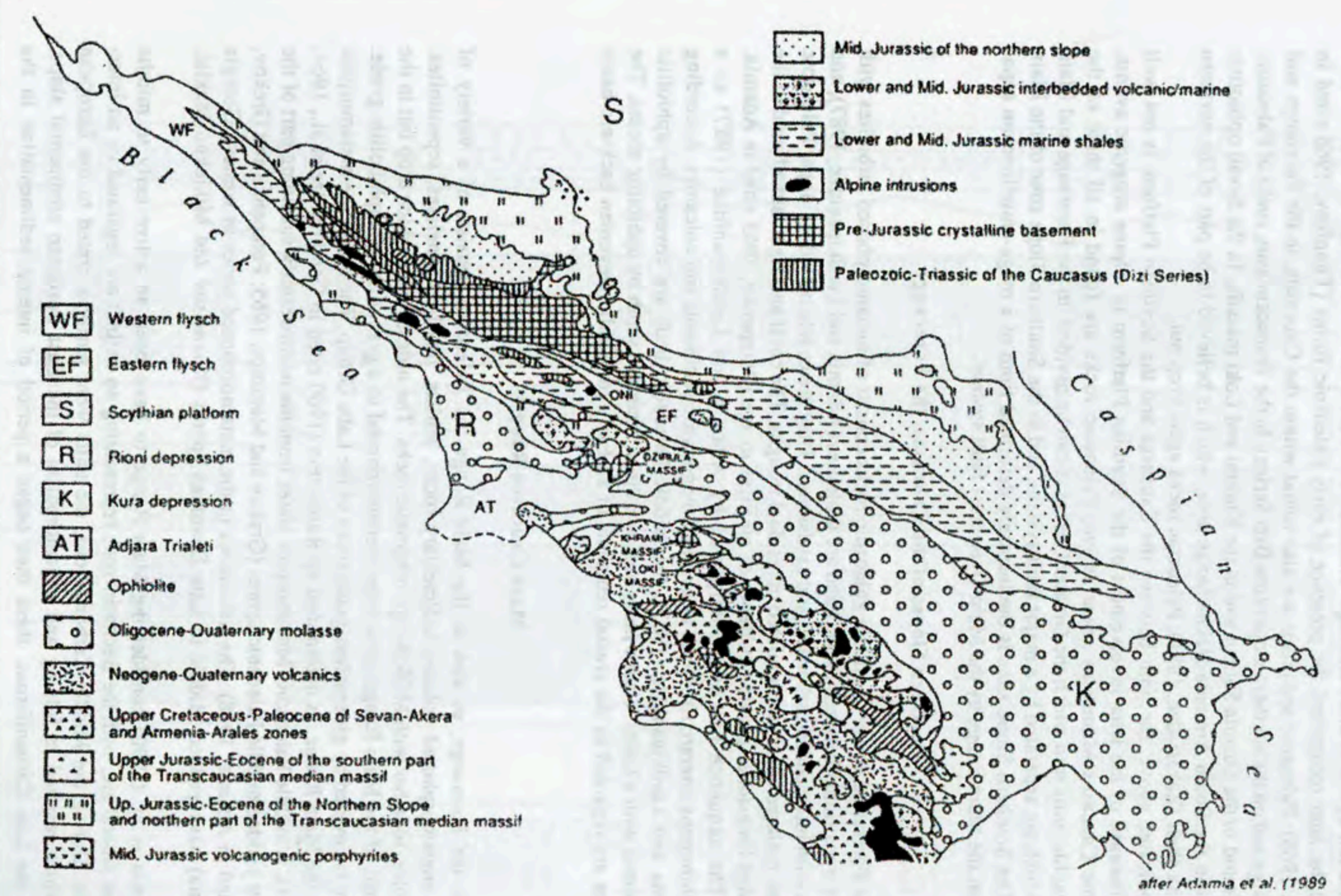


FIGURE 5. Outline geological map of the Caucasus (after Adamia, 1989).

a Precambrian age; however, although Timofeev (1962) identified as Sinian *Pterospermopsis* (Wetzel), he later recognized the presence of early Paleozoic forms (Timofeev, 1966 cited in Adamia, 1968). Paleozoic sediments are also found within the Caucasus, in the Forerange and Main Range and on the southern slopes (the Dizi Series). In the Transcaucasus, rocks of Paleozoic age are found in the Dzirula Salient and in the Khrami and Loki massifs. In the Sevan ophiolitic zone and in the South Armenia-Nakhichevan area, which is believed to be part of the northern Gondwana shelf (Zakariadze, 1981), Paleozoic rocks again crop out.

As indicated above, the limit between the Caucasus and the Scythian Platform is not well defined because of the later involvement of the Scythian Platform in Alpine orogenic events. Within the Caucasus Mountains *sensu stricto*, Paleozoic rocks are found in all three of the physiographic units into which the Greater Caucasus can be divided, in the Forerange and Main Range, which are separated by a major fault system, and in the Southern Slope zone of the Main Range. The Southern Slope zone is the intensely deformed limb of a mega-anticlinorium separated from the Main Range by the Main Overthrust fault system.

Northern Slopes of the Caucasus, the Forerange

In the Forerange, lower to middle Paleozoic rocks consist of metamorphosed turbidites with volcanics transitional between MORB and arc tholeiites (Adamia and Lordkipanidze, 1987), and phyllites with interbedded carbonates and sandstones. They are overlain by thick upper Paleozoic to Triassic molasse which accumulated in residual troughs. The coral and algal fauna found in the interbedded limestones provide evidence of an Eifelian age (Potapenko, 1965 cited in Adamia, 1968). The sequence has been interpreted by Adamia and Lordkipanidze (1987) as a parautochthonous interarc rift facies or as allochthonous arc sediments and volcanics. According to Adamia and Lordkipanidze (1987), the middle Paleozoic beds are covered by ophiolitic olistostromes with a lower Visean fauna and overthrust from the south by ophiolitic sheets. The ophiolites are regarded as the crustal remnants of an Early to Middle Devonian back-arc basin (Fig. 7).

Main Caucasus Range

As in the Forerange, so also in the Main Range the Paleozoic consists of a variety of strongly metamorphosed volcano-sedimentary rocks, schists, phyllites, gneisses, sepentinites, and marbles, together with MORB-type magmatic rocks. The oldest rocks, which crop out in the central part of the Main Range, have been metamorphosed to a granulitic or amphibolitic grade. This core is covered by greenschist-grade rocks of the Laba Group. The age of the metamorphic rocks in the Main Range, as determined by Rubinstein (1960 cited in Gamkrelidze et al., 1964, and 1967), is middle Paleozoic. Metamorphic slates from the northwesterly subsiding part of the basement yielded middle Paleozoic spores (Grekov and Mammot, 1965; Potapenko and Grekov, 1965 cited in Adamia, 1968). The limestones in the metamorphosed series in western Georgia (Abkhasia) have yielded Middle to Late Devonian spores (Kuznetsov and Miklukho-Maklai, 1955).

Adamia et al. (1990) consider the Main Range to have been an active early to middle Paleozoic frontal arc, with the Bechasin zone representing an extinct arc separated by an interarc basin. During the Middle Carboniferous, the units were partly accreted to the European plate, which resulted in folding and metamorphism of the East European continental slope. During the Late Carboniferous, there then began a period of intense sedimentation in the Caucasus.

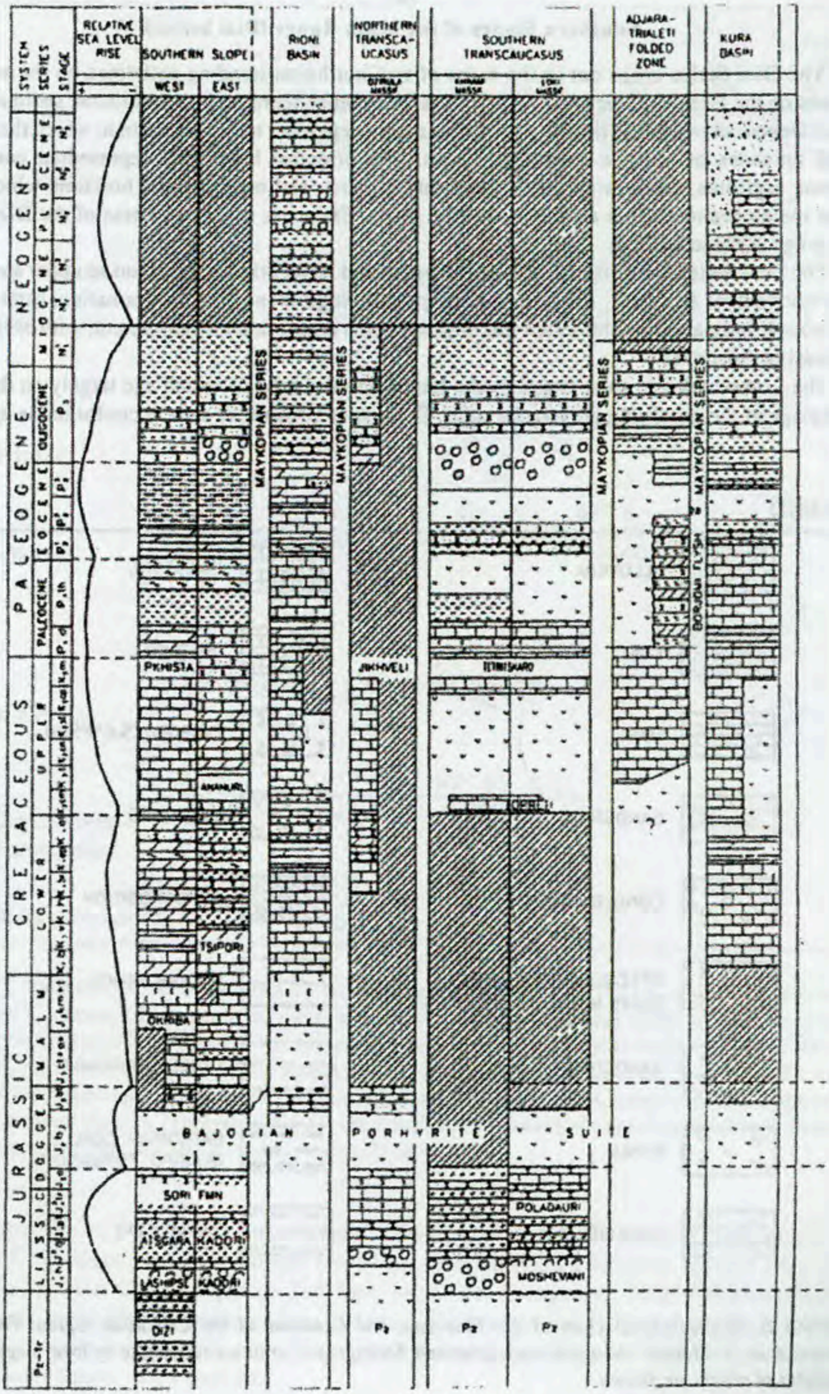

SYSTEM
SERIES
STAGE
RELATIVE SEA LEVEL RISE
SOUTHERN SLOPE
WEST
EAST
RIONI BASIN
NORTHERN TRANSCAUCASUS
SOUTHERN TRANSCAUCASUS
ADJARA-TRIALETI FOLDED ZONE
KURA BASIN
NEOGENE
PALEOGENE
CRETACEOUS
JURASSIC
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
UPPER
LOWER
MALM
DOGGER
LIASSIC
MAYKOPIAN SERIES
MAYKOPIAN SERIES
MAYKOPIAN SERIES
MAYKOPIAN SERIES
BORJOMI FLYSCH
PKHISTA
JIKHVELI
ANANURI
TSIPORI
OKRIBA
BAJOCIAN PORHYRITE SUITE
SORI FMN
AISGARA KADORI
LASHIPSE KADORI
DIZI
POLADAURI
MOSHEVANI
Pz
Pz
Pz

Fig. 6

Southern Slopes of the Main Range (Dizi Series)

The Dizi Series crops out in the cores of two northwest-trending anticlines on the southern slopes of the Greater Caucasus (Fig. 5). It is a sequence representing continuous sedimentation from Devonian to Liassic time in a predominantly deep-water turbiditic basin in which there were brief episodes of shallow-water deposition. The principal lithologies represented consist of marine argillites, sandy-argillaceous turbidites, cherts, and olistostromal horizons which have been metamorphosed to a slate and phyllite grade. Estimates of the thickness of the Dizi are in the range 3000 to 3500 m.

The Dizi Series comprises four units: an upper and lower arkosic suite, and an upper and lower greywacke suite (Adamia, 1968). The principal lithological and faunal information, summarized in Table 1, indicates that the series was deposited in a deep-marine environment, with only minor regressive episodes.

The Lower Arkosic suite is assigned a Late Silurian-Early Devonian age largely on the basis of the age of the overlying greywacke suite. The Lower Greywacke suite is conformable upon the

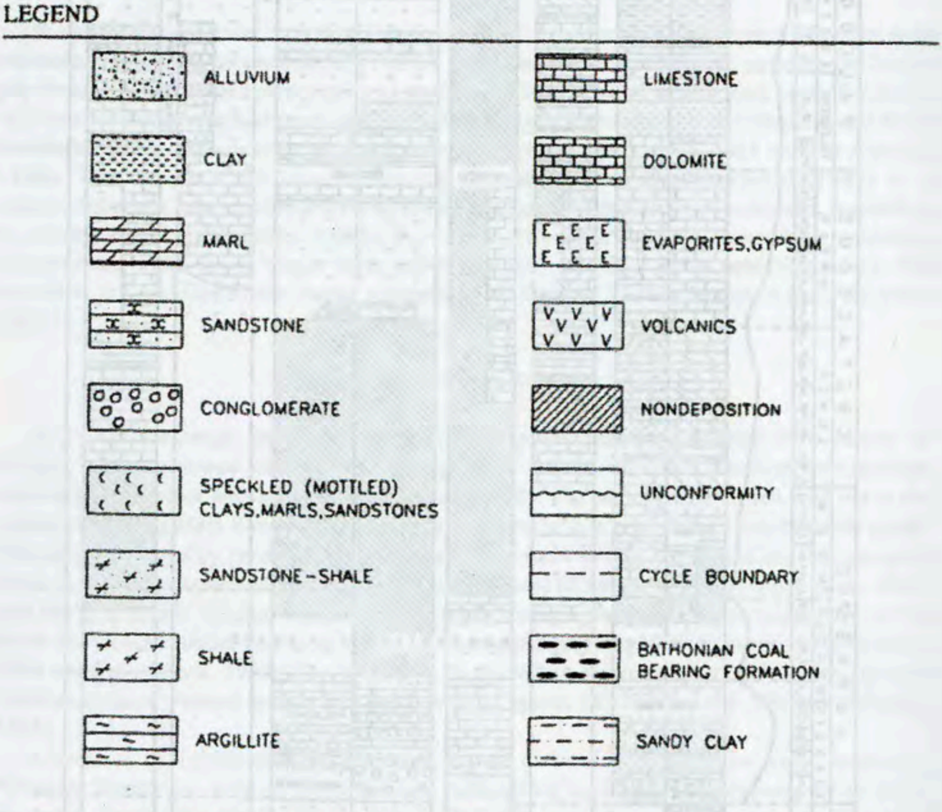


FIGURE 6. Stratigraphical chart of the Mesozoic and Cenozoic of the Caucasian region. Formation nomenclature is informal and application is limited. Stratigraphic units are referred to by local stage names, examples of which are shown.

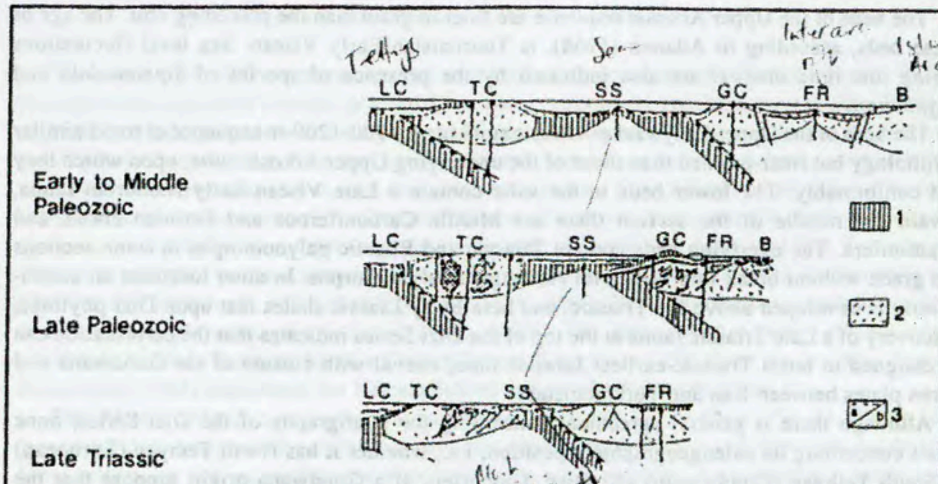


FIGURE 7. Paleotectonic cross sections of the Caucasus (after Adamia, 1987): I) Iranian Platform; GC) Greater Caucasus; LC) Lesser Caucasus (Paleotethys); TC) Transcaucasian island arc; SS) Marginal sea of Greater Caucasus (Main Range); MR) Greater Caucasus (Main Range); MR) Greater Caucasus (Main Range; FR) inter-arc rift of Caucasus Forerange; B) island arc of Greater Caucasus (Bechasin); ST and NT) South and North segments of Transcaucasian island arc; BC) Black Sea-Caspian inter-arc rift (Kura-Rioni intermontane trough); 1) oceanic crust; 2) continental crust; 3) basinal (a) and marginal (b) sediments; 4) volcanics; 5) granitoid bodies; 6) tectonic sheets; 7) faults.

Lower Arkosic suite. Some of the marmorized limestone horizons and the deep-marine phyllites, cherts, and turbidites contain a Middle Devonian fauna, including Eifelian species, such as *Polygnathus* of the *Costatus* group. The Late Devonian, Famennian, form *Palmatolepis* is characteristic of the same depositional environment. The presence of *Polygnathus nodocostatus* and *P. subnormalis* indicates that periods of shallow-water deposition are interspersed within the predominantly deeper water deposits.

The beds of the Upper Arkosic sequence are finer in grain than the preceding unit. The age of these beds, according to Adamia (1968), is Tournaisian-Early Visean. Sea level fluctuations during this time interval are also indicated by the presence of species of *Siphonodola* and *Dryphenotis*.

The beds of the Upper Greywacke-Arkosic suite form a 900-1200-m sequence of rocks similar in lithology but finer-grained than those of the underlying Upper Arkosic suite, upon which they rest conformably. The lower beds in the suite contain a Late Visean-Early Namurian fauna, toward the middle of the section there are Middle Carboniferous and Permian corals and foraminifera. The overlying beds contain Triassic and Rhaetic palynomorphs in some sections and grade without break into beds with Hettangian palynomorphs. In other locations an unconformity is developed above the Triassic, and here Early Liassic shales rest upon Dizi phyllites. Discovery of a Late Triassic fauna at the top of the Dizi Series indicates that the deformation can be assigned to latest Triassic-earliest Jurassic time, coeval with closure of the Gondwana and Turan plates between Iran and Turkmenistan.

Although there is general agreement concerning the stratigraphy of the Dizi Series, none exists concerning its paleogeographical position, i.e., whether it has North Tethyan (European) or South Tethyan (Gondwanan) affinities. Supporters of a Gondwana origin suppose that the series, very similar to the Paleozoic of northwestern Iran according to Sengor (1985), accreted to the Scythian Platform. In this view, from Devonian to Middle Carboniferous the Dizi Series accumulated on a passive Gondwana margin. Subsequent accretion to the Scythian Platform occurred during the Hercynian collisional event associated with the closure of Paleotethys (Kazmin, 1989), which was completed by the Late Triassic (Belov, 1981).

Consistent with the model of an origin on the passive margin of Gondwana, there should be a general absence of volcanics. While this is in general true, there are conflicting opinions as to the significance of the Middle Devonian andesitic tuffs and tuff breccias, and the liparitic and dacitic tuffs of Middle Carboniferous age. Rather than considering the series "almost volcanic-free" (Sengor, 1985), Adamia et al. (1990) consider there to be quite extensive horizons of volcaniclastic turbidites and the presence of large volcanic blocks of island-arc-type basalts and basaltic andesites in olistostromes of the same age. As calc-alkaline and acid volcanics occur in the Carboniferous-Lower Permian and in Middle Triassic-Liassic rocks on the southern edge of the Scythian Platform, they interpret this as evidence of subduction in the Greater Caucasus Basin. Consequently they propose a Northern Tethyan origin, according to which the Dizi Series formed in a small basin at the active margin of a paleo-ocean between the Greater Caucasus island arcs (Fig. 7) and the Transcaucasus. This basin developed without interruption from Hercynian to Kimmerian-Alpine time and continued to exist even during deformation, given the common deformational character of the Dizi Series and the Jurassic. As indicated earlier, there is a conformable gradation between the Triassic and Jurassic in some locations, in others there are short-lived unconformities and associated faults at the Triassic-Jurassic boundary. The faults show only minor displacement.

The faunal assemblage found in the Dizi Series is very similar to coeval series in the Northern Caucasus, Ciscaucasus, Donets, and other European basins, as for example in the occurrence of *Alveolites suborbicularis* Lam. *var. minor* Frech, which is typical of the Frasnian of European Russia and Germany based on the presence of *Chaetetes cf. lonsdalei* Eth. and Ford, known also in the Eifelian of the Ardennes, and with Devonian and Carboniferous conodonts which correspond to northern forms (Kutelia, 1983) but have nothing in common with Armenian forms, which are regarded as characteristic of the Gondwana carbonate shelf. Paleomagnetic data also support the association of the Dizi Series with the active European margin, and distinctive trends can be seen in the Northern Transcaucasian and South Caucasian, Gondwana trends.

Paleozoic History of the Transcaucasus

The fundament of Transcaucasia consists of its Paleozoic basement which is exposed in the Dzirula Salient where it consists of crystalline slates intruded by granitoid masses (Fig. 5). The crystalline slates and phyllites are represented by amphibolites, biotite-hornfels, and mica slates with lenses of serpentinite. The less metamorphosed rocks were formerly arkoses, greywackes, sericitic sandstones, and shales with thin limestone lenses, little different from the rocks presumed to form the basement of the Greater Caucasus. However, the presence in the limestones of *Archaeocyathus* indicates a Cambrian age (Barsanov, 1931 cited in Adamia, 1968; Kuznetzov, 1931) not recorded in the Caucasus, and underlying horizons are assumed to be Precambrian (Zaridze and Tatrishvili, 1953 cited in Gamkrelidze, 1964). The phyllites have yielded Silurian and Devonian palynomorphs (Adamia et al., 1990). The intrusions are biotite or two-mica granitoids dated as Early to Middle Carboniferous. Rhyolites of the same age are also found. Zakariadze (1983) interpreted the Dzirula Salient as part of a Paleozoic island arc.

The Khrami Massif is a largely granitoid massif with crystalline slates (Fig. 5). Within the massif are large wedges of fossiliferous limestone which contain Visean and Namurian corals and foraminifera, as well as sandstones with Bashkirian plant remains. According to Adamia and Lordkipanidze (1987), the faunal and floral assemblages are of European type, and the paleomagnetic data are consistent with this assignment. The Loki Massif, which lies southeast of the Khrami Massif, has lithologies similar to those found in both the Dzirula and Khrami massifs (Fig. 5). It consists of graphitic, chloritic, muscovite, biotite, and andalusite schists and gneisses with amphibolites, marble, and quartzites (Tsulukidze, 1887; Gabunia and Gamkrelidze, 1942 cited in Gamkrelidze, 1964). These rocks are intruded by upper Paleozoic granitoids that yield dates of 370 ± 20 Ma according to Rubinstein (1955 cited in Gamkrelidze, 1964).

In summary, although there is some lithological variation from the Dzirula Salient to the Khrami and Loki massifs, the differences are not inconsistent with all having belonged to the same original body. Rocks representing most of the Paleozoic are present and have undergone extensive metamorphism with the emplacement of granitoid intrusives during "Hercynian" time. As the youngest Carboniferous and Permian rocks appear to have escaped the major period of deformation, some idea of the timing of the deformation is provided. Adamia et al.(1989) assume that these Transcaucasian granitic-metamorphic rocks belonged to the active, northern margin of Paleotethys, and that the combination of their geochemistry and the occurrence of meta-ultrabasic and basic rocks with oceanic affinities points to their former association with an oceanic island arc.

In the Sevan ophiolitic suture zone at the southern margin of the Transcaucasus (Fig. 5), garnet amphibolites occur within a serpentinitic mélange. These have been dated as 330 ± 24 Ma (Meliksetian et al.,1984), and Zakariadze (1983) has shown that the primary rocks were formerly tholeiitic basalts and low-K andesites of an oceanic arc type. Within this oceanic mélange, a fauna has been found and dated as Mid-Carboniferous to Early Permian. If this association is meaningful, then Transcaucasia was separated from the northern margin of Gondwana by an area of ocean of unknown extent, from which it follows that the Hercynian suture buried under the Greater Caucasus does not mark a continent-continent collision, but rather a continent-arc collision, where the affinities of the arc may be more with Eurasia than with Gondwana. This also implies at least a two-phase history of the suture zone.

South of the Sevan suture, in South Armenia-Nakhichevan, in a zone regarded as part of the former Gondwana shelf province (Zakariadze, 1981), there are Devonian and Carboniferous shallow-marine deposits of biogenic limestone and quartzites as well as Permian limestones and dolomites.

Mesozoic and Cenozoic Stratigraphy

The Mesozoic-Cenozoic stratigraphic history of Georgia is complex due to the interplay of small block movements, block accretion and the complications introduced by sea-level fluctuations. Fortunately Lordkipanidze et al., (1984) synthesized the available sedimentary and structural data and produced a series of plate reconstructions, which if not entirely satisfactory, do at least provide a basis upon which to review the geological history of the Georgian region (*sensu lato*). The principal paleogeographic elements south of the edge of the Scythian plate during the Early Jurassic are the two Transcaucasian units, the Northern Transcaucasian and the Southern Transcaucasian arcs which are separated from one another by the Black Sea-Caspian Basin. This small ocean opened to its maximum extent during Late Cretaceous. Between the Northern Transcaucasian arc and the Scythian plate is the relatively narrow Greater Caucasus Basin, and between the Southern Transcaucasian arc and the Nakhichevan Block and the Central Iran Block lay the Lesser Caucasian Channel of Tethys (Fig. 4d). The Northern Caucasian Basin was eliminated as a channel in Bajocian Bathonian time (Fig. 4b); however, the Black Sea-Caspian Basin link and the Southern Channel of Tethys were interrupted only during the early Cenozoic (see Fig. 4e). In Figure 4d a northward displacement of the Elburz-Central Iran block is shown without any tectonic mechanism which could have brought it about. However, this closure marks a significant change in the geological history of the region and introduces a Cenozoic phase dominated by the fill of two now distinct basins, the Black Sea Adjara-Trialeti Basin in the west and the Talish-South Caspian Basin in the east (Fig. 4e).

The post-Triassic stratigraphy of Georgia has been reviewed on the basis of sequence stratigraphy (cf. Van Wagoner et al., 1988). Cycles have been recognized using surface and subsurface data. The oldest transgressive-regressive cycles identified, in the Lower and Middle Jurassic, can be correlated with those of Vail et al., (1977), and a Cretaceous supercycle can be compared with its Vail equivalent, but the discrimination of lower order cycles within this interval requires further work. There is, for example, the occurrence of clastics within the Aptian which extend into the Cenomanian, paralleling the break also found in the Middle East. The Cenozoic cycles also show a poor correlation with the global scale which may be a function of the local tectonics or may be only a reflection of how much work remains to be done.

Liassic Cycle

According to Adamia and Lordkipanidze (1990) the general tectonic environment at the beginning of the Liassic consisted of two deep-water zones where subduction was occurring, the southern slope area of the Greater Caucasus (the Greater Caucasian Basin, Fig. 4a) and the zone currently occupied by the Sevan-Akera ophiolites (Lesser Caucasian Channel, Fig. 4a). These zones were bordered to the north by the Scythian plate and to the south by the northern margin of Gondwana. Subduction was also taking place under the southern margin of the Northern Transcaucasian Massif and is reflected by the occurrence of volcanic activity in all three areas (see Fig. 4a).

The Liassic cycle in Transcaucasia begins with transgressive basal sandstones and conglomerates (?Hettangian) which rest unconformably upon a crystalline basement of the Northern Transcaucasian arc (Vakhania, 1976). The deposits are considerably thinner than those found in the Greater Caucasus to the north, and are marked by numerous disconformities. Part of that sequence is now exposed in the Dzirula Massif and around the smaller Hercynian massifs as the Khrami and Loki massifs, and here the transgressive nature of the Liassic is clearly observed. The massifs themselves are regarded as one probable source for the clastic sediments. Over the Khrami Massif the Liassic now appears as coarse, even conglomeratic, clastics in which are

TABLE 2. Lithological Summary of the Liassic Beds in the Georgian Region (after Nutsubidze, 1964)

Age	Southern slope of the Greater Caucasus			Georgian Block, Dzirula Massif	Artvin-Bolnisi Block	
	Abkhasia, Svaneti, Racha	Georgian military road	Mount Kakheti		Loki Massif	Khrami Massif
Upper	Shales and sandstones 0-1000 m. to the north, schists, 1000 m	Shales and sandstone 1000 m, sandstone and shale 2000 m	Shales and sandstone 1500 m	Red zoogene marblelike limestone, often with Crinoidea; to the NE, marls and shales; 40-200 m	Quartz sandstone, conglomerate and limestone lenses, 40 m; alternating dark mica sandstones and shale, 400 m	Alternation of mica sandstones and shales, 200 m, thin bed of conglomerate
Middle	Schists and rare interbeds of sandstone 1000-2000 m	Schist and rare interbeds of sandstone and quartzite (Tsik-lauri fm) 1000 m	Schists and rare sandstone interbeds 1600-2000 m	Quartz sandstone with conglomerates in basal parts; sandstones dense, thick bedded; 25-200 m		
Lower	Conglomerates, quartzite, sandstone, graphite, 50-250 m	Conglomerates, quartzite, graphite, slate, albitophyre and tuffs, 400-500 m			Conglomerates, quartz sandstone, detrital remnants, 150 m	

interbedded some dark, weakly bituminous shales varying in thickness from a few meters to as much as 100 m. The Liassic beds are preserved only around the margins of the Loki Massif where they crop out as terrigenous arkoses and conglomerates.

In the area of the Southern Slope, the clastics are very much thicker and grade up into the marine shales which formed in the deepest part of the basin of the time (Table 2). During late Liassic time regression occurred which was accompanied by turbidite deposition in the basin and by coal-bearing sequences in the up-dip areas, south of the southern shoreline of the Greater Caucasus marginal sea (Adamia et al., 1990). The facies and thicknesses are illustrated in Figure 8 and the lithologies recorded in Table 2. In the Greater Caucasus trough, early Jurassic igneous activity was associated with terrigenous argillites and turbidites accompanied by some conglomerates and sandstones. These are more extensively, if irregularly, distributed than in Transcaucasia. In the Northern Transcaucasus early to middle Liassic volcanic activity with tholeiitic and calc-alkaline volcanism (see Table 2) was also developed, with albitophyres and

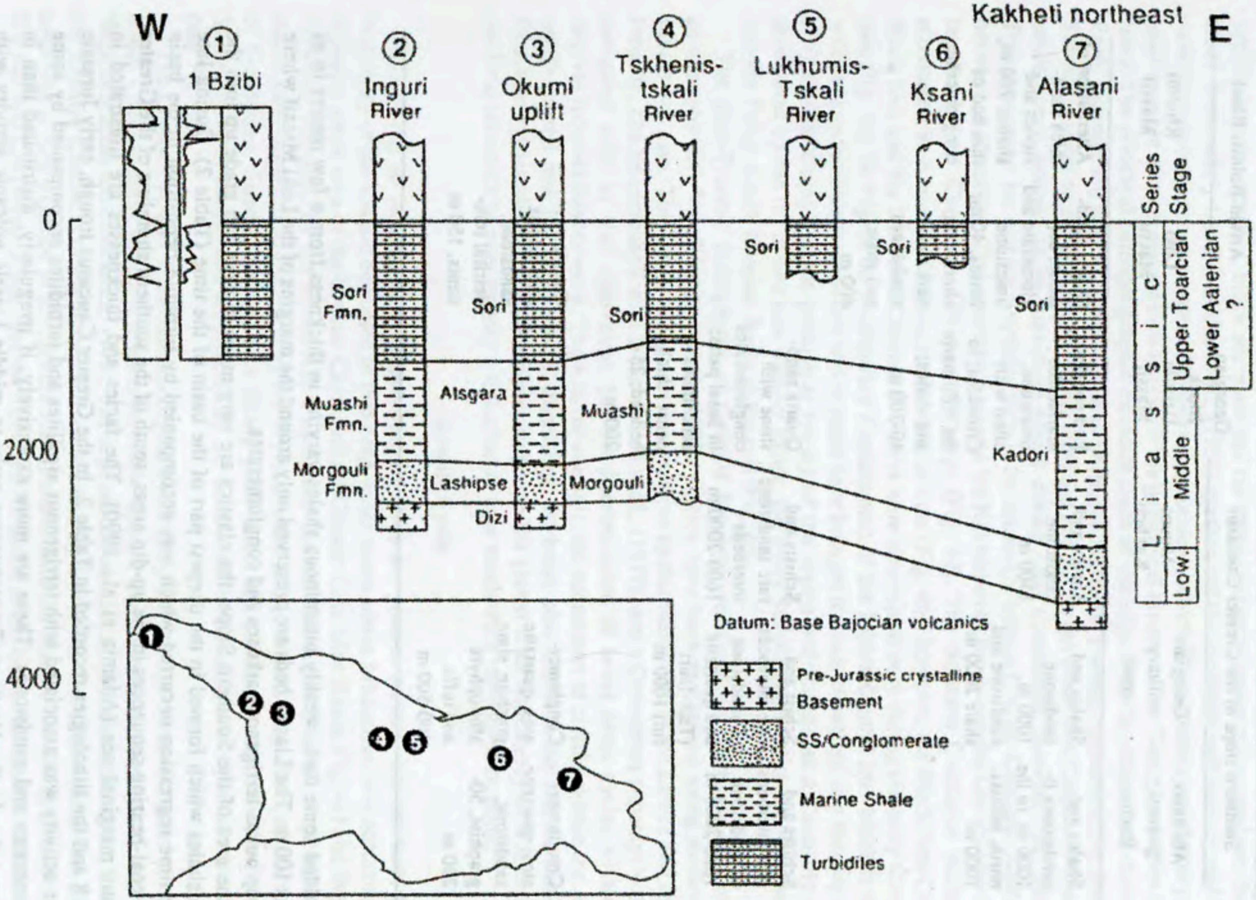


FIGURE 8. Stratigraphic cross section of the beds below the base of the Bajocian volcanics.

associated tuffs intruded by diabase, porphyrite and gabbro-diorite. This is taken to indicate the existence of tensional movements. A volcanic zone found in the Southern Transcaucasus arc is similar, but on the basis of paleomagnetic evidence (Asanidze, 1981), lay several hundred kilometers to the south.

Middle Jurassic, Aalenian-Bathonian Cycle

The plate reconstruction of Lordkipanidze et al. (1984) show a deepening of the Greater Caucasian Basin with its apparent closure to the west. During the Aalenian, only the western and eastern parts of the basin were involved in movement. The conversion of the western part of the Southern Transcaucasian arc to a land area during the Middle Jurassic also occurred, but otherwise the basic paleogeography was largely unchanged (Fig. 4b). Renewed transgression of the Greater Caucasian marginal sea accompanied this subsidence during the Aalenian and this helped accommodate the thick volcanic and deep-water clastic facies deposited during the first part of the sedimentary cycle from Aalenian to Bajocian. In the Northern Transcaucasian island arc a belt of shoshonitic and potassic volcanics developed during Aalenian-Bajocian time, pointing to a north-dipping subducting slab (Fig. 4b). Contemporaneously in the Southern Transcaucasian arc a belt of low-titanium calc-alkaline tholeiites developed associated with subduction of the Lesser Caucasus inter-arc basin (the Lesser Caucasus Channel of Tethys). The island arc volcanoes are marked by alkali-basalt volcanism, basaltic and radiolarian breccias together with occasional lenses of coral limestone. The regressive late Middle Jurassic (Bathonian) phase which completed the cycle, was marked by the deposition of shallow-water clastics and a coal-bearing sequence (Zesashvili, 1964) in the Greater Caucasus and the ending of volcanism. The facies and thicknesses of the Middle Jurassic rocks are summarized in Table 3. Paleomagnetic data from units in the Southern Transcaucasus indicate that this was a period of rapid northerly movement which culminated in the collision of the northern and southern island arcs leading to the temporary closing of the Black Sea-Caspian Basin. Middle Jurassic rocks are widely exposed on the Southern Slope and on the southern margin of the Dzirula Massif, but over the rest of Georgia they crop out only over the Loki Massif and are encountered in drilling in some parts of the Rioni depression. The Middle Jurassic rocks, Bajocian and Bathonian, form two facies bands paralleling the roughly east-west Caucasus trend. The more northerly band consists of homogeneous marine shales which can be traced from the eastern boundary with Azerbaijan, through exposures in the upper reaches of the Ksani and Aragvi rivers, into western Georgia. The southern facies is extensively developed throughout Georgia and is dominated by volcanogenic porphyritic sediments. A zone of Middle Jurassic interbedded volcanic and marine terrigenous sediments crop out peripheral to the massifs (Fig. 5).

Bathonian outcrops are more restricted, and on the Southern Slope are represented by marine shales in eastern Georgia and by epi-continental, mostly coaly sands and shales to the west.

Callovian-Paleocene Cycle

Although covering a long time interval, this succession is recognized in Georgia as a first order transgressive-regressive cycle. Transgression was continuous from the Callovian until the late Cretaceous with only minor interruptions such as the Albian regressions as indicated by the clastic sediments which overlie Aptian carbonates. The Late Cretaceous regression continued until the end of the Paleocene (Fig. 9).

The plate reconstructions of Lordkipanidze et al. (1984) for this time interval show very little change. The principal change from the Middle Jurassic interval is that the more rapid

TABLE 3. Lithological Summary of the Middle Jurassic (Bajocian-Bathonian) Beds in the Georgian Region (after Zesashvili, 1964)

Age	Southern slope of the Greater Caucasus			Georgian Block, Dzirula Massif	Artvin-Bolnisi Block, Loki Massif
	Northern zone	Transformational zone	Southern zone		
Bathonian	Alternation of shales, schists, and sandstones	Sandstone, clay, conglomerates, 600 m	Coal-bearing sequence: quartz mica sandstones, conglomerates, coal interbeds, 220 m	Coal-bearing sequence: quartz-arkose sandstones with coal interbeds, <100 m thin-bedded slates	
Bajocian	Shales, schists with siderite concretions and interbeds of quartz sandstone, locally with diabase tuff nappes	Porphyrite sequence: plagioclase porphyrites, their pyroclastics and diabases; in the lower parts, spilites and their pyroclastics, 2000 m	Porphyrite sequence: various porphyrites and their pyroclastics, 2500-3000 m	Porphyrite sequence: various porphyrites and their pyroclastics, 2000 m	Porphyrite sequence: various porphyrites and their pyroclastics, 3000 m

northerly movement of the Scythian plate led to tension and the re-opening of the Black Sea-Caspian Basin. Rifting in the western part of the former Northern Transcaucasian arc, associated with this tension, led to the extrusion of alkaline basalts, but in the eastern part, the presence of shoshonitic volcanism suggests that subduction was still occurring there (Fig. 4c). The development of a spreading center about the axis of the Black Sea-Caspian Basin gave rise to the southerly displacement of the Southern Transcaucasian arc, and volcanic activity continued uninterruptedly throughout the Late Jurassic. The Black Sea-Caspian Basin reached its maximum opening during the Upper Cretaceous (Fig. 4d). After this time the reconstructions show a reversal of movement such that by the Middle Eocene the continuity of the Black Sea-Caspian Basin was broken, to be replaced by the Black Sea Adjara-Trialeti Basin in the west and the Talish-South Caspian interarc basin in the east. The Lesser Caucasus Tethys Channel was also displaced from a position north of the Nakhichevan Block to south of that unit. In the absence of paleomagnetic data, however, there is less certainty in the palinspastic reconstructions (Fig. 4e).

The Upper Jurassic, Lower and Upper Cretaceous lithofacies are summarized in Tables 4-6. Formational names have been avoided, but can be found through the references provided. In the following commentary, descriptions will be given under the same groupings. Flysch deposition dominated in the eastern (Svaneti, Racha, Oseti and Kakheti) basins and the western (Abkhasian) troughs of the Greater Caucasus. The eastern troughs were separated from the western by the pre-Callovian Svaneti uplift. In the absence of subduction and spreading data the size of the basin

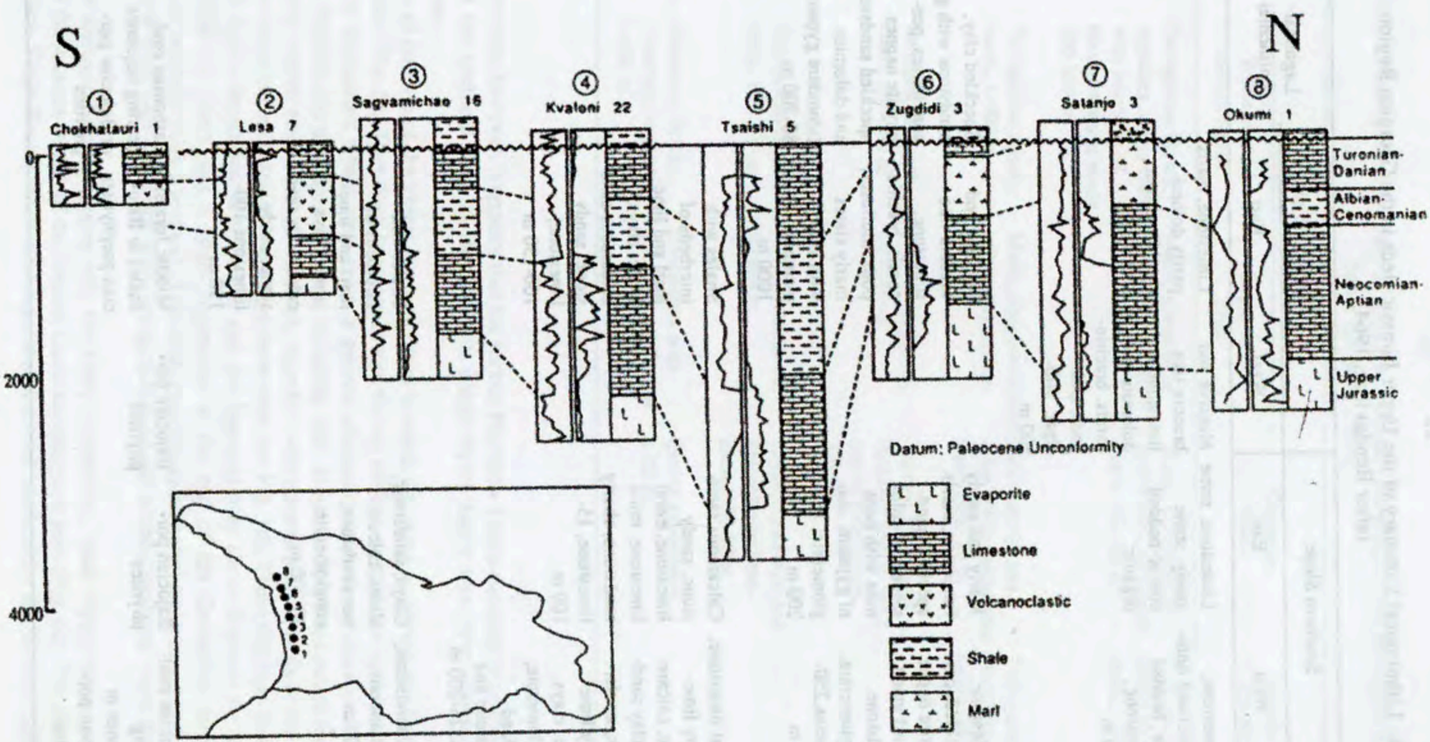


FIGURE 9. Stratigraphic cross section of the beds below the Paleocene unconformity. Post-Paleocene erosional episodes may cut through the Paleocene surface in some wells. Location of the well sections is indicated on the inset map.

TABLE 4. Lithological Summary of the Upper Jurassic Beds in the Georgian Region (after Bendukidze, 1964)

Age	Southern Slope		Flysch		Lagoonal-continental
	West	East	West	East	
Tithonian	Limestone, brecciated dolomite, bedded limestone, 500 m	Limestone, some sandy, some coarse-bedded organic	Massive and breccia-like limestone and dolomite with corals, brachiopods, and algae, 400-500 m	Limestone, marls, partly dolomitized limestone, 500-600 m	
Kimmeridgian	Limestone, speckled, porphyrite nappe (15 m) marls, sandstone, conglomerate, breccias, 250-290 m	Marly and sandy limestone, marls, speckled sandstone and dolomite with beds of gypsum, conglomerate, 15-200 m		Massive and breccia-like limestone, corals, brachiopods, molluscs, marly slates with shale members, 40-1000 m	Speckled clay, sandstone with gypsum lenses, porphyrite nappes, speckled sandstone and dolomite (abundant gypsum), 80-700 m
Oxfordian	Coral limestone, cherty limestone, calcareous clay sandstone, marls, sandy limestone, clays, conglomerate, speckled sandstone and clays, 25-200 m	Calcareous sandstone, sandy limestone, coral limestone, mica sandstone, cherty limestone, 15-100 m		Shales with interbeds of marl and limestone, clays, calcareous sandstone, sandy limestone, 100-150 m	
Callovian	Clay, sandstone, conglomerate, 40-200 m	Clays, sandstone, slates, calcareous sandstone, conglomerate 40-200 m		Shales with interbeds of marl and limestone, clays, calcareous sandstone, sandy limestone 100-150 m	
Bajocian/Bathonian	Bathonian coal-bearing sequence or Bajocian porphyrites	Bajocian porphyrites	Bajocian porphyrites	Middle Jurassic shales or Bajocian porphyrites	Bathonian coal-bearing sequence or Bajocian porphyrites

TABLE 5. Lithological Summary of the Lower Cretaceous Beds in the Georgian Region (after Eristavi, 1964)

Age	Southern Slope Zone		Georgian Block	Adjara-Trialeti folded zones
	Western and eastern flysch	Gagra-Java Zone		
Albian	Terrigenous flysch, argillites, marly slates with interbeds of sandstones and marls, 100-300 m	Marls, glauconitic sandstones, 15-30 m	Slates, tuffogenous sandstones, siltstones, marls, 10-100 m	Tuffogenous rocks, rarely clays and marls, 200-300 m
Aptian	Terrigenous flysch, marls, 4-900 m	Marls, clay limestones, rarely glauconitic, 10-40 m	Tuffogenous and glauconitic sandstones and marls, 30 m	Tuffogenous rocks, rarely clays and marls, 200-300 m
Barremian	Terrigenous flysch, marls, 200-500 m	Pelitic limestones, 100-200 m	Various limestones (organic oolitic, etc.), quartz sandstones, 2-60 m	
Hauterivian	Terrigenous flysch, marls, 200-500 m	Pelitic limestones, 50-300 m	Cryptocrystalline and dolomitized limestones, 30-80 m	
Valanginian	Carbonate flysch, calcareous breccias, 2-400 m	Limestones with brachiopods, 5-20 m	Quartz sandstones, 5-80 m	

remains uncertain; however, it appears that the former Northern Transcaucasian island arc which had formed the southern limit of the Southern Slope flysch basin was now accreted to the Scythian plate.

The area of outcrop of the Upper Jurassic rocks is much the same as during the Middle and Lower Jurassic (Fig. 5). They have been penetrated during drilling operations in several parts of the Kolkhida depression where they show a general division into older Callovian-Oxfordian terrigenous deposits and younger carbonate, including reef, deposits. There are extensive Oxfordian-Tithonian barrier reefs, 100-200 m thick, together with normal marine beds at the limit of the Southern Slope of the Caucasus (the Gagra-Java zone, see Fig. 10). These deposits lie between the areas of flysch deposition to the north and the lagoonal-near shore deposits to the south (Fig. 10, Table 4). There was a slight regression at the end of the Oxfordian so that the Kimmeridgian deposits mark a renewal of the transgression as lagoonal-continental beds, which consist for the most part of eroded Bajocian porphyrites and arkosic clastics, were laid down (Fig. 10).

With the transgression continuing into the Early Cretaceous, thick flysch sequences were deposited in the western trough of the Greater Caucasus marginal seas (Fig. 4c). The eastern part of the Southern Slope Basin, which was separated from the western by the Svaneti uplift, was

TABLE 6. Lithological Summary of the Upper Cretaceous Beds in the Georgian Region (after Tsagareli, 1964)

Age	Southern Slope Zone			Adjara-Trialeti folded zone	Artvin-Bolnisi block
	Flysch basins	Gagra-Java zone	Georgian block		
Maastrichtian	Flysch alternation of marly and cherty argillites and limestone, alternation of sandy limestone, limestone, and marls	Alternation of crystalline and less dense limestone, massive coarse-bedded crystalline, limestone lithographic and pelitic white limestone	Massive and coarse-bedded crystalline limestone; pelitic limestone	Speckled marls and clays	Speckled marls and clays
Upper Campanian				Lithographic limestone and pelitic white limestone	Speckled marls and clays
Lower Campanian/ Upper Santonian	Limestone and speckled marls	Same	Same	Same	Basic porphyrites with limestone interbeds. Quartz porphyry and albitophyre volcanics
Lower Santonian	Lithographic limestone	Same	Same	Same	Quartz-porphyry and albitophyre volcanics
Coniacian	Same	White and red crystalline limestone with red cherts		Same	Same
Upper Turonian	Red limestone	Same		Same	Same
Lower Turonian	Cherty limestone, siliceous rocks, cherty argillites	Same		Limestone and marls	Same
Upper Cenomanian	Same	Marls and marly limestone, tuffites; glauconitic sandstones	Glauconitic sandstones, quartz-glauconitic limestone	Volcanics of porphyrite content	Quartz-porphyry and albitophyre volcanics and limesetone
Lower Cenomanian	Sandstones	Same	Same	Same	Quartz-porphyry and albitophyre volcanics and limestone

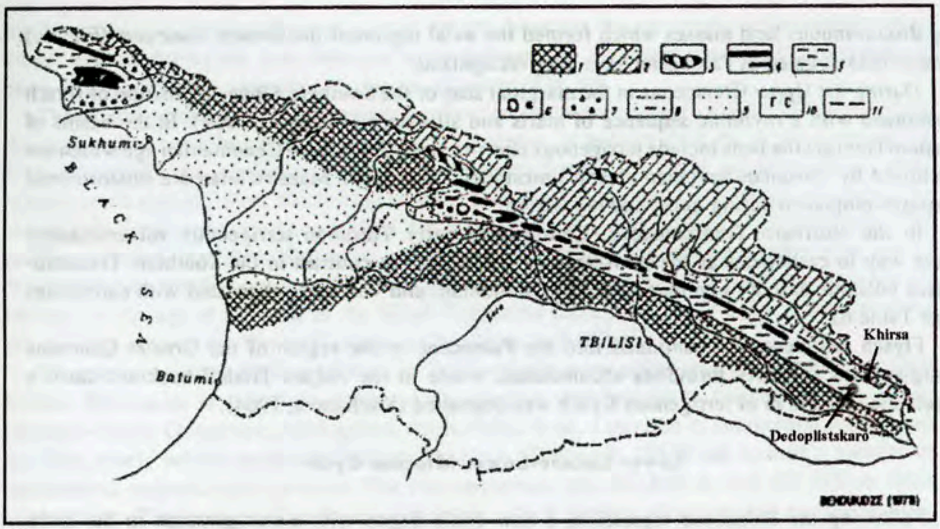


FIGURE 10. A paleogeographic reconstruction of Georgia during the Upper Oxfordian-Lower Tithonian: 1) land, 2-5) Area of flysch reef subformation: 2) carbonate flysch, 3) flysch rhythmical biotects. Area of epicontinental reef subformation: 4) barrier wave resistant reefs, 5) calcareous clays, sandstones, marls. 6-9) Area of the lagoon-reef subformation: 6) individual biotects, 7) conglomerates and breccias, 8) sandstones and clays, 9) variegated lagoon sediments, 10) gypsum, rock salt; 11) regional deep-seated fault.

filled by normal marine carbonates. The beds are now exposed in the Southern Slope and are penetrated by numerous wells in the Rioni depression (Fig. 1). The total thickness of these beds commonly exceeds 1000 m. The upper part of most wells shows the presence of clay-rich limestones with some rare horizons of dolomitized limestone or dolomite (Eristavi, 1964). In the lower part of the section dolomitization is widespread (Table 5). The Neocomian-Aptian in eastern Georgia is lithologically similar, and in the Kartli depression in central Georgia, Kotetishvili (1986) has described wells which penetrate limestones, marly siltstones and silty or sandy marls. Dolomite and dolomitized limestones increase in frequency with increasing depth, indicating a deepening upward sequence.

In the Gagra-Java zone of the Southern Slope Basin, and over the Dzirula Massif of the Transcaucasus normal marine sedimentation occurred.

Further to the south, in the Adjara-Trialeti fold belt (Fig. 5) only the Upper Aptian and Albian rocks crop out in the gorges of the Tedzami and Dzama rivers. The predominantly volcanic lithologies exposed consist of an alternating sequence of tuff conglomerates, tuffs, and tuff breccias, only in the Upper Albian are terrigenous marls and calcareous sediments common. The total thickness reaches 280 m (Papava, 1964, 1967). The sediments of the Khrami Massif have a similar facies. The central part of the Georgian Block was a high during this time and acted as a sedimentary source. It was, however, reduced progressively in size as the transgression advanced during Berriasian to Albian time, and was at its smallest in middle Albian but toward the end of the Late Albian began to re-emerge. A littoral zone existed north and west of the Dzirula Massif with islands and submarine ridges beyond which was a deeper water zone with ammonitic carbonates.

Still farther to the north lie the flysch deposits described earlier. These are limited to the north by discontinuous land masses which formed the axial region of the Greater Caucasus (Fig. 4c) where basalts dated as Paleogene have been recognized.

During the Upper Cretaceous in the marginal seas of the Southern Slope, deposition of flysch continued with a rhythmic sequence of marls and siltstones (Tsagareli, 1964). In the basins of eastern Georgia the beds include terrigenous chert-bearing deposits of Cenomanian age which are followed by Turonian-Senonian clastic limestones. Within the Maestrichtian are olistostromal deposits emplaced during uplift and regression.

In the Northern Transcaucasus, Cenomanian-early Turonian terrigenous volcaniclastics gave way to carbonates as the transgression continued. In contrast in the Southern Transcaucasus volcanic activity continued until the Santonian, and volcanics alternated with carbonates (see Table 6).

Flysch sedimentation continued into the Paleocene in the region of the Greater Caucasus marginal sea as marly turbidites accumulated, while in the Adjara-Trialeti back-arc basin a thickness of 2000 m of terrigenous flysch was deposited (Kacharava, 1964).

Lower Eocene-Lower Miocene Cycle

Following the Paleocene regression, a new cycle began with a transgression in the early Eocene and was completed by a regression beginning in the Oligocene and lasting into Early Miocene. The plate reconstruction of Lordkipanidze et al. (1984) shows a plate assembly which has the basic elements of the present situation (Fig. 4e) without the tectonic complications introduced by the Alpine orogeny (Fig. 4f). Northward movement of the Scythian plate with subduction along its southern margin lasted into the Middle Eocene (Adamia et al., 1990), but from Middle Eocene into Oligocene time movement was reversed and the Eurasian plate moved southward colliding with the northward-advancing Nakhichevan plate apparently during the Late Eocene (Fig. 4e). Associated with the subduction are potassic-shoshonitic volcanics.

These Late Alpine tectonic events involved intense folding, ophiolite formation, the closure of the Adjara-Trialeti rift, the remobilization of structures in the Lesser Caucasus, and the inversion of the Greater Caucasus Basin (Fig. 4f). The effects of the increasing intensity and deformation associated with these tectonic events are seen in the flysch basins of the Southern Slope, where the deposition of over 2000 m of terrigenous coarse flysch was accompanied by the emplacement of olistostromes. Over most of the Northern and Southern Transcaucasus shallow marine conditions persisted with the formation of bioclastic limestones.

In the Adjara-Trialeti Basin both during the Early Oligocene and Late Oligocene-Early Miocene the deposits formed on a continental slope bordering the Rioni trough which lay to the south (Laliev, 1964). Relicts of a deep marine fauna provide evidence that deep-water conditions existed in the southern part of the Rioni or Kolkhida depression and in the Northern Caucasus during Oligocene time. In the Southern Transcaucasus sediments of the Lower Oligocene shallow marine facies are associated with brown coal deposits (Laliev, 1964). During the latter part of the Oligocene and into the Early Miocene these gave way to a monotonous series of sands, argillites, gypsum and jarosite beds assigned to the Maikopian Series. These beds, which are widely recognized throughout the Transcaucasus (Buleishvili, 1964; Laliev, 1964b), point to deposition under anaerobic conditions.

Middle Miocene-Quaternary Cycle

The main phase of folding and thrusting began in Middle Miocene time. Along the subduction zone oceanic crust was eliminated as the Arabian plate collided with the Eurasian. The onset of the main phase of folding beginning in the Middle Miocene was accompanied by transgression which peaked during the Late Miocene to be followed by a general regression interrupted by short-lived, minor transgressions during the Pliocene (Fig. 4f).

The effects of these movements finds a reflection in the sedimentary history of the region, in the eastern and western basins of the Greater Caucasus. In eastern Georgia in the center of the Kura depression the greatest thickness of terrigenous flysch, clays and sandstones with interbedded marls accumulated. The thickness of the beds diminishes both to the north and south. The oldest sediments penetrated by drilling are the Sarmatian, of late Middle Miocene age. The younger of these, the Upper Sarmatian beds, mixed continental and marine clastics, give way to the fresh-water mottled clays and interbedded sandstones of the Eldari Formation (Buleishvili, 1964b). At the top of the beds of the Eldari Formation there is a clearly defined unconformity above which appear the Upper Pliocene Akchakgilian beds (Chelidze, 1964).

There are more than 2000 m of Meotian-Pontian fresh-water sedimentary beds assigned to the Shiraki Formation in the Kura Basin which are also transgressively covered by the Upper Pliocene-Lower Quaternary Akchagilian-Apsheronian beds, a mixture of continental conglomerates and poorly sorted sandstones and marine clays (Tsagareli, 1964) and include a number of interbedded volcanic ash horizons. The two sequences are 800-850 m and 650-800 m thick respectively. The younger Quaternary sediments, which include alluvium and terrace gravels, may reach a thickness of 150 m.

In western Georgia the Neogene section consists of 3-4 km of sandy-argillaceous beds which are sometimes fossiliferous and which are characterized by rapid lithofacies and thickness changes (Chikovani, 1964). In the deep, southern part of the Rioni trough adjacent to the Adjara-Trialeti fold belt, in addition to the clays, clay-marls and sandstones there are biotite tuffs and sandstones with volcanic clastics

Summary and Conclusions

Throughout most of the Phanerozoic Georgia, and the Caucasia-Transcaucasian region in general, have been at a continental margin and involved in more than one sequence of plate tectonic activity. Whereas the Mesozoic-Cenozoic history is better understood, although much still remains to be clarified, the older events are only dimly recognized because of the superimposition of the younger activity. Lordkipanidze et al. (1984) and Adamia et al. (1990) have identified Hercynian as well as Alpine events, including the short-lived Mesozoic, Cimmerian, opening and closure in broad outline. They have indicated the existence of passive margin phenomena, island arc activity and the presence of several sutures. Yet fundamental issues remain to be solved: whether the Transcaucasian region has affiliations with the Gondwanan or the Eurasian margin, and how the existence of the Dizi sequence, said to be relatively undeformed and a continuous succession of deep-water sediments which range in age across the time of the proposed Hercynian subduction and suture, can be reconciled with its geographic position adjacent to coeval Hercynian metamorphics. There is only very limited information which can be brought to bear on the possible recognition of significant strike-slip displacement (Adamia et al., 1990).

The first attempt to interpret the stratigraphic history of the region in terms of the concepts of sequence stratigraphy (Van Wagoner et al., 1988) is praiseworthy, but the lack of correspondence with the established chronology requires investigation. The answer may lie in the tectonic activity of the region, but this remains to be established. An integration of sequence stratigraphy with the tectonic and igneous history of the region would go a long way toward increasing confidence in the interpretation of the geological history of a complex province where data are fragmentary.

Part 2
Western Georgia Peculiarities
Brief Review*

* This part is prepared by D.Papava

Brief Review of Geologic Evidence in Western Georgia

Cretaceous and Jurassic deposits, those connected to positive high prospects of oil and gas content, are widely developed in Western Georgia, within the bounds of Imereti uplift and along the south flange of Grate Caucasus folded system (fig.1)
They also are opened by several wells in submerged part of Kolkheti depression. Minimum thickness (up to 1000meters) of Jurassic sediments is specific for the rising of Dziruli crystalline massive (fig.1), while to the north, in the zone of south mountainside of Grate Caucasus, their total thickness is more than 6000 meters. From them the portion of lower Jurassic is 3000 meters, middle Jurassic -2500 meters and Upper Jurassic - more than 1000 meters.
Cretaceous deposits are mainly presented by carbonate sediments, though in some separate regions in their composition volcanogenic forms play sizeable role. They generally are occurring in the Upper Cretaceous section and have sliding age from Turonian till Maastrichtian inclusively. These sediments, which are spread in the Western Georgia, are known as "Mtavari" series and their thickness is in 0 - 600 meters range.
Based on the drilling data volcanogenic rocks also can be found in the Alb-Cenomanian section of central part of Kakheti depression, in the environs of villages Kvaloni, Chaladidi, Lesa and others.
Total thickness of Cretaceous deposits within the bounds of Kolkheti depression fluctuates from 1000 to 2000 meters, from them the portion of lower Cretaceous is 500-1500 meters.
In regional scheme maximum thickness of lower Cretaceous specified in central part of Kolkheti depression, while minimum thickness is specified for uplifted zones.
In Western Georgia, on the basis of drilling data together with results of surface observation, in Jurassic and Cretaceous sections number of reservoir rocks are singling out, which can contain commercial significance oil and gas, if favorable structural conditions will have place.

Those are: 1) middle Jurassic volcanogenicsedimentary complex within the Kolkheti depression structures, as well as in zones of their regional pinching-out along the north flange of depression; 2) reef-bituminous limestone of Upper Jurassic, which are spread in the north-west part of Georgia, within the Gagra uplift (fig.1) along the south flange of folded system of Grate Caucasus in the interfluve of Rioni and Alazani rivers; 3) thick layered massive limestone of Neocomian and lithographic type layered limestone of Upper Jurassic.
Upper Jurassic section within the Kolkheti depression is presented by volcanogenic (oxford) and lagoon sediments of party-coloured series of Kimmeridgian - Tithonian. Here reef limestone is replaced by evaporate sediments.
Neocomian carbonate complex with high capacity properties is widely spread within the Western Georgia. However, hydrogeological research and drilling materials show absence of prospect of this complex from the oil bearing point of view within the whole Imereti uplift and sizeable north-east part of Kolkheti depression. Whole mentioned area for Neocomian sediments is in the active water-circulation zone.
Lower Cretaceous complex deserves searching interest in the stagnant water-circulation zone, which contains highly mineralized chlorine-calcium waters. Here, on top of all this (oil and gas shows during drilling, mud losses and others), hydrodynamic conditions are favorable for oil and gas deposits preservation in the south-west part of Kolkheti depression and the Black Sea water area (mainly within the borders of Shatsky ridge) (fig.1).
Aside from above mentioned reservoir complexes in the Jurassic and Cretaceous sections the separate horizons of clay and marl are singling out, which can be consider as seals of Jurassic and Cretaceous reservoirs. Those are evaporate party-colored formations of Kimmeridgian-Tithonian for middle and upper Jurassic reservoirs, Apt - Albian marl and clay for Lower Cretaceous reservoirs, and Eocene foraminiferal marl for upper Cretaceous limestone.
Onshore geological data show improvement of oil and gas deposits forming and preserving conditions in both Mesozoic and Paleogene-Neogene sediments, towards the Black Sea water area.

Routes Description (fig.2)

1. **Along highway Tbilisi-Kutaisi.** Stop at village Chumateleti, which is located on south-east submersion of Dziruli crystalline massive. Here, thick layered (thickness not more than 60m) Barremian limestone are transgressively lie on the Paleozoic rocks. Over it laminated limestone with interlayer of Aptian marls and marls and clay of Albian are emerging. The last ones are badly outcropped because of Quaternary formations development.
A few to the north, on the eastern slope of massive consecutively are outcropping upper Cretaceous sediments, presented by glauconite sandstones (Cenomanian) and laminated limestone and marls of Turonian - Cenonian. Here total thickness of upper Cretaceous is up to 630 meters (fig4).

2. Village Cheshura-Kutaisi. Stop at village Cheshura. Here along the road Chokrakian (middle Miocene) limestone are outcropping, which are transgressively ling on clayey thickness of Maycopian series. The lasts, having in the base spongiolite sandstones lied over foraminiferal marls of Eocene. After the small overlap bedded, breccia type limestone of upper Cenomanian is outcropping. Farther, toward to Kutaisi the tufogene rocks of "Mtavari" suit are outcropping (Turonian-Lower Cenonian age). Near Kutaisi on south periphery of Okriba uplift, Cenomanian sediments are presented by limestone (thickness 10-15 meters). Below lied Albian marls and clay with interlayer of glauconite sandstones, which total thickness is not more than 50 meters. Below Albian, in town Kutaisi area in some places laminated limestone is outcropped with marls interlayer, reach of ammonites fauna determining Aptian age of containing rocks. Here their thickness is no more than 25 meters.
Under the Aptian sediments thick layered Neocomian massive limestone are bedding, which are well outcropped along canyon of river Tskaltsitela (left inflow of river Rioni).
Quartz-arcos sandstones are presented in the base of limestone presented with thickness of 30 meters. In environs of village Gelati they are transgressively ling on the rocks of Upper Jurassic party-coloured series. The lasts are presented by interchanging of party-coloured clays and sandstones with crust of olivine basalts. Their total thickness is up to 300 meters. They transgressively lied on different horizons of Okriba uplift middle Jurassic sediments (fig.5).

3. Kutaisi-Tvishi

To the south of Kutaisi on canyon river Rioni intermittingly are outcropped layered tuff-sandstones and argillites of upper Bajocian age, above them near village Tvishi transgressively laid low- thickness party-coloured upper Jurassic sediments (series are badly outcropped). Above dolomites and dolomite-sandstones of Valanginian - Hauterivian (150 meters) are ling and over them laid thick-layered massive limestone of Barremian (300 meters). Section of lower Cretaceous is ended with laminated limestone and marls containing Aptian and Albian fauna with total thickness of not more than 150 meters.
Upper Cretaceous begins with glauconite sandstones (35 meters) with laminated, in lower part in some places Turonian-Cenonian pinkish limestone (550 meters) in above, which are taking part in the structure of some minor folds.
Over Cenonian limestone laminated limestone and marls of Paleocene are positioned, which are well outcropped on mountain Sairme pass (fig 6).

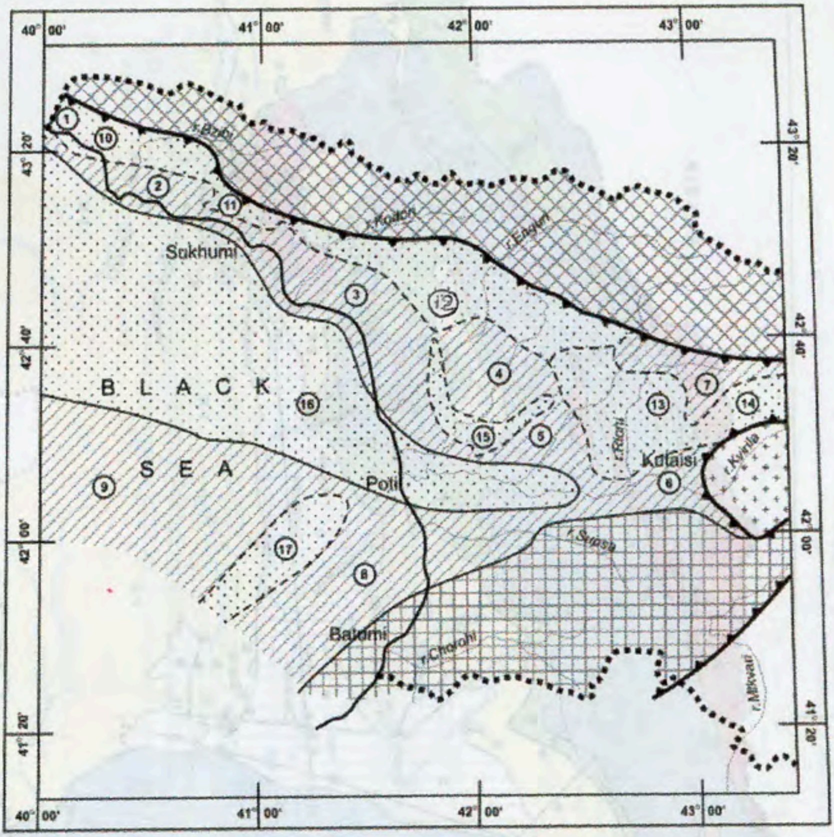
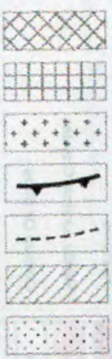


Figure 1. TECTONIC ELEMENTS OF WEST GEORGIA AND ADJACENT BLACK SEA REGION



- Folded belt of the southern slope of the Great Caucasus;
- Adjara-Trialeti folded belt;
- Dzirula massif;
- Eastern border of the east Black Sea oil bearing basin;
- Border of the main tectonic elements;
- Depressions: (1) -Adler; (2) -Gudauta; (3) -Ochamchire; (4) -Central Megrelia; (5) -Khoni; (6) -Adjameti; (7) -Racha-Lechkhumi; (8) -Guria; (9) -East Black Sea
- Uplifts: (10) -Gagra; (11) -Sokhumi; (12) -Okumi; (13) -Okriba; (14) -Upper Imeretia; (15) -Southern Megrelia; (16) -Shatski; (17) -Maltakva

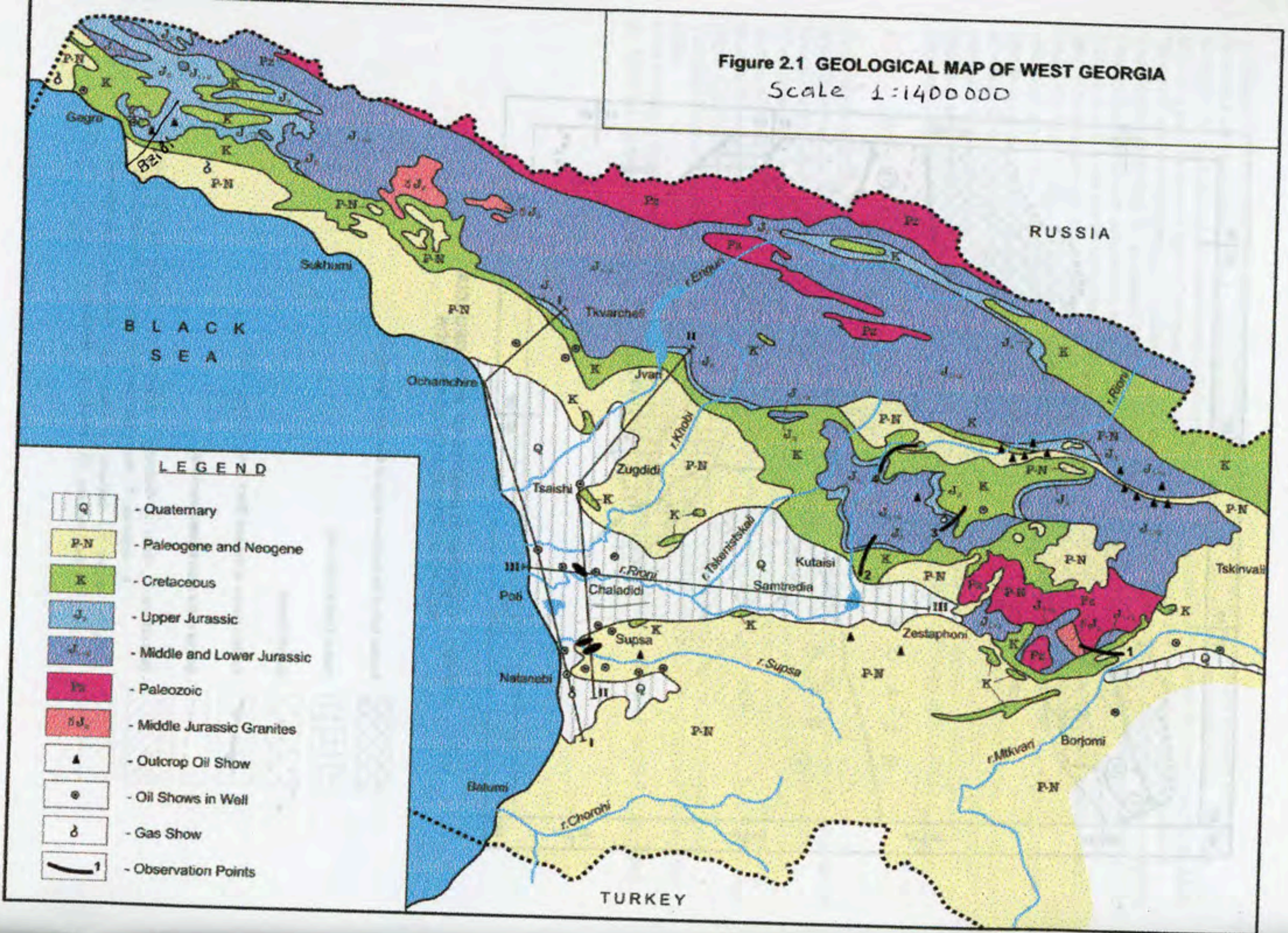
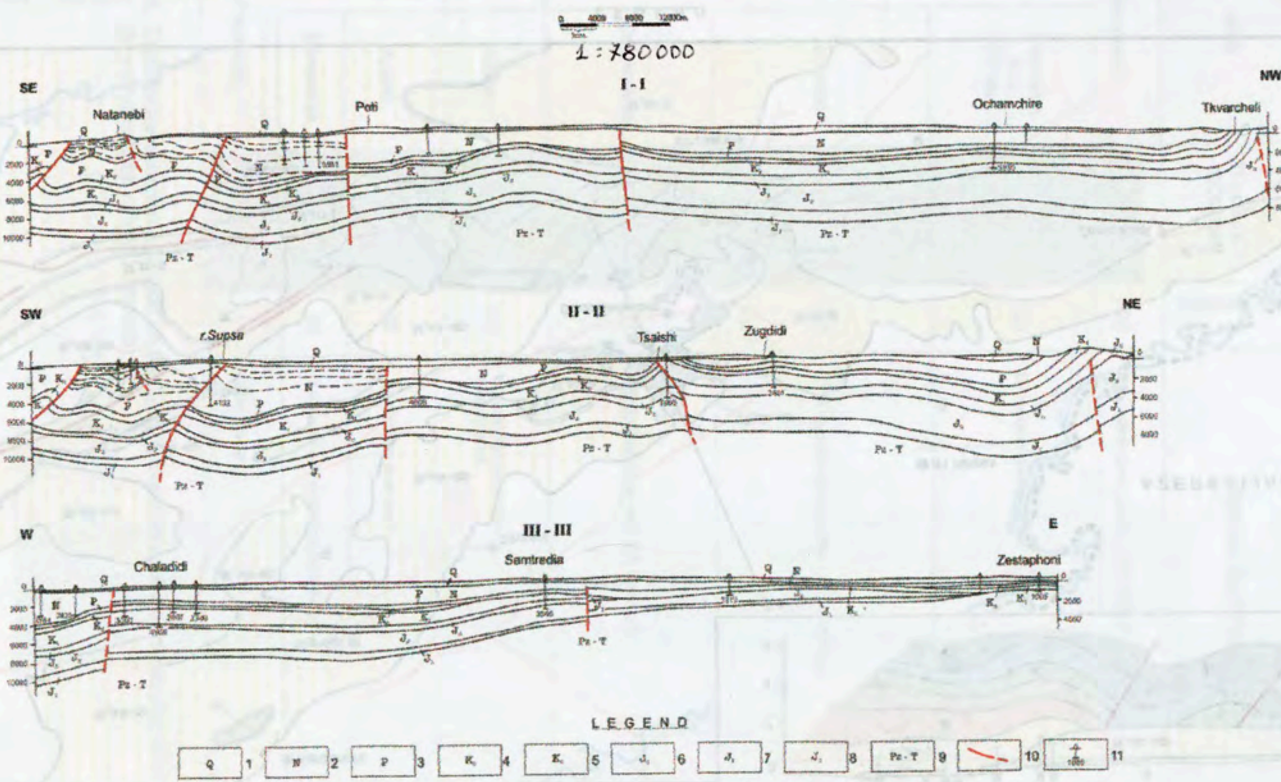


Figure 2.1 GEOLOGICAL MAP OF WEST GEORGIA
Scale 1:1400000

Figure 2.2 GEOLOGICAL CROSSECTIONS



1. Postpliocene? (Quaternary of Pleistocene); 2. Neogene; 3. Paleogene; 4. Upper Cretaceous; 5. Lower Cretaceous; 6. Upper Jurassic; 7. Middle Jurassic; 8. Lower Jurassic; 9. Paleozoic - Triassic; 10. Tectonic fault; 11. Well

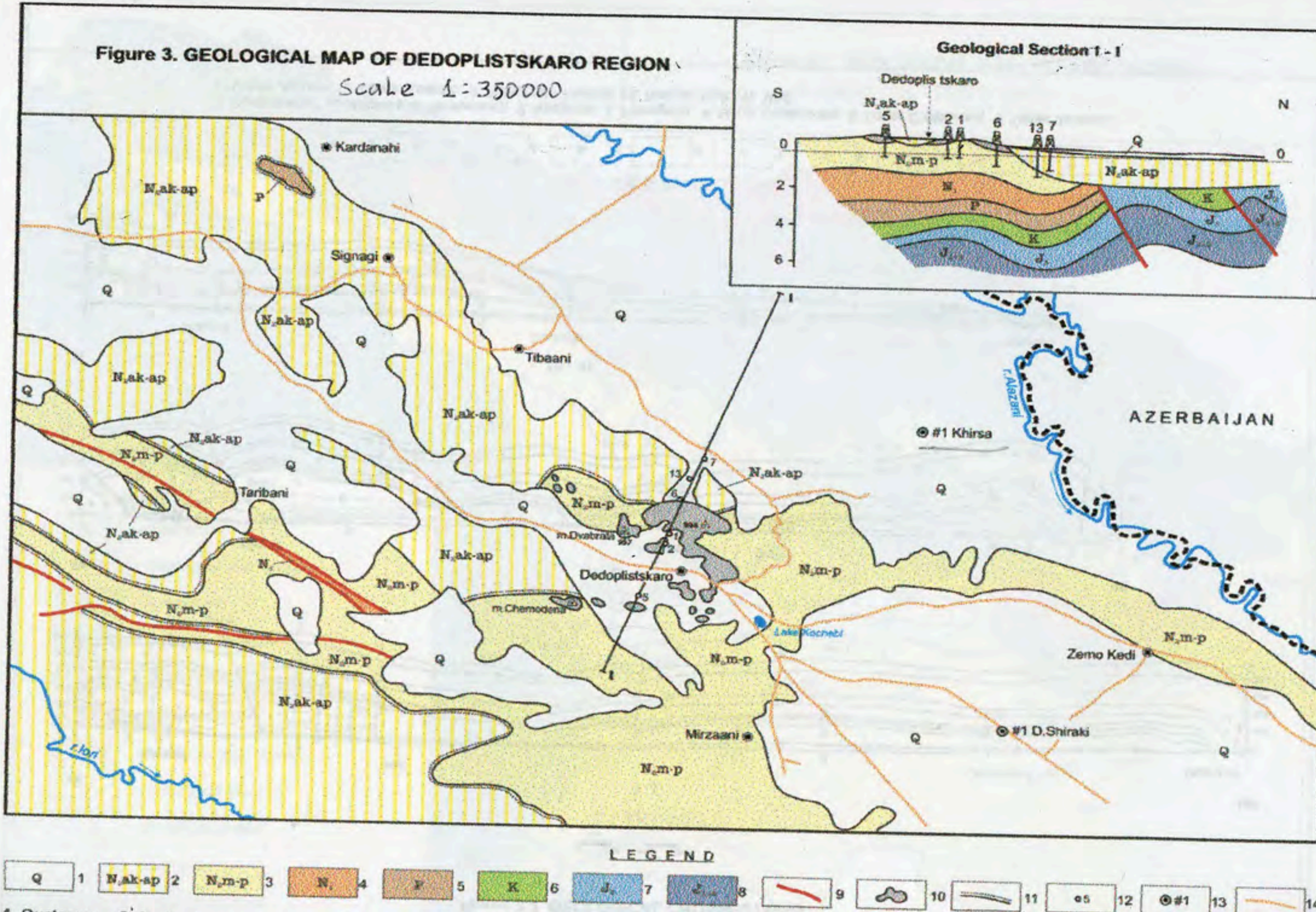


Figure 3. GEOLOGICAL MAP OF DEDOPLISTSKARO REGION

1. Quaternary; 2. Aqchagil - Apsheron; 3. Meotian - Pontian; 4. Miocenian; 5. Paleogene; 6. Cretaceous; 7. Upper Jurassic; 8. Middle and Lower Jurassic; 9. Tectonical fault; 10. Olistostromes of Mesozoic rocks; 11. Transgressive overlapping; 12. Structural Well; 13. Deep Well; 14. Road

AGE			LITHOLOGIC COLUMN	THICKNESS m.	ROCKS DESCRIPTION
Paleogene				>20	Clay, sandstone, party-colored marl
CRETACEOUS	Upper	Cenonian and Danian		100	Limestone and marl
		Turonian		160	Thin layered lithographic type limestone
		Cenomanian		130	Sendy limestone with tuff interbeds
	Lower	Albian		100	Glauconite sandstone Clayey marl
		Aptian		80	Limestone and marl
		Barremian		60	The layered crystalline limestone
Paleozoic					Granitoids

Figure 4. Cretaceous sediments section on the Dzirula massive southeast outlaying area (in v.Chumateleti neighbourhoods)

Observation point 1

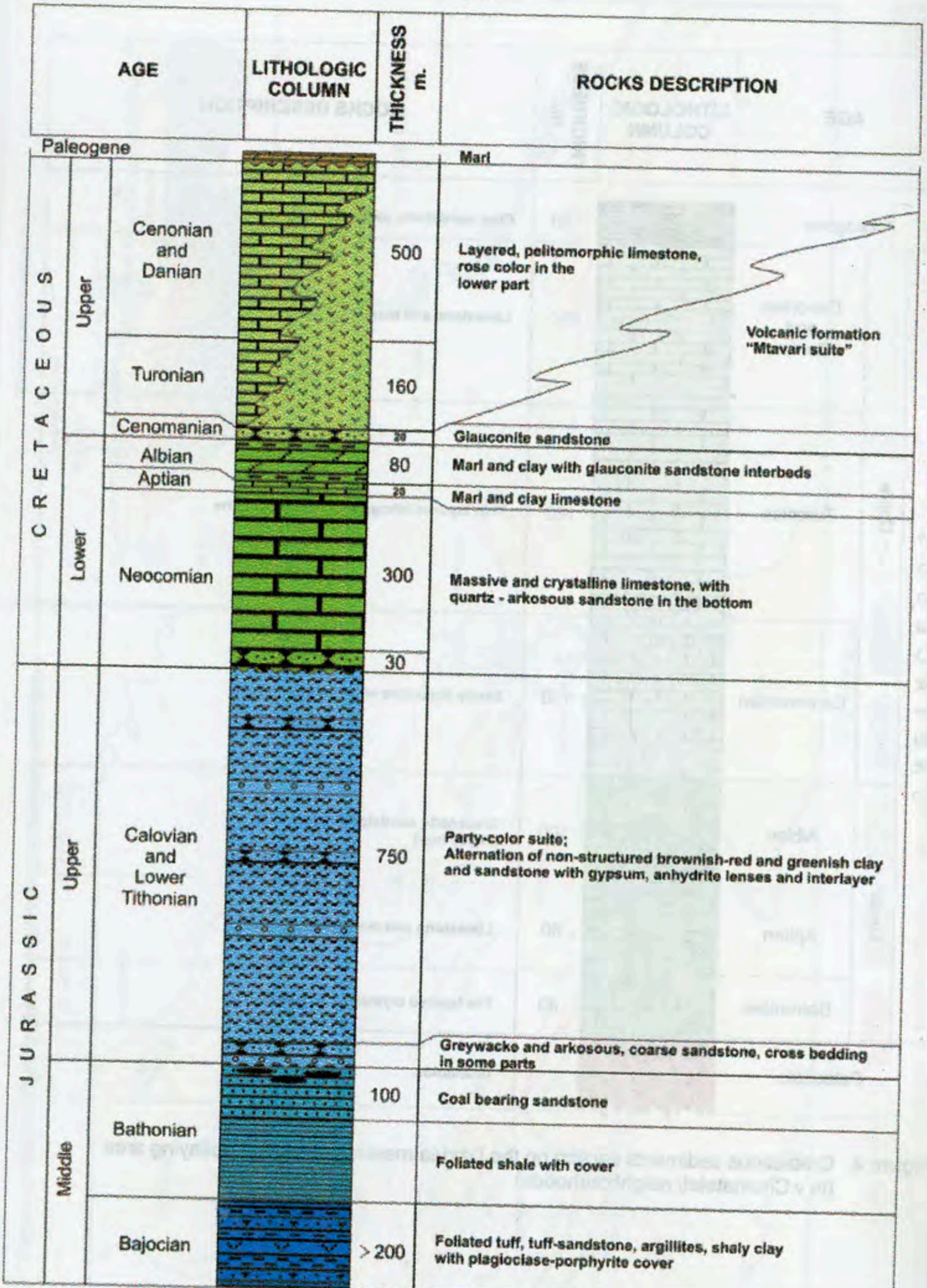


Figure 5. Jurassic and cretaceous sediments section nearby Kutaisi and Tkibuli

Observation points 2-3

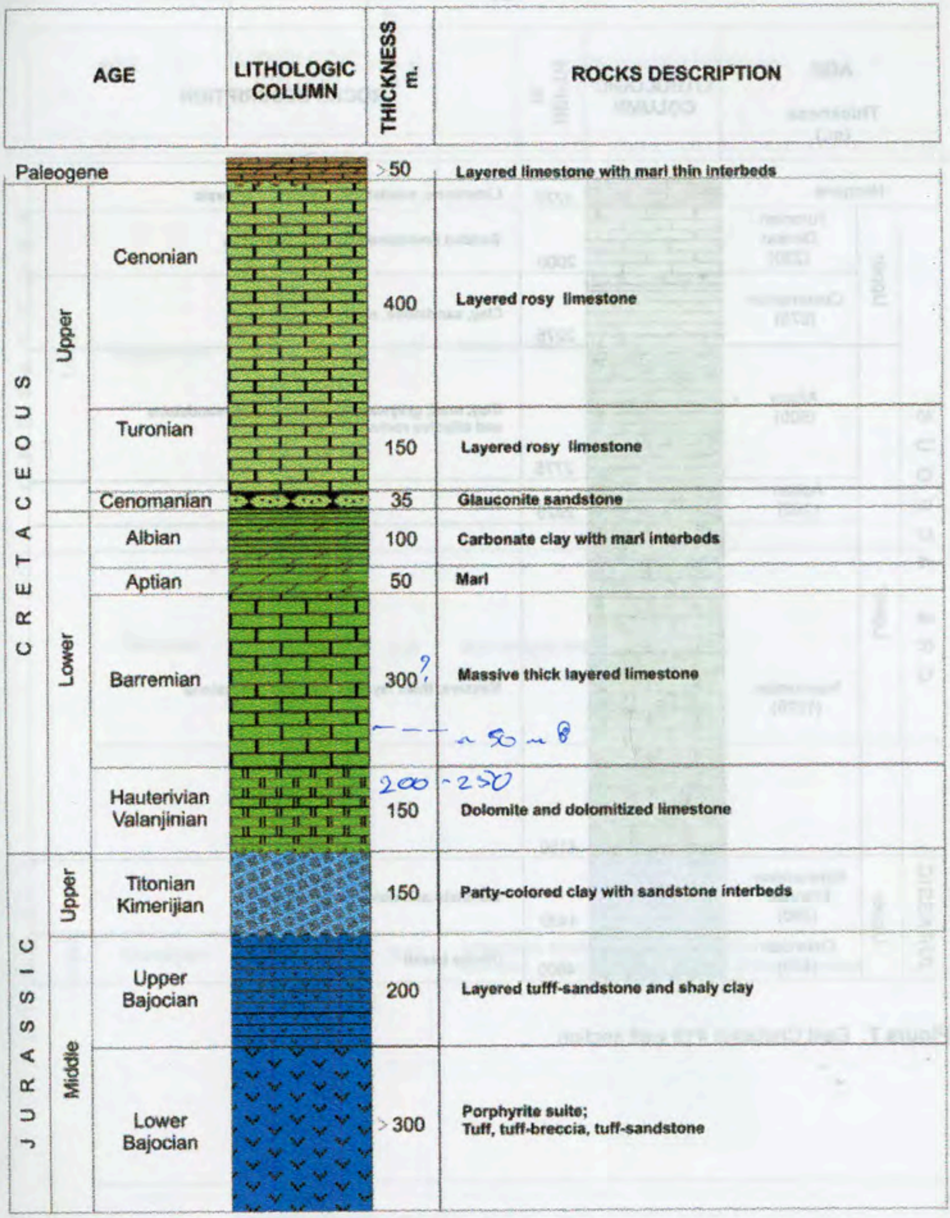


Figure 6. Jurassic and cretaceous sediments section along Rioni river,north to v.Tvishi

Observation point 4

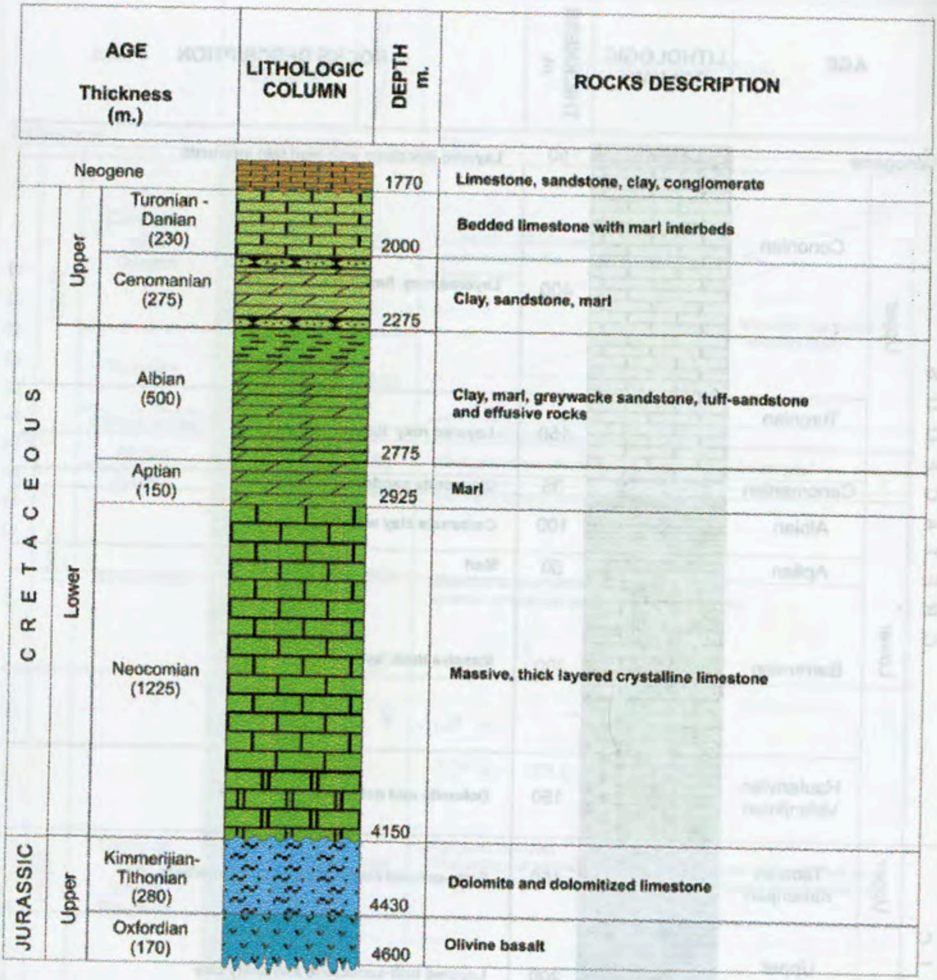


Figure 7. East Chaladidi #18 well section

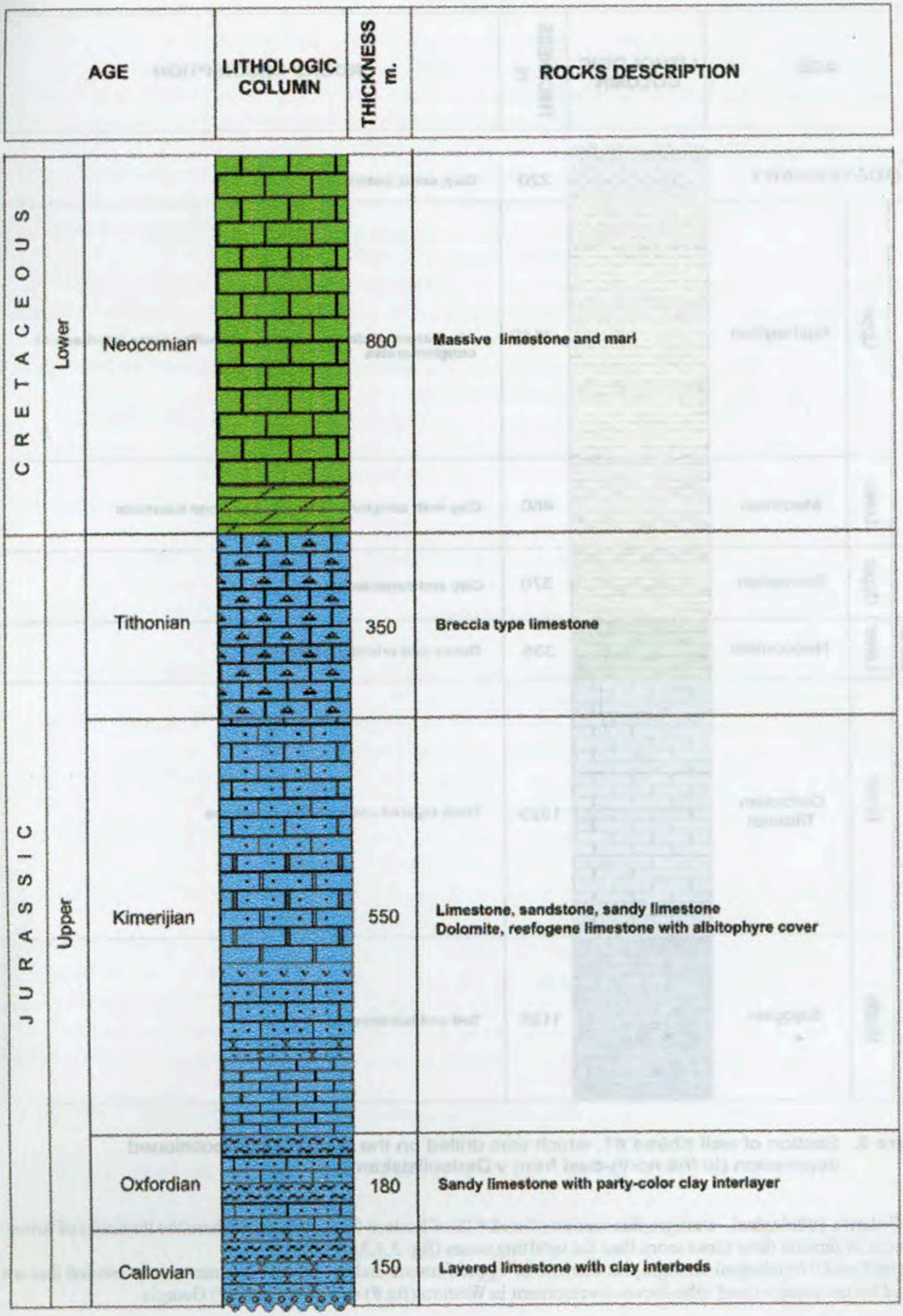


Figure 8. Upper Jurassic - Low cretaceous sediments section along the Bzibi river canyon

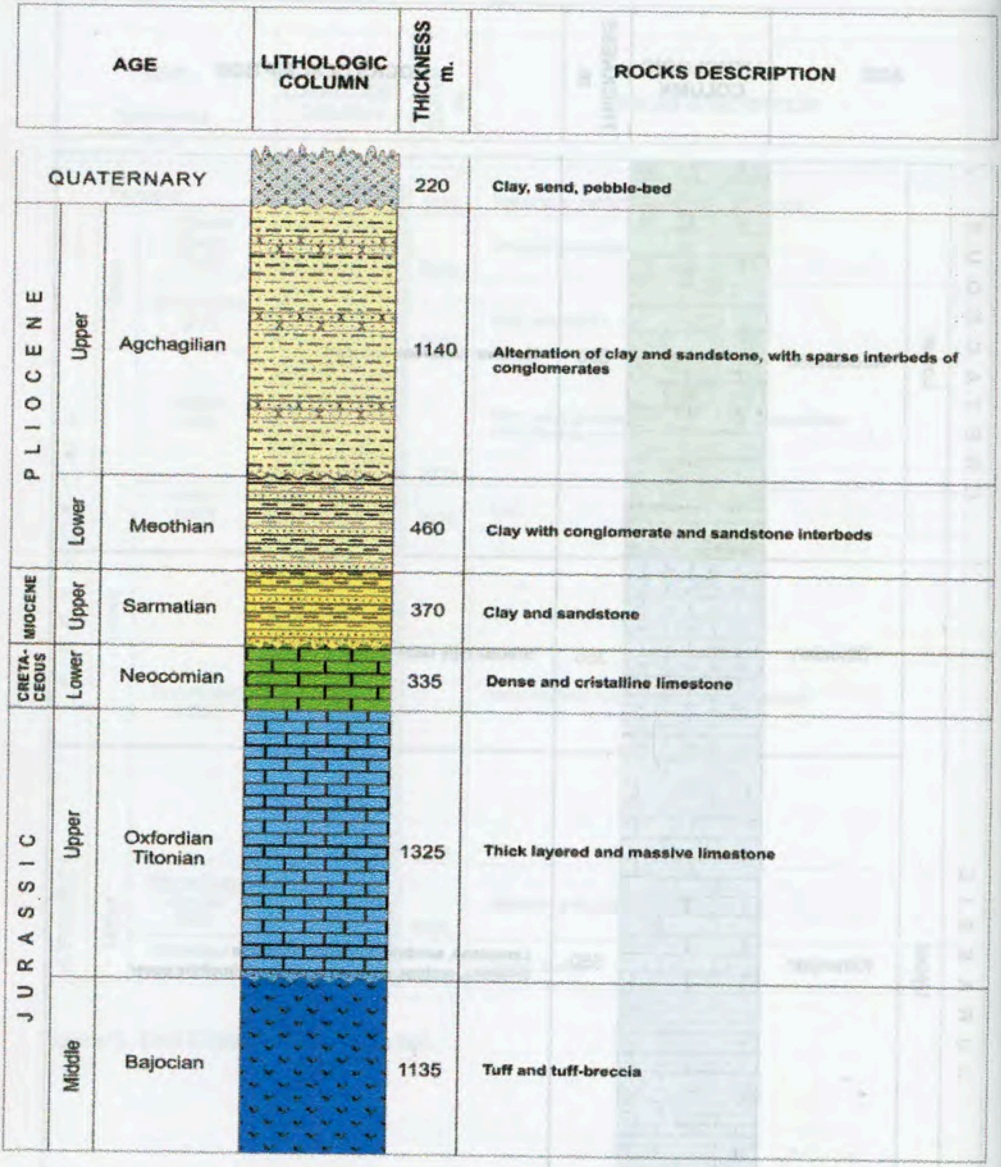


Figure 9. Section of well Khirsa #1, which was drilled on the Alazani superpositioned depression (to the north-east from v.Dedoplistskaro)

Figure 7 shows lithological - stratigraphic section of well #18 of Eastern Chaladidi area, where the thickness of lower Cretaceous sediments three times more than the uplifting zones (fig. 3,4,5,6,7).
On the fig.8 and 9 lithological-stratigraphic sections of Upper Jurassic and Cretaceous sediments are presented that are specified for the zones of reef litho-facies development in Western (fig.8) and Eastern (fig.9) Georgia.

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