GEOLOGY OF IRAQ And Adjacent Area

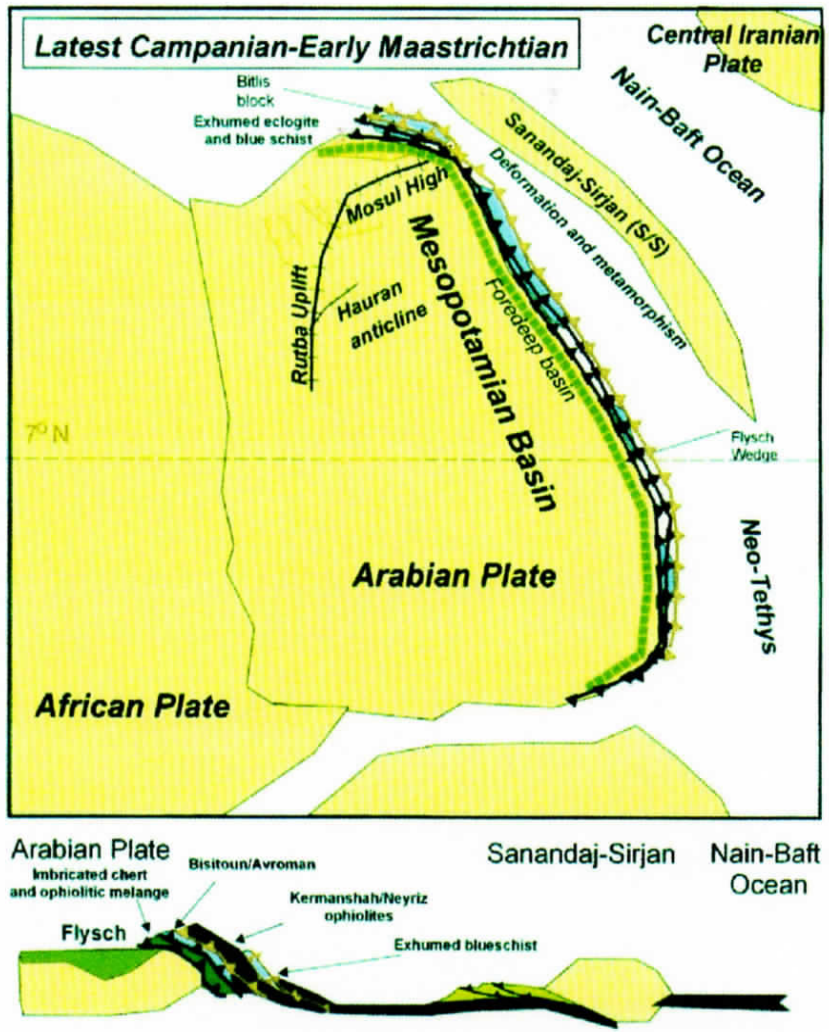
Upper Cretaceous

3- Late Campanian – Maastrichtian

This interval of time was considered by many authors to be of great importance for the paleogeographic development of the Middle East, with special interest in Iraq. Buday (1980) assigned the beginning of this widespread transgressive cycle to the termination of the Sabhercynian movements (Late Cretaceous) in the inner parts of the Eugeosyncline, and with the general shifting of the sedimentary basins towards the craton.

While Jassim & Goff (2006) stated that in Late Campanian-Early Maastrichtian time Neo-Tethyan ophiolites were thrust further into the Arabian Plate, elevated above sea level, and rapidly eroded. The erosion products were deposited as flysch (up to 2000 m thick) in a narrow foredeep basin along the northern and eastern margins of the Arabian Plate extending from SE Turkey through NE Iraq and SW Iran to Oman. Extensional basins subsided strongly during Late Campanian - Early Maastrichtian time. These include the Euphrates Graben, the Azraq - Sirhan Graben and the E-W trending Anah and Tayarat grabens. These basins had originally formed during rifting in early Late Cretaceous time.

Sequences of this period are equated with Arabian Plate Megasequence **AP9** (92 – 63 Ma).



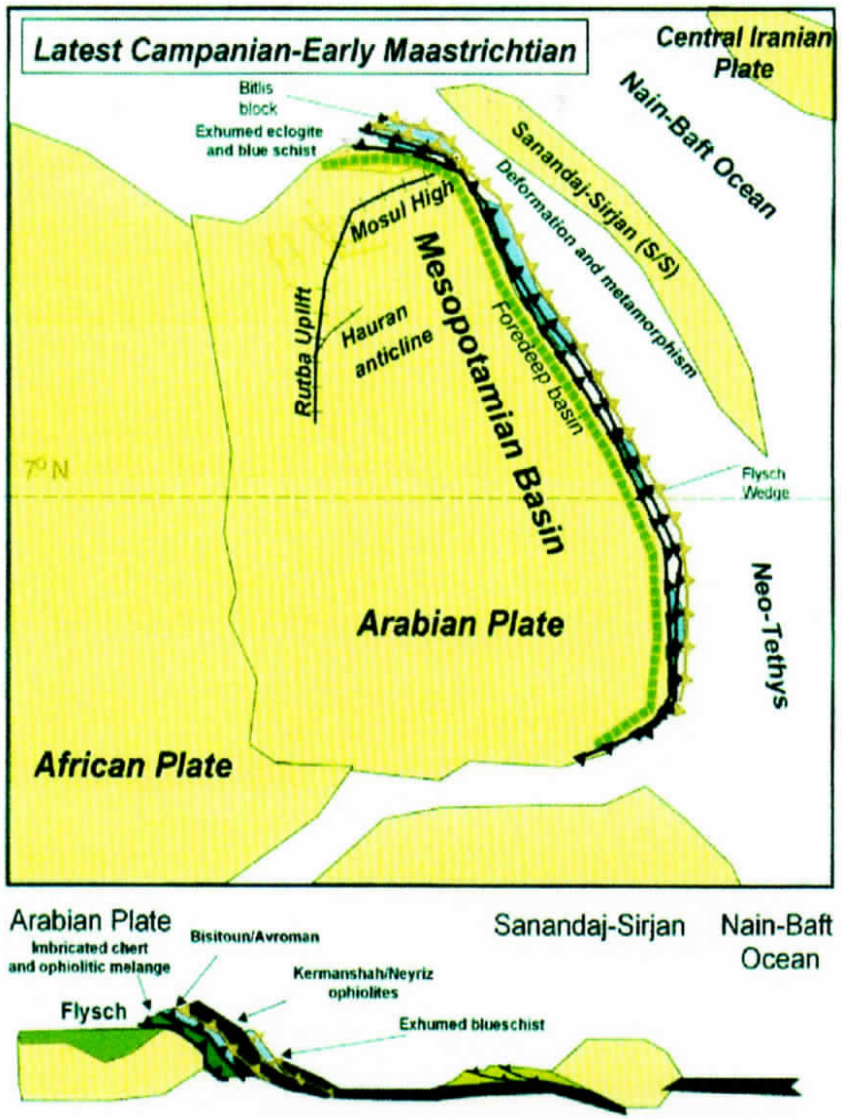
The Paleogeography of Late Campanian – Early Maastrichtian of Iraq shows five facies Belts;

Lagoonal facies of the Hartha Formation are restricted to the Rutbah – Jezira Zone; supratidal facies locally occur especially on the elevated Hauran High in W Iraq and in a N-S basin extending from Mosul in the N to the Salman Zone in S Iraq. The Hartha Formation carbonate shoals were deposited on a carbonate platform bordering the open sea to the E.

The Shiranish Formation was deposited in outer shelf to basinal environment.

The Bekhme Formation was deposited on a carbonate platform developed over the Qamchuqa ridge of the High Folded Zone; this ridge plunged to the SE across the Anah - Qalat Dizeh Fault.

The Tanjero Formation is a flysch facies developed within the Balambo – Tanjero Zone as turbidites drived from uplifted thrust sheets (Jassim & Goff, 2006).

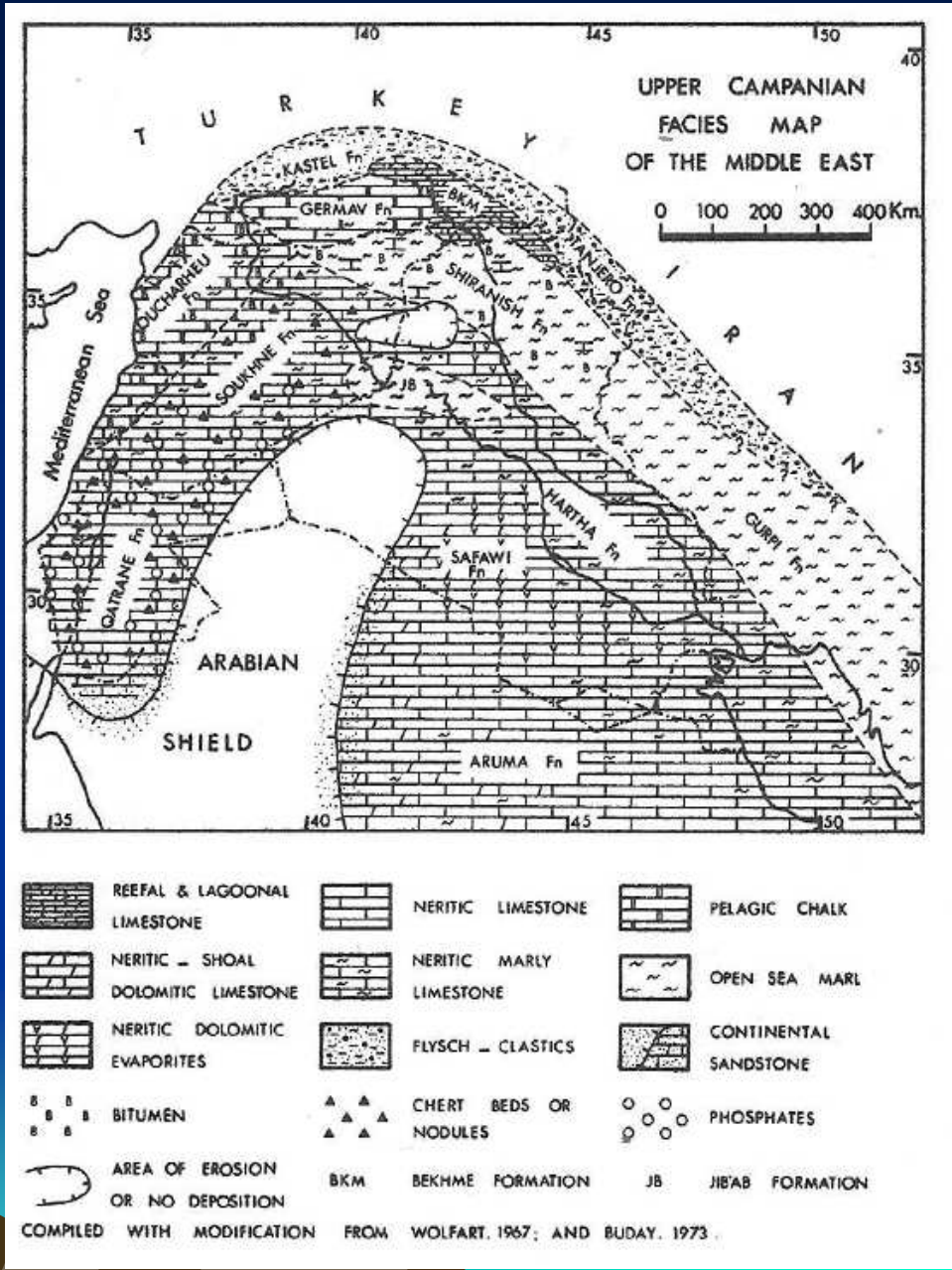


Stable Shelf

During the Upper Campanian, the shelf was dominated by the deposition of neritic and/or littoral sediments. Daniel (in; Dubertret *et al*., 1963) mentioned that there was a barrier swell developed in the southwestern part of the shelf, due to the tectonic movements during the Turonian. This barrier swell was developed where the southern half of the Palestine Coastal Plain now lies, and continued to the north-northeast through Samaria and Tiberias.

To the east of this barrier the phosphatic limestone and chert beds of the **Qatrane Formation** were deposited in a number of wide gentle basins and swells, elongated N - S or N.NE - S.SW, with some tendency to E -W swells and depressions.

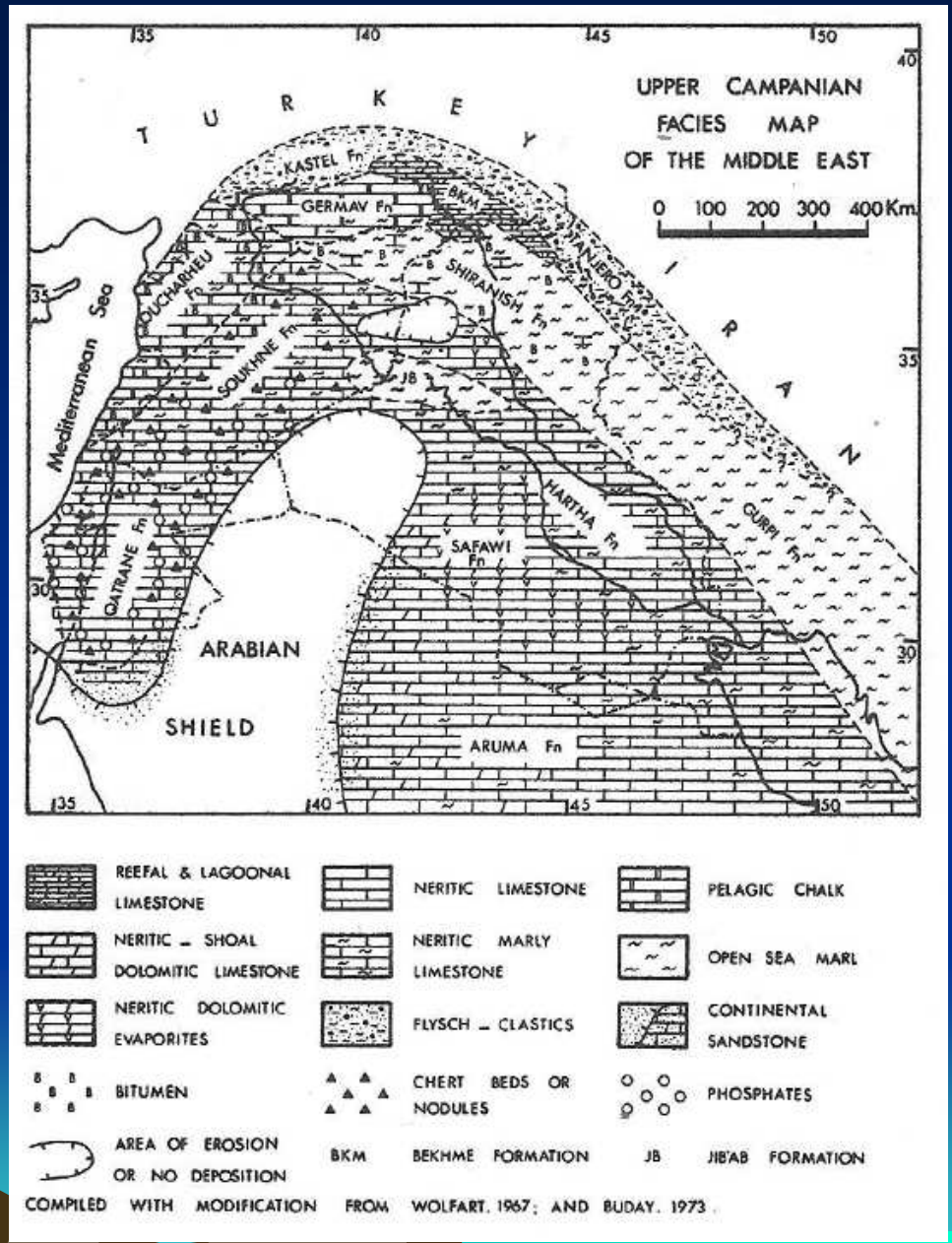
Towards the extreme southeast of Jordan, it wedges out or, together with the underlying Upper Cretaceous rock units, is replaced by continental varicolored sandstone.



Northwards to eastern central Syria, Daniel (in: Dubertret *et al*., 1963) described a sequence equivalent to the Qatrane Formation, called the **Soukhne Formation**.

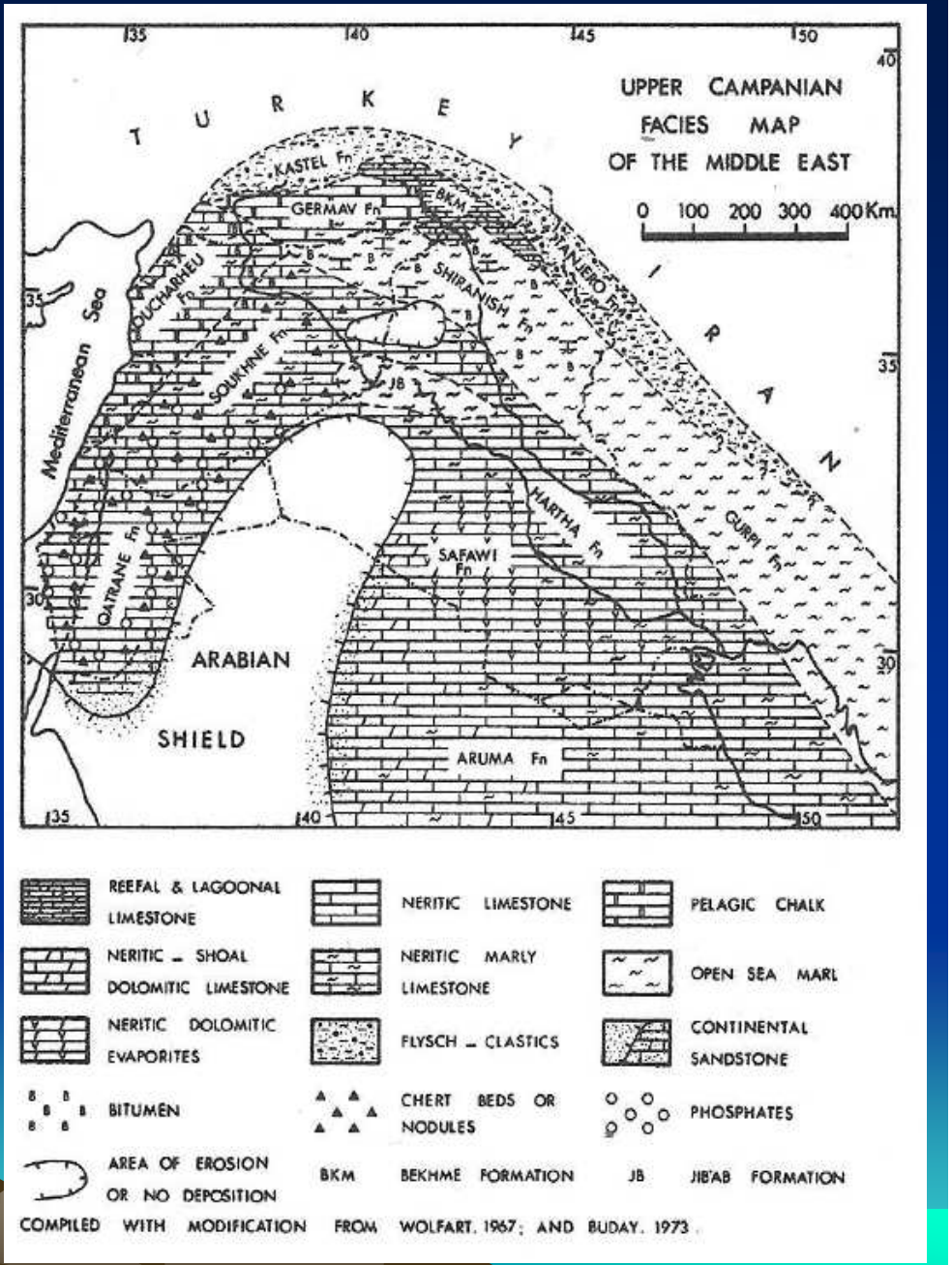
Towards the end of the Campanian a transgression of the sea occurred, with the deposition of a foraminiferal chalk of the "**Shiranish Formation**", which replaced the chert phosphate sedimentation of the Coniacian – Campanian "Soukhne Formation".

Dunnington (in: Bellen *et al*., 1959) & (1960) mentioned that during late Campanian times, an important tectonic movement commenced in northern Iraq, causing the development of two rapidly subsiding troughs with east-west alignments (Jabel Sinjar and Anah Troughs), possibly as a consequence of deep- seated faulting.



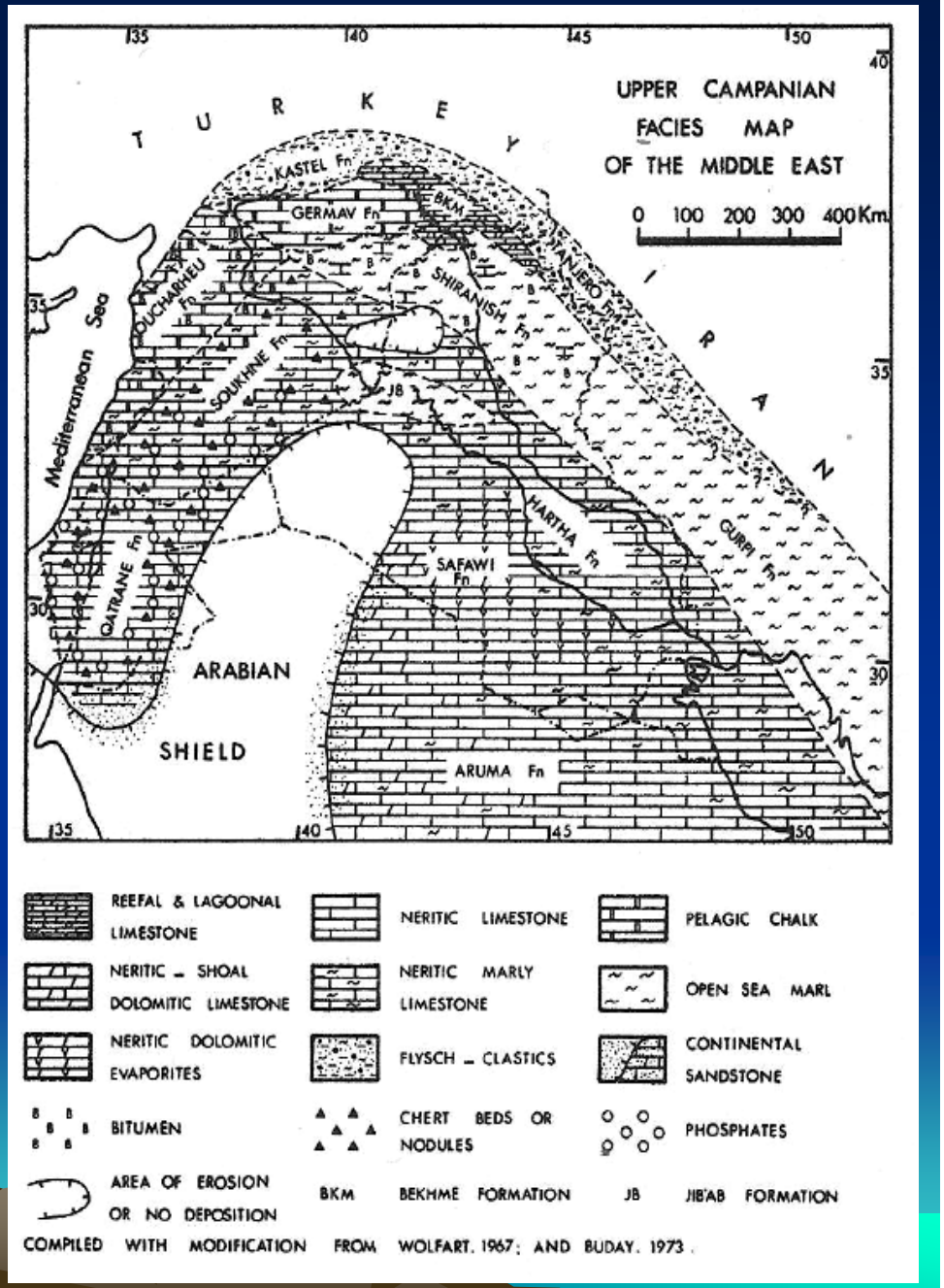
Al-Naqib (1967) assigned the formation of the east-west trending Anah graben trough to the Middle Turonian and Lower Campanian cycle. However, Daniel (in: Dubertret *et al*. 1963) stated that "Towards the end of the Cenomanian and in the Turonian changes occurred which are not clearly understood. It seems they included the uplift to some extent of the twin coastal mountains and subsidence of the Doumar-Damascus depression. While there was considerable volcanism in North Palestine, none is known in Interior Syria". This volcanic activity seems to correspond with the great volume of silica deposited in the Qatrane and Soukhne Formations .

Movements appear to have continued (during the Late Cretaceous), always of epeirogenic and taphrogonic nature. They included especially the sinking of two east-west striking troughs or elongated basins (Jabal Aabd el Aaziz- Jabel Sinjar and Abou Kemal – Anah Troughs). At the same time the Aafrino basin trending NE - SW also sank considerably (Daniel, in: Dubertret *et al*., 1963).



During the Upper Campanian, the neritic or littoral limestone of the **Hartha Formation** was developed east of the area of deposition of the Soukhne Formation, separating the Arabian Shield uplift in the south and southwest from the open sea marls of the mobile shelf. The **Jib'ab Formation** was the main lithological unit developed in the mobile Anah trough, deposited in a basin lying between Abou Kemal and Anah and probably crossing the Euphrates River.

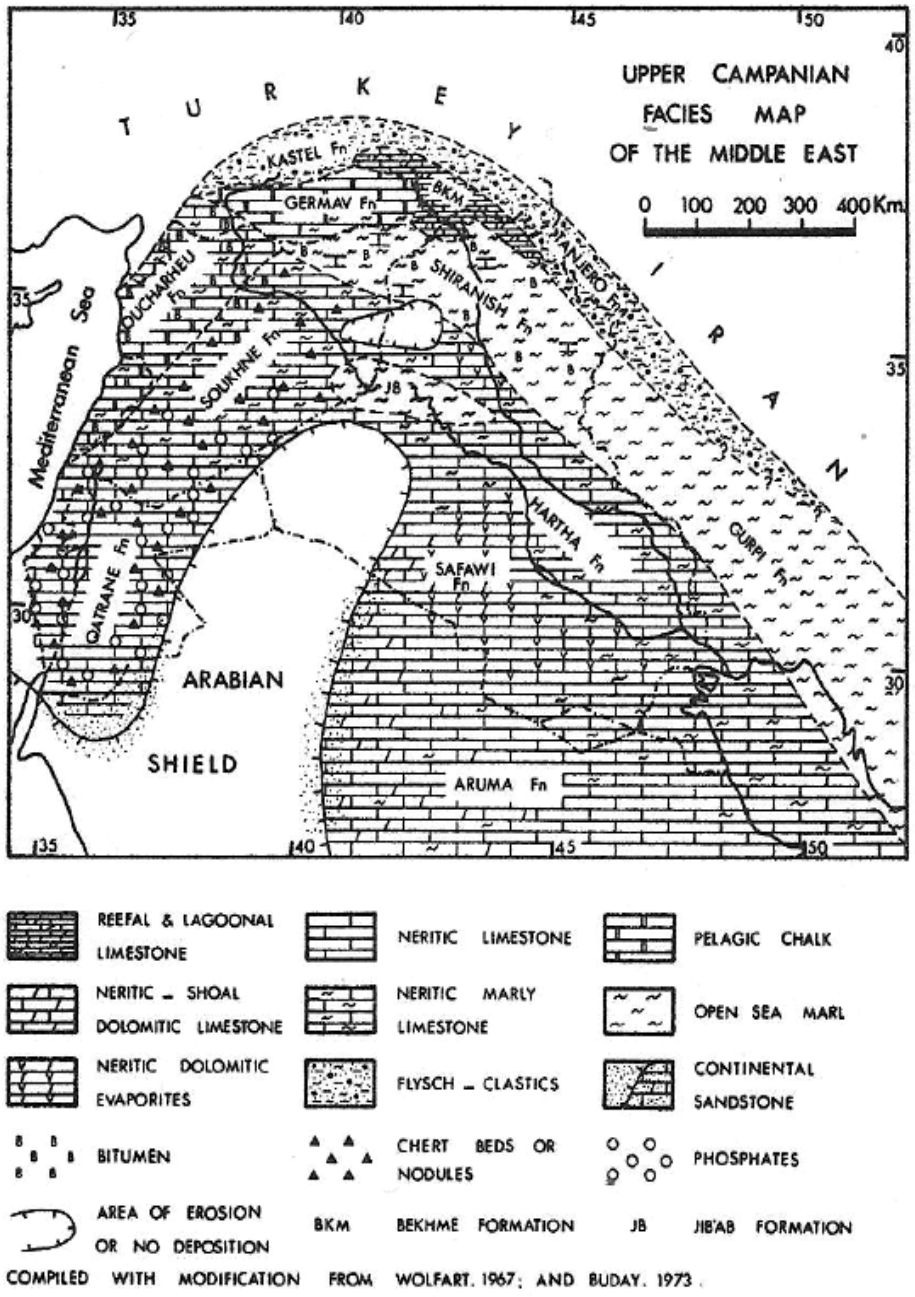
The Jib'ab Formation was deposited in a partly isolated, strongly subsiding trough; but Buday (1980) in accordance with a proposal made by Chatton and Hart(1961), and accepted by Ditmar *et al.* (1971), considered the Jib'ab marl as an aberrant facies of the Shiranish Formation, in spite of the faunal, genetic and geographical differences between those two formations (Dunnington, in: Bellen *et al*., 1959).



The **Hartha Formation** was deposited on the sides of the Anah trough, separating the Jib'ab marls and marly limestone from the Der ez Zor – Khleisia Uplift in the north and the Arabian Shield (Rutbah Uplift) in the south.

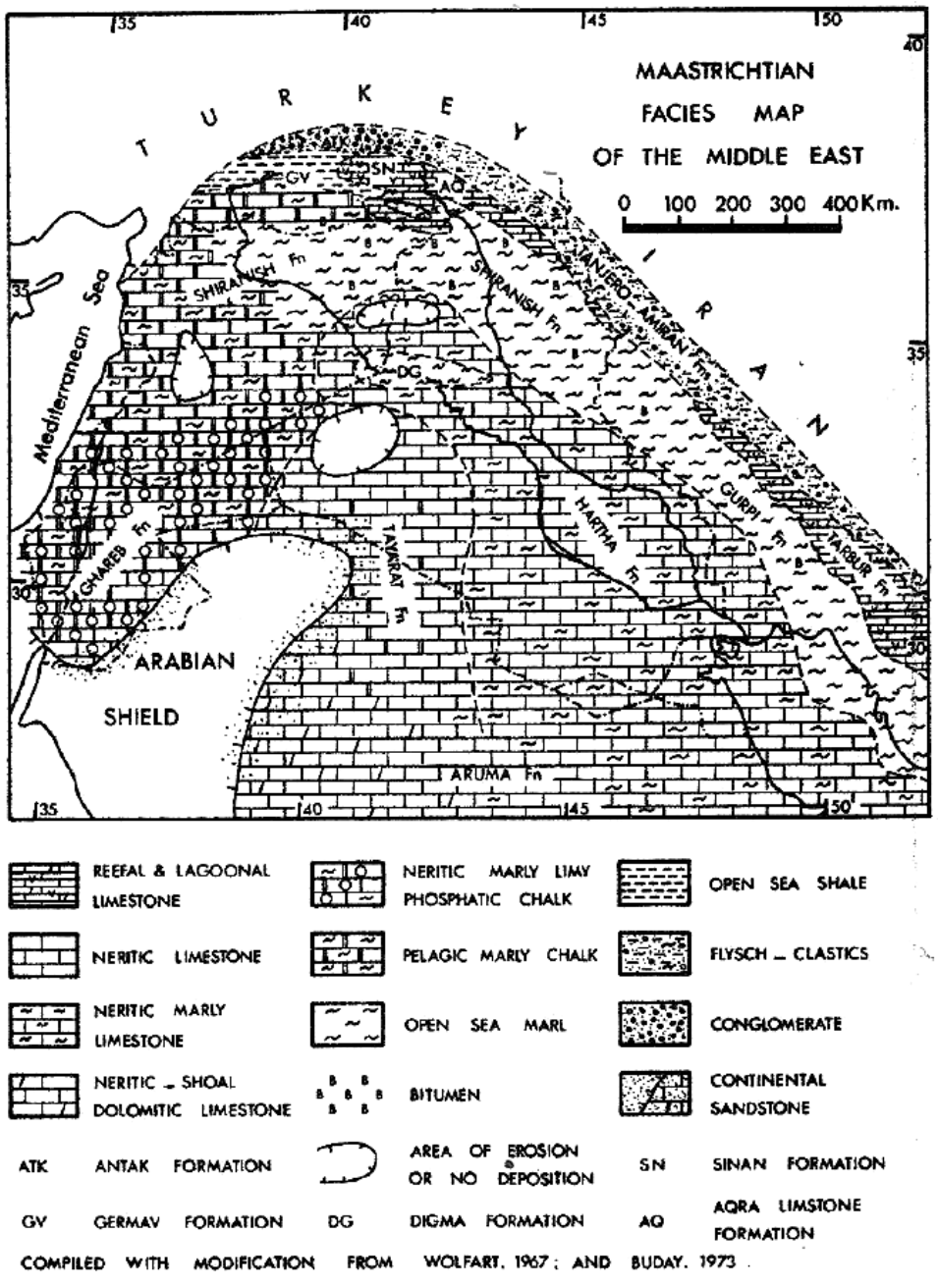
In the western and southwestern parts of Iraq, the lithology of the Hartha Formation changes laterally according to the paleogeographic position of the formation; to the west, near the presumed shore line, the content of dolomite increases; to the east, away from the shore line, there is interfingering of the Safawi anhydrite; further east towards the open sea, the marl content increases (Al-Naqib, 1967).

Southwards in Saudi Arabia, the equivalent of the Hartha Formation is the upper part of the Aruma Formation.



During the Maastrichtian, the maximum transgression of this cycle was reached. In Jordan, Daniel's (in: Dubertret *et al*., 1963) basins and swells began to receive phosphatic and bituminous chalks and marls of the **Ghareb Formation**; to the south the succession is considerably reduced and incomplete, indicating that southern Jordan was again situated in the oscillating neritic or littoral area (Bender, in: Dubertret *et al*., 1963).

Futyan (1968) discussed the paleoecology of the Ghareb Chalks and concluded that they were formed under a subtropical surface temperature, in the central and outer shelf.

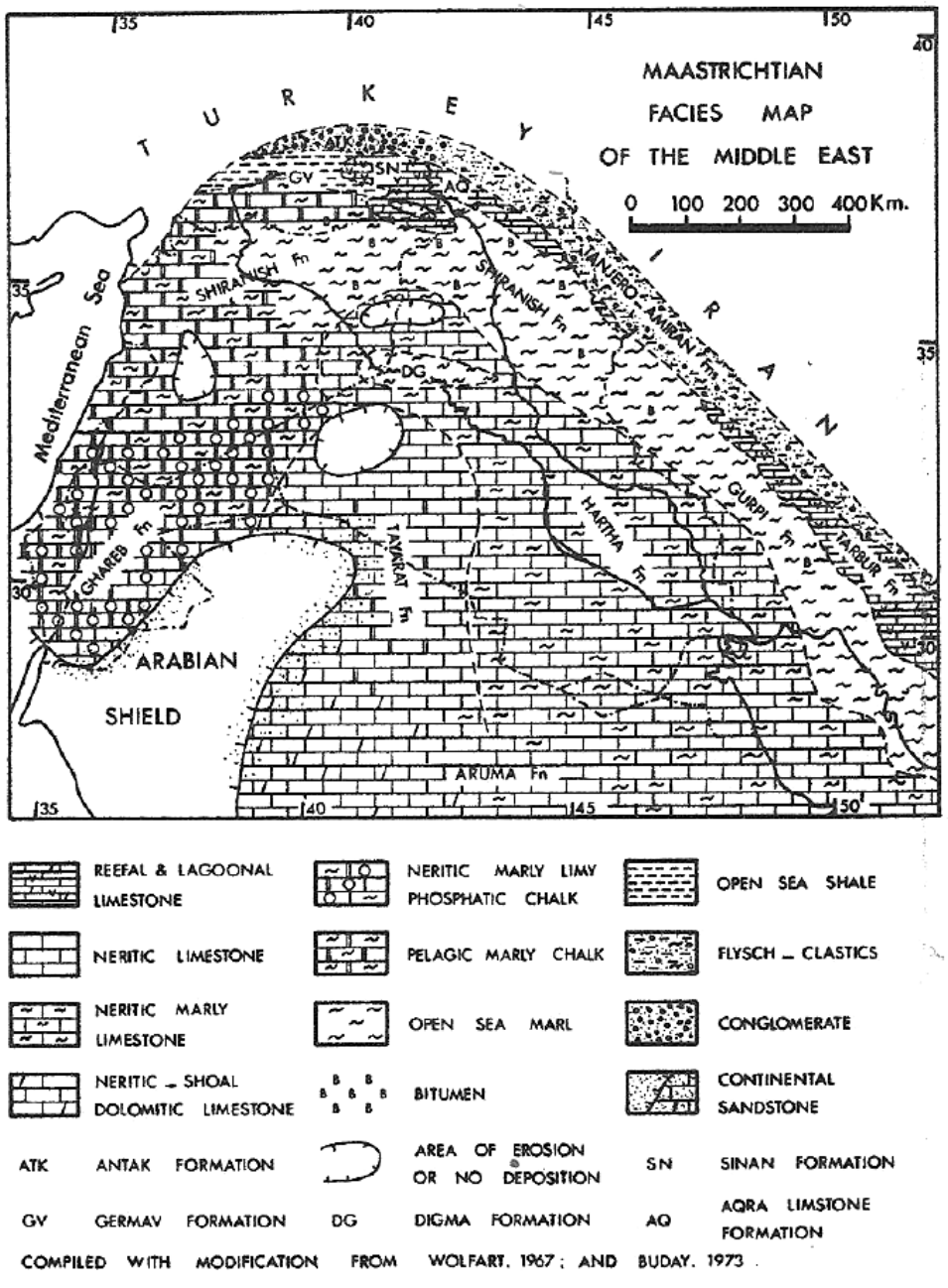


Northwards, towards the south and southeast of Syria, sediments closely resembling the littoral facies of the Ghareb Chalk were recorded by Dubertret (1958) from the Jabel Tenf Well, about 6Km. north of the junction of the frontiers of Syria, Iraq and Jordan.

Further north towards Central Syria an open sea white globigerinal chalk and chalky marl facies of the Shiranish Formation is present.

The stable shelf of western and southwestern Iraq can be divided into two main lithofacies: a neritic-littoral facies, dominated by the deposition of the **Tayarat Formation**, and a neritic facies, the **Hartha Formation**. Both Formations are considered by Jassim and Goff (2006) as carbonate inner shelf facies.

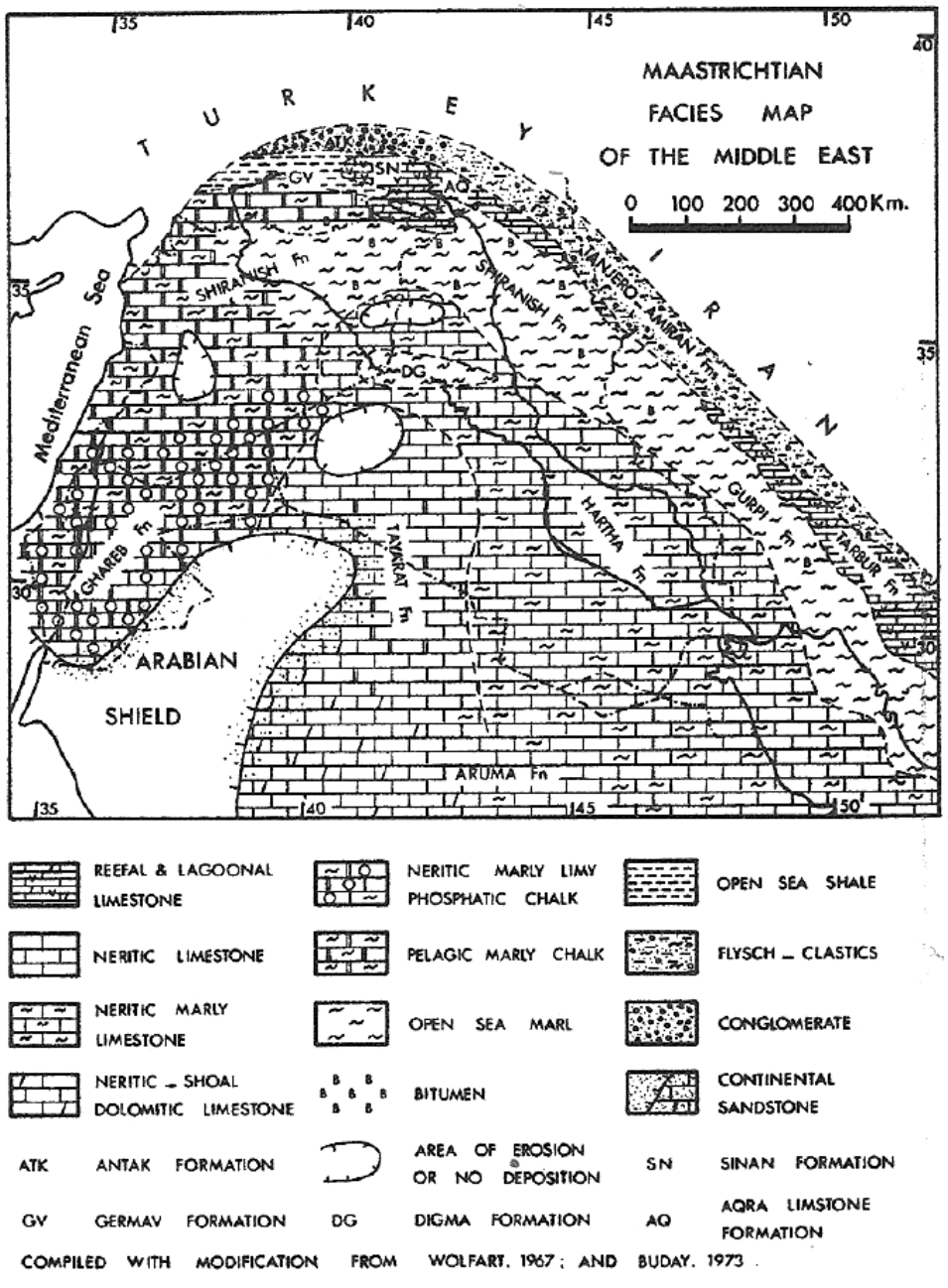
The Tayarat Limestone Formation at its type locality (Jabel Tayarat) south of the Rutbah Uplift is composed of rubbly, Porous, white, buff and pink, rather chalky, fossiliferous, recrystallized, dolomitized, locally sandy limestone, conspicuously more massive at the base.



The fauna of **Tayarat Formation** is characterized by the presence of *Loftusia morgani* (Douville) and *Omphalocyclus macropora* (Lamarck).

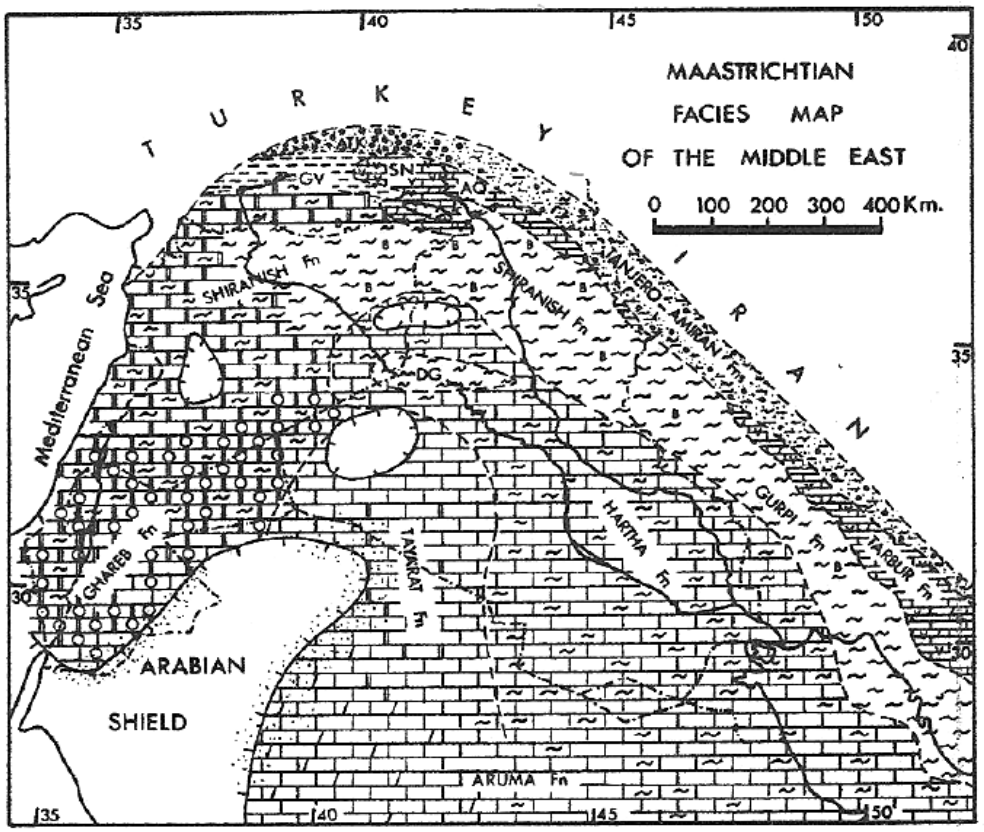
In the Al-Widyan area (just north of the Iraqi-Saudi frontier), Al-Naqib (1967) has described the Tayarat Formation as fossiliferous limestone at top, grading Downwards to yellow marl, then shale, sandstones, and marl again; then changing to dolomite limestone, with several marl intercalations; and finally into yellow marl with some limestone intercalations. The thickness of the Tayarat Formation increases towards the southeast (Basrah - Kuwait area), maintaining the same facies as in the type locality (Owen and Nasr, 1958).

Al Mutter (1976) described the Tayarat Formation from the Akashat area, north of the Rutbah uplift, as mainly limestone, clayey marly limestone, rich in bones and phosphatic pellets, deposited in a sublittoral environment, and lacking the characteristic microfauna of the Tayarat Formation.



The Tayarat Formation of the Akashat area is therefore different from the typical formation to the south, and could be regarded as a sub-littoral facies of the Ghareb Formation of Jordan and southern Syria. The neritic facies of the stable shelf in western and southwestern Iraq was dominated by the deposition of the globigerinal and argillaceous limestone of the Hartha Formation, which becomes glauconitic to the south. The northern part of this formation was mainly deposited between the Der ez Zor- Khleisia uplift in the north and the Rutbah - Ga'ara uplift in the south, and on the margins of the Abou Kemal - Anah trough. The latter was active for the Mid and Upper Maastrichtian (Dunnington *et al*., in: Bellen *et al*., 1959).

In this trough the phosphatic-glauconitic and locally silicified marls of the **Digma Formation** were deposited. Buday (1980) considered that the sediments of this formation were deposited in the latest phases of the progressive transgression of the Maastrichtian Sea.



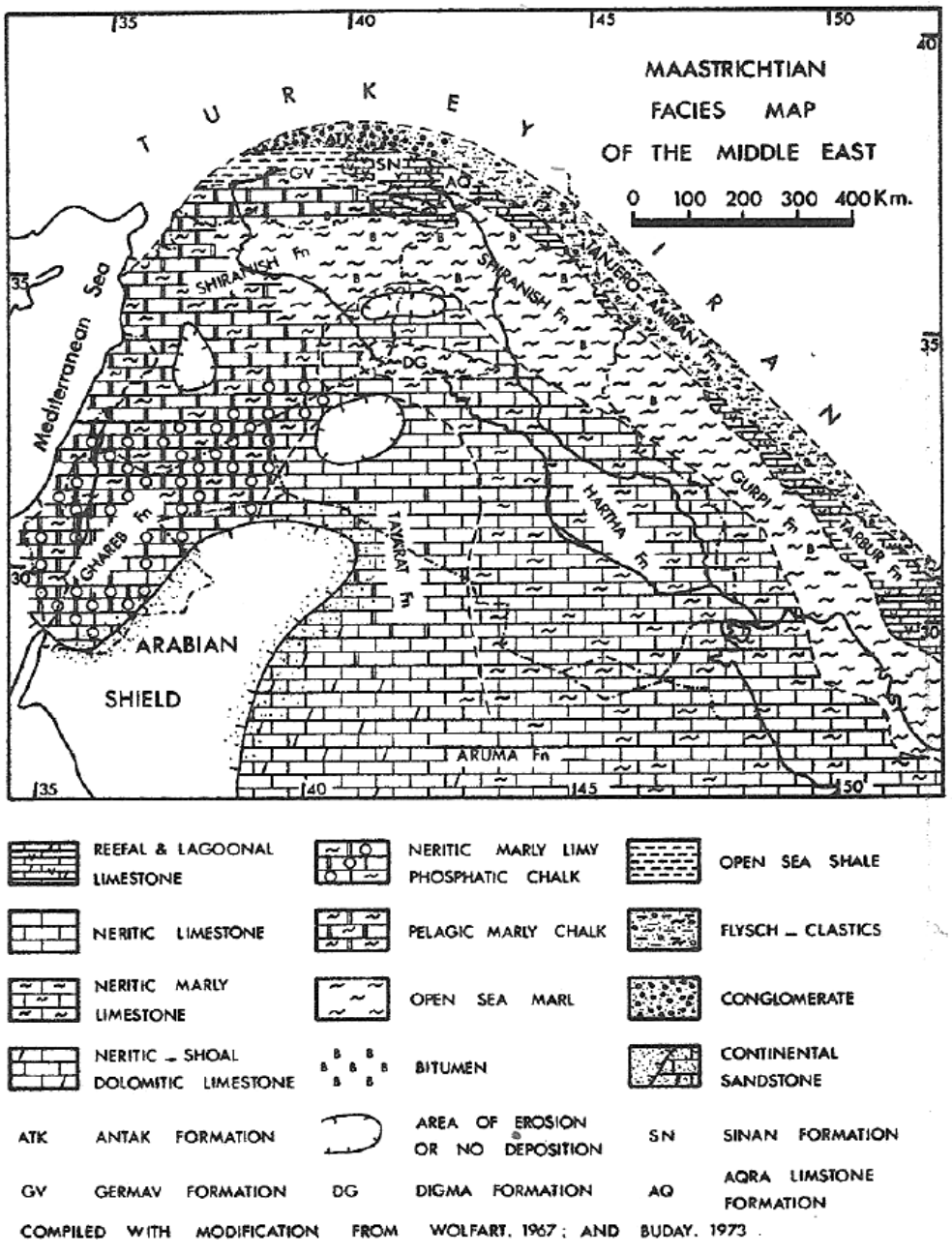
REEFAL & LAGOONAL LIMESTONE
NERITIC MARLY LIMY PHOSPHATIC CHALK
OPEN SEA SHALE
NERITIC LIMESTONE
PELAGIC MARLY CHALK
FLYSCH – CLASTICS
NERITIC MARLY LIMESTONE
OPEN SEA MARL
CONGLOMERATE
NERITIC – SHOAL DOLOMITIC LIMESTONE
BITUMEN
CONTINENTAL SANDSTONE
ATK ANTAK FORMATION
AREA OF EROSION OR NO DEPOSITION
SN SINAN FORMATION
GV GERMAV FORMATION
DG DIGMA FORMATION
AQ AQRA LIMSTONE FORMATION

COMPILED WITH MODIFICATION FROM WOLFART, 1967; AND BUDAY, 1973.

Dunnington *et al*. (in: Bellen *et al*., 1959) separated the Digma Formation from the Jib'ab Formation because of the presence of the normal neritic Hartha Formation in between them, and the abundant, highly specialized fauna of the Digma Formation.

Jassim and Goff (2006) considered the Digma Formation to be deposited within a phosphatic inner and outer shelf.

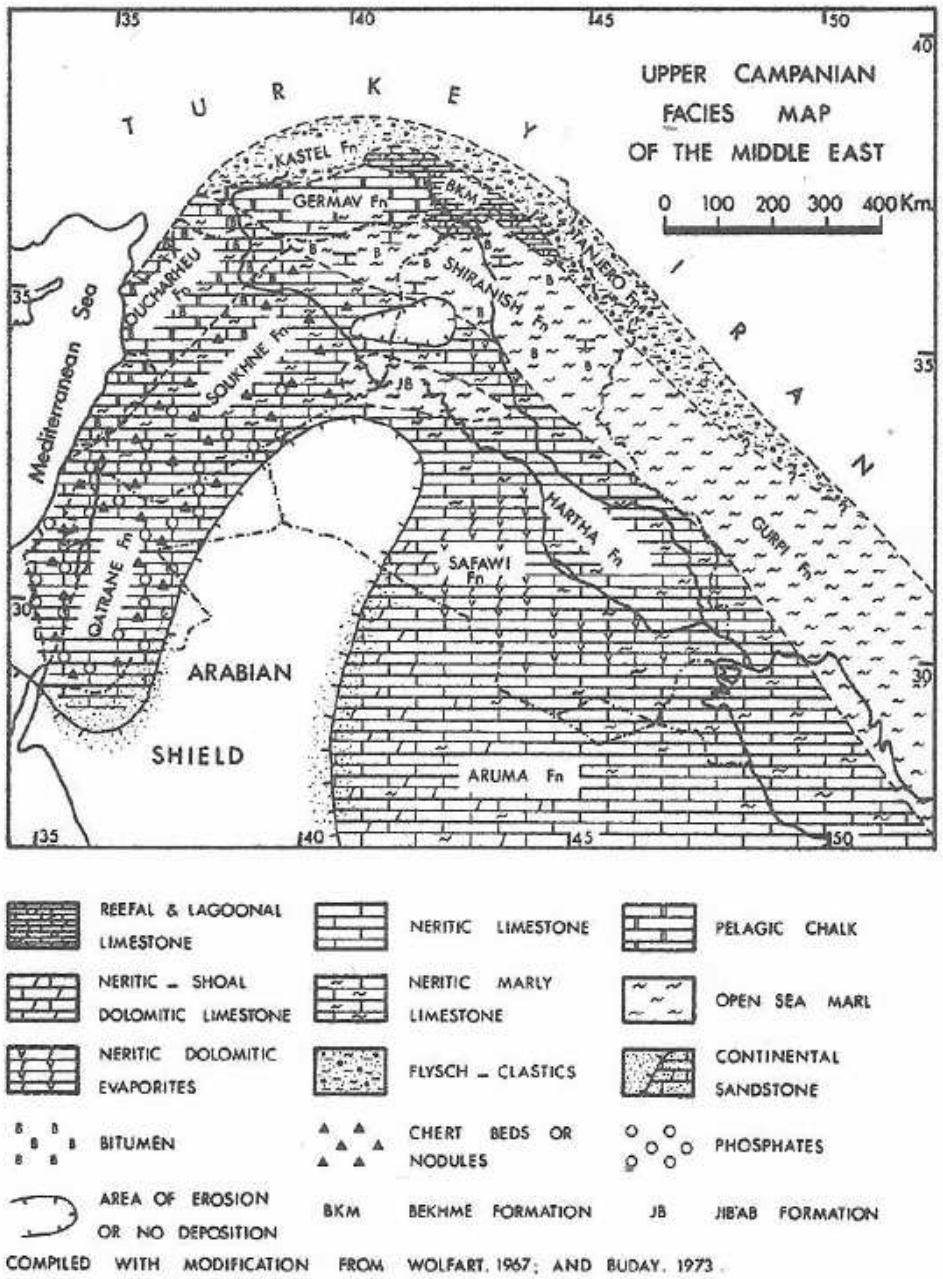
Southwards, the Hartha Formation intercalates with the open sea marls of the Shiranish Formation to the east and with the littoral limestone of the Tayarat Formation to the west, and with both open sea and littoral sediments toward the Basrah area (Owen and Nasr, 1958; Dunnington *et al*. (in: Bellen *et al*., 1959); Al-Naqib, 1967; & Buday, 1980).



Mobile Shelf

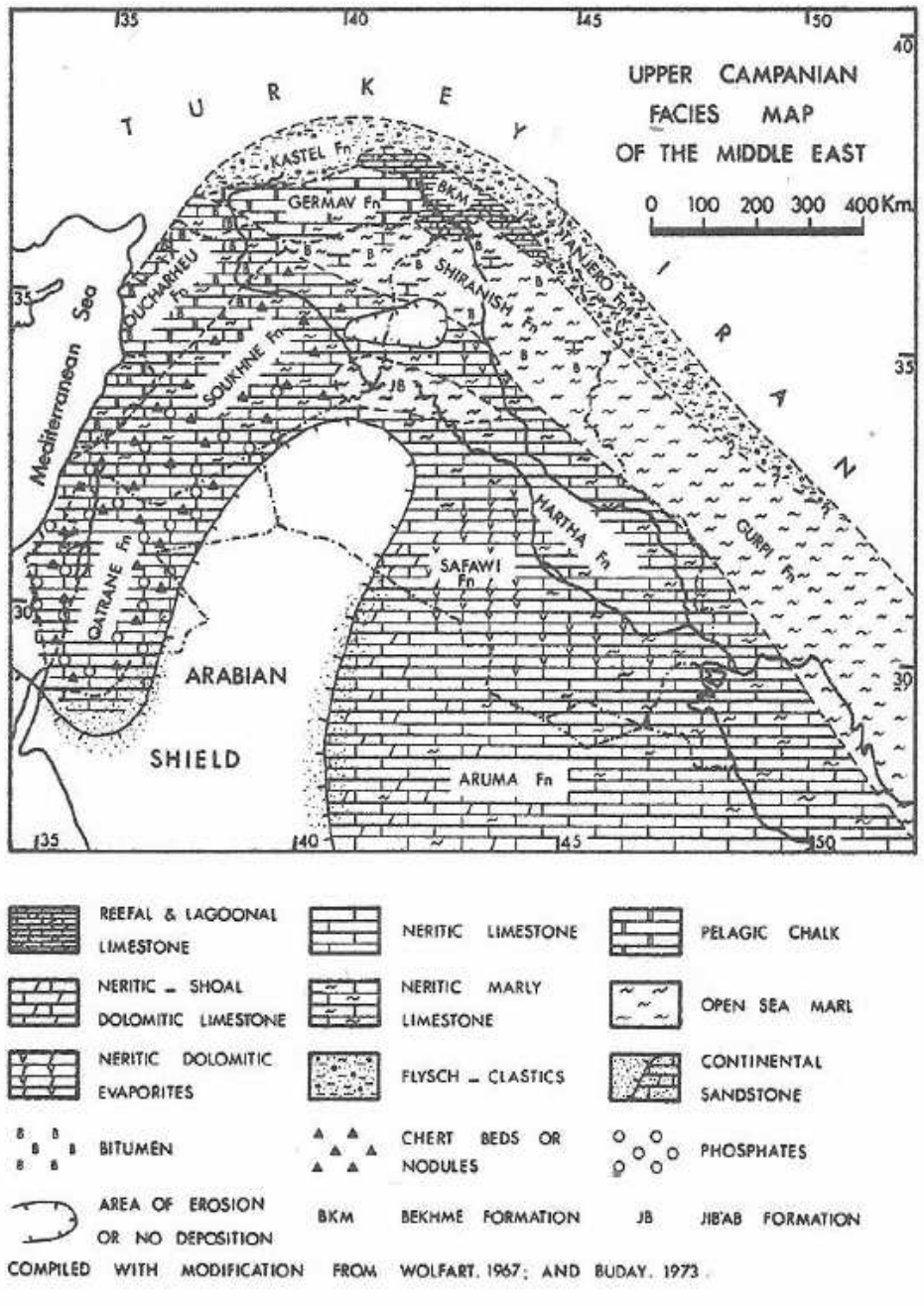
In the Upper Campanian, an important tectonic movement occurred in the Middle East, with some areas being uplifted or even exposed, and with the consequent development of three basins of subsidence. As previously discussed, the Abou Kemal – Anah Trough is one of these, the other two being the Jabel Aabd al Aaziz, Jabel Sinjar and Aafrine Basins.

The Aafrin Basin was located in the northwest part of Syria, trending NE - SW, and was filled during the Late Cretaceous by the bituminous marly limestone of the **Oucharheu Formation**, considered as a lateral equivalent to the Soukhne Formation. It differs in the considerably larger CaCo3 content, with the development of limestone instead of marl etc., and the lack of any salt, gypsum, anhydrite or sand. There is a much reduced silica and phosphate content, particularly their absence in thick beds. There is also a lack of shelly beds and of concretionary limestone.



Oucharheu Formation was possibly deposited in some sort of euxinic environment of "barred basin" type, yet the water was surcharged with minerals as in the Palmyra region, but under more marine conditions. To the east the northern part of Soukhne Formation was deposited within the mobile shelf, and changed laterally into the open sea marls of the Shiranish Formation in the northeast of Syria.

The **Shiranish Formation** (outer shelf – Basinal facies) represents the major part of the Upper Campanian –Maastrichtian mobile shelf, and was deposited in a deep open sea environment, in an E -W striking basin known as the Jabel Aabd el Aaziz - Jabel Sinjar Trough.

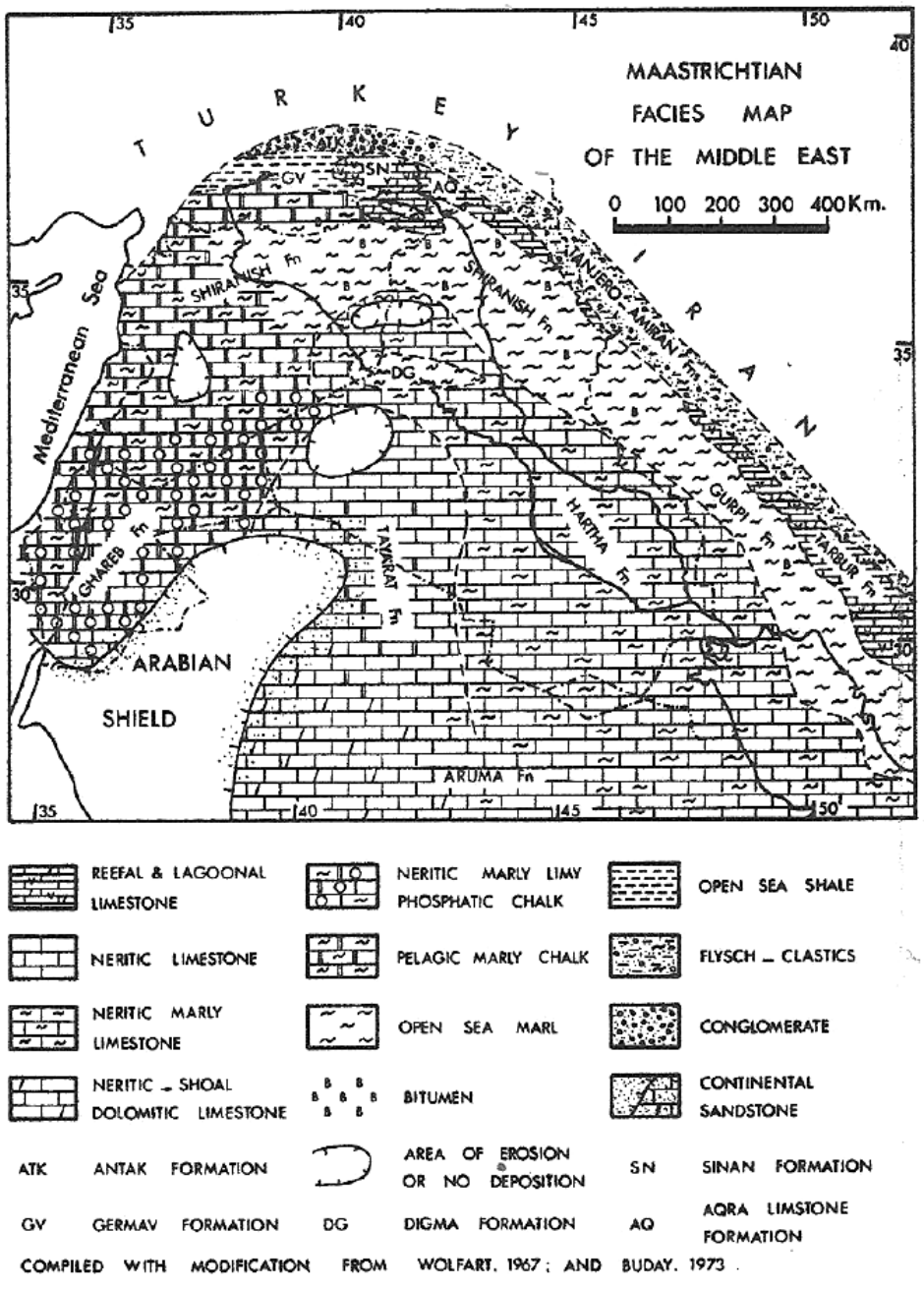


Jabel Sinjar Trough has a southeastern extension, trending NW- SE towards Naft Khanah on the Iraqi -Iranian frontier, and then continuing toward the Abou Ghirab area on the southern Iraqi – Iranian frontier.

The Northwestern part of the trough (Jabel Aabd el Aaziz– Jabel Sinjar areas) had been very mobile and filled with an exceptionally thick development of the **Shiranish Formation**; the trough became progressively deeper towards the southeast, and filled with open sea Shiranish sediments. The Der ez Zor – Khleisia Uplift, with a continuation to the east known as the Mosul Uplift separated the two parts of this trough.

The lithology of the Shiranish Formation in its northern area as open sea, globigerinal marls and marly limestone. In southwestern Iraq, the Shiranish Marls pass into a chalky and marly limestone facies within the Tayarat Formation.

The Shiranish Formation in Syria was deposited during the maximum transgression of the sea during latest Campanian to Maastrichtian times.

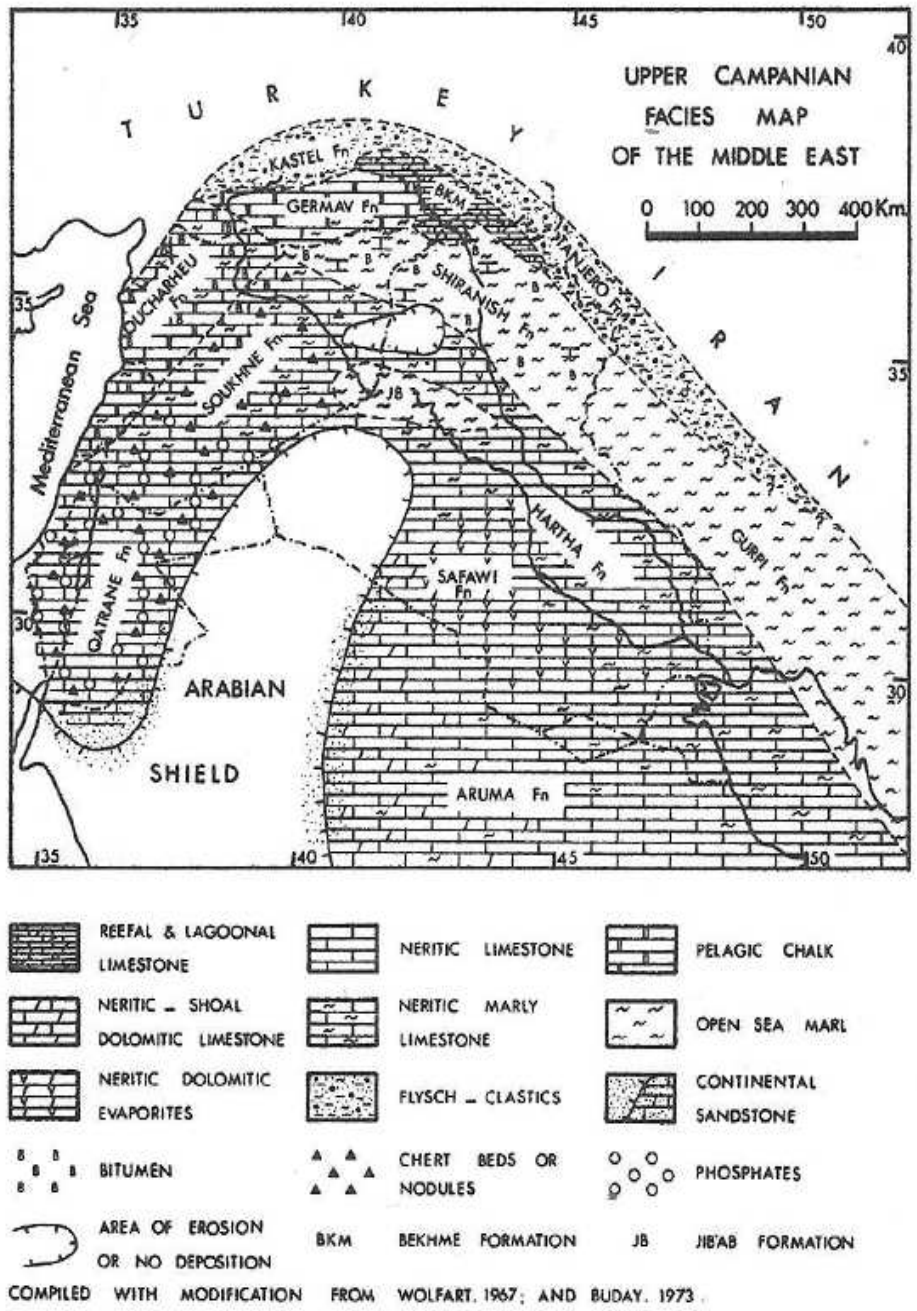


Foredeep Basin

The Late Campanian - Maastrichtian Foredeep Basin is present in the extreme northern and northeastern parts of Iraq, but the major part of the trough lies within Turkey and Iran. It has a N.NW – S.SE alignment this geosynclinal trough was separated from the mobile shelf by a ridge running roughly on the high folded zone, with an axis connecting Aqra and Nador. The **Bekhma and Hadiena Formations** were deposited on the northern part of this ridge during the Late Campanian.

The **Aqra Formation** followed in the Maastrichtian. To the southeast, occasional tongues or lenses of the latter formation are found within the Tanjero Clastics. The Shiranish Formation replaces the above mentioned formations on the southern part of the ridge.

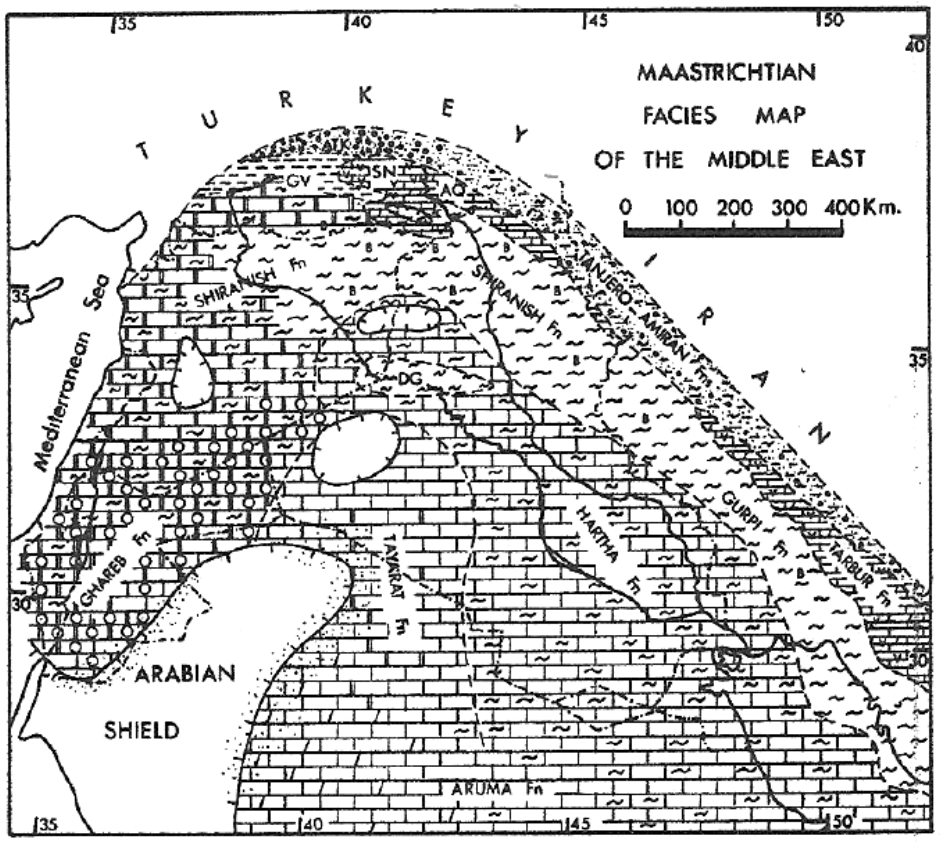
The **Bekhme and Aqra Formations** are both composed of reefal neritic limestone, considered by Jassim and Goff (2006) as a carbonate ramp, and are considered to be two different units because of the presence of an intervening tongue of the Shiranish Formation or/and Tanjero Clastics.

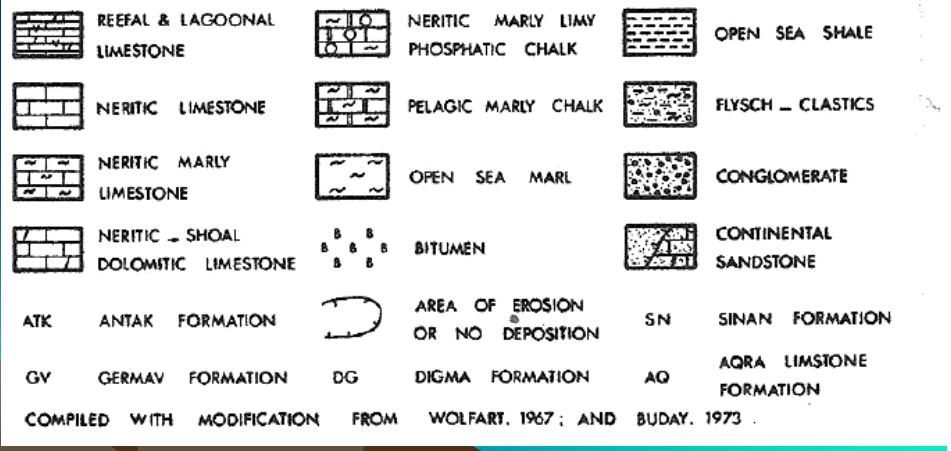


Bekhme and Aqra Formations can be readily distinguished by their different and characteristic faunal assemblages, based on the presence of the *Cosinella Pseudosiderolites* cf. *heracleae* in the Bekhme, and the presence of *Loftusia* spp. in the Aqra Formation. The latter is closely comparable with the Tayarat Formation in age, fauna and facies, but they are recognised as separate units because they are paleogeographically and genetically distinct.

The permanent shallow neritic character of the Aqra – Bekhme Formations, as their main development coincides with the Mosul Uplift, which was already submerged.

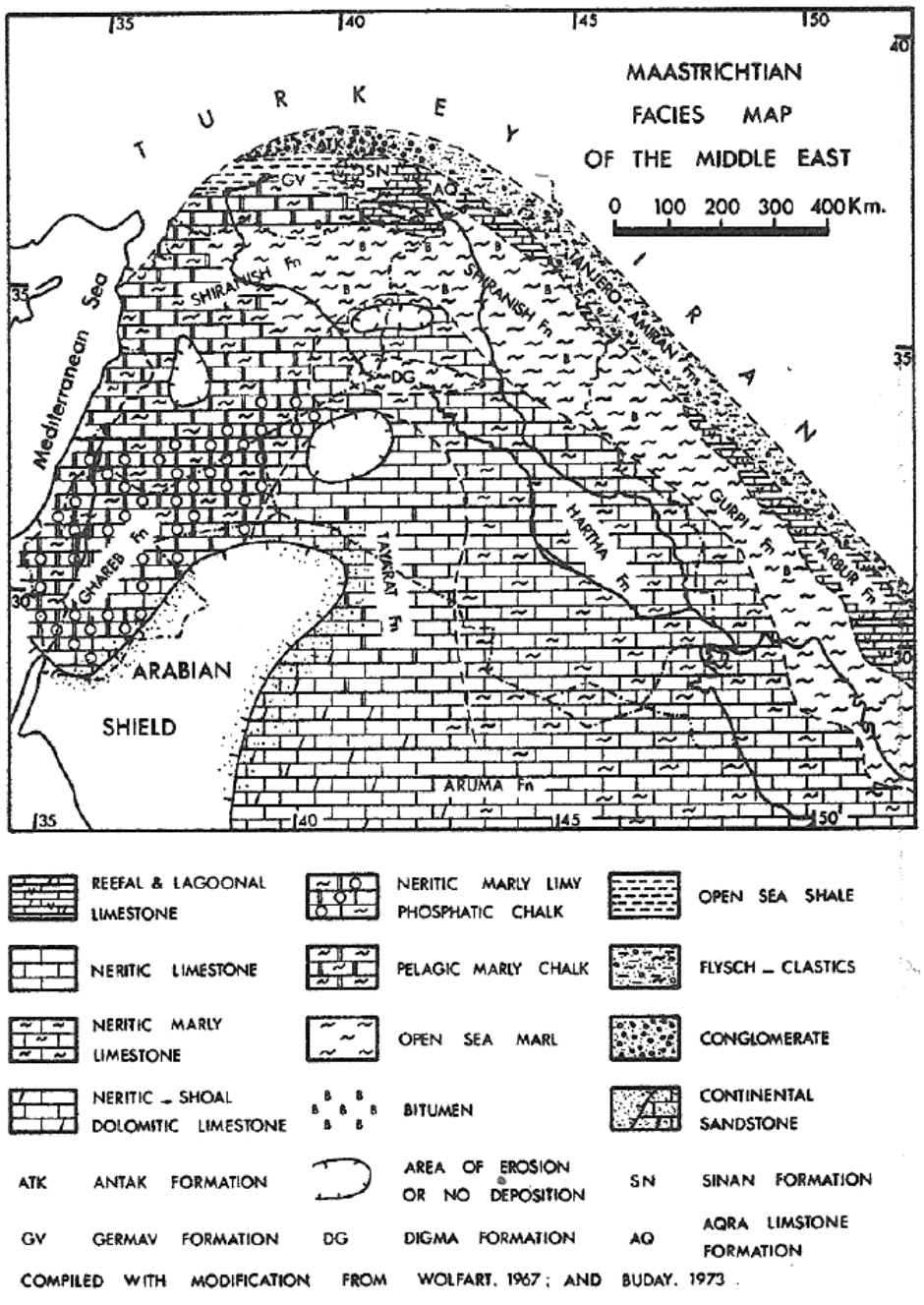
The ridge which was separating the mobile shelf from the Foredeep Basin, had continued towards the west into the Mardin Ridge in Turkey.





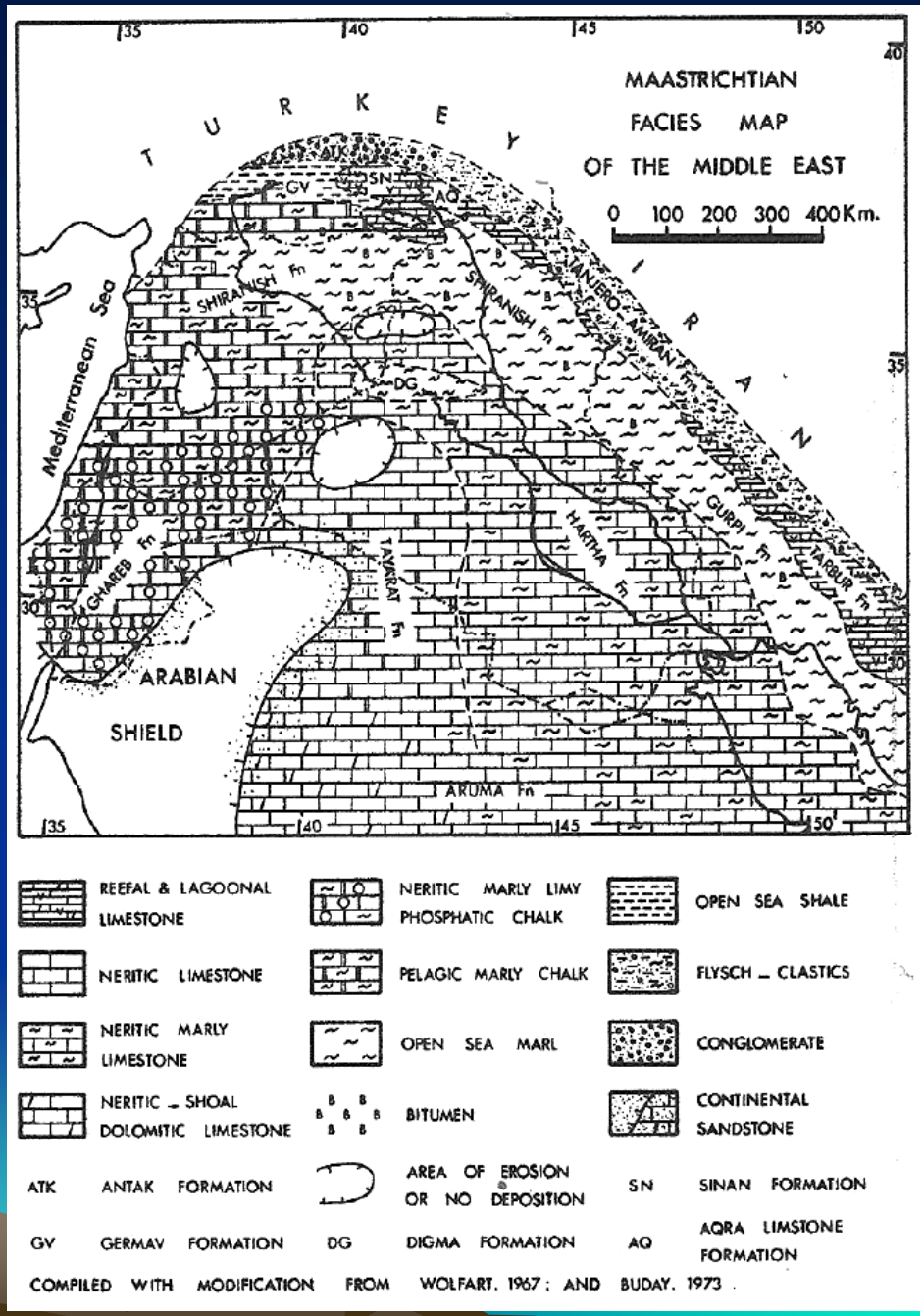
In Iran there was a vary rapidly developed reef called the Tarbur Formation of Late Campanian - Maastrichtian age, rich in shallow water, reefal faunas similar to those of the Aqra and Tayarat Formations and more likely to be correlated with the Aqra Formation (Al-Sheikhly, 1980); both formations are similar in lithology and faunal assemblages, and both lie parallel to the Zagros Crush Zone and acted as a barrier separating the open sea sediments of the Shiranish and Gurpi Formations from the fore-deep clastics or radiolaritos (Tanjero, Amiran Formations and Colored Melange).

Another tectonic-depositional regime was developed in Turkey, the extreme northeast of Iraq and western Iran at the time of the formation of the Jabel Aabd el Aziz- Jabel Sinjar-Abou Ghirab, Abou Kemal - Anah, and Aafrine Troughs. In this area a broad and rapidly subsiding trough developed parallel to the Zagros Crush Zone, receiving a great accumulation of flysch-like clastics. These were derived from a considerable uplift which occurred outside Iraq, referred to as the Sub-Hercynian stage by Buday (1980).



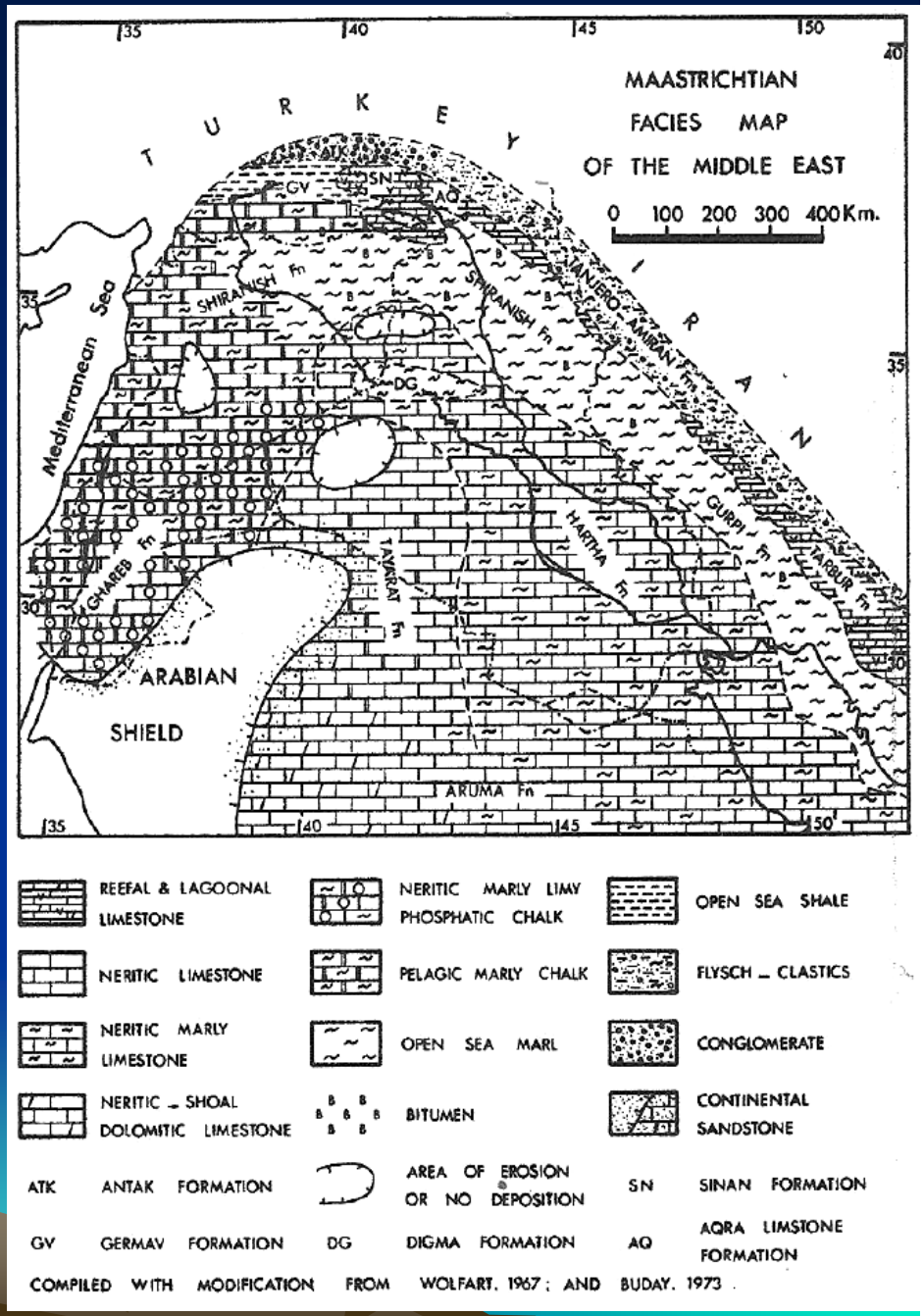
As a result of this uplift, a great thickness of Triassic - Turonian sediments were eroded, amongst which were finer grade detritus of different limestone, and a volcanic calcareous type of sediments with radiolarian cherts. These were deposited as the flysch-like clastics of the **Tanjero Formation** in Iraq (Germav Flysch Beds, Gaziantep Kurd Dagh Flysch and part of Hakkari Complex, in southern Turkey; and the Maastrichtian flysch part of the Amiran Formation in Iran).

Buday (1980) divided the Sub-Hercynian stage of the geosyncline into Mio- and Eugeosynclinal realms. The ridge of the Aqra/Bekhme and Hadiena Formations and the trough of the Tanjero Formation, represent the Miogeosynclinal realm, which is considered by Jassim and Goff (2006) as an isolated basin. The Eugeosynclinal realm lying outside Iraq in Turkey and Iran is represented by a trough with coarse clastics known as the Qulqula Formation; this contains conglomerates composed of calcareous radiolarian sediments. The Qulqula trough represented the outer zone of the Eugeosyncline, while the inner zone was uplifted during that time.



There was a general uplift and regression of the sea throughout the Middle East towards the end of Maastrichtian. In northeast Syria, Iraq, Iran, and Saudi Arabia, the upper beds of the Maastrichtian were eroded. In the west, i.e. Syria, Lebanon, Jordan, and Palestine that sedimentation was continuous from the Late Cretaceous into the Tertiary despite the gentle uplift.

Buday (1980) regarded this uplift to be part of the Laramide orogenic event, connected with folding, thrusting, and finally orogenic uplift of the whole Middle East area.



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