REFERENCES

Badham, J.P.N., "The Origins of Ore Deposits in Sedimentary Rocks," (Tarling, D.H., ed.), Economic Geology and Geotectonics, pp. 149-174., 1981.

Bastin, H.A., v Braun, E., Hess, A., Koch, K.E., Stein,V., Stoppel, D., and Wolfart, R., "Silurian and Early Devonian Biostratigraphy in Northwest Thailand", Newsletter on Stratigraphy, Vol.1, No.2, pp.25-31, 1970.

Berner, R.A., "Sedimentary Pyrite Formation", American Jour. of Science, Vol 268, pp.1-23, 1970.

Blaser, R., "Pb and/or Zinc-rich ore fluids", Metals/Carbonate Workshop, 21 pp., Netherlands, 1976.

______, "Conditions Favourable for the Accumulation of Pb and Zn Sulphides in Carbonate Rocks", Metals/Carbonate Workshop, 28 pp. Netherlands, 1976.

Brown, G.F., Pitakspraivan, K., and Kaeo Phithoon, "Nong Phai Lead-Zinc Mine, Kanchanaburi," (Brown, G.F., et al., ed.) Bull. U.S. Geol. Surv., No.984, pp.82-88., 1953.

Bender, F., Geology of Burma, 293 pp., Geleruder Borntraeger, Berlin-Stuttgard, 1983.

Carroll, D., Clay Minerals A Guide of Their X-ray Identification, pp.45-55, Geol. Soc. America special paper No.126, 1970.

Dennison, "Graphical Aids for Determining Reliability of Sample Means and an Adequate Sample Size", Jour. Sedimentary Petrology, Vol.32, pp.743-750, 1962.

Diehl, P., and Kern, H., "Geology, Mineralogy, and Geochemistry of Carbonat-Hosted Lead-Zinc Deposits in Kanchanaburi Province, Western Thailand", Econ.Geol., Vol.76, p.2128-2146, 1981.

DMR, "Geological Map of Thailand; Scale 1:2,500,000", Bangkok, 1984.

Ernst, W., Geochemical Facies Analysis, Method in Geochemistry and Geophysics, Vol.11, 152 pp., Elsevier, Amsterdam, 1970.

Fairbridge, R.W., Chilingar, G.V., and Bissell, H.J., "Introduction", (Chilingar, G.V., ed.), Developments in Sedimentology 9B, pp. 1-21, Elsevier, 1967.

Flügel, E., Microfacies Analysis of Limestones, 633 pp., Springer-Verlag Berlin, Heidelberg, 1978.

Folk, R.L., Petrology of Sedimentary Rocks, pp.152-170, Hemphill's, Austin Texas, 1968.

GGM, "Final Report of the German Geological Mission to Thailand (1965-1971)", Geological Survey of the Federal Repubbic of German, pp.11-22, Hannover, 1972.

______, "Geological Map of Northern Thailand; Scale 1:250,000", Hannover, 1978.

Hagen, D., and Kemper, E., "Geology of the Thong Pha Phum Area (Kanchanaburi Province, Western Thailand)", Geol.Jb., B 21, pp.53-91, 1976.

Hutchison, C.S., Laboratory Handbook of Petrographic Techniques, pp. 214-216, John Wiley & Sons, Inc., 1974.

James, N.P., Depositional Models for Carbonate Rocks", Sediment Diagenesis (Parker, A., and Sellwood, B.W., eds), pp.289-348, D.Reidel Publishing Company, 1983.

Koch, K.E., "Geology of the Region Sri Sawat-Thong Pha Phum-Sangkhlaburi (Kanchanaburi Province, Thailand)", Geol.Soc. Malaysia Bull, No.6, pp.177-185, Malaysia, 1973.

Kuchelka, R.A., "Song Toh-Development of a new metal mine under tropical conditions in Thailand", Erzmetall, Vol.34, Nr.7/8, p.417-423, 1981.

Longman, M.W. "Carbonate Diagenesis as a Control on Stratigraphic Traps", Bull. AAPG, No.21, pp.120-140, Oklahoma, 1982.

Maynard, J.B., Geochemistry of Sedimentary Ore Deposits, pp.181-204, Springer-Verlag, New York, 1983.

Meteorological Department, "Climatological Data of Thailand 30-year Period (1951-1980)", Ministry of Communications, Bangkok, pp. 30, 1983.

Monaghan, P.H., and Lytle, M.A., "The Origin of Calcareous oolite", Science, Vol.166, pp.1498-1499, 1956.

Newell, N.D., Purdy, E.G., and Imbrie, J., "Bahamian oolitic sand" Jour. Geolology., Vol.68, pp.481-497, 1960.

Permthong, P., "Aspects of Geology and Mineragraphic studies of Strata-bound Lead-Zinc Orebodies at Song Toh Mine, Kanchanaburi", Master of Science Thesis, Chulalongkorn University, Thailand, 1982.

Reeckmann, A., and Friedman, G.M., Exploration for Carbonate Petroleum Reservoirs, pp.1-38, John Wiley & Sons, Inc., New York, 1982.

Rose, A.W., Hawkes, H.E., and Webb, J.S., Geochemistry in Mineral Exploration, pp.61-66, Academic Press Inc., 2th ed., London, 1977.

Sangster, D.F., "Carbonate-Hosted Lead-Zinc Deposits", Handbook of Strata-bound and Stratiform Ore Deposits, Vol.6, pp.447-456, Elsevier, Amsterdam, 1976.

Seigel, F.R., "Properties of uses of the Carbonates," (Chillingar, G.V. ed.), Developments in Sedimentology 9B, pp.343-394, Elsevier,1967.

Smith, R.M., and Rachadawong, S., Report of Examination, Nong Phai Lead-Zinc Mine, Amphoe Sri Sawat, Kanchanaburi Province, Thailand, 11 pp., 1960.

Suksa-gnuan, N, et al., "Mining Geology and Mineral Dresssing of KEMCO Mine," Proceedings of the Second Mining Conference,, pp.241-262, Haad Yai, Songkhla, Thailand (in Thai), 1986.

Teodorovich, G.I., Authigenic Minerals in Sedimentary Rocks, pp 1-24, Consultants Bureau, New York, 1961.

Yokart, B., "Mineralography and Geochemistry of Lead-Zinc Deposits in Northwestern Thailand," Master of Science Thesis (unpublished), Chiang Mai University, Thailand, 1977.

van der Baan, D., "Porosity/Permeability Creating Processes in Carbonate Rocks: Leaching, Fracturing, and Dolomitization", Metals/Carbonate Workshop, 15pp. Netherlands, 1976.

APPENDIX A

DATA SHEET
for
MICROFACIES ANALYSIS of CARBONATE ROCKS

Project title :
Sample No. :
Sampling location : a) Grid references :
b) Base map reference :
c) Geographic location :
Stratigraphic position :
Geological age :
Petrographer(s) :
Remarks : Date :

I. Types and characteristics of allochems

Characteristics Type	Degree of abundance % (Total >10 or <10)	Grain Size siltite <20μ	 arenite 20μ-2mm	 rudite >2mm	Remarks(preservation ,diagenetic fabrics, porosity,etc.)
1. Skeletal grains - gastropod - cephalopod - bivalve - brachiopod - coral - echinoderm - bryozoa - foraminifera - algae - others 2. Intraclasts 3. Oolites 4. Pellets 5. Aggregate grains					

II. Types and characteristics of orthochems

Characteristics Type	Degree of abundance A	 C	 R	Fabrics granular	 drusy	 fibrous	Remarks (porosity, diagenesis, etc.)
1. Micrite(1-4μ) 2. Microsparite(4-10μ 3. Sparite(>10μ)							

III. Other detrital and authigenic components

Characteristics Type	Degree of abundance %	Remarks (grain size, roundness, crystal habit, replacement, fabric, etc.)
1. Detrital quartz 2. Clay 3. Chert 4. Dolomite 5. Barite 6. Extraclasts		

IV. Associated ores

Characteristics Ores	Degree of abundance A	 C	 R	Remarks
1. Pb-ore 2. Zn-ore 3. Gangues				

V. Rock name (Folk, 1968) :

*** Remarks : A = Abundant, C = Common, R = Rare

Sedimentology Lab., Department of Geology, Chulalongkorn University.

APPENDIX B

Table B-1 Classification of the carbonate rocks (Folk, 1968).

<table>
<tr><td colspan="5" rowspan="4"></td><td colspan="6">Limestones, Partly Dolomitized Limestones, and Primary Dolomites (see Notes 1 to 6)</td><td colspan="3">Replacement Dolomites[7] (V)</td></tr>
<tr><td colspan="2">>10% Allochems Allochemical Rocks (I and II)</td><td colspan="3"><10% Allochems Microcrystalline Rocks (III)</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>Sparry Calcite Cement >Microcrystalline Ooze Matrix</td><td>Microcrystalline Ooze Matrix >Sparry Calcite Cement</td><td colspan="2" rowspan="2">1–10% Allochems</td><td rowspan="2"><1% Allochems</td><td rowspan="2">Undisturbed Bioherm Rocks (IV)</td><td colspan="2" rowspan="2">Allochem Ghosts</td><td rowspan="2">No Allochem Ghosts</td></tr>
<tr><td>Sparry Allochemical Rocks (I)</td><td>Microcrystalline Alochemical Rocks (II)</td></tr>
<tr><td rowspan="5">Volumetric Allochem Composition</td><td colspan="4">>25% Intraclasts (i)</td><td>Intrasparrudite (Ii:Lr)
Intrasparite (Ii:La)</td><td>Intramicrudite* (IIi:Lr)
Intramicrite* (IIi:La)</td><td rowspan="5">Most Abundant Allochem</td><td>Intraclasts: Intraclast-bearing Micrite* (IIIi:Lr or La)</td><td rowspan="5">Micrite (IIIm:L); if disturbed, Dismicrite (IIImX:L); if primary dolomite, Dolomicrite (IIIm:D)</td><td rowspan="5">Biolithite (IV:L)</td><td rowspan="5">Evident Allochem</td><td>Finely Crystalline Intraclastic Dolomite (Vi:D3) etc.</td><td rowspan="5">Medium Crystalline Dolomite (V:D4)
Finely Crystalline Dolomite (V:D3)
etc.</td></tr>
<tr><td rowspan="4"><25% Intraclasts</td><td colspan="3">>25% Oölites (0)</td><td>Oösparrudite (Io:Lr)
Oösparite (Io:La)</td><td>Oömicrudite* (IIo:Lr)
Oömicrite* (IIo:La)</td><td>Oölites: Oölite-bearing Micrite* (IIIo:Lr or La)</td><td>Coarsely Crystalline Oölitic Dolomite (Vo:D5) etc.</td></tr>
<tr><td rowspan="3"><25% Oölites</td><td rowspan="3">Volume Ratio of Fossils to Pellets</td><td>>3:1 (b)</td><td>Biosparrudite (Ib:Lr)
Biosparite (Ib:La)</td><td>Biomicrudite (IIb:Lr)
Biomicrite (IIb:La)</td><td>Fossils: Fossiliferous Micrite (IIIb: Lr, La, or Ll)</td><td>Aphanocrystalline Biogenic Dolomite (Vb:Dl) etc.</td></tr>
<tr><td>3:1–1:3 (bp)</td><td>Biopelsparite (Ibp:La)</td><td>Biopelmicrite (IIbp:La)</td><td rowspan="2">Pellets: Pelletiferous Micrite (IIIp:La)</td><td rowspan="2">Very Finely Crystalline Pellet Dolomite (Vp:D2) etc.</td></tr>
<tr><td><1:3 (p)</td><td>Pelsparite (Ip:La)</td><td>Pelmicrite (IIp:La)</td></tr>
</table>

NOTES TO TABLE I

* Designates rare rock types.

[1] Names and symbols in the body of the table refer to limestones. If the rock contains more than 10 per cent replacement dolomite, prefix the term "dolomitized" to the rock name, and use DLr or DLa for the symbol (e.g., dolomitized intrasparite, Li:DLa). If the rock contains more than 10 per cent dolomite of uncertain origin, prefix the term "dolomitic" to the rock name, and use dLr or dLa for the symbol (e.g., dolomitic pelsparite, Ip:dLa). If the rock consists of primary (directly deposited) dolomite, prefix the term "primary dolomite" to the rock name, and use Dr or Da for the symbol (e.g., primary dolomite intramicrite, IIi:Da). Instead of "primary dolomite micrite" (IIIm:D) the term "dolomicrite" may be used.

[2] Upper name in each box refers to calcirudites (median allochem size larger than 1.0 mm.); and lower name refers to all rocks with median allochem size smaller than 1.0 mm. Grain size and quantity of ooze matrix, cements or terrigenous grains are ignored.

[3] If the rock contains more than 10 per cent terrigenous material, prefix "sandy," "silty," or "clayey" to the rock name, and "Ts," "Tz," or "Tc" to the symbol depending on which is dominant (e.g., sandy biosparite, TsIb:La, or silty dolomitized pelmicrite, TzIIp:DLa). Glauconite, collophane, chert, pyrite, or other modifiers may also be prefixed.

[4] If the rock contains other allochems in significant quantities that are not mentioned in the main rock name, these should be prefixed as qualifiers preceding the main rock name (e.g., fossiliferous intrasparite, oölitic pelmicrite, pelletiferous oösparite, or intraclastic biomicrudite). This can be shown symbolically as Ii(b), Io(p), IIb(i), respectively.

[5] If the fossils are of rather uniform type or one type is dominant, this fact should be shown in the rock name (e.g., pelecypod biosparrudite, crinoid biomicrite).

[6] If the rock was originally microcrystalline and can be shown to have recrystallized to microspar (5–15 micron, clear calcite) the terms "microsparite," "biomicrosparite," etc. can be used instead of "micrite" or "biomicrite."

[7] Specify crystal size as shown in the examples.

The crystal size of these rocks is a very important characteristic and should be shown by the following terms and symbols:

Aphanocrystalline	D1	under 0.0039 mm.
Very finely crystalline	D2	0.0039-0.0156 mm.
Finely crystalline	D3	0.0156-0.0625 mm.
Medium crystalline	D4	0.0625-0.2500 mm.
Coarsely crystalline	D5	0.2500-1.0000 mm.
Very coarsely crystalline	D6	1.0000-4.0000 mm.
Extremely coarsely crystalline	D7	over 4.0000 mm.

APPENDIX C

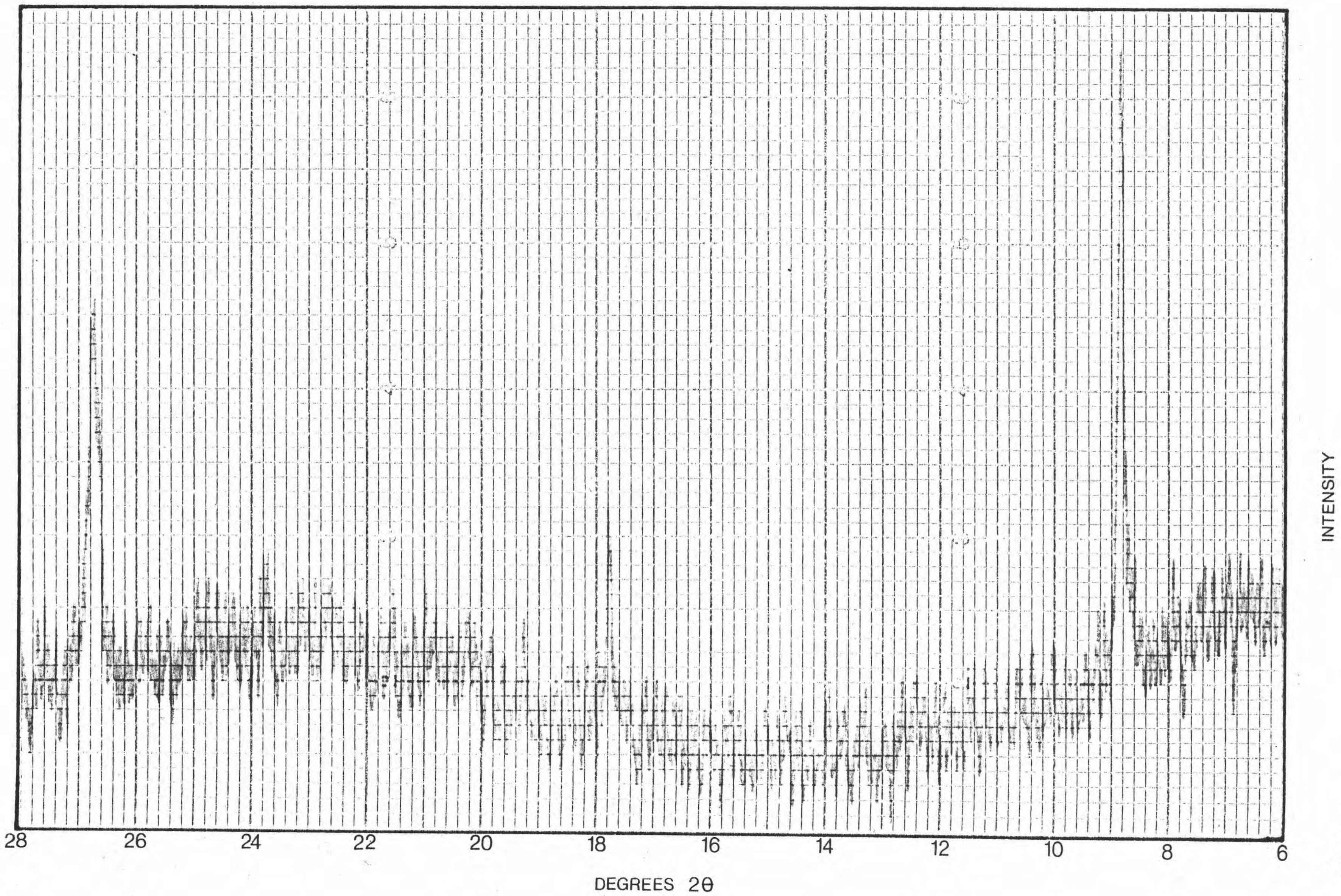


Figure C-1 The representation of 122-X-ray diffractogrammes of the Ordovician carbonate sediments showing

APPENDIX D

Table D-1 Measuring conditions, absorption sentivities, and precision of the elements.

Elements	Wavelength (nm.)	Lamp current (mA.)	Slit width (Å)	Flame	Absorption sentivity(ppm.)	Detection limit (ppm.)	Precision (%)
Ag	328.1	4	6	Air-C_2H_2	0.06	0.1	-
Ba	553.6	10	5	N_2O-C_2H_2	9.50	0.5	0.45
Ca	422.7	5	5	Air-C_2H_2	0.11	0.1	0.50
Cd	228.8	4	4	Air-H_2	0.02	2.0	-
Co	240.7	7	2	Air-C_2H_2	0.11	0.1	3.25
Cu	324.8	3	3	Air-C_2H_2	0.11	0.3	-
Fe	248.3	7	2	Air-C_2H_2	0.13	0.5	4.50
Mg	285.2	4	6	Air-C_2H_2	0.08	0.01	0.52
Mn	279.5	8	2	Air-C_2H_2	0.06	0.2	2.35
Pb	283.3	5	7	Air-H_2	0.70	2.0	2.05
Sr	460.7	5	5	Air-C_2H_2	0.15	0.2	1.51
Zn	213.9	8	5	Air-C_2H_2	0.03	0.3	2.50

N.B. Precision determination of the analytical results used is after Rose, et al. (1976).

APPENDIX E

Table E-1 Characteristics of depositional environments (Reeckmann and Friedman, 1982).

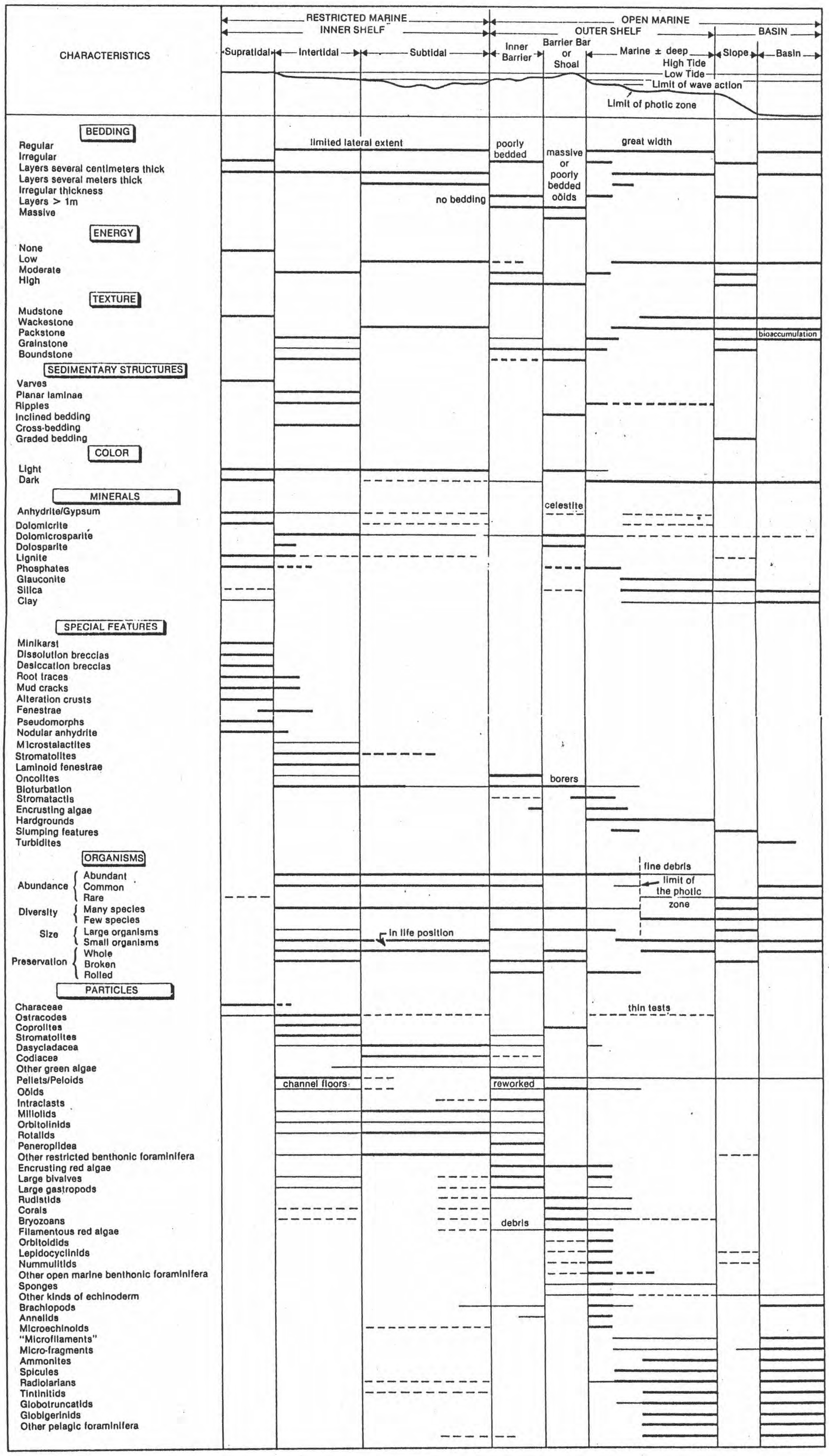


Table E-2 Diagnostic biological characteristics of depositional environments (Reeckmann and Friedman, 1982).

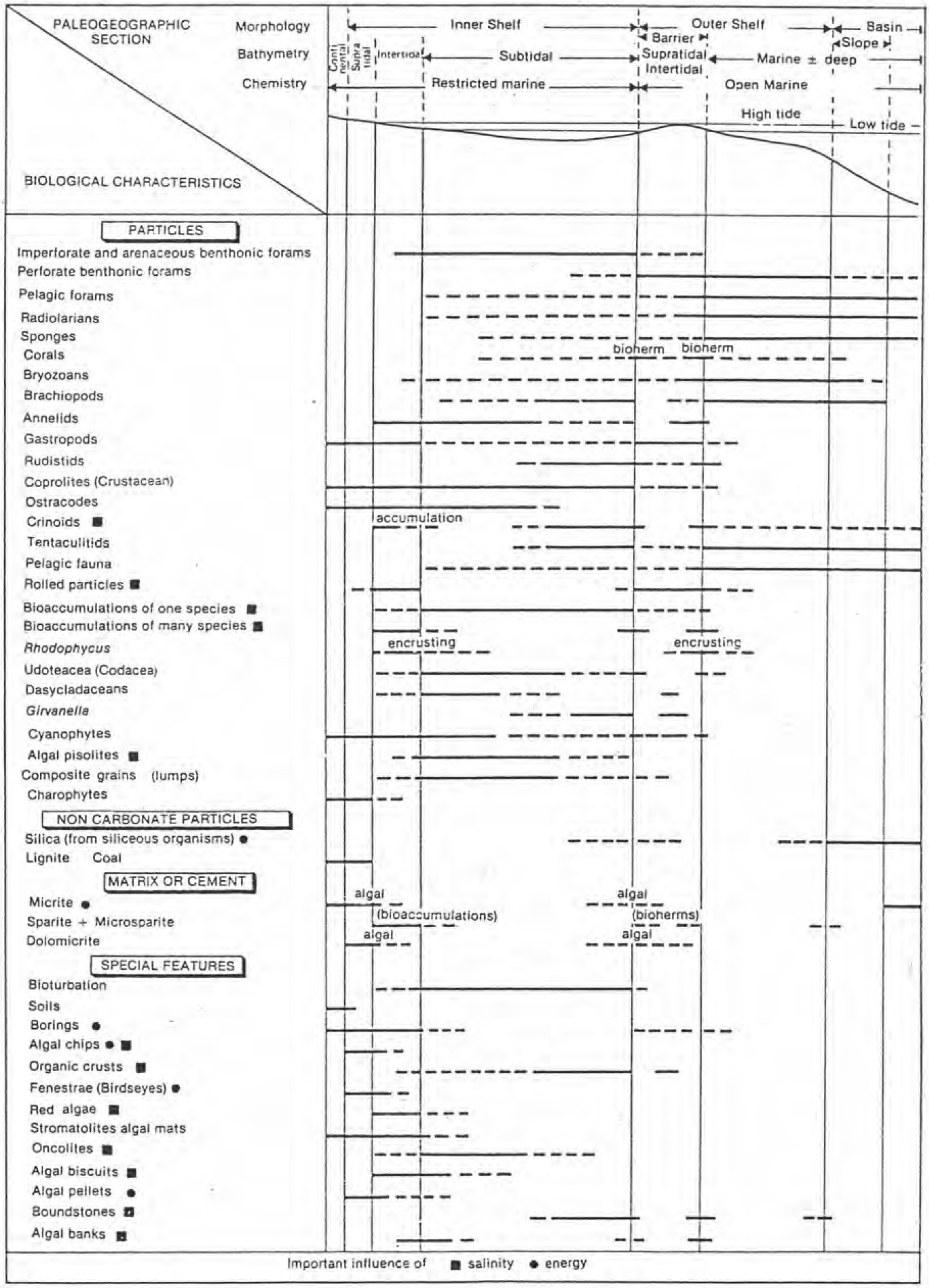


Table E-3 Diagnostic physical characteristics of depositional environments (Reeckmann and Friedman, 1982).

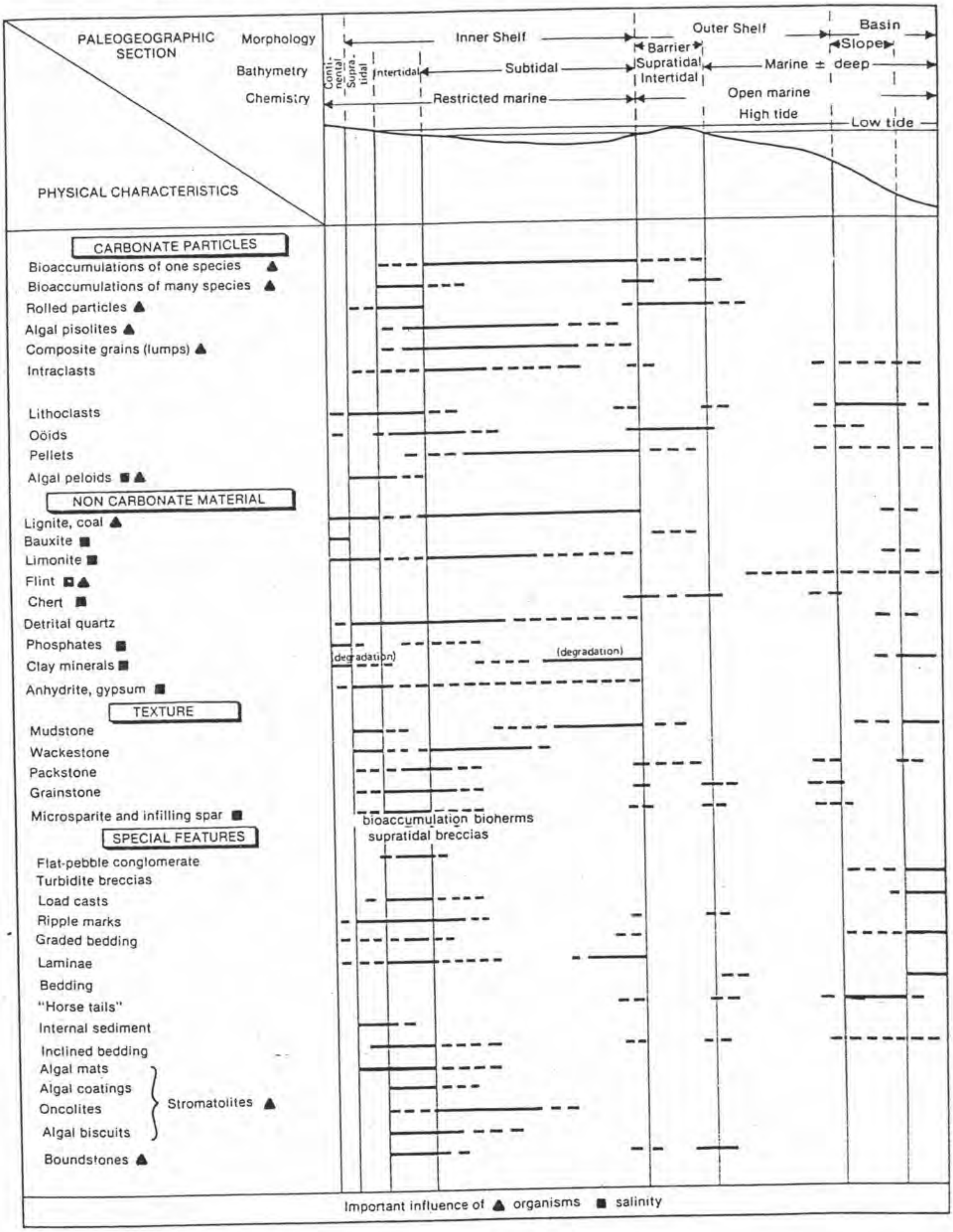


Table E-4 Diagnostic physiochemical characteristics of depositional environments (Reeckmann and Friedman, 1982).

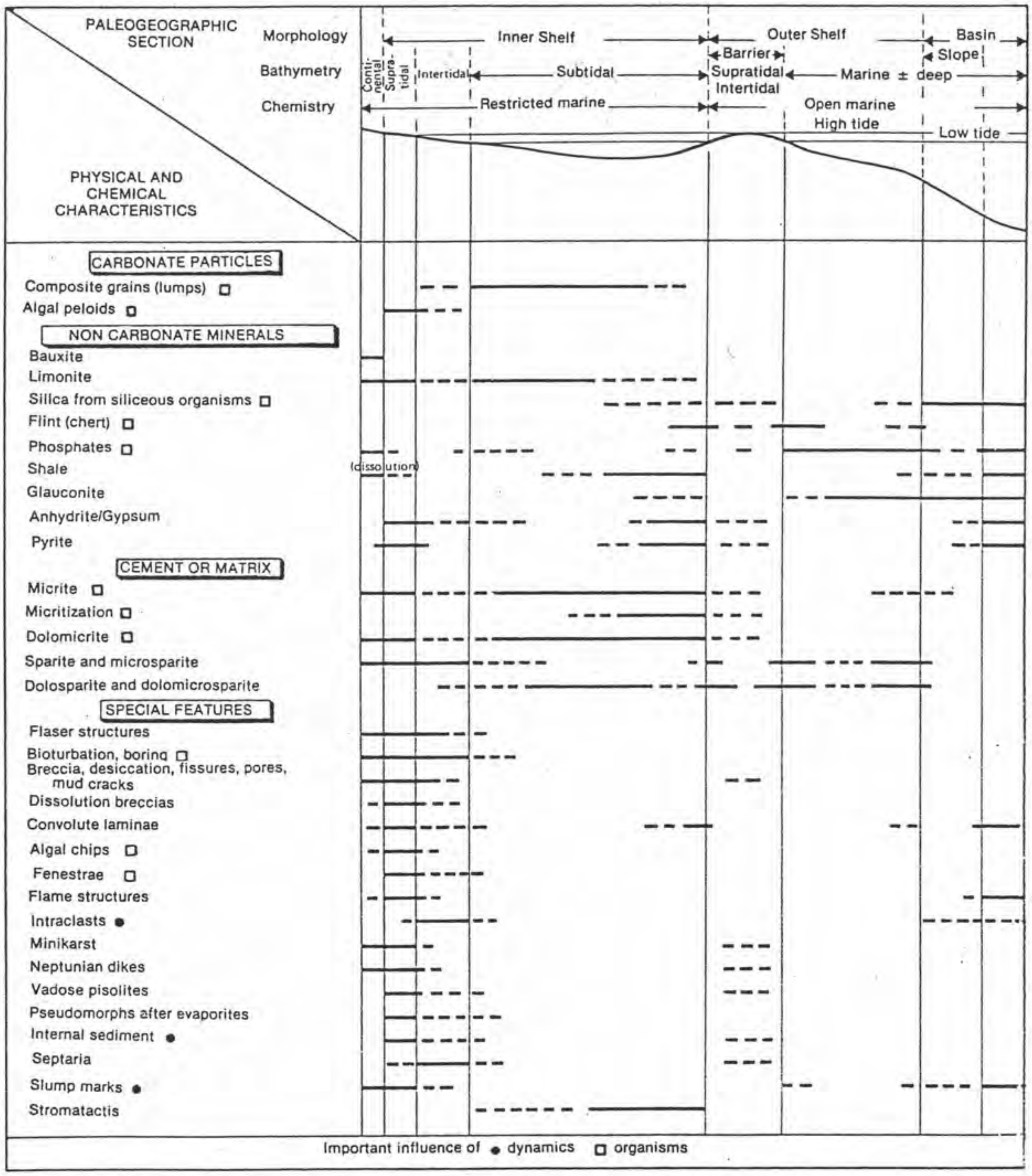
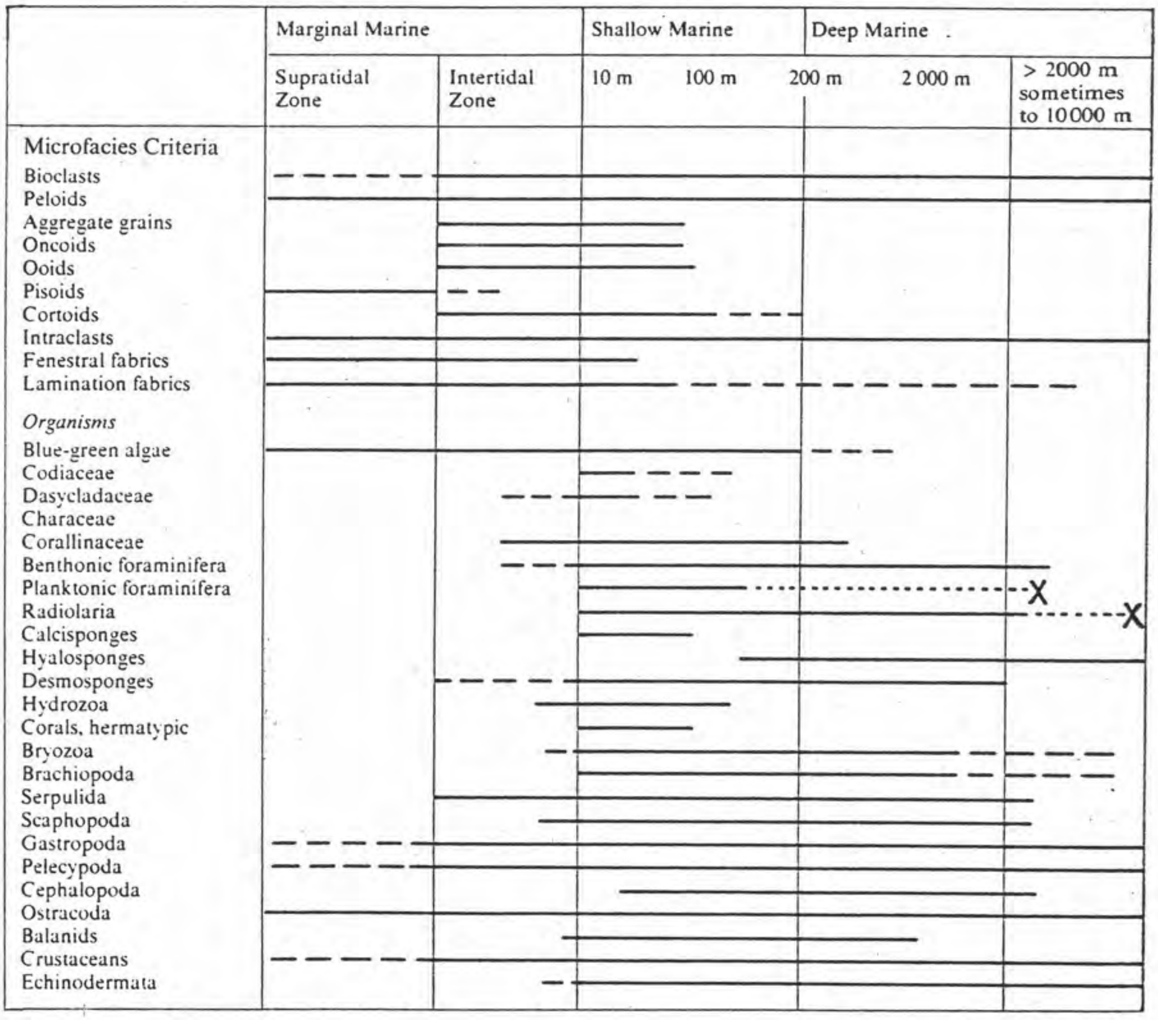


Table E-5 Depth range of Recent Epoch of organisms and microfacies criteria (Flügel, 1978).



x = allochthonous

APPENDIX F

THEORETICAL FRAMEWORK ON THE CARBONATE-HOSTED LEAD-ZINC DEPOSITS.

1 Sources of lead and zinc. (Blaser, 1976).

a) Juvenile hydrothermal ore solution and lead/zinc-rich vapour.

The juvenile hydrothermal lead and/or zinc-rich ore solution can be subdivided into two groups :

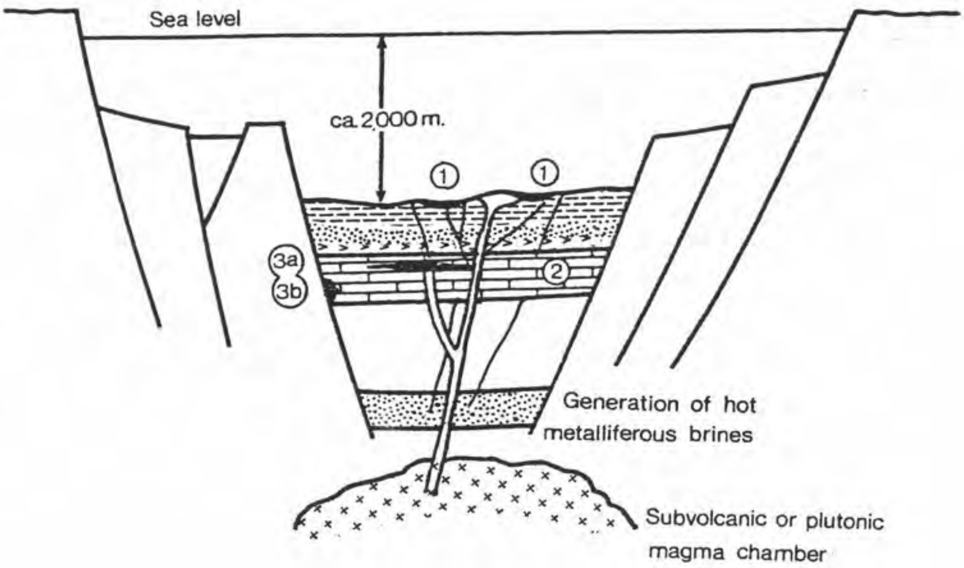
(i) the first group includes vapours or watery segregations from cooling magmas of acid to intermediate plutonic intrusions. The main significance of lead/zinc-bearing juvenile hydrothermal solutions or vapours lies in the formation of important ore accumulation of lead, zinc, and many other metals, which occur mainly in the deeper metamorphosed portion of the earth's crust. In relatively rare cases do these juvenile ore fluids ascend via open faults through unmetamorphosed sediments to form vein-type ore deposits. They probably play a relatively unimportant role in the formation of strata-bound ore deposits.

(ii) the second group of juvenile hydrothermal lead/zinc-rich solution is associated with acid to intermediate volcanism. The vapours and/or watery solutions derived from subvolcanic magma chambers then often rise through faults to the sea floor or to the ground surface. They can cause the formation of vein-type lead/zinc deposits in various types of sediments, preferentially in carbonates, and in the case of submarine volcanism to syngenetic stratiform ore deposits.

b) Lead/zinc-rich brines generated in the deep subsurface of sedimentary basins.

The hot metalliferous brines certainly form a very important category of ore fluids, which can form strata-bound lead/zinc accumulations. A model for fluid migration in tectonically active graben areas is shown in Figure F-1. In this hypothetical model two different mechanisms of fluid migration are taken into account. i) the rise of juvenile hydrothermal fluids induced by the vapour pressure of these fluids and the fluid pressure gradient. ii) the circulation of formation fluids of meteoric origin through aquifers and open faults in an artesian hydrodynamic system.

Another mechanism for the formation of metalliferous heated brines had therefore to be conceived. Jackson and Beales (1967) developed a possible model for the formation of metalliferous brines in sedimentary basins. This concept is schematically shown in Figure F-2 They suggest that in the central part of the subsiding sedimentary basin, the deepest formations would be exposed to such high formation pressure that part of the connate water would be driven out towards the edge of the basin. It is known fact from oil geology that formation waters in the deeper, central portion of the basin assume much higher salinity than sea water, in other words that they acquire the composition of brines. It was therefore suggested that these hot formation waters could possibly leach lead and zinc from shales or from other sediments preconcentrated in these metals and could take them up in solution in the form of chloride-metal complexes. With increasing subsidence and compaction of the basin, these metalliferous brines would migrate laterally upwards the edge



TYPE OF LEAD AND ZINC DEPOSITS:

1 Submarine effusion of lead/zinc (manganese, iron)-bearing brines.

2 Fault mineralization or lateral stratiform mineralization of carbonate sequence.

3 Effusion of lead/zinc-bearing brines from graben boundary faults resulting in syngenetic stratiform mineralization in the graben (3a), or epigenetic mineralization along the graben boundary faults (3b).

Figure F-1 A model for lead and zinc deposits in deep sea grabens (Blaser, 1976).

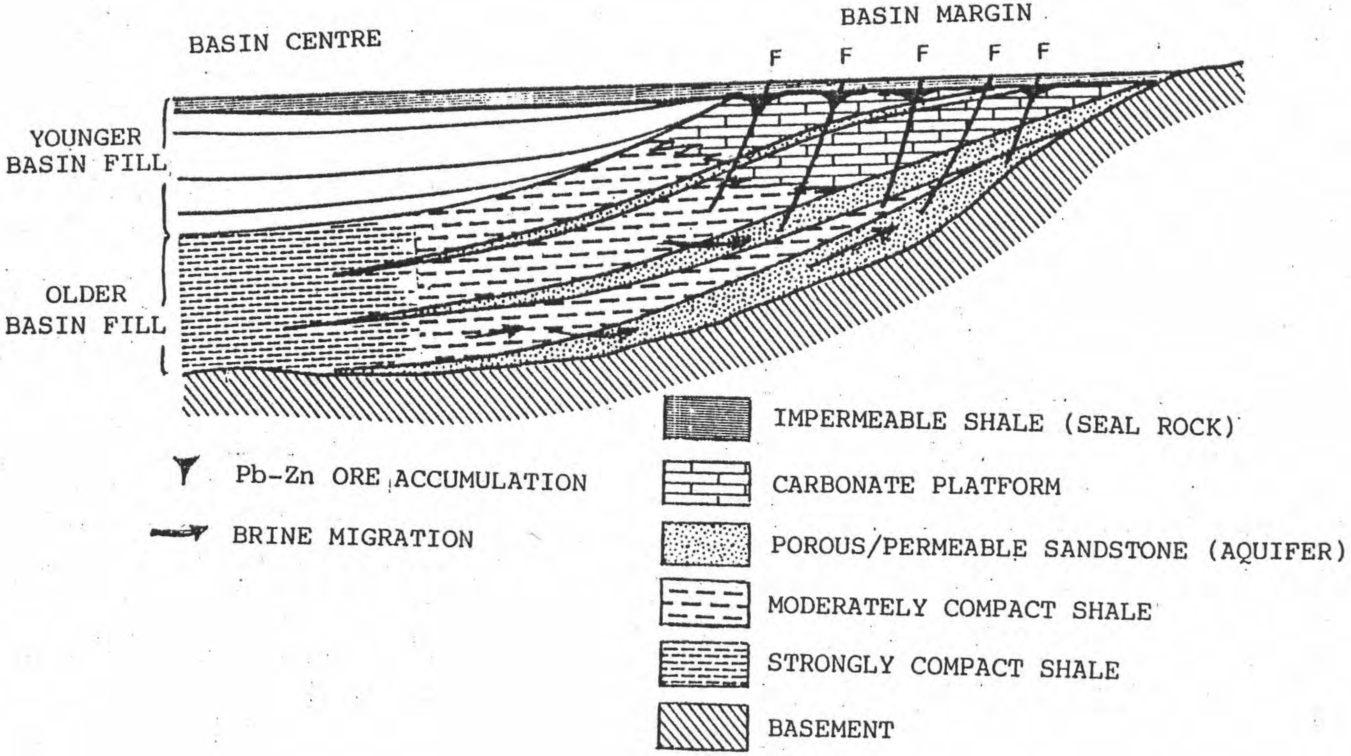


Figure F-2 Lateral updip brine migration from basin centre towards carbonate platform at the shallow margin of the basin (Jackson and Beales, 1967; from Blaser, 1976).

of the basin. Although one can imagine that water migrates from more compacted shales of the basin centre into less compacted shales at the basin margin, it is clear that the migration process would be very slow; water migration could speeded up considerably if porous sandstone layers were intercalated between the shales. These porous and permeable sandstone could act as preferential water conductors or aquifers. For these reasons it was suggested that most of the waters are conducted towards the basin edges via porous and permeable sandatone aquifers. From these regionally persisting aquifers the metalliferous brines could be conducted via open faults into overlying carbonate rocks and precipitate their metal load.

c) Surface or shallow subsurface meteoric waters enriched with lead and zinc.

The meteoric waters are cabable of leaching lead and zinc from exposed sediments and transporting them. The most spectacular geological evidence for this are lead and zinc accumulations in karst cavities. It is probably that the waters responsible for karst formation are rich in CO_2 and O_2 but it is doubtful whether these properties alone could fully explain the solution of significant amounts of lead and zinc. It is suspected that humic acids play an important role in the enrichment of meteoric waters with dissolved lead and zinc, since humic acids can adsorb relatively large amounts of metals and form with them soluble organometallic complexes. If this is true, the formation of lead and zinc accumulations in karst may be especially enhanced in hot humid climated with a dense vegetation. The different type of lead-zinc ore deposits derived from descending meteoric waters are typically stratiform mineralization connected with supratidal to intertidal belts in carbonate depositional areas.These mineralization are formed during the temporary emersion and erosion of carbonate platforms or carbonate built-ups which preferentially takes place in coastal regions. During this emersion period, meteoric waters leach and erode sediments exposed at the land surface and cause lead-zinc mineralization in the leached zone situated below the emersion surface. It should be stressed that the concepts on the nature of meteoric waters considered to be important lead-zinc ore fluids are still theoretical. They are mainly based on the geological circumstances of ore deposits that were clearly formed by meteoric waters and on geochemical investigations that show both of chloride-rich and humic acid-rich waters can carry lead-zinc ion complexes in significant concentrations.

2 Favourable conditions. (Blaser, 1976).

a) Role of H_2S for precipitation of lead-zinc sulphides: the metal-sulphide precipitation can only take place when lead and zinc dissolved in the ore-bearing fluids or react with large concentrations of hydrosulphides (H_2S and HS^-). Some ore-bearing fluids, especially the lead and zinc fluids of magmatic origin contain high hydrosulphide concentrations as primary constituents. In this case, lead-zinc sulphides will precipitated if the physicochemical conditions are favourable conditions (decrease in temperature and pressure or a changing in Eh, and pH; in metamorphosed carbonates PbS and/or ZnS often replace calcite or dolomite). Other ore fluids that were originally deficient in H_2S-rich waters, before lead-zinc precipitation can take place. The lead/zinc-rich fluids of megmatic and probably also those volcanic origin contain sufficient hydrosulphides to warrant the precipitation of large quantities of sulphides. In contrast, in general heated metalliferous brines probably contain too little hydrosulphides to cause the precipitation of substantial amounts of metal sulphides. If this case, in fact, the case they would need to encounter (on their migration path) formation waters rich in hydrosulphides and they have to mix with them. This is probably even more strictly the case for meteoric lead-zinc waters that originate in an environment where oxygen is present. These ore solutions can precipitate galena and shpalerite if they mix with stagnant H_2S-bearing water either stagnant surface water pools or H_2S-bearing ground water.

b) The significance of porosity and permeability for the percolation of ore-bearing fluids and as host rock for precipitation: the mixing of ore fluids with H_2S-rich waters can of course only take place either in open surface water bodies or, what is much more common, in the pore space porous and impermeable rocks, especially carbonates. Dense and permeable carbonate varieties do not permit the passage of these fluids. The porosity and permeability of carbonate rocks are therefore a very important zones within a carbonate sequence do not only provide the channels for migrating ore-bearing fluids but also the pore space in which ore minerals precipitate. Virtually the same carbonate lithologies that are important reservoirs for hydrocarbon accumulations are also potential host rock for lead-zinc deposits. In principle, porosity and permeability in carbonate rocks can be subdivided into three types : primary porosity/ permeability, diagenetic porosity/permeability caused by dolomitization and carbonate leaching, and porosity/ permeability can be due to open faults and fractures.

c) Geological situations where all prerequisites for lead-zinc mineralization are fulfilled : a tentative result of such a comparison shows that three circumstances are of prime important : the paleogeographic and environmental condition, favourable syndepositional and postdepositional structural history, and karst ore formation.

3 The major processes of porosity and permeability creating (van der Bann, 1976).

a) Leaching: The calcium carbonate in contact with solution dissociates in accordance with equilibrium reaction (1) :

$$CO_2 + H_2O + CaCO_3 \longleftrightarrow Ca^{++} + 2HCO_3 \qquad (1)$$

The restricted reversibility of this reaction in sea water, or any solution with a high Mg^{++}/Ca^{++} ratio is a matter of prime importance to carbonate equilibria.

Calcite, high-Mg calcite is not stable but changes slowly to low-Mg calcite. It is also more soluble than low-Mg calcite, whereas aragonite which is metastable at low temperature, and slowly change into low-Mg calcite. Aragonite is more soluble than calcite. The process by which aragonite and high-Mg calcite change into low-Mg calcite is known as $CaCO_3$ stabilization. Of importance are the facts that during stabilization the secondary porosity can be created. Because of the relative abundance aragonite is favourable to later leaching, porosity creating are particularly effective in aragonitic carbonate deposits.

b) Dolomitization: it is a very important porosity creating process, because dolomitization is attended with a volume decrease of 8-13 per cent depending on the original $CaCO_3$ polymorph. In general, if calcium, magnesium or carbonate ions are supplied from outside, all pore will eventually be filled with dolomite.

With respect to the controls on dolomitization, perhaps the most obvious requirement for precipitation of dolomite in carbonates, be it primary or secondary, is that a source of Mg ions be present. The possible sources of Mg ions include : i) sea water, ii) Mg-calcite in the sediment, iii) Mg-rich clays, iv) Mg-rich brines concentrated from sea water via precipitation of evaporites, or v) subsurface brines including those generated by igneous and metamorphic activity. Other controls include such aspects of water chemistry as Mg/Ca ratio, sulphate concentration, iron content organic material, and possibly bacterial activity (Longman, 1982).

c) Fracturing : fractures and joints offer the best pathways for meteoric waters to descend to the water table in limestones. In limestones in which there is no interuption in the continuity of the joints to the water table, little more than enlargement or widening of the joints can be expected. To develop secondary porosity by solution above the water table, it is believed that the flow of water to the water table must be interrupted, so that other outlets may be formed. Several factors, such as close spacing of joints, or large volume of circulating water, may lead to the development of zone of continuous porosity or even cavernous conditions along some beds. The new outlets may also be porous zones parallel with the bedding planes, or they may be calcite-rich zones, where solution will be rapid and penetrative. The presence of water in zones or horizones above the true ground-water table indicates the presence of a type of perched water table in which the underlying barrier is not necessarily entirely impermeable. The outlets may merge at the surface as springs, or if the bedding is not horizontal, porous or even cavernous zones may be developed downdip, until the formation dips into the water table.

4 Classification of carbonate-hosted lead-zinc deposits.

Carbonate-hosted lead-zinc deposits can be divided into two major classes (Sangster, 1976) as follows:

a) Mississippi Valley Type. The presence or absence of structural controls to this class of carbonate-hosted lead-zinc deposits and the relative age of these structural features to that of mineralization has led, and will undoubtedly continue to lead, to a bewildering array of genetic models for these deposits. Because of open-space filling, the mineralization was emplaced into pre-existing rocks. This emplacement took place regradless of the original depositional environment of the carbonate. The characteristic widespread host-rock brecciation, albeit of diverse origins followed by infilling by zinc and lead sulphides, accounts for the epigenetic character of many districts. In some areas the structural control appears to be largely due to what may be referred to as mild tectonic stresses, and the brecciation is apparently only indirectly related to structure in that broad upwards have resulted in erosion and karsting of the carbonate rocks by meteoric waters. As with modern-day caves, carbonate solution is often preferentially directed along strong joints or small faults in the host rock. In many instances, of course, the distinction between structurally controlled and sedimentary controlled brecciations is not clear because processes such as secondary dolomitization or carbonate solution are instigated or directionally controlled by subtle structural features. Thus, with all these variations and combinations of primary and secondary porosity available, it is perhaps not surprising that some of them would serve as traps to other subsurface fluids such as petroleum and associated brines. In fact, comparison of the compositions of oil-field brines and fluid inclusions in Mississippi Valley ores has resulted in widespread advocation of some forms of connate brine as the transporting medium for these deposits. The oil (or hydrocarbon) itself has also been postulated to have played an active role in ore formation by acting as the necessary reductant to convert dissolved sulphate to sulphide. Reduction may be brought about either through the agency of bacteria at low temperatures or non-biologically at higher temperature. The presence or absence of hydrogen sulphide (sour gas) may be the controlling factor in the formation of this type of ore deposit. In clastic rocks, the H_2S may have been stripped out by reaction with iron in the sediment and precipitated as iron sulphides.

The result of these analogies between hydrocarbons and brines has been the establishment of a genetic model for Mississippi Valley deposits which involves more or less independent migration of metal-bearing chloride brines and H_2S-bearing fluids to a common site where precipitation of the metals as sulphides take place. This depositional site may be controlled by porosity brought about by secondary processes such as solution collapse dolomitization or it may be primary porosity such as found within a reef, reef talus or other sedimentary breccias, all of which are also common hydrocarbon traps. Whether it is hydrocarbons or metals, the model presented requires emplacement of the sulphides into pre-existing rocks and traps, presumably some times after lithification of the hot and at some depths to produce the fluid inclusion temperature.

b) Alpine type. as with the Mississippi Valley type, the Alpine type deposits also show epigenetic features such as vein fillings, breccia cementation, and massive replacement bodies. The main difference however, as pointed out by Schneider (1964), is that while the ore bodies have some epigenetic features, the non-economic equivalents are clearly syngenetic or synsedimentary.

BIOGRAPHY

Mr.Wanlop YIMYAI was born on May 1, 1963 in Amphoe Muang, Changwat Phitsanulok, northern part of Thailand. In 1985, he graduated from Chulalongkorn University with a degree of Bachelor of Science (Geology). Afterthat, in 1985 he has continued his post-graduate study leading to the Master of Science Degree in the Graduate School of Chulalongkorn University.