The limestones of Scotland: chemical analyses and petrography — Chapter 5 The petrographical classification of limestones and dolomites

Limestones and dolomites are from the mineralogical point of view simple rocks composed essentially of calcite, $CaCO_3$, and dolomite $CaCO_3.MgCO_3$. Petrographically they present a great variety corresponding to the amount and type of mineral impurity, the absence or presence and the nature of fossil remains, the textural and structural peculiarities. These characters are so diverse that petrographical classification has always proved difficult. Moreover the carbonate rocks being of great importance in the stratigraphical and palaeontological branches of geology and in industry, each interest has developed its own classification so that several systems of classification, in all of which the mineral and textural features of the rocks are of secondary importance, have long been in use. Thus limestones have been classed under such terms as marble, cornstone, cementstone, earthy, sandy, freshwater, marine, chemical, oolitic, algal, crinoidal limestone which have no precise or only a partial petrographical significance.

A review of the literature shows that, in general, systems of classification of the carbonate rocks based on their origin predominate. For example, Black (1952, p. 153 and p. 185) classifying them primarily as limestones, magnesian limestones and dolomite rocks, groups the limestones according to their origin as organic limestones, precipitated limestones and elastic limestones, the dolomites as primary and secondary dolomites. Pettijohn (1949) while stating that thin section study must be the main basis of investigation of sedimentary rocks (Preface) adopts a genetic classification (p. 293) into accretionary or autochtonous, elastic or allochtonous, chemical and dolomitized (later, p. 309, metasomatic) limestones. Dapples, Krumbein and Sloss (1950, pp. 16–17) propose a division, applicable by the use of simple tests and essentially for the routine description of drill cuttings, into fragmental oolitic or pisolitic, crystalline, nodular, normal marine, and dense limestones, these divisions being repeated under each of four classes of sedimentary association—stable shelf, unstable shelf, intracratonic and geosynclinal—that is, on a genetic basis, or as Sloss in an earlier paper (1947, p. 109) puts it on a basis of depositional environments.

Genetic classifications have two fundamental drawbacks from the petrographical point of view: (1) the criteria for discrimination between classes, for example, between accretionary and elastic limestones, or between elastic and chemical limestones may not be applicable: (2) the genesis of a particular limestone or class of limestones may be a matter of hypothesis and controversy. In illustration of the former difficulty attention is drawn to Pettijohn's criteria (1949, p. 293) for the distinction of accretionary from elastic limestones. Of his seven criteria three are determinable only in the field, while in the writer's experience, the others are not mutually exclusive. The second difficulty is prominent in Pettijohn's definition of the chemical class; in this he includes only calcareous tufa, caliche and travertine (p. 293) but finds himself obliged later (p. 308) to include 'freshwater limestone' with algal, pseudobrecciated, clotted and nodular structures. Oolites and calcilutites (calcite-mudstone) are included by him in the elastic class, by Black in a 'precipitated' class. Nevertheless in his subdivision of the clastic or allochtonous class according to the size and nature of the constituent elements and the structure of the rocks, Pettijohn goes far toward a practicable petrographical classification. His subdivisions of this class are:■

Allochtonous (clastic)	1. Calcirudite: (a) coquina; (b) reef breccia. 2. Calcarenite: (a) microcoquina and encrinite; (b) spergenite; (c) oolite. 3. Arenaceous spergenite and oolite. 4. Calcilutite (lithographic stone, marlstone and marlite).

In these subdivisions by grain-size the calcarenites are detrital carbonate rocks of sand-grain size 2 to 1/16 mm, the calcirudites of coarser grain than 2 mm and the calcilutites of grain below 1/16 mm. Spergenite is free or contains less than ten per cent of quartz.

From the descriptive petrographical point of view the most illuminating studies are those by Kaisin (1926 a and b) and Cayeux (1935). In his earlier paper (1926 a) Kaisin classifies the limestones of the Dinantian of Belgium as rocks of organic origin, detrital, and physico-chemical origin. In his later work (1926 b) on the calcareous rocks of Belgium, this genetic classification is amplified largely on a petrographical basis as follows:

Calcaires détritiques	Breches monogenes et polygenes Calcaires organo-detritiques Calcaires ferrugineux Calcaires detritiques charges d'éléments terrigenes Macignos
Calcaires organogènes	Calcaires construits Calcaires organogènes d'accumulation Calcaires sapropéliens Calcaires d'origine bactérienne
Calcaires de précipitation chemique	Calcaires dolomitiques et dolomies Calcaires oolitiques Travertins Stalactites et stalagmites Concrétions

Like those previously mentioned Kaisin's classification is essentially genetic and the resemblance of Pettijohn's is clear. The most exhaustive and philosophical study is found in Cayeux's 'Les roches sedimentaires de la France: Roches carbonatees', Paris, 1935. Cayeux divides the carbonate sediments into three classes: limestones of marine origin, limestones of fresh-water origin and dolomitic rocks including dolomites. In a succinct review (pp. 17–19) of the classification of limestones he points out the difficulties of drawing up a rational classification from the variety of categories under which limestones have been grouped in the past or from comparison with present day deposits. He found himself forced to class the marine limestones first according to their main minerals, then according to the predominant fossils, and lastly according to their structure. His method lends itself to thorough description and in the end to brief designation of a limestone in terms of its mineral and fossil content and its structure. He subdivides the freshwater limestones and the dolomites essentially in terms of their texture and structure. Cayeux's method of designation is not a method of classification but has the great merit of being practicable except in so far as freshwater limestones may not be distinguishable petrographically from marine limestones.

A purely petrographical classification of limestones and dolomites was made by Teodorovitch (1941) on the base of their structure including in this term the nature of the component elements. He divides the rocks into three groups according as they are: I, structurally homogeneous; II, composed of uniformly distributed components of two or more types or: III, structurally heterogeneous. The homogeneous group (I) is divided into granular and purely organogenic limestones with subdivisions according to grain-size in the former; the latter correspond to the autochtonous limestones of Pettijohn. The second class of limestone (II) is separated into (a) predominantly granular limestone with some cemented material (of organic or other origin) in a granular groundmass of carbonate, and (b) limestones in which the cemented material predominates, the latter group having a subgroup in which the cement is very small. The group II(a) is divided according to grain-size of the matrix and number of components, and the group II (b) according to whether the nonmatrical components are definitely organogenic, 'hemogeneous or biohemogeneous', terms which the writer takes to signify partly or uncertainly connected in origin with life of some kind, since the subgroup includes oolites and 'lumpy' (presumably pellet) limestone, and elastic carbonate material. It is not clear whether argillaceous and arenaceous limestones are referred to the granular or to the elastic sub-group of Class II. The limestones of Class III include 'coagulation', patterned, pseudobrecciated, nodular and concretionary limestones. Teodorovitch's classification while petrographically logical and practicable, is by symbols; it is not accompanied by a system of nomenclature and makes scarcely any use of existing type names. For example, 'II.b, I-C bis'—chalk 'in which the principal portion of the fine-grained groundmass consists of minute coccolitho-poride remains', while 'II.a-2-bis' =chalk 'with a microgranular groundmass… not showing a distinctly organogeneous nature'. In its symbolic form this classification is a codification likely to be of only esoteric interest.

Limestones have been classed according to their texture by J. Hirschwald (1908) and a condensed version of his classification·has been given by J. V. Howell (1922). The classification is again one by symbols referring to depicted textural types and is applicable mainly to unfossiliferous limestones. It is based primarily on the grain-size of the purer carbonate rocks and on the nature and distribution of the non-carbonate component in the argillaceous and siliceous types, secondarily on the nature of the grain boundaries and the twinning of the carbonate in the coarser grained rocks, and on the relative proportions of finer and less fine carbonate in varigrained and fine-grained rocks. This method of classification appears to be adapted for close comparison of similar stones rather than to descriptive petrography and in the writer's experience some of the types depicted are only variants which may be expected in any rock diagenetically recrystallized.

In preparing the petrographical descriptions contained in the succeeding pages of this memoir, it was found that even in this collection of limestones, which is comparatively restricted in range, the Mesozoic limestones being only feebly represented, the variety is bewildering. The possibility of evolving a coherent practicable scheme of classification based on mineral composition, texture and structure appeared remote. Nevertheless it was felt that some attempt should be made to formalize the results of petrographical study, and the methods of Cayeux appeared to the writer to offer the best basis for systematic, petrographical designation.

Limestones and dolomites were, therefore, grouped primarily as limestones, dolomitic limestones, calcareous dolomites, and dolomites, limestones being those rocks which show no dolomite though chemical analysis may prove them magnesian. Dolomitic limestones are those in which dolomite may be detected under the microscope in stained or unstained thin section, and calcareous dolomites those in which calcite appears an essential constituent on test with cold dilute acid. Dolomites show only sporadic or pin-point or no effervescence on test with cold dilute acid.

The designation of rocks falling within'. these main divisions are continued by qualifying terms referring to (a) minerals other than carbonates, (b) grain-size, (c) fossil content and (d) microstructure. Lack of reference to minerals indicates that only accessory proportions of minerals other than carbonates are present; to fossils that the rock is unfossiliferous in a random section. No term referring to the rock as marine, freshwater or chemical sediment nor as autochtonous, alloch-tonous or metamorphic has been used, but the qualifying terms frequently give positive indications of the genesis or history of the rock.

In the following paragraphs the qualifying terms used in the designations are explained.

Mineral content

The principal non-carbonate minerals are stated by name except when detrital quartz and clay minerals are so abundant that the term arenaceous or argillaceous is used. In many limestones a noteworthy proportion of detrital noncarbonate matter of silt grade is present and is readily detectable by the dissemination of tiny, angular grains of quartz. As it seemed undesirable to refer to such material as arenaceous or argillaceous the term luteous has been introduced.

It may be noted that the citation of calcsilicates, or specifically garnet, tremolite, diopside, scapolite, etc., indicates the metamorphic character of the rock.

Grain-size

The limits used in describing the grain-size of the rocks are based on the impression of size gained by examination with a one-inch objective and x 10 occular. They are:—coarse-grained >1 mm; medium grained <1 mm, >0.2 mm; fine-grained < 0.2 mm, > 0.02 mm; micrograined < 0.02 mm, > 0.004 mm; pelitomorphic < 0.004 mm. The term cryptocrystalline is considered inappropriate to carbonate rocks. For some rocks in which the grain-size varies greatly but after no structural pattern the term varigrained has been used. In fossiliferous rocks the term defining grain-size applies to the carbonate forming the matrix.

Fossil content

Where the term fossiliferous is used it is implied that fossils are present in an unworn, albeit imperfect condition indicative of their accumulation in place. The term microfossiliferous implies that the untransported fossil remains are all of small fossils, such as foraminifera and ostracods, to the virtual exclusion or only sporadic occurrence of larger shells.

Exceptionally where the rock is composed largely of the remains of one type of fossil the general name coral, algal, crinoidal is used.

Many of the Lower Carboniferous limestones are composed essentially of fossil debris which is usually but little abraded and often sorted, and comprises many classes of organisms (cf. Black 1952, p. 161). Their appearance in thin section indicates accumulation by water transport but, because of the angular and little worn condition of the fragments, transport of small duration or extent. In this memoir limestones composed largely of fossil debris have been termed clastizoic. Such limestones may contain also well-preserved shells and may show bedding, indicating the intermittent deposition of transported debris on to organisms in place, and the combined terms fossiliferous, clastizoic have been used to describe them. Frequently clastizoic limestones contain entire microfossils and the terms micro-fossiliferous, clastizoic have been applied to them though in view of the size and buoyancy of the microfossils these components may have been transported to as great a degree as the fragments. To such limestones Pettijohn's division into autochtonous and allochtonous is difficult to apply. In many cases they are associated with shales, grade into calcareous shales, possess a matrix actually or originally of pelitomorphic grain and show articulated microfossils, but their organic remains are on the whole clastic, washed and often sorted. They are, so to speak, washed autochtonous.

Microstructure

Because of original differences in structure and purity, variety in the quantity, size and state of preservation of fossils, variety of manner and extent of diagenetic recrystallization and development of new structures by dolomitization and by thermal and regional metamorphism, the microstructure of limestones and dolomites is of great diversity and offers corresponding difficulty to significant, brief terminology.

Among original structures of limestones reviewed in this memoir are the bedded, nodular, pebbly or psephitic, phenoplastic, homoiolithic, pelleted, oolitic and pseudo-oolitic. Most of these structures are well known. The term phenoplastic introduced by R. M. Field (Black 1952, p. 59) describes the presence of pieces of sediment which were plastic at the time of incorporation in the limestone. The term homoiolithic is introduced here to signify the presence of pieces, usually of rather ill-defined shape, of limestone of similar character to the enclosing rock. Both terms imply contemporaneous erosion.

Recrystallization, from whatever cause, leads by stages to the obliteration of original structures. The internal structure and the shape of fossils are gradually destroyed; at the stage of recrystallization of a fossiliferous limestone in which, though partly destroyed, fossils are still recognizable by more or less distinct outlines or by traces of internal structure, the structure is described here by the term zoichnic; at the stage when destruction is complete but the former presence of fossil remains is revealed by indications such as a regular pattern of mineral dust or a regular disposition of areas of different grain the structure is termed zoophasmic. The suffixes -ichnic and -phasmic prove useful also to indicate respectively an advanced stage in the destruction and the former presence of oolitic and clastic structures, and the general term taxichnic is usefully applied to rocks such as dolomite to indicate that the original sedimentary structures of the limestone from which it has been derived are more or less well preserved.

Recrystallization leads also to the development of new structures. Limestones which have been recrystallized are in the general sense of the term metamorphic rocks, and terms such as diablastic, granoblastic, etc. have been applied by some petrographers to limestones and other soluble rocks recrystallized under diagenetic processes (Pettijohn 1949, p. 73). This extension of the use of terms introduced to describe structures and textures of rocks which have undergone metamorphism through the action of heat and pressure and of magmatic mineralizers, appears to the writer undesirable and therefore the comparable terms diacrystallic, grano-crystallic, etc. have been introduced here for diagenetically recrystallized carbonate rocks as explanatory of the types of structure yet carrying no implication of thermal or regional metamorphism.

In the course of diagenetic recrystallization more or less regular spatial patterns arise. The pelitomorphic limestones tend to recrystallize in such a way that small spots or clots of dark, pelitomorphic carbonate become isolated in clearer, coarser-grained carbonate, and the resulting structure has long been termed clotted. It may be (*cf* Kaisin 1926a, p. 1261 and 1926b, p. 77) that this type of minutely diffused recrystallization is connected with the presence of traces of bituminous material, which differentially waterproofs the rock and causes recrystallization to start at innumerable nodes of least protection. Recrystallization more commonly proceeds along an irregular, diffuse lattice which, broadening, graduates into and isolates patches of original or less affected carbonate. The resulting structure is called here mesh-crystallized. In some limestones, especially those of cornstone type, recrystallization proceeds along more sharply defined, short, crooked channels which are discontinuous in plane section; the structure is called here crook-veined. When the channels are close-set the rock has the appearance of a breccia and the structure is then referred to as breccioid. The mesh and crook types of recrystalliza-tion may be diagnostic of differences in the conditions of consolidation, the crook-veins being perhaps indicative of an irregular crack system produced by drying out at surface or shallow depth and the diffuse mesh indicative of gradual slow contraction at depth. Complete recrystallization by either process leads to the production of a rock composed of clear granular calcite and the structure is granocrystallic.

The terms used to describe the microstructure of metamorphic limestones of an impure kind are those, such as schistose, foliated, granoblastic, porphyroblastic, etc., normally applicable to metamorphic rocks. It has been found convenient here to apply the term heteroblastic to those rocks in which there is a decided and consistent difference in grain-size of the calcite and the other minerals, usually quartz and micas. Many metamorphic limestones which consist almost wholly of calcite exhibit parallel structures comparable with schistosity and foliation. The calcite grains are in some rocks persistently elongated in one direction and to describe this structure the term granoschistose is proposed. A parallel structure comparable with foliation arises from the alternation of laminae of different grain-size, the grain within an individual lamina remaining constant. The term grain-foliated is proposed for this structure. These new terms may be acceptable for application to other monomineralic rocks such as quartzite to which the terms schistose and foliated in their normal significance cannot apply.

A variety of structures can develop in limestones as the result of shearing under earth stresses. Within the grains of the strained limestone a system of close multiple twinning indicates their adjustment to shear; the twins may be bent within the grains; parallel alignment of the twinning planes throughout lenticles of the rock may be induced. Mechanical breakdown of the grains along their surfaces produces a mortar structure, or when the grains break also along their cleavage planes to angular fragments, a pseudo-gritty structure. Reduction of the carbonate to a microcrystalline aggregate within which the more resistent minerals are cushioned and retain their size produces a pseudo-porphyroblastic structure.

Microstructure of dolomite

The microstructure of limestones which have been thoroughly dolomitized is typically a mosaic, that is, an aggregation of interlocked grains which on the whole show straight edges in section. Frequently the grains are of uniform size; sometimes they vary markedly in size though still on the whole straight edged and the resulting structure is termed here an uneven mosaic. In some dolomites, particularly in those of fine grain, crystal faces are only subordinate and the structure is granular. Grains of irregular size and shape frequently develop in the dolomitization of limestones which have been composed of fragments of fossils in a fine-grained matrix. It is not unusual for the large components to be transformed into or to act as loci for the growth of large dolomite grains. These may enclose small rhombs of dolomite giving a kind of poikilocrystallic structure and contiguous large crystals often interpenetrate in diacrystallic structure. Such structures are commonly found in zoophasmic dolomites (see below) and when no trace of organic structure remains they must be considered as indicative of the former presence of fossils.

Though in thoroughly dolomitized limestones the original structures are generally lost, traces are not infrequent and occasionally they are well preserved. Preservation may be effected by the retention of mineral impurity in its original place in the fine structure, by the crystallization of the dolomite as pseudomorphs of the elements of the original structure or by its crystallization in differential grain controlled by the original structure. The suffix -ichnic, suggested to the writer by the late Mr. C. H. Dinham, is used to indicate such conditions of good or fair preservation and dolomites are zoichnic, clastizoichnic, clastichnic, taxichnic when they show respectively animal fossils, fossil debris, elastic structure, sedimentation structure in a state of identifiable preservation. The suffix-phasmic may be applied when only a trace or ghost of the original structure is detectable; the combinations zoo-phasmic and oophasmic have been used in this memoir.

To conclude this section a list of terms used in the designations following the descriptions on pages 75 to 135 is given below. New terms are in italics.

Glossary of terms used in the petrographical designations

(new terms in italics)

bedded	showing under the microscope depositional layering, e.g., by parallel arrangement of platy fragments, alternation of bands of differing mineral or structural constitution, etc.
blasto-	prefixing a structural term, signifies that this earlier structure is more or less preserved after metamorphism, e.g., blasto-oolitic.
blasto-psephitic	indicates that original pebbles though recrystallized during a period of metamorphism are still recognizable as pebbles.
breccioid	having the appearance of a breccia: the term expresses the irregular distribution of areas of different grain, often sharply separated, consequent on recrystallization along more or less well-defined channels.
calcilutite	a limestone uniformly fine-grained of silt or clay grade, with or without luteous *(q.v.)* or argillaceous component, of unspecified origin.
clastichnic	refers to dolomite in which original elastic structure is preserved. (Gk. *klastos,* broken + *ikhnos,* trace, footprint).
clastizoic	containing animal remains mainly in the form of angular, little-worn debris which may be sorted or unsorted in size. Clastizoic limestones often contain entire microfossils. (Gk. *zoon,* an animal). *Cf.* bioclastic which has a genetic significance.
clastizoichnic	refers to recrystallized limestones and dolomites which have traces of original clastizoic structure.
clotted	structure produced by the distribution of small, round or irregular clots of pelitomorphic calcite or dolomite in recrystallized, clear granular carbonate.
crook-veined	traversed by short, crooked channels of recrystallization. Multiplicity of channels produces a breccioid structure.
diablastic	structure of a metamorphic rock in which contiguous crystals of two main components form an intergrowth.
diacrystallic	structure of a diagenetically recrystallized, essentially mono-mineralic rock in which contiguous crystals interpenetrate in a complicated manner. (Gk. *dia,* through + *krustallos,* ice, crystal).
encrinite	a limestone composed essentially of the skeletal parts of crinoids.
foliated	structure of metamorphic rocks caused by the concentration of one or two of the main minerals in parallel lenticular bands or folia.
fracture-veined	traversed by thin veins which represent fractures filled up (healed) by later deposition of mineral matter, usually a carbonate or silica.

grain foliated	structure of a monomineralic, metamorphic rock in which foliation is shown by parallel arrangement of lenticular bands of different grain-size, each band being of uniform grain.
granoblastic	structure of a metamorphic rock in which the minerals are recrystallized in equidimensional grains.
granoschistose	structure of a monomineralic, metamorphic rock produced by the parallel elongation of grains of a mineral which is normally equidimensional or nearly so.
granular	structure of a limestone or dolomite composed largely of grains without crystal form; the structure is termed uniform granular when the grains are all of approximately the same size. Coatings and scanty interstitial infillings of finely divided mineral matter emphasize the granular appearance.
heteroblastic	structure of metamorphic rocks in which the essential minerals are recrystallized in distinctly different grain-size; the term is used here to describe a granoblastic structure in which calcite is of very different size, usually much larger, than the other constituents.
homoiolithic	containing fragments of similar rock-material, or composed of two similar rock-materials: the structure indicates contemporaneous erosion and redistribution. (Gk. *homoios,* like +*lithos,* stone).
-ichnic	suffix indicating that an original structure is preserved in rocks which have undergone diagenetic recrystallization: equivalent to the prefix blasto- used in a similar manner for metamorphic rocks. (Gk. *ikhnos,* trace, footprint).
laminar	a bedded structure produced by alternation of very thin bands of differing constitution.
luteous	having an essential proportion of muddy sediment, recognized in limestones by the presence of many particles of elastic quartz of silt grade. (L. *luteum,* mud).
mesh-crystallized	structure resulting from the course of recrystallization following a diffuse mesh pattern.
microcoquinoid	limestone composed of small shells, many of them entire, which have accumulated in place in a fine-grained matrix.
mortar-structure	in which relatively large relics of crystals are embedded in a matrix of smaller grains produced by mechanical breakdown (cataclasis); the structure is here qualified as *pseudo-gritty* when the larger relics are angular, owing to fracture along cleavage-planes.
mosaic	the term is used here to describe the structure of a dolomite in which the carbonate is crystallized in rhombs so that in section contiguous grains dovetail. The dolomite crystals are often of uniform size; when the sizes of the individual crystals vary greatly and irregularly the term *uneven mosaic* is used here.
palimpsest	structure in a metamorphic rock characterized by relics of a premetamorphism structure.
pelitomorphic	signifies that the predominant grain-size of a limestone or dolomite or of the matrix of a clastizoic or fossiliferous limestone is of clay grade.

pelleted	structure of a limestone in which small ovoid bodies, 0.2 to 0.5 mm long, of pelitomorphic calcite, usually structureless or without a structural pattern, are prominent.
-phasmic	a suffix used to signify that traces of an original character remain, e.g. oophasmic, indicating that traces of oolitic structure remain. (Gk. *phasma,* phantom).
phenoplastic	containing fragments of rock material which was in a plastic condition when incorporated in the matrix.
poikilocrystallic	structure in which large crystals of one mineral, recrystallized under diagenetic processes, enclose many smaller grains of the same mineral or of another constituent of the sediment. (Gk. *poikilos,* spotted).
porphyroblastic	structure of a metamorphic rock in which one mineral makes much larger crystals than the other minerals.
porphyrocrystallic	structure of a sediment, diagenetically recrystallized, in which large crystals of a mineral lie in a finer-grained matrix which may be composed of the same mineral or have a different composition.
pseudo-oolitic	structure resembling oolitic structure, produced by the presence of numerous bodies composed of finely divided carbonate which resemble ooliths in shape and size but do not possess the internal structure of ooliths.
pseudo-porphyroblastic	structure resembling the porphyroblastic but due to other processes than growth, e.g. to differential granulation.
sheared	showing orientated structures due to mechanical shear.
schistose	showing a fissility due to the recrystallization of platy or prismatic minerals so that the plates lie parallel to one another or so that the long prism axes lie in one planar orientation.
strained	showing evidence of having been affected by shearing stress but without mechanical breakdown, e.g. by development of close-set cleavage or twinning, or of optical anomalies which reveal internal strain.
stylolitic	penetrated by sinuous, peaked films of clayey matter, often bituminous
sub-	this prefix indicates a low degree of development of the structure prefixed, e.g. subpoikilocrystallic indicates that though calcite (or other mineral) encloses grains of another constituent, the calcite has not grown large and the enclosed grains are not numerous.
taxichnic	signifies that the original texture or structure of the limestone has been preserved or is distinguishable in the dolomite. Where the structure preserved is specified, e.g. clastizoic, there is no need to use taxichnic. (Gk. *taksis, order +ikhnos).*
zoichnic	refers to limestones and dolomites in which animal fossils though partly destroyed by recrystallization are still recognizable in outline or by traces of internal structure. (Gk. *zoon+ikhnos*).
zoothasmic	refers to dolomite and recrystallized limestone in which vague but unmistakable indications of the former presence of animal fossils exist. (*Gk. zoon+phasma*).

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