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D.G.H. - D. EXPLOR.
LABORATOIRE DE GEOLOGIE DE PAU
-
GEO/LAB. PAU n° 110/80 RP
/mn

SEDIMENTOLOGICAL STUDY OF THE NINGBING LIMESTONES
(Upper Devonian)
in Aquitaine Keep-River n°1 (from 11,700' to 15,623')
(Northern Territory - Australia)
-
Comparisons with the outcrops of the Ningbing Range and Lennard shelf (Western Australia)

GEO/LAB. PAU n°110/80 RP

NORTHERN TERRITORY
GEOLOGICAL SURVEY

R. ELLOY

August 1980

CONTENTS

List of Maps

Assistance requested by TELEX AAP-M. R. LAWS - n° 15269 du 17/07/80

Work order :

Encl. : Log. 1" to 200'

DISPATCHING LIST

DESTINATAIRES

AQUITAINE AUSTRALIAN PETROLEUM (AAP) (2 ex)

Explor. DIG AMA (1 ex)

Expert Régional (1 ex)

DIVISION GEOLOGIE

Division Géologie PARIS puis DCEG Paris pour archivage

Division Géologie PAU puis retour GEO/LAB.PAU

Lab. Boussens

DOC-Micoulau (2 ex.)

SUMMARY

Lithologies and types of sedimentary environments of the Ningbing Limestones encountered both in the Keep River n° 1 drill hole and in the outcrops of the Ningbing Range, located 50 km westward, are mostly similar. A helpful comparison can also be tempted with the outcrops of the Lennard Shelf in the south-western side of the Kimberley block.

In Keep River n° 1 the "Reef facies" develops under a "Mud-mound" type of build-ups made up of an Algae-stromatactics-mud assemblage. No or very few corals are presents. All the build-ups of this type found throughout the world are usually tight but, most of the time, they are closely linked with "true Reefs" (Canada, Africa...) which can provide good reservoirs.

Overlain by impervious silty shales the "Reef facies" occurs in the upper part of the Ningbing Limestones section of upper Devonian age. This facies is underlain by a broad back-reef of lagoonal lithology deposited in a shallow restricted and reducing environment. The part played by Algae is prominent in such a type of rock which can be a potential source for hydrocarbons.

The basal part, transgressive on very tight, fine grained, silicified quartzites, presumably related to the Cockatoo formation (?), is dolomitized and locally porous. Here also, the environment is restricted ; sulfides recrystallise pyrobitumen (?) contribute to plug partially the porosity.

In this generally restricted back-reef environment some timid marine influxes are noticed from time to time. Reference being made to previous studies, hereunder mentionned, the "reefal" development could be expected in a fringe running NE-SW from Keep River (10).

Eastward, the reef development could be limited by a quick pinching out of the Ningbing Limestones. (In Sorby Hills area we find restricted dolomites bearing sulfides - one could be tempted to correlate with the basal dolomites of Keep River - directly overlain by siltstones of the presumed Burt Range formation).

Althought the whole sequence being transgressive, according to :

- the probable thickening of the Ningbing Limestones (700' and 1200' in the Ningbing and Jeremiah Hills areas against 3000' in Keep River n° 1. See VEEVERS (2) ;
- the possible occurrence of Algal mounds at different periods to explain the drastic, almost permanent, restriction of the broad and thick back-reef,

we suggest a secondary favourable trend toward a basinal northwestern direction from Keep River.

Thus the extension of the favourable area would be conditionned by the steepening of the shelf (and/or synsedimentary faults) which seems to have been very deep during sedimentation at least in the Ningbing Range border of the basin.

10 pages
1 log.

I - GENERALITIES

To precise the environment of deposition of the Ningbing Limestones, cores 16 to 23 have been re-examinated and the 200 thin sections available re-studied. Results are shown in the 1" to 200' log ; Sonic, SP and Gamma-Ray logs are of few help except to delineate the upper part of the Devonian and the extension of the "Algal-reef".

The previous papers mentionned in this study are :

1 - P.E. PLAYFORD and D.C. LOWRY, 1968 - Devonian Reef complexes of the Canning basin - Western Australia.

2 - JJ. VEEVERS and J. ROBERTS, 1968 - Upper Palaeozoic Rocks, Bonaparte Gulf Basin of Northwestern Australia.

3 - JJ. VEEVERS, 1969 - Sedimentology of the Upper Devonian and Carboniferous platform sequence of the Bonaparte Gulf Basin.

4 - B.W. LOGAN and V. SEMINIUK, 1976 - Dynamic metamorphism, processes and products in Devonian Carbonate Rocks, Canning basin, Western Australia.

INTERNAL REPORTS

5 - Well completion report. Keep River n° 1 - 1969.

6 - Resultats préliminaires de l'étude stratigraphique du sondage de Keep River 1.OP 162. Northern Territory - Australia. (R/STR. 216-1969).

7 - Etude de laboratoire du forage de Keep River 1 - Permis OP 162 - Northern Territory. (R/STR. 259-1969).

8 - Etude sedimentologique de quelques coupes effectuées sur la bordure du Bonaparte Gulf Basin - Australia. Mission de terrain du 15/7 au 19/7/71, R. ELLOY - R. BROWN.

9 - Sedimentological Field Survey of the Bonaparte Gulf Basin - Australia - Ningbing Range, W. Australia, 1974, B. PORTHAULT (Mining report)

10 - Synthèse des missions Bonaparte (1963), Alligator (1965 et 1971) effectuées sur le Joseph Bonaparte Gulf Basin (Western Australia et Northern Territory), intervalle Cockatoo à Burt Range, 1972 (Mining report), R. BLANC, R. ELLOY (R/GEO 181/72).

11 - Un exemmple de sédimentation carbonatée de plate-forme : Le Lennard Shelf de Western Australia (Devonien). Essai de reconstitution paléogéographique, comparaison avec des modèles actuels ou anciens, 1975. R. ELLOY, R. BROWN, (GEO/LAB. PAU n°93/75).

II - DESCRIPTION OF THE SECTION - ENVIRONMENTS

From top (11,710') to bottom (15,623' TD).

1) 11,700' - 12,215'

Black silty dolomitic and/or calcareous shale.

The amount of iron and organic matter is high giving the rock its color. This sediment seems to have been deposited in a low energy-reducing environment ; no fossils have been recorded in this part. This lithology affords a good impervious blanket to the limestones deposited underneath. After a "transitionnal" zone (12,180'-12,220'), the contact with the limestones is sharp. The amount of terrigenous supply probably stopped the algal activity.

2) 12,215' - 12,500'

The black limestones infilled with white veins or clouds of spar (core 17) belong to the "reefal" part of the Ningbing limestones. They can be closely compared to the limestones of the Ningbing Range (2,3,8,9) or to the Windjana limestones of the Canning basin (1,11) although the latter are never black but variegated (pink, white, green) and hold locally some Corals and Sponges.

In all locations the composition is nearly similar :

- Large amount of muddy matrix in which the part played by algae, although not clearly identified because of the superimposed processes of recristallisation and micritisation, should have been of the greatest importance.

- Stromatactis and stromatactis-like concretions ;

- Incrusting algae (Renalcis) and Parachaetetes, Girvanella, Sphaerocodium, Calcispheres, Parathurammina ;

- Great amount of Brachiopods and Crinoids ;

- Ostracods, pellets, gravels....

- More or less layered internal sediments in cavities lined by microspar.

- Vertical or oblique fractures lined by spar and infilled by sediments ("neptunian dykes").

This very peculiar lithology cannot be missed and is always linked with reefal features in the same landscape : below the "true reefs" in Canada, (Devonian of Rainbow), below reefs or isolated, nearby the reefs, in the morrocan Sahara at the same period ; beneath some belgium reefs (Vaudecee quarry, Ardennes) ; lateral to the reef (Lennard shelf, Australia).

Unfortunately this facies, up to now, has never been recognized as a reservoir neither in outcrops (Belgium, Sahara, Ningbing, Lennard shelf), nor in subsurface, (Rainbow, East Canada...). Nevertheless the adjoining sediments like true reefs (Rainbow) or back-reef dolomitic beds (Lennard shelf) may show good to very good porosity.

The important fact to retain is the association of this algal-mound type of build-up with others true build-ups in the same area and, optimistically, in some cases, the possible reactivation of the sediment by fractures (eg. core 18 in Keep River) with further solution and/or dolomitization acting favourably on the original tight sediment.

Illustrations of this lithology are given :

. for the Bonaparte by :

JJ. VEEVERS (2) Fig. 32 p.55
Plate 17
(3) Plate 42 Fig. 1

ELLOY-BROWN (8) Plates 8-9

.For the Canning Basin :

PLAYFORD (1). Fig. 9 to 15 ; pp. 37-44.

ELLOY-BROWN (11) ; plates 12 to 17.

3) From 12,500' to 13,195'

These underlaying sediments (including core 18) still show "stromatactis", Renalcis and internal sediments. This zone appears to be a transitionnal one strongly recristallised between the true mud-mound and the sediments below.

At the base, from 13020' to 13195', a slightly more marine tongue precede these transitionnal sediments.

4) From 13,195' to 13,910'

Lagoonal to back-reef environment.

The rock is black ; mainly made up of micritic pellets and gravels due to a strong algal activity followed by the destruction of the successive algal mats. Identified algal remains are numerous (Girvanella, Chaetetes, Calcisphera (very abundant), Parathurammina, Irregularina) and caracteristic of such an environment which was not a good shelter for other forms of life ; scarcely are found : Molluscs or Brachs, Gastropods (R) and spines of crinoids (R,A).

The restriction of the environment is also shown by the very abundant neogenetic needle-like quartz.

This type of rock is found in the back-reef of the Ningbing Range ; it is illustrated by :

. JJ. VEEVERS (2). Fig. 32. p. 55 (3). Plate 32-34.
. B. PORTHAULT (9). Plates 5, 6, 7.
. ELLOY-BROWN (8). Plates 9, 10, 12.

It is worth to notice that the Amphipora so common is the back-reef (Pillara) of the Lennard shelf does not appear in this basin. This is possibly due to the younger age of the Ningbing limestones.

All the intraclasts are closely welded by a calcitic cement or spar of microspar

At the very top of the zone, between 13,020' and 13,150' the occurrence of Pteropods might indicate a possible marine and deeper movement just before the settlement of the area by Mud-mounds reef-types.

5) Between 13,910' and 14,000'

The abundance of big Crinoïdal stems, Brachiopods, Pteropods (?), Molluscs could also be the sign of a more marine environment. A breccia is noticed at 14,000'.

6) Below, down to 15,115'

The environment is nearly the same as the back-reef developping above, from 13,910 to 13,195'.

The conditions seem nevertheless be less restricted with the lack of silica needles, apparition of scarce Bryozoans, greater abundance of Foraminifers Ostracods.

Dolomitic beds are not uncommon, but the rock is always tight, cemented by spary calcite as above.

7) From 15,115' to 15,575'

The bottom of the section can be divided in two parts :

. From 15,115' to 15,275'
Lagoonal very restricted silty limestones, sometimes dolomitized with Gastropods, Lamellibranches, neogenetic quartz and traces of halite. Some ooids are present.

. Below, 15,275' to 15,575'
We are probably dealing with the same type of rock but entirely dolomitized. Only ghosts of pellets and gravels are distinguishable.

Some porosity appears when the rock is largely replaced by hudge cristals of dolomite (drusy porosity). The colour in thin section is deep yellow to brownish.

This secondary dolomite seems due to strong restricted conditions and probably a high magnesium potential existing in the environment when the first sediments were deposited directly above the underlaying sandstones.

REMARKS

These basal dolomites can be related to the basal dolomites encountered at the very bottom of the Ningbing Range section (9), south of Knob Peak area : "These brownish dolomites are coarse grained silty dolomites with laminites and intraformationnal breccia. The upper part of the formation contains oncolites and large Gastropods casts... conspicuous gossans and mineralisations are associated..." In Keep River n°1 some sulphides also occur with black material (pyrobitumen ?) plugging in part the inter-cristalline porosity.

8 - Basal sandstones from 15623' to 15574' (cores 25 to 23)

Very fine grained sandstones, most of the time quartzitic and feldsphathic (up to 10 % Orthoclase), locally cemented with carbonate (dolomite).

The grains are always angular to sub-angular ; the mean size being about 100 microns, the coarser seldom reaching 400 microns.

Except in silty beds the clay fraction (pure illite) does not exceed 10 to 15 %.

At the very top clayey green layers show the ultimate decantation of the finest material. They are very often broken and reworked inside the clastic material which increases locally is size.

- Sedimentation : Marine silt/sandstones deposited in a rather deep low-energy environment. The lack of structure within the sediment is characteristic except at the very top where the energy level increases and creates some reworking and micro-channeling while the grain-size of the material is coarsening. Some burrowing appears.

- Reservoirs : Secondary silica and late carbonate infills make the rock very tight.

This sandstone is reported to belong to the Cockatoo formation of the upper Devonian.

III - CONCLUSION

The Ningbing limestones from bottom to top, display a transgressive sequence starting with very shallow restricted sediments which underwent dolomitization and ending with algal-reefal-mounds built in deeper marine conditions.

In between, develops a thick back-reef in a shallow restricted environment ruled by Algae, only briefly interrupted, from time to time, by slightly more marine thin tongues. The different facies, including the basal dolomite, can be compared to those croping out in the Ningbing Range.

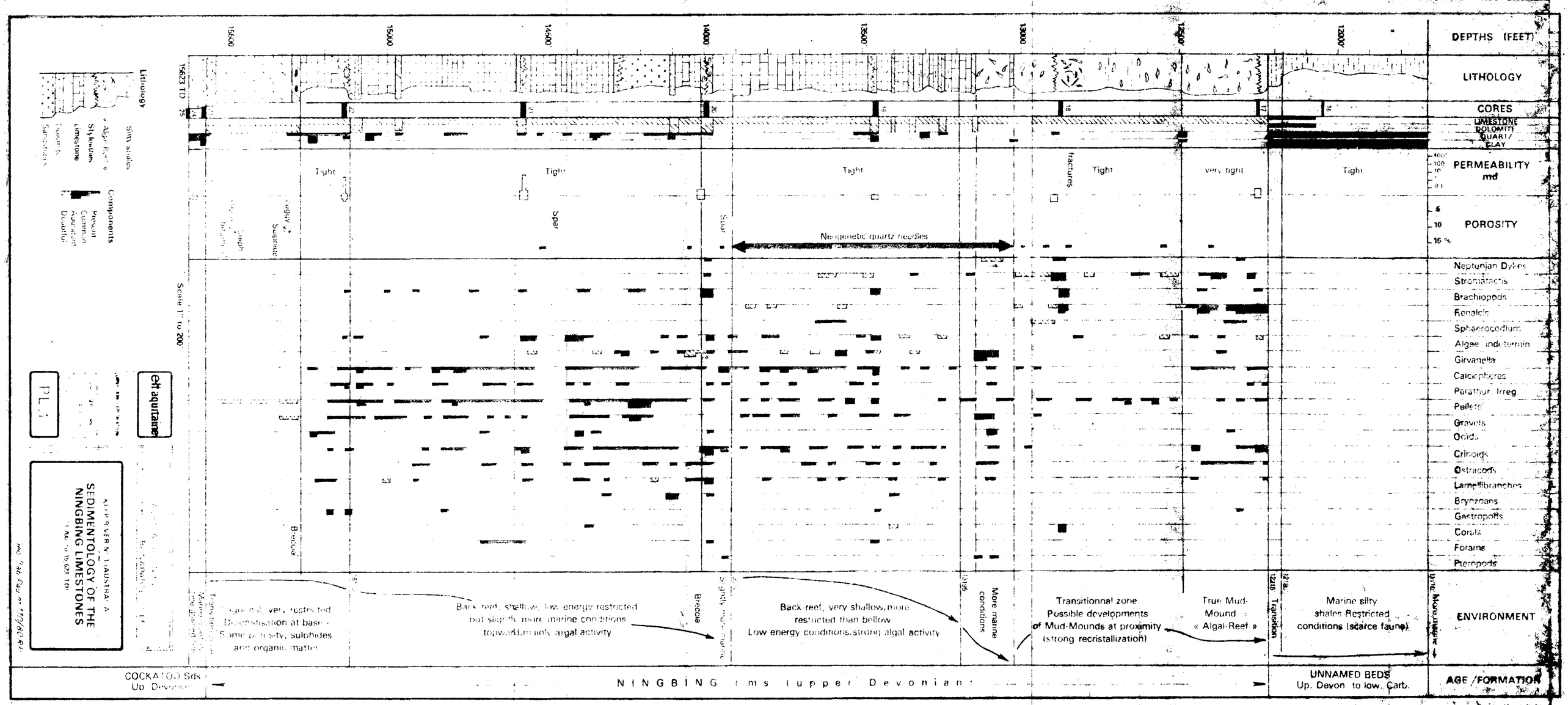
As a whole the section is very tight, even the "algal-reef". The majority of these algal-mounds found elsewhere in the world are usually tight, but are, most of the time, associated with lithologies or "true" reefs (eg. Canada, Africa...) which can afford good to very good reservoir properties.

The development of coral-reefs (bioherms or biostroms) can occur as an over-growth on top of the mounds (Canada, Moroccan Sahara, Belgium) or flanking more or less this lithology (Lennard shelf).

Moreover this type of mounds are able to induce a restriction in the depositionnal environment, source rocks can be expected in the vicinity.

The thickness of the back-reef facies in Keep River 1 suggests that this type of build-up could have existed at several times of its sedimentation to provide sheltered, restricted condition for a long period, allowing the algal-mats to develop intensively.

A presumable extention if this "reefal" facies around the Bonaparte Gulf Basin is shown in Map 2 of the report R/GEO 107/72 (10) and discussed in the summary of this paper.


DEPTHS (FEET)
15500
15000
14500
14000
13500
13000
12500
12000
LITHOLOGY
CORES
LIMESTONE
DOLOMITE
QUARTZ
CLAY
PERMEABILITY md
POROSITY
15623 TD
Tight
Tight
Tight
fractures
Tight
very tight
Tight
Spar
Neogenetic quartz needles
Neptunian Dykes
Stromatactis
Brachiopods
Renalcis
Sphaerocodium
Algae indeterminate
Girvanella
Calcisphères
Parathur. Irreg.
Pellets
Gravels
Oolds
Crinoids
Ostracods
Lamellibranches
Bryozoans
Gastropods
Corals
Forams
Pteropods
Scale 1" to 200
Breccia
Slightly more marine
More marine conditions
Back reef, shallow, low energy restricted but slightly more marine conditions topwards, mainly algal activity
Back reef, very shallow, more restricted than bellow Low energy conditions, strong algal activity
Transitionnal zone Possible developments of Mud-Mounds at proximity (strong recristallization)
True Mud-Mound « Algal-Reef »
Marine silty shales Restricted conditions (scarce faune)
ENVIRONMENT
COCKATOO Sds
Up. Devonian
NINGBING fms (upper Devonian)
UNNAMED BEDS
Up. Devon. to low. Carb.
AGE / FORMATION
Lithology
Components
Present
Common
Abundant
Dolomite
Limestone
Sandstone
PL 1
elf aquitaine
SEDIMENTOLOGY OF THE NINGBING LIMESTONES