(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

Origin of structures and textures of some Kurdistan marbles as inferred from sedimentary ancestor structures, NE-Iraq

Kamal Haji Karim*
* Department of Geology, College of science, University of Sulaimani

Abstract

The Quarries of Iraqi Kurdistan metamorphic marbles (true marble) are distributed along a belt near and parallel to the Iranian border in northeastern Iraq. These marbles associated with low-grade pelitic and calc-schist (green schist facies) and phyllite. They are formed by regional metamorphism of different types of sedimentary parent rocks in an environment not exceeded that of green schist facies (400 C^o and 8kb). The pelitic equivalent of the Kurdistan calcitic marble contains chlorite, albite, muscovite and biotite.

In the latter years, their economic value is rapidly increased as their polished slabs extensively used for decoration purpose. The beautiful features of these marbles are consisting of sophisticated mesoscopic structures of different shapes, size and colors originated from plastic flowage and mixing of different composition and impurities reflecting either the original depositional or diagenetically-introduced materials. Before plastic flowage they suffered from burial and tectonic fracturing which later filled with spary calcite. The origin of the marbles is analyzed according to the stage of paragenesis of the structures such as foliation, banding (layering) and flow structure. The field and lab studies proved that they are all returned to relict of primary and secondary (diagenetic) sedimentary structures. The marbles suffered from various degrees of tendency toward homogenization as the grade of regional metamorphism progressed, this reflected by mixing of foreground and background together. In addition to diffused boundary of contrasting components. Although they resemble the banded and augen gneisses but no ones are formed by metamorphic differentiation. Most of the precursor structures are related to pressure solution seams and stylolites, which are combined with the triangle of Walness which deal with solution seams. Other structures are returned to lamination of the sedimentary parent rocks. Finally the probable stratigraphic unit as the original parent rocks is discussed.

***Key words*:** Marble, pressure solution, sedimentary rocks, metamorphic rocks, metamorphic texture, metamorphic structure, metamorphic paragenesis, Walness, Kurdistan rocks,
commercial marble, true marble, paragenesis.

Introduction

The commercial marble includes both metamorphic (true) and sedimentary rocks that take polish and have enough beauty to be used as ornamental stone. Chook, (1954) [1], used the term orthomarble for limestone that can be used for decoration.

In this paper the term marble is used as a scientific term for only true marble including skarn type. The Iraqi marbles of Mawat and Penjween are locating at the extreme northeast of Iraq near the border with Iran (Fig.1) According to tectonic classification of Buday and Jassim (1984)[2]' these Marbles are located in the Thrust Zone. When the classification of Buday and Jassim (1987) [3] is considered, more accurate position of these marbles can be indicated within Penjween–Walash Subzone of Central Zone of Euogeo-syncline. These marbles are associated with low-grade pelitic and calc-schist (green schist facies) or phyllite (Fig.2). They are ranging from white calcite marble to different colored calc-silicate marbles. They showing complex mesoscopic structures ranging

haji57barzinjy @yahaoo.com

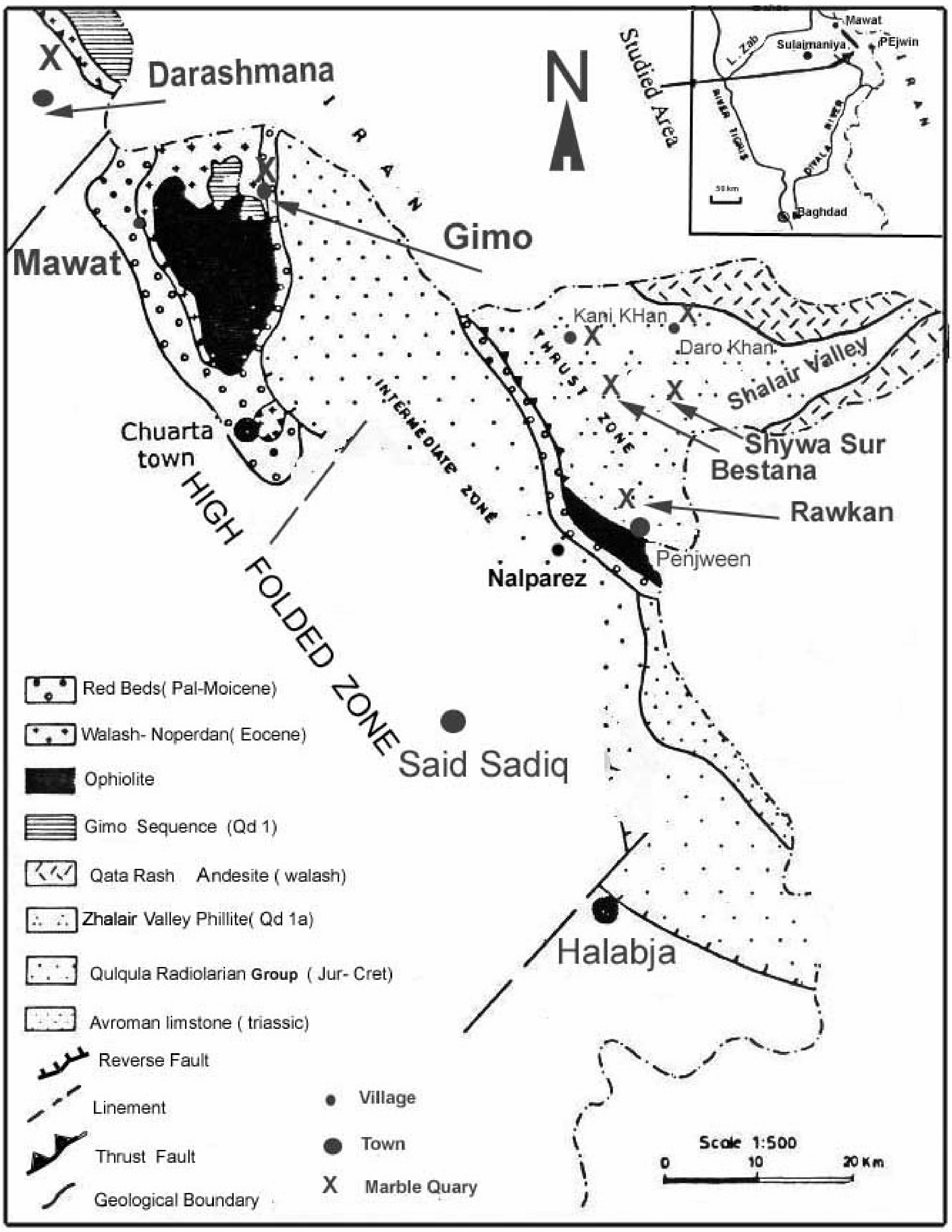


Fig.(1)Geological map of Mawat and Penjween Area (Jassim and Al-Hassan, 1977[4]. The map is Used for showing location of Marble quaries.

from simple featureless to complex faults contoured and foliated. Also some of the small structures may be called texture by some authors but here we use only structures. This is because all features treated here consist of mutual relation between differeent groups of grains (or crystals) so according to definition of Bates and Jackson (1997)[5] all these regarded as structure not texture which expresses relation between one group of grains have common boundary. However, the author inserted both structure and texture in the title of the paper because there is no agreement about the limit between small-scale structure and

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

textures. An other reason for this is that commercially texture refers to all features and ornamentation, including what scientifically called textures that exist in polished slabs

The strikes of the foliation are generally NW-SE but their direction changed near the contact with the igneous bodies to coincide with the boundary of the bodies (Pshdary, 1983) [6].They are associated with the following stratigraphic units:

1.Shalair metamorphic Group (or Shalair Valley phyllite) (Albian-Cenomanian), which located in the Shalair. The main rocks of this group are consisting of phyllite and low-grade schist with some calc-schist and marbles. The following quarries are belonging to this group.

A-Bestana Quarry

B-Shywa Sur Quarry

C-Kani Khan Quarry.

These quarries yield the following marbles which all locally known as Kani Khan Marble:

i. Black marble with white spots and strings (locally called Kani Khan blue Marble), which complicated by flow structure and mesoscopic folds, faults.
ii. Bluish white marble (locally called Kani Khan Gray Marble). with simple featureless background, only contain few ornamentation of pale white sparse strings)
iii. Gray marble with black diffused bands and lenses
iv. Pale yellow ornamented with pale white elongate spots (locally called (white Kani Khan Marble).

D. Rawkan (Plate 1.2), Ashab and Binawasuta Quarries, they located directly to northwest, southeast and east of Penjween Town respectively. The excavated marbles are coarse crystalline white marble without ornamentation (only with pale white sparse strings)

E-Daro Khan Quarry yields pale green marble, ornamented with highly complicated and diffused greenish white spot and strings.

These marbles exist as layers (Plate1.3) and separate blocks of different sized in the phyllite or low-grade schist. Most of them show more or less foliated (Plate 1.1); few of them do not foliated and have granoblastic textures, which metamorphosed in pressure shadow zone inside regional metamorphic rocks. Many evidence exist that these quarries effected by both regional and local metamorphism. This is because many igneous bodies are seen near these quarries (Plate1.3).

2-Walash Nauperdan Series (Paleocene-Eocene). The marbles of this series are generally white to grayish white and coarse crystalline. It includes the following Quarries

a. Gmo Quarry the main marble type is bluish gray of coarse crystalline without ornamentation.
b. Dara Shmana Quarry. East of Qala Diza Town.

Discussion of the Structures Processes during progressive metamorphism of Sedimentary rocks

The end product of progressive metamorphism is not known exactly but the marbles we now using are representing the intermediate stage. The end product may be existed in great depth below the surface of the area. The occurrence area of these marbles is the collision zone of the Arabian and Iranian plate (continent-continent collision) since beginning of Upper Cretaceous (before 90 m.y.) (Numan, 1997)[7]. The sediment (geosynclinal deposits such as shale and greywacke) deposited before and after of the colliding, was suffered from regional metamorphism as a result of directional

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

stress and temperature. This temperature may be associated with igneous activities and temperature of burial geothermal gradient.

In contrast to calcareous and pelitic rocks, the igneous rocks are only slightly metamorphosed because of their resistances to pressure and temperature. According to Rida (1997)[8] the basalts in the Shalair valley are changed to amphibolites at depth of 70 km.

Nearly all Kurdistan marbles are gone through homogenization (Chemical and physical mixing) due to plastic deformation and creep by aid of chemical solution activity under high pressure and intermediate temperature of the regional metamorphism (no more than 400 C^o).

The depth of burial is estimated to be no more than 30km below surface. This is because the pressure was mainly shallow horizontal one.

The homogenization increases by increasing of degrees of metamorphism till early total homogenization. When the rocks enter high grade of metamorphism it begin the processes of differentiation (segregation of materials). This latter process is not found in Kurdistan Marble because it occurs in high-grade metamorphic rocks (granulite and gneiss). According to Hyndman (1981) [9] homogenization is a process toward equilibrium and away from differentiation.

Main structures and their origins

The fieldwork and polished slabs showed that the sedimentary precursor features (structures and textures) could be studied through paragenesis of three types of Kurdistan marbles (as discussed below). The metamorphism of these features gives a series of features range from less to more perfectly formed foliation which belonging to low-grade green schist facies**.** This type of facies is inferred from study of surrounding metamorphosed pelitic rock, which is very sensitive to grade of metamorphism.

There are many other types of marbles, which has simple and featureless background; these include gray, white or black marbles, which are not studied here because their paragenesis is simple which include lithification and metamorphism.

The main marble with complicate features are as following.

Black marbles with white spots

This type of marble exists in Shalair valley and Penjuin area (Fig.1 and 2), which consist of black limestone (background which acts as host rocks) and contain spots and elongate patches of fracture filling recrystallized white calcite cement acts as guest materials, forming the foreground (texture) of this marbles. The end textures or structures show flow structure and gneissoid textures (Plate 2.2,2.3 and 4.2). The calcite is introduced during diagenetic processes before beginning of metamorphism.

This marble passed through the following diagenetic and metamorphic processes.

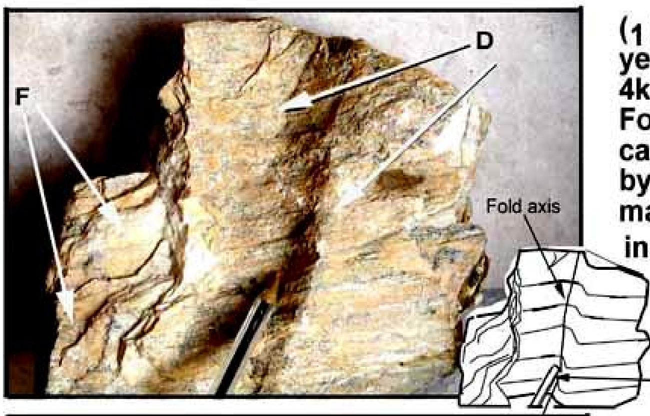
1. Depostion of the lime mud in deep euxinic environment and rich in organic materials (Fig.3). The lime mud latter changed to black fine grain limestones.

This limestone is most possibly returned to Qulqula Radiolarian Formation or Jurassic Units such as Sargelu. This is because of the followings:

A. Qulqula Group especially Qulqula Radiolarian Formation contains similar imestone and located near by the marble quarries of Penjuin and Shalair valleys

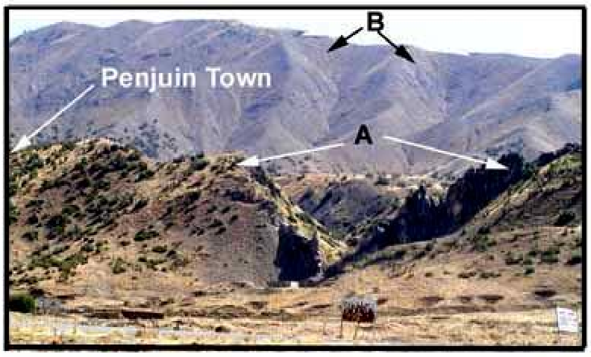
The outcrops of this Formation can be seen at Nal Parez and Kani Manga villages (Fig.1 and 2) which only 5 km far from some quarries.

Plate 1



(1) Hand specimen of light yellow marble, taken from 4km north of Penjuin Town. Foliation(F) and folding(D) can be seen which formed by deformation. These marbles ca be found inside Shalair Phllite. At the lower right corner a sketch of the sample is drawn to show the postion of the fold and its axis.

(2) A gray marble quar ry at Rawkan area (1km north of Penjuin Town.These marbles ca be found in Shelair Phyllite (Qandil Group)



(3) A ridge (A) of metamorphsed limestone (marble) which elongate from southwest to northeast of Penjuin Town. The Penjuin Ophiolite can be seen at the background (B). At least three quarries are existing on this ridge such as Rawkan, Ashab and Binawasuta Quarries.

(4) Outcrop of slightly metamorphosed bedded chert and gray limestone at directly to the NE. of Penjuin Town, which most propably returned Qulqula Group.This is because the neareast similar rocks are that of the group at Kani Manga (5 km southwest of the photo location.

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

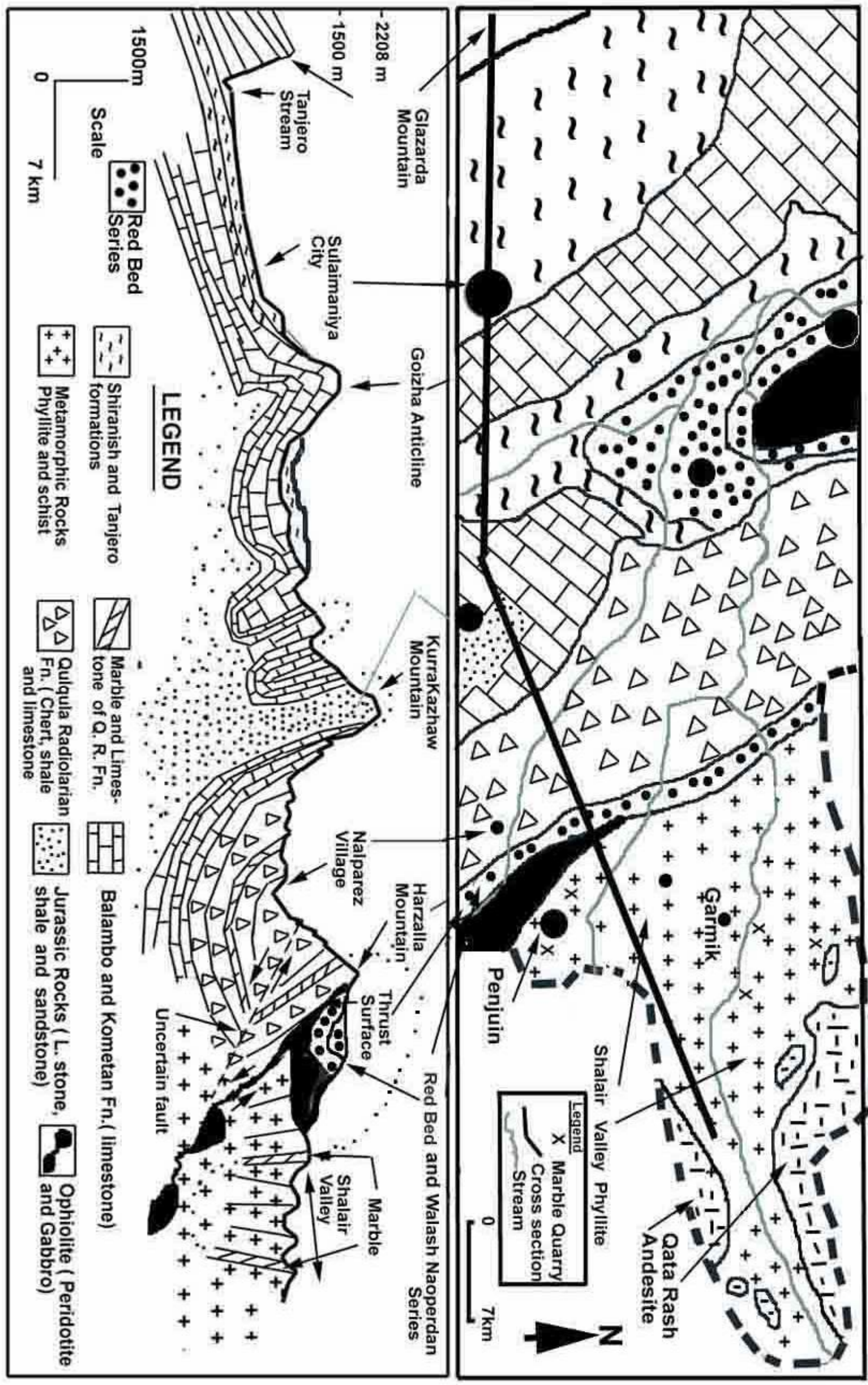


Fig. (2) Geological map and cross section of Penjuin-Sulaimaniya area, showing relation of Kurdistan marble with both Qulqula Radiolarian Formation and Walash Nauperdan Series.

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

. **B.** The age of both Qulqula Radiolarian Formation and Shalair phyllite is near to each other that indicated by Buday (1980)[10] and [3] as Middle Cretaceous. The back limestone of Qulqula may be deposited during Mid-Cretaceous "Global anoxic event", which mentioned by Allen and Allen (1993)[11]. According to latter authors, during Mid-Cretaceous, an oxygen deficient layer is developed as a result of high sea level. This layer preserves organic matter, which gives the resultant limestone black color.

C. The author has found bedded chert inside the phyllite (host rock of the marble) directly south to the Penjuin Town (Plate1. 4). These cherts are only slightly metamorphosed because chert has more resistance to metamorphism as compared to limestone and shale or marl.

2. Deep burial of black marble and fracturing (or brecciation) due to shock or high horizontal tectonic stresses of plate collision. These stresses associated with compressional tectonics and thrust faulting during Arabian and Iranian plates colliding. It is possible that differential load pressure also generate fracturing and brecciation.

The cleavage of phyllites and low-grade schist, which they dip, nearly vertical and strike NW-SE, shows that the tectonic pressure (in the NE-SW direction) was more effective than the load one. The breakage and brecciation generate small and large scale complicated fractures (Plate 2.1) with small fault (Plate 4.1 and 4.3), which later filled with white sparry calcite by crystallization from solution rich in dissolved $CaCO_3$. This type of spary calcite is called, in this study, post tectonic fracture filling calcite cement. This leads to healing of the brecciated black limestone into coherence limestone mass.

The occurrence area of these marbles is regarded as the belt of metamorphism and igneous intrusion activities. Especially at great depth, the limestone is exposed to progressive high temperature and pressure so the calcite is decomposed and CO_2 gas and Ca^{++} released and they migrate upward (as a solution) and along their way, they fill fractures and the $CaCO_3$ is precipitated as coarse white spary calcite cement.

According to Einsele (2000, p.689) [12] the fracturing and faulting during deep burial, change the diagenetic system from normally closed to an open one. This open system, in the Kurdistan marble, is opened to overlying and underlying for flow of solution rich in bicarbonate ions.

3. The farther burial conveys the limestone to the zone of metamorphism (zone of green schist facies). Both fine and coarse limestone crystallizes to more interlocking mosaic texture. When the grade of metamorphism increases the rock go through the phase of plastic deformation, which demonstrated, by flow texture with mobility and mixing of different components of background and foreground (Fig.3). This generates many mesoscopic folds of different patterns, which their axes are inclined at different angles to former foliation. Sengupta and Koyi (2001) [13] showed many type of these deformations.

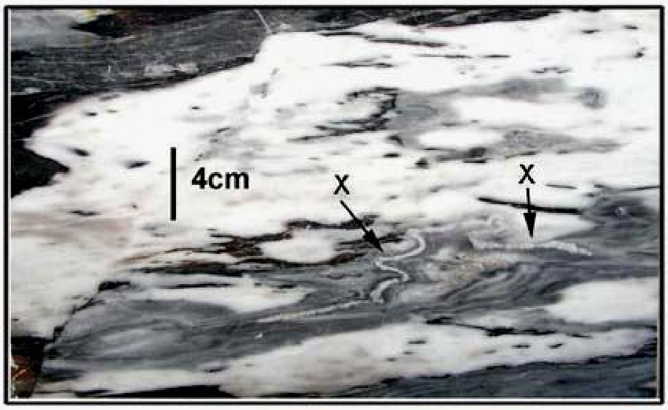
It was observed in all samples that the black background (organic and clay rich limestone) is showing more mobility and deformation and injected in to the pressure shadow areas (Plate 4.3) leading to main foliation texture which may shows flow and gneissoidal subsidiary textures. The more resistive part of the foreground (fracture filling calcite) may show ptygmatic structures (Plate 2.3), which are meandering, and worm-shaped.

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

Plate 2

(1) This type of black limestone exist in both Qulqula Radilarian Formation and in Jurassic units (e.g. Sargelu Fn). But the closest to the marble quarries is the former one. The white areas are calcite filled tension gash fractures arranged nearlyin en echelon pattern. It,s metamorphism yield the similar below marbles.

(2) Black marble with white spots shows slight degree of homogenization and deformation. The areas indicated by (A) are fragments of background in the white calcite.



(3) Plastic stage deformation in black limestone with white spots and flow structure. The photo also shows diffused boundary.
The flowage cause ptygmatic structure (worm like structure) which is indicated by letter X. It,s materials are unmetamorphosed limestone which may be precipitated during early stage of metamorphism.

(4) Gray marble originated from diagenetic and metamorphism processes. The first includes solution of limestone under burial pressure or tectonic stresses and development of non-sutured solution seams (black discontineous lines). while the second one includes recrystallization and some degrees of homoginization with compaction. These type of marbles exist in Rawkan, Gmo and Darashimana area.

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

The homogenization is occurring extensively at this stage, which identified by diffused boundary inter-digitated boundary of black and white components (Fig. 3). Because of this some parts of the marble are changed to gray color.

4. When the rocks enter high grade of metamorphism, nearly total homogenization and mixing of components happen so that both appear as ghost and relict in each other. The mutual and interlocking of coarse crystallization of the two farther enhance.

Field and polished slabs showed that the green marble of Daro Khan is derived from these types of marbles by crystallization of green minerals such as chlorite, diopside and actinolite.

5. The final stage is slow exhumation (Fig.3) of the marble by erosion or tectonic uplift. During this uplift the marble may pass through one or more phases of fracturing, healing and shearing, which in some sample can be seen, on polished slabs as cross- cutting fractures and foliations.

Remark on this type

It is not necessary the background to be always black, the gray, milky or even green ones can be encountered. The same thing is true for foreground (texture and structure), which may take any color but the feature nearly remain same as indicated in the (Fig. 3).

The similar green marble is quarried near Daro Khan Village, Shalair valley. They contain chlorite and quartz minerals as disseminated small crystals, which their materials, most probably, introduced by metasomatism.

An experiment for type of deformations

In order to know the type of deformation (if plastic or brittle in addition to type of plasticity) and mixing of component in Kurdistan Marbles, the author has made use of an experiment using black and white dough (paste). This is done to simulate how Kurdistan marbles are formed, especially the black and green marbles with white spots and strings. The plasticity of the dough was same as that used for making bread in bakeries. The procedure stages of the experiment was as following:

1. Two global pieces of dough is prepared, a large black one and a white smaller one (Plate 3.1). Their weight was 150 and 75grams respectively.

2. Both are sliced in to five parts and then the black and white slices are combined into an alternated single sample. (Plate 3.2). In this sample the black dough is intended to represent the background (original black limestone before fracturing). But the white one is representing the fracture filling white spary calcite (foreground) that fills the fractures after burial of the black limestone.

3. The sample is deformed in two stages by hand. The first stage is included squeezing (kneading) and rolling four times. Then the sample is cut by knife in to two equal halves. The features (structures and texture) resulted from plastic deformation and mixing is photographed (Plate 3.3).

4. The two halves are rigorously deformed together during which more than 12 times flattened and rolled.

The result of the experiment

The features formed in the stage no.3 are much similar to those structures and textures present in the some marble of Kurdistan. This is because of the following:

1. Both shows high undulating foliation, compare between (Plate 3.3) and (Plate 4.2).

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

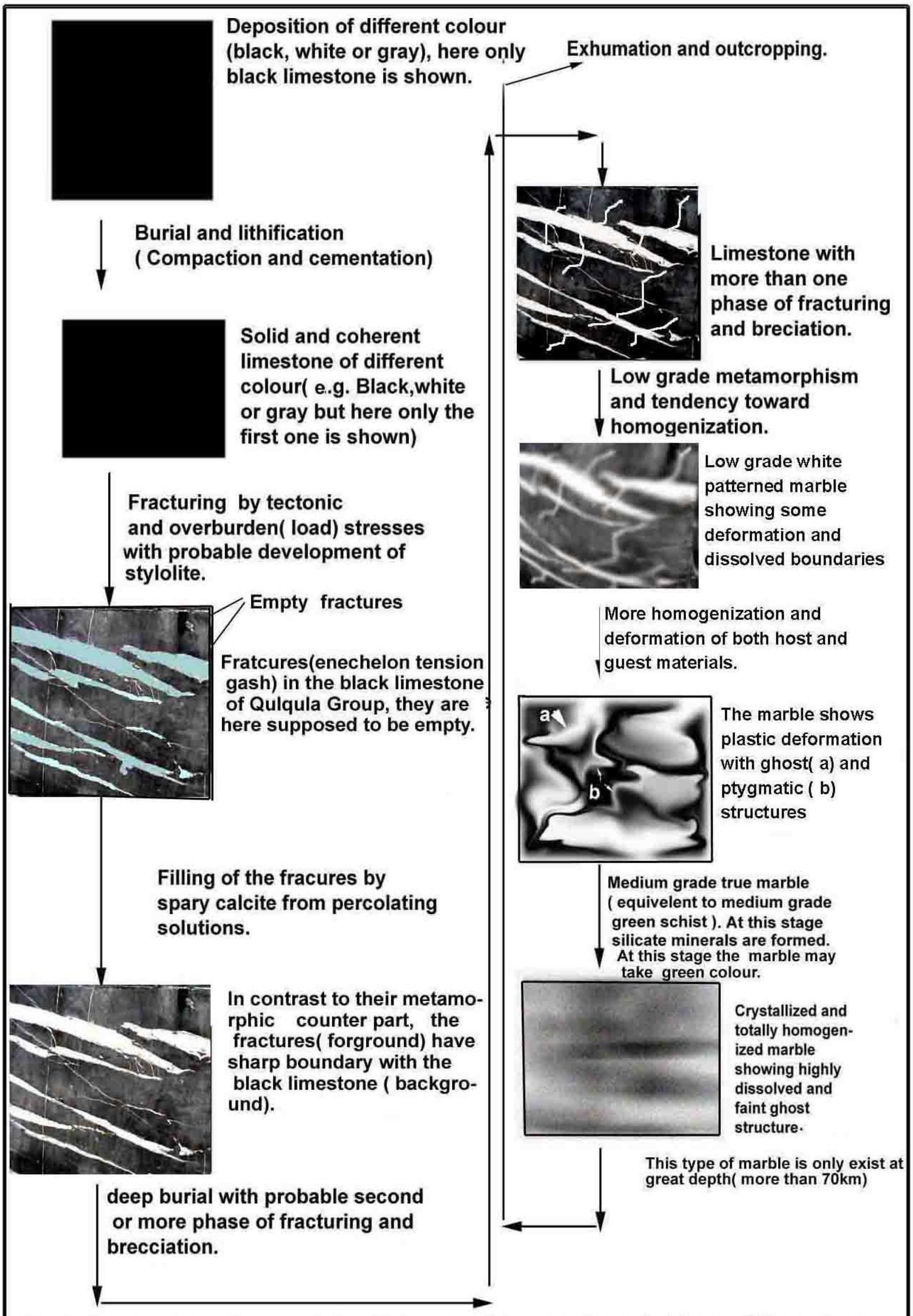


Fig. (3) Parageniss of true marble which formed from metamotphism of limestone

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

Plate 3

(1) Two pieces of of floor dough(paste) small white (B) and black larger one (A). Both used to know how black marbles with white spot and strings are formed. The black one represents the backgr-ound and other one foreground (calcite)

(2) The two pieces are sliced in to equal parts and the white slices alternated in between the bigger black ones. Here the white pieces are assumed to represent the calcite that filled the fractures in the Kurdistan Marbles. The graduated scale at the rear of the photo is in cm.

( ) The alternate pieces are deformed several times by rolling and flatening then3 cut into two equal parts by knife to see the stuctures or textures formed as a result of plastic deformatin and mixing of the two components. The resulted features are similar to those found in some marle of Kurdistan.

(4) The total mixing of the two components as a result of 12 rolling and flatening. Only relicts of the features are remained as a result of homogeniz-ation. The whole sample became slightly gray .In nature the Kurdistan marbles are only suffered from such changewhen both mechanical and meta-somatism act together during long periods of time.

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

2. Both show plastic deformations (Plate 3.3) and (Plate 4.1)

3. Under high pressure and moderate temperatures the Kurdistan Marbles is passed through a stage of plastic deformations similar to dough used for making bread in home or bakeries.

Gray marble with black discontinuous line and lenseoidal seams.

Through this type of marble the author has combined important types of structures and textures of marble with those of sedimentary rocks, which are formed by diagenetic processes. This is done by constructing a triangle derived from the triangle of Walness (1969)[14] to illustrate the metamorphic products of these structure and textures included in the Walness triangle after metamorphism (Fig.4). This latter triangle is showing all features (structures and textures), which produced by solution compaction. These features include solution seams (sutured, non-sutures and stylolites) and non- seam solution. When impure and dirty limestone subjected to pressure, different type of small-scale features produced depend on the intensity of pressure, degree of limestone impurities, and content of pressure resistive or non-resistive grains. In addition to these Walderhanug and Bjorkum,(2004)[15] found stylolite in sandstone (quartz arenite) and attributed stylolite to clay content of the sandstone. These structures can be easily distinguished after metamorphism especially those of low and intermediate grade.

The development of this marble is passed through the following stages.

1.Deposition of gray or white limestones in oxygenated environment. This limestone is most possibly returned either to Walash Naoperdan Series.

Some interval especially Upper part of the Qulqula Radiolarian Formation and Walash Naoperdan Series contain gray or milky medium to thick and brecciated bedded limestone so the gray and bluish gray marble (Plate 2.4) of Shalair and Penjuin area most probably returned to Qulqula Radiolarian Formation. But the bluish gray marble with seams are returned to Naoperdan Series especially those exist at Gemo (or Gimo) and Darashmana area. Because the marble quarries are exactly located on the Series outcrops or at it's boundary.

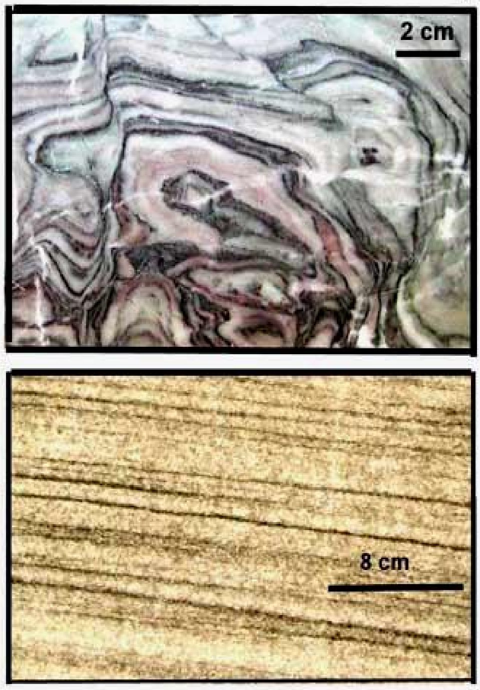
2.Beep burial of the limestone with occurrence of pressure solution and development of stylolite and black seam (Fig.5) as a result of accumulation of insoluble residue of clay minerals and iron oxides. Uevele, *et al*, (2000) [16] returned stylolite growth to thin clay interlayers.

In contrast to black marble with white spots, the pressure on the present one did not suffer from severe shocks or differential pressure so they contain little relict of fractures. Other reasons for this is may be returned to thickness of this limestone in which the pressure released by reduction of thickness due to compaction and subsequent solution. It is also possible that these marbles are affected by temperature more than pressure.

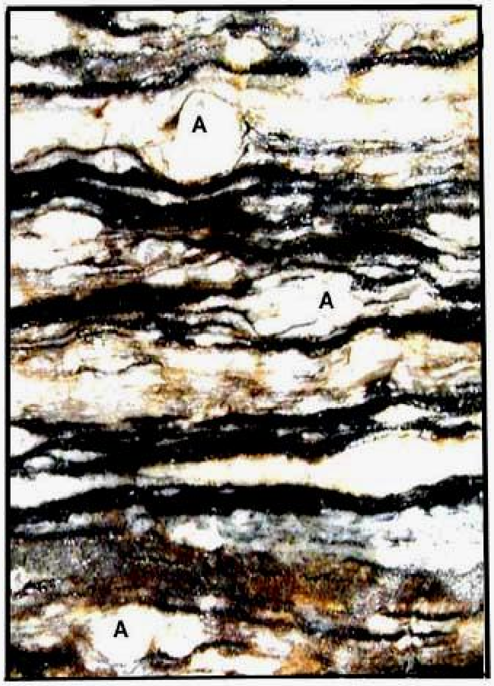
3. During farther burial, the limestone reaches the zone of metamorphism (zone of green schist facies). Both fine and coarse limestone crystallizes to more interlocking mosaic texture. The stylolite and solution seams changes to foliation texture and suffer from homogenization and mixing of materials so that the marble takes a gray or milky color (Plate 2.4) and (Fig.5). But this is a minor as compared to the black marble. This is because, as mentioned above, the pressure is not high during metamorphism.

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

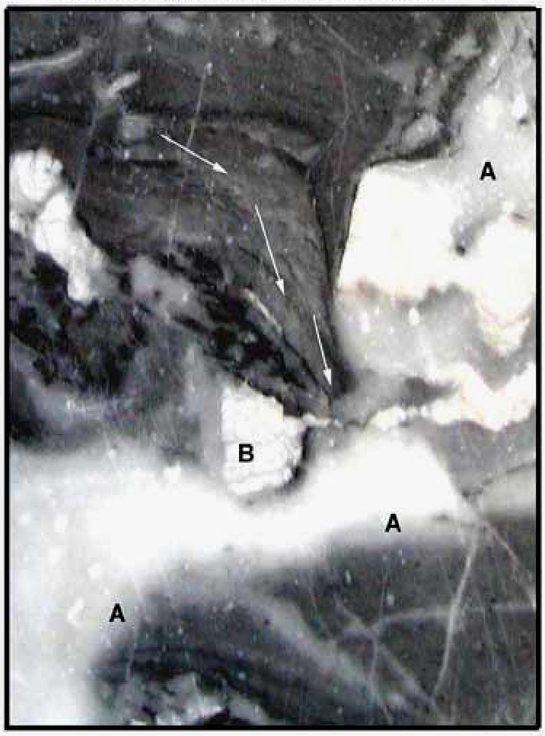
Plate 4



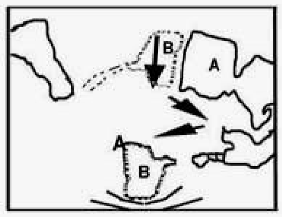
(1)Gray marble of Gmo(below) the back continuous lines are probably relict of original lamination. The above photo is green marble of Daro Khan showing plastic deformation(for comparison with plate)



(2) Black marble with white spots, but the parent rock of this sample is so brecciated that the fracture filling calcite is predominate over the blackground. The augen structure(A) of pressure resistive calcite pockets can be seen.



(3) Black marble of Kani Khan showing difused boundary (A) between the background and calcite fractures filling as a result of homogization during Metamorphism. Always the black background is more susceptible to deformation due to impurities content. The photo and diagram below show the flow of the black background as indicated by arrows. This cause detaching of a piece (B) from main white calcite fragment (C), after the detaching the piece is rotated 180 degrees. The diagram only shows the central area of the photo.



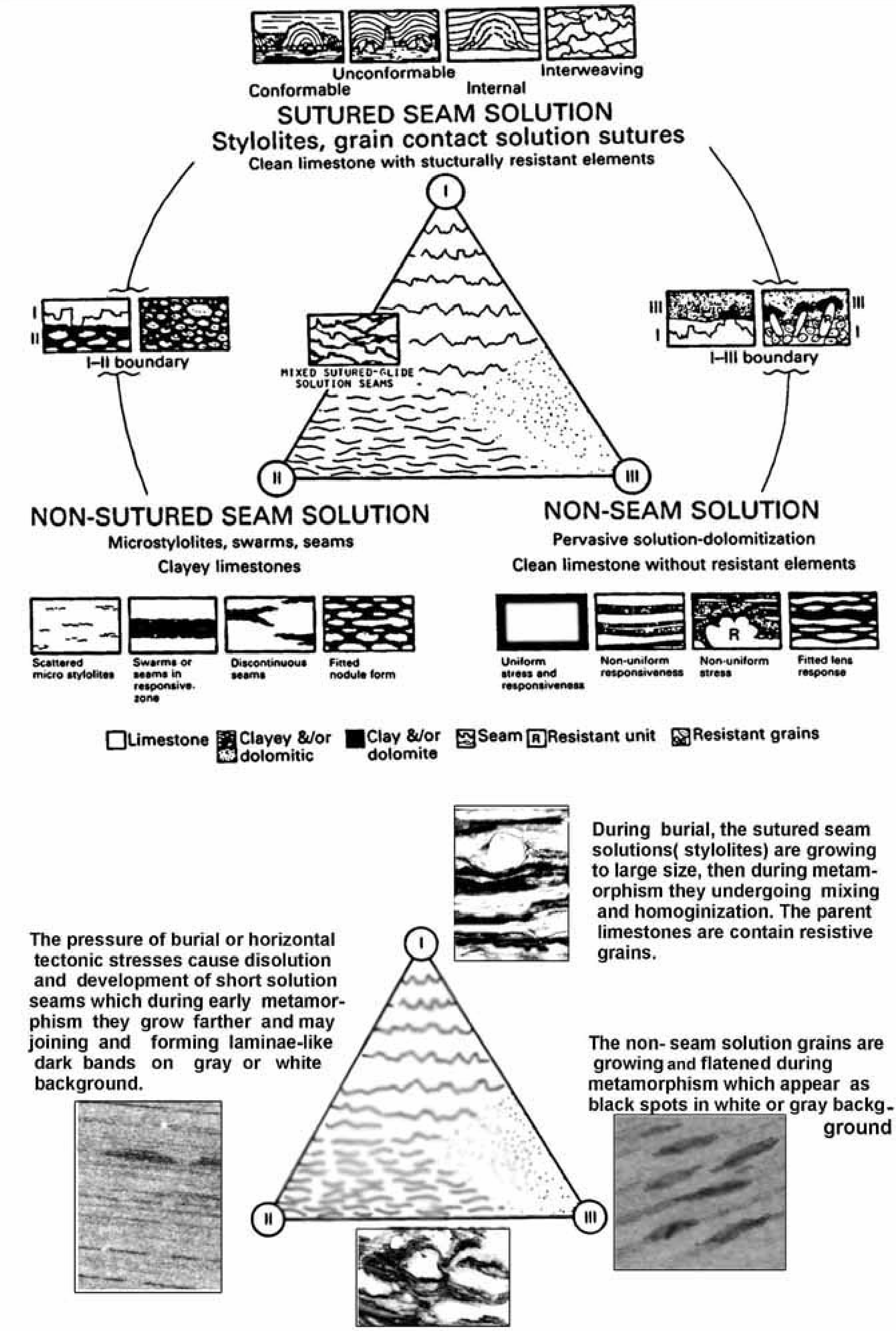


Fig.(4) Basic secondary sedimentary structures of solution compaction in carbonate Wanless(1969)[14] .These strucures can be used as precursor of structures and textures of true marble. The same triangle is drawn below, to show same structures after metamorphism with some degrres of homoginization. For more detail see fig. (5)

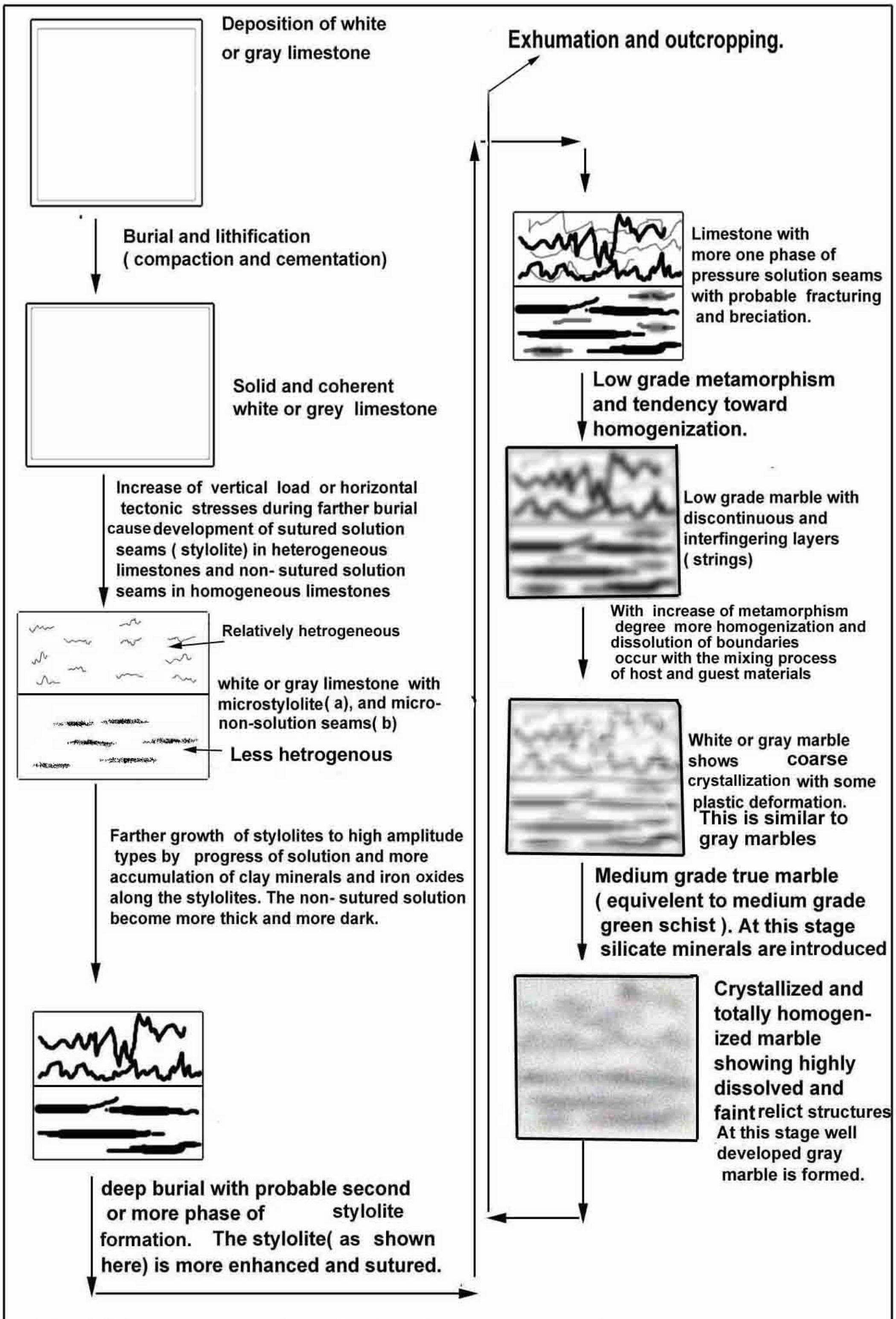


Fig. (5) Paragenesis of spotted white or gray marble as derived from white limestone suffered from pressure solution seams.

(JSZ) Journal of Zankoy Sulaimani, April2004, Vol. 7(1) Part A 69-86)

4. The farther metamorphism when reach the grade of intermediate schist the marble may change to simple featureless gray or blush gray marble.

Gray marble with continuous line and bands

This has gray background contain long continuous black lamina-like bands forming well-developed apparent foliation (Plate4.1). The origin and depositional of these laminations (or bands) are relict of the original clay rich lamination in the parent sedimentary rocks. It is possible that during burial and metamorphism the clay and other insoluble materials are added to the bands so that their size enlarged and colors difference taken more contrast.

The quarries of these marbles exist in the Penjuin and Shalair valley. The author returnes these marble to parent rocks of Qulqula Radiolarian Formation and Walash Naoperdan Series, which contain lamination in the limestone of some parts as seen by the author.

Conclusions

1. The structure and textures of most Kurdistan Marble are returned either to diagenetic or sedimentary precursors.

2. Most of structures of Kurdistan marble are returned to three main types of sedimentary rocks such as, fractured limestones, stylolitic limestone and laminated limestones. .

3. The triangle is made to show the metamorphic product of limestones with dissolution seams and stylolites. This triangle is combined with that of [14].

4. Diagrams are drawn to show the paragenesis from deposition to medium grade metamorphism through burial and tectonic deformations.

5. Qulqula Radiolarian Formation, Sargelu Formation and Walash-Naoperdan Series are the most probable parent rocks of marbles.

6. The studied marbles are belong to green schist facies and suffered from homogenization.

7. The flow structure and mixing of material shows that most marbles are passed by plastic deformation under moderate pressure and temperature.

REFERENCE

[1]. Brooks, H. K. Rock and stone terms of limestone and marble. *American Journal of science*, Vol. **252**,pp.755-760. 1954.

[2]. Buday, T. and Jassim, S.Z. Regional report and the regional geological survey of Iraq, unpubl. Report. S.O.M. Baghdad**.** 1984.

[3]. Buday, T., and Jassim, S.Z. *The Regional geology of Iraq: Tectonism Magmatism, and Metamorphism*. I.I. Kassab and M.J. Abbas (Eds), Baghdad, 445 p. 1987

[4]. Jassim, S. Z. and Al-Hassan. Petrography and Origin of the Mawat and Penjuin Igneous Complexes. *Jour. Geol. Soc. Iraq*. Special Issue on 4th Iraqi Geol. Conf., Baghdad. 1977.

[5]. Bates and Jackson, J.A. (eds.). Glossary of Geology, 4th edition., American Geological Institute, Virginia, 769p. 1997.

[6]. Pshdari, M. A. A., .Mineralogy and geochemistry of contact rocks occurring around Hero and Asnawa, NE- Iraq. Unpub. M. Sc. Thesis, Mosul University. 139p. 1983

[7]. Numan, N.M.S. A plate tectonic scenario for the Phanerozoic succession in Iraq. *Iraqi Geological Journal*, vol.**30**, no. 2, pp.85-110. 1997

[8]. Ridha, A.H. A., 1997. Perogenesis of Volcanic Rocks of Shalair Valley Area (Kata rash Volcanic Group)NE-Iraq, *Unpublished Ph. D. Thesis , University of Baghdad.122p.*

[9]. Hyndman, D. Petrology of Igneous and Metamorphic Rocks. Mc Gaw Hill, New York, 533p. 1981.

[10]. Buday, T. In: T. Buday and J. Tyracek., *Regional Geology of Iraq*, vol. 1 Stratigraphy, I.I.M Kassab and S.Z. Jassim (Eds) D. G. Geol. Surv. Min. Invest. Publ. 445p. 1980

[11]. Allen, P. A. and Allen, J. R. Basin Analysis: Principles and Applications. Blackwell Scientific Publication, 451p. 1993

[12].Einsele, G. Sedimentary Basin: Evolution, Facies and Sediment Budget. 2nd ed. Springer. 792p. 2000.

[13]. Sengupta, S and Koyi, A. K. Modification of early lineation during later folding in simple shear. In: Koyi. H. (Editor), Tectonic *Modeling: A Volume in Honor of Hans Ramberge***.** AAPG Publication. 276p. 2001

[14]. Walness, H.R.,. Limestone response to stress: Pressure solution and dolomitization. *Journal of Sedimentary Petrology*. Vol. **49**, No. 1. 437-462. 1969

[15] Walderhanug, O. and Bjorkum,P. R.The effect of sandstone spacing on Quartz cementation in the Lower Jurassic Sto Fromation < Southern Barents Sea. *Journal of Sedimentary Petrology*. 2004.(In press)

[16]. Uevele, G., Boruemann, O. and Mauthe, F. Origin of stylolite In Upper Permian Zechtein Anhydrite (Gorleben salt dome ,Germany), *Journal of Sedimentary Research*, Vo. **70**, No.3.pp.130-145. (2000)

بنه مای مەرمەڕی كوردستان كه له ستراكتوری بەردی نیشتوه وه زانراوه له سەرووی رۆژهەلاتی عێراق

ثب -له لایەن: كمال حاجی كریم احمد
زانكۆی سلیمانی ، بەشی جیۆلۆجی
haji57barzinjy@yahoo.com

پوختە

كانه بەردەكانی مەرمەڕی بەردی گۆڕاوی كوردستان بلاوبۆتەوه بەدرێژایی پشتێنەی سنوری عێراق‌و ئێران، ئەم بەردە مەرمەڕانە بوونیان لەگەڵ بەدری گۆڕاوی (شیست) و (فیلایت) دایه، وەدروست بوونیان دەگەڕێتەوه بۆ (تحول)ی بەدری نیشتووی جیاواز لەژێر كاریگەری پەستان و گەرمی مام ناوەندا له ناوچەی (تحولی اقلیمی)، ئەم مەرمەڕانە لەم سالانەی دوایدا گرنگی ئابوویان زۆر زیادی كردووه، چونكه پارچەی ساف كراویان بەفراوانی بەكاردێت بۆ جوان كردنی خانووبەره.

شێوەی جوانی ئەم بەردانه دەگەڕێتەوه بۆ بوونی (تراكیب)ی ئالۆزی قەباره ناوەند، كەگەلێك شێوەو ڕەنگ‌و پانی هەیه، ئەم (تراكیب) انه بەهۆی شێوانی هەویری‌و شلەیی‌یەوه پێك هاتوون كەلەگەڵ تێكەڵ بوونی پێك هاتەی جیاوازی ئەم بەردانەوه.، بنەمای ئەم ستراكتورانه برتی‌یه له(تحویری) یان نیشتوویی كه لەدواییدا دەبن به (فۆلێشن) یان (باندین)، مادەی جیاوازی ئەم (تراكیب) انه تووشی یەك چوونبوون بوون، (Homogenization) بەلام هیچی بەهۆی جیاوازبوونەوه (Differentiation) دروست نەبوون، زۆربەی (تراكیب) ەكان بەستراون بەسێگۆشەی بۆ روون كردنەوەی (اصلی) درووست بوونیان (Walness) وەئەوانی تر به(لامینەشین) ەوه، وەهەروەها ئەو پێكهاتووانەی كه بەردی (ئەصلی) مەرمەڕەكان پێك دێنن باسی كراوه.

اصل رخام كردستان المستنتج من تراكيب رسوبية من شمال شرق العراق.

من قبل: كمال حاجي كريم احمد
جامعةالسليمانية ، قسم جيو لوجي
haji57barzinjy@yahoo.com

الخلاصة

تان مقالع رخام تحويري في كردستان منتشرة على طول حزام حدودي بين العراق وايران، ان هذه الصخور يتواجد من الصخور المتحولة من نوع (الفيلاين) و (النضيد الاخضر)، ان تكوين هذه الصخور يرجع الى تحول الصور الرسوبية المختلفة تحت تأثير الضغط والحرارة المتوسطة في التحول الاقليمي، ان رخام كردستان قد تزايد أهميتها الاقتصادية لكونها تستخدم لزينة الابنية المختلفة.

يرجع الشكل الجميل لهذه الصخور الى التراكيب المعقدة المختلفة الاحجام والاشكال والالوان حيث تكونت بواسطة التشوه الانسيابي، ومزج المكونات المختلفة، وان اصلها يرجع الى العمليات التحويرية او الرسوبية حيث يتحول حقا الى التورق او الاحزمة من المواد المختلفة بعد ان تعرضوا الى التجانس التحويري(Homogenization أ، وأثبت ان هذه التراكيب لم يتكونوا بواسطة التفاضل التحويري (Metamorphic differentiation أ وأخيرا تم ربط التراكيب بمثلث (Walness) لتوضيح كيفية تكوينهم وكذلك تم تحديد الوحدات الطبقية التي يرجع اليهم رخام كردستان.